WORKING GROUP ON WIDELY DISTRIBUTED STOCKS (WGWIDE)

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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.

2023 catch advice was drafted for mackerel, Western horse mackerel, blue whiting and herring. For the remainder, multi-annual catch advice was previously published. Benchmark assessments are proposed for 2024 for mackerel, both horse mackerel stocks, herring and striped red mullet with boarfish is scheduled to be benchmarked in 2023. Prior to any benchmark assessment for mackerel, WGWIDE recommends that a workshop to review the latest knowledge with regard to the stock component structure takes place.

Northeast Atlantic Mackerel. This migratory stock is widely distributed throughout the Northeast Atlantic with significant fisheries in several ICES subareas. The assessment conducted in 2022 is an update assessment, based on the configuration agreed during the 2019 inter-benchmark and incorporates updates to the commercial catch, tagging, swept area and egg survey (preliminary) data series. No recruitment index is available for the 2021 year-class as survey coverage was inadequate. Advice is given based on stock reference points which were updated during a management strategy evaluation carried out in 2020. Following a decline since 2014, SSB has been stable (above MSY Btrigger) since 2019. Fishing mortality has been increasing since 2016 and is above FMSY since 2020.

Blue Whiting. This pelagic gadoid is widely distributed in the eastern part of the North Atlantic. The current assessment configuration (inter-benchmark in 2016) uses preliminary catch and sampling data along with the acoustic survey data from the current year. The 2022 update assessment indicates that SSB is increasing following strong recent recruitment and is well above MSY Btrigger. Fishing mortality has been above FMSY since 2014 but is falling.

Norwegian Spring Spawning Herring. This stock is migratory, spawning along the Norwegian coast and feeding throughout much of the Norwegian Sea. The 2022 update assessment is based on an implementation of the XSAM assessment model introduced following a benchmark in 2016 and is consistent with the 2021 assessment. Following a period of decline since 2009, SSB has been relatively stable just above MSY Btrigger in recent years, due to the strong 2016 year-class. However, recruitment since 2016 is estimated to be below average and the stock size is forecast to fall below MSY Btrigger 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 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 2022 assessment indicates that SSB is below Blim and will remain so in 2024, even under the scenario of zero catch in 2023. Based on the MSY approach, advice for 2024 is therefore for zero catch. The assessment continues to display significant retrospective issues which should be investigated by a benchmark 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. No survey index was available in 2020 due to restricted survey coverage, and the 2021 value is a reduction on the 2019 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 from 2018-2020.

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 2022 update assessment continues to show the indicator fluctuating without trend since 2010. However, large uncertainties remain with regard to 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(s)	Andrew Campbell, Ireland
Meeting venue(s) and dates	14-30 August 2022, Copenhagen, Denmark and online (40 participants)

1 Introduction

1.1 Terms of References (ToRs)

The Working Group on Widely Distributed Stocks (WGWIDE), chaired by Andrew Campbell, Ireland, met in ICES, Copenhagen in hybrid format from 24-30 August 2022. 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 where available;

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

   i) descriptions of ecosystem impacts on fisheries

   ii) descriptions of developments and recent changes to the fisheries

   iii) mixed fisheries considerations, and

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

c) Conduct an assessment on the stock(s) to be addressed in 2022 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 COVID-19 pandemic disruption 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 2021.

   iv) For category 3 and 4 stocks requiring new advice in 2022, 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

   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 of https://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/Fisheries%20Resources%20Steering%20Group/2020/WKFORBIAS_2019.pdf) 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, consider whether it is possible and feasible to resolve the issue through an interbenchmark. If this is not possible, consider providing advice using an appropriate Category 2 to 5 approach.;

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

Consistent with ACOM's 2020 decision, the basis for Fpa should be Fp.05.

1) Where Fp.05 for the current set of reference points is reported in the relevant benchmark report, replace the value and basis of Fpa with the information relevant for Fp.05

2) Where Fp.05 for the current set of reference points is not reported in the relevant benchmark report, compute the Fp.05 that is consistent with the current set of reference points and use as Fpa. A review/audit of the computations will be organized.

3) Where Fp.05 for the current set of reference points is not reported and cannot be computed, retain the existing basis for Fpa.

vii) 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;

viii) 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.

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

i. In the section 'Basis for the assessment' Table 3 under input data align the survey names with the ICES survey naming convention

e) 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 2023 for conclusion in 2024;
iii) determine the prioritization score for benchmarks proposed for 2023-2024;
iv) as necessary, document generic issues to be addressed by the Benchmark Oversight Group (BOG)

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

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

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

i) If not completed in 2020, 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.

1.1.1 The WG work 2022 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 and Western horse mackerel. 2021-22 catch advice for Boarfish, North Sea horse mackerel and red gurnard and 2021-23 catch advice for striped red mullet were issued in 2020. All draft advice sheets were agreed in plenary. Advice sheets, report sections and assessments were audited with 2-4 working group members assigned to each stock. In addition, the stock annexes for mackerel and blue whiting were updated.

1.2 Participants at the meeting

WGWIDE 2022 was attended by 40 delegates (5 online) from the Netherlands, Ireland, Spain, Norway, Germany, Portugal, Iceland, UK (England and Scotland), Faroe Islands, France, Denmark, Greenland 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 2022, the group drafted 2023 advice sheets for 4 stocks. 2022 advice for North Sea horse mackerel, boarfish, red gurnard and striped red mullet was issued in 2020 the relevant data series and stock assessments were updated and considered at WGWIDE 2022. 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	2021
Western horse mackerel	hom.27.2a4a5b6a7a-ce-k8	1	Stock Synthesis	1	2021
North Sea horse mackerel	hom.27.3a4bc7d	3.2	Survey trends based	2	2021

Stock	ICES code	Data Category	Assessment method	Assessment Frequency	Last Assessment
NE-Atlantic mackerel	mac.27.nea	1	SAM	1	2021
Striped red mullet	mur.27.67a-ce-k89a	5	No assessment	3	2020
Blue whiting	whb.27.1-91214	1	SAM	1	2021

1.4 Quality and Adequacy of fishery and sampling data

1.4.1 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, this year no Russian data submissions were available (for 2021). Russia has significant catches of NEA Mackerel, Blue Whiting and Norwegian Spring Spawning Herring and usually provides sampling data for these fisheries. Information on total catch for 2021 by ICES division is available from the ICES preliminary catch database. Historically, this matches final estimates closely and was therefore used as an estimate of Russian catch by ICES division in 2021. Catch proportion by quarter in 2021 was assumed to be equal to the recent average (2018-2020). Samples available from other national fisheries operating in the same area and quarter were used to estimate the age structure of Russian catch in 2021.

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.

1.4.2 Catch Data

The WG has on a number of occasions discussed the accuracy of the catch statistics and the possibility of large scale under reporting or species and area misreporting. The working group considers that the best estimates of catch it can produce are likely to be underestimates.

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.

1.4.3 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.

1.4.4 Age-reading

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

1.4.4.1 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.

At the NEA mackerel Inter-benchmark in 2019, concerns related to the quality of age reading of commercial catch were discussed. WGWIDE concludes that additional investigation on the impact of ageing error on stock assessment outputs are required. This includes the development of standardized sensitivity analyses for this purpose, which would be applicable to the different stocks.

1.4.4.2 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.

The objectives of this workshop were to review the current methods of ageing *Trachurus* species, to evaluate the new precision of ageing data of *Trachurus* species and to update guidelines, common ageing criteria and reference collections of otoliths. The exchange results showed a low value of percentage of agreement from 45.1% to 59.1% for the three *Trachurus* species. The Coefficient of Variation was lower for *T. trachurus* (17.3–32.2) than for the other *Trachurus* species (60.1-73.4) because the sampled specimens were older for this species than for the two other species. With feedback from the readers present at the exchange and the discussion during the WKARHOM3 meeting, the main cause of age determination error for *T. trachurus* was identified as otolith preparation techniques (whole/slice).

However, for the three *Trachurus* species, there are several difficulties in age determination: identification of the first growth annulus, presence of many false rings (mainly in the first and second annuli) and the interpretation and identification of the edge characteristics (opaque/ translucent). The second reading was performed during the workshop with 50 images per each species. Each reader read only the images of the species that is read in their laboratory. The percentage of agreement between readers increased to 70.6% with a CV of 18.4 for *T. trachurus* and to 67.8% with a CV of 31.7 for *T. mediterraneus*. Finally, the group reached an agreement on defining an ageing guideline and a reference collection presented in this report and the aim is to employ these tools for all laboratories.

The next workshop (WKARHOM4) and exchange is planned for November 2022 using the SmartDots platform.

1.4.4.3 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 indefinitely. It is therefore recommended to organise a new scale/otolith exchange and a follow up workshop.

There are several topics to cover in the recommended work.

Firstly, 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.

Secondly, 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.

Last year, WGWIDE recommended to organise a scale/otolith exchange and workshop. This work appears to be in progress in WGIPS, WGBIOP and nationally at the institutes, and a workshop is planned for April 2023.

1.4.4.4 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 enables 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.

1.4.4.5 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 preparation for a benchmark assessment in 2023, an ageing exchange has been initiated via SmartDots.

1.4.4.6 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.

1.4.4.7 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.

1.4.5 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 about the fishery, such as under- or over-reporting for which there is firm external evidence.

Official Catch	**Catches as reported by the official statistics to ICES**
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

1.4.6 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 data series, 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 RCMs as specified.

Stock	**Data Problem**	**How to be addressed in**	**By who**
Northeast Atlantic Mackerel	Submission of data	Data submissions must include all the data outlined in the data call and be submitted by	National laboratories

Stock	Data Problem	How to be addressed in	By who
		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.	
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
Northeast Atlantic Mackerel	Sampling of foreign vessels	Any information available from the sampling of foreign vessels should be forwarded to the appropriate person in the national laboratory in order that they may use this information when compiling the data submission.	National laboratories; RCG NA, RCG NS&EA
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
Horse Mackerel – North Sea Stock	Low contribution of countries to the estimation of the age and length distribution of catches	To ensure the sampling of age and length information from all catch fractions and all areas and within all quarters from all commercial fleets with a distribution of sampling effort over the year and areas in the North Sea	National institutes
Norwegian Spring-spawning Herring	Low sampling effort on some nations	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

Stock	Data Problem	How to be addressed in	By who
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

1.4.7 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.

1.4.8 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
4. Using acoustics from commercial trawlers as potential indicators of abundance

1.4.8.1 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 Measurements
2016	9	45	591	1,307	113,900	193	65,212
2017	12	62	840	1,781	177,887	212	91,357
2018	16	86	1,219	2,677	253,237	208	170,306
2019	16	97	1,226	2,658	224,886	183	124,288
2020	17	112	1,424	3,038	305,282	214	163,955
2021	19	119	1,398	2,874	282,097	202	138,481
2022*	18	62	733	1,694	144,718	197	65,457
(all)	583	7,431	16,029	1,502,007	819,056	9,490	819,056

*incomplete

A description of the different fisheries is included in the report. In 2022, a substantial blue whiting fishery was carried out south of the Porcupine back, an area that had hardly been fished in previous years.

In the 2022 self-sampling report, a standardized CPUE calculation has been included for the first time 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)

1.4.8.2 Gonad sampling for mackerel and horse mackerel

During 2022, a dedicated PFA industry researcher carried out three sampling trips on-board of commercial trawlers with the aim to collect fresh and frozen gonad samples of mackerel and horse mackerel to aid the WGMEGS in determining the potential fecundity of mackerel and horse mackerel. In order to determine potential fecundity, it is necessary to collect the gonad samples just prior to spawning Using a commercial vessel for that sampling proved to be an efficient way of collecting the samples as the vessels were targeting mackerel and horse mackerel during the period that the start of spawning could be anticipated.

During 2021 and 2022 DTU Aqua and the Danish Pelagic Producers Organization collected gonads from mackerel in the North Sea, that were fished as bycatch in other fisheries. The gonads have been stored in formalin for accurate maturity staging and egg counting. The sampling has been conducted throughout the year to get more insight into the spawning cycle in the North

Sea. The sampling has been coordinated with the 2021 North Sea mackerel egg survey. Results of the sampling are expected to be available in 2023.

In addition, the PFA is continuing the collection of mackerel gonads throughout the year, as a means of following the maturity development of mackerel (and to a limited extent horse mackerel).

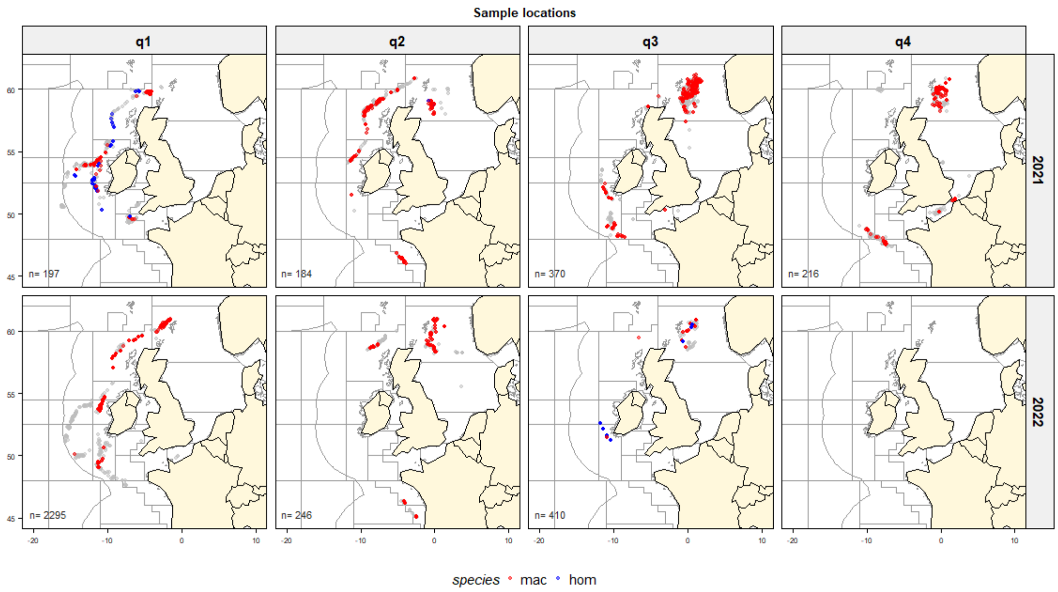

Figure 1.4.8.2 Overview of PFA gonad sampling for mackerel and horse mackerel during 2021 and 2022.

1.4.8.3 Horse mackerel 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 (see ICES, 2015). Further refinements of the definitions of stock units were based on the results from the EU-funded HOMSIR project (2000-2003), which utilised a multidisciplinary approach including various genetic approaches (allozymes, mitochondrial DNA and microsatellites), the use of parasites as biological tags, body morphometrics, otolith shape analysis and the comparative study of life history traits (growth, reproduction and distribution) (Abaunza et al., 2008). However, there remained unresolved issues particularly in areas where mixing between stocks was likely to occur, e.g. between divisions 7e and 7d and in division 4a, and also no reliable method to continue ongoing monitoring.

In response to this, the Pelagic Freezer Trawler Association (PFA) contracted the Wageningen University and Research (WUR) in 2015 to undertake a study on North Sea horse mackerel (Brunel et al., 2016). The primary aim of the study was to improve the data quality used for an analytical stock assessment model of North Sea horse mackerel.

The management boundary between the Western and North Sea stocks in the English Channel (corresponding to the separation between divisions 7e, western Channel and 7d, eastern Channel) does not correspond to a real biological boundary, as mixing of the two stocks is known to occur in division 7d in autumn and winter (Brunel et al., 2016). The catches taken in 7d are officially considered as being North Sea horse mackerel and represent c.80% of the catches from this stock. An unknown proportion of this catch is likely from the western stock, which interferes with the cohort signal in the catch at age matrix, hampering the development of an age-structured assessment model for the North Sea stock. Developing methods to separate catches from the western stock from catches from the North Sea stock in division 7d are therefore necessary to improve the quality of the catch information for the North Sea stock. Within the project, two pilot studies, based on chemical fingerprint analyses and genetics, were conducted to investigate new methods to determine stock structure and to develop techniques to identify the stock origin of the catches taken in the eastern English Channel.

As part of the project, WUR contracted University College Dublin, Ireland (UCD) to undertake a pilot study to develop a method of genetic stock identification for discriminating North Sea and Western horse mackerel (Brunel et al., 2016). The aims of the pilot study were to firstly develop and validate at least 24 polymorphic microsatellites markers in horse mackerel and secondly to screen spawning fish collected in 2015 from the Western and North Sea stocks to establish a genetic baseline of the spawning stocks and test the presence of population structure. Recently developed Next Generation Sequencing (NGS) and Genotyping by Sequencing (GBS) based approaches, which were developed on cod (*Gadus morhua* Linnaeus, 1758), boarfish (*Capros aper* Lacépède, 1802) and 6a, 7b-c herring were used for marker development and screening of spawning samples (Farrell et al., 2016; Vartia et al., 2014 & 2016). The pilot study successfully identified a large number of novel microsatellites, however initial data analyses were confounded by a poor-quality sequencing run and as such the discrimination power between the western and North Sea sample was low. This resulted in the pilot study being unable to separate the two stocks conclusively and unequivocally.

In an effort to resolve these uncertainties, the Northern Pelagic Working Group (NPWG) of the European Association of Fish Producers Organisations (EAPO) contracted EDF Scientific Limited, Ireland and Jens Carlsson (UCD) to undertake a comprehensive genetic stock identification study on Horse Mackerel (Farrell & Carlsson, 2018). Sampling was conducted over three consecutive years and three spawning seasons and covered a large area of the distribution of the species including the Western, North Sea and Southern stock areas and also West African waters. In total 33 population samples, comprising 2,295 individual fish were collected from 2015 to 2017 across the study area (figure 1.4.8.2). Spawning samples were analysed with a panel of 37 novel, putatively neutral microsatellite markers and statistical analyses (F_{ST}, structure, assignment testing, mixed stock analyses and FCA analyses) indicated that horse mackerel in the northeast Atlantic region does not represent a single biological unit. A high level of species misidentification in the West African samples was also observed. On the highest level there are mixed species catches in African waters, a clear separation of the southern North Sea from other regions and further, less pronounced, structure along the northeast Atlantic continental shelf. Exploratory assignment testing and mixed stock analysis of the western and North Sea baselines indicated a success rate of c.60-65% for self-assignment. This was considered relatively low and is due to the relatively low genetic differentiation between the populations at putatively neutral loci. Despite this, further exploratory assignment testing and mixed stock analysis of the fish caught outside spawning time in the northern North Sea and western English Channel indicated that a large component of these fish belonged to the Western stock. No samples from the eastern English Channel (7d) were available for testing.

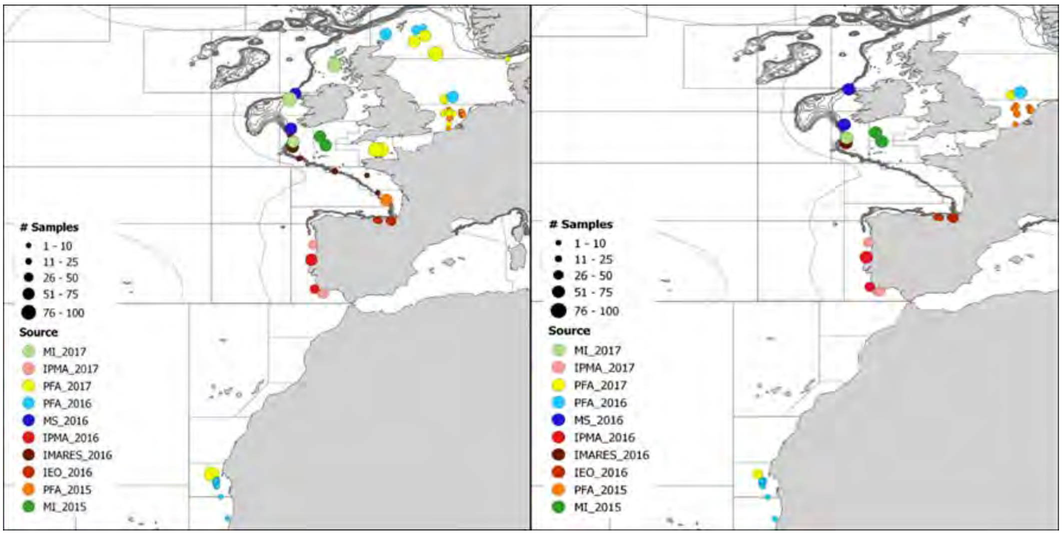

Figure 1.4.8.2. (left panel) The horse mackerel samples collected from 2015 to 2017 and (right panel) those included in the baseline dataset.

The results showed that the genetic information could be used for mixed stock analyses and that the information could be used to delineate the range of the North Sea stock – information that could be taken into account by fisheries management. However, it was suggested in the project report that further genetic analyses were warranted to increase the numbers and types of genetic markers available for this species. This would improve stock discrimination, mixed stock analyses and individual assignment capacity.

In 2019 the NPWG contracted Uppsala University, Sweden and EDF Scientific Limited to apply the same Whole Genome Sequencing (WGS) and pooled population sequencing (Pool-Seq) approaches, that had successfully been developed for herring (see Han et al., 2020), on the horse mackerel samples (Fuentes-Pardo et al., 2020; in review). The aims of the study were to identify informative genetic markers for the stock identification of horse mackerel and to estimate the extent of genetic differentiation among the sampled populations. The samples included in the genome study (figure 1.4.8.3) were primarily a subset of the baseline samples analysed in Farrell and Carlsson (2018). One additional sample from the Alboran Sea in the Mediterranean Sea was provided by the ATLAS Project (https://www.eu-atlas.org/). Samples were aggregated into 12 pools based on spatial and temporal proximity, thus broadly representing most of the geographical range of the species in the northeast Atlantic and the western part of the Mediterranean Sea. Each pooled sample was sequenced and mapped to the newly developed horse mackerel genome (Genner and Collins, 2022).

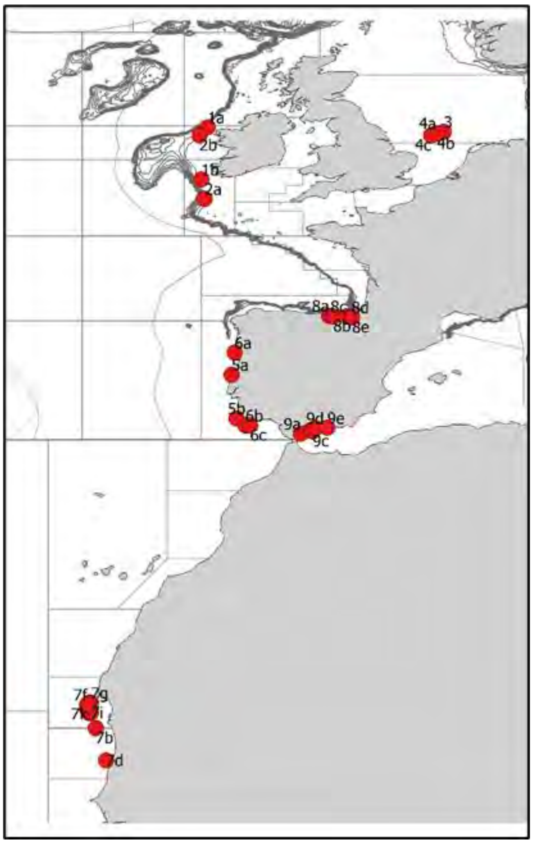

Figure 1.4.8.3. Sampling locations of the Atlantic horse mackerel included in this study. (Left) Sample batches collected at each location.

The results indicated that while the populations only differed in a small fraction of their DNA (< 1.5%), these genetic differences were significant as they likely represented natural selection and local adaptation of populations. A small panel of the highly differentiated genetic variants were validated by genotyping individuals from each population (n=24 per pop), which demonstrated that the variants could be used as informative molecular markers for the genetic identification of the main stock divisions of horse mackerel. The results, based on the analysed samples, indicated that the North Sea horse mackerel are a separate and distinct population. The samples from the Western stock, west of Ireland and the northern Spanish shelf, and the northern part of the Southern stock, northern Portugal, appear to form a genetically close group. There was significant genetic differentiation between the northern Portuguese samples and those collected in Southern Portuguese waters, with those in the south representing a separate population. The North African and Alboran Sea samples were distinct from each other and from all other samples.

These results indicated 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. To this end a new genetic tool has been developed to enable higher throughput of samples and also to standardise the genotyping approach. The DNA TRACEBACK® Fisheries Array (IdentiGEN, Dublin, Ireland) contains c. 4,000 markers that represent informative regions in the 24 chromosomes. The NPWG has agreed to fund the next part of the analysis and it expected that results will be available for presentation at WGWIDE 2023.

1.4.8.4 Use of acoustic data from commercial trawlers as an indicator of abundance

For many years already, acoustic data has been recorded on commercial fishing vessels of the Pelagic Freezer-trawler Association. Many terabytes of data are now available. The equipment is sophisticated, the echo sounders are calibrated and the high fish density regions are visited during the fishing trips with extensive spatio-temporal coverage. But how can we derive meaningful metrics from the acoustic data collected by fishing vessels?

Currently a method is being developed and tested at Wageningen Marine Research to utilize acoustic data collected during commercial fishing operations for biomass estimation. The case study that is explored is the blue whiting stock during the spawning season in March-April. The International Blue Whiting Spawning Stock Survey west of the British Isles (IBWSS) is carried out annually during the spawning season. At the same time, the commercial fishery is taking place in that area.

The acoustic observations during both, the scientific survey and the fishing trips have been processed using the same methods: cleaning noise, removing unwanted regions (e.g. surface and bottom reflections), manually drawn polygons that confine the backscatter regions that can be attributed to the blue whiting, and results exported as integrated acoustic backscatter per nautical mile.

The main difference between the survey and the fishing vessel observations comes from the patterns in the acoustic tracks. The fishing vessels observations comes from localised recordings from high density spots during the actual fishery. The biased property of the acoustic tracks of the fishing vessels makes it difficult to fit them into a statistically meaningful survey design. The method now being developed at Wageningen Marine Research is taking advantage of the good overlap between the commercial fishery and the scientific survey to develop a method to transform the targeted fishing vessel data into unbiased 'survey-like' estimates of abundance.

All commercial acoustic data is broken down into weeks for each fishing trip and polygons were generated around these weekly tracks. Next, synthetic transects were generated in a similar fashion to the survey transects with 1 nautical mile differences between the sampling units and with a predefined inter-transect distance. Acoustic values are assigned to the synthetic transects by taking the average of the acoustic observations within the search radius around each point on the transect.

The use of synthetic transects gives the possibility of interpreting the data from fishing vessels in a similar way as the survey procedures. However, there are two important parameters that need to be determined to generate these synthetic transects: the distance between the transects, and the search radius around the points in the synthetic transects. We looked at the correlation between the survey data and the synthetic transect data with different transect spacing and search radius. The spacing of 0.2 degrees and search radius of 1.2 nautical miles gives a coefficient of determination of 0.94. This promising correlation encourages us to generate time series that can be used to generate trends independent from the survey data.

1.5 Comment on update and benchmark assessments

Updates were presented to the WG for all the eight 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 inter-benchmark 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 inter-benchmark 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 2022 followed a benchmark in February 2021 (WKWEST) during which an index of abundance based on a number of bottom trawl surveys was developed.

The remaining two stocks addressed by the WG (boarfish and striped red mullet) have not been benchmarked recently but were still assessed by the WG.

1.6 Planning future benchmarks

Two of the WGWIDE stocks are yet to be benchmarked; Boarfish for which an exploratory surplus production model is used and Striped red mullet for which there is no assessment in place. Boarfish is scheduled to be benchmarked in 2023. Ongoing sampling of the commercial catch, an expanded acoustic survey time series and advances in modelling techniques *e.g.* VAST will be explored with a view to improving the current assessment and exploring alternative assessment models. Research projects underway for Striped red mullet are due to be completed in the near future and will inform the proposed benchmark for 2024.

The current implementation of the Stock Synthesis model for the assessment of Western horse mackerel has been used since the benchmark in 2017. A number of issues with the assessment and opportunities for improvement were identified at WGWIDE 2021 and a benchmark was proposed and scheduled for 2023. Unfortunately, this could not be achieved and the benchmark had to be postponed. The working group considers that the justification for a benchmark remains strong and it should now take place in 2024 along with North Sea Horse mackerel, which is currently a category 3 assessment with opportunities to improve based on both new data sources and models. Genetic studies (see section 1.4.8.3) have shown that Western and North Sea horse mackerel are genetically distinct. Currently, catches are assigned to stocks on the basis of ICES division and quarter although it is suspected that catches occur on mixed stocks.

WGWIDE 2022 is also proposing benchmark workshops take place for Northeast Atlantic Mackerel and Norwegian Spring Spawning Herring. The benchmark for NEA Mackerel should be precede by a workshop to review the current assumptions with regard to stock structure (components). Terms of reference for the workshop (WKMACEVAL) were drafted by WGWIDE 2022 and will inform a recommendation to ACOM for the WK. 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 (to be considered by WGISDAA), DEPM vs 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, assumptions on maturity in the most recent years and implementation in the mainstream SAM model, which has recently been developed to offer the functionality of the current XSAM model.

Issue lists and benchmark scoring sheets for each of the stocks proposed for benchmarking by WGWIDE 2022 were reviewed and updated during the meeting.

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

Stock	Benchmark History	WGWIDE 2022 Proposal
Boarfish	Benchmark scheduled for 2023	
Red gurnard	Full benchmark 2021	
Norwegian Spring Spawning herring	Full benchmark 2016	Full benchmark
Western horse mackerel	Full benchmark 2017 Reference point inter-benchmark 2019 2022 scheduled benchmark postponed	Full benchmark
North Sea horse mackerel	Full benchmark 2017	Full benchmark
Northeast Atlantic mackerel	Full benchmark 2014 Full benchmark 2017 Inter-benchmark 2019	Full benchmark
Striped red mullet	Never benchmarked	Full benchmark
Blue whiting	Benchmarked 2012 Inter-benchmark 2016	

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

1.7.1 General overview of management system

The North East Atlantic Fisheries Commission (NEAFC) is the Regional Fisheries Management Organisation (RFMO) for the North East 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 North East 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.

1.7.2 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. No agreement on quota shares has been reached since 2015 and catches have exceeded advice since this time. At WGWIDE 2022, the assessment and forecast indicate a strong increase in SSB and catch advice for 2023 is an 81% increase on that for 2022. It should be noted that the management plan clause permitting such an increase (paragraph 6b) was not tested in the 2016 evaluation. 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.

1.7.3 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 summarised 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 41% above the scientific advice and close to the sum of unilateral quota.

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 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.

Yr	Advice Basis	Advised Catch (t)	TAC (t)	Unilateral Quotas (t)	Catch (t)
2010	Do not exceed HCR	1 483 000	1 483 000		1 457 000
2011	Scenarios	1 170 000	988 000		993 000
2012	Follow management plan	833 000	833 000		826 000
2013	Follow management plan	619 000	619 000	692 000	685 000
2014	Follow management plan	418 000	418 487	436 000	461 000
2015	Follow management plan	283 000		328 000	329 000
2016	Follow management plan	317 000		377 000	383 174
2017	Follow management plan	646 075		805 142	721 566
2018	Follow management plan	384 197		546 448	592 899
2019	Follow management strategy (F_{mgt}=0.14, B_{mgt}=3.184 Mt)	588 562	588 562	773 750	777 165
2020	Follow management strategy (F_{mgt}=0.14, B_{mgt}=3.184 Mt)	525 594	525 594	693 915	720 937
2021	Follow management strategy (F_{mgt}=0.14, B_{mgt}=3.184 Mt)	651 033	561 033	881 097	851 813
2022	Follow management strategy (F_{mgt}=0.14, B_{mgt}=3.184 Mt)	598 588	598 588	827 963	
2023	Follow management strategy (F_{mgt}=0.14, B_{mgt}=3.184 Mt)	511 171			

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

Yr	Advice Basis	Advised Catch (t)	TAC (t)	Unilateral Quotas (t)	Catch (t)
2010	Follow proposed management plan	180 000	185 000		203 112
2011	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
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		
2023	MSY approach	0			

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

Yr	Advice Basis	Advised Catch (t)	TAC (t)	Unilateral Quotas (t)	Catch (t)
2010	Harvest control rule	572 000	691 305		875 515

2011	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	1 119 103	1 081 540
2022	MSY approach	794 920	794 920	1 188 227	
20	MSY approach	782 066			

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

Yr	Advice Basis	Advised Catch (t)	TAC (t)	Unilateral Quotas (t)	Catch (t)
2010	Follow the agreed management plan	540 000	548 000		540 000
2011	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	1 107 529	
2023	Long-term management strategy	1 359 629			

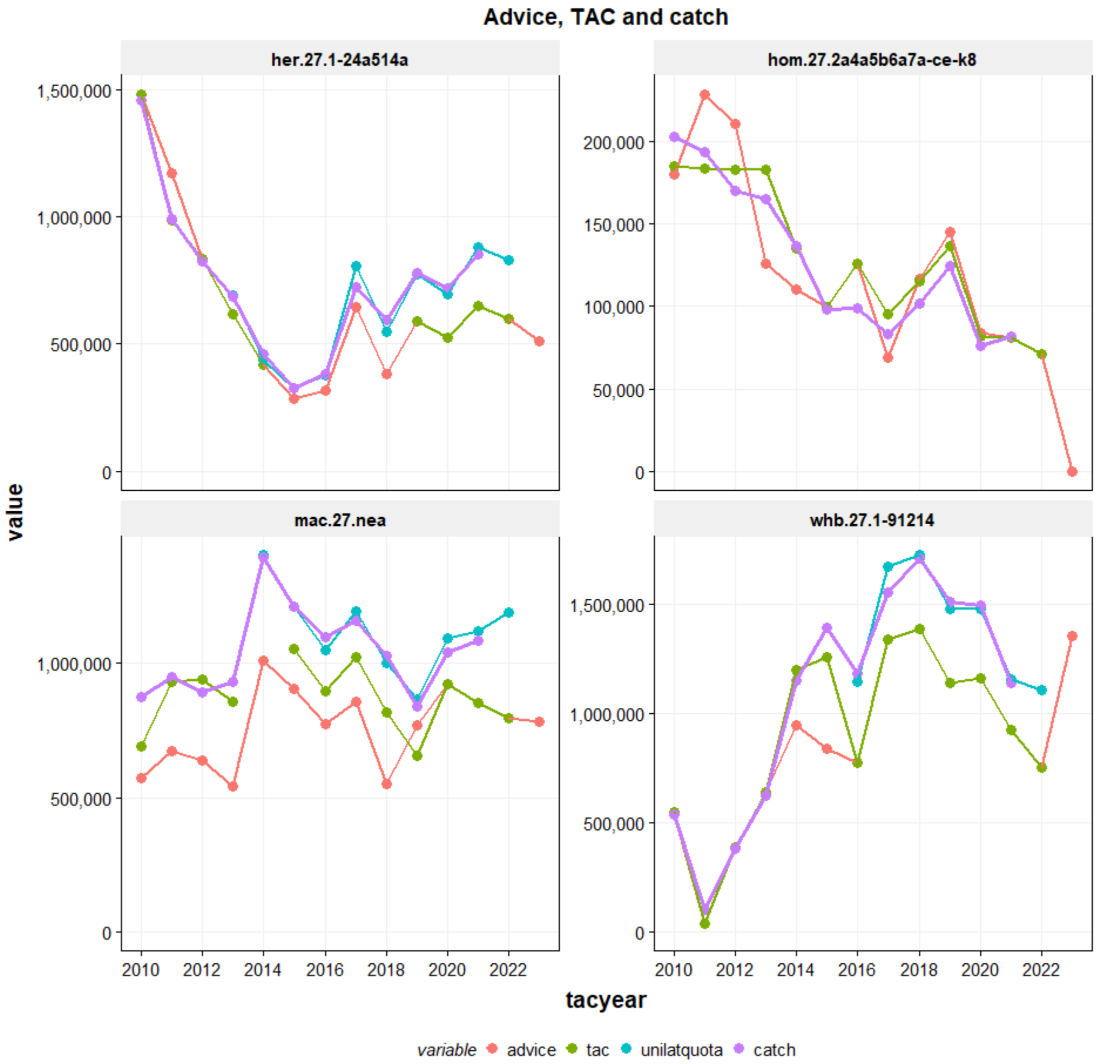

Figure 1.7.3.1: Overview of scientific advice, agreed TAC (or sum of unilateral quota) and catch

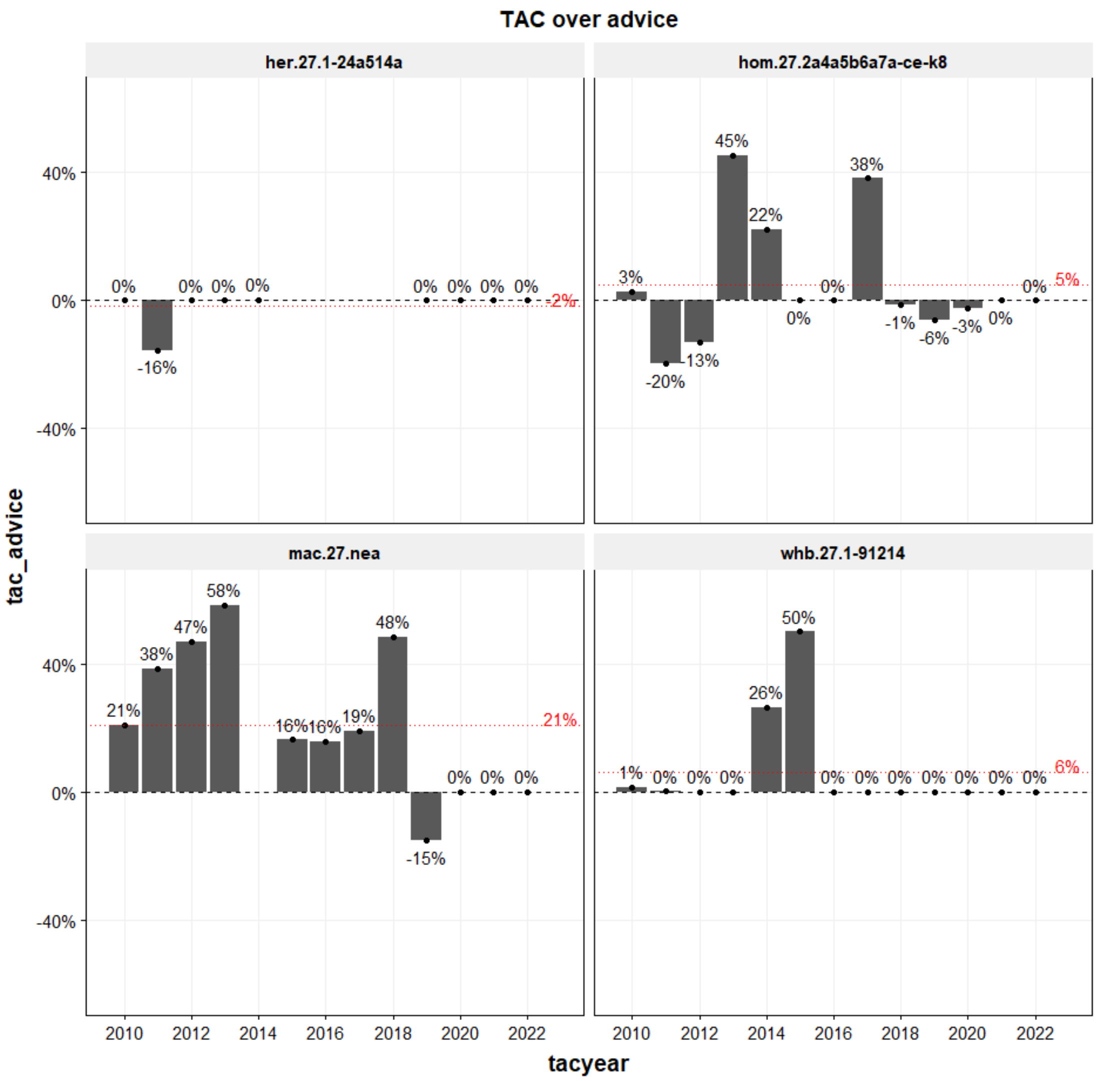

Figure 1.7.3.2: Relative deviations of TAC over advice. Red line indicates average relative deviation over the time series shown.

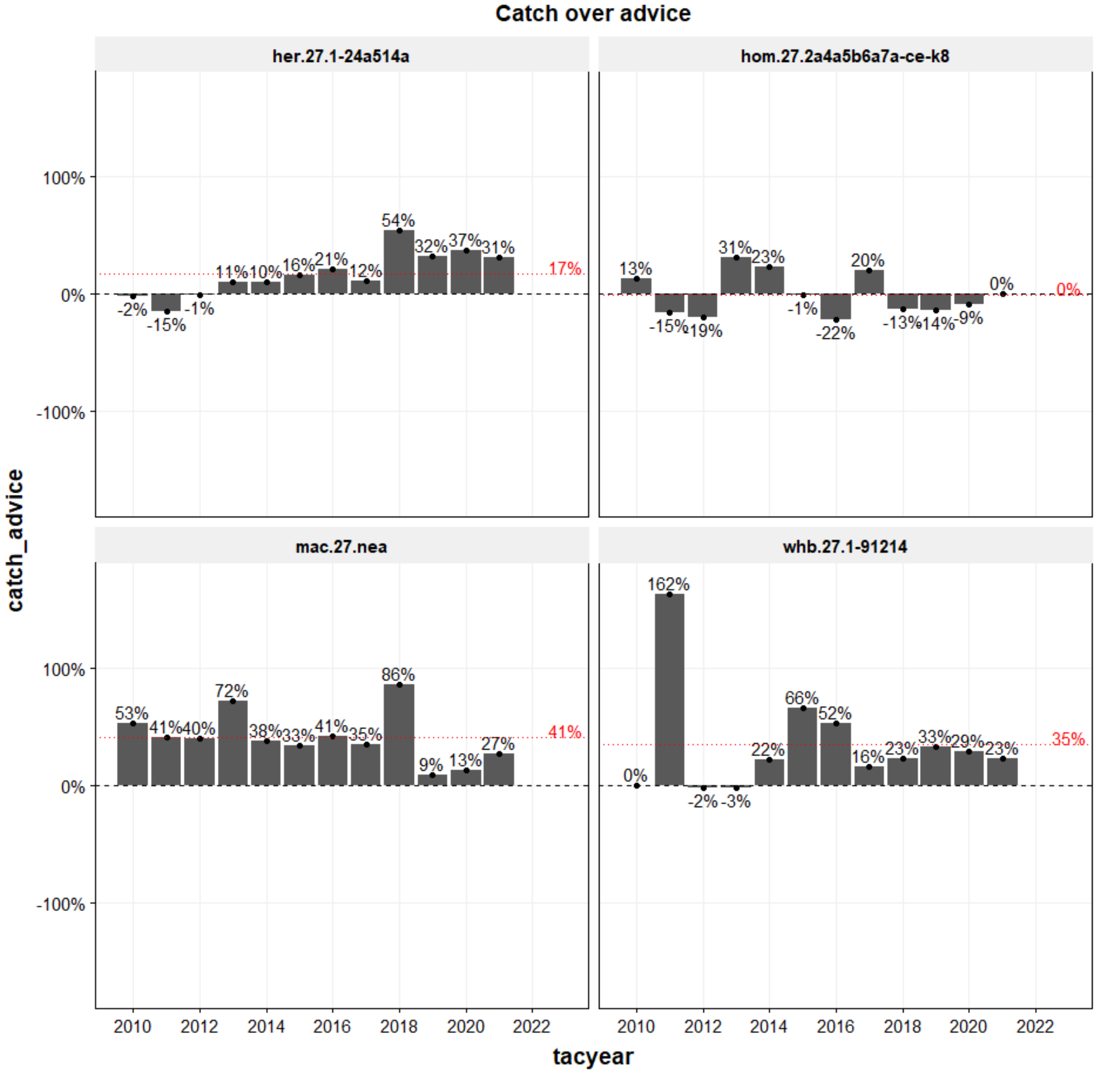

Figure 1.7.3.3: Overview of catch over advice

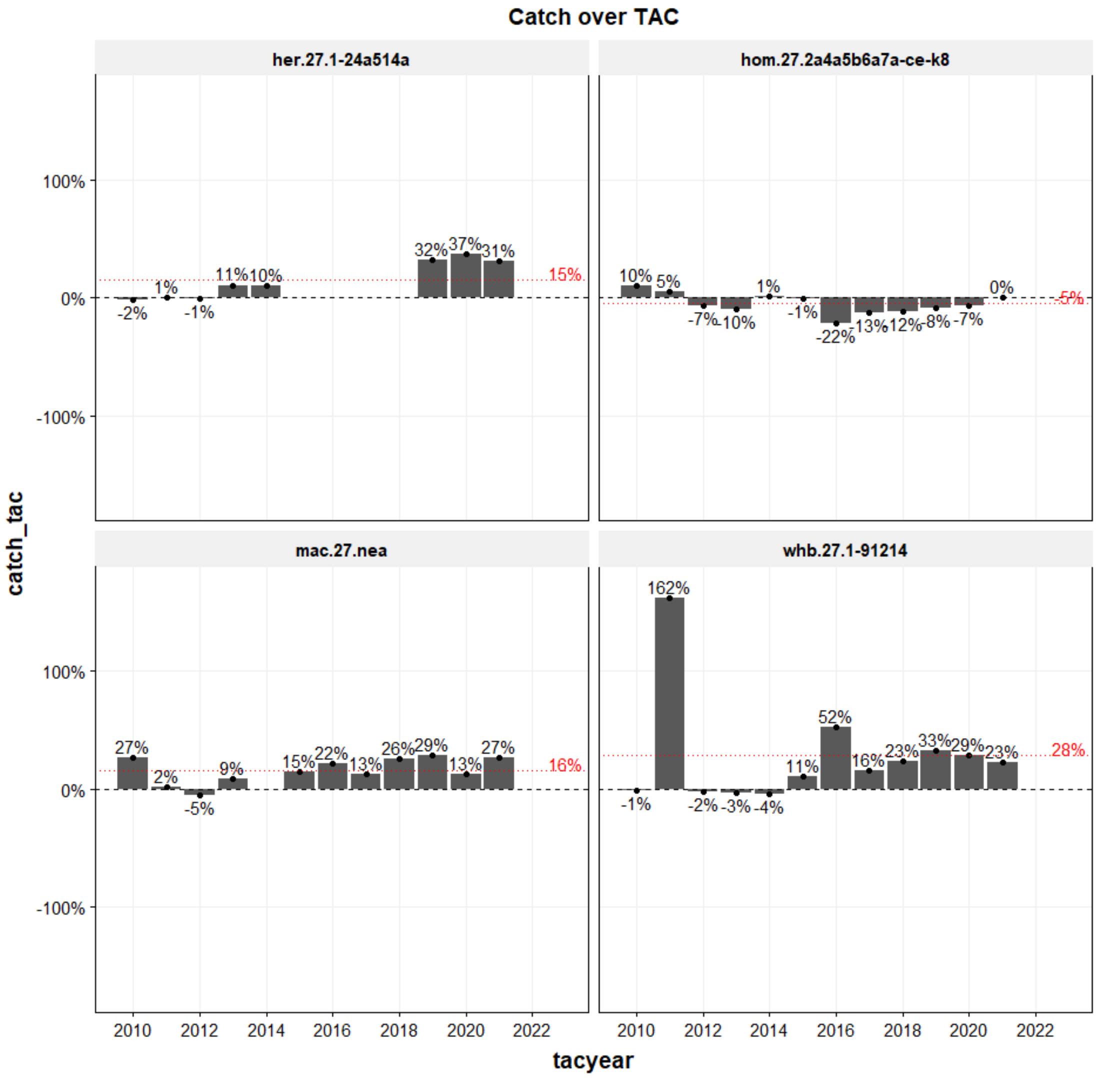

Figure 1.7.3.4: Overview of catch over TAC

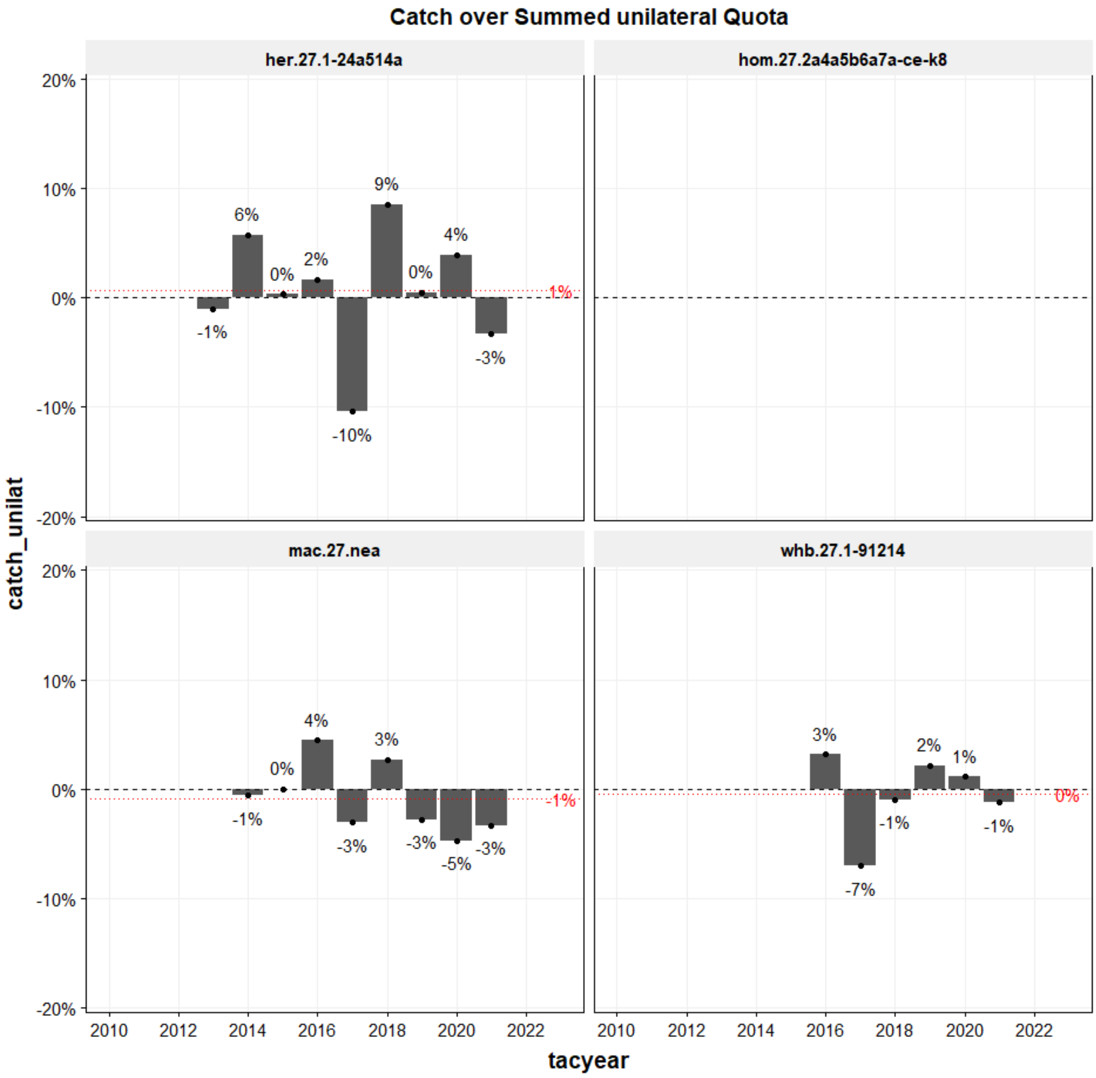

Figure 1.7.3.5: Overview of catch over sum of unilateral quotas.

1.8 General stock trends for widely distributed and migratory pelagic fish

WGWIDE 2022 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.

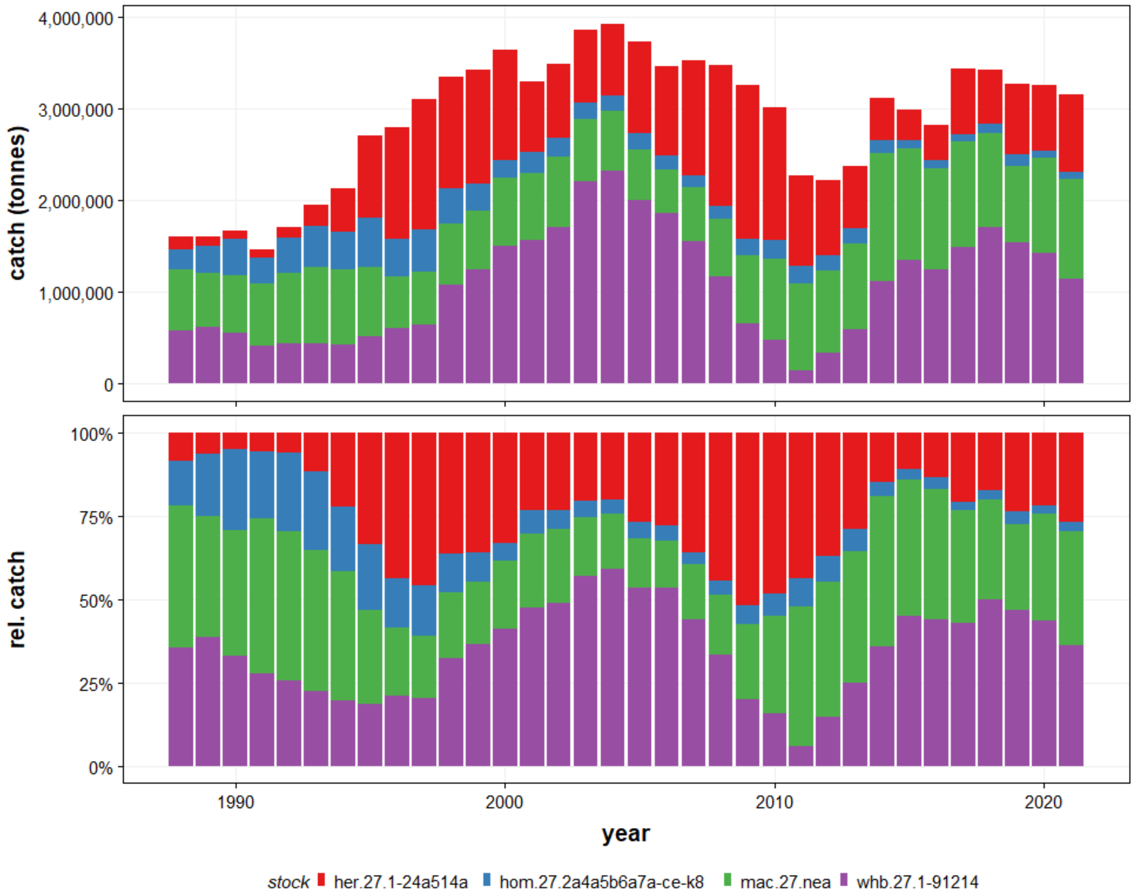

Figure 1.8.1: Catch of blue whiting, mackerel, western horse mackerel and Norwegian spring spawning herring

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 Blue Whiting SSB has increased in the most recent year 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.

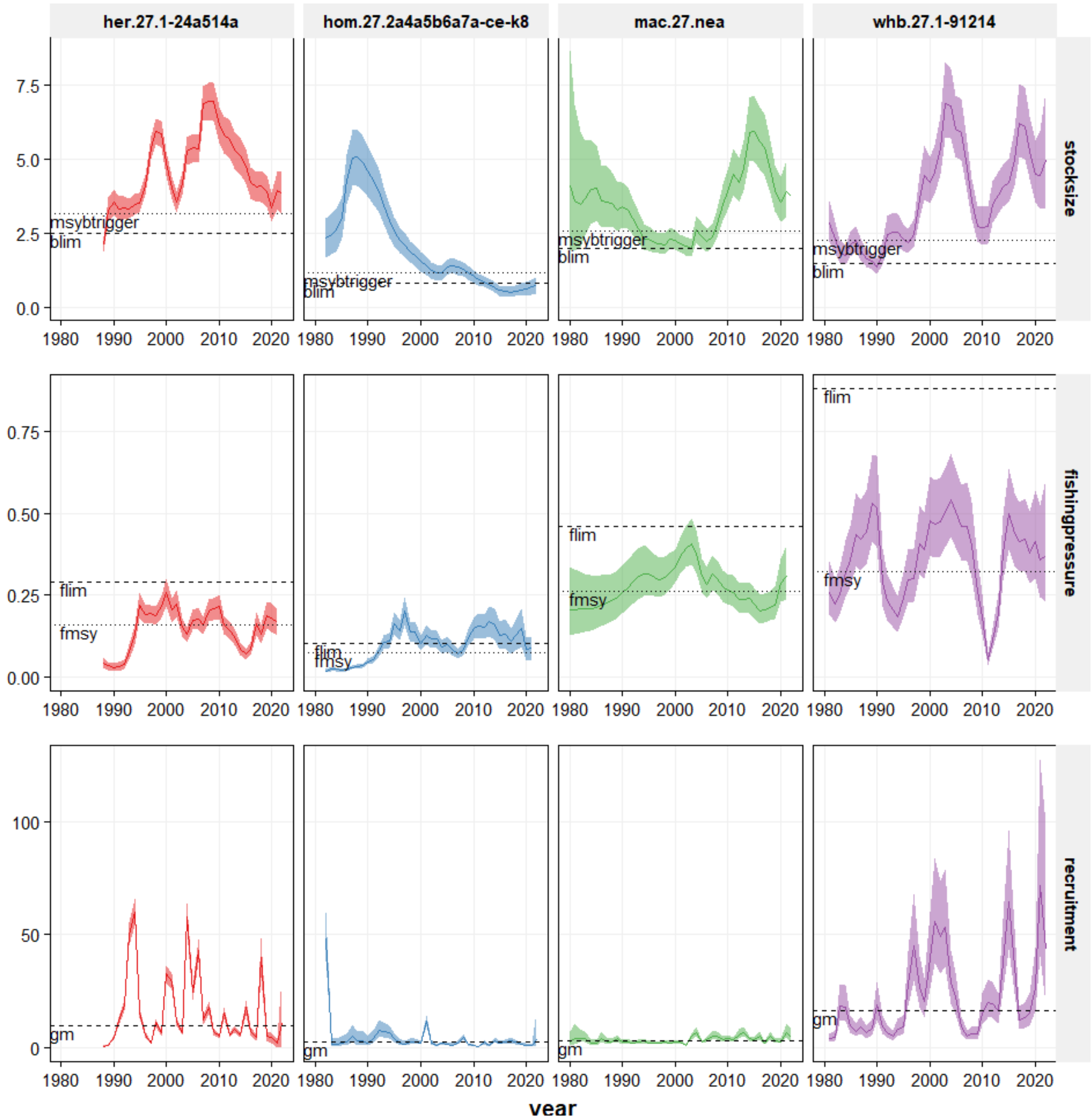

Figure 1.8.2: top - SSB (million tons), middle - fishing mortality and bottom - recruitment (billions) of Norwegian spring spawning herring, western horse mackerel, Northeast Atlantic mackerel and blue whiting from the WGWIDE 2022 update assessments.

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

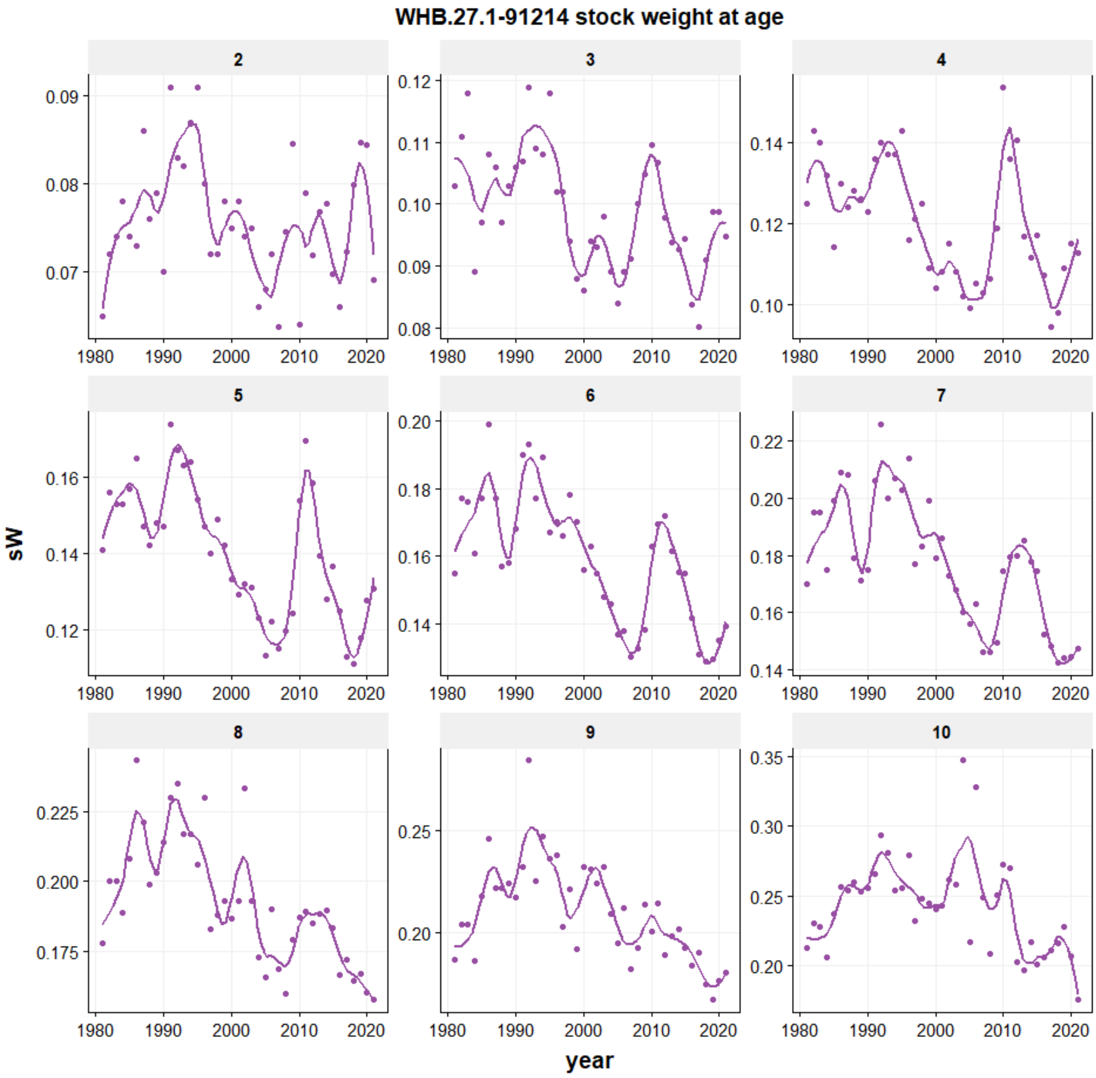

Figure 1.8.4: Stock weight at age of blue whiting

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.

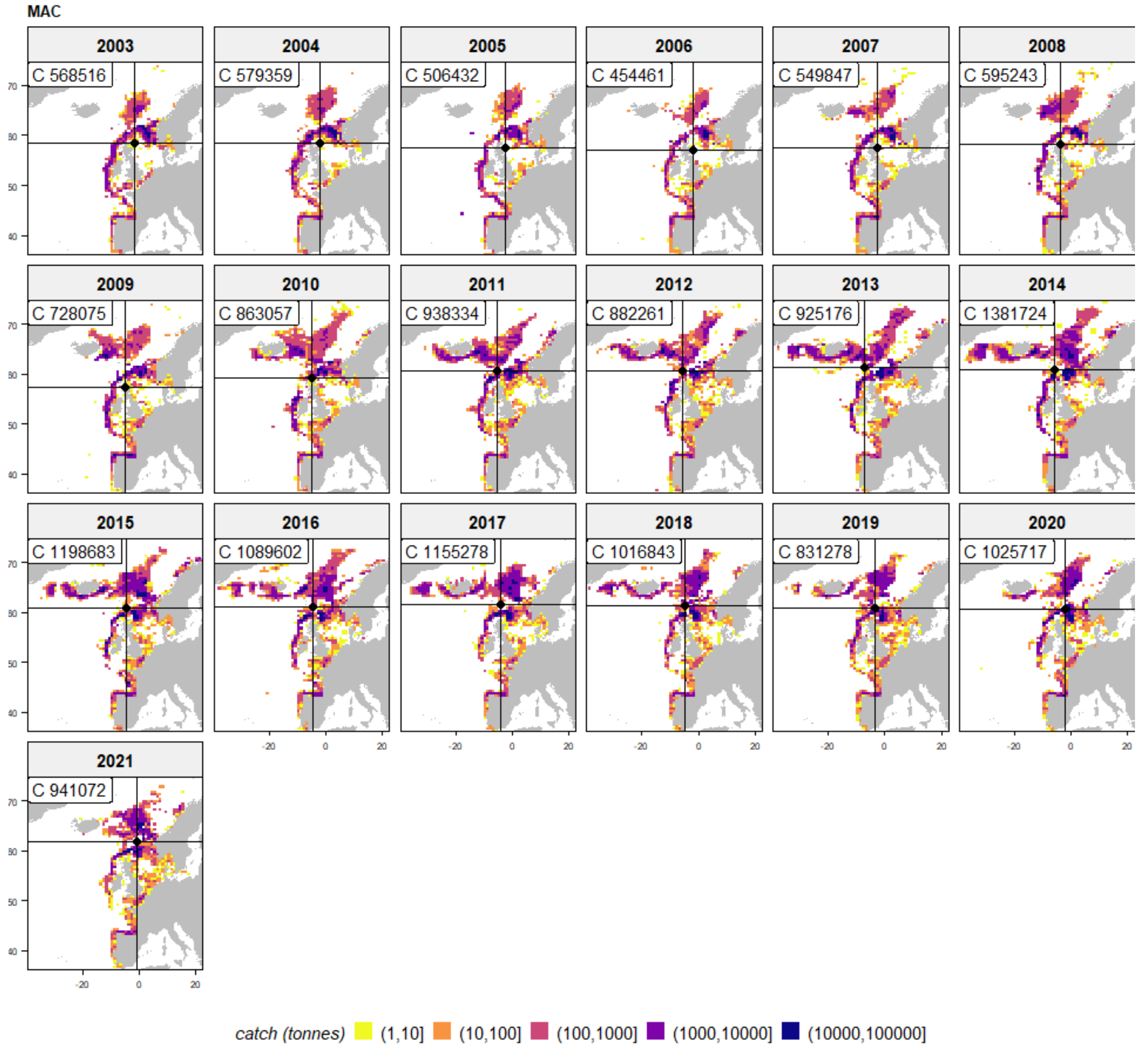

Figure 1.8.5: Catch of mackerel (tonnes) by year and rectangle. Catch by rectangle data do not represent the official catches and cannot be used for management purposes. In general, the total annual catches by rectangle are within 10% from the official catches.

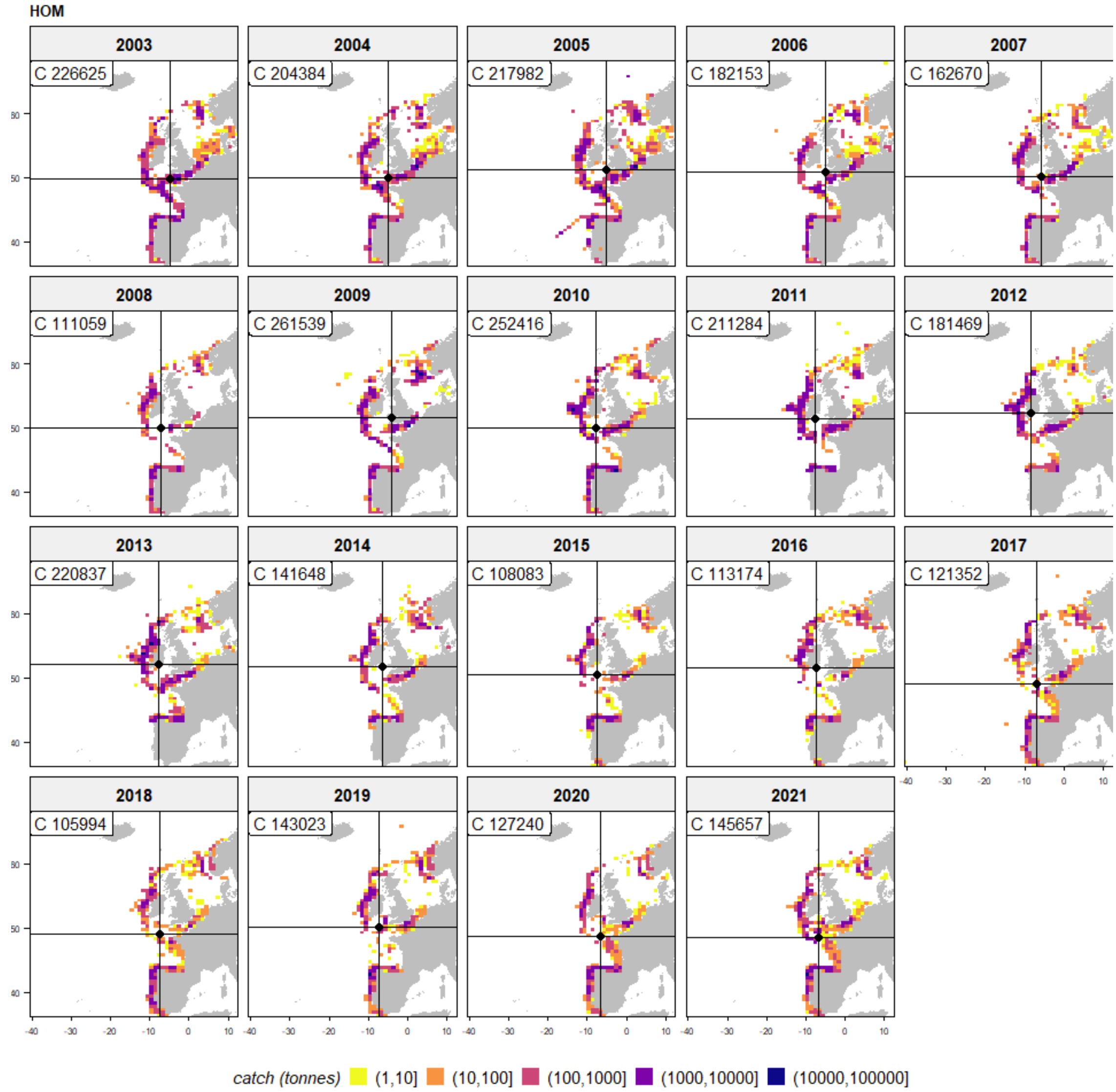

Figure 1.8.6: Catch of horse mackerel (all stocks, tonnes) by year and rectangle. Catch by rectangle data do not represent the official catches and cannot be used for management purposes. In general, the total annual catches by rectangle are within 10% from the official catches.

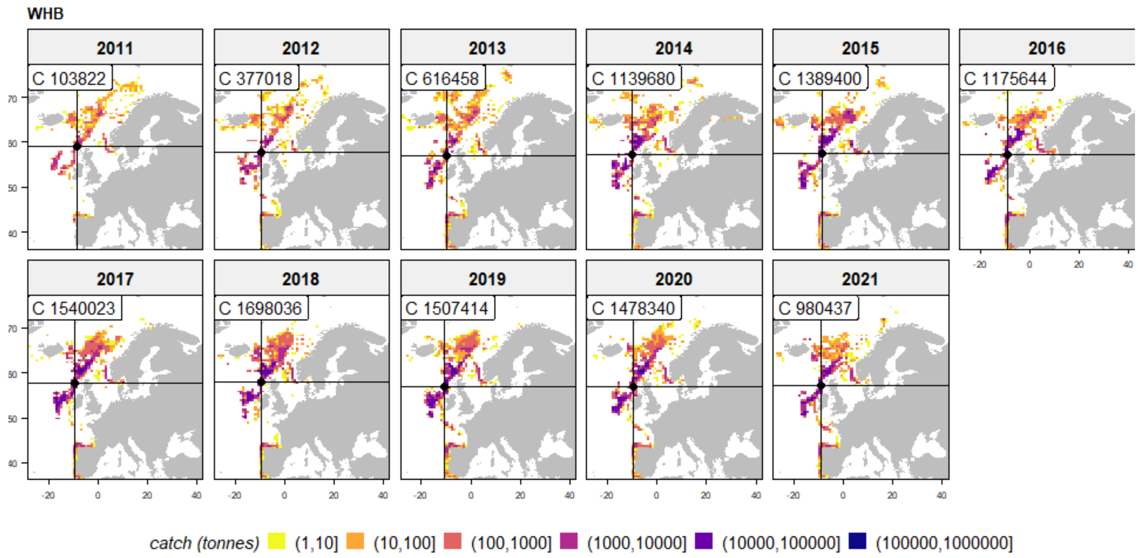

Figure 1.8.7: Catch of blue whiting (tonnes) by year and rectangle. Catch by rectangle data do not represent the official catches and cannot be used for management purposes. In general, the total annual catches by rectangle are within 10% from the official catches.

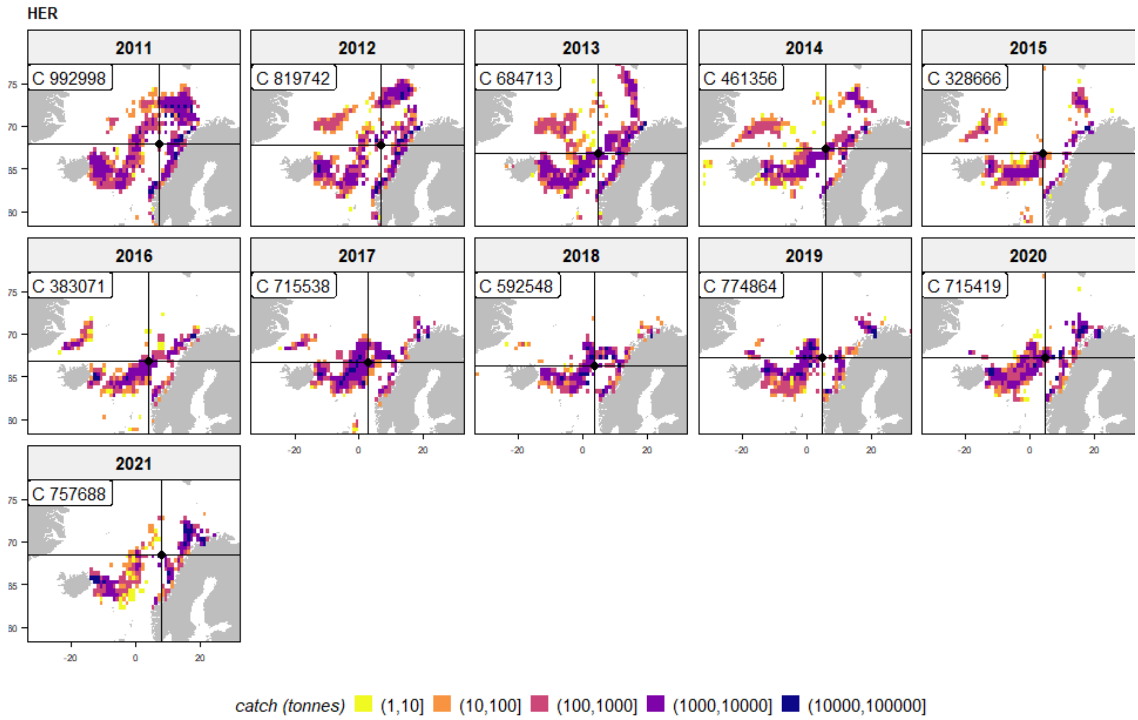

Figure 1.8.8: Catch of Norwegian spring-spawning (Atlanto-scandian) herring (tonnes) by year and rectangle. Catch by rectangle data do not represent the official catches and cannot be used for management purposes. In general, the total annual catches by rectangle are within 10% from the official catches.

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 lines of work in stock assessment should take ecosystem considerations into account in order to reduce the levels of uncertainty regarding the present and future status of commercial stocks. Hence, WGWIDE encourages further work to be carried out on ecosystem considerations linked to widely distributed fish stocks including NEA mackerel, Norwegian spring-spawning herring, blue whiting and horse mackerel. A close collaboration with the Working Group on Integrated Assessment of Norwegian Sea (WGINOR; ICES 2018b; 2022), and hopefully other relevant Integrated Assessment groups within ICES in the near future, will help in operationalizing the ecosystem approach for the widely distributed pelagic stocks assessed by WGWIDE. The text below was largely provided by WGINOR (ICES 2022). The updated text and figures below include summary of Norwegian Sea ecosystem status on climate variability, circulation pattern, recent trends in oceanography, phytoplankton production, zooplankton biomass, pelagic fish biomass and pelagic fish spatial distribution in the Norwegian Sea. The ecosystem status summary shown below is intended for a wide audience, including scientists, teachers, students, decision-makers, and the public interested in the Norwegian Sea ecosystem and marine environmental issues in general. It is prepared by the ICES working group on integrated ecosystem assessment for the Norwegian Sea (WGINOR). It is a summary of the scientific information prepared by the group and does not constitute ICES advice.

Highlights

- The recent 3-4 year trend of colder and fresher Atlantic inflow into the Norwegian Sea has ceased; however, the extent of Arctic Water is still increasing.
- Annual primary production was higher and spring blooms lasted longer for the period 2013-2020 compared to earlier years of time series which begins in 2003. Possible cause is increased inflow of cold and fresh Arctic water.
- Zooplankton biomass declined from around mid-2000´s and has since remained at a lower level.
- The biomasses of Norwegian spring-spawning herring increased in the last year, following the recruitment of a strong year class. Mackerel and blue whiting biomasses continued to decline as in recent years. Recruitment of blue whiting is estimated to be higher in 2020 and 2021 than during the three previous years

Graphical summary

	Topic	Overall trend	Situation in 2021	Certainty	Possible implications
	Ocean climate	General warm and saline conditions prevailed from the early 2000s until 2015-2016. The recent 2017-2019 trend of colder and fresher Atlantic inflow into the Norwegian Sea has ceased. However, the extent of Arctic Water is still increasing.	The recent 3-4 year trend of colder and fresher Atlantic Inflow into the Norwegian Sea has ceased. The extent of Arctic Water continues to increase.	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	Annual primary production was on average 30% higher and length of spring bloom on average 17 days longer for the period 2013-2020 compared to 2003-2012. Start of spring bloom varied from April 25 to June 13 with no temporal trend.	Comparable to the 7 preceding years	Highly certain: the phytoplankton estimates are based on satellite data covering the whole productive season with high geographic resolution.	Increased primary production may have led to increased food resources for herbivores 2013-2020.
	Zooplankton biomass	The spring biomass of mesozooplankton was at a higher level from 1995 to mid-2000s and has been at a lower level afterwards. Summer biomass shows an increasing trend during the last 10 years, except for the last year(s).	Biomass in 2021 was at the same level or decreasing compared to the last years. Summer biomass showed the larger decrease.	Moderately certain: plankton is patchily distributed, which leads to uncertain estimates.	Reduced zooplankton biomass may have caused reduced food resources for planktivorous feeders, including pelagic fish in the recent decade.
	Zooplankton spatial distribution	The spring distribution of zooplankton has changed from higher biomasses in Arctic water	In 2021 the zooplankton was evenly distributed both in spring and summer, but with some	Moderately certain: The spatial distribution reflects and is affected by the timing of the survey	Changes in the spatial distribution of plankton can affect the spatial distribution of planktivorous fish

		in the west to become evenly distributed in the Norwegian Sea.	confined high-concentration areas.	and the timing of the zooplankton seasonal development.	
	Pelagic fish biomass	The spawning biomass of Norwegian spring-spawning herring increased in the last year after a decade of decline. Spawning biomass of mackerel and blue whiting continue declining as in recent years.	Herring spawning biomass increased by 12% whereas mackerel spawning biomass declined by 11% and blue whiting by 17% compared to previous year. Fishing remains above scientific advice in 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	In the mid-2000´s mackerel distribution began expanding westward, into Icelandic and Greenlandic waters but has retracted since 2015 resulting in majority of the mackerel stock feeding in the Norwegian Sea.	No mackerel in Greenlandic waters and low levels in the south-eastern part of Icelandic waters in 2021, as observed in 2020.	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.

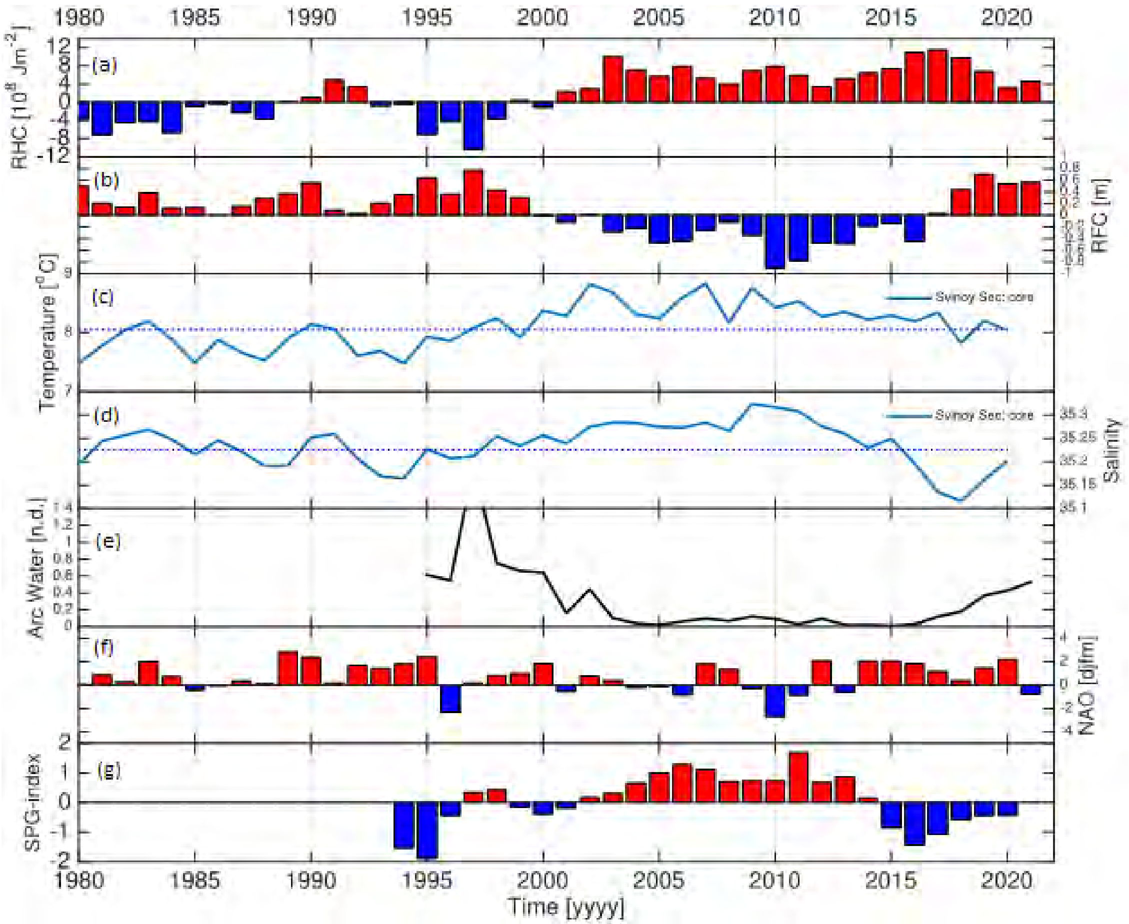

Figure 1.9.1. A subset of climate indicators for the Norwegian Sea: a) Relative heat content (RHC) and b) Relative Fresh-water Content (RFC); Svinøy section Atlantic Water core c) temperature and d) salinity; e) Arctic Water amount in the Norwegian Sea, f) The North Atlantic Oscillation (NAO) winter index, and g) the Sub-polar Gyre (SPG) index (note that strong gyre is represented by negative values and weak gyre with positive values)

Pelagic Fish

Current status

Three fish stocks dominate the pelagic ecosystem of the Norwegian Sea: Norwegian spring-spawning herring (NSS, *Clupea harengus*), Northeast Atlantic (NEA) mackerel (*Scomber scombrus*), and blue whiting (*Micromesistius poutassou*). In 2021, estimated spawning stock biomass (SSB) was similar for all three stocks, ranging from 3.4 to 3.8 million tonnes. Combined SSB for all three stocks was 10.7 million tonnes (figure 1.9.2).

Combined catch of the three stocks was 3.2 million tonnes in 2020, of which approximately 1.5 million tonnes was blue whiting, 1 million tonnes was mackerel, and 0.7 million tonnes was herring. Current exploitation level, relative to biological reference points, show that fishing pressure on herring and blue whiting is above management plan targets and above maximum sustainable yield. Mackerel exploitation is within limits for maximum sustainable yield, however the upper boundary of the 95% confidence interval for fishing mortality is higher than maximum sustainable yield fishing mortality. Stock status, for all three stocks, is good since SSB 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.

Recent changes

The 2021 stock assessment results show an estimated 12% increase in herring SSB in 2021 compared to 2020, after a decade on continuous decline with an overall estimated decline of 52%. Mackerel SSB continue declining in 2021 and has declined by an estimated 37% from peak stock size in 2014-2015. Blue whiting SSB also declined in 2021 compared to previous years and was estimated to be 43% lower than at the last peak size in 2017.

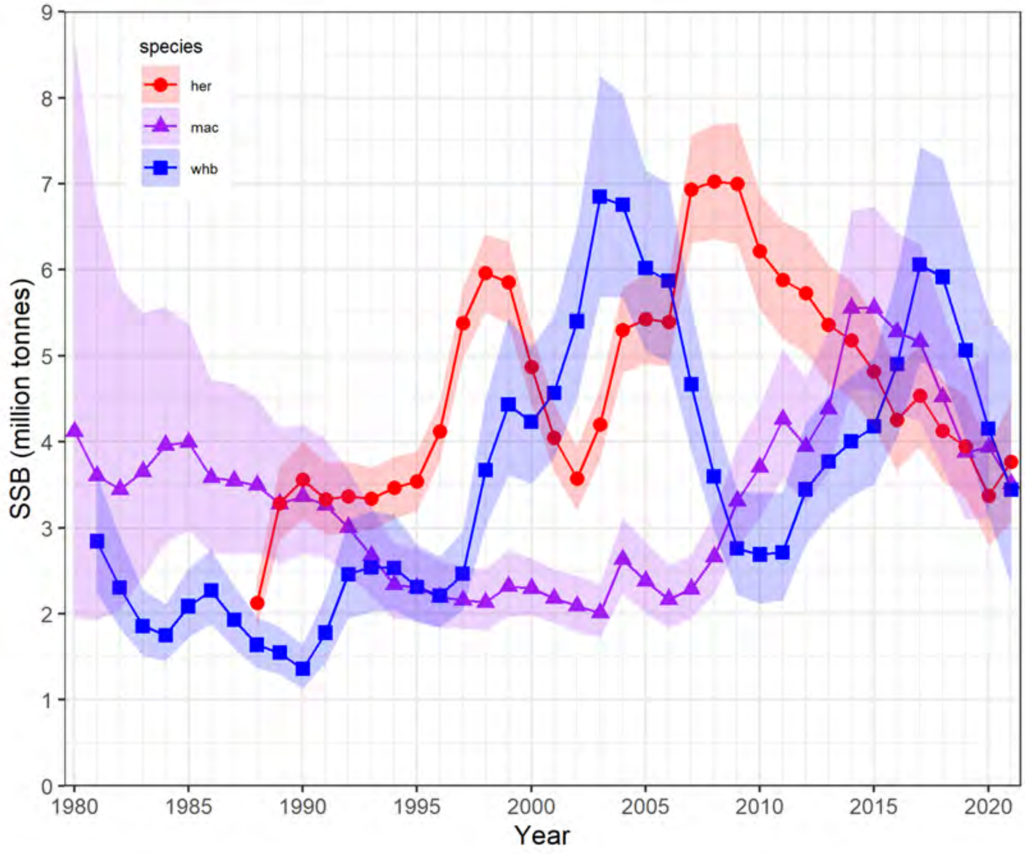

Figure 1.9.2. Estimated spawning stock biomass (lines) including 95% confidence intervals (shaded areas) for Norwegian spring-spawning herring (red filled circles), mackerel (purple filled triangles) and blue whiting (blue filled rectangles) from 1980 to 2021.

Mackerel distribution in the Nordic Seas in summer 2021 was similar to observed distribution in summer 2020 and the western boundary of the distribution was limited to the east coast of Iceland. The distribution of blue whiting in 2021 was similar to the most recent years. The distribution area of herring in May was similar to the most recent period. The large 2016 year-class is now largely distributed throughout the geographical distribution range of the mature herring stock. In July, however, the herring had shifted farther east and north; particularly five-year-old herring was distributed north-easterly.

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 1.9.3). After the large 2002- and 2004-year classes, the recruitment has been below average. Since 2018, surveys have indicated an incoming strong 2016 year-class. The magnitude will be known when the year class is fully recruited at around age seven (*i.e.*, in 2023). Fishing above advised level has accelerated the stock decline during a period of low recruitment. Since 2013, when sharing arrangements in fisheries were no longer agreed upon, annual commercial catch has on average been 31% higher than the advised total allowable catch (TAC). The increase in SBB in 2021 is due to increase in maturity of the large 2016 year-class from 10% mature at age 4 in 2020 to 60% at age 5 in 2020, and a small upward revision of this year-class.

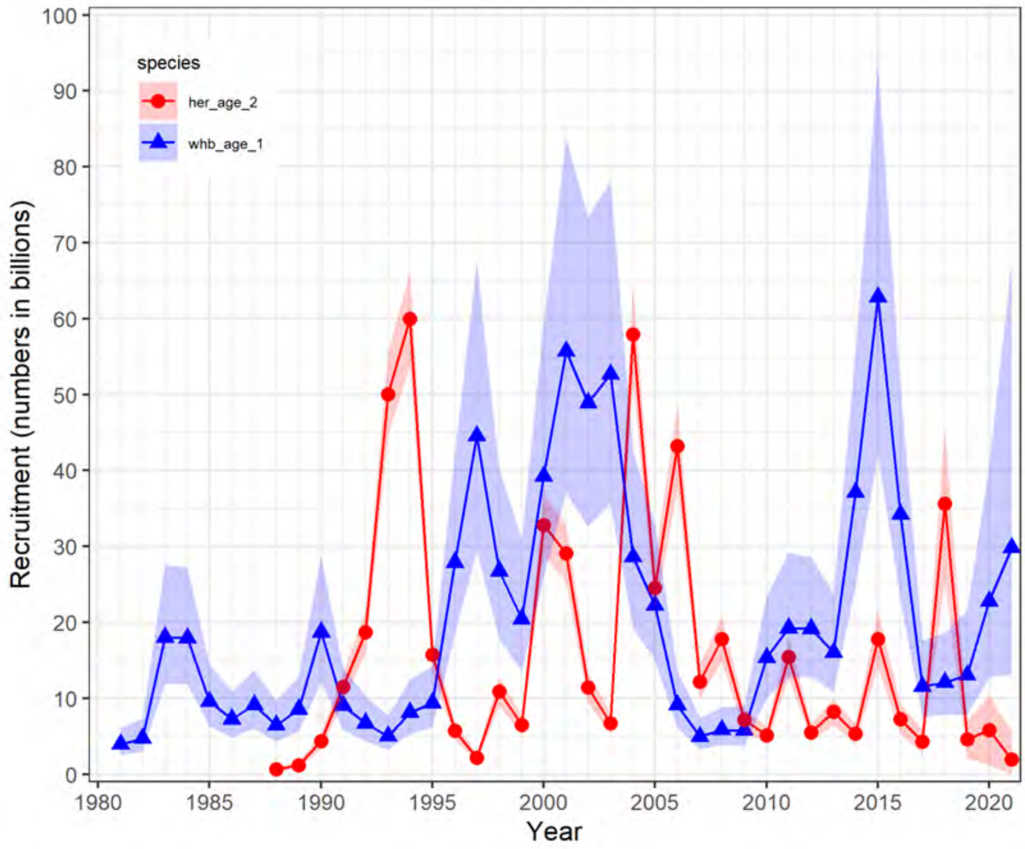

Figure 1.9.3. Estimated year-class size at recruitment for Norwegian spring-spawning herring (age 2; red filled circle) and blue whiting (age 1; blue filled triangle) from 1981 to 2021.

The 2021 assessment of the mackerel stock included an upward revision of SSB and a downward revision of fishing mortality which reduced the perception of stock decline. Changes in assessment perception of the stock is due to changes in relative weights of data sources in the assessment model. Estimates of mackerel recruitment at age 0 are highly uncertain and are thus not presented here. Mackerel year-class strength appears to be established when mackerel enter the fishery at age 2-3 years.

Since mackerel abundance peaked in 2015, the annual commercial catches have on average been 37% higher than the scientific advice. Fishing above advised TAC repeatedly over years contributes to the observed decline in spawning stock size.

Blue whiting's sharp decline in SSB since 2017 is caused by excessive fishing, with catches exceeding the advised TAC by 25% since 2017, in combination with low recruitment in 2017-2019. However, improved recruitment in 2020 and 2021 are estimated to be higher than the three previous years, and these recruits will mature and contribute to the SSB already in 2022.

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

The reasons why mackerel has retracted from the western area from 2015 onwards remain poorly understood. During this period, estimated mackerel stock size has declined by approximately a third, zooplankton abundance has remained within the range observed during period of mackerel presence, and the western area remains warm enough for mackerel presence (> 8-9 °C).

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. A number of 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).

In 2020, WGWIDE discussed and proposed the establishment of a workshop to review information on the stock structure of NEA Mackerel and subsequent implications for the current (component based) regional management measures (minimum landing size, area and seasonal closures). The current basis, whereby the stock is considered to consist of 3 separate components (North Sea, Western and Southern) derives from research conducted several decades ago. Since this time, there have been advances in several stock identification methods (*e.g.* genetics, simulation approaches). 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. WGWIDE 2022 also identified chairs and drafted terms of reference for this workshop and propose convening this workshop in 2023.

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, there are some studies going on and more data being collected to allow clarify the stock definition for this species. In the future, the newly collected information on stock composition should be evaluated on the behalf of a benchmark of this stock.

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, particularly since 2020 has provided the sixth estimate from the survey since it was reintroduced. and the time series is now long enough to do this exercise. An inter-benchmark 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.

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 model XSAM is used for the assessment. The SAM model infrastructure 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.

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 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. This is currently underway and it expected that results will be available for presentation at WGWIDE 2023.

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.

1.10.5 North Sea horse mackerel

Firstly, 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 the Autumn of 2020, while horse mackerel from division 4a have been collected during the NS-IBTS in Q3. With the genetic markers developed, the stock identity of the individual horse mackerel caught can be identified, which will shed light on mixing in the sampled areas during Q3. 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.). More samples and research is needed to confirm these results.

