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Contents

i Executive summary

WGWIDE reports on the status and considerations for management of the 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.

2024 catch advice was drafted for all eight stocks. Benchmark assessments are proposed for 2025 for mackerel, herring, and striped red mullet while both horse mackerel stocks and boarfish are scheduled to be benchmarked in 2024.

Northeast Atlantic mackerel. This migratory stock is widely distributed throughout the Northeast Atlantic with significant fisheries in several ICES subareas. The assessment conducted in 2023 is an update assessment, based on the configuration agreed during the 2019 interbenchmark and incorporates updates to the commercial catch, tagging, swept-area, egg survey, and recruitment index dataseries. Advice is given based on stock reference points which were updated during a management strategy evaluation carried out in 2020. SSB has been declining since 2014 but is above MSY $B_{trigger}$ in 2023. Fishing mortality has been increasing since 2016 and above F_{MSY} since 2021.

Blue whiting. This pelagic gadoid is widely distributed in the eastern part of the North Atlantic. The current assessment configuration (interbenchmark in 2016) uses preliminary catch and sampling data along with the acoustic survey data from the current year. The 2023 update assessment indicates that SSB is increasing following strong recent recruitment and is well above MSY $B_{trigger}$. Fishing mortality has been above F_{MSY} since 2014.

Norwegian spring-spawning herring. This stock is migratory, spawning along the Norwegian coast and feeding throughout much of the Norwegian Sea. The 2023 update assessment is based on an implementation of the XSAM assessment model introduced following a benchmark in 2016 and is consistent with the 2022 assessment. SSB has been declining since 2009, except for an increase in 2021 which was due to the strong 2016 year class entering the SSB. Fishing mortality has been above F_{MSY} since 2019. Recruitment since 2016 is estimated to be below average and SSB is forecast to fall below MSY $B_{trigger}$ in 2024 and decrease further in 2025 even if the management plan is applied in 2024.

Western horse mackerel. The Western stock of horse mackerel is distributed throughout ICES subareas 4, 6, 7, 8, and 9. Following a benchmark in 2017, the stock is assessed using the Stock Synthesis (SS) integrated assessment model. Stock reference points were revised in 2019. Following a period of declining SSB, there has been a modest rise since 2017, albeit from a low level. The 2023 assessment indicates that SSB is below B_{lim} and will remain so in 2025, even under the scenario of zero catch in 2024. Based on the MSY approach, advice for 2024 is therefore for zero catch. The assessment has been displaying significant retrospective bias, but the 2023 assessment is consistent with the 2022 assessment.

North Sea horse mackerel. Catch advice for this stock is issued biennially on the basis of an assessment based on a combined index from groundfish surveys in the North Sea and the Channel. The 2023 value is an increase on the 2022 value for the exploitable stock. A length-based indicator continues to indicate that fishing mortality remains above F_{MSY}.

Northeast Atlantic boarfish. Boarfish is a small, pelagic, planktivorous, shoaling species found over much of the Northeast Atlantic shelf but primarily in ICES subareas 4, 6, 7, and 8. The directed fishery occurs primarily in the Celtic Sea and developed during the early 2000s, initially unregulated before the introduction of a TAC in 2011. The stock is assessed using an exploratory

Bayesian surplus production model with catch and survey data from groundfish surveys and an acoustic survey. The current assessment indicates that, following a sharp decline after 2012, biomass has been increasing in recent years. The most recent acoustic surveys indicate a period of above-average recruitment in recent years. A length-based indicator indicates that fishing mortality is below F_{MSY}.

Northeast Atlantic red gurnard. This stock was first considered by WGWIDE in 2016 with advice issued biennially. The assessment was benchmarked in 2021 and a survey-based relative biomass indicator was developed. The 2023 update assessment continues to show the indicator fluctuating without trend since 2010. However, large uncertainties remain regarding landings data due to poor resolution at the species level and reported discarding levels vary widely.

Striped red mullet in Bay of Biscay, Southern Celtic Seas, Atlantic Iberian waters. No assessment is available for this stock and information on abundance and exploitation level is limited with advice given triennially on the basis of the precautionary approach. However, there are a number of research projects underway which will inform a future benchmark and potential upgrade of the assessment category.

ii Expert group information

Expert group name	Working Group on Widely Distributed Stocks (WGWIDE)
Expert group cycle	Annual
Year cycle started	2022
Reporting year in cycle	1/1
Chair	Erling Kåre Stenevik. Norway
Meeting venue and dates	23–29 August 2023, Copenhagen, Denmark (38 participants)

1 Introduction

Working Group on Widely Distributed Stocks (WGWIDE)

1.1 Terms of References (ToRs)

The **Working Group on Widely Distributed Stocks** (WGWIDE), chaired by Erling Kåre Stenevik, met in ICES HQ in Copenhagen in hybrid format, 23-29 August 2023. The terms of reference for the meeting were the generic ToRs for Regional and Species Working Groups:

a) Consider and comment on Ecosystem and Fisheries Overviews with a focus on:

i) identifying and correcting mistakes and errors (both in the text, tables and figures), and

ii) proposing concrete evidence-based input that is considered essential to the advice but is currently underdeveloped or missing (with references and Data Profiling Tool entries, as appropriate).

The input will feed into the annual updates of the overviews. Delivery of contributions other than those outlined above is also welcomed but will be utilized during the revision process (around every 5 years).

b) Conduct an assessment on the stock(s) to be addressed in 2023 using the method (assessment, forecast or trends indicators) as described in the stock annex; - complete and document an audit of the calculations and results; and produce a **brief** report of the work carried out regarding the stock, providing summaries of the following where relevant:

i) Input data and examination of data quality; in the event of missing or inconsistent survey or catch information refer to the ACOM document for dealing with missing data and the linked template that formulates how deviations from the stock annex are to be reported.

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

iii) For relevant stocks (i.e. all stocks with catches in the NEAFC Regulatory Area), estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2022.

iv) For category 3 and 4 stocks requiring new advice in 2023, implement the methods recommended by WKLIFE X (e.g. SPiCT, rfb, chr, rb rules) to replace the former 2 over 3 advice rule (2 over 5 for elasmobranchs). MSY reference points or proxies for the category 3 and 4 stocks (guidelines)

v) Evaluate spawning-stock biomass, total-stock biomass, fishing mortality, catches (projected landings and discards) using the method described in the stock annex;

1) for category 1 and 2 stocks, in addition to the other relevant model diagnostics, the recommendations and decision tree formulated by WKFORBIAS (see Annex 2) should be considered as guidance to determine whether an assessment remains sufficiently robust for providing advice.

2) If the assessment is deemed no longer suitable as basis for advice, provide advice using an appropriate Category 2-5 approach as described in ICES technical guidance for harvest control rules and stock assessments for stocks in categories 2 and 3 or ICES.

3) If the assessment has been moved to a Category 2-5 approach in the past year consider what is necessary to move back to a Category 1 and develop proposal for the appropriate benchmark process.

vi) Catch scenarios for the year(s) beyond the terminal year of the data for the stocks for which ICES has been requested to provide advice on fishing opportunities;

vii) Historical and analytical performance of the assessment and catch options with a succinct description of associated quality issues. For the analytical performance of category 1 and 2 age-structured assessments, report the mean Mohn's rho (assessment retrospective bias analysis) values for time-series of recruitment, spawning-stock biomass, and fishing mortality rate. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR viii) of the Generic ToRs for Regional and Species Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

c) Produce a first draft of the advice on the stocks under considerations according to ACOM guidelines.

d) Review progress on benchmark issues and processes of relevance to the Expert Group.
i) update the benchmark issues lists for the individual stocks in SID;
ii) review progress on benchmark issues and identify potential benchmarks to be initiated in 2024 for conclusion in 2025;
iii) determine the prioritization score for benchmarks proposed for 2024–2025;
iv) as necessary, document generic issues to be addressed by the Benchmark Oversight Group (BOG)

e) Prepare the data calls for the next year's update assessment and for planned data evaluation workshops;

f) Identify research needs of relevance to the work of the Expert Group.

g) Review and update information regarding operational issues and research priorities on the Fisheries Resources Steering Group SharePoint site.

h) If not completed previously, complete the audit spread sheet 'Monitor and alert for changes in ecosystem/fisheries productivity' for the new assessments and data used for the stocks. Also note in the benchmark report how productivity, species interactions, habitat and distributional changes, including those related to climate-change, could be considered in the advice.

i) Deliver conservation status advice in accordance with the "Technical Guidelines on the conservation status advice". The advice is only to be given when conservation aspects were identified and where clear, demonstrable management action can be recommended for any non-catch anthropogenic pressure. It can also be used to highlight clear demonstrable sensitivity to climate change. The qualification required to show clear, demonstratable management action is high. Avoid generic statements that are of no specific application to management.

j) Update SAG and SID with final assessment input and output

1.1.1 The WG work 2023 in relation to the ToRs

The WG considered updates for all eight stocks within its remit. Based upon these assessments and associated short-term forecasts, the group produced draft advice sheets for Northeast Atlantic mackerel, Blue Whiting, Norwegian spring-spawning herring, Western horse mackerel, North Sea horse mackerel, Boarfish, red gurnard and striped red mullet. All draft advice sheets were agreed in plenary. Advice sheets, report sections and assessments were audited with 2-3 working group members assigned to each stock.

1.2 Participants at the meeting

WGWIDE 2023 was attended by 37 delegates (11 online) from the Netherlands, Ireland, Spain, Norway, Germany, Portugal, Iceland, UK (England and Scotland), Faroe Islands, France, Denmark, and Sweden. The full list of participants, all of whom are authors of this report is given in Annex 1.

All the participants were made aware of ICES Code of Conduct, which all abided by, and none had Conflicts of Interest that prevented them from acting with scientific independence, integrity, and impartiality.

1.3 Overview of stocks within the WG

Eight stocks are assessed by WGWIDE. In 2023, the group drafted 2024 advice sheets for all 8 stocks. A summary of the WGWIDE stocks, current data category and assessment method and advice frequency is given in the table below:

Stock	ICES code	Data category	Assessment method	Assessment frequency	Last assessment
Boarfish	boc.27.6-8	3.2	Bayesian Schafer surplus production model	2	2021
Red gurnard	gur.27.3-8	3.2	Survey trends based	2	2021
Norwegian spring-sp. Herring	her.27.1-24a514a	1	XSAM	1	2022
Western horse mackerel	hom.27.2a4a5b6a7a-ce-k8	1	Stock Synthesis	1	2022
North Sea horse mackerel	hom.27.3a4bc7d	3.2	Survey trends based	2	2021
NE-Atlantic mackerel	mac.27.nea	1	SAM	1	2022
Striped red mullet	mur.27.67a-ce-k89a	5	No assessment	3	2020
Blue whiting	whb.27.1-91214	1	SAM	1	2022

1.4 Quality and adequacy of fishery and sampling data

1.1.2 Sampling data from commercial fishery

Each year, the working group reviews available sampling data and the level of sampling on the commercial fisheries. Details are given in the relevant stock-specific sections of this report.

Generally, the amount and quality of available data to the WG has been unchanged in the most recent years. However, in 2022 no Russian data submissions were available (for 2021). In 2023, Russian catch data for 2022 on NEA Mackerel, Blue Whiting and Norwegian Spring-Spawning Herring were available and used in the assessments of the three stocks.

The WG identified issues associated with the formatting and availability of data from commercial catch sampling programmes such as the requirement for length frequency and age–length key data for the assessment of Western horse mackerel and the availability of data arising from the sampling of catches of North Sea horse mackerel from foreign flagged vessels. The issues have been included on the individual stock issue lists and the ICES data call has been updated such that future data submissions should provide data in the appropriate format.

1.1.3 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.

In the case of red gurnard catch data, the available information is of poor quality. Prior to 1977, red gurnard catches were not reported. Since this time, landings of gurnards have often been reported as mixed gurnards, or using the incorrect species code. With the exception of Portugal, there is no detail provided to the WG on the methodology used to estimate the proportion of red gurnards in mixed landings.

1.1.4 Discards

In 2015, the European Union introduced a landing obligation for fisheries directed on small pelagic fish including mackerel, horse mackerel, blue whiting and herring. The obligation was expanded over the following years in a stepwise fashion such that discarding of small pelagic species could still legally occur in other fisheries. From 2019 onwards the landing obligation is generally effective. A general discard ban is already in place for Norwegian, Faroese and Icelandic fisheries.

Historically, discarding in pelagic fisheries is 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 and van Helmond 2007, Ulleweit and Panten 2007, Borges *et al.* 2008, van Helmond and van Overzee 2009, 2010, van Overzee and van Helmond 2011, Ulleweit *et al.* 2016, van Overzee *et al.* 2013, 2020). 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. In Iberian waters the discard composition of pelagic species, mainly blue whiting, in demersal fisheries were estimated between 20% and 30% of the total catch in weight (Fernandes *et al*. 2015). 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.

1.1.5 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 most recent updates on this aspect for the different stocks are addressed below.

1.4.1.1 Mackerel

The most recent age calibration exercise for this stock was carried out in 2021 using the SmartDots platform under the remit of WGBIOP. The full exercise was completed by 37 readers from 12 countries across Europe. Otolith images (n=237) were provided by 12 of the participating laboratories with the aim to provide a set of images representative of the temporal and spatial coverage of otoliths read for stock assessment purposes (including the southern component, western component, North Sea component and the northern distribution).

Results show a slightly lower percentage of agreement and higher CV in the analysis taking all readers in account than the previous workshop (2018) and exchange (2014) which might be related to an increased number of readers (23 in WK 2018; 37 in Ex 2021 with 10 new (basic) readers). However, lower agreement (and higher CV) was also found for advanced readers. Here, numbers of readers also increased from 2018 to 2021 (15 to 21).

The overall conclusion was that the slightly worse results than in the prior workshops might be related to the increased number of readers. The image quality of otoliths from different areas was also discussed. However, the problem shown in previous workshops and exchanges persists: Agreement for otoliths with modal age 6 and older remains quite low. A new workshop was recommended.

1.4.1.2 Horse mackerel

The most recent workshop on the age reading of *Trachurus trachurus (*also *T. mediterraneus* and *T. picturatus)* was carried out in November 2018 and involved 15 age readers from 9 countries. This was followed by an otolith exchange which was conducted in 2021 for the three horse mackerel species T. Trachurus, T. mediterraneus, and T. picturatus and 28, 14 and 18 readers participated, respectively.

For T. trachurus both whole (N=249) and sliced (N=134) otoliths were read from 10 different areas (5 in the Mediterranean and 5 in the Atlantic). For whole otoliths and all readers, the weighted average percentage agreement (PA) based on modal ages for all readers is 46%, with a weighted average CV of 44% and an APE of 32%. For sliced otoliths and all readers, the weighted average percentage agreement based on modal ages for all readers is 44 %, with a weighted average CV of 22 % and an APE of 15 %. The readers had some difficulties in recognizing first ring and the edge nature, and with overlapped rings in old specimens. CV PA APE decrease for sliced oto-liths; however, high differences in the modal age is observed between same sample/different preparation.

1.4.1.3 Norwegian Spring-spawning Herring

For some years, there have been issues with age reading of herring. These issues were raised around 2010, and since then two scale/otolith exchanges and a workshop have been held; and a final workshop was planned after the second exchange. There were, however, concerns with the second scale/otolith exchange and the final workshop was postponed. It was therefore recommended to organize a new scale/otolith exchange and a follow up workshop.

There are several topics to cover in the recommended work.

First, age-error matrices are needed as input to the stock-assessment, to evaluate sensitivity to ageing errors, and such age-error matrices are an output of age-reading inter-calibrations.

Second, stock mixing is an issue. There are several herring stocks surrounding the distribution area of Norwegian spring-spawning (NSS) herring, *e.g.* North Sea herring, Icelandic summer spawning herring, local autumn-spawning herring in the Norwegian fjords, and Faroese autumn spawning herring. Mixing with these other stocks in the fringe areas of the NSS herring distribution area leads to confounding effects on the survey indices of NSS herring in the ecosystem surveys and potentially also in the catch data. Methods to separate the NSS herring stock from the other herring stocks are needed – both with regards to obtain more accurate age-readings as well as to reduce confounding effects on the survey indices.

Finally, the experience from earlier exchanges is that age of older fish is more prone to be underestimated when aged is read from otoliths as compared to being read from scales. Some of the institutes mainly sample and read scales, whereas other institutes use the otoliths.

In 2021, WGWIDE recommended to organize a scale/otolith exchange and workshop. This workshop, WKRANSSH was held in Bergen 17-21 April 2023 (ICES 2023a). Overall results for both exchanges and the combination were high and at acceptable levels. However, as described above, disagreement between scales and otoliths occurred especially for older individuals (age 8 and above), and disagreement between scales and otoliths occurred especially for older individuals. The next step is to investigate how these discrepancies impacts the stock assessment, based on the general age error matrix from the workshop. Stock mixing seems to be a minor issue that will have no direct impact on the assessment of NSS herring. However, this needs to be investigated in more detail in the near future.

1.4.1.4 Blue Whiting

The most recent workshop on the age reading of blue whiting (WKARBLUE3) took place in 2021 (31 May-4 June). The workshop was preceded by an inter-calibration age reading exchange, which was undertaken in 2020 using the SmartDots platform. In the exchange, the otolith collection included 407 otoliths from the entire stock distribution area, from which 190 otoliths where from the northern areas and 217 where from the southern areas of distribution. The otolith dataset allows a good coverage of samples by area and sex and took into account the differences in growth patterns by areas (northern and southern), and by sex due to the sexual dimorphism in blue whiting (Gonçalves *et al.* 2017).

The overall agreement of the pre-workshop exercise was 66% considering all readers and 70% for the assessment readers (advanced readers). Considering only the otoliths samples from the northern areas and the readers from the northern that usually read the otoliths from those areas for the assessment, 69% of agreement was achieved. Otherwise, considering only the otoliths samples from the southern areas and the readers from the southern that usually read the otoliths from those areas for the assessment, 79% of agreement was achieved. During the workshop, a small exchange was also conducted with 55 otoliths in which 73% agreement between the advanced readers was achieved.

The main issues identified on blue whiting age reading are still: the fact that the otoliths from some areas revealed to be more difficult to read (*e.g.* 27.2.a, 27.5.b); the first ring identification; edge type interpretation and false or double rings identification (Gonçalves, 2021).

During the workshop some of the otoliths from the exercise were polished, to help readers in the cases were the first age ring were not so evident, completely absent, or showing a growth pattern different from the expected. The polishing results revealed to be useful on the ring interpretation and to help in cases here the visible first ring size presents a size higher than the expected and the readers have doubts if an inner first ring are there. The hypothesis of the existence of a non-visible first ring has been described in the otoliths from the adult fish as the otolith becomes thicker and wider.

Although, during the WKARBLUE3 progresses have been made and objective and more clear age reading guidelines had been constructed. The recurrent age reading issues still remain the same, e.g. the identification of the position of the first annual growth ring, false rings and interpretation of the edge. In order to overcome those problems and increase the accuracy on age classifications, age validation studies on blue whiting otoliths to solve growth rings interpretation, were further recommended and should be conducted (ICES. 2023b).

1.4.1.5 Boarfish

Sampling of the commercial catch of boarfish has been included within the EU data collection framework since 2017. An age length key was produced in 2012 following increased sampling of a developing fishery. The age reading was conducted by DTU Aqua on samples from the three main fishery participants: Ireland, Denmark and UK (Scotland). No ageing has been carried out since 2012 although otoliths continue to be collected from the Irish fishery during routine catch sampling.

In November 2022, an ageing exercise was initiated via SmartDots with the aim to age samples less than 10 cm (all samples less than 10cm used in the ALK were estimations), to compile otolith images for future training purposes and to potentially shed light on the possibility of adjusting the plus group designation. A total of 158 boarfish otoliths of varying difficulty were aged by three readers from Denmark and Ireland. The otoliths were sourced from both legs of the 2022 WESPAS survey (14th June to 24th July). The fish length distribution of the samples ranged from 55 – 170mm with one third of the samples in the 55-95 mm length range. To image and read the otoliths, the protocol outlined in the boarfish age reading manual, created by DTU Aqua, was followed.

Results from the ageing exercise found that boarfish within the length range of 5.5 cm - 9.5 cm were between the ages of 1 and 3 years old. Concerning the plus group designation, the exercise wasn't able to advise or provide useful information to support or oppose changes to the plus group. The full results from the exercise were compiled in a report and published on the SmartDots webpage (ID 509).

1.4.1.6 Striped red mullet

In 2011, an otolith exchange was carried out, the second such exercise for the striped red mullet. For details see section 10.5.

1.4.1.7 Red gurnard

Age data are available for red gurnard from the EVHOE and IGFS groundfish surveys. Improvements in the understanding of the age structure of this stock would be improved by reading otoliths from other surveys in the assessment area (*e.g.* NS-IBTS, SCO-WCS, CGFS) which also contribute information on stock status in term of their CPUE series.

1.1.6 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 InterCatch. Co-ordinators collate data using the either the sallocl (Patterson, 1998) application which produces a standard output file (sam.out) or InterCatch.

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 of 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
Logbook 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

1.1.7 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.

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 still have no (or inadequate) 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.

A number of stock data problems relevant to data collections have been brought forward to the contact person in preceding years. Those that still apply are listed in table below for the information of ICES-Working Groups and RCGs 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. Data should include length distributions split by area and quarter. 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, including demersal fleets should be monitored and sampled for discards 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

Stock	Data Problem	How to be addressed in	By who
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 so that they may use this information when compiling the data submission.	National laboratories; RCG NA, RCG NS&EA
Horse Mackerel – Western Stock	Missing sampling data for some parts of the distribution area (e.g. 27.2a, 7e)	Fishing nations to Sample age and length Distributions from commercial fleets	National Institutes
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	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	Lack of length distributions in the discarded component	Sampling of length distribution of discarded individuals	National institutes
Norwegian Spring-spawning Herring	Low sampling effort on some nations	Sampling effort should be increased by nations with little or no samples.	National laboratories; RCG NS&EA
Red gurnard	Species level catch reporting and sampling	Red gurnard catches should be reported to species level and with the appropriate codification. Where reported as mixed gurnards, this should be accompanied by documented procedures for estimating the proportion of red gurnard.	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.	
Northeast Atlantic Blue whiting	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

1.1.8 Quality control of data and assessments, auditing

As a quality control of the data and the assessment, WG participants were appointed as auditors for each stock. The primary aim of the auditing process is to check that the assessment and forecast has been conducted as detailed in the relevant stock annex. Auditors conducted checks of the assessment input data, assessment code (time permitting), draft WG report and draft advice sheet. Auditors completed an audit report upon completion (annex 4). Issues identified in the audit reports were followed up by the appropriate stock coordinator/assessor with updates made where appropriate.

1.1.9 Information from stakeholders

The procedure for the submission of inputs from stakeholders into the scientific advice changed in 2020. Instead of contributing information directly into the Advice Drafting Groups, information from stakeholders is now submitted directly to the expert group for consideration and inclusion into the draft advice, if applicable.

For WGWIDE stocks there are several instances of strong cooperation between research institutes and fishing industry stakeholder in the collection of data that is used in the assessments, *e.g.* the acoustic survey for Norwegian Spring-spawning herring, the extension of the IESSNS survey into the North Sea and several cases where industry vessels are collecting samples for catch monitoring. In these cases, the research institutes are coordinating the activities and bringing the results directly to the expert group(s).

A recent development that started around 2014 involves fishing industry organizations taking initiatives on their own, to collect additional information that is contributed to the expert groups. In many cases these research activities are undertaken in close cooperation with research institutes. During WGWIDE 2022, the following contributions from fishing industry research activities were reported to the working group:

1. PFA self-sampling report 2015-2021
2. Gonad sampling for mackerel and horse mackerel in support of the 2022 egg survey
3. Horse mackerel genetics

1.1.9.1 PFA self-sampling report (WD02)

The Pelagic Freezer-trawler Association (PFA) initiated a self-sampling programme in 2015, aimed at expanding and standardizing ongoing fish monitoring programmes by the vessel quality managers on board of the vessels. An overview of the self-sampling in widely distributed pelagic fisheries from 2016 onwards is presented in the text table below.

Year	Number Vessels	Number Trips	Number Days	Number Hauls	Catch (t)	Catch per Day (t)	Number Length Measure-ments
2017	12	62	842	1,783	178,162	212	0.25%
2018	16	86	1,220	2,679	253,474	208	0.22%
2019	16	97	1,233	2,668	225,059	183	0.29%
2020	17	113	1,434	3,051	306,172	214	0.35%
2021	19	119	1,401	2,881	282,898	202	0.52%
2022	18	114	1,259	2,736	237,438	189	0.69%
2023*	18	68	785	1,934	189,832	242	0.18%
(all)	659	8,174	17,732	1,673,036			

***incomplete**

In the 2023 self-sampling report, a standardized CPUE calculation has been included for most of the stocks. The standardized CPUE is based on a GLM model with a negative binomial distribution. The response variable is catch by week and vessel, with an offset of the log effort (number of fishing days per week) and explanatory variables year, GT category, month, division and depth category. An assumed technical efficiency increase of 2.5% per year has been included in the fitting of the model (Rousseau et al 2019)

The trends in the 2023 Mackerel assessment are very similar to the standardized CPUE for the PFA vessels. The trends for Western horse mackerel CPUE are markedly different from the stock assessment where the CPUE suggests a further decline while the stock assessment points towards slow recovery of the stock. Limited quota may have resulted in a fishery not being representative of full stock exploitation. For North Sea horse mackerel, the assessment suggests a recent increase in stock size while the CPUE shows a continuous decline since 2017. It is suggested to investigate these differences at its next benchmark meeting. The CPUE for blue whiting showed a rather stable stock in the past 7 years while the stock assessment clearly shows a peak at around 2018, a decline followed by a peak again in 2022-2023. PFA will interact with the skippers to find an explanation for this difference in CPUE and stock trends as it is clear that the fishery was good this year.

1.4.1.8 Gonad sampling for mackerel and horse mackerel

During 2023, a dedicated PFA industry researcher carried out one sampling trip on-board of a commercial trawler with the aim to collect frozen gonad samples, all frozen in a different way to assess if the way of freezing has an impact on the fecundity estimates. Samples were delivered to Wageningen Marine Research and results are still pending.

1.4.1.9 Horse mackerel genetic stock identification

In an effort to address the longstanding questions regarding the stock identification of horse mackerel the northern European pelagic fishing industry commissioned a series of research projects to develop genetic methods for discriminating the stocks. Next Generation Sequencing (NGS) based approaches were used to identify informative genetic markers and to screen a larger number of samples, which indicated a clear separation of the southern North Sea spawning samples from other regions and further, less pronounced structure along the Northeast Atlantic continental shelf (Brunel et al., 2016; Farrell and Carlsson, 2018). However, it was concluded that further genetic analyses were required to increase the numbers and types of genetic markers available, which would improve the capacity for accurate genetic assignment.

In 2019 the Northern Pelagic Working Group (NPWG) of the European Association of Fish Producers Organisations (EAPO) commissioned a further project to develop a reference genome assembly for horse mackerel and to undertake whole genome sequencing (pool-seq) of population samples in order to identify informative single-base genetic markers (Single Nucleotide Polymorphisms - SNPs). Analyses of ~12.8 million SNPs indicated that the North Sea spawning samples were the most genetically differentiated group, whereas the structure among the Western, Southern and north African samples was less clear, though a north–south split was observed with a potential mixing zone between the Western and Southern populations in the southern part of Division 9.a, near Lisbon (Fuentes-Pardo et al., 2023). The analyses indicated that the samples from northern Portuguese waters were from the same biological population as those from the Western stock area i.e. the Western population. The samples from southern Portuguese waters comprised a mix of the ‘Western population’ type and a distinct southern population, which was more closely related to the North Africa population. Therefore, it was concluded that the southern limit of the Western stock was likely further south than the current definition of the border between Divisions 8.c and 9.a.

During this study a large number of informative SNPs were identified and c.4,000 of these, spread across the 24 chromosomes, were included on the multispecies genotyping array (IdentiGEN DNA TRACEBACK® Fisheries array FSHSTK1D) that is also being used for genotyping herring in divisions 6.a, 7.b-c, the Irish Sea and the Celtic Sea to allow population level genetic assignment.

In late 2022 the NPWG commissioned a further in-depth analysis of the genetic population structure of horse mackerel and the development of a genetic baseline and genetic assignment model using the new genotyping array. In total 35 samples, comprising 2,304 individuals were genotyped (Figure 1.4.8.3.1), including temporal replicates from all three stocks (See Farrell, 2023). Additional spawning samples from Division 9.a, which were not available for analysis by Fuentes-Pardo et al. (2023), were included and also non-spawning samples from potential mixing zones in divisions 4.a, 7.d and 7.e (Figure 1.4.8.3.1). The genotyping array yielded high quality data from 2,421 SNPs distributed across all twenty-four chromosomes.

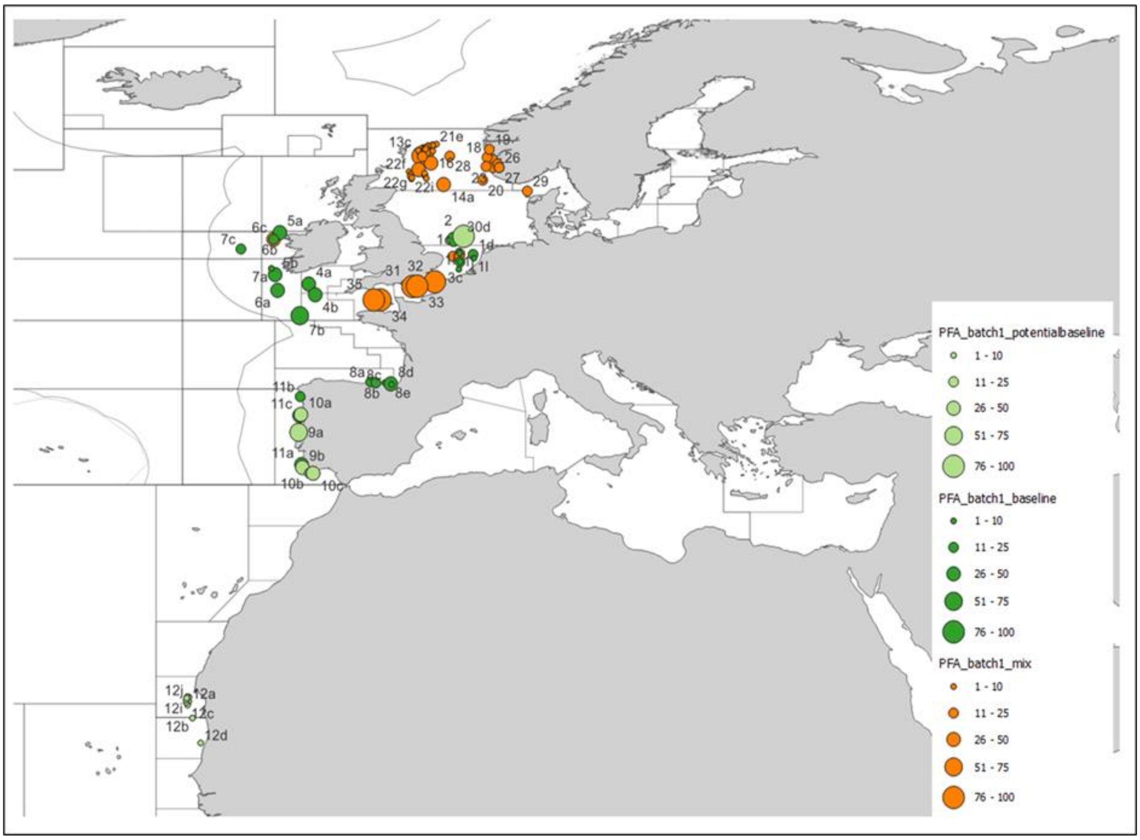


Figure 1.4.8.3.1. The sample locations for the horse mackerel samples genotyped during the latest genetic project. Dark green indicates spawning baseline samples, light green indicates potential baseline samples and orange indicates non-spawning mixed samples.

Exploratory analyses of the data included filtering of the dataset to exclude linked SNPs and testing of different approaches to identify the most informative markers. The different panels of markers, including an 8-SNP panel (Figure 1.4.8.3.2), all indicated the same population structure, which agreed with Fuentes-Pardo et al. (2023). The additional spawning samples from Portuguese waters clustered with the Western population samples and only samples from the southern tip (Cabo de Sao Vicente) and south coast of Portugal were significantly differentiated (Figure 1.4.8.3.2), confirming that the Western population extends further south than the current Western stock limits.

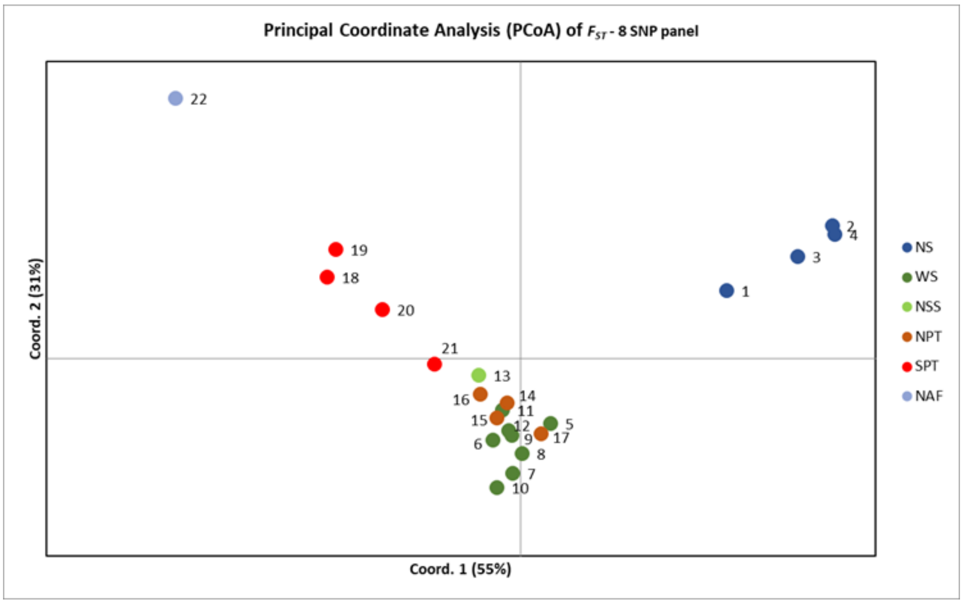


Figure 1.4.8.3.2. Principle Coordinate Analysis (PCoa) of F_{ST} illustrating the differentiation between the analysed baseline and potential baseline samples. NS = North Sea, WS = Western (west/southwest of Ireland), NSS = Northern Spanish Shelf, NPT = Northern Portugal, SPT = Southern Portugal, NAF = North Africa.

There were insufficient representative spawning samples available from the southern population to include in the development of the assignment model, therefore only the North Sea and Western populations were included. A support vector machine learning (svm) based approach was employed based on the available spawning baseline samples: 109 North Sea individuals (3 samples) and 383 Western individuals (10 samples). The assignment models were tested using two approaches, the first using all SNPs with dimensionality reduction through limiting the number of PCs based on the results of cross validation and the second with a reduced panel of 24 SNPs identified as the most informative to discriminate the two populations. The self-assignment rates were over 90% for each of the approaches, though the North Sea samples had a higher error rate than the Western samples.

Potentially mixed samples collected from commercial catches from Divisions 4.a (quarters 1 and 2 and quarters 3 and 4), 7.d and 7.e were assigned to population of origin using the assignment models (Figure 1.4.8.3.3.). The samples from Division 4.a. assigned to primarily to the Western stock regardless of quarter, indicating that these Q 1and2 samples should not be allocated to the North Sea catches as they were from the Western population. The 7.e samples assigned primarily to the Western population though contained a small number of North Sea fish. The 7.d sample from September 2020 assigned primarily to the Western population whereas the November and December 2020 samples assigned primarily to the North Sea population though still contained a significant proportion of Western fish present. The analyses indicated that there was a significant level of mixing between the Western and North Sea populations in the Division 7.d samples analysed.

In summary the analyses undertaken indicated that the Southern stock area contained at least two populations, one which was the same as the western population and one in the south of the area which was a distinct Southern population. Analyses also indicated that the current delineation of the North Sea stock appears to be inappropriate in Division 4.a and that there was significant mixing with the Western population in Division 7.d. Given that the Western stock area extends into Division 9.a, 4.a in all quarters and 7.d it is likely that the recruitment, biomass and catch of the Western population are underestimated. A report with the detailed analyses described above is being prepared and will be submitted to the SIMWG for review in advance of the Horse Mackerel Benchmark (see Section 5.10).

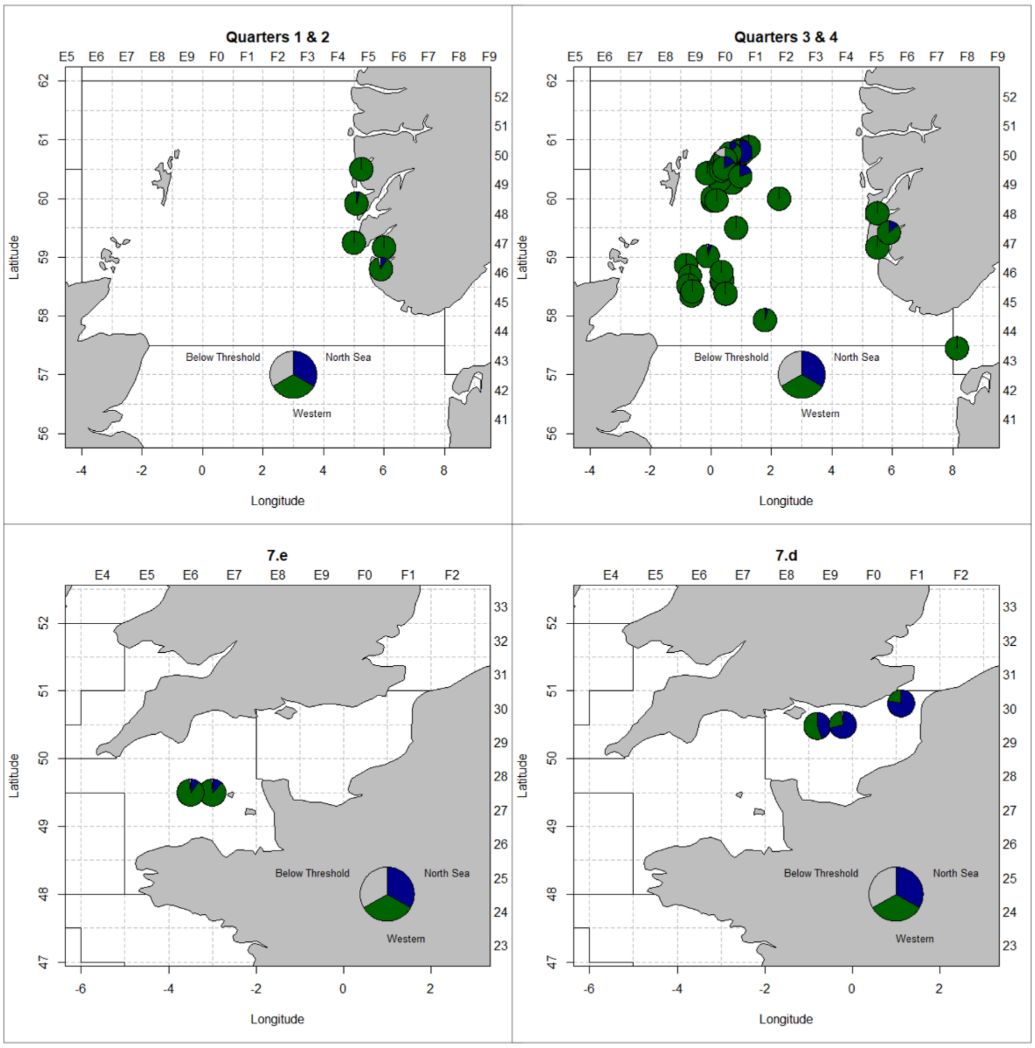


Figure 1.4.8.3.3. The outputs of the exploratory North Sea vs. Western assignment model. Each pie represents a single sample but the number of individuals in the samples varies (see Figure 1.4.8.3.1.).

1.5 Comment on update and benchmark assessments

Updates were presented to the WG for the stocks in the group.

Western and North Sea horse mackerel were assessed on basis of a benchmark that took place in January 2017 (ICES, 2017) and NEA mackerel on an interbenchmark that took place in 2019 (ICES 2019a). Norwegian spring-spawning herring was assessed using the XSAM implementation benchmarked in 2016. The Blue whiting SAM assessment was introduced following a benchmark in 2012. Since this time, an interbenchmark in 2016 incorporated the use of preliminary in-year catch data with the stock weights in the assessment year estimated from catch sampling incorporated in 2019 (previously the average of the most recent three years was used). The acoustic survey time-series was updated in 2020 following recalculation by the StoX platform with minor updates to the historic index. The red gurnard assessment conducted at WGWIDE 2023 followed a benchmark in February 2021 (WKWEST) during which an index of abundance based on a number of bottom trawl surveys was developed. Boarfish was considered at the SPiCT benchmark in January 2023 (WKBMSYSPiCT) but unfortunately it was unsuccessful as no model fit met all the points of the SPiCT checklist.

The remaining stock addressed by the WG (striped red mullet) has not been benchmarked recently but was still assessed by the WG.

1.6 Planning future benchmarks

The striped red mullet stock is still to be benchmarked as there is no assessment in place. A full benchmark is proposed by WGWIDE 2023 to take place before the next advice is scheduled in 2026.

Since boarfish was unsuccessful at WKBMSYSPiCT this year, it is still on the list for a benchmark in 2024. Ongoing sampling of the commercial catch, an expanded acoustic survey time-series and exploring alternative assessment models e.g. Stock synthesis will be explored. Research projects underway for Striped red mullet are due to be completed in the near future and will inform the proposed benchmark for 2025.

Full benchmarks are scheduled for western horse mackerel and North Sea horse mackerel in 2024.

WGWIDE 2023 is proposing full benchmark to take place for Northeast Atlantic Mackerel and Norwegian Spring-spawning Herring.

The workshop to review the current assumptions with regard to stock structure (components) for mackerel (WKMACEVAL) were conducted in 2023. The Workshop rejected the current three-component structure and accepted a single NEA mackerel stock concept to advance towards assessment, management and advice. This conclusion will simplify data issues in a benchmark. Exploratory work is already underway or is planned on a number of issues related to the mackerel assessment including dealing with individual high catch rates in the swept-area survey, DEPMvs.AEPM methodologies for the egg survey time-series, inclusion of additional ages from the tagging dataset, increasing the assessment recruitment age and updating the SAM configuration.

The proposed benchmark of Norwegian Spring-spawning Herring will explore issues such as the splitting of exiting survey indices, inclusion of additional surveys (IESSNS and tagging data), assumptions on maturity in the most recent years.

The XSAM software is used for the assessment. However, the SAM software now supports the XSAM model as an optional model. A switch from the currently used code to the SAM platform should be done in order to make the model more publicly available and to ensure further development of the infrastructure. WGWIDE 2023 recommends conducting an expert group level benchmark in 2024 in order to switch from XSAM to SAM software from 2024 and onwards as the XSAM software is no longer maintained. A comparison between the two software has been made (WD09), resulting in a negligible difference between the two software.

Issue lists and benchmark scoring sheets for each of the stocks proposed for benchmarking by WGWIDE 2023 were reviewed and updated during the meeting.

The current status of the WGWIDE stocks with respect to benchmarking is summarized below:

Stock	Benchmark History	WGWIDE 2023 Proposal
Boarfish	Benchmark scheduled for 2024	
Red gurnard	Full benchmark 2021	
Norwegian Spring Spawning herring	Full benchmark 2016	Expert group level benchmark during WGWIDE 2024 and full benchmark in 2025
Western horse mackerel	Full benchmark 2017 Reference point interbenchmark 2019	

Stock	Benchmark History	WGWIDE 2023 Proposal
	Benchmark scheduled for 2024	
North Sea horse mackerel	Full benchmark 2017 Benchmark scheduled for 2024	
Northeast Atlantic mackerel	Full benchmark 2014 Full benchmark 2017 Inter-benchmark 2019	Full benchmark in 2025
Striped red mullet	Never benchmarked	Full benchmark in 2025
Blue whiting	Benchmarked 2012 Inter-benchmark 2016	

1.7 Scientific advice and management of widely distributed and migratory pelagic fish

1.1.10 General overview of management system

The North East Atlantic Fisheries Commission (NEAFC) is the Regional Fisheries Management Organisation (RFMO) for the Northeast Atlantic. NEAFC is an end-user of ICES advice and provides a forum for its contracting parties (Coastal States and fishing parties) to manage the exploitation of straddling stocks that occur in several EEZs and international waters such as WGWIDE stocks Northeast Atlantic Mackerel, Blue Whiting and Norwegian Spring-spawning herring (also known as Atlanto-Scandian herring). There are 6 contracting parties to NEAFC: Denmark (in respect of the Faroe Islands and Greenland), European Union, Iceland, Norway, Russian Federation and the UK. The management of Western horse mackerel is not considered by NEAFC with sharing subject of separate agreements between EU, Norway and the UK.

1.1.11 Management plans

Catch advice in recent years for two stocks considered by WGWIDE has been given on the basis of an agreed long-term management strategy:

- A long-term management strategy for Norwegian spring-spawning herring was agreed by the European Union, the Faroe Islands, Iceland, Norway and Russian Federation in 2018 following an evaluation by ICES (WKNSSHMSE, ICES, 2018a) which found it to be precautionary. The plan is based on a target fishing mortality of 0.14 when the stock is above B_{pa}. Should SSB fall below B_{pa}, the target fishing mortality is linearly reduced to 0.05 at and below B_{lim}. The plan incorporates TAC change limits of -20% and +25% which are suspended when below B_{pa} and 10% interannual transfer which is suspended when below B_{lim}. The plan is scheduled for review no later than 2023. Although the plan is agreed by the parties involved in the fishery and ICES advice is based on application of the management strategy, there has been no agreement on the relative catch share since 2013 with the total unilaterally declared quotas exceeding the management plan based catch advice since this time.
- A long-term management strategy for Blue Whiting was agreed by the European Union, the Faroe Islands, Iceland and Norway in 2016 following an evaluation by ICES (WKBWMS, ICES, 2016) in 2016 which found it to be precautionary. The plan is based on

a target fishing mortality equivalent to F_{MSY} (0.32) when the stock is above B_{pa}. Should SSB fall below B_{pa}, the target fishing mortality is linearly reduced to 0.05 at and below B_{lim}. The plan incorporates TAC change limits of +/-20% which are suspended when below B_{pa} and 10% interannual transfer. The Coastal States subsequently agreed a long-term management plan for the blue whiting stock with a TAC change limit of -20%/+25% and a new clause (6.b.) stating that the TAC change limit is not applied when the catch advice deviates more than 40% from the TAC of the preceding year (clause 6.b., see Annex 1 in Anon, 2021). This clause was then evaluated by ICES and found precautionary in 2017 (Working Document in ICES, 2017). No agreement on quota shares has been reached since 2015 and catches have exceeded advice since this time. Since the management plan target fishing mortality is equivalent to F_{MSY}, the MSY approach results in the same advice as the LTMS.

There is no currently agreed management strategy for either Northeast Atlantic Mackerel or Western horse mackerel. Strategies have been proposed and evaluated but agreement has not yet been reached on their implementation such that catch advice has been given on the basis of the MSY approach.

1.7.1 Comparison of advice, TAC, and catches

This section presents an overview of the time-series (2010 to present) of ICES catch advice, TAC (either agreed between all fishing parties or a sum of unilaterally declared quotas) and ICES estimates of total catch for Norwegian spring-spawning herring, Western horse mackerel, Northeast Atlantic mackerel and blue whiting. The overviews are based on the history of advice, management and catch as reported in the ICES single-stock advice documents. The information is summarized in Tables 1.7.3.1-4 and figure 1.7.3.1. Figures 1.7.3.2-5 compare the TAC and advice, catch and advice and catch and TAC and catch and the sum of unilateral quotas respectively, each expressed as a percentage difference e.g. (TAC-advice)/advice.

For Norwegian spring-spawning herring some deviations between TAC and advice occurred between 2010-2013, but from 2014 on the sum of unilateral quotas has been in excess of the scientific catch advice which was based on the agreed management plan. Catches have likewise been in excess of the scientific advice and close to the sum of unilateral quotas.

Western horse mackerel: some deviations between TAC and advice have been occurring during the time-series presented, but there does not appear to be a clear trend. No management plan is applicable for western horse mackerel. Catches have generally been at or below the agreed TAC.

Northeast Atlantic mackerel has not had agreed TACs during the period presented. The sum of unilateral quota has always been higher than the scientific advice. Catches have on average been 44% above the scientific advice since 2010. In 2021 and 2022, catches were 10% below the sum of declared unilateral quotas.

Blue whiting: up to 2013, the agreed management plan has been followed. From 2014 onwards, the sum of unilateral quota has been in excess of the scientific advice and the agreed management plan. Catches have likewise been in excess of the scientific advice and close to the sum of unilateral quota.

In summary: although long-term management plans exist for Norwegian spring-spawning herring, Northeast Atlantic mackerel and Blue whiting, they have not been instrumental in limiting the TACs to the pre-agreed values. While the Coastal States may have agreed on the TACs for these stocks, there was no agreement on the distribution of quota between Coastal States. As a consequence, the sum of unilateral quota and the catches have been in excess of both the scientific advice and the rules of the management plans.

Table 1.7.3.1. Overview of scientific advice, agreed TAC, sum of unilateral quotas and catch for Norwegian Spring-spawning Herring.

Year	Advice Basis	Advice (t)	TAC (t)	Unilateral Quota (t)	Catch (t)
2010	Do not exceed the harvest control rule	1,483,000	1,483,000		1,457,000
2011	See scenarios	1,170,000	988,000		993,000
2012	Follow the management plan	833,000	833,000		826,000
2013	Follow the management plan	619,000	619,000	692,000	685,000
2014	Follow the management plan	418,000	418,487	436,000	461,000
2015	Follow the management plan	283,000		328,000	329,000
2016	Follow the management plan	317,000		377,000	383,174
2017	Follow the management plan	646,075		805,142	721,566
2018	Follow the management plan	384,197		546,448	592,899
2019	Follow the management plan, Fmgt = 0.14 and Bmgt = 3.184 Mt)	588,562	588,562	773,750	777,165
2020	Follow the management plan, Fmgt = 0.14 and Bmgt = 3.184 Mt)	525,594	525,594	693,915	720,937
2021	Follow the management plan, Fmgt = 0.14 and Bmgt = 3.184 Mt)	651,033	651,033	881,097	851,813
2022	Follow the management plan, Fmgt = 0.14 and Bmgt = 3.184 Mt)	598,588	598,588	827,963	813,834
2023	Follow the management plan, Fmgt = 0.14 and Bmgt = 3.184 Mt)	511,171	511,171	692,942	
2024	Follow management strategy (Fmgt = 0.123, Bmgt = 3.184 Mt)	390,010			

Table 1.7.3.2. Overview of scientific advice, agreed TAC, sum of unilateral quotas and catch for Western Horse Mackerel.

Year	Advice Basis	Advice (t)	TAC (t)	Unilateral Quota (t)	Catch (t)
2010	Follow proposed management plan	180,000	185,000		203,112
2011	See scenarios	229,000	184,000		193,698
2012	MSY framework	211,000	183,000		169,858
2013	MSY framework	126,000	183,000		165,258
2014	MSY approach	110,546	135,000		136,360
2015	MSY approach	99,304	99,300		98,419
2016	MSY approach	126,000	126,000		98,811

Year	Advice Basis	Advice (t)	TAC (t)	Unilateral Quota (t)	Catch (t)
2017	MSY approach	69,186	95,500		82,961
2018	MSY approach	117,070	115,470		101,682
2019	MSY approach	145,237	136,376		124,947
2020	MSY approach	83,954	81,796		76,422
2021	MSY approach	81,376	81,375		81,557
2022	MSY approach	71,138	71,138		70,114
2023	MSY approach	0	15,277		
2024	MSY approach	0			

Table 1.7.3.3. Overview of scientific advice, agreed TAC, sum of unilateral quotas and catch for Northeast Atlantic Mackerel.

Year	Advice Basis	Advice (t)	TAC (t)	Unilateral Quota (t)	Catch (t)
2010	harvest control rule	572,000	691,305		875,515
2011	See scenarios	672,000	929,943		946,661
2012	Follow the management plan	639,000	938,410		892,353
2013	Follow the management plan	542,000	857,319		931,732
2014	Follow the management plan	1,011,000		1,400,981	1,393,000
2015	Follow the management plan	906,000	1,054,000	1,208,719	1,208,990
2016	MSY approach	773,840	895,900	1,047,432	1,094,066
2017	MSY approach	857,000	1,020,996	1,191,970	1,155,944
2018	MSY approach	550,948	816,797	999,929	1,026,437
2019	MSY approach	770,358	653,438	864,000	840,021
2020	MSY approach	922,064	922,064	1,090,879	1,039,513
2021	MSY approach	852,284	852,284	1,199,103	1,081,540
2022	MSY approach	794,920	794,920	1,188,227	1,046,720
2023	MSY approach	782,066	782,066	1,188,265	
2024	MSY approach	739,386			

Table 1.7.3.4. Overview of scientific advice, agreed TAC, sum of unilateral quotas and catch for Blue Whiting.

Year	Advice Basis	Advice (t)	TAC (t)	Unilateral Quota (t)	Catch (t)
2010	Follow the agreed management plan	540,000	548,000		540,000
2011	See scenarios	40,000	40,100		105,000
2012	Follow the agreed management plan	391,000	391,000		384,000
2013	Follow the agreed management plan	643,000	643,000		626,000
2014	Follow the agreed management plan	948,950	1,200,000		1,155,000
2015	Follow the agreed management plan	839,886	1,260,000		1,396,244
2016	MSY approach	776,000	776,000	1,147,000	1,183,187
2017	MSY approach	1,342,330	1,342,330	1,675,400	1,558,061
2018	Long-term management strategy	1,387,872	1,387,872	1,727,964	1,711,477
2019	Long-term management strategy	1,143,629	1,143,629	1,483,208	1,515,527
2020	Long-term management strategy	1,161,615	1,161,615	1,478,358	1,495,248
2021	Long-term management strategy	929,292	929,292	1,157,604	1,143,450
2022	Long-term management strategy	752,736	752,736	752,736	1,038,736
2023	Long-term management strategy	1,359,629	1,359,629	1,359,629	
2024	Long-term management strategy	1,529,754			

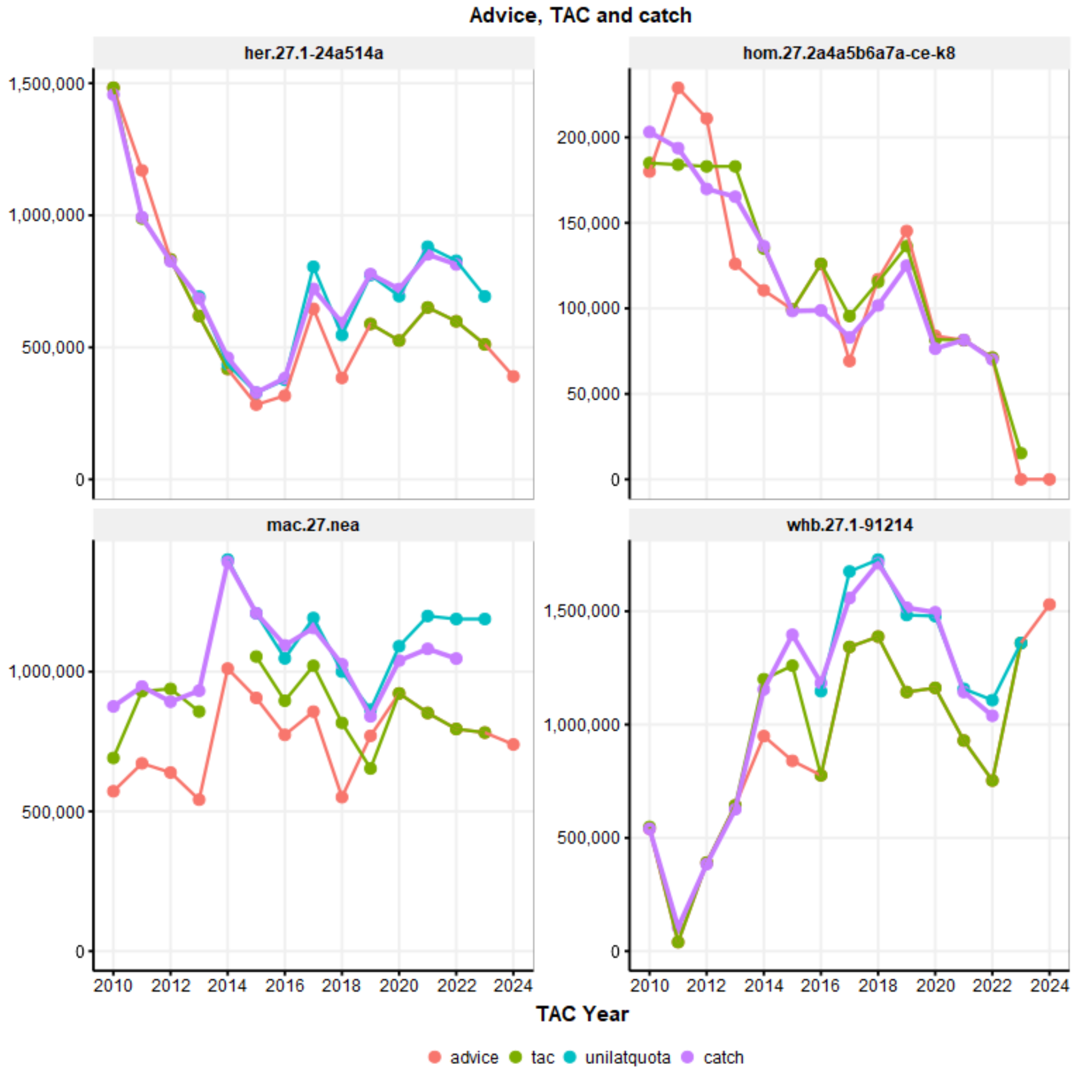


Figure 1.7.3.1: Overview of scientific advice, agreed TAC (or sum of unilateral quota) and catch.

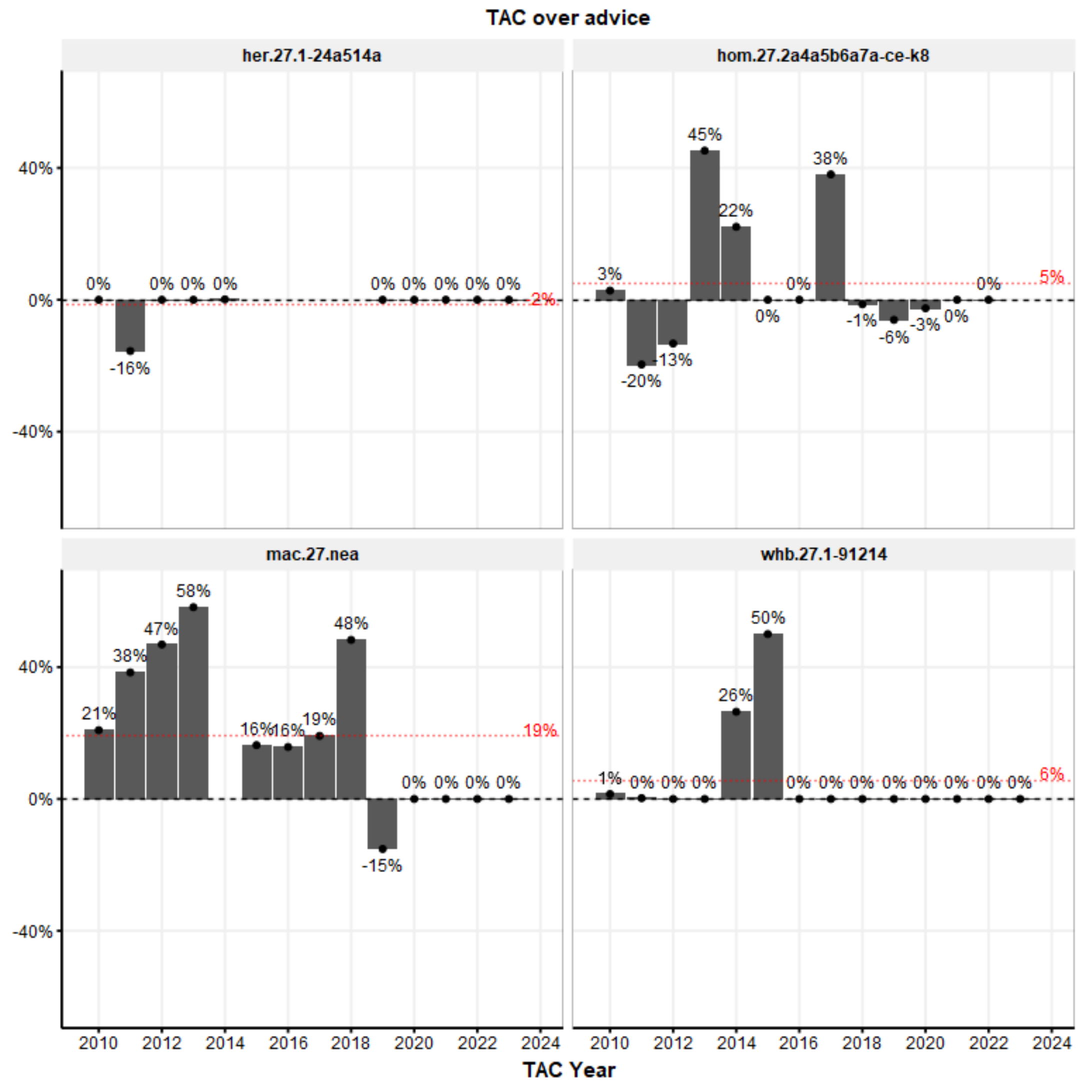


Figure 1.7.3.2: Relative deviations of TAC over advice. Red line indicates average relative deviation over the time-series shown.

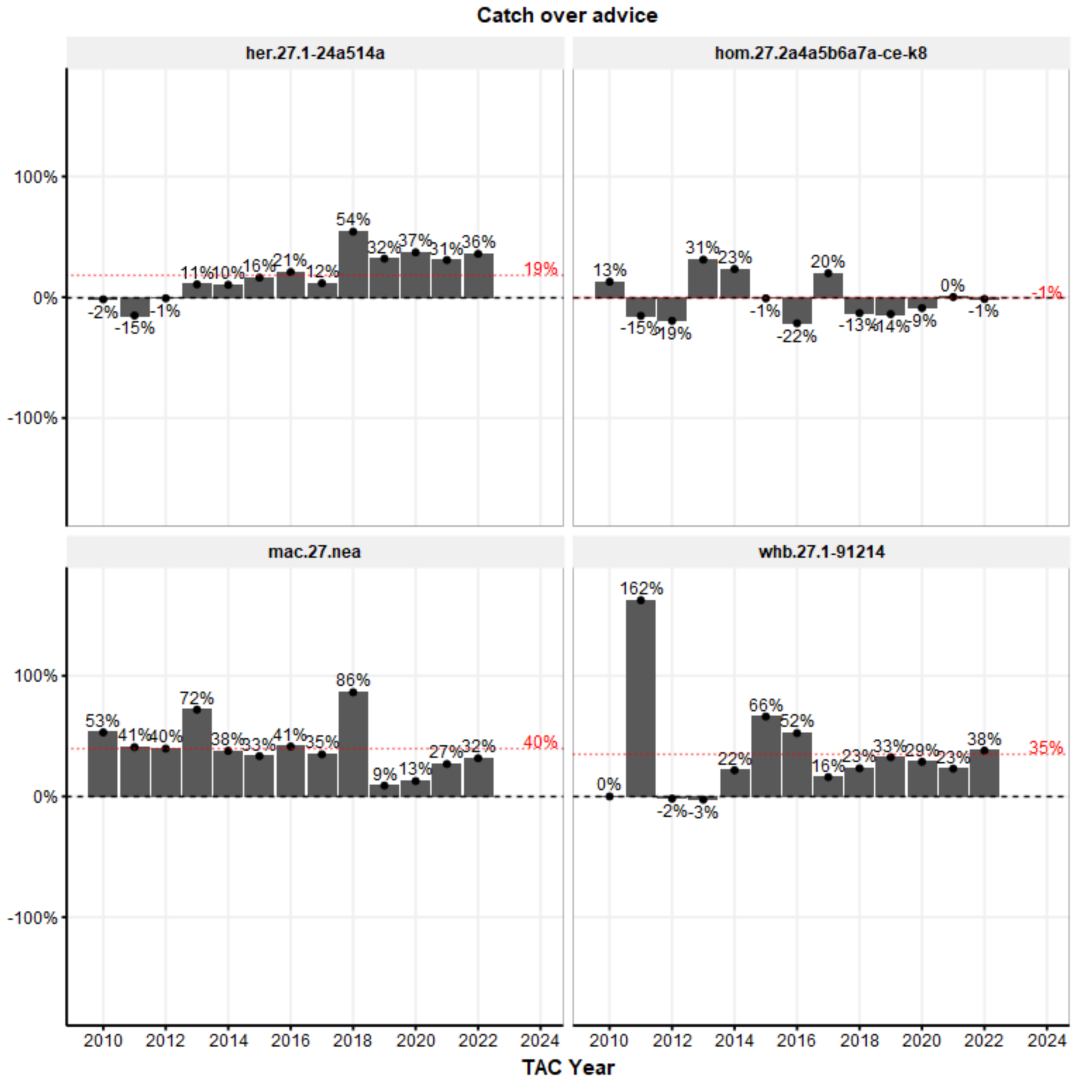


Figure 1.7.3.3: Overview of catch over advice

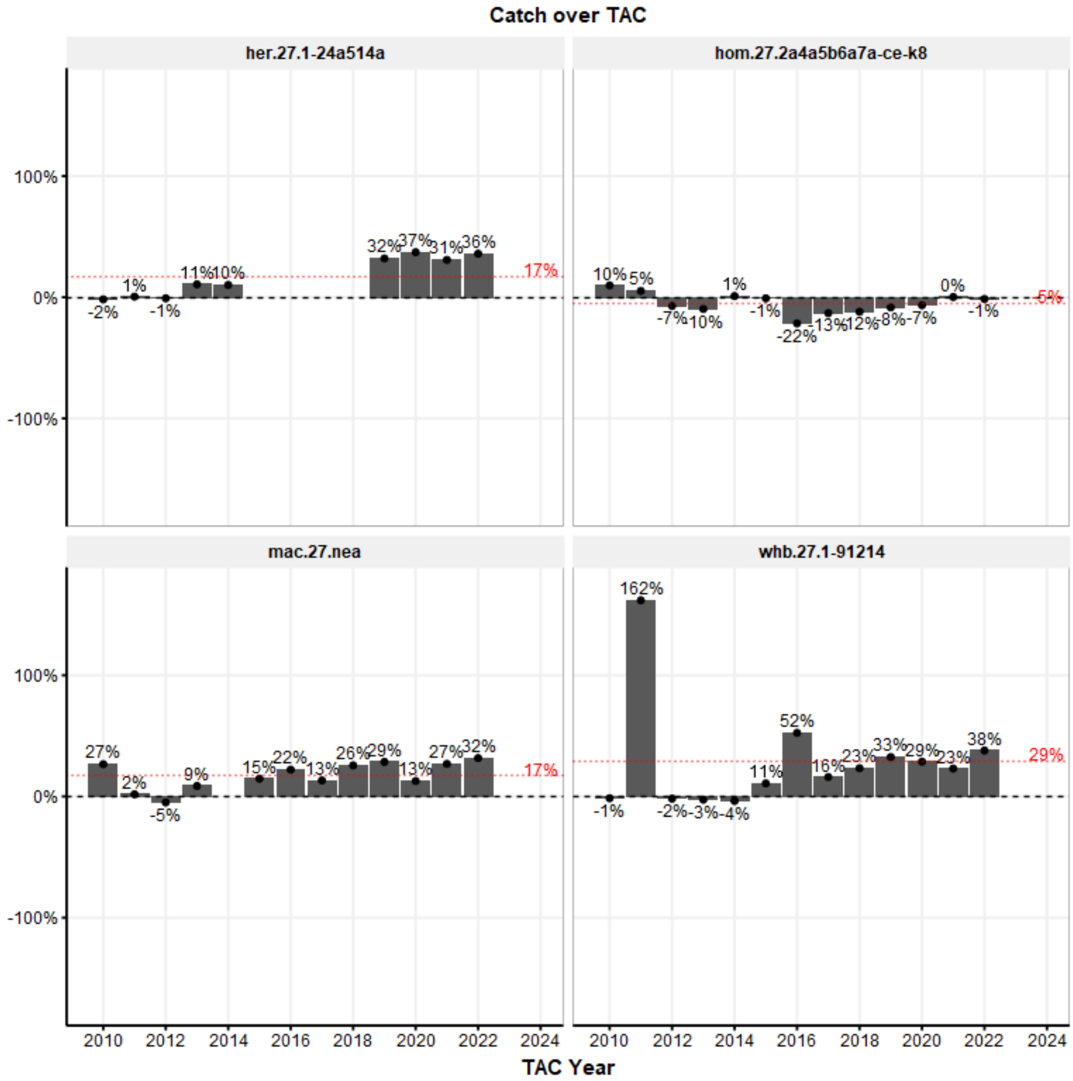


Figure 1.7.3.4: Overview of catch over TAC

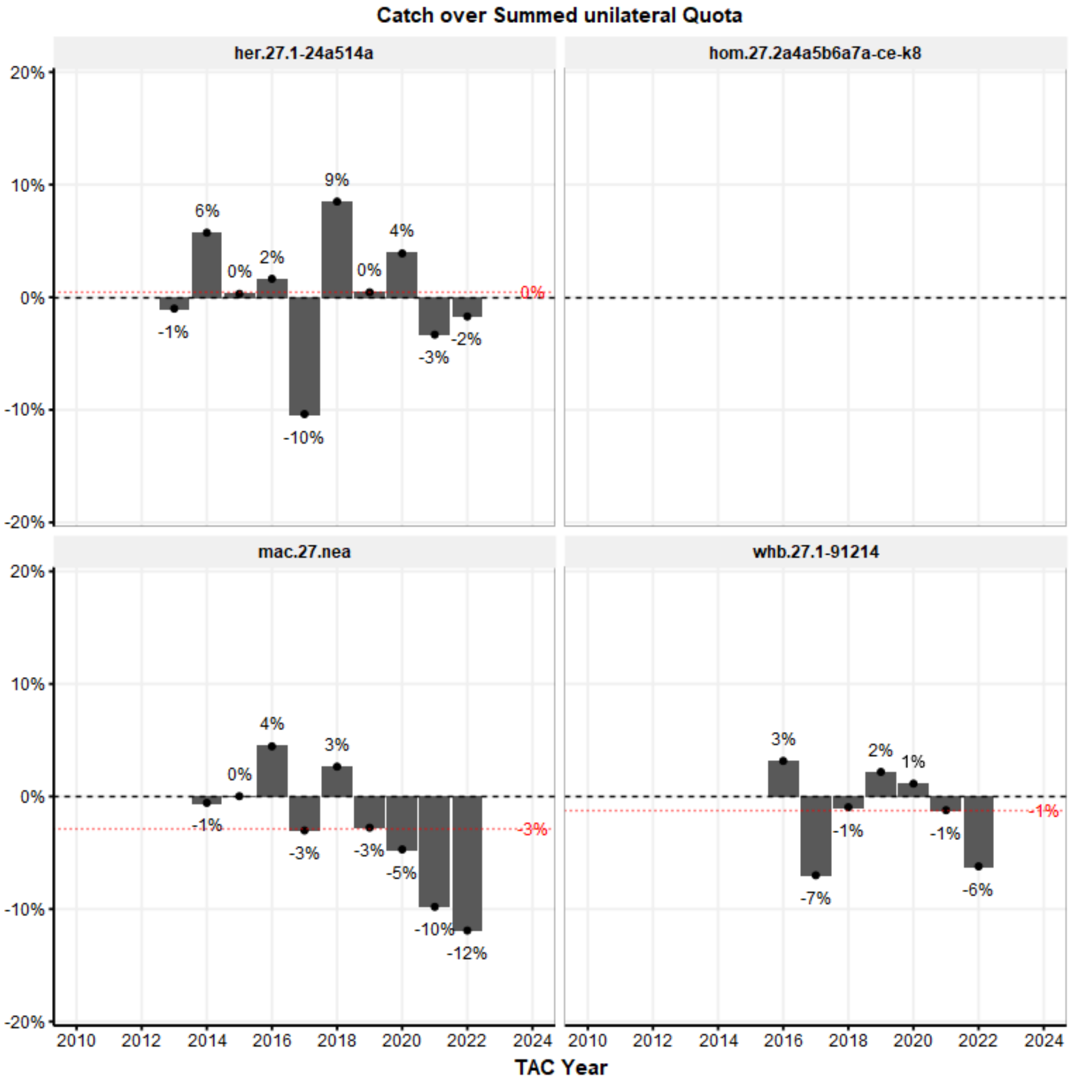


Figure 1.7.3.5: Overview of catch over sum of unilateral quotas.

1.8 General stock trends for widely distributed and migratory pelagic fish

WGWIDE 2023 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) assessments are available for the four 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 time-series of the combined catch of these four stocks since 1988 is shown in figure 1.8.1. The highest combined catch (approx. 4 million tonnes) for these four species was been taken in 2004 and 2005. In the most recent 6 years the total catch has been composed of ~45% blue whiting, ~33% mackerel, ~18% herring and ~3% horse mackerel.

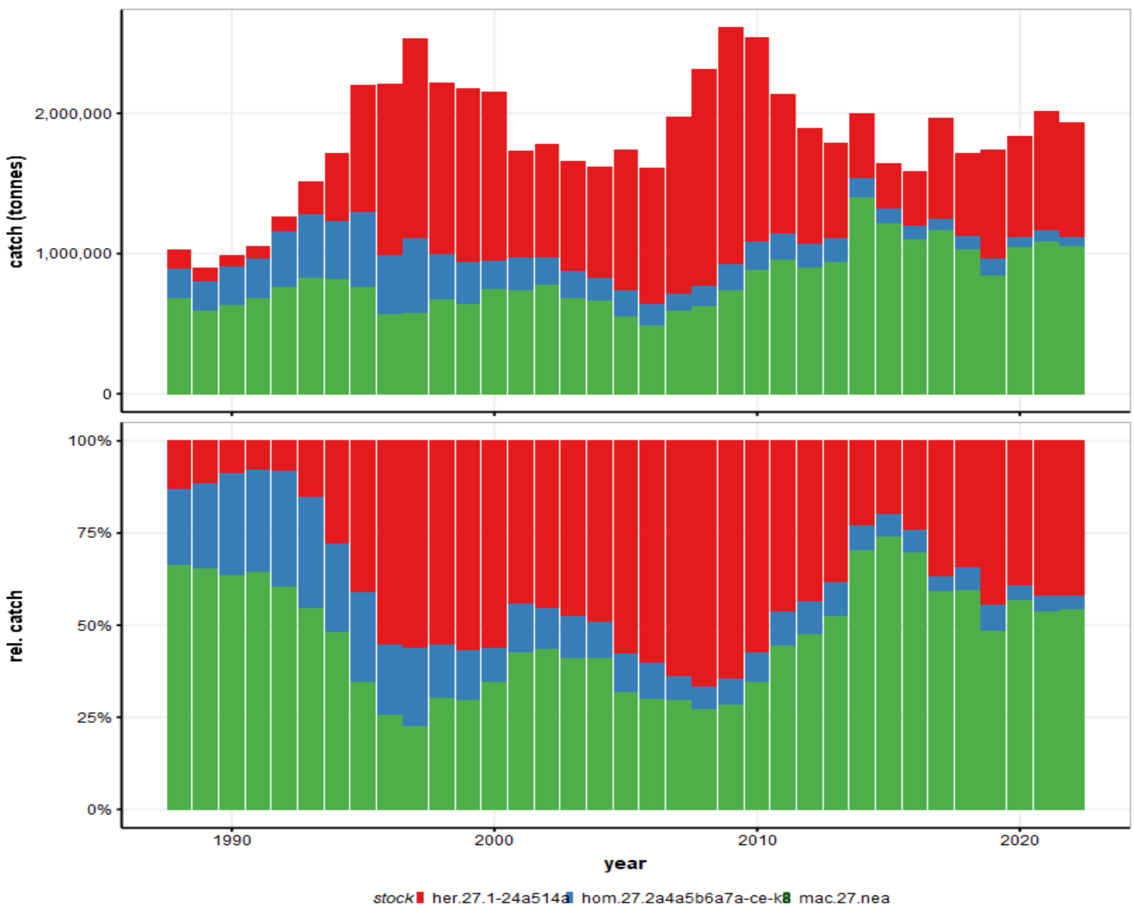


Figure 1.8.1: Catch of blue whiting, mackerel, western horse mackerel and Norwegian spring-spawning herring.

An overview of the key variables for each of the stocks (SSB, fishing mortality and recruitment), is shown in Figure 1.8.2. Stock sizes of herring, mackerel and blue whiting have been declining from historical highs in the recent years, but remain above their respective MSY $B_{trigger}$ reference point values with the exception of Western Horse Mackerel which has been increasing from a historic low in 2017 but is considered to be below B_{lim}. The Norwegian Spring-spawning Herring SSB is forecast to fall below MSY $B_{trigger}$ in 2023. The Blue Whiting SSB has increased in the most recent years following strong recent recruitment.

Fishing mortality for herring, horse mackerel and mackerel has been around F_{MSY} in the most recent period. Fishing mortality for blue whiting has been above F_{MSY} for much of the time-series.

Recruitment estimates for blue whiting and herring are on a comparable scale (billions) and are substantially higher and more variable than those for horse mackerel (with the exception of the 1982 year class) and mackerel.

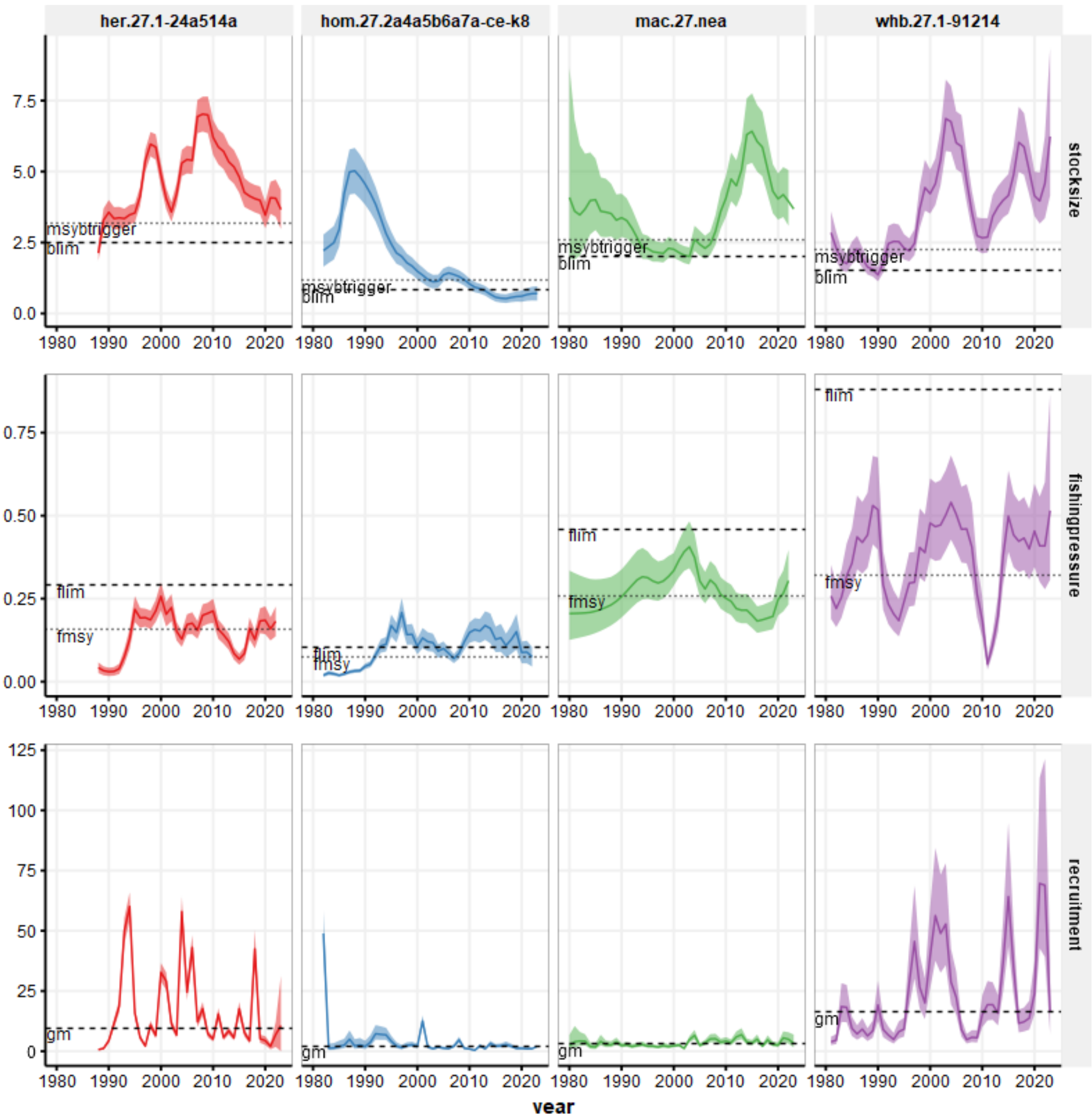


Figure 1.8.2: top - SSB (million tons), middle - fishing mortality and bottom - recruitment (billions) of Norwegian spring-spawning herring, western horse mackerel, Northeast Atlantic mackerel and blue whiting from the WGWIDE 2023 update assessments.

An overview of stock weight-at-age for mackerel and blue whiting is shown in figures 1.8.3 and 1.8.4.

For mackerel, a decline in weight at age started around 2005 for most ages. In more recent years, this has ceased with increases for younger fish noted since 2012.

Weight-at-age of blue whiting shows substantial fluctuations over time. For most ages, a decline in weight at age has been observed from 2010 although this appears to have ceased and, for some ages reversed in the most recent years.

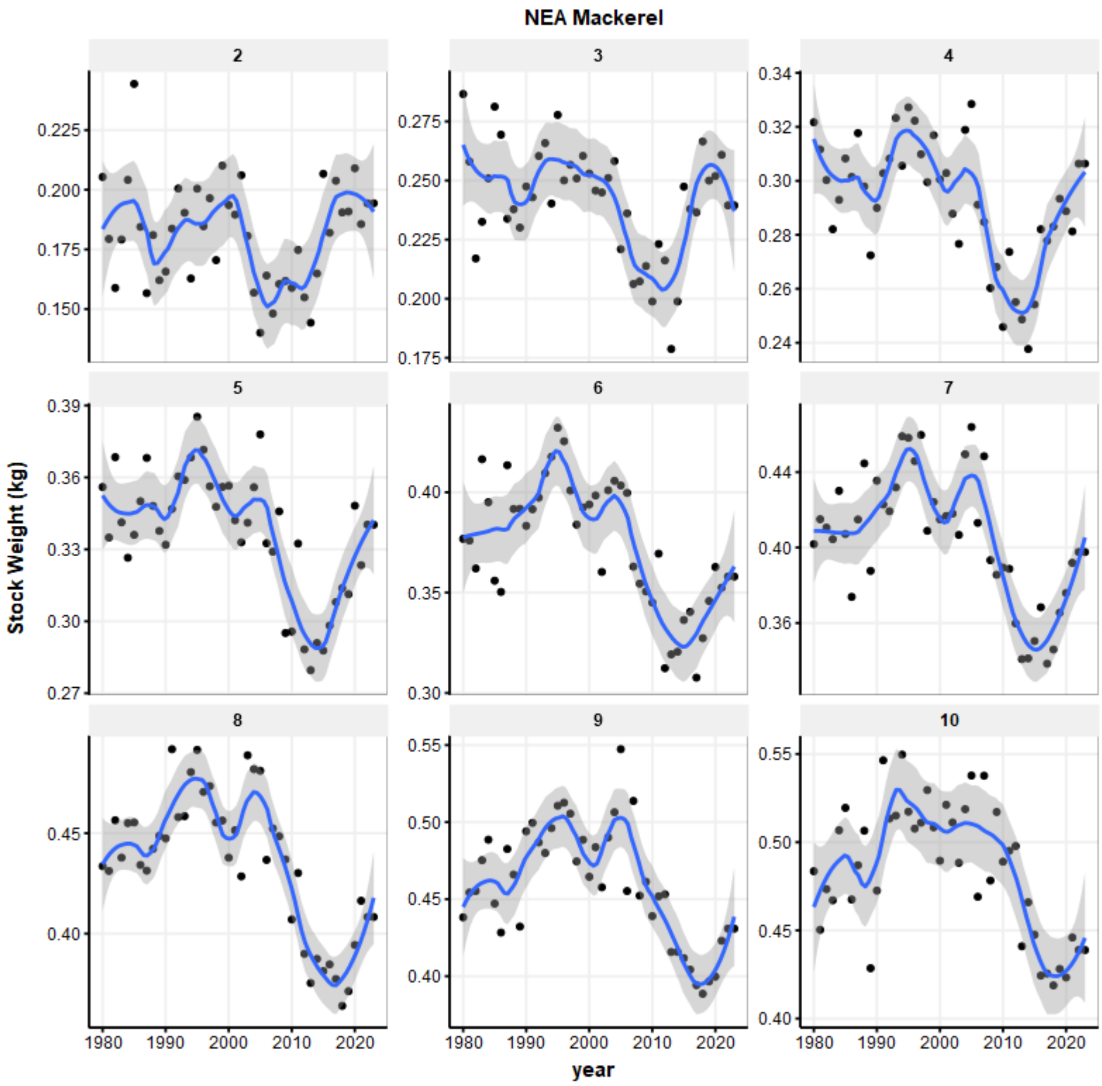


Figure 1.8.3: Stock weight-at-age of NEA mackerel.

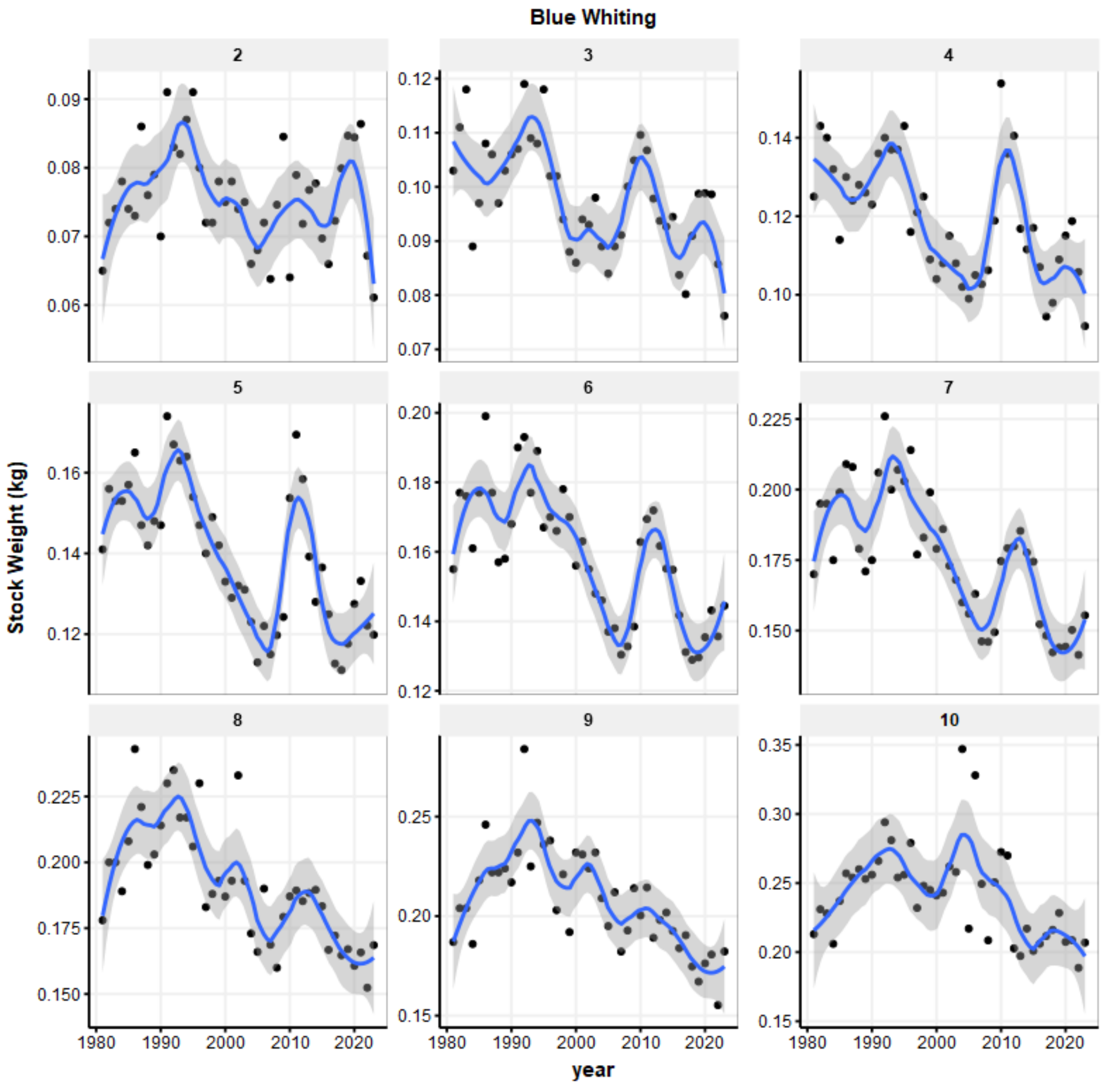


Figure 1.8.4: Stock weight at age of blue whiting.

WGWIDE (and its precursors WGMHSA and WGNPBW) have been publishing catch per statistical rectangle plots in their reports for many years. Catch by rectangle has been compiled by WG members and generally provide an estimate of total catch per rectangle (although catch by rectangle data do not represent the official catches and cannot be used for management purposes). In general, the total annual catches by rectangle are within 10 % from the official catches. In the individual stock report sections, the catch by rectangle is been presented by quarter for the most recent year. For this overview, WGWIDE has collated all the catch by rectangle data that is available for herring, blue whiting, mackerel and horse mackerel. For horse mackerel and mackerel, a long time-series is available, starting in 2001 (horse mackerel) and 1998 (mackerel). The time-series for herring and blue whiting are shorter (from 2011) although additional information could still be derived from earlier WG reports.

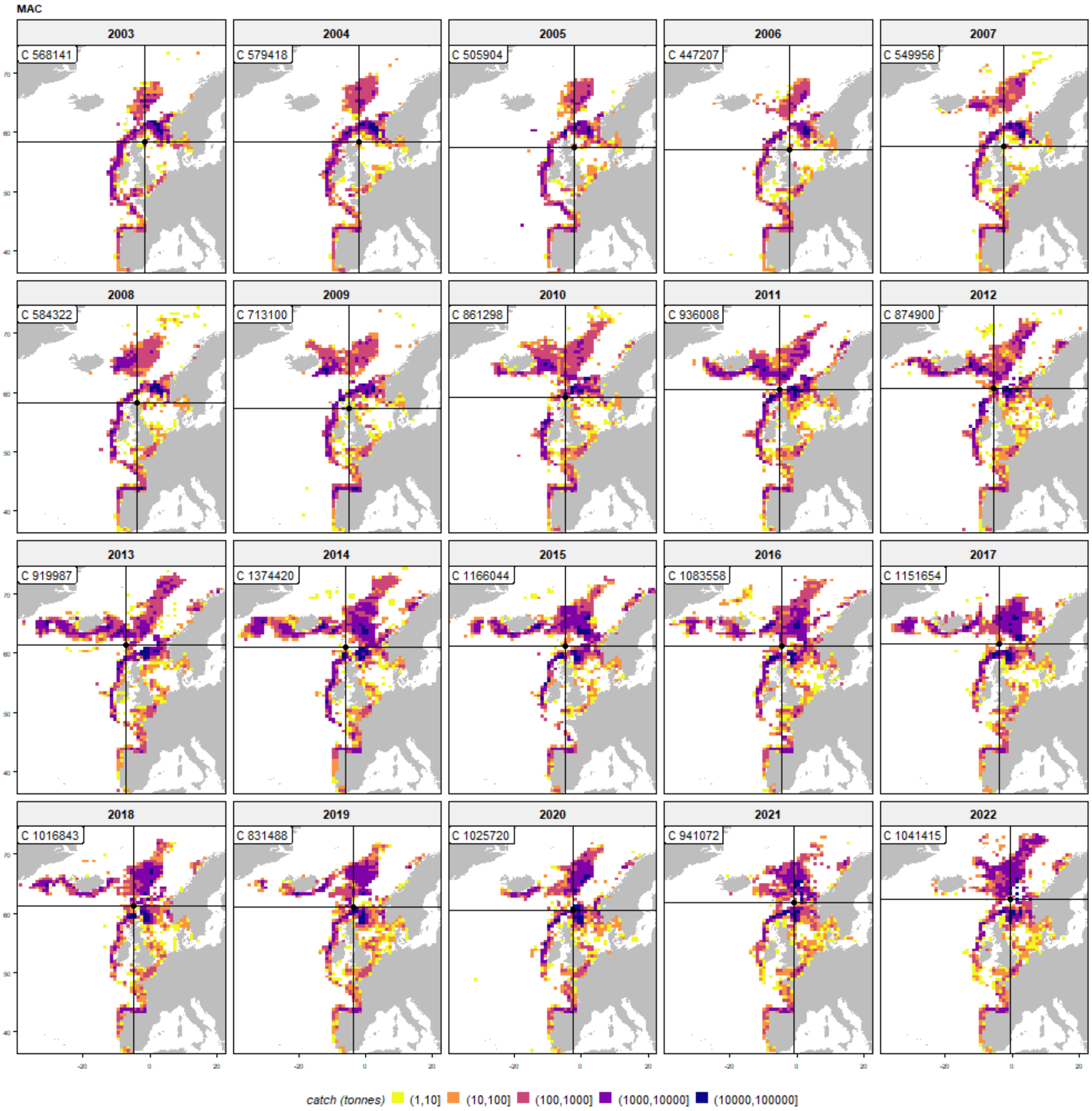


Figure 1.8.5: Catch of mackerel (tonnes) by year and rectangle. Catch by rectangle data do not represent the official catches and cannot be used for management purposes. In general, the total annual catches by rectangle are within 10% from the official catches.

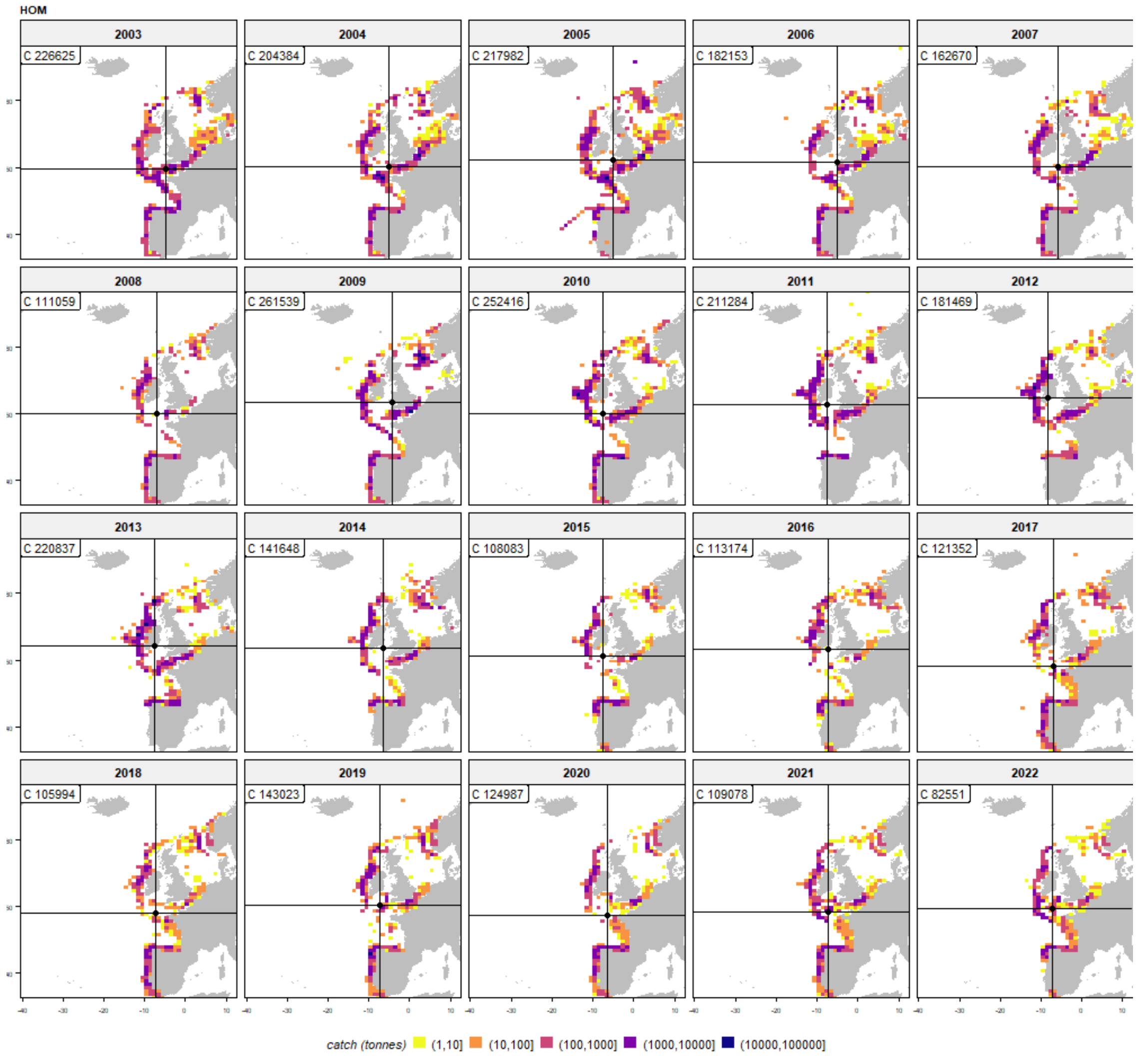


Figure 1.8.6: Catch of horse mackerel (all stocks, tonnes) by year and rectangle. Catch by rectangle data do not represent the official catches and cannot be used for management purposes. In general, the total annual catches by rectangle are within 10% from the official catches.

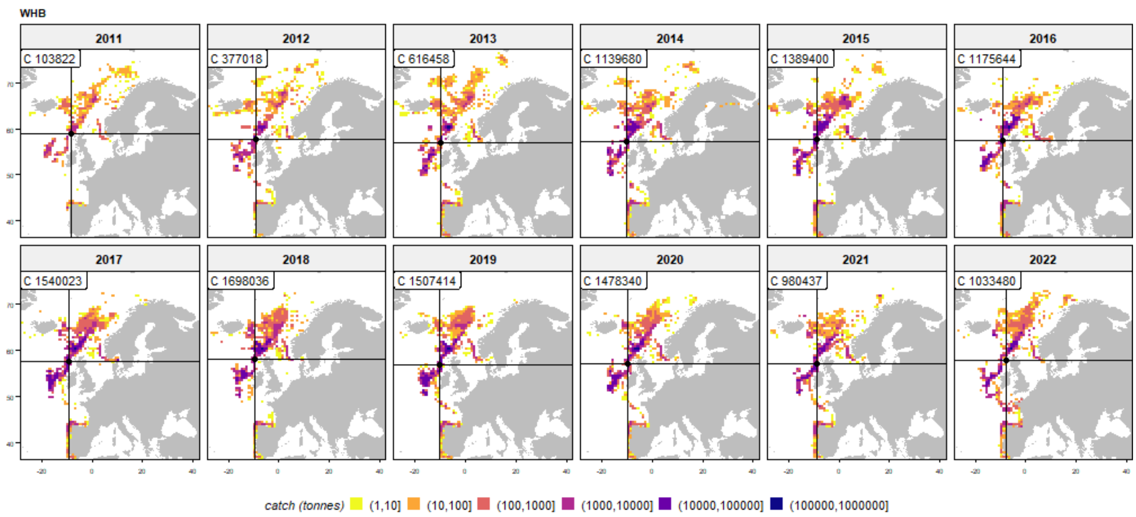


Figure 1.8.7: Catch of blue whiting (tonnes) by year and rectangle. Catch by rectangle data do not represent the official catches and cannot be used for management purposes. In general, the total annual catches by rectangle are within 10% from the official catches.

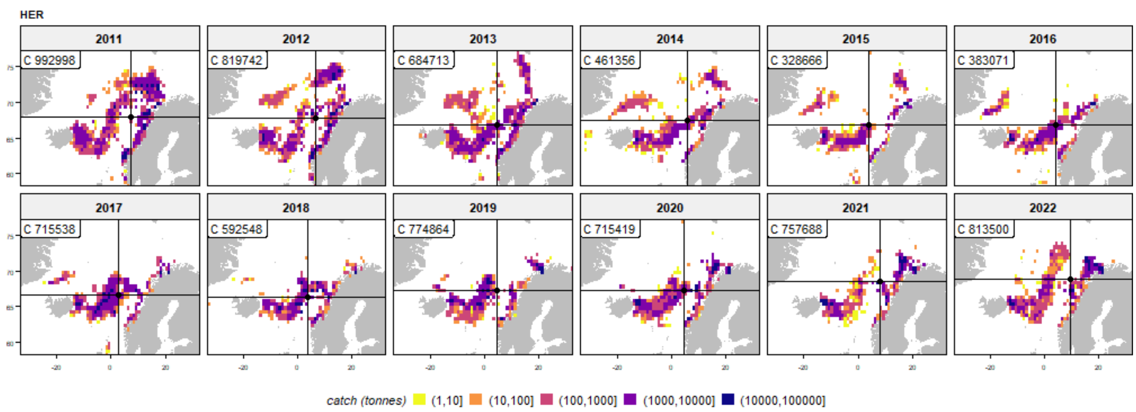


Figure 1.8.8: Catch of Norwegian spring-spawning (Atlanto-scandian) herring (tonnes) by year and rectangle. Catch by rectangle data do not represent the official catches and cannot be used for management purposes. In general, the total annual catches by rectangle are within 10% from the official catches.

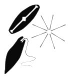
1.9 Ecosystem considerations for widely distributed and migratory pelagic fish species

A number of studies demonstrate that environmental conditions (physical, chemical and biological) can significantly influence stock productivity by changing the level of recruitment, growth rates, survival rates, or inducing variations in their geographical distribution (*e.g.* Skjoldal *et al.*, 2004, Sherman and Skjoldal 2002). It has been acknowledged that future development in stock assessment methods should take ecosystem considerations into account to reduce assessment uncertainty. Therefore, 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 2018b; 2023c), and other relevant Integrated Assessment groups within ICES could help in operationalizing the ecosystem approach for widely distributed pelagic stocks assessed by WGWIDE. The text and figures below include summary of the Norwegian Sea ecosystem status on climate variability, circulation pattern, recent trends in oceanography, phytoplankton production, zooplankton biomass, marine mammals, pelagic fish biomass and pelagic fish spatial distribution in the Norwegian Sea. It was prepared by WGINOR (ICES, 2023c).

Highlights

- Extent of Arctic Water has increased from 2017. This has been accompanied by a freshening and cooling, although heat content in the Norwegian Sea remains above the long-term average.
- Annual primary production has remained stable over the period 2003 to present. The seasonal timing of the peak of production has gradually shifted to a later date.
- Zooplankton spring biomass, measured since 1995, declined in the mid-2000s and has since remained relatively stable.
- Spawning biomass of Norwegian spring-spawning herring and mackerel declined slightly in 2022. After a few years of decline, biomass of blue whiting increased, driven by historically high recruitment.
- Long-term decrease in breeding numbers for Atlantic puffin and black-legged kittiwake continues. Common guillemot remains at high risk of extinction despite increasing abundance at some monitoring colonies over the last decade.
- Seals pup production is declining or at low level. Baleen whales’ distribution has gradually moved from the Norwegian Sea towards the Barents Sea. Bycatch of harbour porpoise remains at unsustainable level.

Graphical summary

	Topic	Overall trend	Situation in 2022	Certainty	Possible implications
	Ocean climate	Generally, warm and saline conditions prevailed from the early 2000s until 2016. Since 2012, temperature of the Atlantic inflow has been close to the long-term mean while salinity has been below the long-term mean since 2016. The extent of Arctic Water has increased from 2017.	The temperature of the Atlantic inflow is close to the long-term mean while salinity is below the long-term mean. The extent of Arctic Water continues to increase and relative heat content continues declining.	Highly certain: dedicated monitoring with good spatial coverage exists.	The recent increase of Arctic Water may lead to increased new production due to relative high winter nutrient concentration.
	Primary production	There is no trend in the level of spring and summer primary production in the Norwegian Sea deep basins since 2003[1]. The timing of peak production has gradually shifted to a later date over the last two decades.	The primary production for 2021 (latest year of data available) is comparable to the mean over the whole period. The timing of the peak production is 2 weeks later than in 2003.	Certain: Phytoplankton estimates are based on satellite data covering the whole productive season with high geographic resolution. The production model is not calibrated for high latitudes and absolute estimates of primary production are uncertain.	Change in timing can lead to seasonal match/mismatch with reproduction and feeding of zooplankton.
	Zooplankton biomass	The spring biomass of mesozooplankton was at a higher level from 1995 to mid-2000s and has been at a lower level in the following years. Summer biomass shows an increasing trend during the first ten years then a decline for the last two years.	Biomass in 2022 was at similar level as the previous year for all subareas and both seasons.	Moderately certain: plankton is patchily distributed, which leads to uncertain estimates. The timing of seasonal development relative to time of sampling can affect the level of biomass measured.	Reduced zooplankton biomass may have caused reduced food resources for planktivorous feeders, including pelagic fish. in the recent decade.

	Topic	Overall trend	Situation in 2022	Certainty	Possible implications
	Zooplankton spatial distribution	The spring distribution of zooplankton has changed from higher biomasses in Arctic water in the west to become evenly distributed in the Norwegian Sea.	In 2022, the zooplankton was relatively evenly distributed in spring and summer, but with some confined high-concentration areas in southeast in spring.	Moderately certain: The spatial distribution reflects and is affected by the timing of the survey and the timing of the zooplankton seasonal development.	Changes in the spatial distribution of plankton can affect the spatial distribution of planktivorous fish
	Pelagic fish biomass	Spawning biomass of Norwegian spring-spawning herring and mackerel remains close to the long-term average whereas blue whiting biomass is above.	Herring spawning-stock biomass decreased by 2% and mackerel by 3% whereas blue whiting increased by 11% compared to previous year. Estimated recruitment of blue whiting is at a historical high. Fishing remains above scientific advice for all stocks.	Highly certain for herring and blue whiting, moderately certain for mackerel: estimates are based on quantitative stock assessments.	Changes in pelagic fish biomass have direct implications for fisheries opportunities.
	Pelagic fish spatial distribution	Since the mid-2000´s, mackerel distribution expanded westward into Icelandic and Greenlandic waters, then retracted eastward from 2015. By 2020, most of the mackerel stock was feeding in the Norwegian Sea. In 2022, mackerel expanded westward again.	No mackerel in Greenlandic waters but increased presence and density in Icelandic Waters in 2022 compared to last two years.	Highly certain: based on ecosystem surveys in the Nordic Seas in spring (May) and summer (July)	Changes in pelagic fish spatial distribution have direct implications for fisheries opportunities.
	Seabirds	Substantial long-term declines for most species, including common guillemot, Atlantic puffin, and black-legged kittiwake.	No clear signs of improvements, except common guillemot abundance appears stable in colonies which provide shelter from eagle predation.	Highly certain: Trends are derived from dedicated monitoring.	Many bird colonies are at risk of extinction, and some have already disappeared.
	Marine mammals	Decline or sustained low levels of pup production in several seal species. Long-term shift in summer distribution of baleen whales from the Norwegian Sea to the Barents Sea. Unsustainable levels of harbour porpoise bycatch.	No new data on abundance and distribution.	Highly certain: Trends in pup production are based on dedicated surveys. Moderately certain: Data are scarce on bycatch and productivity-connectivity for harbour porpoises	Changes in marine mammals affect foodweb structure and long-term viability of marine mammal populations

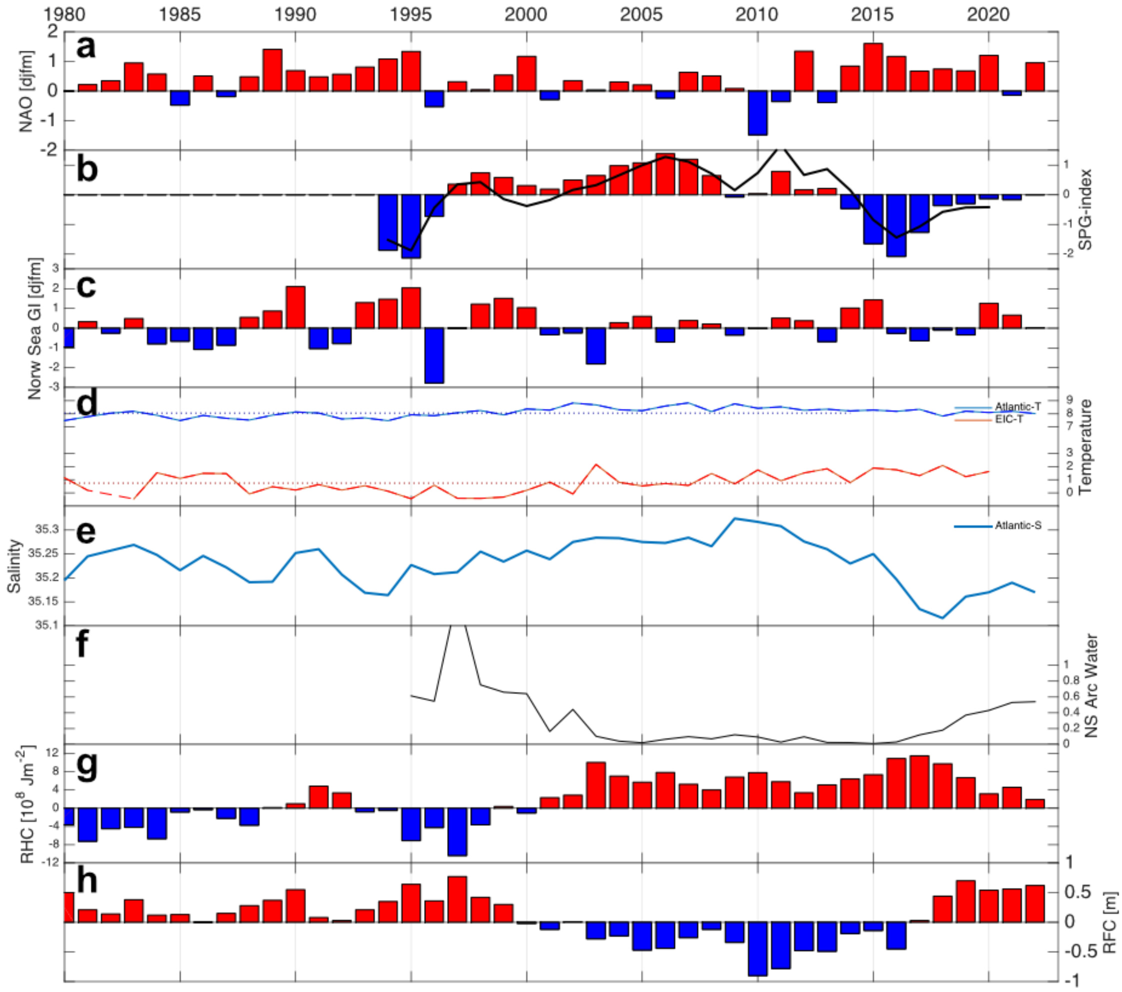


Figure 1.9.1. A subset of climate indicators for the Norwegian Sea: a) North Atlantic Oscillation Index (NAO), b) Subpolar Gyre index (SPG, note that strong gyre is represented by negative values and weak gyre by positive values), c) Norwegian Sea Gyre index, d) Atlantic Water Temperature at Svinøy section and East Icelandic Current Temperature, e) Atlantic Water Salinity at Svinøy section, f) Arctic Water amount in the Norwegian Sea, g) relative heat content (RHC) and h) Relative Freshwater Content (RFC).

Pelagic Fish

Current status

Three fish stocks dominate the pelagic ecosystem of the Norwegian Sea: Norwegian spring-spawning herring (NSSH, *Clupea harengus*), Northeast Atlantic (NEA) mackerel (*Scomber scombrus*), and blue whiting (*Micromesistius poutassou*). In 2022, estimated spawning-stock biomass (SSB) for all three stocks ranged from 3.7 to 5.0 million tonnes. Combined SSB for all three stocks was 12.5 million tonnes[7] (Figure 4a).

Combined catch of the three stocks was 3.1 million tonnes in 2021, of which approximately 1.1 million tonnes was blue whiting, 1.1 million tonnes was mackerel, and 0.9 million tonnes was herring. Current exploitation levels, relative to biological reference points, show that fishing pressure on all three stocks is above that which leads to maximum sustainable yield[7]. Furthermore, herring and blue whiting exploitation is above management plan fishing targets and the 95% confidence interval for mackerel fishing mortality is higher than maximum sustainable yield targets[7]. Stock status, for all three stocks is above all biological reference points related to the risk of impaired reproductive capacity. However, herring SSB is very close to biological reference limits, as the 95 % SSB confidence limits include the reference limits[7].

Recent changes

The 2022 stock assessment results show an estimated 2% decrease in herring SSB in 2022 compared to 2021, after a brief increase in 2021, following a decade of continuous decline with an overall estimated decline of 52%[7]. After a slight increase in 2021, mackerel SSB is estimated to decline by 3% in 2022 and has declined 37% from peak stock size in 2014-2015[7]. Blue whiting SSB increased an estimated 11% in 2022 compared to previous year and was estimated to be 20% lower than at the last peak size in 2017[7].

Mackerel distribution in Nordic Seas in summer 2022 expanded further westward in 2022 compared to the last two years. The western boundary of the distribution was west of Iceland (longitude 30 °W)[8]. Distribution of blue whiting in 2022 was similar to the most recent years[9]. The distribution area of herring in May was comparable with the most recent period and the large 2016 year class is distributed throughout the geographical distribution range of the mature herring stock[10]. In July, the herring had shifted farther east and north[8].

Possible reasons for recent changes

Herring SSB is dominated by recruitment of large year classes at irregular intervals with many years of small year classes in between (Figure 4b). After the large 2002- and 2004-year classes, recruitment was below average until the 2016-year class. The 2016 year class appears to be fully recruited to the spawning stock and contributes approximately half of the SSB[7]. Fishing above the advised level has accelerated the stock decline during a period of low recruitment. Since 2013, unilaterally determined quotas have led to annual commercial catch being 31% higher than the advised total allowable catch (TAC) on average[7].

a) pelagic fish spawning-stock biomass b) pelagic fish recruitment

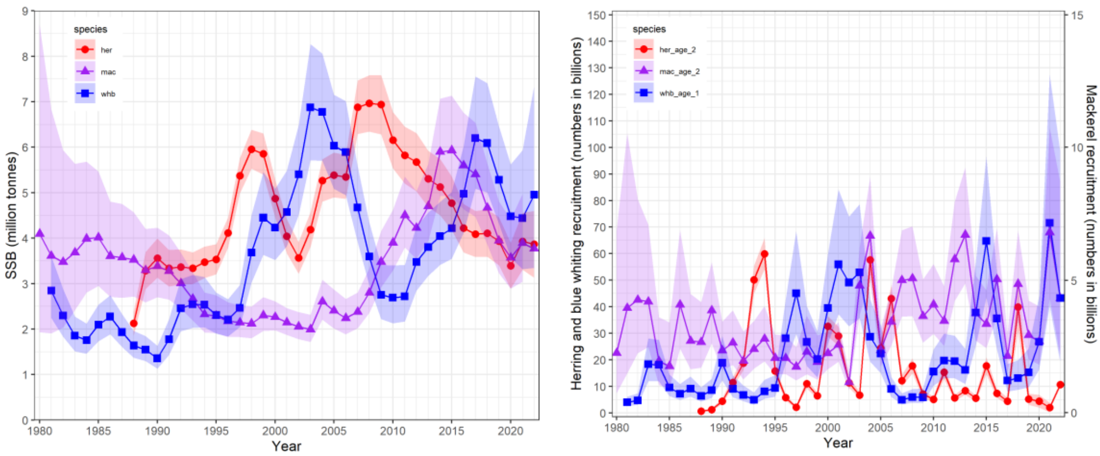


Figure 4. a) estimated spawning-stock biomass (lines) including 95% confidence intervals (shaded areas) for Norwegian spring-spawning herring (red filled circles), mackerel (purple filled triangles) and blue whiting (blue filled rectangles) from first stock assessment year, ranges from 1980 to 1988, to 2022[7]. b) estimated year-class size at recruitment for Norwegian spring-spawning herring (age 2; red filled circle), mackerel (age 2; purple filled triangles) and blue whiting (age 1; blue filled triangle) from first year of assessment, ranges from 1980 to 1988, to 2022[7]. Note the different scale for mackerel recruitment.

The 2022 assessment changed the perception of the mackerel stock. This was due to changes in relative weights of data sources in the assessment model. Prior to 2017 SSB was revised upward and fishing mortality downward. After 2017, SSB was revised downward and fishing mortality upward. This resulted in current fishing pressure being above F_{MSY}[7]. Estimates of ages 0 and 1 are considered highly uncertain and year-class strength appears to be established at age 2-3[7].

After mackerel abundance peaked in 2014-2015, the annual commercial catches have on average been 35% higher than the scientific advice[7]. Fishing above advised TAC is believed to have contributed to the observed decline in spawning stock size.

Blue whiting's sharp decline in SSB from 2018-2020 was caused by excessive fishing. Catches exceeded the advised TAC by 28% since 2018 along with low recruitment in 2017-2019. However, improved recruitment in recent years (2020-2022) explains increased SSB in 2022. Recruitment (age 1) in 2021 (i.e. the 2020 year-class) is estimated to be at a historical high and short-term forecasts project a high SSB in 2023 (6.7 million tonnes)[7].

The blue whiting fishery mostly targets ages 3-5 years. Hence the stock can decline sharply when several years of poor recruitment coincide with excessive fishing. The stock can also recover quickly when recruitment is high, as seen in the stock fluctuations during the early 2000's and late 2010´s.

The reasons why mackerel have retracted from the western area from 2015 onwards remain poorly understood. Since 2015, estimated mackerel stock size has declined by approximately a third, zooplankton abundance has remained within the range observed when mackerel were present, and the western area remains warm enough for mackerel (> 8-9 °C)[8].

1.10 Future Research and Development Priorities

As part of the planning towards future benchmark assessments, the working group maintains, for each stock, a list of research and development priorities on topics including proposed research projects, improved sampling and data collection and development of stock assessment techniques. In addition to these individual stock issues, increased consideration should be given to integrated ecosystem assessments for the stocks within WGWIDE. Several WGWIDE members are also participants in the work of the Working Group on Integrated Assessment for Norwegian Sea (WGINOR). Improving linkages with other regional Integrated Ecosystem Assessment groups within ICES would be beneficial and should be considered in future.

1.10.1 NEA Mackerel

In 2019, the ICES Workshop on a Research Roadmap for Mackerel (WKRRMAC, (ICES, 2019b)) met to discuss the research needs for the provision of advice for the management of NEA Mackerel. The workshop involved a diverse range of stakeholders including industry representatives, managers and scientists and identified a number of priorities (see report of WGWIDE 2019 (ICES, 2019c) for details).

WGWIDE 2022 recommended the establishment of WKEVALMAC (A Workshop on the Evaluation of NEA Mackerel stock components and regional management measures) to review available information from appropriate methods to infer the stock structure of NEA Mackerel. This workshop took place in 2023 (ICES 2023 WKEVALMAC in prep). See section 8.11 for a summary of the conclusions of this workshop.

1.10.2 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, 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, currently a project is going on with more data being collected (NEA and Mediterranean) to allow clarify the stock definition for this species. In future, this newly collected information on stock composition should be evaluated on the behalf of a benchmark of this stock.

1.10.3 NSS Herring

The Norwegian spawning ground survey was reintroduced in 2015 as part of the tuning series (fleet 1). However, changes were made to the survey compared to the older part of the series. At the 2016 assessment benchmark, the inclusion of the surveys from 2015 was accepted as an extension to the tuning series. It is now considered appropriate to investigate the splitting of this survey series since the time-series is now long enough to do this exercise. An interbenchmark exercise to explore this was proposed during WGWIDE 2020, but it was later decided to postpone such exploration for the next benchmark. Some exploratory work was presented in WGWIDE 2021.

- Consider the inclusion of a new tuning series (IESSNS) in the assessment.
- Consider the inclusion of a new tuning series (tagging data based on RFID) in the assessment.
- Consider the inclusion of a new Norwegian recruitment index into the assessment, as the current recruitment index has not been updated since 2021.
- Request and incorporate within the assessment information on the uncertainty in catches from all countries submitting catch data (currently only available from Norway).

The maturity ogive for NSSH is back-calculated but with a delay of 6 years, i.e. the 5 last years use one of two fixed maturity ogives scales (one for small cohort and the other for large cohort). The benchmark report has no objective criteria when to recognize a cohort as strong, and the current model is not optimal for medium-sized cohorts. This may result in deviation in SSB in intermediate year.

There is clear indication of a density-dependent effect on maturity-at-age. A more proper estimate of the maturity for the last 5 years (and for the forecast) should be made using the estimated cohort strength directly, and this should be evaluated through a peer-review process.

The XSAM software is used for the assessment. However, the SAM software now supports the XSAM model as an optional model. A switch from the currently used code to the SAM platform should be done in order to make the model more publicly available and to ensure further development of the infrastructure. The possibility to use the predicting the observation variance in SAM can then be used instead of including external variance from surveys. WGWIDE 2023 recommended to use SAM software from WGWIDE 2024 and onwards as the XSAM software is no longer maintained. A comparison between the two software has been made (WD09), resulting a negligible difference between the two software.

1.10.4 Western Horse Mackerel

Considering the potential of mixing between Western and North Sea horse mackerel occurring in division 7d and 7e, improved 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 Northern Pelagic Working Group in collaboration with University College Dublin and Wageningen Marine Research. In 2018, the results of the genetic analysis have been published (Farrell *et al* 2018) which concluded that the spawners of North Sea and Western horse mackerel can be genetically identified as two distinct stocks. However, at that stage it was not yet possible to separate the two stocks when they occur in mixed samples. Subsequently, a full genome sequencing on horse mackerel has been carried out (Fuentes-Pardo et al 2020), which confirmed the earlier results on separating western, North Sea and southern horse mackerel (see also text below on North Sea horse mackerel). In addition, this study concluded that it would also be possible to distinguish horse mackerel from different spawning populations in mixed samples.

The 2020 study also concluded that 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.

The most recent results indicate that a further large-scale analysis of samples, with a greater temporal and spatial coverage, with the newly identified molecular markers was required to test and reassess the current stock delineations. Results were presented at WGWIDE 2023 and concluded that the stocks boundaries might need revision (see also section 1.4.8.3 for details).

1.10.5 North Sea horse mackerel

Studies on stock identity and the degree of connection and migrations between the North Sea and the Western Stock are considered particularly relevant. On behalf of the Pelagic Advisory Council and the EAPO Northern Pelagic Working Group, a research project on genetic composition of horse mackerel stocks was initiated. Genetic samples have been taken over the whole distribution area of horse mackerel during the years 2015- 2017. The full genome of horse mackerel was sequenced and results indicated that the western horse mackerel stock is clearly genetically different from the North Sea stock (Farrell and Carlsson, 2019; Fuentes-Pardo *et al*., 2020). Markers were identified that are be able to reveal the stock identity of individual horse mackerel caught in potential mixing areas. Horse mackerel samples from division 7d and 7e have been collected by the PFA on board of commercial vessels in autumn 2020, while horse mackerel from division 4a have been collected during the NS-IBTS in Q3. Initial results of this comprehensive genetic research project on stock identification of horse mackerel suggest that the boundaries of the stocks might require revision. This relates to the Northern boundary in 4a to the Southern border in 7d. Additionally, the Institute of Marine Research in Norway sampled horse mackerel in coastal waters within 4a during all quarters in 2019. Preliminary results presented at WGWIDE 2021 showed that the genetic profile of individuals caught in all quarters matched well with the genetic profile of the Western HOM stock, with just one or two individuals matching better with North Sea HOM profile (Florian Berg, pers. comm.). Ongoing and new studies are being undertaken to investigate these issues. Potential changes in the perception of the stock distributions could impact the reliability of the assessments for the three current stocks of horse mackerel in the Northeast Atlantic (see also section 1.4.8.3 for details).

Efforts are required to upload historic age and length data to the InterCatch database. The current stock assessment method is based on length data and, with only data from 2016 onwards currently available in InterCatch, it is impossible to compare the F/F_{MSY} proxy and the length-based indicators that the proxy is based on with information from earlier years. Furthermore, length data are only submitted by accessions to stock coordinators directly, and not through InterCatch. This makes the process of combining the data from different countries prone to error and lack transparency. Since 2020, national data submitters were requested to submit data both via the accessions as well as through InterCatch. A comparative analysis has to be carried out to evaluate the feasibility of using length data from InterCatch only in future. Moreover, it was discovered that several hundred Dutch age readings coming from foreign vessels (mainly UK) have not been uploaded to InterCatch in the past. Efforts will be made to ensure this historic information will be uploaded in order to increase (the currently low) confidence in the estimates of catch-at-age. However, from 2021 onwards Dutch age samples were used in the raising procedure of UK and uploaded to InterCatch. The historic data will be dealt with in the upcoming benchmark.

1.10.6 Boarfish

From 2017, this stock has been included on the list of stocks sampled under the data collection framework (DCMAP). This permitted 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 allow the development of an age-based assessment methodology. The current ALK is static and is based on a limited number of age readings. Also investigating the viability of length based assessments should be explored.

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, for example, the Pélagiques GAScogne (PELGAS) survey should also be explored.

1.10.7 Striped red mullet

In the WGWIDE framework, the assessment of striped red mullet stock is currently absent. The limited and scarce availability of data within the ICES database, coupled with uncertainties regarding data quality, has precluded the establishment of any analytical assessment. The foremost development priorities encompass the enhancement of fishery-dependent information and the creation of biomass indices derived from EVHOE and SP-NSGFS. These indices will be meticulously tailored to the unique characteristics of the stock, which include its coastal distribution and potential variations in dynamics between the Bay of Biscay and the Celtic Sea. Ongoing research initiatives (MATO and ACOST, as detailed in the stock-related section of this report) are anticipated to furnish updated data and published findings pertaining to the sexual maturity of this species, along with reference fleet CPUE, by 2024. Armed with these inputs, an analytical assessment framework could be subjected to intersessional testing and subsequently presented to WGWIDE. This endeavor aims to bolster the potential for a benchmark request in the near future, pertaining to the assessment of this stock.

1.11 References

Anon 2021. Agreed record of conclusions of fisheries consultations between the European Union, the Faroe Islands, Iceland, Norway and UK on the management of blue whiting in the north-east Atlantic in 2022. https://www.regjeringen.no/contentassets/2ea04e97a8fd45c2b1758e2602e79c46/blue-whiting-agreed-record-october-2021.pdf

Borges, L., Rogan, E. and Officer, R. 2005. Discarding by the demersal fishery in the watersaround Ireland. Fisheries Research, 76: 1–13.

Borges, L., van Keeken, O. A., van Helmond, A. T. M., Couperus, B., and Dickey-Collas, M. 2008. What do pelagic freezer-trawlers discard? ICES Journal of Marine Science, 65: 605– 611.

Brunel, T., Farrell, E.D., Kotterman, M., Kwadijk, C., Verkempynck, R., Chen, C and Miller, D. 2016. Improving the knowledge basis for advice on North Sea horse mackerel. Developing new methods to get insight on stock boundaries and abundance. Wageningen, IMARES Wageningen UR (University & Research centre), Wageningen Marine Research report C092/16 57 pp.

Dickey-Collas, M., van Helmond, E., 2007. Discards by Dutch flagged freezer trawlers. Working Document to the Working Group Mackerel, Horse Mackerel, Sardine and Anchovy (ICES CM 2007/ACFM: 31).

Farrell, E.D. 2023 Genetic Stock Identification of Horse Mackerel, Trachurus trachurus. A presentation to WGWIDE, 23-29th August 2023.

Farrell, E. D., & Carlsson, J. (2018). Genetic stock Identification of Northeast Atlantic Horse mackerel, Trachurus trachurus. A report prepared for the members of the Northern Pelagic Working Group. 40pp.

Fernandes, A. C., Pérez, N., Prista, N., Santos, J., Azevedo, M. 2015. Discard composition from Iberian trawl fleets. Marine Policy, 53: 33-44.

Fuentes-Pardo, A.P., Farrell, E.D., Pettersson, M.E., Sprehn, C.G. and Andersson, L. 2023. The genomic basis and environmental correlates of local adaptation in the Atlantic horse mackerel (Trachurus trachurus). Evolutionary Applications, 16: 1201-1219. https://doi.org/10.1111/eva.13559

Genner, M., and Collins, R. (2022). The genome sequence of the Atlantic horse mackerel, Trachurus trachurus (Linnaeus 1758). Wellcome Open Research, 7, 118. https://doi.org/10.12688/wellcomeopenres.17813.1

Gonçalves, P., Ávila de Melo, A., Murta, A. G. and Cabral, H. N. 2017. Blue whiting (Micromesistius poutassou) sex ratio, size distribution and condition patterns off Portugal', Aquatic Living Resoyrces, 30(24), pp. 1–8. doi: 10.1051/alr/2017019.

Gonçalves, P. 2021. Blue whiting age reading - data and issues. Working Document to ICES Third workshop on age reading of blue whiting (WKARBLUE3), 31 May-4 June.

Han, F., Jamsandekar, M., Pettersson, M.E., Su, L., Fuentes-Pardo, A., Davis, B., Bekkevold, D., Berg, F., Cassini, M., Dahle, G., Farrell, E.D., Folkvord, A. and Andersson, L. 2020. Ecological adaptation in Atlantic herring is associated with large shifts in allele frequencies at hundreds of loci. eLife, 2020;9:e61076 (doi:10.7554/eLife.61076)

Hofstede, R. and Dickey-Collas, M. 2006. An investigation of seasonal and annual catches and discards of the Dutch pelagic freezer-trawlers in Mauritania, Northwest Africa. Fisheries Research, 77: 184–191.

ICES. 2014. First Interim Report of the Stock Identification Methods Working Group (SIMWG), by correspondence. ICES CM 2014/SSGSUE:02. 31 pp.

ICES. 2015. Report of the Workshop on Maturity Staging of Mackerel and Horse Mackerel (WKMSMAC2), 28 September–2 October 2015, Lisbon, Portugal. ICES CM 2015/SSGIEOM:17. 93 pp.

ICES. 2017. Report of the Benchmark Workshop on Widely Distributed Stocks (WKWIDE), 30 January–3 February 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:36. 196 pp.

ICES. 2018a. Report of the Workshop on a long-term management strategy for Norwegian Spring-spawning herring (WKNSSHMSE), 26–27 August 2018, Torshavn, Faroe Islands. ICES CM 2018/ACOM:53. 113 pp. https://doi.org/10.17895/ices.pub.5583. Annex 9 is available separately at the ICES website.

ICES. 2018b. Interim Report of the Working Group on InteICEgrated Ecosystem Assessments for the Norwegian Sea (WGINOR). ICES WGINOR REPORT 2017 27 November - 1 December 2017. Tórshavn, Faroe Islands. ICES CM 2018/SSGIEA:10. 38 pp.

ICES. 2019a. Interbenchmark Workshop on the assessment of northeast Atlantic Mackerel (IBPNEAMac). ICES Scientific Reports. 1:5. 71 pp. http://doi.org/10.17895/ices.pub.4985

ICES. 2019b. Workshop on a Research Roadmap for Mackerel (WKRRMAC). ICES Scientific Reports. 1:48. 23 pp. http://doi.org/10.17895/ices.pub.5541

ICES. 2019c. Working Group on Widely Distributed Stocks (WGWIDE). ICES Scientific Reports. 1:36. 948 pp. http://doi.org/10.17895/ices.pub.5574

ICES. 2023a. Workshop on Age reading of Norwegian Spring-spawning Herring (Clupea harengus; WKARNSSH) ICES Scientific Reports. X:X. 58pp.

ICES. 2023b. Workshop on age reading of Blue whiting (WKARBLUE3; outputs from 2021 meeting). ICES Scientific Reports. 5:54. 97 pp. https://doi.org/10.17895/ices.pub.22785875

ICES. 2023c. Working Group on the Integrated Assessments of the Norwegian Sea (WGINOR, outputs from 2022 meeting). ICES Scientific Reports. Report. https://doi.org/10.17895/ices.pub.22110260.v1

Patterson, K.R. 1998: A programme for calculating total international catch-at-age and weight at-age. WD to Herring Assessment Working Group 1998.

Pierce, G. J., J. Dyson, E. Kelly, J. D. Eggleton, P. Whomersley, I. A. G. Young, M. B. Santos, J. J. Wang and N. J. Spencer (2002). Results of a short study on bycatches and discards in pelagic fisheries in Scotland (UK). Aquatic Living Resources 15(6): 327-334.

Rousseau, Y., R.A.Watson, J.L.Blanchard and E.A.Fulton (2019). "Evolution of global marine fishing fleets and the response of fished resources." Proceedings of the National Academy of Sciences 116(25): 12238-12243.

Skjoldal, H. R., Dalpadado, P., and Dommasnes, A., 2004. Food webs and trophic interactions.InTheNorwegian Sea Ecosystem, 1st edn, pp. 263 – 288. Eds. H. R. Skjoldal R. Sætre, A. Fernö, O.A. Misund and I. Røttingen. Tapir Academic Press, Trondheim, Norway. 559 pp.

Sherman, K., and Skjoldal, H.R., 2002. Large Marine Ecosystems of the North Atlantic. Changing states and sustainability. Sherman, K., and Skjoldal H.R. (Eds.)). Elsevier Science B.V. The Netherlands.

Ulleweit, J. and Panten, K., 2007. Observing the German Pelagic Freezer Trawler Fleet 2002 to 2006 – Catch and Discards of Mackerel and Horse Mackerel. Working Document to the Working Group Mackerel, Horse Mackerel, Sardine and Anchovy (ICES CM 2007/ACFM: 31).

Ulleweit, J., Overzee, H. M. J., van Helmond, A. T. M., van Panten, K. (2016): Discard sampling of the Dutch and German pelagic freezer fishery operating in European waters in 2013-2014 – Joint report of the Dutch and German national sampling programmes. Stichting DLO Centre for Fisheries Research (CVO), 62 pages, CVO Report 15.014

van Helmond, A.T.M. and H.J.M. van Overzee 2009. Discard sampling of the Dutch pelagic freezer fishery in 2003-2007. CVO report 09.001

van Helmond, A.T.M. and H.J.M. van Overzee 2010. Discard sampling of the Dutch pelagic freezer fishery in 2008 and 2009. CVO report 10.008

van Overzee, H. M. J., and van Helmond, A. T. M. (2011). Discard sampling of the Dutch pelagic freezer fishery in 2010. (CVO report; No. 11.010). Centrum voor Visserijonderzoek. https://edepot.wur.nl/189414

van Overzee, H. M. J., ; Helmond, A. T. M. van; Ulleweit, J.; Panten, K. (2013): Discard sampling of the Dutch and German pelagic freezer fishery operating in European waters in 2011 and 2012. Stichting DLO Centre for Fisheries Research (CVO), 68 pages, CVO Report 13.013

van Overzee H.M.J., Ulleweit J, Helmond ATM van, Bangma T (2020) Catch sampling of the pelagic freezer trawler fishery operating in European waters in 2017-2018 - joint report of the Dutch and German national sampling programmes. Ijmuiden: Stichting Wageningen Research, Centre for Fisheries Research (CVO), 53 p, CVO Rep 20.004

Vartia, S., Collins, P.C., Cross, T.F., FitzGerald, R.D., Gauthier, D.T., McGinnity, P., Mirimin, L. and Carlsson J. 2014. Multiplexing with three-primer PCR for rapid and economical microsatellite validation. Hereditas, 151: 43–54.

Vartia, S., Villanueva, J.L., ., Finarelli, J., Farrell, E.D., Hughes, G., Carlsson, J.E.L., Collins, P.C., Gauthier, D.T., McGinnity, P., Cross, T.F., FitzGerald, R.D., Mirimin, L., Cotter, P. and Carlsson, J. 2016. A novel method of microsatellite genotyping-by-sequencing using individual combinatorial barcoding. Royal Society Open Science, 3 DOI: 10.1098/rsos.150565.

2 Blue whiting in Northeast Atlantic and adjacent waters

Micromesistius poutassou in subareas 1–9, 12, and 14 (whb.27.1-91214)

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 metres and 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 between the feeding and 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 2022

Fishing mortality (F) is estimated to be above F_{MSY} since 2014. Spawning-stock biomass (SSB) has been decreasing since 2018, but increased again in 2022. SSB is still estimated to remain above MSY $B_{trigger}$. Recruitment (R) from 2017 to 2019 is estimated to be low, followed by a large increase in 2021 and another strong recruitment in 2022. ICES advises that when the long-term management strategy, agreed by the European Union, the Faroe Islands, Iceland, and Norway, is applied, catches in 2023 should be no more than 1 359 629 tonnes.

2.2 The fishery in 2022

As in previous years, the main fisheries on blue whiting were targeting spawning and post-spawning fish (Figures 2.2.1-2). Most of the catches (89.2%) were taken in the first two quarters of the year and the largest part of this was taken along the slopes of the Western European shelf and around the Faroes. Smaller quantities were taken in the Norwegian Sea, in the Norwegian Trench, in the Rockall Trough and along the coast of Spain and Portugal as well as in the Bay of Biscay.

The fishery in the second half of the year was mainly east of the Faroes and in the central Norwegian Sea, with smaller amounts in the Norwegian Trench and along the coast of Portugal and Spain.

The multinational fleet targeting blue whiting in 2022 consisted of several types of vessels from 16 countries. The bulk of the catch is caught by 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 (ICES, 2016a), it was decided to use preliminary within year, quarter 1 and quarter 2, catch-at-age data in the assessment to get additional information to the within year IBWSS survey estimates. In recent years, 85-90% of the total annual catches of the age 3+ fish have been taken in the first half of the year, which makes it reasonable to estimate the total annual catch-at-age from reported first semester (Q1 & Q2) data and expected total catches for the remainder of the year. The catch data sections in this report contain a comprehensive description of the 2022 data as reported to ICES and a brief description of the 2023 preliminary catch data.

2.3.1 Officially reported catch data

Official catches in 2022 were estimated as 1 038 736 tonnes based on data provided by WGWIDE members (Table 2.3.1.1). Data provided as catch by rectangle represented 99.5% of the total WG catch in 2022.

In 2022, the majority of catches were caught on the spawning grounds with largest contribution from ICES divisions 27.5.b, 27.6.a, 27.7.c, 27.7.k, 27.2.a and 27.4.a (Figure 2.3.1.1; Tables 2.3.1.2, 2.3.1.3), caught respectively in quarter 1 and quarter 2 (Figure 2.3.1.3). In the first two quarters, catches are taken over a broad area, with the highest catches in 27.6.a, 27.5.b, 27.7.c and 27.7.k, while later in the year catches are mainly taken further north in division 27.2.a and in the North Sea (27.4.a) (Figures 2.3.1.6 and 2.3.1.7 and Table 2.3.1.3). The spatial and temporal distribution of catches in 2021 are similar to previous years (Figures 2.3.1.2, 2.3.1.3, 2.3.1.4; and Table 2.3.1.4 and Figure 1.10.7 in Section 1). The majority of the blue whiting catch was caught by four nations - Faroe Islands, Norway, Iceland, and Russia, respectively (Figure 2.3.1.5).

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 targeting 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.

The blue whiting discards data provided by Portuguese vessels operating with bottom otter trawl within the Portuguese portions of ICES Division 27.9.a are 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 where it was significant (2004, 2006, 2010) discards ranged between 43% and 38% (in weight). In 2022, discards were 29.7% of the total catches for blue whiting along the Portuguese coast (Table 2.3.1.5). The total catch from Portugal is less than of one percent 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 the catch of the last day 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 7.8% (in weight) in 2022 (Table 2.3.1.5). Spanish catches are around 3% of the international catches.

In general, discards are assumed to be small in the blue whiting directed fishery. Discards data contributed to final catches of the following countries: Denmark, Ireland, Portugal, Spain, Sweeden, UK (England and Wales) and UK (Scotland). The total discards constituted 0.4% of the total catches, 3 641 tonnes. The largest fishing nations, , Faroe Islands, Norway, Iceland and Russia do not have discards on blue whiting.

The total estimated catches (tonnes) inside and outside the NEAFC regulatory area by country were reported on Table 2.3.1.6. The catches inside the NEAFC RA represent 8% of the total catches of blue whiting in 2022.

2.3.1.1 Sampling intensity

In 2022, 77% of catches were covered by the sampling program. In 2022, 1 868 length samples and 1 927 age samples were collected from the fisheries with 167 650 fish measured and 15 636 aged (Table 2.3.1.1.1 and Table 2.3.1.1.2). Sampling intensity for blue whiting with detailed information on catch, proportion of catch covered by the sampling program, the number of samples, number of fish measured, and number of fish aged per year from 2000 to 2022 is given in Table 2.3.1.1.1. Sampling intensity per country, quarter and ICES division for 2021 is listed in Tables 2.3.1.1.2, 2.3.1.1.3 and 2.3.1.1.4. The most intensive sampling, considering the age samples and the number of aged fish, took place in areas 27.2.a, 27.5.b, 27.6.b, 27.7.b, 27.7.c, 27.7.k, 27.8.c and 27.9.a (Figure 2.3.1.1.1). No sampling was carried out by Greenland, Poland and Sweden, which together represent 4% 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 Age compositions

As an example of an age-length key from sampled catches in 2022, data from ICES area 27.6.a is presented by quarter and country (Figure 2.3.1.2.1). The mean length (mm) by age reveals that age classifications do present some differences between countries. A difference in mean length-at-age was observed in ages 0 and 1. Although, the differences in mean length-at-age increase in older ages, higher than age 9.

The catch-at-age numbers reveal a higher proportion of age 2 individuals on quarters 1 and 2, which corresponds to the 2020 annual cohort, when a higher recruitment was observed (Figure 2.3.1.2.2).

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

2.3.2 Preliminary 2022 catch data (Quarters 1 and 2)

The preliminary catches for 2023 as reported by the WGWIDE members are presented in Table 2.3.2.1.

The spatial distribution of these 2022 preliminary catches is similar to the distribution in 2022 with majority of catches taken in division 27.5.b, 27.6.a, 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 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.

WGWIDE estimated the expected total catch for 2022 from the sum of declared national quotas, corrected for expected national uptake and transfer of these quotas (Table 2.3.2.3).

For the period 2016 to 2022, preliminary and final catch estimates are similar with maximum deviation in 2021 when the final catch was 8.3% higher than the preliminary catch (Table 2.3.2.4). Age compositions (Figure 2.3.2.2) are also similar between preliminary and final catch data with the exception of an increase in age 1 in the final data from 2022 compared to the preliminary data. There is no clear pattern in the deviations; it is both the catch at age for young and older fish that change between preliminary and final data.

The estimation of catch at age and mean weight at age followed the method described in the Stock Annex.

2.3.3 Catch-at-age

The catch in numbers-at-age from 1981 to 2023 are presented in Table 2.3.3.1 and catch proportions at age shown in Figure 2.3.3.1. Strong year classes that dominated the catches can be clearly seen in the early 1980s, 1990, the late 1990s and early 2000's. More recently, the propagation of the large 2014 year class is also evident and the newly emerged strong year class of 2020. There is also an indication of the year class of 2021 in the catch data.

Catch curves for the international catch-at-age dataset (Figure 2.3.3.2) indicate a consistent decline in catch number by cohort in years with rather high landings (and probably similar high effort). The catch curves for year classes 2010-2015 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. With an assumed natural mortality (M=0.2), the assessment F around 0.4-0.5 fits well to the Z values estimated from the catch curves.

2.3.4 Weight at age

Table 2.3.4.1 and Figure 2.3.4.1 show the mean weight-at-age for the total catch during 1981-2023 used in the stock assessment. Mean weight at ages 3-9 has generally decreased in the period 2010-2018, followed by an increase in the most recent years, for the most abundant ages in the catches. In 2021 and 2022, a decrease in mean weight in almost all ages was observed, which continued in 2023 for the younger ages (1-5 year) but increased again for the older ages (5-10+ year).

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 Fisheries independent data

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

2.3.6.1 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 the only survey used as input to the assessment model.

The full time series of IBWSS was recalculated in summer 2020, using the same software (StoX; Johnsen et al., 2019) and method as previously applied. The values are presented in Table 2.3.6.1.1 and Figure 2.3.6.1.1 A.

The survey time-series (2004-2023) show variable internal consistency ranging from 0.26 to 0.81 (Figure 2.3.6.1.1 B) The overall internal consistency for age-disaggregated year classes was slightly reduced compared to last year. There is a high internal consistency for the younger ages (1-5 years) and older ages (7-9 years) with correlation between 0.72 and 0.81, but poor (0.2 < r < 0.3) between ages 5 to 7. This may indicate age readings problems for this group of ages.

The distribution of acoustic backscattering densities for blue whiting for the period 2019-2023 is shown in Figure 2.3.6.1.2. The abundance estimate of blue whiting for IBWSS are presented in Table 2.3.6.1.1.

Length and age distributions for the period 2018 to 2023 are given in Figure 2.3.6.1.3.

Survey indices, (ages 1-8 years 2004-2023) as applied in the stock assessment are shown in Table 2.3.6.1.1.

2.3.6.2 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 her-ring and blue whiting (mainly immature fish) in the Norwegian Sea (Table 2.3.6.2.1).

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 reli-able indication of year class strength of blue whiting. The 1-group in this survey is defined as less than 19 cm (Table 2.3.6.2.2).

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 less than 22 cm in March (Table 2.3.6.2.3).

Faroese bottom-trawl survey on the Faroe plateau in spring where blue whiting is caught as bycatch species. The 1-group in this survey is defined as equal or less than 23 cm in March (Table 2.3.6.2.4).

The International Survey in Nordic Seas and adjacent waters in July-August (IESSNS). Blue whiting has been considered as a main target species in this survey since 2016 and as such methods were changed to ensure there was sampling for blue whiting. This was a recom-mendation from WGWIDE 2015 to try to have one more time-series for blue whiting. The estimate for 2023 was not completed before WGWIDE. Data for the survey are not used yet, due to the short time series.

2.4 Stock assessment

The IBWSS survey is the only survey used by the SAM assessment. The survey was cancelled in 2020 due to the COVID-19 pandemic, but conducted in 2021-2023.

The presented assessment in this report follows the recommendations from the Inter-Benchmark Protocol of Blue (ICES, 2016a) to use the SAM model. The configuration of the SAM model was kept unchanged in this year’s assessment.

At WGWIDE in 2021 the time period for estimating recruitment for the short term forecast was changed from the full time series (minus terminal year) to the more recent period since 1996 (minus terminal year). This approach was again followed by WGWIDE 2023.

2.4.1 2023 stock assessment

For a model such 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 2.4.1.1) show a quite random distribution of residuals. There seems to be a year class effect showing in the catch residuals starting in the early 2000s. Similarly, there may be an indication of a "year effect" (too low index values) for the IBWSS 2015 observations which has also be seen in previous assessments. Moreover, a similar but weaker year effect of low index values is seen for the IBWSS 2023 observations.

The estimated parameters from the SAM model from this year's assessment and those from assessments conducted since 2019 are shown in Table 2.4.1.1. There are no abrupt changes in the estimated parameters over the time-series presented. The lowest observation noises, and therefore the largest weight in the assessment model, have in all years been from catches at ages 3-8, which constitute the largest proportion of the catch. The observation noise of age 1 (i.e. recruitment) in the IBWSS has decreased over the years, likely due to the increase in length of the time series. The observation noise of ages 4-6 and 7-8 is slightly higher compare to last year's assessment, indicating that the model slightly lowered the weight of these age groups in the survey in this year's assessment.

The process error residuals ("Joint sample residuals") (Figure 2.4.1.2) are reasonably well randomly distributed. Process noise within SAM is implemented as a "process mortality, Z"; these deviations in mortalities are shown in Figure 2.4.1.3. The deviations in mortality (plus or minus mortality) seems fairly randomly distributed without very pronounced clusters (as also seen in Figure 2.4.1.2).

The correlation matrix between ages for the catches and survey indices (Figure 2.4.1.4) shows a modest observation correlation for the younger ages and a stronger correlation for the older ages. This difference is more distinct for catches, probably because it includes older ages (1-10+) than the survey data (ages 1-8). The correlation of older ages (4-8 year) in the survey is stronger this year compared to last year's assessment (Figure 2.4.1.4). This may be a result of a potential year effect in this year's survey data for the older ages. An indication for this may be found in the low index values of ages 5-8 for 2023, being at their historical lowest or close to their historical lowest value (Table 2.3.6.1.1).

Figure 2.4.1.5 presents the exploitation pattern for the whole time-series. There are no abrupt changes in the exploitation pattern from 2010 to 2023, even though the landings in 2011 were just 19% of the landings in 2010, which might have given a change in exploitation pattern. The plateau in selection at age 6 and older seen since mid-2000s seems more realistic than the more linear selection estimated for the beginning of the time series. The estimated stable exploitation pattern might be influenced by the use of correlated random walks for F at age with a high estimated correlation coefficient (Rho = 0.93, Table 2.4.1.1).

The retrospective analysis (Figure 2.4.1.6) shows a reasonably stable assessment for the last 5 years, with the previous years within the 95% confidence interval for the current assessment. Mohn's rho by year and as the average value over the last five years are presented in (Table 2.4.1.2). The annual values are rather high (and negative) for recruitment such that the average Mohn's rho for recruitment becomes -0.188. The average Mohn's rho for F and SSB indicates no bias. Yet, the most recent value for F is relatively high (-0.188) compared to earlier years. This is because the removal of the first peel in the retrospective analysis leads to a quite lower F value for 2022 (from 0.41 to 0.37).

Stock summary results with added 95% confidence limits (Figure 2.4.1.7 and Table 2.4.1.5) show a decrease in fishing mortality in the period 2004—2011, followed by a steep increase in F up to

2015 after which F has decreased to around 0.40-0.45 (above F_{MSY} at 0.32). In 2023, F is estimated to increase again to 0.515. In Recruitment (age 1) was high in 2015, followed by a series of lower recruitment in 2017-2020. The recruitment in both 2021 and 2022 is estimated to be historically high. After a period of descrease since 2016, SSB has been increasing again since 2022. A further increase in SSB is expected from 2023 to 2024, with both strong year classes being largely recruited to the fishery.

2.4.2 Alternative model runs

During WGWIDE 2023 an alternative configuraton of the Blue Whiting SAM assessment was prepared (available at stockassessment.org; BW2023_freeFRW). In this assessment, the number of parameters to estimate for the F-random walks was increased to allow estimation of these random walks for age 1-3 seperatly from ages 4-10. At the same time, the imposed correlation structure in the catch-at-age data was turned off. The results are very similar to the final accepted model and show only minor differences when it comes to fitting catch-at-age. The overall negative log-likelihood was larger under the alternative configuration. The alternative configuration had no impact on the retrospective pattern either. Figure 2.4.2.1 shows the retrospective pattern as well as the final estimates of SSB for the alternative run.

2.5 Final assessment

Following the recommendations from Inter-Benchmark Protocol on Blue Whiting (ICES, 2016a) the SAM model is used for the final assessment. The model settings can be found in the Stock Annex.

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 2.3.6.1.1.

The model was run for the period 1981—2023, with catch data up to 2022 and preliminary catch data for the first half-year (Q1 and Q2) of 2023 raised to expected annual catches, and survey data from March-April, 2004–2023. SSB 1st January in 2023 is estimated from survivors and estimated recruits (for 2023 estimated 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 2.4.1.3 and 2.4.1.4 and summarized in Table 2.4.1.5 and Figure 2.4.1.7. Residuals of the model fit are shown in Figures 2.4.1.1 and 2.4.1.2.

2.6 State of the Stock

Fishing pressure (2023) on the stock is above F_{MSY} and between F_{pa} and F_{lim}; spawning-stock size (2023) is above MSY $B_{trigger}$, B_{pa} and B_{lim}.

After a small dip in F in 2019 (0.40), F is estimated to be 0.52 in 2023. F has been above F_{MSY} and Fpa 0.32 since 2014. SSB has increased from 2021 (4.0 million tonnes) to a close to historical high in 2023 (6.2 million tonnes). In 2024, SSB is estimated to reach 6.8 million tonnes under geometric recruitment (1996-2022) in 2024. SSB has been above MSY $B_{trigger}$ since 1998.

Recruitment (age 1) in 2022 is estimated to be almost at the same level as the historical high of 2021. Recruitment in 2023 (16.7 billion) is estimated to be below the 1996-2022 geometric mean (23.0 billion).

2.7 Biological reference points

In spring of 2016, the Inter-Benchmark Protocol on Blue Whiting (IBPBLW) (ICES, 2016a) 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) (ICES 2016b). During the WGWIDE meeting 2017, WKBWMSE concluded to keep B_{lim} and B_{pa} unchanged but revised F_{lim}, F_{pa}, and F_{MSY}.

ICES made in 2021 the decision to use F_{p05} as the value for F_{pa}. F_{p05} was estimated by WKBWMSE (ICES 2016b), where it was concluded that the EQSIM simulations showed that $Fp_{0.05}$ (0.32) is less than the F_{MSY} in the constant F simulations, so F_{MSY} was set to this lower value.

The table below summarises 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}	0.32	Fp05; the F that leads to SSB ≥ Blim with 95% probability	ICES (2016b) and WGWIDE 2021

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. The 1–group (2022 year class) is around the median and the 2–group (2021 year class) index from the survey in 2023 was above the median of the historical range.

The 1-group (2022 year class) from The International Blue Whiting Spawning Stock Survey (IBWSS) was below the median in the time series and the 2–group (2021 year class) was the second highest in the time series (Table 2.3.6.1.1).

The Norwegian bottom-trawl survey in the Barents Sea (BS-NoRu-Q1(Btr)) in February-March 2023, showed that 1-group blue whiting was below the median in the time series (Ta-ble 2.3.6.2.2). 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 2023 (2022 year class) from the Icelandic bottom-trawl survey showed a strong decrease compared to 2022 and was below the median in the time-series.

The 1-group estimate in 2023 (2022 year class) from the Faroese Plateau spring bottom-trawl survey showed a slight increase compared to 2022 but was below the median in the time-series. This is the only survey which doesn't pick up a strong signal from the 2020 and 2021 year classes.

In conclusion, the indices from available survey time-series indicate that the 2021 year class is among the strongest in the time series, which corresponds to the SAM assessment results. The 2022 year class estimated from surveys are much weaker and below the median, also seen in the SAM assessment. It was therefore decided not to change the SAM estimates of the 2021 and 2022 year classes for the purposes of the short term forecast.

No information is available for the 2023 and 2024 year classes and the geometric mean of the time-series from 1996-2022) was used for these year classes (23 billion at age 1 in 2023) (Table 2.8.2.1.2).

As described in the Stock Annex, WGWIDE decided in 2021 to change from using the geo-metric mean of the full time-series (since 1981) to use a shorter time-series (since 1996) for the calcula-tions recruitment.

2.8.2 Short-term forecast

As decided at WGWIDE 2014, a deterministic version of the SAM forecast was applied. Details about specific implementation can be found in the Stock Annex.

2.8.2.1 Input

Table 2.8.2.1.1 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 (2021—2023) in accordance with the 2019 updated Stock Annex. 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 as used by the assessment.

Recruitment (age 1) in 2022 and 2023 are assumed as estimated by the SAM model, as additional survey information was not conflicting this result. Recruitment in 2024 and 2025 are assumed as the long-term average from the period with both high and low recruitments (geometric mean of the time-series since 1996, minus the terminal year, 1996-2022).

As the assessment uses preliminary catches for 2023 an estimate of stock size is available for the 1st of January 2024. The normal use of an "intermediate year" calculation is not relevant in this case and F in the "intermediate year" (2023) is as calculated by the assessment model. Catches in 2023 are based on the preliminary catches based on declared national quotas and expected na-tional uptake for 2023. Intermediate year assumptions are summarised in Table 2.8.2.1.2.

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 for the target F from the LTMS implies fishing mortality to be at F_{MSY} = 0.32 which will give a TAC in 2024 at 1 529 754 tonnes. This corresponds to a 12.5% increase compared to the ICES advice last year, and a 8.5% decrease compared to the preliminary estimate of catches in 2023 (1 672 378 tonnes).

SSB in 2025 is predicted to increase by 6.7% to 7 258 384 tonnes, if the advised catches are taken. The high recruitment estimated for 2021 and 2022 contributes to this increase in SSB.

2.8.2.3 Comparison of input with last year's forecast

Tables 2.8.2.3.1 and 2.8.2.3.2 compare the estimated catch numbers at age and catch times weight at age between WGWIDE 2023 and WGWIDE 2022 as they are estimated by both assessment for the last five year (2019-2023). For both the catch numbers and the catch numbers times weight, WGWIDE 2023 estimated lower values than WGWIDE 2022, except for the recruitment in 2022 and age 2 in 2023, which are from the same strong year class in 2021. Recruitment for 2023 (age 1) is estimated much lower in WGWIDE 2023 than WGWIDE 2022, as WGWIDE 2022 took the long-term geometric mean in the forecast (22.5 billion), while WGWIDE 2023 took the estimated value from SAM based on the in year survey and catch data (16.7 billion). A large difference is therefore to be expected for recruitment in the terminal year when catch and survey data point towards a much lower or higher recruitment than the geometric mean.

The mean weight-at-age in the forecast in this year's assessment (average of weight at age from 2021-2023) is slightly lower for age 1-4 compared to last year's assessment (average weight from 2020-2022; Figure 2.8.2.3.1). Vice versa, the weight at age 6 and 7 is slightly lower last year compared to this year. All other ages (8-10) are very similar between the two assessments. Selectivity at age are also very similar between this year's and previous year's assessment (Figure 2.4.1.5).

Table 2.8.2.3.2 shows the intermediate year assumptions and recruitments for the current and previous assessment.

2.8.2.4 Medium term projections

Preliminary medium term projections were undertaken at the working group, progressing the stock another 3 years in time up to 2028. These analyses were undertaken to illustrate how stock biomass and catch would develop under expected exploitation regimes, being Fmsy, F status quo (2023) and F equal to that to realise the 2023 catches while assuming that recruitment would be in line with recent estimates of average recruitment. The results show (Figure 2.8.2.4.1) that SSB is likely to go down from 2024 onwards for the F2023 scenario and from 2025 onwards for the other scenarios. Catches are expected to increase up to 2025 and decline from 2026 onwards under all three scenarios. The stock is expected to remain well above MSY Btrigger under all scenarios up to 2028.

2.9 Comparison with previous assessment and forecast

Comparison of the assessments made in 2022 and 2023 (Figure 2.9.1) shows a revision of the historical values of F, SSB and recruitments. The 2022 recruitment is now estimated to be 68.9 billion, while last year's estimate was 43.2 billion. The 2021 recruitment is adjusted slightly downwards: from 71.56 billion to 69.63. F for 2022 is now estimated to be 0.41 while the same value in last year's assessment was 0.37. SSB for 2022 is now estimated to 4.58 million tonnes while last year's value was 4.96 million tonnes, whereas SSB for 2023 is now estimated to be 6.24 million tonnes compared to 6.62 million tonnes last year.

The effect on SSB and F of the final vs. preliminary catch data from 2022 used in the WGWIDE 2022 assessment are limited (Figure 2.9.2). Hence, the slight downscaling of SSB and upscaling of F in recent years as observed in this year's assessment (Figure 2.9.3) is likely due to the addition of a new year of data rather than of having the final 2022 catch data included in the WGWIDE 2023 assessment. The revision in F and SSB may be resulting from the different weighting of the catch and survey data compared to WGWIDE 2022, with a lower weighting of the survey data for the older age classes in particular (see also discussion in Section 2.4.1).

The reasons for the revision of recruitment is linked to the high survey index for age 2 in 2023 (i.e. the 2021 year class and 2022 recruitment; Table 2.3.6.1.1) corroborated by high commercial catch at age of the same year class in 2022 and 2023 (Table 2.4.1.4), and 2) the use of (uncertain) preliminary catch data for 2022 in the 2022 assessment.

With respect to point 1, while the IBWSS index for age 1 in 2022 is historically high, the catch numbers at age 1 for 2022 in last year's assessment were not that high compared to earlier years in the time series (Table 2.4.1.4). This has likely led to a lower estimate of the 2022 recruitment last year compared to this year, where both catches and survey data indicated a strong year class.

With respect to point 2, catch numbers 'in year' are based on Q1 and Q2, whereas young blue whiting are caught at highest numbers in Q3 and Q4 (2.3.1.2.2). Hence, the final numbers at age in the catch are higher than the preliminary catch for age 1, while the final catch data are lower than the preliminary data for age 2-10+ (Figure 2.3.2.2). The final total catch weight is 6.2% lower than the preliminary values for 2022 (Table 2.3.2.4). Including the final catch data for 2022 in the WGWIDE 2022 assessment leads indeed to a much higher 2022 recruitment estimate (similar to that of WGWIDE 2023) than with the preliminary catch data for 2022 (Figure 2.9.2).

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 2.4.1.7). The retrospective analysis (Figure 2.4.1.6) shows a tendency to underestimate recruitment, but unbiased estimates of F and SSB.

There are several sources of uncertainty: age reading, stock identity, survey indices and the use of preliminary catch data. 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. The estimated correlation for catch at age observations might correspond to the age reading discrepancy as also estimated from intercalibration exercise. The use of additional survey data may be beneficial, especially in years without IBWSS data.

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 potentially biased survey data in the final year are supplemented by additional catch data. The preliminary catch weight was 6.2% higher than the final data for 2022, although the differences are smaller for most years between 2016-2022 (Table 2.3.2.4).

2.11 Management considerations

The assessment this year estimates a lower F(2022), a higher SSB(2023) and a considerably larger 2021 year class size than estimated last year. The 2021 year class will be fully recruited to the fishery in 2023 and contribute considerably to the SSB (82% mature at age 3). Estimated catch proportions of the year classes 2020 and 2021 in 2024 are 44 and 31%, respectively. SSB in 2024 is estimated to be well above MSY $B_{trigger}$, but F remains above F_{MSY}.

The SSB is above 6 million tonnes, which is more than twice the B_{msy} and B_{lim} (2 250 000 tonnes and 1 500 000 tonnes respectively). Blue whiting was by IUCN in 2014 evaluated as a species of least concern (https://www.iucnredlist.org/) and it is neither found on OSPAR's list of threatened and declining species nor on the HELCOM Red List. Thus ICES has not identified any conservation aspects.

2.12 Ecosystem considerations

Blue whiting is one of the most abundant pelagic and mesopelagic fish stocks in the Northeast Atlantic, SSB estimated from 1.4 - 6.9 million tonnes during the period from 1981 to 2020 (ICES, 2020). The stock is widely distributed and highly migratory. Its distribution range is approximately from 30 °N to 80 °N latitude and from the coast of Europe to Greenland, into the Barents Sea and Mediterranean Sea (Trenkel *et al*., 2014). Spawning is in the spring and mostly occurs on the shelf and banks west of Ireland and Scotland. The major summer feeding area is in the Norwegian Sea. Blue whiting is most frequently observed at 100-600 m depth (Heino and Godo, 2002). Their most important prey are euphausiids, amphipods and copepods (Pinnegar *et al*., 2015, Bachiller *et al*., 2016) and they are prey for piscivorous fish (Dolgov *et al*., 2010) and cetaceans (Hátún *et al*., 2009a). Blue whiting is an important species in the NE Atlantic and it´s best documented ecosystem interactions are listed below:

(a) Stock productivity - recruitment: blue whiting population dynamic is driven by large annual variability in recruitment (at age 1 in the assessment model) which is not linked to spawning stock size (ICES, 2020). Changes in recruitment have been correlated to changes in the North Atlantic subpolar gyre between strong and weak states (Hátún *et al*., 2009a,b). Two hypotheses have been suggested to explain a causal relationship between low gyre index and high recruitment (Payne *et al*., 2012). One suggests changes in marine climate where weak gyre results in increased flow of warm subtropical waters and increased abundance of important prey for juvenile blue whiting on their nursing grounds west of Ireland and Scotland. The other suggests increasing predation of mackerel on blue whiting larvae during years of weak index, but neither has been proven right (Payne *et al*., 2012).

(b) Changes in distribution: blue whiting spawning distribution varies between years. It has been linked to the North Atlantic subpolar gyre as a strong gyre (cold and fresh water masses on the Rockall Plateau) shrinks the spawning area compared to a weak gyre (increasing saline and warm waters at Rockall) which expands the spawning area northward and westward into Rockall Plateau (Hátún *et al.,* 2009a,b; Miesner and Payne, 2018). Salinity appears specifically to impact spawning location of blue whiting (Miesner and Payne, 2018).

(c) It is still disputed whether there are one or two blue whiting populations in the Northeast Atlantic (Keating *et al*., 2014; Pointin and Payne, 2014; ICES, 2016c; Mahé *et al*., 2016). Currently blue whiting is considered a single population for management purposes.

(d) Trophic interactions in the Norwegian Sea: there appears to be limited prey competition between blue whiting and the two other abundant pelagic species, Norwegian spring-spawning herring and Atlantic mackerel, as studies show limited dietary overlap between blue whiting and the two other species (Bachiller *et al*., 2016; Pinnegar *et al*., 2015). Limited prey competition between blue whiting and mackerel can be explained by limited vertical spatial overlap, mackerel mostly feed in the surface layer and blue whiting deeper in the water column (Utne *et al*., 2012). Where distribution of blue whiting and herring overlap (Utne *et al*., 2012) they appear to feed on different species, herring mainly feed on copepods and blue whiting mainly on euphausiids and amphipods, although juvenile blue whiting feed on copepods (Bachiller *et al.*, 2016; Pinnegar et al., 2015).

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 a long-term management strategy agreed by the European Union, the Faroe Islands, Iceland and Norway. However there is no agreement between the Coastal States, i.e. EU, Norway, Iceland and the Faroe Islands on the share of the blue whiting TAC. The catch advice does not take into account consistent deviations from the long-term management strategy as evident from the sum of unilateral quotas since 2018. During the evaluation of the management strategy (ICES, 2016b), the implementation error in the form of a consistent overshoot of the TAC was not included. Therefore, the current implementation of the long-term management strategy may no longer be precautionary. See section 1.8 for a comparison of historic advice, TAC and catch.

WGWIDE estimates the total expected catch for 2023 to be 1 672 378 tonnes (Table 2.3.2.3), whereas ICES advised that when the long-term management strategy agreed by the European Union, the Faroe Islands, Iceland, and Norway is applied, catches in 2023 should be no more than 1 359 629 tonnes. This advice was followed by the Coastal States by setting a TAC at the ICES advice, however there was no agreement on the split of TAC between nations. The sum of unilateral quotas for 2023 exceeds the agreed TAC by 23%.

2.13.1 Management plans and evaluations

A response to a 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 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 B_{lim} (1.5 million t), B_{pa} (2.25 million t), and F_{MSY} (0.32).
- The HCR was found to be precautionary both with and without the 20% TAC change limits above B_{pa}. However, the 20% TAC change limits can lead to the TAC being lowered significantly if the stock is estimated to be below B_{pa}, while also limiting how quickly the TAC can increase once the stock is estimated to have recovered above B_{pa}.
- 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.

The managers subsequently agreed a long-term management plan for the blue whiting stock that included a new clause (6.b.) that stated that the 25% restriction in the increase of catch advice (TAC change limit) is not applied when the catch advice deviates more than 40% from the catch advice of the preceding year (see Annex 1 in Anon, 2021). This clause was then evaluated by ICES and found precautionary in 2017 (Working Document in ICES, 2017).

The management strategy evaluation did not take into account consistent deviations from the long-term management strategy as evident from the sum of unilateral quotas in recent years. During the evaluation of the management strategy (ICES, 2016b), the implementation error in the form of a consistent overshoot of the TAC was not included. Therefore, the current implementation of the long-term management strategy may no longer be precautionary.

2.14 References

Anon 2021. Agreed record of conclusions of fisheries consultations between the European Union, the Faroe Islands, Iceland, Norway and UK on the management of blue whiting in the north-east Atlantic in 2022.

Bachiller, E., Skaret, G., Nøttestad, L., Slotte, A. 2016 Feeding ecology of northeast Atlantic mackerel, Norwegian spring- spawning herring and blue whiting in the Norwegian Sea. PLoS One, 11 (2016), 10.1371/journal.pone.0149238

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, 73: 1788-1797. doi:10.1093/icesjms/fsw046

Dolgov, A. V., Johannesen, E., Heino, M., and Olsen, E. 2010. Trophic ecology of blue whiting in the Barents Sea. ICES Journal of MarineScience, 67: 483–493

Hátún H, Payne, M.R., Beaugrand, G., Reid, P.C., Sando, A.B., Drange, H., Hansen, B., Jacobson, J.A. and Bloch., D. 2009a. Large bio-geographical shifts in the north-eastern Atlantic Ocean: From the Subpolar Gyre, via plankton, to blue whiting and pilot whales. Progress in Oceanography 80 (2009b) 149–162.

Hátún H, Payne, M.R., and Jacobson, J.A. 2009b. The North Atlantic Subpolar Gyre regulates the spawning distribution of blue whiting (Micromesistius poutassou). Canadian Journal of Fisheries and Aquatic Science 66: 759–770. doi:10.1139/F09-037441

Heino M., and Godø, O.R. 2002. Blue whiting – a key species in the mid-water ecosystems of the north-eastern Atlantic. ICES C.M. 2002/L:28.

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. 2016a. Report of the Inter-Benchmark Protocol for Blue Whiting (IBPBLW), 10 March–10 May 2016, By correspondence. ICES CM 2016/ACOM:36. 118 pp.

ICES. 2016b. Working Group on Widely Distributed Stocks5Series title. Jan De Haes

ICES. 2016c. Report of the Stock Identification Methods Working Group (SIMWG), By correspondence. ICES CM 2016/SSGEPI:16. 47 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. 1111 pp.

ICES. 2020. Working Group on Widely Distributed Stocks (WGWIDE). ICES Scientific Reports. 2:82. 1019 pp. http://doi.org/10.17895/ices.pub.7475

Johnsen, E., Totland, A., Skålevik, Å., Holmin, A.J., Dingsør, G.E., Fuglebakk, E., Handegard, N.O. 2019. StoX: An open source software for marine survey analyses. Methods Ecol Evol. 2019; 10:1523–1528.

Keating, J.P., Brophy, D., Officer, R.A., and Mullins, E. 2014. Otolith shape analysis of blue whiting suggests a complex stock structure at their spawning grounds in the Northeast Atlantic. Fish. Res. 157: 1–6. doi:10.1016/j.fishres.2014.03.009.

Mahé, K., Oudard, C., Mille, T., Keating, J.P., Gonçalves, P., Clausen, L.W., Petursdöttir, G.G., Rasmussen, H., Meland, E., Mullins, E. and Pinnegar, J.K. 2016. Identifying blue whiting (*Micromesistius poutassou*) stock structure in the Northeast Atlantic by otolith shape analysis. Canadian Journal of Fisheries and Aquatic Sciences, 10.1139/cjfas-2015-0332.

Miesner, A.K., Payne, M.R., 2018. Oceanographic variability shapes the spawning distribution of blue whiting (Micromesistius poutassou). Fish. Oceanogr. 623–638. doi:10.1111/fog.12382

Payne, M. R., Egan, A., Fässler, S. M. M., Hátún, H., Holst, J. C., Jacobsen, J. A., Loeng, H. (2012). The rise and fall of the NE Atlantic blue whiting (Micromesistius poutassou). Marine Biology Research, 8, 475–487. https://doi.org/10.1080/17451000.2011.639778

Pointin F. and Payne, M.R. 2014. A Resolution to the Blue Whiting (Micromesistius poutassou) Population Paradox? PLoSONE 9(9): e106237. doi:10.1371/journal.pone.0106237.

Pinnegar, J. K., Goñi, N., Trenkel, V. M., Arrizabalaga, H., Melle, W., Keating, J., and Óskarsson, G. 2015. A new compilation of stomach content data for commercially important pelagic fish species in the northeast Atlantic, Earth Syst. Sci. Data, 7, 19–28, https://doi.org/10.5194/essd-7-19-2015.

Trenkel, V., Huse,G., MacKenzie, B., Alvarez, P., Arrizabalaga, H.,Castonguay, M., Goñi, N., Grégoire, F., Hátún, H., and Jansen, T. Comparative ecology of widely distributed pelagic fish species in the North Atlantic: implications for modelling climate and fisheries impacts. Prog. Oceanogr., 129 (2014), pp. 219-243.

Utne, K. R., Huse, G., Ottersen, G., Holst, J. C., Zabavnikov, V., Jacobsen, J. A., Oskarsson, G. J., and Nøttestad, L. 2012. Horizontal distribution and overlap of planktivorous fish stocks in the Norwegian Sea during summers 1995–2006. Marine Biology Research (1745-1019) 2012-04, Vol. 8, N. 5–6, P. 420–441.

2.15 Tables

Table 2.3.1.1. Blue whiting. ICES estimated catches (tonnes) by country for the period 1988–2022.

Country	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	2003	2004	2005	2006	2007	2008
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	89 500	41 450	54 663	48 659	18 134
Estonia					6 156	1 033	4 342	7 754	10 982	5 678	6 320		**				
Faroe Islands	79 831	75 083	48 686	10 563	13 436	16 506	24 342	26 009	24 671	28 546	71 218	329 895	322 322	266 799	321 013	317 859	225 003
France		2 191				1 195		720	6 442	12 446	7 984	14 149		8 046	18 009	16 638	11 723
Germany	5 546	5 417	1 699	349	1 332	100	2	6 313	6 876	4 724	17 969	22 803	15 293	22 823	36 437	34 404	25 259
Iceland		4 977						369	302	10 464	68 681	501 493	379 643	265 516	309 508	236 538	159 307
Ireland	4 646	2 014			781		3	222	1 709	25 785	45 635	22 580	75 393	73 488	54 910	31 132	22 852
Japan					918	1 742	2 574										
Latvia					10 742	10 626	2 582										
Lithuania						2 046									4 635	9 812	5 338
Netherlands	800	2 078	7 750	17 369	11 036	18 482	21 076	26 775	17 669	24 469	27 957	48 303	95 311	147 783	102 711	79 875	78 684
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	957 684	738 490	642 451	539 587	418 289
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	3 937	5 190	5 323	3 897	4 220
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	15 612	17 643	15 173	13 557	14 342
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	19 083	2 960	101	467	4
UK (England + Wales)***													2 593	7 356	10 035	12 926	14 147
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	57 028	104 539	72 106	43 540	38 150
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	346 762	332 226	329 100	236 369	225 163
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**	2 380 161	2 034 309	1 976 176	1 625 259	1 260 615

*** From 1992 only Russia.**

**** Estimates from Sweden and Greenland: are not included in the Catch at Age Number.**

**** Estonia (2004): Reported to the EU but not to the ICES WGNPBW. (Landings of 19,467 tonnes).**

***** From 2012.**

Table 2.3.1.1. (continued). Blue whiting. ICES estimated catches (tonnes) by country for the period 1988–2022.

Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Denmark	248	140	165	340	2167	35256	45178	39395	60868	87348	68716	58997	40321	45644
Estonia											0			
Faroe Islands	58354	49979	16405	43290	85768	224700	282502	282416	356501	349838	336569	343372	202415	217401
France	8831	7839	4337	9799	8978	10410	9659	10345	13369	16784	16095	13769	14612	14202
Germany	5044	9108	278	6239	11418	24487	24107	20025	45555	47708	38244	42362	35327	21667
Iceland	120202	87942	5887	63056	104918	182879	214870	186914	228934	292944	268356	243725	190146	191813
Ireland	8776	8324	1195	7557	13205	21466	24785	27657	43238	49903	38836	40135	39514	28972
Lithuania						4717		1129	5300			9543	21183	13149
Netherlands	35686	33762	4595	26526	51635	38524	56397	58148	81156	121864	75020	62309	62017	63249
Norway	225995	194317	20539	118832	196246	399520	489439	310412	399363	438426	351429	354033	233968	194973
Poland									15889	12152	27185	47616	26077	20948
Portugal	2043	1482	603	1955	2056	2150	2547	2586	2046	2497	3481	2819	2522	2784
Spain	20637	12891	2416	6726	15274	32065	29206	31952	28920	24718	22782	23676	25509	26310
Sweden	3	50	1	4	199	2	32	42	90	16**	54	25	40	20
UK (England + Wales)	6176	2475	27	1590	4100	11	131	1374+	3447	1864	4062	7458	8783	7482
UK (Northern Ireland)					1232	2205	1119			4508	2899	2958		
UK (Scotland)	173	5496	1331	6305	8166	24630	30508	37173	64724	66682	54040	41344	65085	42903
Russia	149650	112553	45841	88303	120674	152256	185763	173655	188449	170892	188006	181496	133605^	128002
Greenland					2133				20212	23333	19753	19611	20190	19218
Unallocated				3499									22137	
TOTAL	**641818**	**526357**	**103620**	**384021**	**628169**	**1155279**	**1396244**	**1181850**	**1558061**	**1711461**	**1515527**	**1495248**	**1143450**	**1038736**

** only landings (2018).

+ data updated in 2018.

^ Russia 2021 preliminary data (Q1+Q2) submitted to WGWIDE 2021.

Table 2.3.1.2. Blue whiting. ICES estimated catches (tonnes) by country and ICES division for 2022

ICES Division	Denmark	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Lithuania	Netherlands	Norway	Poland	Portugal	Russia	Spain	Sweden	UK (England and Wales)	UK(Scotland)	Total
27.2.a	17	17599		4	2294	10624	0.837		244.83	12326			33256				2	**76368**
27.3.a	103									0					7.192			**110**
27.4																	201	**201**
27.4.a	96	11142	0		1750	20869			0.79	20300			4770		2		26	**58956**
27.4.b	13									80					11			**104**
27.5.a		1288				28094												**29382**
27.5.b		161657	1170	5106	13774	116955		44	5475.36	11722	1743		62721					**380366**
27.6.a	19808	22029	4581	583	1400	15269	12104.32	8555	16640.39	60427	5006		3943	21		7478	12063	**189909**
27.6.b	1998		102				830			1875			6490	4			2139	**13437**
27.7.a			31															**31**
27.7.b			18				6.192		3.33		1365			8			268	**1667**
27.7.c	16403	3686	2026	8957			12822.21	2895	7731.16	53612	1170		11822	35			17517	**138676**
27.7.e			38													1		**39**
27.7.f			0						0.38							0		**1**
27.7.g									0.55					9		2		**12**
27.7.h			132	111					235.24					20		2		**501**
27.7.j	5		1319	269			18.71		2047.23		1857			143				**5659**
27.7.k	7186		252	6619			3189.748		16547.78	34632	7108		5000	1			10686	**91221**
27.8.a	15		834	18					623.49					58				**1549**
27.8.b			5											516				**521**
27.8.c			0									5		14953				**14958**
27.8.d			3693					**1655**	13698.07		2700			9				**21756**
27.9.a												2779		10531				**13310**
27.9.b														0				**0**
27.14.a						1												**1**
27.14.b						1												**1**
Total	**45644**	**217401**	**14202**	**21667**	**19218**	**191813**	**28972**	**13149**	**63249**	**194973**	**20948**	**2784**	**128002**	**26310**	**20**	**7482**	**42903**	**1038736**

Table 2.3.1.3. Blue whiting. ICES estimated catches (tonnes) by quarter and ICES division for 2022.

ICES Division	Quarter 1	Quarter 2	Quarter 3	Quarter 4	2022*	Total
27.2.a	2132	50488	13752	9997		**76368**
27.3.a	0	40	60	9		**110**
27.4					201	**201**
27.4.a	6215	35454	6133	11154		**58956**
27.4.b	0	80	20	3		**104**
27.5.a		16	1267	28099		**29382**
27.5.b	55090	306682	11	18583		**380366**
27.6.a	36714	149333	1	3824	37	**189909**
27.6.b	12367	1064	4	0	2	**13437**
27.7.a		31				**31**
27.7.b	1647	19	1	0		**1667**
27.7.c	136741	1872	21	42		**138676**
27.7.e	12	1		26		**39**
27.7.f	0			0		**1**
27.7.g	3	4	3	2		**12**
27.7.h	241	8	9	243		**501**
27.7.j	3247	55	219	2138		**5659**
27.7.k	90816	252		153		**91221**
27.8.a	411	40	2	1097		**1549**
27.8.b	119	133	99	172		**521**
27.8.c	3441	4417	4772	2327		**14958**
27.8.d	21372	2	5	377		**21756**
27.9.a	2123	3264	4800	3122		**13310**
27.9.b		0				**0**
27.14.a			1			**1**
27.14.b				1		**1**
Total	**372691**	**553255**	**31180**	**81370**	**240**	**1038736**

***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 1988–2022 by area.

Year	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	55829	426037	45143	527009	30838	557847
1989	42615	475179	75958	593752	33695	627447
1990	2106	463495	63192	528793	32817	561610
1991	78703	218946	39872	337521	32003	369524
1992	62312	318018	65974	446367	28722	475026
1993	43240	347101	58082	448423	32256	480679
1994	22674	378704	28563	429941	29473	459414
1995	23733	423504	104004	551241	27664	578905
1996	23447	478077	119359	620883	25099	645982
1997	62570	514654	65091	642315	30122	672437
1998	177494	827194	94881	1099569	29400	1128969
1999	179639	943578	106609	1229826	26402	1256228
2000	284666	989131	114477	1388274	24654	1412928
2001	591583	1045100	118523	1755206	24964	1780170
2002	541467	846602	145652	1533721	23071	1556792
2003	931508	1211621	158180	2301309	20097	2321406
2004	921349	1232534	138593	2292476	85093	2377569
2005	405577	1465735	128033	1999345	27608	2026953
2006	404362	1428208	105239	1937809	28331	1966140
2007	172709	1360882	61105	1594695	17634	1612330
2008	68352	1111292	36061	1215704	30761	1246465
2009	46629	533996	22387	603012	32627	635639
2010	36214	441521	17545	495280	28552	523832
2011	20599	72279	7524	100401	3191	103592
2012	24391	324545	5678	354614	29402	384016*
2013	31759	481356	8749	521864	103973	625837**
2014	45580	885483	28596	959659	195620	1155279
2015	150828	895684	44661	1091173	305071	1396244
2016	59744	905087	55774	1020604	162583	1183187***
2017	136565	1284105	45474	1466144	91917	1558061
2018	143204	1445957	43484	1632646	78831	1711477
2019	68593	1271883	44856	1385333	130194	1515527
2020	92084	1059197	64327	1215608	279640	1495248
2021	112082	801768	39509	953359	190091	1143450
2022	105752	724086	59371	889209	149527	1038736

*** Official catches by area from Sweden are not included (2012);**

**** Official catches by area from Sweden and Greenland are not included (2013);**

***** Grand total includes only 1336 tonnes from UK(England + Wales) (2016 total catch from UK(England + Wales) = 1374 ton).**

Table 2.3.1.5. Blue whiting. ICES estimates (tonnes) of catches, landings and discards by country for 2022.

Country	BMS landing	Discards	Landings	Catches	% discards
Denmark		127	45517	45644	0.3
Faroe Islands			217401	217401	0.0
France			14202	14202	0.0
Germany			21667	21667	0.0
Greenland			19218	19218	0.0
Iceland			191813	191813	0.0
Ireland		390	28582	28972	1.3
Lithuania			13149	13149	0.0
Netherlands		0	63249	63249	0.0
Norway			194973	194973	0.0
Poland			20948	20948	0.0
Portugal		828	1956	2784	29.7
Russia			128002	128002	0.0
Spain	0	2047	24263	26310	7.8
Sweden		7	13	20	35.6
UK (England & Wales)	0	2	7480	7482	0.0
UK(Scotland)	0	240	42662	42903	0.6
Total	**1**	**3641**	**1035094**	**1038736**	**0.4**

Table 2.3.1.6. Blue whiting. ICES estimated catches (tonnes) inside and outside NEAFC regulatory area for 2022 by country.

Country	Outside NEAFC	Inside NEAFC	Total
Denmark	45644		45644
Faroe Islands	210876	6525	217401
France*	14165	37	14202
Germany	16562	5106	21667
Greenland	13803	5415	19218
Iceland	191405	408	191813
Ireland	28972		28972
Lithuania	13149		13149
Netherlands	57529	5719	63249
Norway*	174401	20572	194973
Poland	19205	1743	20948
Portugal	2784		2784
Russia	87909	40093	128002
Spain	26310		26310
Sweden	20		20
UK (England and Wales)	7482		7482
UK(Scotland)	42903		42903
Total	**953119**	**85618**	**1038736**

*** the values of catches inside/outside NEAFC RA have been estimated based on the ICES Preliminary Catch Statistics.**

Table 2.3.1.1.1. Blue whiting. ICES estimated catches (tonnes), the percentage of catch covered by the sampling programme, No. of age samples, No. of fish measured and No. of fish aged for 2000-2022.

Year	Catch (tonnes)	% catch covered by the sampling programme	No. Length Samples	No. Length measurements	No. Fish 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
2012	373937	80	1143	173206	15745
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
2018	1711078	87	1565	131779	16426
2019	1515527	84	1537	136604	17869
2020	1495248	81	672	89110	16641
2021	1143450	81	1676	129317	15215
2022	1038736	77	1868	167650	15636

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 length samples, No. of age 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 2022.

Country	Catch (tonnes)	% catch covered by the sampling programme	No. of Length Samples	No. of Length Measured	No. of Age Samples	No. Age Readings
Denmark	45644.006	95	18	810	18	807
Faroe Islands	217401	95	16	1644	16	1526
France	14201.75117	0	56	3850	0	0
Germany	21667.404	2	9	2236	9	366
Greenland	19218	0	0	0	0	0
Iceland	191813	99	59	4734	59	1432
Ireland	28972.01355	93	45	11383	25	1400
Lithuania	13149.01716	0	0	0	0	0
Netherlands	63248.6	85	51	10362	51	1229
Norway	194973.044	94	75	2213	75	2213
Poland	20948.14	0	0	0	0	0
Portugal	2783.7031	100	29	2679	29	898
Russia	128002	14	224	66932	224	2980
Spain	26309.59696	99	1155	52028	1155	1830
Sweden	20.192	0	0	0	0	0
UK (England)	7482.381	100	21	3102	246	246
UK(Scotland)	42902.586	99	110	5677	20	709
Total	1038736	77	1868	167650	1927	15636

Table 2.3.1.1.3. Blue whiting. ICES estimated catches (tonnes), No. of Age samples, No. of fish measured and No. of fish aged by country and quarter for 2022 (cont.).

Country	Catches (ton)	No. of Length Samples	No. of Length Measured	No. Age Readings
Denmark				
Quarter 1	25640	10	487	485
Quarter 2	19818	8	323	322
Quarter 3	71	0	0	0
Quarter 4	116	0	0	0
Total	**45644**	**18**	**810**	**807**
Faroe Islands				
Quarter 1	65336	4	441	400
Quarter 2	139663	10	1036	1000
Quarter 3	1836	0	0	0
Quarter 4	10566	2	167	126
Total	**217401**	**16**	**1644**	**1526**
France				
Quarter 1	4773	31	2103	0
Quarter 2	5778	0	0	0
Quarter 3	2	0	0	0
Quarter 4	3649	25	1747	0
Total	**14202**	**56**	**3850**	**0**
Germany				
Quarter 1	15594	0	0	0
Quarter 2	601	0	0	0
Quarter 3	28	1	324	84
Quarter 4	5445	8	1912	282
Total	**21667**	**9**	**2236**	**366**
Greenland				
Quarter 2	19184	0	0	0
Quarter 3	5	0	0	0
Quarter 4	29	0	0	0
Total	**19218**	**0**	**0**	**0**
Iceland				
Quarter 2	157563	49	3993	1185
Quarter 3	2627	1	75	25
Quarter 4	31623	9	666	222
Total	**191813**	**59**	**4734**	**1432**
Ireland				
Quarter 1	17427	25	6332	1000
Quarter 2	11350	10	3137	400
Quarter 4	195	10	1914	0
Total	28972	45	11383	1400

Table 2.3.1.1.3. (continued) Blue whiting. ICES estimated catches (tonnes), No. of Age samples, No. of fish measured and No. of fish aged by country and quarter for 2022 (cont.).

Country	Catches (ton)	No. of Length Samples	No. of Length Measured	No. Age Readings
Lithuania				
Quarter 1	9534	0	0	0
Quarter 4	3615	0	0	0
Total	13149	0	0	0
Netherlands				
Quarter 1	41359	31	6934	739
Quarter 2	14815	20	3428	490
Quarter 3	143	0	0	0
Quarter 4	6932	0	0	0
Total	**63249**	**51**	**10362**	**1229**
Norway				
Quarter 1	111166	43	1264	1264
Quarter 2	67106	25	739	739
Quarter 3	10119	0	0	0
Quarter 4	6582	7	210	210
Total	**194973**	**75**	**2213**	**2213**
Poland				
Quarter 1	18024	0	0	0
Quarter 4	2924	0	0	0
Total	**20948**	**0**	**0**	**0**
Portugal				
Quarter 1	382	5	366	121
Quarter 2	647	10	980	340
Quarter 3	761	8	817	136
Quarter 4	993	6	516	301
Total	**2784**	**29**	**2679**	**898**

Table 2.3.1.1.3. (continued) Blue whiting. ICES estimated catches (tonnes), No. of Age samples, No. of fish measured and No. of fish aged by country and quarter for 2022 (cont.).

Country	Catches (ton)	No. of Length Samples	No. of Length Measured	No. Age Readings
Russia				
Quarter 1	24906	46	11930	558
Quarter 2	89610	158	49025	1879
Quarter 3	6555	20	5977	543
Quarter 4	6931	0	0	0
Total	**128002**	**224**	**66932**	**2980**
Spain				
Quarter 1	5363	295	18110	349
Quarter 2	7262	315	11506	675
Quarter 3	9006	350	14755	489
Quarter 4	4679	195	7657	317
Total	**26310**	**1155**	**52028**	**1830**
Sweden				
Quarter 1	0	0	0	0
Quarter 2	0	0	0	0
Quarter 3	17	0	0	0
Quarter 4	3	0	0	0
Total	**20**	**0**	**0**	**0**
UK (England and Wales)				
Quarter 2	7480	21	3102	246
Quarter 4	2	0	0	0
Total	**7482**	**21**	**3102**	**246**
UK(Scotland)				
Quarter 1	33187	13	1841	484
Quarter 2	9454	7	805	225
Quarter 3	11	0	0	0
Quarter 4	10	0	0	0
2022*	240	90	3031	0
Total	**42903**	**110**	**5677**	**709**
Total Geral	**1038736**	**1868**	**167650**	**15636**

*** discards data provided for the whole year, not raised by quarter 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 length samples, No. of age 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 2022.

ICES Division	Catch (tonnes)	No. Length samples	No. Age samples	No. Fish Measured	No. Aged	No Aged/ 1000 tonnes	No Measured/ 1000 tonnes
27.4	201	62	0	2038	0	0	10150
27.2.a	76368	78	78	21425	1551	20	281
27.3.a	110	0	0	0	0	0	0
27.4.a	58956	17	17	921	542	9	16
27.4.b	104	0	0	0	0	0	0
27.5.a	29382	7	7	515	174	6	18
27.5.b	380366	164	157	37932	2988	8	100
27.6.a	189909	123	333	14689	3239	17	77
27.6.b	13437	12	10	2760	117	9	205
27.7.a	31	0	0	0	0	0	0
27.7.b	1667	5	5	591	50	30	354
27.7.c	138676	133	127	9424	2182	16	68
27.7.e	39	0	0	0	0	0	0
27.7.f	1	0	0	0	0	0	0
27.7.g	12	1	1	0	0	0	0
27.7.h	501	89	76	2399	134	268	4790
27.7.j	5659	83	75	3158	325	57	558
27.7.k	91221	75	61	14383	1429	16	158
27.8.a	1549	49	27	1579	0	0	1019
27.8.b	521	117	117	4839	0	0	9280
27.8.c	14958	449	449	31324	877	59	2094
27.8.d	21756	28	11	3433	257	12	158
27.9.a	13310	376	376	16240	1771	133	1220
27.9.b	0	0	0	0	0	0	0
27.14.a	1	0	0	0	0	0	0
27.14.b	1	0	0	0	0	0	0
TOTAL (2022)	**1038736**	**1868**	**1927**	**167650**	**15636**	**15**	**161**

Table 2.3.2.1. Blue whiting. ICES estimated preliminary landings (tonnes) in 2023 by quarter and ICES division. Data submitted to InterCatch.

	Landings			
ICES Div.	**Quarter 1**	**Quarter 2**	**Quarter 3**	**Total**
27.2.a	13018	22651		35668
27.3.a		4	0	4
27.4.a	20983	49951		70935
27.4.b		1		1
27.5.a	0			0
27.5.b	205409	361019		566428
27.6.a	90371	70702		161072
27.6.b	13366	3891		17257
27.7.b	1532			1532
27.7.c	174451	28653		203104
27.7.g	0			0
27.7.j	8933	4		8938
27.7.k	375968	11		375979
27.8.a	1414	2		1416
27.8.b	42	5		47
27.8.c	3615	4843		8458
27.8.d	696			696
27.9.a	2270	3234		5504
27.12	10670			10670
27.14.b	3	0		3
Total	**922741**	**544972**	**0**	**1467714**

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 2023 preliminary data (quarters 1 and 2). Data submitted to InterCatch.

ICES Division	Catch (ton)	No. samples	No. Measured	No. Aged
27.2.a	35668	4	388	320
27.3.a	4	0	0	0
27.4.a	70935	0	0	0
27.4.b	1	0	0	0
27.5.a	0	0	0	0
27.5.b	566428	36	4760	1662
27.6.a	161072	39	9650	1200
27.6.b	17257	9	2211	251
27.7.b	1532	0	0	0
27.7.c	203104	30	4751	1215
27.7.g	0	0	0	0
27.7.j	8938	1	36	36
27.7.k	375979	95	14008	2241
27.8.a	1416	0	0	0
27.8.b	47	0	0	0
27.8.c	8458	0	0	0
27.8.d	696	0	0	0
27.9.a	5504	10	1577	461
27.12	10670	13	4036	142
27.14.b	3	0	0	0
Total	1467714	237	41417	7528

Table 2.3.2.3. Blue whiting. ICES estimates of catches (tonnes) in 2023, based on (initial) declared quotas and expected uptake estimated by WGWIDE.

Country	2023 Q1	2023 Q2	2023 Q3	2023 Total Catch (Q1+Q2)	Expected re-mained catch	2023 Total Catch
Denmark	55666	20680	7	76353	1330	77683
Faroe Islands	171434	194673		366107	26435	392542
France*	10237	2547		12784	4261	17045
Germany	28916	5684	0	34600	0	34600
Greenland	4200	11222		15422	10378	25800
Iceland	78173	148260		226433	47009	273442
Ireland	38275	15363		53638		53638
Lithuania**	10065	4836		14901	5511	20412
Netherlands	51853	19766	652	72271		79500
Norway	283778	70478		354256		378000
Poland	19713	5934		25647		25647
Portugal	639	607		1246	2000	3246
Russia***	58321	74710		133031	16442	149473
Spain	8869	8773		17643		35285
Sweden	0	0		0		30
UK(England & Wales)	3719	3802		7521	895	8416
UK(Scotland)	61047	26284		87331	10287	97618
Total	884905	613619	659	1499183	124549	1672378

***Provisional 2023 data from the national landing information system for Q1 and Q2. Assumed this is 75% of the total catch (based on final 2022 catches), so estimated 25% still to be caught.**
**** Assumed this is 73% of the total catch (based on final 2022 catches), so estimated 23% still to be caught.**
***** Assumed this is 89% of the total catch (based on final 2022 catches), so estimated 11% still to be caught.**

Table 2.3.2.4. Blue whiting. Comparison of preliminary and final catches (in tonnes) calculated from sum of product of catch number and mean weight at age used in the assessment).

	Final	Preliminary	Change in % *
2016	1180786	1147000	2.9
2017	1555069	1559437	-0.3
2018	1709856	1712874	-0.2
2019	1512026	1444301	4.7

2020	1460507	1478358	-1.2
2021	1139531	1242727	-8.3
2022	1038736	1107529	-6.2

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

Table 2.3.3.1. Blue whiting. Catch-at-age numbers (thousands) by year. Discards included since 2014. Values for 2023 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

Year Age	1	2	3	4	5	6	7	8	9	10+
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
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	418781	541041	3572357	7340084	2983975	1022883	424206	150753	90387	163289
2019	249923	433573	1288871	3778379	5037323	1645999	431925	145916	50622	81357
2020	1135859	834162	1106838	1797157	3072708	3041983	923392	235330	80440	64535
2021	2069387	830692	1266077	1214790	1438769	1404443	1360104	304891	100993	59441
2022	1927303	3265756	1640425	1370794	924112	746761	670201	616695	123772	85610
2023	391151	3847086	8551171	3024159	1356485	529259	527277	395306	376977	162922

Table 2.3.4.1. Blue whiting. Individual mean weight (kg) at age in the catch. Preliminary values for 2023.

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

Year Age	1	2	3	4	5	6	7	8	9	10+
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	0.141	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
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

Year Age	1	2	3	4	5	6	7	8	9	10+
2017	0.056	0.072	0.080	0.094	0.113	0.131	0.148	0.172	0.190	0.212
2018	0.055	0.080	0.091	0.098	0.111	0.129	0.142	0.165	0.175	0.216
2019	0.068	0.085	0.099	0.109	0.118	0.130	0.144	0.167	0.167	0.228
2020	0.063	0.084	0.099	0.115	0.127	0.135	0.144	0.161	0.176	0.207
2021	0.058	0.086	0.099	0.119	0.133	0.143	0.150	0.166	0.181	0.209
2022	0.048	0.067	0.086	0.106	0.122	0.136	0.141	0.152	0.155	0.189
2023	0.045	0.061	0.076	0.092	0.120	0.144	0.155	0.169	0.182	0.207

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 2.3.6.1.1. Blue whiting. Time-series of StoX abundance estimates of blue whiting (millions) by age in the IBWSS. Total biomass in last column (1000 t). Shaded values (ages 1-8; years 2004-2023) are used as input to the assessment

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	TSB
2004	1097	5538	13062	15134	5119	1086	994	593	164	0	3505
2005	2129	1413	5601	7780	8500	2925	632	280	129	23	2513
2006	2512	2224	10881	11695	4717	2719	923	352	198	39	3517
2007	468	706	5241	11244	8437	3155	1110	456	123	65	3274
2008	337	524	1455	6661	6747	3882	1719	1029	269	296	2647
2009	275	329	360	1292	3739	3458	1636	587	250	194	1599
2010*											
2011	312	1361	1135	930	1043	1713	2171	2423	1298	272	1827
2012	1140	1816	6454	1021	595	1415	2220	1777	1249	1085	2347
2013	582	1337	6175	7211	2938	1282	1308	1398	929	1807	3110
2014	4183	1491	5239	8420	10202	2754	772	577	899	2251	3761
2015	3255	4570	1891	3641	1797	466	174	108	206	365	1405
2016	2745	7893	10164	6274	4687	1539	413	133	235	361	2873

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	TSB
2017	262	2248	15682	10176	3762	1793	921	76	84	173	3135
2018	836	628	6615	21490	7692	2187	755	188	72	138	4035
2019	1129	1169	3468	9590	16979	3434	484	513	99	43	4198
2020**											
2021	1948	2095	2545	2275	3914	3197	3379	463	189	114	2357
2022	4461	9313	4830	5460	2587	1880	898	1764	71	178	2707
2023	873	8135	14771	2744	1352	711	520	202	508	67	2501

***Survey discarded. **No survey**

Table 2.3.6.2.1. Blue whiting. Estimated abundance of 1 and 2-year old blue whiting from the International Ecosystem Survey in Nordic Seas (IESNS), 2003–2023.

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	3937	2030
2015	8563	2796
2016	4223	8089
2017	1236	2087
2018	441	1491
2019	3157	215
2020	2822	481
2021	10264	1500
2022	17169	10575
2023	3873	4792

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

Table 2.3.6.2.2. Estimated abundance of 1-group 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. (Time series revised in 2023)

Year	All	< 19 cm
1994	65.43	0.04
1995	29.24	0.79
1996	1502.53	1461.18
1997	1671.57	1360.46
1998	85.99	17.28
1999	75.50	5.96
2000	644.59	554.44
2001	2365.41	1567.94
2002	1157.96	149.59
2003	826.79	192.15
2004	1834.75	676.71
2005	2072.79	722.10
2006	2322.05	26.96
2007	960.64	0.75
2008	162.36	0.17
2009	75.73	0.02
2010	29.63	0.44
2011	10.71	0.05
2012	768.68	752.68
2013	510.46	21.67
2014	227.63	172.10
2015	1227.69	1012.16
2016	701.67	95.35
2017	1299.24	6.36
2018	106.96	0.62
2019	110.02	55.22
2020	209.66	150.22
2021	964.32	828.96
2022	599.84	293.71
2023	343.02	23.59

Table 2.3.6.2.3. 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
2019	0.1
2020	9.8
2021	79.6
2022	91.2

Catch Rate	
Year	**< 22 cm**
2023	6.8

Table 2.3.6.2.4. 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	1401
1995	1162
1996	4821
1997	2307
1998	463
1999	1717
2000	863
2001	4424
2002	4480
2003	1038
2004	15749
2005	35159
2006	23105
2007	11568
2008	1268
2009	4362
2010	855
2011	23323
2012	8366
2013	13254
2014	70139
2015	34806
2016	21316
2017	4446
2018	1890
2019	286

Catch Rate	
Year	**<= 23 cm**
2020	141
2021	2224
2022	1781
2023	3075

Table 2.4.1.1. Blue whiting. Parameter estimates, from final assessment (2023) and previous assessments (2019-2022).

Parameter Year	2019	2020	2021	2022	2023
Random walk variance					
-F Age 1-10	0.37	0.37	0.36	0.36	0.36
Process error					
-log(N) Age 1	0.61	0.61	0.60	0.62	0.66
--- Age 2-10	0.18	0.18	0.18	0.18	0.18
Observation variance					
-Catch Age 1	0.45	0.43	0.43	0.43	0.42
--- Age 2	0.31	0.27	0.28	0.27	0.27
--- Age 3-8	0.19	0.19	0.19	0.18	0.18
--- Age 9-10	0.39	0.38	0.38	0.37	0.37
-IBWSS Age 1	0.81	0.75	0.71	0.74	0.69
--- Age 2	0.38	0.34	0.32	0.33	0.32
--- Age 3	0.41	0.41	0.39	0.39	0.36
--- Age 4-6	0.37	0.37	0.37	0.35	0.37
--- Age 7-8	0.54	0.55	0.53	0.53	0.56
Survey catchability					
-IBWSS Age 1	0.07	0.06	0.06	0.06	0.06
--- Age 2	0.11	0.11	0.11	0.11	0.12
--- Age 3	0.36	0.36	0.37	0.36	0.37
--- Age 4	0.67	0.67	0.67	0.67	0.67
--- Age 5-8	0.86	0.86	0.89	0.88	0.88

Parameter Year	2019	2020	2021	2022	2023
Rho					
--	0.93	0.94	0.93	0.93	0.93

Table 2.4.1.2. Blue whiting. Mohn's rho by year and average over the last five years (n=5).

Last data year	R(age 1)	SSB	Fbar(3-7)
2018	-0.165	-0.075	0.051
2019	-0.260	0.048	-0.073
2020	-0.124	-0.004	-0.013
2021	-0.391	-0.073	0.027
2022	0.003	0.110	-0.188
Rho mean	-0.188	0.001	-0.039

Table 2.4.1.3. Blue whiting. Estimated fishing mortalities. Catch data for 2022 are preliminary.

Year Age	1	2	3	4	5	6	7	8	9	10+
1981	0.078	0.119	0.172	0.212	0.244	0.317	0.346	0.444	0.488	0.488
1982	0.068	0.103	0.149	0.183	0.208	0.270	0.293	0.372	0.406	0.406
1983	0.079	0.119	0.171	0.211	0.239	0.313	0.337	0.419	0.447	0.447
1984	0.096	0.144	0.212	0.265	0.304	0.397	0.418	0.508	0.530	0.530
1985	0.101	0.151	0.230	0.294	0.346	0.447	0.464	0.560	0.575	0.575
1986	0.113	0.169	0.268	0.357	0.431	0.552	0.572	0.690	0.704	0.704
1987	0.100	0.150	0.247	0.337	0.415	0.538	0.560	0.674	0.676	0.676
1988	0.098	0.148	0.253	0.349	0.440	0.578	0.590	0.695	0.678	0.678
1989	0.113	0.171	0.304	0.419	0.527	0.688	0.714	0.843	0.805	0.805
1990	0.105	0.159	0.291	0.407	0.511	0.666	0.714	0.852	0.817	0.817
1991	0.059	0.089	0.167	0.234	0.290	0.368	0.396	0.467	0.451	0.451
1992	0.049	0.073	0.140	0.195	0.233	0.286	0.311	0.370	0.363	0.363
1993	0.042	0.063	0.126	0.176	0.206	0.246	0.268	0.319	0.315	0.315
1994	0.036	0.054	0.113	0.160	0.186	0.219	0.242	0.292	0.287	0.287
1995	0.046	0.070	0.150	0.216	0.243	0.284	0.314	0.384	0.369	0.369
1996	0.056	0.085	0.186	0.272	0.297	0.347	0.383	0.474	0.451	0.451

Year Age	1	2	3	4	5	6	7	8	9	10+
1997	0.054	0.084	0.188	0.280	0.300	0.348	0.381	0.475	0.453	0.453
1998	0.070	0.110	0.252	0.382	0.407	0.471	0.509	0.630	0.592	0.592
1999	0.064	0.101	0.238	0.371	0.397	0.457	0.482	0.594	0.558	0.558
2000	0.073	0.118	0.280	0.447	0.498	0.575	0.588	0.705	0.665	0.665
2001	0.069	0.111	0.265	0.431	0.494	0.571	0.572	0.679	0.643	0.643
2002	0.065	0.104	0.250	0.417	0.503	0.594	0.596	0.701	0.666	0.666
2003	0.067	0.107	0.262	0.441	0.545	0.634	0.628	0.709	0.668	0.668
2004	0.068	0.109	0.269	0.462	0.592	0.690	0.687	0.751	0.708	0.708
2005	0.059	0.095	0.238	0.420	0.557	0.650	0.655	0.702	0.665	0.665
2006	0.051	0.082	0.209	0.373	0.510	0.597	0.606	0.639	0.604	0.604
2007	0.048	0.078	0.198	0.359	0.508	0.606	0.631	0.663	0.630	0.630
2008	0.042	0.068	0.172	0.310	0.447	0.532	0.566	0.593	0.571	0.571
2009	0.027	0.046	0.113	0.200	0.290	0.343	0.373	0.388	0.376	0.376
2010	0.019	0.033	0.081	0.139	0.202	0.237	0.261	0.265	0.258	0.258
2011	0.006	0.010	0.024	0.041	0.058	0.067	0.074	0.075	0.075	0.075
2012	0.012	0.021	0.052	0.086	0.122	0.141	0.160	0.166	0.166	0.166
2013	0.020	0.035	0.091	0.152	0.216	0.244	0.278	0.292	0.291	0.291
2014	0.036	0.067	0.177	0.298	0.417	0.469	0.535	0.564	0.560	0.560
2015	0.047	0.087	0.233	0.394	0.550	0.621	0.695	0.727	0.718	0.718
2016	0.040	0.075	0.202	0.347	0.486	0.555	0.619	0.642	0.633	0.633
2017	0.038	0.071	0.194	0.337	0.468	0.532	0.583	0.595	0.587	0.587
2018	0.037	0.071	0.195	0.344	0.480	0.544	0.598	0.603	0.596	0.596
2019	0.033	0.064	0.179	0.320	0.447	0.502	0.551	0.546	0.539	0.539
2020	0.037	0.072	0.200	0.364	0.510	0.567	0.627	0.616	0.603	0.603
2021	0.033	0.063	0.179	0.330	0.463	0.510	0.565	0.556	0.542	0.542
2022	0.032	0.062	0.176	0.329	0.464	0.508	0.567	0.561	0.546	0.546
2023	0.040	0.077	0.220	0.416	0.586	0.638	0.717	0.713	0.693	0.693

Table 2.4.1.4. Blue whiting. Estimated stock numbers-at-age (thousands). Preliminary catch data for 2023 have been used

Year Age	1	2	3	4	5	6	7	8	9	10+
1981	3911082	3473729	4859801	2075296	2621128	2143701	1644934	1740312	1221857	2968258
1982	4602198	2939240	2515331	3291472	1589148	1501528	1296317	1013740	888114	1934217
1983	18511944	3761895	1872354	1821369	1908069	1220673	1015823	855508	628089	1252877
1984	18224999	14576236	2440767	1233350	1264099	1397667	816298	550749	481952	923189
1985	9520388	13564647	9789557	1453592	750368	912939	747354	459156	265773	722300
1986	7170043	6368528	9420810	5547910	944508	452369	469754	376252	231482	498829
1987	9163882	5031312	4083433	6862350	2566088	394787	253865	238012	156838	293624
1988	6359063	6871581	3521100	2878767	3716632	1268878	199230	125672	99213	170511
1989	8473071	4607143	4989464	2427638	2127429	1681612	350615	102871	60696	115254
1990	19205066	5991549	3097413	2733558	1480861	1184085	558890	120491	33069	85396
1991	8990754	15759464	4278979	1794080	1491151	872836	561284	188263	32130	45347
1992	6672861	7415442	12515142	3314015	1262584	790578	485704	287142	101344	39028
1993	4894647	5104629	5279739	9719706	2262524	978030	516984	282018	156785	74111
1994	8099362	3374421	4055472	3396332	6924951	1439499	764484	327790	207003	115772
1995	9198605	5850926	3119216	2563069	2852882	3745144	1039449	543512	220484	184528
1996	28266556	7067871	4060656	2387530	1550469	1862827	2235973	643804	306019	248576
1997	45544571	21393862	5480012	2562529	1418202	1068062	1060815	1210313	287448	335331
1998	26605119	38011268	16420762	3491627	1375162	927292	782227	603656	615324	291704
1999	20058745	20458339	27603411	10534840	1709849	774185	520421	410492	236055	427025

Year Age	1	2	3	4	5	6	7	8	9	10+
2000	39473578	15207565	16527098	15769090	4333565	1109608	472780	323599	153264	313137
2001	56306875	31702881	12048355	10703454	7436363	1693322	489373	227283	163176	177924
2002	48903240	45414724	20452104	8301987	5446779	3387894	688508	255107	102940	154399
2003	52805994	39055647	35012755	13573643	5072028	2969334	1204544	345754	88733	106793
2004	28725410	41603310	30028060	20843398	7251492	2466098	1313341	500605	151357	80302
2005	22392243	21753535	28287925	18096700	10735002	3224318	1110043	513923	191656	98590
2006	8996712	15466809	22255522	19291815	9477173	4457166	1355475	482997	217912	119959
2007	4795411	5934075	13111009	15898231	10287524	4690708	1832642	607844	228608	162811
2008	5770397	3374375	4312576	11016241	9133410	4897862	1848474	750221	233866	199331
2009	5610707	3935760	2371835	3683213	6911864	4694335	2183024	851727	322225	187523
2010	15216679	4959540	2332092	1837257	3344578	4321932	2823615	1193866	409841	263848
2011	19324947	13120543	3292693	1650381	1605558	2600925	2681037	1341176	806710	388065
2012	19332266	15325739	12433445	2295475	1185709	1613298	2326153	2111414	1071090	891741
2013	15784350	15989114	11603200	7330439	2218277	1092610	1375992	1637117	1340727	1372477
2014	36984108	12509425	13842948	7962259	4344040	1343205	936231	1007046	1019308	1486005
2015	64187156	32150323	10692139	8438945	4190162	1738603	740021	525537	488437	1059802
2016	34652405	56497628	21245289	7590563	4288098	1801796	707388	355953	225142	598518
2017	11587354	27650760	44943359	14927514	4486338	2137213	733011	285910	163047	378334
2018	12227217	8989382	21961337	28906242	8628995	2447842	935525	314034	143534	266617
2019	13717621	9033416	8505214	14588456	16047011	4518270	1120415	403736	138260	197105

Year Age	1	2	3	4	5	6	7	8	9	10+
2020	23895318	11271741	6621636	6480692	8349859	7773497	2129075	559040	194769	159464
2021	69630575	17226052	8478662	4466807	4174926	3865023	3582034	809847	269137	161491
2022	68911606	61711303	12164601	5753449	2678693	2177789	1760578	1674617	368745	223031
2023	16657741	61268959	47123768	8654318	3192184	1268779	1115911	802669	750286	298302
2024	22997749*	13109448	46437229	30950190	4676343	1455027	548909	446069	322198	429264

***assuming GM(1996-2022) recruitment in 2024.**

Table 2.4.1.5. Blue whiting. Estimated recruitment (R) in thousands, spawning-stock biomass (SSB) in tonnes, average fishing mortality for ages 3 to 7 (Fbar 3-7) and total-stock biomass (TSB) in tonnes. Preliminary catch data for 2022 are included. Low and High refer to the 95% confidence limits

Year	R(age 1)	Low	High	SSB	Low	High	Fbar (3-7)	Low	High	TSB	Low	High
1981	3911082	2542552	6016225	2845036	2251018	3595809	0.258	0.189	0.352	3341133	2691467	4147616
1982	4602198	2954287	7169319	2300091	1840037	2875169	0.220	0.164	0.296	2765793	2250133	3399627
1983	18511944	12146933	28212230	1856066	1516723	2271332	0.254	0.192	0.336	2895605	2365942	3543844
1984	18224999	12057609	27546971	1757369	1459001	2116755	0.319	0.245	0.416	3100047	2513487	3823491
1985	9520388	6316880	14348507	2094932	1735590	2528672	0.356	0.276	0.460	3233605	2651342	3943737
1986	7170043	4788339	10736397	2273262	1886703	2739021	0.436	0.339	0.561	3110997	2587794	3739981
1987	9163882	6105371	13754567	1931949	1605869	2324241	0.419	0.325	0.541	2818230	2347189	3383800
1988	6359063	4235323	9547720	1637486	1372285	1953938	0.442	0.343	0.569	2423304	2026541	2897748
1989	8473071	5620281	12773904	1544913	1298703	1837799	0.530	0.414	0.680	2387820	1987296	2869067
1990	19205066	12577484	29324987	1358925	1132465	1630670	0.518	0.397	0.675	2517431	2018815	3139198
1991	8990754	5807979	13917689	1783751	1438091	2212493	0.291	0.216	0.393	3234189	2544773	4110378

Year	R(age 1)	Low	High	SSB	Low	High	Fbar (3-7)	Low	High	TSB	Low	High
1992	6672861	4367243	10195694	2461071	1958396	3092771	0.233	0.173	0.314	3530035	2811833	4431681
1993	4894647	3168318	7561606	2539067	2029521	3176545	0.204	0.152	0.275	3411317	2745255	4238981
1994	8099362	5289445	12401994	2530221	2044110	3131934	0.184	0.136	0.248	3408596	2778748	4181209
1995	9198605	6072120	13934891	2304714	1903350	2790715	0.241	0.183	0.319	3342759	2762181	4045369
1996	28266556	18690153	42749688	2205312	1838629	2645123	0.297	0.226	0.389	3728857	3043650	4568322
1997	45544571	30196797	68692979	2469353	2054331	2968220	0.299	0.229	0.391	5471227	4317244	6933665
1998	26605119	17728779	39925615	3682838	3022328	4487699	0.404	0.313	0.522	6828783	5482856	8505107
1999	20058745	13317535	30212292	4434099	3626579	5421428	0.389	0.301	0.503	7143992	5832994	8749642
2000	39473578	26114854	59665787	4222973	3520188	5066065	0.478	0.373	0.612	7457504	6099569	9117754
2001	56306875	37581210	84363014	4569865	3824137	5461015	0.467	0.364	0.599	9027807	7308440	11151669
2002	48903240	32629977	73292325	5405451	4516418	6469487	0.472	0.367	0.607	10344400	8409324	12724758
2003	52805994	35738139	78025131	6865601	5720699	8239637	0.502	0.396	0.637	11835000	9748635	14367881
2004	28725410	19426922	42474520	6757214	5698044	8013265	0.540	0.428	0.681	10359031	8694742	12341888
2005	22392243	15168475	33056226	6013337	5081192	7116485	0.504	0.397	0.640	8492329	7165256	10065188
2006	8996712	6029168	13424874	5888790	4960696	6990522	0.459	0.359	0.587	7730391	6518375	9167767
2007	4795411	3210720	7162245	4665843	3919153	5554795	0.460	0.356	0.594	5694431	4794995	6762581
2008	5770397	3811865	8735220	3578643	2966020	4317802	0.405	0.306	0.537	4388849	3654892	5270195
2009	5610707	3598884	8747165	2735822	2213093	3382019	0.264	0.194	0.359	3439324	2803707	4219039
2010	15216679	9996269	23163375	2665797	2116773	3357219	0.184	0.132	0.256	3729475	2989665	4652356

Year	R(age 1)	Low	High	SSB	Low	High	Fbar (3-7)	Low	High	TSB	Low	High
2011	19324947	12817112	29137109	2687130	2149471	3359277	0.053	0.036	0.076	4407522	3529158	5504501
2012	19332266	13051426	28635683	3428138	2813103	4177640	0.112	0.084	0.149	5100179	4182729	6218866
2013	15784350	10695254	23294978	3754261	3141104	4487109	0.196	0.150	0.256	5559463	4635590	6667463
2014	36984108	24858889	55023546	3991146	3379263	4713823	0.379	0.293	0.490	6604562	5488538	7947515
2015	64187156	43480822	94754210	4157578	3517303	4914405	0.499	0.391	0.636	8134528	6629840	9980714
2016	34652405	23537436	51016141	4886263	4070905	5864930	0.442	0.344	0.567	9064628	7390861	11117442
2017	11587354	7790955	17233675	6030186	4992140	7284078	0.423	0.330	0.542	8712432	7205761	10534136
2018	12227217	8239911	18143986	5870963	4885116	7055762	0.432	0.336	0.556	7764127	6483086	9298299
2019	13717621	8991825	20927134	5028573	4193676	6029685	0.400	0.307	0.520	6890430	5751963	8254229
2020	23895318	15288265	37348005	4146964	3436547	5004241	0.454	0.345	0.596	6440570	5227127	7935707
2021	69630575	42726573	113475444	3963726	3166661	4961417	0.409	0.301	0.557	8773100	6430844	11968458
2022	68911606	39144619	121314489	4579983	3359598	6243678	0.409	0.278	0.601	10333319	7091684	15056717
2023	16657741	7251643	38264476	6236191	4162399	9343188	0.515	0.307	0.865	9954759	6470727	15314698
2024	22997749*			6799985^								

***assuming GM(1996-2022) recruitment in 2024.**

^ SSB calculated from the survivors age 2-10 and GM(1996-2022) recruitment in 2024

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 2022 are included.

Year	Estimate	Low	High	SOP catch
1981	788159	568629	1092442	922980
1982	544325	415970	712287	550643
1983	513140	398675	660470	553344
1984	564938	438740	727436	615569
1985	639830	504897	810823	678214
1986	759908	599871	962641	847145
1987	638144	504074	807873	654718
1988	569734	450658	720273	552264
1989	618654	492608	776953	630316
1990	554539	438604	701117	558128
1991	408698	319299	523127	364008
1992	438842	347459	554257	474592
1993	439924	346651	558294	475198
1994	424170	332565	541008	457696
1995	507570	404279	637251	505176
1996	597406	475912	749915	621104
1997	641969	507116	812682	639681
1998	1080685	849227	1375226	1131955
1999	1247277	975503	1594767	1261033
2000	1502683	1183719	1907595	1412449
2001	1560764	1229375	1981480	1771805
2002	1710847	1348172	2171086	1556955
2003	2203545	1744202	2783857	2365319
2004	2317253	1841339	2916173	2400795
2005	1996202	1588667	2508281	2018344
2006	1856505	1477663	2332475	1956239
2007	1560030	1239967	1962708	1612269

Year	Estimate	Low	High	SOP catch
2008	1168540	921892	1481176	1251851
2009	656960	517335	834270	634978
2010	477260	370094	615457	539539
2011	136359	101155	183814	103771
2012	325859	259332	409452	375692
2013	588691	467970	740553	613863
2014	1102584	872097	1393988	1147650
2015	1342585	1070110	1684438	1390656
2016	1243089	987995	1564046	1180786
2017	1479682	1174544	1864094	1555069
2018	1705935	1347983	2158940	1709856
2019	1538458	1214042	1949564	1512026
2020	1427786	1131907	1801008	1460507
2021	1148634	916696	1439255	1139531
2022	1085570	861688	1367621	1035891
2023	1641728	1276219	2111918	1672378

Table 2.8.2.1.1. Blue whiting. Input to short-term projection (median values for exploitation pattern and stock numbers). Mean weight in 2024+ is the average weight for 2021-2023.

Age	Mean weight in the stock and catch (kg) in 2023	Mean weight in the stock and catch (kg) in 2024+	Proportion mature	Natural mortality	Exploitation pattern	Stock number (2024) (thousands)
1	0.045	0.050	0.11	0.20	0.077	22997749
2	0.061	0.072	0.40	0.20	0.150	13109448
3	0.076	0.087	0.82	0.20	0.428	46437229
4	0.092	0.106	0.86	0.20	0.806	30950190
5	0.120	0.125	0.91	0.20	1.137	4676343
6	0.144	0.141	0.94	0.20	1.238	1455027
7	0.155	0.149	1.00	0.20	1.391	548909
8	0.169	0.162	1.00	0.20	1.383	446069

Age	Mean weight in the stock and catch (kg) in 2023	Mean weight in the stock and catch (kg) in 2024+	Proportion mature	Natural mortality	Exploitation pattern	Stock number (2024) (thousands)
9	0.182	0.173	1.00	0.20	1.345	322198
10+	0.207	0.201	1.00	0.20	1.345	429264

Table 2.8.2.1.2. Blue whiting. Deterministic forecast, intermediate year assumptions and recruitments.

Variable	Value	Notes
$F_{ages\ 3–7}$ (2023)	0.515	From the assessment (based on assumed 2023 catches)
SSB (2024)	6 799 985	From the forecast; in tonnes
$R_{age\ 1}$ (2023)	16 657 741	From the assessment; in thousands
$R_{age\ 1}$ (2024–2025)	22 997 749	GM (1996–2022); in thousands
Total catch (2023)	1 672 378	As estimated by ICES, based on declared national quotas and expected uptake; in tonnes (see also Table 2.3.2.3)

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

Basis	Catch(2024)	F(2024)	SSB(2025)	% SSB change*	% Catch change**	% Advice change***
Long-term management strategy (F=FMSY)	1529754	0.320	7258384	6.7	-8.5	12.5
MSY approach: FMSY	1529754	0.320	7258384	6.7	-8.5	12.5
F = 0	5	0.000	8709263	28	-100	-100
Fpa	1529754	0.320	7258384	6.7	-8.5	12.5
Flim	3507334	0.880	5411744	-20	110	158
SSB (2025) = Blim	7997215	4.455	1500006	-78	378	488
SSB (2025 = Bpa	7066101	3.043	2250000	-67	323	420
SSB (2025) = MSY Btrigger	7066101	3.043	2250000	-67	323	420
F = F (2023)	2306302	0.515	6528681	-4.0	38	70
SSB (2025) = SSB (2024)	2016931	0.439	6799982	0	21	48
Catch (2024) = Catch (2023)	1672363	0.354	7123994	4.8	0	23
Catch (2024) = Catch (2023) -20 %	1337926	0.276	7439411	9.4	-20	-1.6
Catch (2024) = Catch (2023) +25%	2090423	0.458	6731007	-1.0	25	54
Catch (2024) = Advice (2023) -20 %	1087653	0.220	7676013	12.9	-35	-20
Catch (2024) = Advice (2023) +25%	1699525	0.360	7098416	4.4	1.6	25

Basis	Catch(2024)	F(2024)	SSB(2025)	% SSB change*	% Catch change**	% Advice change***
F = 0.05	263038	0.050	8458687	24	-84	-81
F = 0.10	516613	0.100	8217528	21	-69	-62
F = 0.15	761129	0.150	7985381	17.4	-55	-44
F = 0.16	808979	0.160	7939998	16.8	-52	-41
F = 0.17	856485	0.170	7894957	16.1	-49	-37
F = 0.18	903651	0.180	7850255	15.4	-46	-34
F = 0.19	950478	0.190	7805889	14.8	-43	-30
F = 0.20	996970	0.200	7761855	14.1	-40	-27
F = 0.21	1043130	0.210	7718152	13.5	-38	-23
F = 0.22	1088960	0.220	7674775	12.9	-35	-19.9
F = 0.23	1134464	0.230	7631723	12.2	-32	-16.6
F = 0.24	1179644	0.240	7588992	11.6	-30	-13.2
F = 0.25	1224503	0.250	7546580	11	-27	-9.9
F = 0.26	1269044	0.260	7504483	10.4	-24	-6.7
F = 0.27	1313269	0.270	7462700	9.7	-22	-3.4
F = 0.28	1357181	0.280	7421227	9.1	-18.8	-0.2
F = 0.29	1400783	0.290	7380061	8.5	-16.2	3.0
F = 0.30	1444078	0.300	7339201	7.9	-13.7	6.2
F = 0.31	1487067	0.310	7298643	7.3	-11.1	9.4
F = 0.32	1529754	0.320	7258384	6.7	-8.5	12.5
F = 0.33	1572141	0.330	7218423	6.2	-6.0	15.6
F = 0.34	1614231	0.340	7178756	5.6	-3.5	18.7
F = 0.35	1656026	0.350	7139381	5	-1.0	22
F = 0.45	2058300	0.450	6761149	-0.6	23	51
F = 0.50	2249216	0.500	6582141	-3.2	35	65

*** SSB 2025 relative to SSB 2024.**

**** Catch 2024 relative to expected catch in 2023 (1 672 378 tonnes).**

***** Catch 2024 relative to advice for 2023 (1 359 629 tonnes).**

Table 2.8.2.3.1. Blue whiting. Catch numbers at age estimated by WGWIDE 2023 as a ratio of catch numbers at age estimated by WGWIDE 2023.

Age	2019	2020	2021	2022	2023
1	0.90	0.89	0.97	1.59	0.39
2	0.93	0.88	0.89	0.94	1.79
3	0.94	0.91	0.85	0.88	0.93
4	0.95	0.92	0.87	0.76	0.89
5	0.96	0.93	0.90	0.80	0.69
6	0.97	0.94	0.90	0.88	0.70
7	0.97	0.95	0.89	0.85	0.88
8	0.98	0.96	0.92	0.76	0.79
9	0.99	0.97	0.93	0.93	0.70
10	0.99	0.97	0.94	0.90	0.94

Table 2.8.2.3.2. Blue whiting. Catch numbers * weight at age estimated by WGWIDE 2023 as a ratio of catch numbers * weight at age estimated by WGWIDE 2023. Weight at age in the forecast in WGWIDE 2023 is the average weight at age of 2021-2023, whereas for WGWIDE 2022 this is 2020-2022.

Age	2019	2020	2021	2022	2023
1	0.90	0.89	0.97	1.80	0.36
2	0.93	0.88	0.89	0.98	1.63
3	0.94	0.91	0.85	0.90	0.86
4	0.95	0.92	0.87	0.78	0.84
5	0.96	0.93	0.90	0.82	0.68
6	0.97	0.94	0.90	0.88	0.72
7	0.97	0.95	0.89	0.86	0.91
8	0.98	0.96	0.92	0.73	0.79
9	0.99	0.97	0.93	0.94	0.71
10	0.99	0.97	0.94	0.85	0.92

Table 2.8.2.3.2. Blue whiting. Deterministic forecast, intermediate year assumptions and recruitments used in current and previous assessment.

	WGWIDE 2023		WGWIDE 2022	
	Year	**Value**	**Year**	**Value**
F	2023	0.515	2022	0.371
SSB	2024	6 799 985	2023	6 621 207
Assumed recruitment	2023	16 657 741	2022	43 220 294
	2024–2025	22 997 749	2023–2024	22 537 250
Catch	2023	1 672 378	2022	1 107 529

2.16 Figures

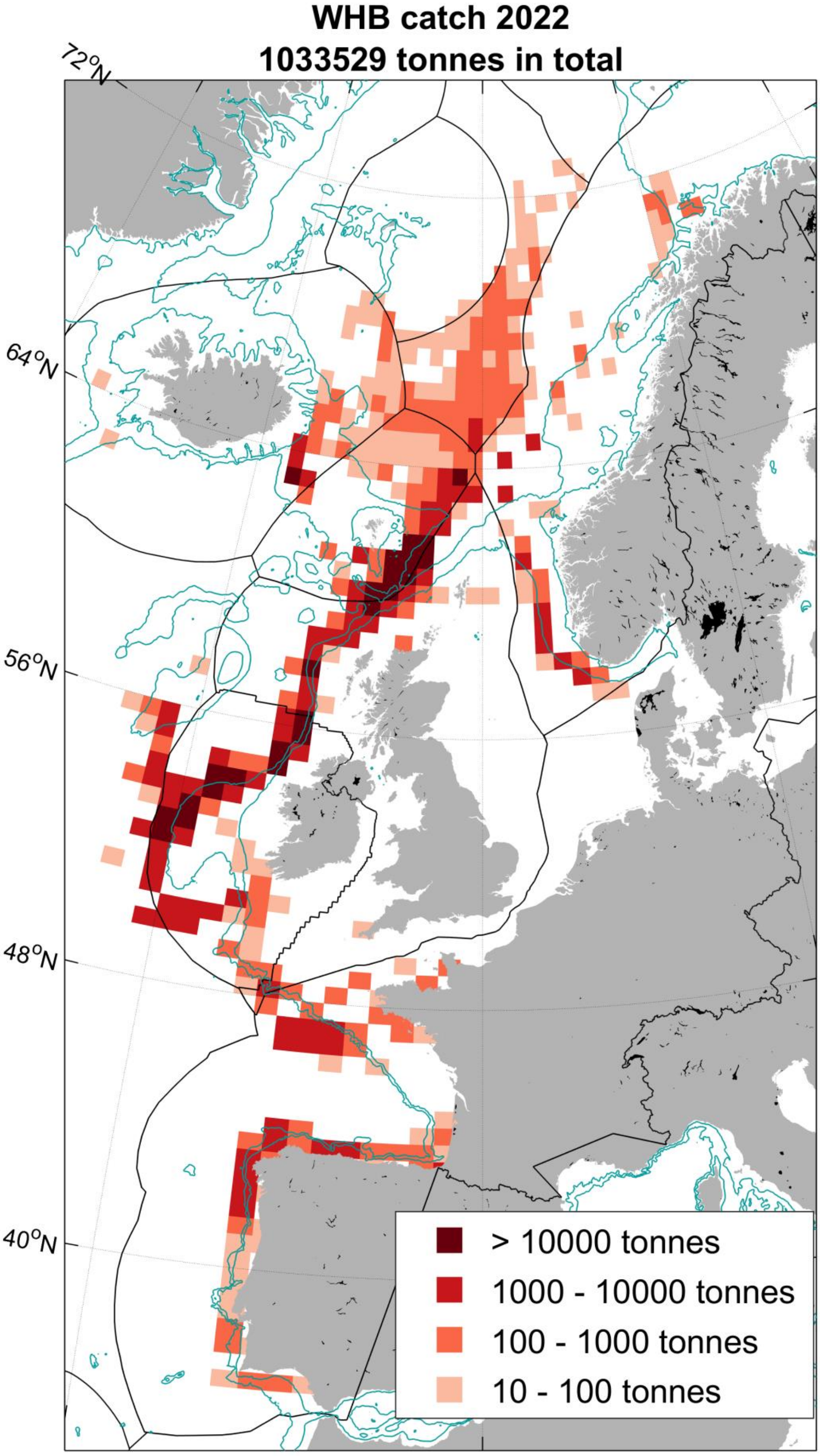


Figure 2.2.1. Blue whiting catches in 2022. The catches on the map constitute 99.5 % of the ICES estimated catches. The 200 m and 1000 m depth contours are indicated in blue.

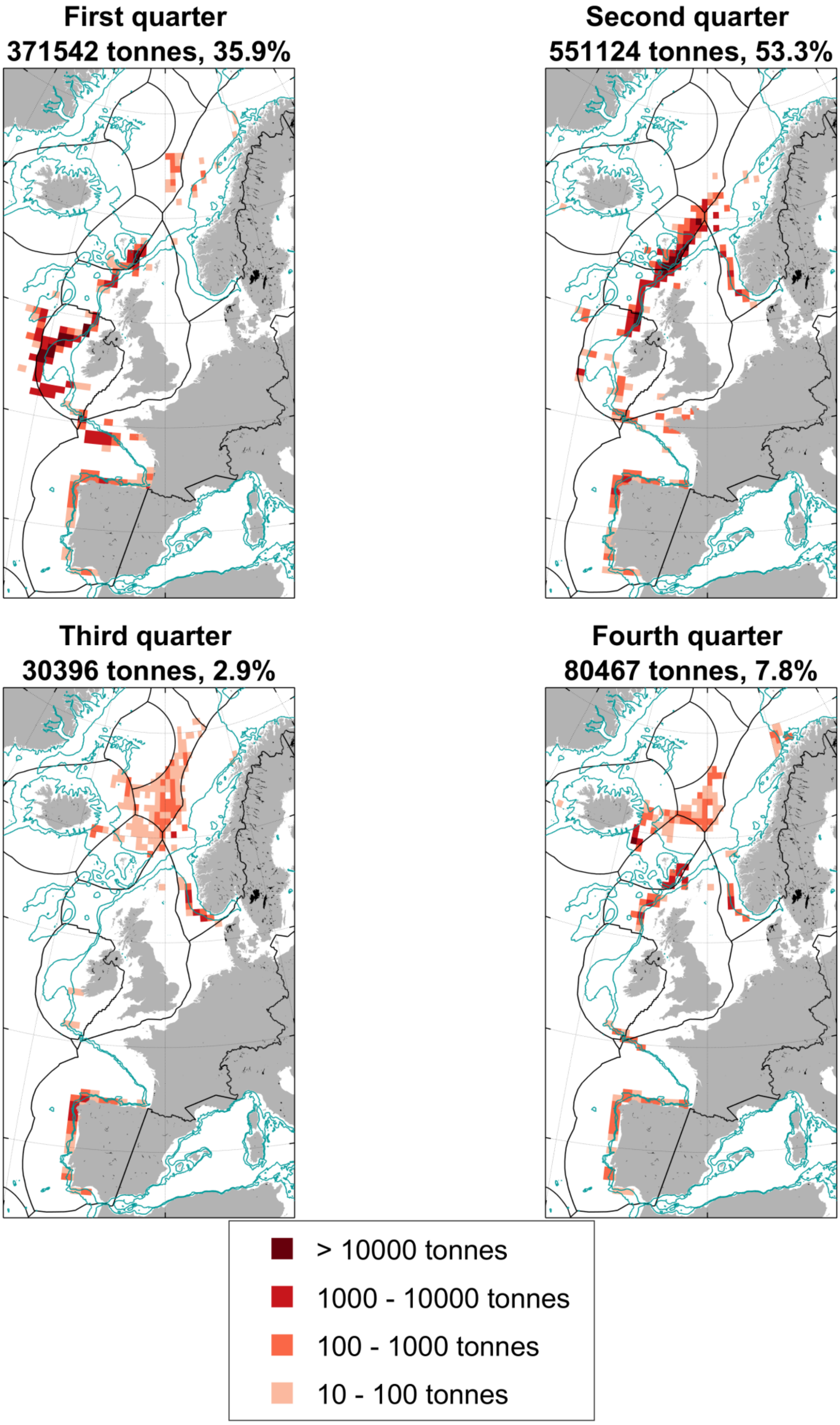


Figure 2.2.2. Blue whiting catches per quarter 2022. The catches on the map constitute 99.5 % of the ICES estimated catches. The 200 m and 1000 m depth contours are indicated in blue.

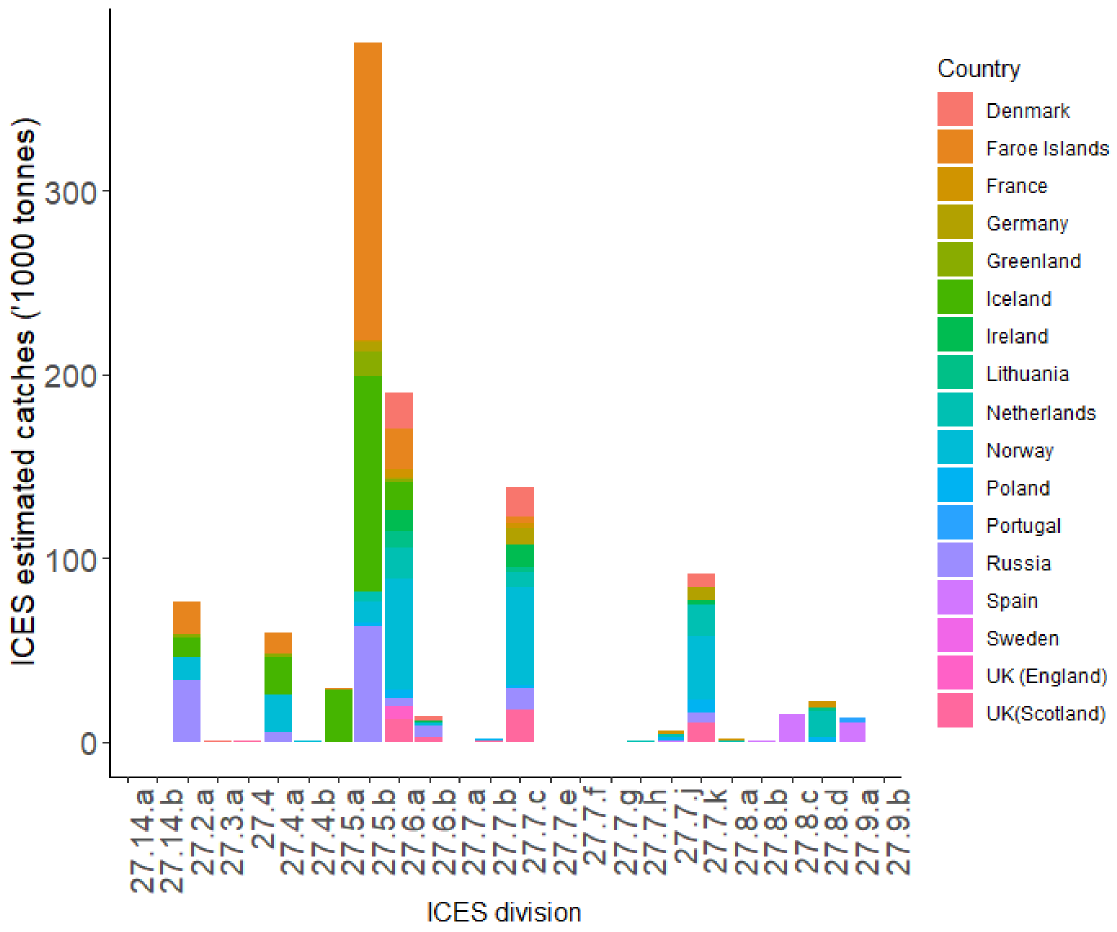
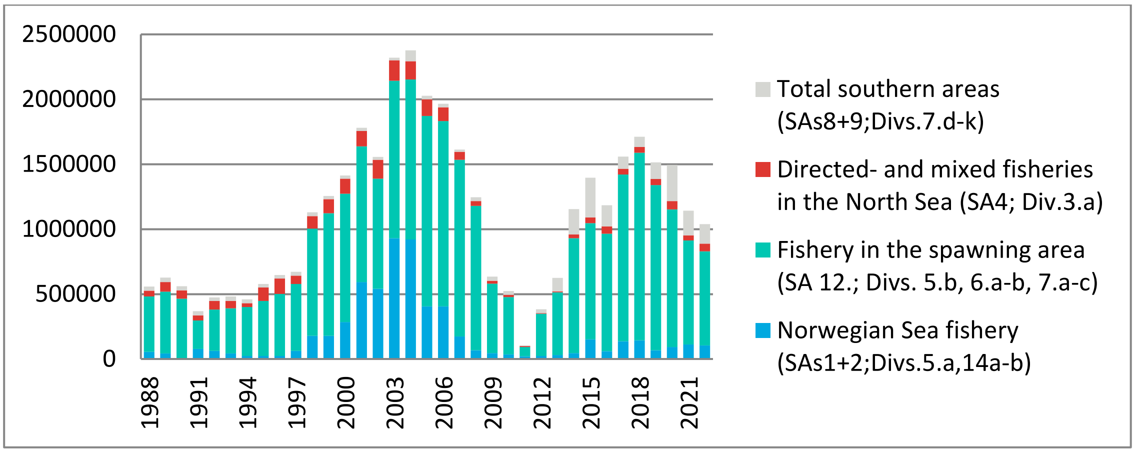


Figure 2.3.1.1. Blue whiting. ICES estimated catches ('1000 tonnes) in 2022 by ICES division and country.

A



B

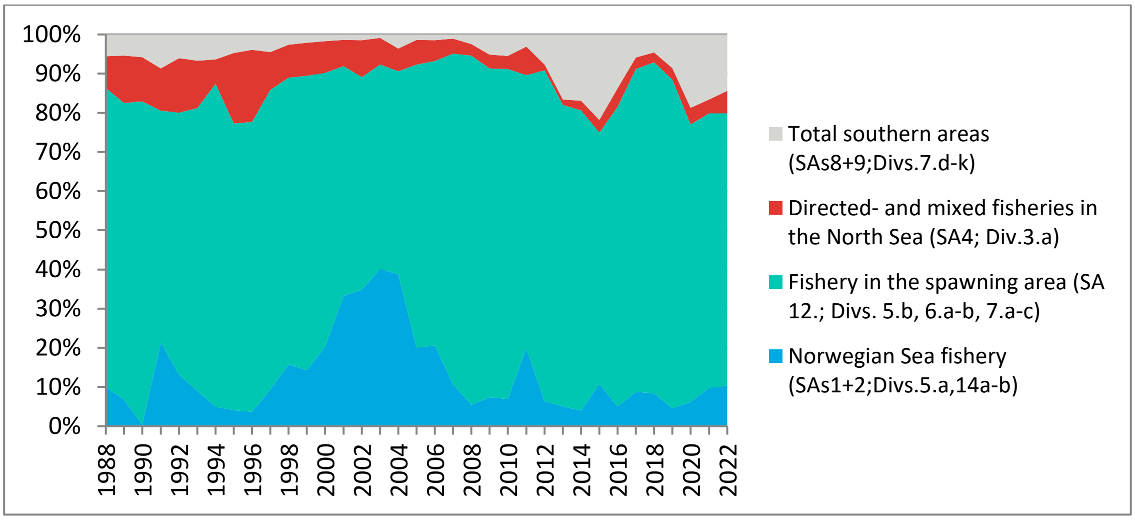


Figure 2.3.1.2. Blue whiting.(A) ICES estimated catches (tonnes) of blue whiting by fishery subareas from 1988-2022 and (B) the percentage contribution to the overall catch by fishery subarea over the same period.

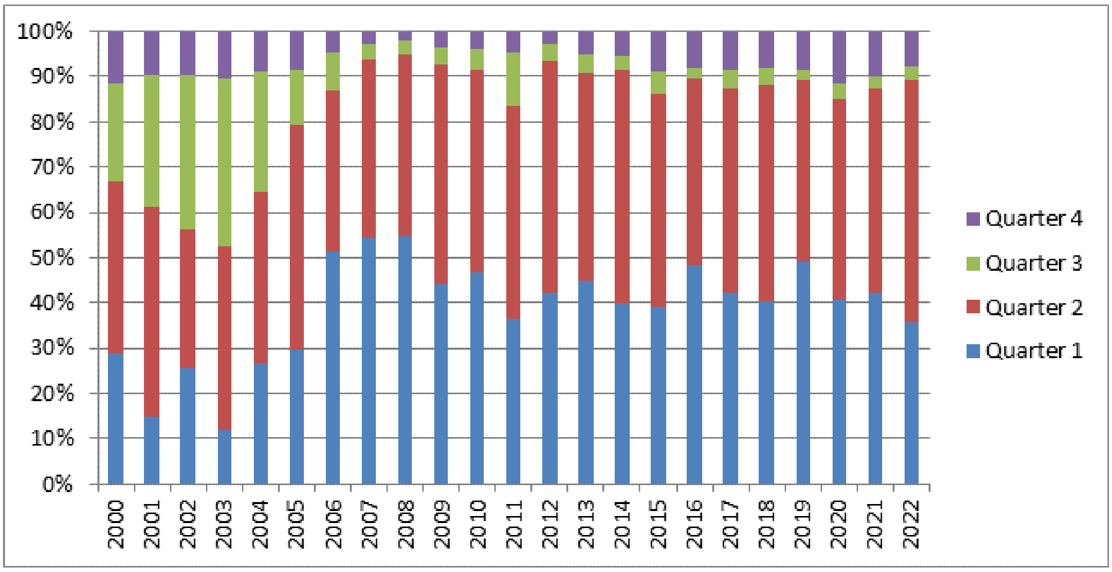


Figure 2.3.1.3. Blue whiting. Distribution of 2022 ICES estimated catches (in percentage) by quarter.

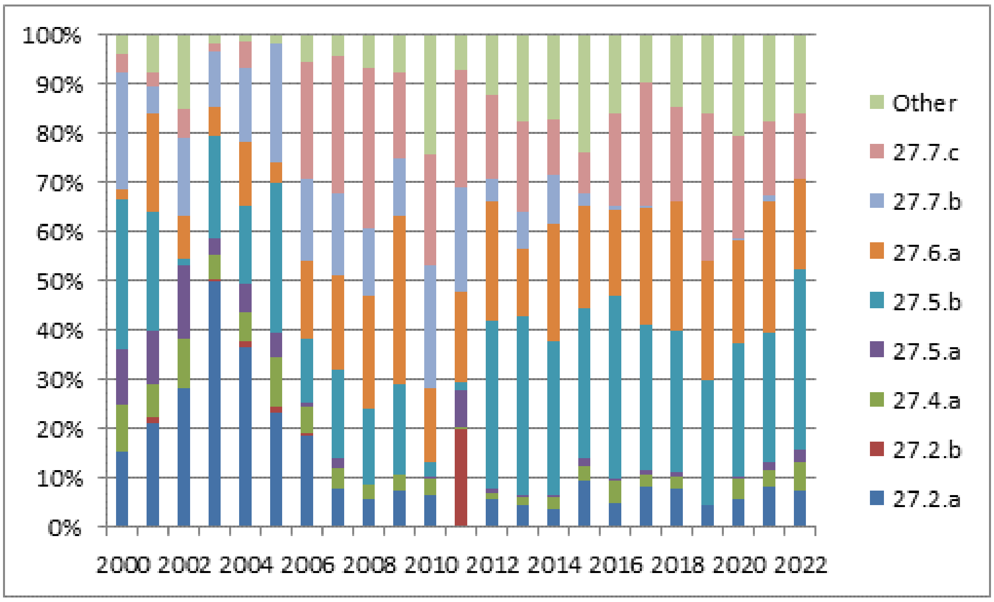


Figure 2.3.1.4. Blue whiting. Distribution of 2022 ICES estimated catches (in percentage) by ICES division area.

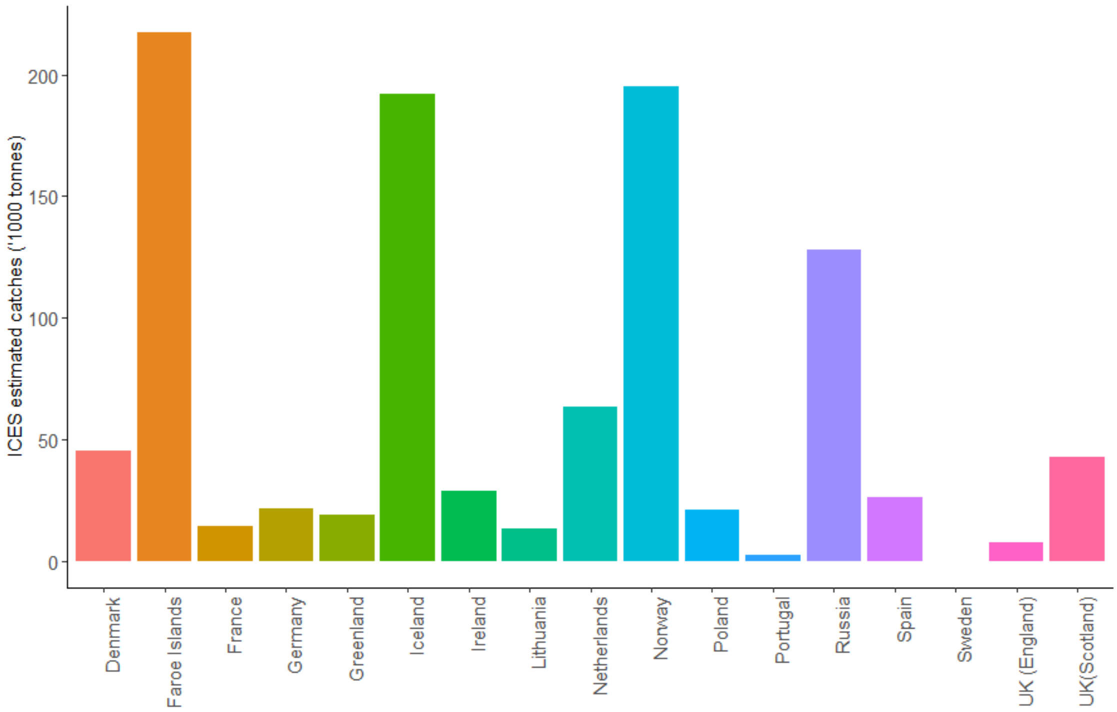


Figure 2.3.1.5. Blue whiting. ICES estimated catches ('1000 tonnes) in 2022 by country.

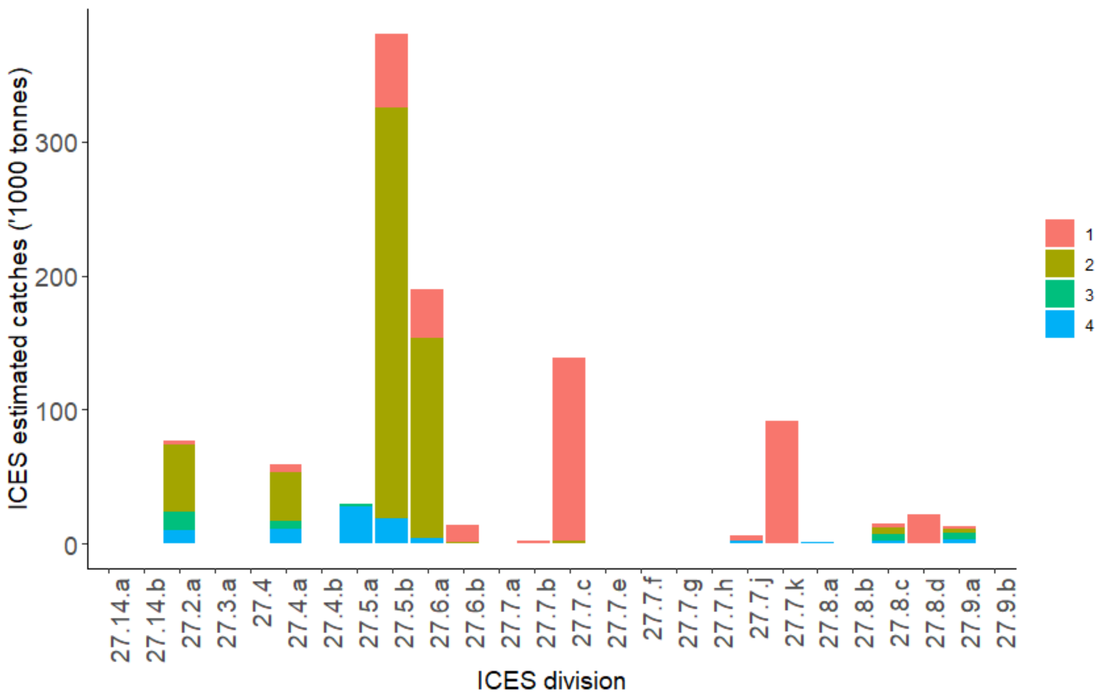


Figure 2.3.1.6. Blue whiting. Distribution of 2022 ICES estimate ed catches ('1000 tonnes) by ICES division and by quarter.

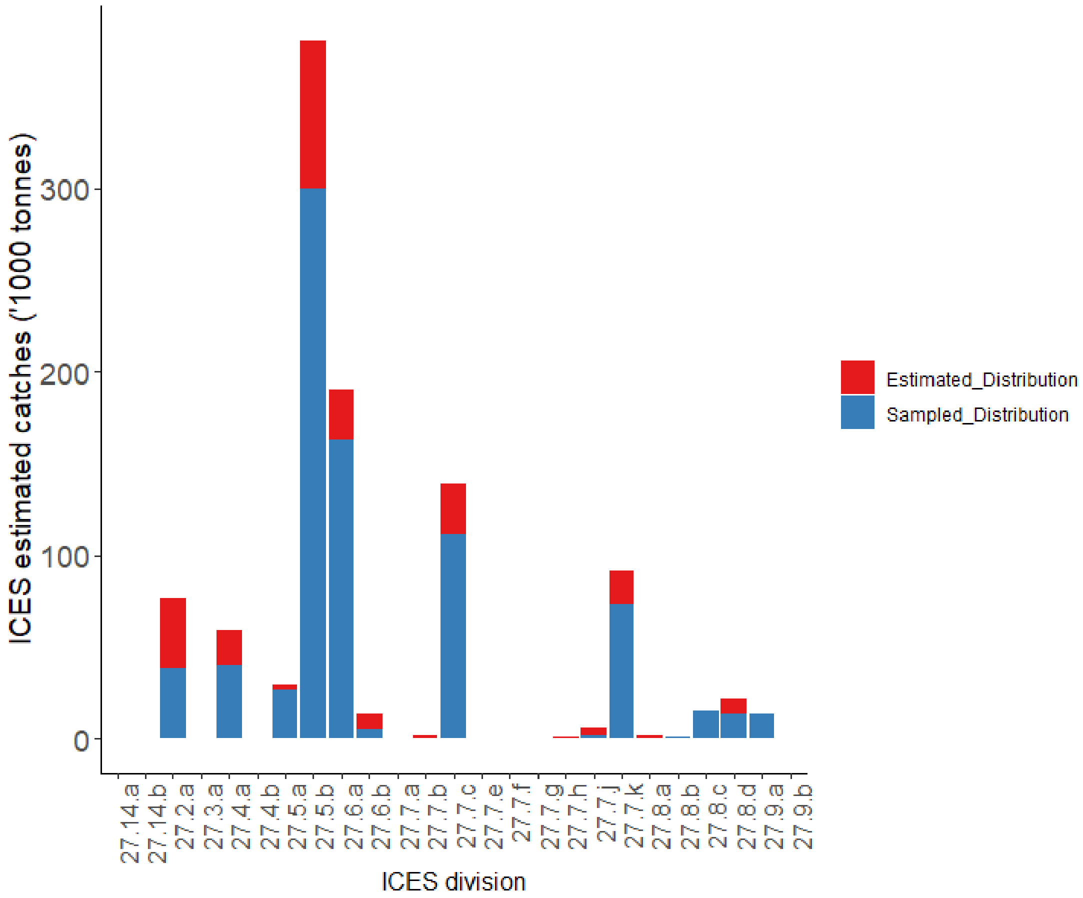


Figure 2.3.1.1.1. Blue whiting. 2022 ICES catches ('1000 tonnes) based on sampled or estimated distribution by ICES division.

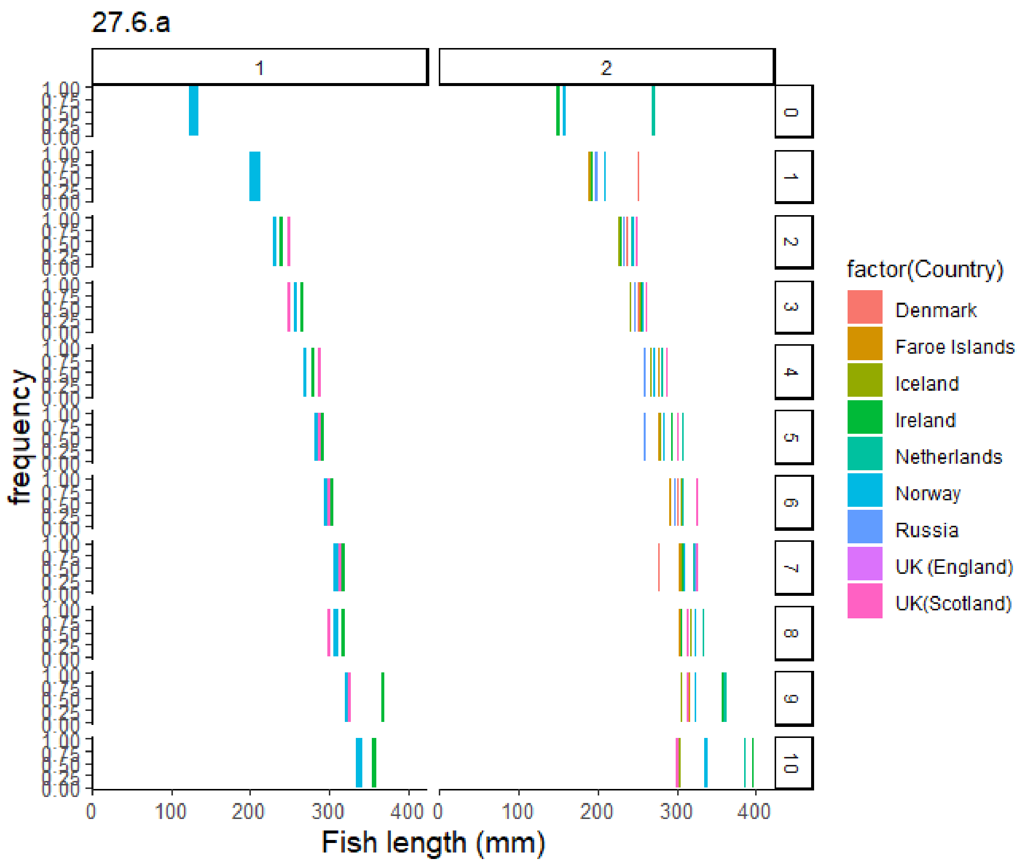


Figure 2.3.1.2.1. Blue whiting. Mean length (mm) by age (0-10 year), by quarter (1,2), by country for ICES division area 27.6.a. These data only comprises the 2022 ICES catch-at-age sampled estimates for ICES division 27.6.a.

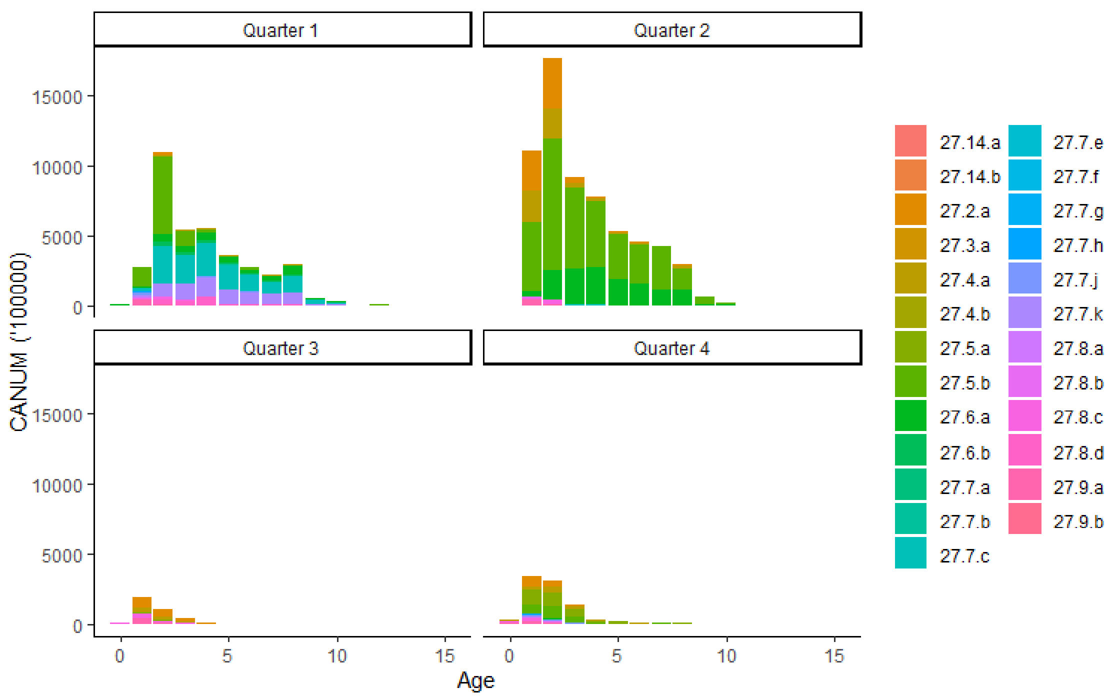


Figure 2.3.1.2.2. Blue whiting. Catch-at-age numbers (CANUM) distribution by quarter and ICES division for 2022.

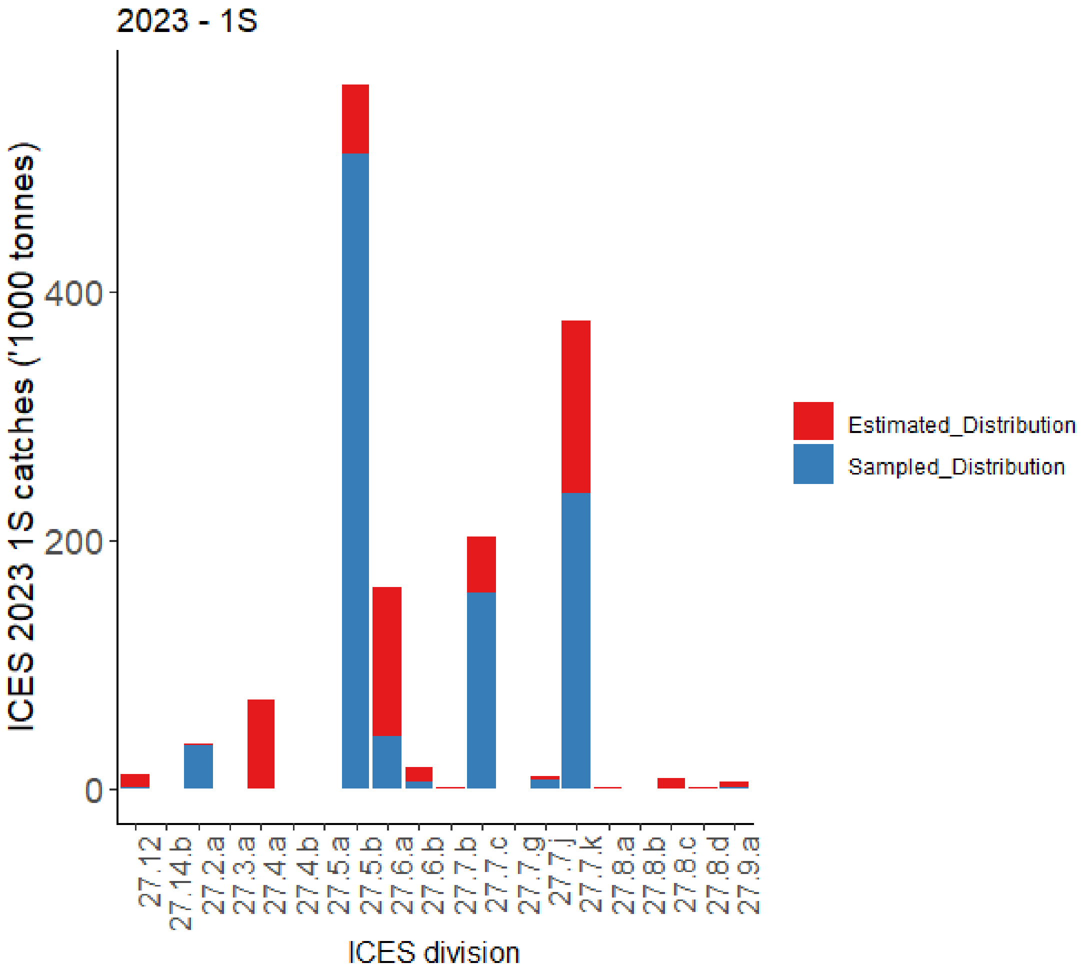


Figure 2.3.2.1. Blue whiting. 2023 ICES preliminary catches ('1000 tonnes) (Quarter 1 + Quarter 2) based on sampled or estimated distribution by ICES division.

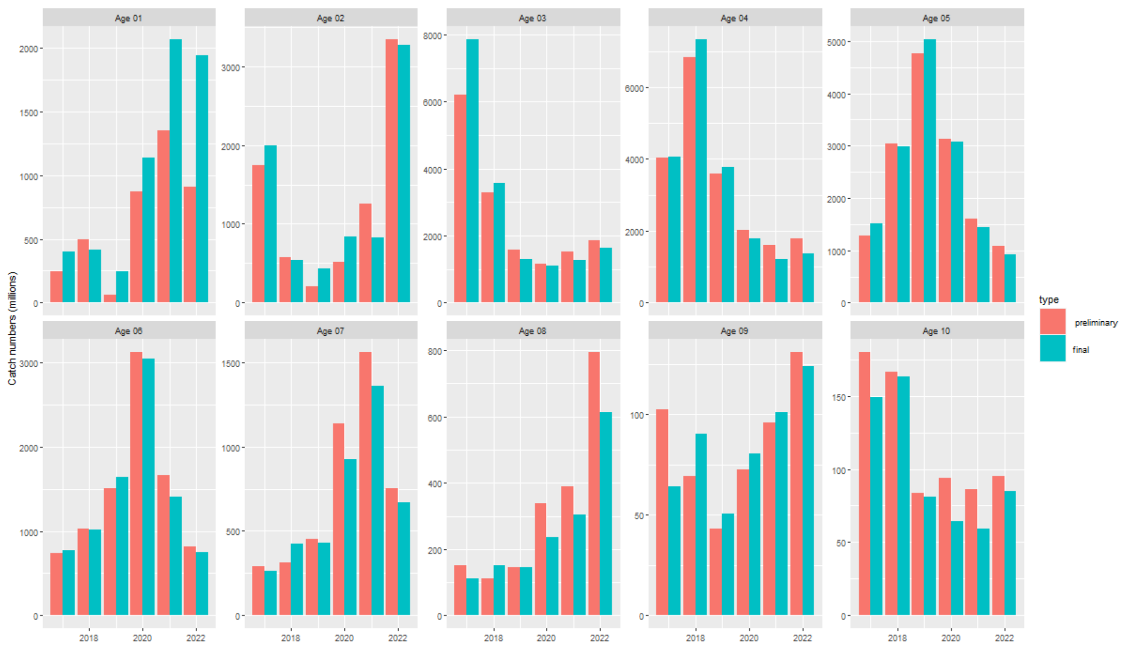


Figure 2.3.2.2 Preliminary and final estimates of catch at age number by age and year (2017-2022).

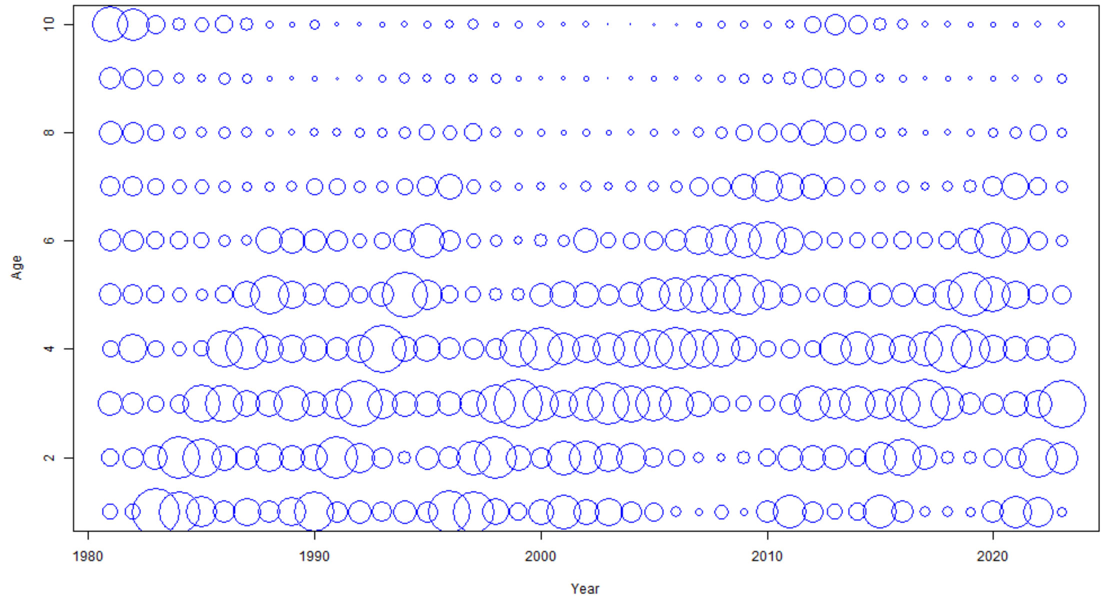


Figure 2.3.3.1. Blue whiting. Catch proportion at age, 1981-2023. Preliminary values for 2023 have been used.

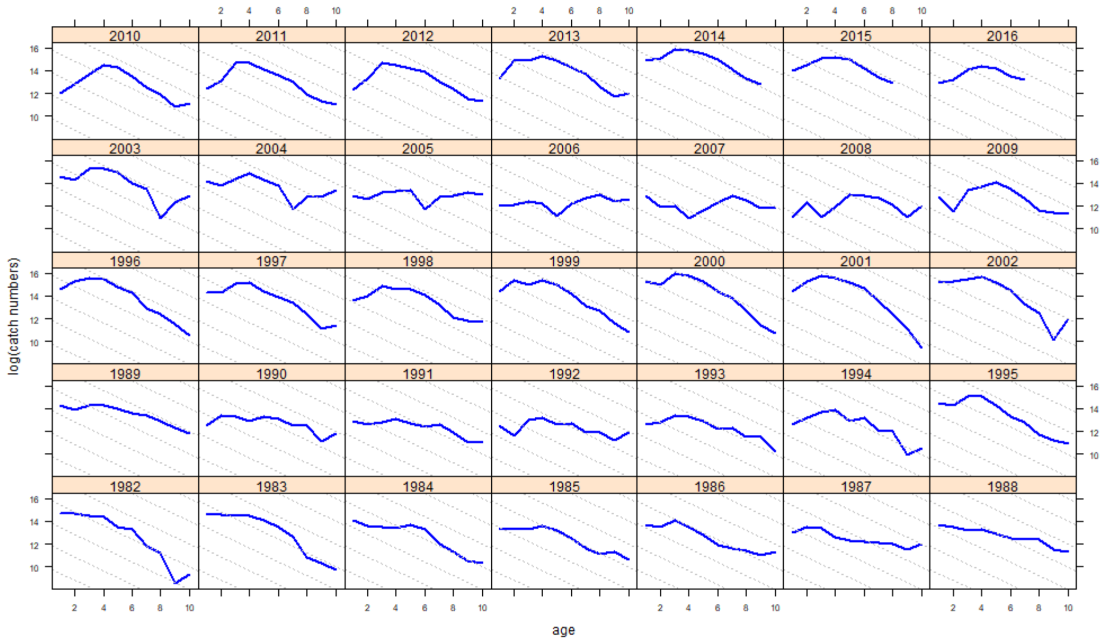


Figure 2.3.3.2. Blue whiting. Age disaggregated catch (numbers) plotted on log scale. The labels for each panel indicate year classes. The grey dotted lines correspond to *Z*=0.6. Preliminary catch-at-age data for 2023 have been used.

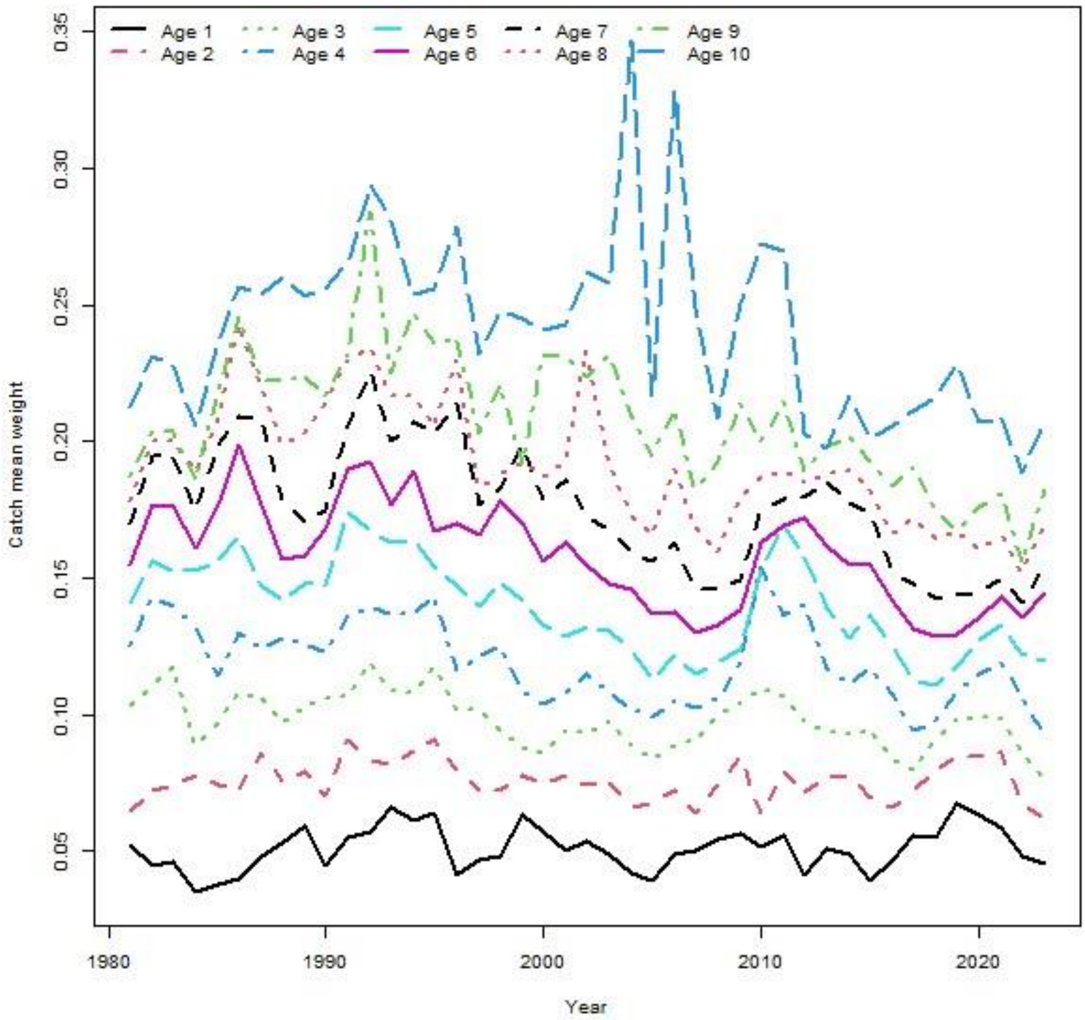
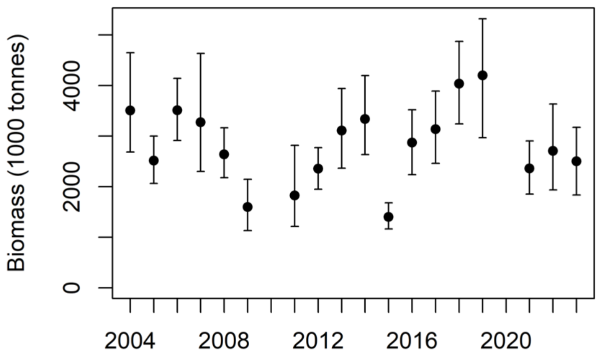


Figure 2.3.4.1. Blue whiting. Mean catch (and stock) weight (kg) at age by year. Preliminary values for 2023 have been used

A



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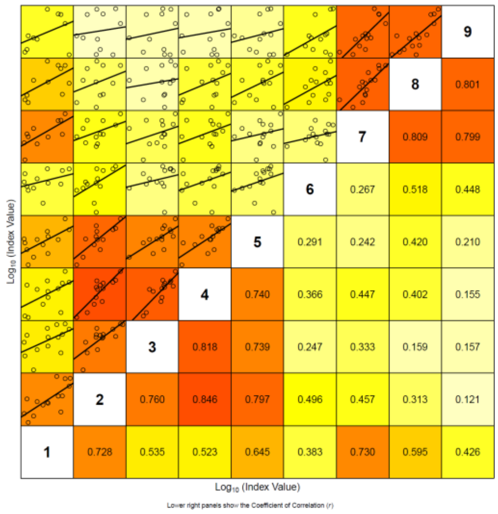
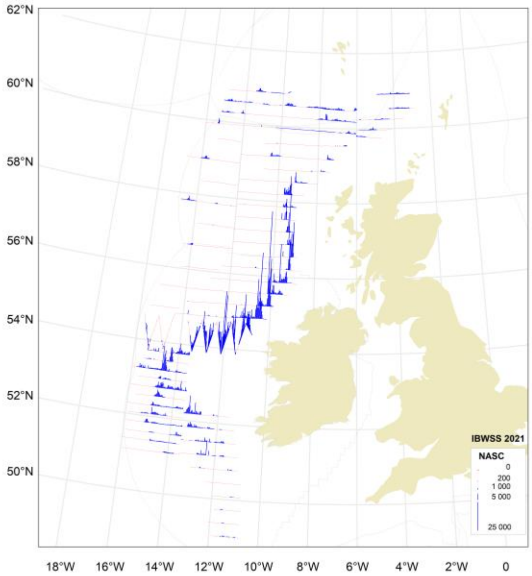


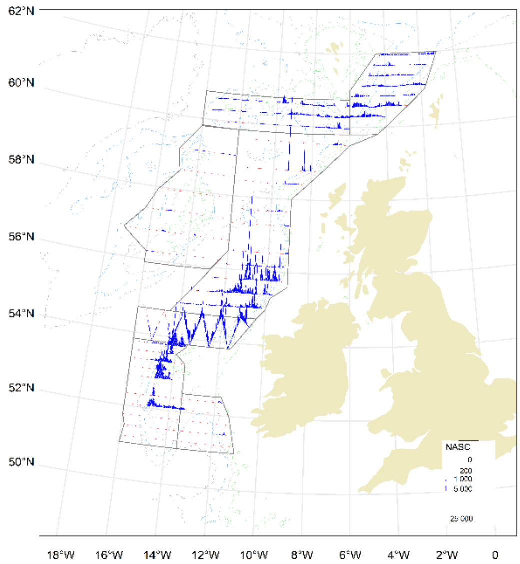
Figure 2.3.6.1.1. Blue whiting. (A) Estimate of total biomass from the International blue whiting spawning stock survey. The black dots and error bands are StoX estimates with 90 % confidence intervals. (B) Internal consistency within the International blue whiting spawning stock survey. The upper left 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.