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 the 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. In 2021, it was the first time that Dutch age samples from 2020 were used in the raising procedure of UK and uploaded to InterCatch.

Future work on the exploitable biomass index will focus on including a spatial component when modelling the joint FR-CGFS and NS-IBTS survey index, and on the missing survey data in 2020. Additionally, application of the SPiCT model to the stock will be evaluated.

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 enable the development of an age-based assessment methodology. The current ALK is static and is based on a limited number of age readings.

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

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

Blue whiting (*Micromesistius poutassou*) is a small pelagic gadoid that is widely distributed in the eastern part of the North Atlantic. The highest concentrations are found along the edge of the continental shelf in areas west of the British Isles and on the Rockall Bank plateau, where it occurs in large schools at depths ranging between 300 and 600 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.

Russian catches for 2021 and preliminary data for 2022 were not reported to ICES for use by WGWIDE 2022, which changed the default data compilation of international catch data, and have probably increased the uncertainty of the assessment.

2.1 ICES advice in 2021

Fishing mortality (F) is estimated to be above F_{MSY} since 2014. Spawning-stock biomass (SSB) has been decreasing since 2018; however, it is estimated to remain above MSY $B_{trigger}$. Recruitment (R) from 2017 to 2019 is estimated to be low, followed by a slight increase. ICES advises that when the long-term management strategy, agreed by the European Union, the Faroe Islands, Iceland, and Norway, is applied, catches in 2022 should be no more than 752 736 tonnes.

2.2 The fishery in 2021

Total catch of blue whiting by Russia in 2021 was not reported to ICES for consideration by WGWIDE 2022. Preliminary catch data for quarters 1 and 2 of 2021 (submitted by Russia to WGWIDE 2021) has therefore been used in compiling the total catch in 2021 (1.143 million tonnes, Table 2.3.1.1 and Section 2.3). The description of the 2021 fishery below does not include the Russian fishery.

As in previous years, the main fisheries on blue whiting were targeting spawning and post-spawning fish (Figures 2.2.1 and 2.2.2). Most of the catches (87.3%) 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 southern part of the Norwegian Sea, in the Norwegian Trench, in the Rockall Trough and along the coast of Spain and Portugal.

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 2021 consisted of several types of vessels from 17 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 2021 data as reported to ICES and a brief description of the 2022 preliminary catch data. A section describing the procedure adopted to estimate the catch-at-age and the catch-at-weight corresponding to the missing data from Russia was also included (2.3.1.3)

2.3.1 Officially reported catch data

Official catches in 2021 were estimated as 1 143 450 tonnes based on data provided by WGWIDE members (Table 2.3.1.1). Data provided as catch by rectangle represented 86% of the total WG catch in 2021.

In 2021, the majority of catches were caught on the spawning grounds with largest contribution from ICES divisions 27.7.c, 27.7.k and 27.5.b, 27.6.a (Figure 2.3.1.1; Tables 2.3.1.2, 2.3.1.3), caught respectively in quarter 1 and quarter 2 (Figure 2.3.1.6). 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; 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 - Norway, Faroe Islands, 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 2021, discards were 44% 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 8% (in weight) in 2021 (Table 2.3.1.5). Spanish catches are around 2% of the international catches.

In general, discards are assumed to be small in the blue whiting directed fishery. Discards data contributed to final catches of the following countries: Denmark, Ireland, Portugal, Spain, UK (England and Wales) and UK (Scotland). The total discards constituted 0.34% of the total catches, 3 936 tonnes. The largest fishing nations, Norway, Faroe Islands, Russia and Iceland 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 16% of the total catches of blue whiting in 2021.

2.3.1.1 Sampling intensity

In 2021, 81% of catches were covered by the sampling program. In 2021, 1 676 length samples and 1 588 age samples were collected from the fisheries with 129 317 fish measured and 15 215 aged. 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 2021 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. No sampling was carried out by Greenland, Lithuania, Poland and Sweden, which together represent 6% 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 2021, 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 age 1. Although, the differences in mean length-at-age increase in older ages, higher than age 7.

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

2.3.1.3 Missing data

ICES estimated missing data from Russia using the 2021 ICES preliminary catch statistics reported by the Russian governmental statistical office and the 2021 preliminary available catch-at-age and catch-at-weight data for quarters 1 and 2 submitted to WGWIDE in 2021. A comparison between the ICES preliminary catch statistics reported by the Russian governmental statistical office with the final data submitted to WGWIDE for the most recent years (2018 to 2020) revealed no differences between the two data sources. Also, the comparison between the submitted data to WGWIDE, i.e. between the preliminary available catch-at-age and catch-at-weight data for quarters 1 and 2 and the final data, was performed. From the comparison between the preliminary data with the finalized data, no differences were found for quarter 1, but for quarter 2 a difference in average of around 8% in total catch was found. For the period between 2018 and 2020, 89% of the Russian total catches were from quarters 1 and 2. The allocation of the total catch by ICES area and quarter was based on the spatial and temporal pattern distribution observed in the period 2018 until 2020. For ICES areas 27.6.b and 27.7, Russian catches were taken during quarter 1 and were included in the data submitted to WGWIDE in 2021. For the other ICES areas (27.2.a, 27.4.a, 27.5.b and 27.6.a), the approach for the ICES estimates by quarter was based on the average catch distribution from the period 2018 to 2020. Russian data on age composition of the catch in 2021 for quarters 3 and 4 were not available, however, samples available from other fishing nations operating in the same areas were used to estimate catch and weight at age.

For the 2022 preliminary catch data, the approach to complete the preliminary ICES estimated catches was based on the assumption that the missing Russian data correspond to 13% of the 2022 ICES estimated total preliminary catch in weight for this stock. This assumed percentage was based on data analysis for the most recent 3 years (2019-2021).

2.3.2 Preliminary 2022 catch data (Quarters 1 and 2)

The preliminary catches for 2022 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 2021 with majority of catches taken in division 27.6.a, 27.5.b, 27.7.c and 27.7.k (Figure 2.3.2.1 and Table 2.3.2.2).

Sampling intensity for blue whiting from the preliminary catches by area 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 2021, preliminary and final catch estimates are similar with maximum deviation in 2021 when the final catch was 8.3% lower 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 2021 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 2022 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. In 2021 there is also an indication of a stronger year class 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 1981-2022 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.

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

2.3.5 Maturity and natural mortality

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

2.3.6 Information from the fishing industry

No new information available.

2.3.7 Fisheries independent data

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

2.3.7.1 International Blue Whiting spawning stock survey

The Stock Annex gives an overview of the surveys available for the blue whiting. The International Blue Whiting Spawning Stock Survey (IBWSS) is 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 2.3.7.1.1 and Figure 2.3.7.1.1 A.

The survey time-series (2004-2022) show variable internal consistency ranging from 0.26 to 0.84 (Figure 2.3.7.1.1 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 0.68 and 0.84, 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 2019-2022 is shown in Figure 2.3.7.1.2. The abundance estimate of blue whiting for IBWSS are presented in Table 2.3.7.1.1.

Length and age distributions for the period 2018 to 2022 are given in Figure 2.3.7.1.3.

Survey indices, (ages 1-8 years 2004-2022) as applied in the stock assessment are shown in Table 2.3.7.1.1.

2.3.7.2 Other surveys

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

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

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

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

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

The International Survey in Nordic Seas and adjacent waters in July-August (IESSNS). Blue whiting have 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 recommendation from WGWIDE 2015 to try to have one more time-series for blue whiting. 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 and 2022.

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 2022.

2.4.1 2022 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 may be an indication of a "year effect" (too low index values) for the IBWSS 2015 observations which has also be seen in previous assessment.

The estimated parameters from the SAM model from this year's assessment and those from assessments conducted since 2018 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 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).

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 2021, 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% CI 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 -0.257. Last year this value was -0.051 due to a large positive value in the first year (which not is used anymore) but also lower absolute values for the negative values in the remaining 4 years. The average Mohn's rho for F and SSB indicates no bias.

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 0.35 (above F_{MSY} at 0.32). Recruitment (age 1) was high in 2015, followed by a lower recruitment in 2016 and much lower recruitments in 2017-2020. The recruitment in 2021 is estimated to be a historical high. SSB has increased since 2021 with a huge increase from 2022 to 2023 when 40% of the large 2021 recruitment is assumed to be mature.

A comparison of the assessments in 2021 and 2022 (Figure 2.4.1.8) shows a substantial revision of the historical values of F, SSB and recruitment for the most recent years of the assessment. The 2021 recruitment is now estimated to be at a historical high (71.6 billion) while last year's estimate for the same year class was 22.8 billion. F for 2021 is now estimated at 0.36 while the same value in last year's assessment was 0.51. Likewise SSB for 2022 is now estimated to 4.96 million tonnes while last year's value was 3.40 million tonnes.

The reasons for this revision is linked to 1) an historical high survey index for the age 2 in 2022 (the 2020 year class) corroborated by high commercial catch at age of the same year class in 2021 and 2022, and 2) the use of (uncertain) preliminary catch data for 2021 in the 2021 assessment.

With respect to point 1, while the IBWSS index for age 2 in 2022 is a historical high, the index for age 1 in 2021 was not especially high such that last year's estimate of year class strength was not especially high. Preliminary catch corroborate the high age 2 index with high age 2 catch numbers in 2022 (6th highest in the time series back to 1981) and high age 1 catches in 2021 (8th highest in the time series). Data for other surveys confirm the large 2020 year class (see section 2.3.7 for further discussion).

With respect to point 2, 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 8.3% lower than the preliminary values for 2021 (Table 2.3.2.4). Figure 2.4.1.9 shows the results from the default assessment configuration, a configuration without preliminary catches for 2022, and a configuration with preliminary catches for 2021 (last year's data not updated) and preliminary data for 2022. When the preliminary catch data for 2021 are maintained (without updating to "final" data), F becomes higher and SSB lower in the final year compared to the default run, as the total catch weigh for the 2021 preliminary catch is higher than the final. Recruitment in 2021 is however estimated lower when the 2021 preliminary data are applied as the catch at age number for age 1 is lower in the preliminary data set. The exclusion of the preliminary catch data provides a similar result for F and SSB as the default configuration. Recruitment in 2021 is also similar but recruitment for 2022 is estimated higher in the run without 2022 catches, as the historically high age 1 index from the IBWSS 2022 data is not corroborated by high catch numbers in the preliminary catch data. If the preliminary catch data for 2021 (applied in last year's assessment) had been a more accurate estimate of the final data, the revision of the historical F and SSB between the 2021 and 2022 assessments would have been smaller. This is seen for the retrospective analysis (Figure 2.4.1.6). F in 2021 was estimated to 0.43 when 2021 was the terminal year (with final 2021 catch at age) whereas the F in 2021 in previous year's assessment was 0.51, as it used the preliminary 2021 catch data.

If the preliminary 2022 catch are not used, estimates of SSB(2022) and F(2021) becomes very similar to the results from the default run compared with the default assessment (Figure 2.4.1.9). Recruitment in 2022 is however estimated considerably higher, as the survey index is at a record high for age 1 in 2022 IBWSSS and there are no additional catch data.

2.4.2 Alternative model runs

The working document WD08 "Blue whiting, an updated alternative assessment including more surveys" (Hølleland *et al.*, 2022) describes an alternative assessment presented to the WGWIDE in 2021. The assessment is a SAM assessment, and makes use of two (IESNS and IESSNS) additional survey indices for blue whiting. The time series for IESSNS is still relatively short (7 years), while the IESNS has been running for 15 years. The alternative assessment gave similar results with a slightly lower SSB and higher F point estimate compared to the presently used SAM (Figure 2.4.2.1). The estimated recruitment in 2021 and 2022 was however larger in the alternative assessment, due to high abundance of age 1 in 2021 and 2022 in both additional surveys.

The WGWIDE assessment for 2021 estimated an F of 0.508, while in the 2022 assessment there was a large correction for this year to 0.356. This could be related to lack of information from the cancelled IBWSS in 2020 or an overestimate of the catches for 2021. The estimated F from the alternative assessment was quite consistent between the 2021 and 2022 assessments (see Figure 2.4.2.2).

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 2.3.7.1.1.

The model was run for the period 1981—2022, with catch data up to 2021 and preliminary catch data for the first half-year (Q1 and Q2) of 2022 raised to expected annual catches, and survey data from March-April, 2004–2022. SSB 1st January in 2022 is estimated from survivors and estimated recruits (for 2022 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 2.4.1.3–2.4.1.4 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 (2022) 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}.

F increased from a historic low at 0.052 in 2011 to around 0.50 in 2015 followed by a decrease in F to 0.37 in 2022. F has been above F_{MSY} and Fpa 0.32 since 2015. SSB has increased from 2020 (4.48 million tonnes) to an almost historical high in 2023 (6.66 million tonnes). SSB has been above MSY $B_{trigger}$ since 1998.

Recruitment (age 1) in 2021 is estimated to be at a historical high. Survey data indicates that the 2022 recruitment is also above average, but this estimate has a high uncertainty.

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 (2021 year class) and the 2–group (2020 year class) indices from the survey in 2022 were both well above the median of the historical range.

The 1-group (2021 year class) and the 2–group (2020 year class) indices from The International Blue Whiting Spawning Stock Survey (IBWSS) were both the highest in the time series (Table 2.3.7.1.1).

The Norwegian bottom-trawl survey in the Barents Sea (BS-NoRu-Q1(Btr)) in February-March 2022, showed that 1-group blue whiting was above the median in the time series (Table 2.3.7.2.2). This index should be used as a presence/absence index, in the way that when blue whiting is present in the Barents Sea, this is usually a sign of a strong year class, as all known strong year classes have been strong also in the Barents Sea.

The 1-group estimate in 2022 (2021 year class) from the Icelandic bottom-trawl survey showed an increase compared to 2021 and was the highest in the time-series.

The 1-group estimate in 2022 (2021 year class) from the Faroese Plateau spring bottom-trawl survey showed a decrease compared to 2021 and 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 2020 year class is among the strongest in the time series, which corresponds to the SAM assessment results. The 2021 year class estimated from surveys are also above the median, also seen in the SAM assessment. It was therefore decided not to change the SAM estimates of the 2020 and 2021 year classes for the purposes of the short term forecast.

No information is available for the 2022 and 2023 year classes and the geometric mean of the time-series from 1996-2021) was used for these year classes (22.5 billion at age 1 in 2023) (Table 2.8.1.1).

As described in the Stock Annex, WGWIDE decided in 2021 to change from using the geometric mean of the full time-series (since 1981) to use a shorter time-series (since 1996) for the calculations 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 (2020—2022) 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 2021 and 2022 are assumed as estimated by the SAM model, as additional survey information was not conflicting this result. Recruitment in 2023 and 2024 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, 1996-2021).

As the assessment uses preliminary catches for 2022 an estimate of stock size is available for the 1st of January 2023. The normal use of an "intermediate year" calculation is not relevant in this case and F in the "intermediate year" (2022) is as calculated by the assessment model. Catches in 2022 are based on the preliminary catches based on declared national quotas and expected national uptake for 2022. 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 2022 at 1 359 629 tonnes. This corresponds to a 80.6% increase compared to the ICES advice last year, and a 22.8% increase compared to the preliminary estimate of catches in 2022.

The LTMS specifies a default TAC constraint at +25/-20%. However, it states that the TAC constraint shall not be applied when the TAC advice deviates more than 40% from the TAC of the preceding year (paragraph 6b in the LTMS). With an increase of 80.6% in catches in relation to the ICES advice last year (LTMS advice), the TAC constraint is not applied.

SSB in 2024 is predicted to increase by 17.5% to 7 781 444 tonnes, if the advised catches are taken. The high recruitment estimated for 2021 and 2022 contributes to this increase in SSB.

2.9 Comparison with previous assessment and forecast

Comparison of the assessment made in 2021 and 2022 (Figure 2.4.1.8) shows a substantial revision of the historical values of F, SSB and recruitments. The 2021 recruitment is now estimated to be historical high (71.6 billion) while last year's estimate was 22.8 billion. F for 2021 is now estimated to 0.36 while the same value in last year's assessment was 0.51. Likewise SSB for 2022 is now estimated to 4.96 million tonnes while last year's value was 3.40 million tonnes. See section 2.4.1 for further discussion.

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. An alternative run (Figure 2.4.2.1) with the SAM model using two additional surveys (IESNS and IESSNS) not covering the full distribution area shows results consistent with the default configuration of the assessment.

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 inter-calibration exercise. The use of additional survey data may be beneficial, especially in years without IBWSSS data, however the length of the time series is still short (7 years) for the survey (IESSNS) with a low observation variance for age 1 and 2.

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 however 9% higher than the final data for 2021, although the differences are smaller for the year 2016-2020.

2.11 Management considerations

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

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. It´s distribution range is approximately from latitude 30 °N to 80 °N and from the coast of Europe to Greenland, into Barents Sea and the Mediterranean Sea (Trenkel *et al*., 2014). Spawning is in the spring and mostly occurs on the shelf and banks west of Ireland and Scotland and 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 purpose.

(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 Island 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 2022 to be 1 107 529 tonnes, 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 2021 should be no more than 752 736 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 2022 exceeds the agreed TAC.

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 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.

The Agreed Records by the Coastal States (25-26 October 2021) states a TAC for blue whiting at 752 736 tonnes for 2022, as advised by ICES (on the basis of the LTMS from 2016). Annex 1 of the Agreed Records "*Arrangement for the long-term management of the blue-whiting stock*" is similar to the managing plan evaluated by ICES in 2016, but the present version of the LTMS includes a paragraph 6: *The TAC constraint described in Paragraph 5 shall not apply if:*" and a paragraph 6b: "*The rules in paragraph 4* [TAC from $F=F_{MSY}$, when SSB is above $B_{trigger}$] *would lead to a TAC that deviates by more than 40% from the TAC of the preceding year.".* The management plan evaluated by ICES in 2015-2016, described in the WKBWMSE (ICES 2016b) report, did not include the deviation from the default -20%/25% TAC constraint as described in paragraph 6 of the presently used LTMS. Therefore , ICES has not evaluated the presently used plan.

2.14 Recommendations

No recommendations.

2.15 Deviations from stock annex caused by missing information from Covid-19 disruption.

The one and only survey used for the SAM assessment, the International Blue Whiting Spawning Stock Survey (IBWSS) was not conducted in 2020, but resumed in 2021 and 2022. The stock assessment this year followed the approach outlined in the Stock Annex.

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2.17 Tables

Table 2.3.1.1. Blue whiting. ICES estimated catches (tonnes) by country for the period 1988–2021.

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

* From 1992 only Russia.

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

*** From 2012.

Table 2.3.1.1. (continued). Blue whiting. ICES estimated catches (tonnes) by country for the period 1988–2021.

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Denmark	89500	41450	54663	48659	18134	248	140	165	340	2167	35256	45178	39395	60868	87348	68716	58997	40321
Estonia	*															0		
Faroe Islands	322322	266799	321013	317859	225003	58354	49979	16405	43290	85768	224700	282502	282416	356501	349838	336569	343372	202415
France		8046	18009	16638	11723	8831	7839	4337	9799	8978	10410	9659	10345	13369	16784	16095	13769	14612
Germany	15293	22823	36437	34404	25259	5044	9108	278	6239	11418	24487	24107	20025	45555	47708	38244	42362	35327
Iceland	379643	265516	309508	236538	159307	120202	87942	5887	63056	104918	182879	214870	186914	228934	292944	268356	243725	190146
Ireland	75393	73488	54910	31132	22852	8776	8324	1195	7557	13205	21466	24785	27657	43238	49903	38836	40135	39514
Lithuania			4635	9812	5338						4717		1129	5300			9543	21183
Netherlands	95311	147783	102711	79875	78684	35686	33762	4595	26526	51635	38524	56397	58148	81156	121864	75020	62309	62017
Norway	957684	738490	642451	539587	418289	225995	194317	20539	118832	196246	399520	489439	310412	399363	438426	351429	354033	233968
Poland														15889	12152	27185	47616	26077
Portugal	3937	5190	5323	3897	4220	2043	1482	603	1955	2056	2150	2547	2586	2046	2497	3481	2819	2522
Spain	15612	17643	15173	13557	14342	20637	12891	2416	6726	15274	32065	29206	31952	28920	24718	22782	23676	25509
Sweden	19083	2960	101	464	4	3	50	1	4	199	2	32	42	90	16**	54	25	40
UK (England + Wales)	2593	7356	10035	12926	14147	6176	2475	27	1590	4100	11	131	1374+	3447	1864	4062	7458	8783
UK (Northern Ireland)										1232	2205	1119			4508	2899	2958	
UK (Scotland)	57028	104539	72106	43540	38150	173	5496	1331	6305	8166	24630	30508	37173	64724	66682	54040	41344	65085
Russia	346762	332226	329100	236369	225163	149650	112553	45841	88303	120674	152256	185763	173655	188449	170892	188006	181496	133605^
Greenland										2133				20212	23333	19753	19611	20190
Unallocated									3499									22137
TOTAL	**2380161**	**2034309**	**1976176**	**1625255**	**1260615**	**641818**	**526357**	**103620**	**384021**	**628169**	**1155279**	**1396244**	**1181850**	**1558061**	**1711461**	**1515527**	**1495248**	**1143450**

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

**** 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 2021.

ICES Division	Denmark	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Lithuania	Netherlands	Norway	Poland	Portugal	Russia ^	Spain	Sweden	UK (England)	UK(Scotland)	Unallocated	Total
27.4																	100		**100**
27.2.a	20	27550	296	21	2933	26450			7.62	7918	121		7214		6			19071	**91606**
27.3.a	98														8				**106**
27.4.a	63	903	467	2095	344	6861		170	457.01	26578	243		34		25		22	1029	**39290**
27.4.b	4									8					1				**13**
27.5.a		1192				19284													**20476**
27.5.b	98	127617	53	636	12750	101488		127	132.25	973	4053		48792					1920	**298640**
27.6.a	14476	19565	7296	23309	4163	32826	18577.45	15865	30921.13	52402	14975		24239	3		6251	41400	117	**306385**
27.6.b		4805				206				1176			2568	20			29		**8804**
27.7.b	8		455	483			2102.687		5693.73	1092				32		58	2807		**12732**
27.7.c	16450	2940	3748	8770		1533	14904.99	5021	10909.26	64982			22809	137		2276	20728		**175208**
27.7.e			62						0.05							1			**64**
27.7.f				1												19			**20**
27.7.g				0			554.4149							14		1			**569**
27.7.h	2		31						260.37					40		4			**336**
27.7.j	2		2	13			109.572		557.52					368		174			**1225**
27.7.k	9098	17843	27			1498	3264.397		9731.67	78841	6686		27949	0					**154937**
27.8.a	3		889						2669.33					9					**3570**
27.8.b			3											160					**164**
27.8.c			0									197		16563					**16760**
27.8.d			1282						676.94										**1959**
27.9.a												2325		8162					**10487**
Total	**40321**	**202415**	**14612**	**35327**	**20190**	**190146**	**39513.51**	**21183**	**62016.88**	**233968**	**26077**	**2522**	**133605**	**25509**	**40**	**8783**	**65085**	**22137**	**1143450**

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

Table 2.3.1.3. Blue whiting. ICES estimated catches (tonnes) by quarter and ICES division for 2021.

ICES Division	Quarter 1	Quarter 2	Quarter 3	Quarter 4	2021*	Total
27.4					100	**100**
27.2.a	1094	56453	14557	19502		**91606**
27.3.a	0	11	93	2		**106**
27.4.a	1084	15793	8037	14376		**39290**
27.4.b	0	7	1	4		**13**
27.5.a	1	262	5	20208		**20476**
27.5.b	52819	227524	16	18281		**298640**
27.6.a	86866	188481	2	31003	33	**306385**
27.6.b	8756	19	0	0	29	**8804**
27.7.b	6443	6263	21	4		**12732**
27.7.c	162839	12325	16	28		**175208**
27.7.e	0	1		62		**64**
27.7.f	20					**20**
27.7.g	0	13	554	1		**569**
27.7.h	6	35	4	291		**336**
27.7.j	151	316	547	212		**1225**
27.7.k	154911	27	0			**154937**
27.8.a	0	10	0	3560		**3570**
27.8.b	80	67	7	10		**164**
27.8.c	4188	4179	5627	2766		**16760**
27.8.d	0			1959		**1959**
27.9.a	1806	4041	2318	2323		**10487**
Total	**481063**	**515826**	**31806**	**114591**	**162**	**1143450**

***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 1988–2021 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**

*** 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 2021.

Country	Catches	Landings	Discards	% discards
Denmark	40321	40269	52	0.13
Faroe Islands	202415	202415	0	0.00
France	14612	14612	0	0.00
Germany	35327	35327	0	0.00
Greenland	20190	20190	0	0.00
Iceland	190146	190146	0	0.00
Ireland	39514	38959	554	1.40
Lithuania	21183	21183	0	0.00
Netherlands	62017	62017	0	0.00
Norway	233968	233968	0	0.00
Poland	26077	26077	0	0.00
Portugal	2522	1417	1105	43.81
Russia ^	133605	133605	0	0.00
Spain	25509	23471	2038	7.99
Sweden	40	40	0	0.00
UK (England)	8783	8758	24	0.28
UK(Scotland)	65085	64923	162	0.25
Unallocated	22137	22137	0	0.00
Total	**1143450**	**1139514**	**3936**	0.34

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

Table 2.3.1.6. Blue whiting. ICES estimated catches (tonnes) inside and outside NEAFC regulatory area for 2021 by country.

Country	Catches inside NEAFC RA	Catches outside NEAFC RA	Total catches
Denmark	1965	38356	40321
Faroe Islands	27809	174606	202415
France*	0	14612	14612
Germany	57	35270	35327
Greenland	11211	8979	20190
Iceland	4737	185409	190146
Ireland	1202	38312	39514
Lithuania	127	21055	21183
Netherlands	5	62012	62017
Norway*	100017	133952	233968
Poland	7531	18546	26077
Portugal	0	2522	2522
Spain	0	25509	25509
Sweden	0	40	40
UK (England)	0	8783	8783
UK(Scotland)	0	65085	65085
Total in 2021**	**154661**	**833047**	**987708**

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

**** without the Russian preliminary catch data and the unallocated catch data.**

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 2000-2021.

Year	Catch (tonnes)	% catch covered by sampling programme	No. Age samples	No. Measured	No. Aged
2000	1412928	*	1136	125162	13685
2001	1780170	*	985	173553	17995
2002	1556792	*	1037	116895	19202
2003	2321406	*	1596	188770	26207
2004	2377569	*	1774	181235	27835
2005	2026953	*	1833	217937	32184
2006	1966140	*	1715	190533	27014
2007	1610090	87	1399	167652	23495
2008	1246465	90	927	113749	21844
2009	635639	88	705	79500	18142
2010	524751	87	584	82851	16323
2011	103591	85	697	84651	12614
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	1711477	87	1565	131779	16426
2019	1515527	84	1253	136604	17869
2020	1495248	81	672	89110	16641
2021	**1143450**	**81**	**1424**	**129317**	**15379**

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 2021.

Country	Catch (ton)	% catch covered by sampling programme	No. Length samples	No. Age samples	No. Measured	No. Aged	No Aged/ 1000 tonnes	No Measured/ 1000 tonnes
Denmark	40321	94	19	19	817	815	20	20
Faroe Islands	202415	93	17	17	1796	1651	8	9
France	14612	15	21	0	3613	0	0	247
Germany	35327	27	4	4	2492	691	20	71
Greenland	20190	0	0	0	0	0	0	0
Iceland	190146	97	64	64	5639	1725	9	30
Ireland	39514	98	53	29	10548	1800	46	267
Lithuania	21183	0	0	0	0	0	0	0
Netherlands	62017	82	55	55	11483	1350	22	185
Norway	233968	90	68	68	2020	2020	9	9
Poland	26077	0	0	0	0	0	0	0
Portugal	2522	83	34	34	3129	1003	398	1241
Russia ^	133605	88	133	133	40413	1382	10	302
Spain	25509	98	984	984	41289	2259	89	1619
Sweden	40	0	0	0	0	0	0	0
UK (England)	8783	0	13	0	95	0	0	11
UK(Scotland)	65085	95	47	17	5983	683	10	92
Unallocated	22137	0	0	0	0	0	0	0
Total Geral	**1143450**	**81**	**1512**	**1424**	**129317**	**15379**	**13**	**113**

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

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 2021.

Country	Catches (ton)	No. of Length Samples	No. of Length Measured	No. Age Readings
Denmark				
Quarter 1	27685	12	541	539
Quarter 2	10331	7	276	276
Quarter 3	102	0	0	0
Quarter 4	2204	0	0	0
Total	**40321**	**19**	**817**	**815**
Faroe Islands				
Quarter 1	64013	9	1025	894
Quarter 2	124078	7	702	688
Quarter 3	2541	0	0	0
Quarter 4	11783	1	69	69
Total	**202415**	**17**	**1796**	**1651**
France				
Quarter 1	237	0	0	0
Quarter 2	12110	5	302	0
Quarter 3	1	0	0	0
Quarter 4	2263	16	3311	0
Total	**14612**	**21**	**3613**	**0**
Germany				
Quarter 1	21899	1	327	162
Quarter 2	11979	0	0	0
Quarter 3	14	0	0	0
Quarter 4	1434	3	2165	529
Total	**35327**	**4**	**2492**	**691**
Greenland				
Quarter 2	17737	0	0	0
Quarter 3	79	0	0	0
Quarter 4	2374	0	0	0
Total	20190	0	0	0
Iceland				
Quarter 1	23123	10	739	244
Quarter 2	129192	37	3650	1116
Quarter 3	1861	0	0	0
Quarter 4	35970	17	1250	365
Total	**190146**	**64**	**5639**	**1725**
Ireland				
Quarter 1	22817	20	5266	1300
Quarter 2	16131	9	2368	500
Quarter 3	554	24	2914	0
Quarter 4	11	0	0	0
Total	**39514**	**53**	**10548**	**1800**

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 2021.

Lithuania				
Quarter 1	9117	0	0	0
Quarter 4	12066	0	0	0
Total	21183	0	0	0
Netherlands				
Quarter 1	22908	30	5544	737
Quarter 2	32039	22	5219	538
Quarter 3	375	0	0	0
Quarter 4	6694	3	720	75
Total	**62017**	**55**	**11483**	**1350**
Norway				
Quarter 1	174903	59	1753	1753
Quarter 2	41332	8	237	237
Quarter 3	8130	0	0	0
Quarter 4	9604	1	30	30
Total	**233968**	**68**	**2020**	**2020**
Poland				
Quarter 1	12445	0	0	0
Quarter 4	13633	0	0	0
Total	26077	0	0	0
Portugal				
Quarter 1	646	6	434	100
Quarter 2	529	12	1092	269
Quarter 3	631	10	825	333
Quarter 4	716	6	778	301
Total	**2522**	**34**	**3129**	**1003**
Russia ^				
Quarter 1	61551	84	25439	1092
Quarter 2	72054	49	14974	290
Total	133605	133	40413	1382
Spain				
Quarter 1	5502	191	8051	200
Quarter 2	8254	268	9292	709
Quarter 3	7340	313	12849	593
Quarter 4	4414	212	11097	757
Total	**25509**	**984**	**41289**	**2259**
Sweden				
Quarter 1	0	0	0	0
Quarter 2	0	0	0	0
Quarter 3	9	0	0	0
Quarter 4	31	0	0	0
Total	**40**	**0**	**0**	**0**

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

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 2021.

UK (England)				
Quarter 1	20	0	0	0
Quarter 2	7136	13	95	0
Quarter 3	180	0	0	0
Quarter 4	1447	0	0	0
Total	**8783**	**13**	**95**	**0**
UK(Scotland)				
Quarter 1	34198	10	2248	456
Quarter 2	30703	7	872	227
Quarter 4	22	0	0	0
2021*	162	30	2863	0
Total	**65085**	**47**	**5983**	**683**
Unallocated				
Quarter 2	2223	0	0	0
Quarter 3	9988	0	0	0
Quarter 4	9925	0	0	0
Total	22137	0	0	0
Total Geral	**1143450**	**1512**	**129317**	**15379**

* discards data 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 2021.

ICES Division	Catch (tonnes)	No. Length samples	No. Age samples	No. Measured	No. Aged	No Aged/ 1000 tonnes	No Measured/ 1000 tonnes
27.4	100	18	0	1508	0	0	15050
27.2.a	91606	19	14	1936	540	6	21
27.3.a	106	0	0	0	0	0	0
27.4.a	39290	2	2	149	58	1	4
27.4.b	13	0	0	0	0	0	0
27.5.a	20476	13	13	932	287	14	46
27.5.b	298640	54	54	11644	2179	7	39
27.6.a	306385	133	124	21812	3501	11	71
27.6.b	8804	7	4	1670	226	26	190
27.7.b	12732	6	6	1210	174	14	95
27.7.c	175208	179	179	26304	3270	19	150
27.7.e	64	0	0	0	0	0	0
27.7.f	20	0	0	0	0	0	0
27.7.g	569	32	0	2950	0	0	5182
27.7.h	336	30	25	376	0	0	1118
27.7.j	1225	109	109	525	24	20	428
27.7.k	154937	74	74	12187	1835	12	79
27.8.a	3570	7	1	744	23	6	208
27.8.b	164	111	111	1465	0	0	8959
27.8.c	16760	383	383	25706	1066	64	1534
27.8.d	1959	10	0	2890	0	0	1475
27.9.a	10487	325	325	15309	2196	209	1460
TOTAL	**1143450**	**1512**	**1424**	**129317**	**15379**	13	113

Table 2.3.2.1. Blue whiting. ICES estimated preliminary landings (tonnes) in 2022 by quarter and ICES division. Data submitted to InterCatch.

	Landings			
ICES div.	**Quarter 1**	**Quarter 2**	**Quarter 3**	**Total**
27.2.a	1487	14702	65	16253
27.3.a		4	6	11
27.4.a	6026	22379		28405
27.4.b		0.09		0.09
27.5.a		15		15
27.5.b	54091	242073	1	296165
27.6.a	31769	113921		145691
27.6.b	5860	680		6540
27.7	4	28		32
27.7.b	1639			1639
27.7.c	116209	855		117065
27.7.f	0.38			0.38
27.7.g	1			1
27.7.j	2165			2165
27.7.k	69116			69116
27.8.a	5	18		23
27.8.c	4574	7183		11757
27.8.d	2700			2700
27.9.a	362	524		886
Total	**296008**	**402383**	**72**	**698463**

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 2022 preliminary data (quarters 1 and 2). Data submitted to InterCatch.

ICES Division	Catch (tonnes)	No. samples	No. Measured	No. Aged
27.2.a	16253	1	116	100
27.3.a	11	0	0	0
27.4.a	28405	1	100	100
27.4.b	0	0	0	0
27.5.a	15	0	0	0
27.5.b	296165	6	494	459
27.6.a	145691	31	4645	1458
27.6.b	6540	1	30	30
27.7	32	0	0	0
27.7.b	1639	0	0	0
27.7.c	117065	27	3964	1349
27.7.f	0	0	0	0
27.7.g	1	0	0	0
27.7.j	2165	0	0	0
27.7.k	69116	11	888	516
27.8.a	23	0	0	0
27.8.c	11757	0	0	0
27.8.d	2700	0	0	0
27.9.a	886	18	1526	369
Total	**698463**	**96**	**11763**	**4381**

Table 2.3.2.3. Blue whiting. ICES estimates of catches (tonnes) in 2022, based on (initial) declared quotas and expected uptake estimated by WGWIDE.

Country	Q1	Q2	Q3	Preliminary Catch	Expected Catch remained catch or Total year catch	Total Catch
Denmark	25639	19782	6	45427	10	45437
Faroe Islands	65427	139620	66	205113	66218	271331
France					9128	9128
Germany	15594	601		16195	13988	30183
Greenland					22878	22878
Iceland	0	157563		157563	12707	174557
Ireland	17232	11221		28453	0	28453
Lithuania					6467	6467
Netherlands	4799			4799	74948	79747
Norway	111166			164650	25350	190000
Poland	18024	2924		20948	5865	26814
Portugal	224	412		636	1364	2000
Spain	4716	7323		12039	10961	23000
UK(Scotland)	35264	16945	1277	53486	0	53486
Sweden				0	70	70
Total reporting countries						**963550**
Russia (assumed 13 % of total)						**143979**
Total						***1107529***

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

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

Table 2.3.3.1. Blue whiting. Catch-at-age numbers (thousands) by year. Discards included since 2014. Values for 2022 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

Year Age	1	2	3	4	5	6	7	8	9	10+
1988	425000	721000	614000	683000	1303000	618000	84000	53000	33000	50000
1989	865000	718000	1340000	791000	837000	708000	139000	50000	25000	38000
1990	1611000	703000	672000	753000	520000	577000	299000	78000	27000	95000
1991	266686	1024468	513959	301627	363204	258038	159153	49431	5060	9570
1992	407730	653838	1641714	569094	217386	154044	109580	79663	31987	11706
1993	263184	305180	621085	1571236	411367	191241	107005	64769	38118	17476
1994	306951	107935	367962	389264	1221919	281120	174256	90429	79014	30614
1995	296100	353949	421560	465358	615994	800201	253818	159797	59670	41811
1996	1893453	534221	632361	537280	323324	497458	663133	232420	98415	82521
1997	2131494	1519327	904074	577676	295671	251642	282056	406910	104320	169235
1998	1656926	4181175	3541231	1044897	383658	322777	303058	264105	212452	85513
1999	788200	1549100	5820800	3460600	412800	207200	151200	153100	68800	140500
2000	1814851	1192657	3465739	5014862	1550063	513663	213057	151429	58277	139791
2001	4363690	4486315	2962163	3806520	2592933	585666	170020	97032	76624	66410
2002	1821053	3232244	3291844	2242722	1824047	1647122	344403	168848	102576	142743
2003	3742841	4073497	8378955	4824590	2035096	1117179	400022	121280	19701	27493
2004	2156261	4426323	6723748	6697923	3044943	1276412	649885	249097	75415	36805
2005	1427277	1518938	5083550	5871414	4450171	1419089	518304	249443	100374	55226
2006	412961	939865	4206005	6150696	3833536	1718775	506198	181181	67573	36688
2007	167027	306898	1795021	4210891	3867367	2353478	935541	320529	130202	88573
2008	408790	179211	545429	2917190	3262956	1919264	736051	315671	113086	126637
2009	61125	156156	231958	594624	1596095	1156999	592090	251529	88615	48908
2010	349637	222975	160101	208279	646380	992214	702569	256604	70487	43693
2011	162997	101810	63954	53863	69717	116396	120359	55470	25943	12542
2012	239667	351845	663155	141854	106883	203419	363779	356785	212492	157947
2013	228175	508122	848597	896966	462714	224066	321310	397536	344285	383601
2014	588717	584084	2312953	2019373	1272862	416523	386396	462339	526141	662747
2015	2944849	2852384	2427329	2465286	1518235	707533	329882	258743	239164	450046
2016	1239331	3518677	2933271	1874011	1367844	756824	339851	185368	131039	288635

Year Age	1	2	3	4	5	6	7	8	9	10+
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	906699	3344062	1873517	1778289	1092800	814544	753595	795714	130995	95271

Table 2.3.4.1. Blue whiting. Individual mean weight (kg) at age in the catch. Preliminary values for 2022.

Year Age	1	2	3	4	5	6	7	8	9	10+
1981	0.052	0.065	0.103	0.125	0.141	0.155	0.170	0.178	0.187	0.213
1982	0.045	0.072	0.111	0.143	0.156	0.177	0.195	0.200	0.204	0.231
1983	0.046	0.074	0.118	0.140	0.153	0.176	0.195	0.200	0.204	0.228
1984	0.035	0.078	0.089	0.132	0.153	0.161	0.175	0.189	0.186	0.206
1985	0.038	0.074	0.097	0.114	0.157	0.177	0.199	0.208	0.218	0.237
1986	0.040	0.073	0.108	0.130	0.165	0.199	0.209	0.243	0.246	0.257
1987	0.048	0.086	0.106	0.124	0.147	0.177	0.208	0.221	0.222	0.254
1988	0.053	0.076	0.097	0.128	0.142	0.157	0.179	0.199	0.222	0.260
1989	0.059	0.079	0.103	0.126	0.148	0.158	0.171	0.203	0.224	0.253
1990	0.045	0.070	0.106	0.123	0.147	0.168	0.175	0.214	0.217	0.256
1991	0.055	0.091	0.107	0.136	0.174	0.190	0.206	0.230	0.232	0.266
1992	0.057	0.083	0.119	0.140	0.167	0.193	0.226	0.235	0.284	0.294
1993	0.066	0.082	0.109	0.137	0.163	0.177	0.200	0.217	0.225	0.281
1994	0.061	0.087	0.108	0.137	0.164	0.189	0.207	0.217	0.247	0.254
1995	0.064	0.091	0.118	0.143	0.154	0.167	0.203	0.206	0.236	0.256
1996	0.041	0.080	0.102	0.116	0.147	0.170	0.214	0.230	0.238	0.279
1997	0.047	0.072	0.102	0.121	0.140	0.166	0.177	0.183	0.203	0.232
1998	0.048	0.072	0.094	0.125	0.149	0.178	0.183	0.188	0.221	0.248
1999	0.063	0.078	0.088	0.109	0.142	0.170	0.199	0.193	0.192	0.245
2000	0.057	0.075	0.086	0.104	0.133	0.156	0.179	0.187	0.232	0.241
2001	0.050	0.078	0.094	0.108	0.129	0.163	0.186	0.193	0.231	0.243

Year Age	1	2	3	4	5	6	7	8	9	10+
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
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	0.042	0.065	0.084	0.104	0.119	0.136	0.139	0.158	0.154	0.199

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

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

Table 2.3.7.1.1. 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 2004-2022) 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
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

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

Table 2.3.7.2.1. Blue whiting. Estimated abundance of 1 and 2-year old blue whiting from the International Ecosystem Survey in Nordic Seas (IESNS), 2003–2022.

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

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

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

Catch Rate		
Year	**All**	**< 19 cm**
1981	0.13	0
1982	0.17	0.01
1983	4.46	0.46
1984	6.97	2.47
1985	32.51	0.77
1986	17.51	0.89
1987	8.32	0.02
1988	6.38	0.97
1989	1.65	0.18
1990	17.81	16.37
1991	48.87	2.11
1992	30.05	0.06
1993	5.80	0.01
1994	3.02	0
1995	1.65	0.10
1996	9.88	5.81
1997	187.24	175.26
1998	7.14	0.21
1999	5.98	0.71
2000	129.23	120.90
2001	329.04	233.76
2002	102.63	9.69
2003	75.25	15.15
2004	124.01	36.74
2005	206.18	90.23
2006	269.2	3.52
2007	80.38	0.16

Catch Rate		
Year	**All**	**< 19 cm**
2008	17.97	0.04
2009	4.50	0.01
2010	3.30	0.08
2011	1.48	0.01
2012	127.71	125.93
2013	39.54	2.33
2014	31.48	24.97
2015	148.4	128.34
2016	86.99	11.31
2017	167.16	0.71
2018	9.19	0.03
2019	12.66	6.00
2020	26.42	19.33
2021	182.86	161.04
2022	79.19	41.55

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

Catch Rate	
Year	**< 22 cm**
1996	6.5
1997	3.4
1998	1.1
1999	6.3
2000	9
2001	5.2
2002	14.2
2003	15.4
2004	8.9
2005	8.3
2006	30.4
2007	3.9
2008	0.1
2009	1.6
2010	0.2
2011	10.8
2012	29.9
2013	11.7
2014	66.3
2015	43.8
2016	6.3
2017	1.8
2018	0.4
2019	0.1
2020	9.8
2021	79.6
2022	91.2

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

Catch Rate	
Year	<= 23 cm
1994	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
2020	141
2021	2224
2022	1781

Table 2.4.1.1. Blue whiting. Parameter estimates, from final assessment (2022) and retrospective analysis (2018-2021).

Parameter Year	2018	2019	2020	2021	2022
Random walk variance					
-F Age 1-10	0.38	0.37	0.37	0.36	0.36
Process error					
-log(N) Age 1	0.62	0.61	0.60	0.61	0.62
--- Age 2-10	0.18	0.18	0.18	0.18	0.18
Observation variance					
-Catch Age 1	0.44	0.43	0.44	0.44	0.43
--- Age 2	0.28	0.28	0.28	0.28	0.27
--- Age 3-8	0.19	0.19	0.19	0.19	0.18
--- Age 9-10	0.40	0.39	0.38	0.38	0.37
-IBWSS Age 1	0.74	0.75	0.74	0.72	0.74
--- Age 2	0.31	0.33	0.33	0.33	0.33
--- Age 3	0.42	0.41	0.41	0.39	0.39
--- Age 4-6	0.39	0.37	0.37	0.36	0.35
--- Age 7-8	0.50	0.54	0.54	0.53	0.53
Survey catchability					
-IBWSS Age 1	0.07	0.07	0.06	0.06	0.06
--- Age 2	0.12	0.11	0.11	0.12	0.11
--- Age 3	0.37	0.37	0.37	0.37	0.36
--- Age 4	0.69	0.68	0.68	0.68	0.67
--- Age 5-8	0.87	0.87	0.88	0.89	0.88
Rho					
--	0.93	0.93	0.93	0.94	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)
2017	-0.109	-0.107	0.142
2018	-0.218	-0.102	0.074
2019	-0.335	-0.001	-0.024
2020	-0.216	-0.076	0.077
2021	-0.406	-0.172	0.180
Rho mean	-0.257	-0.091	0.090

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	0.245	0.318	0.347	0.444	0.486	0.486
1982	0.067	0.102	0.149	0.183	0.209	0.271	0.294	0.372	0.405	0.405
1983	0.078	0.118	0.171	0.211	0.240	0.314	0.338	0.420	0.446	0.446
1984	0.095	0.143	0.212	0.265	0.305	0.397	0.418	0.509	0.530	0.530
1985	0.101	0.150	0.229	0.294	0.346	0.447	0.465	0.560	0.575	0.575
1986	0.113	0.168	0.268	0.357	0.431	0.552	0.573	0.692	0.705	0.705
1987	0.100	0.150	0.247	0.337	0.414	0.537	0.560	0.674	0.676	0.676
1988	0.098	0.148	0.253	0.349	0.439	0.575	0.589	0.694	0.678	0.678
1989	0.113	0.171	0.304	0.420	0.526	0.686	0.712	0.842	0.806	0.806
1990	0.105	0.159	0.292	0.408	0.511	0.665	0.713	0.850	0.817	0.817
1991	0.059	0.089	0.168	0.235	0.290	0.368	0.396	0.466	0.451	0.451
1992	0.048	0.073	0.140	0.196	0.233	0.286	0.311	0.370	0.363	0.363
1993	0.042	0.063	0.125	0.176	0.206	0.246	0.268	0.319	0.314	0.314
1994	0.036	0.054	0.113	0.160	0.186	0.219	0.241	0.292	0.286	0.286
1995	0.046	0.070	0.150	0.216	0.244	0.285	0.314	0.383	0.369	0.369
1996	0.055	0.085	0.185	0.271	0.297	0.348	0.383	0.473	0.451	0.451
1997	0.054	0.084	0.188	0.279	0.300	0.349	0.382	0.474	0.453	0.453
1998	0.070	0.110	0.251	0.382	0.408	0.473	0.510	0.630	0.593	0.593
1999	0.064	0.101	0.237	0.369	0.397	0.458	0.482	0.592	0.558	0.558

Year Age	1	2	3	4	5	6	7	8	9	10+
2000	0.073	0.117	0.279	0.446	0.498	0.576	0.589	0.705	0.665	0.665
2001	0.069	0.111	0.265	0.430	0.494	0.572	0.574	0.679	0.644	0.644
2002	0.065	0.104	0.250	0.418	0.504	0.595	0.597	0.702	0.667	0.667
2003	0.067	0.107	0.261	0.440	0.545	0.634	0.629	0.710	0.670	0.670
2004	0.068	0.109	0.269	0.461	0.592	0.690	0.688	0.753	0.711	0.711
2005	0.059	0.095	0.238	0.419	0.557	0.650	0.656	0.704	0.667	0.667
2006	0.051	0.082	0.208	0.372	0.509	0.596	0.606	0.640	0.606	0.606
2007	0.048	0.077	0.197	0.357	0.506	0.604	0.629	0.661	0.629	0.629
2008	0.041	0.068	0.170	0.309	0.444	0.529	0.563	0.590	0.569	0.569
2009	0.027	0.045	0.112	0.198	0.288	0.342	0.371	0.386	0.375	0.375
2010	0.019	0.032	0.080	0.138	0.201	0.236	0.259	0.264	0.257	0.257
2011	0.006	0.010	0.024	0.040	0.057	0.066	0.073	0.075	0.074	0.074
2012	0.012	0.020	0.051	0.085	0.121	0.141	0.159	0.166	0.165	0.165
2013	0.019	0.034	0.090	0.150	0.214	0.244	0.278	0.292	0.292	0.292
2014	0.036	0.066	0.175	0.295	0.416	0.472	0.538	0.569	0.566	0.566
2015	0.046	0.085	0.230	0.389	0.546	0.624	0.698	0.734	0.727	0.727
2016	0.039	0.073	0.197	0.339	0.478	0.554	0.616	0.644	0.637	0.637
2017	0.037	0.069	0.188	0.326	0.457	0.527	0.577	0.595	0.590	0.590
2018	0.036	0.068	0.187	0.328	0.463	0.534	0.584	0.597	0.594	0.594
2019	0.032	0.060	0.168	0.298	0.421	0.482	0.527	0.531	0.528	0.528
2020	0.035	0.066	0.182	0.326	0.463	0.527	0.577	0.578	0.572	0.572
2021	0.030	0.056	0.156	0.281	0.399	0.453	0.494	0.497	0.491	0.491
2022	0.031	0.058	0.161	0.292	0.417	0.470	0.516	0.518	0.511	0.511

Table 2.4.1.4. Blue whiting. Estimated stock numbers-at-age (thousands). Preliminary catch data for 2022 have been used

Year Age	1	2	3	4	5	6	7	8	9	10+
1981	3948198	3483134	4853128	2063381	2615682	2138821	1642831	1743162	1227396	2980519
1982	4696698	2963754	2517522	3288737	1583208	1494152	1291796	1012284	889662	1940890
1983	18293953	3809208	1877680	1818746	1897666	1218555	1014568	854628	627992	1252407
1984	18077398	14562962	2450003	1233914	1261344	1397475	815593	549720	481649	922153
1985	9550303	13545071	9807290	1453542	749637	914081	747079	458534	265294	722100
1986	7206799	6372536	9406612	5561299	948825	452061	469404	376188	231523	499543
1987	9113538	5032490	4072187	6882719	2568177	394492	253898	238137	156693	293640
1988	6409993	6861313	3511774	2870746	3727659	1275834	199445	125573	99146	170141
1989	8492388	4620755	4994215	2424184	2130302	1684904	350755	103076	60787	115044
1990	18840757	5973402	3093924	2728803	1480249	1186791	560115	120836	33119	85695
1991	9049081	15643199	4259229	1785365	1491130	874989	562933	188115	32126	45442
1992	6698667	7458376	12503692	3310414	1257597	788315	485873	287464	101477	39068
1993	4942776	5123283	5296885	9738212	2263702	976646	516955	281742	156944	74164
1994	8113390	3379619	4070890	3390595	6950171	1439175	766071	328519	207427	115713
1995	9322644	5867025	3129586	2563312	2856905	3741838	1041446	545237	221227	184619
1996	28090039	7109483	4071822	2392659	1544304	1861760	2238167	645981	306922	249290
1997	45080996	21344009	5501906	2566564	1414602	1064387	1059818	1211979	288024	336938

Year Age	1	2	3	4	5	6	7	8	9	10+
1998	26696161	37985412	16454475	3496892	1370190	925363	782485	604708	616206	291964
1999	20303064	20503747	27713908	10599808	1703960	770894	518846	410948	236101	427358
2000	39448363	15270043	16580561	15810425	4338169	1111059	472766	323676	153198	313508
2001	55947436	31755217	12078805	10736413	7446097	1691153	488651	227410	163649	177810
2002	49106855	45338753	20408977	8304748	5441968	3392286	687547	255845	103097	154656
2003	52947963	39192643	35075975	13575701	5077023	2966716	1200986	344891	88649	106704
2004	28714768	42109802	30137706	20847617	7248626	2464658	1312509	500226	151135	80113
2005	22271163	21718324	28499051	18145779	10750885	3223618	1108963	512665	191117	98337
2006	9009113	15413359	22321756	19293696	9481605	4454118	1354232	481870	217274	119414
2007	4913368	5967442	13108559	15933357	10301052	4703381	1836143	608879	228295	162451
2008	5883847	3465837	4331922	11056361	9160778	4912569	1855148	753418	234404	199862
2009	5813482	4042546	2418910	3703135	6937430	4708636	2192796	855782	323765	188156
2010	15534228	5108247	2365111	1853628	3372665	4350095	2847425	1199051	411438	264795
2011	19713440	13522085	3355946	1661963	1613842	2613131	2697703	1346774	811348	389208
2012	19509226	15674187	12781899	2296933	1185528	1619913	2344919	2125776	1077665	896461
2013	16196200	16181915	11820392	7461025	2245751	1097606	1384976	1645697	1349228	1380746
2014	37769539	12759745	14030071	8116097	4403727	1351921	942553	1011060	1026225	1492297
2015	64728113	33248750	10910324	8533489	4211336	1736364	738558	523308	487940	1058255

Year Age	1	2	3	4	5	6	7	8	9	10+
2016	35567778	57871493	21657974	7737276	4336329	1809839	707922	354459	223199	594127
2017	12172965	28851639	46306625	15275299	4577931	2166987	738670	285246	162222	375993
2018	13119298	9414030	22960923	30015459	8861786	2498004	952440	316812	143809	266442
2019	15254049	9759745	9037146	15384432	16762022	4668475	1155173	412610	140328	199051
2020	26772174	12754712	7294693	7026232	8955708	8254837	2249921	583463	201500	163929
2021	71562826	19445326	9940991	5134725	4644904	4294899	4043115	878041	288811	172055
2022	43220294	65372551	13900332	7564442	3356125	2474668	2082227	2211891	397414	249106
2023	22537250*	34317672	50514113	9683829	4624746	1811531	1265829	1018083	1078587	317446

***assuming GM(1996-2021) recruitment in 2023.**

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	3948198	2549746	6113656	2846036	2245456	3607250	0.259	0.189	0.354	3343771	2686598	4161696
1982	4696698	3001694	7348843	2299742	1835126	2881988	0.221	0.164	0.297	2770115	2248453	3412808
1983	18293953	11937083	28036056	1854216	1512075	2273776	0.255	0.192	0.337	2886828	2353546	3540944
1984	18077398	11900836	27459608	1756125	1454927	2119676	0.319	0.244	0.417	3093702	2500953	3826939
1985	9550303	6312234	14449447	2095632	1732609	2534718	0.356	0.275	0.461	3234759	2645700	3954969
1986	7206799	4792760	10836753	2274475	1884455	2745217	0.436	0.339	0.562	3113722	2585083	3750467

Year	R(age 1)	Low	High	SSB	Low	High	Fbar (3-7)	Low	High	TSB	Low	High
1987	9113538	6047121	13734894	1933155	1603976	2329890	0.419	0.324	0.541	2817509	2341994	3389573
1988	6409993	4251396	9664593	1638205	1370653	1957983	0.441	0.342	0.569	2425857	2024649	2906570
1989	8492388	5609692	12856438	1546404	1297863	1842541	0.529	0.412	0.680	2391067	1985764	2879096
1990	18840757	12270809	28928337	1356528	1128145	1631147	0.518	0.396	0.676	2499552	2000264	3123468
1991	9049081	5826489	14054068	1777830	1429325	2211309	0.291	0.216	0.393	3224253	2529151	4110395
1992	6698667	4365051	10279865	2460102	1951887	3100643	0.233	0.173	0.315	3532097	2804852	4447902
1993	4942776	3184796	7671146	2543671	2027313	3191545	0.204	0.151	0.275	3420359	2744348	4262893
1994	8113390	5277115	12474069	2535468	2042807	3146943	0.184	0.136	0.248	3415435	2776614	4201231
1995	9322644	6125353	14188844	2308211	1901995	2801183	0.242	0.183	0.320	3354448	2764391	4070452
1996	28090039	18496998	42658289	2207682	1836837	2653398	0.297	0.226	0.390	3726979	3035570	4575870
1997	45080996	29748090	68316864	2467358	2048273	2972189	0.300	0.229	0.392	5448075	4288051	6921914
1998	26696161	17717886	40224044	3685247	3017327	4501018	0.405	0.313	0.524	6834539	5472054	8536268
1999	20303064	13419599	30717343	4449851	3630259	5454480	0.389	0.300	0.504	7178200	5844370	8816443
2000	39448363	26002313	59847495	4233012	3521792	5087862	0.477	0.372	0.613	7470574	6096978	9153629
2001	55947436	37187292	84171646	4575712	3821738	5478433	0.467	0.363	0.600	9021213	7286025	11169642
2002	49106855	32631938	73899478	5401566	4504809	6476838	0.473	0.367	0.609	10346234	8388365	12761075
2003	52947963	35655989	78625974	6875173	5716742	8268346	0.502	0.395	0.638	11858110	9739057	14438233
2004	28714768	19302031	42717673	6778079	5701925	8057341	0.540	0.428	0.682	10401328	8701897	12432648

Year	R(age 1)	Low	High	SSB	Low	High	Fbar (3-7)	Low	High	TSB	Low	High
2005	22271163	14998683	33069881	6031586	5083744	7156150	0.504	0.396	0.641	8508967	7156398	10117173
2006	9009113	6005043	13515995	5891687	4948048	7015288	0.458	0.358	0.587	7732632	6496994	9203272
2007	4913368	3264414	7395256	4673775	3915203	5579322	0.459	0.355	0.593	5709625	4792945	6801625
2008	5883847	3862867	8962167	3593824	2971047	4347144	0.403	0.303	0.535	4414990	3665381	5317902
2009	5813482	3702391	9128311	2754203	2222003	3413874	0.262	0.192	0.357	3474921	2822816	4277670
2010	15534228	10141289	23795027	2690487	2129607	3399087	0.183	0.131	0.255	3776135	3014174	4730713
2011	19713440	12986631	29924598	2717639	2166277	3409333	0.052	0.036	0.075	4477901	3566528	5622163
2012	19509226	13074672	29110475	3476370	2840438	4254677	0.112	0.084	0.149	5176194	4222226	6345701
2013	16196200	10896851	24072726	3803134	3168694	4564602	0.195	0.149	0.255	5642058	4679857	6802092
2014	37769539	25189811	56631551	4045006	3409524	4798933	0.379	0.292	0.492	6710627	5543292	8123787
2015	64728113	43428474	96474232	4218197	3548784	5013883	0.497	0.389	0.635	8265505	6686427	10217500
2016	35567778	23913789	52901145	4974200	4114630	6013339	0.437	0.339	0.562	9254134	7480583	11448171
2017	12172965	8062125	18379902	6199504	5085700	7557239	0.415	0.322	0.536	8988316	7357708	10980297
2018	13119298	8655930	19884169	6090429	5006887	7408460	0.419	0.322	0.546	8082094	6653535	9817373
2019	15254049	9638265	24141898	5284355	4319920	6464102	0.379	0.285	0.505	7305759	5945587	8977098
2020	26772174	16299607	43973408	4480563	3571612	5620836	0.415	0.302	0.571	7042419	5456145	9089872
2021	71562826	40213851	127350103	4440379	3320100	5938666	0.356	0.243	0.523	9511299	6526756	13860608
2022	43220294	19011128	98257917	4955777	3341999	7348815	0.371	0.228	0.605	9506755	6004619	15051478

Year	R(age 1)	Low	High	SSB	Low	High	Fbar (3-7)	Low	High	TSB	Low	High
2023	22537250*			6621207^								

***assuming GM(1996-2021) recruitment in 2023.**

^ SSB calculated from the survivors age 2-10 and GM(1996-2021) recruitment in 2023

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	3948198	2549746	6113656	2846036	2245456	3607250	0.259	0.189	0.354	3343771	2686598	4161696
1982	4696698	3001694	7348843	2299742	1835126	2881988	0.221	0.164	0.297	2770115	2248453	3412808
1983	18293953	11937083	28036056	1854216	1512075	2273776	0.255	0.192	0.337	2886828	2353546	3540944
1984	18077398	11900836	27459608	1756125	1454927	2119676	0.319	0.244	0.417	3093702	2500953	3826939
1985	9550303	6312234	14449447	2095632	1732609	2534718	0.356	0.275	0.461	3234759	2645700	3954969
1986	7206799	4792760	10836753	2274475	1884455	2745217	0.436	0.339	0.562	3113722	2585083	3750467
1987	9113538	6047121	13734894	1933155	1603976	2329890	0.419	0.324	0.541	2817509	2341994	3389573
1988	6409993	4251396	9664593	1638205	1370653	1957983	0.441	0.342	0.569	2425857	2024649	2906570
1989	8492388	5609692	12856438	1546404	1297863	1842541	0.529	0.412	0.680	2391067	1985764	2879096
1990	18840757	12270809	28928337	1356528	1128145	1631147	0.518	0.396	0.676	2499552	2000264	3123468
1991	9049081	5826489	14054068	1777830	1429325	2211309	0.291	0.216	0.393	3224253	2529151	4110395
1992	6698667	4365051	10279865	2460102	1951887	3100643	0.233	0.173	0.315	3532097	2804852	4447902

Year	R(age 1)	Low	High	SSB	Low	High	Fbar (3-7)	Low	High	TSB	Low	High
1993	4942776	3184796	7671146	2543671	2027313	3191545	0.204	0.151	0.275	3420359	2744348	4262893
1994	8113390	5277115	12474069	2535468	2042807	3146943	0.184	0.136	0.248	3415435	2776614	4201231
1995	9322644	6125353	14188844	2308211	1901995	2801183	0.242	0.183	0.320	3354448	2764391	4070452
1996	28090039	18496998	42658289	2207682	1836837	2653398	0.297	0.226	0.390	3726979	3035570	4575870
1997	45080996	29748090	68316864	2467358	2048273	2972189	0.300	0.229	0.392	5448075	4288051	6921914
1998	26696161	17717886	40224044	3685247	3017327	4501018	0.405	0.313	0.524	6834539	5472054	8536268
1999	20303064	13419599	30717343	4449851	3630259	5454480	0.389	0.300	0.504	7178200	5844370	8816443
2000	39448363	26002313	59847495	4233012	3521792	5087862	0.477	0.372	0.613	7470574	6096978	9153629
2001	55947436	37187292	84171646	4575712	3821738	5478433	0.467	0.363	0.600	9021213	7286025	11169642
2002	49106855	32631938	73899478	5401566	4504809	6476838	0.473	0.367	0.609	10346234	8388365	12761075
2003	52947963	35655989	78625974	6875173	5716742	8268346	0.502	0.395	0.638	11858110	9739057	14438233
2004	28714768	19302031	42717673	6778079	5701925	8057341	0.540	0.428	0.682	10401328	8701897	12432648
2005	22271163	14998683	33069881	6031586	5083744	7156150	0.504	0.396	0.641	8508967	7156398	10117173
2006	9009113	6005043	13515995	5891687	4948048	7015288	0.458	0.358	0.587	7732632	6496994	9203272
2007	4913368	3264414	7395256	4673775	3915203	5579322	0.459	0.355	0.593	5709625	4792945	6801625
2008	5883847	3862867	8962167	3593824	2971047	4347144	0.403	0.303	0.535	4414990	3665381	5317902
2009	5813482	3702391	9128311	2754203	2222003	3413874	0.262	0.192	0.357	3474921	2822816	4277670
2010	15534228	10141289	23795027	2690487	2129607	3399087	0.183	0.131	0.255	3776135	3014174	4730713

Year	R(age 1)	Low	High	SSB	Low	High	Fbar (3-7)	Low	High	TSB	Low	High
2011	19713440	12986631	29924598	2717639	2166277	3409333	0.052	0.036	0.075	4477901	3566528	5622163
2012	19509226	13074672	29110475	3476370	2840438	4254677	0.112	0.084	0.149	5176194	4222226	6345701
2013	16196200	10896851	24072726	3803134	3168694	4564602	0.195	0.149	0.255	5642058	4679857	6802092
2014	37769539	25189811	56631551	4045006	3409524	4798933	0.379	0.292	0.492	6710627	5543292	8123787
2015	64728113	43428474	96474232	4218197	3548784	5013883	0.497	0.389	0.635	8265505	6686427	10217500
2016	35567778	23913789	52901145	4974200	4114630	6013339	0.437	0.339	0.562	9254134	7480583	11448171
2017	12172965	8062125	18379902	6199504	5085700	7557239	0.415	0.322	0.536	8988316	7357708	10980297
2018	13119298	8655930	19884169	6090429	5006887	7408460	0.419	0.322	0.546	8082094	6653535	9817373
2019	15254049	9638265	24141898	5284355	4319920	6464102	0.379	0.285	0.505	7305759	5945587	8977098
2020	26772174	16299607	43973408	4480563	3571612	5620836	0.415	0.302	0.571	7042419	5456145	9089872
2021	71562826	40213851	127350103	4440379	3320100	5938666	0.356	0.243	0.523	9511299	6526756	13860608
2022	43220294	19011128	98257917	4955777	3341999	7348815	0.371	0.228	0.605	9506755	6004619	15051478
2023	22537250*			6621207^								

***assuming GM(1996-2021) recruitment in 2023.**

^ SSB calculated from the survivors age 2-10 and GM(1996-2021) recruitment in 2023

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	788899	568869	1094034	922980
1982	544462	415928	712717	550643
1983	511429	397097	658681	553344
1984	562849	436560	725671	615569
1985	638357	503485	809358	678214
1986	760657	600423	963653	847145
1987	638031	503867	807920	654718
1988	569671	450572	720253	552264
1989	618818	492656	777287	630316
1990	553618	437776	700115	558128
1991	407963	318674	522271	364008
1992	438562	347202	553963	474592
1993	440392	346971	558966	475198
1994	424782	332919	541992	457696
1995	508660	405109	638679	505176
1996	597489	475874	750185	621104
1997	640338	505643	810912	639681
1998	1080858	848979	1376068	1131955
1999	1248067	975731	1596416	1261033
2000	1503388	1184000	1908931	1412449
2001	1560119	1228373	1981459	1771805
2002	1711364	1347754	2173071	1556955
2003	2202490	1742780	2783462	2365319
2004	2319262	1842881	2918785	2400795
2005	1998969	1590932	2511659	2018344
2006	1854141	1475771	2329521	1956239
2007	1558186	1238596	1960237	1612269

Year	Estimate	Low	High	SOP catch
2008	1167284	920948	1479510	1251851
2009	656865	517289	834101	634978
2010	478520	370983	617227	539539
2011	135746	100837	182742	103771
2012	326794	260010	410731	375692
2013	591003	469650	743713	613863
2014	1113687	879716	1409885	1147650
2015	1348361	1074286	1692359	1390656
2016	1243182	987399	1565224	1180786
2017	1481707	1175774	1867243	1555069
2018	1706765	1348261	2160595	1709856
2019	1535424	1211096	1946607	1512026
2020	1428866	1132542	1802721	1460507
2021	1147426	915250	1438500	1139531
2022	1121336	884135	1422175	1107529

Table 2.8.2.1.1. Blue whiting. Input to short-term projection (median values for exploitation pattern and stock numbers).

Age	Mean weight in the stock and catch (kg) in 2022	Mean weight in the stock and catch (kg) in 2023+	Proportion mature	Natural mortality	Exploitation pattern	Stock number (2023) (thousands)
1	0.042	0.055	0.11	0.20	0.083	22537250
2	0.065	0.079	0.40	0.20	0.156	34317672
3	0.084	0.094	0.82	0.20	0.435	50514113
4	0.104	0.113	0.86	0.20	0.787	9683829
5	0.119	0.127	0.91	0.20	1.122	4624746
6	0.136	0.138	0.94	0.20	1.267	1811531
7	0.139	0.145	1.00	0.20	1.389	1265829
8	0.158	0.162	1.00	0.20	1.396	1018083
9	0.154	0.170	1.00	0.20	1.377	1078587
10+	0.199	0.205	1.00	0.20	1.377	317446

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

Variable	Value	Notes
$F_{ages\ 3–7}$ (2022)	0.37	From the assessment (based on assumed 2022 catches)
SSB (2023)	6 621 207	From the forecast; in tonnes
$R_{age\ 1}$ (2022)	43 220 294	From the assessment; in thousands
$R_{age\ 1}$ (2023–2024)	22 537 250	GM (1996–2021); in thousands
Total catch (2022)	1 107 529	As estimated by ICES, based on declared national quotas and expected up-take; in tonnes

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

Basis	Catch(2023)	F(2023)	SSB(2024)	% SSB change*	% Catch change**	% Advice change***
Long-term management strategy (F=FMSY)	1359629	0.320	7781444	17.5	22.8	80.6
MSY approach: FMSY	1359629	0.320	7781444	17.5	22.8	80.6
F = 0	5	0.000	9039585	36.5	-100.0	-100.0
Fpa	1359629	0.320	7781444	17.5	22.8	80.6
Flim	3146002	0.880	6157129	-7.0	184.1	317.9
SSB (2024) = Blim	8696303	6.503	1499996	-77.3	685.2	1055.3
SSB (2024 = Bpa	7715688	4.401	2249993	-66.0	596.7	925.0
SSB (2024) = MSY Btrigger	7715688	4.401	2249993	-66.0	596.7	925.0
F = F (2022)	1550784	0.371	7605942	14.9	40.0	106.0
SSB (2024) = SSB (2023)	2631402	0.698	6621196	-0.0	137.6	249.6
Catch (2023) = Catch (2022)	1107553	0.255	8013430	21.0	0.0	47.1
Catch (2023) = Catch (2022) -20 %	886105	0.200	8217731	24.1	-20.0	17.7
Catch (2023) = Catch (2022) +25%	1384385	0.327	7758694	17.2	25.0	83.9
Catch (2023) = Advice (2022) -20 %	602183	0.133	8480325	28.1	-45.6	-20.0
Catch (2023) = Advice (2022) +25%	940871	0.214	8167163	23.3	-15.0	25.0
F = 0.05	233147	0.050	8822699	33.2	-78.9	-69.0
F = 0.10	458089	0.100	8613869	30.1	-58.6	-39.1
F = 0.15	675211	0.150	8412714	27.1	-39.0	-10.3
F = 0.16	717729	0.160	8373372	26.5	-35.2	-4.7
F = 0.17	759951	0.170	8334319	25.9	-31.4	1.0

Basis	Catch(2023)	F(2023)	SSB(2024)	% SSB change*	% Catch change**	% Advice change***
F = 0.18	801880	0.180	8295552	25.3	-27.6	6.5
F = 0.19	843520	0.190	8257070	24.7	-23.8	12.1
F = 0.20	884872	0.200	8218869	24.1	-20.1	17.6
F = 0.21	925939	0.210	8180947	23.6	-16.4	23.0
F = 0.22	966725	0.220	8143300	23.0	-12.7	28.4
F = 0.23	1007231	0.230	8105927	22.4	-9.1	33.8
F = 0.24	1047460	0.240	8068825	21.9	-5.4	39.2
F = 0.25	1087415	0.250	8031990	21.3	-1.8	44.5
F = 0.26	1127098	0.260	7995421	20.8	1.8	49.7
F = 0.27	1166512	0.270	7959115	20.2	5.3	55.0
F = 0.28	1205659	0.280	7923070	19.7	8.9	60.2
F = 0.29	1244542	0.290	7887282	19.1	12.4	65.3
F = 0.30	1283163	0.300	7851750	18.6	15.9	70.5
F = 0.31	1321525	0.310	7816471	18.1	19.3	75.6
F = 0.32	1359629	0.320	7781444	17.5	22.8	80.6
F = 0.33	1397479	0.330	7746664	17.0	26.2	85.7
F = 0.34	1435076	0.340	7712131	16.5	29.6	90.6
F = 0.35	1472423	0.350	7677841	16.0	32.9	95.6
F = 0.45	1832624	0.450	7347865	11.0	65.5	143.5
F = 0.50	2004100	0.500	7191261	8.6	81.0	166.2

*** SSB 2024 relative to SSB 2023.**

**** Catch 2023 relative to expected catch in 2022 (1 107 529 tonnes).**

***** Catch 2023 relative to advice for 2022 (752 736 tonnes).**

2.18 Figures

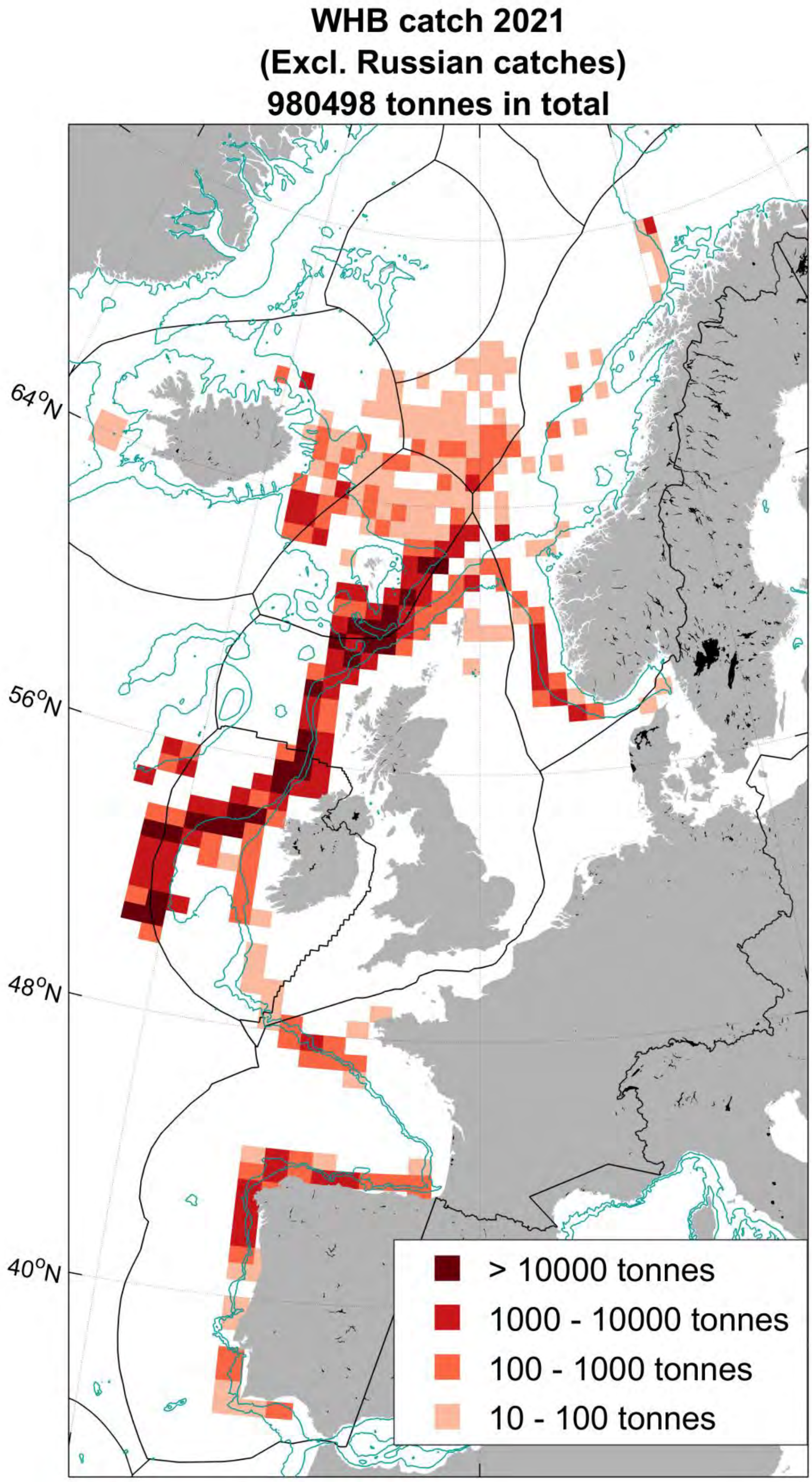


Figure 2.2.1. Blue whiting catches in 2021. Catch data from Russia are not available and the catches on the map constitute 86 % of the ICES estimated catches. The 200 m and 1000 m depth contours are indicated in blue.

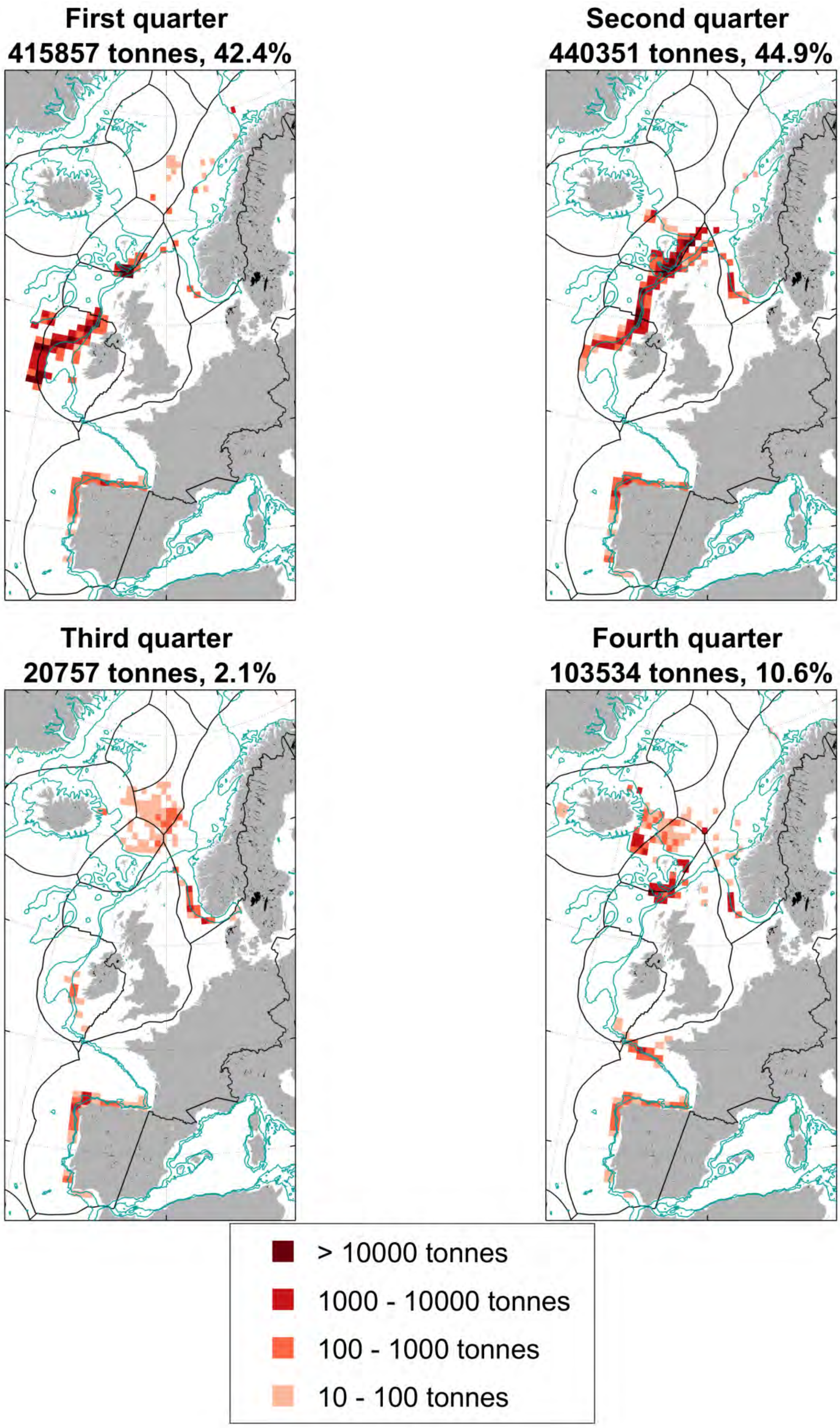


Figure 2.2.2. Blue whiting catches per quarter 2021. Catch data from Russia are not available and the catches on the maps constitute 86 % of the ICES estimated catches and thus, the total catches and percentages shown on each panel might deviate slightly from the ICES estimated catches pr. quarter. The 200 m and 1000 m depth contours are indicated in blue.

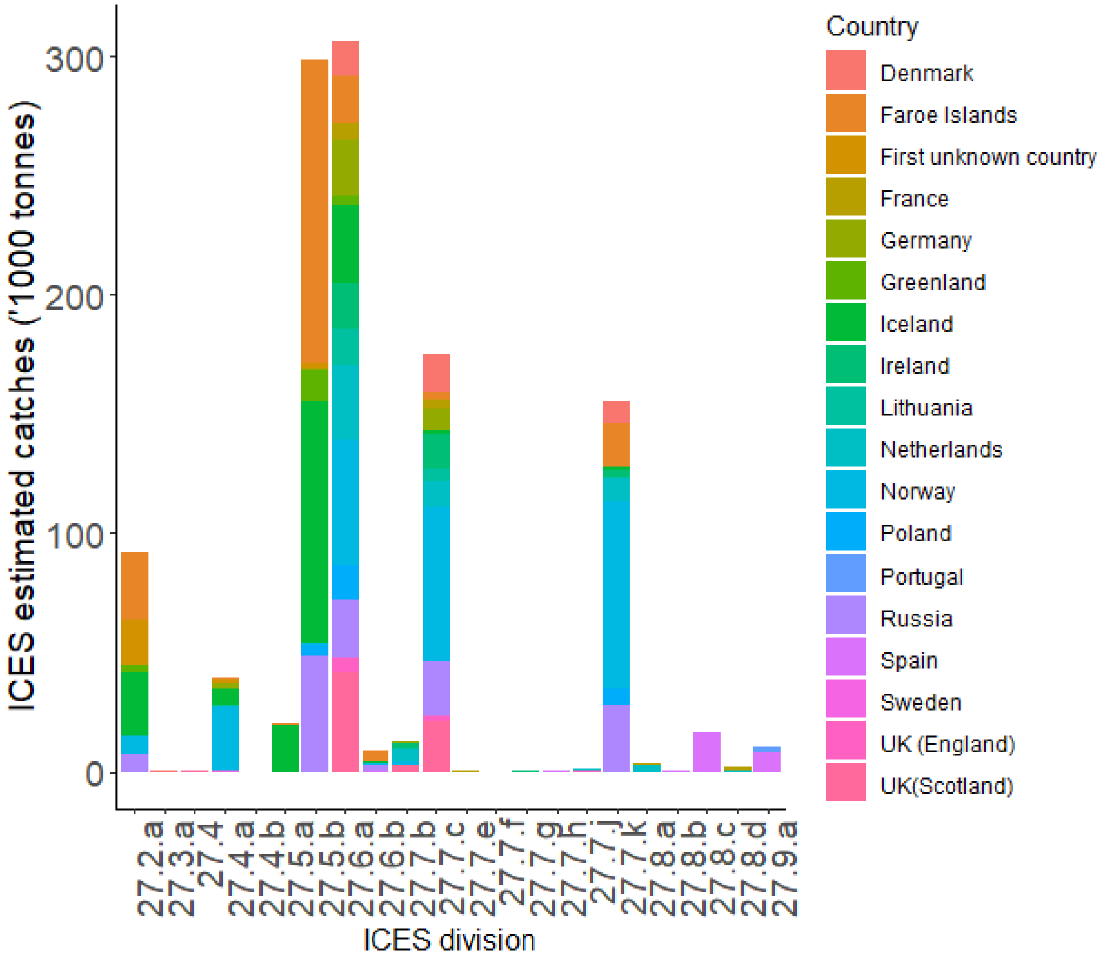
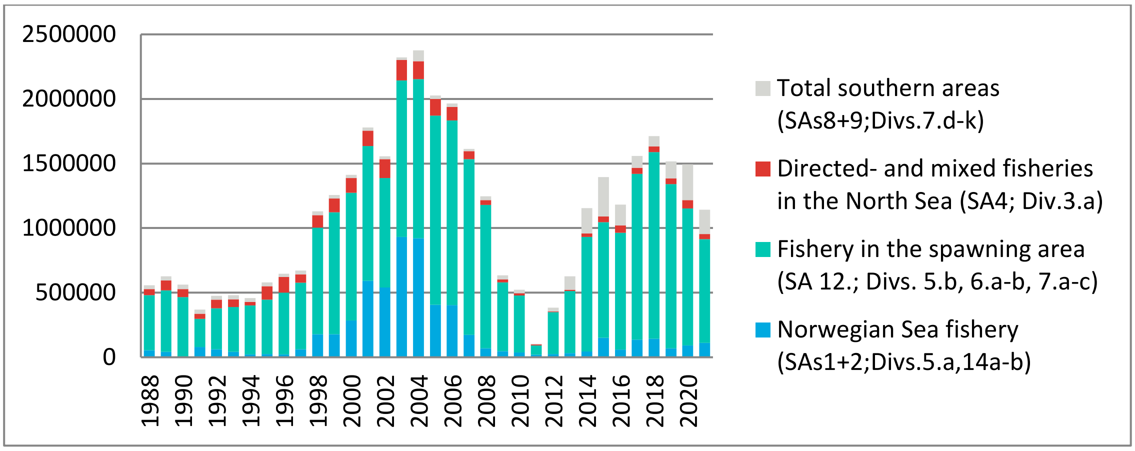


Figure 2.3.1.1. Blue whiting. ICES estimated catches ('1000 tonnes) in 2021 by ICES division and country. Note: Russia 2021 catch data is preliminary and only for quarters 1 and 2, submitted to WGWIDE 2021.

A



B

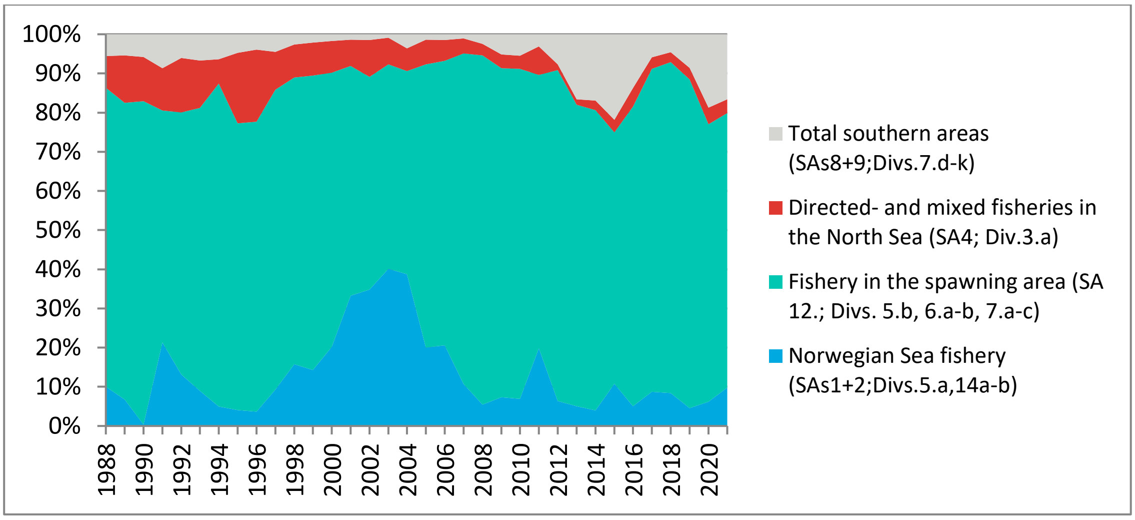


Figure 2.3.1.2. Blue whiting.(A) ICES estimated catches (tonnes) of blue whiting by fishery subareas from 1988-2021 and (B) the percentage contribution to the overall catch by fishery subarea over the same period.

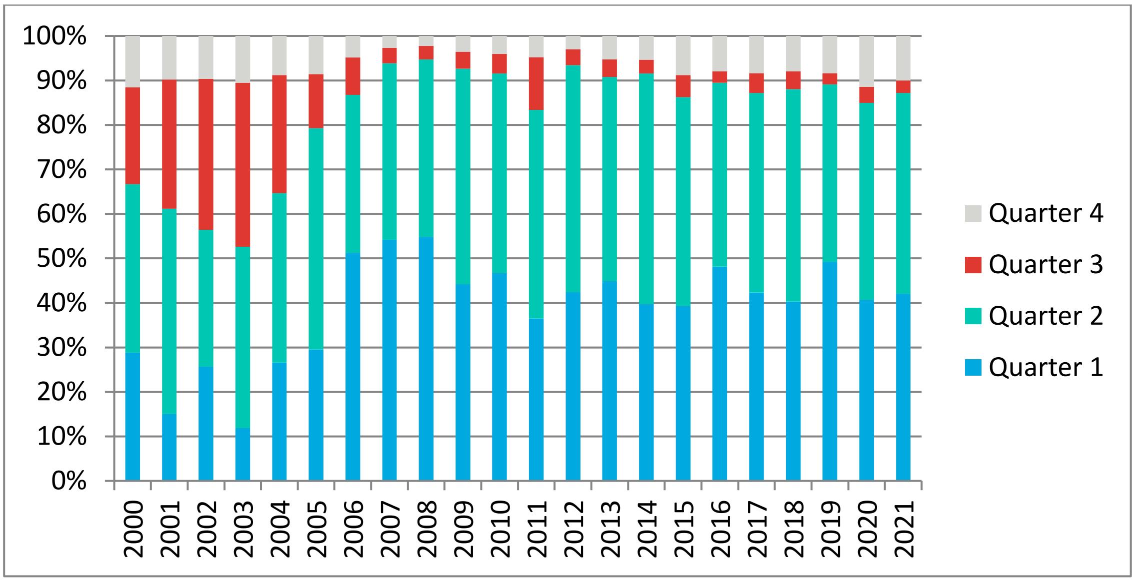


Figure 2.3.1.3. Blue whiting. Distribution of 2021 ICES estimated catches (in percentage) by quarter.

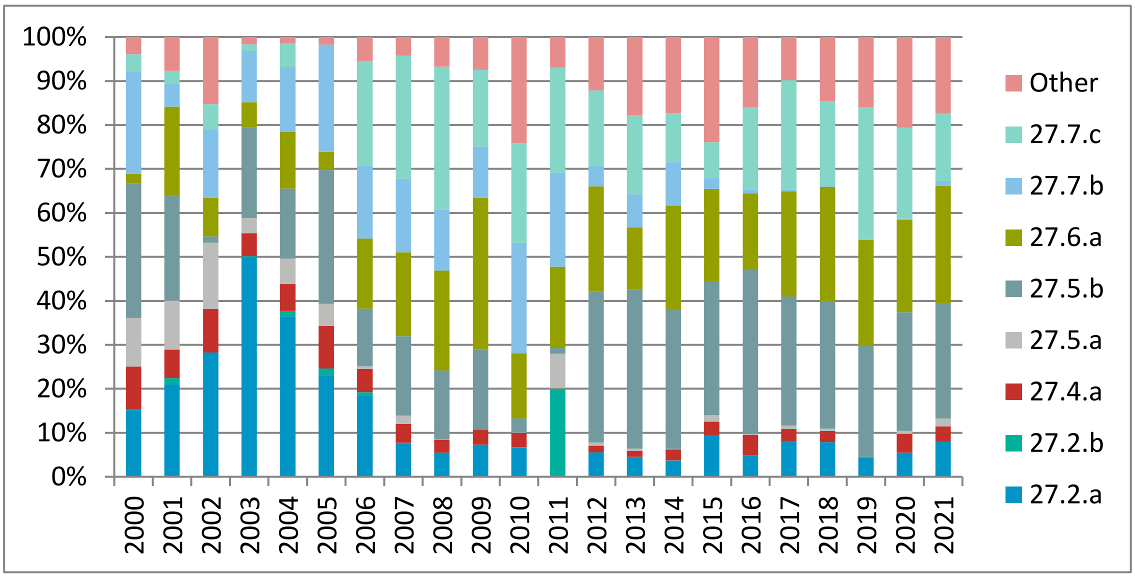


Figure 2.3.1.4. Blue whiting. Distribution of 2021 ICES estimated catches (in percentage) by ICES division area.

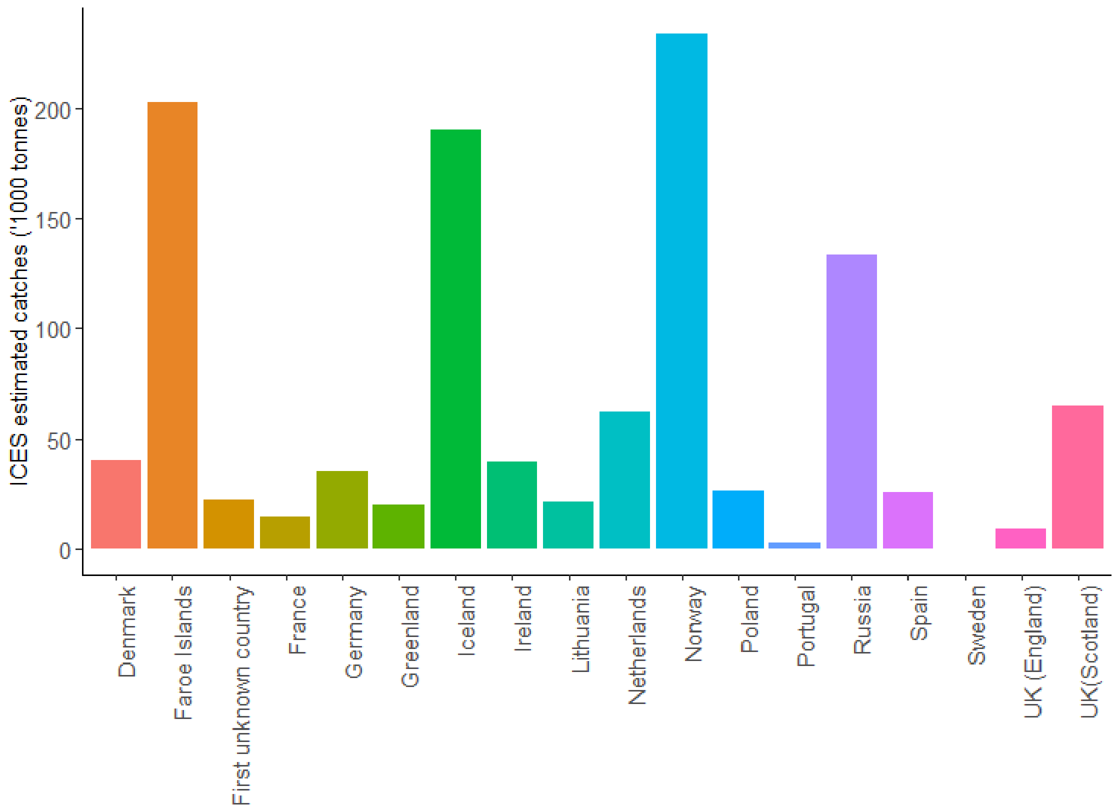


Figure 2.3.1.5. Blue whiting. ICES estimated catches ('1000 tonnes) in 2021 by country. Note: Russia 2021 catch data is preliminary and only for quarters 1 and 2, submitted to WGWIDE 2021.

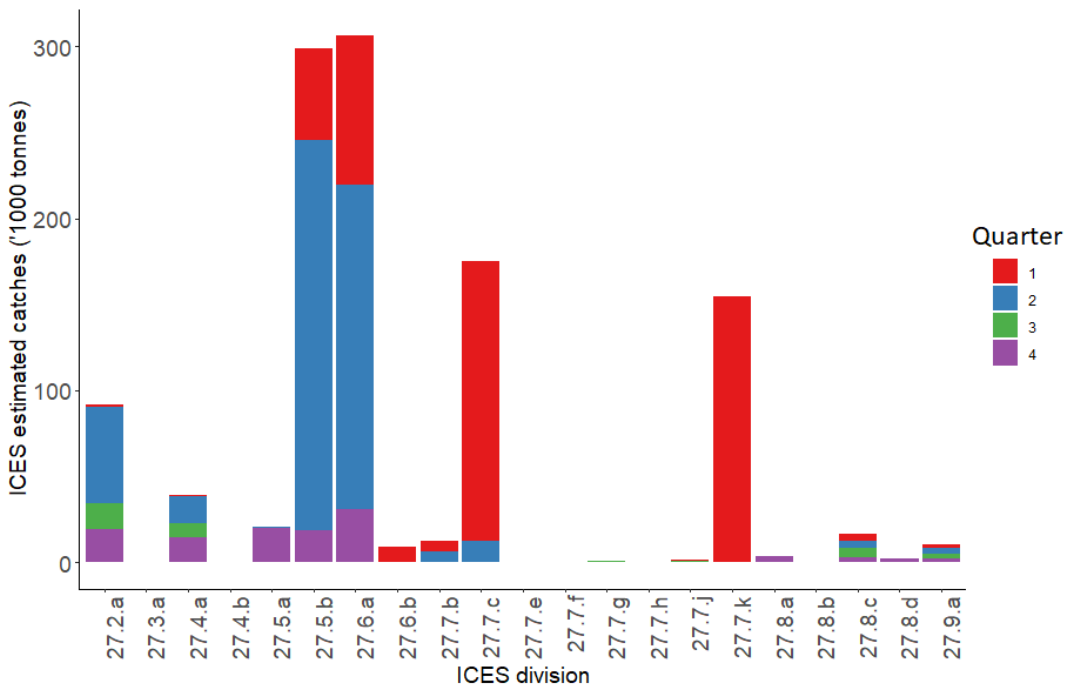


Figure 2.3.1.6. Blue whiting. Distribution of 2021 ICES estimated catches ('1000 tonnes) by ICES division and by quarter.

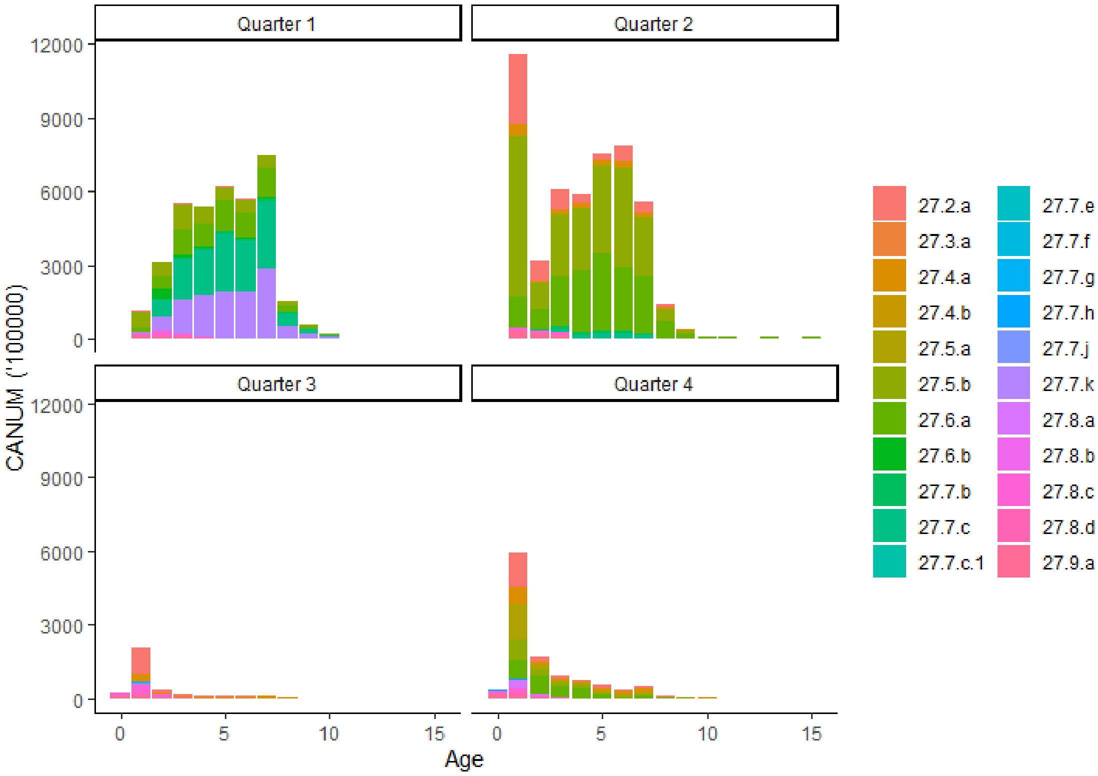


Figure 2.3.1.7. Blue whiting. Catch-at-age numbers (CANUM) distribution by quarter and ICES division for 2021.

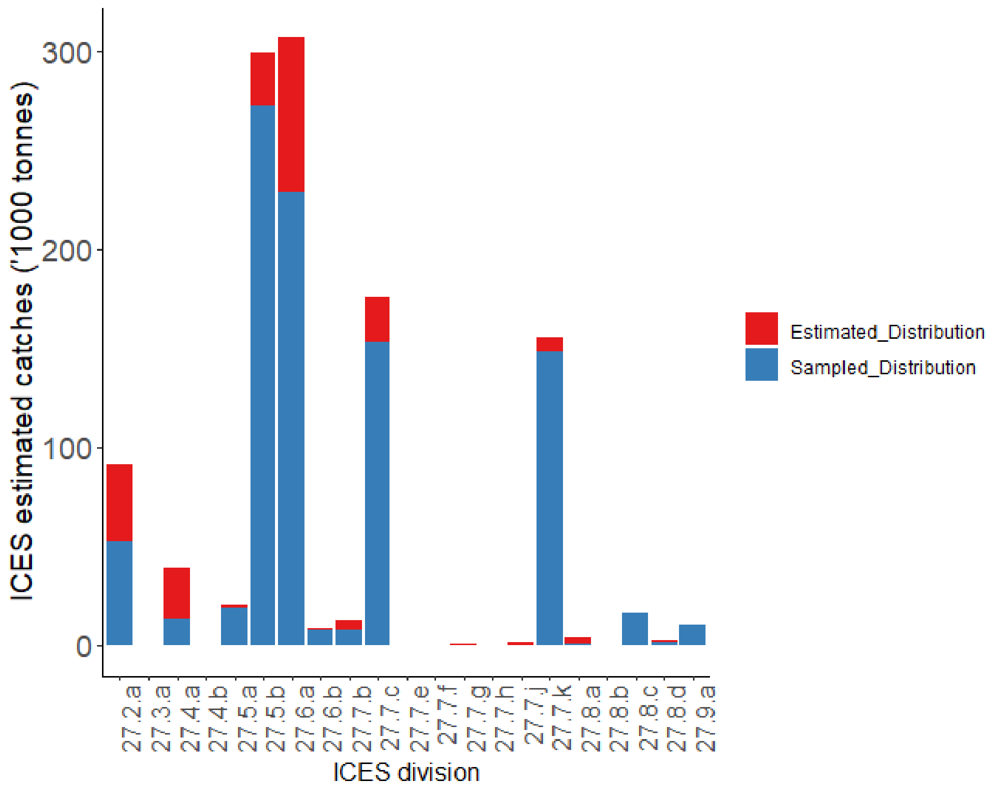


Figure 2.3.1.1.1. Blue whiting. 2021 ICES catches ('1000 tonnes) based on sampled or estimated distribution by ICES division.

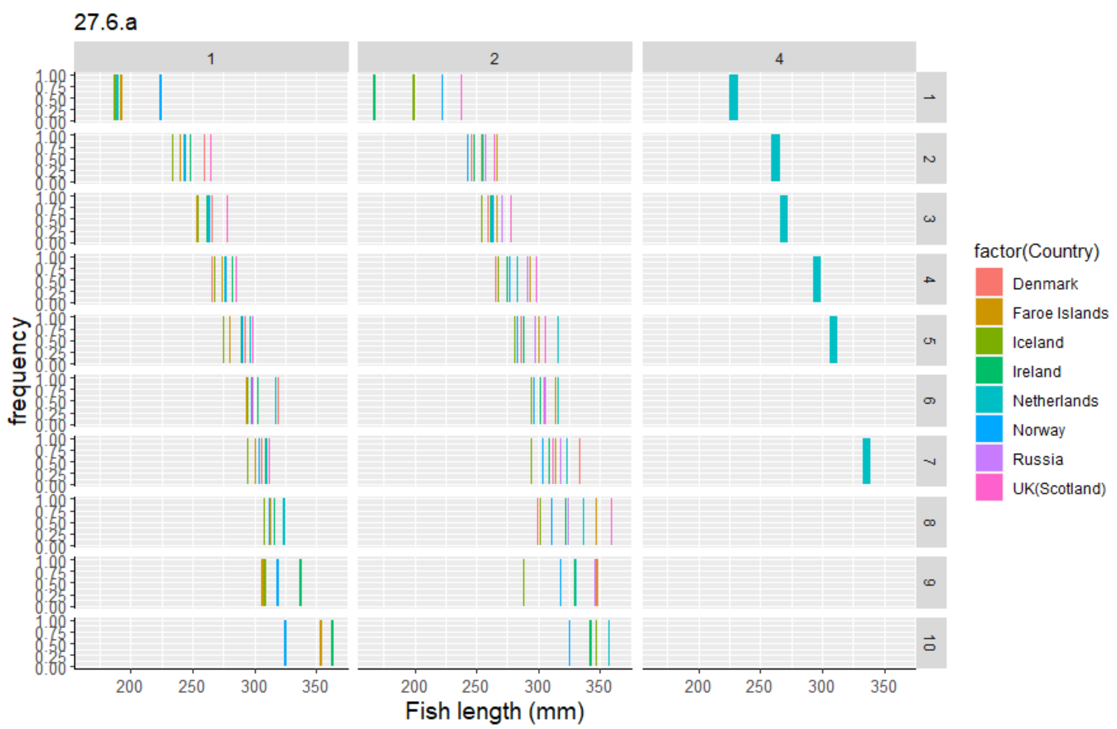


Figure 2.3.1.2.1. Blue whiting. Mean length (mm) by age (0-10 year), by quarter (1,2,4), by country for ICES division area 27.6.a. These data only comprises the 2021 ICES catch-at-age sampled estimates for ICES division 27.6.a.

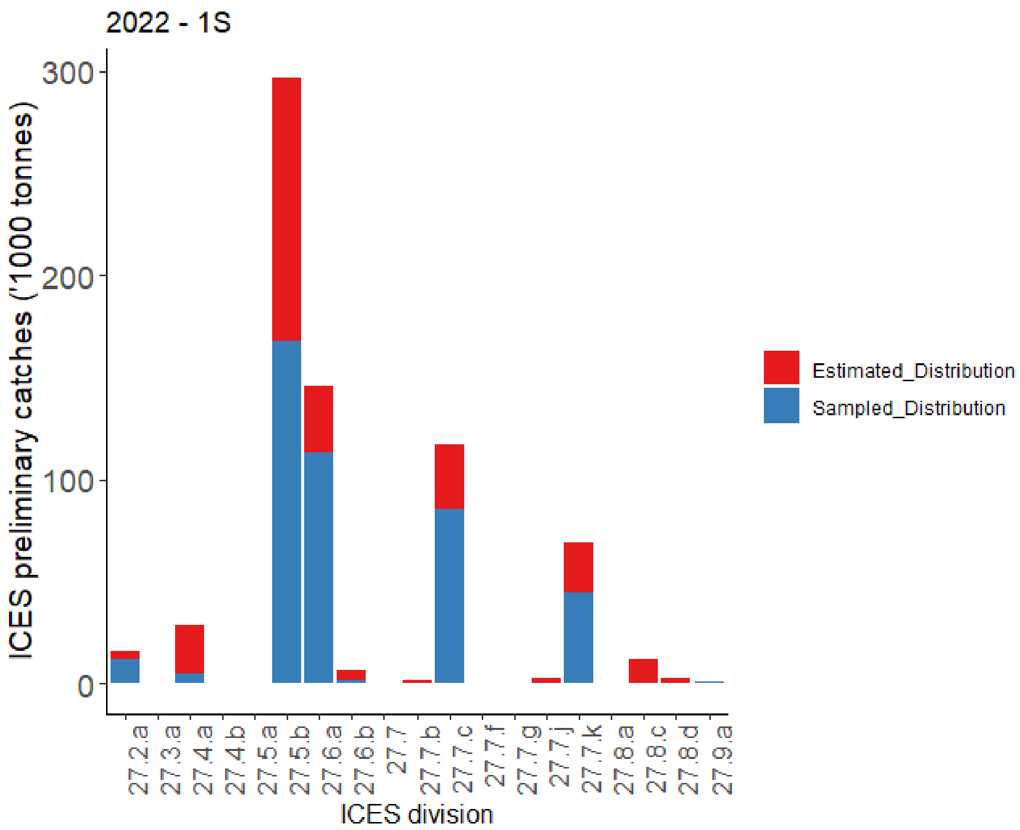


Figure 2.3.2.1. Blue whiting. 2022 ICES preliminary catches ('1000 tonnes) (Quarter 1 + Quarter 2) based on sampled or estimated distribution by ICES division.

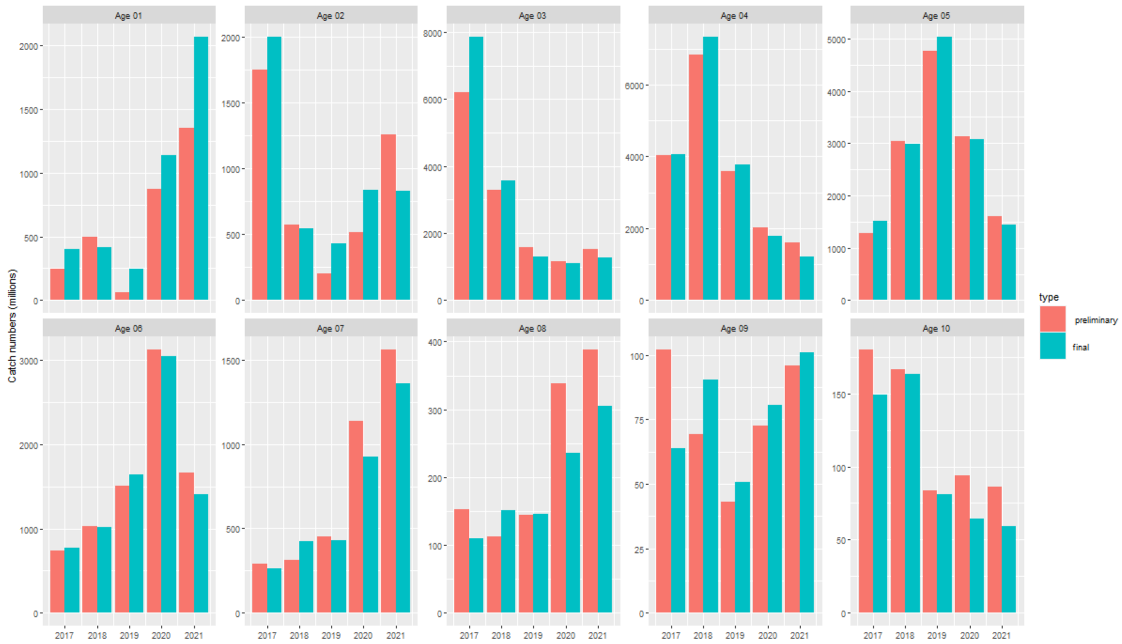


Figure 2.3.2.2 Preliminary and final estimates of catch at age number by age and year.

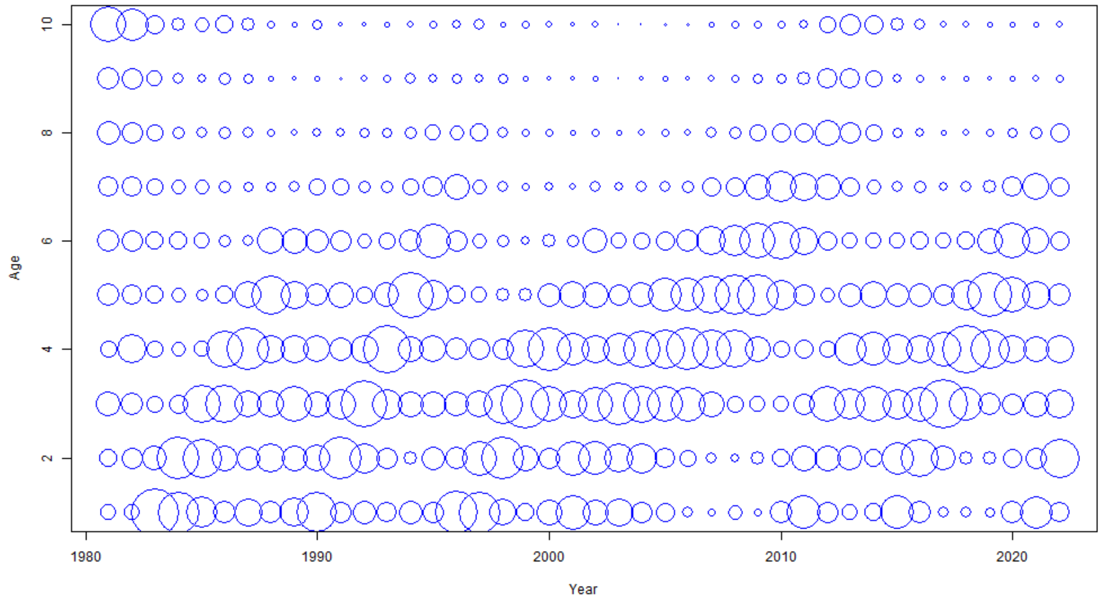


Figure 2.3.3.1. Blue whiting. Catch proportion at age, 1981-2021. Preliminary values for 2022 have been used.

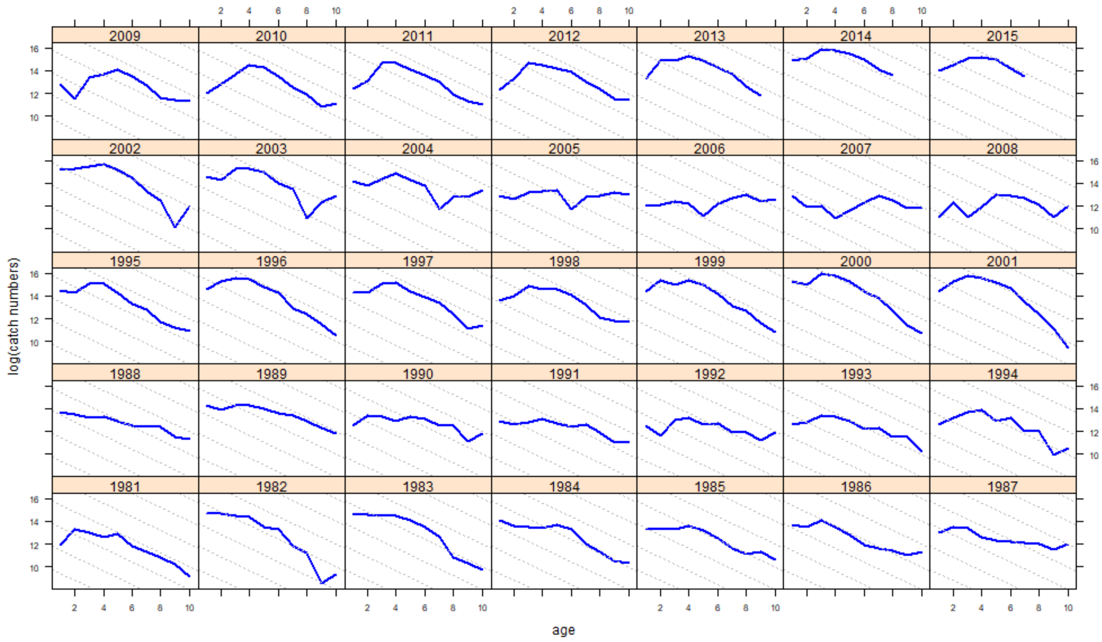


Figure 2.3.3.2. Blue whiting. Age disaggregated catch (numbers) plotted on log scale. The labels for each panel indicate year classes. The grey dotted lines correspond to *Z*=0.6. Preliminary catch-at-age data for 2022 have been used.

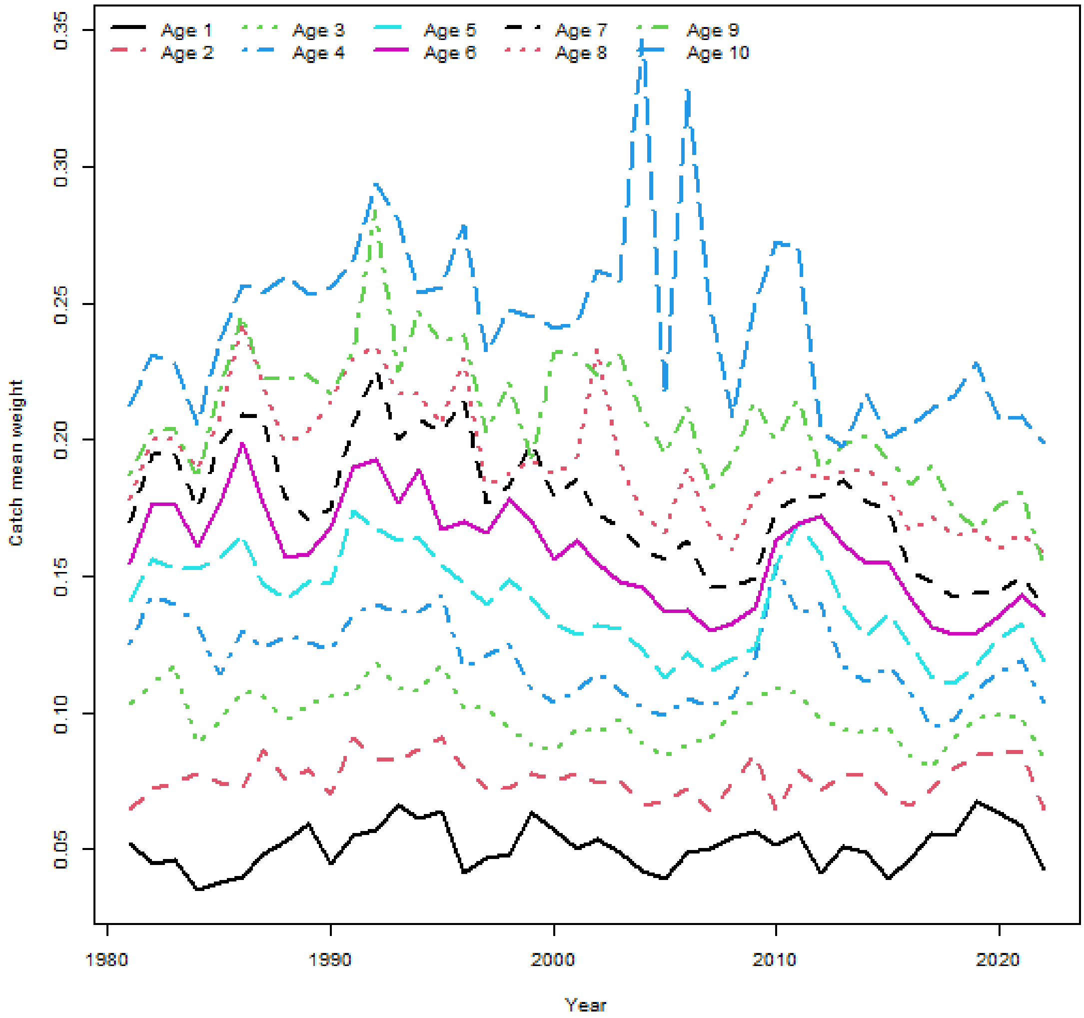


Figure 2.3.4.1. Blue whiting. Mean catch (and stock) weight (kg) at age by year. Preliminary values for 2022 have been used

A **B**

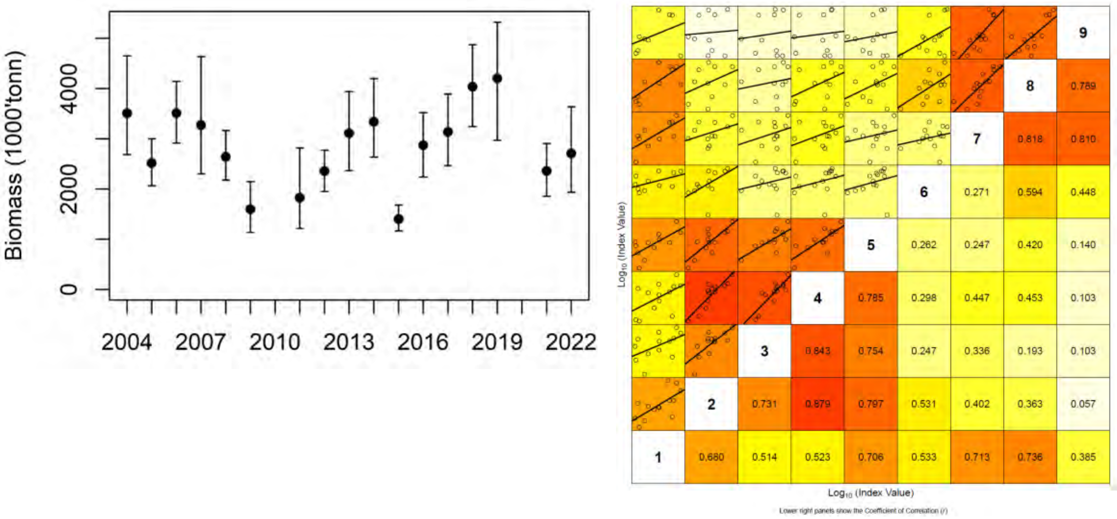
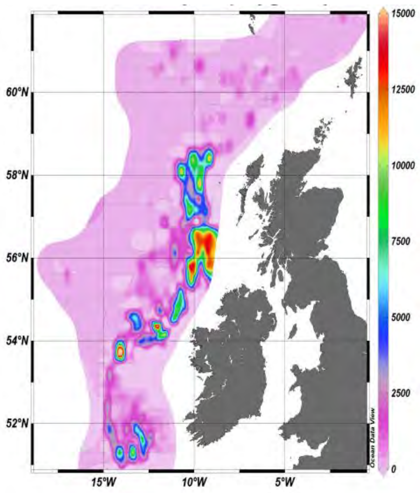
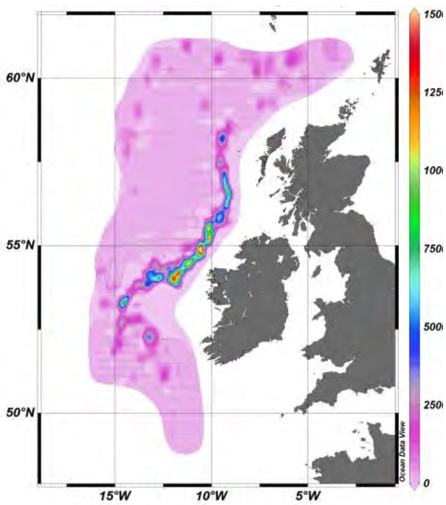


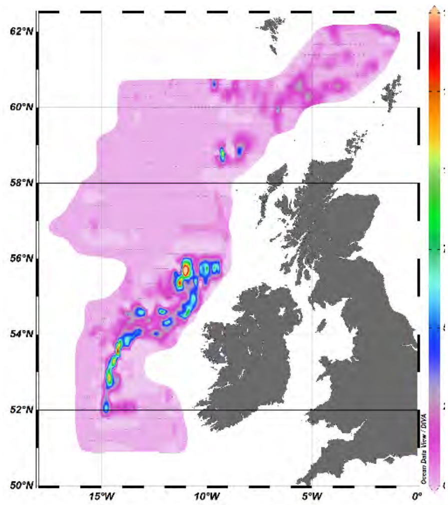
Figure 2.3.7.1.1. Blue whiting. (A) Estimate of total biomass from the International blue whiting spawning stock survey. The black dots and error bands are StoX estimates with 90 % confidence intervals. (B) Internal consistency within the International blue whiting spawning stock survey. The upper left 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

2019 **2020**





2021 **2022**

Figure 2.3.7.1.2. Blue whiting. Distribution of the blue whiting stock in the area to the west of the British Isles, spring 2019 (upper panel) to 2022 (lower panel).

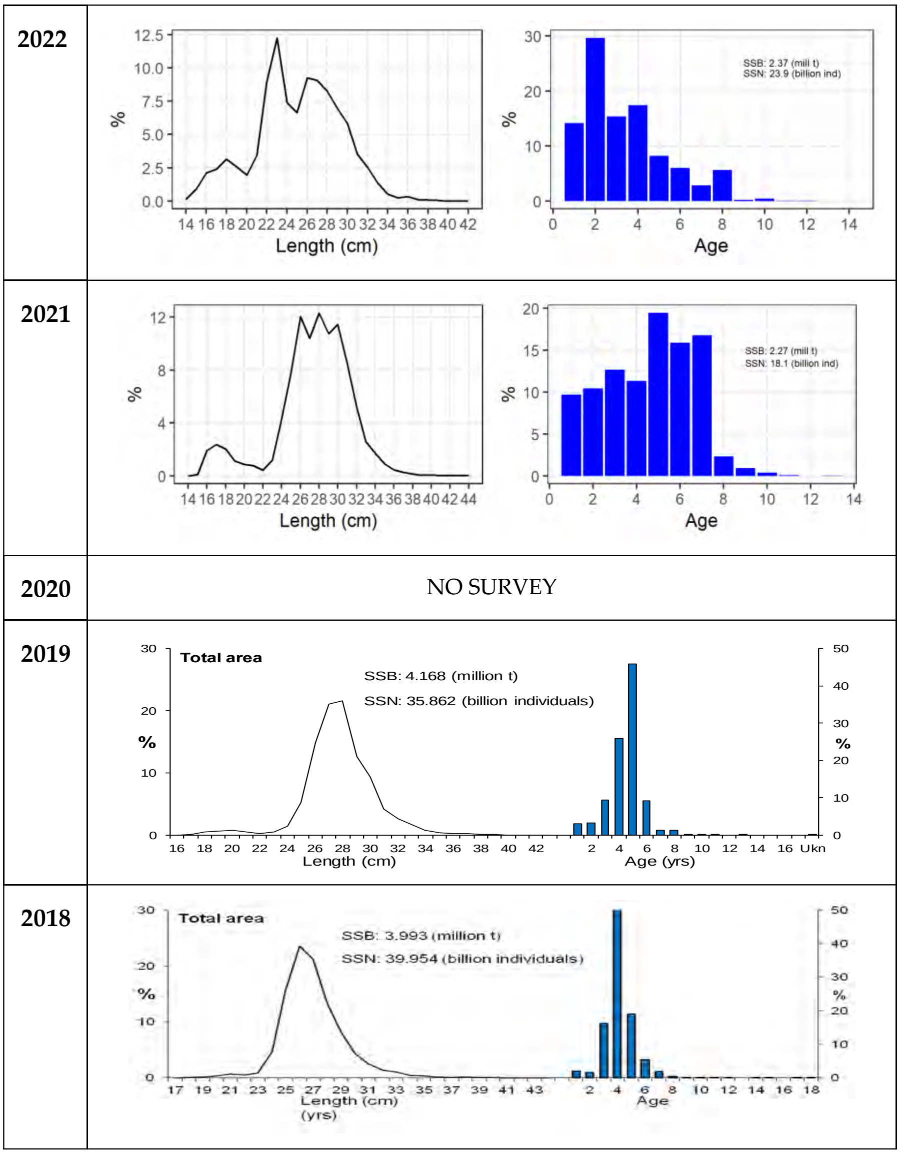


Figure 2.3.7.1.3. Blue whiting. Length (line) and age (bars) distribution of the blue whiting stock in the area to the west of the British Isles, spring 2018 (lower panel) to 2022 (upper panel). Spawning-stock biomass and numbers are given.

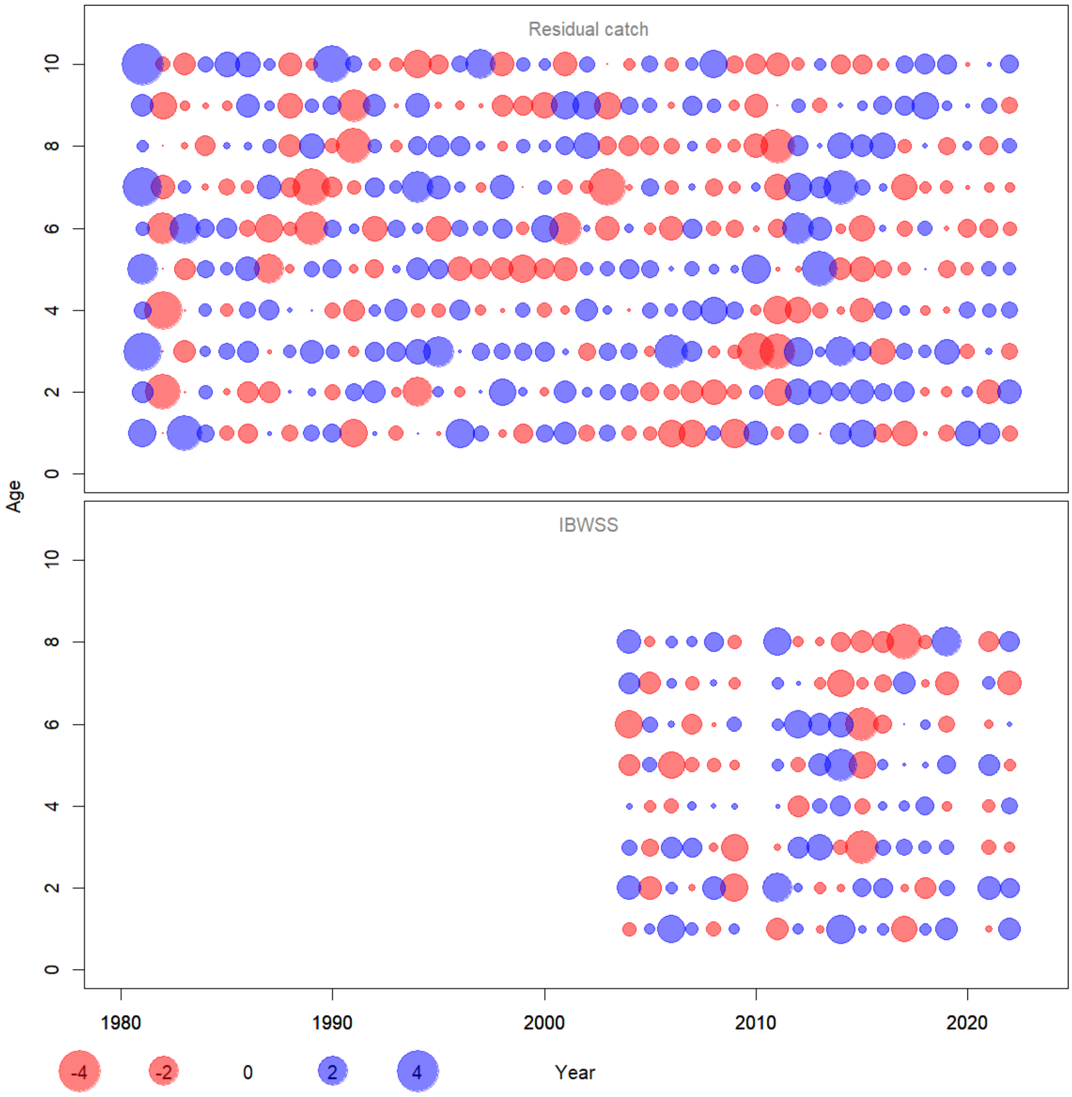


Figure 2.4.1.1. Blue Whiting. OSA (One Step Ahead) residuals (see Berg and Nielsen, 2016) from catch-at-age and the IBWSS survey 2004-2022 (no survey in 2020). Red (lighter) bubbles show that the observed value is less than the expected value. Preliminary catch data for 2022 have been used.

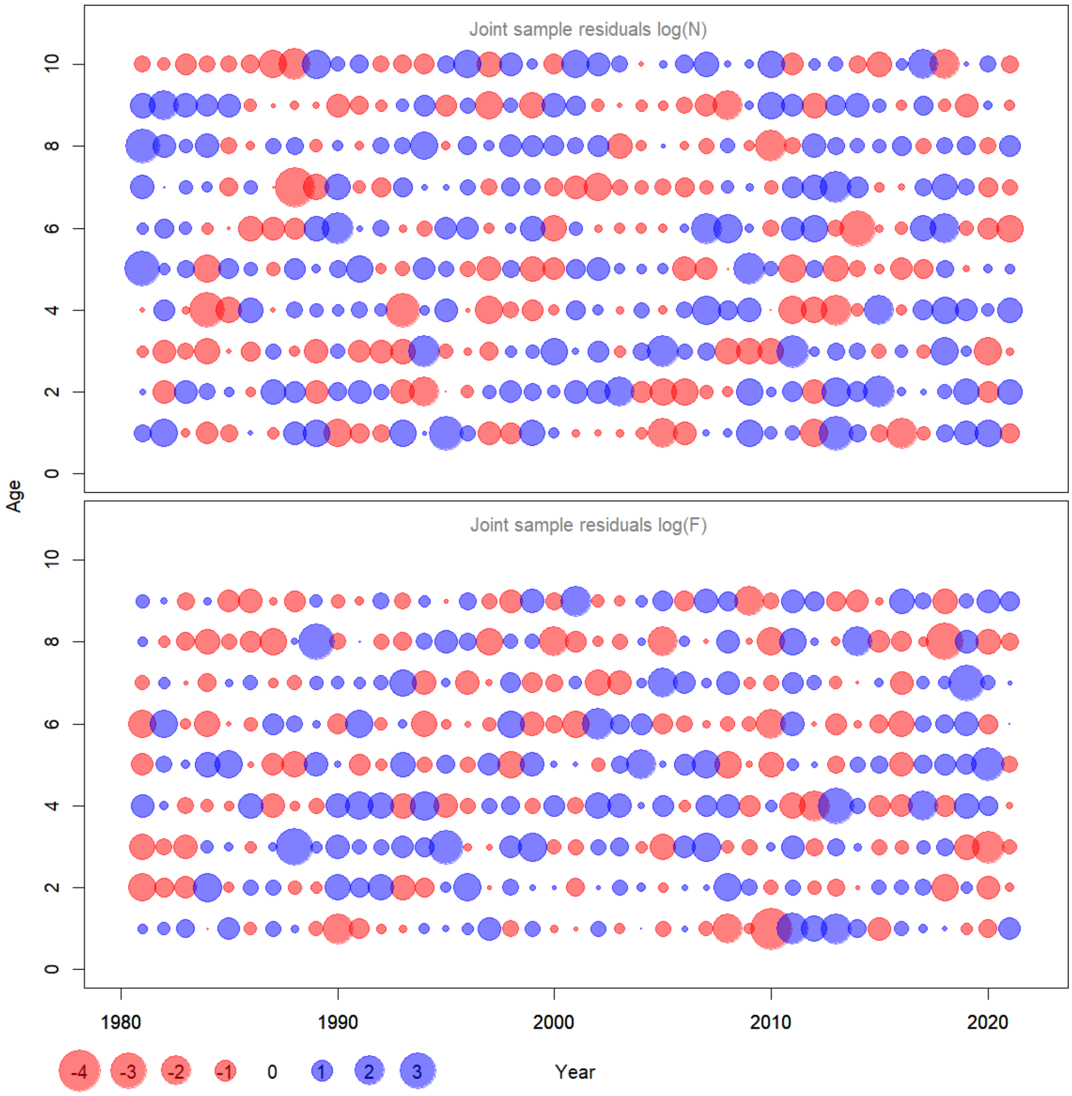


Figure 2.4.1.2 Blue whiting. Joint sample residuals (Process errors) for stock number and F at age. Red (lighter) bubbles show that the observed value is less than the expected value. Preliminary catch data for 2022 have been used.

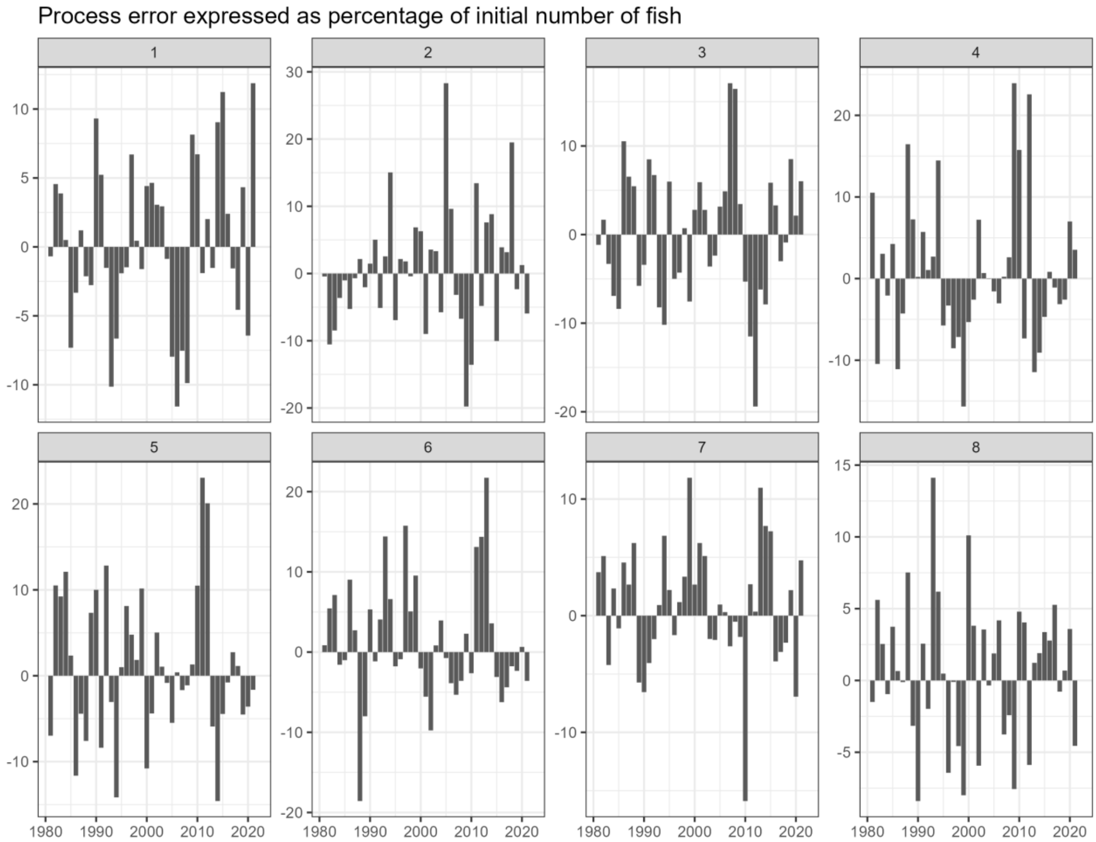


Figure 2.4.1.3. Blue whiting. Process errors expressed as deviation in instantaneous mortality at age by age and year.

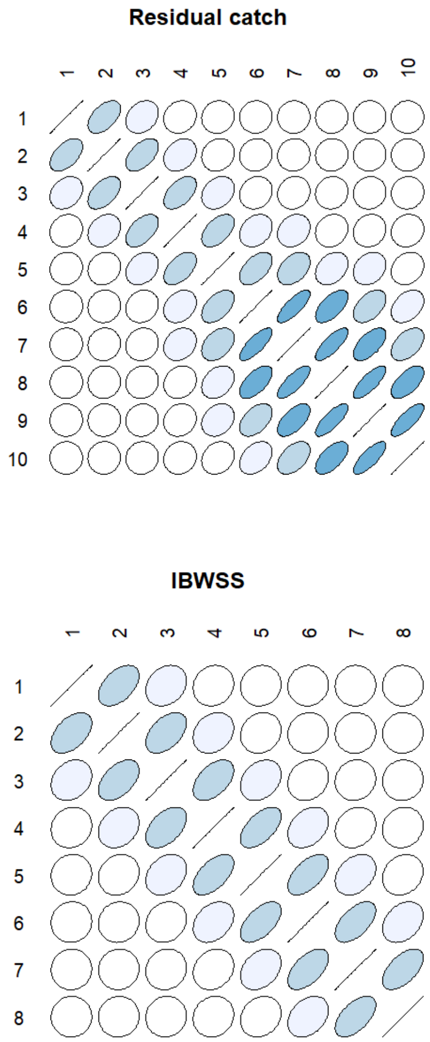


Figure 2.4.1.4. Blue whiting. The correlation matrix between ages for the catches and survey indices. Each ellipse represents the level curve of a bivariate normal distribution with the corresponding correlation. Hence, the sign of a correlation corresponds to the sign of the slope of the major ellipse axis. Increasingly darker shading is used for increasingly larger absolute correlations, while uncorrelated pairs of ages are depicted as circles with no shading. Preliminary catch data for 2022 have been used.

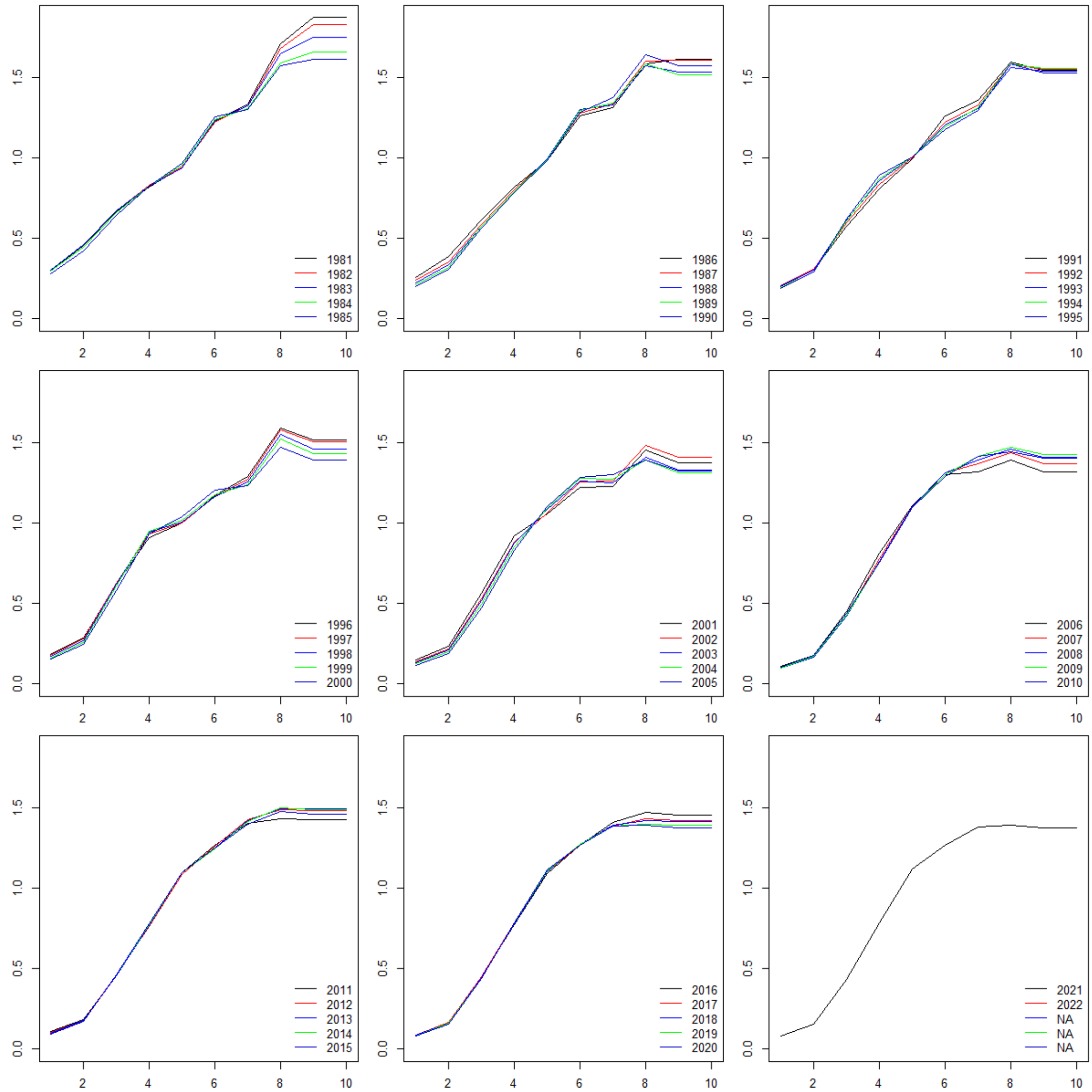


Figure 2.4.1.5. Blue whiting. Exploitation pattern by 5-years' time blocks. Preliminary catch data for 2022 have been used.

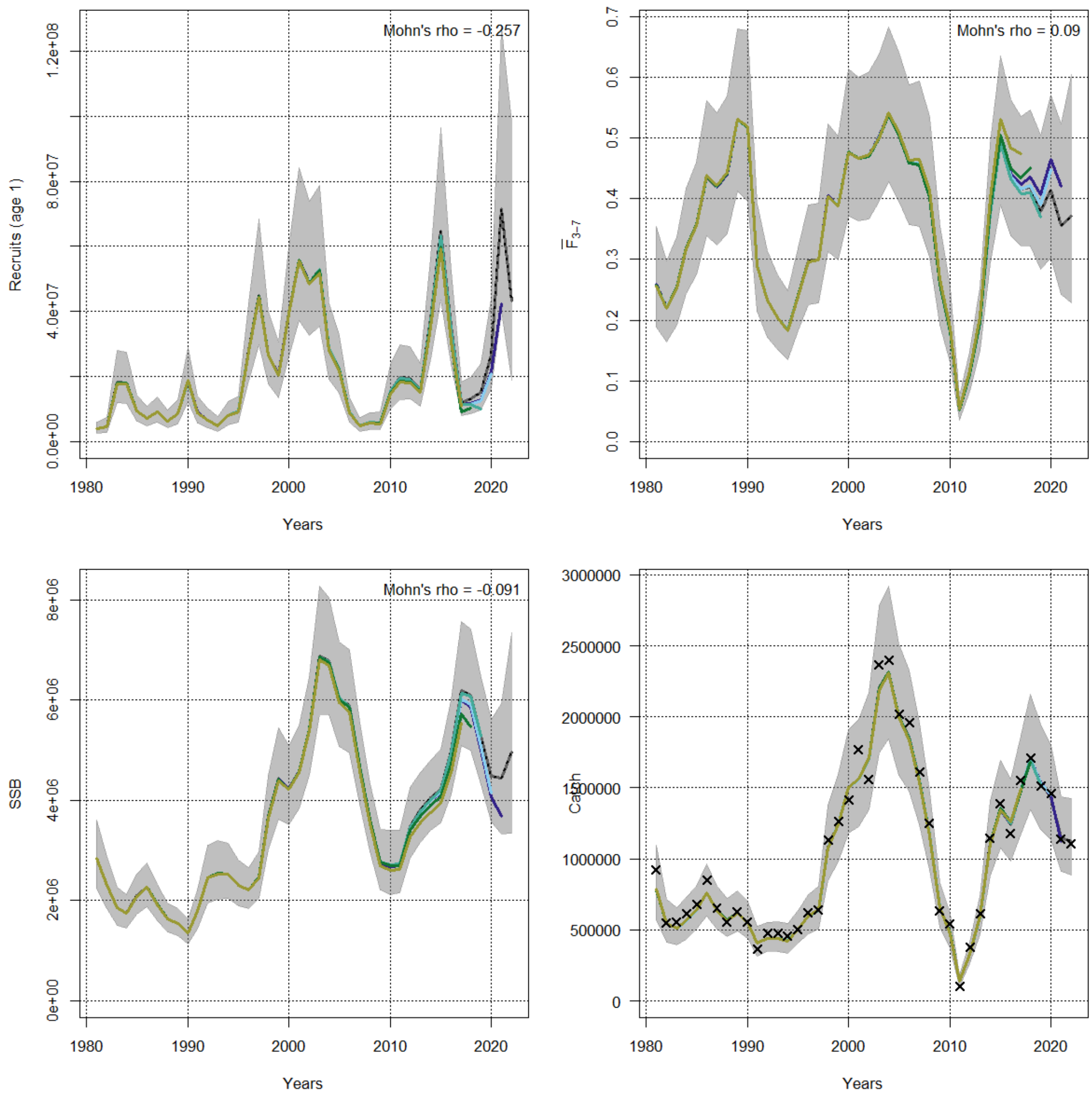


Figure 2.4.1.6. Blue whiting. Retrospective analysis of recruitment (age 1), SSB (tonnes), F and total catch using the SAM model. The 95% confidence interval is shown for the most recent assessment.

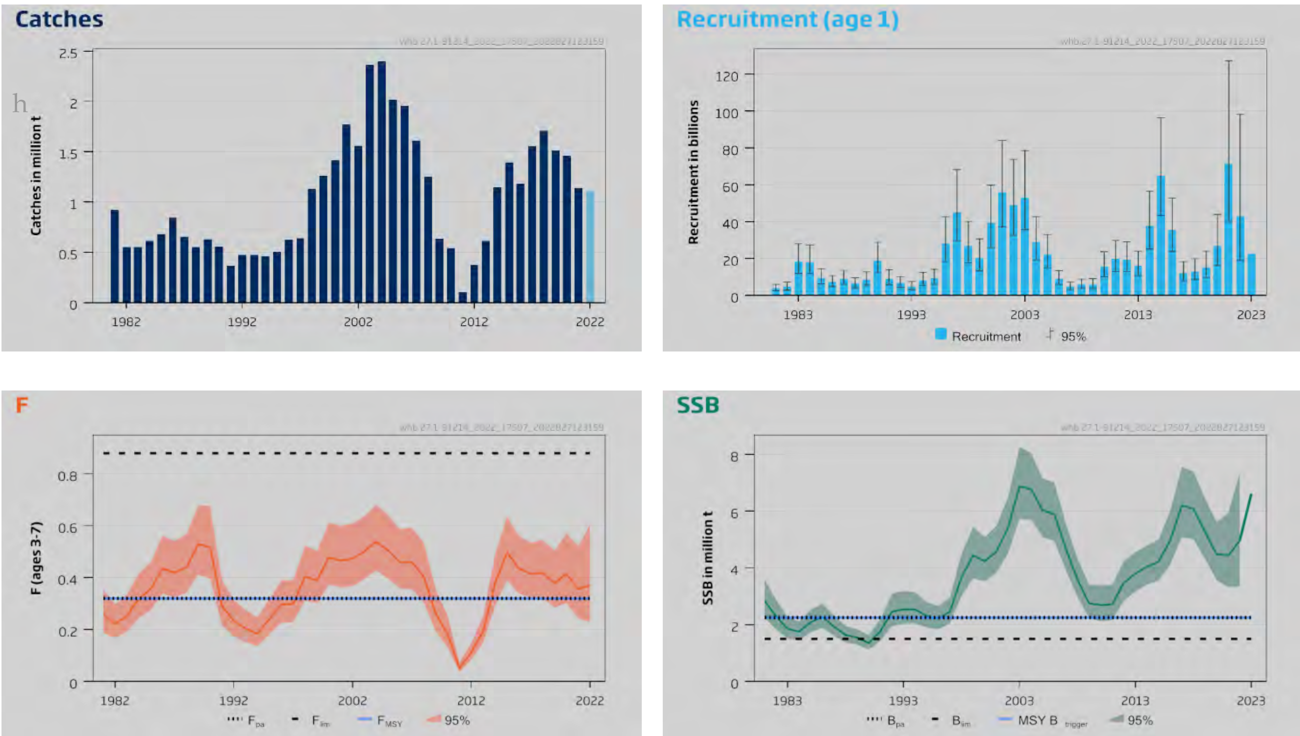


Figure 2.4.1.7. Blue whiting. SAM final run: Stock summary, total catches, recruitment (age 1), F and SSB. The graphs show the median value and the 95% confidence interval. Catches for 2022 are preliminary.

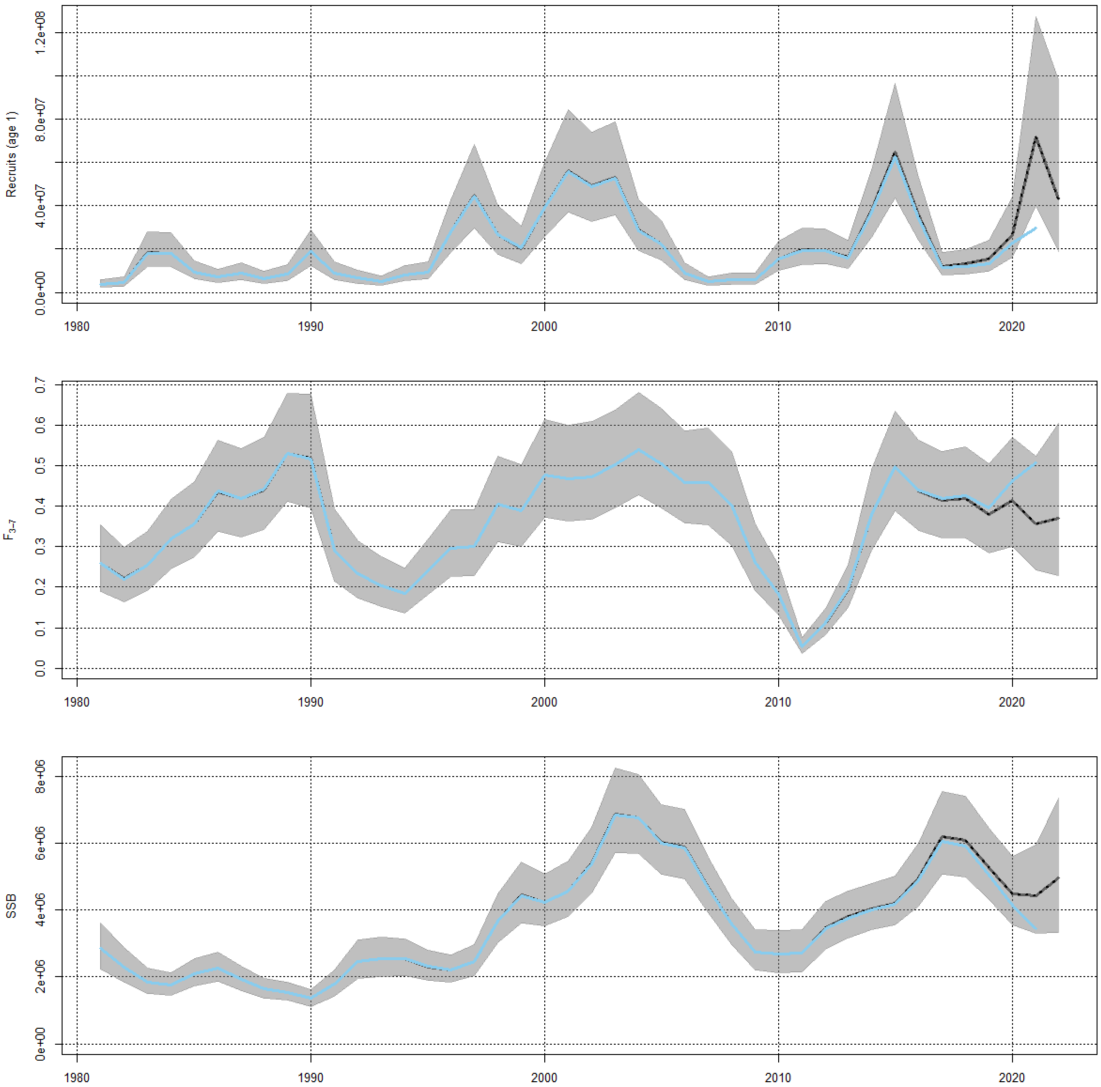


Figure 2.4.1.8. Blue whiting. SAM final run: Comparison of the 2021 and 2022 stock assessments, shown with 95% confidence intervals. Catches for 2022 are preliminary.

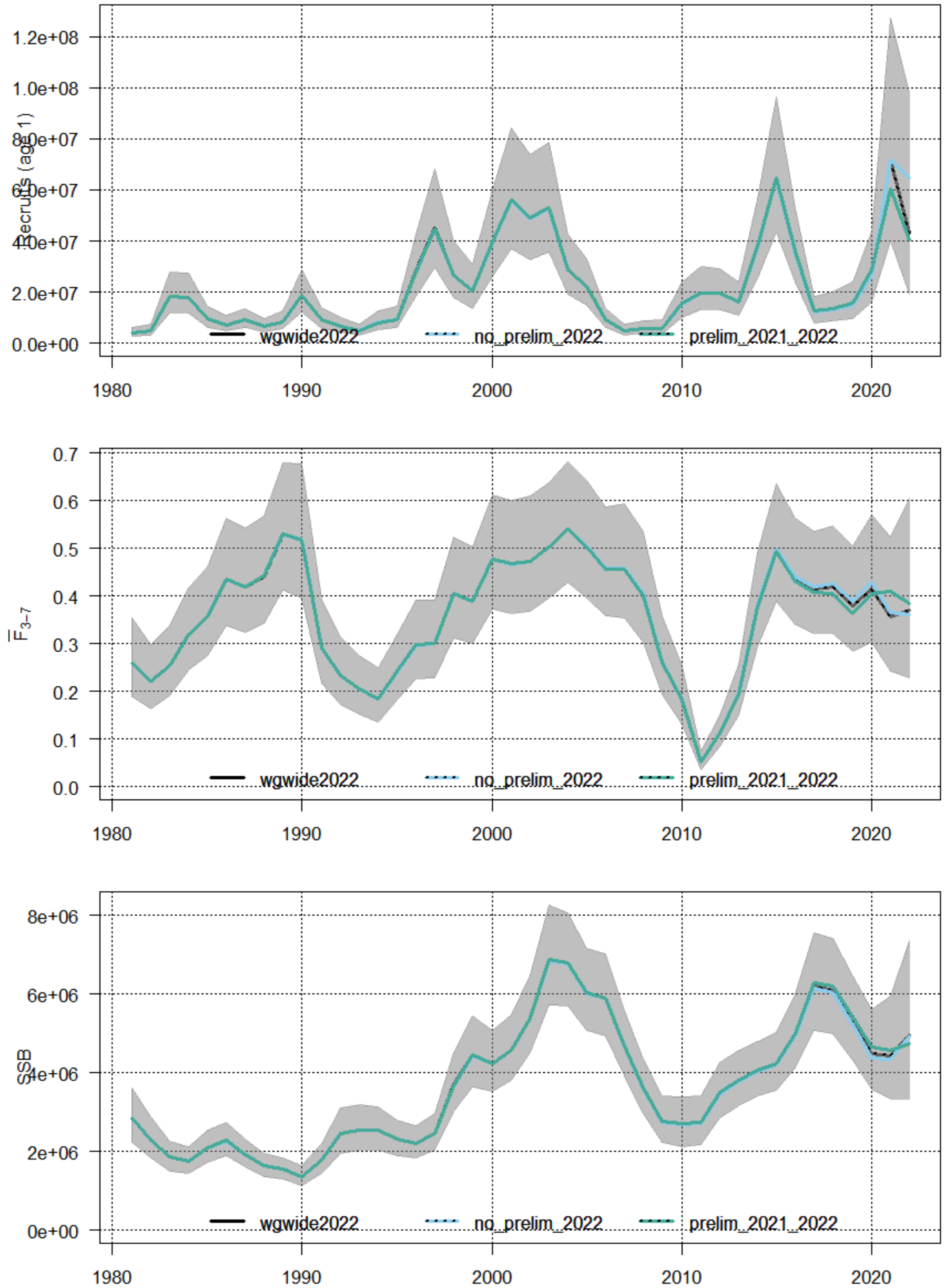


Figure 2.4.1.9. Blue whiting. Comparison of assessment runs with the default configuration (wgwide2020: final 2021 data and preliminary 2022 catch data), a run with no catch information for 2022 ("no_prelim_2022") and a run with preliminary catch data for both 2021 and 2022 ("prelim_2020_2022").

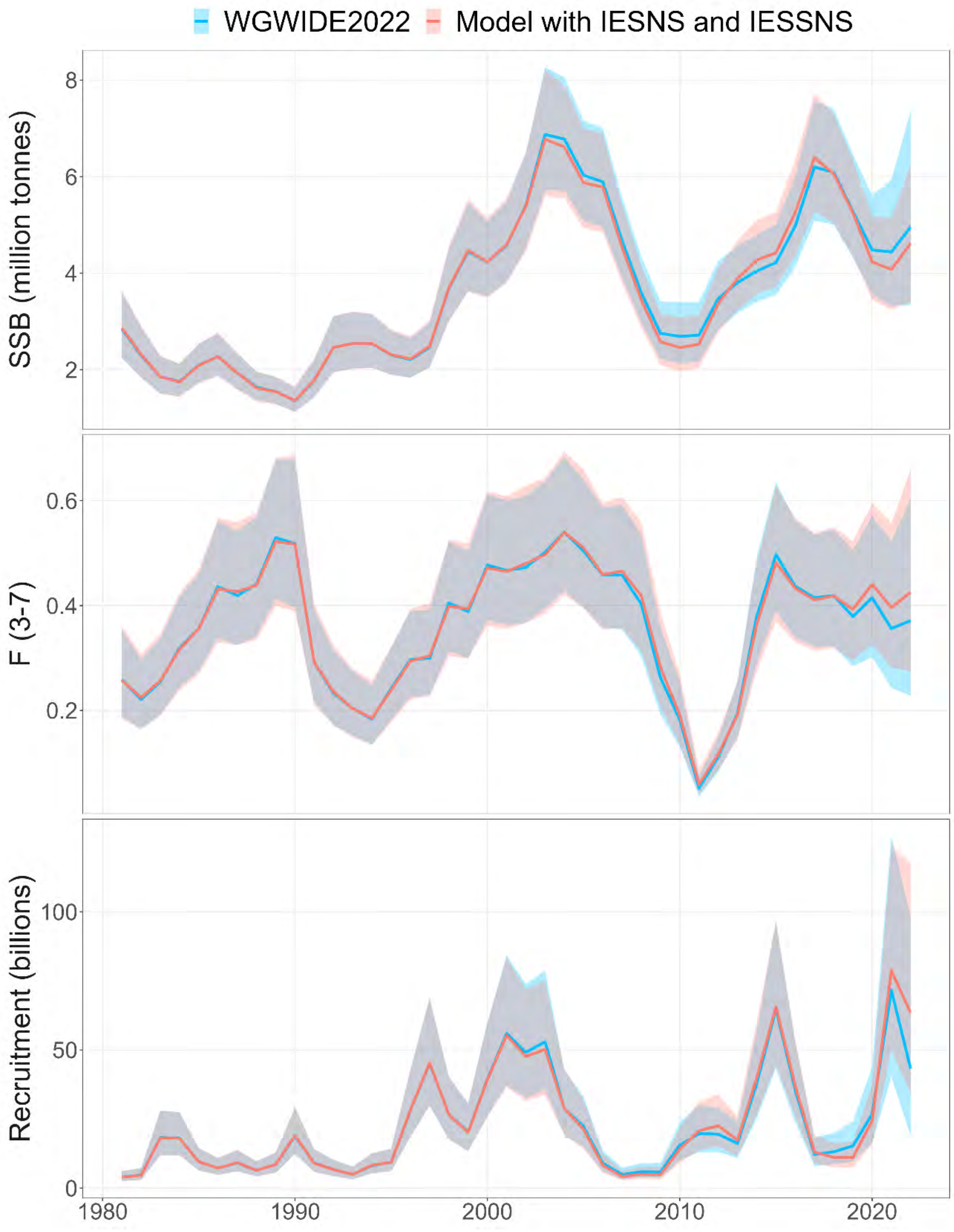


Figure 2.4.2.1. Blue whiting. Comparison of SSB, F and recruitment estimated by the final WGWIDE 2022 SAM model and an alternative version including the two surveys IESNS and IESSNS. Catch values for 2022 are preliminary.

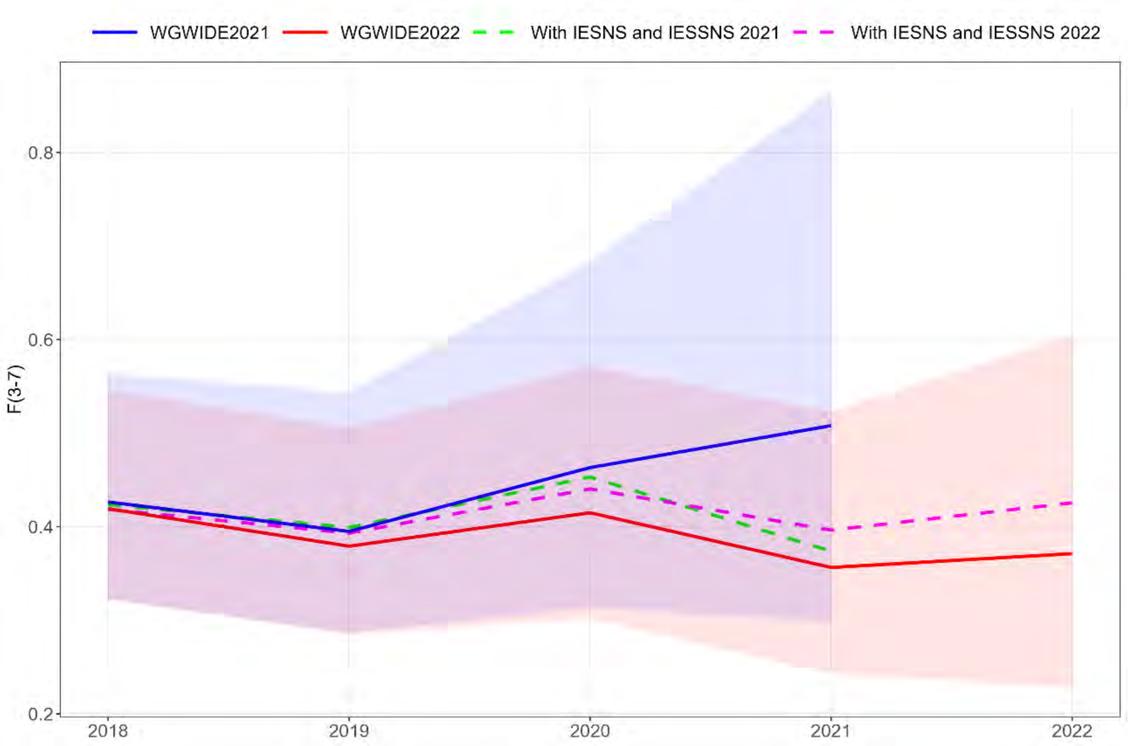


Figure 2.4.2.2. Blue whiting. Historical retrospective F estimated by the final WGWIDE SAM model and the alternative version including the two surveys IESNS and IESSNS for 2021 and 2022 showing only the last 5 years. Catch values for both years and assessments are preliminary. The confidence intervals are from the respective final WGWIDE assessments.

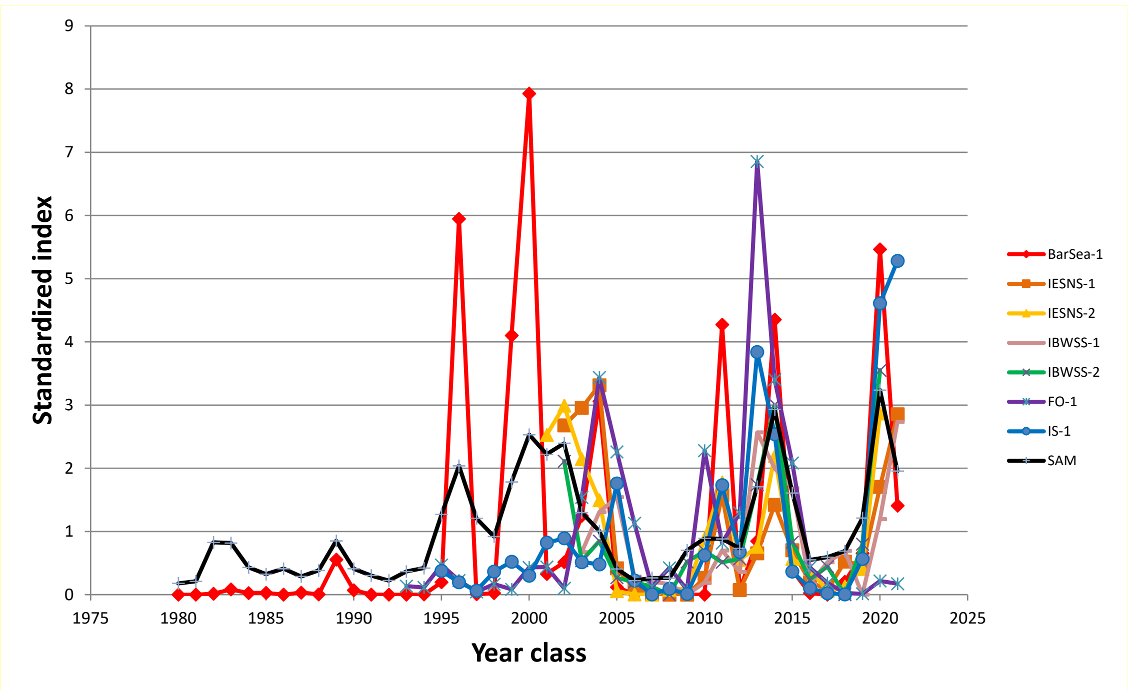


Figure 2.8.1.1. Blue whiting young fish indices from five different surveys and recruitment index from the assessment, standardized by dividing each series by their mean. BarSea - Norwegian bottom-trawl survey in the Barents Sea, IESNS: International Ecosystem Survey in the Nordic Seas in May (1 and 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.

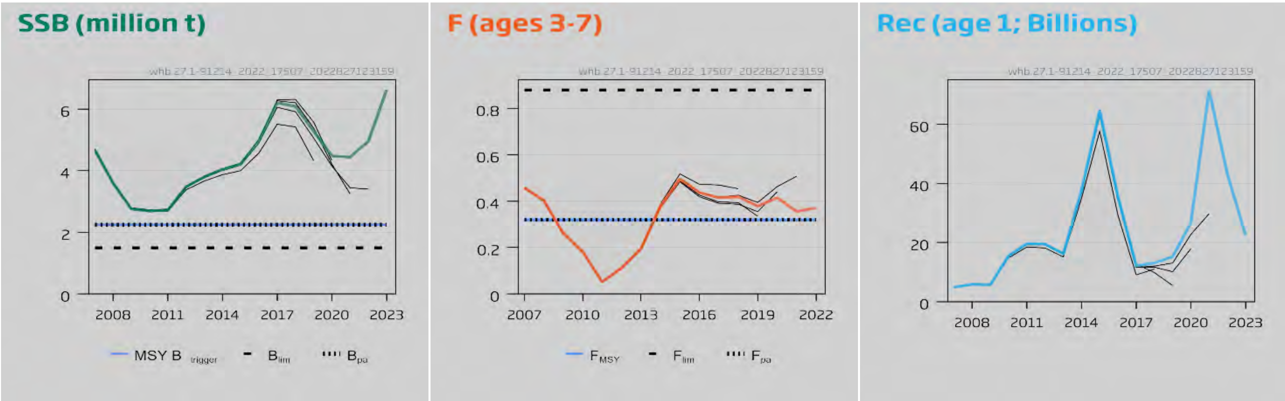


Figure 2.9.1. Blue whiting. Comparison of the 2018 - 2022 assessments (historical retrospective).

3 Northeast Atlantic boarfish (*Capros aper*)

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

Boarfish is targeted in a pelagic trawl fishery for fish meal, to the 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.

An analysis of bottom trawl survey data suggests a continuity of distribution spanning ICES Subareas 27.4, 6, 7, 8 and 9 (Figure 3.1). Isolated occurrences appear in the North Sea (ICES Subarea 27.4) in some years indicating spill-over into this region. A hiatus in distribution was suggested between ICES Divisions 27.8.c and 9.a as boarfish were considered very rare in northern Portuguese waters but abundant further south (Cardador & Chaves 2010). Results from a dedicated genetic study on the stock structure of boarfish within the Northeast Atlantic and Mediterranean Sea suggests that this hiatus represents a true stock separation (Farrell *et al.* (2016); see section 3.12). Based on these data, a single stock is considered to exist in ICES Subareas 27.4, 6, 7, 8 and the northern part of 9.a. This distribution is slightly broader than the current EC TAC area (27.6, 7 and 8) and for the purposes of assessment in 2022 only data from these areas were utilized.

3.1 The fishery

3.1.1 Advice and management applicable from 2011 to 2021

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

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

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

For 2014, ICES advised that, based on 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 is taken into account. For 2014 the TAC was set at 133 957 t by the Council of the European Union. This advice was based on a Schaefer state space surplus production model (see section 3.6.3 for further details).

In 2014 there was concern about the use of the production model (see stock annex). ICES considered that the model was no longer suitable for providing category 1 advice and further model development was required. The model was still considered suitable for category 3 advice. The advised catch for 2015 of 53 296 t was based on the data limited stock HCR and an index calculated (method 3.1; ICES, 2012) using the total stock biomass trends from the model.

For 2016 and 2017 ICES advised based on the precautionary approach that catches should be no more than 42 637 t and 27 288 t respectively. In 2017, 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 stable and at a low level. In 2019, advice of 19 152 t was issued for each of 2020 and 2021, once again on the basis of the precautionary approach. In 2021, with indications of an increase in recruitment, 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

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

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.

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.

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

3.1.2 The fishery in recent years

In 2017 a total of 17 388 t of boarfish were caught. Ireland was the main participant landing 15 484 t although landings were almost 20% below the 18 858 t quota. Denmark landed only 548 t, (less than 10% of its national quota of 6 696 t). UK reported almost zero boarfish landings. Total reported discards accounted for 1 173 t. Approximately 90% of the Irish landings were taken in ICES divisions-7.h and 8.a (Tables 3.1.2.5 and 3.1.2.7). 35 Irish registered fishing vessels reported catches with almost entirely from in Q1 (8 570 t) and Q4 (6 270 t).

In 2018 a total of 11 286 t of boarfish were caught. This represented 55% of the 2018 quota of 20 380 t. Ireland continued to be the main participant landing 9 513 t (68% of its national quota). The Irish catch represented 85% of the total boarfish catch in 2018. Other countries reporting boarfish in 2018 were Denmark (94 t), The Netherlands (172 t), Spain (148t), UK England (0.085 t) and UK Scotland (0.229 t). Discards accounted for 1 359 t. Tables 3.1.2.5 and 3.1.2.7 show that 82% of the Irish landings were taken in ICES divisions 7.h and 8.a.

A total of 11 312 t of boarfish was caught in 2019. This represents 52% of the 2019 quota of 21 830 t. 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. Tables 3.1.2.5 and 3.1.2.7 shows that about 87% of Irish landings were taken in ICES divisions 7.h and 8.a.

In 2020, the total catch was 15 649 t which represented 82% of the quota (19 152 t). Ireland was the main participant 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 3.1.2.4 and 3.1.2.5).

3.1.3 The fishery in 2021

In 2021, 17 693 t of boarfish was caught, representing 92% of the total allowable catch (19 152 t) for the year (Table 3.1.2.1). 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.

3.1.4 Regulations and their effects

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

3.1.5 Changes in fishing technology and fishing patterns

The expansion of the fishery in the mid-2000s was associated with developments in the pumping and processing technology for boarfish catches. In the past (2009- 2012), the majority of boarfish landings by Danish, Irish and Scottish vessels have been into Skagen, Denmark and Fuglafjorour, Faroe Islands for fishmeal. In recent years, most landings are made into Ireland, although vessels monitor the price in different countries before making a decision on where to land.

In the past two years, the fishery has noticed an increase in the abundance of boarfish, in the southern Celtic Sea, where boarfish had been sparse for many years. There has also been a shift in distribution, with fishable marks being observed along the western Irish coast even up to 57°N. In 2021, with the improvement in the stock and more vessels targeting boarfish, allocations were re-established with 85-90% allocated for Q1 and the remainder for Q3 and Q4. The division in allocations may initiate a change in fishing pattern as boats may wait until Q3/4 to utilise their full allocation, especially if the quota is low (E. Farrell, pers comm).

3.1.6 Discards

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

Since 2003, the major sources of discard estimates are the Dutch pelagic freezer trawlers and both the Irish and Spanish demersal fleets. More sporadic discards are observed in German pelagic freezer trawlers and the UK demersal fleet. In 2016, Lithuania declared discards for the first time but has not provided estimates since 2018. Denmark has only declared discards in 2017 and 2018. 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 9a are also available but are not included in the assessment as they are outside the TAC area. Presently Ireland, Spain and the UK are the only countries to declare discards from the fishery since 2019. Table 3.1.2.2 shows the total annual discards and estimates from the demersal and non-target fisheries respectively.

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

3.2 Biological composition of the catch

3.2.1 Catches in numbers-at-age

Catch numbers-at-age were prepared from Irish, Danish, Dutch, Spanish, Polish and English landings using the ALK in Table 3.2.1.1 together with available samples from the fishery. This general ALK was constructed based on 814 aged fish from Irish, Danish and Scottish caught samples from 2012 (see the stock annex for a description of ALKs prior to 2012). In 2021, 12 samples, comprising of 564 fish, were collected and measured for length from the catch (Table 3.2.1.3). These samples covered the most heavily fished areas of 7j and 7b and equated to one sample per 1474 t landed.

The results of the application of the ALK to commercial length-frequency data (available for the years 2007-2021) produced proxy catch numbers-at-age values which are available in Table 3.2.1.4. In the most recent years, there has been the appearance of strong year classes in the catch numbers. A high number of 3-5 year olds were present in the 2021 data. The modal age from 2007-2011 was 6 and in 2012-2018 it was 7. The modal age for 2021 is 4. 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).

3.2.2 Quality of catch and biological data

Length-frequencies of the international commercial landings by year are presented in Table 3.2.2.1. Sampling in the early years of the fishery (2006-2009) was sparse as there was no dedicated sampling programme in place. The sampling programme was initiated in 2010 and good coverage of the landings has been achieved since then. Full details of the sampling programme in the earlier years are presented in the stock annex. Until 2017, boarfish was not included on the DCF list of species for sampling. Irish sampling comprises only samples from Irish registered vessels. Samples are collected on-board directly from the fish pump during fishing operations and are frozen until the vessel returns to port, which ensures high quality samples. Each sample consists of approximately 6 kg of boarfish. This equates to approximately 150 fish which, given the limited size range of boarfish, is sufficient for determining a representative length frequency. The established sampling target is one sample per 1 000 t of landings per ICES Division, which is also standard in other pelagic fisheries. Since 2017, all fish in each sample should be measured to the 0.5 cm below for length frequency. Following standard protocols 5 fish per 0.5 cm length class should be randomly selected from each sample for biological data collection *i.e.* otolith extraction, measurement to the 1mm below and sex and maturity determination. There is no sampling programme in place for Scottish catches.

The current surplus production model used to assess boarfish is considered an interim measure prior to the development of an aged-based assessment. In 2017, boarfish was included in the list of species to be sampled by the Data Collection Multi Annual Programme (DCMAP) which should provide estimates of catch at age and facilitate the future development of an age-based stock assessment method.

3.3 Fishery Independent Information

3.3.1 Acoustic Surveys

The Boarfish Acoustic Survey (BFAS) was first conducted in July 2011. The 2022 survey was carried out by the RV *Celtic Explorer* and run in conjunction with the Malin Shelf herring survey as the WESPAS survey (Western European Shelf Pelagic Acoustic Survey). The survey was carried out over a 42-day period beginning on the 14 June in the south (47°30N) and working northwards to 59°30N ending on 24 July.

Calculation of acoustic abundance

The StoX software package (Johnsen et. al., 2019) was used to calculate acoustic abundance from survey data (StoX V3.4.0 and R-StoX V3.4.0). 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, 2015).

Survey results 2022

The estimate of boarfish biomass is presented in Table 3.3.1.1 and the spatial distribution of the echotraces attributed to boarfish in 2022 are presented in Figure 6.3.1.1b. Overall, the WESPAS survey provided continuous synoptic coverage from south to north over 42 days, relating to an area coverage of over 49,988 nmi^2 (boarfish strata) and transect mileage of over 5,084 nmi. In total, 40 trawl stations were undertaken with 26 hauls containing boarfish providing 6,575 individual lengths, 2,498 length and weight measurements and 1,270 otoliths for use during the analysis.

The 2022 estimate of total stock biomass (TSB) was comparable to that observed in 2021 (443,777 t in 2021 and 451,415 t in 2022). Survey effort, in terms of survey miles and area coverage, saw a reduction of 10% and 17% respectively when compared to 2021, as a consequence of poor weather. Over 61.5% of the standing stock biomass was observed in the Celtic Sea stratum followed by 32.5% along the Irish west coast. The southern Celtic Sea/Northern Biscay area contained a high abundance of fish, dominated by newly recruited fish (2-year-olds) and first and second year spawning fish (3-4 yrs old). Older age classes dominated further north along the Irish and Scottish west coasts and on the Porcupine Bank, with the exception of a discreet cluster of aggregations of immature and newly recruited fish south of the Minch.

Overall, immature boarfish represented only 5% of total stock abundance compared to 61% observed in 2021. In both years, the highest proportions of immature fish were observed in the Celtic Sea stratum. Preliminary results from the PELGAS survey in the Bay of Biscay, saw for the second successive year a high abundance of boarfish in the northern and mid-Biscay region, surpassing the abundance reported in 2021 (M. Doray, pers comm.). Therefore, it is feasible to suggest that the southern boundary of the stock was not contained within the survey area during WESPAS 2022.

The 3-year age class dominated the 2022 estimate contributing over 32% of TSB and 40.5% of total abundance (TSN), followed by the 4-year-old (27.2% TSB & 22.9% TSN) and 2-year-old (9.3% TSB & 17.4% TSN) fish respectively. Combined, these three successive year classes have tracked well through the index and represent a strong growth period for the stock, and is consistent with the previous observations. Older year classes (5 to 15+-year-old) are still evident and well represented within the stock.

The 2022 biomass saw an increase in TSB of 2% compared to 2021 and an increase of 26% in SSB. The increase in SSB has largely driven new recruitment (over 98% of 2 yr old fish reported as mature) and the lower numbers of immature fish present in the survey area this year. Survey effort was reduced in the core Celtic Sea stratum due to poor weather, and combined with observations from the PELGAS survey would indicate that containment was not fully achieved. That said, comprehensive trawl and biological sampling was undertaken.

3.3.2 International bottom trawl survey (IBTS) Indices Investigation

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

- EVHOE, French Celtic Sea and Biscay Survey, (Q4) 1997 to 2021
- IGFS, Irish Groundfish Survey, (Q4) 2003 to 2021
- WCSGFS, West of Scotland, (Q1 and Q4) 1986 to 2009 (survey design changed in 2010)
- SPPGFS, Spanish Porcupine Bank Survey, (Q3) 2001 to 2021
- SPNGFS, Spanish North Coast Survey, (Q3/Q4) 1991 to 2021
- ECSGFS, CEFAS English Celtic Sea Groundfish Survey, (Q4) 1982 to 2003

From the IBTS data, CPUE was computed as the number of boarfish per 30 min haul. The abundance of boarfish per year per ICES 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. Length frequencies are presented in Table 3.3.2.1 for each survey. These surveys cover the majority of the observed range of boarfish in the ICES Area (Figure 3.1). Figure 3.3.2.1 shows the haul positions for each of the 6 surveys analysed.

A detailed analysis of the IBTS data was carried out in 2012 to investigate the main areas of abundance of boarfish in these surveys. This analysis included GAM modelling based on the probability of occurrence of boarfish. The full details of this work are presented in the stock annex. The IBTS appears to give a relative index of abundance, with good resolution between periods of high and low abundance. The main centres of abundance in the survey (Figure 3.3.2.2) correspond to main fishing grounds (Figure 3.1.2.1). Figures 3.3.2.3a 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 3.6.3), biomass indices were extracted from each of the IBTS surveys using a delta-lognormal model (Stefánsson 1996). Many of the surveys exhibited a large proportion of zero tows with occasionally very large tows, hence the decision to explicitly model the probability of a non-zero tow and the mean of the positive tows. A delta-lognormal fit comprises fitting two generalized linear models (GLMs). The first model (binomial GLM) is used to obtain the proportion of non-zero tows and is fit to the data coded as 1 or 0 if the tow contained a positive or zero CPUE, respectively. The second model is fit to the positive only CPUE data using a lognormal GLM. Both GLMs were fit using ICES statistical rectangle and year as explanatory factor variables. Where the number of tows per rectangle was less than 5 over the entire series, they are grouped into an “others” rectangle. An index per rectangle and year is constructed, according to Stefánsson (1996), by the product of the estimated probability of a positive tow times the mean of the positive tows. The station indices are aggregated by taking the estimated average across all rectangles within a year. To propagate the uncertainty, all survey index analyses were conducted in a Bayesian framework using Markov chain Monte

Carlo (MCMC) sampling (Kery 2010). The analyses were performed in WinBUGS from R with the R2WinBUGS package.

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

Mean weight-at-age was obtained from the ageing studies of Hüssy *et al.* (2012b). These mean weights are presented in the text table below. The variation in weight-at-age is due to 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, see Section 3.6.5). 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 (Section 3.6.5) a single value of M was considered appropriate.

3.5 Recruitment

The common ALK (Table 3.2.1.1.) was applied to the IBTS number-at-length data. The length-frequency is presented in Table 3.3.2.1. and the age-structured index in Table 3.6.1.1. and Figure 3.6.1.1.

A cohort effect can be seen with those cohorts from the early 2000s appearing weak. This coincides with a decline in overall abundance in the early 2000s. From the mid-2000s onwards recruitment improved as observed in the abundance of 1-5 year olds in the EVHOE and Spanish northern shelf surveys (It should be noted however that the IBTS data is measured to the 1.0cm not the 0.5cm until 2015. Therefore, application of the common ALK to this data must be viewed with caution).

The EVHOE, IGFS and SPNGFS surveys provide the best indices of recruitment as this is where the juveniles appear to be most abundant (Table 3.3.2.1) For example, in the EVHOE survey, particularly high recruitment has been noted between the years 2018 and 2021 for ages 1-3. And also, in the IGFS survey, signs of high recruitment could be observed as early as 2018, peaking in 2020. In 2021, the progression of the cohort can be seen as 3-5 years old.

3.6 Exploratory assessment

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

3.6.1 IBTS data

Some of the IBTS CPUE indices display 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 display a consistently higher proportion of positive tows. The variability of the data is reflected in the estimated mean CPUE indices (Figure 3.6.1.2). The West of Scotland survey index had been increasing between 2000 and 2009 but is uncertain 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. The spatial extent of each survey is shown in Figure 3.3.2.1.

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

Pair-wise correlations between the annual mean survey indices is variable. The updates described above with respect to data and analysis code corrections have resulted in increased correlation between the surveys most affected *i.e.* IGFS and EVHOE (Figure 3.6.1.5). The WCSGFS displayed positive correlations with all five surveys except the Spanish north coast survey (SPNGFS). The SPPGFS displayed a negative correlation with EVHOE and IGFS. Weighting the correlations by the sum of the pair-wise variances resulted in a largely similar correlation structure (Figure 3.6.1.6). Note that though some surveys displayed weak or no correlation, no surveys were excluded a-priori from the assessment. Sensitivity tests were conducted in 2013, which led to the exclusion of the surveys mentioned previously (see the stock annex).

3.6.2 Biomass estimates from acoustic surveys

The Boarfish Acoustic Survey (BFAS) series was initiated in 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. In the most recent surveys, the contribution of immature boarfish to the total estimate has been increasing such that the increase seen between 2020 and 2021 is largely due to juveniles. In 2022, the abundance of juvenile boarfish decreased; however, this year, the survey was dominated by a high abundance of 2-4 year olds. No substantial evidence exists for removing any of the survey points from the time series although 2016 may be considered an outlier (Table 3.3.1.1).

The PELACUS survey is conducted annually in waters to the south of the boarfish (WESPAS) survey. For the second successive year, PELACUS recorded an increase in biomass on its northern and mid-Biscay transects in 2022, (immediately south of the WESPAS southern limit), in broad agreement with increases noted on WESPAS. The PELACUS survey takes place approximately 1 month prior to the boarfish survey.

3.6.3 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, IBTS data, and acoustic biomass data. 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.

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, $B_t = P_tK$, 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 input directly from the delta-lognormal fits (Figure 3.6.1.2) as opposed to estimating a measurement error within the assessment. The measurement error is obtained from:

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

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

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

Prior assumptions on the parameter distributions are:

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

Specification

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

The specifications for the final boarfish assessment model runs are:

Acoustic survey

Years: 2011–2022

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

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

IBTS surveys

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

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

First 9 years omitted from ECSGFS

Following discussion of the sensitivity runs in 2013, it was decided that the final run be based on a run that includes all surveys with the omission of the first 5 years of the WCSGFS and first 9 years of the ECSGFS 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

2003–2021 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.

Run convergence

Parameters for the 2022 model run converged with good mixing of the chains and Rhat values lower than 1.1 indicating convergence and acceptable autocorrelation (Figures 3.6.3.1-3).

Diagnostic plots are provided in Figure 3.6.3.4 showing residuals about the model fit. A fairly balanced residual pattern is evident. In some cases, outliers are apparent, for instance in the English survey in the final year (2003). However, these points are down weighted according to the inverse of their variance and hence do not contribute much to the model fit. For the early years of the acoustic survey (BFAS), it overestimates the stock in the first 3 years, then underestimates it for the next 4 years before again overestimating it slightly in 2020. This suggests that this index is perhaps not representative of the whole stock. For the last two years, the residuals have been well behaved. Figure 3.6.3.5 shows the prior and posterior distributions of the parameters of the biomass dynamic model. The estimate of q is less than 1.0, leading to a higher estimate of final stock biomass than the acoustic survey result.