NO SURVEY

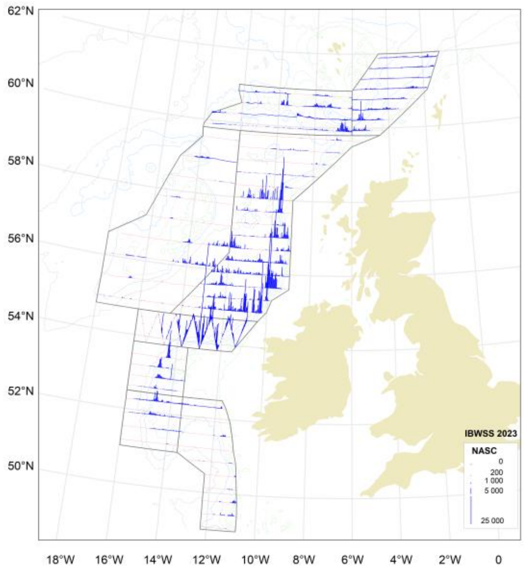
2020



2021



2022



2023

Figure 2.3.6.1.2. Blue whiting. NASC distribution of the blue whiting stock in the area to the west of the British Isles, spring 2020 (upper panel) to 2023 (lower panel).

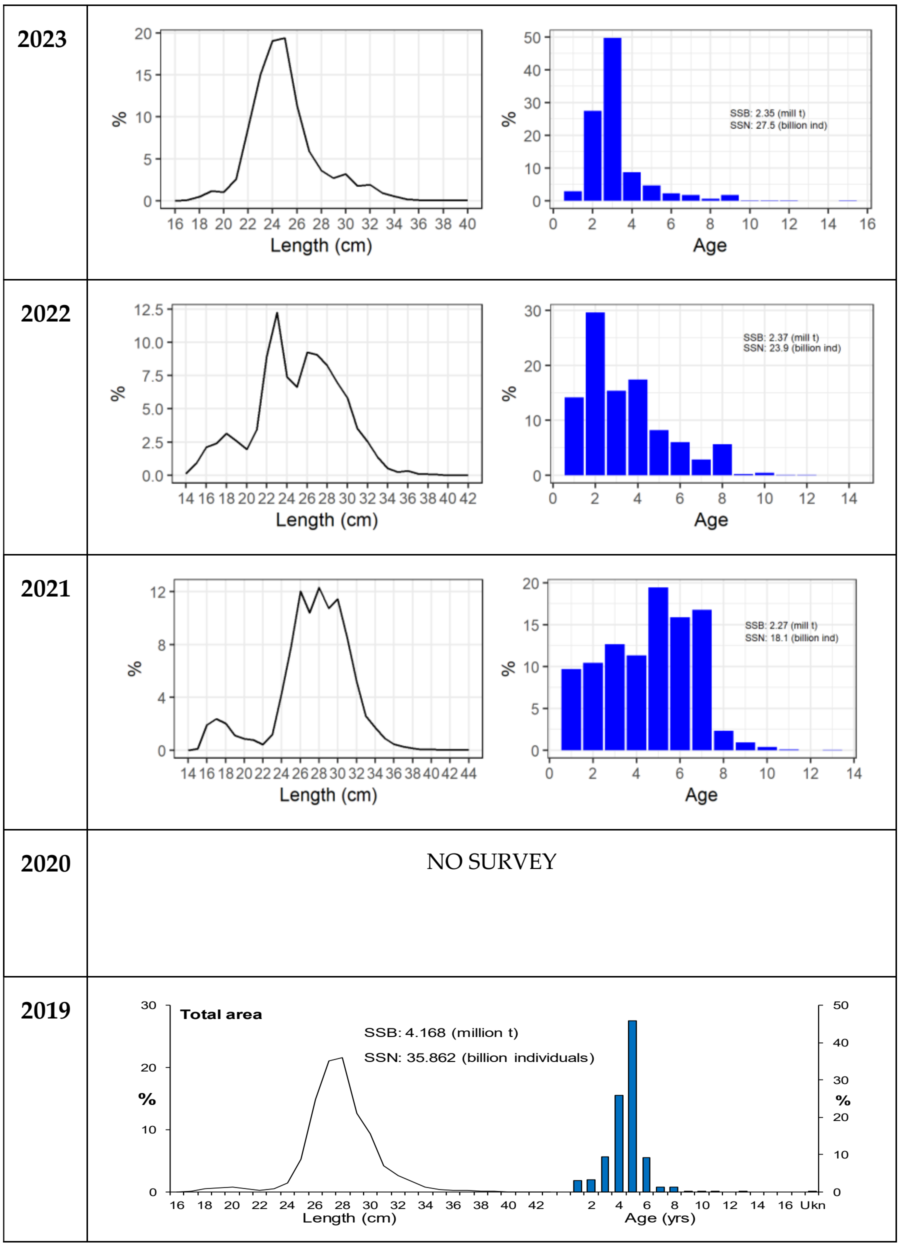


Figure 2.3.6.1.3. Blue whiting. Length (line) and age (bars) distribution of the blue whiting stock in the area to the west of the British Isles, spring 2019 (lower panel) to 2023 (upper panel). Spawning-stock biomass and numbers are given.

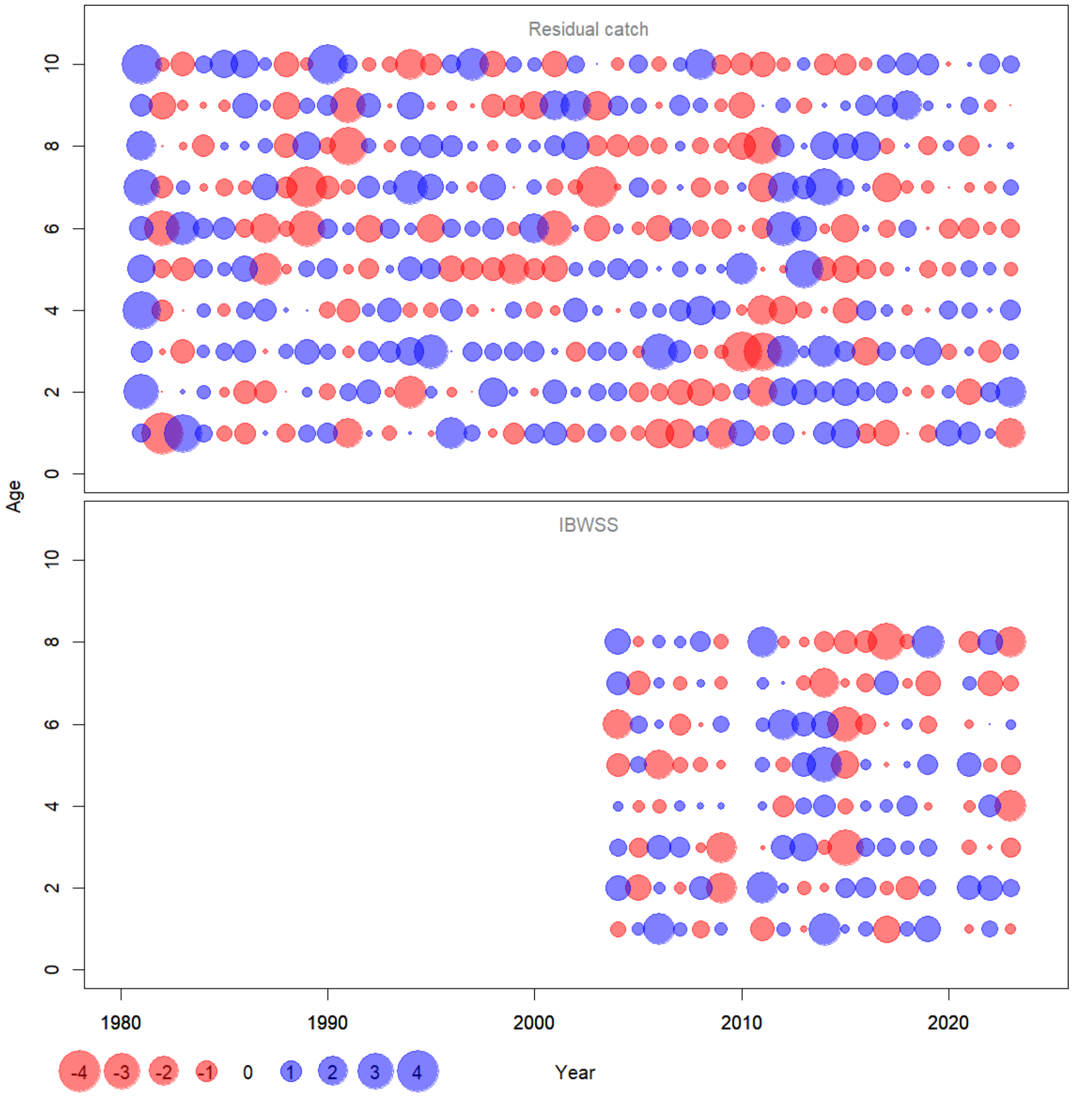


Figure 2.4.1.1. Blue Whiting. OSA (One Step Ahead) residuals (see Berg and Nielsen, 2016) from catch-at-age and the IBWSS survey 2004-2023 (no survey in 2010 and 2020). Red (lighter) bubbles show that the observed value is less than the expected value. Preliminary catch data for 2023 have been used.

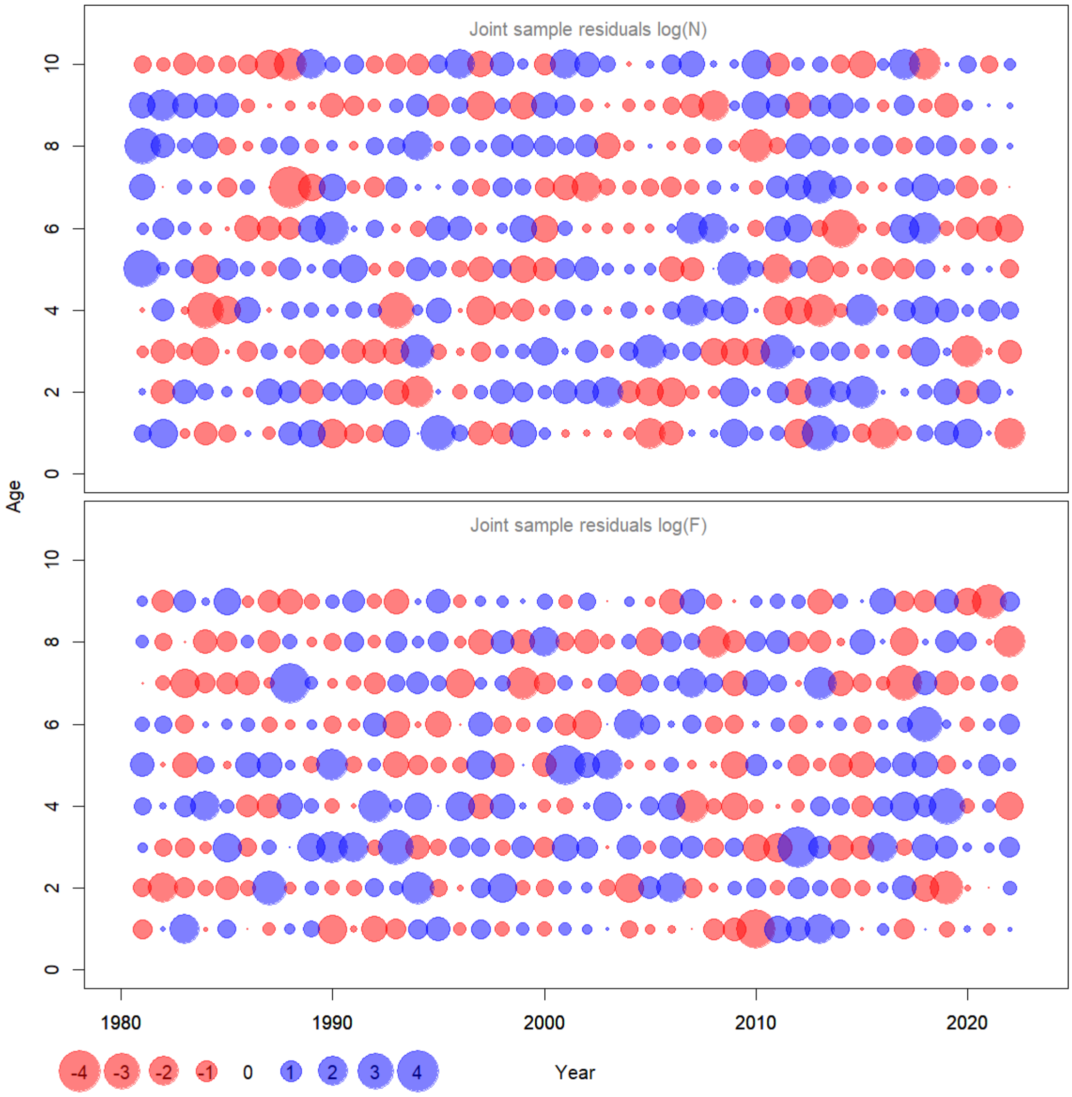


Figure 2.4.1.2 Blue whiting. Joint sample residuals (Process errors) for stock number and F at age. Red (lighter) bubbles show that the observed value is less than the expected value. Preliminary catch data for 2023 have been used.

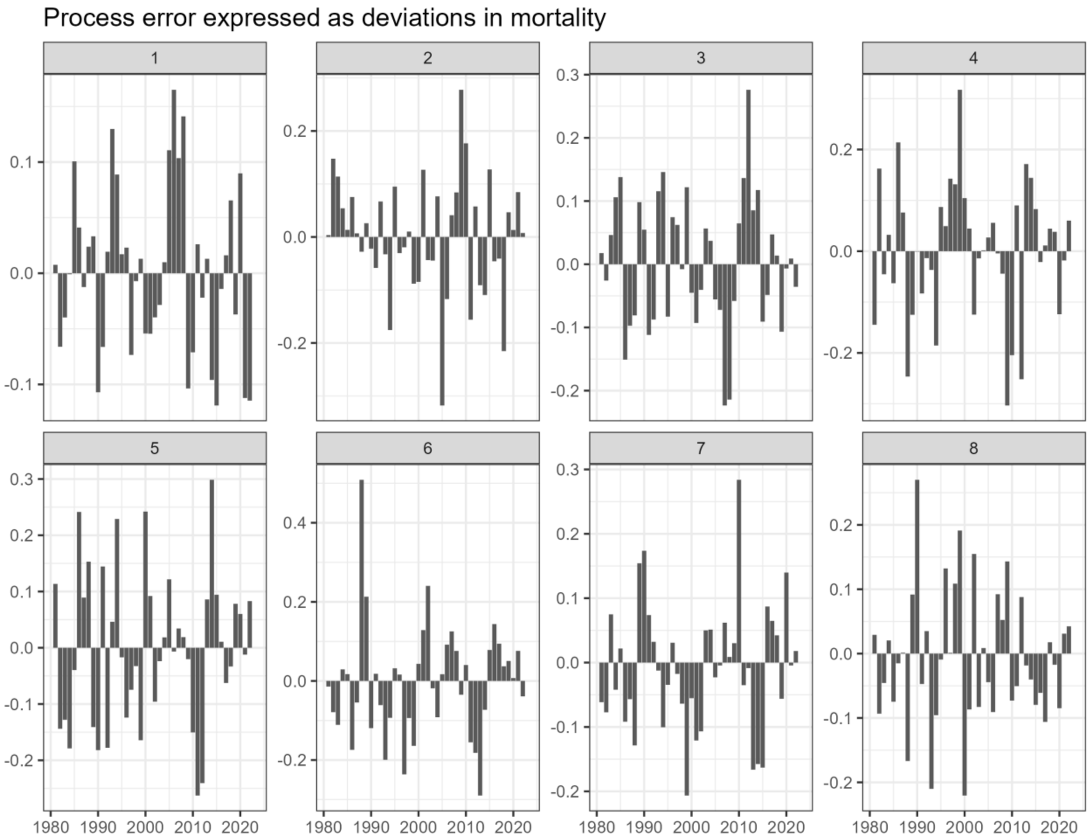


Figure 2.4.1.3. Blue whiting. Process errors expressed as deviation in instantaneous mortality at age by age and year.

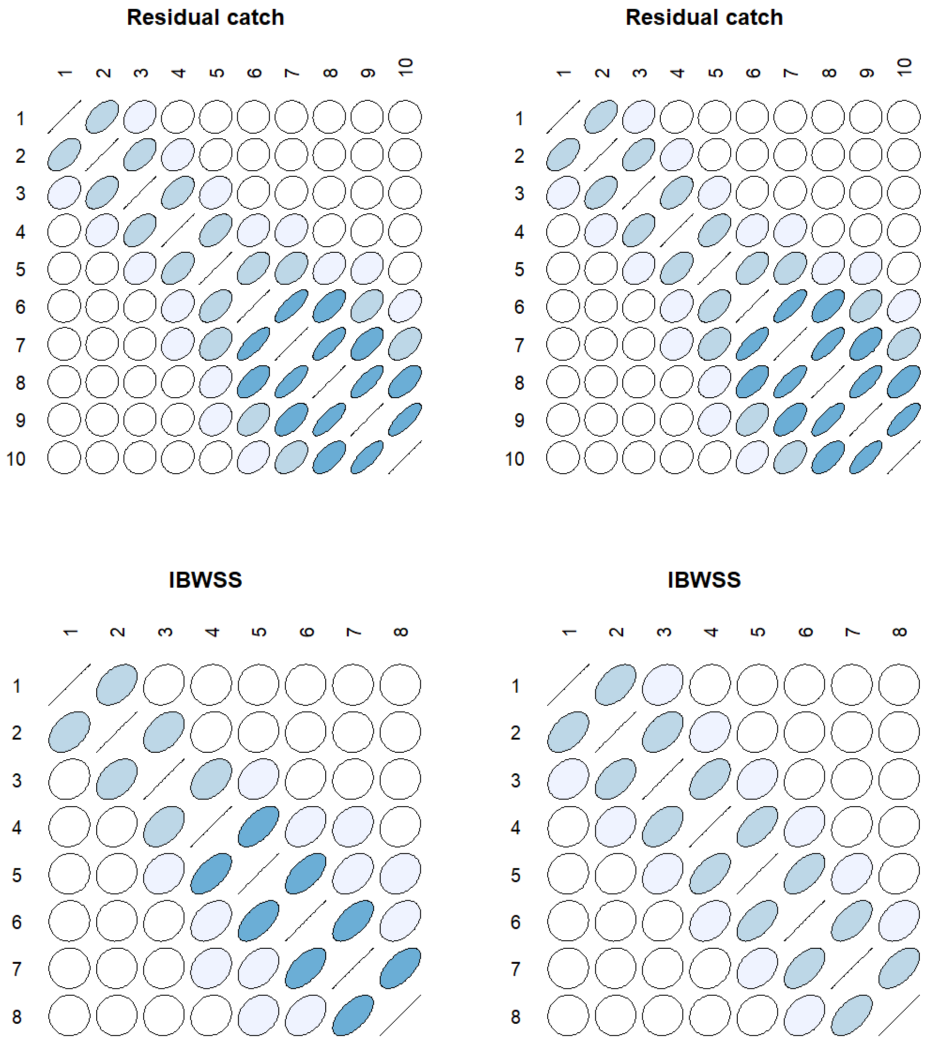


Figure 2.4.1.4. Blue whiting. The correlation matrix between ages for the catches and survey index of this year's assessment (WGWIDE 2023; left) and last year's assessment (WGWIDE 2022; right). Each ellipse represents the level curve of a bivariate normal distribution with the corresponding correlation. 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. Preliminary catch data for 2023 have been used in this year's assessment and preliminary catch data for 2022 in last year's assessment.

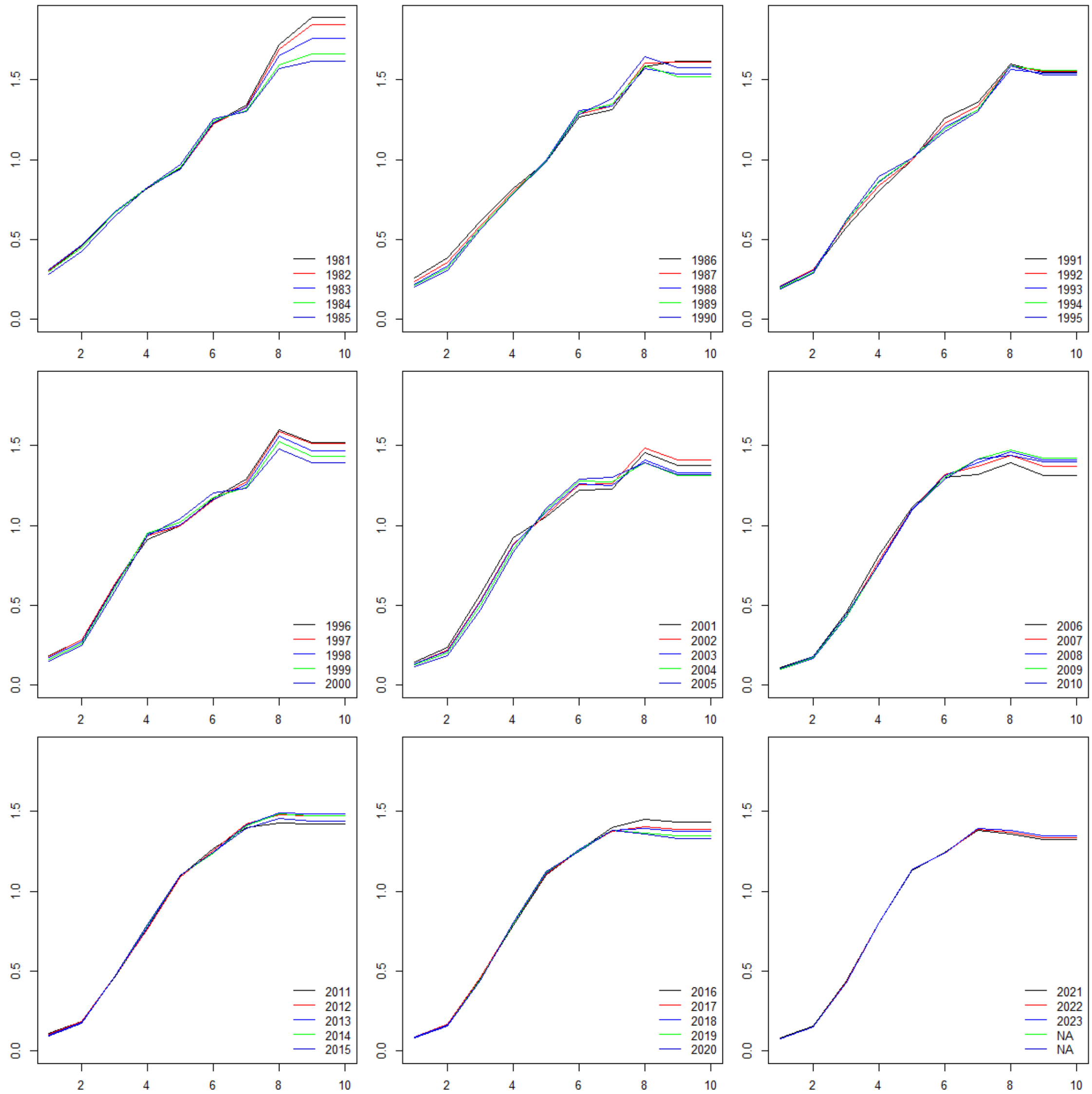


Figure 2.4.1.5. Blue whiting. Exploitation pattern by 5-years' time blocks. Preliminary catch data for 2023 have been used.

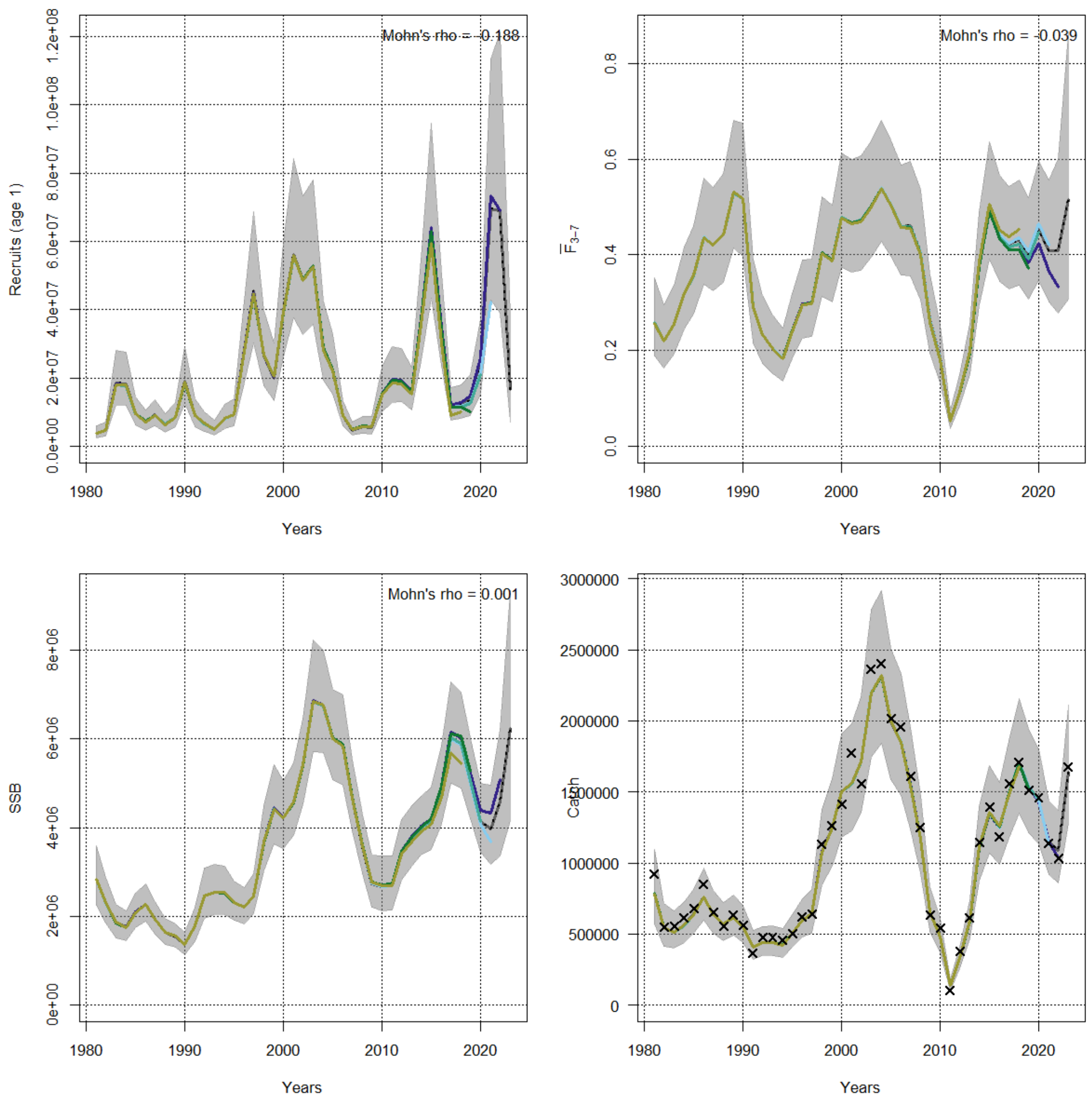


Figure 2.4.1.6. Blue whiting. Retrospective analysis of recruitment (age 1), F, SSB (tonnes) and total catch using the SAM model. The 95% confidence interval is shown for the most recent assessment.

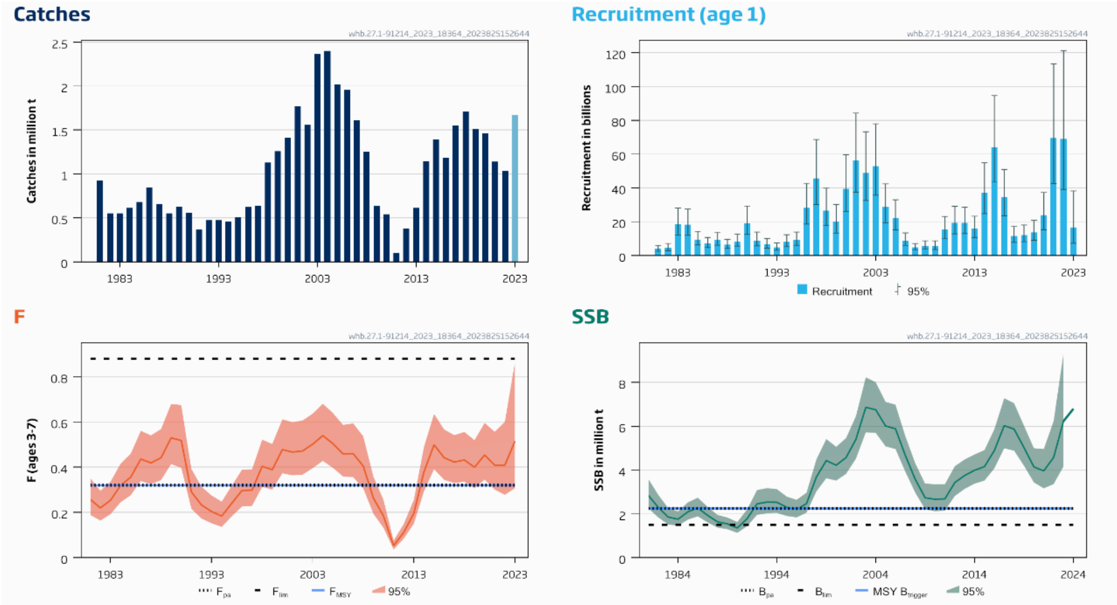


Figure 2.4.1.7. Blue whiting. SAM final run: total catches, recruitment (age 1), F and SSB. The graphs show the median value and the 95% confidence interval. Catches for 2023 are preliminary (shaded).

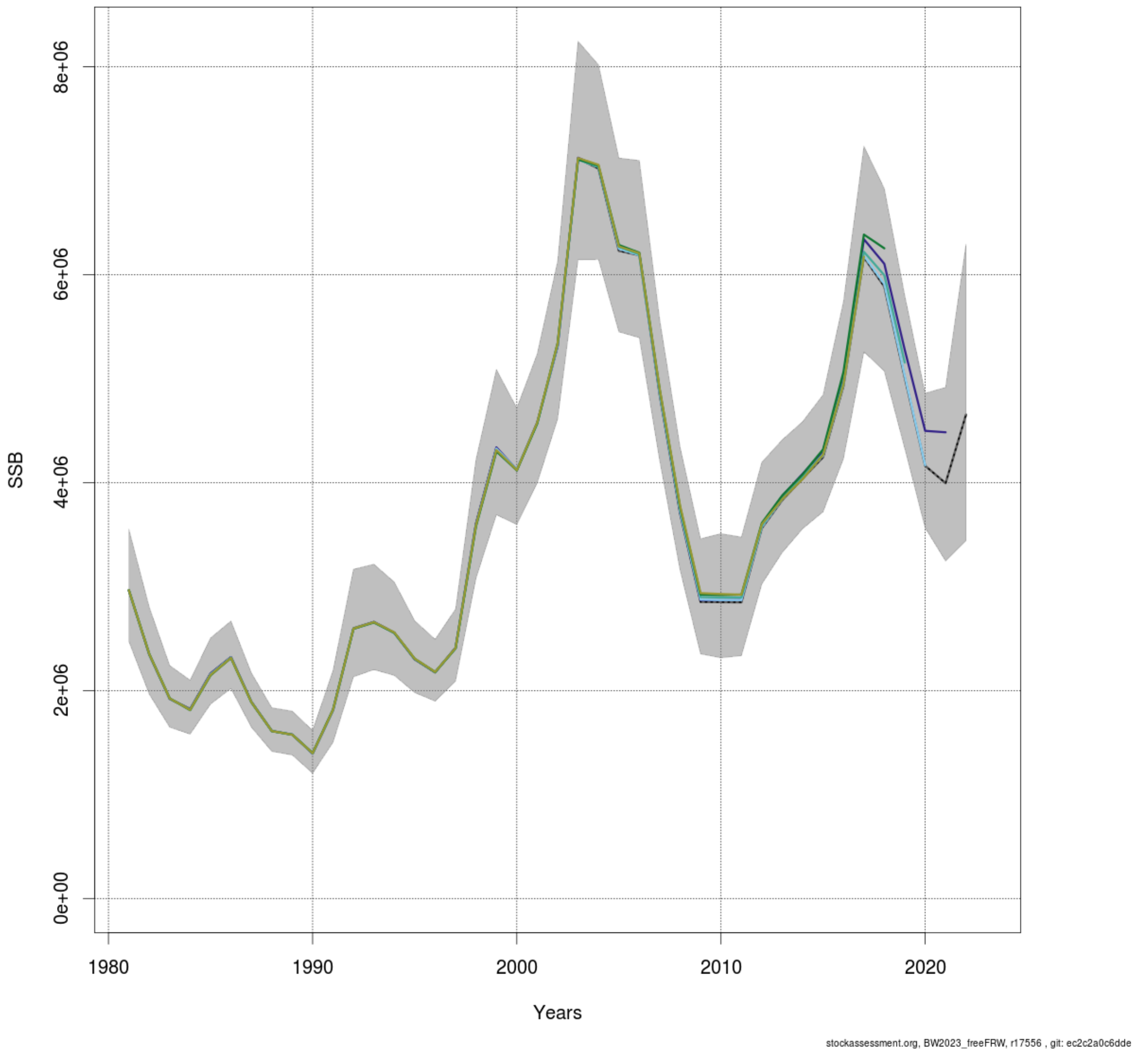


Figure 2.4.2.1. Blue whiting. Retrospective in SSB for the alternative configuration of the SAM model.

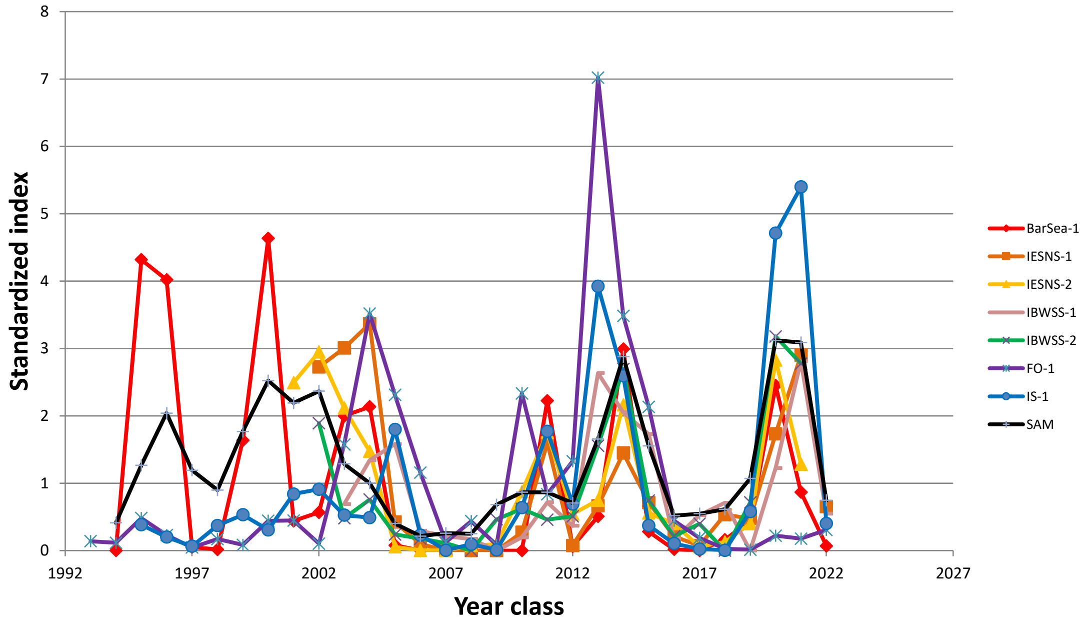


Figure 2.8.1.1. Blue whiting young fish indices from five different surveys and recruitment index from the assessment, standardized by dividing each series by their mean. BarSea - Norwegian bottom-trawl survey in the Barents Sea, IESNS: International Ecosystem Survey in the Nordic Seas in May (1 and 2 is the age groups), IBWSS (Not updated in 2020): 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.

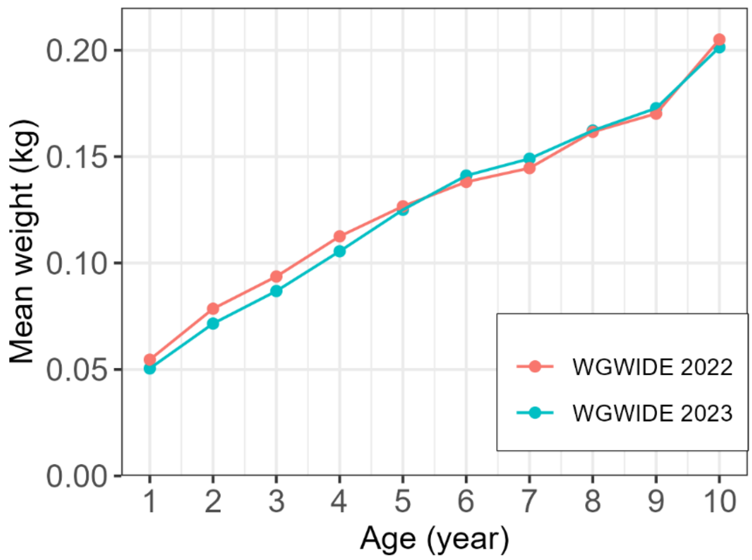


Figure 2.8.2.3.1. Blue whiting. Mean weight at age used in the forecast of current and last year's assessment. The mean is taken as the last three years of each assessment, including the terminal year. Weight-at-age values of the terminal year are based on preliminary catch data.

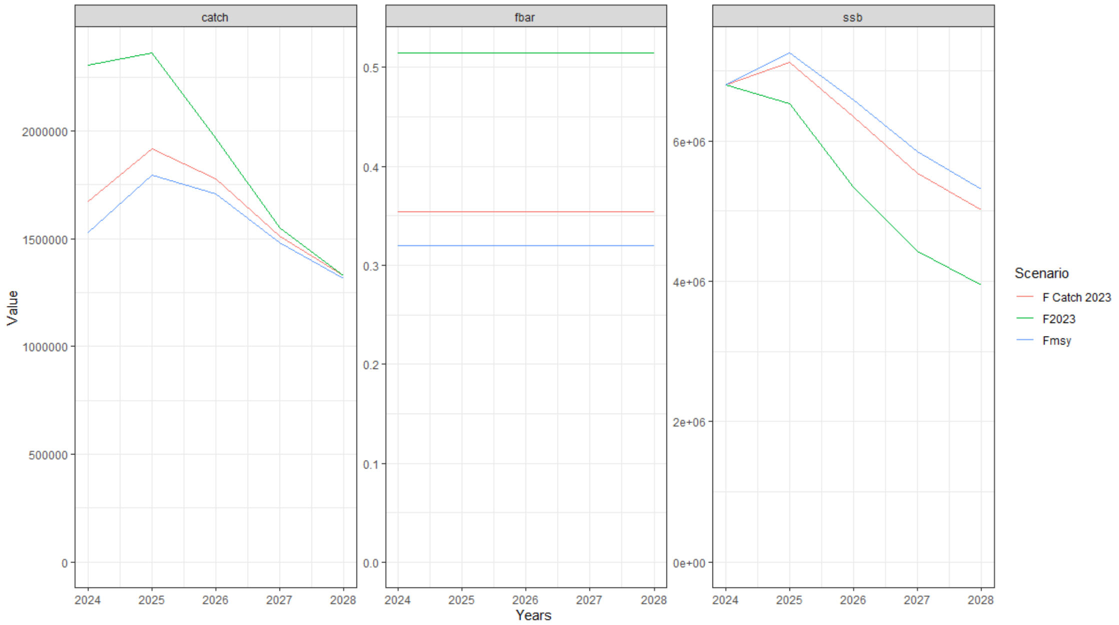


Figure 2.8.2.4.1 Blue whiting. Medium term projection under three F scenarios: Fmsy, F=F2023 and F=catches in 2023. Left-hand panel shows the catch (in tonnes), the middle panel shows the F (per year) and the right-hand panel shows the trajectory of SSB up to 2028 (in tonnes).

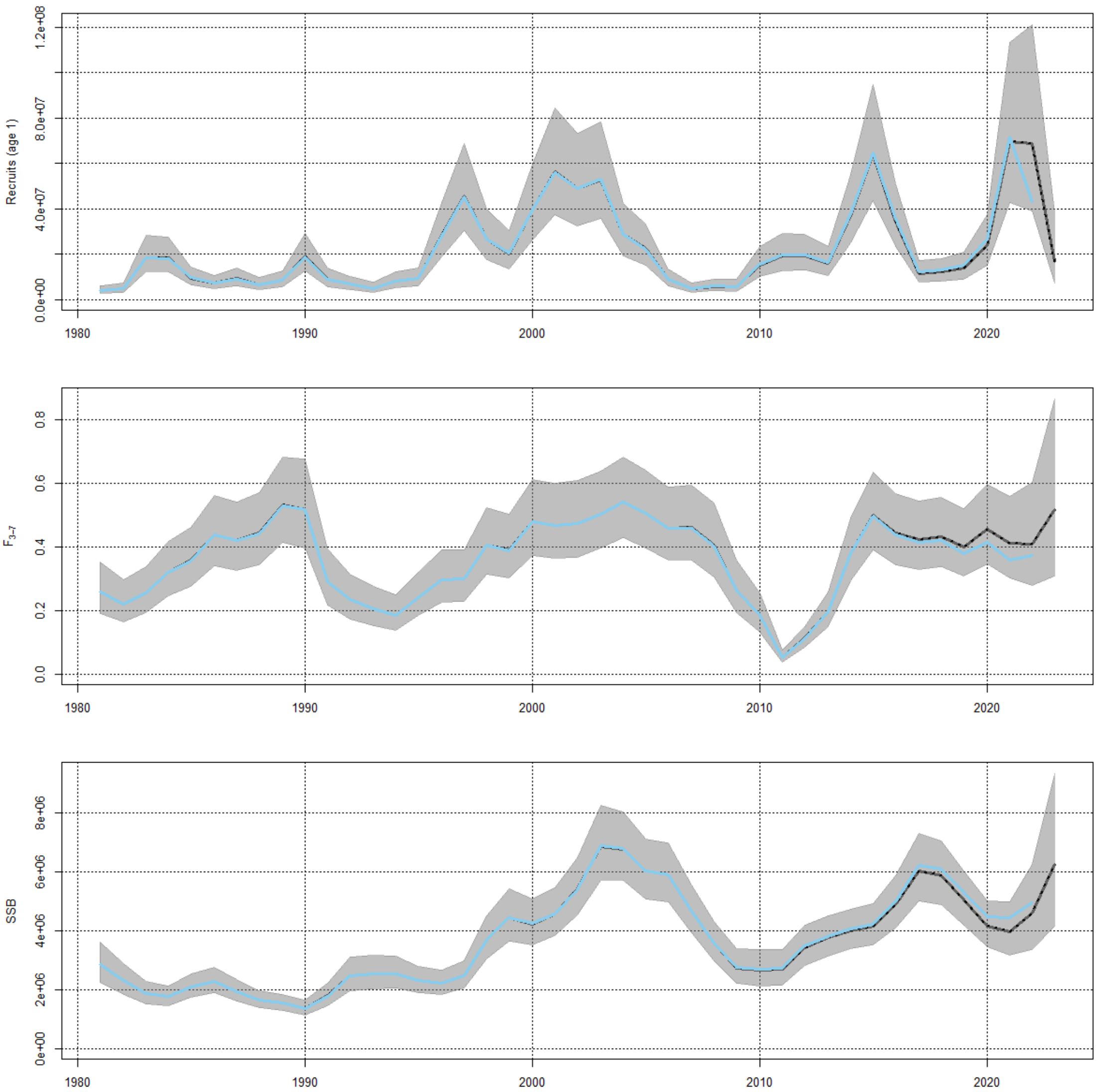


Figure 2.9.1. Blue whiting. SAM final run: Comparison of the 2022 (light blue line) and 2023 (black line) stock assessments, shown with 95% confidence intervals. Preliminary catch data for 2023 have been used.

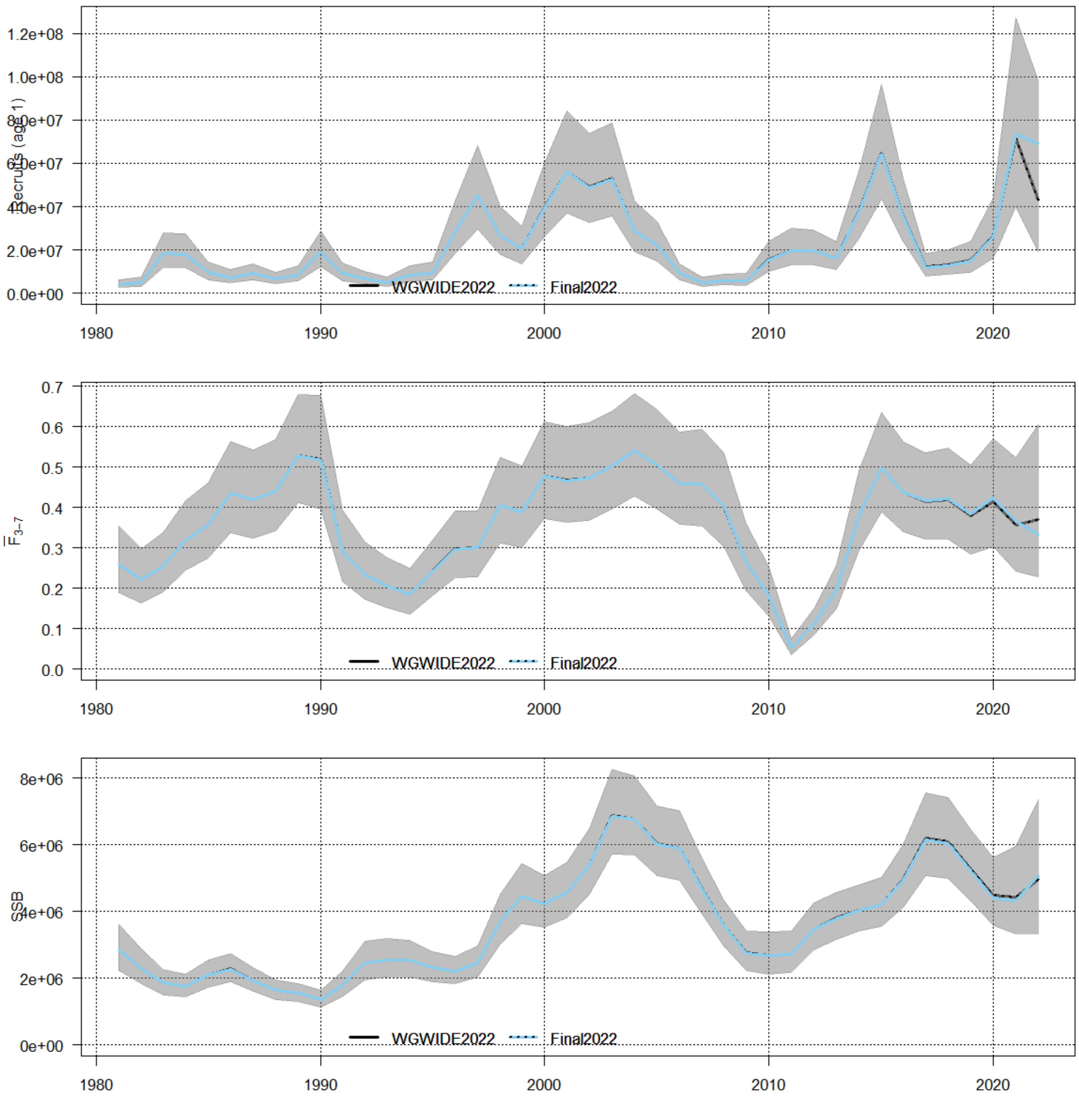


Figure 2.9.2. Blue whiting. Comparison of assessment runs with the configuration from WGWIDE 2022 with preliminary data for 2022 (black line) and the WGWIDE 2022 assessment with final data for 2022 (blue line).

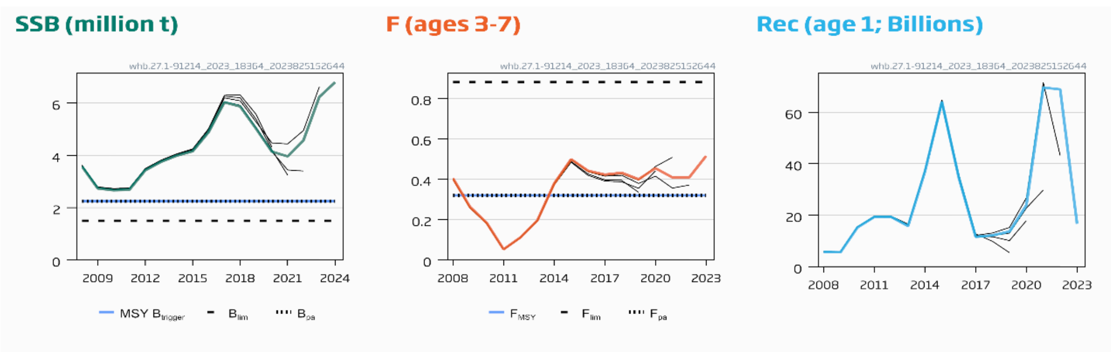


Figure 2.9.3. Blue whiting. Comparison of the 2019 - 2023 assessments (historical retrospective).

3 Boarfish in Celtic Seas, English Channel, and Bay of Biscay)

Capros aper in subareas 6–8 (boc.27.6-8)

3.1 Biological features and population parameters

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).

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 the small sample size and the seasonal variation in weight and maturity stage.

Age	0	1	2	3	4	5	6	7	8	9
Mean Weight (g)	0.84	6.65	14.6	19.5	23.7	26.8	33.3	37.7	40	47.1

Age	10	11	12	13	14	15	16	17	18	19
Mean Weight (g)	50.2	51.2	62.8	56.4	62.2	68.9	50.5	86.7	77.9	64.6

Age	20	21	22	23	24	25	26	27	28	29
Mean Weight (g)	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 assumed that M was the mortality that would reduce a population to 1% of its initial size over the lifespan of the stock. Based on a maximum age of 31, M was calculated as follows

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

Following this procedure, M = 0.16 year^{-1}was considered a good estimate of natural mortality over the life span of the boarfish stock, as it was similar to the total mortality estimate from 2007, (Z = 0.18). Given that catches in 2007 were relatively low, this estimate of total mortality was 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 was 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 will be 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, a single value of M was considered appropriate.

3.1.1 Stock Identity

An analysis of bottom trawl survey data suggests a continuity of distribution spanning ICES Subareas 27.4, 6, 7, 8 and 9 (Figure 3.1.1.1). 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 Figure 3.1.1.2). 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 this year's assessment only data from these areas were utilized.

3.2 The fishery

Boarfish is targeted in a pelagic trawl fishery for fish meal, to the south and southwest of Ireland and Northern Biscay. The boarfish fishery is conducted in shelf waters with the first landings reported in 2001. Landings were at very low levels from 2001-2005. The main expansion period of the fishery took place between 2006 and 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 catch advice for 2012 for the first time.

3.2.1 Advice and management

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. The plan was enacted in legislation by Ireland but not in other countries. The details of the measures can be found in the Annex. In August 2012 the Pelagic RAC proposed a long term management plan for boarfish. The management plan was not fully evaluated by ICES; however, in 2013 ICES advised that Tier 1 of the plan could be considered precautionary if a Category 1 assessment was available. For 2014, ICES advised that, based on F_{MSY} (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 3.4 for further details). There was also 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.

A revised draft management strategy was proposed by the Pelagic AC in July 2015. This management strategy aimed 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 it followed the rationale for TAC setting enshrined in the ICES advice, but with additional caution (ICES, 2015a).

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 continued since.

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 was applied resulting in a 36% reduction compared to the year before. The acoustic survey suggested that the stock abundance was at an historic low. The Advice Drafting Group decided the advice of 21 830 proposed (20% reduction) would stand for 2 years. The update assessments in 2018 and 2019 confirmed that the biomass was rather stable and at a low level.

In 2021, with the stock showing a strong recruitment signal, advice of 22 791 t was given for 2022 and 2023 based on the precautionary approach.

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 table below. The effect of this is that a quantity not exceeding the value 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
2019	759	5956
2020	688	3531
2021	701	3513
2022	173	2459
2023	448	658

3.2.2 The fishery in recent years (2019 – 2021)

A total of 11 312 t of boarfish was caught in 2019. This represents 52% of the 2019 quota of 21 830 t (Table 3.2.2.1). The main participant in the fishery, Ireland, landed 9 910 t (75% of its national quota). The Irish catch represents 88% of the total boarfish catch in 2019. Other countries reporting boarfish catches in 2019 were Denmark (757 t), the Netherlands (317 t), England (19 t) and Spain (2.5 t). Discards accounted for 306 t overall (Table 3.2.2.2). Tables 3.2.2.5 and 3.2.2.7 shows that about 87% of Irish landings were taken in ICES divisions 7.h and 8.a respectively.

In 2020, the total catch was 15 649 t which represented 82% of the quota (19 152 t). Ireland was the main partaker in the fishery (14 666 t) and landed more than its national quota (13 234 t) for the first time since TAC and quota regulations were established. The Irish landings accounted for 94% of the total catch. The other countries reporting catches are Denmark (196 t), the Netherlands (416 t), England (62 t), Poland (109 t) and Spain (1 t). The total discards for this year were 198 t. The majority of landings were taken in ICES divisions 7.b and 7.h (Tables 3.2.2.4 and 3.2.2.5).

In 2021, 17 693 t of boarfish was caught, representing 92% of the total allowable catch (19 152 t) for the year (Table 3.2.2.1). Ireland was the main contributor to the fishery landing 11 830 t, 89% of their quota (13 234 t). Other countries reporting landings for 2021 were Denmark (4 322 t), the Netherlands (781 t), England (45 t), Poland (45 t), Spain (11 t) and Scotland (9 t). Total discards were 651 t. ICES divisions 7.j and 7.b had the highest landings of 10 466 t and 3984 t respectively (Tables 3.2.2.5 and 3.2.2.4).

3.2.3 Catch distribution

The fishery operates during the first and fourth quarters of the year. In recent years (2019 – 2021) a larger proportion of the total catch has been taken in the fourth quarter. In 2022, the majority of the total catch was in the first quarter. The bulk of the catches were taken in ICES divisions 7.j and 7.b (Tables 3.2.2.5 and 3.2.2.4). Historically, the largest catches have been taken in 7.j although between 2016 and 2019, an increased proportion of the catch was taken in Northern Biscay (8.a).

Results from a questionnaire with Irish fishers found that the majority observed good marks of boarfish along the Irish west coast even up to 57°N which is a change from 2009/2010 when fishable marks were mainly found south from the Pistola Bank. In 2022, some decent catches were taken west of Aran and west of the Blasket islands. The fishers also remarked that since 2020, they have noticed a return of boarfish to the banks of the southern Celtic sea region where they had been absent in previous years. Also, the schools of boarfish are more dispersed than they were in high catch period of the fishery (2009/2010) but they are larger than in previous few years. Some behavioural changes observed are that boarfish are often encountered close to the sea bed instead of dense shoals in the water column. Also, they commented that they can fish both day and night for boarfish in the west of Ireland.

3.2.4 Discards

It is to be expected that discarding occurred before 2003, particularly in demersal fisheries, however it is difficult to predict what the levels may have been. Since 2003, the major sources of discard estimates are the Dutch pelagic freezer trawlers (Borges et al. 2008) and both the Irish and Spanish demersal fleets. Sporadic discards were observed in German pelagic freezer trawlers before 2015 and the UK demersal fleet beginning in 2015. In 2016, Lithuania declared discards for the first time but hasn't since then. 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. Discard sampling data have improved in recent years with Ireland, Spain, England and Scotland providing sampling data in 2022. Table 3.2.2.2 show the total annual discards and estimates from the demersal and non-target fisheries respectively.

3.2.5 Sampling data

Length-frequencies of the international commercial landings by year are presented in Table 3.2.5.1. 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. Before 2017, boarfish was not included in the list of species to be sampled by the Data Collection Multi Annual Programme (DCMAP). In 2022, 21 samples, comprising of 4 756 fish, were collected and measured for length from Ireland and Denmark (Tables 3.2.5.2 and 3.2.5.3). These samples covered the most heavily fished areas of 7.j and 7.b as well as 7.h. and 6.a and in quarters 1,3 and 4.

Following standard protocols, 9 samples from the Irish catch were randomly selected for biological data collection i.e. otolith extraction, sex and maturity determination. Samples are collected on-board during fishing operations and are frozen until the vessel returns to port, which ensures high quality samples. 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 are be measured to the 0.5 cm below for length frequency.

3.3 Input data

3.3.1 Catch data

In 2022, 16 860 t of boarfish was caught, representing 74% of the total allowable catch (22 791 t) for the year (Table 3.2.2.1). Ireland was the main contributor to the fishery landing 14 055 t, 89% of their quota (15 749t). Other countries reporting landings for 2022 were Denmark (1 859 t), the Netherlands (858 t), England (73 t), Spain (10 t) and Portugal (5t). Total discards were 1 037 t (Table 3.2.2.2). ICES divisions 7.j and 7.b had the highest landings of 13 242 t and 3 279 t respectively (Tables 3.2.2.5 and 3.2.2.4). Landings from Denmark were revised from 1 859 t to 4 305 t; however, the revision was made after the assessment was completed and the new figure will be included in next year’s assessment.

A general ALK was constructed based on 814 aged fish from Irish, Danish and Scottish caught samples from 2012 (Table 3.3.1.1). A description of the ALKs prior to 2012 can be found in the stock annex. The results of the application of the ALK to commercial length-frequency data (available for the years 2007-2022) produced proxy catch numbers-at-age values which are available in Table 3.3.1.2. In the last couple of years, there has been the appearance of strong year classes in the catch numbers (Figure 3.3.1.1). A high number of 2-5 year olds were present in the 2022 data. The modal age from 2007-2011 was 6, 7 in 2012-2018, 2 in 2019-2020 and 4 in 2021. It should be noted that in WGWIDE 2011 and 2012 the plus 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 Hüssy *et al*. (2012a; b). The age range is similar to the published growth information presented by White *et al.* (2011).

3.3.2 Acoustic Survey

The Boarfish Acoustic Survey (BFAS) series was initiated in 2011 in partnership with industry. The 2011 survey collected data over 24 hours. In 2012, the protocol was changed to exclude the hours between 00:00 and 04:00 as aggregations break up during the hours of darkness. The 2011 data was reworked in 2015 to exclude the data between 00:00 and 04:00. An acoustic target strength model of (-66.2dB) was developed in 2013 (Fässler *et al.* (2013)) and is applied to all surveys in the time series. Over the time series of the survey total biomass has been estimated in the range 863 kt (in 2012) to 70 kt (2016) with CV estimates ranging 0.11 to 0.31. Total biomass estimates declined sharply between 2012 and 2016 after which an increasing trend is seen (Figure 3.3.2.1).

An annual index of biomass and abundance has been reported for boarfish since 2011. The 2023 survey was carried out onboard the RV *Celtic Explorer* during the WESPAS survey (Western European Shelf Pelagic Acoustic Survey). The survey was carried out over a 42-day period beginning on the 10 June in the south (47°30N) and working northwards to 59°30N ending on 20 July.

Calculation of acoustic abundance
The StoX software package (Johnsen et. al., 2019) was used to calculate acoustic abundance from survey data (StoX V3.6.1 and R-StoX V3.6.1). Aggregated survey data are available for download from the ICES Trawl Acoustic database. Survey design and analysis procedures adhere to guidelines laid out in the Manual for International Pelagic Surveys (ICES, 2015b).

Survey results 2023
The estimate of boarfish biomass is presented in Table 3.3.2.1 and the spatial distribution of the echotraces attributed to boarfish in 2023 are presented in Figure 3.3.2.2. Overall, the WESPAS survey provided continuous synoptic coverage from south to north over 42 days, relating to an area coverage of over 59,632 nmi^2 (boarfish strata) and transect mileage of over 4,597 nmi. In total, 53 trawl stations were undertaken with 29 hauls containing boarfish providing 4,377 individual lengths, 1,800 length and weight measurements and 876 otoliths for use during the analysis.

Survey effort was comparable to 2022, with a 2% increase in both acoustic sampling effort (survey miles) and area coverage. Boarfish TSB (total stock biomass) and abundance (TSN) estimates were 525,701 t and 15,938,301,000 individuals (CV 0.11) respectively. The 2023 estimate saw an increase of 16% in TSB compared to 2022, while TSN saw a reduction of 14%. Spawning stock biomass (SSB) increased by 18% as compared to 2022. The reported increase in biomass (TSB & SSB) and reduction in abundance (TSN) is largely driven by the reduced numbers of immature fish observed during the survey.

The geographical distribution of boarfish was comparable to earlier years in the time series in terms of latitudinal range. Within this range, clusters of individual schools were most frequently found towards the shelf margin in the northern and western strata and more widespread across the shelf in the Celtic Sea. The centre of gravity of schools during this year's survey in the Celtic Sea stratum was more towards the shelf edge than in recent years. It is possible this more westward distribution was linked to the hydrographic conditions encountered this year compared to recent years; with a cool pool of water extending across the seafloor in the Celtic Sea.

Over 65% of the standing stock biomass was observed in the Celtic Sea stratum (50% TSN), followed by the Irish west coast (28% TSB & 22% TSN), the southern Hebrides stratum (13% TSB & 9% TSN), the western Hebrides stratum (8% TSB & 5% TSN) and the Porcupine Bank stratum (2% TSB & 1% TSN) (Figure 3.3.2.3).

The 4-year age class dominated the 2023 estimate contributing 25% of TSB and 29.4% of TSN. Ranked second and third were the 3-year old (16% TSB & 24.9% TSN) and 7-year old fish (14.1% TSB & 11.5% TSN) respectively. Ranked fourth is the 6-year old fish (12.2% TSB & 11.4% TSN). Combined, these four age classes represented 67% of TSB and 77% of TSN. The survey has successfully tracked these four cohorts from recruitment. The 15+ age class represented 10.4% of TSB and 4.3% of TSN (Figure 3.3.2.4).

Maturity analysis indicated over 99.6% of TSB and 99% of TSN was represented by mature fish. The proportion of immature fish in the stock estimate has decreased from a high in 2021 (41% TSN) over recent years (2022; 5% and 2023; 1%). This differs with observations from the PELGAS survey where the overall abundance of boarfish, notably immature fish, has increased over the same period.

3.3.3 International bottom trawl survey (IBTS) Indices

An index of abundance was constructed from the following surveys:

- EVHOE, French Celtic Sea and Biscay Survey, (Q4) 1997 to 2022
- IGFS, Irish Groundfish Survey, (Q4) 2003 to 2022
- WCSGFS, West of Scotland, (Q1 and Q4) 1986 to 2009 (survey design changed in 2010)
- SPPGFS, Spanish Porcupine Bank Survey, (Q3) 2001 to 2022
- SPNGFS, Spanish North Coast Survey, (Q3/Q4) 1991 to 2022
- ECSGFS, CEFAS English Celtic Sea Groundfish Survey, (Q4) 1982 to 2003

The spatial extent and haul positions of each survey is shown in Figure 3.3.3.1 and the length frequencies are presented in Table 3.3.3.1 for each survey. These surveys cover the majority of the observed range of boarfish in the ICES area (Figure 3.3.3.2). The index of abundance, CPUE, was computed as the number of boarfish per 30 min haul. The abundance of boarfish per year per ICES statistical 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. The West of Scotland survey index had been increasing between 2000 and 2009 but is uncertain and was stopped soon after. The English Celtic Sea survey showed an upward trend in the last couple of years before the survey ended in 2003. Of the four current bottom trawl surveys, the French, Irish and Spanish Porcupine groundfish surveys experienced an increase in CPUE, particularly the French survey.

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 3.3.3.3).

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 correspond to main fishing grounds. Figures 3.3.3.4a and b shows the signal in abundance and biomass, increasing gradually in the 1990s, slowly declining in the early 2000s, before increasing again with a strong increase in the most recent period. Much of this increase which is stronger in terms of abundance is due to increased recruitment since 2017. The low estimates for the 2017 survey are partly explained by issues with the execution of the EVHOE survey. Due to mechanical breakdown, the majority of the survey stations could not be completed. The missed stations would have covered the area in North Biscay typically associated with the highest catch rates of boarfish.

For subsequent surplus production modelling (see Section 3.4), biomass indices were extracted from each of the IBTS surveys using a delta-lognormal model (Stefánsson 1996); details of which can be found in the annex.

When the indices were recalculated in 2021, (following a refresh of the input data from DATRAS and national data submitters), the following issues were encountered

- An error with the coding of the EVHOE 2018 data in DATRAS was corrected, revising upwards the estimates from 2018 for this survey
- The truncated EVHOE 2017 dataset was removed from the analysis. In previous years, this data was retained but, because the available data only corresponds to a small fraction of the total survey area (where boarfish are not usually encountered in significant quantities) a very low survey estimate resulted. It was considered appropriate to remove this data from the analysis. In future, explicit modelling of spatial and temporal correlations may permit this data to be considered again.
- An error in the analysis was discovered whereby hauls with more than one catch category were underrepresented as only a single catch category was included during the model fitting. Multiple catch categories are usually the result of splitting the catch into adult and juvenile portions and using an appropriate subsampling strategy for each. This issue is particularly relevant for the IGFS which, over the most recent 4 years has 2 catch categories for boarfish recorded for approximately 20% of hauls. The outcome is an increase in CPUE for these hauls and a subsequent increase in the survey index for the IGFS in recent years (2016 onwards).

3.4 Biomass dynamic model

In 2012 an exploratory biomass dynamic model was developed for the assessment of boarfish. The model is a Bayesian state space surplus production model (Meyer & Millar 1999), incorporating the catch data, delta-lognormal estimated IBTS survey indices and acoustic biomass estimates. Following the initial development of the model, the assessment was 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 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 and the stock assessment was moved from ICES category 1 to 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 has not changed with annual updates to the input data only. The details of the progression of the production model can be found in the Annex.

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

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

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 estimation, the biomass is scaled by the carrying capacity, denoting the scaled biomass $P_t = B_t / K$. A 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 log-normally 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 3.3.3.3) 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

$$\sigma_{\varepsilon,acoustic,t}^2 = ln(CV_{acoustic,t}^2 + 1)$$

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 $\frac{1}{\sigma_u^2} \sim gamma(0.001, 0.001)$

3.4.1 Specification

The specifications for the final boarfish assessment model runs are:

Acoustic survey

Years: 2011–2023

No substantial evidence exists for removing any of the survey points from the time series although 2016 may be considered an outlier (Table 3.3.2.1).

In the index value from 2011 – 2015 is calculated using a bespoke protocol as outlined below

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

For the years 2016 – present, the StoX software package (Johnsen et. al., 2019) was used to calculate the acoustic abundance index.

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)

The final run is 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 as it was 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 initial data year was set at 1991 when 3 groundfish survey indices are available (SPNGFS, ECSGFS and WCSGFS). The survey indices are weighted such that highly uncertain values receive lower weight in the fitting.

Catches

2003–2022 time-series

Priors

The final run assumes a strong prior for the acoustic survey catchability with $ln(q_{acoustic}) \sim N(1, 1/4)$ (mean 1, standard deviation 0.25), which has 95% of the density between 0.5 and 2. Given the relatively short acoustic series 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.

3.4.2 Results

Run convergence

Parameters for the 2023 model run converged with good mixing of the chains and Rhat values lower than 1.1 indicating convergence and acceptable autocorrelation (Figures 3.4.2.1-3).

Diagnostic plots are provided in Figure 3.4.2.4 showing residuals about the model fit. A fairly balanced residual pattern is evident. In some cases, outliers are apparent, for instance in the later years of WCSGFS survey. Large residuals tend to be observed where the model has ignored data points that had high uncertainties. However, these points are down weighted according to the inverse of their variance and hence do not contribute much to the model fit. The acoustic survey (WESPAS) overestimates the stock in the first 3 years, then underestimates it for the next 4 years before again overestimating it slightly until the present survey. This suggests that this index is perhaps not representative of the whole stock. Figure 3.4.2.5 shows the prior and posterior distributions of the parameters of the biomass dynamic model. The estimate of q for the acoustic survey is 0.79, leading to a higher estimate of final stock biomass than the acoustic survey result.

Trajectories of observed and expected indices are shown in Figure 3.4.2.6, 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 3.4.2.1. Biomass in 2023 is estimated to be 734 kt, continuing the increasing trend in stock size since 2016. The extremely low biomass estimate from the 2016 acoustic survey appears to be largely considered as an outlier by the model. This is also the case for the high survey estimate in 2012 although the drop in biomass between these points is seen in a number of the input data series. Retrospective plots of TSB and F, presented in Figure 3.4.2.6, show that the perception of the stock is stable over the most recent 5 years.

IBTS

Diagnostics from the positive component of the delta-lognormal fits indicate relatively good agreement with a normal distribution on the natural logarithmic scale (Figure 3.4.2.8). 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 updates described in section 3.3.3 with respect to data and analysis code corrections have resulted in increased correlation between the surveys most affected *i.e.* IGFS and EVHOE (Figure 3.4.2.9). The WCSGFS displayed positive correlations with all five surveys except the Spanish north coast survey (SPNGFS). The SPPGFS displayed a small negative correlation with EVHOE. Weighting the correlations by the sum of the pair-wise variances resulted in a largely similar correlation structure (Figure 3.4.2.9). Note that though some surveys displayed weak or no correlation, no surveys were excluded a-priori from the assessment.

3.4.3 State of the stock

This year's assessment indicates that total stock biomass increased from a low to average level from the early to mid-1990s (Figure 3.4.2.7). The stock fluctuated around this level until 2009, before increasing until 2012. A sharp decline is seen between 2013 and 2014. Since 2014, the abundance has increased and is close to the historic maximum from the assessment (2012) in 2023. 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 is considered satisfactory 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 is considered likely an outlier and has little influence on stock abundance estimates. The assessment is characterised by relatively high uncertainty reflecting 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.

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.

MSY reference points can be estimated from the production model assessment parameter values. In 2023, F_{MSY} (r/2) is estimated to be 0.16, similar to estimates from previous assessments and MSY $B_{trigger}$ (K/4) 173kt. Throughout the history of the fishery, estimates of total biomass have remained above MSY $B_{trigger}$. Fishing mortality (F) was briefly larger than the estimate of F_{MSY} between 2009 and 2010 and again in 2014, but has decreased since. In 2023, the stock is in the green area of the Kobe plot (Figure 3.4.3.1).

Recruitment

Estimates of recruitment are not available from the stock assessment. However, all available data sources (catch, acoustic survey and IBTS surveys) indicate above average recruitment over the period 2019-2021. The common ALK (Table 3.3.1.1.) was applied to the IBTS number-at-length data. The length-frequency is presented in Table 3.3.3.1. and the age-structured index in Table 3.3.3.2. and Figure 3.3.3.5.

The EVHOE, IGFS and SPNGFS surveys provide the best indices of recruitment as this is where the juveniles appear to be most abundant (Table 3.3.3.1). It appears that recruitment was high in the late 1990s in the EVHOE survey with 2010 and 2015 also indicating above average recruitment. Particularly strong recruitment has been noted in each of 2018-2020, especially for the EVHOE survey but also the IGFS in 2020.

The PELGAS survey is conducted annually in waters to the south of the boarfish (WESPAS) survey. In 2021, PELGAS recorded a significant increase in biomass on its most northerly transects (immediately south of the WESPAS southern limit) compared to 2019 (no survey was conducted in 2020), in broad agreement with increases noted on WESPAS. In 2022 and 2023, boarfish was encountered as far south as 45°N, primarily on the western extent of the survey transects. Estimates of biomass in 2022 and 2023 were approximately 70kt. The PELGAS survey takes place approximately 1 month prior to the boarfish survey.

3.5 Short Term Projections

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

3.6 Long term simulations

No long term simulations were conducted.

3.7 Candidate precautionary and yield based reference points

3.7.1 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 3.7.1.1). *F0.1* was considered to be well estimated (Figure 3.7.1.2). No new yield per recruit analyses were performed in subsequent years.

3.7.2 Precautionary reference points

No reference points have been defined for boarfish.

3.7.3 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).

3.8 Quality of the assessment

ICES considers the current basis for the advice on this stock to be an interim measure. Extensive sampling of the commercial catch and information from surveys will permit assessment development as the available data improves. The acoustic survey has undergone several developments to improve its suitability with updates to methodology in 2012, a change in direction in 2017 and extension of transects at the boundaries to improve containment. The current 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 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 (*e.g.* WCSGFS for instance) may require revision.

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 an appropriate means of dealing with such data. The biomass dynamic model used in the stock assessment is based on the assessment of megrim in Sub-divisions 4 and 6 with the model further developed by including acoustic survey biomass estimates. A drawback of the current assessment model is that it does not provide estimates of recruitment although estimates of recruitment strength are available from the Spanish and French bottom trawl surveys.

3.9 Basis for 2024 and 2025 advice

Advice for boarfish in 6-8 has been issued biennially since 2018 and is based on the trend in the relative TSB from the assessment. Advice for 2024 and 2025 is based on the updated assessment presented in this report and the application of the updated ICES guidance for stocks in category 3, based on the work of the ICES WKLIFE series of workshops (ICES 2022).

Although considered by the SPiCT benchmark workshop (WKBMSYSPiCT2) in 2023, an accepted SPiCT assessment could not be achieved for this stock. However, with an index of abundance available from the current assessment model, comprehensive length sampling of the commercial catch and available estimates of the von Bertalanffy growth parameter (k), method 2.1, an rfb rule with m=0.95 can be used to derive category 3 MSY advice for this stock.

Estimates of k are available from White *et al* (2011) (0.186 $year^{-1}$) and the more comprehensive study of Hüssy *et al* (2012b) (0.145 $year^{-1}$ for females, 0.181 $year^{-1}$ for males).

The calculations for the individual rfb components are described below:

Biomass ratio (r)

r is based on the relative TSB from the 2023 update assessment over the most recent 5 years. Index A, the mean for the most recent 2 years (2022,2023) is 1.82. Index B, the mean over the 3 years prior to this (2019-2021) is 1.23 such that the resultant r parameter value is 1.48.

Fishing pressure proxy (f)

Based on the analyses carried out during WKBMSYSPiCT2, L_{inf} is estimated as 153.5mm the average of the individual male (160mm) and female (147mm) estimates.

Extensive length sampling of the commercial catch of boarfish has been carried out by Ireland since 2007. Irish catches account for by far the greatest proportion of the total catch and the sampling programme covers the entire fleet exploiting boarfish.

For the purposes of calculating the target reference length ($L_{F=M}$), length at first capture (L_c) is based on the most recent 4-year period, following strong recent recruitment to the stock and is estimated at 70mm, the smallest length class for which the estimate of total catch in numbers exceeds half of the estimate at the modal length. Identical estimates of L_c result when extending the historic period to include the most recent 10 years of length sampling information. When combined with the above estimate of L_{inf}, $L_{F=M} = 0.75L_c + 0.25L_{inf} = 91$mm. The mean length in the catch for the most recent year (2022) is estimated as 103mm resulting in a fishing pressure proxy of 1.13.

Biomass safeguard (b)

The minimum relative biomass occurred in the first year of the assessment (0.52) although similar levels were reached in 2003 (0.63) and 2016 (0.62), leading to an $I_{trigger}$ of 1.4*0.52 = 0.73. With the most recent estimate of relative biomass in 2023 of 1.88, the b parameter value for application of the rfb rule is set to 1.

The selected rfb rule specifies an additional precautionary multiplier (m) of 0.95 which, when applied in conjunction with the most recent advice (22,791t), the r, f and b values outlined above leads to an advice for 2024 and 2025 more than 20% above that for 2022-23. As such, the stability rule is invoked and the increase limited to 20% (27, 349t).

3.10 Management considerations

This stock is placed in category 3 with advice is based on the harvest control rules developed by ICES WKLIFE (ICES 2022). The biomass estimate from the Bayesian model is considered reliable for trends and is used as an index of stock development. Advice is based on rfb method 2.1 (as the von Bertalanffy k parameter for boarfish is estimated to be less than 0.2). The advice is calculated 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, a biomass safeguard, a length-based fishing mortality proxy, a precautionary multiplier and the most recent advice. Table 3.9.1.1 shows the biomass estimates from the model from which the index was calculated. Although not currently accepted as the basis for an analytic assessment, the surplus production model still provides the best unified view of this stock (Figure 3.4.2.5).

3.11 Stock structure

A dedicated study on the stock structure of boarfish within the Northeast Atlantic and Mediterranean Sea was carried out in 2013. Details can be found in the stock annex. Ecosystem considerations

3.12 Ecosystem considerations

The main ecosystem aspects for boarfish in the NE Atlantic are outlined in the stock annex. Management plan.

3.13 Proposed management plan

In 2012 and 2015 the Pelagic Advisory Council submitted a proposed management strategy for Northeast Atlantic boarfish. Details of the plans and their evaluations can be found in the stock annex.

3.14 References

Beverton, R. & Holt, S. 1957. On the dynamics of exploited fish populations, fishery investigations series II volume XIX, ministry of agriculture. *Fisheries and Food*, **22**.

Blanchard, F. & Vandermeirsch, F. 2005. Warming and exponential abundance increase of the subtropical fish Capros aper in the Bay of Biscay (1973–2002). *Comptes Rendus Biologies*, **328**, 505–509.

Borges, L., Keeken, V., A, O., Helmond, V., M, A.T., Couperus, B. & Dickey-Collas, M. 2008. What do pelagic freezer-trawlers discard? *ICES Journal of Marine Science*, 65, 605–611.

Cardador, F. & Chaves, C. 2010. Boarfish (*capros aper*) distribution and abundance in Portuguese continental waters (ICES div. IXa).

Farrell, E.D., Carlsson, J.E.L. & Carlsson, J. 2016. Next gen pop gen: Implementing a high-throughput approach to population genetics in boarfish (*capros aper*). *Open Science*, **3**, 160651.

Farrell, E.D., Hüssy, K., Coad, J.O., Clausen, L.W. & Clarke, M.W. 2012. Oocyte development and maturity classification of boarfish (*capros aper*) in the northeast Atlantic. *ICES Journal of Marine Science*, **69**, 498–507.

Fässler, S.M.M., O'Donnell, C. & Jech, J.M. 2013. Boarfish (*capros aper*) target strength modelled from magnetic resonance imaging (MRI) scans of its swimbladder. *ICES Journal of Marine Science*, **70**, 1451–1459.

Hüssy, K., Coad, J.O., Farrell, E.D., Clausen, L.A.W. & Clarke, M.W. 2012a. Age verification of boarfish (*capros aper*) in the northeast Atlantic. *ICES Journal of Marine Science*, **69**, 34–40.

Hüssy, K., Coad, J.O., Farrell, E.D., Clausen, L.W. & Clarke, M.W. 2012b. Sexual dimorphism in size, age, maturation, and growth characteristics of boarfish (*capros aper*) in the northeast Atlantic. *ICES Journal of Marine Science*, **69**, 1729–1735.

ICES. 2011. Report of the Working Group on Widely Distributed Stocks (WGWIDE). 23-29 August 2011, ICES HQ, Copenhagen, Denmark. ICES CM 2011/ACOM:15, 624 pp.

ICES. 2012. ICES Implementation of Advice for Data-limited Stocks in 2012 in its 2012 Advice. ICES CM 2012/ACOM 68. 42 pp.

ICES. 2015a. EU request for ICES to evaluate the management strategy for boarfish (Capros aper) in Subareas VI–VIII (Celtic Seas and the English Channel Bay of Biscay). In Report of the ICES Advisory Committee,2015. ICES Advice 2015, Book 9, Section 9.2.3.4.2pp

ICES. 2015b. Manual for International Pelagic Surveys (IPS). Series of ICES Survey Protocols SISP 9 – IPS. 92 pp.

ICES. 2022. ICES technical guidance for harvest control rules and stock assessments for stocks in categories 2 and 3. In Report of ICES Advisory Committee, 2022. ICES Advice 2022, Section 16.4.11. https://doi.org/10.17895/ices.advice.1980156

Johnsen, E., Totland, A., Skålevik, Å., Holmin, A., Dingsør, G., Fuglebakk, E. & Handegard, N. 2019.

StoX: An open source software for marine survey analyses. *Methods in Ecology and Evolution*, **10**,

1523– 1528. https://doi .org/10.1111/2041-210X.13250

King, M. 1995. Fisheries biology, assessment and management. Oxford.

Meyer, R. & Millar, R.B. 1999. BUGS in Bayesian stock assessments. *Canadian Journal of Fisheries and Aquatic Sciences*, **56**, 1078–1087.

Minto, C., Clarke, M.W. & Farrell, E.D. 2011. Investigation of the yield- and biomass-per-recruit of the boarfish *capros aper*. Working document to WGWIDE 2011.

Stefánsson, G. 1996. Analysis of groundfish survey abundance data: Combining the GLM and delta approaches. *ICES Journal of Marine Science*, **53**, 577–588.

White, E., Minto, C., Nolan, C.P., King, E., Mullins, E. & Clarke, M. 2011. First estimates of age, growth, and maturity of boarfish (*Capros aper*): A species newly exploited in the Northeast Atlantic. *ICES Journal of Marine Science*, **68**, 61–66.

3.15 Tables

Table 3.2.2.1. Boarfish in ICES Subareas 27.6, 7, 8. Landings by country, total discards and TAC by year (t), 2001–2021. (Data provided by Working Group members)

	Den-mark	Ger-many	Ire-land	Neth-er-	Eng-land	Po-land	Scot-land	Spain	Por-tugal	Dis-cards	Total	TAC
2001			120								120	
2002			91								91	
2003			458							10929	11387	
2004			675							4476	5151	
2005			165							5795	5960	
2006			2772							4365	7137	
2007			17615				772			3189	21576	
2008	3098		21585				0			10068	34751	
2009	15059		68629							6682	90370	
2010	39805		88457				9241			6544	144047	
2011	7797		20685				2813			5802	37097	33000
2012	19888		55949				4884			6634	87354	82000
2013	13182		52250				4380			5598	75410	82000
2014	8758		34622				38			1813	45231	133957
2015	29	4	16325	375	104					929	17766	53296
2016	337	7	17496	171	21					1283	19315	47637
2017	548		15485	182	0					1173	17388	27288
2018	94		9513	172	0		0	148		1359	11286	21830
2019	757		9910	318	19			3		306	11312	21830
2020	196		14666	416	62	109		1		198	15649	19152
2021	4322		11830	781	45	45	9	11		651	17693	19152
2022	1859		14055	858	73			10	5	1037	17898	22791
	0 = <0.5t											

Table 3.2.2.2. Boarfish in ICES Subareas 27.6, 7, 8. Discards in demersal and non-target pelagic fisheries by year (data provided by Working Group members)

Year	Denmark	Germany	Ireland	Nether-lands	Spain	UK	Lithuania	Portugal
2003			119	1998	8812			
2004			60	837	3579			
2005			55	733	5007			
2006			22	411	3933			
2007			549	23	2617			
2008			920	738	8410			
2009			377	1258	5047			
2010			85	512	5947			
2011		49	107	185	5461			
2012			181	88	6365			
2013		22	47	11	5518			
2014		117	50	477	1119	50		
2015			7		921	1		
2016		869	20	41	348	4	1	
2017	386		640	146			1	
2018	744		525	89			1	
2019			57		240	8		
2020			64		133	1		
2021			11		594	46		
2022	0		5	0	1017	15		0

0 = <0.5t

Table 3.2.2.3 Boarfish in ICES Subareas 27.6

Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Denmark															37	67	172	10	23	0
England													9				9	7		9
Ireland	65	292	10	21	99*	28	45	1356	26	125	538	182	116	377	907	269	568	1214	378	114
Netherlands													128	45	34	78	79	108	52	1
Scotland								10			15	30							6	2
*6t in 5b, 0=0-0.5t																				

Table 3.2.2.4 Boarfish in ICES Subareas 27.7bc

Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Denmark											80	12	8	21				85	13	1002
England													85	1			0	32	10	3
Germany													4	5						
Ireland	214	224	105	15	1259	3	74	2293	283	4609	10405	3262	2829	1198	124	163	241	6818	3732	2262
Nether-lands													33*	35	138	10	150	212	228	12
Scotland								4		1745	100								2	
*Division 7, 0=0-0.5t																				

Table 3.2.2.5 Boarfish in ICES Subareas 27.7h-k

Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Denmark								39132	7779	18203	11828	8747	5	330	239	6	268	101	4151	775
England													10	16	0	0	3	23	23	47
Ireland	179	122	12	2360	16131	21370	63597	81160	19565	50507	38358	30925	12152	8623	2994	3745	6222	6365	6956	11680
Nether-lands														90	9	68	80	79	325	809
Poland																		109	12	
Scotland					772			9227	2813	3139	3381	8				0				
Spain																	0	0		
0=0-0.5t																				

Table 3.2.2.6 Boarfish in ICES Divisions 7e-g

Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Denmark								674							1		1	0	23	2
England															0		6		12	14
Ireland				375	120	184	4912	3649	811	616	1808	135	547		1	2		1	764	
Netherlands														0	0	3	7	1	126	2
Scotland											883									
0=0-0.5t																				

Table 3.2.2.7 Boarfish in ICES Subarea 8

Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Denmark									18		1354		6	7	271		315		111	81
England														5						
Germany													1	1						
Ireland		38	38	1	5					93	1140	119	682	7297	11458	5336	2876	269		
Netherlands													2014			14	0	17	48	33
Spain																148*	2	1	11	11
Portugal																				5
*94t in 9a, 0=0-0.5t																				

Table 3.2.5.1. Boarfish in ICES Subareas 27.6, 7, 8. Length-frequency distributions of the international catches (raised numbers in '000s) for the years 2007-2022

Length	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
4.5									14							
5.0									878							1
5.5									515					2746		
6.0				156					810		765		15868	37073	537	5058
6.5				439					14		4607	203	70362	150810	2147	1453
7.0				1090	522	56	52		513	417	5250	405	80160	233347	13936	26532
7.5			1354	1574			551		10598	1684	12616	2635	85420	147915	25740	21853
8.0			677	375	1345	185	1419		80716	8685	11473	4703	115154	38949	30699	30617
8.5				1082		555	3592	1064	49508	6412	10115	3559	67471	43556	45234	16174
9.0			677	5382	851	555	7263	327	10219	7104	3874	6554	16504	101918	107121	50374
9.5		7473	17367	7883	7012	641	47509	4916	213	23065	14047	6196	3147	115103	191656	121067
10.0	9609	11209	54130	29410	33243	2791	94702	31649	1211	46010	32346	5559	9173	100550	177751	173811
10.5		52308	174796	130889	15848	6132	59833	71344	3865	39071	36242	4450	10144	55049	98863	135187
11.0	84555	63517	343283	361774	70615	24571	18359	108261	12226	14181	32445	17658	5796	9475	72207	104658
11.5		59781	321637	655875	93487	81928	20938	82470	28142	18249	31589	22826	22722	3172	44227	64098
12.0	44199	119561	297737	739025	189434	264888	98564	84288	41613	30975	33618	24070	22353	2396	14710	29920
12.5		70990	207739	564347	114904	398772	204868	112826	42461	51110	41650	24514	17521	3251	5711	8411
13.0	82633	52308	147965	353484	133539	419060	315063	172416	59990	57000	46495	30665	28815	9494	6738	4477

Length	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
13.5		29890	149314	246146	51235	307533	285688	153742	52625	58696	43121	38698	16688	13707	8599	6754
14.0	117224	22418	105782	224611	50857	176710	210137	138549	50139	76872	45353	34080	20053	16381	8468	9886
14.5		14945	71273	127711	25309	89726	105571	74059	28771	37755	39524	29908	13809	14913	7389	8555
15.0	65338	33627	47816	125463	25569	52791	62175	43347	16087	23137	21854	15561	5710	12563	7222	18872
15.5		11209	13082	81386	5473	25065	31122	22629	8572	7841	4932	5778	1513	4304	2880	
16.0	13452	11209	19397	24256	4181	13149	14990	7672	4331	625	1020	1948	143	1041	633	
16.5		3736	4061	6209	2280	2738	4918	2134	2081	128		54	143	353	457	
17.0		3736	677	1913	456	827	1109	1361	289							
17.5							407		23					353		
18.0				283			296									
18.5									592							

Table 3.2.5.2 Boarfish in ICES Subareas 27.6, 7, 8. Number of samples collected from the catch per year

Year	Landings	Percent landings covered by sampling	No. samples	No. measured	No. aged
2001	120	0	0	0	0
2002	91	0	0	0	0
2003	458	0	0	0	0
2004	675	0	0	0	0
2005	165	0	0	0	0
2006	2772	0	0	0	0
2007	18387	NA	3	217	0
2008	24683	NA	1	152	0
2009	83688	NA	9	1475	0
2010	137503	NA	95	10675	403*
2011	31295	NA	27	4066	704
2012	80720	NA	80(68)***	9656(8565)***	814**
2013	69812	NA	76	9392	0****
2014	43418	NA	54	7008	0****
2015	16837	NA	32	3356	0****
2016	18031	NA	27	3861	0****
2017	16215	NA	18	1140	0****
2018	9927	NA	12	556	0****
2019	11006	NA	8	371	0****
2020	15451	NA	10	534	0****
2021	17042	NA	12	564	0****
2022	16860	NA	21	4756	0****

*** A common ALK was developed from fish collected from both commercial and survey samples. This comprehensive ALK was used to produce catch numbers at age data for pseudo-cohort analyses.**

**** A common ALK was developed from fish collected from Danish, Irish and Scottish commercial landings. This comprehensive ALK was used for all métiers to produce catch numbers-at-age for the pseudo-cohort analysis.**
Only aged fish measured to the 0.5cm were included in the ALK.

***** Only Irish collected samples were used for the length frequency, see stock annex.**

****** 2012 ALK was used.**

Table 3.2.5.3. Boarfish in ICES Subareas 27.6, 7, 8. Catch per country and corresponding number of samples collected in 2021

Official catch	Country	No. samples	No. measured	No. aged
1859	DK	1	263	0
10	ES	0	0	0
14055	IE	20	4 493	0
858	NL	0	0	0
5	PT	0	0	0
73	UKE	0	0	0

Table 3.3.1.1. 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+
7.25	1	1													
7.75	1	1													
8.25		1													
8.75		1	1												
9.25		1	1												
9.75			1												
10.25			1												
10.75			2	10	3										
11.25			1	29	14	2	2								
11.75				9	21	21	18	2	2	1					
12.25				4	17	22	38	12	8						1
12.75					5	9	42	37	14	6	2		1	1	1
13.25					2	4	31	28	24	12	6	2	3	1	5
13.75					1	3	25	22	21	14	6	5	4	2	11
14.25							6	8	18	22	8	3	7	1	20
14.75						1	1	2	3	8	1	6	6	6	30
15.25							1	1		2	2	2	5	2	19
15.75										2				2	19
16.25															8
16.75															1
17.25															1
17.75															1
18.25															1
18.75															1

Table 3.3.1.2. Boarfish in ICES Subareas 27.6, 7, 8. Proxy catch numbers-at-age of the international catches (raised numbers in '000s) for the years 2007-2022

Age	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
1	0	0	1575	2415	0	28	301	0	5556	218	1862	314	17427	40397	4147	16995
2	352	5488	15043	11229	2894	893	7148	695	116135	2385	4387	1736	37620	57719	21195	71996
3	2114	21140	65744	72709	41913	5467	156680	49503	32248	10737	8830	2628	9737	37192	56256	359182
4	40851	105575	338931	294382	28148	41278	58522	127520	16588	25114	34448	13610	9944	26433	78892	170175
5	48915	141300	475619	567689	30116	110272	59797	93705	24564	20263	27266	15570	12682	10162	41988	85079
6	62713	195339	543707	878363	175696	146582	68949	67275	26566	18025	21103	14731	12716	2583	16995	31560
7	26132	104031	307333	522703	143967	492078	302967	193061	74115	61229	55189	38686	29513	9113	22437	39024
8	29766	66570	172783	293719	107126	365840	250341	139124	52052	47573	38229	26821	18819	7487	8077	11792
9	56075	53159	155477	276672	77861	271916	212318	121042	44615	42478	32258	23670	15875	7897	7021	9566
10	44875	46893	130148	232122	60022	173486	160137	94225	34264	35150	25716	19395	11359	8164	5266	7206
11	14019	15289	42521	78588	46079	69396	63025	36078	12999	13297	9560	7148	4272	3049	1818	2218
12	32359	21178	61350	114600	40468	40968	41490	24895	9114	9132	7564	5846	2937	2786	1532	2085
13	4848	11854	39609	59932	24352	58888	59380	36309	13362	13774	10922	8183	4256	4152	2316	3359
14	16837	13570	31569	59060	19724	30277	30355	19064	7152	6682	5924	4554	2156	2333	1314	2379
15+	109481	112947	196967	349320	157707	217260	239366	150688	59139	49589	40797	32130	14864	17663	10006	20904

Table 3.3.2.1. Boarfish in ICES Subareas 27.6. 7, 8. Acoustic survey abundance and biomass estimates

Age	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
0										1084	259		
1	5	22			199	5	111	77	782	897	9523	587	14
2	12	11	78		319	36	127	31	389	1157	3392	3234	299
3	58	174	1843	15	17	46	345	115	97	967	2955	7537	4011
4	187	65	696	98	34	44	367	68	93	113	1315	4259	4737
5	437	95	382	102	80	6	156	107	88	157	463	619	1143
6	1166	736	254	105	112	10	209	166	106	183	150	509	1834
7	1184	974	1057	415	437	169	493	321	446	913	953	752	1857
8	704	759	879	344	363	113	463	198	183	885	207	266	554
9	1095	849	801	342	354	118	397	293	288	721	378	302	470
10	1032	956	704	332	360	97	286	625	290	331	249	122	191
11	333	651	264	130	132	17	121	339	50	81	151	41	19
12	653	1100	203	105	113	32	82	264	192	195	188	23	14
13	336	857	297	166	174	49	74	198	79	299	81	127	161
14	385	656	170	89	108	18	220	117	57	267	327	90	100
15+	3519	6354	1464	855	1195	400	931	302	759	1641	1213	148	685
TSN	11104	14257	9091	3098	3996	1157	4387	3221	3899	9888	21805	18614	16091
TSB	670176	863446	439890	187779	232634	69690	230062	186252	179156	399872	443777	451415	525701
SSB	669392	861544	423158	187654	226659	69103	218810	184624	169213	357871	351955	422722	523588
CV	21.2	10.6	17.5	15.1	17.0	19	21.9	19.9	25.4	34.8	31.0	24.0	11.0

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

EVHOE

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1997	0	5	12	7	17	195	2645	5006	3691	3570	4422	12054	16633	7200	3472	503	18	1	0	0
1998	0	1	4	25	70	2083	18263	8566	6117	5961	7082	11828	14363	9600	5261	971	8	0	0	1
1999	0	0	13	52	33	245	10949	25911	23235	6484	2818	4632	7780	6151	1357	268	8	0	0	0
2000	0	17	79	120	8	1508	26901	17725	9864	22076	16424	29584	36849	16508	5399	988	76	0	0	0
2001	0	1	45	687	490	916	21328	37173	13322	28492	31640	18378	12315	6507	3193	1272	81	4	0	0
2002	0	2	18	23	11	547	9634	29844	17728	13175	9280	9513	9615	6185	2458	642	37	1	1	0
2003	0	0	17	47	17	57	426	1663	7155	20073	24977	21358	21939	15004	7355	1599	35	0	0	0
2004	0	0	33	534	397	123	1248	1420	1308	1083	3102	7308	7224	6353	7866	3630	241	5	0	0
2005	0	2	94	964	1264	146	1097	2302	1225	1551	3182	13394	15782	9879	6012	1658	117	70	0	0
2006	1	26	111	77	74	15506	37545	10729	3611	2128	1518	1960	4165	4024	2601	940	93	2	12	0
2007	0	7	188	473	234	1511	22812	127331	65589	6442	6823	5477	6110	6003	4268	1411	118	11	0	0
2008	0	3	432	2795	823	5487	54355	256210	169633	163128	69199	38406	18310	17213	9157	3486	745	6	1	0
2009	0	6	128	194	69	1482	19663	35649	5260	3906	9562	12271	9402	10835	6722	775	39	1	0	0
2010	0	21	529	116	154	5774	46490	74999	27177	12168	37971	59369	38501	37683	15699	1555	248	8	1	0
2011	0	61	95	214	5	536	2232	8210	14905	32671	29788	50316	56963	36588	11723	3058	572	159	47	0
2012	0	9	146	594	142	2913	28823	26800	6124	11739	13607	22370	37138	44084	19963	4893	127	1	0	0
2013	0	3	48	92	10	305	2187	2141	2558	13769	9938	15006	37563	40266	20130	6888	686	0	3	0
2014	0	2	693	1386	508	84	1440	885	3074	8732	28586	39397	74122	69736	26871	3908	59	433	0	0

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2015	0	5	183	5898	4143	607	19075	179269	119004	15765	18014	61575	62024	59904	21525	5487	541	429	8	0
2016	5	31	379	846	115	733	10284	14280	17251	42132	25304	68583	130633	131220	48538	11611	1358	26	0	0
2018	0	14	4957	193861	173779	210	10910	76288	48343	29096	45773	85164	132174	157883	48603	14951	592	18	0	0
2019	2	997	6467	589	10688	531908	561517	329850	59733	4505	3418	8451	32547	61582	30031	7468	962	204	0	0
2020	3	283	1280	657	21381	408706	595107	142947	218153	421028	220190	54726	70612	97364	74415	30606	4736	1	0	0
2021	0	35	166	27	32861	954046	852223	313053	640456	208802	106995	57674	96633	65504	12047	3416	387	53	0	0
2022	0	25	78	66	15	6041	88521	309670	433131	585482	250402	80362	41907	18504	4317	885	68	0	0	0

IGFS

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2003	0	1	33	22	7	22	129	172	879	2942	2322	1325	3823	4629	2898	896	163	38	0	0
2004	0	23	63	34	8	117	628	1444	423	397	464	2276	4325	4709	3972	1019	90	5	1	0
2005	0	8	59	52	20	203	1024	585	288	636	341	3463	11457	11348	7955	1744	382	2	1	0
2006	5	60	68	48	35	212	969	621	2046	4190	8044	7946	24208	42119	32168	12296	2454	532	0	0
2007	1	6	44	18	31	501	923	1251	1638	1166	2510	3581	8275	10740	7093	1934	92	0	0	0
2008	0	0	26	18	23	127	672	531	2095	13780	17664	19268	16980	19484	15953	8789	1747	76	1	0
2009	0	3	80	76	25	94	228	486	1000	1139	9081	7749	5138	6921	5592	1084	68	1	0	0
2010	0	6	42	3	18	199	272	463	920	393	7914	34236	28611	16063	8161	1974	433	0	0	0
2011	0	7	17	5	4	189	772	592	556	669	2600	20246	22121	10851	5319	2218	269	9	6	0
2012	0	7	36	20	10	130	271	378	702	2143	1183	11104	34005	22731	10905	3901	525	4	0	0
2013	1	3	9	9	20	127	352	340	1320	2833	3971	15572	51637	52868	20485	6560	492	20	0	0

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2014	0	10	68	54	4	18	13	25	60	130	1127	3251	19125	23016	10355	2988	284	18	0	0
2015	0	3	11	16	24	193	1008	3708	848	105	713	6315	29727	48220	33024	17350	1885	531	0	0
2016	4	31	121	63	7	67	187	1515	4057	2891	1349	4111	32753	57753	40907	15527	3670	85	0	0
2017	0	0	37	131	48	132	460	652	11411	20321	5909	5520	16426	33117	29972	15815	3194	369	0	0
2018	4	51	247	139	32	45	286	585	1194	6107	17005	15168	48895	61833	36519	10722	2030	63	0	0
2019	4	19	117	47	52	262	583	173	106	487	2677	4967	6863	12080	10480	5125	772	71	4	0
2020	9	388	233	21	16	1772	2052	13941	65121	24505	7709	17859	12157	17223	9125	2499	110	2	0	0
2021	2	7	98	36	293	16275	125036	87742	210710	171970	67893	20086	16044	22040	23112	4589	816	7	1	0
2022	0	8	43	133	59	611	2778	26375	45984	58006	106343	51790	21705	25100	20712	7111	2614	318	70	0

SPNGFS

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1990	0	0	8	0	16	317	1817	2496	260	141	154	314	632	613	689	97	0	0	0	0
1991	0	1	0	0	31	690	1311	313	49	9	6	7	7	4	0	0	0	6	0	0
1992	0	57	38	9	178	3290	2743	282	48	10	8	69	162	390	779	246	95	0	0	0
1993	0	57	1206	488	97	3730	3753	421	105	54	7	4	8	3	2	0	0	0	0	0
1994	1	40	33	0	342	4789	10162	8920	3195	53	106	20	9	12	1	0	0	0	0	0
1995	0	84	108	4	342	3063	2157	220	84	65	58	105	105	90	20	4	0	0	0	0
1996	0	218	537	143	245	4457	4449	267	820	722	82	145	126	219	96	39	2	0	0	0
1997	2	102	809	441	235	3458	6824	2189	1923	534	156	353	161	88	3	0	0	0	0	0
1998	3	2	7	4	49	1920	4685	2217	337	153	125	88	147	135	86	13	2	3	0	0

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1999	0	6	59	13	134	2736	3010	193	106	83	109	143	390	645	402	69	0	0	0	0
2000	0	7	3729	2046	17	554	1947	489	277	486	756	1252	999	1021	199	34	13	0	0	0
2001	0	68	4	1	153	3241	5085	659	225	206	205	236	692	407	120	22	9	0	0	0
2002	0	4	20	0	133	2333	2013	284	50	58	54	60	231	314	72	9	0	0	0	0
2003	0	4	950	567	4	77	221	57	39	28	16	22	17	23	16	5	1	0	0	0
2004	0	6	22	4	43	2289	3808	443	110	83	58	219	931	776	303	2	1	0	0	0
2005	0	16	451	25	9	754	1007	207	85	102	30	54	257	218	90	44	2	0	0	0
2006	0	14	156	160	50	2238	8913	4507	175	94	9	36	229	419	169	9	2	0	0	0
2007	0	49	40	1	111	3025	6620	1099	129	260	81	7	93	215	89	21	3	0	0	0
2008	7	4	92	247	1	936	1561	1326	234	1483	304	537	11	833	201	186	11	0	0	0
2009	1	17	62	119	11	2587	3893	4070	119	250	45	142	59	819	120	17	1	1	0	0
2010	0	55	102	5	232	13090	22032	3169	1160	1056	89	82	179	1007	1981	518	9	0	0	0
2011	0	29	260	105	46	2805	5511	1278	148	340	145	100	144	591	724	134	3	1	0	0
2012	0	29	132	35	556	7550	7844	1364	88	53	59	170	1051	2394	1553	432	21	0	0	0
2013	0	0	2	11	126	2163	4664	854	302	609	251	61	113	134	156	81	8	0	0	0
2014	0	75	117	6	12	263	465	79	1083	1175	1174	1266	998	2444	3623	817	31	1	0	0
2015	0	13	67	3	58	1889	4248	534	75	465	750	970	695	1173	1473	453	70	1	0	0
2016	0	17	99	5	41	922	2423	473	925	746	346	548	452	561	169	22	4	0	0	0
2017	1	23	20	1	16	641	1947	755	134	165	285	405	579	967	936	177	13	3	0	0
2018	0	0	2	0	45	708	1635	258	43	99	230	605	1370	3324	3865	949	3	0	0	2

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2019	0	12	2	1	259	4128	3887	379	18	83	273	329	717	4200	8402	2215	202	0	0	0
2020	0	8	33	2	33	1218	2123	525	387	314	75	225	705	2518	4751	1603	10	0	0	0
2021	1	10	11	0	42	803	2654	562	127	1367	3149	1102	2200	4773	6485	1175	118	1	0	0
2022	0	12	38	2	35	1640	3395	550	220	465	1945	3197	3705	9321	7926	3200	39	0	0	0

SPPGFS

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2001	0	1	0	1	1	2	0	44	5	52	133	162	667	1129	230	40	0	0	0	0
2002	0	0	0	0	0	0	0	0	1	4	90	212	791	843	313	60	0	0	0	0
2003	0	0	0	0	0	1	0	3	15	22	21	62	268	426	249	51	2	1	0	0
2004	0	1	0	0	0	6	3	0	5	6	23	124	385	592	390	52	1	0	0	0
2005	0	1	0	1	8	1	20	11	10	16	8	118	628	1118	833	272	23	0	0	0
2006	0	0	1	1	8	120	118	26	43	95	34	58	431	863	716	252	13	1	0	0
2007	0	0	0	0	4	5	12	20	16	12	37	34	96	202	191	34	5	0	0	0
2008	0	1	0	0	0	1	17	10	23	19	79	156	349	666	442	113	7	0	0	0
2009	0	8	7	0	3	10	11	1	0	2	220	457	1333	1746	1698	474	11	0	0	0
2010	2	0	0	1	6	17	4	1	6	3	43	390	710	976	620	164	13	0	0	0
2011	0	0	0	0	0	0	0	4	20	22	6	180	815	960	522	151	17	0	2	0
2012	0	0	0	1	1	0	0	2	2	1	10	87	456	570	267	79	4	0	0	0
2013	0	0	0	1	0	8	24	7	10	0	1	48	500	1032	564	163	15	1	0	0
2014	0	10	9	0	1	0	3	17	62	11	6	85	2453	6703	3168	2115	162	82	0	0

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2015	0	0	0	2	1	0	0	1	1	0	0	32	300	471	316	151	43	0	0	0
2016	0	0	3	0	0	0	1	0	13	7	0	9	157	336	220	84	19	0	0	0
2017	0	67	19	0	0	0	10	0	0	1	18	26	148	498	529	268	17	0	0	0
2018	0	2	1	0	0	0	1	0	0	0	0	37	1159	3574	2449	1131	159	0	0	0
2019	5	36	4	0	0	0	0	0	3	4	0	15	426	952	796	192	15	0	0	0
2020	0	5	1	0	0	4	1	1	2	4	0	26	250	616	851	661	111	0	0	1
2021	1	20	0	0	5	12	0	5	34	38	24	39	129	916	768	357	147	3	0	0
2022	1	0	3	6	4	6	3	9	16	79	102	45	74	395	409	222	42	3	0	0

WCSGFS

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	3	2	0	3	24	42	62	172	210	1286	856	450	52	17	0	0	0	0
1991	0	0	0	2	0	31	138	80	183	644	683	848	226	89	12	1	2	4	0	0
1992	0	0	0	1	0	8	12	14	44	478	1160	4028	1674	502	5	0	0	0	0	0
1993	0	0	0	0	0	1	109	2	670	2078	1074	4904	2753	2882	28	2	0	0	0	0
1994	0	0	2	0	0	0	15	30	30	205	283	312	454	388	147	0	0	0	0	0
1995	8	12	18	4	2	10	40	30	94	162	640	1485	1770	1139	318	14	2	4	6	0

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1996	0	0	0	4	0	10	48	27	49	48	64	188	920	1888	416	18	1	0	0	0
1997	0	0	4	0	0	1	17	42	120	64	116	249	436	301	91	8	4	0	0	0
1998	0	0	0	1	0	1	7	6	7	16	47	69	105	171	78	8	2	0	0	0
1999	0	0	1	0	0	2	6	8	189	221	312	458	346	221	69	0	0	0	0	0
2000	0	0	0	0	0	0	3	3	42	118	230	303	206	108	54	8	0	0	0	0
2001	0	1	0	0	0	0	0	1	12	27	54	90	233	414	242	80	15	1	0	0
2002	0	0	0	0	0	1	8	2	1	82	759	3243	5711	5896	1558	189	1	0	0	0
2003	0	0	1	0	0	0	3	52	9	107	326	1536	3294	5409	3553	413	37	0	0	0
2004	0	0	0	1	0	0	6	2	45	83	744	4576	8611	9526	5698	954	84	0	0	0
2005	0	2	0	0	0	9	38	15	30	31	113	442	1115	1747	818	141	9	3	2	0
2006	0	1	2	1	0	2	9	4	22	256	311	508	1524	2964	2104	449	73	2	0	0
2007	0	0	3	2	0	8	14	65	118	182	795	2938	5220	6953	5332	1538	116	0	0	0
2008	0	1	3	0	0	16	37	38	200	482	1406	3218	9904	22777	18407	6293	575	71	0	0
2009	0	0	1	0	1	1	4	6	64	2460	2246	694	505	416	338	136	12	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	530	1443	1384	1357	828	149	29	0	0	0

Table 3.3.3.2 Boarfish in ICES Subareas 27.6, 7, 8. IBTS length-frequency data converted to age-structured indices by application of the 2012 common ALK rounded down to 1cm length classes

EVHOE

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1997	1323	5891	4835	3829	3369	3053	9614	6955	5556	3779	1521	973	1456	828	6235
1998	9132	16881	8109	6147	4527	3452	9545	6632	5452	4058	1597	1312	1733	1022	8419

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1999	5474	30494	25366	5015	2592	1427	4373	3215	2887	2276	855	564	888	491	3675
2000	13450	28555	16758	19454	12310	8420	23424	16159	12783	8538	3354	1885	3099	1722	12485
2001	10664	39887	26874	27998	16428	8946	15285	7816	5688	3538	1301	863	1271	750	6396
2002	4817	30622	24313	11299	6215	3393	7688	4838	3852	2716	1035	726	1060	611	4928
2003	213	3707	9293	20716	13365	8409	18107	11109	8937	6448	2467	1932	2635	1547	12700
2004	624	2006	1574	1777	1923	1842	5376	3816	3078	2541	1075	1423	1434	932	11369
2005	549	2492	1901	2205	2758	2983	9853	7261	5865	4310	1727	1437	1869	1110	9951
2006	18772	27129	6395	1838	1086	692	2217	1683	1593	1407	557	586	688	416	4256
2007	11406	118156	87434	6252	3796	2250	4968	3140	2686	2208	861	923	1067	657	6591
2008	27177	254528	229646	124210	54539	19047	30818	15021	10954	7348	2618	2251	2934	1795	16959
2009	9832	35351	16200	5643	4832	3830	8969	5783	4721	3809	1459	1524	1806	1110	9216
2010	23245	82303	45710	20517	19648	16749	39369	25075	19324	14156	5280	4343	5906	3511	26732
2011	1116	11557	19043	30617	20479	14495	39161	26846	21792	15613	5980	3928	6016	3404	27139
2012	14412	34320	15329	11984	8843	6877	21882	16580	15805	14165	5382	5221	6581	3893	34397
2013	1093	3373	5082	11975	7436	5156	18526	14722	14572	13248	5121	5049	6254	3703	35819
2014	720	2334	4216	15081	14776	13252	40953	30549	28568	24182	9208	7776	10517	6071	49039
2015	9537	168718	142196	16589	15129	14025	43805	31952	26892	21239	8025	6461	8982	5218	43843
2016	5142	20412	24368	35467	23775	18507	68150	53795	50979	44038	16743	14289	19326	11149	95082
2018	5455	72428	63489	33998	28889	24760	79148	59901	56898	49999	18526	15688	21690	12453	106474
2019	280759	520569	150645	4035	3104	2844	14950	13581	15700	16891	6358	7404	8669	5219	49538

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2020	297553	465569	273832	332726	148543	51435	79125	38909	36296	32676	12326	15407	16693	10460	118335
2021	426111	848299	571349	164881	76916	31315	65603	40367	35579	26598	9833	5812	9725	5289	39566
2022	44260	395084	503808	445388	190241	59875	81650	32581	22992	12777	4165	1890	3565	2040	12932

IGFS

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2003	64	472	1214	2586	1401	743	2065	1523	1556	1484	578	653	750	456	4672
2004	314	1418	842	434	493	543	2252	1838	1732	1603	653	802	864	541	5422
2005	512	998	509	567	717	908	4790	4166	4162	3867	1557	1730	1973	1201	11568
2006	484	1580	2423	5269	4211	3388	12623	10487	11436	12263	4853	6606	6952	4368	50651
2007	462	1842	1748	1576	1408	1235	4362	3474	3496	3378	1326	1557	1754	1076	10509
2008	336	1388	4302	14466	9811	6581	15265	9859	8231	6912	2728	3247	3553	2238	28119
2009	114	772	1117	3682	3665	2967	5991	3553	2883	2398	928	1136	1233	783	7266
2010	136	752	906	3336	6161	7220	21721	15262	11417	7656	3025	2151	3055	1795	14845
2011	386	966	715	1598	3198	4038	13856	10232	7932	5384	2159	1453	2121	1224	10962
2012	136	622	1006	1911	2306	2843	13844	11639	10956	8966	3576	2903	3900	2242	21003
2013	176	843	1557	3292	3917	4545	21801	18670	19029	17278	6613	5870	7777	4484	40599
2014	6	43	82	492	927	1262	7300	6613	7255	7083	2717	2714	3384	1986	18529
2015	504	3259	1827	403	1251	1945	12476	11625	13072	13999	5512	7082	7697	4765	58017
2016	93	2456	3763	2302	1775	1846	13082	12553	14753	16394	6464	8634	9226	5742	65723
2017	230	4468	11683	14642	6277	2402	9024	7578	8395	9474	3824	5785	5766	3703	49915

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2018	143	930	2275	9391	8194	6861	23782	19030	19873	19320	7511	8412	9756	5903	59025
2019	292	442	242	1229	1449	1419	4664	3618	3540	3626	1453	2058	2107	1346	16899
2020	1026	32027	52719	18043	8761	4356	11714	8061	6664	5578	2105	2193	2649	1618	14790
2021	62518	191249	202522	128995	53951	16137	23800	10942	9297	7968	3069	4310	4329	2815	28141
2022	1389	34301	51195	70323	46874	28049	43180	20071	14649	10314	3757	4203	4709	3015	32808

SPNGFS

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1990	909	2660	1033	142	110	93	335	263	243	224	95	128	129	83	770
1991	656	880	138	8	4	2	6	3	3	2	1	0	1	0	8
1992	1371	1575	128	10	13	16	97	89	92	122	57	124	102	71	965
1993	1877	2192	220	36	13	2	5	3	2	2	1	0	1	0	3
1994	5081	12093	5114	66	43	23	28	9	7	5	1	1	1	1	5
1995	1079	1254	142	61	41	29	78	54	44	33	12	8	13	7	53
1996	2225	2676	772	479	175	40	109	77	70	65	24	25	31	18	181
1997	3412	5512	2113	389	183	84	198	123	82	47	17	6	14	8	43
1998	2343	3933	993	137	76	41	96	64	58	49	19	19	23	14	125
1999	1505	1669	151	88	66	53	202	168	181	188	73	89	100	61	556
2000	973	1392	445	562	447	351	877	582	475	359	130	88	138	78	577
2001	2542	3057	410	197	130	93	311	237	219	170	66	43	66	36	286
2002	1006	1212	139	54	35	26	103	87	95	92	33	28	40	22	172

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2003	110	162	50	23	12	7	16	11	9	8	3	3	4	2	25
2004	1904	2236	237	74	66	71	359	310	313	273	106	88	120	68	508
2005	504	670	145	74	36	21	99	85	86	76	30	25	34	19	191
2006	4457	7519	1636	62	27	14	93	89	106	114	42	46	56	33	268
2007	3310	4086	502	187	74	19	50	39	50	56	20	24	28	17	155
2008	781	1743	878	1031	419	134	290	185	174	186	60	69	89	53	594
2009	1947	4700	1483	173	75	31	113	100	138	174	56	59	81	46	363
2010	11016	13516	2029	689	234	34	167	157	182	283	134	313	253	178	2099
2011	2756	3657	590	260	117	46	134	106	121	158	67	127	114	77	791
2012	3922	4860	523	54	58	68	465	450	551	640	247	337	361	225	2268
2013	2332	3002	602	460	194	59	100	54	51	48	19	28	28	18	238
2014	232	646	978	1123	697	431	1071	739	675	751	325	610	539	367	3971
2015	2124	2505	322	542	409	300	726	482	406	388	162	260	245	163	1874
2016	1211	1835	917	584	300	157	397	267	226	184	67	55	77	45	347
2017	974	1522	374	199	161	129	397	301	291	298	121	178	178	115	1130
2018	817	1004	135	145	163	171	810	719	786	945	398	690	641	424	4531
2019	1943	2202	156	143	137	120	669	645	749	1182	560	1325	1065	752	9058
2020	1062	1540	492	224	113	68	460	447	505	731	341	759	623	436	5435
2021	1327	1744	554	1855	1300	818	1784	1197	1245	1445	616	1116	1005	675	7033
2022	1698	2138	433	955	1015	934	2952	2295	2350	2592	1026	1553	1560	1004	11458

SPPGFS

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2001	0	31	29	77	73	68	300	262	304	308	110	94	135	76	596
2002	0	0	2	34	58	71	330	283	294	270	103	92	122	70	584
2003	0	7	15	21	20	21	115	105	117	123	48	57	65	39	366
2004	1	3	5	13	25	34	177	158	169	175	69	85	94	58	515
2005	10	21	14	14	25	38	264	251	288	319	126	172	182	114	1218
2006	59	91	56	71	39	28	184	176	209	242	97	142	145	92	1021
2007	6	25	20	20	18	15	54	46	50	58	23	36	36	23	230
2008	8	23	23	40	47	48	193	163	176	188	73	95	104	64	636
2009	6	7	3	78	127	147	639	540	550	561	232	325	329	210	2203
2010	2	5	5	22	61	85	379	317	313	301	118	138	156	96	930
2011	0	9	19	19	35	52	320	290	310	301	118	125	149	89	861
2012	0	2	3	5	18	28	176	161	177	174	67	68	84	50	466
2013	12	20	9	1	12	22	197	197	244	277	105	132	148	90	899
2014	2	33	49	11	45	89	992	1044	1403	1685	624	783	898	543	6669
2015	0	1	1	1	7	14	112	109	126	137	54	68	75	46	564
2016	1	5	10	5	4	6	61	62	78	91	35	48	51	32	360
2017	5	5	0	7	10	12	80	80	100	132	54	96	90	59	786
2018	0	0	0	1	19	41	501	534	718	906	349	516	536	337	4050
2019	0	1	3	3	8	15	167	172	215	260	104	157	158	101	1040

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2020	0	2	2	3	7	11	113	115	136	177	77	146	129	87	1519
2021	0	15	32	32	20	14	104	109	154	219	86	149	144	94	1290
2022	2	13	29	82	50	28	76	60	74	100	41	75	69	46	655

WCSGFS

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	12	61	90	197	233	248	736	509	363	224	85	38	74	41	261
1991	69	184	275	631	405	256	482	257	153	72	25	8	19	12	63
1992	6	30	133	733	849	840	2097	1321	823	409	155	41	112	63	301
1993	54	279	846	1723	1227	981	2777	1908	1446	1017	359	177	351	191	1165
1994	8	38	71	222	157	112	292	202	179	143	54	43	60	35	250
1995	20	71	109	328	387	385	1141	811	665	480	184	116	183	102	718
1996	24	59	51	53	58	67	398	375	458	490	174	160	222	126	953
1997	8	76	107	81	76	71	233	174	154	119	46	31	47	26	197
1998	4	10	10	26	25	22	68	52	52	50	19	20	24	15	121
1999	3	71	173	244	182	134	315	199	150	100	38	24	37	21	141
2000	2	18	53	151	122	93	205	125	90	56	22	14	21	12	92

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2001	0	5	14	35	33	30	122	103	112	118	45	55	62	38	397
2002	4	6	23	347	634	778	3010	2402	2269	1942	725	559	813	459	3480
2003	2	39	46	196	311	380	1730	1482	1545	1585	619	774	853	528	4647
2004	3	19	52	367	802	1054	4442	3641	3470	3148	1237	1315	1553	939	8289
2005	19	39	32	63	97	118	547	472	504	506	191	207	250	149	1307
2006	4	15	67	266	208	177	781	680	760	834	326	442	470	294	2900
2007	7	90	141	415	626	727	2893	2356	2285	2205	881	1104	1195	746	7600
2008	18	110	248	798	948	1026	5180	4696	5396	6246	2479	3677	3739	2381	26466
2009	2	27	524	2249	1182	537	771	336	263	187	68	70	81	51	531
2010	0	0	4	191	315	347	1030	738	612	492	192	191	231	140	1236

Table 3.4.2.1 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

Parameter	Mean	SD	2.5	25	50	75	97.5
r	0.32	0.16	0.05	0.21	0.31	0.43	0.67
K	691791	434944	321000	457800	573100	760400	1890000
Fmsy	0.16	0.08	0.03	0.10	0.16	0.21	0.34
Bmsy	345896	217472	160500	228900	286550	380200	945000
TSB	734324	352743	393000	540200	656900	823300	1517000

Table 3.4.2.2 2Boarfish in ICES Subareas 27.6, 7, 8. Estimates of total stock biomass and F

Year	TSB.2.5	TSB.50	TSB.97.5	F2.5	F.50	F.97.5
1991	95650	182100	445100			
1992	155000	280000	663500			
1993	189400	341900	811997			
1994	222800	404800	967800			
1995	194100	351100	836697			
1996	194600	350400	840500			
1997	166700	295600	700997			
1998	219500	386500	911995			
1999	163600	291400	690297			
2000	143600	254700	603597			
2001	160300	278900	655097			
2002	138100	239600	561897			
2003	127400	220700	514000	0.02	0.05	0.09
2004	174200	300300	702892	0.01	0.02	0.03
2005	168800	292100	685900	0.01	0.02	0.04
2006	214400	365300	850797	0.01	0.02	0.03
2007	193400	333300	775900	0.03	0.06	0.11
2008	237000	402600	931097	0.04	0.09	0.15
2009	241800	407700	933800	0.10	0.22	0.37
2010	357702	600400	1389975	0.10	0.24	0.40
2011	316600	536100	1256000	0.03	0.07	0.12
2012	453300	745000	1704000	0.05	0.12	0.19
2013	304000	509400	1188000	0.06	0.15	0.25
2014	144600	241300	559700	0.08	0.19	0.31
2015	171902	288600	668997	0.03	0.06	0.10
2016	127400	215600	502200	0.04	0.09	0.15
2017	223000	376400	875397	0.02	0.05	0.08
2018	239500	404200	937197	0.01	0.03	0.05
2019	203400	342200	795597	0.01	0.03	0.06

Year	TSB.2.5	TSB.50	TSB.97.5	F2.5	F.50	F.97.5
2020	238300	408200	950695	0.02	0.04	0.07
2021	320500	543800	1259000	0.01	0.03	0.06
2022	367402	617500	1419000	0.01	0.03	0.05
2023	393000	656900	1517000			

3.16 Figures

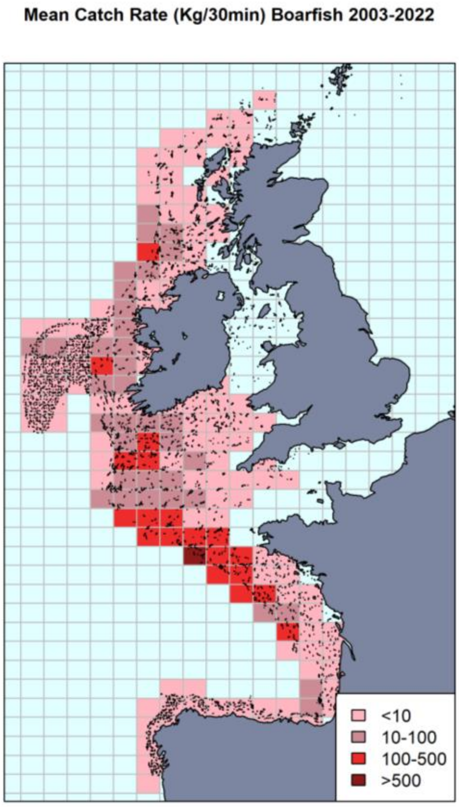


Figure 3.1.1.1. Boarfish in ICES Subareas 4, 27.6, 7, 8 and 9. Distribution and mean catch rates of boarfish in the NE Atlantic area from IBTS surveys (all years).

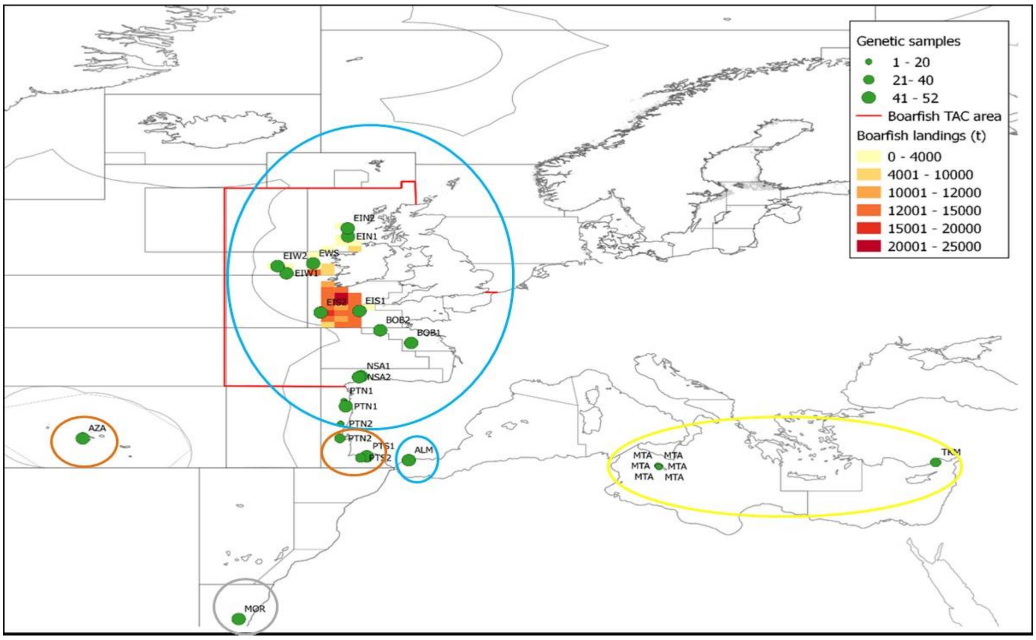


Figure 3.1.1.2. Boarfish in ICES Subareas 27.6, 7, 8. Boarfish samples included in the genetic stock identification study are indicated in green. Population clusters identified by the STRUCTURE analyses are indicated by colour coded circles.

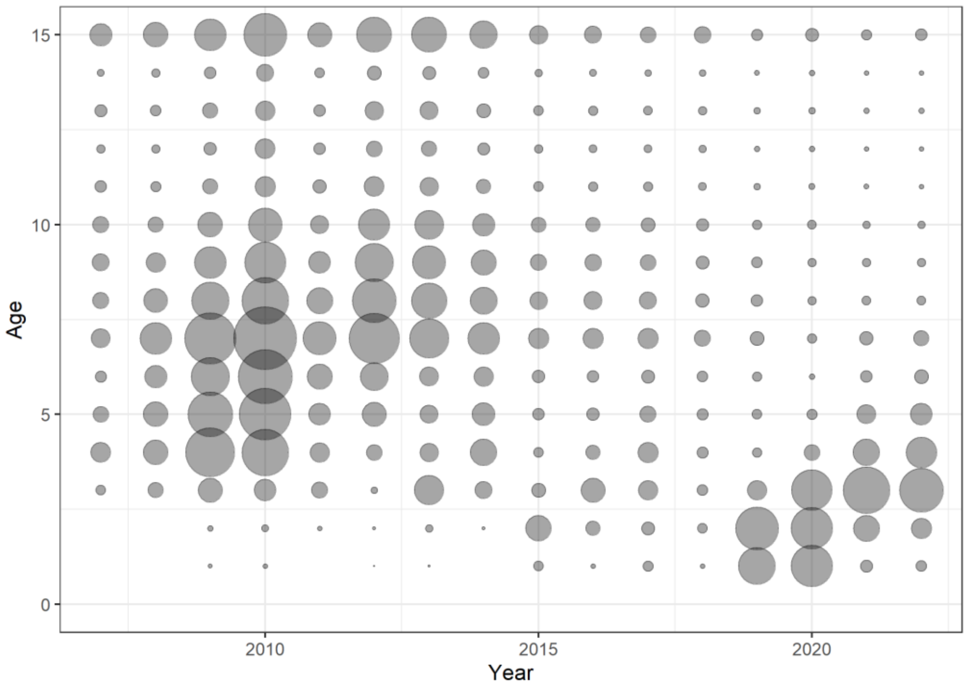


Figure 3.3.1.1. Boarfish in ICES Subareas 27.6, 7, 8. Catch numbers-at-age standardised by yearly mean. 15+ is the plus group.

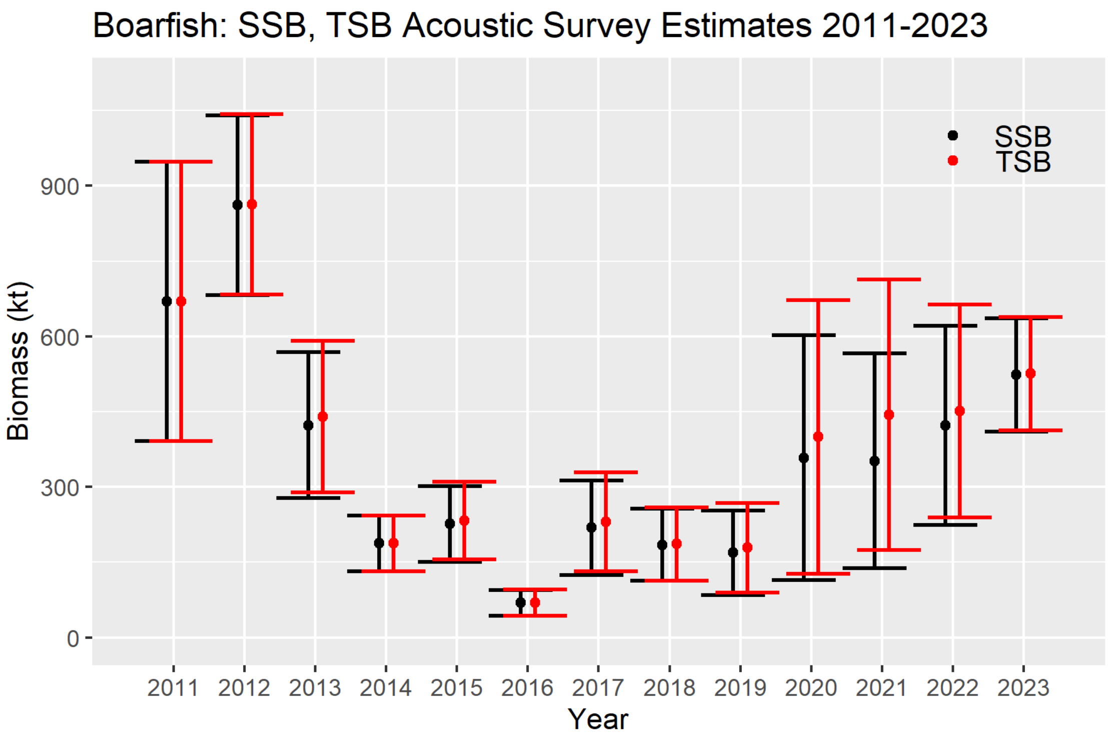


Figure 3.3.2.1. Boarfish in ICES Subareas 27.6, 7, 8. Boarfish acoustic survey track and haul positions 2023 (left), estimates of biomass at length by stratum (right).

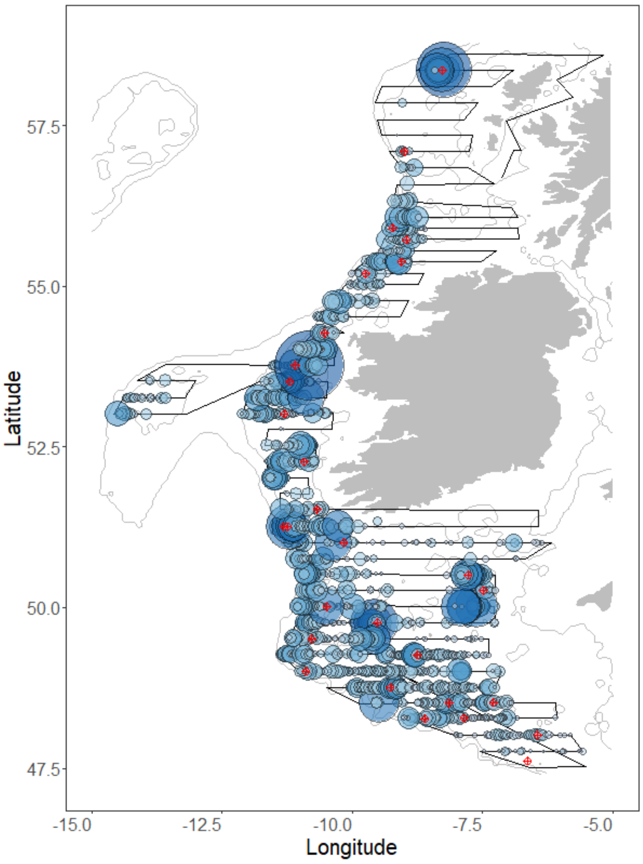


Figure 3.3.2.2. Boarfish in ICES Subareas 27.6, 7, 8. Boarfish acoustic survey track and haul positions 2023

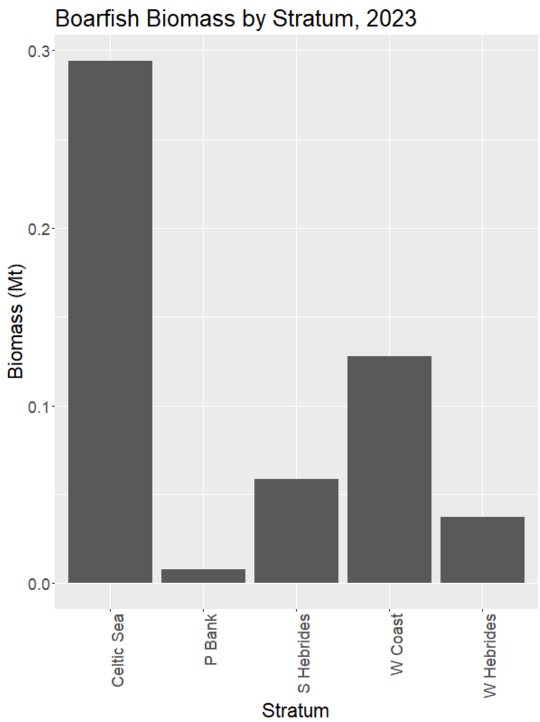


Figure 3.3.2.3. Boarfish in ICES Subareas 27.6, 7, 8. Boarfish acoustic survey biomass estimate by stratum, 2023.

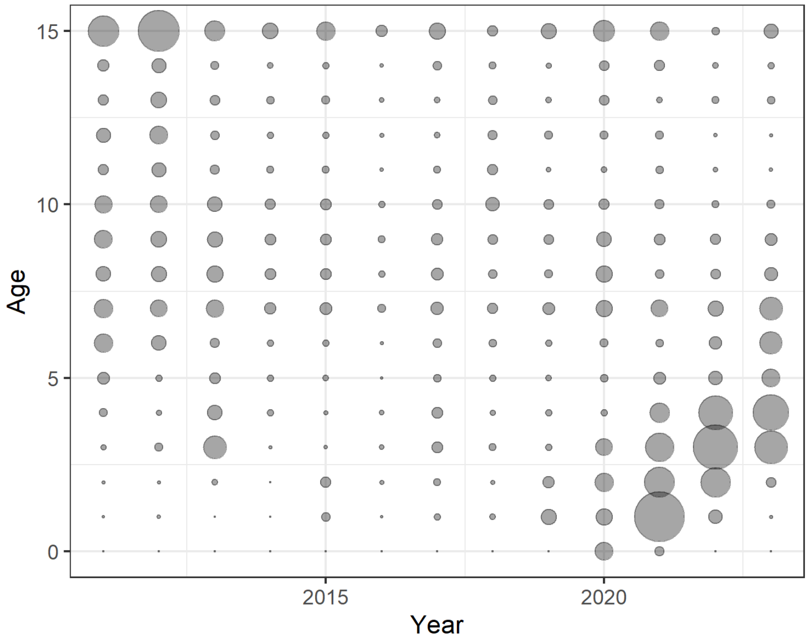


Figure 3.3.2.4. Boarfish in ICES Subareas 27.6, 7, 8. Boarfish acoustic survey time series of acoustic estimates of abundance at age, 2011 - 2023.

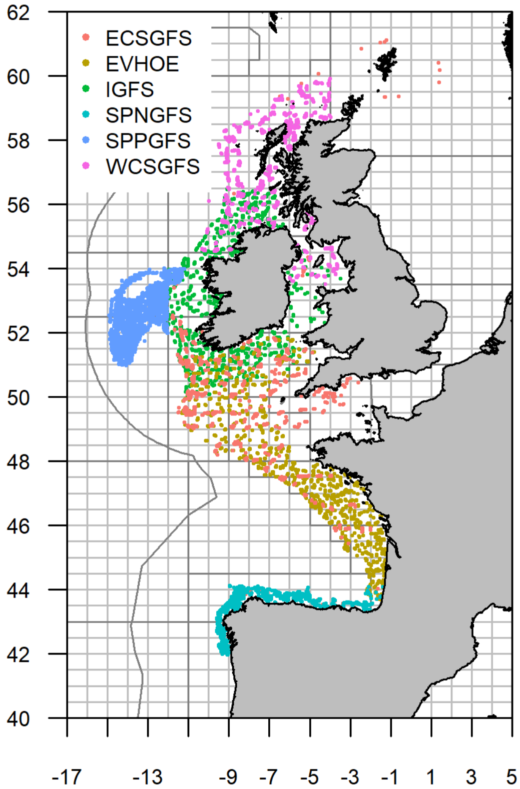


Figure 3.3.3.1. Boarfish in ICES Subareas 27.6, 7, 8. Spatial coverage and haul positions of bottom trawl surveys analysed as an index for boarfish abundance.

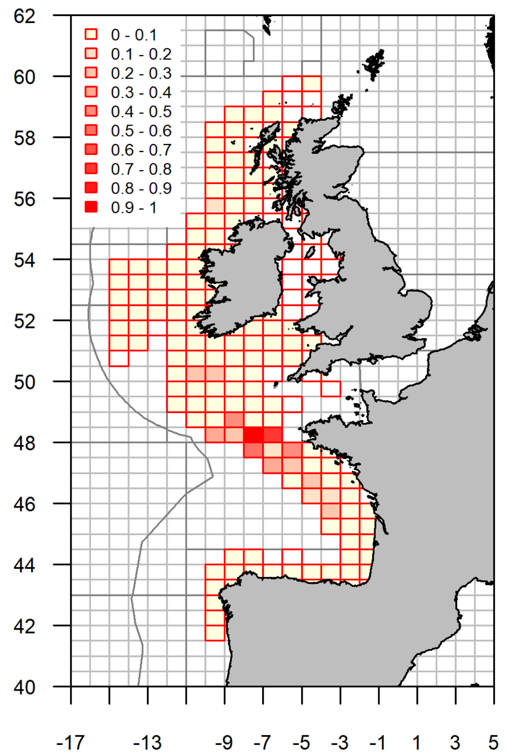


Figure 3.3.3.2. Boarfish in ICES Subareas 27.6, 7, 8. Distribution of boarfish in the NE Atlantic from the 6 IBTS surveys.

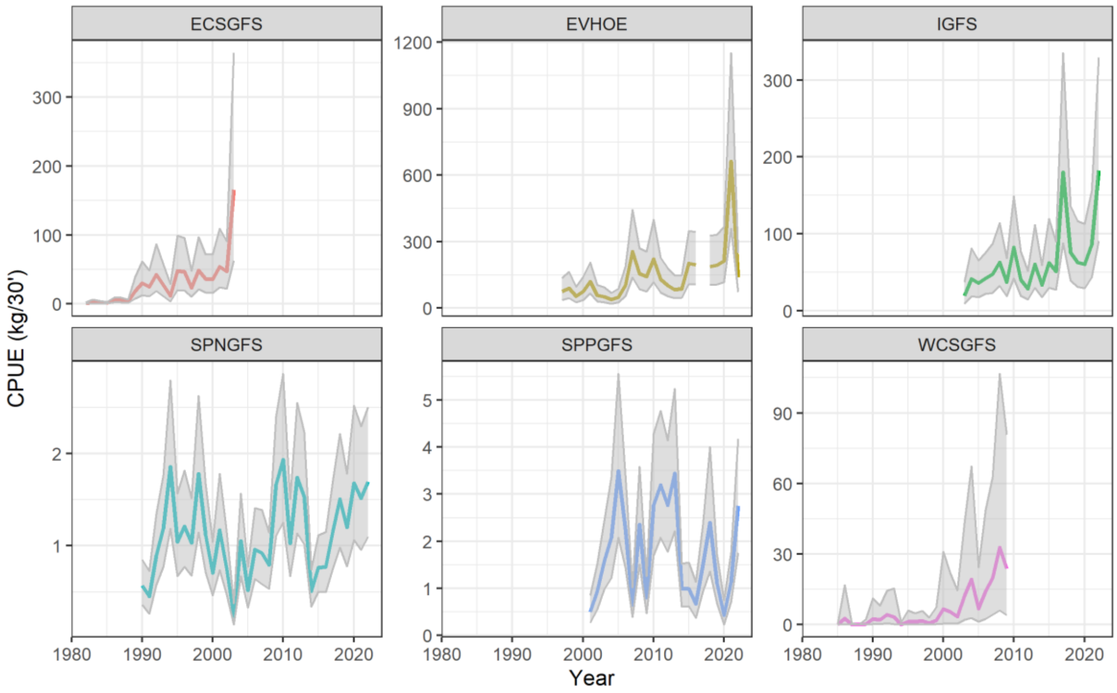


Figure 3.3.3.3 Boarfish in ICES Subareas 27.6, 7, 8. Boarfish IBTS survey CPUE fitted delta-lognormal mean (solid line) and 95% credible intervals (grey region).

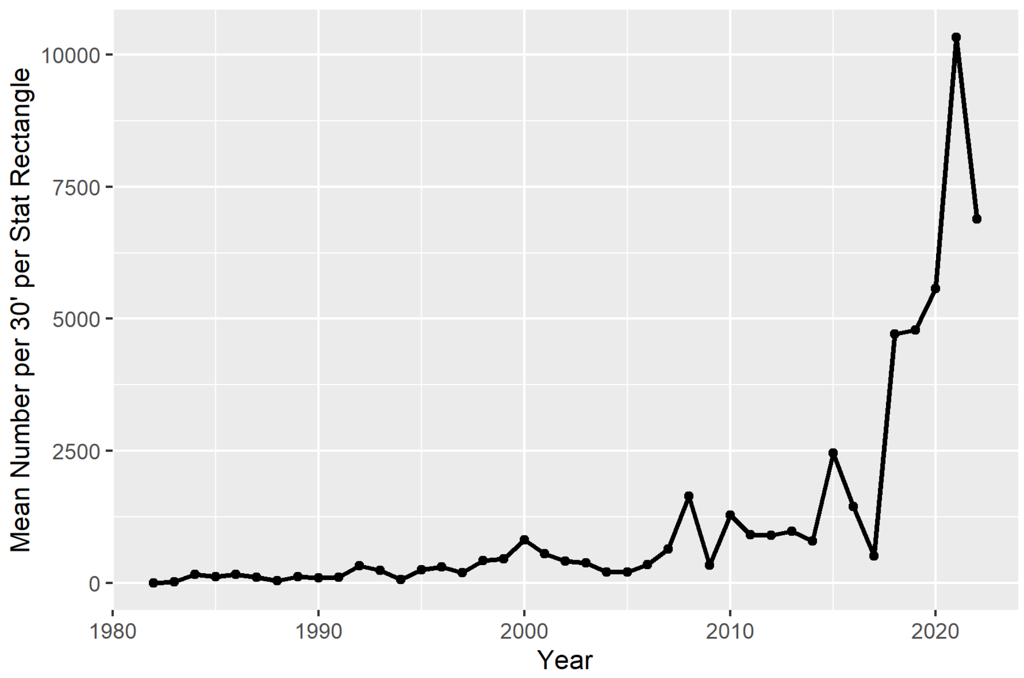


Figure 3.3.3.4a. Boarfish in ICES Subareas 27.6, 7, 8. CPUE in number per 30-minute haul of boarfish per rectangle in the western IBTS survey 1982 to 2022.

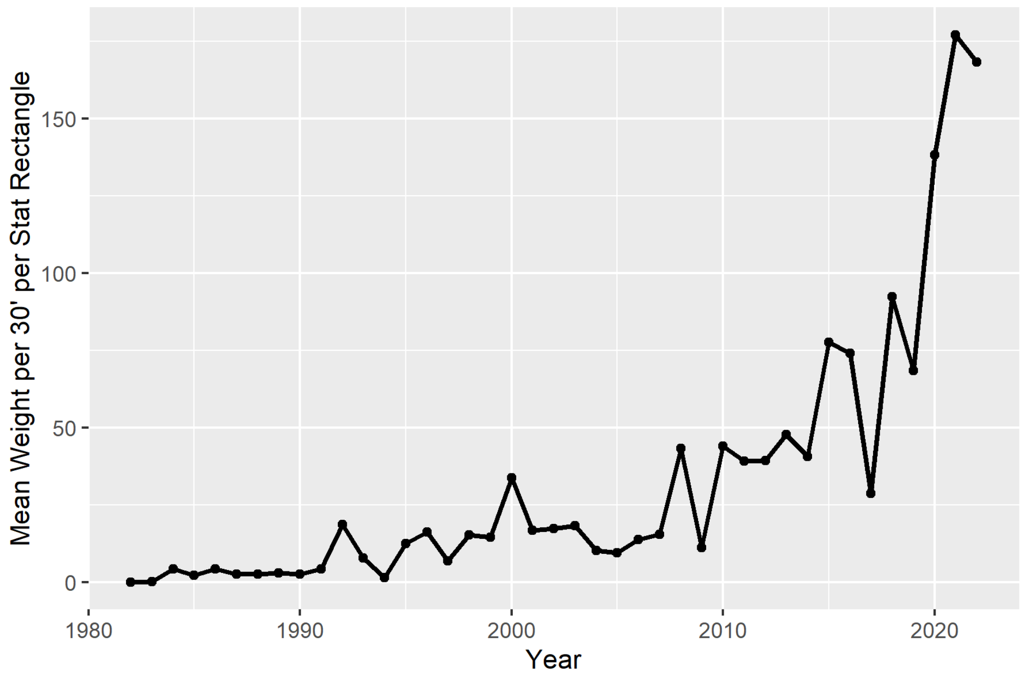


Figure 3.3.3.4b. Boarfish in ICES Subareas 27.6, 7, 8. CPUE in kg per 30-minute haul of boarfish per rectangle in the western IBTS survey 1982 to 2022.

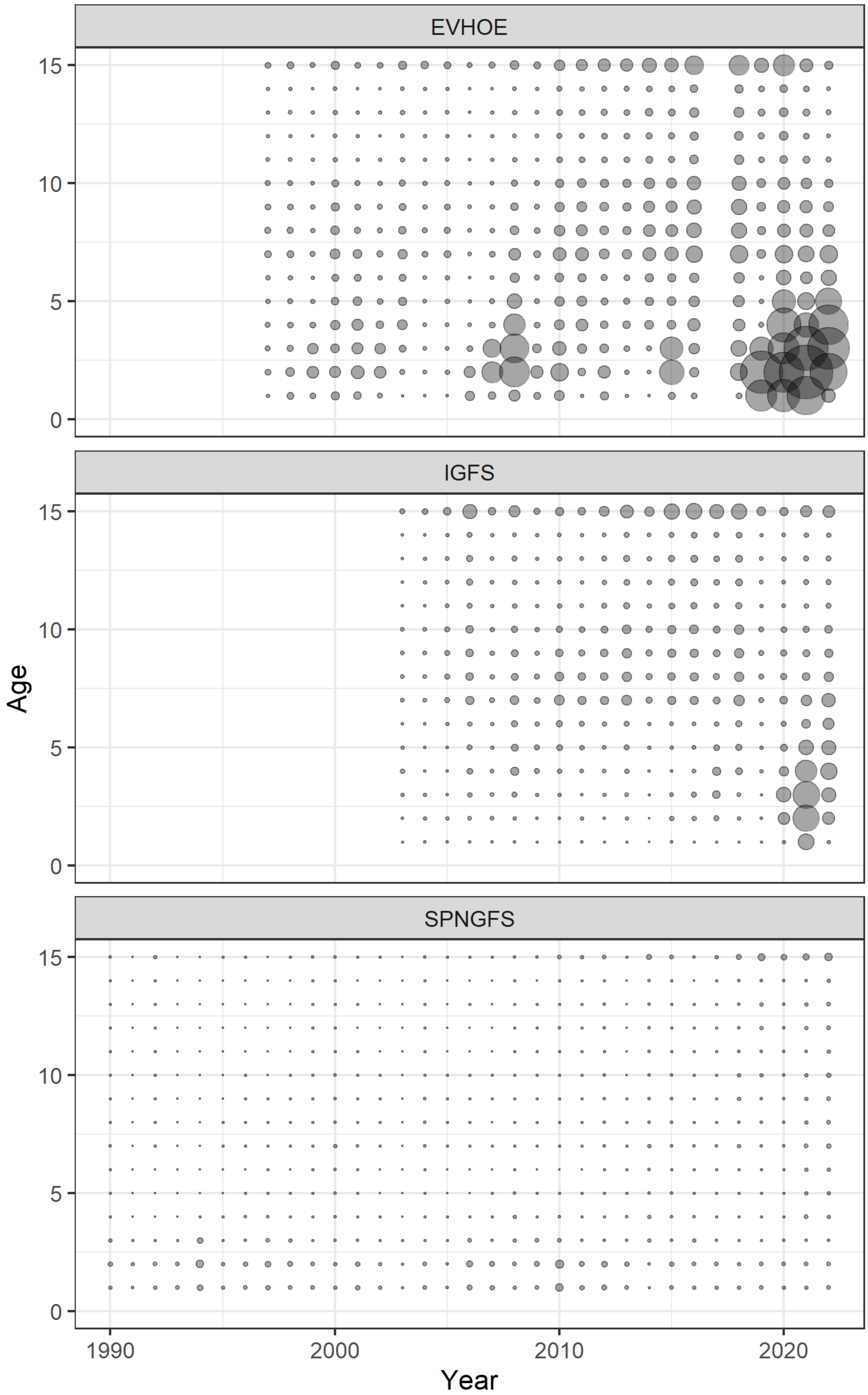


Figure 3.3.3.5. Boarfish in ICES Subareas 27.6, 7, 8. Abundance-at-age in EVHOE, IGFS and SPNGFS surveys. Yearly mean standardised abundance-at-age.

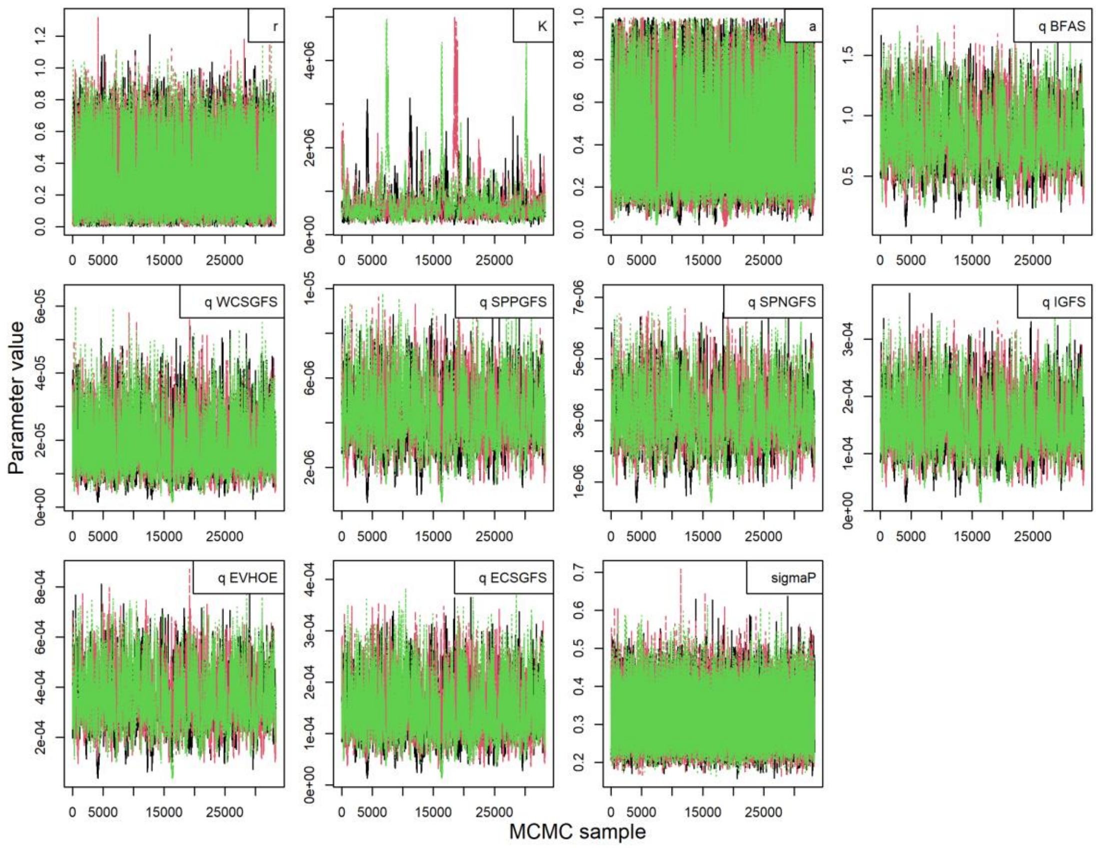


Figure 3.4.2.1. Boarfish in ICES Subareas 27.6, 7, 8. MCMC chain autocorrelation for final run.

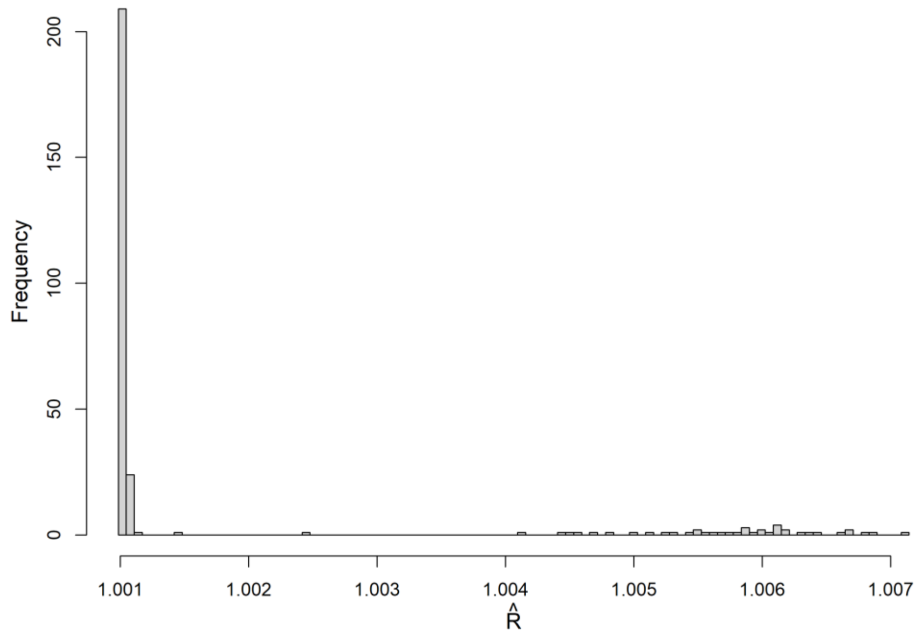


Figure 3.4.2.2. Boarfish in ICES Subareas 27.6, 7, 8. Rhat values lower than 1.01 indicating convergence.

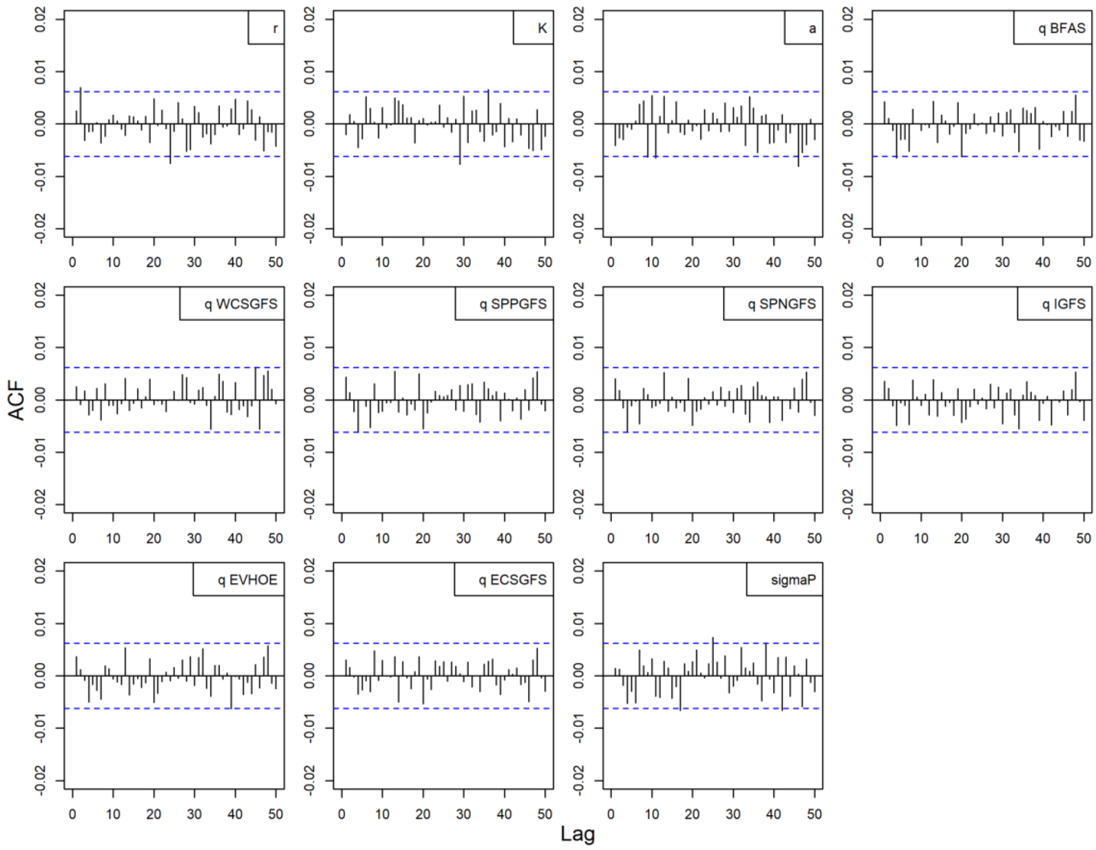


Figure 3.4.2.3. Boarfish in ICES Subareas 27.6, 7, 8. Parameters for final run converged with good mixing of the chains.

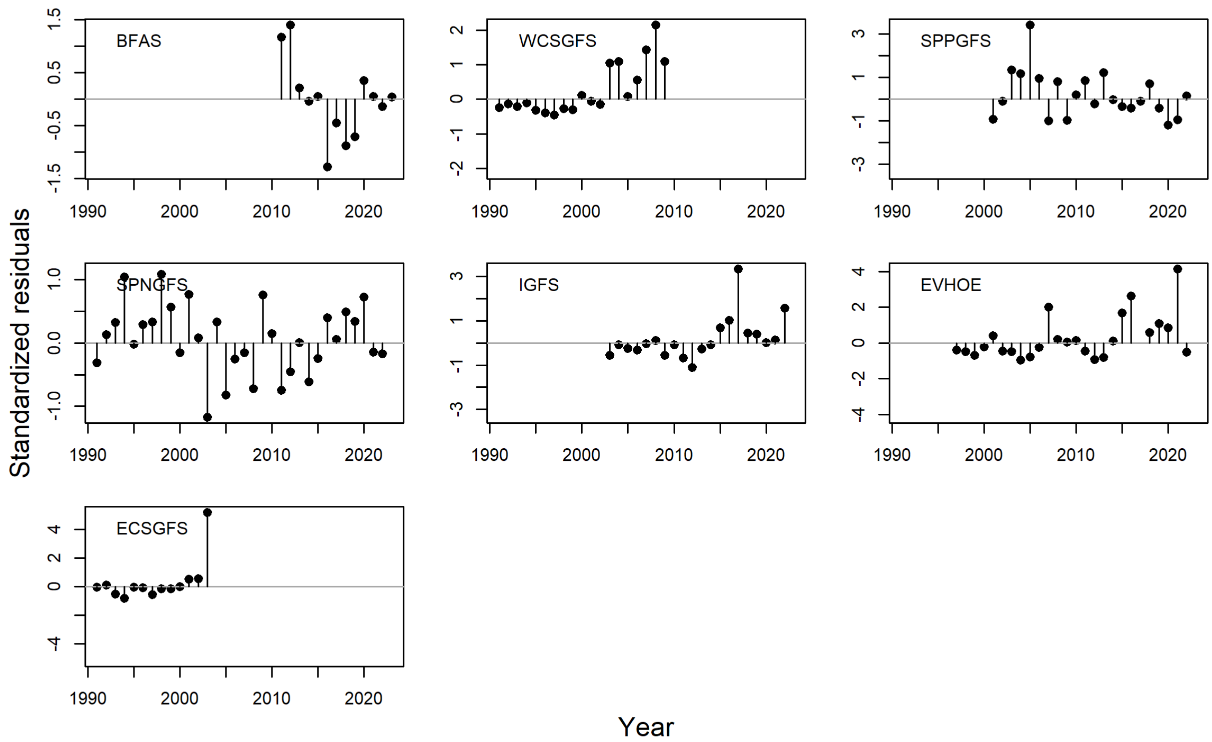


Figure 3.4.2.4. Boarfish in ICES Subareas 27.6, 7, 8. Residuals around the model fit for the final assessment run.

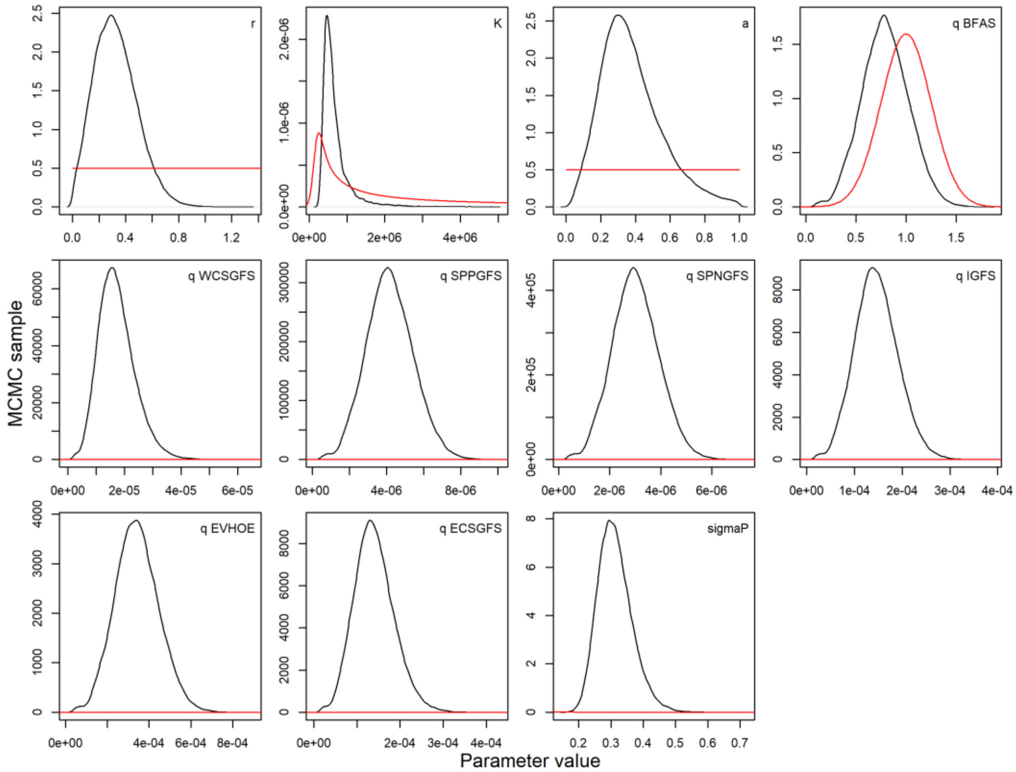


Figure 3.4.2.5. Boarfish in ICES Subareas 27.6, 7, 8. Prior (red) and posterior (black) distributions of the parameters of the biomass dynamic model.

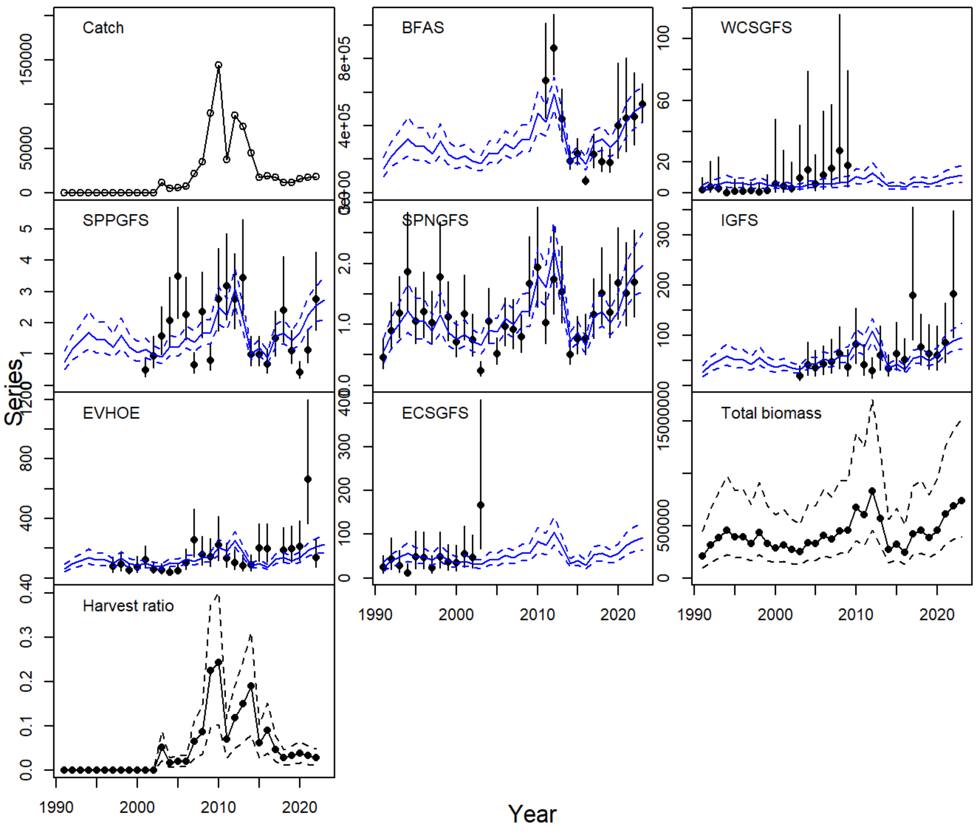


Figure 3.4.2.6. Boarfish in ICES Subareas 27.6, 7, 8. Trajectories of observed and expected indices for the final assessment run. The stock size over time and a harvest ratio (total catch divided by estimated biomass) are also shown.

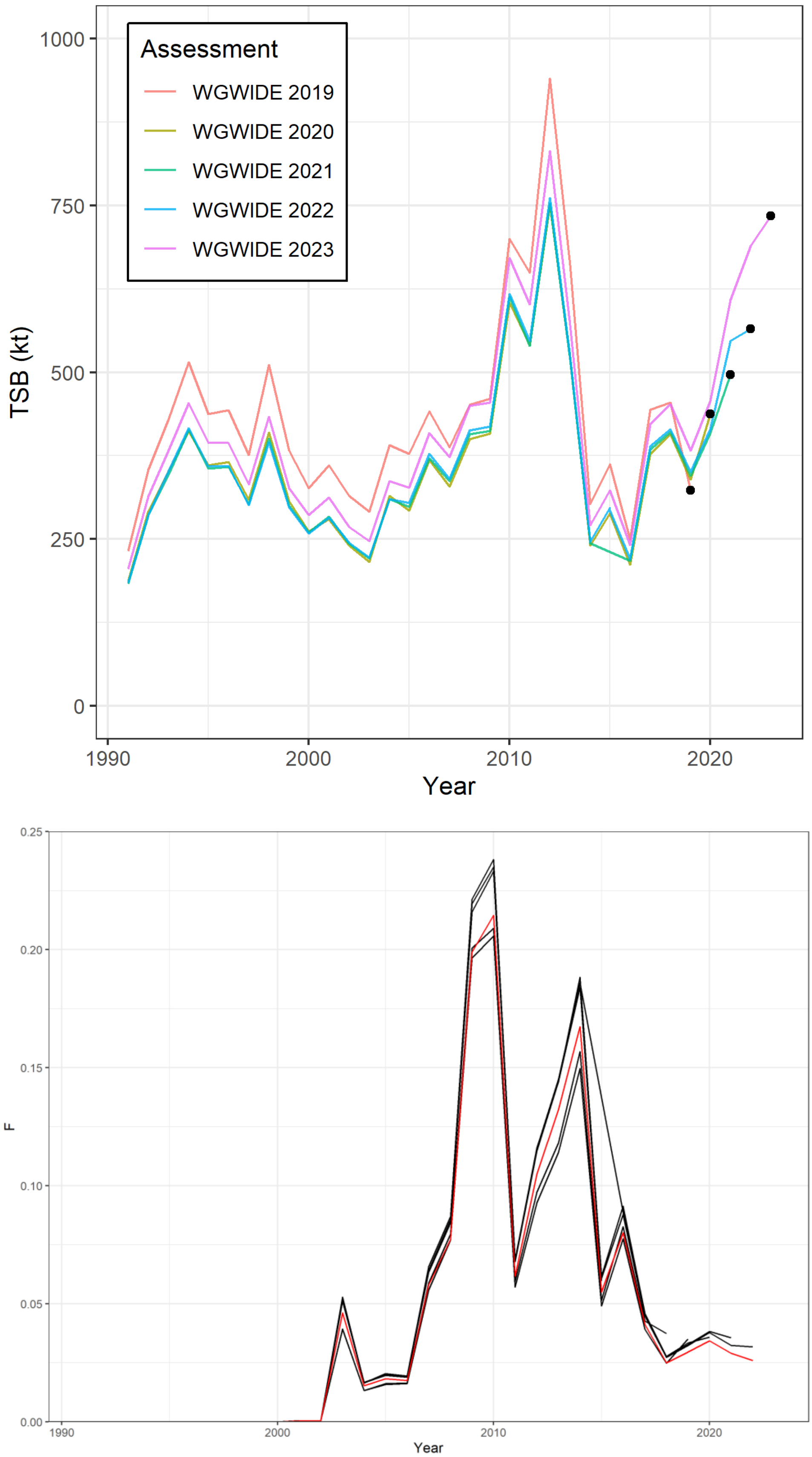


Figure 3.4.2.7. Boarfish in ICES Subareas 27.6, 7, 8. Retrospective plot of total stock biomass (above) and fishing mortality (below) from the surplus production model in 2013-2022.

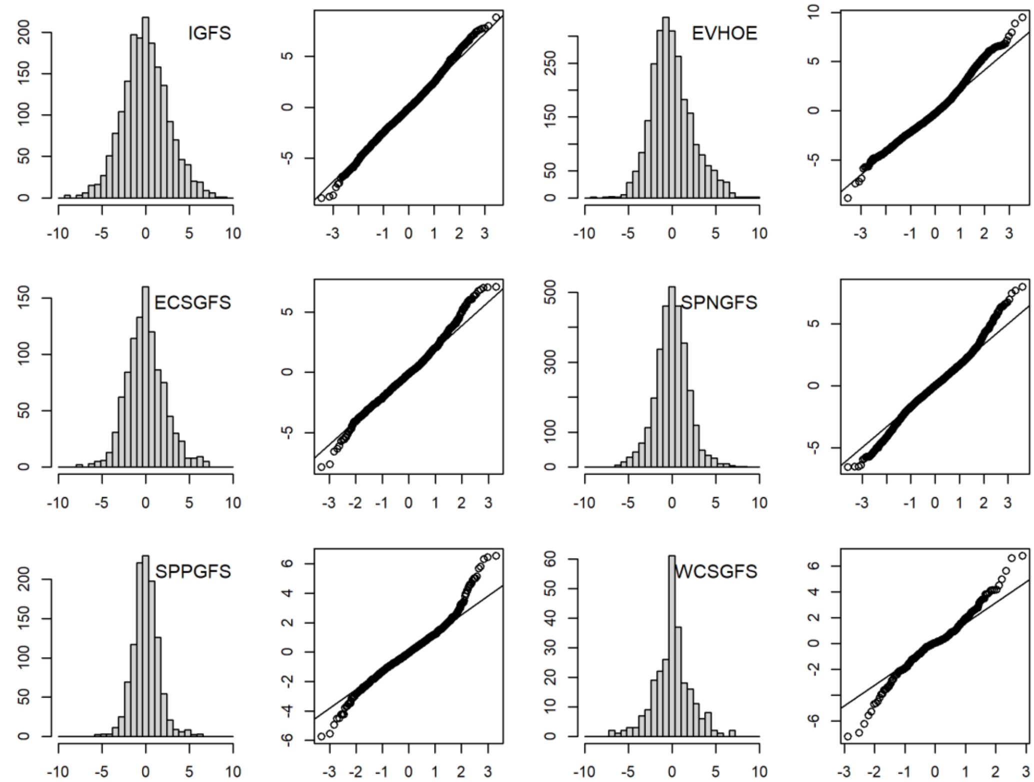


Figure 3.4.2.8. Boarfish in ICES Subareas 27.6, 7, 8. Diagnostics from the positive component of the delta-lognormal fits

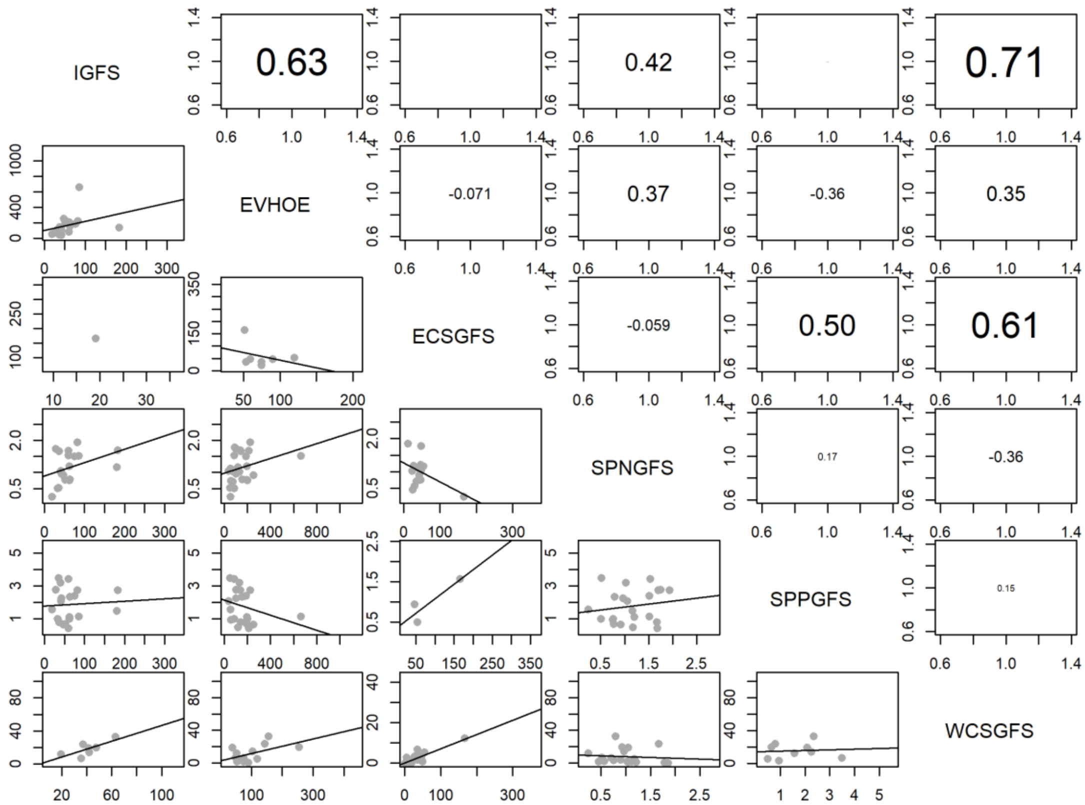


Figure 3.4.2.9. Boarfish in ICES Subareas 27.6, 7, 8. Pair-wise correlation between the annual mean survey indices.

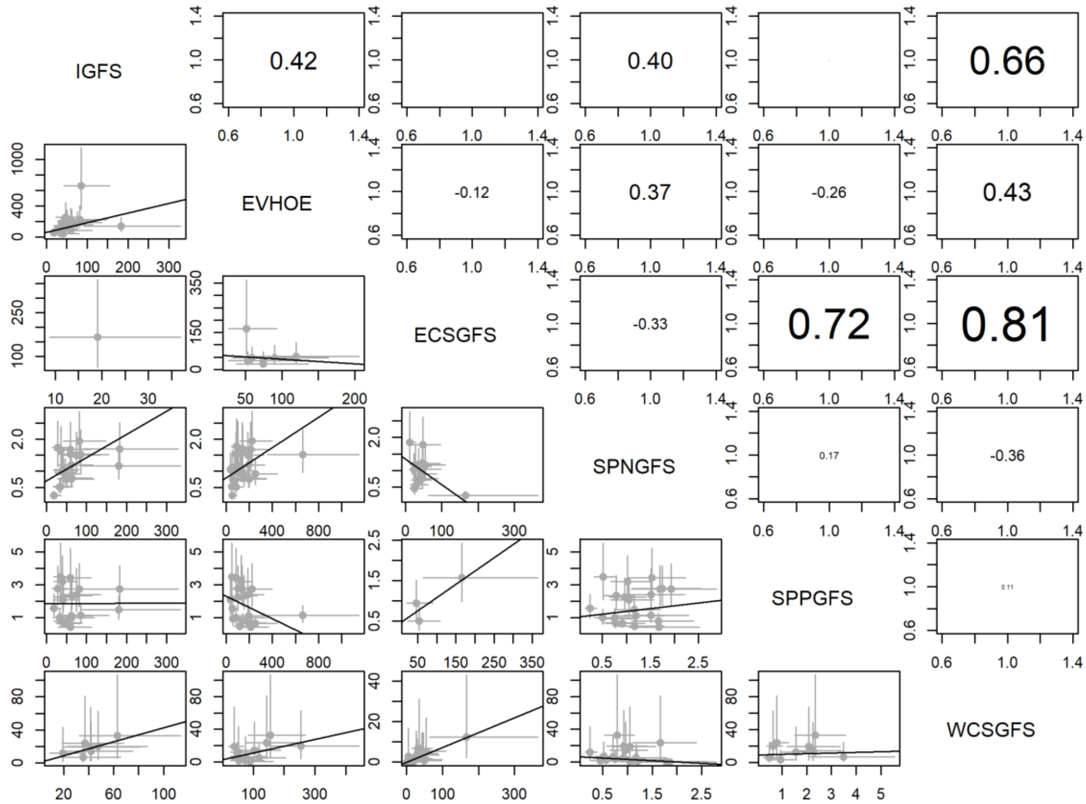


Figure 3.4.2.10. Boarfish in ICES Subareas 27.6, 7, 8. Weighted correlation between the annual mean survey indices. Correlations are weighted by the sum of the pair-wise variances.

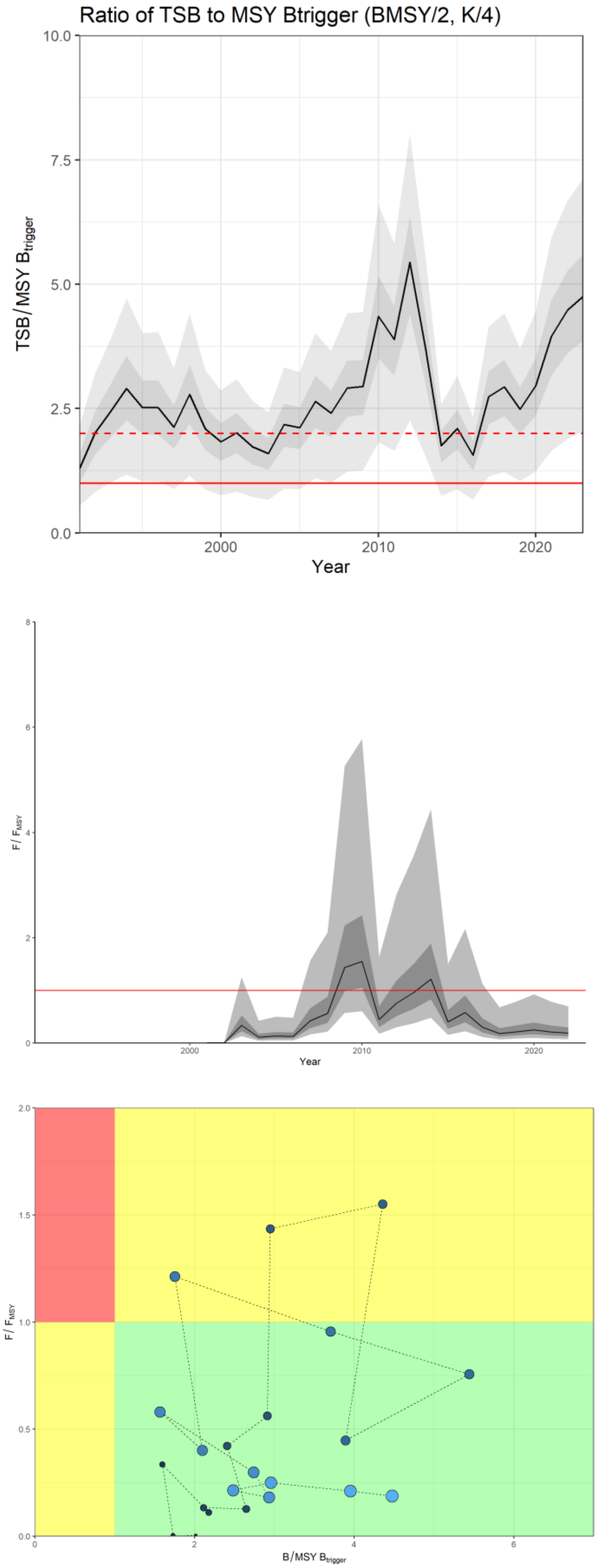


Figure 3.4.3.1. Boarfish in ICES Subareas 27.6, 7, 8. Ratios 'B / MSYBtrigger' and 'F / FMSY' through time and corresponding Kobe plot. Confidence intervals (50 and 95%) are given for the first two panels, the third displays median estimates only with the pink point representing the first point of the time series and the purple point the last.

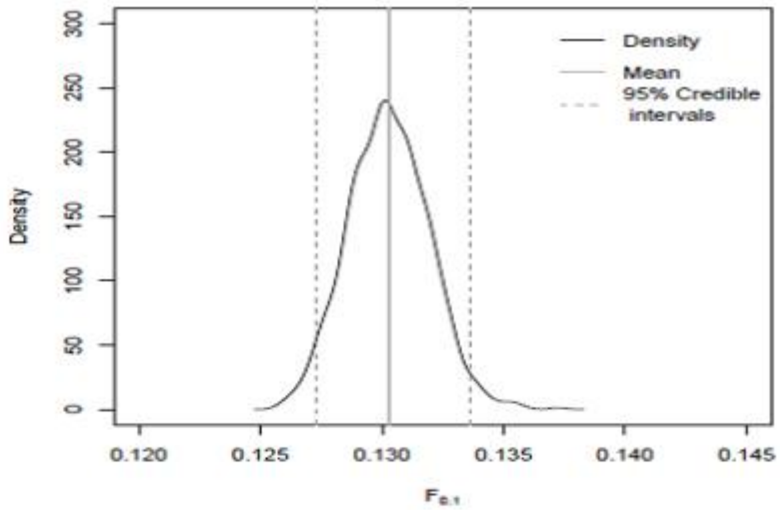


Figure 3.7.1.1. Boarfish in ICES Subareas 27.6, 7, 8. Sensitivity of estimation of F0.1.

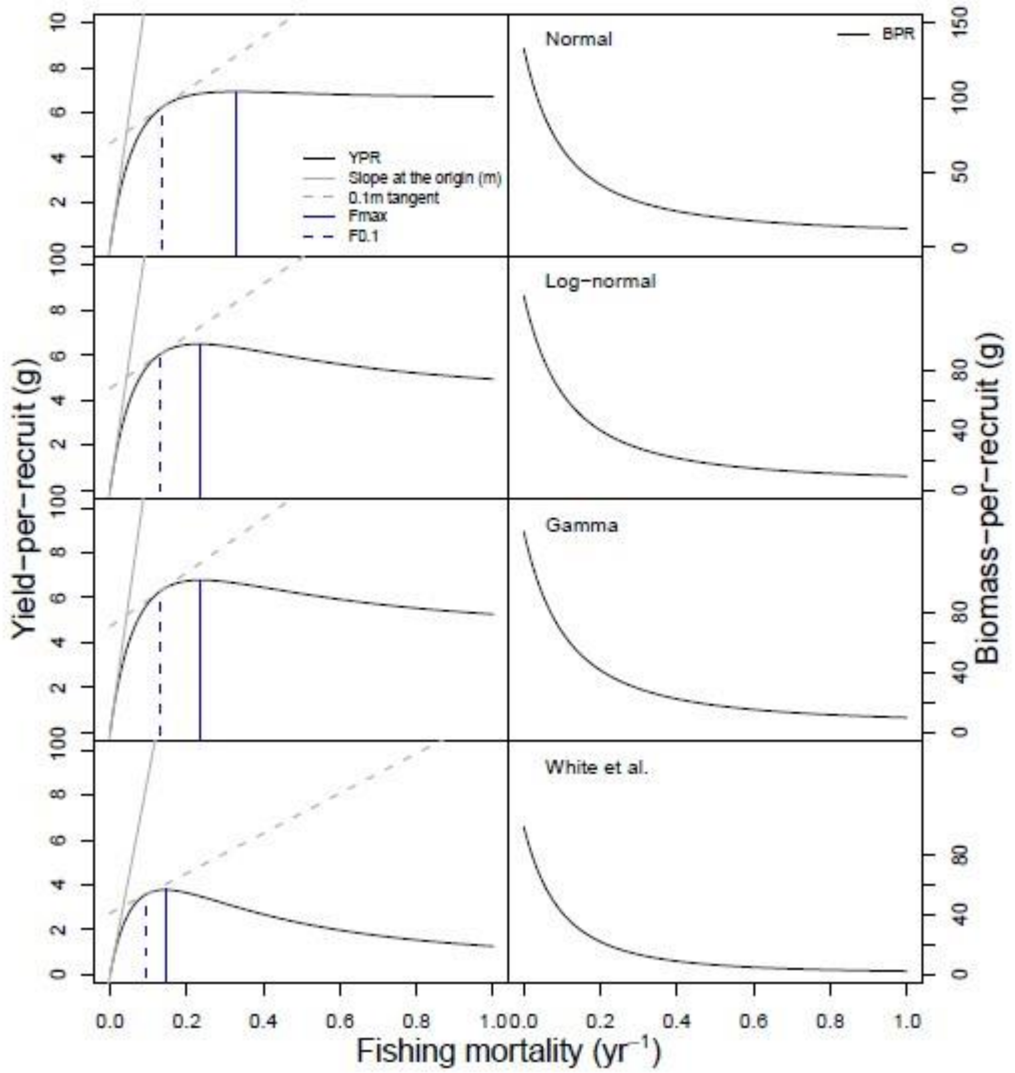


Figure 3.7.1.2. Boarfish in ICES Subareas 27.6, 7, 8. Results of exploratory yield per recruit analysis. Beverton and Holt model applied to various fits of the VBGF and for comparison with the VBGF parameters provided by White *et al*. 2011.

4 Norwegian spring-spawning herring in Northeast Atlantic and Arctic Ocean

Clupea harengus in subareas 1, 2, 5 and divisions 4.a and 14.a (her.27.1-24a514a)

4.1 ICES advice in 2022

ICES advised that when the long-term management strategy agreed by the European Union, the Faroe Islands, Iceland, Norway, and the Russian Federation is applied, catches in 2023 should be no more than 511 171 tonnes. The advice for 2023 was 15% lower than that for 2022.

4.2 The fishery in 2022

4.2.1 Description and development of the fisheries

The distribution of the Norwegian spring-spawning herring (NSSH) fishery in 2022 for all countries by ICES rectangles is shown in Figure 4.2.1.1. The catches by ICES statistical rectangle and quarter are seen in Figure 4.2.1.2. The 2022 herring fishing pattern was similar to recent years. The fishery began in January on the Norwegian shelf and focused on overwintering, pre-spawning, 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). In summer, the fishery moved into mainly Icelandic, Faroese and International waters and in early autumn started in the overwintering area off Lofoten (Figure 4.2.1.2, quarter 3). In autumn and winter, the fishery continued in Icelandic and Faroese waters but also in the overwintering area in the fjords and oceanic areas off Lofoten (Figure 4.2.1.2, quarter 4). 66% of the catches were taken in the fourth quarter. Catches of Norwegian spring-spawning herring inside the NEAFC regulatory area was estimated by the working group to be 65 015 tonnes in 2022, which represents 10 % of the total catch. Note though that this does not include catches from the Russian Federation.

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 to a lesser extent blue whiting) and oceanographic conditions (*e.g.* limitations due to cold areas). Besides environmental factors, the age distribution in the stock will also influence the migration. Changes in the migration pattern of NSSH, as well as that 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. This pattern does not appear to be prevalent for NSS herring during the feeding season, where changes in distribution occur for all age-classes simultaneously (Eliasen et al., 2021). The large 2016 year-class has now entered the adult stock. The distribution of the 2016 year-class in the feeding area in 2023 as observed in the ecosystem survey in May appeared to be primarily distributed in the western part of the survey area. 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) since 2017/2018 while the older fish seemed to have had an oceanic wintering area. A different pattern was observed during the winter 2022/2023. The wintering of old fish in the Norwegian Sea was not observed in 2023 catches The oldest and largest fish move farthest south and west during feeding, and the older year classes were in May-July 2023 concentrated in the south-western 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 2022 were available from Denmark, Faroe Islands, Germany, Greenland, Iceland, Ireland, The Netherlands, Norway, Sweden, United Kingdom and Russia. The total working group catch in 2022 was 813 834 tonnes (Table 4.4.1.1) compared to the ICES-recommended catch of a maximum of 598 588 tonnes. The majority of the catches (around 83%) were taken in division 2.a as in previous years. Age samples were not provided by Greenland, Germany, The Netherlands or Sweden. Sampled catches accounted for 97 % of the total catches, which is higher compared to last year. The sampling levels of catches in 2022 in total, by country and by ICES division are shown in Tables 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. This year Russian age sample information and catch by quarter and ICES division and ICES rectangle for 2022 were officially delivered to IMR Norway, and ICES decided to use this information. This information from Russia were not available for 2021 and this and the implications are described in the WGWIDE report from 2022.

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 number of fish was added to the catches.

The Working Group has not had access to comprehensive data to estimate discards of herring. Although discarding may occur on this stock, it is considered to be low and a minor problem for the assessment. This is confirmed by estimates from sampling programmes carried out by some EU countries in the Data Collection Framework. Estimates of 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%.

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.

4.4.3 Age composition of the catch

The estimated catch-at-age in numbers by year are shown in Table 4.4.3.1. The numbers are calculated using the SALLOC software. In 2022, catches (in numbers) were dominated by the 2016 year-class which comprised around 53% of the catch followed by the 2013 year class which comprises around 10% of the catch. 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 flatter 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 2022 was 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 generally increased in 2010–2013 but levelled off around 2014. Since around 2015 the weight-at-age have decreased for most ages – earlier for the younger ages than for the older ages. From 2020 to 2021 all ages decreased in weight and the decrease was generally larger than the preceding years and from 2021 to 2022 weight increased for all ages. A similar pattern is observed in weight-at-age in the stock, however, the weight trend in 2021 and 2022 is more in line with the cohort trends (Figure 4.4.4.2 and Table 4.4.4.2). The mean weight-at-age in the stock was based on the survey in the wintering area until 2008. Since then, the mean weight-at-age in the stock 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 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 the most recent years since all year classes have to be fully matured before the calculation can be made. Therefore, assumptions have to be made for the recent year classes. For recent year classes, WGWIDE (ICES, 2010b) decided to use average back-calculated maturity for “normal” and “big“year classes 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 year class	0	0	0	0	0.4	0.8	1	1	1	1	1	1	1	1	1	1
strong year class	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. In 2023 the year 2018 was updated with back-calculated values used in the present assessment. Assumed (old) and updated values for 2018 are shown in figure 4.4.5.1. The 2016 year-class was considered a strong year-class by the working group based on the assessment where several survey indices of this year-class are included. The resulting 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 natural mortality 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. This 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 in February (“Fleet 1”).

The cruise reports from the IESNS (WD03) and spawning survey (WD04) in 2023 are available as working documents to this report. The spawning survey and IESNS in the Norwegian Sea were both carried out successfully in 2023, however like in 2022, the IESNS in the Barents Sea was not carried out by Russia this year.

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 4.4.7.3 and Figure 4.4.7.1. In 2020 it was decided to use the bootstrap mean values as point estimates of abundance instead of the baseline estimates. This applies to the years were the software Stox is used to estimate abundance. Variance estimates from the bootstrap runs were already being used in the assessment, thus it is more logical to also use point estimates from the bootstrap. A comparison using point estimates for both bootstrap and baseline was made, and the effect on the assessment was negligible.

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 numbers 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 2010-2022 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) and Johnsen *et al.* (2019). For Fleet 1, estimates are available for the years 1988–1989, 1994–1996, 1998–2000, 2005–2008, and 2015–2023, for Fleet 4 estimates of sampling errors are available for 2009–2019 and 2021, and for Fleet 5 for 2008–2023. Missing values for sampling variances are imputed using the Taylor function which provides good fits (R^2_{adj}'s are 0.95, 0.98 and 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 was made available to the working group.

4.5 Stock assessment

The first benchmark of the NSSH assessment took place in 2008 with the assessment tool TASACS selected as the standard assessment tool for the stock. A second benchmark took place in 2016 (WKPELA - ICES, 2016a) where three assessment models were explored - TASACS, XSAM and one separable model. WKPELA accepted XSAM as the standard assessment tool for the NSSH. During the WGWIDE meeting in 2023, it was agreed to recommend using the SAM software with the same model and configuration as the XSAM software for WGWIDE 2024 and onwards. The reason was that the XSAM software is no longer maintained and will fail to compute if upgrading the R software or R packages.

4.5.1 XSAM final assessment 2023

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 the sum of national quotas) along with the precision of the prediction. This approach was changed in 2017 when it was found that the model estimated a highly variable and significantly lower catch 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 2023 assessment, *i.e.* the catch prediction for 2023 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 note that this has marginal effect on the assessment, but larger effects on the prediction and short-term forecast.

The 2023 XSAM assessment was performed with the same model options as in 2017. In summary, this means that the model was fit 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), and a scaling constant common for all input data to allow additional variability in the input data that is not controlled by sampling is estimated. Additional details on the assessment 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 from ages 3–12+ with input data catch-at-age, Fleet 1 and Fleet 5, At 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 was 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. It should be noted, that the recruitment index has not been updated since 2021.

The parameter estimates from the 2023 assessment are shown in Table 4.5.1.1 and in Figure 4.5.1.10. For a precise definition of the parameters, refer to Aanes 2016a in ICES (2016a). Note that the variance components σ_1^2 (variability in the separable model for F) and σ_R^2 (variability in recruitment) are rather imprecise. The estimate of the scaling constant h is larger than 1, indicating 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 (variability in the separable model for F, logs2_1 in figure) and σ_2^2 (variability in the AR process for time varying selectivity, logs2_2 in figure) 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 are given larger weight to the model than weaker 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 tool 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. A 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 year 1994, 1999, 2006 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 12+ from 2015 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. Some serial correlation for residuals for ages 3 and 4 in Fleet 1 can also be detected, but is down weighted as these is found to be uncertain. 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 and the smallest indices for Fleet 4. 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 comparison of 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 tend 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 Fleets 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 within the estimated levels of precision (Figure 4.5.1.7), and has a reasonably low Mohn's rho value for SSB of -0.06 and -0.017 for F

(Mohn, 1999; Brooks and Legault, 2016). Note that the retrospective patterns are remarkably stable.

Figure 4.5.1.8 illustrates the conflict in data and increased uncertainty in estimates for the most recent years. The spawning-stock biomass shown for each survey index is calculated using the stock weights at age and proportion mature at age, with the abundance indices are scaled to the absolute abundance by the estimated catchabilities. A fairly good temporal match between the model estimate of SSB and the survey SSBs is seen, except for the years 2015 for Fleet 1, which displays a significantly faster reduction in the stock compared to Fleet 5 which shows a flatter trend in the same years. Both Fleet 1 and Fleet 5 indicate an increase in SSB from 2007 to 2009. It is worth noting that, although the point estimate of SSB based on Fleet 1 appears very much higher than Fleet 5 in 2015, the uncertainty in the estimates are very high, such that the respective estimates do not appear as significantly different. Since 2016 the conflict between Fleet 1 and Fleet 5 has become less.

The results of leave-one-out runs are presented in Figure 4.5.1.11 and can be used to assess the influence of individual data sources on the assessment. Removing Fleet 1 leads to a downward revision of SSB and an upward revision of F. The overall assessment uncertainty is similar to the base run which includes all data sources. Removing Fleet 5 results in an upward revision of SSB and a downward revision of F, with an increase in uncertainty. Removing Fleet 4 does not influence the SSB nor F.

The final 2023 assessment results are shown in Figure 4.5.1.9. The estimate of fishing mortality for 2019 to 2022 is rather high, as a response to the high catch in the last years with a point estimates from ~0.17 to ~0.19. In 2018 the fishing mortality is estimated to be lower than in 2017 and 2019. The spawning stock shows a declining trend since 2009 but an increase in 2021 and 2022 before continuing to decrease. The 95% confidence interval of the stock level in 2023 ranges from ~2.974 to ~4.3 million tonnes with a point estimate of 3.664 which is above B_{mp}=3.184 million tonnes, such that the probability of the stock being above B_{lim}=2.5 million tonnes is high.

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.

4.6 NSSH reference points

ICES last reviewed the reference points of Norwegian spring spawning herring in April 2018 during WKNSSHREF (ICES, 2018a). ICES concluded that B_{lim} should remain unchanged at 2.5 million tonnes and MSY $B_{trigger}$ = B_{pa} was estimated at 3.184 million tonnes. F_{MSY} was estimated at the reference point workshop, but during the subsequent Management Strategy Evaluation WKNSSHMSE (ICES, 2018b) the fishing mortality reference points were revisited as issues were found with numerical instability and settings during the reference point workshop. F_{MSY} was re-estimated to be 0.157.

4.6.1 PA reference points

The PA reference points for the stock were last estimated by WKNSSHREF and WKNSSHMSE in 2018. The WKNSSHREF group concluded that B_{lim} should be kept at 2.5 million tonnes and B_{pa} was estimated at 3.184 million tonnes. WKNSSHMSE estimated F_{pa}=0.227. However, following recent ICES guidelines F_{pa} is now based on Fp05 which was estimated at 0.157 by WKNSSHMSE in 2018.

4.6.2 MSY reference points

The MSY reference points were evaluated by WKNSSHREF and WKNSSHMSE in 2018. In the ICES MSY framework B_{pa} is proposed/adopted as the default trigger biomass $B_{trigger}$ and was estimated by WKNSSHREF at 3.184 million tonnes. F_{MSY} was estimated by WKNSSHMSE at 0.157.

4.6.3 Management reference points

In the current management strategy, which was agreed upon in October 2018, the Coastal States have agreed a target reference point defined at F_{target} = 0.14 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 0.14 at B_{pa} to 0.05 at B_{lim}.

4.7 State of the stock

The SSB on 1 January 2022 is estimated by XSAM to be 3.66 million tonnes which is above B_{pa} (3.184 million t). The spawning stock has been declining since 2009 but increased in 2021 and 2022 followed by a decrease again in 2023. The SSB time-series from the 2023 assessment is consistent with the SSB time-series from the 2022 assessment. In the last 20 years, several large year classes have been produced (1998, 1999, 2002, and 2004). The year classes 2005-2015 and 2017-2019 are estimated to be average or small, while the 2016 year-class is estimated to be above average in the 2023 assessment. Since there was no recruitment survey in 2023, the size of the 2021 year-class at age 2 was defined as the stochastic median recruitment in the time series. Fishing mortality in 2022 is estimated to be 0.182 which is above the management strategy F (0.140).

4.8 NSSH Catch predictions for 2024

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 was performed to determine levels of precision in the forecast. Table 4.8.1.1 lists 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 (2020-2022).

For the weight-at-age in the stock, the values for 2023 were obtained from the commercial fisheries in the wintering areas in January. For the years 2024 and 2025 the average of the last 3 years (2021-2023) 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 (1988-2022) 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. Note that the 2016 year-class is regarded as large; hence, the maturity is set to be lower than for smaller year-classes. This results in the contribution of the 2016 year-class to the SSB being delayed.

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

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

where $F_{a,y}$and $N_{a,y}$ are fishing mortalities and numbers by age and year. This procedure is in accordance with that used in previous years for this stock although the age range was shifted from 5-11 to 5-12+ from 2018.

There was no agreement between the fishing parties on the sharing of the TAC for 2023. Therefore, to obtain an estimate of the total catch to be used as input for the catch-constraint projections for 2023, the sum of the unilateral quotas was used. In total, the expected outtake from the stock in 2023 amounts to 692 942 tonnes. F in 2023 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 692 942 tonnes is taken in 2023, it is expected that the SSB will decrease from 3.664 million tonnes on 1 January in 2023 to 3.059 million tonnes in 2024, which is bellow $B_{trigger}$ (3.184 million tonnes). The weighted F over ages 5-12+ is 0.186. The model predicts that the catch in 2023 to be dominated by three age groups, age 8 (45%), age 11 (8%), and age 12+ (11%).

4.8.3 Comparison between forecast 2022 and 2023

The stock number at age used as the input for the forecast in 2022 and 2023 is seen in Fig. 4.8.3.1, along with the revised stock numbers in 2022 from the 2023 assessment and the predicted stock number in 2023 from the 2022 forecast. Small revisions were observed, i.e., for 2022 estimates, stock number at age 2 is negatively revised with the inclusion of new data and the stock number at age 6 is slightly positively revised. The predicted stock numbers in 2023 from the 2022 forecast similar to the stock number used in the 2023 forecast, with just smaller revisions.

Comparing the selection pattern used in the 2022 and the 2023 forecast, small differences were identified for the ages 9 to 12. The weight-in-stock between the two forecast years only has revisions. The difference between the basis for the short-term prediction in 2022 and the revised values from the 2023 assessment are summarised below.

	Forecast values 2022	Assessment values 2023	%difference
Landings 2022	827 963	813 833	-1.7
Recruitment (age 2) billions	10.671	6.944	-35
SSB (2023)	3.532	3.664	3.8
F (2022)	0.192	0.182	-5

4.9 Comparison with previous assessment

A comparison between the assessments 2011-2023 is shown in Figure 4.9.1. In the years 2011-2015 the assessments were made with TASACS, but 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 (ICES, 2018a) this was further changed to 5-12+.

The table below shows the SSB (thousand tonnes) on 1 January in 2022 and weighted F in 2021 as estimated in 2022 and 2023.

	ICES 2022	WG2023	%difference
SSB (2022)	3 867	4 060	5.0%
Weighted F (2021)	0.168	0.159	-5.4%

4.10 Management plans and evaluations

The current management strategy for the Norwegian spring spawning herring fishery was agreed by the Coastal States in October 2018.

The implemented long-term management strategy of Norwegian spring spawning herring is consistent with the precautionary approach and the MSY approach (WKNSSHREF, ICES, 2018a; WKNSSHMSE, ICES, 2018b) and aims at ensuring harvest rates within safe biological limits.

Coastal States Agreed Record (4th November 2022)

1. The Parties agree to implement a long-term management strategy for the fisheries on the Norwegian Spring Spawning (Atlanto-Scandian) Herring stock, which is consistent with the precautionary approach and the MSY approach, aiming at ensuring harvest rates within safe biological limits.
2. For the purpose of this long-term management strategy, in the following text, “TAC” means the total allowable catch as agreed by Coastal States.
3. As a priority, the long-term management strategy shall ensure with high probability that the size of the stock is maintained above B_{lim}.
4. In the case that the spawning biomass is forecast to be above or equal to $B_{trigger}$ (=B_{pa}) on 1 January of the year for which the TAC is to be set, the TAC shall be fixed to a fishing mortality of F_{mgt}=0.14.
5. Where the rules in paragraph 4 would lead to a TAC, that deviates by more than 20% below or 25% above the TAC of the preceding year, the Parties shall fix a TAC that is respectively no more than 20% less or 25% more than the TAC of the preceding year. The TAC constraint shall not apply if the spawning biomass at 1 January in the year for which the TAC is to be set is less than $B_{trigger}$
6. In the case that the spawning biomass (SSB) is forecast to be less than the precautionary biomass ($B_{trigger}$) but above or equal to Blim on 1 January of the year for which the TAC is to be set, the TAC shall be fixed at a level that is consistent with a fishing mortality given by:
7. Target F = 0.05 +[(SSB-B_{lim})*(F_{mgt} –0.05) I($B_{trigger}$ -B_{lim})]
8. In the case that the spawning biomass is forecast to be less than B_{lim} on 1 January of the year for which the TAC is to be set, the TAC will be fixed corresponding to a fishing mortality F=0.05.

9. Each Party may transfer to the following year unutilised quantities of up to 10% of the quota allocated to it. The quantity transferred shall be in addition to the quota allocated to the Party concerned in the following year.
10. Each Party may authorize fishing by its vessels of up to 10% beyond the quota allocated. However, this shall not apply if the stock is forecast to be under $B_{trigger}$ at the end of the TAC year. All quantities fished beyond the allocated quota for one year shall be deducted from the Party's quota allocated for the following year.
11. The Parties, on the basis of ICES advice, shall review this long-term management strategy at intervals not exceeding five years. The first such review shall take place no later than 2023, in time for ICES to issue advice for 2024.

Whilst the Coastal States stated a review of the long-term management strategy was due in 2023 this has not been undertaken as it was considered appropriate to do this after an impending benchmark.

A brief history of management strategies is in the stock annex. There has been no agreement on sharing of the TAC since 2013, resulting in the total catch being higher than the advised catch.

4.11 Management considerations

Perception of the stock has not changed since last year's assessment (estimated SSB in 2022 is 5% higher in this year's assessment).

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 in 2005-2015. The 2016 year-class was however, estimated to be well above average in the 2023 assessment and resulted in an increase in SSB from 2020 to 2021. SSB, however, declined in 2022-2023 and is predicted to be below B_{mgt} in both 2024 and 2025 even if the management strategy (F_{mgt}=0.123) is applied in 2024.

Between 1999 and 2013, catches were regulated through an agreed management. 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 strategy resulting in steeper reduction in the SSB than otherwise.

A new management strategy was implemented 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 adjacent 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 because 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.

- Following a maximum in zooplankton biomass in May during the early 2000s the biomass declined with a minimum in 2006. From 2010, the trend turned to an increase and the last five years the zooplankton biomass has fluctuated around the long-term mean in the Lofoten and Norwegian Basins (IESNS survey report - ICES, 2023a), but is still low compared to the early years in East Iceland waters and the Jan Mayen front. Interestingly, all the areas, excluding east of Iceland and on few occasions Jan Mayen, show co-varying changes in zooplankton biomass.

- The Atlantic water mass in the Norwegian Sea was warmer and saltier over the period 2000–2016 than the long-term mean (WGINOR - ICES, 2023b). However, since 2017, the extent of Artic water has increased resulting in a marked freshening of the water masses, but the temperature remain above long -term average. Two different mechanisms can explain this, increased fraction of subpolar water (fresh and cold) and low heat loss to the atmosphere in the Norwegian Atlantic flow. The recent trend of colder and fresher Atlantic Inflow into the Norwegian Sea has ceased (ICES, 2023b).
- The sea temperature in 2023 was generally below the long-term mean (1995-2021) in the Norwegian Sea, but the pattern was fragmented from 0m-200m depth, with the central part mostly above the mean (ICES, 2023a). The Arctic front in the southern Norwegian Sea was more southerly and easterly located in 2023 compared to the long-term mean.
- In general, the herring stock has had a more westerly feeding distribution (ICES, 2023a) in the recent years than what was previously observed. In May 2023, the herring in west was more northerly distributed than in recent years, with the southeastern areas virtually absent of herring. The large 2016-year class was by far the most abundant year class in areas where herring was found. The westerly distribution might be due to either 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 (ICES, 2023c).
- Where herring and mackerel overlap spatially, they compete for food to some extent (Bachiller *et al*., 2016, 2018; Debes *et al*., 2012; Langøy *et al*., 2012; Óskarsson *et al*., 2016). There are studies showing mackerel being more effective feeder, which might indicate that the herring is forced to the southwestern and northeastern fringe of Norwegian Sea (ICES, 2023b). Alternatively, the higher zooplankton biomass in the southwest could also attract the herring into this location, since zooplankton biomass is much lower in the northeast (ICES, 2023b).
- Since 2005, herring have tended to stay longer in the western feeding areas into the autumn months (Homrum et al., 2022). During this same period, herring have had generally stable good somatic condition and started to build gonads in the autumn months. This trend is more pronounced for older herring. The most likely explanation is, that herring is able to utilize zooplankton resources in autumn – for example *Calanus finmarchicus,* which has been shown to be in the area in the autumn months (Strand et al., 2020).
- 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). Sampling in June 2017 and 2018, specifically studying mackerel predation on herring larvae, found significant numbers of herring larvae in mackerel stomachs in the area just south of Lofoten (Allan *et al*., 2021).
- The 2016 year-class of herring was the strongest since the 2004-year class in the Norwegian Sea as 4-year-olds, but as expected abundance is now beginning to visibly decrease (see the IESNS survey 2023 (Table 4.4.7.3).
- In the winter 2017/2018, the overwintering grounds shifted northward along the coast of Norway with older individuals occurring in oceanic areas. Such changes previously coincided with large year classes entering the spawning stock, however this recent change did not. Also, the onset of the overwintering period has been later in the year since the end of the 2000s.

  Around spawning time of 2023 most of the spawning stock was found west of Lofoten and Vesterålen, further north and more concentrated than usual but similar to the 2022 survey. The observed maturity indicated a later spawning compared to the previous year (WGWIDE WD04).

4.13 Changes in fishing patterns

The fishery for Norwegian spring spawning herring has previously (before 2013) been described as progressing clockwise in the Nordic Seas during the year. However, the last 5-9 years the annual progression of the fishery has changed into a pendular behaviour, starting in the winter along the Norwegian coast, moving gradually to the west towards Iceland in the summer, and then east again into the central Norwegian Sea in the last quarter of the year.

The fishery reached its lowest catches since the mid-nineties in 2015, after which the catches increased again, reaching a maximum in 2021 of 850 000 tonnes (Table 4.4.1.1). It is mainly the fishery in the fourth quarter that has increased since 2015, with up to 2/3 of the catches taken in this quarter. The fishery in quarter four in the last few years has partly been north and west of Lofoten and partly in the central Norwegian Sea and east of Iceland, whereas before 2015 it used to be stretched out towards the coast of Norway and north towards the Bear Island.

The change in migration pattern since 2017/18, where the part of the stock (old fish) overwinters in the central Norwegian Sea, has caused the fishery in this area to be extended to later in the winter, and in 2022 there was fishery in the central Norwegian Sea in the first quarter as well as the fourth.

4.14 Recommendations

For some years there have been proposed issues with age reading of NSS herring. Following a recommendation from WGWIDE a scale/otolith exchange was organised in autumn 2022 and spring 2023 and a subsequent workshop was held in April 2023. The main results from the workshop were presented to the working group and final report will be published later this year. The main conclusions were that there was generally good agreement among age-readers up until age 8 (otoliths) – 9 (scales) when the outermost added winter-rings become difficult to distinguish. Agreement was particularly good within the groups that read scales and otoliths respectively, but also agreement was good between scale- and otolith readers. For older fish (~older than 8-9 years) agreement decreased and more significantly for otolith-readers than for scale readers. It was concluded that age-readers generally followed the same procedures (closely adhering to a proposed protocol formulated in 2016 (ICES, 2016b). The workshop could not come up with suggestions to improve agreement for age-reading of older fish, since all age-readers are adhering to the proposed protocol. Mixture with other herring stocks did not appear to largely hamper age-reading of NSS-herring, since there was good agreement among age-readers with regards to how to distinguish between NSS-herring and other herring stocks (i.e. otolith characteristics and/or maturity stage).

4.15 References

Aanes, S. 2016a. A statistical model for estimating fish stock parameters accounting for errors in data: Applications to data for Norwegian Spring-spawning herring. WD4 in 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. 106pp.

Aanes, S. 2016b. Diagnostics of models fits by XSAM to herring data. WD12 in 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. 106pp.

Aanes, S. 2016c. Forecasting stock parameters of Norwegian spring spawning herring using XSAM. WD at WGWIDE in 2016.

Allan, B.J.M., Ray, J.L., Tiedemann, M., Komyakova, V., Vikebø, F., Skaar, K.S. Stiasny, M.H., Folkvord, A., Nash, R.D.M., Stenevik, E.K. and Kjesbu, O.S. 2021. Quantitative molecular detection of larval Atlantic herring (Clupea harengus) in stomach contents of Atlantic mackerel (Scomber scombrus) marks regions of predation pressure. Scientific Reports, 11(1): 5095. https://doi.org/10.1038/s41598-021-84545-7

Bachiller E., Skaret G., Nøttestad L., and Slotte A. 2016. Feeding Ecology of Northeast Atlantic Mackerel, Norwegian Spring-Spawning Herring and Blue Whiting in the Norwegian Sea. PlosONE 11(2): e0149238. doi:10.1371/journal.pone.0149238.

Bachiller E., Utne K. R., Jansen T., and Huse G. 2018. Bioenergetics modeling of the annual consumption of zooplankton by pelagic fish feeding in the Northeast Atlantic. PlosONE 13(1): e0190345. https://doi.org/10.1371/journal.pone.0190345

Brooks, E.N. and Legault, C.M. 2016. Retrospective forecasting — evaluating performance of stock projections in New England groundfish stocks. Canadian Journal of Fisheries and Aquatic Sciences 73: 935–950.

Debes, H., Homrum, E., Jacobsen, J. A., Hátún, H., and Danielsen, J. 2012. The feeding ecology of pelagic fish in the southwestern Norwegian Sea – Inter species food competition between herring (Clupea harengus) and mackerel (Scomber scombrus). ICES CM 2012/M:07. 19 pp.

Engelhard, G.H., Dieckmann, U and Godø, O.R. 2003. Age at maturation predicted from routine scale measurements in Norwegian spring-spawning herring (Clupea harengus) using discriminant and neural network analyses. ICES Journal of Marine Science, 60: 304–313.

Engelhard, G.H. and Heino, M. 2004. Maturity changes in Norwegian spring-spawning herring before, during, and after a major population collapse. Fisheries Research, 66: 299-310.

Harvey, A.C. 1990. Forecasting, structural time series models and the Kalman Filter. Cambridge University Press. ISBN 0 521 40573 4.

Hirst, D., Storvik, G., Rognebakke, H., Aldrin, M., Aanes, S., and Volstad, J.H. 2012. A Bayesian modelling framework for the estimation of catch-at-age of commercially harvested fish species. Can. J. Fish. Aquat. Sci. 69(12): 2064– 2076.

Homrum, E. í, Óskarsson, G.J., Ono, K., Hølleland, S. and Slotte, A. 2022. Changes towards stable good somatic condition and increased gonad investment of Norwegian spring-spawning herring (Clupea harengus) after 2005 are linked to extended feeding period. Front. Mar. Sci. 9:803171. doi: 10.3389/fmars.2022.803171

ICES. 1998. Northern Pelagic and Blue Whiting Fisheries Working Group, ICES CM 1998/ACFM:18

ICES. 2008. Report of the Working Group on Widely Distributed Stocks (WGWIDE). 2-11 September 2008, ICES Headquarters Copenhagen. ICES CM 2008/ACOM:13: 691pp.

ICES. 2010a. Report of the Workshop on estimation of maturity ogive in Norwegian spring-spawning herring (WKHERMAT), 1–3 March 2010, Bergen, Norway. ICES CM 2010/ACOM:51. 47 pp

ICES. 2010b. Report of the Working Group on Widely Distributed Stocks (WGWIDE), 28 August –3 September 2010, Vigo, Spain. ICES CM 2010/ACOM:12.

ICES. 2016a, Report of the benchmark workshop on pelagic stocks (WKPELA). 29 February – 4 March 2016, ICES Headquarters Copenhagen. ICES CM 2016/ACOM:34.

ICES. 2016b. Report of the Workshop on Age estimation of Norwegian Spring Spawning Herring between, Norway, Denmark, Iceland and the Faroe Islands (WKNSSAGE), 9–10 November 2015, Charlottelund, Denmark. ICES CM 2015/SSGIEOM:37. 46 pp.

ICES. 2017. Report of the Working Group on Inter-benchmark Protocol on Northeast Arctic Cod (2017), 4–6 April 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:29. 236 pp.

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

ICES. 2018b. Report of the Workshop on a long-term management strategy for Norwegian Spring-spawning herring (WKNSSHMSE), 26-27 August 2018, Torshavn, Faroe Islands. ICES CM 2018/ACOM: 53. 108 pp.

ICES. 2023a. International ecosystem survey in the Nordic Sea (IESNS) in April to May 2023. WD03 to Working Group on International Pelagic Surveys (WGIPS) and Working Group on Widely distributed Stocks (WGWIDE) Copenhagen, 23.-29. August 2023. 33 pp.

ICES. 2023b. Working Group on the Integrated Assessments of the Norwegian Sea (WGINOR; outputs from 2022 meeting). ICES Scientific Reports. 5:15. 57pp. https://doi.org/10.17895/ices.pub.22110260

ICES. 2023c. Preliminary Ccruise report from the International Ecosystem Summer Survey in the Nordic Seas (IESSNS), 1 July – 3 August 2023. WD01 to ICES Working Group on Widely Distributed Stocks (WGWIDE), Copenhagen 23-29 August 2023. 55pp.

Johnsen, E., Totland, A., Skålevik, Å., Holmin, A.J., Dingsør, G.E., Fuglebakk, E., Handegard, N.O. 2019. StoX: An open source software for marine survey analyses. Methods Ecol Evol. 2019, 10:1523–1528.

Langøy, H., Nøttestad, L., Skaret, G., Broms, C. and Fernö, A. 2012. Overlap in distribution and diets of Atlantic mackerel (Scomber scombrus), Norwegian spring- spawning herring (Clupea harengus) and blue whiting (Micromesistius poutassou) in the Norwegian Sea during late summer. Marine biology research, 8: 442—460.

Mohn, R. 1999. The retrospective problem in sequential population analysis: An investigation using cod fishery and simulated data. ICES Journal of Marine Science 56: 473–488.

Óskarsson, G.J., A. Gudmundsdottir, S. Sveinbjörnsson & Þ. Sigurðsson 2016. Feeding ecology of mackerel and dietary overlap with herring in Icelandic waters. Marine Biology Research, 12: 16-29.

Salthaug, A. and Aanes, S. 2015. Estimating the Norwegian catch at age of blue whiting, mackerel, North Sea herring and Norwegian spring-spawning herring with the ECA model. Working document in the Report of the working group on widely distributed stocks (WGWIDE). ICES CM 2015 / ACOM:15.

Skaret G., Bachiller E., Langøy H., Stenevik, E.K. 2015. Mackerel predation on herring larvae during summer feeding in the Norwegian Sea. ICES Journal of Marine Science 72(8), 2313-2321. doi:10.1093/icesjms/fsv087

Strand, E., Bagøien, E., Edwards, M., Broms, C., and Klevjer, T. 2020. Spatial distributions and seasonality of four calanus species in the northeast Atlantic. Prog. Oceanogr. 185, 102344. doi: 10.1016/j.pocean.2020.102344

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

Year	Norway	USSR/ Russia	Denmark	Faroes	Iceland	Ireland	Netherlands	Greenland	UK	Germany	France	Poland	Sweden	Total
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
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

Year	Norway	USSR/ Russia	Denmark	Faroes	Iceland	Ireland	Netherlands	Greenland	UK	Germany	France	Poland	Sweden	Total
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
2018	332028	64185	17052	82062	83393	2428	4290	2465	2582	1989	0	0	425	592899
2019	430507	84364	21207	113945	108045	2775	5111	3190	1801	4188	0	1327	705	777165
2020	409436	74936	16523	103029	98173	2704	5060	3546	143	2969	0	1352	3065	720937
2021**	489632	92841	15854	114291	114299	1793	10939	6456	0	3365	0	1242	1101	851813
2022	445938	85870	15014	122083	112739	3209	3783	6818	9620	5600	0	0	3160	813834

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

****The Russian catch for 2021 was taken from the ICES preliminary catches database**

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
2018	592899	97	253	22106	6047
2019	777165	97	361	29856	7421
2020	720937	98	232	34232	6742
2021	851813	88	207	18830	5975
2022	813834	97	299	23100	5844

Table 4.4.1.3 Norwegian spring-spawning herring. Sampling coverage by country in 2022.

COUNTRY	OFFICIAL CATCH	% catch covered by sampling programme	NO. SAMPLES	NO. MEASURED	NO. AGED
Denmark	15014	100	11	850	256

COUNTRY	OFFICIAL CATCH	% catch covered by sampling programme	NO. SAMPLES	NO. MEASURED	NO. AGED
Faroes	122083	100	16	581	581
Germany	5600	0	0	0	0
Greenland	6818	0	1	200	0
Iceland	112739	100	65	2950	1498
Ireland	3209	83	3	262	159
Netherlands	3783	0	0	0	0
Norway	445938	99	85	2363	2363
Russia	85870	98	114	15536	757
Scotland	9620	100	4	358	230
Sweden	3160	0	0	0	0
Total	813834	97	299	23100	5844

Table 4.4.1.4 Norwegian spring-spawning herring. Sampling coverage by ICES Division in 2022.

Area	Official Catch	No Samples	No Aged	No Measured	No Aged/ 1000 tonnes	No Measured/ 1000 tonnes
2.a	676478	244	4699	20701	7	31
2.b	408	0	0	0	0	0
4.a	185	0	0	0	0	0
5.a	136618	55	1145	2399	8	18
5.b	145	0	0	0	0	0
Total	813834	299	5844	23100	7	28

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

Line	Country	Quarter	Div.	Catch (T)	Samples allocated (line)
1	Norway	1	IIa	147792	
2	Norway	2	IIa	80	12,18,31
3	Norway	3	IIa	4400	13,19,32
4	Norway	4	IIa	293665	
5	Sweden	1	IIa	3160	1,15,17,27,35

Line	Country	Quarter	Div.	Catch (T)	Samples allocated (line)
6	Germany	4	IIa	5600	4,14,16,20,33
7	Greenland	3	IIa	796	13,19,32
8	Greenland	4	IIa	5873	4,14,16,20,33
9	Greenland	3	IIb	150	13,19,32
10	Iceland	3	Va	53762	
11	Iceland	4	Va	47363	
12	Iceland	2	IIa	278	
13	Iceland	3	IIa	10713	
14	Iceland	4	IIa	623	
15	Denmark	1	IIa	7931	
16	Denmark	4	IIa	7082	
17	Faroes	1	IIa	10537	
18	Faroes	2	IIa	4370	
19	Faroes	3	IIa	10230	
20	Faroes	4	IIa	60945	
21	Faroes	3	IIb	258	13,19,32
22	Faroes	2	IVa	185	12,18,31
23	Faroes	4	Va	35493	
24	Faroes	2	Vb	24	12,18,31
25	Faroes	3	Vb	1	10
26	Faroes	4	Vb	40	11,23
27	Ireland	1	IIa	2676	
28	Ireland	4	IIa	533	4,14,16,20,33
29	Netherlands	4	IIa	3783	4,14,16,20,33
30	Russia	1	IIa	1640	1,15,17,27,35
31	Russia	2	IIa	512	
32	Russia	3	IIa	6979	
33	Russia	4	IIa	76659	
34	Russia	2	Vb	80	12,18,31

Line	Country	Quarter	Div.	Catch (T)	Samples allocated (line)
35	Scotland	1	IIa	9620	

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

	AGE															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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
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

	AGE														
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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

	AGE															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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
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

	AGE														
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2018	0	1261	22414	25638	59802	264182	150759	179628	109121	180968	85954	99061	212052	113841	136096	39249
2019	0	769	2205	148669	64237	185336	557804	146597	217346	119855	167569	133910	104730	220400	91773	121229
2020	0	1299	8252	49455	544337	70633	150932	412498	118081	156696	94975	188852	100408	96557	132619	103350
2021	204	3644	2368	25015	110359	1432164	162903	203923	345729	117846	127846	73558	68834	60477	40165	113929
2022	0	8136	26087	22384	91375	148378	1365208	97514	203324	248904	72439	79165	63398	73962	38289	63347

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

	age															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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		

	age														
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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
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

	age														
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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
2018		0.068	0.127	0.207	0.240	0.276	0.321	0.348	0.371	0.380	0.399	0.404	0.400	0.407	0.408	0.418
2019		0.135	0.186	0.209	0.235	0.269	0.298	0.327	0.345	0.376	0.387	0.403	0.409	0.423	0.417	0.449
2020		0.131	0.170	0.204	0.236	0.274	0.306	0.317	0.342	0.358	0.374	0.395	0.402	0.408	0.415	0.444
2021	0.050	0.122	0.130	0.195	0.229	0.256	0.278	0.319	0.325	0.363	0.364	0.384	0.386	0.397	0.412	0.431
2022		0.086	0.161	0.224	0.231	0.268	0.287	0.316	0.345	0.356	0.382	0.397	0.417	0.423	0.431	0.468

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

	AGE														
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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
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

	AGE															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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

	AGE															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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
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

	AGE															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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
2019	0.001	0.01	0.054	0.104	0.151	0.203	0.277	0.311	0.331	0.355	0.353	0.363	0.381	0.376	0.385	0.382
2020	0.001	0.01	0.054	0.104	0.150	0.203	0.266	0.301	0.328	0.343	0.358	0.366	0.374	0.367	0.384	0.391
2021	0.001	0.01	0.054	0.104	0.160	0.209	0.266	0.284	0.302	0.325	0.352	0.366	0.384	0.376	0.404	0.391
2022	0.001	0.01	0.054	0.104	0.125	0.168	0.243	0.287	0.303	0.323	0.352	0.366	0.384	0.376	0.404	0.391
2023	0.001	0.01	0.054	0.118	0.125	0.202	0.255	0.280	0.311	0.336	0.337	0.345	0.384	0.376	0.404	0.391

**** 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. Maturity at age.

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

Year/Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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
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

Year/Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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	0.3	0.9	0.9	1	1	1	1	1	1	1	1	1
2015	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1
2016	0	0	0	0	0.1	0.5	0.9	1	1	1	1	1	1	1	1	1
2017	0	0	0	0	0.2	0.6	0.8	1	1	1	1	1	1	1	1	1
2018	0	0	0	0	0.2	0.8	0.9	1	1	1	1	1	1	1	1	1
2019	0	0	0	0	0.4	0.8	1	1	1	1	1	1	1	1	1	1
2020	0	0	0	0	0.1	0.8	1	1	1	1	1	1	1	1	1	1
2021	0	0	0	0	0.4	0.6	1	1	1	1	1	1	1	1	1	1
2022	0	0	0	0	0.4	0.8	0.9	1	1	1	1	1	1	1	1	1
2023	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 (mean of bootstrap with 1000 iterations in 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	392	307	8015	81	33	12	36	22	45	0	0	0	0	8943	1621
1989	161	16	338	91	3973	101	12	4	55	0	4	42	0	9	4813	1169
1990																
1991																
1992																
1993																
1994	37	100	48	848	483	62	13	144	49	1836	4	4	0	0	3665	1207
1995	4	450	4679	3211	1957	299	20	0	106	55	2327	0	0	0	13745	2860
1996	119	186	1976	7960	2326	875	301	0	0	136	0	1760	0	0	15645	3366
1997																
1998	51	308	978	2982	12859	8133	1851	592	163	43	0	329	0	1400	29705	6886
1999	114	1530	369	1351	2669	9334	7004	1666	511	130	0	0	353	373	25438	6262
2000	1394	691	2600	109	477	1144	4282	2838	493	50	2	0	7	228	14315	3285
2001																
2002																
2003																
2004																

Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	Biomass
2005	38	238	661	2128	5947	8328	613	503	156	92	576	1152	587	9	21026	5260
2006	26	90	6054	548	882	3362	3311	110	86	20	89	58	246	63	14951	3431
2007	33	367	1618	12397	815	655	2956	3205	141	228	40	204	284	470	23427	5350
2008	15	48	2564	2824	8882	522	471	1566	1567	161	102	46	128	136	19090	4553
2009																
2010																
2011																
2012																
2013																
2014																
2015	204	533	2754	744	3267	388	692	2715	784	7222	367	1658	51	237	21662	6365
2016	18	197	237	594	365	2119	240	514	2930	652	3995	199	824	97	12982	4182
2017	19	110	1076	641	880	428	1326	181	206	2026	303	2542	80	729	10550	3314
2018	104	146	1720	2771	459	845	639	1095	444	370	1159	368	1538	354	12013	3262
2019	2	372	310	940	3778	754	879	660	1054	736	412	1807	182	2161	14166	4250
2020	6	44	3502	571	1212	3337	530	609	364	650	131	279	677	825	12750	3274
2021	21	112	293	10210	733	738	1932	427	451	312	219	395	208	1153	17250	4021
2022	27	72	162	760	6393	317	563	1515	301	486	301	255	385	630	12183	3302

Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	Biomass
2023	0	205	189	568	594	6014	351	1057	1349	304	537	508	538	807	13037	3910

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 2009–2022 are estimated with StoX (mean of bootstrap with 1000 iterations). "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	0.289	0.300	0.233	0.060	
2010	5.196	1.380	0.000	0.000	
2011	1.166	3.920	0.041	0.000	
2012	0.787	0.030	0.000	0.000	
2013	0.107	2.190	0.211	0.070	
2014	4.239	3.110	1.728	0.127	0.043
2015	0.345	11.760	1.183	0.206	0.000
2016	1.826	5.620	1.568	0.101	0.038
2017	14.522	3.080	0.000	0.000	

	age				
Year	1	2	3	4	5
2018	7.329	17.420	0.827	0.009	
2019	0.113	2.370	17.481	0.044	
2020***					
2021	0.021	0.002	0.086	0.002	
2022***					
2023***					

***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 2008-2022 are estimated indices by StoX (mean of bootstrap with 1000 iterations). "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	1213	655	10997	8406	14798	1543	2232	4890	2790	511	148	172	244	529	49187	10655
2009	0	137	1817	2280	12118	8599	9735	2054	1433	2608	1375	237	198	112	248	43057	9692
2010	231	119	572	2296	1828	8395	5918	5676	923	888	1002	550	89	42	62	28772	6649
2011	0	1110	921	1663	3592	2605	9303	4390	4257	771	956	732	269	29	33	30731	7336

	Age															Total
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	Biomass
2012	0	396	2942	410	668	1736	2633	4328	1884	2148	297	604	303	139	41	18540	4476
2013	0	201	718	3555	425	1161	1859	2905	4449	2772	1865	678	790	222	102	21722	5653
2014	13	515	1258	784	2788	715	1118	2634	2268	2806	1118	703	337	72	212	17350	4504
2015	0	391	432	1316	1132	3535	1309	1191	3156	2526	4457	687	816	290	211	21450	5851
2016	0	75	3550	1538	2229	1749	2631	938	1092	1806	1882	2853	934	436	130	21851	5408
2017	10	131	948	4295	1198	1543	826	1414	317	738	1008	1741	2230	507	237	17159	4152
2018	0	496	1004	1968	5664	970	1409	569	1279	354	675	1564	1464	1498	500	19412	4987
2019	4	157	2625	680	2187	4656	1158	1223	952	1232	823	655	1406	917	803	19487	4805
2020	0	43	472	13065	513	1009	2492	786	629	434	694	324	505	726	902	22616	4210
2021	15	34	1109	1290	11906	698	1051	2039	501	551	476	462	442	615	1515	22984	5096
2022	0	507	383	1207	1286	9633	1151	1640	2064	577	339	325	293	115	288	19817	4427
2023	57	185	584	341	996	1218	9459	462	558	1100	304	214	218	256	514	16479	4055

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	0.368	0.193	0.263	0.094	0.364	0.498	0.424	0.315	0.371	0.544	0.382
1989	0.262	0.539	0.5	0.431	0.112	0.508	0.827	0.874	0.516	0.691	0.711
1990	0.308	0.29	0.555	0.337	0.347	0.126	0.706	0.668	0.606	0.573	0.621
1991	0.514	0.378	0.546	0.685	0.314	0.371	0.128	0.566	0.994	1.731	0.658
1992	0.697	0.33	0.24	0.45	0.724	0.336	0.429	0.126	0.567	0.891	0.673
1993	0.397	0.252	0.162	0.173	0.375	0.499	0.249	0.29	0.104	NA	NA
1994	0.383	0.241	0.161	0.108	0.14	0.308	0.382	0.23	0.234	0.089	0.436
1995	0.737	0.199	0.11	0.09	0.089	0.125	0.308	0.306	0.187	0.176	0.079
1996	0.247	0.237	0.086	0.066	0.079	0.104	0.164	0.431	0.395	0.19	0.081
1997	0.275	0.152	0.119	0.063	0.061	0.084	0.112	0.196	0.283	0.241	0.098
1998	0.176	0.186	0.123	0.107	0.064	0.071	0.106	0.152	0.22	0.262	0.126
1999	0.449	0.149	0.233	0.15	0.102	0.066	0.073	0.116	0.163	0.315	0.132
2000	0.316	0.176	0.093	0.235	0.16	0.104	0.071	0.076	0.128	0.185	0.15
2001	0.602	0.165	0.142	0.102	0.227	0.168	0.115	0.082	0.097	0.184	0.205
2002	0.194	0.132	0.089	0.121	0.112	0.248	0.169	0.12	0.088	0.11	0.177
2003	0.465	0.182	0.112	0.086	0.137	0.14	0.271	0.183	0.128	0.093	0.119
2004	0.218	0.265	0.17	0.102	0.086	0.16	0.149	0.257	0.205	0.139	0.089
2005	0.281	0.101	0.169	0.139	0.089	0.079	0.155	0.155	0.229	0.191	0.09
2006	0.216	0.182	0.086	0.177	0.139	0.086	0.084	0.173	0.181	0.247	0.106
2007	0.377	0.127	0.108	0.063	0.144	0.123	0.086	0.096	0.213	0.262	0.141
2008	0.154	0.232	0.094	0.088	0.058	0.132	0.121	0.092	0.107	0.249	0.145
2009	0.159	0.133	0.145	0.073	0.079	0.062	0.147	0.12	0.102	0.124	0.15
2010	0.195	0.165	0.13	0.134	0.075	0.086	0.069	0.138	0.136	0.11	0.122
2011	0.122	0.195	0.163	0.125	0.129	0.085	0.094	0.089	0.171	0.157	0.132
2012	0.326	0.129	0.209	0.156	0.117	0.12	0.085	0.113	0.108	0.205	0.154
2013	0.28	0.196	0.118	0.186	0.159	0.117	0.123	0.092	0.139	0.146	0.212
2014	0.68	0.252	0.199	0.121	0.208	0.185	0.133	0.146	0.106	0.176	0.179
2015	0.519	0.304	0.201	0.206	0.144	0.237	0.191	0.143	0.164	0.131	0.176
2016	0.578	0.215	0.219	0.16	0.174	0.14	0.206	0.184	0.138	0.168	0.121

Year/Age	2	3	4	5	6	7	8	9	10	11	12+
2017	0.303	0.192	0.114	0.158	0.122	0.141	0.116	0.166	0.151	0.118	0.105
2018	0.273	0.261	0.197	0.12	0.145	0.136	0.161	0.136	0.174	0.166	0.097
2019	0.59	0.145	0.192	0.135	0.094	0.146	0.128	0.156	0.14	0.15	0.095
2020	0.38	0.21	0.094	0.186	0.145	0.103	0.157	0.143	0.169	0.134	0.102
2021	0.576	0.263	0.16	0.068	0.141	0.131	0.11	0.157	0.153	0.184	0.117
2022	0.259	0.273	0.171	0.145	0.069	0.167	0.131	0.122	0.185	0.179	0.124

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	0.326	0.344	0.168	0.46	0.559	0.698	0.549	0.611	0.523	NA
1989	0.655	0.336	0.448	0.196	0.438	0.698	0.887	0.5	NA	0.5
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	0.439	0.515	0.275	0.311	0.487	0.686	0.405	0.513	0.232	0.762
1995	0.316	0.189	0.206	0.229	0.346	0.624	NA	0.433	0.5	0.221
1996	0.383	0.229	0.169	0.221	0.273	0.345	NA	NA	0.41	0.235
1997	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1998	0.343	0.267	0.209	0.152	0.168	0.232	0.298	0.395	0.528	0.236
1999	0.242	0.33	0.249	0.214	0.163	0.173	0.237	0.307	0.415	0.285
2000	0.288	0.215	0.431	0.312	0.258	0.193	0.211	0.31	0.511	0.364
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	0.363	0.291	0.225	0.18	0.167	0.295	0.308	0.398	0.447	0.221
2006	0.449	0.179	0.303	0.273	0.204	0.204	0.43	0.454	0.624	0.315
2007	0.33	0.239	0.153	0.278	0.291	0.209	0.206	0.407	0.367	0.266
2008	0.515	0.216	0.212	0.165	0.306	0.313	0.241	0.241	0.396	0.322

Year/Age	3	4	5	6	7	8	9	10	11	12+
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	0.305	0.213	0.283	0.205	0.326	0.288	0.213	0.28	0.172	0.221
2016	0.379	0.364	0.297	0.331	0.225	0.363	0.307	0.21	0.291	0.186
2017	0.43	0.261	0.293	0.273	0.32	0.25	0.386	0.375	0.227	0.2
2018	0.404	0.236	0.212	0.315	0.275	0.293	0.26	0.317	0.33	0.203
2019	0.329	0.343	0.269	0.199	0.282	0.273	0.291	0.262	0.284	0.191
2020	0.525	0.202	0.3	0.255	0.204	0.305	0.296	0.331	0.292	0.23
2021	0.428	0.347	0.16	0.284	0.284	0.23	0.32	0.316	0.342	0.229
2022	0.472	0.395	0.282	0.177	0.341	0.301	0.242	0.345	0.311	0.241
2023	0.375	0.382	0.3	0.297	0.179	0.334	0.262	0.249	0.344	0.219

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

Year/Age	2
1991	0.462
1992	0.419
1993	0.395
1994	0.364
1995	0.444
1996	0.620
1997	0.741
1998	0.466
1999	0.464
2000	0.392
2001	0.445
2002	0.475

Year/Age	2
2003	NA
2004	NA
2005	0.468
2006	0.383
2007	0.477
2008	0.595
2009	0.609
2010	0.525
2011	0.474
2012	0.763
2013	0.502
2014	0.485
2015	0.426
2016	0.458
2017	0.486
2018	0.410
2019	0.498
2020	NA
2021	1.006
2022	NA
2023	NA

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	0.203	0.136	0.154	0.195	0.239	0.346	0.772	0.909	0.439	0.216
1997	0.273	0.21	0.142	0.153	0.229	0.248	0.425	0.517	0.379	0.22
1998	0.358	0.277	0.2	0.147	0.164	0.239	0.298	0.422	NA	0.329
1999	0.235	0.37	0.286	0.218	0.159	0.185	0.294	0.389	0.984	0.376
2000	0.264	0.223	0.496	0.355	0.266	0.178	0.191	0.25	0.385	0.419
2001	0.172	0.26	0.259	0.424	0.411	0.215	0.19	0.27	0.494	0.422

Year/Age	3	4	5	6	7	8	9	10	11	12+
2002	0.183	0.166	0.261	0.3	0.357	0.294	0.242	0.228	0.261	0.431
2003	0.182	0.165	0.165	0.257	0.305	0.445	0.401	0.245	0.231	0.239
2004	0.256	0.192	0.156	0.162	0.278	0.322	0.519	0.372	0.36	0.228
2005	0.141	0.264	0.248	0.184	0.191	0.313	0.354	0.45	0.388	0.24
2006	0.374	0.151	0.262	0.24	0.182	0.179	0.31	0.307	0.428	0.236
2007	0.221	0.187	0.14	0.268	0.241	0.181	0.189	0.314	0.335	0.222
2008	0.313	0.161	0.172	0.15	0.256	0.234	0.195	0.222	0.332	0.277
2009	0.246	0.233	0.158	0.171	0.166	0.239	0.26	0.226	0.263	0.299
2010	0.323	0.233	0.246	0.172	0.186	0.188	0.289	0.291	0.283	0.304
2011	0.289	0.251	0.21	0.226	0.168	0.2	0.201	0.301	0.286	0.279
2012	0.22	0.349	0.311	0.249	0.226	0.201	0.244	0.237	0.377	0.278
2013	0.306	0.21	0.346	0.273	0.245	0.22	0.199	0.223	0.245	0.247
2014	0.268	0.3	0.222	0.306	0.276	0.225	0.234	0.222	0.276	0.265
2015	0.345	0.265	0.275	0.21	0.266	0.272	0.216	0.228	0.199	0.24
2016	0.21	0.256	0.235	0.248	0.226	0.287	0.277	0.246	0.244	0.2
2017	0.287	0.201	0.271	0.256	0.296	0.261	0.371	0.304	0.283	0.197
2018	0.283	0.241	0.188	0.285	0.261	0.323	0.267	0.361	0.311	0.194
2019	0.226	0.31	0.236	0.197	0.274	0.27	0.286	0.27	0.296	0.207
2020	0.338	0.155	0.331	0.283	0.228	0.3	0.316	0.345	0.309	0.229
2021	0.276	0.267	0.158	0.308	0.28	0.239	0.333	0.326	0.337	0.218
2022	0.355	0.271	0.267	0.166	0.274	0.252	0.239	0.322	0.365	0.282
2023	0.321	0.365	0.283	0.27	0.167	0.339	0.325	0.277	0.375	0.271

Table 4.5.1.1. Norwegian spring-spawning herring. Parameter estimates of the final XSAM model fit. The estimates from the final 2022 assessment are also shown.

Parameter	Estimate	Std. Error	CV	Estimate 2022	Std. Error 2022
$\log(N_{3,1988})$	7.085	0.163	0.023	7.085	0.163
$\log(N_{4,1988})$	6.631	0.201	0.03	6.631	0.201
$\log(N_{5,1988})$	9.586	0.066	0.007	9.586	0.066
$\log(N_{6,1988})$	4.834	0.375	0.078	4.837	0.380

Parameter	Estimate	Std. Error	CV	Estimate 2022	Std. Error 2022
$\log(N_{7,1988})$	3.521	0.522	0.148	3.527	0.532
$\log(N_{8,1988})$	3.078	0.583	0.189	3.079	0.594
$\log(N_{9,1988})$	4.066	0.449	0.11	4.073	0.455
$\log(N_{10,1988})$	3.277	0.657	0.201	3.282	0.669
$\log(N_{11,1988})$	3.172	0.684	0.215	3.191	0.691
$\log(N_{12,1988})$	3.574	0.741	0.207	3.585	0.753
$\log(q_3^{F1})$	-9.666	0.17	0.018	-9.657	0.173
$\log(q_4^{F1})$	-8.158	0.123	0.015	-8.143	0.124
$\log(q_5^{F1})$	-7.506	0.11	0.015	-7.487	0.111
$\log(q_6^{F1})$	-7.302	0.11	0.015	-7.283	0.110
$\log(q_7^{F1})$	-7.157	0.119	0.017	-7.165	0.123
$\log(q_8^{F1})$	-6.917	0.085	0.012	-6.926	0.086
$\log(q_2^{F4})$	-14.533	0.184	0.013	-14.525	0.189
$\log(q_3^{F5})$	-7.678	0.102	0.013	-7.654	0.105
$\log(q_4^{F5})$	-7.148	0.09	0.013	-7.133	0.093
$\log(q_5^{F5})$	-6.924	0.088	0.013	-6.913	0.091
$\log(q_6^{F5})$	-6.803	0.091	0.013	-6.796	0.094
$\log(q_7^{F5})$	-6.708	0.096	0.014	-6.721	0.101
$\log(q_8^{F5})$	-6.555	0.103	0.016	-6.541	0.106
$\log(q_9^{F5})$	-6.555	0.114	0.017	-6.537	0.118
$\log(q_{10}^{F5})$	-6.495	0.126	0.019	-6.474	0.132
$\log(q_{11}^{F5})$	-6.457	0.121	0.019	-6.433	0.126
$\log(\sigma_1^2)$	-5	1.419	0.284	-5.000	1.409
$\log(\sigma_2^2)$	-2.827	0.247	0.087	-2.777	0.243
$\log(\sigma_4^2)$	-2.31	0.295	0.128	-2.281	0.299
$\log(\sigma_R^2)$	-0.047	0.249	5.278	-0.022	0.255
$\log(h)$	1.518	0.062	0.041	1.565	0.063
μ_R	9.27	0.171	9.27	9.275	0.176

Parameter	Estimate	Std. Error	CV	Estimate 2022	Std. Error 2022
α_Y	-0.489	0.288	-0.489	-0.492	0.294
β_Y	0.817	0.105	0.817	0.816	0.107
α_{2U}	-1.239	0.162	-1.239	-1.239	0.164
α_{3U}	-0.627	0.093	-0.627	-0.629	0.095
α_{4U}	-0.213	0.057	-0.213	-0.215	0.059
α_{5U}	0.053	0.048	0.053	0.054	0.049
α_{6U}	0.203	0.052	0.203	0.199	0.054
α_{7U}	0.262	0.057	0.262	0.263	0.058
α_{8U}	0.326	0.063	0.326	0.319	0.065
α_{9U}	0.363	0.068	0.363	0.368	0.070
α_{10U}	0.42	0.074	0.42	0.419	0.076
β_U	0.601	0.051	0.601	0.603	0.052

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	673	1194	759	14554	126	34	22	58	27	24	36
1989	1172	260	964	635	12034	104	28	16	40	16	43
1990	4345	471	219	816	531	10030	86	22	13	30	47
1991	11486	1760	400	186	685	444	8384	70	18	10	61
1992	18699	4664	1507	341	157	575	372	6987	58	14	58
1993	50139	7596	3999	1280	286	131	480	309	5778	47	59
1994	60080	20363	6507	3373	1044	231	107	388	249	4579	82
1995	15817	24390	17438	5480	2640	780	178	83	300	187	3443
1996	5733	6412	20835	14604	4180	1759	510	128	60	207	2248
1997	2151	2319	5442	17238	11168	2805	1130	335	89	41	1357
1998	10937	868	1923	4384	13139	7774	1749	665	209	54	755
1999	6486	4415	715	1485	3384	9624	5449	1121	414	123	458
2000	32755	2625	3679	557	1134	2513	6830	3655	702	246	300
2001	29101	13269	2198	2743	417	833	1796	4670	2254	410	271
2002	11450	11797	11254	1750	2009	312	617	1292	3244	1489	452

Year/Age	2	3	4	5	6	7	8	9	10	11	12+
2003	6733	4635	9968	9087	1290	1411	226	433	879	2162	1295
2004	57974	2730	3927	8241	7135	950	1033	164	305	592	2262
2005	24559	23525	2320	3272	6664	5494	708	749	119	214	1769
2006	43071	9960	19890	1912	2617	5105	3888	484	509	79	1137
2007	12179	17468	8470	16458	1537	2048	3745	2663	335	353	708
2008	17671	4932	14817	6974	12616	1165	1502	2552	1769	226	720
2009	7135	7128	4173	12213	5394	8791	824	1035	1635	1120	630
2010	5094	2862	5967	3425	9437	3837	5724	553	646	980	1083
2011	15441	2044	2386	4905	2730	7114	2674	3574	347	399	1130
2012	5712	6196	1708	1958	3954	2132	5364	1817	2393	226	974
2013	8495	2309	5188	1409	1576	3132	1630	3937	1281	1677	847
2014	5577	3441	1947	4253	1136	1249	2440	1217	2878	926	1973
2015	17619	2263	2928	1625	3454	920	1002	1919	933	2165	2318
2016	7702	7154	1932	2465	1344	2820	750	803	1518	722	3577
2017	4314	3126	6104	1621	2023	1080	2255	593	626	1156	3336
2018	42477	1749	2646	5004	1286	1521	801	1644	431	431	3205
2019	5170	17235	1486	2202	4042	984	1153	598	1224	312	2557
2020	4424	2096	14642	1225	1737	3001	722	819	423	865	1822
2021	2043	1793	1774	12075	967	1317	2201	517	572	292	1743
2022	6944	827	1513	1438	9159	697	944	1537	348	377	1402
2023	10619	2811	697	1224	1099	6644	502	645	1063	230	1235

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	0.049	0.064	0.028	0.04	0.042	0.042	0.142	0.227	0.338	0.174	0.174
1989	0.011	0.021	0.017	0.027	0.032	0.035	0.077	0.11	0.152	0.093	0.093
1990	0.004	0.012	0.015	0.024	0.031	0.029	0.052	0.073	0.098	0.071	0.071
1991	0.001	0.005	0.011	0.019	0.025	0.025	0.032	0.043	0.057	0.049	0.049
1992	0.001	0.004	0.013	0.025	0.031	0.03	0.035	0.04	0.055	0.057	0.057
1993	0.001	0.005	0.02	0.054	0.063	0.058	0.064	0.068	0.083	0.104	0.104

Year/Age	2	3	4	5	6	7	8	9	10	11	12+
1994	0.002	0.005	0.022	0.095	0.141	0.115	0.099	0.107	0.134	0.153	0.153
1995	0.003	0.008	0.027	0.121	0.256	0.275	0.176	0.17	0.222	0.329	0.329
1996	0.005	0.014	0.04	0.118	0.249	0.292	0.271	0.211	0.244	0.443	0.443
1997	0.008	0.038	0.066	0.122	0.212	0.323	0.381	0.323	0.351	0.465	0.465
1998	0.007	0.044	0.108	0.109	0.161	0.205	0.294	0.324	0.375	0.419	0.419
1999	0.004	0.032	0.099	0.12	0.147	0.193	0.249	0.318	0.369	0.511	0.511
2000	0.004	0.028	0.144	0.141	0.158	0.186	0.23	0.333	0.387	0.552	0.552
2001	0.003	0.015	0.078	0.161	0.141	0.149	0.179	0.214	0.264	0.259	0.259
2002	0.004	0.018	0.064	0.155	0.204	0.17	0.204	0.235	0.256	0.255	0.255
2003	0.003	0.016	0.04	0.092	0.155	0.162	0.17	0.201	0.246	0.274	0.274
2004	0.002	0.013	0.032	0.062	0.111	0.144	0.171	0.172	0.202	0.328	0.328
2005	0.003	0.018	0.044	0.074	0.117	0.196	0.232	0.236	0.263	0.406	0.406
2006	0.002	0.012	0.039	0.068	0.095	0.16	0.228	0.217	0.216	0.39	0.39
2007	0.004	0.015	0.044	0.116	0.127	0.16	0.234	0.259	0.244	0.238	0.238
2008	0.008	0.017	0.043	0.107	0.211	0.197	0.223	0.295	0.307	0.257	0.257
2009	0.014	0.028	0.047	0.108	0.191	0.279	0.249	0.322	0.362	0.33	0.33
2010	0.013	0.032	0.046	0.077	0.132	0.211	0.321	0.316	0.332	0.452	0.452
2011	0.013	0.03	0.048	0.066	0.097	0.132	0.236	0.251	0.277	0.3	0.3
2012	0.006	0.028	0.042	0.067	0.083	0.119	0.159	0.199	0.206	0.199	0.199
2013	0.004	0.021	0.049	0.066	0.082	0.1	0.142	0.164	0.175	0.096	0.096
2014	0.002	0.011	0.031	0.058	0.06	0.071	0.09	0.116	0.134	0.074	0.074
2015	0.001	0.008	0.022	0.04	0.053	0.055	0.072	0.085	0.106	0.076	0.076
2016	0.002	0.009	0.026	0.048	0.068	0.074	0.084	0.099	0.122	0.104	0.104
2017	0.003	0.017	0.049	0.081	0.136	0.149	0.166	0.171	0.222	0.188	0.188
2018	0.002	0.013	0.034	0.063	0.118	0.127	0.142	0.144	0.173	0.202	0.202
2019	0.003	0.013	0.044	0.087	0.148	0.159	0.192	0.196	0.197	0.304	0.304
2020	0.003	0.017	0.043	0.087	0.127	0.16	0.184	0.208	0.221	0.283	0.283
2021	0.004	0.02	0.06	0.126	0.177	0.183	0.209	0.246	0.267	0.222	0.222
2022	0.004	0.021	0.062	0.119	0.171	0.179	0.231	0.218	0.264	0.215	0.215

Year/Age	2	3	4	5	6	7	8	9	10	11	12+
2023	0.004	0.019	0.055	0.107	0.155	0.167	0.21	0.212	0.251	0.222	0.222

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) millions	High	Low	Stock Size: SSB thousand tonnes	High	Low	Catches thousand tonnes	Fishing Pressure: F Ages 5-12	High	Low
1988	673	991	355	2128	2392	1865	135.301	0.042	0.058	0.026
1989	1172	1644	699	3292	3700	2884	103.83	0.033	0.046	0.019
1990	4345	5358	3332	3566	3998	3134	86.411	0.03	0.042	0.017
1991	11486	13358	9613	3343	3747	2940	84.683	0.031	0.044	0.018
1992	18699	21323	16075	3371	3757	2985	104.448	0.039	0.054	0.023
1993	50139	55387	44891	3344	3691	2997	232.457	0.076	0.099	0.053
1994	60080	65952	54208	3476	3822	3130	479.228	0.128	0.159	0.098
1995	15817	18145	13489	3543	3874	3212	905.501	0.218	0.258	0.179
1996	5733	6846	4620	4126	4456	3795	1220.283	0.192	0.222	0.162
1997	2151	2708	1594	5385	5775	4996	1426.507	0.193	0.22	0.166
1998	10937	12704	9171	5966	6394	5538	1223.131	0.186	0.214	0.158
1999	6486	7696	5277	5865	6315	5415	1235.433	0.213	0.246	0.18
2000	32755	36631	28879	4884	5298	4471	1207.201	0.257	0.299	0.215
2001	29101	32706	25496	4055	4427	3683	766.136	0.203	0.24	0.166
2002	11450	13326	9574	3579	3925	3234	807.795	0.223	0.264	0.182
2003	6733	8010	5456	4209	4590	3828	789.51	0.152	0.18	0.124
2004	57974	64050	51898	5300	5763	4837	794.066	0.128	0.152	0.105
2005	24559	27906	21212	5426	5915	4936	1003.243	0.172	0.203	0.142
2006	43071	48228	37913	5393	5873	4912	968.958	0.176	0.209	0.143
2007	12179	14310	10047	6937	7523	6351	1266.993	0.155	0.182	0.129
2008	17671	20469	14874	7025	7640	6410	1545.656	0.2	0.233	0.167
2009	7135	8546	5724	6997	7643	6351	1687.373	0.206	0.238	0.174
2010	5094	6178	4010	6205	6819	5592	1457.014	0.213	0.25	0.177
2011	15441	17926	12955	5867	6482	5253	992.998	0.158	0.187	0.129
2012	5712	6855	4569	5712	6335	5088	825.999	0.141	0.168	0.114
2013	8495	10026	6964	5344	5944	4744	684.743	0.121	0.146	0.096

Year	Recruitment (Age 2) millions	High	Low	Stock Size: SSB thousand tonnes	High	Low	Catches thousand tonnes	Fishing Pressure: F Ages 5-12	High	Low
2014	5577	6700	4455	5164	5758	4571	461.306	0.085	0.103	0.066
2015	17619	20510	14728	4816	5380	4252	328.74	0.068	0.084	0.051
2016	7702	9333	6071	4263	4771	3755	383.174	0.085	0.105	0.065
2017	4314	5445	3182	4136	4619	3653	721.566	0.16	0.193	0.127
2018	42477	50403	34551	4046	4528	3563	592.899	0.127	0.154	0.1
2019	5170	6854	3486	3986	4479	3494	777.165	0.183	0.221	0.146
2020	4424	6247	2600	3461	3923	2998	720.937	0.185	0.227	0.143
2021	2043	3303	783	4077	4642	3512	851.813	0.159	0.194	0.124
2022	6944	12099	1790	4060	4714	3406	813.8337	0.182	0.226	0.137
2023	10619	31256	0	3664	4353	2974				
Average	15888	18873	13182	4611	5091	4132	791	0.146	0.175	0.118

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	2023							
	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	10619	0.90	0.0	0	0	0.054	0.004	0.154
3	2811	0.15	0.0	0	0	0.118	0.02	0.207
4	697	0.15	0.4	0	0	0.125	0.058	0.232
5	1224	0.15	0.8	0	0	0.202	0.112	0.266
6	1099	0.15	0.9	0	0	0.255	0.162	0.29
7	6644	0.15	1.0	0	0	0.28	0.175	0.317
8	502	0.15	1.0	0	0	0.311	0.22	0.338
9	645	0.15	1.0	0	0	0.336	0.222	0.359
10	1063	0.15	1.0	0	0	0.337	0.263	0.373
11	230	0.15	1.0	0	0	0.345	0.233	0.392
12	1235	0.15	1.0	0	0	0.389	0.233	0.421

Input for	2024/2025							
	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	10619	0.90	0.0	0	0	0.054	0.004	0.154
3		0.15	0.0	0	0	0.118	0.02	0.207
4		0.15	0.4	0	0	0.125	0.058	0.232
5		0.15	0.8	0	0	0.202	0.112	0.266
6		0.15	0.9	0	0	0.255	0.162	0.29
7		0.15	1.0	0	0	0.28	0.175	0.317
8		0.15	1.0	0	0	0.311	0.22	0.338
9		0.15	1.0	0	0	0.336	0.222	0.359
10		0.15	1.0	0	0	0.337	0.263	0.373
11		0.15	1.0	0	0	0.345	0.233	0.392
12		0.15	1.0	0	0	0.389	0.233	0.421

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

Basis:	
SSB (2023):	3.664 million t
Landings(2023):	692 294 (sum of national quotas)
SSB(2024):	3.059 million t
Fw5-12+(2023)	0.186
Recruitment(2023-2024):	10.61916, 10.61916, 10.61916

The catch options:

Rationale	**Catches (2023)**	**Basis**	**FW (2023)**	**SSB (2024)***	**P(SSB2024 <B_{lim})**	**% SSB change***	**%TAC change**	**%CATCH change**
Management strategy	390010	F=0.14	0.124(0.098, 0.162)	2913.275(2134.794, 3758.246)	0.157	-4.778(-30,23)	-23.7	-44
F_{MSY} × SSB (2024) /MSY $B_{trigger}$	469953	F=0.157	0.151(0.121, 0.198)	2844.892(2097.299, 3829.202)	0.208	-7.013(-31,25)	-8.1	-32
Zero Catch	0	F=0.0	0(0, 0)	3248.398(2530.315, 4265.225)	0.019	6.175(-17,39)	-100	-100
F_{pa}	487686	F=0.157	0.157(0.123, 0.203)	2829.739(2113.425, 3746.169)	0.212	-7.509(-31,22)	-4.6	-30
Fl_{im}	850085	F=0.291	0.291(0.226, 0.397)	2521.394(1779.128, 3521.787)	0.514	-17.587(-42,15)	66.3	23
$SSB_{2025}=B_{lim}$	875324	F=0.299	0.301(0.234, 0.416)	2500.022(1788.411, 3430.535)	0.529	-18.286(-42,12)	71.2	26
$SSB_{2025}=B_{pa}$	74667	F=0.100	0.023(0.018, 0.028)	3184.058(2471.529, 4076.192)	0.029	4.072(-19,33)	-85.4	-89
Status quo	570511	F=0.189	0.186(0.149, 0.241)	2759.039(2042.021, 3728.537)	0.277	-9.82(-33,22)	11.6	-18

*95% confidence interval

4.17 Figures

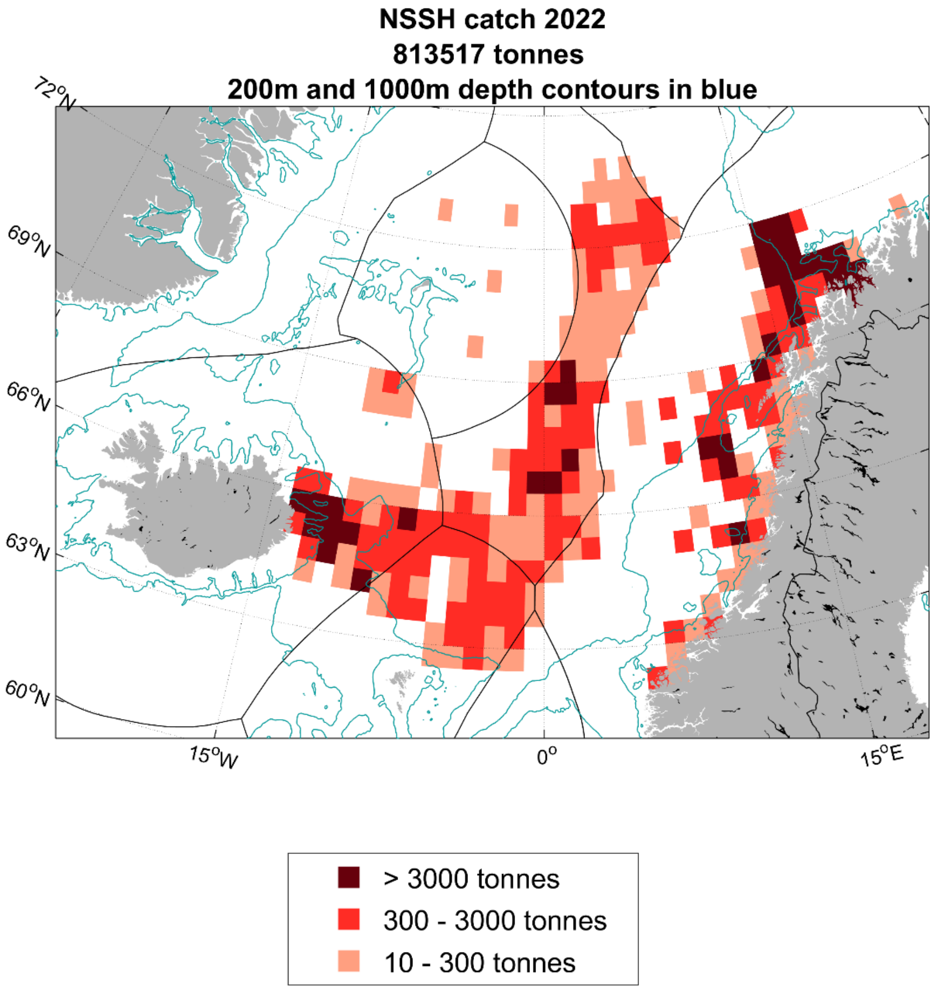


Figure 4.2.1.1. Total reported landings (ICES estimates) of Norwegian spring-spawning herring in 2022 by ICES rectangle. Landings below 10 tonnes per statistical rectangle are not included.

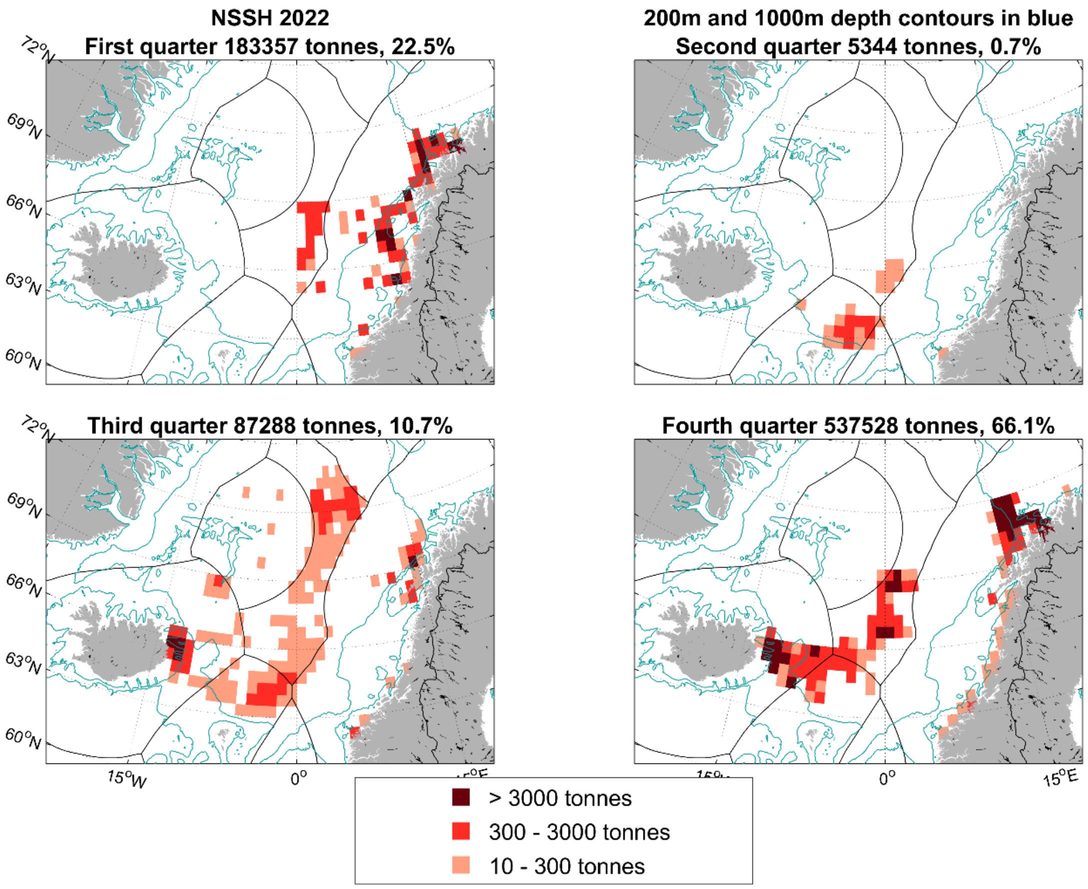
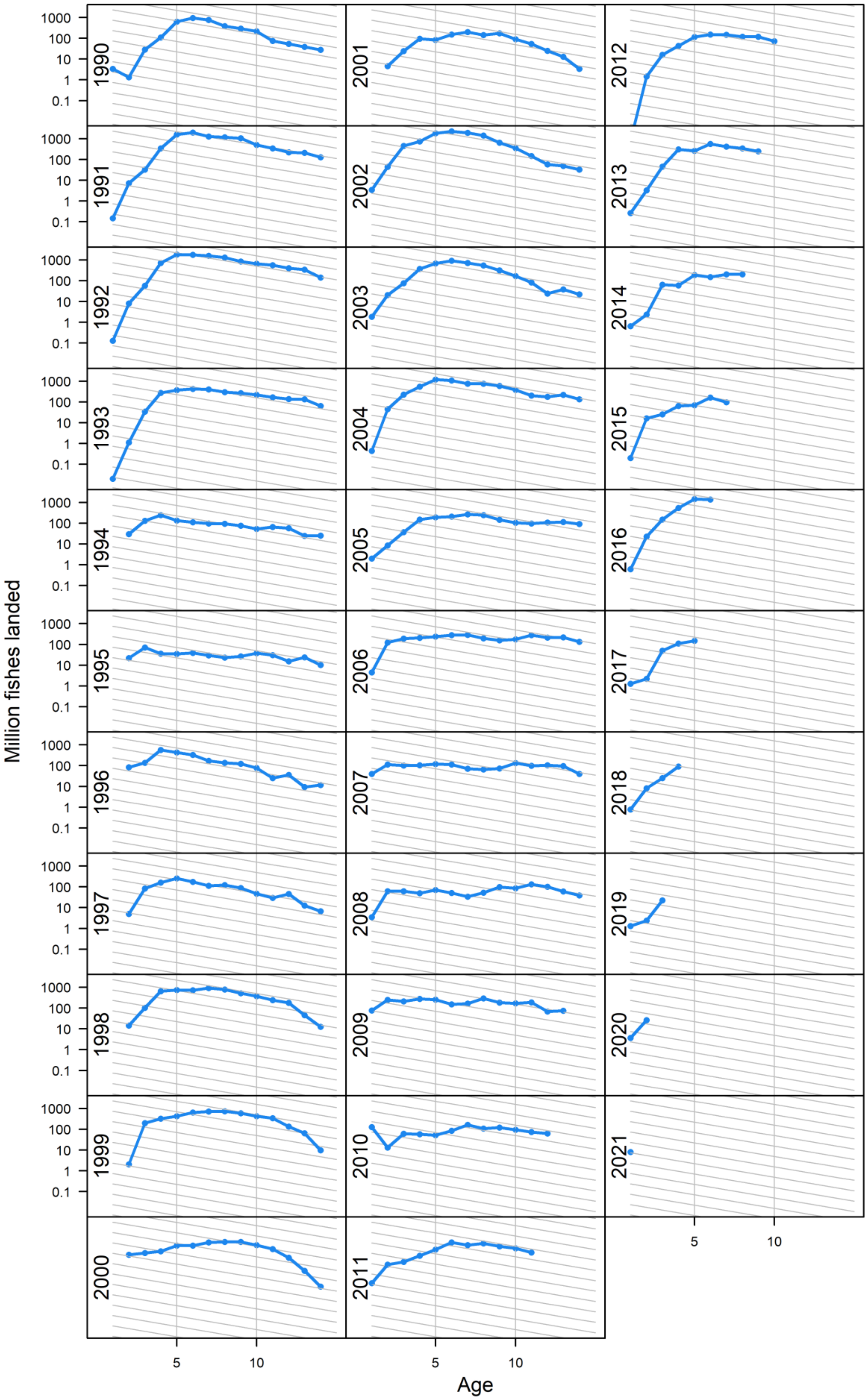


Figure 4.2.1.2. Total reported landings (ICES estimates) of Norwegian spring-spawning herring in 2022 by quarter and ICES rectangle. Landings below 10 tonnes per statistical rectangle are not included.


1000
100
10
1
0.1
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1991
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2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
Million fishes landed
5
10
Age

Figure 4.4.3.1. Norwegian spring spawning herring. Age disaggregated landings 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.

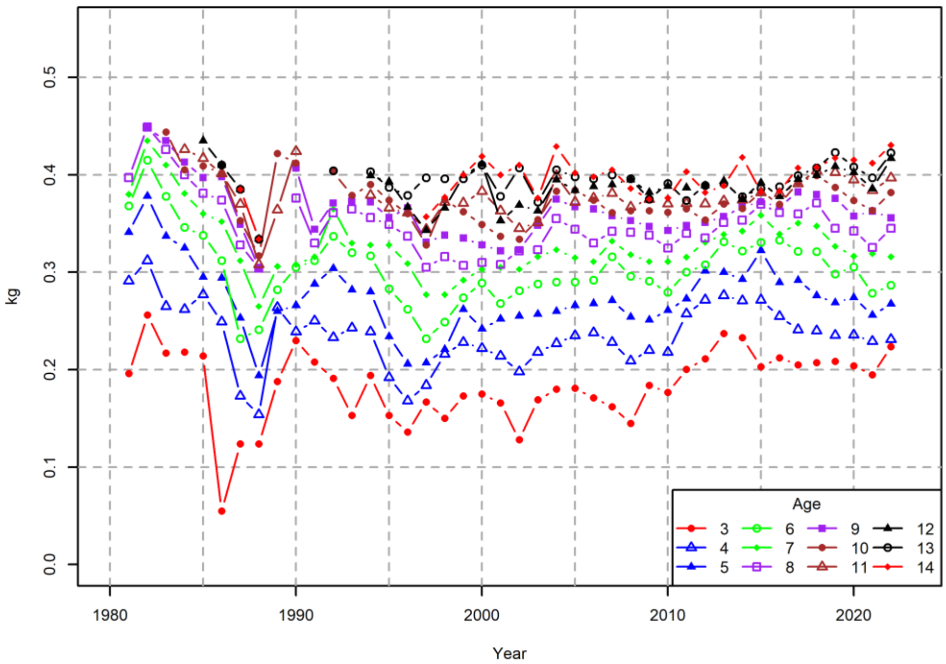


Figure 4.4.4.1. Norwegian spring spawning herring. Mean weight at age by age groups 3–14 in the years 1981—2022 in the landings.

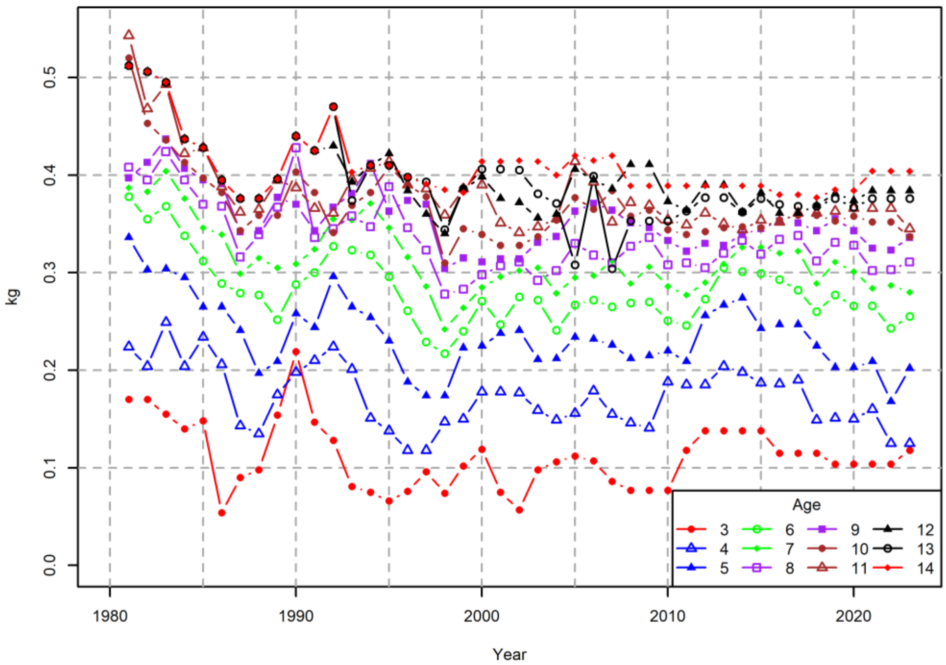


Figure 4.4.4.2. Norwegian spring-spawning herring. Mean weight at age in the stock by age groups 3–14 for the years 1981—2023.

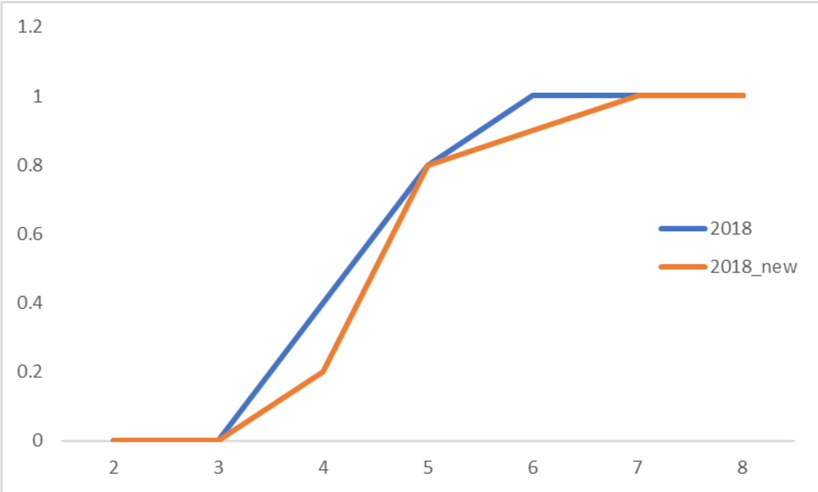


Figure 4.4.5.1. Old assumed (blue line) and new back-calculated (orange line) maturity-at-age for the year 2018.

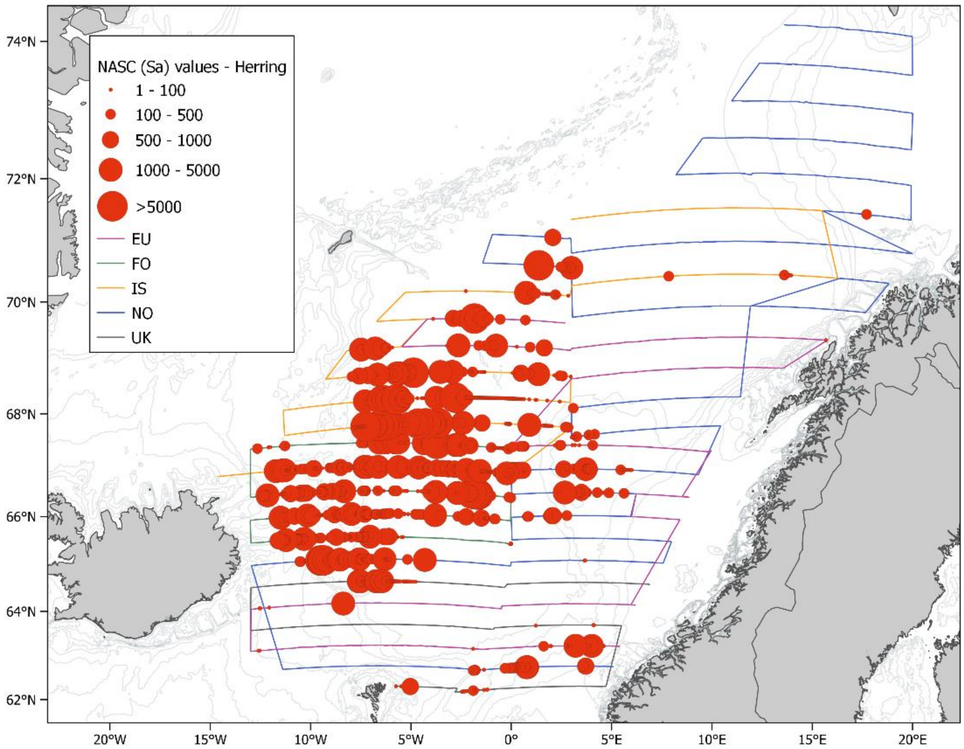


Figure 4.4.7.1. Distribution of Norwegian spring-spawning herring as measured during the IESNS survey in April-June 2023 in terms of NASC values (m^2/nm^2).