Results

Trajectories of observed and expected indices are shown in Figure 3.6.3.6, along with the stock size over time and a harvest ratio (total catch divided by estimated biomass). Parameter estimates from the model run are summarized in Table 3.6.3.1. TSB in 2022 is estimated to be 565 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 3.6.3.7, show that the perception of the stock is stable over the most recent 5 years.

3.6.4 State of the stock

The most recent assessment indicates that total stock biomass increased from a low to average level from the early to mid-1990s (Figure 3.6.3.6). The stock fluctuated around this level until 2009, before increasing until 2012. A sharp decline is seen between 2013 and 2014. Since 2014, the abundance has increased although it remains below that from the previous high period. 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 95% uncertainty bounds are relatively large 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 in F. The considerable catches in recent years do not appear to have significantly truncated the size or age structure of the stock and 15+ group fish are still abundant (Figure 3.2.1.1).

MSY reference points can be estimated from the production model assessment parameter values. In 2021, F_{MSY} (r/2) is estimated to be 0.17 and MSY $B_{trigger}$ (K/4) 138kt. 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 2021, the stock is in the green area of the Kobe plot (Figure 3.6.6.1).

Estimates of recruitment are not available from the stock assessment. However, all available data sources (catch, acoustic survey and IBTS surveys) indicate above average recruitment since 2017. The large juvenile biomass observed in the 2021 acoustic survey is tracking well through the index and is present in the 2022 survey as newly recruited fish of the 2-4 year classes.

3.7 Short Term Projections

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

3.8 Long term simulations

No long term simulations were conducted.

3.9 Candidate precautionary and yield based reference points

3.9.1 Yield per Recruit

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

3.9.2 Precautionary reference points

No reference points have been defined for boarfish.

3.9.3 Other yield based reference points

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

3.10 Quality of the assessment

ICES considers the current basis for the advice on this stock to be an interim measure prior to development of an age-based assessment. 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 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.

3.11 Management considerations

As this stock is placed in category 3, the advice is based on harvest control rules for data limited stocks (ICES 2012). Since the biomass estimate from the Bayesian model is considered reliable for trends based assessment, an index can be calculated according to Method 3.1 of ICES (2012). The advice is based on a comparison of the average of the two most recent index values with the average of the three preceding values multiplied by the most recent catch. Table 3.6.5.1 shows the biomass estimates from the model from which the index was calculated. 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 3.6.3.6).

3.12 Stock structure

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

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

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

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

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

3.13 Ecosystem considerations

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

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

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

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

Sea and Bay of Biscay did not report any boarfish in the stomachs of hake caught during the 2001 EVHOE survey (Mahe *et al.* 2007).

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

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

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

3.14 Proposed management plan

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

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

1) The TAC shall be set in accordance with the following procedure, depending on the ICES advice
   a) If category 1 advice (stocks with quantitative assessments) is given based on a benchmarked assessment, the TAC shall be set following that advice.
   b) If category 1 or 2 (qualitative assessments and forecasts) advice is given based on a non-benchmarked assessment the TAC shall be set following this advice.
   c) Categories 3-6 are described below as follows:
      i) Category 3: stocks for which survey-based assessments indicate trends. This category includes stocks with quantitative assessments and forecasts which for a variety of reasons are considered indicative of trends in fishing mortality, recruitment, and biomass.

    ii) Category 4: stocks for which only reliable catch data are available. This category included stocks for which a time series of catch can be used to approximate MSY.
    iii) Category 5: landings only stocks. This category includes stocks for which only landings data are available.
    iv) Category 6: negligible landings stocks and stocks caught in minor amounts as bycatch.
2) Notwithstanding paragraph 1, if, in the opinion of ICES, the stock is at risk of recruitment impairment, a TAC may be set a lower level.
3) If the stock, estimated in either of the 2 years before the TAC is to be set, is at or below B_{lim} or any suitable proxy thereof, the TAC shall be set at 0 t.
4) The TAC shall not exceed 75,000 t in any year.
5) The TAC shall not be allowed to increase by more than 25% per year. However, there shall be no limit on the decrease in TAC.
6) Closed seasons, closed areas, and moving on procedures shall apply to all directed boarfish fisheries as follows:
    i) A closed season shall operate from 31st March to 31st August. This is because it is known that herring and mackerel are present in these areas and may be caught with boarfish.
    ii) A closed area shall be implemented inside the Irish 12-miles limit south of 52°30 from 12th February to 31st October, in order to prevent catches of Celtic Sea herring, known to form aggregations at these times.
    iii) If catches of other species covered by a TAC amount to more than 5% of the total catch by day by ICES statistical rectangle, then all fishing must cease in that rectangle for 5 consecutive days.

3.15 References

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3.16 Tables

Table 3.1.2.1. 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)

	Denmark	Germany	Ireland	Netherlands	England	Poland	Scotland	Spain	Discards	Total	TAC
2001			120							120	
2002			91							91	
2003			458						10929	11387	
2004			675						4476	5151	
2005			165						5795	5959	
2006			2772						4365	7137	
2007			17615				772		3189	21576	
2008	3098		21585				0		10068	34751	
2009	15059		68629						6682	90370	
2010	39805		88457				9241		6544	144047	
2011	7797		20685				2813		5802	37096	33000
2012	19888		55949				4884		6634	87355	82000
2013	13182		52250				4380		5598	75409	82000
2014	8758		34622				38		1813	45231	133957
2015	29	4	16325	375	104				929	17766	53296
2016	337	7	17496	171	21				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

0 = <0.5t

Table 3.1.2.2. 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	Netherlands	Spain	UK	Lithuania
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	
0 = <0.5t							

Table 3.1.2.3. 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
Denmark															37	67	172	10	23
England													9				9	7	
Ireland	65	292	10	21	99*	28	45	1356	26	125	538	182	116	377	907	269	568	1214	378
Netherlands													128	45	34	78	79	108	52
Scotland								10			15	30							6
*6t in 5b, 0=0-0.5t																			

Table 3.1.2.4 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
Denmark											80	12	8	21				85	13
England													85	1			0	32	10
Germany													4	5					
Ireland	214	224	105	15	1259	3	74	2293	283	4609	10405	3262	2829	1198	124	163	241	6818	3732
Netherlands													33*	35	138	10	150	212	228
Scotland								4		1745	100								2
*Division 7, 0=0-0.5t																			

Table 3.1.2.5 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
Denmark								39132	7779	18203	11828	8747	5	330	239	6	268	101	4151
England													10	16	0	0	3	23	23
Ireland	179	122	12	2360	16131	21370	63597	81160	19565	50507	38358	30925	12152	8623	2994	3745	6222	6365	6956
Nether-lands														90	9	68	80	79	325
Poland																		109	12
Scotland					772			9227	2813	3139	3381	8				0			
Spain																	0	0	
0=0-0.5t																			

Table 3.1.2.6 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
Denmark								674							1		1	0	23
England															0		6		12
Ireland				375	120	184	4912	3649	811	616	1808	135	547		1	2		1	764
Netherlands														0	0	3	7	1	126
Scotland											883								
0=0-0.5t																			

Table 3.1.2.7 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
Denmark									18		1354		6	7	271		315		111
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
Spain																148*	2	1	11

*94t in 9a, 0=0-0.5t

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

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
7.25	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 3.2.1.2. 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****

*** 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 3.2.1.3. 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
4 322	DK	0	0	0
11	ES	0	0	0
11 830	IE	12	564	0
781	NL	0	0	0
45	PL	0	0	0
45	UKE	0	0	0
9	UKS	0	0	0

Table 3.2.1.4. Boarfish in ICES Subareas 27.6, 7, 8. Proxy catch numbers-at-age of the international catches (raised numbers in '000s) for the years 2007-2021

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

Table 3.2.2.1. Boarfish in ICES Subareas 27.6, 7, 8. Length-frequency distributions of the international catches (raised numbers in '000s) for the years 2007-2021

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

Length	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
13.0	82633	52308	147965	353484	133539	419060	315063	172416	59990	57000	46495	30665	28815	9494	6738
13.5		29890	149314	246146	51235	307533	285688	153742	52625	58696	43121	38698	16688	13707	8599
14.0	117224	22418	105782	224611	50857	176710	210137	138549	50139	76872	45353	34080	20053	16381	8468
14.5		14945	71273	127711	25309	89726	105571	74059	28771	37755	39524	29908	13809	14913	7389
15.0	65338	33627	47816	125463	25569	52791	62175	43347	16087	23137	21854	15561	5710	12563	7222
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 3.3.1.1. 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
0										1084	259	
1	5	22			199	5	111	77	782	897	9523	587
2	12	11	78		319	36	127	31	389	1157	3392	3234
3	58	174	1843	15	17	46	345	115	97	967	2955	7537
4	187	65	696	98	34	44	367	68	93	113	1315	4259
5	437	95	382	102	80	6	156	107	88	157	463	619
6	1166	736	254	105	112	10	209	166	106	183	150	509
7	1184	974	1057	415	437	169	493	321	446	913	953	752
8	704	759	879	344	363	113	463	198	183	885	207	266
9	1095	849	801	342	354	118	397	293	288	721	378	302
10	1032	956	704	332	360	97	286	625	290	331	249	122
11	333	651	264	130	132	17	121	339	50	81	151	41
12	653	1100	203	105	113	32	82	264	192	195	188	23
13	336	857	297	166	174	49	74	198	79	299	81	127
14	385	656	170	89	108	18	220	117	57	267	327	90
15+	3519	6354	1464	855	1195	400	931	302	759	1641	1213	148
TSN	11104	14257	9091	3098	3996	1157	4387	3221	3899	9888	21805	18614
TSB	670176	863446	439890	187779	232634	69690	230062	186252	179156	399872	443777	451415
SSB	669392	861544	423158	187654	226659	69103	218810	184624	169213	357871	351955	422722
CV	21.2	10.6	17.5	15.1	17.0	19	21.9	19.9	25.4	34.8	31.0	24.0

Table 3.3.2.1. 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

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
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
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

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

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
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
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

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

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
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
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

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
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
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

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

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
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
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

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
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

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
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 3.6.1.1. 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
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

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

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

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

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

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

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

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

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

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

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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
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 3.6.3.1. Boarfish in ICES Subareas 27.6, 7, 8. Key parameter estimates from the exploratory Schaeffer state space surplus production model. Posterior parameter distributions are provided in Figure 3.6.3.5

Parameter	Mean	SD	2.5	25	50	75	97.5
r	0.34	0.17	0.06	0.22	0.33	0.45	0.70
K	685102	511831	310500	443300	550600	730600	2116000
F_{MSY}	0.17	0.08	0.03	0.11	0.17	0.23	0.35
B_{MSY}	171276	127958	77625	110825	137650	182650	529000
TSB	628184	293425	306800	450800	565050	723900	1314975

Table 3.6.5.1. Boarfish 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	96640	184200	440800			
1992	159300	286400	666697			
1993	194200	351200	815395			
1994	229100	416300	977795			
1995	198000	358800	833400			
1996	199000	360000	835500			
1997	168900	300800	694097			
1998	222900	394750	910187			
1999	168000	297300	686197			
2000	145700	258600	598497			
2001	162400	281900	642600			
2002	140400	244100	559400			
2003	128700	222500	506200	0.02	0.05	0.09
2004	179300	310100	706997	0.01	0.02	0.03
2005	175400	303900	690000	0.01	0.02	0.03
2006	220700	377500	855997	0.01	0.02	0.03
2007	198000	340400	769000	0.03	0.06	0.11
2008	242900	412500	935397	0.04	0.08	0.14
2009	248400	418500	932997	0.10	0.22	0.36
2010	367200	617600	1388000	0.10	0.23	0.39
2011	323000	546700	1226000	0.03	0.07	0.11
2012	464500	761200	1690000	0.05	0.11	0.19
2013	313300	523400	1178000	0.06	0.14	0.24
2014	147100	245800	550997	0.08	0.18	0.31
2015	176500	296500	668197	0.03	0.06	0.10
2016	130200	220150	497697	0.04	0.09	0.15
2017	230100	389450	880500	0.02	0.04	0.08
2018	246200	414400	933292	0.01	0.03	0.05

Year	TSB.2.5	TSB.50	TSB.97.5	F2.5	F.50	F.97.5
2019	207800	350600	790090	0.01	0.03	0.05
2020	242300	414300	938790	0.02	0.04	0.06
2021	323800	547300	1231000	0.01	0.03	0.05
2022	306800	565050	1314975			

3.17 Figures

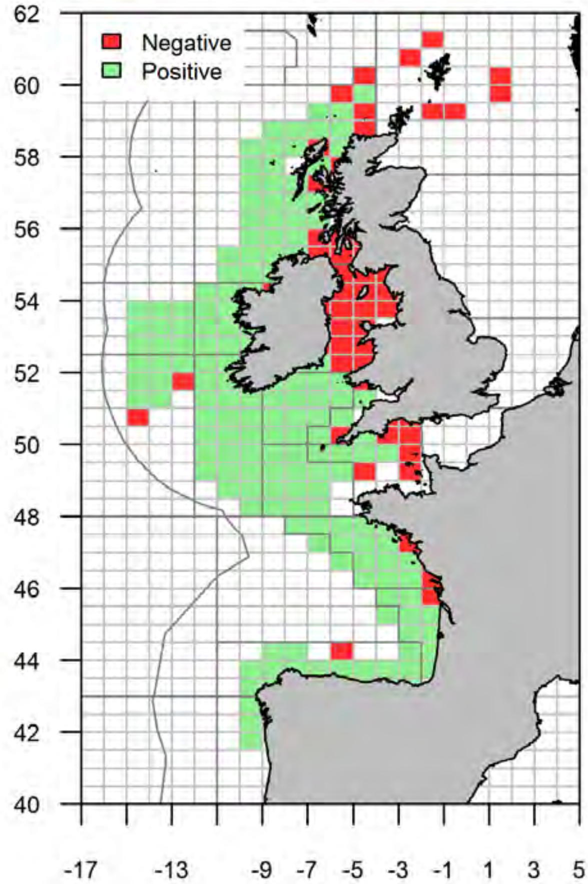

Figure 3.1. Boarfish in ICES Subareas 4, 6, 7, 8 and 9. Distribution of boarfish in the NE Atlantic area based on presence and absence in IBTS surveys (all years).

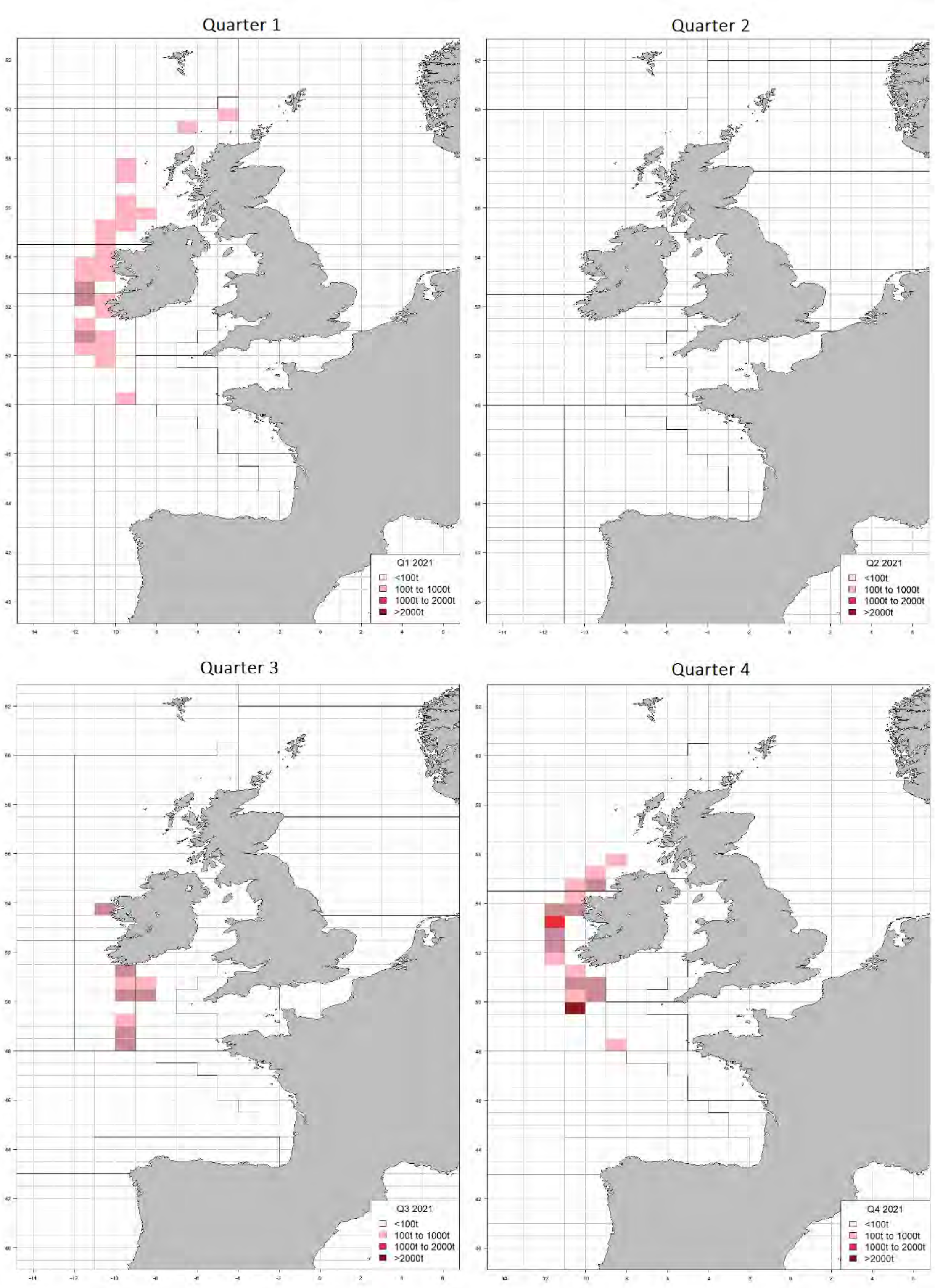

Figure 3.1.2.1. Boarfish in ICES Subareas 27.6, 7, 8. Irish boarfish landings for 2021 by statistical rectangle and quarter.

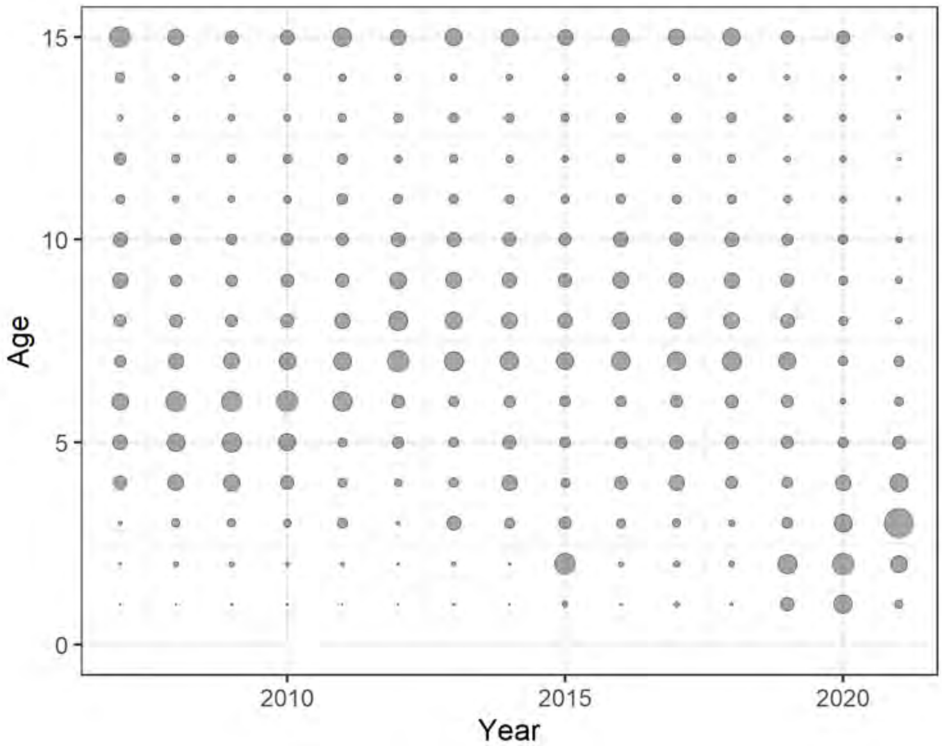

Figure 3.2.1.1. Boarfish in ICES Subareas 27.6, 7, 8. Catch numbers-at-age standardised by yearly mean. 15+ is the plus group.

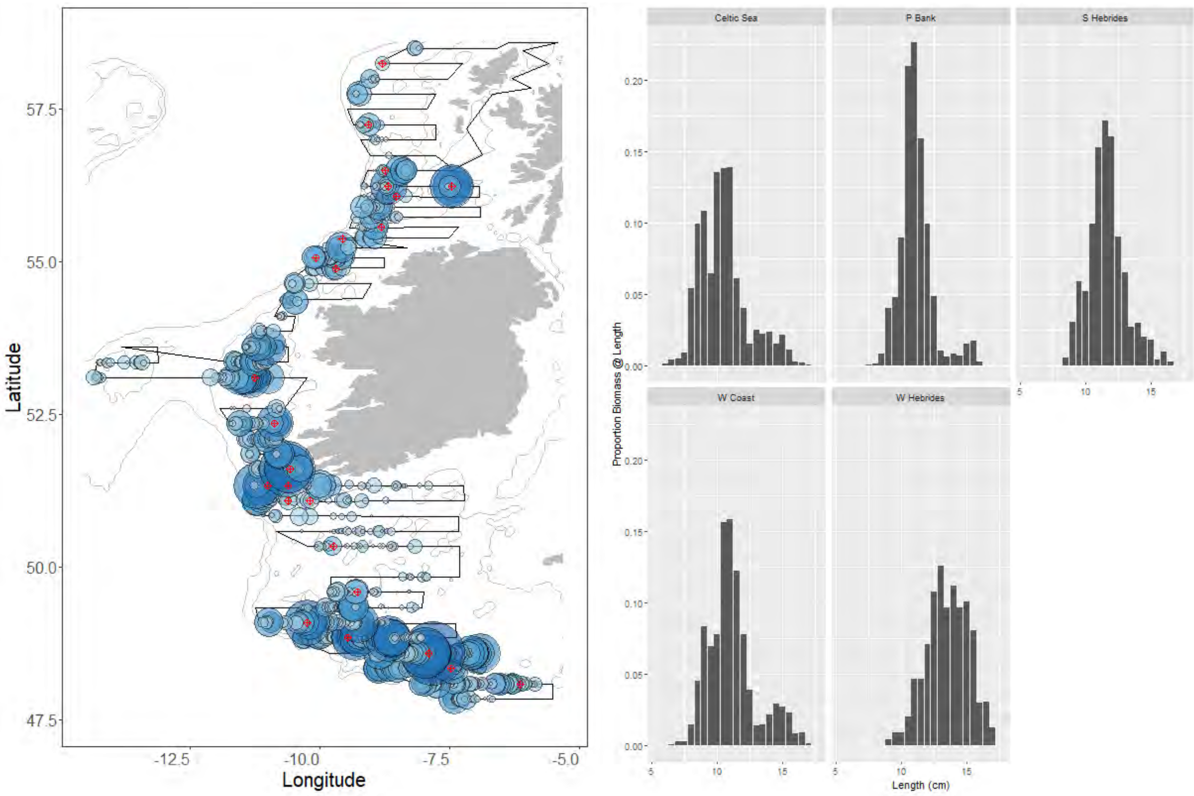

Figure 3.3.1.1. Boarfish in ICES Subareas 27.6, 7, 8. Boarfish acoustic survey track and haul positions 2022 (left), estimates of biomass at length by stratum (right).

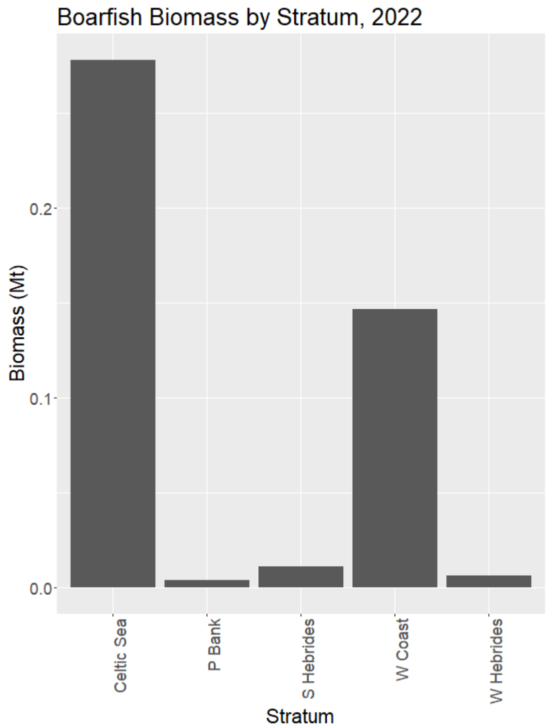

Figure 3.3.1.2. Boarfish in ICES Subareas 27.6, 7, 8. Boarfish acoustic survey biomass estimate by stratum, 2022.

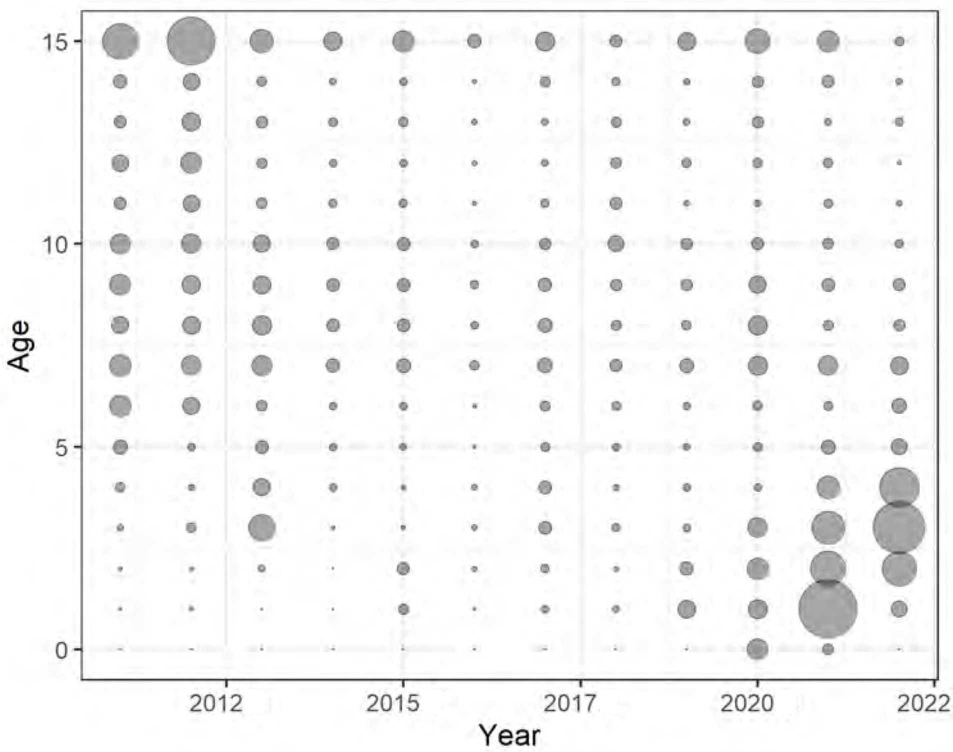

Figure 3.3.1.3. Boarfish in ICES Subareas 27.6, 7, 8. Boarfish acoustic survey time series of acoustic estimates of abundance at age, 2011 - 2022.

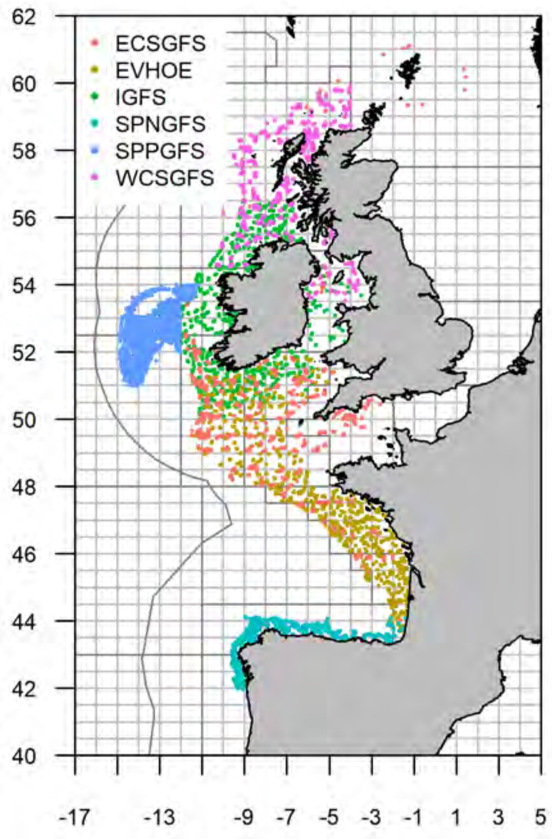

Figure 3.3.2.1. Boarfish in ICES Subareas 27.6, 7, 8. The haul positions of bottom trawl surveys analysed as an index for boarfish abundance.

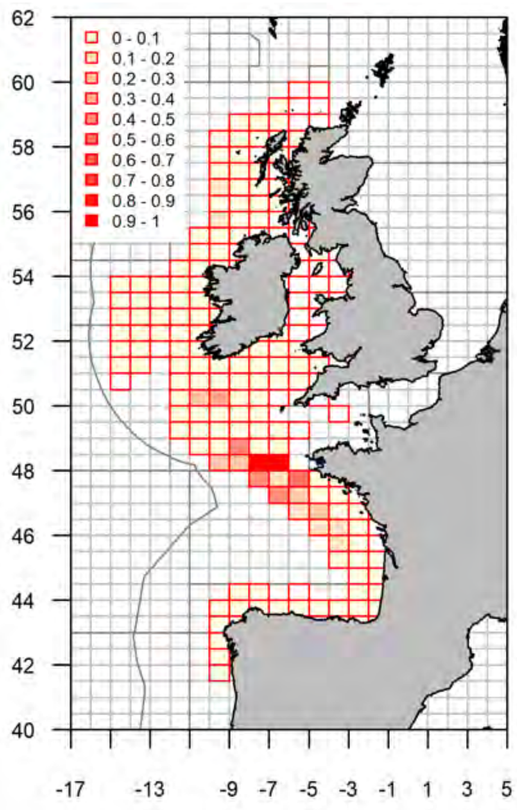

Figure 3.3.2.2. Boarfish in ICES Subareas 27.6, 7, 8. Distribution of boarfish in the NE Atlantic from the 6 IBTS surveys.

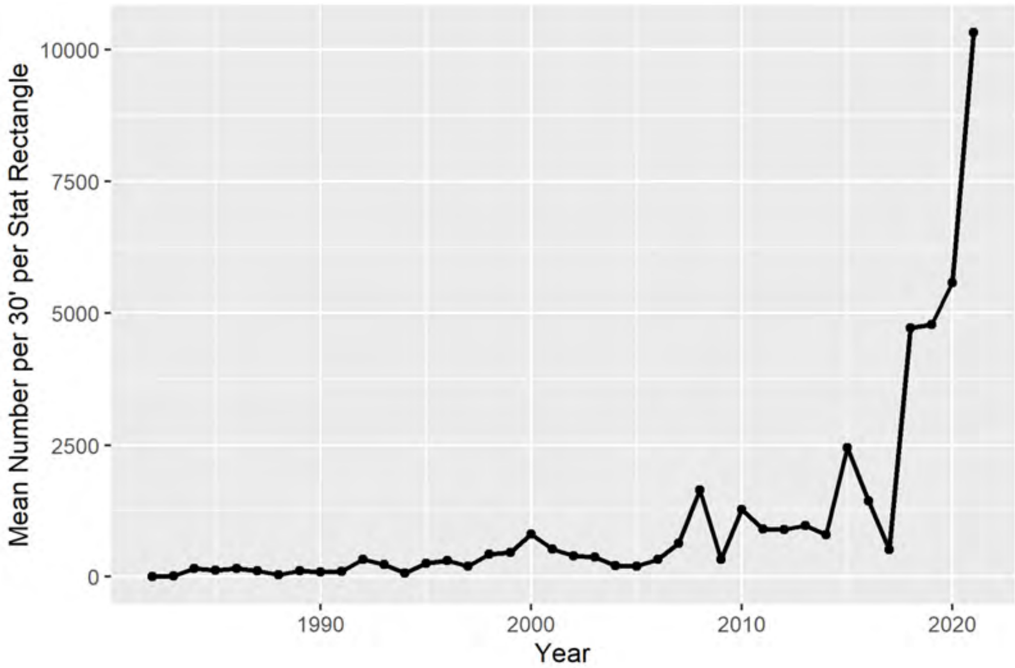

Figure 3.3.2.3a. Boarfish in ICES Subareas 27.6, 7, 8. CPUE in number per 30-minute haul of boarfish per rectangle in the western IBTS survey 1982 to 2021.

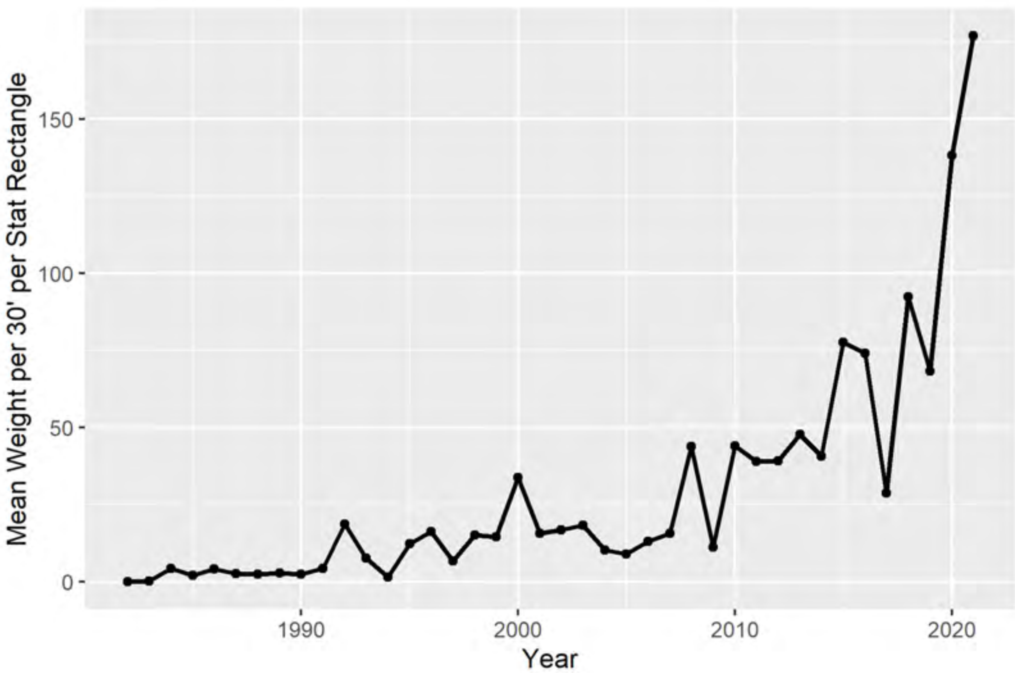

Figure 3.3.2.3b. Boarfish in ICES Subareas 27.6, 7, 8. CPUE in kg per 30-minute haul of boarfish per rectangle in the western IBTS survey 1982 to 2021.

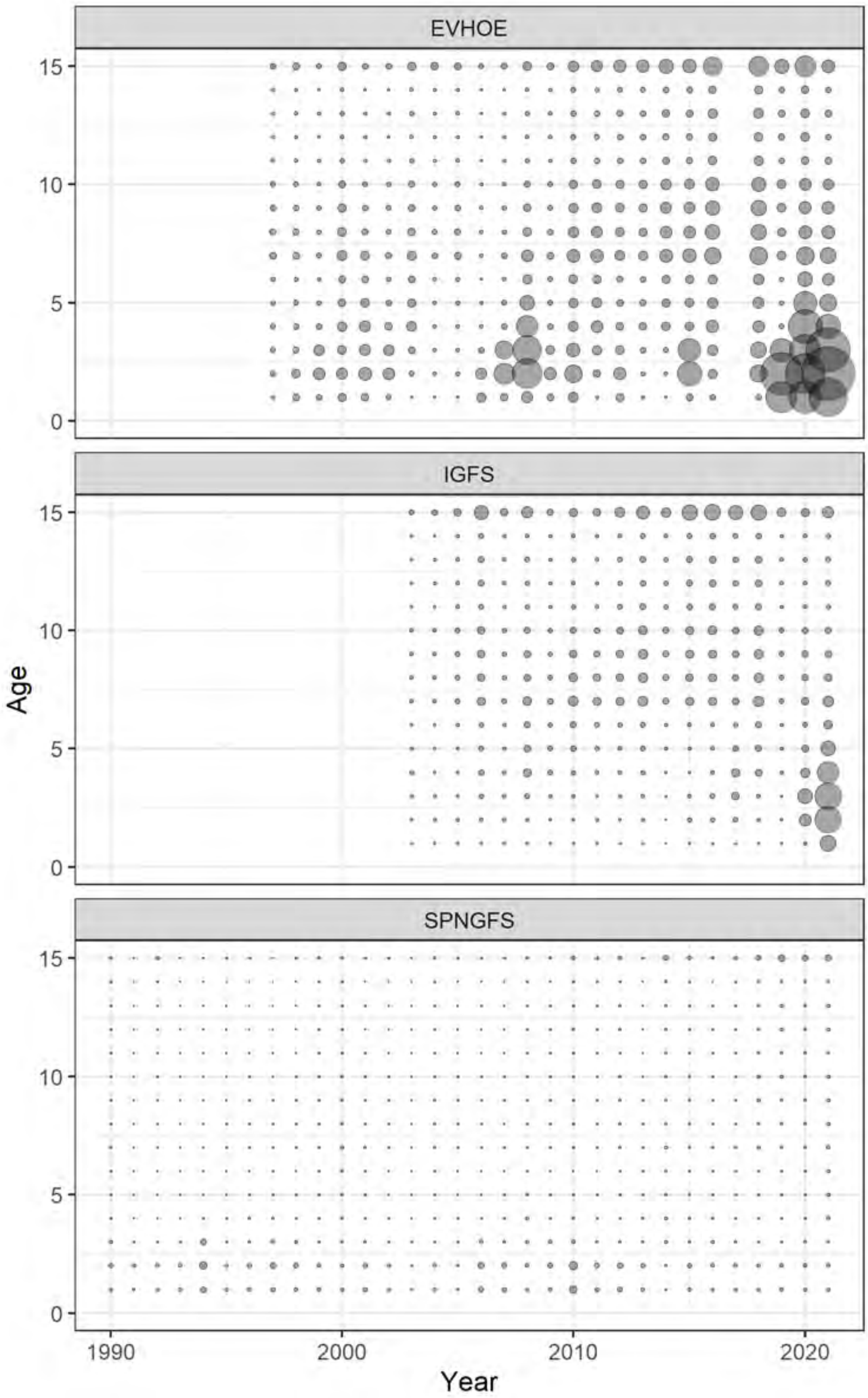

Figure 3.6.1.1. Boarfish in ICES Subareas 27.6, 7, 8. Abundance-at-age in EVHOE, IGFS and SPNGFS surveys. Yearly mean standardised abundance-at-age.

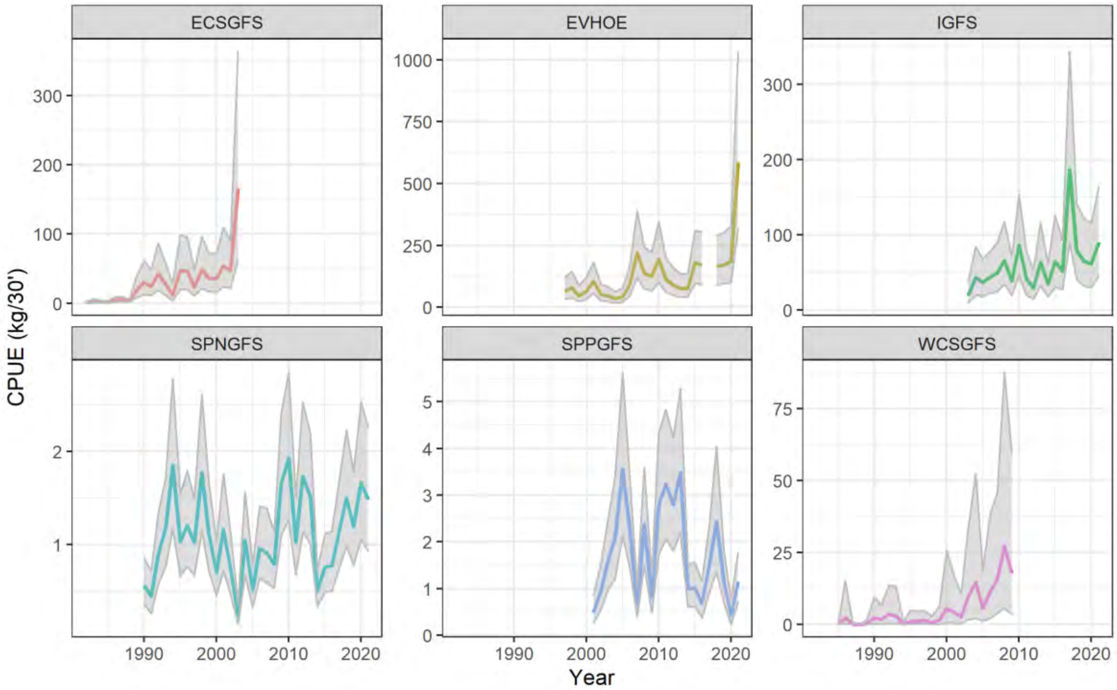

Figure 3.6.1.2. Boarfish in ICES Subareas 27.6, 7, 8. Boarfish IBTS survey CPUE fitted delta-lognormal mean (solid line) and 95% credible intervals (grey region).

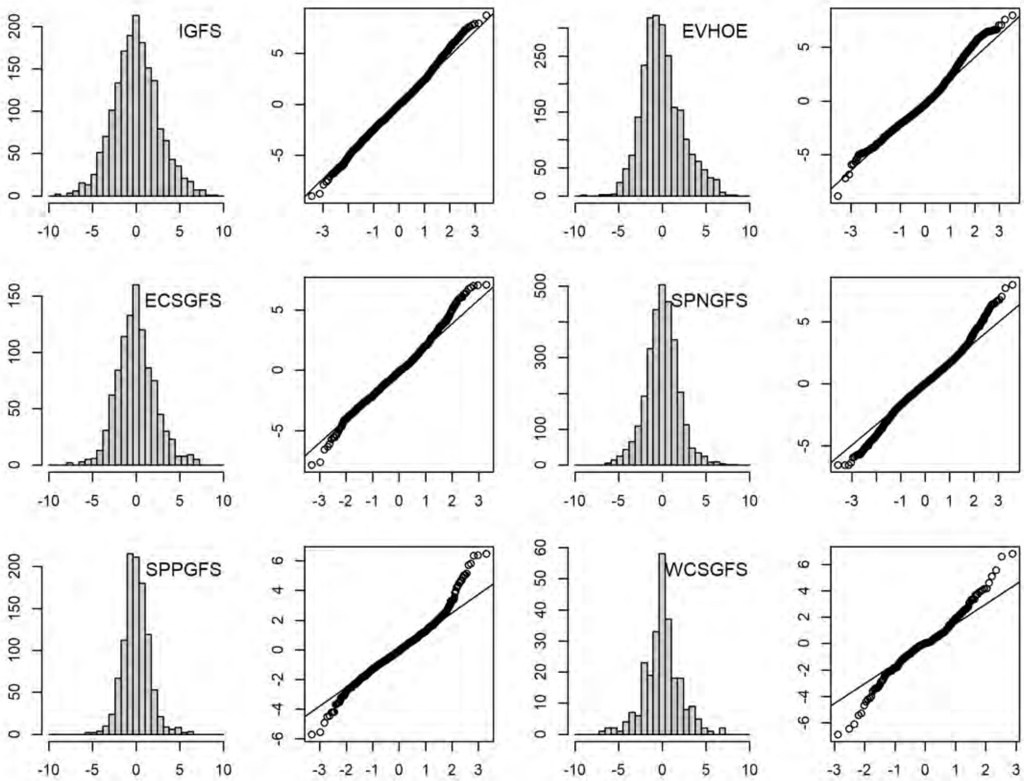

Figure 3.6.1.4. Boarfish in ICES Subareas 27.6, 7, 8. Diagnostics from the positive component of the delta-lognormal fits

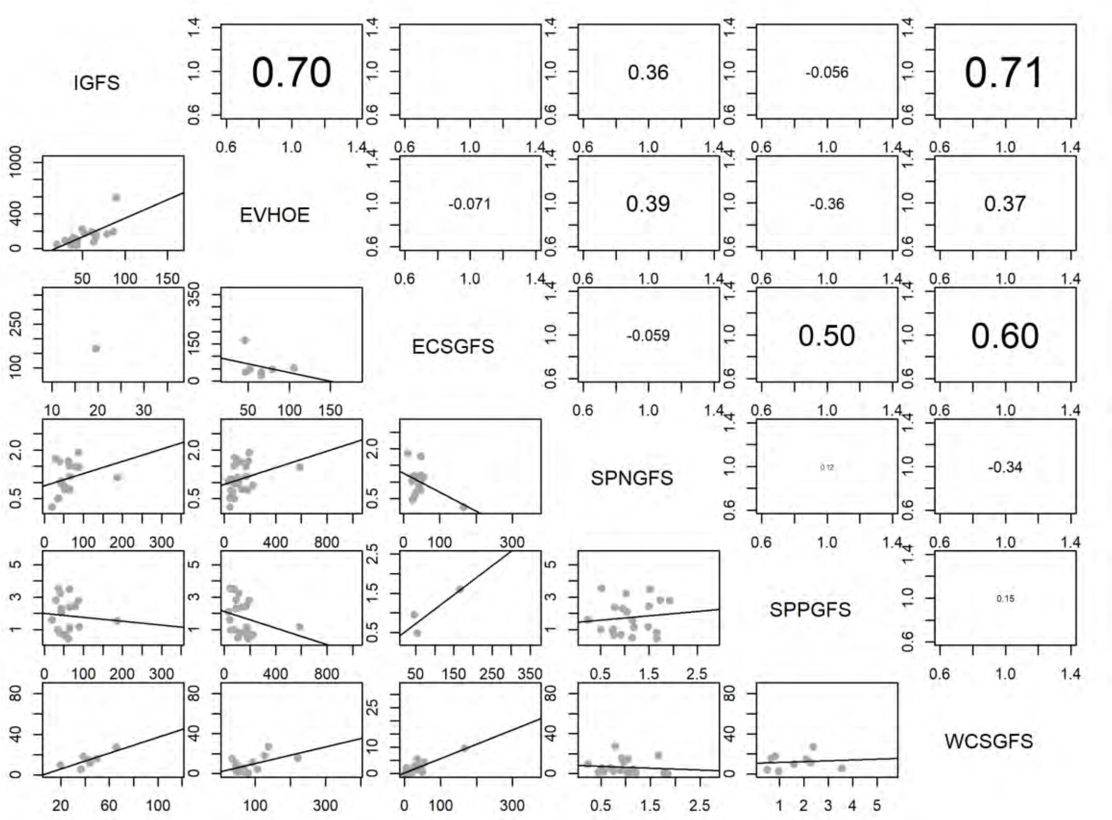

Figure 3.6.1.5. Boarfish in ICES Subareas 27.6, 7, 8. Pair-wise correlation between the annual mean survey indices.

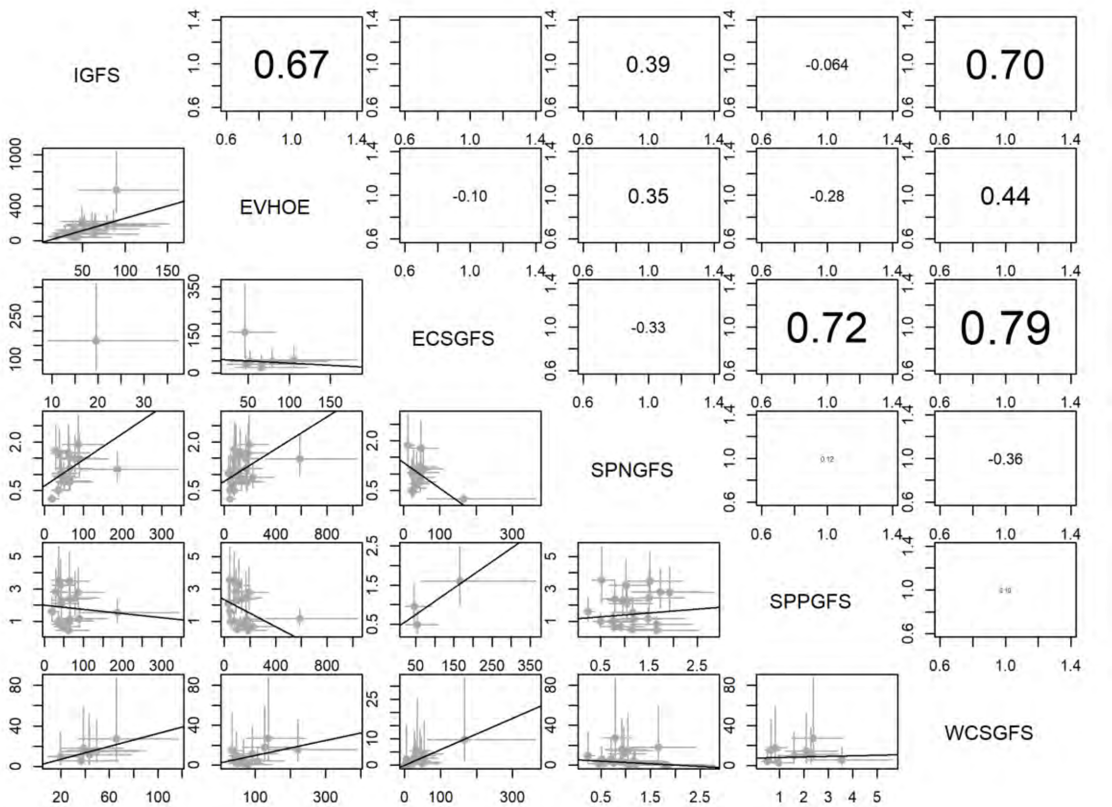

Figure 3.6.1.6. Boarfish in ICES Subareas 27.6, 7, 8. Weighted correlation between the annual mean survey indices. Correlations are weighted by the sum of the pair-wise variances.

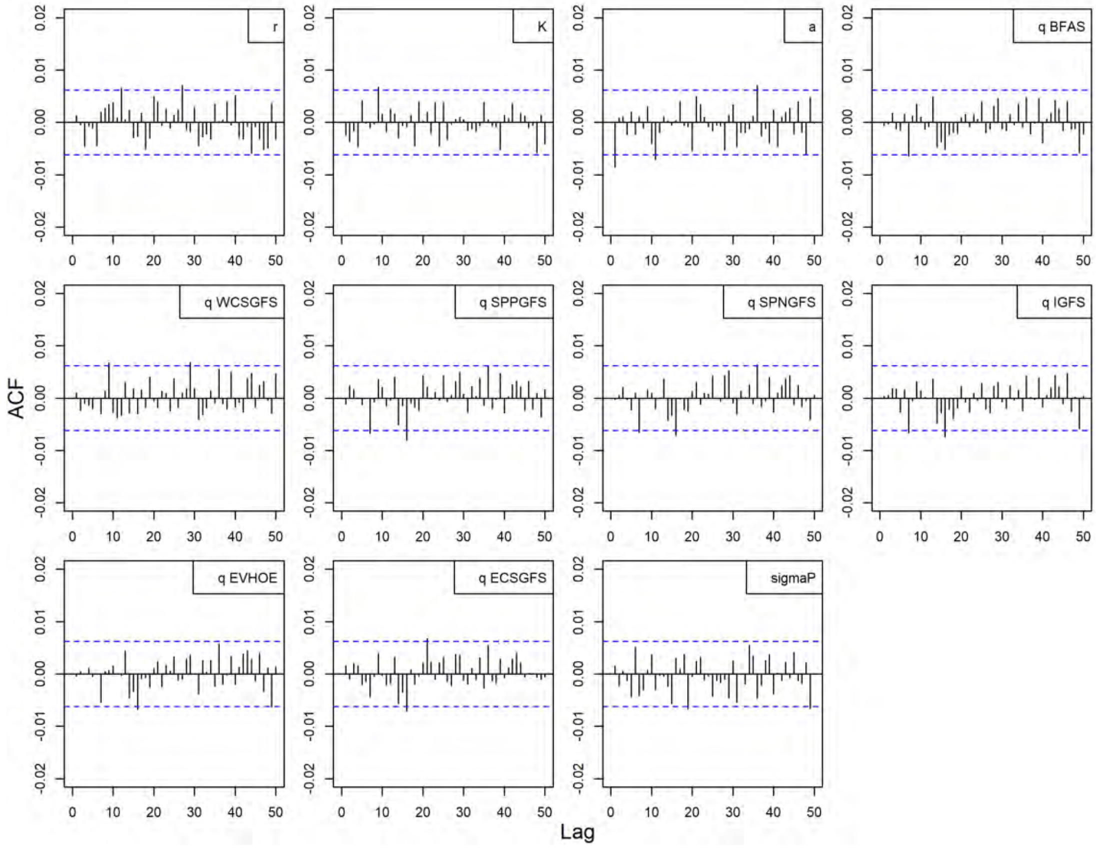

Figure 3.6.3.1. Boarfish in ICES Subareas 27.6, 7, 8. MCMC chain autocorrelation for final run.

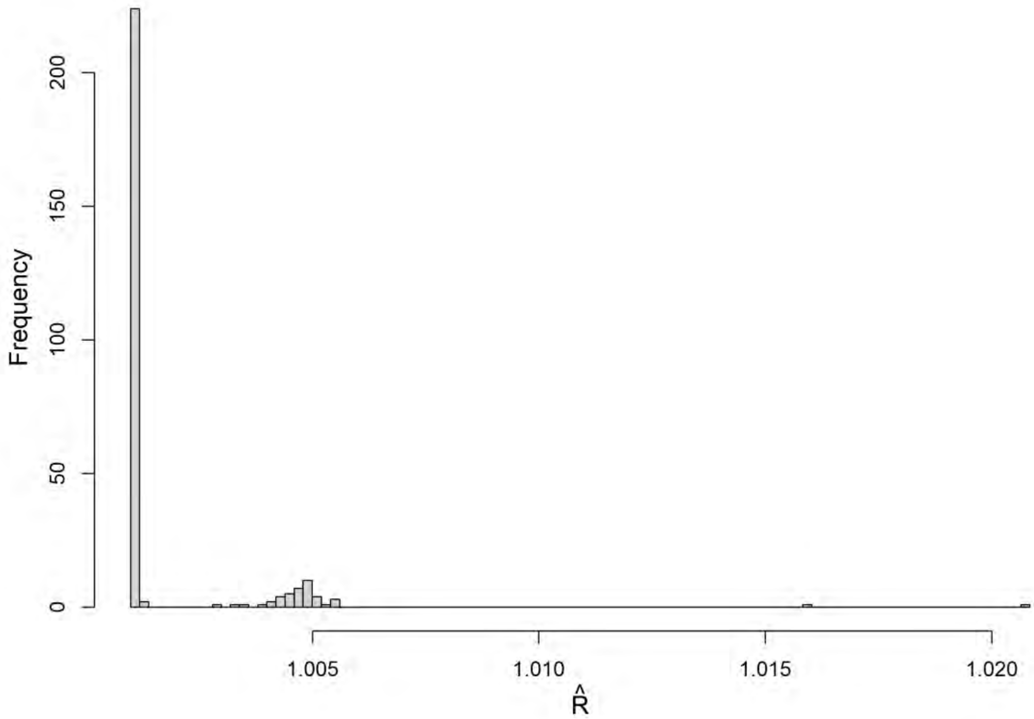

Figure 3.6.3.2. Boarfish in ICES Subareas 27.6, 7, 8. Rhat values lower than 1.01 indicating convergence.

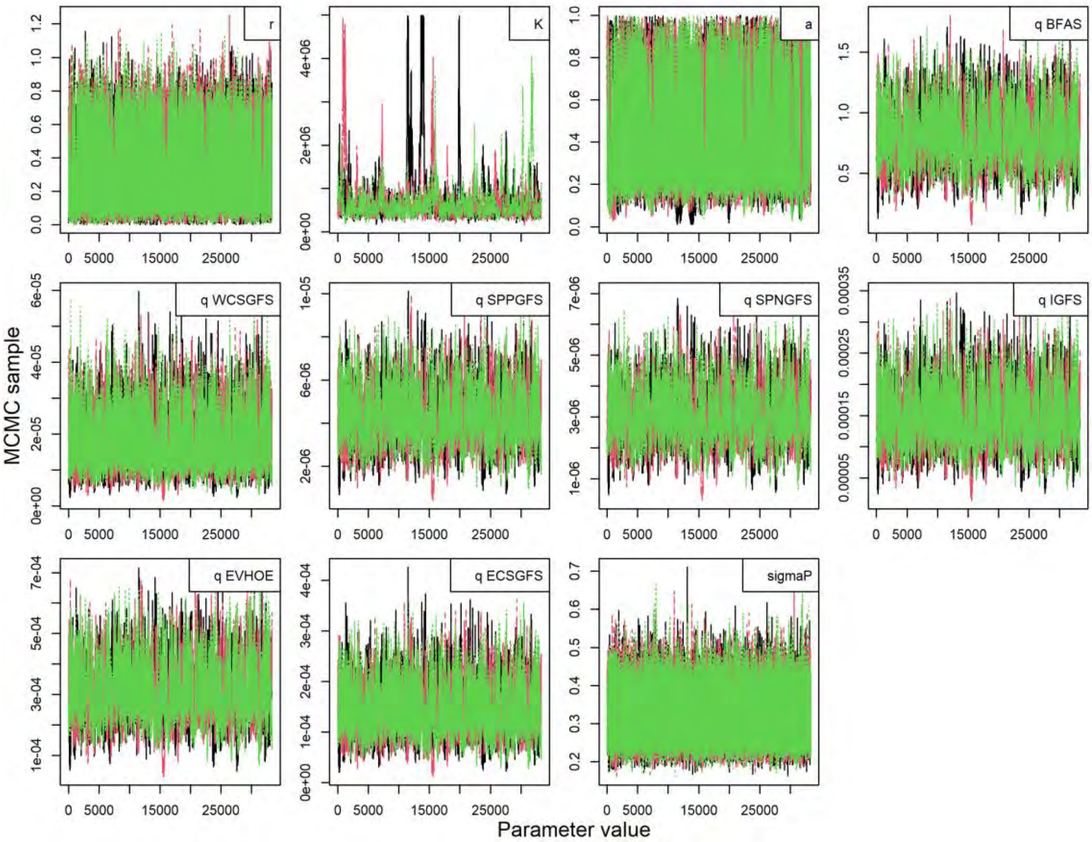

Figure 3.6.3.3. Boarfish in ICES Subareas 27.6, 7, 8. Parameters for final run converged with good mixing of the chains.

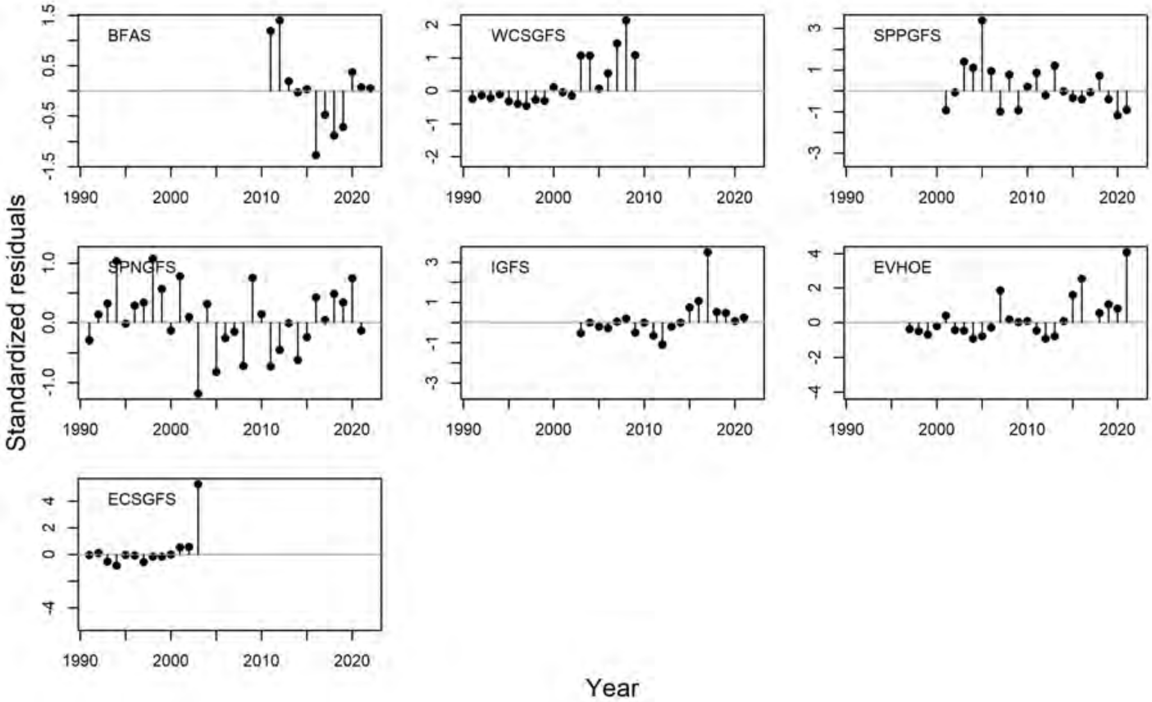

Figure 3.6.3.4. Boarfish in ICES Subareas 27.6, 7, 8. Residuals around the model fit for the final assessment run.

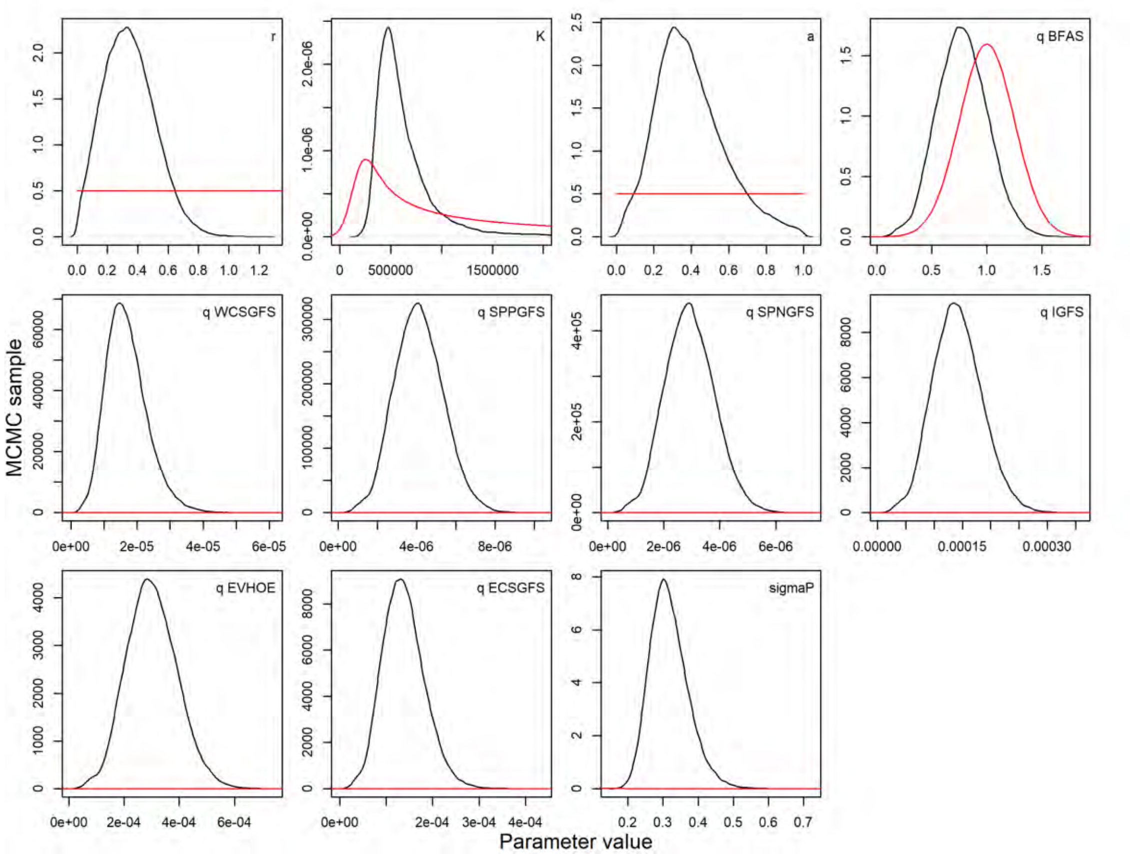

Figure 3.6.3.5. Boarfish in ICES Subareas 27.6, 7, 8. Prior (red) and posterior (black) distributions of the parameters of the biomass dynamic model.

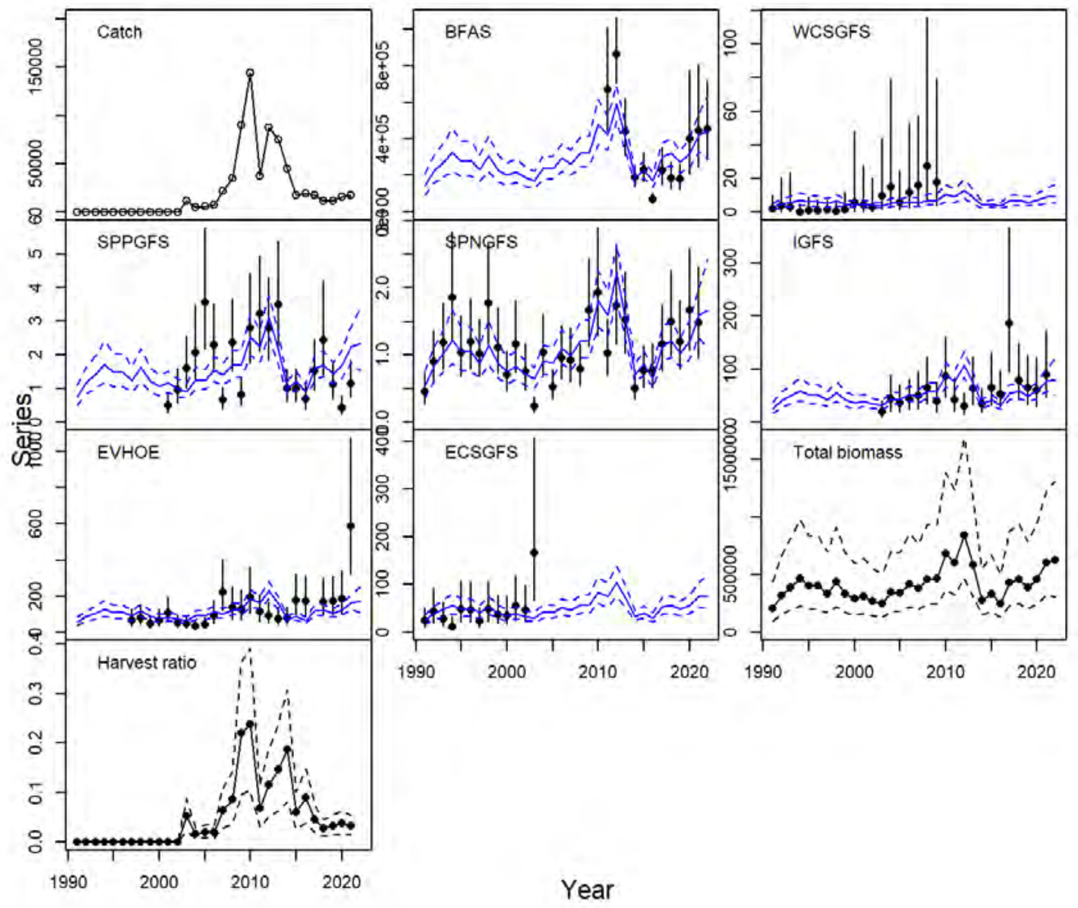

Figure 3.6.3.6. Boarfish in ICES Subareas 27.6, 7, 8. Trajectories of observed and expected indices for the final assessment run. The stock size over time and a harvest ratio (total catch divided by estimated biomass) are also shown.

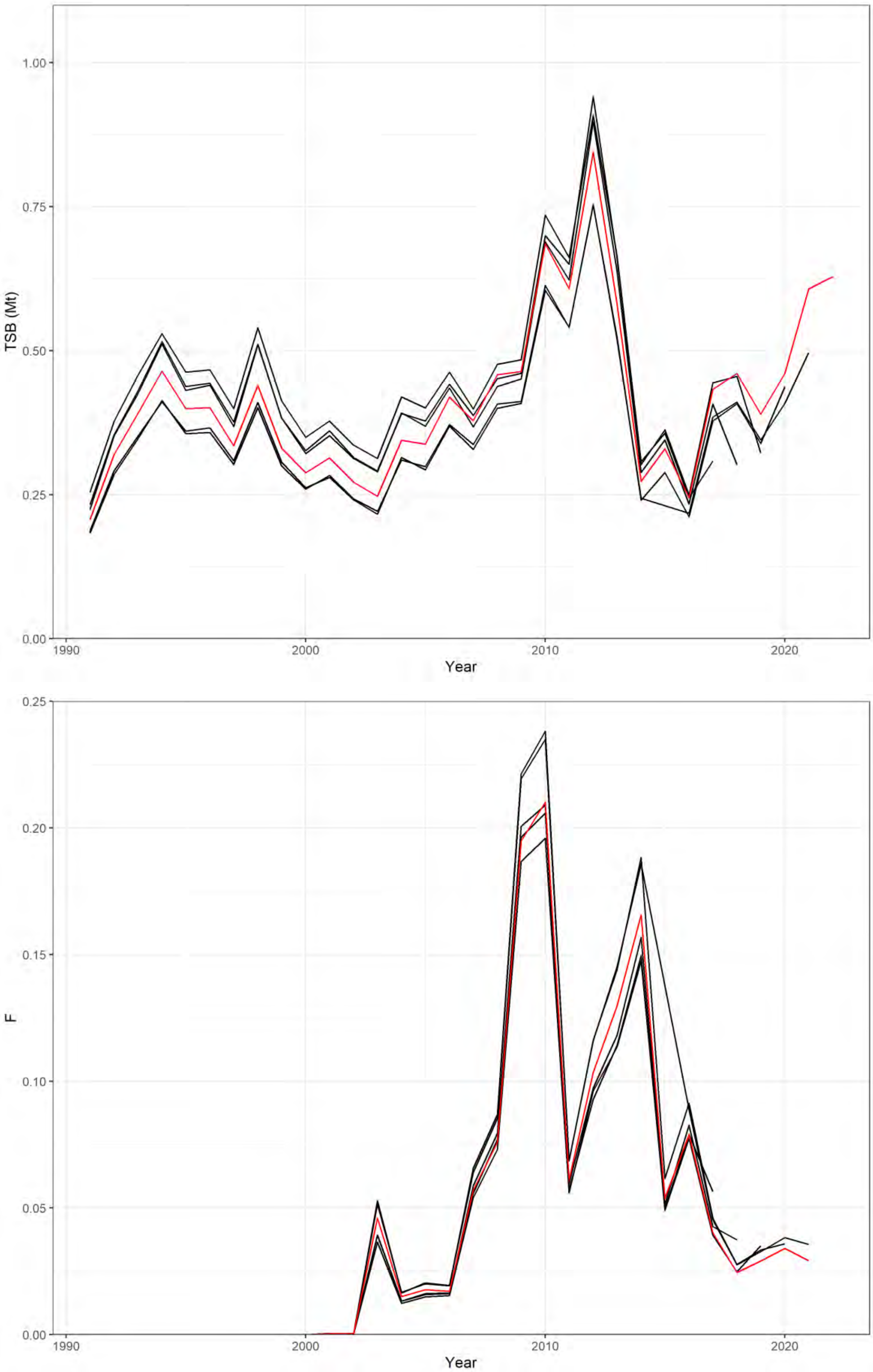

Figure 3.6.3.7. Boarfish in ICES Subareas 27.6, 7, 8. Retrospective plot of total stock biomass (above) and fishing mortality (below) from the surplus production model in 2013-2021.

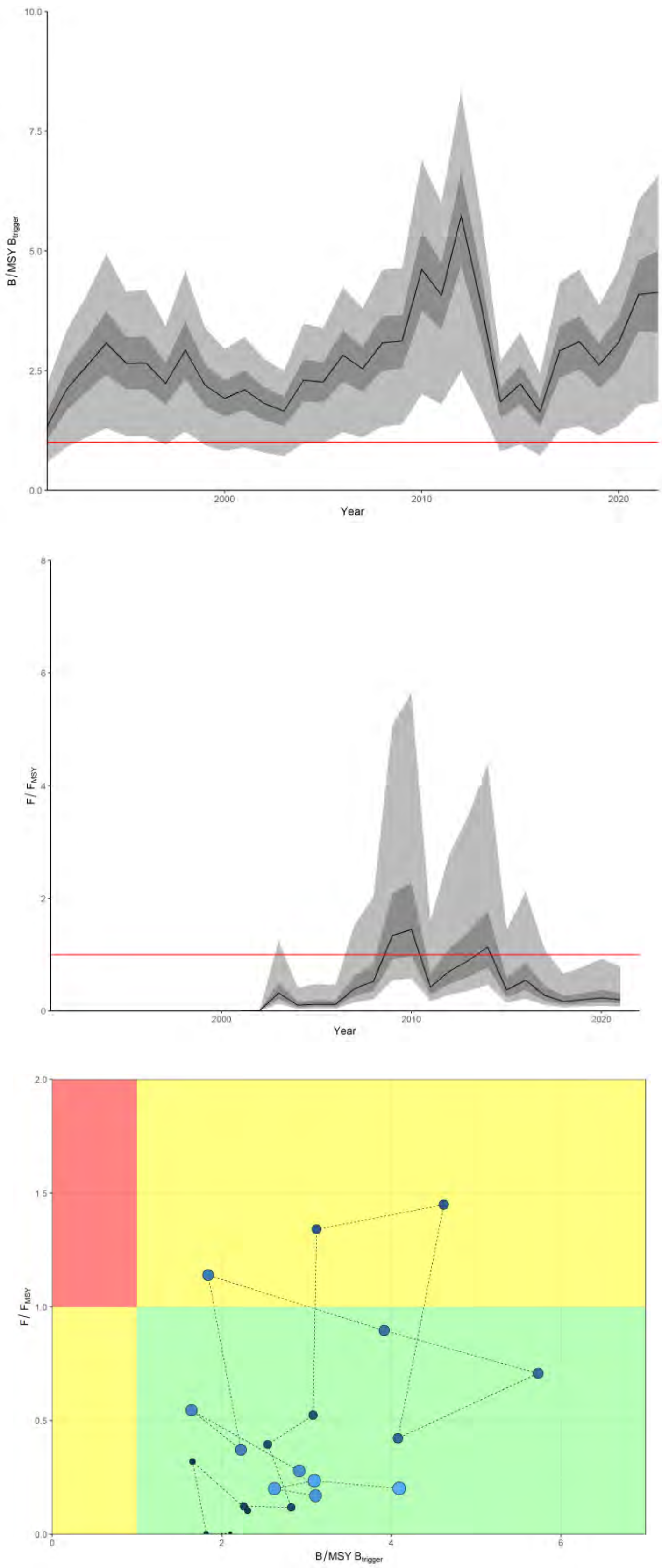

Figure 3.6.6.1. Boarfish in ICES Subareas 27.6, 7, 8. Ratios 'B / MSYBtrigger' and 'F / FMSY' through time and corresponding Kobe plot. Confidence intervals (50 and 95%) are given for the first two panels, the third displays median estimates only with the small dark blue point representing the first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

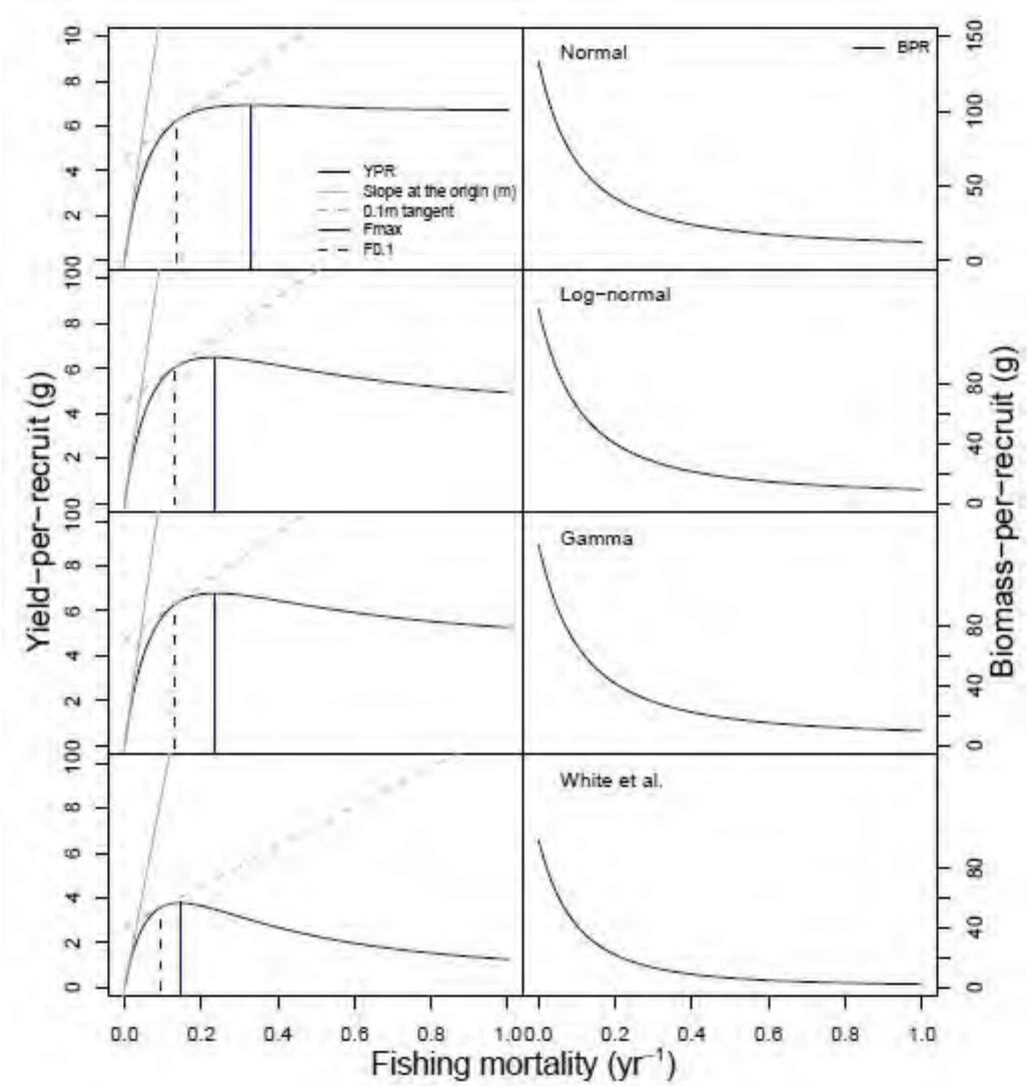

Figure 3.9.1.1. Boarfish in ICES Subareas 27.6, 7, 8. Results of exploratory yield per recruit analysis. Beverton and Holt model applied to various fits of the VBGF and for comparison with the VBGF parameters provided by White *et al*. 2011.

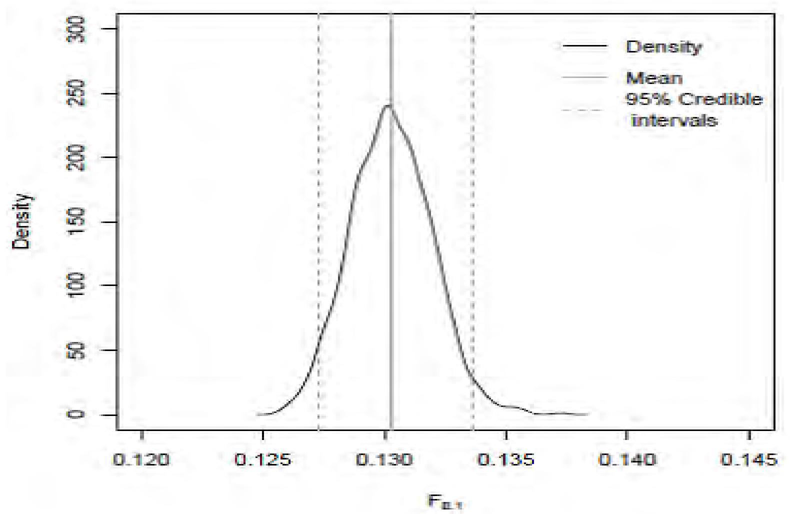

Figure 3.9.1.2. Boarfish in ICES Subareas 27.6, 7, 8. Sensitivity of estimation of F0.1.

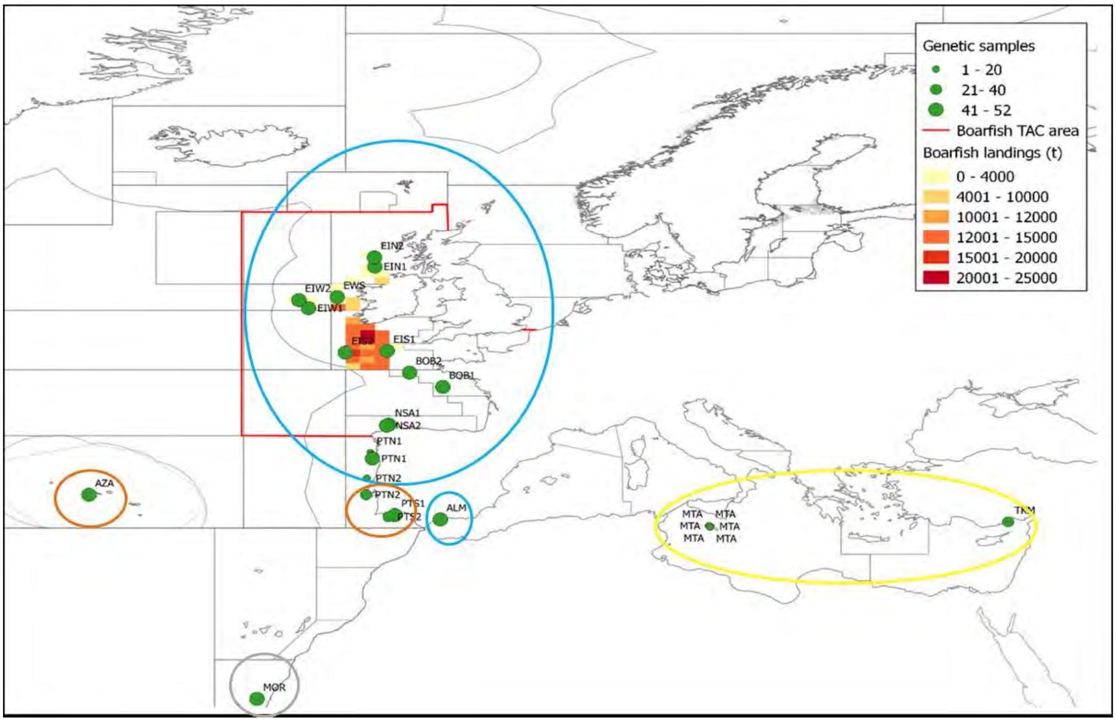

Figure 3.12.1. Boarfish in ICES Subareas 27.6, 7, 8. Boarfish samples included in the genetic stock identification study are indicated in green. Population clusters identified by the STRUCTURE analyses are indicated by colour coded circles.

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

4.1 ICES advice in 2021

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 2022 should be no more than 598 588 tonnes. The advice for 2022 was 8% lower than that for 2021.

4.2 The fishery in 2021

4.2.1 Description and development of the fisheries

The distribution of the 2021 Norwegian spring-spawning herring (NSSH) fishery 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 2021 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 and International waters and in early autumn commenced 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). 60% 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 20 347 tonnes in 2021, which represents 2% of the total catch. Note though that this does not include catches from the Russian Federation.

Since spatial and seasonal data were not available from the Russian fleet, Russian landings were not included in the description of the fisheries in 2021.

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. The large 2016 year-class has now entered the adult stock. The distribution of the 2016 year-class in the feeding area in 2022 as observed in the ecosystem survey in May appeared to be distributed throughout 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 similar pattern was observed during the winter 2021/2022. The old fish wintered in the Norwegian Sea while part of the 2016 year-class wintered in Kvænangen. From Norwegian catches during winter, it was, however observed that a large fraction of the 2016 year-class wintered in the ocean further north (north of 70°N). The oldest and largest fish move farthest south and west during feeding, and the older year classes were in May-July 2022 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 2021 were available from Denmark, Faroe Islands, Germany, Greenland, Iceland, Ireland, The Netherlands, Norway, Poland and Sweden. This year the only information available from Russia was total catch by ICES division from the ICES preliminary catches data base. The total working group catch in 2021 was 851 813 tonnes (Table 4.4.1.1) compared to the ICES-recommended catch of a maximum of 651 033 tonnes. The majority of the catches (around 85%) were taken in division 2.a as in previous years. Samples were not provided by Russia, Greenland, Ireland, Poland or Sweden. Sampled catches accounted for 88 % of the total catches, which is somewhat lower compared to previous years. The sampling levels of catches in 2021 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. Regarding the Russian catch, some assumptions were made in order to make it possible to handle these data using the existing method: see next paragraph. 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. Note that the cells with Russian catches were assumed unsampled, so sample information from other countries in the same cells were allocated.

4.4.1.1 Missing catch data in 2021

No Russian catch data or samples by ICES sub-division and quarter were delivered for 2021. The only information available on Russian catches in 2021 is from the ICES preliminary catches database for the entire year: 92840 tonnes in sub-division 2.a and 1 ton in 5.b, which corresponds to about 11% of total catches. Some assumptions regarding the spatial and temporal distribution of the Russian catches had to be made in order to make it possible to estimate numbers and weights at age for the total international catch, and it was decided to base these assumptions on data from the period 2018-2020. Figure 4.4.1.1.1 shows the proportion by quarter of the Russian catch within each of the years 2018-2020, and the proportions are quite constant between years with most of the catches taken in the last two quarters. Table 4.4.1.1.1 shows the proportion of Russian catches by ICES sub-division for the years 2018-2020 and in practice all the catch was taken in area 2.a. Figures 4.4.1.1.2 and 4.4.1.1.3 show the Russian catch by ICES rectangle compared with the corresponding total international catch; the Russian fishery has been conducted in the same areas as the other nation's fishery in 2018-2020. Based on these results it was decided to assume that the Russian catch in 2021 (taken from the ICES preliminary catch database) was taken in area 2.a and that the distribution by quarter corresponded to the average proportions in 2018-2020. The Russian catches in the different quarter-area cells were treated as unsampled and sample information from other nations was allocated to these according to the standard SALLOC procedure. Two additional figures are shown here that are relevant for the assumptions in the forecast: Figure 4.4.1.1.4 shows the Russian proportions of the total international catch per year in the period 2001-2020 and Figure 4.4.1.1.5 shows the Russian landings as a function of ICES advice for the period 2001-2020. The Russian proportions have been quite constant in recent years and there is a strong linear relationship between ICES advice and Russian landings.

4.4.2 Discards

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

The Working Group has not had access to comprehensive data to estimate discards of 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%.

In order to provide information on unaccounted mortality caused by fishing operations in the Norwegian fishery, Ipsos Public Affairs, in cooperation with IMR and the fishing industry, conducted a survey in January/February 2016. The survey was done by phoning skippers and interviewing them. A total of 146 herring skippers participated in the survey, 31 skippers representing the bigger vessel group and 115 skippers representing the smaller vessel group. The data provided an indication that there have been periods of increased occurrence of net bursting. This was seen especially in the period 2007–2010. There was, however, no trend in the size of catches where bursting has occurred.

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

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 2021, catches (in numbers) were dominated by the 2016 year-class which comprised around 50 % 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 2021 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 have generally been increasing in 2010–2013 but levelled off around 2014. In the most recent years the weight-at-age seems to have decreased slightly for most ages – earlier for the younger ages than for the older. The decrease from 2020 to 2021 was generally larger than the preceding years. A similar pattern is observed in weight-at-age in the stock which is presented in Figure 4.4.4.2 and Table 4.4.4.2. 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 2022 the year 2017 was updated with back-calculated values used in the present assessment. Assumed and updated values 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, and maturity at age 6 was set to 0.9 for this year-class in the 2022 assessment according to the table above. The maturity ogives used in the present assessment are presented in Table 4.4.5.1.

4.4.6 Natural mortality

In this year's assessment, the natural mortality M=0.15 was used for ages 3 and older and M=0.9 was used for ages 0–2. These levels of 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 (WD05) and spawning survey (WD04) in 2022 are available as working documents to this report. The spawning survey and IESNS in the Norwegian Sea were both carried out successfully in 2022, however, 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 2010-2021 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 2015–2021, for Fleet 4 estimates of sampling errors are available for 2009–2019 and 2021, and for Fleet 5 for 2008–2021. 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, 2016) where three assessment models were explored - TASACS, XSAM and one separable model. WKPELA accepted XSAM as the standard assessment tool for the NSSH.

4.5.1 XSAM final assessment 2022

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 2022 assessment, *i.e.* the catch prediction for 2022 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 2022 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.

The parameter estimates from the 2022 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 (2016). 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 -0.04 and -0.13 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, then a decrease in 2020 before an increase in 2021. 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 2022 assessment results are shown in Figure 4.5.1.9. The estimate of fishing mortality for 2019 to 2021 is rather high, as a response to the high catch in both 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 (F=0.129). The spawning stock shows a declining trend since 2009 but an increase in 2021 and then a small decrease in 2022, and the 95% confidence interval of the stock level in 2022 ranges from ~3.134 to ~4.6 million tonnes with a point estimate of 3.867 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.

4.5.2 Exploratory assessments

4.5.2.1 TASACS

TASACS was run according to the benchmark in 2008 using the VPA population model in the TASACS toolbox with the same model options as the benchmark (see Stock Annex). The information used in the TASACS run is catch data and survey data from eight surveys. The analysis was restricted to the years 1988–2022. The model was run with catch data from 1988 to 2021, and projected forwards through 2022 assuming Fs in 2022 equal to those in 2021, to include survey data from 2022. The larval survey (SSB fleet) was discontinued in 2017 and no new information is therefore available from this survey. Additionally, no new index was provided for fleet 7 since 2019 (0-group from the autumn survey in the Barents Sea) since this index was not updated by the survey group. This time series (0-group) is presently being re-calculated.

Residuals of the tuning series are shown in Figure 4.5.2.1.1. Particularly survey 8 (larval survey) seems to have a poor fit. This is seen as a block of positive residuals for this survey in later years. The residual plot for survey 5 (IESNS) also shows some pattern with consecutive series of negative and positive residuals indicating year-effects.

The results from TASACS are compared to those from XSAM and SAM in Figure 4.5.2.1.2. The time-series of SSB show similar trends for XSAM, SAM (configured as XSAM) and TASACS, although SSB in recent years are higher in TASACS due to an upward revision in the 2021 TASACS assessment. For most of the years, the estimates from TASACS are within the confidence limits estimated by XSAM except for the assessment year 2022 where the SSB from TASACS is slightly above the upper confidence limit. The SSB on 1 January 2022 is estimated by TASACS to be 4.63 million tonnes.

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 3.87 million tonnes which is above B_{pa} (3.184 million t). The spawning stock has been declining since 2009 but increased in 2021 followed by a decrease again in 2022. The SSB time-series from the 2022 assessment is consistent with the SSB time-series from the 2021 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 2022 assessment. Since there was no recruitment survey in 2022, the size of the 2020 year-class at age 2 was defined as the stochastic median recruitment in the time series. Fishing mortality in 2021 is estimated to be 0.168 which is above the management strategy F (0.140) that was used to give advice for 2021. A new management strategy was implemented for the 2019 advisory year.

4.8 NSSH Catch predictions for 2023

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 (2019-2021).

For the weight-at-age in the stock, the values for 2022 were obtained from the commercial fisheries in the wintering areas in January. For the years 2023 and 2024 the average of the last 3 years (2020-2022) 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 (1988-2021) 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 2021. Therefore, to obtain an estimate of the total catch to be used as input for the catch-constraint projections for 2022, the sum of the unilateral quotas was used. In total, the expected outtake from the stock in 2021 amounts to 827 963 tonnes. F in 2022 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 827 963 tonnes is taken in 2022, it is expected that the SSB will decrease from 3.867 million tonnes on 1 January in 2022 to 3.532 million tonnes in 2023. The weighted F over ages 5-12+ is 0.192. The model predicts that the catch in 2023 to be dominated by three age groups, age 7 (46%), age 10 (11%), and age 12+ (12%).

4.9 Comparison with previous assessment

A comparison between the assessments 2011-2022 is shown in Figure 4.9.1. In the years 2011-2015 the assessments were made with TASACS, whereas since 2016 XSAM has been applied, as accepted by WKPELA 2016. With the change of the assessment tool in 2016 the age of the recruitment changed from 0 to 2 and the age span in the reference F changed from 5-14 to 5-11. In WKNSSHREF (ICES, 2018a) this was further changed to 5-12+.

The table below shows the SSB (thousand tonnes) on 1 January in 2021 and weighted F in 2020 as estimated in 2021 and 2022.

	ICES 2021	WG 2022	%difference
SSB (2021)	3 765	3 930	4.4%
Weighted F (2020)	0.188	0.19	1.1%

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. The management strategy in use contains the following elements:

As a priority, the long-term management strategy shall ensure with high probability that the size of the spawning stock is maintained above B_{lim}.

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 (*i.e.* the TAC agreed by Coastal States) is to be set, the TAC shall be fixed to a fishing mortality of F_{mgt} = 0.14.

If F_{mgt} (0.14) 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 $B_{trigger}$.

If SSB is forecast to be lower than $B_{trigger}$ but above B_{lim} on the 1 January of the TAC-year, TAC is to be set using F, which decreases linearly from F_{mgt} to F = 0.05 over the biomass range from $B_{trigger}$ to B_{lim}.

The Coastal States Parties may transfer 10% of quotas between neighbouring years, except when SSB is less than B_{lim}; those years the management plan does not allow fishing of next year's quota.

The Coastal States Parties, on the basis of ICES advice, shall review the long-term management strategy at intervals not exceeding five years. The first such review shall take place no later than 2023.

A brief history of management strategies is in the stock annex. In general, the stock has been managed in compliance with the management strategy. There has, however, 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 2021 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 2021 assessment and resulted in an increase in SSB from 2020 to 2021. SSB, however, declined in 2022 and is predicted to be below B_{mgt} in 2024 even if the management strategy (F=0.14) is applied in 2023.

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 as a consequence of variation in migration pattern, prey density, stock size, size of year classes and stock sizes of competing stocks for resources and predators. Recent features of some of these ecosystem factors of relevance for the stock are summarized below.

- 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, 2022a), 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, 2022b). However, during the period, 2017-2020 the temperature remained relatively warm while the salinity had a marked decrease. 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. The extent of Arctic water continues to increase (ICES, 2022b).
- The sea temperature in 2022 was generally below the long-term mean (1995-2021) in the Norwegian Sea, but the pattern was more fragmented below 50 m depth. The Arctic front in the southern Norwegian Sea was more southerly and easterly located in 2022 compared to the long-term mean.
- In general, the herring stock has had a more westerly feeding distribution (ICES, 2022a; IESSNS survey report - 2022c) in the recent years than what was previously observed. In May 2022, the herring in west was more northerly distributed than in recent years. The large 2016 year -lass was now widely distributed into the south-western feeding area. 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, 2022c).
- 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 south western and north eastern fringe of Norwegian Sea (ICES, 2021b). Alternatively, the higher zooplankton biomass in the southwest could also attract the herring into this location, since zooplankton biomass is much lower in the north east (ICES, 2022b).
- 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 2022 (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 2022 most of the spawning stock was found outside Lofoten and Vesterålen, further north and more concentrated than usual. 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 5-8 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 of Lofoten and partly in the central Norwegian Sea, 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 2021 there was fishery in the central Norwegian Sea in the first quarter as well as the fourth.

Annual fishing pattern 2011-2020 is shown in Section 1.8.

4.14 Recommendations

For some years there have been issues with age reading of herring. WGWIDE has recommended organising a scale/otolith exchange and workshop. This workshop is now scheduled for April 2023 with a preceding exchange in winter 2022/2023.

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4.16 Tables

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

Year	Norway	USSR/ Russia	Denmark	Faroes	Iceland	Ireland	Netherlands	Greenland	UK	Germany	France	Poland	Sweden	Total
1972	13161	-	-	-	-	-	-	-	-	-	-	-	-	13161
1973	7017	-	-	-	-	-	-	-	-	-	-	-	-	7017
1974	7619	-	-	-	-	-	-	-	-	-	-	-	-	7619
1975	13713	-	-	-	-	-	-	-	-	-	-	-	-	13713
1976	10436	-	-	-	-	-	-	-	-	-	-	-	-	10436
1977	22706	-	-	-	-	-	-	-	-	-	-	-	-	22706
1978	19824	-	-	-	-	-	-	-	-	-	-	-	-	19824
1979	12864	-	-	-	-	-	-	-	-	-	-	-	-	12864
1980	18577	-	-	-	-	-	-	-	-	-	-	-	-	18577
1981	13736	-	-	-	-	-	-	-	-	-	-	-	-	13736
1982	16655	-	-	-	-	-	-	-	-	-	-	-	-	16655
1983	23054	-	-	-	-	-	-	-	-	-	-	-	-	23054
1984	53532	-	-	-	-	-	-	-	-	-	-	-	-	53532
1985	167272	2600	-	-	-	-	-	-	-	-	-	-	-	169872
1986	199256	26000	-	-	-	-	-	-	-	-	-	-	-	225256

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

***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 4.4.1.1.1 Proportion (%) of Russian catches by ICES sub-division for the years 2018-2020.

	1	2.a	5.b
2018	0	100	0
2019	0.04	98.33	1.64
2020	0	99.93	0.07

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

Table 4.4.1.3 Norwegian spring-spawning herring. Sampling coverage by country in 2021.

COUNTRY	OFFICIAL CATCH	% catch covered by sampling programme	NO. SAMPLES	NO. MEASURED	NO. AGED
Denmark	15854	100	11	1129	292
Faroe Islands	114291	98	17	958	861
Germany	3365	100	32	10555	337
Greenland	6456	0	0	0	0
Iceland	114299	100	55	2446	1958
Ireland	1793	0	0	0	0
The Netherlands	10939	100	12	1514	299
Norway	489632	100	80	2228	2228
Poland	1242	0	0	0	0
UK	0	0	0	0	0
Sweden	1101	0	0	0	0
Russia	92841	0	0	0	0
Total for Stock	851814	88	207	18830	5975

Table 4.4.1.4 Norwegian spring-spawning herring. Sampling coverage by ICES Division in 2021.

Area	Official Catch		No Samples	No Aged	No Measured	No Aged/ 1000 tonnes	No Measured/ 1000 tonnes
2.1	725400	161	4038	16763	6	23	
4.a	113	0	0	0	0	0	
5.a	126279	46	1937	2067	15	16	
5.b	21	0	0	0	0	0	
Total	851813	207	5975	18830	7	22	

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	2a	203631.8	
2	Norway	2	2a	168.2	1
3	Norway	3	2a	22706.5	
4	Norway	4	2a	263110	

Line	Country	Quarter	Div.	Catch (T)	Samples allocated (line)
5	Norway	3	4a	15.9	3
6	Iceland	2	2a	516	
7	Iceland	3	2a	6302	
8	Iceland	3	5a	57001	
9	Iceland	4	5a	50480	
10	Faroe Islands	1	2a	10574	
11	Faroe Islands	2	2a	163	6
12	Faroe Islands	3	2a	1800	3,7
13	Faroe Islands	4	2a	82935	
14	Faroe Islands	3	5a	49	8
15	Faroe Islands	4	5a	18749	
16	Faroe Islands	3	5b	21	3,7,8
17	Russia	1	2a	236.3	1,10
18	Russia	2	2a	58.4	6
19	Russia	3	2a	13868.4	3,7
20	Russia	4	2a	78677.9	4,13,21,23,24
21	Denmark	4	2a	15854.5	
22	Germany	3	2a	0.5	3,7
23	Germany	4	2a	3364.9	
24	Netherlands	4	2a	10939.1	
25	Greenland	3	2a	71.9	3,7
26	Greenland	4	2a	6384	4,13,21,23,24
27	Ireland	4	2a	1792.6	4,13,21,23,24
28	Poland	4	2a	1144.3	4,13,21,23,24
29	Poland	4	4a	97.4	4,13,21,23,24
30	Sweden	4	2a	1101	4,13,21,23,24

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

	AGE															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1966	3926500	662800	1678000	2048700	26900	466600	1306000	2884500	37900	14300	17400	26200	11000	69100	72100	556700
1967	426800	9877100	70400	1392300	3254000	26600	421300	1132000	1720800	8900	5700	3500	8500	8900	17500	104400
1968	1783600	437000	388300	99100	1880500	1387400	14220	94000	134100	345100	2000	1100	830	2500	2600	17000
1969	561200	507100	141900	188200	800	8800	4700	700	11700	33600	36000	300	200	200	200	2400
1970	119300	529400	33200	6300	18600	600	3300	3300	1000	13400	26200	28100	300	100	200	2000
1971	30500	42900	85100	1820	1020	1240	360	1110	1130	360	4410	6910	5450	0	20	120
1972	347100	41000	20400	35376	3476	3583	2481	694	1486	198	0	494	593	593	0	0
1973	29300	3500	1700	2389	25200	651	1506	278	178	0	0	0	0	0	180	0
1974	65900	7800	3900	100	241	24505	257	196	0	0	0	0	0	0	0	0
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

	AGE															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1983	127000	4680	1670	3183	21191	9521	6181	6823	1293	4598	7329	143	40	143	860	0
1984	33860	1700	2490	4483	5388	61543	18202	12638	15608	7215	16338	6478	0	0	0	1650
1985	28570	13150	207220	21500	15500	16500	130000	59000	55000	63000	10000	31000	50000	0	0	2640
1986	13810	1380	3090	539785	17594	14500	15500	105000	75000	42000	77000	19469	66000	80000	0	2470
1987	13850	6330	35770	19776	501393	18672	3502	7058	28000	12000	9500	4500	7834	6500	7000	450
1988	15490	2790	9110	62923	25059	550367	9452	3679	5964	14583	8872	2818	3356	2682	1560	540
1989	7120	1930	25200	2890	3623	5650	324290	3469	800	679	3297	1375	679	321	260	0
1990	1020	400	15540	18633	2658	11875	10854	226280	1289	1519	2036	2415	646	179	590	480
1991	100	3370	3330	8438	2780	1410	14698	8867	218851	2499	461	87	690	103	260	540
1992	1630	150	1340	12586	33100	4980	1193	11981	5748	225677	2483	639	247	1236	0	0
1993	6570	130	7240	28408	106866	87269	8625	3648	29603	18631	410110	0	0	0	0	0
1994	430	20	8100	32500	110090	363920	164800	15580	8140	37330	35660	645410	2830	460	100	2070
1995	0	0	1130	57590	346460	622810	637840	231090	15510	15850	69750	83740	911880	4070	250	450
1996	0	0	30140	34360	713620	1571000	940580	406280	103410	5680	7370	66090	17570	836550	0	0
1997	0	0	21820	130450	270950	1795780	1993620	761210	326490	60870	20020	32400	90520	19120	370330	300
1998	0	0	82891	70323	242365	368310	1760319	1263750	381482	129971	42502	25343	3478	112604	5633	108514
1999	0	0	5029	137626	35820	134813	429433	1604959	1164263	291394	106005	14524	40040	7202	88598	63983

	AGE														
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2000	0	0	14395	84016	560379	34933	110719	404460	1299253	1045001	216980	71589	16260	22701	23321	71811
2001	0	0	2076	102293	160678	426822	38749	95991	296460	839136	507106	73673	23722	3505	3356	22164
2002	0	0	62031	198360	643161	255516	326495	29843	93530	264675	663059	339326	52922	12437	7000	10087
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

	AGE														
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2017	0	618	16390	64275	305483	114976	248192	162566	289931	98836	133145	276874	107473	220368	22357	49442
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

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

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

**** 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
1978	0	0	0	0.2	0.9	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+
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
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

Year/Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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	0.4	0.8	1	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

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

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

	age				
Year	1	2	3	4	5
2017	14.522	3.080	0.000	0.000	
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***					

***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

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	0.366	0.190	0.260	0.092	0.361	0.497	0.422	0.312	0.369	0.544	0.380
1989	0.259	0.539	0.499	0.430	0.109	0.507	0.832	0.879	0.515	0.693	0.713
1990	0.305	0.287	0.554	0.334	0.345	0.124	0.708	0.670	0.607	0.573	0.622
1991	0.514	0.375	0.546	0.687	0.311	0.369	0.125	0.566	1.002	1.760	0.659
1992	0.699	0.328	0.237	0.448	0.727	0.333	0.427	0.124	0.567	0.897	0.675
1993	0.395	0.249	0.159	0.170	0.373	0.498	0.246	0.287	0.101	NA	NA
1994	0.381	0.238	0.158	0.105	0.138	0.305	0.380	0.227	0.231	0.087	0.435
1995	0.740	0.196	0.107	0.088	0.087	0.123	0.306	0.303	0.184	0.173	0.077
1996	0.244	0.234	0.084	0.064	0.076	0.101	0.161	0.429	0.393	0.187	0.079
1997	0.272	0.149	0.116	0.061	0.059	0.082	0.109	0.193	0.280	0.238	0.096
1998	0.173	0.183	0.121	0.105	0.062	0.069	0.104	0.149	0.217	0.259	0.123
1999	0.447	0.146	0.230	0.147	0.100	0.064	0.071	0.113	0.160	0.312	0.129
2000	0.313	0.173	0.091	0.232	0.157	0.102	0.068	0.074	0.125	0.182	0.147
2001	0.603	0.162	0.139	0.100	0.224	0.165	0.113	0.079	0.094	0.181	0.202
2002	0.191	0.129	0.087	0.119	0.109	0.245	0.167	0.117	0.086	0.108	0.174
2003	0.463	0.179	0.109	0.083	0.135	0.137	0.268	0.180	0.125	0.091	0.116
2004	0.215	0.263	0.167	0.100	0.084	0.157	0.146	0.254	0.202	0.136	0.086
2005	0.278	0.098	0.166	0.136	0.087	0.077	0.152	0.152	0.226	0.188	0.088
2006	0.213	0.179	0.083	0.174	0.136	0.083	0.082	0.170	0.178	0.244	0.103
2007	0.375	0.124	0.105	0.061	0.141	0.121	0.083	0.094	0.210	0.259	0.138
2008	0.151	0.229	0.092	0.086	0.056	0.129	0.119	0.090	0.105	0.246	0.143
2009	0.156	0.130	0.142	0.070	0.077	0.060	0.144	0.118	0.100	0.121	0.147
2010	0.192	0.162	0.127	0.131	0.073	0.084	0.066	0.135	0.133	0.108	0.119
2011	0.120	0.192	0.160	0.122	0.127	0.082	0.092	0.087	0.168	0.154	0.129
2012	0.324	0.126	0.206	0.153	0.115	0.117	0.083	0.111	0.106	0.202	0.151
2013	0.277	0.193	0.115	0.183	0.156	0.114	0.121	0.089	0.136	0.144	0.209
2014	0.682	0.249	0.196	0.118	0.205	0.182	0.130	0.143	0.104	0.173	0.176
2015	0.518	0.301	0.198	0.203	0.141	0.234	0.188	0.140	0.161	0.129	0.173

Year/Age	2	3	4	5	6	7	8	9	10	11	12+
2016	0.578	0.212	0.216	0.157	0.171	0.138	0.203	0.181	0.135	0.165	0.118
2017	0.300	0.189	0.112	0.155	0.120	0.138	0.114	0.163	0.148	0.115	0.102
2018	0.270	0.258	0.194	0.117	0.142	0.134	0.158	0.133	0.171	0.163	0.094
2019	0.591	0.142	0.189	0.132	0.091	0.143	0.125	0.153	0.137	0.148	0.092
2020	0.378	0.207	0.092	0.183	0.142	0.101	0.154	0.140	0.166	0.131	0.099
2021	0.576	0.260	0.157	0.066	0.138	0.128	0.107	0.154	0.150	0.181	0.115

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	0.316	0.334	0.161	0.449	0.549	0.687	0.538	0.600	0.512	NA
1989	0.645	0.327	0.438	0.189	0.427	0.687	0.878	0.489	NA	0.489
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	0.428	0.505	0.266	0.302	0.477	0.675	0.395	0.502	0.224	0.752
1995	0.306	0.182	0.198	0.221	0.336	0.613	NA	0.423	0.489	0.212
1996	0.373	0.220	0.161	0.212	0.264	0.335	NA	NA	0.400	0.226
1997	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1998	0.333	0.258	0.201	0.145	0.161	0.224	0.288	0.384	0.517	0.227
1999	0.233	0.320	0.240	0.206	0.156	0.166	0.229	0.298	0.404	0.275
2000	0.278	0.207	0.420	0.302	0.249	0.185	0.203	0.300	0.500	0.353
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	0.353	0.281	0.217	0.172	0.160	0.286	0.299	0.388	0.436	0.212
2006	0.439	0.172	0.293	0.264	0.196	0.196	0.419	0.443	0.613	0.305
2007	0.321	0.230	0.146	0.268	0.282	0.201	0.198	0.397	0.357	0.257
2008	0.505	0.208	0.203	0.158	0.296	0.303	0.232	0.232	0.385	0.312

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	0.295	0.205	0.274	0.197	0.317	0.278	0.205	0.271	0.165	0.213
2016	0.368	0.353	0.288	0.321	0.217	0.352	0.297	0.202	0.282	0.178
2017	0.419	0.252	0.283	0.264	0.310	0.241	0.375	0.365	0.219	0.192
2018	0.394	0.227	0.204	0.305	0.266	0.283	0.251	0.307	0.320	0.195
2019	0.320	0.333	0.260	0.191	0.273	0.264	0.281	0.253	0.275	0.183
2020	0.514	0.194	0.291	0.246	0.196	0.295	0.286	0.321	0.282	0.222
2021	0.418	0.337	0.153	0.275	0.274	0.221	0.310	0.306	0.332	0.220
2022	0.461	0.385	0.273	0.170	0.331	0.291	0.234	0.335	0.301	0.232

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
2003	NA

Year/Age	2
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

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	0.347	0.774	0.912	0.44	0.216
1997	0.273	0.21	0.142	0.153	0.229	0.248	0.425	0.518	0.38	0.22
1998	0.359	0.277	0.2	0.147	0.164	0.239	0.298	0.423	NA	0.329
1999	0.236	0.37	0.286	0.218	0.159	0.185	0.294	0.39	0.987	0.376
2000	0.264	0.223	0.497	0.355	0.266	0.178	0.191	0.25	0.385	0.42
2001	0.172	0.26	0.259	0.425	0.412	0.215	0.19	0.27	0.495	0.422
2002	0.183	0.166	0.261	0.301	0.357	0.295	0.242	0.228	0.261	0.432
2003	0.182	0.165	0.165	0.258	0.305	0.446	0.401	0.245	0.231	0.239

Year/Age	3	4	5	6	7	8	9	10	11	12+
2004	0.256	0.192	0.156	0.162	0.279	0.322	0.52	0.373	0.36	0.228
2005	0.14	0.264	0.248	0.184	0.191	0.313	0.354	0.451	0.388	0.24
2006	0.375	0.151	0.262	0.24	0.182	0.179	0.31	0.307	0.428	0.236
2007	0.221	0.187	0.139	0.268	0.241	0.181	0.189	0.314	0.336	0.222
2008	0.313	0.161	0.172	0.15	0.256	0.235	0.195	0.223	0.332	0.277
2009	0.246	0.233	0.157	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	0.35	0.312	0.249	0.226	0.201	0.244	0.237	0.377	0.278
2013	0.306	0.21	0.347	0.274	0.245	0.22	0.199	0.223	0.245	0.247
2014	0.268	0.3	0.223	0.307	0.276	0.226	0.234	0.222	0.276	0.265
2015	0.345	0.266	0.275	0.21	0.266	0.272	0.216	0.228	0.199	0.241
2016	0.21	0.256	0.235	0.248	0.226	0.288	0.278	0.247	0.244	0.2
2017	0.287	0.201	0.272	0.256	0.296	0.261	0.371	0.304	0.283	0.197
2018	0.283	0.242	0.188	0.285	0.261	0.324	0.267	0.362	0.311	0.194
2019	0.226	0.31	0.236	0.197	0.274	0.27	0.287	0.27	0.297	0.207
2020	0.338	0.155	0.332	0.283	0.229	0.3	0.316	0.345	0.309	0.229
2021	0.277	0.267	0.158	0.308	0.28	0.24	0.333	0.326	0.337	0.218
2022	0.355	0.271	0.267	0.166	0.274	0.252	0.239	0.323	0.366	0.282

Table 4.5.1.1. Norwegian spring-spawning herring. Parameter estimates of the final XSAM model fit. The estimates from the final 2021 assessment are also shown.

Parameter	Estimate	Std. Error	CV	Estimate 2021	Std. Error 2021
$\log(N_{3,1988})$	7.088	0.164	0.023	7.087	0.167
$\log(N_{4,1988})$	6.631	0.203	0.031	6.621	0.206
$\log(N_{5,1988})$	9.584	0.066	0.007	9.584	0.069
$\log(N_{6,1988})$	4.837	0.380	0.079	4.825	0.381
$\log(N_{7,1988})$	3.527	0.532	0.151	3.518	0.529
$\log(N_{8,1988})$	3.079	0.594	0.193	3.087	0.591
$\log(N_{9,1988})$	4.073	0.455	0.112	4.076	0.457

Parameter	Estimate	Std. Error	CV	Estimate 2021	Std. Error 2021
$\log(N_{10,1988})$	3.282	0.669	0.204	3.286	0.667
$\log(N_{11,1988})$	3.191	0.691	0.216	3.180	0.695
$\log(N_{12,1988})$	3.585	0.753	0.210	3.578	0.753
$\log(q_3^{F1})$	-9.657	0.173	0.018	-9.669	0.179
$\log(q_4^{F1})$	-8.143	0.124	0.015	-8.108	0.128
$\log(q_5^{F1})$	-7.487	0.111	0.015	-7.474	0.115
$\log(q_6^{F1})$	-7.283	0.110	0.015	-7.296	0.117
$\log(q_7^{F1})$	-7.165	0.123	0.017	-7.152	0.128
$\log(q_8^{F1})$	-6.926	0.086	0.012	-6.939	0.091
$\log(q_2^{F4})$	-14.525	0.189	0.013	-14.515	0.193
$\log(q_3^{F5})$	-7.654	0.105	0.014	-7.653	0.107
$\log(q_4^{F5})$	-7.133	0.093	0.013	-7.123	0.095
$\log(q_5^{F5})$	-6.913	0.091	0.013	-6.904	0.093
$\log(q_6^{F5})$	-6.796	0.094	0.014	-6.805	0.097
$\log(q_7^{F5})$	-6.721	0.101	0.015	-6.734	0.103
$\log(q_8^{F5})$	-6.541	0.106	0.016	-6.557	0.109
$\log(q_9^{F5})$	-6.537	0.118	0.018	-6.543	0.121
$\log(q_{10}^{F5})$	-6.474	0.132	0.020	-6.490	0.135
$\log(q_{11}^{F5})$	-6.433	0.126	0.020	-6.433	0.131
$\log(\sigma_1^2)$	-5.000	1.409	0.282	-5.000	1.441
$\log(\sigma_2^2)$	-2.777	0.243	0.088	-2.769	0.256
$\log(\sigma_4^2)$	-2.281	0.299	0.131	-2.250	0.303
$\log(\sigma_R^2)$	-0.022	0.255	11.598	-0.008	0.275
$\log(h)$	1.565	0.063	0.040	1.595	0.065
μ_R	9.275	0.176	0.019	9.275	0.180
α_Y	-0.492	0.294	0.596	-0.513	0.300
β_Y	0.816	0.107	0.131	0.810	0.108
α_{2U}	-1.239	0.164	0.133	-1.242	0.167

Parameter	Estimate	Std. Error	CV	Estimate 2021	Std. Error 2021
α_{3U}	-0.629	0.095	0.151	-0.620	0.096
α_{4U}	-0.215	0.059	0.273	-0.214	0.060
α_{5U}	0.054	0.049	0.916	0.043	0.051
α_{6U}	0.199	0.054	0.271	0.196	0.055
α_{7U}	0.263	0.058	0.222	0.264	0.060
α_{8U}	0.319	0.065	0.203	0.327	0.066
α_{9U}	0.368	0.070	0.191	0.368	0.072
α_{10U}	0.419	0.076	0.182	0.420	0.078
β_U	0.603	0.052	0.086	0.603	0.053

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	672	1197	759	14529	126	34	22	59	27	24	36
1989	1173	260	967	635	12012	104	28	16	40	16	44
1990	4339	471	219	818	531	10012	86	22	13	30	47
1991	11466	1758	401	186	687	444	8370	71	18	10	62
1992	18683	4656	1505	341	157	577	372	6977	58	15	59
1993	50101	7589	3992	1278	286	131	482	310	5769	47	59
1994	59953	20347	6502	3367	1041	231	106	389	249	4571	83
1995	15751	24339	17426	5476	2632	778	177	83	301	187	3436
1996	5722	6386	20794	14597	4174	1750	507	128	60	207	2243
1997	2152	2315	5420	17205	11160	2798	1122	333	89	41	1353
1998	10941	868	1919	4366	13115	7770	1742	659	207	54	754
1999	6461	4417	715	1480	3371	9610	5447	1117	410	122	458
2000	32626	2615	3680	557	1130	2504	6817	3652	698	243	299
2001	28927	13217	2189	2739	416	830	1788	4661	2248	406	267
2002	11339	11726	11211	1742	2003	311	615	1286	3236	1483	446
2003	6678	4590	9908	9050	1282	1405	226	432	873	2155	1284
2004	57658	2707	3888	8191	7103	944	1027	164	303	587	2247
2005	24428	23396	2301	3240	6622	5467	703	745	119	213	1753

Year/Age	2	3	4	5	6	7	8	9	10	11	12+
2006	43044	9907	19779	1895	2590	5071	3862	479	504	78	1122
2007	12127	17457	8425	16363	1524	2027	3714	2639	331	349	695
2008	17706	4911	14809	6936	12530	1154	1484	2526	1747	222	705
2009	7109	7141	4155	12207	5361	8717	815	1022	1613	1102	614
2010	5074	2851	5979	3412	9431	3809	5662	546	635	963	1055
2011	15315	2035	2376	4915	2719	7112	2651	3524	341	390	1095
2012	5658	6144	1700	1950	3964	2124	5363	1798	2352	222	939
2013	8319	2287	5142	1403	1569	3140	1623	3936	1265	1644	813
2014	5491	3370	1928	4213	1130	1244	2446	1211	2875	913	1917
2015	17709	2228	2868	1609	3420	916	997	1924	927	2162	2259
2016	7341	7190	1902	2414	1330	2791	746	799	1521	717	3525
2017	4432	2980	6134	1595	1979	1068	2229	590	622	1158	3288
2018	39850	1797	2521	5028	1264	1483	789	1622	427	428	3167
2019	5149	16169	1527	2097	4059	965	1120	588	1204	308	2521
2020	4358	2088	13732	1257	1649	3012	706	791	413	847	1786
2021	1958	1766	1767	11303	990	1245	2203	504	545	282	1693
2022	10671	793	1491	1431	8497	716	882	1547	331	353	1346

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	0.050	0.064	0.029	0.040	0.042	0.042	0.142	0.224	0.334	0.170	0.170
1989	0.012	0.021	0.018	0.028	0.032	0.035	0.077	0.110	0.152	0.092	0.092
1990	0.004	0.012	0.015	0.024	0.030	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	0.044	0.057	0.050	0.050
1992	0.001	0.004	0.013	0.025	0.031	0.031	0.035	0.040	0.055	0.058	0.058
1993	0.001	0.005	0.020	0.055	0.063	0.059	0.063	0.068	0.083	0.105	0.105
1994	0.002	0.005	0.022	0.096	0.142	0.116	0.099	0.107	0.135	0.153	0.153
1995	0.003	0.007	0.027	0.121	0.258	0.278	0.175	0.171	0.223	0.330	0.330
1996	0.005	0.014	0.039	0.118	0.250	0.295	0.271	0.213	0.244	0.444	0.444
1997	0.008	0.038	0.066	0.121	0.212	0.324	0.382	0.325	0.352	0.464	0.464

Year/Age	2	3	4	5	6	7	8	9	10	11	12+
1998	0.007	0.044	0.109	0.109	0.161	0.205	0.294	0.326	0.378	0.417	0.417
1999	0.004	0.032	0.100	0.120	0.147	0.193	0.250	0.321	0.373	0.514	0.514
2000	0.004	0.028	0.145	0.141	0.158	0.187	0.230	0.335	0.391	0.557	0.557
2001	0.003	0.015	0.078	0.163	0.141	0.150	0.180	0.215	0.266	0.262	0.262
2002	0.004	0.018	0.064	0.157	0.205	0.171	0.204	0.237	0.256	0.257	0.257
2003	0.003	0.016	0.040	0.092	0.156	0.163	0.170	0.203	0.248	0.276	0.276
2004	0.002	0.013	0.032	0.063	0.112	0.145	0.172	0.174	0.204	0.330	0.330
2005	0.002	0.018	0.044	0.074	0.117	0.197	0.234	0.240	0.266	0.411	0.411
2006	0.002	0.012	0.040	0.068	0.095	0.161	0.231	0.220	0.219	0.396	0.396
2007	0.004	0.015	0.045	0.117	0.128	0.162	0.236	0.262	0.248	0.242	0.242
2008	0.008	0.017	0.043	0.108	0.213	0.199	0.224	0.298	0.311	0.262	0.262
2009	0.014	0.028	0.047	0.108	0.192	0.281	0.250	0.326	0.366	0.336	0.336
2010	0.013	0.032	0.046	0.077	0.132	0.213	0.324	0.321	0.337	0.462	0.462
2011	0.013	0.030	0.048	0.065	0.097	0.132	0.238	0.254	0.281	0.308	0.308
2012	0.006	0.028	0.043	0.067	0.083	0.119	0.159	0.202	0.208	0.205	0.205
2013	0.004	0.021	0.049	0.066	0.082	0.100	0.143	0.164	0.177	0.098	0.098
2014	0.002	0.011	0.031	0.059	0.060	0.071	0.090	0.117	0.135	0.075	0.075
2015	0.001	0.008	0.022	0.040	0.053	0.055	0.072	0.085	0.107	0.077	0.077
2016	0.002	0.009	0.026	0.049	0.069	0.075	0.084	0.100	0.123	0.105	0.105
2017	0.003	0.017	0.049	0.082	0.138	0.152	0.168	0.173	0.225	0.189	0.189
2018	0.002	0.013	0.034	0.064	0.120	0.130	0.145	0.148	0.175	0.205	0.205
2019	0.003	0.013	0.044	0.090	0.148	0.163	0.198	0.203	0.202	0.310	0.310
2020	0.003	0.017	0.045	0.089	0.131	0.163	0.187	0.222	0.231	0.292	0.292
2021	0.004	0.019	0.061	0.135	0.174	0.195	0.203	0.269	0.284	0.233	0.233
2022	0.004	0.018	0.054	0.113	0.152	0.175	0.191	0.236	0.257	0.269	0.269

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 thousnd tonnes	High	Low	Catches thousand tonnes	Fishing Pressure: F Ages 5-12	High	Low
1988	672	996	349	2126	2389	1863	135.301	0.042	0.058	0.026
1989	1173	1653	693	3287	3694	2881	103.830	0.033	0.046	0.019
1990	4339	5358	3320	3562	3993	3131	86.411	0.029	0.042	0.017
1991	11466	13340	9592	3340	3743	2937	84.683	0.031	0.044	0.018
1992	18683	21308	16058	3368	3753	2982	104.448	0.039	0.054	0.023
1993	50101	55342	44859	3340	3687	2993	232.457	0.076	0.100	0.053
1994	59953	65811	54096	3471	3817	3125	479.228	0.129	0.160	0.099
1995	15751	18082	13419	3536	3868	3205	905.501	0.219	0.259	0.179
1996	5722	6843	4601	4118	4450	3787	1220.283	0.192	0.223	0.162
1997	2152	2716	1587	5374	5765	4984	1426.507	0.193	0.220	0.166
1998	10941	12719	9163	5954	6383	5526	1223.131	0.186	0.214	0.158
1999	6461	7677	5246	5854	6304	5403	1235.433	0.214	0.247	0.180
2000	32626	36501	28751	4873	5287	4458	1207.201	0.257	0.300	0.215
2001	28927	32527	25328	4043	4416	3669	766.136	0.204	0.241	0.167
2002	11339	13212	9465	3565	3913	3218	807.795	0.224	0.265	0.183
2003	6678	7956	5399	4189	4571	3806	789.510	0.153	0.181	0.125
2004	57658	63732	51584	5269	5734	4805	794.066	0.129	0.152	0.105
2005	24428	27784	21072	5389	5880	4898	1003.243	0.174	0.204	0.143
2006	43044	48247	37840	5350	5832	4868	968.958	0.178	0.211	0.145
2007	12127	14277	9976	6882	7471	6294	1266.993	0.157	0.184	0.130
2008	17706	20549	14863	6965	7584	6346	1545.656	0.202	0.235	0.169
2009	7109	8536	5681	6937	7588	6285	1687.373	0.207	0.239	0.174
2010	5074	6171	3977	6154	6775	5533	1457.014	0.215	0.251	0.178
2011	15315	17846	12785	5824	6450	5198	992.998	0.158	0.188	0.129
2012	5658	6812	4504	5673	6312	5034	825.999	0.142	0.169	0.115
2013	8319	9879	6760	5307	5926	4687	684.743	0.122	0.147	0.097

Year	Recruitment (Age 2) millions	High	Low	Stock Size: SSB thousnd tonnes	High	Low	Catches thousand tonnes	Fishing Pressure: F Ages 5-12	High	Low
2014	5491	6681	4300	5123	5741	4506	461.306	0.086	0.105	0.067
2015	17709	20913	14504	4772	5360	4183	328.740	0.068	0.085	0.052
2016	7341	9094	5588	4220	4750	3690	383.174	0.086	0.106	0.066
2017	4432	5752	3113	4091	4596	3585	721.566	0.162	0.196	0.127
2018	39850	48793	30907	4110	4630	3590	592.899	0.129	0.157	0.100
2019	5149	7231	3066	3934	4463	3406	777.165	0.187	0.228	0.147
2020	4358	6757	1958	3393	3895	2891	720.937	0.190	0.236	0.144
2021	1958	3768	148	3930	4555	3304	851.813	0.168	0.208	0.127
2022	10671	31681	0	3867	4600	3134	NA	NA	NA	NA
Average	16011	19044	13273	4605	5091	4120	790.000	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	2022							
	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	10671	0.90	0.0	0	0	0.054	0.004	0.162
3	793	0.15	0.0	0	0	0.104	0.020	0.202
4	1491	0.15	0.4	0	0	0.125	0.059	0.233
5	1431	0.15	0.8	0	0	0.168	0.124	0.266
6	8497	0.15	0.9	0	0	0.243	0.167	0.294
7	716	0.15	1.0	0	0	0.287	0.191	0.321
8	882	0.15	1.0	0	0	0.303	0.209	0.338
9	1547	0.15	1.0	0	0	0.323	0.258	0.365
10	331	0.15	1.0	0	0	0.352	0.281	0.375
11	353	0.15	1.0	0	0	0.366	0.294	0.394
12	1346	0.15	1.0	0	0	0.389	0.294	0.418
2	10671	0.90	0.0	0	0	0.054	0.014	0.162
3		0.15	0.0	0	0	0.104	0.066	0.202
4		0.15	0.4	0	0	0.145	0.192	0.233
5		0.15	0.8	0	0	0.193	0.395	0.266

Input for	2022							
	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
6		0.15	1.0	0	0	0.258	0.547	0.294
7		0.15	1.0	0	0	0.291	0.633	0.321
8		0.15	1.0	0	0	0.311	0.705	0.338
9		0.15	1.0	0	0	0.330	0.842	0.365
10		0.15	1.0	0	0	0.354	0.933	0.375
11		0.15	1.0	0	0	0.366	1.000	0.394
12		0.15	1.0	0	0	0.386	1.000	0.418

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

Basis:	
SSB (2022):	3.867 million t
Landings(2022):	827 963 t (sum of national quotas)
SSB(2023):	3.532 million t
Fw5-12+(2022)	0.192
Recruitment(2022-2024):	10.671,10.671,10.671

The catch options:

Rationale	Catches (2023)	Basis	FW (2023)	SSB (2024)*	P(SSB2024 <Blim)	% SSB change*	%TAC change	%CATCH change
Management strategy	511171	F=0.14	0.14(0.109, 0.184)	3147.97(2346.187, 4370.752)	0.072	-10.863(-34,24)	-14.6	-38
Fmsy	568410	F=0.157	0.157(0.122, 0.205)	3098.334(2311.504, 4137.013)	0.085	-12.268(-35,17)	-5	-31
Zero Catch	0	F=0.0	0(0, 0)	3592.99(2805.748, 4706.388)	0.001	1.738(-21,33)	-100	-100
Fpa	568410	F=0.157	0.157(0.123, 0.208)	3098.334(2310.189, 4164.463)	0.076	-12.268(-35,18)	-5	-31
Flim	986742	F=0.291	0.291(0.224, 0.391)	2736.98(1977.623, 3870.454)	0.318	-22.5(-44,10)	64.8	19
$SSB_{2024}=B_{lim}$	1262850	F=0.39	0.39(0.303, 0.545)	2500.025(1716.133, 3502.222)	0.514	-29.21(-51,-1)	111	53
$SSB_{2024}=B_{pa}$	469646	F=0.128	0.128(0.101, 0.17)	3184.005(2376.571, 4212.338)	0.054	-9.843(-33,19)	-21.5	-43
Status quo	684536	F=0.192	0.192(0.15, 0.254)	2997.77(2265.999, 4034.589)	0.128	-15.116(-36,14)	14.4	-17

***95% confidence interval**

4.17 Figures

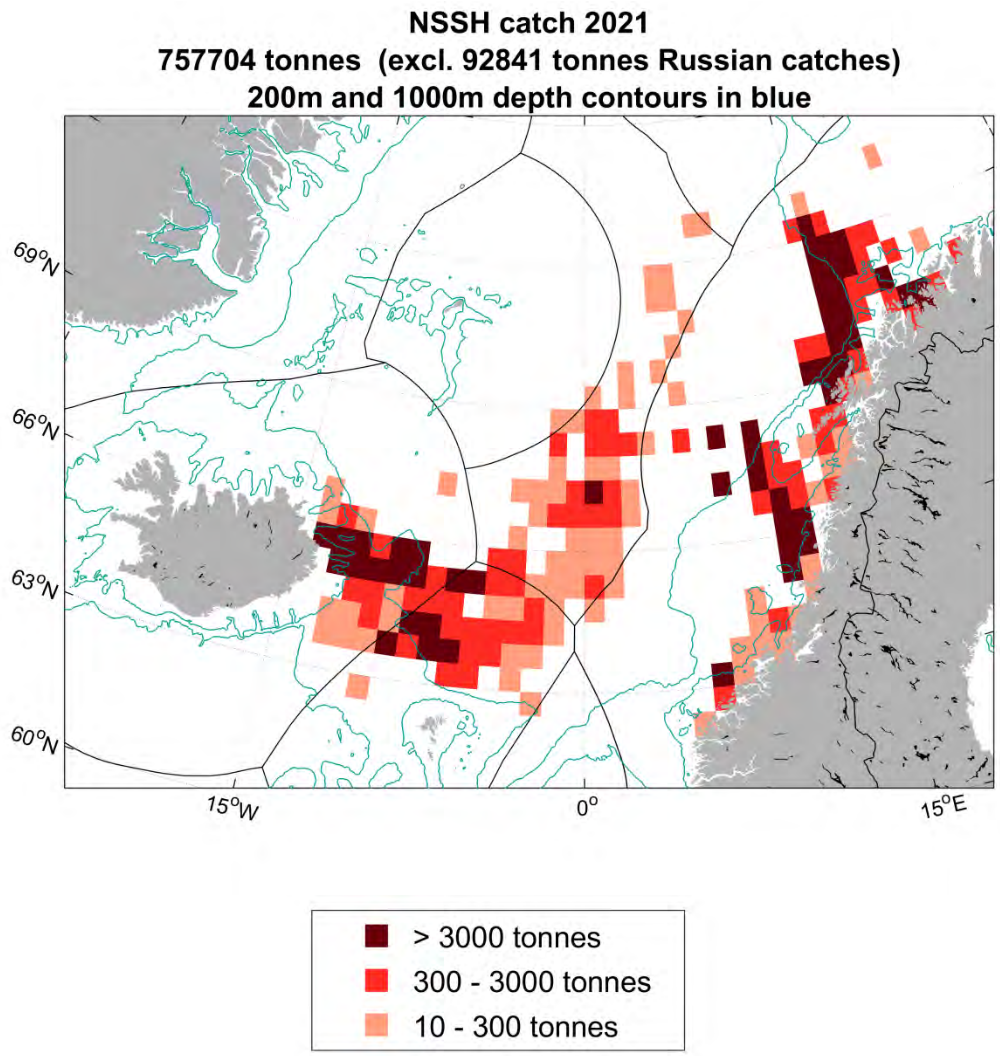

Figure 4.2.1.1. Total reported landings (ICES estimates) of Norwegian spring-spawning herring in 2021 by ICES rectangle. Landings below 10 tonnes per statistical rectangle are not included. Catch data by ICES rectangle from Russia are not available. The landings with information on statistical rectangle constitute 89% of the reported landings.

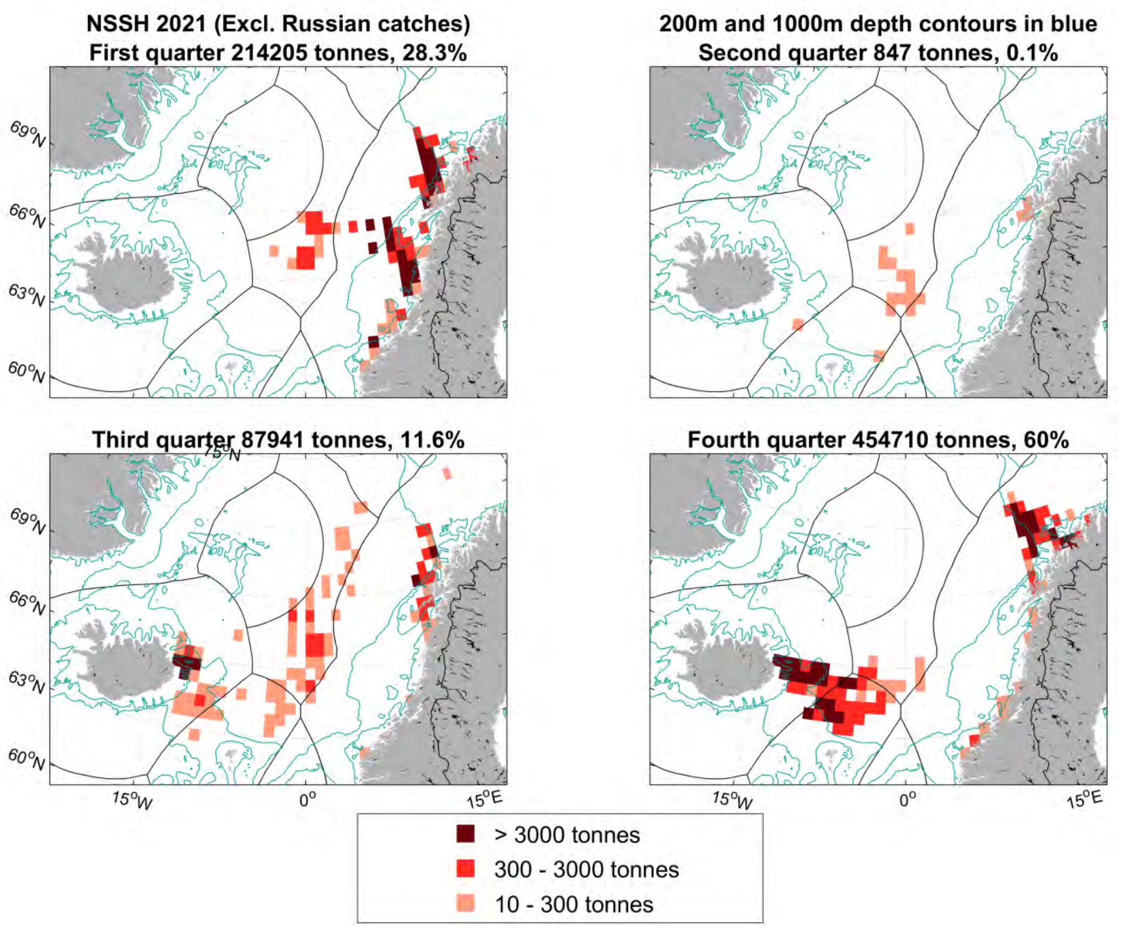

Figure 4.2.1.2. Total reported landings (ICES estimates) of Norwegian spring-spawning herring in 2021 by quarter and ICES rectangle. Landings below 10 tonnes per statistical rectangle are not included. Catch data by ICES rectangle from Russia are not available. The landings with information on statistical rectangle constitute 89% of the reported landings.

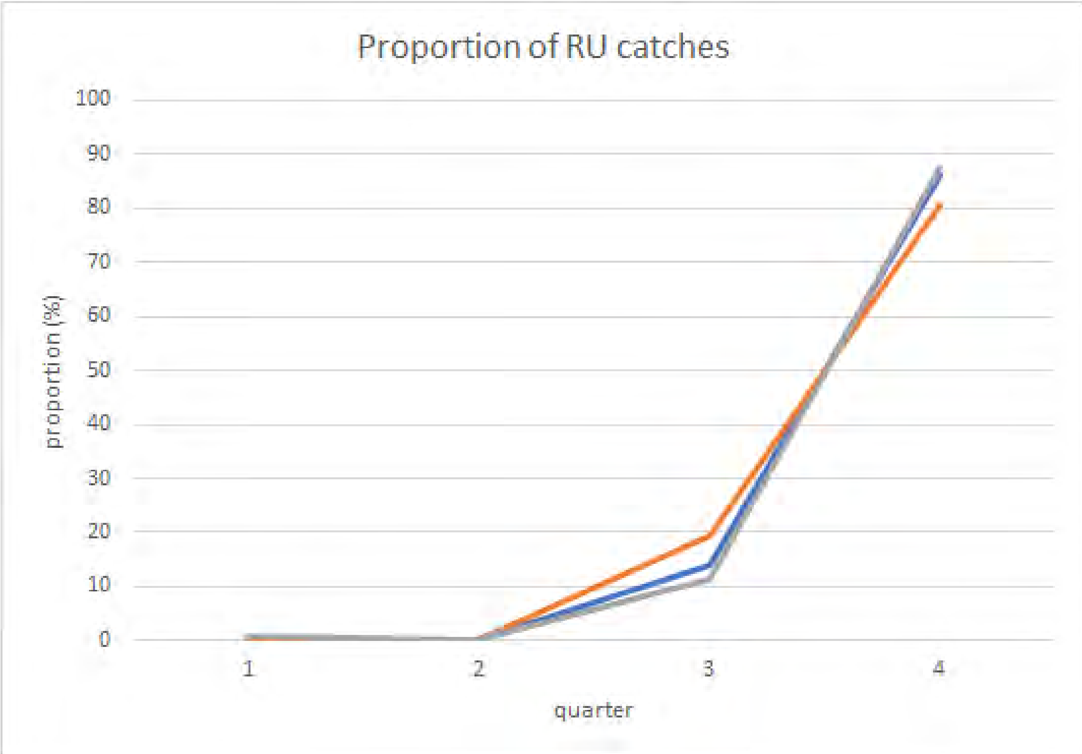

Figure 4.4.1.1.1. Proportion of Russian catches by quarter for the years 2018-2020.

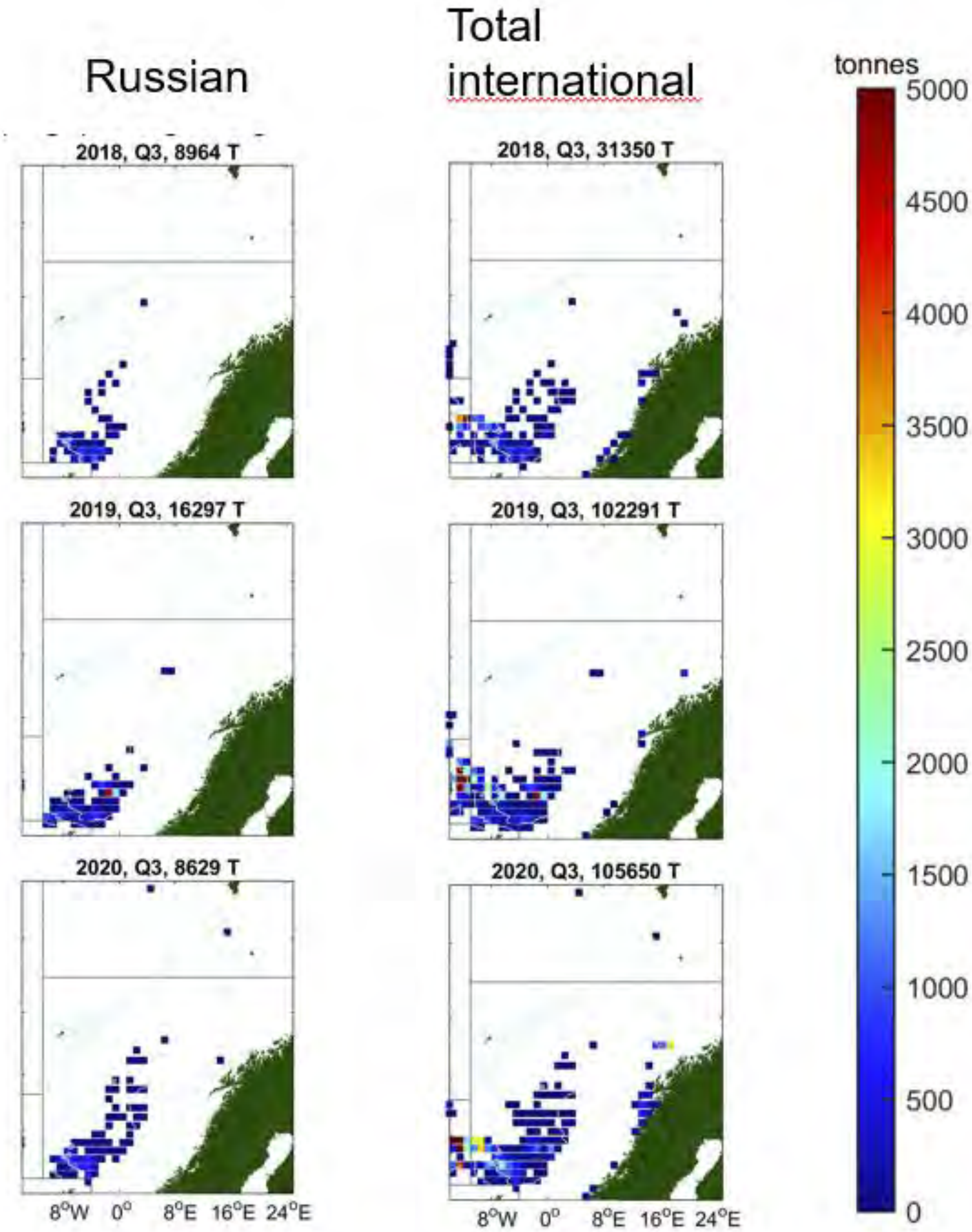

Figure 4.4.1.1.2. Russian and international catch per ICES rectangle in quarter 3 for the years 2018-2020. Lines in the map are limits for ICES sub-divisions.

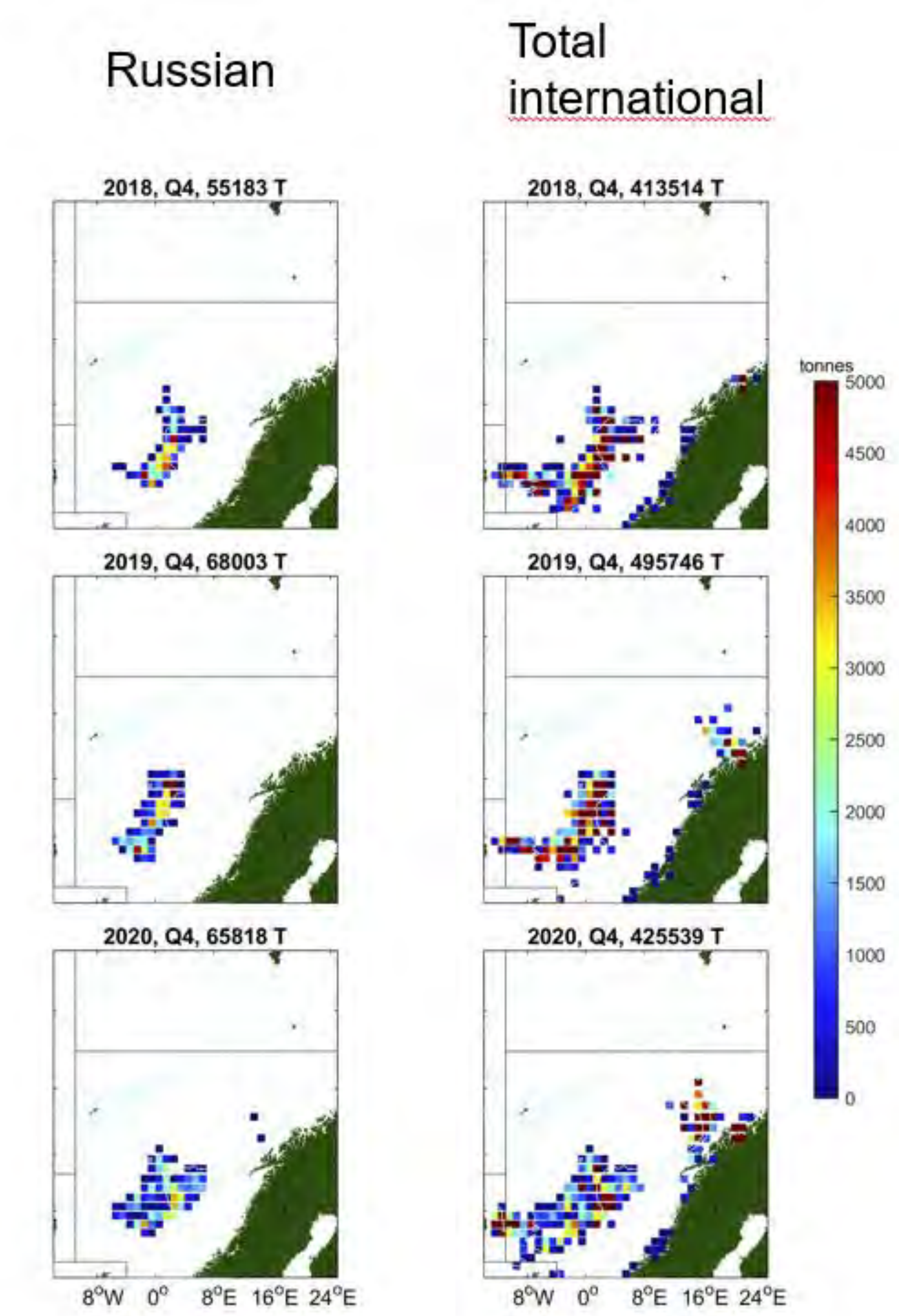

Figure 4.4.1.1.3. Russian and international catch per ICES rectangle in quarter 4 for the years 2018-2020. Lines in the map are limits for ICES sub-divisions.

Figure 4.4.1.1.4. Russian proportion of the total international catch for the period 2001-2020.

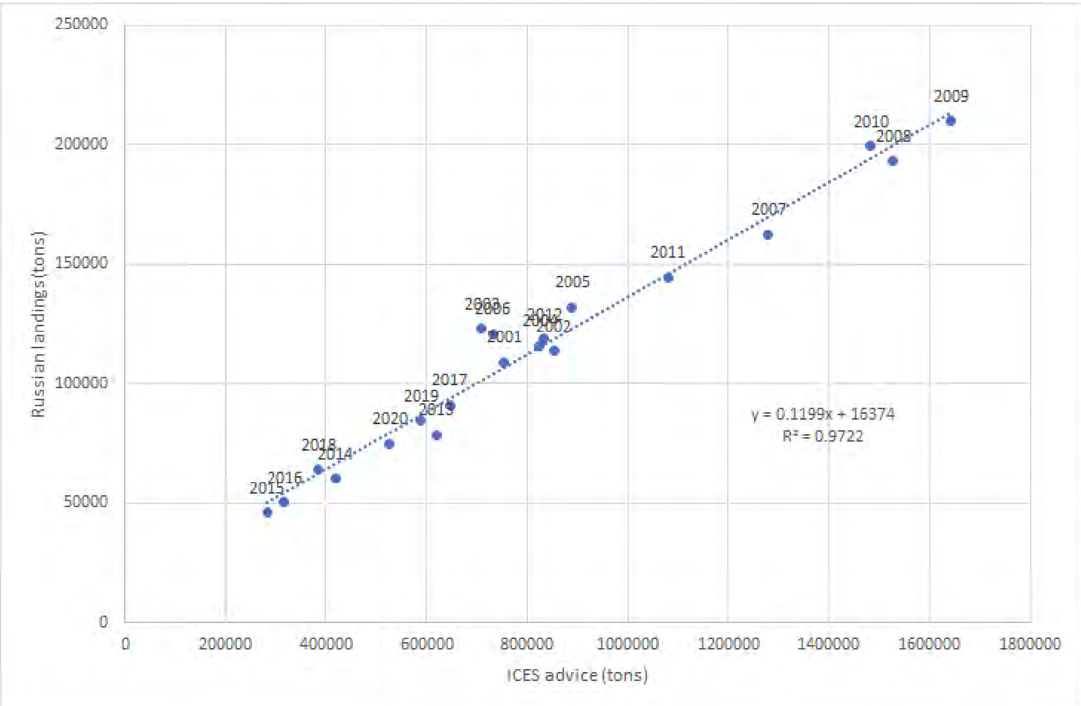

Figure 4.4.1.1.5. Russian landings and ICES advice for the period 2001-2020.

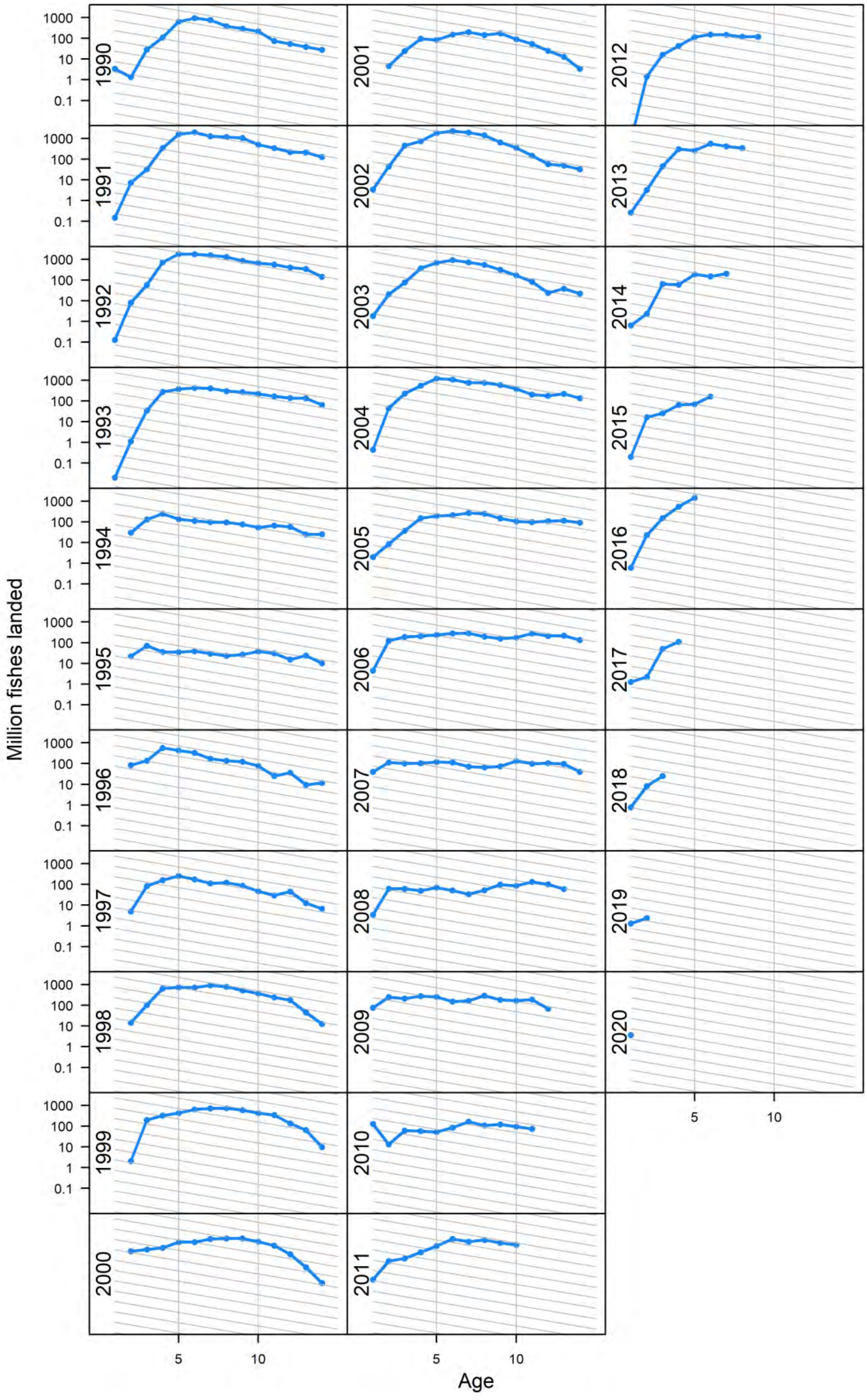

Figure 4.4.3.1. Norwegian spring spawning herring. Age disaggregated landings in numbers plotted on a log scale. Age is on x-axis. The labels indicate year classes and grey lines correspond to Z = 0.3.

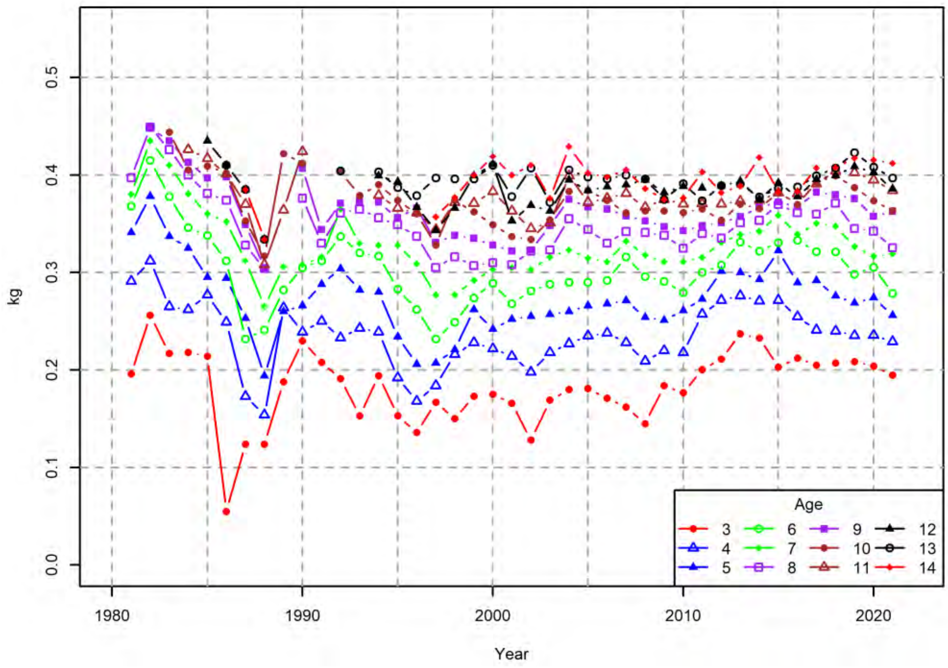

Figure 4.4.4.1. Norwegian spring spawning herring. Mean weight at age by age groups 3–14 in the years 1981—2021 in the landings.

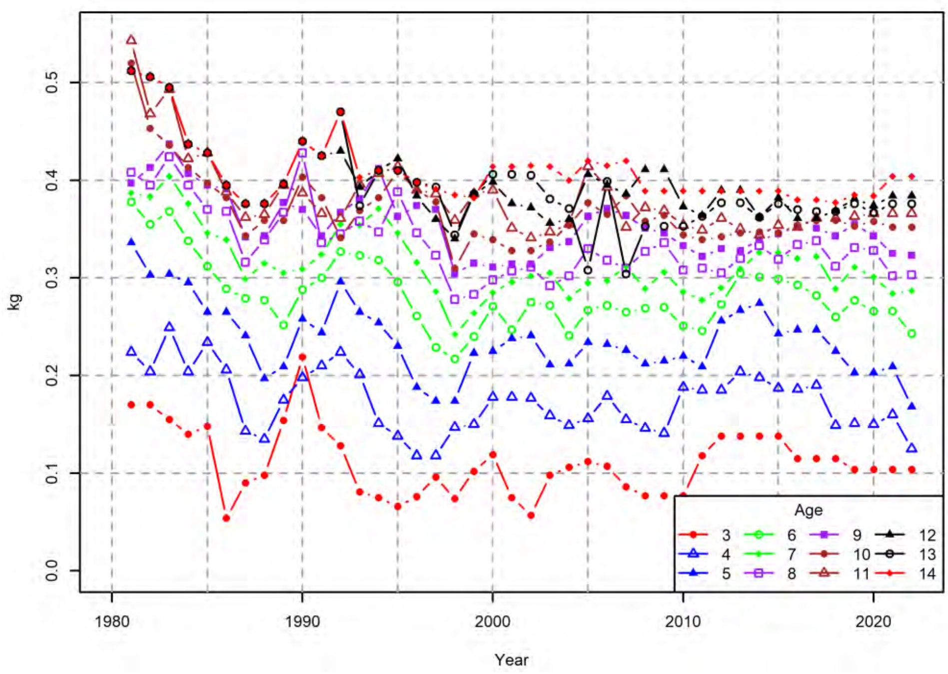

Figure 4.4.4.2. Norwegian spring-spawning herring. Mean weight at age in the stock by age groups 3–14 for the years 1981—2022.

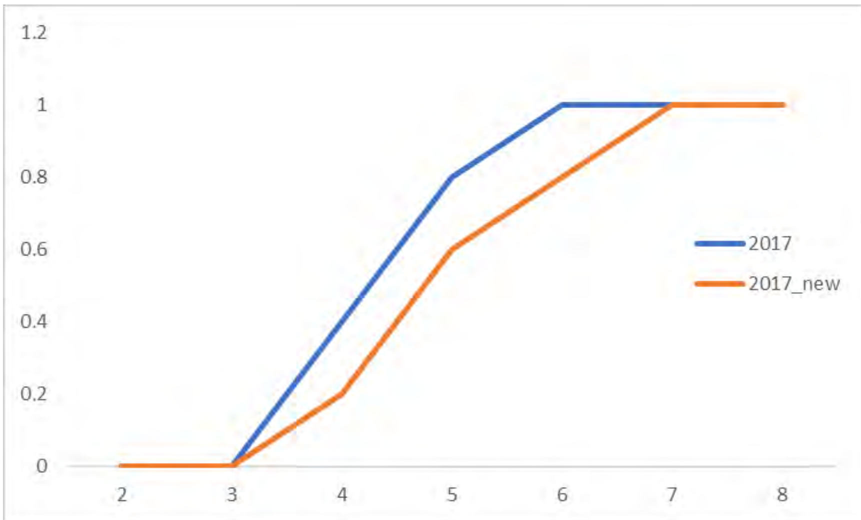

Figure 4.4.5.1. Assumed (blue line) and back-calculated (orange line) maturity-at-age for the year 2017.

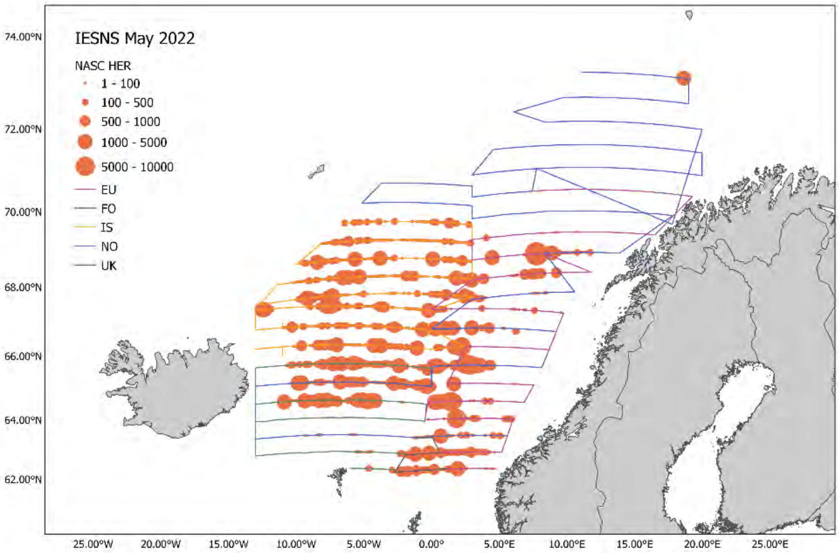

Figure 4.4.7.1. Distribution of Norwegian spring-spawning herring as measured during the IESNS survey in April-June 2022 in terms of NASC values (m^2/nm^2).

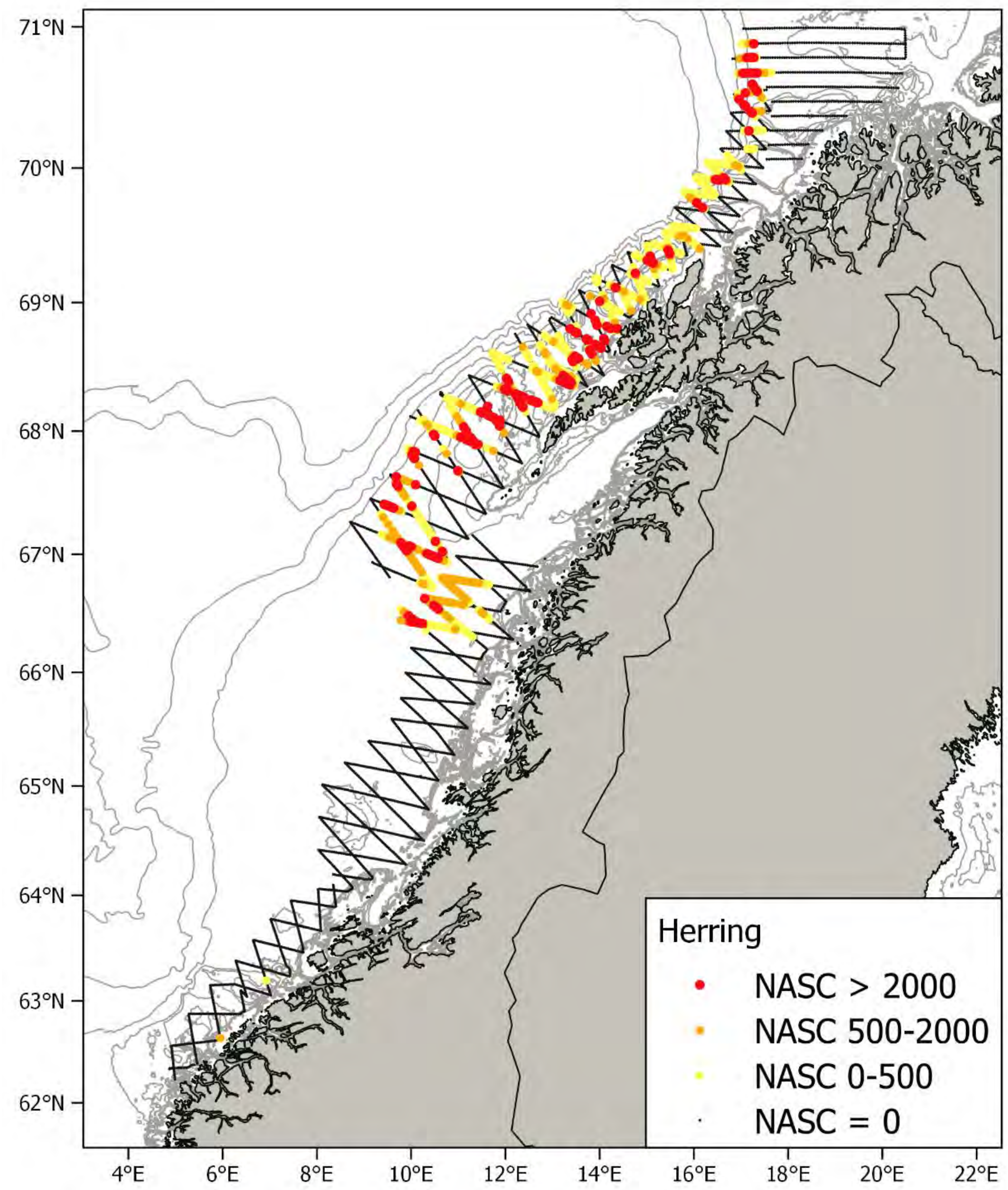

Figure 4.4.7.2. Norwegian acoustic survey on the NSSH spawning grounds. Distribution and acoustic density of herring recorded in 2022.

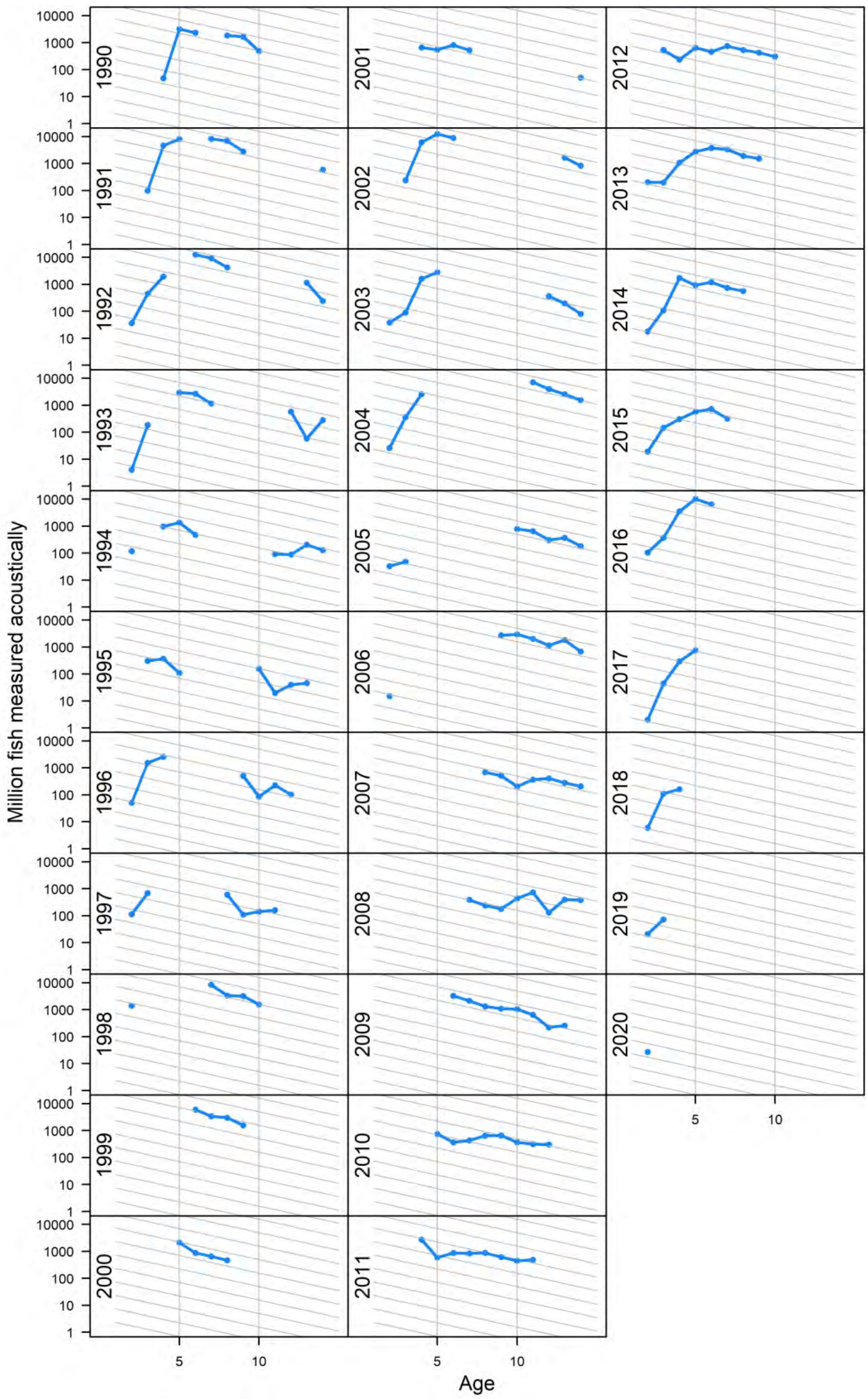

Figure 4.4.7.3. Norwegian spring spawning herring. Age disaggregated abundance indices (millions) from the acoustic survey on the spawning area in February-March (Fleet 1) plotted on a log scale. The labels indicate year classes and grey lines correspond to Z = 0.3. Age is on x-axis.

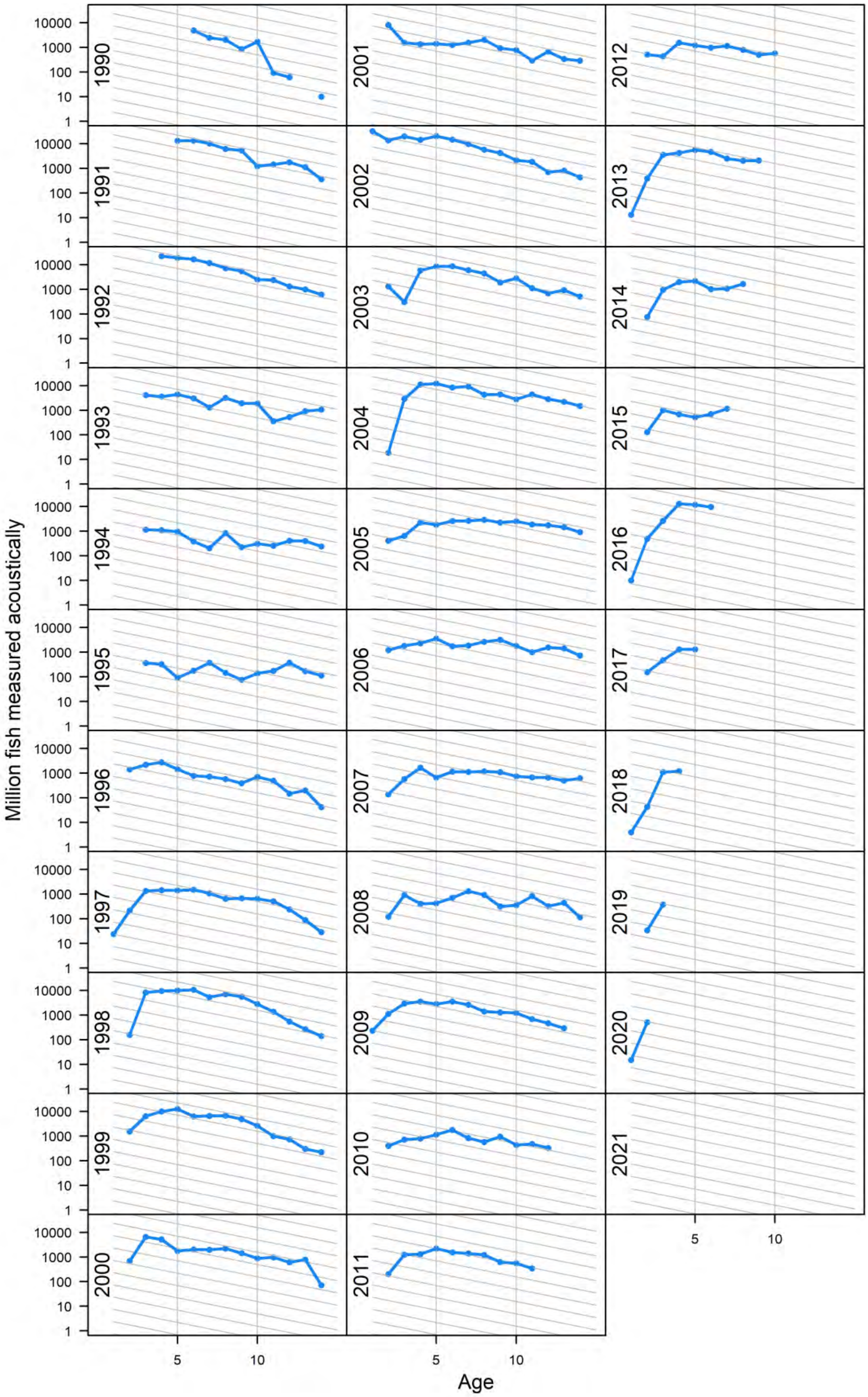

Figure 4.4.7.4. Norwegian spring spawning herring. Age disaggregated abundance indices (millions) from the acoustic survey in the feeding area in the Norwegian Sea in May (Fleet 5) plotted on a log scale. The labels indicate year classes and grey lines correspond to Z = 0.3.

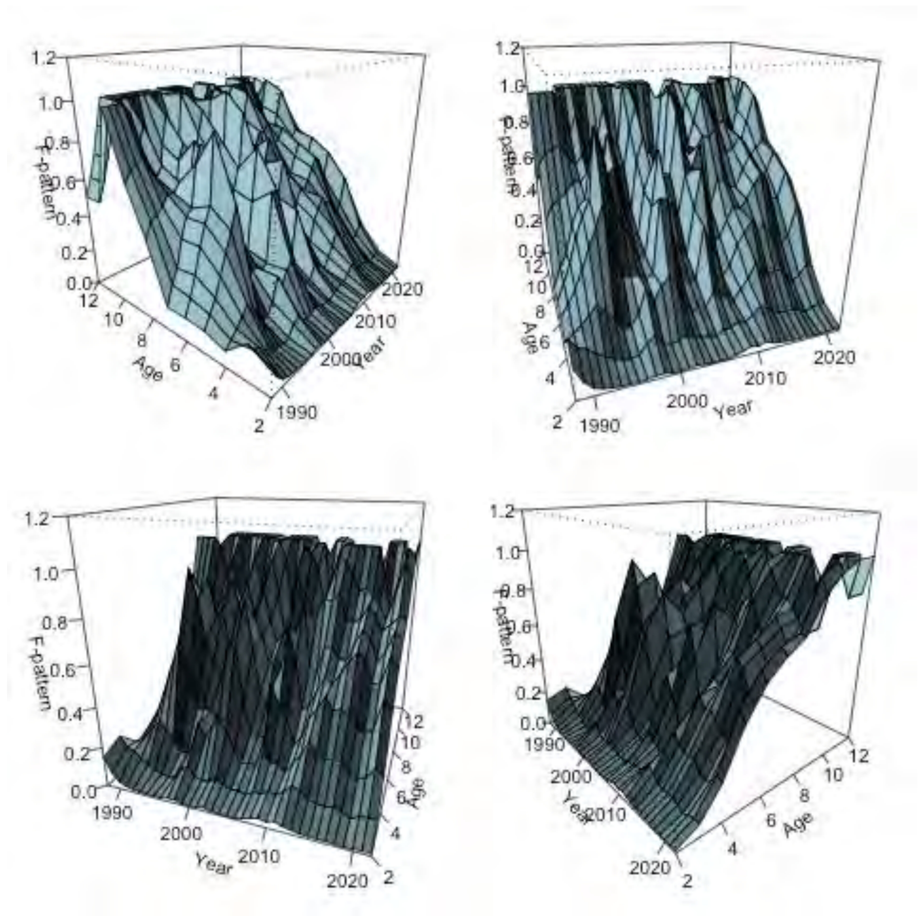

Figure 4.5.1.1. Estimated exploitation pattern for the years 1988–2022 by the XSAM model fit. All panels show the same data, but depicted at different angles to improve visibility at different time periods

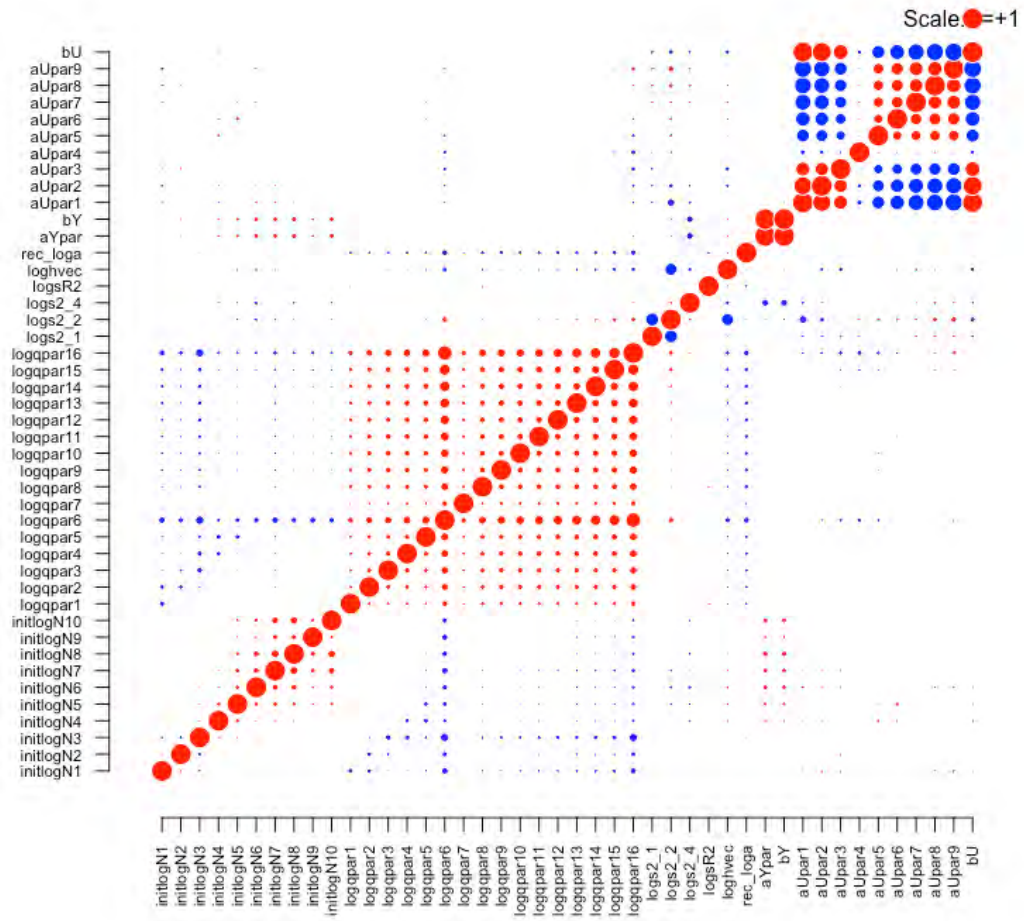

Figure 4.5.1.2. Norwegian spring spawning herring. Correlation between estimated parameters in the final XSAM model fit.

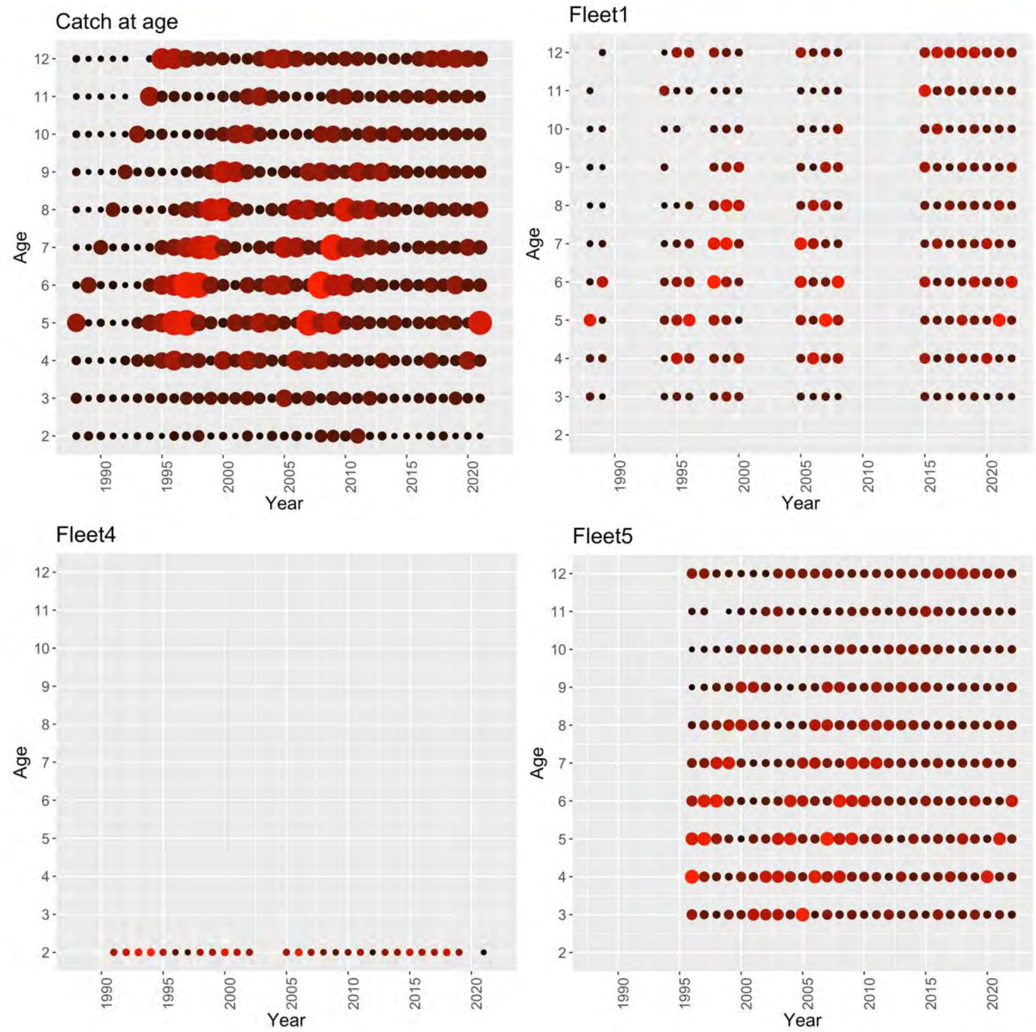

Figure 4.5.1.3. Norwegian spring spawning herring. Weights (inverse of variance) of data-input of the final XSAM model fit.

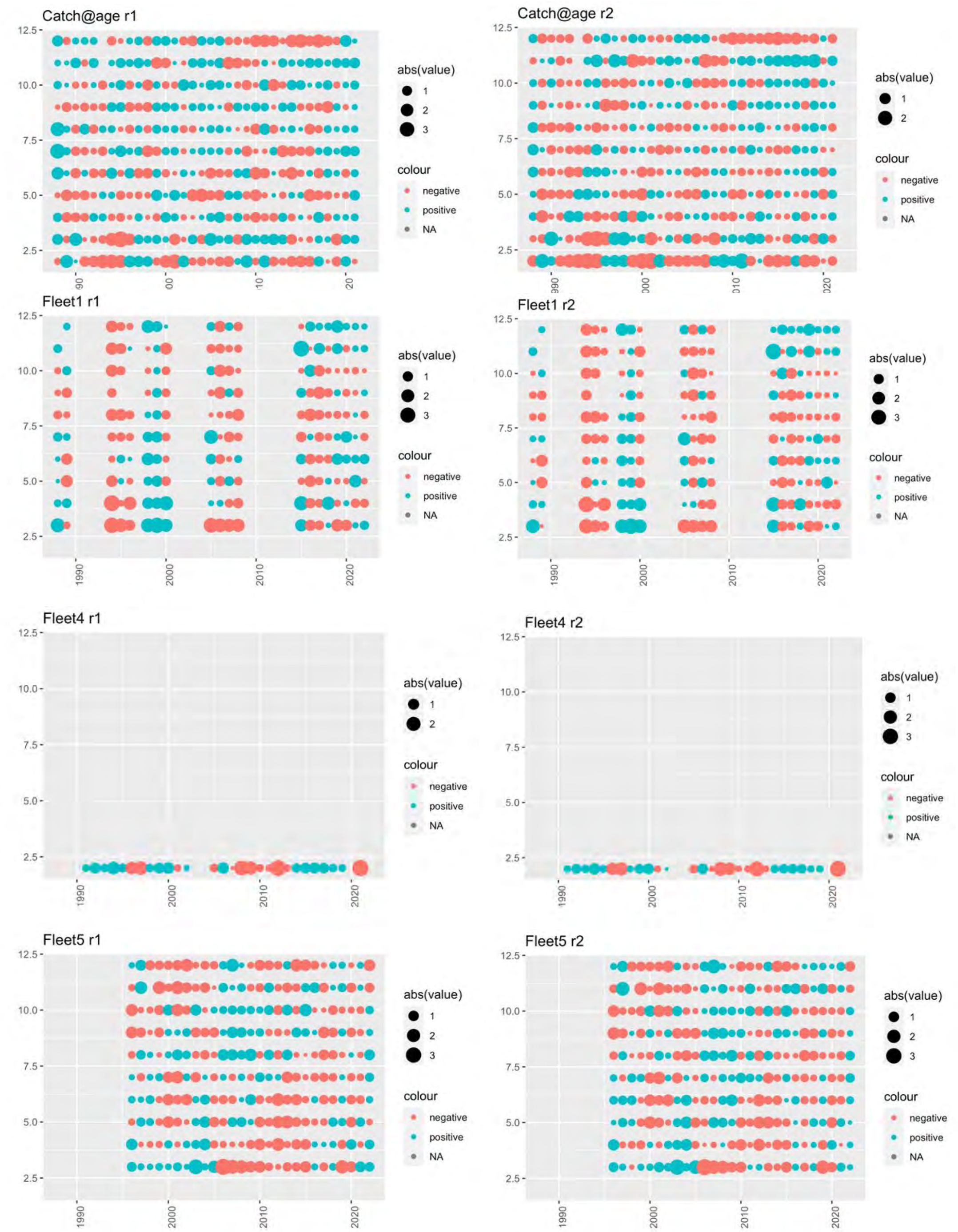

Figure 4.5.1.4. Norwegian spring spawning herring. Standardized residuals type 1 (left) and type 2 (right) (see text) of data-input of the final XSAM model fit. Red is negative and blue is positive residuals.

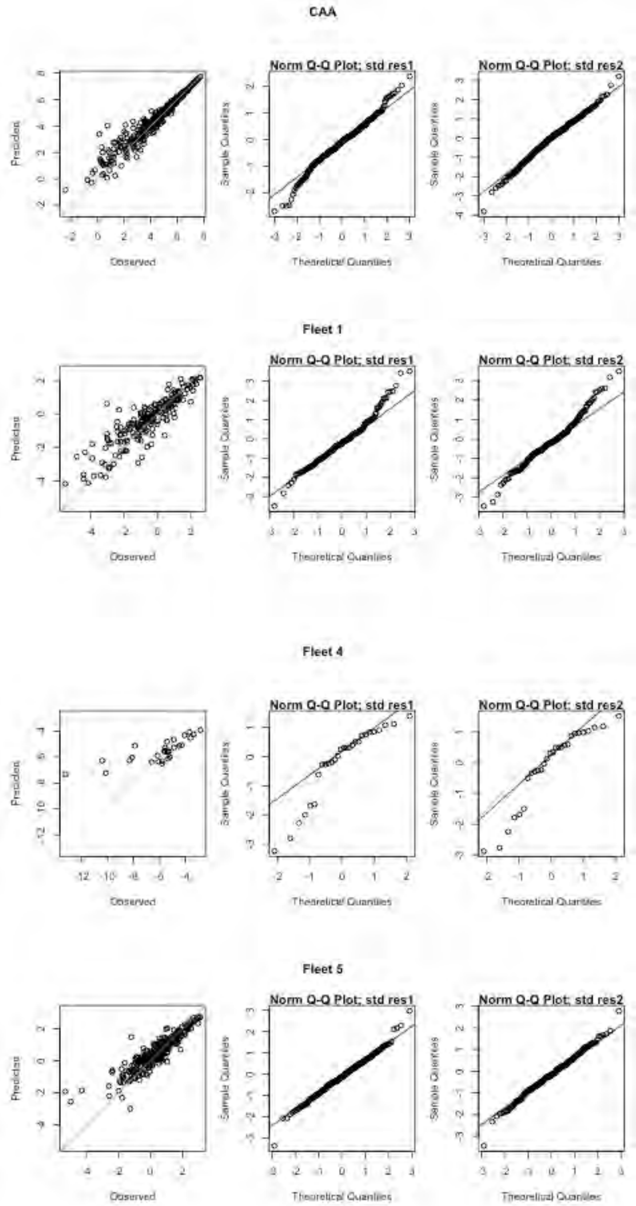

Figure 4.5.1.5. Norwegian spring spawning herring. Observed vs. predicted values (left column) and qq-plot based on type 1 (middle) and type 2 (right) residuals (see text) based on the final XSAM model fit.