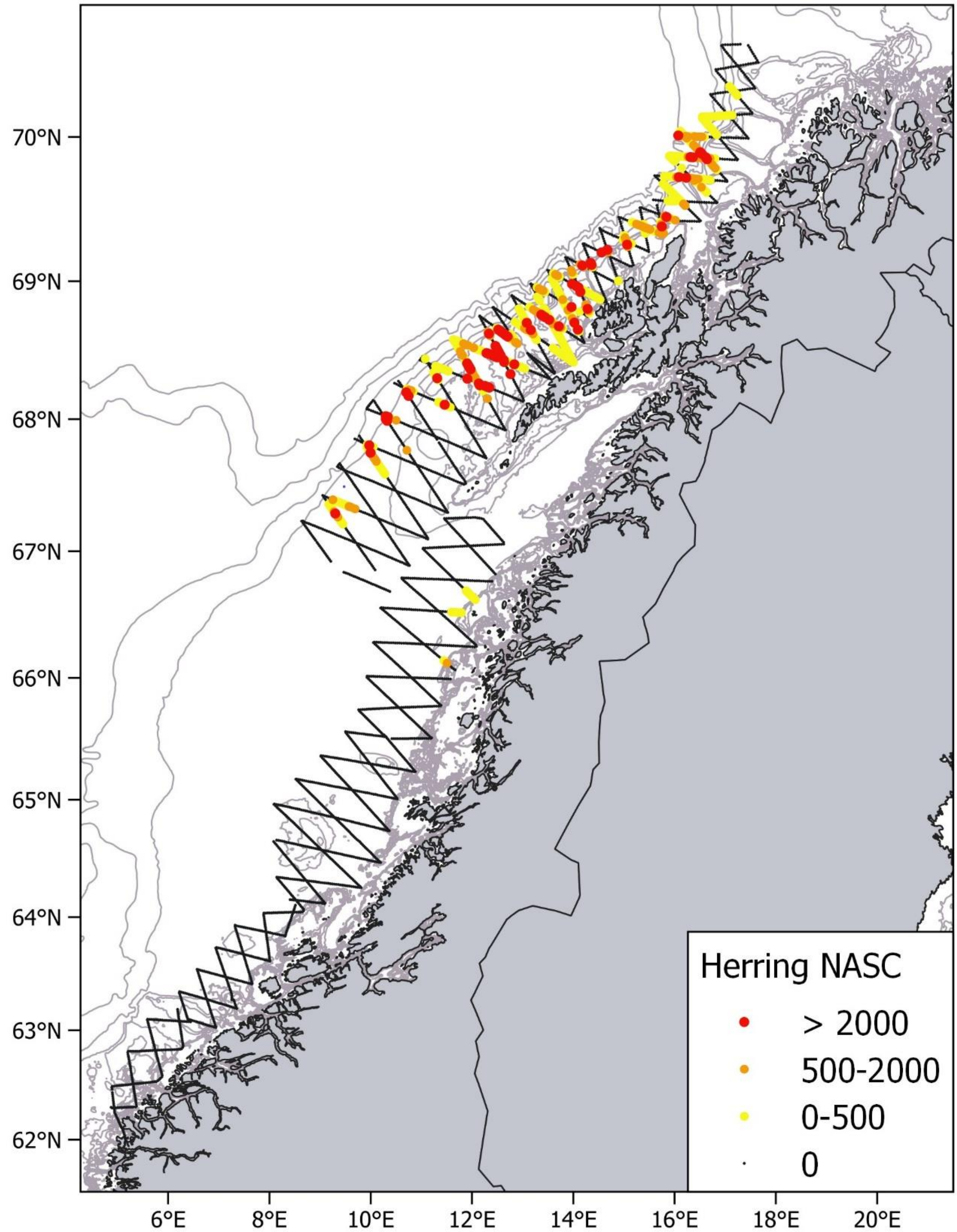


Figure 4.4.7.2. Norwegian acoustic survey on the NSSH spawning grounds. Distribution and acoustic density of herring recorded in 2023.

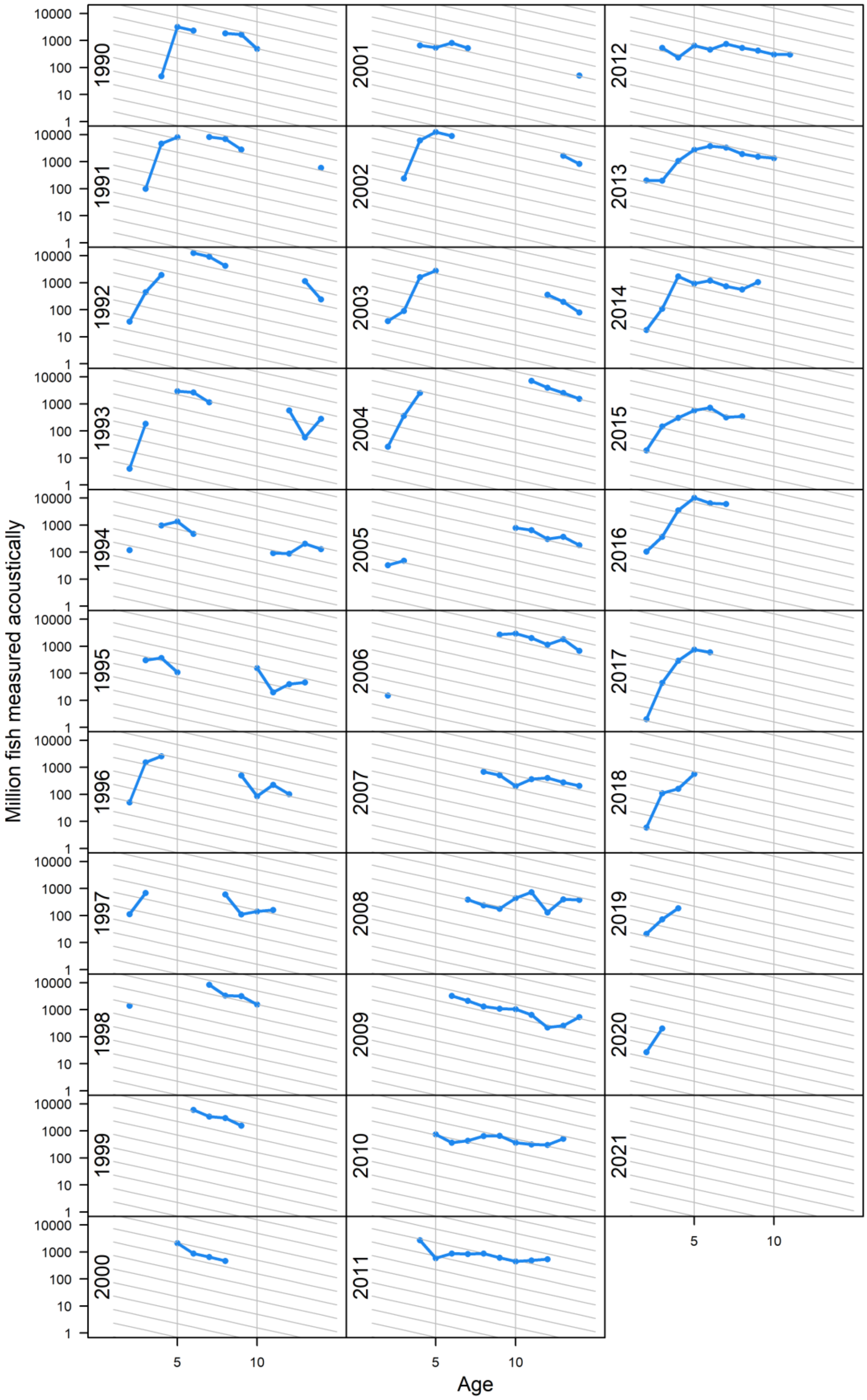


Figure 4.4.7.3. Norwegian spring spawning herring. Age disaggregated abundance indices (millions) from the acoustic survey on the spawning area in February-March (Fleet 1) plotted on a log scale. The labels indicate year classes and grey lines correspond to Z = 0.3. Age is on x-axis.

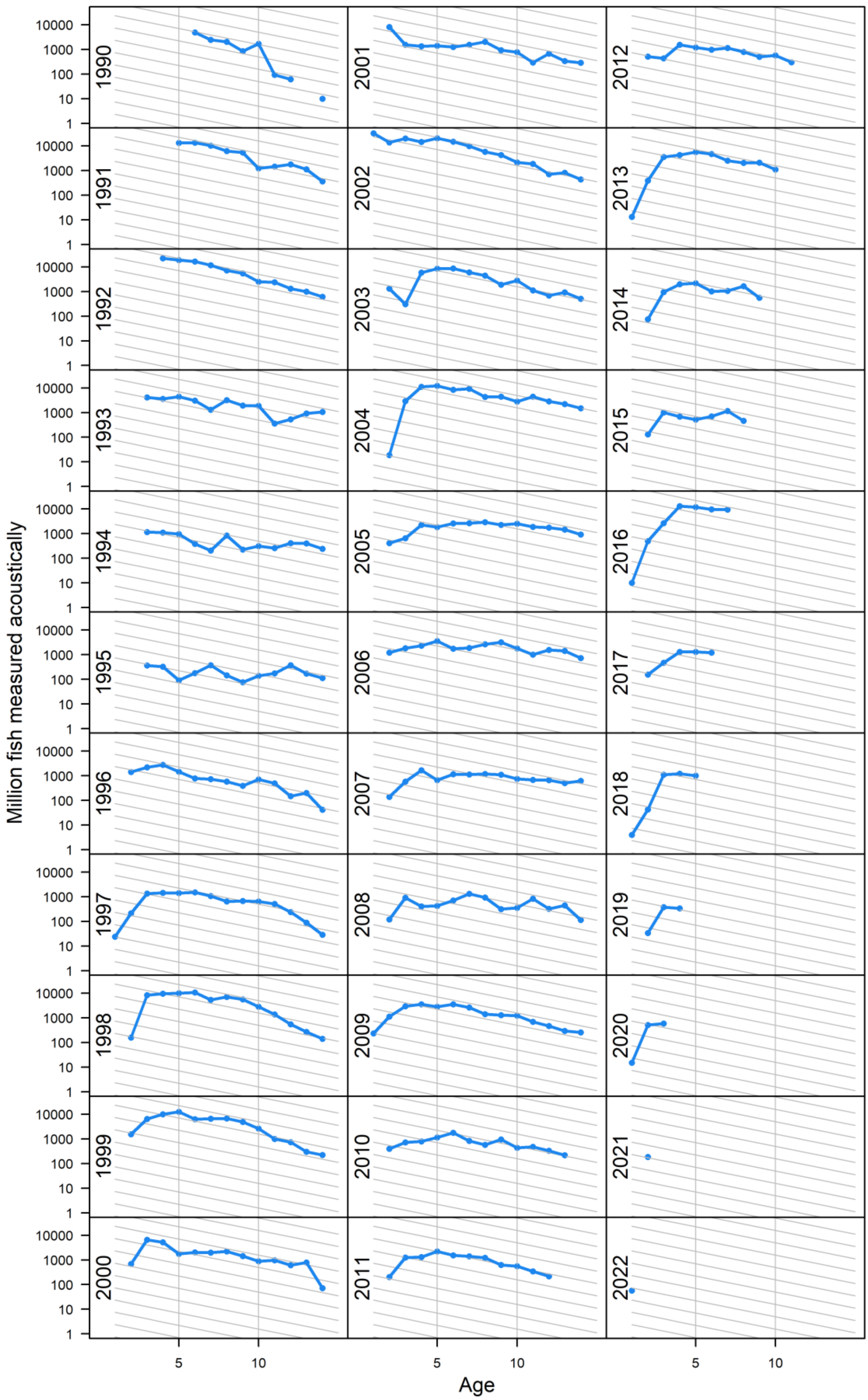


Figure 4.4.7.4. Norwegian spring spawning herring. Age disaggregated abundance indices (millions) from the acoustic survey in the feeding area in the Norwegian Sea in May (Fleet 5) plotted on a log scale. The labels indicate year classes and grey lines correspond to Z = 0.3.

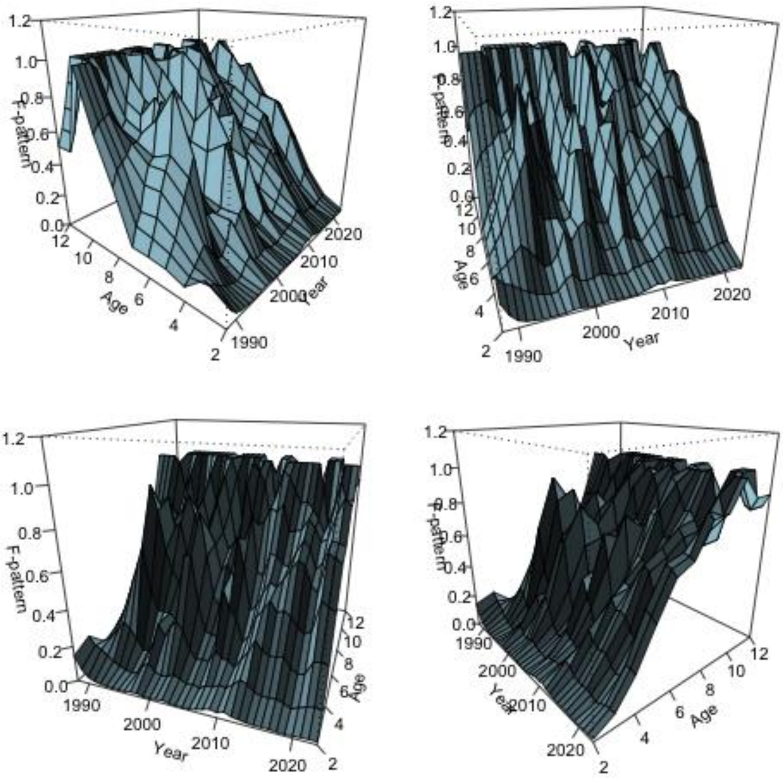


Figure 4.5.1.1. Estimated exploitation pattern for the years 1988–2023 by the XSAM model fit. All panels show the same data, but depicted at different angles to improve visibility at different time periods

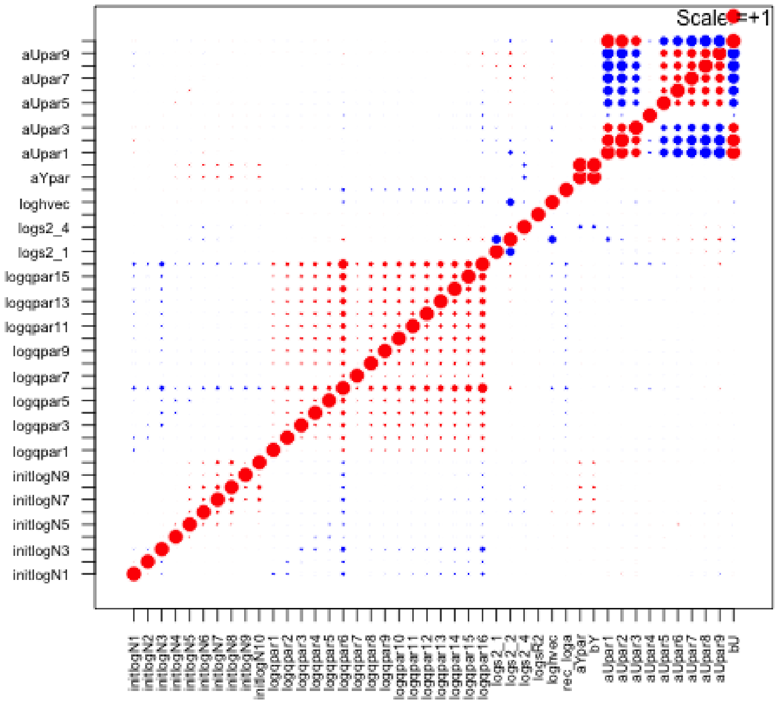


Figure 4.5.1.2. Norwegian spring spawning herring. Correlation between estimated parameters in the final XSAM model fit.

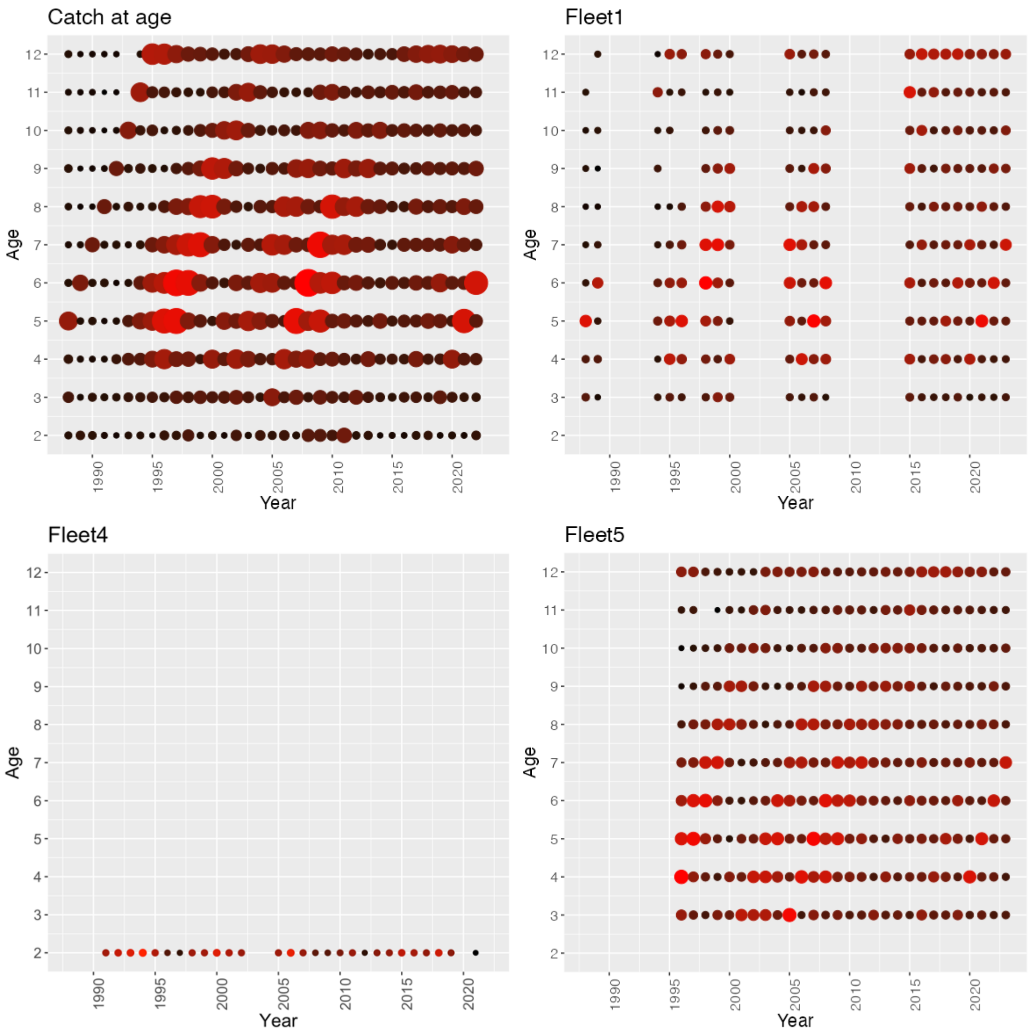


Figure 4.5.1.3. Norwegian spring spawning herring. Weights (inverse of variance) of data-input of the final XSAM model fit.

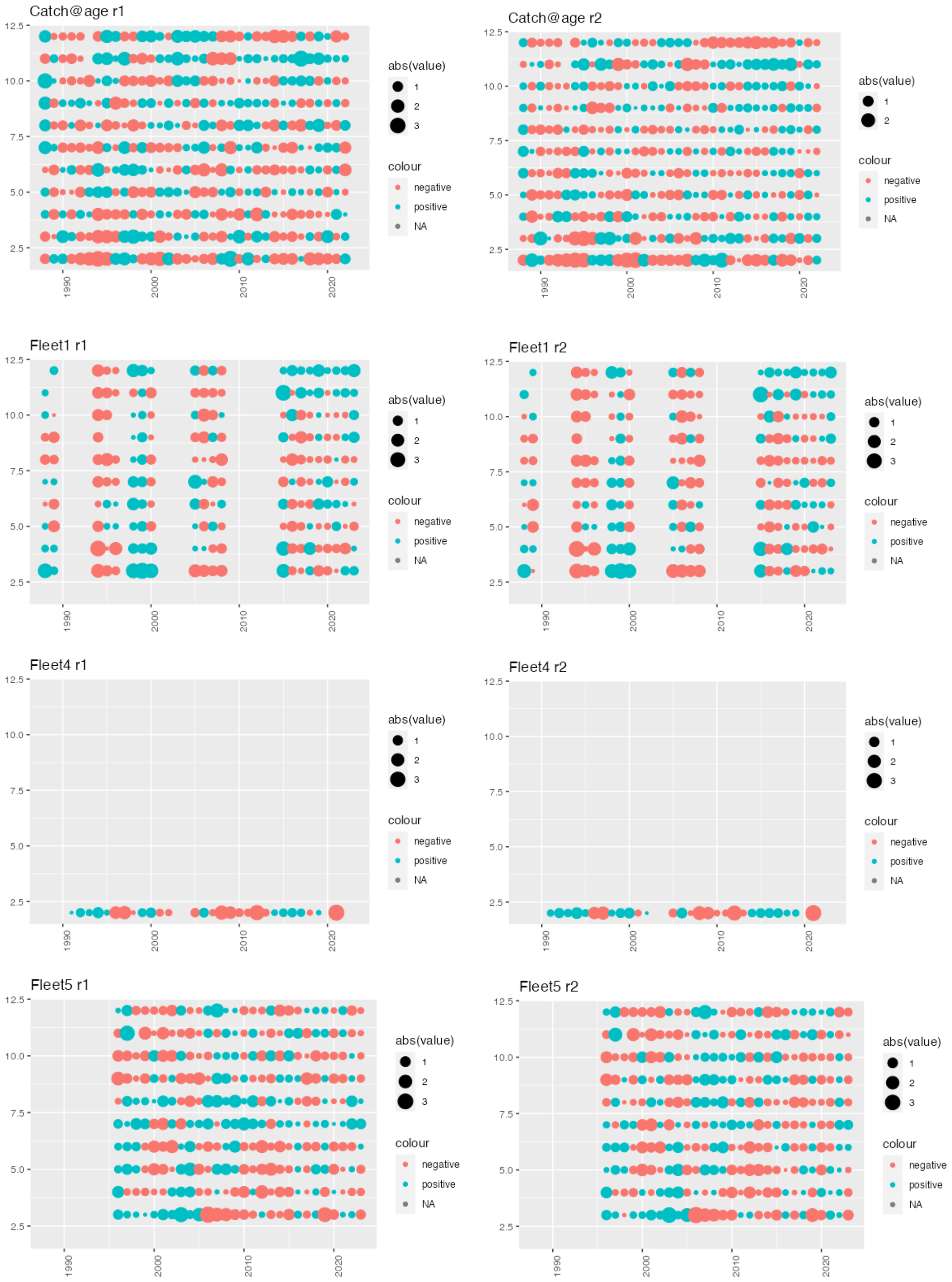


Figure 4.5.1.4. Norwegian spring spawning herring. Standardized residuals type 1 (left) and type 2 (right) (see text) of data-input of the final XSAM model fit. Red is negative and blue is positive residuals.

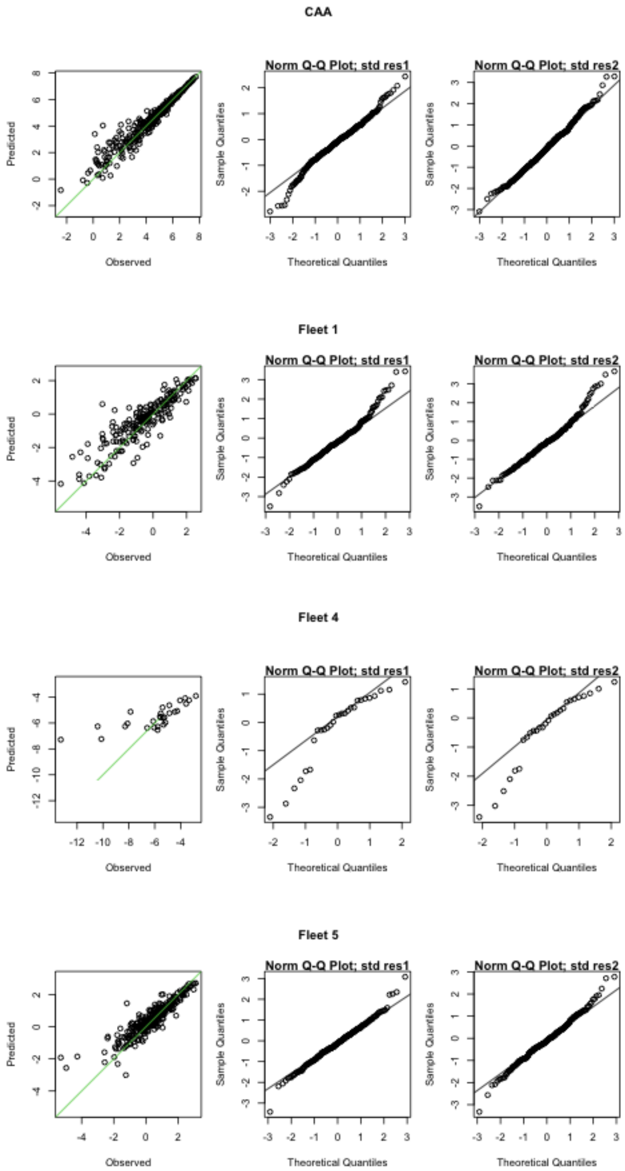


Figure 4.5.1.5. Norwegian spring spawning herring. Observed vs. predicted values (left column) and qq-plot based on type 1 (middle) and type 2 (right) residuals (see text) based on the final XSAM model fit.

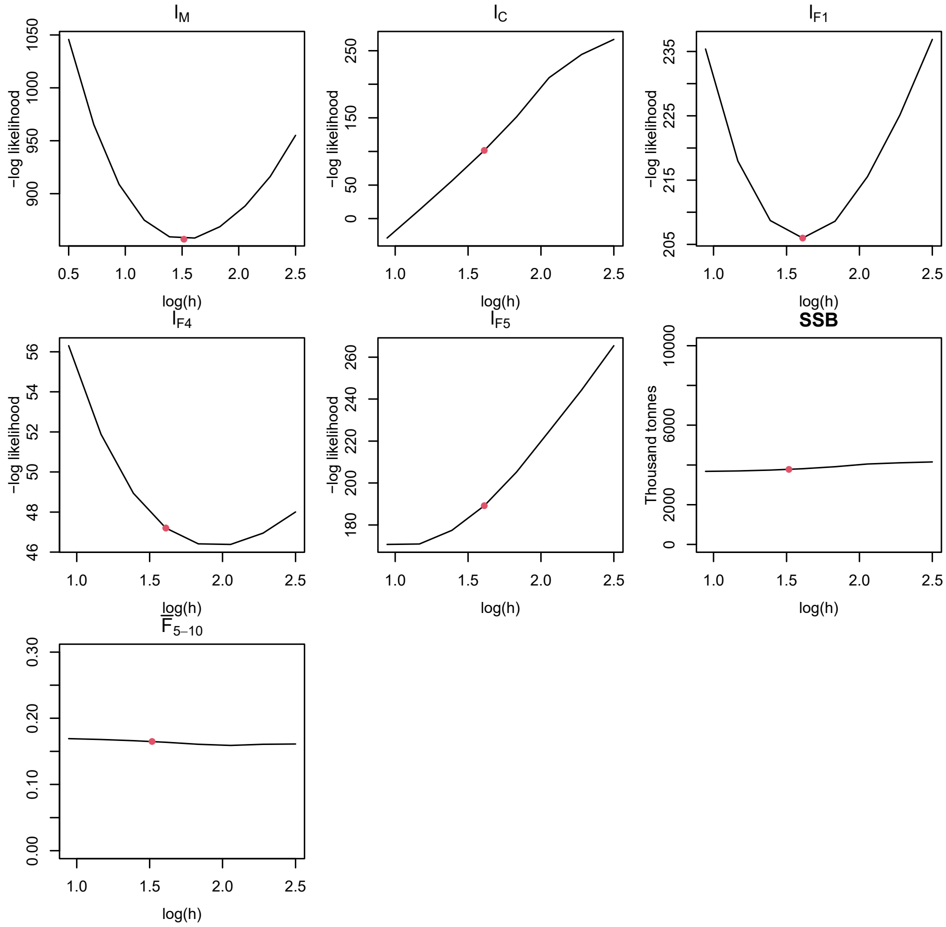


Figure 4.5.1.6. Norwegian spring spawning herring. Profiles of marginal log-likelihood $\mathbf{l_M}$, the catch component $\mathbf{l_C}$, Fleet 1 component $\mathbf{l_{F1}}$, Fleet 4 component $\mathbf{l_{F4}}$, Fleet 5 component $\mathbf{l_{F5}}$, point estimate of SSB and average F (ages 5-12+) in 2023 over the common scaling factor for variance in data $\mathbf{h}$ for the final XSAM fit. The red dots indicate the value of the respective scaling factors for which the log-likelihood is maximized.

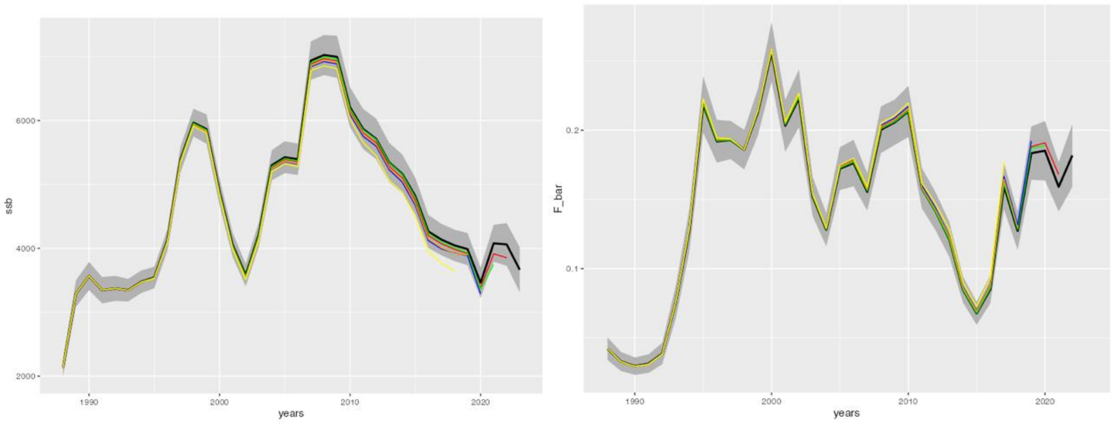


Figure 4.5.1.7. Norwegian spring spawning herring. Retrospective XSAM model fits of SSB and weighted average of fishing mortality ages 5-12 for the years 2017-2023. Mohn's rho computed to be -0.06 for SSB and -0.02 for F.

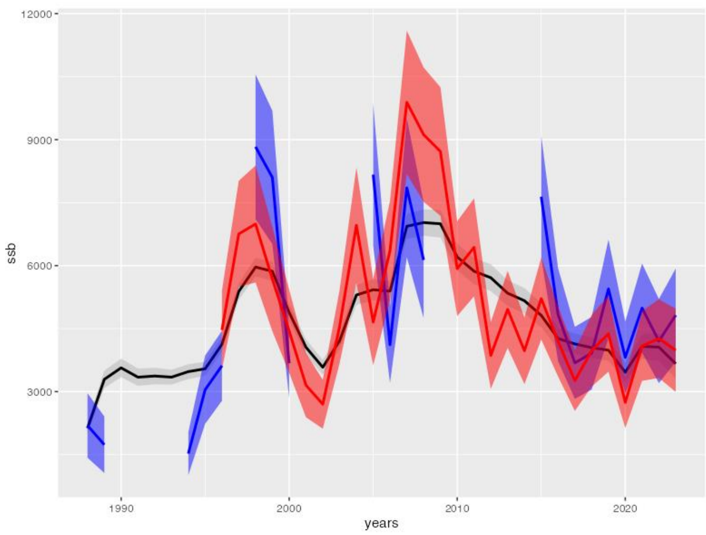


Figure 4.5.1.8. Norwegian spring spawning herring. Point estimates of Spawning-stock biomass by years 1988-2023 from model (black lines) and by survey indices from Fleet 1 (blue) and Fleet 5 (red). Shaded area is approximate to standard deviation.

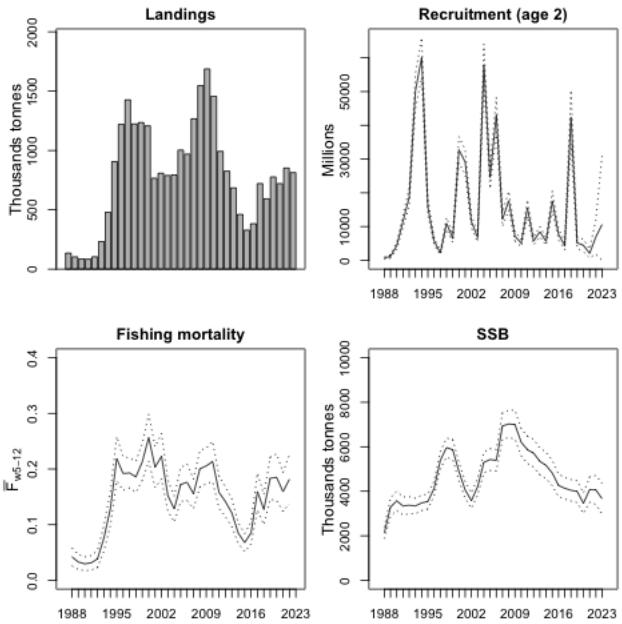


Figure 4.5.1.9. Total reported landings 1988-2022, estimated recruitment, weighted average of fishing mortality (ages 5-12) and spawning-stock biomass for the years 1988–2023 based on the final XSAM model fit.

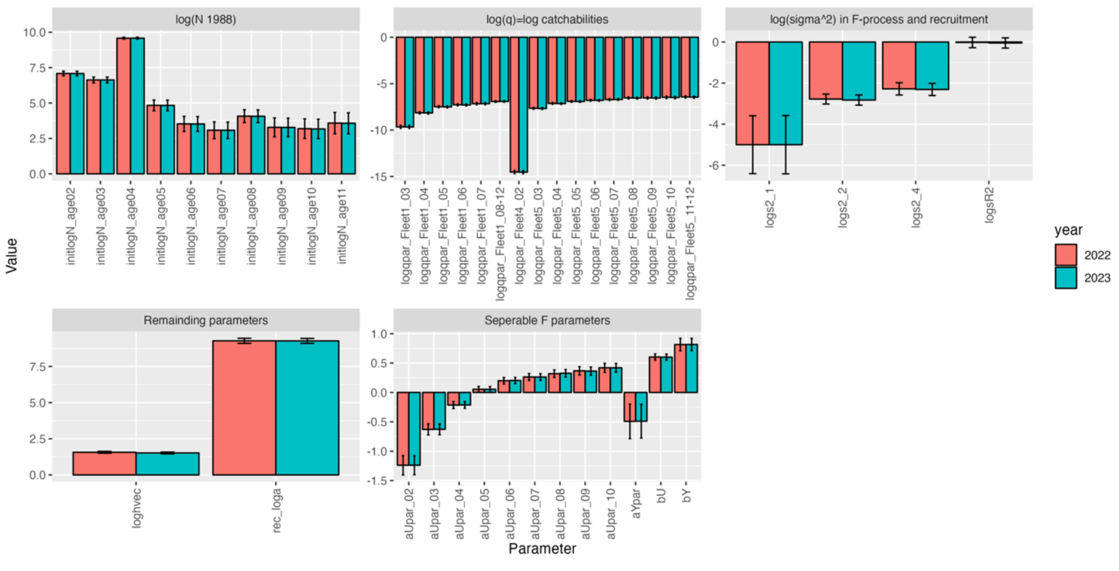


Figure 4.5.1.10. Norwegian spring-spawning herring. A visual representation of parameter estimates of the final XSAM model fit (see table 4.5.1.1). The estimates from the 2022 assessment are also shown (red).

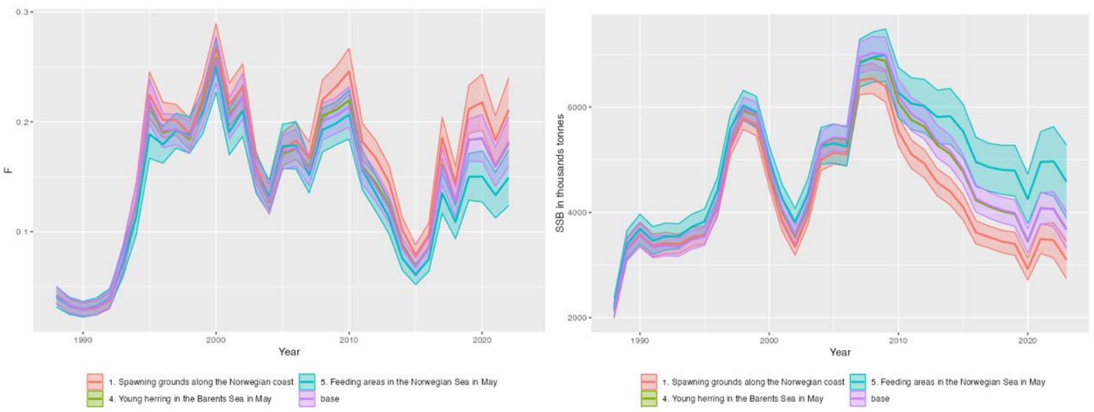


Figure 4.5.1.11. Norwegian spring-spawning herring. Alternative runs showing the effect of leaving one fleet out. The F is shown to the left and SSB to the right. The base run is shown as purple, leaving out Fleet 1 is red, leaving out Fleet 4 is green and leaving out Fleet 5 is shown as blue. Shaded regions show the standard deviation.

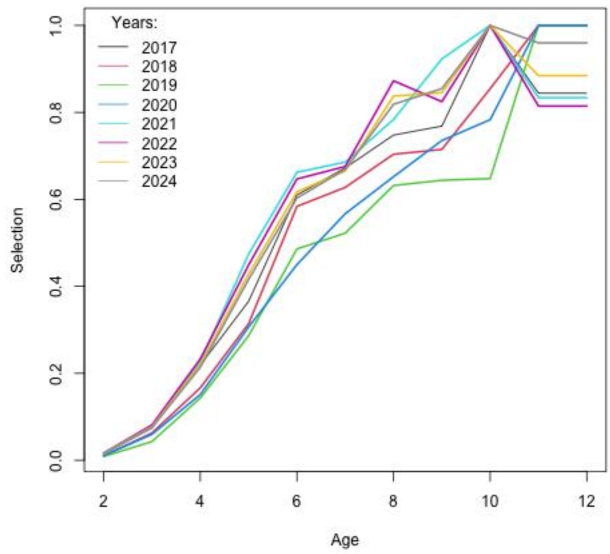


Figure 4.8.1.1. XSAM estimated selection pattern; selected years (estimates for 2017–2022 and predictions for 2023-2024) are shown in colours as indicated in the legend.

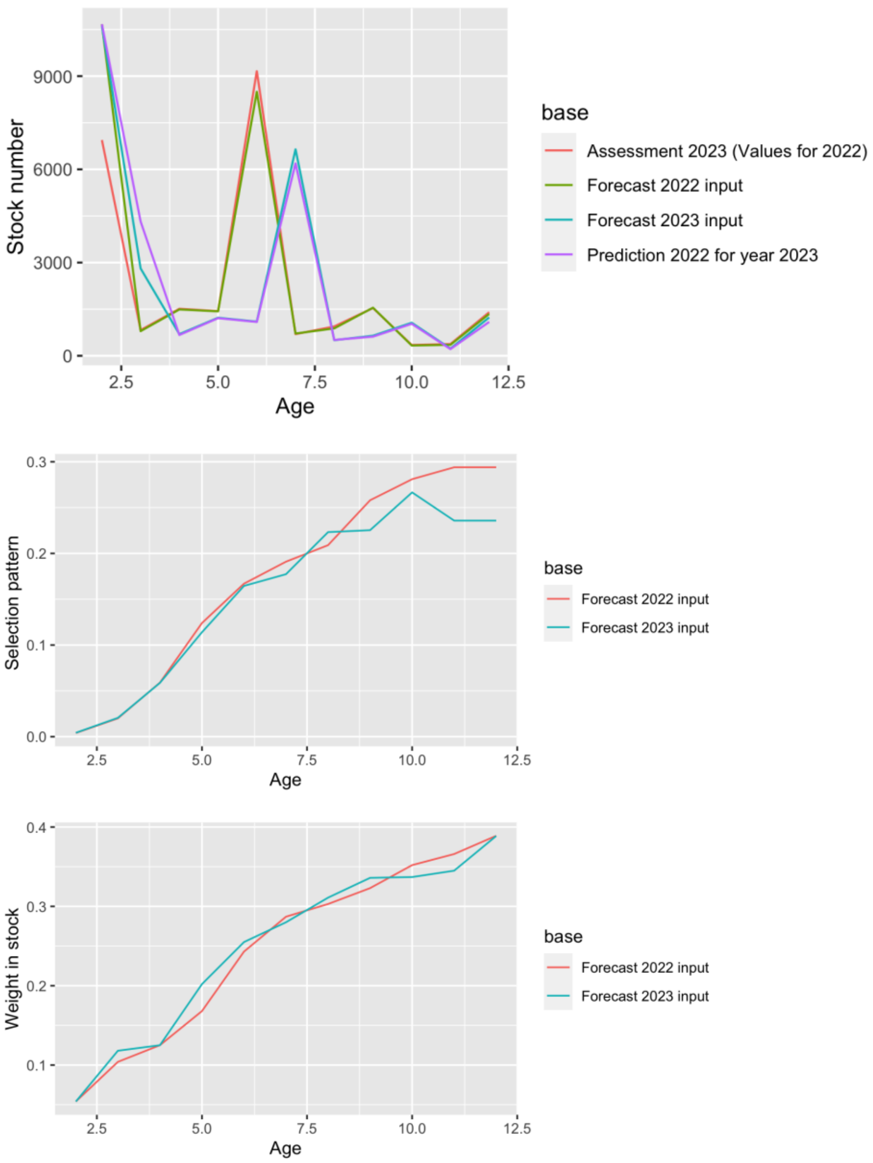


Figure 4.8.3.1. In upper panel, the input of the stock number at age for the 2022 and the 2023 forecast is seen as green and blue lines respectively. The stock number at age in 2022 from the 2023 assessment is the red line, and purple line presents the predicted stock number in 2023 from the 2022 forecast. Middle panel, the selection pattern used in the 2022 (red) and 2023 (blue) forecast. Bottom panel, the weight in stock used in the 2022 (red) and 2023 (blue) forecast.

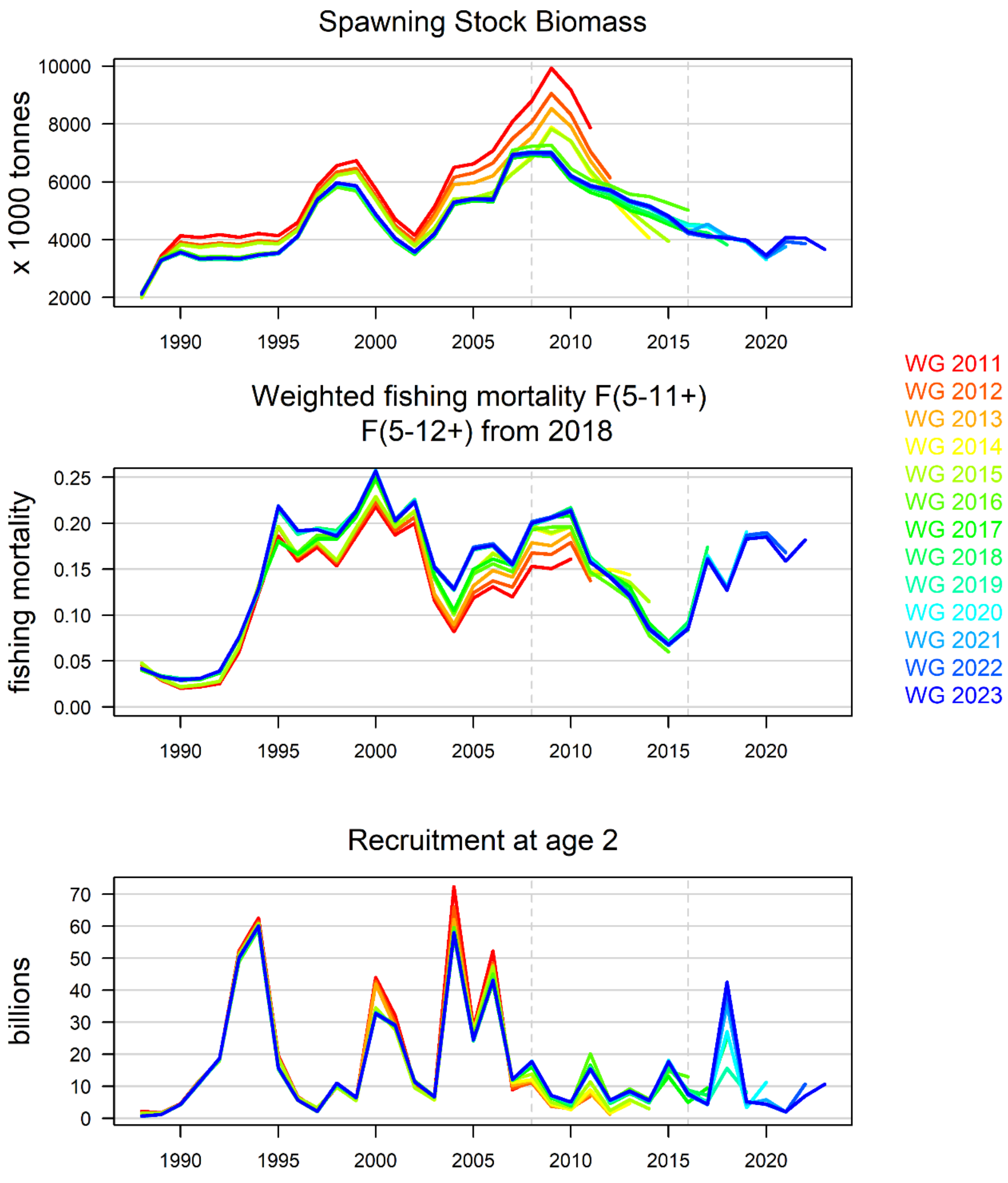


Figure 4.9.1. Norwegian spring spawning herring. Comparisons of spawning stock; weighted fishing mortality F (5-11/5-12+); and recruitment at age 2 with previous assessments. In 2016 the proportion mature in the years 2006-2011 was changed; recruitment age changed from 0 to 2 and fishing mortality is calculated over ages 5 to 11. In 2018 (WKNSSHREF) the age range for the fishing mortality changed to ages 5 to 12+. The vertical dotted lines indicate the benchmark years 2008 and 2016.

5 Horse mackerel in Northeast Atlantic

Trachurus trachurus

5.1 Fisheries in 2022

The total international catches of horse mackerel in the North East Atlantic are shown in Table 5.1.1. Since 2011, the southern horse mackerel stock is assessed by ICES WGHANSA. The total catch from all areas in 2022 for the Western and North Sea stocks was 78,491t which is 14,148t less than in 2021 and the 2nd lowest in the time series.

Ireland, Germany and the Netherlands have a directed trawl fishery and Norway and France a directed purse-seine fishery for horse mackerel. Spain has directed as well as mixed trawl and purse-seine fisheries targeting horse mackerel. 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 Subdivision in 2022 are given in Table 5.1.2 and the distributions of the fisheries are given in Figures 5.1.1.a–d. Note that the figures also include catches of southern horse mackerel but without Portuguese catches in 9a. The maps are based on data provided by Belgium, Denmark, France, Germany, Ireland, Netherlands, Norway, Poland, Portugal, Spain, Sweden and the UK. They represent all catches of North Sea and Western Horse Mackerel. The distribution of the fishery is similar to recent years with the highest catches taken in the 1st and 4th quarter. The historic catch by rectangle and year is also shown in section 1.10 of this report.

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 37,568 t (48% of the total catch of the combined Western and North Sea horse mackerel catch). 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: 7,854 t. As usual, catches were significantly lower than in the first quarter as the second quarter is the main spawning period. Most of the catch were taken along the Spanish coast and Bay of Biscay. (Figure 5.1.1.b)

Third quarter: 11,574 t. Most of the catch were taken in Spanish waters, West of Ireland, in the Channel area and at the Norwegian coast (Figure 5.1.1.c).

Fourth quarter: Catches were 19,972 t (25% of the total catch). The catches were distributed in five main areas (Figure 5.1.1.d):

- Spanish waters,
- Western and Northern Irish waters and West of Scotland
- Norwegian coast
- Eastern part of the Channel
- Along the shelf edge of the Celtic Sea

5.2 Stock units

For many years the Working Group has considered the horse mackerel in the Northeast Atlantic as consisting of three separate stocks: the North Sea, the Southern and the Western stocks (ICES 1990, ICES 1991). For further information, see the Western Horse Mackerel Stock Annex and 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.

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 (Costas, 2017a).

As a result of this review, catches and catch-at-age of reported historical data of both North Sea and Western stocks of horse mackerel were updated (Figures 5.3.1 and 5.3.2). Catch statistics were reviewed since 1990 onward for the Western stock and since 2000 onward for the North Sea stock. The main mismatches between the catch statistics in working group reports and these reviewed data were due to several reasons such as late availability of some data for the report or the availability of official catch data only.

It is expected that the upcoming benchmark will also result in a review of the catch statistics for the North Sea and Western horse mackerel.

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 2021 were allocated to the three stocks as follows:

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

North Sea stock: 1st and 2nd quarters: Divisions 3.a and 4.a Quarters 1-4: 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 1982-2021 are shown in Figures 5.4.2-3. The catches by stock and countries for the period 1997-2021 are given in Table 5.4.2-5.4.3.

Recent genetic investigations show that the current boundaries might need to be newly evaluated in future (see also section 1.4.8.3 and section 5.10).

5.5 Estimates of discards

Only the Netherlands have provided data on discards over an extended period with occasional estimates from Germany and Spain. Since 2017 however, additional countries have provided estimates of discards with 8 countries reporting in 2022. However, following the introduction of the European landing obligation for the pelagic fisheries targeting horse mackerel in large areas of the overall fishing area and for Norwegian waters there is a general discard ban in place and discards in recent years have decreased substantially. The discard rate is estimated to be 4.8% in weight for the combined horse mackerel stocks. The discard rate for the North Sea stock is estimated to be 0.5% and for the Western stock 4.8% in 2022.

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*.

In general, *T. mediterraneus*, fishery takes place mainly in the eastern part of the ICES division. 8.c. There is no clear trend in the catches of *T. mediterraneus* in this area and they have been fairly stable over the last few years. (Table 5.6.1). Information on the *T. picturatus* fishery is available in the WGHANSA Report (Working Group on Horse Mackerel, Anchovy and Sardine).

Taking into account that the WGWIDE horse mackerel assessments are 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:

France, Germany, Ireland, the Netherlands, UK (England, Northern Ireland and Scotland), Norway and Spain provided length distributions for their catches in 2022. The length distributions cover approximately 75% of the total landings of the Western and North Sea horse mackerel catches and are shown in Figure 5.7.1.

5.8 Comparing trends between areas and stocks

Horse mackerel (*Trachurus trachurus*) in the northeast Atlantic is assumed to consist of three separate 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 between 2000 and 2022 are shown in figure 5.4.1 and indicate an overall decline in the catches of horse mackerel since 2009.

A detailed analysis on the development of the catch by age data was presented to the 2017 working group (Pastoors, 2017). In this analysis it was indicated that there is 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. These catches could be seen mostly in division 7.d and to a lesser extent, 7.e.

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 based on the InterCatch input. Since 2011 the Southern horse mackerel is dealt with by ICES WGHANSA.

Countries that historically sample are Ireland, the Netherlands, Germany, Norway and Spain, covering 42—100% of their respective catches. In 2020, due to the Covid pandemic, sampling activities in some countries were hampered which lead to an overall lower sampling coverage for 2020. However, due to the fact that for the recent years it was possible to upload age samples taken from English vessels in the Netherlands for North Sea horse mackerel the proportion of sampling increased in comparison to the years before.

Table 5.9.2 shows the sampling intensity for the Western stock in 2022 and table 5.9.3 shows the sampling intensity for the North Sea stock in 2022 by country.

In 2022, France, Germany, Ireland, the Netherlands, Norway, Spain and UK (England), UK Scotland and UK (Northern Ireland) provided samples and length distributions and Germany, Ireland, the Netherlands, Norway, Spain and UK (England), and UK (Northern Ireland) provided also age distributions. However, the lack of age and length 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.

An analysis of the sampling intensity was carried out for the period 2000-2019 for both the North Sea and the Western stock. 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 of 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 (or at-length) and weight-at-age which are often used as inputs for the stock assessment models. In addition, in the 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 recent years. In relation to age composition sampling level are dramatically lower in recent years (Figure 5.9.2) but due to the inclusion of samples of English vessels sampled in the Netherlands this situation improved substantially in the last two years. However, divisions that are usually not sampled can affect the precision and accuracy of total catch-at-age and weight-at-age. For the North Sea stock, samples were only available for area 4.a (Quarter 1,2), 4.c for quarters 1, 3 and 4 and from 7.d from also the 1st, 3rd and 4th quarter. Therefore, these estimates can be biased, especially, since samples are sometimes less than the recommended 100 fish per sample. (Table 5.9.1)

The proportion of the sampled catches by region for the Western stock are shown in figure 5.9.3. The general index of sampling intensity dropped in comparison to last year but remains on a good level (74%).Divisions (regions) that are not sampled can affect the precision and accuracy of total catch-at-age and weight at age (Figure 9.5.4).

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 do not reflect 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 and omit the horse mackerel target fleet. This lack of coverage may also affect the accuracy and reliability of the assessment and is a matter of concern for the Working Group.

5.10 Recommendation on genetic stock identification

ICES has long considered horse mackerel in the northeast Atlantic to consist of three stocks, the separation of which was based on a variety of factors including the temporal and spatial distribution of the fisheries, the observed egg and larval distributions, information from acoustic and trawl surveys and from parasite infestation rates. Further refinements of the definitions of stock units were based on the results from the EU-funded HOMSIR project (2000-2003).

However, initial results of a recent comprehensive genetic research project on stock identification of horse mackerel suggest that the boundaries of the stocks might require revision. This relates to the Northern boundary in 4a where the western horse mackerel stock might be present all year round, and not only in quarters 3 and 4 as samples analysed from Q1 and Q2 in 4a were determined to be western horse mackerel. Furthermore, analysed samples indicate that the southern boundary of the western stock might within division 9.a rather than between 8.c and 9.a. The western stock has also been shown to mix with the North Sea stock in division 7.d., in the commercial catches that have been analysed. Ongoing and new studies are being undertaken to investigate these issues. Potential changes in the perception of the stock distributions could impact the reliability of the assessments for the three current stocks of horse mackerel in the Northeast Atlantic (see also section 1.4.8.3 for details).

Based on this genetic investigations WGWIDE recommends that the stock identification methods working group (SIMWG) conduct a review of ongoing genetic research into the stock structure of horse mackerel.

5.11 References

Brunel, T., 2016. Revision of the Maturity Ogive for the Western Spawning Component of NEA Mackerel. Working document to WKWIDE, 6pp.

Costas, G. 2017a. Review of Horse Mackerel catch data. North Sea and Western Stocks. WD to WGWIDE 2017. 11 pp.

Costas, G. 2017b. Sampling coverage for Horse Mackerel Stocks. Presentation to WGWIDE 2017.

ICES, 1990. Report of the Working Group on the Assessment of the Stocks of Sardine, Horse Mackerel and Anchovy. ICES, C.M. 1990/Assess: 24.

ICES, 1991. Working group on the Assessment of the Stocks of Sardine, Horse Mackerel, and Anchovy. ICES CM 1991/Assess: 22. 138 pp.

Pastoors, M. (2017). A look at all the horse mackerel. WD to WGWIDE 2017.

5.12 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.

Sub-area	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

Sub-area	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

Sub-area	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

Sub-area	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

Sub-area	2011	2012	2013	2014	2015	2016	2017	2018
2	647.588	66.02912	30	424.291	10	45.276	5	718
4 + 3.a	25,158	5,234	8,183	17,270	10,560	11,565	12,609	11,758
6	39,496	44,971	43,266	32,444	24,153	32,186	28,170	38,896
7	120,340	120,476	100,859	66,853	49,644	46,901	33,297	38,816
8	35,245	17,209	26,983	30,844	19,822	17,511	18,307	23,393
9[1]	22,575	25,316	29,382	29,205	33,179	41,081	37,080	31,920
Disc	430	3,279	4,582	1,904	6,232	5,944	5,488	2,873
Total	243,892	216,552	213,285	178,945	143,600	155,232	134,956	148,374

Sub-area	2019	2020	2021	2022
2	867	290	12	157*
4 + 3.a	12,593	13,792	7,672	5,102
6	47,351	19,037	13,727	12,016
7	42,973	33,310	49,934	38,285
8	29,640	19,639	19,602	17125
9[1]	34,080	31,344	26,745	24,997
Disc	3,326	2,942	1,692	3,786
Total	170,829	120,347	119,384	103,488

[1] - Southern Horse Mackerel (ICES Division 9) is assessed by ICES WGHANSA since 2011,

*** - 10t of landings in 5b included**

Table 5.1.2 HORSE MACKEREL Western and North Sea Stock combined.
Quarterly catches (t) by Division and Subdivision in 2022.

Division	1Q	2Q	3Q	4Q	TOTAL
2.a+5.b	51	69	16	19	157
3	0	0	29	190	220
4.a	1357	276	1638	1610	5596 [1]
4.bc	10	270	1244	521	2065 [2]
7.d	1452	188	974	2043	4678 [3]
6.a,b	8925	90	5	2545	12329 [4]
7.a–c,e–k	21701	331	2550	9885	34467
8.a-e	4072	6633	5117	3158	18979
Sum	37568	7858	11574	19972	78491 [5]

[1] for the total 714t were added which were only declared as yearly catch

[2] for the total 20t were added which were only declared as yearly catch

[3] for the total 22t were added which were only declared as yearly catch

[4] for the total 764t were added which were only declared as yearly catch

[5] for the total 1519t were added which were only declared as yearly catch

Table 5.4.1 HORSE MACKEREL General. Landings and discards (t) by year and ICES 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

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
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

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
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
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

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
2017	0	22	2,557	10,787	1,213	14,579	5	697	9,332	28,170	22,510	18,307	3,939	82,961	97,540	37,088	134,956
2018	0	1,418	1,413	11,677	265	14,773	718	380	8,547	38,896	27,140	23,393	2,609	101,683	116,456	31,920	148,376
2019	0.5	2,571	1,217	7,829	185	11,803	867	490	8,314	47,351	35,144	29,640	3,141	124,947	136,750	34,080	170,830
2020	0	2,211	1,099	9,077	201	12,587	290	96	10,387	19,037	24,232	19,359	2,741	76,422	89,009	31,344	120,347
2021	1	2,270	1,639	7,120	52	11,082	12	12	3,751	13,727	42,813	19,602	1,641	81,557	92,639	26,745	119,384
2022	0	1,632	2,020	4,678	435	8,377	157	191	3,280	12,016	33,994	17,125	3,352	70,114	78,491	24,997	103,488

***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	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	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	2018	2019	2020	2021	2022
Belgium									
Denmark	5,945	4,556	321	4,541	6,302	7,764	5,487	6,042	5,265
Faroe Islands	68	-	-	180	-	26	-		106
France	3,428	3,247	2,797	3,923	3,443	4,382	2,217	2,710	2,613
Germany	17,161	9,417	11,414	7,172	4,734	9,211	954	5,530	4,263
Ireland	32,667	21,654	27,605	23,560	25,347	28,899	17,390	18,770	15,799
Lithuania	-	-	2,596	-	-	-	0		-
Netherlands	25,053	24,958	23,792	14,269	25,942	29,656	14,240	20,786	18,474
Norway	14,353	8,897	9,438	9,885	9,319	9,021	10,666	3,663	3,131
Poland	-	-	--	-	-	127	1,002	1,605	-
Spain	19,442	13,071	14,235	14,901	20,362	25,776	18,582	16,191	13,424
Sweden	0	10	-	41	23	323	83	4	3
UK (Engl. + Wales)	4,832	2,063	842	549	2,443	4,036	1,496	2,651	2,316
UK (N. Ireland)	1,579	1,204	-		1,080	1,907	1,231	1,350	811
UK (Scotland)	1,389	738	970	-	-	678	333	615	558
Unallocated	8,545	4,377	1,010	3,994	74	-	-	-	-
Discard	1,896	4,228	4,417	3,928	2,609	3,141	2,741	1,641	3,352
Total	136,360	98,419	98,810	82,950	101,682	124,947	76,422	81,557	70,114

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	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

Country	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
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	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. + Wales)	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	2018	2019	2020	2021	2022
Belgium	63	51	67	44	18	39	38	30
Denmark	800	268	294	397	100	177	72	37
Faroe Islands	0	0	4	0	10	109		
France	934	1,322	1,863	1,443	935	758	503	433

Germany	644	1,879	949	2,766	946	3	87	67
Ireland	0	0	0	0	0	0	174	0
Lithuania	0	0	0	0	1,254	0	0	0
Netherlands	3,305	3,892	5,638	5,184	2,089	4,803	3,377	2,490
Norway	662	1,701	5	1,423	2,543	2,090	2,091	1,640
Sweden	9	0	0	0	0	1	0	0
UK (Engl. + Wales)	3,581	4,697	4,546	3,250	3,632	4,381	4,669	3,203
UK (Northern Ireland)	0	0	0	0	53	0	0	0
UK (Scotland)	0	0	0	0	38	24	19	42
Unallocated	0	0	0	0	0	0	0	0
Discard	2,004	1,527	1,213	265	185	201	52	435
Total	12,002	15,337	14,579	14,773	11,802	12,587	11,082	8,377

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

	7	8.ab	8.c East	8.c West	TOTAL
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
2018	0.4	38	640	0	678
2019	0.02	81	384	1	466
2020	0	0	558	2	560
2021	0.9	265	390	0	656
2022	29	306	267	2	605

Table 5.9.1. Summary of the overall sampling intensity on horse mackerel catches in recent years in all areas 1992—2022

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

Year	Total Catch (ICES estimate)	% catch covered by sampling programme*	No. samples	No. Measured	No. Aged
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
2018	116455	74	1584	117768	6965
2019	136750	64	1014	77211	7476
2020	89,009	52	516	41811	5662
2021	92,639	77	977	59222	8080
2023	78,491	78	1162	65991	5814

***Percentage related to catch (catch at age) according to ICES estimation**

Table 5.9.2. Horse mackerel sampling intensity for the Western stock in 2022.

Country	Catch	% Catch Sampled*	No. Samples	No. Measured	No. Aged
Denmark	5265	0	0	0	0
Faroe Islands	106	0	0	0	0
France**	3288	12	426	2769	0

Country	Catch	% Catch Sampled*	No. Samples	No. Measured	No. Aged
Germany	4263	76	56	9767	780
Ireland	15799	94	78	9065	2012
Netherlands	18474	81	48	5663	1145
Norway	3131	97	7	285	193
Spain	13424	97	740	28502	47
Sweden	3	0	0	0	0
UK (England)	2316	87	77	4187	401
UK(Northern Ireland)	811	58	184	184	46
UK(Scotland)	558	81	89	3473	0
Total	70114	74	1112	56891	4624

***Percentage based on ICES estimate with regards to age samples**

****provided only length distributions**

***** age samples processed by the Netherlands**

Table 5.9.3. Horse mackerel sampling intensity for the North Sea stock in 2022.

Country	Catch	% Catch Sampled*	No. Samples	No. Measured	No. Aged
Belgium	30	0	0	0	0
Denmark	37	0	0	0	0
Faroe Islands	0	0	0	0	0
France**	433	25	59	464	0
Germany	67	79	11	307	208
Netherlands	2490	76	13	2556	322
Norway	1640	99	4	193	117
Sweden	0	0	0	0	0
UK (England)****	3202	94	22	6046	543
UK(Scotland)***	42	0	0	0	0
Total	8377	78	109	9566	1190

*** Percentage based on ICES estimate with regards to age samples.**

****provided only length distributions**

*****provided length distributions not incl. in InterCatch**

******age samples processed by the Netherlands**

5.13 Figures

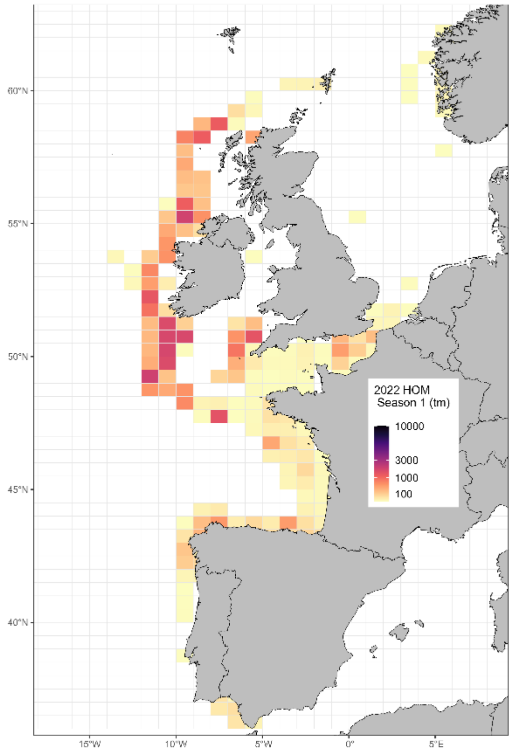


Figure 5.1.1a. Horse mackerel catches (prov. without Portuguese catch) 1st quarter 2022

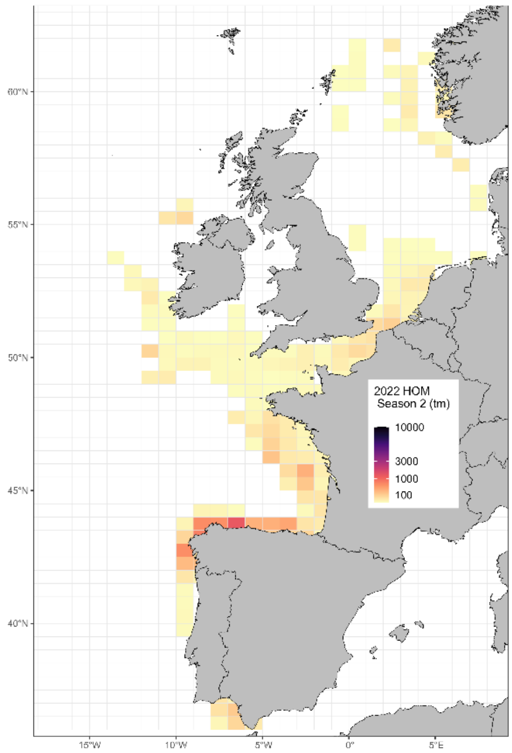


Figure 5.1.1b. Horse mackerel catches (prov. without Portuguese catch) 2nd quarter 2022

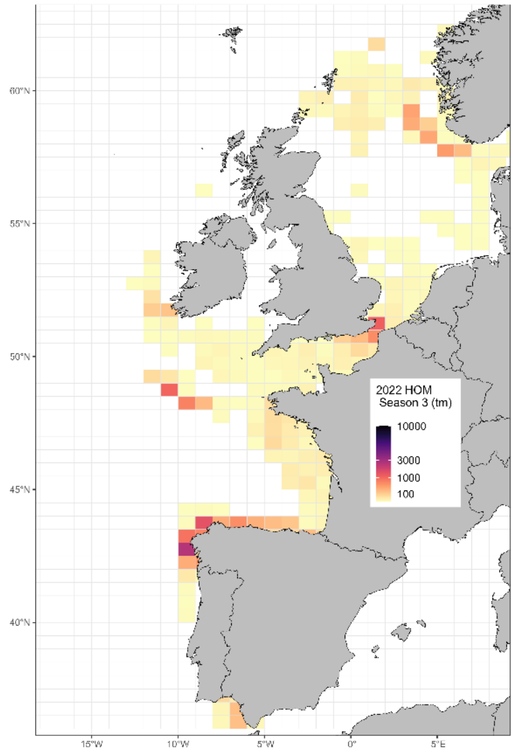


Figure 5.1.1c. Horse mackerel catches (prov. without Portuguese catch) 3rd quarter 2022

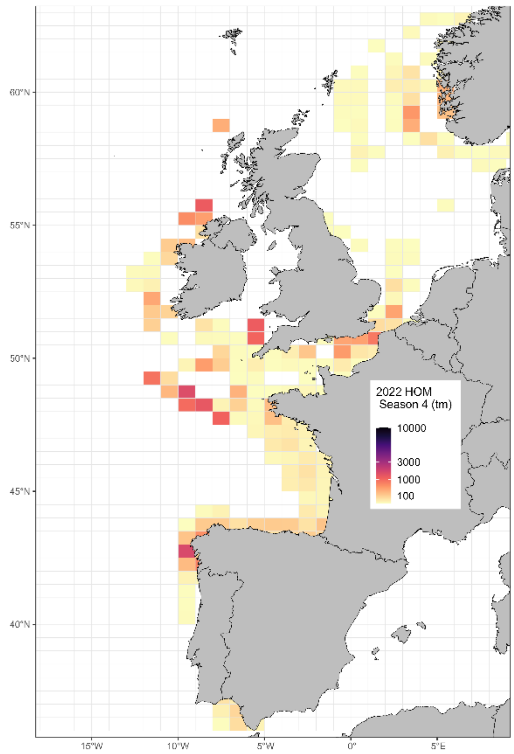


Figure 5.1.1d. Horse mackerel catches (prov. without Portuguese catch) 4th quarter 2022.

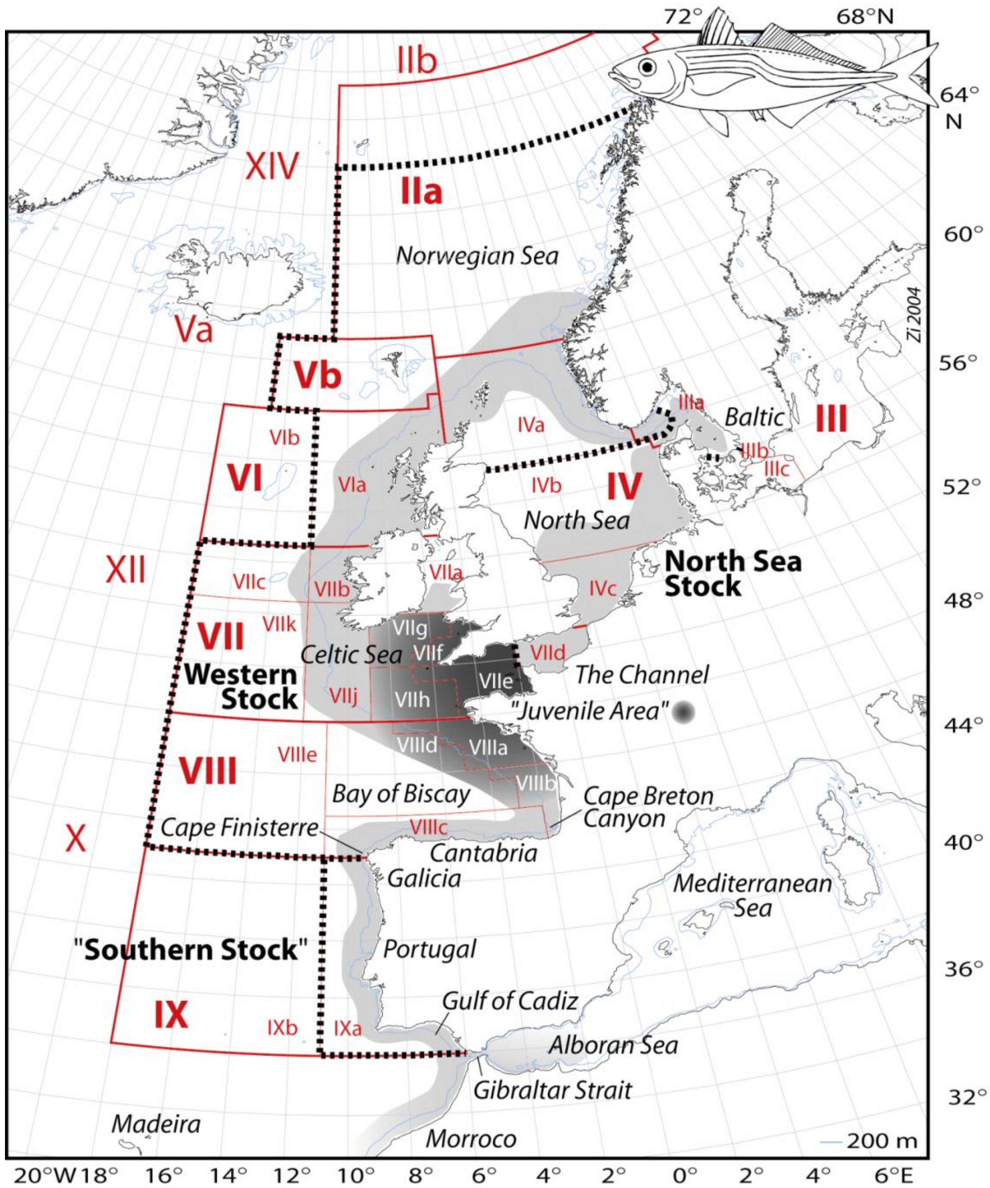


Figure 5.2.1: Distribution of Horse Mackerel in the Northeast-Atlantic: Stock definitions as used by the 2004 WGMHSA. Note that the “Juvenile Area” is currently only defined for the Western Stock distribution area – juveniles do also occur in other areas (like in Div. 7.d). Map source: GEBCO, polar projection, 200 m depth contour drawn.

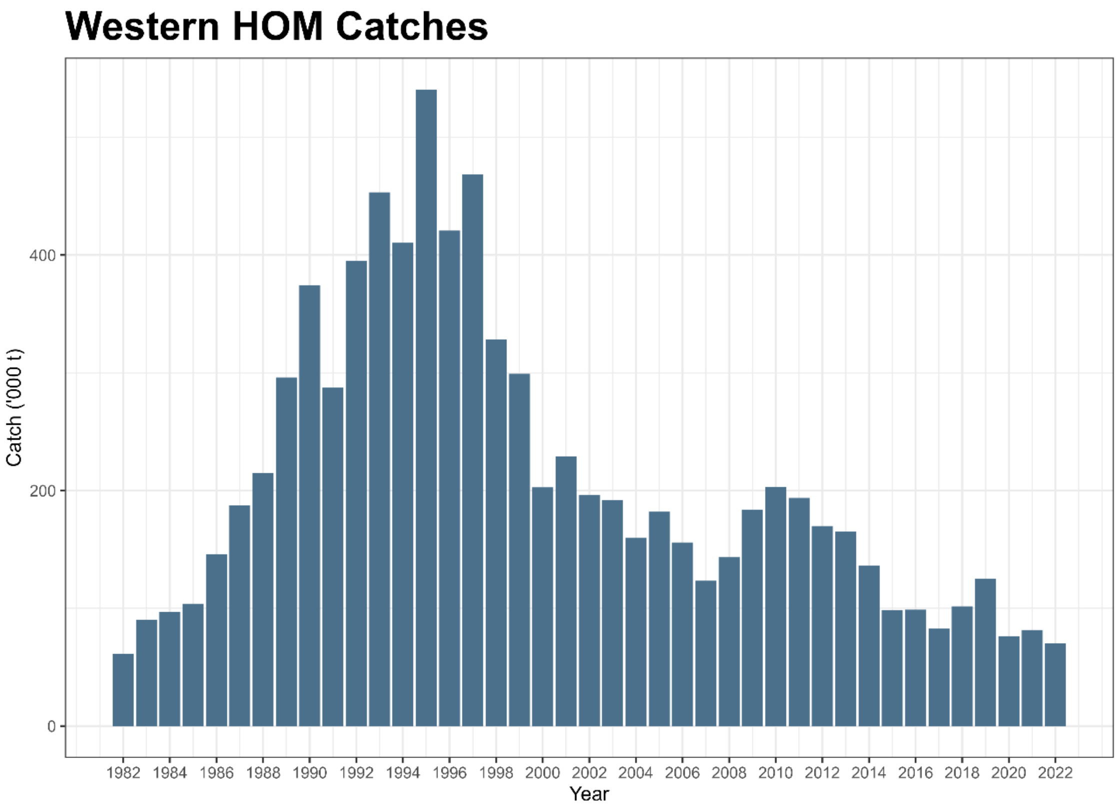


Figure 5.3.1. Total catch for Western Horse Mackerel stock, 1982–2022.

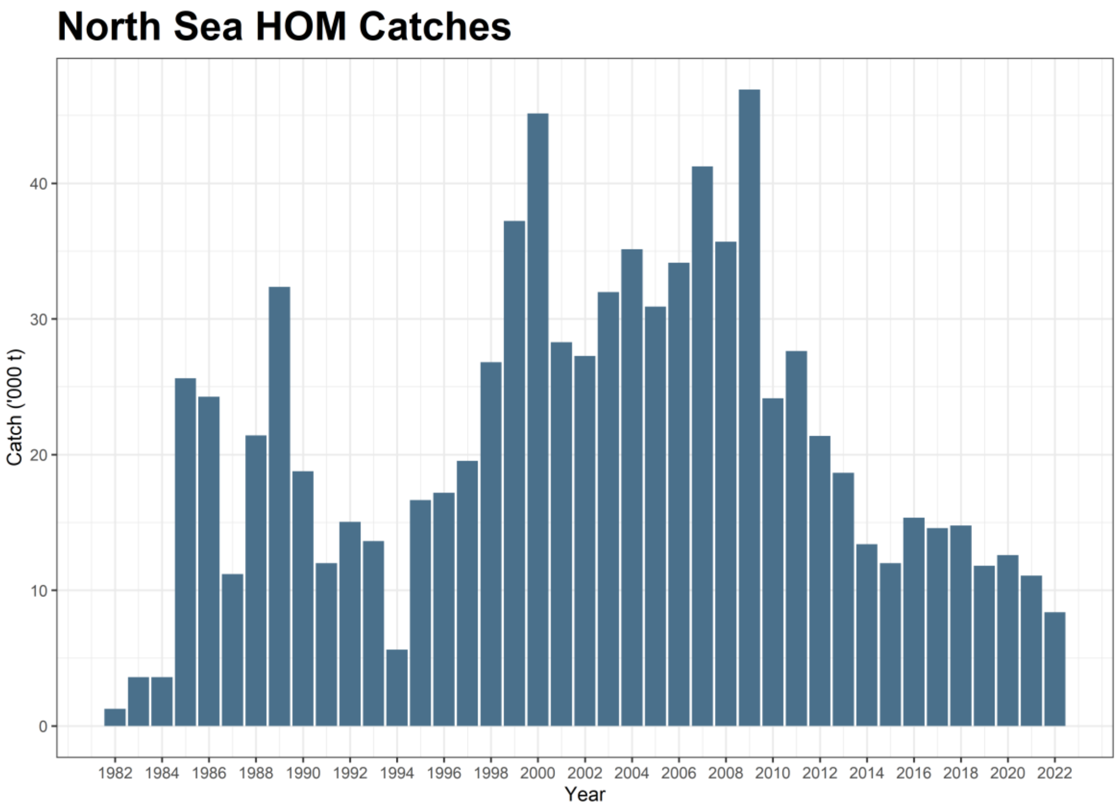


Figure 5.3.4. Total catch for North Sea Horse Mackerel stock, 1982–2022

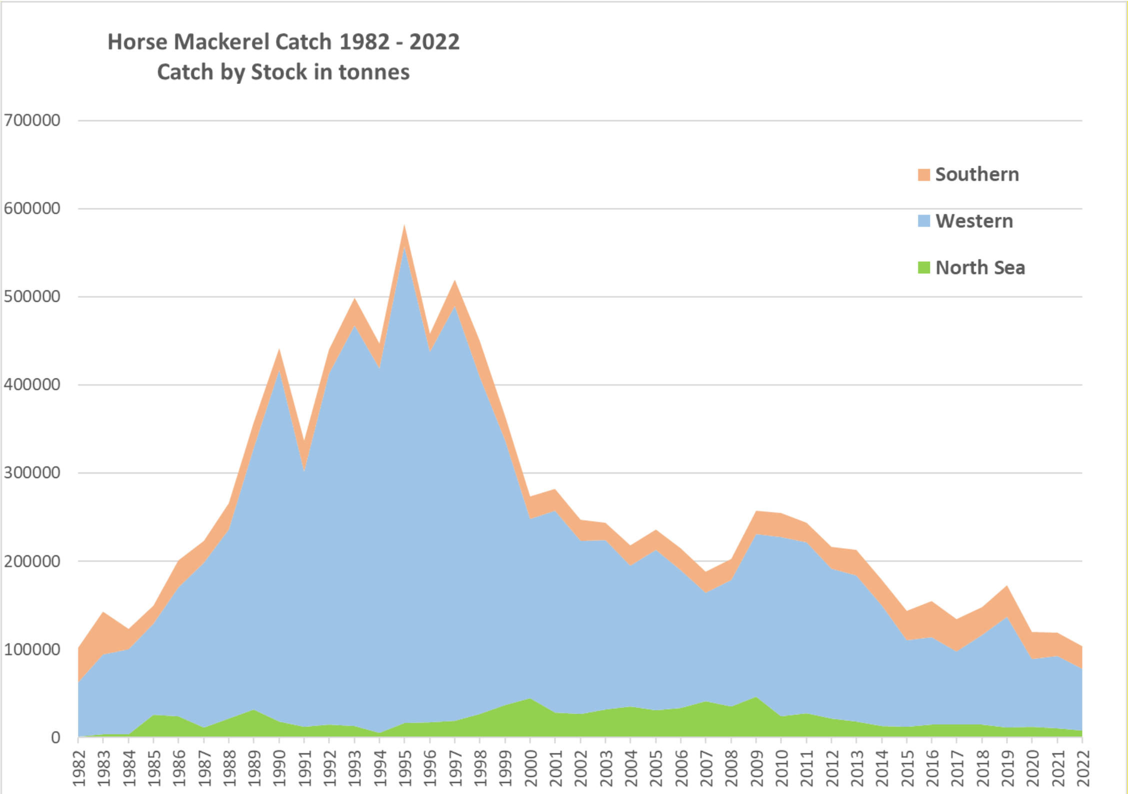


Figure 5.4.1 Horse mackerel general overview. Total catches in the northeast Atlantic during the period 1982—2022. The catches taken from the southern, western and North Sea horse mackerel stocks are shown in relation to the total catches in the northeast Atlantic. Catches from Div. 8.c were transferred from southern stock to western stock from 1982 onwards. Southern horse mackerel is assessed by ICES WGHANSA since 2011.

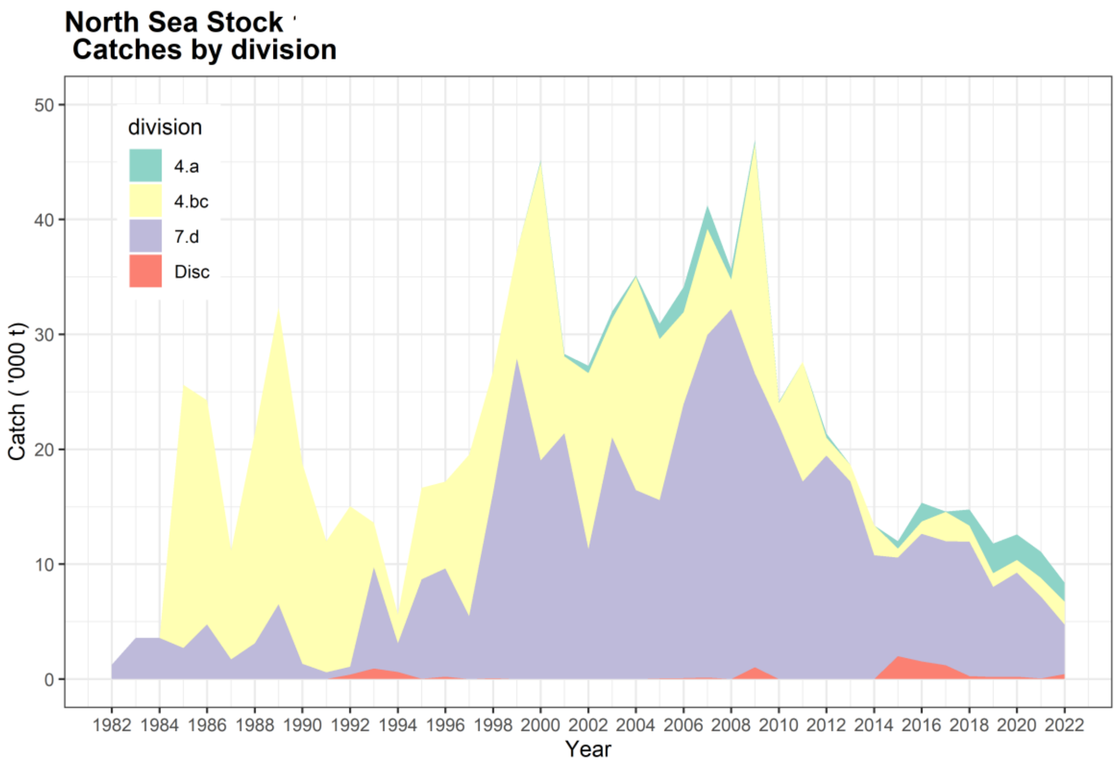
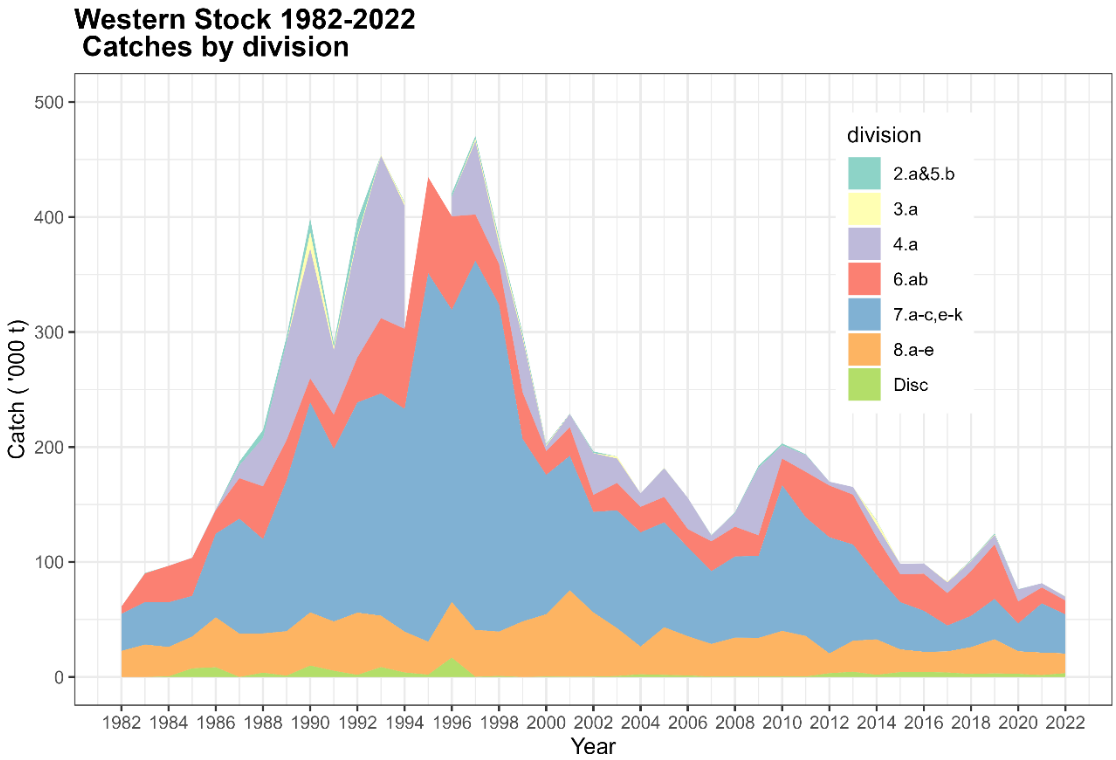


Figure 5.4.2. North Sea horse mackerel stock. Total catches by Division during the period 1982–2022.


Western Stock 1982-2022
Catches by division
Catch ('000 t)
500
400
300
200
100
0
1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 2022
Year
division
2.a&5.b
3.a
4.a
6.ab
7.a-c,e-k
8.a-e
Disc

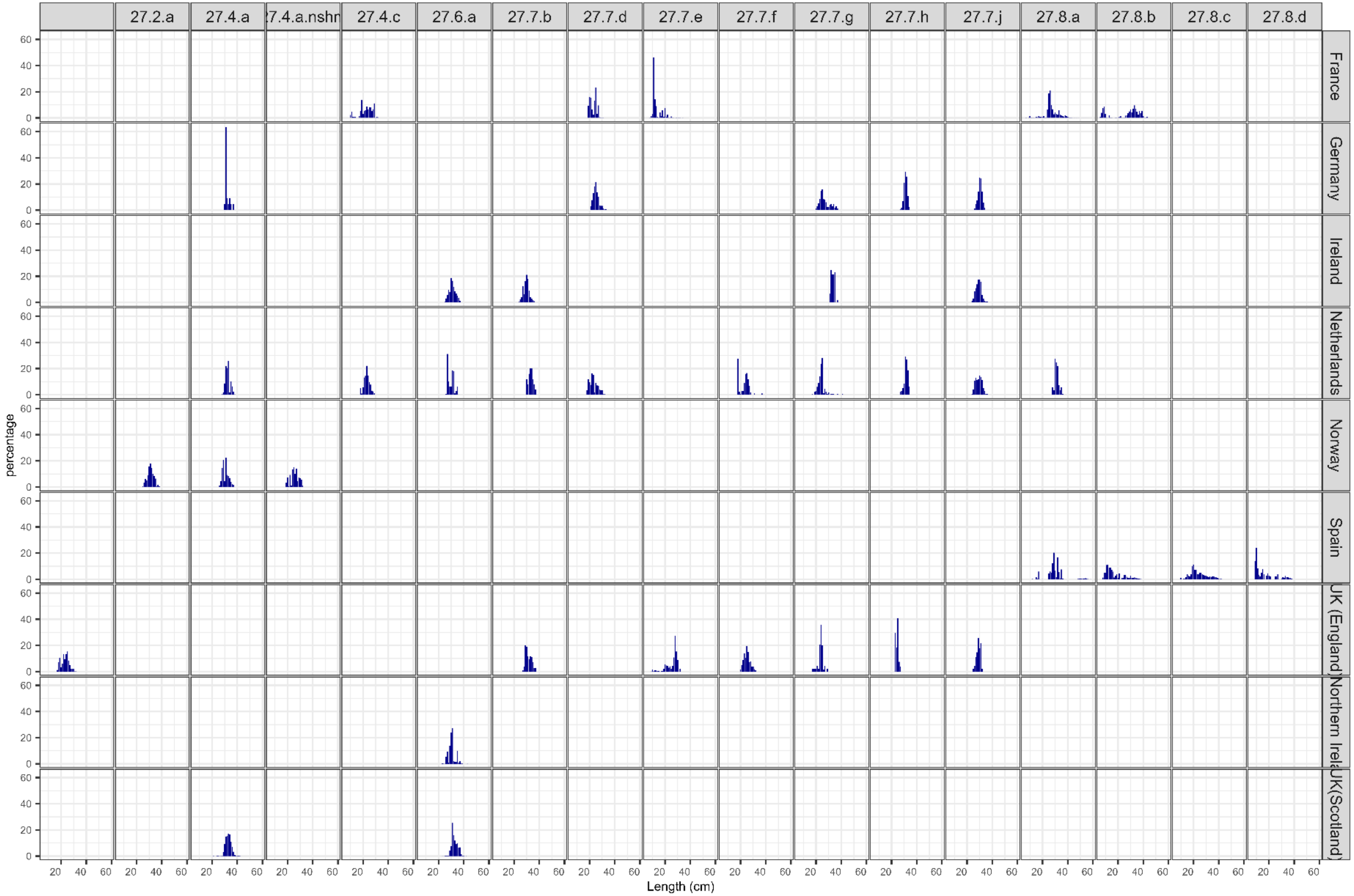


Figure 5.7.1. Length distributions contributed by country and area of the Western and North Sea horse mackerel 2022.

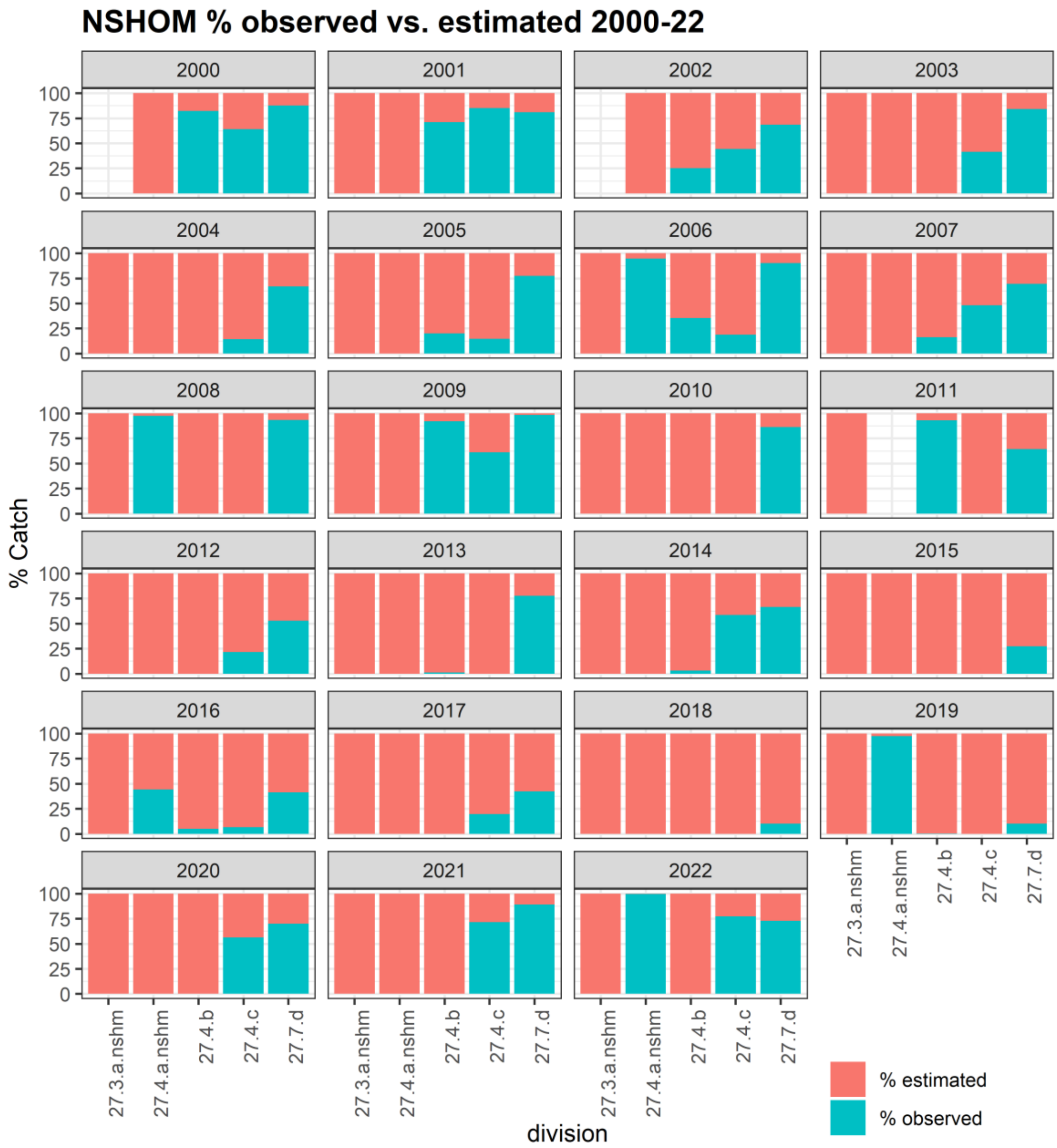


Figure 5.9.1 North Sea horse mackerel stock. Percentage sampled catch (blue) vs. unsampled catch (red) by division and year, 2000–2022.

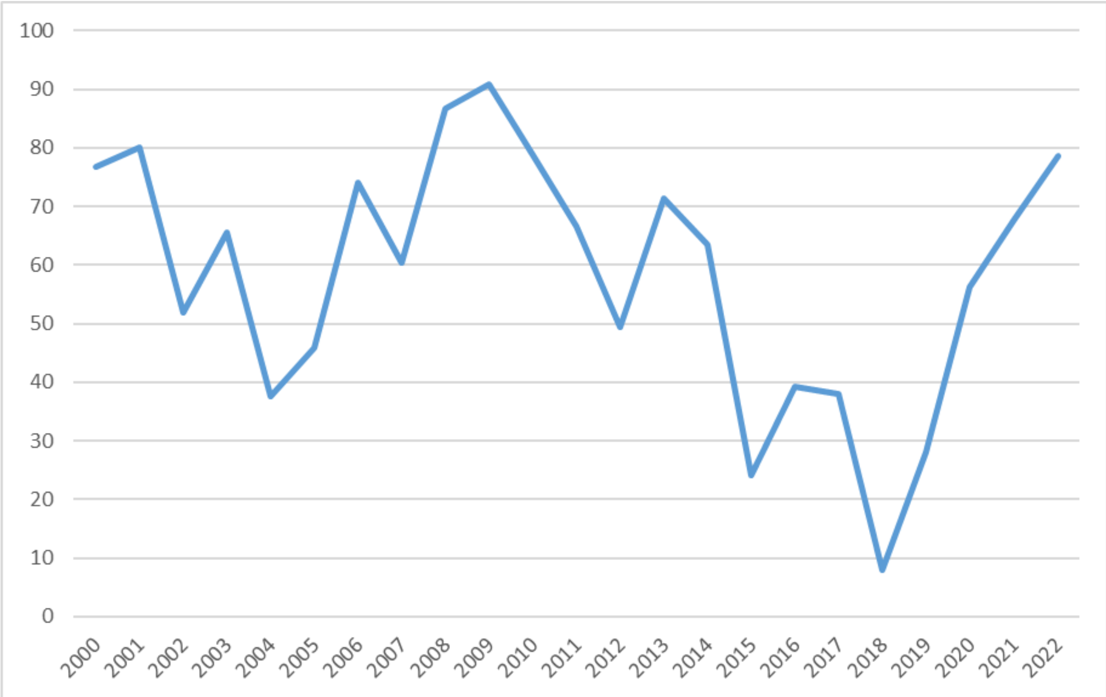


Figure 5.9.2. North Sea horse mackerel stock. Sampling intensity index as percentage sampled catch in total catch by year, 2000–2022.

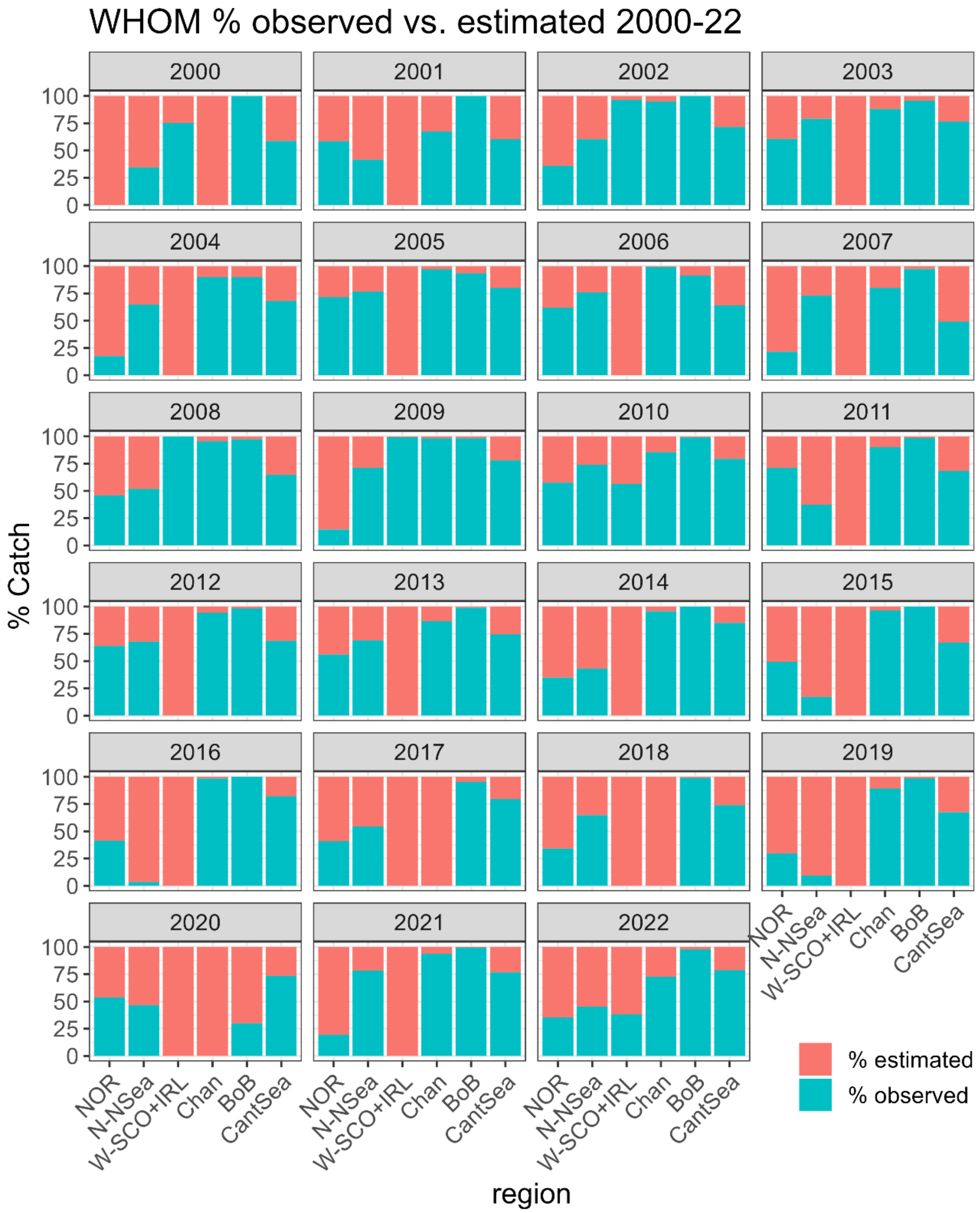


Figure 5.9.5. Western horse mackerel stock. Percentage sampled catch (blue) vs. unsampled catch (red) by division and year. Period 2000–2022. Area of distribution of Western stock was divided into different regions. Chan: (7.e,f,h); W-SCO+IRL (7.a-c, 7.j-k and 6.a); BoB (8.a,b,d); CantSea(8.c); N-Nsea (3.a and 4.a); NOR (2.a and 5.a).

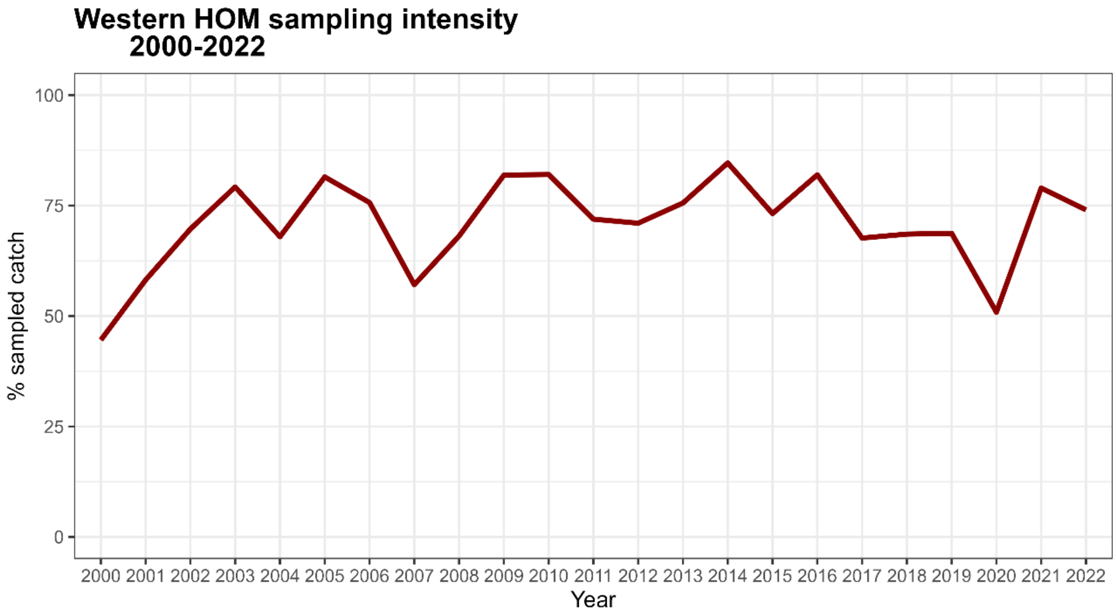


Figure 5.9.6. Western horse mackerel stock. Sampling intensity index as percentage sampled catch in total catch by year, 2000–2022.

6 Horse mackerel in Skagerrak, Kattegat, southern and central North Sea, and eastern English Channel

Trachurus trachurus in divisions 3.a, 4.b–c, and 7.d (hom.27.3a4bc7d)

6.1 ICES advice 2022

In 2012, the North Sea horse mackerel (NSHOM) was classified as a category 5 stock, based on the ICES approach to data-limited stocks (DLS). Since then, a progressive reduction in TAC was advised by ICES, from 25 500 tonnes in 2013–2014 to 15 200 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 French Channel Ground Fish Survey (CGFS) since 2014. Additionally, in 2015, information on discards in non-directed fisheries became available that has been taken into account in the advice since 2017.

In 2017, this stock was benchmarked and the NS-IBTS and CGFS survey indices where modelled together. The resulting joint index was considered an appropriate indicator of trend in abundance over time and the NSHOM stock assessment was upgraded to category 3. The joint index showed an increasing trend in 2014 to 2016, but was followed by a decrease in 2017. In 2018, the index remained at a similar level as in 2017, while the index slightly increased in 2019. In 2020 no index value was calculated due to the absence of UK-stations in the French Ground fish survey. In 2021 the survey index decreased to values similar to 2018, but in 2022 the index is at the highest estimate since the last 5 years at a value of 265 fish/hour. Length-based DLS methods have been applied to data from 2016 onwards. The length-based F/F_{MSY} ratio indicated that F is still slightly above F_{MSY} in till 2022. Stock size relative to reference points is unknown.

Biannual advice for 2024 and 2025 was provided in 2023, based on the data up to 2022 (ICES, 2023b). The advice follows the rfb rule (ICES 2022, ICES 2023a). The stock biomass trend indicated a ratio of 1.23 for last two years compared to the three years prior. The fishing pressure proxy $L_{F=M}/L_{mean}$ n 2022 was 1.02 , indicating that the fishing mortality was above F_{MSY}. The biomass safeguard multiplier was above 1, so it did not have to be applied. The stability clause also did not have to be applied, since the advice did only change 8.5%. The approach resulted in a catch advice for 2024 and 2025 of 9730 tonnes.

6.2 Fishery of North Sea horse mackerel stock

Based on historical catches taken by the Danish industrial fleet for reduction to 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 4b and 7d. 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, an 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 proportion of the catches have been taken in a directed horse mackerel fishery for human consumption by the Dutch-owned 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 2010-2014 (approximately 50%; Figure 6.2.1)). However, following the sharp reduction in TAC in 2015, uptake increased significantly in the years thereafter. In 2020, 91% of the TAC was used, with the highest catches taken by the Netherlands, followed by UK, Norway and France. For 2021 the TAC utilization is 79% with the highest catches taken by the UK, followed by Netherlands, Norway and France, and in 2022 the uptake was 94% with the highest catches taken again by the same countries in that consecutive order (Figure 6.2.2)

Catches taken in Divisions 3a and 4a during the two first quarters and all year round in Divisions 4b, 4c and 7d are currently regarded as North Sea horse mackerel (Section 5, Table 5.4.1). The catches were relatively low during the period 1982—1997 with an average of 18 000 t, but increased between 1998 (30 500 t) and 2000 (45 130 t). From 2000 to 2010, the catches varied between 24 149 and 45 883 t. Since 2014, a steep decline in catches is observed, both due to the reduction in the TAC since 2014 but also due to the underutilization of the quota. In 2021 the catch was 11 082 t similar to 2019, but in 2022 catch has decreased to 8377 and catches from 7d are on a decline. In 2020 catches from that area were 72%. In 2021 catches from that area were 65% and in 2022 catches from that area amounted to 56 % of the total catch (Figure 6.2.4). This is because catches in area 4c have increased to 24%. Relative catches in other areas were comparable to 2021.

Over the period 1985–2001 most catches were taken in the 4b (Figure 6.2.3). However, since the early 2000s the proportion of catches from 7d increased steadily until 2013, when the 92% of total catches were fished in this area (Figure 6.2.4). In 2022, the UK accounted for most of the landings, followed by Netherlands, Norway and France (Figure 6.2.5). The majority was still caught in quarter 4 in 7d, whereas the Norwegian catches were taken during quarters 1 and 2 in 4a. The relative contribution of the catches in 4a has been increasing since 2015, with the exception of 2017 when catches in 4a were negligible. In 2014 the contribution from 4a was only 0.02% but in 2022 the contribution is 20%, partially because absolute catches in other areas have gone down.

Most of the discards reported were from 7d 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 was 10%. Complete discard information for earlier years has not been submitted to ICES. Information from national discard reports for the non-directed bottom-trawl fisheries indicates a similar level of discarding in earlier years. In 2017 and 2018 the discard rate was 8.3% and 1.8%, respectively, while it decreased to 1.6% in 2019 and 2020. In 2021 the discard rate dropped to 0.5%, but in 2022 the rate has increased to 5.2%.

6.3 Biological data

6.3.1 Catch in Numbers at Age

For the third year in a row in 2022, it was possible to include samples taken from English vessels in the Netherlands, increasing further the biological sampling coverage. Also Norway had supplied samples for 2022. For 2022, the proportion of sampling increased to 78% in comparison to 67% in 2021, 56% in 2020 and to 2019 where only 1/3 of the landings were sampled. Age samples in 2022 were available from four countries (the Netherlands and UK/England, Norway and Germany). Coverage was decent, as the temporal and spatial overlap between the catch and sampling was high. In prior years there had been a biased perception of the age distribution of catches over the year and areas as sampling effort was partially and unevenly distributed.

Annual catch numbers at age are shown in Table 6.3.1. Catch-at-age for the whole period 1995-2022 are given in Table 6.3.2 and in Figures 6.3.1 and 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. However, this decrease could be due to the low age sampling, in particular in 2018 (maximum age observed 7 years). In parallel to the rejuvenation of catches, the comparison of catch-at-age data after 1998 by area (Figure 6.3.2) shows that since 2010 commercial catches have stayed relatively stable in 7d in comparison to 3a and 4a, b and c where a decreasing pattern is seen. Due to the low level of sampling effort in 2018, data for this year are only based on a single sample from 7d in Q4. Following 2018, the older ages are represented again, but the representation of older ages in the catch is still marginal, especially in 7d.

Although the 2015 cohort seems to be clear in the catch-at-age distribution, in general, cohort structure is not clearly detectable in the data. In addition to the low sampling levels, this may partly be due to the shifts in the distribution of the fishery. It may also 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 data in all years. There are indications that environmental conditions may be an important factor (possibly stronger than stock size) contributing to spawning success of horse mackerel. This is, for example, illustrated by the largest year-classes (1982 and 2001) observed in the Western stock which were produced at the lowest observed stock sizes. Since 2001 is considered to have been a relatively strong year class in the Western stock, 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.

The potential for mixing of fish from the Western and North Sea stock in 7d and 7e 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. On behalf of the Pelagic Advisory Council and the EAPO Northern Pelagic Working Group, a research project on genetic composition of horse mackerel stocks was initiated in 2015 with University College Dublin (Ireland) with the intention of clarifying the mixing among the North Sea and the Western horse mackerel stocks. Genetic samples have been taken over the entire distribution area of horse mackerel during the years 2015, 2016, and 2017, with a specific focus on the separation between horse mackerel in the western waters and horse mackerel in the North Sea. The results of the whole-genome sequencing indicated that the North Sea horse mackerel stock is clearly genetically different from the Western stock (Farrell and Carlsson, 2019; Fuentes-Pardo *et al.*, 2020). Markers were identified that could distinguish with up to 95% accuracy between individuals collected in the North Sea and Western stocks. Follow-up work on this project is described in Section 6.7.

6.3.2 Mean weight at age and mean length at age

The mean annual weight and length over the period 2000–2022 are presented in Table 6.3.2 and Figures 6.3.3 and 6.3.4, respectively.

There do not seem to be strong differences over this period, although for the last two years a decline had been observed. In 2022 however, the annual means for weight and length have experienced an increase again. Zooming into the values per area however, mean length and weight of the stock for age 7-9 for area 4a are substantially higher than for the other areas.

Catches defined as NSHOM catches in this area are taken in Q1 and Q2. A closer look at the distribution of those catches revealed them to originate from within the Norwegian fjords, where the size at age was sigificantly higher than in landings farther west in the North Sea during Q3 and Q4. That, and the ongoing work on stock delineation supports the notion that these fish are not North Sea horse mackerel. Additionally, the fish caught in 2022 were only age 7 and older, no fish younger than age 7 were caught in the fjords. Further work on the biology of the horse mackerel need to be done to explain this anomaly.

6.3.3 Maturity-at-age

Peak spawning in the North Sea occurs 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 calculate the negative slope to get an estimate of total mortality (Z). Fully selected ages 3 to 15+ from the 1992–2015 period provide complete data for the 1992 to 2007 cohorts and partial data for younger cohorts (Figure 6.4.1). The estimated negative slopes by cohort (Figure 6.4.2) indicate an increasing trend in total mortality up to the late 1990s, after which Z fluctuates from year to year up till late 00's after which a steeper increase followed by a steep decrease are observed. However, due to the low quality of the signals for some cohorts these Z estimates should 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 9vs.10 age groups were positively and significantly correlated in the catch. This analysis has not been updated since, 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 Rückert *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 meeting exploratory model fits were attempted with the JAXass model, 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. JAXass 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 carried out 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), additional 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 catch-at-age data
- Scientific index derived from a survey not specifically designed for horse mackerel and limited coverage of one of the main fishing grounds for the stock (7d)

Catches taken in 7d 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 conditions, or changes in abundance of either of the two stocks, that some proportion of the catches taken in 7d actually originated from the Western horse mackerel stock. Nevertheless, all assessment models used assume that 100% of fish caught in area 7d belong to the North Sea horse mackerel stock. This is in agreement with current stock and management definitions.

In 2018, the working group explored the Surplus Production model in Continuous Time (SPiCT) model for North Sea horse mackerel. SPiCT is one of the methods in the ICES guidelines to estimate MSY reference points for category 3 and 4 stocks (ICES, 2018). The model was run using the joint survey index as input or with separate survey indices (NS-IBTS and CGFS). The model with the joint survey index led to conflicting results with the perception of the stock, as biomass was estimated to be above B_{MSY} and fishing mortality below F_{MSY}. The model with two separate indices resulted in stock biomass and fishing mortality that were more in line with the perception of the stock. However, there were strong retrospective patterns and wide confidence intervals in recent years. Furthermore, additional work is necessary on the setting of the priors, and on ensuring that model assumptions are not violated.

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 (Gordo *et al.* 2008). Therefore, egg abundance could only be considered a relative index of SSB. The Mackerel and Horse Mackerel Egg Surveys in the North Sea do not cover the spawning area of the North Sea horse mackerel stock.

6.4.3.2 North Sea International Bottom Trawl Survey

Many pelagic species are frequently found close to the bottom during daytime (which is when the North Sea IBTS survey operates) and migrate upwards predominantly during the night when they are susceptible to semi-pelagic fishing gear and to bottom trawls (Barange *et al.* 1998). Macer (1977) observed that dense shoals are formed close to the bottom during daytime, but the top of the shoals may extend into midwater. 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 NS-IBTS is considered a reasonable alternative.

NS-IBTS data from quarter 3 were obtained from DATRAS and analysed. Based on a comparison of NS-IBTS data from all 4 quarters in the period 1991—1996, Rückert *et al.* (2002) showed that horse mackerel catches in the NS-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 of 20 cm and larger is the most appropriate for the purpose of interpreting trend in the stock.

To create indices, a subset of ICES statistical rectangles was identified. 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. Rückert *et al.* (2002) also identified a larger distribution area of the North Sea stock. Based on the above, WGWIDE 2013 identified 61 rectangles to be included in the index area as shown in Figure 6.4.3.

6.4.3.3 French Channel Groundfish Survey

In order to improve data basis for the North Sea horse mackerel assessment, alternative survey indices have been explored. Previous indices only covered the North Sea distribution of the stock, while the majority of catches in recent years come from the eastern English Channel (7d). We evaluated the potential contribution of the French Channel Groundfish Survey (FR-CGFS) in 7d in quarter 4. The FR-CGFS has been carried out since 1990 and has frequent captures of horse mackerel. Although this survey is conducted in a different quarter to the NS-IBTS, the observed seasonal migration patterns of horse mackerel indicate that fish move into the Channel following quarter 3, so the timing is considered appropriate.

In 2015, the RV Gwen Drez was replaced by the RV Thalassa to carry out the FR-CGFS. 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 7d 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 of 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 below that depth range would have a relatively minor impact in the estimated abundance.

For these reasons it was considered appropriate to continue using the FR-CGFS, standardizing the time-series of abundance for the period 1990–2015 with the estimated conversion factor 10.363.

6.4.3.4 Impact of Covid-19

Due to the Covid-19 pandemic and the lockdown in place in France at that time there was a delay in submitting the cruise application form for the FR-CGFS in 2020 to the French Foreign Ministry. The result was that no authorisation was provided in time to allow the survey to trawl within

UK waters in 2020. Therefore, only French waters were sampled, meaning that only 70% of the core survey stations were completed (ICES, 2021b).

To assess the potential impact of missing UK stations in the FR-CGFS on the resulting abundance index for the exploitable stock, we tested the impact of

i) removing all UK sampling stations from the 1992-2019 time series,
ii) removing UK sampling stations from 2016-2019, one year at the time, and
iii) removing the FR-CGFS in 2016-2019, one year at the time, when modelling the abundance and calculating the index.

Removing all UK sampling stations from all years did not change the overall trend of the abundance index, but there were quite some deviations for individual years (Figure 6.4.6). Removing UK stations from one year at a time for 2016-2019 resulted in virtually no change for 2017 and 2018, but more apparent changes for 2016 and 2019 (Figure 6.4.7). Both these exercises suggest that basing the abundance index on NS-IBTS and French stations from FR-CGFS only may lead to different index values compared to when UK stations are included. The French sampling stations in the FR-CGFS only are thus not representative for the abundance of adult horse mackerel in the entire eastern Channel. As a further exploration, the abundance index was modelled by leaving out the FR-CGFS entirely for 2019. However, the hurdle model was not able to run, and therefore a zero-inflated model was run instead. This model was considered to be the second-best model during the benchmark process in 2017 and performed almost equally well as the hurdle model (ICES, 2017). Removing the FR-CGFS one year at a time for 2016-2019 resulted in minimal change for 2017 and 2018, but more apparent changes for 2016 and 2019 (Figure 6.4.8). Similar to (i) and (ii), leaving out the FR-CGFS may lead to different index values compared to when FR-CGFS is included.

As the investigations suggest that the missing UK stations from the FR-CGFS or leaving out the FR-CGFS entirely may lead to changes in the abundance index, it was decided that no reliable index value for 2020 could be produced. For the 2021 assessment, the approach of previous year was continued and thus no index value for 2020 was modelled. UK stations were visited in 2021 so the index value for 2021 was modelled according to the method with the hurdle model.

6.4.4 Length distributions from the surveys

The highest proportion of fish caught in 2022 were around 6-8 cm in the NS-IBTS, this was similar to 2021 (Figure 6.4.9). No group of strong year classes from previous years could be observed. In the FR-CGFS, the highest proportion of fish were between 18-30 cm, similar to 2019, when also the larger fish were dominating the catches (Figure 6.4.10). Despite that in 2020 the length frequencies are only based on French sampling stations, the length frequencies from 2021 show a similar pattern.

6.4.5 Length distributions from commercial catches

Currently, length distributions from catch data are available from 2016 to 2021. Future work is needed to retrieve historic length data in order to present a longer time series. The data used for the analysis come from the commercial catch sampling by national sampling programmes. For comparison, the analysis has also been run in the past with length data from the self-sampling programme of the Pelagic-Freezer-trawler Association (PFA), see for instance ICES (2019, 2020).

The length distributions based on the commercial catch data from 7d show a consistent distribution in time with a mean length between 22.15 and 25.5 cm each year, although with the exception of 24.7 cm in 2019 and the value for 2022 at 25.2 (Figure 6.4.11). Lengths in 4c were on average 21.7 cm in 2019, 22.0 cm in 2020, 23.8 in 2021, and 22.4 in 2022 (Figure 6.4.12).

An error was found in the calculation of the length frequency distributions in the previous 2016 to 2020 assessments. Furthermore, the length frequency distribution calculated in 2019 included French data from only quarters 3 and 4, whereas data is also available for quarters 1 and 2. The length frequency distributions for 2018-2020 were re-calculated using all available data, and upgraded code. No recalculation could be done for 2016-2017 since the original files are not available.

6.5 Stock assessment

6.5.1 Modelling the survey data

In January 2017, a benchmark of the North Sea horse mackerel assessment was conducted (ICES, 2017). Based on a capacity to model the over-dispersion and the high proportion of zero values in the survey catch data, a hurdle model was considered the best option of all model alternatives tested. The log-likelihood ratio test, 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 of 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 of zero in haul *i* as a function Year and Survey.

The expected CPUE of North Sea horse mackerel per haul i, 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 FR-CGFS and NS-IBTS and predict the average annual CPUE index as an indicator of trends in stock abundance. Separate models were fitted to the juvenile (<20cm) and adult exploitable (≥20cm) sub-stocks. The contribution of the two surveys to the combined index is weighted taken into consideration their respective area coverage as well as the mean wing spread. This index model allowed upgrading of the NSHOM to a category 3 stock within the ICES classification.

Similar to the 2019 assessment (ICES, 2019) ,2020 assessment (ICES, 2020), and 2021 assessment (ICES, 2021a), the model for the adult sub-stock that was run this year returned a warning despite the fact that the model converged. All parameter coefficients were estimated, but not the standard error for the intercept and the parameter θ of the count model. To check the robustness of the hurdle model with the warning, a zero-inflated model was run with the same set-up as the hurdle model. This zero-inflated model was considered to be the second-best model during the benchmark process in 2017 and performed almost equally well as the hurdle model (ICES, 2017). The fitted values of the zero-inflated model were very similar to that of the hurdle model with warning (Figure 6.5.1). The hurdle model from this year and its resulting index values where thus considered robust. Should the warning continue to occur in future assessments, additional testing and investigation should be conducted.

Due to the exclusion of the 2020 survey for modelling the abundance index, during the 2021 assessment the same time period (1992-2019) was used as during the 2020 assessment (ICES, 2020). In the current 2022 assessment the 2020 survey is still excluded. Since the last the 2021 assessment the updated abundance index resulted in a higher value for 2016 for the exploitable stock compared to last year (ICES 2021; Figure. 6.5.2). For each assessment, survey data from all years are extracted so that any underlying changes in the raw data stored in DATRAS are taken account of. Changes in reported raw HOM catches in 2016 in the NS-IBTS led to a higher mean catch rate of HOM (Figure 6.5.3), resulting in a higher abundance index value for 2016.

6.5.2 Summary of index trends and survey length distributions

The survey index for both the juvenile and exploitable sub-stock experienced a marked decline in the early 1990s and fluctuated at relatively low levels thereafter (Figures 6.5.4; Table 6.5.1). This reduction was partly due to the decline of the average abundance per haul over time, but also due to the increase of hauls with zero catch of the adult sub-stock (Figure 6.5.5). The survey index was at its third and second lowest in 2017 and 2018 (lowest in 2009), shows a slight increase again in 2019, but shows an average decline again in 2021, because of the low index of the NS-IBTS. In 2022 the combined index has increased again since both indices show an increase (Figure 6.5.4).

The index trend for the juvenile sub-stock shows large fluctuations since 2015 (Figure 6.5.4). These are mainly attributed to the fluctuating trend of juveniles in the NS-IBTS (Figure 6.5.6), caused by some hauls with high catches of small horse mackerel in 2016 and 2018 (Figure 6.4.9). Fitted values for juveniles in the FR-CGFS show decreasing trend since 2014, but a slight increase again in 2019 and in 2021. The 2022 value is slightly lower again but similar to the year before (Figure 6.5.6). The index of abundance of individuals <20 cm could be considered a recruitment index, but future analyses should be carried out to study the correlation between the abundances and survey indices of year classes over time in more detail.

6.5.3 Length-based indicator 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 Stock (DLS) methods to estimate MSY proxy reference points (ICES, 2012, 2018) for the North Sea horse mackerel were previously explored (Pérez-Rodríguez, 2017). The Length Based Indicators analysis is the DLS method used in previous years assessments.

As most length samples and catches originate from 7d, length distributions from this area were used to calculate the MSY proxy. In 2021, the F/F_{MSY} proxy based on the commercial catch samples indicated that fishing mortality was still slightly above F_{MSY}, with $L_{mean}/L_{F=M}$ = 22.86 cm / 24.33 cm = 0.94 (Figure 6.5.7).

Due to the recalculation of the 2018-2020 length distributions the F/F_{MSY} ratios in those years changed from 0.927 to 0.932 for 2018, from 0.978 to 0.972 for 2019, and from 0.927 to 0.912 from 2020. These revisions have no effect on the advice given in the 2021 assessment.

For WGWIDE 2023 the new rfb rules for category 3 stocks are implemented (ICES 2022, ICES 2023a). This rule still uses the 2-over-3 rule for the the calculation of the trend in the abundance index. The approach with a cap and buffer as was previously done, is dropped. A multiplier and a biomass safeguard is now calculated instead. Additionally, there is a slight change in the calculation of the Fmsy proxy value. Whereas previously the Lfm was calculated based on the yearly Lc, currently this value is based on the Lc derived from pooled length data from 2019-2022. This is because for these years enough detailed information is available to provide Lc. As a result, Lmean and Lfm for 2019-2022 can be recalculated using this new pooled Lc value. For 2016-2018, this was not possible and the values provided in the advice for those years are still derived with the yearly Lc.

The implication of this new approach is that the values for $L_{mean}/L_{F=M}$ from 2019-2021 have changed again; for 2019 the value changed from 0.972 1.046, for 2020 it changed from 0.912 to 0.929, for 2021 from 0.926 to 0.939. These revisions have no implications on the advice given in the 2021 assessment year. For the current assessment year the value is 0.980

6.6 Basis for 2024 and 2025 advice

Stock advice for North Sea horse mackerel is biennial. The NS-IBTS and FR-CGFS were modelled together to produce a joint abundance index for the exploitable part of the stock (≥20 cm). No index value for 2020 could be produced. For this reason, the 2-over-3 rule applied to the index could only make use of index values from 2018 to 2019 and from 2021-2022. The resulting index ratio indicated that the adult sub-stock declined by 23%. The $L_{mean}/L_{F=M}$ ratio in 2022 was 0.98 indicating that the fishing mortality is above F_{MSY}. The biomass safeguard estimated by dividing the last index value by the $I_{trigger}$ value, which is the lowest value observed in the index multiplied by 1.4, was higher than 1 , and thus the biomass safeguard was set at 1. The multiplier based on life history characteristics was 0.9 under a *k* value of 0.205. Under these circumstances, and based on the previous catch advice of 8969 t, ICES advised that catches of North Sea horse mackerel in 2024 and 2025 should be no more than 9730 t.

There are some signs of improved recruitment in some years (e.g. 2016, 2018 and to a lesser extend in 2021), but the trend of the abundance index for the juvenile sub-stock is fluctuating and, when separated, the two surveys, NS-IBTS and FR-CGFS, do not show the same trend. It remains to be seen if the weak signs of improved recruitment result in higher adult abundance. In 2019 there was a slight increase in the index of the exploitable sub-stock but that trend has not continued in 2021. In 2022 a slight increase can be recognized again.

6.7 Ongoing work

On behalf of the Pelagic Advisory Council and the EAPO Northern Pelagic Working Group, a research project on genetic composition of horse mackerel stocks was initiated in 2015 with University College Dublin (Ireland). Genetic samples have been taken over the whole distribution area of horse mackerel during the years 2015, 2016, and 2017, with a specific focus on the separation between horse mackerel in the western waters and horse mackerel in the North Sea. The result of the research indicated that the western horse mackerel stock is clearly genetically different from the North Sea stock (Farrell and Carlsson, 2019; Fuentes-Pardo *et al.*, 2020). Markers were identified that are able to reveal the stock identity of individual horse mackerel from potential mixing areas, namely Division 7.d, 7.e and 4.a. Following this, the Institute of Marine Research in Norway sampled horse mackerel in coastal waters within 4.a during all quarters in 2019. Preliminary results presented at WGWIDE 2021 showed that the genetic profile of individuals caught in all quarters matched well with the genetic profile of the Western HOM stock, with just one or two individuals matching better with North Sea HOM profile (Florian Berg, pers. comm.). Results presented at WGWIDE 2023 endorsed the view of the preliminary results presented during WGWIDE 2021. In another research project, horse mackerel from 7d and 7e have been collected by the PFA on board of commercial vessels in the Autumn of 2020, while during the same period horse mackerel from 4a have been collected during the NS-IBTS in Q3. The stock identity of the sampled fish will be investigated. The Norwegian research as well as the ongoing research described here may have large implications for stock delineation as the North Sea horse mackerel stock could have a more restricted distribution than currently presumed. During WGWIDE 2023 it was presented that samples analysed from Q1 and Q2 in 4a were determined to be Western Horse mackerel. In addition there is also mixing occurring with Western horse mackerel in area 7.d. Potential changes in the perception of the stock distributions could impact the reliability of the assessments for the three current stocks of horse mackerel in the Northeast Atlantic.

6.8 Management considerations

In the past, Division 7d was included in the management area for Western horse mackerel together with Divisions 2a, 7a–c, 7e–k, 8a, 8b, 8d, 8e, Subarea 6, EU and international waters of Division 5b, and international waters of Subareas 12 and 14. ICES considers Division 7d now to be part of the North Sea horse mackerel distribution area. Since 2010, the TAC for the North Sea area has included Divisions 4.b, c and 7d. Considering that a majority of the catches are taken in Division 7d, the total North Sea horse mackerel catches are effectively constrained by the TAC since the realignment of the management areas in 2010.

Catches in Divisions 3a (Western Skagerrak) and 4a 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 4a and 3a are variable. In recent years only Norway has had significant catches in this area, but these are only taken in some years. Recent work suggest that all horse mackerel caught in 4a belong to the Western stock, and ongoing genetic research on samples from 4a and 7d will shed more light on the proportions of the two stocks in catches from these areas.

6.9 Deviations from stock annex caused by missing information from COVID-19 disruption

1. Stock: **hom.27.3a4bc7d**

2. Missing or deteriorated survey data:

The assessment is based on two surveys, NS-IBTS and FR-CGFS. Due to the pandemic, trawling authorization in UK EEZ was not delivered in time, consequently FR-CGFS survey was not allowed to sample stations within UK waters in 2020.

3. Missing or deteriorated catch data:

Related to age sampling coverage was 56% and was covering only Q3, Q4 in areas 27.4.c and 27.7.d. Although most landed catch is taken from 27.7.d in Q4, other areas and quarters remain uncovered. Length sampling were impacted by the pandemic as samples were only available by two countries.

4. Missing or deteriorated commercial LPUE/CPUE data:

Not applicable

5. Missing or deteriorated biological data:

Not applicable

6. Brief description of methods explored to remedy the challenge:

Effects of having only UK stations in FR-CGFS in all years or a single year, and excluding FR-CGFS entirely for a single year on the combined survey index were investigated.

7. Suggested solution to the challenge, including reason for this selecting this solution:

Exploration methods suggested that leaving out UK stations or FR-CGFS entirely may affect the survey index and would lead to a survey index value not representative of stock abundance. It was therefore decided to produce no survey index value for 2020.

8. Was there an evaluation of the loss of certainty caused by the solution that was carried out?

The chosen solution affects the 2-over-3 rule by that only four instead of five index values can be used to assess the change in stock abundance. Like this year's assessment for 2022 and 2023, this will also affect the advice given in 2023 for 2024 and 2025.

6.10 References

Barange, M., Pillar, S. C., and Hampton, I. 1998. Distribution patterns, stock size and life-history strategies of Cape horse mackerel *Trachurus trachurus capensis*, based on bottom trawl and acoustic surveys. South African Journal of Marine Science, 19: 433–447.

Bolle, L.J., Abaunza, P., Albrecht, C., Dijkman-Dulkes, A., Dueñas, C., Gentschouw, G., Gill, H., Holst, G., Moreira, A., Mullins, E., Rico, I., Rijs, S., Smith, T., Thaarup, A., Ulleweit, J. 2011 . Report of the Horse Mackerel Exchange and Workshop 2006. CVO report: 11.007.

Eaton, D. R. 1983. Scad in the North-East Atlantic. Laboratory Leaflet, Ministry of Agriculture, Fisheries and Food, Directorate of Fisheries Research, Lowestoft, 56: 20 pp.

Fuentes-Pardo, A.P., Petterson, M., Sprehn, C.G., Andersson, L., Farrell, E. 2020. Population structure of the Atlantic horse mackerel (*Trachurus trachurus*) revealed by whole-genome sequencing, July 2020.

Farrell, E. D. and J. Carlsson (2019). Genetic stock identification of Northeast Atlantic Horse mackerel, Trachurus trachurs. , EDF, December 2018.

Fournier, D.A., Skaug, H.J., Ancheta, J., Ianelli, J., Magnusson, A., Maunder, M.N., Nielsen, A., Sibert, J. 2012. AD Model Builder: using automatic differentiation for statistical inference of highly parameterized complex nonlinear models. Optimization Methods and Software, 27: 233-249.

Gordo, L. S., Costa, A., Abaunza, P., Lucio, P., Eltink, A. T. G. W., & Figueiredo, I. (2008). Determinate versus indeterminate fecundity in horse mackerel. Fisheries Research, 89: 181-185.

ICES. 2012. ICES Implementation of Advice for Data-limited Stocks in 2012 in its 2012 Advice. ICES CM 2012/ACOM 68. 42 pp.

ICES. 2017. Report of the Benchmark Workshop on Widely Distributed Stocks (WKWIDE), 30 January–3 February 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:36. 196 pp.

ICES. 2018. ICES reference points for stocks in categories 3 and 4. ICES Technical Guidelines. 13 February 2018. http://www.ices.dk/sites/pub/Publication%20Reports/Guidelines%20and%20Policies/16.04.03.02_Category_3-4_Reference_Points.pdf

ICES. 2019. Report of the Working Group on Widely Distributed Stock (WGWIDE. ICES Scientific Reports. 1:36. 948 pp.

ICES. 2020. Working Group on Widely Distributed Stocks (WGWIDE). ICES Scientific Reports. 2:82. 1019 pp. http://doi.org/10.17895/ices.pub.7475

ICES 2021a. Working Group on Widely Distributed Stocks (WGWIDE). ICES Scientific Reports. Report. https://doi.org/10.17895/ices.pub.8298

ICES. 2021b. International Bottom Trawl Survey Working Group (IBTSWG). ICES Scientific Reports. 3:69. 201 pp. https://doi.org/10.17895/ices.pub.8219

ICES. 2022. ICES technical guidance for harvest control rules and stock assessments for stocks in categories 2 and 3. ICES Technical Guidelines. Report. https://doi.org/10.17895/ices.advice.19801564.v1

ICES. 2023a. Advice on fishing opportunities (2023). General ICES Advice guidelines. Report. https://doi.org/10.17895/ices.advice.22240624.v1

ICES. 2023b. Working Group on Widely Distributed Stocks (WGWIDE). ICES Scientific Reports. 5:82. https://doi.org/10.17895/ices.pub.24025482

Macer, C.T. 1974. The reproductive biology of the horse mackerel *Trachurus trachurus* (L.) in the North Sea and English Channel. J. Fish Biol., 6(4): 415-438.

Macer, C.T. 1977. Some aspects of the biology of the horse mackerel [*Trachurus trachurus* (L.)] in waters around Britain. Journal of Fish Biology, 10: 51-62.

Pérez-Rodríguez, A. 2017. Use of Length Based Indicators to estimate reference points for the North Sea horse mackerel. Working Document to WGWIDE, 6pp.

Rückert, C., Floeter, Temming, J.A. 2002. An estimate of horse mackerel biomass in the North Sea, 1991-1997. ICES Journal of Marine Science, 59: 120-130.

6.11 Tables

Table 6.3.1. North Sea Horse Mackerel stock. Catch in numbers (1000) by quarter and area in 2022

	Number/1000					
1Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0.00	0.00	0.00	0.00	0.00
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0.02	0.04	0.03	1.84	507.5	509.43
4	0.07	0.21	0.13	8.68	2388.27	2397.36
5	0.07	0.21	0.14	8.75	2410.71	2419.88
6	0.03	0.1	0.06	3.99	1099.54	1103.72
7	0.01	107.83	0.02	0.99	163.85	272.69
8	0.05	215.65	0.08	5.35	1258.52	1479.65
9	0.01	100.26	0.02	1.3	258.11	359.69
10	0.02	508.54	0.04	2.26	114.2	625.05
11	0	0	0	0	0	0

12	0	90.96	0.01	0.4	20.43	111.8
13	0.01	312.54	0.02	1.39	70.18	384.15
14	0.03	833.2	0.06	3.71	187.11	1024.11
15	0.03	761.58	0.05	3.39	171.02	936.07
Sum	0.35	2931.12	0.66	42.05	8649.44	11623.6
2Q						
Ages	27.3.a	27.4.a	27.4.b	27.4.c	27.7.d	Total
0	0.00	0.00	0.00	0.00	0.00	0.00
1	0	4.08	11.07	188.2	138.82	342.18
2	0.01	6.28	17.03	289.4	213.47	526.18
3	0	3.05	8.27	140.64	103.74	255.71
4	0.01	6.74	18.27	310.48	229.02	564.51
5	0	3.48	9.44	160.41	118.32	291.66
6	0	1.73	4.7	79.97	58.99	145.4
7	0	4.3	1.26	21.4	15.79	42.75
8	0	10.19	5.21	88.48	65.26	169.14
9	0	22.26	1.2	20.39	15.04	58.88
10	0	45.55	1.96	33.31	24.57	105.39
11	0	20.61	0.07	1.24	0.91	22.84
12	0	46.43	0.49	8.26	6.09	61.27
13	0	73.62	1.37	23.21	17.12	115.32
14	0	58.37	3.15	53.59	39.53	154.65
15	0	221.82	3.48	59.12	43.6	328.02
Sum	0.02	528.51	86.97	1478.1	1090.27	3183.9
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	65.55	2564.29	1509.6	4139.44
2	0	0	100.8	3699.21	2565.34	6365.36
3	0	0	40.3	1250.35	1254.01	2544.66

4	0	0	67.27	2101.47	2079.18	4247.92
5	0	0	14.64	564.76	345.33	924.73
6	0	0	9.07	283.96	279.58	572.61
7	0	0	2.73	103.79	65.82	172.33
8	0	0	5.43	179.35	158.09	342.87
9	0	0	0.52	0.47	31.79	32.78
Sum	0	0	306.31	10747.65	8288.74	19342.7
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	12.17	731.98	2957.93	3702.08
2	0	0	17.69	1379.58	3968.73	5366.01
3	0	0	14.56	757.47	3636.92	4408.95
4	0	0	22.63	1382.77	5429.11	6834.51
5	0	0	4.82	144.77	1306.41	1456
6	0	0	2.01	166.57	436.26	604.84
7	0	0	0.65	10.39	182.99	194.03
8	0	0	0.33	52.94	46.31	99.59
Sum	0	0	74.86	4626.47	17964.66	22666.01
1-4Q						
Ages	27.3.a	27.4.a	27.4.b	27.4.c	27.7.d	Total
0	0.00	0.00	0.00	0.00	0.00	0.00
1	0	4.08	90.77	3508.5	4634.71	8238.07
2	0.01	6.28	138.48	5404.12	6789.93	12338.82
3	0.02	3.09	65.1	2173.87	5529.98	7772.06
4	0.08	6.94	111.78	3845.67	10175.45	14139.93
5	0.08	3.69	30.25	893.49	4198.24	5125.75
6	0.04	1.83	16.42	541.46	1882.6	2442.34
7	0.01	112.13	4.78	138.13	430.3	685.35
8	0.05	225.83	11.46	331.07	1534.03	2102.44

9	0.01	122.51	1.8	22.96	305.88	453.17
10	0.02	554.09	1.99	35.57	138.77	730.44
11	0	20.61	0.07	1.24	0.91	22.84
12	0	137.39	0.49	8.66	26.52	173.06
13	0.01	386.16	1.39	24.6	87.31	499.47
14	0.03	891.58	3.21	57.3	226.64	1178.76
15	0.03	983.4	3.53	62.5	214.63	1264.1
Sum	0.39	3459.61	481.52	17049.14	36175.9	57166.6

Table 6.3.2. Numbers at age (millions). weight at age (kg) and length at age (cm) for the North Sea horse mackerel 1995-2022 in the commercial fleet catches (2018 distribution based on one sample only due to low sampling level).

Catch no

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
0																										0.10		
1	1.8	4.6	12.6	2.3	12.4	77.2	2.8	71.4	13.5	12.8	13.8	5.8	3.1	1.8	34.2	2.9	7.3	9.5	7.6	15.4	49.7	3.6	20.7	27.4		4.75	7.26	8.24
2	3.1	13.8	27.2	22.1	31.5	75.8	15.6	21.4	41.9	14.7	73.7	26.5	15	8.9	14.2	22	19.5	24.3	9.9	15.3	23.8	65.2	20.9	49.1	1	58.99	21.89	12.34
3	7.2	11	14.1	36.7	23.1	29.2	32.5	24.5	24.2	27.8	39.8	58.8	22.3	36.2	29.1	9	72.1	20.3	21.2	8.7	10.1	15.9	62.6	13.2	5.8	24.57	32.23	7.77
4	10.3	11.9	14.9	38.8	17.6	24.1	16.8	13.9	35.7	14.7	32.6	40.1	82.9	16.8	22.6	15.3	36.4	40.1	22.1	30.2	5.8	9.8	10.2	32.7	3.1	21.02	17.11	14.14
5	12.1	9.6	14.6	20.8	23.1	33.3	8.3	6.6	30.3	28.1	16.4	67.6	72.5	36.3	17.4	25.2	13.4	25.7	27.1	13.8	7.2	7.7	6	4.5	12.1	2.24	12.71	5.13
6	13.2	12.5	12.4	12.1	26.2	21.5	10.8	6.5	11.4	21	19.8	23	31.2	36.1	17.1	15.9	9.2	20.8	6	7.1	3.8	5.7	3.4	0.7	2	4.00	1.38	2.44
7	11.4	8	10.1	14	20.6	16.8	15.7	6.2	7.3	10.9	4.4	12.6	24.3	27.2	22.3	29.4	3.5	3.1	7.2	2.7	3.3	2.5	2.8	0.7	1.8	0.42	6.37	0.69
8	12.6	6.6	8.6	10.8	21.8	8.7	12.9	11.6	10.7	4	2.4	5.6	17.6	21.9	46.8	5.1	6.8	5	4.2	3.4	1.4	5.1	2.4		1.3	0.09	1.06	2.1
9	7.3	1.5	2.5	8.3	12.9	9.5	9.9	7	11.8	5.8	2.1	1.2	8.5	10.1	11.1	5.6	3	4.6	4	0.9	1.6	1.2	0.9		4.7	0.28	0.04	0.45
10	5.9	5.3	0.8	4	8.2	5.6	10	7.7	1.3	12	3.5	1.3	1.7	7.5	9.3	8.6	8.4	1.5	5.4	1	0.9	0.1	0.3		2.8	0.35	0	0.73
11	0	0.3	0.3	2.7	2.1	4.6	9.6	5.9	3.6	6.7	3.8	0.1	1.1	1.9	7.1	2.6	6.1	0.5	3.7	1.3	0.2	0.1	0.5		3.5	0.27	0.09	0.02

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
12	8.8	1.3	0.3	0.7	0.4	1.7	5.4	3.4	3.1	5	1.3	1.5	0.2	2.1	3.6	0.3	3.5	0.1	1	0.4	0.9	0.4	0		0.7	0.13	0.19	0.17
13	0.2	8.9		1.8	1.4	1.2	3.7	2.4	2.4	6.8	2.7	0.4	0.8	0.4	0.3	0.3	0.4	0	0.6	0	0.2	1.4	0		0.7	0.03	0.12	0.5
14	4.4	8	1.4	0.3	3.8	0	2	1.4	3.4	2.5	2.1	0.8	0.8	2.4	1	0.2	0.3	0.2	0	0.2	0.2	0.5	0.3		0.3	0.03		1.18
15+				5.1	4	6.7	5.8	3	3.7	8.8	5.5	0.7	0	1.1	6.1	1.1	0.5	0	0.1	0.1	0	3.1	0.3		7.7	0.07		1.26

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	2018	2019	2020	2021	2022
0	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	0.047	NA	NA
1	0.076	0.107	0.063	0.063	0.063	0.075	0.067	0.066	0.074	0.076	0.07	0.074	0.0615	0.063	0.074	0.077	0.06	0.069	0.077	0.078	0.062	0.07	0.06	0.061	NA	0.057	0.068	0.061
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	0.093	0.111	0.086	0.079	0.095
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	0.131	0.125	0.119	0.099	0.12
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	0.147	0.155	0.132	0.123	0.134
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	0.151	0.155	0.145	0.152	0.166	0.144	0.169	0.158	0.173	0.17	0.165	0.191	0.143	0.158
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	0.16	0.182	0.183	0.166	0.172	0.18	0.177	0.196	0.155	0.189	0.189	0.202	0.174	0.138	0.188

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
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	0.201	0.261	0.247	0.198	0.271
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	NA	0.248	0.306	0.185	0.243
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	NA	0.261	0.308	0.258	0.316
10	0.173	0.241	0.259	0.259	0.259	0.283	0.246	0.253	0.269	0.29	0.287	0.286	0.255	0.296	0.322	0.227	0.334	0.204	0.226	0.22	0.312	0.359	0.233	NA	0.304	0.313	0	0.453
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	NA	0.301	0.339	0.29	0.526
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	NA	NA	0.411	0.378	0.431	0.48
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	NA	0.262	0.252	0.351	0.242	NA	NA	0.42	0.325	0.262	0.478
14	0.348	0.277	0.299	0.299	0.299	NA	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	NA	0.429	0.389	NA	0.475
15+	0.348	0.277	0.36	0.36	0.36	0.35	0.336	0.39	0.353	0.402	0.375	0.404	0	0.389	0.46	0.351	0.475	0	0.339	0.273	0	0.378	0.26	NA	0.431	0.37	NA	0.508

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	2018	2019	2020	2021	2022
0																										18		NA
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	19.51		19.3	20	19.4

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
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	22.19	23.5	21.7	21.2	22.4
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	22.6	23.2	23.2	23.9	23	23.5	23.5	23.5	24.6	23.6	23.3	24.67	24.4	24.3	22.9	24.1
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	25.58	26.1	24.8	24.5	24.9
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	26.78	26.6	27.5	25.4	26.6
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	27.5	28.1	27	25.4	28.2
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	27.9	28.1	28.1	28.3	27.7	27.1	28.3	27.5	30.4	27.5	27.5	28.04	30.6	29.5	28	30.5
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	27.1	28.9	28	31.7	30.2	28		30	31.8	27.3	30.3
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		30.6	31.6	29.5	32.9
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		32.1	32.1		36.3
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		32.1	32.7	30.5	37.7
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			36	34.4	34.5	36.8
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			36.3	31.5	30.5	37

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
14	31.1	31.1	31.1	31.1	31.1		32.1	32.4	32.6	33	34.4	32.5	34.5	32.3	34.2	33	36	27.5	38.5	36	30.5	36.1	30.5		36.6	35.5		37
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		36.5	33		37.8

Table 6.3.3. North Sea Horse Mackerel stock. Mean weight at age (grams) in the catch by area for all quarters in 2022

Q1-Q4

Ages	27.3.a (Q1.2)	27.4.a(Q1.2)	27.4.b	27.4.c	27.7.d	Total
0	0	0	0	0	0	0
1	60.5	60.5	60.7	60.4	61.6	61.1
2	97.4	97.4	96.6	96.5	93.4	94.8
3	92.1	120.7	125.5	127.7	117.6	120.5
4	113.1	128.2	137.5	136.1	133.8	134.5
5	151.4	161.7	175.5	186.3	152.4	158.5
6	189.5	194.4	197.5	198.4	185.5	188.4
7	304	425.4	267.6	285.6	226	270.9
8	245.9	434.8	232.3	228.8	217.7	242.8
9	312.5	452.2	290.9	314.3	261.9	316.1
10	448.2	453.8	453.7	453.4	449	452.9
11	526	526	526	526	526	526
12	459.4	483.3	483	482.1	463.8	480.3
13	466.6	479.8	479.6	479.1	468.7	477.8
14	471.2	475.8	475.7	475.4	471.8	475
15+	494.8	510.4	510.2	509.5	497.3	508.1

Table 6.3.4. North Sea Horse Mackerel stock. Mean length (mm) at age in the catch by area for all quarters in 2022

1-4Q

Ages	27.3.a (Q1.2)	27.4.a(Q1.2)	27.4.b	27.4.c	27.7.d	Total
0	0	0	0	0	0	0
1	191.6	191.6	192.3	192.1	195.1	191.6
2	222.9	222.9	223.1	222.8	224.3	222.9
3	227.5	240.6	243.2	243.8	240.4	227.5
4	241.5	245.4	248.8	248.1	249.7	241.5
5	266.7	268.3	269.3	272.2	264.5	266.7
6	291	286.8	278.7	277.2	283.2	291
7	321.6	354	300.4	304.7	292.9	321.6

Ages	27.3.a (Q1.2)	27.4.a(Q1.2)	27.4.b	27.4.c	27.7.d	Total
8	306.2	358	295.1	292.8	296.7	306.2
9	330.1	361.4	316.1	328.1	315.8	330.1
10	362	363.1	363	363	362.2	362
11	377	377	377	377	377	377
12	364.3	369.1	369	368.8	365.2	364.3
13	368.1	370.5	370.4	370.3	368.5	368.1
14	369	369.8	369.8	369.8	369.1	369
15+	376.1	378.7	378.7	378.5	376.5	376.1

Table 6.5.1. North Sea Horse Mackerel. CPUE Indices of abundance (number/hour) for the juvenile (<20cm) and exploitable (≥20cm) sub-stock. estimated as a combined index for the NS-IBTS Q3 and the FR-CGFS in Q4. The survey indices are derived from the prediction of a hurdle model fit to data over the period 1992-2022 and include a 95% confidence interval based on a bootstrapping procedure (CI_low = lower bound. CI_high = upper bound). Survey data from 2020 were not included in the modelling procedure as not all sampling stations of FR-CGFS could be visited in 2020, and therefore no reliable index value for 2020 could be calculated.

	Exploitable sub-stock (> 20 cm)			Juvenile sub-stock (< 20 cm)		
Year	Index	CI_low	CI_high	Index	CI_low	CI_high
1992	1376	572	2889	4272	1928	9541
1993	555	274	986	1857	912	3738
1994	1168	519	2156	2591	1269	5252
1995	1347	535	2790	2020	1072	4349
1996	1054	460	1998	732	312	1505
1997	626	274	1156	2166	972	4857
1998	407	191	769	650	318	1247
1999	447	210	808	1439	750	2602
2000	422	212	762	1567	815	3050
2001	517	240	956	2181	1196	4981
2002	425	204	829	2394	1205	4780
2003	288	134	574	1787	927	3350
2004	351	156	644	1003	525	1805
2005	658	304	1252	803	419	1524
2006	697	312	1330	531	282	969
2007	344	154	708	601	320	1099

	Exploitable sub-stock (> 20 cm)			Juvenile sub-stock (< 20 cm)		
2008	163	79	366	532	287	941
2009	98	44	206	691	364	1253
2010	195	81	402	2259	1067	4443
2011	234	108	474	504	257	936
2012	151	80	410	316	167	649
2013	188	75	413	1089	543	2060
2014	329	154	735	1547	795	2992
2015	447	186	923	1471	701	2907
2016	519	227	996	3056	1478	6178
2017	134	55	298	940	428	1925
2018	114	48	218	3163	1609	7417
2019	201	92	434	812	372	1677
2020						
2021	122	49	245	1663	788	3226
2022	265	107	578	1447	698	2912

6.12 Figures

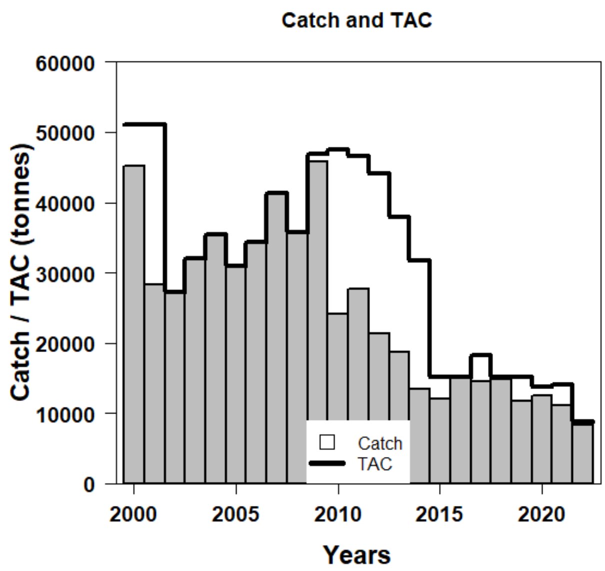


Figure 6.2.1. North Sea horse mackerel. Utilisation of quota from 2000 to 2022.

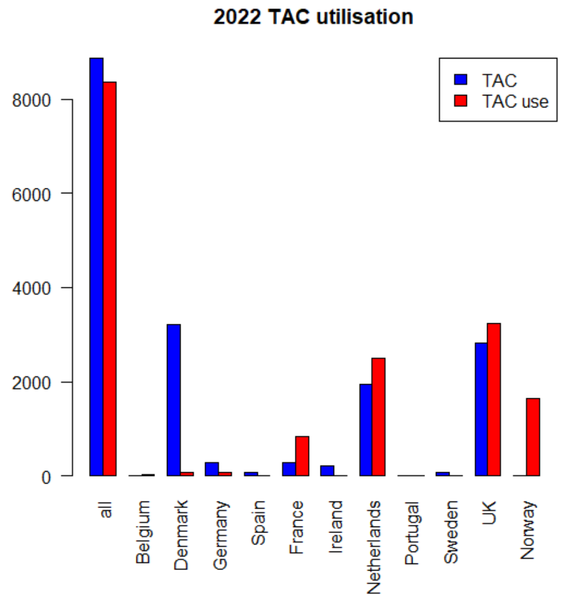


Figure 6.2.2. North Sea horse mackerel. Utilisation of quota by country in 2022.

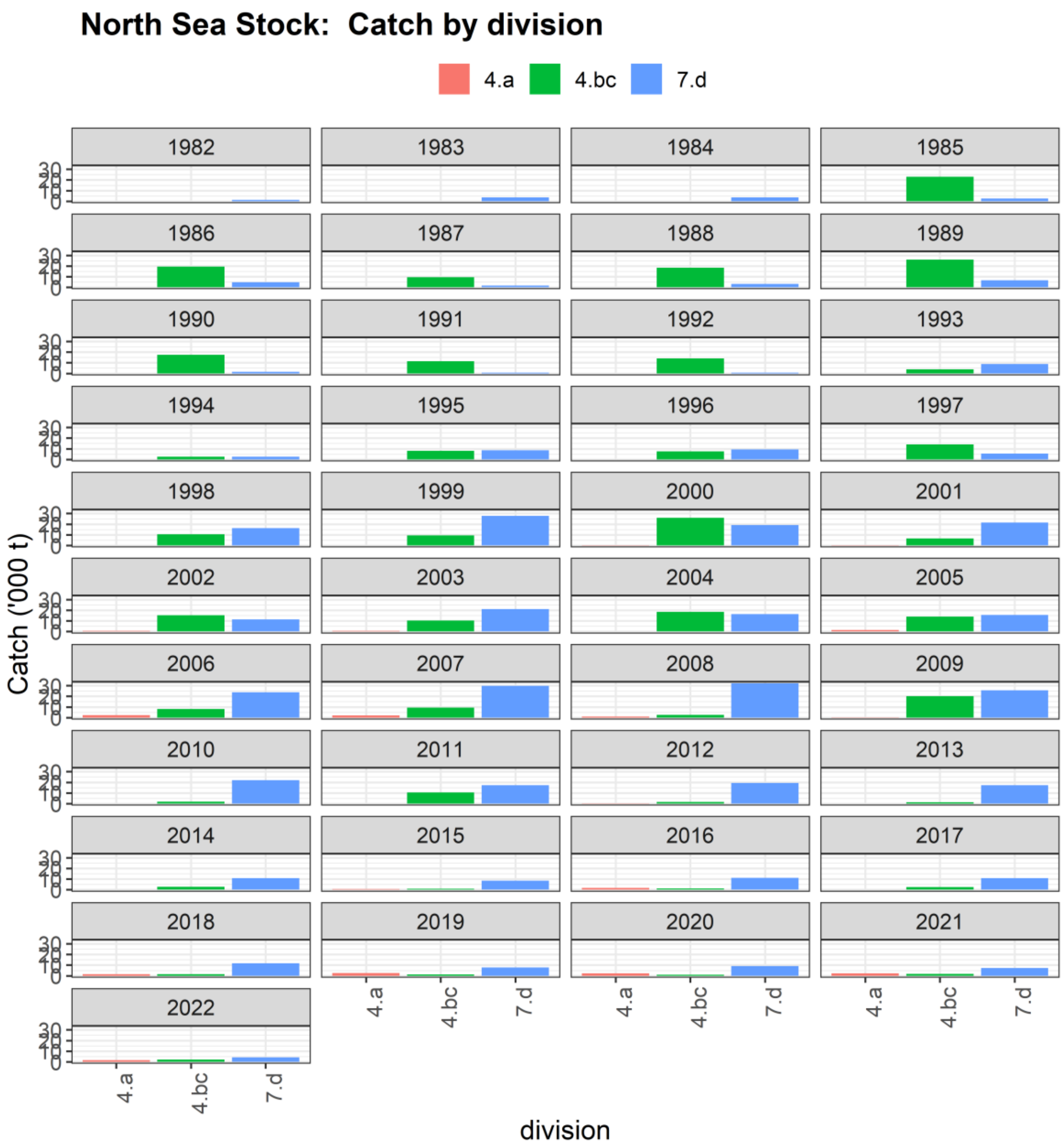


Figure 6.2.3. North Sea horse mackerel. Catch in (1000 t) by division and year from 1982 to 2022.

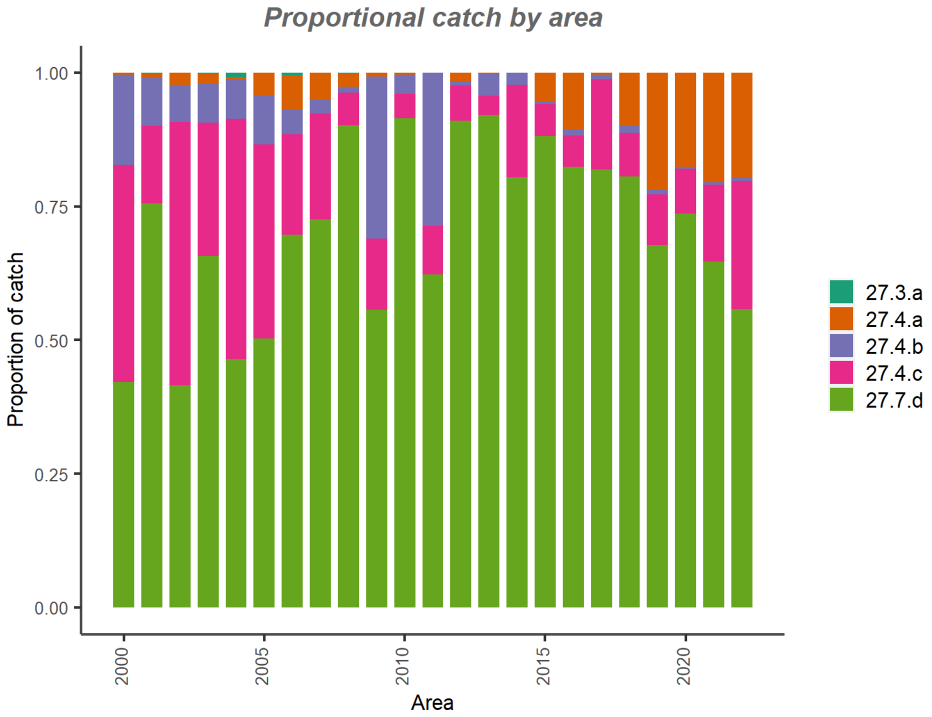
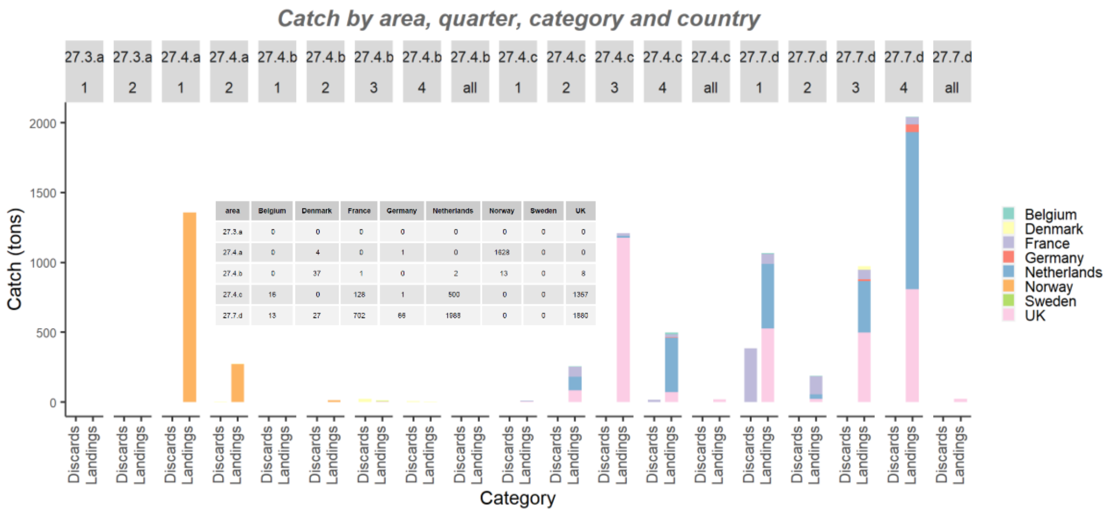


Figure 6.2.4. North Sea horse mackerel. Proportion of catches by ICES division from 2000 to 2022.



area	Belgium	Denmark	France	Germany	Netherlands	Norway	Sweden	UK
27.3.a	0	0	0	0	0	0	0	0
27.4.a	0	4	0	1	0	1628	0	0
27.4.b	0	37	1	0	2	13	0	8
27.4.c	16	0	128	1	500	0	0	1357
27.7.d	13	27	702	66	1988	0	0	1880

Figure 6.2.5. North Sea Horse Mackerel. Total catch (in tonnes) by ICES division, quarter, catch category and country in 2022.

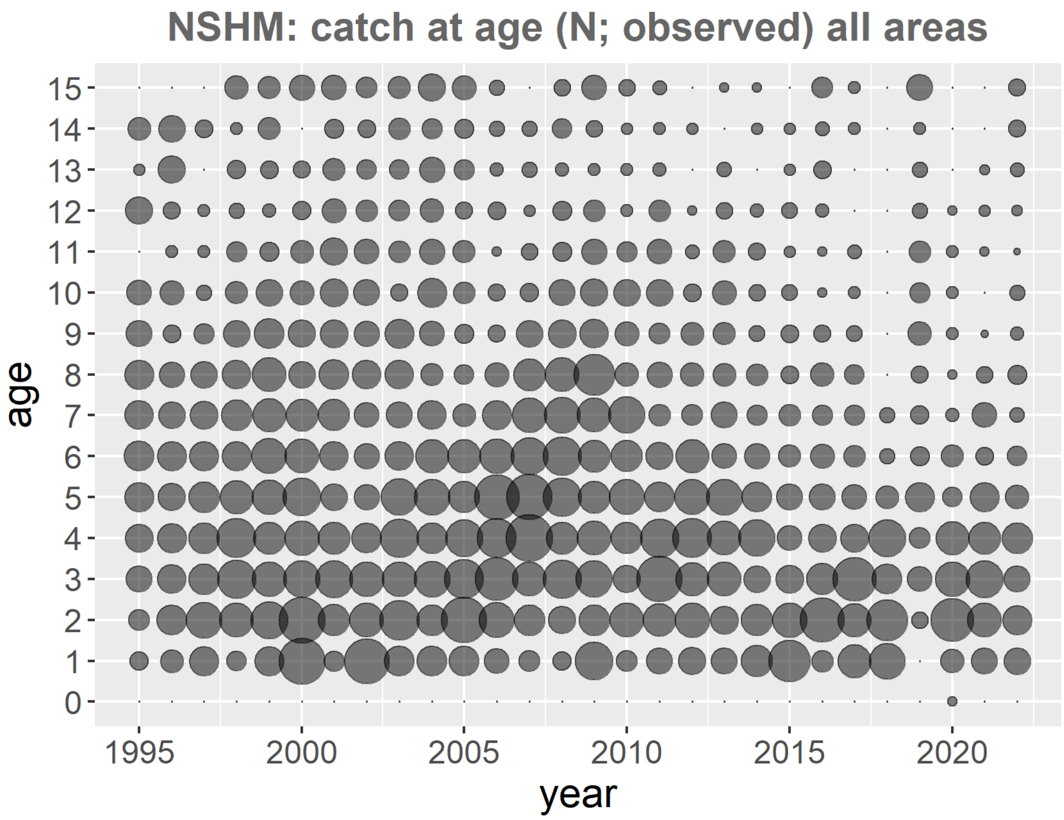


Figure 6.3.1. North Sea horse mackerel age distribution in the catch for 1995-2022. The size of bubbles is proportional to the catch number. Note that age 15 is a plus g

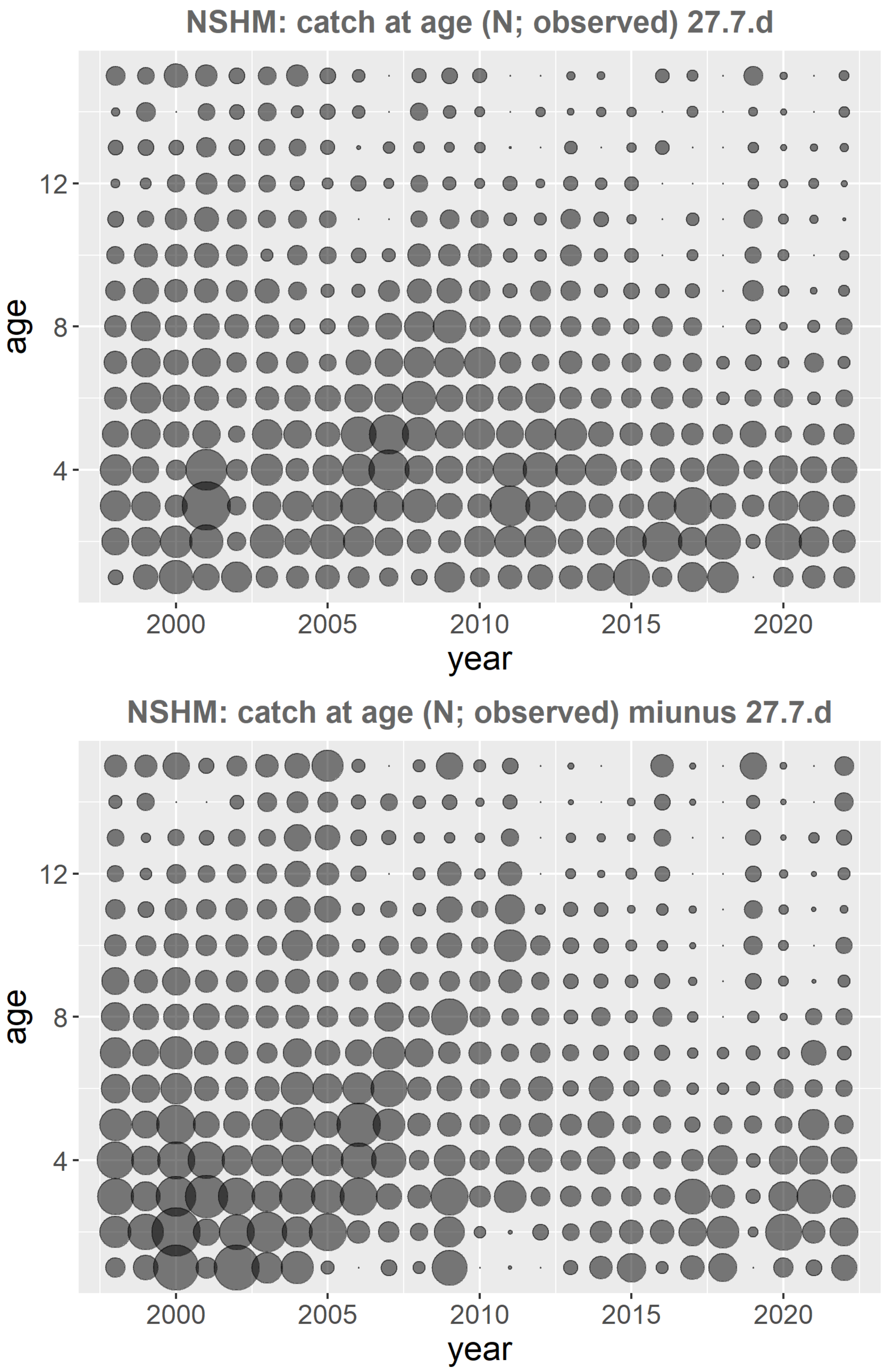


Figure 6.3.2. North Sea horse mackerel. Bubble plots of age distribution in the catch by area for 1998-2022 for area 7.d (upper panel) and without 7.d (bottom panel). The size of bubbles is proportional to the catch numbers. Note that age 15 is a plus group.

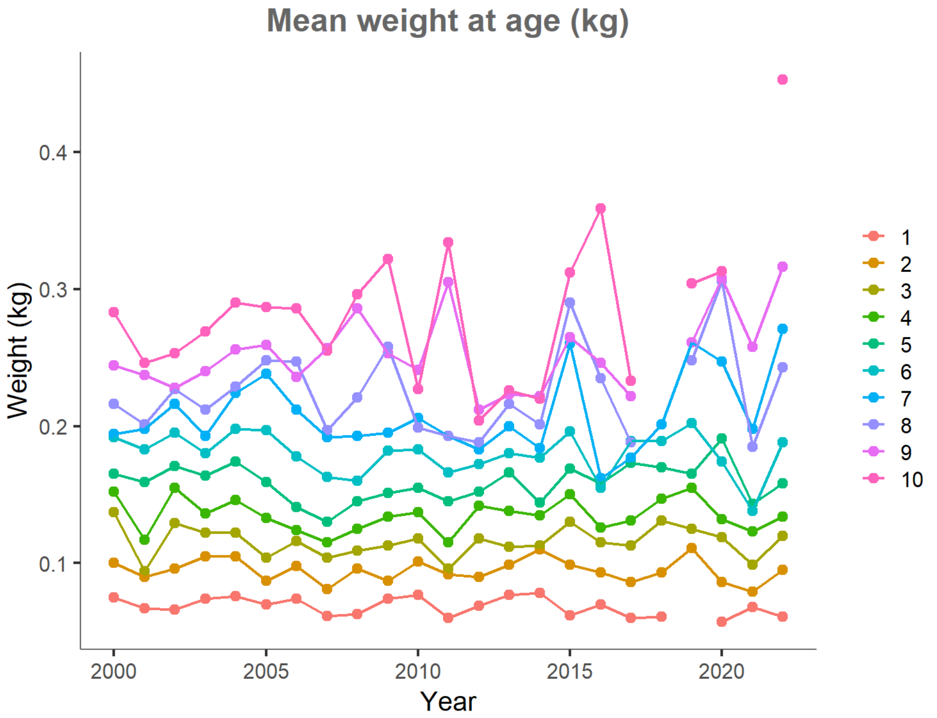


Figure 6.3.3. North Sea horse mackerel. Mean weight at age in commercial catches over the period 2000-2022. Note that only age 1-10 are presented and that 10 is not a plus group.

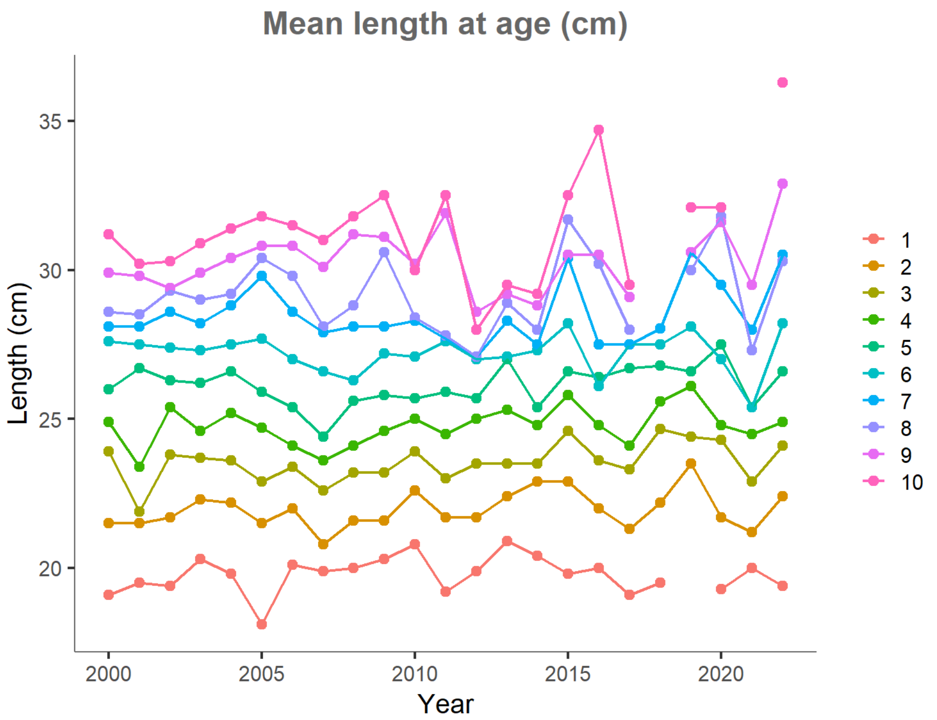


Figure 6.3.4. North Sea horse mackerel. Mean length at age in commercial catches over the period 2000-2022. Note that only age 1-10 are presented and that 10 is not a plus group.

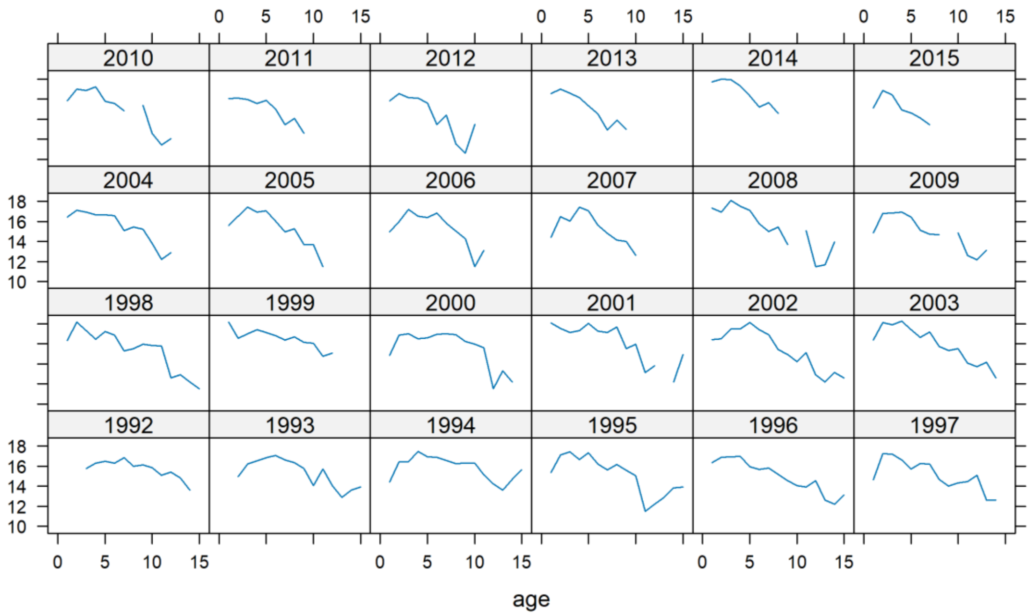


Figure 6.4.1. North Sea Horse Mackerel. Catch curves for the 1992 to 2015 cohorts, ages from 3 to 15+. Values plotted on the vertical axis are the log(catch) values for each cohort in each year. The negative slope of these curves estimates total mortality (Z) in the cohort.

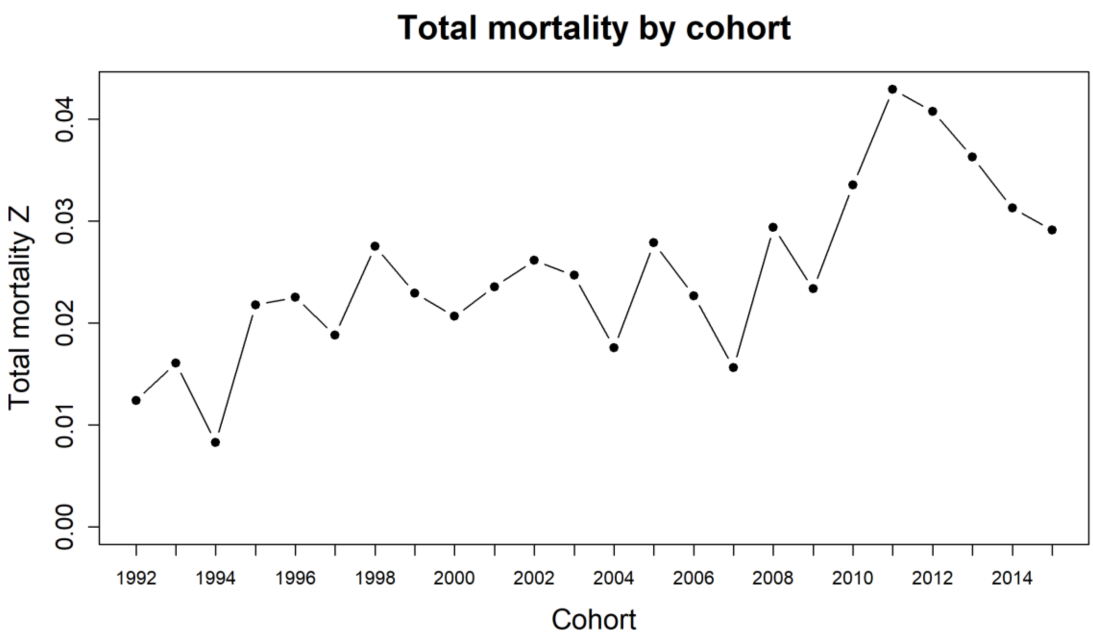


Figure 6.4.2. North Sea Horse Mackerel. Total mortality by cohort (Z) estimated from the negative gradients of the 1992—2015 cohort catch curves (Figure 6.4.1).

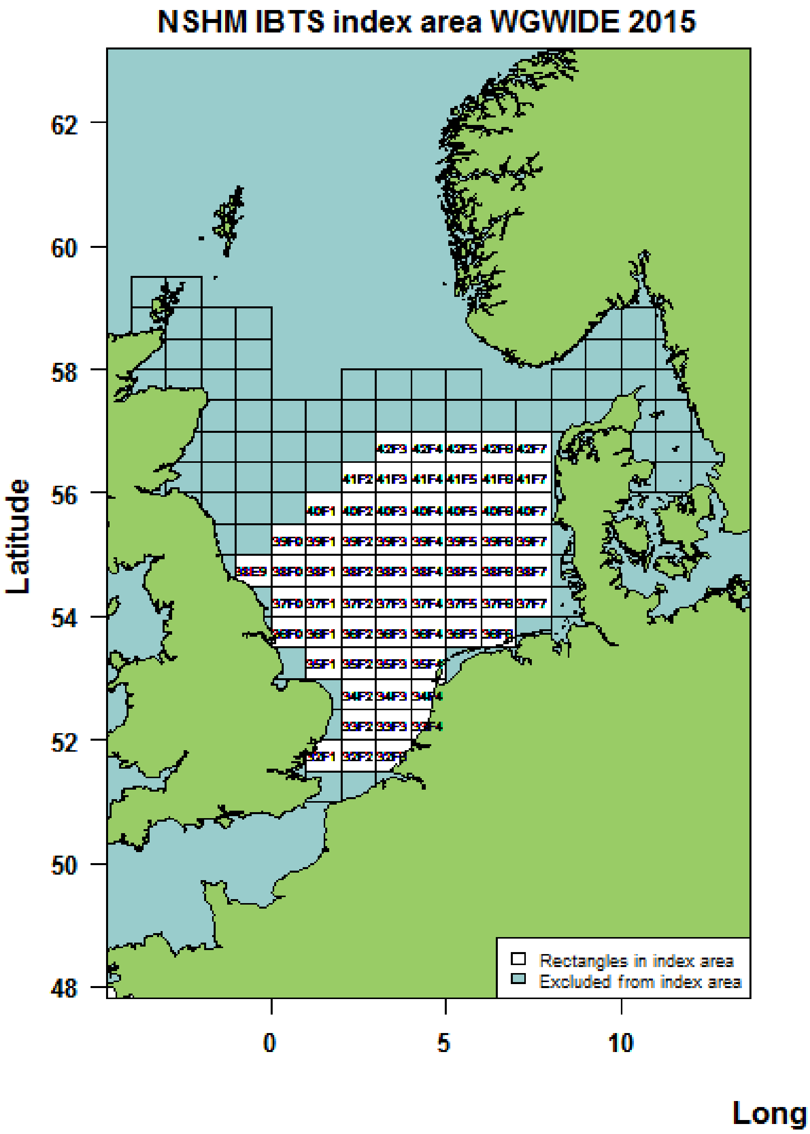


Figure 6.4.3. North Sea horse mackerel. ICES rectangles selected by WGWIDE in 2013 and currently used by the working group.

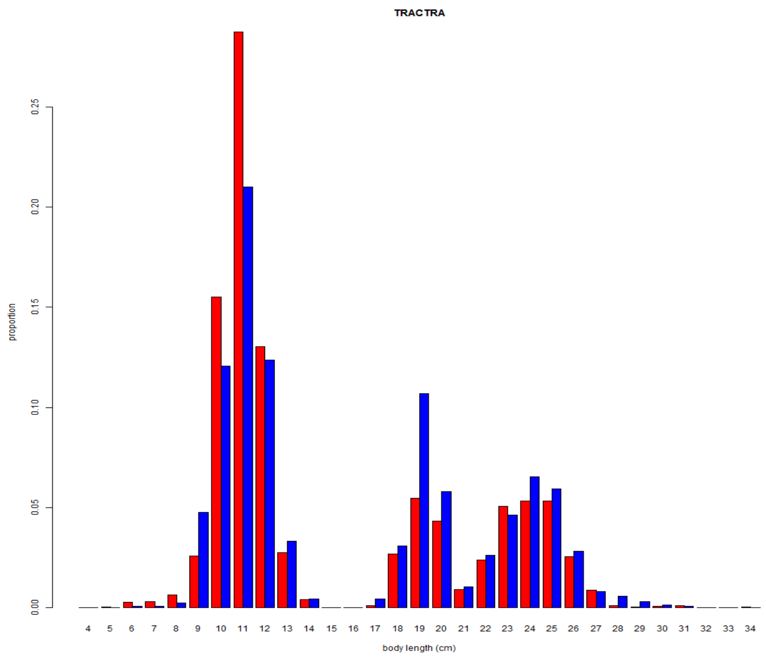


Figure 6.4.4. North Sea horse mackerel. Size distribution of North Sea horse mackerel catches during the inter-calibration exercise conducted in 2014 between the RV Gwen Drez (red bars) and Thalassa (blue bars).

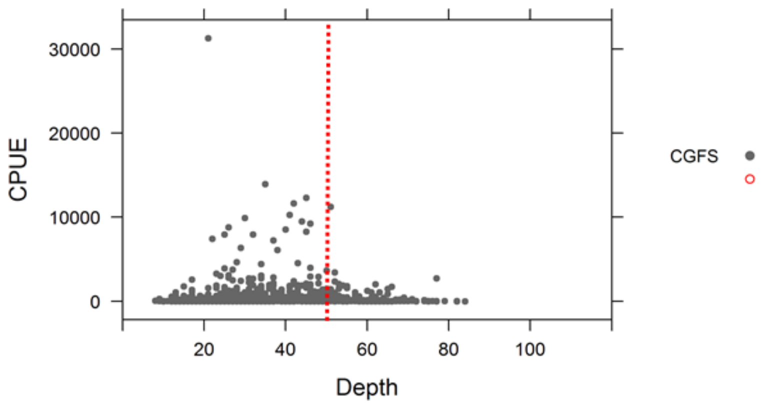


Figure 6.4.5. North Sea horse mackerel. CPUE by depth for the CGFS survey from 1992 to 2017.

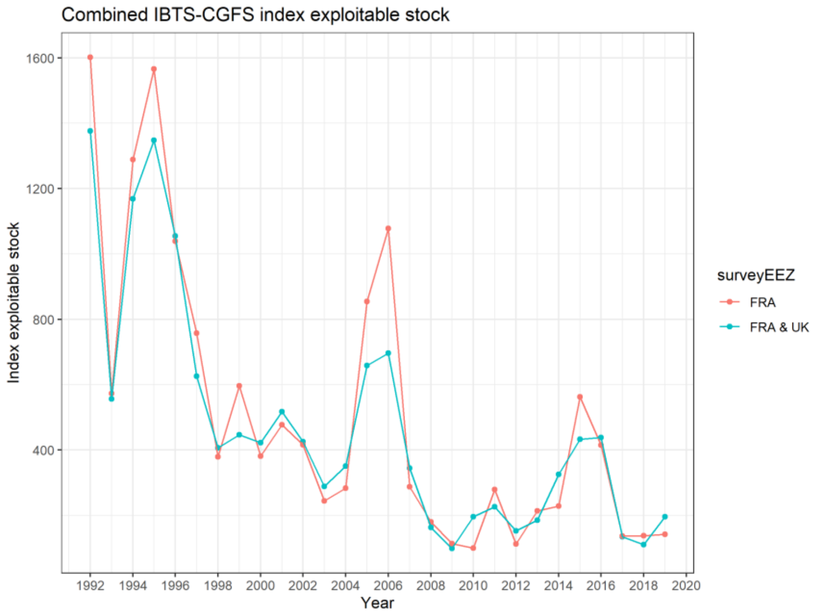


Figure 6.4.6. North Sea horse mackerel. Modelled abundance index from 1992-2019 including both UK and French stations in the FR-CGFS (blue) and excluding UK stations in the FR-CGFS (red) for the exploitable sub-stock (≥20 cm).

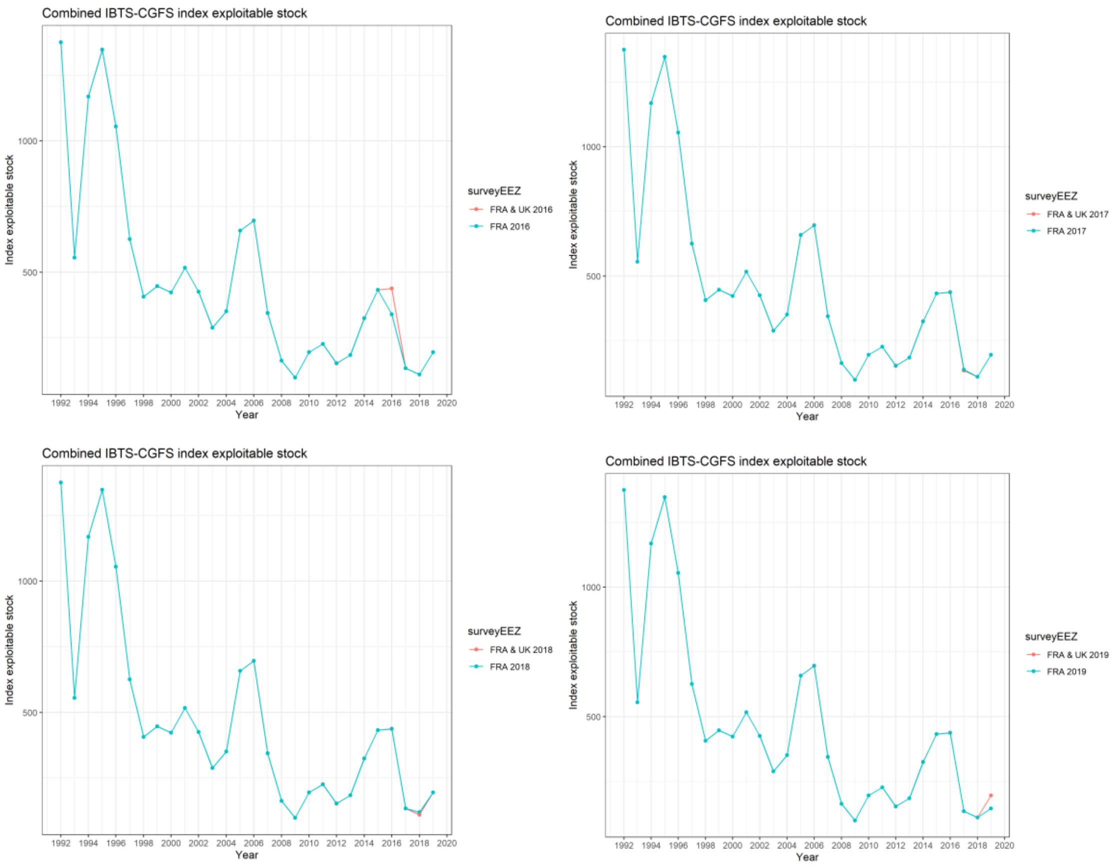


Figure 6.4.7. North Sea horse mackerel. Modelled abundance index from 1992-2019 for the exploitable sub-stock (≥20 cm) for when UK sampling stations from FR-CGFS have been excluded for 2016 (top left), 2017 (top right), 2018 (bottom left) and 2019 (bottom right).

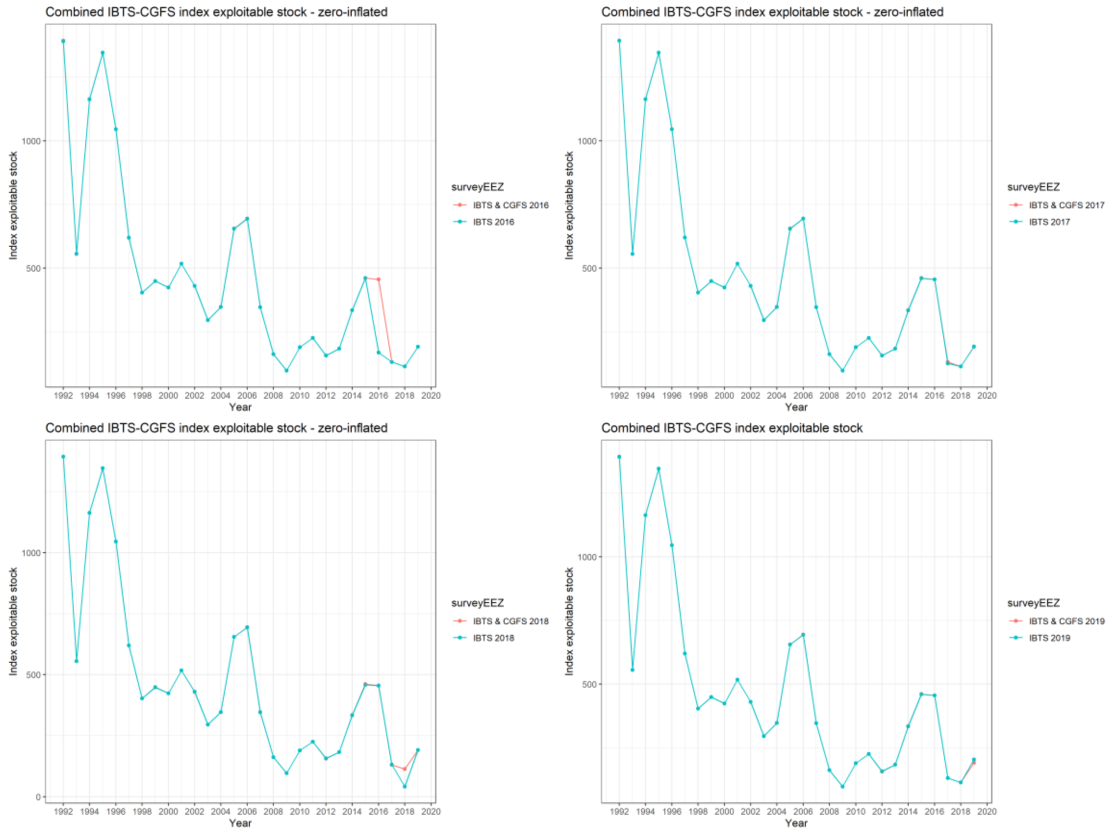


Figure 6.4.8. North Sea horse mackerel. Modelled abundance index from 1992-2019 for the exploitable sub-stock (≥20 cm) for when the FR-CGFS has been excluded for 2016 (top left), 2017 (top right), 2018 (bottom left) and 2019 (bottom right).

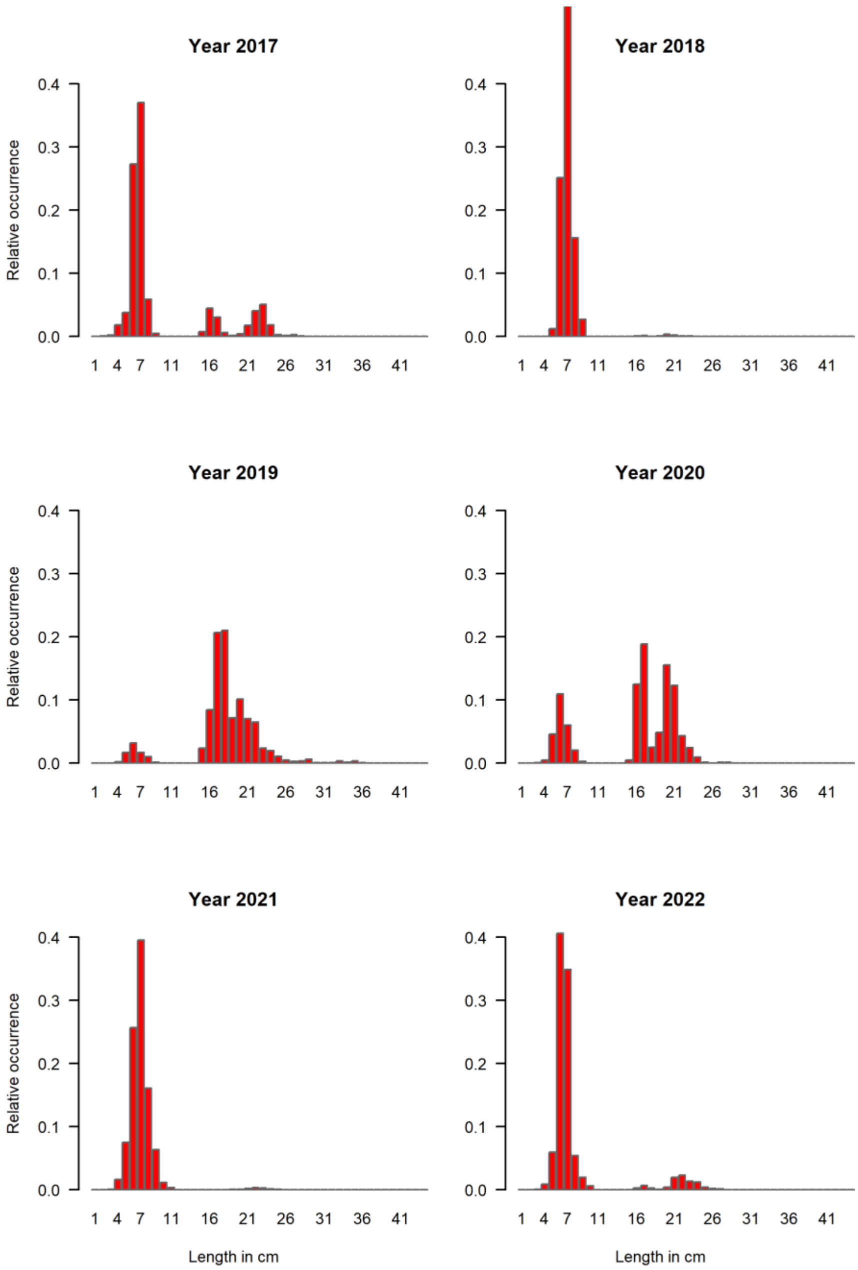


Figure 6.4.9. North Sea horse mackerel. Relative occurrence by length for the period 2017-2022 in the NS-IBTS.

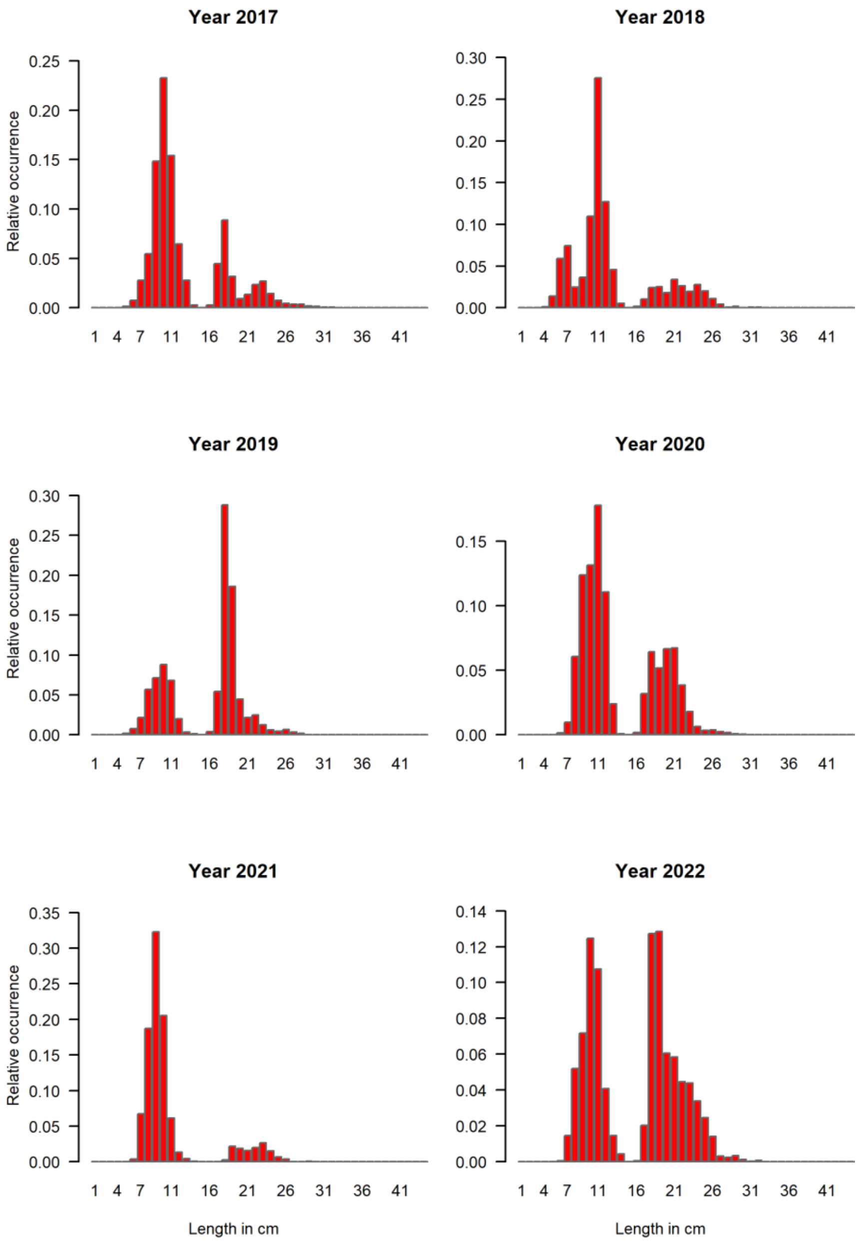


Figure 6.4.10. North Sea horse mackerel. Relative occurrence by length for the period 2017-2022 in the FR-CGFS. Note that stations in UK waters could not be visited in 2020.

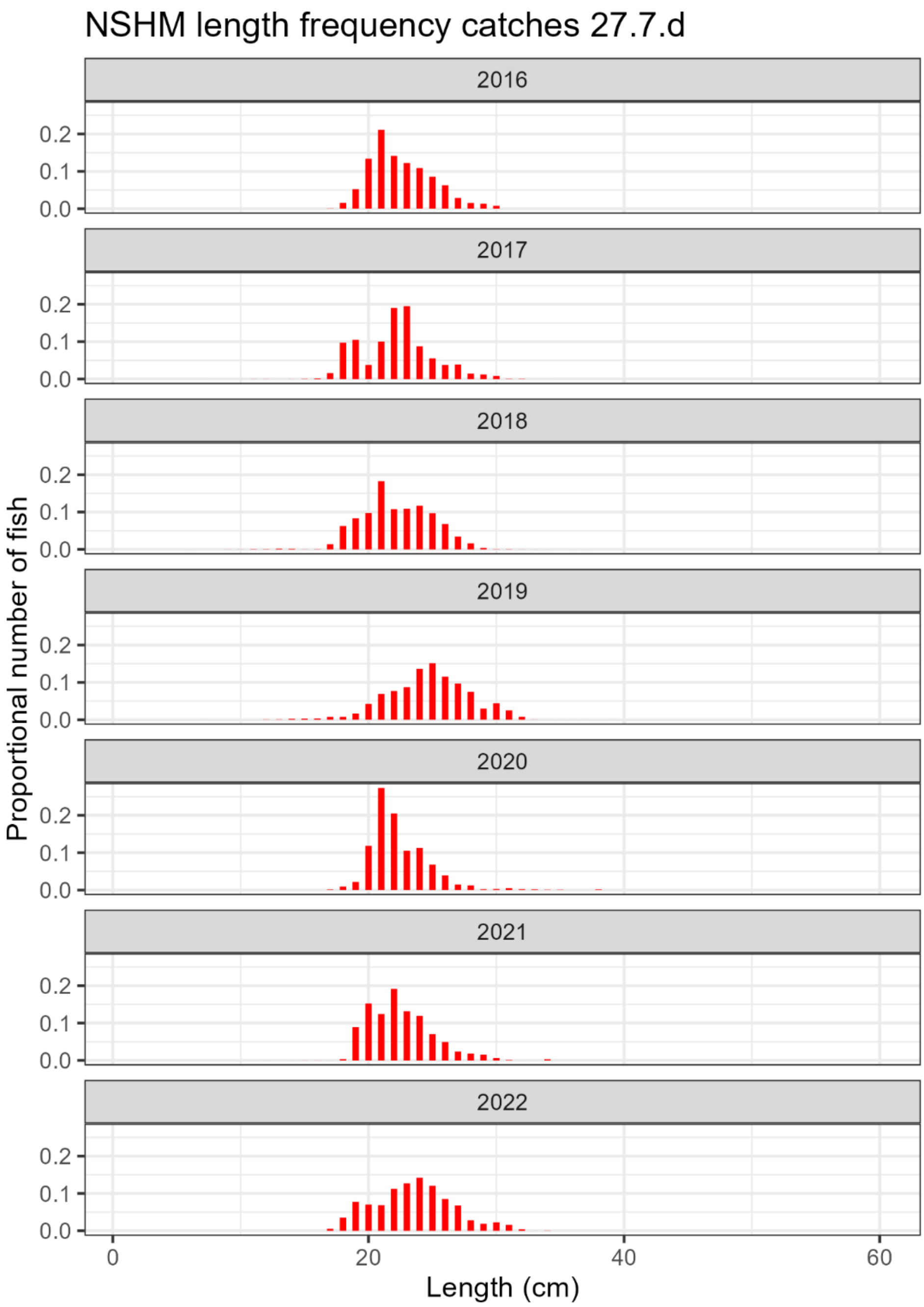


Figure 6.4.11. North Sea horse mackerel. Length distributions in proportion to catch numbers from commercial catches in 27.7.d for the period 2016-2022.

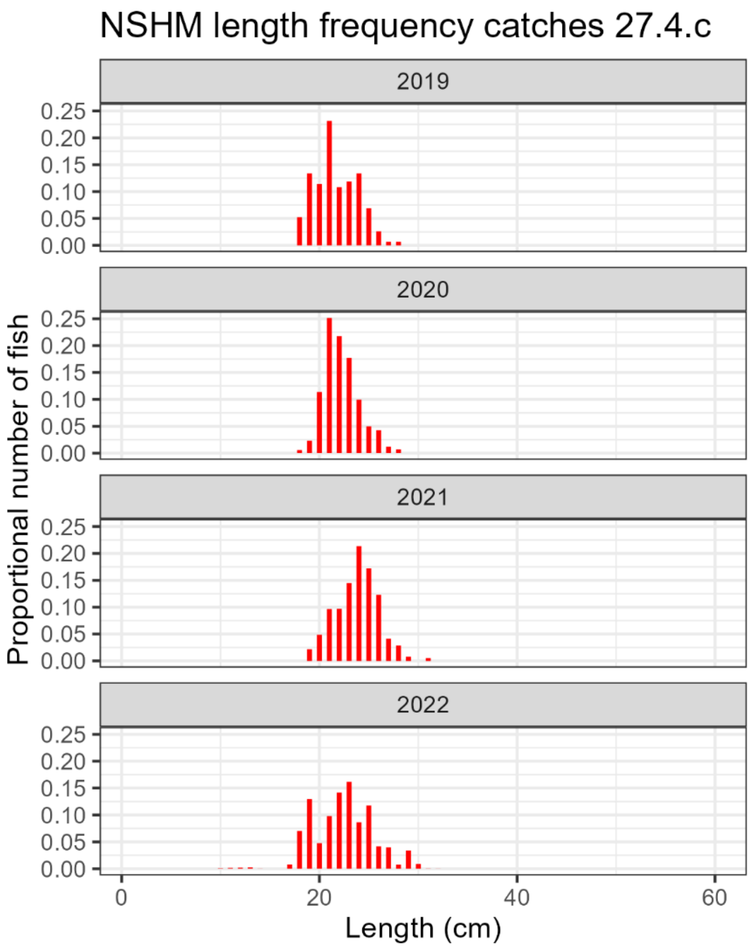


Figure 6.4.12. North Sea horse mackerel. Length distributions in proportion to catch numbers from commercial catches in 27.4.c in 2019 - 2022.

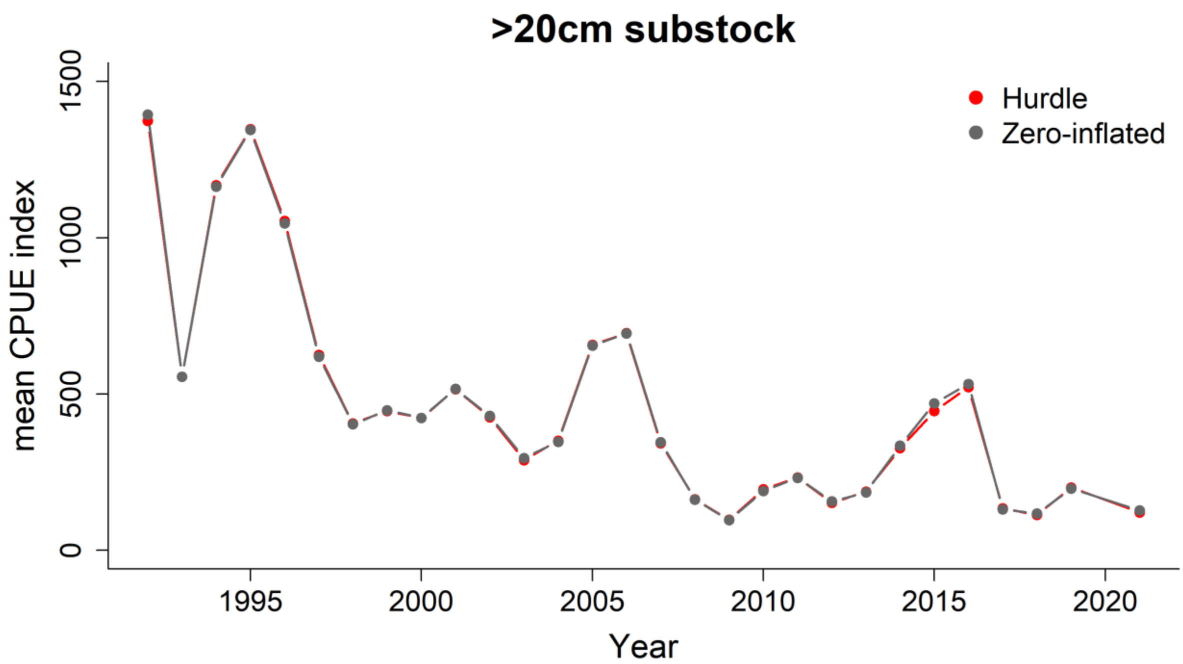


Figure 6.5.1. North Sea horse mackerel. CPUE per year of the exploitable sub-stock (≥20 cm) from 1992 to 2021 as modelled by the hurdle model (red) that returned a warning when ran, and the zero-inflated model (grey).

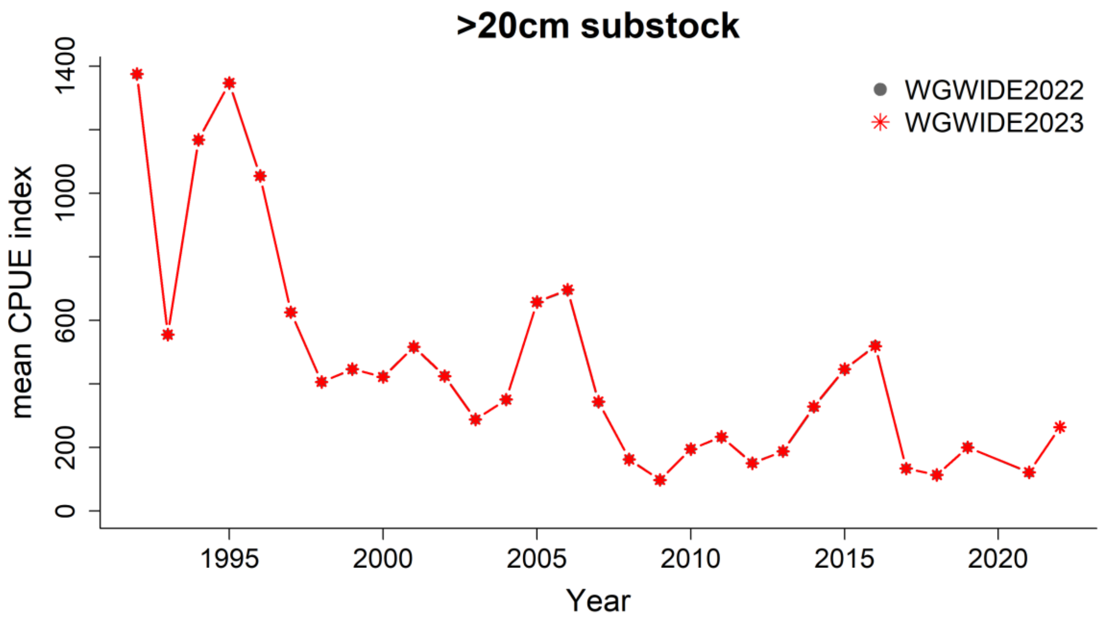


Figure 6.5.2. North Sea horse mackerel. CPUE per year of the exploitable sub-stock (≥20 cm) from 1992 to 2022 as modelled by the hurdle model at WGWIDE 2022 (grey) and WGWIDE 2023 (red). In the model the 2020 index value for the exploitable sub-stock (≥20 cm) is left out and the index is modelled using a Hurdle model. Complete overlap between last and current year is observed.

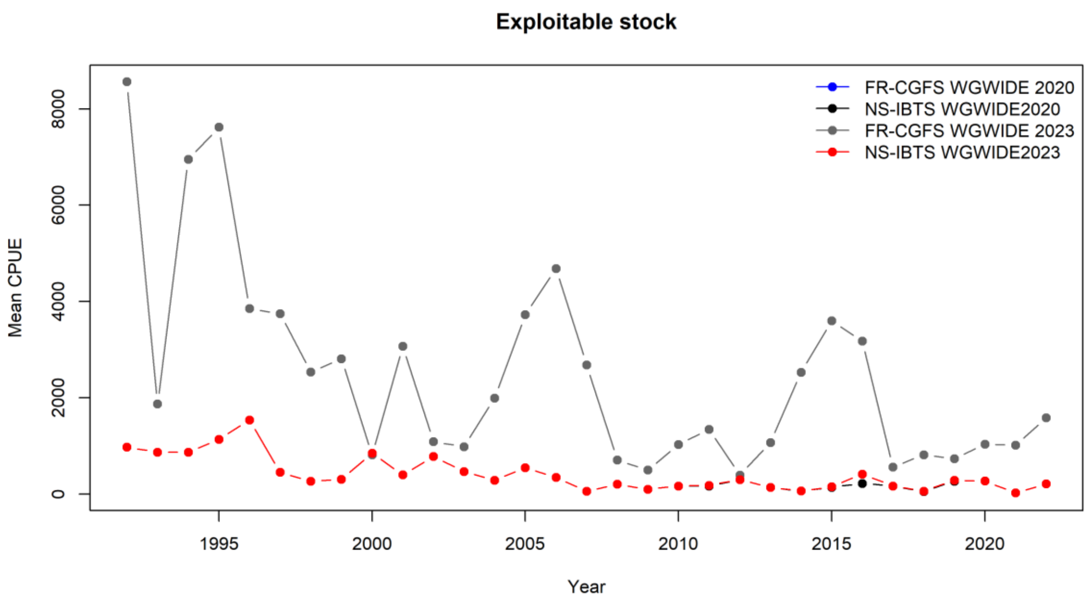
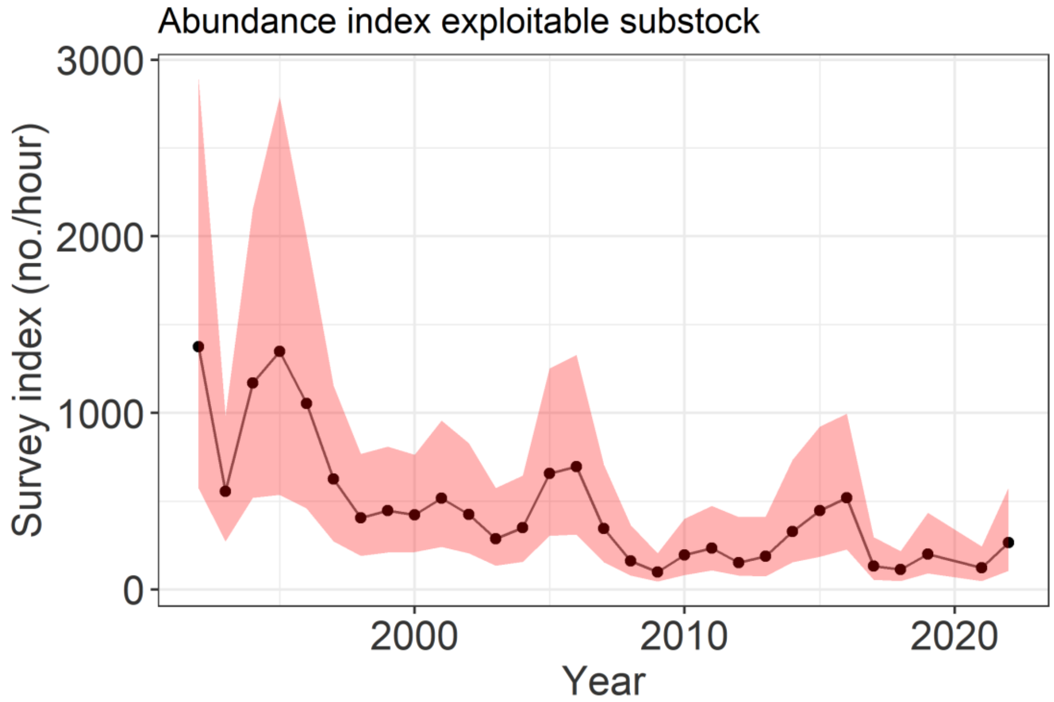


Figure 6.5.3. North Sea horse mackerel. Mean CPUE across hauls of the exploitable sub-stock (≥20 cm) from 1992 to 2023 for the FR-CGFS (blue WGWIDE 2020 (not visible), grey WGWIDE 2021) and the NS-IBTS (black WGWIDE 2020, red WGWIDE 2023). Small changes in reported catches of NS-IBTS resulted in a higher index value for 2016.



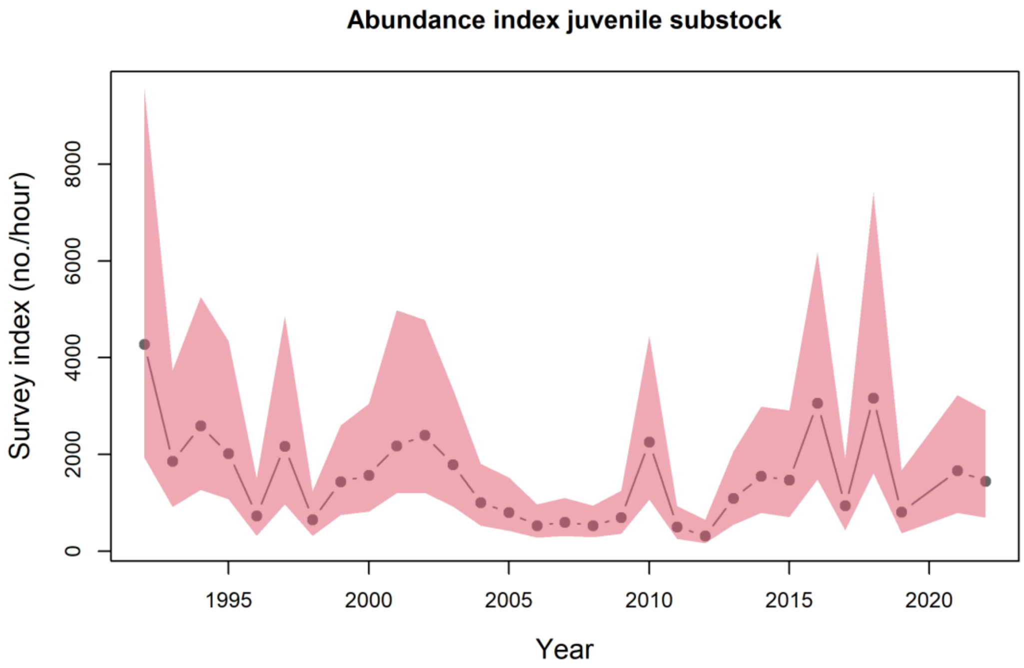


Figure 6.5.4. North Sea Horse Mackerel. Joint CPUE survey index (number/hour) derived from the hurdle model fit to the NS-IBTS survey in the North Sea and the FR-CGFS survey in the Eastern English channel for the period 1991-2022. No index value for 2020 could be produced due to sampling issues in the FR-CGFS. Top: exploitable sub-stock (≥20 cm), bottom: juvenile sub-stock (<20 cm). Red shaded area represent the 95% confidence interval, which is determined by bootstrap resampling of Pearson residuals with 999 iterations.

Figure 6.5.5. North Sea horse mackerel. Proportion of hauls with zero catch for the exploitable (≥20cm) and juvenile (<20 cm) sub-stocks in the NS-IBTS (blue) and the FR-CGFS (red) from 1992 to 2022. Note that the FR-CGFS 2020 values are based on French stations only, as UK stations could not be sampled.

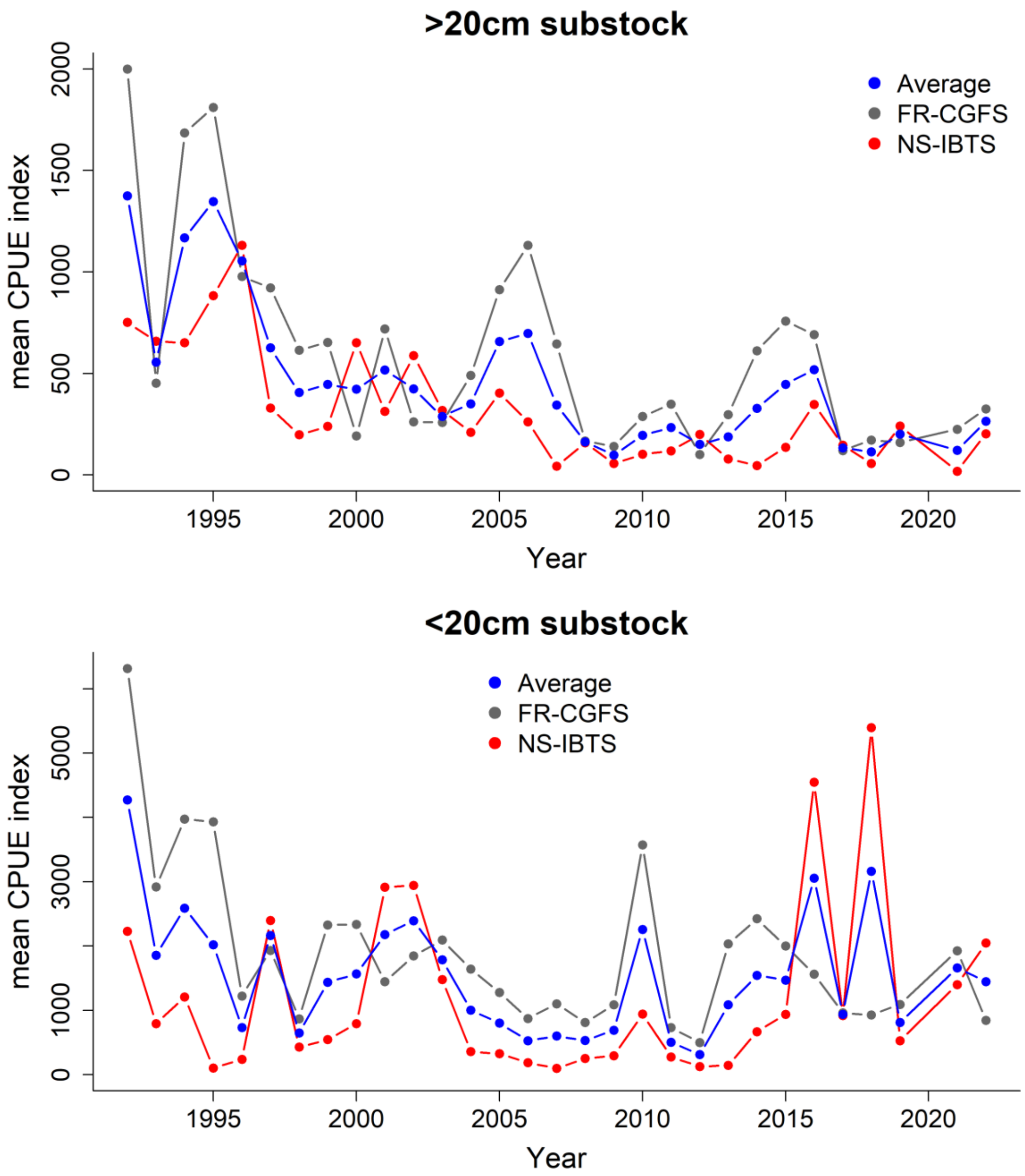


Figure 6.5.6. North Sea Horse Mackerel. Mean CPUE survey index (number/hour) obtained from the hurdle model fit to the NS-IBTS survey in the North Sea (in red), the FR-CGFS survey in the English channel (in grey) and the joint survey index (in blue). Top: exploitable sub-stock (≥20cm), bottom: juvenile sub-stock (<20 cm). No index values for 2020 could be produced due to COVID-19 pandemic impacting the FR-CGFS.

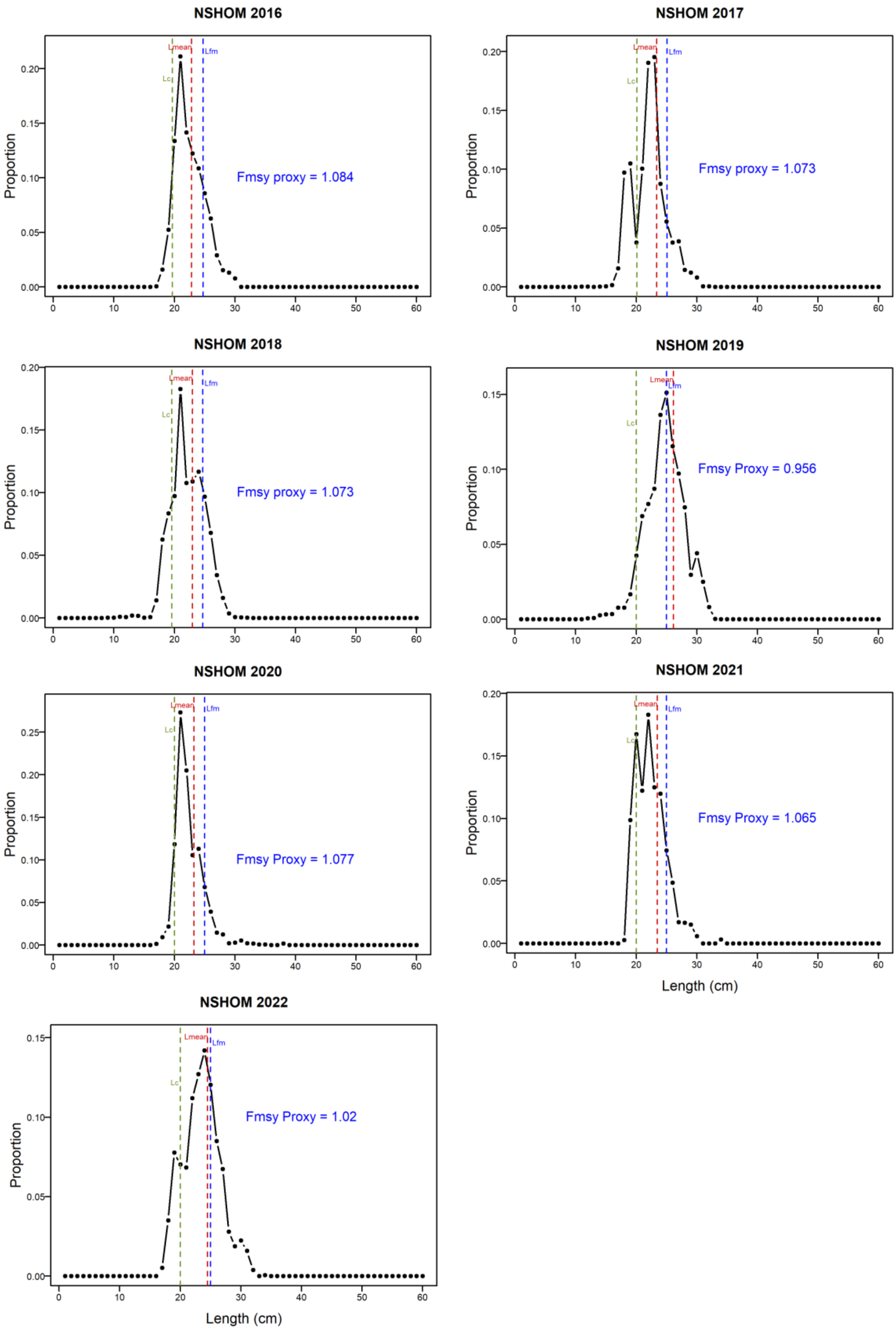


Figure 6.5.7. Length distribution (cm), estimated parameters L_c, L_{mean}, $L_{F=M}$ (cm) and F/F_{MSY} as Fmsy Proxy ratio for 2016-2022. Length samples from commercial catches in ICES division 27.7.d. Recalculations for 2018 till 2020 have been performed for the constructions of these plots. Values for plots of 2019 till 2022 are based on the latest WKLife method for cat3 stocks.

7 Western horse mackerel

Trachurus trachurus in Subarea 8 and divisions 2.a, 4.a, 5.b, 6.a, 7.a–c, e–k (hom.27.2a4a5b6a7a-ce-k8)

7.1 TAC and ICES advice applicable to 2022 and 2023

Since 2011, the TACs cover areas in line with the distribution areas of the stock.

For 2022 the TAC was the following (EU 2022/109):

Areas	TAC 2022	Stocks fished in this area
2.a, 4.a, 5.b, 6, 7.a-c, 7.e-k, 8.abde, 12, 14	49 178 t	Western stock & North Sea stock in 4.a 1-2 quarters
4.b,c, 7.d	3 461 t	North Sea stocks
Division 8.c	2 780 t	Western stock

For 2023 the TAC was the following (EU 2023/194):

Areas	TAC 2023	Stocks fished in this area
2.a, 4.a, 5.b, 6, 7.a-c, 7.e-k, 8.abde, 12, 14	13 157 t	Western stock & North Sea stock in 4.a 1-2 quarters
4.b,c, 7.d	8 969 t	North Sea stocks
Division 8.c	2 120 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 2022, ICES advised on the basis of MSY approach that Western horse mackerel catches in 2023 should be zero. The Western horse mackerel TAC for 2023 is 15 277 tonnes. The TAC should apply to the total distribution area of this stock. The horse mackerel catches in Division 3.a are taken outside the horse mackerel TACs.

7.1.1 The fishery in 2022

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 2022 was 70 114 tonnes, which is 11 443 tonnes less than in 2021 and exceeds the ICES advice by 18 156 tonnes. 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 some countries. Prior to 2013, the estimates available are considered to be an underestimate (Figure 7.1.2.1).

In 2022, most countries have submitted discard information. Countries that reported discard estimates for horse mackerel were Denmark, France, Germany, Ireland, Sweden, Spain, UK (England and Wales, and Scotland). 2022 discard estimates for the Netherlands and Norway are considered to be equal to zero. Total discards for Western horse mackerel were 3352 tonnes, equal to 4.8% in weight of the total catches, a increase in comparison to last year.

Discard data are included in the assessment as part of the total catches.

Length frequency distributions of discards were provided by Spain, France, Germany, Ireland, and UK but are not included in the assessment length-frequency input data.

7.1.3 Stock description and management units

The Western horse mackerel 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 (for more details see Section 5.3 and Figure 7.1.3.1) and spawns in the Bay of Biscay, and in UK and Irish waters before parts of the stock migrate northwards into the Norwegian Sea and the North Sea where they are fished in the third and fourth quarter (note for area 4.a, only catches taken in quarters 3 and 4 are considered to be from the western stock). The western stock is considered a management unit and advised accordingly with TAC set in accordance with the distribution of the stock (note that catches in division 3.a are taken outside the TAC).

7.2 Scientific data

7.2.1 Egg survey estimates

In 2022 a new egg survey was carried out in the western and southern spawning areas with details given in section 8.6.1 of this report. Data from the 1992-2022 surveys are used in the assessment. The time series of TAEP estimates used in the assessment is shown in table 7.2.1.1.

2022 egg survey results

The time series of egg production estimates for western horse mackerel is presented in Table 7.2.1.1 and Figure 7.2.1.1. In 2022, the total annual egg production (TAEP) of Western horse mackerel is $5.51 \cdot 10^{14}$, a 310% increase in comparison to the 2019 TAEP (ICES, 2023). The estimated TAEP in 2019 was the lowest production in the historical time series.

Figure 7.2.1.3 shows the horse mackerel production by period since 2007. In 2022, egg production was very low throughout all survey periods, with a clear peak in period 6 (June) (Figure 7.2.1.2).

In addition, egg production has been estimated using the Daily Egg Production Method (DEPM). Horse mackerel eggs at stage 1a were used to estimate the daily egg production. Peak spawning for western horse mackerel was expected to occur in period 6. The average daily egg production and total spawning area were estimated for calculating egg production (Table 7.2.1.2) (ICES, 2023).

Fecundity parameters

The sampling of horse mackerel was based on the DEPM method and took place during survey periods 6 and 7 (June and July). The sampling was carried out as described in the survey protocols (ICES, 2019), with emphasis on the need to collect sufficient samples for the fecundity analysis. During the 2022 MEGS surveys, 1648 female horse mackerel were sampled during the peak spawning periods (periods 6 and 7). A significant contribution to the number of females sampled came from the commercial fleet (ICES, 2023). Preliminary results of the adult DEPM parameters are summarized in Table 7.2.1.3.

SSB is then calculated as a ratio of total daily egg production to daily fecundity (DF, eggs day/g female) during period 6. Preliminary results are shown in Table 7.2.1.4.

7.2.2 Other surveys for Western horse mackerel

Bottom-trawl surveys

A bottom-trawl survey index for recruitment was available for 2022. The recruitment 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 2022. A Bayesian Delta-GLMM is used to calculate an index of juvenile abundance based on catch rates, and the index is updated every year when new data become available (ICES, 2017a). The updated values are shown in Figure 7.2.2.1 (middle panel) and the indices estimated in 2020-2022 are given in Table 7.2.2.1. Annual revisions of the index are minor. The 2017 data point was highly uncertain due to very limited coverage of the French survey: the French research vessel had technical issues and could therefore only cover less than 1/3 of the stations usually sampled. Despite this high uncertainty, the 2017 data point suggested a very strong recruitment to be expected the following year. This perception was confirmed by the presence of numerous small fish in the 2017 and 2018 catch data. The overall trend suggests an increase in recruitment from 2013 to 2017 and a decrease back down to 2016 levels in 2018. Recruitment in 2019 and 2020 decreased further and was close to the lowest values of the time series, followed by a small increase again in 2021 and 2022.

Acoustic surveys

In the Bay of Biscay two coordinated acoustic surveys take place in spring, PELGAS (Ifremer-France) and PELACUS (IEO-Spain). Only the PELACUS survey, which cover the ICES division 8c, is used in the assessment. There is no biomass estimate for 2020 because the survey was cancelled due to the Covid-19 pandemic. The estimate for 2023 is shown in this report (Figure 7.2.2.1, Table 7.2.2.2.), but it is not part of the assessment this year (no catches available yet for 2023).

The biomass estimated by the PELACUS survey was high in the 1990s, reaching the maximum value in 1998 (139 395 t). Biomass values are lower in the 21st century, peaking in 2010 (53 417 t) and 2015 (67 068 t). Biomass has fluctuated around 10 000 t over the most recent 4 surveys.

7.2.3 Effort and catch per unit effort

No new information was presented on effort and catch per unit effort.

7.2.4 Catch in numbers

In 2022, the Netherlands (4a, 6a, 7bfghj, 8a), Ireland (6a, 7bgj), Norway (2a,4a), Spain (8bc), UK (England & Northern Ireland) (6a, 7beffghj) and Germany (7ghj) provided catch in numbers-at-age (Figure 7.2.4.1). The catch sampled for age readings in 2022 covered 74% of the total reported catch, which is a 5% less in comparison to last year. Catch in number-at-length were available from the Netherlands (4a, 6a, 7bcefghj, 8a), Germany (4.a, 7ghj), Ireland (6a, 7bghj), Norway (2a, 4a), Spain (8abcd) and UK (England, Northern Ireland & Scotland) (4a, 6a, 7befghj) as well as from France (7e, 8ab).

The total annual and quarterly catches in number for western horse mackerel in 2022 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 Figures 7.2.4.2 and 7.2.4.3. The latter 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 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.

Spain, Ireland, the Netherlands and UK (England) also provided the age length keys (ALK) for 2022. The combined ALK is showed in Table 7.2.4.4.

7.2.5 Length and age data

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 2022 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

Prior to 2017, estimates of mean weight-at-age in the stock for the assessment were based on catch weight-at-age from Q1 and Q2, (Table 7.2.5.3). At present, the stock weight-at-age used in the forecast is an output of the assessment (presented in Table 7.4.1). 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 stakeholders

The EU fishing industry, partly in conjunction with the Pelagic Advisory Council (PELAC), has been working on a number of research projects relevant to Western horse mackerel that are briefly reported here. More details can be found in section 1.4.8 of this report and (WD02: Hintzen 2023). The Pelagic Freezer-trawler Association (PFA) provided an annual report on the self-sampling programme that started in 2015. The Western horse mackerel fishery takes place from October through to March of the subsequent year. Overall, the self-sampling activities for the Western horse mackerel fisheries during the years 2017 - 2023 (up to 02/06/2023) covered 244 fishing trips with 3096 hauls, a total catch of 116548 tonnes and 121815 individual length measurements. The main fishing areas are ICES division 27.6.a, division 27.7.b and division 27.7.j. Western horse mackerel have a wide range in the length distributions in the catch. Median lengths have fluctuated between 22.2 and 30.0 cm (for more details see WD02: Hintzen 2023).

There is also an industry-science collaboration aimed at improving the knowledge on gonad development of mackerel and horse mackerel. Samples were taken by the fishing industry (PFA vessels) on both targeted and by-catches of mackerel and/or horse mackerel. During 2023, a dedicated PFA industry researcher carried out one sampling trip on-board of a commercial trawler with the aim to collect frozen gonad samples, all frozen in a different way to assess if the way of freezing has an impact on the fecundity estimates. Samples were delivered to Wageningen Marine Research and results are still pending.

Recently genetic samples have been also collected on board of commercial vessels in the Autumn of 2020, as well as from 4.a during the NS-IBTS in Q3. Preliminary results suggest that the western horse mackerel stock could have a wider distribution than currently presumed, as the samples analysed from Q1 and Q2 in 4a were determined to be western horse mackerel. There is also mixing occurring with North Sea horse mackerel in area 7.d. See section 1.4.8.3 for further details.

7.2.10 Data exploration

The length frequency distributions of the landings for the entire fleet included in the model are shown in Figures 7.2.10.1-2. The length distributions 2015-2020 show a considerable amount of very small fish, mostly from Spanish catches. In 2021 the recent trend of large catches of small fish changed and the length distribution was a more normal distribution with the most common landed lengths around 30cm. 2022 trends are similar to 2021 but there are once again large amounts of fish caught below 20cm. The main mode of the distribution continuously increased since 2004 to 2017 due to the growth of the small individuals observed in recent years. The length distribution of discards has been provided by some countries since 2018. However, this information was not available at the last benchmark (2017) and therefore they are not included in the current assessment.

Within-cohort consistency of the catch-at-age matrix is investigated in Figure 7.2.10.3: 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 slight trend towards younger individuals when moving from the beginning of the time-series towards the end (Figure 7.2.10.4).

The indices of abundance used in the assessment cover different areas and therefore represent different parts of the stock. Negative correlations between indices that should represent the same portion of the population may lead to problems in the fitting of the model. The correlation between time-series was therefore estimated and is presented in Figure 7.2.10.5. There was no strong correlation between the IBTS recruitment index and the other two surveys. The egg survey index, which aims to represent the adult portion of the stock was strongly positively correlated with the PELACUS acoustic survey biomass estimate.

7.2.11 Assessment model, diagnostics

A one fleet, one sex, one area stock synthesis model (SS; Stock Synthesis v3.30) 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 presented is an update of the 2022 assessment, with the inclusion of the 2022 biomass estimates from the three fishery independent surveys (IBTS, PELACUS, and the egg survey), the 2022 length frequency distribution of the landings and the survey PELACUS, and the 2022 total catch and conditional ALKs. As in last year 's assessment, the length and age distributions were tuned using the Francis reweighting approach within the model.

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. The model does not fit well to the biomass estimates and length composition provided by the PELACUS survey. The fitting to the most recent length frequency distributions and the conditional ALKs remains sub-optimal. The model does not capture the small fish observed in recent years and substantially over predicts the proportion of large >20cm fish in 2022.

The assessment shows a strong retrospective pattern, with peels falling outside the confidence intervals of SSB (1 peel) and recruitment (3 peels) estimates (Figure 7.2.11.3). However, the ouptuts of the 2022 and 2023 assesements are similar, and the consistent downward rescaling of the SSB and upward scaling of F perceived in previous years has not been observed. The Mohn's rho values improved significantly compared last year, being 0.179 for SSB and -0.163 for F.

7.3 State of the stock

7.3.1 Stock assessment

The SS model with new biomass, length and age data 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 7.2.11.2. SSB peaked in 1988 following the recruitment of the exceptionally strong 1982 year-class. Subsequently, SSB slowly declined until 2003 and then recovered again following the moderate-to-strong year-class of 2001 (a third of the size of the 1982 year-class). SSB reached the minimum values of the time series in 2017 (834 480 t), increasing slightly in recent years. In 2023, SSB is estimated to be below B_{lim}.

The recruitment has been weak since 2001, reaching the lowest value in 2011. Recruitment estimates for 2014-2018 are the highest observed since 2008 and are higher than the geometric mean estimated over the years 1983-2022 (2 088 520 thousands of individuals). Recruitment has been very low again since 2019.

Fishing mortality (ages 1-10) has oscillated over the time series. It increased after 2007 as a result of increasing catches and decreasing biomass as the 2001 year-class was reduced. The fishing mortality decreased between 2013 and 2017 due to a decrease in catches and a reduced proportion of the adult population in the exploited stock. The fishing mortality in 2022 (0.075) is just above F_{MSY} (0.074) and lower than the previous year, making it the lowest value in the time series since 2008.

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 estimated fishing mortality in 2022 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.

The expected catch for the intermediate year was set at 100% of the TAC (15 277 t). Note that although the plus group in the catch was set at 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

Recent assessments (2019-2022) show a strong retrospective pattern with a consistent downward revision in absolute level of SSB and an upward revision in $F_{1\text{-}10}$, although this year assessment is in line with last year.

The fitting to the fishery independent indices remains good for two of the three surveys used: IBTS and MEGS. A degradation of the fitting to the IBTS recruitment index was observed 2015-2018 but more recent estimates now once again fall within the confidence intervals. The fit to the PELACUS acoustic index remains poor (Figure 7.2.11.1).

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, the model tends to overestimate the mean age of the last decade. The selectivity issue should be further investigated and addressed: for example, it is not clear whether the high presence of small specimens 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 was implemented in 2015 for pelagic species) or if this is due to an effective change in selectivity (i.e. catchability of the gear and availability of the stock).

The model fixes 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 may not be appropriate when it comes to the use of an egg survey as index of spawning biomass. During the benchmark in 2017 an attempt was made to estimate the parameters relative to fecundity, however, the information provided to the model was not sufficient. The inclusion of this feature, whenever appropriate data become available, would help to improve the reliability of the assessment.

The assumed value for natural mortality should be investigated. However, there is no data available (such as tagging) that could assist in estimating natural mortality more accurately. Nevertheless, total mortality appears to be low, given the persistence of the 1982-year class in the catch data for 14 years.

The assessment, as was developed at the benchmark, has an increased amount of information for providing more robust estimates of recruitment, also informed when occasional strong year classes are observed in the catch. On the contrary, the SSB is informed only by the triennial egg survey and by the acoustic survey (which only covers a small part of the stock distribution and size ranges, has a very low weight in the model and is very noisy): a new index for the spawning biomass would therefore be beneficial for the future stability of this assessment. The development of a combined SSB index estimated from appropriate surveys in the area (e.g., PELACUS, PELGAS, WESPAS) should be pursued.

7.6 Comparison with previous assessment and forecast

A comparison of the update assessment with the historic ones (previous 4 years) is shown in Figure 7.2.11.4: the new information broke the pattern of recent years asesseements and did not create a downward rescaling of the assessment biomass and upward revision of F. Recruitment, on the other hand, remains fairly stable until 2015 but a downward revision is estimated from then on.

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} and other biological reference points. During WGWIDE 2017 further investigations were carried out and summarised in a Working Document attached to WGWIDE 2017 report (ICES, 2017b).

Reference points were subsequently revised during an inter-benchmark workshop carried out in July-August 2019 as those derived during the 2017 benchmark were deemed no longer appropriate in light of the retrospective pattern observed in the model. More robust reference points were therefore put forward after a number of alternatives were examined, following ICES guidelines, and based on the 2018 assessment. The detailed rationale can be found in the inter-benchmark report (ICES, 2019).

SSB in 2003 was adopted as a proxy for B_{pa} on the basis that fishing mortality had been relatively low for the data period (F_{bar} mean ~0.11, natural mortality = 0.15), and there was no indication of impaired recruitment below the associated B_{lim}, despite a continuing decline in SSB. F_{MSY} was derived from stochastic simulations as before and evaluated at 0.074. In 2021, F_{pa} was re-defined as F_{p05} (ICES, 2021a). These updated reference points were used in determining the MSY based 2024 catch advice.

7.7.2 Management plans and evaluations

An overview of earlier management plans and management plan 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. The Pelagic Advisory Council (PELAC), together with several researchers have carried out an evaluation of potential harvest control rules for Western horse mackerel (ICES, 2021b). This rebuilding plan has not been approved by the European Commission and the UK, and the working group no longer considers it appropriate as it is outdated by 3 years.

7.8 Management considerations

The 2001 year-class has now entered the plus group but no other detectable very strong year-classes entering the fishery, even though a higher amount of age 1-2 years old fish have been observed in the catches in the past 4-5 years.

Due to the SSB remaining below B_{lim}, the advice for 2023 is catches in 2024 should be zero. It is expected that even with 0 catch there will be some discard landings in 2024 available as with previous years. Nevertheless, a scientific monitoring quota should be considered to support the stock assessment and the advice in future years. Mixed fisheries considerations might be relevant due to horse mackerel being taken as by-catch in some areas.

There are potential issues with stock boundaries for horse mackerel (see section 1.4.8.3), which are subject to ongoing investigation. Mismatches between the stock and management unit could undermine the effectiveness of any management action. Note that subarea 8.c is included in the ICES advice for Western horse mackerel but currently an independent TAC is applied to horse mackerel in this Subarea.

The stock is distributed within the NEAFC regulatory areas, but the fishery rarely takes place in there. In the last three years only 10 tonnes were estimated to belong the NEAFC regulatory area (Table 7.4.3).

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 trend in the distribution of Western horse mackerel. However, from catch data it appears that the stock is concentrated in the southern areas, and it is mostly characterized by small individuals.

7.10 Regulations and their effects

There are horse mackerel management agreements between EU and the UK, but not with Norway. The TAC set by EU and the UK therefore only applies to EU and UK waters and the EU and UK fleet in international waters. The minimum landing size of horse mackerel by the EU and UK fleet is 15 cm (10% undersized allowed in the catches). 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.

An overview of the scientific advice, the TACs (or sum of unilateral quota) and the catches is shown in Figure 7.10.1. From 2001 onwards, TACs and catches have fluctuated around the scientific advice, where in some years the TACs were set higher and in other years lower than the scientific advice.

7.11 Changes in fishing technology and fishing patterns

The description of the fishery is given in Section 5.1 and no large changes in fishing areas or patterns have taken place.

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.

It has been reported 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 later in the year (October-November) since 1987 (Iversen *et al.* 2002).

7.13 References

Abaunza, P., Gordo, L., Karlou-Riga, C., Murta, A., Eltink, A. T. G. W., García Santamaría, M. T., Zimmermann, C., Hammer, C., Lucio, P., Iversen, S. A., Molloy J., and Gallo, E. 2003. Growth and reproduction of horse mackerel, *Trachurus* (carangidae). Reviews in Fish Biology and Fisheries, 13: 27–61.

ICES 2017a. Report of the Benchmark Workshop on Widely Distributed Stocks (WKWIDE), 30 January–3 February 2017, ICES HQ, Copenhagen, Denmark. ICES CM 2017/ACOM:36. 196 pp.

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

ICES. 2019. Interbenchmark Protocol on Reference points for Western 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) (IBPWHM). ICES Scientific Reports. 84 pp.

ICES. 2021a. ICES fisheries management reference points for category 1 and 2 stocks; Technical Guidelines. In Report of the ICES Advisory Committee, 2021. ICES Advice 2021, Section 16.4.3.1. https://doi.org/10.17895/ices.advice.7891.

ICES.2021b. Workshop for the review of the assessment of a new rebuilding plan for Western Horse Mackerel (WKWHMRP).ICES Scientific Reports. 3:37. 232pp. http://doi.org/10.17895/ices.p ub.8023

ICES. 2023. Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS). ICES Scientific Reports. 5:81. 118 pp. https://doi.org/10.17895/ices.pub.23790201

Iversen, S., A., Skogen, M., D., and Svendsen, E. 2002. Availability of horse mackerel (*Trachurus trachurus*) in the northeastern North Sea, predicted by the transport of Atlantic water. Fish. Oceanogr., 11(4): 245-250.

7.14 Tables

Table 7.1.1.1. Western horse mackerel. Catches (t) in Subarea 2 by country (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	2011	2012	2013
Faroe Islands	-	-	3	-	-	-	222	224	-	-
Denmark	-	-	-	-	-	-	-	-	-	-
France	-	-	-	-	-	-	-	-	+	-
Germany	-	-	-	-	-	-	-	-	-	-
Ireland	-	-	-	-	-	-	-	-	-	-
Netherlands	-	-	-	-	-	-	-	1	-	-
Norway	42	176	27	-	572	1,847	1,364	298	66	30
Russia	-	-	-	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-	-	-	-	-
Estonia	-	-	-	-	-	-	-	-	-	-
Total	42	176	27	0	572	1,847	1,586	-	66	30

	2014	2015	2016	2017	2018	2019	2020	2021	2022	
Faroe Islands	-	-	-	-	-	-	-	-	10*	-
Denmark	-	-	-	-	-	-	-	-	-	-
France	-	-	-	-	-	-	-	-	-	-
Germany	-	-	-	-	-	-	-	-	-	-
Ireland	-	-	-	-	-	-	-	-	-	-
Netherlands	107	-	-	-	-	-	-	-	-	-
Norway	302	10	45	5	718	867	290	12	146	
Russia		-	-	-	-	-	-	-	-	-
UK (England + Wales)		-	-	-	-	-	-	-	-	-
Estonia		-	-	-	-	-	-	-	-	-
Total	409	10	45	5	718	867	290	12	156	

[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	2312	1891	7841
Germany, Fed.Rep.	+	139	30	52	+	+	-	3	153
Ireland	1,161	412	-	-	-	-	-	-	-
Netherlands	101	355	559	2,0292	824	1602	6002	8503	1,0603
Norway2	119	2,292	7	322	2	203	776	11,7283	34,4253
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	2,469[4]	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	12,482[3]	-317[3]	-750[3]	-278[5]	-3,270	1,511	-28	136	-31,615[6]
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	2,048	2,026	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	4,620	4,072	0	0	4	534	0	44	1
Ireland	-	404	32	332	11	93	378	-	-
Lithuania	-	-	-	-	-	-	-	-	-
Netherlands	4,548	3,285	10	1	0	36	0	0	0
Norway	13,129	44,344	1,141	7,912	34,843	20,349	10,687	24,733	27,087
Russia	-	-	2	-	-	-	-	-	-
Sweden	1,761	1,957	1,009	68	561	1,002	567	216	0
UK (Engl. + Wales)	1	12	-	-	-	-	0	-	-
UK (Scotland)	3,041	1,658	3,054	3,161	252	0	0	22	61
Unallocated+discards	737	-325	10	0	0	-36	0	0	0
Total	30,311	58,422	5,338	11,572	36,395	23,079	11,756	25,267	27,210

[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. [6] Negative values when there were overestimations of catch when comparing scientific with official data

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

Country	2015	2016	2017	2018	2019	2020	2021	2022
Denmark	37	7	21	289	183	22	11	211
Faroe Islands	0	0	67	0	6	-	-	96
France	12	4	1	2	98	0	2	8
Germany, Fed.Rep.	6	28	1	1	5	0.5	3	11
Ireland	8	-	-	-	-	-	-	
Netherlands	-	0	14	7	72	1	27	53
Lithuania	12	130	-	-	-	0	-	
Norway	8,887	8,765	9,880	8,601	8,154	10,376	3,651	2984
Sweden	10	0	41	23	323	83	4	3
UK (Engl. + Wales)	134	13	4	0	-	0	0.5	3
UK (Scotland)	36	14	-	-	50	-	63	102
Unallocated +discards	32	97	87	162**	339	1239	160	711
Total	9,175	9,057	10,117	9,085	9144	11,700	3,923	4182

**** 3t landings from UK (Northern Ireland incl.)**

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

Country	1989	1990	1991	1992	1993	1994	1995	1996	1997
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.

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

Country	2016	2017	2018	2019	2020	2021	2022
Denmark		3,462	4,982	6,467	2,267	1,853	1,043
Faroe Islands		113		20		-	
France	23	1,025	197	550	3	908	74
Germany	4,069	2,884	2,779	1,418	0	-	
Ireland	15,381	15,123	17,959	21,109	9,187	8,530	9462
Lithuania	2,510					-	
Netherlands	9,246	5,497	11,921	14,421	5,202	1,309	500
Norway							
Spain							
UK (Engl. + Wales)		66	32	830	817	249	8
UK (N.Ireland)	0		1,026	1,907	1,229	417	471
UK (Scotland)	956			627	331**	459	456

Country	2016	2017	2018	2019	2020	2021	2022
Unallocated+disc.		116	55	129	108	91	313
Total	32,186	28,286	38,950	47,480	19,146	13,818	12,329

**** 1.4t BMS included**

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

Country	1989	1990	1991	1992	1993	1994	1995	1996	1997
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	4,010	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

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		

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015
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	2018	2019	2020	2021	2022
Denmark	314	1057	1,031	690	3,198	3,540	2,489
France	551	595	1,067	907	1,486	990	1,802
Germany	7313	4077	1,401	7,673	952	5,525	3,931
Ireland	12193	7857	7,169	7,753	7,870	10,240	6,336
Lithuania	86						
Netherlands	14415	8445	14,009	15,159	9,036	17,473	16,835
Poland				127	1,000	1,605	
Spain	0		0	1	6	14	16
UK (Engl. + Wales)	820	478	2,410	2,862	679**	2,401***	2,204
UK (Scotland)					3	92	
UK (Northern Ireland)			52	0	2	933	340
Unallocated+discards	1692	830	548	918	311	677	473
Total	37384	23340	27,687	36,062	24,544	43,490	34,467

[2]French catches landed in the Netherlands **21t BMS landings included

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+discards	-	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+discards	1,884	-8658	5,093	4,365	1,705	2,785	2,202	7,302	4,013

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006
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
Denmark	2,687	3,289	3,109	632	200	581	14			
France	10,741	2,848			326	1,218	2,849	2,277	1,618	2,219
Germany		918	281	64	61		417	19	49	4
Ireland	694					39			0	32
Netherlands	211	6,269	1,848	98	49	7	1,057	526	635	1
Spain	14,265	19,840	21,071	38,742	34,581	13,502	22,542	19,443	13,072	14,235
UK (Engl. + Wales)		120	224	112	28		104	35	72	9
Unallocated+dis-cards		67	913	7,412	417	431	2,055	182	9,314	6,643
Total	28,598	33,352	27,447	47,060	35,662	15,777	29,039	22,483	24,760	23,143

Country	2017	2018	2019	2020	2021	2022
Denmark	1		422		638	1,582
France	2,303	2,176	2,914	728	808	728
Germany	210	554	144	2	2	321
Ireland	580	219	36	332	-	
Netherlands	313	6	3	0.5	1,976	1,085
Spain	14,901	20,362	25,775	19,163	16,177	13,380
UK (Engl. + Wales)		2	344			1
Unallocated+discards	2,907	1,921	1,755	1,104	713	1,853
Total	21,213	25,240	31,396	20,742	20,314	18,951

[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 (*e12)
1992	2094
1995	1344
1998	1242
2001	864

2004	884
2007	1486
2010	1033
2013	366
2016	331
2019	178
2022	551

Table 7.2.1.2. 1 Daily egg production estimate for the 2022 using DEPM.

Period	Po (eggs/m2/day)	Spawning area (m2) (x1011)	Ptot (eggs/day)(x1013)
6	133.857	1.390603962	0.186

Table 7.2.1.3. Preliminary mean parameter estimates for 2022 adult horse mackerel period 6 (spawning peak)

Period	Parameter	mean	var	cv
6	Female Mean weight (g)	275.4	124.9	0.673
6	Mean Sex Ratio	0.508	0	0.006
6	Mean Spawning Fraction	0.187	0	0.049
6	Mean batch fecundity (N.eggs)	59860	4173054	8.349
6	Relative mean batch fecundity (eggs/g female)	219.5	2.56	0.108
6	Daily fecundity (eggs/g female day)	20.9	NA	NA

Table 7.2.1.4. Preliminary SSB estimate for the 2022 Western horse mackerel DEPM

Period	Daily fecundity (eggs/g female day)	Ptot (eggs/day)(x1013)	SSB (kt)
6	20.865	0.186	891.445

Table 7.2.2.1. Western horse mackerel. Time series of recruitment index estimated from the IBTS Surveys (2003-2022) in 2021-2023.

Year	Index 2023		Index 2022	Index 2021
	Mean	CV		
2003	805259	0.30	728100	732297
2004	2705361	0.29	2516442	2453310
2005	2337356	0.34	2199332	2151351
2006	1616567	0.34	1501474	1499811
2007	3447979	0.31	3125619	3121579
2008	8041550	0.32	7824230	7481365
2009	1240984	0.26	1127972	1148964
2010	976048	0.34	872244	864772
2011	189761	0.35	175162	178188
2012	4674962	0.31	4435133	4339882
2013	1182836	0.25	1099932	1111210
2014	3108626	0.21	2905589	2931963
2015	4269281	0.26	4123241	4060794
2016	5579049	0.29	5421010	5280009
2017	10473049	0.47	9395798	9460399
2018	6150061	0.31	5720857	5657414
2019	1767282	0.30	1648372	1637102
2020	940822	0.27	879804	878484
2021	1091943	0.25	1015429	
2022	1339122	0.29		

Table 7.2.2.2. Western horse mackerel. Time series of biomass from the PELACUS acoustic survey (in tonnes).

Year	Biomass	CV
1992	57188	0.32

Year	Biomass	CV
1993	25028	0.32
1995	93825	0.32
1997	74364	0.32
1998	139395	0.32
1999	71744	0.32
2000	26192	0.32
2001	40864	0.32
2002	41788	0.32
2003	26647	0.32
2004	23992	0.32
2005	40082	0.32
2006	13934	0.32
2007	28173	0.32
2008	33614	0.32
2009	24020	0.32
2010	53417	0.32
2011	7687	0.32
2012	15479	0.32
2013	5532	0.32
2014	30454	0.32
2015	67068	0.32
2016	32581	0.32
2017	13845	0.32
2018	9270	0.32
2019	13075	0.32
2020	NA	NA
2021	10233	0.32
2022	18584	0.32
2023	10336	0.32

Table 7.2.4.1. Western Horse Mackerel stock. Catch in numbers (thousands) at age by quarter and area in 2022 (15 = 15+ group)

Q1																					
Age	27.2.a	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.k	27.8.a	27.8.b	27.8.c	27.8.e	27.8.c.w	27.8.d	27.8.d.2	total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	7487.76	16020.66	0.57	1140.21	84.20	1.88	0.50	24735.77
2	0	0	0.00	2.92	0.03	0.03	54.37	16.00	6.24	66.09	13	0.21	0.00	632.56	583.58	0.09	302.15	575.32	0.16	0.05	2253.12
3	0.00	0.00	0.00	7.83	0.09	0.09	66.23	154.08	16.71	121.87	35.68	29.91	0.00	810.24	51.66	0.76	98.18	1711.23	0.20	0.04	3104.81
4	2.52	439.71	0.06	238.77	1.77	1.82	226.71	2019.51	331.46	272.13	707.77	5860.61	0.00	518	13.11	0.80	53.20	726.58	0.10	0.01	11414.41
5	26.43	4611.19	0.20	2363.11	6.17	6.35	529.79	3388.76	1158.80	398.63	2474.39	24294.22	0.01	1005	15.62	0.23	92.73	617.38	0.11	0.02	40989.60
6	10.77	1878.40	0.06	807.09	1.96	2.02	168.24	1161.41	367.63	92.75	784.99	7572.33	0.00	1569	36.28	0.10	215.48	977.44	0.19	0.03	15646.36
7	16.12	2812.72	0.05	660.40	1.42	1.46	119.43	683.27	266.35	67.20	568.73	5594.57	0.00	1363	36.64	0.04	195.56	522.94	0.14	0.02	12909.86
8	92.80	16190.64	0.20	4487.59	6.20	6.38	528.90	3102.41	1164.39	293.76	2486	22384.05	0.01	1275	49.53	0.03	170.52	333.30	0.11	0.02	52571.95
9	5.14	896.48	0.02	329.91	0.65	0.67	54.53	311.95	121.60	30.68	260	2519.92	0.00	289	36.46	0.01	121.15	111.78	0.04	0.01	5089.85
10	13.63	2378.02	0.01	243.33	0.19	0.20	16.23	92.85	36.20	9.13	77	575.70	0.00	379	71.12	0.02	242.35	162.59	0.06	0.01	4297.57
11	3.48	607.47	0.01	123.94	0.17	0.18	14.62	83.66	32.61	8.23	70	630.29	0.00	141	41.04	0.01	203.89	80.78	0.04	0.00	2041.29
12	1.55	269.67	0.00	59.63	0.12	0.12	9.98	57.08	22.25	5.61	48	461.16	0.00	122	31.40	0.01	194.94	55.53	0.03	0.00	1338.86
13	5.44	948.87	0.01	107.40	0.21	0.22	17.95	102.72	40.04	10.10	85	829.80	0.00	43	9.15	0.00	74.63	14.62	0.01	0.00	2289.39
14	12.46	2173.35	0.02	290.77	0.54	0.56	45.41	259.80	101.27	25.55	216	2080.05	0.00	110	19.27	0.01	207.78	25.14	0.03	0.00	5567.77
15+	11.20	1954.82	0.00	206.05	0.07	0.07	5.83	33.35	13.00	3.28	28	64.03	0.00	131	16.50	0.01	243.94	41.47	0.03	0.00	2752.62

Q2																					
Ages	27.2.a	27.5.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.j.2	27.7.k.2	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	27.8.d	27.8.d.2	Total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2214.06	1989.25	0.27	3387.27	1449.47	0.63	3.18	9044.13
2	0	0.00	0.00	0.05	0.00	0.09	0.24	0.01	0.06	0.12	0.97	0.91	0.01	3387.29	194.28	4.25	2326.96	7936.53	0.96	2.92	13855.64
3	0.00	0	0.00	0.14	0.00	0.27	0.72	0.03	0.17	0.35	2.90	2.71	0.02	4033.99	90.45	13.36	2624.04	9757.00	1.15	0.28	16527.58
4	0.00	0	0.00	2.70	0.02	5.24	14.03	0.64	3.32	6.75	56.54	52.88	0.44	1087.61	31.73	5.94	2080.83	1244.54	0.31	0.39	4593.90
5	0.00	0	0.00	8.90	0.08	17.27	46.28	2.11	10.95	22.28	186.55	174.48	1.44	691.34	30.37	4.53	1770.98	328.71	0.20	0.53	3296.98
6	0.00	0	0.00	2.99	0.03	5.80	15.55	0.71	3.68	7.49	62.67	58.61	0.48	666.70	40.66	7.63	1798.68	205.31	0.19	1.16	2878.33
7	0.85	0	1.27	2.45	0.02	4.75	12.73	0.58	3.01	6.13	51.30	47.98	0.40	282.61	38.03	8.22	715.64	102.23	0.08	0.40	1278.81
8	1.82	0	2.75	10.27	0.09	19.93	53.39	2.43	12.63	25.71	215.22	201.29	1.66	187.80	83.73	7.21	394.58	88.83	0.05	0.39	1310.07
9	4.80	1	7.24	1.04	0.01	2.02	5.41	0.25	1.28	2.61	21.81	20.40	0.17	94.71	99.42	2.01	121.89	65.93	0.03	0.48	452.32
10	9.87	2	14.89	0.37	0.00	0.72	1.94	0.09	0.46	0.93	7.81	7.30	0.06	221.22	301.58	1.27	233.29	132.49	0.06	6.79	942.80
11	4.53	1	6.84	0.25	0.00	0.49	1.33	0.06	0.31	0.64	5.34	5.00	0.04	199.10	254.10	0.20	263.10	92.98	0.06	5.89	841.04
12	10.18	2	15.36	0.17	0.00	0.33	0.88	0.04	0.21	0.42	3.53	3.31	0.03	213.51	228.16	0.01	339.21	87.26	0.06	7.18	911.56
13	16.09	3	24.28	0.30	0.00	0.58	1.55	0.07	0.37	0.75	6.25	5.85	0.05	79.72	76.99	0.00	132.50	34.98	0.02	2.73	385.78
14	12.59	2	19	1	0	1	4	0	1	2	16	15.00	0.12	201.30	206.60	0.02	318.90	94.18	0.06	6.76	901.97
15+	48.55	8	73	0	0	0	1	0	0	0	2	2.12	0.02	224.29	184.46	0.17	436.01	72.29	0.06	4.48	1057.39

Table 7.2.4.1 cont. Western Horse Mackerel stock. Catch in numbers (thousands) at age by quarter and area in 2022 (15 = 15+ group)

Q3																					
Ages	27.2.a	27.3.a	27.3.a.20	27.4.a	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	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	27.8.d	27.8.d.2	Total
0	0	0	0	1	0	0	0	0	0	0	0	0	0	5	55.12	39.26	47	6.80	0	3	156.37
1	0	0	0	0	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	146	46.80	4.68	3785.04	683.67	0.01	7.27	4673.23
2	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	44	11.36	4.37	407.15	930.65	0.00	2.05	1399.23
3	0	0	0	1	0.00	0.06	0.06	2.27	0.07	0.14	0.97	18.83	19.01	34.11	8.88	2.00	214	832.55	0.00	1.60	1135.99
4	0	0.68	0.00	38.19	0.13	0.95	1.00	37.65	1.11	2.37	12.63	53.99	618.84	25.43	6.62	1.47	194	586.06	0.00	1.19	1582.99
5	0.49	0.86	0.00	48.06	0.16	1.16	1.23	46.18	1.36	2.91	29.76	27.75	787.38	27.64	7.40	0.83	224.29	624.72	0.00	1.31	1833.51
6	2.24	3.94	0.01	219.92	0.73	1.04	1.10	41.41	1.22	2.61	6.73	22.61	731.85	32.69	9.34	0.02	276.43	728.01	0.00	1.57	2083.49
7	11.55	20.35	0.04	1134.99	3.75	1.90	2.01	75.32	2.22	4.74	121.46	30.40	1216.51	15.71	4.67	0.01	87.90	394.71	0.00	0.74	3128.97
8	6.31	11.11	0.02	619.48	2.05	6.54	6.92	259.71	7.66	16.35	568.94	36.00	4099.76	41.54	19.00	0.05	157.93	1111.80	0.00	1.95	6973.11
9	3.90	6.86	0.01	382.76	1.26	0.55	0.59	22.00	0.65	1.39	60.52	0.89	335.48	35.60	33.33	0.10	149.23	923.74	0.00	1.70	1960.57
10	3.45	6.08	0.01	338.91	1.12	0.42	0.44	16.64	0.49	1.05	8.76	0.67	296.85	52.74	65.31	0.06	361.84	1213.18	0.00	2.53	2370.55
11	1.15	2.02	0.00	112.66	0.37	0.05	0.05	2.02	0.06	0.13	16.10	0.08	18.46	37	37.85	0.07	337.73	780.79	0.00	1.78	1348.57
12	2.14	3.77	0.01	210.30	0.69	0.01	0.01	0.52	0.02	0.03	4.01	0.02	4.92	23	22.04	0.06	236.78	450.26	0.00	1.08	959.50
13	3.65	6.43	0.01	358.94	1.19	0.00	0.00	0.12	0.00	0.01	0.01	0.00	2.15	26	22.88	0.03	255.85	519.66	0.00	1.21	1197.85
14	3.16	5.57	0.01	310.43	1.02	0.05	0.05	2.01	0.06	0.13	0.67	0.08	36.31	34	21.17	0.02	354.17	687.54	0.00	1.61	1458.29
15+	10.56	18.60	0.04	1037.65	3.43	0.05	0.05	1.82	0.05	0.11	0.40	0.07	33.03	134	24.40	0.04	517	1368.10	0.00	2.98	3151.88

Q4																					
Ages	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.j.2	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	27.8.d	27.8.d.2	Total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	377	110	111	0	13	0	4	615
1	0	0	0	0	2	0	1	98	1952	405	258	0	9	1544	125	27	54	3278	0	5	7759
2	0	0	0	0	12	1	1	134	1592	1630	354	1	12	1034	83	16	84	2217	0	1	7172
3	0.23	2.28	1.51	48.34	42.74	0.83	1.02	210.57	1764.30	2873.16	559.77	0.77	66.76	435.40	18.84	2.62	55.25	933.76	0.00	0.25	7018.40
4	6.13	60.88	40.39	1289.48	658.77	1.59	1.95	417.58	3526.79	4120.76	1039.39	1.47	809.90	270.50	7.63	0.08	25.68	368.60	0.00	0.26	12647.84
5	33.13	329.04	1013.72	6174.35	775.86	1.57	1.93	611.64	1264.10	1081.02	1581.56	1.46	5254.76	356.88	11.93	0.09	40.55	402.01	0.00	0.34	18935.95
6	5.46	54.27	238.18	947.30	237.80	0.44	0.54	298.18	69.29	100.25	685.53	0.41	1571.16	548.61	17.05	0.13	62.25	543.18	0.00	0.22	5380.24
7	7.00	69.56	1035.19	484.28	76.53	0.56	0.68	203.67	0.00	66.12	1407.00	0.52	1996.06	840.80	9.26	0.12	29.68	152.63	0.00	0.03	6379.68
8	23.09	229.34	2657.39	2352.60	281.17	1.74	2.13	479.56	0.00	266.19	3491.52	1.61	7192.55	914.63	37.52	0.14	84.47	219.96	0.00	0.35	18235.96
9	0.41	4.03	2.67	85.32	4.14	0.20	0.24	65.38	0.00	31.46	502.94	0.18	720.00	412.50	88.22	0.07	109.65	51.42	0.00	1.70	2080.53
10	2.68	26.60	437.92	143.09	9.11	0.14	0.17	32.38	0.00	29.66	110.05	0.13	738.81	243.66	206.97	0.08	190.31	49.41	0.00	4.52	2225.67
11	1.05	10.39	195.89	31.16	0.18	0.05	0.06	10.99	0.00	27.95	42.00	0.04	230.66	153.53	133.42	0.05	147.54	32.98	0.00	3.20	1021.12
12	0.05	0.50	0.33	10.61	0.03	0.01	0.01	2.15	0.00	14.93	40.22	0.01	2.38	88.34	74.05	0.03	94.47	11.33	0.00	1.97	341.44
13	0.25	2.46	1.63	52.05	0.03	0.01	0.01	1.96	33.70	2.52	8.33	0.01	8.09	82.49	68.26	0.03	92.19	9.49	0.00	1.79	365.28
14	0.14	1.39	0.92	29.35	0.10	0.03	0.03	6.02	0.00	65.00	20.33	0.02	78.00	78.44	51.67	0.03	107.33	10.59	0.00	1.53	450.92
15+	0.29	2.87	44.12	18.47	3.42	0.01	0.01	1.67	0.00	34.04	4.40	0.01	2.99	86.32	43.02	0.03	129.69	19.83	0.00	1.40	392.58

Table 7.2.4.1 cont. Western Horse Mackerel stock. Catch in numbers (thousands) at age by quarter and area in 2022 (15 = 15+ group)

all Q Ages	27.2.a	27.3.a	27.3.a.20	27.4.a	27.5.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	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	27.8.d	27.8.d.2	Total
0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	381	165	150	47	20	0	7	772
1	0	0	0	0	0	0	0	2	0	1	98	1952	405	258	0	9	0	0	11391	18181	32	8367	5495	3	16	46212
2	0	0	0	0	0	0	0	15	1	1	189	1608	1637	420	15	13	0	0	5097	872	25	3121	11660	1	6	24680
3	0.24	2.30	0.00	5.00	0.00	50.82	0.00	50.76	0.92	1.44	279.79	1918.48	2890.18	682.96	58.18	118.40	0.00	0.02	5313.73	169.82	18.74	2991.71	13234.53	1.36	2.17	27791.57
4	9.04	61.56	0.00	162.47	0.00	1819.13	0.06	901.19	3.38	10.01	695.96	5548.05	4457.91	1330.90	819.78	7342.23	0.00	0.44	1901.33	59.08	8.29	2354.00	2925.78	0.41	1.85	30412.85
5	60.05	329.91	0.00	1618.08	0.00	11381.33	0.20	3149.03	7.82	26.79	1233.89	4656.33	2253.67	2032.24	2690.15	30510.84	0.01	1.44	2081.30	65.34	5.68	2128.55	1972.82	0.32	2.19	66207.97
6	18.47	58.21	0.01	616.02	0.00	2995.51	0.06	1048.92	2.43	9.46	523.37	1232.63	474.16	792.49	870.68	9933.96	0.00	0.48	2817.21	103.33	7.88	2352.84	2453.95	0.38	2.98	26315.45
7	35.53	89.90	0.04	2435.80	0.14	3586.43	0.05	741.28	2.00	8.90	411.15	686.07	340.21	1601.78	650.94	8855.13	0.00	0.40	2501.94	88.59	8.39	1028.79	1172.51	0.22	1.18	24247.36
8	124.02	240.45	0.02	4338.07	0.31	19684.27	0.20	4785.57	8.03	35.37	1321.56	3112.50	1459.56	4379.92	2739.15	33877.65	0.01	1.66	2418.70	189.78	7.44	807.50	1753.89	0.17	2.71	81288.52
9	14.24	10.89	0.01	453.23	0.81	1062.90	0.02	335.64	0.85	3.51	147.31	312.85	155.72	596.75	282.54	3595.80	0.00	0.17	832.01	257.43	2.20	501.93	1152.88	0.07	3.88	9723.66
10	29.63	32.67	0.01	938.23	1.66	2709.92	0.01	253.23	0.33	1.53	67.19	93.43	67.36	128.87	85.89	1618.66	0.00	0.06	896.27	644.99	1.43	1027.79	1557.67	0.13	13.85	10170.79
11	10.21	12.41	0.00	354.64	0.76	695.20	0.01	124.42	0.22	0.78	28.96	83.78	61.00	66.97	75.10	884.41	0.00	0.04	531.06	466.41	0.34	952.25	987.54	0.10	10.87	5347.48
12	13.92	4.27	0.01	235.13	1.71	322.57	0.00	59.84	0.13	0.47	13.52	57.14	37.42	50.27	51.08	471.78	0.00	0.03	446.94	355.66	0.11	865.39	604.38	0.09	10.24	3602.10
13	25.43	8.89	0.01	428.22	2.70	1098.81	0.01	107.74	0.22	0.81	21.58	136.49	42.94	19.18	91.76	845.90	0.00	0.05	230.61	177.28	0.07	555.16	578.74	0.04	5.73	4378.37
14	28.35	6.95	0.01	436.24	2.11	2356.45	0.02	291.68	0.57	2.13	57.42	260.04	167.34	48.46	232.39	2209.36	0.00	0.12	423.50	298.72	0.08	988.18	817.45	0.09	9.90	8637.57
15+	70.60	21.47	0.04	1234.02	8.14	2212.98	0.00	209.62	0.08	0.34	9.88	33.43	47.28	8.35	30.10	102.17	0.00	0.02	575.38	268.37	0.25	1326.58	1501.69	0.10	8.85	7669.74

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	1276730	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	20176	24021	56066	17977	159643	97147	49515	21713	17148	1028420	20309	12161	43665	8141	7053	25553
1992	14888	229694	36332	80550	56280	255874	126816	48711	18992	23447	1099780	13409	23002	65250	11967	33246

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1993	46	131108	109807	16738	62342	105760	325674	141148	68418	55289	30689	1075610	11373	24018	68137	32140
1994	3686	60759	911713	115729	53056	44520	38769	221863	106390	40988	43083	22380	918512	10143	14599	36635
1995	2702	233030	646753	526053	269658	74592	114649	36076	228687	113304	96624	59874	63187	951901	39278	148243
1996	10729	19774	659641	864188	189273	87562	52050	55914	53835	57361	56962	91690	67114	56012	349086	165611
1997	4860	110451	471611	732959	408648	256563	141168	143166	143769	123044	133166	96058	176730	98196	51674	283110
1998	744	91505	184443	488661	359590	217571	153136	119309	77494	67072	50108	58791	30535	65839	57583	141362
1999	14822	97561	83715	176919	265820	254516	212217	187196	147271	77622	35582	22909	34440	29743	41830	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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2011	1136	17035	61864	106032	51259	35380	38626	59428	59031	61017	239472	88764	29187	17731	9783	35379
2012	5350	48100	42653	64221	171284	56012	37917	28132	25608	45490	41255	162118	50523	24043	11621	30567
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	104771	135690	26426	132175	34464	49849	23046	14115	22170	52786	12603	6491	6110	6919	7284	33718
2018	25736	107004	42957	54376	257565	43887	39837	14438	8809	19014	44833	10875	8065	4589	3645	35529
2019	7643	53043	59271	50945	52717	280292	42996	38021	16292	12752	19572	33296	10418	4690	3940	30219
2020	22256	57801	40360	50895	17318	32781	162029	19134	13415	4799	4292	5888	14437	5012	2647	11550
2021	2921	22236	20310	55002	91506	39834	50698	107895	14412	13362	9923	6880	5403	7861	3217	9047
2022	772	46212	24680	27792	30413	66208	26315	24247	81289	9724	10171	5347	3602	4378	8638	7670

Table 7.2.4.3. Western horse mackerel. Marginal age-distribution (Timing = month of year, Fleet = 1 [commercial], sex = mixed, and sample size = no. samples/100).

year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Timing	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Fleet	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Sex	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Sample size	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	4.5	7.5	6.1	4.8	6.3	7.5	6.2	5.1	2.8	3.2	3.6
0	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.013	0.007	0.000	0.001	0.001	0.004	0.001	0.000	0.008	0.000	0.036	0.009
1	0.013	0.022	0.000	0.002	0.000	0.000	0.023	0.000	0.010	0.015	0.107	0.058	0.023	0.065	0.007	0.033	0.042	0.054	0.051	0.056	0.322
2	0.073	0.006	0.400	0.006	0.000	0.000	0.005	0.000	0.022	0.035	0.017	0.049	0.345	0.179	0.233	0.140	0.085	0.046	0.101	0.123	0.078
3	0.465	0.090	0.007	0.717	0.002	0.000	0.002	0.013	0.068	0.011	0.038	0.007	0.044	0.146	0.305	0.217	0.226	0.098	0.050	0.100	0.101
4	0.040	0.147	0.060	0.005	0.690	0.003	0.004	0.012	0.030	0.099	0.026	0.028	0.020	0.075	0.067	0.121	0.166	0.147	0.092	0.068	0.078
5	0.046	0.042	0.248	0.050	0.009	0.801	0.016	0.003	0.016	0.060	0.120	0.047	0.017	0.021	0.031	0.076	0.101	0.141	0.179	0.072	0.042
6	0.040	0.122	0.037	0.119	0.066	0.002	0.780	0.009	0.005	0.031	0.059	0.144	0.015	0.032	0.018	0.042	0.071	0.118	0.156	0.085	0.044
7	0.031	0.144	0.063	0.015	0.112	0.037	0.010	0.814	0.010	0.013	0.023	0.063	0.084	0.010	0.020	0.042	0.055	0.104	0.128	0.156	0.060
8	0.006	0.049	0.056	0.019	0.026	0.082	0.033	0.008	0.676	0.011	0.009	0.030	0.040	0.063	0.019	0.043	0.036	0.082	0.084	0.131	0.084
9	0.001	0.009	0.024	0.007	0.022	0.011	0.056	0.038	0.018	0.639	0.011	0.024	0.016	0.031	0.020	0.036	0.031	0.043	0.042	0.066	0.056
10	0.006	0.015	0.007	0.011	0.016	0.009	0.008	0.053	0.034	0.013	0.514	0.014	0.016	0.027	0.020	0.039	0.023	0.020	0.011	0.023	0.029
11	0.023	0.009	0.000	0.000	0.003	0.017	0.014	0.009	0.050	0.008	0.006	0.476	0.008	0.017	0.032	0.028	0.027	0.013	0.013	0.014	0.019
12	0.064	0.047	0.001	0.001	0.001	0.008	0.014	0.015	0.007	0.027	0.011	0.005	0.348	0.018	0.024	0.052	0.014	0.019	0.014	0.010	0.016
13	0.099	0.065	0.003	0.004	0.001	0.001	0.004	0.009	0.017	0.005	0.031	0.011	0.004	0.264	0.020	0.029	0.030	0.016	0.014	0.008	0.007
14	0.067	0.105	0.008	0.001	0.000	0.000	0.004	0.006	0.009	0.004	0.006	0.030	0.006	0.011	0.123	0.015	0.027	0.023	0.008	0.011	0.008
15	0.028	0.127	0.084	0.041	0.053	0.030	0.027	0.012	0.028	0.016	0.016	0.014	0.014	0.041	0.058	0.084	0.065	0.068	0.056	0.039	0.046

year	2003*	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Timing	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Fleet	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
Sex	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sample size	7.9	6.8	7.8	7.2	6.2	7.7	8.7	7.8	6.2	6.8	7.7	8.1	6.4	8.2	6.8	6.9	6.9	5.1	7.9	7.4
0	0.001	0.017	0.001	0.002	0.006	0.035	0.052	0.004	0.001	0.006	0.096	0.028	0.134	0.181	0.157	0.036	0.011	0.048	0.006	0.002
1	0.196	0.122	0.050	0.052	0.040	0.090	0.095	0.065	0.019	0.057	0.142	0.038	0.169	0.228	0.203	0.148	0.074	0.124	0.048	0.122
2	0.309	0.089	0.114	0.057	0.048	0.028	0.035	0.117	0.068	0.050	0.035	0.122	0.040	0.132	0.040	0.060	0.083	0.087	0.044	0.065
3	0.086	0.372	0.207	0.074	0.051	0.062	0.063	0.066	0.116	0.076	0.035	0.051	0.081	0.025	0.198	0.075	0.071	0.110	0.118	0.074
4	0.090	0.062	0.361	0.089	0.077	0.066	0.044	0.028	0.056	0.203	0.078	0.042	0.049	0.042	0.052	0.357	0.074	0.037	0.197	0.081
5	0.054	0.076	0.047	0.472	0.141	0.097	0.040	0.029	0.039	0.066	0.254	0.091	0.039	0.025	0.075	0.061	0.391	0.071	0.086	0.175
6	0.036	0.053	0.050	0.056	0.433	0.063	0.069	0.049	0.042	0.045	0.069	0.225	0.072	0.020	0.034	0.055	0.060	0.349	0.109	0.070
7	0.029	0.038	0.041	0.036	0.060	0.344	0.063	0.105	0.065	0.033	0.026	0.083	0.186	0.031	0.021	0.020	0.053	0.041	0.232	0.064
8	0.032	0.025	0.030	0.041	0.036	0.058	0.301	0.071	0.065	0.030	0.019	0.032	0.043	0.109	0.033	0.012	0.023	0.029	0.031	0.215
9	0.062	0.040	0.015	0.017	0.027	0.042	0.075	0.272	0.067	0.054	0.021	0.024	0.020	0.026	0.079	0.026	0.018	0.010	0.029	0.026
10	0.035	0.042	0.018	0.012	0.011	0.029	0.046	0.067	0.263	0.049	0.032	0.035	0.017	0.014	0.019	0.062	0.027	0.009	0.021	0.027
11	0.019	0.025	0.029	0.017	0.009	0.017	0.034	0.033	0.097	0.192	0.021	0.035	0.020	0.014	0.010	0.015	0.046	0.013	0.015	0.014
12	0.016	0.010	0.016	0.031	0.011	0.015	0.023	0.023	0.032	0.060	0.108	0.036	0.018	0.020	0.009	0.011	0.015	0.031	0.012	0.010

year	2003*	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
13	0.005	0.010	0.005	0.013	0.017	0.011	0.009	0.014	0.019	0.028	0.022	0.084	0.011	0.022	0.010	0.006	0.007	0.011	0.017	0.012
14	0.005	0.003	0.005	0.007	0.010	0.015	0.007	0.014	0.011	0.014	0.017	0.037	0.076	0.025	0.011	0.005	0.006	0.006	0.007	0.023
15	0.025	0.016	0.012	0.024	0.023	0.028	0.044	0.042	0.039	0.036	0.025	0.035	0.025	0.085	0.050	0.049	0.042	0.025	0.019	0.020

***From 2003 the marginal age composition is replaced by the age-length key in the assessment.**

Table 7.2.4.4. Western horse mackerel. Conditional age-length key.