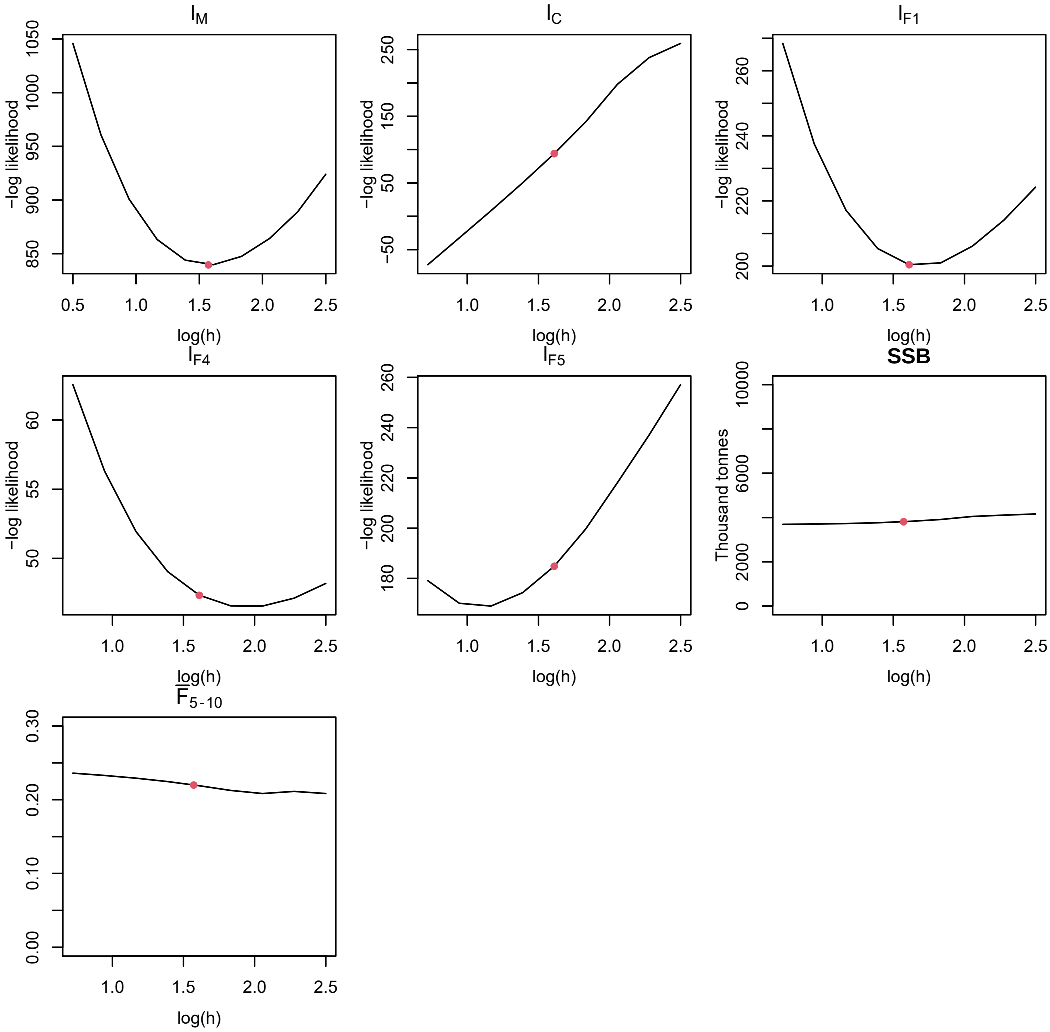

Figure 4.5.1.6. Norwegian spring spawning herring. Profiles of marginal log-likelihood $\mathbf{l_M}$, the catch component $\mathbf{l_C}$, Fleet 1 component $\mathbf{l_{F1}}$, Fleet 4 component $\mathbf{l_{F4}}$, Fleet 5 component $\mathbf{l_{F5}}$, point estimate of SSB and average F (ages 5-12+) in 2022 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.

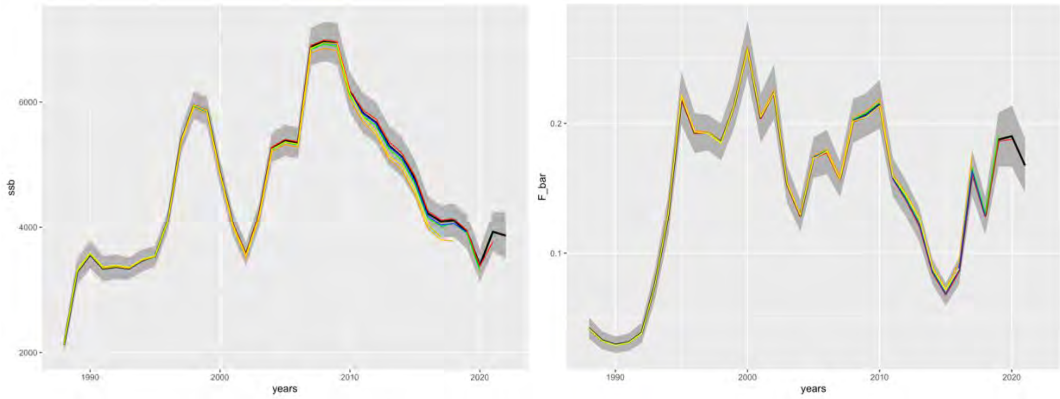

Figure 4.5.1.7. Norwegian spring spawning herring. Retrospective XSAM model fits of SSB and weighted average of fishing mortality ages 5-12 for the years 2017-2022. Mohn's rho computed to be -0.04 for SSB and -0.12 for F.

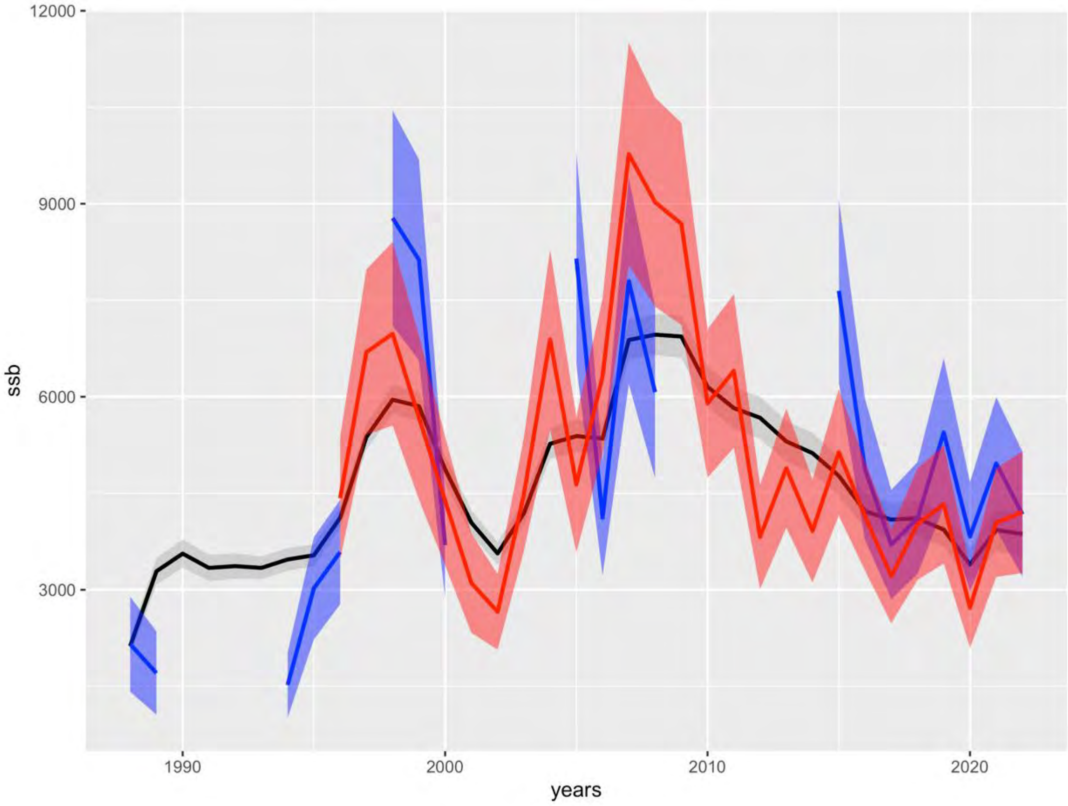

Figure 4.5.1.8. Norwegian spring spawning herring. Point estimates of Spawning-stock biomass by years 1988-2022 from model (black lines) and by survey indices from Fleet 1 (blue) and Fleet 5 (red). Shaded area is approximate to standard deviation.

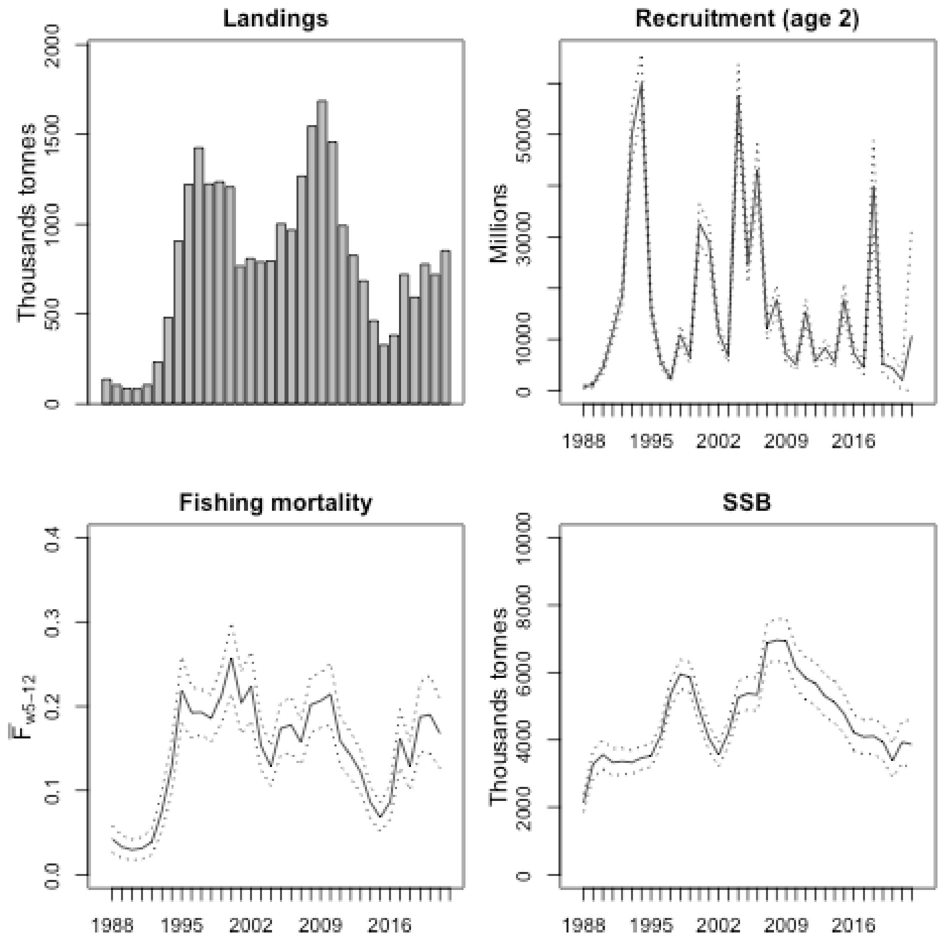

Figure 4.5.1.9. Total reported landings 1988-2021, estimated recruitment, weighted average of fishing mortality (ages 5-12) and spawning-stock biomass for the years 1988–2022 based on the final XSAM model fit.

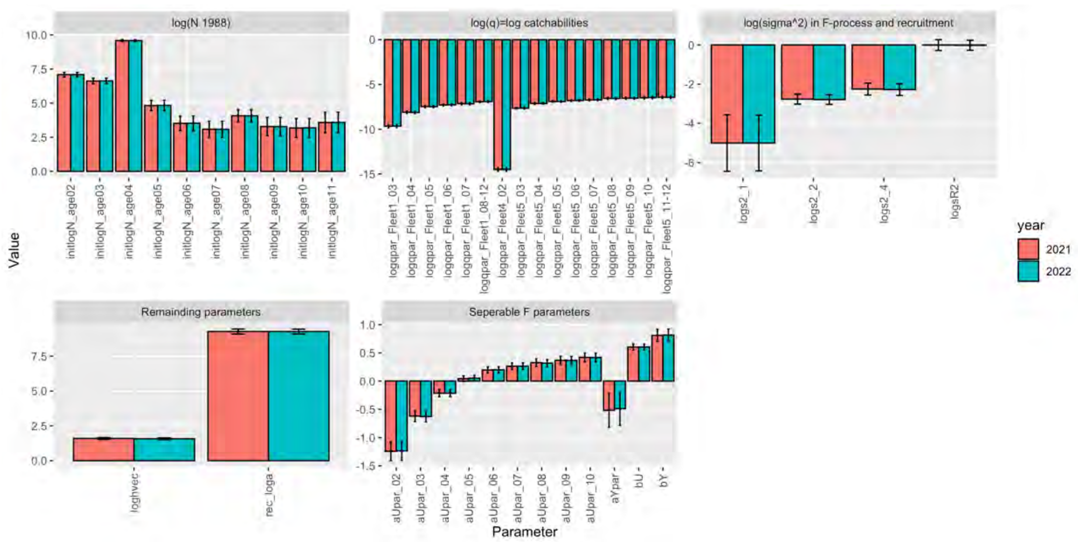

Figure 4.5.1.10. Norwegian spring-spawning herring. A visual representation of parameter estimates of the final XSAM model fit (see table 4.5.1.1). The estimates from the 2021 assessment are also shown (red).

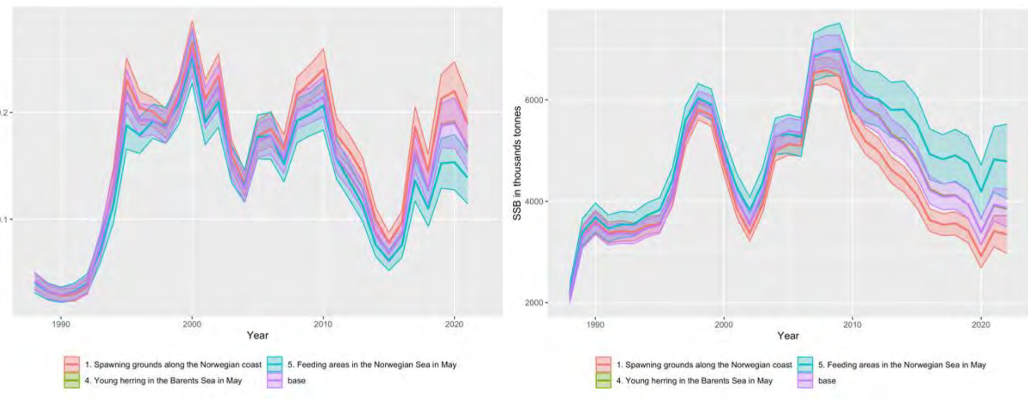

Figure 4.5.1.11. Norwegian spring-spawning herring. Alternative runs showing the effect of leaving one fleet out. The F is shown to the left and SSB to the right. The base run is shown as purple, leaving out Fleet 1 is red, leaving out Fleet 4 is green and leaving out Fleet 5 is shown as blue. Shaded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

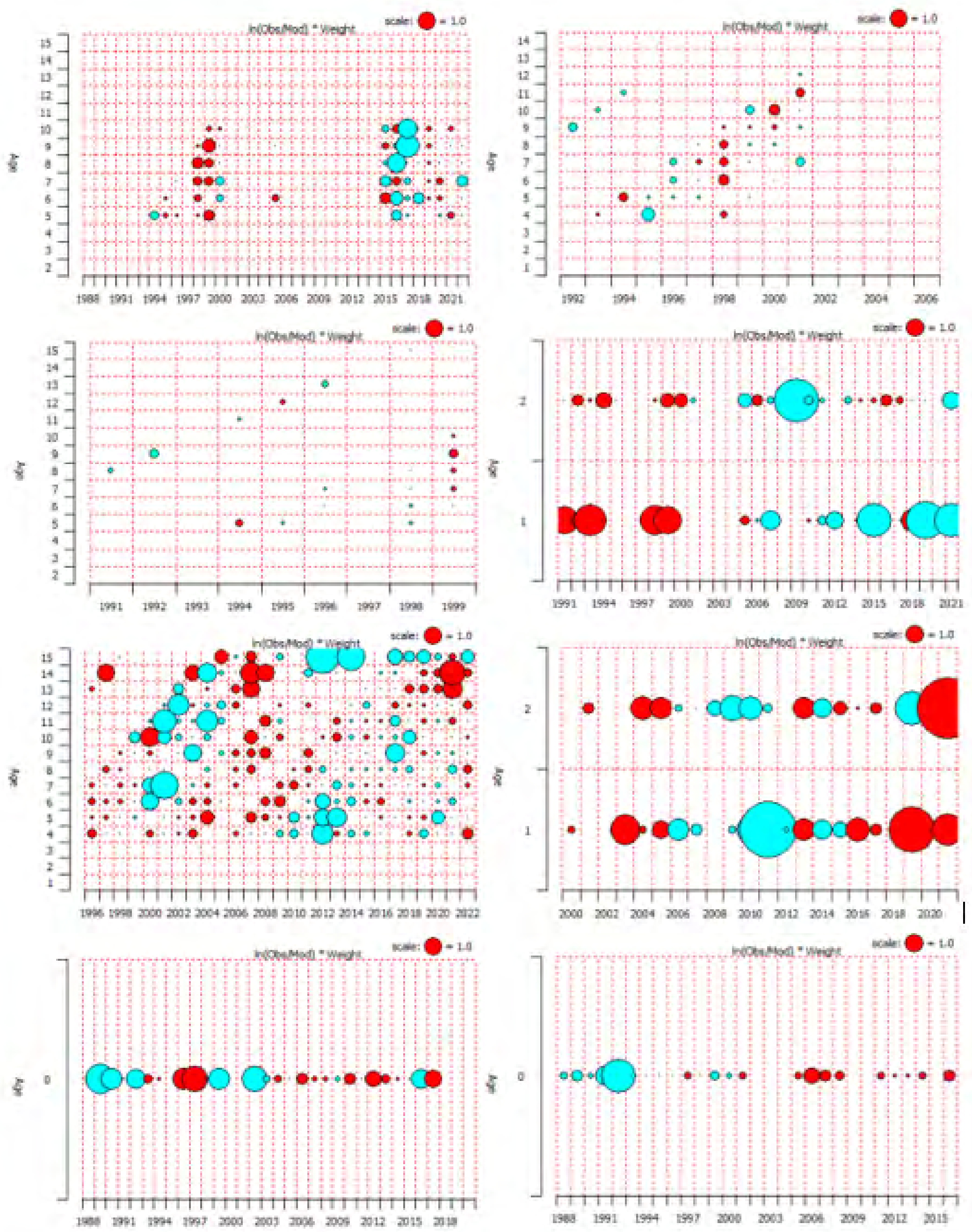

Figure 4.5.2.1.1. Norwegian spring-spawning herring. Residual sum of squares in the surveys separately from TASACS. First row starts with survey 1 and the last one in row four is larval survey.

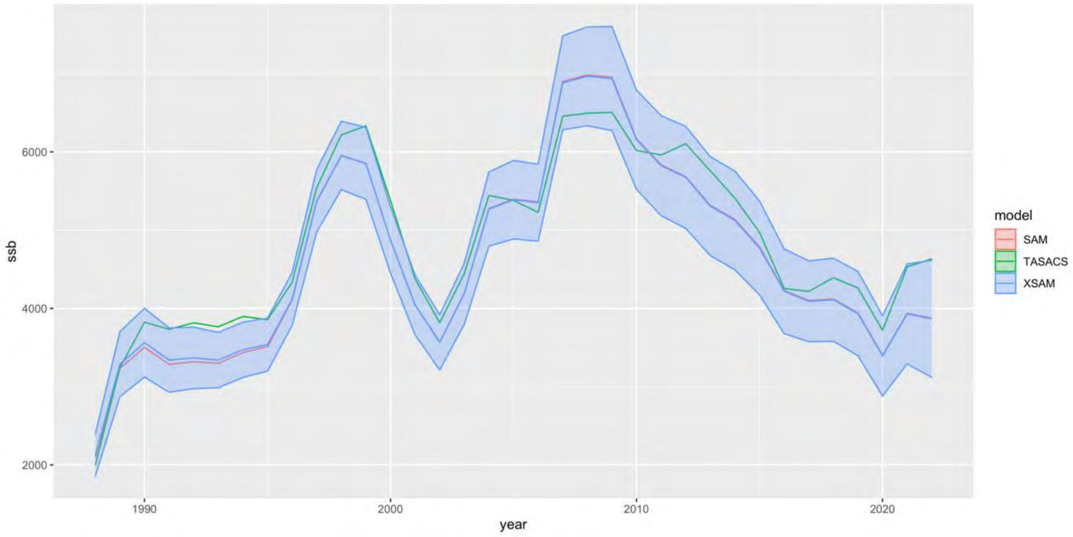

Figure 4.5.2.1.2. Comparison of SSB time-series from the final assessment from XSAM (blue) and exploratory runs from TASACS (green) following the 2008 benchmark procedure) and SAM (red) with XSAM configurations.

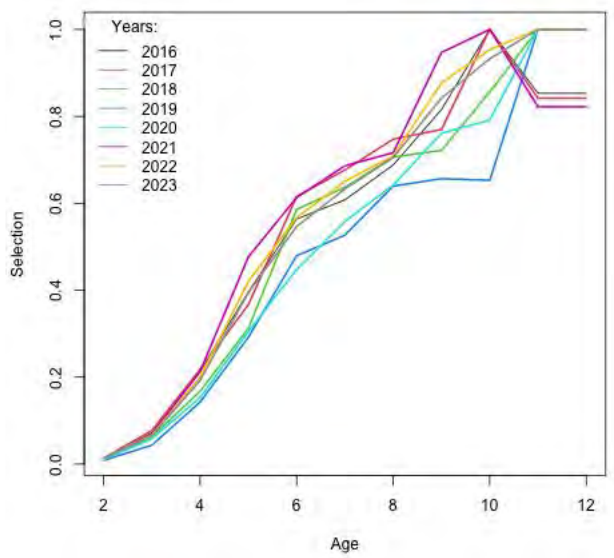

Figure 4.8.1.1. XSAM estimated selection pattern; selected years (estimates for 2016–2021 and predictions for 2022-2023) are shown in colours as indicated in the legend.

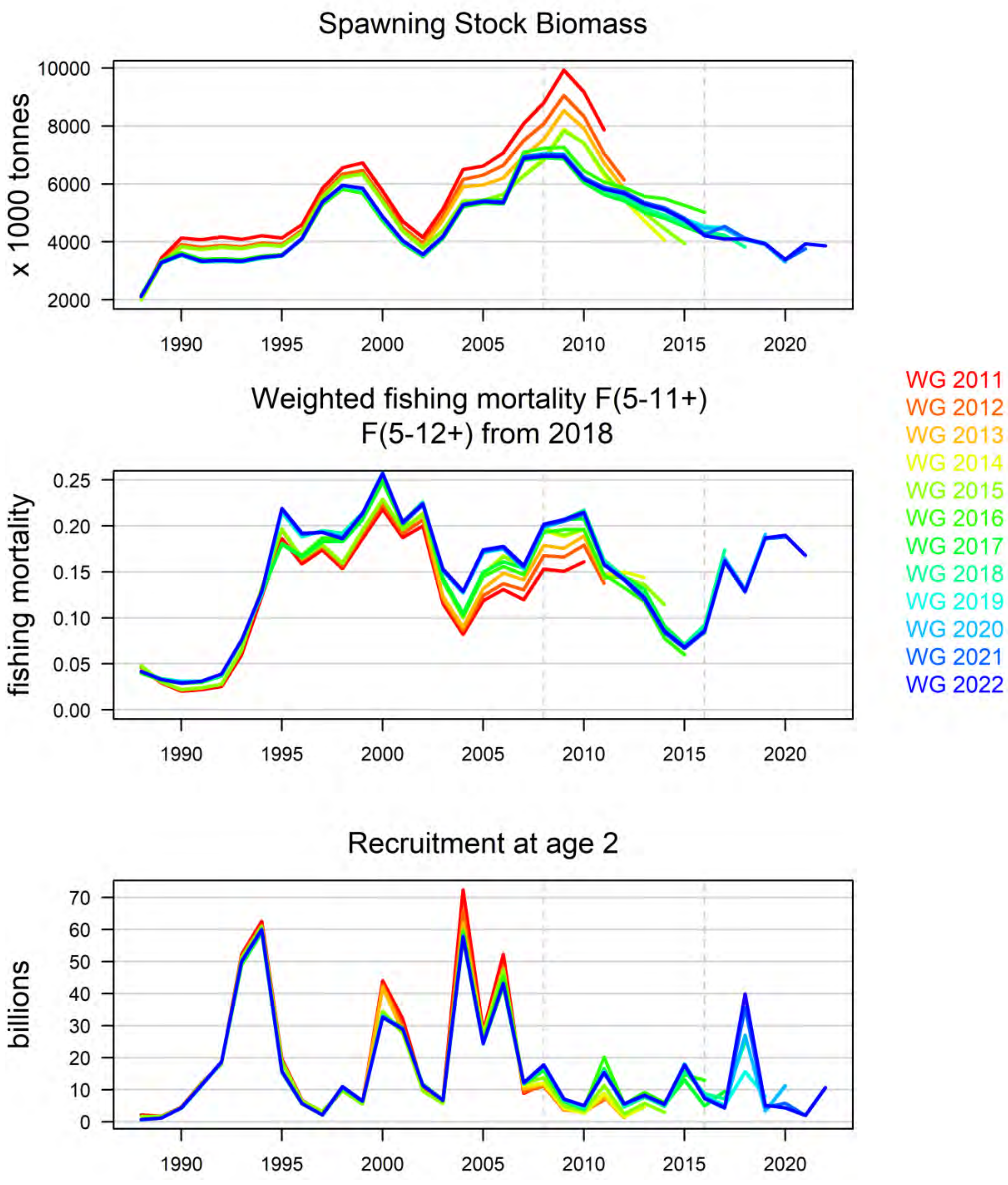

Figure 4.9.1. Norwegian spring spawning herring. Comparisons of spawning stock; weighted fishing mortality F(5-11/5-12+); and recruitment at age 2 with previous assessments. In 2016 the proportion mature in the years 2006-2011 was changed; recruitment age changed from 0 to 2 and fishing mortality is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

7 Horse Mackerel in the Northeast Atlantic

7.1 Fisheries in 2021

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 2021 for the Western and North Sea stocks was 92,639t which is 3,630t more than in 2020 and the 3rd lowest in the time series.

France, 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 2021 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. The maps are based on data provided by Belgium, Denmark, France, Germany, Ireland, Netherlands, Norway, Poland, Portugal, Spain, Sweden and the UK and represent 99% of the total catches. 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 43,160 t (46% 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: 8,046 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 West of Ireland and along the Spanish coast. (Figure 5.1.1.b)

Third quarter: 13,517 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 27,073 t (29% 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

7.2 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.

7.3 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.

7.4 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 section 1.4.8.3).

7.5 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 6 countries reporting in 2021. 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 1.8% 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 2.0% in 2021.

7.6 *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*.

The *T. mediterraneus* fishery mainly takes place in the eastern part of ICES division 8.c. There is no clear trend in *T. mediterraneus* catches in this area although the most recent catch is the second lowest in the time series (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.

7.7 Length Distribution by Fleet and by Country:

Germany, Ireland, the Netherlands, France, UK (England and Scotland) and Spain provided length distributions for their catches in 2021. The length distributions cover approximately 79% of the total landings of the Western and North Sea horse mackerel catches and are shown in Figure 5.7.1.

7.8 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 2021 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.

7.9 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 first time 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 last year for this stock. Overall, sampling improved again in 2021.

Table 5.9.2 shows the sampling intensity for the Western stock in 2021 and table 5.9.3 shows the sampling intensity for the North Sea stock in 2021 by country.

In 2021, France, Germany, Ireland, the Netherlands, UK (England), UK Scotland, and Spain provided samples and length distributions and Germany, Ireland, the Netherlands, Norway, UK (England), and Spain 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. The sampling intensity in relation to the length composition of catch was >60%. 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.c for all quarters and 7.d from the 3rd and 4th quarters. Therefore, these estimates can be biased, especially, since samples are usually 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 increased in 2021 to 78% in comparison to 51% last year which was mainly due to the impact of the pandemic on sampling. 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.

7.10 References

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7.11 Tables

Table 5.1.1 HORSE MACKEREL general. Catches (t) by Sub-area. Data as submitted by Working Group members. Data of limited discard information are only available for some years.

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
2	867	290	12
4 + 3.a	12,593	13,792	7,672
6	47,351	19,037	13,727
7	42,973	33,310	49,934
8	29,640	19,639	19,602
9[1]	34,080	31,344	26,745
Disc	3,326	2,942	1,692
Total	170,829	120,347	119,384

[1] - Southern Horse Mackerel (ICES Division 9) is assessed by ICES WGHANSA since 2011

Table 5.1.2 HORSE MACKEREL Western and North Sea Stock combined. Quarterly catches (t) by Division and Subdivision in 2021.

Division	1Q	2Q	3Q	4Q	TOTAL
2.a+5.b	5	1	0	6	12
3	1	0	7	6	14
4.a	2080	190	1897	1790	6180 x
4.bc	371	257	487	524	1639
7.d	888	203	140	5922	7172*
6.a,b	10691	2	8	2568	13819**
7.a–c,e–k	26735	590	5481	10592	43490***
8.a-e	2389	6805	5496	5624	20314
Sum	43160	8048	13516	27032	92460****

*** for the total 221t were added which were only declared as yearly catch**

**** for the total 19t were added which were only declared as yearly catch**

***** for the total 550t were added which were only declared as yearly catch**

****** for the total 92t were added which were only declared as yearly catch**

******* for the total 882t were added which were only declared as yearly catch**

X includes 222t 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 Sto-cks
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 Sto-cks
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 Sto-cks
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 Sto-cks
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

***Divisions 3.a and 4.b,c combined.**

****Norwegian catches in 4.b included in Western horse mackerel.**

[x] Southern Horse Mackerel is assessed by ICES WGHANSA since 2011

Table 5.4.2 National catches of the Western Horse mackerel stock.

Country	1997	1998	1999	2000	2001	2002	2003	2004	2005
Belgium	18	19	21	0	-	-	-	-	-
Denmark	62,897	31,023	26,040	16,385	21,254	10,147	11340	11,667	10,155
Estonia	78	22	-	0	-	-	-	3,826	3,695
Faroe Islands	1,095	216	1,040	24	800	671	4	8,056	10,690
France	39,188	26,667	25,141	20,457	15,145	18,951	10,381	17,744	16,364
Germany, Fed.Rep.	28,533	33,716	23,549	13,014	11,491	12,658	15,696	26,432	34,607
Ireland	74,250	73,672	57,983	55,229	51,874	36,422	35,857	-	-
Lithuania	-	-	-	-	-	-	-	40986	41,057
Netherlands	82,885	103,246	83,450	57,261	73,440	44,997	48,924	10729	24,909
Norway	45,058	13,363	46,648	1,982	7,956	36,164	20,371	16,272	16,636
Russia	554	345	121	80	16	3	2	567	216
Spain	31,087	43,829	39,831	24,204	23,537	24,763	24,599	4,617	3,560
Sweden	1,761	3411	1,957	1009	68	561	1,002	458	210
UK (Engl. + Wales)	19,778	13,068	9,268	4,554	7,096	5,970	4,438	1,522	143
UK (N. Ireland)	-	1,158	-	625	1140	1129	914	14,506	17,962
UK (Scotland)	32,865	18,283	11,197	10,283	8,026	2,905	721	2356	1802
Unallocated	17,158	15,262	23,763	-2757	6,978	472	16,765	159,737	182,006
Discard	158	913	-	382	254	307	842	-	-
Total	437,363	378,213	350,009	202,732	229,075	196,120	191,856	11,667	10,155

Country	2006	2007	2008	2009	2010	2011	2012	2013
Belgium	-	-	-	-	19	2	0.2	14
Denmark	8,411	7,617	5,261	6,027	5,940	6,108	4,002	6,820
Faroe Islands	-	478	841	-	377	349	-	
France	11,031	12,748	12,626	-	260	8,271	1,797	3,595
Germany, Fed.Rep.	10,862	5,784	11,801	15,122	17,688	21,114	17,063	24,835
Ireland	26,779	29,759	35,332	40,754	44,488	38,466	45,239	35,791
Lithuania	6,828	5,467	5,548	-	-	-	-	
Netherlands	37,130	29,462	43,648	39,453	61,504	55,690	66,396	53,697
Norway	27,114	4,182	12,223	59,764	11,978	13,755	3,251	6,596
Spain	13,877	14,277	19,851	21,077	38,745	34,581	13560	22,541
Sweden	-	76	8	258	2	90	-	1
UK (Engl. + Wales)	3,574	5,482	3,365	6,482	12,714	11,716	12,122	3,959
UK (N. Ireland)	103	-	-	-	59	198	-	2,325
UK (Scotland)	468	776	1,077	1,412	2,349	2,928	1,335	504
Unallocated	8,292	6,878	-8,703	-7,014	6,556	-	1815	-
Discard	1353	370	474	447	432	430	3,280	4,582
Total	155,822	123,356	143,352	183,782	203,111	193,698	169,860	165,260

Country	2014	2015	2016	2017	2018	2019	2020	2021
Belgium								
Denmark	5,945	4,556	321	4,541	6,302	7,764	5,487	6,042
Faroe Islands	68	-	-	180	-	26	-	
France	3,428	3,247	2,797	3,923	3,443	4,382	2,217	2,710
Germany, Fed.Rep.	17,161	9,417	11,414	7,172	4,734	9,211	954	5,530
Ireland	32,667	21,654	27,605	23,560	25,347	28,899	17,390	18,770
Lithuania	-	-	2,596	-	-	-	0	
Netherlands	25,053	24,958	23,792	14,269	25,942	29,656	14,240	20,786
Norway	14,353	8,897	9,438	9,885	9,319	9,021	10,666	3,663
Poland	-	-	--	-	-	127	1,002	1,605
Spain	19,442	13,071	14,235	14,901	20,362	25,776	18,582	16,191
Sweden	0	10	-	41	23	323	83	4
UK (Engl. + Wales)	4,832	2,063	842	549	2,443	4,036	1,496	2,651
UK (N. Ireland)	1,579	1,204	-		1,080	1,907	1,231	1,350
UK (Scotland)	1,389	738	970	-	-	678	333	615
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
Total	136,360	98,419	98,810	82,950	101,682	124,947	76,422	81,557

Table 5.4.3. National catches of the North Sea Horse mackerel stock.

Country	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Belgium	-	19	21			30	5	4	4	-
Denmark	180	1,481	3,377	4,403	885	2,315	3,301	8,690	3,987	8,353
Faroe Islands	-	-	135	-	-	28	804	21	-	-
France	3,246	2,399	-	-		1,246	2,326	231	5,236	1,205
Germany, Fed.Rep.	7,847	5,844	5,920	3,728	974	6,532	2,936	5,194	2,725	11,034
Ireland	-	2,861	27	201	338	61	-	1	753	10,863
Lithuania	-	10,711	-	-	-	-	-	-	-	26,779
Netherlands	36,855	-	8,117	8,697	13,867	12,209	24,119	26,303	27,730	6,829
Norway	-	-	238	105	36	525	144	22	204	37,130

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, Fed.Rep.	1,125	65	1,081	1,539	3,794	3,461	5,356	2,941	1,619
Ireland	2,077		887	25	-	-	0		0
Lithuania	1,999	297	-	-	-	-	0		0
Netherlands	27,285	31,153	19,439	22,546	17,093	16,289	12,157	8,725	4,925
Norway	113	1,243	21	12,855	526	7,359	129	377	0
Sweden	9	21	36	401	-	-	0		1
UK (Engl. + 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
Belgium	63	51	67	44	18	39	38
Denmark	800	268	294	397	100	177	72
Faroe Islands	0	0	4	0	10	109	
France	934	1,322	1,863	1,443	935	758	503

Germany, Fed.Rep.	644	1,879	949	2,766	946	3	87
Ireland	0	0	0	0	0	0	174
Lithuania	0	0	0	0	1,254	0	
Netherlands	3,305	3,892	5,638	5,184	2,089	4,803	3,377
Norway	662	1,701	5	1,423	2,543	2,090	2,091
Sweden	9	0	0	0	0	1	0
UK (Engl. + Wales)	3,581	4,697	4,546	3,250	3,632	4,381	4,669
UK (Northern Ireland)	0	0	0	0	53	0	
UK (Scotland)	0	0	0	0	38	24	19
Unallocated	0	0	0	0	0	0	0
Discard	2,004	1,527	1,213	265	185	201	52
Total	12,002	15,337	14,579	14,773	11,802	12,587	11,082

Table 5.6.1. Catches (t) of *Trachurus mediterraneus* in Divisions 8.ab, 8.c and Sub-Area 7

	7	8.ab	8.c East	8.c West	TOTAL
1989	0	23	3903		3926
1990	0	298	2943		3241
1991	0	2122	5020		7142
1992	0	1123	4804		5927
1993	0	649	5576		6225
1994	0	1573	3344		4917
1995	0	2271	4585		6856
1996	0	1175	3443		4618
1997	0	557	3264		3821
1998	0	740	3755		4495
1999	0	1100	1592		2692
2000	59	988	808		1854
2001	1	525	1293		1820
2002	1	525	1198		1724
2003	0	340	1699		2039
2004	0	53	841		894

	7	8.ab	8.c East	8.c West	TOTAL
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

Table 5.9.1. Summary of the overall sampling intensity on horse mackerel catches in recent years in all areas 1992—2021

Year	Total Catch (ICES estimate)	% catch covered by sampling programme*	No. samples	No. Measured	No. Aged
1992	436 500	45	1 803	158447	5797
1993	504190	75	1178	158954	7476
1994	447153	61	1453	134269	6571
1995	580000	48	2041	177803	5885
1996	460200	63	2498	208416	4719
1997	518900	75	2572	247207	6391
1998	399700	62	2539	245220	6416
1999	363033	51	2158	208387	7954
2000	247862	50	378	33317	4126
2001	257411	61	467	46885	7141

Year	Total Catch (ICES estimate)	% catch covered by sampling programme*	No. samples	No. Measured	No. Aged
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

***Percentage related to catch (catch at age) according to ICES estimation**

Table 5.9.2. Horse mackerel sampling intensity for the Western stock in 2021.

Country	Catch	% Catch Sampled*	No. Samples	No. Measured	No. Aged
Denmark	6042	0	0	0	0
Faroe Islands	-	0	0	0	0
France**	3288	-*	106	2034	0
Germany	5530	99	21	7952	21
Ireland	18770	96	49	9609	49
Netherlands	20785	89	59	7774	59

Country	Catch	% Catch Sampled*	No. Samples	No. Measured	No. Aged
Norway	3662	99	8	422	8
Poland	1605	0	0	0	0
Spain	16994	97	763	23750	195
Sweden	6	0	0	0	0
UK (England)	2658	100	67	3391	249
UK(Northern Ireland)	1350	0	0	0	0
UK(Scotland)	863	-*	35	1344	0
Total	81557	78	951	52702	7433

***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 2021.

Country	Catch	% Catch Sampled*	No. Samples	No. Measured	No. Aged
Belgium	37	0	0	0	0
Denmark	72	0	0	0	0
Faroe Islands	0	0	0	0	0
France**	549	-*	19	373	0
Germany	87	0	0	0	0
Netherlands	3377	88	9	1600	225
Norway	2091	0	0	0	0
Sweden	0	0	0	0	0
UK (England)****	4674	100	24	5137	422
UK(Northern Ireland)	0	0	0	0	0
UK(Scotland)***	19	0	0	0	0
Total	11082	68	26	6520	647

*** 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**

7.12 Figures

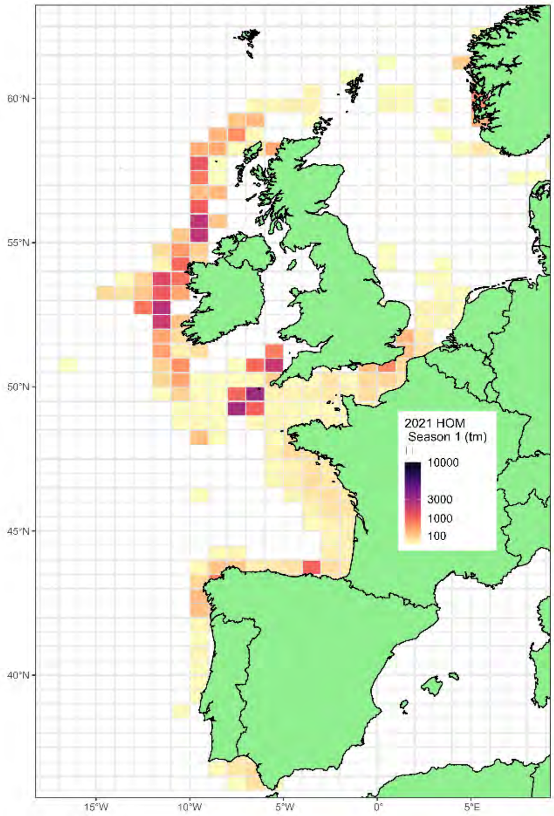

Figure 5.1.1a. Horse mackerel catches 1st quarter 2021

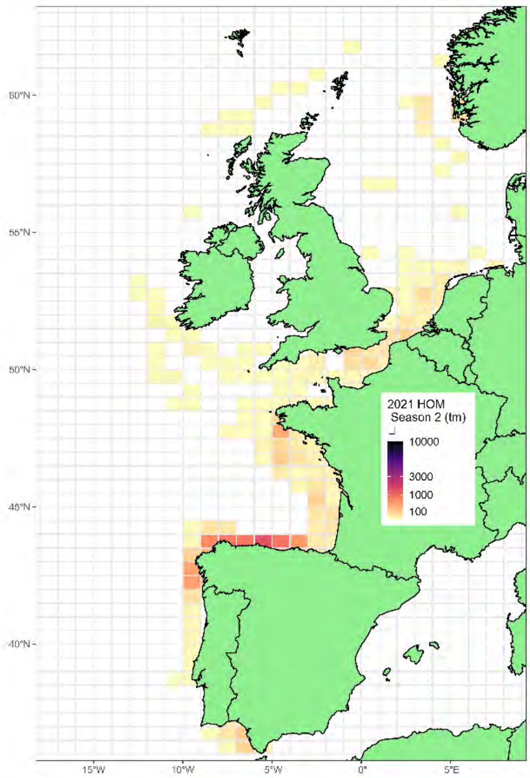

Figure 5.1.1b. Horse mackerel catches 2nd quarter 2021.

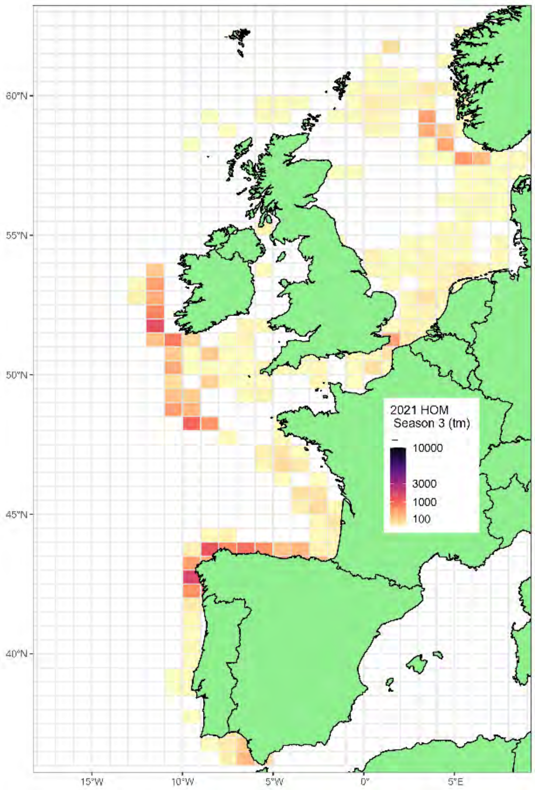

Figure 5.1.1c. Horse mackerel catches 3rd quarter 2021.

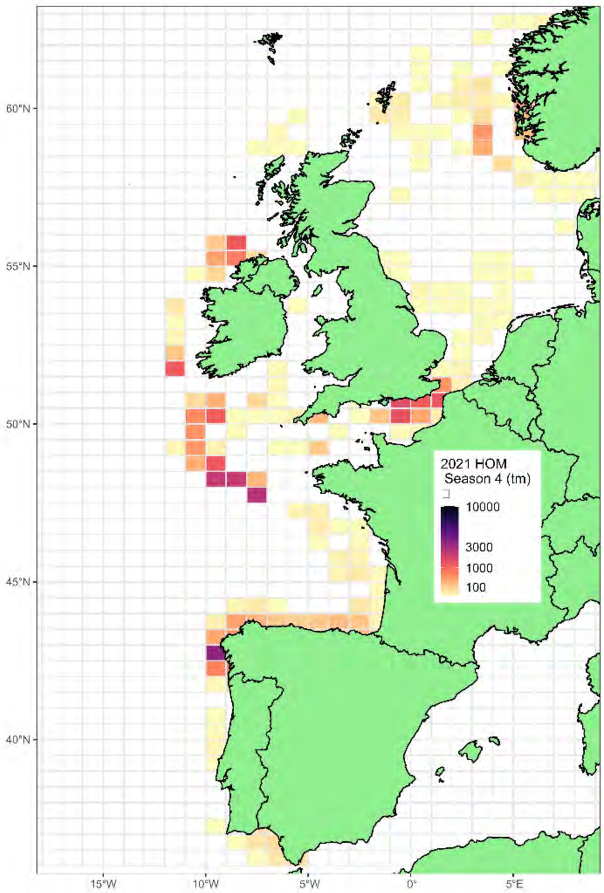

Figure 5.1.1d. Horse mackerel catches 4th quarter 2021.

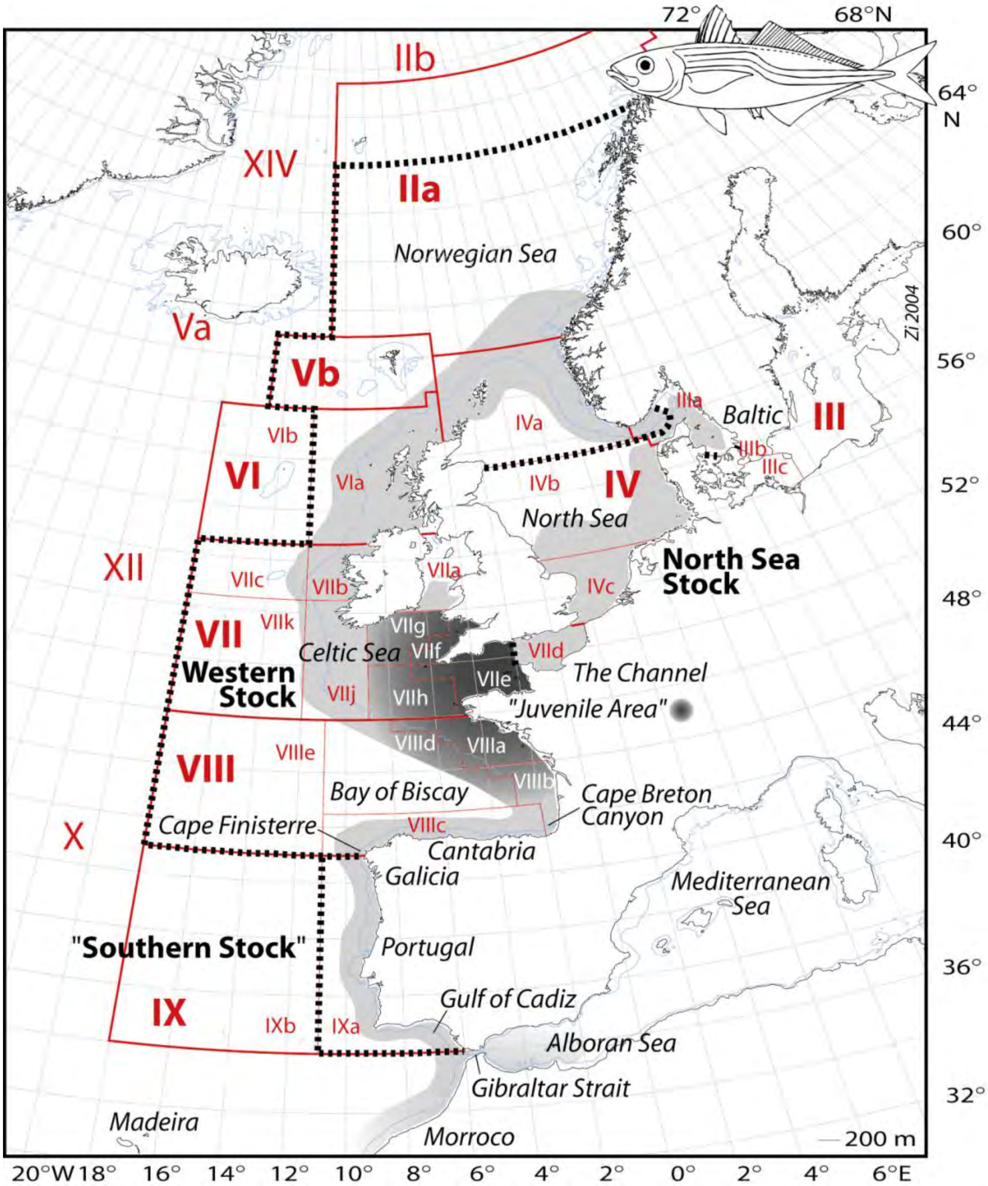

Figure 5.2.1: Distribution of Horse Mackerel in the Northeast-Atlantic: Stock definitions as used by the 2004 WGMHSA. Note that the "Juvenile Area" is currently only defined for the Western Stock distribution area – juveniles do also occur in other areas (like in Div. 7.d). Map source: GEBCO, polar projection, 200 m depth contour drawn.

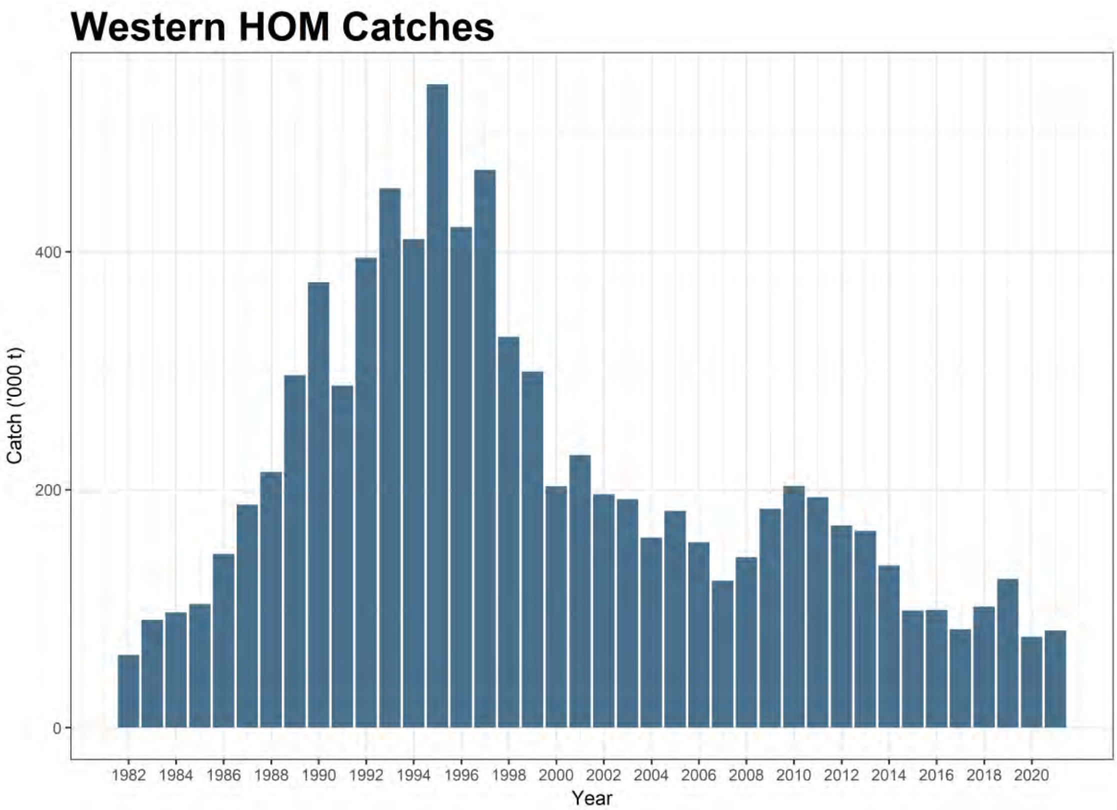

Figure 5.3.1. Total catch for Western Horse Mackerel stock, 1982–2021.

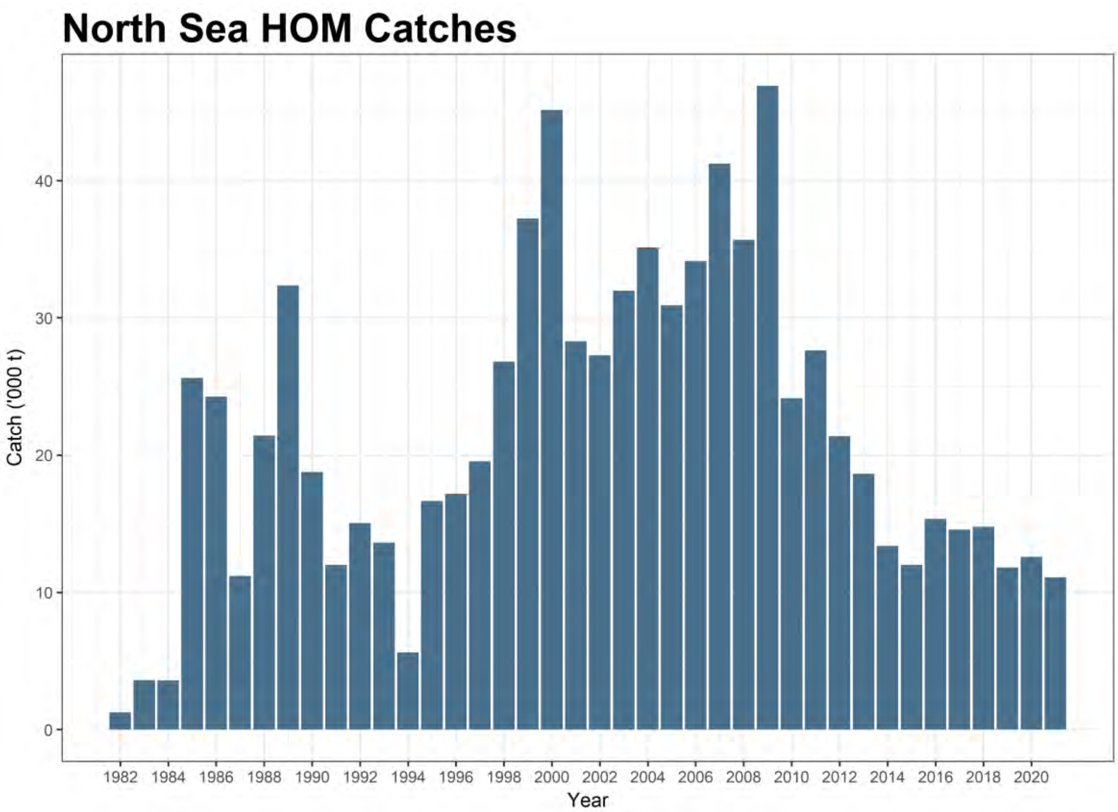

Figure 5.3.4. Total catch for North Sea Horse Mackerel stock, 1982–2021

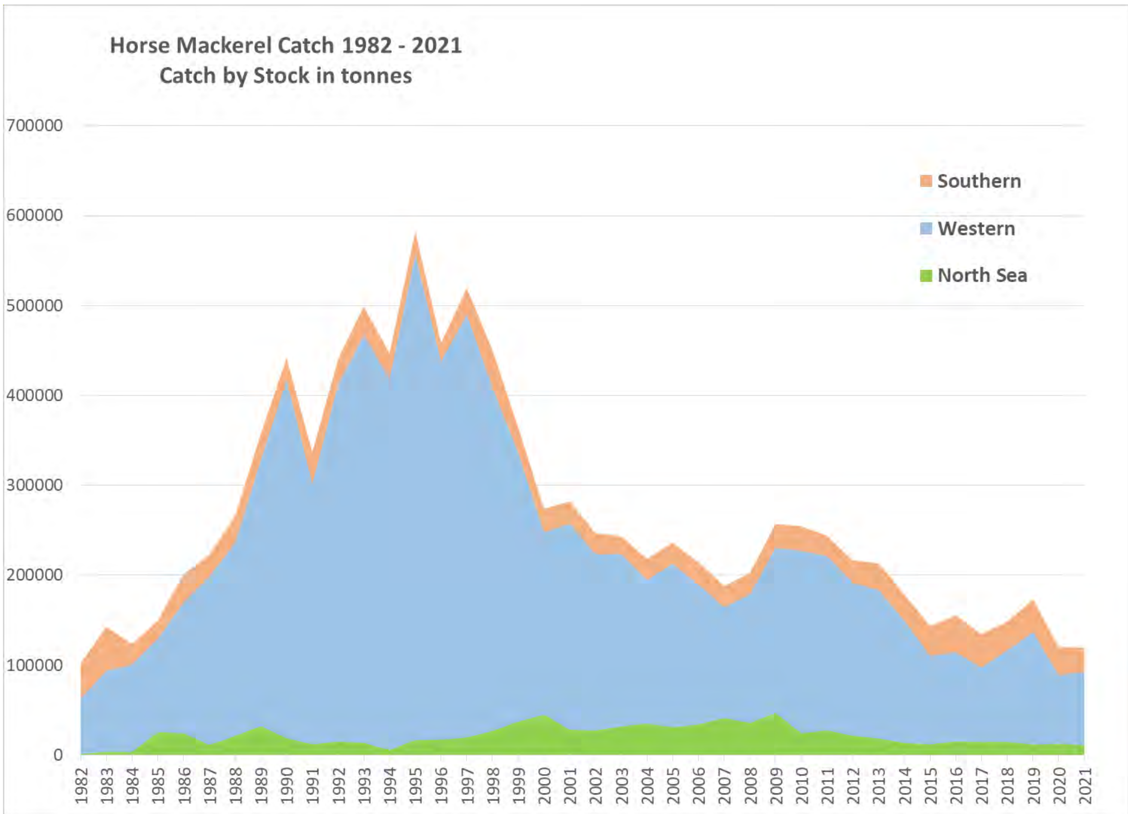

Figure 5.4.1 Horse mackerel general overview. Total catches in the northeast Atlantic during the period 1982—2021. The catches taken from the southern, western and North Sea horse mackerel stocks are shown in relation to the total catches in the northeast Atlantic. Catches from Div. 8.c were transferred from southern stock to western stock from 1982 onwards. Southern horse mackerel is assessed by ICES WGHANSA since 2011.

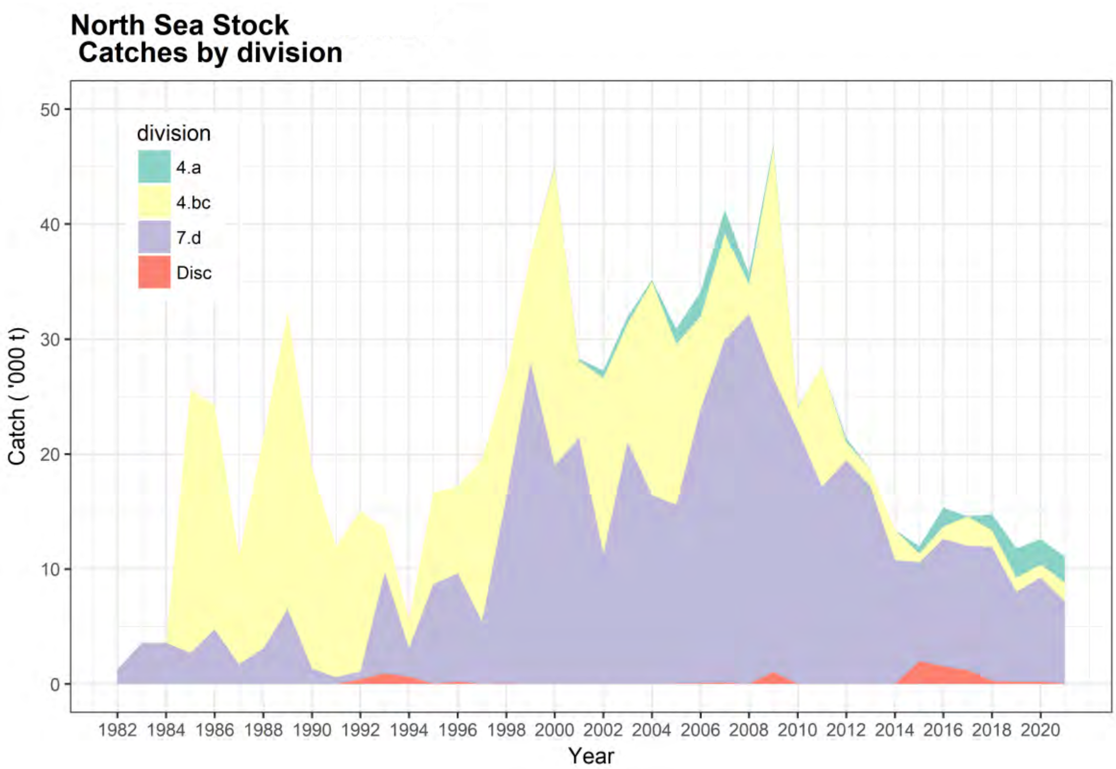

Figure 5.4.2. North Sea horse mackerel stock. Total catches by Division during the period 1982–2021.

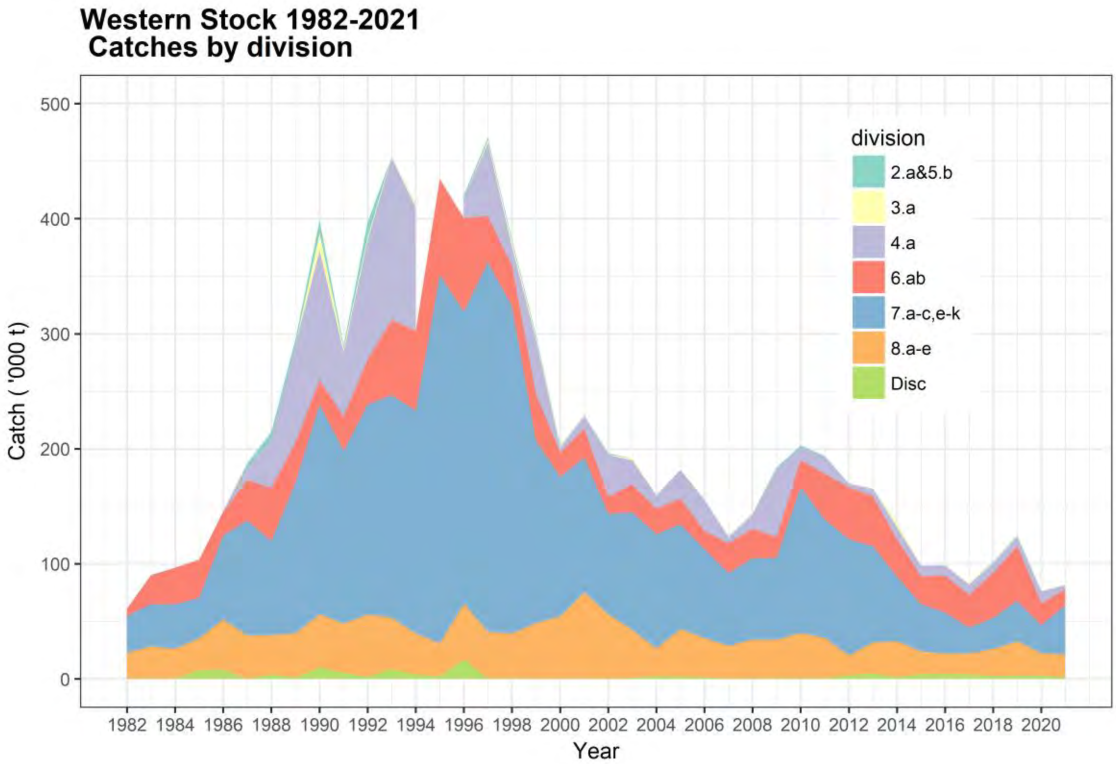

Figure 5.4.3. Western horse mackerel stock. Total catches by Sub-Area during the period 1982–2021.

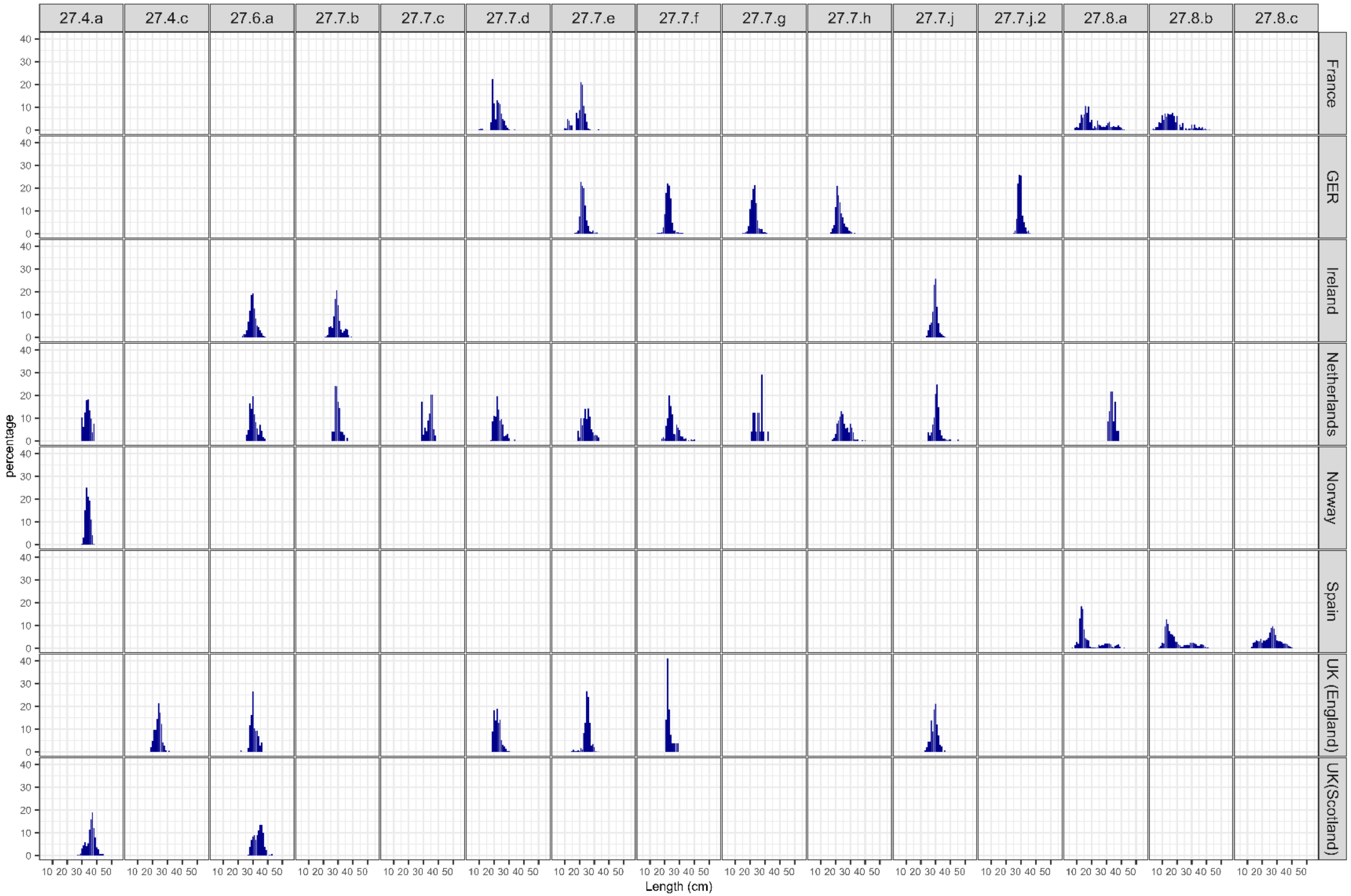

Figure 5.7.1. Length distributions contributed by country and area of the Western and North Sea horse mackerel 2021.

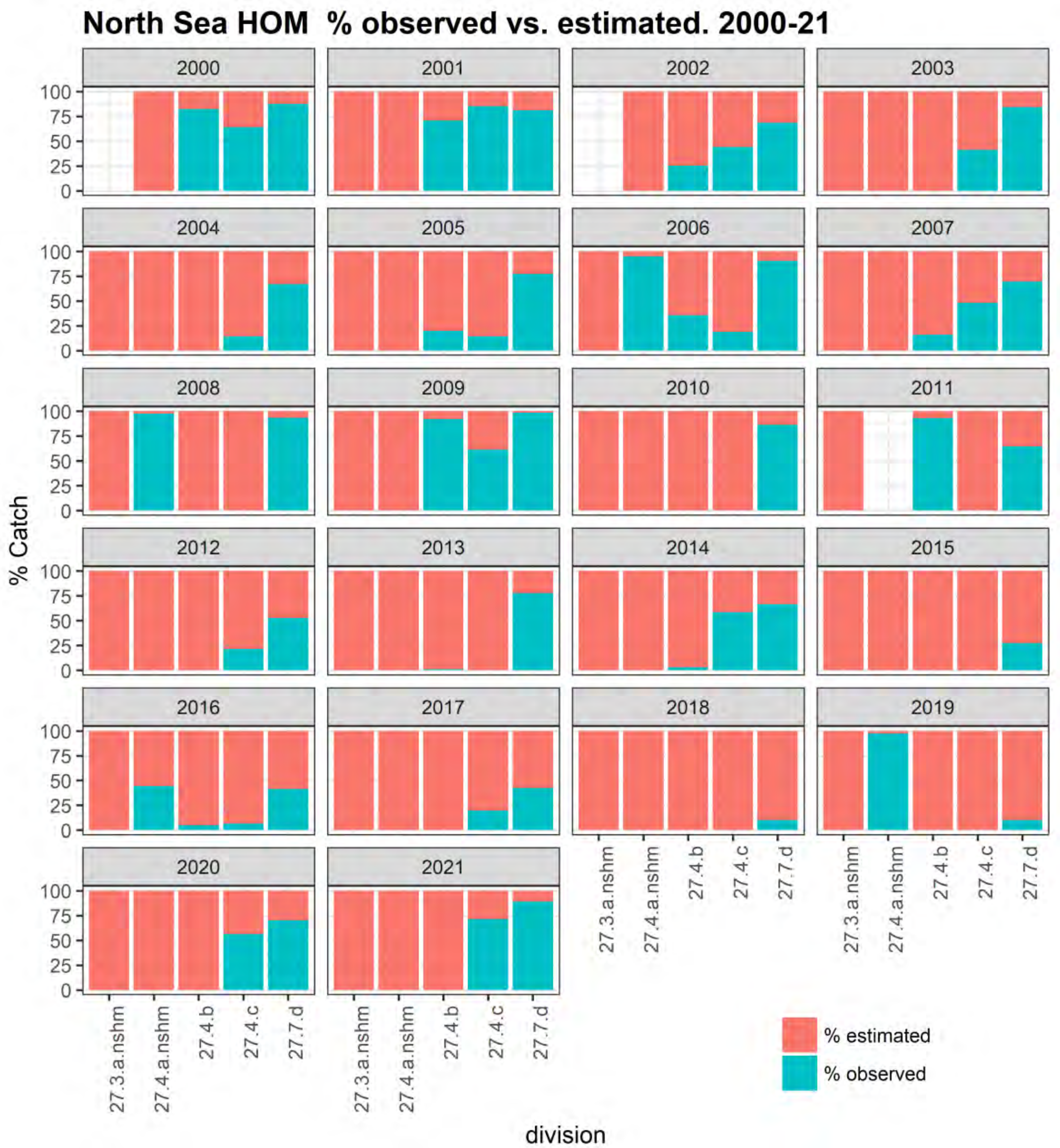

Figure 5.9.1 North Sea horse mackerel stock. Percentage sampled catch (blue) vs. unsampled catch (red) by division and year, 2000–2021.

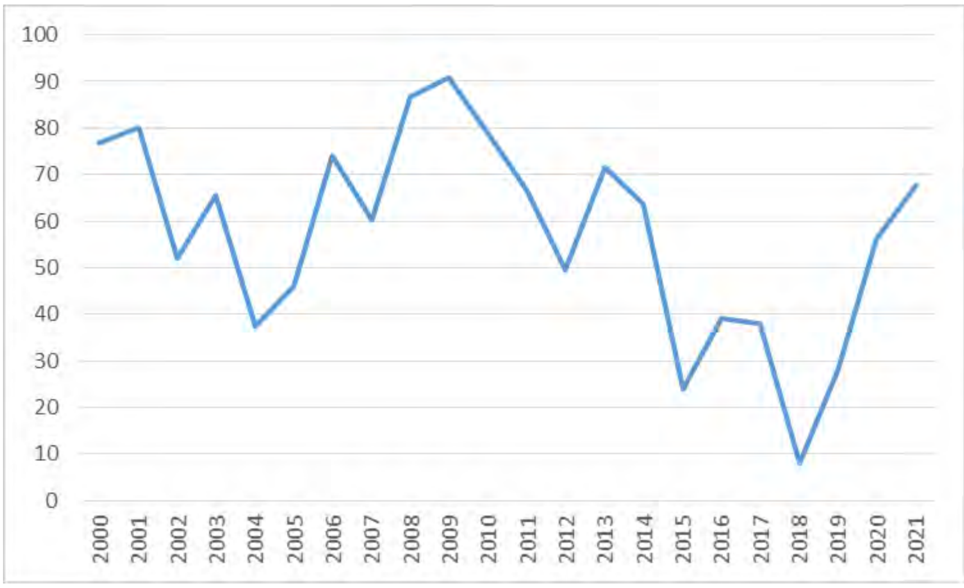

Figure 5.9.2. North Sea horse mackerel stock. Sampling intensity index as percentage sampled catch in total catch by year, 2000–2021.

Figure 5.9.5. Western horse mackerel stock. Percentage sampled catch (blue) vs. unsampled catch (red) by division and year. Period 2000–2021. 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).

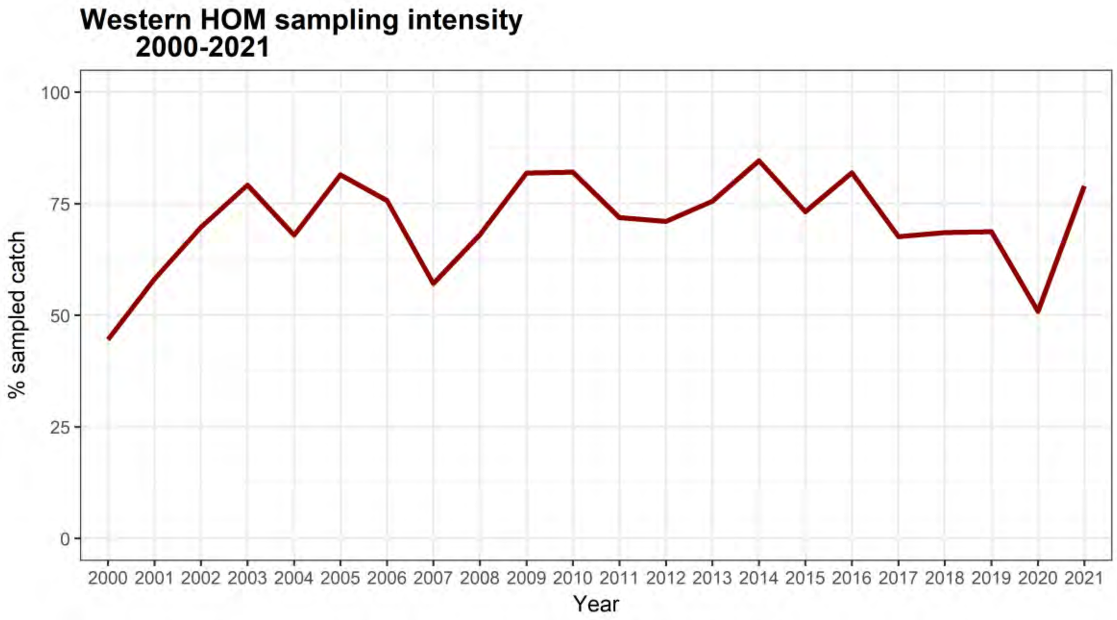

Figure 5.9.6. Western horse mackerel stock. Sampling intensity index as percentage sampled catch in total catch by year, 2000–2021.

6 North Sea Horse Mackerel: Divisions 27.4.a (Q1 and Q2), 27.3.a (excluding Western Skagerrak Q3 and Q4), 27.4.b, 27.4.c and 27.7.d

6.1 ICES Advice 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. Length-based DLS methods have been applied to data from 2016 onwards. The length-based F/F_{MSY} ratio has been decreasing since 2016, and F was estimated to be still slightly above F_{MSY} up till 2021. Stock size relative to reference points is unknown.

Biannual advice for 2022 and 2023 was provided in 2021, based on the data up to 2020 (ICES, 2021a). The uncertainty cap was applied, as the index ratio indicated a decrease of more than 20% in 2019-2020 compared to 2016-2018. The $L_{mean}/L_{F=M}$ ratio in 2020 was 0.912, indicating that the fishing mortality was above F_{MSY}. Since the precautionary buffer was applied last in 2017 (more than three years ago), the PA buffer was applied again in 2021. This resulted in a catch advice for 2022 and 2023 of 8 969 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 (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, with 65% of the total catch being caught in 7d, less than in 2020 (72%, Figure 6.2.4).

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 2020, the Netherlands accounted for most of the landings, followed by UK, 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 2021 the contribution is 20.5%, 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%.

6.3 Biological Data

6.3.1 Catch in Numbers at Age

For the second year in a row in 2021, it was possible to include samples taken from English vessels in the Netherlands, increasing further the biological sampling coverage. For 2021, the proportion of sampling increased to 67% in comparison to 56% in 2020 and for 2019 where only 1/3 of the landings were sampled. Age samples were available from two countries (the Netherlands and UK/England) from all quarters in 4c and for Q1 and Q4 in 7d. Although most landed catch was taken from 7d in Q4, substantial parts of the landings were fished in other areas and quarters (Figure 6.2.5). In order to avoid a biased perception of the age distribution of catches over the year and areas, this partial and uneven sampling effort should be avoided in future years.

Annual catch numbers at age are shown in Table 6.3.1. Catch-at-age for the whole period 1995-2021 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 increased in 7d in comparison to 3a and 4a, b and c where the opposite pattern was found. 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.

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 2000–2021 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 the values at age 2-5 seem to be in decline and are relatively low.

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 1992–2009 period provide complete data for the 1992 to 2009 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. 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 not covering 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 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 2021 were around 6-8 cm in the NS-IBTS (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 10-11 cm, while in 2019, 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 shows a similar pattern A cluster of larger fish can be observed, possibly a remainder of the strong year class from 2020.

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 22.5 cm each year, although with the exception of 24.7 cm in 2019 (Figure 6.4.11). Lengths in 4c were on average 21.7 cm in 2019, 22.0 cm in 2020, and 23.8 in 2021 (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. Because for the calculation of the F/F_{msy} proxy only the length frequency of the current assessment year is used, these older files are not needed for the calculations of advice anymore.

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 (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 also in 2021 (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 this assessment.

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.

6.6 Basis for 2022 and 2023 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 2016 to 2019. The resulting index ratio (index value of 2019 over mean index value of 2016-2018) indicated that the adult sub-stock declined by 21%. As the decline was more than 20%, the uncertainty cap of 0.8 was applied to the catch advice. The $L_{mean}/L_{F=M}$ ratio in 2020 was 0.912, indicating that the fishing mortality is above F_{MSY}. Because the precautionary buffer was last applied in 2017, and thus more than three years ago, the buffer was applied once again in 2021. Under these circumstances, and based on the previous catch advice of 14 014 t, ICES advised that catches of North Sea horse mackerel in 2022 and 2023 should be no more than 8 969 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 2019there was a slight increase in the index of the exploitable sub-stock but that trend has not continued this year.

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.). More samples and research is needed to confirm these results. 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.

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

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6.11 Tables

Table 6.3.1. North Sea Horse Mackerel stock. Catch in numbers (1000) by quarter and area in 2021

	Number/1000					
1Q						
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	0.00	0.00	0.00	0.00	0.00	0.00
2	0.21	355.84	0.02	25.24	190.21	571.51
3	4.08	7056.29	0.34	911	3361.25	11332.95
4	1.79	3100.26	0.15	477.27	1399.79	4979.27
5	2.62	4537.8	0.22	1143.79	1603.62	7288.06
6	0.34	582.68	0.03	96.63	256.16	935.83
7	1.24	2139.24	0.1	340.5	954.71	3435.79
8	0.24	408.16	0.02	128.21	118.91	655.54
9	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00
13	0.04	66.19	0	4.69	35.38	106.3
Sum	10.56	18246.46	0.88	3127.33	7920.03	29305.25
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	10.34	0.24	66.2	11.03	87.82
2	0.02	100.04	2.28	475.39	106.7	684.42
3	0.12	616.2	14.01	674.74	657.23	1962.3
4	0.05	274.18	6.24	318.52	292.44	891.44
5	0.08	396.27	9.01	433.92	422.65	1261.93
6	0.01	50.88	1.16	55.72	54.27	162.04
7	0.04	190.26	4.33	226.63	202.93	624.18

8	0.01	35.64	0.81	39.03	38.02	113.51
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
13	0	5.78	0.13	6.33	6.16	18.41
Sum	0.33	1679.59	38.21	2296.48	1791.43	5806.05
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	49.1	206.53	141.39	397.02
2	0	0	141.3	783.18	406.9	1331.37
3	0	0	129.76	1256.95	373.67	1760.38
4	0	0	76.92	411.33	221.5	709.75
5	0	0	28.52	433.38	82.12	544.01
6	0	0	1.89	2.81	5.45	10.14
7	0	0	15.87	299.9	45.71	361.49
8	0	0	1.98	2.94	5.7	10.62
9	0	0	0.26	0.39	0.76	1.41
10	0	0	0	0	0	0
11	0	0	0.63	0.93	1.81	3.37
12	0	0	1.27	1.89	3.67	6.83
13	0	0	0	0	0	0
Sum	0	0	447.5	3400.23	1288.68	5136.39
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	5.45	191.78	6563.36	6760.59
2	0	0	15.53	312.84	18928.67	19257.04
3	0	0	13.81	1724.58	15381.03	17119.41

4	0	0	8.47	985.63	9504.59	10498.68
5	0	0	2.9	644.4	2949.8	3597.09
6	0	0	0.21	0.99	264.68	265.88
7	0	0	1.56	7.24	1931.81	1940.61
8	0	0	0.22	1.04	276.95	278.21
9	0	0	0.03	0.14	36.82	36.99
10	0	0	0	0	0	0
11	0	0	0.07	0.33	88.05	88.45
12	0	0	0.14	0.67	178.29	179.1
13	0	0	0	0	0	0
Sum	0	0	48.39	3869.64	56104.05	60022.05
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	10.34	54.79	464.51	6732.43	7262.07
2	0.23	455.88	159.12	1596.64	19681.29	21893.16
3	4.2	7672.49	157.91	4567.27	19824.98	32226.85
4	1.85	3374.45	91.77	2192.75	11447.82	17108.63
5	2.7	4934.07	40.65	2655.48	5073.05	12705.95
6	0.35	633.57	3.29	156.14	581.87	1375.21
7	1.27	2329.5	21.87	874.27	3143.02	6369.94
8	0.24	443.81	3.03	171.22	440.72	1059.02
9	0	0	0.29	0.53	37.67	38.49
10	0	0	0	0	0	0
11	0	0	0.7	1.26	90.07	92.03
12	0	0	1.42	2.56	182.39	186.37
13	0.04	71.97	0.13	11.02	41.62	124.78
Sum	10.88	19926.08	534.97	12693.65	67276.93	100442.5

Table 6.3.2. Numbers at age (millions). weight at age (kg) and length at age (cm) for the North Sea horse mackerel 1995-2021 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
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
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
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
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
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
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
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
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
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
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
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
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
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
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	
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	

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
0																										0.047	
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		0.057	0.046
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	0.057
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	0.086
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	0.119
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	0.132
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	0.191
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	0.174
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		0.248	0.306	0.247
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		0.261	0.308	0.306
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		0.304	0.313	0.308

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
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		0.301	0.339	0.313
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			0.411	0.378	0.339
13	0.241	0.258	0.367	0.367	0.367	0.316	0.287	0.317	0.356	0.301	0.338	0.267	0.339	0.375	0.383	0.288	0.474		0.262	0.252	0.351	0.242			0.42	0.325	0.378
14	0.348	0.277	0.299	0.299	0.299		0.295	0.32	0.316	0.338	0.373	0.302	0.414	0.277	0.362	0.315	0.415	0.187	0.559	0.408	0.235	0.39	0.214		0.429	0.389	0.325
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		0.431	0.37	0.389

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
0																										18	
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
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
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
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
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
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
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

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
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
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
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	
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
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
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
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	
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	

Table 6.3.3. North Sea Horse Mackerel stock. Mean weight at age (grams) in the catch by area for all quarters in 2020

Q1-Q4

Ages	27.3.a (Q1.2)	27.4.a(Q1.2)	27.4.b	27.4.c	27.7.d	Total
0	46.5	46.5	46.5	46.5	46.5	46.5
1	57.4	57.4	57.4	60.3	57.1	57.4
2	86	86	86	87.7	85.8	86.0
3	119	119	119	112.2	119.8	119.0
4	132.1	132.1	132.1	130.8	132.2	132.1
5	191	191	191	175.7	193.1	191.0
6	173.6	173.6	173.6	165.4	174.6	173.6
7	246.7	246.7	246.7	208.7	253	246.8
8	305.7	305.7	305.7	305.7	305.7	305.7
9	307.8	307.8	307.8	307.8	307.8	307.8
10	313.3	313.3	313.3	313.3	313.3	313.3
11	339	339	339	339	339	339
12	378.1	378.1	378.1	378.1	378.1	378.1
13	325	325	325	325	325	325
14	389	389	389	389	389	389
15+	370	370	370	370	370	370

Table 6.3.4. North Sea Horse Mackerel stock. Mean length (mm) at age in the catch by area for all quarters in 2020

1-4Q

Ages	27.3.a (Q1.2)	27.4.a(Q1.2)	27.4.b	27.4.c	27.7.d	Total
0	180	180	180	180	180	180
1	192.9	192.9	192.9	193	192.9	192.9
2	217.4	217.4	217.4	217.1	217.5	217.4
3	243.5	243.5	243.5	235.6	244.4	243.5
4	248.3	248.3	248.3	245.9	248.5	248.2
5	275.4	275.4	275.4	266	276.7	275.4
6	269.7	269.7	269.7	264.3	270.3	269.6
7	295	295	295	281.3	297.2	295.0

Ages	27.3.a (Q1.2)	27.4.a(Q1.2)	27.4.b	27.4.c	27.7.d	Total
8	318.3	318.3	318.3	318.3	318.3	318.3
9	315.7	315.7	315.7	315.7	315.7	315.7
10	321	321	321	321	321	321
11	327.3	327.3	327.3	327.3	327.3	327.3
12	343.9	343.9	343.9	343.9	343.9	343.9
13	315	315	315	315	315	315
14	355	355	355	355	355	355
15+	329.7	329.7	329.7	329.7	329.7	329.7

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 1992-2021 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.

	Juvenile sub-stock (<20 cm)			Exploitable sub-stock (>20 cm)		
Year	Index	CI_low	CI_high	Index	CI_low	CI_high
1992	4268	2077	9435	4268	2077	9435
1993	1854	894	3675	1854	894	3675
1994	2589	1291	5153	2589	1291	5153
1995	2016	1049	4220	2016	1049	4220
1996	730	320	1598	730	320	1598
1997	2171	928	4715	2171	928	4715
1998	650	323	1270	650	323	1270
1999	1438	755	2593	1438	755	2593
2000	1566	813	3110	1566	813	3110
2001	2188	1148	4925	2188	1148	4925
2002	2398	1282	4992	2398	1282	4992
2003	1787	933	3234	1787	933	3234
2004	1002	522	1837	1002	522	1837
2005	802	434	1590	802	434	1590
2006	530	278	918	530	278	918
2007	600	324	1099	600	324	1099

	Juvenile sub-stock (<20 cm)			Exploitable sub-stock (>20 cm)		
2008	532	287	932	532	287	932
2009	691	356	1227	691	356	1227
2010	2257	1105	4387	2257	1105	4387
2011	504	263	933	504	263	933
2012	315	158	669	315	158	669
2013	1087	573	2080	1087	573	2080
2014	1545	835	2979	1545	835	2979
2015	1471	735	3035	1471	735	3035
2016	3044	1460	6036	3044	1460	6036
2017	941	427	1948	941	427	1948
2018	3171	1594	7299	3171	1594	7299
2019	812	375	1628	812	375	1628
2020	-	-	-	-	-	-
2021	1663	785	3309	1663	785	3309

6.12 Figures

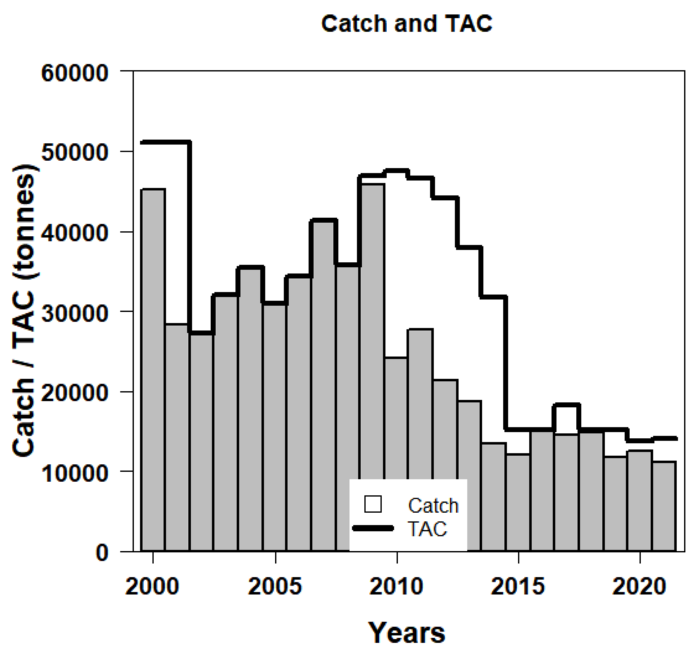


Figure 6.2.1. North Sea horse mackerel. Utilisation of quota from 2000 to 2021.

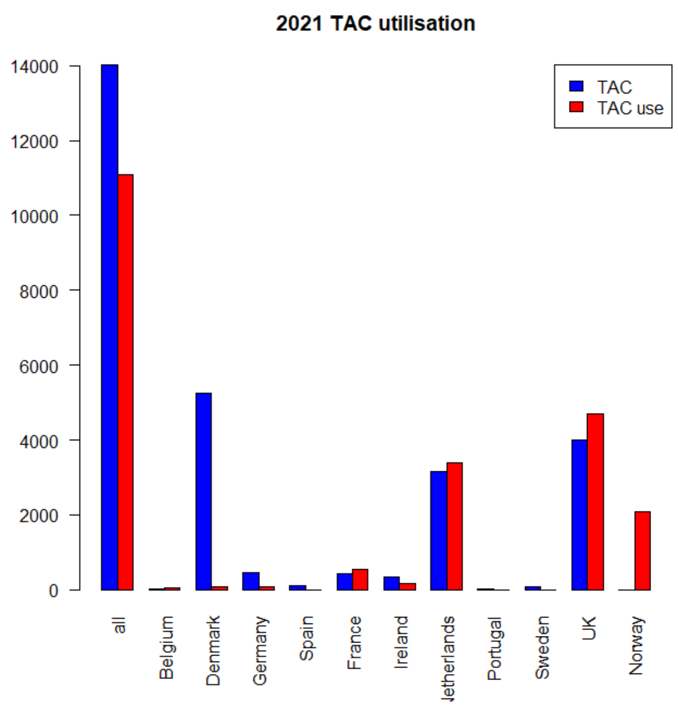


Figure 6.2.2. North Sea horse mackerel. Utilisation of quota by country in 2021.