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2003	18	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	19	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	20	0	2	7	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	21	0	2	11	1	0	0	0	0	0	0	0	0	0	0	0	0
2003	22	0	3	18	9	0	0	0	0	0	0	0	0	0	0	0	0
2003	23	0	0	13	15	3	1	0	0	0	0	0	0	0	0	0	0
2003	24	0	1	24	63	32	7	2	2	0	1	1	0	0	0	0	0
2003	25	0	0	8	72	88	22	8	2	1	4	5	0	0	0	0	0
2003	26	0	0	2	41	111	57	11	14	18	12	1	0	0	0	1	0
2003	27	0	0	0	9	72	81	33	29	29	32	5	1	1	0	0	0
2003	28	0	0	0	1	34	54	43	33	25	47	11	3	1	1	1	3
2003	29	0	0	0	0	14	30	28	29	49	50	23	11	3	2	0	3

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2003	30	0	0	0	0	1	8	22	23	33	52	19	5	7	2	2	5
2003	31	0	0	0	0	1	3	4	4	15	29	29	13	2	3	2	17
2003	32	0	0	0	0	0	2	3	2	7	15	10	8	6	2	3	5
2003	33	0	0	0	0	0	0	0	1	0	7	8	5	7	2	2	8
2003	34	0	0	0	0	0	1	0	2	1	3	6	2	2	0	4	4
2003	35	0	0	0	0	0	0	0	0	1	0	3	3	1	2	2	5
2003	36	0	0	0	0	0	0	0	0	1	1	1	2	1	0	0	8
2003	37	0	0	0	0	0	0	0	0	0	0	1	1	2	1	1	10
2003	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8
2003	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
2003	40	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3
2004	21	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
2004	22	0	0	17	18	0	0	0	0	0	0	0	0	0	0	0	0
2004	23	0	0	52	126	2	1	0	0	0	0	0	0	0	0	0	0
2004	24	0	0	51	186	14	5	0	0	0	0	0	0	0	0	0	0
2004	25	0	0	29	164	44	27	6	3	2	2	2	0	0	0	0	0
2004	26	0	0	4	95	71	64	21	5	2	13	3	4	1	0	0	1
2004	27	0	0	2	28	65	108	35	9	6	10	11	4	0	0	0	1

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2004	28	0	0	1	2	36	73	50	9	9	21	5	7	0	1	0	2
2004	29	0	0	0	1	10	32	20	7	13	16	4	6	2	0	0	1
2004	30	0	0	0	0	2	4	11	5	8	8	12	3	4	0	1	2
2004	31	0	0	0	0	0	2	2	0	3	4	3	3	2	0	0	3
2004	32	0	0	0	0	0	1	1	0	3	1	1	3	1	1	1	6
2004	33	0	0	0	0	0	0	1	0	0	3	0	2	0	1	0	3
2004	34	0	0	0	0	0	0	0	0	0	3	1	1	2	1	0	7
2004	35	0	0	0	0	0	0	0	1	0	3	1	2	1	0	2	3
2004	36	0	0	0	0	0	0	0	0	1	0	3	0	2	1	1	5
2004	37	0	0	0	0	0	0	0	0	0	0	1	1	3	0	0	3
2004	38	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
2004	39	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2
2004	40	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
2004	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
2004	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2004	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
2004	44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
2004	45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2005	22	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0
2005	23	0	0	1	42	54	0	0	0	0	0	0	0	0	0	0	0
2005	24	0	0	0	75	151	2	2	0	0	0	0	0	0	0	0	0
2005	25	0	0	0	61	230	4	4	2	0	0	0	0	0	0	0	0
2005	26	0	0	0	30	248	22	17	7	4	3	2	3	0	0	0	0
2005	27	0	0	0	18	160	40	35	7	8	7	7	6	2	0	2	1
2005	28	0	0	0	3	37	45	51	18	8	12	9	6	2	1	0	0
2005	29	0	0	0	0	3	21	39	26	8	19	20	10	3	0	0	3
2005	30	0	0	0	0	1	4	22	24	11	15	19	13	7	0	1	2
2005	31	0	0	0	0	0	1	10	12	6	6	15	14	2	0	2	3
2005	32	0	0	0	0	0	2	13	11	7	8	8	8	3	2	0	4
2005	33	0	0	0	0	0	1	0	3	0	2	9	5	3	2	0	9
2005	34	0	0	0	0	0	0	1	2	3	3	3	8	6	2	3	7
2005	35	0	0	0	0	0	0	0	1	2	0	1	5	6	5	1	11
2005	36	0	0	0	0	0	0	0	0	1	0	4	2	5	4	2	16
2005	37	0	0	0	0	0	0	0	1	0	1	1	2	3	0	1	15
2005	38	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	14
2005	39	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	3

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2005	40	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	3
2005	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2005	44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2006	23	0	0	0	3	4	18	0	0	0	0	0	0	0	0	0	0
2006	24	0	0	0	4	20	201	3	2	0	0	0	0	0	0	0	0
2006	25	0	0	0	2	15	308	11	2	0	0	0	0	0	0	0	0
2006	26	0	0	0	0	7	303	24	12	3	3	0	0	0	0	0	0
2006	27	0	0	0	0	2	290	30	20	5	2	0	3	4	2	0	0
2006	28	0	0	0	0	1	129	67	34	31	5	1	6	8	7	0	0
2006	29	0	0	0	0	0	54	46	36	24	6	7	6	9	6	5	1
2006	30	0	0	0	0	0	14	22	21	27	8	6	6	8	5	3	2
2006	31	0	0	0	0	0	6	9	10	9	6	5	2	4	10	2	7
2006	32	0	0	0	0	0	2	4	9	6	4	2	2	8	3	4	7
2006	33	0	0	0	0	0	0	0	0	4	4	0	3	5	3	3	6
2006	34	0	0	0	0	0	0	1	0	0	2	2	3	4	3	3	6
2006	35	0	0	0	0	0	0	0	0	1	0	0	1	2	5	1	2
2006	36	0	0	0	0	0	0	0	0	0	0	0	0	3	3	2	5
2006	37	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	4

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2006	38	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3
2006	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2007	22	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2007	23	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0
2007	24	0	0	0	1	12	2	39	0	0	0	0	0	0	0	0	0
2007	25	0	0	0	0	27	9	234	2	0	0	0	0	0	0	0	0
2007	26	0	0	0	0	7	7	334	9	2	0	0	0	1	0	0	0
2007	27	0	0	0	0	1	3	360	7	5	3	1	1	0	0	0	0
2007	28	0	0	0	0	0	0	280	25	23	9	0	3	3	4	1	1
2007	29	0	0	0	0	0	2	213	27	27	19	10	2	1	9	4	2
2007	30	0	0	0	0	0	1	126	32	43	34	7	5	11	9	7	7
2007	31	0	0	0	0	0	0	54	22	34	28	15	13	9	16	6	14
2007	32	0	0	0	0	0	0	22	9	18	25	9	7	6	6	8	15
2007	33	0	0	0	0	0	0	8	7	8	17	2	3	1	8	6	24
2007	34	0	0	0	0	0	0	1	1	9	10	6	2	3	11	5	19
2007	35	0	0	0	0	0	0	0	0	6	2	2	5	4	5	5	18
2007	36	0	0	0	0	0	0	0	0	2	3	3	3	1	4	4	15
2007	37	0	0	0	0	0	0	0	0	0	1	4	0	0	3	6	11

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2007	38	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	15
2007	39	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	14
2007	40	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3
2007	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
2008	24	0	0	0	0	2	1	0	4	0	0	0	0	0	0	0	0
2008	25	0	0	0	0	14	19	4	52	1	0	0	0	0	0	0	0
2008	26	0	0	0	0	14	46	13	197	3	1	0	0	0	0	0	0
2008	27	0	0	0	0	7	29	15	353	1	7	1	0	1	0	0	0
2008	28	0	0	0	0	5	18	9	391	9	8	2	2	0	1	1	0
2008	29	0	0	0	0	0	6	5	358	27	18	7	3	2	1	4	3
2008	30	0	0	0	0	0	3	2	276	39	32	12	2	7	3	8	7
2008	31	0	0	0	0	0	0	4	188	39	35	27	6	5	7	4	8
2008	32	0	0	0	0	0	0	2	79	25	29	28	7	2	7	13	16
2008	33	0	0	0	0	0	0	0	42	12	24	25	9	7	6	10	18
2008	34	0	0	0	0	0	0	0	14	9	25	19	5	5	6	5	28
2008	35	0	0	0	0	0	0	0	3	4	9	12	4	3	4	6	34
2008	36	0	0	0	0	0	0	0	1	1	8	11	6	7	3	4	20
2008	37	0	0	0	0	0	0	0	2	0	0	8	4	6	0	10	18

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2008	38	0	0	0	0	0	0	0	0	0	3	4	2	0	1	7	26
2008	39	0	0	0	0	0	0	0	0	1	2	1	1	0	0	3	23
2008	40	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	13
2008	41	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	4
2008	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
2008	44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2009	24	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2009	25	0	0	0	5	4	6	1	0	3	0	0	0	0	0	0	0
2009	26	0	0	0	6	24	36	25	8	37	0	0	0	0	0	0	0
2009	27	0	0	0	0	23	64	67	26	167	5	2	3	0	0	0	0
2009	28	0	0	0	0	5	41	70	36	262	10	4	1	0	1	1	0
2009	29	0	0	0	0	1	12	45	22	314	22	8	2	2	0	0	5
2009	30	0	0	0	0	0	2	28	14	301	32	17	6	2	4	1	2
2009	31	0	0	0	0	0	1	11	5	229	38	17	17	6	1	2	9
2009	32	0	0	0	0	0	0	1	3	154	25	21	15	6	4	7	19
2009	33	0	0	0	0	0	0	0	4	87	21	19	12	9	1	8	27
2009	34	0	0	0	0	0	0	0	0	44	10	12	10	2	6	4	32
2009	35	0	0	0	0	0	0	0	0	17	4	10	15	3	4	3	26

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2009	36	0	0	0	0	0	0	0	0	6	7	13	11	4	3	0	17
2009	37	0	0	0	0	0	0	0	0	2	2	7	8	3	3	1	18
2009	38	0	0	0	0	0	0	0	0	0	0	6	3	3	3	2	16
2009	39	0	0	0	0	0	0	0	0	0	0	0	2	1	1	0	20
2009	40	0	0	0	0	0	0	0	0	0	0	0	5	0	1	0	11
2009	41	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	6
2009	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
2009	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2010	23	0	0	2	0	1	1	0	0	0	0	0	0	0	0	0	0
2010	24	0	0	3	2	0	0	0	0	0	0	0	0	0	0	0	0
2010	25	0	0	0	5	4	1	0	0	0	0	0	0	0	0	0	0
2010	26	0	0	0	2	4	7	3	3	0	1	0	0	0	0	0	0
2010	27	0	0	0	0	13	17	27	19	5	25	1	1	0	0	0	0
2010	28	0	0	0	0	4	12	17	26	12	69	3	2	1	1	0	1
2010	29	0	0	0	0	0	2	13	31	11	103	3	0	4	0	0	1
2010	30	0	0	0	0	0	1	10	13	11	145	4	5	1	1	1	1
2010	31	0	0	0	0	0	2	3	12	6	149	9	6	3	1	1	5
2010	32	0	0	0	0	0	0	1	1	2	133	6	12	5	2	1	8

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2010	33	0	0	0	0	0	0	1	1	2	86	10	9	4	4	3	15
2010	34	0	0	0	0	0	0	1	1	3	57	8	10	3	2	1	6
2010	35	0	0	0	0	0	0	0	0	1	30	9	7	6	3	2	11
2010	36	0	0	0	0	0	0	0	1	0	18	10	5	7	1	2	16
2010	37	0	0	0	0	0	0	0	0	1	14	8	7	8	3	3	15
2010	38	0	0	0	0	0	0	0	0	0	12	2	7	4	3	3	13
2010	39	0	0	0	0	0	0	0	0	0	3	3	6	1	4	0	17
2010	40	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	17
2010	41	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	9
2010	42	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
2011	21	0	0	7	2	0	0	0	0	0	0	0	0	0	0	0	0
2011	22	0	0	20	10	0	0	0	0	0	0	0	0	0	0	0	0
2011	23	0	0	17	39	0	0	0	0	0	0	0	0	0	0	0	0
2011	24	0	0	10	52	2	0	0	0	0	0	0	0	0	0	0	0
2011	25	0	0	9	51	4	1	0	0	0	0	0	0	0	0	0	0
2011	26	0	0	8	33	17	4	2	1	2	0	2	0	0	0	0	0
2011	27	0	0	4	15	21	18	8	7	5	2	10	1	1	0	0	0
2011	28	0	0	0	2	18	23	15	17	14	5	28	2	0	0	0	2

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2011	29	0	0	0	0	2	10	18	28	17	7	81	1	0	1	0	1
2011	30	0	0	0	0	0	3	6	27	19	7	120	3	2	1	0	2
2011	31	0	0	0	0	1	2	4	9	9	6	136	2	6	2	1	4
2011	32	0	0	0	0	0	1	1	2	6	4	132	6	7	4	1	10
2011	33	0	0	0	0	0	1	1	1	1	2	99	11	7	7	1	9
2011	34	0	0	0	0	0	0	0	0	2	0	73	9	11	8	1	10
2011	35	0	0	0	0	0	0	0	0	0	0	44	15	8	3	3	10
2011	36	0	0	0	0	0	0	0	0	0	1	32	6	14	10	2	11
2011	37	0	0	0	0	0	0	0	0	0	0	27	4	6	9	2	18
2011	38	0	0	0	0	0	0	0	0	0	0	8	6	8	8	1	15
2011	39	0	0	0	0	0	0	0	0	0	0	4	5	4	2	2	8
2011	40	0	0	0	0	0	0	0	0	0	0	3	3	4	5	1	9
2011	41	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	3
2011	42	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
2011	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2012	22	0	0	0	4	3	0	0	0	0	0	0	0	0	0	0	0
2012	23	0	0	1	21	22	0	0	0	0	0	0	0	0	0	0	0
2012	24	0	0	0	20	51	0	0	0	0	0	0	0	0	0	0	0

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2012	25	0	0	0	10	92	6	0	0	0	0	0	0	0	0	0	0
2012	26	0	0	0	4	107	14	1	1	0	0	0	0	0	0	0	0
2012	27	0	0	0	0	97	28	3	2	1	2	0	1	0	0	0	0
2012	28	0	0	0	2	74	27	16	2	6	5	0	15	1	0	1	0
2012	29	0	0	0	0	26	34	20	9	16	16	5	44	0	1	0	1
2012	30	0	0	0	0	6	12	17	22	17	32	4	85	6	2	1	1
2012	31	0	0	0	0	0	4	8	13	26	26	8	113	2	4	0	4
2012	32	0	0	0	0	0	1	5	9	8	12	13	119	3	5	3	2
2012	33	0	0	0	0	0	0	0	2	7	12	1	118	7	5	2	4
2012	34	0	0	0	0	0	0	0	2	4	4	3	90	2	6	4	9
2012	35	0	0	0	0	0	0	0	0	1	1	5	71	6	6	4	8
2012	36	0	0	0	0	0	0	0	0	2	2	3	55	8	6	4	11
2012	37	0	0	0	0	0	0	0	0	0	1	2	25	3	5	5	16
2012	38	0	0	0	0	0	0	0	0	0	0	1	14	2	5	5	10
2012	39	0	0	0	0	0	0	0	0	0	0	1	4	1	2	4	3
2012	40	0	0	0	0	0	0	0	0	0	0	0	2	1	2	3	3
2012	41	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	5
2012	43	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2013	20	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2013	21	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2013	22	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
2013	23	0	0	0	1	6	5	0	0	0	0	0	0	0	0	0	0
2013	24	0	0	1	2	18	20	0	0	0	0	0	0	0	0	0	0
2013	25	0	0	0	2	14	59	0	0	0	0	0	0	0	0	0	0
2013	26	0	0	0	1	27	116	1	0	0	0	0	0	0	0	0	0
2013	27	0	0	0	0	18	153	8	1	0	0	0	0	0	0	0	0
2013	28	0	0	0	0	9	141	33	5	2	1	1	0	1	0	0	0
2013	29	0	0	0	0	4	103	47	6	5	6	6	2	19	1	1	0
2013	30	0	0	0	0	2	44	38	14	6	19	16	4	56	4	2	0
2013	31	0	0	0	0	0	11	20	13	14	26	18	2	90	5	6	3
2013	32	0	0	0	0	0	3	10	13	10	15	13	7	119	4	2	3
2013	33	0	0	0	0	0	1	2	4	11	13	11	3	91	7	6	5
2013	34	0	0	0	0	0	0	2	4	0	0	9	3	68	5	7	3
2013	35	0	0	0	0	0	0	0	0	0	3	1	2	60	3	4	8
2013	36	0	0	0	0	0	0	0	0	2	2	2	0	49	6	3	9
2013	37	0	0	0	0	0	0	0	0	0	0	0	1	29	4	9	7

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2013	38	0	0	0	0	0	0	0	0	0	0	1	0	23	3	2	12
2013	39	0	0	0	0	0	0	0	0	0	0	0	1	13	3	8	8
2013	40	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	7
2013	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4
2013	42	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	5
2013	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2013	45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2014	23	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0
2014	24	0	0	5	6	2	0	0	0	0	0	0	0	0	0	0	0
2014	25	0	0	8	22	4	9	8	0	0	0	0	0	0	0	0	0
2014	26	0	0	6	17	10	16	27	2	1	0	0	0	0	0	0	0
2014	27	0	0	4	6	8	34	54	7	0	0	0	0	0	0	0	0
2014	28	0	0	0	0	8	24	83	21	0	0	0	0	0	0	0	0
2014	29	0	0	0	0	2	17	76	35	2	1	2	1	0	3	0	0
2014	30	0	0	0	0	0	8	65	30	7	6	3	5	5	9	1	0
2014	31	0	0	0	0	1	4	38	23	3	5	8	6	10	27	6	3
2014	32	0	0	0	0	0	2	9	10	9	11	13	9	13	42	3	2
2014	33	0	0	0	0	0	0	2	5	3	3	9	12	10	27	8	7

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2014	34	0	0	0	0	0	0	0	1	6	2	3	6	8	31	4	5
2014	35	0	0	0	0	0	0	0	0	0	0	4	2	5	24	2	6
2014	36	0	0	0	0	0	0	0	0	0	1	0	3	4	16	8	5
2014	37	0	0	0	0	0	0	0	0	0	0	2	0	2	13	4	5
2014	38	0	0	0	0	0	0	0	0	0	0	0	0	0	4	5	3
2014	39	0	0	0	0	0	0	0	0	0	0	0	0	0	4	2	3
2014	40	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3
2014	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2014	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
2014	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2015	20	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	21	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	22	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
2015	23	0	0	2	2	1	0	0	0	0	0	0	0	0	0	0	0
2015	24	0	0	0	8	2	2	0	0	0	0	0	0	0	0	0	0
2015	25	0	0	0	22	5	4	2	0	0	0	0	0	0	0	0	0
2015	26	0	0	0	15	22	4	2	2	0	0	0	0	0	0	0	0
2015	27	0	0	0	8	12	13	11	16	0	0	0	0	0	0	0	0

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2015	28	0	0	0	5	16	9	11	43	1	1	0	0	0	0	0	0
2015	29	0	0	0	3	4	3	18	82	3	1	1	0	0	0	1	0
2015	30	0	0	0	0	1	5	15	85	8	2	2	1	1	1	5	1
2015	31	0	0	0	0	0	0	12	75	11	3	0	0	4	4	15	5
2015	32	0	0	0	0	0	1	4	36	10	6	1	5	9	5	34	5
2015	33	0	0	0	0	0	0	2	20	7	4	5	7	9	3	51	7
2015	34	0	0	0	0	0	1	0	9	0	10	6	5	10	4	43	12
2015	35	0	0	0	0	0	0	0	2	1	4	5	7	6	6	42	11
2015	36	0	0	0	0	0	0	0	0	0	2	2	1	2	1	32	9
2015	37	0	0	0	0	0	0	0	1	0	0	0	1	3	2	18	4
2015	38	0	0	0	0	0	0	0	0	0	0	1	0	2	1	5	5
2015	39	0	0	0	0	0	0	0	0	0	0	0	1	1	0	6	3
2015	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1
2015	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1
2016	17	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	18	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	19	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	20	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2016	21	0	0	22	1	0	0	0	0	0	0	0	0	0	0	0	0
2016	22	0	0	21	3	2	0	0	0	0	0	0	0	0	0	0	0
2016	23	0	0	16	13	6	0	0	0	0	0	0	0	0	0	0	0
2016	24	0	0	9	14	9	0	0	0	0	0	0	0	0	0	0	0
2016	25	0	0	0	10	13	3	1	0	0	0	0	0	0	0	0	0
2016	26	0	0	0	3	12	4	4	0	0	0	0	0	0	0	0	0
2016	27	0	0	0	0	5	2	0	0	0	0	0	0	0	0	0	0
2016	28	0	0	0	0	4	0	2	1	1	0	0	0	0	0	0	0
2016	29	0	0	0	0	1	1	4	4	5	0	0	0	0	0	0	0
2016	30	0	0	0	0	0	0	2	12	12	0	0	0	1	0	0	0
2016	31	0	0	0	0	0	0	1	8	15	2	0	0	1	0	0	0
2016	32	0	0	0	0	0	0	1	7	15	4	1	1	2	2	7	4
2016	33	0	0	0	0	0	0	1	7	7	2	0	2	5	3	5	7
2016	34	0	0	0	0	0	0	0	0	2	0	3	2	5	5	5	7
2016	35	0	0	0	0	0	0	0	0	1	1	1	1	2	4	7	6
2016	36	0	0	0	0	0	0	0	1	0	0	0	0	3	6	5	7
2016	37	0	0	0	0	0	0	0	0	0	0	0	0	1	5	13	7
2016	38	0	0	0	0	0	0	0	0	0	0	0	0	1	3	9	3

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2016	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	7
2016	40	0	0	0	0	0	0	0	0	0	2	0	0	0	1	6	5
2016	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3
2016	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
2017	9	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	10	10	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	11	10	91	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	12	10	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	13	10	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	14	4	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	15	0	29	10	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	16	0	22	34	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	17	0	23	74	3	0	0	0	0	0	0	0	0	0	0	0	0
2017	18	0	19	79	35	0	0	0	0	0	0	0	0	0	0	0	0
2017	19	0	7	40	70	0	0	0	0	0	0	0	0	0	0	0	0
2017	20	0	1	22	98	0	0	0	0	0	0	0	0	0	0	0	0
2017	21	0	0	8	97	2	0	0	0	0	0	0	0	0	0	0	0
2017	22	0	0	4	104	11	0	0	0	0	0	0	0	0	0	0	0

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2017	23	0	0	0	112	23	1	0	0	0	0	0	0	0	0	0	0
2017	24	0	0	1	105	53	11	0	0	0	0	0	0	0	0	0	0
2017	25	0	0	0	69	112	44	13	0	0	0	0	0	0	0	0	0
2017	26	0	0	1	47	88	128	39	5	1	0	0	0	0	0	0	0
2017	27	0	0	0	27	50	145	83	12	0	0	0	0	0	0	0	0
2017	28	0	0	0	6	29	117	136	50	4	7	1	0	0	0	0	2
2017	29	0	0	0	3	20	107	53	83	21	28	1	0	0	0	0	1
2017	30	0	0	0	0	6	73	24	27	99	74	11	0	0	0	1	2
2017	31	0	0	0	0	3	33	13	7	46	137	14	1	2	2	2	5
2017	32	0	0	0	0	2	7	3	11	40	97	80	7	2	3	8	6
2017	33	0	0	0	0	0	2	4	2	30	69	22	35	9	10	7	8
2017	34	0	0	0	0	0	0	1	2	10	47	16	20	31	16	15	6
2017	35	0	0	0	0	0	0	0	1	9	16	7	12	16	16	17	5
2017	36	0	0	0	0	0	0	0	0	3	14	6	10	6	9	27	4
2017	37	0	0	0	0	0	0	0	0	2	4	3	2	10	4	10	2
2017	38	0	0	0	0	0	0	0	0	0	5	3	2	0	1	2	1
2017	39	0	0	0	0	0	0	0	0	0	3	0	0	3	1	1	1
2017	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2017	41	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
2017	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
2018	5	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	6	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	7	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	8	9	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	9	13	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	10	14	118	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	11	3	160	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	12	2	68	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	13	18	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	14	18	76	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	15	11	83	8	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	16	0	54	42	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	17	0	56	31	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	18	0	66	24	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	19	0	55	61	19	0	0	0	0	0	0	0	0	0	0	0	0
2018	20	0	42	102	41	5	0	0	0	0	0	0	0	0	0	0	0

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2018	21	0	21	184	100	49	0	0	0	0	0	0	0	0	0	0	0
2018	22	0	10	112	104	167	1	0	0	0	0	0	0	0	0	0	0
2018	23	0	0	70	119	431	11	1	0	0	0	0	0	0	0	0	0
2018	24	0	0	15	113	584	52	0	0	0	0	0	0	0	0	0	0
2018	25	0	0	0	52	531	79	27	3	3	2	0	0	0	0	0	0
2018	26	0	0	0	6	409	146	49	10	3	3	0	0	0	0	0	0
2018	27	0	0	0	3	175	203	140	39	13	6	0	1	0	0	0	1
2018	28	0	0	0	0	81	145	217	93	15	15	4	0	0	0	0	0
2018	29	0	0	0	0	24	74	177	158	54	12	19	1	1	0	0	0
2018	30	0	0	0	0	3	34	130	59	138	61	55	8	0	0	0	2
2018	31	0	0	0	0	3	15	78	25	43	139	121	30	9	4	3	13
2018	32	0	0	0	0	0	3	41	40	16	65	229	39	16	8	4	40
2018	33	0	0	0	0	0	2	13	12	14	40	192	116	33	10	8	62
2018	34	0	0	0	0	0	0	2	7	4	27	102	63	91	27	18	106
2018	35	0	0	0	0	0	0	1	1	2	16	62	21	70	47	32	115
2018	36	0	0	0	0	0	0	0	2	1	6	26	15	16	15	45	135
2018	37	0	0	0	0	0	0	0	0	0	0	4	8	8	7	11	128
2018	38	0	0	0	0	0	0	0	0	0	1	5	1	4	7	3	79

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2018	39	0	0	0	0	0	0	0	0	0	0	1	0	4	6	5	37
2018	40	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	32
2018	41	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	9
2018	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
2018	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
2018	44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
2018	45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
2018	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
2018	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
2018	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
2018	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
2018	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
2018	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
2019	6	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	7	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	8	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	9	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	10	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2019	11	12	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	12	6	68	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	13	2	63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	14	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	15	0	25	13	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	16	0	29	33	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	17	0	17	47	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	18	0	23	52	1	0	0	0	0	0	0	0	0	0	0	0	0
2019	19	0	26	52	1	0	0	0	0	0	0	0	0	0	0	0	0
2019	20	0	25	80	23	1	0	0	0	0	0	0	0	0	0	0	0
2019	21	0	19	99	63	2	2	0	0	0	0	0	0	0	0	0	0
2019	22	0	3	92	101	17	2	0	0	0	0	0	0	0	0	0	0
2019	23	0	2	67	101	45	31	1	0	0	0	0	0	0	0	0	0
2019	24	0	0	30	107	77	145	1	0	0	0	0	0	0	0	0	0
2019	25	0	0	5	67	108	358	0	0	0	0	0	0	0	0	0	0
2019	26	0	0	0	12	114	509	20	2	0	0	0	0	0	0	0	1
2019	27	0	0	0	1	83	526	80	18	0	0	1	1	0	0	0	3
2019	28	0	0	0	2	63	404	119	48	6	3	1	1	0	0	0	0

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2019	29	0	0	0	2	28	219	103	88	22	4	6	5	0	0	0	0
2019	30	0	0	0	1	7	98	78	93	78	38	8	26	3	0	0	3
2019	31	0	0	0	0	2	40	42	110	33	75	49	61	7	0	0	3
2019	32	0	0	0	0	0	14	24	75	19	22	110	96	12	5	2	14
2019	33	0	0	0	0	0	2	8	53	17	11	54	136	29	3	2	38
2019	34	0	0	0	0	0	1	3	25	15	8	17	88	68	22	7	56
2019	35	0	0	0	0	0	1	1	10	9	8	15	45	35	37	21	71
2019	36	0	0	0	0	0	0	0	0	5	1	8	24	10	12	34	60
2019	37	0	0	0	0	0	0	1	0	2	1	2	13	8	3	11	71
2019	38	0	0	0	0	0	0	0	1	0	2	2	8	2	4	2	54
2019	39	0	0	0	0	0	0	0	0	0	0	0	2	1	2	0	34
2019	40	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	18
2019	41	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	8
2019	42	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	9
2019	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
2019	44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
2020	7	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	8	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2020	9	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	10	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	11	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	12	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	13	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	14	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	15	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	16	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	17	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	18	0	38	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	19	0	56	29	3	0	0	0	0	0	0	0	0	0	0	0	0
2020	20	0	24	107	16	0	0	0	0	0	0	0	0	0	0	0	0
2020	21	0	4	203	40	0	1	0	0	0	0	0	0	0	0	0	0
2020	22	0	4	136	75	6	0	0	0	0	0	0	0	0	0	0	0
2020	23	0	0	97	111	10	1	0	0	0	0	0	0	0	0	0	0
2020	24	0	0	21	109	16	2	1	0	0	0	0	0	0	0	0	0
2020	25	0	0	12	89	66	23	14	0	0	0	0	0	0	0	0	0
2020	26	0	0	0	58	76	35	83	3	0	0	0	0	0	0	0	0

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2020	27	0	0	1	24	69	60	185	11	0	0	0	0	0	0	0	0
2020	28	0	0	0	1	40	101	333	25	3	0	1	0	0	0	0	0
2020	29	0	0	0	3	6	121	321	31	17	0	0	0	0	0	0	0
2020	30	0	0	0	0	5	58	322	68	24	2	4	0	4	0	0	0
2020	31	0	0	0	0	4	23	197	102	49	15	8	10	12	0	0	0
2020	32	1	0	0	0	0	4	74	62	113	18	10	19	41	5	0	6
2020	33	0	0	0	0	0	1	21	29	72	99	15	18	54	2	3	16
2020	34	0	0	0	0	0	0	6	21	39	35	77	24	56	8	4	28
2020	35	0	0	0	0	0	0	7	9	24	16	40	25	36	11	3	33
2020	36	0	0	0	0	0	0	6	15	9	19	8	27	24	15	4	39
2020	37	0	0	0	0	0	0	4	8	9	5	8	15	31	8	1	28
2020	38	0	0	0	0	0	0	2	0	2	6	3	6	6	13	10	16
2020	39	0	0	0	0	0	0	0	1	0	2	5	6	0	0	8	12
2020	40	0	0	0	0	0	0	0	0	0	2	2	4	4	0	0	10
2020	41	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	5
2020	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
2021	5	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	6	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2021	7	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	8	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	9	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	10	32	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	11	31	66	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	12	28	122	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	13	4	189	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	14	0	152	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	15	4	96	15	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	16	7	98	31	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	17	7	56	30	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	18	1	31	60	9	0	0	0	0	0	0	0	0	0	0	0	0
2021	19	1	24	81	33	0	0	0	0	0	0	0	0	0	0	0	0
2021	20	0	15	125	37	0	0	0	0	0	0	0	0	0	0	0	0
2021	21	0	5	115	71	2	0	0	0	0	0	0	0	0	0	0	0
2021	22	0	5	66	120	18	1	1	0	0	0	0	0	0	0	0	0
2021	23	0	0	41	111	87	1	1	0	0	0	0	0	0	0	0	0
2021	24	0	0	12	123	160	55	6	0	0	0	0	0	0	0	0	0

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2021	25	0	0	2	85	264	69	25	0	0	0	0	0	0	0	0	0
2021	26	0	0	0	20	261	138	55	11	0	0	0	0	0	0	0	0
2021	27	0	0	0	13	117	170	159	45	1	0	0	0	0	0	0	0
2021	28	0	0	1	16	93	73	191	139	0	0	0	0	0	0	0	0
2021	29	0	0	0	9	41	79	153	230	16	3	0	0	0	0	0	0
2021	30	0	0	0	1	15	58	79	402	58	19	0	0	0	0	0	0
2021	31	0	0	0	0	11	39	98	295	115	84	15	2	5	10	1	0
2021	32	0	0	0	1	6	17	74	265	81	152	31	2	14	15	0	3
2021	33	0	0	0	0	0	10	38	146	38	118	68	15	4	23	1	3
2021	34	0	0	0	0	0	3	19	61	19	44	69	38	12	23	5	17
2021	35	0	0	0	0	0	1	2	17	17	23	46	54	30	30	6	24
2021	36	0	0	0	0	0	0	1	14	17	19	16	10	59	54	15	27
2021	37	0	0	0	0	0	0	0	8	7	14	7	9	26	75	45	23
2021	38	0	0	0	0	0	0	0	0	6	5	6	4	3	22	78	13
2021	39	0	0	0	0	0	0	0	0	0	0	3	0	10	2	51	9
2021	40	0	0	0	0	0	0	0	0	0	0	0	0	1	4	12	1
2021	41	0	0	0	0	0	0	0	1	0	0	0	0	0	0	4	6
2021	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2021	46	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3	0
2022	7	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2022	8	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2022	9	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2022	10	49	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2022	11	41	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2022	12	17	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2022	13	6	61	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2022	14	2	91	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2022	15	0	106	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2022	16	0	62	6	0	0	0	0	0	0	0	0	0	0	0	0	0
2022	17	0	84	33	1	0	0	0	0	0	0	0	0	0	0	0	0
2022	18	1	83	53	5	0	0	0	0	0	0	0	0	0	0	0	0
2022	19	0	49	59	18	0	0	0	0	0	0	0	0	0	0	0	0
2022	20	0	25	37	25	1	0	0	0	0	0	0	0	0	0	0	0
2022	21	0	19	44	30	3	0	0	0	0	0	0	0	0	0	0	0
2022	22	0	17	38	29	7	0	0	0	0	0	0	0	0	0	0	0
2022	23	0	10	30	46	32	1	0	0	0	0	0	0	0	0	0	0

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2022	24	0	0	15	51	77	21	1	0	1	0	0	0	0	0	0	0
2022	25	0	0	1	30	117	53	4	1	0	0	0	0	0	0	0	0
2022	26	0	0	0	16	87	135	21	3	1	0	0	0	0	0	0	0
2022	27	0	0	0	6	60	192	35	5	8	0	0	0	0	0	0	0
2022	28	0	0	0	2	43	162	49	18	21	1	0	0	0	0	0	0
2022	29	0	0	0	1	16	123	56	57	106	5	0	0	0	0	0	0
2022	30	0	0	0	0	10	63	57	46	220	11	3	1	0	1	0	0
2022	31	0	0	0	1	5	40	50	70	248	52	16	3	0	1	2	2
2022	32	0	0	0	0	2	19	27	71	229	54	86	14	3	5	6	4
2022	33	0	0	0	0	2	11	19	42	158	42	111	53	16	11	20	5
2022	34	0	0	0	1	0	1	5	14	64	25	66	82	44	26	35	18
2022	35	0	0	0	0	0	0	2	4	18	11	40	53	62	30	29	31
2022	36	0	0	0	0	0	0	0	1	2	2	8	11	16	47	69	45
2022	37	0	0	0	0	1	0	0	0	1	1	5	3	2	16	50	48
2022	38	0	0	0	0	0	0	0	0	1	0	0	1	1	3	20	55
2022	39	0	0	0	0	0	0	0	0	0	0	1	0	0	1	4	23
2022	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
2022	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2

	Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2022	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4

Table 7.2.4.5. Western horse mackerel. Catch-at-length distribution from the commercial fleet.

year		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Timing		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Fleet		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Sex		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sample number		42	50	40	47	53	57	37	46	87	68	49	48	66	63	82	101	108	104	96	51	95	111
Length bins (cm)	5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	6	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	7	0.004	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	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	8	0.003	0.003	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	9	0.001	0.006	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.030	0.001	0.000	0.000	0.000	0.000	0.000	0.000
	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059	0.001	0.000	0.000	0.000	0.000	0.000	0.000
	11	0.009	0.007	0.000	0.002	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.037	0.001	0.000	0.000	0.000	0.000	0.000	0.000
	12	0.035	0.034	0.000	0.010	0.004	0.002	0.001	0.003	0.000	0.002	0.000	0.000	0.001	0.000	0.020	0.004	0.000	0.001	0.004	0.002	0.000	0.001
	13	0.014	0.055	0.001	0.018	0.003	0.002	0.002	0.003	0.002	0.005	0.000	0.000	0.004	0.000	0.016	0.007	0.002	0.007	0.011	0.016	0.002	0.002
	14	0.008	0.045	0.002	0.016	0.007	0.004	0.002	0.004	0.044	0.006	0.001	0.001	0.020	0.000	0.010	0.009	0.028	0.016	0.017	0.015	0.007	0.005
	15	0.016	0.039	0.007	0.022	0.017	0.007	0.001	0.033	0.054	0.010	0.003	0.002	0.048	0.001	0.012	0.014	0.017	0.026	0.016	0.003	0.009	0.014
	16	0.024	0.040	0.011	0.029	0.014	0.010	0.004	0.045	0.012	0.009	0.004	0.005	0.067	0.002	0.012	0.012	0.010	0.010	0.009	0.004	0.012	0.010

year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
17	0.042	0.049	0.011	0.020	0.006	0.014	0.008	0.021	0.008	0.009	0.010	0.009	0.052	0.002	0.008	0.018	0.010	0.003	0.008	0.011	0.010	0.008
18	0.044	0.054	0.016	0.025	0.007	0.013	0.012	0.020	0.014	0.009	0.017	0.009	0.043	0.003	0.011	0.019	0.022	0.008	0.005	0.016	0.010	0.016
19	0.044	0.037	0.021	0.035	0.012	0.012	0.012	0.008	0.024	0.010	0.017	0.022	0.026	0.006	0.024	0.028	0.027	0.013	0.011	0.019	0.015	0.033
20	0.052	0.030	0.031	0.042	0.018	0.012	0.024	0.009	0.036	0.026	0.016	0.034	0.022	0.015	0.024	0.047	0.029	0.029	0.018	0.019	0.013	0.036
21	0.061	0.033	0.027	0.091	0.054	0.023	0.036	0.014	0.019	0.057	0.030	0.046	0.022	0.025	0.021	0.055	0.043	0.051	0.030	0.046	0.027	0.025
22	0.072	0.031	0.027	0.109	0.120	0.039	0.076	0.044	0.024	0.062	0.041	0.035	0.022	0.028	0.019	0.041	0.060	0.069	0.038	0.034	0.029	0.027
23	0.098	0.034	0.032	0.117	0.120	0.086	0.123	0.065	0.032	0.044	0.048	0.039	0.026	0.024	0.026	0.023	0.072	0.121	0.038	0.030	0.039	0.024
24	0.112	0.054	0.026	0.092	0.113	0.161	0.102	0.067	0.031	0.034	0.059	0.049	0.026	0.026	0.031	0.016	0.065	0.135	0.053	0.047	0.048	0.031
25	0.087	0.077	0.029	0.088	0.084	0.139	0.109	0.081	0.037	0.033	0.051	0.072	0.045	0.030	0.032	0.022	0.058	0.109	0.097	0.021	0.059	0.042
26	0.069	0.063	0.040	0.069	0.071	0.086	0.114	0.101	0.049	0.041	0.041	0.076	0.075	0.036	0.031	0.026	0.039	0.077	0.126	0.041	0.065	0.059
27	0.059	0.044	0.071	0.063	0.058	0.068	0.099	0.110	0.084	0.067	0.050	0.066	0.087	0.060	0.038	0.033	0.042	0.048	0.132	0.103	0.075	0.066
28	0.043	0.032	0.094	0.042	0.048	0.049	0.069	0.097	0.105	0.092	0.055	0.052	0.076	0.102	0.060	0.037	0.050	0.033	0.103	0.171	0.102	0.073
29	0.027	0.026	0.106	0.031	0.038	0.034	0.048	0.072	0.098	0.119	0.083	0.064	0.058	0.118	0.075	0.060	0.056	0.032	0.067	0.117	0.113	0.093
30	0.021	0.025	0.107	0.019	0.028	0.024	0.030	0.053	0.066	0.106	0.117	0.087	0.050	0.112	0.093	0.083	0.069	0.032	0.050	0.091	0.116	0.119
31	0.014	0.021	0.111	0.014	0.024	0.017	0.020	0.041	0.043	0.078	0.101	0.094	0.054	0.109	0.095	0.092	0.074	0.039	0.042	0.052	0.087	0.104
32	0.012	0.023	0.098	0.008	0.019	0.022	0.016	0.033	0.035	0.062	0.072	0.073	0.046	0.096	0.063	0.098	0.066	0.039	0.034	0.033	0.055	0.075
33	0.009	0.025	0.047	0.009	0.021	0.028	0.013	0.023	0.033	0.041	0.052	0.055	0.035	0.077	0.063	0.088	0.057	0.032	0.032	0.029	0.030	0.047
34	0.008	0.029	0.027	0.010	0.024	0.031	0.014	0.016	0.032	0.026	0.043	0.036	0.025	0.047	0.029	0.069	0.045	0.028	0.025	0.028	0.022	0.031

year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
35	0.004	0.027	0.004	0.008	0.027	0.035	0.016	0.010	0.036	0.020	0.031	0.025	0.020	0.030	0.021	0.041	0.028	0.018	0.017	0.021	0.018	0.023
36	0.003	0.022	0.023	0.006	0.020	0.027	0.013	0.009	0.029	0.011	0.020	0.018	0.015	0.019	0.010	0.028	0.015	0.010	0.009	0.016	0.015	0.016
37	0.001	0.014	0.018	0.006	0.014	0.020	0.011	0.007	0.021	0.007	0.014	0.013	0.014	0.012	0.006	0.014	0.008	0.005	0.005	0.007	0.009	0.010
38	0.001	0.008	0.006	0.002	0.013	0.017	0.010	0.004	0.012	0.005	0.009	0.007	0.010	0.007	0.005	0.005	0.003	0.003	0.003	0.004	0.005	0.005
39	0.000	0.005	0.004	0.001	0.006	0.008	0.005	0.003	0.009	0.004	0.005	0.003	0.005	0.006	0.002	0.003	0.002	0.001	0.001	0.002	0.003	0.004
40	0.000	0.004	0.000	0.000	0.005	0.006	0.004	0.002	0.005	0.003	0.004	0.005	0.002	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.003	0.001
41	0.000	0.002	0.000	0.000	0.002	0.003	0.002	0.001	0.003	0.002	0.002	0.001	0.003	0.001	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.001
42	0.000	0.001	0.000	0.000	0.001	0.001	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.001
43	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
44	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
45	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
46	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
47	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
48	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
49	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
50	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
51	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 7.2.4.6. Western horse mackerel. Catch-at-length distribution from the PELACUS survey (fleet 5).

year		**1995**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2021**	**2022**	**2023**
Timing		5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08
Sex		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number samples		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Length bins (cm)	5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	7	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000
	8	0.000	0.000	0.000	0.012	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000
	9	0.000	0.000	0.000	0.038	0.000	0.000	0.002	0.000	0.000	0.024	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.002	0.000	0.000	0.000	0.001
	10	0.000	0.000	0.000	0.055	0.000	0.000	0.207	0.000	0.004	0.148	0.000	0.000	0.004	0.000	0.049	0.000	0.047	0.017	0.003	0.002	0.000	0.002
	11	0.002	0.000	0.002	0.006	0.014	0.000	0.257	0.000	0.006	0.113	0.000	0.000	0.009	0.003	0.058	0.009	0.112	0.101	0.077	0.058	0.004	0.041
	12	0.043	0.017	0.009	0.002	0.046	0.000	0.092	0.000	0.001	0.025	0.000	0.000	0.024	0.015	0.108	0.014	0.097	0.068	0.144	0.110	0.041	0.231
	13	0.066	0.028	0.016	0.002	0.025	0.000	0.063	0.000	0.000	0.007	0.001	0.000	0.080	0.012	0.126	0.003	0.060	0.081	0.096	0.073	0.147	0.154
	14	0.047	0.084	0.013	0.000	0.006	0.000	0.038	0.000	0.000	0.009	0.000	0.001	0.083	0.003	0.095	0.009	0.034	0.087	0.038	0.029	0.167	0.088
	15	0.029	0.140	0.005	0.000	0.019	0.000	0.018	0.000	0.000	0.017	0.004	0.003	0.020	0.001	0.035	0.053	0.014	0.124	0.051	0.039	0.189	0.038
	16	0.018	0.123	0.000	0.000	0.025	0.000	0.005	0.000	0.001	0.034	0.020	0.004	0.027	0.011	0.007	0.165	0.017	0.184	0.068	0.052	0.061	0.023
	17	0.079	0.089	0.001	0.000	0.018	0.000	0.002	0.017	0.000	0.020	0.018	0.001	0.023	0.039	0.012	0.144	0.106	0.130	0.081	0.062	0.043	0.021
	18	0.148	0.045	0.005	0.000	0.003	0.000	0.004	0.024	0.000	0.012	0.019	0.003	0.021	0.066	0.020	0.059	0.120	0.039	0.091	0.069	0.073	0.059
	19	0.163	0.073	0.005	0.000	0.001	0.000	0.002	0.019	0.001	0.001	0.017	0.012	0.020	0.081	0.022	0.059	0.076	0.029	0.072	0.055	0.060	0.073

year	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2013	2014	2015	2016	2017	2018	2019	2021	2022	2023
20	0.083	0.008	0.005	0.000	0.007	0.000	0.005	0.016	0.018	0.002	0.009	0.057	0.024	0.195	0.036	0.057	0.043	0.036	0.039	0.030	0.077	0.039
21	0.032	0.031	0.007	0.002	0.012	0.000	0.013	0.018	0.126	0.002	0.047	0.117	0.013	0.235	0.053	0.059	0.034	0.032	0.050	0.039	0.083	0.040
22	0.012	0.017	0.003	0.007	0.007	0.002	0.010	0.030	0.123	0.008	0.087	0.171	0.011	0.089	0.059	0.052	0.031	0.028	0.032	0.026	0.015	0.029
23	0.014	0.026	0.007	0.035	0.023	0.004	0.004	0.056	0.129	0.026	0.073	0.142	0.022	0.039	0.083	0.073	0.035	0.024	0.019	0.027	0.011	0.023
24	0.028	0.032	0.011	0.066	0.064	0.025	0.008	0.073	0.078	0.035	0.072	0.070	0.026	0.009	0.100	0.061	0.031	0.012	0.027	0.058	0.002	0.013
25	0.042	0.053	0.003	0.076	0.125	0.109	0.047	0.098	0.083	0.063	0.071	0.064	0.024	0.034	0.068	0.053	0.021	0.001	0.024	0.056	0.006	0.006
26	0.042	0.040	0.008	0.039	0.123	0.244	0.083	0.179	0.136	0.087	0.090	0.086	0.038	0.028	0.026	0.045	0.028	0.000	0.020	0.033	0.010	0.007
27	0.025	0.042	0.029	0.029	0.109	0.293	0.074	0.134	0.141	0.091	0.136	0.083	0.048	0.027	0.011	0.039	0.027	0.000	0.013	0.026	0.008	0.014
28	0.023	0.030	0.099	0.044	0.084	0.141	0.037	0.098	0.058	0.088	0.103	0.076	0.077	0.016	0.007	0.017	0.022	0.001	0.013	0.026	0.002	0.023
29	0.031	0.044	0.212	0.146	0.094	0.089	0.015	0.097	0.037	0.069	0.077	0.051	0.127	0.027	0.007	0.009	0.013	0.001	0.009	0.025	0.000	0.021
30	0.029	0.047	0.275	0.179	0.100	0.062	0.008	0.061	0.029	0.059	0.056	0.039	0.134	0.021	0.003	0.002	0.007	0.001	0.012	0.032	0.000	0.018
31	0.017	0.016	0.166	0.120	0.067	0.021	0.001	0.041	0.022	0.033	0.042	0.014	0.080	0.013	0.006	0.000	0.002	0.000	0.012	0.032	0.000	0.013
32	0.009	0.017	0.078	0.062	0.016	0.008	0.001	0.028	0.005	0.017	0.040	0.004	0.047	0.016	0.005	0.003	0.003	0.000	0.005	0.014	0.000	0.013
33	0.005	0.000	0.024	0.029	0.010	0.002	0.000	0.006	0.003	0.009	0.014	0.002	0.014	0.008	0.003	0.002	0.004	0.000	0.001	0.004	0.000	0.003
34	0.004	0.000	0.009	0.021	0.003	0.000	0.000	0.002	0.000	0.002	0.003	0.000	0.006	0.009	0.001	0.001	0.002	0.003	0.001	0.002	0.000	0.002
35	0.004	0.000	0.004	0.012	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.001	0.002	0.001	0.004	0.001	0.000	0.000	0.000	0.000	0.002
36	0.002	0.000	0.003	0.011	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.001	0.000	0.000	0.000	0.000	0.001
37	0.001	0.000	0.001	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.000	0.000	0.000	0.001

year	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2013	2014	2015	2016	2017	2018	2019	2021	2022	2023
38	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
39	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
40	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
41	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
42	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
43	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
44	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
45	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.000	0.000
46	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000
47	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000
48	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000
49	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000
50	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
51	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 7.2.5.1. Western horse mackerel stock. Mean weight (kg) in catch-at-age by quarter and area in 2022 (15 = 15+ group)

Q1																					
Ages	27.2.a	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.k	27.8.a	27.8.b	27.8.c	27.8.e	27.8.c.w	27.8.d	27.8.d.2	total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0.000	0.000	0.021	0.021	0.021	0.028	0.050	0.021	0.028	0.021
2	0	0	0.079	0.079	0.079	0.079	0.062	0.079	0.079	0.093	0.079	0.079	0.079	0.062	0.045	0.089	0.051	0.085	0.062	0.059	0.063
3	0.000	0.000	0.115	0.115	0.115	0.115	0.082	0.146	0.115	0.101	0.115	0.067	0.115	0.097	0.078	0.116	0.084	0.098	0.097	0.084	0.099
4	0.139	0.139	0.139	0.136	0.139	0.139	0.123	0.166	0.139	0.119	0.139	0.129	0.139	0	0.137	0.130	0.143	0.132	0.143	0.143	0.138
5	0.166	0.166	0.158	0.166	0.158	0.158	0.158	0.160	0.158	0.149	0.158	0.157	0.158	0	0.171	0.147	0.170	0.164	0.171	0.174	0.160
6	0.221	0.221	0.201	0.202	0.201	0.201	0.199	0.214	0.201	0.201	0.201	0.199	0.201	0	0.198	0.178	0.193	0.188	0.201	0.196	0.204
7	0.234	0.234	0.225	0.226	0.225	0.225	0.225	0.225	0.225	0.225	0.225	0.225	0.225	0	0.219	0.219	0.221	0.213	0.219	0.214	0.226
8	0.247	0.247	0.222	0.232	0.222	0.222	0.221	0.221	0.222	0.222	0.222	0.219	0.222	0	0.243	0.253	0.238	0.233	0.253	0.250	0.230
9	0.277	0.277	0.253	0.253	0.253	0.253	0.253	0.253	0.253	0.253	0.253	0.253	0.253	0	0.268	0.263	0.272	0.266	0.263	0.257	0.258
10	0.307	0.307	0.311	0.301	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.316	0.311	0	0.299	0.303	0.301	0.299	0.303	0.303	0.307
11	0.324	0.324	0.352	0.341	0.352	0.352	0.352	0.352	0.352	0.352	0.352	0.355	0.352	0	0.335	0.342	0.347	0.335	0.342	0.342	0.342
12	0.345	0.345	0.346	0.341	0.346	0.346	0.346	0.346	0.346	0.346	0.346	0.347	0.346	0	0.369	0.372	0.375	0.368	0.372	0.372	0.354
13	0.330	0.330	0.400	0.336	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.410	0.400	0	0.399	0.404	0.406	0.397	0.404	0.404	0.372
14	0.344	0.344	0.270	0.301	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.265	0.270	0	0.436	0.440	0.440	0.446	0.440	0.440	0.310
15+	0.358	0.358	0.348	0.354	0.348	0.348	0.348	0.348	0.348	0.348	0.348	0.324	0.348	0	0.508	0.514	0.511	0.534	0.514	0.514	0.381

Q2																					
Ages	27.2.a	27.5.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.j.2	27.7.k.2	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	27.8.d	27.8.d.2	Total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0
3	0.000	0.000	0.000	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.087	0.085	0.099	0.092	0.086	0.087	0.068	0.087
4	0.000	0.000	0.000	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.130	0.135	0.130	0.139	0.117	0.130	0.145	0.131
5	0.000	0.000	0.000	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.158	0.162	0.162	0.160	0.151	0.158	0.169	0.158
6	0.000	0.000	0.000	0.204	0.204	0.204	0.204	0.204	0.204	0.204	0.204	0.204	0.204	0.180	0.187	0.192	0.181	0.177	0.180	0.191	0.182
7	0.481	0.481	0.481	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.211	0.219	0.224	0.209	0.218	0.211	0.198	0.213
8	0.502	0.502	0.502	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.233	0.245	0.239	0.229	0.240	0.233	0.239	0.232
9	0.511	0.511	0.511	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.270	0.270	0.260	0.269	0.272	0.270	0.270	0.275
10	0.519	0.519	0.519	0.306	0.306	0.306	0.306	0.306	0.306	0.306	0.306	0.306	0.306	0.303	0.305	0.290	0.303	0.300	0.303	0.308	0.309
11	0.526	0.526	0.526	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.342	0.288	0.358	0.346	0.350	0.353	0.352
12	0.533	0.533	0.533	0.348	0.348	0.348	0.348	0.348	0.348	0.348	0.348	0.348	0.348	0.376	0.370	0.376	0.379	0.377	0.376	0.376	0.380
13	0.539	0.539	0.539	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.404	0.405	0.404	0.404	0.406	0.404	0.404	0.419
14	0.545	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.271	0.271	0.440	0.439	0.481	0.442	0.436	0.440	0.437	0.437
15+	0.567	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.348	0.348	0.506	0.497	0.502	0.510	0.509	0.506	0.488	0.513

Table 7.2.5.1 cont. Western horse mackerel stock. Mean weight (kg) in catch-at-age by quarter and area in 2022 (15 = 15+ group)

Q3																					
Ages	27.2.a	27.3.a	27.3.a.20	27.4.a	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	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	27.8.d	27.8.d.2	Total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0
3	0	0	0	0	0.318	0.171	0.171	0.171	0.171	0.171	0.179	0.174	0.167	0.138	0.138	0.132	0.132	0.139	0.138	0.138	0.139
4	0.300	0.300	0.300	0.300	0.300	0.188	0.188	0.188	0.188	0.188	0.191	0.194	0.188	0.165	0.165	0.164	0.165	0.165	0.165	0.165	0.179
5	0.294	0.294	0.294	0.294	0.294	0.216	0.216	0.216	0.216	0.216	0.219	0.243	0.214	0.180	0.181	0.165	0.180	0.180	0.180	0.180	0.200
6	0.315	0.315	0.315	0.315	0.315	0.235	0.235	0.235	0.235	0.235	0.218	0.232	0.236	0.208	0.208	0.208	0.205	0.209	0.208	0.208	0.230
7	0.324	0.324	0.324	0.324	0.324	0.244	0.244	0.244	0.244	0.244	0.266	0.228	0.242	0.233	0.235	0.240	0.227	0.234	0.233	0.233	0.272
8	0.326	0.326	0.326	0.326	0.326	0.268	0.268	0.268	0.268	0.268	0.268	0.253	0.268	0.255	0.263	0.266	0.254	0.255	0.255	0.255	0.271
9	0.336	0.336	0.336	0.336	0.336	0.271	0.271	0.271	0.271	0.271	0.282	0.271	0.269	0.287	0.298	0.278	0.294	0.286	0.287	0.288	0.293
10	0.341	0.341	0.341	0.341	0.341	0.291	0.291	0.291	0.291	0.291	0.330	0.291	0.290	0.329	0.330	0.335	0.338	0.326	0.329	0.329	0.325
11	0.347	0.347	0.347	0.347	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.359	0.378	0.364	0.350	0.354	0.354	0.353
12	0.349	0.349	0.349	0.349	0.349	0.421	0.421	0.421	0.421	0.421	0.448	0.421	0.395	0.389	0.387	0.393	0.391	0.388	0.389	0.388	0.380
13	0.355	0.355	0.355	0.355	0.355	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.421	0.410	0.408	0.424	0.420	0.421	0.420	0.400
14	0.358	0.358	0.358	0.358	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.454	0.457	0.460	0.462	0.461	0.461	0.435
15+	0.368	0.368	0.368	0.368	0.368	0.348	0.348	0.348	0.348	0.348	0.357	0.348	0.348	0.920	0.530	0.552	0.533	0.544	0.563	0.563	0.496

Q4																					
Ages	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.j.2	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	27.8.d	27.8.d.2	Total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0.186	0.186	0.186	0.186	0.156	0.132	0.132	0.141	0.126	0.121	0.133	0.132	0.196	0.187	0.167	0.173	0.164	0.164	0.173	0.157	0.140
5	0.213	0.213	0.262	0.205	0.177	0.185	0.185	0.199	0.131	0.128	0.198	0.185	0.206	0.219	0.190	0.198	0.185	0.181	0.198	0.176	0.197
6	0.238	0.238	0.275	0.229	0.197	0.226	0.226	0.231	0.217	0.232	0.241	0.226	0.223	0.231	0.210	0.217	0.208	0.204	0.217	0.192	0.227
7	0.279	0.279	0.288	0.260	0.228	0.256	0.256	0.257	0.000	0.309	0.269	0.256	0.246	0.271	0.258	0.263	0.234	0.224	0.263	0.263	0.263
8	0.271	0.271	0.292	0.247	0.223	0.251	0.251	0.253	0.000	0.314	0.259	0.251	0.246	0.275	0.277	0.269	0.258	0.249	0.269	0.293	0.258
9	0.265	0.265	0.265	0.265	0.278	0.267	0.267	0.268	0.000	0.335	0.284	0.267	0.252	0.306	0.301	0.300	0.290	0.278	0.300	0.305	0.277
10	0.300	0.300	0.302	0.293	0.266	0.280	0.280	0.280	0.000	0.321	0.283	0.280	0.278	0.331	0.336	0.333	0.332	0.327	0.333	0.337	0.302
11	0.306	0.306	0.304	0.316	0.295	0.295	0.295	0.295	0.000	0.505	0.297	0.295	0.269	0.359	0.362	0.358	0.361	0.330	0.358	0.366	0.327
12	0.322	0.322	0.322	0.322	0.319	0.319	0.319	0.319	0.000	0.379	0.292	0.319	0.401	0.386	0.383	0.386	0.389	0.371	0.386	0.387	0.372
13	0.262	0.262	0.262	0.262	0.415	0.415	0.415	0.415	0.432	0.406	0.405	0.415	0.356	0.412	0.404	0.413	0.420	0.403	0.413	0.408	0.390
14	0.337	0.337	0.337	0.337	0.317	0.317	0.317	0.317	0.000	0.371	0.325	0.317	0.269	0.452	0.448	0.453	0.456	0.456	0.453	0.455	0.393
15+	0.335	0.335	0.328	0.351	0.308	0.619	0.619	0.619	0.000	0.669	0.619	0.619	0.394	0.511	0.483	0.512	0.518	0.543	0.512	0.478	0.495

Table 7.2.5.1 cont. Western horse mackerel stock. Mean weight (kg) in catch-at-age by quarter and area in 2022 (15 = 15+ group)

all Q																										
Ages	27.2.a	27.3.a	27.3.a.20	27.4.a	27.5.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	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	27.8.d	27.8.d.2	Total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0.159	0.152	0.318	0.192	0.000	0.151	0.115	0.117	0.110	0.115	0.106	0.112	0.108	0.111	0.134	0.131	0.115	0.120	0.093	0.089	0.106	0.095	0.094	0.089	0.127	0.098
4	0.178	0.188	0.300	0.208	0.000	0.175	0.139	0.151	0.136	0.145	0.138	0.140	0.122	0.131	0.142	0.141	0.139	0.143	0.150	0.143	0.136	0.141	0.136	0.134	0.160	0.140
5	0.193	0.213	0.294	0.239	0.000	0.189	0.158	0.169	0.164	0.164	0.180	0.152	0.144	0.188	0.159	0.167	0.158	0.160	0.179	0.171	0.163	0.163	0.170	0.163	0.177	0.172
6	0.237	0.244	0.315	0.279	0.000	0.224	0.201	0.201	0.206	0.208	0.220	0.214	0.208	0.236	0.202	0.205	0.201	0.204	0.211	0.196	0.192	0.185	0.197	0.191	0.200	0.209
7	0.278	0.289	0.324	0.302	0.481	0.240	0.225	0.227	0.234	0.234	0.244	0.225	0.242	0.267	0.226	0.232	0.225	0.229	0.237	0.224	0.224	0.214	0.222	0.216	0.221	0.242
8	0.259	0.273	0.326	0.288	0.502	0.247	0.222	0.231	0.228	0.236	0.242	0.222	0.239	0.257	0.223	0.231	0.222	0.229	0.267	0.253	0.240	0.239	0.249	0.247	0.257	0.241
9	0.372	0.310	0.336	0.329	0.511	0.279	0.253	0.253	0.256	0.258	0.262	0.253	0.270	0.282	0.253	0.254	0.253	0.255	0.283	0.284	0.262	0.282	0.283	0.267	0.293	0.271
10	0.381	0.308	0.341	0.317	0.519	0.308	0.311	0.300	0.298	0.299	0.291	0.311	0.315	0.288	0.310	0.294	0.311	0.306	0.314	0.317	0.294	0.320	0.321	0.304	0.321	0.311
11	0.414	0.312	0.347	0.320	0.526	0.326	0.352	0.341	0.340	0.345	0.328	0.352	0.422	0.300	0.352	0.332	0.352	0.350	0.351	0.349	0.320	0.358	0.348	0.347	0.357	0.343
12	0.483	0.346	0.349	0.349	0.533	0.353	0.346	0.341	0.344	0.349	0.345	0.346	0.359	0.311	0.346	0.348	0.346	0.348	0.377	0.374	0.388	0.382	0.384	0.375	0.380	0.369
13	0.465	0.329	0.355	0.351	0.539	0.332	0.400	0.336	0.400	0.400	0.401	0.408	0.400	0.402	0.400	0.409	0.400	0.400	0.409	0.405	0.410	0.416	0.418	0.405	0.408	0.384
14	0.435	0.354	0.358	0.354	0.545	0.345	0.270	0.301	0.272	0.273	0.278	0.270	0.309	0.294	0.270	0.266	0.270	0.271	0.444	0.442	0.461	0.450	0.459	0.441	0.444	0.350
15+	0.503	0.364	0.368	0.366	0.567	0.365	0.348	0.354	0.373	0.355	0.394	0.348	0.579	0.491	0.348	0.334	0.348	0.348	0.605	0.498	0.512	0.520	0.542	0.511	0.511	0.451

Table 7.2.5.2. Western horse mackerel stock. Mean length (cm) in catch-at-age by quarter and area in 2022 (15 = 15+ group)

Q1																					
Ages	27.2.a	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.k	27.8.a	27.8.b	27.8.c	27.8.e	27.8.c.w	27.8.d	27.8.d.2	total
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NA
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.1	12.9	13.1	14.5	17.5	13.1	14.4	13.1
2	0.0	0.0	22.1	22.1	22.1	22.1	20.3	22.1	22.1	23.5	22.1	22.1	22.1	18.8	17.0	21.1	17.7	21.1	18.8	18.6	19.0
3	0.0	0.0	24.7	24.7	24.7	24.7	22.6	26.7	24.7	24.1	24.7	20.6	24.7	22.1	20.5	23.5	21.0	22.2	22.1	21.1	22.5
4	26.4	26.4	26.5	26.3	26.5	26.5	25.5	27.6	26.5	25.6	26.5	26.1	26.5	27.2	24.9	24.5	25.2	24.5	25.3	25.3	26.3
5	27.9	27.9	27.8	28.0	27.8	27.8	27.8	27.8	27.8	27.3	27.8	27.8	27.8	28.4	27.0	25.6	26.7	26.4	27.3	27.4	27.8
6	30.5	30.5	29.8	29.8	29.8	29.8	29.7	30.2	29.8	29.8	29.8	29.8	29.8	30.2	28.3	27.4	27.9	27.7	28.8	28.4	29.8
7	31.1	31.1	30.6	30.8	30.6	30.6	30.6	30.6	30.6	30.6	30.6	30.5	30.6	30.6	29.3	29.8	29.2	28.9	29.8	29.5	30.6
8	31.6	31.6	31.0	31.1	31.0	31.0	31.0	30.9	31.0	31.0	31.0	30.9	31.0	32.1	30.3	31.2	30.0	29.8	31.2	30.7	31.2
9	32.9	32.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.4	31.2	31.3	31.3	31.1	31.3	30.9	32.0
10	33.9	33.9	34.9	33.8	34.9	34.9	34.9	34.9	34.9	34.9	34.9	35.5	34.9	33.8	32.4	32.8	32.4	32.4	32.8	32.8	34.0
11	34.7	34.7	35.3	35.0	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.4	35.3	33.8	33.6	33.8	34.0	33.6	33.8	33.8	34.8
12	35.3	35.3	34.6	35.0	34.6	34.6	34.6	34.6	34.6	34.6	34.6	34.5	34.6	34.8	34.7	34.8	34.9	34.7	34.8	34.8	34.8
13	34.7	34.7	37.1	35.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.4	37.1	35.8	35.6	35.8	35.8	35.6	35.8	35.8	36.0
14	35.2	35.2	33.5	33.9	33.5	33.5	33.5	33.5	33.5	33.5	33.5	33.4	33.5	36.8	36.7	36.8	36.8	37.0	36.8	36.8	34.4
15+	35.6	35.6	35.5	35.6	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.0	35.5	38.8	38.6	38.8	38.7	39.2	38.8	38.8	36.1

Q2																					
Ages	27.2.a	27.5.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.j.2	27.7.k.2	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	27.8.d	27.8.d.2	Total
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NA
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.5	12.9	17.7	15.7	18.5	15.5	15.4	15.5
2	0.0	0.0	0.0	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	19.9	18.3	21.2	19.6	20.0	19.9	17.7	19.9
3	0.0	0.0	0.0	24.9	24.9	24.9	24.9	24.9	24.9	24.9	24.9	24.9	24.9	21.3	21.1	22.3	21.7	21.2	21.3	19.5	21.3
4	0.0	0.0	0.0	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	24.4	24.7	24.4	25.0	23.5	24.4	25.4	24.5
5	0.0	0.0	0.0	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	26.1	26.3	26.3	26.2	25.7	26.1	26.7	26.4
6	0.0	0.0	0.0	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	27.3	27.6	27.9	27.3	27.1	27.3	27.8	27.4
7	35.9	35.9	35.9	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	28.7	29.1	29.3	28.7	29.1	28.7	28.2	28.9
8	37.1	37.1	37.1	31.1	31.1	31.1	31.1	31.1	31.1	31.1	31.1	31.1	31.1	29.7	30.3	30.0	29.6	30.1	29.7	30.0	30.3
9	37.3	37.3	37.3	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	31.3	31.3	30.9	31.2	31.3	31.3	31.3	31.5
10	37.5	37.5	37.5	34.4	34.4	34.4	34.4	34.4	34.4	34.4	34.4	34.4	34.4	32.5	32.6	32.0	32.5	32.4	32.5	32.7	32.7
11	37.7	37.7	37.7	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2	34.1	33.8	32.0	34.4	34.0	34.1	34.2	34.1
12	37.9	37.9	37.9	34.6	34.6	34.6	34.6	34.6	34.6	34.6	34.6	34.6	34.6	34.9	34.7	34.9	35.0	35.0	34.9	34.9	35.0
13	38.1	38.1	38.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.1	35.8	35.8	35.8	35.8	35.8	35.8	35.8	36.1
14	38.2	38.2	38.2	33.5	33.5	33.5	33.5	33.5	33.5	33.5	33.5	33.5	33.5	36.8	36.8	37.9	36.9	36.7	36.8	36.8	36.7
15+	38.8	38.8	38.8	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	38.6	38.3	38.5	38.7	38.6	38.6	38.1	38.6

Table 7.2.5.2 cont. Western horse mackerel stock. Mean length (cm) in catch-at-age by quarter and area in 2022 (15 = 15+ group)

Q3 Ages	27.2.a	27.3.a	27.3.a.20	27.4.a	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	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	27.8.d	27.8.d.2	Total
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.2	10.7	11.0	14.8	12.2	12.2	10.8	12.2
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.3	16.9	21.8	16.7	21.1	17.3	17.2	17.3
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.7	22.7	23.0	20.7	23.6	22.7	22.7	22.7
3	33.0	33.0	33.0	33.0	33.0	26.8	26.8	26.8	26.8	26.8	27.0	27.5	26.0	24.9	24.9	24.6	24.5	25.0	24.9	24.9	25.0
4	32.5	32.5	32.5	32.5	32.5	28.0	28.0	28.0	28.0	28.0	28.0	28.4	28.0	26.5	26.5	26.5	26.5	26.5	26.5	26.5	27.4
5	32.2	32.2	32.2	32.2	32.2	29.1	29.1	29.1	29.1	29.1	29.0	30.4	29.0	27.3	27.3	26.5	27.3	27.3	27.3	27.3	28.3
6	33.2	33.2	33.2	33.2	33.2	30.0	30.0	30.0	30.0	30.0	29.0	30.5	30.0	28.6	28.6	28.6	28.5	28.7	28.6	28.6	29.7
7	33.5	33.5	33.5	33.5	33.5	30.2	30.2	30.2	30.2	30.2	31.9	30.5	30.0	29.7	29.8	30.0	29.5	29.8	29.7	29.7	31.3
8	33.7	33.7	33.7	33.7	33.7	32.0	32.0	32.0	32.0	32.0	32.0	31.4	32.0	30.7	31.0	31.1	30.6	30.7	30.7	30.7	31.9
9	34.0	34.0	34.0	34.0	34.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	31.9	32.3	31.6	32.1	31.9	31.9	31.9	32.4
10	34.2	34.2	34.2	34.2	34.2	33.1	33.1	33.1	33.1	33.1	34.7	33.1	33.0	33.4	33.4	33.6	33.7	33.3	33.4	33.4	33.4
11	34.3	34.3	34.3	34.3	34.3	34.0	34.0	34.0	34.0	34.0	32.0	34.0	36.0	34.2	34.4	35.0	34.5	34.1	34.2	34.2	34.2
12	34.5	34.5	34.5	34.5	34.5	37.5	37.5	37.5	37.5	37.5	38.0	37.5	37.0	35.3	35.3	35.5	35.4	35.3	35.3	35.3	35.1
13	34.7	34.7	34.7	34.7	34.7	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	36.3	35.9	35.9	36.3	36.2	36.3	36.3	35.8
14	34.8	34.8	34.8	34.8	34.8	35.0	35.0	35.0	35.0	35.0	35.8	35.0	35.0	37.4	37.2	37.3	37.4	37.4	37.4	37.4	36.8
15+	35.1	35.1	35.1	35.1	35.1	35.0	35.0	35.0	35.0	35.0	35.6	35.0	35.0	46.2	39.0	39.5	39.2	39.5	39.8	39.8	38.2

Q4 Ages	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.j.2	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	27.8.d	27.8.d.2	Total
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	10.7	11.0	12.3	17.4	12.3	11.1	11.7
1	0.0	0.0	0.0	0.0	19.0	19.0	19.0	19.0	19.1	18.5	19.0	19.0	19.0	20.5	18.7	20.5	21.0	20.8	20.7	16.7	20.1
2	0.0	0.0	0.0	0.0	22.7	22.1	22.1	22.1	22.1	22.2	22.1	22.1	22.1	22.2	20.7	21.9	22.2	22.2	22.2	20.5	22.1
3	26.5	26.5	26.5	26.5	25.0	24.6	24.6	24.7	24.6	24.6	24.8	24.6	26.5	24.8	23.4	23.8	24.8	24.8	24.8	24.6	24.7
4	28.5	28.5	28.5	28.5	27.4	26.1	26.1	26.3	25.8	25.5	26.1	26.1	29.0	28.1	26.7	27.1	26.5	26.5	27.1	26.1	26.4
5	29.5	29.5	30.7	29.4	28.6	28.5	28.5	28.4	26.1	25.8	29.1	28.5	29.5	29.6	27.8	28.4	27.5	27.3	28.4	27.1	28.9
6	30.6	30.6	31.1	30.4	29.7	30.4	30.4	29.5	29.1	29.4	31.0	30.4	30.6	30.3	28.8	29.3	28.6	28.5	29.3	27.9	30.2
7	31.5	31.5	31.6	31.4	31.2	31.8	31.8	31.0	0.0	33.2	32.3	31.8	31.4	32.3	31.3	31.8	29.8	29.4	31.8	31.8	31.7
8	31.4	31.4	31.8	31.0	31.0	31.8	31.8	31.6	0.0	33.1	32.0	31.8	31.7	32.5	31.7	32.0	30.8	30.5	32.0	32.2	31.7
9	32.0	32.0	32.0	32.0	33.3	32.1	32.1	31.5	0.0	34.3	32.8	32.1	31.5	33.2	32.4	32.8	32.0	31.6	32.8	32.6	32.3
10	32.3	32.3	32.2	32.5	32.9	32.5	32.5	32.5	0.0	33.7	32.6	32.5	32.5	33.8	33.6	33.6	33.5	33.3	33.6	33.7	32.8
11	32.2	32.2	32.1	32.7	34.6	34.6	34.6	34.6	0.0	37.5	34.1	34.6	34.4	34.4	34.5	34.4	34.4	33.4	34.4	34.6	33.9
12	34.0	34.0	34.0	34.0	35.0	35.0	35.0	35.0	0.0	35.8	34.6	35.0	36.8	35.2	35.2	35.2	35.3	34.8	35.2	35.3	35.1
13	31.8	31.8	31.8	31.8	37.0	37.0	37.0	37.0	37.5	37.0	36.6	37.0	35.0	36.0	35.8	36.0	36.3	35.7	36.0	35.9	35.5
14	34.6	34.6	34.6	34.6	33.9	33.9	33.9	33.9	0.0	35.6	34.1	33.9	32.3	37.2	37.0	37.2	37.3	37.3	37.2	37.2	35.8
15+	33.7	33.7	33.2	34.7	34.5	39.9	39.9	39.9	0.0	40.6	39.9	39.9	38.1	38.7	38.0	38.7	38.9	39.5	38.7	37.9	38.0

Table 7.2.5.2 cont. Western horse mackerel stock. Mean length (cm) in catch-at-age by quarter and area in 2022 (15 = 15+ group)

all Q																										
Ages	27.2.a	27.3.a	27.3.a.20	27.4.a	27.5.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	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	27.8.d	27.8.d.2	Total
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	10.7	11.0	14.8	15.6	12.3	11.0	11.8
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.0	19.0	19.0	19.0	19.1	18.5	19.0	19.0	19.0	0.0	0.0	14.6	13.0	20.6	16.0	20.2	13.7	16.6	15.1
2	0.0	0.0	0.0	0.0	0.0	0.0	22.1	22.6	22.1	22.1	21.6	22.1	22.2	22.4	22.1	22.1	22.1	22.1	20.2	17.7	22.0	19.6	20.8	19.8	19.8	20.6
3	26.8	26.6	33.0	28.1	0.0	26.5	24.7	24.9	24.6	24.8	24.2	24.7	24.6	24.7	25.6	24.9	24.7	24.9	21.7	21.4	22.8	21.9	21.8	21.4	24.1	22.4
4	28.0	28.5	32.5	29.2	0.0	27.9	26.5	27.1	26.3	26.6	26.1	26.4	25.6	26.0	26.6	26.6	26.5	26.6	25.7	25.2	24.8	25.1	24.7	24.6	26.2	26.1
5	28.9	29.6	32.2	30.1	0.0	28.8	27.8	28.1	28.0	27.9	28.2	27.4	26.9	28.7	27.8	28.1	27.8	27.8	27.8	26.9	26.4	26.4	26.8	26.6	27.1	28.1
6	30.9	30.8	33.2	31.8	0.0	30.5	29.8	29.7	30.0	29.9	29.6	30.1	29.8	30.8	29.9	29.9	29.8	29.9	29.5	28.1	27.9	27.5	28.1	28.0	28.3	29.6
7	32.1	32.0	33.5	32.5	35.9	31.2	30.6	30.8	30.9	30.5	30.7	30.6	31.1	32.2	30.6	30.7	30.6	30.5	31.0	29.5	29.4	28.9	29.3	29.5	29.2	30.9
8	31.7	31.5	33.7	32.0	37.1	31.5	31.0	31.1	31.2	31.3	31.4	30.9	31.4	32.0	31.0	31.2	31.0	31.1	32.1	30.6	30.0	30.0	30.4	30.7	30.8	31.3
9	34.7	33.2	34.0	33.9	37.3	32.9	31.9	32.0	32.0	32.0	31.8	31.9	32.4	32.7	31.9	31.9	31.9	32.0	32.3	31.8	31.0	31.7	31.7	31.3	32.1	32.2
10	35.0	32.6	34.2	33.2	37.5	33.8	34.9	33.8	33.9	33.9	33.3	34.9	34.3	33.0	34.8	33.6	34.9	34.4	33.5	33.0	32.2	33.1	33.1	32.7	33.1	33.5
11	35.7	32.5	34.3	33.1	37.7	34.6	35.3	35.0	35.2	35.1	35.0	35.3	36.3	33.8	35.3	35.1	35.3	35.2	34.1	34.0	33.0	34.4	34.0	34.0	34.3	34.4
12	37.1	34.5	34.5	34.6	37.9	35.4	34.6	35.0	34.6	34.7	34.8	34.6	35.1	34.9	34.6	34.5	34.6	34.6	35.0	34.9	35.3	35.1	35.2	34.9	35.0	35.0
13	36.8	33.9	34.7	34.7	38.1	34.7	37.1	35.1	37.1	37.1	37.1	37.2	37.1	36.9	37.1	37.4	37.1	37.1	35.9	35.8	35.9	36.1	36.2	35.8	35.9	35.9
14	36.5	34.8	34.8	34.9	38.2	35.3	33.5	33.9	33.5	33.5	33.6	33.5	34.3	33.8	33.5	33.4	33.5	33.5	36.9	36.9	37.4	37.1	37.3	36.9	36.9	35.1
15+	37.7	34.9	35.1	35.1	38.8	35.7	35.5	35.6	35.9	35.5	36.2	35.5	39.2	37.8	35.5	35.1	35.5	35.5	40.4	38.4	38.7	38.9	39.4	38.7	38.6	37.4

Table 7.2.5.3. Western horse mackerel. Catch weights-at-age (kg), from Q1 and Q3 data

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1982	0.024	0.052	0.066	0.080	0.207	0.232	0.269	0.280	0.292	0.305	0.369	0.348	0.348	0.348	0.356	0.366
1983	0.024	0.052	0.066	0.080	0.171	0.227	0.257	0.276	0.270	0.243	0.390	0.348	0.348	0.348	0.356	0.366
1984	0.024	0.052	0.064	0.077	0.122	0.155	0.201	0.223	0.253	0.246	0.338	0.348	0.348	0.348	0.356	0.366
1985	0.024	0.052	0.066	0.081	0.148	0.140	0.193	0.236	0.242	0.289	0.247	0.241	0.251	0.314	0.346	0.321
1986	0.024	0.052	0.066	0.080	0.105	0.134	0.169	0.195	0.242	0.292	0.262	0.319	0.287	0.345	0.260	0.360
1987	0.024	0.052	0.066	0.080	0.105	0.126	0.150	0.171	0.218	0.254	0.281	0.336	0.244	0.328	0.245	0.373
1988	0.024	0.052	0.066	0.080	0.105	0.126	0.141	0.143	0.217	0.274	0.305	0.434	0.404	0.331	0.392	0.424
1989	0.024	0.052	0.066	0.080	0.105	0.103	0.131	0.159	0.127	0.210	0.252	0.381	0.400	0.421	0.448	0.516
1990	0.024	0.052	0.066	0.080	0.105	0.127	0.135	0.124	0.154	0.174	0.282	0.328	0.355	0.399	0.388	0.379
1991	0.024	0.052	0.066	0.080	0.121	0.137	0.143	0.144	0.150	0.182	0.189	0.303	0.323	0.354	0.365	0.330
1992	0.024	0.052	0.066	0.080	0.105	0.133	0.151	0.150	0.158	0.160	0.182	0.288	0.306	0.359	0.393	0.401

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1993	0.024	0.052	0.066	0.080	0.105	0.153	0.166(	0.173	0.172	0.170	0.206	0.238	0.308	0.327	0.376	0.421
1994	0.024	0.052	0.066	0.080	0.105	0.147	0.185	0.169	0.191	0.191	0.190	0.275	0.240	0.326	0.342	0.383
1995	0.024	0.052	0.059	0.066	0.119	0.096	0.152	0.166	0.178	0.187	0.197	0.222	0.215	0.246	0.237	0.298
1996	0.024	0.052	0.073	0.095	0.118	0.129	0.148	0.172	0.183	0.185	0.202	0.224	0.233	0.229	0.280	0.332
1997	0.024	0.052	0.066	0.080	0.112	0.124	0.162	0.169	0.184	0.188	0.208	0.241	0.229	0.268	0.286	0.266
1998	0.024	0.052	0.071	0.090	0.108	0.129	0.142	0.151	0.162	0.174	0.191	0.220	0.229	0.268	0.286	0.271
1999	0.024	0.052	0.081	0.110	0.120	0.130	0.160	0.170	0.180	0.190	0.210	0.241	0.233	0.268	0.286	0.274
2000	0.024	0.052	0.102	0.115	0.128	0.158	0.169	0.181	0.208	0.224	0.225	0.227	0.247	0.247	0.272	0.378
2001	0.020	0.048	0.077	0.109	0.133	0.160	0.169	0.176	0.187	0.205	0.220	0.241	0.265	0.244	0.266	0.308
2002	0.020	0.039	0.067	0.133	0.152	0.164	0.175	0.194	0.202	0.222	0.242	0.275	0.299	0.307	0.306	0.329
2003	0.022	0.060	0.089	0.114	0.142	0.160	0.175	0.178	0.194	0.205	0.226	0.249	0.267	0.286	0.278	0.317
2004	0.036	0.064	0.100	0.120	0.148	0.168	0.186	0.201	0.219	0.209	0.221	0.233	0.262	0.260	0.322	0.303
2005	0.023	0.053	0.071	0.114	0.136	0.158	0.184	0.196	0.197	0.202	0.222	0.230	0.247	0.281	0.268	0.344
2006	0.019	0.038	0.078	0.114	0.141	0.154	0.180	0.199	0.212	0.222	0.235	0.229	0.235	0.248	0.253	0.304
2007	0.024	0.048	0.067	0.092	0.130	0.150	0.163	0.186	0.210	0.233	0.248	0.256	0.264	0.286	0.310	0.347
2008	0.031	0.051	0.082	0.116	0.144	0.164	0.176	0.190	0.240	0.251	0.251	0.281	0.279	0.289	0.293	0.352
2009	0.025	0.047	0.070	0.107	0.156	0.177	0.187	0.203	0.225	0.252	0.270	0.292	0.306	0.322	0.316	0.370
2010	0.026	0.048	0.087	0.118	0.151	0.178	0.201	0.212	0.229	0.248	0.274	0.305	0.312	0.335	0.329	0.376

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2011	0.028	0.051	0.079	0.112	0.151	0.172	0.192	0.211	0.223	0.243	0.261	0.288	0.305	0.324	0.329	0.330
2012	0.044	0.060	0.087	0.118	0.151	0.175	0.198	0.213	0.232	0.256	0.266	0.286	0.312	0.307	0.347	0.357
2013	0.040	0.058	0.102	0.130	0.154	0.172	0.195	0.228	0.243	0.249	0.248	0.288	0.288	0.321	0.348	0.355
2014	0.032	0.053	0.094	0.127	0.143	0.180	0.201	0.224	0.247	0.259	0.273	0.278	0.289	0.311	0.304	0.353
2015	0.021	0.082	0.083	0.137	0.144	0.176	0.200	0.219	0.235	0.256	0.279	0.285	0.297	0.313	0.312	0.348
2016	0.016	0.055	0.096	0.133	0.164	0.192	0.200	0.225	0.249	0.254	0.306	0.295	0.310	0.335	0.337	0.339
2017	0.016	0.039	0.077	0.098	0.124	0.173	0.199	0.216	0.249	0.266	0.286	0.307	0.333	0.334	0.337	0.370
2018	0.013	0.028	0.074	0.092	0.113	0.161	0.207	0.236	0.231	0.270	0.282	0.295	0.336	0.339	0.327	0.358
2019	0.011	0.032	0.074	0.108	0.156	0.159	0.205	0.237	0.268	0.277	0.304	0.309	0.346	0.386	0.400	0.402
2020	0.026	0.028	0.051	0.083	0.121	0.170	0.181	0.235	0.259	0.288	0.297	0.315	0.318	0.373	0.371	0.386
2021	0.027	0.042	0.072	0.090	0.122	0.169	0.205	0.219	0.262	0.282	0.301	0.328	0.340	0.334	0.383	0.408
2022	0.021	0.035	0.077	0.098	0.140	0.172	0.209	0.242	0.241	0.271	0.311	0.343	0.369	0.384	0.350	0.451

Table 7.2.6.1. Western horse mackerel. Maturity-at-age.

	0	1	2	3	4	5	6	7	8	9	10	11+
1982	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
1983	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
1984	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
1985	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
1986	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
1987	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
1988	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
1989	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
1990	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
1991	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
1992	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
1993	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
1994	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
1995	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
1996	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
1997	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
1998	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
1999	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
2000	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
2001	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
2002	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
2003	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
2004	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
2005	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
2006	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
2007	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
2008	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00

	0	1	2	3	4	5	6	7	8	9	10	11+
2009	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
2010	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
2011	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
2012	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
2013	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
2014	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
2015	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
2016	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
2017	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
2018	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
2019	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
2020	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
2021	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00
2022	0.00	0.00	0.05	0.27	0.73	0.95	0.99	1.00	1.00	1.00	1.00	1.00

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.
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
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
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
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
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
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
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
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
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
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
0.32	1.647	0.135	0.793	0.22	1.324			0.393	1.279	0.101	0.853	0.144	1.265

1987		1992		1995		1998		2000		2001		2001 (cont)	
w	pfec.	w	pfec.	w	pfec.	w	pfec.	w	pfec.	w	pfec.	w	pfec.
0.273	1.956	0.131	1.039	0.236	1.221			0.393	0.668	0.106	1.133	0.171	0.956
0.212	2.83	0.136	1.06	0.261	1.21			0.413	0.694	0.107	0.935	0.121	0.607
0.268	1.687	0.138	1.489	0.245	1.445			0.421	1.339	0.107	0.494	0.122	0.689
0.32	1.088	0.147	1.214	0.306	1.693			0.423	0.798	0.11	0.85	0.139	0.915
0.318	1.208	0.151	1.158	0.314	1.312			0.445	1.03	0.111	0.67	0.153	0.943
0.343	1.933	0.16	1.349	0.46	1.575			0.446	1.208	0.103	0.632	0.154	0.709
0.378	1.429	0.165	1.359	0.449	1.43			0.152	0.643	0.111	0.547	0.156	0.773
0.404	1.849	0.165	0.945					0.165	0.579	0.118	0.88	0.162	1.158
0.428	2.236	0.167	1					0.175	0.596	0.107	0.944	0.174	1.389
0.398	1.538	0.168	1.545					0.179	0.997	0.104	0.724	0.175	1.426
0.431	1.223	0.18	1.299					0.19	0.744	0.111	0.86	0.179	1.248
0.432	1.465	0.174	1.487					0.197	0.613	0.11	0.728	0.179	1.236
0.421	1.843	0.178	1.594					0.203	0.702	0.111	0.544	0.18	2.353
0.481	1.757	0.185	1.475					0.219	0.472	0.129	0.935	0.184	2.255
0.494	1.611	0.195	1.41					0.223	0.806	0.114	0.901	0.139	0.931
0.54	1.754	0.203	1.937					0.227	0.606	0.114	0.557	0.161	1.037
0.564	2.255	0.205	1.534					0.289	1.273	0.151	1.377	0.162	0.893
0.585	1.221	0.213	1.577					0.294	1.395	0.153	1.596	0.169	0.691
		0.222	0.958					0.3	1.305	0.154	1.699	0.18	1.609
		0.275	2.444							0.103	0.679	0.185	1.776
										0.12	1.14	0.211	2.102
										0.12	0.631	0.224	1.466
										0.121	0.834	0.162	0.849
										0.144	0.626	0.17	0.668
										0.116	0.668	0.187	1.453
										0.118	1.194	0.198	1.371
										0.112	0.779	0.219	1.847
										0.126	0.782	0.22	1.578

1987		1992		1995		1998		2000		2001		2001 (cont)	
w	pfec.	w	pfec.	w	pfec.	w	pfec.	w	pfec.	w	pfec.	w	pfec.
										0.139	1.244	0.201	0.878
										0.119	1.212	0.206	1.196
										0.109	0.755	0.223	1.115
										0.122	0.841	0.225	1.43
										0.131	0.929	0.233	1.724
8										0.135	0.862	0.241	1.131
										0.142	1.834	0.219	0.96
										0.146	1.689	0.237	1.33
										0.148	1.357	0.241	0.918
										0.151	1.817	0.34	0.605
										0.164	1.631	0.407	1.189
										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	48926600	966277	2488720	5930340	925492	1297550	1186520	638142	353277	314413	299159	398806	549779	781414	393843	204764	184075	164441	147082	130723	1070810
1983	1232840	42075300	828797	2124590	5034730	781934	1092520	996951	535580	296327	263654	250827	334351	460906	655083	330166	171656	154312	137852	123300	1007250
1984	1374200	1059880	36044000	705461	1794890	4225600	653219	910095	829202	445114	246179	218993	208319	277673	382764	544011	274182	142549	128145	114476	938830
1985	1981030	1181540	908394	30715500	597137	1510370	3540950	545991	759649	691643	371144	205234	182553	173647	231453	319045	453445	228535	118816	106810	877937
1986	2548770	1703630	1013470	775545	26080300	504603	1271990	2975920	458351	637350	580130	311261	172108	153082	145611	194081	267528	380224	191631	99630	825725
1987	5018780	2191470	1460210	863742	656583	21951700	422972	1063540	2484830	382449	531624	483814	259562	143515	127647	121415	161829	223070	317036	159785	771568
1988	2229280	4314080	1876330	1241350	728169	549497	18276400	351045	881168	2056960	316457	439799	400203	214693	118702	105576	100420	133845	184495	262211	770290
1989	2624600	1915990	3691560	1592920	1044110	607523	455821	15107700	289628	726302	1694640	260654	362202	329571	176795	97747	86936	82690	110213	151920	850194
1990	1986280	2255680	1639300	3133030	1339150	870529	503549	376459	12453000	238501	597798	1394470	214458	297989	271134	145444	80412	71518	68025	90666	824375
1991	3772940	1706080	1925370	1383520	2609360	1102470	710797	409100	305016	10075800	192841	483190	1126930	173297	240784	219077	117517	64971	57785	54962	739317
1992	7252100	3239790	1454610	1620650	1147170	2135320	893797	572994	328770	244740	8078430	154554	387181	902917	138841	192902	175508	94145	52049	46291	636291

year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1993	6984160	6219500	2748300	1209860	1317160	913697	1676510	695653	443856	254061	188902	6231650	119186	298531	696121	107036	148709	135297	72574	40123	526172
1994	6792520	5982550	5250560	2260010	964734	1022410	695804	1261950	520331	330931	189124	140509	4633380	88599	221891	517373	79548	110516	100546	53933	420831
1995	4142280	5817040	5045780	4308160	1795450	745100	773977	520350	937497	385255	244617	139682	103732	3419870	65386	163744	381777	58698	81547	74190	350305
1996	2170740	3538560	4857030	4043030	3289180	1314110	529237	539808	359333	644150	264052	167453	95559	70942	2338390	44704	111942	260987	40125	55744	290166
1997	1453810	1856100	2965740	3926530	3133060	2456340	955935	378884	383109	253902	454165	185972	117873	67246	49914	1645110	31448	78746	183588	28225	243314
1998	2401900	1239730	1538770	2336780	2914660	2207530	1667820	634606	248463	249678	164966	294634	120554	76378	43563	32331	1065490	20367	50997	118891	175841
1999	2665510	2054330	1040210	1247290	1818930	2189810	1617350	1203380	454092	177039	177535	117180	209176	85563	54201	30911	22940	755975	14450	36181	209101
2000	2016840	2279670	1723350	842745	970059	1365010	1602190	1165230	859734	323042	125682	125903	83057	148221	60620	38397	21897	16249	535480	10235	173733
2001	12509500	1727700	1924980	1417960	672633	753937	1041060	1208000	873069	642135	240903	93653	93781	61853	110368	45136	28588	16302	12098	398660	136960
2002	1790280	10704200	1452320	1567110	1111760	510333	558827	760767	875969	630626	462926	173505	67419	67493	44508	79412	32474	20568	11729	8703	385334
2003	1029400	1532650	9015690	1187800	1238240	852371	382984	413952	559563	641988	461362	338377	126767	49246	49294	32504	57991	23714	15019	8564	287723
2004	1679960	881387	1291610	7383260	940597	952174	641930	284793	305705	411797	471642	338654	248271	92989	36119	36151	23837	42527	17390	11013	217263

year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2005	1270120	1440030	746164	1069170	5952880	741117	738076	492667	217394	232718	313057	358312	257191	188515	70600	27421	27445	18096	32283	13201	173286
2006	1092890	1088350	1217390	615613	857254	4655240	569376	560953	372246	163769	175056	235318	269235	193215	141606	53029	20596	20613	13591	24246	140057
2007	2038530	937084	922481	1010590	498709	679797	3636050	440637	431947	285910	125628	134203	180344	206303	148038	108490	40626	15778	15791	10412	125867
2008	4683580	1749160	796549	770965	827989	401566	540673	2870290	346423	338889	224085	98413	105103	141219	161534	115908	84941	31807	12353	12363	106692
2009	1219530	4015870	1482570	661225	624539	656559	313632	418398	2210050	266058	259946	171779	75417	80530	108192	123749	88792	65068	24365	9463	91198
2010	927332	1044050	3382620	1212710	522593	478988	492917	232424	307883	1620480	194738	190098	125565	55115	58843	79050	90412	64870	47537	17800	73536
2011	366399	792910	875011	2734350	939637	390195	348357	352796	164912	217491	1142230	137118	133777	88338	38768	41387	55595	63584	45620	33430	64229
2012	2206870	313165	663486	704700	2105520	695714	280969	246627	247479	115143	151505	794774	95352	93000	61400	26943	28762	38634	44184	31701	67860
2013	1005390	1886580	262239	535266	544201	1565020	503282	199926	173922	173730	80649	106000	555745	66655	64999	42910	18828	20098	26996	30874	69566
2014	3189580	858851	1575200	210115	408633	398265	1111480	350966	138042	119484	119056	55201	72506	380015	45570	44433	29331	12869	13737	18451	68646
2015	2088380	2725750	718212	1266720	161391	301539	285640	783476	245073	95933	82841	82448	38204	50166	262878	31520	30731	20285	8900	9500	60233
2016	2223730	1787320	2293010	585728	996135	122942	224572	209826	571244	178011	69552	60004	59691	27652	36305	190229	22808	22237	14678	6440	50454

year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2017	2692990	1902750	1502250	1866170	459017	755275	91055	163967	152017	412234	128211	50046	43155	42919	19880	26098	136737	16394	15983	10550	40891
2018	2056230	2306680	1606040	1234850	1487070	355972	574540	68458	122492	113197	306475	95243	37162	32038	31859	14756	19370	101487	12167	11862	38178
2019	1188070	1759840	1940670	1310080	971441	1133380	265272	422328	49948	89036	82127	222149	69005	26918	23203	23071	10685	14026	73486	8810	36232
2020	1197570	1015740	1474240	1567060	1013250	723564	821903	189264	298664	35164	62544	57628	155793	48379	18869	16263	16170	7488	9830	51499	31565
2021	1001050	1026720	860517	1222390	1267020	801398	563397	633906	145219	228559	26876	47771	44002	118934	36929	14402	12413	12342	5715	7502	63396
	1031500	858195	869637	713170	987547	1001010	623196	433914	485665	110964	174417	20496	36419	33539	90646	28144	10976	9459	9405	4355	54026

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	0.001	0.003	0.008	0.014	0.019	0.022	0.024	0.025	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026
1983	0.001	0.005	0.011	0.019	0.025	0.030	0.033	0.034	0.035	0.035	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036
1984	0.001	0.004	0.010	0.017	0.023	0.027	0.029	0.031	0.031	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
1985	0.001	0.003	0.008	0.014	0.018	0.022	0.024	0.025	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026
1986	0.001	0.004	0.010	0.017	0.022	0.026	0.029	0.030	0.031	0.031	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
1987	0.001	0.005	0.012	0.021	0.028	0.033	0.036	0.038	0.039	0.039	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
1988	0.001	0.006	0.014	0.023	0.031	0.037	0.040	0.042	0.043	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044

year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1989	0.001	0.006	0.014	0.024	0.032	0.038	0.041	0.043	0.044	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
1990	0.002	0.008	0.020	0.033	0.044	0.053	0.058	0.060	0.062	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063
1991	0.002	0.009	0.022	0.037	0.050	0.060	0.066	0.069	0.070	0.071	0.071	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072
1992	0.004	0.015	0.034	0.057	0.078	0.092	0.101	0.105	0.108	0.109	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110
1993	0.005	0.019	0.046	0.076	0.103	0.122	0.134	0.140	0.144	0.145	0.146	0.146	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147
1994	0.005	0.020	0.048	0.080	0.108	0.128	0.141	0.147	0.151	0.152	0.153	0.153	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154
1995	0.008	0.030	0.072	0.120	0.162	0.192	0.210	0.220	0.225	0.228	0.229	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230
1996	0.007	0.027	0.063	0.105	0.142	0.168	0.184	0.193	0.197	0.199	0.201	0.201	0.201	0.202	0.202	0.202	0.202	0.202	0.202	0.202	0.202
1997	0.009	0.037	0.088	0.148	0.200	0.237	0.260	0.272	0.278	0.281	0.283	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.285	0.285
1998	0.006	0.025	0.060	0.101	0.136	0.161	0.176	0.185	0.189	0.191	0.192	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193
1999	0.006	0.026	0.061	0.101	0.137	0.162	0.178	0.186	0.191	0.193	0.194	0.194	0.194	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
2000	0.005	0.019	0.045	0.075	0.102	0.121	0.132	0.139	0.142	0.143	0.144	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145
2001	0.006	0.024	0.056	0.093	0.126	0.149	0.164	0.171	0.175	0.177	0.178	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179
2002	0.005	0.022	0.051	0.086	0.116	0.137	0.150	0.157	0.161	0.163	0.163	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
2003	0.005	0.021	0.050	0.083	0.113	0.134	0.146	0.153	0.157	0.158	0.159	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160
2004	0.004	0.017	0.039	0.065	0.088	0.105	0.115	0.120	0.123	0.124	0.125	0.125	0.125	0.125	0.126	0.126	0.126	0.126	0.126	0.126	0.126
2005	0.004	0.018	0.042	0.071	0.096	0.114	0.124	0.130	0.133	0.135	0.135	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136
2006	0.004	0.015	0.036	0.061	0.082	0.097	0.106	0.111	0.114	0.115	0.116	0.116	0.116	0.116	0.116	0.116	0.116	0.116	0.116	0.116	0.116

year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2007	0.003	0.012	0.029	0.049	0.067	0.079	0.086	0.091	0.093	0.094	0.094	0.094	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095
2008	0.004	0.015	0.036	0.061	0.082	0.097	0.106	0.111	0.114	0.115	0.116	0.116	0.116	0.116	0.116	0.116	0.117	0.117	0.117	0.117	0.117
2009	0.005	0.022	0.051	0.085	0.115	0.137	0.150	0.157	0.160	0.162	0.163	0.163	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
2010	0.007	0.027	0.063	0.105	0.142	0.168	0.184	0.193	0.198	0.200	0.201	0.201	0.202	0.202	0.202	0.202	0.202	0.202	0.202	0.202	0.202
2011	0.007	0.028	0.066	0.111	0.151	0.178	0.195	0.205	0.209	0.212	0.213	0.213	0.214	0.214	0.214	0.214	0.214	0.214	0.214	0.214	0.214
2012	0.007	0.027	0.065	0.108	0.147	0.174	0.190	0.199	0.204	0.206	0.207	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.209
2013	0.008	0.030	0.072	0.120	0.162	0.192	0.210	0.220	0.225	0.228	0.229	0.230	0.230	0.230	0.230	0.230	0.231	0.231	0.231	0.231	0.231
2014	0.007	0.029	0.068	0.114	0.154	0.182	0.200	0.209	0.214	0.216	0.217	0.218	0.218	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219
2015	0.006	0.023	0.054	0.090	0.122	0.145	0.158	0.166	0.170	0.172	0.173	0.173	0.173	0.173	0.173	0.174	0.174	0.174	0.174	0.174	0.174
2016	0.006	0.024	0.056	0.094	0.127	0.150	0.165	0.172	0.176	0.178	0.179	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180
2017	0.005	0.020	0.046	0.077	0.104	0.124	0.135	0.142	0.145	0.146	0.147	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148
2018	0.006	0.023	0.054	0.090	0.122	0.144	0.158	0.165	0.169	0.171	0.172	0.172	0.173	0.173	0.173	0.173	0.173	0.173	0.173	0.173	0.173
2019	0.007	0.027	0.064	0.107	0.145	0.171	0.188	0.196	0.201	0.203	0.204	0.205	0.205	0.205	0.205	0.205	0.205	0.206	0.206	0.206	0.206
2020	0.004	0.016	0.037	0.063	0.085	0.100	0.110	0.115	0.118	0.119	0.119	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120
2021	0.004	0.016	0.038	0.063	0.086	0.101	0.111	0.116	0.119	0.120	0.121	0.121	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122
2022	0.003	0.013	0.032	0.053	0.072	0.085	0.093	0.098	0.100	0.101	0.101	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102

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	48926600	2886380	2214000	20000	0.0260	0.008	0.023	0.019
1983	1232840	3417510	2355730	61197	0.0365	0.011	0.031	0.026
1984	1374200	4083800	2493800	90442	0.0370	0.010	0.028	0.024
1985	1981030	4690830	2953590	96244	0.0316	0.008	0.023	0.019
1986	2548770	5121830	4243370	96343	0.0319	0.010	0.028	0.023
1987	5018780	5318200	4987120	137499	0.0372	0.013	0.035	0.029
1988	2229280	5301870	5027500	187338	0.0416	0.014	0.039	0.032
1989	2624600	5136480	4820510	210989	0.0431	0.015	0.040	0.033
1990	1986280	4881420	4554180	209583	0.0600	0.020	0.055	0.046
1991	3772940	4509120	4228340	275968	0.0671	0.023	0.063	0.053
1992	7252100	4129240	3847640	287438	0.1003	0.035	0.097	0.081
1993	6984160	3706390	3344520	393631	0.1316	0.047	0.129	0.108
1994	6792520	3320740	2817850	453246	0.1407	0.049	0.135	0.113
1995	4142280	3061080	2448980	412291	0.2098	0.074	0.202	0.169
1996	2170740	2720820	2133210	538950	0.1870	0.065	0.177	0.148
1997	1453810	2485770	2009990	422396	0.2510	0.091	0.249	0.208
1998	2401900	2105910	1786560	534673	0.1724	0.062	0.169	0.142
1999	2665510	1895400	1670020	325340	0.1707	0.063	0.171	0.143
2000	2016840	1690470	1487800	298992	0.1302	0.047	0.127	0.106
2001	12509500	1612350	1350840	202732	0.15	0.058	0.157	0.131
2002	1790280	1580000	1201490	229081	0.19	0.053	0.144	0.121
2003	1029400	1616600	1117590	196120	0.18	0.051	0.140	0.117
2004	1679960	1642320	1139280	191856	0.17	0.040	0.110	0.092
2005	1270120	1653470	1358210	159742	0.12	0.044	0.120	0.100
2006	1092890	1590610	1428260	182001	0.13	0.037	0.102	0.085
2007	2038530	1511380	1371930	155827	0.11	0.030	0.083	0.069
2008	4683580	1452440	1300820	123356	0.09	0.037	0.102	0.085
2009	1219530	1384180	1189100	143349	0.12	0.053	0.144	0.120

Year	Recruit (thousands)	Total Biomass	Spawning Biomass	Catch	Yield/SSB	Fbar(1-3)	Fbar(4-8)	Fbar(1-10)
2010	927332	1282560	1040540	183782	0.18	0.065	0.177	0.148
2011	366399	1153290	926289	203112	0.22	0.069	0.188	0.157
2012	2206870	1019960	875406	193698	0.22	0.067	0.183	0.153
2013	1005390	902284	798308	169859	0.21	0.074	0.202	0.169
2014	3189580	795012	676175	165258	0.24	0.070	0.192	0.160
2015	2088380	734778	573436	136360	0.24	0.056	0.152	0.127
2016	2223730	732393	537917	98419	0.18	0.058	0.158	0.132
2017	2692990	747672	523956	98810	0.19	0.048	0.130	0.109
2018	2056230	790967	564703	82961	0.15	0.055	0.152	0.127
2019	1188070	817635	597289	101682	0.17	0.066	0.180	0.151
2020	1197570	810395	609356	124947	0.21	0.039	0.105	0.088
2021	1001050	831413	666427	76422	0.11	0.039	0.107	0.089
2022	1031500	828094	699502	81557	0.12	0.033	0.090	0.075

Table 7.4.1. Western Horse Mackerel. Short term prediction: INPUT DATA. *geometric mean of the recruitment time series from 1983 to 2022. ** from assessment output

Age	N	Mat	M	PF	PM	Stock weight at age**
0	2088520*	0.000	0.150	0	0	0.0041
1	884863	0.000	0.150	0	0	0.0180
2	728781	0.050	0.150	0	0	0.0421
3	725136	0.250	0.150	0	0	0.0730
4	582070	0.700	0.150	0	0	0.1069
5	791065	0.950	0.150	0	0	0.1407
6	791264	1.000	0.150	0	0	0.1726
7	488647	1.000	0.150	0	0	0.2014
8	338739	1.000	0.150	0	0	0.2267
9	378294	1.000	0.150	0	0	0.2484
10	86337	1.000	0.150	0	0	0.2668
11	135634	1.000	0.150	0	0	0.2821
12	15934	1.000	0.150	0	0	0.2948

Age	N	Mat	M	PF	PM	Stock weight at age**
13	28309	1.000	0.150	0	0	0.3053
14	26068	1.000	0.150	0	0	0.3138
15	70451	1.000	0.150	0	0	0.3208
16	21873	1.000	0.150	0	0	0.3264
17	8530	1.000	0.150	0	0	0.3309
18	7352	1.000	0.150	0	0	0.3346
19	7309	1.000	0.150	0	0	0.3376
20	45371	1.000	0.150	0	0	0.3419

Table 7.4.2. Western Horse Mackerel. Short term prediction; single area management option table. Assumption: Catch 2023: 15 277 t (100% of 2023 TOTAL TAC).

Scenarios	F_{factor}	F_{bar}	Catch_2023	Catch_2024	SSB_2024	SSB_2025	Change_SSB_2024-2025(%)	Change_Catch_2023-2024(%)
SSB_{2025} = MSY $B_{trigger}$ = B_{pa} = B_{lim}	The B_{pa}, B_{lim} and MSY $B_{trigger}$ options were left blank because B_{pa}, B_{lim} and MSY $B_{trigger}$ cannot be achieved in 2025, even with a zero catch in 2024.							
F = F_{MSY}	0.99	0.074	15277	73124	744547	715711	-3.9	378.7
F = F_{P05} = F_{pa}	1.06	0.079	15277	77837	744547	711377	-4.5	409.5
F = F_{lim}	1.38	0.103	15277	100070	744547	690950	-7.2	555.0
F = 0	0.00	0.000	15277	0	744547	783126	5.2	-100.0
F = F_{2023}	0.21	0.016	15277	16082	744547	768273	3.2	5.3
PelAC proposed HCR	0.20	0.015	15277	15348	744547	768951	3.3	0.5

Table 7.4.3. Western Horse Mackerel. Landings inside and outside the NEAFC Regulatory Area (RA), as estimated by ICES, as well as total landings. Weights are in tonnes.

Year	Inside the NEAFC RA	Outside the NEAFC RA	Total catches	% inside the NEAFC RA
2020	0	76422	76422	0
2021	10	81547	81557	0.01
2022	0	70114	70114	0

7.15 Figures

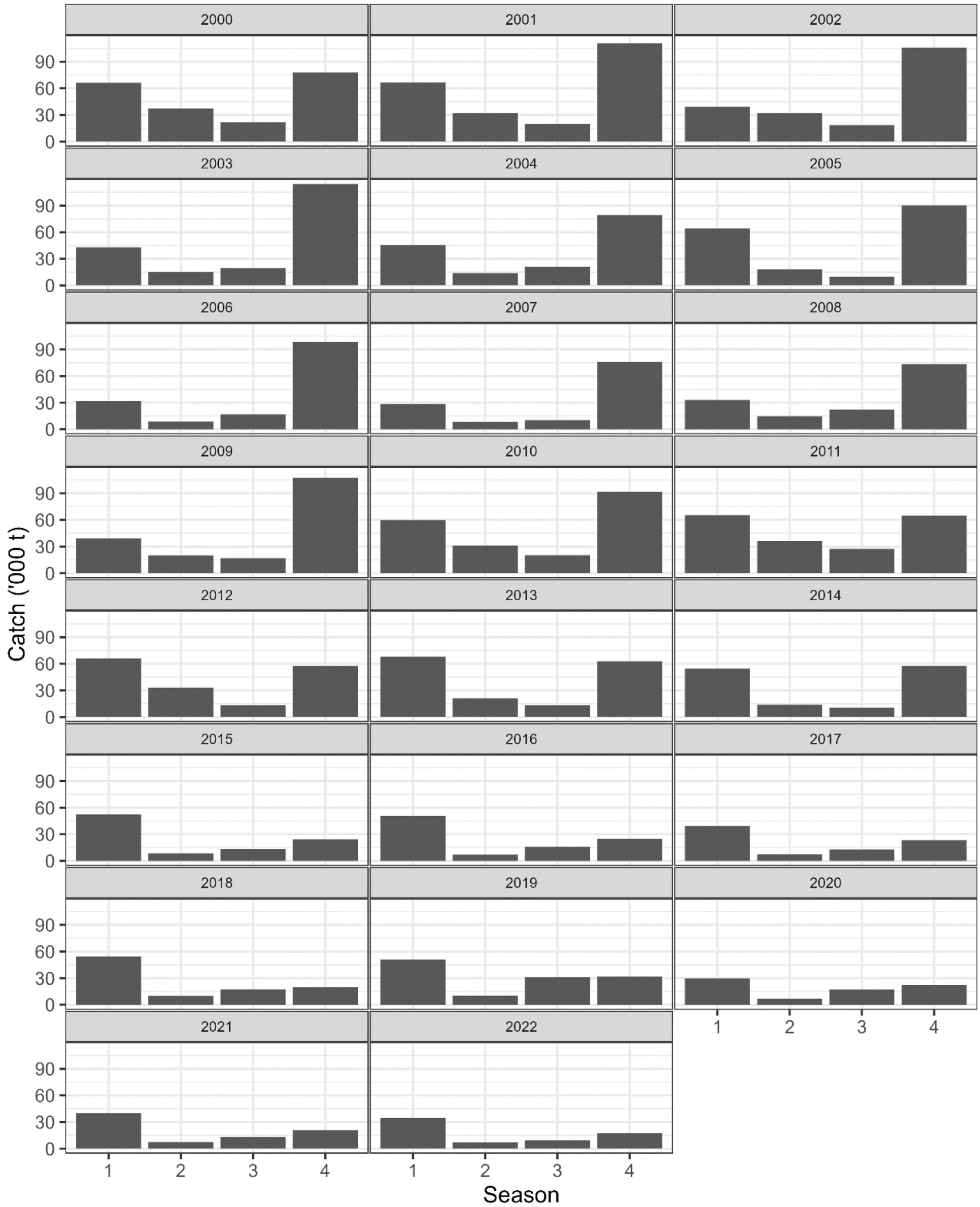


Figure 7.1.1.1: Western horse mackerel. Catch by quarter and year for 2000-¬2022.

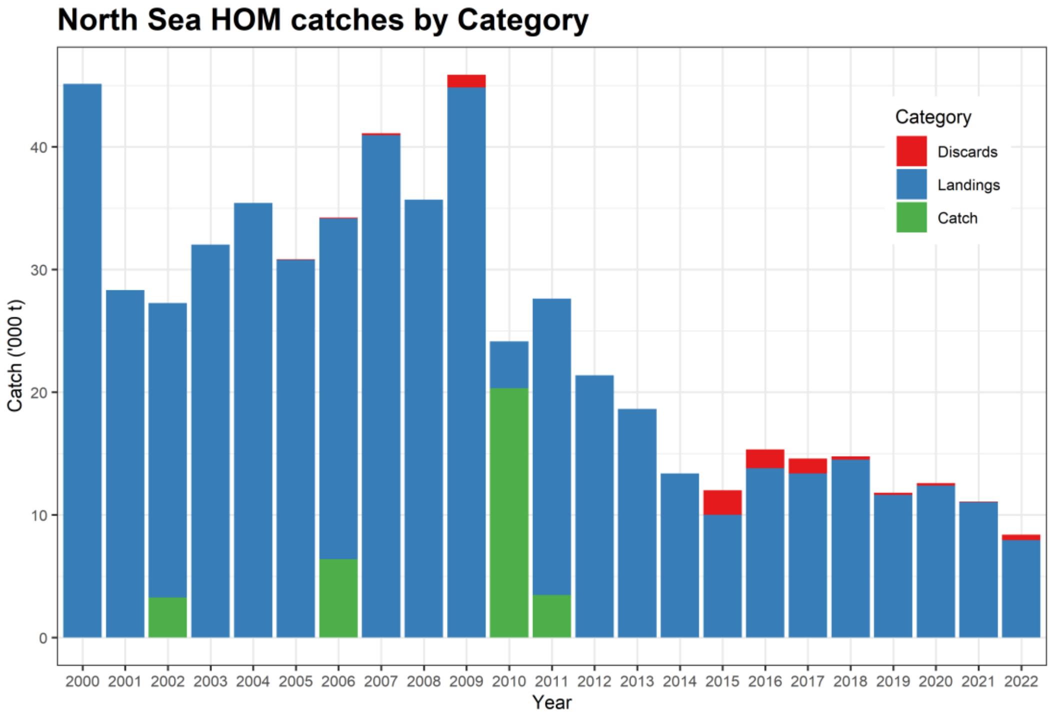


Figure 7.1.2.1. Western horse mackerel. Catch categories since 2000 (green bars indicate when countries have submitted catch data without specifying landings/discards).

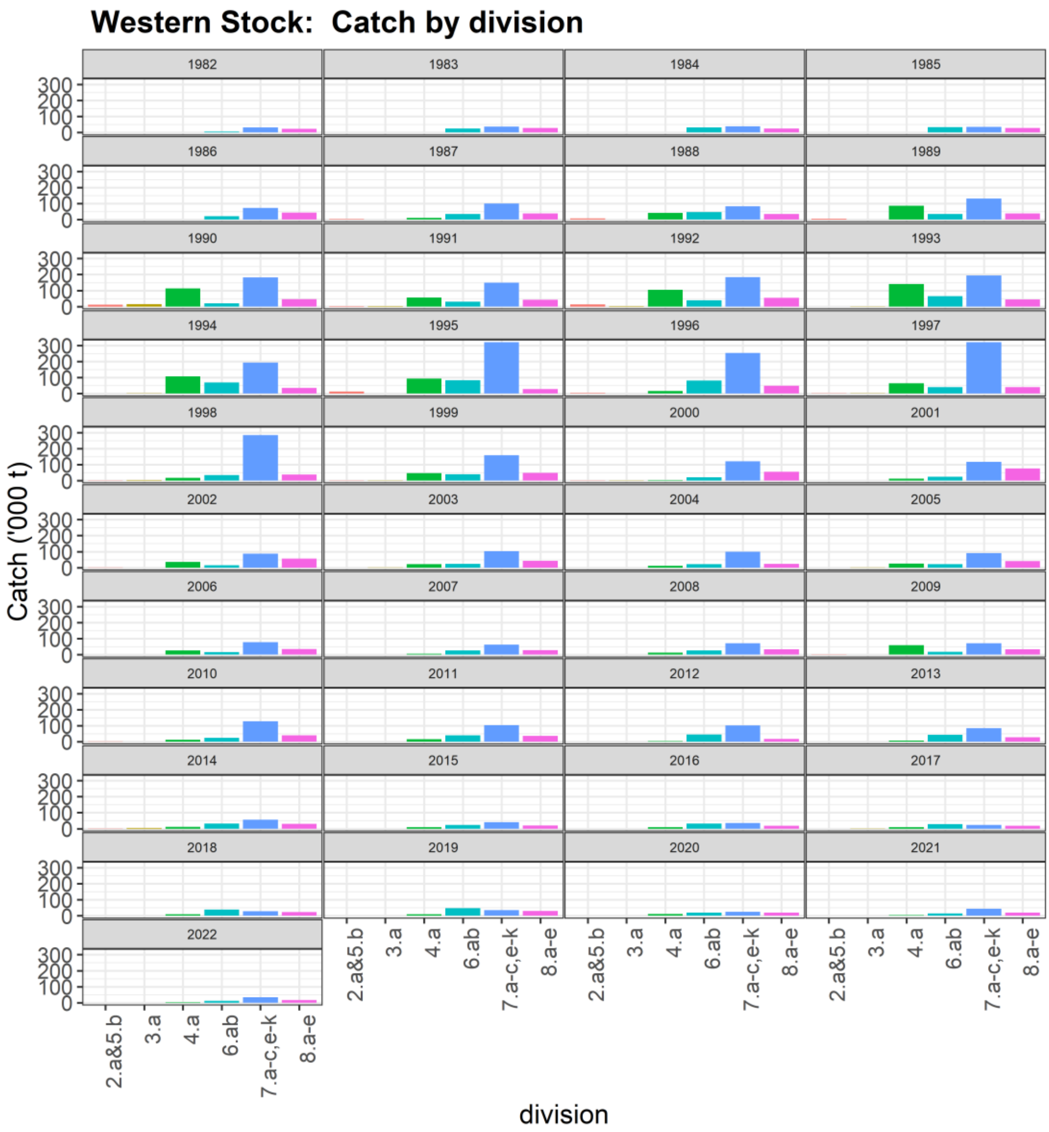


Figure 7.1.3.1: Western horse mackerel. Catch by ICES Division and year for 1982-2022.

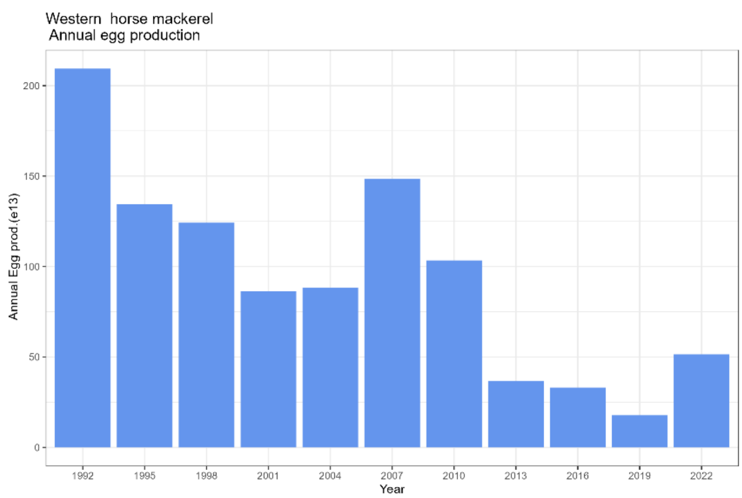
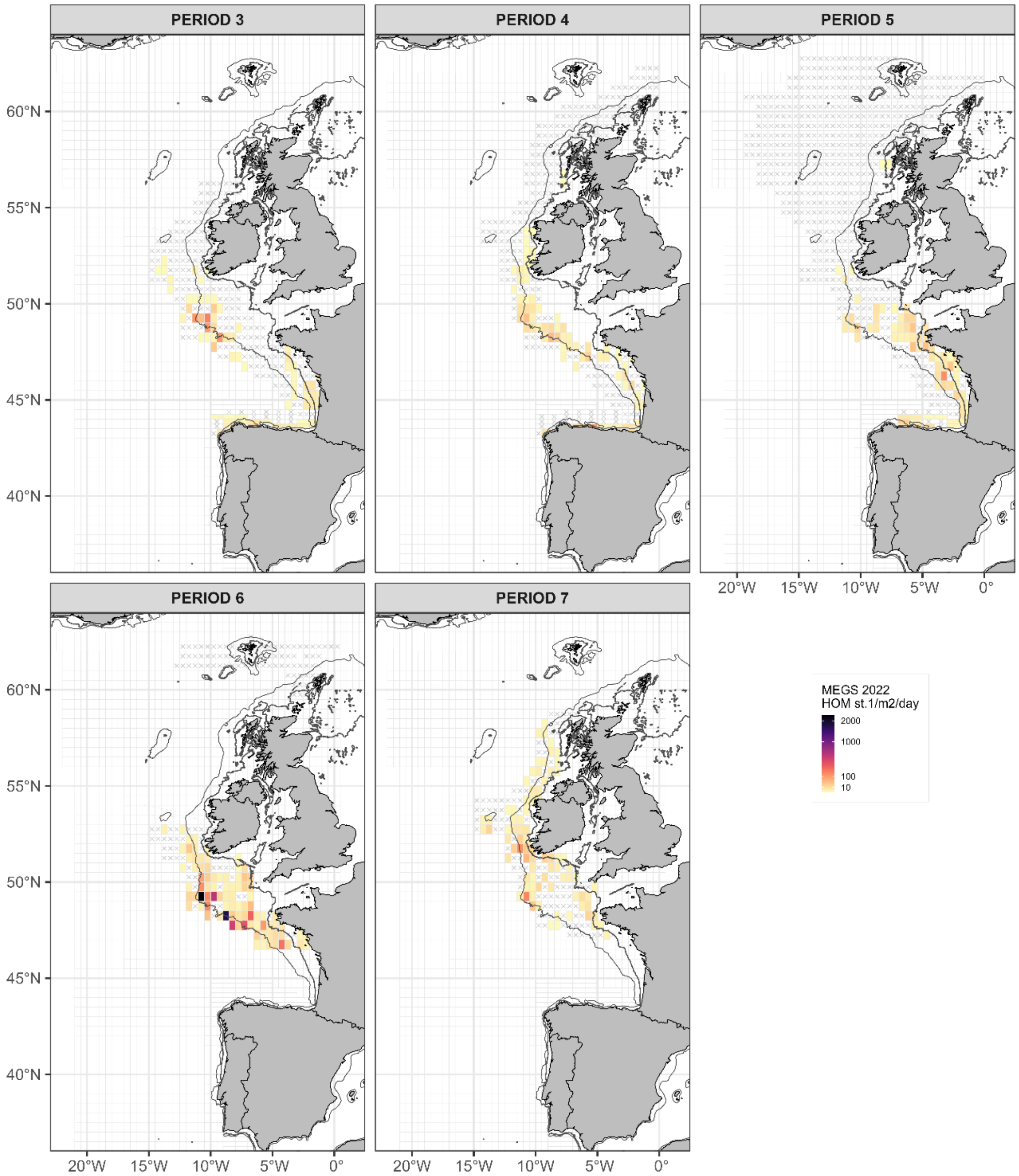


Figure 7.2.1.1The total annual horse mackerel egg production for 1992 – 2022 for the western horse mackerel stock



Figures 7.2.1.2 Western horse mackerel egg production by half rectangle and survey period. Colour scale represents mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

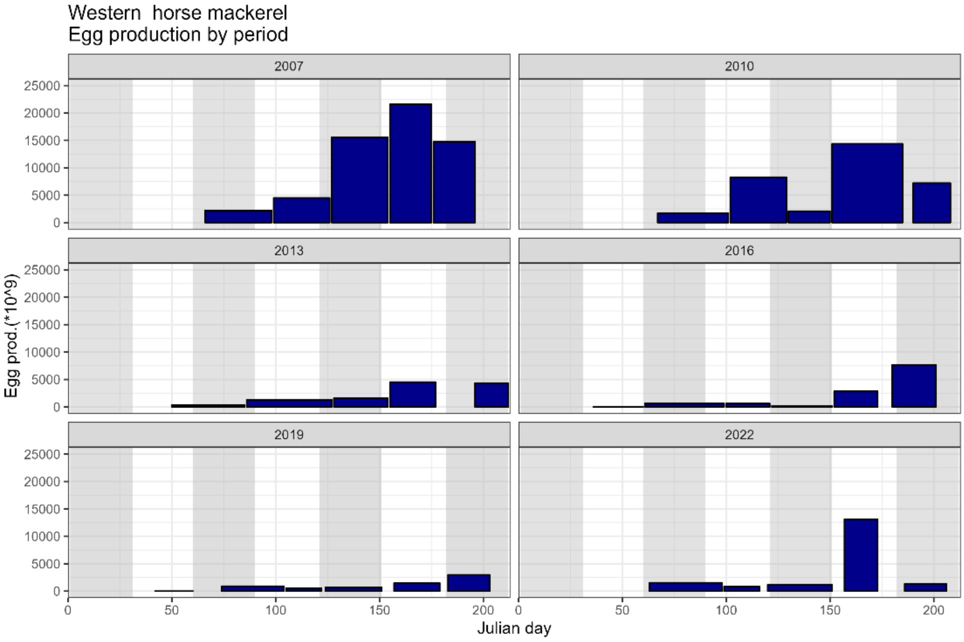


Figure 7.2.1.3. Egg production by period for the western horse mackerel stock since 2007

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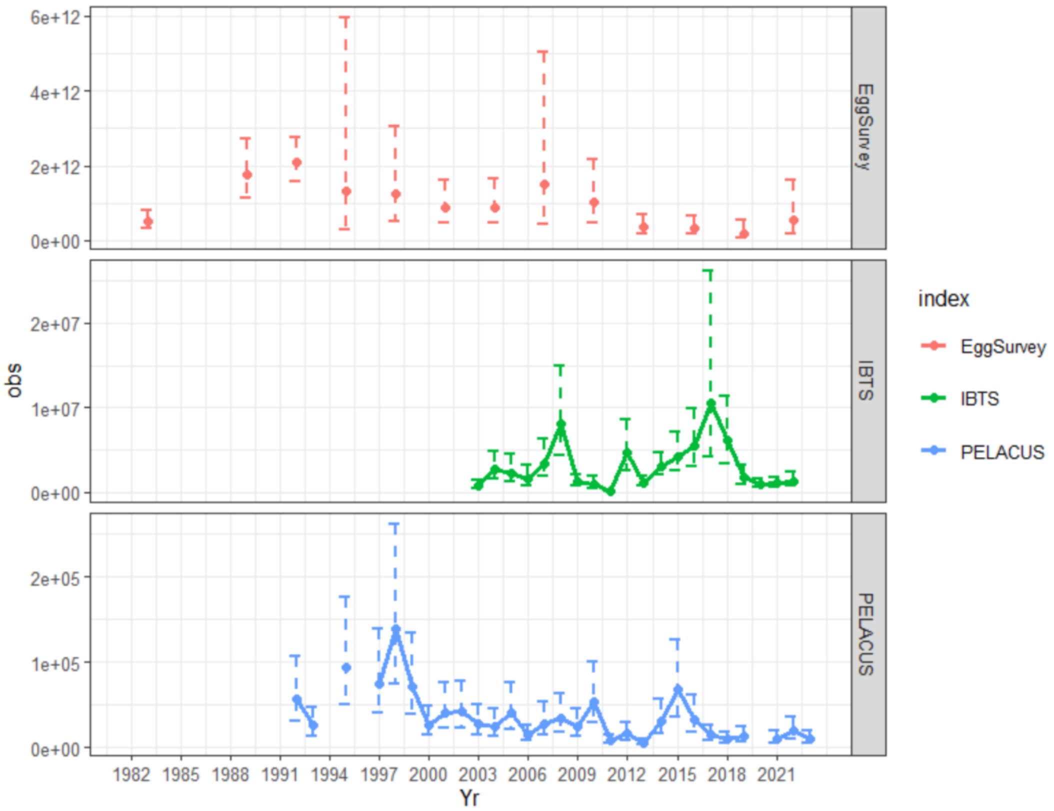


Figure 7.2.2.1: Western horse mackerel. Trend of the fisheries independent indices of abundance used in the assessment of Western Horse mackerel. Top: Spawning index from egg survey; middle: recruitment index from IBTS survey; bottom: biomass estimates from PELACUS acoustic survey. Confidence intervals are shown as well.

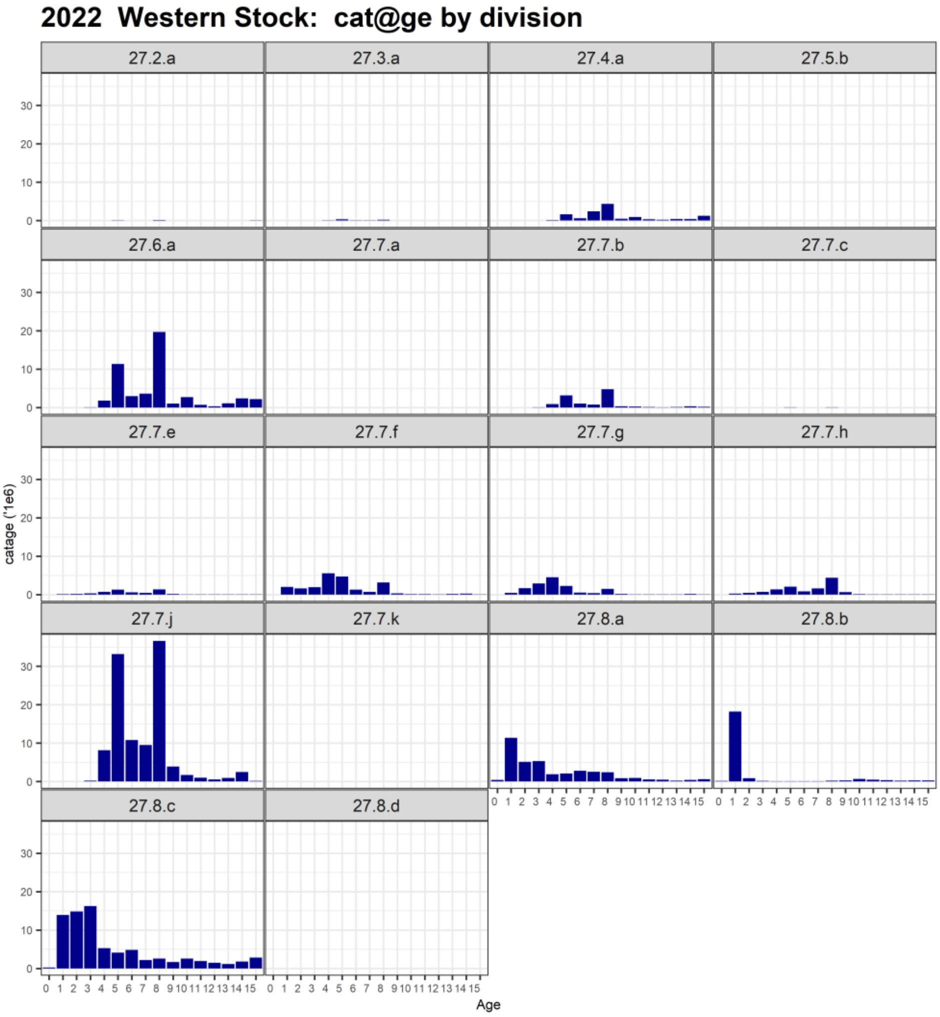


Figure 7.2.4.1: Western horse mackerel. Catch-at-age (millions) by ICES division in 2022.

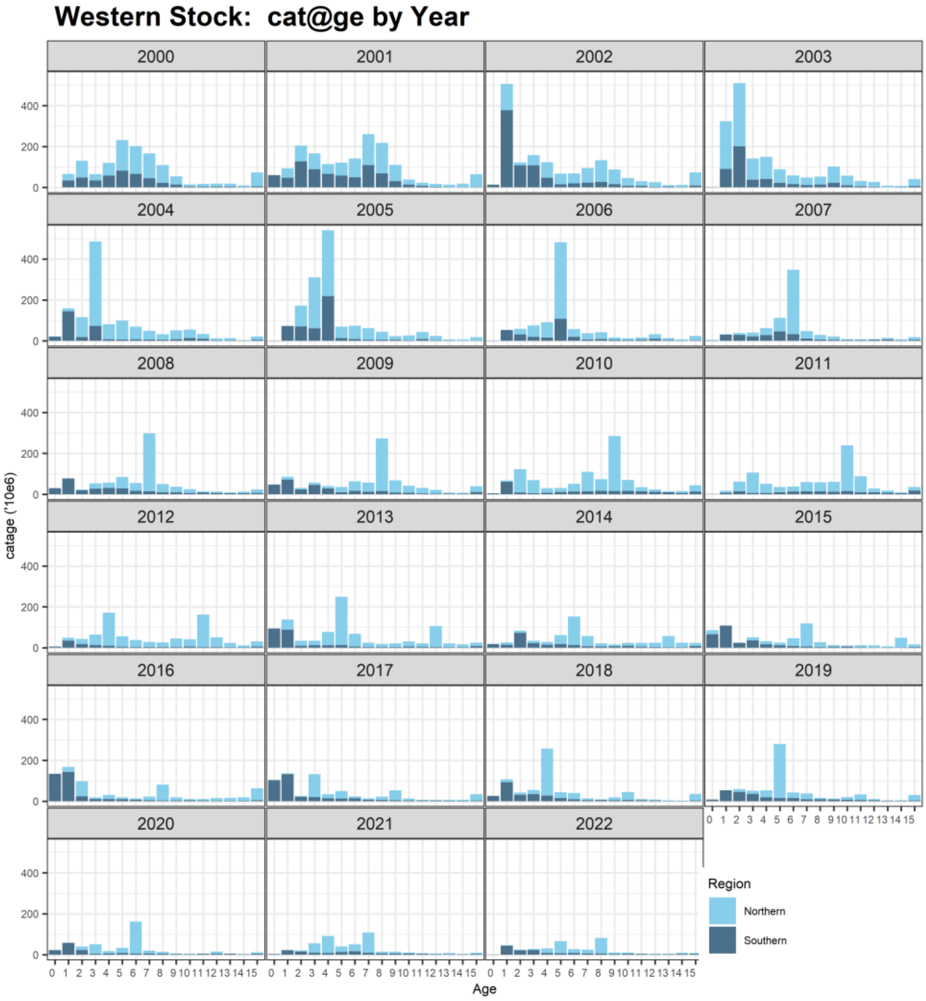


Figure 7.2.4.2: Western horse mackerel. Catch-at-age (millions) by Year.

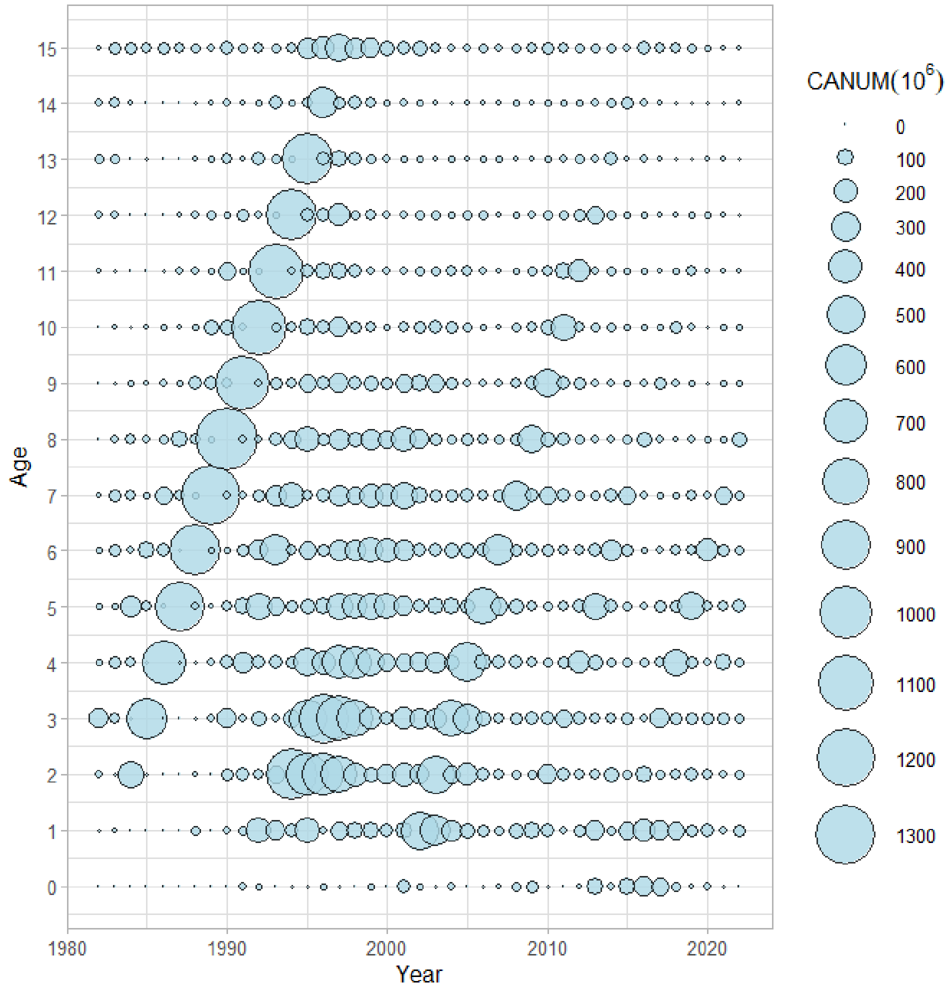


Figure 7.2.4.3: Western horse mackerel. Catch-at-age - the area of bubbles is proportional to the catch number. Age 15 is a plus group.

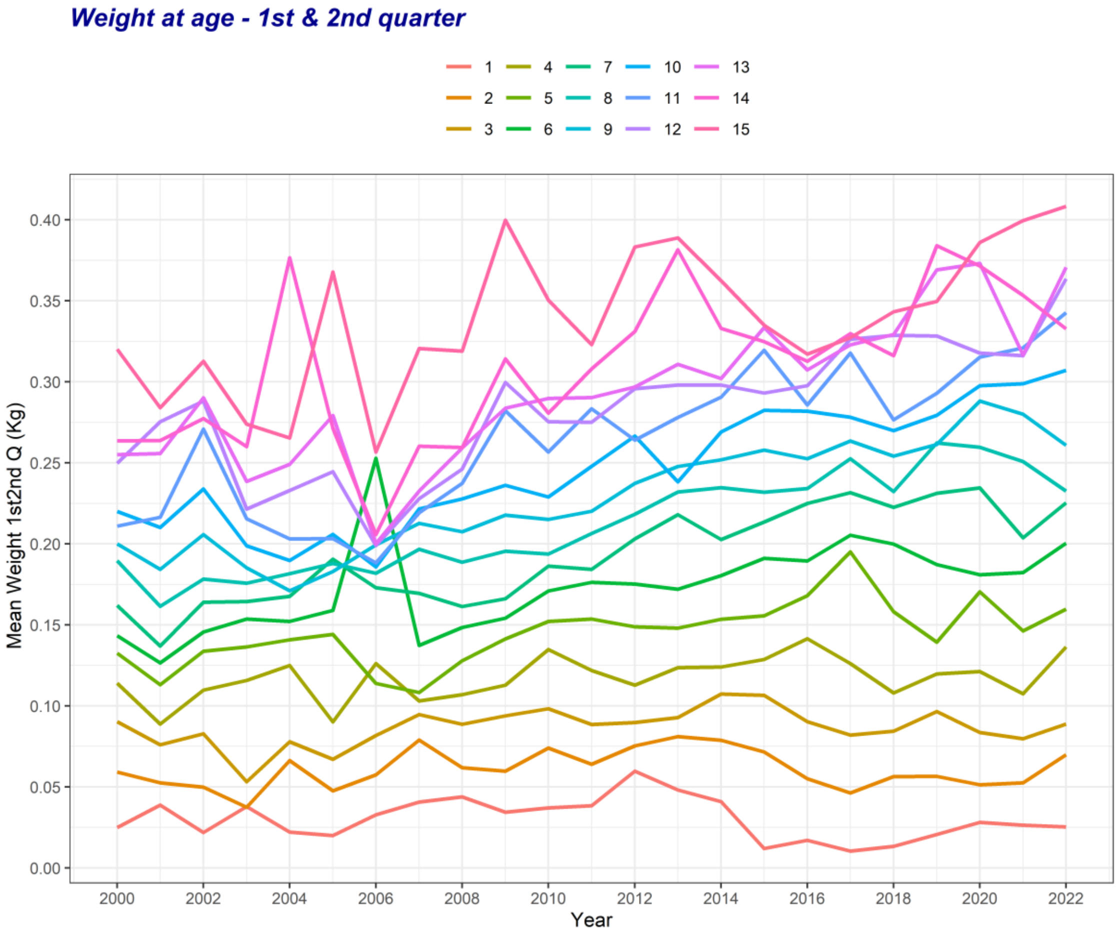


Figure 7.2.5.1: Western horse mackerel. Weight at age in the catch (kg) by year.

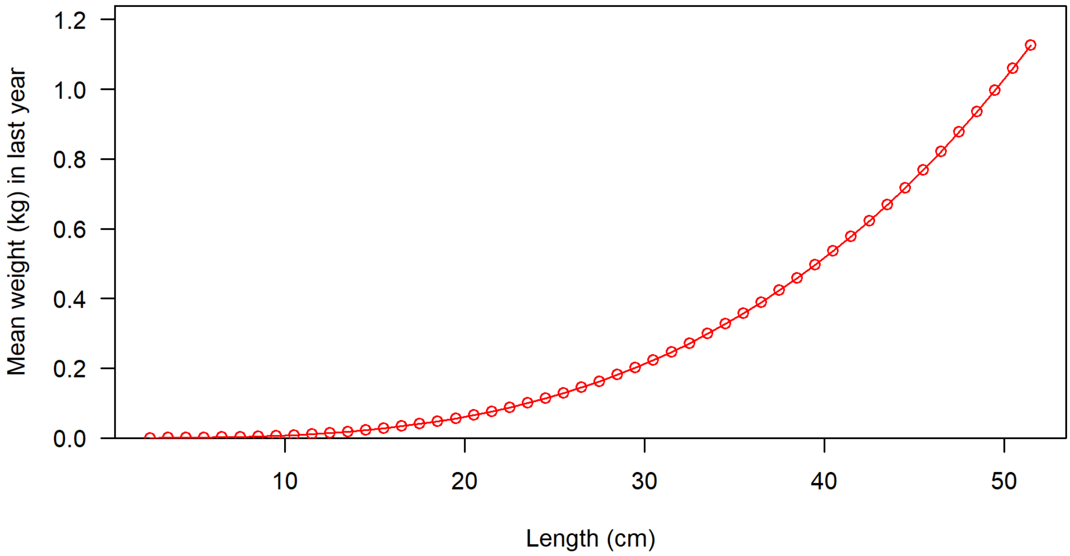


Figure 7.2.5.2: Western horse mackerel. Weight at length in the stock (kg) as estimated by the stock assessment.

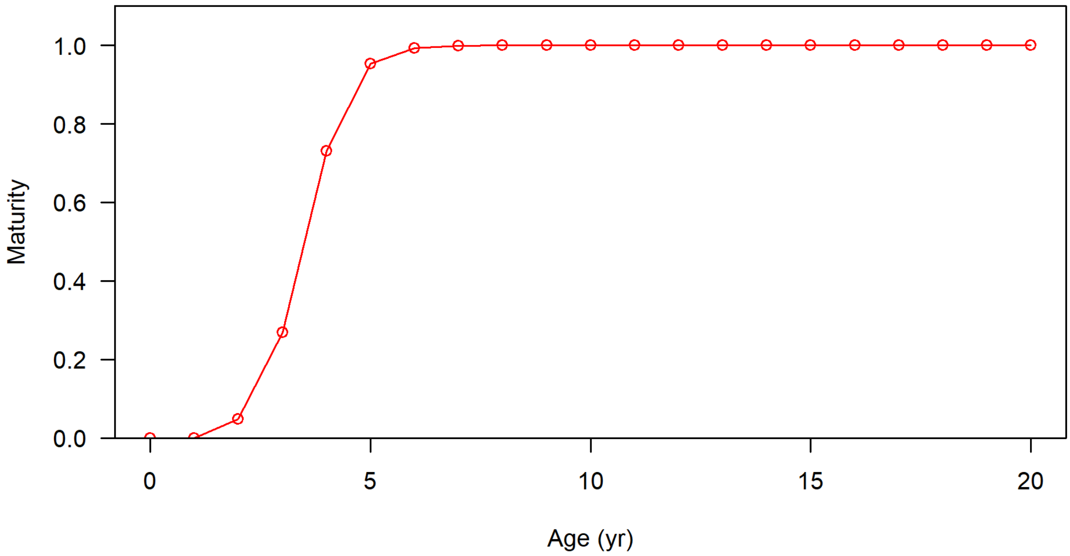


Figure 7.2.6.1: Western horse mackerel. Maturity at age as used in the assessment model.

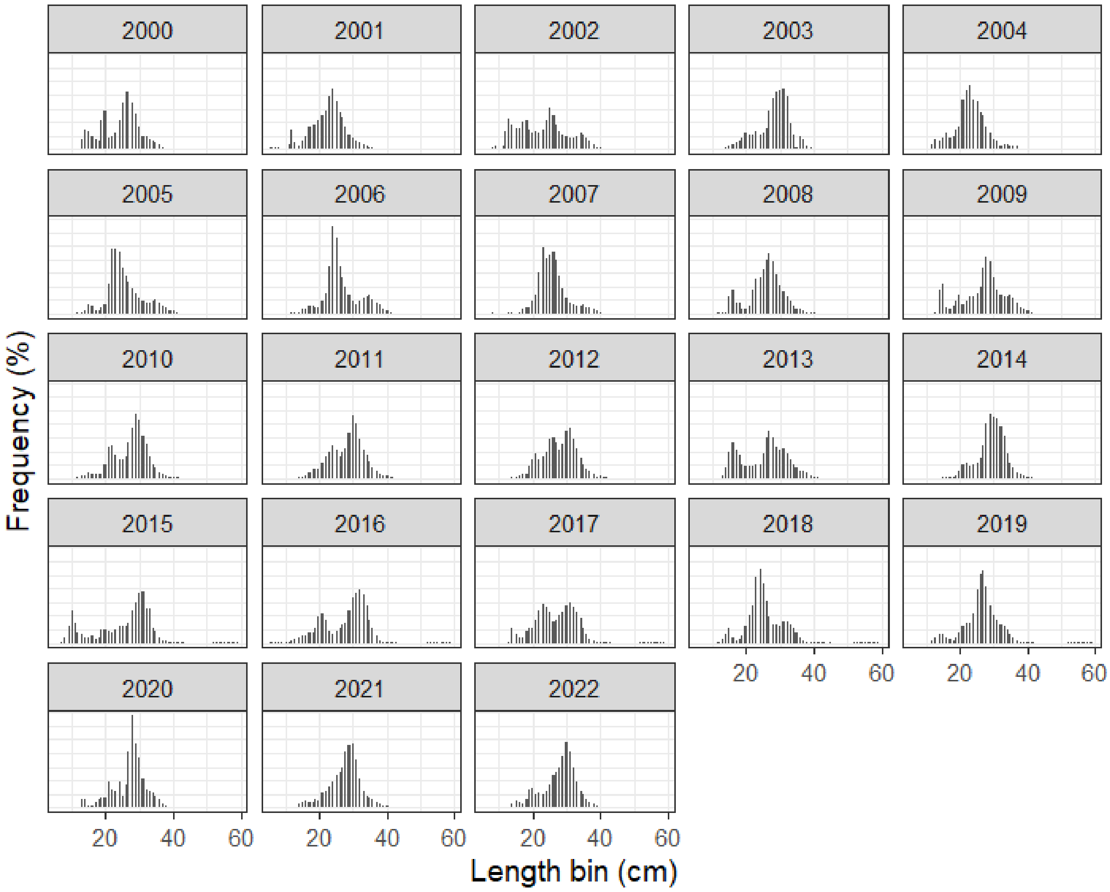


Figure 7.2.10.1: Western horse mackerel. Length frequency distribution of the landing data as used in the assessment model.

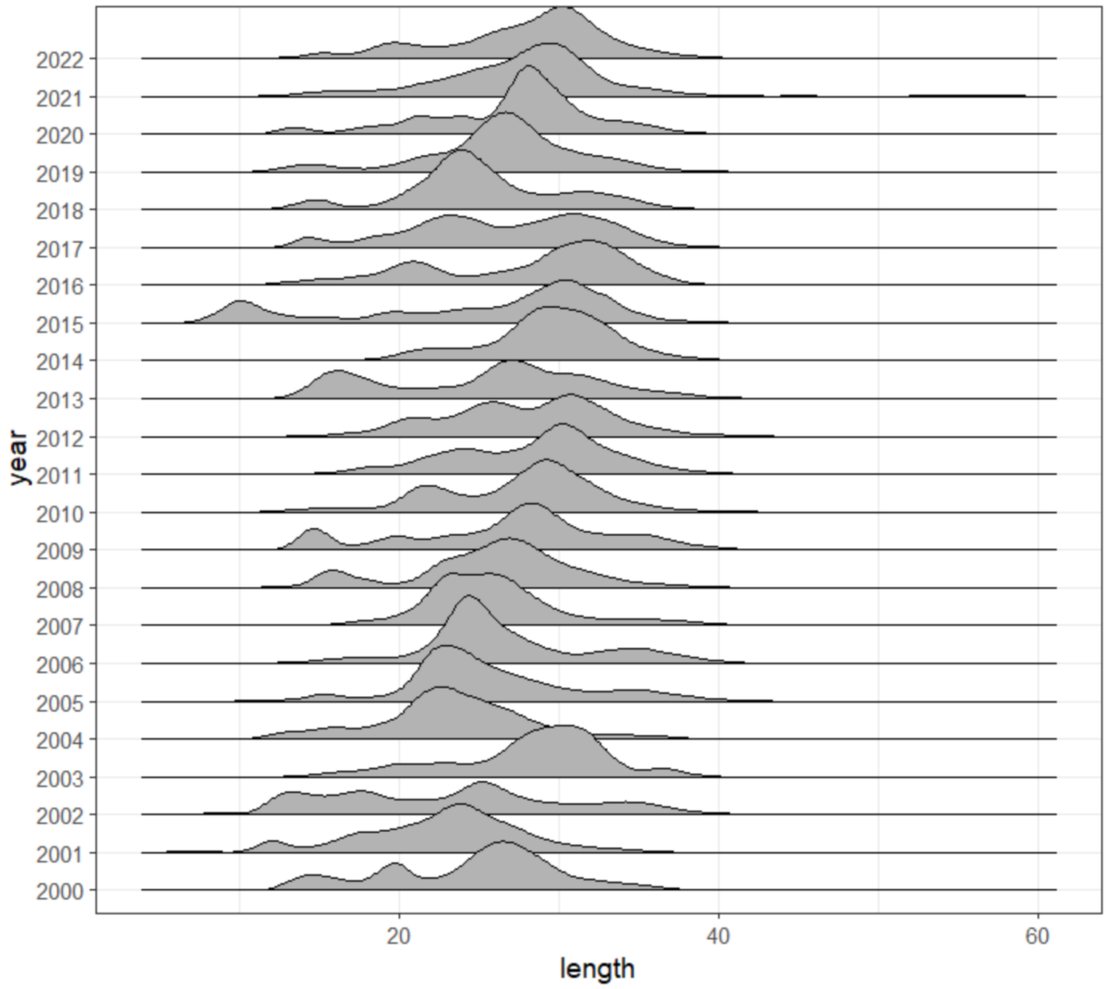


Figure 7.2.10.2: Western horse mackerel. Stacked length frequency distribution of the landing data as used in the assessment model.

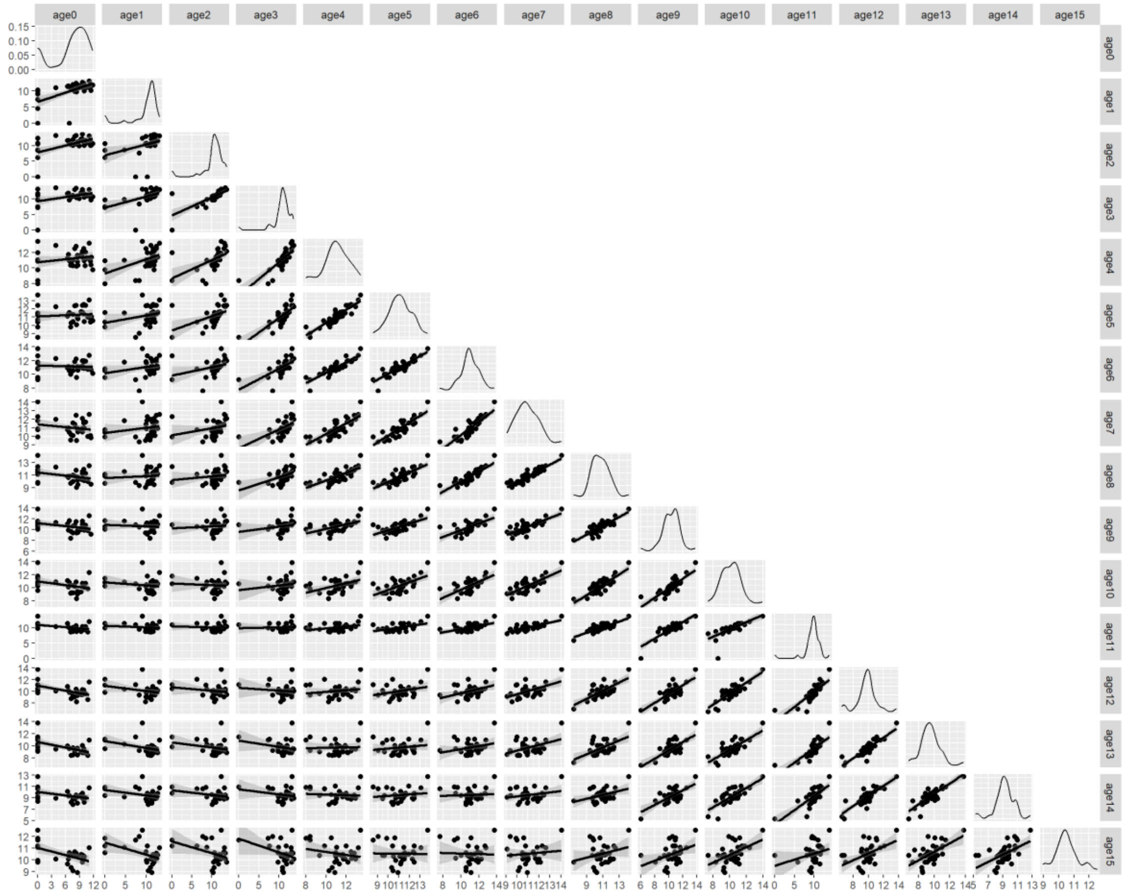


Figure 7.2.10.3: Western horse mackerel. Within-cohort consistency in the catch-at-age matrix, shown by plotting the log-catch of a cohort at a particular age against the log-catch of the same cohort at subsequent ages.

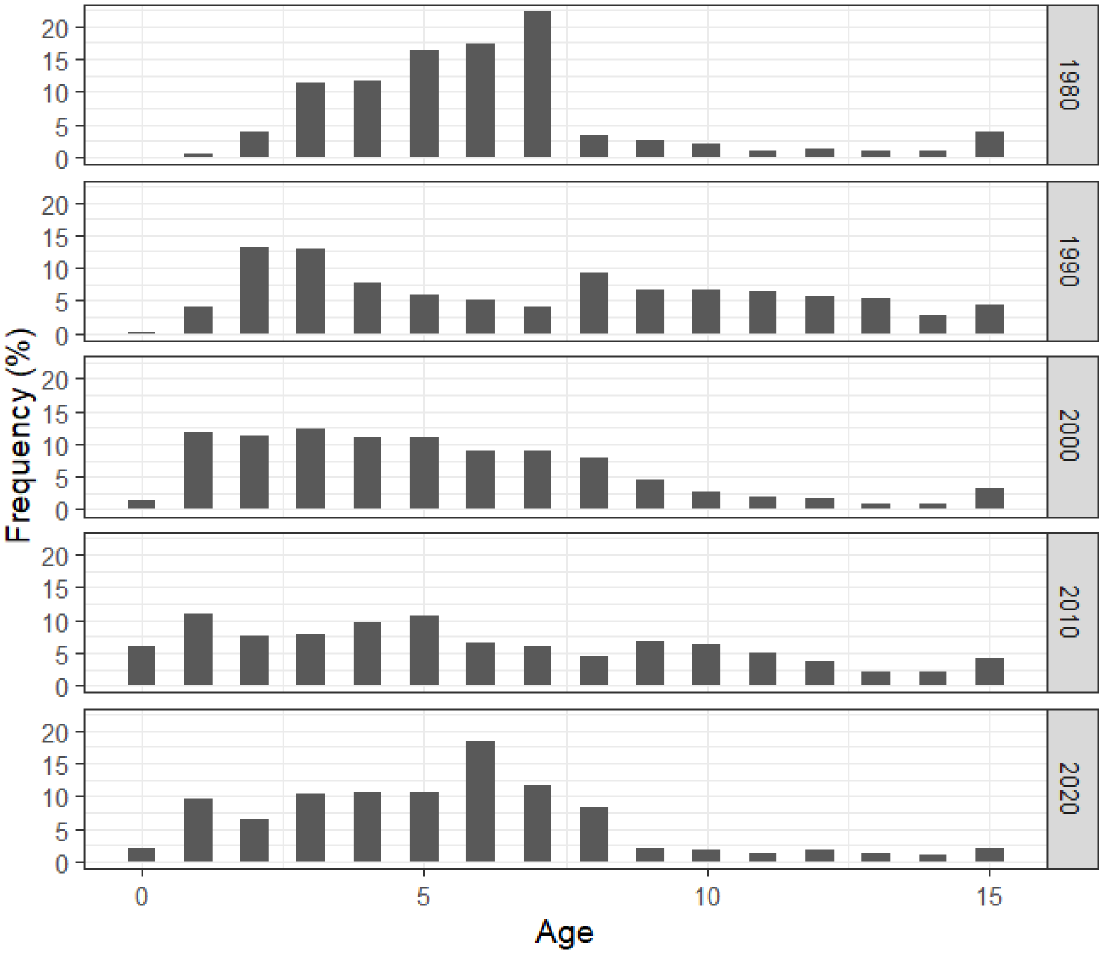


Figure 7.2.10.4: Western horse mackerel. Catch numbers at age composition by decade (*year* specifies start of decade i.e., 1980 = 1980-1999, also note that 2020 only includes years 2020-2022).

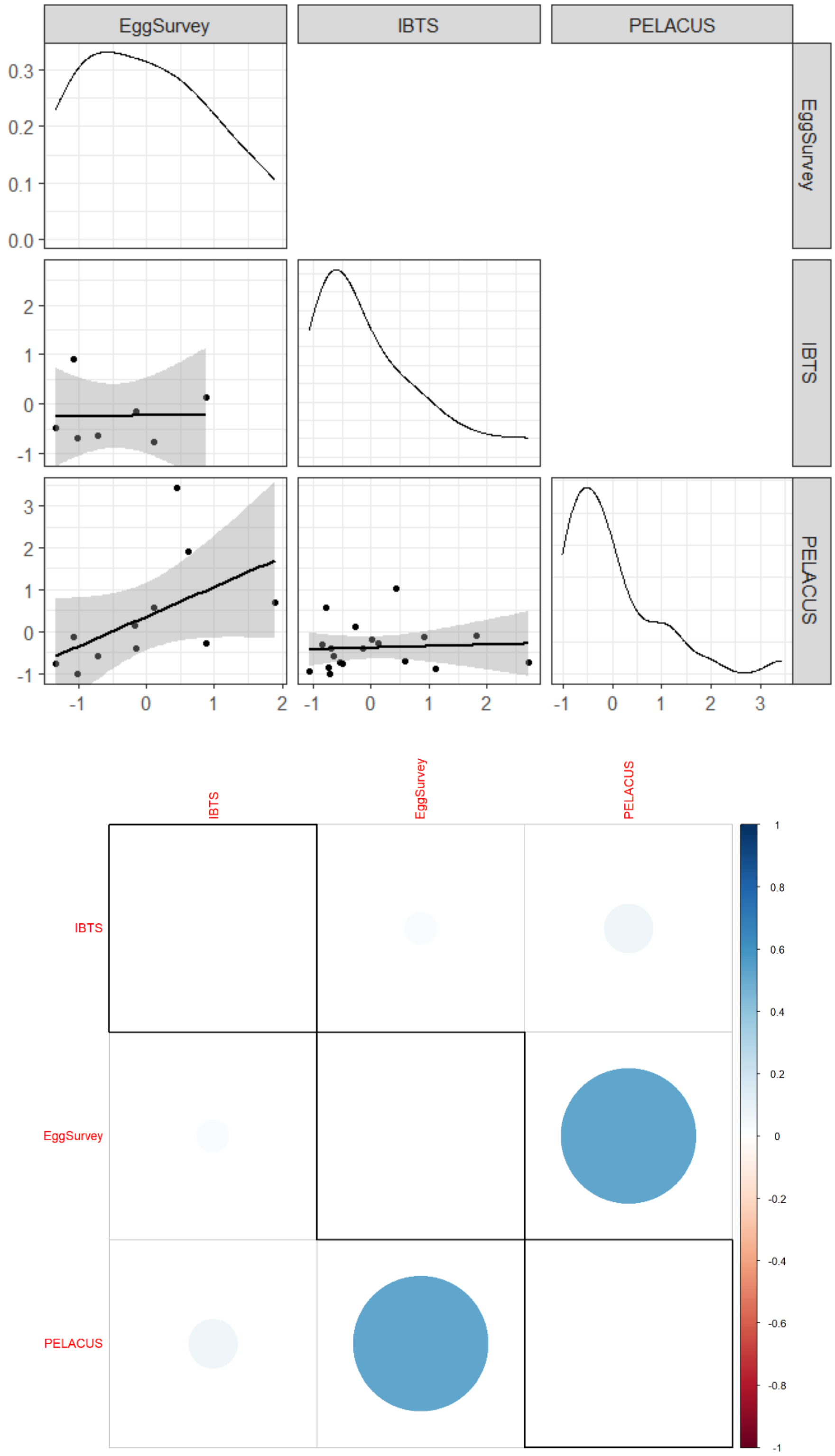


Figure 7.2.10.5: Western horse mackerel. Data exploration. Correlation plots between indices of abundance (including 2022 data points). Size and shade of circle indicates magnitude of correlation and color indicated sign (blue positive, red negative).

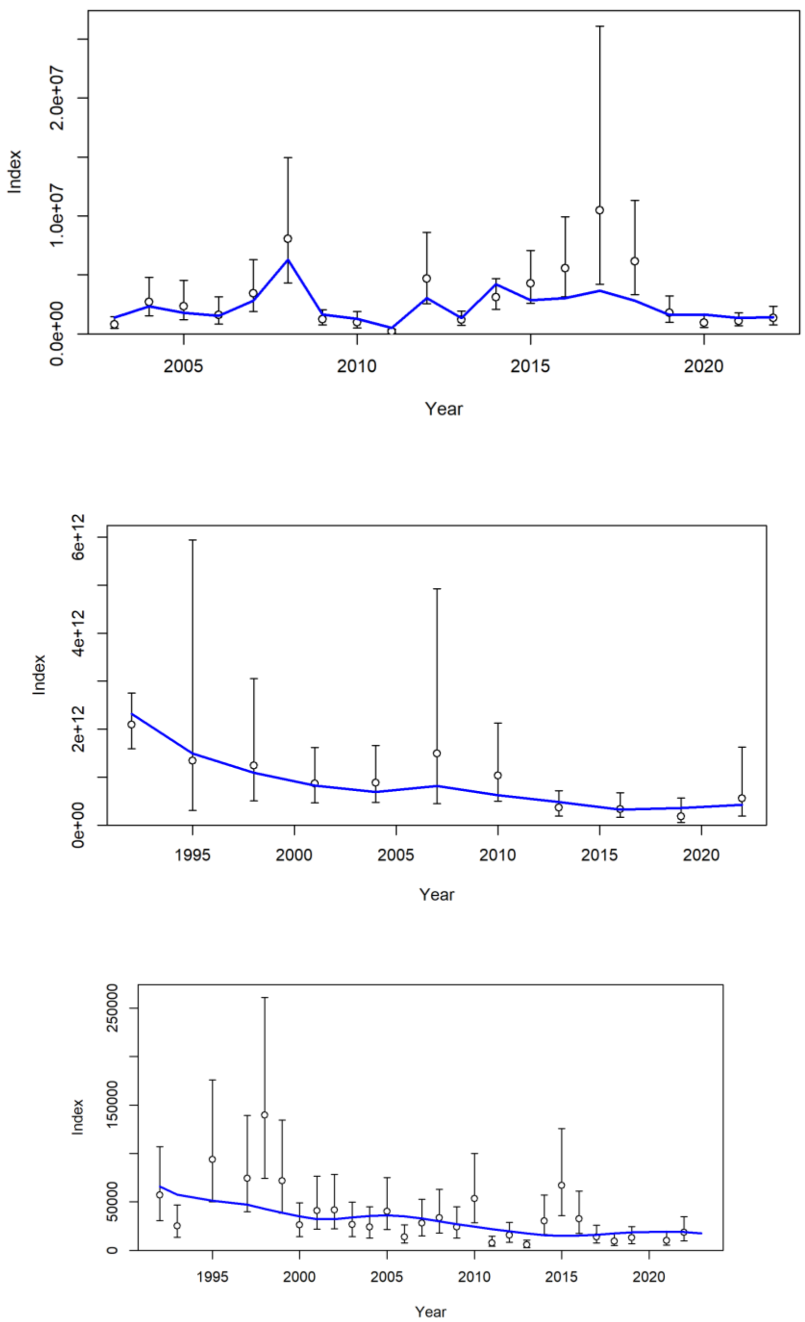


Figure 7.2.11.1: Western horse mackerel. Model fitting. Fitting of the model to the fisheries-independent indices. From top to bottom: IBTS, egg survey, PELACUS. Dots represent observations (with confidence intervals) and blue line the model.

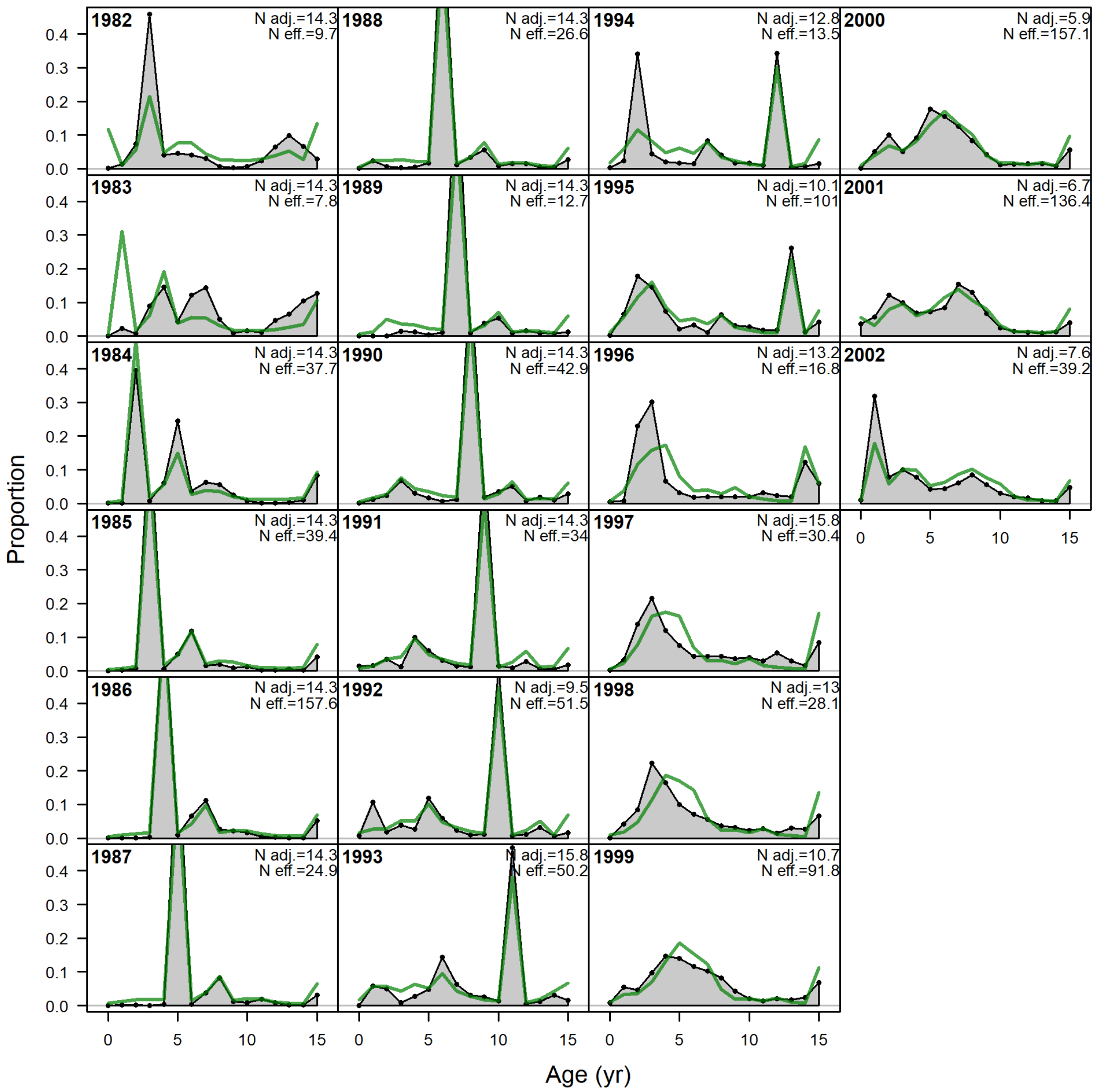


Figure 7.2.11.1 cont.: Western horse mackerel. Model fitting. Fitting of the model to the catch at age matrix from 1982 to 2002. Black joined dots represent observations and green line represents model.

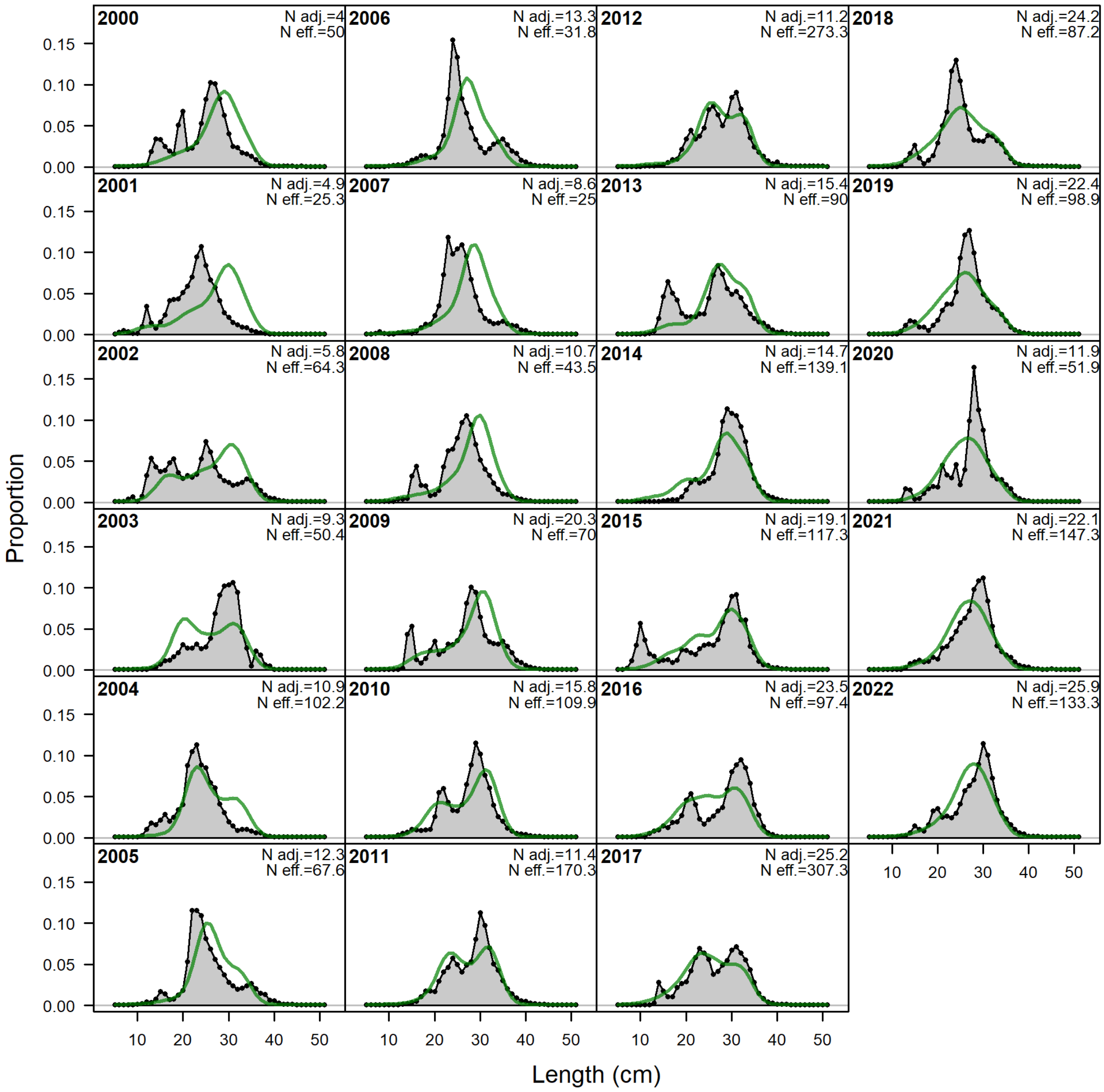


Figure 7.2.11.1 cont.: Western horse mackerel. Model fitting. Fitting of the model to the length composition of the landing data from 2000 to 2022.

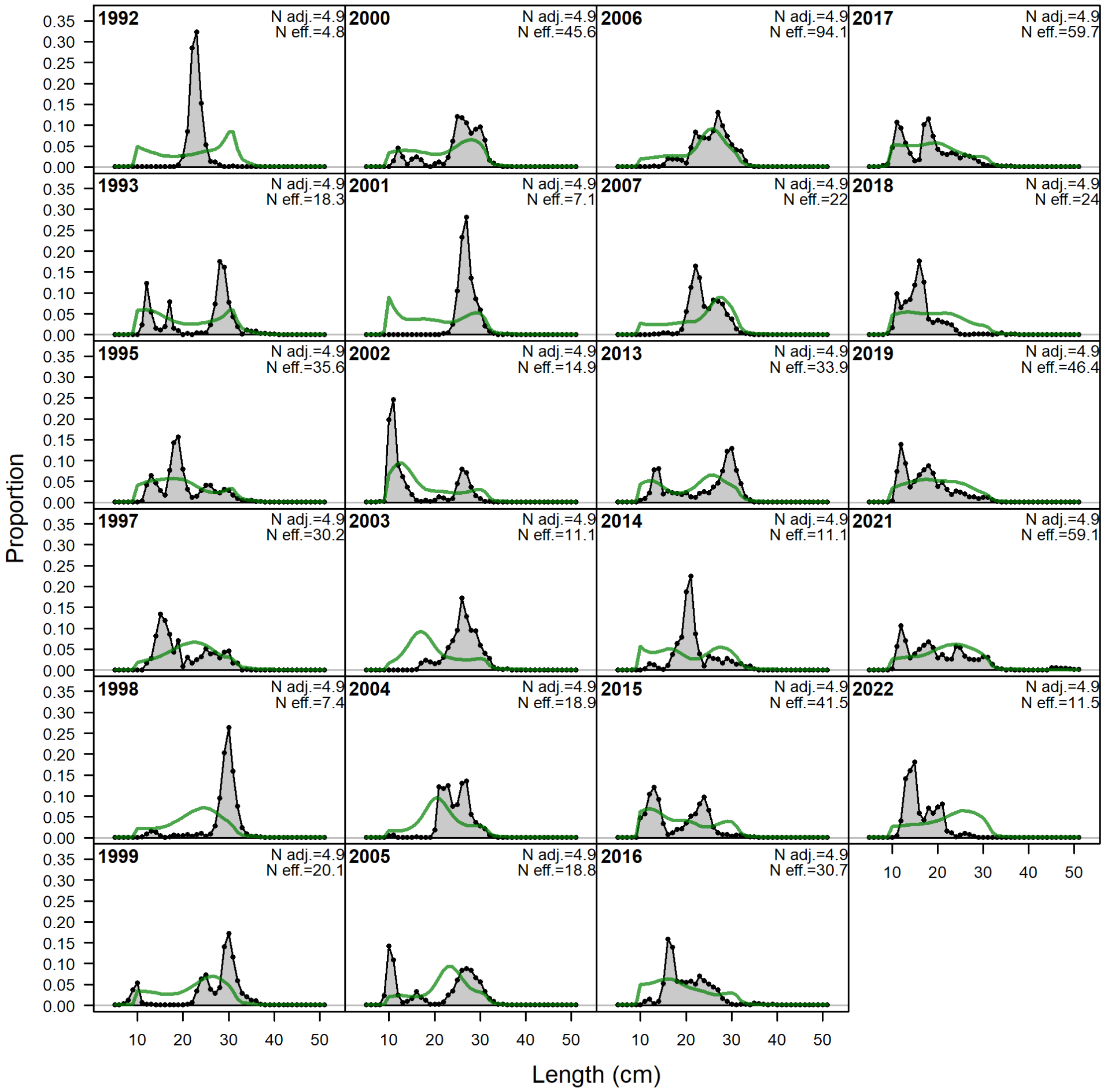
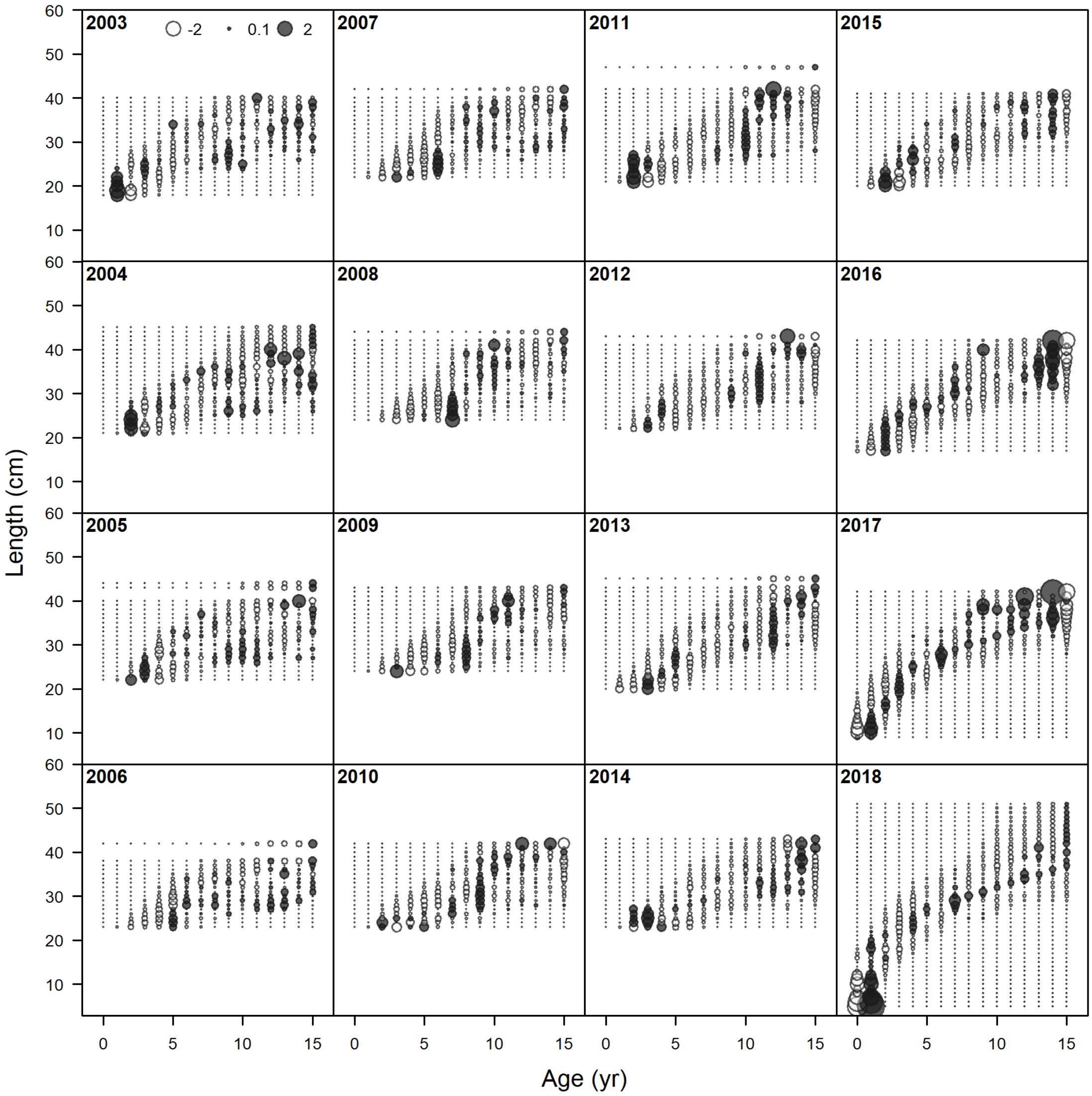


Figure 7.2.11.1 cont.: Western horse mackerel. Model fitting. Fitting of the model to the length composition of the acoustic survey.


2003
-2
0.1
2
2007
2011
2015
2004
2008
2012
2016
2005
2009
2013
2017
2006
2010
2014
2018
Length (cm)
Age (yr)
60
50
40
30
20
10
0
5
10
15

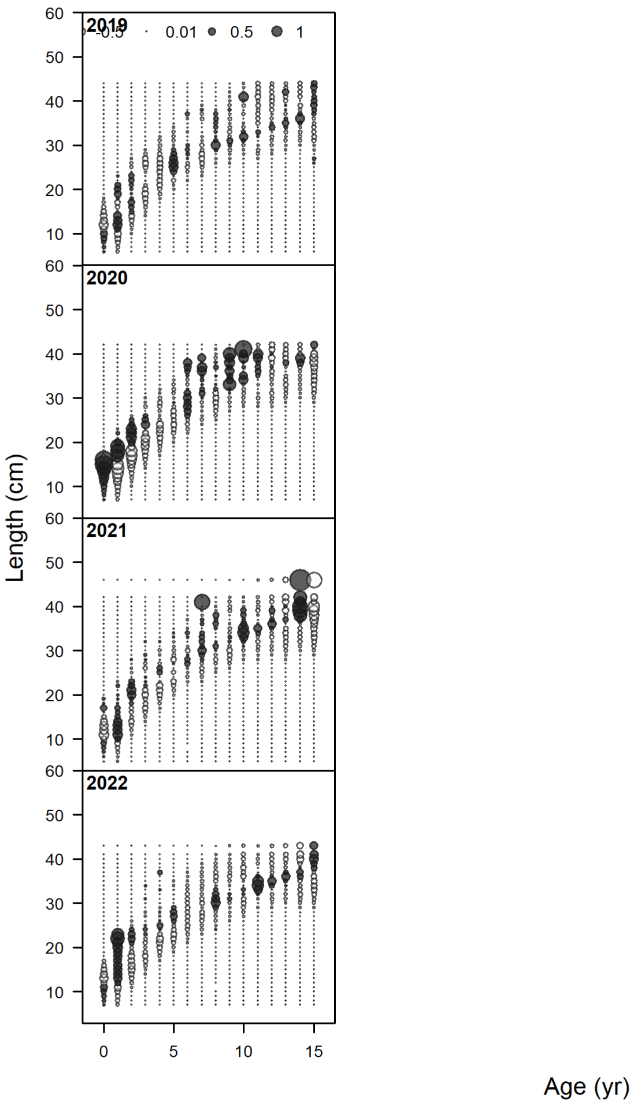
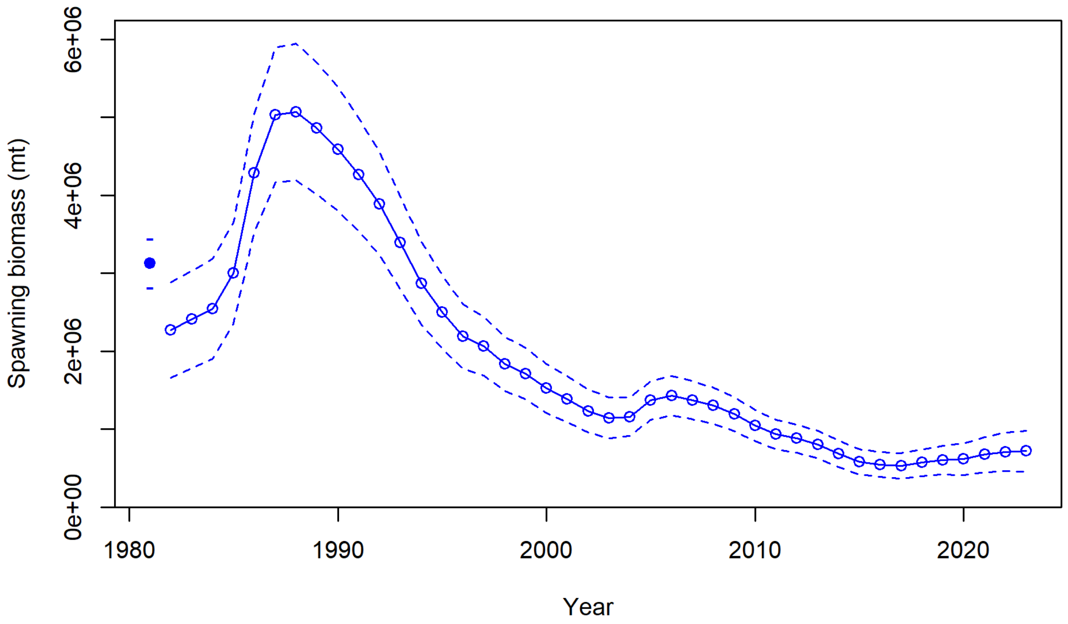


Figure 7.2.11.1 cont.: Western horse mackerel. Model fitting. Fitting of the model to the Age length comp of the catch.



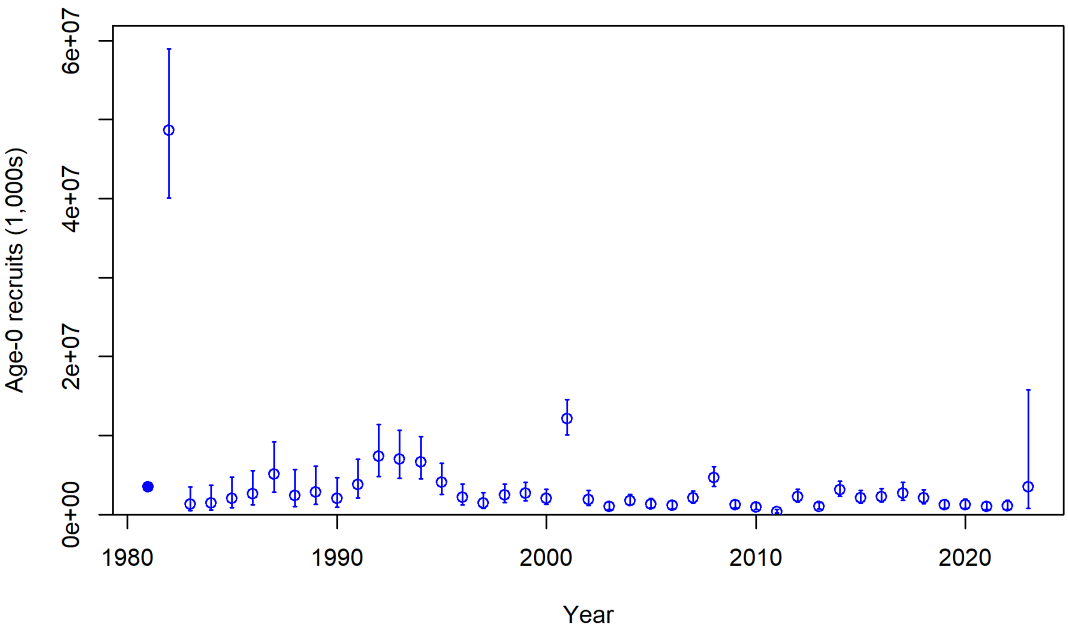


Figure 7.2.11.2: Western horse mackerel. Model results. Spawning stock biomass (0.5 of the overall SSB only is shown; plot on the top) and recruitment estimates (plot on the bottom) from the assessment model from 1982 to 2023. 95% CI are shown. Note this figure is a standard SS output. Whilst the y-axis denotes spawning biomass in mt, the axis values reflect the actual (data) values. Therefore, the axis values should be between 0 and 6 to correspond to the axis title.

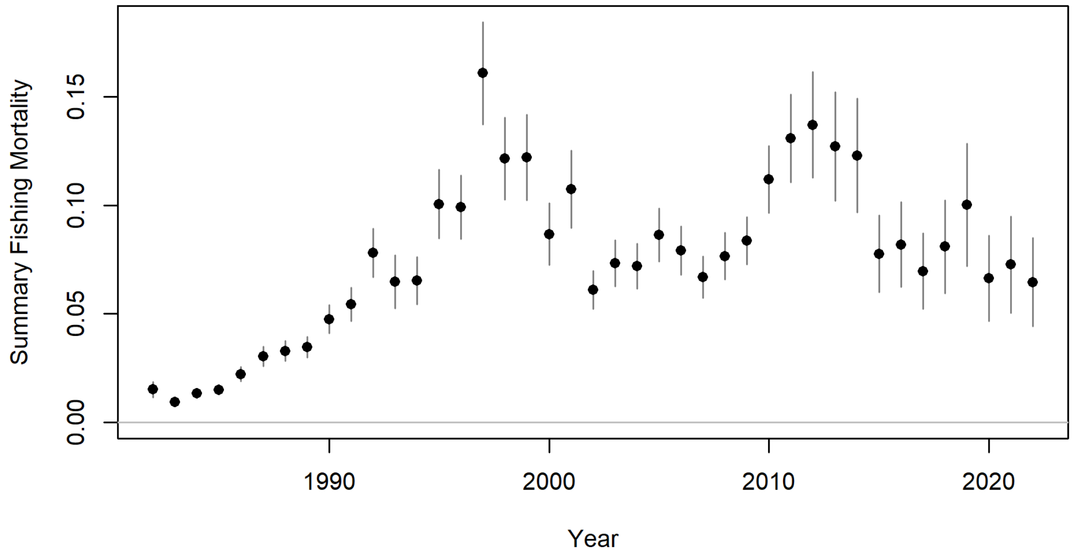


Figure 7.2.11.2 cont.: Western horse mackerel. Model results. Fishing mortality estimates (Fbar ages 1-10) from the assessment model from 1982 to 2022. 95% CI are shown.

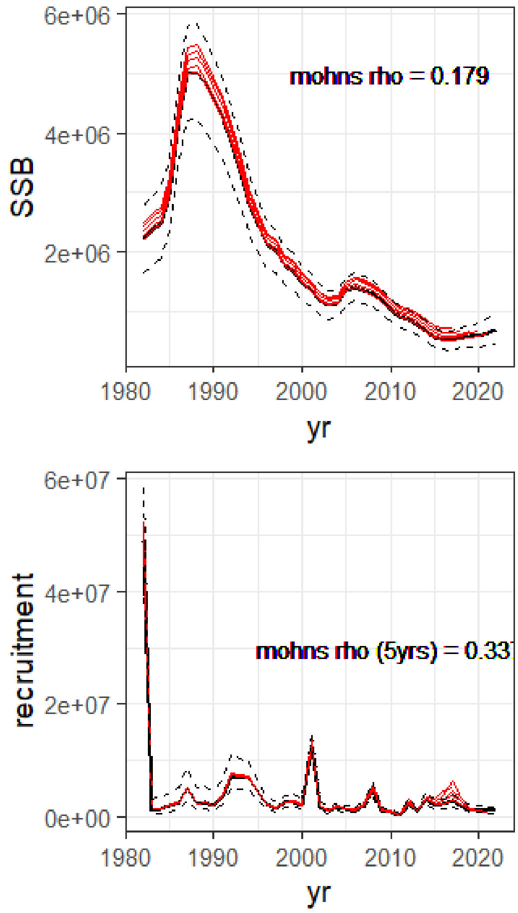


Figure 7.2.11.3: Western horse mackerel. 5 years of retrospective analysis for SSB, F and Recruitment. Dash lines are the 2023 assessment confidence intervals.

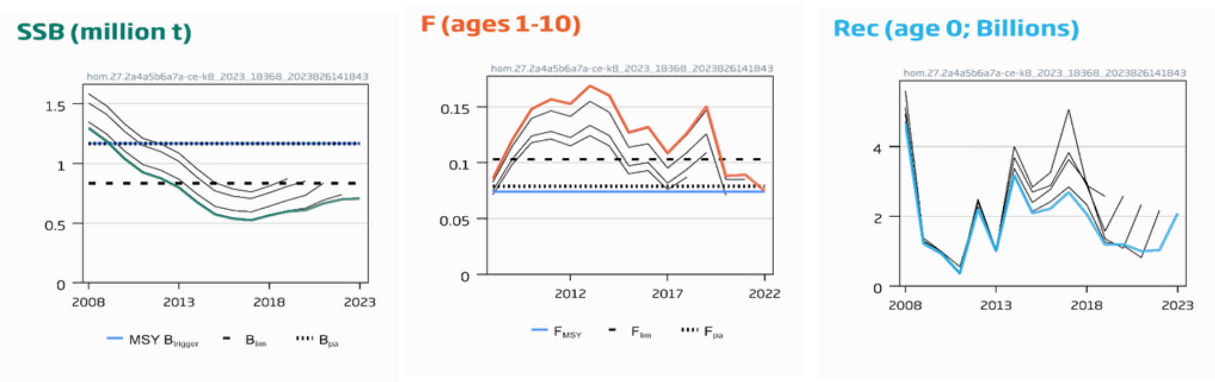
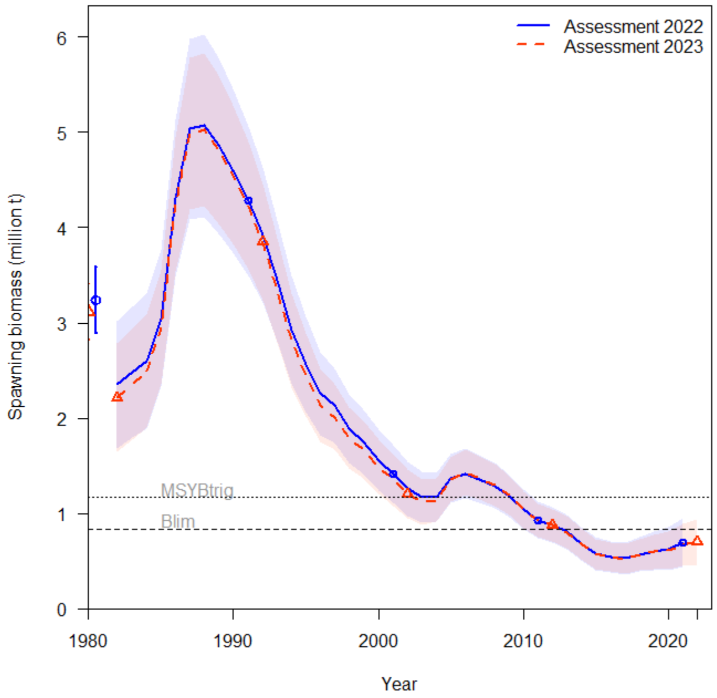


Figure 7.2.11.4: Western horse mackerel. Historical model assessment results.

Figure 7.10.1. Western horse mackerel. Top: comparison of (max) scientific advice, TAC (or sum of unilateral quota) and Total Catch. Bottom: percentage deviation from ICES advice, CoA is Catch over Advice, ToA is TAC over Advice.



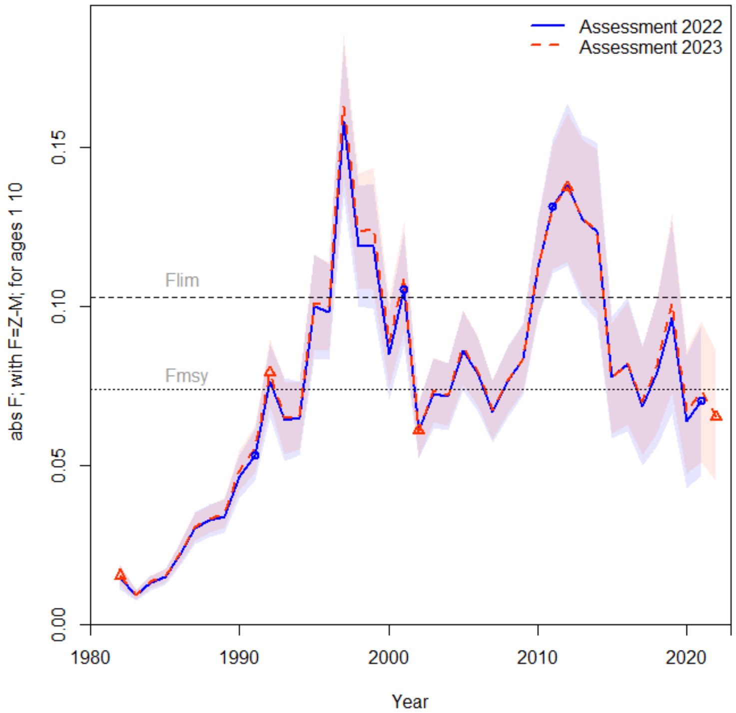


Figure 7.13.1. Sensitivity of the model to new data. Spawning biomass and fishing mortality (ages 1-10) as estimated in the model conducted in 2022 (in blue) and in 2023 (in red).

8 Mackerel in Northeast Atlantic and adjacent waters

Scomber scombrus in subareas 1–8 and 14 and division 9.a (mac.27.nea)

8.1 ICES advice and international management applicable to 2022

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 was reached among the Coastal States on the sharing of the mackerel quotas. In 2014, three of the Coastal States (European Union, Norway and the Faroe Islands) agreed on a Management Strategy for 2014 to 2018. In November 2018, the 2014 agreement was extended for a further two years until 2020. No agreement on the share of the stock has been reached since 2021. Despite various agreements, the total declared quotas in each of the years 2015 to 2022 all exceeded the TAC advised by ICES. An overview of declared quotas and transfers for 2023, as available to WGWIDE, is given in the text table below. An estimate of the expected quota uptake in 2023 was carried out based on the declared quotas by nation including transfer from previous year, and an estimation of uptake for the remainder of the year. This was based on the fishery up to the end of August 2023 and knowledge of the fishery development from September to December in the last two years. Total removals of mackerel are expected to be approximately 1.15 million tonnes in 2023, exceeding the ICES advice for 2023 by approximately 365 341 tonnes (47%).

The quota figures and transfers in the text table below were based on national regulations as reported to NEAFC and discard estimates.

Estimation of 2023 catch (t)	Declared quotas [1]	Transfer from previous year [1]	Sum	Expected uptake [2]	Justification
EU	177,048		177,048	177,048	Full uptake
Faroe Islands	153,285	66,700	219,985	200,000	Faroese expected catch [3]
Greenland	50,834		50,834	34,000	Greenland expected catch [3]
Iceland	125,311	18,728	144,039	140,000	Icelandic expected catch [3]
Norway	249,870	14,119	263,989	263,989	Full uptake
Russia	118,000		118,000	118,000	Full uptake
UK	210,814		210,814	210,814	Full uptake
Discards [4]	3,556		3,556	3,556	Full uptake
Total expected catch (incl. discards) [5]				1,147,407	tonnes

[1] **Quotas as reported to NEAFC by each party for 2023 and include exchange to other parties.**
[2] **Expected uptake in 2023 excluding any exchange/transfer to other parties.**
[3] **The uptake of mackerel in 2023 was estimated to follow a similar development in the fishery for the remainder of the 2023 season as in the last two years.**
[4] **Previous years estimate.**
[5] **No estimates of banking from 2023 to 2024 are available.**

8.2 The fishery

8.2.1 Fleet Composition in 2022

The total fleet can be considered to consist of the following components: freezer trawlers, purse seiners, pelagic trawlers, lines and jigging, and gillnets (see stock annex for detailed description of each component).

8.2.2 The fishery in 2022

The 2022 fishery includes catch from 18 countries. Catches per ICES statistical rectangle are shown in Figures 8.2.2.1 to 8.2.2.4. 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.

Of the total catch in 2022, Norway accounted for the greatest proportion (28%) followed by Scotland (15%), Faroes (13%), Iceland (12%) and Russia (10%) (Table 8.2.2.1). In the absence of sharing arrangements, the fishing parties declared unilateral quotas for 2022.

In 2022, catches in the northern areas (Subareas 1, 2, 5, 14) remained high and amounted to 571 403, a decrease from the high of 663 111 tonnes in 2021 (see Table 8.2.2.1). Norwegian catches were over 290 kt and Icelandic, Russian, Scottish and Faroese catches were all over 100 kt. Catches from Division 2.a accounted for 54% of the total catch in 2022. The wide geographical distribution of the fishery noted in previous years has continued. In 2022 there was only a small amount of catch from southern Iceland with the fishery moving further east and north into the International zone. There were low catches of around 100 tonnes from Subarea 14 and a reduced fishery in Subarea 5.

The time series of catches by country from the North Sea, Skagerrak and Kattegat (Subarea 4, Division 3.a) is given in Table 8.2.2.2. Catches in 2022 increased to over 353 kt from 221 340 tonnes in 2021. The majority of the catch is from Subarea 4. 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) decreased again in 2022 to under 90 000 t. This is a decrease of around 75 000 t from 2021. The catches are detailed in Table 8.2.2.3.

Table 8.2.2.4 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 in 2022 of 32 264 is similar to the 2021 catch of 31 928 tonnes.

8.2.3 Quarterly Distribution of the catch

The proportion of the catches by quarter (%) is presented in Table 8.2.3.1 and figure 8.2.3.1.

The quarterly distribution of catch from 2010- 2022 is similar to recent years with the northern summer fishery in Q3 accounting for the greatest proportion of the total catch. The average proportion taken in quarter 3 from 2010-2022 is 48%. In 2022 this proportion increased to 58% and is higher than the quarter 1 and quarter 4 catches which when combined account for 36% of the total. The proportion of the catch taken in quarter 2 has remained stable.

- First quarter 2022 (188 172 tonnes – 18%)

The distribution of catches in the first quarter is shown in Figure 8.2.2.1. The proportion of the fishery taken in quarter 1 has decreased in 2022 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 2022 (57 159 tonnes – 6%)

The distribution of catches in the second quarter is shown in Figure 8.2.2.2. The quarter 2 fishery is traditionally the smallest and this was also the case in 2022. Quarter 2 is the start of the summer fishery in northern waters by Icelandic, Norwegian and Russian fleets in Division 2.a. There are also significant catches taken in Division 8.c.

- Third quarter 2022 (610 648 tonnes – 58%)

Figure 8.2.2.3 shows the distribution of the quarter 3 catches. Large catches were taken throughout Division 2.a, with high concentrations in international waters. Fishing was carried out mainly by vessels from Russia, Norway, Iceland, the Faroes and Greenland. There were also catches from Division 4.a but very little from Division 5.a.

- Fourth quarter 2022 (190 741 tonnes – 18%)

The fourth quarter distribution of catches is shown in Figure 8.2.2.4. The proportion of the catch taken in the fourth quarter has decreased to 18% 2022. The summer fishery in northern waters has largely finished with some catches reported from Division 2.a. The largest catches in quarter 4 are taken by Scotland around the Shetland Isles in Division 4.a.

8.3 Quality and adequacy of sampling data from commercial fishery

The sampling of the commercial catch of Northeast Atlantic mackerel in table 8.3.1. Overall sampling effort in 2022 was higher than 2021 with 88 % of the catch sampled. Nations with large, directed fisheries are capable of sampling 100 % of their catch which may conceal deficiencies in sampling elsewhere.

The 2022 sampling levels by country are shown in table 8.3.2. The majority of countries achieved a high level of sampling coverage. Belgian catches consist of 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. Belgium, Denmark, Sweden, Greenland, Northern Ireland and Poland did not supply sampling information in 2022. Portugal sampled landings from 9.a only. England sampled landings from the handline fleet operating off the Cornish coast as well as from freezer trawlers. Cooperation between the Dutch and German sampling programmes is designed to provide complete coverage for the freezer trawlers operating under these national flags and also those of England and France.

Catch sampling levels per ICES Division (for those with a WG catch of >100 t) are shown in table 8.3.3. 94% of the total catch is taken in divisions 2.a, 4.a and 6.a and these areas are well sampled. In general, areas with insufficient sampling have relatively low levels of catch.

8.4 Catch data

8.4.1 ICES Catch Estimates

Total Catch 2022

The total ICES estimated catch for 2022 was 1 046 720 tonnes which represents a decrease from 1 081 540 tonnes in 2021.

The combined 2022 estimated catch uptake, arising from agreements and autonomous quotas, and transfers amounted to 1 131 416 tonnes. The ICES catch estimate (1 046 720 tonnes) represents an undershoot of this and is still above the ICES advice of 794 920 tonnes for 2022. The combined fishable TAC for 2023, as best ascertained by the Working Group (see Section 8.1), amounts to 1 147 407 tonnes.

Catches reported for 2022 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 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. A detailed basis for the ICES catch estimates is presented in the stock annex.

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 that the estimates for these areas are incomplete. In 2022, discard data for mackerel were provided by France, Germany, Ireland, Spain, Denmark, England, Scotland and Sweden. Total discards amounted to 3 556 tonnes which is a small increase from 2021 (3 129 tonnes). The German, Dutch 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.

8.4.2 Catch at Age

This catch in numbers relates to a total ICES estimated catch of 1 046 720 tonnes. 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 England, Germany, Faroes, Iceland, Ireland, the Netherlands, Norway, Portugal, Scotland and Spain. There remain gaps in the age sampling of catches, notably from France (length samples were provided), Belgium, Sweden, Denmark, Greenland, Northern Ireland and Poland.

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 catch numbers at age show a number of strong year classes in this fishery. Over 81 % of the catch in numbers in 2022 consists of 2 to 10-year olds with the 2016-year class again being the strongest. The 2016 year-class was strong in the fishery in previous years and accounted for 14% of the catch numbers at age in 2021. The 2019-year class, which are now 3 years old accounts for 11% of the catch numbers at age and were also strong as 2 year olds in the fishery in 2021. The 2015 year-class does not look as strong as the other year classes and represents 7 % of the total. In 2022 there was a significant increase in the proportion of fish in the plus group. The plus group now represents 12% of the catch numbers at age, an increase from 7% in 2021. The big 2010 year class is now in the plus group and contributes to this increase.

There is a small presence of juvenile (age 0) fish within the 2022 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 length-at-age in the catch for 2022 is 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. The range of lengths recorded in 2021 for 0 group mackerel is 16.5 cm-27.8 cm. The rapid growth of 0-group fish combined with variations in sampling between northern and southern areas 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).

8.5.2 Weights at Age in the Catch and Stock

The mean weight-at-age in the catch for 2022 are given in Table 8.7.1.3. There is a trend towards lighter weight-at-age for the most age classes (except 0 to 2 years old) starting around 2005, continuing until 2013 (Figure 8.5.2.1). This decrease in the catch mean weight-at-age seems to have stopped since 2013 and values for the last seven 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). In 2022, however, the mean weight-at-age in the catches have decreased for all ages compared to 2021.

The Working Group used weight-at-age in the stock calculated as the average of the weight-at-age in three areas, corresponding to definition of the former spawning components, weighted by the relative mackerel biomass in each area (as estimated by the 2022 egg survey for the southern and western areas and the 2017 egg survey for the North Sea area). Mean weight-at-age in 2022 for the western area 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, 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 weight-at-age in the western spawning area. For the North Sea area, mean weight-at-age in 2022 were calculated from samples of the commercial catches collected from Divisions 4.a and 4.b in the second quarter of 2022. Stock weights for the southern area, are based on samples from the Spanish catches and surveys in Divisions 8.c and 9a in the 2nd quarter of the year. The mean weights in the three area and in the stock in 2022 are shown in table 8.5.2.

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 8 years show an increasing trend (except for weights of ages 0 and 1 which have been stable, Figure 8.5.2.2). The mean weight in the stock do not show, contrary to the mean weights in the stock, any specific decrease from 2021 to 2022.

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 2022 was calculated as the average of the ogives of the three areas weighted by the relative biomass of mackerel in these areas, calculated as described above for the stock weights. The ogives for the North Sea and Southern areas are fixed over time. For the Western area the ogive is updated every year, using maturity data from commercial catch samples from Germany, Ireland, the Netherlands and the UK collected during the first and second quarters (ICES, 2014 and Stock Annex). The 2022 maturity ogives for the three areas and for the mackerel stock are shown in the table 8.5.3.

A trend towards earlier maturation (increasing proportion mature at age 2) has been observed from around 2008 to 2015. A change in the opposite direction has been observed after that year until 2018. Since then, there is again a trend towards earlier maturation (Figure 8.5.3.1).

8.6 Fishery independent data

8.6.1 International Mackerel Egg Survey

8.6.1.1 Annual egg production for mackerel in 2022

The Mackerel and Horse Mackerel Egg Survey is an ICES co-ordinated international survey in the North-East Atlantic. The survey is a combined plankton and fisheries survey which has been conducted triennially since the late 1970s under the coordination of the ICES Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS).

The main objective is to estimate a Northeast Atlantic mackerel biomass index and a Western horse mackerel egg abundance index using the Annual Egg Production Method (AEPM) during this series of individual cruises from January to July.

Plankton and fecundity samples were analysed according to sampling protocols described in the WGMEGS survey manual (ICES, 2019a) and fecundity manual (ICES, 2019b).

Mackerel egg production (using stage I mackerel eggs) is used in combination with AEPM fecundity parameters to estimate SSB.

The 2022 survey was divided into 6 separate sampling periods. A total of 16 individual cruises have been conducted during 2022. More details can be found in the working paper (WD10: Costas et al. 2023) presented at the WGWIDE 2023 meeting and in the WGMEGS 2023 report (ICES, 2023).

Maps of the distribution of daily egg production for the western and southern areas and the area covered are shown in Figure 8.6.1.1.1. The distribution and timing of mackerel spawning peaks have remained fairly stable in recent surveys. In 2022, spawning peak occurred during the period 5 (Figure 8.6.1.1.2). In 2022 the western and northwestern expansion observed in periods 5 and 6 in 2016 was reported again. (WD10 Costas et al., ICES, 2023), The total annual egg production (TAEP) for the western area in 2022 was calculated to be 1.80 * 10^{15}, which is an increase of 47% compared to the TAEP in 2019 in that area. The TAEP for the southern area in 2022 was calculated to be 2.93*10^{14} (Table 8.6.1.1.1). That is a reduction of 30% compared to the 2019 TAEP in that area. TAEP for both the western and southern areas combined in 2022 is 2.093*10^{15}. This is an increase in production of 28% compared to 2019 (Figure 8.6.1.1.3) (Table 8.6.1.1.1).

8.6.1.2 Mackerel fecundity and atresia estimation

Thanks to the cooperation of the pelagic fishing industry (PFA), the number of fecundity samples collected in 2022 (2312) was significantly increased compared to previous surveys. Additional samples for DEPM analysis were collected in periods 3 and 4 (details in ICES, 2023).

Fecundity estimates are presented as realised fecundity, which is the potential fecundity minus the atresia rate. Relative potential fecundity in 2022 was 1313 oocytes/ g. female fish, slightly higher than the estimates for 2019 (Table 8.6.1.2.1). Realised fecundity was estimated using an average 3% atresia rate, which gives an estimate of 1268 eggs /g female fish in the year 2022 (Table 8.6.1.2.1). (see WD10Costas et al. 2023 for details)

8.6.1.3 Mackerel biomass estimates.

The total spawning stock biomass (SSB) using the AEPM, resulted in an estimated SSB of 3,065 Mt for the western area and 0.499 Mt for the southern area (see Table 8.6.1.1.1). Combining these two areas gives a total of 3.563 Mt, which represents an 18% increase compared to the SSB estimate in 2019 (Figure 8.6.1.3.1).

8.6.1.4 2022 North Sea mackerel egg survey

In 2022, a DEPM North Sea mackerel egg survey was carried out in June by Denmark, England and Norway (Figure 8.6.1.4.1). The survey covered the entire spawning area of the North Sea. The spatial distribution of stage Ia eggs was similar to that of 2021, but egg numbers appeared to be more evenly distributed. No clear pattern in egg densities was observed in the survey. (Figure 8.6.1.4.2) The total survey area in 2022 was slightly smaller than in 2021, with an estimated spawning area of 371126 km2. The total daily egg production for 2022 was 0.6909*10^{13} eggs/day (Table 8.6.1.4.1). This is a decrease of 50% compared to the number of eggs reported in 2021 (Table 8.6.1.4.2), see WD10 Costas et al. 2023 and ICES, 2023 report for more details. The results for the DEPM fecundity parameters should be considered as very preliminary as a full review of the application of the daily method to mackerel will be carried out at WKMADE in November 2023.

8.6.2 Demersal trawl surveys in October – March (IBTS Q4 and Q1)

8.6.2.1 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 NEA mackerel stock annex.

The data were compiled from several bottom trawl surveys conducted between October and March from 1998-2023 by research institutes in (Denmark, England, France, Germany, Ireland, Nederland, 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), although several of the surveys use different names. 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, 2013b). 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.

No estimation of the 2021 cohort was done because of cancellation of essential Scottish surveys. All surveys in 2022 Q4 and 2023 Q1 were conducted according to standards, so the 2022 cohort could be estimated. Figure 8.6.2.1.1 provides an overview of the distribution and number of samples.

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.

8.6.2.2 Results

The index of survivors in the first autumn-winter (recruitment index) was updated with data from surveys in 2022 Q4 and 2023 Q1. Parameter estimates and standard errors in the final model are listed in Table 8.6.2.1. The modelled average recruitment index (squared CPUE) surfaces were mapped (Figure 8.6.2.2.1) and the time series of spatially integrated recruitment index values (Table 8.6.2.2) is used in the assessment as a relative abundance index of mackerel at age 0 (recruits). The estimated index value for the 2022 year class is below the previous 5 values, closer to the mean of the time series (Figure 8.6.2.2.2).

8.6.2.3 Discussion

The model is being refitted to the entire dataset during the update each year. All index values will therefore be slightly different from year to year, but with the same interannual pattern. This does not affect the stock assessment because it is used in the assessment as a relative abundance index.

The combined demersal surveys have incomplete 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, (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 NS-IBTS in Q1 should be extended to include the south-western Norwegian shelf and shelf edge in proximity to the Norwegian trench.

Finally, WGWIDE encourage studies of vertical distribution and catchability of age-0 mackerel in the Q4 and Q1 surveys, to evaluate if it is comparable in all areas (see acoustic information in Jansen et al., 2015).

8.6.3 International Ecosystem Summer Survey in Nordic Seas (IESSNS, A7806)

IESSNS is the only annual survey providing data used in the assessment and covers summer feeding distribution of mackerel age 3+ in Nordic Seas. The survey was successfully conducted in 2023. Major survey results worth mentioning is that survey coverage retracted 19% compared to 2022 as Greenlandic waters were not survey, strata 10 and 11, and mackerel distribution south of Iceland was limited to latitude 62°N in the Iceland basin and on the Reykjanes ridge. The zero-line for mackerel abundance was reached for the part of the survey area located north of latitude 60°N, but not on the European shelf, where mackerel are present west of the British Isles and in the southern North Sea. Value of the mackerel index was not impacted by extremely large catches as occurred in 2022. Western part of the Norwegian Sea (stratum 9) five surface trawl stations were added during the survey at a shorter distance than used between other stations in that strata to find the boundary of the mackerel distribution. However, these additional stations were excluded when calculating the age segregated abundance index which is opposite to what was done in 2022. Furthermore, part of Faroese waters, northern Norwegian Sea by Bear island, and west of Iceland were under sampled as four predetermined surface stations were not sampled due to lack of survey time and mechanical vessel issues, see details in the cruise report. The IESSNS cruise report is available as a working document to this report (WD01) and a detailed survey description is available in the mackerel Stock Annex.

The main results are that estimated total stock abundance and total biomass declined 42% compared to 2022. Most of the surveyed mackerel are still distributed in the Norwegian Sea. However, they were more easterly and northeasterly distributed compared to 2022. The distribution of mackerel in the Norwegian Sea retracted compared to the last decade, particularly withdrawal from the northernmost part was observed. Internal consistency increased compared to 2022, particularly for ages 5-8 years which had lower consistency than other ages in 2022. Abundance estimates by age are displayed in input data for the assessment (Table 8.7.1.9). Figures 8.6.3.1-2 display estimates of total stock abundance and stock biomass with confidence intervals for the time series. Figures 8.6.3.3-4 show the internal consistency and catch curves for abundance at age from 2012 to 2022. Figures 8.6.3.5-6 display swept area trawl catch rate and mean mackerel density per rectangle for 2023, and mean mackerel density per rectangle for years 2010 and from 2012 to 2023.

Analytical work to develop index calculation method less sensitive to extreme catches was undertaken at ICES Working Group on Improving use of Survey Data for Assessment and Advice (WGISDAA) at their annual meeting in October 2022. The report from the meeting has not yet been published. The meeting did not provide an alternative method for index calculation, therefore the StoX framework was used for index calculation in 2023 as in previous years.

8.6.4 Tag Recapture data

Information from steel tagging experiments conducted by Institute of Marine Research in Bergen (IMR) on mackerel at spawning grounds west of Ireland and British Isles in May-June and the respective recaptures at Norwegian factories with metal detectors (Tenningen et al. 2011) was introduced to the mackerel assessment during ICES WKPELA 2014 (ICES, 2014). Data from release years 1980-2004, and recapture years 1986-2006 have been used in the update assessments following this benchmark. From 2011 onwards IMR changed tagging methodology to radio-frequency identification (RFID), more specifically passive integrated transponder tags (PIT-tags). This allowed for more automated data processing with recaptures from scanned landings at factories also outside Norway now being updated in real time to an IMR database over internet.

The data format is the same for both tag types; a table containing the numbers of tagged fish per year class in each release year, and the corresponding numbers scanned and recaptured of the same year classes in all years after release. The RFID data is a separate time series with a different scaling factor (survival) than the steel tags, and it has been used in update assessments following the ICES WKWIDE2017 benchmark (ICES, 2017). For steel tags data from ages 2-11 and all recapture years are used in the assessment. During the 2017 benchmark it was decided to use the same filtering for the RFID data from release year 2011 onwards. However, following decisions made during ICES IBPNEAMac 2019 (ICES 2019c) update assessments are now only using RFID data from release years 2013 onwards, ages 5-11 and recapture year 1 and 2 after release for reasons described below.

During 2011-2019, most of the mackerel were tagged off Ireland, only a minor part farther north of The British Isles, whereas in the years 2020-2023 most of the fish were tagged off the British Isles (Figure 8.6.4.1). The scanned landings and recaptures in time and space changed from 2014 onwards when Iceland and Scotland installed scanners and a larger part of the fishery was covered (Figures 8.6.4.2-3). The numbers recaptured have increased significantly over the years. This is a result of an increasing tagged population, higher biomass scanned as well as a reduced stock. The recaptures are stemming from a wide range of factories, some contributing with more recaptures, which is mainly linked to the biomass scanned (Figure 8.6.4.4). Note that the exclusion of recapture years 3 and longer after release is due to potential tag loss over time. The exclusion of release years 2011-2012 is mainly based on the change with more scanners from 2014 onwards. The exclusion of ages 1-4, was mainly because the tagged numbers of these age groups were relatively few early in the time series compared with the scanned fish year 1 and 2 after release, leading to some noise in the data. However, the age structure of tagged and scanned fish year 1-2 after release has developed over time series to be more overlapping, and high proportions of tagged mackerel are now at ages 2-4 (Figure 8.6.4.5), implying a potential to also include data from the younger ages in future assessments.

It is difficult to grasp any trends in the raw data of released, scanned and recaptured mackerel used as input to the stock assessment. Hence, we also describe the trend in these data as indices of year class abundance and biomass. The trends in year class abundance indices from RFID data based on recaptures year 1 and 2 after release now seem consistent and informative for assessment from ages 2-12 (Figures 8.6.4.6-7). Note that an alternative assessment at WGWIDE 2023 using these indices for the selected ages 5-11 instead of the raw data table resulted in negligible differences in final SSB, but an improved retrospective pattern. Hence, in a future benchmark it should be explored if using such indices rather than the raw data table as input to stock assessment is more meaningful. By doing that we may also have more comparable diagnostics with the other input data. Translating these abundance indices into different age-aggregated biomass indices also show comparable time trend with SSB from WGWIDE 2023 from release years 2013 onwards (Figure 8.6.4.8), yet with a tendency to be lower in the two last years used in the assessment 2020-2021.

The overall conclusion is that the RFID time series seems informative for stock assessment. However, these data show higher total mortality rate signals than the other input data, resulting in higher SSB if excluded from the assessment. Such conflicting trends suggest that year to year variations in assessment and leave out effects may frequently occur in coming years when time series are short. Finally, the new development of the time series suggests that the current filtering of RFID data for use in stock assessment should be revised in a future benchmark. This especially counts for the inclusion of younger ages 2-4 now contributing with a large proportion among the tagged fish.

8.6.5 Other surveys

8.6.5.1 International Ecosystem survey in the Norwegian Sea (IESNS, A3675)

After the mid-2000s an increasing amount of NEA mackerel has been observed in catches in the Norwegian Sea during the International Ecosystem survey in the Norwegian Sea in May (IESNS) targeting herring and blue whiting (Salthaug *et al*. 2019; 2020).

Mackerel was present in the southern and eastern part of the Norwegian Sea in the beginning of May 2023. The spatial distribution of catches in 2023 was similar to 2022, i.e. a lower northward extent than in the period 2008-2021. No further quantitative information can be drawn from these data as this survey is not designed to monitor mackerel.

8.6.5.2 Acoustic estimates of mackerel in the Iberian Peninsula and Bay of Biscay (PELACUS, A2548)

PELACUS survey data was not available for WGWIDE 2023 and therefore, no new information from the Bay of Biscay on mackerel distribution and abundance during spawning time is available.

8.7 Stock assessment

8.7.1 Update assessment in 2023

The update assessment was carried out by fitting the state-space assessment model SAM (Nielsen and Berg, 2014) using the R library *stockassessment* (downloadable at install_github("fishfollower/SAM/stockassessment")) 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 2022 (with a strong down-weighting of the catches for the period 1980-1999) and three surveys: 1) the SSB estimates from the triennial Mackerel Egg survey (every three years in the period 1992-2022), 2) the recruitment index from the western Europe bottom trawl IBTS Q1 and Q4 surveys (1998-2020, 2022) and 3) the abundance estimates for ages 3 to 11 from the IESSNS survey (2010, 2012-2023). 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 2014 and 2022 (age 5 and older at release) 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 abundances at ages 1-11.

The differences in the new data used in this assessment compared to the last year’s assessment were:

- Addition of the 2023 abundance-at-age index from IESSNS.

- Revision of the 2022 SSB index from the mackerel egg survey. The final index value is 8% lower than the preliminary value used in 2022.
- Addition of the 2022 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 2022

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, only the data from the last year of recaptures is given in this report (table 8.7.1.10).

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 estimates different observation standard deviations for young fish and for older fish. Reflecting the suspected high uncertainty in the catches of age 0 fish (mainly discards), the model gives a very poor fit to this data (large observation standard deviation). The standard deviation of the observation errors on catches of age 1 is lower, though still high, indicating a better fit. For the age 2 and older, the fit to the catch data is very good, with a very low observation standard deviation.

The observation standard deviations for the egg survey 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 compared to the catches. The IESSNS age 3 is very poorly fitted in the assessment (high observation standard deviation). Overdispersion of the tag recaptures has the same meaning as the observation standard deviations, but is not directly comparable.

The catchability of the egg survey is 1.13, 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 0.81 for age 3 to 1.65 for age 9. 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 mortality estimate is higher for the steel tags (around 40%) than for the RFID tags (around 18%).

The process error standard deviation (ages 1-11) is moderate as well as the standard deviation of the F and recruitment random walks.

The catchability parameters for the egg survey, recruitment index and post tagging survival appear to be estimated more precisely than other parameters (table 8.7.2.1). The catchability for the IESSNS have a slightly higher standard deviation, except for the catchability of the IESSNS at age 3 which has a much higher standard deviation. Uncertainty on the observation standard deviations is larger for the egg survey, the IESSNS age 3 , for the recruitment index and for the catches at age 1 than for the other observations. The uncertainty on the observation variance estimates is not particularly high, especially for the data sources with the lowest observation variances, which are the most influential on the assessment (Figure 8.7.2.2). Uncertainty on the overdispersion of the tag data is high. The standard deviation on the estimate of process error is low, and the standard deviations for the estimates of F random walk variances of age 0 and 1 are both very high. The uncertainty on the random walk variance for recruitment is very large, indicating that the parameter was poorly estimated. Overall, parameters related to age groups 0 and 1 are estimated with larger uncertainty than other parameters in the model, indicating that the model has difficulties representing the dynamics of these age groups based on the data available.

The estimated AR1 error correlation structure for the observations from the IESSNS survey age 3 to 11 has a high correlation between the errors of adjacent ages (r=0.78), then decreasing exponentially with age difference (Figure 8.7.2.3.). 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 reflected in the high observation standard deviation for this survey.

There are some correlations between parameter estimates (Figure 8.7.2.4):

- Catchabilities are positively correlated (especially for the IESSNS age 4 to 11), and negatively correlated to the survival rate for the RFID tags. This simply represents the fact that all scaling parameters are linked, which is to be expected.
- The observation variance for the recruitment index is inversely correlated to the variance of the random walk of the recruitment. This implies that when the model relies less on the recruitment index, the estimated recruitment time series becomes smoother.
- The parameter related to the magnitude of the correlation in the AR1 matrix for the IESSNS is correlated to the observation variance for this survey, which reflects the fact that a strong correlation for the errors is linked to lower weight of the surveys.

Residuals

The "one step ahead" (uncorrelated) residuals for the catches showed some weak pattern in the residuals, with a prevalence of positive residuals for ages 3 to 10 between 2008 and 2014 (Figure 8.7.2.5). Empirical correlation plot in the residuals shows positive correlations between ages 3 to 12 (Figure 8.7.2.6) which suggest that incorporating a correlation structure in the observation error for the catches might be appropriate. Residuals are of a similar size for all ages, indicating that the model configuration with respect to the decoupling of the observation variances for the catches is appropriate.

The residuals for the egg survey shows a strong temporal pattern with large positive residuals for the period 2007-2010-2013, followed by large negative residuals for 2016, 2019 and 2022. This pattern reflects the fact that the model, based on all the information available, does not follow the trend present in the egg survey, with a steep decline between 2013 and 2016 (when the stock was at its highest according to the assessment model) and the very low 2019 value. The relatively high observation variance for this survey indicates a poor fit with the egg survey due mainly to these observations which point towards a very different direction from the other observations.

Residuals for the IESSNS indices are relatively well balanced for most of the years. Despite the strong drop in the abundances at age in 2018 and 2021, the residuals for these years do not indicate any year effect (e.g. no large residuals of the same sign observed across ages). Correlations between age in the observation errors for this survey are explicitly modelled in the assessment, and as a result, empirical correlations in the one step ahead residuals between ages are low (Figure 8.7.2.7).

Residuals to the recruitment index show no particular pattern, and appear to be relatively randomly distributed in the earlier years, but positive residuals are consistently observed over the last 6 years of data, indicating that the model has difficulties agreeing with this period of sustained high values in the index.

Finally, inspection of the residuals for the tag recaptures (Figure 8.7.2.8) suggest that there is a tendency to have more positive residuals in the RFID tag recaptures for the fish tagged at a young age (age 5 or 6) and more negative residuals for fish tagged at older age (10 and 12 year olds). This pattern may potentially be explained by age related differences in survival after release, or in tag loss. For the steel tags, there is a tendency to have more positive residuals at the end of the period which could indicate that using a constant survival rate for this dataset may not be appropriate.

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 8.7.2.9).

All leave one out runs showed parallel trajectories in SSB and Fbar, except the one leaving out the RFID tag information, which shows a less steep decline in the SSB after 2014 that the other runs and a higher fishing mortality between 2006 and 2017. For recruitment, all runs also resulted in similar trajectories, expect the run without the recruitment index, which recruitment decreased from high levels in the mid-2010s to historical low levels currently.

Removing the IESSNS resulted estimates very close to the base case run, with only some minor difference for Fbar over the period covered by the survey. This behaviour, already observed in 2022, contrasts with what was observed in previous years, where removing the IESSNS index resulted in a markedly smaller SSB estimated, indicating that this survey was pulling stock estimates upwards. This suggests that this survey is becoming increasingly in agreement with the information provided by the catches-at-age, which are the most influential data source.

Removing the recruitment index resulted in lower estimates of SSB over the last 5 years, and, to a lesser extent, higher estimates of Fbar. Without the recruitment index, the estimates of age 0 abundance are only informed by the catch data. As a result, the estimated recruitment for this specific run has a very different trajectory, which – despite the adjustments of year-class strength through the process error as fish become older – has a certain effect on SSB estimates. However, the current model configuration is not appropriate when run without the recruitment index. The remaining data (catch-at-age 0 and 1) is not informative enough to allow for a good estimation of the various parameters specific to ages 0 and 1 (observation and random walk variances).

Removing the egg survey resulted in a larger estimated stock, exploited with a lower fishing mortality. The run leaving out the RFID also resulted in a higher SSB than in the assessment using all data for the years after 2017, and a slightly higher fishing mortality between 2011 and 2015, but lower after 2019.

Additional sensitivity runs

There was a small (-8%) revision of the 2022 SSB index from the mackerel egg survey. In order to test the sensitivity of the model to such a revision, and potentially explain any revision of stock perception between last year and this year's assessments, the model was run again with the value used in 2022. Model fit and model output were found to be insensitive to this small revision of the SSB index (less than 0.5% and 0.3% in SSB and F_{bar} respectively).

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. The spawning stock biomass is estimated to have increased almost continuously from just above 2 million tonnes in the late 1990s and early 2000s to above 6 million tonnes between 2014 and 2016 and subsequently declined to reach a level just under 4 million tonnes in 2022. The fishing mortality has declined from levels between Fpa (0.36) and Flim (0.46) in the early-2000s to levels at or below 0.20 between 2016 to 2019 and increased sharply after that to 0.30 in 2022. The recruitment time series from the assessment is not considered a reliable indicator of year-class strength (see section 8.7.5.1).

There are clear indications of changes in the selectivity of the fishery over the last 30 years (Figure 8.7.3.2.). In the years 1990s, the fishery seems to have had a steeper selection pattern (more rapid increase in fishing mortality with age). Between the end of the 1990s and the end of the 2000s, the selection on the ages 1 to 5 decreased, and selection of older fish (7 and older) increased. After 2008, the pattern started reversing towards a steeper selection pattern, until 2017. Since then, selection on age 2 to 5 decreased sharply, has the fishery targeted more the older part of the population (age 6 and older).

8.7.4 Quality of the assessment

Parametric uncertainty

Large confidence intervals are associated with the SSB in the years before 1992 (Figure 8.7.3.1). This results from the absence of information from the egg survey index, the down-weighting of the information from the catches and the assessment being only driven by the tagging data and natural mortality in the early period. The uncertainty in SSB and Fbar decreases 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 (Figure 8.7.4.1 and Figure 8.7.3.1). The uncertainty increases slightly after that, but more sharply in the final assessment year and the SSB estimate for 2022 is estimated with a precision of +/- 24.8% (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 $F_{bar4\text{-}8}$ in 2022 has a precision of +/- 27.0%.

Model instability

The retrospective analysis was carried out for 7 retro years, (or peels) by fitting the assessment using the 2023 data, removing successively 1 year of data (Figure 8.7.4.2.). There was a systematic retrospective pattern found in Fbar for the older retrospective peels (current year -7 to current year -5) with a systematic downwards revision. The was also a pattern in the opposite direction for the SSB (current year -6 to current year -5). However this pattern is not apparent in the most recent peals (current -1 to -4), and the Mohn's rho value calculated over the last 5 years is of 0.25 for Fbar and -0.15 for SSB. Recruitment at age 0 appears to be quite consistently estimated for the older peals (current -7 to -4), but the perception changed for the last 3 peals. This change was associated to an increase in the observation variance for the recruitment index (from 0.17 in the older peel to 0.27 in the current assessment), meaning that the recruitment estimates were more influenced by the recruitment index in the older peels, which was less the case in the last 3 peels.

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 8.7.4.3) shows indications of some pattern across time and ages. There is a predominance of positive deviations in the recent years for age-classes 5 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 temporally.

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 8.7.4.4). 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 (1991-1994, 2004-2005, and 2017-2019). For the years between 2007 and 2016, the biomass cumulated process error remains positive, and large (reaching in 2013 almost the magnitude of the catches). The reason for this misbehaviour of the model could not be identified.

8.7.5 Exploratory runs

8.7.5.1 Assessment starting at age 2

The age 0 estimates in the current assessment mainly rely on the recruitment index; the catch-at-age 0 information is considered by the model as uninformative (large observation variance). Catch-at-age information becomes influential at age 2 (very low observation variance). The recruitment signal provided by abundances estimated at age 2 or 3 (when the fish enters the fishery), is different from the signal in the age 0 abundance (Figure 8.7.5.1). Age 0 abundances are less variable than abundances at age 2 and 3. For the period before 2012, there is a broad agreement in the perception of year class strength, although some year classes that do not appear particularly large at age 0 are perceived as very large at age 2 and 3 (e.g. 2002 year-class). For the more recent period (since the 2013 year-class), there is a greater discrepancy between recruitment at age 0 and at older ages. While the age 0 abundances indicate very high recruitment for the year-classes 2012 to 2020, number of those year-classes appear as particularly poor based on age 2 and 3 abundances (2015, 2017 and 2018). As very little fishing occurs between age 0 and 2 and 3, exploitation is not likely to explain these changes in perception of cohort strength. Such variations could be possibly due to variations in natural mortality (e.g. the strength of a cohort may not be fully determined at age 0 and processes occurring during the first years of life may still be determining year-class strength). However, some cohorts increase in size as they become older (e.g. 2002, 2010 and 2011), which clearly indicates that this is more likely a model artefact. The cohort strength at age 0, based on the recruitment index, is progressively revised, due to the process error occurring on annual survival, so that cohort strength at age 2 corresponds to the information coming from the catches.

This discrepancy between the recruitment estimates at age 0 and the actual size of the cohort when entering the fishery implies that the age 0 recruitment does not give an accurate indication on year-class strength, and should not be used to make speculations on future stock development.

As very little fishing occurs on 0 and 1 year olds, and catch-at-age data is considered very noisy, and since there appears to be a disagreement between the recruitment index at age 0 and at older ages in the recent years, it does not seem relevant to start the assessment at age 0 or 1. An exploratory run was conducted starting the assessment at age 2 (and hence removing catch-at-age information for age 0 and 1 and the recruitment index, while leave the rest of the data and model configuration unchanged).

This exploratory run gave a slightly different perception of the stock in the recent years, with a lower SSB for the years 2020 to 2023 and a slightly higher Fbar on the same period (Figure 8.7.5.2). The recruitment at age 2 (in blue on Figure 8.7.5.2, note that the curve should be shifted backwards by 2 years to compare year-class strength with the recruitment at age 0, red curve) shows a much variable year-class strength signal, with the same perception of year class strength as the age 0 recruitment for some years (broadly between year-classes 2000 and 2012), but a much lower estimated year-class strength since 2012. The recruitment at age 2 shows similar variations as the age 2 abundances in the update assessment (Figure 8.7.5.1). A retrospective analysis conducted on the assessment starting at age 2 shows similar Mohn's rho values as for the update assessment (-0.16 and 0.25 for SSB and Fbar respectively).

In conclusion, both models broadly agree both in terms of fit to the data and in terms of stock trajectories, and the model starting at age 2 could be considered as potential alternative to the current model at the next benchmark for this stock.

8.7.5.2 Assessment using the tagging information expressed as a survey index

During the last interbenchmark on the mackerel stock (ICES 2019c), alternative ways of using the tagging data were investigated. One of them consisted in computing an abundance-at-age index using the tag recaptures after one year at liberty. The advantage of this approach is that it offers more consistency in the way the difference data sources are used (same distribution used for the observation errors, thereby making it easier to compare how the different data sources are fitted in the model) and a similar number of data points (with the current approach the tagging data growth by 14 data point each year, compared to 9 for the IESSNS and 1 for each of the other surveys).

The model using the tagging data as index gives a very similar perception of stock development over time compared to the update assessment (Figure 8.7.5.3). The SSB over the years 2014-2020 is slightly lower and the Fbar value is slightly higher, but overall the model as very comparable (including parameter values). The model using the tags as index has lower Mohn's rho values (-0.10 and 0.16 for SSB and Fbar respectively (Figure 8.7.5.4). However the residuals for the tagging index show some temporal structure indicating that alternative model configuration (with correlated observation error) should be tested. This is in line with the conclusions from the 2019 interbenchmark.

8.8 Short term forecast

The short-term forecast provides estimates of SSB and catch in 2024 and 2025 (given an assumed catch for the current (intermediate) year) and a range of management options for 2024.

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 (2023) is based on declared quotas, interannual transfers and information from the fisheries 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 (2022) is considered too uncertain to be used directly, because this year-class has not yet fully recruited into the fishery. The last recruitment estimate is therefore replaced by predictions from the RCT3 software (Shepherd, 1997). The RCT3 software evaluates the historical performance of the IBTS recruitment index as predictor for the SAM recruitment, by performing a linear regression between the index and the SAM estimates over the period 1998 to the year before the terminal year (2021). The recruitment is then calculated as a weighted mean of the prediction from this linear regression based on the IBTS index value in the corresponding year (2022), and a time tapered weighted mean of the SAM estimates from 1990 to the year before the terminal year (2021). The time tapered weighted 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 RCT3 prediction done this year lead to a recruitment for 2022 of 5 635 503 millions, based for 40% on the time tapered weighted mean (5 759 032) and for 60% on the prediction from the linear regression (5 555 006).

The assumption for the subsequent recruitments in 2023 and 2024 was 4 498 424 million, the geometric mean calculated based on the SAM estimates for the period 1990-2021.

8.8.3 Short term forecast

A deterministic short-term forecast was conducted using FLR (www.flr-project.org). Table 8.8.3.1 lists the input data to the forecast and tables 8.8.3.2 and 8.8.3.3 provide projections for various fishing mortality multipliers and catch options in 2024.

Assuming catches for 2023 of 1 147 407 t, Fbar in 2023 is forecasted to be at 0.38 (above F_{MSY}) and SSB at 3.68 Mt (above B_{pa}) in spring 2023. If catches in 2024 equal to the assumed catch for 2023, Fbar is expected to increase to 0.43 (above F_{pa}) in 2024 with a corresponding decrease in SSB to 3.37 Mt in spring 2023. Assuming an F of 0.40 again in 2025, the SSB will further decrease to 3.10 Mt in spring 2025 (Figure 8.8.1).

Following the MSY approach, the target fishing mortality in 2024 shall be at F_{MSY} (0.26). This would result in catches of 739 386 t and a decrease in SSB to 3.46 Mt in spring 2024 (2% decrease). During the subsequent year, SSB would remain at a similar level (3.43 Mt) in spring 2024.

The forecasted population is partly based on cohorts for which there are abundance estimates from the assessment, and on cohorts for which abundance is based on assumption (RCT3 or geometric mean). The majority of the catches and SSB in 2024 for management option based on the F_{MSY} approach is based on cohorts with SAM estimates. However the abundance of the 2022 year class predicted by the RCT3 software also contributes to a non-negligible proportion of the catches and SSB in the advice year (16% and 24% respectively). The cohorts based on the geometric mean assumption contribute to a negligible part of the 2024 values (Figure 8.8.2).

8.9 Biological reference points

A management strategy evaluation Workshop on northeast Atlantic mackerel (WKMSEMAC) was conducted during 2020 (ICES, 2020) which resulted in the adoption of new reference points for NEA mackerel stock by ICES.

The table below summarises the currently used reference points.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	2.58 million tonnes	B_{pa}	ICES (2020)
	F_{MSY}	0.26	Stochastic simulations	ICES (2020)
Precautionary approach	B_{lim}	2.00 million tonnes	B_{loss} in 2003 from the 2019 WGWIDE assessment (ICES, 2019d	ICES (2020)
	B_{pa}	2.58 million tonnes	B_{lim} x exp(1.645 × σ), with σ_{SSB} = 0.15	ICES (2020)
	F_{lim}	0.46	F that, on average, leads to B_{lim}	ICES (2020)
	F_{pa}	0.36	F_{p05} (the F that leads to SSB ≥ Blim with 95 % probability)	ICES (2020)

8.10 Comparison with previous assessments and forecast

Historical assessment results

The inclusion of a new year of data modifies the relative weight of the different data sources in the assessment, which leads to revisions of the perception of the stock. The relative weights of the data sources in the assessment are dependent on both the length of the time series and the consistency of the information. The recent assessments have systematically revised the estimates of SSB upwards and Fbar downwards for the years prior to 2018 (Figure 8.10.1). Such systematic revisions do not happen for estimates of the most recent years in the assessment period and the assessment results are more consistent. In 2023, there has been an upwards revision of SSB and a downwards revision of fishing mortality

Comparison of the last two assessments

The last available assessment used to provide advice was carried out in 2022 during the WGWIDE. The new 2023 WGWIDE assessment gives a slightly different perception of the development of the stock, with a higher SSB estimated for the period after 2014 and a lower Fbar estimated since 2009 (Figure 8.10.2). For the latest comparable year between the 2 assessments, 2021, the differences TSB, SSB and Fbar estimates between the previous and the present assessments are of 11.1%, 7.58% and -13.6% respectively, similar to the differences observed last year (table below). The upward revision of stock size in 2021 is mainly due to the revision of the abundance of the older age classes (7 year olds and older, Figure 8.10.3). The younger age classes have been revised downwards, especially age 2 (2019 year class).

	TSB 2021	SSB 2021	Fbar4-8 2021
2022 WGWIDE	4 710 861 tonnes	3 891 546 tonnes	0.308
2023 WGWIDE	5 238 323 tonnes	4 186 470 tonnes	0.266
% difference	11.1%	7.58%	-13.6%

The addition of a new year of data modified only marginally the model parameters compared to last year (Figure 8.10.4). The observation standard deviation has decreased slightly for the IESSNS survey while it increased (only marginally) for the other data sources. Process variances were similar as last year, except for the random walk variance of fishing mortality on age 1, that increased sharply. There was also a decrease in the catchabilities for the IESSNS survey, which results from the revised perception of stock size for the period covered by the survey.

The uncertainty on the estimates of the model parameters is very similar to last year, except for the uncertainty on the observation variance on the catches at age 1 that have increased markedly. The uncertainty on SSB and $F_{bar4\text{-}8}$ in this year's assessment is slightly higher than last year for the period 2002-2019, but is similar for the last 2 years of the assessment period (Figure 8.7.4.1).

Short term forecast

The estimation for the intermediate year (2022) catch used for the short-term forecast in the advice given last year was 8.09% higher than the actual catches (table below). This is a discrepancy of the same order of magnitude as for 2021 (for years before that, the intermediate year catch estimate was always very close to the actual catch value). It should however be noted, that there is a +-10% flexibility clause in the management strategy that the countries implement, although the strategy is not formally accepted by the parties. It is impossible to anticipate whether the quota will be utilised in full or 10% less or more. The above mentioned overshoot is within this range.

The intermediate year assumption is made by summing the unilateral TAC declared, taking interannual transfers into account, and adding anticipated discards. During the WGWIDE, participants may provide information from their national administration and industry on the expected rate of use of the TAC (most often 100%), which can lead to a modification of the expected national catches. In 2021 and 2022, several countries were not able to catch their national TAC, due to access restrictions, and this could not be anticipated at the time of the working group. This undershoot of some of the national TACs therefore lead to a too high assumption on the intermediate year catch. In the 2023 estimation of expected catches, some parties provided a lower than declared quota catches to pre-empt a more precise the outtake for 2023 (see text table in section 8.1).

Running the 2022 forecast with the correct value of the intermediate year catch would have resulted in a lower Fbar (-8.33%) but a similar SSB value in 2022 (only 20% of the fishing mortality occurs before spawning time, table below). The corresponding catch advice for 2023 would have been 798 744 t instead for 782 066 t (2% difference).

The SSB from the 2022 forecast (both using the 2022 estimate of the 2022 catch, or the 2023 data) is slightly lower than the SSB estimated by the 2023 assessment. The main reason is a revision of the 2022 abundance-at-age (final year estimates in the 2022, second last year estimates for the 2023 assessment). The abundances of younger age groups (3 to 5) are revised downwards, but the abundances of the older age groups (7 to 12+) are revised upwards (Figure 8.10.3).

	Catch (2022)	SSB (2022)	F_{bar4-8} (2022)
2022 WGWIDE forecast	1 131 416 t	3 769 326 t	0.36
2022 WGWIDE forecast with correct 2022 catch assumption	1 046 720 t	3 790 078t	0.33
Difference with 2022 forecast	8.09%	0.55%	-8.33%
2023 WGWIDE assessment	1 046 720 t	3 951 017 t	0.30
Difference with 2022 forecast	8.09%	4.82 %	-15.9%

Despite this upwards revision of the 2022 stock size with the new assessment, the forecasted catch corresponding to F_{MSY} for 2024 is 5% lower than the previous advice. This is mainly a consequence of the decline in the exploitable biomass of the stock, that is forecasted to continue in 2024 (Figure 8.10.5). This decline is explained by a the decrease in abundance of the oldest age groups on the stock (on which the fishery currently relies) which is not yet compensated by the entry of the good 2019 and 2020 cohorts in the exploitable stock (fish of lower weight, with lower fisheries selection).

8.11 Management considerations

Details and discussion on quality issues in this year's assessment is given in Section 8.7 above.

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 was reached among the Coastal States on the sharing of the mackerel quotas. In 2014, three of the Coastal States (EU, NO and FO) agreed on a Management Strategy and sharing arrangement for 2014 to 2018. In November 2018, the agreement from 2014 was extended for two more years until 2020. In January 2020 the UK separated from the EU and assumed the status of a separate Coastal State. There has been no new agreement on a new Management Strategy or share of the stock since 2020. Despite agreeing to abide by the ICES advice, the total declared quotas in each of the years 2015 to 2022 all exceed the advised catch by ICES (Figure 8.11.1).

The mackerel in the Northeast Atlantic was traditionally characterised as three distinct 'spawning components': the southern component, the western component and the North Sea component. The basis for the components was 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) were not been able to demonstrate significant differences between animals from different components. A review of the mackerel in the North Sea, carried out during WKWIDE 2017 (ICES, 2017) 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.

In 2023 a Workshop which was tasked with an Evaluation of NEA Mackerel stock components (WKEVALMAC) presented the following conclusions (ICES WKEVALMAC 2023):

1. The workshop acknowledges that there are spatial and temporal patterns in demography (e.g., size and age) which are primarily related to the highly migratory and dynamic nature of the stock, and not due to separate components.
2. Recent directed genetics, tagging, otolith chemistry investigations; ongoing surveys, catch data, fisher perspective and preliminary modelling studies, all failed to support the three-component concept for NEA mackerel.
3. The Workshop therefore rejected the current three-component structure and accepted a single NEA mackerel stock concept to advance towards assessment, management and advice.
4. Given conclusion three, the workshop recommends that the current 'headline advice', based on a single stock assumption should continue.
5. The advice sheet should give no reference to components within the Northeast Atlantic Mackerel stock.

Further to the above conclusions the Workshop considers that within the frame of stock structure, there is no justifiable scientific reason for considering closed areas, closed seasons or spatial quota measures since this is one widely ranging stock. In addition, any reference to minimum landing sizes should apply to the whole stock equally.

Conservation aspects

The most recent stock assessment shows that the SSB is well above the B_{msy}, B_{pa} and B_{lim} (B_{msy} = B_{pa} = 2 580 000 tonnes, B_{lim} = 2 000 000 tonnes). Atlantic Mackerel was by IUCN in 2015 evaluated as a species of least concern (https://www.iucnredlist.org/) and it is neither found on OSPAR's list of threatened and declining species nor on the HELCOM Red List. Furthermore, the WGWIDE has not identified any anthropogenic pressure threatening the stock. Thus ICES has not identified any conservation aspects.

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)

Since 2012 the recruitment index (age 0) has been estimating substantially larger year-classes than what is later estimated at age 3 when they enter the fishery and the other surveys. It is not known if this mismatch is a sampling bias or altered mortality of the juveniles between age 0 and 3.

The rapid increase in stock size up until around 2015 was suggested to drive the recent expansion of the spawning northward into new areas (Jansen, 2016). There are several indications of a northward shift and/or expansion in spawning and nursery area towards northern and north-eastern areas since 2016 (ICES, 2016; Nøttestad *et al*., 2018; Bjørdal, 2019; Bjørdal et al. 2022). This northerly shift seems to have continued (Nøttestad *et al*., 2018). However, spawning in the Norwegian Sea was shown to be of little quantitative significance in 2021 (Burns and O'Hea, WD 15 to WGWIDE 2021 (ICES, 2021b)). Nevertheless, both increased biomass and extended distribution based on a more northward extension of the mackerel egg survey in Norwegian offshore and coastal waters in 2022 (Anon, 2022) and poleward spawning of NEA mackerel, up to 75°N (dos Santos Schmidt et al. 2023) clearly document that mackerel seem to be spawning in increasing numbers in recent years in the Norwegian Sea. An on-going extension of spawning activities into the Norwegian Sea feeding area (62-75 & DEG;N), reached stable levels around 2012 onwards. This poleward expansion of spawning increased as more fish entered the area, whilst the maximum proportions of spawners concurrently dropped from about 75 to 15% from May to July (dos Santos Schmidt et al. 2023).

Growth (*i.e.* length- and weight-at-age) have declined substantially in recent times for all ages (*e.g.* 0-3 year-old in 1998-2012, Jansen and Burns, 2015; all ages in 2005-2015, Jansen and Burns, 2015; Ólafsdóttir *et al*., 2015). The variations in growth of mackerel in all ages are correlated with mackerel density, *e.g.* mean weight-at-length have been shown to be positively related to location, day-of-year, temperature and SSB. Furthermore, the density dependent regulation of growth from juvenile to adult mackerel, appears to reflect the spatial dynamics observed in the migration patterns during the feeding season. As such, growth rates of the juveniles were tightly correlated with the density of juveniles in the nursery areas (Jansen and Burns, 2015) and growth for adults (age 3-8) 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, possibly also coinciding with decreased prey availability. Nevertheless, weight-at-age of mackerel both from the catches and the surveys have increased during the last few years, particularly for the younger year classes from 1 to 6 years of age (ICES, 2019c; 2020; 2021b, 2022), coinciding with reduced abundance of mackerel in recent years.

Drivers of the spatial distribution of mackerel

In the mid-2000s, the summer feeding distribution of Northeast Atlantic mackerel (*Scomber scombrus*) in Nordic Seas began expanding into new areas (Nøttestad *et al*., 2016). During the period 2007 - 2016 the mackerel distribution range increased three-fold and the centre-of-gravity shifted westward by 1650 km and northward by 400 km (Ólafsdóttir *et al*., 2019). Distribution range peaked in 2014/2015 and was positively correlated to SSB (ICES, 2022; Ólafsdóttir *et al.*, 2019). During this period mackerel stock expansion during the feeding season in summer increased from 1.3 mill km^2 in 2007 to at least 2.9 mill km^2 in 2014, both westwards into Icelandic and Greenlandic waters and northward in the Norwegian Sea (Nøttestad *et al*., 2016). The distribution area was stable around 2.8-2.9 mill km^2 during the years 2017-2019 (Nøttestad *et al*., 2017; 2019; ICES, 2018a). However, we witnessed a substantial shift in mackerel concentrations and distribution during summers of 2020-2023, when no mackerel were registered in Greenland waters, and a substantial decline was documented in Icelandic waters, whereas increased biomasses of mackerel were distributed in the central and northern part of the Norwegian Sea (Nøttestad *et al*., 2020a; WD09 in ICES 2021b). Overall, we have witnessed that mackerel had a much more eastern distribution in 2018-2023 compared to 2014-2017 (ICES, 2018a; Nøttestad *et al*., 2019; 2020a; 2021).

Ólafsdóttir *et al*. (2018) modelled (GAM) IESSNS data (2007-2016) and found that mackerel was present in temperatures ranging from 5 °C to 15 °C, but preferred areas between 9 °C and 13 °C. The model showed that both mackerel occurrence and density were positively related to location, temperature, meso-zooplankton density and SSB. Thus, 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. However, these results are limited by time-series length (1997-2016; Olafsdottir *et al.*, 2019). Notably, this seems to have changed during the most recent period from 2019 and onwards (e.g. high mackerel concentrations in 2020 at lower temperatures of 7-8 °C; Nøttestad *et al*., 2019; 2020a; WD09 in ICES 2021b). It is not clear what causes this distributional shift, but the SST were 1-2°C lower in the western and south-western areas as compared to a 20-years mean (1999-2009), and substantially lower zooplankton concentrations in Icelandic and Greenland waters in 2019 and 2020 might partly explain such changes (ICES, 2018a; Nøttestad *et al*., 2019; 2020a). Marine climate with multi-decadal variability might also have affected the observed distributional changes but were not evaluated. Furthermore, tagging data suggest that when mackerel grow older and larger, they seem to cover a progressively wider area of its annual migration cycle, although large inter-annual variability in the recapture patterns likely reflect changes in environmental conditions such as prey availability and ocean currents (Ono et al. 2022)

Trophic interactions

There are strong indications for interspecific competition for food between mackerel, NSS-herring and blue whiting (Huse *et al*., 2012), where the competition between mackerel and herring being the best studied relationship. Both higher stomach fullness and prey shift for mackerel compared to herring during low stock size periods indicates that herring may suffer from this competition. Thus, an opportunistic (i.e. rapid shift in diet) and more generalist diet (i.e. wider range of prey) may be advantageous for mackerel in periods with low zooplankton abundances (Langøy *et al*. 2012; Debes *et al*. 2012; Óskarsson *et al*. 2015; Bachiller *et al*. 2016). Feeding activity seem to be highest in areas associated with colder water masses (Bachiller *et al*., 2016), and bioenergetics indicate that mackerel consumption may be as high as both herring and blue whiting in some years (122-135 mill t year^{-1}, Bachiller *et al*. 2018). Distribution overlap between mackerel and NSS herring during the summer feeding season is generally highest in the south-western part of the Norwegian Sea (Faroe and east Icelandic area) (Nøttestad *et al*., 2016; 2017; Ólafsdóttir *et al*., 2017). This spatiotemporal overlap between mackerel and herring have been present from 2016-2019 (ICES, 2018a, Nøttestad *et al*., 2016; 2017; 2019). In addition, increasing distribution overlaps in the north-western parts of the Norwegian Sea have also been observed since 2019 and onwards, which is in contrast to previous years (Nøttestad *et al*., 2019; 2020a; WD09 in ICES 2021b). Overlapping distributions of mackerel and Norwegian spring-spawning herring (NSSH) were particularly present in the western and north-western part of the Norwegian Sea in 2022.

Recently, a number of predators have been highlighted as potential sources of mortality for mackerel. Although limited spatial overlap between marine mammals and mackerel during summers in the Nordic Seas (Nøttestad *et al*., 2019; Løviknes, 2019), orcas have been observed to actively search and hunt for mackerel schools (Nøttestad *et al*., 2014; Nøttestad *et al*., 2020a; 2021, 2022). Furthermore, the increases of 0- and 1-groups mackerel found along major coastlines of Norway (2016-2018, Nøttestad *et al*., 2018; Bjørdal, 2019) have coincided with predation by increasing numbers of adult Atlantic bluefin tuna (*Thynnus thunnus*, Boge, 2019; Nøttestad *et al*., 2020b). Additionally, stomach samples from several species document that smaller sized mackerel is now eaten by different predators in northern waters (e.g. cod, saithe, marine mammals and seabirds; Bjørdal, 2019). Although, fewer 1-groups have been observed in coastal Norway waters in recent years (2019-2023, IESSNS; Nøttestad *et al*., 2019; 2020b; 2021; 2022; 2023) predation by the Atlantic bluefin tuna is still evident. The predation pressure and associated mortality from various predators on NEA mackerel (both juveniles and adults) are still unknown, but could have ecological impact in both time (i.e. population) and space (i.e. local and regional) (ICCAT, 2019; Nøttestad *et al*., 2020b).

8.13 References

Anon. 2022. Report of the Coastal States Working Group on the distribution of Northeast Atlantic Mackerel. 28th February 2022. With Errata: 31st March 2022. 105pp.

Bachiller, E., Skaret, G., Nøttestad, L. and Slotte, A. 2016. Feeding ecology of Northeast Atlantic mackerel, Norwegian spring-spawning herring and blue whiting in the Norwegian Sea. PLoS ONE 11(2): e0149238. doi:10.1371/journal.pone.0149238

Bachiller E, Utne KR, Jansen T, Huse G. 2018. Bioenergetics modeling of the annual consumption of zooplankton by pelagic fish feeding in the Northeast Atlantic. PLOS ONE 13(1): e0190345. https://doi.org/10.1371/journal.pone.0190345

Boge, E. 2019. The return of the Atlantic bluefin tuna to Norwegian waters. Master thesis in Fisheries Biology and Management, Department of Biological Sciences, University of Bergen, Norway. 84 p.

Bjørdal, V.R. 2019. Juvenile mackerel (*Scomber scombrus*) along the Norwegian Coast: distribution, condition and feeding ecology. Master thesis in Fisheries Biology and Management, Department of Biological Sciences, University of Bergen, Norway. 73 p.

Bjørdal, V.R., Mørk, H. L., Utne, K. R., Fernö, A., and Nøttestad, L. 2022. The diet of juvenile Atlantic mackerel (Scomber scombrus) feeding in new northern nursery areas along the Norwegian coast. Provisionally accepted. Marine Biology Research.

Debes, H., Homrum, E., Jacobsen, J.A., Hátún, H. and Danielsen, J. 2012. The feeding ecology of pelagic fish in the southwestern Norwegian Sea –Inter species food competition between Herring (*Clupea harengus*) and mackerel (*Scomber scombrus*). ICES CM 2012/M:07. 19 pp.

Costas, G., O' Hea, B., Burns, F., Korta, M., Thorsen, A. 2023. 2022 Mackerel and Horse Mackerel Egg Survey. Working Document to ICES Working Group on Widely Distributed Stocks (WGWIDE, No. 10) ICES HQ, Copenhagen, Denmark, 24. – 30. August 2023. 34 pp.

dos Santos Schmidt, T.C., Slotte, A., Olafsdottir, A.H., Nøttestad, L., Jansen, T., Jacobsen, J.A., Bjarnason, S., Lusseau, S.M., Ono, K., Hølleland, S., Thorsen, A., Sandø, A.B., Kjesbu, O.S. 2023. Poleward spawning of Atlantic mackerel (Scomber scombrus) is facilitated by ocean warming but triggered by energy constraints. ICES Journal of Marine Science. DOI: 10.1093/icesjms/fsad098

Huse, G., Holst, J.C, Utne, K.R., Nøttestad, L., Melle, W., Slotte, A., Ottersen, G., Fenchel, T. and Uiblein, F. 2012. Effects of interactions between fish populations on ecosystem dynamics in the Norwegian Sea – results of the INFERNO project. Marine Biology Research 8(5-6): 415-419.

ICCAT. 2019. Report of the Standing Committee on Research and Statistics (SCRS). Spain, Madrid, 30. September to 4 October 2019, ICCAT Collective Volume of Scientific Papers. PLE-104, 459 pp.

ICES. 1974. Report of the Mackerel Working Group, 30 January - 1 February 1974. Charlottenlund, Denmark. ICES C.M. 1974/H:2. 20pp.

ICES. 2014. Report of the Benchmark Workshop on Pelagic Stocks (WKPELA). 17–21 February 2014. Copenhagen, Denmark. ICES CM 2014/ACOM:43. 344 pp.

ICES. 2016. Second Interim Report of the Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS). By correspondence. ICES CM 2016/SSGIEOM:09.

ICES. 2017. Report of the Benchmark Workshop on Widely Distributed Stocks (WKWIDE), 30 January–3 February 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:36. 196 pp.

ICES. 2018a. Cruise report from the International Ecosystem Summer Survey in the Nordic Seas (IESSNS) 30th of June – 6th of August 2018. Working Document to ICES Working Group on Widely Distributed Stocks (WGWIDE), Havstovan, Tórshavn, Faroe Islands, 28. August – 3. September 2018, 39 pp.

ICES. 2018b. Report of the Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS), 9 - 13 April 2018, Marine Institute, Dublin, Ireland. ICES CM 2018/EOSG:17 70 pp.

ICES, 2019a. Manual for mackerel and horse mackerel egg surveys, sampling at sea. Series of ICES Survey Protocols SISP 6. 82pp. http://doi.org/10.17895/ices.pub.5140

ICES, 2019b. Manual for the AEPM and DEPM estimation of fecundity in mackerel and horse mackerel. Series of ICES Survey Protocols, SISP 5. 89 pp. http://doi.org/10.17895/ices.pub.5139

ICES. 2019c. Interbenchmark Workshop on the assessment of northeast Atlantic mackerel (IBPNEAMac). ICES Scientific Reports. 1:5. 71 pp.

ICES. 2019d. Working Group on Widely Distributed Stocks (WGWIDE). ICES Scientific Reports. 1:36. 948 pp. http://doi.org/10.17895/ices.pub.5574

ICES. 2020. Workshop on Management Strategy Evaluation of mackerel (WKMSEMAC). ICES Scientific Reports 2:74, 175pp. http://doi.org/10.17895/ices.pub.7445

ICES. 2021a. Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS). ICES Scientific Reports. 3:82. 40pp. https://doi.org/10.17895/ices.pub.8249

ICES. 2021b. Working Group on Widely Distributed Stocks (WGWIDE). ICES Scientific Reports. 3:95. 874 pp. http://doi.org/10.17895/ices.pub.8298

ICES. 2022. Working Group on Widely Distributed Stocks (WGWIDE). ICES Scientific Reports. 4:73. 922 pp. http://doi.org/10.17895/ices.pub.21088804

ICES. 2023. ICES. 2023. Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS). ICES Scientific Reports. 5:81. 118 pp. https://doi.org/10.17895/ices.pub.23790201

Jansen, T. 2016. First-year survival of North East Atlantic mackerel (*Scomber scombrus*) from 1998 to 2012 appears to be driven by availability of Calanus, a preferred copepod prey. Fisheries Oceanography 25: 457–469. doi:10.1111/fog.12165

Jansen, T. and Burns F. 2015. Density dependent growth changes through juvenile and early adult life of North East Atlantic Mackerel (*Scomber scombrus*). Fisheries Research 169: 37-44.

Jansen, T., Kristensen, K., van der Kooij, J., Post, S., Campbell, A., Utne, K.R., Carrera, P., Jacobsen, J.A., Gudmundsdottir, A., Roel, B.A. and Hatfield, E.M.C. 2015. Nursery areas and recruitment variation of North East Atlantic mackerel (*Scomber scombrus*). ICES Journal of Marine Science 72(6): 1779-1789.

Langøy, H., Nøttestad, L., Skaret, G., Broms, C., and Fernö, A. 2012. Overlap in distribution and diets of Atlantic mackerel (*Scomber scombrus*), Norwegian spring- spawning herring (*Clupea harengus*) and blue whiting (*Micromesistius poutassou*) in the Norwegian Sea during late summer. Marine biology research 8(5-6): 442-460.

Løviknes, S. 2019. Distribution and feeding ecology of fin (Balaenoptera physalus) and humpback whales (Megaptera novaeangliae) in the Norwegian Sea during the summers of 2013 to 2018. Master thesis in Biodiversity, Evolution and Ecology, Department of Biological Sciences, University of Bergen, Norway. 59 p.

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

Nøttestad L., Sivle, L. D., Krafft, B. A., Langård, L., Anthonypillai, V., Bernasconi, M., Langøy, H., and Fernø, A. 2014: Prey selection of offshore killer whales *Orcinus orca* in the Northeast Atlantic in late summer: spatial associations with mackerel. Marine Ecology Progress Series 499:275-283. DOI:10.3354/meps10638.

Nøttestad, L., Anthonypillai, V., Tangen, Ø., Utne, K.R., Óskarsson, G.J., Jónsson S., Homrum, E., Smith, L., Jacobsen, J.A. and Jansen, T. 2016. Cruise report from the International Ecosystem Summer Survey in the Nordic Seas (IESSNS) with M/V "M. Ytterstad", M/V "Vendla", M/V "Tróndur í Gøtu", M/V "Finnur Fríði" and R/V "Árni Friðriksson", 1 – 31 July 2016. Working Document to ICES Working Group on Widely Distributed Stocks (WGWIDE). ICES HQ, Copenhagen, Denmark, 31 August – 6 September 2016. 41 pp.

Nøttestad, L., Ólafsdóttir, A.H., Anthonypillai, V. Homrum, E., Jansen, T. *et al*. 2017. Cruise report from the International Ecosystem Summer Survey in the Nordic Seas (IESSNS) with M/V "Kings Bay", M/V "Vendla", M/V "Tróndur í Gøtu", M/V "Finnur Fríði" and R/V "Árni Friðriksson", 3rd of July – 4th of August 2017. ICES Working Group on Widely Distributed Stocks (WGWIDE), ICES HQ, Copenhagen, Denmark, 30. August – 5. September 2017. 45 p.

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.

Nøttestad, L., Ólafsdóttir, A.H., Anthonypillai, V. Homrum, E., Jansen, T.; Wieland K. *et al*. 2019. Cruise report from the International Ecosystem Summer Survey in the Nordic Seas (IESSNS) 28th June – 5th August 2019. Working Group Document to ICES Working group on Widely Distributed Stocks (WGWIDE, No. 5). Spanish Institute of Oceanography (IEO), Santa Cruz, Tenerife, Canary Islands 28. August – 3 September 2019. 51 pp.

Nøttestad, L., Ólafsdóttir, A.H., Anthonypillai, V. Homrum, E., Jansen, T.; Wieland K. et al. 2020a. Cruise report from the International Ecosystem Summer Survey in the Nordic Seas (IESSNS) 1st July – 4th August 2020. Working Group Document to ICES Working group on Widely Distributed Stocks (WGWIDE, No. 3), ICES HQ, Copenhagen, Denmark, (digital meeting) 26. August – 1. September 2020. 55 pp.

Nøttestad, L., Boge, E. and Ferter, K. 2020b. The comeback of Atlantic bluefin tuna (*Thunnus thynnus*) to Norwegian waters. Fisheries Research 231, November 2020.

Nøttestad, L., Anthonypillai, V., dos Santos Schmidt, T.C., Høines, Å., Salthaug, A., Ólafsdóttir, A.H., Kennedy, J., et al. 2021. Cruise report from the International Ecosystem Summer Survey in the Nordic Seas (IESSNS) 30th June – 3rd August 2021. Working Document to ICES Working Group on Widely Distributed Stocks (WGWIDE, No. 09) ICES HQ, Copenhagen, Denmark, (digital meeting) 25. – 31. August 2021.

Nøttestad, L., Høines, Å., Stenevik, E.K., Diaz, J., Tonheim, S., Salthaug A., Ólafsdóttir, A.H., et al. Preliminary cruise report from the International Ecosystem Summer Survey in the Nordic Seas (IESSNS) 1st July – 3rd August 2022. Working Document to ICES Working Group on Widely Distributed Stocks (WGWIDE, No. 1) ICES HQ, Copenhagen, Denmark, (hybrid meeting) 24. – 30. August 2022.

Ono, K. Slotte, A., Hølleland, S., Mackinson S., Jónsson Sd, Jacobsen, J.A., and Ólafsdóttir A.H. 2022. Space-time-recapture dynamics of PIT-tagged Northeast Atlantic mackerel (Scomber scombrus) reveal size-dependent migratory behaviour. Frontiers in Marine Science. 9:983962. Doi: 10.3389/fmars.2022.983962

Ólafsdóttir, A.H., Slotte, A., Jacobsen, J.A., Oskarsson, G.J., Utne, K.R. and Nøttestad, L. 2015. Changes in weight-at-length and size at-age of mature Northeast Atlantic mackerel (*Scomber scombrus*) from 1984 to 2013: effects of mackerel stock size and herring (*Clupea harengus*) stock size. ICES Journal of Marine Science 73(4): 1255-1265. doi:10.1093/icesjms/fsv142

Ólafsdóttir, A.H., Utne, K.R., Nøttestad, L., Jacobsen, J.A., Jansen, T., Óskarsson, G.J., Jónsson, S. Þ., Smith, L., Salthaug, A., Hömrum, E. and Slotte, A. 2017. Preparation of data from the International Ecosystem Summer Survey in Nordic Seas (IESSNS) for use as an annual tuning series in the assessment of the Northeast Atlantic mackerel (*Scomber scombrus L.*) stock. Working Document to the Benchmark Workshop on Widely Distributed Stocks (WKWIDE), Copenhagen, Denmark, 30 January–3 February 2017. 36 pp.

Ólafsdóttir, A., Utne, K.R., Jansen, T., Jacobsen, J.A., Nøttestad, L., Óskarsson, G.J., Slotte, A., Melle, W. 2019. Geographical expansion of Northeast Atlantic mackerel (Scomber scombrus) in the Nordic Seas from 2007 - 2014 was primarily driven by stock size and constrained by temperature. Deep-Sea Research Part II. 159, 152-168.

Óskarsson, G.J., Guðmundsdóttir, A., Sveinbjörnsson, S. and Sigurðsson, T. 2015. Feeding ecology of mackerel and dietary overlap with herring in Icelandic waters Ecological impacts of recent extension of feeding migration of NE-Atlantic mackerel into the ecosystem around Iceland. Marine Biology Research 12: 16–29. doi:10.1080/17451000.2015.1073327

Salthaug, A., Stæhr, K.J., Óskarsson, G.J., Homrum, E. Krevoshey, P. *et al*. 2019. International ecosystem survey in the Nordic Sea (IESNS) in May-June 2019. Working Document to ICES Working Group on Widely Distributed Stocks (WGWIDE No. 11). Spanish Institute of Oceanography (IEO), Santa Cruz, Tenerife, Canary Islands 28. August – 3 September 2019. 33 pp.

Salthaug, A., Wieland, K., Olafsdottir, A.H.., Jacobsen, J.A.. *et al*. 2020. International ecosystem survey in the Nordic Sea (IESNS) in May-June 2020. Working Document to ICES Working Group on Widely Distributed Stocks (WGWIDE No. 4). Copenhagen 26. August – 1. September 2020. 38 pp.

Shepherd, J.G. 1997. Prediction of year-class strength by calibration regression analysis of multiple recruit index series. ICES Journal of Marine Science 54: 741–752.

Tenningen, M., Slotte, A. and Skagen, D. 2011. Abundance estimation of Northeast Atlantic mackerel based on tag–recapture data – A useful tool for stock assessment? Fisheries Research 107: 68–74.

8.14 Tables

Table 8.2.2.1. NE Atlantic Mackerel. ICES estimated catch (t) in Subareas 1, 2, 5 and 14, 2000–2022 (Data submitted by Working Group members).