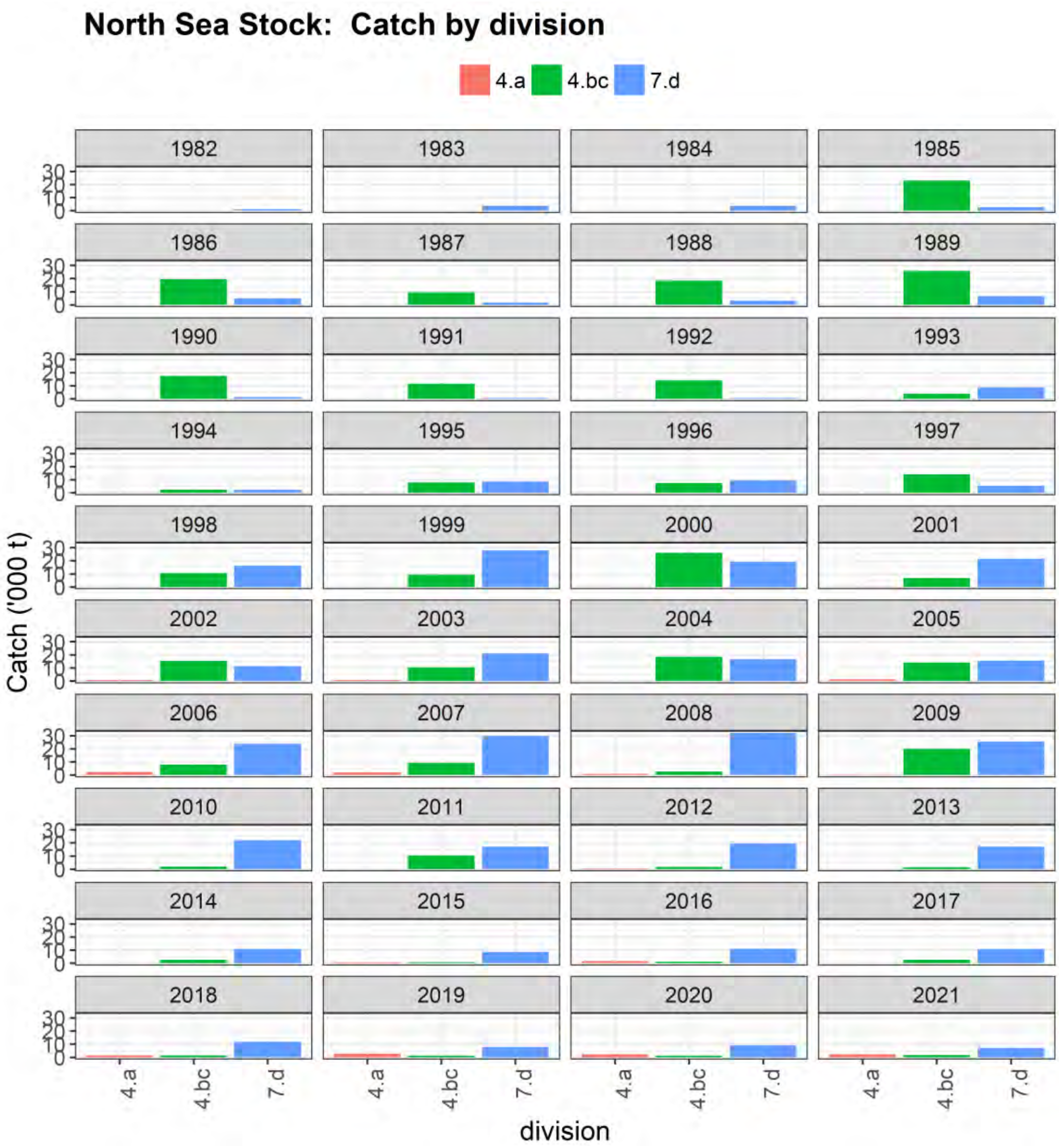


Figure 6.2.3. North Sea horse mackerel. Catch in (1000 t) by division and year from 1982 to 2021.

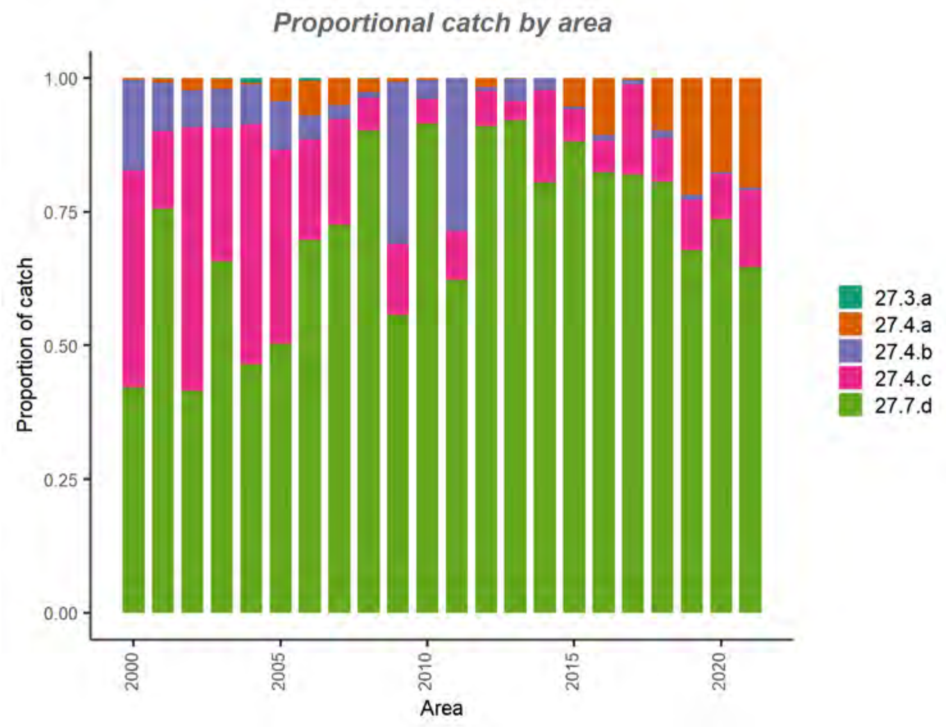
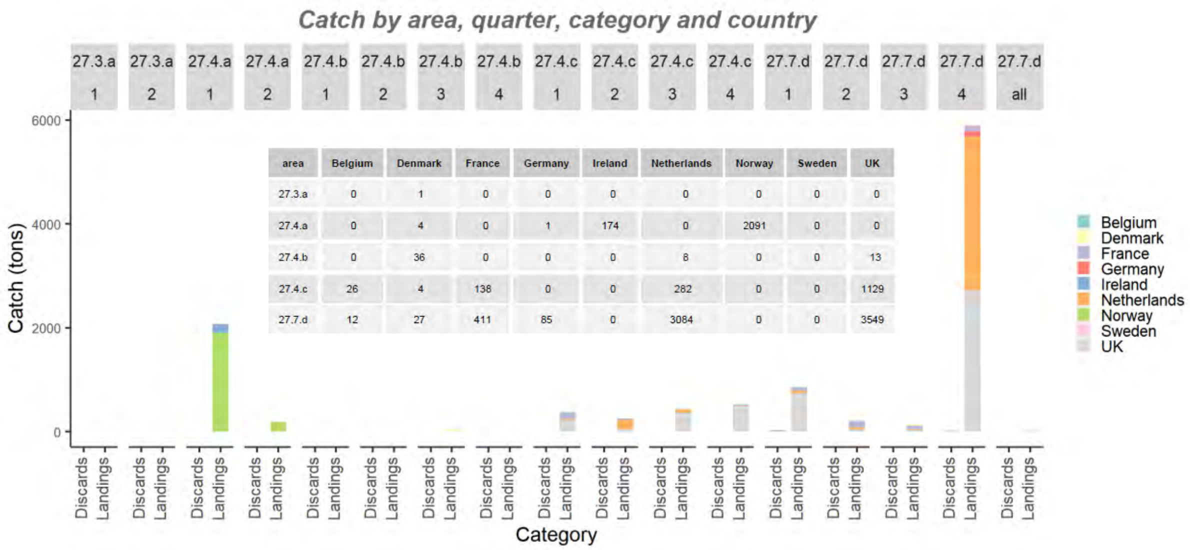


Figure 6.2.4. North Sea horse mackerel. Proportion of catches by ICES division from 2000 to 2021.



area	Belgium	Denmark	France	Germany	Ireland	Netherlands	Norway	Sweden	UK
27.3.a	0	1	0	0	0	0	0	0	0
27.4.a	0	4	0	1	174	0	2091	0	0
27.4.b	0	36	0	0	0	8	0	0	13
27.4.c	26	4	138	0	0	282	0	0	1129
27.7.d	12	27	411	85	0	3084	0	0	3549

Figure 6.2.5. North Sea Horse Mackerel. Total catch (in tonnes) by ICES division, quarter, catch category and country in 2021.

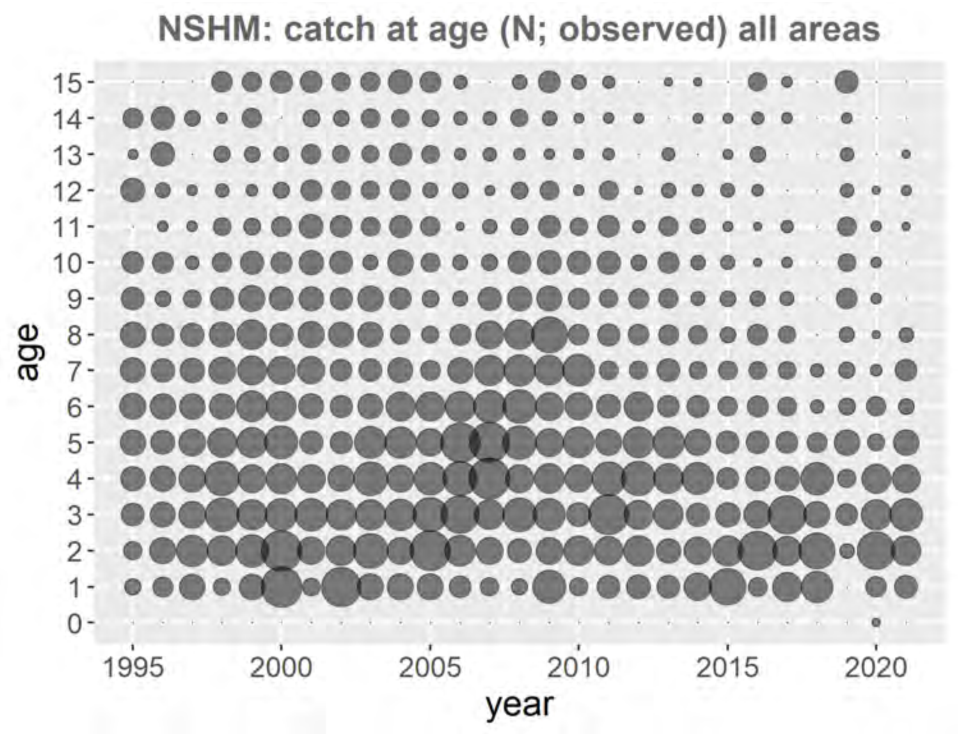


Figure 6.3.1. North Sea horse mackerel age distribution in the catch for 1995-2021. The size of bubbles is proportional to the catch number. Note that age 15 is a plus g

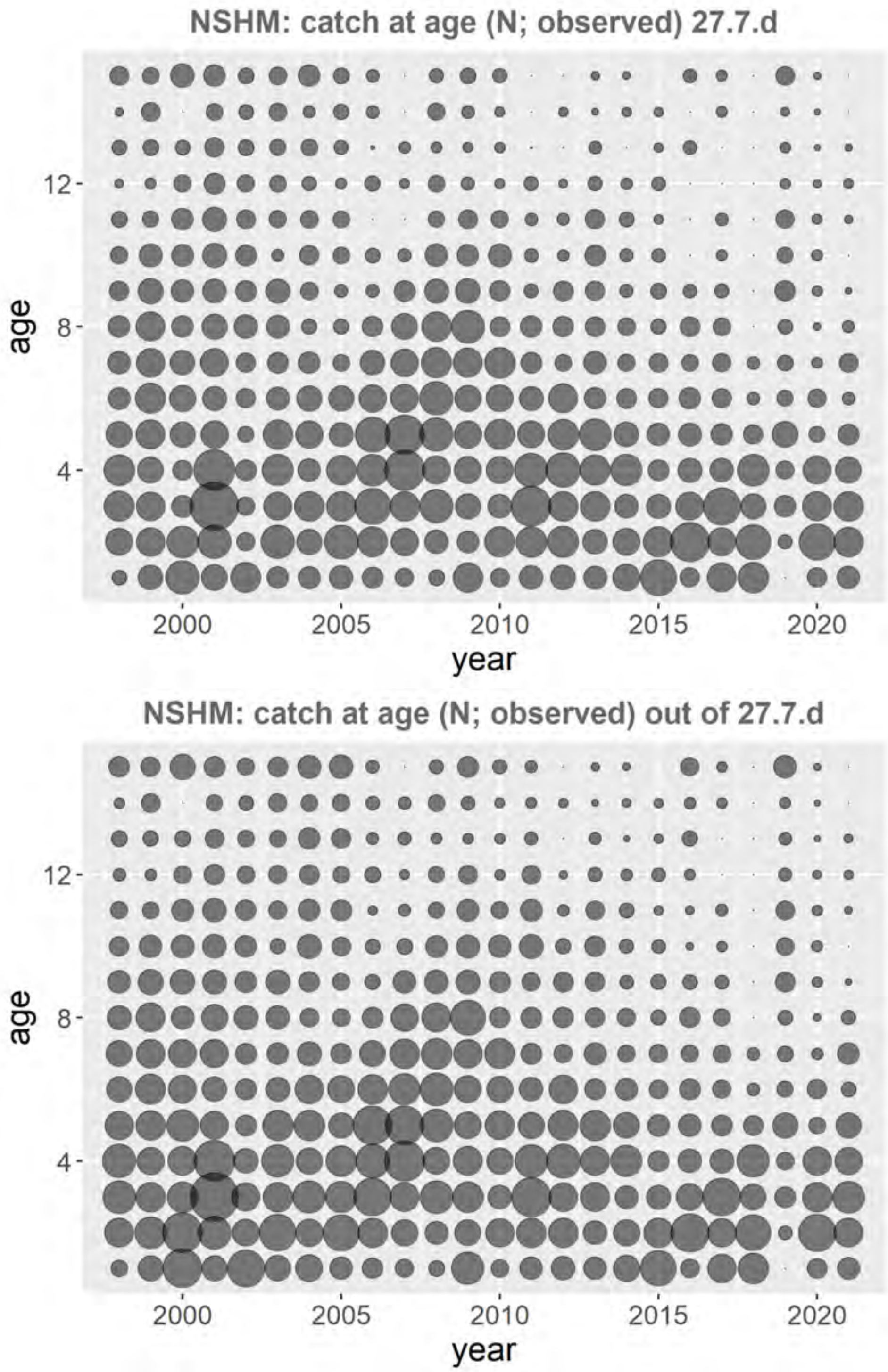


Figure 6.3.2. North Sea horse mackerel. Bubble plots of age distribution in the catch by area for 1998-2021 for area 7.d (upper panel) and without 7.d (bottom panel). The size of bubbles is proportional to the catch numbers. Note that age 15 is a plus group.

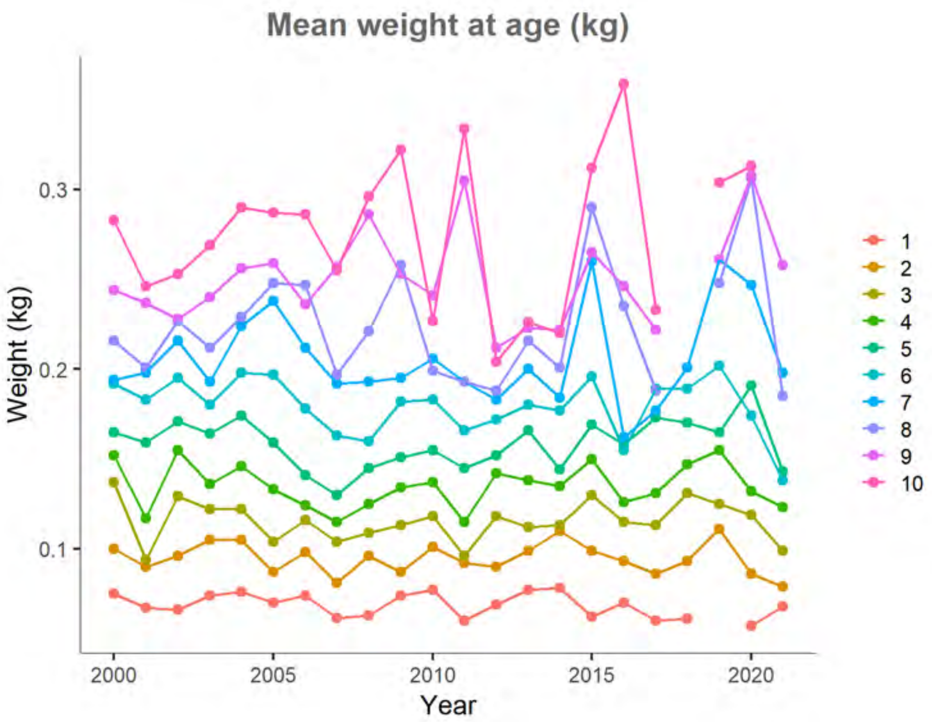


Figure 6.3.3. North Sea horse mackerel. Mean weight at age in commercial catches over the period 2000-2021. Note that only age 1-10 are presented and that 10 is not a plus group.

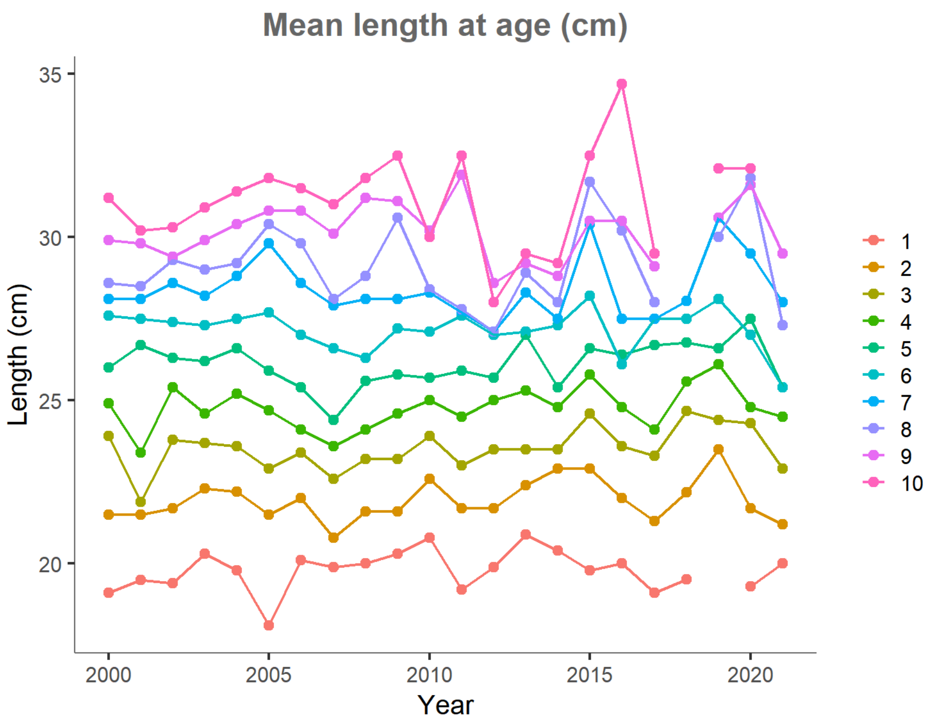


Figure 6.3.4. North Sea horse mackerel. Mean length at age in commercial catches over the period 2000-2021. Note that only age 1-10 are presented and that 10 is not a plus group.

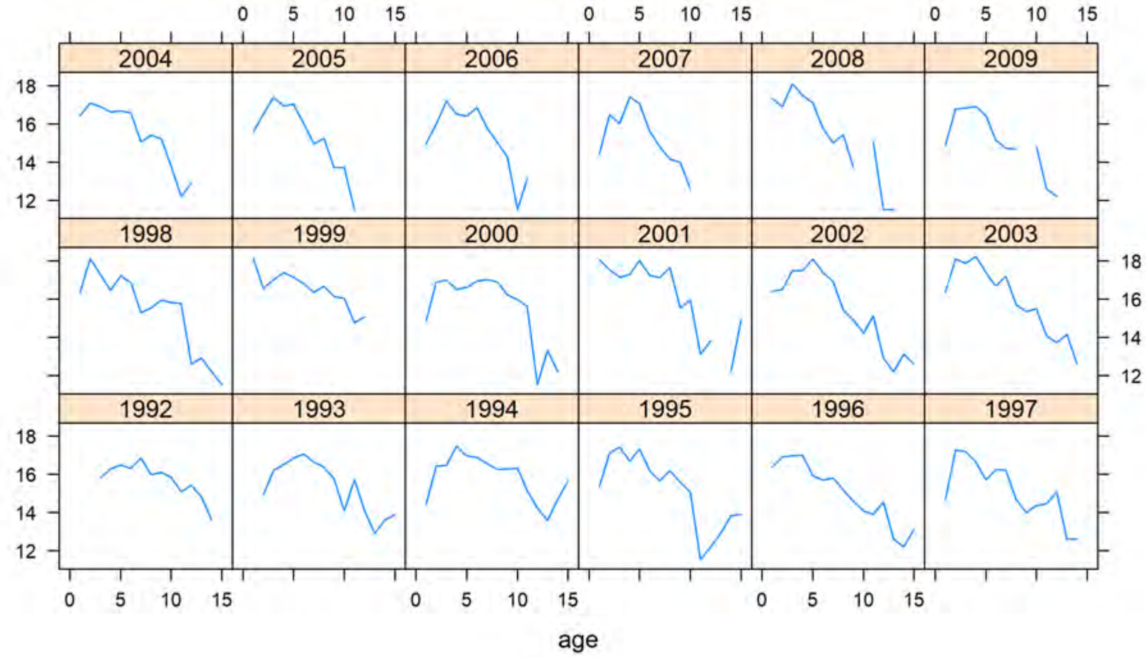


Figure 6.4.1. North Sea Horse Mackerel. Catch curves for the 1992 to 2009 cohorts, ages from 3 to 15+. Values plotted on the vertical axis are the log(catch) values for each cohort in each year. The negative slope of these curves estimates total mortality (Z) in the cohort.

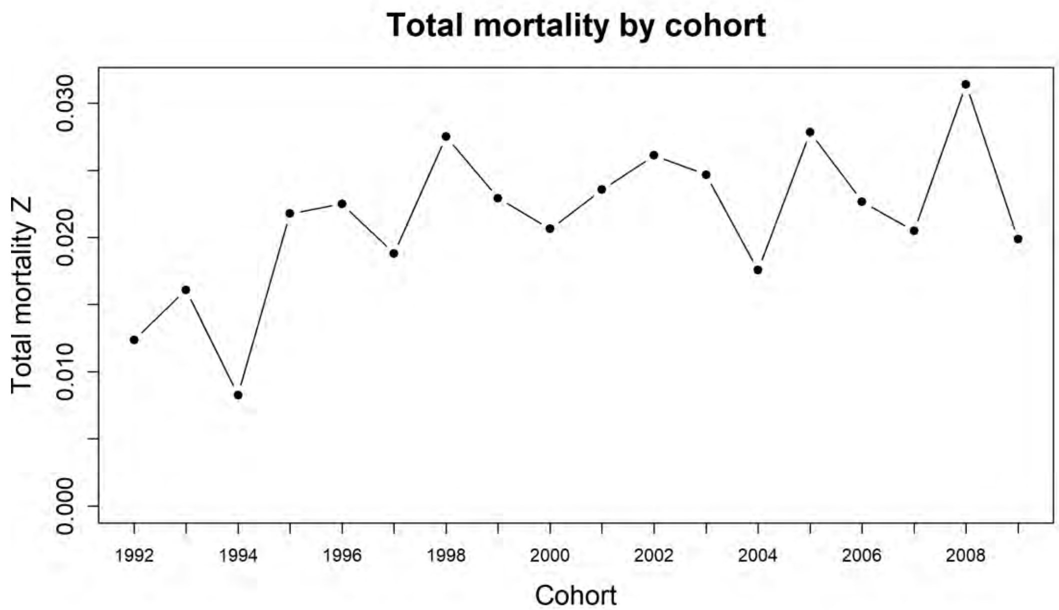


Figure 6.4.2. North Sea Horse Mackerel. Total mortality by cohort (Z) estimated from the negative gradients of the 1992—2009 cohort catch curves (Figure 6.4.1).

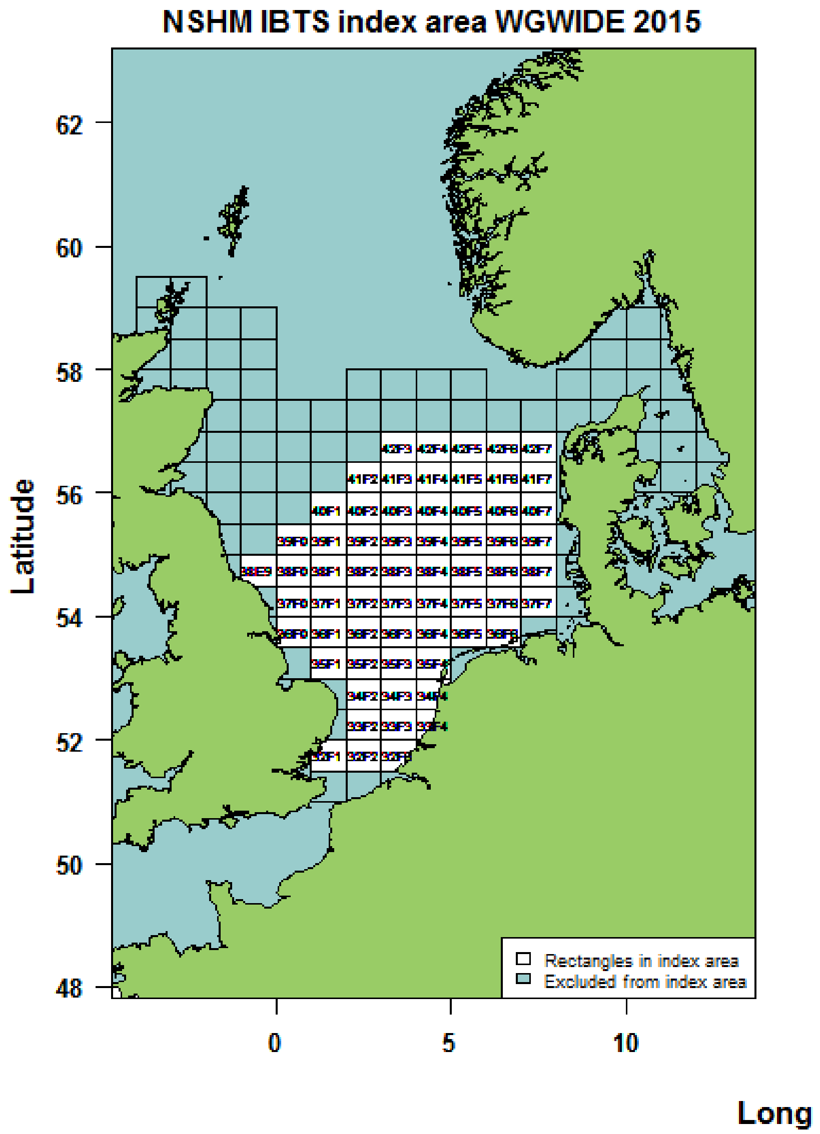


Figure 6.4.3. North Sea horse mackerel. ICES rectangles selected by WGWIDE in 2013 and currently used by the working group.

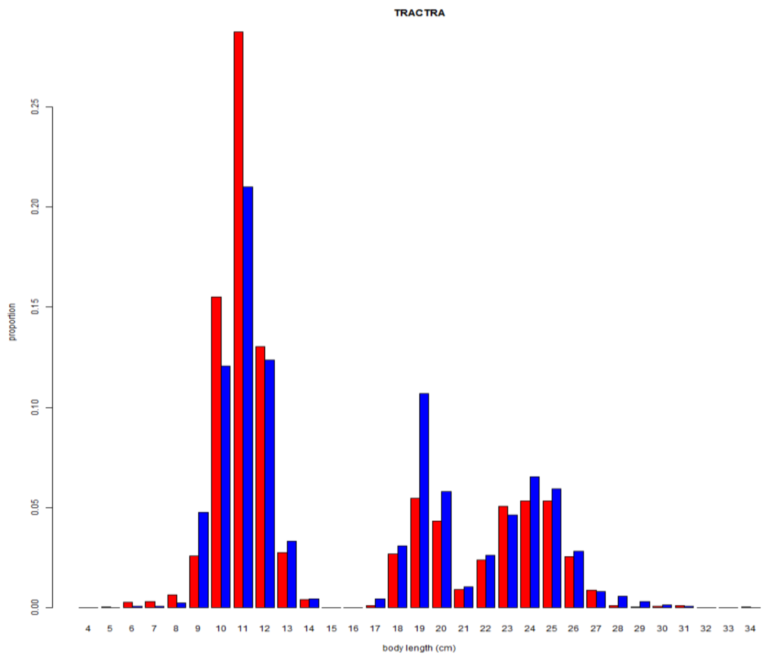


Figure 6.4.4. North Sea horse mackerel. Size distribution of North Sea horse mackerel catches during the inter-calibration exercise conducted in 2014 between the RV Gwen Drez (red bars) and Thalassa (blue bars).

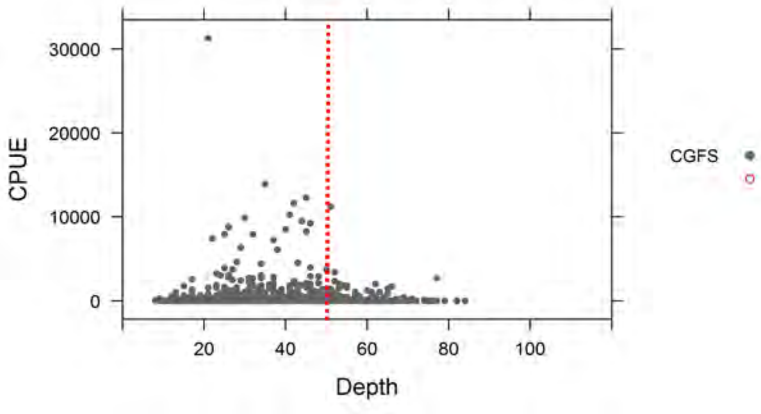


Figure 6.4.5. North Sea horse mackerel. CPUE by depth for the CGFS survey from 1992 to 2017.

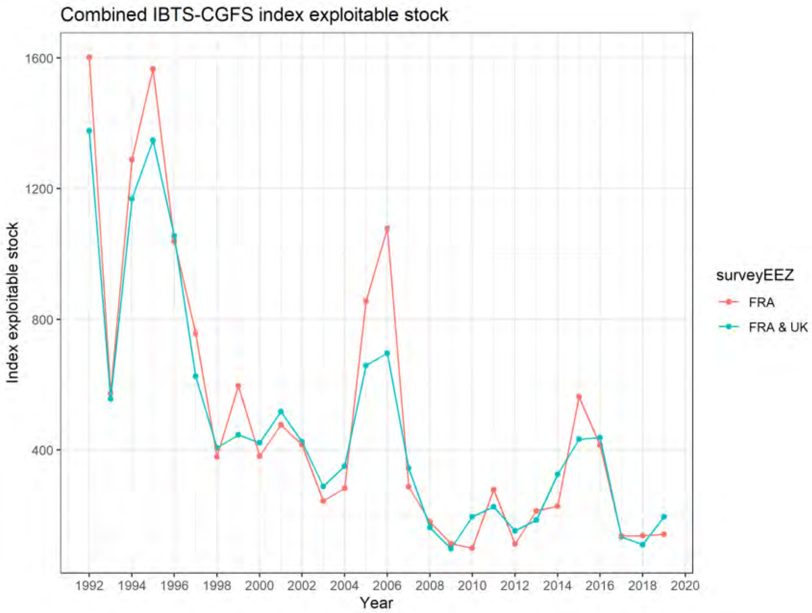


Figure 6.4.6. North Sea horse mackerel. Modelled abundance index from 1992-2019 including both UK and French stations in the FR-CGFS (blue) and excluding UK stations in the FR-CGFS (red) for the exploitable sub-stock (≥20 cm).

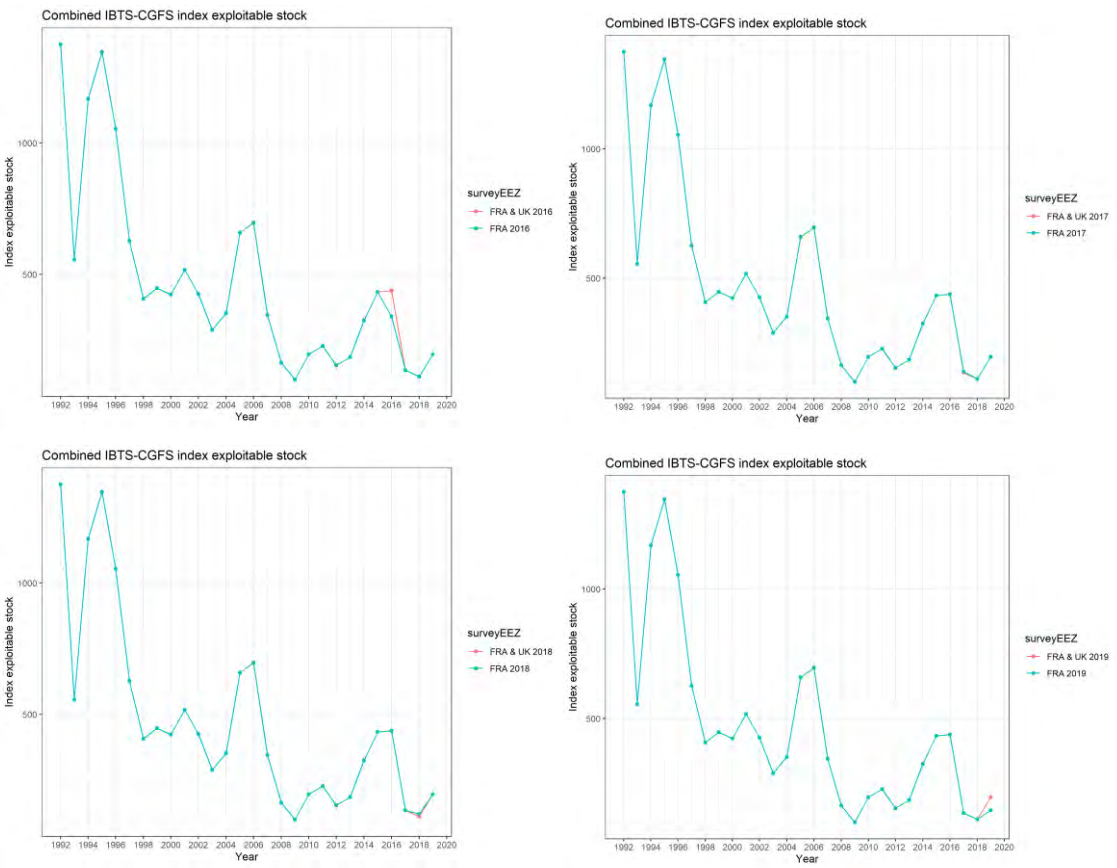


Figure 6.4.7. North Sea horse mackerel. Modelled abundance index from 1992-2019 for the exploitable sub-stock (≥20 cm) for when UK sampling stations from FR-CGFS have been excluded for 2016 (top left), 2017 (top right), 2018 (bottom left) and 2019 (bottom right).

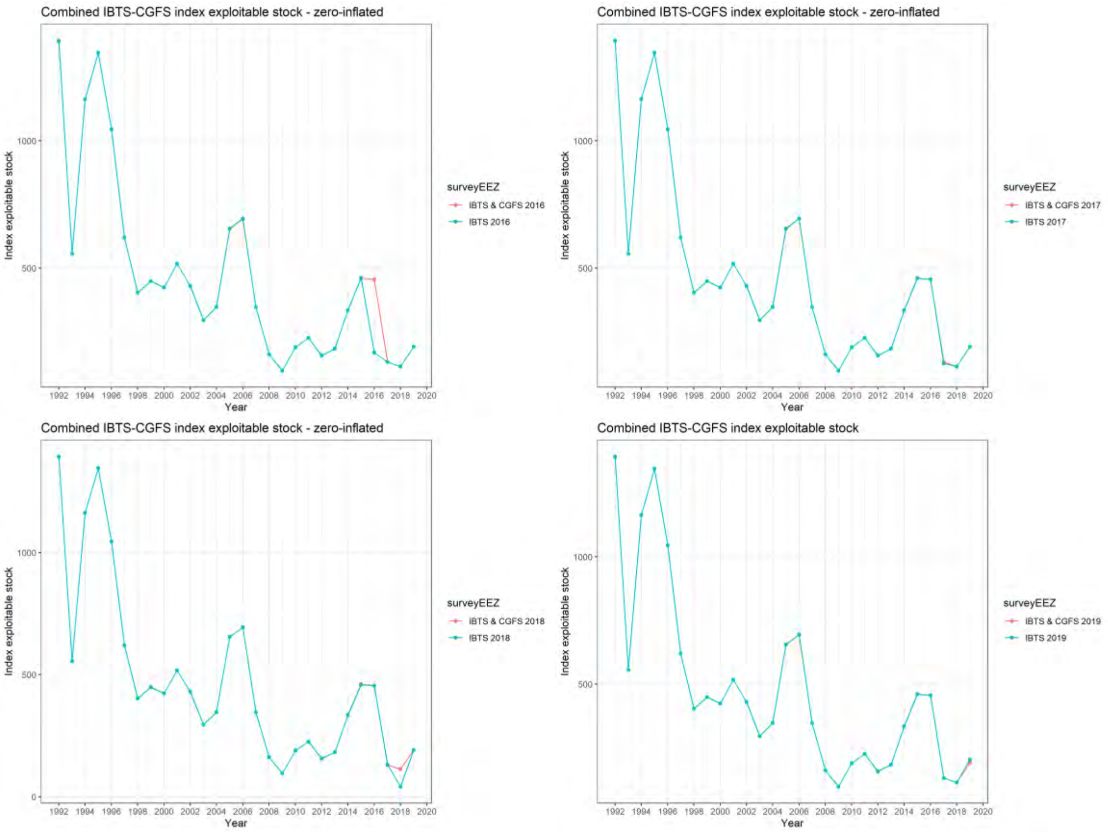


Figure 6.4.8. North Sea horse mackerel. Modelled abundance index from 1992-2019 for the exploitable sub-stock (≥20 cm) for when the FR-CGFS has been excluded for 2016 (top left), 2017 (top right), 2018 (bottom left) and 2019 (bottom right).

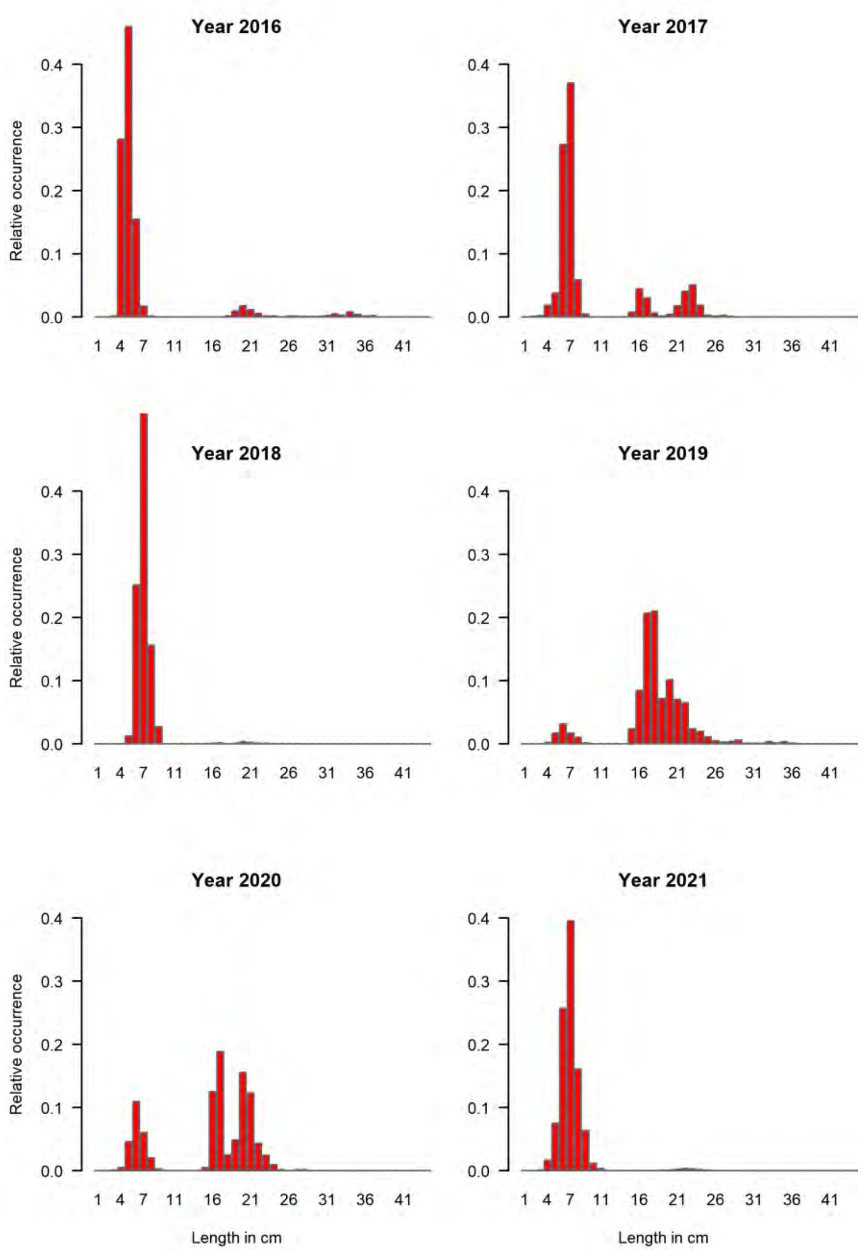


Figure 6.4.9. North Sea horse mackerel. Relative occurrence by length for the period 2014-2021 in the NS-IBTS.

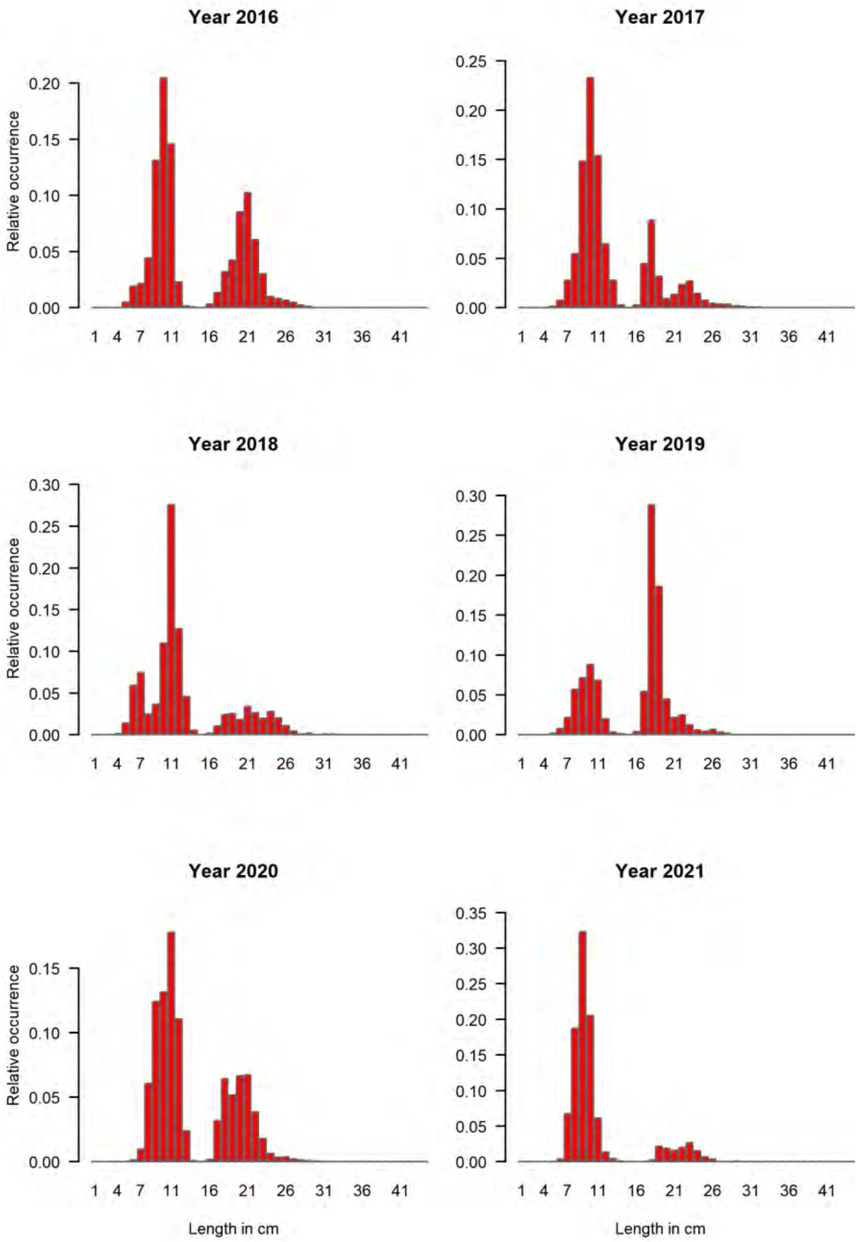


Figure 6.4.10. North Sea horse mackerel. Relative occurrence by length for the period 2015-2021 in the FR-CGFS. Note that stations in UK waters could not be visited in 2020.

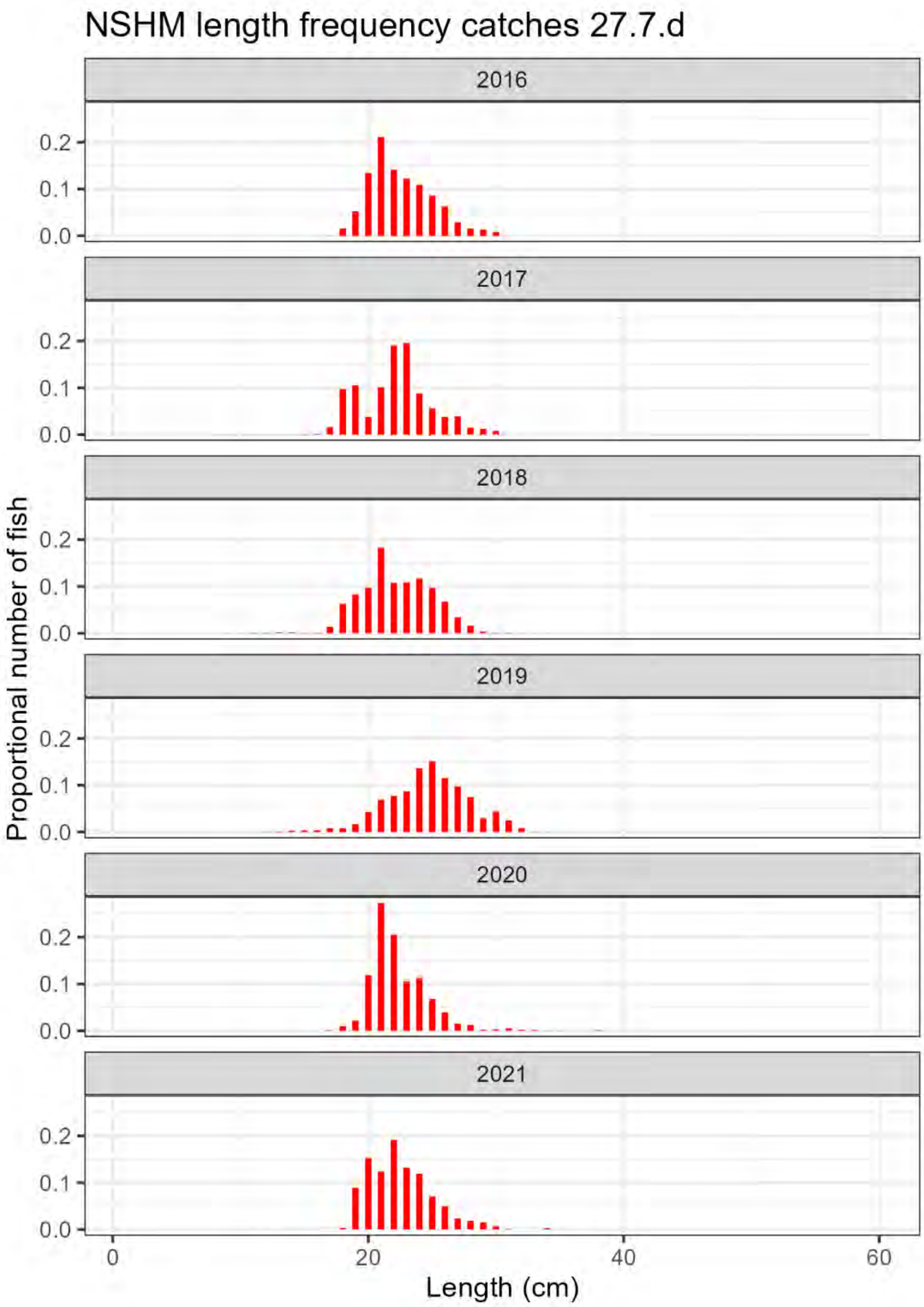


Figure 6.4.11. North Sea horse mackerel. Length distributions in proportion to catch numbers from commercial catches in 27.7.d for the period 2016-2021.

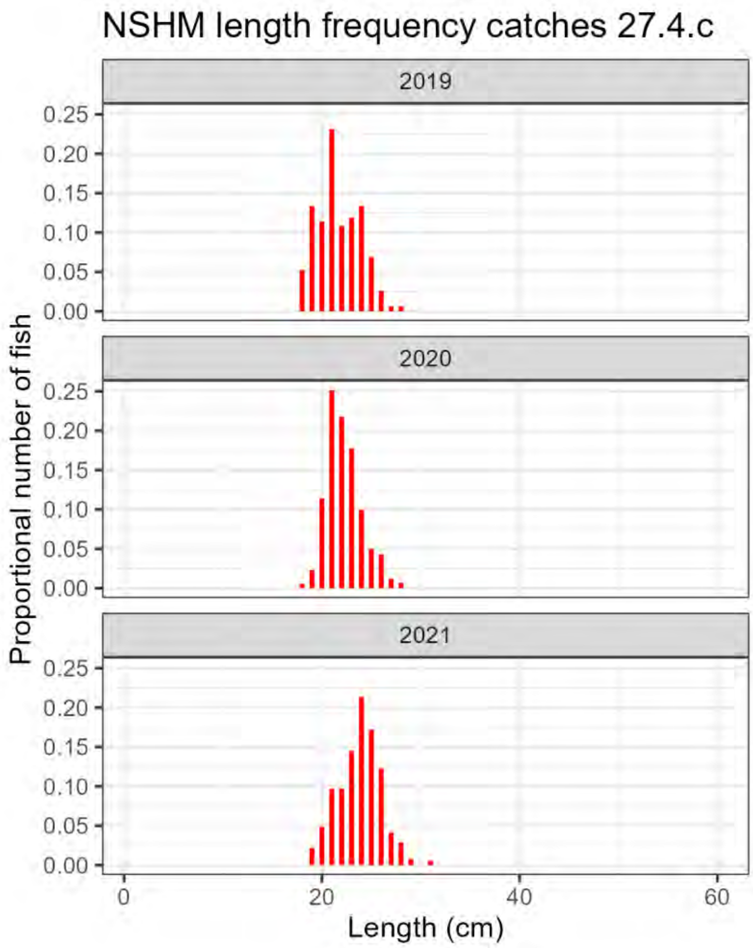


Figure 6.4.12. North Sea horse mackerel. Length distributions in proportion to catch numbers from commercial catches in 27.4.c in 2019 and 2021.

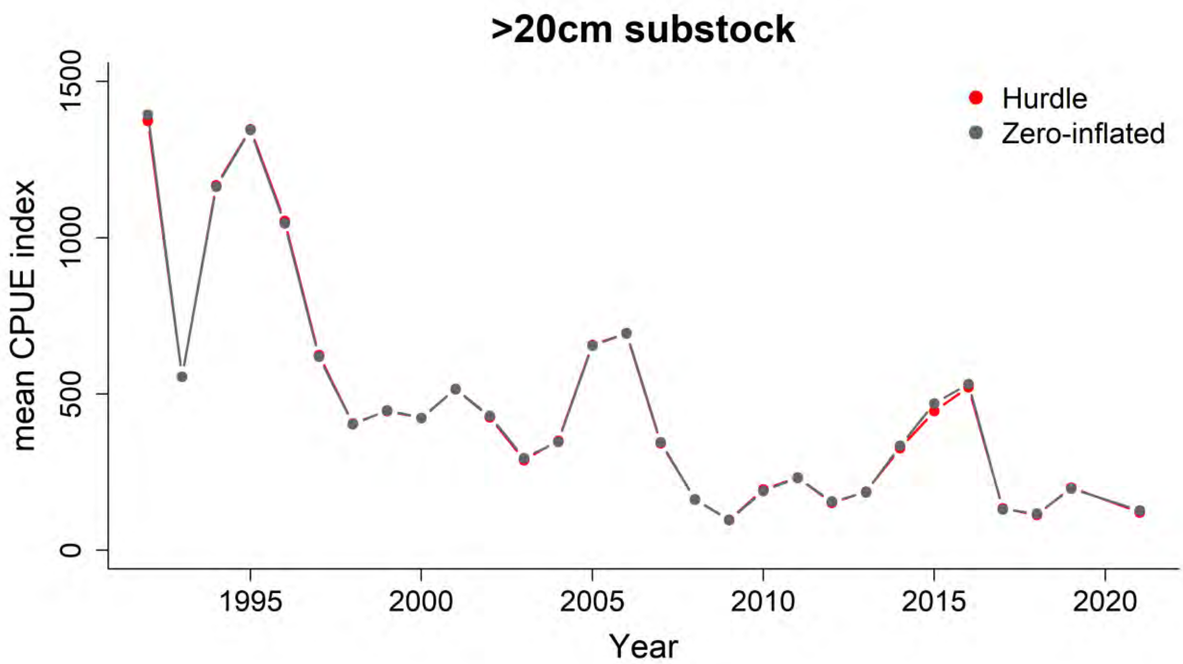


Figure 6.5.1. North Sea horse mackerel. CPUE per year of the exploitable sub-stock (≥20 cm) from 1992 to 2021 as modelled by the hurdle model (red) that returned a warning when ran, and the zero-inflated model (grey).

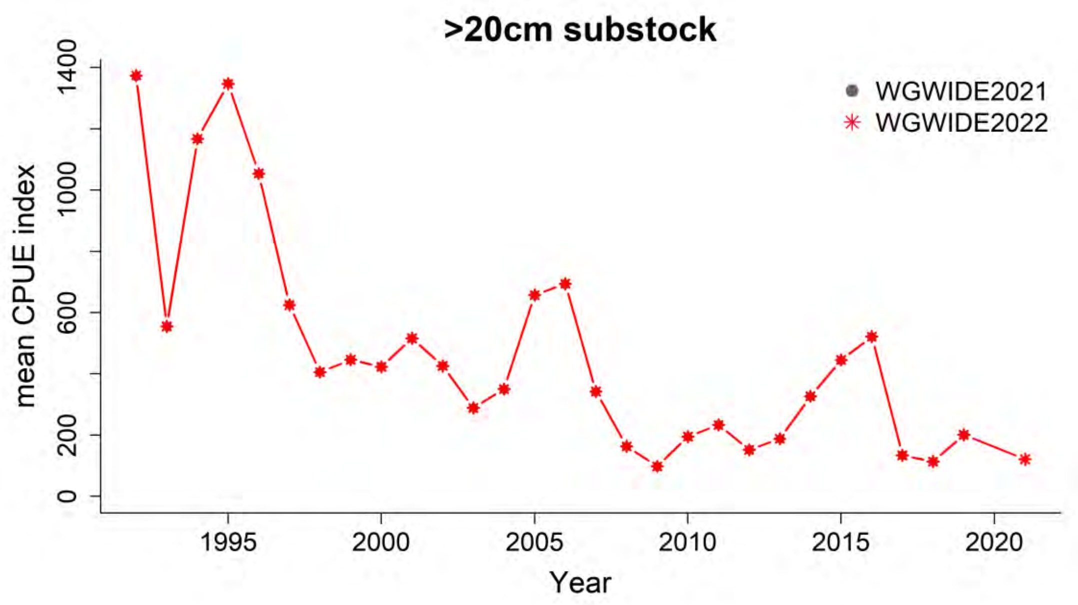


Figure 6.5.2. North Sea horse mackerel. CPUE per year of the exploitable sub-stock (≥20 cm) from 1992 to 2019 as modelled by the hurdle model at WGWIDE 2020 (grey) and WGWIDE 2021 (red). In the model the 2020 index value for the exploitable sub-stock (≥20 cm) is left out and the index is modelled using a Hurdle model. Complete overlap between last and current year is observed.

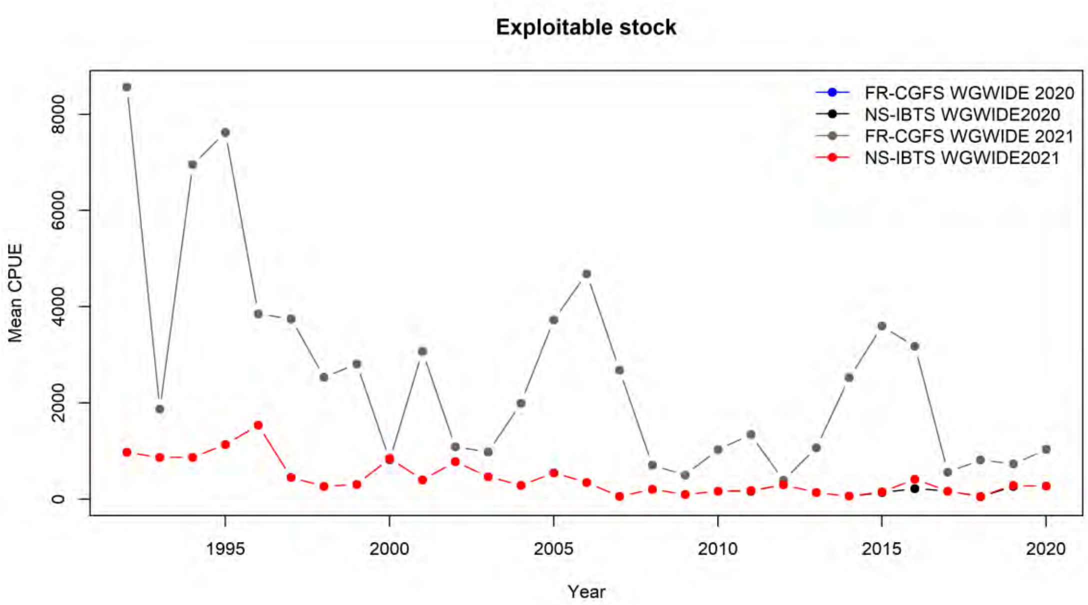


Figure 6.5.3. North Sea horse mackerel. Mean CPUE across hauls of the exploitable sub-stock (≥20 cm) from 1992 to 2019 for the FR-CGFS (blue WGWIDE 2020 (not visible), grey WGWIDE 2021) and the NS-IBTS (black WGWIDE 2020, red WGWIDE 2021). Small changes in reported catches of NS-IBTS resulted in a higher index value for 2016.

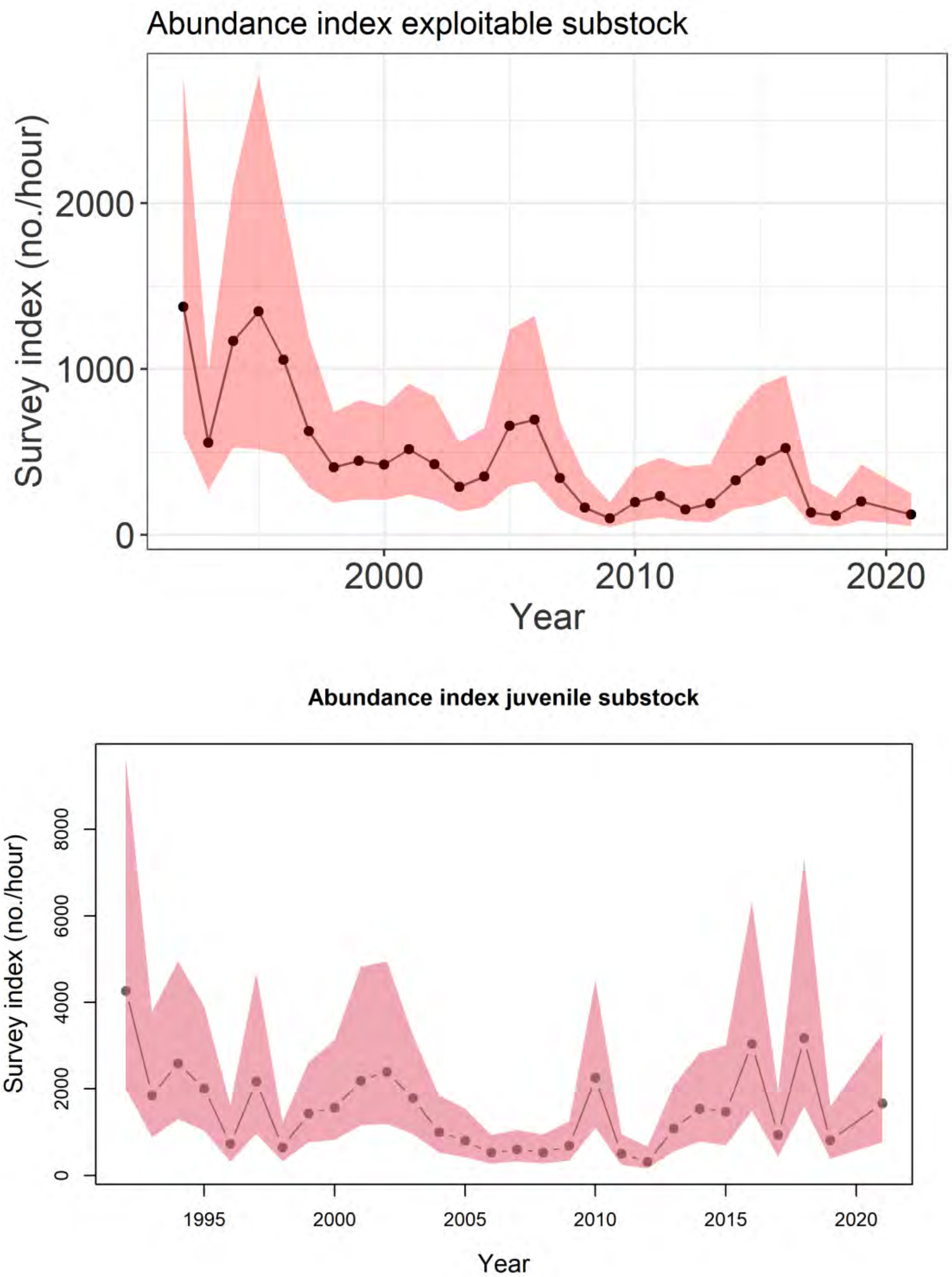


Figure 6.5.4. North Sea Horse Mackerel. Joint CPUE survey index (number/hour) derived from the hurdle model fit to the NS-IBTS survey in the North Sea and the FR-CGFS survey in the Eastern English channel for the period 1991-2021. No index value for 2020 could be produced due to sampling issues in the 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.

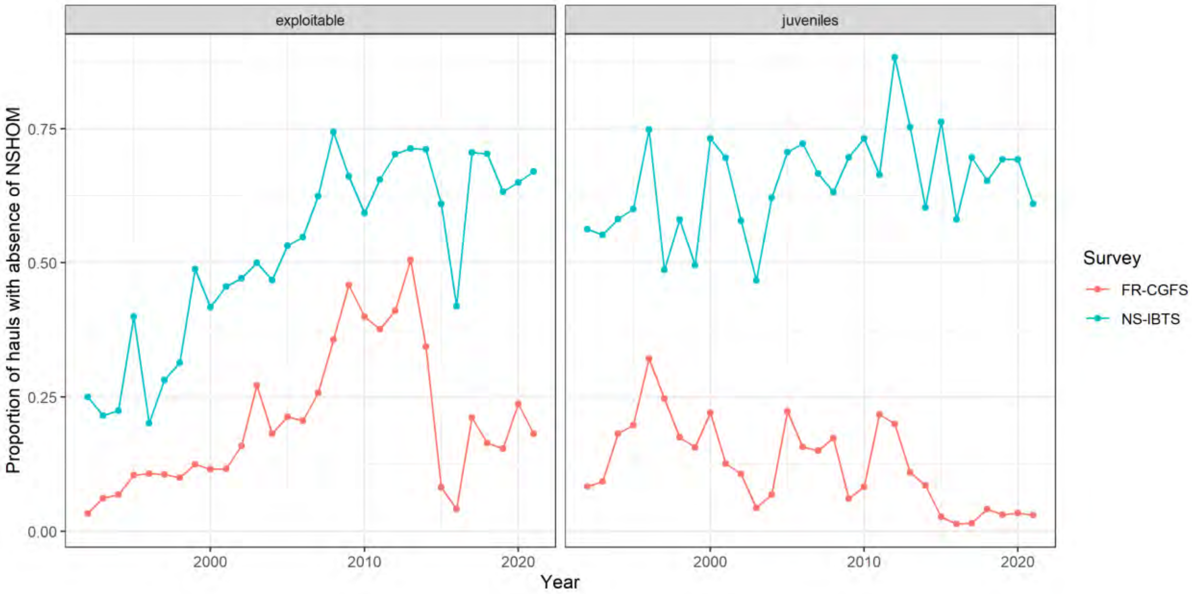


Figure 6.5.5. North Sea horse mackerel. Proportion of hauls with zero catch for the exploitable (≥20cm) and juvenile (<20 cm) sub-stocks in the NS-IBTS (blue) and the FR-CGFS (red) from 1992 to 2021. Note that the FR-CGFS 2020 values are based on French stations only, as UK stations could not be sampled.

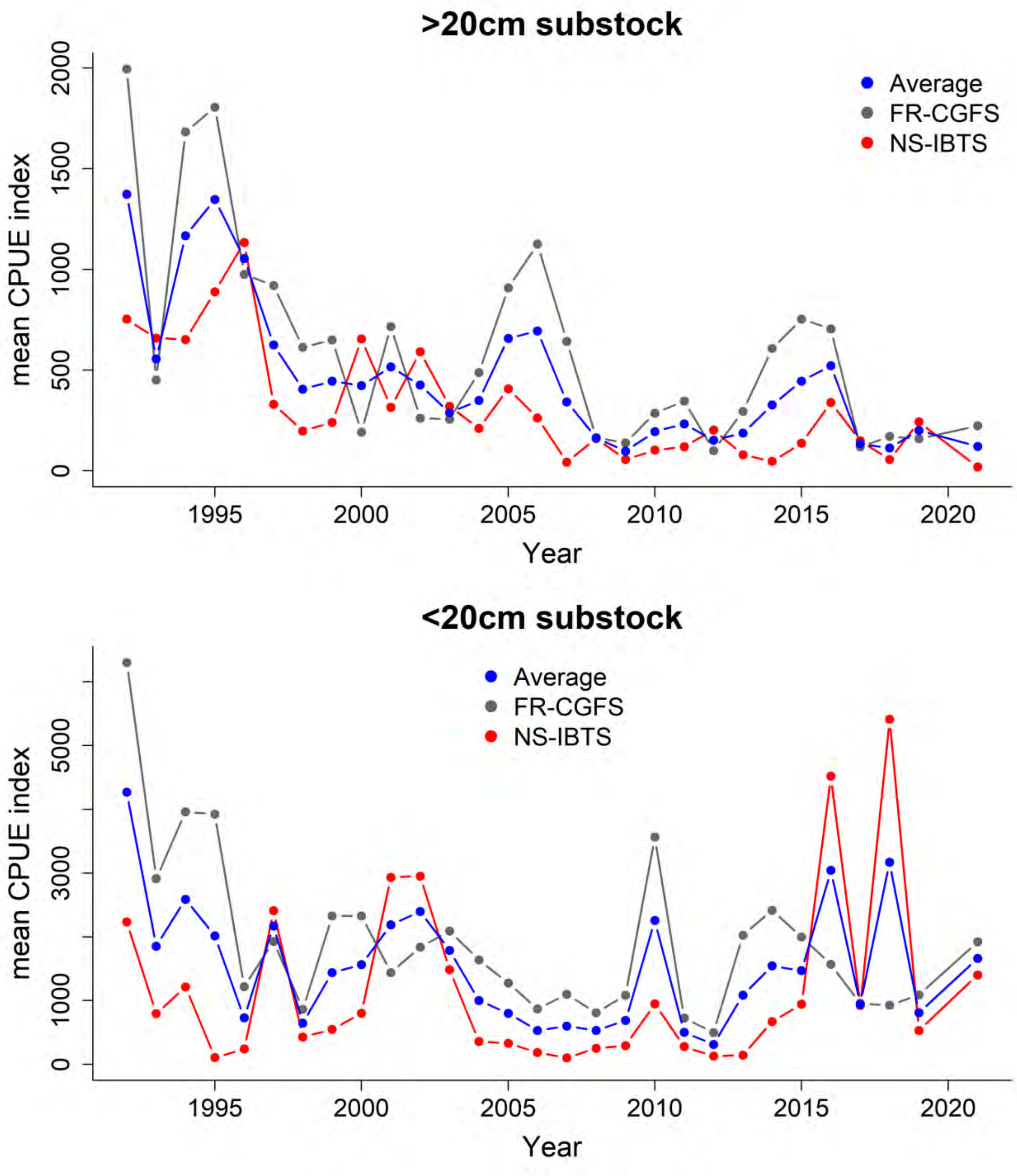


Figure 6.5.6. North Sea Horse Mackerel. Mean CPUE survey index (number/hour) obtained from the hurdle model fit to the NS-IBTS survey in the North Sea (in red), the FR-CGFS survey in the English channel (in grey) and the joint survey index (in blue). Top: exploitable sub-stock (≥20cm), bottom: juvenile sub-stock (<20 cm). No index values for 2020 could be produced due to COVID-19 pandemic impacting the FR-CGFS.

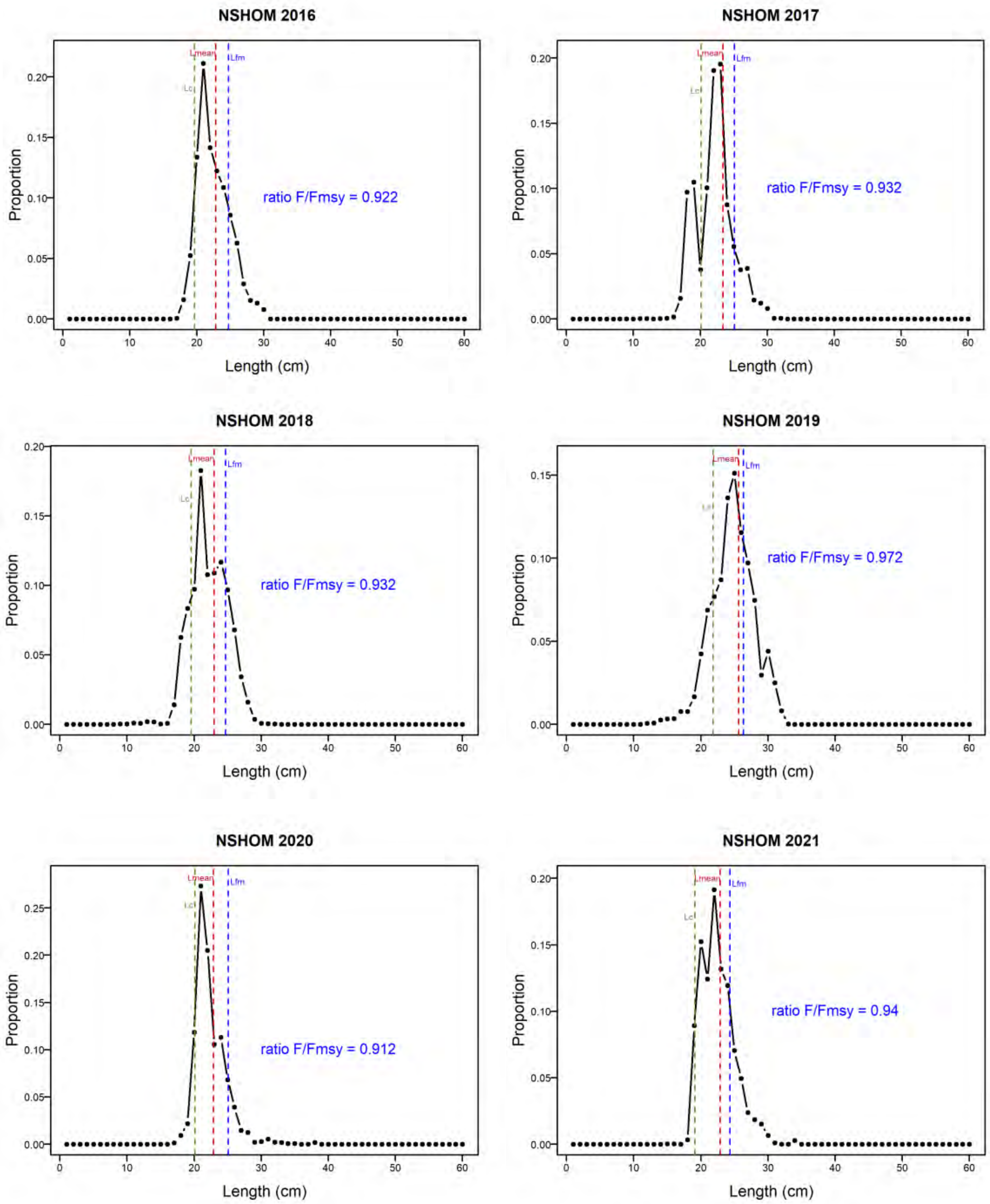


Figure 6.5.7. Length distribution (cm), estimated parameters L_c, L_{mean}, $L_{F=M}$ (cm) and F/F_{MSY} ratio for 2016-2021. Length samples from commercial catches in ICES division 27.7.d. Recalculations for 2018 till 2020 have been performed for the constructions of these plots.

7 Western Horse Mackerel –in Subarea 8 and divisions 2.a, 3.a (Western Part), 4.a, 5.b, 6.a, 7.a–c and 7.e–k

7.1 TAC and ICES advice applicable to 2021 and 2022

Since 2011, the TACs cover areas in line with the distribution areas of the stock.

For 2021 the TAC was the following (EU 2021/1239):

Areas	TAC 2021	Stocks fished in this area
2.a, 4.a, 5.b, 6, 7.a-c, 7.e-k, 8.abde, 12, 14	70 254 t	Western stock & North Sea stock in 4.a 1-2 quarters
4.b,c, 7.d	14 014 t	North Sea stocks
Division 8.c	11 121 t	Western 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

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 2021, ICES advised on the basis of MSY approach that Western horse mackerel catches in 2022 should be no more than 71 138 tonnes. The Western horse mackerel TAC for 2022 is 71 138 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 2021

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 2021 was 81 375 tonnes which is 421 tonnes less than in 2020 and matched the ICES advice. The catches of horse mackerel by country and area are shown in Tables 7.1.1.1-5 while the catches by quarter since 2000 are shown in Figure 7.1.1.1.

7.1.2 Estimates of discards

Discard data are available since 2000 for some countries. Prior to 2013, the estimates available are considered to be an underestimate (Figure 7.1.2.1).

In 2021, most countries have submitted discard information. Countries that reported discard estimates for horse mackerel were Spain, France, Ireland, and UK). 2021 discard estimates for Germany, the Netherlands and Norway are considered to be equal to zero. Total discards for Western horse mackerel were 1 641 tonnes, equal to 2% in weight of the total catches, a decrease 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, 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 and a working document with preliminary results of the survey was presented to WGWIDE members (WD07: O'Hea *et al*. 2022). Final results for 2022 will be available for the WGWIDE meeting 2023. Details of this mackerel and horse mackerel egg survey are also given in section 8.6.1 of this report. The 2022 egg survey results are not used in the 2022 assessment (the SS model is not configured to use in-year survey data and catch data would also be required, which is not available until the end of the year). Data from the 1992-2019 surveys are therefore used in the assessment (O'Hea *et al*. 2019). The time series of TAEP estimates used in the assessment is shown in table 7.2.1.1.

2022 (preliminary) egg survey results

Sampling was undertaken over 6 sampling periods. Egg abundance plots displaying the spatial distribution of stage 1 horse mackerel eggs are presented for periods 3-7 in figures 7.2.1.1-5. 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. In general, egg numbers were low with occasional high counts are some stations.

During the 2022survey, peak spawning for horse mackerel occurred during period 6 with high egg numbers recorded from the Celtic Sea to the northern Bay of Biscay, close to the 200m contour (figure 7.2.1.5).

Egg production by survey period (plotted at mid-period) is shown in figure 7.2.1.6. The results from previous surveys are also shown for comparison. The shape of the egg production curve does not suggest that spawning start and end dates should be altered for the 2022 survey. Total annual egg production for 2022 is estimated to be 5.15×10^{14}, a threefold increase on the 2019 estimate of 1.78×10^{14}, which is the lowest estimate in the time series.

Fecundity parameters

In 2022, only DEPM ovary samples were collected in periods 6 and 7 for horse mackerel, during peak of spawning. In addition, samples were collected from the Irish WESPAS surveys in periods 6 and 7. At the time of writing, no horse mackerel fecundity results are available. All samples will be analysed and results presented at the 2023 WGMEGS meeting.

The Western horse-mackerel egg data of the DEPM survey are still under revision. Data are expected to be analysed and results will be presented at the 2023 WGMEGS.

7.2.2 Other surveys for Western horse mackerel

Bottom-trawl surveys

A bottom-trawl survey index for recruitment was available for 2021. 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 2021. 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 2017). 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 an increase again in 2021.

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, however the survey resumed in 2021. The estimate for 2022 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 2022).

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 2021, the Netherlands (4a, 6a, 7bcefghj, 8a), Ireland (6a, 7bj), Norway (4a), Spain (8bc), UK (England & Scotland) (4a, 6a, 7efj) and Germany (7efghj) provided catch in numbers-at-age (Figure 7.2.4.1). The catch sampled for age readings in 2021 covered 79% of the total reported catch which is a considerable increase in comparison to last year. Last year´s reduction to 51% was primarily due to the impact of the Covid pandemic on the national sampling programs. Catch in number-at-length were available from the Netherlands (4a, 6a, 7bcefghj, 8a), Ireland (6a, 7bgj), Spain (6a, 7bcghjk, 8abc) and UK (England & Scotland) (4a, 6a, 7efj) as well as from France (7e, 8ab), Norway (4a) and Germany 7efghj).

The total annual and quarterly catches in number for western horse mackerel in 2021 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 2021.

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 2021 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: Pastoors, 2022).

The Pelagic Freezer-trawler Association (PFA) provided an annual report on the self-sampling programme that started in 2015. Currently, all members (15 vessels in 2021) participate in the programme providing data during the main fishing season (October–March). Overall, the self-sampling activities for the horse mackerel fisheries during the years 2016-2022 (up to 11/08/2022) covered 250 fishing trips with 3316 hauls, a total catch of 128 553 tonnes and 130 146 individual length measurements. The main fishing areas are ICES division 6.a, division 7.b and division 7.j. Western horse mackerel have a wide range in the length distributions in the catch. Median lengths in divisions 6.a, 7.b and 7.j have fluctuated between 25.2 and 31.9 cm. In ICES division 7.h, median lengths in the catch have been smaller and fluctuated between 20.7 and 24.5 cm (for more details see WD02: Pastoors, 2022).

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. The overall aim for Western horse mackerel is to identify the spawning period in 2020 and investigate if the current egg survey (MEGS) is covering this period for details see section 1.4.8.3.

Additionally, genetic samples have been also collected from 7.d and 7.e by the PFA on board of commercial vessels in the Autumn of 2020, as well as from 4.a during the NS-IBTS in Q3. The study has shown evidence for separating western, North Sea and southern horse mackerel for details see section 1.4.8.3.

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 has changed and the length distribution is a more normal distribution with the most common landed lengths around 30cm. The main mode of the distribution continuously increased since 2004 to 2017. It has been lower in recent years, but has started to increase, probably 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 2021 assessment, with the inclusion of the 2021 estimates for the IBTS recruitment index, the 2021 length frequency distribution of the landings, and the 2021 total catch and conditional ALKs. The biomass estimates and length distribution provided by the PELACUS survey were not available in 2020 because the survey was cancelled due to the Covid pandemic (see section 7.13), but the survey resumed in 2021 and was used in this assessment. As in last year 's assessment, the length and age distributions were tuned using the Francis reweighting approach.

Fits to the available data are given in Figure 7.2.11.1, and model estimates with associated precision in Figure 7.2.11.2. Model estimates and residual patterns are similar to those presented in the benchmark (ICES, 2017b) and remain unchanged from last year's assessment for almost all variables, except for some patterns noted in the 2018 and 2020 ALK, that was not evident in 2019 or 2021. Recruitment estimates are higher than last year's assessment. 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 and it does not capture the small fish observed in recent years.

The 2022 assessment shows strong retrospective patterns, with peels falling outside the confidence intervals of SSB (2 peels) and recruitment (3 peels) estimates (Figure 7.2.11.3). The pattern is very consistent and has led to a rescaling of the SSB (downwards) and F (upwards) in the past years. Further investigation is needed to identify the reason of the pattern and resolve it. The Mohn's rho values are now above the limit of the tolerance threshold with 0.329 for SSB and -0.251 for F.

7.3 State of the Stock

7.3.1 Stock assessment

The SS model with new length and age data from the commercial fleet, and the 2021 information from the IBTS index 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 2022, SSB is estimated to be below B_{lim}.

The recruitment has been weak since 2001, reaching the lowest values in 2009-2011 and 2013. Recruitment estimates for 2014-2018 are the highest observed since 2008 and are higher than the geometric mean estimated over the years 1983-2021. Recruitment in 2019 -2021was low again with an increase to remain above the mean in 2022.

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 2021 (0.086) is just above F_{MSY} (0.074) and slightly higher than the previous year but continues to be close to the lowest value in the time series since 2007.

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 2021 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 landings for the intermediate year were set at 100% of the TAC (71 138 t) after confirmation from individual institutes that TAC was close to being fully taken by August 2022. 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

Despite the increased amount of data used and information available to the stock assessment, the model suffers from a retrospective pattern whenever a new year of data is included. This year rescaling is relatively significant with a pattern over the past 5 years (rescaling biomass down and vice-versa for F_{1-10}).

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 the past couple of years, but the estimates remained within the confidence intervals provided. The fit to the PELACUS acoustic index remains poor.

The change in selectivity, which is detected from both the length and the age composition of the catch data, is not entirely picked up from the model. In general, 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 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.

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 created 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, 2017a).

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, 2019a).

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, 2021b). These updated reference points were used in determining the MSY based 2023 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 (for details see Stock Annex). This rebuilding plan has not been currently approved by the European Commission and the UK. The working group no longer considers this management plan appropriate as it is outdated by 2 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 downward revision of the stock, and SSB falling below B_{lim}, following the MSY approach, the advice for 2023 is catches in 2023 should be zero. It is expected that even with 0 catch there will be some discard landings in 2023 available as with previous years.

Note that subarea 8.c is included in the ICES advice for Western horse mackerel.

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.

The stock allocations were changed in 2005 following the results of the HOMSIR project (Abaunza *et al.* 2003) and 8.c is considered to be the western stock. Landings from 7.d are now allocated to the North Sea horse mackerel stock. Results of a recent genetic research project on stock structure of horse mackerel has been reported in sections 1.4.8.3. of this report.

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, Iversen WD presented in ICES 2007/ACFM:31).

7.13 Deviations from stock annex caused by missing information from historic Covid-19 disruption

1. Stock: hom.27.2a4a5b6a7a-ce-k8

2. Missing or deteriorated survey data:

The length composition and the biomass index annually provided by the PELACUS survey were not available in 2020 because the survey was cancelled due to the Covid pandemic.

3. Missing or deteriorated catch data:

The samples for age readings in 2020 covered only 51% of the catch, whereas in previous years was 69%. This decrease is due to the impact of the Covid pandemic on the national sampling programs. Spain had to reduce its sampling program and no sampling from Germany and Norway were available.

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:

Not applicable

7. Suggested solution to the challenge, including reason for this selecting this solution:

The assessment was carried out without the 2020 data from PELACUS. No alternative options were found.

8. Was there an evaluation of the loss of certainty caused by the solution that was carried out?

To test the sensitivity of the model to the PELACUS data, the assessment conducted in 2020 was carried out without the PELACUS data for 2019 and the results were compared with the outputs of the actual assessment in 2020. The fishing mortality was slightly higher and the spawning biomass slightly lower in recent years in the model without survey data, although the differences were inside of the confidence intervals of the parameters (Figure 7.13.1).

7.14 References

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7.15 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
Faroe Islands	-	-	3	-	-	-	222	224
Denmark	-	-	-	-	-	-	-	-
France	-	-	-	-	-	-	-	-
Germany	-	-	-	-	-	-	-	-
Ireland	-	-	-	-	-	-	-	-
Netherlands	-	-	-	-	-	-	-	1
Norway	42	176	27	-	572	1,847	1,364	298
Russia	-	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-	-	-
Estonia	-	-	-	-	-	-	-	-
Total	42	176	27	0	572	1,847	1,586	-

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Faroe Islands	-	-	-	-	-	-	-	-	-	-
Denmark	-	-	-	-	-	-	-	-	-	-
France	+	-	-	-	-	-	-	-	-	-
Germany	-	-	-	-	-	-	-	-	-	-
Ireland	-	-	-	-	-	-	-	-	-	-
Netherlands	-	-	107	-	-	-	-	-	-	-
Norway	66	30	302	10	45	5	718	867	290	12
Russia	-	-		-	-	-	-	-	-	-
UK (England + Wales)	-	-		-	-	-	-	-	-	-
Estonia	-	-		-	-	-	-	-	-	-
Total	66	30	409	10	45	5	718	867	290	12

[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
Denmark	37	7	21	289	183	22	11
Faroe Islands	0	0	67	0	6	-	-
France	12	4	1	2	98	0	2
Germany, Fed.Rep.	6	28	1	1	5	0.5	3
Ireland	8	-	-	-	-	-	-
Netherlands	-	0	14	7	72	1	27
Lithuania	12	130	-	-	-	0	-
Norway	8,887	8,765	9,880	8,601	8,154	10,376	3,651
Sweden	10	0	41	23	323	83	4
UK (Engl. + Wales)	134	13	4	0	-	0	0.5
UK (Scotland)	36	14	-	-	50	-	63
Unallocated +discards	32	97	87	162**	339	1239	160
Total	9,175	9,057	10,117	9,085	9144	11,700	3,923

**** 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

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015
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
Denmark		3,462	4,982	6,467	2,267	1,853
Faroe Islands		113		20		-
France	23	1,025	197	550	3	908
Germany	4,069	2,884	2,779	1,418	0	-
Ireland	15,381	15,123	17,959	21,109	9,187	8,530
Lithuania	2,510					-
Netherlands	9,246	5,497	11,921	14,421	5,202	1,309
Norway						
Spain						
UK (Engl. + Wales)		66	32	830	817	249
UK (N.Ireland)	0		1,026	1,907	1,229	417
UK (Scotland)	956			627	331**	459
Unallocated+disc.		116	55	129	108	91
Total	32,186	28,286	38,950	47,480	19,146	13,818

**** 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

Country	1980	1981	1982	1983	1984	1985	1986	1987	1988
Norway	394	-	-	-	-	-	-	-	-
Spain	50	234	104	142	560	275	137	148	150
UK (Engl. + Wales)	12,933	2,520	2,670	1,230	279	1,630	1,824	1,228	3,759
UK (Scotland)	1	-	-	-	1	1	+	2	2,873
USSR	-	-	-	-	-	120	-	-	-
Total	45,697	34,749	33,478	40,526	42,952	39,034	77,628	100,734	90,253

Country	1989	1990	1991	1992	1993	1994	1995	1996	1997
Faroe Islands	-	28	-	-	-	-	-	-	-
Belgium	-	+	-	-	-	1	-	-	18
Denmark	34,474	30,594	28,888	18,984	16,978	41,605	28,300	43,330	60,412
France	4,576	2,538	1,230	1,198	1,001	-	-	-	30,571
Germany, Fed.Rep.	7,743	8,109	12,919	12,951	15,684	14,828	17,436	15,949	28,267
Ireland	12,645	17,887	19,074	15,568	16,363	15,281	58,011	38,455	43,624
Netherlands	43,582	111,900	104,107	109,197	157,110	92,903	116,126	114,692	131,701
Norway	-	-	-	-	-	-	-	-	-
Spain	14	16	113	106	54	29	25	33	6
UK (Engl. + Wales)	4,488	13,371	6,436	7,870	6,090	12,418	31,641	28,605	17,464
UK (N.Ireland)	-	-	2,026	1,690	587	119	-	-	1,093
UK (Scotland)	+	139	1,992	5,008	3,123	9,015	10,522	11,241	7,902
Unallocated + discards	28,368	7,614	24,541	15,563	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

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006
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		
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
Denmark	314	1057	1,031	690	3,198	3,540
France	551	595	1,067	907	1,486	990
Germany	7313	4077	1,401	7,673	952	5,525

Country	2016	2017	2018	2019	2020	2021
Ireland	12193	7857	7,169	7,753	7,870	10,240
Lithuania	86					
Netherlands	14415	8445	14,009	15,159	9,036	17,473
Poland				127	1,000	1,605
Spain	0		0	1	6	14
UK (Engl. + Wales)	820	478	2,410	2,862	679**	2,401***
UK (Scotland)					3	92
UK (Northern Ireland)			52	0	2	933
Unallocated+discards	1692	830	548	918	311	677
Total	37384	23340	27,687	36,062	24,544	43,490

[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
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+discards		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
Denmark	1		422		638
France	2,303	2,176	2,914	728	808
Germany	210	554	144	2	2
Ireland	580	219	36	332	-
Netherlands	313	6	3	0.5	1,976

Country	2017	2018	2019	2020	2021
Spain	14,901	20,362	25,775	19,163	16,177
UK (Engl. + Wales)		2	344		
Unallocated+discards	2,907	1,921	1,755	1,104	713
Total	21,213	25,240	31,396	20,742	20,314

[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). (*) means preliminary.

Year	TAEP
1992	2094
1995	1344
1998	1242
2001	864
2004	884
2007	1486
2010	1033
2013	366
2016	311
2019	178
2022*	515

Table 7.2.2.1. Western horse mackerel. Time series of recruitment index estimated from the IBTS Surveys (2003-2021) in 2020-2022.