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Denmark	1375	7	1								4845
Estonia	2673	219									
Faroe Islands	5546	3272	4730		650	30		278	123	2992	66312
France					2	1					
Germany								7			
Greenland											
Iceland			53	122		363	4222	36706	112286	116160	121008
Ireland				495	471						
Latvia											
Lithuania	2085										
Netherlands			569	44	34	2393		10	72		90
Norway	31778	21971	22670	125481	10295	13244	8914	493	3474	3038	104858
Poland											
Sweden		8									
United Kingdom		54	665	692	2493				4		

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
Russia	49101	41566	45811	40026	49489	40491	33580	35408	32728	414141	58613	
Misreported			-570		-553							
Unallocated				-44	32	-2393		-10	-18			
Discards					9				112		5	
Total	92557	67097	73929	53883	62922	54129	46716	72891	148781	163604	355729	

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Denmark	269		391	2345	4321	1	2	289			0.691	0.09
Estonia			13671									
Faroe Islands	121499	107198	142976	103896	76889	61901	66194	52061	37418	33291	105096	122237
France	2		197	8	36			733		8	0.2	
Germany		107	74		2963	3499	4064	577	190	206	9	
Greenland	621	74021	541481	875811	30351	36142	46388	62973	30241	26555	33360	18039
Iceland	159263	149282	151103	172960	169333	170374	167366	168330	128008	151534	132109	129975
Ireland	90			1725	6	2						
Latvia												
Lithuania				1082		1931				2		

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
Netherlands	178	5	1	5887	6996	8599	7671	2697	13	0.73		119
Norway	43168	110741	33817	192322	204574	153228	167739	46853	22605	15937	256124	198801
Poland								2		0.044	8.2	102
Sweden		4	825	3310	740	730	1720	910		220	228	
United Kingdom			2	5534	7851	5240	4601	2009		426		2
Russia	73601	74587	80812	116433	128433	121614	138061	118255	126543	128805	136176	102129
Misreported												
Unallocated												
Discards	28	1	151	911	78	54	62	51	18	0.05		
Total	398160	449326	465729	684173	632571	563315	603869	455740	345036	356985	663111	571403

Table 8.2.2.2. NE Atlantic Mackerel. ICES estimated catch (t) in the North Sea, Skagerrak and Kattegat (Subarea 4 and Division 3.a), 2000-2022 (Data submitted by Working Group members).

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Belgium	146	97	22	2	4	1	3	1	2	3	27
Denmark	27720	21680	343751	275081	25665	232121	242191	252171	26716	23491	36552
Faroe Islands	10614	18751	12548	11754	11705	9739	12008	11818	7627	6648	4639
France	1588	1981	2152	1467	1538	1004	285	7549	490	1493	686
Germany Fed. Rep.	78	4514	3902	4859	4515	4442	2389	5383	4668	5158	25621

Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	
Iceland												
Ireland	9956	10284	20715	17145	18901	15605	4125	13337	11628	12901	14639	
Lithuania												
Netherlands	2262	2441	11044	6784	6366	3915	4093	5973	1980	2039	1300	
Norway	142320	158401	161621	150858	147068	106434	113079	131191	114102	118070	129064	
Poland						109						
Sweden	49941	5090	52321	4450	4437	3204	3209	38581	36641	73031	34291	
United Kingdom	58282	52988	61781	67083	62932	37118	28628	46264	37055	47863	52563	
Russia	1672	1				4					696	
Misreported (Area 6.a)	8591	39024	49918	62928	23692	37911	8719		17280	1959		
Unallocated	34761	24873	22985	-730	-783	7043	171	2421	2039	-629	660	
Discards	1912	24	8583	11785	11329	4633	8263	4195	8862	8120	883	
Total	304896	339970	394878	365894	317369	254374	209192	257208	236111	235049	247700	
Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Belgium	21	39	62	56	38	99	107	110	13	75	77	185
Denmark	32800	36492	31924	21340	35809	21696	27457	22207	25374	34375	28295	16537

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
Faroe Islands	543	432	25	42919	25672	18193	12915	15475	17460	32860		10896
France	1416	5736	1788	4912	7827	3448	5942	6714	5455	8959	5041	6342
Germany Fed. Rep.	52911	4560	5755	4979	6056	10172	11185	12091	7778	15946	9939	11903
Iceland												
Ireland	15810	20422	13523	45167	34167	24437	35957	24567	1678	15395	11021	11818
Lithuania				8340		596				813	6655	
Netherlands	9881	6018	4863	24536	17547	11434	17401	13844	8957	18425	15983	21892
Norway	162878	64181	130056	85409	36344	55089	51960	135715	135083	195515	14518	95284
Poland					24		0.721	4041	1394	16	559	3
Sweden	32481	4560	2081	1112	3190	2933	1981	3056	2152	3451	3277	3244
United Kingdom	69858	75959	70840	145119	129203	99945	104499	103707	101890	130650	125553	172657
Russia			4						0.12			
Misreported (Area 6.a)												
Unallocated												
Discards	1906	1089	337	334	34	559	400	620	812	732	423	2470
Total	303652	219489	261258	384221	295911	248611	269804	342147	308047	457211	221340	353231

Table 8.2.2.3. NE Atlantic Mackerel. ICES estimated catch (t) in the Western area (Subareas 6 and 7 and Divisions 8.a,b,d,e), 2000–2022 (Data submitted by Working Group members).

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Belgium					1					1	2
Denmark	82	835		113				6	10		48
Faroe Islands	4863	2161	2490	2260	674		59	1333	3539	4421	36
France	17857	18975	19726	21213	18549	15182	14625	12434	14944	16464	10301
Germany	22901	20793	22630	19200	18730	14598	14219	12831	10834	17545	16493
Guernsey							10				
Ireland	61277	60168	51457	49715	41730	30082	36539	35923	33132	48155	43355
Isle of Man											14
Jersey						9	8	6	7	8	6
Lithuania							95	7			
Netherlands	30123	33654	21831	23640	21132	18819	20064	18261	17920	20900	21699
Norway								7	3948	121	30
Poland						461	1368	978			
Russia											1
Spain	4500	4063	3483			4795	4048	2772	7327	8462	6532
United Kingdom	126620	139589	131599	167246	149346	115586	67187	87424	768821	109147	107840
Misreported (Area 4.a)	-3775	-39024	-43339	-62928	-23139	-37911	-8719		-17280	-1959	

Country	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Unallocated	31564	37952	27558	5587	9714	13412	4783	10042	-952	490	4503
Discards	1920	1164	15191	7111	7696	20359	14723	10177	27351	6848	7518
Total	297932	280553	252620	233157	244432	190597	169009	192201	177662	230603	218377

Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Belgium					14	44	21	58	53	49	34	58
Denmark	2889	8	903	18538	6741	19443	12569	8194	5189	4110	4463	4897
Faroe Islands	8			3421	5851	13173	20559	13543	7787	2913		624
France	11304	14448	12438	16627	17820	16634	16925	13974	12371	12816	11308	10929
Germany	18792	14277	15102	23478	19238	9740	9608	7214	8936	8878	2049	2225
Greenland										22		
Guernsey	10	5	9	9	4			12	9			
Iceland									69			1
Ireland	45696	42627	42988	56286	54571	52087	48957	42181	51635	58720	49731	40455
Isle of Man	11	11	8	3		8	2	3	3	2		1
Jersey	7	8	8	7	3	3	0.003	3	2	5		0.1

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
Lithuania	23			176	554	13						
Netherlands	18336	19794	16295	16242	15264	17896	18694	13851	13727	11895	8611	4374
Norway	2019	1101	734		1313	1035	2657	4639	1420	221	11	1
Poland								14	2312	5286	1155	
Portugal									46	35	32	
Russia						30			1	10		0.06
Spain	1257	773	635	1796	951	1253	786	4471	1220	1784	704	1008
Sweden									805			
United Kingdom	111103	93775	92957	137195	110932	112268	116308	84309	50253	72637	84323	24342
Unallocated	399	16	-144		34			13				
Discards	7153	10654	2105	1742	3185	2126	2142	1701	6046	8405	2640	907
Total	219007	197496	183857	275519	236475	245754	249229	194180	161883	187788	165060	89822

Table 8.2.2.4. NE Atlantic Mackerel. ICES estimated catch (t) in Divisions 8.c and 9.a, 2000–2022 (Data submitted by Working Group members). 9.b is included in 2020.

Country	Div	2004	2005	2006	2007	2008	2009	2010	2011	2012
France	8.c	177	151	43	55	168	383	392	44	283
Portugal	8.c							1758	2302	4867.944
Portugal	9.a	2289	1509	2620	2605	2381	1753	2363	962	824

Country	Div	2004	2005	2006	2007	2008	2009	2010	2011	2012
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	55466	28146	33239

Country	Div	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
France	8.c	220	171	21	106	83	50	43	96	93	103
Portugal	8.c	5134	7334	6836	6069	3697	3709	3188	4189	3738	2738
Portugal	9.a	254	618	1456	619	634	855	706	575	953	829
Spain	8.c	14617	33783	29726	26553	30893	27190	19148	31143	25272	26999
Spain	9.a	1162	2227	3853	2229	1206	1656	747	1379	1807	1417
Russia									2		
Discards	8.c	1428	2821	4724	2469	84	324	760	28	18	35
Discards	9.a	1027	1463	2409	751	143	194	172	115	47	143

Country	Div	2004	2005	2006	2007	2008	2009	2010	2011	2012	
Unallocated	8.c	-573	8795	11	1357		300				
Unallocated	9.a	4053	662	1831	2123						
Total	9.a	6497	4308	9550	5722	1983	2736	1625	2070	2807	2389
Total		27322	57874	50867	42276	36740	34279	24764	37529	31928	32264

Table 8.2.3.1. NE Atlantic Mackerel. Proportion of the catch by quarter 1990-2022

Year	Q1	Q2	Q3	Q4
1990	28	6	26	40
1991	38	5	25	32
1992	34	5	24	37
1993	29	7	25	39
1994	32	6	28	34
1995	37	8	27	28
1996	37	8	32	23
1997	34	11	33	22
1998	38	12	24	27
1999	36	9	28	27
2000	41	4	21	33
2001	40	6	23	30
2002	37	5	29	28
2003	36	5	22	37
2004	37	6	28	29
2005	46	6	25	23
2006	41	5	18	36
2007	34	5	21	40
2008	34	4	35	27
2009	38	11	31	20
2010	26	5	54	15
2011	22	7	54	17
2012	22	6	48	24
2013	19	5	52	24
2014	20	4	46	30
2015	20	5	44	31
2016	23	4	44	29
2017	24	3	45	28
2018	20	3	40	37

Year	Q1	Q2	Q3	Q4
2019	28	5	42	26
2020	31	4	34	31
2021	19	5	56	20
2022	18	6	58	18

Table 8.3.1. NE Atlantic Mackerel. Sampling coverage from 1992-2022

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	877272	91	1241	124695	29462
2011	948963	88	923	97818	22817
2012	899551	89	1216	135610	38365

Year	WG Total Catch (t)	% catch covered by sampling programme	No. Samples	No. Measured	No. Aged
2013	938299	89	1092	115870	25178
2014	1401788	90	1506	117250	43475
2015	1215827	88	2132	137871	24283
2016	1100135	89	2200	149216	21456
2017	1159641	87	2183	151548	24104
2018	1023144	83	1858	139590	20703
2019	839727	88	1835	141561	17646
2020	1039513	87	1430	142991	15685
2021	1081540	79	1783	76325	18736
2022	1046720	88	1862	118573	16771

Table 8.3.2. NE Atlantic Mackerel. 2022 sampling by country.

Country	ICES catch	% WG catch covered by sampling programme	No. Samples	No. Measured	No. Aged
Belgium	242	0%	0	0	0
Denmark	21446	0%	0	0	0
Faroe Islands	133757	98%	18	921	892
France	17785	0%	0	0	0
Germany	14473	52%	138	3875	697
Greenland	18039	0%	8	1600	0
Iceland	129976	99%	97	4005	2344
Ireland	52303	99%	45	8114	1958
Netherlands	26385	31%	21	1467	517
Norway	294086	98%	79	2015	1877
Poland	105	0%	0	0	0
Portugal	3567	23%	35	1768	833
Russia	102129	99%	136	43244	1160
Spain	29898	100%	1062	34890	3264

Country	ICES catch	% WG catch covered by sampling programme	No. Samples	No. Measured	No. Aged
Sweden	3244	0%	0	0	0
UK (England & Wales)	22987	92%	154	11426	1199
UK (Northern Ireland)	15117	0%	0	0	0
UK (Scotland)	161182	94%	69	5248	2030

Table 8.3.3. NE Atlantic Mackerel. 2022 sampling by ICES division.

Division	Official Catch (t)	WG Catch (t)	No. Samples	No. Measured	No Aged
2.a	567564	567564	309	50992	5546
2.b	5	5	0	0	0
3.a	551	551	0	0	0
3.b	26	26	0	0	0
3.c	3	3	0	0	0
3.d	4	4	0	0	0
4.a	349349	349349	215	12998	3863
4.b	2296	2296	0	0	0
4.c	1002	1002	17	489	92
5.a	573	573	1	50	25
5.b	3150	3150	2	104	100
6.a	64049	64049	38	5256	1348
6.b	23	23	0	0	0
7.a	4	4	0	0	0
7.b	10272	10272	12	1595	346
7.c	24	24	0	0	0
7.d	5724	5724	7	721	175
7.e	799	799	53	2870	434
7.f	331	331	75	5480	269
7.g	27	27	0	0	0
7.h	24	24	0	0	0

Division	Official Catch (t)	WG Catch (t)	No. Samples	No. Measured	No Aged
7.j	2932	2932	36	1360	476
7.k	0.33	0.33	0	0	0
8.a	2980	2980	11	204	4
8.b	2618	2618	132	2608	41
8.c	29875	29875	587	27539	2453
8.d	15	15	7	100	3
9.a	2389	2389	360	6207	1596
14.a	110.7	110.7	0	0	0

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.a, 8.b, 8.d, and 8.e			Subareas 3 and 4			Subareas 1, 2, 5, and 14			Divisions 8.c and 9.a			Total		
	Land.	Disc.	Catch	Land.	Disc.	Catch	Land.	Disc.	Catch	Land.	Disc.	Catch	Land.	Disc.	Catch	Land.	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
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	23309	7431	243740	101000		101000	24789		24789	594697	7431	602128
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	44 164		44164	658652	8012	666664
1999	116362		116362	94290		94290	313014		313014	72848		72848	43796		43796	640311		640311
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

Year	Subarea 6			Subarea 7 and divisions 8.a, 8.b, 8.d, and 8.e			Subareas 3 and 4			Subareas 1, 2, 5, and 14			Divisions 8.c and 9.a			Total		
	Land.	Disc.	Catch	Land.	Disc.	Catch	Land.	Disc.	Catch	Land.	Disc.	Catch	Land.	Disc.	Catch	Land.	Disc.	Catch
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
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	50826	4640	55466	864229	13045	877272
2011	160756	1836	162592	51098	5317	56415	301746	1906	303652	398132	28	398160	26337	1807	28144	938070	10894	948963
2012	121115	952	122067	65728	9701	75429	218400	1089	219489	449325	1	449326	29809	3431	33240	884377	15174	899551
2013	132062	273	132335	49871	1652	51523	260921	337	261258	465846	15	465861	24867	2455	27322	933567	4732	938299
2014	180068	340	180408	93709	1402	95111	383887	334	384221	684082	91	684173	53591	4284	57875	1395337	6451	1401788
2015	134728	30	134757	98563	3155	101718	295877	34	295911	632493	78	632571	43735	7133	50869	1205396	10431	1215827
2016	206326	200	206526	37300	1927	39227	248041	570	248611	563440	54	563494	39056	3220	42276	1094163	5971	1100135
2017	225959	151	226110	21128	1992	23119	269404	400	269804	603806	62	603869	36512	227	36739	1156809	2832	1159641
2018	157239	90	157329	32037	1611	33649	341527	620	342147	455689	51	455740	33761	518	34279	1020254	2890	1023144
2019	122995	144	123139	32840	5902	38742	307235	812	308047	345019	18	345037	23832	931	24763	831920	7807	839727
2020	130577	341	130918	48806	8065	56871	456479	732	457211	356985		356985	37386	143	37529	1030233	9280	1039513
2021	146519	117	146635	15901	2524	18425	221019	423	221442	663111		663111	31862	65	31928	1078411	3129	1081540
2022	63850	222	64072	25065	685	25750	350760	2470	353231	571403		571403	32086	178	32264	1043164	3556	1046720

Table 8.5.1.1. NE Atlantic Mackerel. Mean length (cm) -at-age by area for 2022 (Q1-Q4).

Age	2.a	2.b	3.a	3.b	3.c	3.d	4.a	4.b	4.c
0									25.14
1	28.23	28.00	28.28	28.28	28.28	30.57	28.52	29.69	29.71
2	31.64	30.94	31.25	31.29	29.86	31.03	31.51	31.18	31.36
3	33.12	32.75	33.01	32.78	32.78	32.38	33.26	32.20	33.07
4	33.48	34.94	34.72	34.65	34.69	34.30	34.71	34.16	34.42
5	34.61	35.60	35.45	35.39	35.42	35.40	35.54	35.24	35.60
6	35.89	36.39	36.33	36.31	36.39	37.03	36.57	35.42	36.74
7	36.54	37.60	37.30	37.34	37.35	37.43	37.29	36.75	37.44
8	37.39	37.85	37.64	37.65	37.68	37.92	37.72	37.27	38.19
9	37.86	38.47	38.36	38.15	38.23	38.29	38.10	37.94	38.49
10	37.98	38.61	38.41	38.31	38.36	38.56	38.33	38.44	39.01
11	38.58	38.67	38.81	38.62	38.57	39.29	38.78	38.26	38.44
12	38.95	39.28	39.16	39.03	39.05	39.02	39.14	39.16	39.14
13	39.00	39.37	39.64	39.62	39.71	39.22	39.62	39.61	39.58
14	39.30	39.56	40.18	40.23	40.27	38.64	40.05	40.18	40.15
15	39.92	39.39	40.03	38.76	38.46	39.44	40.33	40.12	39.21

Age	5.a	5.b	6.a	6.b	6.b2	7.a	7.b	7.c	7.d
0			16.5			16.5			25.14
1			18.693			18.5			29.7
2	33.44	30.38	29.98	30.10	28.96	29.26	29.75	29.80	29.82
3	33.70	32.78	32.63	32.75	31.62	32.50	32.73	32.69	32.26
4	35.40	34.60	34.79		34.20	35.00	34.92	34.92	33.90
5	36.11	35.79	35.86	35.79	34.76	36.13	35.96	35.96	36.02
6	36.86	36.68	36.69	36.69	36.02	36.58	36.53	36.50	35.78
7	37.75	37.18	37.68	37.18	37.51	37.71	37.85	37.88	38.20
8	37.96	38.27	38.15	38.28	37.53	38.12	38.28	38.26	38.65
9	38.69	37.82	38.45	37.82	37.89	38.52	38.90	38.84	
10	38.63	38.72	38.71	38.72	38.01	38.79	39.44	39.59	
11	38.63	38.48	38.87	38.48	38.72	38.90	39.20	39.31	
12	39.47	38.32	39.12	38.30	38.68	39.27	39.17	39.23	
13	39.57	38.71	39.88	38.70	39.64	39.88	39.63	39.63	
14	39.63	39.71	39.62	39.70	40.61	39.22		40.10	
15	39.59	43.24	40.30	43.30	40.28	40.30		40.70	

Age	7.e	7.f	7.g	7.h	7.j	7.k	8.a	8.b	8.c
0	25.86	25.92						16.73	17.36
1	26.31	26.76					20.12	19.98	28.24
2	29.40	30.00	29.21	29.85	30.22	28.39	30.25	29.42	31.35
3	32.26	32.33	32.53	32.35	32.60	31.81	31.46	31.70	33.37
4	33.99	34.03	34.85	33.45	34.75	34.22	33.86	34.72	35.60
5	35.89	35.89	35.96	36.19	36.13	36.96	36.74	36.88	36.53
6	35.77	36.96	36.55	37.48	36.81	37.91	38.36	38.10	37.38
7	38.17	37.37	37.89	38.44	38.10	38.28	38.27	38.21	37.93
8	38.65	37.24	38.35	38.48	38.37	38.34	38.28	38.37	38.13
9	42.50	37.42	38.69	38.61	38.68	38.42	38.44	38.79	38.76
10	38.40	38.01	39.21	39.18	39.21	38.65	38.97	39.24	39.20
11		37.83	39.08	39.08	39.08	38.50	39.01	39.35	39.39
12	39.00	38.00	38.37	38.38	38.37	39.50	40.37	40.34	40.38
13	41.00		40.25	40.25	40.25		40.03	40.10	40.76
14							41.50	43.09	43.19
15									

Age	8.d	9.a	9.aN	14.a	All
0	18.93	27.81	18.59		20.47
1	18.85	29.16	26.91		24.98
2	29.94	29.42	28.88	33.44	31.41
3	31.68	33.68	31.08	33.70	33.11
4	35.57	37.15	33.63	35.40	34.14
5	36.63	38.72	35.37	36.11	35.12
6	37.36	39.22	37.03	36.86	36.25
7	37.95	39.09	37.69	37.75	37.01
8	38.06	38.98	38.05	37.96	37.64
9	38.78	39.12	38.84	38.69	38.07
10	39.20	40.00	39.20	38.63	38.22
11	39.42	39.00	39.46	38.63	38.69
12	40.02	41.00	40.16	39.47	39.03
13	40.27		41.20	39.57	39.33
14	43.31		44.45	39.63	39.46
15				39.59	40.00

Table 8.5.2. NE Atlantic Mackerel. Mean weight-at-age in the stock for 2022 per area and for the whole NEA mackerel stock

Age	North Sea area	Western area	Southern area	NEA Mackerel 2022 Weighted mean*
0				0.000
1		0.123	0.109	0.121
2	0.184	0.202	0.157	0.194
3	0.282	0.244	0.193	0.239
4	0.346	0.305	0.296	0.306
5	0.399	0.335	0.340	0.340
6	0.392	0.354	0.365	0.358
7	0.425	0.396	0.391	0.398
8	0.442	0.407	0.400	0.408
9	0.492	0.426	0.428	0.431
10	0.482	0.435	0.436	0.439
11	0.491	0.434	0.460	0.442
12+	0.494	0.484	0.477	0.484
Area Weighting	7.1%	78.6%	14.3%	
Number of fish sampled	148	1224	559	

*** Missing value of mean weight-at-age per component are replaced by component mean value in the calculation of the stock weights**

Table 8.5.3. NE Atlantic Mackerel. Mean proportion of mature fish-at-age for 2022 per area and for the whole NEA mackerel stock

Age	North Sea area	Western area	Southern area	NEA Mackerel
0	0	0	0	0
1	0	0.162	0.02	0.13
2	0.37	0.643	0.54	0.61
3	1	0.970	0.70	0.93
4	1	0.997	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
Area Weighting	7.1%	78.6%	14.3%	

Table 8.6.1.1.1 Total annual egg production and SSB for the western and southern areas and for combined area. Temporal series

Area	Year	TAEP ($*10^{12}$)	SSB (kt)
Combined	1992	2570	3874
Combined	1995	2230	3766
Combined	1998	2020	4199
Combined	2001	1670	3234
Combined	2004	1500	3107
Combined	2007	1770	3783
Combined	2010	2380	4811
Combined	2013	2700	4832
Combined	2016	1770	3524
Combined	2019	1640	3088
Combined	2022	2090	3563
Southern	1992	336	507
Southern	1995	186	370
Southern	1998	479	883
Southern	2001	318	417
Southern	2004	138	309
Southern	2007	348	745
Southern	2010	459	926
Southern	2013	506	904
Southern	2016	225	447
Southern	2019	423	797
Southern	2022	293	499
Western	1992	2230	3367
Western	1995	2050	3396
Western	1998	1540	3316
Western	2001	1350	2816
Western	2004	1360	2798
Western	2007	1420	3038

Area	Year	TAEP (*10^12)	SSB (kt)
Western	2010	1920	3884
Western	2013	2200	3928
Western	2016	1550	3077
Western	2019	1220	2291
Western	2022	1800	3064

Table 8.6.1.2.1 Time series of estimated fecundity parameters for adults

Parameter	Y1998	Y2001	Y2004	Y2007	Y2010	Y2013	Y2016	Y2019	Y2022
Fecundity samples (n)	96	187	205	176	74	132	97	62	396
Prevalence of atresia (n)	112	290	348	416	511	735	713	252	243
Intensity of atresia (n)	112	290	348	416	511	56	66	64	74
Relative potential fecundity (n/g)	1206	1097	1127	1098	1140	1257	1159	1191	1313
Prevalence of atresia	0.55	0.2	0.28	0.38	0.33	0.22	0.3	0.28	0.28
Geometric mean intensity of atresia (n/g	46	40	33	30	26	27	30	19	20
Potential fecundity lost per day (n/g)	3.37	1.07	1.25	1.48	1.16	0.8	1.2	0.71	0.75
Potential fecundity lost (n/g)	202	64	75	89	70	48	72	43	45
Relative potential fecundity lost (%)	17	6	7	9	6	4	6	4	3
Realised fecundity (n/g)	1002	1033	1052	1009	1070	1209	1087	1147	1268

Table 8.6.1.4.1. Daily egg production estimate for mackerel (stage 1a)(P0) and spawning area in the North Sea in 2022.

Year	P0 (eggs/m2/day)	Spawning area (km2)	Ptot (eggs/day)(*10^13)
2022	18.6	371126	0.69

Table 8.6.1.4.2. Comparison of Total Daily Egg production (Ptot) between 2022 and 2021 in the North Sea.

	2022	2021
Ptot *10^13	0.69	1.28

Table 8.6.2.1 Parameter estimates and standard errors used in the final model.

Parameter	Estimate	Std error
T	2	0.33
H	452.9	79.64
I (log(WingSpread [m]/ 1852))	-1	0.56
Log Nugget	3.7	NA
Variance (YS)	5.6	NA
Variance (IS)	5.3	NA

Table 8.6.2.2 Time series of spatially integrated recruitment index values of mackerel.

Cohort	Index
1998	0.010865
1999	0.016203
2000	0.011533
2001	0.017867
2002	0.022812
2003	0.011024
2004	0.025715
2005	0.033349
2006	0.030347
2007	0.019732
2008	0.017922
2009	0.012704
2010	0.019502
2011	0.032806
2012	0.023792
2013	0.026081
2014	0.019404
2015	0.021442
2016	0.037628
2017	0.038159
2018	0.033926
2019	0.038053
2020	0.031681
2021	0.025708

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 -2022		Yes
Catch-at-age in numbers	1980 -2022	0-12+	Yes
Weight-at-age in the commercial catch	1980 –2022	0-12+	Yes
Weight-at-age of the spawning stock at spawning time.	1980 –2022	0-12+	Yes
Proportion of natural mortality before spawning	1980 -2022	0-12+	Yes
Proportion of fishing mortality before spawning	1980 -2022	0-12+	Yes
Proportion mature-at-age	1980 -2022	0-12+	Yes
Natural mortality	1980 -2022	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, 2013,2016,2019,2022.	Not applicable (gives SSB)
Survey (abundance index)	IBTS Recruitment index (log transformed)	1998-2020, 2022	Age 0
Survey (abundance index)	International Ecosystem Summer Survey in the Nordic Seas (IESSNS)	2010, 2012-2023	Ages 3-11
Tagging/recapture	Norwegian tagging program	Steal tags : 1980 (release year)-2006 (recapture years) RFID tags : 2013 (release year) 2022 (recapture year)	Ages 5 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	0/0/0/0/0/0/0/0/0/0/0/0/0 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 0/0/0/3/4/5/6/7/8/9/10/10/0	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	1/2/3/3/3/3/3/3/3/3/3/3/3	Separate F random walk variances for age 0, age 1 and a same variance for older ages
Coupling of log abundance random walk variances	1/2/2/2/2/2/2/2/2/2/2/2/2	Same variance used for the log abundance random walk of all ages except for the recruits (age 0)
Coupling of the observation variances	1/2/3/3/3/3/3/3/3/3/3/3/3 0/0/0/0/0/0/0/0/0/0/0/0/0 4/0/0/0/0/0/0/0/0/0/0/0/0	Separate observation variances for age 0 and 1 than for the older ages in the catches One observation variance for the egg survey

	0/0/0/5/6/6/6/6/6/6/6/6/0	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
0	33101	56682	11180	7333	287287	81799	49983	7403	57644	65400
1	411327	276229	213936	47914	31901	268960	58126	40126	152656	64263
2	393025	502365	432867	668909	86064	20893	424563	156670	137635	312739
3	64549	231814	472457	433744	682491	58346	38387	663378	190403	207689
4	328206	32814	184581	373262	387582	445357	76545	56680	538394	167588
5	254172	184867	26544	126533	251503	252217	364119	89003	72914	362469
6	142978	173349	138970	20175	98063	165219	208021	244570	87323	48696
7	145385	116328	112476	90151	22086	62363	126174	150588	201021	58116
8	54778	125548	89672	72031	61813	19562	42569	85863	122496	111251
9	130771	41186	88726	48668	47925	47560	13533	34795	55913	68240
10	39920	146186	27552	49252	37482	37607	32786	19658	20710	32228
11	56210	31639	91743	19745	30105	26965	22971	25747	13178	13904
12	104927	199615	156121	132040	69183	97652	81153	63146	57494	35814

age \ year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	24246	10007	43447	19354	25368	14759	37956	36012	61127	67003
1	140534	58459	83583	128144	147315	81529	119852	144390	99352	73597
2	209848	212521	156292	210319	221489	340898	168882	186481	229767	132994
3	410751	206421	356209	266677	306979	340215	333365	238426	264566	223639
4	208146	375451	266591	398240	267420	275031	279182	378881	323186	261778
5	156742	188623	306143	244285	301346	186855	177667	246781	361945	281041
6	254015	129145	156070	255472	184925	197856	96303	135059	207619	244212
7	42549	197888	113899	149932	189847	142342	119831	84378	118388	159019
8	49698	51077	138458	97746	106108	113413	55812	66504	72745	86739
9	85447	43415	51208	121400	80054	69191	59801	39450	47353	50613
10	33041	70839	36612	38794	57622	42441	25803	26735	24386	30363
11	16587	29743	40956	29067	20407	37960	18353	13950	16551	17048
12	27905	52986	68205	68217	57551	39753	30648	24974	22932	32446

age \ year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
0	36345	26034	70409	14744	11553	12426	75651	19302	25886	17615
1	102407	40315	222577	187997	31421	46840	149425	88439	59899	36514
2	142898	158943	70041	275661	453133	135648	173646	190857	167748	113574
3	275376	234186	367902	91075	529753	668588	159455	220575	399086	455113
4	390858	297206	350163	295777	147973	293579	470063	215655	284660	616963
5	295516	309937	262716	235052	258177	120538	195594	455131	260314	319465
6	241550	231804	237066	183036	145899	121477	97061	203492	255675	224848
7	175608	195250	151320	133595	89856	63612	73510	77859	124382	194326
8	106291	120241	118870	94168	65669	38763	33399	59652	57297	73171

9	52394	72205	79945	75701	40443	23947	18961	30494	32343	29738
10	31280	42529	43789	45951	35654	18612	13987	16039	19482	14989
11	18918	20546	21611	25797	16430	7955	8334	11416	6798	7470
12	34202	40706	40280	30890	19509	10669	10186	12801	9581	5003

	year									
age	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	23453	30429	23877	11325	62142	6732	716	28306	6995	6236
1	78636	62748	66370	47077	44558	104282	57466	43763	40332	41921
2	137351	115701	204121	235494	138880	127940	205840	89101	236207	126073
3	304647	323847	216711	400036	672022	250575	258176	461621	136779	350611
4	740816	471564	417953	371713	832975	583694	427212	353230	376312	114606
5	613418	656507	458718	445515	568835	651786	593046	398273	257069	295731
6	285438	490219	514489	433533	554367	453084	534943	505073	294539	226640
7	143537	244725	325982	340686	506804	416897	341408	432242	424715	229725
8	102446	113277	143643	190660	341618	356936	270586	262799	316779	267491
9	45963	53512	69962	113220	142398	206045	170574	189449	197761	204818
10	21268	25081	30761	46269	63871	107830	94849	138347	140403	102991
11	6272	12322	11657	19025	21501	26978	33910	59278	82812	66976
12	8529	10792	11720	17890	14123	22741	24427	51139	60485	74918

age	2020	2021	2022
0	6443	2332	2410
1	52637	29202	8215
2	107302	326976	240690
3	182163	217298	270019
4	266760	281925	177836
5	166627	366644	237153
6	270154	182783	291996
7	246268	300014	178966
8	274182	208961	257886
9	311215	228236	193025
10	241775	198134	177568
11	128294	128957	185354
12	179703	118150	290793

Table 8.7.1.3. NE Atlantic Mackerel. WEIGHTS AT AGE IN THE CATCH

Units : Kg

	year											
age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
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
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
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
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
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
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
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
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
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
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
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
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
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

age \ year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
0	0.051	0.061	0.046	0.072	0.058	0.076	0.065	0.062	0.063	0.069	0.052	0.081
1	0.167	0.134	0.136	0.143	0.143	0.143	0.157	0.176	0.135	0.172	0.160	0.170
2	0.239	0.240	0.255	0.234	0.226	0.230	0.227	0.235	0.227	0.224	0.256	0.267
3	0.333	0.317	0.339	0.333	0.313	0.295	0.310	0.306	0.306	0.305	0.307	0.336
4	0.397	0.376	0.390	0.390	0.377	0.359	0.354	0.361	0.363	0.376	0.368	0.385
5	0.460	0.436	0.448	0.452	0.425	0.415	0.408	0.404	0.427	0.424	0.424	0.438
6	0.495	0.483	0.512	0.501	0.484	0.453	0.452	0.452	0.463	0.474	0.461	0.477
7	0.532	0.527	0.543	0.539	0.518	0.481	0.462	0.500	0.501	0.496	0.512	0.522
8	0.555	0.548	0.590	0.577	0.551	0.524	0.518	0.536	0.534	0.540	0.536	0.572
9	0.597	0.583	0.583	0.594	0.576	0.553	0.550	0.569	0.567	0.577	0.580	0.612
10	0.651	0.595	0.627	0.606	0.596	0.577	0.573	0.586	0.586	0.603	0.600	0.631
11	0.663	0.647	0.678	0.631	0.603	0.591	0.591	0.607	0.594	0.611	0.629	0.648
12	0.669	0.679	0.713	0.672	0.670	0.636	0.631	0.687	0.644	0.666	0.665	0.715

age \ year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	0.067	0.048	0.038	0.089	0.051	0.104	0.048	0.029	0.089	0.091	0.043	0.051
1	0.156	0.151	0.071	0.120	0.105	0.153	0.118	0.113	0.123	0.173	0.126	0.154
2	0.263	0.268	0.197	0.215	0.222	0.213	0.221	0.231	0.186	0.234	0.231	0.242
3	0.323	0.306	0.307	0.292	0.292	0.283	0.291	0.282	0.284	0.277	0.282	0.294
4	0.400	0.366	0.357	0.372	0.370	0.331	0.331	0.334	0.340	0.336	0.324	0.320
5	0.419	0.434	0.428	0.408	0.418	0.389	0.365	0.368	0.374	0.360	0.362	0.351
6	0.485	0.440	0.479	0.456	0.444	0.424	0.418	0.411	0.401	0.386	0.394	0.392
7	0.519	0.496	0.494	0.512	0.497	0.450	0.470	0.451	0.431	0.405	0.422	0.420
8	0.554	0.539	0.543	0.534	0.551	0.497	0.487	0.494	0.469	0.431	0.443	0.443
9	0.573	0.556	0.584	0.573	0.571	0.538	0.515	0.540	0.503	0.454	0.467	0.465
10	0.595	0.583	0.625	0.571	0.620	0.586	0.573	0.580	0.537	0.472	0.482	0.489
11	0.630	0.632	0.636	0.585	0.595	0.599	0.603	0.611	0.537	0.493	0.523	0.522
12	0.684	0.655	0.689	0.666	0.662	0.630	0.630	0.664	0.585	0.554	0.589	0.561

age \ year	2016	2017	2018	2019	2020	2021	2022
0	0.035	0.018	0.066	0.057	0.057	0.049	0.075
1	0.154	0.178	0.147	0.112	0.174	0.163	0.144
2	0.240	0.266	0.247	0.260	0.285	0.277	0.271
3	0.297	0.311	0.320	0.297	0.322	0.338	0.316
4	0.329	0.356	0.355	0.360	0.360	0.374	0.345
5	0.356	0.377	0.397	0.388	0.389	0.406	0.378
6	0.383	0.397	0.410	0.429	0.417	0.441	0.413
7	0.411	0.415	0.426	0.441	0.444	0.457	0.434
8	0.438	0.444	0.446	0.453	0.459	0.477	0.456
9	0.453	0.465	0.469	0.472	0.471	0.486	0.473
10	0.479	0.484	0.492	0.497	0.495	0.501	0.488
11	0.499	0.497	0.507	0.514	0.519	0.514	0.507
12	0.520	0.531	0.537	0.537	0.554	0.548	0.538

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
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
1	0.114	0.112	0.112	0.111	0.108	0.111	0.104	0.075	0.099	0.058	0.096	0.174
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
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
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
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
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
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
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
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
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
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
12	0.532	0.530	0.542	0.528	0.566	0.590	0.541	0.581	0.594	0.556	0.536	0.619

age \ year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
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
1	0.130	0.145	0.114	0.116	0.097	0.084	0.083	0.087	0.093	0.113	0.109	0.112
2	0.201	0.190	0.163	0.200	0.185	0.196	0.170	0.210	0.194	0.190	0.206	0.181
3	0.260	0.266	0.240	0.278	0.250	0.257	0.251	0.260	0.253	0.246	0.245	0.251
4	0.308	0.323	0.306	0.327	0.322	0.310	0.300	0.317	0.301	0.303	0.288	0.277
5	0.360	0.359	0.368	0.385	0.372	0.356	0.348	0.356	0.357	0.342	0.333	0.341
6	0.397	0.410	0.418	0.432	0.425	0.401	0.384	0.392	0.394	0.398	0.360	0.401
7	0.419	0.432	0.459	0.458	0.446	0.460	0.409	0.424	0.415	0.417	0.418	0.407
8	0.458	0.459	0.480	0.491	0.471	0.473	0.455	0.456	0.438	0.451	0.429	0.489
9	0.487	0.480	0.496	0.511	0.513	0.505	0.475	0.489	0.464	0.484	0.458	0.490
10	0.513	0.515	0.550	0.517	0.508	0.511	0.530	0.508	0.489	0.521	0.511	0.488
11	0.543	0.547	0.592	0.560	0.538	0.546	0.500	0.545	0.514	0.535	0.523	0.521
12	0.572	0.580	0.608	0.603	0.573	0.583	0.549	0.575	0.551	0.572	0.558	0.540

age \ year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
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
1	0.112	0.114	0.114	0.095	0.133	0.112	0.096	0.080	0.089	0.076	0.107	0.078
2	0.157	0.140	0.164	0.148	0.160	0.162	0.159	0.175	0.155	0.144	0.165	0.207
3	0.258	0.221	0.236	0.206	0.207	0.214	0.199	0.223	0.216	0.179	0.199	0.247
4	0.319	0.328	0.291	0.285	0.260	0.268	0.246	0.274	0.255	0.249	0.238	0.254
5	0.356	0.378	0.333	0.329	0.346	0.295	0.296	0.332	0.288	0.280	0.291	0.288
6	0.406	0.403	0.400	0.363	0.354	0.351	0.345	0.369	0.312	0.319	0.321	0.336
7	0.449	0.464	0.413	0.448	0.393	0.386	0.389	0.389	0.360	0.341	0.341	0.350
8	0.482	0.481	0.437	0.452	0.448	0.437	0.407	0.430	0.390	0.375	0.387	0.381
9	0.506	0.547	0.455	0.514	0.452	0.461	0.439	0.452	0.453	0.416	0.416	0.412
10	0.519	0.538	0.469	0.538	0.478	0.517	0.489	0.495	0.498	0.441	0.466	0.447
11	0.579	0.509	0.531	0.542	0.487	0.548	0.532	0.518	0.503	0.496	0.472	0.485
12	0.588	0.603	0.566	0.585	0.510	0.557	0.572	0.525	0.558	0.522	0.517	0.551

age \ year	2016	2017	2018	2019	2020	2021	2022
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.059	0.058	0.064	0.070	0.104	0.134	0.121
2	0.182	0.204	0.190	0.191	0.209	0.186	0.194
3	0.238	0.237	0.266	0.250	0.252	0.261	0.239

4	0.282	0.278	0.283	0.293	0.289	0.281	0.306
5	0.298	0.308	0.314	0.311	0.348	0.323	0.340
6	0.340	0.308	0.327	0.346	0.363	0.352	0.358
7	0.368	0.338	0.346	0.365	0.376	0.392	0.398
8	0.385	0.377	0.364	0.371	0.394	0.416	0.408
9	0.404	0.394	0.389	0.397	0.400	0.423	0.431
10	0.424	0.426	0.419	0.428	0.423	0.446	0.439
11	0.440	0.430	0.437	0.431	0.445	0.458	0.442
12	0.473	0.499	0.491	0.482	0.488	0.494	0.484

Table 8.7.1.5. NE Atlantic Mackerel. NATURAL MORTALITY

Units : NA

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
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
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
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
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
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
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
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
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
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
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
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
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
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

age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
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
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
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
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
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
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
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
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
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
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
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
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
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

age	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
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
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
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
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
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
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
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
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
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
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
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
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
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

Table 8.7.1.6. NE Atlantic Mackerel. PROPORTION MATURE

ear

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
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
1	0.093	0.097	0.097	0.098	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102
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
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
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
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
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
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
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
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
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
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
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

year

age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
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
1	0.102	0.102	0.102	0.102	0.102	0.097	0.097	0.097	0.104	0.104	0.104	0.106
2	0.520	0.534	0.621	0.599	0.586	0.621	0.688	0.669	0.692	0.675	0.710	0.690
3	0.928	0.934	0.938	0.931	0.936	0.880	0.886	0.876	0.909	0.909	0.937	0.940
4	0.996	0.996	0.994	0.993	1.000	0.993	0.994	0.989	0.989	0.987	0.992	0.988
5	0.997	0.997	0.997	0.994	1.000	0.998	0.999	0.999	0.998	0.998	1.000	1.000
6	0.994	0.994	0.993	0.987	0.994	0.999	0.999	0.999	0.999	0.999	1.000	1.000
7	1.000	1.000	0.999	0.999	0.999	1.000	1.000	1.000	1.000	0.999	1.000	0.999
8	1.000	1.000	1.000	1.000	1.000	0.994	0.995	0.996	0.997	0.997	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
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
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
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

year

age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
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
1	0.106	0.106	0.095	0.095	0.095	0.096	0.096	0.096	0.094	0.092	0.092	0.104
2	0.761	0.616	0.589	0.546	0.524	0.541	0.667	0.655	0.604	0.683	0.675	0.763
3	0.962	0.959	0.928	0.921	0.917	0.919	0.930	0.927	0.926	0.921	0.916	0.944
4	0.993	0.993	0.994	0.994	0.999	0.999	0.999	0.999	0.999	0.998	0.999	0.998
5	0.999	0.999	1.000	1.000	0.999	1.000	1.000	1.000	0.999	1.000	1.000	0.999
6	1.000	1.000	1.000	1.000	1.000	1.000	0.999	0.999	0.999	0.999	0.999	1.000
7	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	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
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
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
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

year

age	2016	2017	2018	2019	2020	2021	2022
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.138	0.136	0.114	0.114	0.114	0.130	0.130
2	0.633	0.606	0.464	0.534	0.559	0.591	0.608
3	0.937	0.945	0.902	0.910	0.913	0.940	0.934
4	0.997	0.998	0.998	0.999	0.998	0.998	0.998

5	0.999	1.000	1.000	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000	1.000	1.000	1.000
7	0.999	0.999	0.999	1.000	1.000	0.999	1.000
8	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
10	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
12	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

	year											
age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
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
1	0.166	0.166	0.166	0.166	0.166	0.166	0.166	0.166	0.166	0.166	0.139	0.111
2	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.240	0.272
3	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.240	0.272
4	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.240	0.272
5	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.393	0.406
6	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.393	0.406
7	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.393	0.406
8	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.393	0.406
9	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.393	0.406
10	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.393	0.406
11	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.393	0.406
12	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.393	0.406

	year											
age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
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
1	0.084	0.165	0.249	0.331	0.269	0.206	0.144	0.125	0.106	0.088	0.142	0.197
2	0.304	0.301	0.298	0.296	0.295	0.295	0.295	0.320	0.347	0.373	0.360	0.347
3	0.304	0.301	0.298	0.296	0.295	0.295	0.295	0.320	0.347	0.373	0.360	0.347
4	0.304	0.301	0.298	0.296	0.295	0.295	0.295	0.320	0.347	0.373	0.360	0.347
5	0.419	0.444	0.469	0.494	0.494	0.494	0.495	0.461	0.426	0.392	0.408	0.425
6	0.419	0.444	0.469	0.494	0.494	0.494	0.495	0.461	0.426	0.392	0.408	0.425
7	0.419	0.444	0.469	0.494	0.494	0.494	0.495	0.461	0.426	0.392	0.408	0.425
8	0.419	0.444	0.469	0.494	0.494	0.494	0.495	0.461	0.426	0.392	0.408	0.425
9	0.419	0.444	0.469	0.494	0.494	0.494	0.495	0.461	0.426	0.392	0.408	0.425
10	0.419	0.444	0.469	0.494	0.494	0.494	0.495	0.461	0.426	0.392	0.408	0.425
11	0.419	0.444	0.469	0.494	0.494	0.494	0.495	0.461	0.426	0.392	0.408	0.425
12	0.419	0.444	0.469	0.494	0.494	0.494	0.495	0.461	0.426	0.392	0.408	0.425

	year											
age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
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
1	0.251	0.262	0.274	0.285	0.206	0.125	0.047	0.092	0.138	0.183	0.170	0.156
2	0.334	0.317	0.300	0.284	0.266	0.249	0.232	0.176	0.119	0.064	0.117	0.171
3	0.334	0.317	0.300	0.284	0.266	0.249	0.232	0.176	0.119	0.064	0.117	0.171
4	0.334	0.317	0.300	0.284	0.266	0.249	0.232	0.176	0.119	0.064	0.117	0.171
5	0.441	0.409	0.376	0.344	0.310	0.275	0.242	0.233	0.225	0.216	0.203	0.189
6	0.441	0.409	0.376	0.344	0.310	0.275	0.242	0.233	0.225	0.216	0.203	0.189
7	0.441	0.409	0.376	0.344	0.310	0.275	0.242	0.233	0.225	0.216	0.203	0.189
8	0.441	0.409	0.376	0.344	0.310	0.275	0.242	0.233	0.225	0.216	0.203	0.189
9	0.441	0.409	0.376	0.344	0.310	0.275	0.242	0.233	0.225	0.216	0.203	0.189
10	0.441	0.409	0.376	0.344	0.310	0.275	0.242	0.233	0.225	0.216	0.203	0.189
11	0.441	0.409	0.376	0.344	0.310	0.275	0.242	0.233	0.225	0.216	0.203	0.189
12	0.441	0.409	0.376	0.344	0.310	0.275	0.242	0.233	0.225	0.216	0.203	0.189

	year						
age	2016	2017	2018	2019	2020	2021	2022
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.143	0.232	0.393	0.581	0.533	0.187	0.336
2	0.224	0.152	0.179	0.183	0.184	0.090	0.131
3	0.224	0.152	0.179	0.183	0.184	0.090	0.131
4	0.224	0.152	0.179	0.183	0.184	0.090	0.131

5	0.180	0.297	0.197	0.301	0.312	0.227	0.207
6	0.180	0.297	0.197	0.301	0.312	0.227	0.207
7	0.180	0.297	0.197	0.301	0.312	0.227	0.207
8	0.180	0.297	0.197	0.301	0.312	0.227	0.207
9	0.180	0.297	0.197	0.301	0.312	0.227	0.207
10	0.180	0.297	0.197	0.301	0.312	0.227	0.207
11	0.180	0.297	0.197	0.301	0.312	0.227	0.207
12	0.180	0.297	0.197	0.301	0.312	0.227	0.207

Table 8.7.1.8. NE Atlantic Mackerel. FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

	year											
age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
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
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
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
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
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
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
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
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
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
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
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
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
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

	year											
age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
0	0.333	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355
1	0.333	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355
2	0.333	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355
3	0.333	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355
4	0.333	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355
5	0.333	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355
6	0.333	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355
7	0.333	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355
8	0.333	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355
9	0.333	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355
10	0.333	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355
11	0.333	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355
12	0.333	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355

	year											
age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	0.350	0.346	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311
1	0.350	0.346	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311
2	0.350	0.346	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311
3	0.350	0.346	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311
4	0.350	0.346	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311
5	0.350	0.346	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311
6	0.350	0.346	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311
7	0.350	0.346	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311
8	0.350	0.346	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311
9	0.350	0.346	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311
10	0.350	0.346	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311
11	0.350	0.346	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311
12	0.350	0.346	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311

	year						
age	2016	2017	2018	2019	2020	2021	2022
0	0.343	0.327	0.312	0.296	0.312	0.329	0.345
1	0.343	0.327	0.312	0.296	0.312	0.329	0.345
2	0.343	0.327	0.312	0.296	0.312	0.329	0.345
3	0.343	0.327	0.312	0.296	0.312	0.329	0.345
4	0.343	0.327	0.312	0.296	0.312	0.329	0.345

5	0.343	0.327	0.312	0.296	0.312	0.329	0.345
6	0.343	0.327	0.312	0.296	0.312	0.329	0.345
7	0.343	0.327	0.312	0.296	0.312	0.329	0.345
8	0.343	0.327	0.312	0.296	0.312	0.329	0.345
9	0.343	0.327	0.312	0.296	0.312	0.329	0.345
10	0.343	0.327	0.312	0.296	0.312	0.329	0.345
11	0.343	0.327	0.312	0.296	0.312	0.329	0.345
12	0.343	0.327	0.312	0.296	0.312	0.329	0.345

Table 8.7.1.9. NE Atlantic Mackerel. SURVEY INDICES

```
SSB-egg-based-survey

1992            2022

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
1               3087517.078
1               -1
1               -1
1               3562657.162
R-idx

1998            2022

1               1               0               0

0               0

1               0.010864743
1               0.01620321
1               0.011533235
1               0.017866817
1               0.022812264
```

```
1               0.011024186
1               0.025714749
1               0.033349294
1               0.030346953
1               0.019732337
1               0.017922417
1               0.012704437
1               0.019501867
1               0.03280643
1               0.023792277
1               0.02608089
1               0.019404049
1               0.021441518
1               0.037627731
1               0.038158683
1               0.033925745
1               0.038052761
1               0.03168093
1               -1
1               0.025707856
Swept-idx

2010            2023

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
1	3814661	1211770	2920591	2856932	1948653	3906891	3824410	1499778	1248160
1	1430995	3361778	2134411	2528651	2525460	2032783	2904239	3835479	1495649
1	709444	1220543	1527964	367017	1291607	811226	1051955	969868	927410
1	2355905	944385	1307793	1043409	598182	956129	995936	1862024	1605735
1	3539644	1703188	549158	460261	786940	321450	483156	387485	450229

Table 8.7.1.10. NE Atlantic Mackerel. RFID recapture data for the year 2022

Release Yr	Recapture Yr	Year-class	age at re-lease	Numbers scanned in recapture Yr	Numbers Released in Release Year	Numbers re-captured
2020	2022	2009	11	23221600	2191	19
2020	2022	2010	10	63969402	5001	44
2020	2022	2011	9	82262728	5081	45
2020	2022	2012	8	53631347	5474	49
2020	2022	2013	7	43891854	2665	25
2020	2022	2014	6	86709988	4339	37
2020	2022	2015	5	47572116	1509	14
2021	2022	2010	11	63969402	5810	72
2021	2022	2011	10	82262728	5039	65
2021	2022	2012	9	53631347	2815	36
2021	2022	2013	8	43891854	2588	35
2021	2022	2014	7	86709988	3970	53
2021	2022	2015	6	47572116	1384	20
2021	2022	2016	5	100784920	9976	142

Table 8.7.2.1. NE Atlantic Mackerel. SAM parameter estimates for the 2023 update.

	estimate	std.dev	confidence interval lower bound	confidence interval upper bound
observation standard deviations				
Catches age 0	0.87	0.17	0.61	1.23
Catches age 1	0.36	0.33	0.19	0.71
Catches age 2-12	0.13	0.12	0.10	0.16
Egg survey	0.35	0.24	0.22	0.57
Recruitment index	0.27	0.29	0.15	0.48
IESSNS age 3	0.60	0.22	0.38	0.94
IESSNS ages 4-11	0.41	0.12	0.32	0.52
Recapture overdispersion tags	1.26	0.23	1.41	1.17
random walk standard deviation				
F age 0	0.29	0.41	0.13	0.66
F age 1	0.27	0.44	0.11	0.66
F age 2+	0.15	0.13	0.12	0.20
N@age0	0.19	0.58	0.06	0.62
process error standard deviation				
N@age1-12+	0.21	0.08	0.18	0.24
catchabilities				
egg survey	1.13	0.12	0.89	1.44
recruitment index	4.39E-09	0.11	3.50E-09	5.50E-09
IESSNS age 3	0.81	0.20	0.54	1.21
IESSNS age 4	1.14	0.15	0.84	1.55
IESSNS age 5	1.50	0.15	1.10	2.04
IESSNS age 6	1.46	0.16	1.07	1.99
IESSNS age 7	1.63	0.16	1.19	2.23
IESSNS age 8	1.55	0.16	1.12	2.12
IESSNS age 9	1.65	0.16	1.20	2.26
IESSNS ages 10-11	1.60	0.16	1.17	2.18
post tagging survival steal tags	0.40	0.11	0.34	0.45
post tagging survival RFID tags	0.18	0.11	0.15	0.21

Table 8.7.3.1. NE Atlantic Mackerel. STOCK SUMMARY.

Year	Recruitment			SSB			Total	F		
	Low Re-cruit-ment	Midpoint Recruit-ment	High Re-cruit-ment	Low SSB	Midpoint	High SSB	Catch	Low	Mid-point	High
	thousands			tonnes			tonnes			
1980	738556	2236661	6773556	1929717	4089931	8668385	734950	0.126	0.21	0.33
1981	1482481	3935162	10445665	1906223	3606692	6824085	754045	0.129	0.21	0.33
1982	2255093	4250320	8010857	2031684	3472009	5933427	716987	0.133	0.21	0.32
1983	2477846	4181532	7056617	2405542	3678958	5626478	672283	0.137	0.21	0.31
1984	1055106	1953170	3615633	2791467	3979779	5673949	641928	0.141	0.21	0.31
1985	914783	1763044	3397881	2941137	4008008	5461878	614371	0.146	0.21	0.31
1986	2413122	4062330	6838664	2703953	3602549	4799773	602201	0.153	0.22	0.31
1987	1645845	2707304	4453334	2684762	3569947	4746984	654992	0.161	0.22	0.31
1988	1705889	2665714	4165588	2714143	3521030	4567797	680491	0.170	0.23	0.32
1989	2621896	3850196	5653929	2577521	3288174	4194763	585920	0.181	0.24	0.33
1990	1614577	2351096	3423590	2695479	3373583	4222278	626107	0.193	0.26	0.34
1991	1807124	2641378	3860763	2642309	3273562	4055622	675665	0.21	0.27	0.36
1992	1256626	1957547	3049428	2448205	3002776	3682970	760690	0.22	0.29	0.38
1993	1664834	2394688	3444507	2189003	2663959	3241967	824568	0.24	0.31	0.39
1994	1933108	2783885	4009096	1921814	2321191	2803563	819087	0.25	0.32	0.40
1995	1451810	2073325	2960908	1913380	2290216	2741269	756277	0.25	0.31	0.39
1996	1466815	2063895	2904021	1825198	2174716	2591166	563472	0.25	0.30	0.37
1997	1218996	1735510	2470881	1823874	2144903	2522439	573029	0.24	0.30	0.36
1998	1451094	2299761	3644767	1797995	2118203	2495437	666316	0.25	0.30	0.37
1999	1255030	1906540	2896261	1955252	2297701	2700127	640309	0.27	0.32	0.38
2000	1631376	2231701	3052937	1963930	2261229	2603532	738606	0.29	0.33	0.39
2001	1905587	2546612	3403273	1870992	2145615	2460547	737463	0.31	0.37	0.43
2002	858620	1155583	1555255	1776826	2053280	2372746	771422	0.33	0.39	0.46
2003	3661266	4783942	6250872	1727292	2006047	2329787	679287	0.34	0.41	0.48
2004	4904673	6577625	8821210	2201692	2609154	3092025	660491	0.31	0.37	0.45
2005	1760759	2399484	3269909	2032428	2433808	2914455	549514	0.26	0.30	0.36
2006	2549599	3480919	4752431	1927087	2296686	2737170	481181	0.24	0.28	0.33
2007	3664024	5095654	7086659	2064174	2441423	2887618	586206	0.26	0.31	0.36
2008	3714761	5197356	7271667	2419214	2891383	3455707	623165	0.24	0.29	0.35
2009	2691002	3749368	5223987	2998720	3599313	4320194	737969	0.22	0.26	0.31

2010	3016440	4193134	5828850	3401426	4057815	4840869	877272	0.21	0.25	0.30
2011	2556669	3556127	4946294	3957832	4736686	5668809	948963	0.20	0.24	0.29
2012	4281527	5939342	8239066	3751514	4500692	5399482	899551	0.181	0.22	0.27
2013	4942486	6867546	9542402	4203695	5057375	6084418	938299	0.176	0.22	0.26
2014	2765711	3834283	5315712	5239637	6303439	7583226	1401788	0.176	0.22	0.26
2015	2447345	3387247	4688118	5310901	6418653	7757462	1215827	0.162	0.20	0.25
2016	3615580	5004656	6927402	4996244	6056742	7342338	1100135	0.147	0.183	0.23
2017	1523690	2120346	2950643	4830993	5859454	7106864	1159641	0.150	0.186	0.23
2018	3323155	4681101	6593949	4187213	5076992	6155849	1023144	0.154	0.191	0.24
2019	1964768	2814162	4030761	3530572	4306452	5252841	839727	0.158	0.197	0.24
2020	1748546	2544660	3703247	3305920	4038542	4933521	1039513	0.199	0.25	0.31
2021	3700171	5528431	8260036	3398574	4186470	5157025	1081540	0.21	0.27	0.33
2022	3116177	4953325	7873566	3091402	3951017	5049663	1046720	0.23	0.30	0.40
2023	1549418	3269823	6900492		3681064†					
Av-er-age	2280090	3402852	5217379	2792719	3532891	4536291	783747	0.21	0.26	0.34

† Estimated value from the forecast.

Table 8.7.3.2. NE Atlantic Mackerel. ESTIMATED POPULATION ABUNDANCE

Units:Thousands

year

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
0	4993795	4604685	3797410	3627594	4124798	4019352	3998993	4091728	3716101	3544801
1	4756420	4674563	4449821	2755669	2556728	4152007	3336161	3299389	4020954	2991042
2	2236661	3935162	4250320	4181532	1953170	1763044	4062330	2707304	2665714	3850196
3	908772	1804561	3293937	4024415	4215998	1348926	1232760	3985118	2145255	2326513
4	1556855	703232	1365141	2780216	3656294	3972222	1007201	840192	3691712	1666522
5	3392903	1162259	509463	943935	2127641	2996480	3117457	788673	530559	2947938
6	2621608	2408066	842135	378398	653611	1594903	2205898	2151188	603020	344817
7	823436	1782822	1634657	575372	268131	457848	1072888	1495225	1407653	463670
8	309595	573410	1242900	1136803	396300	194834	310709	766018	1041604	1062944
9	849547	215588	398854	866074	788871	277686	138902	210017	544322	728955
10	233888	591940	150046	277134	602658	546476	196327	96148	141046	374104
11	341930	162895	411773	104401	192481	417907	376503	135066	66068	92214
12	691584	720410	614275	711119	564497	523704	646553	697062	563917	423905

year

age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	3296690	3320330	3331859	3102977	2966742	2857519	2949914	2913000	2972230	3251063
1	3101668	2571518	2857170	3087322	2573261	2510057	2258953	2641902	2391332	2607841
2	2351096	2641378	1957547	2394688	2783885	2073325	2063895	1735510	2299761	1906540
3	3869183	2107804	2529093	1615862	1962776	2374987	2149403	1921972	1228406	2345975
4	1822699	3017243	1510622	2012102	1085678	1414842	1796396	1771019	1626367	1229880
5	1073317	1242251	1911691	978289	1369952	674441	964620	1200357	1502045	1264800
6	1962651	774645	942991	1152046	584416	963652	489065	723483	853197	899973
7	215155	1217902	473982	568446	647643	344411	571827	320366	478247	612014
8	351224	137739	729875	309316	335059	280904	212429	344689	261577	310193
9	728116	248271	88656	410067	181481	175430	136189	149900	211121	180565
10	477091	495048	159188	52777	214699	107923	92125	85631	101280	131744
11	251205	302048	310677	96684	29468	129039	61967	49195	53050	63056
12	343426	388693	440253	464220	337416	217410	207613	167601	139152	124229

year

age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
0	3111203	4389093	5043317	4042636	4959806	6098294	6166509	5211531	4832639	4710740
1	2975840	1845140	4979934	6070821	2909754	3983490	5962938	5711013	4436918	4272735
2	2231701	2546612	1155583	4783942	6577625	2399484	3480919	5095654	5197356	3749368
3	1771718	1732818	2455311	813382	3935118	5320042	1787244	2633659	4699279	5347442
4	1823904	1273154	1508857	1565163	753503	1945485	3294304	1549549	2116110	4177835
5	993678	1246480	967594	904320	1002265	547341	1091047	2164268	1299684	1737520
6	861901	648281	808643	568995	474680	492802	383418	773503	1183153	964198
7	618805	597414	399006	382446	268251	236713	289691	261814	442503	733724
8	374774	413668	343720	236868	184628	136236	136142	187464	182714	280012
9	191184	239635	226796	191079	116149	88903	75309	96372	104843	115566
10	114039	125262	126860	115440	90595	62673	53883	47829	59922	55504
11	70927	68986	62614	65355	47189	32353	32859	34601	22893	30682
12	121908	125471	110198	80294	57035	41447	39651	40541	32654	22419

year

age	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	5605915	6429152	5734036	5470180	5529895	5047612	5839707	6128054	6146977	6857188
1	4336537	5724823	6564180	4632674	4239607	5579064	3434145	5089660	4179739	4085434
2	4193134	3556127	5939342	6867546	3834283	3387247	5004656	2120346	4681101	2814162
3	3600369	3960768	2959315	5858933	7316370	3118790	2712386	4350708	1353985	3391438

4	5068330	3335577	3358824	2674386	5541704	5233421	2930306	2163318	2903339	940422
5	3180406	3798337	2718361	2873748	2710128	4199358	3959586	2334086	1468854	1590813
6	1406509	2355237	2822336	2651438	2786983	2298245	3418982	3461790	1650074	1090025
7	616194	1009091	1546129	1927603	2383142	2180015	1830017	3078698	2602387	1162159
8	408409	451129	680309	1024509	1593249	1789912	1598989	1481687	2170698	1847241
9	183166	228872	299367	468474	717702	1159140	1080442	1275224	1157749	1533436
10	78709	104192	140474	189118	315531	544508	640531	776177	787023	688691
11	27837	50274	60085	94692	108251	166776	280838	440284	553097	502967
12	34558	42903	55928	78882	80482	121290	165694	313193	404377	523901

	year			
age	2020	2021	2022	2023
0	6354080	5326079	5411404	5411404
1	6352981	5630840	3814513	4653840
2	2544660	5528431	4953325	3269823
3	1956909	1934161	3316479	4548413
4	2161348	1711833	1146833	2369765
5	796428	1500772	1126092	733023
6	1254771	621457	1083888	646205
7	944893	1212405	542038	764105
8	983003	783212	827062	325610
9	1330291	891399	601710	468196
10	1135584	946266	670247	362107
11	508044	743797	643854	404920
12	731508	590979	964063	955340

Table 8.7.3.3. NE Atlantic Mackerel. ESTIMATED FISHING MORTALITY

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.008	0.008
1	0.035	0.035	0.035	0.035	0.035	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
2	0.058	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.058	0.058	0.059
3	0.105	0.105	0.105	0.105	0.106	0.108	0.110	0.112	0.115	0.118	0.122	0.125	0.129
4	0.173	0.173	0.174	0.174	0.175	0.179	0.183	0.191	0.196	0.204	0.210	0.217	0.221
5	0.192	0.193	0.193	0.195	0.197	0.200	0.205	0.209	0.216	0.222	0.226	0.233	0.243
6	0.237	0.238	0.239	0.240	0.244	0.249	0.254	0.261	0.267	0.280	0.292	0.304	0.314
7	0.212	0.212	0.212	0.213	0.214	0.217	0.222	0.229	0.239	0.253	0.275	0.304	0.336
8	0.212	0.212	0.212	0.213	0.214	0.217	0.222	0.229	0.239	0.253	0.275	0.304	0.336
9	0.212	0.212	0.212	0.213	0.214	0.217	0.222	0.229	0.239	0.253	0.275	0.304	0.336
10	0.212	0.212	0.212	0.213	0.214	0.217	0.222	0.229	0.239	0.253	0.275	0.304	0.336
11	0.212	0.212	0.212	0.213	0.214	0.217	0.222	0.229	0.239	0.253	0.275	0.304	0.336
12	0.212	0.212	0.212	0.213	0.214	0.217	0.222	0.229	0.239	0.253	0.275	0.304	0.336

age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.007	0.007	0.006	0.005	0.005
1	0.035	0.035	0.035	0.035	0.034	0.034	0.033	0.033	0.030	0.031	0.026	0.019	0.017
2	0.060	0.061	0.062	0.063	0.064	0.066	0.067	0.069	0.069	0.068	0.066	0.069	0.061
3	0.133	0.135	0.138	0.140	0.144	0.149	0.157	0.167	0.161	0.161	0.142	0.146	0.134
4	0.224	0.227	0.227	0.227	0.226	0.231	0.241	0.256	0.268	0.265	0.237	0.220	0.190
5	0.250	0.253	0.258	0.267	0.280	0.299	0.316	0.340	0.326	0.333	0.326	0.310	0.271
6	0.322	0.326	0.325	0.323	0.324	0.329	0.343	0.366	0.411	0.405	0.409	0.384	0.336
7	0.368	0.387	0.378	0.349	0.327	0.328	0.342	0.355	0.412	0.477	0.530	0.478	0.358
8	0.368	0.387	0.378	0.349	0.327	0.328	0.342	0.355	0.412	0.477	0.530	0.478	0.358
9	0.368	0.387	0.378	0.349	0.327	0.328	0.342	0.355	0.412	0.477	0.530	0.478	0.358
10	0.368	0.387	0.378	0.349	0.327	0.328	0.342	0.355	0.412	0.477	0.530	0.478	0.358
11	0.368	0.387	0.378	0.349	0.327	0.328	0.342	0.355	0.412	0.477	0.530	0.478	0.358
12	0.368	0.387	0.378	0.349	0.327	0.328	0.342	0.355	0.412	0.477	0.530	0.478	0.358

age	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
0	0.005	0.005	0.005	0.004	0.004	0.004	0.003	0.003	0.003	0.002	0.001	0.001	0.001
1	0.019	0.017	0.015	0.013	0.014	0.013	0.012	0.012	0.013	0.015	0.014	0.011	0.010
2	0.053	0.043	0.037	0.035	0.036	0.036	0.037	0.038	0.040	0.042	0.045	0.047	0.052
3	0.109	0.099	0.096	0.095	0.094	0.090	0.085	0.084	0.095	0.096	0.106	0.115	0.116
4	0.173	0.165	0.162	0.167	0.166	0.161	0.152	0.158	0.161	0.147	0.163	0.172	0.157
5	0.241	0.247	0.237	0.225	0.222	0.208	0.200	0.196	0.213	0.192	0.186	0.199	0.211
6	0.320	0.313	0.283	0.274	0.252	0.242	0.222	0.209	0.222	0.217	0.194	0.190	0.212
7	0.331	0.404	0.389	0.324	0.308	0.299	0.263	0.257	0.241	0.222	0.185	0.185	0.188
8	0.331	0.404	0.389	0.324	0.308	0.299	0.263	0.257	0.241	0.222	0.185	0.185	0.188
9	0.331	0.404	0.389	0.324	0.308	0.299	0.263	0.257	0.241	0.222	0.185	0.185	0.188
10	0.331	0.404	0.389	0.324	0.308	0.299	0.263	0.257	0.241	0.222	0.185	0.185	0.188
11	0.331	0.404	0.389	0.324	0.308	0.299	0.263	0.257	0.241	0.222	0.185	0.185	0.188
12	0.331	0.404	0.389	0.324	0.308	0.299	0.263	0.257	0.241	0.222	0.185	0.185	0.188

age	2019	2020	2021	2022
0	0.001	0.001	0.001	0.001
1	0.009	0.008	0.006	0.004
2	0.051	0.051	0.058	0.055
3	0.115	0.111	0.115	0.101
4	0.150	0.155	0.178	0.182

5	0.225	0.245	0.267	0.264
6	0.238	0.269	0.324	0.333
7	0.185	0.283	0.281	0.371
8	0.185	0.283	0.281	0.371
9	0.185	0.283	0.281	0.371
10	0.185	0.283	0.281	0.371
11	0.185	0.283	0.281	0.371
12	0.185	0.283	0.281	0.371

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	Exploita-tion pat-tern	Weights in the catch
2023								
0	4498424	0.15	0.000	0.000	0.329	0.000	0.001	0.060
1	4846566	0.15	0.125	0.352	0.329	0.120	0.006	0.160
2	3269823	0.15	0.586	0.135	0.329	0.196	0.055	0.278
3	4548413	0.15	0.929	0.135	0.329	0.251	0.110	0.325
4	2369765	0.15	0.998	0.135	0.329	0.292	0.172	0.360
5	733023	0.15	1.000	0.249	0.329	0.337	0.260	0.391
6	646205	0.15	1.000	0.249	0.329	0.358	0.309	0.424
7	764105	0.15	1.000	0.249	0.329	0.388	0.311	0.445
8	325610	0.15	1.000	0.249	0.329	0.406	0.311	0.464
9	468196	0.15	1.000	0.249	0.329	0.418	0.311	0.477
10	362107	0.15	1.000	0.249	0.329	0.436	0.311	0.495
11	404920	0.15	1.000	0.249	0.329	0.448	0.311	0.513
12+	955340	0.15	1.000	0.249	0.329	0.489	0.311	0.547
2024 and 2025								
0	4498424	0.15	0.000	0.000	0.329	0.000	0.001	0.060
1	-	0.15	0.125	0.352	0.329	0.120	0.006	0.160
2	-	0.15	0.586	0.135	0.329	0.196	0.055	0.278
3	-	0.15	0.929	0.135	0.329	0.251	0.110	0.325
4	-	0.15	0.998	0.135	0.329	0.292	0.172	0.360
5	-	0.15	1.000	0.249	0.329	0.337	0.260	0.391
6	-	0.15	1.000	0.249	0.329	0.358	0.309	0.424
7	-	0.15	1.000	0.249	0.329	0.388	0.311	0.445
8	-	0.15	1.000	0.249	0.329	0.406	0.311	0.464
9	-	0.15	1.000	0.249	0.329	0.418	0.311	0.477
10	-	0.15	1.000	0.249	0.329	0.436	0.311	0.495
11	-	0.15	1.000	0.249	0.329	0.448	0.311	0.513
12+	-	0.15	1.000	0.249	0.329	0.489	0.311	0.547

Table 8.8.3.2. NE Atlantic Mackerel. Short-term prediction: Multi-option table for 1 131 416 t catch in 2022 and a range of F-values in 2023.

2023			
TSB	SSB	F_{bar}	Catch
4 965 336	3 681 064	0.38	1 147 407

2024				2025		
TSB	SSB	Fbar	Catch	TSB	SSB	Implied change in the catch
4565496	3593282	0	0	5127054	4174174	-100%
-	3587818	0.01	31447	5100357	4141755	-97%
-	3582366	0.02	62634	5073885	4109684	-95%
-	3576926	0.03	93564	5047636	4077959	-92%
-	3571499	0.04	124241	5021608	4046576	-89%
-	3566084	0.05	154665	4995799	4015529	-87%
-	3560681	0.06	184839	4970206	3984815	-84%
-	3555290	0.07	214766	4944829	3954430	-81%
-	3549911	0.08	244449	4919663	3924369	-79%
-	3544544	0.09	273889	4894708	3894630	-76%
-	3539189	0.1	303088	4869962	3865208	-74%
-	3533846	0.11	332050	4845422	3836099	-71%
-	3528516	0.12	360775	4821087	3807300	-69%
-	3523197	0.13	389267	4796954	3778807	-66%
-	3517890	0.14	417528	4773022	3750616	-64%
-	3512595	0.15	445560	4749289	3722723	-61%
-	3507312	0.16	473365	4725753	3695126	-59%
-	3502040	0.17	500945	4702411	3667819	-56%
-	3496781	0.18	528302	4679263	3640801	-54%
-	3491533	0.19	555438	4656306	3614067	-52%
-	3486297	0.2	582356	4633539	3587615	-49%
-	3481072	0.21	609057	4610959	3561440	-47%
-	3475860	0.22	635544	4588565	3535539	-45%
-	3470659	0.23	661818	4566355	3509910	-42%
-	3465469	0.24	687882	4544328	3484548	-40%
-	3460291	0.25	713737	4522481	3459451	-38%
-	3455125	0.26	739386	4500813	3434616	-36%
-	3449970	0.27	764830	4479323	3410039	-33%
-	3444827	0.28	790071	4458008	3385718	-31%
-	3439695	0.29	815112	4436867	3361649	-29%
-	3434575	0.3	839953	4415898	3337829	-27%
-	3429466	0.31	864598	4395100	3314256	-25%
-	3424368	0.32	889047	4374471	3290926	-23%
-	3419282	0.33	913302	4354009	3267837	-20%
-	3414207	0.34	937366	4333713	3244986	-18%
-	3409143	0.35	961240	4313582	3222370	-16%
-	3404090	0.36	984926	4293613	3199985	-14%
-	3399049	0.37	1008425	4273806	3177830	-12%
-	3394019	0.38	1031740	4254159	3155902	-10%
-	3389000	0.39	1054872	4234669	3134198	-8%
-	3383993	0.4	1077823	4215337	3112716	-6%
-	3378996	0.41	1100593	4196159	3091452	-4%
-	3374011	0.42	1123187	4177136	3070404	-2%
-	3369036	0.43	1145603	4158265	3049571	0%
-	3364073	0.44	1167845	4139544	3028948	2%
-	3359120	0.45	1189914	4120974	3008534	4%
-	3354179	0.46	1211812	4102552	2988326	6%
-	3349248	0.47	1233540	4084276	2968323	8%
-	3344329	0.48	1255099	4066146	2948520	9%
-	3339420	0.49	1276492	4048160	2928917	11%

-	3334522	0.5	1297719	4030316	2909511	13%
-	3329635	0.51	1318783	4012614	2890299	15%
-	3324759	0.52	1339684	3995052	2871279	17%
-	3319894	0.53	1360425	3977629	2852450	19%
-	3315039	0.54	1381006	3960344	2833808	20%
-	3310195	0.55	1401430	3943194	2815352	22%
-	3305362	0.56	1421697	3926180	2797079	24%
-	3300539	0.57	1441809	3909299	2778988	26%
-	3295727	0.58	1461768	3892551	2761076	27%
-	3290926	0.59	1481575	3875934	2743341	29%
-	3286135	0.6	1501230	3859447	2725781	31%
-	3281355	0.61	1520737	3843089	2708394	33%
-	3276585	0.62	1540095	3826858	2691178	34%
-	3271826	0.63	1559307	3810754	2674131	36%
-	3267077	0.64	1578374	3794776	2657252	38%
-	3262339	0.65	1597296	3778921	2640537	39%
-	3257611	0.66	1616076	3763190	2623987	41%
-	3252894	0.67	1634714	3747580	2607597	42%
-	3248187	0.68	1653212	3732091	2591367	44%
-	3243490	0.69	1671572	3716722	2575295	46%
-	3238804	0.7	1689793	3701472	2559379	47%
-	3234128	0.71	1707878	3686339	2543617	49%
-	3229462	0.72	1725829	3671322	2528007	50%
-	3224807	0.73	1743645	3656421	2512548	52%
-	3220161	0.74	1761328	3641634	2497238	54%
-	3215526	0.75	1778880	3626960	2482075	55%
-	3210901	0.76	1796301	3612398	2467058	57%
-	3206286	0.77	1813594	3597948	2452184	58%
-	3201681	0.78	1830758	3583608	2437453	60%
-	3197087	0.79	1847795	3569377	2422863	61%
-	3192502	0.8	1864707	3555254	2408411	63%
-	3187928	0.81	1881494	3541238	2394097	64%
-	3183363	0.82	1898158	3527329	2379919	65%
-	3178808	0.83	1914699	3513525	2365875	67%
-	3174264	0.84	1931119	3499825	2351965	68%
-	3169729	0.85	1947418	3486229	2338185	70%
-	3165204	0.86	1963599	3472735	2324535	71%
-	3160689	0.87	1979661	3459342	2311014	73%
-	3156184	0.88	1995606	3446050	2297620	74%
-	3151689	0.89	2011435	3432858	2284351	75%
-	3147204	0.9	2027150	3419765	2271207	77%
-	3142728	0.91	2042750	3406769	2258185	78%
-	3138262	0.92	2058237	3393871	2245284	79%
-	3133806	0.93	2073613	3381069	2232503	81%
-	3129359	0.94	2088877	3368362	2219841	82%
-	3124923	0.95	2104031	3355749	2207297	83%
-	3120495	0.96	2119077	3343230	2194868	85%
-	3116078	0.97	2134014	3330804	2182554	86%
-	3111670	0.98	2148844	3318470	2170354	87%
-	3107272	0.99	2163569	3306227	2158265	89%
-	3102883	1	2178187	3294074	2146288	90%
-	3098504	1.01	2192702	3282010	2134420	91%
-	3094134	1.02	2207113	3270036	2122661	92%
-	3089774	1.03	2221422	3258149	2111009	94%
-	3085423	1.04	2235629	3246349	2099463	95%
-	3081082	1.05	2249735	3234636	2088021	96%
-	3076750	1.06	2263742	3223008	2076684	97%
-	3072427	1.07	2277649	3211465	2065449	99%
-	3068114	1.08	2291459	3200006	2054316	100%
-	3063810	1.09	2305171	3188630	2043283	101%
-	3059516	1.1	2318787	3177337	2032349	102%

Table 8.8.3.3. NE Atlantic Mackerel. Short-term prediction: specific management options.

Rationale	Catch (2024)	F_{bar} (2024)	SSB (2024)	SSB (2025)	% SSB change *	% catch change **	% advice change ***
Fbar(2024) = 0.26 (Fmsy)	739386	0.26	3455125	3434616	-1%	-36%	-5%
Catch(2024) = Zero	0	0	3593282	4174174	16%	-100%	-100%
Catch(2024) = 2023 catch -20%	917926	0.33	3418309	3277843	-4%	-20%	17%
Catch(2024) = 2023 catch	1147407	0.43	3368635	3107830	-8%	0%	47%
Catch(2024) = 2023 catch +25%	1434259	0.57	3302353	2895825	-12%	25%	83%
Fbar(2024) = Fbar(2023)	1039888	0.38	3392255	3148251	-7%	-9%	33%
Fbar(2024) = 0.36 (Fpa)	984926	0.36	3404090	3199985	-6%	-14%	26%
Fbar(2024) = 0.46 (Flim)	1211812	0.46	3354179	2988326	-11%	6%	55%
SSB2025 =Blim	2359065	1.13	3046688	2000132	-34%	106%	202%
SSB2025=Bpa	1671572	0.69	3243490	2575295	-21%	46%	114%

*** SSB 2025 relative to SSB 2024.**

**** Catch in 2024 relative to assumed catches in 2023 (1 147 40 t). There is no internationally agreed TAC for 2023.**

***** Catch in 2024 relative to the advice value for 2023 (782 066t).**

8.15 Figures

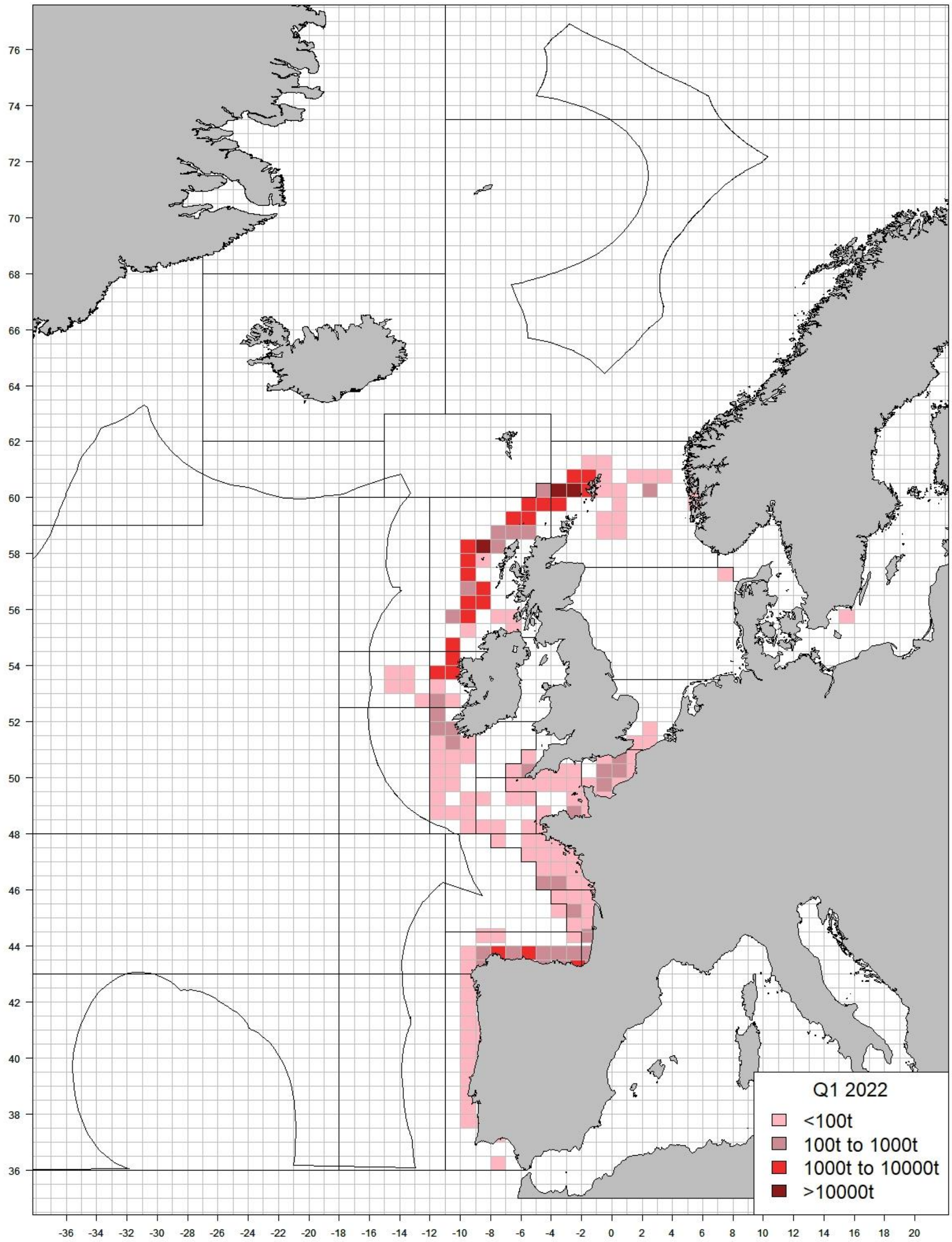


Figure 8.2.2.1. NE Atlantic Mackerel. Commercial catches in 2022, quarter 1.

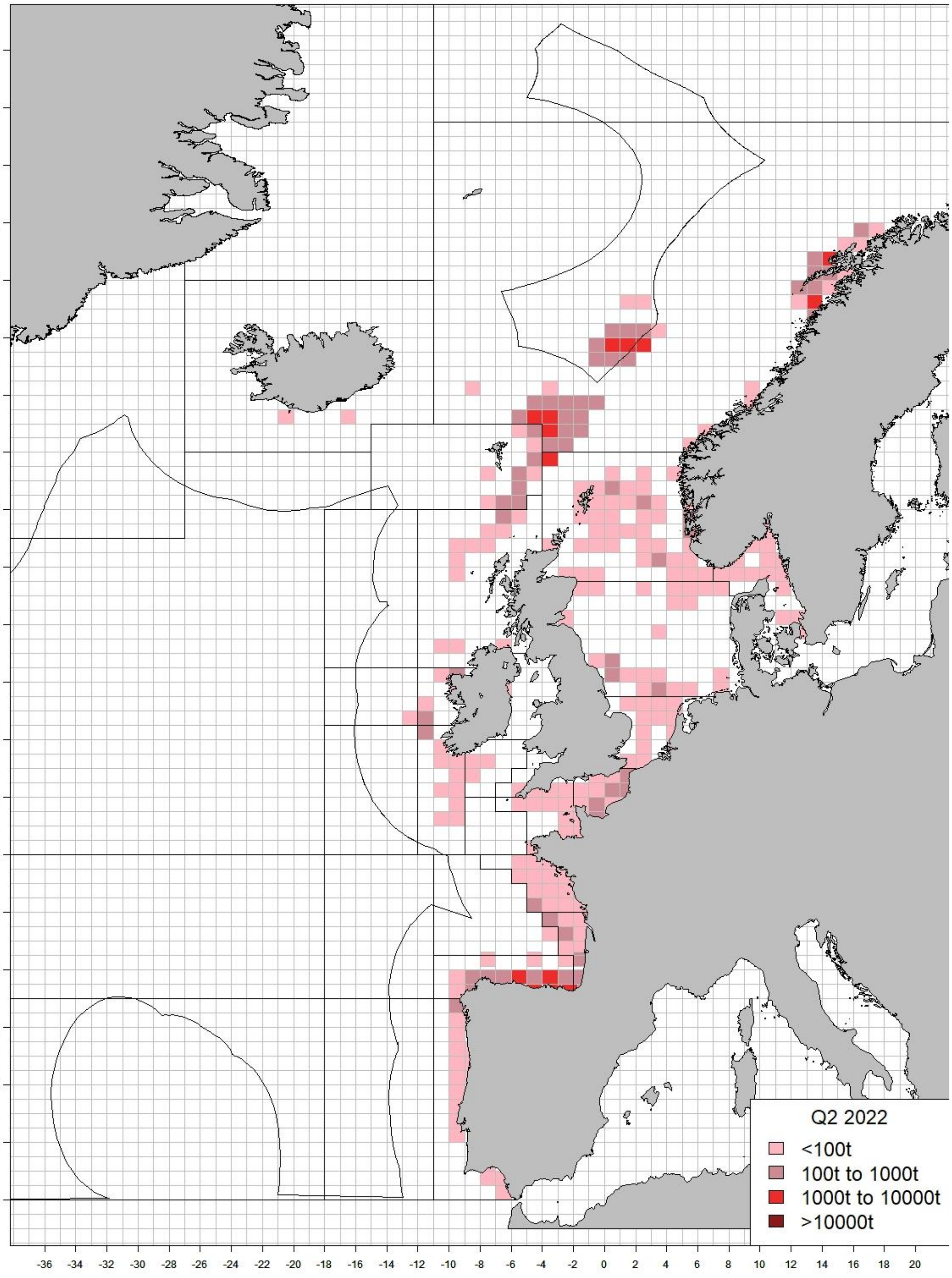


Figure 8.2.2.2. NE Atlantic Mackerel. Commercial catches in 2022, quarter 2.

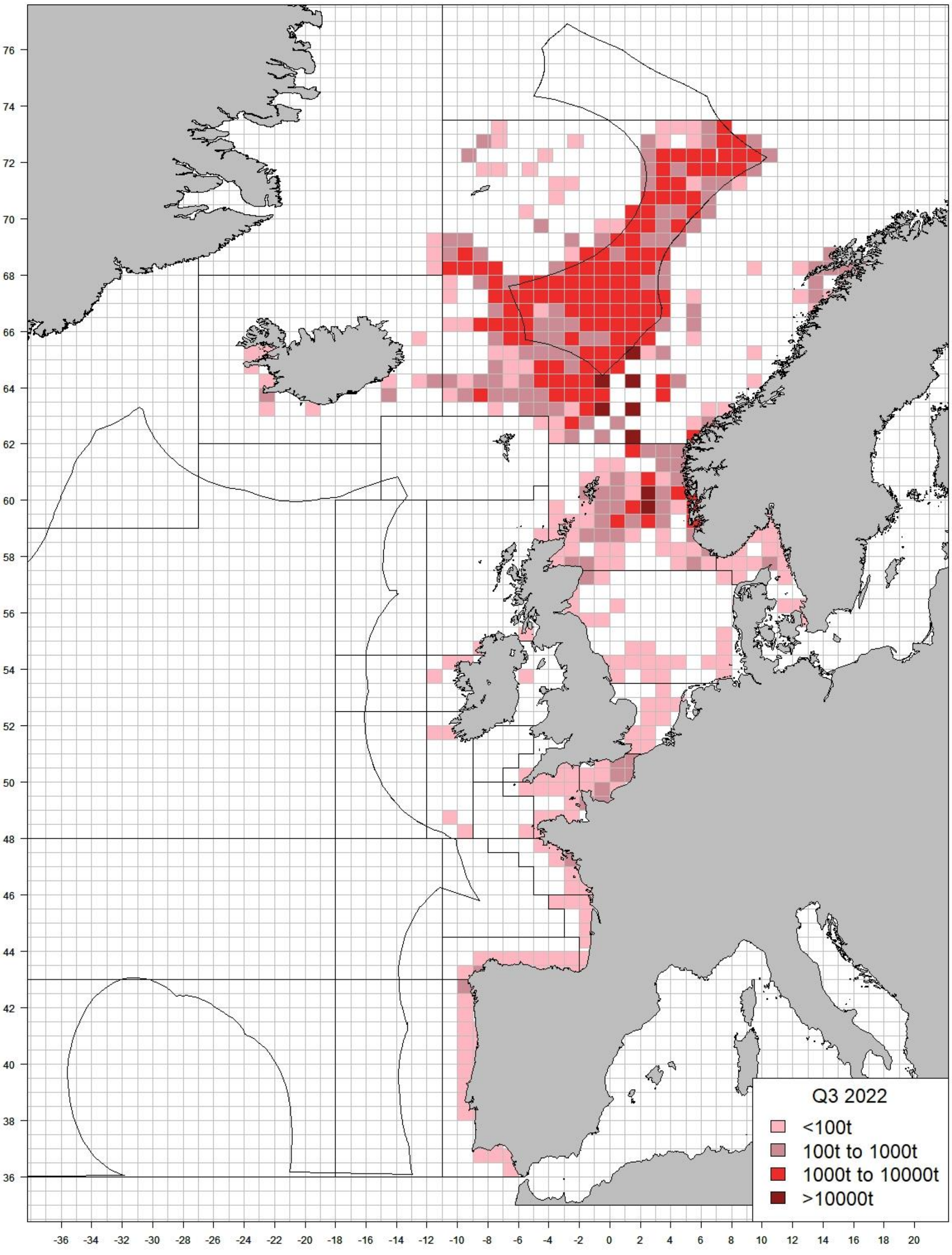


Figure 8.2.2.3. NE Atlantic Mackerel. Commercial catches in 2022, quarter 3.

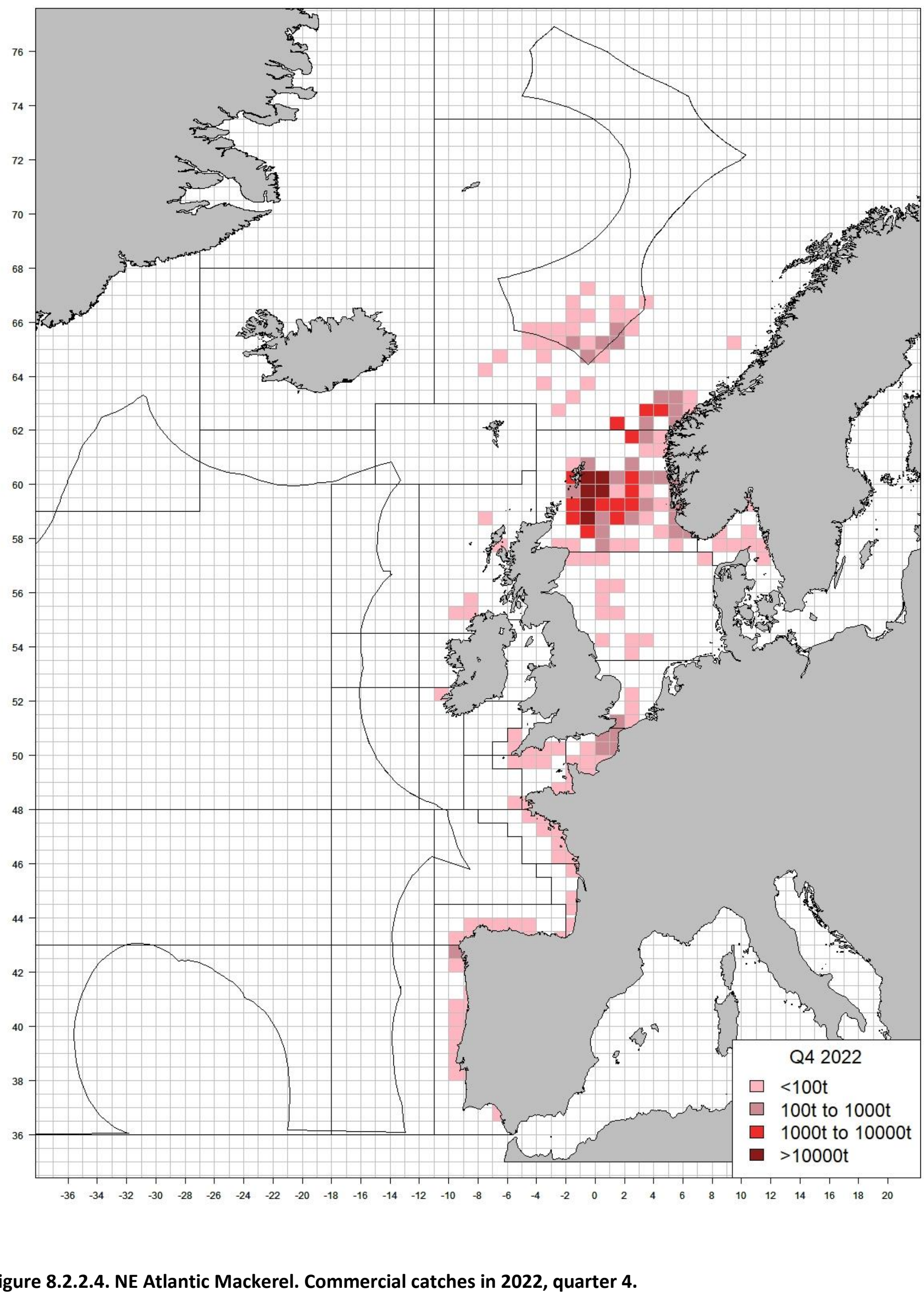


Figure 8.2.2.4. NE Atlantic Mackerel. Commercial catches in 2022, quarter 4.

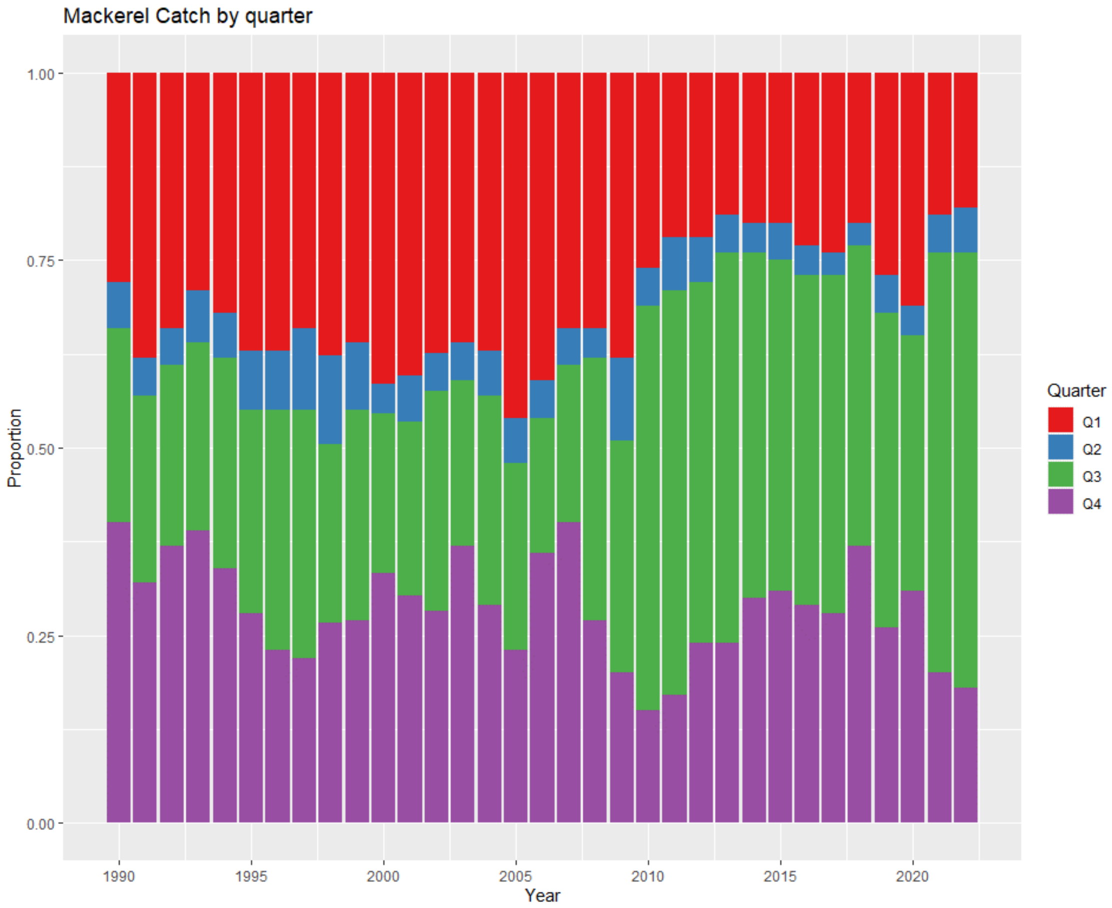


Figure 8.2.3.1. NE Atlantic Mackerel. Proportion of the catch by quarter by year.

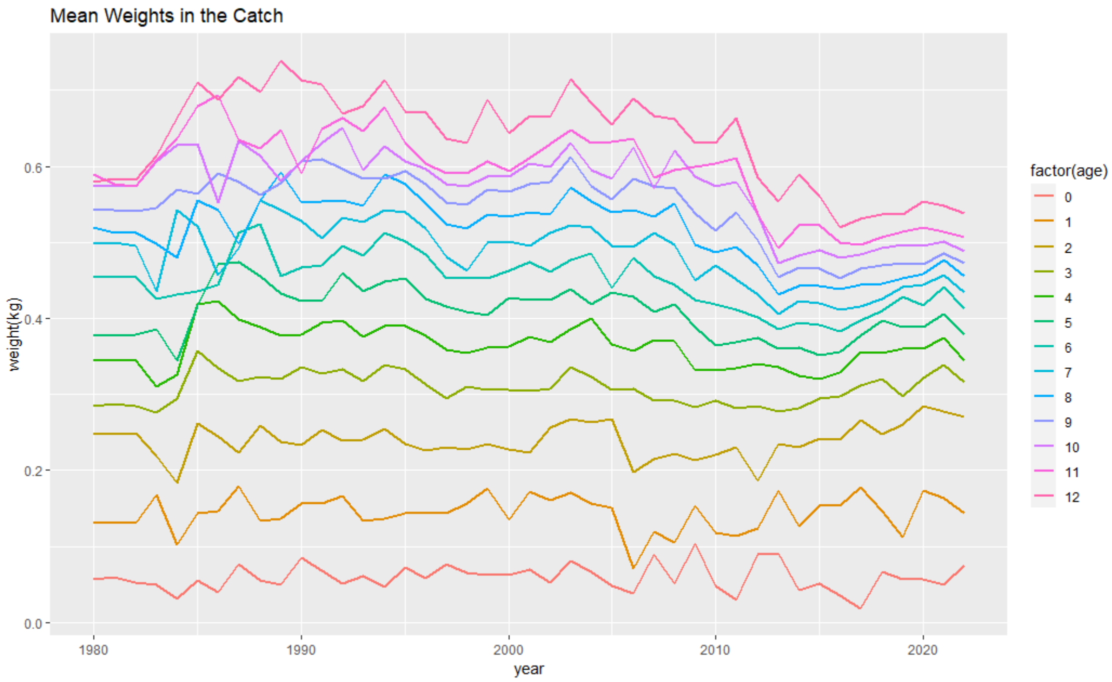


Figure 8.5.2.1. NE Atlantic mackerel. Weights-at-age in the catch.

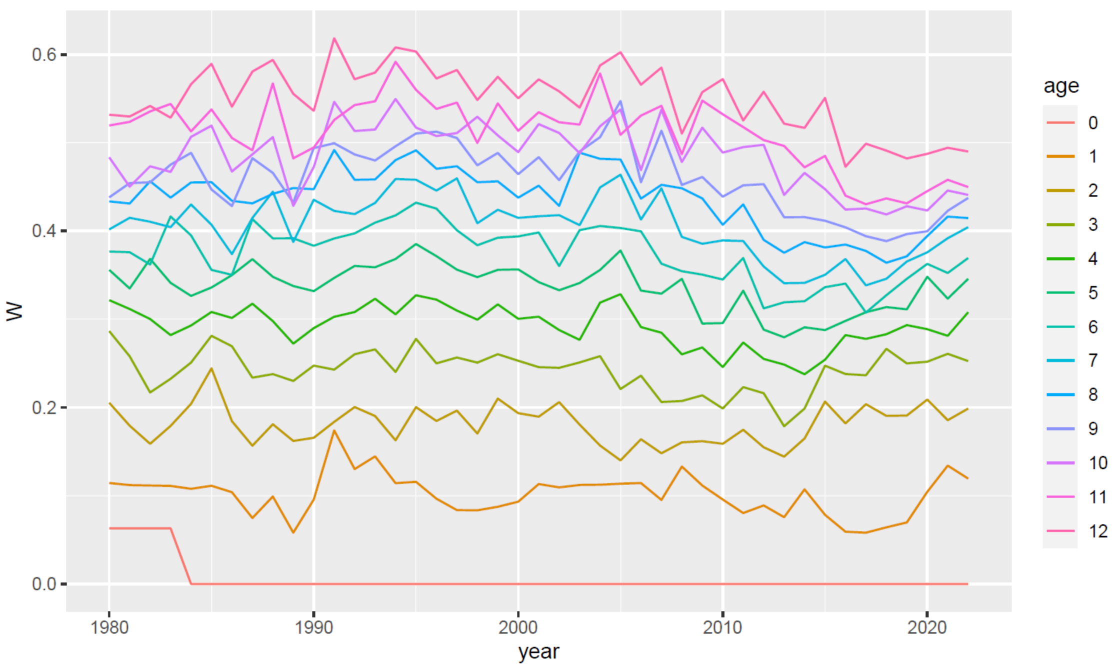


Figure 8.5.2.2. NE Atlantic mackerel. Weights-at-age in the stock.

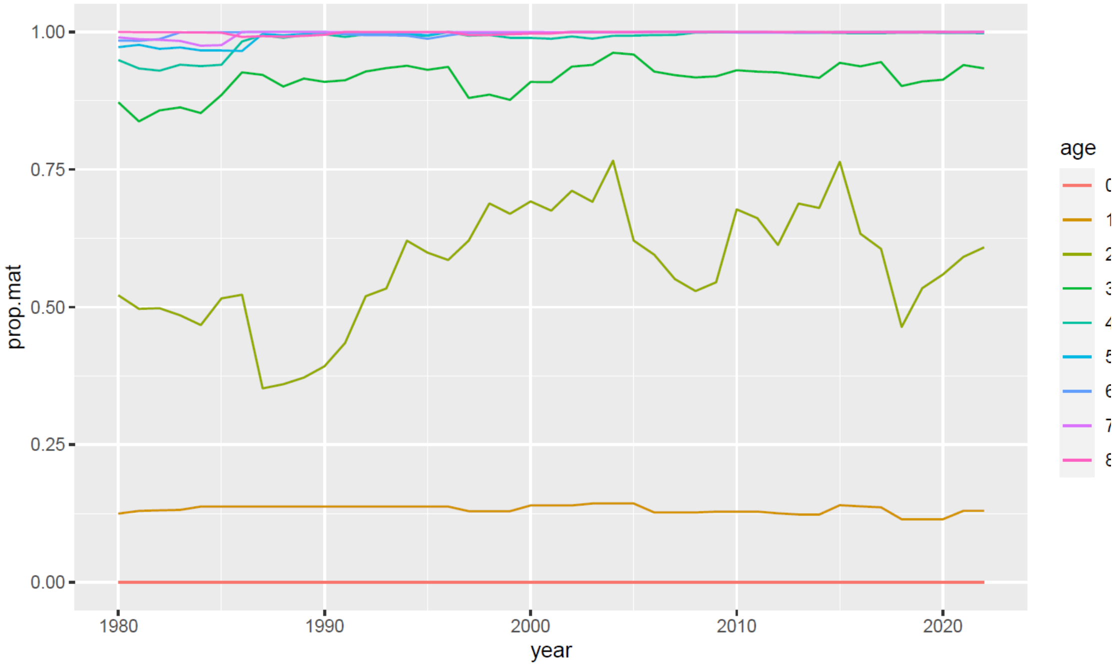


Figure 8.5.3.1. NE Atlantic mackerel. Proportion of mature fish at age.

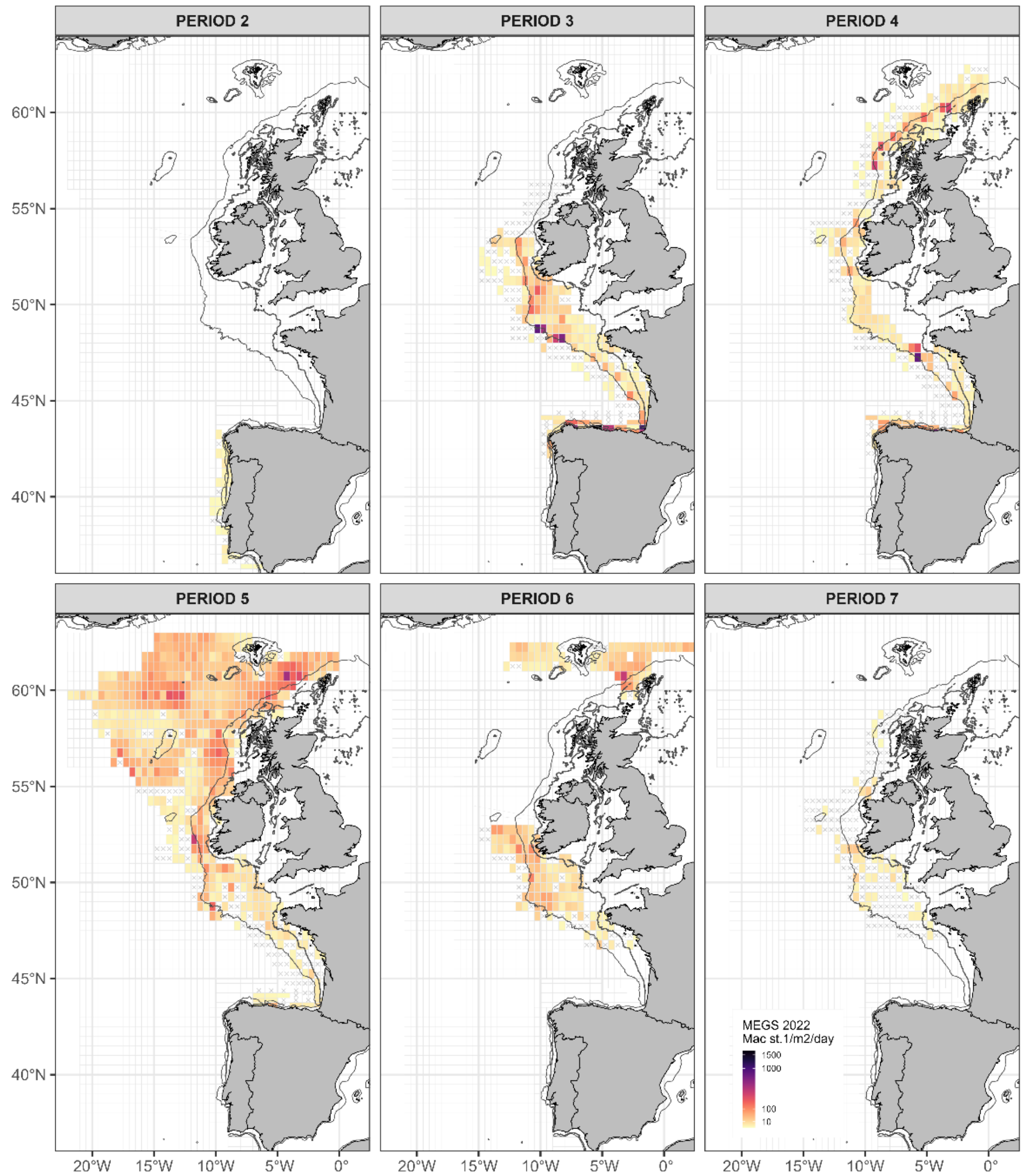


Figure 8.6.1.1.1. Mackerel egg production by half rectangle and survey period. Colour scale represents mackerel stage I eggs/m2/day by ICES half rectangle. Crosses represent zero values

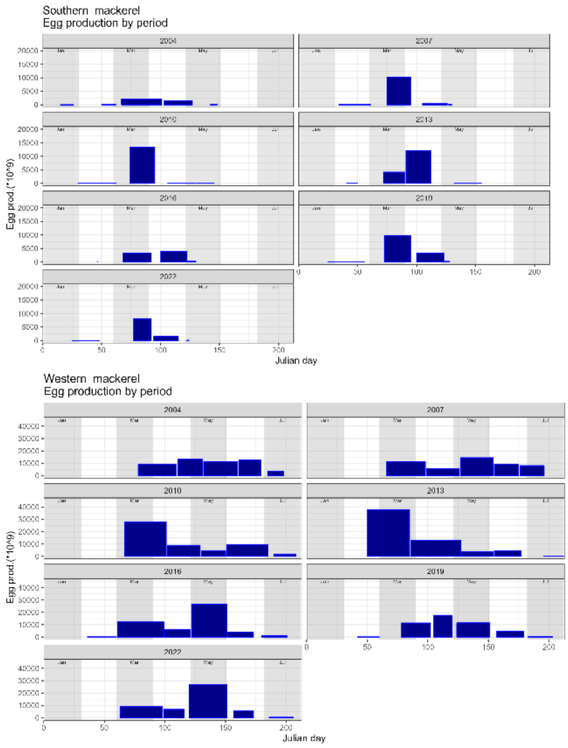


Figure 8.6.1.1.2. Egg production by period for the southern (left) and western (right) areas for the NEA mackerel stock since 2004

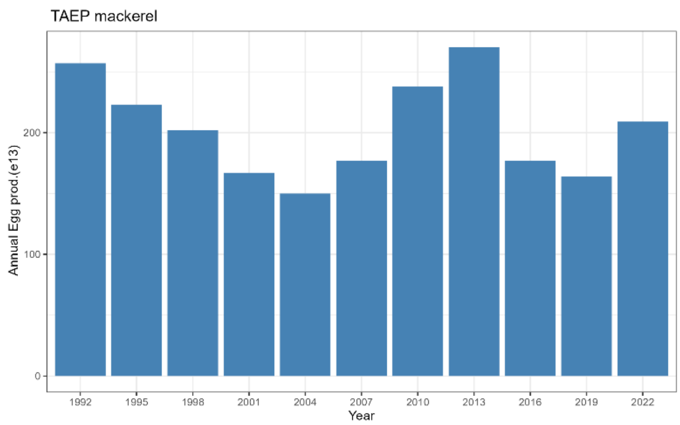


Figure 8.6.1.1.3. Combined mackerel TAEP estimates (southern and western areas)(*10^{13}) - 1992 – 2022.

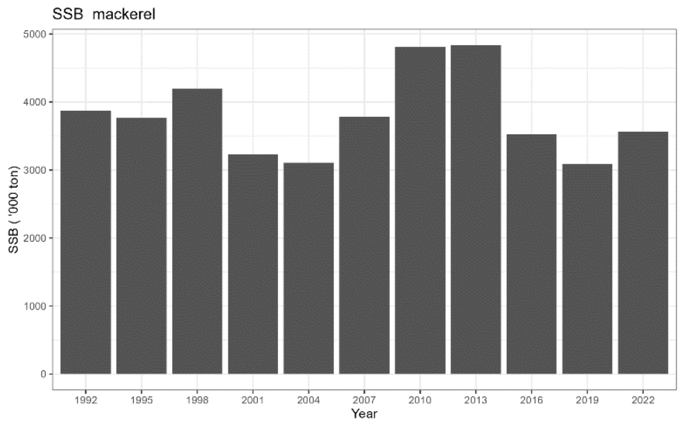


Figure 8.6.1.3.1. SSB estimates using AEPM for NEA mackerel. 1992-2022

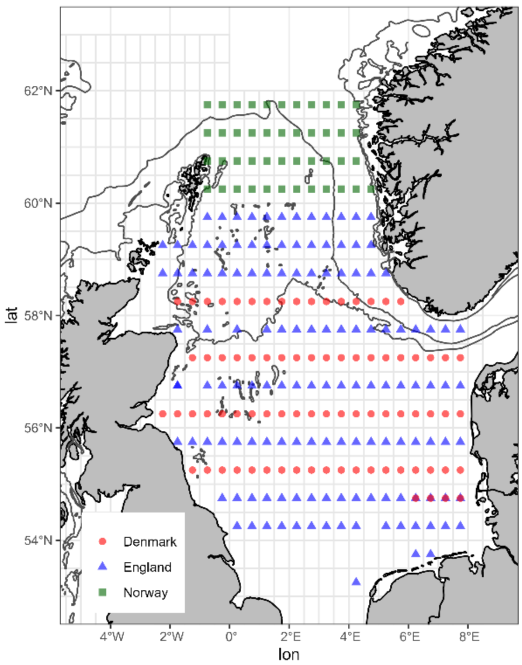


Figure 8.6.1.4.1. Survey coverage for the North Sea, 2022.Norway (Green), England (Blue), Denmark (Red).

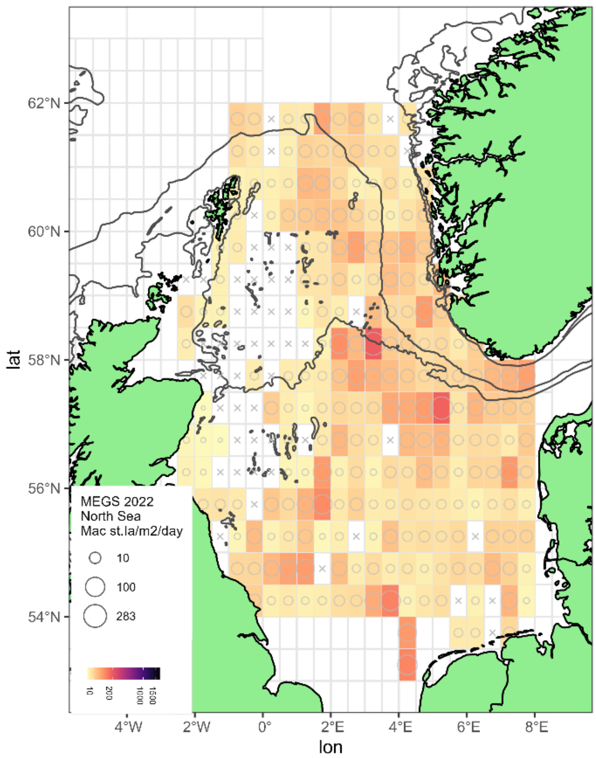


Figure 8.6.1.4.2. Heat map of Stage Ia mackerel egg production (eggs. m2. day-1) by half rectangle for the North Sea, 2022. Grey circles represent observed values, crosses represent observed zeros.

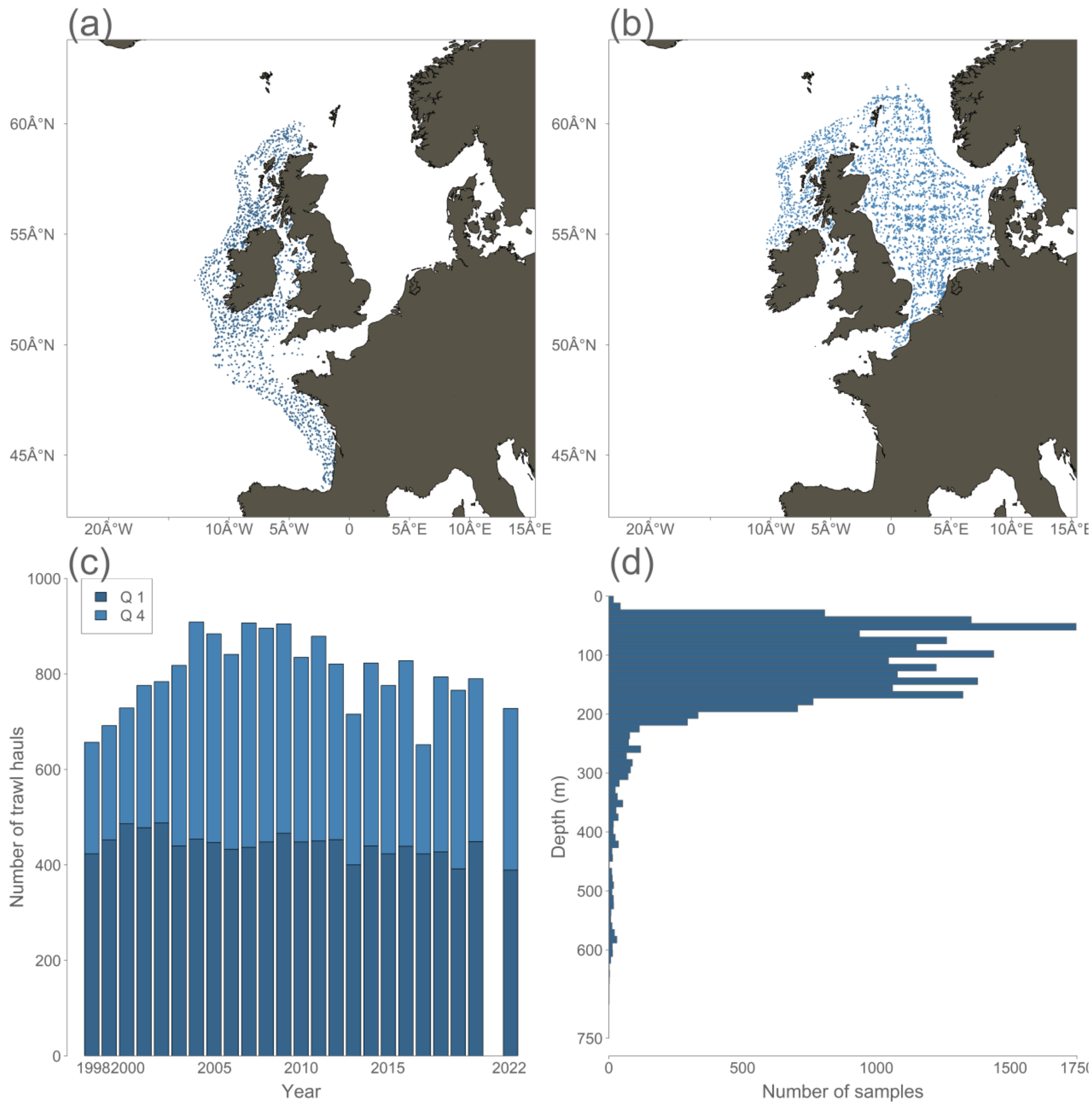


Figure 8.6.2.1.1. Overview of the distribution of trawl hauls and number of samples in IBTS in the period 1998-2023. a) Geographical positions of hauls in Q4. b) Geographical positions of hauls in Q1 hauls. c) Number of hauls from Q1 and Q4. d) Vertical distribution of all hauls.

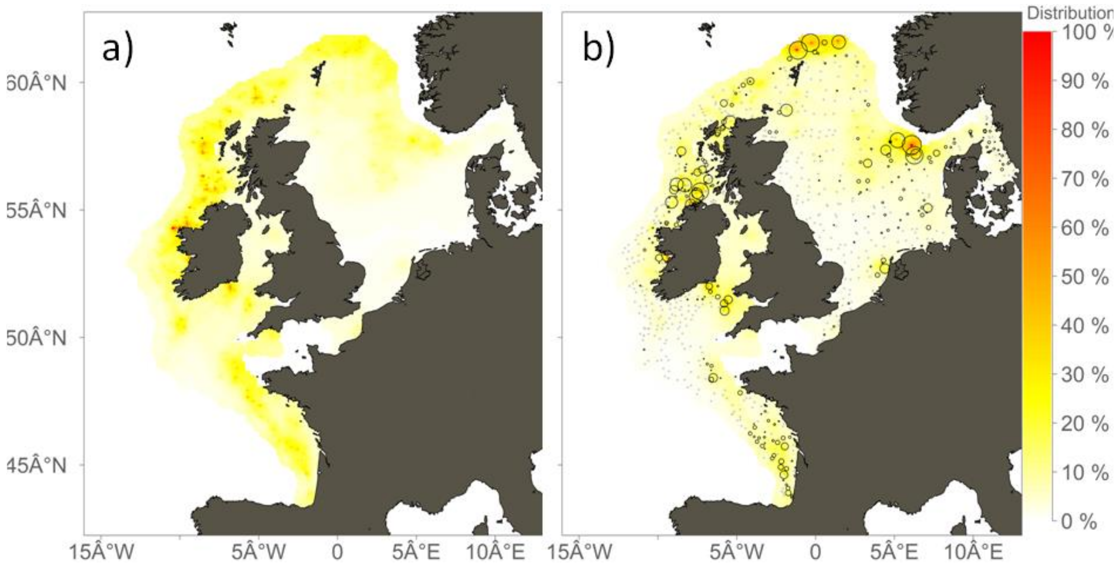


Figure 8.6.2.2.1. Spatial distribution of mackerel juveniles at age 0 in October to March. a) Average for cohorts from 1998-2022. b) 2022 cohort. Mackerel squared catch rates by trawl haul (circle areas represent catch rates in kg/km²) overlaid on modelled squared catch rates per 10 x 10 km rectangle. Each rectangle is coloured according to the expected squared catch rate in percent of the highest value for that year. See Jansen et al. (2015) for details.

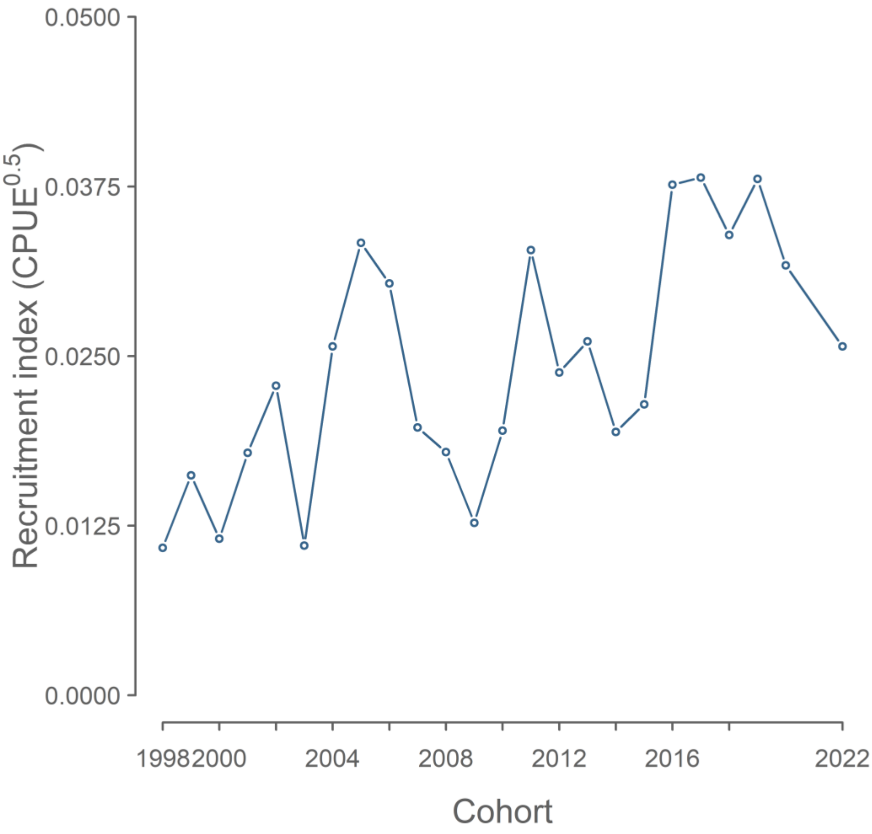


Figure 8.6.2.2.2. Index of mackerel juveniles at age 0 in October to March proxied by annual integration of square root of expected catch in demersal trawl surveys (Blue lines). See Jansen et al. (2015) for details.

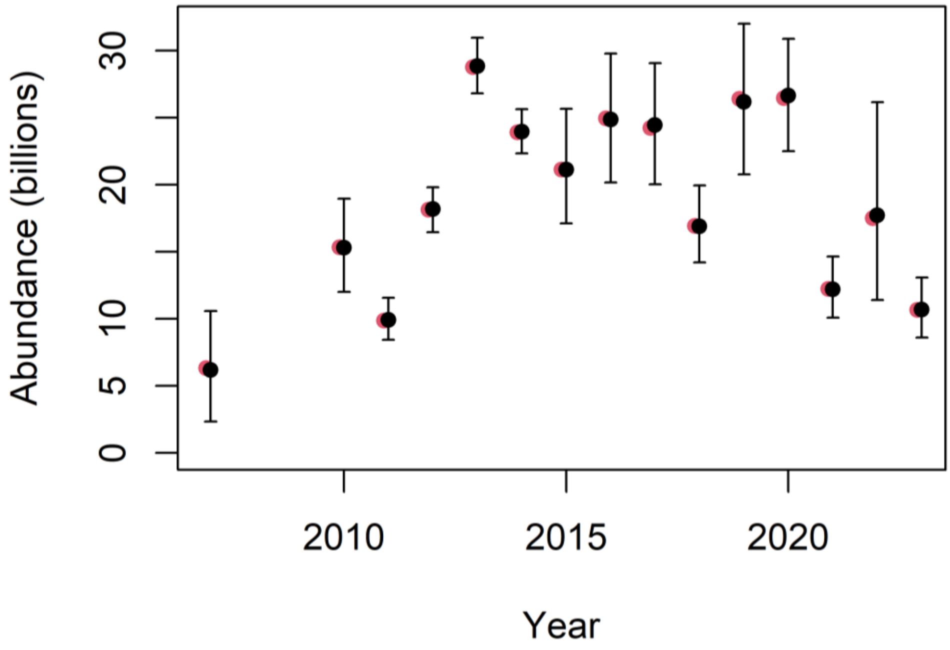


Figure 8.6.3.1. Estimated total stock numbers (TSN) of mackerel from IESSNS calculated using StoX for the years 2007 and from 2010 to 2023. Displayed is StoX baseline estimate (red dot) and a bootstrap estimate (black dot), calculated using 1000 replicates, with 90% confidence intervals (vertical line) based on the bootstrap. Analysis excludes the North Sea and survey coverage was incomplete in 2007 and 2011.

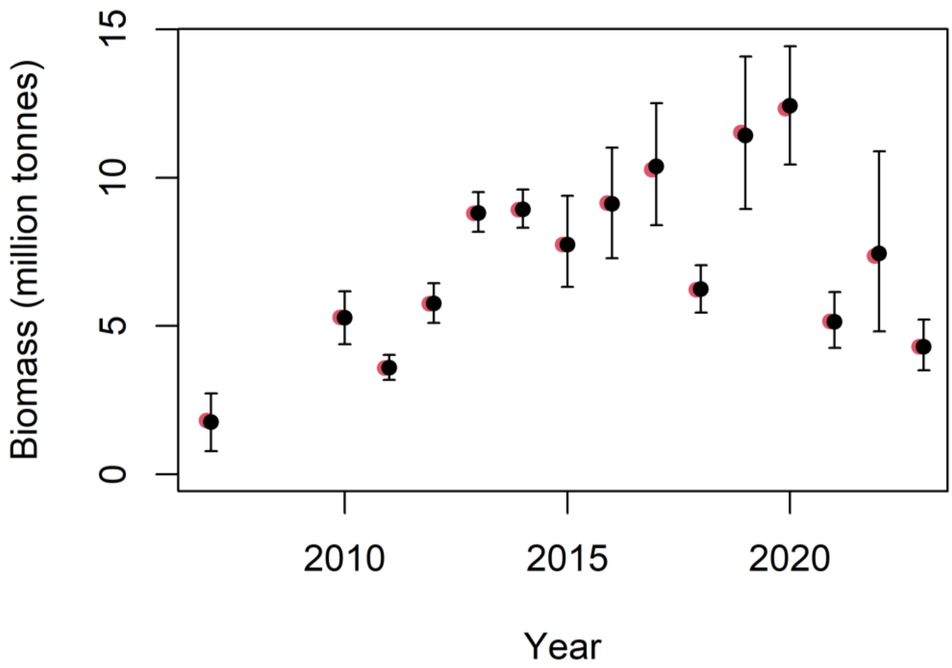


Figure 8.6.3.2. Estimated total stock biomass of mackerel from IESSNS calculated using StoX for the years 2007 and from 2010 to 2023. Displayed is StoX baseline estimate (red dot) and a bootstrap estimate (black dot), calculated using 1000 replicates, with 90% confidence intervals (vertical line) based on the bootstrap. Analysis excludes the North Sea and survey coverage was incomplete in 2007 and 2011.

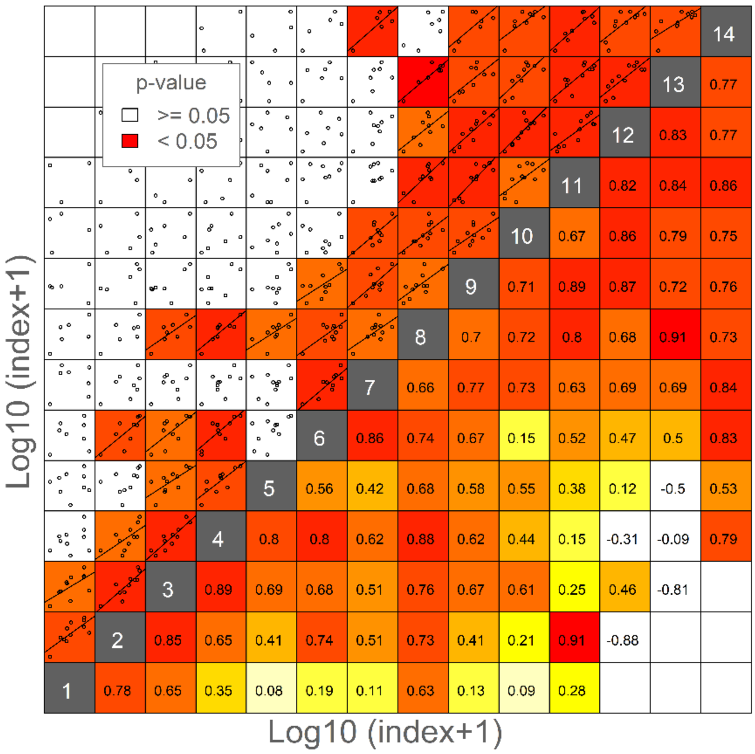


Figure 8.6.3.3. Internal consistency of the mackerel abundance index from the IESSNS survey including data from 2012 to 2023, excluding North Sea. Ages indicated by white numbers in grey diagonal cells. Statistically significant positive correlations (*p<0.05*) are indicated by regression lines and red cells in upper left half. Correlation coefficients (r) are given in the lower right half.

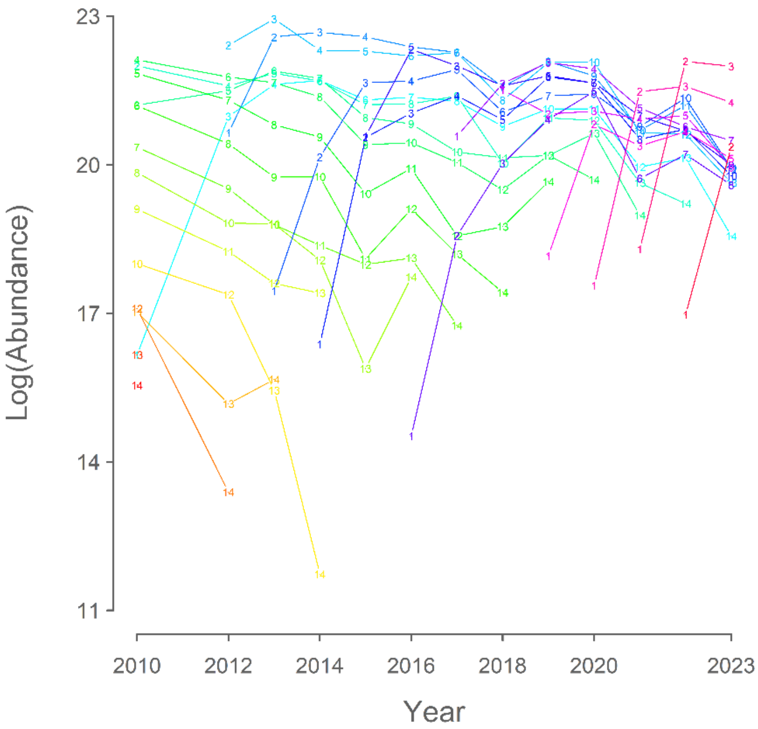


Figure 8.6.3.4. Mackerel catch curves from the estimate stock size at age from the IESSNS in 2010 and from 2012 to 2023, excluding the North Sea. Each cohort is marked by a uniquely coloured line that connects the estimates indicated by the respective ages.

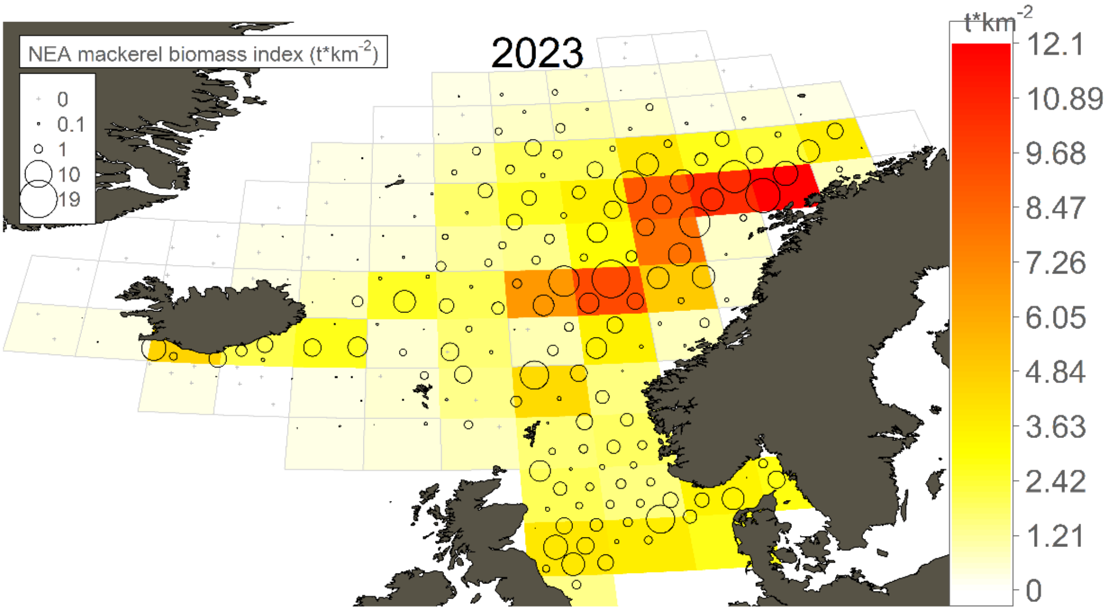
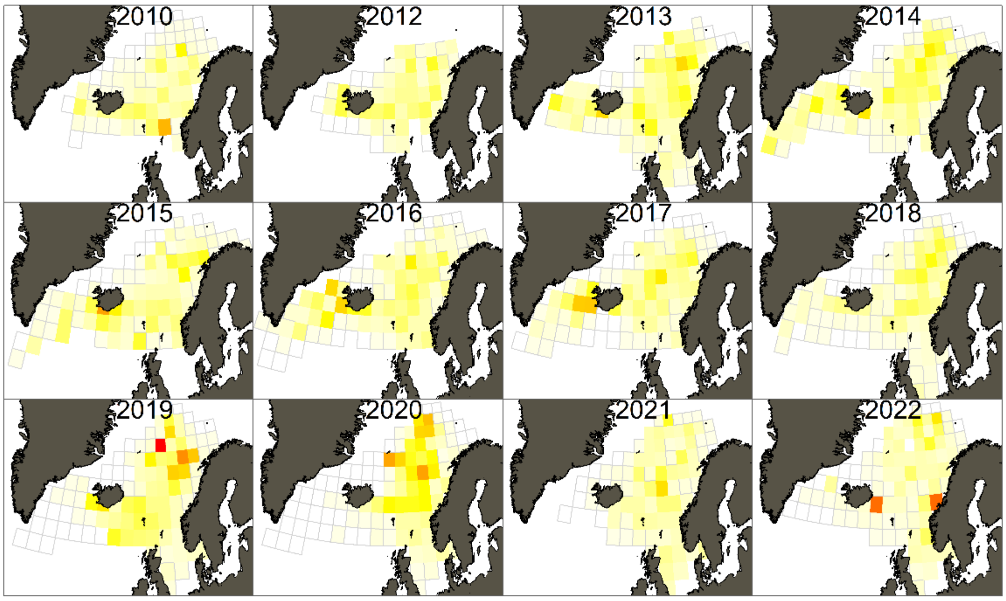


Figure 8.6.3.5. Mackerel catch rates from predetermined surface trawl stations (circle size represents catch rate in kg/km2) overlaid on mean catch rate per standardized rectangle (2° lat. x 4° lon.) from the 2023 IESSNS, including North Sea. Zero mackerel catches are displayed as grey crosses.



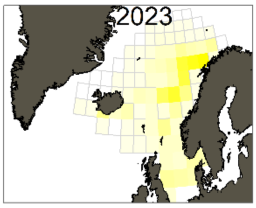


Figure 8.6.3.6. Mackerel annual distribution proxied by the absolute distribution of mean mackerel catch rates per standardized rectangles (2° lat. x 4° lon.), from predetermined surface trawl stations from IESSNS in 2010 and from 2012 to 2023, including North Sea. Colour scale goes from white (= 0) to red (= maximum value for the given year).

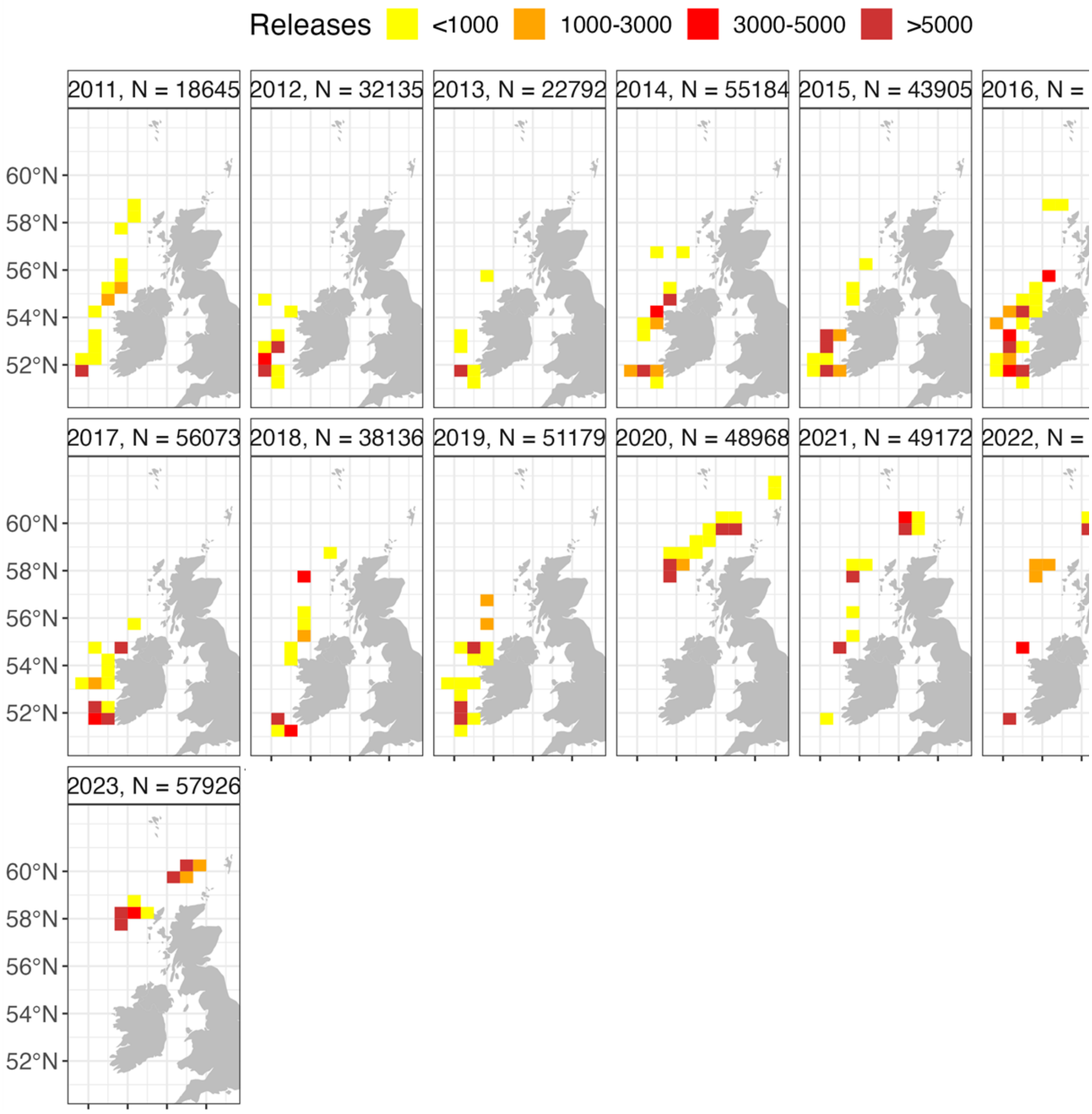


Figure 8.6.4.1. Number and distribution of RFID tagged mackerel from experiments west of Ireland and British Isles during 2011-2023. Note that data from releases 2011-2012 are not used in the stock assessment, based on decisions in the ICES IBPNEAMac 2019 meeting (ICES 2019c), and data from experiments in 2022-2023 are not included as there are no full years with recaptures yet.

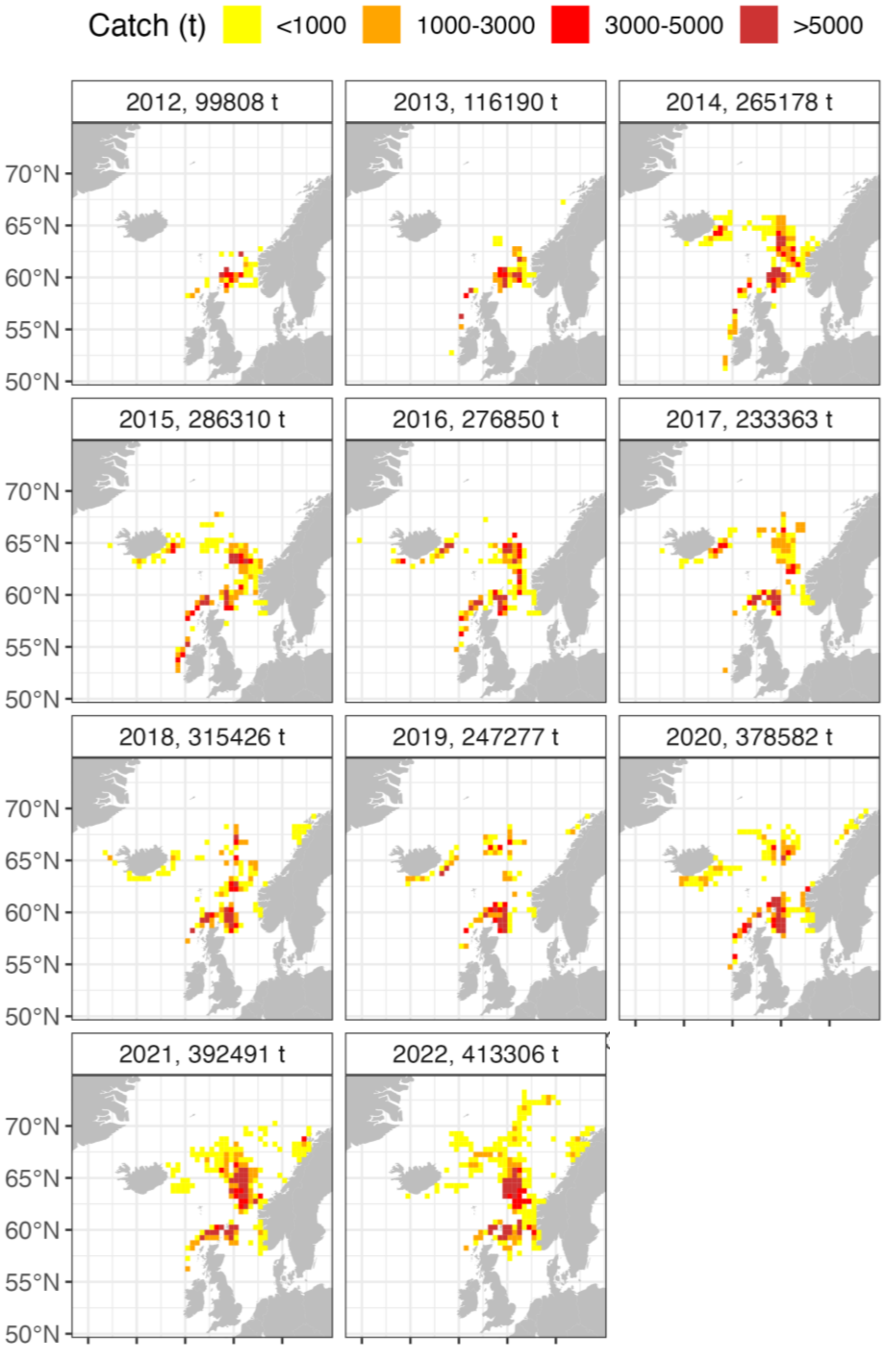


Figure 8.6.4.2. Biomass and distribution of catches scanned for RFID tagged mackerel during 2012-2022. Note that data from scanned catches in 2012-2013 are not used in the stock assessment based on decisions in the ICES IBPNEAMac 2019 meeting (ICES 2019c).

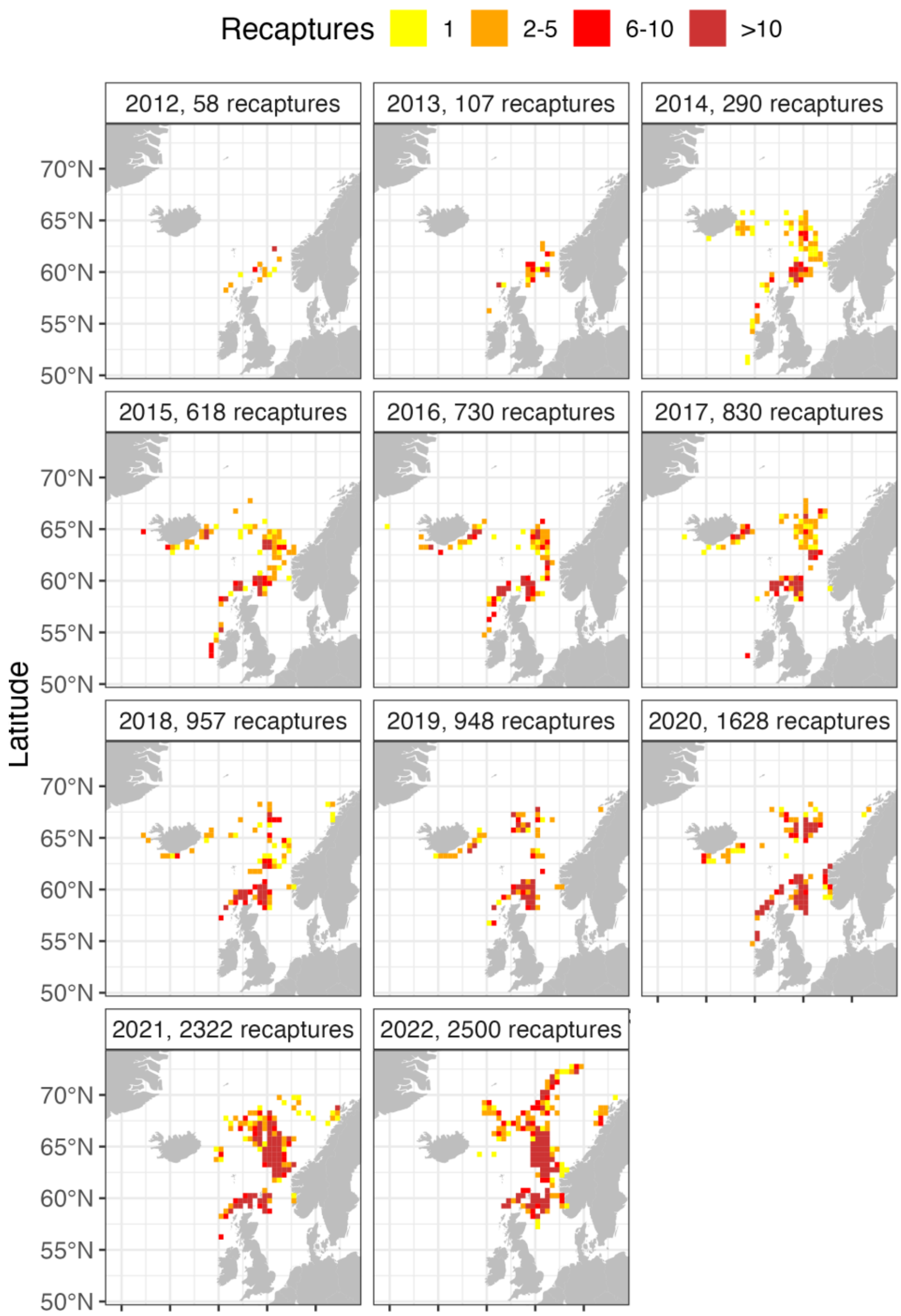


Figure 8.6.4.3. Distribution of recaptures of RFID tagged mackerel west off Ireland and British Isles during 2011-2022. Note that data on recaptures in 2012-2013 are not used in the stock assessment based on decisions in the ICES IBPNEAMac 2019 meeting (ICES 2019c).

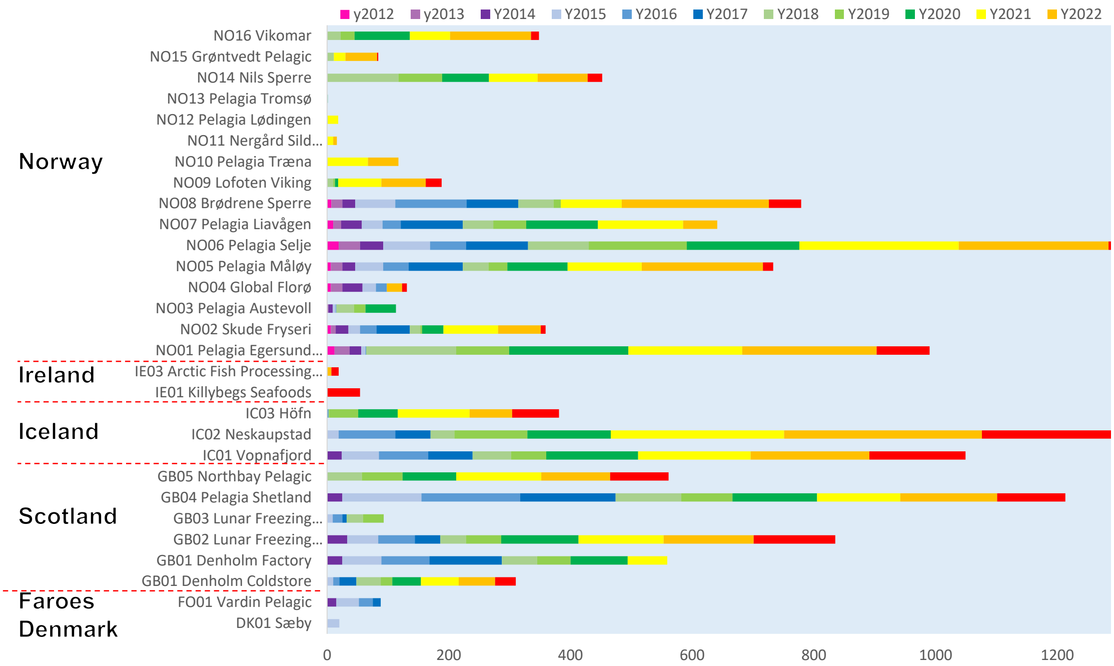
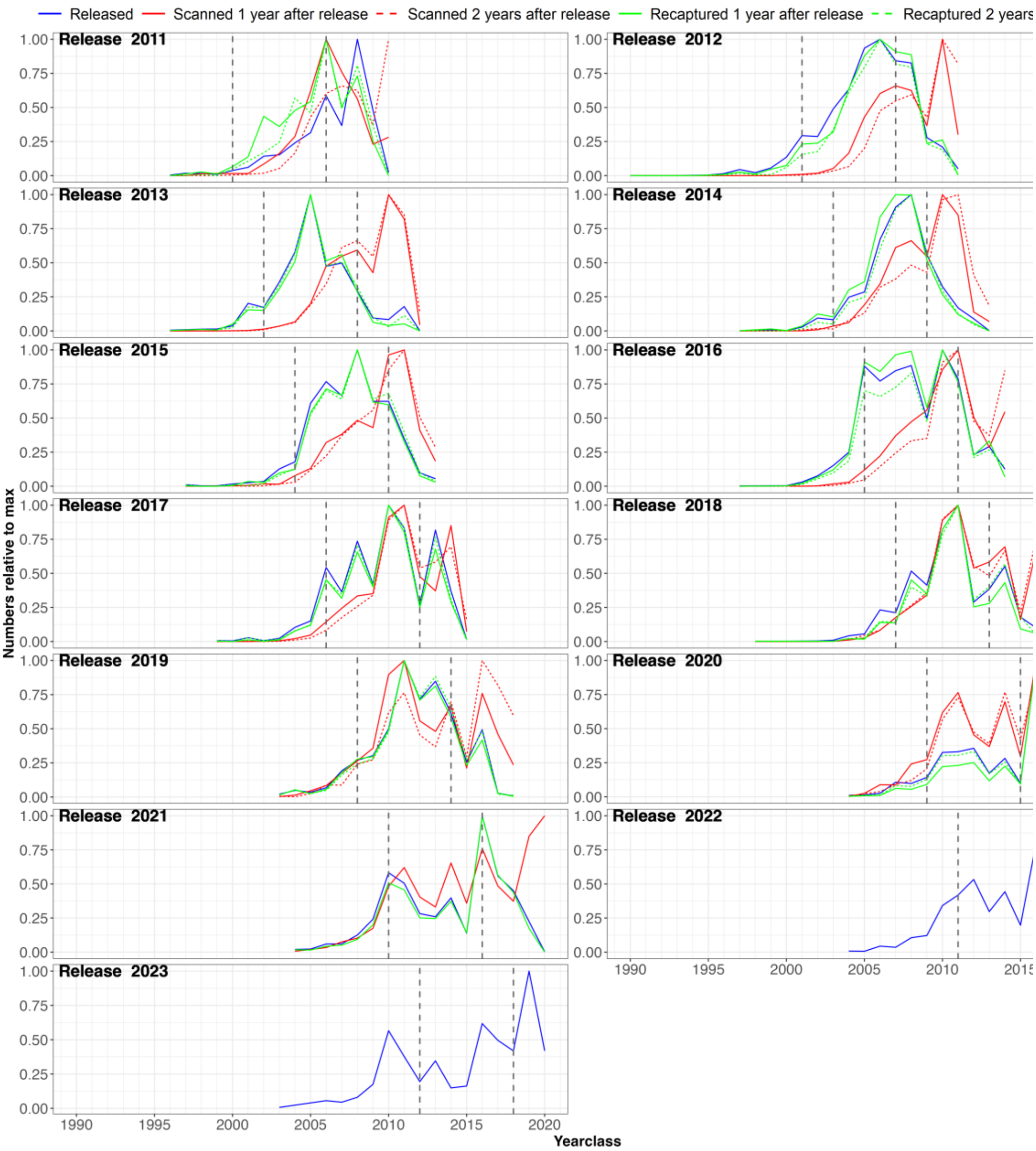


Figure 8.6.4.4. Number of recaptures per factory over the years 2012-2023 (22.Aug)



8.6.4.5. Overview of the relative year class distribution among RFID tagged mackerel per release year 2011-2023 from experiments west of Ireland and British Isles in April-June, compared with the number scanned and recaptured in year 1 and 2 after release of the same year classes. Note that data from releases in 2011-2012 are not used in the stock assessment based on decisions in the ICES IBPNEAMac 2019 meeting (ICES 2019c). Note also that it was decided to only use ages 5-11 in updated assessments, and limits for this age span is marked (vertical grey dotted lines) for each release year.

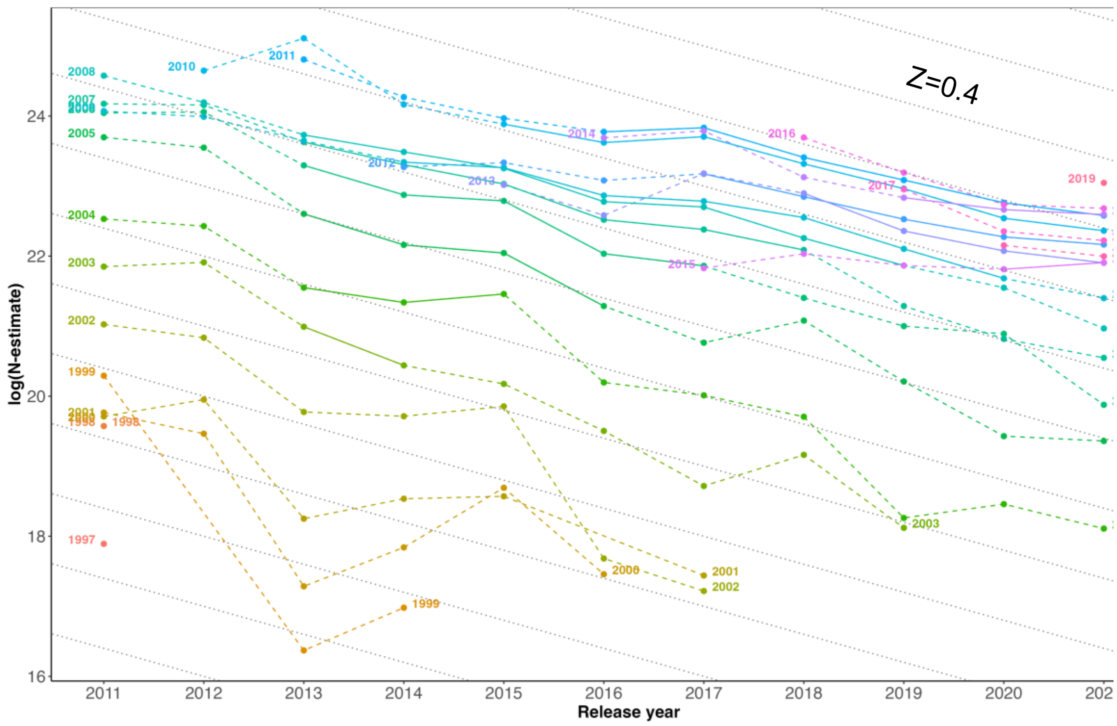


Figure 8.6.4.6. Trends in year class abundance (N=numbers released/numbers recaptured*numbers scanned) from RFID tag-recapture data based on aggregated data on recaptures and scanned numbers in year 1 and 2 after each release year. Data that are excluded in the stock assessment based on decisions in the ICES IBPNEA-Mac 2019 meeting (ICES 2019c), i.e., release years 2011-2012 and ages 2-4 and 12+, are marked with dotted lines in year class trends.

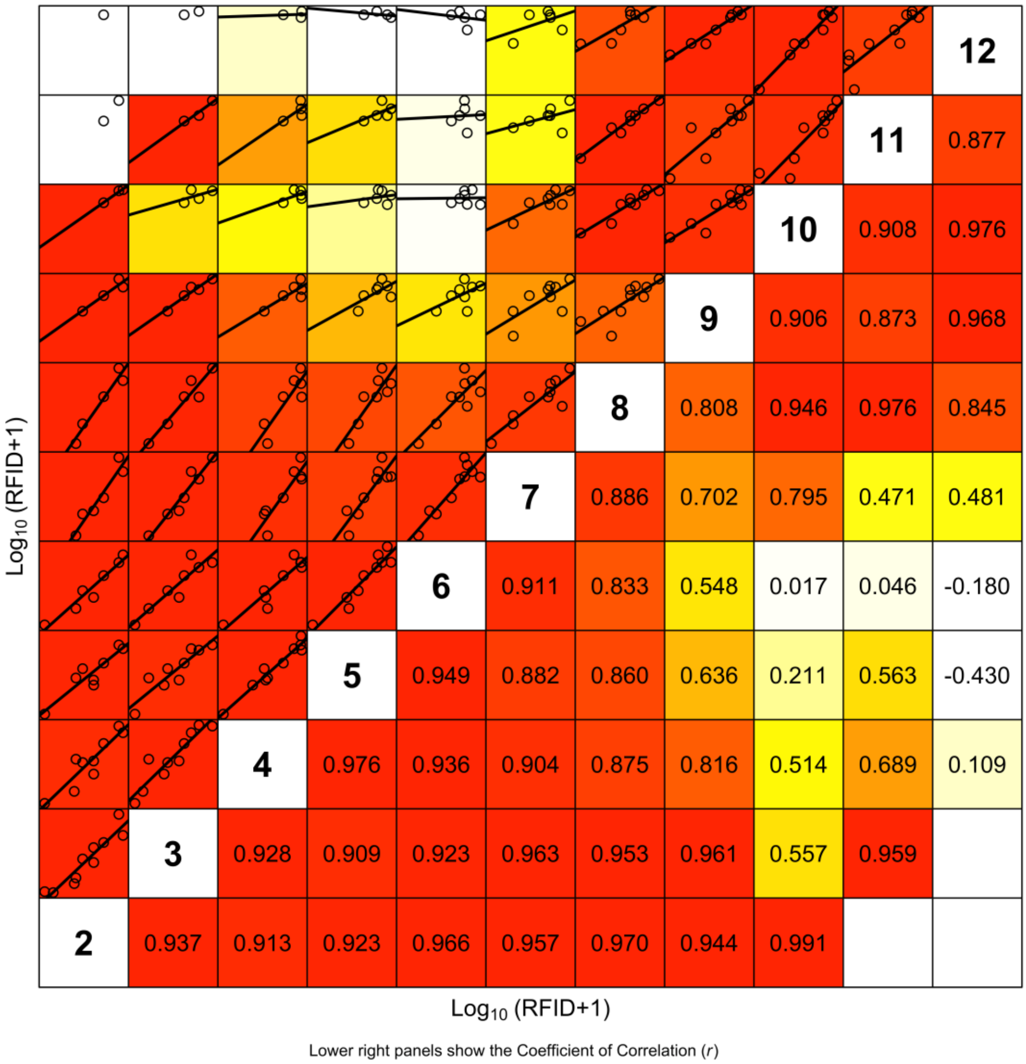


Figure 8.6.4.7. Consistency plot showing correlations between age groups in the from the RFID indices of year class abundance (Figure 8.6.4.6)

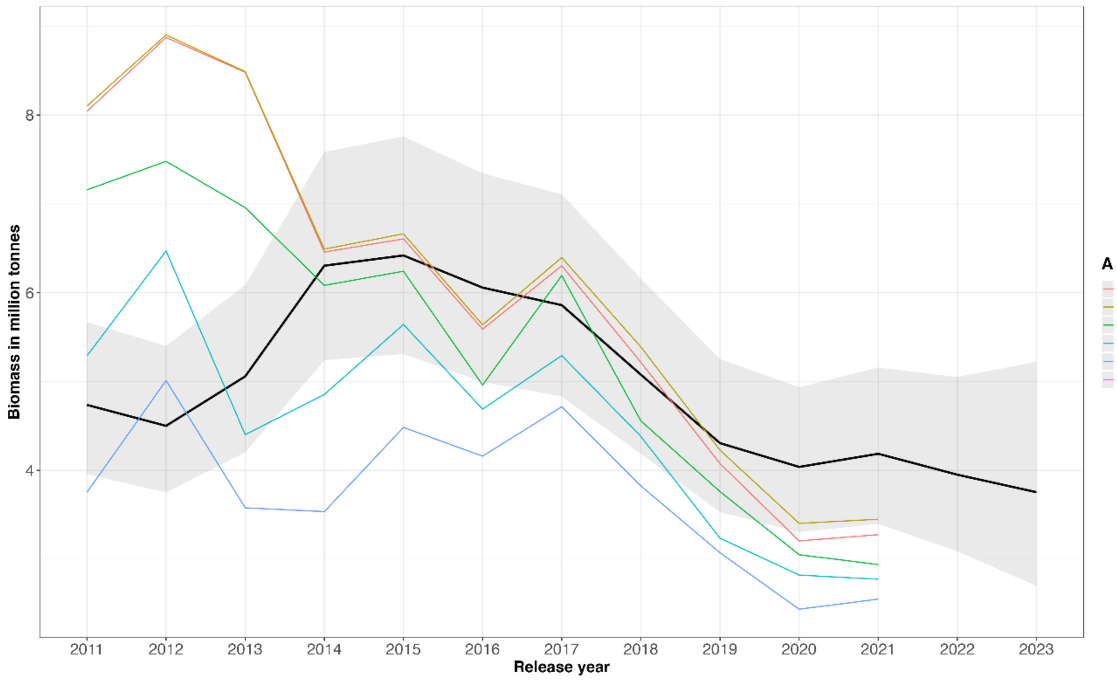


Figure 8.6.4.8. Trends in various age aggregated biomass indices from RFID tag-recapture data compared with the SSB (±95 confidence intervals) from the WGWIDE2023 stock assessment. Data are based on a combination of estimated numbers by year class (Figure 8.6.4.6) scaled by survival parameter (0.1778) and weight at age in stock from WGWIDE2021. Note that data from release years 2011-2012, and ages 2-4 and 12+ are excluded from the stock assessment.

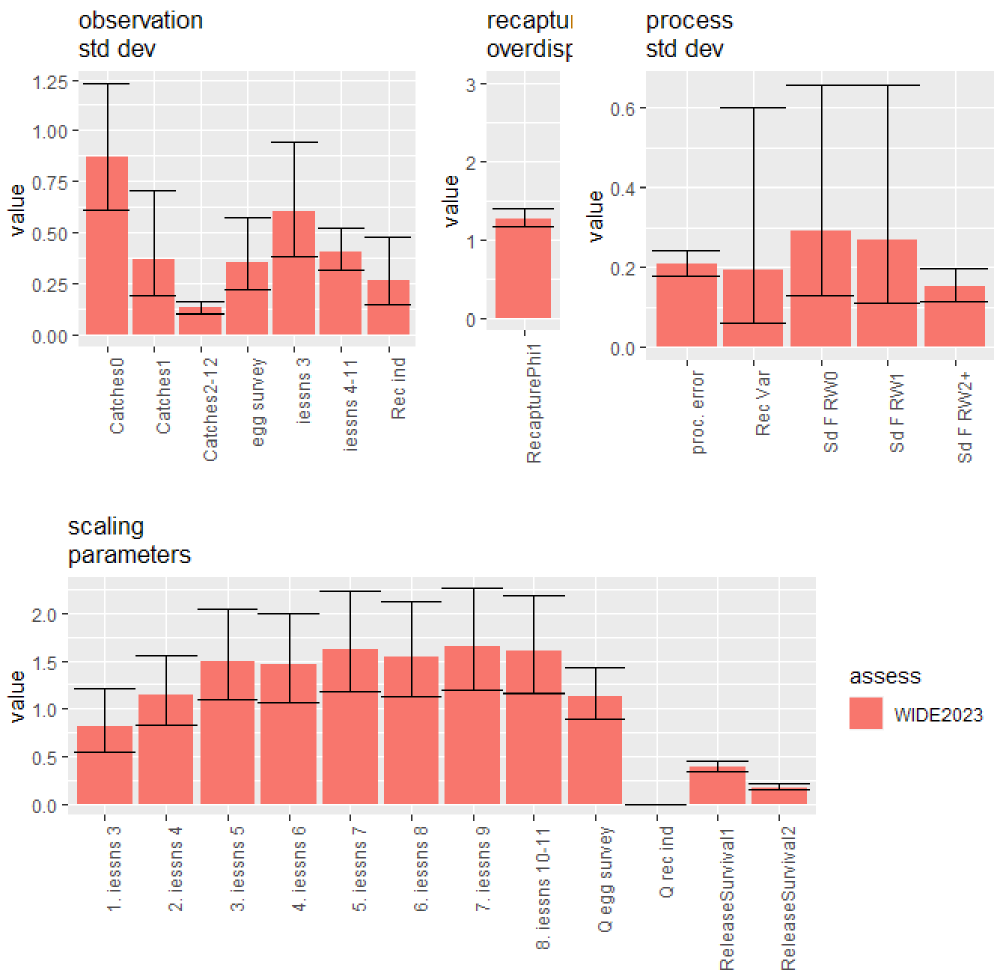


Figure 8.7.2.1. NE Atlantic mackerel. Parameter estimates from the SAM model (and associated confidence intervals) for the WGWIDE 2023 update assessment. top left : estimated standard deviation for the observation errors, top centre: estimated overdispersion for the errors on the tag recaptures, top right: standard deviation for the processes, bottom: survey catchabilities and post-release survival of tagged fish.

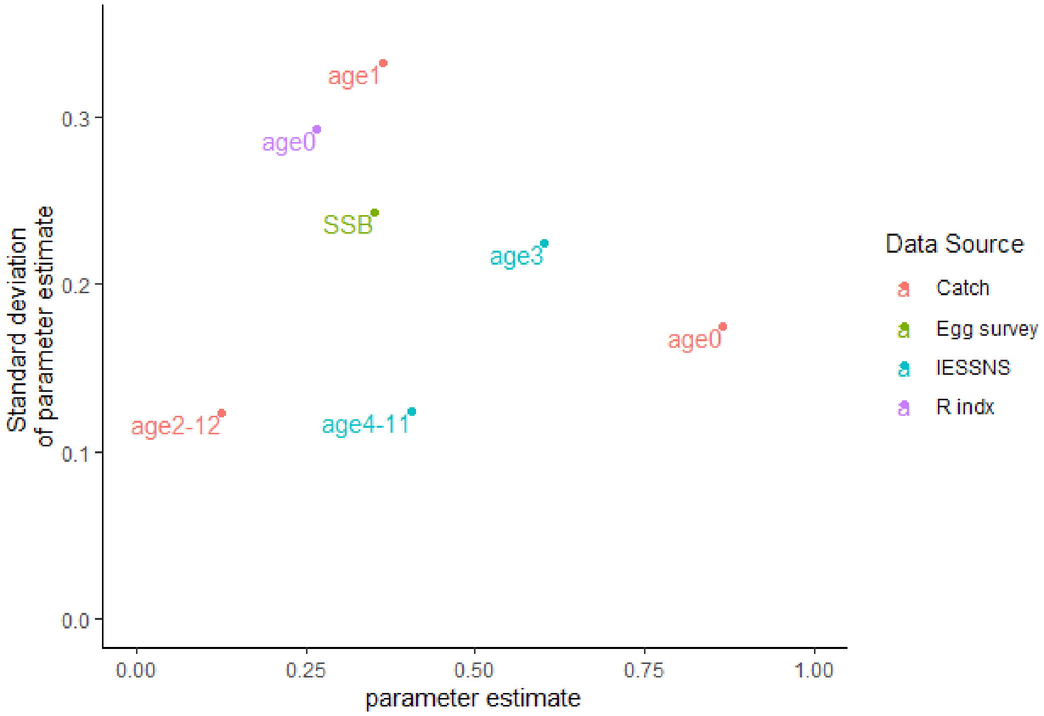


Figure 8.7.2.2. NE Atlantic mackerel. Parameter uncertainty (standard deviation of estimate) versus parameter value for the observation variances.

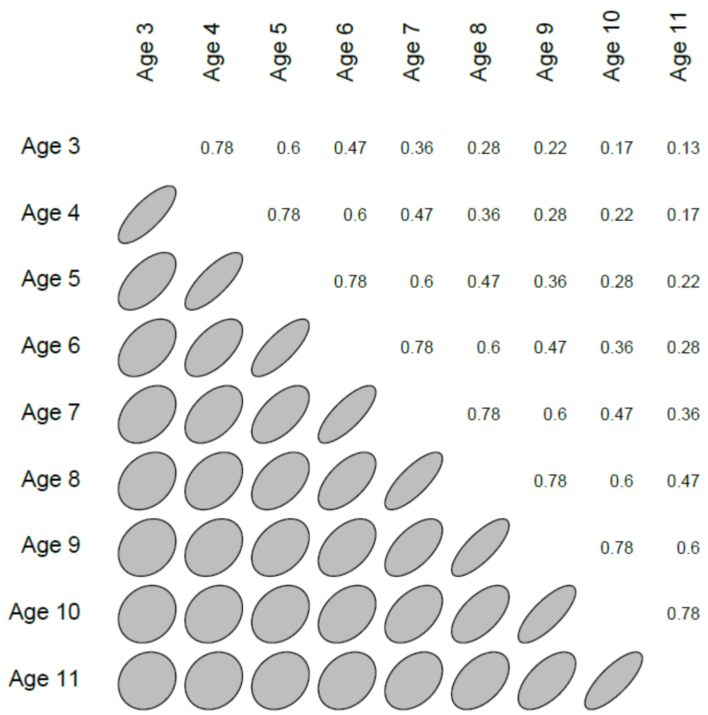


Figure 8.7.2.3. NE Atlantic mackerel. Estimated AR1 error correlation structure for the observations from the IESSNS survey age 3 to 11.

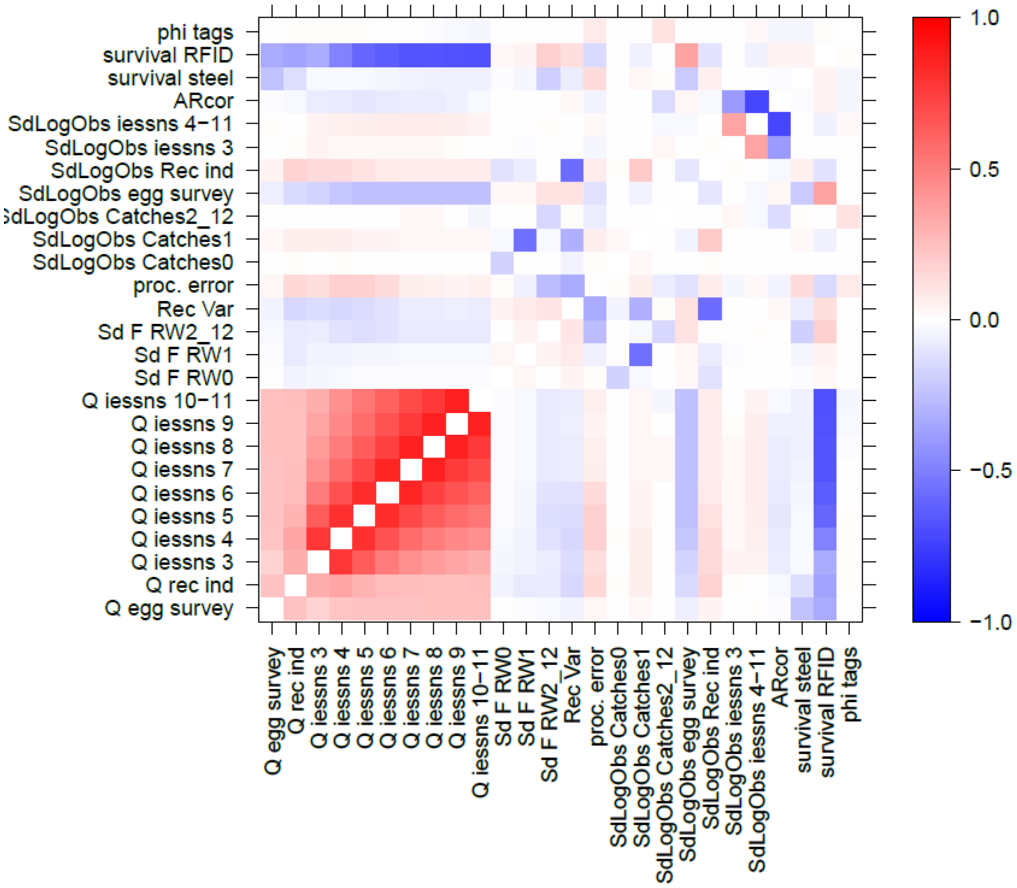


Figure 8.7.2.4. NE Atlantic mackerel. Correlation between parameter estimates from the SAM model for the WGWIDE 2023 update assessment

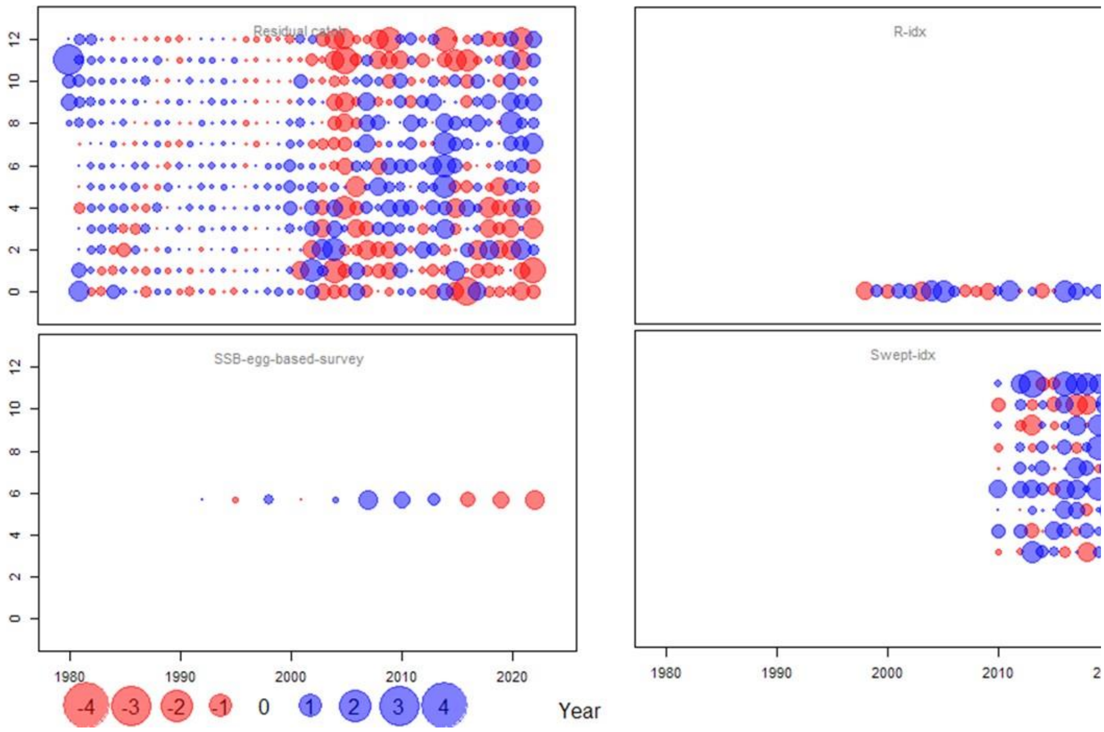


Figure 8.7.2.5. NE Atlantic mackerel. One Step Ahead Normalized residuals for the fit to the catch data (catch data prior to 2000 are not used to fit the model). Blue circles indicate positive residuals (observation larger than predicted) and filled red circles indicate negative residuals.

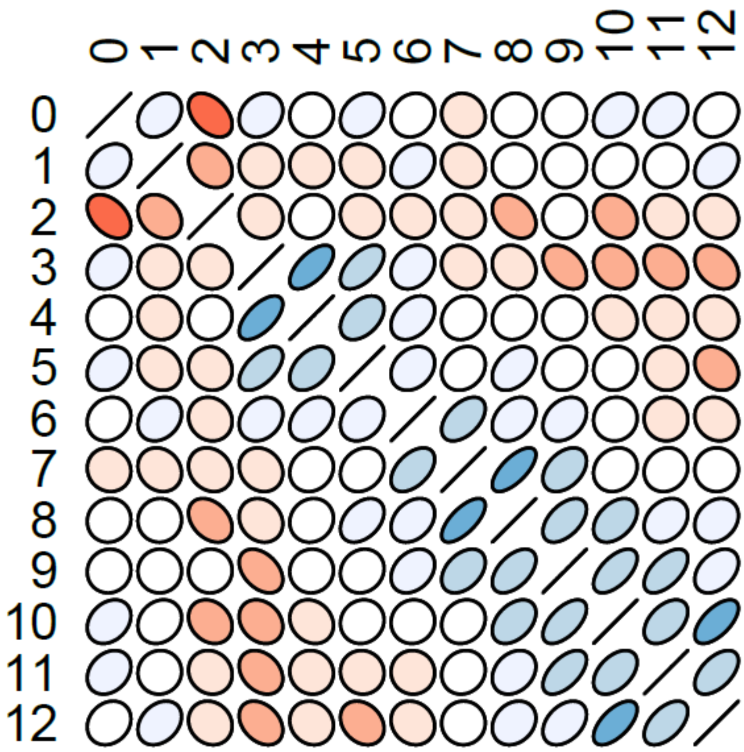


Figure 8.7.2.6. NE Atlantic mackerel. Empirical correlations between ages in the One Step Ahead residuals for the catch-at-age data.

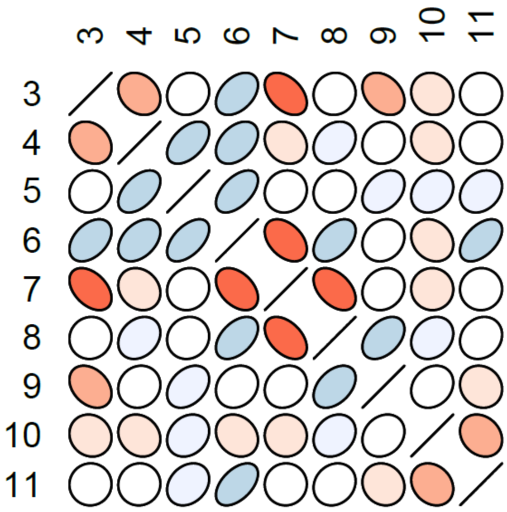


Figure 8.7.2.7. NE Atlantic mackerel. Empirical correlations between ages in the One Step Ahead residuals for the IESSNS abundances-at-age.

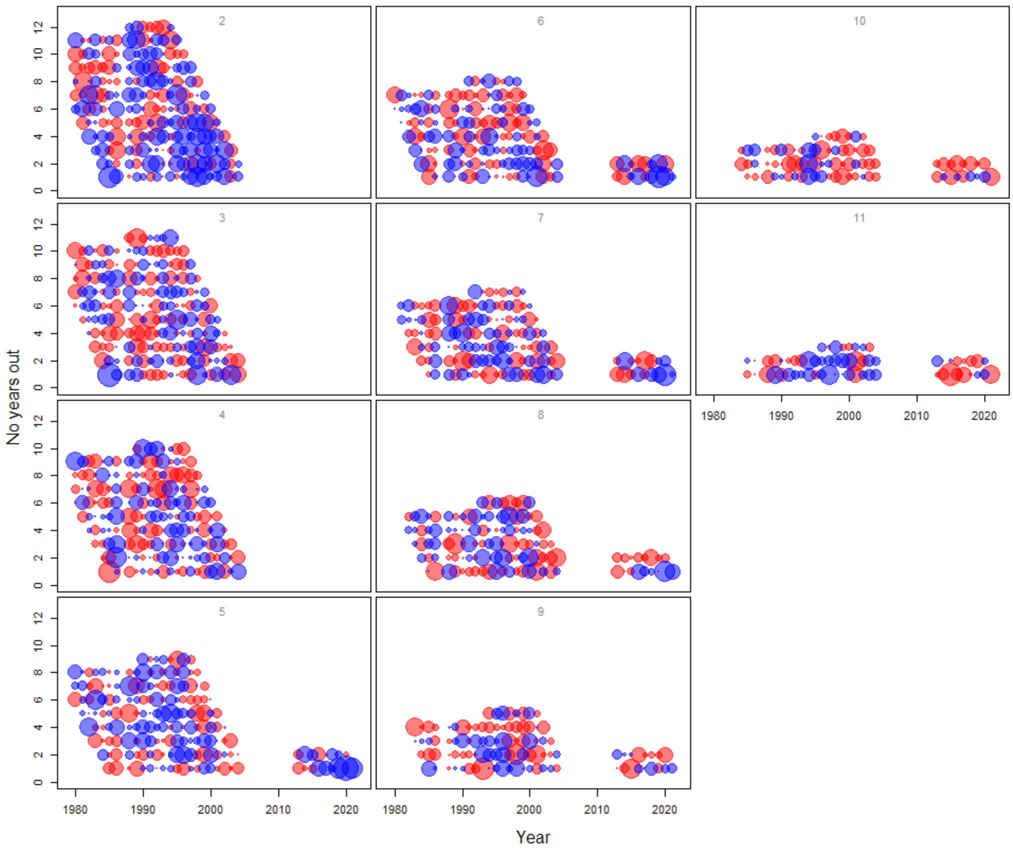


Figure 8.7.2.8. NE Atlantic mackerel. One step ahead residuals for the fit to the recaptures of tags in the final assessment. The x-axis represents the release year, and the y-axis is the number of years between tagging and recapture. Each panel correspond to a given age at release. Blue circles indicate positive residuals (observation larger than predicted) and filled red circles indicate negative residuals.

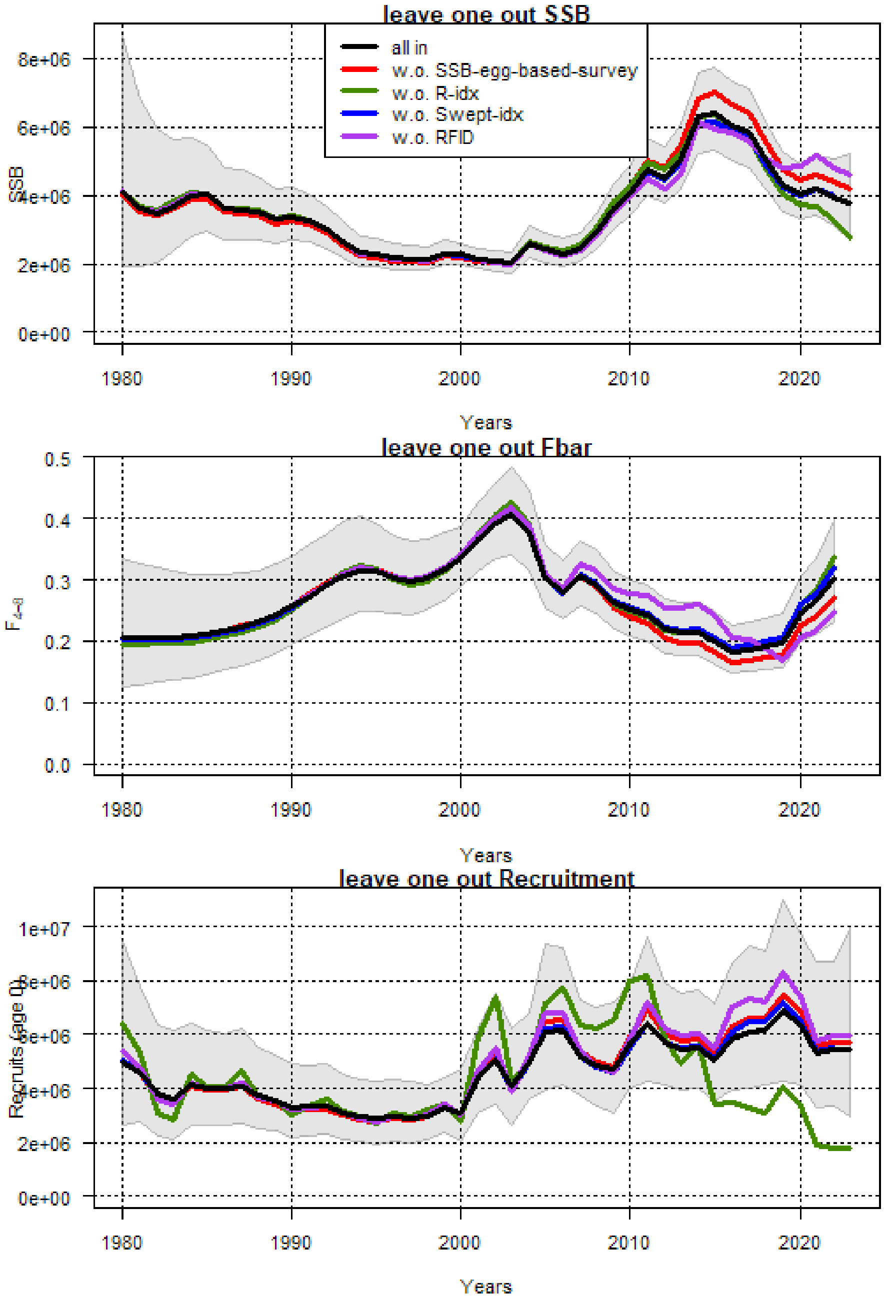


Figure 8.7.2.9. NE Atlantic mackerel. Leave one out assessment runs. SAM estimates of SSB , Fbar and recruitment, for assessments runs leaving out one of the observation data sets.

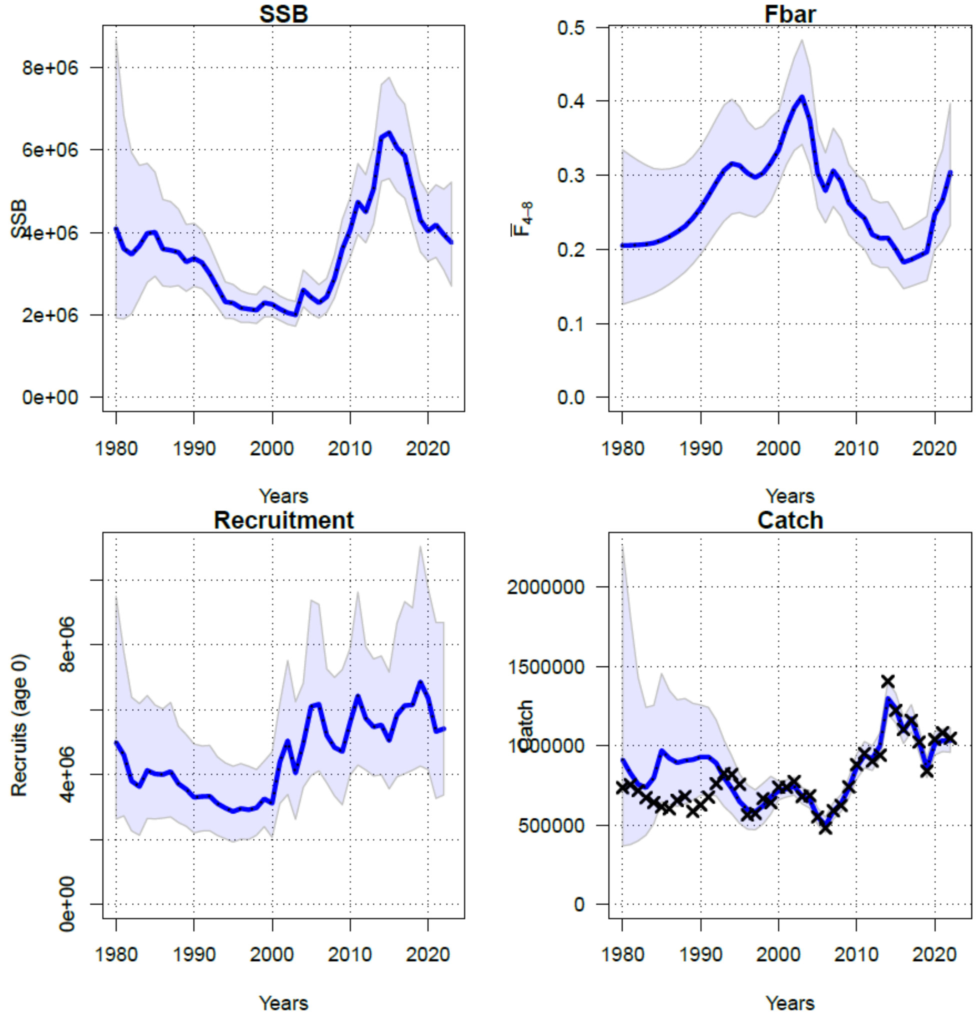


Figure 8.7.3.1. NE Atlantic mackerel. Perception of the NEA mackerel stock, showing the SSB, F_{bar}4-8 and recruitment (with 95% confidence intervals) from the SAM assessment. crosses in the catch panel represent the catch data.

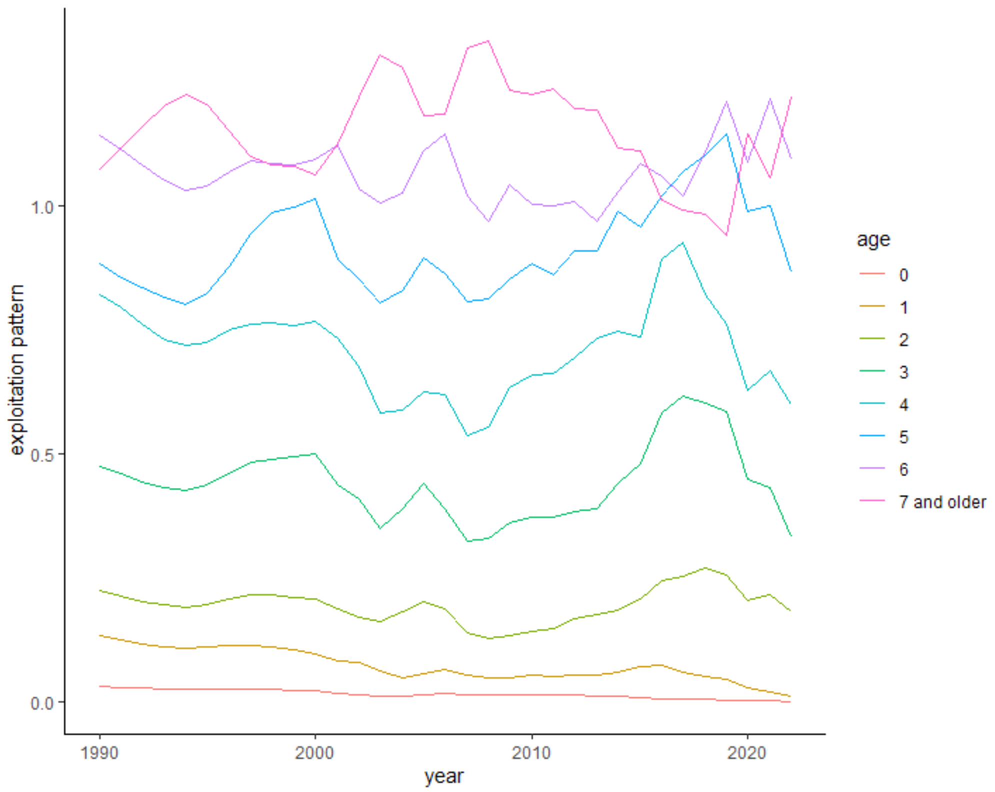


Figure 8.7.3.2. NE Atlantic mackerel. Estimated exploitation pattern for the period 1990 to 2022, calculated as the ratio of the estimated fishing mortality-at-age and the Fbar4-8 value in the corresponding year.

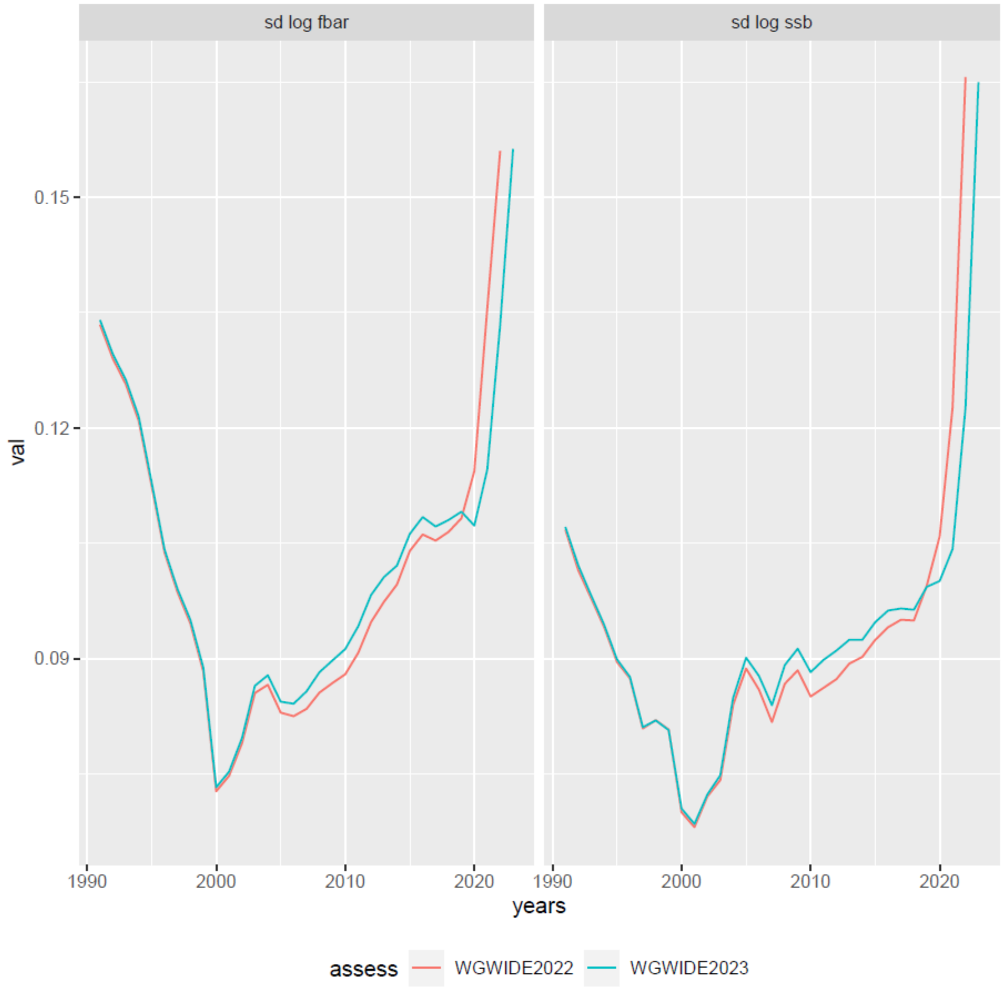


Figure 8.7.4.1. NE Atlantic mackerel. Uncertainty (standard deviation of the log values) of the estimates of SSB and Fbar from the SAM for the 2022 and 2023 WGWIDE assessments.

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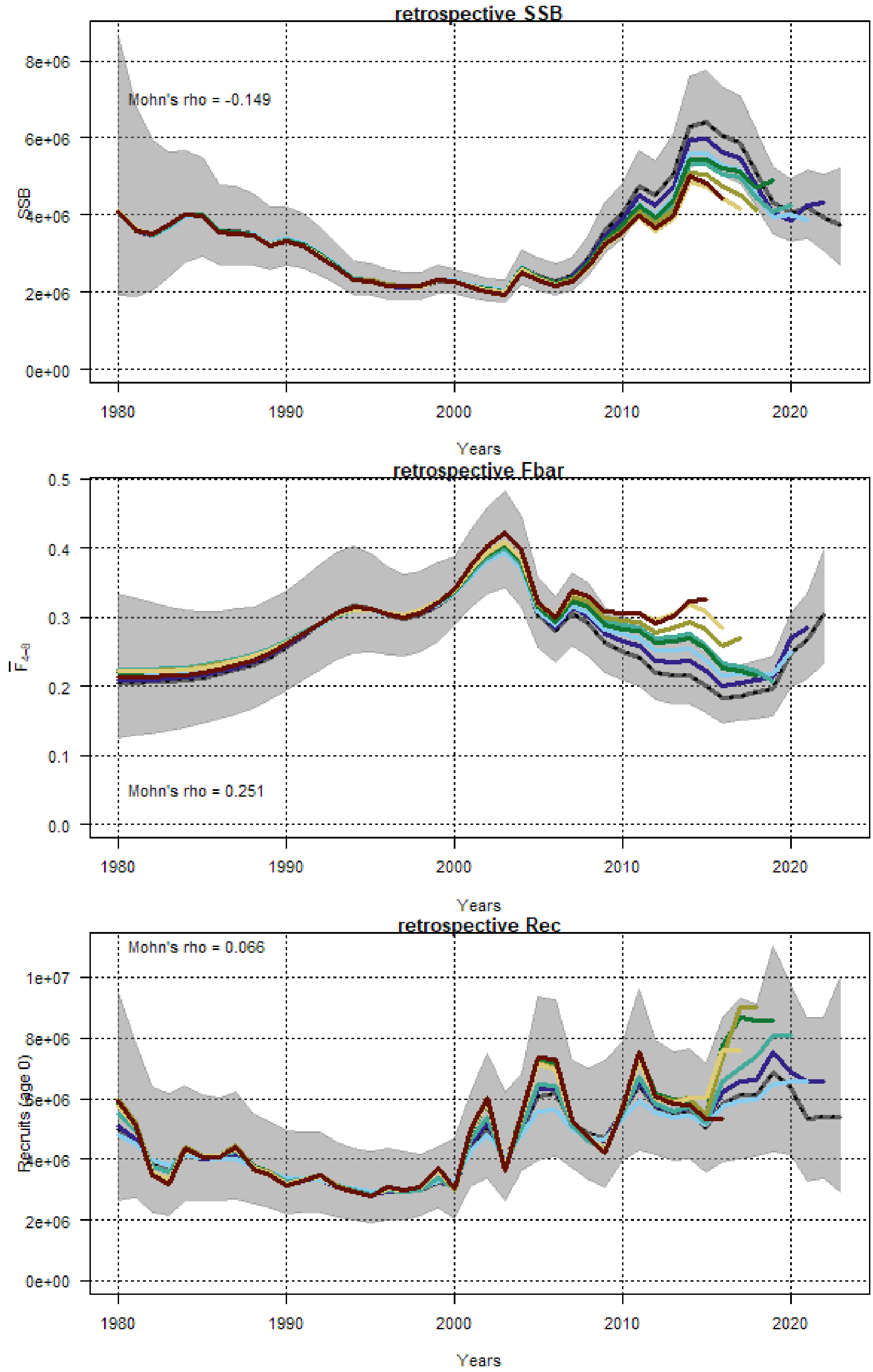


Figure 8.7.4.2. NE Atlantic mackerel. Analytical retrospective patterns (8 years back) of SSB, F_{bar}4-8 and recruitment from the WGWIDE 2022 update assessment. the Mohn's rho values are calculated based on 5 retro years .

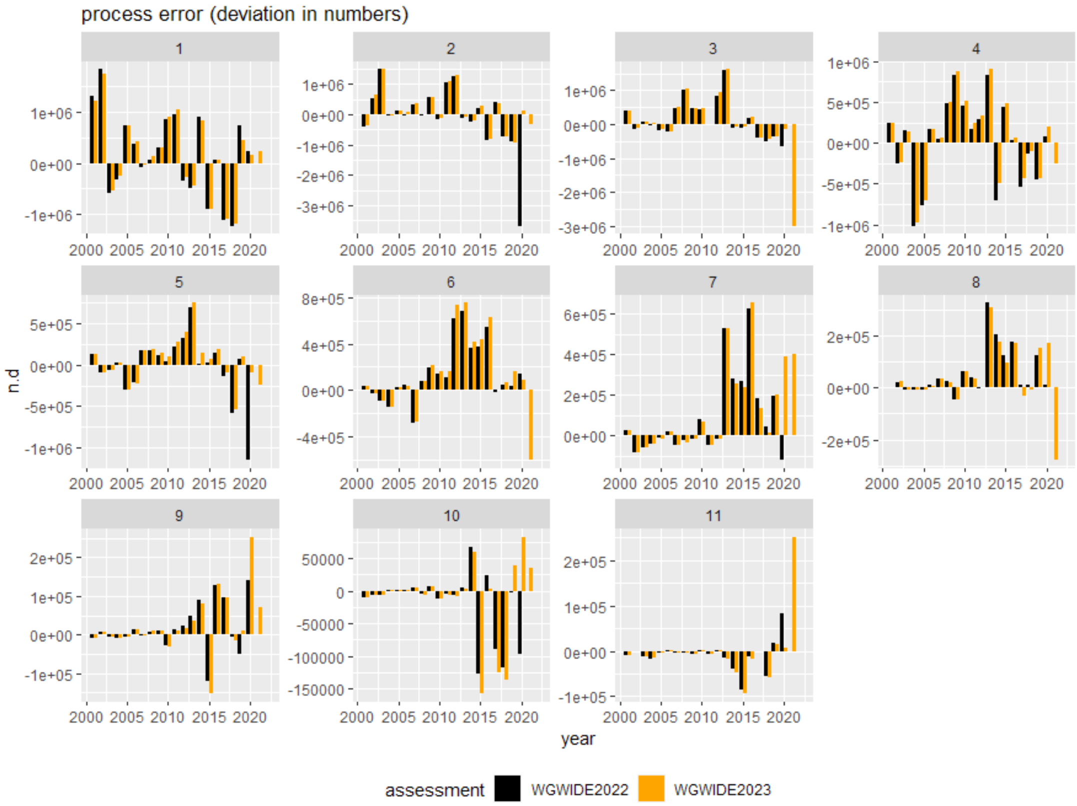


Figure 8.7.4.3. NE Atlantic mackerel. Process error expressed as annual deviations of abundances at age, for the 2023 WGWIDE assessment and from the 2022 WGWIDE assessment.

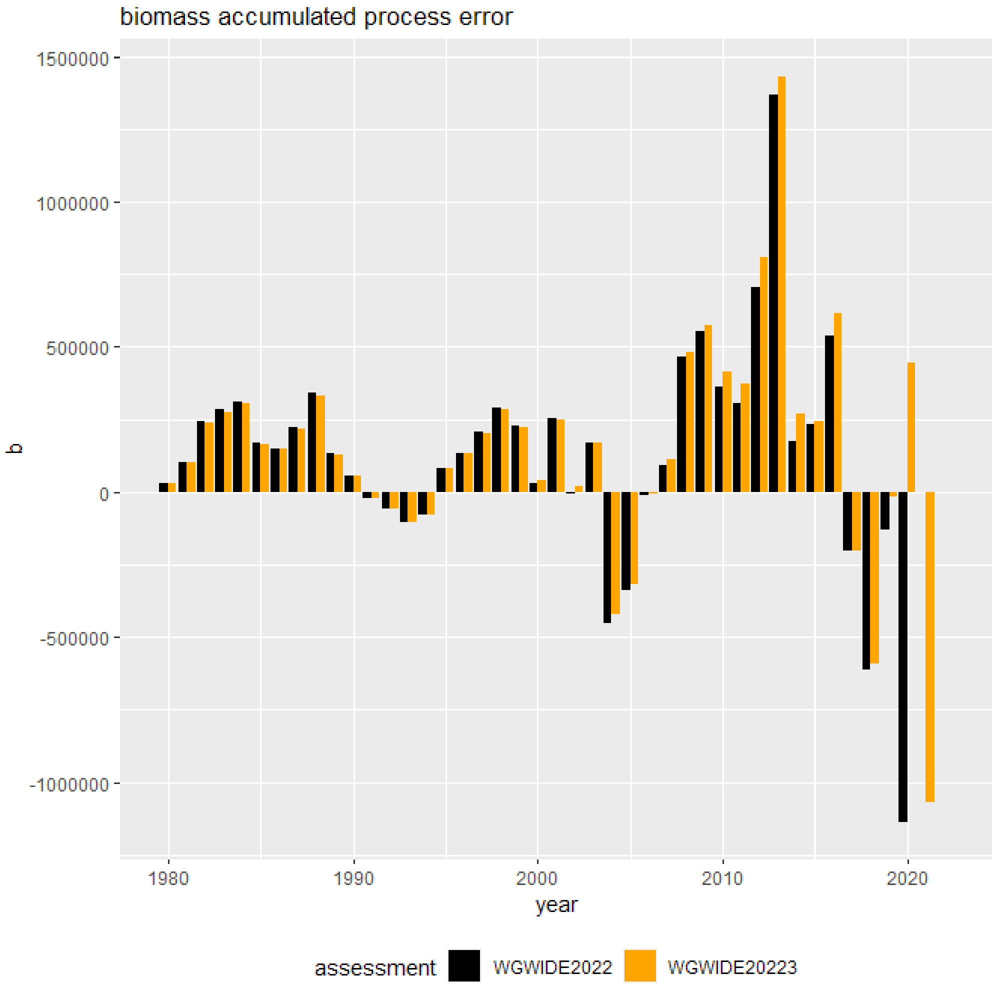


Figure 8.7.4.4. NE Atlantic mackerel. Model process error expressed in biomass cumulated across age-group for the 2023 WGWIDE assessment and for the 2022 WGWIDE assessment.

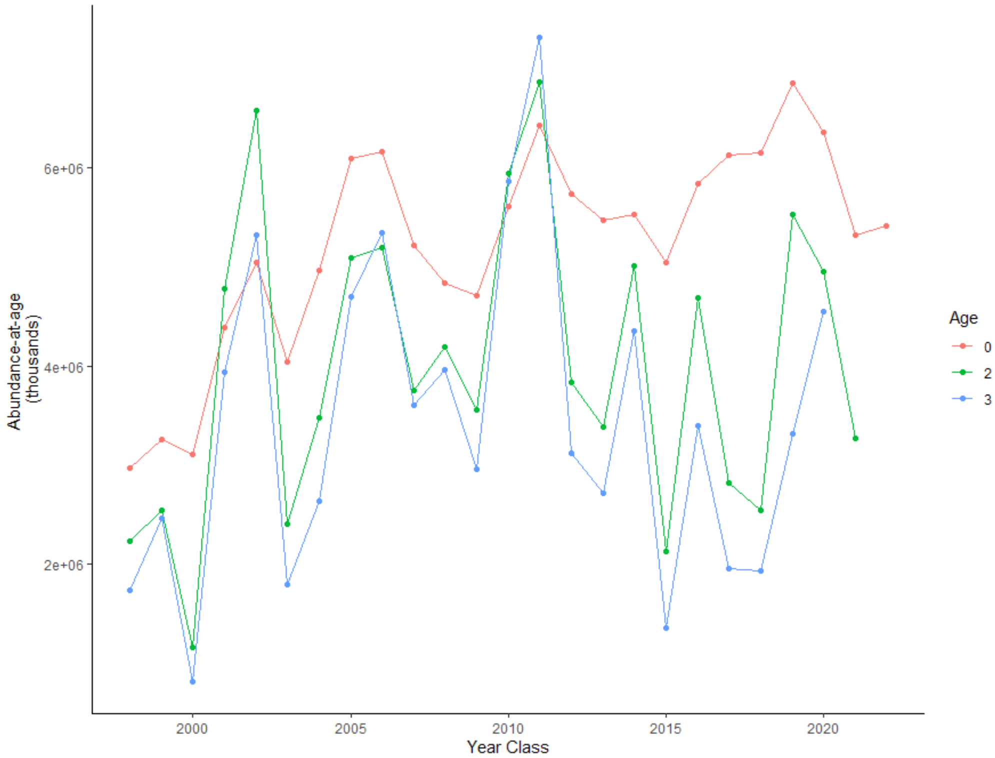


Figure 8.7.5.1. NE Atlantic mackerel. Model. comparison of the cohort signal based on SAM estimates at age 0, 2 and3.

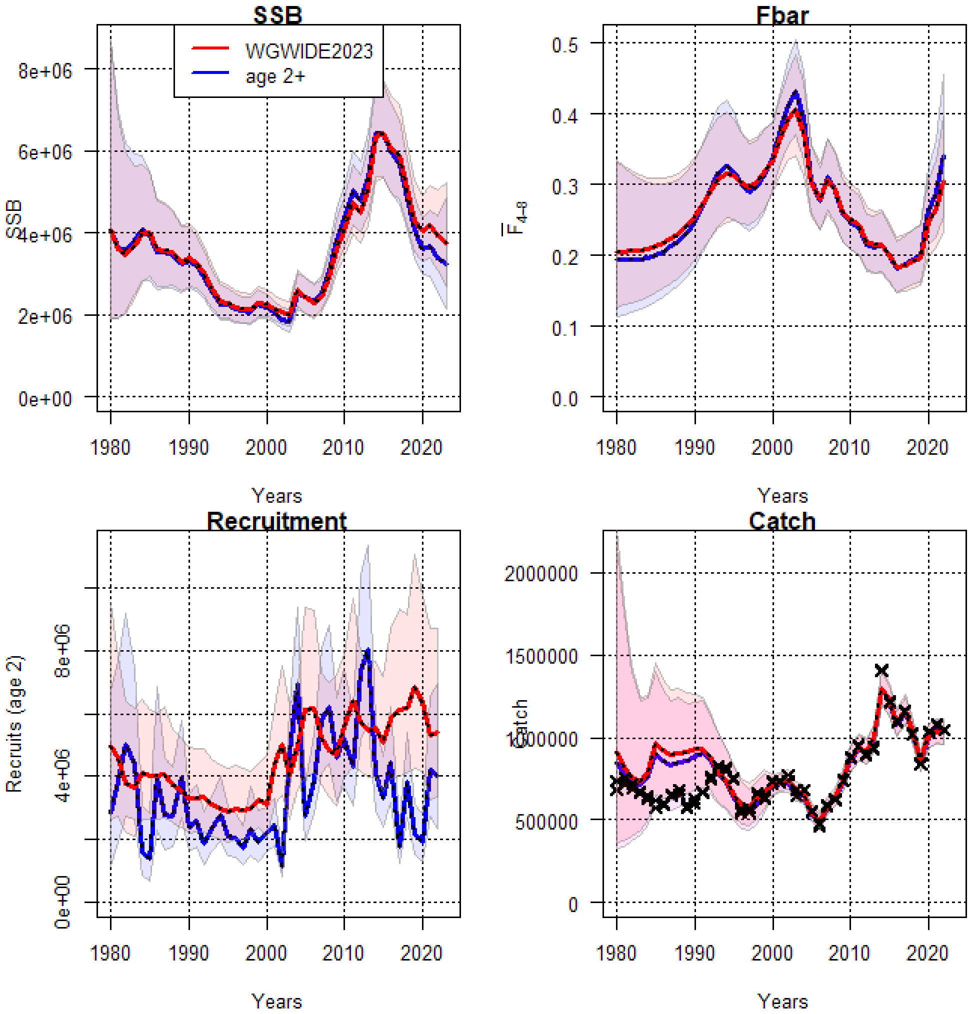


Figure 8.7.5.2. NE Atlantic mackerel. Model. comparison of the perception of the stocks from the WGWIDE 2023 assessment, and the assessment starting at age2.

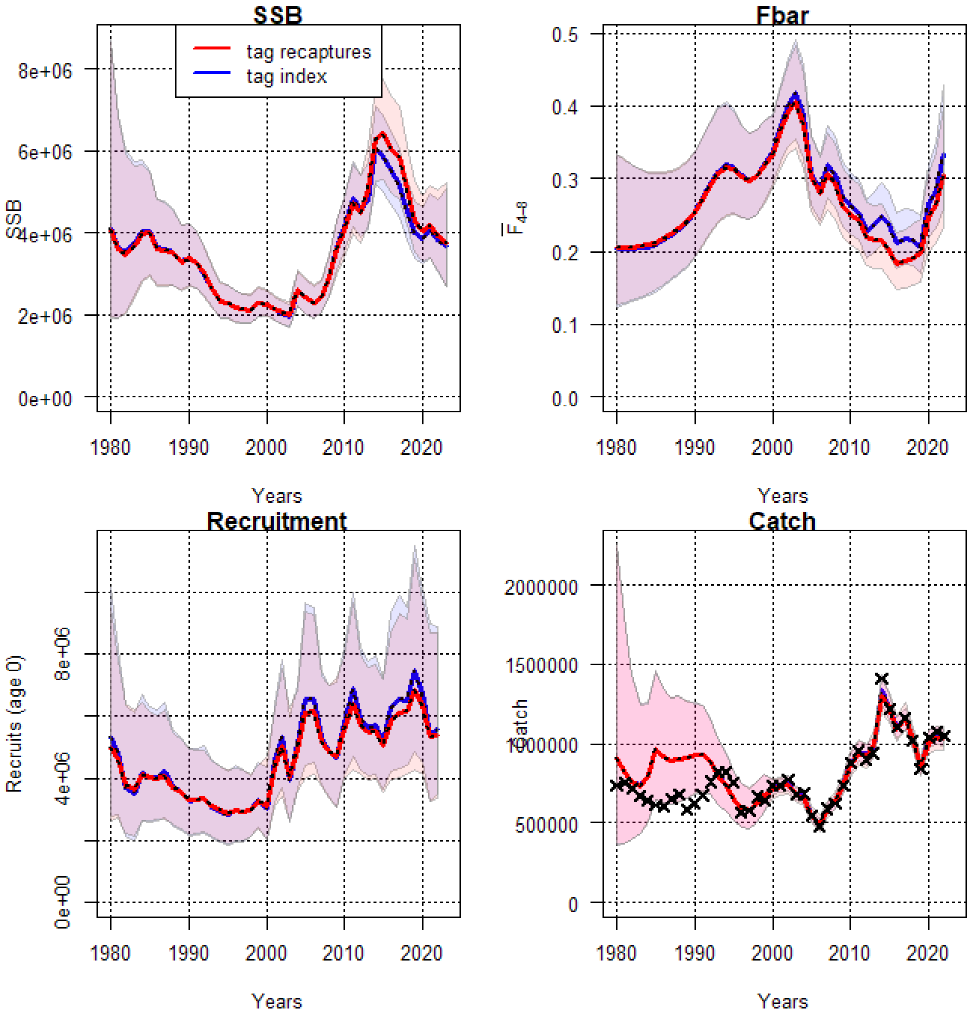


Figure 8.7.5.3. NE Atlantic mackerel. Model. comparison of the perception of the stocks from the WGWIDE 2023 assessment, and an assessment in which the tagging data is used as a survey index instead of modelling the recaptures. Crosses in the catch panel represent the actual catch data.

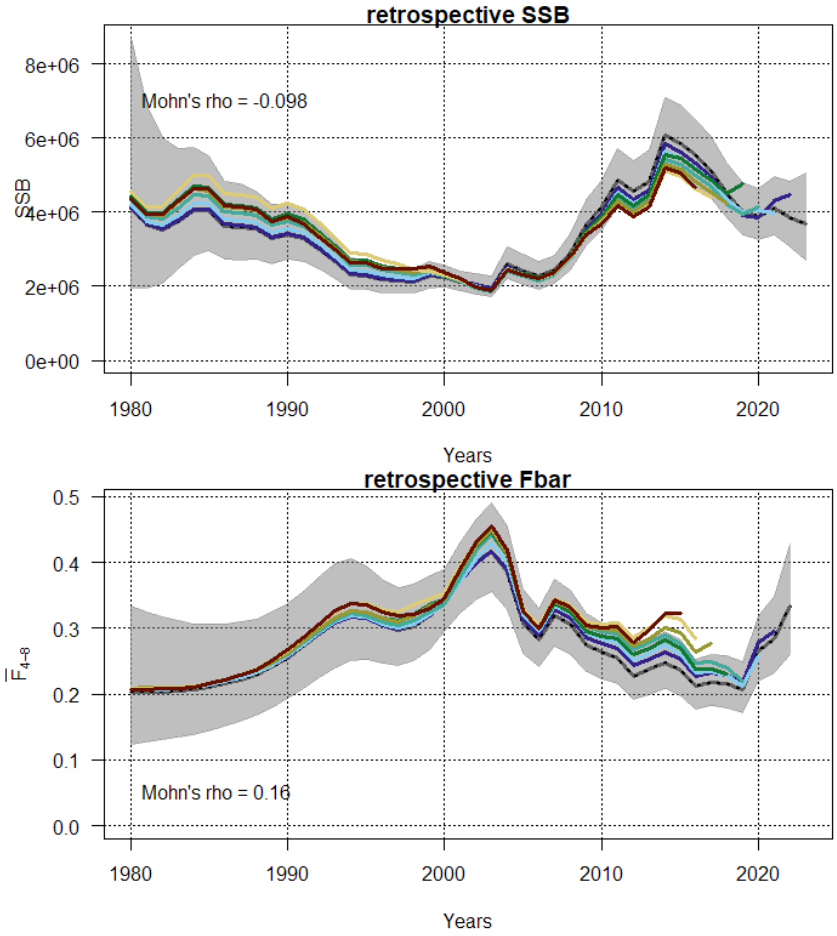


Figure 8.7.5.4. NE Atlantic mackerel. Analytical retrospective patterns (8 years back) of SSB, Fbar4-8 and recruitment from an assessment using the tagging information as survey index instead of modelling the recaptures. The Mohn's rho values are calculated based on 5 retro years

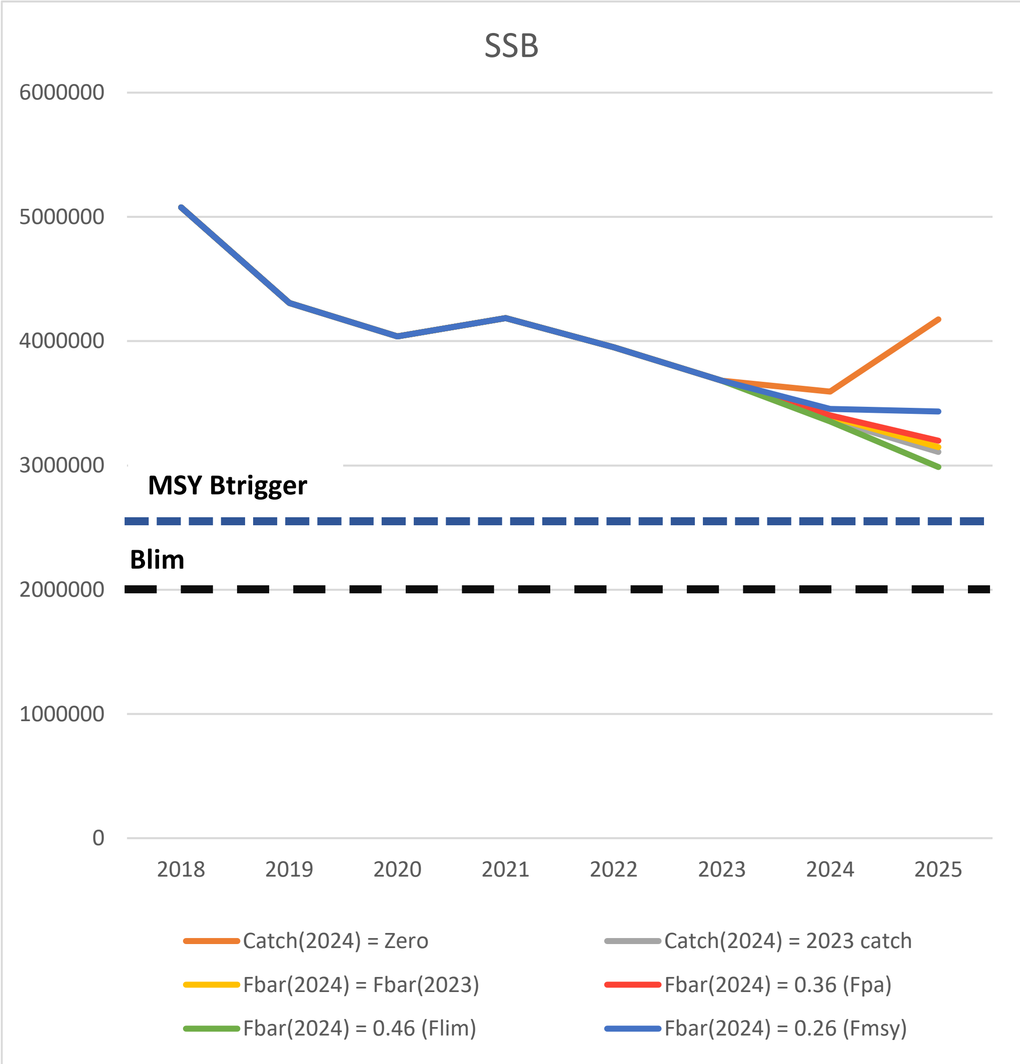


Figure 8.8.1. NE Atlantic mackerel. Recent and forecasted future SSB trajectories for a number of management options

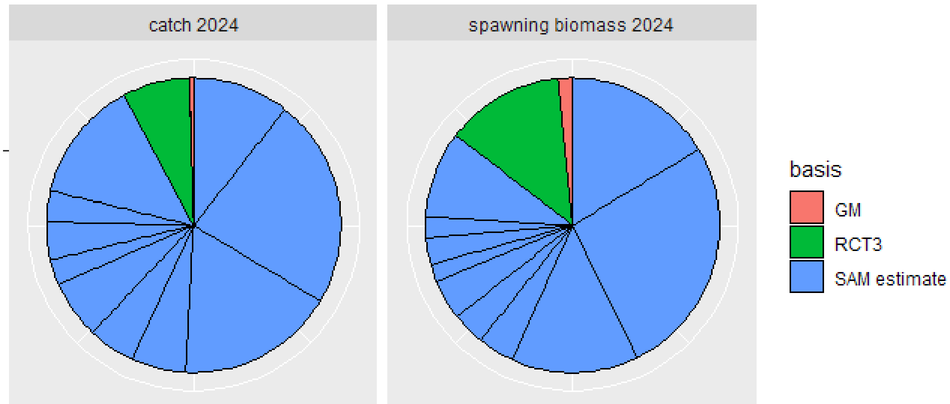


Figure 8.8.2. NE Atlantic mackerel. Contribution of the different age groups to the catches and SSB in 2024 in the mackerel forecast. Year classes that are derived from abundances estimated by the stock assessment model in 2023 are depicted in blue. Year class based on assumption are depicted in red (geometric mean recruitment assumption for the recruitment in 2023 and 2024) and in green (RCT3 prediction for the recruitment in 2022)

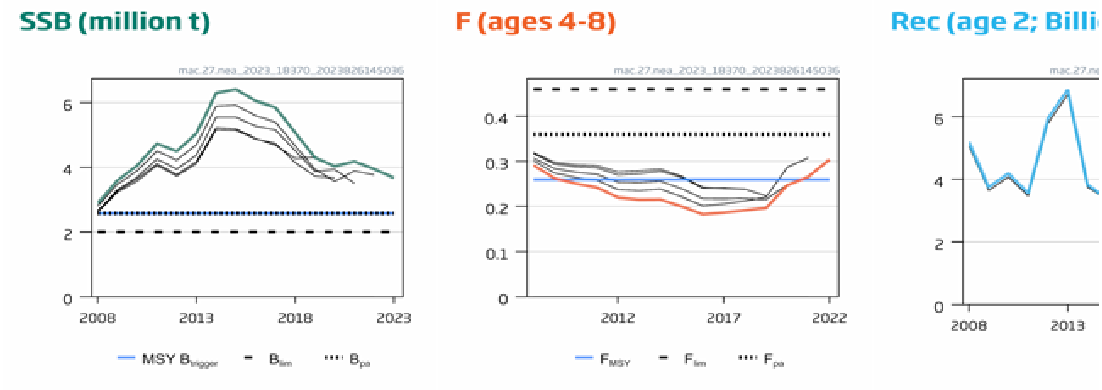


Figure 8.10.1. NE Atlantic mackerel. Historical assessment results. Prior to the 2022 assessment, recruitment was presented as age 0 and is not shown.

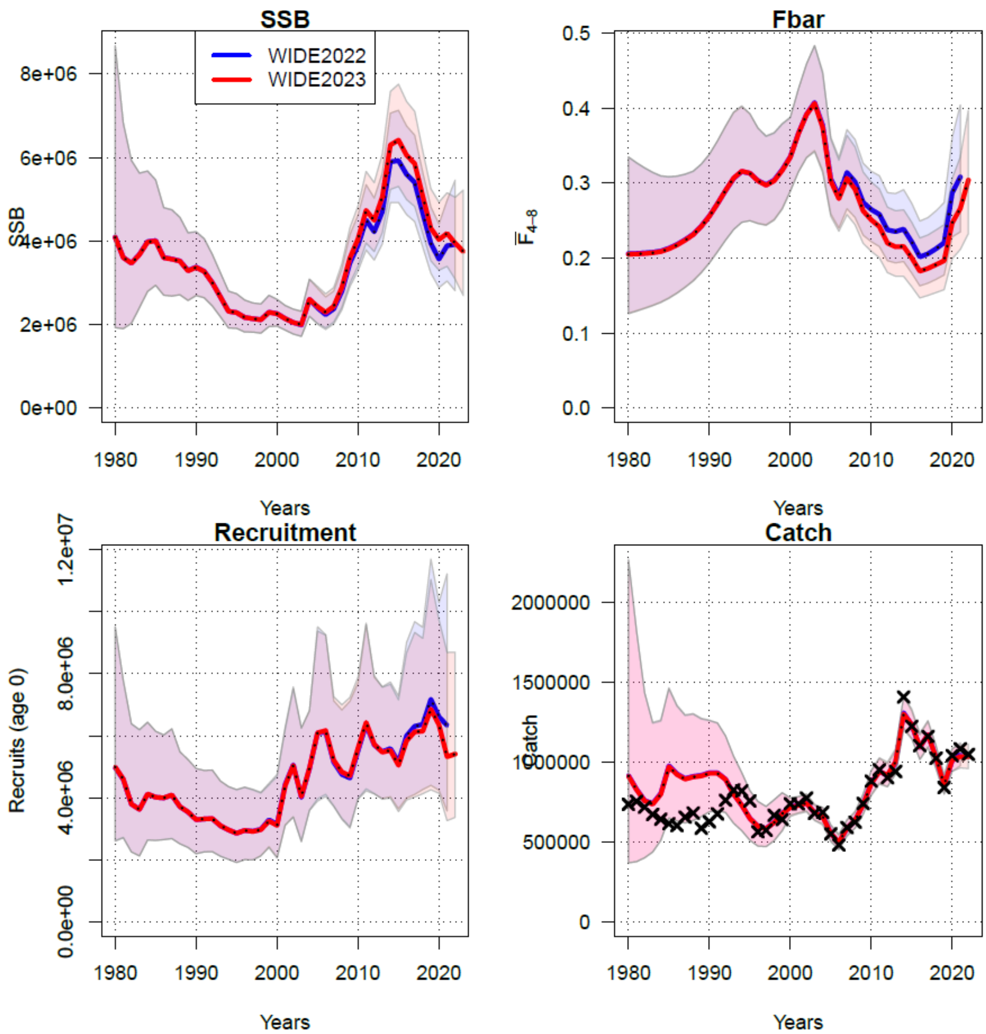


Figure 8.10.2. NE Atlantic mackerel. Comparison of the stock trajectories between the 2023 WGWIDE assessment and the 2022 WGWIDE assessment.

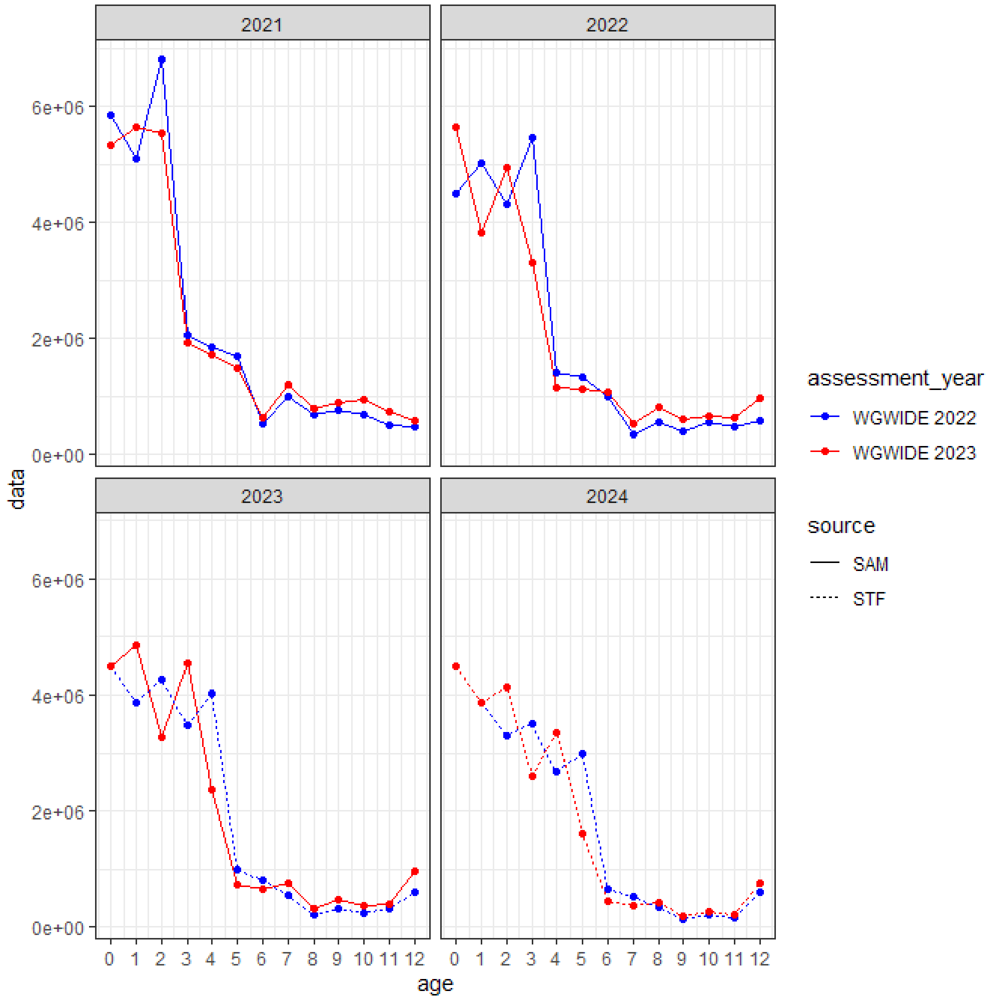


Figure 8.10.3. NE Atlantic mackerel. Comparison of the abundances at age from 2020 to 2023 estimated from the SAM assessments (solid lines) and forecasts (dotted lines) carried out at WGWIDE2022 (blue) and WGWIDE2023 (red).

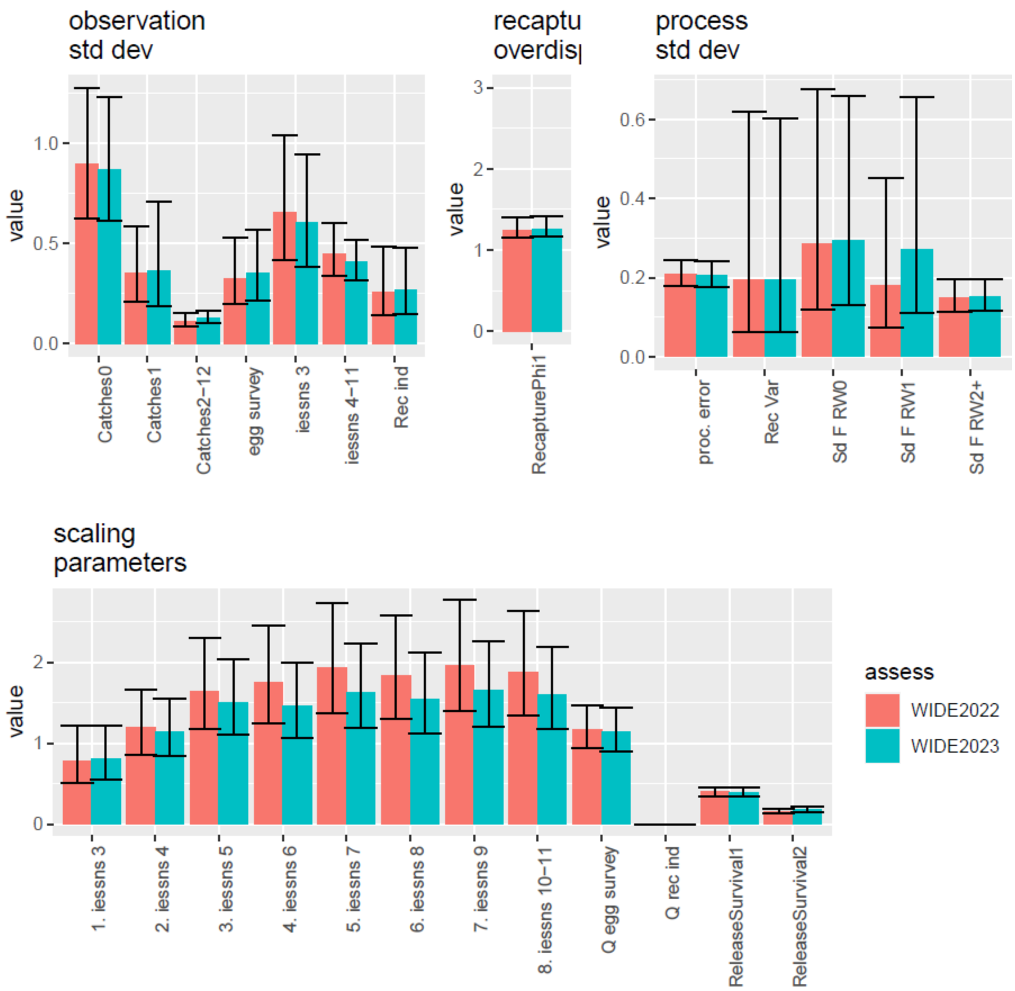


Figure 8.10.4. NE Atlantic mackerel. Comparison of model parameters and their uncertainty for the 2023 WGWIDE and the 2022 WGWIDE assessment

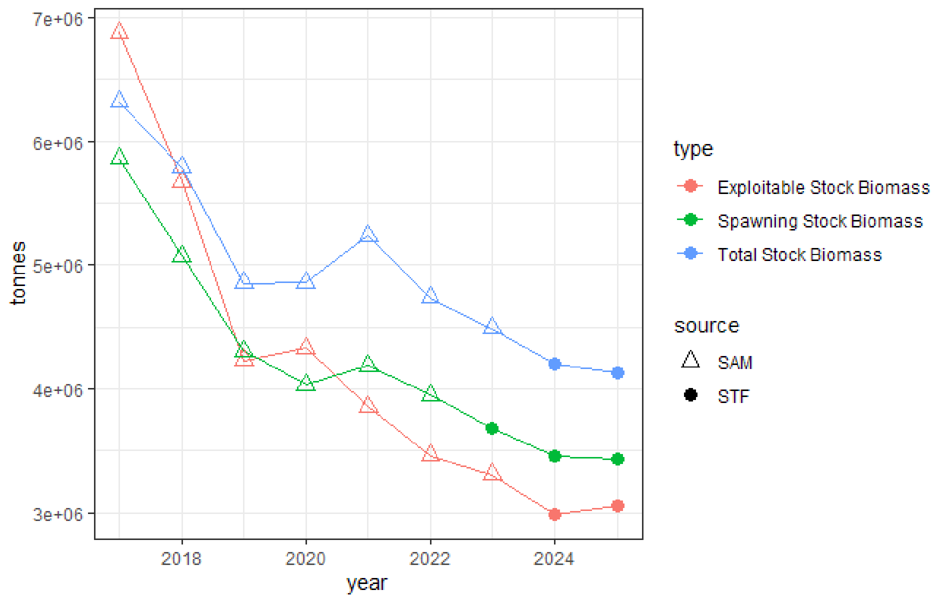
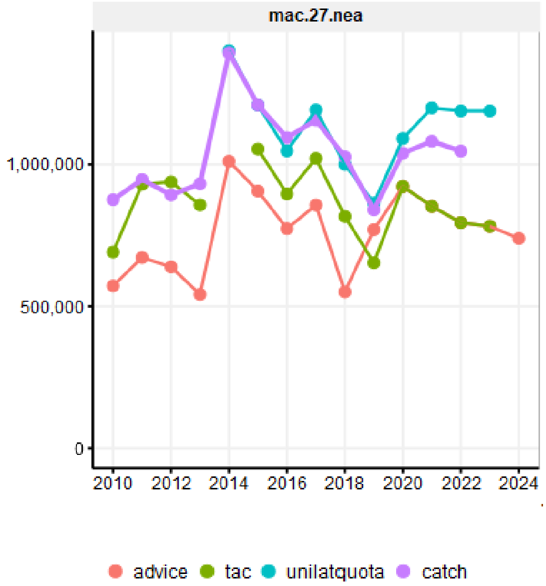


Figure 8.10.5. NE Atlantic mackerel. Estimated (triangles) and forecasted (dots) trends in exploitable, spawning and total stock biomass from the 2023 WGWIDE assessment and forecast.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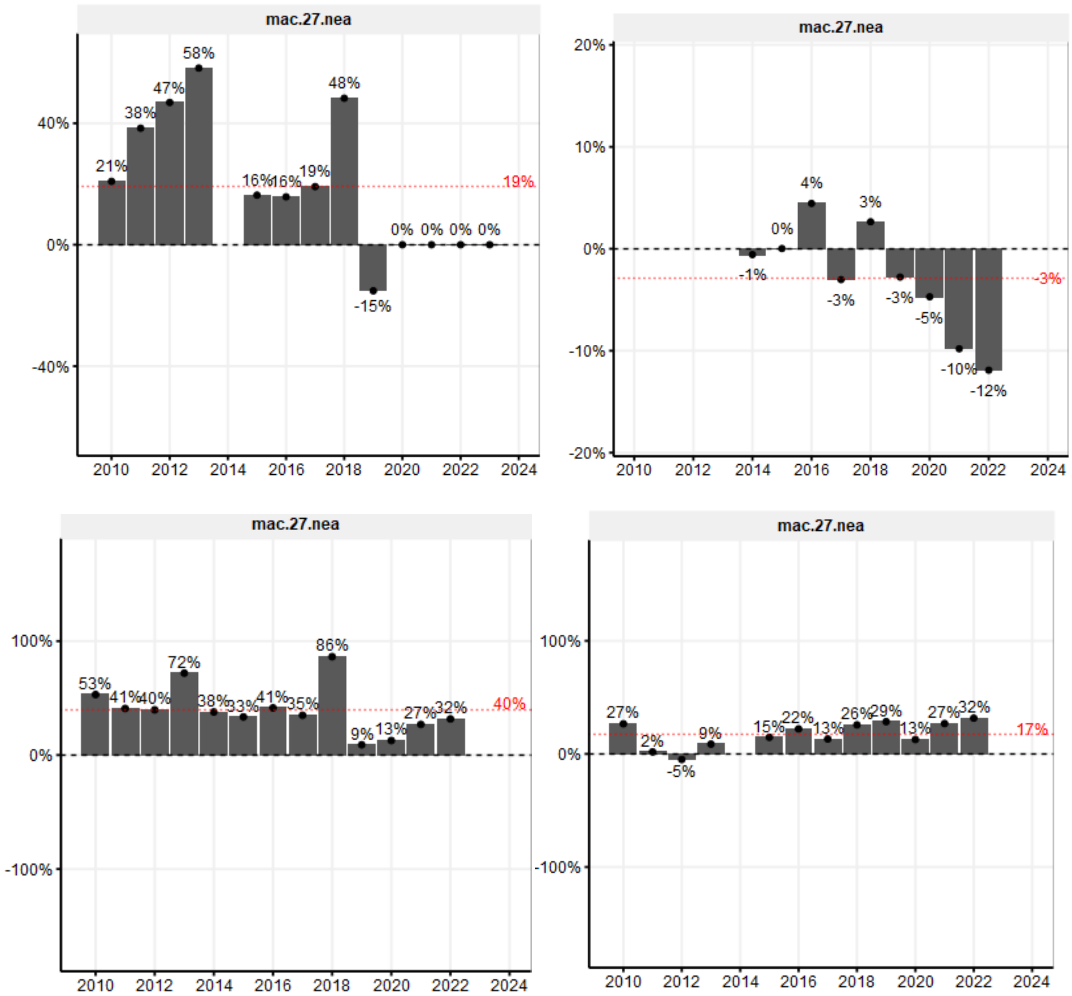


Figure 8.11.1. NE Atlantic mackerel. Top: comparison of the ICES advice, the agreed TAC, the sum of the declared quotas and total catch. Bottom: calculated percentage of TAC over Advice (top left), Catch over Sum of unilateral quota (top right), catch over Advice (bottom left) and Catch over TAC (bottom right).

9 Red gurnard in Northeast Atlantic

Chelidonichthys cuculus in subareas 3–8 (gur.27.3-8)

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 North-east 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), the shelf West of Brittany (7h, 8a), and west of Scotland (6a), living on gravel or coarse sand. In the Channel, the size at first maturity is ~25 cm 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 these Ecoregions does not seem appropriate. Divergent trends in survey abundances have been observed within the assessment area, with a sustained spike in abundance in Division 6a in the early 2010's which is not seen in surveys covering Subareas 7–8. Further investigations, such as morphometric studies, tagging and genetic population studies, would be needed to progress on stock boundaries, however SIMWG has advised that for now, there is insufficient evidence to carry out assessments on smaller spatial units.

9.3 Management regulations

Currently no technical measures are 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 by-catch by demersal trawlers in mixed fisheries, predominantly in Divisions 7d, 7e and 7h (Tables 9.1–2). 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 of red gurnard reported to ICES are presented in Tables 9.1 and 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 (GUX). Use of this code is not consistent across countries reporting landings, and some report mixed landings of gurnards under the code GUU – which is unfortunately the FAO species code for tub gurnard (*Chelidonichthys lucerna*).

A questionnaire was circulated to WGCATCH to gather information on how landings of gurnards are assigned to species. For those countries who responded, only Portugal has presented information on how the reporting of landings at a species level is achieved. Other countries accept the species code as declared at the point of landing, without further validation. This makes interpretation of the records of official landings, and trends within them difficult. Landings of gurnards (red, grey, tub and mixed) are shown in Figure 9.1.

International landings have fluctuated between 2941 –5049 tonnes between 2006–2022. Landings in the most recent year (2022) were 2971 tonnes – the second lowest on record. France is the main contributor of 'red gurnard' landings, with around 75% of landings from Divisions 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 (Divisions 6a–b, 7a–c, 7j) and Bay of Biscay (Subarea 8) have been consistently low.

9.4.2 Discards

Discard data for red gurnard has been provided for 2015–2022 through Intercatch (Table 9.3). For those countries which provided data, discard rates are variable but high (Table 9.4). Given the uncertainty associated with landings data, these figures should be treated with caution.

9.5 Survey data

Information on gurnard abundance are available in DATRAS for a number of surveys. Those covering the core area of the stock as determined by WKWEST (ICES, 2021) are the Scottish West Coast Groundfish Survey (SCOWCGFS and SWC-IBTS), Irish Groundfish Survey (IE-IGFS), English Channel Beam Trawl Survey (BTS), French Q4 surveys EVHOE in the Celtic Sea and Bay of Biscay and FR-CGFS in Division 7d, and additionally recent data from NS-IBTS Q1 and Q3 (from 2020 onwards). Each of these surveys covers a specific area of red gurnard distribution and no individual survey covers the entire stock area. Lengths at age are available from FR-CGFS-Q4 and (for some years) from IE-IGFS.

SCO-WCGFS and SWC-IBTS (Q1 and Q4)

Before 1996, red gurnard was scarce on the west of Scotland. The CPUE trended strongly upwards after 1997, reaching a peak in 2013, before declining to around the series average in recent years. The values for 2021 were low. There was, however, a slight increase in 2022–2023 (with no survey in Q1 in 2022, Figures 9.2–3).

CGFS (Q4)

Over the time-series 1988–2011, CPUE has fluctuated, peaked in 1994, reached a low in 2011, but is above long term mean since 2016. Values in 2022 were down (Figure 9.4).

EVHOE (Q4)

Over the period 1997–2022, the CPUE has fluctuated. It has been on an increasing trend since 2018, and 2022 is the second highest value in the series(Figure 9.4). Age reading of red gurnards caught during the 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.

IE-IGFS (Q4)

The CPUE of red gurnard in the IE-IGFS series has varied around the series mean without trend between 2003 and 2022. Values in 2022 were slightly up (Figure 9.5).

BTS (Q1)

CPUE in this relatively short series has fluctuated without apparent trend since 2006. Values in 2022 were down (Figure 9.5).

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. Accurate estimates of landings are still lacking for this species.

9.8 Assessment

Having explored the trends in available survey data, the delta-lognormal assessment method developed during WKWEST (ICES, 2021) was applied. This approach extracts the estimates of year effect from the log-normal part of the model (there is no temporal term in the binomial part), together with their associated standard error, and standardises the series relative to its mean value, to provide an index of biomass across the multiple surveys. Goodness of fit metrics of the model remain acceptable (Figures 9.6–7) and the log-normal part of the model has an adjusted r^2 value of 0.22.

After a period of relative stability, the biomass indicator declined in 2018–2019, before recovering strongly in 2020 (Figure 9.8). It declined in the two following years but remains above the biomass limit reference level of 0.81.

The influence of COVID-19 related disruption to surveys in the Channel during 2020 has not been investigated for this stock.

9.9 Data requirements

Gurnards are still not always reported by species, but rather as mixed gurnards. National approaches to validating the species composition of mixed gurnard landings are undocumented, other than for Portuguese landings. This makes interpretation of the records of official landings difficult. An international approach to the collection of data on species composition of gurnard landings is required to support the provision of advice for this stock.

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.

ICES. 2021. Benchmark Workshop on selected stocks in the Western Waters in 2021 (WKWEST). ICES Scientific Reports. 3:31. 504 pp. https://doi.org/10.17895/ices.pub.8137

Table 9.1. Red gurnard in Subareas 3–8. Official landings by country in tonnes.

Year	Belgium	Denmark	France	Germany	Guernsey	Ireland	Isle of Man	Jersey	Netherlands	Portugal	Spain	UK	Total
2006	313	0	4552	0	10	0	0	0	57	0	0	115	5047
2007	328	0	4494	0	4	0	0	1	66	0	0	156	5049
2008	352	0	4045	0	8	0	0	+	92	+	0	166	4664
2009	227	0	3307	0	6	0	1	+	160	1	0	263	3966
2010	237	0	3426	0	2	0	0	0	251	0	0	362	4278
2011	306	0	3168	0	2	0	1	1	295	1	0	257	4029
2012	306	0	2698	0	4	26	0	3	329	7	0	257	3629
2013	288	0	3152	0	9	16	2	3	267	+	532	329	4598
2014	263	0	3781	0	6	0	5	3	241	1	364	283	4946
2015	187	0	2919	0	3	0	+	2	210	1	82	341	3744
2016	238	0	2598	0	2	9	1	3	224	+	70	381	3526
2017	265	0	2396	0	1	9	4	0	226	+	75	335	3311
2018	314	0	2968	0	1	1	1	0	306	+	78	347	4014
2019	289	0	2448	0	5	3	+	1	247	+	80	478	3551
2020	211	0	2327	0	2	8	+	1	235	+	101	257	3142
2021	92	0	2244	0	+	7	+	0	160	+	68	370	2941
2022*	117	1	2327	3	+	7	+	0	128	0	75	312	2971
2022**	118	1	2328	3	0	7	+	+	127	0	25	312	2922

*** Preliminary data**

**** InterCatch data**

+ <0.5 t

Table 9.1. Red gurnard in Subareas 3–8. Official landings by area in tonnes.

Year	3a	4a	4b	4c	5b	6a	6b	7a	7b	7c	7d	7e	7f	7g	7h	7j	7k	8a	8b	8c	8d	8e	Total
2006	0	13	83	64	0	32	1	11	9	12	1101	2804	229	16	446	5	+	153	60	1	5	0	5047
2007	0	12	120	55	2	21	0	7	7	15	1229	2674	246	15	437	4	+	139	59	3	2	0	5049
2008	0	34	64	54	+	28	3	5	7	16	1236	2451	249	9	408	5	+	66	24	3	1	0	4664
2009	0	58	59	92	0	94	2	4	8	6	1293	1557	112	22	510	7	0	98	40	1	3	0	3966
2010	0	79	63	86	0	101	46	13	8	10	1531	1608	132	23	433	9	0	100	33	0	2	0	4278
2011	0	66	29	51	0	69	54	13	5	6	1295	1753	124	20	372	9	0	112	46	1	3	+	4029
2012	0	83	71	78	0	51	7	8	2	5	1244	1441	145	53	294	2	+	83	50	8	1	+	3629
2013	0	88	109	60	0	47	0	10	2	6	1193	1692	170	58	477	2	0	79	72	532	1	0	4598
2014	0	102	52	68	0	47	3	7	1	2	1294	1642	115	19	1069	1	0	82	75	363	3	+	4946
2015	0	133	102	53	0	58	1	4	3	1	790	1553	87	6	703	1	+	95	70	81	2	+	3744
2016	+	112	83	117	+	76	1	11	3	1	906	1270	114	16	608	1	+	87	63	56	1	0	3526
2017	0	53	44	90	0	27	1	14	1	+	874	1424	83	38	473	3	0	78	48	59	1	0	3311
2018	0	109	40	113	+	43	0	7	+	+	903	1785	164	28	631	4	+	80	43	62	2	0	4014
2019	0	128	19	75	+	84	+	12	1	+	959	1516	75	24	477	5	+	73	38	65	+	0	3551
2020	0	57	13	65	2	51	4	12	1	4	685	1504	90	19	424	4	+	69	51	88	1	0	3142
2021	0	58	18	55	0	112	4	4	2	+	592	1390	46	15	471	4	0	61	40	62	+	0	2941

2022*	1	64	10	61	+	40	1	4	+	0	520	1549	45	24	481	5	0	61	38	67	+	0	2971

Table 9.2. Red gurnard in Subareas 3–8. Discards in tonnes by country, 2015–2022.

Country	2015	2016	2017	2018	2019	2020	2021	2022
France	1323	2249	2232	770	3132	292	623	1690
Ireland	10	147	93	251	180	76	56	83
Spain	0	286	272	189	122	161	128	123
UK (ENG)	74	30	0	207	506	110	708	2562
UK (SCO)	649	411	198	512	331	117	0	40
Total	2056	3123	2795	1929	4270	757	1515	4498

Table 9.3. Red gurnard in Subareas 3–8. Discarding of Red gurnard in the Northeast Atlantic, as a percentage of catch, by country, 2017–2022.

	Discard rate (%)					
Country	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
France	48	21	56	11	22	42
Ireland	91	95	95	88	87	92
Spain	72	68	78	91	80	83
UK (England)	NA	NA	67	51	83	95
UK (Scotland)	68	92	60	45	NA	22

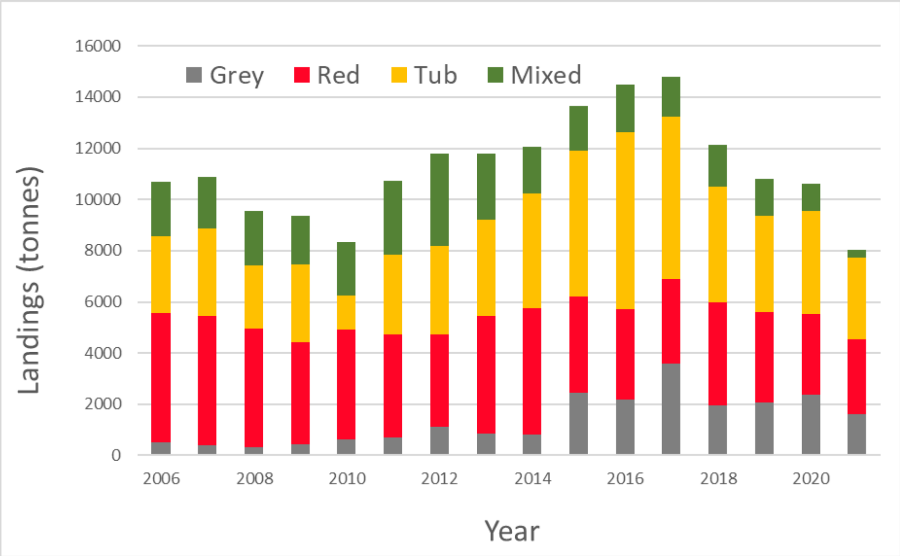


Figure 9.1. Red gurnard in Subareas 3–8. Official landings of grey, red, mixed and tub gurnards from the subareas in 2006–2020.

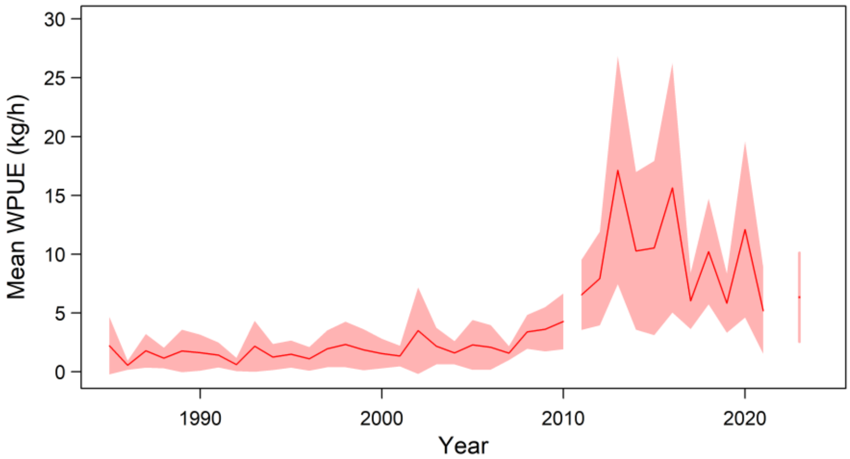


Figure 9.2. Red Gurnard in Subareas 3–8. Trends in mean abundance (kg/hr) in the Q1 Scottish IBTS (1985–2010) and Q1 Scottish West Coast Groundfish Survey (2011–2023, excluding 2022)

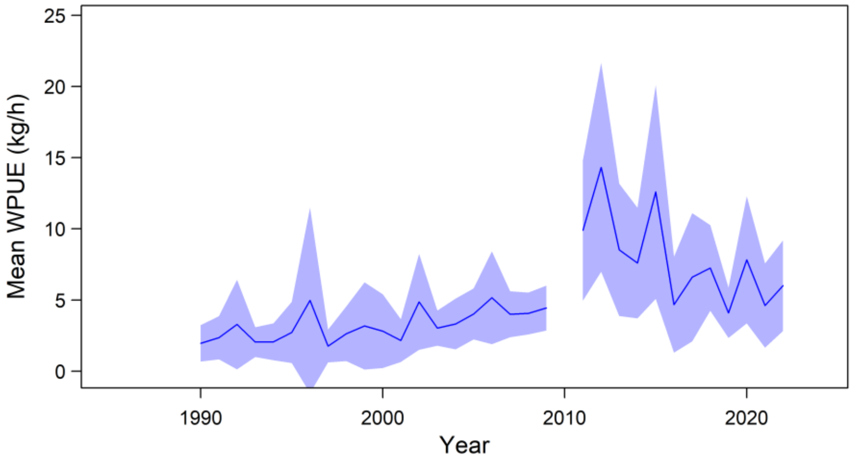


Figure 9.3. Red gurnard in Subareas 3–8. Trends in mean abundance (kg/h) in the Q4 Scottish IBTS (1990–2009) and Q4 Scottish West Coast Groundfish Survey (2011–2022).

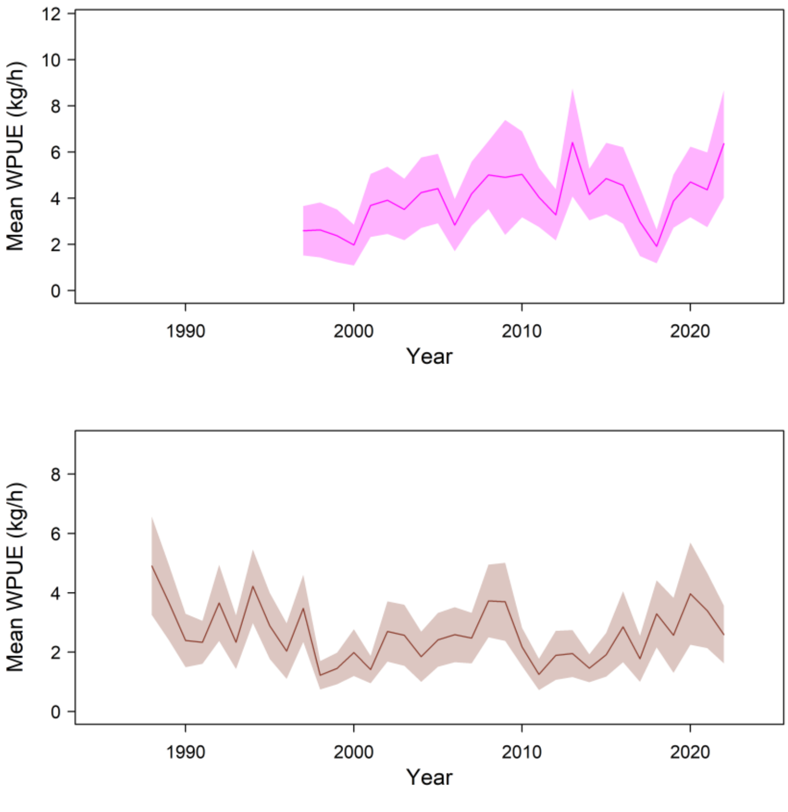


Figure 9.4. Red gurnard in Subareas 3–8. Trends in mean abundance (kg/h) in the EVHOE (top) and French Channel Groundfish Survey (bottom).

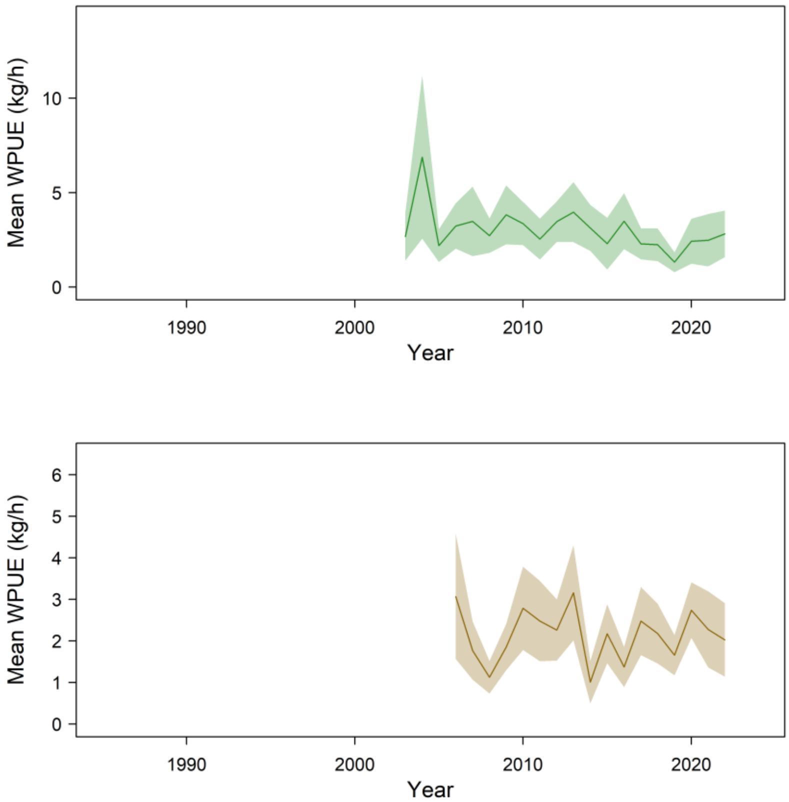


Figure 9.5. Red Gurnard in Subareas 3–8. Trends in mean abundance (kg/h) in the Irish Groundfish Survey (top) and English Channel Beam Trawl Survey (bottom).

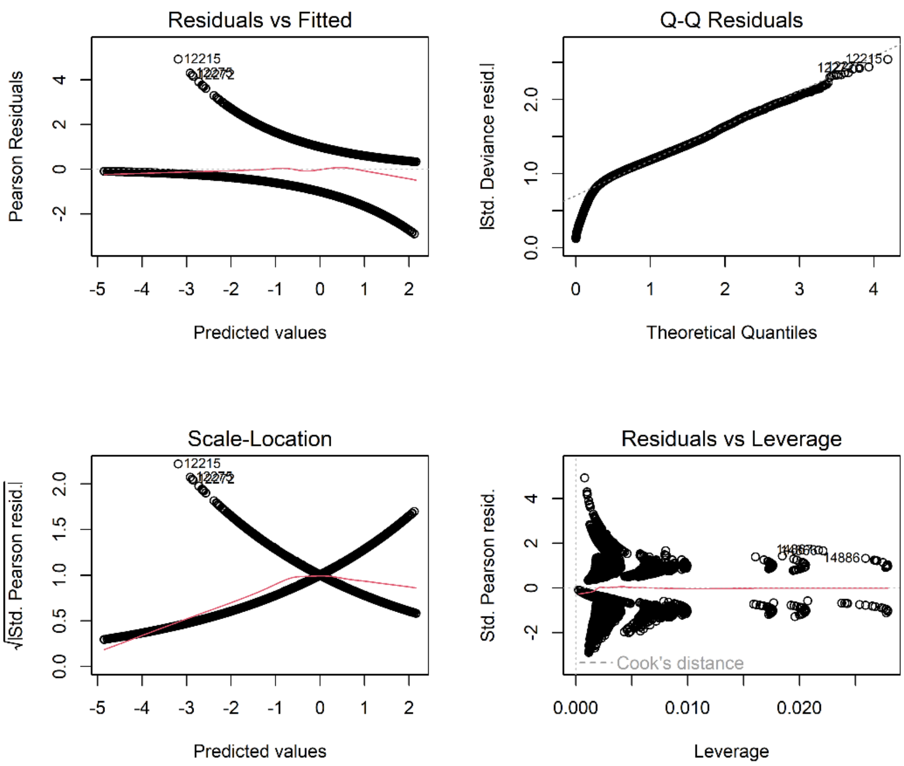


Figure 9.6. Red gurnard in Subareas 3–8. Measures of goodness of fit of the binomial part of the assessment model.

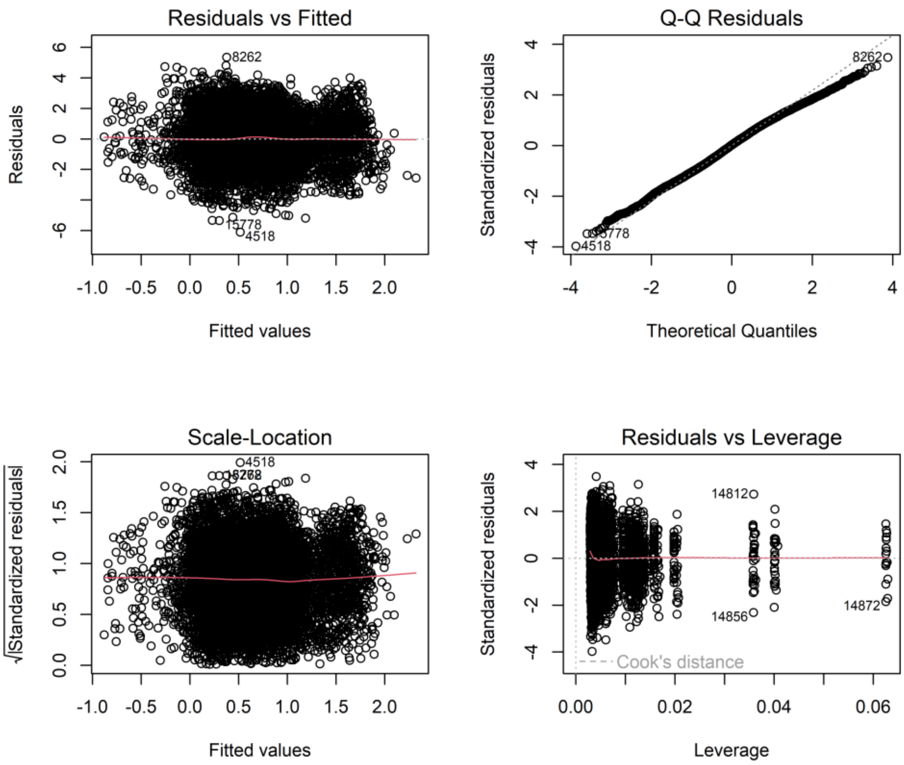


Figure 9.7. Red gurnard in Subareas 3–8. Measures of goodness of fit of the lognormal part of the assessment model.

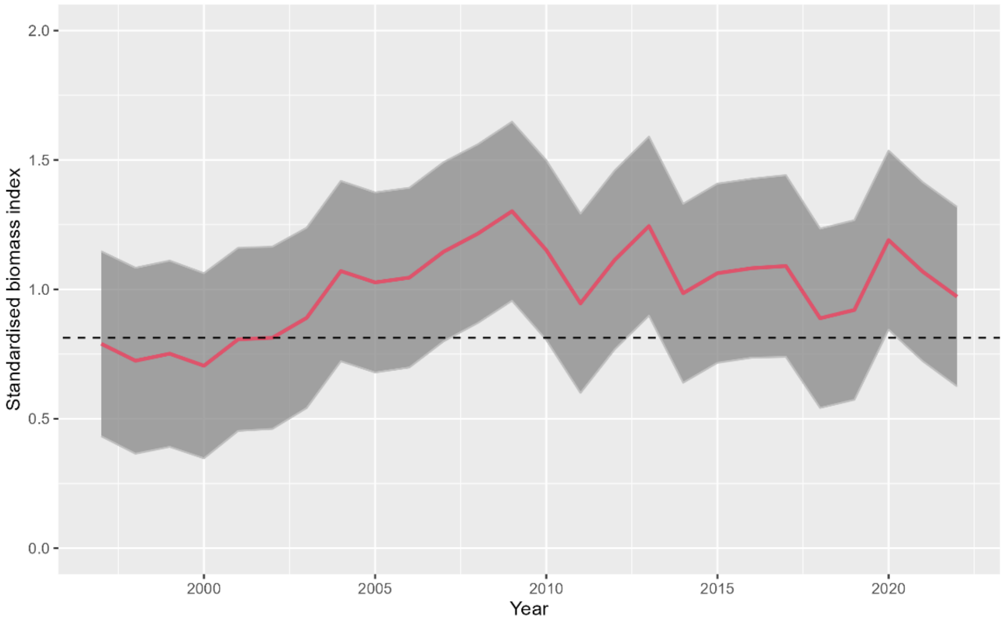


Figure 9.6. Red gurnard in Subareas 3–8. Results of the assessment model. Shading corresponds to 2 standard errors around the estimate. The dashed line represents MSY $B_{trigger}$ (0.81).

10 Striped red mullet in the North Sea, Bay of Biscay, southern Celtic Seas, and Atlantic Iberian waters

Mullus surmuletus in subareas 6 and 8, and divisions 7.a–c, 7.e–k, and 9.a (mur.27.67a-ce-k89a)

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 (Mahe *et al.*, 2005). Young fish are distributed in lower salinity coastal areas, while adults have a more offshore distribution.

Adult red mullets feed on small crustaceans, annelid worms, and molluscs, using their chin barbels to detect prey and search the mud. Consequently, striped red mullets 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 mullets 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 (Mahe *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 22 cm. Along the continental shelf off the Island of Majorca, males and females mature at 15 and 16cm, respectively corresponding to 1 year of age (Reñones *et al.*, 1995).

Spawning occurs in the spring and early summer -May to June according to Desbrosses (1933)- with a spawning peak in June in the northern Bay of Biscay (N'Da and Déniel, 1993). Eggs and larvae average 2.8mm and are pelagic (Sabatés *et al.*, 2015). The hatching takes place after three days at 18°C and after eight days at a temperature of 9°C (Quéro and Vayne, 1997) After metamorphosis juveniles become first demersal and 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 and Déniel, 2005). The growth rate 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 age 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 *et al.*, 2006).

The maximum reported age of the striped red mullet is 11 years (Quéro and Vayne, 1997; ICES, 2012), while the maximum length given is 44.5cm in the Bay of Biscay (Dorel, 1986) and 40cm elsewhere (Whitehead *et al.*, 1984; Fischer *et al.*, 1987). The maximum reported mass is 1kg (Muus and Nielsen, 1999).

10.2 Management regulations

Before 2002, France enforced a minimum landing size of 16 cm. Since 2013 a minimal size requirement has been established to 15 cm (France, 2013). 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 in striped red mullets between those from the Eastern English Channel and those from the Bay of Biscay (Mahe *et al.*, 2014). 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 (Figure 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 considered if manamgement measures are implemented.

10.4 Fisheries data

Official landings have been recorded since 1975 and after early increases they have declined in recent years. France and Spain accounts for most removals (Table 10.1) and landings are mainly taken from Subarea 7 and 8 (Table 10.2). Main landings are taken in area 8 by France and Spain (Figure 10.2). Official fishing effort is only reported by 5 countries and seems stable in the last 5 years (Figure 10.3). The striped red mullet is one species among the set of benthic and 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 due to 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 comprise the smallest units (85% are less than 12m long), while 52% of bottom trawlers are less than 15m; 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.

The length distribution of the catches has been available discontinuously in Intercatch since 2012 (Figure 10.4). The pattern shown in this information is relatively stable over time.

Discards represented between 3% and 18% of the total catch in 2014–22 (Table 10.3). Since 2018, the discard rates have reported reported below 5%, but in 2022 the discard rate reaches 14%. However, there are concerns about how these discards have been estimated due to some countries' lack of discards data. From the data provided to Intercatch in 2022, discards are composed of individuals measuring less than 20 cm (Figure 10.4).

10.5 Survey data

In DATRAS, five surveys report length measurements of red mullet in the stock area since 1993. Survey data is available in DATRAS during 1997-2021 for the French EVHOE survey, covering the Bay of Biscay and the Celtic Sea, during 2001 – 2016 for the northern Spanish groundfish survey (SP-NSGFS), and from 2002 onwards for the Portuguese groundfish survey (PT-IBTS), covering the Portuguese coast (Figure 10.5). For this working group in the WGWIDE data call framework, indices from two surveys are provided: French EVHOE indices (survey map in Figure 10.6) and Northern Spanish Shelf surveys (survey map in Figure 10.7).

Two indices from the EVHOE survey are variable around the series mean between 1987 – 2011 before falling to a lower level thereafter and reaching average values during the last three years (Figure 10.8). Abundance and biomass indices in the Spain NSGFS are highly variable around the mean before 2017, then decreasing to a low level since 2017 (Figure 10.9). The mean stratified length distribution from Spain NSGFS is a bit higher in 2022 than in the previous three years but still very low compared with the last 30 years (Figure 10.10).

10.6 Biological sampling

In the Bay of Biscay, sexual maturity and length measures were taken in 2009 by AZTI. 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 aimed to optimize age estimation between countries. In 2011, an Otolith Exchange Scheme was carried out, the second exercise for the Striped red mullet. Four readers of this exchange interpreted an image collection from the Bay of Biscay, the Spanish and the Mediterranean coasts (Spain and Italy). A set of Mullus surmuletus otoliths (N=75) from the Bay of Biscay presented the highest percentage of agreement (82%). On 75 otoliths, 34 were read with 100% agreement (45%) and thus a CV of 0%. The modal age of these fishes was comprised between 0 and 3 years (Mahe *et al.*, 2012).

10.7 Current research programs

Two research projects are currently investigating (1) the evolution of striped red mullet abundance indices from fishery-dependent data and (2) the temporal evolution of the size and age at maturity for this species in the Bay of Biscay. The first research project (ACOST) extends the analysis presented in
Caill-Milly *et al.* (2017) and Caill-Milly *et al.* (2019) and computes 5 abundances indices from 2005 to 2022 based on the landings per unit effort for 5 french fleets. The second project (MATO) updates the maturity data for the species in the Bay of Biscay thanks to a monthly longitudinal study over one reproduction cycle between 2021 and 2022. The final results will be published in 2023, and the references will be added to the next report.

10.8 Analysis of stock trends/assessment

An age-structured analytical stock assessment has yet to be developed due to the quality of the data available in the ICES database and the limited size of the available time series.

10.8.1 Data requirements

Regular sampling of biological parameters of striped red mullet catches must be continued under DCF. A benchmark to update the available information on this species and to assess the quality of the data presently available in Intercatch and DATRAS would be beneficial to the description of the ongoing fishery, as this species is supposed to expand its distribution area with the warming of the North Atlantic waters (Cheung *et al.*, 2012). Recent studies show a link between the environmental parameters and the catch rates in the fishery for this species (Leitão, 2023).

10.9 References

Benzinou, A., Carbini, S., Nasreddine, K., Elleboode, R., and Mahé, K. 2013. Discriminating stocks of striped red mullet (Mullus surmuletus) in the Northwest European seas using three automatic shape classification methods. Fisheries Research, 143: 153–160.

Caill-Milly, N., Lissardy, M., and Leaute, J.-P. 2017. Improvement of the fishery knowledge of striped red mullet of the Bay of Biscay. Ifremer.

Caill-Milly, N., Lissardy, M., Bru, N., Dutertre, M.-A., and Saguet, C. 2019. A methodology based on data filtering to identify reference fleets to account for the abundance of fish species: Application to the Striped red mullet (Mullus surmulletus) in the Bay of Biscay. Continental Shelf Research, 183: 51–72. Elsevier BV.

Cheung, W. W. L., Pinnegar, J., Merino, G., Jones, M. C., and Barange, M. 2012. Review of climate change impacts on marine fisheries in the UK and Ireland: CLIMATE CHANGE AND MARINE FISHERIES IN IRELAND AND THE UK. Aquatic Conservation: Marine and Freshwater Ecosystems, 22: 368–388.

Déniel, C. 1991. Biologie et élevage dudesbrosse rouget barbet Mullus surmuletus en Bretagne. Contrat Anvar-UBO A 8911096 E 00.

Desbrosses, P. 1933. Contribution à la connaissance de la biologie du rouget-barbet en atlantique nord, mullus barbatus (rond) surmuletus fage mode septentrional fage. Revue des Travaux de l'Institut des Pêches Maritimes, 6: 249–270. ISTPM.

Dorel, D. 1986. Poissons de l'Atlantique Nord-Est : Relations Taille-Poids.

Fischer, W., Schneider, D. C., and Bauchot, L. 1987. Guide Fao d'Identification des Espèces pour les Besoins de la Pêche Méditerranée et Mer Noire - Zone de Pêche 37 Volume 2: Vertébrés.

France. 2013, January. Arrêté du 29 janvier 2013 modifiant l'arrêté du 26 octobre 2012 déterminant la taille minimale ou le poids minimal de capture des poissons et autres organismes marins (pour une espèce donnée ou pour une zone géographique donnée) effectuée dans le cadre de la pêche maritime de loisir.

ICES. 2012. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK). ICES, ICES Headquarters, Copenhagen.

Leitão, F. 2023. Environmental Conditions Affect Striped Red Mullet (Mullus surmuletus) Artisanal Fisheries. Oceans, 4: 220–235. Multidisciplinary Digital Publishing Institute.

Mahe, K., Destombe, A., Coppin, F., Koubbi, P., Vaz, S., Le Roy, D., and Carpentier, A. 2005. Le rouget barbet de roche Mullus surmuletus (L. 1758) en Manche orientale et mer du Nord.

Mahe, K., Elleboode, R., Charilaou, C., Ligas, A., Carbonara, P., and Intini, S. 2012. Red mullet (Mullus surmuletus) and striped red mullet (M. Barbatus) otolith and scale exchange 2011.

Mahe, K., Villanueva, M. C., Vaz, S., Coppin, F., Koubbi, P., and Carpentier, A. 2014. Morphological variability of the shape of striped red mullet Mullus surmuletus in relation to stock discrimination between the Bay of Biscay and the eastern English Channel. Journal of Fish Biology, 84: 1063–1073.

Muus, B. J. 1926.-2006., and Nielsen, J. G. 1923.-. 1999. Sea fish. Scandinavian Fishing Year Book, Hedehusene [Denmark].

N'Da, K., and Déniel, C. 1993. Sexual cycle and seasonal changes in the ovary of the red mullet, Mullus surmuletus, from the southern coast of Brittany. Journal of Fish Biology, 43: 229–244.

N'Da, K., and Déniel, C. 2005. Croissance des juvéniles du rouget de roche (Mullus surmuletus) dans le nord du golfe de Gascogne. Cybium, 29.

N'Da, K., Déniel, C., and Yao, K. 2006. Croissance du rouget de roche Mullus surmuletus dans le nord du golfe de Gascogne. Cybium, 30.

Quéro, J.-. C., and Vayne, J.-. J. 1997. LES POISSONS DE MER DES PECHES FRANCAISES. Identification, inventaire et répartition de 209 espèces.

Reñones, O., Massutí, E., and Morales-Nin, B. 1995. Life history of the red mullet Mullus surmuletus from the bottom-trawl fishery off the Island of Majorca (north-west Mediterranean). Marine Biology, 123: 411–419.

Sabatés, A., Zaragoza, N., and Raya, V. 2015. Distribution and feeding dynamics of larval red mullet (Mullus barbatus) in the NW Mediterranean: The important role of cladocera. Journal of Plankton Research, 37: 820–833.

Whitehead, P. J. P., Bauchot, M.-L., and Hureau, J.-C. (Eds). 1984. Fishes of the North-eastern Atlantic and the Mediterranean. Unesco, Paris, France.

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	France	Guernsey	Ireland	Jersey	Netherlands	Portugal	Spain	UK	Total
2,006	33	1,947	8	16	1	115	10	387	170	2,688
2,007	43	1,941	9	23	1	148	222	398	194	2,978
2,008	26	1,394	9	22	0	165	169	394	165	2,345
2,009	20	1,562	5	16	0	110	199	520	134	2,567
2,010	20	1,743	5	8	0	128	276	479	133	2,793
2,011	21	1,740	0	8	0	130	245	508	155	2,806
2,012	37	1,342	0	7	1	125	217	332	122	2,183
2,013	28	932	5	4	0	50	187	246	71	1,522
2,014	12	926	5	2	0	2	221	265	53	1,487
2,015	23	1,215	5	3	0	111	282	248	102	1,989
2,016	28	1,179	0	4	0	69	204	194	83	1,761
2,017	36	997	0	10	0	13	154	327	64	1,601
2,018	37	896	0	0	0	95	122	321	67	1,538
2,019	30	1,358	0	12	0	91	159	267	55	1,973
2,020	50	965	0	6	0	82	109	261	89	1,562
2,021	53	836	0	18	0	54	117	274	93	1,445
2,022	43	1,057	0	20	1	18	136	336	81	1,691

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	6.a	7.a	7.b	7.c	7.e	7.f	7.g	7.h	7.j	7.k	8.a	8.b	8.c	8.d	9.a	8.e	6.b	Total
2,006	0	1	1	0	869	50	24	103	11	0	1,023	468	71	28	39	0	0	2,688
2,007	1	1	1	1	1,047	54	22	104	24	0	861	473	90	32	267	0	0	2,978
2,008	0	1	1	0	880	46	16	72	26	0	639	246	86	35	296	0	0	2,345
2,009	2	1	2	2	592	25	9	74	35	0	879	460	156	88	243	0	0	2,567
2,010	2	1	3	2	642	26	10	59	32	1	1,033	467	146	38	331	0	0	2,793
2,011	1	1	0	0	665	20	10	55	11	0	970	513	214	35	310	0	1	2,806
2,012	0	0	0	0	493	23	7	34	9	0	696	387	200	53	280	0	0	2,183
2,013	0	0	1	0	232	23	7	36	4	0	473	328	166	12	241	0	0	1,522
2,014	1	0	0	0	192	15	3	40	3	0	523	240	151	23	297	0	0	1,487
2,015	0	0	1	0	595	10	2	36	2	0	506	327	126	15	369	0	0	1,989
2,016	0	0	2	0	417	21	7	35	5	0	548	311	117	21	277	0	0	1,761
2,017	0	0	1	0	277	27	21	37	3	0	514	324	160	5	231	0	0	1,601
2,018	0	0	0	0	361	26	7	39	1	0	453	276	144	2	226	0	0	1,538
2,019	0	1	1	0	377	23	20	35	1	0	770	388	123	4	229	0	0	1,973
2,020	0	2	1	0	386	43	18	40	4	0	502	265	128	3	170	0	0	1,562
2,021	0	1	0	0	302	52	30	54	3	0	416	281	114	2	188	0	0	1,445
2,022	0	1	0	0	232	39	42	58	2	0	698	284	110	1	224	0	0	1,691

Figure 10.2: Striped red mullet in Subareas and Divisions 6, 7a-c, e-f, 8 and 9a. Official landings by area and country in tonnes.

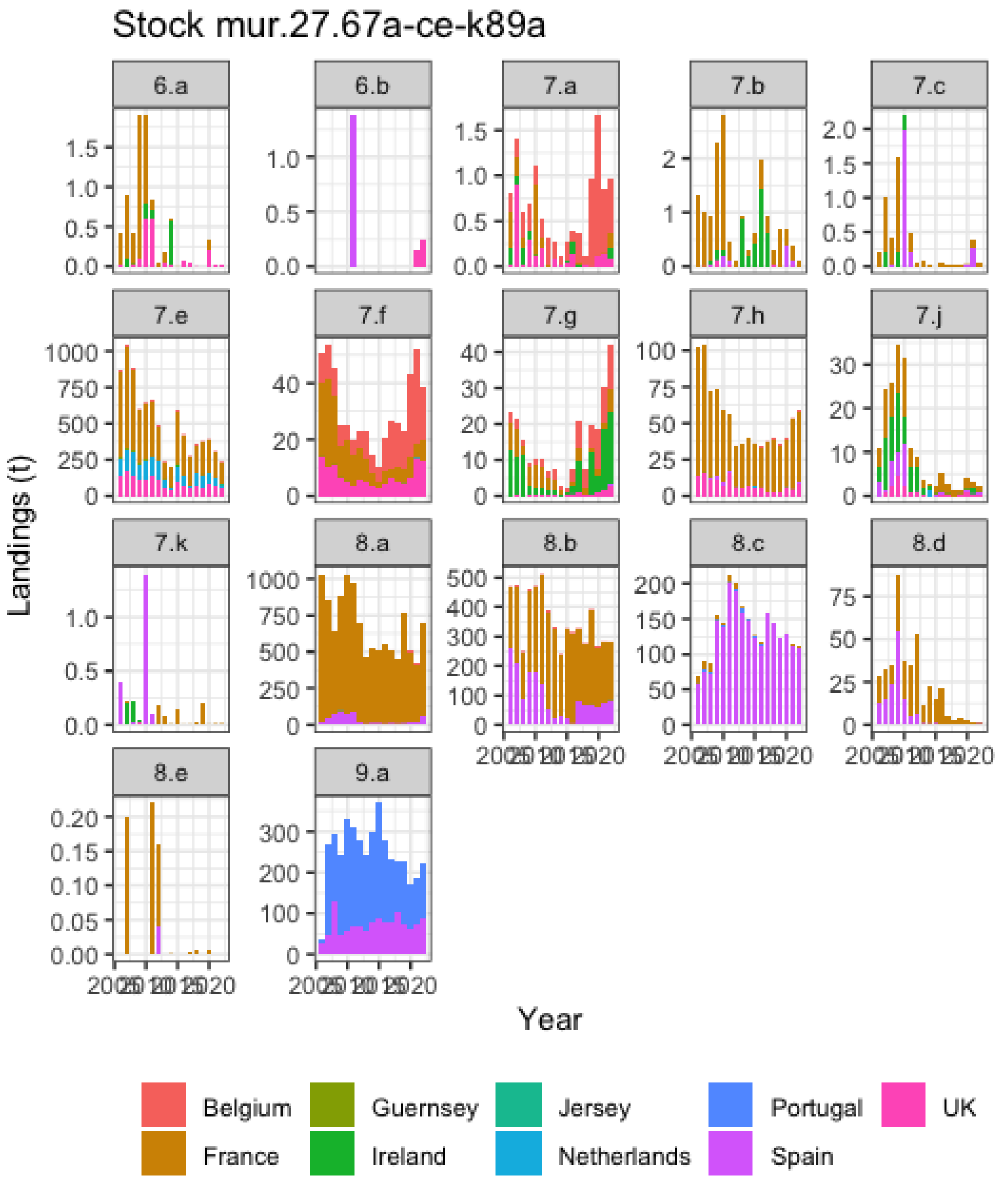


Figure 10.3: Striped red mullet in Subareas and Divisions 6, 7a-c, e-f, 8 and 9a. Official fishing effort reported

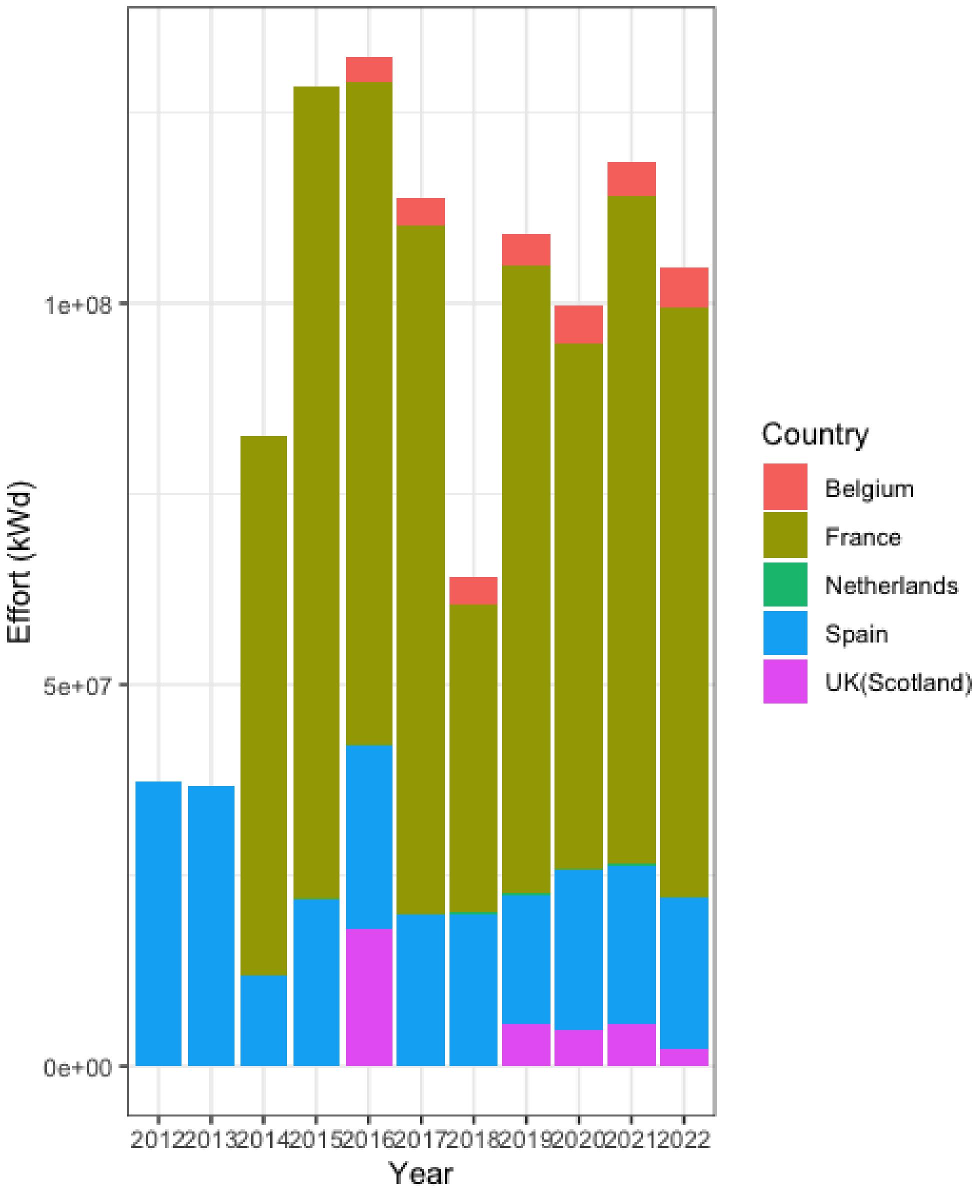


Table 10.3: Striped red mullet in Subareas and Divisions 6, 7a-c, e-k, 8 and 9a. Official discards by country in tonnes. Total is presented with the total discards rates in %

Year	UK	France	Belgium	Portugal	Spain	Ireland	Nether-lands	Total
2,013	0							0 (0%)
2,014		98						98 (6.2%)
2,015	77	115						192 (8.8%)
2,016	171	213	1	0	8			394 (18.3%)
2,017	11	74	2	0	0	0		87 (5.1%)
2,018	14	35	3	0	2	0		53 (3.3%)
2,019	29	67	3		1	0		100 (4.8%)
2,020	39	28	4		1	9	0	82 (5%)
2,021	9	49	4		0	6	0	67 (4.5%)
2,022	109	162	4		0	0	0	275 (14%)

Figure 10.1: Striped red mullet in Subareas and Divisions 6, 7a-c, e-f, 8 and 9a. Landings by statistical rectangle for BEL, FRA, IRE, PT, UK (E&W), UK (SCO) from 2014 to 2021 (Fishery Dependent Information database 2023).

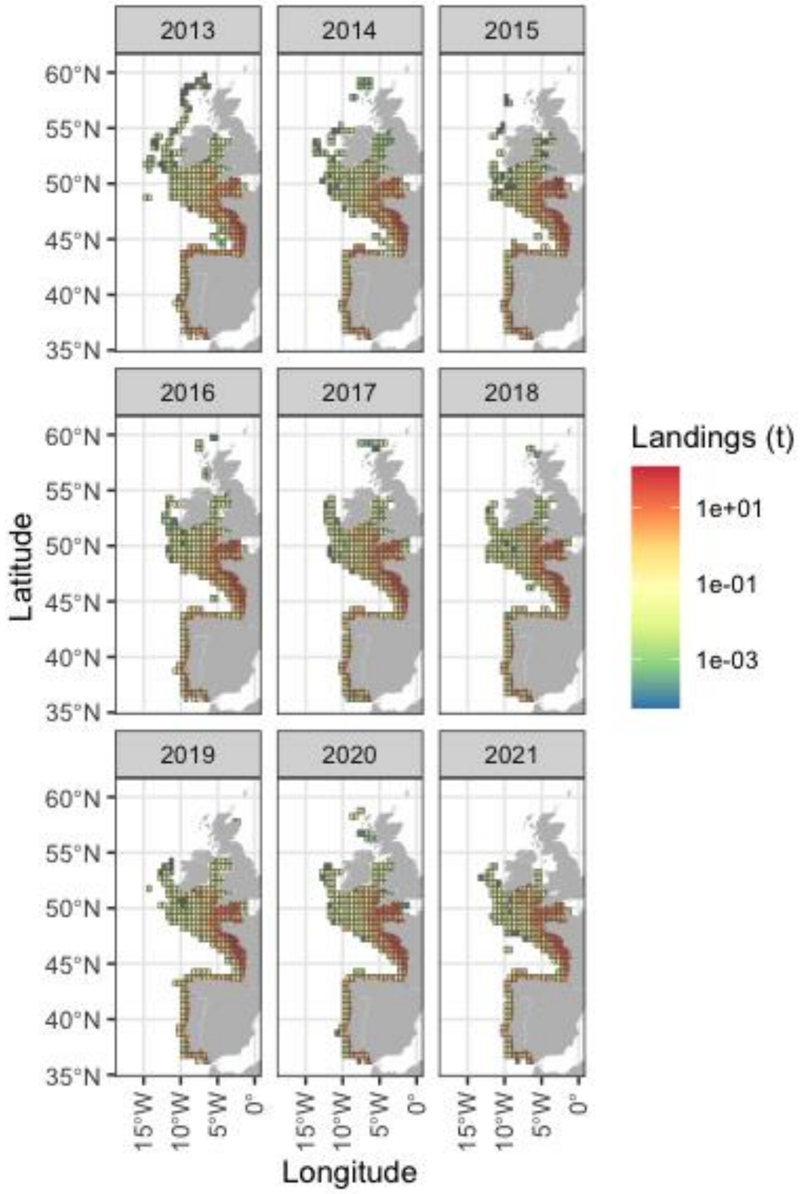


Figure 10.4: Striped red mullet in Subareas and Divisions 6, 7a-c, e-f, 8 and 9a. Length distribution from 2014 to 2021 from Intercatch (D: Discards, L: Landings)

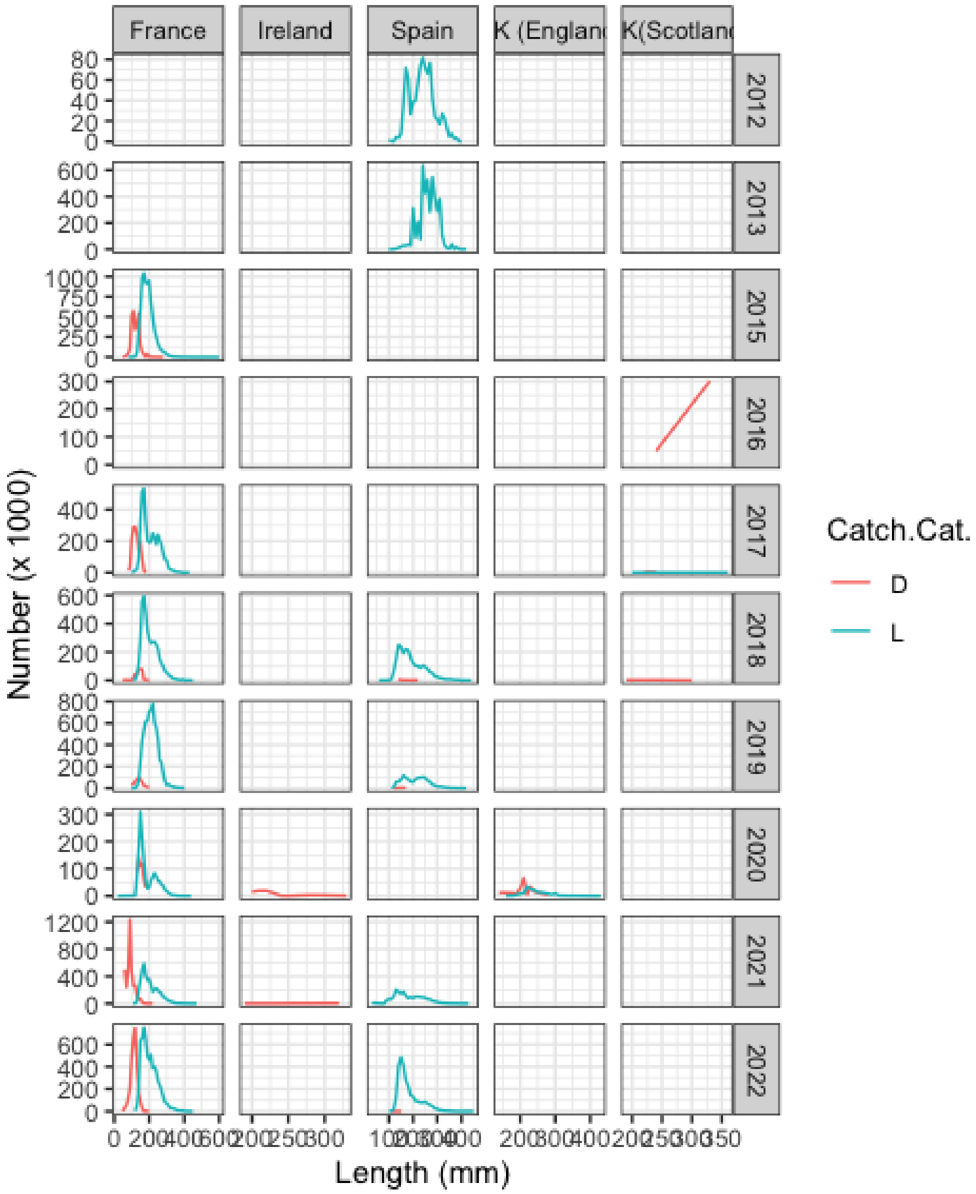


Figure 10.5: Percentage of hauls with striped red mullet length measurement, by year and survey. Black cross means no data.

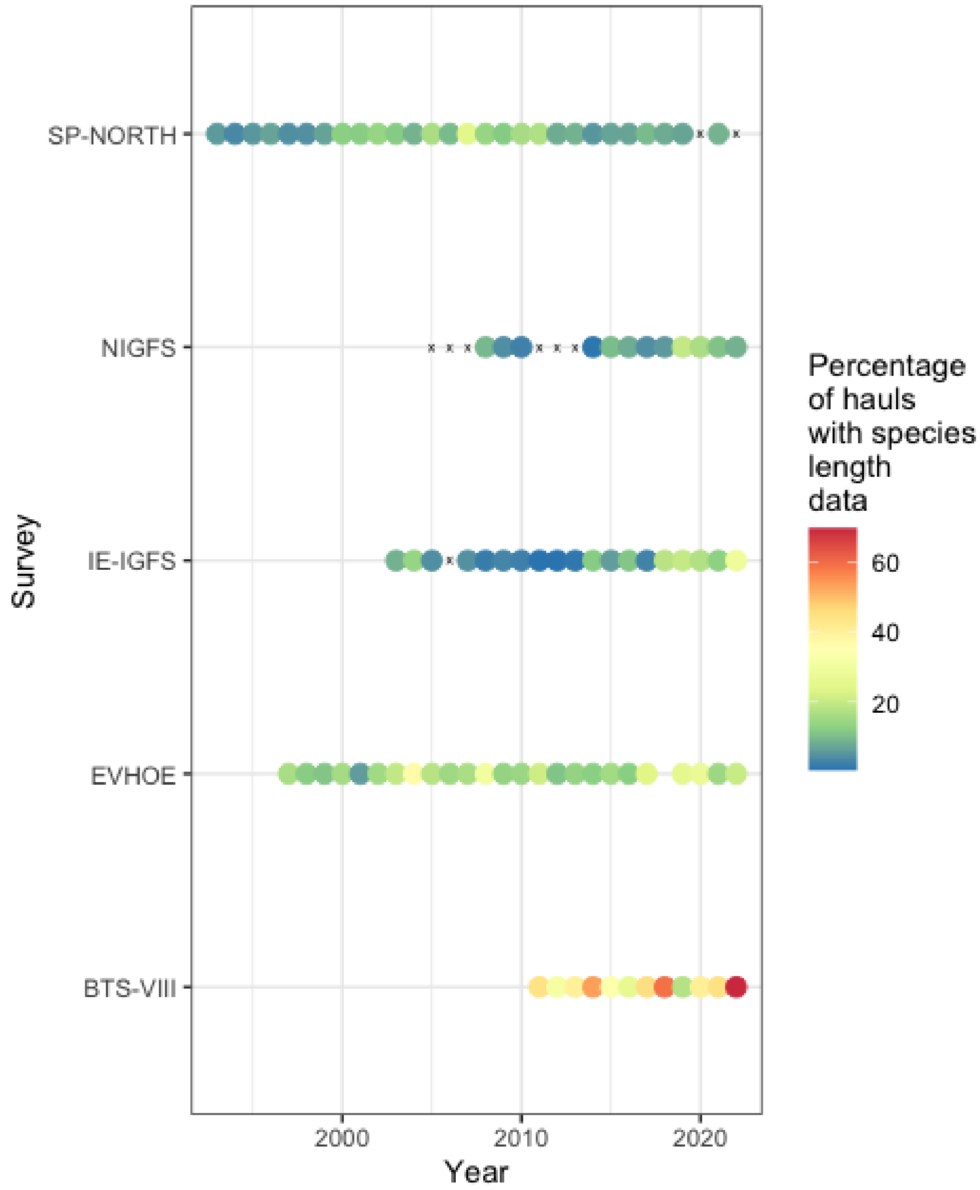


Figure 10.7: NSGFS survey station map

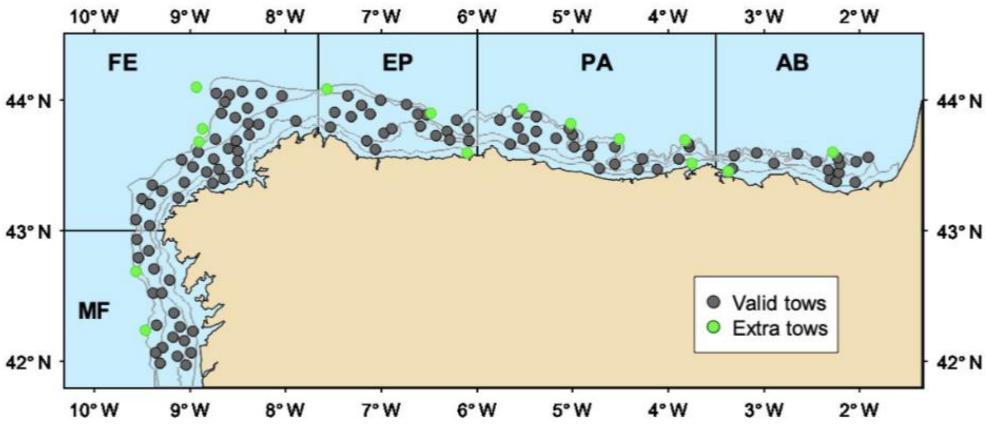


Figure 10.11: EVHOE survey station map

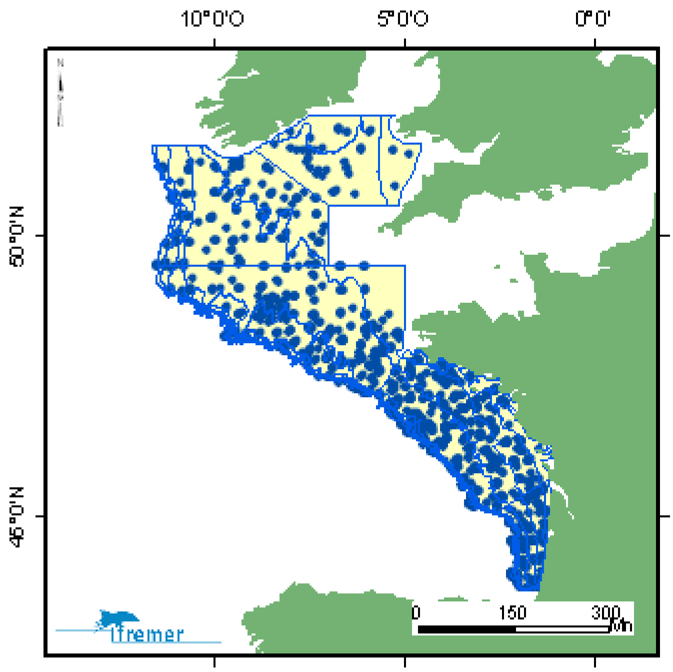


Figure 10.12: Abundance and biomass indices (black line, with the grey ribbon for the standard deviation) striped red mullet in Subareas and Divisions 6, 7a-c, e-f, 8 and 9a., estimated from the EVHOE campaign, 1987-2022. The blue line is a loess regression underlining the trend in the series.

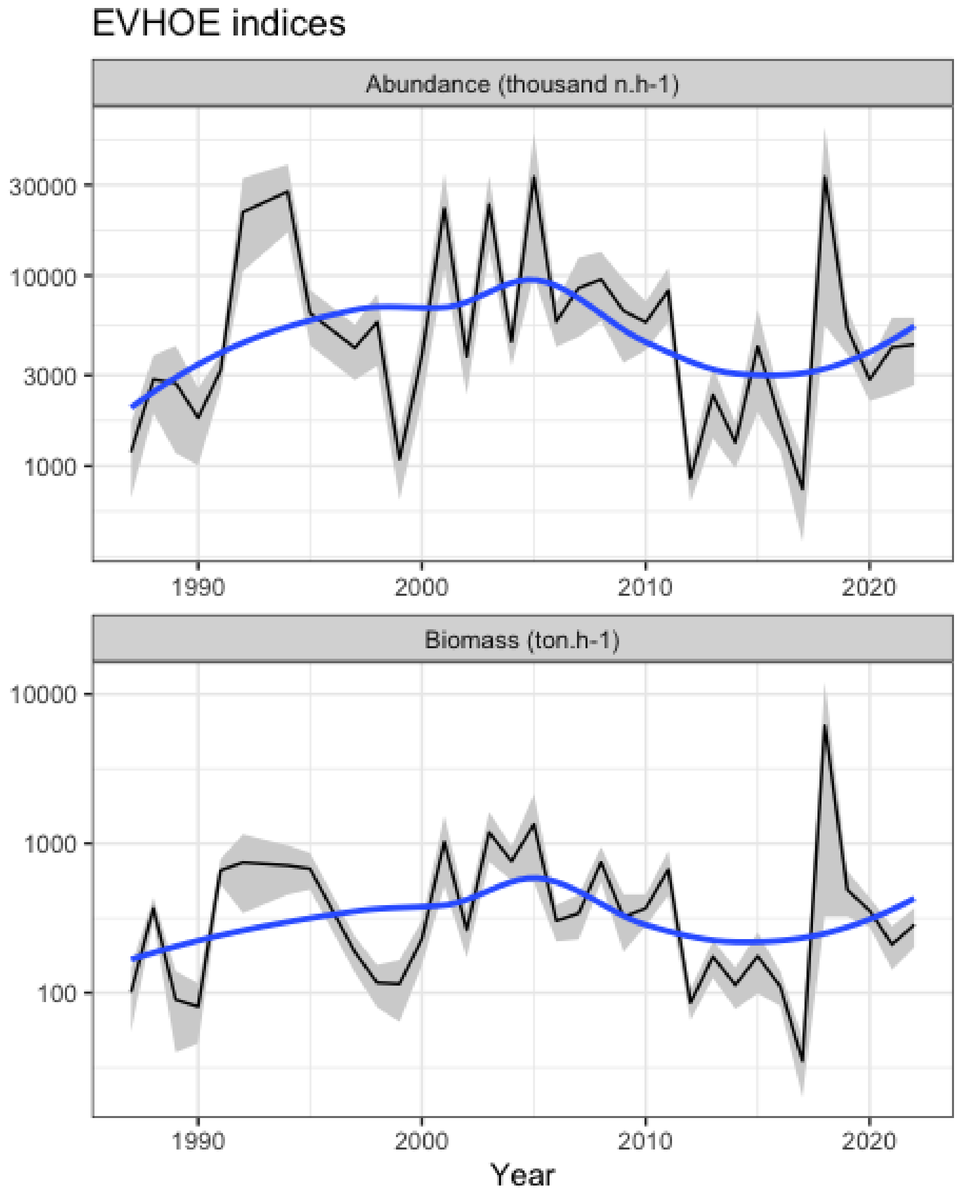


Figure 10.13: Abundance and biomass indices (black line, with the grey ribbon for the standard error) striped red mullet in Subareas and Divisions 6, 7a-c, e-f, 8 and 9a., estimated from the NSGFS campaign, 1983-2022. The blue line is a loess regression underlining the trend in the series.

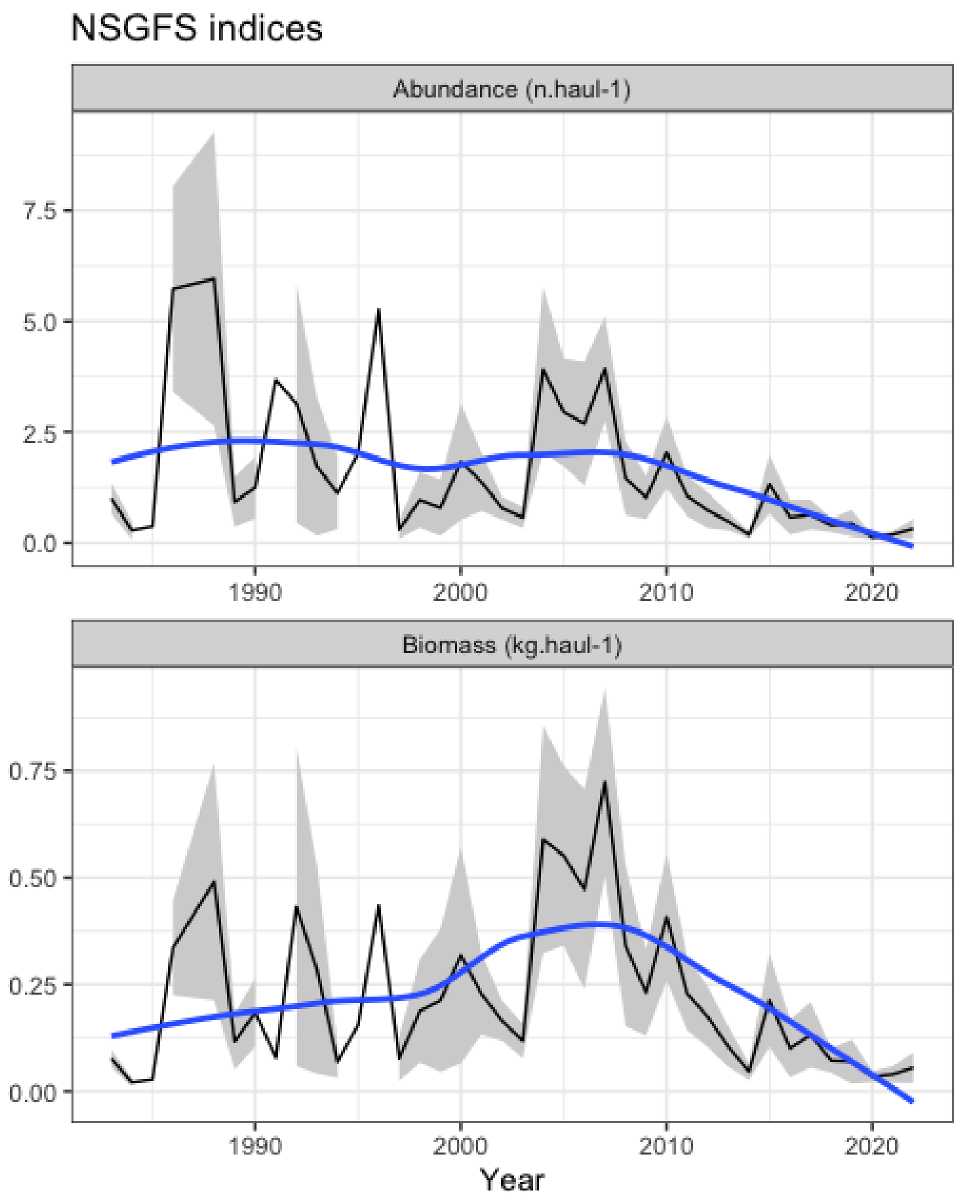
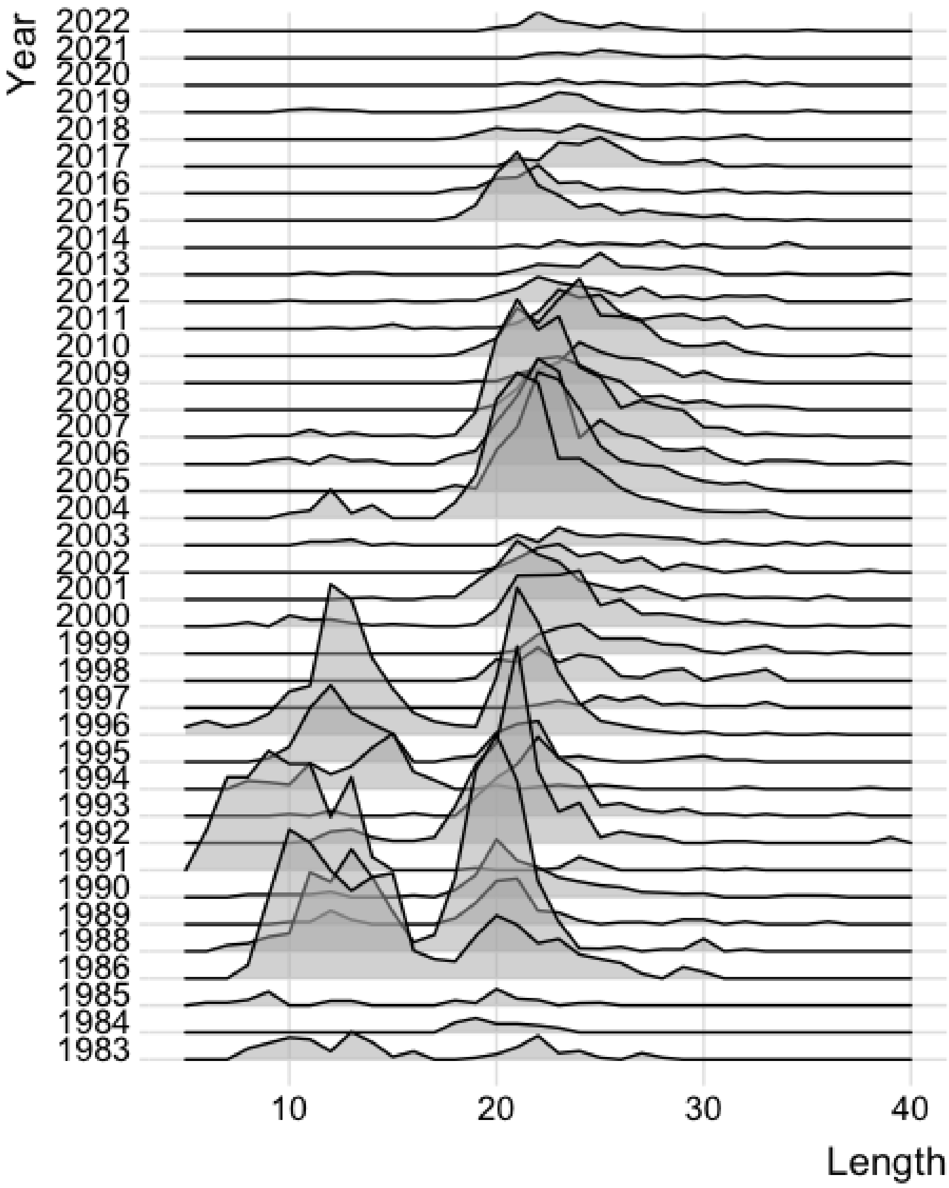


Figure 10.14: Main stratified length distributions of the striped red mullet in Subareas and Divisions 6, 7a-c, e-f, 8 and 9a., estimated from the NSGFS campaign, 1983-2022.



Annex 1: List of participants

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Annex 2: Resolutions

This resolution was approved on the resolution Forum in June 2023

2022/2/FRSG20 The **Working Group on Widely Distributed Stocks** (WGWIDE), chaired by Erling Kåre Stenevik, Norway, will meet 23–29 August 2023 in ICES HQ, Copenhagen, Denmark to:

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

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

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

WGWIDE will report by 4 September for the attention of ACOM.

Only experts appointed by national Delegates or appointed in consultation with the national Delegates of the expert's country can attend this Expert Group

Generic ToRs for Regional and Species Working Groups

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

The working group should focus on:

a) Consider and comment on Ecosystem and Fisheries Overviews with a focus on:

   i) identifying and correcting mistakes and errors (both in the text, tables, and figures);

   ii) proposing concrete evidence-based input that is considered essential to the advice but is currently underdeveloped or missing (with references and Data Profiling Tool entries, as appropriate).

   The input will feed into the annual updates of the overviews. Delivery of contributions other than those outlined above is also welcomed but will be utilized during the revision process (around every 5 years).

b) Conduct an assessment on the stock(s) to be addressed in 2023 using the method (assessment, forecast or trends indicators) as described in the stock annex; complete and document an audit of the calculations and results; and produce a **brief** report of the work carried out regarding the stock, providing summaries of the following where relevant:

   i) Input data and examination of data quality; in the event of missing or inconsistent survey or catch information refer to the ACOM document for dealing with missing data and the linked template that formulates how deviations from the stock annex are to be reported;

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

   iii) For relevant stocks (i.e. all stocks with catches in the NEAFC Regulatory Area), estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2022;

   iv) For category 3 and 4 stocks requiring new advice in 2023, implement the methods recommended by WKLIFE X (e.g. SPiCT, rfb, chr, rb rules) to replace the former 2 over 3 advice rule (2 over 5 for elasmobranchs). MSY reference points or proxies for the category 3 and 4 stocks (ICES technical guidance for harvest control rules and stock assessments for stocks in categories 2 and 3);

   v) Evaluate spawning-stock biomass, total-stock biomass, fishing mortality, and catches (projected landings and discards) using the method described in the stock annex:

      1) For category 1 and 2 stocks, in addition to the other relevant model diagnostics, the recommendations and decision tree formulated by WKFORBIAS (see Annex 2) should be considered as guidance to determine whether an assessment remains sufficiently robust for providing advice.

      2) If the assessment is deemed no longer suitable as basis for advice, provide advice using an appropriate Category 2–5 approach as described in ICES technical guidance for harvest control rules and stock assessments for stocks in categories 2 and 3 or ICES.

      3) If the assessment has been moved to a Category 2–5 approach in the past year consider what is necessary to move back to a Category 1 and develop proposal for the appropriate benchmark process.

   vi) Catch scenarios for the year(s) beyond the terminal year of the data for the stocks for which ICES has been requested to provide advice on fishing opportunities;

   vii) Historical and analytical performance of the assessment and catch options with a succinct description of associated quality issues. For the analytical performance of category 1 and 2 age-structured assessments, report the mean Mohn's rho (assessment retrospective bias analysis) values for time-series of recruitment, spawning-stock biomass, and fishing mortality rate. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR viii) of the Generic ToRs for Regional and Species Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

c) Produce a first draft of the advice on the stocks under consideration according to ACOM guidelines.

d) Review progress on benchmark issues and processes of relevance to the Expert Group:

   i) update the benchmark issues lists for the individual stocks in SID;

   ii) review progress on benchmark issues and identify potential benchmarks to be initiated in 2024 for conclusion in 2025;

   iii) determine the prioritization score for benchmarks proposed for 2024–2025;

   iv) as necessary, document generic issues to be addressed by the Benchmark Oversight Group (BOG).

e) Prepare the data calls for the next year's update assessment and for planned data evaluation workshops.

f) Identify research needs of relevance to the work of the Expert Group.

g) Review and update information regarding operational issues and research priorities on the Fisheries Resources Steering Group SharePoint site.

h) If not completed previously, complete the audit spreadsheet 'Monitor and alert for changes in ecosystem/fisheries productivity' for the new assessments and data used for the stocks. Also note in the benchmark report how productivity, species interactions, habitat and distributional changes, including those related to climate change, could be considered in the advice.

i) Deliver conservation status advice in accordance with the Technical guidelines on conservation status advice. The advice is only to be given when conservation aspects were identified and where clear, demonstrable management action can be recommended for any non-catch anthropogenic pressure. It can also be used to highlight clear demonstrable sensitivity to climate change. The qualification required to show clear, demonstratable management action is high. Avoid generic statements that are of no specific application to management.

j) Update SAG and SID with final assessment input and output.

Information on the stocks to be considered by each Expert Group is available here.

Annex 3: Stock annex edits

Stock ID	Stock name	Update	Link
boc.27.6-8	Boarfish (*Capros aper*) in subareas 6-8 (Celtic Seas, English Channel, and Bay of Biscay)		
gur.27.3-8	Red gurnard (*Chelidonichthys cuculus*) in subareas 3-8 (Northeast Atlantic)		
her.27.1-24a514a	Herring (*Clupea harengus*) in subareas 1, 2, 5 and divisions 4.a and 14.a, Norwegian spring-spawning herring (the Northeast Atlantic and Arctic Ocean)		
hom.27.2a4a5b6a7a-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)		
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)		
mac.27.nea	Mackerel (*Scomber scombrus*) in subareas 1-8 and 14 and division 9.a (the Northeast Atlantic and adjacent waters)		
mur.27.67a-ce-k89a	Striped red mullet (*Mullus surmuletus*) in subareas 6 and 8, and divisions 7.a-c, 7.e-k, and 9.a (North Sea, Bay of Biscay, southern Celtic Seas, and Atlantic Iberian waters)		
whb.27.1-91214	Blue whiting (*Micromesistius poutassou*) in subareas 1-9, 12, and 14 (Northeast Atlantic and adjacent waters)	WGWIDE 2023	https://doi.org/10.17895/ices.pub.24218679

Annex 4: Audit reports

<u>Format for audits</u> (to be drawn up by expert groups and not review groups)

Review of ICES Scientific Report for WGWIDE meeting August 23-29th, 2023.

Reviewers: Richard Nash, Anna H. Ólafsdóttir, and Joseph Watson

Expert group Chair: Erling K. Stenevik

Secretariat representative: David Miller

Audience to write for: advice drafting group, ACOM, and next year's expert group

General
Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)

This is an update assessment with advice provided in 2023 for 2024 and 2025.

For single-stock summary sheet advice

Stock: boc.27.6-8.

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update/SPALY
2) Assessment: was accepted. Category 3 with biennial advice
3) Forecast: not presented
4) Assessment model: Bayesian state space surplus production model fitted using catch data, 6 delta-lognormal estimated IBTS survey indices, and 1 acoustic survey estimate.
5) Consistency: This updated assessment is consistent with the assessment carried out in 2021. Minor difference in IBTS survey indices in recent years compared to 2021 assessment input data, changes to DATRAS.
6) Stock status: Fishing pressure on the stock is below FMSY proxy, and the stock size index is above Itrigger.
7) Management Plan: management plan agreed in 2016. In 2023, advice based on MSY approach instead of precautionary approach as per ICES guidelines (2022; method 2.1, rfb rule) for category 3 stocks.

General comments:

- Clarify whether MSY or Precautionary and the use of the Management plan.

Technical comments:

- Advice sheet has minor errors in reference list and rounding of numbers.
- Assessment data file for length in the catch cannot be found on sharepoint, hence calculations for fproxy not checked.
- The data reported in the Advice sheet Table 8 are not in the report – this information should be in the report to allow cross validation.
- Report text reference list needs updating, many reference included which are not referred to. In text appears to be referred to wrong figure, see comments on report file.

Conclusions
(Single tables or figures can be added in the text, longer texts should be added as annexes.)

Template for audit of assessments made by EG members

Text in italics is explanatory – to be deleted from final report

Audit of Red Gurnard stock assessment

Date: 01.09.2023

Auditor: Joseph Watson and Are Salthaug

General

Assessment of this stock is not possible due to a lack of reliable catch data. Red gurnard is mainly landed as by-catch by demersal trawlers in mixed fisheries, predominantly in divisions 7d, 7e and 7h. High discard rates and lack of resolution at a species level make interpretation of spatial trends in catches in other areas problematic.

Landings by country and divisions are available from 2006 to 2022 and discard data has been provided for 2015 – 2022. Information on red gurnard abundance is available from 6 surveys. A combined biomass index built on the time series from these using a delta-lognormal model.

For single stock summary sheet advice:

1) **Assessment type:** delta-lognormal assessment (from WKWEST)
2) **Assessment**: trend analyses
3) **Forecast**: not presented
4) **Assessment model**: surveys indices combined using a delta-lognormal model in an index of biomass to evaluate stock trend
5) **Data issues:** general lack of catch data reported at species level
6) **Consistency:** undefined
7) **Stock status**: undefined.
8) **Management Plan**: there is no management plan.

General comments

The section of red gurnard is well structured and documented. The section includes a description regarding the lack of reporting data at species level and also the method used on the computation of a biomass index for this stock.

Technical comments

Conclusions

The combined biomass index appears to be correctly computed. There is no assessment for this stock.

Template for audit of assessments made by EG members

Text in italics is explanatory – to be deleted from final report

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?

Audit of Western Horse Mackerel data and assessment

Date: 03/09/2023
Auditor: Leif Nøttestad, Sólvá Káradóttir Eliasen, Steve Mackinson

General

Western horse mackerel is assessed as a Category 1 stock. A Stock Synthesis (SS3) model is run to determine the state of the stock in relation to reference points for western horse mackerel.

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment**: analytical.
3) **Forecast**: presented
4) **Assessment model**: SS3 model with commercial catches (length and age data) and three survey indices: Triennial egg survey index (1992–2019); IBTS recruitment index; PELACUS acoustic biomass.
5) **Data issues:** No data issues.
6) **Consistency**: The view of the WG was that the assessment should be accepted.
7) **Stock status**: Fishing pressure on the stock is above F_{MSY} but below F_{pa} and F_{lim}; spawning-stock size is below MSY $B_{trigger}$, B_{pa} and B_{lim}.
8) **Management Plan**: No management plan

General comments

The assessment and forecast have been available for review. Input and output data were correct.

Technical comments

There are four tables in the tables section to which there, in the text section, are no references (Tables 7.2.4.3 – 7.2.4.6).

Advice, Table 8, "Total western stock" column is not identical to what is in the input sheets and not identical to what is shown in advice sheet, Figure 1, "SSB panel".

With regards to the WGWIDE report: It's difficult to make audit when the report is still not finished and the audit quality is not as what it would have been if the text was finished.

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, but it needs to be updated
- 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, no management plan
- 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, but partly No. A zero catch advice on WHOM for 2024, as done for the first time for 2023, raises some fundamental questions and practical concerns that need to be solved. In the advice sheet for 2024 there are three new important issues raised this year, which was not included in last years advice sheet for WHOM:

  1) A comprehensive genetic research project on stock identification of horse mackerel has being carried out, and initial results suggest that the boundaries of the stocks require revision.
  2) A scientific monitoring quota should be considered to support the stock assessment and the advice in future years.
  3) Mixed fisheries considerations might be relevant due to horse mackerel being taken as by-catch in some areas.

The first issue influence the quality of the assessment, and the other two are issues relevant for the advice. All these issues need to be dealt with quantitatively during the upcoming benchmark of WHOM in 2024. A sentence stating that this will be dealt with during the benchmark in 2024, will be useful to add to the advice sheet at the end of section issues relevant for the advice.

Template for audit of assessments made by EG members

Audit of North Seas Horse mackerel stock (hom.27.3a4bc7d)

Date: 29/08/2023 – 04/09/2023

Auditor: Aril Slotte, Eydna í Homrum

General

Biannual advice for 2024 and 2025

For single stock summary sheet advice:

Stock: North Sea Horse mackerel

Assessment type: SALY – Survey trends based assessment
Assessment: Survey index and length-based analysis with F/Fmsy proxy, rfb-rule approach
Forecast: There is no forecast in the applied DLS approach
Assessment model:
Consistency:
Stock status: no reference points for stock size have been defined for this stock.
Management plan: There is no management plan for horse mackerel in this area. Advice basis is MSY-approach.

General comments

The text is well written and gives the reader a good overview of the stock, input data and methodology behind assessment and advice. The recent development in genetics suggest that all horse mackerel caught in 4a belong to the Western stock, with additional mixture between Western and North sea in 7d, which likely bias this stock assessment significantly. This is issue is, however, well presented in the report and will also have focus the upcoming benchmark.

For a general reader, given the suspected mixtures, some comparisons on the biology between Western and North Sea stocks would have been interesting, such as weight and length at age, length/age at maturity, to better grasp the differences in life history strategies.

I find chapter 6.3 the Biology chapter to be lacking valuable information. It is difficult dot understand that a stock that has been monitored over so many years have no information on maturity ogives, maturation at age/length. It is also strange that the Western stock has old fish that are almost absent in the North Sea stock. In a biological sense this is hard to grasp, and it is not described or discussed anywhere in the text. Is this linked to sampling, aging, high exploitation, high natural mortality, or simply uncertainties in stock structure, annual migrations etc??

PS! I noticed in tables 6.3.3-4, that the weight/length at ages 7-9 in 4a were significantly larger than in all the other ICES areas, so much that it potentially may be errors, which can be looked further into.

Technical comments

Advised catch value matches catch scenarios
Advice years are 2024 and 2025 – correct
Units in plots are same as 2021-advice. Titles are correct/meaningful. Legends are correct/meaningful and caption is descriptive (however, $I_{trigger}$ is not described in caption …).
Values in plots match summary table in end of advice.

Template for audit of assessments made by EG members

Catch and SSB are given in tonnes. A short advice change description is given with catch scenarios.
Basis of advice (MSY-approach with proxy MSY reference point) is described consistently throughout the advice sheet.
Basis of assessment is last benchmarked in 2017 – this is consistent in text and tables. DLS-approach has, however, changed and ICES advice is now based on MSY-approach as opposed to Precautionary approach in last advice (2021).
History of advice is consistent with last year's advice and advice for 2024 matches headline advice.

The references for ICES framework for category 3 stocks appear to be missing in the reference list …

(From quality of the assessment: 'The advice framework changed from the previous ICES framework for category 3 stocks (ICES, 2012), to the new framework- for DLS using the rfb rule; method 2.1 (ICES, 2022).')

Conclusions
No inconsistency was seen, with exception of what is mentioned above in Tables 6.3.3-4 and the reference list.

Template for audit of assessments made by EG members

1 Audit of the NEA Mackerel assessment (mac.27.nea)

Date: 01/09/2023
Auditor: Patricia, Jan Arge, Niels

General

The mackerel assessment is carried out using the SAM model and runs locally at the machine of the stock assessor but is uploaded to the sharepoint under Data. This audit focuses on input data, assessment, forecast and draft advice document.

ICES no longer consider the NEA mackerel stock to consist of three spawning components, i.e. the western, the southern, and the North Sea components, as in previous assessments (see section 8.11 Management Considerations). This has led to removal of all reference to components in the report and advice sheet.

For single stock summary sheet advice:

1) **Assessment type: updated/SALY**
2) **Assessment**: analytical
3) **Forecast**: presented; derived directly from the outputs of the SAM model. Appropriate settings according to Stock Annex.
4) **Assessment model**: SAM with 3 survey fleet and tagging data
5) **Data issues:** Russian data was made available through Norway, no further data issues
6) **Consistency**: The retrospective bias (10 years considered), where the F has consistently been overestimated and SSB underestimated, is still present in older years but has become less apparent in recent years. The reason to this behaviour is only partly understood. The model shows an upward revision of the stock due to the addition of new tagging data
7) **Stock status**: Above biomass trigger and above Fmsy
8) **Management Plan**: none agreed. ICES based its advice on the MSY approach.

Commented [JanArge1]: We discussed the systematic upward revision of the stock with every successive assessment at WGWIDE, but were not able to explain this behaviour satisfactorily. We have e.g. underestimated the SSB by almost one third back in 2014 in relation to today (see my suggested text above.
-Thus I wonder if the added tagging data have caused this retrospective behaviour the last 10 or so years? Or have I misunderstood this statement?

General comments

The assessment is performed in line with the stock annex; there were some minor issues with input data on the egg survey data which were resolved during the working group. The stock would benefit from moving to TAF and sourcing more directly its input data from established/referenced sources. At this stage, tracing back the input data for the auditors was difficult and relied completely on the provision of data from the stock assessor. In this situation, the auditors could only check if the assessor entered the provided data into the assessment correctly, but not if the source of the data up to the input data was consistent.

The report is very detailed and very well written, allowing a comprehensive understanding of the particularities of the input data used and on the model configurations. The advice sheet is well documented.

Technical comments

Explorations on alternative model settings by scientists other than the stock assessor were performed during the WG but the process was rather untransparent and adding these analyses to the report (not available yet) may not be appropriate.

Conclusions

The assessment was carried out in line with the SA and catch and survey data was in line with the data used in the assessment.

Template for audit of assessments made by EG members

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? There is no active agreed management plan by the coastal states and unilateral quota setting exceeding the ICES advice has been the case for the past decade.
- 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

Format for audits

Review of ICES Scientific Report, (*WGWIDE*) *(2023)* (*30/08/2023*)

Reviewers: Iosu Paradinas and Åge Høines

Expert group Chair:

Secretariat representative:

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

Stock: **Striped red mullet in Subareas and Divisions 6, 7a–c, e–k, 8, and 9a**

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update
2) Assessment: no assessment due to sparsity and uncertainty in historical data
3) Forecast: not presented
4) Assessment model: none
5) Consistency: undefined
6) Stock status: undefined
7) Management plan: there is no agreed management plan

General comments
Figure 1 still missing.

Technical comments

Conclusions

Template for audit of assessments made by EG members

1 Audit of the Norwegian Spring spawning herring (her.27.1-24a514a)

Date: 29 August 2023
Auditor: Alessandro Orio, Richard Nash, Claus R. Sparrevohn

General

Norwegian Spring Spawning Herring is assessed as a Category 1 stock. A XSAM model is run to determine the state of the stock in relation to reference points for Norwegian Spring Spawning Herring.

For single stock summary sheet advice:

1) **Assessment type: update/SPALY**
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: XSAM with 3 survey fleets. The recruitment survey was not undertaken in 2021 nor 2022.
5) **Data issues:** No data issues.
6) **Consistency**: The assessment is consistent with last year and the decrease in biomass was also predicted in 2022 although it was a little more pronounced in the 2023 assessment.
7) **Stock status**: Fishing pressure on the stock is above F_{MSY} and F_{pa} but below F_{lim}. The stock is above MSY $B_{trigger}$ in 2023 but is predicted to fall below MSY $B_{trigger}$ in 2024 (1st of January).
8) **Management Plan**: There is an agreed management plan which has been evaluated by ICES and found precautionary.

General comments

The assessment and forecast were available for review. However, the assessment is a XSAM model which at present only can run on one designated MAC computer. Therefore, it is, at present, not possible to re-run the assessment and the forecast but just check input and configuration. A SAM version of the assessment (with the same settings and properties as the XSAM) is developed and shows – except for some very minor details – the same result. The same is the case for the forecast. Therefore, the EG highly recommended moving from using XSAM to the SAM platform to avoid the reliance on using software which is not maintained through the ongoing R updates and to increase reproducibility and transparency. Input and output data were correct. The report was also available for the audit. A few inconsistencies were found in the advice sheet and report and are outlined in the technical comments.

Technical comments

Advice sheet:

- Suggest changing the formulation "Fishing pressure on the stock is above F_{MSY} and between F_{pa} and F_{lim}" to "Fishing pressure on the stock is above F_{MSY} and F_{pa} but below F_{lim}".
- In table 6 year 2024 it says "Follow the management strategy, F_{mgt} = 0.123 and B_{mgt} = 3.184 million tonnes". F_{mgt} should be changed to 0,124 as the F_{mgt} according to the LTMP is 0,123614.
- *Some comments added into the advice sheet by Coby – suggested responses given.*

Report:

Commented [AO1]: The sentence in the advice sheet is the standard sentence that is in the ICES guidelines so I don't think we can change it.

Commented [RN(2]: This can be deleted after checking the advice sheet.

Template for audit of assessments made by EG members

- The order of the Figures in chapter 4.5.1 is not following the order in which they are presented in the text. This is only minor but could be easily fixed.

Conclusions

The assessment has been performed correctly.

Template for audit of assessments made by EG members

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. The F_{mgt} is below F_{MSY} and the HCR different.**
- 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? **Yes**

Template for audit of assessments made by EG members

1 Audit of the Blue whiting assessment (whb.27.1-91214)

Date: 31/08/2023

Auditor: Afra Egan, Gersom Costas, Sigurvin Bjarnason

General

The blue whiting assessment is carried out using the SAM model and is available on Stockassessment.org (WHB-2023) and on SharePoint. This audit focuses on input data, assessment, forecast and draft advice document.

For single stock summary sheet advice:

1) **Assessment type:** update/SALY
2) **Assessment**: analytical
3) **Forecast**: presented; derived directly from the outputs of the SAM model. Appropriate settings according to Stock Annex.
4) **Assessment model**: SAM with 1 survey index
5) **Data issues:** The final data for 2022 are presented in the report. Data for 2023 are preliminary but are included in the model. Data sources are described in the stock annex.
6) **Consistency**: The assessment is consistent with last years with an upward trend in SSB. There is a revision upward in recruitment at age 1 in 2022 due to a high survey index value and high catch at age of the 2021 year class. The WG accepted the assessment.
7) **Stock status**: The fishing pressure on the stock is above F_{MSY}, F_{MGT} and Fpa (but below F_{lim}). Spawning-stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}.
8) **Management Plan**: Agreed by the Coastal States in October 2016 after evaluation of the management strategy by ICES. The long-term management strategy was found to be consistent with the precautionary approach. According to the strategy F is set at F_{MSY} when SSB is forecast to be above or equal to $B_{trigger}$, which is the case for 2024.

General comments

The input data and assessment are documented as described in the stock annex and the report sections are well ordered.

Technical comments

In The stock annex Fpa is 0.53. This should be updated to 0.32 as per the advice sheet. The technical basis should be updated also.

Conclusions

The assessment has been performed correctly.

Template for audit of assessments made by EG members

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 (in some cases the SA will need minor updates) 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

Annex 5: Working documents

Working Document to

ICES Working Group on Widely Distributed Stocks (WGWIDE, No. 1)
ICES HQ, Copenhagen, Denmark, (hybrid meeting) 23. – 29. August 2023

Preliminary cruise report from the International Ecosystem Summer Survey in the Nordic Seas (IESSNS) 1st July – 3rd August 2023

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Contents

1 Executive summary

The International Ecosystem Summer Survey in the Nordic Seas (IESSNS) was performed within approximately 5 weeks from July 1st to August 3rd in 2023 using five vessels from Norway (2), Iceland (1), Faroe Islands (1) and Denmark (1). The main objective is to provide annual age-segregated abundance index, with an uncertainty estimate, for northeast Atlantic mackerel (*Scomber scombrus*). The index is used as a tuning series in stock assessment according to conclusions from the 2017 and 2019 ICES mackerel benchmarks. A standardised pelagic swept area trawl method is used to obtain the abundance index and to study the spatial distribution of mackerel in relation to other abundant pelagic fish stocks and to environmental factors in the Nordic Seas, as has been done annually since 2010. Another aim is to construct a new time series for blue whiting (*Micromesistius poutassou*) abundance index and for Norwegian spring-spawning herring (NSSH) (*Clupea harengus*) abundance index. This is obtained by utilizing standardized acoustic methods to estimate their abundance in combination with biological trawling on acoustic registrations. The time series for blue whiting and NSSH now consists of eight years (2016-2023).

The total swept-area mackerel index in 2023 was 4.30 million tonnes in biomass and 10.67 billion in numbers, a decline by 42% for biomass and 39% for abundance compared to 2022. In 2023, the most abundant year classes were 2020, 2019, respectively. The cohort internal consistency improved compared to last year, particularly for ages 4-7 years. The catch curves showed clear year effects, and that mackerel of ages 1, 2 and to some extent also age 3, are not completely recruited to the survey. Most of the surveyed mackerel are still distributed in the Norwegian Sea. However, they were more easterly and northeasterly distributed compared to 2022. The distribution of mackerel in the Norwegian Sea retracted compared to the last decade, particularly withdrawal from the northernmost part was observed. The zero-line was reached for the whole survey area, north of latitude 60°N.

Other fish species were also monitored such as lumpfish (*Cyclopterus lumpus*), capelin (*Mallotus villosus*), polar cod (*Boreogadus saida*), and Atlantic salmon (*Salmo salar*). Lumpfish were caught at 76% of surface trawl stations distributed across the surveyed area from southwestern part of Iceland, central part of North Sea to southwestern-western part of the Svalbard. Both size and abundance were greater north of latitude 72°N compared to southern areas. Capelin were caught in the surface trawl on 29 stations along the cold fronts: north of Iceland, north- and northwest of Jan Mayen, northwest of Bear Island and west of Svalbard. There were more trawl stations with catches of capelin in the west and north of Jan Mayen than previous years The polar cod were caught in larger areas in the north and northeast of Iceland compared to the time-series. A total of 62 North Atlantic salmon were caught in 24 stations both in coastal and offshore areas from 62°N to 74°N in the upper 30 m of the water column. The salmon ranged from 0.084 kg to 2.7 kg in weight, dominated by post-smolt and 1 sea-winter individuals. We caught from 1 to 12 salmon during individual surface trawl hauls. The length of the salmon ranged from 21 cm to 82 cm, with the highest fraction between 21 cm and 29 cm.

Satellite measurements of sea surface temperature (SST) in the Northeast Atlantic in July 2023 show that the northern regions of the Nordic Seas were slightly warmer than the average, while the East Greenland Current was cooler than the long-term average. The SST in the Irminger Sea and Iceland Basin were slightly warmer than the average.

The average zooplankton biomass increased in the Norwegian Sea and in Icelandic waters compared to 2022. Zooplankton showed patchy distribution throughout the area.

In the present preliminary report, no results of herring and blue whiting measurements are presented. A final survey report including these two species will be published in the fall of 2023.

2 Introduction

During approximately five weeks of survey in 2023 (1st of July to 3rd of August), five vessels; the M/V "Eros" and M/V "Vendla" from Norway, "Jákup Sverri" operating from Faroe Islands, the R/V "Árni Friðriksson" from Iceland and M/V "Ceton", operating in the North Sea by Danish scientists, participated in the International Ecosystem Summer Survey in the Nordic Seas (IESSNS).

The major aim of the coordinated IESSNS was to collect data on abundance, distribution, migration, and ecology of Northeast Atlantic (NEA) mackerel (*Scomber scombrus*) during its summer feeding migration phase in the Nordic Seas and surrounding coastal and offshore waters. The resulting abundance index will be used in the stock assessment of NEA mackerel at the annual meeting of ICES working group of widely distributed stocks (WGWIDE). The IESSNS mackerel index time series goes back to 2010. Since 2016, systematic acoustic abundance estimation of both Norwegian spring-spawning herring (*Clupea harengus*) and blue whiting (*Micromesistius poutassou*) have also been conducted. This is considered as potential input for stock assessment since the time series are sufficiently long. Furthermore, the IESSNS is a pelagic ecosystem survey collecting data on physical oceanography, plankton, and other fish species such as lumpfish, polar cod, and Atlantic salmon. Opportunistic whale observations were also recorded from Norway and Faroe Islands. The wide geographical coverage, standardization of methods, sampling on many trophic levels and international cooperation around this survey facilitates research on the pelagic ecosystem in the Nordic Seas, see e.g. Nøttestad et al. (2016), Jansen et al. (2016), Bachiller et al. (2018), Olafsdottir et al. (2019), Nikolioudakis et al. (2019), dos Santos Schmidt et al. (2023).

The methods have evolved over time since the survey was initiated by Norway in the Norwegian Sea in the beginning of the 1990s. The main elements of international standardization were conducted in 2010. Smaller improvements have been implemented since 2010. Faroe Islands and Iceland have participated in the joint mackerel-ecosystem survey since 2009. Greenland since 2013 and Denmark from 2018. Greenland did not participate in 2021 and 2023 but participated with their new research vessel R/V "Tarajoq" in 2022.

The North Sea was included in the survey area for the sixth time in 2023, following the recommendations of WGWIDE. This was done by scientists from DTU Aqua, Denmark. The commercial fishing vessels "Ceton S205" was used. No problems applying the IESSNS methods were encountered. Area coverage, however, was restricted to the northern part of the North Sea at water depths deeper than 50 m (see Appendix 1 for comparison with the 2018 - 2023 results).

3 Material and methods

Coordination of the IESSNS 2023 was done during the WGIPS 2023 virtual meeting in January 2023, and by correspondence in December 2022 and during spring and summer 2023. The participating vessels together with their effective survey periods are listed in Table 1.

Overall, the weather conditions were calmer and less windy than usual for the two Norwegian vessels during the entire survey, thus providing very good survey progress as well as favourable conditions for the acoustic recordings and pelagic trawling. The Icelandic vessel, operating in Icelandic waters, experienced in general calm weather for duration of the survey with no survey delay, however three WP2-net sampling were skipped due to high winds. For the Faroese vessel, the survey was not hampered by weather; however technical issues with the trawl (a repair on land was needed) reduced the survey time with approximately two days in addition to skipped trawl stations in southwestern survey area. The chartered vessel Ceton had good weather conditions throughout the survey.

During the IESSNS, the special designed pelagic trawl, Multpelt 832, has been applied by all participating vessels since 2012. This trawl is a product of cooperation between participating institutes in designing and constructing a standardized sampling trawl for the IESSNS. The work was led by trawl gear scientist John Willy Valdemarsen, Institute of Marine Research (IMR), Bergen, Norway (Valdemarsen et al. 2014). The design of the trawl was finalized during meetings of fishing gear experts and skippers at meetings in

January and May 2011. Further discussions on modifications in standardization between the rigging and operation of Multpelt 832 was done during a trawl expert meeting in Copenhagen 17-18 August 2012, in parallel with the post-cruise meeting for the joint ecosystem survey, and then at the WKNAMMM workshop and tank experiments on a prototype (1:32) of the Multpelt 832 pelagic trawl, conducted as a sequence of trials in Hirtshals, Denmark from 26 to 28 February 2013 (ICES 2013a). The swept area methodology was presented and discussed during the WGISDAA workshop in Dublin, Ireland in May 2013 (ICES 2013b). The standardization and quantification of catchability from the Multpelt 832 pelagic trawl was further discussed during the mackerel benchmark in Copenhagen in February 2014. Recommendations and requests coming out of the mackerel benchmark in February 2014, were considered and implemented during the IESSNS survey in July-August 2014 and in the surveys thereafter. Furthermore, recommendations and requests resulting from the mackerel benchmark in January-February 2017 (ICES 2017), were carefully considered and implemented during the IESSNS survey in July-August 2017. In 2018, the Faroese and Icelandic vessels employed new, redesigned cod-ends with the capacity to hold 50 tonnes. This was done to avoid the cod-end from bursting during hauling of large catches as occurred at three stations in the 2017 IESSNS.

Table 1. Survey effort by each of the five vessels during the IESSNS 2023. The number of predetermined ("fixed") trawl stations being part of the swept-area stations for mackerel in the IESSNS are shown after the total number of trawl stations.

Vessel	Effective survey period	Length of cruise track (nmi)	Total trawl stations/ Fixed stations	CTD stations	Plankton stations
Árni Friðriksson	3-21/7	3250	43/38	38	35
Jákup Sverri	1-16/7	2825	31/27	27	27
Ceton	4-13/7	1987	36/39	36	-
Vendla	4/7-3/8	4077	66/57	57	57
Eros	4/7-3/8	3349	64/57	57	57
Total	1/7-3/8	15488	240/218	215	176

3.1 Hydrography and Zooplankton

The hydrographical and plankton stations by all vessels combined are shown in Figure 1. Eros, Vendla, Árni Friðriksson and Jákup Sverri were all equipped with a SEABIRD CTD sensor and Árni Friðriksson and Jákup Sverri moreover also had a water rosette. Ceton used a Seabird SeaCat offline CTD. The CTD-sensors were used for recording temperature, salinity, and pressure (depth) from the surface down to 500 m, or to the bottom when at shallower depths.

Zooplankton was sampled with a WP2-net on 4 vessels, excluding Ceton which operates in the North Sea. Mesh sizes were 180 µm (Eros and Vendla) and 200 µm (Árni Friðriksson and Jákup Sverri). The net was hauled vertically from a depth of 200 m (or bottom depth at shallower stations) to the surface at a speed of 0.5 m/s. All samples were split in two, one half preserved for species identification and enumeration, and the other half dried and weighed. The zooplankton was sorted into three size categories (µm), > 2000, 1000–2000, 180/200–1000, on the Norwegian and Faroese vessels; and two size fractions (µm), > 1000 and 200–1000, on the Icelandic vessel. Detailed description of the zooplankton and CTD sampling is provided in the survey manual (ICES 2014a).

Three planned WP2-plankton samples were not taken due to bad weather. The number of stations taken by the different vessels is provided in Table 1.

3.2 Trawl sampling

All vessels used the standardized Multpelt 832 pelagic trawl (ICES 2013a; Valdemarsen et al. 2014; Nøttestad et al. 2016) for trawling, both for fixed surface stations and for trawling at greater depths to confirm acoustic registrations and to target blue whiting registrations identified by echograms. Standardization of trawl deployment was emphasised during the survey as in previous years (ICES 2013a; ICES 2014b; ICES 2017). Sensors on the trawl doors, headrope and ground rope of the Multpelt 832 trawl recorded data, and allowed live monitoring, of effective trawl width (actually door spread) and trawl depth. The properties of the Multpelt 832 trawl and rigging on each vessel is reported in Table 2.

Trawl catch was sorted to the highest taxonomical level possible, usually to species for fish, and total weight per species recorded. The processing of trawl catch varied between nations. The Norwegian vessels sorted the whole catch to species but the Faroese vessel sub-sampled the catch before sorting if catches were more than 500 kg. Sub-sample size ranged from 90 kg (if it was clean catch of either herring or mackerel) to 200 kg (if it was a mixture of herring and mackerel); however, other species were mostly sorted out of the full catch. On the Icelandic vessel, the whole catch was sorted to species for all species except mackerel and herring when the catch is large (> 1000 kg) and mostly a mix of the two before mentioned species. Then approximately 10% of the mixed herring and mackerel catch is sorted to species.

The biological sampling protocol for trawl catch varied between nations in number of specimens sampled per station (Table 3).

Results from the survey expansion southward into the North Sea are analyzed separately from the traditional survey grounds north of latitude 60°N as per stipulations from the 2017 mackerel benchmark meeting (ICES 2017). However, data collected with the IESSNS methodology from the Skagerrak and the northern and western part of the North Sea are now available for six years (2018-2023).

Table 2. Trawl settings and operation details during the international mackerel survey in the Nordic Seas from 1st July to 3rd August 2023. The column for influence indicates observed differences between vessels likely to influence performance. Influence is categorized as 0 (no influence) and + (some influence).

Properties	**Árni Friðriksson**	**Vendla**	**Ceton**	**Jákup Sverri**	**Eros**	**Influence**
Trawl producer	Ísfell new trawl in 2023	Egersund Trawl AS	Egersund Trawl AS	Vónin (2018)	Egersund Trawl AS	0
Warp in front of doors	Dynex-34 mm	Dynex -34 mm	Dynex	Dynex – 38 mm	Dynex-34 mm	+
Warp length during towing	350	350	270-320	350 (350-360)	350	0
Difference in warp length port/starb. (m)	16	2-10	10	0-10	5-10	0
Weight at the lower wing ends (kg)	2×400 kg	2×400	2×400	2×400	2×400	0
Setback (m)	14	6	6	6	6	+
Type of trawl door	Jupiter	Seaflex 7.5 m^2 adjustable hatches	Thybron type 15	Twister	Seaflex 7.5 m^2 adjustable hatches	0
Weight of trawl door (kg)	2200	1700	1970	1650	1700	+
Area trawl door (m^2)	6	7.5 with 25% hatches (effective 6.5)	7	4.5	7 with 50% hatches (effective 6.5)	+
Towing speed (knots) mean (min-max)	5.1 (4.6-5.6)	4.6 (4.1-5.5)	5.1 (4.5-5.8)	4.7 (4-5.4)	4.7 (4.1-5.725)	+

Trawl height (m) mean (min-max)	31 (23-37)	25-32	30 (24-38)	32.1 (25–51)	25-32	+
Door distance (m) mean (min-max)	107 (110 - 130)	121.8 (118-126)	125 (118-133)	114 (102-122)	135 (113-140)	+
Trawl width (m)*	68.4	63.8	69.7	64.1	67.5	+
Turn radius (degrees)	5-10	5-12 SB turn	5-10	5 BB/SB turn	5-8 SB turn	+
Fish lock front of cod-end	Yes	Yes	Yes	Yes	Yes	+
Trawl door depth (port, starboard, m) (min-max)	7-25, 7-21	6-22, 8-23	6-26, 6-26	5-17, 5-17	6-18, 8-20	+
Headline depth (m)	0	0	0	0	0	+
Float arrangements on the headline	Kite + 1 buoy on each wingtip	Kite with fender buoy +2 buoys on each wingtip	Kite with fender buoy + 2 buoys on each wingtip	Kite with + 1 buoys and kite on each wingtip	Kite + 2 buoy on each wingtips	+
Weighing of catch	All weighed	All weighted	All weighed	All weighed	All weighted	+

* calculated from door distance (Table 6)

Table 3. Protocol of biological sampling during the IESSNS 2023. Numbers denote the maximum number of individuals sampled for each species for the different determinations.

	Species	Faroes	Iceland	Norway	Denmark
Length measurements	Mackerel	200/100*	150	100	≥ 125
	Herring	200/100*	200	100	75
	Blue whiting	200/100*	100	100	75
	Lumpfish	all	all	all	all
	Salmon	All (1)	all	all	-
	Capelin	-	50	25-30	
	Other fish sp.	20-50	50	25	As appropriate
Weight, sex and maturity determination	Mackerel	15-25	50	25	***
	Herring	25-50	50	25	0
	Blue whiting	15-50	50	25	0
	Lumpfish	0-6	1^	25	0
	Salmon	All	0	25	0
	Capelin	-	50		
	Other fish sp.	0-20	0	0	0
Otoliths/scales collected	Mackerel	15-25	25	25	***
	Herring	25-50	25	25	0
	Blue whiting	15-50	50	25	0
	Lumpfish	0	1^	0	0
	Salmon	-	0	0	0
	Capelin		50		
	Other fish sp.	0	0	0	0
Fat content	Mackerel	0	10	0	0
	Herring	0	10**	0	0
	Blue whiting	0	10	0	0
Stomach sampling	Mackerel	5	10	10	0
	Herring	5	10**	10	0
	Blue whiting	5	10	10	0
	Other fish sp.	0	0	10	0
Tissue for genotyping	Mackerel	0	0	0	0
	Herring	0	0	25	0

*Length measurements / weighed individuals
**Sampled at every third station
*** Up to one fish per cm-group < 25 cm, two fish 25 – 30 cm and three fish > 30 cm from each station was weighed and aged.
^All live lumpfish were tagged and released, only otoliths taken from fish which were dead when brought aboard.

This year's survey was quite well synchronized in time and was conducted over a relatively short period (33 days) given the large spatial coverage of around 2.4 million km² (Figure 1). This was in line with recommendations put forward in 2016, that the survey period should be around four weeks with mid-point around 20th of July. The main argument for this time-period was to make the IESSNS survey as synoptic as possible in space and time, and at the same time be able to finalize data and report for inclusion in the assessment for the same year.

Underwater camera observations during trawling

M/V "Eros" and M/V "Vendla" employed an underwater video camera (GoPro HD Hero 5 Black Edition, www.gopro.com) to observe mackerel aggregation, swimming behaviour and possible escapement from the cod end and through meshes. The camera was put in a waterproof box which tolerated pressure down to approximately 100 m depth. No light source was employed with cameras; hence, recordings were limited to day light hours. Some recordings were also taken during night-time when there was midnight sun and good underwater visibility. Video recordings were collected at 74 trawl stations. The camera was attached on the trawl in the transition between 200 mm and 400 mm meshes.

3.3 Marine mammals

Opportunistic observations of marine mammals were conducted by scientific personnel and crew members from the bridge between 4th July and 2nd August 2023 onboard M/V "Eros" and M/V "Vendla", and onboard Jákup Sverri (30th of June – 17th of July) opportunistic observations were done from the bridge by crew members.

3.4 Lumpfish tagging

Lumpfish caught during the survey by vessels R/V "Árni Friðriksson", M/V "Eros", M/V "Vendla" were tagged with Peterson disc tags and released. When the catch was brought aboard, any lumpfish caught were transferred to a tank with flow-through sea water. After the catch of other species had been processed, all live lumpfish larger than ~15-20 cm were tagged. The tags consisted of a plastic disc secured with a titanium pin which was inserted through the rear of the dorsal hump. Contact details of Biopol (www.biopol.is) were printed on the tag. The fish were returned to the tank until all fish were tagged. The fish were then released, and the time of release was noted which was used to determine the latitude and longitude of the release location.

3.5 Acoustics

Multifrequency echosounder

The acoustic equipment onboard Vendla and Eros were calibrated 3rd July 2023 for 18, 38, 70, 120 and 200 kHz. Árni Friðriksson was calibrated 4th of May 2023 for frequencies 18, 38, 70, 120 and 200 kHz. Jákup Sverri was calibrated on 23rd March 2023 for 18, 38, 120, 200 and 333 kHz. Ceton did not conduct any acoustic data collection because no calibrated equipment was available, and acoustics are done in the same area and period of the year during the ICES coordinated North Sea herring acoustic survey (HERAS). All the other vessels used standard hydro-acoustic calibration procedure for each operating frequency (Foote 1987). CTD measurements were taken in order to get the correct sound velocity as input to the echosounder calibration settings.

Acoustic recordings were scrutinized to herring and blue whiting on daily basis using the post-processing software (LSSS, see Table 4 for details of the acoustic settings by vessel). Species were identified and partitioned using catch information, characteristic of the recordings, and frequency between integration on 38 kHz and on other frequencies by a scientist experienced in viewing echograms.

To estimate the abundance from the allocated NASC-values the following target strengths (TS) relationships were used.

Blue whiting: TS = 20 log(L) – 65.2 dB (rev. acc. ICES CM 2012/SSGESST:01)
Herring: TS = 20 log(L) – 71.9 dB (Foote, 1987)

Table 4. Acoustic instruments and settings for the primary frequency (38 kHz) during IESSNS 2023.

	R/V Árni Friðriksson	M/V Vendla	R/V Jákup Sverri	M/V Eros
Echo sounder	Simrad EK80	Simrad EK60	Simrad EK80	Simrad EK80
Frequency (kHz)	18, 38, 70, 120, 200	18, 38, 70, 120, 200	18, **38**, 70, 120, 200, 333	18, 38, 70, 120, 200, 333
Primary transducer	ES38-7	ES38B	ES38-7	ES38B
Transducer installation	Drop keel	Drop keel	Drop keel	Drop keel
Transducer depth (m)	9.6	8	6-9	6
Upper integration limit (m)	15	15	12	15
Absorption coeff. (dB/km)	9.8	9.9	10.3	9.3
Pulse length (ms)	1.024	1.024	1.024	1.024
Band width (kHz)	2.425	2.43	3.06	2.43
Transmitter power (W)	2000	2000	2000	2000
Angle sensitivity (dB)	18	21.90	21.9	21.9
2-way beam angle (dB)	-20.30	-20.70	-20.4	-20.7
TS Transducer gain (dB)	27.02	25.22	26.94	25.22
s_A correction (dB)	0.02	-0.73	-0.13	-0.72
3 dB beam width alongship:	6.43	6.88	6.47	6.85
3 dB beam width athw. ship:	6.43	6.76	6.54	6.79
Maximum range (m)	500	500	500	500
Post processing software	LSSS v.2.14.1	LSSS 2.12.0	LSSS 2.14.1	LSSS 2.12.0

M/V Ceton: No acoustic data collection because other survey in the same area in June/July (HERAS).

Multibeam sonar

Both M/V Eros and M/V Vendla were equipped with the Simrad fisheries sonar. Medium frequency CS90 sonar (frequency range: 70-90 kHz) on M/V Eros and low frequency ST90 sonar (frequency range: 14-24 kHz) on M/V Vendla with a scientific output incorporated which allow the storing of the beam data for post-processing. Acoustic multibeam sonar data was stored continuously onboard Eros and Vendla for the entire survey.

Cruise tracks

The five participating vessels followed predetermined survey lines with predetermined surface trawl stations (Figure 1). Calculations of the mackerel index are based on swept area approach with the survey area split into 10 strata, of which 6 are permanent (1, 2, 3, 7, 10 and 13) and four dynamic (4, 5, 6 and 9) (Figure 2). Distance between predetermined surface trawl stations is constant within stratum but variable between strata and ranged from 40 to 70 nmi. The survey design using different strata is done to allow the calculation of abundance indices with uncertainty estimates, both overall and from each stratum in the software program StoX (see Salthaug et al. 2017). Temporal survey progression by vessel along the cruise tracks in July-August 2023 is shown in Figure 3. The cruising speed was between 10-11 knots if the weather permitted, otherwise the cruising speed was adapted to the weather situation.

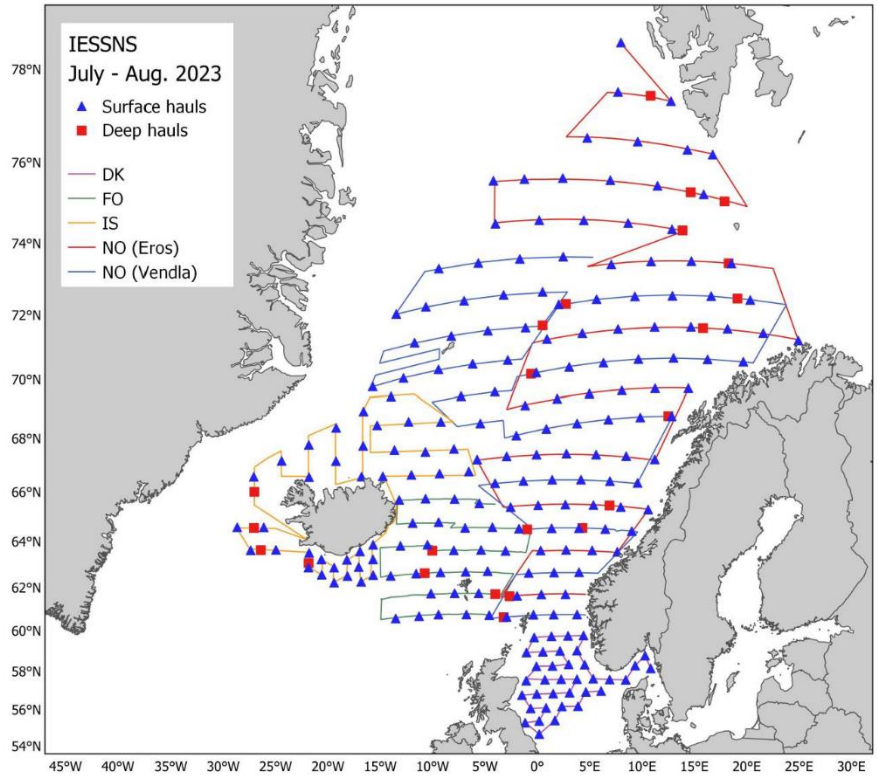


Figure 1 a. Fixed predetermined trawl stations and additional deep hauls included in the IESSNS from July 1st to August 3rd 2023. At each station a 30 min surface trawl haul was performed.

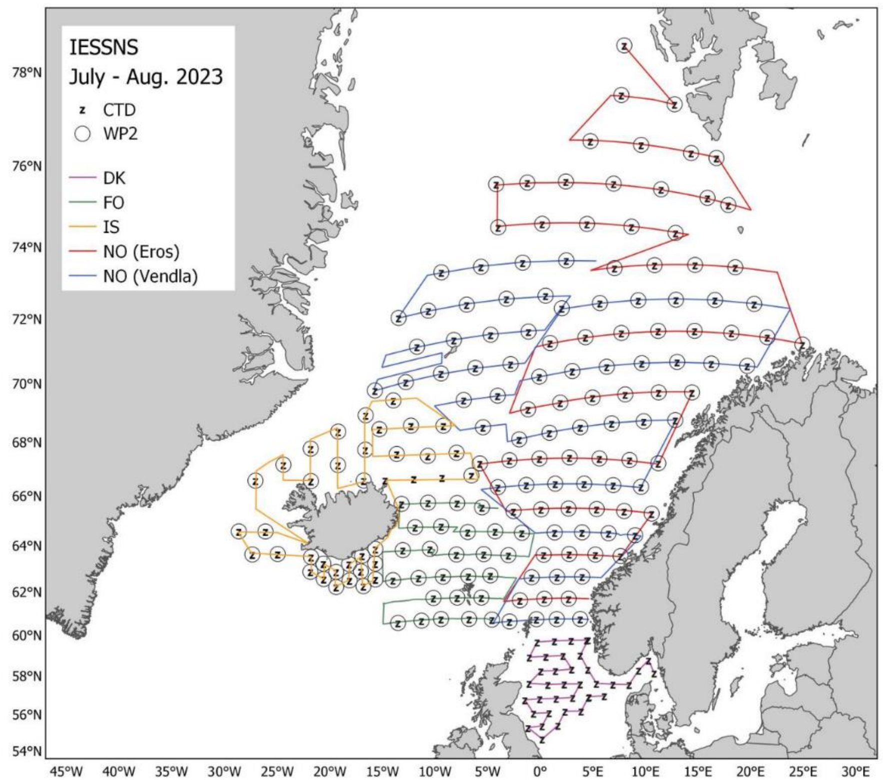


Figure 1 b. Fixed predetermined hydrographic stations (CTD and WP2) included in the IESSNS from July 1st to August 3rd 2023. CTD station (0-500 m) and WP2 plankton net samples (0-200 m depth).

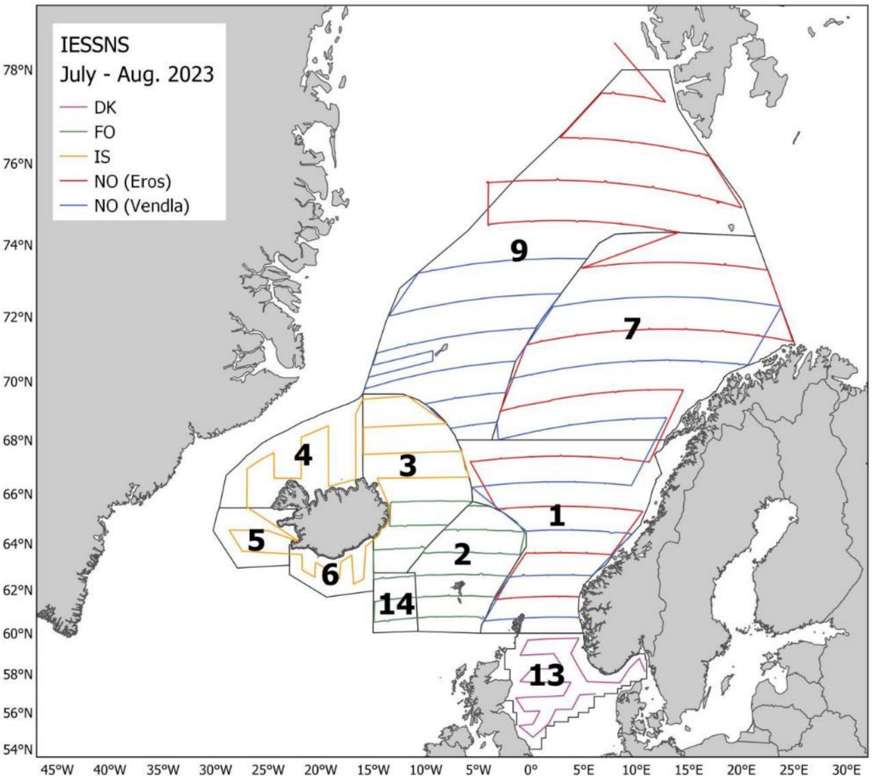


Figure 2. Permanent and dynamic strata used in StoX for IESSNS 2023. The survey area is split into 10 strata, of which 6 are permanent (1, 2, 3, 7, 10 and 13) and four dynamic (4, 5, 6 and 9). The former stratum 8 (along the Norwegian coast) was merged into adjacent strata 1 and 7. Stratum 10 (northern Greenland waters) and 11 (southern Greenland waters) were not surveyed in 2023 and are not displayed. The former stratum 12 (offshore south of Iceland) is not used any longer, since the southern boundaries of strata 5 and 6 have been converted to dynamic boundaries. For original strata boundaries see WGIPS manual (ICES 2014a). In 2023, stratum 2 was split in two strata, 2 and 14, as two predetermined surface trawl stations were not sampled on the western end of the 2nd transect from the south, see Figure 1a. Due to large variability in mackerel density within in stratum 2, the area around the skipped predetermined stations was defined as a separated stratum to reflect the mackerel density in the area. This was done to prevent inflation on mackerel abundance in the stratum 2 due to under sampling in a low-density part of stratum 2.

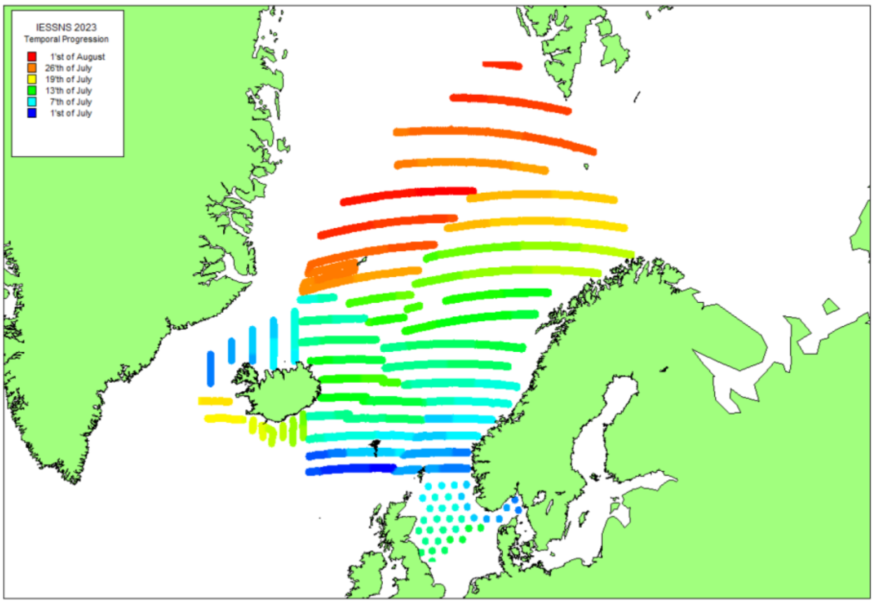


Figure 3. Temporal survey progression by vessel along the cruise tracks during IESSNS 2023: Blue represents effective survey start (1'st of July) progressing to red representing a five-week span (survey ended 3rd of August). As Ceton did not submit acoustics, they have been represented by station positions.

3.6 StoX

The recorded acoustic and biological data were analysed using the StoX software package which has been used for some years now for WGIPS coordinated surveys. A description of StoX can be found in Johnsen et al. (2019) and here: www.imr.no/forskning/prosjekter/stox. Mackerel swept-area abundance index, excluding the North Sea, was calculated using StoX version 3.6.1. The herring and blue whiting acoustic abundance indices were calculated using StoX version 3.6.2.

3.7 Swept area index and biomass estimation

This year the input data for the swept area calculations were taken from the ICES database. Up until 2020 the input data were extracted from the PGNAPES database.

The swept area age segregated index is calculated separately for each stratum (see stratum definition in Figure 2). Individual stratum estimates are added together to get the total estimate for the whole survey area which is approximately defined by the area between 60°N and 77°N and 40°W and 20°E in 2023. An additional run is made, including the North Sea. The density of mackerel on a trawl station is calculated by dividing the total number caught by the assumed area swept by the trawl. The area swept is calculated by multiplying the towed distance by the horizontal opening of the trawl. The horizontal opening of the trawl is vessel specific, and the average value across all hauls is calculated based on door spread (Table 5 and Table 6). An estimate of total number of mackerel in a stratum is obtained by taking the average density based on the trawl stations in the stratum and multiplying this with the area of the stratum.

Table 5. Descriptive statistics for trawl door spread, vertical trawl opening and tow speed for each vessel during IESSNS 2023 at predetermined surface trawl stations. Number of trawl stations used in calculations is also reported. Horizontal trawl opening was calculated using average vessel values for trawl door spread and tow speed (details in Table 6).

	Jákup Sverri	RV Árni Friðriksson	Eros	Vendla	Ceton
Trawl doors horizontal spread (m)					
Number of stations	27	29	57	57	36
Mean	113	122	122	112	125.2
max	120	130	136	120	132.7
min	102	110	115	100	117.7
st. dev.	4.2	4.6	4.8	4.0	3.8
Vertical trawl opening (m)					
Number of stations	27	36	57	57	36
Mean	32	30.8	28	29	30.4
max	49	23.2	33	32.0	37.7
min	25	37.2	25	24	23.6
st. dev.	5.9	2.9	2.9	4.3	3.2
Horizontal trawl opening (m)					
Mean	63.7	68.4	71.7	65.1	69.7
Speed (over ground, nmi)					
Number of stations	27	38	57	57	36
Mean	4.7	5.1	4.5	4.6	5.1
max	5.5	5.6	5.2	5.3	5.8
min	3.4	4.6	4.2	4.2	4.5
st. dev.	0.5	0.2	0.5	0.3	0.3

Horizontal trawl opening was calculated using average vessel values for trawl door spread and tow speed (Table 6). The estimates in the formulae were based on flume tank simulations in 2013 (Hirtshals, Denmark) where formulas were developed from the horizontal trawl opening as a function of door spread, for two towing speeds, 4.5 and 5 knots:

Towing speed 4.5 knots: Horizontal opening (m) = 0.441 * Door spread (m) + 13.094

Towing speed 5.0 knots: Horizontal opening (m) = 0.3959 * Door spread (m) + 20.094

Table 6. Horizontal trawl opening as a function of trawl door spread and towing speed. Relationship based on simulations of horizontal opening of the Multpelt 832 trawl towed at 4.5 and 5 knots, representing the speed range in the 2014 survey, for various door spread. See text for details. In 2017, the towing speed range was extended from 5.0 to 5.2, in 2020 the door spread was extended to 122 m and in 2022 the towing speed range was extended down to 4.3 knots and up to 5.5 knotsThe door spread was furthermore extended to 135 m in 2023. See also Appendix 4.

	Towing speed (knots)												
Door spread(m)	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5	5.1	5.2	5.3	5.4	5.5
100	56.5	56.9	57.2	57.7	58.2	58.7	59.2	59.7	60.2	60.7	61.2	61.7	62.2
101	56.9	57.3	57.6	58.1	58.6	59.1	59.6	60.1	60.6	61.1	61.5	62.0	62.5
102	57.3	57.7	58.1	58.6	59.0	59.5	60.0	60.5	60.9	61.4	61.9	62.4	62.9
103	57.7	58.1	58.5	59.0	59.5	59.9	60.4	60.9	61.3	61.8	62.3	62.8	63.2
104	58.1	58.5	59.0	59.4	59.9	60.3	60.8	61.3	61.7	62.2	62.7	63.1	63.6
105	58.6	59.0	59.4	59.9	60.3	60.8	61.2	61.7	62.1	62.6	63.0	63.5	63.9
106	59.0	59.4	59.8	60.3	60.7	61.2	61.6	62.1	62.5	62.9	63.4	63.8	64.3
107	59.5	59.9	60.3	60.7	61.2	61.6	62.0	62.5	62.9	63.3	63.8	64.2	64.6
108	59.9	60.3	60.7	61.1	61.6	62.0	62.4	62.9	63.3	63.7	64.1	64.6	65.0
109	60.4	60.8	61.2	61.6	62.0	62.4	62.8	63.2	63.7	64.1	64.5	64.9	65.3
110	60.9	61.2	61.6	62.0	62.4	62.8	63.2	63.6	64.1	64.5	64.9	65.3	65.6
111	61.3	61.7	62.0	62.4	62.8	63.2	63.6	64.0	64.4	64.8	65.2	65.6	66.0
112	61.8	62.1	62.5	62.9	63.3	63.7	64.0	64.4	64.8	65.2	65.6	66.0	66.3
113	62.2	62.6	62.9	63.3	63.7	64.1	64.4	64.8	65.2	65.6	66.0	66.3	66.7
114	62.7	63.0	63.4	63.7	64.1	64.5	64.9	65.2	65.6	66.0	66.3	66.7	67.0
115	63.1	63.5	63.8	64.2	64.5	64.9	65.3	65.6	66.0	66.3	66.7	67.0	67.3
116	63.6	63.9	64.3	64.6	65.0	65.3	65.7	66.0	66.4	66.7	67.0	67.4	67.7
117	64.0	64.4	64.7	65.0	65.4	65.7	66.1	66.4	66.8	67.1	67.4	67.7	68.0
118	64.5	64.8	65.1	65.5	65.8	66.1	66.5	66.8	67.2	67.5	67.8	68.1	68.4
119	64.9	65.3	65.6	65.9	66.2	66.6	66.9	67.2	67.6	67.9	68.1	68.4	68.7
120	65.4	65.7	66.0	66.3	66.6	67.0	67.3	67.6	67.9	68.2	68.5	68.8	69.1
121	65.8	66.1	66.5	66.8	67.1	67.4	67.7	68.0	68.3	68.6	68.9	69.1	69.4
122	66.3	66.6	66.9	67.2	67.5	67.8	68.1	68.4	68.7	69.0	69.2	69.5	69.8
123	66.7	67.0	67.3	67.6	67.9	68.2	68.5	68.8	69.1	69.3	69.6	69.9	70.1
124	67.2	67.5	67.8	68.0	68.3	68.6	68.9	69.2	69.5	69.7	70.0	70.2	70.4
125	67.6	67.9	68.2	68.5	68.8	69.0	69.3	69.6	69.8	70.1	70.3	70.6	70.8
126	68.1	68.4	68.7	68.9	69.2	69.5	69.7	70.0	70.2	70.5	70.7	70.9	71.1
127	68.6	68.8	69.1	69.4	69.6	69.9	70.1	70.4	70.6	70.9	71.1	71.3	71.5
128	69.0	69.3	69.5	69.8	70.0	70.3	70.5	70.8	71.0	71.2	71.4	71.6	71.8
129	69.5	69.7	70.0	70.2	70.5	70.7	71.0	71.2	71.4	71.6	71.8	72.0	72.1
130	69.9	70.2	70.4	70.7	70.9	71.1	71.4	71.6	71.8	72.0	72.2	72.3	72.5
131	70.4	70.6	70.9	71.1	71.3	71.6	71.8	72.0	72.2	72.3	72.5	72.7	72.8
132	70.8	71.1	71.3	71.5	71.8	72.0	72.2	72.4	72.5	72.7	72.9	73.0	73.1
133	71.3	71.5	71.7	72.0	72.2	72.4	72.6	72.7	72.9	73.1	73.2	73.3	73.4
134	71.7	71.9	72.2	72.4	72.6	72.8	72.9	73.1	73.3	73.4	73.5	73.6	73.7
135	72.1	72.4	72.6	72.8	73.0	73.1	73.3	73.5	73.6	73.7	73.8	73.9	74.0

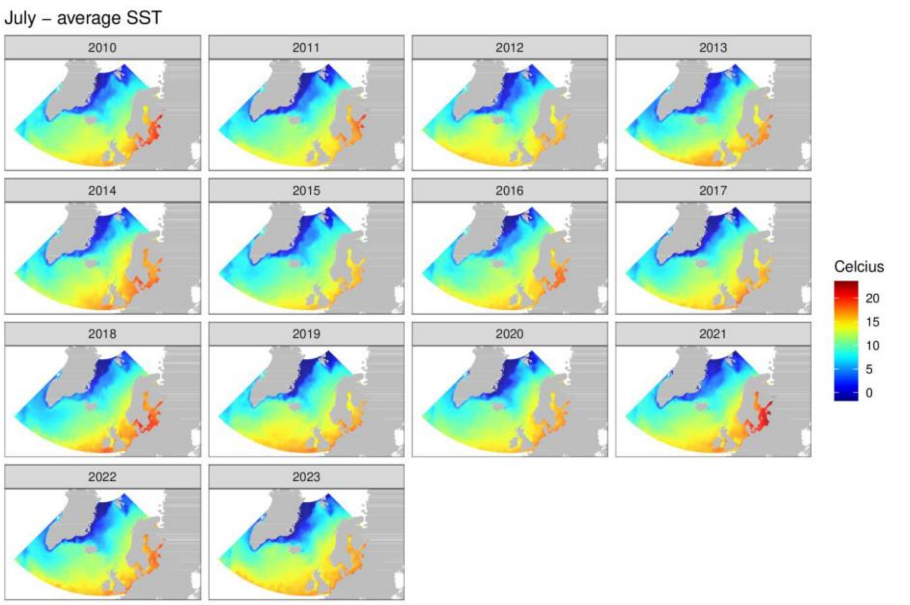
4 Results and discussion

4.1 Hydrography

Satellite measurements (NOAA OISST) of sea surface temperature (SST) in the central areas in the Northeast Atlantic in July 2023 were slightly warmer than the long-term average for July 1990-2009 based on SST plots (Figure 4a) and SST anomaly plots (Figure 4b). The northern regions of the Nordic Seas were slightly warmer than the average while the East Greenland Current was cooler than the long-term average. The SST in the Irminger Sea and Iceland Basin were slightly warmer than the average.

It should be mentioned that the NOAA SST are sensitive to the weather conditions (i.e. wind and cloudiness) prior to and during the observations and do therefore not necessarily reflect the oceanographic condition of the water masses in the areas, as seen when comparing detailed *in situ* features of SSTs between years (Figures 4a,b-5). However, since the anomaly is based on the average for the whole month of July, it should give representative results of the surface temperature.

The temperature distribution at 10, 50, 100 and 400 m depths is shown in Figure 5. At 10 m depth, the temperatures ranged from less than 1°C in the Greenland Sea to 16°C in the North Sea. At all depths there is a clear signal from the cold East Icelandic Current which carries cold and fresh water into the central and south-eastern part of the Norwegian Sea. Along the Norwegian Shelf and in the southernmost areas, the water masses are dominated by warmer waters of Atlantic origin. The CTD measurements at 10 m depths showed that north of Jan-Mayen the 8°C isotherm was found more easterly than last year. South of Jan-Mayen the 8°C isotherm was found more westerly than last year and was closely aligned to the Jan-Mayen Ridge.



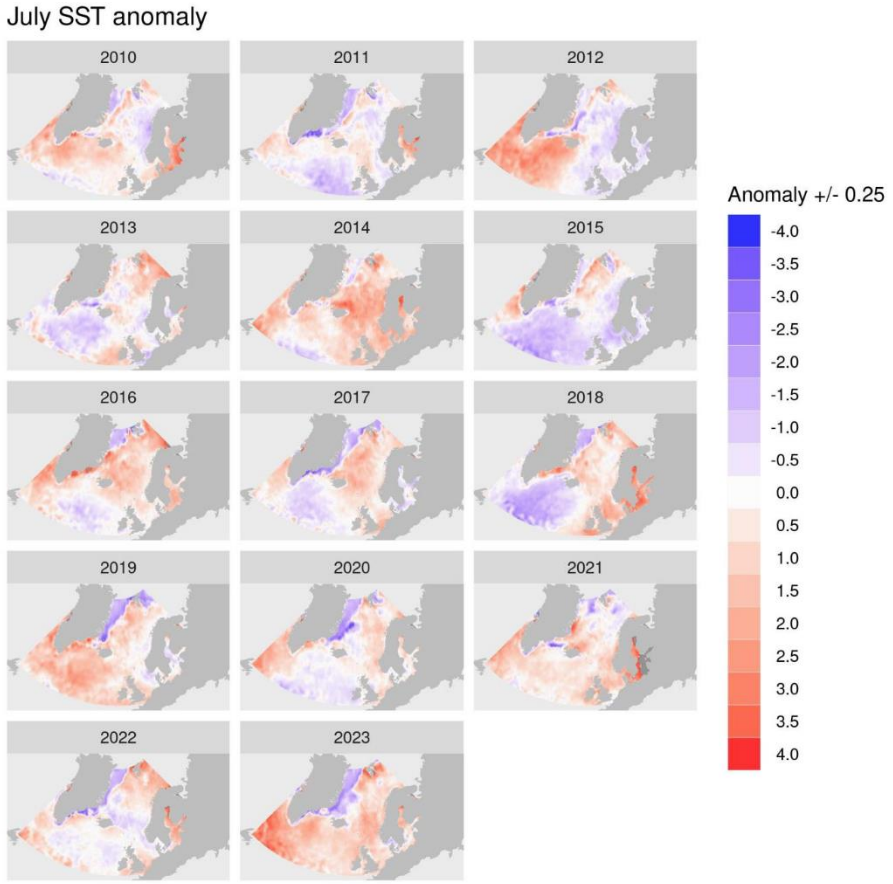


Figure 4. Annual sea surface temperature (a; top panel) and its anomaly (b; lower panel; -4 to +4°C) in Northeast Atlantic for the month of July from 2010 to 2023 showing warm and cold conditions in comparison to the average for July 1990-2009. Based on monthly averages of daily Optimum Interpolation Sea Surface Temperature (Ver. 2.1 NOAA OISST, AVHRR-only, Banzon et al. 2016, https://www.ncei.noaa.gov/products/optimum-interpolation-sst).

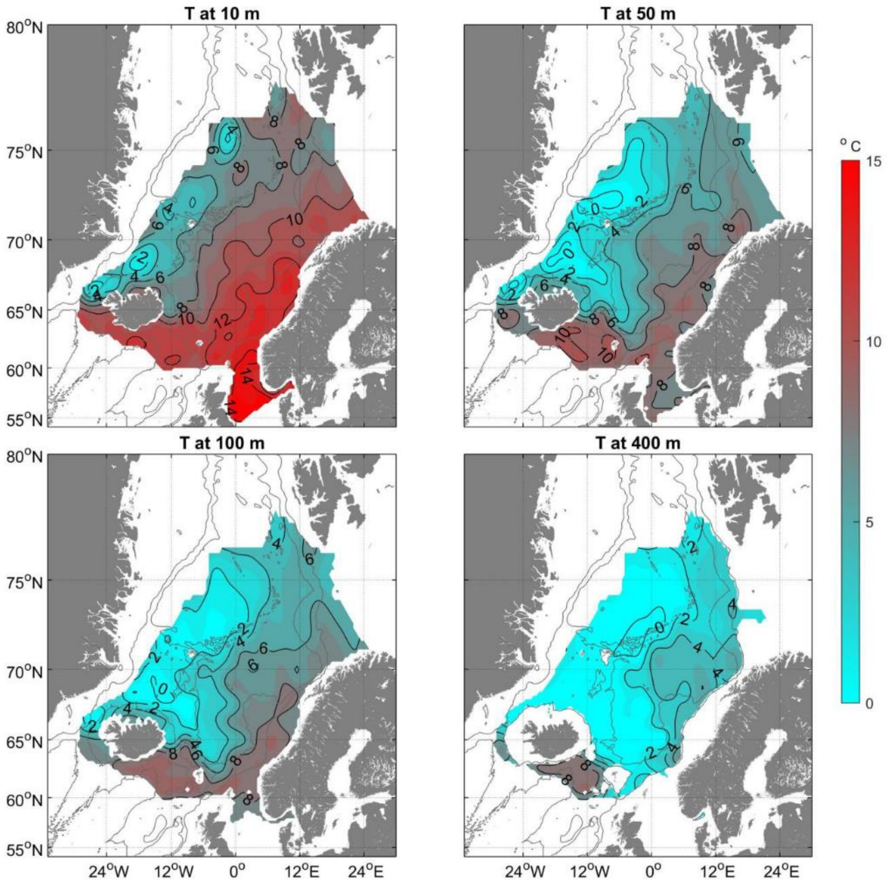


Figure 5. Interpolated temperature (°C) at 10, 50, 100 and 400 m depth in Nordic Seas and the North Sea in July-August 2023. 500 m and 2000 m depth contours are shown in light grey.

4.2 Zooplankton

The zooplankton biomass varied between areas with a patchy distribution throughout the area (Figure 6a). In the Norwegian Sea areas, the average zooplankton biomass was around 8 g/m^2, which is higher than the last two years (Figure 6b).

The time-series of zooplankton biomass was averaged by three subareas: Greenland region (not covered in 2023), Iceland region, and the Norwegian Sea region is shown in Figure 6b (see definitions in legend). In the Icelandic region and the Norwegian Sea the level was higher than in 2022. The biomass index in the Norwegian Sea varied less compared to the other two indices, and in 2023 it was comparable to 2019-2020 (Figure 6b). The lower variability over time in the Norwegian Sea might in part be explained by the more homogeneous oceanographic conditions in the area defined as Norwegian Sea.

These plankton indices should be treated with some caution as it is only a snapshot of the standing stock biomass, not of the actual production in the area, which complicates spatio-temporal comparisons.

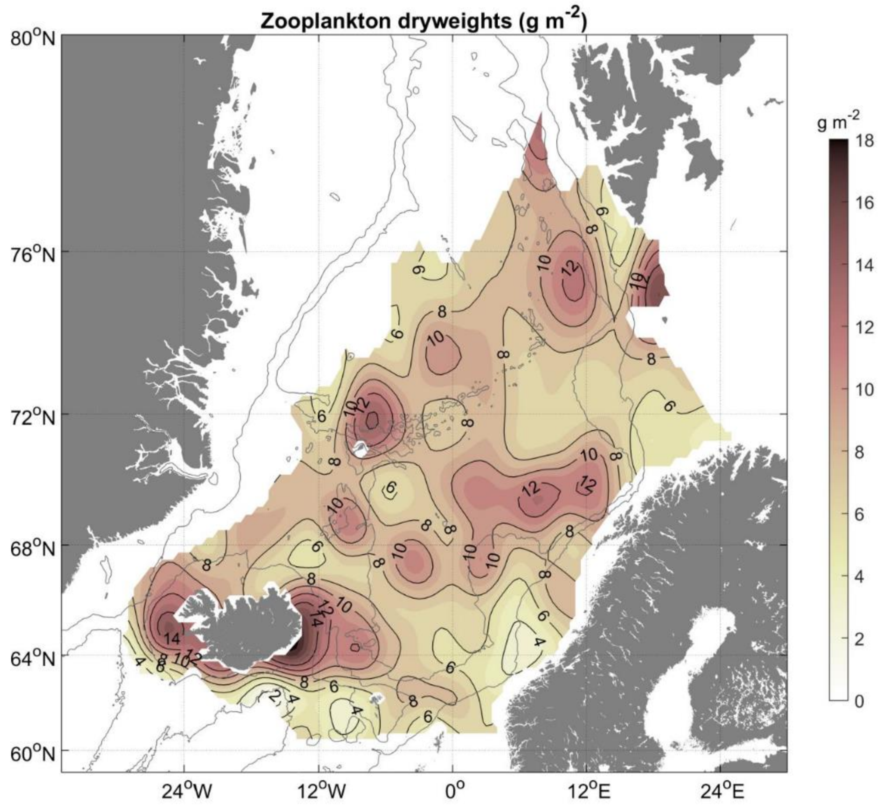


Figure 6a. Interpolated zooplankton biomass (g dw/m2, 0-200 m) in Nordic Seas in July-August 2023. 500 m and 2000 m depth contours are shown in light grey.

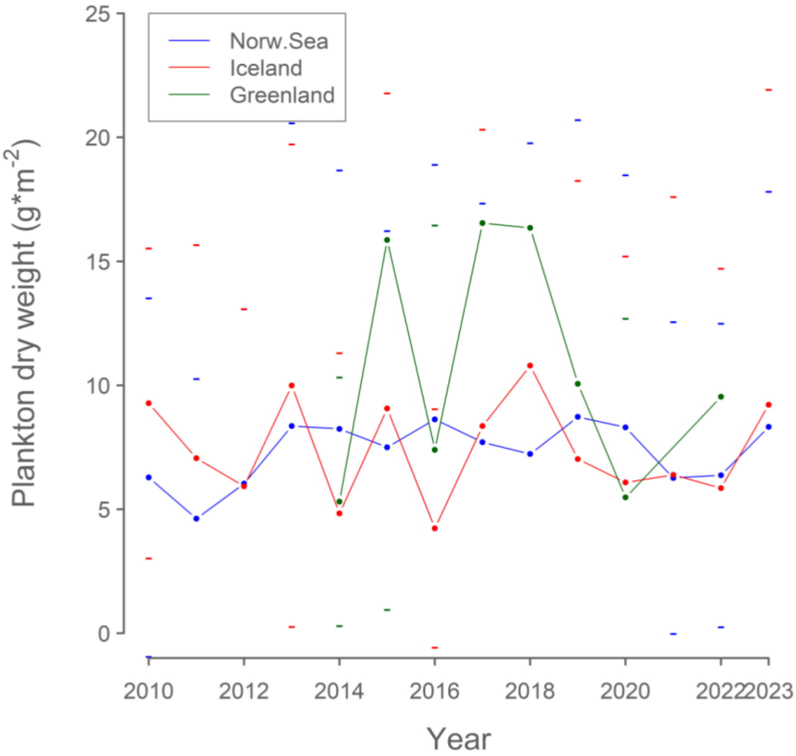


Figure 6b. Zooplankton biomass indices (g dw/m², 0-200 m). Time-series (2010-2023) of mean zooplankton biomass for three subareas within the survey range: Norwegian Sea (between 14°W-17°E & north of 61°N), Icelandic waters (14°W-30°W) and Greenlandic waters (2014-2022, west of 30°W).

4.3 Mackerel

The total swept-area mackerel index in 2023 was 4.30 million tonnes in biomass and 10.67 billion in numbers, a decrease of 42% for biomass and 39% for abundance compared to 2022. The survey coverage area (excl. the North Sea, 0.28 million km²) was 2.36 million km² in 2023, which is 19% smaller compared to 2022. No extreme catches were taken this year, the highest catch was 5.7 tonnes. This reduces the uncertainty of the index in the biomass, CV = 0.12 in 2023 compared to CV = 0.25 in 2022.

Most of the surveyed mackerel still appears to be in the Norwegian Sea. However, they were more easterly and northeasterly distributed compared to 2022. The zero-line was reached for the whole survey area, north of latitude 60°N.

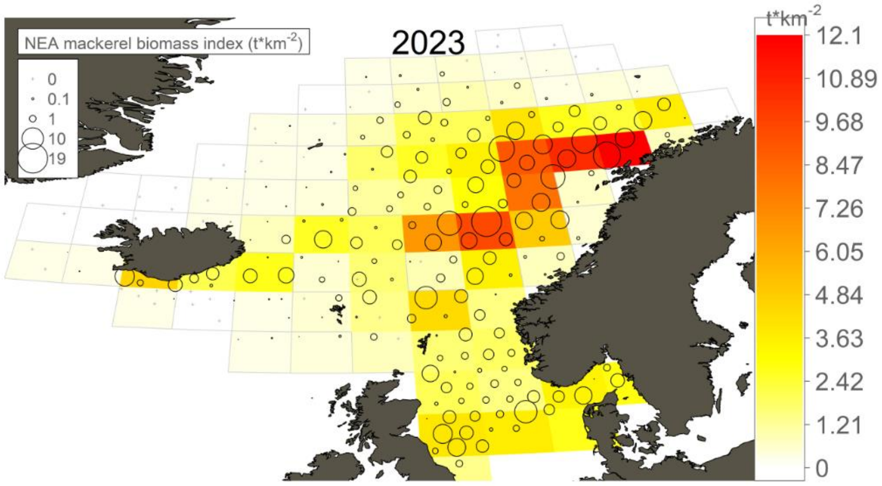


Figure 7. Mackerel catch rates by Multpelt 832 pelagic trawl haul at predetermined surface trawl stations (circle areas represent catch rates in kg/km²) overlaid on mean catch rates per standardized rectangles (2° lat. x 4° lon.) in Nordic Seas in July-August 2023.

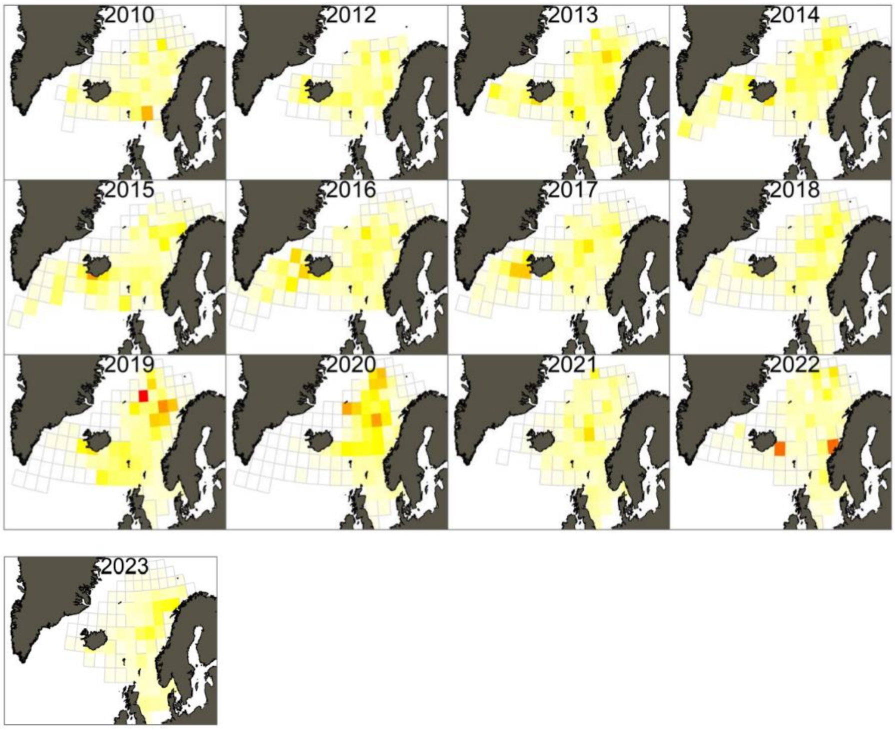


Figure 8. Annual distribution of mackerel proxied by the absolute distribution of mean mackerel catch rates per standardized rectangles (2° lat. x 4° lon.), from Multpelt 832 pelagic trawl hauls at predetermined surface trawl stations in Nordic Seas in June-August 2010-2023. Colour scale goes from white (= 0) to red (= maximum value for the highest year).

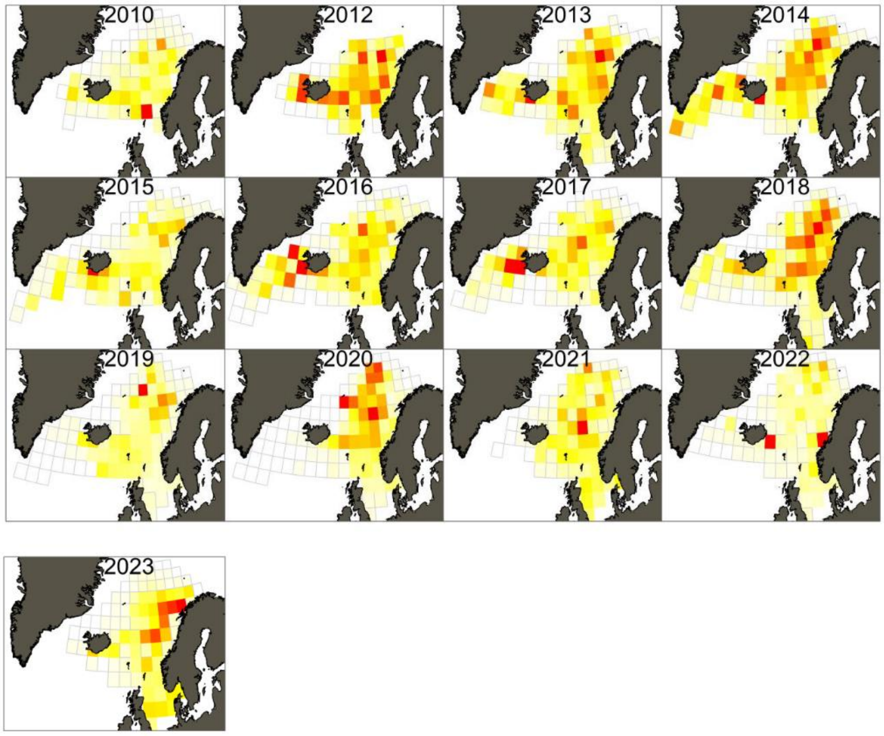


Figure 9. Annual distribution of mackerel proxied by the relative distribution of mean mackerel catch rates per standardized rectangles (2° lat. x 4° lon.), from Multpelt 832 pelagic trawl hauls at predetermined surface trawl stations stations in Nordic Seas in June-August 2010-2023. Colour scale goes from white (= 0) to red (= maximum value for the given year).

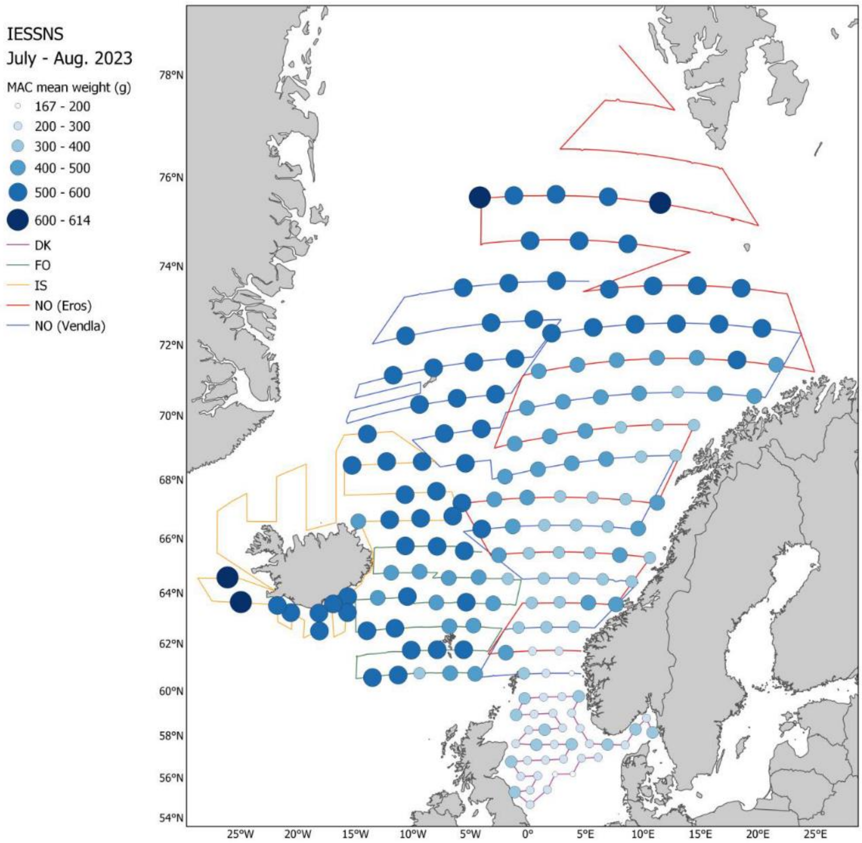


Figure 10. Average weight of mackerel at predetermined surface trawl stations during IESSNS 2023.

The mackerel weight varied between 37 to 858 g with an average of 439 g. The length of mackerel caught in the pelagic trawl hauls onboard the five vessels varied from 17.5 to 45.5 cm, with an average of 34.2 cm. In total we measured 17464 mackerel. Mackerel length distribution followed the same overall pattern as previous years both in the Norwegian Sea, with increasing size towards the distribution boundaries in the north and the north-west, and in the western area with increasing size westward (Figure 10). The spatial distribution and overlap between the major pelagic fish species (mackerel, herring, blue whiting) in 2023 according to surface trawl catches is shown in Figure 11.

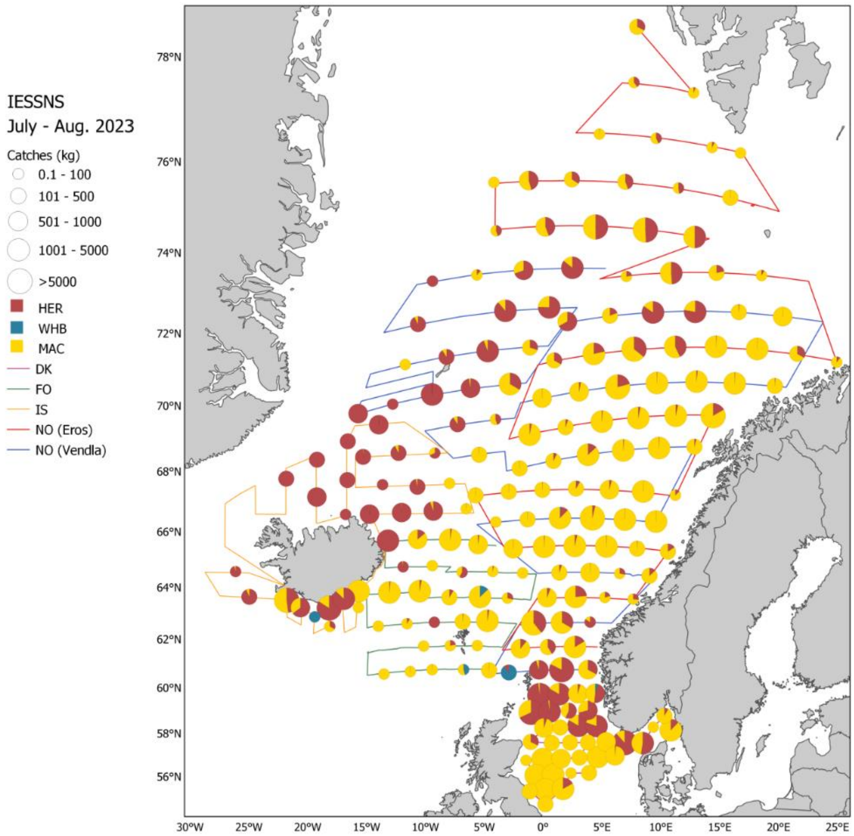


Figure 11. Distribution and spatial overlap between mackerel, herring, and blue whiting, at all surface trawl stations during IESSNS 2023. Vessel tracks are shown as continuous lines and predetermined surface trawl stations with no catch of the three species is displayed as +.

Swept area analyses from standardized pelagic trawling with Multpelt 832

The swept area estimates of mackerel biomass from the 2023 IESSNS were based on abundance of mackerel per stratum (see strata definition in Figure 2) and calculated in StoX version 3.6.1. Mackerel abundance index in 2023 was 39% lower than in 2022, and 46% lower index than the average for the last 5 years (Table 7a; Figure 12) and the biomass index was 42% lower than in 2022, and 50% lower than the average for the last 5 years (Table 7c). Mackerel estimates of abundance, biomass and mean weight by age and length are displayed in Table 7d. There is no pattern in changing size-at-age between years (Table 7b). In 2023, the two most abundant year-classes were 2020 (age 3), 2019 (age 4), respectively (Figure 13). The 2020-year class contributed with 33%, followed by 2019-year class with 16%. Mackerel of age 1, 2 and to some extent also age 3 are not completely recruited to the survey (Figure 15), because the main part of the nursery area was further south than the survey area. Therefore, information on recruitment is uncertain. Variance in age index estimation is provided in Figure 14.

The overall internal consistency improved slightly compared to last year (Figure 16). There is a good to strong internal consistency for the younger ages (1-5 years) and older ages (9-14 years) with r between 0.71 and 0.89. The internal consistency is more variable between age 5 to 9, but improved with the addition of the data from this year, confirming the relations between 5, 6 and 7, and adding a new contrasting data point to the relation between 7 and 8. More information on the relation between 7 and 8 (which have been the weakest link in the internal consistency since the beginning of the survey) is expected in IESSNS 2024 as the weak 2018 year class gets surveyed at age 8.

Mackerel index calculations from the catch in the North Sea (Figure 2) were excluded from the index calculations presented in the current chapter to facilitate comparison to previous years and because the 2017 mackerel benchmark stipulated that trawl stations south of latitude 60°N be excluded from index calculations (ICES 2017). Results from the mackerel index calculations for the North Sea are presented in Appendix 1.

The indices used for NEA mackerel stock assessment in WGIWIDE are the number-at-age indices for age 3 to 11 year (Table 7a).

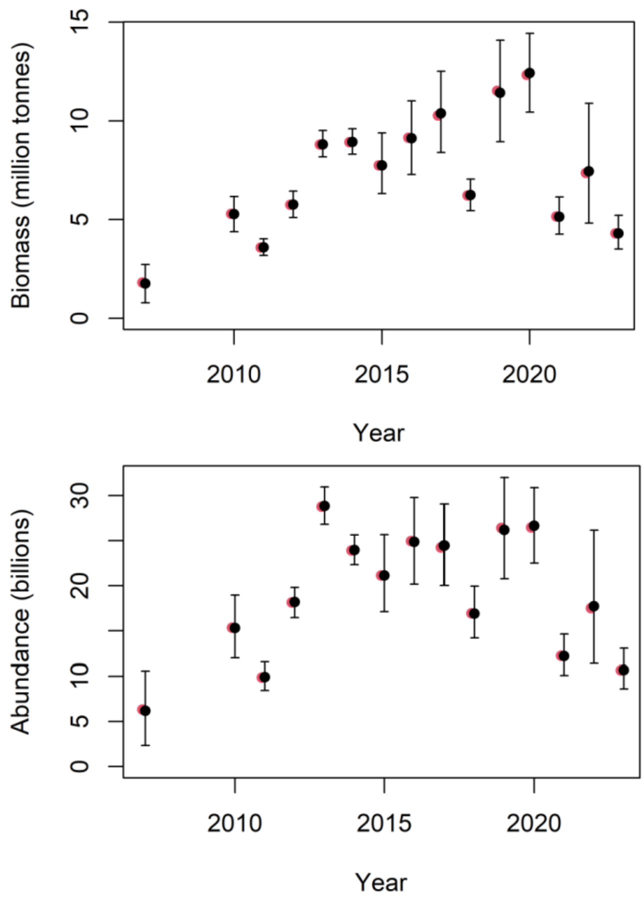


Figure 12. Estimated total stock biomass (upper panel) and total stock numbers (lower panel) of mackerel from StoX for the years 2007 and from 2010 to 2023. The red dots are baseline estimates, the black dots are mean of 1000 bootstrap replicates while the error bars represent 90 % confidence intervals based on the bootstrap. Note, in 2011 the northern part of the Norwegian was not surveyed, hence the index for that year is not representative of mackerel stock size. See IESSNS 2011 cruise report for details.

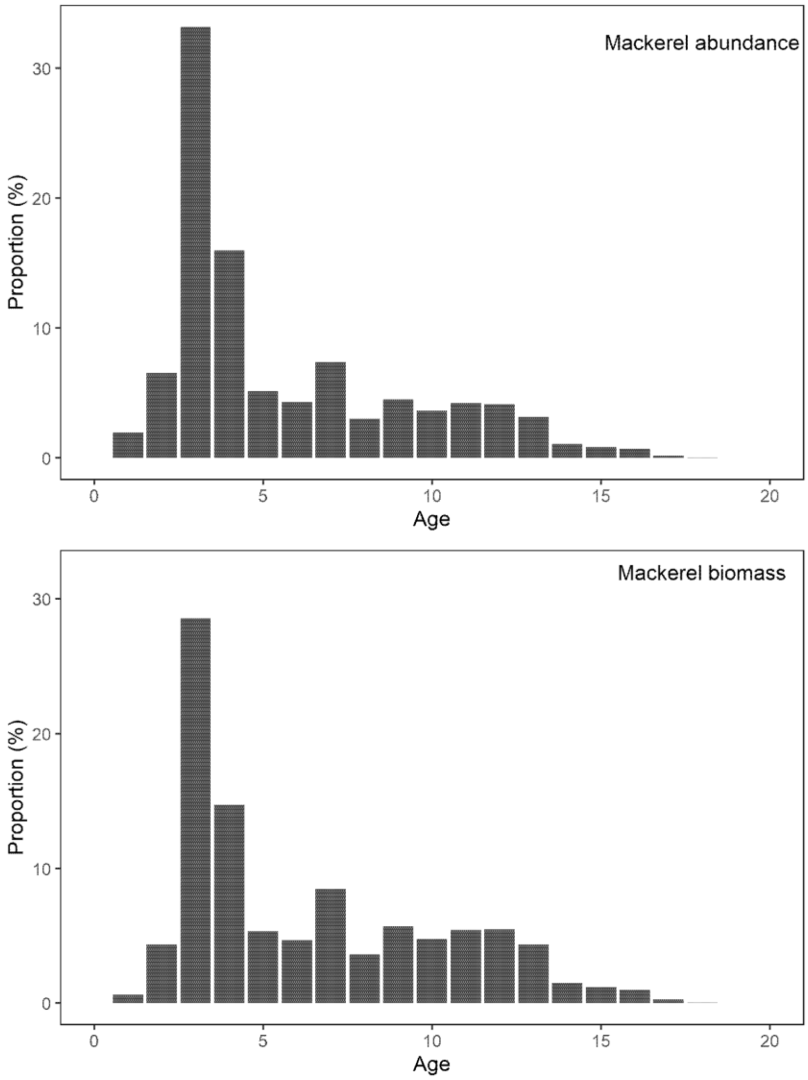


Figure 13. Mackerel age distribution in numbers (%) and in biomass (%) from IESSNS 2023.

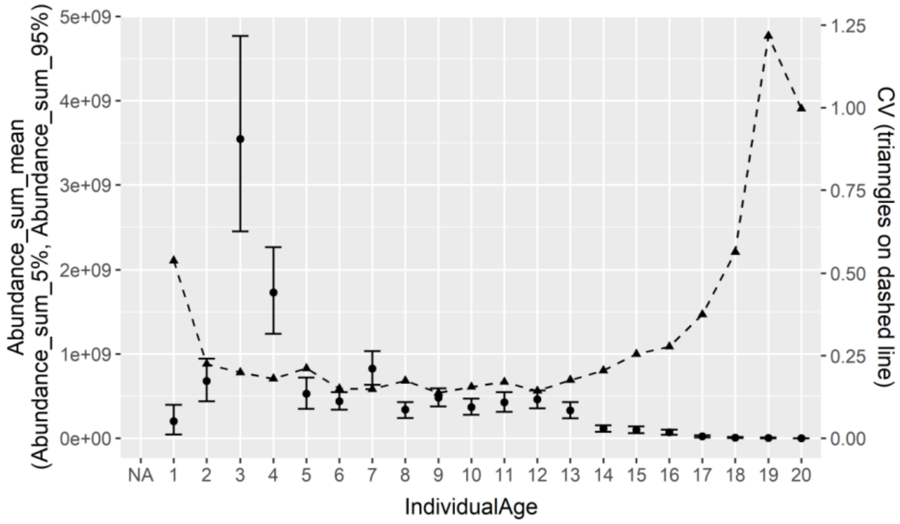


Figure 14. Number by age for mackerel in 2023. Plot of abundance (5% percentile, mean, 95% percentile) and relative standard error (CV) obtained by bootstrapping with 1000 replicates using the StoX software.

Table 7. a-d) StoX baseline (point estimate) time series of the IESSNS showing (a) age-disaggregated abundance indices of mackerel (billions), (b) mean weight (grams) per age, (c) estimated biomass at age (million tonnes) in 2007 and from 2010 to 2023, and (d) estimates of abundance, biomass and mean weight by age and length.

a)

Year\Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14(+)	Tot N
2007	1.33	1.86	0.90	0.24	1.00	0.16	0.06	0.04	0.03	0.01	0.01	0.00	0.01	0.00	5.65
2010	0.03	2.80	1.52	4.02	3.06	1.35	0.53	0.39	0.20	0.05	0.03	0.02	0.01	0.01	13.99
2011	0.21	0.26	0.87	1.11	1.64	1.22	0.57	0.28	0.12	0.07	0.06	0.02	0.01	0.00	6.42*
2012	0.50	4.99	1.22	2.11	1.82	2.42	1.64	0.65	0.34	0.12	0.07	0.02	0.01	0.01	15.91
2013	0.06	7.78	8.99	2.14	2.91	2.87	2.68	1.27	0.45	0.19	0.16	0.04	0.01	0.02	29.57
2014	0.01	0.58	7.80	5.14	2.61	2.62	2.67	1.69	0.74	0.36	0.09	0.05	0.02	0.00	24.37
2015	1.20	0.83	2.41	5.77	4.56	1.94	1.83	1.04	0.62	0.32	0.08	0.07	0.04	0.02	20.72
2016	<0.01	4.98	1.37	2.64	5.24	4.37	1.89	1.66	1.11	0.75	0.45	0.20	0.07	0.07	24.81
2017	0.86	0.12	3.56	1.95	3.32	4.68	4.65	1.75	1.94	0.63	0.51	0.12	0.08	0.04	24.22
2018	2.18	2.50	0.50	2.38	1.20	1.41	2.33	1.79	1.05	0.50	0.56	0.29	0.14	0.09	16.92
2019	0.08	1.35	3.81	1.21	2.92	2.86	1.95	3.91	3.82	1.50	1.25	0.58	0.59	0.57	26.4
2020	0.04	1.10	1.43	3.36	2.13	2.53	2.53	2.03	2.90	3.84	1.50	1.18	0.92	0.98	26.47
2021	0.09	2.13	0.71	1.22	1.53	0.37	1.29	0.81	1.05	0.97	0.93	0.46	0.34	0.33	12.22
2022	0.02	3.91	2.36	0.94	1.31	1.04	0.60	0.96	1.00	1.86	1.61	0.90	0.56	0.45	17.51
2023	0.21	0.70	3.54	1.70	0.55	0.46	0.79	0.32	0.48	0.39	0.45	0.44	0.34	0.30	10.67

b)

Year\Age	1	2	3	4	5	6	7	8	9	10	11	12	13
2007	133	233	323	390	472	532	536	585	591	640	727	656	685
2010	133	212	290	353	388	438	512	527	548	580	645	683	665

2011	133	278	318	371	412	440	502	537	564	541	570	632	622
2012	112	188	286	347	397	414	437	458	488	523	514	615	509
2013	96	184	259	326	374	399	428	445	486	523	499	547	677
2014	228	275	288	335	402	433	459	477	488	533	603	544	537
2015	128	290	333	342	386	449	463	479	488	505	559	568	583
2016	95	231	324	360	371	394	440	458	479	488	494	523	511
2017	86	292	330	373	431	437	462	487	536	534	542	574	589
2018	67	229	330	390	420	449	458	477	486	515	534	543	575
2019	153	212	325	352	428	440	472	477	490	511	524	564	545
2020	99	213	315	369	394	468	483	507	520	529	539	567	575
2021	140	253	357	377	409	451	467	487	497	505	516	523	544
2022	125	263	330	408	438	431	462	508	525	519	531	531	549
2023	128	269	347	371	416	435	462	484	506	526	517	533	557

c)

Year\Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14(+)	Tot B
2007	0.18	0.43	0.29	0.09	0.47	0.09	0.03	0.02	0.02	0.01	0.01	0.00	0.01	0.00	1.64
2010	0.00	0.59	0.44	1.42	1.19	0.59	0.27	0.20	0.11	0.03	0.02	0.01	0.01	0.00	4.89
2011	0.03	0.07	0.28	0.41	0.67	0.54	0.29	0.15	0.07	0.04	0.03	0.01	0.01	0.00	2.69*
2012	0.06	0.94	0.35	0.73	0.72	1.00	0.72	0.30	0.17	0.06	0.03	0.01	0.00	0.00	5.09
2013	0.01	1.43	2.32	0.70	1.09	1.15	1.15	0.56	0.22	0.10	0.08	0.02	0.01	0.01	8.85
2014	0.00	0.16	2.24	1.72	1.05	1.14	1.23	0.80	0.36	0.19	0.05	0.03	0.01	0.00	8.98
2015	0.15	0.24	0.80	1.97	1.76	0.87	0.85	0.50	0.30	0.16	0.04	0.04	0.02	0.01	7.72
2016	<0.01	1.15	0.45	0.95	1.95	1.72	0.83	0.76	0.53	0.37	0.22	0.10	0.04	0.04	9.11
2017	0.07	0.03	1.18	0.73	1.43	2.04	2.15	0.86	1.04	0.33	0.28	0.07	0.05	0.03	10.29
2018	0.15	0.57	0.16	0.93	0.50	0.63	1.07	0.85	0.51	0.26	0.30	0.16	0.08	0.05	6.22
2019	0.01	0.29	1.24	0.43	1.25	1.26	0.92	1.86	1.87	0.77	0.65	0.33	0.32	0.32	11.52
2020	<0.01	0.23	0.45	1.24	0.84	1.18	1.22	1.03	1.51	2.03	0.81	0.67	0.53	0.58	12.33
2021	0.01	0.54	0.25	0.46	0.62	0.17	0.60	0.39	0.52	0.49	0.48	0.24	0.18	0.19	5.15
2022	0.00	1.03	0.78	0.39	0.57	0.45	0.28	0.49	0.52	0.97	0.85	0.48	0.31	0.26	7.37
2023	0.03	0.19	1.23	0.63	0.23	0.20	0.36	0.16	0.24	0.20	0.23	0.24	0.19	0.17	4.30

*In 2011 the northern part of the Norwegian was not surveyed, hence the index for that year is not representative of mackerel stock size. See IESSNS 2011 cruise report for details.

d)	Age in years (year class)														Number	Biomass	Mean
Length	1	2	3	4	5	6	7	8	9	10	11	12	13+	NA			weight
(cm)	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011			(10^6)	(10^6 kg)	(g)
17-18														<1	<1	<1	37.5
18-19														1	1	<1	47.0
19-20	3														3	<1	50.9
20-21	7														7	<1	64.1
21-22	9														9	<1	75.8
22-23	9														9	1	91.7
23-24	46														46	1	102.5
24-25	44		2												46	5	111.6
25-26	31														31	5	124.0
26-27	27														27	4	145.5
27-28	16														16	4	166.7
28-29		26													26	3	193.7
29-30	11	96													108	5	219.8
30-31		185	18												202	24	247.5
31-32		194	56												250	50	276.2
32-33	3	75	597	84											760	69	311.4
33-34		100	1307	216	19	3									1 645	237	337.9
34-35		20	1122	611	26	15	17	1							1 812	556	360.5
35-36	3	1	346	537	153	65	25		5						1 135	653	389.1
36-37			87	189	217	149	172	29	9		2	5			858	441	414.5
37-38			3	62	99	155	325	97	68	41	16	29	16		912	356	456.0
38-39			0	4	19	60	172	131	184	97	170	131	96		1 063	416	491.3
39-40			2		16	12	63	43	124	166	158	131	161		877	522	532.6
40-41		0				1	13	20	88	64	78	95	185		545	467	560.8
41-42									6	12	17	37	129		201	306	600.8
42-43										7	8	9	40		65	121	639.4
43-44												3	11		14	42	675.8
44-45													2		2	10	740.5
45-46														<1	<1	1	821.5
NA														<1	<1	<1	0.0
TSN(mill)	211.3	696.6	3 539.6	1 703.2	548.7	460.3	786.8	321.3	482.9	387.5	450.2	441.0	640.3	1.1	10 670.7	4298	
TSB(1000 t)	27.0	187.4	1 227.6	632.4	228.7	200.2	363.5	155.7	244.6	203.9	233.0	235.2	358.8	0.4	4 298		
Mean length(cm)	24.5	30.8	33.4	34.4	35.9	36.5	37.1	37.8	38.5	38.8	38.8	39.0					
Mean weight(g)	128	269	347	371	416	435	462	484	506	526	517	533					

Table 8. Bootstrap estimates from StoX (based on 1000 replicates) of mackerel in 2023. Numbers by age and total number (TSN) are in millions and total biomass (TSB) in million tons.

Age	5th percentile	Median	95th percentile	Mean	SD	CV
1	45.6	192.5	395.4	200.2	107.7	0.54
2	439.9	672.8	943.7	677.5	152.4	0.22
3	2449.2	3526.3	4768.9	3544.2	706.9	0.20
4	1240.4	1715.4	2267.2	1728.9	311.6	0.18
5	350.0	521.1	721.1	529.5	112.1	0.21
6	337.7	438.1	548.6	439.8	66.1	0.15
7	633.0	818.3	1034.3	826.4	122.7	0.15
8	240.7	340.6	429.3	338.6	58.9	0.17
9	378.2	480.0	591.7	481.4	65.9	0.14
10	278.4	366.8	469.4	368.7	57.4	0.16
11	311.9	423.1	548.0	426.7	72.6	0.17
12	355.3	460.4	567.8	462.4	66.2	0.14
13	235.7	326.2	428.1	328.4	57.8	0.18
14	77.3	115.1	154.6	115.9	23.8	0.21
15	59.8	97.5	141.4	99.0	25.2	0.25
16	40.2	70.6	102.8	70.3	19.5	0.28
17	9.1	20.8	34.8	21.1	7.9	0.37
18	1.6	6.4	14.2	6.8	3.8	0.56
19	0.2	1.3	7.8	2.2	2.7	1.22
20	0.0	0.3	0.9	0.3	0.3	1.00
TSN	8590	10680	13081	10680	1344	0.13
TSB	3.50	4.28	5.21	4.30	0.51	0.12

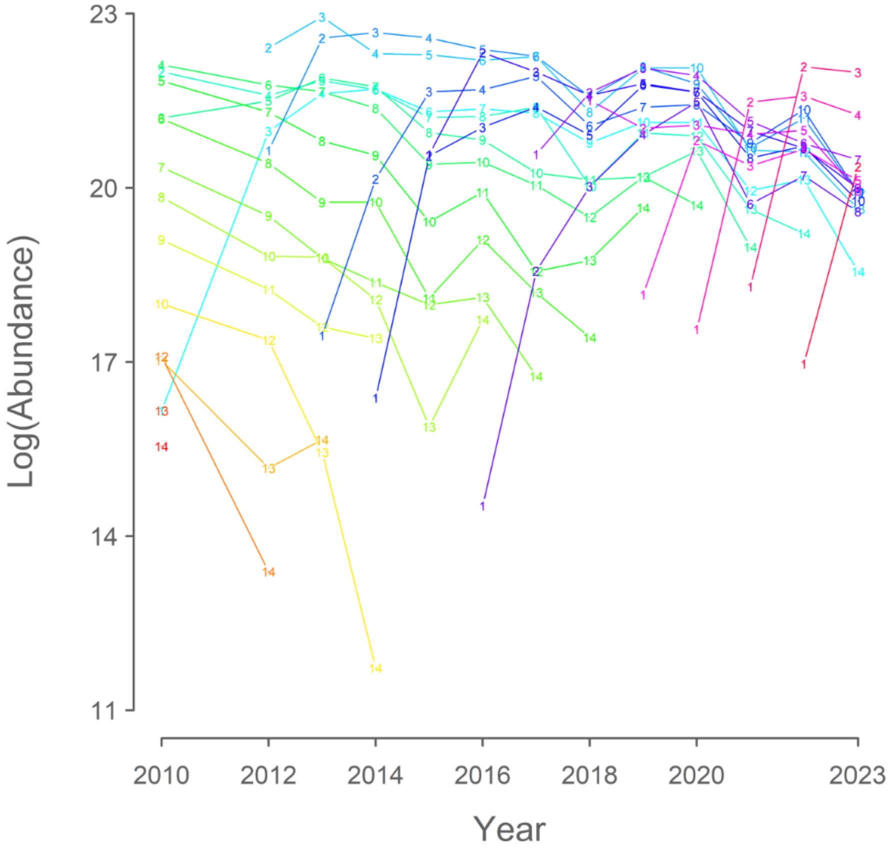


Figure 15. Catch curves for the years 2010; 2012-2023. Each cohort of mackerel is marked by a uniquely coloured line that connects the estimates indicated by the respective ages.

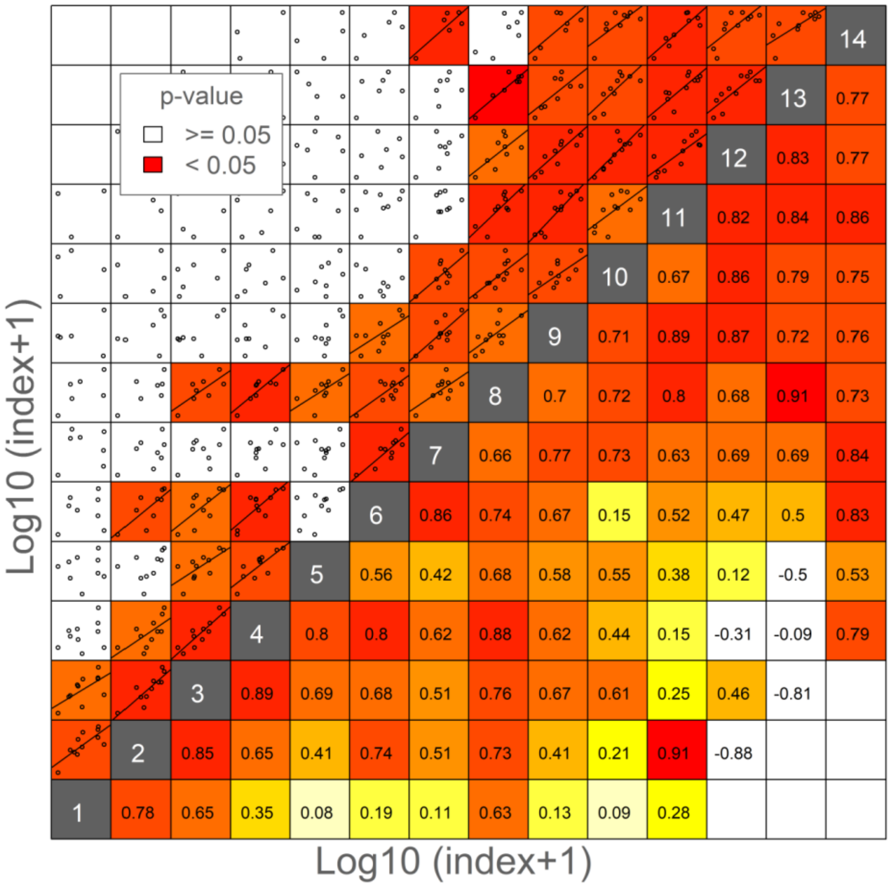


Figure 16. Internal consistency of the of mackerel density index from 2012 to 2023. Ages indicated by white numbers in grey diagonal cells. Statistically significant positive correlations (*p<0.05*) are indicated by regression lines and red cells in upper left half. Correlation coefficients (r) are given in the lower right half.

The swept area method assumes that potential distribution of mackerel outside the survey area – both vertically and horizontally – is a constant percentage of the total biomass. In some years, this assumption may be violated, e.g. mackerel may be distributed below the footrope of the trawl or if the proportion of mackerel outside the survey coverage varies among years. In order to improve the precision of the swept area estimate it would be beneficial to extend the survey coverage further south, such that it covers the southwestern waters south of 60°N, e.g. UK waters.

The standard swept area method using the average horizontal trawl opening by each participating vessel (ranging 63.7-71.7 m; Table 5), assuming that a constant fraction of the mackerel inside the horizontal trawl opening are caught. Further, that if mackerel is distributed below the depth of the trawl (footrope), this fraction is assumed constant from year to year.

As in previous years, there was overlap in the spatio-temporal distribution of mackerel and herring (Figure 11). This overlap occurred mostly between mackerel and Norwegian spring-spawning herring (NSSH) in the western, north-western and north-eastern part of the Norwegian Sea.

4.4 Norwegian spring-spawning herring

In the present preliminary report, no results of herring measurements are presented. A final survey report including these two species will be published in the fall of 2023. Figures 17 – 19, and tables 9 – 11 will be added in the final report.

4.5 Blue whiting

In the present preliminary report, no results of blue whiting measurements are presented. A final survey report including these two species will be published in the fall of 2023. Figures 20 – 22, and tables 12 and 13 will be added in the final report.

4.6 Other species

Lumpfish (*Cyclopterus lumpus*)

Lumpfish was caught in 69% of trawl stations across the five vessels (Figure 23) and where lumpfish was caught, 70% of the catches were ≤10kg. Lumpfish was distributed across the entire survey area, from west of Iceland to the Barents Sea in the northeast, and into the North Sea in the southern part of the covered area. Abundance was greatest north of 71°N, with lower densities in the central Norwegian Sea and mostly absent directly south of Iceland, and south and southwest of the North Sea. The zero line was not hit to the northeast, northwest and west of the survey so it is likely that the distribution of lumpfish extends beyond the survey coverage.

The length of lumpfish caught varied from 4 to 51 cm with a bimodal distribution with the left peak (5-20 cm) likely corresponding to 1-group lumpfish and the right peak consisting of a mixture of age groups (Figure 24). Only a small number of fish were sexed (115 of 1985) but for fish ≥20 cm in which sex was determined, the males (n=15) were 22-29 cm in length. The females (n=100) ranged in length from 21 to 46 cm. Generally, the mean length and mean weight of the lumpfish was highest in Faroese waters, and around Iceland and along the shelf edges of Norway and lowest in the central and northern Norwegian Sea.

A total of 374 fish (126 by R/V "Árni Friðriksson", 149 by M/V "Eros" and 99 by M/V Vendla) between 11 and 49 cm were tagged during the survey (Figure 25).

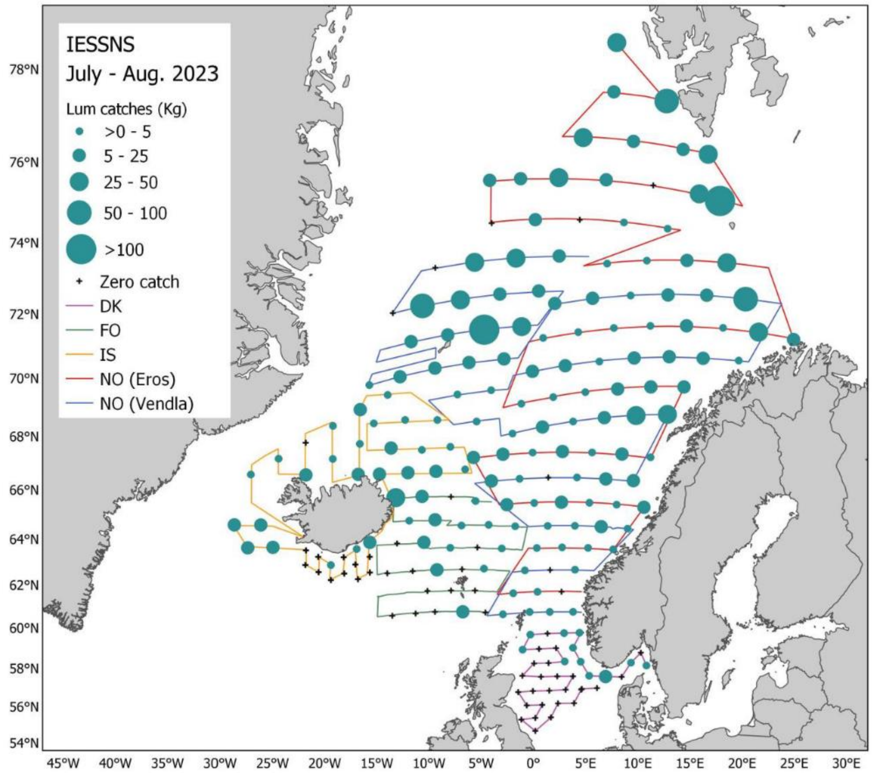


Figure 23. Lumpfish catches at surface trawl stations during IESSNS 2023.

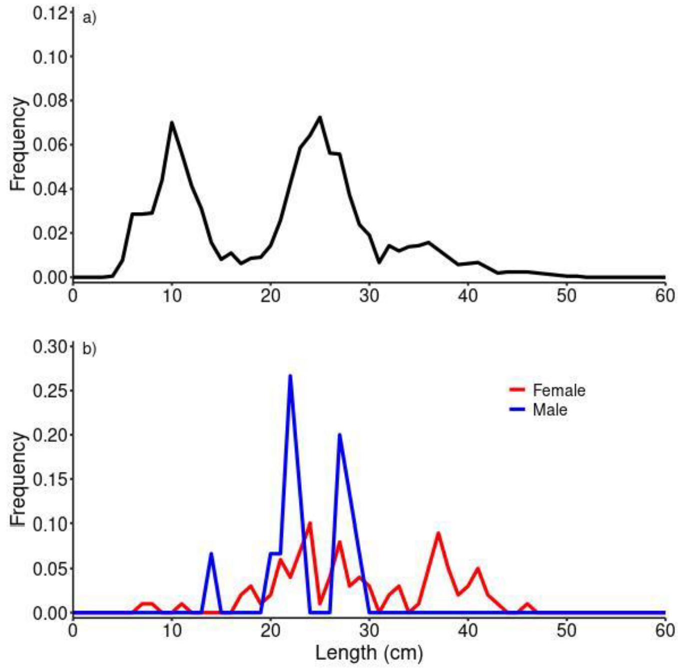


Figure 24. Length distribution of a) all lumpfish caught during the survey and b) length distribution of fish in which sex was determined.

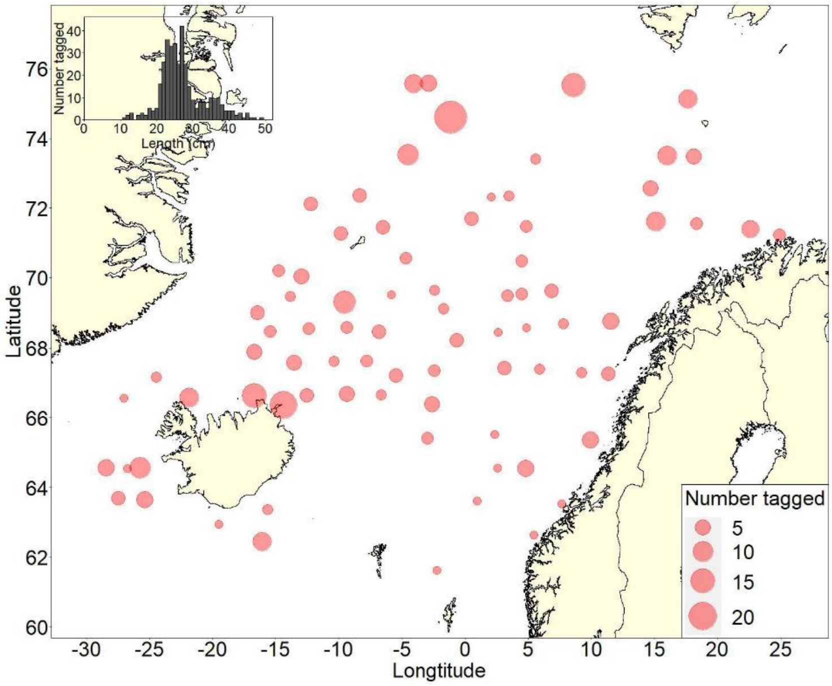


Figure 25. Number tagged, and release location, of lumpfish. Insert shows the length distribution of the tagged fish.

Salmon (*Salmo salar*)

A total of 62 North Atlantic salmon were caught in 38 stations both in coastal and offshore areas from 62°N to 74°N in the upper 30 m of the water column during IESSNS 2023 (Figure 26). The salmon ranged from 0.084 kg to 2.7 kg in weight, dominated by post-smolt and 1 sea-winter individuals. We caught from 1 to 12 salmon during individual surface trawl hauls. The length of the salmon ranged from 20 cm to 82 cm, with the highest fraction between 20 cm and 29 cm.

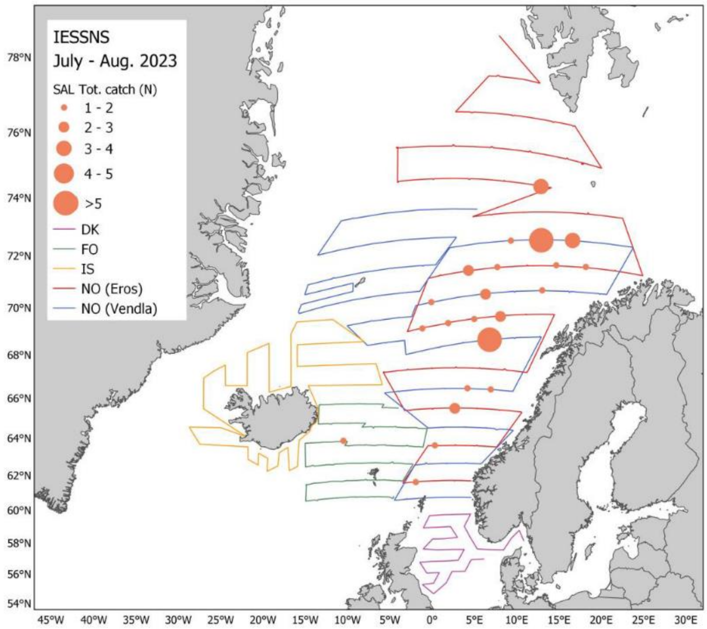


Figure 26. Catches of salmon at surface trawl stations during IESSNS 2023.

Capelin (*Mallotus villosus*)

Capelin was caught in the surface trawl on 29 stations along the cold fronts: North of Iceland, north-northwest of Jan Mayen, northwest of Bear Island and west of Svalbard (Figure 27a). Both juvenile and adult capelin were caught during the survey. The average length ranged from 6.9 to 18.8 cm and average weight ranged from 1,2 to 32.6 g in the trawl hauls. There were more pelagic trawl stations with catches of capelin in the western and northern part of the Jan Mayen.

Polar cod (*Boreogadus saida*)

Polar cod was caught in the surface trawl on 11 stations north and northeast of Iceland (Figure 27b). The catch weight per station ranged from 10 g to 5 kg. The polar cod ranged in total length from 9 cm to 20 cm and in total weight from 5 g to 36 g. Mean length was 13.2 cm (standard deviation = 1.5, n = 225) and mean weight was 15.3 g (standard deviation = 5.4, n = 224). Polar cod was caught in larger area and in greater abundance in 2023 compared to all previous years of the IESSNS survey, hence it was added to the report chapter on other species.

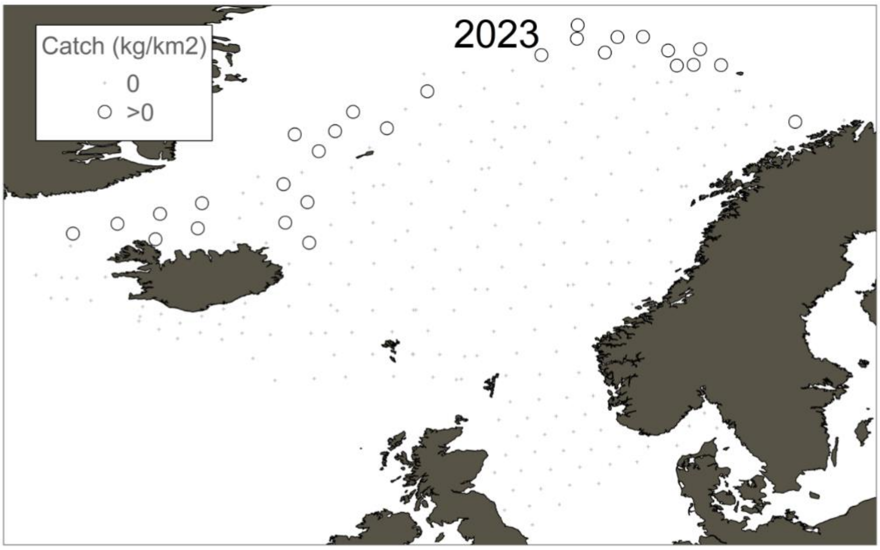


Figure 27a. Presence of capelin in surface trawl stations during IESSNS 2023.

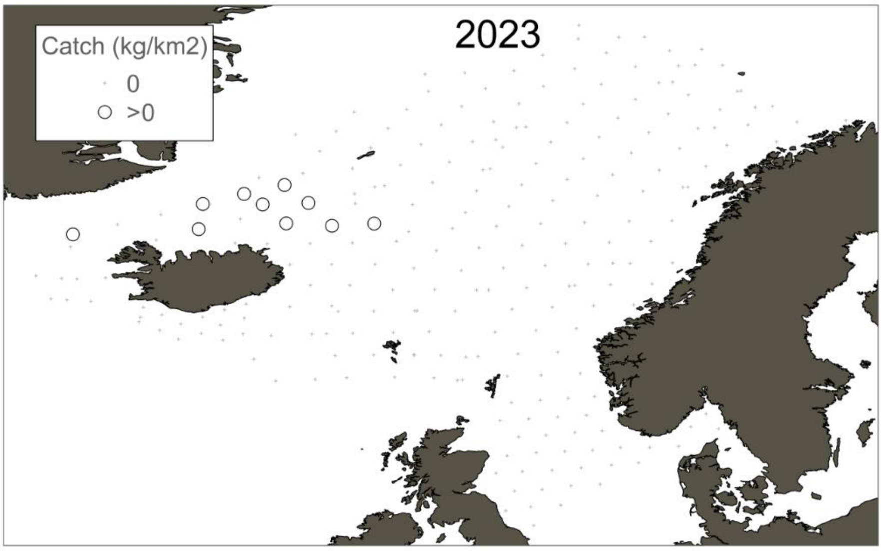


Figure 27b. Presence of polar cod in surface trawl stations during IESSNS 2023.

4.7 Marine Mammals

Opportunistic whale observations were done by M/V "Eros" and M/V "Vendla" from Norway in addition to R/V "Jákup Sverri" from Faroe Islands from 1st July to 3rd August 2023 (Figure 28). Overall, 1078 marine mammals of 10 different species were observed, which was an increase from an overall 711 marine mammals observed in 2022.

The species that were observed included blue whales (*Balaenoptera musculus*), fin whales (*Balaenoptera physalus*), minke whales (*Balaenoptera acutorostrata*), humpback whales (*Megaptera novaeangliae*), Northern bottlenose whales (*Hyperoodon ampullatus*), pilot whales (*Globicephala sp.*), killer whales (*Orcinus orca*), sperm whales (*Physeter macrocephalus*), sei whales (*Baleanoptera borealis*), white sided dolphins (*Lagenorhynchus acutus*) white beaked dolphins (*Lagenorhynchus albirostris*). Basking sharks (*Cetorhinus maximus*) were also observed during the survey. The dominant number of marine mammal observations were found around along the continental shelf west and north of Jan Mayen and in the southwestern and western areas of Svalbard. We observed higher number of marine mammals in the central part of the Norwegian Sea in July 2023 compared with last year. Altogether eight blue whales were observed in the western and northern areas of Jan Mayen. They appeared either solitary or in groups of two individuals, and was most probably feeding on large swarms of amphipods in cold water. Fin whales (n = 82, group size = 1-20 (average group size = 2.5)) and humpback whales (n = 44, group size = 1-50 (average group size = 2.4)) dominated among the large whale species. They were distributed from 64°N to 78.30°N and from 25°E to 15°W and they had hotspot southwest and west of Svalbard as well as west and northwest of Jan Mayen. Few sperm whales (n = 8, group size = 1-2 (average group size = 1.3)) where observed. Killer whales (n = 56, group size = 1-10 (average groups size = 6.2)) dominated in the southern, north-eastern part of the Norwegian Sea, partly overlapping and presumably feeding on NEA mackerel in the upper water masses. Pilot whales (n = 112, group size = 5-100 (average groups size = 37)) where mostly observed in Faroese waters during IESSNS 2023. Five sei whale and 46 northern bottlenose whale were observed in Faroese waters, whereas three basking sharks were observed in Faroese waters and west of Lofoten. White beaked dolphins (n = 123, group size = 1-50 (average group size = 9.5)) were present in the northern part of the Norwegian Sea. Minke whales (n = 22, group size = 1-4 (average group size = 1.4)) were distributed over large areas from western coast of Norway to west of Svalbard, and from 60°N to 77°N, including overlapping and likely feeding on NSS herring in the upper 10-40 m of the water column. There is available a publication summarizing the main results on marine mammals from the IESSNS surveys from 2013 to 2018, with major focus on hot spot areas of fin whales and humpback whales from 2013 to 2018 (Løviknes et al. 2021)

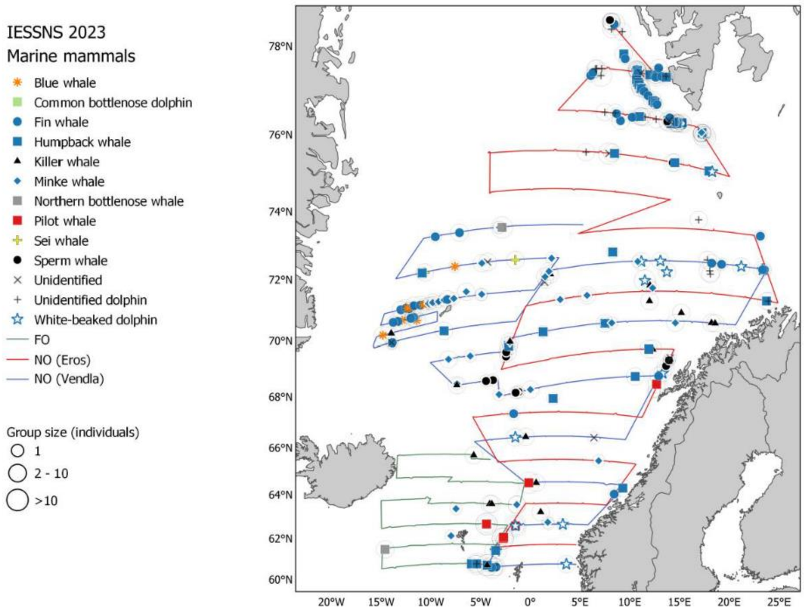


Figure 28. Overview of all marine mammals sighted during IESSNS 2023.

5 Recommendations

The group suggested the following recommendation from WGIPS	To whom
The surveys conducted by Denmark in 2018-2022 have clearly demonstrated that the IESSNS methodology works also for the northern North Sea (i.e. north and west from Doggerbank) and the Skagerrak area deeper than 50 m. The survey provides essential fishery-independent information on the stock during its feeding migration in summer and WGIPS recommends that the Danish survey should continue as a regular annual survey.	WGWIDE, RCG NANSEA

6 Action points for survey participants

Action points	Responsible
Criteria and guidelines should be established for discarding substandard trawl stations using live monitoring of headline, footrope and trawl door vertical depth, and horizontal distance between trawl doors. For predetermined surface trawl station, discarded hauls should be repeated until performance is satisfactory. Explicit guideline for incomplete trawl hauls is to repeat the station or exclude it from future analysis. It is not acceptable to visually estimate mackerel catch, it must be hauled onboard and weighed. If predetermined trawl hauls are not satisfactory according to criteria the station will be excluded from mackerel index calculations, i.e. treated as if it does not exist, but not as a zero mackerel catch station.	All
We encourage registrations of opportunistic marine mammal observations.	All
We should consider calculating the zooplankton index from annually gridded field polygons to extract area-mean time-series. WGINOR is currently working on Norwegian Sea polygons, and further work on this issue will start when their work is finalized.	All
In 2023 the IESSNS survey in the North Sea has been conducted for six consecutive years (2018-2023). It is recommended that a comprehensive report is written about the major results from the NEA mackerel time series from the IESSNS surveys in the North Sea, where an update of the internal consistency between years in the survey for selected age groups is also evaluated. This report should be made available for consideration in the next benchmark. A major aim will be to at some stage evaluate and consider the possibility to include and implement the IESSNS survey in the North Sea as an abundance index used in ICES for NEA mackerel.	DTU-Aqua (KW and co-workers)
Country representatives for the IESSNS survey should rewrite the respective sections (e.g. trawl performance, trawl station data collection) in the survey manual according to the new format by mid-September 2023.	All

7 Survey participants

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9 References

Bachiller E, Utne KR, Jansen T, Huse G. 2018. Bioenergetics modelling of the annual consumption of zooplankton by pelagic fish feeding in the Northeast Atlantic. PLOS ONE 13(1): e0190345. doi.org/10.1371/journal.pone.0190345.

Banzon, V., Smith, T. M., Chin, T. M., Liu, C., and Hankins, W., 2016. A long-term record of blended satellite and in situ sea-surface temperature for climate monitoring, modelling and environmental studies. Earth System Science Data. 8, 165–176, doi:10.5194/essd-8-165-2016.

dos Santos Schmidt, T.C., Slotte, A., Olafsdottir, A.H., Nøttestad, L., Jansen, T., Jacobsen, J.A., Bjarnason, S., Lusseau, S.M., Ono, K., Hølleland, S., Thorsen, A., Sandø, A.B., Kjesbu, O.S. 2023. Poleward spawning of Atlantic mackerel (*Scomber scombrus*) is facilitated by ocean warming but triggered by energy constraints. ICES Journal of Marine Science. DOI: 10.1093/icesjms/fsad098

Foote, K. G., 1987. Fish target strengths for use in echo integrator surveys. Journal of the Acoustical Society of America. 82: 981-987.

Gilbey; J., Utne K.A., Wennevik V. et al. 2021. The early marine distribution of Atlantic salmon in the North-East Atlantic: A genetically informed stocks-specific synthesis. Fish and Fisheries:2021;00:1.-33. DOI:10.1111/faf.12587.

ICES. 2012. Report of the International Bottom Trawl Survey Working Group (IBTSWG), 27–30 March 2012, Lorient, France. ICES CM 2012/SSGESST:03. 323 pp.

ICES 2013a. Report of the Workshop on Northeast Atlantic Mackerel monitoring and methodologies including science and industry involvement (WKNAMMM), 25–28 February 2013, ICES Headquarters, Copenhagen and Hirtshals, Denmark. ICES CM 2013/SSGESST:18. 33 pp.

ICES. 2013b. Report of the Working Group on Improving Use of Survey Data for Assessment and Advice (WGISDAA), 19-21 March 2013, Marine Institute, Dublin, Ireland. ICES CM 2013/SSGESST:07.22 pp.

ICES 2014a. Manual for international pelagic surveys (IPS). Working document of Working Group of International Surveys (WGIPS), Version 1.02 [available at ICES WGIPS sharepoint] 98 pp.

ICES 2014b. Report of the Benchmark Workshop on Pelagic Stocks (WKPELA), 17–21 February 2014, Copenhagen, Denmark. ICES CM 2014/ACOM: 43. 341 pp

ICES. 2017. Report of the Benchmark Workshop on Widely Distributed Stocks (WKWIDE), 30 January-3 February 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:36. 196 pp.

Jansen, T., Post, S., Kristiansen, T., Oskarsson, G.J., Boje, J., MacKenzie, B.R., Broberg, M., Siegstad, H., 2016. Ocean warming expands habitat of a rich natural resource and benefits a national economy. Ecol. Appl. 26: 2021–2032. doi:10.1002/eap.1384

Johnsen, E., Totland, A., Skålevik, Å., Holmin, A.J., Dingsør, G.E., Fuglebakk, E., Handegard, N.O. 2019. StoX: An open source software for marine survey analyses. Methods Ecol Evol. 2019; 10:1523–1528.

Jolly, G. M., and I. Hampton. 1990. A stratified random transect design for acoustic surveys of fish stocks. Canadian Journal of Fisheries and Aquaculture Science. 47: 1282-1291.

Løviknes; S.., Jensen, K.H., Krafft, B.A., Nøttestad, L. 2021. Feeding hotspots and distribution of fin and humpback whales in the Norwegian Sea from 2013 to 2018. Frontiers in Marine Science 8:632720. doi.org/10.3389/fmars.2021.632720

Nikolioudakis, N., Skaug, H. J., Olafsdottir, A. H., Jansen, T., Jacobsen, J. A., and Enberg, K. 2019. Drivers of the summer-distribution of Northeast Atlantic mackerel (Scomber scombrus) in the Nordic Seas from 2011 to 2017; a Bayesian hierarchical modelling approach. ICES Journal of Marine Science. 76(2): 530-548. doi:10.1093/icesjms/fsy085

Nøttestad, L., Utne, K.R., Óskarsson, G. J., Jónsson, S. Þ., Jacobsen, J. A., Tangen, Ø., Anthonypillai, V., Aanes, S., Vølstad, J.H., Bernasconi, M., Debes, H., Smith, L., Sveinbjörnsson, S., Holst, J.C., Jansen, T. and Slotte, A. 2016. Quantifying changes in abundance, biomass and spatial distribution of Northeast Atlantic (NEA) mackerel (*Scomber scombrus*) in the Nordic Seas from 2007 to 2014. ICES Journal of Marine Science. 73(2): 359-373. doi:10.1093/icesjms/fsv218.

Ólafsdóttir, A., Utne, K.R., Jansen, T., Jacobsen, J.A., Nøttestad, L., Óskarsson, G.J., Slotte, A., Melle, W. 2019. Geographical expansion of Northeast Atlantic mackerel (Scomber scombrus) in the Nordic Seas from 2007 - 2014 was primarily driven by stock size and constrained by temperature. Deep-Sea Research Part II. 159, 152-168.

Rosen, S., Jørgensen, T., Hammersland-White, Darren, Holst, J.C. 2013. Canadian Journal of Fisheries and Aquatic Sciences. 70(10):1456-1467. doi.org/10.1139/cjfas-2013-0124.

Salthaug, A., Aanes, S., Johnsen, E., Utne, K. R., Nøttestad, L., and Slotte, A. 2017. Estimating Northeast Atlantic mackerel abundance from IESSNS with StoX. Working Document (WD) for WGIPS 2017 and WKWIDE 2017. 103 pp.

Utne K., Diaz Pauli, B., Haugland, M. et al. 2021. Starving at sea? Poor feeding opportunities for salmon post-smolts in the Northeast Atlantic Ocean. ICES Journal of Marine Science (in press).

Valdemarsen, J.W., J.A. Jacobsen, G.J. Óskarsson, K.R. Utne, H.A. Einarsson, S. Sveinbjörnsson, L. Smith, K. Zachariassen and L. Nøttestad 2014. Swept area estimation of the North East Atlantic mackerel stock using a standardized surface trawling technique. Working Document (WD) to ICES WKPELA. 14 pp.

10 Appendices

Appendix 1

Denmark joined the IESSNS in 2018 for the first time extending the original survey area into the North Sea. The commercial fishing vessels "Ceton S205" was used. No problems applying the IESSNS methods were encountered. Area coverage, however, was restricted to the northern part of the North Sea at water depths larger 50 m. No plankton samples were taken, and no acoustic data were recorded because this is covered by the HERAS survey in June/July in this area.

Based on the experiences made in the previous years, new limits for the stratum in the North Sea were defined in 2022 (Fig. 2, stratum 13). The northern limit for the North Sea and the Skagerrak were defined as 60 °N and 59 °N, respectively. The western geographical limit in the North Sea was set to 1 ° 30′ W in the north and 2 ° 30′ W further south following the UK coastline where the Inner Moray Firth and the Firth of Forth were excluded because mackerel was not recorded there and a high abundance of 0-group gadoids, sandeel and other species makes a quantitative analysis of the catches very time consuming. The easter limit in the Skagerrak was set to 11 °E, and the southern limit in the North Sea was approximated by the 50 m isobath, which is about the shallowest depth limit for a safe setting of the Multpelt 832 trawl.

In 2023, 36 stations were taken (PT and CTD). Average mackerel catch amounted to 2362 kg/km^2, which was considerably higher than in the previous year (2022: 1689 kg/km^2) and is the second highest in the time series (2021: 2429 kg/km^2, 2020: 1318 kg/km^2, 2019: 1009 kg/km^2, 2018: 1743 kg/km^2) (Fig. A1-1). The length and age composition indicate a relative high amount of small (< 25 cm) individuals and the abundance of older (≥ age 3) mackerel was higher than in the previous years (Fig. A1-2).

The StoX (version 3.6.1) baseline estimates of mackerel biomass and abundance in the North Sea for 2023 were 650 371 tonnes and 3.3 billion individuals (Table A1-1) which is a 27 % higher biomass and a 40 % higher abundance than last year. The biomass and abundance estimates are based on the stratum limits as shown in Fig. 2 (stratum 13). The area of this polygon is 285 781 km^2.

Catches curves indicate that all ages including age 1 and 2 are well represented in the survey data, and the 2022-year class is the highest at age 1 in the time series (Fig. A1-3).

The internal consistency plots (Fig. A1-4), however, do not show any significant correlations. This is likely due to the low number of observations which are so far available. Furthermore, interannual variations in the migration of the cohorts in and out of the North Sea may have an effect as well.

Table A1-1. StoX (version 3.6.1) baseline estimates of age segregated and length segregated mackerel indices for the North Sea in 2023.

	Age in years / Year class													Number	Biomass	Mean
Length	1	2	3	4	5	6	7	8	9	10	11	12	13			weight
(cm)	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	(10^6)	(ton)	(g)
17-18																
18-19																
19-20																
20-21	10.7													10.7	800	75
21-22	151.2													151.2	12122	80
22-23	605.8													605.8	55116	91
23-24	572.8													572.8	56187	98
24-25	258.9													258.9	29431	114
25-26	77.8													77.8	9934	128
26-27	50.3													50.3	7418	148
27-28	33.3	4.6												38.0	6594	174
28-29	58.8	34.0												92.8	18114	195
29-30	71.8	49.7												121.5	26646	219
30-31	55.9	93.6	0.4											149.9	36760	245
31-32	18.5	195.4	18.3	0.7										232.9	61810	265
32-33		256.6	93.9	4.7	3.0									358.2	107294	299
33-34		75.9	159.1	53.6										288.5	92445	320
34-35		0.6	69.5	53.6	25.5	2.7								151.9	52262	344
35-36			7.2	13.2	19.4	18.2	13.6	1.4						73.1	26473	362
36-37			0.8	1.5	19.7	21.2	4.3	2.1						49.6	19162	386
37-38					2.5	10.8	6.7	6.2	1.3	0.1				27.6	11670	423
38-39					1.6	0.4	6.5	12.7	0.7	0.7	0.2	0.2		23.0	10843	472
39-40					0.8		0.8	3.1	3.8	0.3	0.3	0.1		9.1	4421	485
40-41							0.8	1.4		0.1	0.7	0.3	0.3	3.6	2015	560
41-42									0.1	0.1	0.6			0.8	486	573
42-43														0.0	0	
43-44									1.1					1.1	915	858
44-45																
TSN (mill)	1965.8	710.3	349.1	127.4	72.5	53.3	32.6	26.9	7.0	1.4	1.7	0.5	0.3	3,349	648919	
TSB (ton)	222558	194721	110530	42839	26509	20636	13029	12420	3690	658	911	265	153			
Mean length (cm)	23.5	31.1	32.9	33.6	35.0	35.8	36.4	37.7	39.2	38.6	40.0	39.2	40.0			
Mean weight (g)	113	274	317	336	366	387	399	462	530	476	522	494	476			

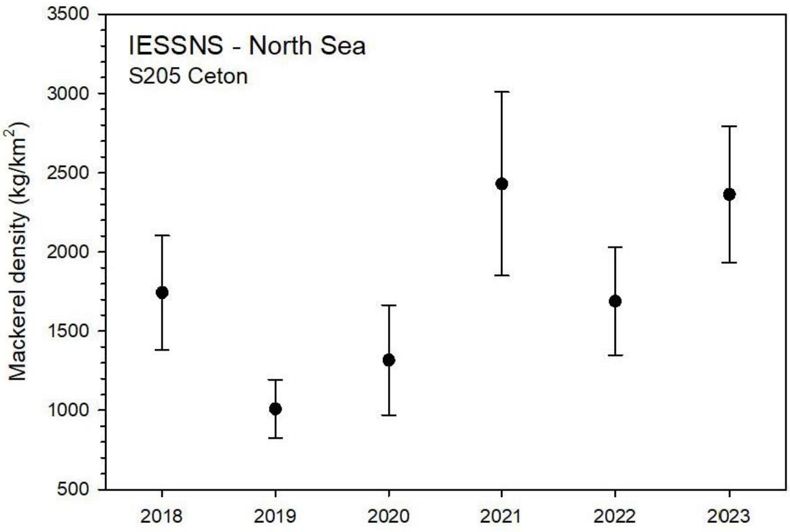

Fig. A1-1. Biomass density (mean and standard error) of mackerel in the North Sea 2018 to 2023.

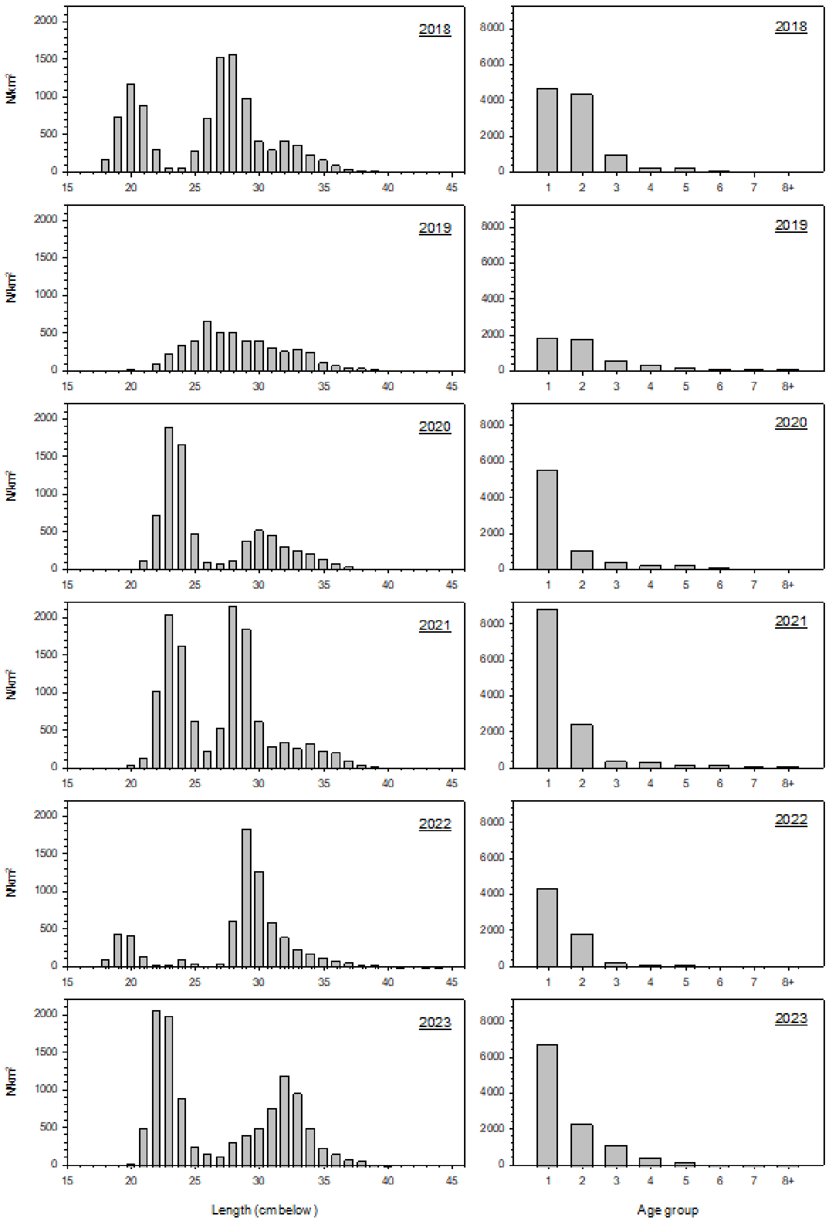

Fig. A1-2. Comparison of length and age distribution of mackerel in the North Sea 2018 to 2023.

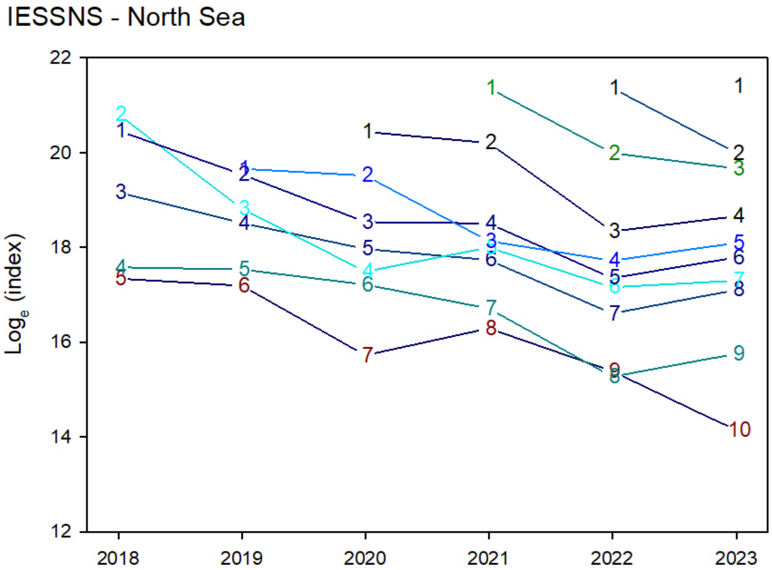

Fig. A1-3. Catch curves for mackerel year classes 2013 to 2022 in the North Sea (lines represents cohorts, numbers denote ages).

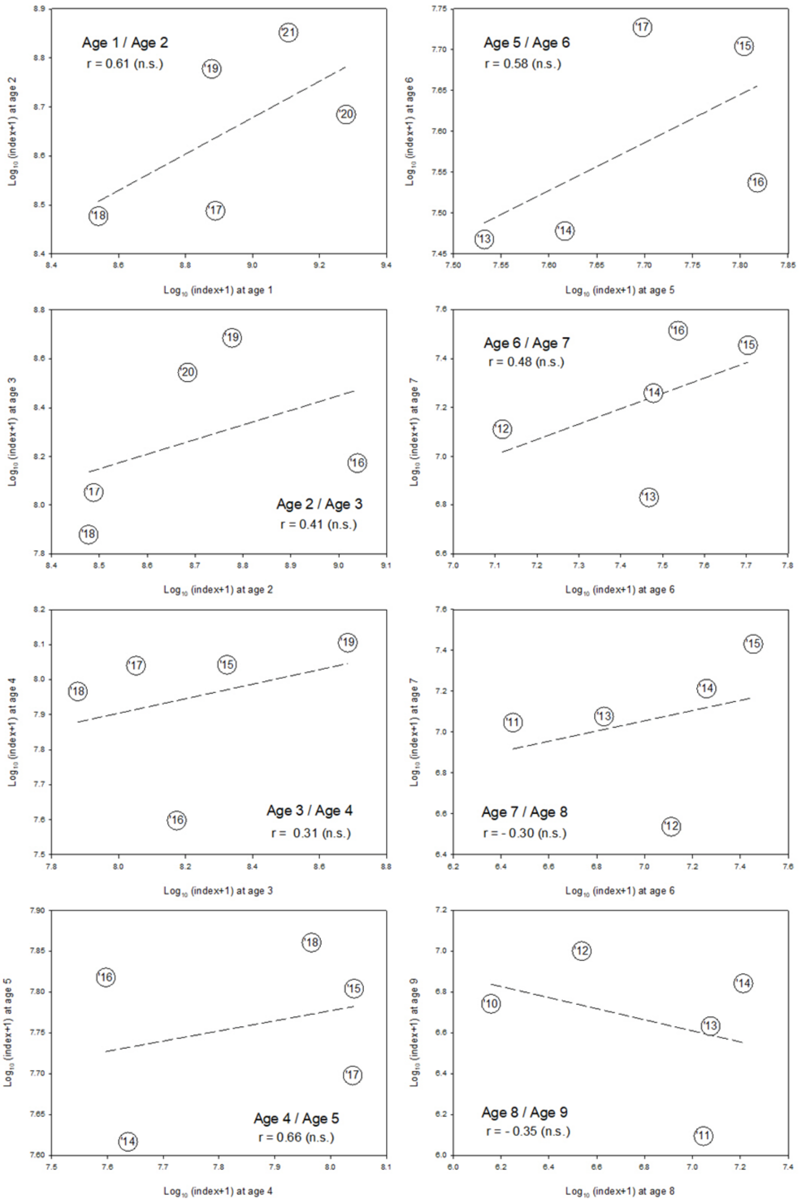

Fig. A1-4. Internal consistency of mackerel density indices ages 1 to 9 for the North Sea from 2018 to 2023 (numbers in symbols indicate 2000'er year classes).

Appendix 2

The mackerel index is calculated on all valid surface stations. That means, that invalid and potential extra surface stations and deeper stations need to be excluded. Below is the exclusion list used when calculating the mackerel abundance index for IESSNS 2023.

Vessel	Country	Horizontal trawl opening (m)	Exclusion list	
			Cruise	Stations
Vendla	Norway	65.1	2023203003	53, 59, 69, 76, 77, 80, 89, 94, 100, 105, 110
Eros	Norway	71.7	202204002	12, 19, 42, 47, 51, 57, 58, 62, 64, 65, 70, 72
R/V Árni Friðriksson	Iceland	68.4	A8-2023	280, 281, 315, 318, 321
R/V Jákup Sverri	Faroe Islands	64.1	2334	21, 28, 37, 45*
Ceton	Denmark	69.7	IESSNS2023	9,30

* Observe that in PGNAPES and the national database station numbers are 4-digit numbers preceded by 2230 (e.g. '22300005')

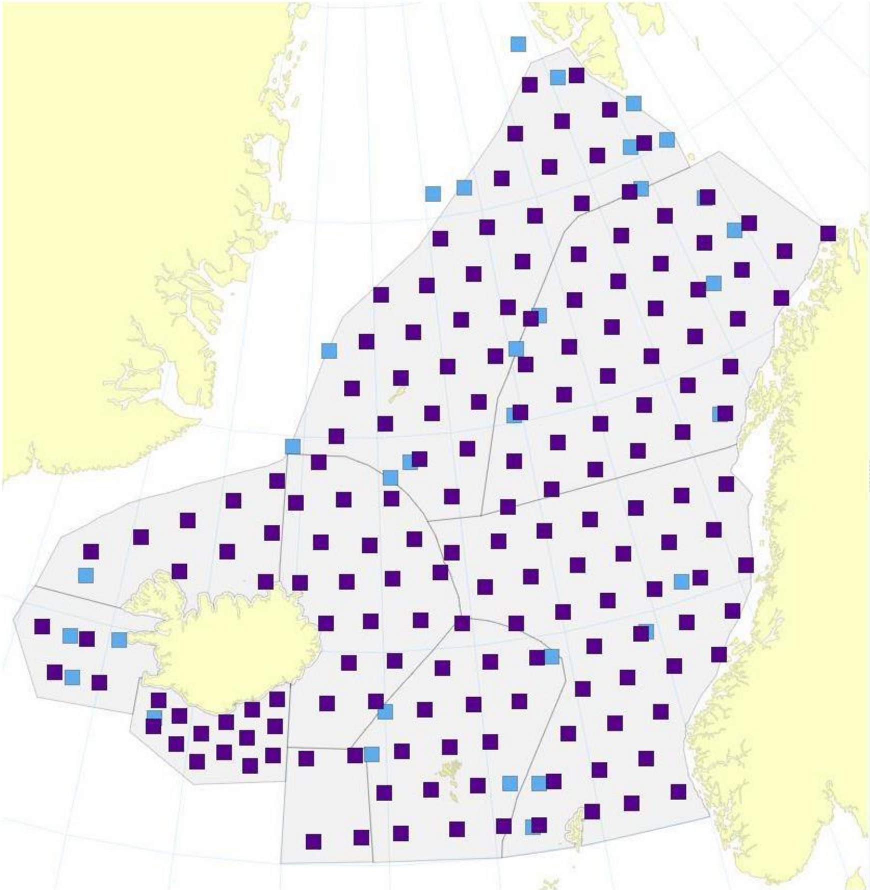

Figure A2-1. IESSNS 2023. Surface trawl stations included (filled dark blue rectangle) and excluded (filled light blue rectangle) in calculations of mackerel age segregated index used in the assessment. Strata boundary also displayed (grey solid lines).

Appendix 3

Horizontal trawl opening of the Multpelt 832 trawl is a function of trawl door spread and tow speed (Table 6 in the 2022 report). The estimates in table 6 are originally based on flume tank simulations in 2013 (Hirtshals, Denmark) where two formulas were empirically derived for two towing speeds, 4.5 and 5 knots:

Towing speed 4.5 knots: Horizontal opening (m) = 0.441 * Door spread (m) + 13.094

Towing speed 5.0 knots: Horizontal opening (m) = 0.3959 * Door spread (m) + 20.094

In 2017, the towing speed range was increased to 5.2 knots, i.e. an extrapolation of the trawl opening as a function of door spread and speed was performed. In 2022 the towing speed range was further extended down to 4.3 knots and up to 5.5 knots, using a kriging gridding method, see figure A4-1. In 2023, the trawl opening was extended to 135m (Table 6).

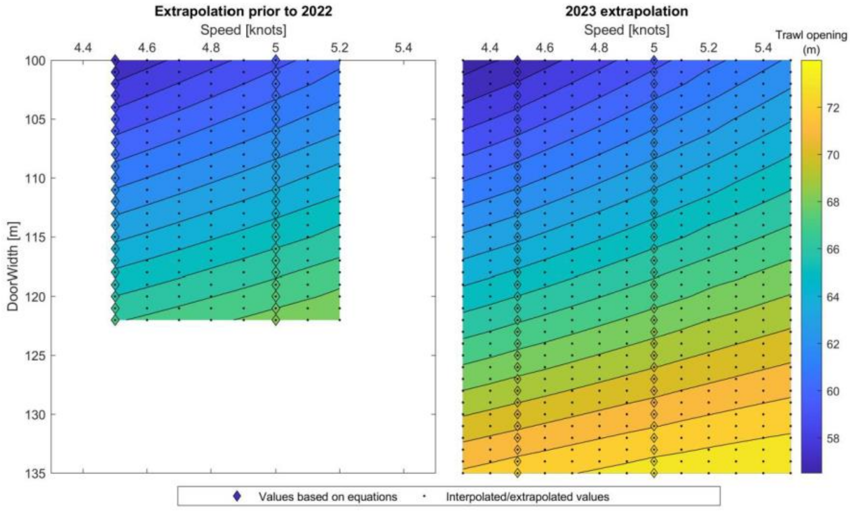

Figure A3-1. Table 6 in the report shown as a plot.

Working document 01, WGWIDE 2023

PFA self-sampling report for WGWIDE 2023

Niels Hintzen, 11/07/2023 14:06:54

PFA report 2023_07

Executive summary

The Pelagic Freezer-trawler Association (PFA) is an association that has nine member companies that together operate 19 (in 2022) freezer trawlers in six European countries (www.pelagicfish.eu). In 2015, the PFA has initiated a self-sampling program that expands the ongoing monitoring programs on board of pelagic freezer-trawlers aimed at assessing the quality of fish. The expansion in the self-sampling program consists of recording of haul information, recording the species compositions by haul and regularly taking length measurements from the catch. The self-sampling is carried out by the vessel quality managers on board of the vessels, who have a long experience in assessing the quality of fish, and by the skippers/officers with respect to the haul information. The scientific coordination of the self-sampling program is carried out by Niels Hintzen (PFA chief science officer) with support of Lina de Nijs and Floor Quirijns (contractor). The self-sampling program has been incrementally implemented in the fishery and by 2018 all vessels in the PFA fleet participated in the self-sampling.

This report for WGWIDE presents an overview of the results of the Pelagic Freezer-Trawler Association (PFA) self-sampling program for the fisheries for widely-distributed pelagic stocks: Northeast Atlantic mackerel, Blue whiting, Horse mackerel and Atlanto-scandian herring (herring caught north of 62 degrees). The selection of hauls to be included in the analyses was based on first summing all catches by vessel, trip, species and week. For each vessel-trip-species-week combination, the proportion of the species in the catch were calculated. The following filter criteria have applied to the weekly data:

- for horse mackerel: latitude > 45, proportion in the catch > 10%, weekly catch > 10 tonnes
- for mackerel : latitude > 45, proportion in the catch > 10%, weekly catch > 10 tonnes
- for blue whiting : latitude > 50, proportion in the catch > 10%, weekly catch > 10 tonnes
- for herring : division = 27.2.a, proportion in the catch > 10%, weekly catch > 10 tonnes

Trips from 2017 up to 02/06/2023 have been processed for this overview. Pelagic fisheries within the Pelagic Freezer-trawler Association are carried out by vessels from different countries. Overall, around 48% of the catch volume of trips in this overview were taken by Dutch trawlers, 19% German trawlers, 13% UK trawlers and 19% other countries. Blue whiting constitutes the majority of the catch in those trips (57%), followed by mackerel (25%) and horse mackerel (10%). Atlanto-scandian herring

only constitutes around 1% of the volume in the PFA widely distributed fishery. Note that the North Sea herring fishery is not included in this overview.

The **Mackerel fishery** takes place from October through to March of the subsequent year. Bycatches of mackerel may also occur during other fisheries,e.g. for horse mackerel or herring. Overall, the self-sampling activities for the mackerel fisheries during the years 2017 - 2023 (up to 02/06/2023) covered 507 fishing trips with 6977 hauls, a total catch of 416958 tonnes and 112296 individual length measurements. The main fishing areas are ICES division 27.4.a and division 27.6.a. Compared to the previous years, mackerel in the catch in 2022 have been relatively large with a median length of 36.3 cm. The median weight at 400 grams was among average compared to preceding years.

The **Western horse mackerel fishery** takes place from October through to March of the subsequent year. Overall, the self-sampling activities for the Western horse mackerel fisheries during the years 2017 - 2023 (up to 02/06/2023) covered 244 fishing trips with 3096 hauls, a total catch of 116548 tonnes and 121815 individual length measurements. The main fishing areas are ICES division 27.6.a, division 27.7.b and division 27.7.j. Western horse mackerel have a wide range in the length distributions in the catch. Median lengths have fluctuated between 22.2 and 30.0 cm.

The **North Sea horse mackerel fishery** takes place from October through to January of the subsequent year. Overall, the self-sampling activities for the North Sea horse mackerel fisheries during the years 2017 - 2023 (up to 02/06/2023) covered 120 fishing trips with 969 hauls, a total catch of 46562 tonnes and 38981 individual length measurements. The main fishing areas is ICES division 27.7.d with some minor catches in 27.4.c. Catches in division 27.4.a have been counted as Western Horse mackerel. North Sea horse mackerel have a narrow range in the length distributions in the catch. Median lengths have fluctuated between 21.5 and 23.9 cm.

The **blue whiting** fishery takes place from February through to May although some minor fisheries for blue whiting may remain over the other months. Overall, the self-sampling activities for the horse mackerel fisheries during the years 2017 - 2023 (up to 02/06/2023) covered 356 fishing trips with 9426 hauls, a total catch of 945762 tonnes and 554926 individual length measurements. The main fishing areas are ICES division 27.6.a, division 27.7.c and division 27.7.k. Compared to the previous years, blue whiting in the catches during 2020-2022 have been relatively large with a median length of 27.5 cm compared to 24.2-27.1 in the preceding years.

The fishery for **Atlanto-scandian herring** (ASH) is a relatively smaller fishery for PFA and takes place mostly in October. Overall, the self-sampling activities for the Atlanto-scandian herring fisheries during the years 2017 - 2023 (up to 02/06/2023) covered 27 fishing trips with 249 hauls, a total catch of 16374 tonnes and 4634 individual length measurements. Only the herring fishery in ICES division 27.2.a is considered for ASH. Note that there are herring catches in other divisions within the selected trips. These are trips where North Sea herring has been fished with some bycatches of mackerel for example. Atlanto-scandian herring have a relatively narrow range in the length distributions in the catch. Median lengths have been between 30.8 and 35.2 cm.

In this 2023 self-sampling report, a standardized CPUE calculation has been included again for for most of the stocks. The standardized CPUE is based on a GLM model with a negative binomial distribution. The response variable is the catch by week and vessel, with an offset of the log effort (number of fishing days per week) and explanatory variables year, GT category, month, division and depth category. An assumed technical efficiency increase of 2.5% per year has been included in the fitting of the model (Rousseau et al 2019) Due to changes in the fishery, e.g. low TAC / closure of the Western horse mackerel fishery, CPUEs are also low as most catches are reflective of bycatch rather than targeted fishery catches.

1 Introduction

The Pelagic Freezer-trawler Association (PFA) is an association that has nine member companies that together operate 18 freezer trawlers (in 2022) in six European countries (www.pelagicfish.eu). In 2015, the PFA has initiated a self-sampling program that expands the ongoing monitoring programs on board of pelagic freezer-trawlers by the specialized crew of the vessels. The primary objective of that monitoring program is to assess the quality of fish. The expansion in the self-sampling program consists of recording of haul information, recording the species compositions per haul and regularly taking random length-samples from the catch. The self-sampling is carried out by the vessel quality managers on board of the vessels, who have a long experience in assessing the quality of fish, and by the skippers/officers with respect to the haul information. The scientific coordination of the self-sampling program is carried out by Niels Hintzen (PFA chief science officer) with support of Lina de Nijs and Floor Quirijns (contractor).

2 Overview of self-sampling methodology

The PFA self-sampling program has been implemented incrementally on many vessels that belong to the members of the PFA. The self-sampling program is designed in such a way that it follows as closely as possible the working practices on board of the different vessels and that it delivers relevant information for documenting the performance of the fishery and to assist stock assessments of the stocks involved. The following main elements can be distinguished in the self-sampling protocol:

- haul information (date, time, position, weather conditions, environmental conditions, gear attributed, estimated catch, optionally: species composition)
- batch information (total catch per batch=production unit, including variables like species, average size, average weight, fat content, gonads y/n and stomach fill)
- linking batch and haul information (essentially a key of how much of a batch is caught in which of the hauls)
- length information (length frequency measurements, either by batch or by haul)

The self-sampling information is collected using standardized Excel worksheets. Each participating vessel will send in the information collected during a trip by the end of the trip. The data will be checked and added to the database by Lina de Nijs, who will also generate standardized trip reports (using RMarkdown) which will be sent back to the vessel within one or two days. The compiled data for all vessels is being used for specific purposes, e.g. reporting to expert groups, addressing specific fishery or biological questions and supporting detailed biological studies. The PFA publishes an annual report on the self-sampling program.

A major feature of the PFA self-sampling program is that it is tuned to the capacity of the vessel-crew to collect certain kinds of data. Depending on the number of crew and the space available on the vessel, certain types of measurements can or cannot be carried out. That is why the program is essentially tuned to each vessel separately. And that is also the reason that the totals presented in this report can be somewhat different dependent on which variable is used. For example the estimate of total catch is different from the sum of the catch per species because not all vessels have supplied data on the species composition of the catch.

In order to supply relevant information to WGWIDE, the PFA self-sampling data has been filtered using the following approach. First, all catches per vessel, trip and species have been summed by week. For each vessel-trip-species-week combination, the proportion of the species in the catch were calculated. Then the following filter criteria have applied to the weekly data:

- for horse mackerel: latitude > 45, proportion in the catch > 10%, catch > 10 tonnes
- for mackerel : latitude > 45, proportion in the catch > 10%, catch > 10 tonnes

- for blue whiting : latitude > 50, proportion in the catch > 10%, catch > 10 tonnes
- for herring : division = 27.2.a, proportion in the catch > 10%, catch > 10 tonnes

For this report, data have been processed for 2017 - 2023 (up to 02/06/2023).

3 Results

3.1 General

An overview of all the self-sampled trips for mac, hom, whb, her_ash in 27.2.a, 27.4.a, 27.6.a, 27.7.b, 27.7.j, 27.7.h, 27.4.c, 27.7.d, 27.7.c, 27.7.k, 27.5.b, 27.8.d. The percentage non-target species is defined as the catch of non-pelagic species relative to the catch of pelagic species.

year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nontarget	nlength	nbio
2017	12	62	842	1,783	178,162	212	0.25%	91,881	0
2018	16	86	1,220	2,679	253,474	208	0.22%	171,600	641
2019	16	97	1,233	2,668	225,059	183	0.29%	126,772	1,055
2020	17	113	1,434	3,051	306,172	214	0.35%	167,340	2,379
2021	19	119	1,401	2,881	282,898	202	0.52%	140,339	1,433
2022	18	114	1,259	2,736	237,438	189	0.69%	96,762	4,150
2023*	18	68	785	1,934	189,832	242	0.18%	120,862	662
(all)		659	8,174	17,732	1,673,036			915,557	10,320

*Table 3.1.1: PFA fisheries for widely distributed species Self-sampling Summary of number of vessels, trips, days, hauls, catch (tonnes), catch per day and number of fish measured. * denotes incomplete year*

Catch and number of self-sampled hauls by year and division

division	2017	2018	2019	2020	2021	2022	2023*	all	perc
27.6.a	75,493	126,130	116,241	125,729	113,522	61,529	83,551	702,195	42.0%
27.4.a	23,842	36,129	39,494	63,061	61,135	64,700	11,022	299,383	17.9%
27.7.c	29,371	30,524	26,772	44,548	28,885	20,391	9,471	189,962	11.4%
27.7.k	96	7,646	2,036	11,339	16,684	29,327	77,358	144,486	8.6%
27.7.j	663	3,648	8,635	16,322	14,976	17,193	2,061	63,499	3.8%
27.7.d	8,404	9,853	10,373	10,763	9,934	5,463	4,563	59,353	3.5%
27.2.a	20,469	18,096	4,607	10,000	2,595	1,028	0	56,795	3.4%
27.7.b	8,605	5,324	10,530	11,649	13,205	6,007	145	55,464	3.3%
27.5.b	8,061	7,933	3,925	10,277	8,689	9,970	70	48,925	2.9%
27.8.d	275	237	173	889	802	17,913	876	21,165	1.3%
27.7.h	1,330	6,571	1,236	111	9,012	1,503	0	19,761	1.2%
27.4.c	1,555	1,385	1,036	1,483	3,460	2,414	715	12,048	0.7%
(all)	178,162	253,474	225,059	306,172	282,898	237,438	189,832	1,673,036	100.0%

division	2017	2018	2019	2020	2021	2022	2023*	all	perc
27.6.a	668	1,267	1,281	1,209	966	740	948	7,079	39.9%
27.4.a	191	374	436	548	560	676	111	2,896	16.3%
27.7.c	255	243	252	328	255	154	74	1,561	8.8%
27.7.k	3	59	17	95	131	244	659	1,208	6.8%
27.7.d	153	187	187	187	206	157	103	1,180	6.7%
27.7.j	17	60	137	208	289	320	14	1,045	5.9%
27.7.b	139	88	175	207	202	88	2	901	5.1%
27.2.a	237	207	86	142	24	24	0	720	4.1%
27.5.b	66	82	38	87	54	70	1	398	2.2%
27.7.h	30	94	24	6	144	50	0	348	2.0%
27.4.c	22	16	25	21	55	54	14	207	1.2%
27.8.d	2	2	10	13	7	159	8	201	1.1%
(all)	1,783	2,679	2,668	3,051	2,893	2,736	1,934	17,744	100.0%

*Table 3.1.2: PFA fisheries for widely distributed species Self-sampling Summary of catch (top) and number of hauls (bottom) per year and division. * denotes incomplete year*

Catch and number of self-sampled hauls by year and month

month	2017	2018	2019	2020	2021	2022	2023*	all	perc
Jan	28,644	25,647	35,499	37,485	51,537	40,516	46,091	265,420	15.9%
Feb	19,390	32,600	32,829	28,300	31,967	44,851	58,858	248,795	14.9%
Mar	29,642	32,910	27,992	48,658	36,936	40,093	46,958	263,188	15.7%
Apr	28,510	58,665	28,857	66,042	29,472	25,878	26,738	264,163	15.8%
May	12,367	30,227	21,332	29,189	14,466	8,521	10,748	126,850	7.6%
Jun	0	6,866	1,498	4,219	2,467	0	438	15,488	0.9%
Jul	665	791	6,185	1,566	12,330	1,174	0	22,711	1.4%
Aug	6,545	4,551	3,844	4,234	4,779	3,467	0	27,420	1.6%
Sep	9,898	8,334	7,775	12,586	9,134	12,297	0	60,024	3.6%
Oct	17,478	22,975	25,570	27,648	39,924	27,883	0	161,478	9.7%
Nov	21,875	20,385	22,225	27,061	30,033	28,894	0	150,472	9.0%
Dec	3,148	9,522	11,453	19,184	19,853	3,866	0	67,027	4.0%
(all)	178,162	253,474	225,059	306,172	282,898	237,438	189,832	1,673,036	100.0%

month	2017	2018	2019	2020	2021	2022	2023*	all	perc
Jan	311	309	452	355	568	474	469	2,938	16.6%
Feb	207	325	362	287	344	435	525	2,485	14.0%
Mar	227	299	314	422	333	389	464	2,448	13.8%
Apr	201	494	289	574	240	359	306	2,463	13.9%
May	145	372	250	312	167	144	164	1,554	8.8%
Jun	0	77	23	97	42	0	6	245	1.4%
Jul	12	10	75	26	113	19	0	255	1.4%
Aug	58	39	41	53	33	30	0	254	1.4%
Sep	130	145	149	154	187	177	0	942	5.3%
Oct	198	232	306	296	398	370	0	1,800	10.1%
Nov	269	291	318	331	305	306	0	1,820	10.3%
Dec	25	86	89	144	163	33	0	540	3.0%
(all)	1,783	2,679	2,668	3,051	2,893	2,736	1,934	17,744	100.0%

Table 3.1.3: PFA fisheries for widely distributed species Self-sampling summary of catch (top) and number of hauls (bottom) per year and month.

Catch and number of self-sampled hauls by year and country (flag)

flag	2017	2018	2019	2020	2021	2022	2023*	all	perc
DEU	27,500	55,468	40,385	69,764	54,075	35,977	43,857	327,027	19.5%
FR	0	11,981	19,356	14,739	12,257	14,124	11,586	84,043	5.0%
LIT	0	0	1,414	13,744	23,150	10,566	14,915	63,788	3.8%
NL	114,844	139,403	107,049	117,284	124,972	126,082	83,262	812,896	48.6%
POL	0	15,966	28,044	54,615	29,675	16,202	18,975	163,478	9.8%
UK	35,818	30,657	28,811	36,026	35,341	34,487	17,237	218,376	13.1%
NA	0	0	0	0	3,428	0	0	3,428	0.2%
(all)	178,162	253,474	225,059	306,172	282,898	237,438	189,832	1,673,036	100.0%

flag	2017	2018	2019	2020	2021	2022	2023*	all	perc
DEU	276	637	456	633	463	376	446	3,287	18.5%
FR	0	237	357	245	205	234	186	1,464	8.3%
LIT	0	0	34	142	165	69	104	514	2.9%
NL	1,177	1,403	1,318	1,374	1,392	1,489	842	8,995	50.7%
POL	0	111	189	323	187	146	169	1,125	6.3%
UK	330	291	314	334	394	422	187	2,272	12.8%
NA	0	0	0	0	75	0	0	75	0.4%
(all)	1,783	2,679	2,668	3,051	2,881	2,736	1,934	17,732	100.0%

Table 3.1.4: PFA fisheries for widely distributed species Self-sampling summary of catch (top) and number of hauls (bottom) per year and month.

Catch by species and year

species	english_name	scientific_name	2017	2018	2019	2020	2021	2022	2023	all	perc
whb	blue whiting	Micromesistius poutassou	79,108	154,733	113,434	174,971	149,988	122,877	150,653	945,763	56.5%
mac	mackerel	Scomber scombrus	63,279	55,989	54,005	84,855	69,094	63,097	26,639	416,958	24.9%
hom	horse mackerel	Trachurus trachurus	20,874	28,501	31,565	25,061	34,130	20,381	2,599	163,112	9.7%
her	herring	Clupea harengus	6,870	7,851	17,286	9,154	19,912	18,615	3,189	82,876	5.0%
arg	argentines	Argentina spp	2,596	4,097	4,566	7,036	5,457	9,595	5,449	38,794	2.3%
her_ash	NA	NA	4,913	1,367	3,373	3,563	2,379	778	0	16,375	1.0%
boc	boarfish	Capros aper	245	153	288	603	846	744	28	2,907	0.2%
pil	pilchard	Sardina pilchardus	61	371	155	32	325	449	970	2,364	0.1%
hke	hake	Merluccius merluccius	107	270	197	181	240	329	131	1,456	0.1%
spr	sprat	Sprattus sprattus	0	0	0	415	138	0	0	553	0.0%
had	haddock	Melanogrammus aeglefinus	5	15	46	42	66	121	47	342	0.0%
sqr	squid	Loligo vulgaris	0	8	8	26	133	68	8	251	0.0%
brb	black seabream	Spondyliosoma cantharus	2	22	3	83	5	6	86	209	0.0%
mcd	NA	Ceratoscopelus maderensis	0	0	32	28	20	105	8	194	0.0%
whg	whiting	Merlangius merlangus	0	24	31	31	30	63	2	181	0.0%
oth	NA	NA	101	74	70	91	134	210	22	703	0.0%
(all)	(all)	(all)	178,162	253,474	225,059	306,172	282,898	237,438	189,832	1,673,036	100.0%

Table 3.1.5: PFA fisheries for widely distributed species Self-sampling Summary of total catch (tonnes) by species. OTH refers to all other species that are not the main target species

Haul positions

An overview of all self-sampled hauls in the PFA fisheries for widely distributed species.

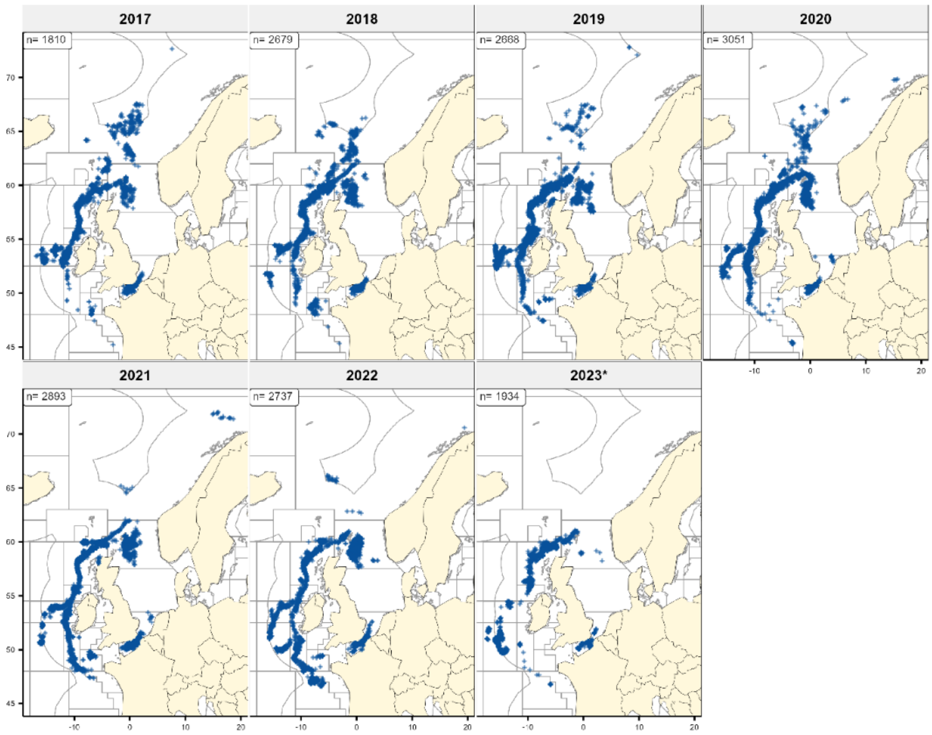

Figure 3.1.1: PFA fisheries for widely distributed species Self-sampling haul positions. N indicates the number of hauls.

Catches for the main target species

Summed catches (tonnes) of the main target species aggregated in rectangles.

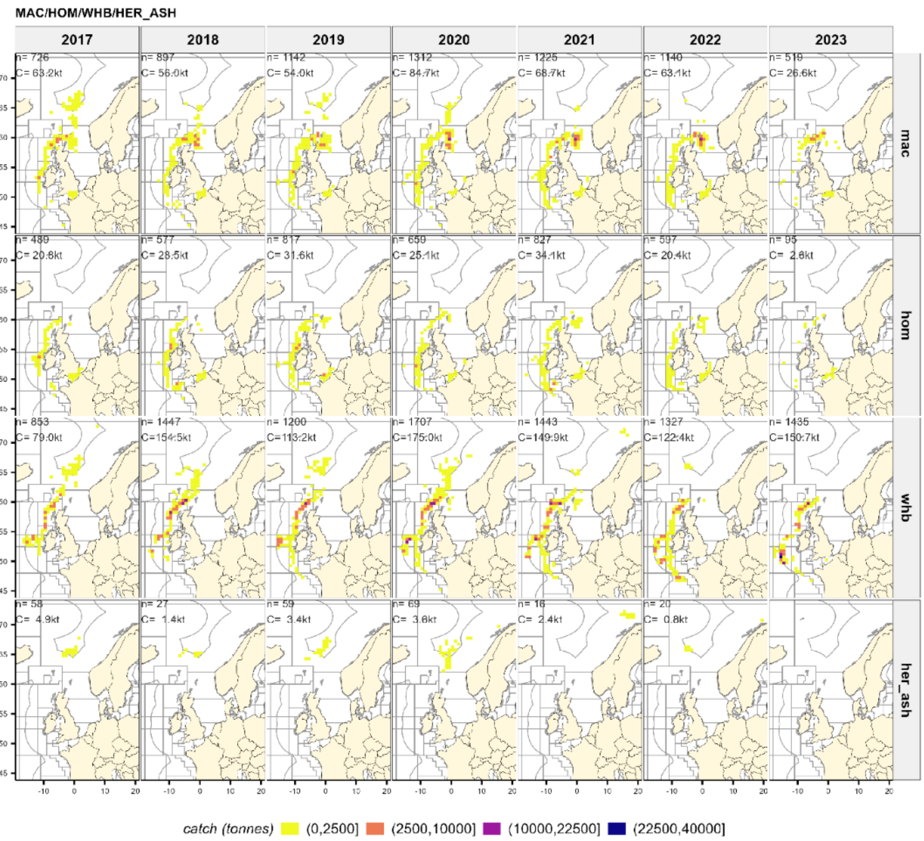

Figure 3.1.2: PFA fisheries for widely distributed species Self-sampling catch per species and per rectangle. N indicates the number of hauls. Catch refers to the total catch per year.

Catch rates (catch/day) for the main target species

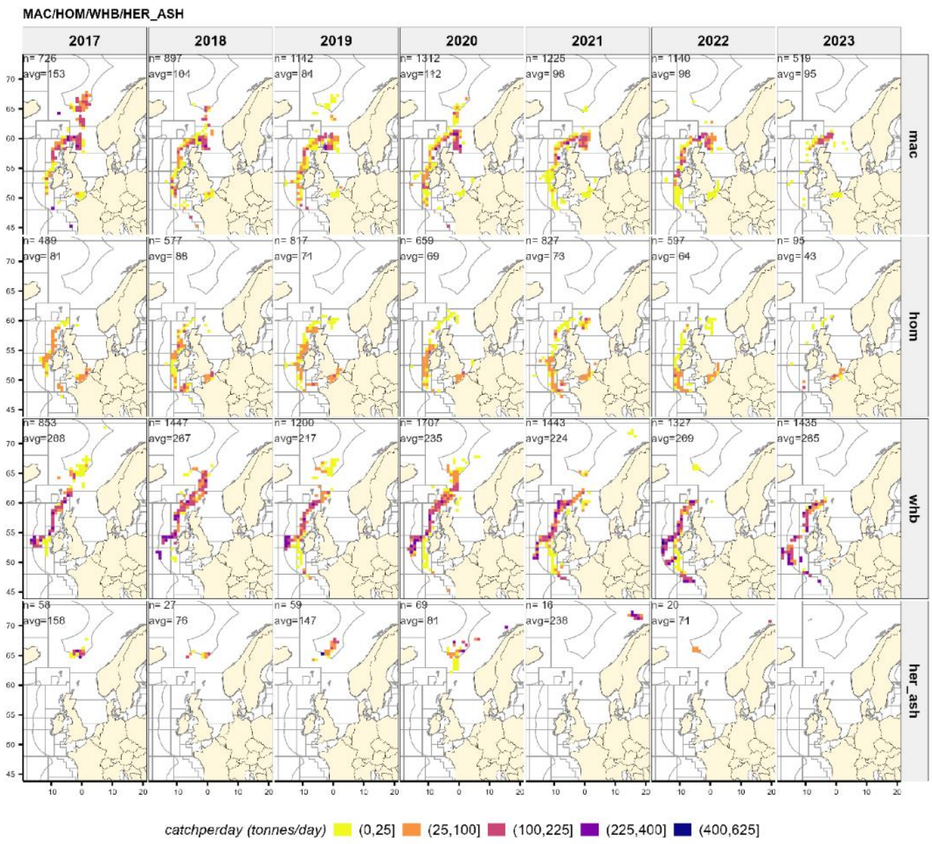

Figure 3.1.3: Average catch per day, per species and per rectangle. N indicates the number of hauls; avg refers to the average catch per day.

Average surface temperature by quarter and by rectangle.

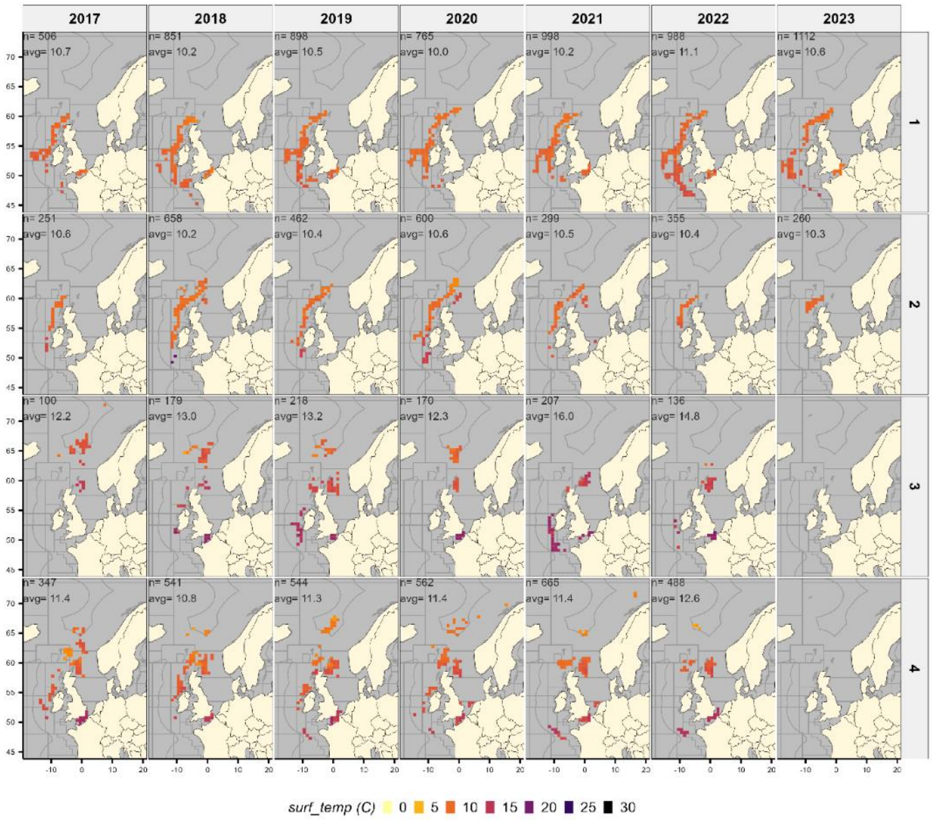

Figure 3.1.4: PFA fisheries for widely distributed species Average surface temperature (C) by year and quarter. N indicates the number of hauls. Avg refers to the average temperature.

Average fishing depth.

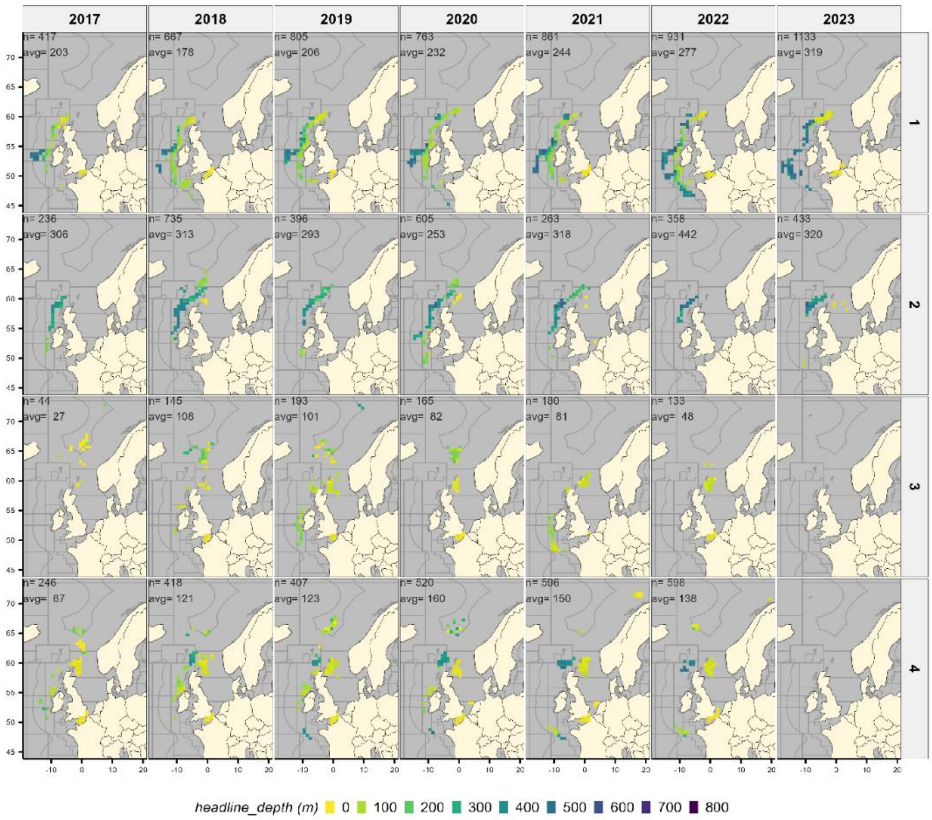

Figure 3.1.5: PFA fisheries for widely distributed species Average fishing depth (m) by year and quarter. N indicates the number of hauls. Avg refers to the average fishing depth.

Average wind force.

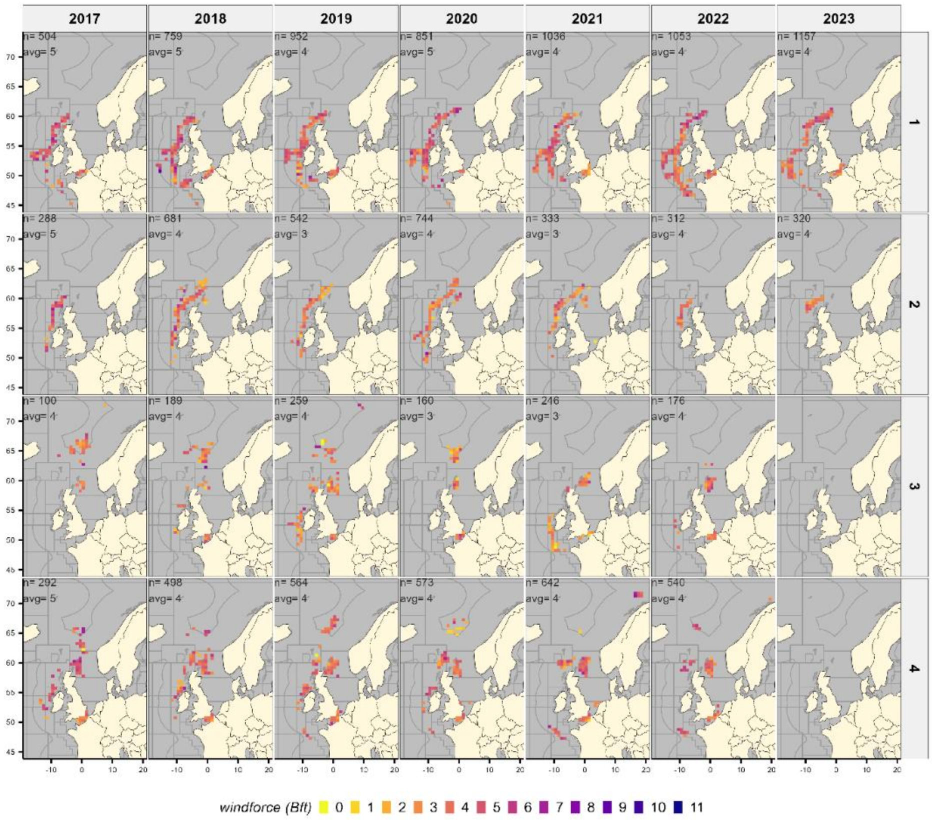

Figure 3.1.6: PFA fisheries for widely distributed species Average windforce (Bft) by year and quarter. N indicates the number of hauls. Avg refers to the average windforce.

3.2 Northeast Atlantic mackerel (MAC, Scomber scombrus)

Northeast Atlantic mackerel self-sampling summary.

species	year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nlength	nbio
mac	2017	11	48	386	690	62,715	162	11,731	0
mac	2018	16	56	501	841	55,186	110	13,789	32
mac	2019	15	72	615	1,105	53,525	87	18,037	476
mac	2020	17	84	712	1,258	83,876	118	31,555	646
mac	2021	18	78	606	1,054	68,466	113	11,297	684
mac	2022	14	74	568	1,031	62,847	111	15,347	3,874
mac	2023	14	26	243	468	26,279	108	5,752	129
(all)	(all)		438	3,631	6,447	412,894		107,508	5,841

Table 3.2.1: Northeast Atlantic mackerel. Self-sampling summary with the number of days, hauls, trips, vessels, catch (tonnes), catch rate (ton/day), number of fish measured, number of biological observations.

Northeast Atlantic mackerel. Catch by division

species	division	2017	2018	2019	2020	2021	2022	2023*	all	perc
mac	27.2.a	12,967	4,803	204	706	9	120	0	18,809	4.6%
mac	27.4.a	17,325	28,511	24,293	50,545	44,514	47,966	9,341	222,494	53.9%
mac	27.6.a	28,288	18,071	21,298	15,847	21,989	9,854	16,917	132,264	32.0%
mac	27.7.b	3,640	1,111	5,386	6,044	1,094	4,539	13	21,827	5.3%
mac	27.7.j	496	2,689	2,345	10,734	861	368	8	17,500	4.2%
(all)	(all)	62,715	55,186	53,525	83,876	68,466	62,847	26,279	412,894	100.0%

Table 3.2.2: Northeast Atlantic mackerel. Self-sampling summary with the catch (tonnes) by year and division

Northeast Atlantic mackerel. Catch by month

species	month	2017	2018	2019	2020	2021	2022	2023*	all	perc
mac	Jan	18,550	11,546	18,715	20,750	14,806	13,050	20,294	117,712	28.5%
mac	Feb	8,199	7,297	11,862	19,376	5,678	6,925	5,188	64,525	15.6%
mac	Mar	4,469	1,292	4,374	5,114	2,840	6,613	13	24,716	6.0%
mac	Apr	955	1,226	1,326	604	366	98	731	5,306	1.3%
mac	May	288	192	489	1,239	97	71	51	2,428	0.6%
mac	Jun	0	60	96	173	35	0	3	368	0.1%
mac	Jul	89	0	262	83	907	55	0	1,396	0.3%
mac	Aug	237	59	431	296	360	389	0	1,772	0.4%
mac	Sep	9,096	4,779	3,039	6,284	2,624	3,406	0	29,228	7.1%
mac	Oct	7,866	19,437	11,457	20,161	30,743	17,733	0	107,398	26.0%
mac	Nov	11,595	8,934	1,473	9,461	10,009	14,231	0	55,704	13.5%
mac	Dec	1,370	363	0	334	0	275	0	2,342	0.6%
(all)	(all)	62,715	55,186	53,525	83,876	68,466	62,847	26,279	412,894	100.0%

Table 3.2.3: Northeast Atlantic mackerel. Self-sampling summary with the catch (tonnes) by year and month

Northeast Atlantic mackerel. Catch by country

species	flag	2017	2018	2019	2020	2021	2022	2023*	all	perc
mac	DEU	6,934	9,760	8,735	22,795	10,305	12,261	11,376	82,166	19.9%

mac	FR	0	8,096	8,962	6,375	7,086	6,226	3,003	39,748	9.6%
mac	LIT	0	0	0	827	6,876	0	0	7,704	1.9%
mac	NL	29,171	12,670	14,885	27,424	20,674	23,163	4,464	132,452	32.1%
mac	POL	0	4,051	3,601	5,502	1,771	0	140	15,066	3.6%
mac	UK	26,610	20,608	17,341	20,952	19,704	21,197	7,296	133,708	32.4%
mac	NA	0	0	0	0	2,049	0	0	2,049	0.5%
(all)	(all)	62,715	55,186	53,525	83,876	68,466	62,847	26,279	412,894	100.0%

Table 3.2.4: Northeast Atlantic mackerel. Self-sampling summary with the catch (tonnes) by year and country

Northeast Atlantic mackerel. Catch by rectangle

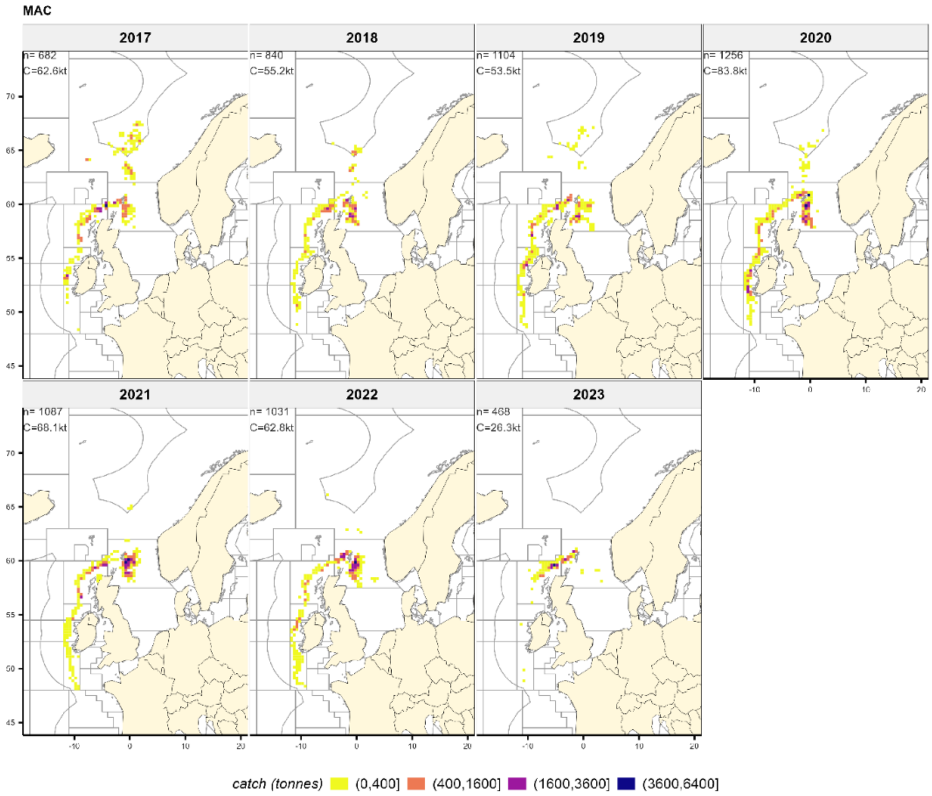

Figure 3.2.1: Northeast Atlantic mackerel. Catch per per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

Northeast Atlantic mackerel. Catchrate (ton/day) by rectangle

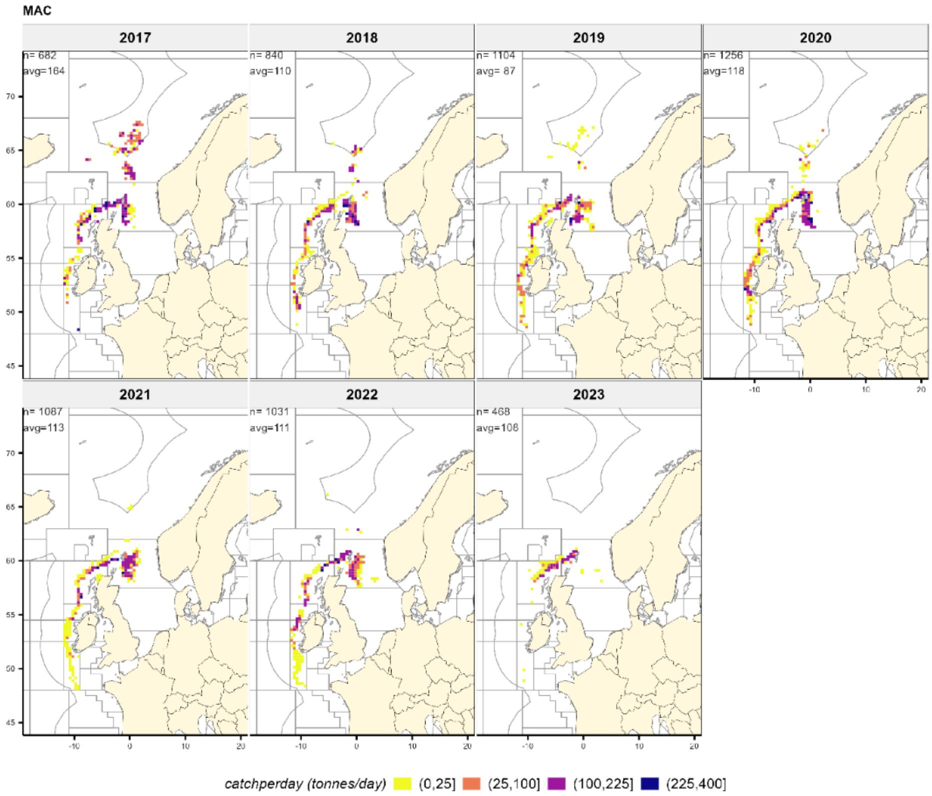

Figure 3.2.2: Northeast Atlantic mackerel. Catchrate (ton/day) per rectangle. N indicates the number of hauls; Avg refers to the average catchrate per rect.

Northeast Atlantic mackerel. Spatio-temporal evolution of catch by month and rectangle

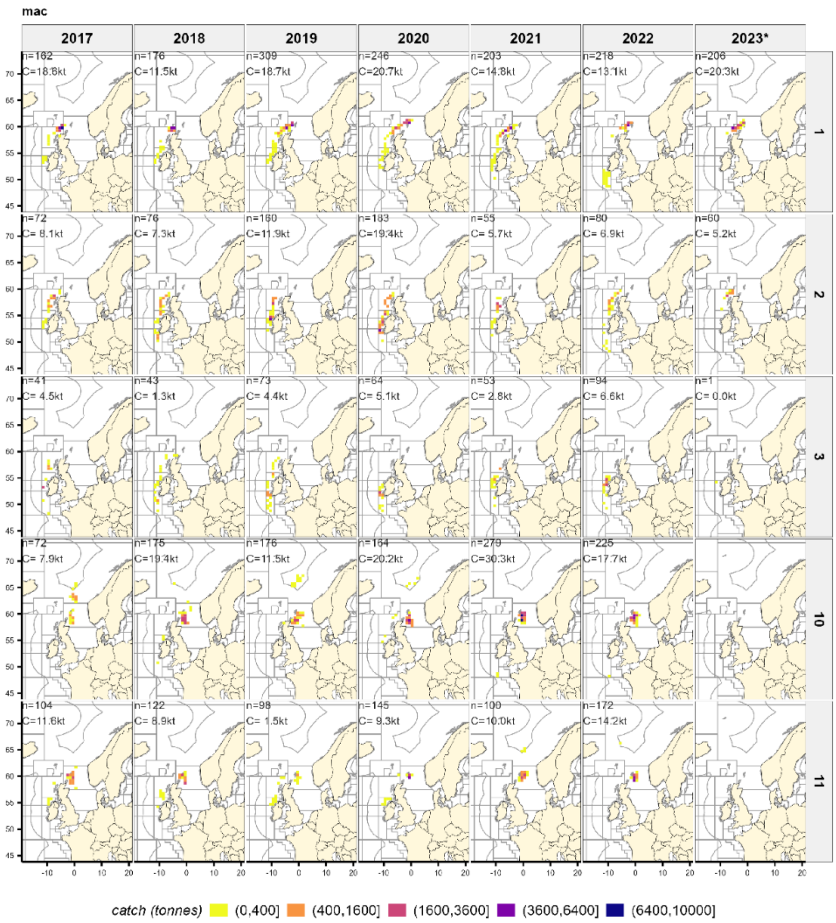

Figure 3.2.3: Northeast Atlantic mackerel. Spatio-temporal evolution of the catches per rectangle and month. N indicates the number of hauls; C refers to the total catch by year and month.

Northeast Atlantic mackerel. Catch proportion at depth

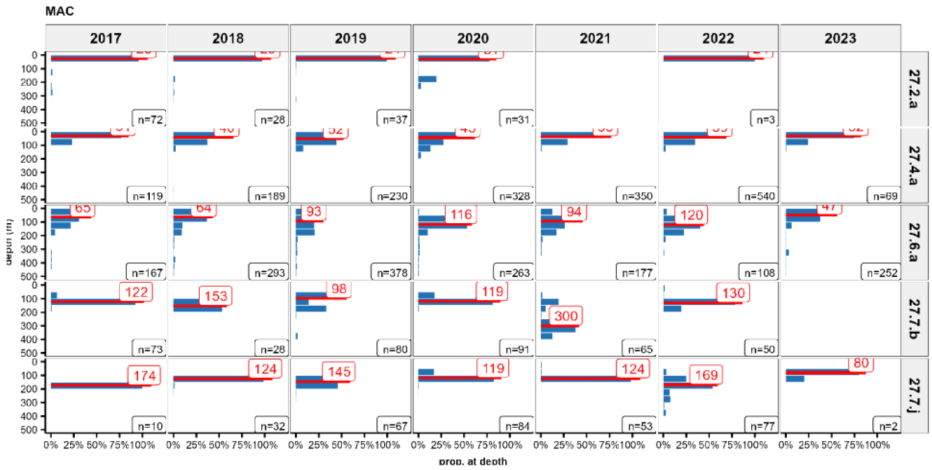

Figure 3.2.4: Northeast Atlantic mackerel. Catch proportion at depth. N indicates the number of hauls.

Northeast Atlantic mackerel. Length distributions of the catch

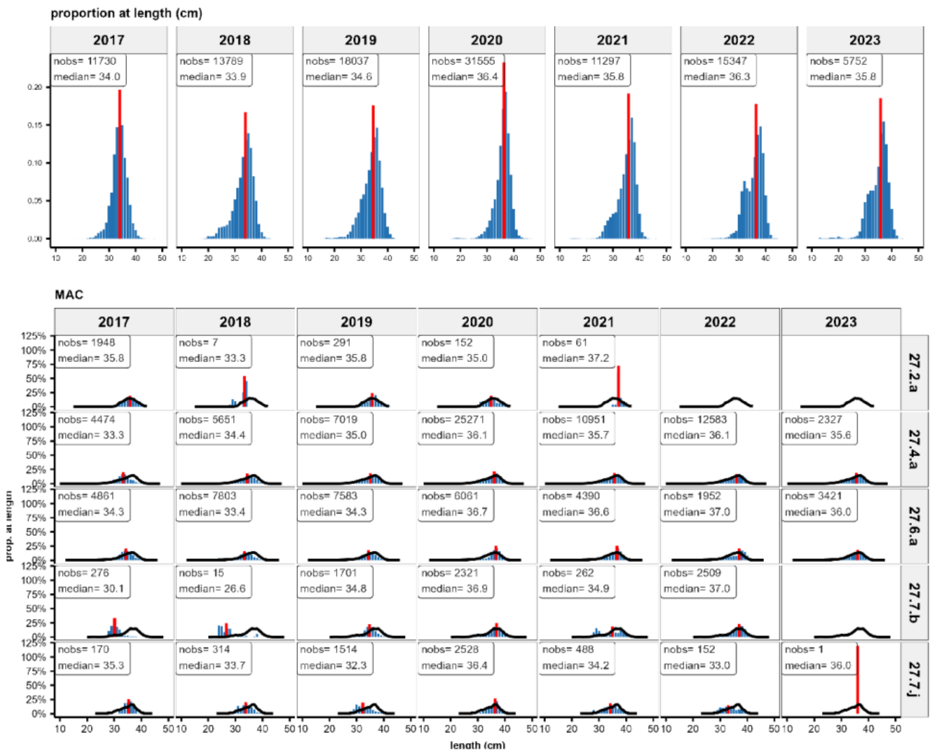

Figure 3.2.5: Northeast Atlantic mackerel. Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

Northeast Atlantic mackerel. Length distributions as proportions by (large) rectangle

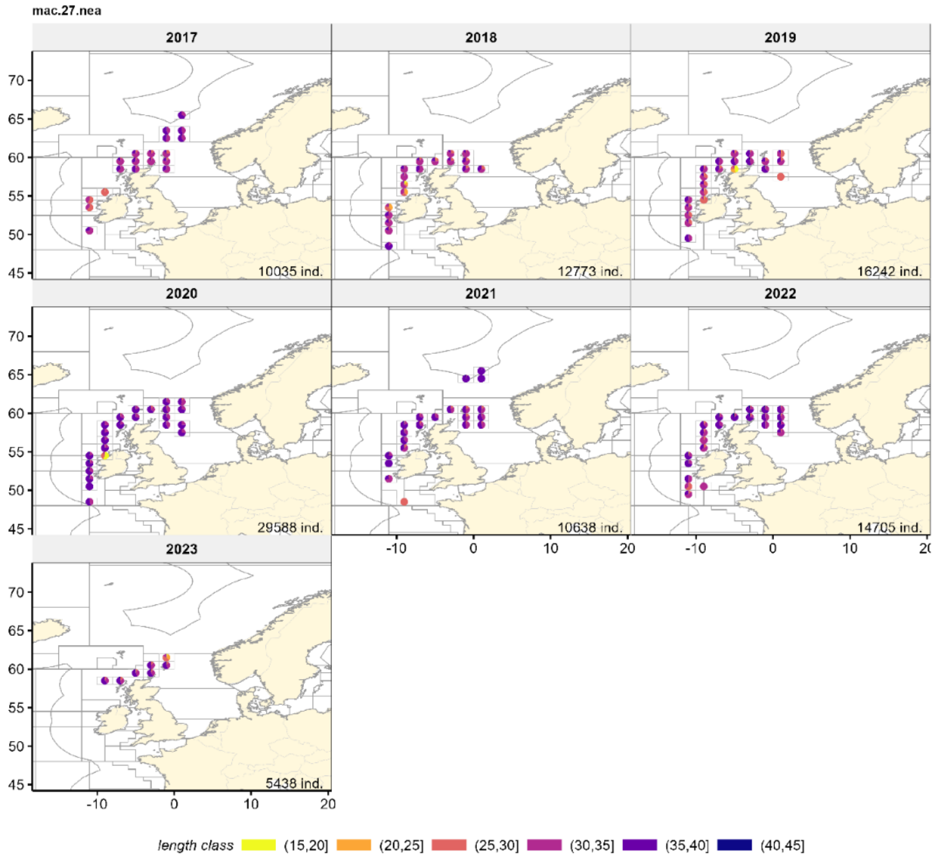

Figure 3.2.6: Northeast Atlantic mackerel. Length distributions as proportions by large rectangle. Ind. refers to the number of length measurements

Northeast Atlantic mackerel. Average length, weight and fat content by year and month

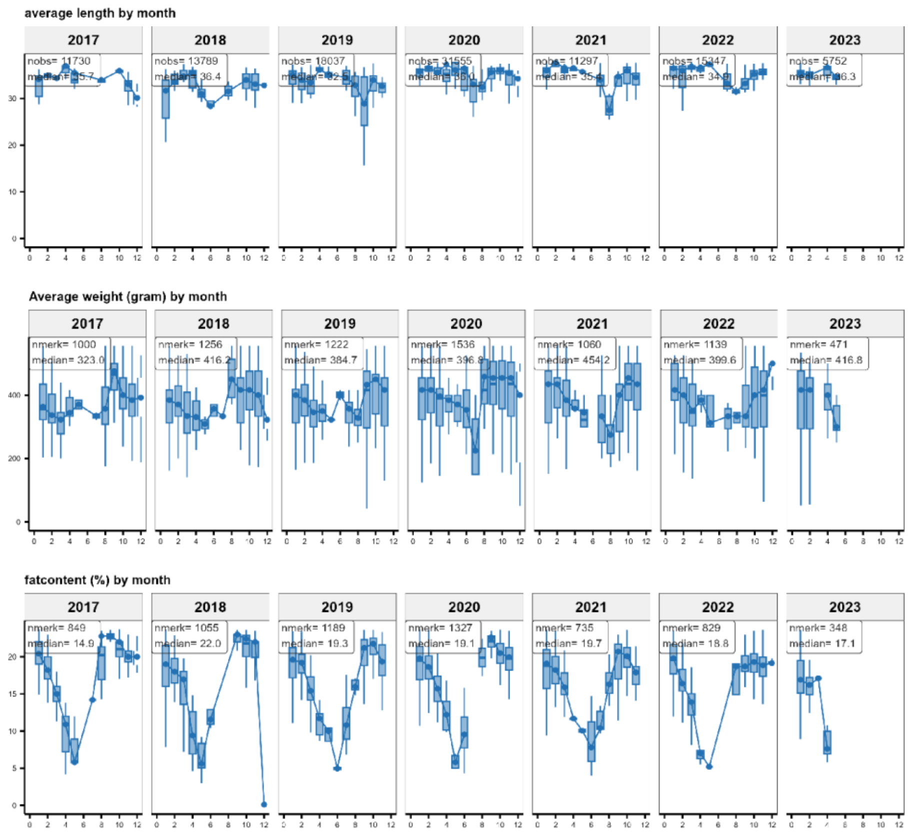

Figure 3.2.7: Northeast Atlantic mackerel. Average length, average weight, and average fat content. Nobs indicates the number of measurements, median indicates the median values

Northeast Atlantic mackerel (MAC). Standardized CPUE

Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset. It is assumed that a 2.5% annual efficiency increase takes place (Rousseau et al 2019).

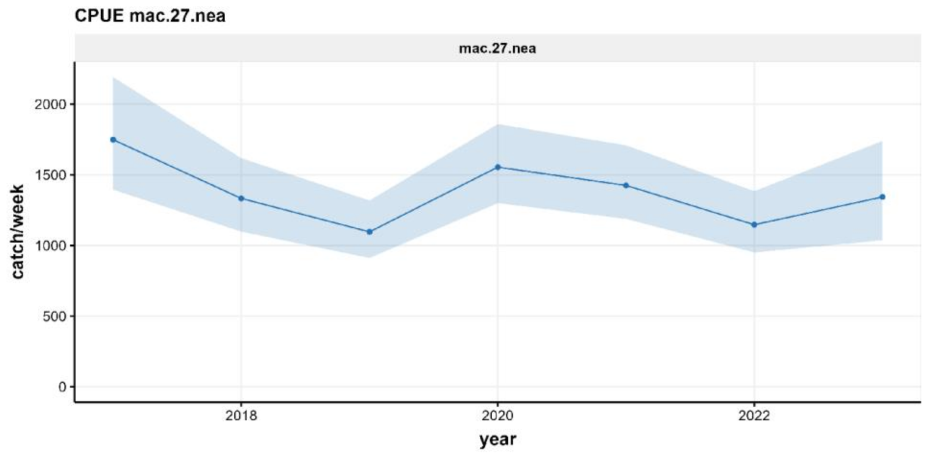

Figure 3.2.8: Northeast Atlantic mackerel. Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset

3.3 Western horse mackerel (HOM, Trachurus trachurus)

Western horse mackerel self-sampling summary.

species	year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nlength	nbio
hom	2017	10	25	161	304	11,578	72	8,259	0
hom	2018	13	35	244	431	21,412	88	22,001	0
hom	2019	15	47	363	668	24,022	66	14,172	25
hom	2020	14	40	268	508	16,334	61	13,601	203
hom	2021	17	53	366	643	26,576	73	24,753	59
hom	2022	13	39	229	453	15,291	67	10,652	269
hom	2023	5	5	12	17	176	15	94	0
(all)	(all)		244	1,643	3,024	115,388		93,532	556

Table 3.3.1: Western horse mackerel. Self-sampling summary with the number of days, hauls, trips, vessels, catch (tonnes), catch rate (ton/day), number of fish measured, number of biological observations.

Western horse mackerel. Catch by division

species	division	2017	2018	2019	2020	2021	2022	2023*	all	perc
hom	27.4.a	6	0	11	13	1,007	24	9	1,071	0.9%
hom	27.6.a	5,343	12,067	13,849	5,901	1,564	552	23	39,299	34.1%
hom	27.7.b	4,741	2,250	4,176	5,226	4,743	335	0	21,471	18.6%
hom	27.7.h	1,329	6,282	984	55	8,551	1,469	0	18,669	16.2%
hom	27.7.j	159	813	5,002	5,138	10,712	12,911	144	34,878	30.2%
(all)	(all)	11,578	21,412	24,022	16,334	26,576	15,291	176	115,388	100.0%

Table 3.3.2: Western horse mackerel. Self-sampling summary with the catch (tonnes) by year and division

Western horse mackerel. Catch by month

species	month	2017	2018	2019	2020	2021	2022	2023*	all	perc
hom	Jan	6,666	10,627	9,610	7,017	4,894	9,511	14	48,339	41.9%
hom	Feb	3,052	5,392	3,257	4,774	6,634	909	18	24,036	20.8%
hom	Mar	212	3,027	1,284	1,237	245	413	0	6,418	5.6%
hom	Apr	0	31	45	0	6	0	144	226	0.2%
hom	May	156	7	42	529	2	0	0	735	0.6%
hom	Jun	0	227	1,357	642	0	0	0	2,226	1.9%
hom	Jul	112	15	5,342	420	5,809	274	0	11,971	10.4%
hom	Aug	0	0	8	0	1,005	13	0	1,026	0.9%
hom	Sep	0	429	335	0	4,300	60	0	5,125	4.4%
hom	Oct	15	126	259	1	831	3,813	0	5,046	4.4%
hom	Nov	1,262	1,410	2,483	1,713	2,629	298	0	9,796	8.5%
hom	Dec	103	120	0	0	221	0	0	444	0.4%
(all)	(all)	11,578	21,412	24,022	16,334	26,576	15,291	176	115,388	100.0%

Table 3.3.3: Western horse mackerel. Self-sampling summary with the catch (tonnes) by year and month

Western horse mackerel. Catch by country

species	flag	2017	2018	2019	2020	2021	2022	2023*	all	perc
hom	DEU	1,803	4,069	2,602	977	4,155	725	5	14,337	12.4%

hom	FR	0	622	864	1,370	788	1,406	13	5,062	4.4%
hom	NL	9,239	14,617	18,011	11,535	18,234	12,698	149	84,483	73.2%
hom	POL	0	0	4	1,005	1,210	0	0	2,219	1.9%
hom	UK	535	2,104	2,541	1,447	2,014	462	9	9,113	7.9%
hom	NA	0	0	0	0	175	0	0	175	0.2%
(all)	(all)	11,578	21,412	24,022	16,334	26,576	15,291	176	115,388	100.0%

Table 3.3.4: Western horse mackerel. Self-sampling summary with the catch (tonnes) by year and country

Western horse mackerel. Catch by rectangle

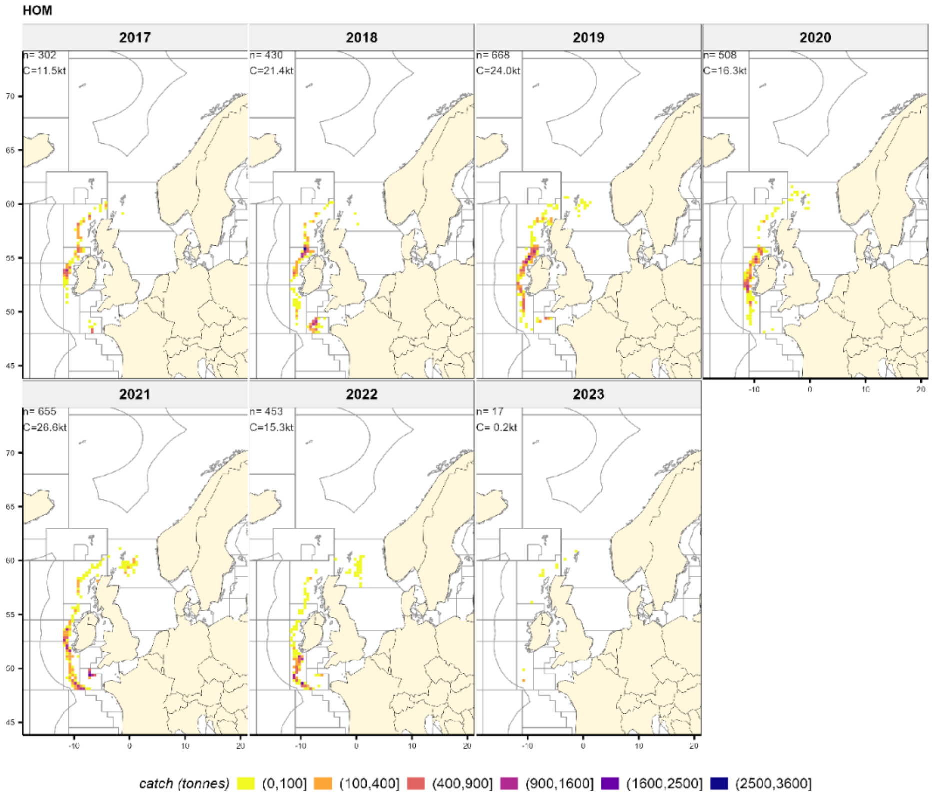

Figure 3.3.1: Western horse mackerel. Catch per per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

Western horse mackerel. Catchrate (ton/day) by rectangle

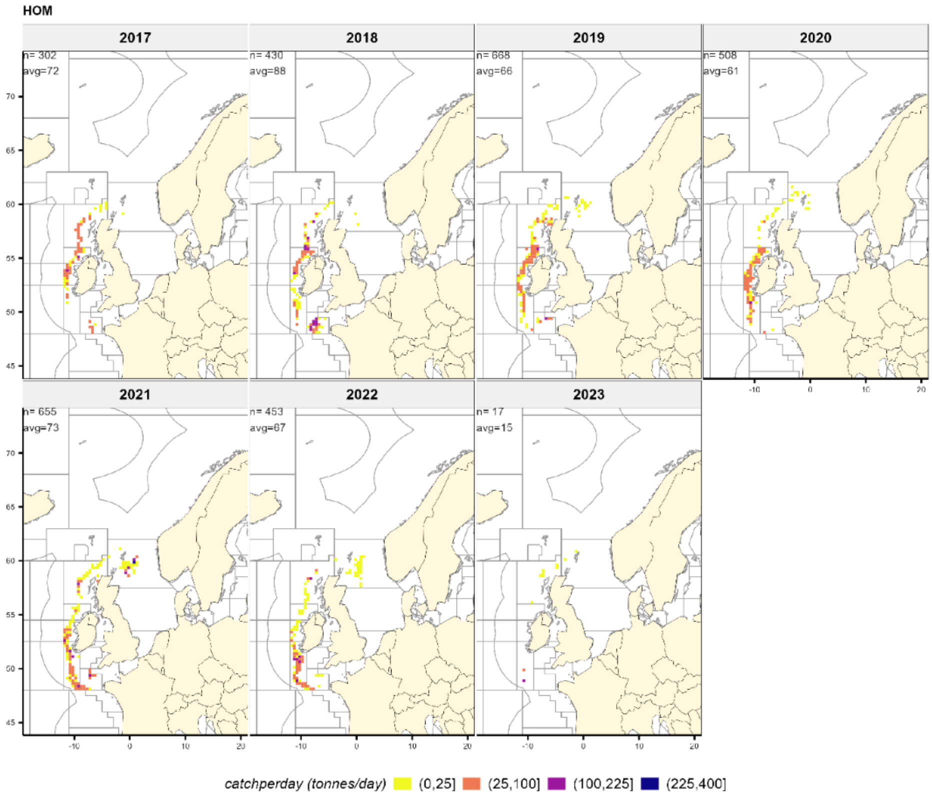

Figure 3.3.2: Western horse mackerel. Catchrate (ton/day) per rectangle. N indicates the number of hauls; Avg refers to the average catchrate per rect.

Western horse mackerel. Spatio-temporal evolution of catch by month and rectangle

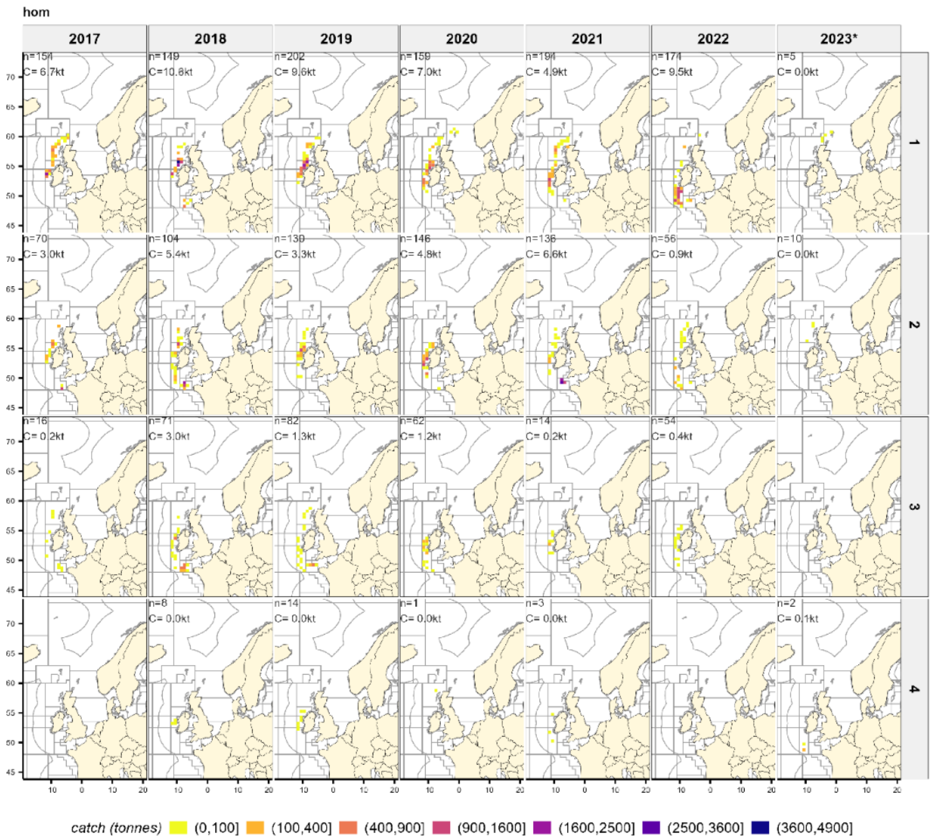

Figure 3.3.3: Western horse mackerel. Spatio-temporal evolution of the catches per rectangle and month. N indicates the number of hauls; C refers to the total catch by year and month.

Western horse mackerel. Catch proportion at depth

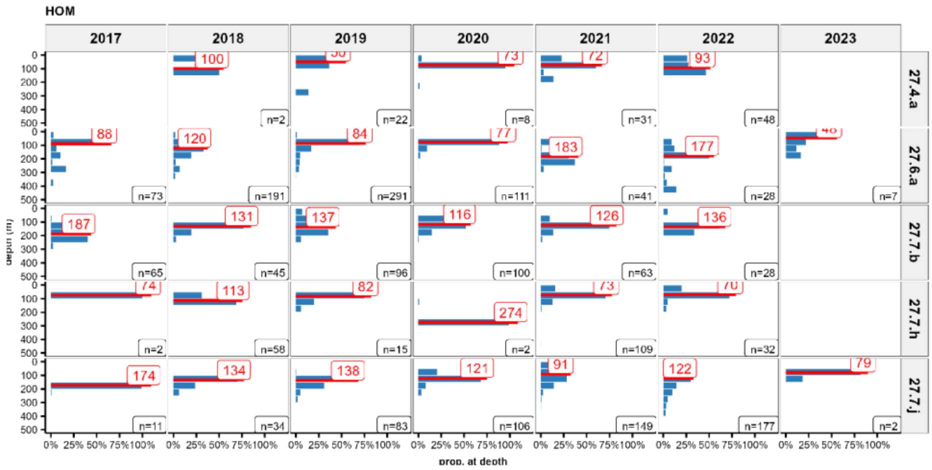

Figure 3.3.4: Western horse mackerel. Catch proportion at depth. N indicates the number of hauls.

Western horse mackerel. Length distributions of the catch

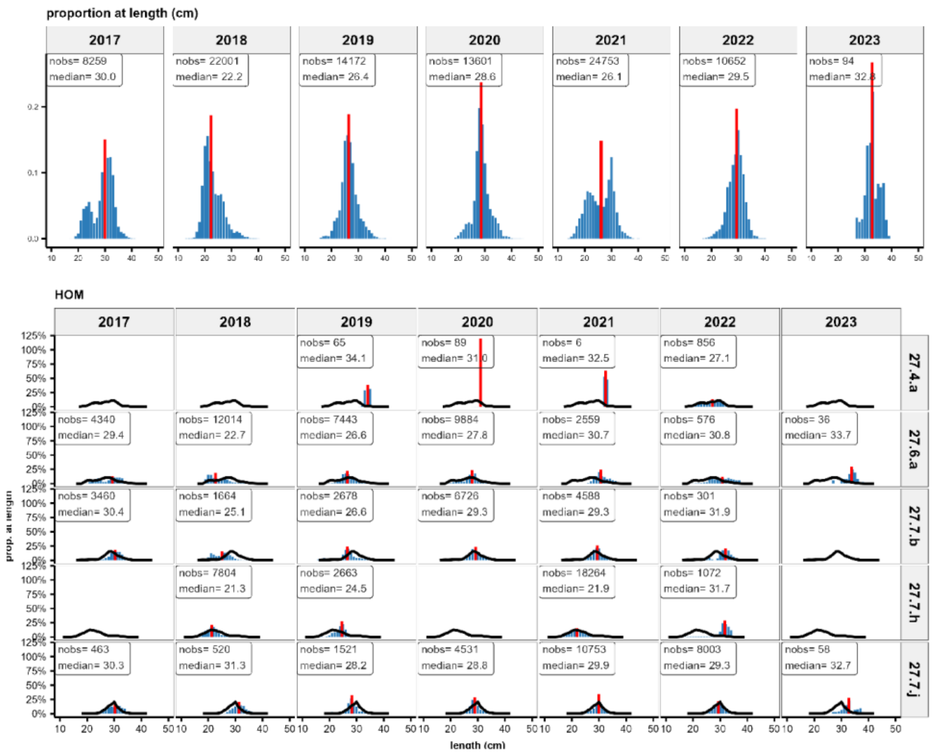

Figure 3.3.5: Western horse mackerel. Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

Western horse mackerel. Length distributions as proportions by (large) rectangle

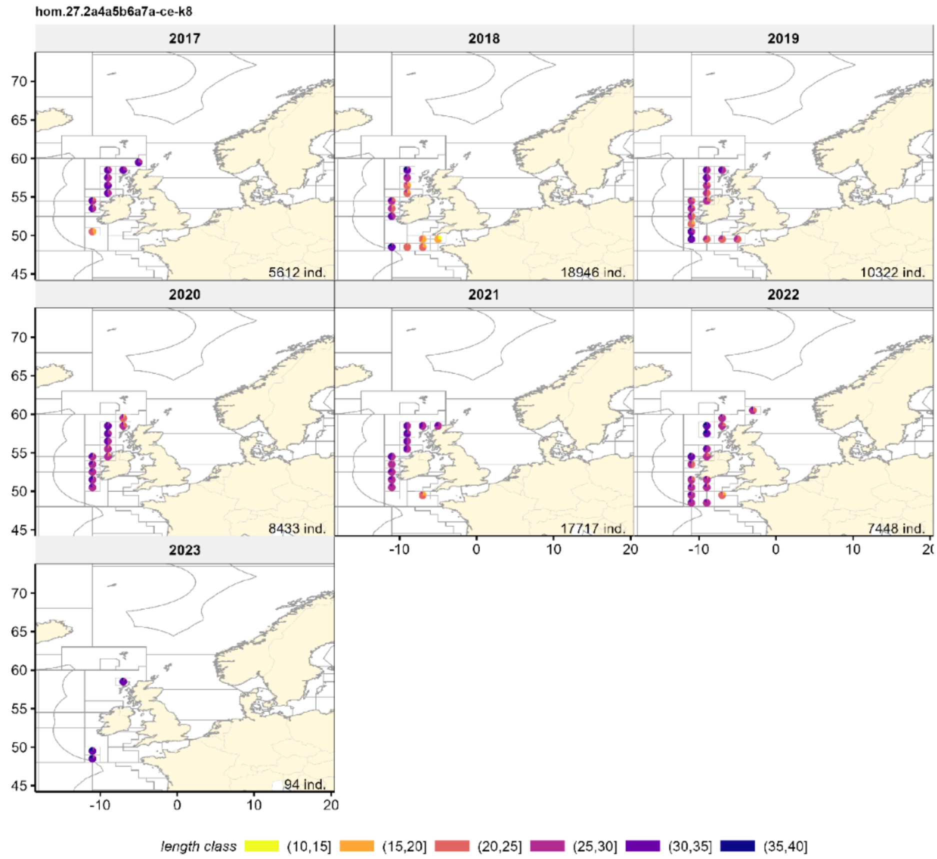

Figure 3.3.6: Western horse mackerel. Length distributions as proportions by large rectangle. Ind. refers to the number of length measurements

Western horse mackerel. Average length, weight and fat content by year and month

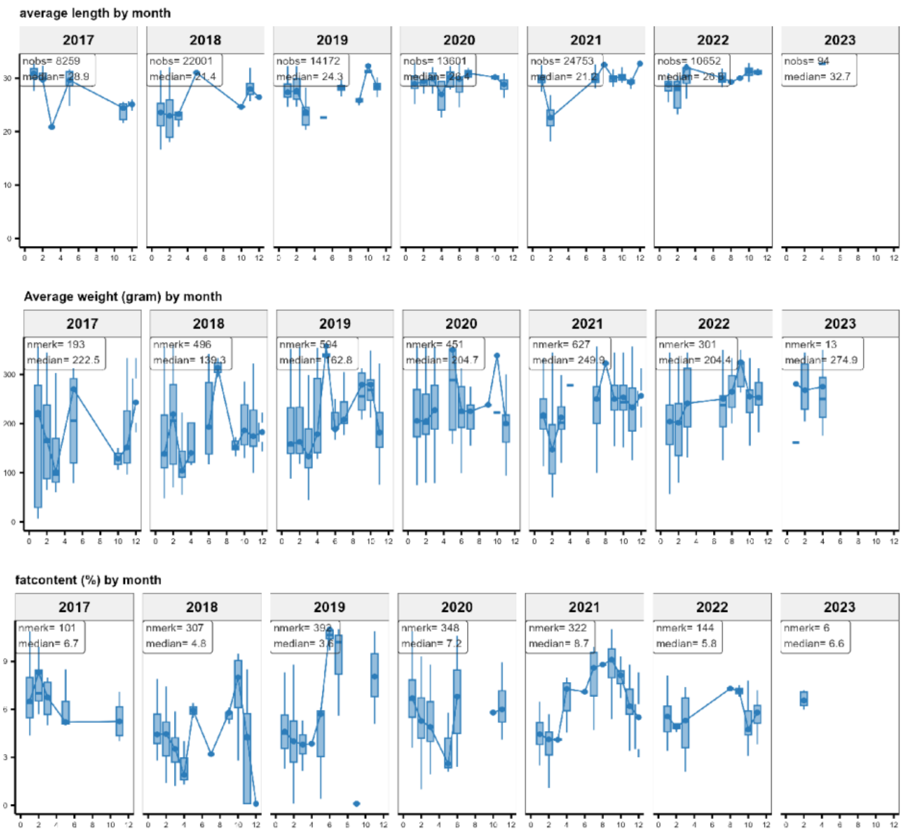

Figure 3.3.7: Western horse mackerel. Average length, average weight, and average fat content. Nobs indicates the number of measurements, median indicates the median values

Western horse mackerel (HOM). Standardized CPUE

Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset. It is assumed that a 2.5% annual efficiency increase takes place (Rousseau et al 2019).

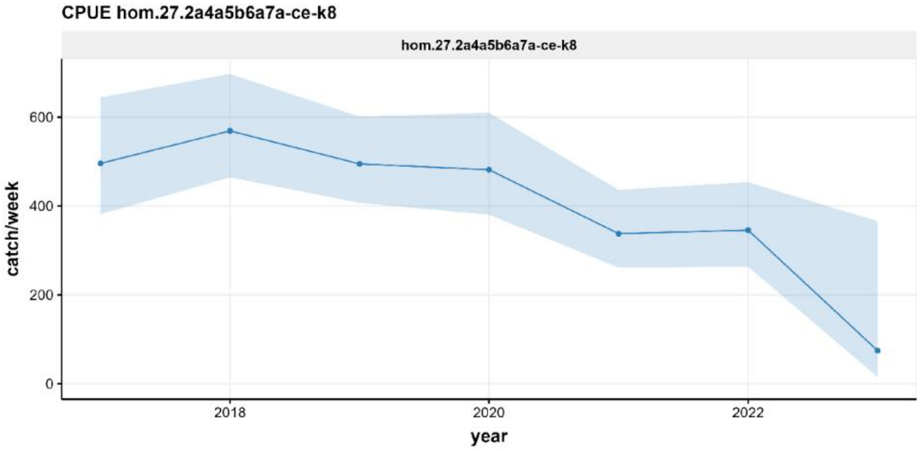

Figure 3.3.8: Western horse mackerel. Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset

3.4 North Sea horse mackerel (HOM, Trachurus trachurus)

North Sea horse mackerel self-sampling summary.

species	year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nlength	nbio
hom	2017	6	14	81	156	8,568	106	1,013	0
hom	2018	5	13	80	146	7,079	88	4,349	0
hom	2019	8	14	78	143	7,417	95	9,454	0
hom	2020	7	21	94	150	8,726	93	10,685	829
hom	2021	8	22	94	153	7,259	77	6,320	0
hom	2022	7	23	88	144	5,090	58	4,756	0
hom	2023	5	13	47	77	2,423	52	2,404	0
(all)	(all)		120	562	969	46,563		38,981	829

Table 3.4.1: North Sea horse mackerel. Self-sampling summary with the number of days, hauls, trips, vessels, catch (tonnes), catch rate (ton/day), number of fish measured, number of biological observations.

North Sea horse mackerel. Catch by division

species	division	2017	2018	2019	2020	2021	2022	2023*	all	perc
hom	27.4.c	1,371	853	369	898	1,149	1,558	715	6,913	14.8%

hom	27.7.d	7,198	6,226	7,048	7,829	6,111	3,531	1,708	39,650	85.2%
(all)	(all)	8,568	7,079	7,417	8,726	7,259	5,090	2,423	46,563	100.0%

Table 3.4.2: North Sea horse mackerel. Self-sampling summary with the catch (tonnes) by year and division

North Sea horse mackerel. Catch by month

species	month	2017	2018	2019	2020	2021	2022	2023*	all	perc
hom	Jan	2,362	892	1,382	2	1,013	538	1,294	7,484	16.1%
hom	Feb	0	310	0	0	97	376	849	1,632	3.5%
hom	Mar	0	0	0	0	0	0	280	280	0.6%
hom	Jun	0	0	0	6	25	0	0	31	0.1%
hom	Sep	135	1,471	2,009	3,860	422	1,953	0	9,850	21.2%
hom	Oct	4,490	1,391	1,967	1,834	2,349	1,398	0	13,429	28.8%
hom	Nov	1,581	2,018	1,110	1,463	1,218	485	0	7,876	16.9%
hom	Dec	0	998	949	1,561	2,134	340	0	5,982	12.8%
(all)	(all)	8,568	7,079	7,417	8,726	7,259	5,090	2,423	46,563	100.0%

Table 3.4.3: North Sea horse mackerel. Self-sampling summary with the catch (tonnes) by year and month

North Sea horse mackerel. Catch by country

species	flag	2017	2018	2019	2020	2021	2022	2023*	all	perc
hom	DEU	0	1,378	958	0	0	12	0	2,348	5.0%
hom	FR	0	422	400	238	202	0	0	1,262	2.7%
hom	LIT	0	0	1,373	0	0	0	0	1,373	2.9%
hom	NL	4,887	1,578	1,682	4,167	2,356	2,103	904	17,675	38.0%
hom	UK	3,682	3,701	3,004	4,322	3,674	2,975	1,519	22,876	49.1%
hom	NA	0	0	0	0	1,028	0	0	1,028	2.2%
(all)	(all)	8,568	7,079	7,417	8,726	7,259	5,090	2,423	46,563	100.0%

Table 3.4.4: North Sea horse mackerel. Self-sampling summary with the catch (tonnes) by year and country

North Sea horse mackerel. Catch by rectangle

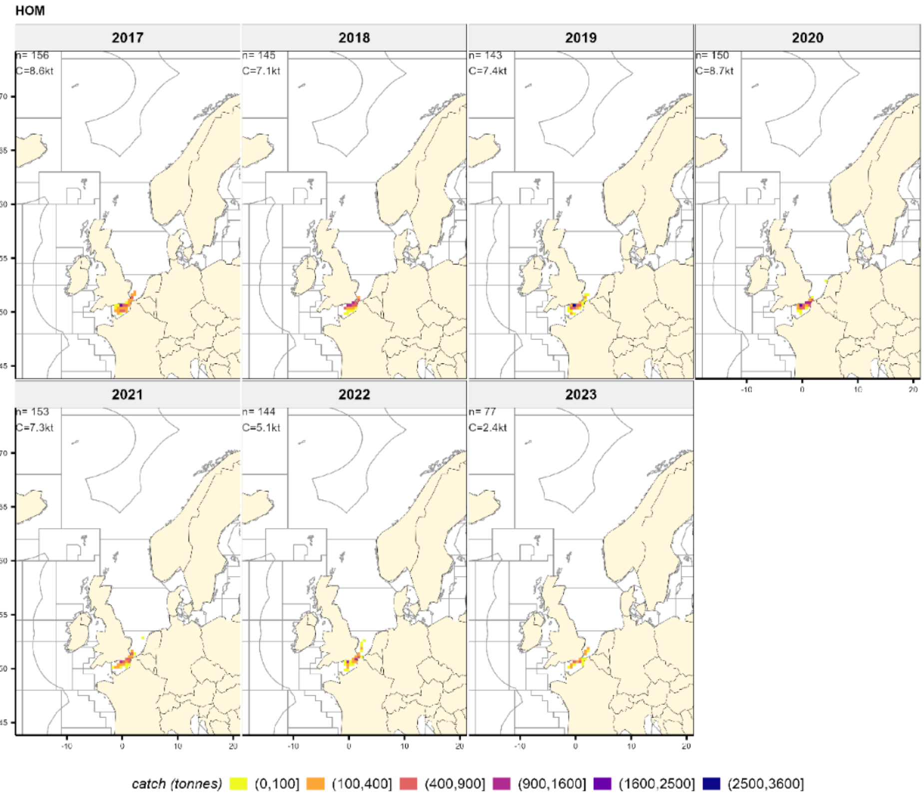

Figure 3.4.1: North Sea horse mackerel. Catch per per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

North Sea horse mackerel. Catchrate (ton/day) by rectangle

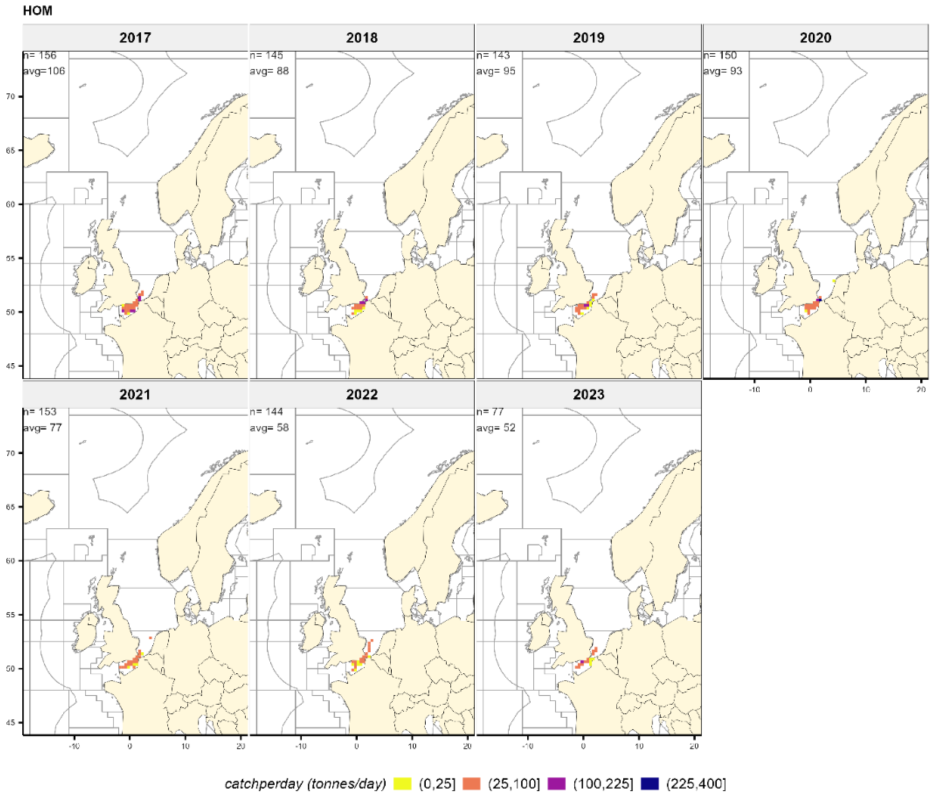

Figure 3.4.2: North Sea horse mackerel. Catchrate (ton/day) per rectangle. N indicates the number of hauls; Avg refers to the average catchrate per rect.

North Sea horse mackerel. Spatio-temporal evolution of catch by month and rectangle

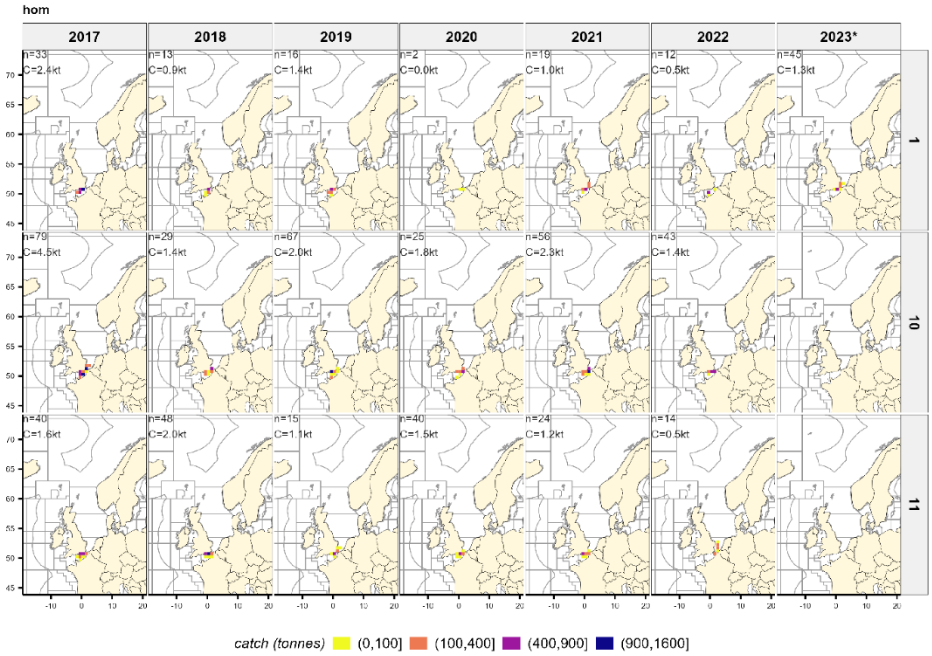

Figure 3.4.3: North Sea horse mackerel. Spatio-temporal evolution of the catches per rectangle and month. N indicates the number of hauls; C refers to the total catch by year and month.

North Sea horse mackerel. Catch proportion at depth

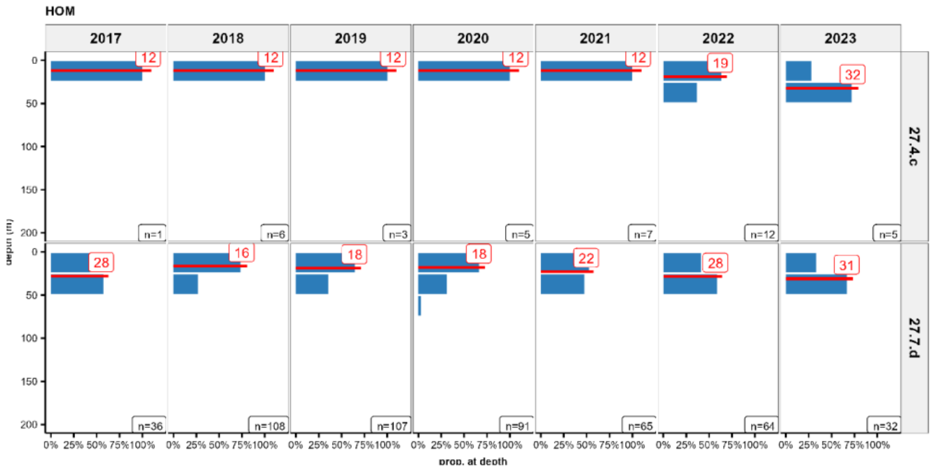

Figure 3.4.4: North Sea horse mackerel. Catch proportion at depth. N indicates the number of hauls.

North Sea horse mackerel. Length distributions of the catch

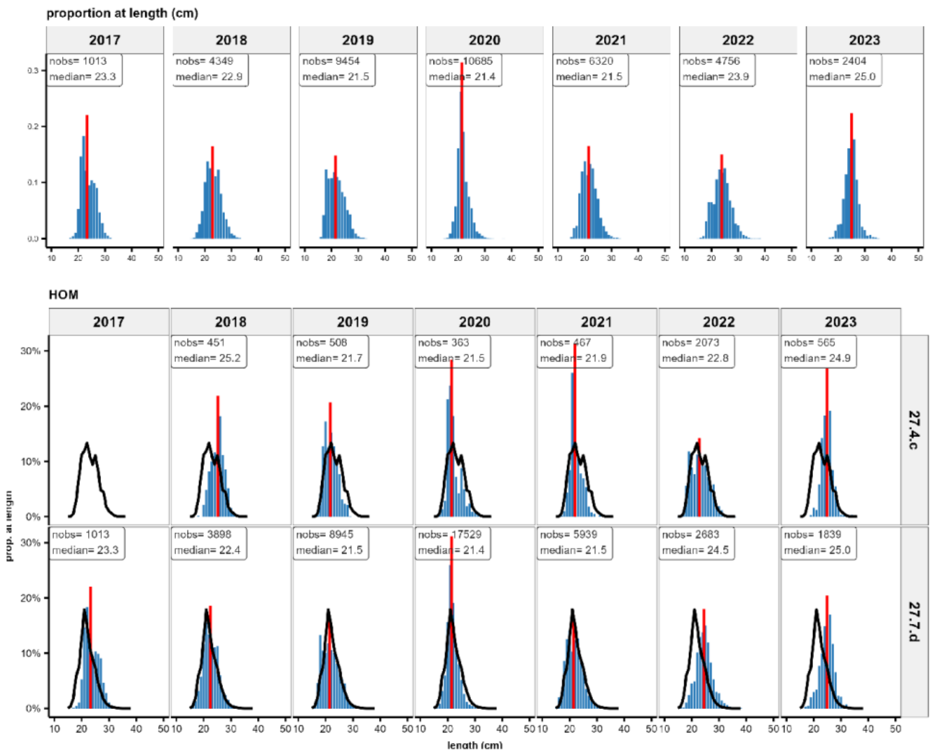

Figure 3.4.5: North Sea horse mackerel. Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

North Sea horse mackerel. Length distributions as proportions by (large) rectangle

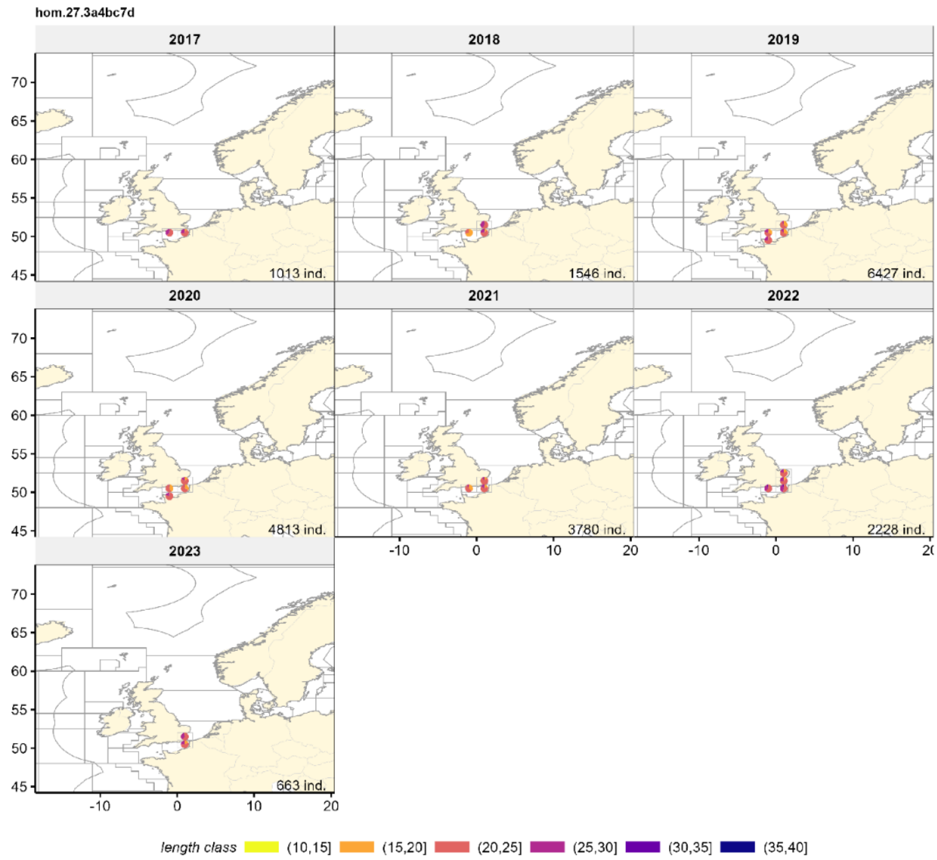

Figure 3.4.6: North Sea horse mackerel. Length distributions as proportions by large rectangle. Ind. refers to the number of length measurements

North Sea horse mackerel. Average length, weight and fat content by year and month

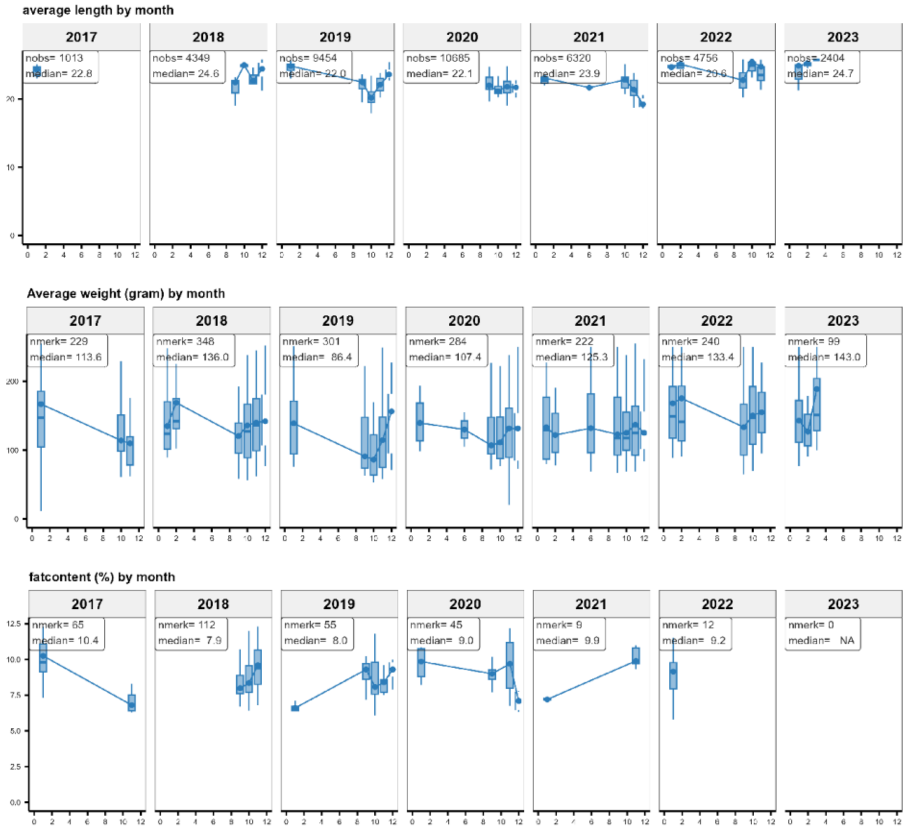

Figure 3.4.7: North Sea horse mackerel. Average length, average weight, and average fat content. Nobs indicates the number of measurements, median indicates the median values

North Sea horse mackerel (HOM). Standardized CPUE

Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset. It is assumed that a 2.5% annual efficiency increase takes place (Rousseau et al 2019).

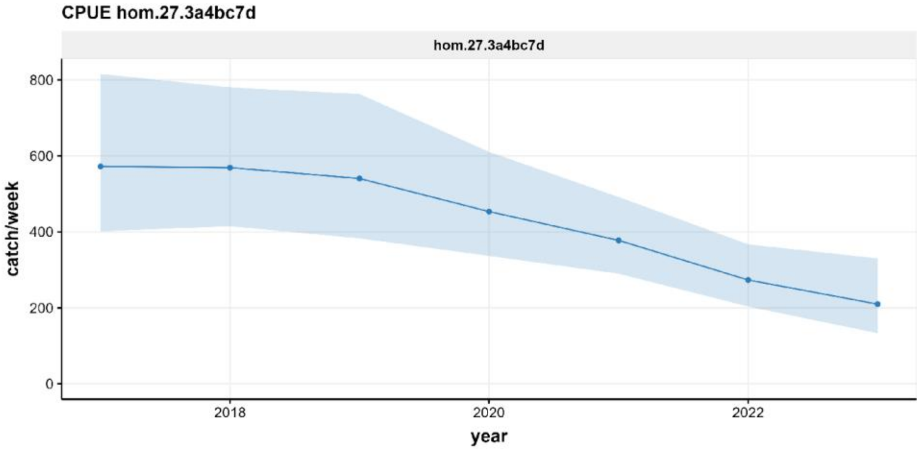

Figure 3.4.8: North Sea horse mackerel. Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset

3.5 Blue whiting (WHB, Micromesistius pouttasseu)

Blue whiting self-sampling summary.

species	year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nlength	nbio
whb	2017	8	32	348	767	79,056	227	64,477	0
whb	2018	14	45	577	1,440	152,791	265	119,752	0
whb	2019	15	51	507	1,176	112,619	222	56,187	0
whb	2020	13	61	738	1,692	174,836	237	90,496	178
whb	2021	17	68	635	1,356	143,665	226	61,743	0
whb	2022	15	48	579	1,312	121,762	210	46,958	0
whb	2023	15	48	567	1,432	150,495	265	101,318	533
(all)	(all)		353	3,951	9,175	935,225		540,932	711

Table 3.5.1: Blue whiting. Self-sampling summary with the number of days, hauls, trips, vessels, catch (tonnes), catch rate (ton/day), number of fish measured, number of biological observations.

Blue whiting. Catch by division

species	division	2017	2018	2019	2020	2021	2022	2023*	all	perc
whb	27.2.a	2,550	11,907	998	5,718	190	125	0	21,487	2.3%
whb	27.4.a	727	2,947	2,087	5,567	2,995	1	47	14,370	1.5%
whb	27.5.b	7,960	7,928	3,905	10,220	8,665	9,798	65	48,540	5.2%
whb	27.6.a	39,085	91,738	75,707	97,232	84,794	41,129	60,795	490,481	52.4%

whb	27.7.c	28,731	30,504	26,587	44,309	28,613	20,360	9,471	188,575	20.2%
whb	27.7.j	4	122	1,127	159	1,062	3,112	1,883	7,469	0.8%
whb	27.7.k	0	7,646	2,036	11,307	16,684	29,327	77,358	144,357	15.4%
whb	27.8.d	0	0	171	324	663	17,912	876	19,945	2.1%
(all)	(all)	79,056	152,791	112,619	174,836	143,665	121,762	150,495	935,225	100.0%

Table 3.5.2: Blue whiting. Self-sampling summary with the catch (tonnes) by year and division

Blue whiting. Catch by month

species	month	2017	2018	2019	2020	2021	2022	2023*	all	perc
whb	Jan	185	957	4,287	9,527	29,603	14,664	21,746	80,969	8.7%
whb	Feb	8,027	19,108	17,504	4,051	18,915	35,879	52,004	155,488	16.6%
whb	Mar	24,683	26,954	21,414	41,462	30,137	32,928	45,949	223,527	23.9%
whb	Apr	27,316	55,654	26,391	61,978	25,153	19,539	24,163	240,194	25.7%
whb	May	9,394	26,728	17,281	24,321	10,661	4,020	6,632	99,038	10.6%
whb	Jun	0	5,094	13	872	461	0	0	6,440	0.7%
whb	Jul	0	0	102	59	703	75	0	939	0.1%
whb	Aug	1,265	4,219	337	2,043	207	1	0	8,072	0.9%
whb	Sep	538	414	246	1,327	128	26	0	2,678	0.3%
whb	Oct	39	92	1,483	2,417	5	27	0	4,063	0.4%
whb	Nov	5,935	6,619	13,930	10,934	11,373	11,421	0	60,212	6.4%
whb	Dec	1,675	6,952	9,632	15,845	16,318	3,182	0	53,603	5.7%
(all)	(all)	79,056	152,791	112,619	174,836	143,665	121,762	150,495	935,225	100.0%

Table 3.5.3: Blue whiting. Self-sampling summary with the catch (tonnes) by year and month

Blue whiting. Catch by country

species	flag	2017	2018	2019	2020	2021	2022	2023*	all	perc
whb	DEU	15,914	36,842	24,596	41,792	35,153	21,740	31,139	207,176	22.2%
whb	FR	0	1,656	4,912	5,069	2,789	4,199	7,244	25,868	2.8%
whb	LIT	0	0	0	11,653	15,807	10,566	14,902	52,928	5.7%
whb	NL	59,757	100,416	54,574	61,743	54,702	62,387	70,590	464,170	49.6%
whb	POL	0	11,850	24,393	46,900	26,524	15,221	18,835	143,723	15.4%
whb	UK	3,385	2,028	4,144	7,678	8,690	7,650	7,785	41,360	4.4%
(all)	(all)	79,056	152,791	112,619	174,836	143,665	121,762	150,495	935,225	100.0%

Table 3.5.4: Blue whiting. Self-sampling summary with the catch (tonnes) by year and country

Blue whiting. Catch by rectangle

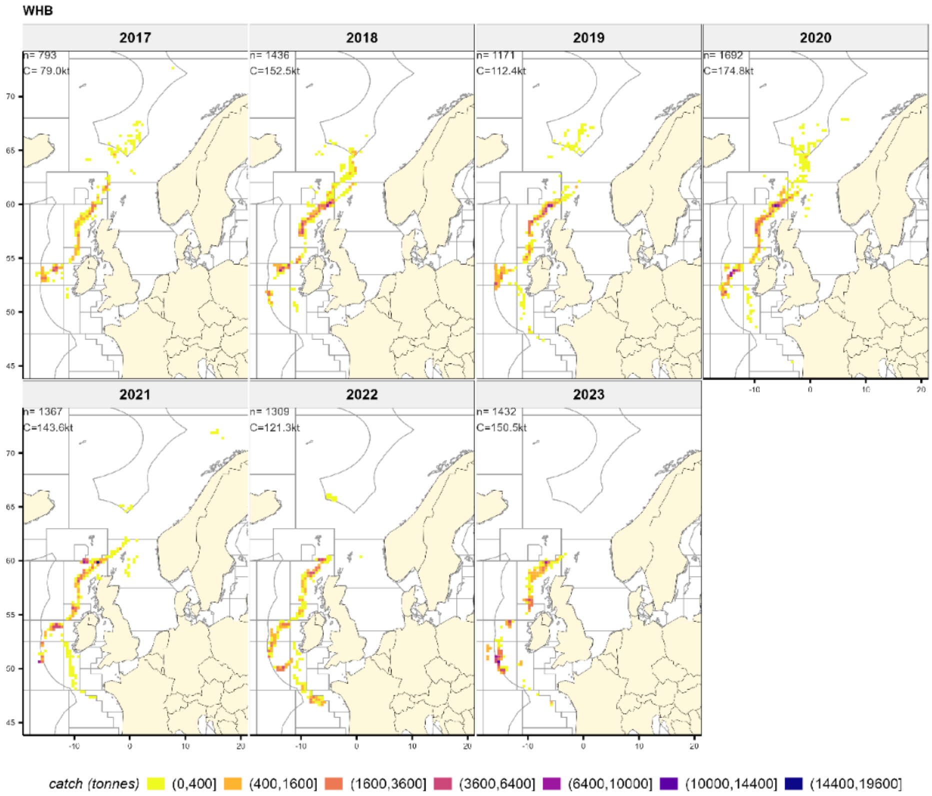

Figure 3.5.1: Blue whiting. Catch per per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

Blue whiting. Catchrate (ton/day) by rectangle

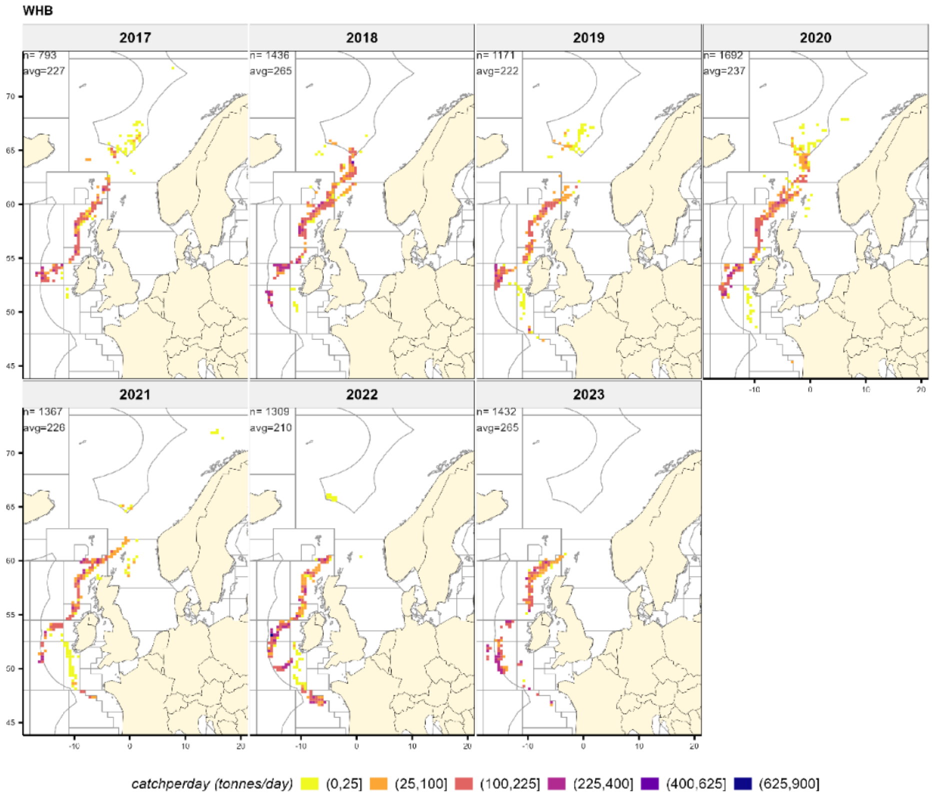

Figure 3.5.2: Blue whiting. Catchrate (ton/day) per rectangle. N indicates the number of hauls; Avg refers to the average catchrate per rect.

Blue whiting. Spatio-temporal evolution of catch by month and rectangle

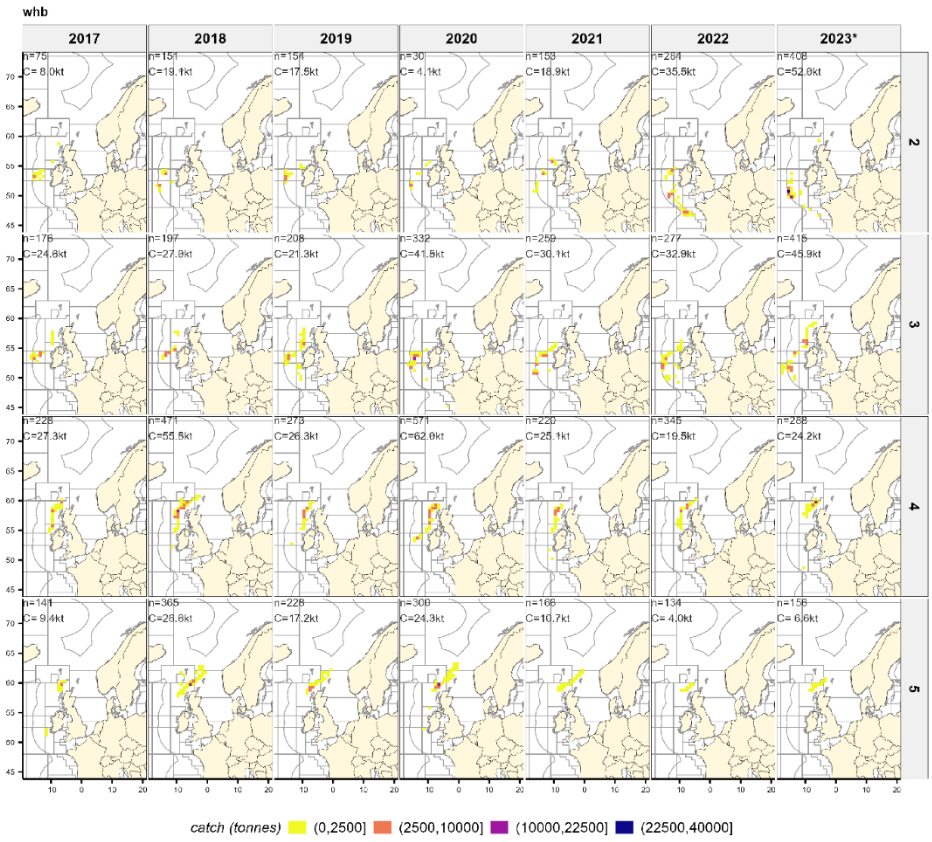

Figure 3.5.3: Blue whiting. Spatio-temporal evolution of the catches per rectangle and month. N indicates the number of hauls; C refers to the total catch by year and month.

Blue whiting. Catch proportion at depth

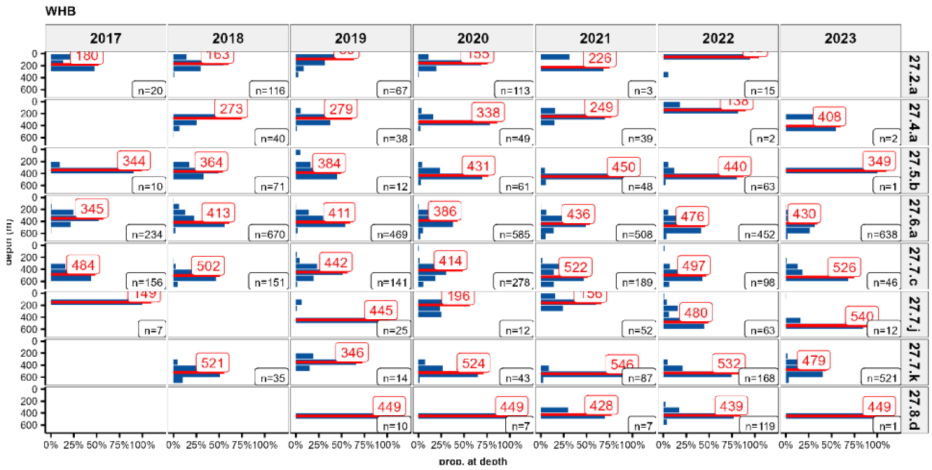

Figure 3.5.4: Blue whiting. Catch proportion at depth. N indicates the number of hauls.

Blue whiting. Length distributions of the catch

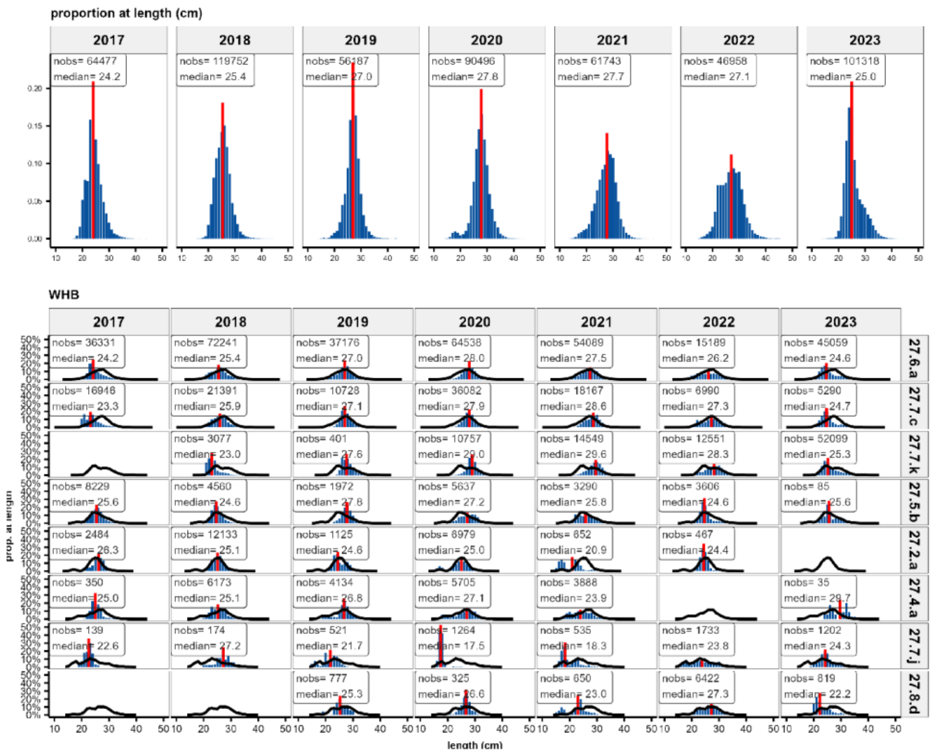

Figure 3.5.5: Blue whiting. Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

Blue whiting. Length distributions as proportions by (large) rectangle

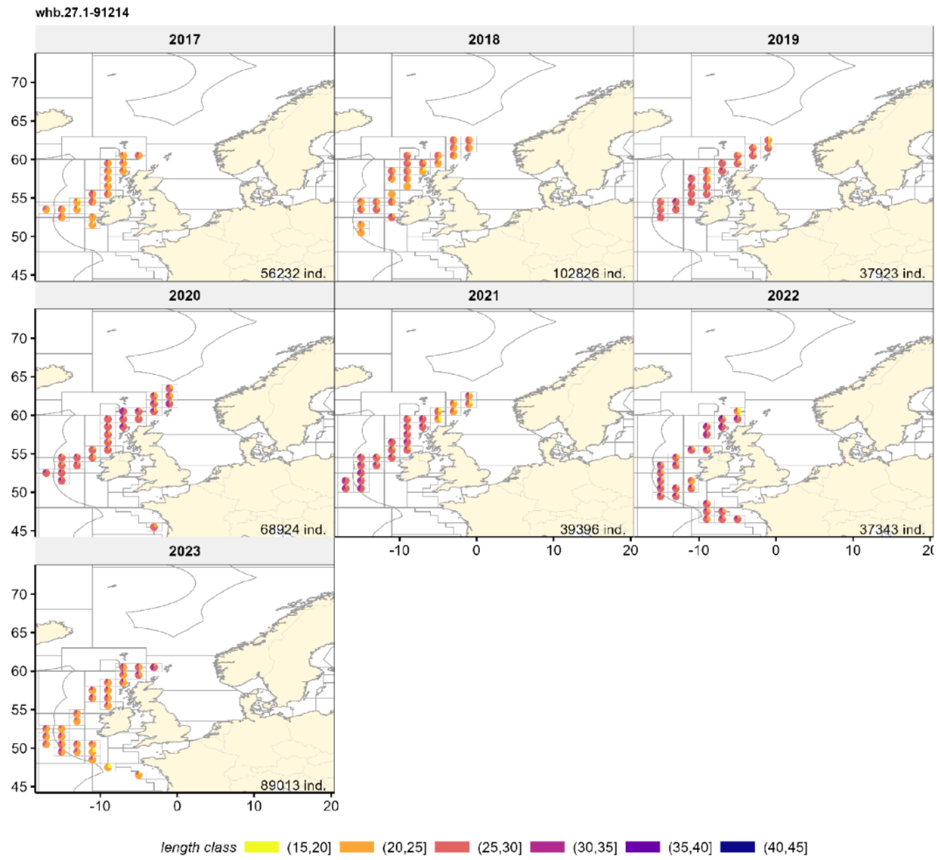

Figure 3.5.6: Blue whiting. Length distributions as proportions by large rectangle. Ind. refers to the number of length measurements

Blue whiting. Average length, weight and fat content by year and month

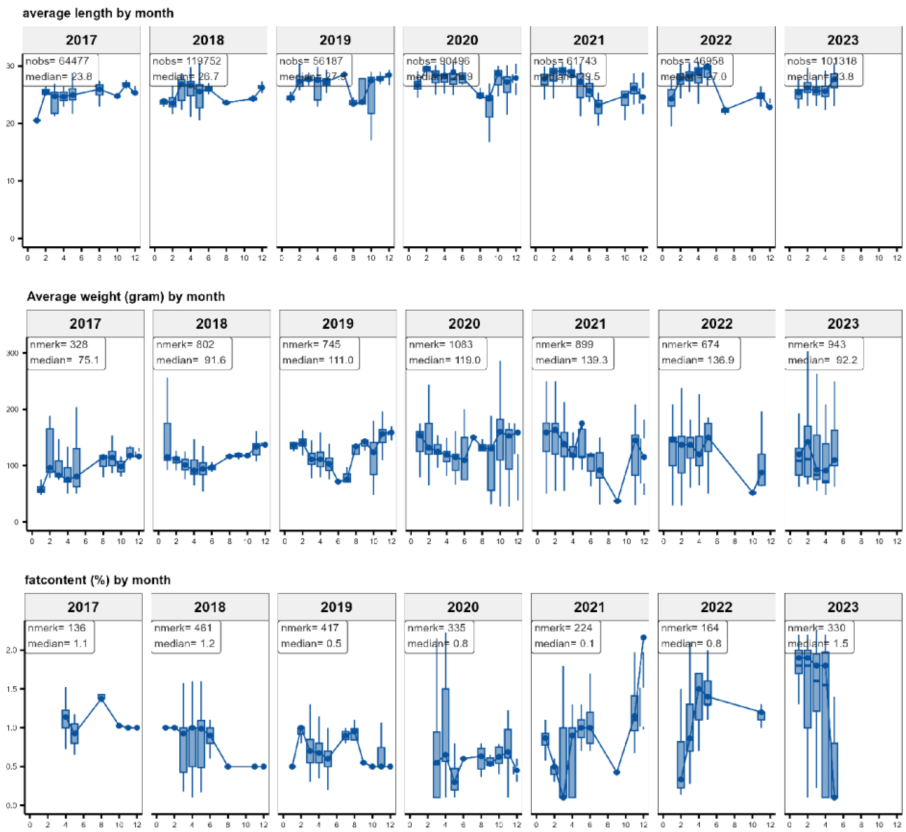

Figure 3.5.7: Blue whiting. Average length, average weight, and average fat content. Nobs indicates the number of measurements, median indicates the median values

Blue whiting (WHB). Standardized CPUE

Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset. It is assumed that a 2.5% annual efficiency increase takes place (Rousseau et al 2019).

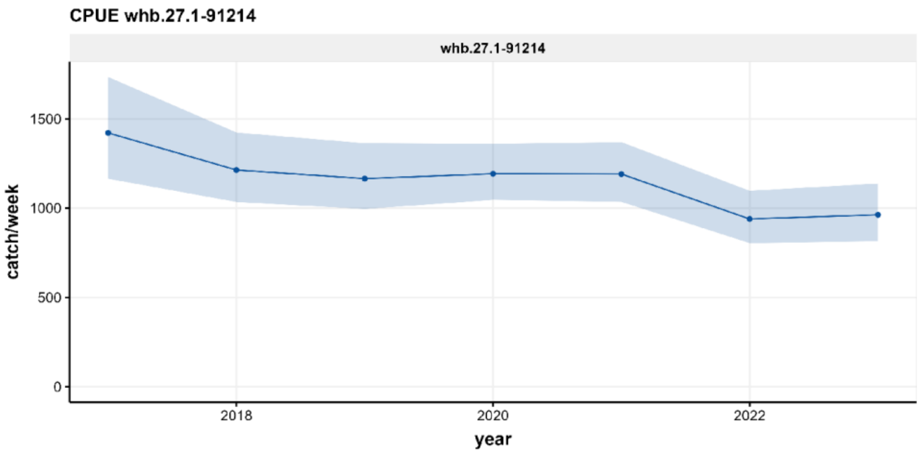

Figure 3.5.8: Blue whiting. Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset

3.6 Atlanto-scandian herring (HER_ASH, Clupea harengus)

Atlanto-scandian herring self-sampling summary.

species	year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nlength
her_ash	2017	4	7	31	58	4,913	158	678
her_ash	2018	2	3	18	27	1,367	76	4
her_ash	2019	3	4	23	59	3,373	147	838
her_ash	2020	6	8	44	69	3,563	81	989
her_ash	2021	3	3	10	16	2,379	238	1,469
her_ash	2022	2	2	11	20	778	71	657
(all)	(all)		27	137	249	16,375		4,635

Table 3.6.1: Atlanto-scandian herring. Self-sampling summary with the number of days, hauls, trips, vessels, catch (tonnes), catch rate (ton/day), number of fish measured, number of biological observations.

Atlanto-scandian herring. Catch by division

species	division	2017	2018	2019	2020	2021	2022	all	perc
her_ash	27.2.a	4,913	1,367	3,373	3,563	2,379	778	16,375	100.0%
(all)	(all)	4,913	1,367	3,373	3,563	2,379	778	16,375	100.0%

Table 3.6.2: Atlanto-scandian herring. Self-sampling summary with the catch (tonnes) by year and division

Atlanto-scandian herring. Catch by month

species	month	2017	2018	2019	2020	2021	2022	all	perc
her_ash	May	0	0	0	26	0	0	26	0.2%
her_ash	Aug	118	52	0	61	0	0	232	1.4%
her_ash	Sep	7	405	362	53	0	0	827	5.1%
her_ash	Oct	4,788	910	2,184	2,480	1,659	0	12,021	73.4%
her_ash	Nov	0	0	828	942	721	778	3,269	20.0%
(all)	(all)	4,913	1,367	3,373	3,563	2,379	778	16,375	100.0%

Table 3.6.3: Atlanto-scandian herring. Self-sampling summary with the catch (tonnes) by year and month

Atlanto-scandian herring. Catch by country

species	flag	2017	2018	2019	2020	2021	2022	all	perc
her_ash	DEU	707	0	719	1,036	721	0	3,182	19.4%
her_ash	LIT	0	0	0	1,098	0	0	1,098	6.7%
her_ash	NL	4,185	1,367	2,654	524	1,659	778	11,167	68.2%
her_ash	POL	0	0	0	859	0	0	859	5.2%
her_ash	UK	21	0	0	48	0	0	69	0.4%
(all)	(all)	4,913	1,367	3,373	3,563	2,379	778	16,375	100.0%

Table 3.6.4: Atlanto-scandian herring. Self-sampling summary with the catch (tonnes) by year and country

Atlanto-scandian herring. Catch by rectangle

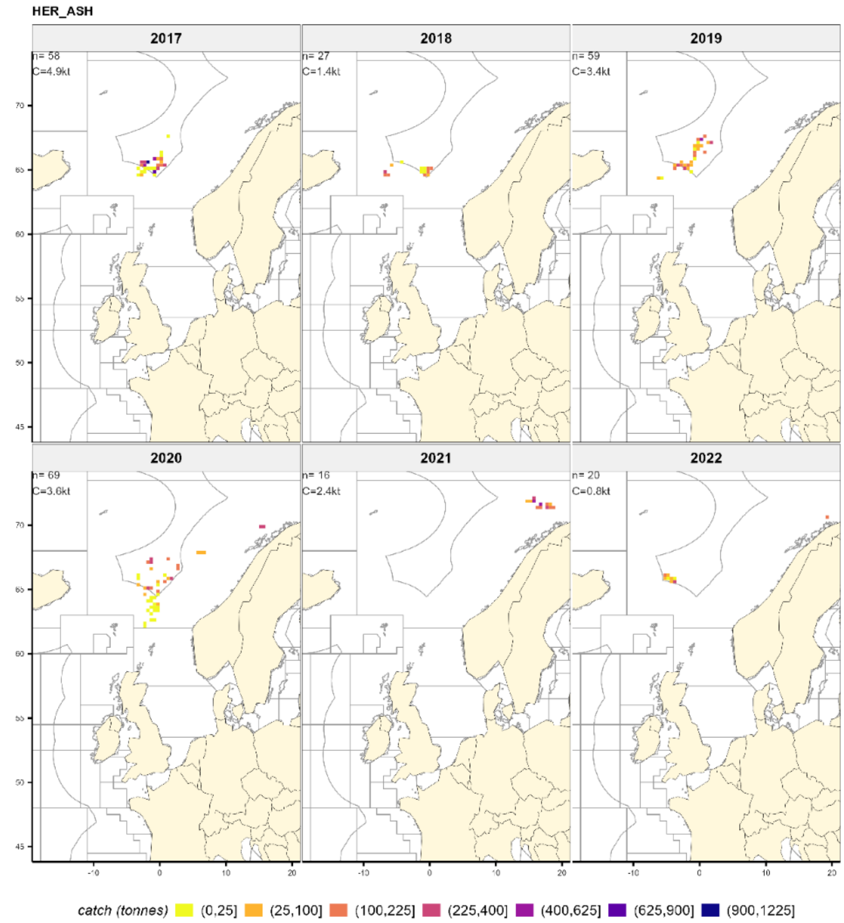

Figure 3.6.1: Atlanto-scandian herring. Catch per per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

Atlanto-scandian herring. Catchrate (ton/day) by rectangle

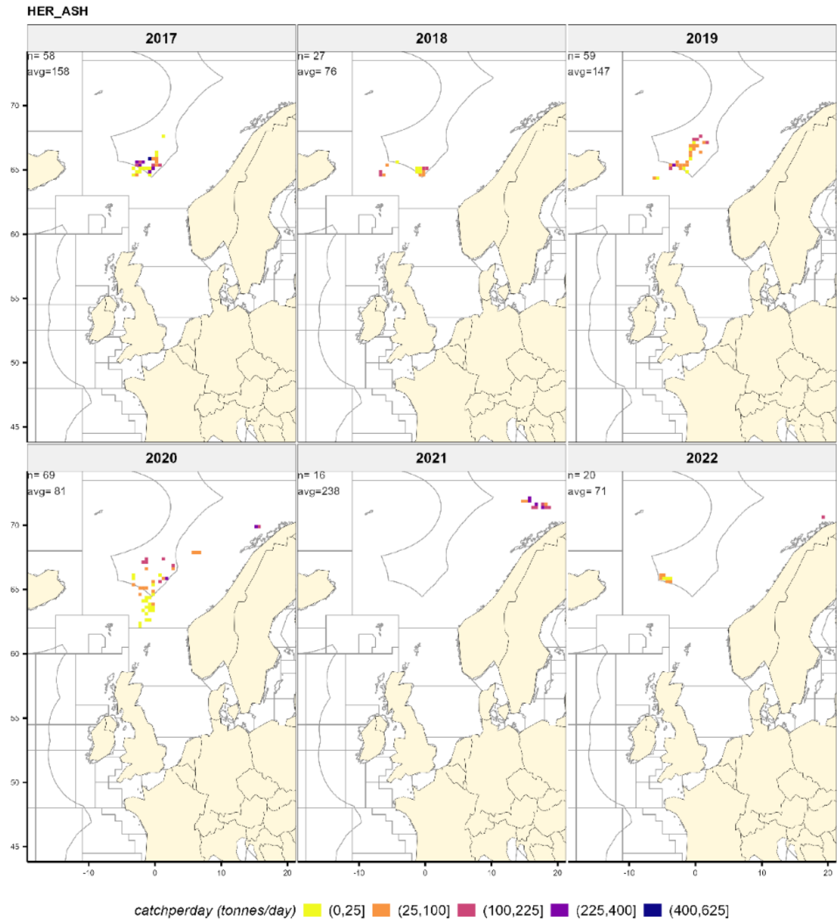

Figure 3.6.2: Atlanto-scandian herring. Catchrate (ton/day) per rectangle. N indicates the number of hauls; Avg refers to the average catchrate per rect.

Atlanto-scandian herring. Spatio-temporal evolution of catch by month and rectangle

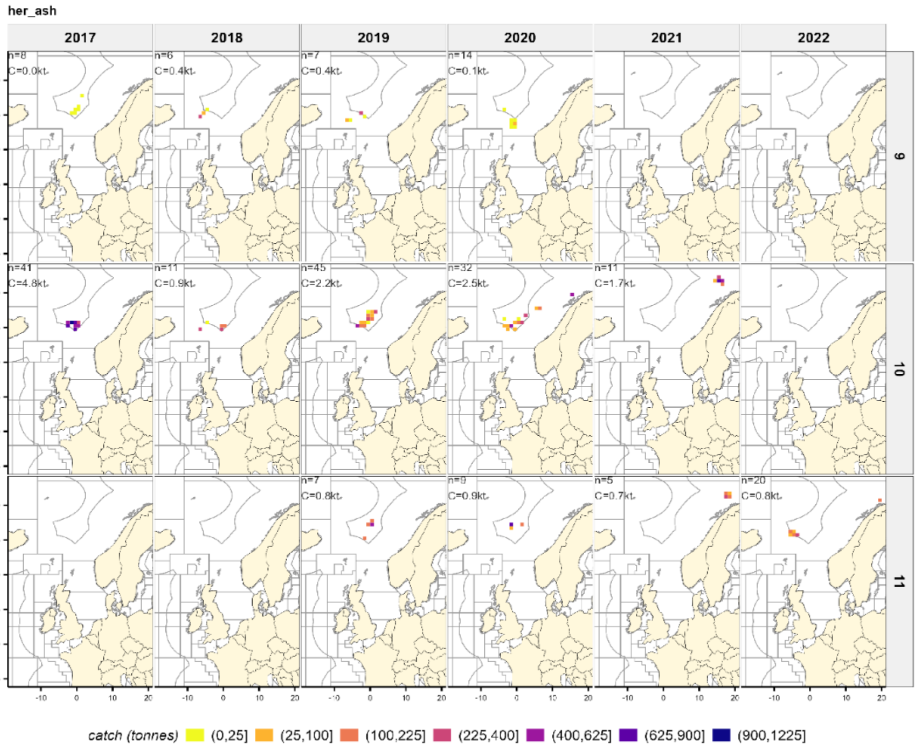

Figure 3.6.3: Atlanto-scandian herring. Spatio-temporal evolution of the catches per rectangle and month. N indicates the number of hauls; C refers to the total catch by year and month.

Atlanto-scandian herring. Catch proportion at depth

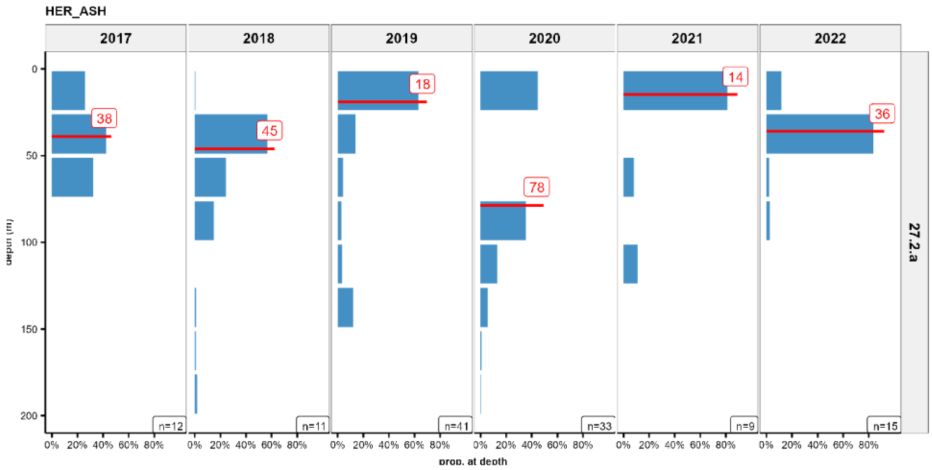

Figure 3.6.4: Atlanto-scandian herring. Catch proportion at depth. N indicates the number of hauls.

Atlanto-scandian herring. Length distributions of the catch

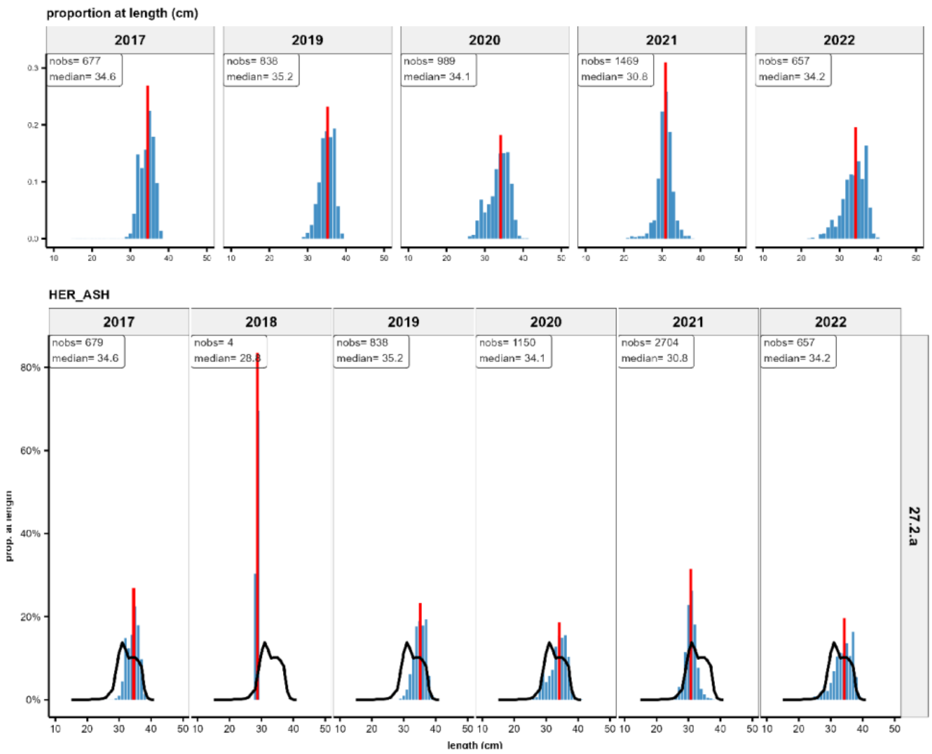

Figure 3.6.5: Atlanto-scandian herring. Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

Atlanto-scandian herring. Length distributions as proportions by (large) rectangle

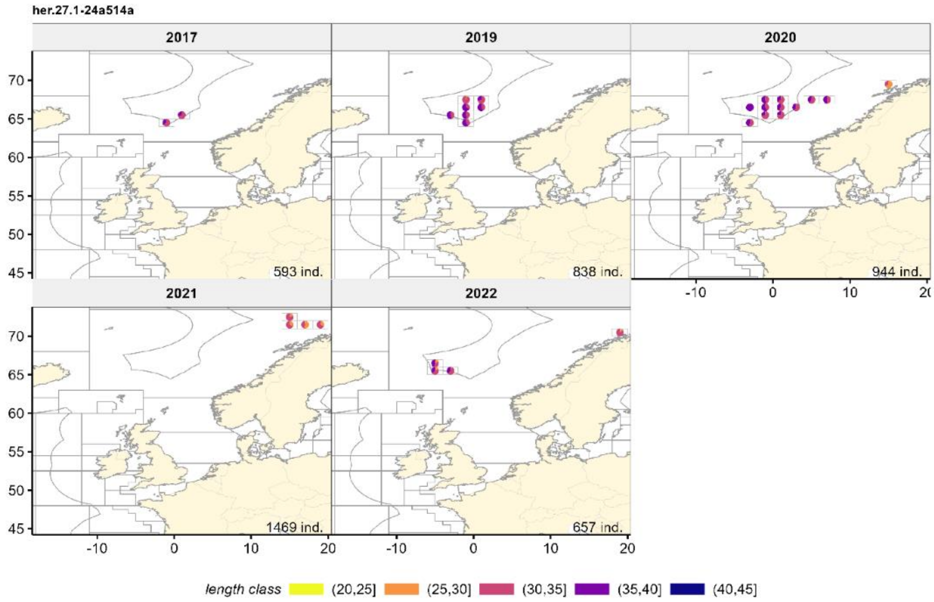

Figure 3.6.6: Atlanto-scandian herring. Length distributions as proportions by large rectangle. Ind. refers to the number of length measurements

Atlanto-scandian herring. Average length, weight and fat content by year and month

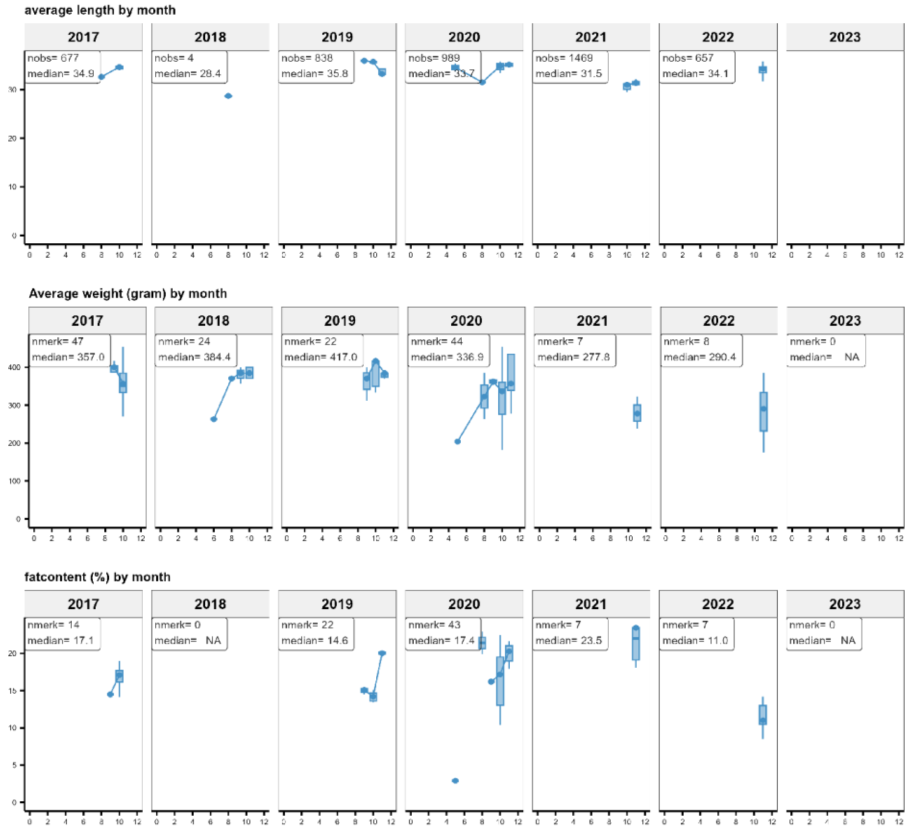

Figure 3.6.7: Atlanto-scandian herring. Average length, average weight, and average fat content. Nobs indicates the number of measurements, median indicates the median values

4 Discussion and conclusions

The PFA self-sampling program has been carried out for the nineth year in a row (2015-2023). Here, results have been presented for the years 2017-2023 in terms of meta-information on the sampling (number of vessels, trips, days and length measurements per area and/or season), in terms of the spatio-temporal distribution of catches and the length and weight compositions by area and/or season.

The definition of what constitutes the 'widely distributed fishery' has been approached by selecting all combination of vessel-trip-weeks where hauls were taken in a certain area and where the catch composition consisted of a minimum percentage of certain species (blue whiting, mackerel, horse mackerel, Atlanto-scandian herring) and a minimum weekly catch of 10 tons. Although for herring we aimed to select only trips for Atlanto-scandian herring (in division 27.2.a) some trips with North Sea herring have been included because they were combined with some fishing for mackerel.

The CPUE of Mackerel shows a relative stable picture of the stock in the recent years with a small downward trend from 2020 to 2022. Some smaller fish has been caught in the early part of 2023 that has been absent in previous years. The fishery has been similar in distribution compared to other years except that almost no catches have been taken in the NEAFC area (banana area) in 2021-2022. Fish were less fat in 2022 compared to the years before with an average of 18.8% of fat compared to 19.1-22% in recent years.

The CPUE of Blue whiting shows a relatively stable pattern with a small decline from 2021 to 2022. The fishery had a relatively wide spectrum of fish sizes being landed while the distribution of the fishery was more focused on areas 6.a and 7.c. 7.k. and 7.b and not so much on the NEAFC area or area 2.a. The fish was relatively heavy at around 137 grams.

The CPUE of Western horse mackerel shows a declining trend since 2018 and due to bycatch quota only in 2023 the CPUE drops even further. The size range of fish caught was rather tight in 2022 compared to preceding years and the fishery caught most of the horse mackerel further south compared to previoius years in which more substantial catches were also made in area 6.a. The fish had lower fatcontent compared to 2020-2021 but were not that dissimilar from 2018-2019. Length distribution and weight was comparable to the preceding years.

The CPUE of North Sea horse mackerel shows, similar to the Western horse mackerel CPUE, a declining trend since 2018. The fishery had larger catches in 4.c. compared to previous years and mean size of the fish was lower compared to other years. The averge weight however was quite a bit larger than the previous years which may indicate that fish were fatter than in previous years. There were too few fat measurements however to support any statement on this.

Given the low number of hauls of Atlanto-Scandian herring, we did not perform CPUE analyses for this fishery. The catch distribution of this fishery varies substantially from year to year with catches in 2022 all located in the NEAFC area while in previous years also closer to the Norwegian coast catches had been made.

5 Acknowledgements

The skippers, officers and the quality managers of many of the PFA vessels are putting in a lot of effort to make the PFA the self-sampling work. Without their efforts, there would be no self-sampling.

6 References and publications

Hansen, F. T., F. Burns, S. Post, U. H. Thygesen and T. Jansen (2018). Length measurement methods of Atlantic mackerel (Scomber scombrus) and Atlantic horse mackerel (Trachurus trachurus) – current practice, conversion keys and recommendations. Fisheries Research 205: 57-64.

Pastoors, M. A., A. T. M. Van Helmond, H. M. J. Van Overzee, I. Wojcek and S. Verver (2018). Comparison of PFA self-sampling with EU observer data, SPRFMO, SC6-JM04.

Pastoors, M. A. and F. J. Quirijns (2021). PFA self-sampling report 2015-2020, PFA. 2021/02.

Pastoors, M. A. and F. J. Quirijns (2022). PFA self-sampling report 2016-2021, PFA. 2022/02.[This report]

Pastoors, M. A. (2020). Self-sampling Manual v 2.13, PFA. 2020/09.

Pastoors, M. A. and F. J. Quirijns (2021). PFA selfsampling report for North Sea herring fisheries, 2015-2020 (including 6a herring, sprat and pilchards), PFA. 2021_03.

Pastoors, M. A. (2021). PFA selfsampling report for WGDEEP 2021, PFA. 2021/04.

Pastoors, M. A. (2021). PFA selfsampling report for WGWIDE, 2015-2021, PFA. PFA report 2021_08.

Pastoors, M. A. (2021). PFA selfsampling report for the SPRFMO Science Committee 2021, PFA. PFA 2021_07 / SPRFMO SC9-JM06.

Pastoors, M. A. and I. Wojcek (2020). Comparison of PFA self-sampling with EU observer data, SPRFMO. SC8-JM03.

Quirijns, F. J. and M. A. Pastoors (2020). CPUE standardization for greater silversmelt in 5b6a. WKGSS 2020, WD03.

Rousseau, Y., R. A. Watson, J. L. Blanchard and E. A. Fulton (2019). "Evolution of global marine fishing fleets and the response of fished resources." Proceedings of the National Academy of Sciences 116(25): 12238-12243.

7 More information

Please contact Niels Hintzen (nhintzen@pelagicfish.eu) if you would have any questions on the PFA self-sampling program or the specific results presented here.

8 Northeast Atlantic mackerel: detailed tables

Northeast Atlantic mackerel Sampling overview

species	year	quarter	area	division	catch	sampleweight	nsamples	count	catchnumber
mac	2022	1	27	27.4.a	11982	1209	82	3659	24087
mac	2022	1	27	27.6.a	9707	502	42	1570	15056
mac	2022	1	27	27.7.b	4535	443	33	1447	10193
mac	2022	1	27	27.7.j	363	42	16	138	416
mac	2022	2	27	27.4.a	23	NA	NA	NA	NA
mac	2022	2	27	27.6.a	146	12	8	32	158
mac	2022	3	27	27.2.a	120	NA	NA	NA	NA
mac	2022	3	27	27.4.a	3721	181	32	584	5562
mac	2022	3	27	27.7.b	3	5	1	12	10
mac	2022	3	27	27.7.j	3	4	4	14	103
mac	2022	4	27	27.2.a	0	NA	NA	NA	NA
mac	2022	4	27	27.4.a	32238	1739	195	7891	59952
mac	2022	4	27	27.7.j	0	NA	NA	NA	NA
mac	2023	1	27	27.4.a	9331	709	41	2270	12373
mac	2023	1	27	27.6.a	16150	999	68	3168	18582
mac	2023	1	27	27.7.b	13	NA	NA	NA	NA
mac	2023	2	27	27.4.a	9	0	1	57	142
mac	2023	2	27	27.6.a	767	94	38	256	1533
mac	2023	2	27	27.7.j	8	0	1	1	18

Northeast Atlantic mackerel Length frequencies 2022

species	stockname	stockcode	area	year	quarter	division	length	count	catchnumber	prop
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	26	10	36464	0.0015
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	27	54	346705	0.0144
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	28	49	340570	0.0141
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	29	64	412899	0.0171
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	30	68	412400	0.0171
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	31	82	489344	0.0203
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	32	94	569007	0.0236
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	33	109	526606	0.0219
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	34	181	1047462	0.0435
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	35	269	1703142	0.0707
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	36	450	2723107	0.1131
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	37	648	4162473	0.1728
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	38	689	4592406	0.1907
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	39	508	3774323	0.1567
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	40	266	1885261	0.0783
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	41	92	756625	0.0314
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	42	21	243746	0.0101
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	43	2	7439	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	44	3	57399	0.0024
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	17	1	4150	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	18	1	4150	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	19	1	4150	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	23	4	15424	0.0010
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	24	5	30313	0.0020
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	25	8	34891	0.0023
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	26	12	85246	0.0057
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	27	14	137644	0.0091
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	28	24	273784	0.0182
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	29	22	150308	0.0100
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	30	45	398239	0.0265
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	31	64	554722	0.0368
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	32	84	782862	0.0520
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	33	120	1156090	0.0768
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	34	95	882994	0.0586
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	35	115	1091725	0.0725
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	36	105	1096835	0.0728
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	37	209	2050525	0.1362
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	38	274	2565070	0.1704
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	39	214	2171710	0.1442
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	40	117	1193579	0.0793
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	41	29	282289	0.0187
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	42	7	89517	0.0059
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	20	3	34527	0.0034

mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	21	5	57545	0.0056
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	22	7	80563	0.0079
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	23	7	80563	0.0079
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	24	4	46036	0.0045
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	25	5	57545	0.0056
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	26	4	46036	0.0045
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	27	4	35245	0.0035
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	28	3	31860	0.0031
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	29	7	84735	0.0083
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	30	25	216377	0.0212
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	31	24	196195	0.0192
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	32	31	296552	0.0291
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	33	45	315556	0.0310
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	34	72	507485	0.0498
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	35	162	1101891	0.1081
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	36	203	1318078	0.1293
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	37	201	1323574	0.1298
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	38	270	1866023	0.1831
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	39	211	1395078	0.1369
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	40	110	751821	0.0738
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	41	34	283483	0.0278
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	42	6	46318	0.0045
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	43	3	9300	0.0009
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	44	1	10778	0.0011
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	25	2	6604	0.0159
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	26	1	3302	0.0079
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	27	2	10388	0.0250
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	28	2	6163	0.0148
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	29	7	34010	0.0817
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	30	15	55985	0.1345
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	31	10	47240	0.1135
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	32	10	44617	0.1072
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	33	13	48956	0.1176
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	34	15	44410	0.1067
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	35	16	30610	0.0736
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	36	17	21822	0.0524
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	37	11	26273	0.0631
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	38	8	18422	0.0443
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	39	6	12616	0.0303
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	40	3	4754	0.0114
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	34	4	20848	0.1319
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	35	5	31786	0.2011
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	36	5	28235	0.1786
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	37	6	27219	0.1722
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	38	6	28043	0.1774
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	39	3	14125	0.0894
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	40	1	2102	0.0133
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	41	1	2102	0.0133
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	42	1	3602	0.0228
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	25	5	18037	0.0032
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	26	15	53765	0.0097
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	27	10	36074	0.0065
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	28	20	72148	0.0130
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	29	15	132662	0.0239
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	30	89	985972	0.1773
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	31	117	1255600	0.2257
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	32	97	977413	0.1757
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	33	66	687811	0.1237
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	34	44	386556	0.0695
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	35	23	210254	0.0378
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	36	25	218654	0.0393
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	37	29	302428	0.0544
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	38	22	180212	0.0324
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	39	6	31873	0.0057
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	40	1	12791	0.0023
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	32	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	34	5	4369	0.4168
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	35	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	36	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	37	2	1747	0.1667
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	38	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	40	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	31	1	4751	0.0457
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	32	2	17221	0.1656
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	33	1	12469	0.1199
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	34	1	9293	0.0894
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	35	3	14255	0.1371
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	36	2	9503	0.0914
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	37	1	13494	0.1298
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	38	2	18246	0.1755

mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	39	1	4751	0.0457
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	24	1	1806	0.0000
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	25	1	16414	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	26	7	41869	0.0007
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	27	18	82129	0.0014
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	28	29	173550	0.0029
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	29	53	361704	0.0060
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	30	207	1585267	0.0264
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	31	625	4705556	0.0785
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	32	849	6064281	0.1012
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	33	703	4940919	0.0824
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	34	583	4329125	0.0722
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	35	666	5068623	0.0845
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	36	814	7045002	0.1175
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	37	977	7928056	0.1322
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	38	1030	7884558	0.1315
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	39	772	5641257	0.0941
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	40	398	2789539	0.0465
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	41	133	1066549	0.0178
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	42	19	185216	0.0031
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	43	4	36034	0.0006
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	44	1	3324	0.0001
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	45	1	1929	0.0000

Northeast Atlantic mackerel Length frequencies 2023

species	stockname	stockcode	area	year	quarter	division	length	count	catchnumber	prop
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	20	6	7095	0.0006
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	21	8	9143	0.0007
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	22	6	6710	0.0005
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	23	3	3606	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	24	7	14339	0.0012
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	25	19	38546	0.0031
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	26	23	46971	0.0038
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	27	34	76906	0.0062
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	28	43	164557	0.0133
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	29	66	340411	0.0275
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	30	141	824473	0.0666
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	31	157	854314	0.0690
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	32	142	750761	0.0607
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	33	148	771996	0.0624
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	34	151	834645	0.0675
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	35	203	1251271	0.1011
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	36	284	1741581	0.1407
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	37	344	1974576	0.1596
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	38	249	1460466	0.1180
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	39	142	742746	0.0600
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	40	63	348290	0.0281
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	41	15	89649	0.0072
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	42	2	18736	0.0015
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	43	1	2073	0.0002
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	16	0	985	0.0001
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	17	1	7268	0.0004
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	18	5	27792	0.0015
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	19	3	19368	0.0010
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	20	9	47732	0.0026
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	21	3	17037	0.0009
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	22	0	1663	0.0001
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	25	0	3719	0.0002
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	26	4	27399	0.0015
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	27	7	46455	0.0025
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	28	28	146393	0.0079
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	29	95	525911	0.0283
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	30	132	733950	0.0395
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	31	192	1070533	0.0576
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	32	212	1274502	0.0686
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	33	203	1197143	0.0644
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	34	232	1343748	0.0723
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	35	299	1643786	0.0885
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	36	424	2467270	0.1328
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	37	497	2878717	0.1549
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	38	395	2400487	0.1292
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	39	245	1535283	0.0826
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	40	123	795265	0.0428
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	41	39	271188	0.0146
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	42	8	93608	0.0050

mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	44	1	5597	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	13	13	32497	0.2281
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	14	5	12499	0.0877
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	15	5	12499	0.0877
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	16	6	14999	0.1053
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	17	16	39997	0.2807
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	18	5	12499	0.0877
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	19	2	4999	0.0351
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	20	3	7499	0.0526
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	21	2	4999	0.0351
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	20	1	16884	0.0110
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	29	1	1822	0.0012
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	32	7	46453	0.0303
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	33	18	93502	0.0610
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	34	21	130212	0.0849
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	35	29	211340	0.1378
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	36	37	296837	0.1936
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	37	32	197298	0.1287
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	38	40	217112	0.1416
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	39	29	141405	0.0922
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	40	25	127183	0.0830
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	41	8	39508	0.0258
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	42	4	13639	0.0089
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.7.j	36	1	18415	1.0000

9 Western horse mackerel: detailed tables

Western horse mackerel Sampling overview

species	year	quarter	area	division	catch	sampleweight	nsamples	count	catchnumber
mac	2022	1	27	27.4.a	11982	1209	82	3659	24087
mac	2022	1	27	27.6.a	9707	502	42	1570	15056
mac	2022	1	27	27.7.b	4535	443	33	1447	10193
mac	2022	1	27	27.7.j	363	42	16	138	416
mac	2022	2	27	27.4.a	23	NA	NA	NA	NA
mac	2022	2	27	27.6.a	146	12	8	32	158
mac	2022	3	27	27.2.a	120	NA	NA	NA	NA
mac	2022	3	27	27.4.a	3721	181	32	584	5562
mac	2022	3	27	27.7.b	3	5	1	12	10
mac	2022	3	27	27.7.j	3	4	4	14	103
mac	2022	4	27	27.2.a	0	NA	NA	NA	NA
mac	2022	4	27	27.4.a	32238	1739	195	7891	59952
mac	2022	4	27	27.7.j	0	NA	NA	NA	NA
mac	2023	1	27	27.4.a	9331	709	41	2270	12373
mac	2023	1	27	27.6.a	16150	999	68	3168	18582
mac	2023	1	27	27.7.b	13	NA	NA	NA	NA
mac	2023	2	27	27.4.a	9	0	1	57	142
mac	2023	2	27	27.6.a	767	94	38	256	1533
mac	2023	2	27	27.7.j	8	0	1	1	18

Western horse mackerel Length frequencies 2022

species	stockname	stockcode	area	year	quarter	division	length	count	catchnumber	prop
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	26	10	36464	0.0015
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	27	54	346705	0.0144
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	28	49	340570	0.0141
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	29	64	412899	0.0171
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	30	68	412400	0.0171
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	31	82	489344	0.0203
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	32	94	569007	0.0236
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	33	109	526606	0.0219
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	34	181	1047462	0.0435
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	35	269	1703142	0.0707
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	36	450	2723107	0.1131
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	37	648	4162473	0.1728
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	38	689	4592406	0.1907
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	39	508	3774323	0.1567
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	40	266	1885261	0.0783
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	41	92	756625	0.0314
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	42	21	243746	0.0101
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	43	2	7439	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	44	3	57399	0.0024
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	17	1	4150	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	18	1	4150	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	19	1	4150	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	23	4	15424	0.0010
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	24	5	30313	0.0020
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	25	8	34891	0.0023
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	26	12	85246	0.0057
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	27	14	137644	0.0091
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	28	24	273784	0.0182
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	29	22	150308	0.0100
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	30	45	398239	0.0265
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	31	64	554722	0.0368
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	32	84	782862	0.0520
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	33	120	1156090	0.0768
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	34	95	882994	0.0586
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	35	115	1091725	0.0725
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	36	105	1096835	0.0728
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	37	209	2050525	0.1362
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	38	274	2565070	0.1704
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	39	214	2171710	0.1442
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	40	117	1193579	0.0793
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	41	29	282289	0.0187
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	42	7	89517	0.0059
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	20	3	34527	0.0034

mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	21	5	57545	0.0056
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	22	7	80563	0.0079
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	23	7	80563	0.0079
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	24	4	46036	0.0045
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	25	5	57545	0.0056
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	26	4	46036	0.0045
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	27	4	35245	0.0035
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	28	3	31860	0.0031
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	29	7	84735	0.0083
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	30	25	216377	0.0212
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	31	24	196195	0.0192
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	32	31	296552	0.0291
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	33	45	315556	0.0310
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	34	72	507485	0.0498
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	35	162	1101891	0.1081
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	36	203	1318078	0.1293
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	37	201	1323574	0.1298
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	38	270	1866023	0.1831
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	39	211	1395078	0.1369
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	40	110	751821	0.0738
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	41	34	283483	0.0278
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	42	6	46318	0.0045
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	43	3	9300	0.0009
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	44	1	10778	0.0011
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	25	2	6604	0.0159
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	26	1	3302	0.0079
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	27	2	10388	0.0250
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	28	2	6163	0.0148
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	29	7	34010	0.0817
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	30	15	55985	0.1345
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	31	10	47240	0.1135
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	32	10	44617	0.1072
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	33	13	48956	0.1176
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	34	15	44410	0.1067
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	35	16	30610	0.0736
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	36	17	21822	0.0524
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	37	11	26273	0.0631
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	38	8	18422	0.0443
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	39	6	12616	0.0303
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	40	3	4754	0.0114
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	34	4	20848	0.1319
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	35	5	31786	0.2011
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	36	5	28235	0.1786
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	37	6	27219	0.1722
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	38	6	28043	0.1774
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	39	3	14125	0.0894
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	40	1	2102	0.0133
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	41	1	2102	0.0133
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	42	1	3602	0.0228
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	25	5	18037	0.0032
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	26	15	53765	0.0097
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	27	10	36074	0.0065
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	28	20	72148	0.0130
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	29	15	132662	0.0239
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	30	89	985972	0.1773
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	31	117	1255600	0.2257
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	32	97	977413	0.1757
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	33	66	687811	0.1237
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	34	44	386556	0.0695
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	35	23	210254	0.0378
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	36	25	218654	0.0393
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	37	29	302428	0.0544
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	38	22	180212	0.0324
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	39	6	31873	0.0057
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	40	1	12791	0.0023
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	32	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	34	5	4369	0.4168
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	35	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	36	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	37	2	1747	0.1667
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	38	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	40	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	31	1	4751	0.0457
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	32	2	17221	0.1656
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	33	1	12469	0.1199
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	34	1	9293	0.0894
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	35	3	14255	0.1371
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	36	2	9503	0.0914
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	37	1	13494	0.1298
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	38	2	18246	0.1755

mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	39	1	4751	0.0457
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	24	1	1806	0.0000
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	25	1	16414	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	26	7	41869	0.0007
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	27	18	82129	0.0014
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	28	29	173550	0.0029
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	29	53	361704	0.0060
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	30	207	1585267	0.0264
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	31	625	4705556	0.0785
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	32	849	6064281	0.1012
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	33	703	4940919	0.0824
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	34	583	4329125	0.0722
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	35	666	5068623	0.0845
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	36	814	7045002	0.1175
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	37	977	7928056	0.1322
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	38	1030	7884558	0.1315
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	39	772	5641257	0.0941
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	40	398	2789539	0.0465
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	41	133	1066549	0.0178
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	42	19	185216	0.0031
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	43	4	36034	0.0006
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	44	1	3324	0.0001
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	45	1	1929	0.0000

Western horse mackerel Length frequencies 2023

species	stockname	stockcode	area	year	quarter	division	length	count	catchnumber	prop
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	20	6	7095	0.0006
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	21	8	9143	0.0007
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	22	6	6710	0.0005
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	23	3	3606	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	24	7	14339	0.0012
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	25	19	38546	0.0031
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	26	23	46971	0.0038
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	27	34	76906	0.0062
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	28	43	164557	0.0133
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	29	66	340411	0.0275
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	30	141	824473	0.0666
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	31	157	854314	0.0690
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	32	142	750761	0.0607
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	33	148	771996	0.0624
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	34	151	834645	0.0675
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	35	203	1251271	0.1011
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	36	284	1741581	0.1407
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	37	344	1974576	0.1596
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	38	249	1460466	0.1180
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	39	142	742746	0.0600
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	40	63	348290	0.0281
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	41	15	89649	0.0072
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	42	2	18736	0.0015
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	43	1	2073	0.0002
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	16	0	985	0.0001
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	17	1	7268	0.0004
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	18	5	27792	0.0015
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	19	3	19368	0.0010
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	20	9	47732	0.0026
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	21	3	17037	0.0009
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	22	0	1663	0.0001
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	25	0	3719	0.0002
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	26	4	27399	0.0015
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	27	7	46455	0.0025
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	28	28	146393	0.0079
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	29	95	525911	0.0283
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	30	132	733950	0.0395
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	31	192	1070533	0.0576
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	32	212	1274502	0.0686
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	33	203	1197143	0.0644
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	34	232	1343748	0.0723
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	35	299	1643786	0.0885
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	36	424	2467270	0.1328
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	37	497	2878717	0.1549
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	38	395	2400487	0.1292
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	39	245	1535283	0.0826
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	40	123	795265	0.0428
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	41	39	271188	0.0146
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	42	8	93608	0.0050

mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	44	1	5597	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	13	13	32497	0.2281
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	14	5	12499	0.0877
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	15	5	12499	0.0877
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	16	6	14999	0.1053
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	17	16	39997	0.2807
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	18	5	12499	0.0877
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	19	2	4999	0.0351
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	20	3	7499	0.0526
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	21	2	4999	0.0351
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	20	1	16884	0.0110
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	29	1	1822	0.0012
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	32	7	46453	0.0303
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	33	18	93502	0.0610
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	34	21	130212	0.0849
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	35	29	211340	0.1378
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	36	37	296837	0.1936
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	37	32	197298	0.1287
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	38	40	217112	0.1416
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	39	29	141405	0.0922
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	40	25	127183	0.0830
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	41	8	39508	0.0258
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	42	4	13639	0.0089
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.7.j	36	1	18415	1.0000

10 North Sea horse mackerel: detailed tables

North Sea horse mackerel Sampling overview

species	year	quarter	area	division	catch	sampleweight	nsamples	count	catchnumber
mac	2022	1	27	27.4.a	11982	1209	82	3659	24087
mac	2022	1	27	27.6.a	9707	502	42	1570	15056
mac	2022	1	27	27.7.b	4535	443	33	1447	10193
mac	2022	1	27	27.7.j	363	42	16	138	416
mac	2022	2	27	27.4.a	23	NA	NA	NA	NA
mac	2022	2	27	27.6.a	146	12	8	32	158
mac	2022	3	27	27.2.a	120	NA	NA	NA	NA
mac	2022	3	27	27.4.a	3721	181	32	584	5562
mac	2022	3	27	27.7.b	3	5	1	12	10
mac	2022	3	27	27.7.j	3	4	4	14	103
mac	2022	4	27	27.2.a	0	NA	NA	NA	NA
mac	2022	4	27	27.4.a	32238	1739	195	7891	59952
mac	2022	4	27	27.7.j	0	NA	NA	NA	NA
mac	2023	1	27	27.4.a	9331	709	41	2270	12373
mac	2023	1	27	27.6.a	16150	999	68	3168	18582
mac	2023	1	27	27.7.b	13	NA	NA	NA	NA
mac	2023	2	27	27.4.a	9	0	1	57	142
mac	2023	2	27	27.6.a	767	94	38	256	1533
mac	2023	2	27	27.7.j	8	0	1	1	18

North Sea horse mackerel Length frequencies 2022

species	stockname	stockcode	area	year	quarter	division	length	count	catchnumber	prop
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	26	10	36464	0.0015
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	27	54	346705	0.0144
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	28	49	340570	0.0141
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	29	64	412899	0.0171
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	30	68	412400	0.0171
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	31	82	489344	0.0203
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	32	94	569007	0.0236
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	33	109	526606	0.0219
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	34	181	1047462	0.0435
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	35	269	1703142	0.0707
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	36	450	2723107	0.1131
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	37	648	4162473	0.1728
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	38	689	4592406	0.1907
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	39	508	3774323	0.1567
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	40	266	1885261	0.0783
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	41	92	756625	0.0314
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	42	21	243746	0.0101
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	43	2	7439	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	44	3	57399	0.0024
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	17	1	4150	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	18	1	4150	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	19	1	4150	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	23	4	15424	0.0010
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	24	5	30313	0.0020
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	25	8	34891	0.0023
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	26	12	85246	0.0057
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	27	14	137644	0.0091
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	28	24	273784	0.0182
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	29	22	150308	0.0100
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	30	45	398239	0.0265
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	31	64	554722	0.0368
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	32	84	782862	0.0520
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	33	120	1156090	0.0768
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	34	95	882994	0.0586
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	35	115	1091725	0.0725
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	36	105	1096835	0.0728
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	37	209	2050525	0.1362
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	38	274	2565070	0.1704
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	39	214	2171710	0.1442
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	40	117	1193579	0.0793
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	41	29	282289	0.0187
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	42	7	89517	0.0059
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	20	3	34527	0.0034

mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	21	5	57545	0.0056
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	22	7	80563	0.0079
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	23	7	80563	0.0079
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	24	4	46036	0.0045
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	25	5	57545	0.0056
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	26	4	46036	0.0045
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	27	4	35245	0.0035
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	28	3	31860	0.0031
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	29	7	84735	0.0083
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	30	25	216377	0.0212
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	31	24	196195	0.0192
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	32	31	296552	0.0291
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	33	45	315556	0.0310
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	34	72	507485	0.0498
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	35	162	1101891	0.1081
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	36	203	1318078	0.1293
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	37	201	1323574	0.1298
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	38	270	1866023	0.1831
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	39	211	1395078	0.1369
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	40	110	751821	0.0738
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	41	34	283483	0.0278
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	42	6	46318	0.0045
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	43	3	9300	0.0009
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	44	1	10778	0.0011
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	25	2	6604	0.0159
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	26	1	3302	0.0079
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	27	2	10388	0.0250
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	28	2	6163	0.0148
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	29	7	34010	0.0817
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	30	15	55985	0.1345
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	31	10	47240	0.1135
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	32	10	44617	0.1072
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	33	13	48956	0.1176
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	34	15	44410	0.1067
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	35	16	30610	0.0736
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	36	17	21822	0.0524
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	37	11	26273	0.0631
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	38	8	18422	0.0443
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	39	6	12616	0.0303
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	40	3	4754	0.0114
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	34	4	20848	0.1319
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	35	5	31786	0.2011
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	36	5	28235	0.1786
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	37	6	27219	0.1722
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	38	6	28043	0.1774
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	39	3	14125	0.0894
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	40	1	2102	0.0133
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	41	1	2102	0.0133
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	42	1	3602	0.0228
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	25	5	18037	0.0032
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	26	15	53765	0.0097
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	27	10	36074	0.0065
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	28	20	72148	0.0130
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	29	15	132662	0.0239
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	30	89	985972	0.1773
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	31	117	1255600	0.2257
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	32	97	977413	0.1757
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	33	66	687811	0.1237
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	34	44	386556	0.0695
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	35	23	210254	0.0378
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	36	25	218654	0.0393
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	37	29	302428	0.0544
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	38	22	180212	0.0324
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	39	6	31873	0.0057
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	40	1	12791	0.0023
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	32	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	34	5	4369	0.4168
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	35	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	36	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	37	2	1747	0.1667
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	38	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	40	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	31	1	4751	0.0457
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	32	2	17221	0.1656
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	33	1	12469	0.1199
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	34	1	9293	0.0894
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	35	3	14255	0.1371
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	36	2	9503	0.0914
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	37	1	13494	0.1298
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	38	2	18246	0.1755

mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	39	1	4751	0.0457
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	24	1	1806	0.0000
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	25	1	16414	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	26	7	41869	0.0007
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	27	18	82129	0.0014
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	28	29	173550	0.0029
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	29	53	361704	0.0060
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	30	207	1585267	0.0264
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	31	625	4705556	0.0785
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	32	849	6064281	0.1012
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	33	703	4940919	0.0824
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	34	583	4329125	0.0722
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	35	666	5068623	0.0845
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	36	814	7045002	0.1175
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	37	977	7928056	0.1322
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	38	1030	7884558	0.1315
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	39	772	5641257	0.0941
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	40	398	2789539	0.0465
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	41	133	1066549	0.0178
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	42	19	185216	0.0031
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	43	4	36034	0.0006
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	44	1	3324	0.0001
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	45	1	1929	0.0000

North Sea horse mackerel Length frequencies 2023

species	stockname	stockcode	area	year	quarter	division	length	count	catchnumber	prop
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	20	6	7095	0.0006
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	21	8	9143	0.0007
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	22	6	6710	0.0005
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	23	3	3606	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	24	7	14339	0.0012
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	25	19	38546	0.0031
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	26	23	46971	0.0038
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	27	34	76906	0.0062
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	28	43	164557	0.0133
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	29	66	340411	0.0275
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	30	141	824473	0.0666
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	31	157	854314	0.0690
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	32	142	750761	0.0607
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	33	148	771996	0.0624
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	34	151	834645	0.0675
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	35	203	1251271	0.1011
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	36	284	1741581	0.1407
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	37	344	1974576	0.1596
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	38	249	1460466	0.1180
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	39	142	742746	0.0600
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	40	63	348290	0.0281
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	41	15	89649	0.0072
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	42	2	18736	0.0015
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	43	1	2073	0.0002
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	16	0	985	0.0001
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	17	1	7268	0.0004
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	18	5	27792	0.0015
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	19	3	19368	0.0010
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	20	9	47732	0.0026
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	21	3	17037	0.0009
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	22	0	1663	0.0001
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	25	0	3719	0.0002
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	26	4	27399	0.0015
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	27	7	46455	0.0025
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	28	28	146393	0.0079
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	29	95	525911	0.0283
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	30	132	733950	0.0395
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	31	192	1070533	0.0576
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	32	212	1274502	0.0686
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	33	203	1197143	0.0644
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	34	232	1343748	0.0723
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	35	299	1643786	0.0885
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	36	424	2467270	0.1328
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	37	497	2878717	0.1549
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	38	395	2400487	0.1292
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	39	245	1535283	0.0826
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	40	123	795265	0.0428
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	41	39	271188	0.0146
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	42	8	93608	0.0050

mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	44	1	5597	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	13	13	32497	0.2281
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	14	5	12499	0.0877
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	15	5	12499	0.0877
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	16	6	14999	0.1053
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	17	16	39997	0.2807
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	18	5	12499	0.0877
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	19	2	4999	0.0351
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	20	3	7499	0.0526
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	21	2	4999	0.0351
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	20	1	16884	0.0110
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	29	1	1822	0.0012
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	32	7	46453	0.0303
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	33	18	93502	0.0610
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	34	21	130212	0.0849
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	35	29	211340	0.1378
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	36	37	296837	0.1936
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	37	32	197298	0.1287
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	38	40	217112	0.1416
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	39	29	141405	0.0922
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	40	25	127183	0.0830
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	41	8	39508	0.0258
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	42	4	13639	0.0089
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.7.j	36	1	18415	1.0000

11 Blue whiting: detailed tables

Blue whiting Sampling overview

species	year	quarter	area	division	catch	sampleweight	nsamples	count	catchnumber
mac	2022	1	27	27.4.a	11982	1209	82	3659	24087
mac	2022	1	27	27.6.a	9707	502	42	1570	15056
mac	2022	1	27	27.7.b	4535	443	33	1447	10193
mac	2022	1	27	27.7.j	363	42	16	138	416
mac	2022	2	27	27.4.a	23	NA	NA	NA	NA
mac	2022	2	27	27.6.a	146	12	8	32	158
mac	2022	3	27	27.2.a	120	NA	NA	NA	NA
mac	2022	3	27	27.4.a	3721	181	32	584	5562
mac	2022	3	27	27.7.b	3	5	1	12	10
mac	2022	3	27	27.7.j	3	4	4	14	103
mac	2022	4	27	27.2.a	0	NA	NA	NA	NA
mac	2022	4	27	27.4.a	32238	1739	195	7891	59952
mac	2022	4	27	27.7.j	0	NA	NA	NA	NA
mac	2023	1	27	27.4.a	9331	709	41	2270	12373
mac	2023	1	27	27.6.a	16150	999	68	3168	18582
mac	2023	1	27	27.7.b	13	NA	NA	NA	NA
mac	2023	2	27	27.4.a	9	0	1	57	142
mac	2023	2	27	27.6.a	767	94	38	256	1533
mac	2023	2	27	27.7.j	8	0	1	1	18

Blue whiting Length frequencies 2022

species	stockname	stockcode	area	year	quarter	division	length	count	catchnumber	prop
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	26	10	36464	0.0015
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	27	54	346705	0.0144
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	28	49	340570	0.0141
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	29	64	412899	0.0171
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	30	68	412400	0.0171
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	31	82	489344	0.0203
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	32	94	569007	0.0236
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	33	109	526606	0.0219
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	34	181	1047462	0.0435
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	35	269	1703142	0.0707
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	36	450	2723107	0.1131
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	37	648	4162473	0.1728
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	38	689	4592406	0.1907
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	39	508	3774323	0.1567
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	40	266	1885261	0.0783
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	41	92	756625	0.0314
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	42	21	243746	0.0101
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	43	2	7439	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	44	3	57399	0.0024
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	17	1	4150	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	18	1	4150	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	19	1	4150	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	23	4	15424	0.0010
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	24	5	30313	0.0020
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	25	8	34891	0.0023
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	26	12	85246	0.0057
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	27	14	137644	0.0091
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	28	24	273784	0.0182
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	29	22	150308	0.0100
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	30	45	398239	0.0265
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	31	64	554722	0.0368
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	32	84	782862	0.0520
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	33	120	1156090	0.0768
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	34	95	882994	0.0586
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	35	115	1091725	0.0725
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	36	105	1096835	0.0728
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	37	209	2050525	0.1362
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	38	274	2565070	0.1704
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	39	214	2171710	0.1442
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	40	117	1193579	0.0793
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	41	29	282289	0.0187
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	42	7	89517	0.0059
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	20	3	34527	0.0034

mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	21	5	57545	0.0056
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	22	7	80563	0.0079
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	23	7	80563	0.0079
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	24	4	46036	0.0045
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	25	5	57545	0.0056
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	26	4	46036	0.0045
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	27	4	35245	0.0035
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	28	3	31860	0.0031
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	29	7	84735	0.0083
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	30	25	216377	0.0212
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	31	24	196195	0.0192
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	32	31	296552	0.0291
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	33	45	315556	0.0310
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	34	72	507485	0.0498
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	35	162	1101891	0.1081
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	36	203	1318078	0.1293
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	37	201	1323574	0.1298
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	38	270	1866023	0.1831
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	39	211	1395078	0.1369
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	40	110	751821	0.0738
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	41	34	283483	0.0278
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	42	6	46318	0.0045
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	43	3	9300	0.0009
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	44	1	10778	0.0011
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	25	2	6604	0.0159
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	26	1	3302	0.0079
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	27	2	10388	0.0250
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	28	2	6163	0.0148
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	29	7	34010	0.0817
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	30	15	55985	0.1345
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	31	10	47240	0.1135
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	32	10	44617	0.1072
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	33	13	48956	0.1176
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	34	15	44410	0.1067
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	35	16	30610	0.0736
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	36	17	21822	0.0524
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	37	11	26273	0.0631
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	38	8	18422	0.0443
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	39	6	12616	0.0303
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	40	3	4754	0.0114
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	34	4	20848	0.1319
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	35	5	31786	0.2011
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	36	5	28235	0.1786
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	37	6	27219	0.1722
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	38	6	28043	0.1774
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	39	3	14125	0.0894
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	40	1	2102	0.0133
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	41	1	2102	0.0133
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	42	1	3602	0.0228
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	25	5	18037	0.0032
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	26	15	53765	0.0097
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	27	10	36074	0.0065
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	28	20	72148	0.0130
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	29	15	132662	0.0239
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	30	89	985972	0.1773
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	31	117	1255600	0.2257
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	32	97	977413	0.1757
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	33	66	687811	0.1237
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	34	44	386556	0.0695
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	35	23	210254	0.0378
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	36	25	218654	0.0393
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	37	29	302428	0.0544
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	38	22	180212	0.0324
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	39	6	31873	0.0057
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	40	1	12791	0.0023
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	32	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	34	5	4369	0.4168
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	35	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	36	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	37	2	1747	0.1667
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	38	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	40	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	31	1	4751	0.0457
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	32	2	17221	0.1656
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	33	1	12469	0.1199
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	34	1	9293	0.0894
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	35	3	14255	0.1371
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	36	2	9503	0.0914
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	37	1	13494	0.1298
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	38	2	18246	0.1755

mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	39	1	4751	0.0457
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	24	1	1806	0.0000
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	25	1	16414	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	26	7	41869	0.0007
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	27	18	82129	0.0014
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	28	29	173550	0.0029
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	29	53	361704	0.0060
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	30	207	1585267	0.0264
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	31	625	4705556	0.0785
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	32	849	6064281	0.1012
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	33	703	4940919	0.0824
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	34	583	4329125	0.0722
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	35	666	5068623	0.0845
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	36	814	7045002	0.1175
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	37	977	7928056	0.1322
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	38	1030	7884558	0.1315
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	39	772	5641257	0.0941
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	40	398	2789539	0.0465
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	41	133	1066549	0.0178
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	42	19	185216	0.0031
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	43	4	36034	0.0006
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	44	1	3324	0.0001
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	45	1	1929	0.0000

Blue whiting Length frequencies 2023

species	stockname	stockcode	area	year	quarter	division	length	count	catchnumber	prop
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	20	6	7095	0.0006
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	21	8	9143	0.0007
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	22	6	6710	0.0005
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	23	3	3606	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	24	7	14339	0.0012
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	25	19	38546	0.0031
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	26	23	46971	0.0038
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	27	34	76906	0.0062
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	28	43	164557	0.0133
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	29	66	340411	0.0275
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	30	141	824473	0.0666
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	31	157	854314	0.0690
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	32	142	750761	0.0607
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	33	148	771996	0.0624
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	34	151	834645	0.0675
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	35	203	1251271	0.1011
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	36	284	1741581	0.1407
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	37	344	1974576	0.1596
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	38	249	1460466	0.1180
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	39	142	742746	0.0600
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	40	63	348290	0.0281
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	41	15	89649	0.0072
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	42	2	18736	0.0015
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	43	1	2073	0.0002
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	16	0	985	0.0001
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	17	1	7268	0.0004
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	18	5	27792	0.0015
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	19	3	19368	0.0010
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	20	9	47732	0.0026
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	21	3	17037	0.0009
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	22	0	1663	0.0001
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	25	0	3719	0.0002
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	26	4	27399	0.0015
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	27	7	46455	0.0025
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	28	28	146393	0.0079
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	29	95	525911	0.0283
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	30	132	733950	0.0395
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	31	192	1070533	0.0576
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	32	212	1274502	0.0686
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	33	203	1197143	0.0644
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	34	232	1343748	0.0723
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	35	299	1643786	0.0885
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	36	424	2467270	0.1328
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	37	497	2878717	0.1549
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	38	395	2400487	0.1292
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	39	245	1535283	0.0826
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	40	123	795265	0.0428
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	41	39	271188	0.0146
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	42	8	93608	0.0050

mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	44	1	5597	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	13	13	32497	0.2281
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	14	5	12499	0.0877
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	15	5	12499	0.0877
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	16	6	14999	0.1053
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	17	16	39997	0.2807
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	18	5	12499	0.0877
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	19	2	4999	0.0351
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	20	3	7499	0.0526
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	21	2	4999	0.0351
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	20	1	16884	0.0110
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	29	1	1822	0.0012
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	32	7	46453	0.0303
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	33	18	93502	0.0610
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	34	21	130212	0.0849
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	35	29	211340	0.1378
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	36	37	296837	0.1936
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	37	32	197298	0.1287
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	38	40	217112	0.1416
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	39	29	141405	0.0922
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	40	25	127183	0.0830
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	41	8	39508	0.0258
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	42	4	13639	0.0089
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.7.j	36	1	18415	1.0000

12 Atlanto-scandian herring: detailed tables

Atlanto-scandian herring Sampling overview

species	year	quarter	area	division	catch	sampleweight	nsamples	count	catchnumber
mac	2022	1	27	27.4.a	11982	1209	82	3659	24087
mac	2022	1	27	27.6.a	9707	502	42	1570	15056
mac	2022	1	27	27.7.b	4535	443	33	1447	10193
mac	2022	1	27	27.7.j	363	42	16	138	416
mac	2022	2	27	27.4.a	23	NA	NA	NA	NA
mac	2022	2	27	27.6.a	146	12	8	32	158
mac	2022	3	27	27.2.a	120	NA	NA	NA	NA
mac	2022	3	27	27.4.a	3721	181	32	584	5562
mac	2022	3	27	27.7.b	3	5	1	12	10
mac	2022	3	27	27.7.j	3	4	4	14	103
mac	2022	4	27	27.2.a	0	NA	NA	NA	NA
mac	2022	4	27	27.4.a	32238	1739	195	7891	59952
mac	2022	4	27	27.7.j	0	NA	NA	NA	NA
mac	2023	1	27	27.4.a	9331	709	41	2270	12373
mac	2023	1	27	27.6.a	16150	999	68	3168	18582
mac	2023	1	27	27.7.b	13	NA	NA	NA	NA
mac	2023	2	27	27.4.a	9	0	1	57	142
mac	2023	2	27	27.6.a	767	94	38	256	1533
mac	2023	2	27	27.7.j	8	0	1	1	18

Atlanto-scandian herring Length frequencies 2022

species	stockname	stockcode	area	year	quarter	division	length	count	catchnumber	prop
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	26	10	36464	0.0015
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	27	54	346705	0.0144
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	28	49	340570	0.0141
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	29	64	412899	0.0171
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	30	68	412400	0.0171
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	31	82	489344	0.0203
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	32	94	569007	0.0236
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	33	109	526606	0.0219
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	34	181	1047462	0.0435
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	35	269	1703142	0.0707
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	36	450	2723107	0.1131
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	37	648	4162473	0.1728
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	38	689	4592406	0.1907
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	39	508	3774323	0.1567
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	40	266	1885261	0.0783
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	41	92	756625	0.0314
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	42	21	243746	0.0101
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	43	2	7439	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.4.a	44	3	57399	0.0024
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	17	1	4150	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	18	1	4150	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	19	1	4150	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	23	4	15424	0.0010
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	24	5	30313	0.0020
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	25	8	34891	0.0023
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	26	12	85246	0.0057
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	27	14	137644	0.0091
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	28	24	273784	0.0182
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	29	22	150308	0.0100
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	30	45	398239	0.0265
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	31	64	554722	0.0368
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	32	84	782862	0.0520
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	33	120	1156090	0.0768
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	34	95	882994	0.0586
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	35	115	1091725	0.0725
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	36	105	1096835	0.0728
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	37	209	2050525	0.1362
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	38	274	2565070	0.1704
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	39	214	2171710	0.1442
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	40	117	1193579	0.0793
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	41	29	282289	0.0187
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.6.a	42	7	89517	0.0059
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	20	3	34527	0.0034

mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	21	5	57545	0.0056
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	22	7	80563	0.0079
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	23	7	80563	0.0079
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	24	4	46036	0.0045
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	25	5	57545	0.0056
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	26	4	46036	0.0045
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	27	4	35245	0.0035
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	28	3	31860	0.0031
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	29	7	84735	0.0083
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	30	25	216377	0.0212
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	31	24	196195	0.0192
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	32	31	296552	0.0291
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	33	45	315556	0.0310
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	34	72	507485	0.0498
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	35	162	1101891	0.1081
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	36	203	1318078	0.1293
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	37	201	1323574	0.1298
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	38	270	1866023	0.1831
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	39	211	1395078	0.1369
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	40	110	751821	0.0738
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	41	34	283483	0.0278
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	42	6	46318	0.0045
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	43	3	9300	0.0009
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.b	44	1	10778	0.0011
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	25	2	6604	0.0159
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	26	1	3302	0.0079
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	27	2	10388	0.0250
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	28	2	6163	0.0148
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	29	7	34010	0.0817
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	30	15	55985	0.1345
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	31	10	47240	0.1135
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	32	10	44617	0.1072
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	33	13	48956	0.1176
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	34	15	44410	0.1067
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	35	16	30610	0.0736
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	36	17	21822	0.0524
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	37	11	26273	0.0631
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	38	8	18422	0.0443
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	39	6	12616	0.0303
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	1	27.7.j	40	3	4754	0.0114
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	34	4	20848	0.1319
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	35	5	31786	0.2011
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	36	5	28235	0.1786
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	37	6	27219	0.1722
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	38	6	28043	0.1774
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	39	3	14125	0.0894
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	40	1	2102	0.0133
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	41	1	2102	0.0133
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	2	27.6.a	42	1	3602	0.0228
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	25	5	18037	0.0032
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	26	15	53765	0.0097
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	27	10	36074	0.0065
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	28	20	72148	0.0130
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	29	15	132662	0.0239
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	30	89	985972	0.1773
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	31	117	1255600	0.2257
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	32	97	977413	0.1757
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	33	66	687811	0.1237
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	34	44	386556	0.0695
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	35	23	210254	0.0378
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	36	25	218654	0.0393
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	37	29	302428	0.0544
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	38	22	180212	0.0324
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	39	6	31873	0.0057
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.4.a	40	1	12791	0.0023
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	32	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	34	5	4369	0.4168
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	35	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	36	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	37	2	1747	0.1667
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	38	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.b	40	1	873	0.0833
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	31	1	4751	0.0457
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	32	2	17221	0.1656
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	33	1	12469	0.1199
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	34	1	9293	0.0894
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	35	3	14255	0.1371
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	36	2	9503	0.0914
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	37	1	13494	0.1298
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	38	2	18246	0.1755

mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	3	27.7.j	39	1	4751	0.0457
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	24	1	1806	0.0000
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	25	1	16414	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	26	7	41869	0.0007
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	27	18	82129	0.0014
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	28	29	173550	0.0029
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	29	53	361704	0.0060
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	30	207	1585267	0.0264
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	31	625	4705556	0.0785
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	32	849	6064281	0.1012
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	33	703	4940919	0.0824
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	34	583	4329125	0.0722
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	35	666	5068623	0.0845
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	36	814	7045002	0.1175
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	37	977	7928056	0.1322
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	38	1030	7884558	0.1315
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	39	772	5641257	0.0941
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	40	398	2789539	0.0465
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	41	133	1066549	0.0178
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	42	19	185216	0.0031
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	43	4	36034	0.0006
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	44	1	3324	0.0001
mac	Northeast Atlantic mackerel	mac.27.nea	27	2022	4	27.4.a	45	1	1929	0.0000

Atlanto-scandian herring Length frequencies 2023

species	stockname	stockcode	area	year	quarter	division	length	count	catchnumber	prop
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	20	6	7095	0.0006
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	21	8	9143	0.0007
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	22	6	6710	0.0005
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	23	3	3606	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	24	7	14339	0.0012
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	25	19	38546	0.0031
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	26	23	46971	0.0038
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	27	34	76906	0.0062
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	28	43	164557	0.0133
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	29	66	340411	0.0275
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	30	141	824473	0.0666
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	31	157	854314	0.0690
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	32	142	750761	0.0607
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	33	148	771996	0.0624
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	34	151	834645	0.0675
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	35	203	1251271	0.1011
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	36	284	1741581	0.1407
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	37	344	1974576	0.1596
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	38	249	1460466	0.1180
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	39	142	742746	0.0600
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	40	63	348290	0.0281
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	41	15	89649	0.0072
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	42	2	18736	0.0015
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.4.a	43	1	2073	0.0002
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	16	0	985	0.0001
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	17	1	7268	0.0004
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	18	5	27792	0.0015
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	19	3	19368	0.0010
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	20	9	47732	0.0026
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	21	3	17037	0.0009
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	22	0	1663	0.0001
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	25	0	3719	0.0002
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	26	4	27399	0.0015
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	27	7	46455	0.0025
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	28	28	146393	0.0079
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	29	95	525911	0.0283
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	30	132	733950	0.0395
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	31	192	1070533	0.0576
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	32	212	1274502	0.0686
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	33	203	1197143	0.0644
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	34	232	1343748	0.0723
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	35	299	1643786	0.0885
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	36	424	2467270	0.1328
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	37	497	2878717	0.1549
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	38	395	2400487	0.1292
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	39	245	1535283	0.0826
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	40	123	795265	0.0428
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	41	39	271188	0.0146
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	42	8	93608	0.0050

mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	1	27.6.a	44	1	5597	0.0003
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	13	13	32497	0.2281
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	14	5	12499	0.0877
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	15	5	12499	0.0877
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	16	6	14999	0.1053
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	17	16	39997	0.2807
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	18	5	12499	0.0877
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	19	2	4999	0.0351
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	20	3	7499	0.0526
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.4.a	21	2	4999	0.0351
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	20	1	16884	0.0110
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	29	1	1822	0.0012
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	32	7	46453	0.0303
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	33	18	93502	0.0610
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	34	21	130212	0.0849
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	35	29	211340	0.1378
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	36	37	296837	0.1936
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	37	32	197298	0.1287
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	38	40	217112	0.1416
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	39	29	141405	0.0922
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	40	25	127183	0.0830
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	41	8	39508	0.0258
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.6.a	42	4	13639	0.0089
mac	Northeast Atlantic mackerel	mac.27.nea	27	2023	2	27.7.j	36	1	18415	1.0000

IESNS post-cruise meeting, Teams 13-15/6 2023

Working Document to

Working Group on International Pelagic Surveys (WGIPS)
22 – 26 January 2023
and
Working Group on Widely Distributed Stocks (WGWIDE)
23 – 29 August 2023

INTERNATIONAL ECOSYSTEM SURVEY IN NORDIC SEA (IESNS) in April - May 2023

Post-cruise meeting on Teams, 13-15 June 2023

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IESNS post-cruise meeting, Teams 13-15/6 2023

Introduction

In April-June 2023, four research vessels and one hired commercial vessel participated in the International ecosystem survey in the Nordic Seas (IESNS); R/V Dana, Denmark (joint EU survey by Denmark, Germany, Ireland, The Netherlands and Sweden), R/V Jákup Sverri, Faroe Islands, R/V Árni Friðriksson, Iceland, R/V G.O. Sars, Norway and M/S Resolute, United Kingdom (UK). Like in 2022, the Barents Sea was not surveyed by a Russian research vessel. The aim of the survey was to cover the whole distribution area of the Norwegian Spring-spawning herring with the objective of estimating the total abundance of the herring stock, in addition to collect data on plankton and hydrographical conditions in the area. The survey was initiated by the Faroes, Iceland, Norway and Russia in 1995. Since 1997 the EU has also participated (except 2002 and 2003) and from 2004 onwards the survey has been more integrated into an ecosystem survey.

This report represents analyses of data from this International survey in 2023 that are stored in the PGNAPES database and the ICES acoustic database and supported by national survey reports from some survey participants (Dana: Cruise Report R/V Dana Cruise 03/2023. International Ecosystem survey in the Nordic Seas (IESNS) in 2023, Árni Friðriksson: A6-2023 Cruise Report, Bjarnason, 2023, Jákup Sverri: Cruise Report 2320).

Material and methods

Coordination of the survey was done during the WGIPS meeting in January 2023 and by correspondence. Planning of the acoustic transects, hydrographic stations and plankton stations were carried out by using the survey planner function in the r-package Rstox version 1.11 (see https://www.hi.no/en/hi/forskning/projects/stox). The survey planner function generates the survey plan (transect lines) in a cartesian coordinate system and transforms the positions to the geographical coordinate system (longitude, latitude) using the azimuthal equal distance projection, which ensures that distances, and also equal coverage, if the method used is designed with this prerequisite, are preserved in the transformation. Figure 1 shows the planned acoustic transects and hydrographic and plankton stations in each stratum. Only parallel transects were used this year, however, because the transects follow great circles they appear bended in a Mercator projection. The participating vessels together with their effective survey periods are listed in the table below:

IESNS post-cruise meeting, Teams 13-15/6 2023

Vessel	Institute	Survey period
Dana	DTU Aqua - National Institute of Natural Resources, Denmark	28/04-24/05
G.O. Sars	Institute of Marine Research, Bergen, Norway	27/04-01/06
Jákup Sverri	Faroe Marine Research Institute, Faroe Islands	05/05-16/05
Árni Friðriksson	Marine and Freshwater Research Institute, Iceland	08/05-27/05
Resolute	CEFAS, United Kingdom	24/04-06/05

Figure 2 shows the cruise tracks, Figure 3 the hydrographic and WPII plankton stations and, Figure 4 Macroplankton trawl and Multinet stations and Figure 5 the pelagic trawl stations. Survey effort by each vessel is detailed in Table 1. Daily contacts were maintained between the vessels during the course of the survey, primarily through electronic mail. The temporal progression of the survey is shown in Figure 6.

In general, the weather conditions did not affect the survey even if there were a few days in the northern part at the end of the survey that were not favourable and trawling, WP2 and Multinet sampling at some stations were prevented. The weather conditions in the first part of the survey, when most of the herring was observed, were unusually good. The survey was based on scientific echosounders using 38 kHz frequency. Transducers were calibrated with the standard sphere calibration (Foote *et al.*, 1987) prior to the survey. Salient acoustic settings are summarized in the text table below.

Acoustic instruments and settings for the primary frequency (boldface).

	Dana	G. O. Sars	Arni Friðriksson	Jákup Sverri	Resolute
Echo sounder	Simrad EK60	Simrad EK80	Simrad EK80	Simrad EK80	Simrad EK80
Frequency (kHz)	**38**	**38**, 18, 70, 120, 200, 333	**38**, 18, 70, 120, 200	18,**38**, 70, 120, 200, 333	**38**,200
Primary transducer	ES38BP	ES 38-7	ES38-7	ES38-7	ES38-7
Transducer installation	Towed body	Drop keel	Drop keel	Drop keel	Hull-mounted
Transducer depth (m)	4-6	6	6.9	6-9	6
Upper integration limit (m)	10	15	12	15	10
Absorption coeff. (dB/km)	8.9	10.1	10.6	10.3	10.1
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Band width (kHz)	2.425	2.43	2.425	3.06	2.425
Transmitter power (W)	2000	2000	2000	2000	2000
Angle sensitivity (dB)	21.9	21.9	18	21.9	18
2-way beam angle	-20.5	-20.7	-20.3	-20.4	-20.7

IESNS post-cruise meeting, Teams 13-15/6 2023

	Dana	G. O. Sars	Arni Friðriksson	Jákup Sverri	Resolute
(dB)					
Sv Transducer gain (dB)					
Ts Transducer gain (dB)	25.51	26.11	27.05	26.94	26.75
s_A correction (dB)	-0.60	-0.04	0.01	-0.13	-0.07
3 dB beam width (dg)					
alongship:	6.76	6.39	6.44	6.47	6.32
athw. ship:	6.99	6.38	6.52	6.54	6.40
Maximum range (m)	500	500	500	500	500
Post processing software	LSSS	LSSS	LSSS	LSSS	Echoview

All participants except UK used the same post-processing software (LSSS). The UK data were, however, scrutinized using Echoview. Scrutinization was carried out according to an agreement at the PGNAPES scrutinizing workshop in Bergen in February 2009 (ICES 2009), and "Notes from acoustic Scrutinizing workshop in relation to the IESNS", Reykjavík 3.-5. March 2015 (Annex 4 in ICES 2015). Generally, acoustic recordings were scrutinized on daily basis and species identified and partitioned using catch information, characteristic of the recordings, and frequency between integration on 38 kHz and on other frequencies by a scientist experienced in viewing echograms. Immediately after the 2023 survey an online meeting was held to standardise the scrutiny and to agree on particularly difficult scrutiny situations encountered. All vessels used a large or medium-sized pelagic trawl as the main tool for biological sampling. The salient properties of the trawls, plankton nets and hydrographic equipment are as follows:

	Dana	**G.O. Sars**	**Arni Friðriksson**	**Jákup Sverri**	**Resolute**
Trawl dimensions					
Circumference (m)		**496**	**832**	**832**	**972**
Vertical opening (m)	**20-30**	**25-30**	**20–35**	**45–55**	**30-50**
Mesh size in codend (mm)	**18**	**24**	**20**	**45**	**20**
Typical towing speed (kn)	**3.5-4.5**	**3.0–4.5**	**3.1–5.0**	**3.5–4.5**	**3.5-5**
Plankton sampling					
Sampling net	**WP2**	**WP2**	**WP2**	**WP2**	**WP2**
Standard sampling depth (m)	**200**	**200**	**200**	**200**	**200**

IESNS post-cruise meeting, Teams 13-15/6 2023

	Dana	G.O. Sars	Arni Friðriksson	Jákup Sverri	Resolute
<u>Hydrographic sampling</u>					
CTD unit	**SBE911**	**SBE911**	**SBE911**	**SBE911**	**SAIV SD208**
Standard sampling depth (m)	**1000**	**1000**	**1000**	**1000**	**250**

Catches from trawl hauls were sorted and weighed; fish were identified to species level, when possible, and other taxa to higher taxonomic levels. A subsample of herring, blue whiting and mackerel were sexed, aged, and measured for length and weight, and their maturity status was estimated using established methods. An additional sample of fish was measured for length. For the Norwegian, Icelandic and Faroese vessel, a smaller subsample of stomachs was sampled for further analyses on land. As part of ongoing stock identity research, herring genetic samples were collected. Salient biological sampling protocols for trawl catches are listed in the table below.

	Species	Dana	G.O. Sars	Arni Friðriksson	Jákup Sverri	Resolute
Length measurements	Herring	200-300	100	300	100-200	100
	Blue whiting	200-300	100	50	100-200	100
	Mackerel	100-200	100	50	100-200	100
	Other fish sp.	50	30	30	100-150	30
Weighed, sexed and maturity determination	Herring	50	25-100	100	50*	50
	Blue whiting	50	25-100	50	50*	50
	Mackerel	50	25-100	50	50*	50
	Other fish sp.	0	0	0	0*	0
Otoliths/scales collected	Herring	50	25-30	100	25-50	50
	Blue whiting	50	25-30	50	25-50	50
	Mackerel	0	25-30	50	25-50	50
	Other fish sp.	0	0	0	0	0
Stomach sampling	Herring	0	10	10	5	0
	Blue whiting	0	10	10	5	0
	Mackerel	0	10	10	5	0
	Other fish sp.	0	0	0	0	0
Genetic samples	Herring	50		0	30	50

* If the catch is sufficiently large 100 individuals are always weighed.

Acoustic data were analysed using the StoX software package (version 3.6.1) which has been used for many years now for WGIPS coordinated surveys. A description of StoX can be found in Johnsen et al. (2019) and here: https://www.hi.no/en/hi/forskning/projects/stox. Estimation of abundance from acoustic surveys with StoX is carried out according to the stratified transect design model developed by Jolly and Hampton (1990). This method requires pre-defined strata, and the survey area was therefore split into 5 strata with pre-defined acoustic transects (this year only 4 strata, as the Barents Sea was not surveyed).

Within each stratum, parallel transects with equal distances were used. The distance between transects was based on available survey time, and the starting point of the first transect in each stratum was randomized. This approach allows for robust statistical analyses of uncertainty of the acoustic estimates. The strata and transects used in StoX are shown in Figure 2. Generally, and in accordance with most WGIPS coordinated surveys, all trawl stations within a given stratum with catches of the target species (either blue whiting or herring) were assigned to all transects within the stratum, and the length distributions were weighted equally within the stratum.

The following target strength (TS)-to-fish length (L) relationships were used:

Blue whiting: TS = 20.0 log(L) – 65.2 dB (ICES 2012)

Herring: TS = 20.0 log(L) – 71.9 dB (Foote et al. 1987)

The target strength for herring is the traditionally one used while this target strength for blue whiting was first applied in 2012 (ICES 2012).

The hydrographical and plankton stations by survey are shown in Figure 3. Most vessels collected hydrographical data using a SBE 911 CTD. Maximum sampling depth was 1000 m.

Zooplankton was sampled by WP2 nets on all vessels, according to the standard procedure for the surveys. Mesh sizes were 180 or 200 µm. The net was hauled vertically from 200 m to the surface or from the bottom whenever bottom depth was less than 200 m. All samples were split in two and one half was preserved in formalin while the other half was dried and weighed. The samples for dry weight were size fractionated before drying by sieving the samples through 2000 µm and 1000 µm sieves, giving the size fractions 180/200 – 1000 µm, 1000 – 2000 µm, and > 2000 µm. Data are presented as total mg dry weight per m2. For the zooplankton distribution map, all stations are presented. Interpolation was carried out using Bratseth's Successive Correction Method (Bratsheth, 1986). This method was designed specifically for marine data, and it uses bottom depth to calculate the similarity among the interpolation points. More specifically, it uses objective analysis with a Gaussian correlation function where the effective distance between the observations and the nodes of the interpolation grids is defined based on the difference in bottom depths, as follows:

$$r^2 = r_x^2 + r_y^2 + \left(\lambda \frac{H_a - H_o}{H_a + H_o}\right)^2$$

where rx and ry is the geographic distance in the zonal and meridional directions, and Ha and Ho are the bottom depths at the analysis and observation points, respectively (Skagseth and Mork, 2012). The analysis was done using an R script based on a MATLAB routine developed by Kjell Arne Mork (Mork et al. 2014). For the time series, stations in the Norwegian Sea delimited to east of 14°W and west of 20°E have been included. Estimates of the statistical distribution of the zooplankton biomass indices is done by simple bootstrapping by re-sampling with replacement.

Results and Discussion

Hydrography

The temperature distributions in the ocean, averaged over selected depth intervals; 0-50 m, 50-200 m, and 200-500 m, are shown in Figures 7a-c. The temperatures in the surface layer (0-50 m) ranged from below 0°C in the Greenland Sea to 9-10°C in the southern part of the Norwegian Sea (Figure 7a). The Arctic front was encountered south of 65°N east of Iceland extending eastwards towards about 2°W where it turned north-eastwards to 65°N and then almost straight northwards. The front sharpened and had a more eastern location with depths. Further to west at about 8°W, another front runs northward to Jan Mayen, the Jan Mayen Front, that was most distinct in the upper 200 m. The warmer North Atlantic water formed a broad tongue that stretched far northwards along the Norwegian coast with temperatures about 5 °C to the Bear Island at 74.5°N in the surface layer.

Relative to the long-term mean, from 1995 to 2021, the temperatures at 0-50 m were below the mean at the western and eastern parts of Norwegian Sea while in the central areas, the temperatures were mostly above the mean (Figure 7a). At 50-200 m depth, the patterns were also fragmented, but the Norwegian Sea was, in general, colder than the long-term mean in the western part and in the Lofoten Basin (Figure 7b). At 200-500 m depth, the patterns were less fragmented and nearly the whole Norwegian Sea was colder than the long-term mean (Figure 7c). The negative anomalies North of the Faroese derive likely from increased influenced of the East Iceland Current compared to the long-term mean.

Two main features of the circulation in the Norwegian Sea, where the herring stock is grazing, are the Norwegian Atlantic Current (NWAC) and the East Icelandic Current (EIC). The NWAC with its offshoots forms the northern limb of the North Atlantic current system and carries relatively warm and salty water from the North Atlantic into the Nordic Seas. The EIC, on the other hand, carries Arctic waters. To a large extent this water derives from the East Greenland Current, but to a varying extent, some of its waters may also have been formed in the Iceland and Greenland Seas. The EIC flows into the southwestern Norwegian Sea where its waters subduct under the Atlantic waters to form an intermediate Arctic layer. While such a layer has long been known in the area north of the Faroes and in the Faroe-Shetland Channel, it is in the last four decades a similar layer has been observed all over the Norwegian Sea. Also, in periods this layer has been less well-defined.

This circulation pattern creates a water mass structure with warm Atlantic Water in the eastern part of the area and more Arctic conditions in the western part. The NWAC is rather narrow in the southern Norwegian Sea, but when meeting the Vøring Plateau off Mid Norway it is deflected westward. The western branch of the NWAC reaches the area of Jan Mayen at about 71°N. Further northward in the Lofoten Basin the lateral extent of the Atlantic water gradually narrows again, apparently under topographic influence of the mid-ocean ridge. It has been shown that atmospheric forcing largely controls the distribution of the water masses in the Nordic Seas. Hence, the lateral extent of the NWAC, and consequently the position of the Arctic Front, that separates the warm North Atlantic waters from the cold Arctic waters, is correlated with the large-scale distribution of the atmospheric sea level pressure. The local air-sea heat flux in addition influence the upper layer and it is found that it can explain about half of the year-to-year variability of the ocean heat content in the Norwegian Sea.

Zooplankton

The zooplankton biomass (mg dry weight m^{-2}) distribution in the upper 200 m in 2023 is shown in Figure 8b). Sampling stations were evenly spread over the area, covering Atlantic water, Arctic water, and the Arctic frontal zone. The highest zooplankton biomasses were found in the Iceland Sea, northeast of Iceland. This was also reflected in the time series. A smaller area with high biomass was also found outside the Norwegian continental shelf, at 66°N. In the rest of the investigated area there was a relatively even distribution of zooplankton biomass. This was different from the distribution in 2022, where the highest zooplankton biomasses were found in the eastern and southeastern parts.

Figure 9b) shows the zooplankton time series indices for the sampling area (delimited to east of 14°W and west of 20°E). To examine regional biomass differences, the area was divided into 4 sub-areas 1) East of Iceland, 2) the Jan Mayen Arctic front, 3) the Lofoten Basin (covering the northern Norwegian Sea, and 4) the Norwegian Basin (covering the southern Norwegian Sea), figure 10 a). The zooplankton biomass index for 2023 was respectively: 13394, 8009, 8484 and 9688 mg dry weight m^{-2}. There was an increase in zooplankton biomass in Icelandic water, where the biomass was almost three times higher in 2023 compared to 2022. For the other sub-areas minor changes were observed from last year. The zooplankton biomass indices for the Norwegian Sea in May have been estimated since 1995. All sub-areas had a high biomass period until mid-2000, and a lower period thereafter. The long-term decrease has been most pronounced in the Iceland Sea. In the Lofoten- and Norwegian Basins there has been an increasing trend during the low-biomass period.

The reasons for the changes in zooplankton biomass are not obvious. It is worth noting that the period with lower zooplankton biomass coincides with higher-than-average heat content in the Norwegian Sea (ICES, 2020) and reduced inflow of Arctic water into the southwestern Norwegian Sea (Kristiansen et al., 2019; Skagseth et al., 2022). Timing effects, such as match/mismatch with the phytoplankton bloom, can also affect the zooplankton abundance. The high biomass of pelagic fish feeding on zooplankton has been suggested to be one of the main causes for the reduction in zooplankton biomass. However, carnivorous zooplankton and not pelagic fish may be the main predators of zooplankton in the Norwegian Sea (Skjoldal et al., 2004), and we do not have good data on the development of the carnivorous zooplankton stocks.

IESNS post-cruise meeting, Teams 13-15/6 2023

Norwegian spring-spawning herring

Survey coverage in the Norwegian Sea was considered adequate in 2023. The zero-line was believed to be reached for adult NSS herring in most of the areas. It is recommended that the results from IESNS 2023 can be used for assessment purpose. The herring was primarily distributed in the western and northwestern area this year (Figure 10). The 2016-year-class was by far the most abundant year class in the areas where most of the herring biomass was found. It is a commonly observed pattern that the older fish are distributed in the southwest while the younger fish are found closer to the nursery areas in the Barents Sea (Figure 11).

Seven-year-old herring (2016-year class) dominated both in terms of number and biomass (both around 57%) on basis of the StoX bootstrap estimates for the Norwegian Sea (Table 2). The point estimate of abundance of the 2016 year-class decreased by 2% compared to last year's estimate which is much less than the decline between 2021 and 2022 (Figure 12). However, the 2015-2013 year classes decrease with 47-66% compared to last year's estimates. This indicates that the mortality of older herring has been higher than that of the 2016 year class. Uncertainty estimates for number at age based on bootstrapping within StoX are shown in Figure 13 and Table 2. The relative standard error (CV) is 23% for the total biomass and 22% for the total numbers estimate, and the relative standard errors for the dominating age groups is around 24-32% (Figure 13).

The total estimate of herring in the Norwegian Sea from the 2023 survey was 16.5 billion in number and the biomass was 4.1 million tonnes. The biomass estimate is about 8% lower than the 2022 survey estimate and the estimated number is about 17% lower than in 2022. The biomass estimate decreased significantly from 2009 to 2012 and has since then been rather stable at 4.1 to 5.9 million tonnes with similar confidence interval (Figure 14), with the lowest abundance occurring in 2023.

Since 2015 an increased awareness has been raised around the age reading of herring. It appeared that the age distributions from the different participants some years showed differences and also the older specimens appear to have uncertain ages. An age-reading workshop was held in Bergen 17.-19. April 2023 (WKARNSSH2). This workshop was based on otoliths and scales collected in 2021 and subsequently exchanged between the participating countries. At the publication of this survey report the concluding report from WKARNSSH2 is not yet available, but it will be for next year's survey report.

With respect to age-reading, the comparison between the nations, in this year's survey, show that there were some differences within strata (Figure 15). Particularly, in stratum 2 there were differences between the EU vessel (3-year-olds dominating) and the Norwegian vessel (7-year-olds dominating). This could at least partly be explained by spatial differences in sampling between vessels; the EU vessel have all their samples in the northern part of stratum 2 while the Norwegian vessel have samples both from the northern and the southern part of the stratum. It is well known that mean age of herring in the IESNS generally decreases with increasing latitude.

Recently, concerns have been raised by the survey groups for the International ecosystem surveys in the Nordic Seas (IESNS and IESSNS) on mixing issues between Norwegian spring-spawning herring and other herring stocks (e.g. Icelandic summer-spawning, Faroese autumn-spawning, Norwegian summer-spawning and North Sea type autumn-spawning herring) occurring in some of the fringe regions in the Norwegian Sea. Until now, fixed cut lines have been used by the survey group to exclude herring of presumed other types than NSS herring, however this simple procedure is thought to introduce some contamination of the stock indices of the target NSS herring. WGIPS noted in their 2019 report that the separation of different herring stock components is an issue in several of the surveys coordinated in WGIPS and the needs for development of standardized stock splitting methods was also noted in the WKSIDAC (ICES 2017).

Blue whiting

Boostrap estimates of abundance, biomass, mean length and mean weight of blue whiting during IESNS 2023 are shown in Table 3. The estimated biomass was 961 thousand tons (CV=0.14) which is a 36% decrease from last year's estimate, and slightly below the average from the period 2008-2022. The estimated total abundance was 12.8 billion (CV=0.15) which is a 57% decrease from last year's estimate. The stock is dominated by 1-3 years old blue whiting. Uncertainty estimates for numbers at age based on bootstrapping with StoX are shown in Figure 18 and Table 3.

The spatial distribution of blue whiting in 2023 is shown in Figure 16. As usual, most of the fish was registered in the eastern part of the Norwegian Sea. The largest fish was found in the northwestern part of the of the survey area (Figure 17). Comparison of the size and age distributions of blue whiting by stratum and country are shown in Figure 19 and 20, and they seem to be in fairly good agreement.

Mackerel

Trawl catches of mackerel are shown in Figure 21. Mackerel was present in the southern and eastern part of the Norwegian Sea in the beginning of May. The spatial distribution of catches in 2023 were similar to 2022, i.e. a lower northward extent than in the period 2008-2021. No further quantitative information can be drawn from these data as this survey is not designed to monitor mackerel.

IESNS post-cruise meeting, Teams 13-15/6 2023

General recommendations and comments

Recommendation	Addressed to
1. Continue the methodological research in distinguishing between herring and blue whiting in the interpretation of echograms.	WGIPS
2. Implement logging of sonar data to measure the amount of herring in the surface blind zone	WGIPS

Next year's post-cruise meeting

We will aim for next meeting in 16-18 June 2024. The final decision will be made at the next WGIPS meeting.

Concluding remarks

- The sea temperature in 2023 was generally below the long-term mean (1995-2021) in the Norwegian Sea.
- The 2023 indices of meso-zooplankton biomass in the Norwegian Sea and adjoining waters were fairly similar to last year's estimates for all areas except the Icelandic area where the index is much higher compared to the most recent years.
- The total biomass estimate of NSSH in herring in the Norwegian Sea was 4.1 million tonnes, which is an 8% decrease from the 2022 survey estimate. The estimate of total number of NSSH was 16.5 billion, which is 17% lower than in the 2022 survey. The survey followed the pre-planned protocol and the survey group recommends using the abundance estimates in the analytical assessment.
- The 2016 year class of NSSH dominated in the survey indices both in numbers and biomass (both 57%). The abundance of the 2016 year-class decreased by 2% compared to last year's estimate.
- The biomass of blue whiting measured in the 2022 survey decreased by 36% from last year's survey and 57% in terms of numbers. The stock is dominated by the 2020 to 2022 year classes.

References

Bratseth, A. M. (1986). Statistical interpolation by means of successive corrections. Tellus A 38A(5), 439-447.

Foote, K. G., Knudsen, H. P., Vestnes, G., MacLennan, D. N., and Simmonds, E. J. 1987. Calibration of acoustic instruments for fish density estimation: a practical guide. ICES Coop. Res. Rep. 144: 1–57.

ICES 2009. Report of the PGNAPES Scrutiny of Echogram Workshop (WKCHOSCRU) 17–19 February 2009, Bergen, Norway ICES CM 2009/RMC

ICES. 2012. Report of the Workshop on implementing a new TS relationship for blue whiting abundance estimates (WKTSBLUES), 23–26 January 2012, ICES Headquarters, Copenhagen, Denmark. ICES CM 2012/SSGESST:01. 27 pp.

ICES. 2015. Report of the Workshop on scrutinisation procedures for pelagic ecosystem surveys (WKSCRUT), 7-11 September 2015, Hamburg, Germany. ICES CM 2015/SSGIEOM:18. 107pp.

ICES. 2016. Report of the Working Group on the Integrated Assessments of the Norwegian Sea (WGINOR), 7-11 December 2015, Reykjavik, Iceland. ICES CM 2015/SSGIEA:10. 150 pp.

ICES. 2017. Workshop on Stock Identification and Allocation of Catches of Herring to Stocks (WKSIDAC). ICES WKSIDAC Report 2017 20-24 November 2017. Galway, Ireland. ICES CM 2017/ACOM:37. 99 pp.

ICES. 2020. Working Group on the Integrated Assessments of the Norwegian Sea (WGINOR; outputs from 2019 meeting). ICES Scientific Reports. 2:29. 46 pp. http://doi.org/10.17895/ices.pub.5996

Johnsen, E., Totland, A., Skålevik, Å., Holmin, A.J., Dingsør, G.E., Fuglebakk, E., Handegard, N.O. 2019. StoX: An open source software for marine survey analyses. Methods Ecol Evol. 2019, 10:1523–1528.

Jolly, G. M., and I. Hampton. 1990. A stratified random transect design for acoustic surveys of fish stocks. Can.J. Fish. Aquat. Sci. 47: 1282-1291.

Kristiansen, I., Hátun H., Petursdottir, H., Gislason, A., Broms, C., Melle, W., Jacobsen, J.A., Eliasen S.K., Gaard E. 2019. Decreased influx of Calanus spp. into the south-western Norwegian Sea since 2003. Deep Sea Research, 149, 103048

Mork, K. A., Ø. Skagseth, V. Ivshin, V. Ozhigin, S. L. Hughes, and H. Valdimarsson (2014), Advective and atmospheric forced changes in heat and fresh water content in the Norwegian Sea, 1951–2010, Geophys. Res. Lett., 41, 6221–6228, doi:10.1002/ 2014GL061038.

Skagseth, Ø., and K. A. Mork (2012), Heat content in the Norwegian Sea, 1995–2010, ICES J. Mar. Sci., 69(5), 826–832.

Skagseth Ø, Broms C, Gundersen K, Hátún H, Kristiansen I, Larsen KMH, Mork KA, Petursdottir H and Søiland H (2022). Arctic and Atlantic Waters in the Norwegian Basin, Between Year Variability and Potential Ecosystem Implications. Front. Mar. Sci. 9:831739. doi: 10.3389/fmars.2022.831739

Skjoldal, H.R., Dalpadado, P., and Dommasnes, A. 2004. Food web and trophic interactions. *In* The Norwegian Sea ecosystem. Ed. by H.R. Skjoldal. Tapir Academic Press, Trondheim, Norway: 447-506.

IESNS post-cruise meeting, Teams 13-15/6 2023

Tables

Table 1. Survey effort by vessel for the International ecosystem survey in the Nordic Seas in May - June 2023.

Vessel	Effective survey period	Effective acoustic cruise track (nm)	Trawl stations	Ctd stations	Aged fish (HER)	Length fish (HER)	Plankton stations
Dana	28/4-19/5	2218	31	38	154	335	37
Jákup Sverri	6/5-14/5	1297	17	22	569	1849	22
Árni Fridriksson	10/5-24/5	2700	19	31	1424	4608	29
G.O. Sars	27/4-01/6	3858	36	78	226	557	67
Resolute	24/4-06/5	1345	13	19	145	244	19

Table 2. IESNS 2023 in the Norwegian Sea. Estimates of abundance, mean weight and mean length of Norwegian spring-spawning herring. The estimates are mean of 1000 bootstrap replicates in Stox.

Length	Age in years (year class)																			Number	Biomass	Mean
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Unknown			weight
(cm)	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005		(10^6)	(10^6 kg)	(g)
11-12																			1.1	1.1	0.0	10.0
12-13	3.2																		0.2	3.4	0.0	13.6
13-14	22.6																		0.0	26.2	0.4	15.5
14-15	20.4																		0.2	20.5	0.4	18.7
15-16	4.7																		0.2	6.7	0.2	23.1
16-17	5.7																		0.1	5.7	0.2	34.3
17-18		4.9																	0.8	5.7	0.2	38.5
18-19		12.4																		12.4	0.6	48.3
19-20		16.0																		16.0	0.9	56.7
20-21		30.9	5.7																	36.7	2.3	61.6
21-22		74.5	30.3																	104.8	7.8	74.8
22-23		20.4	53.3																	73.6	6.2	84.9
23-24		22.4	38.1	6.5																67.1	6.4	94.2
24-25		1.9	53.8	6.1																61.8	6.7	109.0
25-26			67.4	17.9															0.0	85.3	10.6	121.1
26-27			97.8	3.4	8.4															109.6	14.6	134.1
27-28			68.1	47.7	3.4		7.3													126.5	19.3	153.6
28-29			95.4	37.6	37.0	102.8	14.9	10.8												298.5	49.2	164.9
29-30			43.0	83.0	285.5	75.7	35.6	4.7	5.0	4.7										597.2	99.0	183.3
30-31			24.8	53.9	246.2	65.4	146.4	15.4	10.4	10.2				4.7						577.4	116.0	201.0
31-32				57.4	255.1	390.1	861.8	27.8	5.7											1 597.9	352.7	219.8
32-33			2.8	27.2	142.0	411.4	3076.3	40.0		11.1										3 710.8	878.2	236.1
33-34					18.9	144.0	3616.7	108.6	91.3	115.6										4 095.1	1030.3	251.3
34-35						28.2	1483.1	141.7	171.7	316.1	25.2			5.2						2 151.2	582.6	270.2
35-36							209.3	73.4	220.9	370.4	88.7	47.7	18.8		6.0	6.9				1 032.1	302.7	292.7
36-37							20.9	36.4	42.3	257.2	136.3	108.8	96.9	90.4	74.0	30.5	13.6	18.4		925.7	296.1	318.6
37-38							7.0	3.6	11.1	24.3	37.3	39.1	80.4	108.7	72.8	85.0	18.7	12.3		500.4	168.0	335.8
38-39											21.4	18.0	26.9	28.6	27.6	34.8	46.4	20.6		224.3	78.7	351.3
39-40														18.5	18.1		17.3	3.0	0.1	57.0	21.6	379.0
40-41															1.3	2.0	2.6	2.3		8.2	3.2	392.0
TSN(mill)	56.6	185.2	584.0	340.7	996.4	1217.7	9459.2	462.4	558.4	1109.7	303.8	213.5	218.1	256.2	199.9	159.2	98.7	56.6		16 478.8		
cv(TSN)	0.86	0.52	0.34	0.31	0.29	0.25	0.24	0.29	0.27	0.27	0.38	0.34	0.31	0.35	0.39	0.40	0.46	0.61		0.22		
TSB(1000 t)	1.1	13.0	77.1	62.2	200.2	270.0	2 328.9	123.3	156.3	324.3	95.9	70.2	72.2	86.4	67.8	53.1	33.9	19.3		4 055.3		
cv(TSB)	0.80	0.54	0.35	0.31	0.29	0.25	0.24	0.29	0.28	0.27	0.33	0.34	0.31	0.35	0.40	0.41	0.46	0.60		0.23		
Mean length(cm)	13.8	20.1	25.0	29.1	30.4	31.4	32.7	33.6	34.4	34.8	35.9	36.2	36.7	36.9	37.1	37.1	37.9	37.7				
Mean weight(g)	19.8	65.5	125.5	185.2	203.3	224.5	247.7	270.2	281.8	293.1	317.0	328.6	333.2	334.9	342.8	335.1	345.6	345.7				

IESNS post-cruise meeting, Teams 13-15/6 2023

Table 3. IESNS 2023 in the Norwegian Sea. Estimates of abundance, mean weight and mean length of blue whiting. The estimates are mean of 1000 bootstrap replicates in Stox.

	Age in years (year class)												Number	Biomass	Mean
Length	1	2	3	4	5	6	7	8	9	10	15	Unknown			weight
(cm)	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2008		(10^6)	(10^6 kg)	(g)
16-17												9,4	9,4	0,2	18,0
17-18	102,2												102,2	2,9	28,5
18-19	813,8	19,9										0,1	833,8	28,5	34,5
19-20	1439,5												1 439,5	55,4	38,8
20-21	1192,6	129,1	154,6										1 476,4	68,2	47,0
21-22	316,1	396,1	45,7										758,0	40,6	55,1
22-23	1,4	1198,6	125,6										1 325,5	85,9	66,2
23-24	7,5	1550,3	426,9										1 984,8	146,3	74,8
24-25		1183,2	652,0	28,9	1,6								1 865,7	155,0	83,6
25-26		247,7	768,0	70,5	1,1	13,0							1 100,4	104,2	95,4
26-27		62,9	530,0	73,4	3,1								669,4	71,3	107,0
27-28		3,9	213,1	114,0	8,4		17,3						356,7	42,6	119,8
28-29			64,2	61,3	41,4	29,3		28,0					224,2	32,3	139,4
29-30			11,7	32,1	17,2	34,6	36,0	19,7					151,3	25,3	161,5
30-31				15,7	43,3	22,2	41,6				3,9		126,6	22,2	171,4
31-32				18,0	27,7	26,4	24,4	36,5	2,6	4,1			139,5	26,9	191,8
32-33					22,7	32,1	20,2	17,8	8,7				101,4	22,5	209,1
33-34				13,1	14,5	10,9	15,4						53,9	13,1	240,0
34-35					4,5		23,5	3,8				0,0	31,9	8,2	254,5
35-36															
36-37												2,3	2,3		
37-38					13,9							0,6	14,5	4,8	348,0
38-39							12,9						12,9	5,0	388,0
TSN(mill)	3873	4792	2992	427	199	168	191	106	11	4	4		12 780,1		
cv (TSN)	0,36	0,19	0,17	0,28	0,48	0,54	0,59	0,59	0,89	0,99	1,35		0,15		
TSB(1000 t)	157,4	348,5	269,3	54,2	37,9	29,9	40,1	19,8	2,5	0,8	0,6		961,3		
cv (TSB)	0,33	0,18	0,17	0,29	0,49	0,56	0,59	0,60	0,90	0,99	1,40		0,14		
Mean length(cm	19,4	23,1	24,9	27,1	29,9	30,0	30,8	30,2	31,6	32,0	30,0				
Mean weight(g)	42	76	95	126	174	177	198	186	213	200	154				

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Figures

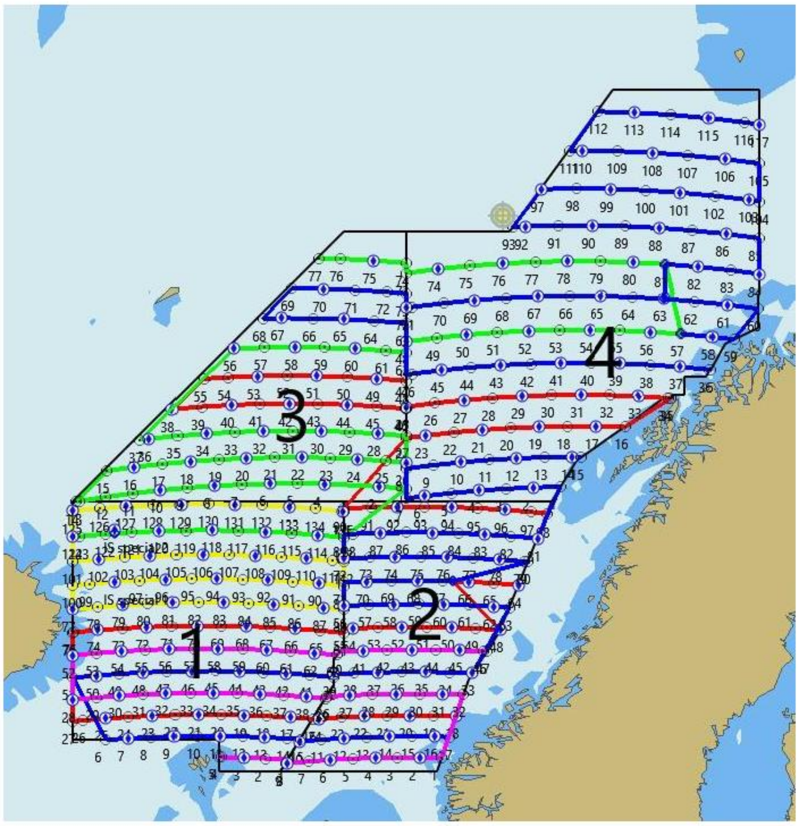

Figure 1. The pre-planned strata and transects for the IESNS survey in 2023 (red: EU, dark blue: Norway, yellow: Faroes Islands, violet: UK, green: Iceland). Hydrographic stations and plankton stations are shown as blue circles with diamonds. All the transects have numbered waypoints for each 30 nautical mile and at the ends.

IESNS post-cruise meeting, Teams 13-15/6 2023

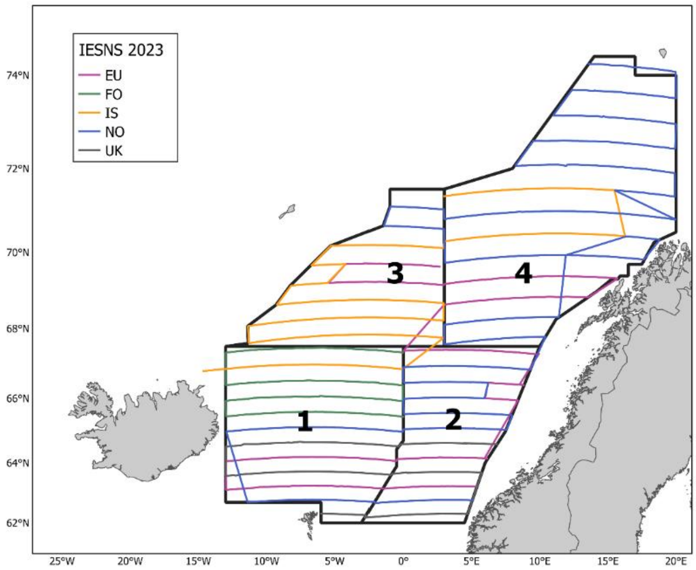

Figure 2. Cruise tracks and strata (with numbers) for the IESNS survey in May 2023.

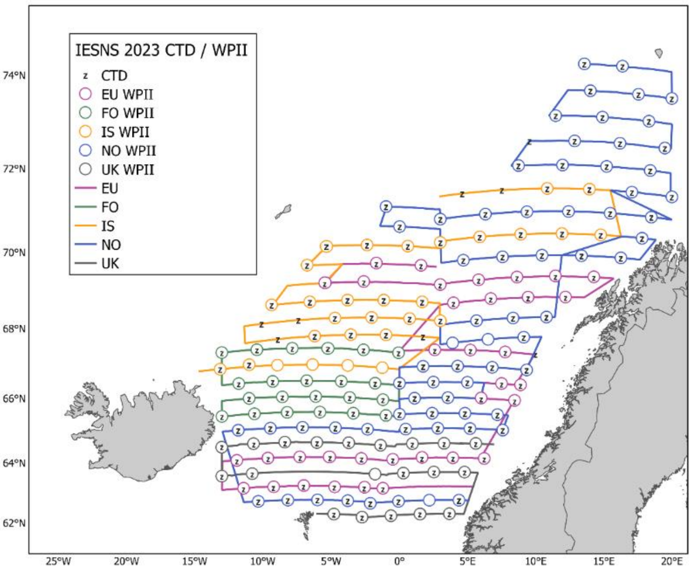

Figure 3. IESNS survey in May 2023: location of hydrographic and WPII plankton stations.

IESNS post-cruise meeting, Teams 13-15/6 2023

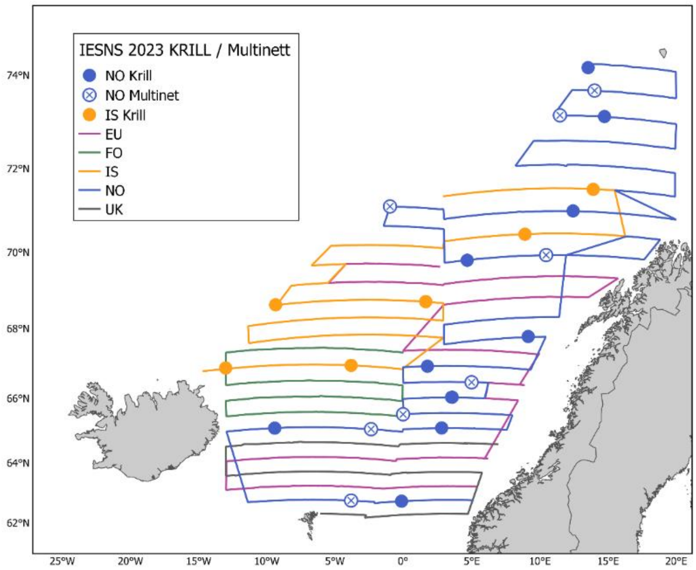

Figure 4. IESNS survey in May 2023: location of Macroplankton/Krill trawl and Multinet stations.

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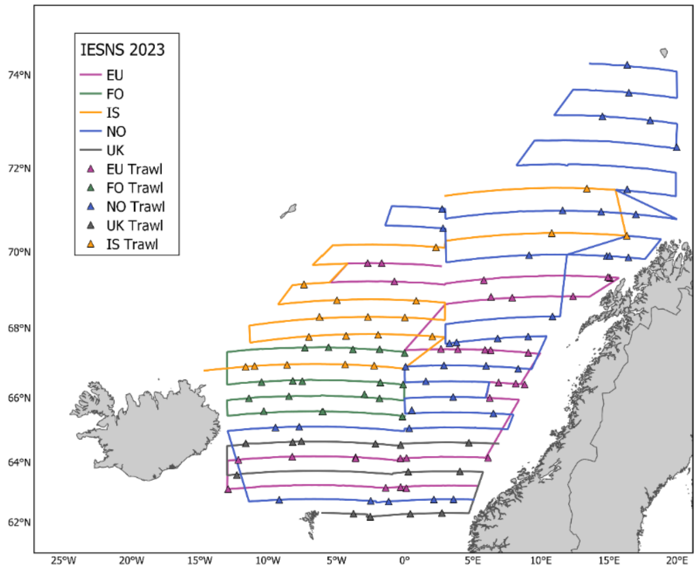

Figure 5. IESNS survey in May 2023: cruise tracks and location of pelagic trawl stations.

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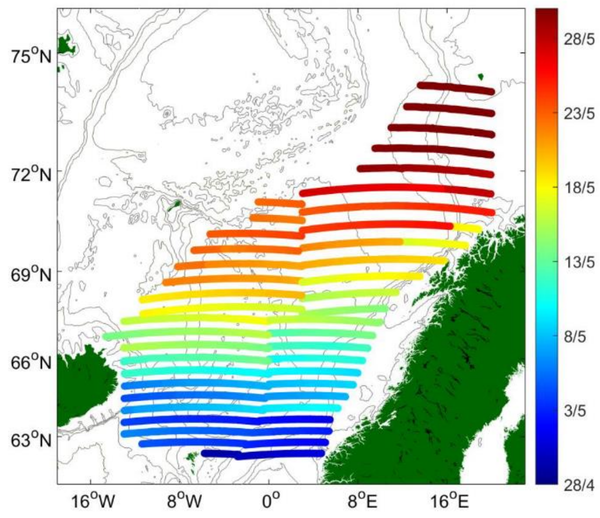


Figure 6. Temporal progression IESNS in April-May 2023.

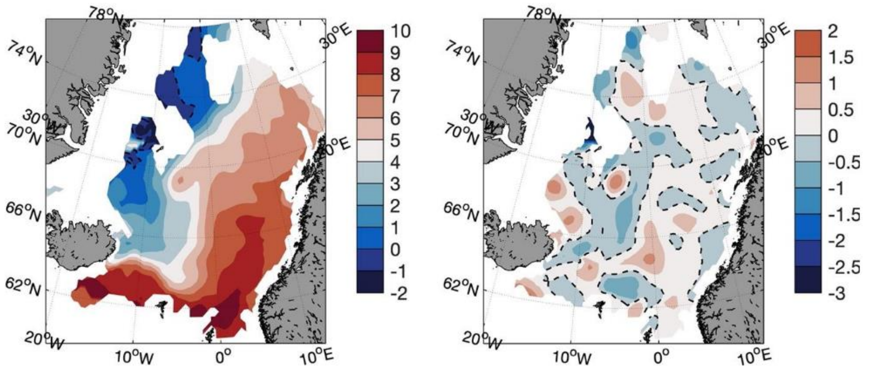


Figure 7a. Temperature (left) and temperature anomaly (right) averaged over 0-50 m depth in May 2023. Anomaly is relative to the 1995-2021 mean.

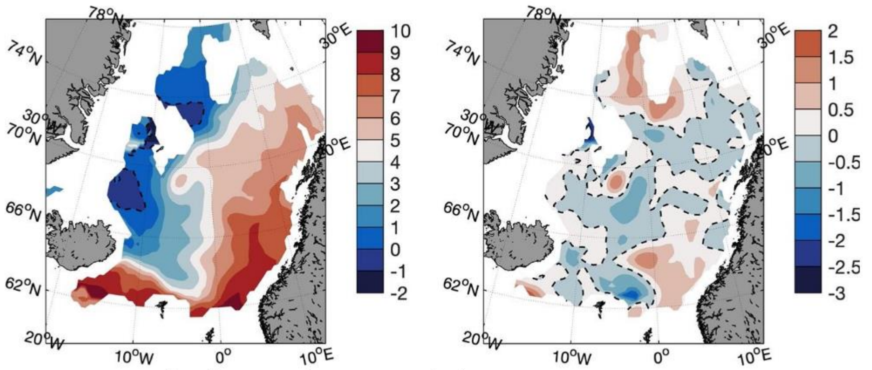


Figure 7b. Same as above but averaged over 50-200 m depth.

IESNS post-cruise meeting, Teams 13-15/6 2023

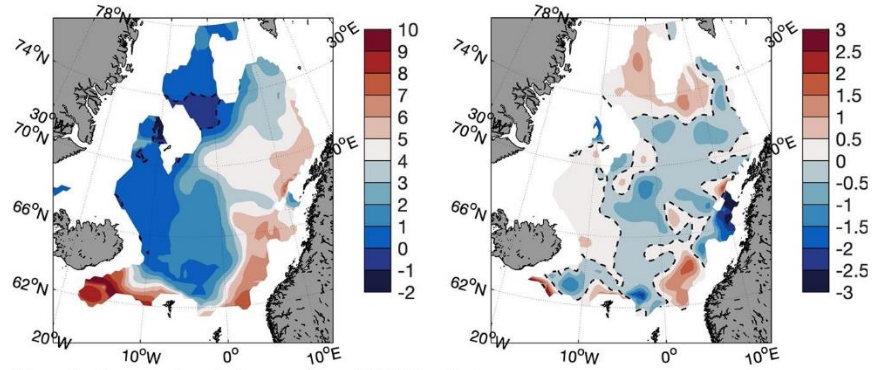


Figure 7c. Same as above but averaged over 200-500 m depth.

a) b)

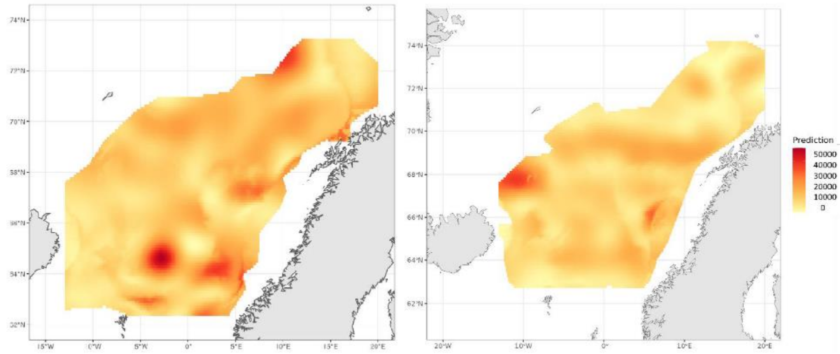
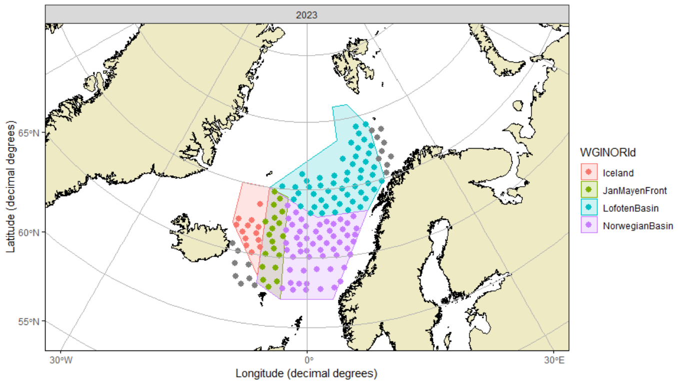


Figure 8. Distribution of zooplankton biomass (mg dry weight m^{-2}) in the upper 200 m in May a) IESNS 2022 and b) IESNS 2023.

IESNS post-cruise meeting, Teams 13-15/6 2023

a)



b)

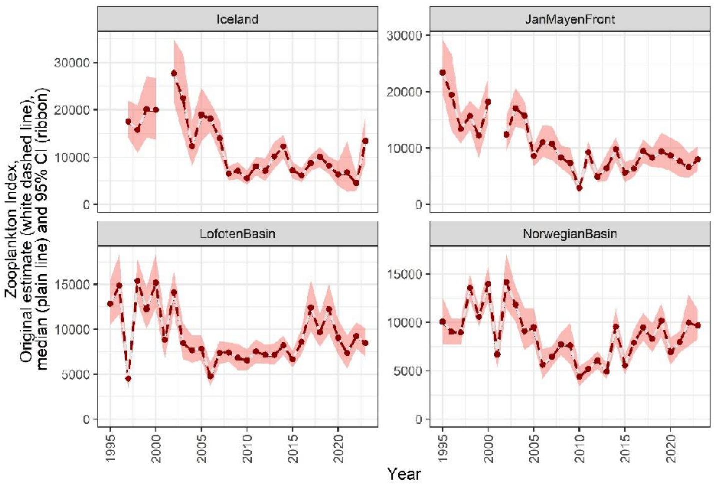
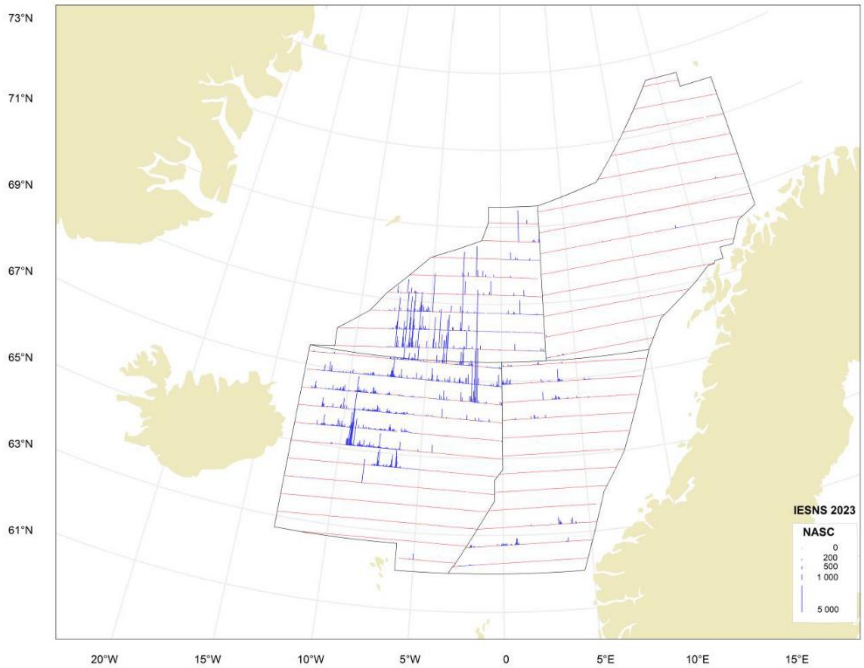


Figure 9 a) shows the sub-areas, and b) the indices of zooplankton biomass (mg dry weight m^{-2}) sampled by WP2 in May from 1995-2023.

IESNS post-cruise meeting, Teams 13-15/6 2023

(a)



IESNS post-cruise meeting, Teams 13-15/6 2023

(b)

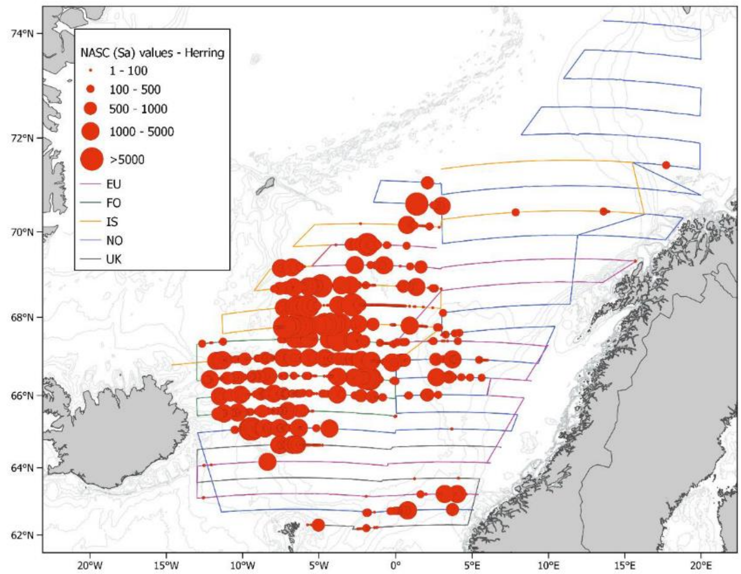


Figure 10. Distribution of Norwegian spring-spawning herring as measured during the IESNS survey in May 2023 in terms of NASC values (m²/nm²) averaged for every 1 nautical mile. The NASC values are represented as both bars (a) and bubbles (b).

IESNS post-cruise meeting, Teams 13-15/6 2023

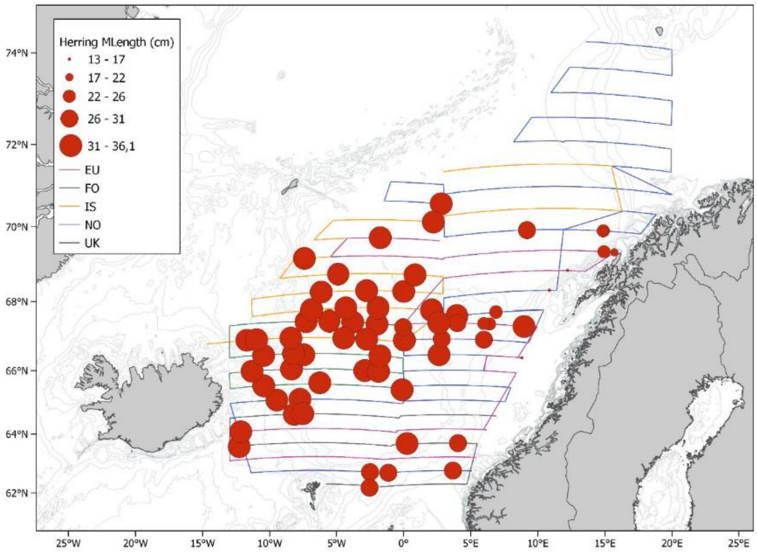


Figure 11. Mean length of Norwegian spring-spawning herring in all hauls in IESNS 2023.

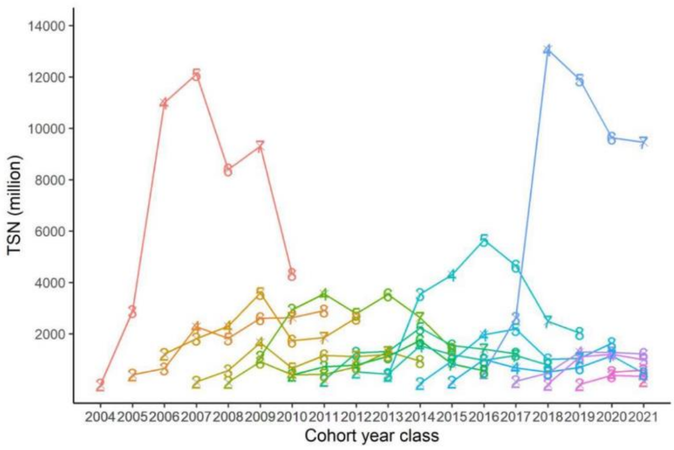


Figure 12. Tracking of the Total Stock Number at age (TSN, in billions) of Norwegian spring-spawning herring for each cohort since 2004 from age 2 to age 8. From 2008, stock is estimated using the StoX software. Prior to 2008, stock was estimated using BEAM.

IESNS post-cruise meeting, Teams 13-15/6 2023

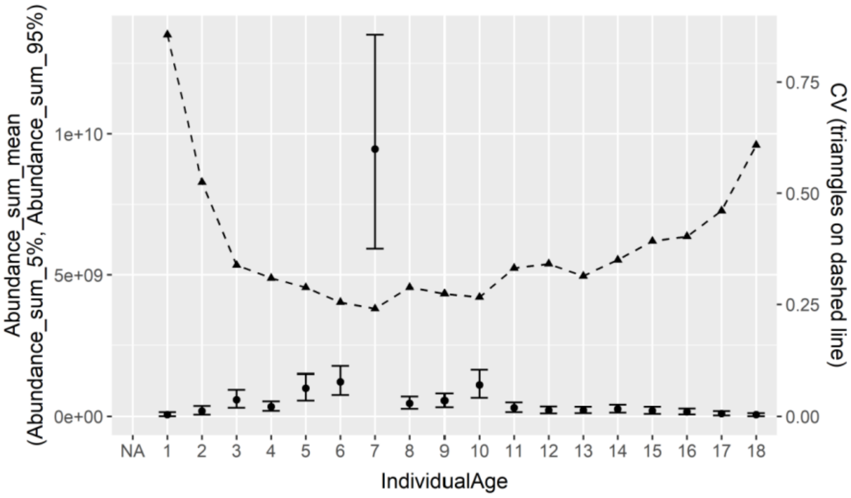


Figure 13. IESNS 2023. Norwegian spring-spawning herring in the Norwegian Sea: R boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 1000 replicates using the StoX software.

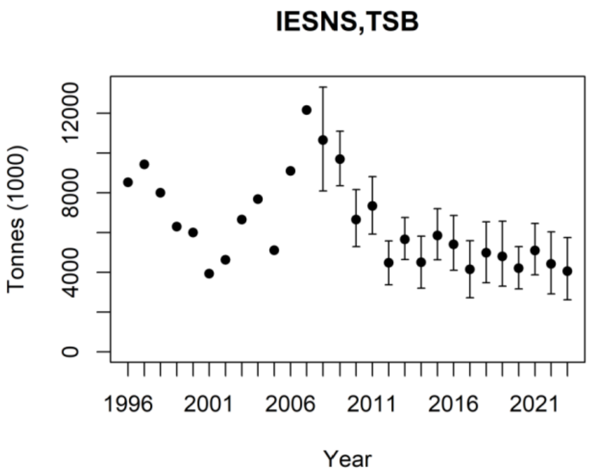


Figure 14. Biomass estimates of Norwegian-spring spawning herring in the IESNS survey (Barents Sea, east of 20°E, is excluded) from 1996 to 2023 as estimated using BEAM (1996-2007; calculated on basis of rectangles) and as estimated with the software StoX (2008-2023; bootstrap means with 90% confidence interval; calculated on basis of standard stratified transect design).

IESNS post-cruise meeting, Teams 13-15/6 2023

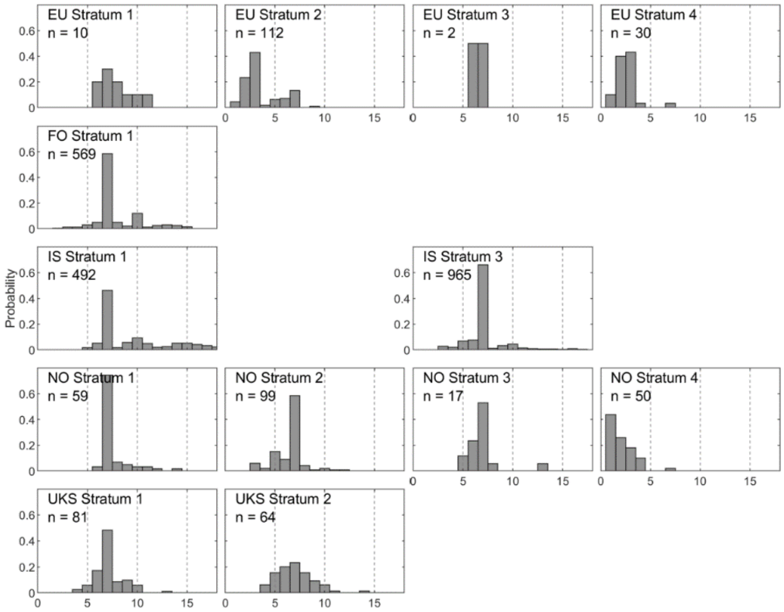
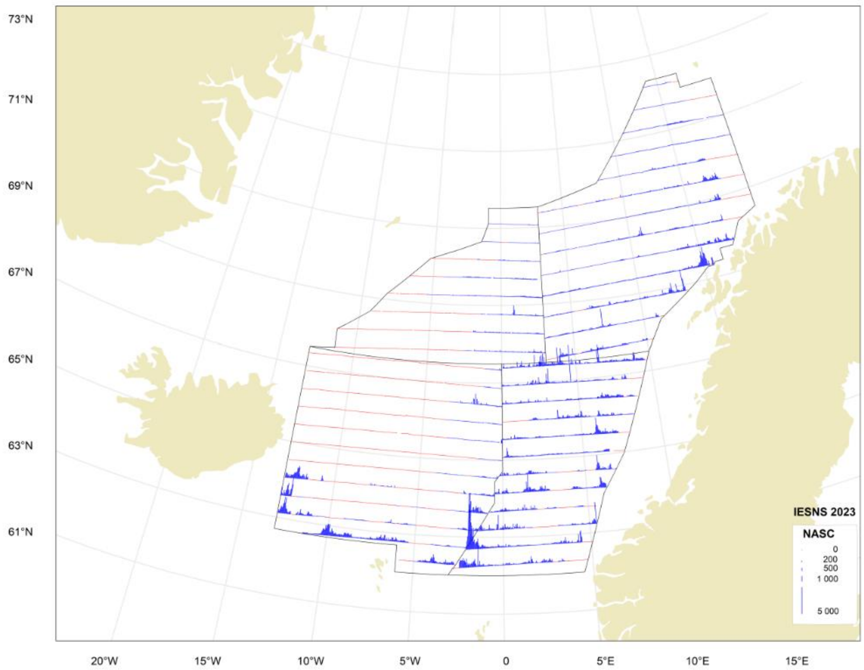


Figure 15. Comparison of the age distributions of NSS-herring by stratum and country in IESNS 2023. The strata are shown in Figure 3.

IESNS post-cruise meeting, Teams 13-15/6 2023

(a)



IESNS post-cruise meeting, Teams 13-15/6 2023

(b)

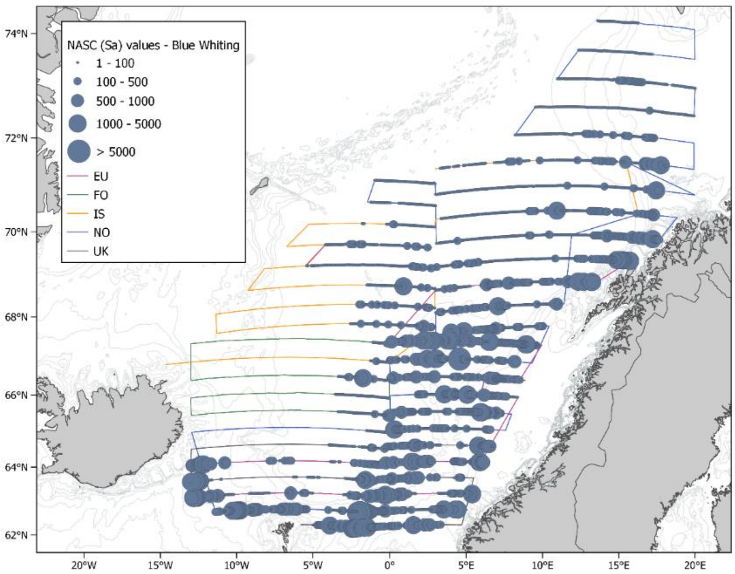


Figure 16. Distribution of blue whiting as measured during the IESNS survey in May 2023 in terms of NASC values (m^2/nm^2) (a) averaged for every 1 nautical mile. The NASC values are represented as both bars (a) and bubbles (b).

IESNS post-cruise meeting, Teams 13-15/6 2023

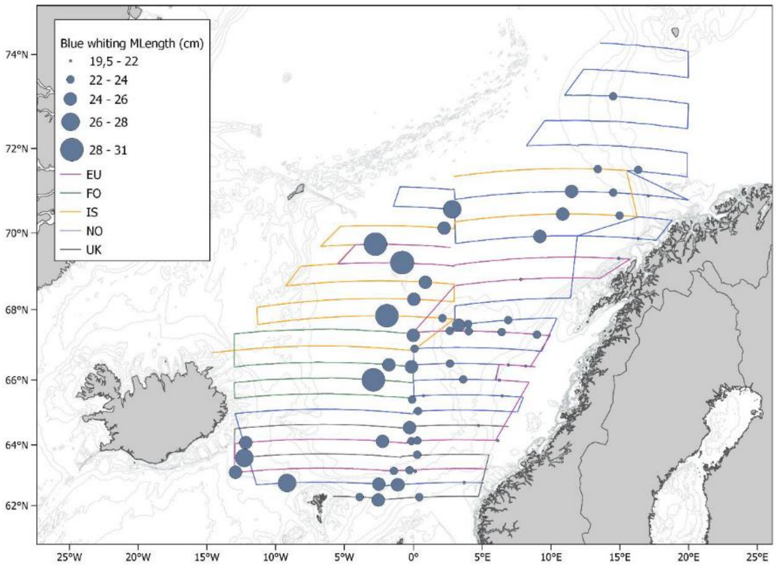


Figure 17. Mean length of blue whiting in all hauls in IESNS 2023. The strata are shown.

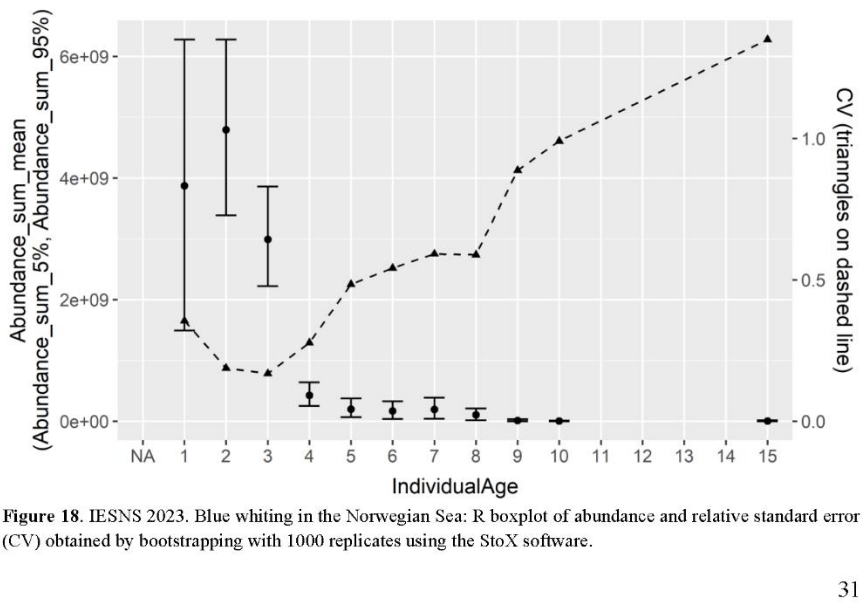


Figure 18. IESNS 2023. Blue whiting in the Norwegian Sea: R boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 1000 replicates using the StoX software.

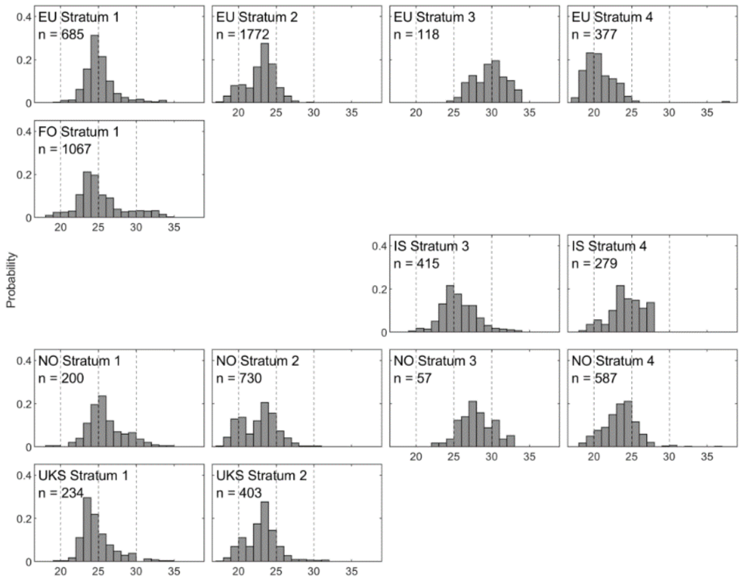


Figure 19. Comparison of the length distributions of blue whiting by stratum and country in IESNS 2023. The strata are shown in Figure 3.

IESNS post-cruise meeting, Teams 13-15/6 2023

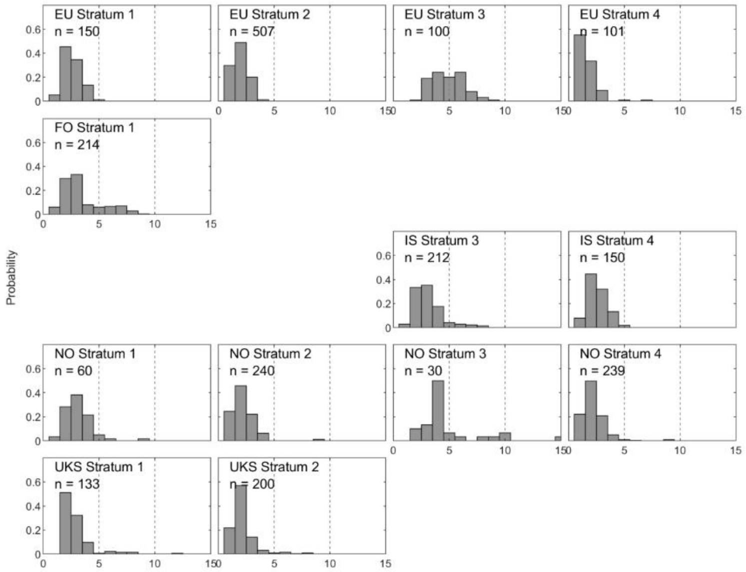


Figure 20. Comparison of the age distributions of blue whiting by stratum and country in IESNS 2023. The strata are shown in Figure 3.

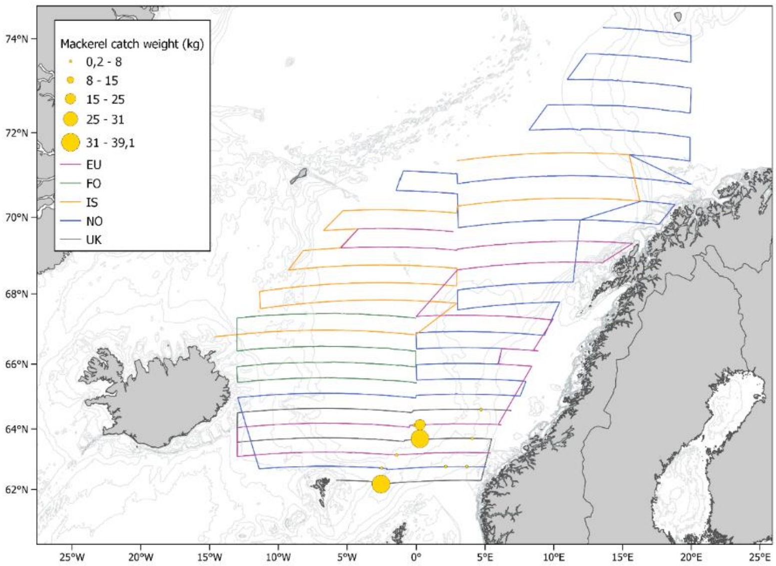


Figure 21. Pelagic trawl catches of mackerel in IESNS 2023.

DISTRIBUTION AND ABUNDANCE OF NORWEGIAN SPRING-SPAWNING HERRING DURING THE SPAWNING SEASON IN 2023

Are Salthaug og Erling Kåre Stenevik (HI)

RAPPORT FRA
HAVFORSKNINGEN
NR. 2023-21

Tittel (norsk og engelsk):

Distribution and abundance of Norwegian spring-spawning herring during the spawning season in 2023

Fordeling og mengde av norsk vårgytende sild under gytesesongen i 2023

Rapportserie: Rapport fra havforskningen

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22

Sammendrag (norsk):

I perioden 13. - 26. Februar 2023 ble gytefeltene til norsk vårgytende sild fra Møre (62°15´N) til Troms (70°37'N) dekket akustisk med de kommersielle fartøyene MS Eros og MS Vendla. Den estimerte biomassen var omtrent 18 % høyere, og det estimerte antallet omtrent 7 % høyere sammenlignet med fjorårets tokt. Usikkerheten i årets estimater er imidlertid vesentlig høyere enn i de seks foregående årene, til tross for at gjennomføringen av toktet gikk i henhold til planen. Gytebestanden var dominert av 2016-årsklassen med 46 % i antall og 42 % i vekt. Mesteparten av gytebestanden befant seg vest av Lofoten i år, mer konsentrert enn tidligere år. Sammenlignet med toktet i fjor var silda kommet kortere i modningsprosessen i år noe som indikerer senere gyting. Det anbefales å bruke estimatene av relativ mengde fra toktet i 2023 i ICES sin bestandsvurdering av norsk vårgytende sild.

Sammendrag (engelsk):

During the period 13-26th of February 2023 the spawning grounds of Norwegian spring-spawning herring from Møre (62°15´N) to Troms (70°37'N) were covered acoustically by the commercial vessels MS Eros and MS Vendla. The estimated biomass was about 18 % higher, and the estimated total number was about 7 % higher this year compared to the last year's survey. The uncertainty of the estimates in 2023 was much higher than what was observed the last six years, although the survey was conducted according to the plan. The spawning stock was dominated by the 2016 year class; 46 % in numbers and 42 % in biomass. Most of the spawning stock was found west of Lofoten this year, more concentrated than earlier years. Compared with last year's survey the herring was earlier in the spawning process this year which indicates later spawning. The estimates of relative abundance from the survey in 2023 are recommended to be used in this year's ICES stock assessment of Norwegian spring-spawning herring.

Innhold

1 - Introduction

Acoustic surveys on Norwegian spring-spawning herring during the spawning season has been carried out regularly since 1988, with some breaks (in 1992-1993, 1997, 2001-2004 and 2009-2014). In 2015 the survey was initiated again partly based on the feedback from fishermen and fishermenâ€™s organizations that IMR should conduct more surveys on this commercially important stock. Since then this survey, hereafter termed the NSSH spawning survey, has continued using hired commercial fishing vessels. In the ICES benchmark assessment of NSS herring in 2016 it was decided to use the data from this time series as input to the stock assessment, together with the ecosystem survey in the Norwegian Sea in May and catch data. Thus, the results from the NSSH spawning survey, have significant influence on the ICES catch advice.

The objective of the NSSH spawning survey 2023 was to continue the time series of abundance estimates, both point estimates and uncertainty, for use in the ICES WGWIDE stock assessment. Moreover, other biological information about the surveyed spawning stock of Norwegian spring-spawning herring is presented: spatial distribution of biomass and acoustic densities, spatial patterns in maturity and variations in temperature.

2 - Material and methods

2.1 – Survey design

During the period 13-26th of February 2023 (same period as in 2017-2022) the spawning grounds from Møre (62º15´N) to Troms (70º37´N) were covered acoustically by the commercial fishing vessels MS Eros and MS Vendla. The survey was planned based on information from the previous spawning surveys and the distribution of the herring fishery during the 2022/2023 season and earlier years. Figure 1 shows the distribution of commercial herring catches during the 2022/2023 winter season. The fishery seems to follow the herring migration from the continental slope area north of Andenes in the October into the overwintering areas around Kvænangen in November-January, and out again in January-February to start the spawning migration heading south. During the last nine years in November-January there has also been a fishery that seemed to follow a herring migration from the Norwegian Sea towards Røst and the Træna deep, however, this was not observed in 2023. In the two weeks prior to the start of the survey in 2023 the fishery had not moved south of Andenes, which is unusually far north for this period. Thus, the information from the fishery prior to the survey was sparse this year. Based on the observations from previous years it was decided to plan the survey coverage to take account of herring both migrating from the North along Lofoten and Vesterålen, and herring entering the Røst/Træna deep area from the west (i.e. from Norwegian Sea). As seen in Figure 1, the fishery during the survey in 2023 took place west and southwest of Røst and Lofoten, and north of Andenes, which is further north than usual at this time. The survey design followed a standard stratified design (Jolly and Hampton 1990), where the survey area was stratified before the survey start according to the assumed density structures of herring during the spawning migration (based on previous surveys and fisheries). All strata were covered with a zigzag design since this is the most efficient use of survey effort (Harbitz 2019). The survey planner function in the Rstox_1.11 package in r was used to generate the transects, and this function generates survey tracks with uniform coverage of strata and a random starting position in the start of each stratum. Each straight line in the zigzag track within a stratum was considered as a transect and a primary sampling unit (Simmonds and MacLennan 2005). Transit tracks between strata, i.e. from the end of the zigzag in one stratum to the start of the zigzag in the next stratum, were not used as primary sampling units. Prior to the start of the survey in 2023 all reported NSSH catches had been taken north of Lofoten, hence, the survey coverage (see Aglen 1989) was planned to be low to moderate south of 66°N since it was assumed that the fishing fleet followed the front of the herring migrating south and that the abundance of herring south of the fleet therefore was insignificant.

Trawl sampling was planned to be carried out on a regular basis during the survey to confirm the acoustic observations along transects and to be able to give estimates of abundance for different size and age groups. Both vessels used a Multpelt 832 scientific sampling trawl with small meshed (20 mm) inner net in the codend and a slit (so called "splitt") close to the codend to avoid too large catches. The following variables of individual herring were analysed from each station with herring catch: total weight in grams and total length in cm (rounded down to the nearest 0.5 cm) of up to 100 individuals per sample. In addition, age from scales, sex, maturity stage, stomach fullness and gonad weight in grams were recorded in up to 50 individuals per sample. Some genetic samples and otoliths were also collected to be used in later research projects.

CTD casts (using Seabird 911 systems) were taken by both vessels, spread out haphazardly in the survey area.

Echosounder data from the 38 kHz transducers was, as usual, the basis for measurement of fish density. The software LSSS version 2.14.0 was used for post-processing. Echogram scrutinization was carried out by the cruise leader and the chief instrument officer. Data was partitioned into the following categories: "herring", "other", "capelin" and "air bubbles" (upper 20 meters from the transducer near field).

2.2 – Abundance estimation

The acoustic density values were stored by species category in nautical area scattering coefficient (NASC) [m2 n.mi.-2] units (MacLennan et al. 2002) in a database with a horizontal resolution of 0.1 nmi and a vertical resolution of 10 m, referenced to the sea surface. The software Stox version 3.6 (Johnsen et al. 2019) was used to estimate abundance. More details and equations can be found in Salthaug et al. (2021). All trawl stations with herring were used to derive a common length distribution for all transects within the respective strata and all stations had equal weight. Abundance of fish in numbers and biomass were estimated based on 1000 bootstrapping iterations of biotic stations and acoustic transects. All results presented in this report are based on the output of this. The following target strength (TS)-to-fish length (L) relationship was used for herring: TS = 20logL – 71.9 (Foote 1987).

3 - Results and discussion

3.1 – Survey coverage

The cruise tracks of the NSSH spawning survey in 2023, together with pelagic trawl stations and CTD stations are shown in Figure 2. As mentioned above, the coverage south of 66°N was low to moderate since we expected low abundance in this area, which turned out to be the case (see below). Thus, most of the available survey effort was used to carry out dense coverage of the strata north of 66°N. The survey coverage (see Aglen 1989) of the first three strata was 5, 7 and 9 respectively (starting from south) and 11 in the two strata west of Lofoten and Vesterålen. The northernmost stratum had a survey coverage of 9. Pelagic trawl hauls were carried out regularly (Fig. 2) in the areas where herring like marks were observed on the echo sounder, to confirm the acoustic observations based on species composition in the catch and to obtain biological samples like size, maturity stage and age of herring. A total of 29 CTD casts were carried out in the surveyed area (Fig. 2). Bad weather prevented some of the planned CTD casts. Nautical area scattering coefficients (NASC) allocated to herring from acoustic transects by each nautical mile are shown in Figure 3. Marks on the echosounders that seemed like herring started to occur near Træna around 66°N, but these were weak registrations. A trawl haul also confirmed presence of herring in the area. Strong herring registrations were not observed before north of 67°N, approximately 60 nautical miles southwest of Røst. Herring was observed on the echosounder and in trawl hauls in all strata north of this. The highest concentrations were observed west of Lofoten, both around the shelf edge and on the banks nearer land. The zero-line was established in the north at around 70.3°N, which is further south than last year. A few capelin marks were observed on the northernmost transects and these were also confirmed by trawl samples.

3.2 – Estimates of abundance

The abundance estimates from this survey are viewed as relative, i.e. as indices of abundance, since there are highly uncertain scaling parameters like acoustic target strength and compensation for herring migrating in the opposite direction of the survey. The abundance estimates are shown in Table 1 and 2. In terms of the point estimates, the 2016 year class (age 7) dominated both in numbers (46 %) and biomass (42 %). Compared with the point estimates from last year (see Salthaug et al. 2022) the 2016 year class was reduced by 6-9 % in numbers (largest reduction for the median). The point estimate (mean) of total stock biomass (TSB) in the survey area was 3.91 million tons which is 18 % higher than last year's estimate. The time series of mean of total stock biomass from the survey is shown in Figure 4. The point estimate of total stock number (TSN) in the survey area was 13.04 billion which is 7 % higher than last year's estimate. This year's estimate of TSB corresponds to the mean of the time series while TSN is below the mean. The relative standard error (CV) of TSB is 40 % and that of TSN is 39 % (Tab. 1 and 2). These estimates of sample uncertainty are much higher compared to those from the last six surveys (7-17 %). The CV per age (Tab.1, Tab. 2 and Fig. 5) shows the normal pattern with high uncertainty for the very young and old ages and lower but still very high uncertainty (around 50 %) for the most abundant ages in the survey. The uncertainty estimates are mainly driven by the highly patchy observations in the stratum west/southwest of Lofoten which contained most of the estimated abundance (see below). Some very strong/dense schools in this area caused high variation in the values of acoustic density samples (EDSUs), i.e. some values were much higher than the rest. One way to reduce the uncertainty when the fish have such patchy distributions is to increase the sampling effort. However, the degree of coverage in this stratum was already high (11) since we expected high densities of fish here. It was therefore unexpected that the uncertainty estimates become much higher than in the most recent years, and we conclude that this is due to randomness. Some years the survey will "hit" large schools which increases the uncertainty and point estimates compared to years when fewer such large schools are observed. This phenomenon is a well-known problem in abundance surveys, see e.g. Pennington (1996). It is doubtful whether changing the survey design or timing of the survey would have prevented the high uncertainty. Figure 6 shows estimates of number per year class in the four most recent surveys. These numbers are expected to decline between consecutive years due to mortality, for ages that are fully recruited to the survey (seems to be age 5 or 6). Such declines are observed for the 2013 and 2016 year classes which are the two strongest in the survey, however, many of the other weaker year classes show an increase from 2022 to 2023. The latter "unexpected" observation is probably a reflection of the very high uncertainty in the 2023 estimates. As observed in the most recent surveys, the 2016 and 2013 year classes are estimated to be the most abundant also in 2023 which shows that this survey is fairly internally consistent. Mean weight and length from the 2023 spawning survey are shown in Table 3. The point estimates are higher than last year for ages 3-6 which indicates more favorable growth conditions.

3.3 - Spatial distribution of the stock and maturity

The relative distribution of the estimated biomass per stratum is shown in Figure 7. Most of the biomass (87%) was found in the stratum west and southwest of Lofoten and a significant proportion (10 %) was found in the stratum west of Vesterålen. This shows that the spawning stock was very concentrated and far north this year. Figure 8 shows the proportion of different maturation stages at different latitudes. Most of the herring was classified as maturing or ripe. The proportion of maturing herring was highest (i.e. lowest proportion of spawning and ripe) in the northernmost area as usual. Regarding spawning area, the fishery, like last year, indicates that most of the spawning occurred west of Lofoten around the Røst bank this year (Fig. 1). The fishery in 2023 south of 67°N has been insignificant and based on this it is likely that the spatial distribution of the herring observed during the spawning survey reflects the spawning area. The proportion of the different spawning stages among mature herring is shown for the period 2017-2023 in Figure 9 (the surveys have been carried out in the second part of February during all these years). The large proportion of maturing herring and low proportion of spawning/ripe herring in 2023 compared to earlier years indicates that the spawning is late this year, however, the distribution in 2019 was very similar so not exceptional late.

3.4 - Geographical variation in temperatures experienced by the herring

Temperatures experienced by herring from close to the surface and down to 250 m are shown in Figure 10 for the areas south and north of 67°N, for the years after 2016 when the survey has been carried out in the same period (latter half of February). The temperatures in 2023 varied from 8.1°C at 150 m depth south of 67°N to 6.6°C at 5 m depth north of 67N. This range is lower than last year when the variation was large, and the temperature in 2023 was higher at all depths compared to last year. At typical spawning depths of herring at 100-200 m depth, the temperature conditions were quite similar to those observed during the most recent NSSH spawning surveys.

3.5 - Quality of the survey

Both vessels were equipped with multifrequency equipment on a drop keel. The weather conditions were more challenging this year than last, and the vessels had to lie still and wait for better conditions a couple of times, but acoustic data with good quality was recorded and trawling on registrations could be carried out adequately most of the time. Luckily, the weather was very nice in the area where most of the stock was found. Like last year the zero line was clearly established in the north, and we are not aware of any observations that indicates presence of mature NSS herring outside the survey area during the survey this year. To conclude, the acoustic and biological data recorded in 2023 on the NSSH spawning survey were of satisfactory quality and the estimates from the survey are recommended to be used in the stock assessment of Norwegian spring-spawning herring in 2023.

4 - References

Aglen, A. 1989. Empirical results on precision effort relationships for acoustic surveys. Int. Coun. Explor. Sea CM 1989 B:30, 28pp.

Foote, K. 1987. Fish target strengths for use in echo integrator surveys. J. Acoust. Soc. Am. 82: 981-987.

Harbitz, A. 2019.A zigzag survey design for continuous transect sampling with guaranteed equal coverage probability. Fisheries Research 213, 151-159.

Johnsen, E., Totland, A., Skålevik, Å., Holmin, A.J., Dingsør, G.E., Fuglebakk, E., Handegard, N.O. 2019. StoX: An open source software for marine survey analyses. Methods in Ecology and Evolution 10:1523–1528.

Jolly, G.M., and Hampton, I. 1990. A stratified random transect design for acoustic surveys of fish stocks. Canadian Journal of Fisheries and Aquatic Sciences 47: 1282-1291.

MacLennan, D.N., Fernandes, P., and Dalen, J. 2002. A consistent approach to definitions and symbols in fisheries acoustics. ICES J. Mar. Sci., 59: 365-369.

Pennington, M. 1996. Estimating the mean and variance from highly skewed marine data. Fishery Bulletin, US, 47: 1623– 1624.

Simmonds, J, and David N. MacLennan. 2005. Fisheries acoustics: theory and practice. John Wiley & Sons, 2008.

Salthaug, A., Stenevik, E.K., Vatnehol, S., Anthonypillai, V., and Slotte, A. 2021. Distribution and abundance of Norwegian spring spawning herring during the spawning season in 2021. Survey report / Institute of Marine Research/ISSN 15036294/Nr. 1– 2021.

Salthaug, A., Stenevik, E.K., Vatnehol, S., and Slotte, A. 2022. Distribution and abundance of Norwegian spring spawning herring during the spawning season in 2022. Survey report / Institute of Marine Research/ISSN 1503-6294/No. 2– 2021.

5 - Tables

Table 1. Abundance estimates (million individuals) of Norwegian spring-spawning herring during the spawning survey 13.-26. February 2023, based on 1000 bootstrap replicates in Stox.

Age	5th percentile	Median	95th percentile	Mean	SD	CV
3	55	184	402	205	115	0.56
4	25	170	425	189	132	0.70
5	200	538	1015	568	255	0.45
6	247	550	1094	594	269	0.45
7	2725	5751	10287	6014	2333	0.39
8	111	327	712	351	181	0.52
9	359	981	1981	1057	523	0.49
10	521	1280	2379	1349	585	0.43
11	79	277	622	304	171	0.56
12	160	496	1039	537	279	0.52
13	152	460	1025	508	270	0.53
14	142	483	1151	538	316	0.59
15	97	293	643	324	175	0.54
16	23	97	276	116	79	0.68
17	88	314	766	356	221	0.62
19	0	9	30	10	10	1.00
TSN	5725	12572	21883	13037	5040	0.39

Table 2. Biomass estimates (thousand tons) of Norwegian spring-spawning herring during the spawning survey 13.-26. February 2023, based on 1000 bootstrap replicates in Stox.

Age	5th percentile	Median	95th percentile	Mean	SD	CV
3	6	23	53	26	15	0.58
4	4	31	83	35	27	0.76
5	42	107	199	113	51	0.45
6	59	133	263	143	64	0.45
7	745	1591	2852	1657	648	0.39
8	34	106	237	114	61	0.53
9	118	323	663	350	175	0.50
10	174	430	802	453	197	0.44
11	28	98	223	109	62	0.57
12	61	187	395	204	107	0.52
13	56	169	376	187	100	0.53
14	53	183	438	204	121	0.59
15	38	112	249	125	68	0.54
16	9	38	109	46	31	0.68
17	34	119	292	134	83	0.61
19	0	4	11	4	4	0.99
TSB	1674	3768	6660	3910	1560	0.40

Table 3. Estimated length and weight of individuals by age group of Norwegian spring-spawning herring during the spawning survey 13.-26. February 2023, based on 1000 bootstrap replicates in Stox.

Age	mean weight (g)	CV(weight)	mean length (cm)	CV(length)
3	121.1	0.050	26.2	0.012
4	166.7	0.081	28.7	0.025
5	193.7	0.043	29.7	0.009
6	236.9	0.023	31.4	0.006
7	269.5	0.008	32.7	0.002
8	318.4	0.034	34.4	0.011
9	328.7	0.014	35.0	0.003
10	332.5	0.009	35.0	0.003
11	352.8	0.022	35.9	0.006
12	379.8	0.017	36.9	0.006
13	365.8	0.014	36.4	0.004
14	381.4	0.019	37.0	0.006
15	385.5	0.019	37.4	0.006
16	390.1	0.028	37.3	0.010
17	385.0	0.021	37.0	0.009
19	390.2	0.016	37.9	0.006

6 - Figures

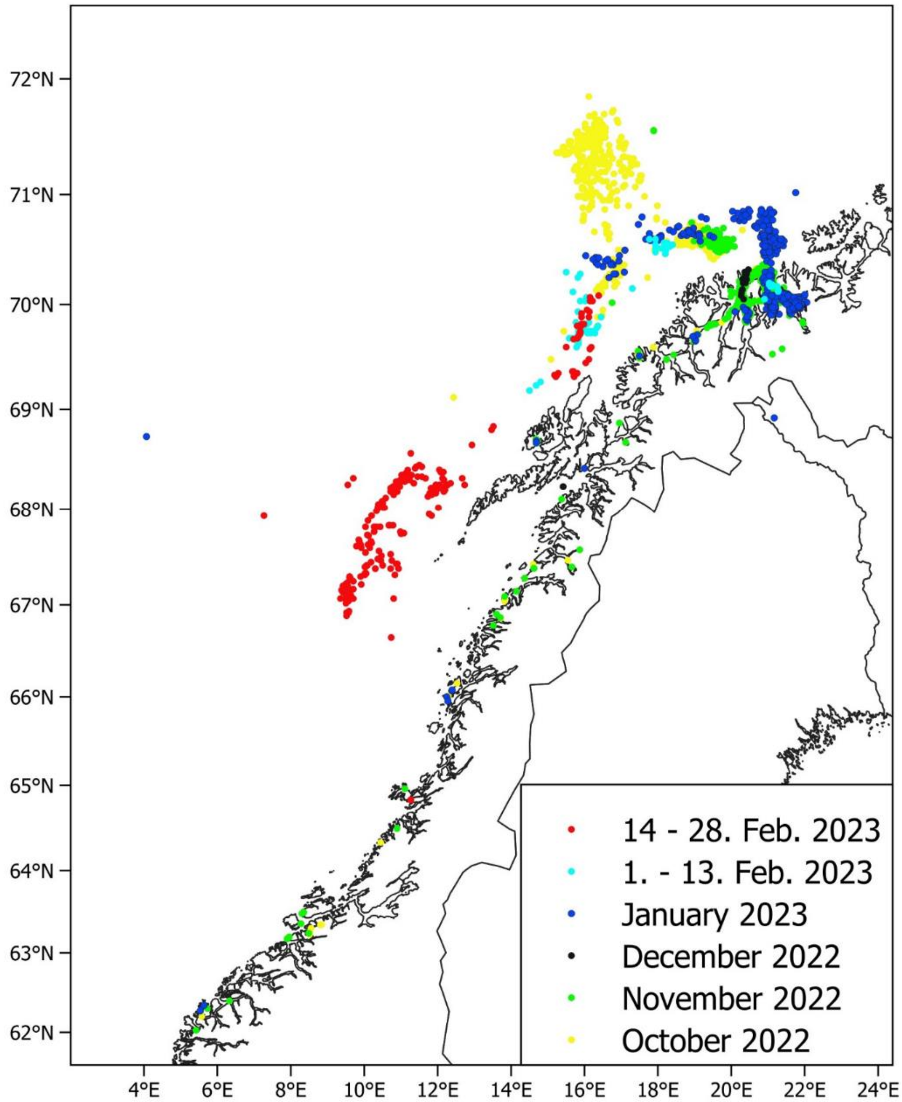

Figure 1. Distribution of commercial catches of Norwegian spring-spawning herring from October 2022 until February 2023, based on electronic logbooks. Each point represent one catch, only catches larger than 10 tons are shown.

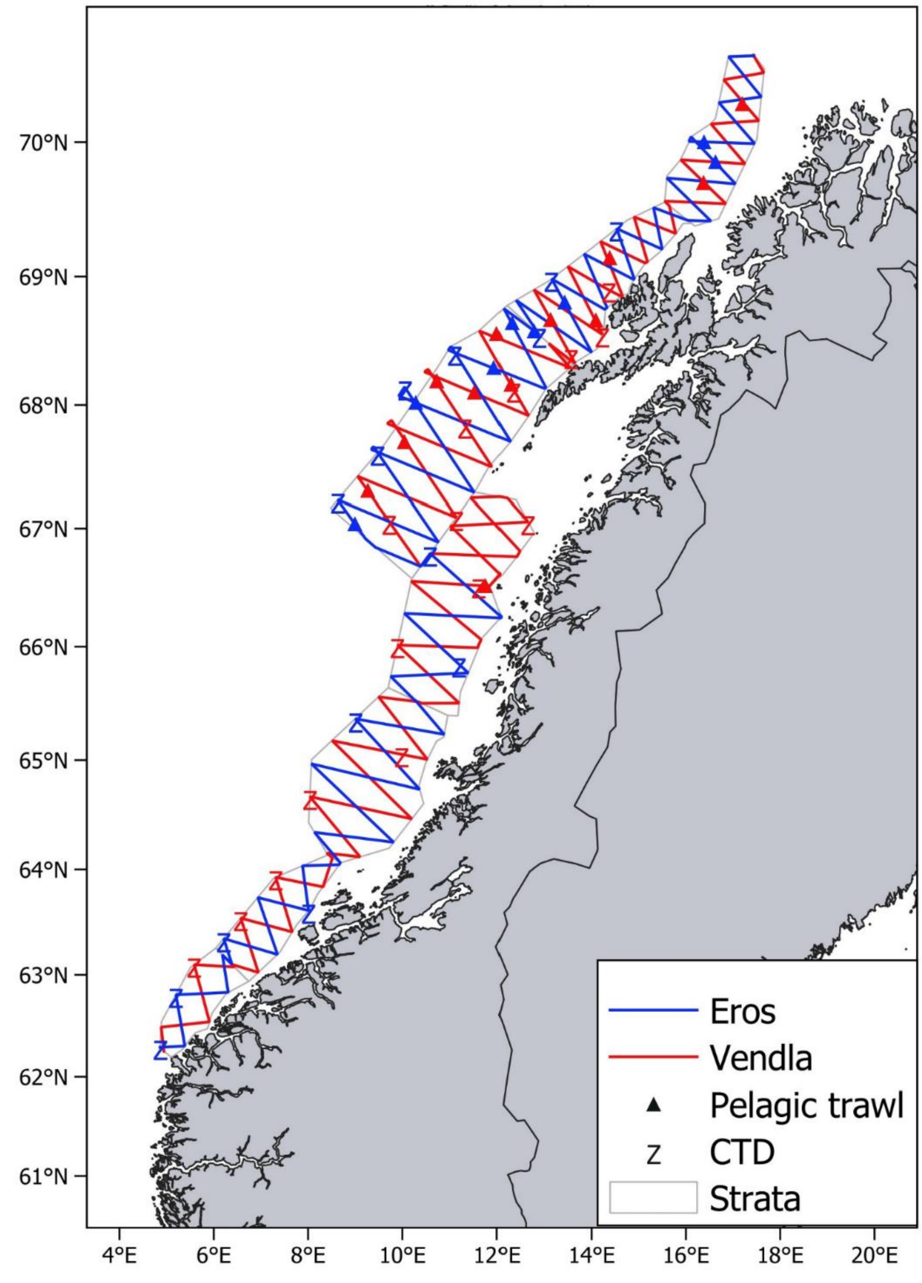

Figure 2. Cruise tracks (mostly acoustic transects), pelagic trawl stations (triangles), and CTD stations (Z) covered by Eros and Vendla on the Norwegian spring-spawning herring spawning survey 13.-26. February 2023. Strata limits area also shown.

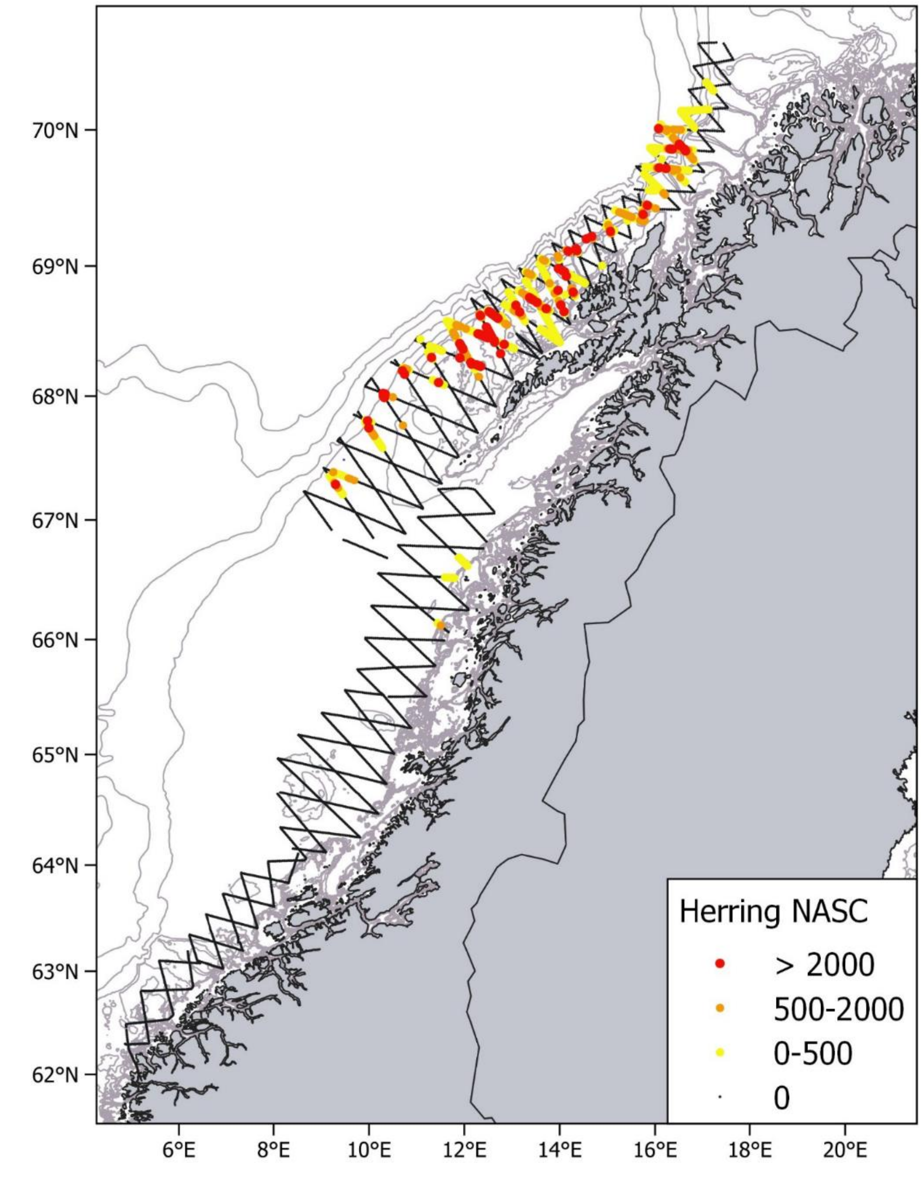

Figure 3. Acoustic densities (NASC) of herring recorded during the Norwegian spring-spawning herring spawning survey 13.-26. February 2023. Points represent NASC values per nautical mile. Depth contours are shown for 50 m, 100 m, 150 m, 200 m, 500 m, 1000 m, 1500 m and 2000 m.

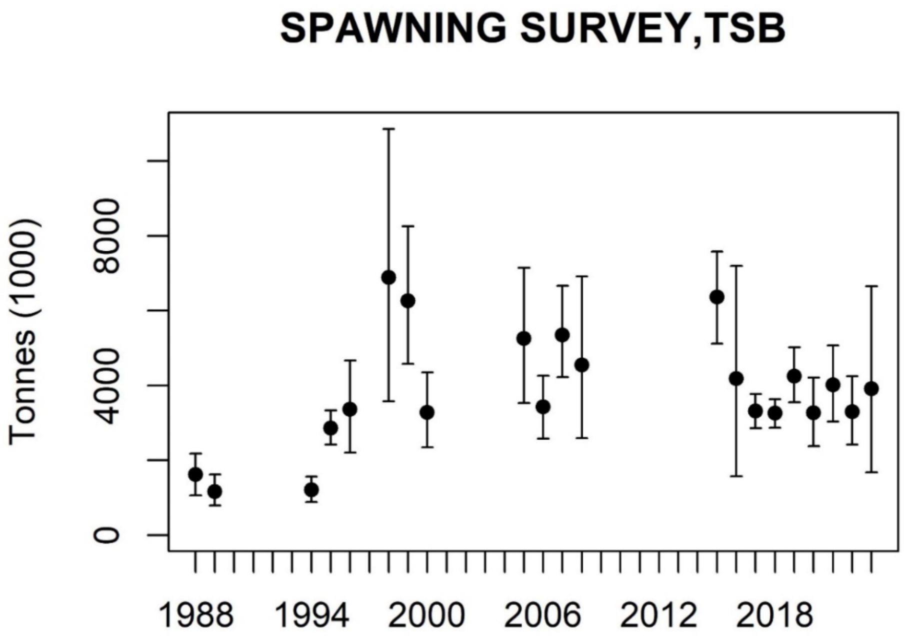

Figure 4. Estimates of total biomass from the Norwegian spring-spawning herring spawning surveys during 1988-2023. The estimates are mean of 1000 bootstrap replicates in Stox and the error bars represent 90 % confidence intervals.

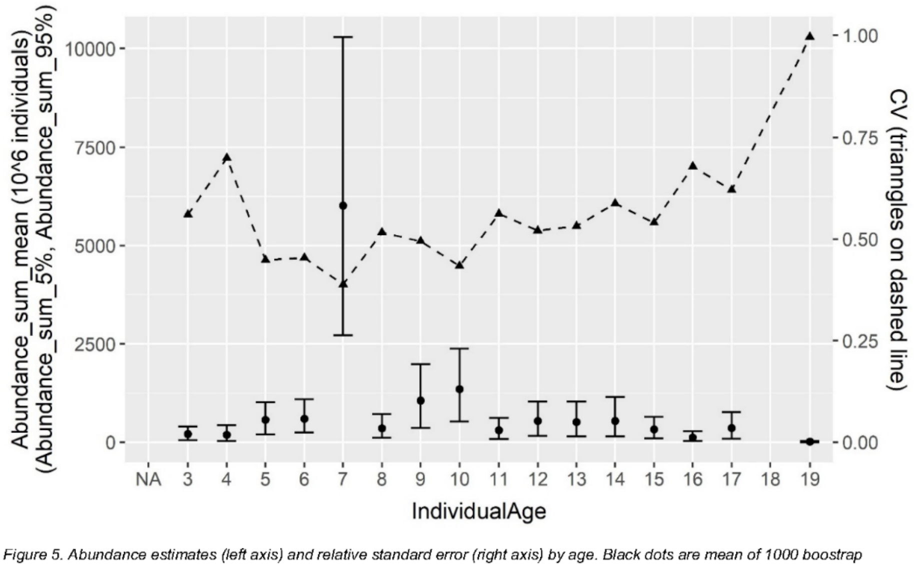

Figure 5. Abundance estimates (left axis) and relative standard error (right axis) by age. Black dots are mean of 1000 boostrap replicates in Stox, error bars represent 90 % confidence intervals and triangles relative standard error (CV).

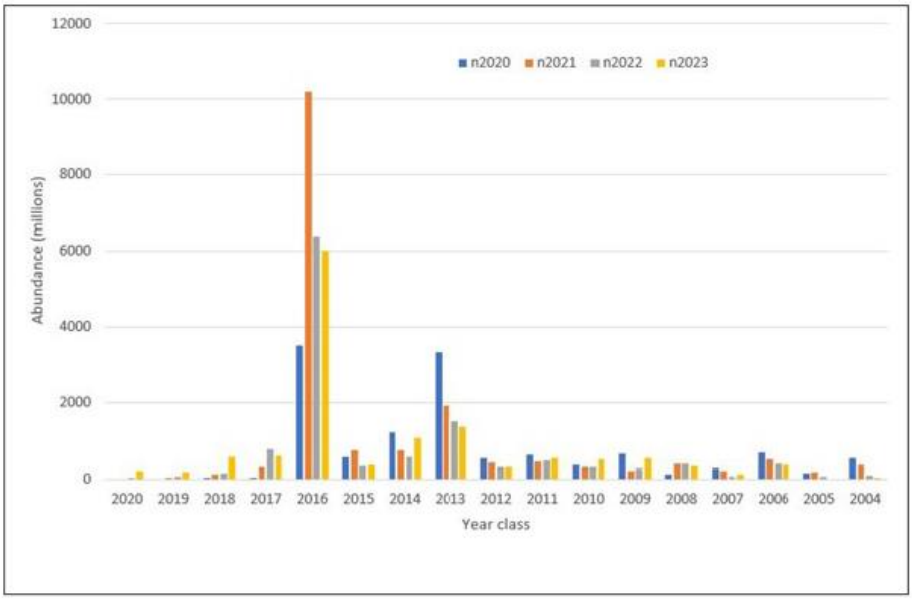

Figure 6. Abundance by year class estimated during the Norwegian spring-spawning herring spawning surveys in 2020-2023 (mean of 1000 bootstrap replicates). Legend: Separate color for each survey year.

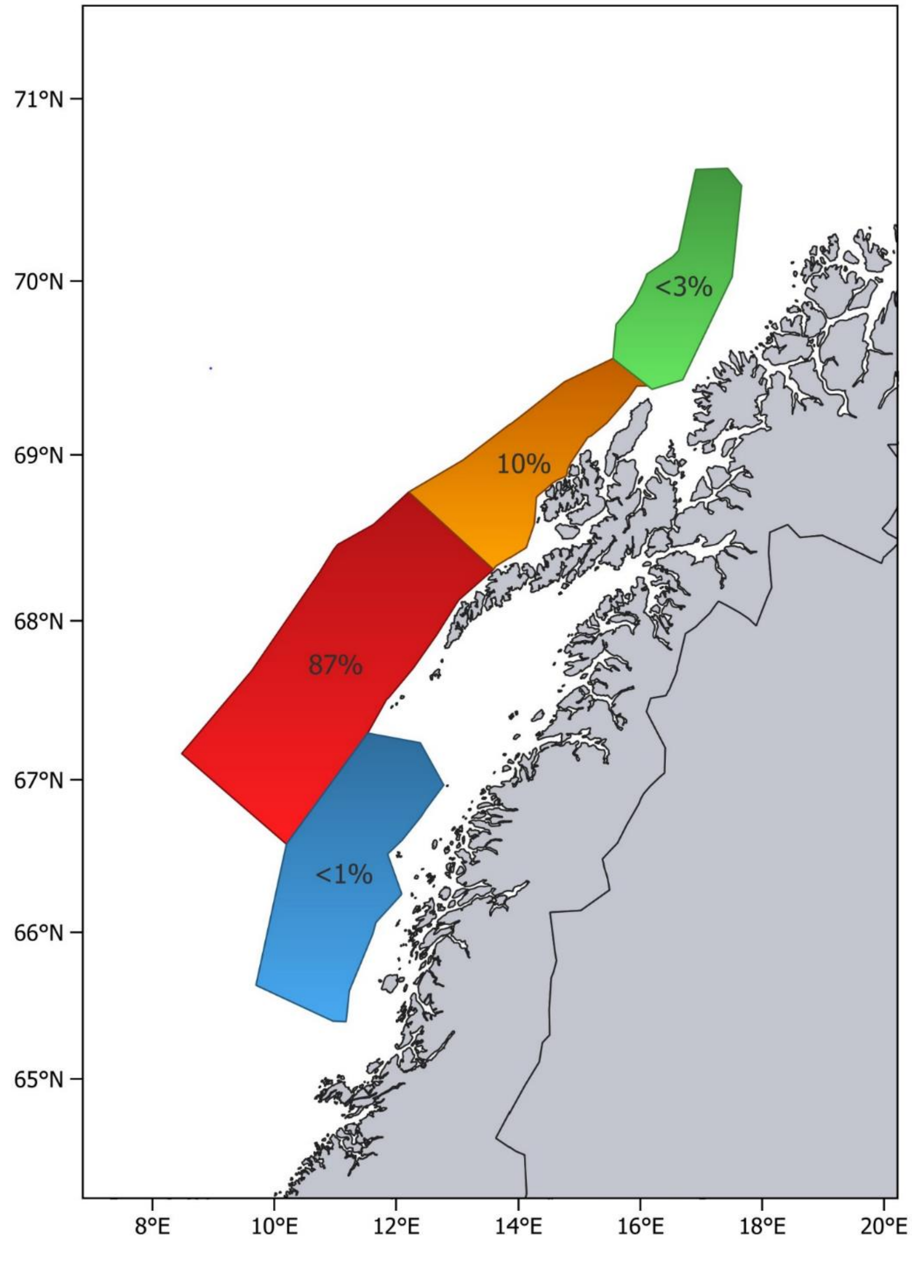

Figure 7. Relative distribution by stratum of the biomass of herring from the Norwegian spring-spawning herring spawning survey 13.-26. February 2023 (mean of 1000 bootstrap replicates).

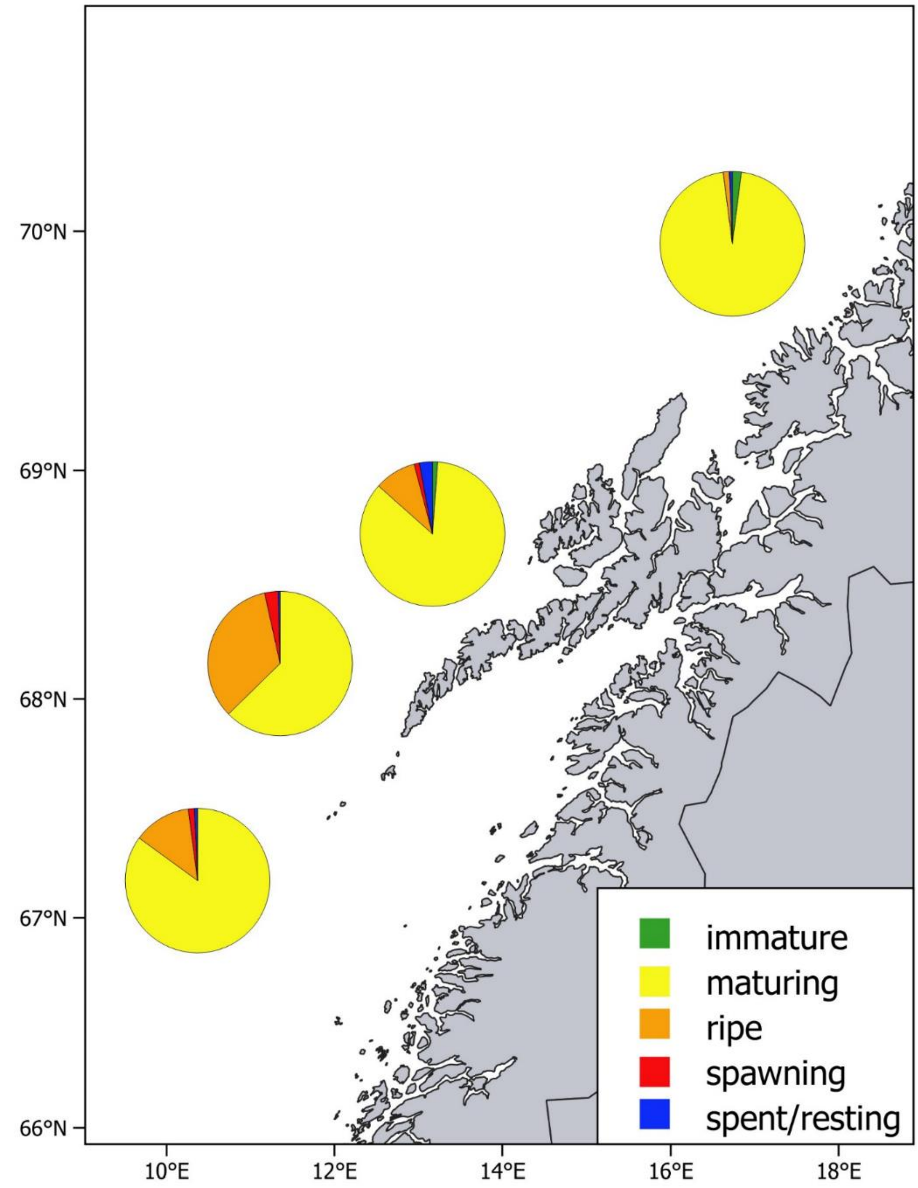

Figure 8. Proportions of different maturity stages from the Norwegian spring-spawning herring spawning survey 13.-26. February 2023. The proportions are based on sampled herring in the following latitude intervals: <68°N, 68-68.5°N, 68.5-69.3°N, >69.3°N.

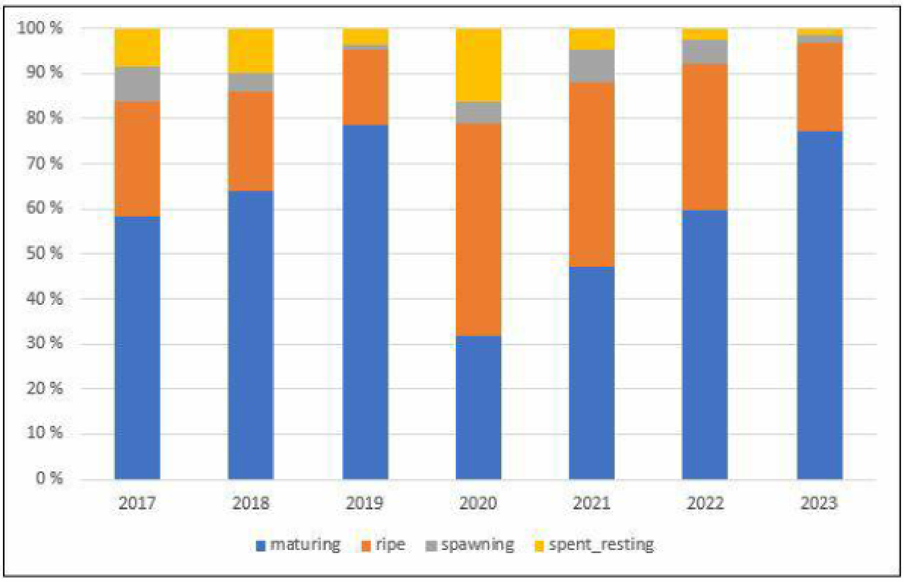

Figure 9. Proportion of the different maturity stages among mature herring in samples from the Norwegian spring-spawning herring spawning surveys in 2017-2023.

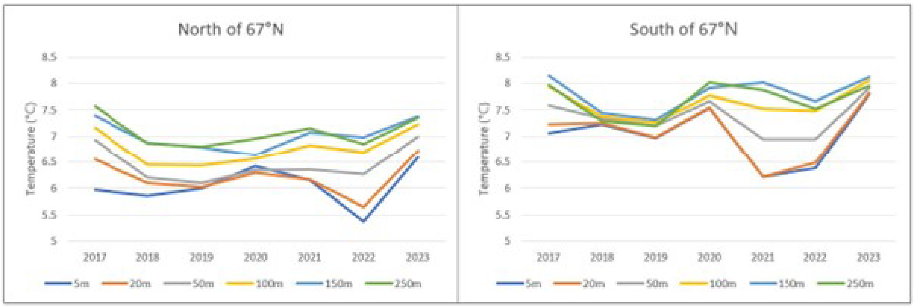

Figure 10. Mean temperatures at 5, 20, 50, 100, 150, 250 m in the area covered during the Norwegian spring-spawning herring spawning surveys in 2017-2023.

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WD05 – Mix of herring stocks from catch data Sólvá Káradóttir Elisen

Farose herring catch samples 2022
Mix between spring spawning and summer/autumn spawning herring – highlighting the importance of doing genetic sampling of herring

Samples taken in winter (Jan 2022 and Dec 2022) in the international zone (Lat > 67N and Lon > ½° E) had 6%, 16%, 34% and 46% of hyaline otoliths, respectively. This indicates a relatively high mix of autumn and spring spawners that occupy the central part of the Norwegian Sea in the winter (Dec-Jan).

Hyaline otoliths are also more prevalent in samples taken close to Iceland.

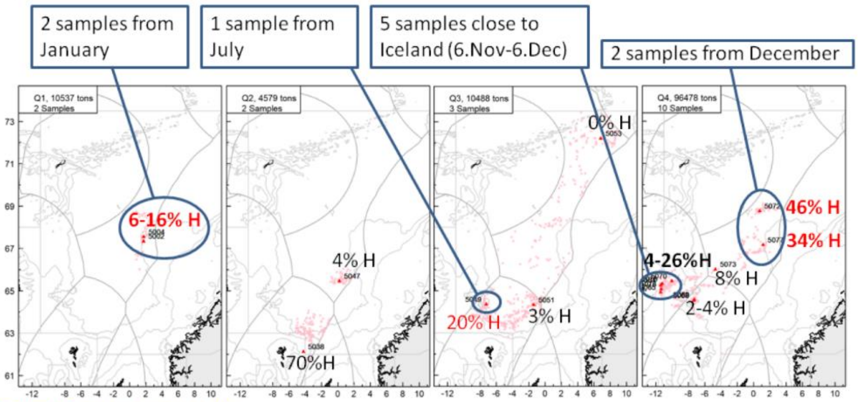


Figure 1 Faroese samples 2022

Thus, the fishery close to Iceland in the second semester of the year, and in the central part of the Norwegian Sea in the early winter (which is the quarter when most of the catch is taken), not only targets NSSH, but also other herring stocks.

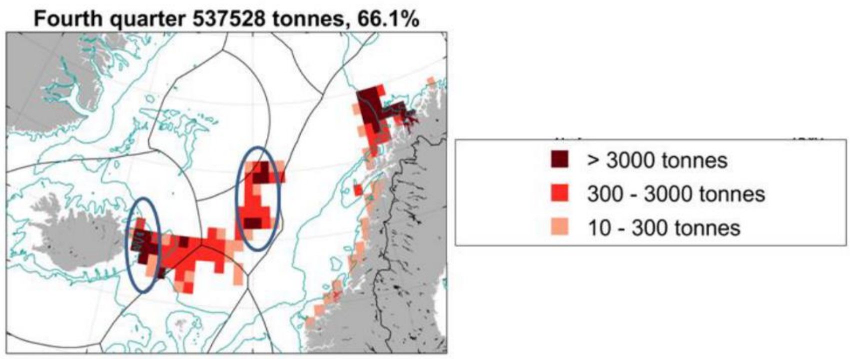
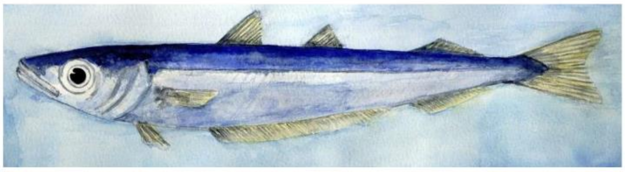


Figure 2 Total NSSH catches in Q4

Working Document

Working Group on International Pelagic Surveys
January 2024

Working Group on Widely Distributed Stocks
August 2023



INTERNATIONAL BLUE WHITING SPAWNING STOCK SURVEY (IBWSS) SPRING 2023

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R/V *Tridens*

Michael O'Malley[4,] Ciaran O'Donnell[4]* and Eugene Mullins[4]
R/V *Celtic Explorer*

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Material and methods

Survey planning and Coordination

Coordination of the survey was initiated at the meeting of the Working Group on International Pelagic Surveys (WGIPS) in January 2023 and continued by correspondence until the start of the survey. During the survey, effort was refined and adjusted by the survey coordinator (Norway) using real time observations. Participating vessels together with their effective survey periods are listed below:

Vessel	Institute	Survey period
Celtic Explorer	Marine Institute, Ireland	25/3 – 04/04
Jákup Sverri	Faroe Marine Research Institute, Faroe Islands	25/3 – 04/04
Tridens	Wageningen Marine Research, the Netherlands	25/3 – 31/03
Vendla	Institute of Marine Research, Norway	19/3 – 01/04
Vizconde de Eza	Spanish Institute of Oceanography, Spain	26/3 – 02/04

Survey design was based on methods described in ICES Manual for International Pelagic Surveys (ICES, 2015). Overall, weather conditions were mixed compared to 2022, with poor weather delaying the start of the survey by 4 days in the south for the Irish and Dutch vessels. Further north, further downtime was experienced by some vessels, accounting for slowed progress. The entire survey was completed in 17 days, within the agreed 21-day target threshold (Figure 4). Area coverage was considered comprehensive in both core and peripheral areas, with all vessels completing the planned routes. Spanish survey effort (Strata 1b) was included into the 2023 estimate as temporal alignment was achieved compared to 2022.

Vessel cruise tracks, trawl positions and survey stratification are shown in Figure 1. CTD and plankton stations are in shown in Figure 2. Communication between vessels occurred daily via email to the coordinator (Norway) exchanging up to date information on blue whiting distribution, echograms, fleet activity and biological information. Tridens keeps a weblog during the survey with echograms, catches and additional information.

Sampling equipment

All vessels employed a single midwater trawl for biological sampling, the properties of which are given in Table 1. Acoustic equipment for data collection and processing are presented in Table 2. Survey abundance estimates are based on acoustic data collected from calibrated scientific echo sounders using an operating frequency of 38 kHz. All transducers were calibrated using a standardised sphere calibration (Demer et al. 2015) prior, during or directly after the survey. Acoustic settings by vessel are summarised in Table 2.

Biological sampling

All components of the trawl haul catch were sorted and weighed; fish and other taxa were identified to species level where possible. A summary of biological sampling by vessel is provided in Table 3.

Hydrographic sampling

Hydrographic sampling (vertical CTD casts) was carried out by each vessel at predetermined locations (Figure 3 and Table 3). Depth was capped at a maximum depth of 1000 m in open water, with the exception of the Faroese and Spanish vessels (500 m).

Plankton sampling

Plankton sampling, by way of vertical WP2 casts, was carried out by the RV *Jákup Sverri* (FO) to a depth of 200 m (Table 3). WP2 casts were also carried out by FV *Vendla* (NO), with a focus on sampling blue whiting eggs to a depth of 400 m.

Acoustic data processing

Echogram scrutinisation for blue whiting was carried out by experienced personnel, with the aid of trawl composition information. Post-processing software and procedures are described by vessel below;

On RV *Celtic Explorer*, acoustic data were backed up every 24 hrs and scrutinised using Echoview (V 13.0) post-processing software for the previous day's work. Data was partitioned into the following categories: blue whiting and mesopelagic fish species. For mesopelagic fish, categorisation was based on criteria agreed at WGIPS 2021 (ICES 2021, Annex 22).

On RV *Jákup Sverri*, acoustic data were scrutinised every 24 hrs on board using LSSS (2.14.1) post processing software. Data was partitioned into the following categories: plankton, mesopelagics/krill and blue whiting. Partitioning of data into the above categories was based on trawl samples and acoustic characteristics on the echograms.

On RV *Tridens*, acoustic data were backed up continuously and scrutinised every 24 hrs using the Large Scale Survey System LSSS (2.10.0) post-processing software. Blue whiting was identified and separated from other recordings based on trawl catch information and characteristics of the recordings. Recordings have been assigned to blue whiting and mesopelagic fish species, based on the criteria at WGIPS 2021 (ICES 2021, Annex 22).

On FV *Vendla*, the acoustic recordings were scrutinized using LSSS (V. 2.14.0) once or twice per day. Data was partitioned into the following categories: plankton (<120 m depth layer), mesopelagic species and blue whiting.

On RV *Vizconde de Eza*, acoustic data were backed up every 24 hrs and scrutinised after the survey using Echoview (V 9.0) post processing software. Data were partitioned into the following categories: Blue whiting and Mueller's pearlside and boarfish which were identified and separated from other recordings based on trawl catch information and characteristics of the recordings.

Acoustic categorisation and targeted biological sampling of mesopelagic fish species is ongoing and will be further refined during future surveys. Progress updates will be reported through WGIPS.

Acoustic data analysis

Acoustic data were analysed using the StoX software package (V3.6.0) and R-StoX packages software package (RStoX Framework 3.6.0, RStoX Base 1.11.0 and RStoX Data 1.8.0). A description of StoX software package is provided by Johnsen et. al. (2019). Estimation of abundance from acoustic surveys using StoX is carried out according to the stratified transect design model developed by Jolly and Hampton (1990). Baseline survey strata, established in 2017, were adjusted based on survey effort and observations in 2023 (Figure 1). Area stratification and transect design are shown in Figure 1 and 4. Within StoX, length and weight data from trawl samples were equally weighted and applied across all transects within a given stratum (Figure 4).

Following the decisions made at the Workshop on implementing a new TS relationship for blue whiting abundance estimates (WKTSBLUES, ICES 2012), the following target strength (TS)-to-fish length (L) relationship (Pedersen et al. 2011) is used:

$$TS = 20 \log10 (L) - 65.2$$

In StoX an impute super-individual table is produced where abundance is linked to population parameters including age, length, weight, sex, maturity etc. This table is used to split the total abundance estimate by any combination of population parameters. The StoX project folder for 2023 is available on request.

Estimate of relative sampling error

For the baseline run, StoX estimates the number of individuals by length group which are further grouped into population characteristics such as numbers at age and sex.

A total length distribution is calculated, by transect, using all the trawl stations assigned to the individual transects. Conversion from NASC (by transect) to mean density by length group by stratum uses the calculated length distribution and a standard target strength equation with user defined parameters. Thereafter, the mean density by stratum is estimated by using a standard weighted mean function, where each transect density is weighted by transect distance. The number of individuals by stratum is given as the product of stratum area and area density.

The bootstrap procedure to estimate the coefficient of variance randomly replaces transects and trawl stations within a stratum on each successive run. The output of all runs are stored in a RData-file, which is used to calculate the relative sampling error.

Results

Stock size

The estimated total stock biomass (TSB) of blue whiting for the 2023 international survey was 2.5 million tonnes, representing an abundance of 29.9×10^9 individuals (Table 4). This is an 8% decrease in total stock biomass and a 5% decrease in total stock numbers (TSN) from observations in 2022 (Table 4). The spawning stock biomass (SSB) was estimated at 2.3 million tonnes representing 27.5×10^9 individuals (Table 5). This is a 1% decrease in the observed spawning stock biomass and a 15% increase in the spawning stock numbers (SSN) compared to last year. Spawning stock biomass, as determined from biological samples, showed a slight decrease in SSB with a moderate increase in SSN driven by recruitment of fish from the strong 2021-year class to the spawning stock.

Distribution of blue whiting

In total, 8,571 nmi (nautical miles) of survey transects were completed across six strata, relating to an overall geographical coverage of 147,968 nmi² (Figure 1, Tables 3 & 7), Area coverage increased by 17% as compared to 2022. Acoustic sampling (transect miles) saw an increase of 47% compared to 2022 (from 5,812 nmi to 8,571 nmi). The increase in acoustic sampling effort and area coverage can be accounted for by the below average effort in 2022, due to the early departure of the RV *Celtic Explorer* and the addition of Spanish survey effort this year in the south. The westward extension of blue whiting observed in 2023 was notable from previous years and required further survey effort to ensure containment in the west.

The stock was considered contained within core and peripheral abundance areas (Rockall Bank, Porcupine Bank and Porcupine Seabight). The distribution of blue whiting, as observed during the survey, is shown in Figures 5 and 6. The main body of the stock occurred between 54° to 57°N and schools in this stratum were observed to span the Rockall Trough from east to west. Blue whiting were observed in moderate numbers on the western flanks of the Rockall Bank (Stratum 5) for the first time in recent years.

Overall, the distribution of blue whiting was found further west into open water than observed in either 2021 or 2022, most notably in the Rockall Trough. This considered, the highest concentrations still occurred in the east at the continental shelf break in stratum 3.

The stock was distributed within core strata 1-3, totalling 77.5% of TSB and 78.8% of TSN (Table 4). A second area of abundance, somewhat geographically distinct from the main body of the stock, was observed in the northern strata (4 & 6) accounting for 13.8% of TSB and 12.8% of TSN and composed of mainly 2, 3, 4 and 1-year-old fish respectively.

The Rockall Trough (stratum 3) contained the highest abundance overall, accounting for 52% of TSB and 51% of TSN (Table 4), within this stratum the highest densities of fish were observed between 55°N to 58°N. Compared to 2022, this stratum saw a moderate increase in both TSB and TSN of 12%. The Porcupine Bank (Strata 1) saw a large decrease in TSB of 67% compared to 2022 and a corresponding decrease in TSN of 55%, indicating the bulk of the stock had already migrated northwards. The North Porcupine (Strata 2) saw a decrease of 21% of TSB and 5% in TSN. An increase of 12% TSB and TSN was recorded in Stratum 3 (Rockall Trough). The Rockall Bank (Strata 5) saw a marked increase of 1,162% TSB (from 15,000 t to 183,000 t) and an increase of 1,677% TSN as compared to 2022.

Last year the most notable change was the large increase in biomass observed in northern survey area; south Faroes and Faroe/Shetland Channel (Strata 4 & 6, respectively). In 2023, these strata also contained a relatively high proportion of the stock (13%) compared to 20% in 2022 (Table 4). The south Faroes strata showed a slight decrease in TSB of 4% (from 193,000 t to 186,000 t) and 6% in TSN compared to 2022, whereas the Faroe/Shetland Channel saw a decrease of 29% in TSB (from 226,000 t to 159,000 t) and 56% in TSN. Both strata were dominated by 2- and 3-year-old fish, followed by 4- and 1-year-old fish, respectively.

Echograms

The highest s_A value (91, 787 m²/nmi² - per 1 nmi EDSU) observed during the combined survey was recorded by FV *Vendla* in the North Porcupine stratum (Figure 7a). The second highest density value, was recorded in the Rockall Trough stratum, by the RV *Tridens* (65, 955 m²/nmi² - per 1 nmi EDSU), Figure 7b. The third highest value (56, 888 m²/nmi² - per 1 nmi EDSU) was recorded by RV *Celtic Explorer* on the shelf edge in the Rockall Trough stratum (Figure 7c). Blue whiting observations by RV Jákup Sverri (Figure 7d) on the Wywille Thompson ridge (in the Faroe-Shetland Channel stratum) showing a scattering layer of relatively high concentrations at depths between 400-500 m. The only significant concentrations of Blue Whiting observed by RV *Vizconde de Eza* were in the western part of the South Porcupine Bank at a depth of 400 m. (Figure 7e).

Stock composition

Survey samples found fish ages from 1 to 15 years (10+ group) during the survey (Table 5).

The main contribution to the spawning stock biomass was composed of the age groups 3, 2, 4 and 5 years, respectively. Combined these age cohorts represent 84% of TSB. In terms of abundance, 3-year-olds (2020 year-class) were most abundant (49%), followed by the 2-year-olds (27%), 4-year-olds (9%) and 5-year-olds (5%), respectively (Table 5).

The largest mean length value of blue whiting by strata obtained from catches came from Stratum 5 (25.5 cm), Figure 8. The largest mean weight came from Stratum 4 and was 96.3 g (Figure 9).

The bulk of the stock was composed of mixed age classes of 1 to 15 years, and dominated by mature individuals aged 3 and 4 (Figure 11). The aggregations in the northern area were dominated by 2 & 3-year-old fish with a relatively high proportion of mature individuals

(Figure 11). The abundance of these two year classes in 2023 were the highest in the time series and above the numbers associated with the 2014 record year class (Table 6, Figure 12).

Immature fish represented 5% of TSB and 7% of TSN. Over 87% of the 2-year old fish were mature contributing to the SSB of the stock (Table 5).

The CV of the total estimate of abundance was 0.16, which is lower than 2022 (2022= 0.19 and 2021= 0.14).

The survey time series (2004-2023) of TSN and TSB are presented in Figures 13 and 14 respectively and Table 6.

Hydrography

A total of 102 CTD casts were undertaken over the course of the survey (Table 1). Horizontal plots of temperature and salinity at depths of 50 m, 100 m, 200 m and 500 m as derived from vertical CTD casts are displayed in Figures 15-18, respectively. A decrease in salinity observed in 2017 persisted through 2018 and 2019, but seems to have reversed again in 2020 with an increasing trend (K.M. Larsen, pers. comm., Faroe Marine Research Institute). Pre-2020, this is thought to have limited the western extent of the blue whiting spawning distribution on the Rockall and Hatton Bank areas in recent years. Observations in 2022 and 2023 are in agreement with a reversing trend (in salinity mainly), with a more western extension of fish into the Rockall Trough than observed in recent years, with blue whiting approaching the eastern slopes of the Rockall Plateau in 2023.

Mesopelagic fish

Echogram scrutinisation for mesopelagic fish species was conducted by participants during the survey and will be uploaded to the ICES database after further analysis. Due to ongoing complexities regarding representative trawl catches these data are considered as experimental and outputs reported to the ICES database should be treated as such.

Concluding remarks

Main results

- Weather conditions were mixed and the survey start was delayed by 4 days in the southern area (Ireland & Netherlands).
- The total area surveyed and acoustic sampling effort increased from 2022 (17% and 48% respectively) and was required to contain the stock in the west and from contributions for the Spanish survey in the south.
- In terms of biological sampling effort, the number of trawl stations was reduced due to the mechanical breakdown on the RV *CE* that prevented any fishing for the duration of the survey. However, RV *Tridens* undertook trawling on some aggregations identified by the RV *CE*. The total number of fish aged and measured was comparable to 2022. The stock was considered representatively sampled in number, and across the distribution area.
- The International Blue Whiting Spawning Stock Survey 2023 shows an 8% decrease in TSB and a corresponding 5% decrease in TSN when compared to the 2022 estimate for comparable survey effort and coverage.
- In terms of abundance, 3-year-olds (2020 year-class) were most abundant (49%), followed by the 2-year-olds (27%), 4-year-olds (9%) and 5-year-olds (5%), respectively.
- Immature fish represented 5% of TSB and 7% of TSN. Over 87% of the 2-year old fish were mature contributing to the SSB of the stock.
- The abundance of the two year classes, 2 & 3-year-old fish, in 2023 were the highest in the time series and above the numbers observed associated with the previous 2014 record year class.
- Estimated uncertainty around the total stock abundance was CV=0.16 (CV=0.19 in 2022).
- The survey was carried out over 17 days, below the 21-day time window target. With core areas representatively sampled by multiple vessels.

Interpretation of the results

- The group considers the 2023 estimate of abundance as robust. Good stock containment was achieved for both core and peripheral strata.
- Temporal progression was miss aligned due to poor weather delaying the vessels starting in the south leading to a mismatch timing in core regions. However, the group considers this as not ideal but acceptable nonetheless.
- The bulk of SSB was distributed from northern Porcupine Bank northwards in the Rockall Trough from 54°N to 57°N.
- Contribution of the 2020-year class remains significant as the largest and strongest year class in the time series, surpassing the previous in 2014. This year class is now considered fully recruited to the spawning stock.

Recommendations

- The group recommends that coverage in the western Rockall/Hatton Bank (stratum 5) should be carried out based on real time observations. Stock size and distribution in recent years combined with hydrographic conditions would indicate a period of westward expansion that requires monitoring.

- To facilitate the process of calculating global biomass the group requires that all data be made available at least 72 hours in advance of the meeting start date and made available through the ICES database.
- Hydrographic and Plankton data along with Log book files formats should still be submitted in the PGNAPES format.
- The group recommends that the process of producing output reporting tables, figures and maps from StoX outputs files (StoX) are standardised in R code for consistency of reporting and replication.
- It is recommended that the effective timing of the survey starting point is maintained to begin around the 20th March in 2024.
- Faroes and Spain collect CTD data to 1,000 m in line with the other participants

Achievements

- Good stock containment within the survey area, with comprehensive trawl and biological sampling achieved.
- All survey data were uploaded to the ICES trawl-acoustic database in advance of the post cruise meeting, with the exception of the Spanish data, where corrected data was provided 7 days after the meeting.
- Survey area covered completed within 17 days.

References

Demer, D. A., Berger, L., Bernasconi, M., Bethke, E., Boswell, K., Chu, D., Domokos, R., *et al*. 2015. Calibration of acoustic instruments. ICES Cooperative Research Report No. 326.

ICES. 2012. Report of the Workshop on implementing a new TS relationship for blue whiting abundance estimates (WKTSBLUES), 23–26 January 2012, ICES Headquarters, Copenhagen, Denmark. ICES CM 2012/SSGESST:01. 27 pp.

ICES. 2015. Manual for International Pelagic Surveys (IPS). Series of ICES Survey Protocols SISP 9 – IPS. 92 pp.

ICES. 2021. Working Group of International Pelagic Surveys (WGIPS). ICES Scientific Reports. 3:40. https://doi.org/10.17895/ices.pub.8055

Johnsen, E, Totland, A, Skålevik, Å, et al. StoX: An open source software for marine survey analyses. Methods Ecol Evol. 2019; 10: 1523– 1528. https://doi.org/10.1111/2041-210X.13250

Jolly, G. M., and I. Hampton. 1990. A stratified random transect design for acoustic surveys of fish stocks. Canadian Journal of Fisheries and Aquatic Sciences 47(7): 1282-1291.

Pedersen, G., Godø, O. R., Ona, E., and Macaulay, G. J. 2011. A revised target strength–length estimate for blue whiting (*Micromesistius poutassou*): implications for biomass estimates. ICES Journal of Marine Science, doi:10.1093/icesjms/fsr142.

Table 1. Country and vessel specific details, IBWSS March-April 2023.

	Celtic Explorer	Jákup Sverri	Tridens	Vendla	Vizconde de Eza
Trawl dimensions					
Circumference (m)	768	832	860	832	752
Vertical opening (m)	50	45	30-70	45	30
Mesh size in codend (mm)	20	45	40	40	20
Typical towing speed (kts)	3.5	3.4	3.5-4.0	3.5-4.0	3.5-4.0
Plankton sampling					
Sampling net	-	WP2 plankton net	-	WP2 plankton net	
Standard sampling depth (m)	-	200	-	400	
Hydrographic sampling					
CTD Unit	SBE911	SBE911	SBE911	SBE25	SBE25Plus
Standard sampling depth (m)	1000	500	1000	1000	1000

Table 2. Acoustic instruments and settings for the primary acoustic sampling frequency, IBWSS March-April 2023.

	Celtic Explorer	Jákup Sverri	Tridens	Vendla	Vizconde de Eza
Echo sounder	Simrad EK 60	Simrad EK80	Simrad EK 80	Simrad EK 80	Simrad EK 80
Frequency (kHz)	**38**, 18, 120, 200	18, **38**, 70, 120, 200, 333	18, **38**, 70, 120, 200, 333	18, **38**, 70	**38**, 18, 70, 120, 200
Primary transducer	ES 38B	38-7	ES 38B	ES 38B	ES 38-7
Transducer installation	Drop keel	Drop keel	Drop keel	Drop keel	Drop keel
Transducer depth (m)	8.8	6	8	8.5	5
Upper integration limit (m)	20	15	15	15	23.91
Absorption coeff. (dB/km)	9.4	10	9.5	9.5	9.4
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Band width (kHz)	2.43	3.06	2.43	2.43	3.06
Transmitter power (W)	2000	2000	2000	2000	2000
Angle sensitivity (dB)	21.9	21.9	21.9	21.9	21.9
2-way beam angle (dB)	-20.6	-20.4	-20.6	-20.7	-20.7
Ts Transducer gain (dB)	25.86	26.87	27.27	25.28	26.84
s_A correction (dB)	-0.66	-0.1377	-0.01	-0.66	-0.246
3 dB beam width (dg)					
alongship:	6.78	6.44	6.86	6.89	6.51
athw. ship:	6.91	6.40	6.89	6.85	6.6
Maximum range (m)	1000	750	750	750	1000
Post processing software	Echoview	LSSS	LSSS	LSSS	Echoview

Table 3. Survey effort by vessel, IBWSS March-April 2023. RV *Tridens* carried out 4 trawl hauls on the transects of RV *Celtic Explorer*.

Vessel	Effective survey period	Length of cruise track (nmi)	Trawl stations	CTD stations	Mesopelagic sampling	Aged fish	Length-measured fish
Celtic Explorer^	24/03-04/04	2 279	-	29	-	-	-
Jákup Sverri	25/03-04/04	1 688	8	26	-	548	1 931
Vendla	19/03- 01/04	2 558	18	31	-	527	1 723
Tridens	25/03-31/03	793	13	16	2	1 200	3 499
Vizconde de Eza*	26/03-02/04	1 253	3	-	-	90	645
Total	24/03-04/04	8 571	42	102	2	2 365	7 798

^ No trawl sampling carried out by Ireland due to mechanical failure of the net Sonde winch
*CTD data from the RV *Vizconde de Eza* not available due to failure of the equipment.

Table 4. Abundance and biomass estimates of blue whiting by strata in 2022 and 2021. IBWSS March-April 2023.

		2023				2022				Difference 2023-2022	
Strata	Name	TSB (10^3 t)	TSN (10^6)	% TSB	% TSN	TSB (10^3 t)	TSN (10^6)	% TSB	% TSN	TSB	TSN
1	Porcupine Bank	170	2,116	6.8	7.1	510	4,714	18.9	15.0	-67%	-55%
2	N Porcupine Bank	475	6,156	19.0	20.6	599	6,469	22 1	20.6	-21%	-5%
3	Rockall Trough	1,295	15,261	51.8	51.1	1,151	13,672	42.5	43.5	12%	12%
4	South Faroes	186	1,930	7.4	6.5	193	2,042	7.1	6.5	-4%	-6%
5	Rockall Bank	183	2,083	7.3	7.0	15	117	0.5	0.4	1,162%	1,677%
6	Faroe/Shetland Ch.	159	1,897	6.4	6.3	226	4,276	8 3	13.6	-29%	-56%
7	Porcupine Seabight	33	439	1.3	1.5	13	151	0.5	0.5	163%	190%
	Total	2,501	29,883	100	100	2,707	31,442	100	100	-8%	-5%

Table 5. Survey stock estimate of blue whiting (determined from StoX baseline output), IBWSS March-April 2023.

	Age in years (year class)										Number	Biomass	Mean	Prop
Length	1	2	3	4	5	6	7	8	9	10+			weight	Mature
(cm)	2021	2020	2019	2018	2017	2016	2015	2014	2013		(10^6)	(10^6 kg)	(g)	
14-15											0	0	0.0	0
15-16											0	0	0.0	0
16-17	1										1	0	26.0	0
17-18	30										30	1	25.2	0
18-19	148										148	4	29.4	31
19-20	305	48									354	13	36.3	35
20-21	242	70									312	14	43.7	23
21-22	148	551	78								777	39	50.3	71
22-23		2,364	218	9							2,591	148	57.0	91
23-24		3,135	1,349	14							4,497	285	63.3	93
24-25		1,504	3,932	253							5,690	394	69.3	95
25-26		328	5,063	410							5,801	444	76.5	93
26-27		110	2,627	527	119						3,383	292	86.4	94
27-28		25	1,014	560	169						1,768	178	100.9	96
28-29			297	439	155	24	107	20	30		1,071	125	116.6	97
29-30			127	231	222	140	42	8	39		810	108	133.9	100
30-31			43	151	453	190	70	39	10		955	142	148.6	100
31-32			12	120	123	82	80	28	91		536	86	161.3	97
32-33			12	8	51	172	158	16	159		575	98	170.9	100
33-34				20	46	33	49	83	51		281	52	184.3	99
34-35					14	28	8	9	94		153	35	228.9	93
35-36						19			13	29	61	14	234.9	100
36-37									13	13	25	6	240.0	100
37-38						8			8		16	6	348.5	100
38-39						16					16	5	283.5	100
39-40										13	13	4	352.0	100
40-41							6			13	19	7	379.0	100
41-42											0	0	0.0	100
42-43											0	0	0.0	100
43-44														
44-45														
TSN(mill)	873	8,135	14,771	2,744	1,352	711	520	202	508	67	29,883			
TSB(1000 t)	33.6	517.4	1,143.0	265.9	190.3	117.8	84.8	31.1	96.5	20.6	2,501.0			
Mean length(cm	19.4	22.9	24.9	27.0	29.2	31.0	30.5	31.3	32.0					
Mean weight(g)	39	63	77	103	138	172	158	159	183					
% Mature	23	87	96	97	99	97	99	100	99	100				
SSB (1000 t)	7.6	452.5	1098.2	256.6	188.7	114.0	84.3	31.1	95.7	20.6	2,349.3			
SSN (mill)	198	7,115	14,192	2,648	1,341	688	517	202	503	67	27,470.4			

Table 6. Time series of StoX abundance estimates of blue whiting (millions) by age in the IBWSS, 2023. Total biomass in last column (1000 t). Note: * indicates survey excluded or not undertaken.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	ΓSB(1000 t)
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
2019	1,129	1,169	3,468	9,590	16,979	3,434	484	513	99	144	4,198
2020*											
2021	1,948	2,095	2,545	2,275	3,914	3,197	3,379	463	189	114	2,357
2022	4,461	9,313	4,830	5,460	2,587	1,880	898	1,764	71	178	2,707
2023	873	8,135	14,771	2,744	1,352	711	520	202	508	67	2,501

Table 7. IBWSS survey effort time series.

Survey effort	Survey area (nmi²)	Transect n. miles (nmi)	Trawls	CTDs	Plankton	Bio sampling (WHB) Measured	Aged
2004	149 000		76	196			
2005	172 000	12 385	111	248	-	29 935	4 623
2006	170 000	10 393	95	201	-	7 211	2 731
2007	135 000	6 455	52	92		5 367	2 037
2008	127 000	9 173	68	161	-	10 045	3 636
2009	133 900	9 798	78	160	-	11 460	3 265
2010	109 320	9 015	62	174	-	8 057	2 617
2011	68 851	6 470	52	140	16	3 810	1 794
2012	88 746	8 629	69	150	47	8 597	3 194
2013	87 895	7 456	44	130	21	7 044	3 004
2014	125 319	8 231	52	167	59	7 728	3 292
2015	123 840	7 436	48	139	39	8 037	2 423
2016*	134 429	6 257	45	110	47	5 390	2 441
2017	135 085	6 105	46	100	33	5 269	2 477
2018	128 030	7 296	49	101	45	5 315	2 619
2019	121 397	7 610	38	118	17	6 228	1 938
2021	118 169	7 794	45	102	8	12 019	2 089
2022^	126 235	5 812	47	99	57	6 499	2 372
2023	147,968	8 571	42	102	54	7 798	2 365

* End of Russian participation, ^ excluding Spanish effort due to temporal mismatch.

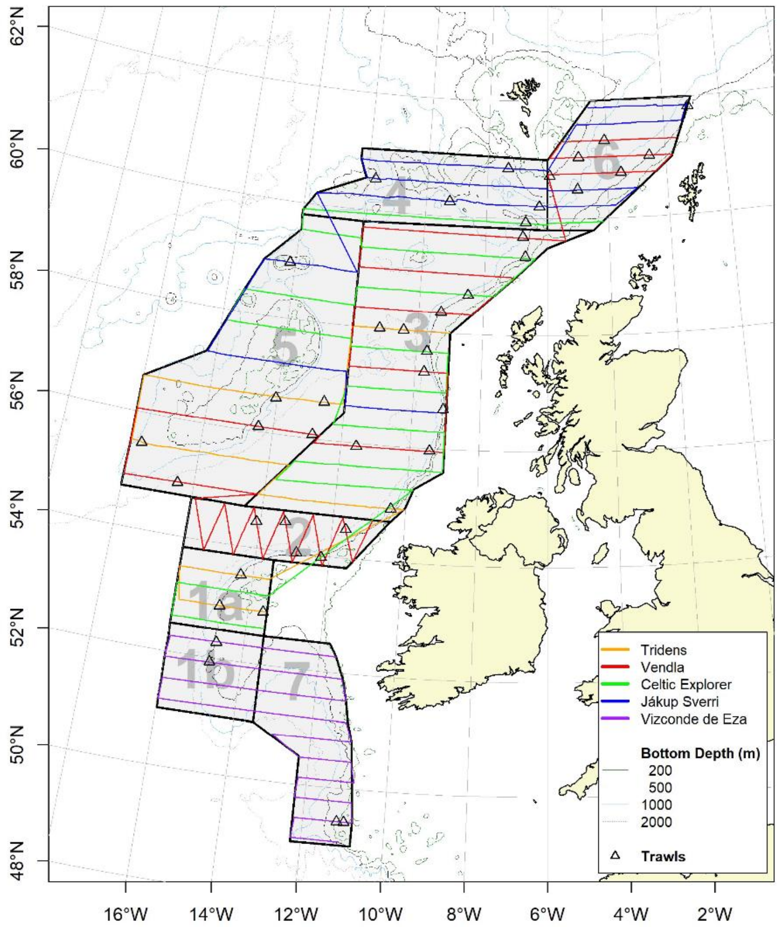


Figure 1. Strata, cruise tracks and trawl hauls for the individual vessels (country) during the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2023. Faroe Islands (RV *Jákup Sverri*); Ireland (RV *Celtic Explorer*); Netherlands (RV *Tridens)*; Norway (FV *Vendla*); Spain (RV *Vizconde de Eza*).

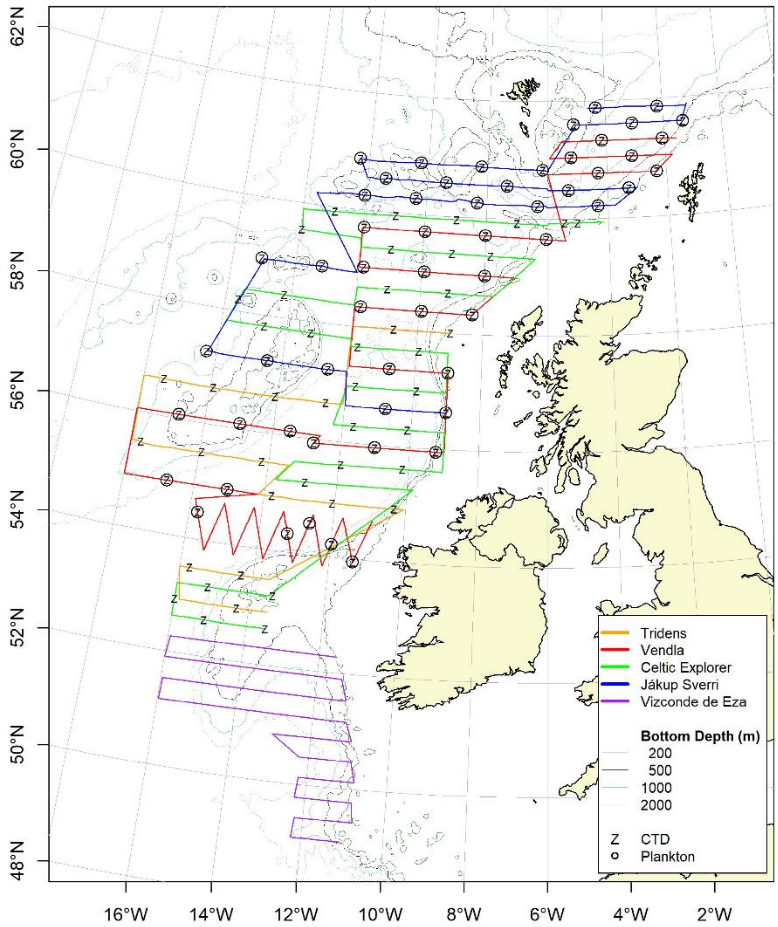


Figure 2. Vessel cruise tracks with hydrographic CTD stations (z) and WP2 plankton net samples (circles) during the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2023.

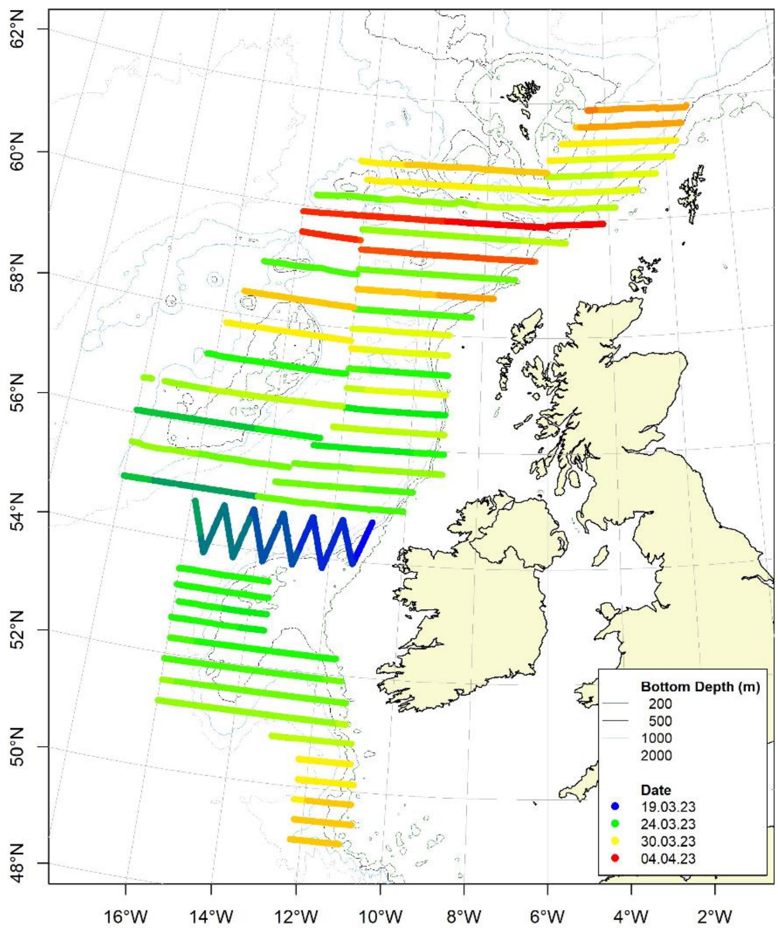


Figure 3. Temporal progression for the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2023.

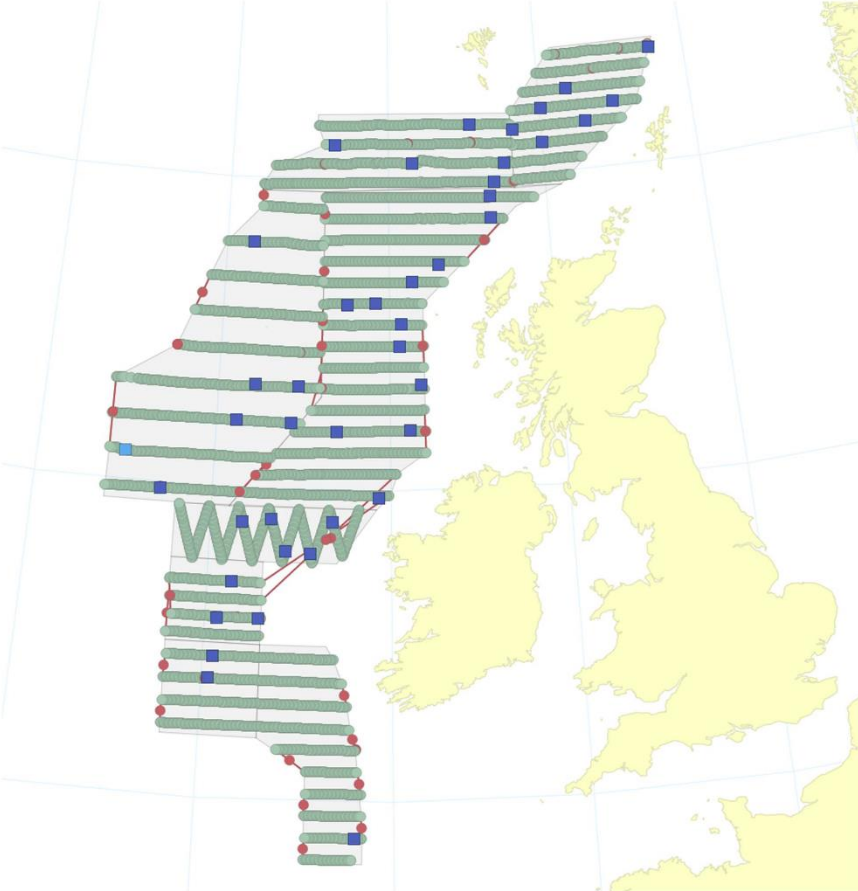


Figure 4. Tagged acoustic transects (green circles) with associated trawl stations containing blue whiting (dark blue squares) used in the StoX abundance estimation. IBWSS March-April 2023.

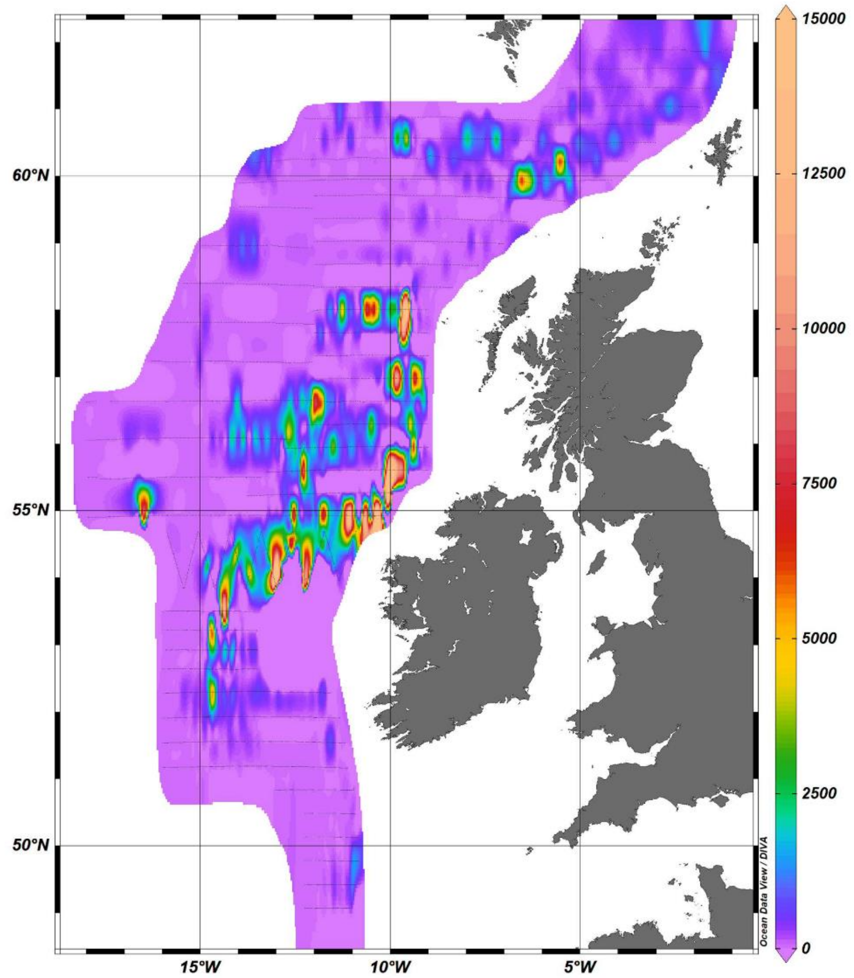


Figure 5. Acoustic density heat map (s_A m^2/nmi^2) of blue whiting during the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2023.

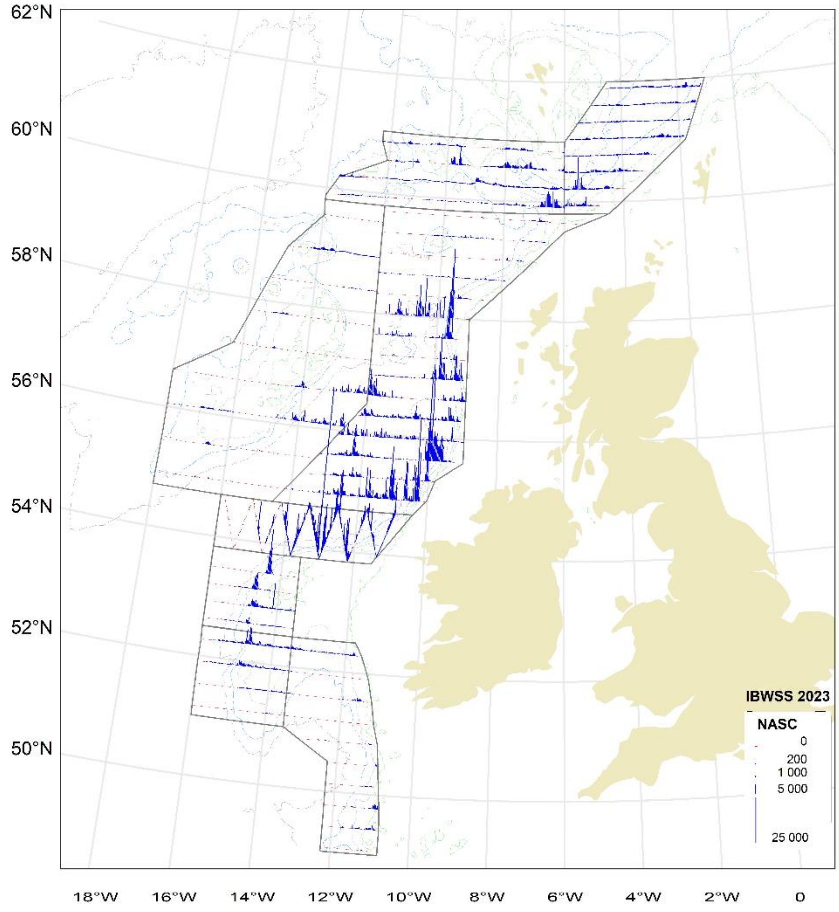
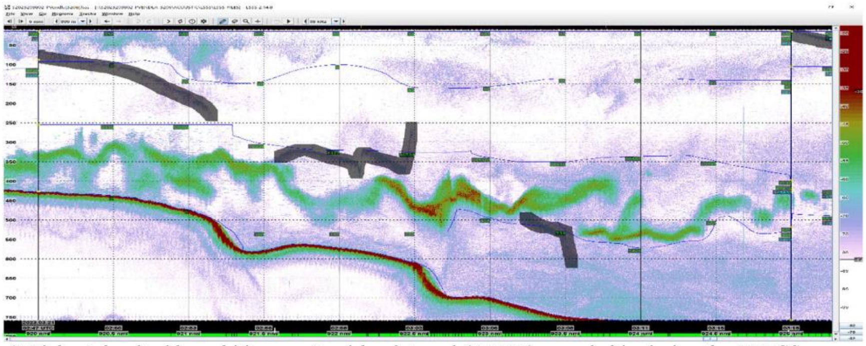
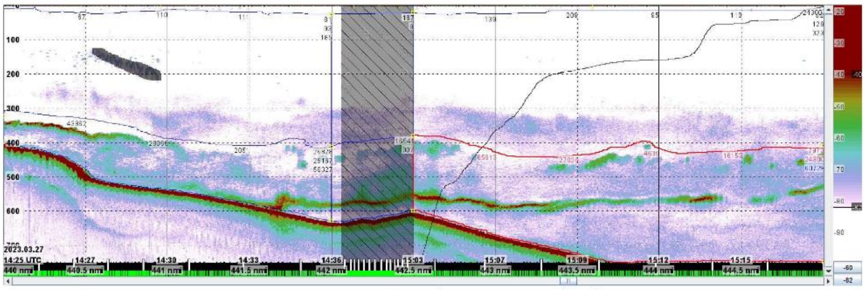


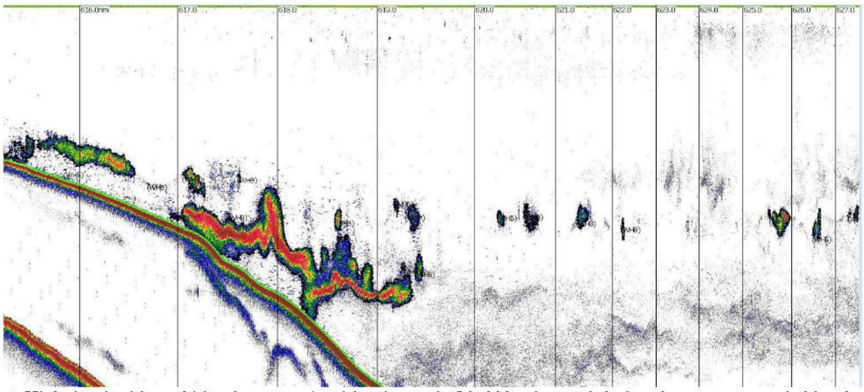
Figure 6. Map of proportional acoustic density (s_A m^2/nmi^2) of blue whiting by 1 nmi sampling unit. IBWSS March-April 2023.



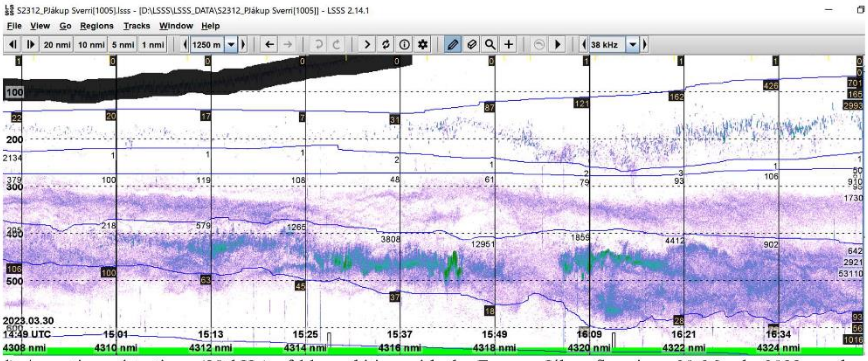
a) Highest density blue whiting per 1nmi log interval (91,787) recorded in during the IBWSS survey in the North Porcupine area (Strata 2) FV *Vendla*, Norway.



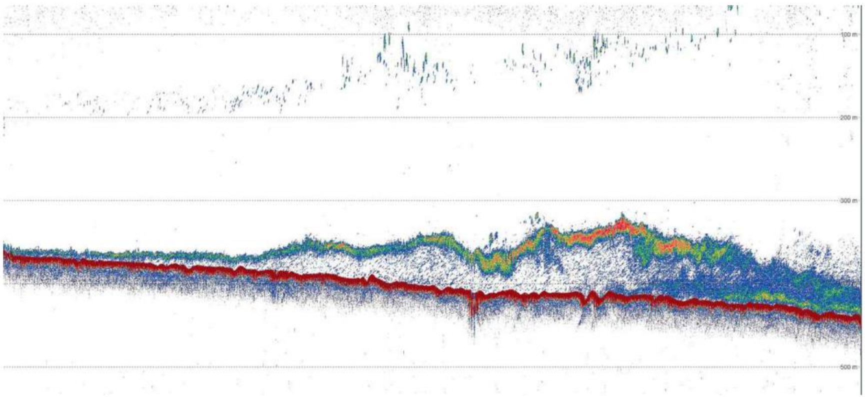
b) Single highest density blue whiting layer (s_A value 65955 m²/nmi²) by 1nmi recorded by the RV *Tridens* at the shelf edge at 54.56N-10.25W (Stratum 3).



c) High density blue whiting layer per 1nmi log interval (56, 888) observed during the survey recorded by the RV *Celtic Explorer* on the shelf margin in the southern Rockall Trough (Stratum 3) in 300 – 400 m.



d) Acoustic registrations (38 kHz) of blue whiting with the Faroese Jákup Sverri on 30 March, 2023 on the Wyville Thomson ridge.



e) Blue Whiting concentration recorded by RV *Vizconde de Eza* in the western shelf edge of South Porcupine Bank on 26 March 2023 (Stratum 1b)

Figure 7. Echograms of interest encountered during the IBWSS, March-April 2023. Vertical banding represents 1 nmi acoustic sampling intervals (EDSU). All echograms presented at 38 kHz.

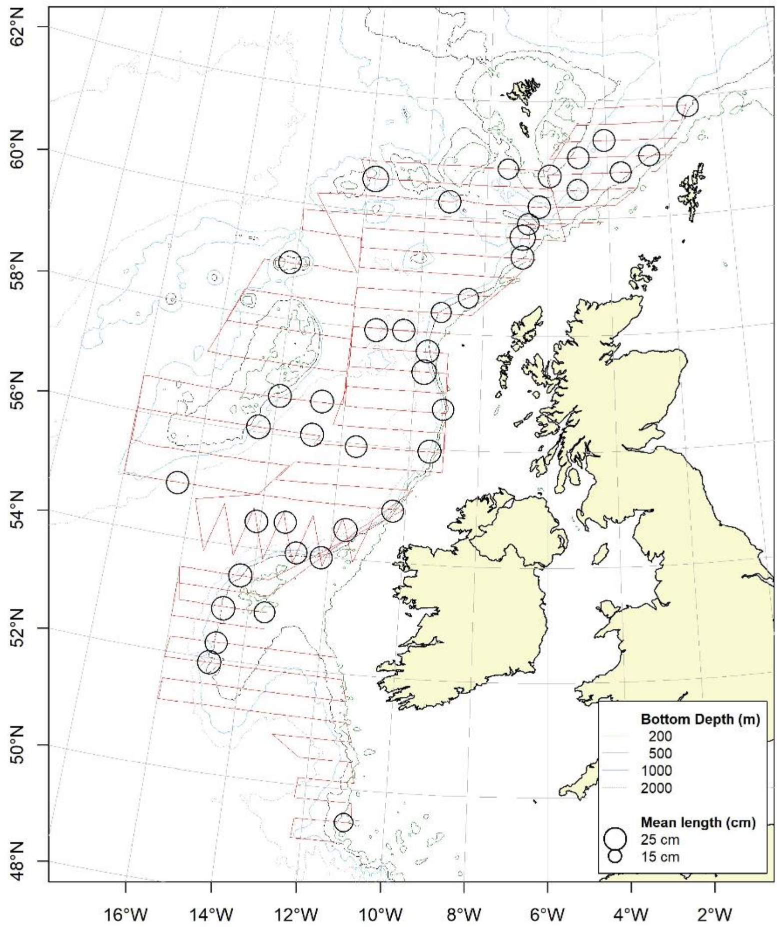


Figure 8. Combined mean length of blue whiting from trawl catches by vessel, IBWSS in March- April 2023.

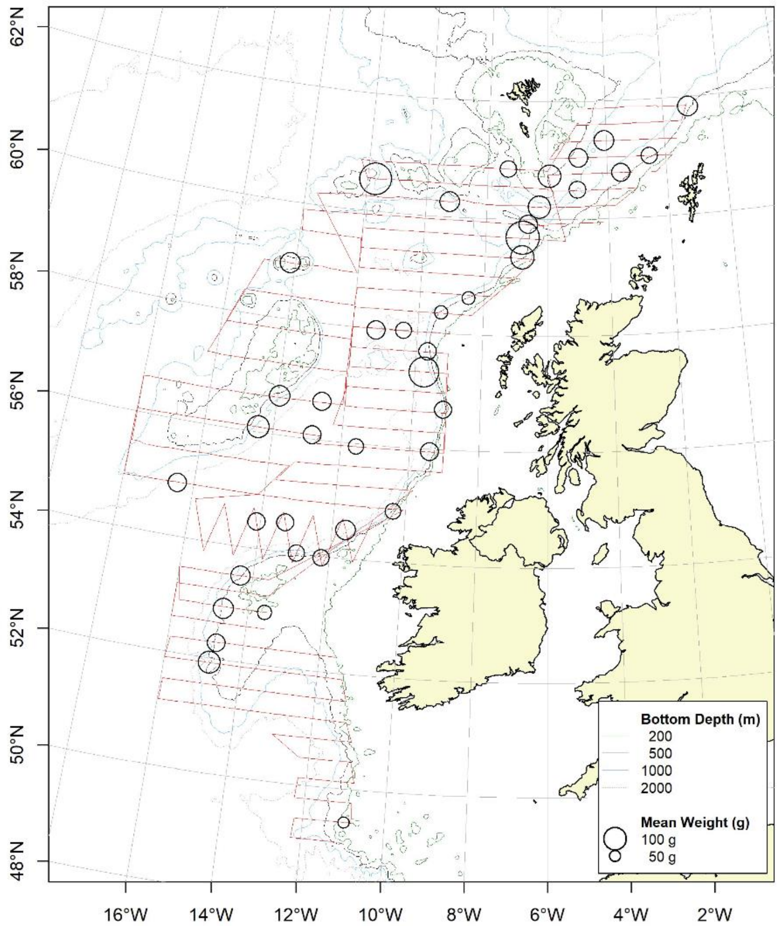


Figure 9. Combined mean weight of blue whiting from trawl catches, IBWSS March- April 2023.

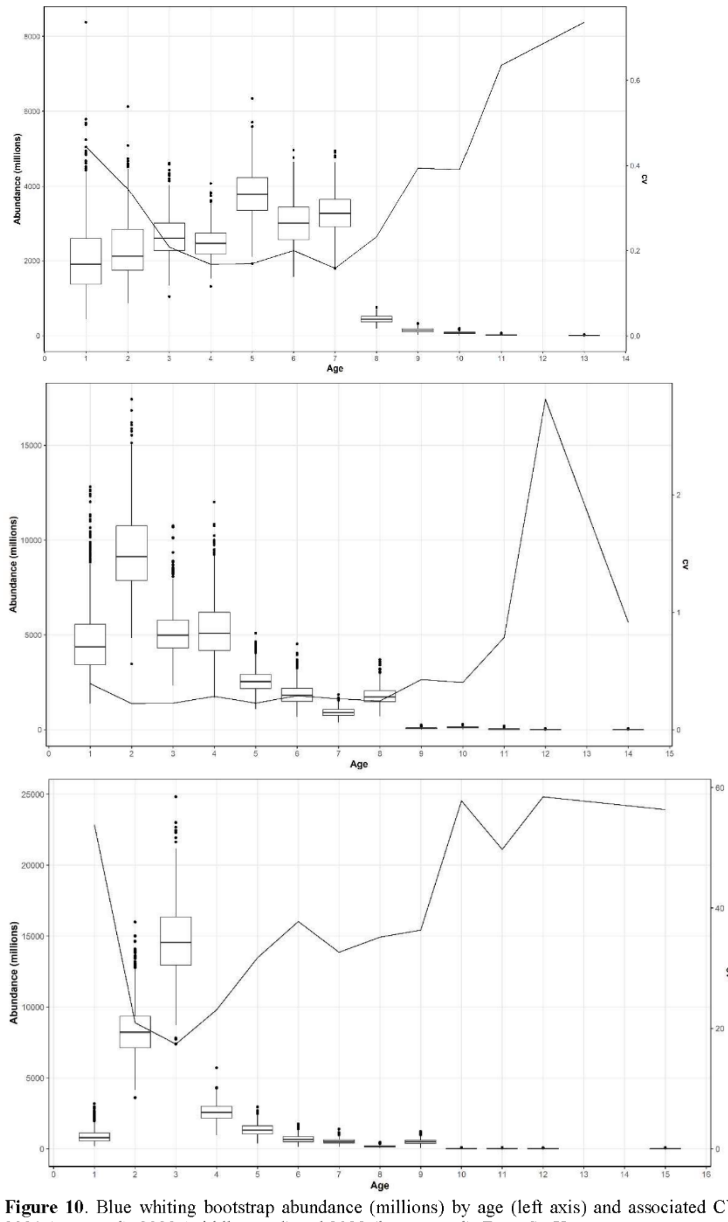


Figure 10. Blue whiting bootstrap abundance (millions) by age (left axis) and associated CVs (right axis) in 2021 (top panel), 2022 (middle panel) and 2023 (lower panel). From StoX.

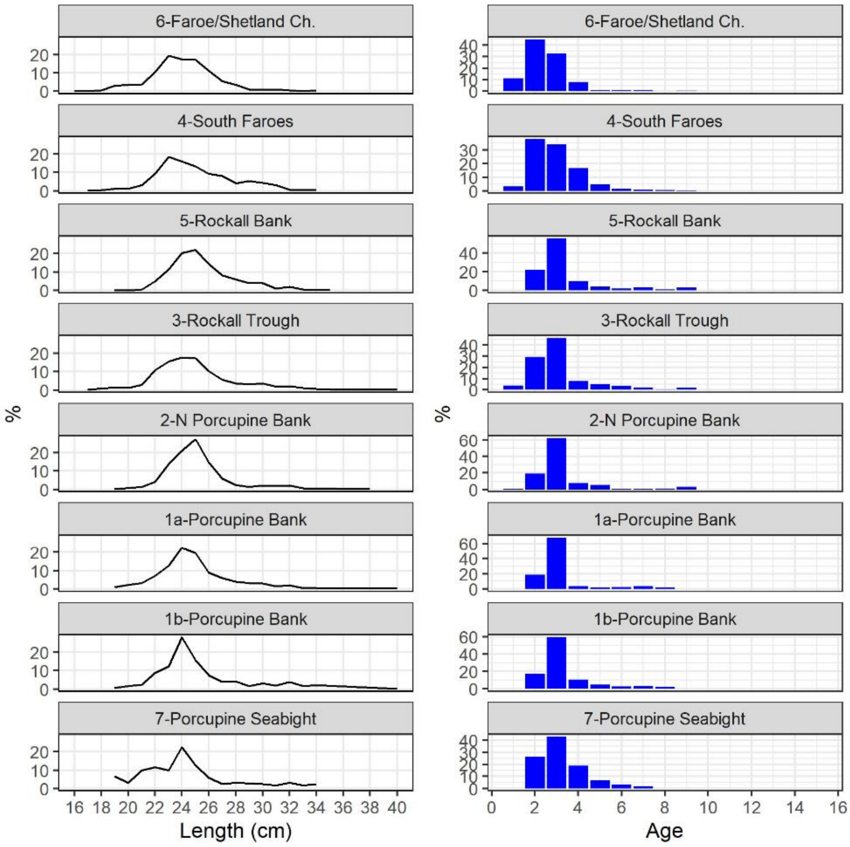


Figure 11. Length and age distribution (numbers) of blue whiting by survey strata. March-April 2023.

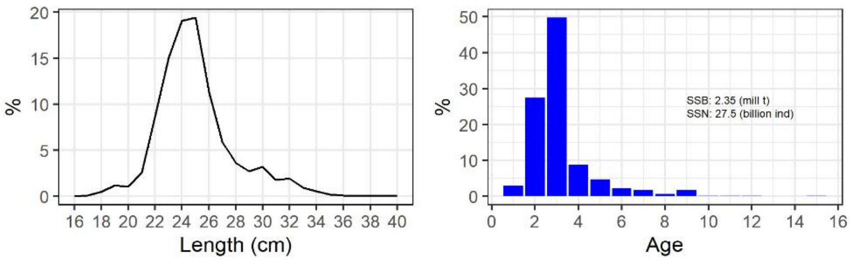


Figure 12. Length and age distribution (numbers) of total stock of blue whiting. March-April 2023.

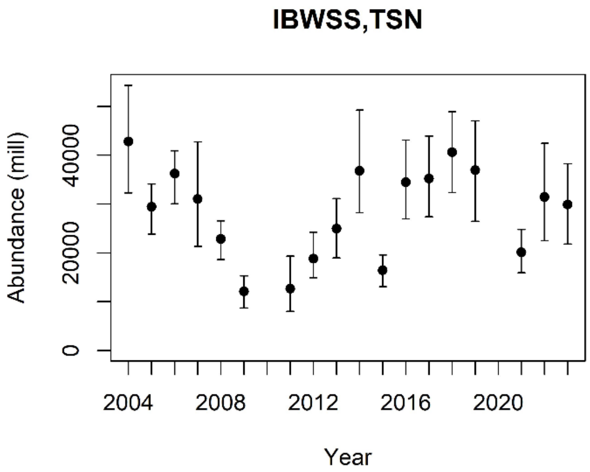


Figure 13. Time series of StoX survey indices of blue whiting abundance, 2004-2023, excluding 2010 and 2020.

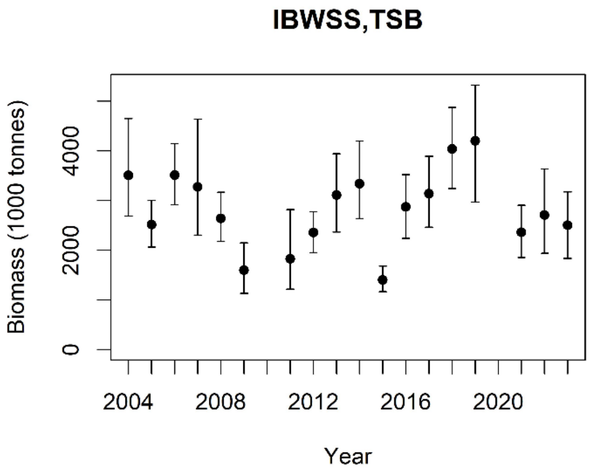


Figure 14. Time series of StoX survey indices of blue whiting biomass, 2004-2023, excluding 2010 and 2020.

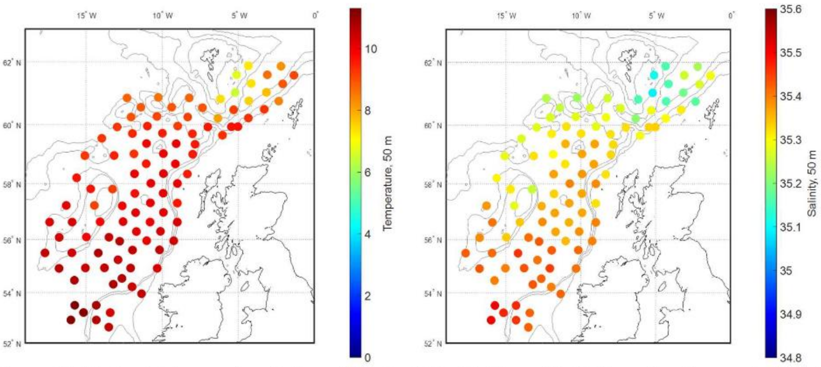


Figure 15. Horizontal temperature (left panel) and salinity (right panel) at 50 m subsurface as derived from vertical CTD casts. IBWSS March-April 2023.

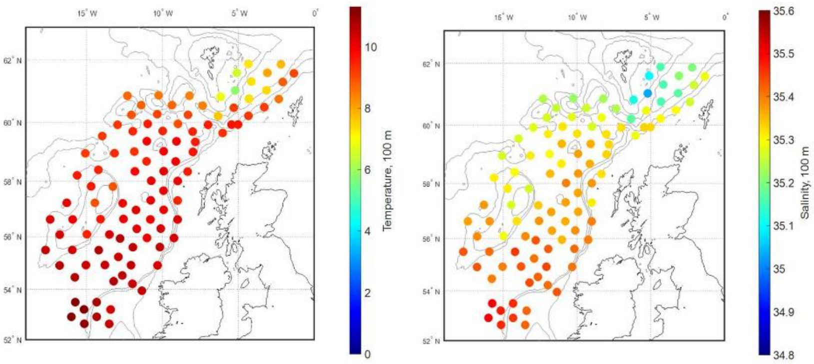


Figure 16. Horizontal temperature (left panel) and salinity (right panel) at 100 m subsurface as derived from vertical CTD casts. IBWSS March-April 2023.

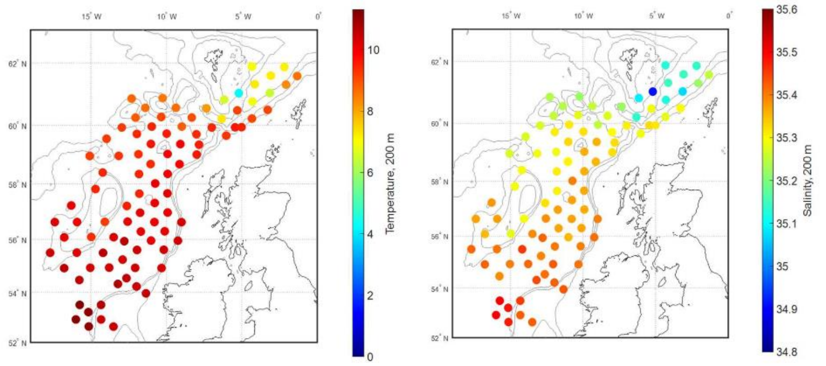


Figure 17. Horizontal temperature (left panel) and salinity (right panel) at 200 m subsurface as derived from vertical CTD casts. IBWSS March-April 2023.

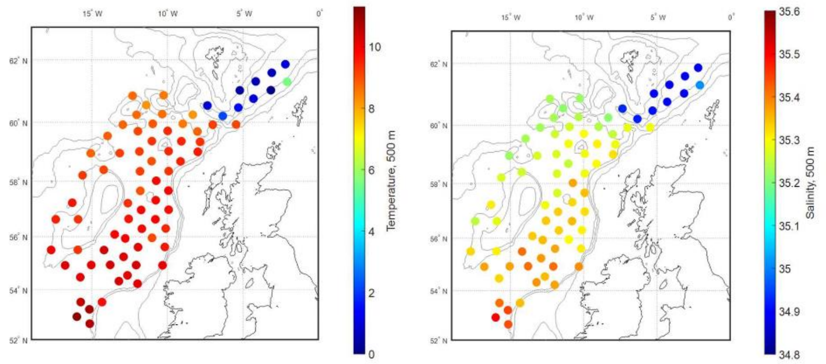


Figure 18. Horizontal temperature (left panel) and salinity (right panel) at 500 m subsurface as derived from vertical CTD casts. IBWSS March-April 2023.

Analysis of Mackerel assessment 2023

Höskuldur Björnsson

2023-08-28

The Muppet model was run as comparison with the SAM assessment conducted at WGWIDE. There are a number of differences between the setup, one important difference is the lack of process error that plays a large role in the official assessment as the data are relatively poor and inconsistent.

The main differences in setup are.

1. Selection in Muppet pattern fixed for 2 periods, 1980-1998 and 1999-2022. Selection pattern in SAM variable. Selection pattern of the models is similar and variability in SAM not large (figure 5).

2. F for ages 9 and older is constant, 7 and older in SAM (figure 5).

3. Tagdata used are from all tagging experiments 2011-2021 and recaptures 2012-2022. Recaptures in the tagging year not included. Tagloss estimated.
   4 The tagging data have the tendency to take over the assessment. The number data points are 1320 and grow quite rapidly with more years. In retrospective runs the tagging data have quickly less weight.

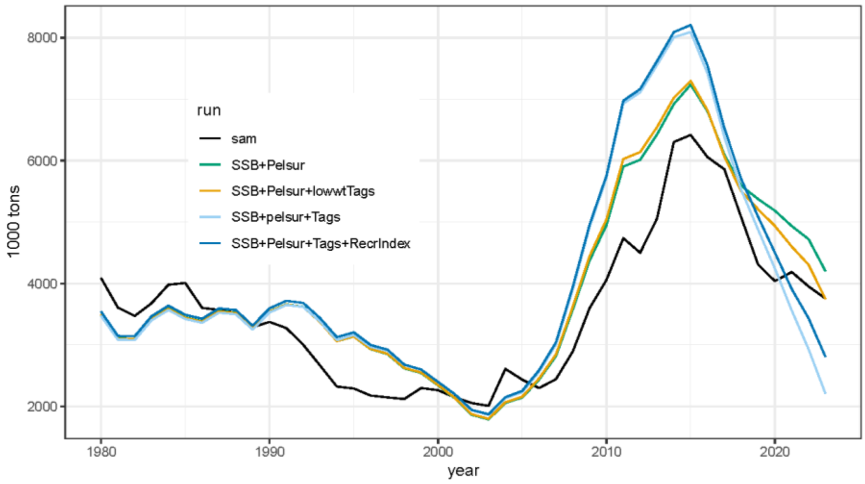
4. One of the Muppet runs includes the recruitment index that is estimated poor by the Muppet model (CV estimated 0.75-1.1 in different runs but 0.26 in the sam run).

5. In muppet, **q** in the Pelagic survey is constrained to be the same for ages 7 and older. In the SAM run it is constrained to be the same for ages 10 and 11 (10 and older). Estimated Q in the survey does not change much after age 7 so this difference is probably not important.

6. In Muppet, CV of residuals in survey and catch is specified as a multiplier on a pattern given but in SAM the CV is constrained to be identical for a large range of age groups.

7. In Muppet pM and pF proportions of F and M before spawning are constant in time. Those values vary with time in the adopted SAM assessment. Therefore SSB is not comparable.

8. The treatment of catch data before 1998 is different from the adopted asssessment. In the Muppet run catch in numbers by age are used in the traditional way before 1998 but a multiplier on the catches estimated. In different runs the value of the multiplier was estimated as $1.25 - 1.38$ with standard error of 0.16-0.20. Interpreting this factor as misreporting means misreporting of 25-40%. Considerable difference in results from Muppet and SAM before 1998 is therefore expected.



Biomass of age 3 and older was calculated for both models to solve the problem of SSB not being comparable, the values of B3+ and SSB are though similar. Looking at the Muppet results (figure 1), the weight of tagging data has most effect on the estimated biomass. The run labelled "SSB+Pelsur+lowwtTags" is based on weight of 0.1 for the tagging data but the number of data points in the tag-recapture file is 1320,certainly not 1320 independent data points. 119 observations are used for the RFID tags in SAM and the weight of 0.1 fits reasonably well to get same effective number of data points.

One interesting difference between Muppet and Sam results is that average recruitment at age 3 is much less in SAM (figure 2), still the biomass is similar. It has always been known that number at ages 0 and 1 were questionable, if looked at from the "fixed M world", but that difference should not be seen so strong at age 3. The difference is really large enough that the results should be investigated to see if there was something wrong with the data in either model. Muppet is just a simple catch at age model that where fish can only be lost by catches and M=0.15. SAM has more ways of loosing or adding fish.
Recruitment at age 0 is remarkably stable in SAM (figure 3). This is to be able to fit the recruitment survey that is estimated good ($CV \approx 0.26$). Also the the parameter "logSdLogN" is -1.6372523 for age 0 and -1.5756247 for ages 1-12, very unconventual as the most of the uncertainty in recruitment is usually taken up by the first parameter.

There is as shown above considerable uncertainty about the stock size of Mackerel. The tagging data indicate that the stock might be decreasing, we are getting too many tags back compared to recent years. The recruitment index leads to too optimistic recruitment estimates but it has too much weight in the adopted runs. Looking at the 4 alternative Muppet runs the advice for 2024 would be 407, 541, 769 and 872 thous tonnes, quite some difference between runs. F_{msy} from the SAM assessment gives advice of 740 thous tonnes. The Muppet run with weight of tag data closest to what it is in the SAM assessment gives an advice of 769 thous. tonnes based on $F = 0.26$. The advice is surprisingly similar taking into account how different stock in numbers by age are (figures 6,??,3 and 2).

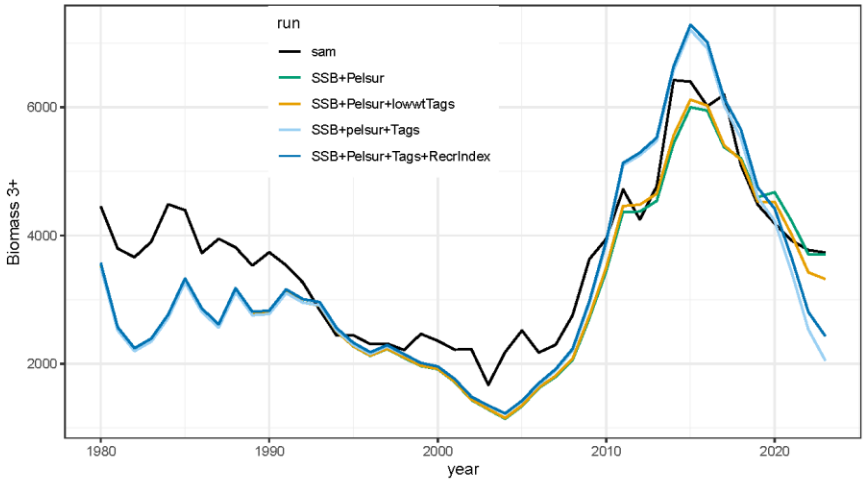


Figure 1: Biomass of age 3 and older for various setup of Muppet and the adopted SAM assessment

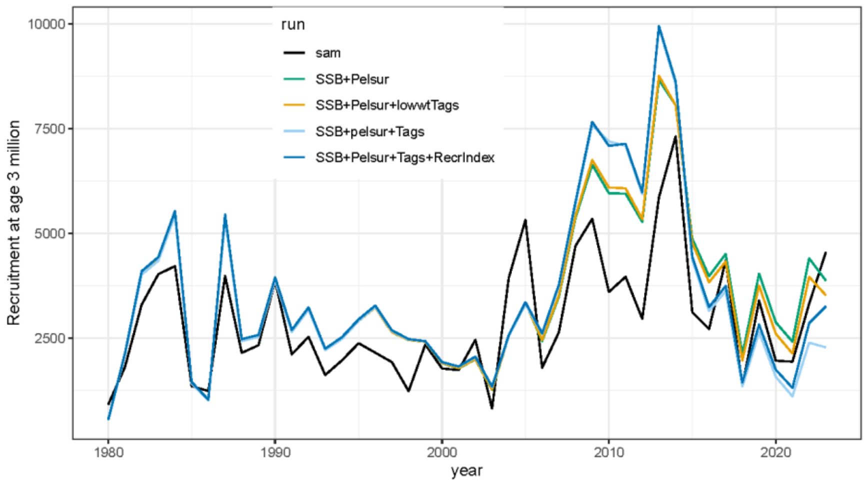


Figure 2: Recruitment at age 3 for various setup of Muppet and the adopted SAM assessment

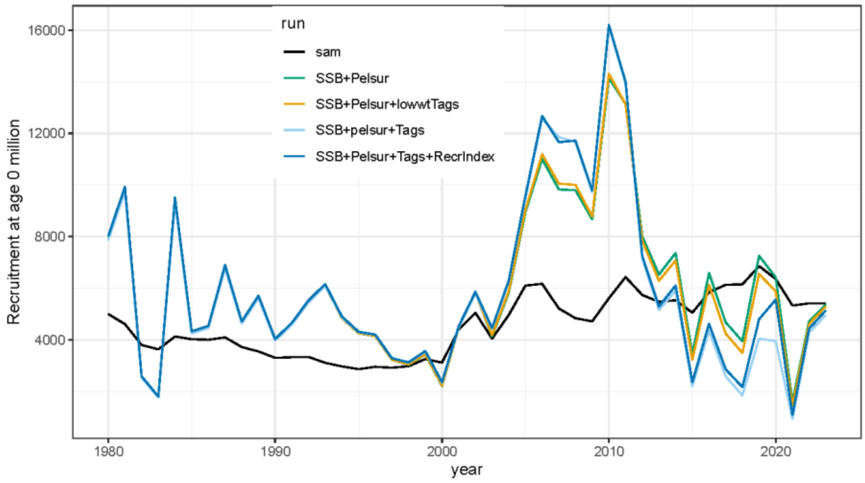


Figure 3: Recruitment at age 0 for various setup of Muppet and the adopted SAM assessment

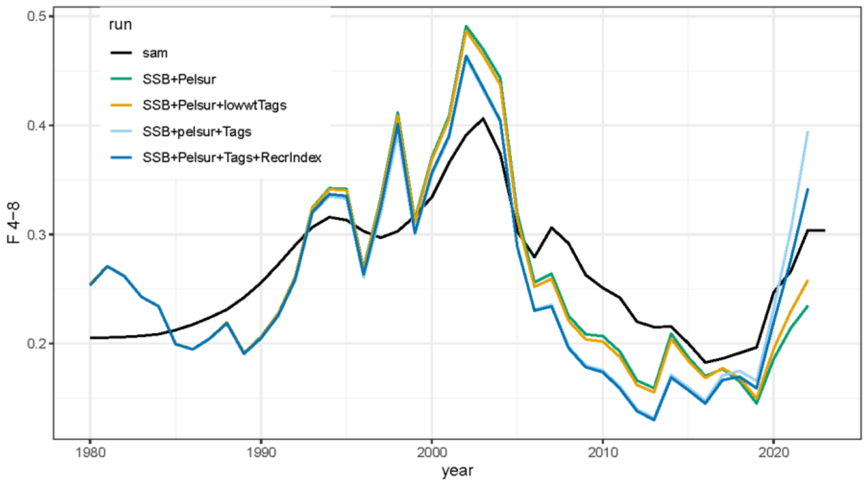


Figure 4: F4-8 of Muppet and the adopted SAM assessment

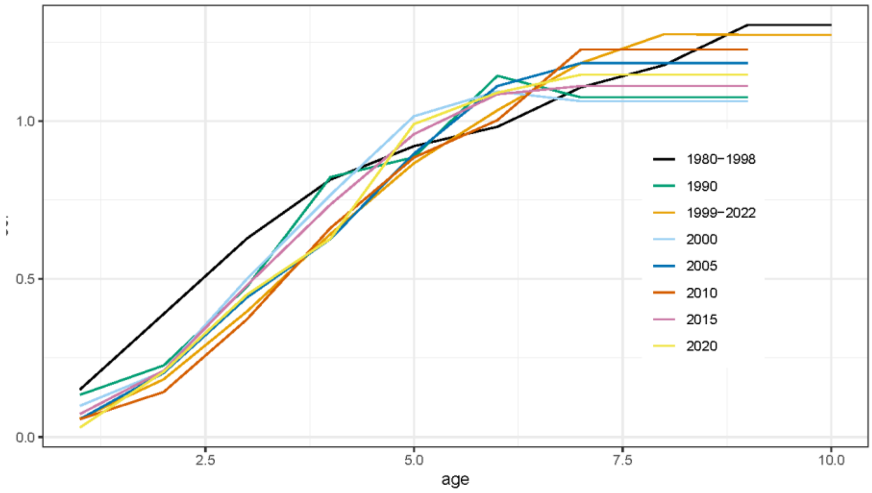


Figure 5: Selection pattern in Muppet and SAM. Values from Muppet are labelled as range of years.

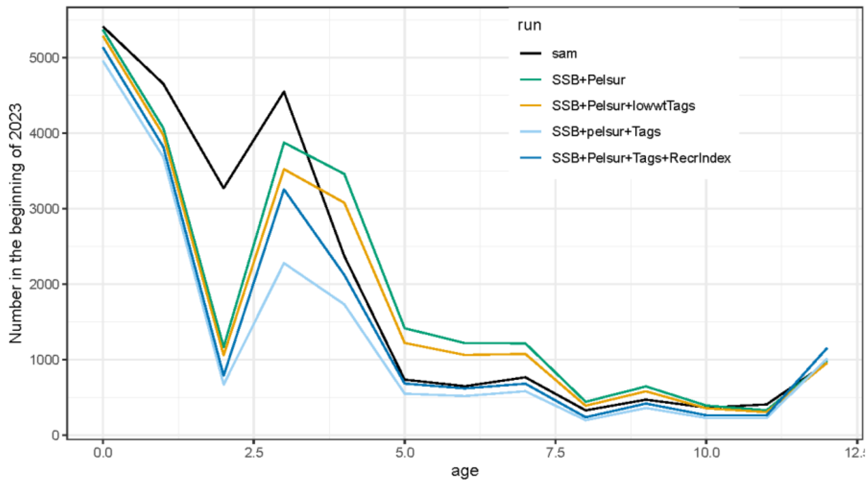
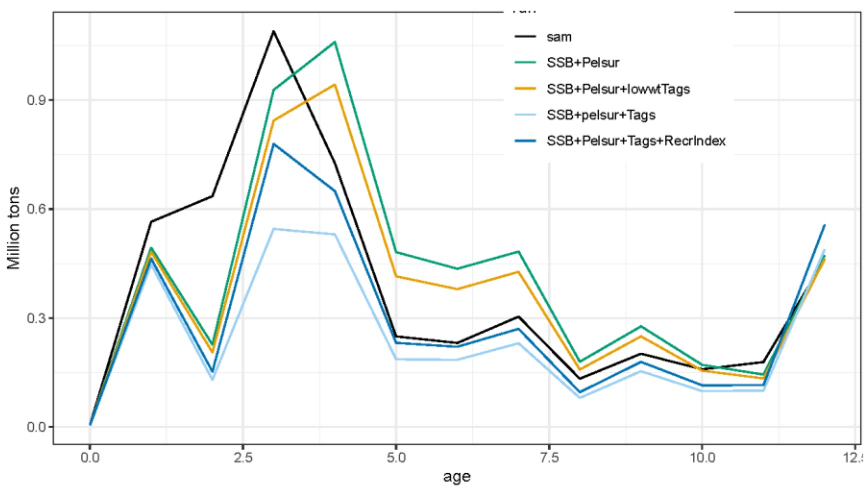


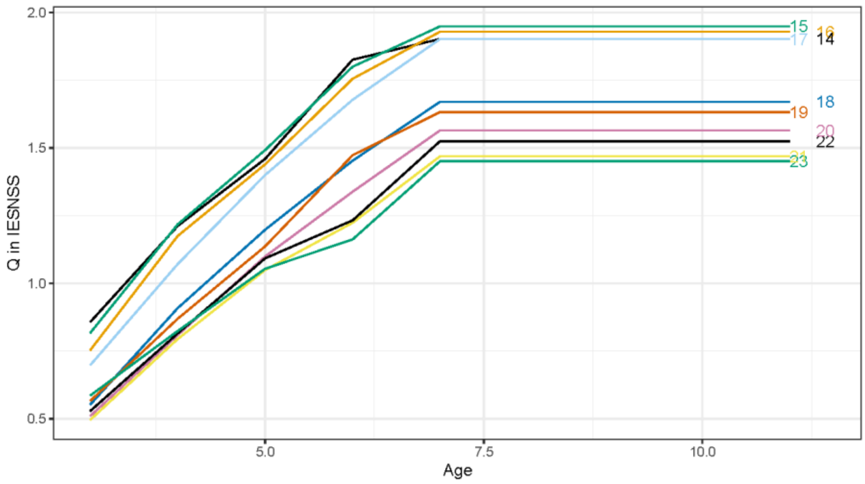
Figure 6: Stock in numbers 2023 for various setup of the Muppet model and the adopted SAM assessment

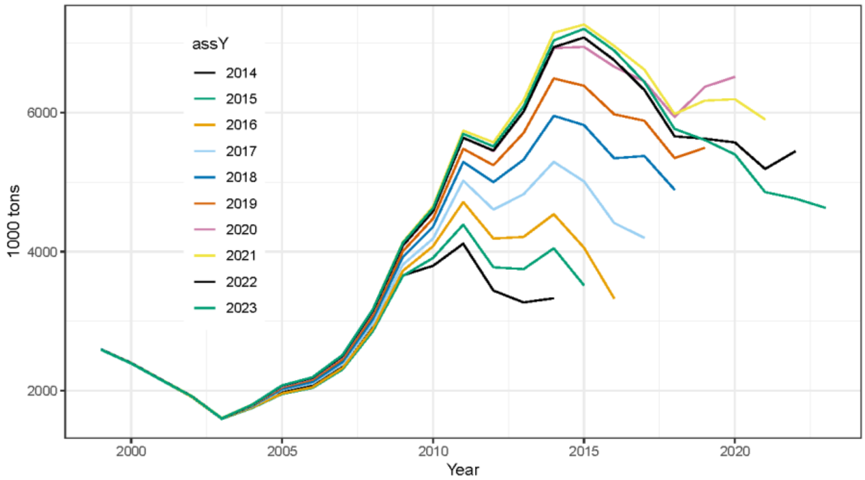


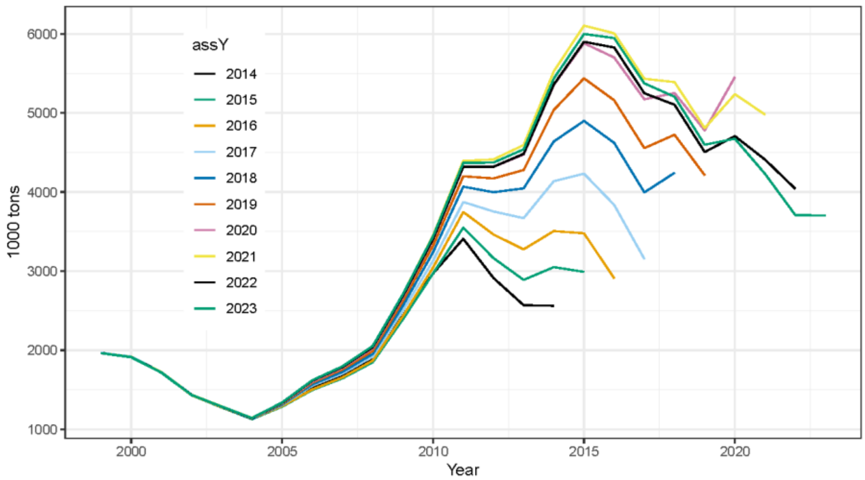
Retrospective pattern

It has been claimed that the Mackerel assessment is always an underestimate. This has probably been true, the reason being that tuning data were extremely scarce. IESNSS started in 2010, 2011 is not used but has been conducted every year since 2012. The run shown here uses age 3-11 in the survey but it would be better also to include the plus group (age 12+).

Relatively much change is seen between 2017 and 2018 but after that the stock is over and underestimated in this model run. F as estimated now was relatively low in the period after IESNSS started leading to slow convergence of estimated q.







Looking at observed and predicted survey biomass (figure 7) 2019 and 2020 are outliers. What is happening there? 2022 is the survey with really high CV. Interesting with this picture is that the survey biomass and B4+ are about the same **(q=1)**.

Taking a simple stupid approach from this picture B4+ now should be similar to what it was 2010 and 2012. Average from 2010 and 2012 is 3900 tons but 3700 tons in 2023 so this works ???!!!

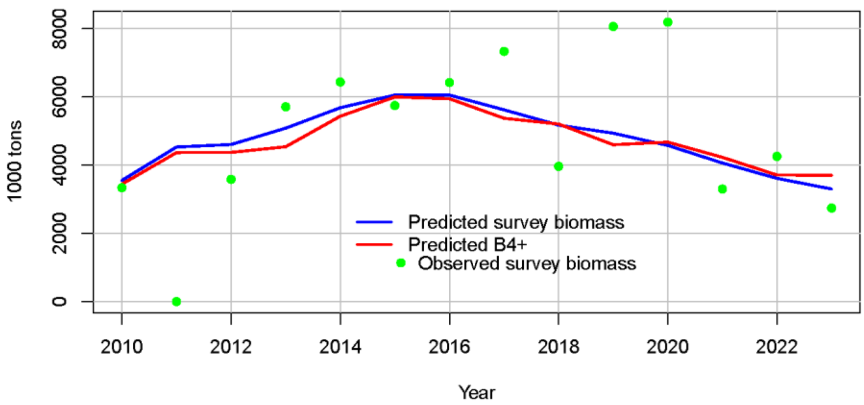


Figure 7: Observed and predicted biomass from IESNSS and B4+ from assessment based on the survey. B4+ is shown as age 3 is only half recruited to this survey

Analysis of blue whiting assessment 2023

Höskuldur Björnsson

2023-08-27

The Muppet model was run as comparison with the SAM assessment conducted at WGWIDE. There are a number of differences between the setup but the results are generally more consistent than for example for the Mackerel.
The main differences in setup are.

1. Selection in Muppet pattern fixed for 2 periods, 1980-1996 and 1997-2022. Selection pattern in SAM variable. Selection pattern of the models is similar and variability in SAM not large (figure 7).

2. F for ages 7 and older is constant, 9 and older in SAM (figure 7).
3. 2 Versions of Muppet are run, one using only Tac constraint in the assessment year (Muppet)but the other using catch in numbers in the assement year (Muppetw2023)
4. In Muppet, CV of residuals in survey and catch is specified as an estimate multiplier on a pattern given, but in SAM the CV is constrained to be identical for specified range of age groups. The setting of those patterns affects the results but were not investigated much this time. The pattern of survey CV was set using the Muppet model in VPA mode, estimating the survey CV for each age group (can in principle be done by a VPA model)
5. Fishing mortality is modelled by random walk in SAM but not in Muppet. The random walk limits varibility in F and does lead to larger estimated stock when F is increasing and vice versa. The random walk constraint is probably weak in the blue withing stock where F has been quite variable (logSdLogFsta = -1.03353539 and corFlag=2)

All the models show similar trends in the stock unlike what was seen for Mackerel. There is though difference in the estimate of current stocksize with the SAM model giving indicating larger stock than the Muppet models (figures 1 and 3). The Muppet model using catch at age 2023 indicates smaller stock than the one using TAC constraint in 2023.

The models agree on the amount of older fish (figure 2) but considerable difference is seen regarding yearclasses 2020 and 2021 (figure 8).

The Muppet model includes prediction and the TAC for 2024 based on F=0.32 is 960 thous tonnes for the model using catch at age 2023 and 1216 thous. tonnes for the model not using catch at age 2023. Comparable number for the adopted model is around 1500 thous. tonnes.

In the Muppet model the first guess of each yearclass is geometric mean (or SSB recruitment function). CV around this mean is estimated and this term can have substantial effect on estimate of yearclasses far from the geometric mean, how much depends on the quality of the survey data. This term is downweighted in the runs here (weight=0.1) and does not have large effects.

In summary, considerable difference can be seen by different models and settings. Most of the stock is from 2 yearclasses 2020 and 2021 and the weighting by age of survey and and catchdata might have considerable effect on the results.

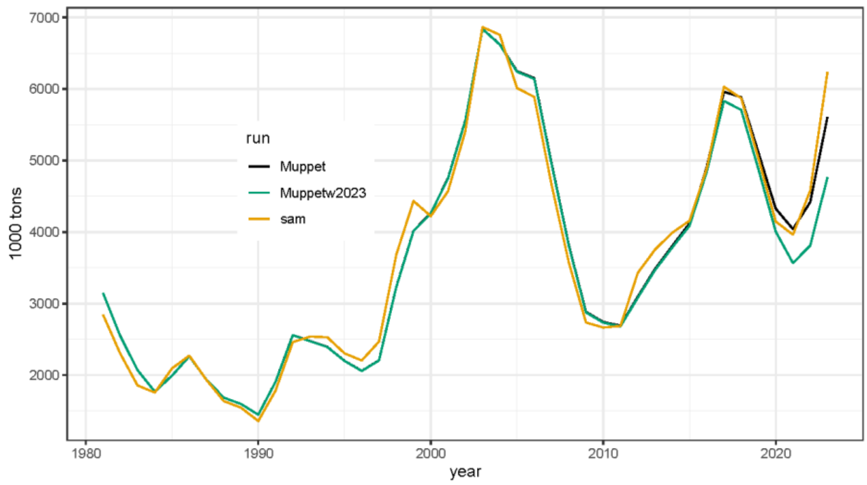


Figure 1: SSB from Muppet and from the adopted SAM assessment

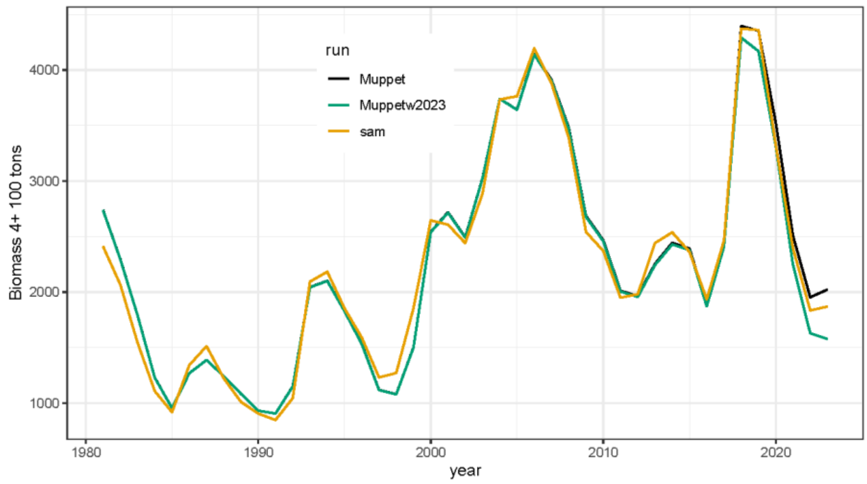


Figure 2: Biomass of age 4 and older from Muppet and the adopted SAM assessment

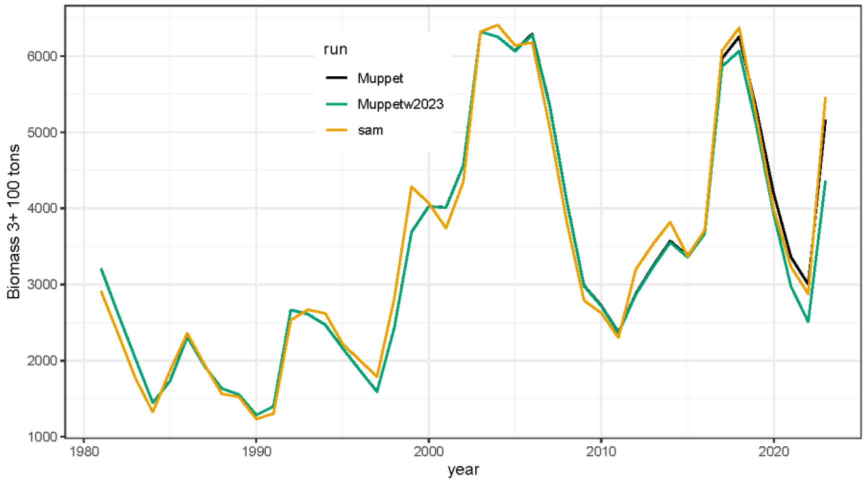


Figure 3: Biomass of age 3 and older fromMuppet and the adopted SAM assessment

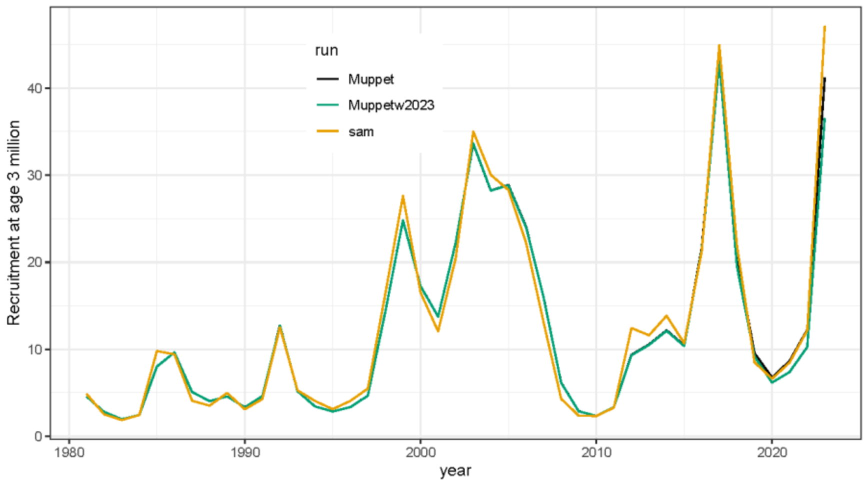


Figure 4: Recruitment at age 3 from Muppet and the adopted SAM assessment

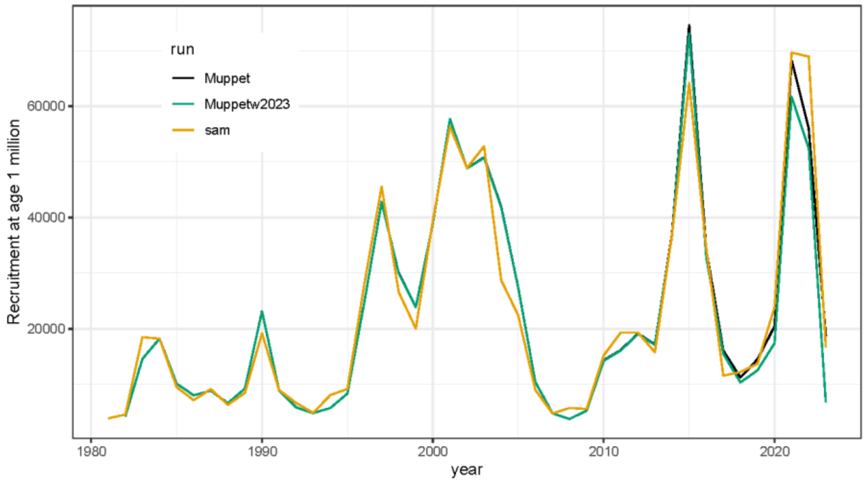


Figure 5: Recruitment at age 1 from Muppet and the adopted SAM assessment

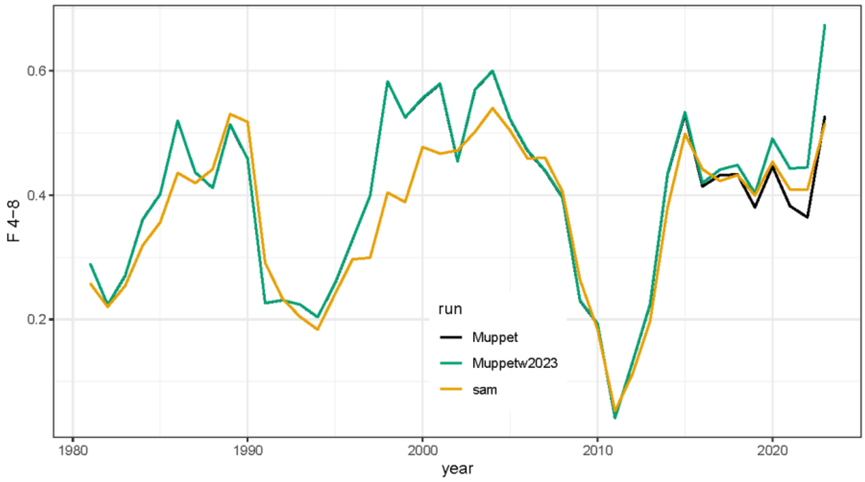


Figure 6: F4-8 from Muppet and the adopted SAM assessment

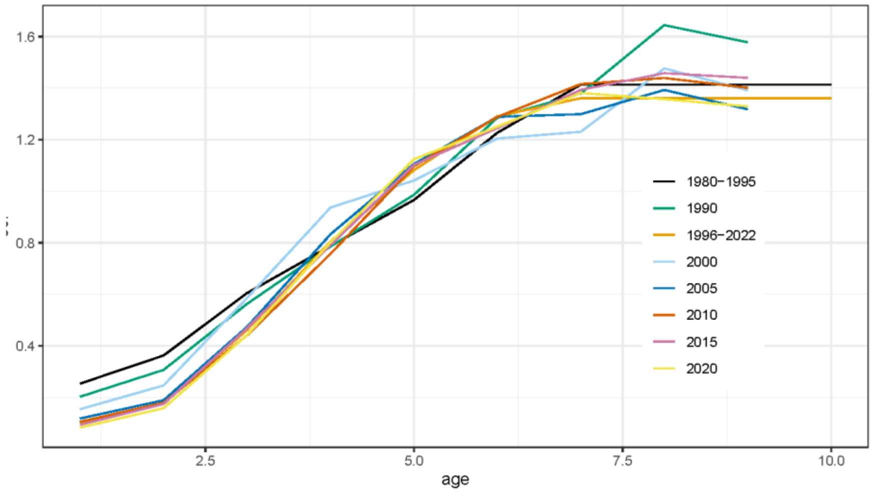


Figure 7: Selection pattern from Muppet and SAM. Values from Muppet are labelled as range of years (2 selection periods).

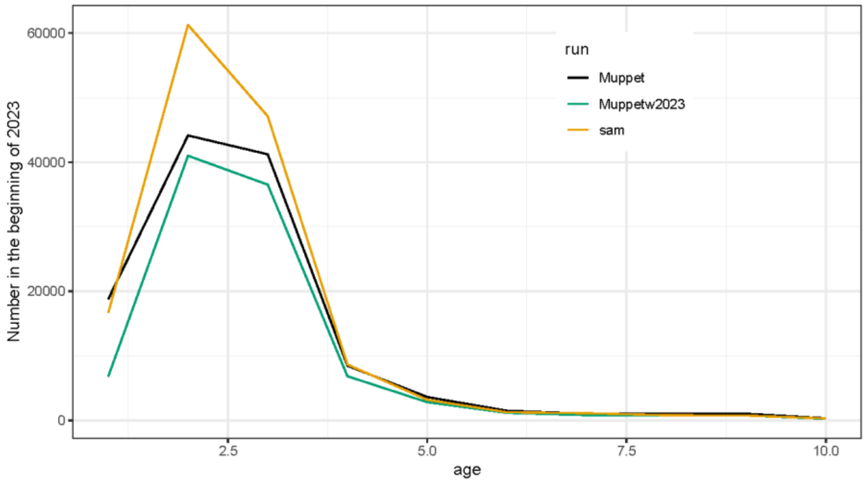


Figure 8: Stock in numbers 2023 from the Muppet model and the adopted SAM assessment

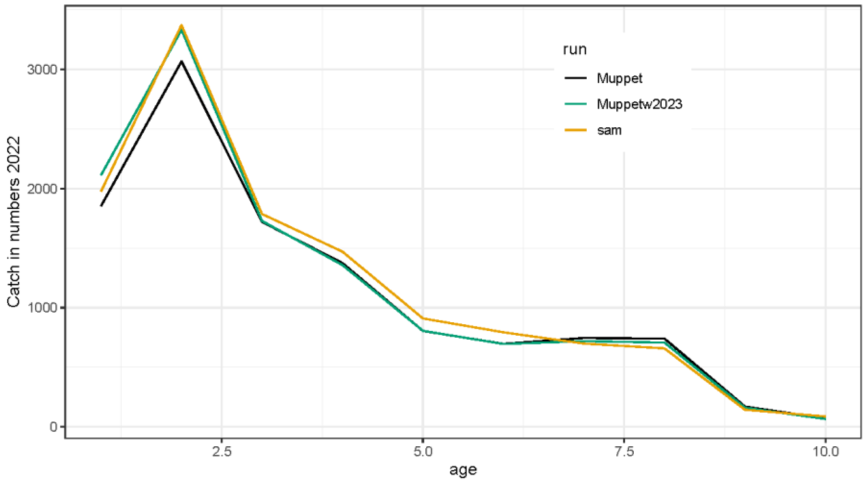


Figure 9: Catch in numbers 2022 from the Muppet model and the adopted SAM assessment

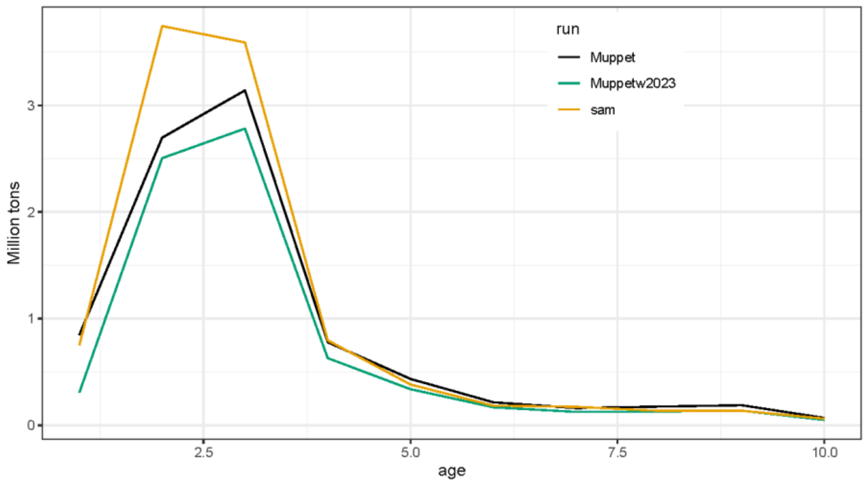


Figure 10: Biomass by age 2023 from the Muppet model and the adopted SAM assessment

Working Group on Widely Distributed Stocks (WGWIDE)
23 – 29 August 2023, Copenhagen (Denmark)

Identification of new reference fleets regarding striped red mullet from professional fishing data for Subareas 7 and 8.

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Context

For striped red mullet (*Mullus surmuletus*), there is no scientific campaign to provide one or more robust abundance indices for the mur-west stock. One of the objectives of the ACOST project is therefore to construct, and in some cases consolidate, abundance indices based on commercial fishing data. Classically, two approaches can be developed to build such indices:

- the "design-based" approach, based on the selection of representative statistical units (in this case, vessels), from which data are then collected to build an abundance index;
- the "model-based" approach, which, on the other hand, studies the variability of catch data and reworks them to construct such an index.

The design-based approach was initiated during the ROMELIGO project (Léauté et al., 2018). It is based on a data-filtering method that examines the activity of fishing fleets that are potential candidates to be retained to provide an index of abundance through mandatory and optional criteria. These criteria were defined and discussed throughout the project in working groups involving the fishing industry. At the end of the ROMELIGO project, five reference fleets were proposed because their Landings Per Unit Effort (LPUE) were considered to be potentially able to account for the level of abundance of striped red mullet in the Bay of Biscay (ICES Subarea 8) (Léauté et al., 2018 with publication of the method in Caill-Milly et al., 2019). These fleets were as follows:

- « OTB » fleet - cluster 1 - mesh size class 70 - 79 mm;
- « GNS » fleet - cluster 2 - mesh size class 50 - 59 mm - 2nd quarter;
- « GNS » fleet - cluster 2 - mesh size class 50 - 59 mm - 3rd quarter;
- « GNS » fleet - cluster 2 - mesh size class 60 - 69 mm - 2nd quarter;
- « GNS » fleet - cluster 2 - mesh size class over 90 mm - 2nd quarter.

Since the ROMELIGO project, their CPUE has been updated and transmitted to ICES WGWIDE. Of the five original fleets, there are now four reference fleets, as the second one (« GNS » fleet - cluster 2 - mesh size class 50 - 59 mm - 2nd quarter) has been withdrawn as its use reached a very low level (around 40 fishing trips in 2018).

Within the framework of the ACOST project and for this ICES Subarea 8, the present work aims to consider the interest of a new fleet using Danish seines. The latter were not considered before because the time series was too short. The interest of an extent of the methodology

to ICES Subarea 7 and/or ICES Subareas 7 and 8 for OTB, GNS and SDN is also viewed to take into account the entire geographical area delimiting the mur-west stock.
NB: the ACOST project also deploys a model-based approach based on the standardization of LPUE using statistical models. It has been used for whiting and pollack, and is currently being adapted for red mullet, to be communicated to WGWIDE at a later date.

This WD refers only to new results obtained with the design-based approach.

1. Data and approach

1.1. Data origin

The data used relate to commercial fishing catches and are of two types: data regarding landings (SACROIS data) and data regarding discards (OBSMER data). SACROIS data have been available since 2000; they were extracted for the period 2000-2022. For the area corresponding to the spatial delimitation of the mur-west stock, 3,263,982 fishing trips were related to striped red mullet catch (each line containing the quantity of red mullet landed per fishing trips and per vessel). It therefore represents a quantification of landings per unit effort (LPUE). OBSMER data have been available since 2003; they were extracted for the period 2003-2021. To use the OBSMER data, the following criteria were considered: the availability of a sufficient number of observations, the proportion of discards mean by month and by year from the number of total operations realized and observed, the stability of this proportion over time, and the size composition of the discards. Regarding size, there is no minimum size in force for striped red mullet, but a minimum commercial weight set at 40 grams, equivalent to individuals of around 18 cm. For the area corresponding to the spatial delimitation of the mur-west stock, 6,504 fishing operations were observed entirety (landing part, discard part, all species). Their breakdown by Subarea and by gear is provided in Table 1.

Table 1: Number of fishing operations observed according to the Subareas and gears considered over the 2003-2021 period.

	OTB	GNS	SDN
Subarea 7	3 453	383	353
Subarea 8	1 001	941	373

Regarding the vessels, their technical characteristics may change over time as a result of modifications (such as remotorization, changes in fishing gear, etc.). In order to provide the most accurate information throughout a vessel's life cycle, the annual characteristics were collected from the Community fishing fleet register (https://webgate.ec.europa.eu/fleet-europa/search_en).

1.2. Selection, cleaning and data preparation

Three gears were selected using their FAO code: "OTB" for the bottom otter trawls (1 vessel), "GNS" for the set gillnets and "SDN" for the Danish seines. As OBSMER data for OTB and GNS in Subarea 8 has already been processed by Léauté et al. (2018), these data were not considered in this report.

1.2.1. Data extraction and definition of the study population

Differences in activity for the three gears exist between Subarea 7 and Subarea 8 (seasonality, average vessel length, year of first use of gear, etc.). Analyses by gear are therefore initially undertaken separately for these two Subareas:

- For Subarea 7, the spatial coverage selection corresponds to ICES divisions "27.7.a", "27.7.b", "27.7.c", "27.7.e", "27.7.f", "27.7.g", "27.7.h", "27.7.j" and "27.7.k";
- For Subarea 8, it corresponds to ICES divisions "27.8.a", "27.8.b", "27.8.c", "27.8.d" and "27.8.e".

The reference fleet selection for the construction of abundance indices consists in selecting vessels that will enable us to pinpoint the phenomenon of interest, namely striped red mullet catches. Therefore, vessels were selected in these 2 subareas, according to 2 criteria:

- Criterion 1: those having caught striped red mullet at least once between 2000 and 2020 for each Subarea;
- Criterion 2: only statistical rectangles consistent with the bathymetric distribution of striped red mullet were selected. They correspond to rectangles with bathymetries of less than 300 m and/or an intersection with this depth (except for rectangles 28E8 and 29E8, which have been excluded because they have a surface almost entirely in "27.7.d" and not in "27.7.e").

Vessels were then selected on the basis of activity, namely a realization of at least 24 fishing trips per year with striped red mullet, using trawls, nets or Danish seines respectively.

At the end of this first stage, 757 vessels formed the statistical population considered.

1.2.2. Data cleaning and final data set preparation

The “cleaning” related only to the landing data. It included detected outliers following expert opinions (atypical values of landings, unrealistic values of gear mesh sizes), data corresponding to vessels with fishing time equal to zero or not filled in and non-available data (fishing sequences without statistical rectangles information). The deletion also affected lines describing fishing sequences whose occurrence per month was less than 2 (as they cannot be used to consider the variability of landings for a given year, month, rectangle and gear) and the sequences for the year 2020 due to the health crisis linked to Covid19 and its impact on fishing activity (this year deemed too atypical to be considered for the fleet selection process).

For landings, to conduct the analyses, level indicators (mean, median) and dispersal indicators (interquartile range IQR, variance Var, standard deviation StD, and coefficient of variation CV) of the LPUE were calculated and displayed in columns using the following aggregation: year, month, rectangle, month, vessel registration, vessel length, vessel power, vessel tonnage, gear and gear mesh size (grouped in mesh class).

For discards, the calculated column parameters were the mean, the median and the standard deviation of the catches and the discards. The aggregation used was: year, month, rectangle and gear.

1.3. Analytical process of landing data to select a representative fleet

The approach was described by Caill-Milly et al (2019); only the main outlines are given hereafter.

Preliminary stage: a focus on discards is presented first due to the nature of the professional data available (related to landings). A condition for the indicators constructed to reflect abundance at the time of capture, it is first necessary to ensure that the loss of information linked to discards between catch and landing is controlled, or at least acceptable. To this end, an analysis of OBSMER data was carried out for the pre-selected fleets; note that this consideration of discards is not always made in the literature.

Once this stage has been completed, the approach developed comprises four steps (Figure 1):

- a focus on the variability of LPUE and a hierarchization of causes (spatio-temporal variables, vessel and gear characteristics);

- a clustering to obtain a typology of vessels based on the technical characteristics of the vessels that emerge as the main explanatory factors for the variability of LPUE (excluding spatio-temporal variables);

- analysis of average LPUE per cluster. To identify clusters (or fleets) particularly useful for providing an overview of abundance, a multi-criteria approach with mandatory and optional conditions was applied (Table 2); it sets conditions for the level, variability and duration of activity and is applied for each cluster. Then for these conditions, a points system was developed. Points were attributed by expert opinion on a scale of 3 (1 - null or weak; 2 - medium; 3 - strong);

Table 2: Mandatory and optional conditions applied to identify the cluster of interest

Mandatory conditions	**Optional conditions**
- a sufficient number of vessels constituting the cluster, set at a minimum of 10 for OTB, GNS and SDN; - presence in the subarea for a long period. It is considered here that the series must be available for a period longer than the maximum longevity known for striped red mullet, *i.e.* 12 years; - a sufficient average level of LPUE. The value for this criterion varies according to the gear. It is set at 5 kg for nets and trawls, and 10 kg for Danish seines, based on an examination of LPUE values.	- a seasonal signal stable in amplitude and periodicity; - activity north and south of the Bay of Biscay for Subarea 8, in 7e-k for Subarea 7; - moderate seasonal variability.

- Once selected, fleets were refined using gear mesh sizes or mesh classes, and possibly seasonal (quarterly) activity considerations.

NB : the analyses carried out to identify new reference fleets were started in 2021; they were therefore conducted over the 2005-2019 period for trawl and net, and over the 2007-2019 or 2008-2019 period for Danish seine (2020 having been excluded due to COVID). Since the start of these analyses, other years have become available: 2021 and 2022. The question of their impact on the results if they had been included in the analyses was therefore raised at the WG Reference Fleet associating the professional structures. Steps 1 to 2 were therefore reworked to take them into account. The results are similar to the previous ones in terms of fleet selection. This does not justify repeating all the graphs and tables presented (because of the time it would take). However, for the fleets selected, the "number of uses" and "average LPUE" indicators were updated using the latest SACROIS database available, which includes 2021 and 2022.

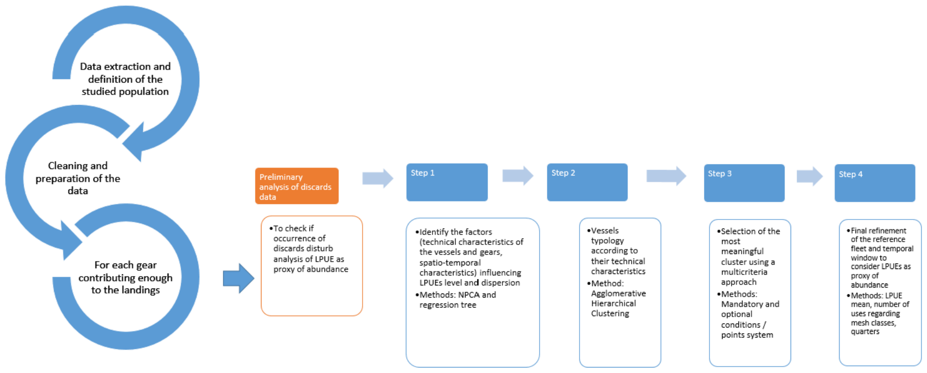


Figure 1: Retained methodology for the identification of reference fleets from the LPUE study (from Caill-Milly, 2023)

1.4. Engagement of organizations representing professional fishermen

As with the ROMELIGO project, exchanges with professional representatives have been organized throughout the ACOST project. These took place in Working Groups (WG) "Reference Fleets", attended by scientists, representatives of producers' organizations, fisheries committees and Aglia.... These groups enable scientists to present the data used and the method(s) selected, to discuss the relevance of thresholds and aggregations, to detect possible biases linked to changes in regulations (from local to European level), etc. in the construction of indices. Appendix 1 details the progress of the WGs regarding striped red mullet. The approach adopted can be described as collaborative research. The nature of the collaboration with professional representatives is presented in Table 3, given that the entire project is not yet complete.

Table 3: Detailed participation of the professional stakeholders in the various stages of the ACOST research project by 08/31/2023, using the modalities described by Macher et al. (2022)

Nature of the collaboration	Realization ACOST framework by 31/08/2023	Comments
Stakeholder participation in data analysis		
Stakeholder participation in project management		
Stakeholder participation in interpreting results	X	
Stakeholder participation in financing project	X	
Stakeholder participation in disseminating results	(X)	Planned but not yet implemented as project in progress
Co-construction of research questions	X	
Stakeholder participation in data collection	X	By auto-sampling ...
Stakeholder consultation/knowledge gathering	X	
Knowledge transfer from science to stakeholders	(X)	Planned but not yet implemented as project in progress

In terms of stakeholder engagement[1], ICES has recently produced a document describing the key principles of engagement in the work of the council and defining the roles of the professional parties as well as those of scientists (ICES, 2023a). In addition, ICES organized a workshop in May 2023 dedicated to the implementation of this stakeholder engagement strategy (WKSTIMP). This provided an opportunity to deepen some definitions and propose actions (ICES, 2023b). With reference to these two documents, and as far as the ACOST project is concerned, the reason for stakeholder involvement can be defined by the term "knowledge production", with stakeholders playing a "contributor" role. The last document also notes the importance of effective communication and learning for successful engagement. At the end of the ACOST project, feedback will be provided to professional structures to identify possible improvements for future projects.

[1] « ICES defines stakeholders as those who affect or are affected by a decision, process, or action of ICES, including scientists and knowledge providers operating within ICES network. Because of the central role that scientists in the network play in framing and conducting the work of ICES, scientists have a unique role as “internal stakeholders” from within the organization, and this strategy generally reserves the word “stakeholders” to denote all other stakeholders. » Extracted from ICES (2023).

2. Results for the data-filtering approach

For this WD and for the fleets studied (gear/Subarea combination) but not retained, the reasons for their exclusion are presented but not detailed. For each fleet selected, the presentation of results begins with the vessel typology. This typology is based on the technical characteristics that have the greatest influence on the variability of LPUE. Steps 2 to 4 are therefore presented and detailed. The figures and tables regarding the preliminary stage and step 1 are available in the appendixes 2, 3 and 4. This choice was made because all the stages have already been presented in a WD transmitted and presented to the WGWIDE in 2018 (Caill-Milly et al., 2018) for other fleets.

2.1. Applied to vessels using Danish seine (SDN) in Subareas 8 and 7

In previous work, the length of the Danish seine data series was too limited. This is no longer the case, so this document aims to consider the interest of the Danish seine metier in defining, or not, additional reference fleet(s).

For Subarea 8

Spatio-temporal factors are more important than technical characteristics in accounting for the variability of LPUE (Appendix 2). Once these factors have been removed, technical characteristics of the gear and vessels are highlighted. Regarding vessel characteristics and for SDN Subarea 8, they relate to gauge and length.

Vessel typology using technical characteristics and evolution of average LPUE for each cluster - Danish seine (SDN)

Implementation of Agglomerative Hierarchical Clustering (AHC) on the technical characteristics (gauge and vessel length) allows distinguishing two clusters (figure 2; characteristics displayed in table 4).

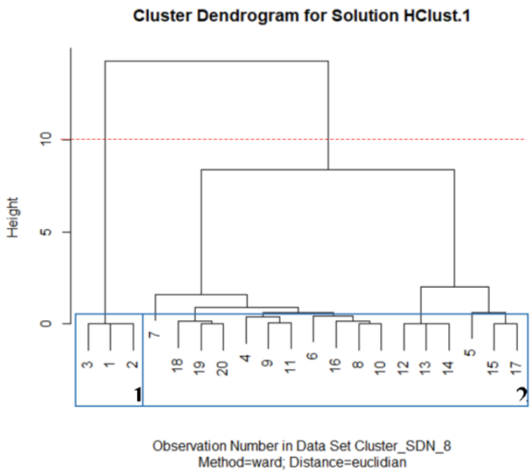


Figure 2: AHC of vessels using SDN in Subarea 8 according to their technical characteristics – gauge and length (standardized) (red line: visual cut)

Table 4 : Values of technical characteristics per cluster for vessels using SDN in Subarea 8

Cluster		Vessel length (m)			Gauge (grt)			Engine power (kW)		
Code	Number	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
1	3	34.0	34.0	34.0	274	274	274	588	588	588
2	17	18.0	22.0	24.9	88	149	227	331	459	626
Total	20									

For each candidate cluster, changes in landing average calculated by month and by year are shown in Figure 3. Cluster 1 displays highly variable activity (with a very high peak in 2009) at the start of the period, with a stop from 2014 onwards. Cluster 2 is only interrupted at the end of 2009/beginning of 2010, and shows a relative cyclicality in the LPUE levels.

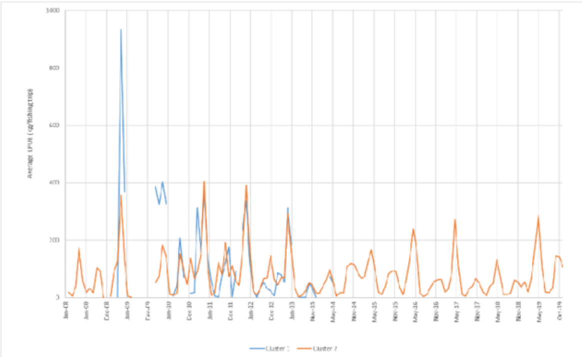


Figure 3: Average LPUEs of striped red mullet per cluster of vessels using SDN in Subarea 8

Within the area studied in the Bay of Biscay, an additional North (8a) / South (8b) division was applied. This division is made at latitude 46°0' N. In the northern part of the Bay of Biscay (delimitation 46°0' N) (Figure 4) and for each cluster, the average LPUE is very similar to that observed for the entire Bay.

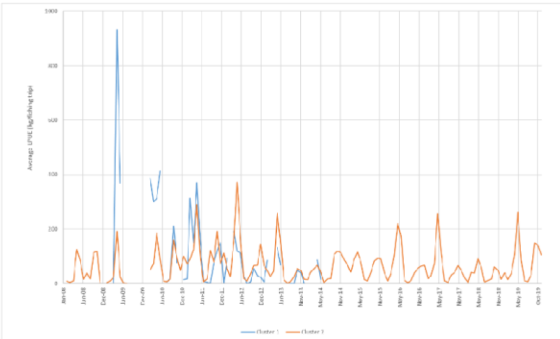


Figure 4: Average LPUEs of striped red mullet per cluster of vessels using SDN in the northern part of Subarea 8

In the southern Bay of Biscay (Figure 5) and for both clusters, the average LPUE is close to that observed for the whole Bay, but there are differences in levels for both clusters at some periods compared with Figure 3. Moreover, the series are discontinuous for both clusters.

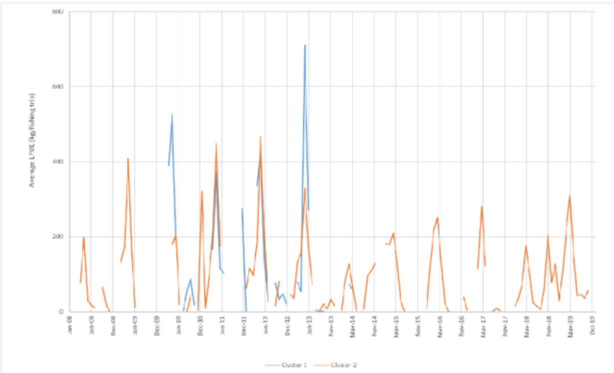


Figure 5: Average LPUEs of striped red mullet per cluster of vessels using SDN in the southern part of Subarea 8

LPUE levels differ according to the technical characteristics of the vessels. Among all the series observed, the northern Bay of Biscay shows the most cyclical and uninterrupted trend in average catch levels for Cluster 2.

Cluster selection with a multicriteria approach

Table 5 summarizes the results following the application of the madatory and optional conditions on the data series.

Table 5: Classification of clusters for SDN in Subarea 8

Multi-criteria selection method			
Level of obligation	Vessel typology (technical characteristics)	Cluster 1	Cluster 2
Mandatory	Sufficient number of vessels (> 10)		X
	Long data series (> 12 years)		X
	LPUE levels medium to high (> 10 kg/UE) over the period	X (133)	X (77)
Optional	Stable seasonal signal (both in amplitude and periodicity) during the series	1/3	2/3
	Activity present in N and S of the Bay of Biscay	1/3	2/3
	Moderate seasonal variability	1/3	2/3
Notation		3/9	6/9
Proposed ranking		2	1

The points system allows us to propose cluster 2 for Danish sein (SDN) in Subarea 8. This cluster 2 is composed of medium vessels with a mean length of 22 m (between 18.0 et 24.9 m), with a gauge between 88 and 227 grt, and an engine power between 331 and 626 kW.

The question of spatial selection was posed for Cluster 2. In order not to reduce the number of observations, and because the signals between the northern and southern Bay of Biscay were fairly similar, we chose to keep the whole Subarea 8 for this fleet. The following analyses therefore refer solely to this cluster.

Study of mesh sizes and seasonal variations in LPUE for Danish seine Cluster 2 (SDN)

Mesh sizes were considered according to several criteria: representativeness of the landing levels, continuity of use and a sufficient number of uses. The 70 mm mesh size is by far the most represented class for this cluster over the period (Figure 6).

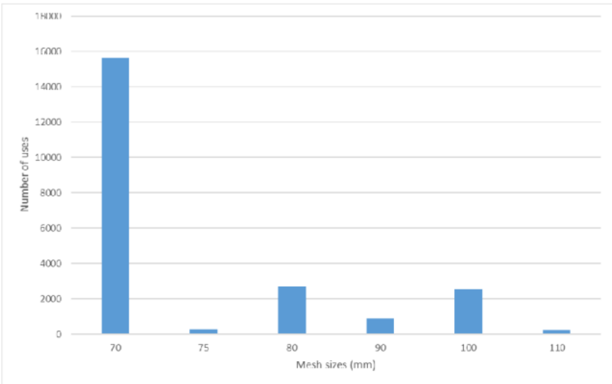


Figure 6: Number of mesh uses between 2008 and 2019 for Cluster 2 - Danish seine (SDN) - Subarea 8

Ffigure 7 shows the monthly evolution of LPUE for the three main meshes of cluster 2 (70 mm, 80 mm and 100 mm).

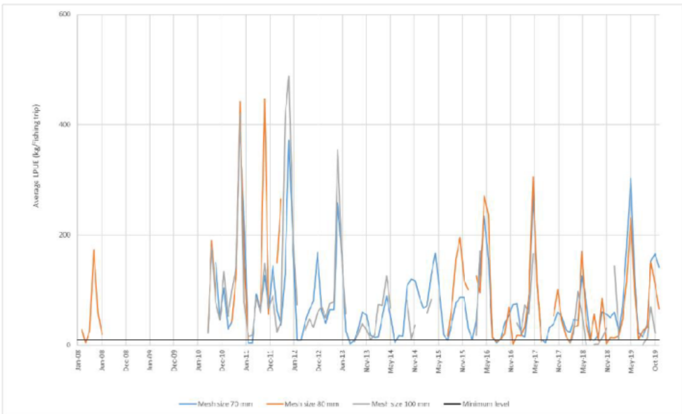


Figure 7: Monthly evolution of LPUE for the main mesh sizes used by Cluster 2 - Danish seine (SDN) - Subarea 8

For the criteria considered (Table 6), the 70 mm mesh size for the Danish seine (SDN) - cluster 2 is seen as the most interesting. This result, presented at the WG Reference Fleets, was discussed and it was decided to extend it to the 70-80 mm class. There are regulatory reasons for this, as some vessels previously working with 70 mm have already been required to use 80 mm in certain months as part of the management of the Bay of Biscay common sole stock[2]. The 70-80 mm class is therefore preferred, as it will make it possible to anticipate other possible 80 mm obligations for these vessels, and thus facilitate the construction of a long-term series.

Table 6: Mesh size results for Cluster 2 - Danish seine (SDN) - Subarea 8

	Proposed mesh size selection(s)					
Métier	Danish seine					
Cluster	2					
Mesh size (mm)	70	75	80	90	100	110
Sufficient LPUE level	X	X	X	X	X	X
Availability over a long period	X		X		X	
High number of uses	X					
Limited confidence interval	(X)	(X)	(X)		(X)	
Proposed mesh size	X					
Quarterly study	Yes					

For the 70-80 mm mesh class for SDN cluster 2, LPUE displays strong seasonality over the period, with higher levels in May. The confidence interval (CI) is also widest in May (Figure 8).

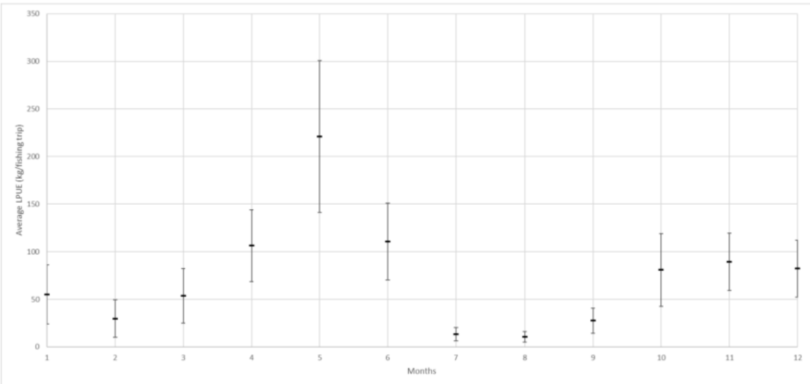


Figure 8: Average LPUE (with CI) per month over the period 2010-2019 for Cluster 2 - Danish Seine for mesh size class 70-80 mm - Subarea 8

Based on these characteristics, working on quarter 2 is proposed for this fleet.

[2] Arrêté du 12 février 2015 créant un régime national de gestion pour la pêcherie de la sole commune (Solea solea) dans le golfe de Gascogne (divisions CIEM VIII a et b)

Number of uses and LPUE levels per year

For cluster 2 - SDN with a 70 - 80 mm gear mesh size, the evolution of its use over time and of the LPUEs for the whole Bay of Biscay are considered.

The number of uses has been rising since 2012. It has reached a level of around 1,000 sequences per year since 2015, with 2021 marking the highest value in the series, with 1,356 sequences. The first LPUEs appear in 2008, with an interruption in 2010 (they only related to one vessel in 2008 and 2009). In 2011, average LPUE is high (around 270 kg/fishing trip). They fall until 2014 (67 kg/fishing trip), then rise between 2014 and 2016, then fall until 2018, before rebounding in 2019 to 210 kg/fishing trip. The last two years, 2021 and 2022, average around 100 kg/fishing trip (Figure 9).

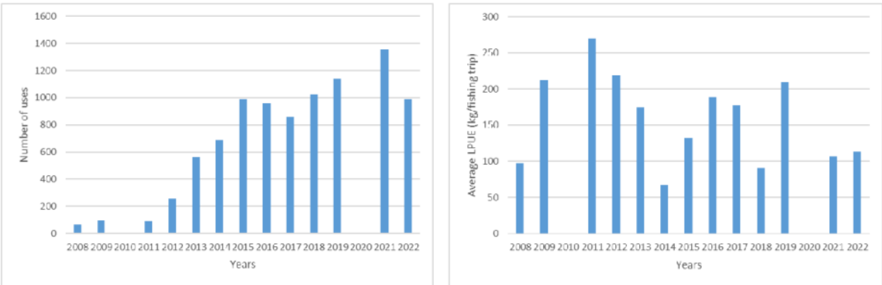


Figure 9: Number of uses and associated average LPUE levels for the Bay of Biscay - Danish seine - cluster 2 - mesh size class 70-80 mm - Quarter 2

For Subarea 7

Implementation of Agglomerative Hierarchical Clustering (AHC) on the technical characteristics accounting for the variability of LPUE (power engine) allows distinguishing two clusters (Figure 10). However, neither of these 2 clusters is made up of a sufficient number of vessels (5 and 2 respectively). In addition, the length of the LPUE series for the 2 clusters is insufficient (data not shown). There is therefore no Danish seine reference fleet proposed for Subarea 7.

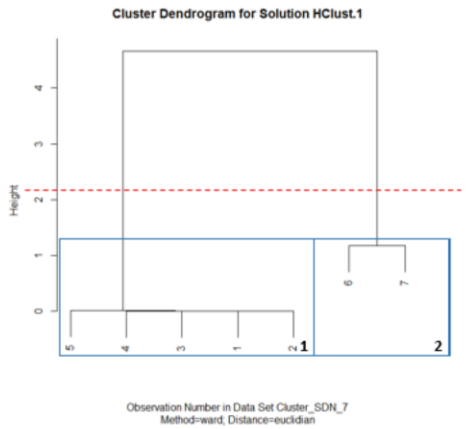


Figure 10: AHC of vessels using SDN in Subarea 7 according to their technical characteristics – engine power (standardized) (red line: visual cut)

Summary

The data-filtering method applied on vessels using Danish seine vessels allows to propose a reference fleet for the Bay of Biscay (Subarea 8). This fleet is composed of vessels using SDN with a mesh size of 70-80 mm in quarter 2 and having an average length of 22.0 m (between 18.0 and 24.9 m), an average gauge of 149 grt (between 88 and 227 grt) and an average engine power of 459 kW (between 331 and 626 kW).

No reference fleet is proposed for SDN in Subarea 7.

2.2. Applied to vessels using otter bottom trawls (OTB) in Subarea 7

Vessel typology using technical characteristics and evolution of average LPUE for each cluster – otter bottom trawls (OTB)

Implementation of Agglomerative Hierarchical Clustering (AHC) on the technical characteristics accounting for the variability of LPUE (vessel length, gauge and power engine) allows distinguishing three clusters (figure 11; characteristics displayed in Table 7).

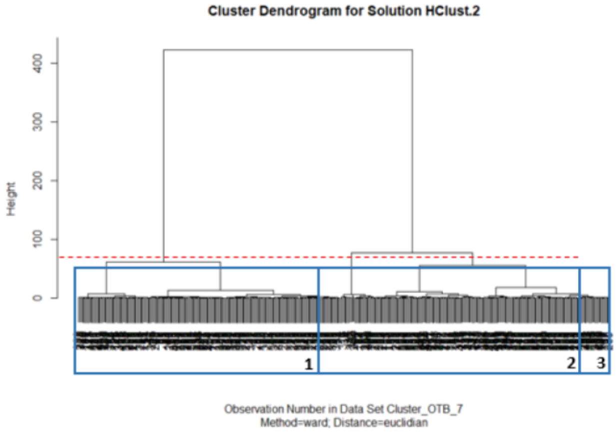


Figure 11: AHC of vessels using OTB in Subarea 7 according to their technical characteristics – vessel length, gauge and engine power (standardized) (red line: visual cut)

Table 7: Values of technical characteristics per cluster for vessels using OTB in Subarea 7

Cluster		Vessel length (m)			Gauge (grt)			Engine power (kW)		
Code	Number	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
1	203	9.00	12.5	17.6	4	27	92	71	177	350
2	27	28.4	33.4	38.0	179	271	453	459	625	883
3	181	17.5	22.5	26.1	83	146	226	305	463	738
Total	411									

For each candidate cluster, changes in landing average calculated by month and by year are shown in Figure 12. The three clusters display highly variable activity. Cluster 1 shows a low level of CPUE, as does Cluster 2, with additional breaks in the data series from 2013 onwards. Cluster 3 shows low activity, generally around the months of April, May and June.

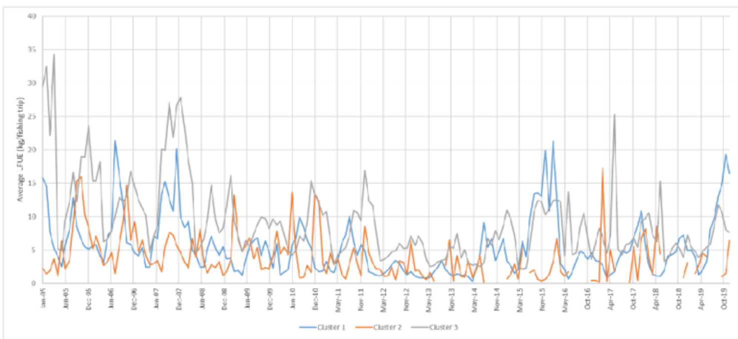


Figure 12: Average LPUEs of striped red mullet per cluster of vessels using OTB in Subarea 7

The catches distribution by statistical rectangle for Cluster 3 over the period 2005-2019 presents a concentration of catches in 7E, with four rectangles accounting for 67% of catches (Figure 13). 37% of catches are even located on the eastern border of the mur-west stock. Under these conditions, the indicator that could be constructed from this fleet does not seem to us to adequately reflect the stock under consideration (mur-west). An interaction with the mur.27.3a47d stock is likely.

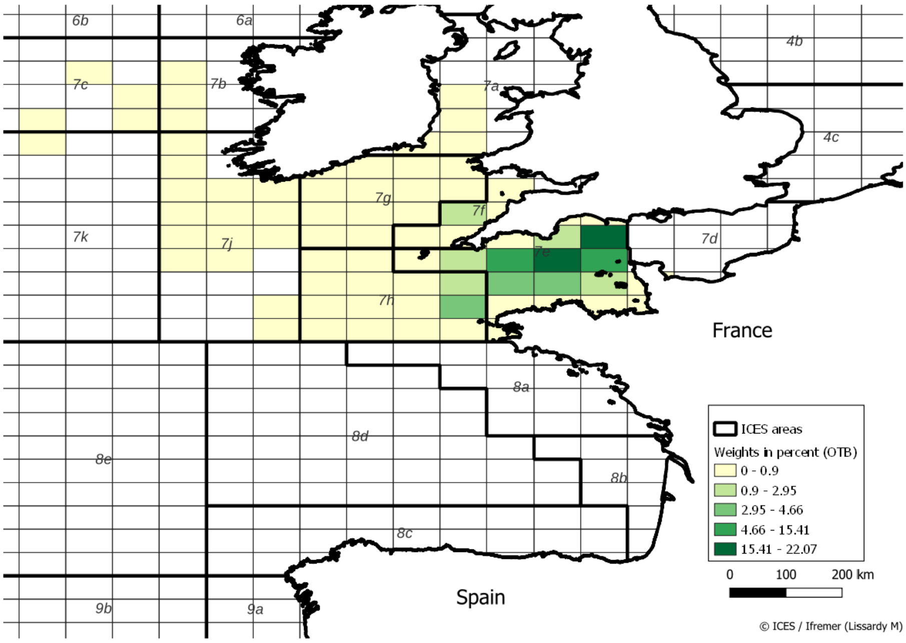


Figure 13: Distribution (in percentages) of trawl catches (OTB) - cluster 3 - between 2005 and 2019 in Subarea 7

Summary

No indicator of striped red mullet abundance from vessels using bottom otter trawls in Subarea 7 is proposed. In addition, the Brexit has repercussions on the activity both in terms of the number of licenses and access to specific statistical rectangles. This fleet is too heavily impacted by regulatory aspects to be retained as a reference fleet.

2.3. Applied to vessels using set gillnet (GNS) in Subarea 7

Vessel typology using technical characteristics and evolution of average LPUE for each cluster –set gillnets (GNS)

Implementation of Agglomerative Hierarchical Clustering (AHC) on the technical characteristics accounting for the variability of LPUE (vessel length and gauge) allows distinguishing three clusters (Figure 14; characteristics displayed in Table 8).

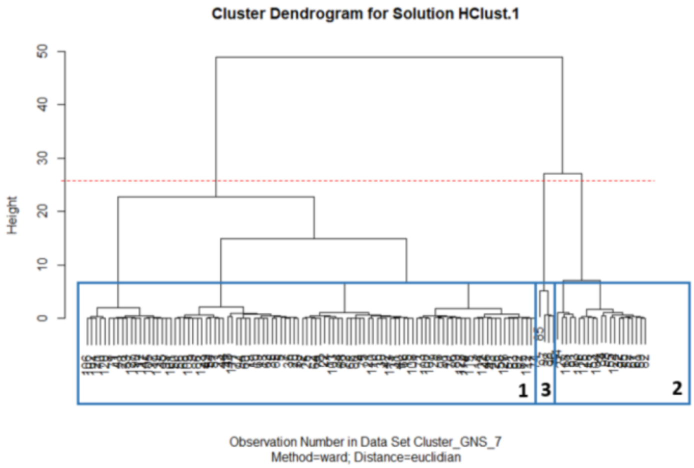


Figure 14: AHC of vessels using GNS in Subarea 7 according to their technical characteristics – vessel length and gauge (standardized) (red line: visual cut)

Table 8: Values of technical characteristics per cluster for vessels using GNS in Subarea 7

Cluster		Vessel length (m)			Gauge (grt)			Engine power (kW)		
Code	Number	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
1	103	5.2	7.8	10.2	0.5	3.8	8.6	7	72	177
2	21	10.0	11.2	13.1	7.3	13.4	31.0	61	141	275
3	4	15.4	16.8	19.4	59.4	72.6	105.0	191	272	336
Total	128									

For each candidate cluster, changes in landing average calculated by month and by year are shown in Figure 15. Clusters 1 and 2 display relatively similar activity from 2015 onwards, while at the start of the period, Cluster 1 is marked by occasionally high levels. There is almost no data for cluster 3.

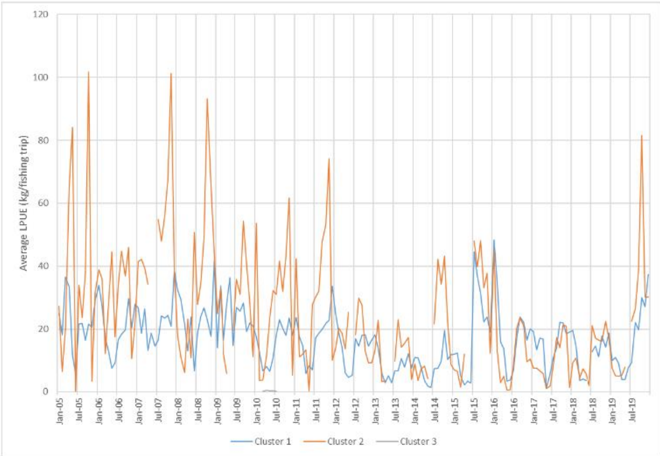


Figure 15: Average LPUEs of striped red mullet per cluster of vessels using GNS in Subarea 7

The catches distribution by statistical rectangle for Clusters 1 and 2 over the period 2005-2019 presents a concentration of catches in 7E at the Brittany extremity, with three rectangles accounting for 90% of catches (Figure 16). These statistical rectangles extend the statistical rectangles that concentrate a large proportion of the Bay of Biscay's catches.

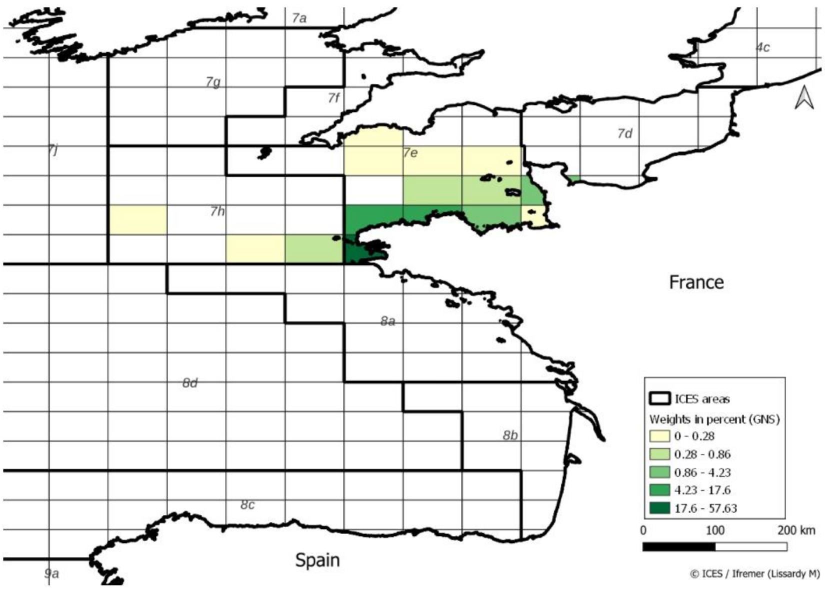


Figure 16: Distribution (in percentages) of gillnetters (GNS) – clusters 1 and 2 - between 2005 and 2019 in Subarea 7

Summary

No indicator of striped red mullet abundance from vessels using gillnets in Subarea 7 is proposed. Instead, it might be worthwhile reworking these data by integrating them with those for Subarea 8, in order to build a "gillnet" indicator for Subareas 7-8.

2.4. Applied to vessels using set gillnet (GNS) in Subareas 7-8

Vessel typology using technical characteristics and evolution of average LPUE for each cluster –set gillnets (GNS)

Implementation of Agglomerative Hierarchical Clustering (AHC) on the technical characteristics accounting for the variability of LPUE (vessel length, gauge and engine power) allows distinguishing three clusters (figure 17; characteristics displayed in Table 9).

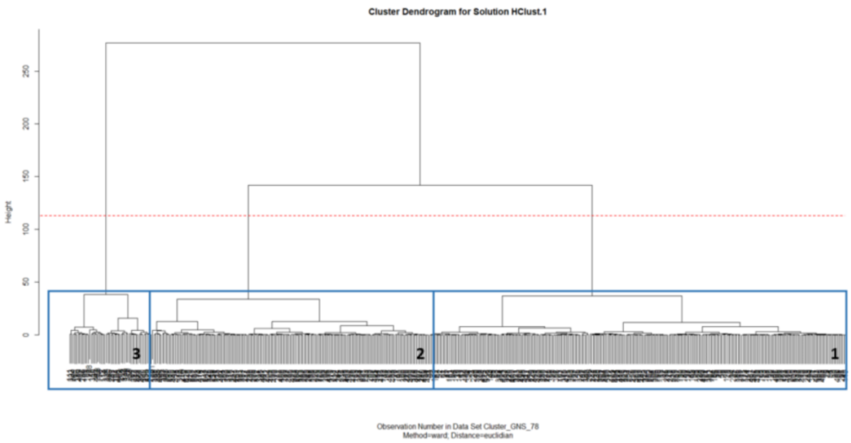


Figure 17: AHC of vessels using GNS in Subareas 7-8 according to their technical characteristics – vessel length, gauge and engine power (standardized) (red line: visual cut)

Table 9: Values of technical characteristics per cluster for vessels using GNS in Subareas 7-8

Cluster		Vessel length (m)			Gauge (grt)			Engine power (kW)		
Code	Number	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
1	253	4.2	7.7	10.2	0.4	3.7	22.3	4	63	124
2	168	7.5	10.8	14.8	2.0	11.4	31.0	70	151	525
3	50	15.1	19.3	30.3	32.4	104.4	195.0	152	310	558
Total	471									

For each candidate cluster, changes in landing average calculated by month and by year are shown in Figure 18. Clusters 1 and 2 show relatively similar activity, with cluster 2 generally showing higher values. Cluster 3 is characterized by breaks in the data series, with high peaks in the first half of the period followed by low levels in the second half. The highest levels are mainly observed around May or June, although this seems less evident in the second half of the period.

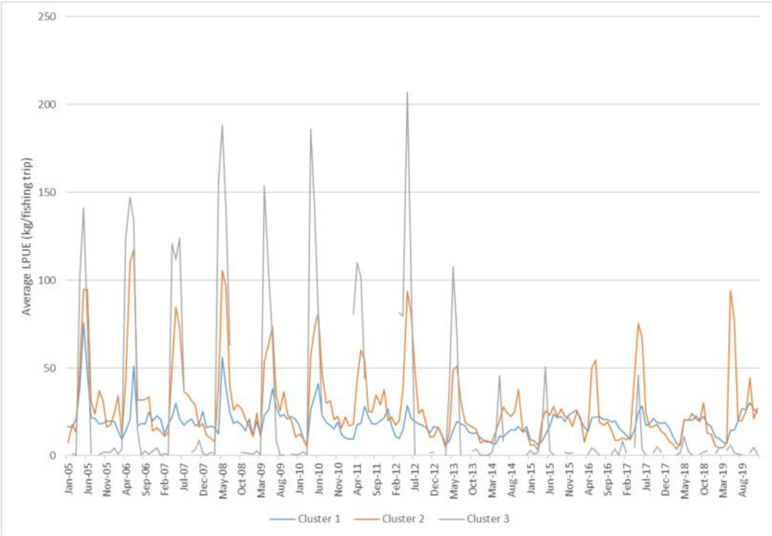


Figure 18: Average LPUEs of striped red mullet per cluster of vessels using GNS in Subareas 7-8

In the Subarea 8 (Figure 19) and for each cluster, the average LPUE is very similar to that observed for the entire zone comprising Subareas 7 and 8.

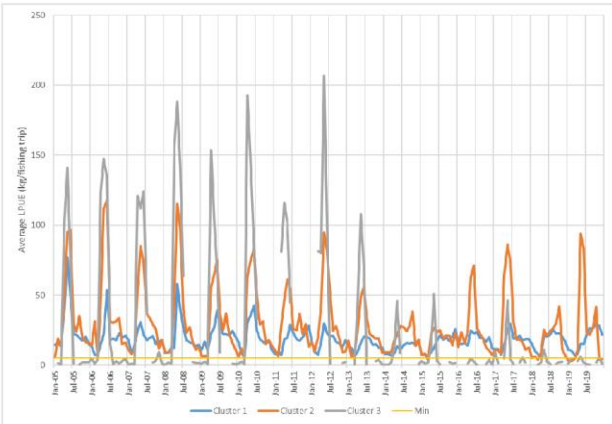


Figure 19: Average LPUEs of striped red mullet per cluster of vessels using GNS in Subarea 8

In the Subarea 7 (Figure 20), and for clusters 1 and 2 overall, seasonality is much less marked than in zone 8. The beginning of the period is marked by strong variations; the second period seems a little more synchronized in terms of seasonality for clusters 1 and 2. There is very little data for cluster 3 in this subarea.

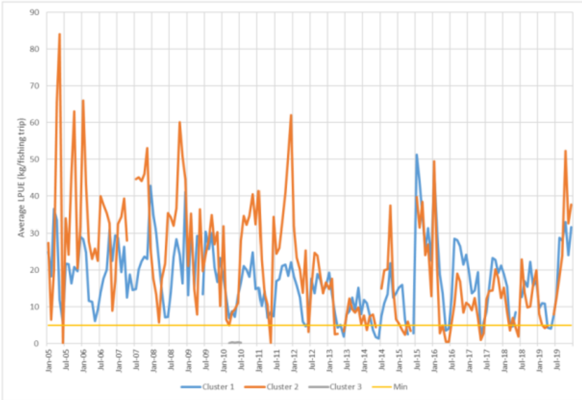


Figure 20: Average LPUEs of striped red mullet per cluster of vessels using GNS in Subarea 7

LPUE levels differ according to the technical characteristics of the vessels. The trend in average catch levels is the most cyclical, with no interruption for clusters 1 and 2 for the entire zone comprising Subareas 7 and 8.

Cluster selection with a multicriteria approach

Ttable 10 summarizes the results following the application of the madatory and optional conditions on the data series.

Table 10: Classification of clusters for GNS in Subareas 7-8

Multi-criteria selection method				
Level of obligation	Vessel typology (technical characteristics)	Cluster 1	Cluster 2	Cluster 3
Mandatory	Sufficient number of vessels (> 10)	X	X	X
	Long data series (> 12 years)	X	X	
	LPUE levels medium to high (> 5 kg/UE) over the period	X (19)	X (29)	(28)
Optional	Stable seasonal signal (both in amplitude and periodicity) during the series	1/3	2/3	
	Activity present in N and S of the zone comprising Subareas 7 and 8	2/3	2/3	
	Moderate seasonal variability	2/3	1/3	
Note		5/9	5/9	
Intra engin		1	1	

The points system ranks clusters 1 and 2 ex aequo. Compared with the average LPUE of cluster 1 in Subarea 7, those of cluster 2 in Subarea 7 seem to show seasonal trends closer to those observed for Subareas 7-8 as a whole. In addition, discussions in the Reference Fleets WG also highlighted the fact that Cluster 1 comprises small, polyvalent vessels (which are therefore likely to use the line or other gear as well). These factors lead us to choose Cluster 2 for GNS. The vessels in this cluster have an average size of 10.8 m (between 7.5 and 14.8 m), an average gauge of 11.4 grt (between 2.0 and 31.0 grt) and an average power of 151 kW (between 70 and 525 kW). The following analyses therefore refer solely to this cluster.

Study of mesh sizes and seasonal variations in LPUE for Gillnet Cluster 2 (GNS)

Mesh sizes were considered according to several criteria: representativeness of the landing levels, continuity of use and a sufficient number of uses. The mesh size class greater than 90 mm is the most used over the period, although it is mainly the 100 mm mesh size (Figure 21). The other mesh size classes heavily used are 50-59 mm and 60-69 mm.

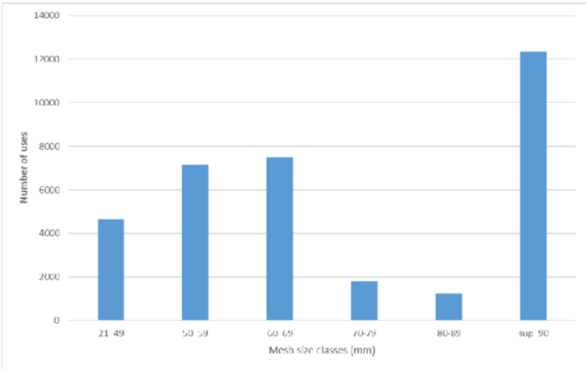


Figure 21: Number of mesh uses between 2005 and 2019 for Cluster 2 - Gillenet (GNS) - Subareas 7-8

Figure 22 shows the monthly evolution of LPUE for the three main meshes of cluster 2 (50-59 mm, 60-69 mm and above 90 mm).

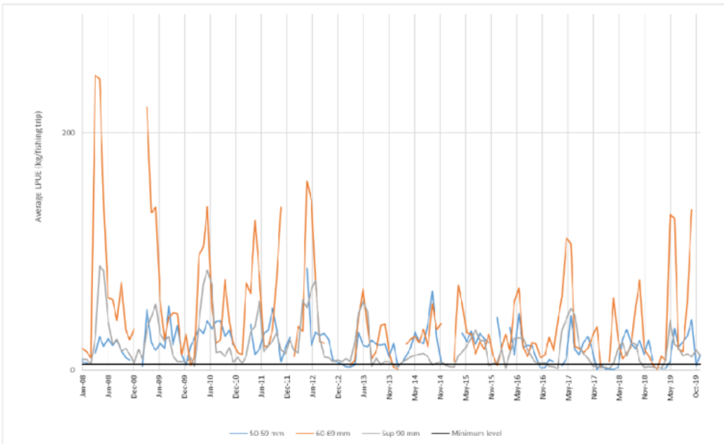


Figure 22: Monthly evolution of LPUE for the main mesh sizes used by Cluster 2 - Gillnet (GNS) - Subareas 7-8

For the criteria considered (Table 11), the three mesh size classes 50 - 59, 60 - 69 mm and above 90 mm are seen as interesting for gillnet. However, the presentation of these results to the WG Reference Fleets highlights the need to handle information on the class above 90 mm with care. In this case, there may be a problem with the accuracy of declarations for striped red mullet. For a single gear declared in the logbook (*e.g.* GNS with 100 mm mesh), some 50 mm mesh nappes targeting striped red mullet may have been used.

Table 11: Mesh size results for Cluster 2 - Gillnet (GNS) - Subareas 7-8

	Proposed mesh size selection(s)		
Métier	Gillnet		
Cluster	2		
Mesh size (mm)	50-59	60-69	Sup 90
Sufficient LPUE level	X	X	X
Availability over a long period	X	X	X
High number of uses	X	X	X
Limited confidence interval		(X)	(X)
Proposed mesh size	Oui	Oui	Oui
Quarterly study	T3	T2	T2

For the 50-59 mm mesh class for GNS cluster 2, LPUE displays low LPUE in the first quarter then higher. The highest levels are observed in September and October. Confidence intervals are particularly wide for many months, particularly in May (Figure 23).

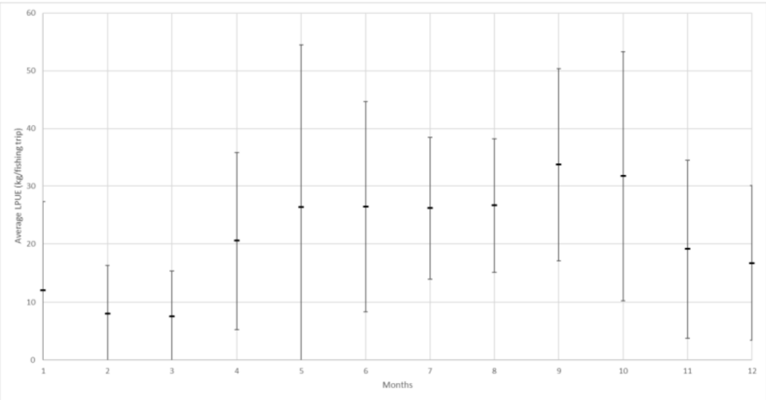


Figure 23: Average LPUE (with CI) per month over the period 2005-2019 for Cluster 2 - Gillnet for mesh size class 50-59 mm – Subareas 7-8

The 60 - 69 mm mesh size class displays high LPUE from April to June. Confidence intervals around the mean are widest between April and June (Figure 24).

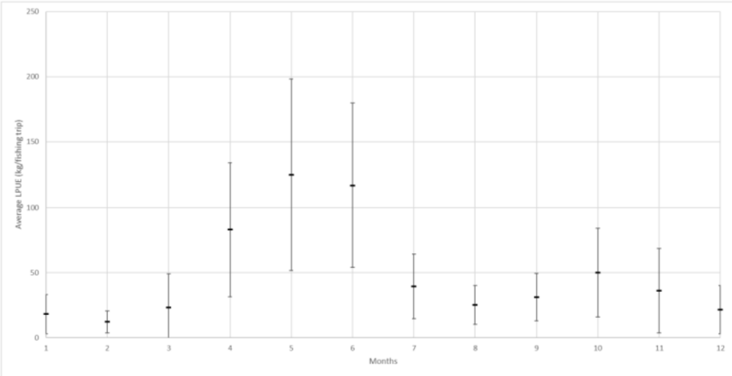


Figure 24: Average LPUE (with CI) per month over the period 2005-2019 for Cluster 2 - Gillnet for mesh size class 60-69 mm – Subareas 7-8

Mesh sizes larger than 90 mm have high LPUE in April, May, June and July. Confidence intervals around the mean are widest between May and July (Figure 25).

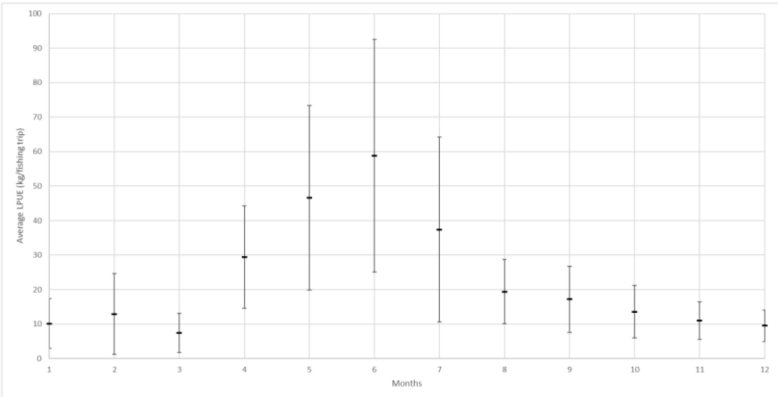


Figure 25: Average LPUE (with CI) per month over the period 2005-2019 for Cluster 2 - Gillnet for mesh size class above 90 mm – Subareas 7-8

For gillnets (GNS), a selection of quarters appears necessary: quarter 3 for the 50 - 59 mm mesh class (quarter 2 having particularly wide confidence intervals), quarter 2 for the 60-69 mm and over 90 mm mesh classes.

Number of uses and LPUE levels per year

For cluster 2 - GNS with a 50-59 mm, 60-69 mm and above 90 mm gear mesh size classes, and for selected quarters, the evolution of their respective uses over time and of the LPUEs for the Subareas 7-8 are considered.

The number of uses of the 50-59 mm mesh class in quarter 3 for GNS cluster 2 remains at a fair level of uses (around 250) up to 2019, then presents a lower level. The level of average LPUE does not display any significant trend over the period (Figure 26).

The number of uses of the 60-69 mm mesh class in quarter 2 for GNS cluster 2 shows a downward trend over the period. The level of average LPUE is marked by low levels in 2014, 2015, 2016 and 2018. The highest levels are observed at the beginning of the period (Figure 27).

The number of uses of the mesh sizes above 90 mm in quarter 2 for GNS cluster 2 also displays a downward trend over the period. The level of average LPUE is again marked by low levels in 2014, 2015, 2016 and 2018. The highest levels are observed at the beginning of the period (Figure 28). It should also be remembered that discussions at the WG Reference Fleets alerted us to the precautions to be taken when using data for this mesh size and for striped red mullet (see p21 above).

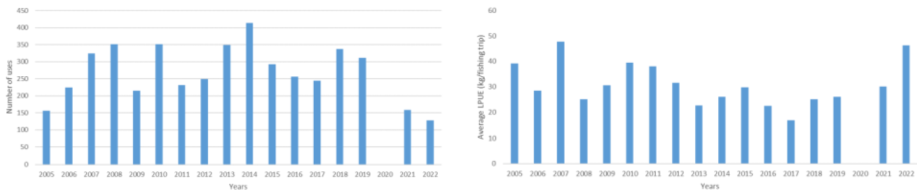


Figure 26: Number of uses and associated average LPUE levels for Subareas 7-8 - Gillnet - cluster 2 - mesh size class 50-59 mm - Quarter 3

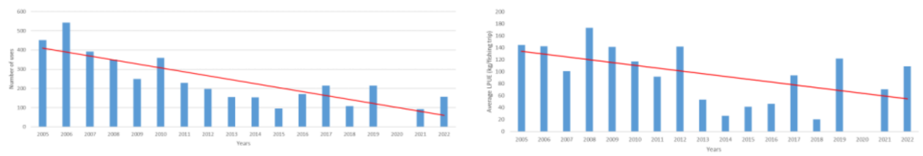


Figure 27: Number of uses and associated average LPUE levels for Subareas 7-8 - Gillnet - cluster 2 - mesh size class 60-69 mm - Quarter 2

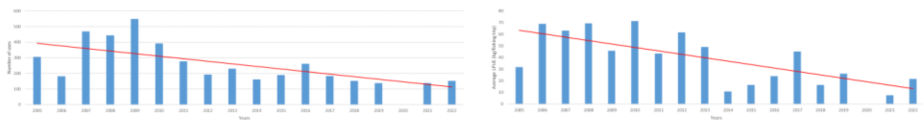


Figure 28: Number of uses and associated average LPUE levels for Subareas 7-8 - Gillnet - cluster 2 - mesh sizes above 90 mm - Quarter 2

Summary

The downward trend in the number of uses observed for all the mesh size classes (recently for 50-59 mm, all along the period for 60-69 mm and above 90 mm), and the above alert for mesh sizes above 90 mm, lead us to be very careful if using a GNS reference fleet. The first one, sub-cluster GNS - cluster 2, using mesh sizes 50-59 mm in quarter 3, may be used if its number of uses increases again.

3. Discussion of the relevance of applying the method to the area comprising Subareas 7 and 8 for Danish seine, trawl and gillnet.

The use of the Danish seine appears too different between Subareas 7 and 8 (vessel length, seasonality, etc.) to be relevant to define a single reference fleet for Subareas 7 and 8. Moreover, in Subarea 8, activity is fairly homogeneously distributed throughout the zone, whereas in Subarea 7, significant activity is found at the eastern limit of the stock's spatial extent.

For vessels using OTB, there is no interest in reworking Subarea 7 data by integrating them with OTB data from Subarea 8 to build a "bottom otter trawl" indicator for Subareas 7-8. The reason for this is that a significant proportion of catches come from the eastern limit of the mur-west stock boundary zone, and interactions with the mur.27.3a47d stock cannot be excluded.

For vessels using GNS, there was an interest in reworking the data by integrating those from Subarea 7 with those from Subarea 8 to build a "gillnet" Subareas 7-8 indicator. The reason for this is that the catches in Subarea 7 are highly localized, and the statistical rectangles in question extend the statistical rectangles that account for a large proportion of the catch in the Bay of Biscay. This work has led us to propose a sub-fleet for GNS in Subareas 7-8 even if attention must be paid to its use.

Acknowledgments

This work is part of the ACOST project that is funded by FFP (France Filière Pêche) on the call for « Future issues » projects. The authors are grateful to the representatives of producers' organizations, fisheries committees and Aglia for their participation to the Working Groups (WG) "Reference Fleets" of the ACOST project.

References

Caill-Milly, N., 2023. De la collecte des données à l'appropriation des résultats par les utilisateurs – contribution à l'amélioration des connaissances sur les ressources exploitées et d'intérêt pour les navires de Nouvelle-Aquitaine. Mémoire d'HDR en préparation. UPPA, 103 p.

Caill-Milly, N., Lissardy, M., Bru, N., 2020. Suites du projet ROMELIGO : mise à jour des indices issus de CPUE et premier pas vers l'intégration des résultats du projet dans le processus d'émission des avis du CIEM. DPMA - Direction des Pêches Maritimes & de l'Aquaculture, Sous-direction des ressources halieutiques, Bureau de l'appui scientifique et des données, La Défense, Ref. DG/2020.282 - n°19-015164 du 24 décembre 2019, 4p., 2p., 19p.https://archimer.ifremer.fr/doc/00615/72732/

Caill-Milly, N., Lissardy, M., Bru, N., Dutertre, M.-A., Saguet, C., 2019. A methodology based on data filtering to identify reference fleets to account for the abundance of fish species: Application to the Striped red mullet (*Mullus surmulletus*) in the Bay of Biscay. Continental Shelf Research, 183, 51-72. Publisher's official version: https://doi.org/10.1016/j.csr.2019.06.004, Open Access version: https://archimer.ifremer.fr/doc/00503/61495/

Demanèche, S., Bégot, E., Gouëllo, A., Campéas, A., Habasque, J., Merrien, C., Leblond, E., Berthou, P., Harscoat, V., Fritsch, M., Leneveu, C., and Laurans, M., 2013. PROJET SACROIS « IFREMER / DPMA » V 3.2.5 - 11/2013. 43 p.

ICES, 2023a. ICES Stakeholder Engagement Strategy. Version 01. ICES Guidelines and Policies. 12 pp. https://doi.org/10.17895/ices.pub.21815106

ICES. 2023b. Workshop on Implementation of Stakeholder Engagement Strategy (WKSTIMP). ICES Scientific Reports. 5:77. 68 pp. https://doi.org/10.17895/ices.pub.23507958

Léauté, J.-P., Caill-Milly, N., Lissardy, M., Bru, N., Dutertre, M.-A., Saguet, C., 2018. ROMELIGO. Amélioration des connaissances halieutiques du ROuget-barbet, du MErlan et du LIeu jaune du GOlfe de Gascogne. RBE/HGS/LRHLR et ODE/UL/LERAR/18-001. https://archimer.ifremer.fr/doc/00440/55126/

Macher, C., Caill-Milly, N., Rollet, C., 2022. Collaborations Scientifiques-Acteurs. Résultats de l'enquête 2020. Panorama et retours d'expériences. Projet PARTAGE.

Versions Sacrois utilisées : V.3.3.11 en janvier 2022 et V.3.3.12 à partir de mars 2023.

Appendixes

Appendix 1

Details of COPIL and GT ACOST reference fleets, with focus on striped red mullet

Date	Designation	Items presented/discussed	Decisions
11/03/2021	COPIL 1	* Scheduled approach for the ACOST project (data, tools, etc.) on striped red mullet * Dedicated WG Reference Fleets announced	
22/11/2021	WG Reference Fleets 1	* Detection of outlier data for trawls, gillnets and Danish seines in Subareas 7 and 8 * OBSMER SDN data in Subareas 7 and 8 * Update of LPUE for OTB and GNS fleets identified during the ROMELIGO project * Application of the "ROMELIGO" method to Danish seines in Subareas 8 and 7, interest in an index for Subareas 7+8?	* For the selected clusters, further analysis of 6 trips identified as outliers for final decision. * Verification of the use of 100 mm mesh in Subarea 8 for Danish seine* * For SDN Subarea 8, look at what the results would be if 70-80 mm meshes were grouped together
09/06/2022	COPIL 2 and WG Reference Fleets 2	* Further data cleaning for the 3 gears * Verification of 100 mm mesh sizes in Subareas 8 for Dansih seine * Application of the ROMELIGO method in Subarea 7 for trawl and gillnet and interest in building an index for Subareas 7 + 8 for trawl and gillnet * First tests of decomposition methods (season, trend) and generalized additive models (GAMs)	* The 6 trips were eliminated from the data set * For the next WG Reference Fleets : - look at what the results would be if the 70-80 mm meshes in zone 8 were grouped together; - test the method on gillnets in Subareas 7+8
23/11/2022	WG Reference Fleets 3	No red mullet element presented - GT dedicated to whiting and pollack	
02/02/2023	WG Reference Fleets 4	No red mullet element presented - GT dedicated to whiting and pollack	
28/03/2023	COPIL 3	* Brief review of work presented at the WG Reference Fleets 1 and 2 regarding striped red mullet * Start of the model-based method (first handling of data with presentation of first descriptive analyses)	
06/06/2023	WG Reference Fleets 5	* Presentation of all that has been done on the selection of reference fleets by data-filtering for discussion and validation. * Presentation of the work in progress regarding LPUE	* Rework the section describing collaboration with professional structures, based on the work of C. Macher and the ICES "Stakeholder

		standardization by modeling, as part of the Master 2 internship on the subject. The aim was to validate the filters used, answer any methodological questions and explain the work still to be done. In both cases, a document was prepared and sent to all participants prior to the WG.	Engagement Strategy" approach. * Redo the analyses leading to the selection of fleets by integrating 2021 and 2022 and see if this would have changed the results. * Addition of regulatory elements provided by professional structures and useful for analysis and interpretation. * Checking of the vessels having worked with the Danish seine in Subarea 8 (the POs concerned send a list of vessels).

Appendix 2

SDN – preliminary stage and step 1 – Figures and tables

Analysis of discards data

- For Subarea 8

Table 1: Distribution of fishing operations observed by the OBSMER program - SDN - Subarea 8 between 2011 and 2021

	1	2	3	4	5	6	7	8	9	10	11	12	Total général
2011					16						26		42
2012	3	5	2		5	5	2		2	2	3	1	30
2013	2			5	8	3	2	2	2	4	2	27	57
2014					5	7	2		4	5	2	2	27
2015			3	5		4		2		3			17
2016	2				11		7	7	3	3	5	2	40
2017			7	1	7	3			5		7	3	33
2018	2			4	14		14		3	9	6	1	53
2019	3			15	4	6	2	4		6	6	3	49
2020		8						3					11
2021					6	8							14
Total général	12	13	12	30	76	36	29	18	19	32	57	39	**373**

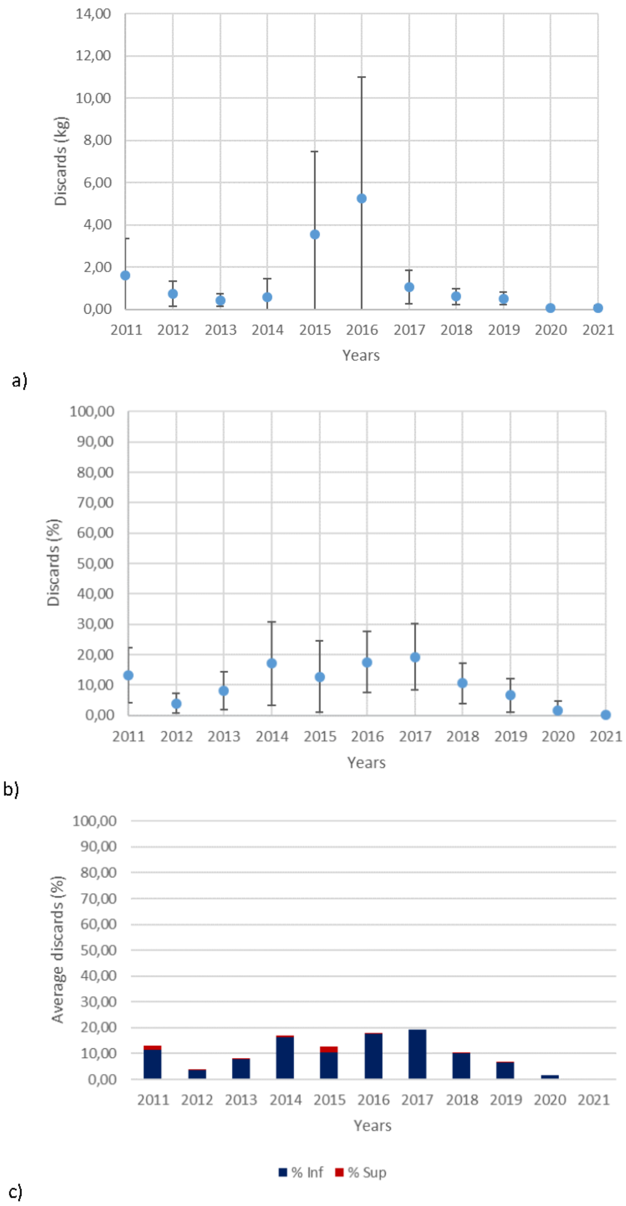
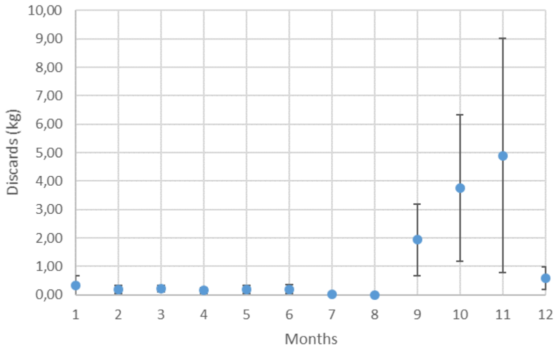
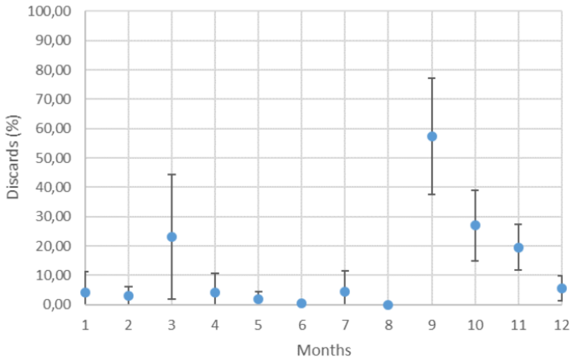


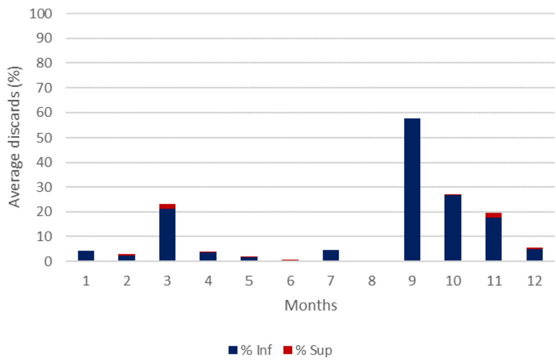
Figure 1: Annual characteristics of discards observed per fishing operation for SDN – Subarea 8: a) mean and standard error in kg; b) mean percentage and its standard error; c) cumulative mean percentage for individuals below and above the minimum commercial weight.



a)



b)



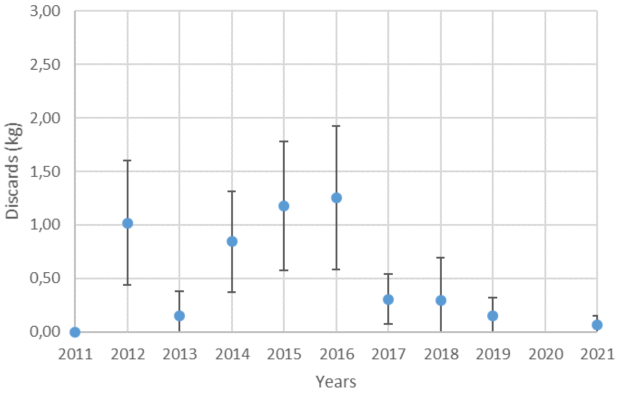
c)

Figure 2: Monthly characteristics of discards observed per fishing operation for SDN – Subarea 8: a) mean and standard error in kg; b) mean percentage and its standard error; c) cumulative mean percentage for individuals below and above the minimum commercial weight.

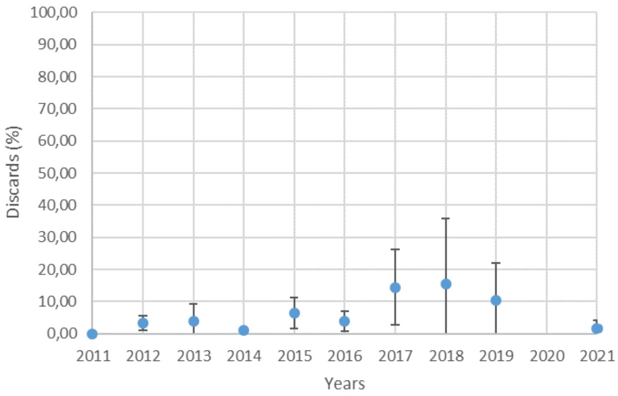
- For Subarea 7

Table 2: Distribution of fishing operations observed by the OBSMER program - SDN - Subarea 7 between 2011 and 2021

	1	2	3	4	5	6	7	8	9	10	11	12	Total général
2011											15		15
2012							37	4			27		68
2013		1	6			5	8						20
2014			11	9				1		18			39
2015		9		19	4		12			6	21		71
2016	25			17						24			66
2017	11			9							3	12	35
2018							2	7		4			13
2019		6				8			4				18
2020	Pas de données												
2021				2					6				8
Total général	36	16	17	56	4	13	59	12	10	52	66	12	**353**



a)



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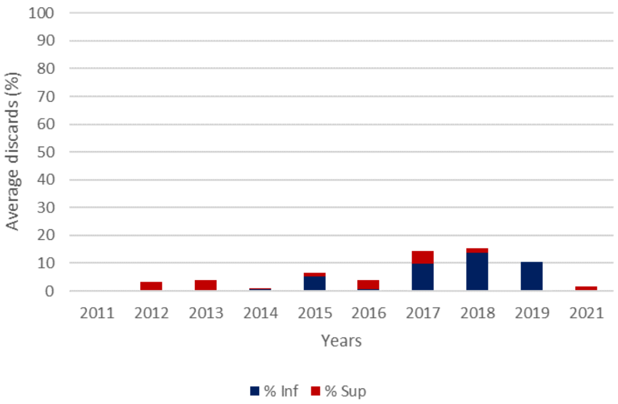
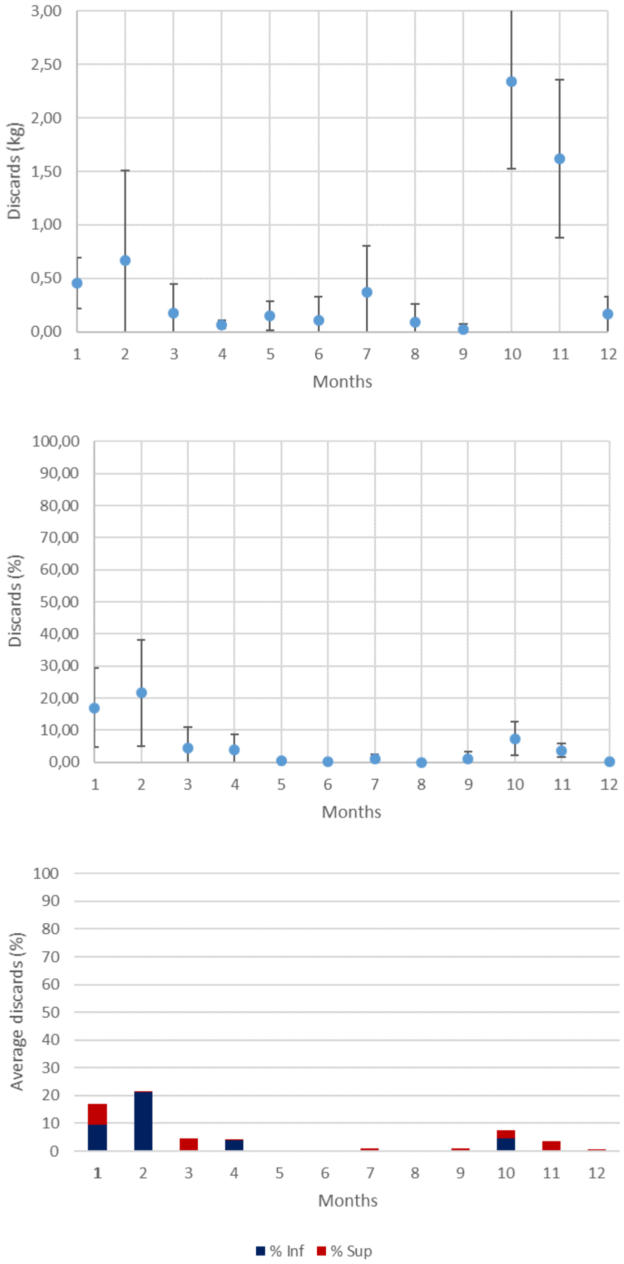


c)

Figure 3: Annual characteristics of discards observed per fishing operation for SDN – Subarea 7: a) mean and standard error in kg; b) mean percentage and its standard error; c) cumulative mean percentage for individuals below and above the minimum commercial weight



a)

b)

c)

Figure 4: Monthly characteristics of discards observed per fishing operation for SDN – Subarea 7: a) mean and standard error in kg; b) mean percentage and its standard error; c) cumulative mean percentage for individuals below and above the minimum commercial weight

Analysis of LPUE data for Subarea 8

Search for linear relationships between variables of interest characterizing LPUE, vessel and gear characteristics, and spatio-temporal factors

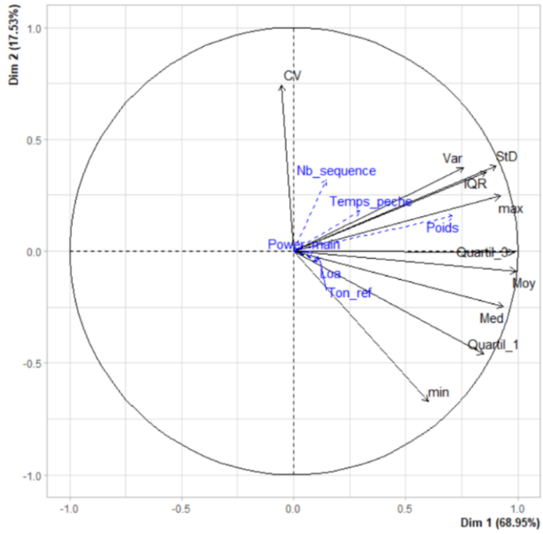


Figure 5: Correlation circle for SDN – Subarea 8 using the first two dimensions

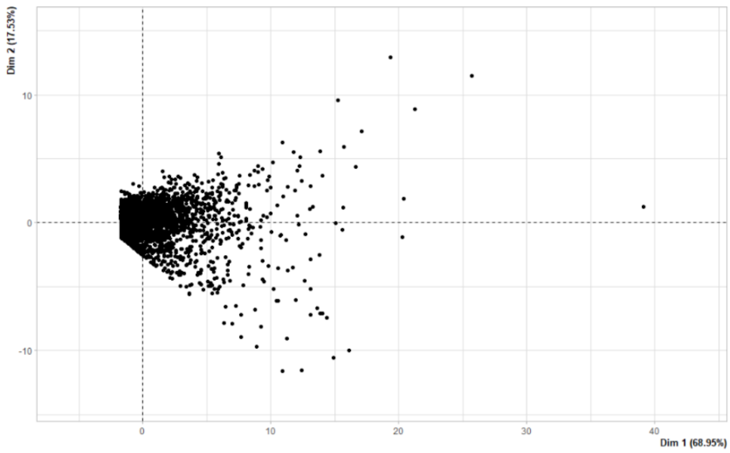


Figure 6: Individuals plot on the first factorial plane of the PCA for the "Danish seine" gear (SDN) - Subarea 8

Figure 7: Barycenter plot of years on the PCA principal factorial plane and associated CAH for the "Danish Seine" gear (SDN) - Subarea 8

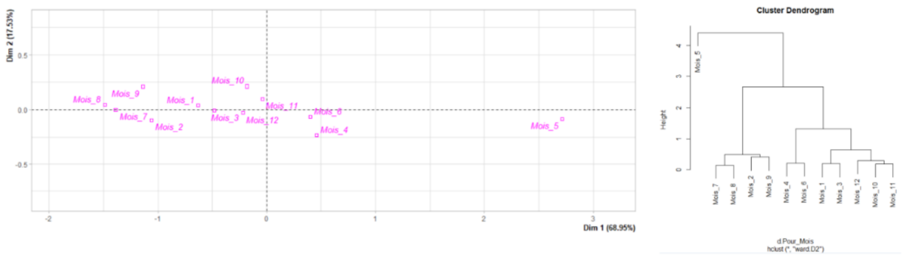


Figure 8 : Barycenter plot of months on the PCA principal factorial plane and associated CAH for the "Danish Seine" gear (SDN) – Subarea 8

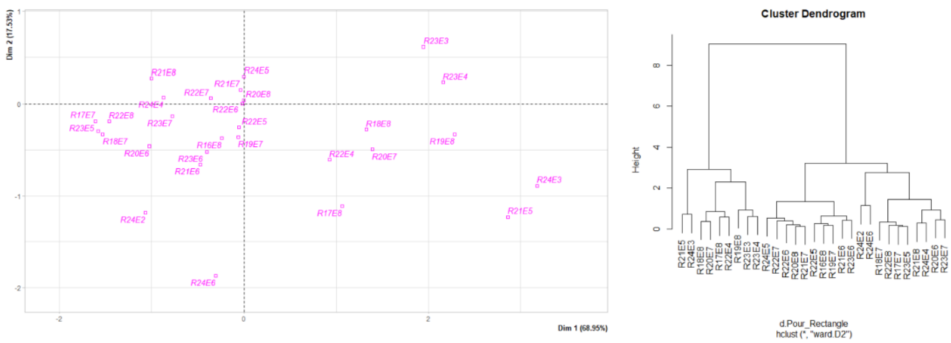


Figure 9: Barycenter plot of statistical rectangles on the PCA principal factorial plane and associated CAH for the "Danish Seine" gear (SDN) - Subarea 8

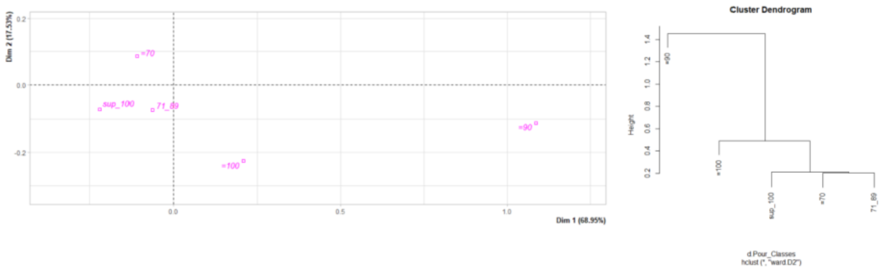
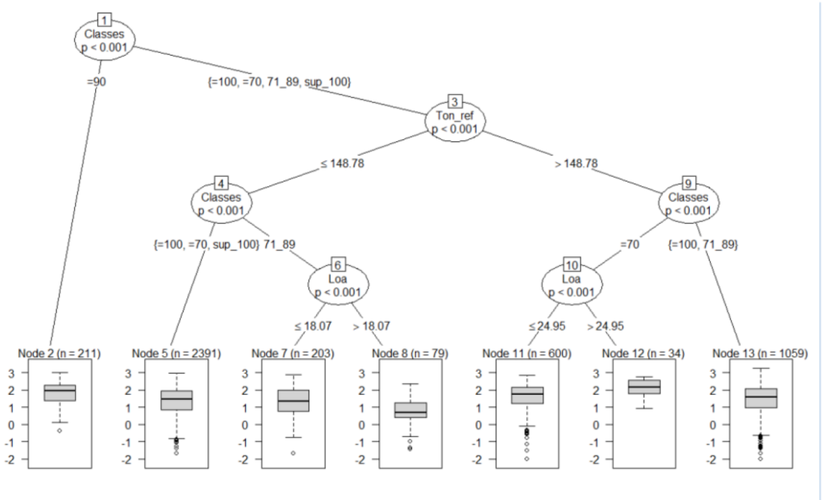


Figure 10: Barycenter plot of mesh size classes on the PCA principal factorial plane and associated CAH for the "Danish Seine" gear (SDN) - Subarea 8

Search for other relationships between variables of interest characterizing LPUE, vessel and gear characteristics, and spatio-temporal factors



Moy	**140**	73	72	19	101	**211**	99
Med	**87**	30	23	5	57	**147**	39
N	211	2391	203	79	600	34	1059

Figure 11: Conditional regression tree on log10Moy (standardized LPUE) with technical characteristics (the values in columns correspond to the values of each node) for SDN - Subarea 8

Analysis of LPUE data for Subarea 8

Search for linear relationships between variables of interest characterizing LPUE, vessel and gear characteristics, and spatio-temporal factors

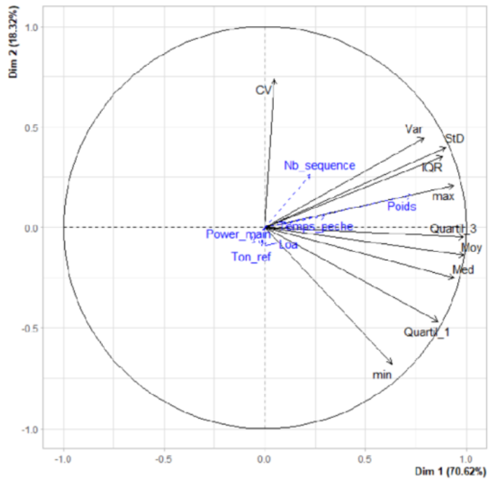


Figure 12: Correlation circle for SDN – Subarea 7 using the first two dimensions

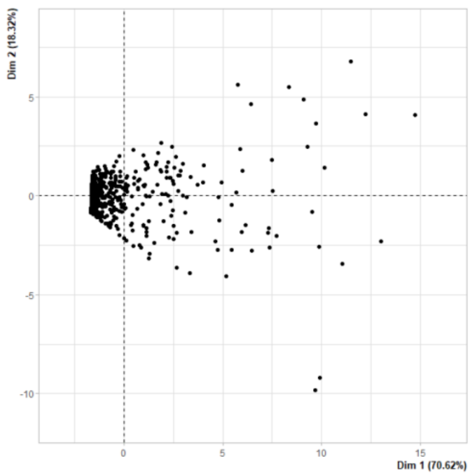


Figure 13: Individuals plot on the first factorial plane of the PCA for the "Danish seine" gear (SDN) - Subarea 7

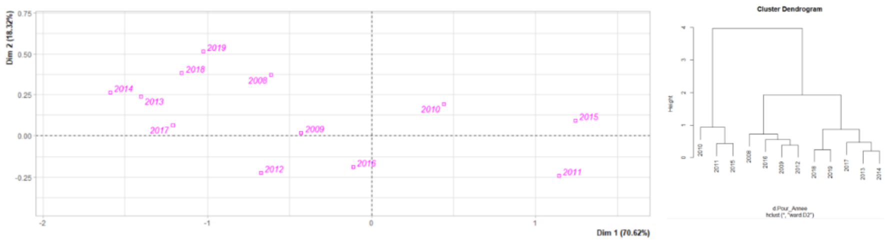


Figure 14: Barycenter plot of years on the PCA principal factorial plane and associated CAH for the "Danish Seine" gear (SDN) - Subarea 7

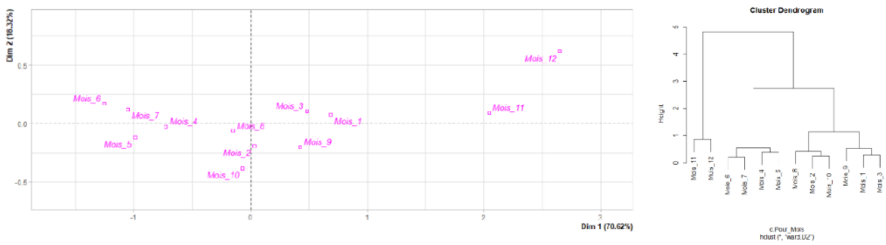


Figure 15: Barycenter plot of months on the PCA principal factorial plane and associated CAH for the "Danish Seine" gear (SDN) - Subarea 7

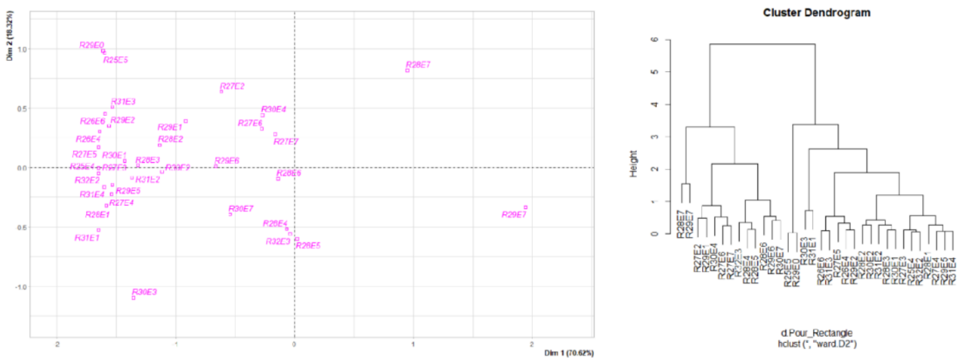


Figure 16: Barycenter plot of statistical rectangles on the PCA principal factorial plane and associated CAH for the "Danish Seine" gear (SDN) - Subarea 7

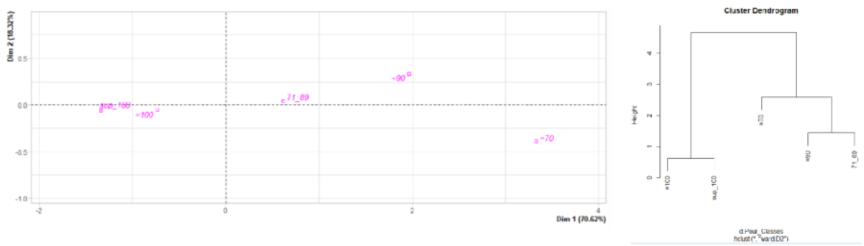
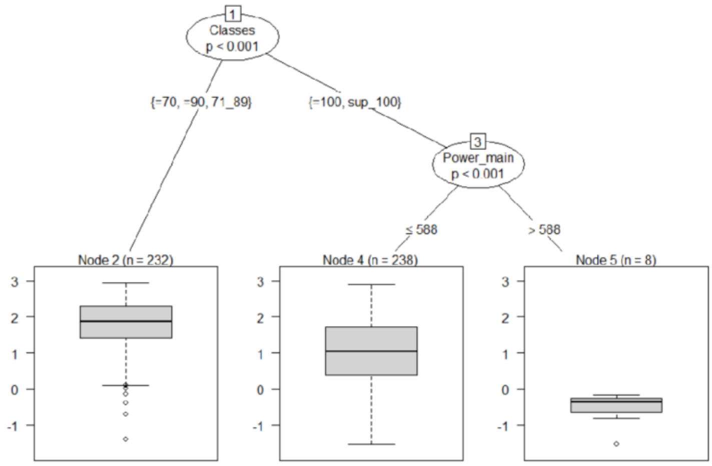


Figure 17: Barycenter plot of mesh size classes on the PCA principal factorial plane and associated CAH for the "Danish Seine" gear (SDN) - Subarea 7

Search for other relationships between variables of interest characterizing LPUE, vessel and gear characteristics, and spatio-temporal factors



Moy	**142**	58	~ 0
Med	**75**	11	~ 0
N	232	238	8

Figure 18: Conditional regression tree on log10Moy (standardized LPUE) with technical characteristics (the values in columns correspond to the values of each node) for SDN - Subarea 7

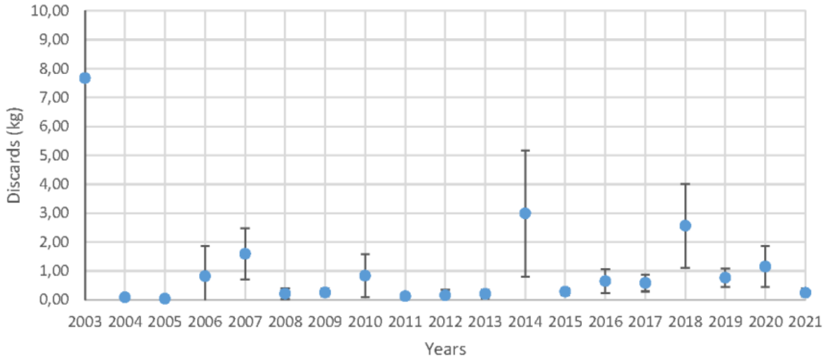
Appendix 3

OTB in Subarea 7 – preliminary stage and step 1 – Figures and tables

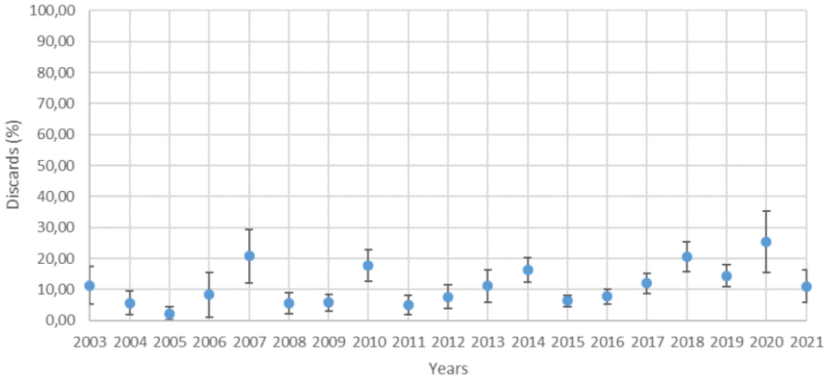
Analysis of discards data

Table 1: Distribution of fishing operations observed by the OBSMER program - OTB - Subarea 7 between 2003 and 2021

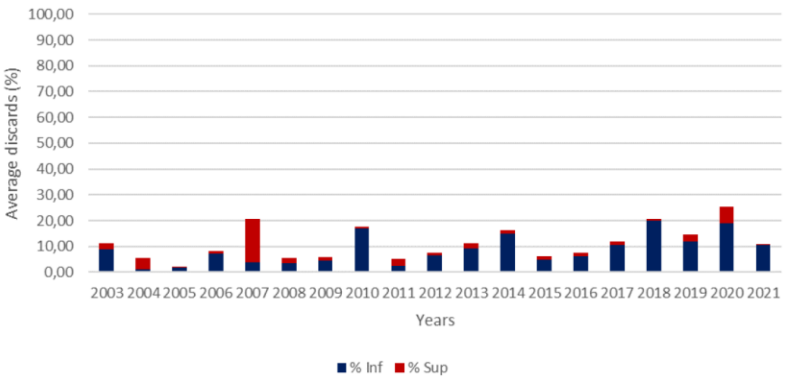
	1	2	3	4	5	6	7	8	9	10	11	12	Total général
2003						2		6	14	27	5		54
2004					2	2	22	46	25	19	14		130
2005					3		25	39	27	33	13	6	146
2006			13	11			6	5		7		4	46
2007					2		9	24		25	11	2	73
2008	3	4		8	1	12	24	10	6	32	14	22	136
2009	14		10	59	46	10	11	13	7	40	24	6	240
2010	19	1		4	13	16	20	31	41	27	5	7	184
2011	2	5	14	19	15	10	26	12	31	22	23	4	183
2012	20	13	12	7	11	7	20	13	34	6	14	3	160
2013		4	3	4	7	8	15	17	20	17	5	5	105
2014	24	8	17	16	13	16	30	19	48	19	23	16	249
2015	10	5	31	20	39	51	43	43	49	46	61	45	443
2016	15	23	15	23	29	35	31	42	41	32	31	44	361
2017	39	33	14	27	13	30	15	23	33	15	11	45	298
2018	7	2	11	3	19	24	11	22	25	37	17	20	198
2019	2	32	26	5	35	15	16	28	55	26	24	19	283
2020	9	16	2				5	4	7		9	8	60
2021	7	14	9	5	7	24	4	12	22				104
Total général	171	160	177	211	255	262	333	409	485	430	304	256	**3453**



a)

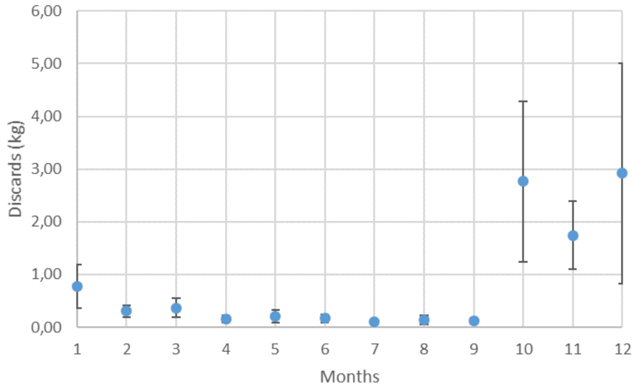


b)

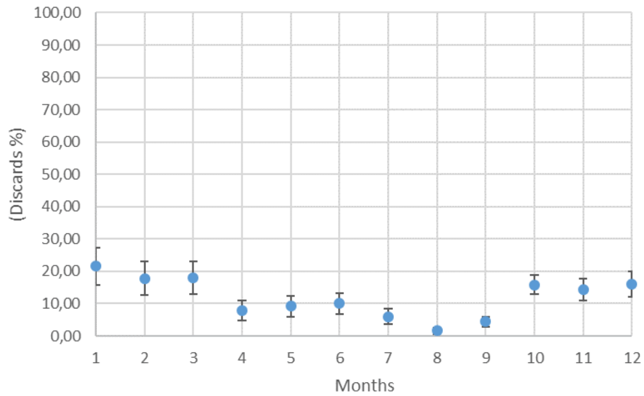


c)

Figure 1: Annual characteristics of discards observed per fishing operation for OTB – Subarea 7: a) mean and standard error in kg; b) mean percentage and its standard error; c) cumulative mean percentage for individuals below and above the minimum commercial weight



a)



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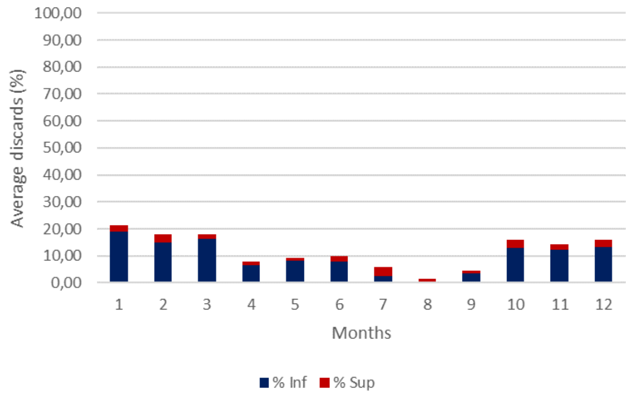


c)

Figure 2: Monthly characteristics of discards observed per fishing operation for OTB – Subarea 7: a) mean and standard error in kg; b) mean percentage and its standard error; c) cumulative mean percentage for individuals below and above the minimum commercial weight

Analysis of LPUE data

Search for linear relationships between variables of interest characterizing LPUE, vessel and gear characteristics, and spatio-temporal factors

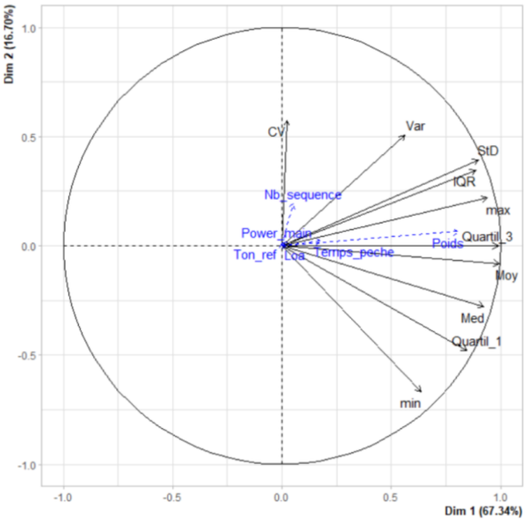


Figure 3: Correlation circle for OTB – Subarea 7 using the first two dimensions

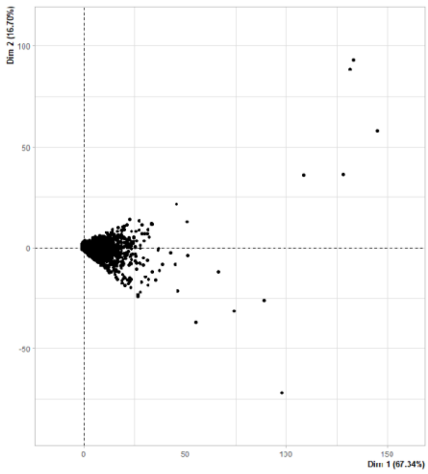


Figure 4: Individuals plot on the first factorial plane of the PCA for the "Bottom otter trawl" gear (OTB) - Subarea 7

Figure 5: Barycenter plot of years on the PCA principal factorial plane and associated CAH for the " Bottom otter trawl " gear (OTB) - Subarea 7

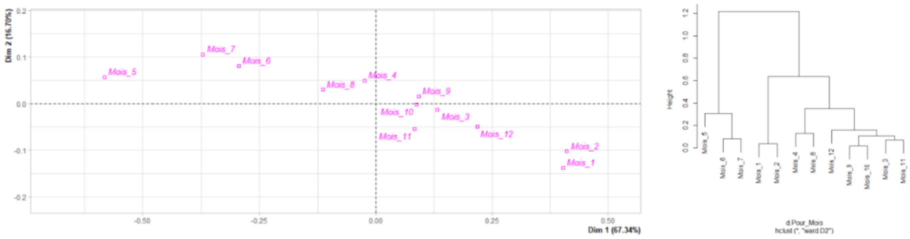


Figure 6: Barycenter plot of months on the PCA principal factorial plane and associated CAH for the " Bottom otter trawl " gear (OTB) - Subarea 7

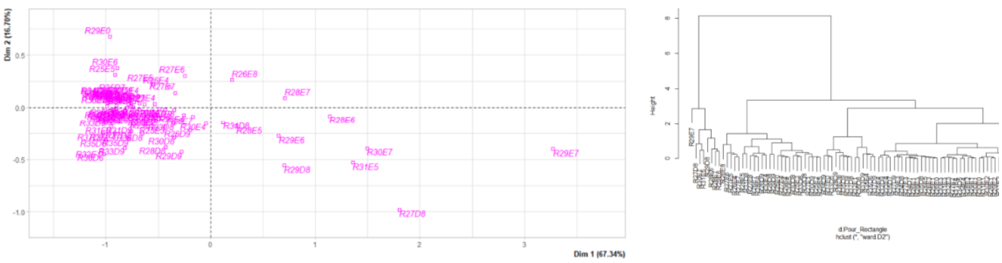


Figure 7: Barycenter plot of statistical rectangles on the PCA principal factorial plane and associated CAH for the " Bottom otter trawl " gear (OTB) - Subarea 7

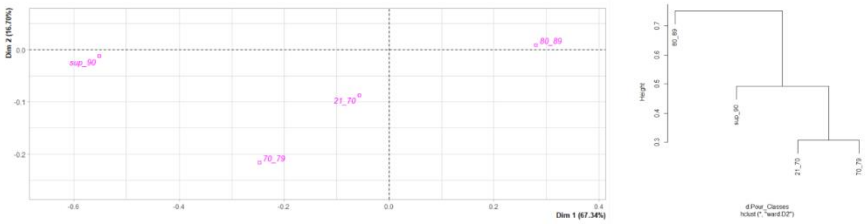
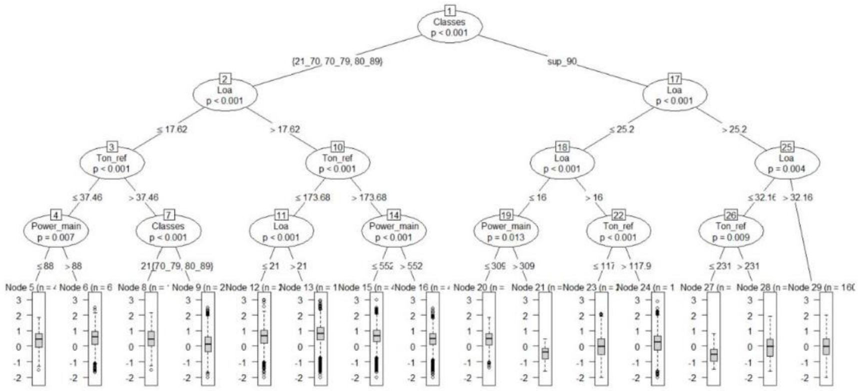


Figure 8: Barycenter plot of mesh size classes on the PCA principal factorial plane and associated CAH for the " Bottom otter trawl " gear (OTB) - Subarea 7

Search for other relationships between variables of interest characterizing LPUE, vessel and gear characteristics, and spatio-temporal factors



Moy	5.6	7.5	8.6	5.6	**11.2**	**15.2**	**11.2**	5.2	5.6	0.6	3.2	4.3	0.6	4.4	3.2
Med	2.8	3.9	2.9	1.3	**4.7**	**6.7**	**4.7**	3.1	3.0	0.4	0.9	1.8	0.3	0.9	0.9
N	412	6118	145	2661	**2570**	**14996**	**4487**	4793	779	13	2321	13084	61	56	1607

Figure 9: Conditional regression tree on log10Moy (standardized LPUE) with technical characteristics (the values in columns correspond to the values of each node) for OTB - Subarea 7

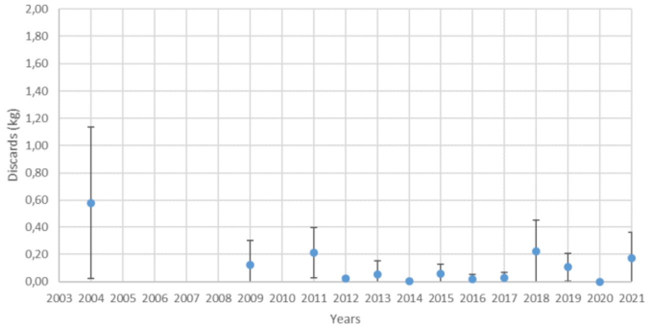
Appendix 4

GNS – preliminary stage and step 1 – Figures and tables

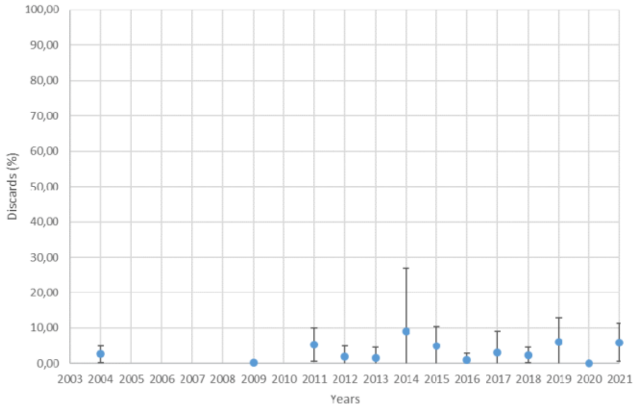
Analysis of discards data

Table 1: Distribution of fishing operations observed by the OBSMER program - GNS - Subarea 7 between 2004 and 2021

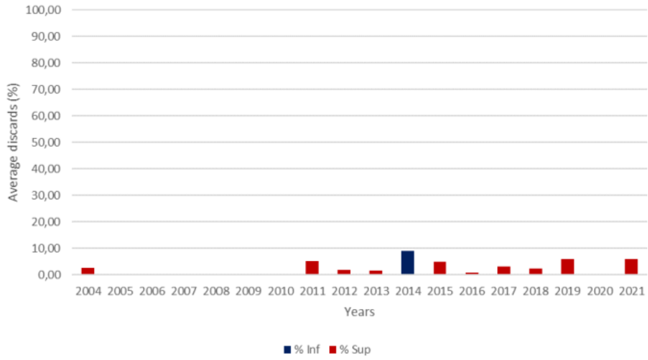
	1	2	3	4	5	6	7	8	9	10	11	12	Total général
2004							9	3				4	16
2007				1									1
2008									1				1
2009								1	2	9			12
2010		1		1									2
2011								4	3	4	9	1	21
2012	6	16	8		1	1	6	12	2	2	10	4	68
2013				2		2	1	5	2		2		14
2014				1			2	2	3	2	1		11
2015	2			1			8		15	16	2	10	54
2016	8	4	6	1				3	2	2	1	6	33
2017	8	4	1		1			7	2	2	9		34
2018	5	4		3			3	6		3	9	1	34
2019		12	2	2			1		9	3	2		31
2020		2					2				10	1	15
2021	1		2				8	17	8				36
Total général	30	43	19	12	2	3	40	60	49	43	55	27	**383**



a)

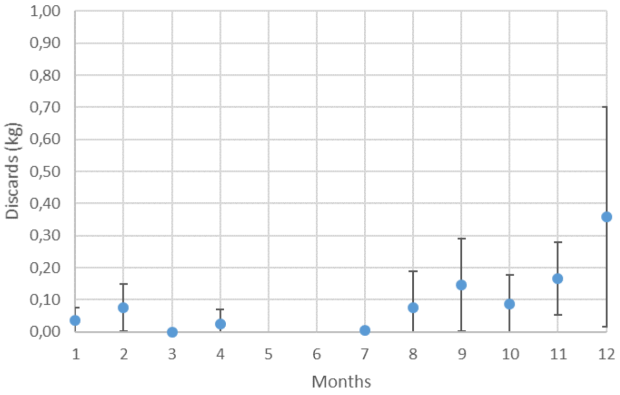


b)

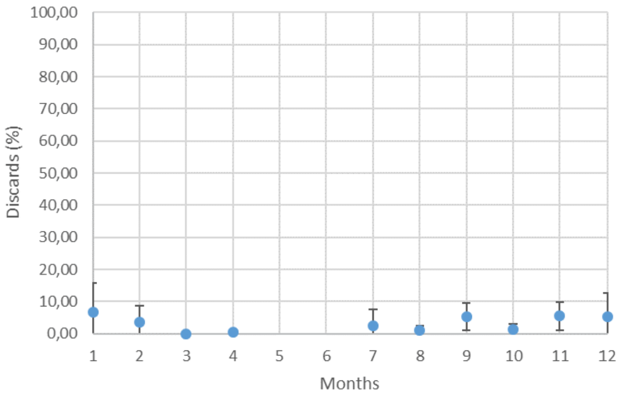


c)

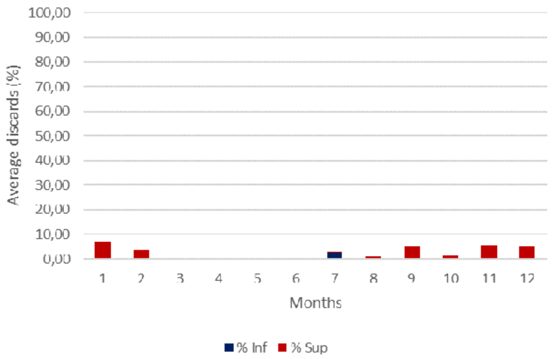
Figure 1: Annual characteristics of discards observed per fishing operation for GNS – Subarea 7: a) mean and standard error in kg; b) mean percentage and its standard error; c) cumulative mean percentage for individuals below and above the minimum commercial weight



a)



b)



c)

Figure 2: Monthly characteristics of discards observed per fishing operation for GNS – Subarea 7: a) mean and standard error in kg; b) mean percentage and its standard error; c) cumulative mean percentage for individuals below and above the minimum commercial weight

Analysis of LPUE data for Subarea 7

Search for linear relationships between variables of interest characterizing LPUE, vessel and gear characteristics, and spatio-temporal factors

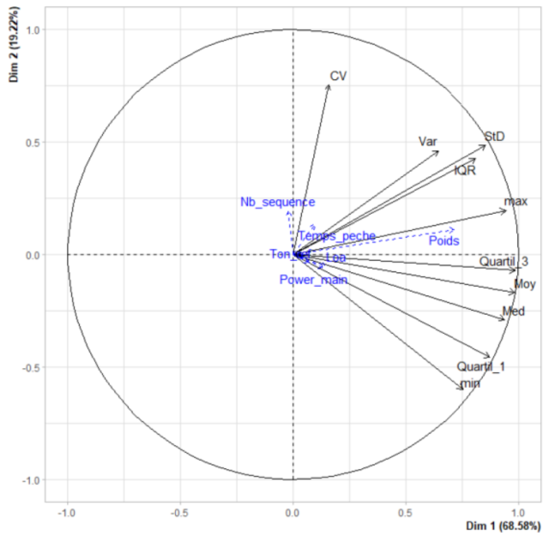


Figure 3: Correlation circle for GNS – Subarea 7 using the first two dimensions

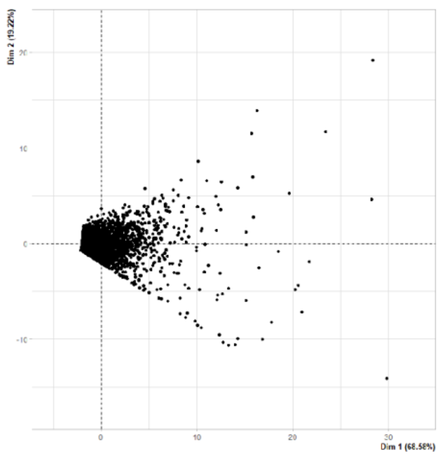


Figure 4: Individuals plot on the first factorial plane of the PCA for the "Gillnet" gear (GNS) - Subarea 7

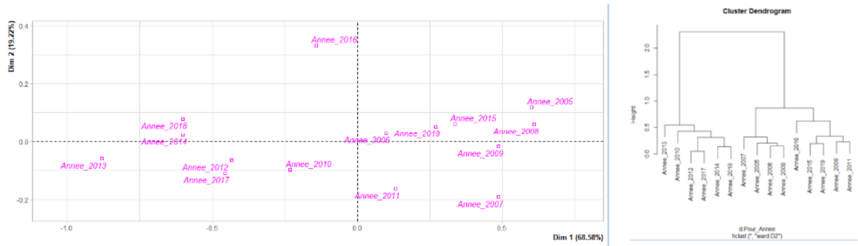


Figure 5: Barycenter plot of years on the PCA principal factorial plane and associated CAH for the " Gillnet " gear (GNS) - Subarea 7

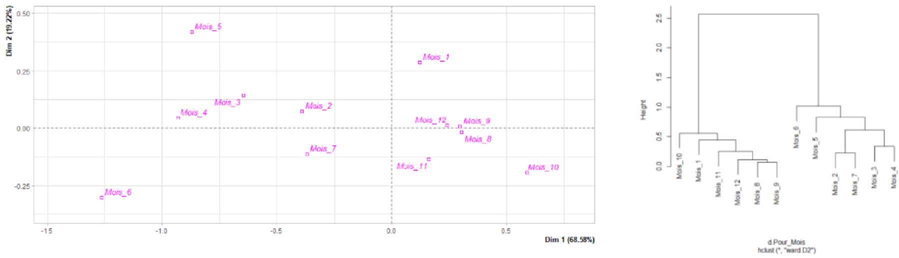


Figure 6: Barycenter plot of months on the PCA principal factorial plane and associated CAH for the " Gillnet " gear (GNS) - Subarea 7

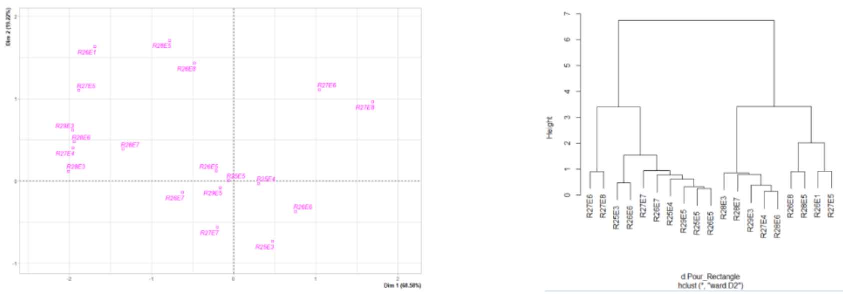


Figure 7: Barycenter plot of statistical rectangles on the PCA principal factorial plane and associated CAH for the " Gillnet " gear (GNS) - Subarea 7

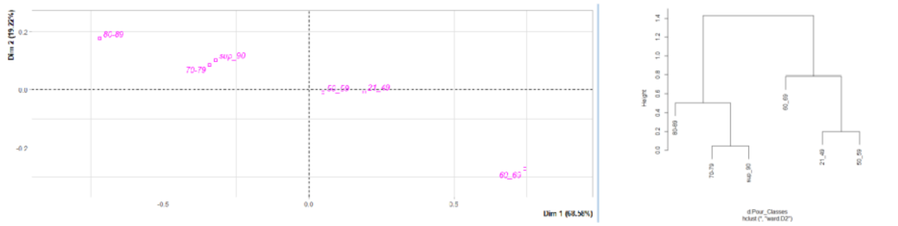
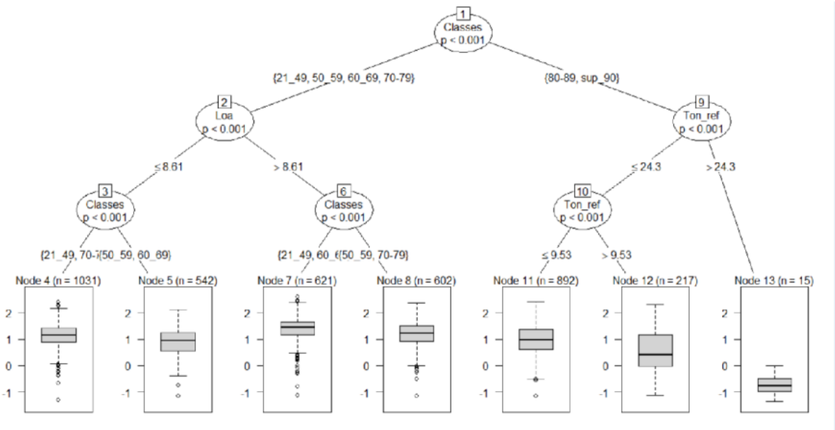


Figure 8: Barycenter plot of mesh size classes on the PCA principal factorial plane and associated CAH for the " Gillnet " gear (GNS) - Subarea 7

Search for other relationships between variables of interest characterizing LPUE, vessel and gear characteristics, and spatio-temporal factors



Moy	20.2	13.6	37.0	25.7	17.6	17.8	0.3
Med	14.0	8.9	27.9	16.0	9.4	2.6	0.2
N	1031	542	621	602	892	217	15

Figure 9: Conditional regression tree on log10Moy (standardized LPUE) with technical characteristics (the values in columns correspond to the values of each node) for GNS - Subarea 7

Analysis of LPUE data for Subareas 7-8

Search for linear relationships between variables of interest characterizing LPUE, vessel and gear characteristics, and spatio-temporal factors

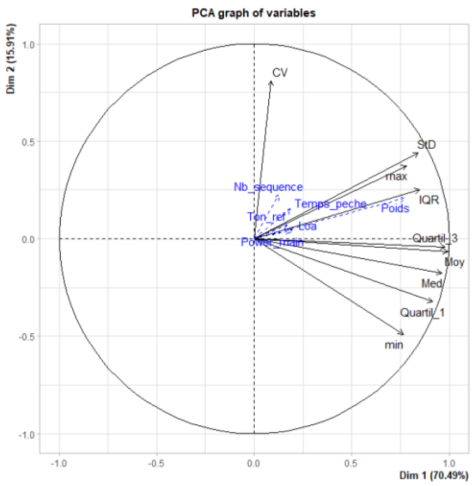


Figure 10: Correlation circle for GNS – Subareas 7-8 using the first two dimensions

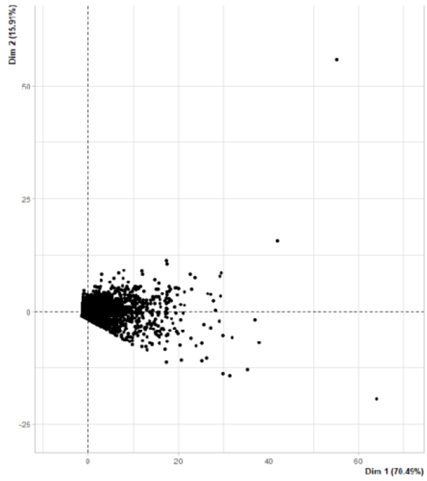


Figure 11: Individuals plot on the first factorial plane of the PCA for the "Gillnet" gear (GNS) - Subareas 7-8

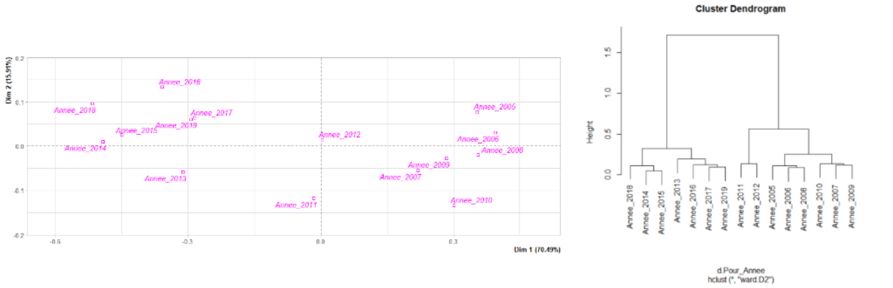


Figure 12: Barycenter plot of years on the PCA principal factorial plane and associated CAH for the " Gillnet " gear (GNS) - Subareas 7-8

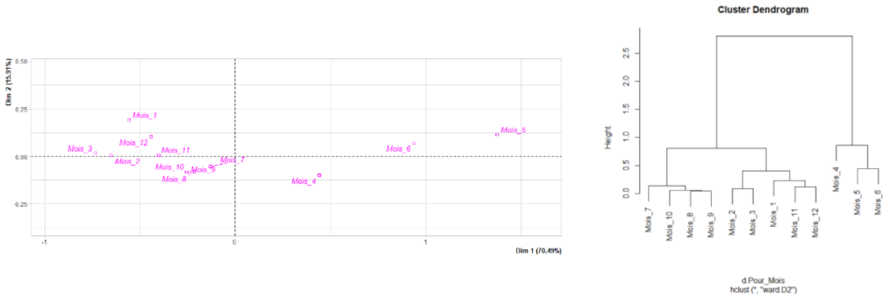


Figure 13: Barycenter plot of months on the PCA principal factorial plane and associated CAH for the " Gillnet " gear (GNS) - Subareas 7-8

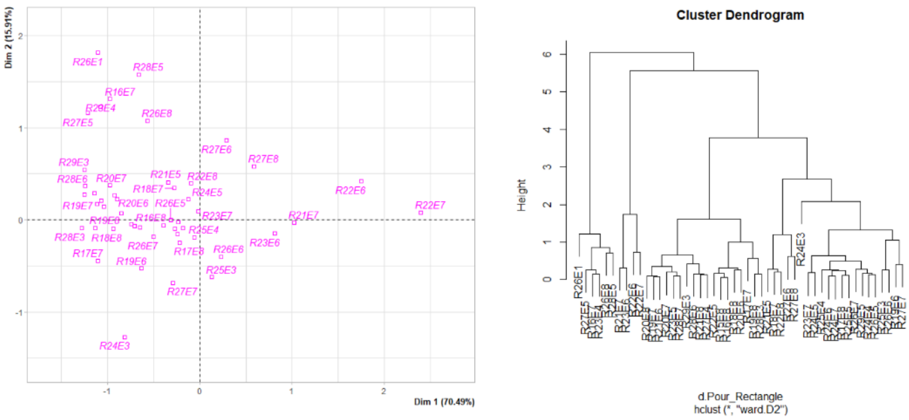


Figure 14: Barycenter plot of statistical rectangles on the PCA principal factorial plane and associated CAH for the " Gillnet " gear (GNS) - Subareas 7-8

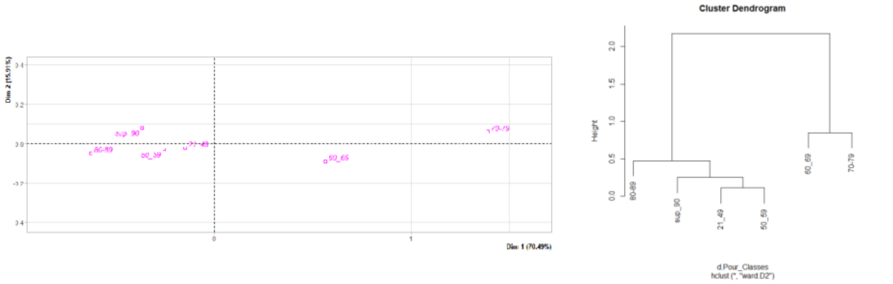
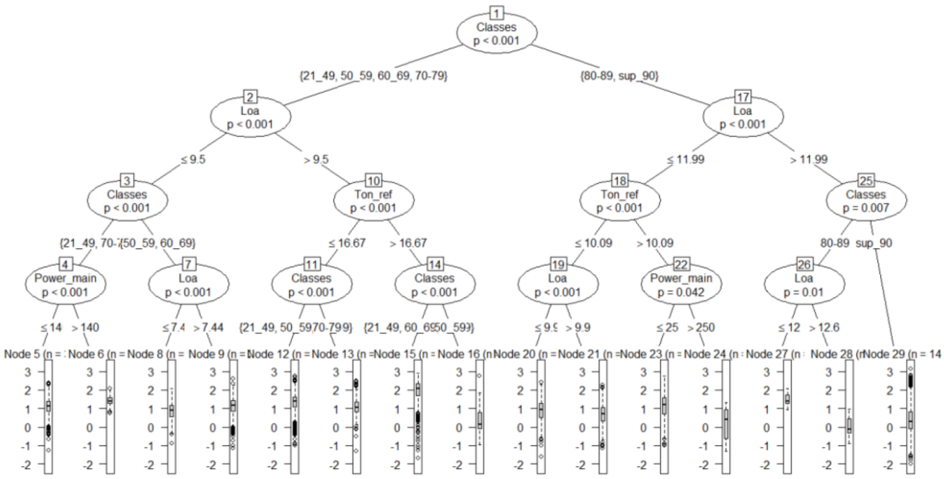


Figure 15: Barycenter plot of mesh size classes on the PCA principal factorial plane and associated CAH for the " Gillnet " gear (GNS) - Subareas 7-8

Search for other relationships between variables of interest characterizing LPUE, vessel and gear characteristics, and spatio-temporal factors



Moy	19.4	31.3	11.0	20.8	36.6	24.7	154.7	22.1	15.1	10.2	36.0	4.9	36.6	2.3	17.1
Med	13.7	24.9	7.8	14.8	23.7	11.6	118.8	1.4	8.2	5.1	15.3	2.4	23.7	0.7	1.9
N	3418	166	1503	2948	2200	295	660	39	2786	825	870	35	13	7	1448

Figure 16: Conditional regression tree on log10Moy (standardized LPUE) with technical characteristics (the values in columns correspond to the values of each node) for GNS - Subareas 7-8

Validation of prediction–variance relation in a state-space fish stock assessment model

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Abstract

It has been proposed by Breivik et al. (2021) that an observation variance can be estimated within an assessment model through the relationship $v = \alpha\mu^{\beta}$, where α and β are positive parameters and μ is the expectation on natural scale. They show that this feature gives a better optimisation for their case studies, but it is not validated against externally estimated variances. One can certainly argue that it does not matter as long as you get a better fit to data, but since survey indices from standard software often come with a variance estimate, it is a good exercise to compare the internal- and the external variance estimates. This is our main objective. For case studies, we use the Norwegian spring-spawning herring and blue whiting assessments. In the former, the external variance estimates are used in the assessment but not for the latter.

Keywords: SAM, stock assessment, prediction-variance

1 Introduction

Breivik et al. (2021) proposed that an observation variance can be estimated through the relationship $v = \alpha\mu^{\beta}$ (Taylor, 1961), where α and β are positive parameters and μ is the expectation on natural scale. A key feature is that both α and β are estimated within the model, which has the benefits that the parameter estimator uncertainty propagates correctly and it is convenient for the user. We will refer to their method as the internal Taylor approach. The authors test this new feature of the SAM model (Nielsen and Berg, 2014) on both the cod and the haddock assessments and conclude that it improves the fit to data.

This relationship, originally proposed by Taylor (1961), has been shown to be adequate both for fishery independent estimates and for catch at age estimates (Aanes, 2016). An implementation of this relationship in SAM, or any other assessment models, is thus sound, and can give a better observation variance if the assumption of this relationship is valid for the different input data. However, our concern is that this model configuration may be influential for the assessment, and that the estimated variances may not reflect the uncertainty of the computed indices.

Both fishery dependent and fishery independent indices from surveys are typically computed via existing software, where these may also include estimates of the survey variance (Johnsen et al., 2019; Hirst et al., 2004). With a few exceptions, the variance estimates are typically not included in the assessment. The reason for this may be that either the assessment model does not facilitate inclusion of variance estimates, or that the variance has not been estimated. In ICES (2021), there is some survey data that also has variance estimates that can be used to validate the internal Taylor approach. While the approach assumes no changes in the Taylor (1961) relationship over time, the externally estimated index variance takes into account inflated uncertainty in certain years due to the occurrence of special events. Thus, these estimates can be used as confirmation or falsification of the homogeneity assumption across years.

In this paper we investigate firstly, if the internally estimated observation variances are consistent with the external ones, and secondly; if this may have substantial influence on a stock's development for Norwegian spring-spawning herring and blue whiting.

2 Method

To evaluate the new model configuration proposed by Breivik et al. (2021) we use the 2021 assessments of two pelagic fish species; the Norwegian spring-spawning herring (Clupea Harengus) and blue whiting (Micromesistius Poutassou) (ICES, 2021). For both species, the surveys indices and variances have been computed using the StoX software (Johnsen et al., 2019) for the fishery independent data. Henceforth, we refer to these as external variances, as opposed to the internal ones predicted by SAM. The data input and general assessment configurations are described in the subsequent sections for each species. With the exception of model features directly linked to the observation variance, we keep the model configurations the same as from the official assessments. In the technical terms of the current implementation of SAM, this means exclusively adjusting the *keyVarObs* and *predVarLink* options of the model configuration.

These two options control the α_{ia} and β_{ia} parameters, for fleet i and age group a, which give the observation variance $v_{iay} = \alpha_{ia}\mu_{iay}^{\beta_{ia}}$, where y denotes the year of the observation. In SAM the observations are log-transformed and the variance of the log-observations is given by

$$\sigma_{iay}^2 = \log\left(\frac{v_{iay}}{\mu_{iay}^2} + 1\right) = \log(\alpha_{ia}\mu_{iay}^{\beta_{ia}-2} + 1), \tag{1}$$

inserting the assumed relation between v_{iay} and μ_{iay}. Note that we have constant variance for a particular fleet i and age group a if $\beta_{ia} = 2$. If $\beta_{ia} = 1$ the variance increases linearly with μ_{iay} on the natural scale and $\beta_{ia} < 2$ means σ_{iay}^2 decreases with increasing μ_{iay}. As indicated by the notation used, α_{ia} and β_{ia} are allowed to vary with fleet and age group, but assumed constant over time. In the implementation of Breivik et al. (2021), it is assumed that $\beta_{ia} > 1$ with default value of $\beta_{ia} = 2$ corresponding to constant variance.

2.1 Herring data and assessment

The assessment of the Norwegian spring-spawning herring has four indices indicating abundance at age; the catch at age (caa), the acoustic-trawl spawning survey in February (NORHERSS), the international acoustic-trawl survey in May (IESNS), and the acoustic-trawl recruitment at age 2 index survey in the Barent Sea (RI). The caa is developed by aggregating the estimated catch at age from each nation. The external variance is computed using the ECA-model (Hirst et al., 2004) directly on the Norwegian part of the caa. The approximation by Taylor (1961) is used on the Norwegian data, and this relationship is then used to compute the variance of the combined caa. The external variance of the survey input data is estimated from the StoX software, but is smoothed using the approximation by Taylor (1961). The age structured model uses age groups 2-12+, 3-12$^+$, 2, 3-12$^+$ for the caa, NORHERSS, RI and IESNS, respectively. The 12$^+$ indicates a plus group for age 12 and older. Note that there are more available ages from the indices computation from StoX, but these are the ones used in the assessment. Also note that we use the raw variance output from StoX, not the smoothed that are used in the assessment.

The official assessment model is the XSAM model developed by Aanes (2016) where the variance from all data sources can be included in the model. For this analyses we use the SAM framework (Nielsen and Berg, 2014). The current implementation of the

SAM framework has adopted the general model from XSAM and can produce similar, but not identical, estimates as XSAM. The similarity is still sufficient for the purpose of this exercise.

2.2 Blue whiting data and assessment

The ICES assessment of blue whiting (ICES, 2021) uses caa and the *international blue whiting spawning stock survey* (IBWSS) as input data and the assessment model is implemented in the SAM framework (Nielsen and Berg, 2014). The IBWSS index is estimated using StoX (Johnsen et al., 2019). The external variances are also estimated, but this information is currently not being used in the official assessment model, as opposed to the herring case. For the caa, no estimates of the observation variance for blue whiting have been made. The age structured model uses age groups 1-10^+ and 1-8 for the caa and IBWSS, respectively. Similar to herring, there are more ages available, but these are the ones used in the assessment. The 10^+ indicates a plus group for age 10 and older. The assessment from 2021 is available at stockassessment.org.

2.3 Objectives

We have two main objectives: 1) Compare the internally estimated relationship between observation variance and mean against the external ones, and 2) compare the differences in model output using the current assessment versus the alternative using the proposed internal Taylor feature. We will not change anything in the configuration not related to this feature. For the alternative assessment using internal Taylor variances, we assume one α and β-parameter for each data source. That is, α and β are assumed constant across age groups, except age 2 for herring caa, to maintain consistency with the external procedure.

The two case studies are interesting in their own ways. In both cases, it will be interesting to compare the externally estimated variances to the internal ones. In the specific herring case, we can study the effects of either specifying the index variances as fixed weights fed into the model or allowing the model to estimate these variances so that they are in accordance with the data and model structure. For the blue whiting assessment, the differences are more related to taking into account the Taylor relationship or not doing so.

3 Result

The external variance estimates from the StoX software for both species, all ages, and for the different input data are shown as black dots in Figure 1 with a linear regression attached to each data. The slope of the regression line is shown as β^{ext} in Table 1. The coloured lines indicate the internally estimated log-variance from α^{int} and β^{int} for the different age spans. Values for β^{int}, with their 95% confidence intervals, are also shown in Table 1. The model configurations of this run is shown in Appendix A. Note that β^{int} had to be excluded for age 2 for herring for the model to converge, where this is likely due to few data points for those ages. Also, no external variance estimates for caa is available for blue whiting.

Both Figure 1 and Table 1 show a difference between the β^{int} and β^{ext} values, but β^{ext} is within the 95% confidence interval of β^{int}. For herring caa β^{int} is higher than β^{ext}, while all other cases the β^{int} is lower.

With the internal Taylor approach, AIC for blue whiting is lower, from 605.3 (22 parameters) to 587.3 (17 parameters), than for the official assessment, while for herring, external weighting changes the input data and not just the model setup, making AIC comparison controversial. The consequence from the different cases are shown in Figure 2, for both estimated spawning stock biomass (SSB), fishing mortality (Fbar) and recruitment. The stock development for both species show an upward revision in the recruitment for the larger cohorts when using the method proposed by Breivik et al. (2021). A larger recruitment of these cohorts will thus increase the SSB and reduce the Fbar. Note however that (almost) all changes are within the confidence intervals of the official assessment estimates.

4 Discussion and Conclusion

In many cases, for both fishery-dependent and fishery-independent surveys, the Taylor relationship between mean and variance is observed empirically; but for several surveys, the variance has not been calculated. The approach by Breivik et al. (2021) suggests that this relationship can be estimated by the assessment model itself in any case where the variance is not available. In their case studies, the internal Taylor approach produced a better optimisation in terms of AIC and this feature removed a clear pattern between the one-step-ahead residuals and the prediction, but the predicted variance development was not validated with any external variances. The focus in this work is to compare the variance from the internal Taylor approach with available external variance estimates. The configuration settings used in the cases is thus to evaluate the performance of this configuration, not to find the best configuration for estimating stock dynamics with the purpose of developing a catch advice.

The internal estimates describe a prediction-variance link, but the external procedure do not have the prediction, and must therefore use the observation directly as an approximation. In this regard, the external Taylor approach is an observation-variance link. Assuming that the predictions are proportional to the observations on log-scale (i.e. $\log \mu \approx \log x$, where x is a observation and μ the corresponding expected value). By comparing the predictions from the alternative assessments to the observations, we find this assumption to be reasonable (see appendix B).

The α parameters are different between the externally and internally developed variances (Figure 1). The estimated α is not only dependent on the state of the data, but also the configuration of the model. The internal and external α estimates should thus not be compared directly, but it should be noted that this parameter is also important for the weighting of the different data sources. Since α is different, and this difference is not constant between the different data sources, then this indicates that the weight of the data sources has changed. A direct comparison can be made for the β parameter. The β parameter shows if the development between log variance and log expectation is similar when compared to an externally computed log variance. Our findings show that there is a difference in the β parameters, but this difference is within the 95% confidence intervals of the internally estimated ones (Table 1).

For herring, we experienced some convergence issues when including a β estimate for age 2 for RI. Correspondingly, we excluded age 2 for caa due to an issue with infinite standard error for the β estimate. This could also be solved by splitting α and β further based on age, but we maintain the same β for each fleet for comparison reasons.

In Appendix B we have included some supplementary plots of one-step-ahead residuals by year and age for the different fleets, models and species. In Figure B.2 (herring) and B.3 (blue whiting) we observed minor differences in the patterns. We have also conducted a simulation study and checked that most of the simulations fall within the confidence intervals of the corresponding models.

In simple terms, $\beta \neq 2$ will cause the log observation within and across a time series to be weighted depending the relationship shown in eq. 1. When $\beta \leq 2$, for the cases shown in Table 1, this causes the higher values of log observation to be weighted more in an assessment model. This effect apply both when the β is estimated within or outside the model. The impact this functionality will have on a stock estimation depends on the stock dynamics. For species with a spasmodic recruitment, i.e. sudden large cohorts, the effect will be larger than for species without a spasmodic recruitment, e.g. cod (Breivik et al., 2021). Herring and blue whiting are species with a spasmodic recruitment, and for blue whiting it is shown that the recruitment for the larger cohorts increases when applying this relationship (Figure 2). For herring, the official assessment uses external variance from the data but the recruitment of the larger cohort are still being increased when instead estimating the variance within the assessment model. It should be noted that this increase cannot be explained by a different β value alone, as the different configuration settings may cause the weighting of the data sources to vary.

External variances can be included in the assessment if these are available, as the case for the herring assessment. The benefit of external variance is that any temporal effects, i.e. increasing or reducing the survey efficiency, are then also included in the assessment.

The benefit of using the internal Taylor method is that the uncertainty in the β parameter is propagated to the entire uncertainty of the assessment, but any temporal effects is ignored. The latter is also true if the Taylor approximation has been used externally. If temporal effects can be ignored, the approach of estimating the variance within the model is appealing and we have found that, if configured correctly, β^{ext} is within the uncertainty of β^{int} and will thus produce similar development of the variance. This approach can thus be implemented in cases where any external variance is not available; but, we will still argue that the external variance should be computed with the purpose to evaluate if the approach proposed by Breivik et al. (2021) is suitable.

Species	Data	β^{int}	β^{ext}
Herring	caa	1.49 ± 0.11	1.35
Herring	NORHERSS	1.30 ± 0.28	1.56
Herring	IESNS	1.37 ± 0.25	1.52
Herring	RI	-	1.81
Blue Whiting	caa	1.45 ± 0.21	-
Blue Whiting	IBWSS	1.33 ± 0.36	1.49

Table 1: The internally (β^{int} with 95% CI) and externally estimated (β^{ext}) slope parameters between log observation and log variance for the different input data and species.

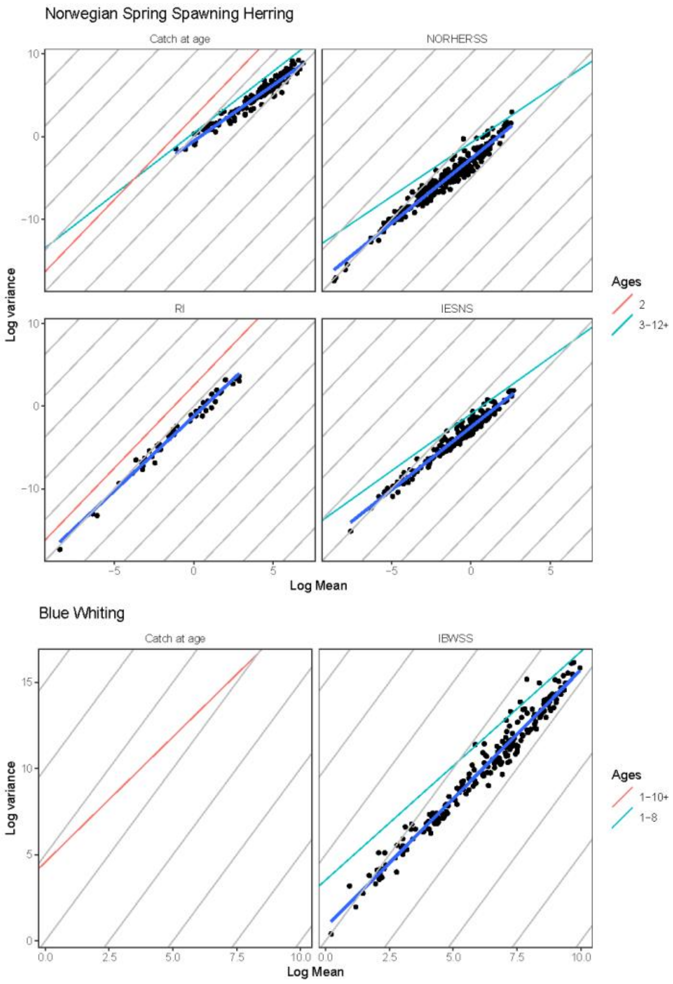

Figure 1: The relationship between the log variance and the log observation. The black dots with a blue regression line show the relationship between externally estimated log variance and log observation for all available ages, while the lines colored by age group show relationship as outputted from the assessment model. Grey lines indicate the relationship when $\beta = 2$, but with different values for α.

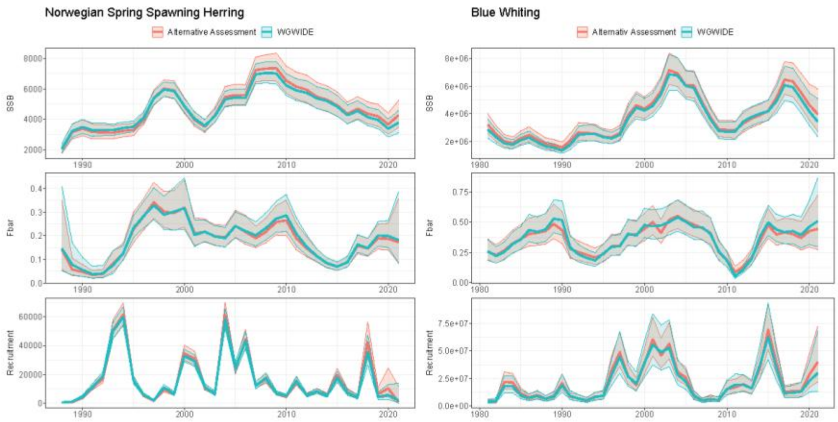

Figure 2: Stock estimates (SSB, Fbar and recruitment) from the two different cases, the official WGWIDE assessments and the alternative assessments, with herring to the left and blue whiting to the right.

Acknowledgement

We would like to thank Olav Nikolai Breivik for discussion and clarification on the SAM implementation. Thanks to the *Advanced Stock Assessment modelling* (ASAM, w/ Edvin Fuglebakk) project at Institute of Marine Research for funding this work.

Data availability statement

All the code and data necessary to reproduce the results are available at: `https://github.com/IMRpelagic/PredLinkVsExternalweights`.

Author Contribution

Both authors contributed equally in all parts of this study.

A Configurations

The configurations of *$keyVarObs* and *$predVarObsLink* for the official and alternative assessments for the two species are reported below. The full configuration files can be found in the github repository.

Herring

Official assessment

```
$keyVarObs
   0   0   0   0   0   0   0   0   0   0   0
  -1   0   0   0   0   0   0   0   0   0   0
   0  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1   0   0   0   0   0   0   0   0   0   0
$predVarObsLink
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  NA  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  NA  NA  NA  NA  NA  NA  NA  NA  NA  NA
  NA  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
```

Alternative assessment

```
$keyVarObs
   0   1   1   1   1   1   1   1   1   1   1
  -1   2   2   2   2   2   2   2   2   2   2
   3  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1   4   4   4   4   4   4   4   4   4   4
$predVarObsLink
  -1   0   0   0   0   0   0   0   0   0   0
  NA   1   1   1   1   1   1   1   1   1   1
  -1  NA  NA  NA  NA  NA  NA  NA  NA  NA  NA
  NA   2   2   2   2   2   2   2   2   2   2
```

Blue whiting

Official assessment

```
$keyVarObs
   0   1   2   2   2   2   2   2   3   3
   4   5   6   7   7   7   8   8  -1  -1
$predVarObsLink
  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1  -1  -1  NA  NA
```

Alternative assessment

```
$keyVarObs
   0   0   0   0   0   0   0   0   0   0
   1   1   1   1   1   1   1   1  -1  -1
$predVarObsLink
   0   0   0   0   0   0   0   0   0   0
   1   1   1   1   1   1   1   1  NA  NA
```

B Supplementary plots

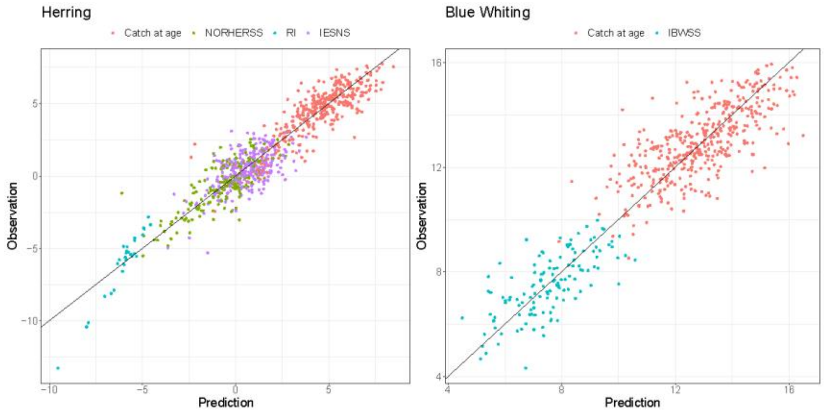

Figure B.1: Observation versus prediction for the alternative models for herring and blue whiting.

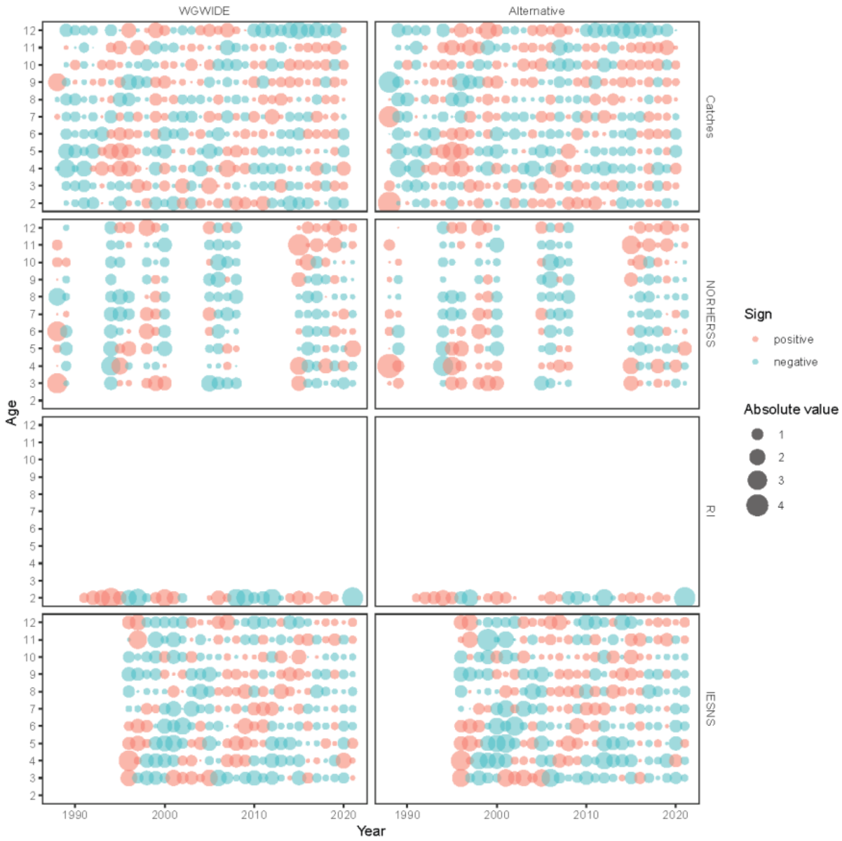

Figure B.2: One-step-ahead residuals by model, survey, age and year for herring. The size of each buble is proportional to the absolute value of the residual while the color indicates if it is positive or negative.

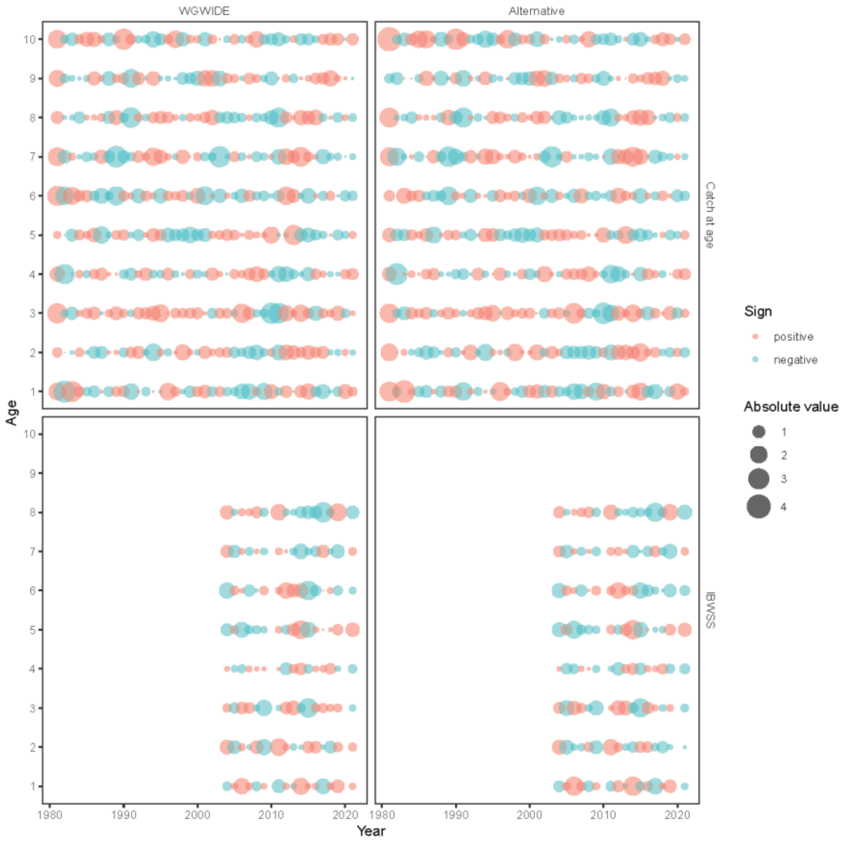

Figure B.3: One-step-ahead residuals by model, survey, age and year for blue whiting. The size of each buble is proportional to the absolute value of the residual while the color indicates whether it is positive or negative.

References

S. Aanes. A statistical model for estimating fish stock parameters accounting for errors in data: Applications to data for norwegian spring-spawning herring. 2016. Working document.

O. N. Breivik, A. Nielsen, and C. W. Berg. Prediction–variance relation in a state-space fish stock assessment model. *ICES Journal of Marine Science*, 2021.

D. Hirst, S. Aanes, G. Storvik, R. B. Huseby, and I. F. Tvete. Estimating catch at age from market sampling data by using a bayesian hierarchical model. *Journal of the Royal Statistical Society: Series C (Applied Statistics)*, 53(1):1–14, 2004.

ICES. Working group on widely distributed stocks (WGWIDE). 3(95), 2021.

E. Johnsen, A. Totland, Å. Skålevik, A. J. Holmin, G. E. Dingsør, E. Fuglebakk, and N. O. Handegard. Stox: An open source software for marine survey analyses. *Methods in Ecology and Evolution*, 10(9):1523–1528, 2019.

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

L. R. Taylor. Aggregation, variance and the mean. *Nature*, 189(4766):732–735, 1961.

2022 Mackerel and Horse Mackerel Egg Survey

by

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Introduction

The mackerel and horse mackerel egg survey is an ICES-coordinated international study in the north east Atlantic conducted during the first half of 2022. This study is a combined plankton and fishery investigation formed by a series of individual surveys which have taken place triennially since the late 1970s and is coordinated by the ICES Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS).

The main objective is to estimate a biomass index for the Northeast Atlantic mackerel stock and an egg abundance index for the Western horse mackerel stock using the AEPM, and an SSB index for the Southern horse mackerel stock using the DEPM during thiigs series of individual cruises from January to July.. A secondary objective is to estimate the SSB indices for the western and southern areas as well as for the North Sea area using the DEPM. The results have been used in the assessment for NEA mackerel stock since 1977 and for western horse mackerel stock since 1992. The mackerel and horse mackerel egg survey is still the main source of data providing fisheries independent information for these stocks.

The general method is to quantify the freshly spawned eggs in the water column on the spawning grounds. To be able to establish a relationship between eggs and biomass of the spawning stock, the fecundity of the females must also be determined. This is undertaken by sampling ovaries before and during spawning. The potential fecundity is counted from whole mount volumetric subsamples using a dissecting microscope while atresia is counted histologically from slides. Realised fecundity is estimated as potential fecundity minus atresia. The realised fecundity is used in combination with the calculated number of freshly spawned eggs in the water to estimate the spawning stock biomass. (ICES 2019a; ICES 2019b)

To provide reliable estimates of spawned eggs and fecundity an extensive coverage of the spawning area is required both in time and space. The spawning of the southern horse mackerel stock and mackerel starts in late December off the Portuguese coast. Spawning proceeds further north along the continental shelf edge as water temperature increases during late winter and spring. In the past peak spawning of mackerel has normally occurred in April-May in the area of the Sole Banks with an extension to the Porcupine Bank. Whilst the distribution and timing of peak western horse mackerel spawning has remained fairly stable during recent surveys the same cannot be said for NEA mackerel. Recent surveys in 2010 and 2013 saw peak mackerel spawning in March with 2013 also demonstrating a shift in the geographical centre of spawning further south within the southern Biscay region. Away from these areas mackerel spawning is now observed over a large region of the Northeast Atlantic both on and off the continental shelf, ranging as far west as Hatton Bank and as far north as Iceland and the Faroe Islands as well as the Shetland Islands and the Norwegian coast in the Northeast.

Survey effort

As a consequence of the long spawning period and the large survey area involved, the mackerel and horse mackerel egg surveys have always relied on broad international participation. In 2022 a total of 16 individual cruises were carried out with a total of 284 survey days in the western and southern areas, with the contribution of Spain (IEO: 42 days at sea, AZTI: 30 days), Scotland (59 days), the Netherlands (39 days), Ireland (28 days), Portugal (34 days), Germany (23 days), Norway (15 days) and the Faroe Islands (14 days). The North Sea survey was carried out in the same year as the Atlantic surveys for the first time. Thirty five survey days were devoted to this survey, with England contributing 23 days and Denmark 12 days.

Survey design

The aim of the triennial egg survey is to determine the annual egg production (AEP). This is calculated using the mean daily egg production rates per pre-defined sampling period for the complete spawning area of the Northeast Atlantic Mackerel and Horse Mackerel Stocks. To achieve this, one plankton haul per each half rectangle (separated by approximately 15 nm) is conducted on alternating transects covering the complete spawning area. The 2022 egg survey was designed in order to maximise both the spatial and temporal coverage in each of the sampling periods. Given the very large area to be surveyed this design minimises the chances of under/overestimation of the egg production (ICES 2008).

The 2022 survey plan was split into 6 sampling periods (Table 1). Originally Portugal were assigned a Period 1 survey which would extend into Period 2. Due to a delay in the start of their survey it was decided to modify the start date of period 2 in the southern area and include the survey into period 2. No sampling was scheduled to take place in ICES division 9a after Period 2. Sampling of the western area commenced in period 3, and included coverage of the west of Scotland, west of Ireland and Biscay. Surveying in the Cantabrian sea ended at the end of period 5. In periods 6 and 7 the surveys were designed to identify a southern boundary of spawning and to survey all areas north of this boundary.

Maximum deployment of effort in the western area was during periods three, four, five and six. Historically these periods would have coincided with the expected peak spawning of both mackerel and horse mackerel. Recent years have seen mackerel peak spawning taking place during periods 3 and 5.

Due to the expansion of the spawning area which has been observed since 2007 the emphasis was even more focused on full area coverage and delineation of the spawning boundaries. Cruise leaders had been asked to cover their entire assigned area using alternate transects and then use any remaining time to fill in the missed transects.

Table 1. Participating countries, vessels, areas covered, dates and sampling periods of the 2022 surveys.

Country	Vessel	Area	Dates	Period
Portugal	Vizconde de Eza	Portugal	Jan 23rd – Feb 20th	2
Ireland	Celtic Explorer	West of Ireland, Celtic Sea, Biscay,	March 2nd – 22nd	2
	Prince Madog	West of Ireland, west of Scotland	June 11th – 18th	6
Scotland	Altaire	West of Scotland	April 12th – 27th	4
	Scotia	West of Scotland, west of Ireland	May 13th – June 2nd	5
	Altaire	West of Scotland, west of Ireland, Celtic Sea, Biscay	July 4th – 26th	7
Spain (IEO)	Miguel Oliver	Cantabrian sea, Galicia, southern Biscay	March 14th – April 3rd	3
	Miguel Oliver	Cantabrian sea, Galicia, Biscay	April 4th – April 30th	4
Spain (AZTI)	Ramon Margalef	Northern Biscay	March 10th – 30th	3
	Vizconde de Eza Emma Bardan	Biscay, Cantabrian Sea	April 30th – May 19th	5
Germany	Walther Herwig	Celtic sea, west of Ireland	March 31st – April 8th	3
	Walther Herwig	Celtic sea, west of Ireland, west of Scotland	April 10th – 22nd	4
Netherlands	Tridens	Northern Biscay, Celtic Sea	May 8th – 26th	5
	Tridens	Biscay, Celtic Sea	June 5th – 24th	6
Norway	Brennholm	North Sea, Faroes & Norway	June 7th – 20th	6
Faroes	Jakup Sverri	Faroes, Iceland	May 19th – June 1st	5
Denmark	Dana	North Sea	June 7th – 19th	6
England	Cefas Endeavour	North Sea	June 4th - 25th	6

Processing of samples

The analysis of the plankton and fecundity samples were carried out according to the sampling protocols as described in the WGMEGS Survey Manual (ICES, 2019a) & Fecundity manual (ICES, 2019b).

A total of 2184 plankton samples were collected and sorted. Mackerel and horse mackerel eggs were identified and the egg development stages determined. Depending on the vessel facilities and the experience of the participants this was done either during the cruise or back in the national institutes.

Double micropipette samples and slices from ovaries of mackerel were taken during each survey. Additional samples were collected during periods 3 and 4 by participants in an effort to carry out DEPM analysis. Fecundity sampling for horse mackerel only took place during the expected peak spawning periods, 6 and 7. After each survey the ovary screening and fecundity samples were sent to different European research institutes for histological and whole mount analysis to determine the realised fecundity (potential fecundity minus atresia). Fecundity samples have to be analysed in the laboratory upon return from sea and the procedures for analyses are time consuming. The last samples were collected in July. Additional samples were collected during period 3 with the cooperation of the Netherlands PFA.

Horse mackerel is considered to be an indeterminate spawner and therefore since 2007 IPMA has adopted the DEPM methodology for southern horse mackerel in ICES division 9a. The egg survey design in the western area is directed at the AEP method for mackerel which produces an estimate of SSB. Fecundity samples for horse mackerel were taken during the survey in the western area in order to develop a modified DEPM approach for estimating the biomass of the southern horse mackerel stock.

Survey coverage and mackerel egg production by period

The 2022 MEGS was split into 6 survey periods, the start and end dates of which can be found in **¡Error! No se encuentra el origen de la referencia.**. For each of the six sampling periods, the following can be noted

Period 2 – Portugal started the 2022 survey series on January 23**rd**. This is a DEPM survey mainly targeting the southern horse mackerel stock and is designed for this purpose, however it also delivers mackerel egg abundance data. The survey is usually undertaken between Cadiz and Galicia and is confined to ICES division 9a (Figure 1).

Period 3 – Period 3 marks the commencement of the western area surveys as well as a continuation of sampling in the southern area. Sampling was undertaken by Ireland (West of Scotland, west of Ireland, Celtic Sea), Germany (Celtic Sea) and AZTI (northern Biscay). Further south the Bay of Biscay, Cantabrian Sea and Galicia were covered by Spain (IEO).
No eggs were found by Ireland in northern waters so after a number of days the vessel turned south and sampled in the Celtic Sea. Due to issues with COVID cases among the crew, the German survey was delayed in starting, however it was successful in linking with the Irish vessel. Both IEO and AZTI experienced difficulties with their vessels, and lost a number of sampling days, however full coverage was achieved (Figure 2).
Egg numbers were relatively low to the west of Ireland. In contrast, further south large numbers of eggs were found close to the 200m contour line. In Biscay and the Cantabrian Sea AZTI and IEO recorded a number of stations with large numbers of mackerel eggs. 298 stations were sampled and there were only 13 interpolations. There were 52 replicate samples with the majority being completed in the Cantabrian Sea.

Period 4 – This period was covered by three surveys. Scotland sampled the area from the northwest of Ireland to the Shetland Islands. Germany surveyed west of Ireland, Celtic Sea and northern Biscay while IEO completed the survey coverage in southern Biscay and the Cantabrian Sea (Figure 3).
Due to difficulties in acquiring diplomatic clearance, the Scottish survey was unable to sample in Irish waters. As a result, Germany extended their survey area northwards to ensure continuity of survey coverage.
Once again moderate levels of eggs were recorded throughout the area, with the highest concentrations still being found close to the 200m contour line. Large numbers of mackerel eggs were once again recorded to the west of Scotland, however, they were lower within this area and time period than those reported in 2019. 327 stations were sampled and there were 46 interpolations. 52 replicate samples were taken and once again most of these were collected from the Cantabrian Sea.

Period 5 – In period 5, the entire spawning area from the Cantabrian Sea to the West of Scotland, and up to Faroese waters at around 61°N was surveyed by AZTI, the Netherlands, Scotland, and Faroes. Spawning in the Cantabrian Sea was tailing off with only low egg numbers being found. Throughout Biscay and into the southern Celtic Sea numbers were generally low to moderate (Figure 4). This pattern continued west of Ireland, to around 54°N, with spawning remaining on and around the shelf edge. North of this, however, and similar to that noted in 2016 and 2019, spawning activity fanned out both west- and northwards. Due to the large area Scotland had to survey, their vessel was forced to restrict exploration of the western boundary around the SW of Rockall Bank. Egg counts recorded from the boundary stations within this area were lower than reported in 2019 so while the western boundary wasn't fully delineated, MEGS is happy that the survey has captured the majority of egg production in this area. North of this, the Faroese survey completed stations North of Hatton Bank and up towards the Icelandic coast. Some egg production was found to the north of Rockall, however the largest number of eggs were encountered west of the Shetland Islands. In total 444 stations were sampled and there were 214 interpolations. One replicate sample was undertaken.

Period 6 – During period 6 northern Biscay, northwards from 46°N and also the Celtic Sea were covered by the Netherlands while Ireland was to cover west of Ireland and also west of Scotland. Norway surveyed the area north of 59°N from the south of Iceland to the Norwegian coast, as well as carrying out four transects in the northern North Sea to assist England and Denmark in providing full coverage for the DEPM survey.

Ireland had planned to charter a research vessel from Northern Ireland to conduct the period 6 survey. One week prior to departure the vessel had to go to dry dock for emergency repairs. After much searching, a smaller Welsh RV was contracted as a replacement. Once at sea however it quickly became clear that the replacement vessel was wholly unsuitable and not up to the task. With only two stations successfully completed the decision was made to abandon the survey leaving the area from 53N to 61N unsampled. Norway and Netherlands both completed their survey sampling successfully.

Low levels of spawning were observed in Biscay and to the south to the West of Ireland and Porcupine bank (Figure 5). Similarly, in the northern area, spawning was observed at low levels, with the exception once again of the area west of the Shetland Islands. Due to an unavoidable reduction in the number of survey days available, Norway was unable to secure either the northwestern or northern boundary within the northern area, while Netherlands secured the western boundary in their area. 184 stations were sampled with 36 interpolations. No replicate stations were completed.

Period 7 – This period was covered entirely by Scotland sampling on alternate transects in the area from 47°15N to north of the Hebrides and 59°N (Figure 6). Due to the lack of eggs encountered, the Scottish survey adhered very closely to the 200m contour and 144 stations were sampled with 24 interpolations. Two replicate stations were completed. Only very low levels of spawning were observed and these were confined to the continental shelf and shelf edge with all spawning boundaries being delineated successfully.

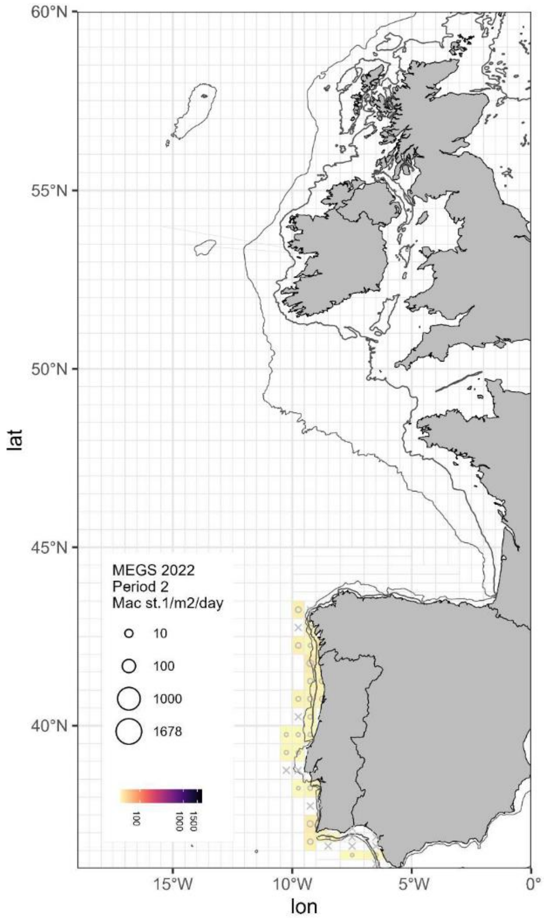

Figure 1 Mackerel egg production by half rectangle for period 2 (Jan 23rd – Feb 19th). Circle areas and colour scale represent mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

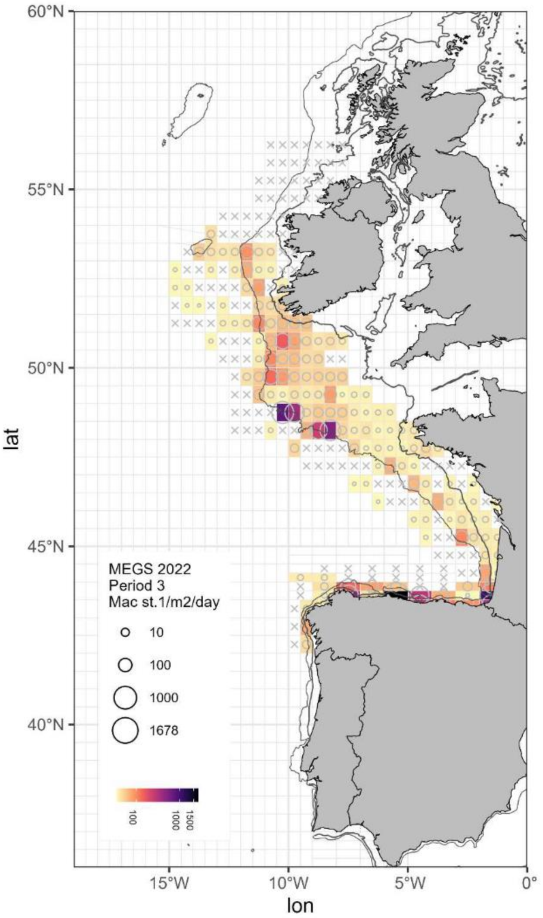

Figure 2 Mackerel egg production by half rectangle for period 3 (Mar 4th – Apr 8th). Circle areas and colour scale represent mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

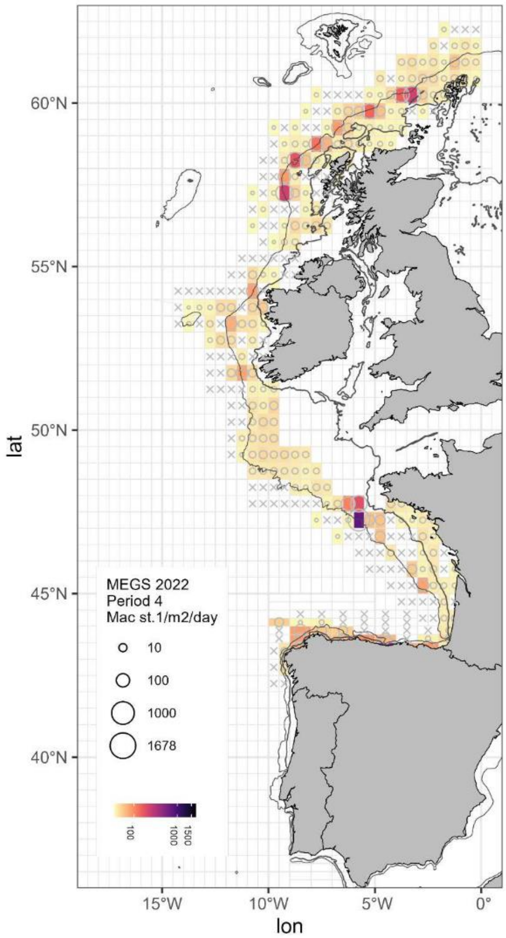

Figure 3 Mackerel egg production by half rectangle for period 4 (Apr 9th – 29th). Circle areas and colour scale represent mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

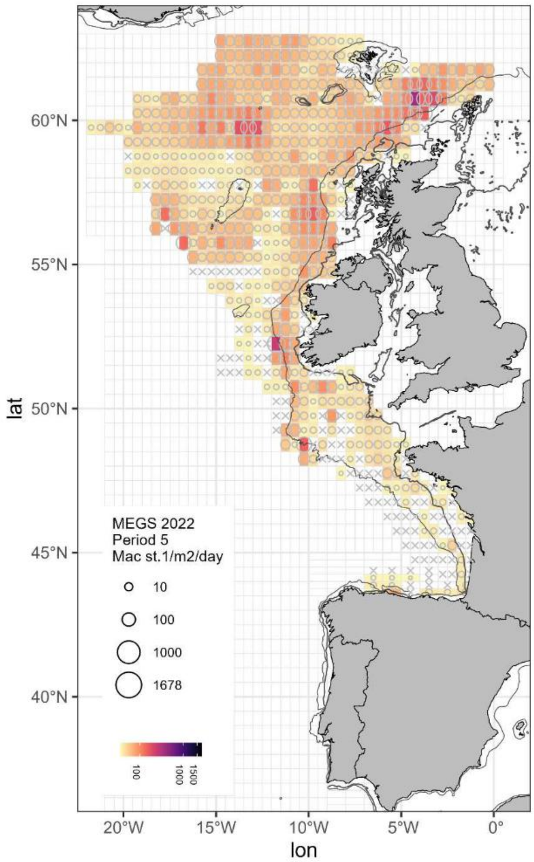

Figure 4 Mackerel egg production by half rectangle for period 5 (Apr 30th – May 31st). Circle areas and colour scale represent mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

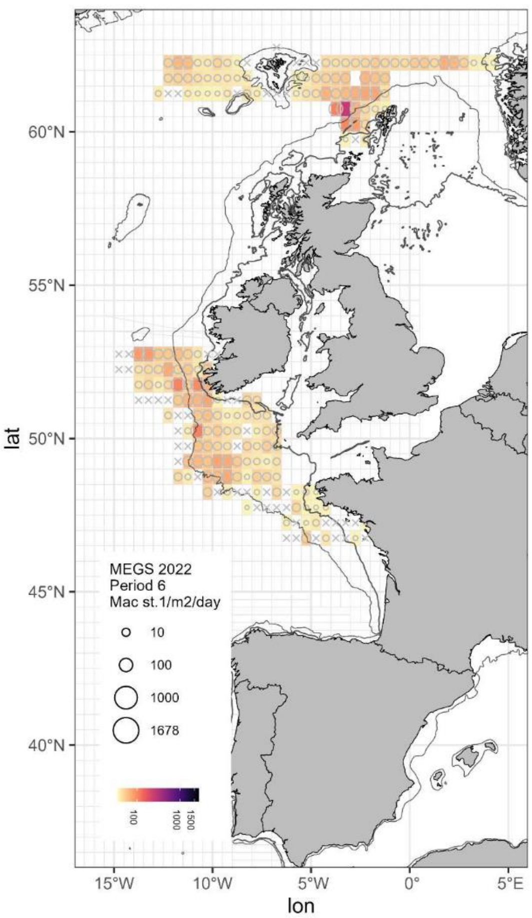

Figure 5 Mackerel egg production by half rectangle for period 6 (June 1st – 30th). Circle areas and colour scale represent mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

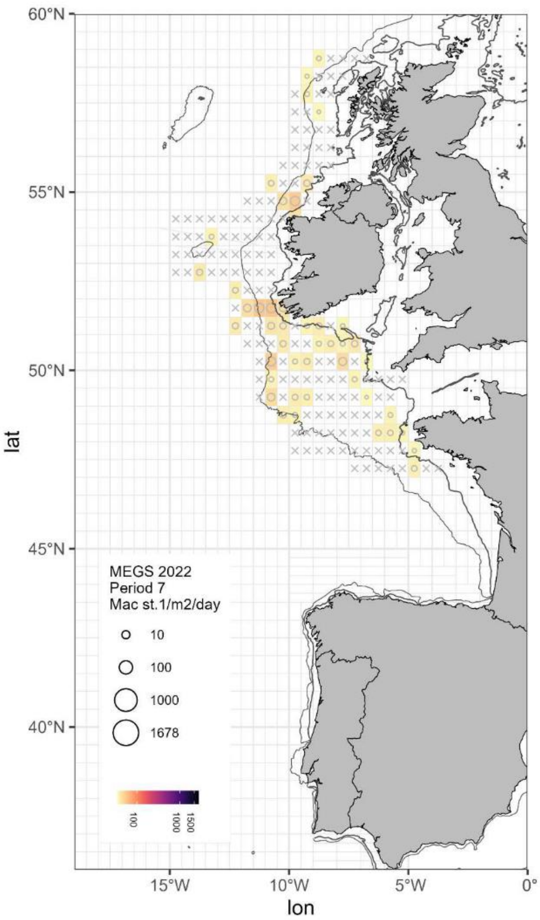

Figure 6 Mackerel egg production by half rectangle for period 7 (July 1st – 31st). Circle areas and colour scale represent mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

Results - MACKEREL

Stage I Egg production in the Western area

2010 provided an unusually large spawning event early in the spawning season, 2013 yielded an even larger spawning event indicating that spawning was probably taking place well before the nominal start date of 10th February (day 42). In 2016 the first survey commenced on February 5th which is five days prior to the nominal start date. That year however mackerel migration was later and slower than that recorded in the previous two surveys. The pattern in 2019 followed that of 2016 with no early peak spawning being recorded (Fig. 8 & Table 2). In 2022 peak spawning was found to have taken place in period 4. The expansion observed in the western and north-western areas of the western area in the 5 and 6 periods of 2016 is reported again in the 2022 period., however egg numbers were not as large as in 2016. During period 5 the northern and northwestern boundaries were once again not delineated, however the exploratory egg surveys carried out in this region during both 2017 and 2018 provide significant evidence that while some spawning has been missed the loss of egg abundance is not sufficiently large to significantly impact the SSB estimate.

The cancelling of the Irish survey in period 6 was addressed by WGMEGS. The group estimated the spawning area that was missed, and also estimated mean daily egg production for the period. The survey area from 53°N to 61°N, and 3.5°W to 21°W was looked at for the same time interval in the 2013 (period 5), 2016 (period 6) and 2019 (period 6) surveys. Positive stations were selected where stage I eggs were found in a rectangle on at least two occasions over these three surveys (Figure 7, blue rectangles). WGMEGS estimated this amounted to 127 missed stations during the period. WGMEGS then calculated mean daily egg production from all the observed survey stations for period 6 in 2022 to be 19.58 stage I eggs/m^2/day, and applied this figure to the 127 missed stations. **¡Error! No se encuentra el origen de la referencia.**8 shows the spawning curve for 2022, with and without the correction for the Irish survey.

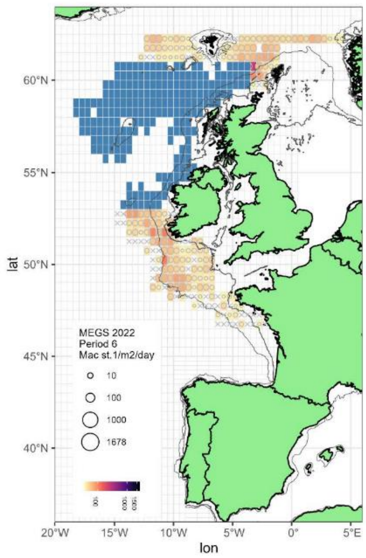

Figure 7 Area, blue colour, where it is estimated eggs would have been found during the Irish period 6 survey.

The nominal start and end dates of spawning are February 10th and July 31st respectively. These are the same dates that were used during previous survey years and the shape of the egg production curve for 2022 does not suggest that the chosen end date needs to be altered. The provisional total annual egg production (TAEP) for the western area in 2022 was calculated as **1.80 * 10^{15}** (Table 2). This is a 47% increase on the 2019 TAEP estimate which was 1.22 * 10^{15}.

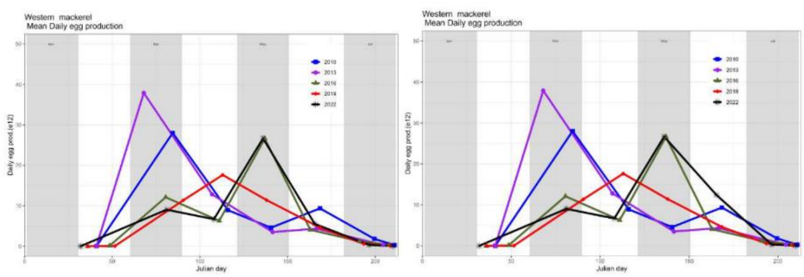

Figure 8: The daily mackerel egg production curves for 2010 – 2022 surveys with (right) and without (left) corrected estimates for period 6 of 2022 (black lines). The curves for 2010, 2013, 2016 and 2019 are included for comparison.

Table 2. Western area estimate of mackerel total stage I egg production by period using the histogram method for 2022

Dates	Period	Days	Annual stage I egg production * 10^{15}
Feb 5th – Mar 3rd	Pre 3	31	0.087
Mar 4th – Apr 8th	3	36	0.319
Apr 9th – Apr 26th	4	18	0.120
Apr 27th – Apr 29th	4 – 5	3	0.043
Apr 30th – May 31st	5	32	0.863
Jun 1st – 5th	5 – 6	5	0.068
Jun 6th – Jun 22nd	6	17	0.211
Jun 23rd – Jul 4th	6 – 7	12	0.081
Jul 5th – Jul 25th	7	21	0.007
July 26th – July 31st	Post 7	6	0.0003
Total			1.7993

Stage I Egg production in the Southern area

The start date for spawning in the southern area was the 23rd January (**¡Error! No se encuentra el origen de la referencia.**3). Portugal surveyed in Period 2 in division 9a. Sampling in the Cantabrian Sea where the majority of spawning occurs within the Southern area commenced on the 18th March. The same end of spawning date of July 17th was used again this year and the spawning curve suggests that there is no reason for this to change (**¡Error! No se encuentra el origen de la referencia.**9). As in 2022 the survey periods were not completely contiguous and this has been accounted for (**¡Error! No se encuentra el origen de la referencia.**3). The total annual egg production (TAEP) for the southern area in 2022 was calculated as **2.93 * 10^{14}** (**¡Error! No se encuentra el origen de la referencia.**3). This is a 30% decrease on the 2019 TAEP estimate which was 4.23 * 10^{14}.

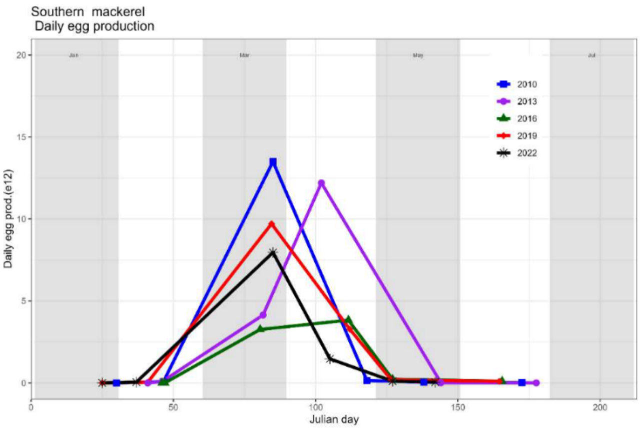

Figure 9: Annual egg production curve for mackerel in the southern spawning area for 2022, black line). The curves for 2010, 2013, 2016 and 2019 are included for comparison.

Table 3: Estimate of the 2022 total mackerel stage I egg production by period for the southern compo-nent using the histogram method..

Dates	Period	Days	Annual stage I egg production x 10^{14}
Jan 25th – Feb 17th	2	24	0.012
Feb 18th – Mar 17th	2 – 3	28	1.213
Mar 18th – Apr 2nd	3	16	1.274
Apr 3rd	3 – 4	1	0.052
Apr 4th – 25th	4	22	0.327
Apr 26th – May 1st	4 – 5	6	0.036
May 2nd – 11th	5	10	0.011
May 12th – May 31st	Post 5	20	0.009
Total	2.930		

Total egg production (Western and Southern areas)

Total annual eggs production (TAEP) for both the western and southern areas combined in 2022 is **2.093*10^{15}.** (Fig. 10). This is an increase in production of **28%** compared to 2019, 1.64*10^{15} (Figure 10).

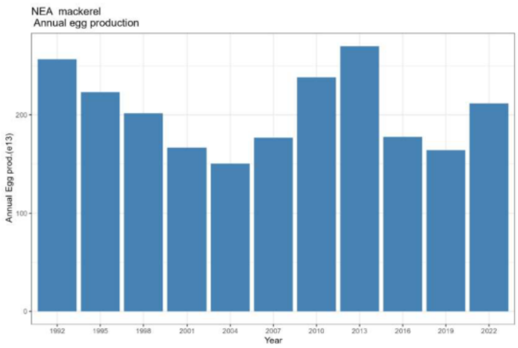

Figure 10 Combined mackerel TAEP estimates (*1013) - 1992 – 2022.

Fecundity estimates

Results Mackerel AEPM - Fecundity

During the 2022 survey, 6784 adult mackerel were collected from 170 trawl hauls between 36.30°N and 61.75°N during periods 2–7. This year there has been a significant increase in the number of samples collected (2312) compared to previous surveys thanks to the valuable collaboration of the pelagic fishing industry (PFA). Only females were chosen for reproductive studies, so in this section, the results refer to mackerel females. In all, 1811 ovary samples were used for AEPM (annual egg production method). Only 43% of the samples planned were collected. Deviation from the initial plan was observed in all periods; the interannual variability in the mackerel migration as well as the probability of successful fishing effort makes it difficult to fit into the original sampling scheme.

Adult Parameters

Screening

From the 1813 ovary samples, a total of 1717 samples were screened by histology and classified as described in the manual (ICES, 2019a; for DEPM samples see DEPM section). 1699 were valid for further analysing. samples could be used for potential fecundity analyses, and 51% of the females were classified as spawning. Spawning females were only used for analyses of atresia.

From the histological screening, a total of 492 samples qualified for potential fecundity analysis, which represents ~29% of the total samples screened by histology (N = 1699). After the whole mount screening, this number decreased to 396 samples. The reasons for disqualifications after the whole mount screening was mostly due to the detection of spent ovaries and the presence of hydrated oocytes. According to the manual (ICES 2019a, SISP 5), ovaries with a leading cohort smaller than 400 µm are considered to be not fully recruited yet; not all oocytes that are going to be spawned may have reached the 185 µm threshold that is used to classify oocytes as maturing.

Different to previous years WGMEGS decided for the fecundity analysis samples that had signs of stage 4 oocytes (migratory nucleus stage) should also be included. Stage 4 oocytes can be regarded as a marker for imminent spawning. This was an extra measure taken to assure that no spawning fish were included in the potential fecundity estimate. More details in ICES, 2023

Potential fecundity

For all mackerel females used for potential fecundity analysis an initial check (Figure 11 a-d) was done on the distribution of fish length, weight, Fulton's condition factor (100 × weight/length3), and gonad-somatic index (GSI; 100 × Ovary weight/Fish weight).

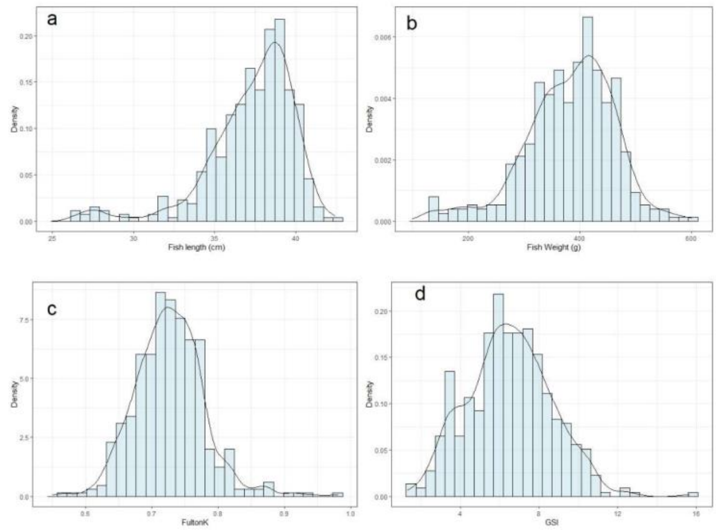

Figure 11 Histogram of the distribution of a) Fish length b) Fish weight, c) FultonK index and d) GSI of individuals analysed for fecundity.

Similar to the previous surveys only fish with condition factor between 0.5 and 1.2, and GSI between 1 and 25 were included (ICES 2014) in the fecundity and atresia estimates. In 2022, as in 2019, no females were excluded from the analysis based on these biological parameters.

Relative potential fecundity in 2022 ranged from 34 to 3212 oocytes/g fish, with a median value of 1313 oocytes/g fish (Figure 12). In surveys prior to 2013, values below 300 µm and above 2100 µm were excluded. Since the 2013 survey (ICES 2014) it was agreed not to delete them however, but instead replace the use of arithmetic mean by median. The median is considered to be a more robust measure than the arithmetic mean.. In 2019, this issue was discussed again, and it was agreed to test a trimmed mean as an alternative to the median. WGMEGS analysed the time-series (ICES 2021) and found that the median estimates were close to the mean and trimmed mean estimates. In 2022 the trimmed mean, removing 10% of the data, was 1311 oocytes/g fish, practically similar to the median and mean estimations. For consistency with previous years, we continue to use the median and calculate realised fecundity based on the detailed calculation manual completed with corresponding STATA and R-code by the working group in 2020.

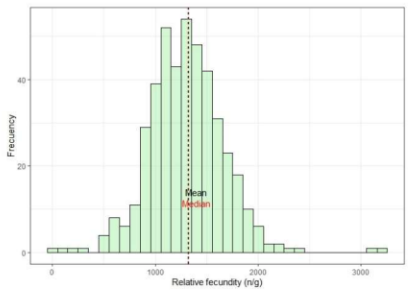

Figure 12 Relative fecundity values of 2022 mackerel samples. The red and black dotted lines are the median and mean values of relative potential fecundity (1313 n oocytes/g fish and 1319 n oocytes/g fish, respectively).

As previously mentioned about the fecundity estimate, this year we also included ovary samples with stage 4 oocytes. Oocyte stage 4 samples represented about half the total number of fecundity samples and had almost similar median fecundity value as the other samples; 1314 versus 1302 (n/g). This difference was not significant (P = 0.726, Pearson median test).

In 2022 the Netherlands pelagic commercial fleet contributed significantly to the sampling of adult fish. WGMEGS was concerned about the impact of this new supplier on the size distribution of fish. As described above, fecundity is size-dependent, and the fecundity in 2022 was 10% higher than in 2019. Thus, if the samples provided by the commercial fleet had come from a different fraction of the population, i.e., considering that commercial fishing gear selects larger fish compared to scientific gear, this could have affected fecundity. The mean and scatter plot of fish length distribution by sampling source indicates no difference between the length distribution of fish caught in scientific or commercial surveys.

Atresia and realized fecundity

The samples used for the analysis of atresia were collected from the entire survey area and during all periods. Of the 858 fish which were classified as spawning, 243 showed signs of early alpha atresia, which resulted in a prevalence of 28% (Table 4). This value was similar to the value obtained in 2019 (Table 4). For the 2022 surveys, 74 samples were analysed for intensity of atresia. The geometric mean for the intensity of atresia for 2022 was slightly higher than found for 2019 (20 vs 19 n/g) as was also the loss per day (45 vs 43 n/g) and total loss during the spawning period (45 vs 43 n/g). However, since the potential fecundity was higher for 2022 compared to 2019 and previous years back to 1998, the percentage loss was the lowest recorded; 3 % for 2022 versus 4 % for 2019, which was the previous lowest.

By subtracting the atretic loss from the potential fecundity, a realized fecundity of 1268 (oocytes/g fish) was obtained. From 1998 to 2019 (Table 4), the final estimates of realized fecundity ranged from 1002 to 1209 (grand mean = 1076, SD = 71). The 2022 estimate of realized fecundity (1268 oocytes/g fish) is 18% higher than the mean for those years. Furthermore, the number of samples analysed in 2022 was the highest in the series, indicating that the fecundity estimate sufficiently reflects the stock fecundity of 2022. Therefore, it is considered suitable for calculating the 2022 SSB.

Table 1. Time series of estimated parameters for adults..

Parameter	Y1998	Y2001	Y2004	Y2007	Y2010	Y2013	Y2016	Y2019	Y2022
Fecundity samples (n)	96	187	205	176	74	132	97	62	396
Prevalence of atresia (n)	112	290	348	416	511	735	713	252	243
Intensity of atresia (n)	112	290	348	416	511	56	66	64	74
Relative potential fecundity (n/g)	1206	1097	1127	1098	1140	1257	1159	1191	1313
Prevalence of atresia	0.55	0.2	0.28	0.38	0.33	0.22	0.3	0.28	0.28
Geometric mean intensity of atresia (n/g	46	40	33	30	26	27	30	19	20
Potential fecundity lost per day (n/g)	3.37	1.07	1.25	1.48	1.16	0.8	1.2	0.71	0.75
Potential fecundity lost (n/g)	202	64	75	89	70	48	72	43	45
Relative potential fecundity lost (%)	17	6	7	9	6	4	6	4	3
Realised fecundity (n/g)	1002	1033	1052	1009	1070	1209	1087	1147	1268

Biomass estimation for NEA mackerel

Total spawning stock biomass (SSB) was estimated using the realised fecundity estimate of 1268 oocytes/gr female, a sex ratio of 1:1 and a raising factor of 1.08 (ICES, 1987). According to the Annual Egg production Method (AEPM) the spawning stock biomass (SSB) was estimated as shown below:

$$SSB = \frac{TAEP}{F'} * s * cf$$

Where F' represents realized fecundity,s means a sex ratio of 1:1 and cf is a fixed raising factor at 1.08 to convert pre-spawning fish to spawning fish.. Spawning stock biomass was thus calculated :

- 3.065 million tonnes for western area (2019: 2.301).
- 0.499 million tonnes for southern area (2019: 0.792).
- 3.565 million tonnes for western and southern areas combined (2019: 3.093)

This is an increase in SSB estimate of 18% compared to the 2019 SSB estimate (Figure 13)

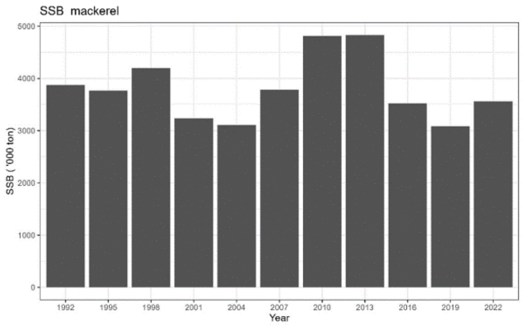

Figure 13. SSB estimates for NEA mackerel. 1992-2022

Table 5. Total annual egg production and SSB for the western and southern areas and for combined area. Temporal series

Area	Year	TAEP (*10^{12})	SSB (kt)
Combined	1992	2570	3874
Combined	1995	2230	3766
Combined	1998	2020	4199
Combined	2001	1670	3234
Combined	2004	1500	3107
Combined	2007	1770	3783
Combined	2010	2380	4811
Combined	2013	2700	4832
Combined	2016	1770	3524
Combined	2019	1640	3088
Combined	2022	2090	3563
Southern	1992	336	507
Southern	1995	186	370
Southern	1998	479	883
Southern	2001	318	417
Southern	2004	138	309
Southern	2007	348	745
Southern	2010	459	926
Southern	2013	506	904
Southern	2016	225	447
Southern	2019	423	797
Southern	2022	293	499
Western	1992	2230	3367
Western	1995	2050	3396
Western	1998	1540	3316
Western	2001	1350	2816

Western	2004	1360	2798
Western	2007	1420	3038
Western	2010	1920	3884
Western	2013	2200	3928
Western	2016	1550	3077
Western	2019	1220	2291
Western	2022	1800	3064

HORSE MACKEREL

Western horse mackerel egg production by period

Period 3 – In period 3 horse mackerel spawning started in the Cantabrian Sea and southern Biscay, but numbers of eggs found were very low. Higher spawning took place in the Celtic Sea but again numbers were still low (Figure 14).

Period 4 – Horse mackerel spawning continued in the Cantabrian Sea, extending into southern Biscay. Eggs were again found in the Celtic Sea but numbers were lower than in period 3 (Figure 15).

Period 5 – Horse mackerel spawning continues in the Cantabrian Sea, Celtic Sea and northern Bay of Biscay, but still in low numbers. Some eggs were also found south and west of Ireland (Figure 16).

Period 6 –Spawning continued in northern Biscay, the Celtic Sea and to the southwest of Ireland. For the first time in a number of years large numbers of eggs were reported in a number of stations close to the 200m contour. Peak spawning took place during this period (Figure 17).

Period 7 – Eggs were found from northern Biscay to west of Scotland, being concentrated off the southwest of Ireland. In general egg numbers were low but occasional stations with moderate to high counts were observed (Figure 18).

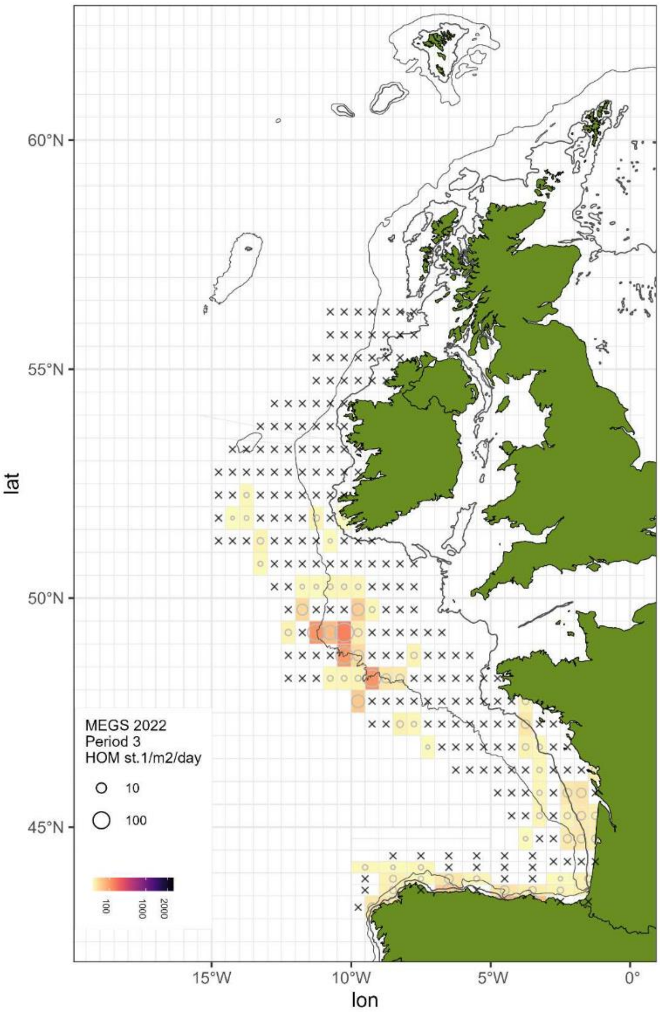

Figure 14. Western horse mackerel egg production by half rectangle for period 3 (March 4th – April 8th). Circle areas and colour scale represent horse mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

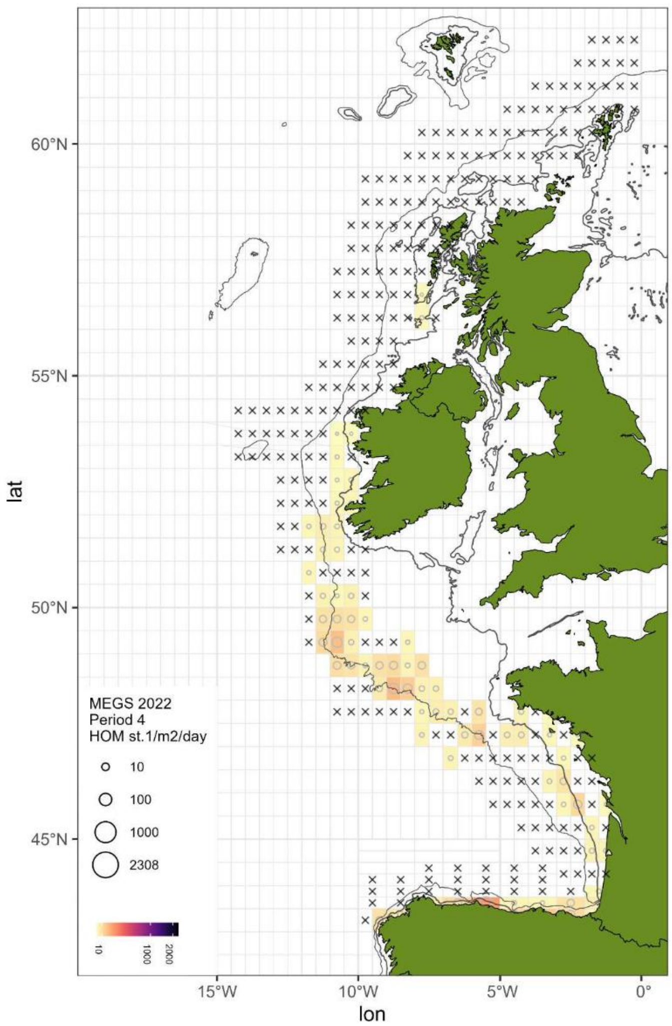

Figure 15 Western horse mackerel egg production by half rectangle for period 4 (April 9th – 29th). Circle areas and colour scale represent horse mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

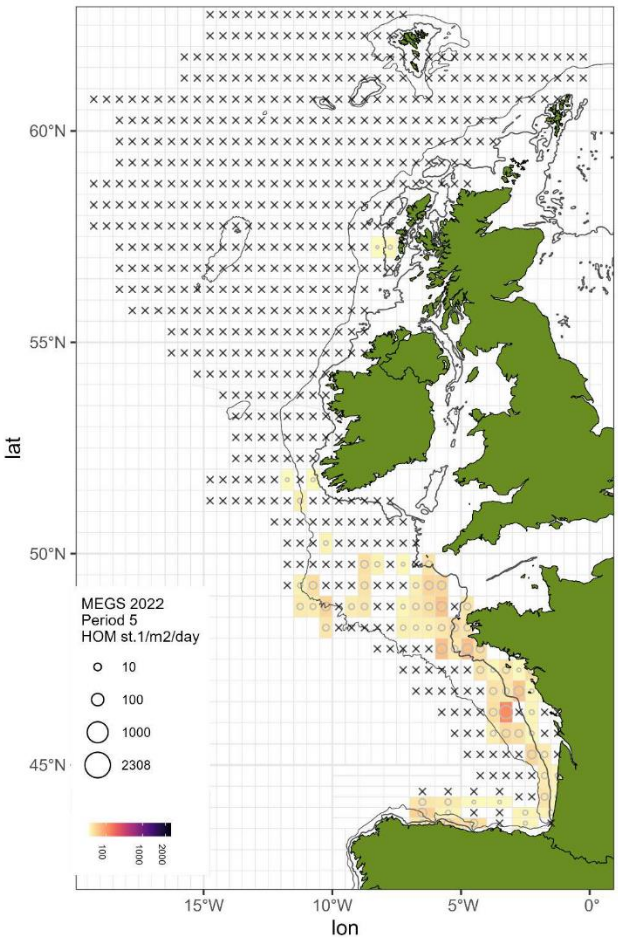

Figure 16 Western horse mackerel egg production by half rectangle for period 5 (Apr 30th – May 31st). Circle areas and colour scale represent horse mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

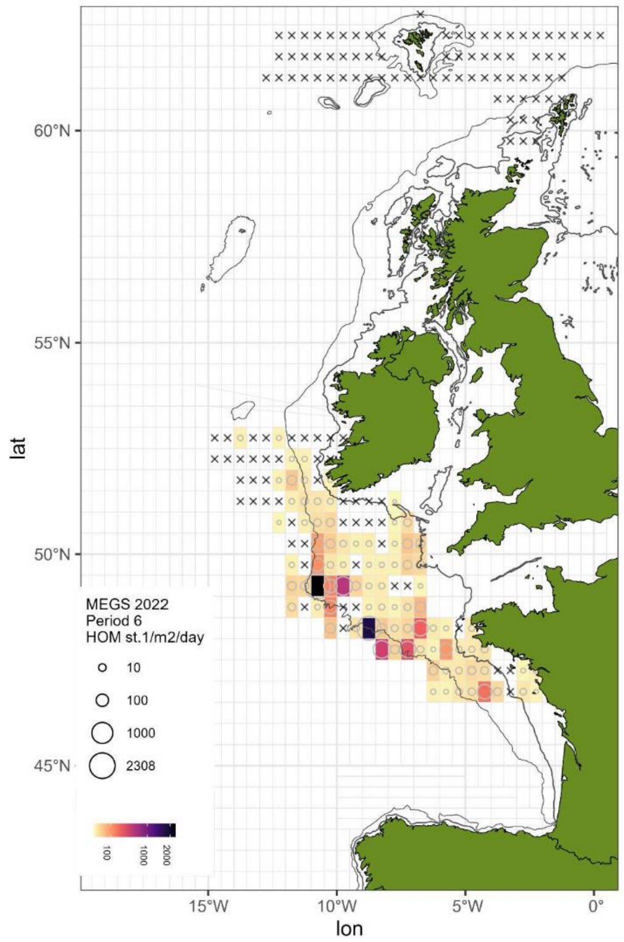

Figure 17 Western horse mackerel egg production by half rectangle for period 6 (June 1st – 30th). Circle areas and colour scale represent horse mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

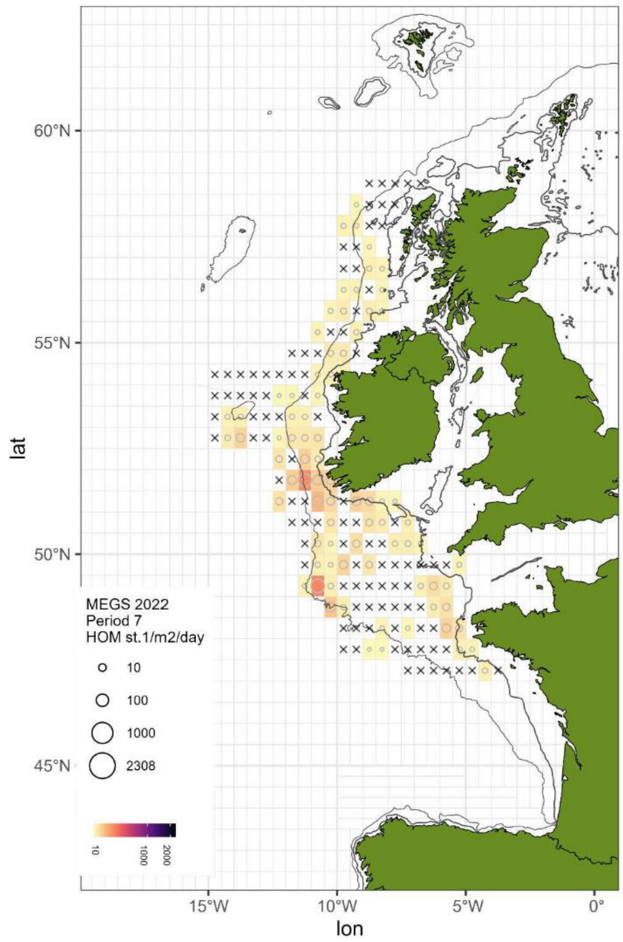

Figure 18 Horse mackerel egg production by half rectangle for period 7 (July 1st – July 31st). Circle areas and colour scale represent horse mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

TAEP results – Western Horse Mackerel

Period number and duration are the same as those used to estimate the western mackerel stock, as are the dates defining the start and end of spawning (Table 5). The shape of the egg production curve does not suggest that those dates should be altered for 2022 (ICES, 2023). An exercise, similar to the one carried out for mackerel in period 6, was not carried out for horse mackerel as WGMEGS feel that the Netherlands period 6 survey adequately delineated the northern boundary of horse mackerel spawning during this period. The total annual egg production was estimated at 5.51 x 10^{14}. This is more than a threefold increase on 2019 which at 1.78 × 10^{14} was the lowest estimate of annual egg production ever recorded for this species. (Figure 20, Table 6)

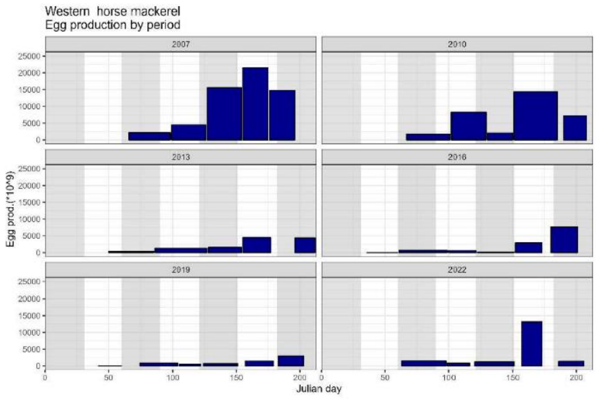

Figure 19: Egg production by period for the western horse mackerel stock since 2007.

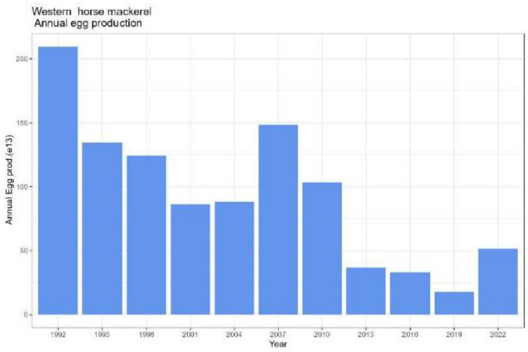

Figure 20: The total annual horse mackerel egg production for 1992 – 2022 for the western stock.

Table 5: Estimate of Western horse mackerel total stage I egg production by period using the histogram method for 2022

Dates	Period	Days	Annual stage I egg production * 10^{15}
Feb 1st – Mar 3rd	Pre 3	31	0.015
Mar 4th – Apr 8th	3	36	0.055
Apr 9th – 26th	4	18	0.016
Apr 27th – 29th	4 - 5	3	0.003
Apr 30th – May 31st	5	32	0.040
Jun 1st – 5th	5 - 6	5	0.047
Jun 6th – 22nd	6	17	0.246
Jun 23rd – Jul 4th	6 – 7	12	0.010
Jul 5th – 25th	7	21	0.028
July 26th – July 31st	Post 7	6	0.001
Total			0.551

Table 6. Western horse mackerel. The time series of Total Annual Egg Production (TAEP) estimates (10^{12} eggs).

Year	TAEP (*e^{12})
1992	2094
1995	1344
1998	1242
2001	864
2004	884
2007	1486
2010	1033
2013	366
2016	331
2019	178
2022	551

Daily Egg Production Method for western horse mackerel.

Horse mackerel eggs at stage 1a were used to estimate daily egg production. Peak spawning for western horse mackerel is expected to occur in period 6 Peak spawning for western horse mackerel is expected to occur in period 6. Average daily egg production and total spawning area were estimated for calculating egg production (Table 7) (ICES 2023).

Table 7. Daily egg production estimate for the 2022 using DEPM.

Period	Po (eggs/m²/day)	Spawning area (m²) (x10¹¹)	Ptot (eggs/day)(x10¹³)
6	133.857	1.390603962	0.186

Fecundity investigations

Fecundity samples for western horse mackerel were taken during the expected peak spawning period in survey in order to develop a modified DEPM approach for estimating the biomass of the horse mackerel stock. The DEPM requires an intensive sampling to estimate adult parameters and it has proved to be difficult to achieve the planned number of samples. During the peak spawning, the probability of finding valid samples increases and therefore adult sampling should be targeted to the months when peak spawning is expected.During the 2022 MEGS surveys, it was planned to collect samples of 1840 female horse mackerel in the peak of spawning (periods 6 and 7). In total 1658 horse mackerel were caught from 41 trawl hauls between 46.70°N and 60.70°N. Of these fish, 587 were females and these ovaries were used for the application of the DEPM. Regarding achieving the sampling goal, only 32% of the planned samples were collected. Difficulties in reaching the adult sampling target are common during WGMEGS surveys, so deviation from the initial plan was perceived in both periods. Nevertheless, this year the number of females collected increased considerably (587compared to 182 in 2019) thanks to the sampling contribution of the commercial fleet.

Preliminary results of the adult DEPM parameters for western horse mackerel are summarised in Table 8. (ICES 2023)

Table 8 Preliminary mean parameter estimates for 2022 adult horse mackerel period 6 (spawning peak)

Period	Parameter	mean	var
6	Female Mean weight (g)	275.4	124.9
6	Mean Sex Ratio	0.508	0
6	Mean Spawning Fraction	0.187	0
6	Mean batch fecundity (N.eggs)	59860	4173054
6	Relative mean batch fecundity (eggs/g female)	219.5	2.56
6	Daily fecundity (eggs/g female day)	20.9	NA

SSB is then calculated as a ratio of total daily egg production to daily fecundity (DF, eggs day/g female) during period 6. Preliminary results are shown in Table 9).

Table 9. Preliminary SSB estimate for the 2022 Western horse mackerel DEPM

Period	Daily fecundity (eggs/g female day)	Ptot (eggs/day)(x10^{13})	SSB (kt)
6	20.865	0.186	891.445

Horse mackerel length varied from 19.9 to 42 cm in period 6 and from 22 to 40.5 cm in period 7. The mode was slightly higher in period 6 (31.6 cm) than in period 7 (30.2 cm). Total weight ranged from 70-548 g in period 6 and from 96.5 to 550 g in period 7. As for length, the mode for weight was 253 and 230 g for period 6 and period 7 respectively.

Daily Egg Production Method analyses for mackerel in the western, North Sea and Southern areas

The western and Southern areas

Following the recommendation of WKMSPA (ICES, 2012b) to compare the Annual Egg Produc-tion Method (AEPM) and the Daily Egg Production Method (DEPM), during 2022 the DEPM was implemented again next to the AEPM, as has been done in last MEGS surveys since 2013 for-ward. Daily egg production has been estimated using stage 1a mackerel eggs. The peak spawn-ing for mackerel in the western and southern spawning areas is expected to be in Periods 3 and 4 (March and April) (ICES 2021).

Consequently, Total Daily Egg Production (Ptot) was estimated as 1.98 * 10^{13} eggs/day for period 3 and 1.09 * 10^{13} eggs/day for period 4. Therefore, P0 tot for period 3 is around twice as high as that for period 4

The results for 2022 DEPM fecundity parameters should be considered preliminary, as an extensive review of the application of the daily method in mackerel will be carried out next autumn 2023 at the Workshop on Mackerel Daily Egg production (WKMADE). The workshop will look into the calculations of spawning fraction and batch fecundity, and derive a Daily Egg Production Method (DEPM) based estimates of Spawning Stock Biomass (SSB)

The North Sea area

The egg survey in the North Sea has been designed for utilizing the Daily Egg Production Method (DEPM). In 2022 Denmark, England and Norway conducted the North Sea mackerel egg survey in June (period 6). The samples were collected and analysed according to the WGMEGS manuals (ICES 2019a, ICES,2019b)..

The North Sea mackerel survey was carried out from 5th June to 24th June. During this period the spawning area between 53ºN and 62ºN was surveyed once, receiving a single coverage (Figure 21). The survey is designed to cover the entire spawning area with samples collected every half ICES statistical rectangle (ICES 2014).

The spatial stage Ia egg distribution is shown in Figure 22. Egg distributions are comparable to 2021, however egg numbers seemed to be more evenly distributed throughout the survey area this year. The egg production was calculated for the North Sea between 53°N and 62°N and bounded by the relevant coastlines to the east and west. No clear pattern in the distribution of egg densities can be observed (Figure 22).

Due to technical reasons, allied to the sampling, the majority of the stations along the transects between 53 and 54°N do not have valid quantitative data, however qualitative data describing the mackerel stage Ia and Ib egg abundance are available to interpret the overall egg distribution in this area.(ICES, 2023)

The total area sampled in 2022 was slightly smaller than the area sampled in 2021, the first full transect was started at 54° 15'N compared to 53° 15'N in 2021. The spawning area estimated for 2022 is 371126 km2 and the average Daily egg production (P0) using stage Ia mackerel eggs is 18.6 eggs/m2/day. The total Daily egg production (Ptot) was calculated for the total investigated area (Table 10). The total Daily egg production for 2022 was 0.6909*10^{13} eggs/day. This is a 50% decrease in egg numbers reported in 2021 (Table 11).

Table 10. Daily egg production estimate for mackerel (stage 1a)(P0) and spawning area in the North Sea in 2022.

Year	P0 (eggs/m2/day)	Spawning area (km2)	Ptot (eggs/day)(*10^{13})
2022	18.6	371126	0.69

Table 11 Comparison of Total Daily Egg production (Ptot) between 2022 and 2021.

	2022	2021
Ptot *10^{13}	0.69	1.28

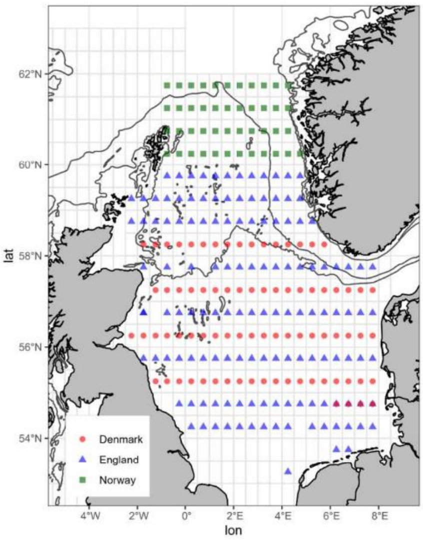

Figure 21. Survey coverage for the North Sea, 2022.Norway (Green), England (Blue), Denmark (Red).

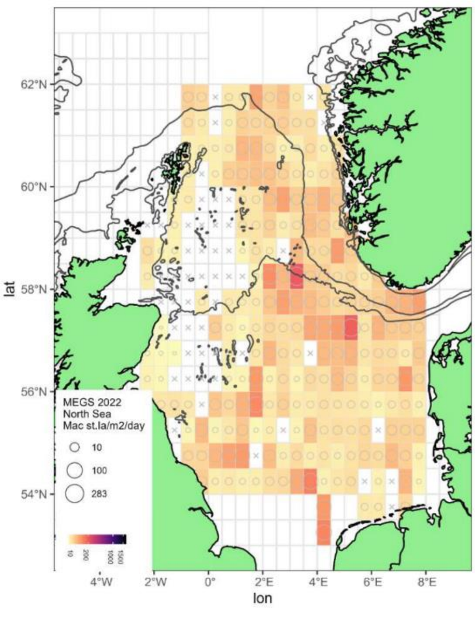

Figure 22 Heat map of Stage Ia mackerel egg production (eggs. m2. day-1) by half rectangle for the North Sea, 2022. Grey circles represent observed values, crosses represent observed zeros.

The results for the DEPM fecundity parameters should be considered very preliminary, since a full review of the application of the daily method to mackerel will be undertaken at the WKMADE next autumn.

References

ICES, 2014. Report of the Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS). ICES CM 2014/SSGESST:14. 116 pp.

ICES, 2019a. Manual for mackerel and horse mackerel egg surveys, sampling at sea. Series of ICES Survey Protocols SISP 6. 82pp. http://doi.org/10.17895/ices.pub.5140

ICES, 2019b. Manual for the AEPM and DEPM estimation of fecundity in mackerel and horse mackerel. Series of ICES Survey Protocols, SISP 5. 89 pp. http://doi.org/10.17895/ices.pub.5139

ICES. 2023. ICES. 2023. Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS). ICES Scientific Reports. 5:81. 118 pp. https://doi.org/10.17895/ices.pub.23790201