Year	Index 2022		Index 2021	Index 2020
	Mean	CV		
2003	728100	0.30	732297	724708
2004	2516442	0.31	2453310	2439512
2005	2199332	0.33	2151351	2148828
2006	1501474	0.33	1499811	1482969
2007	3125619	0.29	3121579	3088715
2008	7824230	0.30	7481365	7272792

Year	Index 2022		Index 2021	Index 2020
	Mean	CV		
2009	1127972	0.27	1148964	1135301
2010	872244	0.30	864772	860652
2011	175162	0.35	178188	180361
2012	4435133	0.31	4339882	4356450
2013	1099932	0.24	1111210	1092849
2014	2905589	0.24	2931963	2922237
2015	4123241	0.28	4060794	4030569
2016	5421010	0.29	5280009	5216531
2017	9395798	0.49	9460399	9450737
2018	5657414	0.29	5657414	4000271
2019	1637102	0.29	1637102	1636554
2020	878485	0.27	878484	
2021	1015429	0.24		

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
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

Year	Biomass	CV
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

Table 7.2.4.1. Western Horse Mackerel stock. Catch in numbers (thousands) at age by quarter and area in 2021 (15 = 15+ group)

Q1																	
Age	27.2.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	27.7.k.1	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	27.8.d	Total
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	176.35	752.15	120.21	63.17	2043.64	0.72	3156.24
2	0	0	133.80	95.92	886.13	495.17	166.46	1323.10	3.08	63.16	0	49.37	245.53	182.76	161.46	244.24	0.20	4050.36
3	0.04	79.67	1903.08	1228.80	11121.17	4629.76	3470.68	17349.72	39.43	826.03	0.02	24.51	19.61	161.41	65.21	167.85	0.10	41087.08
4	0.83	1866.14	5518.74	1954.61	14505.82	8440.11	7269.86	25341.21	62.72	1438.23	0.02	18.43	2.65	0	12.17	296.52	0.08	66728.15
5	0.98	2198.85	2768.86	483.61	3207.53	1381.36	1674.92	4888.14	14.71	714.82	0.01	44.08	6.45	0	108.37	629.84	0.18	18122.70
6	1.68	3765.30	5691.95	434.04	1711.22	597.99	676.09	2948.37	13.52	1840.62	0.01	89.32	13.09	0	266.84	1228.99	0.36	19279.40
7	11.83	26467.51	17066.48	1392.89	2000.11	1857.82	1084.79	3410.17	38.23	12477.64	0.01	60.23	9.77	0	370.69	636.97	0.25	66885.38
8	1.07	2389.65	1403.38	103.16	102.87	118.92	13.51	176.32	2.50	653.03	0	60.60	11.09	0	569.06	443.63	0.25	6049.04
9	1.43	3196.87	1538.38	89.18	73.97	127.01	6.37	262.43	2.86	844.09	0	54.47	10.49	0	629.95	279.81	0.22	7117.53
10	0.33	731.31	913.53	81.55	373.17	33.93	2.12	200.45	1.81	253.56	0	54.71	11.84	0	575.97	336.34	0.22	3570.83
11	0.30	660.54	574.12	23.90	19.82	14.39	0.66	42.37	0.77	112.98	0	47.10	9.25	0	527.26	259.22	0.19	2292.87
12	0.38	860.39	296.77	58.72	19.71	14.31	1.32	39.11	0.76	354.02	0	23.40	4.61	0	260.51	130.12	0.10	2064.24
13	1.08	2418.11	877.00	119.15	478.28	133.04	3.29	110.73	1.98	318.27	0	9.10	1.62	0	126.88	25.24	0.04	4623.81
14	0.18	395.74	53.53	1.90	1.57	1.14	0.01	3.12	0.06	1.25	0	6.66	0.96	0	83.60	27.88	0.03	577.62
15+	0.70	1568.27	232.92	541.08	183.30	157.48	11.87	285.16	1.59	217.52	0	18.83	2.84	0	237.99	77.26	0.08	3536.88

Q2																	
Ages	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	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	27.8.d	Total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	115.39	0.20	17.44	66.96	0.21	2.24	6.51	2.12	53.42	86.47	1362.73	38.75	332.22	50.88	0.11	2135.63
2	0	0.01	796.06	1.39	120.34	461.99	1.42	15.43	44.94	14.60	368.58	49.34	728.18	246.68	12.19	303.67	0.08	3164.89
3	0.01	0	206.90	0.36	31.28	120.07	0.37	4.01	11.68	3.79	95.79	80.20	273.22	327.36	306.39	3381.58	0.26	4843.28
4	0.24	0	20.97	0.04	3.17	11.43	0.04	0.41	1.18	0.38	10.45	66.82	70.57	15.81	1384.61	2320.77	0.23	3907.12
5	0.31	0	62.92	0.11	9.51	34.30	0.11	1.22	3.55	1.15	31.35	117.98	152.35	3.02	5285.07	1201.77	0.40	6905.14
6	0.50	0	62.92	0.11	9.51	34.30	0.11	1.22	3.55	1.15	31.35	127.66	173.69	1.82	6418.45	553.20	0.43	7419.97
7	3.49	0	125.84	0.22	19.02	68.59	0.22	2.44	7.10	2.31	62.70	98.57	140.05	0.24	4115.03	254.41	0.27	4900.52
8	0.54	0	41.95	0.07	6.34	22.86	0.07	0.81	2.37	0.77	20.90	56.33	159.58	0.15	1856.97	392.47	0.14	2562.33
9	0.50	0	83.89	0.15	12.68	45.73	0.15	1.63	4.74	1.54	41.80	43.45	182.72	0.22	1108.58	374.21	0.10	1902.08
10	0.21	0	20.97	0.04	3.17	11.43	0.04	0.41	1.18	0.38	10.45	40.53	186.71	0.19	1075.14	527.36	0.11	1878.31
11	0.12	0	41.95	0.07	6.34	22.86	0.07	0.81	2.37	0.77	20.90	38.14	156.55	0.24	743.91	495.42	0.08	1530.61
12	0.16	0	20.97	0.04	3.17	11.43	0.04	0.41	1.18	0.38	10.45	40.37	63.68	0.13	285.96	282.56	0.04	720.98
13	0.38	0	20.97	0.04	3.17	11.43	0.04	0.41	1.18	0.38	10.45	27.39	33.50	0.05	138.93	68.76	0.02	317.10
14	0.14	0	0	0	0	0	0	0	0	0	0	3.00	24.12	0.12	57.98	80.88	0.01	166.26
15+	0.46	0	0	0	0	0	0	0	0	0	0	37.17	93.32	1.32	232.62	431.50	0.05	796.44

Table 7.2.4.1 cont. Western Horse Mackerel stock. Catch in numbers (thousands) at age by quarter and area in 2021 (15 = 15+ group)

Q3																							
Ages	27.2.a	27.3.a	27.4.a	27.6.a	27.7.a	27.7.b	27.7.c.2	27.7.e	27.7.f	27.7.g	27.7.h	27.7.j	27.7.j.2	27.7.k.2	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	27.8.d	27.8.d.2	27.8.e	Total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.85	79.42	0	149.96	0	0	0.01	0	234
1	0	0	0	0	0	0.88	0.01	5.12	0	0.14	0.09	0.00	0.02	0	148.35	502.62	45.81	6467.41	4.64	0.37	0.21	0.04	7175.72
2	0	0	0	0	0.05	34.70	0.36	1.78	0.12	5.54	3.68	158.69	41.69	0	77.61	174.72	52.75	3379.52	65.94	0.19	0.11	0.02	3997.47
3	0	0	0	0	0.36	254.51	2.65	11.58	0.87	40.60	27.00	898.38	572.70	0.03	40.63	68.28	0	1253.11	601.25	0.10	0.06	0.01	3772.13
4	0	0.01	1.54	0.01	0.58	412.80	4.30	18.94	1.41	65.86	43.79	1233.82	1152.02	0.06	44.82	70.92	0	1077.88	972.39	0.11	0.06	0.01	5101.32
5	0.11	0.62	163.11	0.65	0.49	348.35	3.63	15.86	1.19	55.58	36.95	891.00	1122.46	0.05	80.33	128.20	0.01	1384.43	2288.96	0.20	0.11	0.02	6522.28
6	0.05	0.29	76.29	0.31	1.16	830.86	8.65	37.04	2.84	132.56	88.14	2147.21	2656.01	0.11	121.08	201.64	0.03	1750.24	3778.11	0.30	0.17	0.03	11833.12
7	0.33	1.90	501.87	2.01	1.50	1072.86	11.17	47.71	3.67	171.16	113.81	1549.35	4652.98	0.15	47.18	110.32	0.05	765.52	1356.63	0.12	0.07	0.01	10410.34
8	0.83	4.78	1264.97	5.07	0.21	150.32	1.56	6.78	0.51	23.98	15.95	240.86	628.04	0.02	17.18	52.29	0.10	312.67	448.15	0.04	0.02	0	3174.33
9	0.32	1.85	488.88	1.96	0.08	57.14	0.59	3.22	0.20	9.12	6.06	56.77	272.91	0.01	22.34	64.42	0.10	289.49	702.94	0.06	0.03	0.01	1978.49
10	0.40	2.32	615.40	2.46	0.05	39.22	0.41	1.71	0.13	6.26	4.16	56.76	170.01	0.01	21.12	58.16	0.06	307.55	633.61	0.05	0.03	0.01	1919.89
11	0.14	0.80	211.62	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	17.69	36.36	0.14	298.00	502.49	0.04	0.02	0	1068.16
12	0.18	1.04	276.42	1.11	0.03	22.08	0.23	0.96	0.08	3.52	2.34	53.25	74.45	0	10.04	16.77	0.09	153.47	304.98	0.03	0.01	0	921.10
13	0.25	1.47	388.91	1.56	0.01	7.71	0.08	0.34	0.03	1.23	0.82	0.00	44.59	0	12.04	19.83	0.08	374.52	175.26	0.03	0.02	0	1028.79
14	0.32	1.85	490.47	1.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	12.33	18.00	0.04	410.97	154.31	0.03	0.02	0	1090.29
15+	0.94	5.45	1443.63	5.78	0.02	13.30	0.14	0.58	0.05	2.12	1.41	0.01	76.92	0	15.09	19.52	0	482.00	212.53	0.04	0.02	0	2279.56

Q4																				
Ages	27.2.a	27.3.a	27.4.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	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	Total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1529.36	770.70	0.91	0.11	385.72	2686.80
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5293.83	1019.14	115.08	752.91	2587.13	9768.10
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4848.31	205.47	128.25	1528.48	2378.86	9089.36
3	0.21	0.21	0.09	154.76	0.01	6.35	0.02	1.53	99.06	2.04	20.14	1060.58	146.84	1880.53	971.11	81.18	3.02	390.59	370.27	5188.53
4	4.79	4.97	2.04	3601.82	0.04	66.25	0.06	4.95	432.64	6.63	65.32	2091.14	476.32	7292.19	684.38	78.66	1.53	159.01	352.97	15325.72
5	1.90	1.97	89.95	1339.08	0.02	23.65	0.03	2.49	303.72	3.33	32.86	1033.35	239.61	3610.44	738.85	92.46	1.59	169.87	374.19	8059.36
6	2.02	2.10	407.39	1114.13	0.03	13.78	0.05	4.07	323.65	5.45	53.73	2263.30	391.83	5528.57	943.76	132.27	0.94	278.33	400.97	11866.38
7	7.80	8.09	906.59	4961.01	0.06	42.88	0.09	8.15	502.41	10.91	107.52	4066.96	784.00	11653.37	593.19	117.05	0.17	197.97	191.20	24159.43
8	0.88	0.91	422.99	238.01	0.00	1.73	0.01	0.43	23.35	0.58	5.69	26.48	41.46	808.54	453.84	75.58	0.03	171.05	143.03	2414.59
9	0.72	0.75	308.92	235.90	0.00	0.65	0	0.22	11.96	0.30	2.91	13.57	21.24	414.53	622.91	76.68	0.12	251.06	209.56	2172.01
10	0.47	0.49	323.57	31.56	0.00	0.10	0	0.06	3.16	0.08	0.77	3.59	5.62	109.70	1064.44	110.50	0.20	357.48	453.97	2465.76
11	0.38	0.39	264.16	22.23	0.00	0.01	0	0.01	0.31	0.01	0.07	0.35	0.54	10.60	873.63	78.71	0.08	282.41	398.84	1932.73
12	0.75	0.78	513.55	54.35	0.00	0.20	0	0.12	6.51	0.16	1.58	7.38	11.55	225.63	422.02	27.59	0.10	105.73	234.75	1612.77
13	0.82	0.85	461.29	158.37	0.00	0.50	0	0.13	7.09	0.18	1.73	8.04	12.59	245.47	448.33	39.88	0.04	142.24	206.27	1733.82
14	0.48	0.50	351.51	11.94	0.00	0.01	0	0.01	0.36	0.01	0.09	0.41	0.64	12.53	505.66	54.10	0.02	140.06	240.94	1319.27
15+	1.26	1.30	885.97	59.48	0.00	0.16	0	0.10	5.23	0.13	1.27	5.93	9.29	181.38	585.91	81.93	0.04	151.62	263.23	2234.24

Table 7.2.4.1 cont. Western Horse Mackerel stock. Catch in numbers (thousands) at age by quarter and area in 2021 (15 = 15+ group)

all Q Ages	27.2.a	27.3.a	27.4.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	27.7.k.1	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	27.8.e	Total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1534.21	850.13	0.91	150.06	385.87	0.01	0.01	0	2921.20
1	0	0	0	0	0	116.28	0.20	17.45	72.09	0.21	2.39	6.61	2.12	53.44	0	0	5705.00	3636.64	319.84	7615.71	4686.29	1.20	0.21	0.04	22235.72
2	0	0	0	0	0.06	966.67	1.39	216.62	1349.90	496.71	192.58	1371.87	176.36	473.58	0	0	5024.63	1353.90	610.43	5081.65	2992.71	0.47	0.11	0.02	20309.67
3	0.24	0.21	3.47	242.83	0.37	2398.53	0.38	1264.25	11351.89	4633.05	3603.28	18451.03	1088.45	3377.13	0.02	0.03	1116.46	442.28	491.80	2015.31	4520.95	0.46	0.06	0.01	55002.47
4	5.62	4.98	82.50	5663.86	0.62	6065.82	0.09	1967.03	14968.84	8448.18	7516.73	27480.82	1773.24	9896.42	0.02	0.06	814.46	222.81	17.34	2633.67	3942.66	0.41	0.06	0.01	91506.26
5	2.99	2.59	303.54	3664.04	0.51	3217.47	0.14	499.23	3561.40	1386.00	1798.13	5963.00	1146.47	5480.10	0.01	0.05	981.25	379.45	4.63	6947.74	4494.77	0.77	0.11	0.02	39834.41
6	3.75	2.39	552.06	5049.73	1.19	6616.41	0.16	456.27	2106.20	606.39	905.03	5304.62	2553.72	10057.83	0.01	0.11	1281.83	520.68	2.79	8713.86	5961.28	1.09	0.17	0.03	50697.59
7	19.95	9.99	1811.24	32432.52	1.57	18346.36	0.31	1431.23	2618.81	1872.62	1459.73	7600.88	2373.88	28849.56	0.01	0.15	799.16	377.19	0.47	5449.21	2439.21	0.63	0.07	0.01	107894.78
8	2.77	5.69	1745.98	2777.10	0.21	1600.11	0.08	111.50	155.86	120.08	50.68	221.32	285.59	2110.71	0	0.02	587.96	298.54	0.28	2909.75	1427.28	0.43	0.02	0	14411.98
9	2.47	2.60	850.69	3566.35	0.08	1682.37	0.15	102.68	134.87	127.65	25.68	286.97	82.41	1573.51	0	0.01	743.17	334.31	0.44	2279.09	1566.52	0.38	0.03	0.01	13362.44
10	1.20	2.81	962.83	824.70	0.06	975.20	0.04	85.19	389.48	34.18	12.92	209.48	64.57	543.82	0	0.01	1180.80	367.20	0.45	2316.14	1951.28	0.38	0.03	0.01	9922.76
11	0.81	1.19	491.26	722.13	0	616.56	0.07	30.24	42.99	14.47	2.75	45.12	2.08	144.52	0	0	976.55	280.87	0.46	1851.58	1655.98	0.32	0.02	0	6880.01
12	1.32	1.83	813.27	973.77	0.03	340.75	0.04	62.24	38.62	14.59	8.60	50.07	65.95	664.60	0	0	495.83	112.64	0.32	805.67	952.41	0.16	0.01	0	5402.73
13	2.16	2.32	893.84	2686.59	0.01	907.62	0.04	122.53	497.13	133.28	10.17	120.87	14.96	618.90	0	0	496.86	94.83	0.17	782.57	475.53	0.08	0.02	0	7860.50
14	0.98	2.35	860.15	454.85	0	53.58	0	1.90	1.93	1.15	0.21	3.53	0.70	13.78	0	0	527.64	97.18	0.18	692.60	504.02	0.07	0.02	0	3216.85
15+	2.90	6.76	2385.70	1773.09	0.02	247.55	0	541.31	189.11	157.66	18.13	292.59	10.88	475.90	0	0	657.00	197.60	1.37	1104.24	984.51	0.16	0.02	0	9046.51

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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1992	14888	229694	36332	80550	56280	255874	126816	48711	18992	23447	1099780	13409	23002	65250	11967	33246
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

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2010	4331	68198	122386	69381	29371	30496	51312	110033	73973	285281	70041	34486	24421	14887	14942	44201
2011	1136	17035	61864	106032	51259	35380	38626	59428	59031	61017	239472	88764	29187	17731	9783	35379
2012	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

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
catch	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
Timing	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
Sex	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
catch	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	6.6	5.1	11.1
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
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
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
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
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
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
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
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
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
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
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
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

year	2003*	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
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
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
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
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

***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.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2003	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	2	7	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	2	11	1	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	3	18	9	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	13	15	3	1	0	0	0	0	0	0	0	0	0	0
2003	0	1	24	63	32	7	2	2	0	1	1	0	0	0	0	0
2003	0	0	8	72	88	22	8	2	1	4	5	0	0	0	0	0
2003	0	0	2	41	111	57	11	14	18	12	1	0	0	0	1	0
2003	0	0	0	9	72	81	33	29	29	32	5	1	1	0	0	0
2003	0	0	0	1	34	54	43	33	25	47	11	3	1	1	1	3

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2003	0	0	0	0	14	30	28	29	49	50	23	11	3	2	0	3
2003	0	0	0	0	1	8	22	23	33	52	19	5	7	2	2	5
2003	0	0	0	0	1	3	4	4	15	29	29	13	2	3	2	17
2003	0	0	0	0	0	2	3	2	7	15	10	8	6	2	3	5
2003	0	0	0	0	0	0	0	1	0	7	8	5	7	2	2	8
2003	0	0	0	0	0	1	0	2	1	3	6	2	2	0	4	4
2003	0	0	0	0	0	0	0	0	1	0	3	3	1	2	2	5
2003	0	0	0	0	0	0	0	0	1	1	1	2	1	0	0	8
2003	0	0	0	0	0	0	0	0	0	0	1	1	2	1	1	10
2003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8
2003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
2003	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3
2004	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	17	18	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	52	126	2	1	0	0	0	0	0	0	0	0	0	0
2004	0	0	51	186	14	5	0	0	0	0	0	0	0	0	0	0
2004	0	0	29	164	44	27	6	3	2	2	2	0	0	0	0	0
2004	0	0	4	95	71	64	21	5	2	13	3	4	1	0	0	1

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2004	0	0	2	28	65	108	35	9	6	10	11	4	0	0	0	1
2004	0	0	1	2	36	73	50	9	9	21	5	7	0	1	0	2
2004	0	0	0	1	10	32	20	7	13	16	4	6	2	0	0	1
2004	0	0	0	0	2	4	11	5	8	8	12	3	4	0	1	2
2004	0	0	0	0	0	2	2	0	3	4	3	3	2	0	0	3
2004	0	0	0	0	0	1	1	0	3	1	1	3	1	1	1	6
2004	0	0	0	0	0	0	1	0	0	3	0	2	0	1	0	3
2004	0	0	0	0	0	0	0	0	0	3	1	1	2	1	0	7
2004	0	0	0	0	0	0	0	1	0	3	1	2	1	0	2	3
2004	0	0	0	0	0	0	0	0	1	0	3	0	2	1	1	5
2004	0	0	0	0	0	0	0	0	0	0	1	1	3	0	0	3
2004	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
2004	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2
2004	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
2004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
2004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
2004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
2005	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	1	42	54	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	75	151	2	2	0	0	0	0	0	0	0	0	0
2005	0	0	0	61	230	4	4	2	0	0	0	0	0	0	0	0
2005	0	0	0	30	248	22	17	7	4	3	2	3	0	0	0	0
2005	0	0	0	18	160	40	35	7	8	7	7	6	2	0	2	1
2005	0	0	0	3	37	45	51	18	8	12	9	6	2	1	0	0
2005	0	0	0	0	3	21	39	26	8	19	20	10	3	0	0	3
2005	0	0	0	0	1	4	22	24	11	15	19	13	7	0	1	2
2005	0	0	0	0	0	1	10	12	6	6	15	14	2	0	2	3
2005	0	0	0	0	0	2	13	11	7	8	8	8	3	2	0	4
2005	0	0	0	0	0	1	0	3	0	2	9	5	3	2	0	9
2005	0	0	0	0	0	0	1	2	3	3	3	8	6	2	3	7
2005	0	0	0	0	0	0	0	1	2	0	1	5	6	5	1	11
2005	0	0	0	0	0	0	0	0	1	0	4	2	5	4	2	16
2005	0	0	0	0	0	0	0	1	0	1	1	2	3	0	1	15
2005	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	14

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2005	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	3
2005	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	3
2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2006	0	0	0	3	4	18	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	4	20	201	3	2	0	0	0	0	0	0	0	0
2006	0	0	0	2	15	308	11	2	0	0	0	0	0	0	0	0
2006	0	0	0	0	7	303	24	12	3	3	0	0	0	0	0	0
2006	0	0	0	0	2	290	30	20	5	2	0	3	4	2	0	0
2006	0	0	0	0	1	129	67	34	31	5	1	6	8	7	0	0
2006	0	0	0	0	0	54	46	36	24	6	7	6	9	6	5	1
2006	0	0	0	0	0	14	22	21	27	8	6	6	8	5	3	2
2006	0	0	0	0	0	6	9	10	9	6	5	2	4	10	2	7
2006	0	0	0	0	0	2	4	9	6	4	2	2	8	3	4	7
2006	0	0	0	0	0	0	0	0	4	4	0	3	5	3	3	6
2006	0	0	0	0	0	0	1	0	0	2	2	3	4	3	3	6
2006	0	0	0	0	0	0	0	0	1	0	0	1	2	5	1	2
2006	0	0	0	0	0	0	0	0	0	0	0	0	3	3	2	5

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2006	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	4
2006	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3
2006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2007	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0
2007	0	0	0	1	12	2	39	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	27	9	234	2	0	0	0	0	0	0	0	0
2007	0	0	0	0	7	7	334	9	2	0	0	0	1	0	0	0
2007	0	0	0	0	1	3	360	7	5	3	1	1	0	0	0	0
2007	0	0	0	0	0	0	280	25	23	9	0	3	3	4	1	1
2007	0	0	0	0	0	2	213	27	27	19	10	2	1	9	4	2
2007	0	0	0	0	0	1	126	32	43	34	7	5	11	9	7	7
2007	0	0	0	0	0	0	54	22	34	28	15	13	9	16	6	14
2007	0	0	0	0	0	0	22	9	18	25	9	7	6	6	8	15
2007	0	0	0	0	0	0	8	7	8	17	2	3	1	8	6	24
2007	0	0	0	0	0	0	1	1	9	10	6	2	3	11	5	19
2007	0	0	0	0	0	0	0	0	6	2	2	5	4	5	5	18
2007	0	0	0	0	0	0	0	0	2	3	3	3	1	4	4	15

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2007	0	0	0	0	0	0	0	0	0	1	4	0	0	3	6	11
2007	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	15
2007	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	14
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
2008	0	0	0	0	2	1	0	4	0	0	0	0	0	0	0	0
2008	0	0	0	0	14	19	4	52	1	0	0	0	0	0	0	0
2008	0	0	0	0	14	46	13	197	3	1	0	0	0	0	0	0
2008	0	0	0	0	7	29	15	353	1	7	1	0	1	0	0	0
2008	0	0	0	0	5	18	9	391	9	8	2	2	0	1	1	0
2008	0	0	0	0	0	6	5	358	27	18	7	3	2	1	4	3
2008	0	0	0	0	0	3	2	276	39	32	12	2	7	3	8	7
2008	0	0	0	0	0	0	4	188	39	35	27	6	5	7	4	8
2008	0	0	0	0	0	0	2	79	25	29	28	7	2	7	13	16
2008	0	0	0	0	0	0	0	42	12	24	25	9	7	6	10	18
2008	0	0	0	0	0	0	0	14	9	25	19	5	5	6	5	28
2008	0	0	0	0	0	0	0	3	4	9	12	4	3	4	6	34
2008	0	0	0	0	0	0	0	1	1	8	11	6	7	3	4	20

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2008	0	0	0	0	0	0	0	2	0	0	8	4	6	0	10	18
2008	0	0	0	0	0	0	0	0	0	3	4	2	0	1	7	26
2008	0	0	0	0	0	0	0	0	1	2	1	1	0	0	3	23
2008	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	13
2008	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	4
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2009	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	5	4	6	1	0	3	0	0	0	0	0	0	0
2009	0	0	0	6	24	36	25	8	37	0	0	0	0	0	0	0
2009	0	0	0	0	23	64	67	26	167	5	2	3	0	0	0	0
2009	0	0	0	0	5	41	70	36	262	10	4	1	0	1	1	0
2009	0	0	0	0	1	12	45	22	314	22	8	2	2	0	0	5
2009	0	0	0	0	0	2	28	14	301	32	17	6	2	4	1	2
2009	0	0	0	0	0	1	11	5	229	38	17	17	6	1	2	9
2009	0	0	0	0	0	0	1	3	154	25	21	15	6	4	7	19
2009	0	0	0	0	0	0	0	4	87	21	19	12	9	1	8	27
2009	0	0	0	0	0	0	0	0	44	10	12	10	2	6	4	32

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2009	0	0	0	0	0	0	0	0	17	4	10	15	3	4	3	26
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2013	0	0	0	0	0	0	0	0	0	3	1	2	60	3	4	8
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2016	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
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2016	0	0	21	3	2	0	0	0	0	0	0	0	0	0	0	0
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2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
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2017	10	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	10	91	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	10	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	10	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	4	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	29	10	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	22	34	0	0	0	0	0	0	0	0	0	0	0	0	0
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2017	0	1	22	98	0	0	0	0	0	0	0	0	0	0	0	0
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2017	0	0	0	3	20	107	53	83	21	28	1	0	0	0	0	1
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2017	0	0	0	0	0	2	4	2	30	69	22	35	9	10	7	8
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2017	0	0	0	0	0	0	0	1	9	16	7	12	16	16	17	5
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2017	0	0	0	0	0	0	0	0	2	4	3	2	10	4	10	2
2017	0	0	0	0	0	0	0	0	0	5	3	2	0	1	2	1
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2018	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	9	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	13	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	14	118	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	3	160	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	2	68	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	18	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	18	76	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	11	83	8	0	0	0	0	0	0	0	0	0	0	0	0	0
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2018	0	66	24	0	0	0	0	0	0	0	0	0	0	0	0	0
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2018	0	42	102	41	5	0	0	0	0	0	0	0	0	0	0	0
2018	0	21	184	100	49	0	0	0	0	0	0	0	0	0	0	0
2018	0	10	112	104	167	1	0	0	0	0	0	0	0	0	0	0
2018	0	0	70	119	431	11	1	0	0	0	0	0	0	0	0	0
2018	0	0	15	113	584	52	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	52	531	79	27	3	3	2	0	0	0	0	0	0
2018	0	0	0	6	409	146	49	10	3	3	0	0	0	0	0	0
2018	0	0	0	3	175	203	140	39	13	6	0	1	0	0	0	1
2018	0	0	0	0	81	145	217	93	15	15	4	0	0	0	0	0
2018	0	0	0	0	24	74	177	158	54	12	19	1	1	0	0	0
2018	0	0	0	0	3	34	130	59	138	61	55	8	0	0	0	2
2018	0	0	0	0	3	15	78	25	43	139	121	30	9	4	3	13
2018	0	0	0	0	0	3	41	40	16	65	229	39	16	8	4	40
2018	0	0	0	0	0	2	13	12	14	40	192	116	33	10	8	62
2018	0	0	0	0	0	0	2	7	4	27	102	63	91	27	18	106
2018	0	0	0	0	0	0	1	1	2	16	62	21	70	47	32	115
2018	0	0	0	0	0	0	0	2	1	6	26	15	16	15	45	135
2018	0	0	0	0	0	0	0	0	0	0	4	8	8	7	11	128

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2018	0	0	0	0	0	0	0	0	0	1	5	1	4	7	3	79
2018	0	0	0	0	0	0	0	0	0	0	1	0	4	6	5	37
2018	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	32
2018	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	9
2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
2019	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2019	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	12	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	6	68	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	2	63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	0	25	13	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	0	29	33	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	0	17	47	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	0	23	52	1	0	0	0	0	0	0	0	0	0	0	0	0
2019	0	26	52	1	0	0	0	0	0	0	0	0	0	0	0	0
2019	0	25	80	23	1	0	0	0	0	0	0	0	0	0	0	0
2019	0	19	99	63	2	2	0	0	0	0	0	0	0	0	0	0
2019	0	3	92	101	17	2	0	0	0	0	0	0	0	0	0	0
2019	0	2	67	101	45	31	1	0	0	0	0	0	0	0	0	0
2019	0	0	30	107	77	145	1	0	0	0	0	0	0	0	0	0
2019	0	0	5	67	108	358	0	0	0	0	0	0	0	0	0	0
2019	0	0	0	12	114	509	20	2	0	0	0	0	0	0	0	1
2019	0	0	0	1	83	526	80	18	0	0	1	1	0	0	0	3

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2019	0	0	0	2	63	404	119	48	6	3	1	1	0	0	0	0
2019	0	0	0	2	28	219	103	88	22	4	6	5	0	0	0	0
2019	0	0	0	1	7	98	78	93	78	38	8	26	3	0	0	3
2019	0	0	0	0	2	40	42	110	33	75	49	61	7	0	0	3
2019	0	0	0	0	0	14	24	75	19	22	110	96	12	5	2	14
2019	0	0	0	0	0	2	8	53	17	11	54	136	29	3	2	38
2019	0	0	0	0	0	1	3	25	15	8	17	88	68	22	7	56
2019	0	0	0	0	0	1	1	10	9	8	15	45	35	37	21	71
2019	0	0	0	0	0	0	0	0	5	1	8	24	10	12	34	60
2019	0	0	0	0	0	0	1	0	2	1	2	13	8	3	11	71
2019	0	0	0	0	0	0	0	1	0	2	2	8	2	4	2	54
2019	0	0	0	0	0	0	0	0	0	0	0	2	1	2	0	34
2019	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	18
2019	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	8
2019	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	9
2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
2020	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
2020	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	0	38	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	0	56	29	3	0	0	0	0	0	0	0	0	0	0	0	0
2020	0	24	107	16	0	0	0	0	0	0	0	0	0	0	0	0
2020	0	4	203	40	0	1	0	0	0	0	0	0	0	0	0	0
2020	0	4	136	75	6	0	0	0	0	0	0	0	0	0	0	0
2020	0	0	97	111	10	1	0	0	0	0	0	0	0	0	0	0
2020	0	0	21	109	16	2	1	0	0	0	0	0	0	0	0	0
2020	0	0	12	89	66	23	14	0	0	0	0	0	0	0	0	0

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2020	0	0	0	58	76	35	83	3	0	0	0	0	0	0	0	0
2020	0	0	1	24	69	60	185	11	0	0	0	0	0	0	0	0
2020	0	0	0	1	40	101	333	25	3	0	1	0	0	0	0	0
2020	0	0	0	3	6	121	321	31	17	0	0	0	0	0	0	0
2020	0	0	0	0	5	58	322	68	24	2	4	0	4	0	0	0
2020	0	0	0	0	4	23	197	102	49	15	8	10	12	0	0	0
2020	1	0	0	0	0	4	74	62	113	18	10	19	41	5	0	6
2020	0	0	0	0	0	1	21	29	72	99	15	18	54	2	3	16
2020	0	0	0	0	0	0	6	21	39	35	77	24	56	8	4	28
2020	0	0	0	0	0	0	7	9	24	16	40	25	36	11	3	33
2020	0	0	0	0	0	0	6	15	9	19	8	27	24	15	4	39
2020	0	0	0	0	0	0	4	8	9	5	8	15	31	8	1	28
2020	0	0	0	0	0	0	2	0	2	6	3	6	6	13	10	16
2020	0	0	0	0	0	0	0	1	0	2	5	6	0	0	8	12
2020	0	0	0	0	0	0	0	0	0	2	2	4	4	0	0	10
2020	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	5
2020	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
2021	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2021	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	32	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	31	66	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	28	122	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	4	189	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	0	152	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	4	96	15	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	7	98	31	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	7	56	30	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	1	31	60	9	0	0	0	0	0	0	0	0	0	0	0	0
2021	1	24	81	33	0	0	0	0	0	0	0	0	0	0	0	0
2021	0	15	125	37	0	0	0	0	0	0	0	0	0	0	0	0
2021	0	5	115	71	2	0	0	0	0	0	0	0	0	0	0	0
2021	0	5	66	120	18	1	1	0	0	0	0	0	0	0	0	0
2021	0	0	41	111	87	1	1	0	0	0	0	0	0	0	0	0

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2021	0	0	12	123	160	55	6	0	0	0	0	0	0	0	0	0
2021	0	0	2	85	264	69	25	0	0	0	0	0	0	0	0	0
2021	0	0	0	20	261	138	55	11	0	0	0	0	0	0	0	0
2021	0	0	0	13	117	170	159	45	1	0	0	0	0	0	0	0
2021	0	0	1	16	93	73	191	139	0	0	0	0	0	0	0	0
2021	0	0	0	9	41	79	153	230	16	3	0	0	0	0	0	0
2021	0	0	0	1	15	58	79	402	58	19	0	0	0	0	0	0
2021	0	0	0	0	11	39	98	295	115	84	15	2	5	10	1	0
2021	0	0	0	1	6	17	74	265	81	152	31	2	14	15	0	3
2021	0	0	0	0	0	10	38	146	38	118	68	15	4	23	1	3
2021	0	0	0	0	0	3	19	61	19	44	69	38	12	23	5	17
2021	0	0	0	0	0	1	2	17	17	23	46	54	30	30	6	24
2021	0	0	0	0	0	0	1	14	17	19	16	10	59	54	15	27
2021	0	0	0	0	0	0	0	8	7	14	7	9	26	75	45	23
2021	0	0	0	0	0	0	0	0	6	5	6	4	3	22	78	13
2021	0	0	0	0	0	0	0	0	0	0	3	0	10	2	51	9
2021	0	0	0	0	0	0	0	0	0	0	0	0	1	4	12	1
2021	0	0	0	0	0	0	0	1	0	0	0	0	0	0	4	6

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2021	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
2021	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3	0

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
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
catch		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	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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

year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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

year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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

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
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
Sex		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
catch		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sample number		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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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

year	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2013	2014	2015	2016	2017	2018	2019	2021
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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

year	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2013	2014	2015	2016	2017	2018	2019	2021
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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

Table 7.2.5.1. Western horse mackerel stock. Mean weight (kg) in catch-at-age by quarter and area in 2021 (15 = 15+ group)

Q1																	
Ages	27.2.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	27.7.k.1	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	27.8.d	Total
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	0.027	0.022	0.029	0.032	0.029	0.027	0.027
2	0	0	0.053	0.053	0.055	0.054	0.048	0.051	0.053	0.053	0.053	0.047	0.045	0.054	0.051	0.042	0.047	0.051
3	0.103	0.103	0.080	0.078	0.079	0.079	0.076	0.078	0.078	0.078	0.078	0.080	0.065	0.064	0.071	0.102	0.080	0.078
4	0.119	0.119	0.116	0.106	0.107	0.104	0.107	0.104	0.106	0.110	0.106	0.128	0.128	0	0.133	0.128	0.128	0.107
5	0.180	0.180	0.160	0.146	0.134	0.158	0.137	0.134	0.143	0.164	0.143	0.151	0.151	0	0.158	0.149	0.151	0.148
6	0.194	0.194	0.198	0.192	0.155	0.192	0.161	0.179	0.192	0.239	0.192	0.173	0.173	0	0.178	0.172	0.173	0.191
7	0.213	0.213	0.196	0.203	0.185	0.207	0.186	0.196	0.202	0.214	0.202	0.201	0.207	0	0.209	0.195	0.201	0.206
8	0.256	0.256	0.253	0.257	0.239	0.247	0.221	0.249	0.256	0.271	0.256	0.265	0.265	0	0.287	0.238	0.265	0.258
9	0.284	0.284	0.269	0.264	0.264	0.307	0.266	0.271	0.264	0.246	0.264	0.310	0.299	0	0.330	0.264	0.310	0.279
10	0.325	0.325	0.318	0.302	0.289	0.305	0.303	0.350	0.305	0.244	0.305	0.305	0.293	0	0.326	0.271	0.305	0.309
11	0.343	0.343	0.298	0.295	0.295	0.295	0.301	0.296	0.295	0.277	0.295	0.335	0.324	0	0.354	0.296	0.335	0.324
12	0.334	0.334	0.304	0.293	0.272	0.272	0.258	0.272	0.272	0.242	0.272	0.337	0.335	0	0.344	0.322	0.337	0.311
13	0.322	0.322	0.327	0.306	0.221	0.384	0.318	0.294	0.293	0.262	0.293	0.392	0.377	0	0.406	0.319	0.392	0.312
14	0.340	0.340	0.265	0.265	0.265	0.265	0.265	0.265	0.265	0.265	0.265	0.386	0.386	0	0.388	0.380	0.386	0.341
15+	0.346	0.346	0.399	0.358	0.311	0.478	0.411	0.505	0.393	0.335	0.393	0.448	0.447	0	0.438	0.478	0.448	0.377

Q2																	
Ages	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	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	27.8.d	Total
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
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.092	0.076	0.072	0.114	0.095	0.093	0.094
4	0.119	0.213	0.213	0.213	0.213	0.213	0.213	0.213	0.213	0.213	0.213	0.119	0.120	0.105	0.126	0.115	0.119	0.120
5	0.189	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.144	0.144	0.121	0.147	0.131	0.144	0.145
6	0.197	0.257	0.257	0.257	0.257	0.257	0.257	0.257	0.257	0.257	0.257	0.165	0.167	0.125	0.166	0.142	0.165	0.166
7	0.215	0.279	0.279	0.279	0.279	0.279	0.279	0.279	0.279	0.279	0.279	0.195	0.196	0.173	0.180	0.225	0.184	0.189
8	0.274	0.356	0.356	0.356	0.356	0.356	0.356	0.356	0.356	0.356	0.356	0.248	0.280	0.371	0.224	0.277	0.237	0.241
9	0.288	0.372	0.372	0.372	0.372	0.372	0.372	0.372	0.372	0.372	0.372	0.278	0.324	0.393	0.271	0.296	0.282	0.291
10	0.318	0.293	0.293	0.293	0.293	0.293	0.293	0.293	0.293	0.293	0.293	0.280	0.318	0.407	0.279	0.280	0.283	0.283
11	0.336	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.312	0.356	0.383	0.319	0.304	0.318	0.322
12	0.332	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.329	0.342	0.341	0.333	0.325	0.330	0.334
13	0.324	0.465	0.465	0.465	0.465	0.465	0.465	0.465	0.465	0.465	0.465	0.333	0.416	0.486	0.413	0.353	0.390	0.401
14	0.339	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.383	0.387	0.391	0.388	0.378	0.383	0.383
15+	0.353	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.429	0.471	0.465	0.466	0.473	0.469	0.469

Table 7.2.5.1 cont. Western horse mackerel stock. Mean weight (kg) in catch-at-age by quarter and area in 2021 (15 = 15+ group)

Q3 Ages	27.2.a	27.3.a	27.4.a	27.6.a	27.7.a	27.7.b	27.7.c.2	27.7.e	27.7.f	27.7.g	27.7.h	27.7.j	27.7.j.2	27.7.k.2	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	27.8.d	27.8.d.2	27.8.e	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
1	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
3	0	0	0	0	0.173	0.173	0.173	0.171	0.173	0.173	0.173	0.180	0.161	0.173	0.120	0.120	0.120	0.115	0.129	0.120	0.120	0.120	0.145
4	0.210	0.210	0.210	0.210	0.192	0.192	0.192	0.190	0.192	0.192	0.192	0.192	0.192	0.192	0.148	0.149	0.148	0.148	0.148	0.148	0.148	0.148	0.173
5	0.269	0.269	0.269	0.269	0.231	0.231	0.231	0.230	0.231	0.231	0.231	0.234	0.229	0.231	0.176	0.181	0.198	0.173	0.178	0.176	0.176	0.176	0.199
6	0.277	0.277	0.277	0.277	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.245	0.243	0.244	0.193	0.197	0.220	0.192	0.193	0.193	0.193	0.193	0.219
7	0.288	0.288	0.288	0.288	0.255	0.255	0.255	0.257	0.255	0.255	0.255	0.251	0.256	0.255	0.211	0.223	0.239	0.209	0.211	0.211	0.211	0.211	0.247
8	0.298	0.298	0.298	0.298	0.270	0.270	0.270	0.274	0.270	0.270	0.270	0.276	0.268	0.270	0.237	0.243	0.235	0.235	0.237	0.237	0.237	0.237	0.272
9	0.306	0.306	0.306	0.306	0.312	0.312	0.312	0.351	0.312	0.312	0.312	0.296	0.315	0.312	0.256	0.258	0.252	0.257	0.256	0.256	0.256	0.256	0.280
10	0.313	0.313	0.313	0.313	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.364	0.295	0.312	0.287	0.284	0.293	0.288	0.287	0.287	0.287	0.287	0.299
11	0.321	0.321	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.335	0.330	0.338	0.348	0.327	0.335	0.335	0.335	0.332
12	0.328	0.328	0.328	0.328	0.373	0.373	0.373	0.373	0.373	0.373	0.373	0.418	0.342	0.373	0.355	0.354	0.351	0.362	0.352	0.355	0.355	0.355	0.350
13	0.333	0.333	0.333	0.333	0.368	0.368	0.368	0.368	0.368	0.368	0.368	0.368	0.368	0.368	0.388	0.386	0.382	0.392	0.380	0.388	0.388	0.388	0.366
14	0.338	0.338	0.338	0.338	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.413	0.410	0.387	0.413	0.413	0.413	0.413	0.413	0.379
15+	0.359	0.359	0.359	0.359	0.328	0.328	0.328	0.328	0.328	0.328	0.328	0.328	0.328	0.328	0.485	0.486	0.423	0.481	0.493	0.485	0.485	0.485	0.398

Q4 Ages	27.2.a	27.3.a	27.4.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	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	Total
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
2	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
4	0.169	0.169	0.169	0.169	0.172	0.164	0.172	0.172	0.173	0.172	0.172	0.169	0.172	0.173	0.145	0.147	0.141	0.144	0.145	0.169
5	0.214	0.214	0.308	0.208	0.222	0.211	0.222	0.222	0.206	0.222	0.222	0.220	0.222	0.224	0.175	0.184	0.169	0.176	0.171	0.212
6	0.248	0.248	0.321	0.221	0.246	0.241	0.246	0.246	0.241	0.246	0.246	0.245	0.246	0.246	0.196	0.203	0.177	0.198	0.192	0.239
7	0.252	0.252	0.332	0.237	0.250	0.234	0.250	0.250	0.250	0.250	0.250	0.251	0.250	0.249	0.232	0.247	0.193	0.228	0.227	0.249
8	0.312	0.312	0.342	0.258	0.281	0.274	0.281	0.281	0.281	0.281	0.281	0.281	0.281	0.281	0.251	0.271	0.270	0.244	0.248	0.279
9	0.319	0.319	0.351	0.277	0.291	0.303	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.264	0.268	0.278	0.261	0.265	0.283
10	0.358	0.358	0.359	0.339	0.289	0.289	0.289	0.289	0.289	0.289	0.289	0.289	0.289	0.289	0.293	0.292	0.281	0.291	0.295	0.302
11	0.362	0.362	0.367	0.304	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.331	0.330	0.345	0.333	0.329	0.336
12	0.367	0.367	0.375	0.295	0.454	0.454	0.454	0.454	0.454	0.454	0.454	0.454	0.454	0.454	0.354	0.355	0.359	0.353	0.354	0.374
13	0.367	0.367	0.382	0.325	0.275	0.286	0.275	0.275	0.275	0.275	0.275	0.275	0.275	0.275	0.388	0.392	0.372	0.388	0.387	0.362
14	0.387	0.387	0.388	0.338	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.415	0.419	0.406	0.413	0.414	0.406
15+	0.408	0.408	0.410	0.372	0.507	0.507	0.507	0.507	0.507	0.507	0.507	0.507	0.507	0.507	0.476	0.483	0.479	0.481	0.470	0.450

Table 7.2.5.1 cont. Western horse mackerel stock. Mean weight (kg) in catch-at-age by quarter and area in 2021 (15 = 15+ group)

all Q Ages	27.2.a	27.3.a	27.4.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	27.7.k.1	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	27.8.e	Total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.027	0.019	0.049	0.022	0.047	0.022	0.021	0.021	0.027
1	0	0	0	0	0.058	0.068	0.069	0.069	0.067	0.068	0.067	0.068	0.069	0.069	0.000	0.044	0.048	0.029	0.040	0.041	0.045	0.031	0.042	0.042	0.042
2	0	0	0	0	0.135	0.088	0.092	0.074	0.068	0.055	0.055	0.052	0.127	0.096	0.053	0.146	0.075	0.056	0.057	0.078	0.071	0.061	0.079	0.079	0.072
3	0.146	0.153	0.140	0.136	0.172	0.092	0.106	0.079	0.080	0.079	0.078	0.083	0.174	0.138	0.078	0.173	0.113	0.091	0.069	0.112	0.101	0.096	0.120	0.120	0.090
4	0.162	0.169	0.157	0.152	0.191	0.122	0.188	0.107	0.109	0.104	0.108	0.110	0.184	0.166	0.106	0.192	0.143	0.138	0.108	0.136	0.127	0.129	0.148	0.148	0.122
5	0.205	0.227	0.269	0.191	0.231	0.169	0.214	0.148	0.141	0.159	0.142	0.150	0.230	0.217	0.143	0.231	0.170	0.166	0.137	0.153	0.161	0.154	0.176	0.176	0.169
6	0.224	0.252	0.302	0.201	0.244	0.204	0.253	0.195	0.172	0.192	0.181	0.208	0.245	0.244	0.192	0.244	0.191	0.188	0.144	0.173	0.184	0.175	0.193	0.193	0.205
7	0.229	0.259	0.295	0.217	0.255	0.200	0.270	0.205	0.201	0.208	0.201	0.227	0.250	0.235	0.202	0.255	0.224	0.220	0.187	0.188	0.210	0.195	0.211	0.211	0.219
8	0.286	0.300	0.308	0.257	0.271	0.257	0.351	0.262	0.264	0.248	0.259	0.255	0.277	0.275	0.256	0.270	0.252	0.270	0.313	0.239	0.249	0.253	0.237	0.237	0.262
9	0.297	0.310	0.322	0.284	0.312	0.275	0.370	0.277	0.305	0.307	0.293	0.274	0.295	0.273	0.264	0.312	0.268	0.298	0.329	0.284	0.268	0.295	0.256	0.256	0.282
10	0.334	0.321	0.329	0.325	0.312	0.317	0.293	0.301	0.289	0.305	0.307	0.348	0.355	0.270	0.305	0.312	0.293	0.304	0.335	0.294	0.284	0.297	0.287	0.287	0.301
11	0.348	0.335	0.347	0.342	0.385	0.304	0.385	0.314	0.343	0.295	0.326	0.301	0.352	0.301	0.295	0.000	0.330	0.344	0.363	0.336	0.316	0.331	0.335	0.335	0.328
12	0.352	0.345	0.358	0.333	0.376	0.314	0.394	0.299	0.341	0.275	0.361	0.307	0.423	0.328	0.272	0.373	0.351	0.347	0.350	0.345	0.340	0.338	0.355	0.355	0.340
13	0.341	0.346	0.358	0.323	0.362	0.331	0.458	0.311	0.227	0.384	0.314	0.295	0.282	0.278	0.293	0.368	0.385	0.399	0.410	0.397	0.376	0.390	0.388	0.388	0.334
14	0.362	0.349	0.359	0.341	0.325	0.265	0.325	0.265	0.276	0.266	0.295	0.272	0.320	0.320	0.265	0.000	0.414	0.409	0.392	0.408	0.406	0.398	0.413	0.413	0.383
15+	0.377	0.368	0.378	0.348	0.335	0.395	0.507	0.358	0.316	0.478	0.406	0.504	0.490	0.399	0.393	0.328	0.473	0.477	0.466	0.469	0.477	0.463	0.485	0.485	0.408

Table 7.2.5.2. Western horse mackerel stock. Mean length (cm) in catch-at-age by quarter and area in 2021 (15 = 15+ group)

Q1																	
Ages	27.2.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	27.7.k.1	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	27.8.d	Total
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	14.3	13.1	14.6	15.0	14.6	14.3	14.3
2	0	0	19.1	19.1	19.5	19.3	18.2	18.8	19.1	19.1	19.1	17.4	17.0	18.2	17.8	16.7	17.4	18.7
3	23.9	23.9	22.0	21.8	22.0	22.0	21.5	21.8	21.8	21.9	21.8	20.9	19.4	19.4	20.0	22.7	20.9	21.8
4	25.0	25.0	25.0	24.4	24.6	24.2	24.0	24.3	24.4	24.6	24.4	24.7	24.7	0	25.1	24.7	24.7	24.4
5	28.5	28.5	27.7	27.0	26.6	27.6	26.5	26.4	26.9	27.9	26.9	26.2	26.2	0	26.6	26.1	26.2	27.1
6	29.3	29.3	29.8	29.4	28.0	29.5	28.1	29.0	29.4	30.9	29.4	27.5	27.5	0	27.8	27.4	27.5	29.2
7	30.3	30.3	29.6	30.0	29.4	30.0	29.2	29.7	29.9	30.4	29.9	28.9	29.1	0	29.3	28.6	28.9	30.0
8	32.1	32.1	32.4	32.4	31.8	32.4	31.0	32.1	32.4	32.6	32.4	31.7	31.7	0	32.6	30.6	31.7	32.1
9	33.3	33.3	33.0	32.9	32.9	34.0	33.1	32.9	32.9	32.5	32.9	33.5	33.1	0	34.3	31.7	33.5	33.1
10	34.8	34.8	34.9	33.6	32.8	33.9	34.4	34.2	33.9	32.1	33.9	33.4	32.9	0	34.1	32.1	33.4	33.9
11	35.4	35.4	34.1	34.0	34.0	34.0	34.4	34.0	34.0	33.4	34.0	34.5	34.1	0	35.2	33.2	34.5	34.6
12	35.2	35.2	34.2	34.4	33.2	33.2	32.6	33.2	33.2	32.1	33.2	34.7	34.6	0	35.0	34.2	34.7	34.3
13	34.7	34.7	35.1	34.5	31.5	35.5	35.1	33.9	33.8	32.8	33.8	36.5	36.0	0	37.0	34.0	36.5	34.3
14	35.4	35.4	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	36.4	36.4	0	36.5	36.2	36.4	35.3
15+	35.5	35.5	37.2	35.8	33.4	38.9	38.4	38.6	36.5	35.6	36.5	38.3	38.3	0	38.0	39.2	38.3	36.2

Q2																	
Ages	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	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	27.8.d	Total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA
1	0	19	19	19	19	19	19	19	19	19	19	14	14	16	14	16	14	14
2	0	21	21	21	21	21	21	21	21	21	21	18	18	18	17	20	18	20
3	23.9	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.9	20.5	20.1	23.7	22.2	22.1	22.0
4	25.0	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	24.1	24.1	23.1	24.6	23.8	24.1	24.2
5	28.7	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	25.8	25.8	24.2	25.9	24.9	25.7	25.8
6	29.4	32.2	32.2	32.2	32.2	32.2	32.2	32.2	32.2	32.2	32.2	27.0	27.1	24.4	27.1	25.6	27.0	27.1
7	30.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	28.9	28.6	27.4	27.8	29.9	28.0	28.3
8	32.2	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	31.2	32.3	35.9	29.9	32.3	30.5	30.7
9	33.2	36.3	36.3	36.3	36.3	36.3	36.3	36.3	36.3	36.3	36.3	32.6	34.0	36.6	32.0	33.0	32.5	32.8
10	33.9	33.5	33.5	33.5	33.5	33.5	33.5	33.5	33.5	33.5	33.5	32.7	33.8	37.1	32.4	32.5	32.6	32.6
11	34.8	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	33.8	35.2	36.2	34.0	33.4	33.9	34.1
12	34.8	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	34.9	34.9	34.9	34.6	34.3	34.5	34.6
13	34.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	34.6	37.3	39.5	37.1	35.2	36.4	36.7
14	34.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.3	36.5	36.6	36.5	36.2	36.3	36.3
15+	35.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.8	39.0	38.9	38.8	39.1	38.9	38.9

Table 7.2.5.2 cont. Western horse mackerel stock. Mean length (cm) in catch-at-age by quarter and area in 2021 (15 = 15+ group)

Q3																							
Ages	27.2.a	27.3.a	27.4.a	27.6.a	27.7.a	27.7.b	27.7.c.2	27.7.e	27.7.f	27.7.g	27.7.h	27.7.j	27.7.j.2	27.7.k.2	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	27.8.d	27.8.d.2	27.8.e	Total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13.16	13.07	13.16	13.21	13.16	13.16	13.16	13.16	13.1614922
1	0	0	0	0	17	17	17	17	17	17	17	17	17	17	17	16	18	17	17	17	17	17	17
2	0	0	0	0	25	25	25	24	25	25	25	24	27	25	21	20	19	21	24	21	21	21	21
3	0	0	0	0	26.9	26.9	26.9	26.7	26.9	26.9	26.9	27.0	26.7	26.9	24.1	24.1	24.1	23.8	24.8	24.1	24.1	24.1	25.4
4	30.5	30.5	30.5	30.5	28.2	28.2	28.2	28.0	28.2	28.2	28.2	28.0	28.3	28.2	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	27.3
5	31.1	31.1	31.1	31.1	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.1	30.0	30.0	27.6	27.9	28.8	27.5	27.7	27.6	27.6	27.6	28.6
6	31.4	31.4	31.4	31.4	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.3	30.7	30.5	28.6	28.8	29.9	28.5	28.6	28.6	28.6	28.6	29.5
7	32.0	32.0	32.0	32.0	31.1	31.1	31.1	31.1	31.1	31.1	31.1	31.0	31.1	31.1	29.5	30.0	30.8	29.3	29.5	29.5	29.5	29.5	30.8
8	32.4	32.4	32.4	32.4	32.2	32.2	32.2	32.2	32.2	32.2	32.2	32.1	32.2	32.2	30.7	31.0	30.6	30.6	30.7	30.7	30.7	30.7	31.9
9	32.8	32.8	32.8	32.8	33.4	33.4	33.4	34.1	33.4	33.4	33.4	31.5	33.8	33.4	31.6	31.6	31.4	31.6	31.5	31.6	31.6	31.6	32.2
10	33.1	33.1	33.1	33.1	33.0	33.0	33.0	33.0	33.0	33.0	33.0	34.5	32.5	33.0	32.8	32.7	33.0	32.9	32.8	32.8	32.8	32.8	32.9
11	33.5	33.5	33.5	33.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.6	34.5	34.8	35.1	34.4	34.6	34.6	34.6	34.4
12	33.8	33.8	33.8	33.8	35.7	35.7	35.7	35.7	35.7	35.7	35.7	36.5	35.1	35.7	35.4	35.3	35.2	35.6	35.3	35.4	35.4	35.4	34.9
13	34.0	34.0	34.0	34.0	35.8	35.8	35.8	35.8	35.8	35.8	35.8	35.8	35.8	35.8	36.5	36.4	36.3	36.6	36.2	36.5	36.5	36.5	35.5
14	34.2	34.2	34.2	34.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.3	37.2	36.5	37.3	37.3	37.3	37.3	37.3	35.9
15+	34.8	34.8	34.8	34.8	33.8	33.8	33.8	33.8	33.8	33.8	33.8	33.8	33.8	33.8	39.4	39.5	37.6	39.3	39.6	39.4	39.4	39.4	36.2

Q4																				
Ages	27.2.a	27.3.a	27.4.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	27.8.a	27.8.b	27.8.c	27.8.c.e	27.8.c.w	Total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13.95	12.6	17.59	13.69	17.33	14.0492178
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	16	18	17	19	18
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	21	19	21	20	20
3	26.8	26.8	26.8	26.8	26.9	25.7	26.9	26.9	26.4	26.9	26.9	27.0	26.9	26.8	23.8	24.4	24.0	23.4	24.0	25.8
4	27.7	27.7	27.7	27.7	27.5	27.4	27.5	27.5	27.0	27.5	27.5	27.2	27.5	27.6	25.8	25.9	25.6	25.8	25.8	27.4
5	29.8	29.8	32.3	29.6	30.0	29.8	30.0	30.0	28.3	30.0	30.0	30.1	30.0	30.1	27.6	28.1	27.2	27.6	27.4	29.6
6	30.9	30.9	32.8	30.2	31.0	31.1	31.0	31.0	30.3	31.0	31.0	31.0	31.0	31.1	28.7	29.0	27.7	28.8	28.5	30.7
7	31.3	31.3	33.3	30.9	31.3	30.8	31.3	31.3	31.2	31.3	31.3	31.5	31.3	31.3	30.4	31.0	28.5	30.2	30.2	31.3
8	33.0	33.0	33.7	31.8	32.4	32.5	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	31.3	32.0	32.1	31.0	31.2	32.2
9	33.4	33.4	34.1	32.6	32.8	33.5	32.8	32.8	32.8	32.8	32.8	32.8	32.8	32.8	31.9	32.0	32.5	31.8	31.9	32.4
10	34.4	34.4	34.4	34.8	32.8	32.8	32.8	32.8	32.8	32.8	32.8	32.8	32.8	32.8	33.1	33.0	32.6	33.0	33.2	33.3
11	34.6	34.6	34.7	33.6	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	34.5	34.5	35.0	34.6	34.4	34.5
12	34.8	34.8	35.0	33.1	37.8	37.8	37.8	37.8	37.8	37.8	37.8	37.8	37.8	37.8	35.3	35.4	35.5	35.3	35.3	35.5
13	35.0	35.0	35.3	34.3	32.7	33.1	32.7	32.7	32.7	32.7	32.7	32.7	32.7	32.7	36.5	36.6	36.0	36.5	36.5	35.4
14	35.5	35.5	35.5	34.7	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	37.4	37.5	37.1	37.3	37.3	36.8
15+	36.2	36.2	36.2	36.1	39.7	39.7	39.7	39.7	39.7	39.7	39.7	39.7	39.7	39.7	39.2	39.4	39.3	39.3	39.0	37.9

Table 7.2.5.2 cont. Western horse mackerel stock. Mean length (cm) in catch-at-age by quarter and area in 2021 (15 = 15+ group)

all Q																								
Ages	27.2.a	27.3.a	27.4.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	27.7.k.1	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	27.8.e	Total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	14.0	12.7	17.6	13.2	17.3	13.2	13.2	13.2	14.0
1	0	0	0	0	18.0	19.0	19.0	19.0	18.8	19.0	18.8	19.0	19.0	19.0	0	16.5	17.3	14.5	16.3	16.5	16.8	14.9	16.6	16.6	16.5
2	0	0	0	0	24.0	20.5	20.5	19.9	19.9	19.3	18.6	18.9	23.8	20.9	19.1	24.8	20.4	18.4	18.6	20.7	20.0	18.9	20.8	20.8	20.1
3	26.3	26.8	26.0	25.8	26.8	22.4	21.3	21.8	22.0	22.0	21.6	22.1	26.8	25.4	21.8	26.9	23.6	21.7	19.9	23.6	22.7	22.3	24.1	24.1	22.5
4	27.3	27.7	27.1	26.8	28.1	25.3	29.1	24.4	24.6	24.3	24.1	24.5	27.8	27.3	24.4	28.2	25.7	25.4	23.3	25.2	24.6	24.7	26.0	26.0	25.1
5	29.4	30.1	31.1	28.9	30.0	28.1	30.4	27.1	26.8	27.6	26.7	27.1	30.0	29.8	26.9	30.0	27.3	27.0	25.3	26.3	26.7	26.3	27.6	27.6	27.6
6	30.2	31.0	32.3	29.5	30.5	29.9	31.8	29.5	28.5	29.5	28.7	29.9	30.4	30.9	29.4	30.5	28.4	28.3	25.6	27.5	28.0	27.6	28.6	28.6	29.3
7	30.7	31.4	32.3	30.4	31.1	29.8	32.7	30.0	29.9	30.1	29.7	30.7	31.1	30.9	29.9	31.1	30.0	29.8	28.2	28.2	29.4	28.6	29.5	29.5	30.3
8	32.5	32.5	32.7	32.1	32.2	32.5	36.2	32.7	32.6	32.4	32.0	32.2	32.2	32.5	32.4	32.2	31.3	32.0	33.7	30.6	31.1	31.2	30.7	30.7	31.8
9	33.2	33.0	33.3	33.2	33.5	33.1	36.2	33.3	34.0	34.0	33.3	32.9	32.0	32.9	32.9	33.4	32.0	33.1	34.3	32.5	32.0	32.9	31.6	31.6	32.8
10	34.1	33.3	33.6	34.7	33.0	34.8	33.5	33.6	32.8	33.9	33.4	34.1	34.3	32.4	33.9	33.0	33.1	33.4	34.5	33.0	32.7	33.1	32.8	32.8	33.3
11	34.7	33.9	34.2	35.3	37.4	34.3	37.5	34.7	35.9	34.0	35.2	34.2	35.9	34.2	34.0	0.0	34.5	34.9	35.6	34.6	33.9	34.4	34.6	34.6	34.4
12	34.8	34.2	34.6	35.1	35.7	34.5	36.6	34.5	35.0	33.3	35.4	34.1	36.7	34.4	33.2	35.7	35.3	35.1	35.2	35.0	34.9	34.8	35.4	35.4	34.8
13	34.7	34.4	34.7	34.6	35.6	35.2	38.3	34.6	31.6	35.5	34.4	33.8	33.0	33.0	33.8	35.8	36.4	36.8	37.2	36.8	36.1	36.5	36.5	36.5	34.8
14	35.1	34.5	34.8	35.3	34.5	32.6	34.5	32.6	32.9	32.6	33.5	32.8	34.3	34.3	32.6	0.0	37.3	37.2	36.7	37.1	37.1	36.8	37.3	37.3	36.2
15+	35.6	35.0	35.3	35.5	34.0	37.0	39.7	35.8	33.6	38.9	37.7	38.6	39.3	36.9	36.5	33.8	39.1	39.2	38.9	38.9	39.2	38.8	39.4	39.4	36.9

Table 7.2.5.3. Western horse mackerel. Catch weights-at-age (kg), from Q1 and Q2 data (note that 2021 data is from Q1 and Q3).

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

Table 7.2.6.1. Western horse mackerel. Maturity-at-age.

	0	1	2	3	4	5	6	7	8	9	10	11+
1982	0	0	0.4	0.8	1	1	1	1	1	1	1	1
1983	0	0	0.3	0.7	1	1	1	1	1	1	1	1
1984	0	0	0.1	0.6	0.85	1	1	1	1	1	1	1
1985	0	0	0.1	0.4	0.8	0.95	1	1	1	1	1	1
1986	0	0	0.1	0.4	0.6	0.9	1	1	1	1	1	1
1987	0	0	0.1	0.4	0.6	0.8	1	1	1	1	1	1
1988	0	0	0.1	0.4	0.6	0.8	1	1	1	1	1	1
1989	0	0	0.1	0.4	0.6	0.8	1	1	1	1	1	1
1990	0	0	0.1	0.4	0.6	0.8	1	1	1	1	1	1
1991	0	0	0.1	0.4	0.6	0.8	1	1	1	1	1	1
1992	0	0	0.1	0.4	0.6	0.8	1	1	1	1	1	1
1993	0	0	0.1	0.4	0.6	0.8	1	1	1	1	1	1
1994	0	0	0.1	0.4	0.6	0.8	1	1	1	1	1	1
1995	0	0	0.1	0.4	0.6	0.8	1	1	1	1	1	1
1996	0	0	0.1	0.4	0.6	0.8	1	1	1	1	1	1
1997	0	0	0.1	0.4	0.6	0.8	1	1	1	1	1	1
1998	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
1999	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2000	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2001	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2002	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2003	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2004	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2005	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2006	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2007	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2008	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2009	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1

	0	1	2	3	4	5	6	7	8	9	10	11+
2010	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2011	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2012	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2013	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2014	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2015	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2016	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2017	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2018	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2019	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2020	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2021	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1

Table 7.2.8.1. Western horse mackerel. Potential fecundity (10^6 eggs) per kg spawning female vs. weight in kg.

1987		1992		1995		1998		2000		2001		2001 (cont)	
w	pfec.	w	pfec.	w	pfec.	w	pfec.	w	pfec.	w	pfec.	w	pfec.
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
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

1987		1992		1995		1998		2000		2001		2001 (cont)	
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
										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

1987	1992	1995	1998	2000	2001		2001 (cont)	
					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	47836900	1224800	2508310	5767780	1065790	1377590	1251940	752509	489208	437032	407175	470482	564493	707171	403839	258724	229811	203001	178882	157708	1174820
1983	1506360	41138300	1050670	2142280	4901320	901783	1162120	1054260	633103	411396	367440	342303	395503	474520	594447	339464	217481	193176	170640	150365	1120100
1984	1618940	1295010	35245400	894754	1811780	4120630	755036	970653	879452	527798	342867	306190	285222	329540	395370	495288	282836	181201	160950	142173	1058520
1985	2127570	1391930	1109950	30043000	757875	1526320	3458410	632296	811919	735217	441117	286521	255855	238326	275352	330354	413838	236323	151401	134481	1003230
1986	2659390	1829580	1193880	947683	25516700	640806	1286540	2909760	531476	682139	617558	370485	240630	214869	200146	231238	277426	347534	198459	127144	955422
1987	5227420	2286430	1567970	1017420	802401	21485400	537501	1076700	2432270	444004	569712	515708	309362	200924	179411	167115	193075	231640	290176	165705	903891
1988	2828290	4492990	1957240	1332670	857669	671669	17897500	446460	892982	2015780	367846	471913	427144	256224	166407	148588	138404	159902	191841	240319	885819
1989	3172420	2430540	3843680	1661100	1120710	715617	557387	14804800	368692	736831	1662640	303347	389131	352198	211262	137204	122511	114113	131839	158171	928487
1990	2213230	2726170	2079000	3261050	1396150	934424	593360	460650	12214400	303926	607154	1369770	249889	320540	290109	174016	113014	100910	93993	108592	895053
1991	3917750	1900710	2326150	1753880	2715350	1149580	763457	482586	373756	9898750	246170	491643	1109020	202307	259495	234855	140871	91487	81689	76089	812460
1992	7659570	3363580	1620000	1957330	1454190	2223110	932988	616429	388597	300565	7955340	197780	394942	890818	162496	208425	188631	113144	73480	65610	713647
1993	6961380	6567500	2852190	1347130	1591500	1159880	1749720	728580	479399	301606	233059	6165760	153254	305993	690143	125885	161463	146127	87648	56922	603652

year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1994	6385880	5961650	5542790	2346090	1075830	1239210	887447	1325000	548746	360116	226277	174744	4621630	114856	229306	517156	94329	120986	109493	65674	494957
1995	3836720	5467840	5028040	4552080	1868720	834775	944280	669045	993332	410263	268886	168848	130354	3447040	85658	171004	385655	70342	90219	81648	418053
1996	2155970	3276980	4566950	4037690	3493900	1379850	600088	668167	469507	694263	286191	187397	117623	90786	2400390	59644	119067	268516	48975	62814	347903
1997	1497210	1843270	2747700	3700430	3145290	2631450	1015270	435502	481423	337096	497632	204971	134161	84191	64974	1717820	42682	85204	192146	35046	293894
1998	2574170	1276540	1529040	2171820	2766860	2242550	1815420	686963	291691	320850	224131	330496	136052	89025	55858	43104	1139550	28313	56518	127454	218185
1999	2711470	2201370	1071410	1241750	1698190	2094400	1659810	1326010	498296	210865	231571	161640	238257	98062	64159	40253	31061	821152	20402	40725	249056
2000	1999390	2318580	1847000	869408	969665	1283180	1546940	1209610	959566	359355	151821	166598	116243	171307	70499	46123	28936	22328	590261	14665	208295
2001	11846100	1712520	1957970	1521330	695878	757304	985274	1175960	914706	723765	270718	114306	125396	87481	128911	53049	34705	21773	16800	444126	167758
2002	2179360	10134800	1439700	1596120	1197020	531176	566053	727393	862551	668803	528397	197499	83361	91432	63780	93979	38673	25299	15872	12247	446038
2003	1064110	1865450	8536920	1178950	1265280	922884	401720	423267	540682	639288	495005	390827	146032	61627	67587	47144	69464	28584	18699	11731	338718
2004	1949000	910936	1571990	6997360	936037	977550	699678	301190	315498	401870	474517	367184	289813	108270	45687	50103	34947	51492	21188	13861	259767
2005	1481480	1670320	770991	1301550	5648980	739481	760790	539744	231269	241708	307549	362958	280787	221592	82778	34929	38303	26717	39364	16198	209178
2006	1231430	1269120	1411440	635985	1044310	4426210	569975	580750	409927	175211	182904	232595	274423	212265	167502	62569	26401	28951	20193	29752	170341

year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2007	1956800	1055620	1075230	1171330	515397	829243	3465500	442570	448977	316241	135031	140891	179125	211311	163437	128966	48173	20326	22289	15547	154049
2008	4945330	1678710	897001	898450	960040	415500	660907	2743430	349120	353562	248830	106205	110793	140845	166144	128499	101395	37874	15980	17524	133333
2009	1277190	4239420	1422400	744600	728405	762764	325533	513549	2122550	269538	272694	191824	81855	85380	108532	128021	99011	78126	29182	12313	116234
2010	938294	1093160	3570050	1164040	589646	560805	575922	242984	381021	1570170	199114	201310	141563	60397	62992	80069	94444	73041	57633	21527	94826
2011	344757	802108	916174	2889600	905176	443052	411492	416708	174525	272692	1121840	142145	143654	100998	43085	44933	57112	67364	52097	41107	82987
2012	2417070	294622	671386	739362	2236040	675707	322604	295259	296710	123802	193092	793689	100523	101569	71400	30457	31762	40370	47615	36824	87712
2013	1053240	2066080	246842	543011	574223	1677340	494832	232924	211602	211872	88251	137530	565074	71553	72289	50814	21675	22603	28728	33884	88619
2014	3375470	899701	1726570	198463	417618	425139	1209580	351342	164041	148433	148342	61733	96161	395008	50012	50523	35512	15147	15796	20076	85606
2015	2396120	2884780	753259	1394150	153720	312140	310017	869306	250586	116563	105286	105132	43733	68107	279736	35415	35775	25145	10725	11184	74828
2016	2777670	2050940	2429710	616682	1104730	118452	235918	231657	645708	185589	86209	77817	77678	32307	50308	206619	26157	26423	18572	7921	63524
2017	3633800	2377160	1726350	1986380	487532	848642	89202	175591	171363	476216	136678	63446	57250	57138	23762	37000	151956	19237	19432	13658	52541
2018	2968230	3113140	2009260	1424950	1595430	382530	655178	68213	133605	130069	361042	103565	48061	43362	43273	17995	28020	115073	14568	14715	50129
2019	1356420	2541200	2624340	1648280	1132900	1234880	290637	492372	50969	99551	96788	268490	76992	35724	32228	32160	13373	20823	85515	10826	48187

year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2020	1083960	1160330	2135440	2137200	1294770	862859	920631	213963	360089	37155	72459	70397	195208	55967	25966	23423	23373	9719	15133	62148	42886
2021	816224	998917	912502	1384850	1341580	875566	581151	630308	143506	239066	25200	46793	43929	121924	38258	15285	13605	13479	5583	8454	62126

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	0.013	0.017	0.020	0.022	0.023	0.023	0.023	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
1983	0.001	0.005	0.011	0.018	0.023	0.028	0.030	0.031	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.033	0.033	0.033	0.033	0.033	0.033
1984	0.001	0.004	0.010	0.016	0.021	0.025	0.027	0.029	0.029	0.029	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
1985	0.001	0.003	0.008	0.013	0.018	0.021	0.023	0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
1986	0.001	0.004	0.010	0.016	0.022	0.026	0.028	0.029	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
1987	0.001	0.005	0.013	0.021	0.028	0.033	0.036	0.037	0.038	0.038	0.038	0.038	0.038	0.038	0.039	0.039	0.039	0.039	0.039	0.039	0.039
1988	0.002	0.006	0.014	0.023	0.031	0.037	0.040	0.041	0.042	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043
1989	0.002	0.006	0.014	0.024	0.032	0.037	0.041	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
1990	0.002	0.009	0.020	0.033	0.044	0.052	0.057	0.059	0.060	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061
1991	0.003	0.010	0.023	0.037	0.050	0.059	0.064	0.067	0.068	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069
1992	0.004	0.015	0.034	0.057	0.076	0.089	0.097	0.101	0.103	0.104	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105
1993	0.005	0.020	0.045	0.075	0.100	0.118	0.128	0.133	0.136	0.137	0.138	0.138	0.138	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139
1994	0.005	0.020	0.047	0.077	0.104	0.122	0.132	0.138	0.141	0.142	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143

year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1995	0.008	0.030	0.069	0.115	0.153	0.180	0.196	0.204	0.208	0.210	0.211	0.212	0.212	0.212	0.212	0.212	0.212	0.212	0.212	0.212	0.212
1996	0.007	0.026	0.060	0.100	0.133	0.157	0.171	0.178	0.181	0.183	0.184	0.184	0.184	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185
1997	0.009	0.037	0.085	0.141	0.188	0.221	0.241	0.251	0.256	0.258	0.259	0.260	0.260	0.260	0.260	0.260	0.260	0.260	0.261	0.261	0.261
1998	0.006	0.025	0.058	0.096	0.128	0.151	0.164	0.171	0.174	0.176	0.177	0.177	0.177	0.178	0.178	0.178	0.178	0.178	0.178	0.178	0.178
1999	0.007	0.026	0.059	0.097	0.130	0.153	0.166	0.173	0.177	0.179	0.179	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180
2000	0.005	0.019	0.044	0.073	0.097	0.114	0.124	0.129	0.132	0.133	0.134	0.134	0.134	0.134	0.134	0.134	0.134	0.134	0.134	0.134	0.134
2001	0.006	0.024	0.054	0.090	0.120	0.141	0.153	0.160	0.163	0.165	0.165	0.166	0.166	0.166	0.166	0.166	0.166	0.166	0.166	0.166	0.166
2002	0.006	0.022	0.050	0.082	0.110	0.129	0.141	0.147	0.150	0.151	0.152	0.152	0.152	0.152	0.152	0.152	0.152	0.152	0.152	0.152	0.152
2003	0.005	0.021	0.049	0.081	0.108	0.127	0.138	0.144	0.147	0.148	0.149	0.149	0.149	0.149	0.149	0.149	0.149	0.149	0.149	0.149	0.149
2004	0.004	0.017	0.039	0.064	0.086	0.101	0.110	0.114	0.116	0.117	0.118	0.118	0.118	0.118	0.119	0.119	0.119	0.119	0.119	0.119	0.119
2005	0.005	0.018	0.043	0.070	0.094	0.110	0.120	0.125	0.128	0.129	0.129	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130
2006	0.004	0.016	0.036	0.060	0.081	0.095	0.103	0.107	0.109	0.110	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.112	0.112	0.112
2007	0.003	0.013	0.030	0.049	0.065	0.077	0.084	0.087	0.089	0.090	0.090	0.090	0.090	0.090	0.091	0.091	0.091	0.091	0.091	0.091	0.091
2008	0.004	0.016	0.036	0.060	0.080	0.094	0.102	0.107	0.109	0.110	0.110	0.110	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111
2009	0.006	0.022	0.050	0.083	0.111	0.131	0.142	0.148	0.151	0.153	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154
2010	0.007	0.027	0.061	0.102	0.136	0.160	0.174	0.181	0.185	0.186	0.187	0.187	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188
2011	0.007	0.028	0.064	0.106	0.142	0.167	0.182	0.190	0.193	0.195	0.196	0.196	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.197
2012	0.007	0.027	0.062	0.103	0.137	0.162	0.176	0.183	0.187	0.188	0.189	0.190	0.190	0.190	0.190	0.190	0.190	0.190	0.190	0.190	0.190

year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2013	0.008	0.030	0.068	0.113	0.151	0.177	0.192	0.201	0.205	0.206	0.207	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
2014	0.007	0.028	0.064	0.105	0.141	0.166	0.180	0.188	0.192	0.193	0.194	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
2015	0.006	0.022	0.050	0.083	0.111	0.130	0.141	0.147	0.150	0.152	0.152	0.153	0.153	0.153	0.153	0.153	0.153	0.153	0.153	0.153	0.153
2016	0.006	0.022	0.051	0.085	0.114	0.134	0.145	0.151	0.154	0.156	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.157
2017	0.005	0.018	0.042	0.069	0.093	0.109	0.118	0.123	0.126	0.127	0.127	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128
2018	0.005	0.021	0.048	0.079	0.106	0.125	0.136	0.141	0.144	0.146	0.146	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147
2019	0.006	0.024	0.055	0.091	0.122	0.144	0.156	0.163	0.166	0.168	0.168	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169
2020	0.003	0.014	0.031	0.052	0.069	0.081	0.088	0.092	0.094	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095
2021	0.004	0.016	0.037	0.061	0.082	0.096	0.106	0.111	0.113	0.115	0.115	0.116	0.116	0.116	0.116	0.116	0.116	0.116	0.116	0.116	NA

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	47973500	3007480	2351030	61197	0.0260	0.0081	0.0218	0.0183
1983	1409080	3517800	2477960	90442	0.0365	0.0111	0.0299	0.0251
1984	1529300	4168190	2600980	96244	0.0370	0.0101	0.0271	0.0227
1985	2061350	4763890	3044610	96343	0.0316	0.0083	0.0223	0.0187
1986	2605390	5186500	4307560	137499	0.0319	0.0102	0.0274	0.0230
1987	5209590	5376550	5036810	187338	0.0372	0.0128	0.0345	0.0289
1988	2733740	5358590	5073630	210989	0.0416	0.0143	0.0384	0.0322
1989	3106180	5198870	4865000	209583	0.0431	0.0145	0.0392	0.0328
1990	2128810	4956330	4599300	275968	0.0600	0.0203	0.0546	0.0458
1991	3848570	4599130	4282640	287438	0.0671	0.0229	0.0617	0.0517
1992	7613940	4233590	3922920	393631	0.1003	0.0349	0.0941	0.0789
1993	6952140	3823250	3443150	453246	0.1316	0.0461	0.1242	0.1041
1994	6397130	3445010	2930260	412291	0.1407	0.0479	0.1290	0.1081
1995	3888900	3184580	2568610	538950	0.2098	0.0711	0.1915	0.1605
1996	2130800	2835840	2258940	422396	0.1870	0.0620	0.1671	0.1400
1997	1455050	2588010	2130370	534673	0.2510	0.0875	0.2357	0.1975
1998	2488060	2194950	1887400	325340	0.1724	0.0596	0.1605	0.1345
1999	2653150	1973540	1751820	298992	0.1707	0.0603	0.1624	0.1361
2000	1952630	1759820	1556520	202732	0.1302	0.0450	0.1211	0.1015
2001	11569200	1668810	1411810	229081	0.1623	0.0557	0.1499	0.1256
2002	1982640	1619510	1257880	196120	0.1559	0.0512	0.1380	0.1156
2003	988367	1638910	1167000	191856	0.1644	0.0505	0.1360	0.1140
2004	1801970	1650310	1171620	159742	0.1363	0.0402	0.1083	0.0908
2005	1366060	1652080	1362250	182001	0.1336	0.0442	0.1191	0.0998
2006	1137640	1584930	1418690	155827	0.1098	0.0380	0.1024	0.0859
2007	2071850	1505090	1359080	123356	0.0908	0.0310	0.0835	0.0700
2008	4713810	1447290	1290160	143349	0.1111	0.0381	0.1025	0.0859
2009	1196590	1381580	1183320	183782	0.1553	0.0534	0.1438	0.1205

Year	Recruit (thousands)	Total Biomass	Spawning Biomass	Catch	Yield/SSB	Fbar(1-3)	Fbar(4-8)	Fbar(1-10)
2010	893847	1282810	1039260	203112	0.1954	0.0656	0.1765	0.1480
2011	338534	1155520	928577	193698	0.2086	0.0692	0.1865	0.1563
2012	2277900	1022860	880027	169859	0.1930	0.0674	0.1814	0.1521
2013	982006	905486	803142	165258	0.2058	0.0745	0.2006	0.1681
2014	3140900	797965	679877	136360	0.2006	0.0706	0.1901	0.1593
2015	2138820	737343	576525	98419	0.1707	0.0560	0.1507	0.1263
2016	2419130	735636	541909	98810	0.1823	0.0581	0.1564	0.1310
2017	2846550	753910	527801	82961	0.1572	0.0477	0.1284	0.1076
2018	2329200	803522	568172	101682	0.1790	0.0554	0.1491	0.1249
2019	1260210	839611	604308	124947	0.2068	0.0652	0.1755	0.1471
2020	1165290	842494	625449	76422	0.1222	0.0376	0.1014	0.0850
2021	816224	871032	693991	81557	0.1175	0.0377	0.1015	0.0851

Table 7.4.1. Western Horse Mackerel. Short term prediction: INPUT DATA. *geometric mean of the recruitment time series from 1983 to 2021. ** from assessment output

Age	N	Mat	M	PF	PM	Stock weight at age**
0	816224	0.000	0.150	0	0	0.0091
1	998917	0.000	0.150	0	0	0.0251
2	912502	0.050	0.150	0	0	0.0493
3	1384850	0.250	0.150	0	0	0.0798
4	1341580	0.700	0.150	0	0	0.1166
5	875566	0.950	0.150	0	0	0.1519
6	581151	1.000	0.150	0	0	0.1824
7	630308	1.000	0.150	0	0	0.2087
8	143506	1.000	0.150	0	0	0.2312
9	239066	1.000	0.150	0	0	0.2503
10	25200	1.000	0.150	0	0	0.2664
11	46793	1.000	0.150	0	0	0.2799
12	43929	1.000	0.150	0	0	0.2911

Age	N	Mat	M	PF	PM	Stock weight at age**
13	121924	1.000	0.150	0	0	0.3004
14	38258	1.000	0.150	0	0	0.3080
15	15285	1.000	0.150	0	0	0.3142
16	13605	1.000	0.150	0	0	0.3193
17	13479	1.000	0.150	0	0	0.3234
18	5583	1.000	0.150	0	0	0.3268
19	8454	1.000	0.150	0	0	0.3294
20	62126	1.000	0.150	0	0	0.3334

Table 7.4.2. Western Horse Mackerel. Short term prediction; single area management option table. Assumption: Catch 2022: 71 138 t (100% of 2022 TOTAL TAC).

Scenarios	F_{factor}	F_{bar}	Catch_2022	Catch_2023	SSB_2023	SSB_2024	Change_SSB_2023-2024(%)	Change_Catch_2022-2023(%)
SSB_{2024} = 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 2024, even with a zero catch in 2023.							
F = F_{MSY}	0.870	0.074	71 138	73 950	754 163	737 593	-2.2	3.95
F = F_{P05} = F_{pa}	0.929	0.079	71 138	78 719	754 163	733 196	-2.8	10.7
F = F_{lim}	1.211	0.103	71 138	101 225	754 163	712 461	-5.5	42.3
F = 0	0	0	71 138	0	754 163	805 946	6.9	-100
F = F_{2022}	0.844	0.072	71 138	71 813	754 163	739 564	-1.94	0.95
PelAC proposed HCR	0.341	0.015	71 138	15 513	754 163	791 583	4.96	-78

7.16 Figures

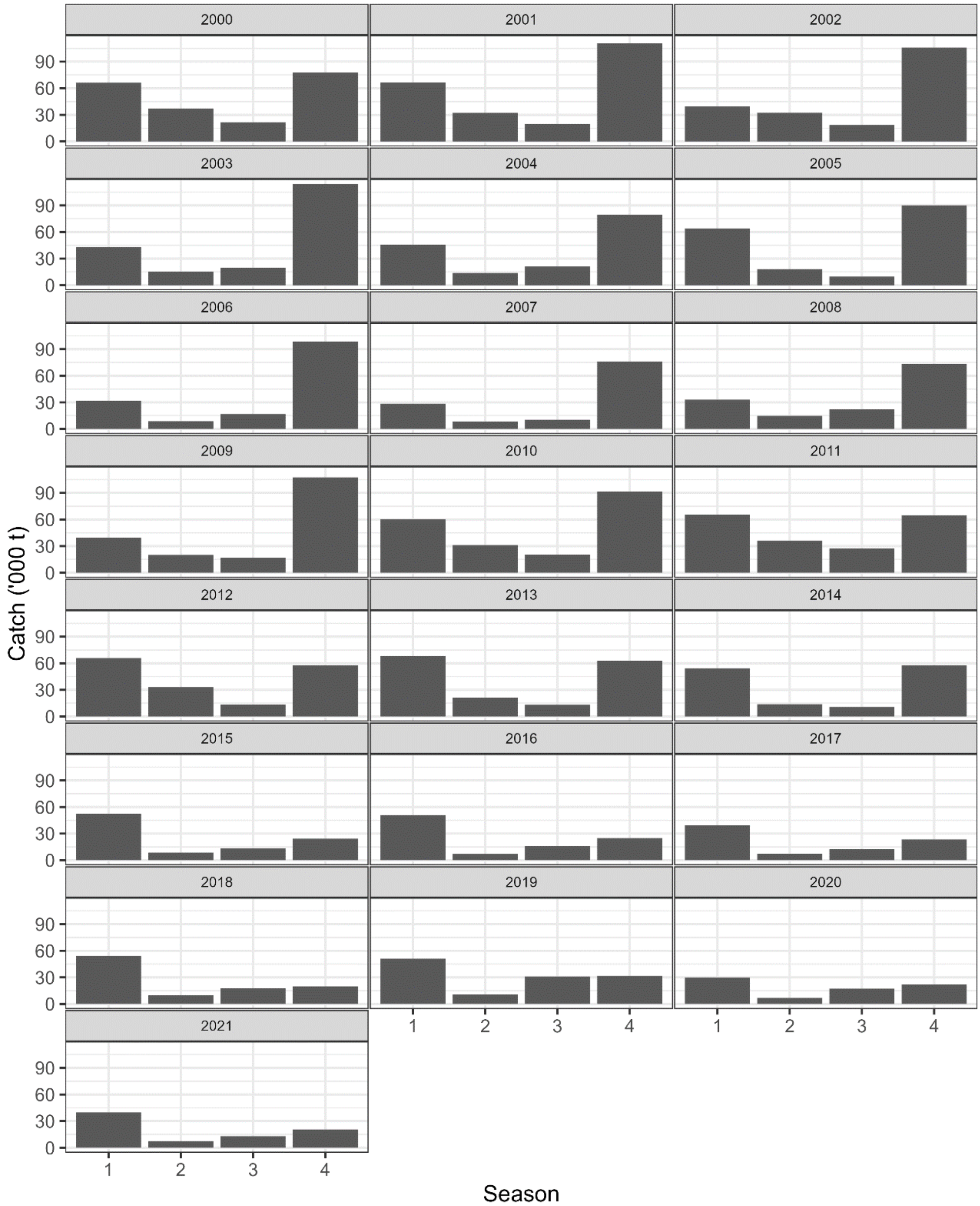

Figure 7.1.1.1: Western horse mackerel. Catch by quarter and year for 2000-2021.

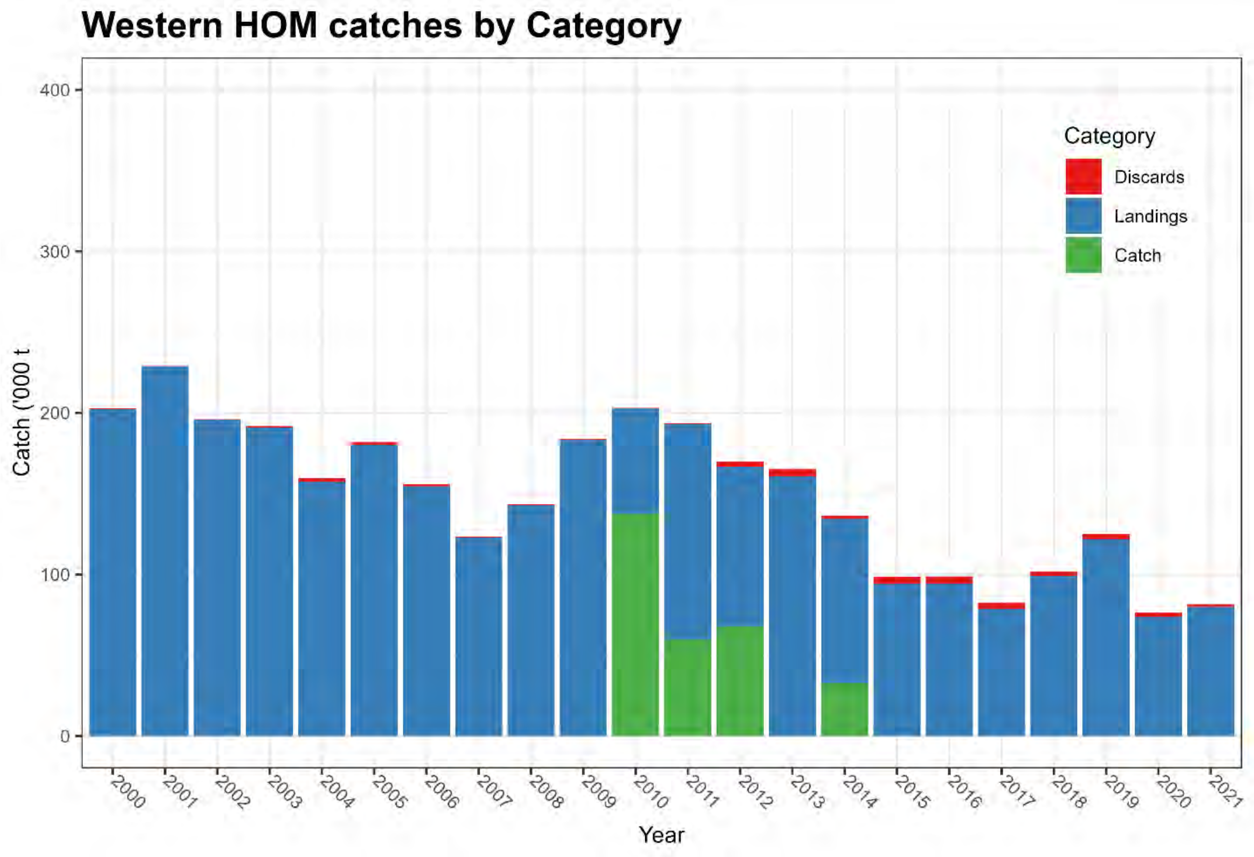

Figure 7.1.2.1. Western horse mackerel. Catch categories since 2000 (green bars indicate when countries have submitted catch data without specifying landings/discards).

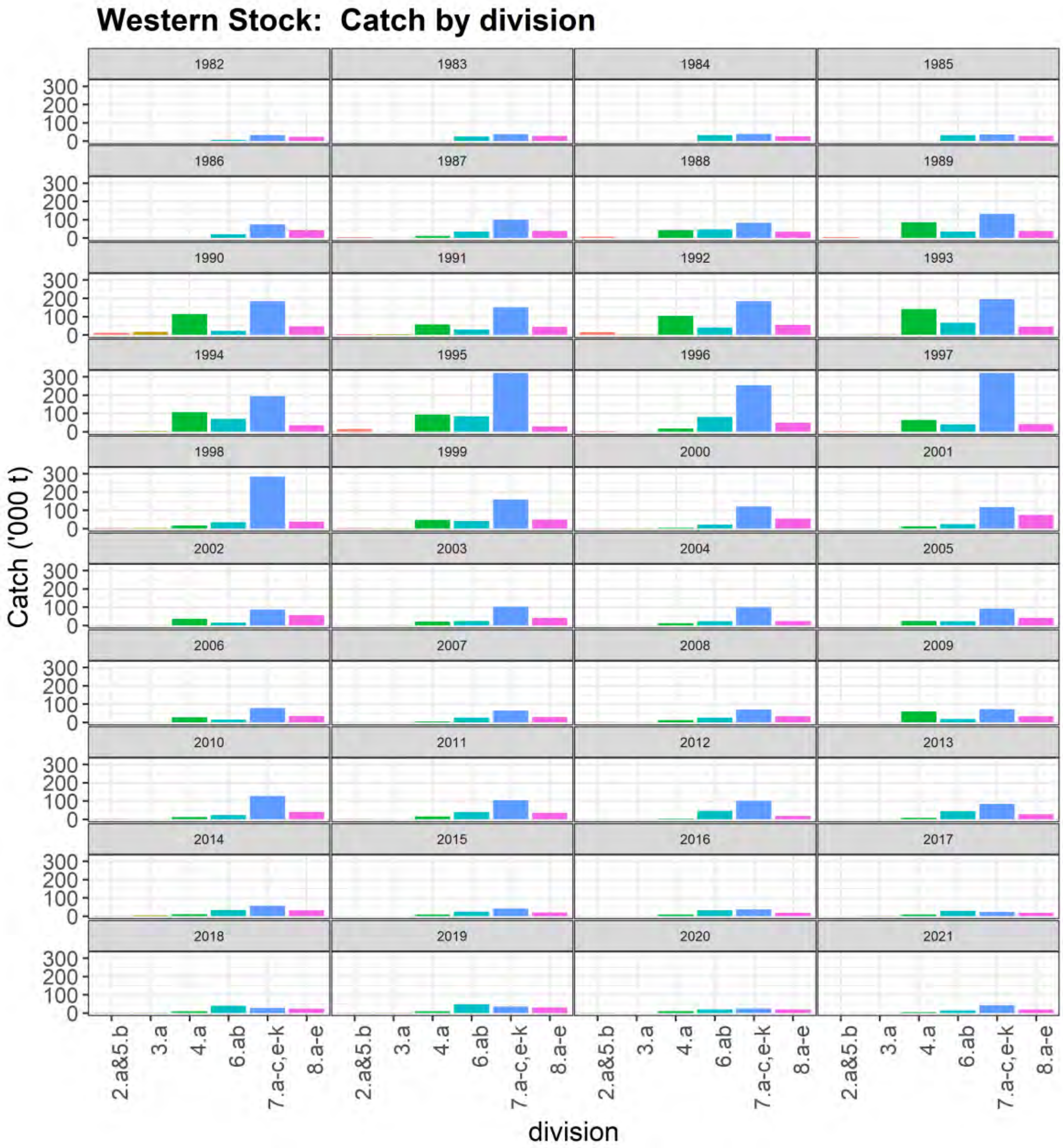

Figure 7.1.3.1: Western horse mackerel. Catch by ICES Division and year for 1982-2021.

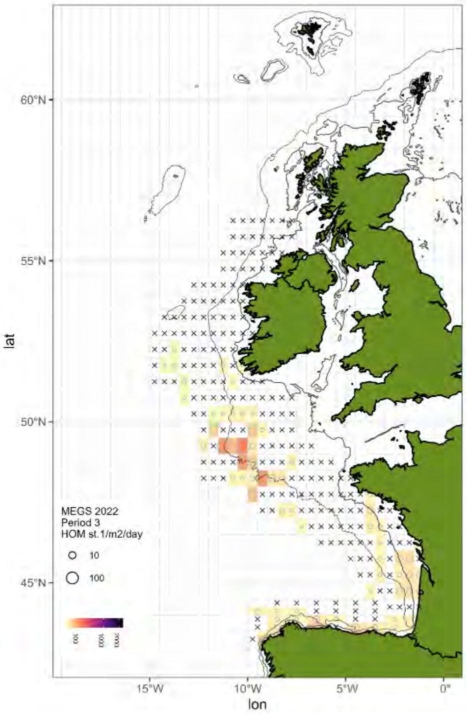

Figure 7.2.1.1: Western Horse mackerel egg production by half rectangle for period 3 (March 4th – April 8th, 2022). Circle areas and colour scale represent horse mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

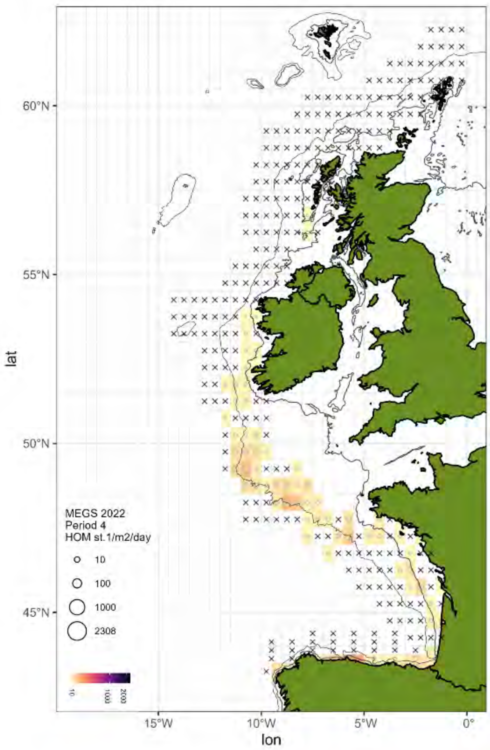

Figure 7.2.1.2: Western Horse mackerel egg production by half rectangle for period 4 (April 9th – 29th, 2022). Circle areas and colour scale represent horse mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

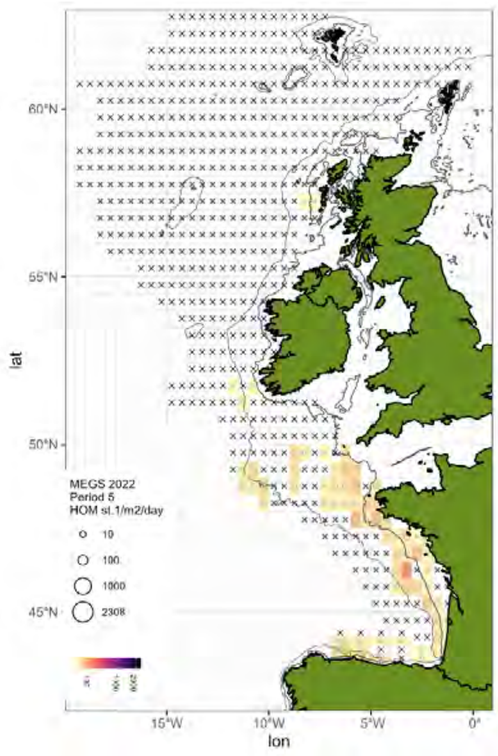

Figure 7.2.1.3: Western Horse mackerel egg production by half rectangle for period 5 (Apr 30th – May 31st, 2022). Circle areas and colour scale represent horse mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

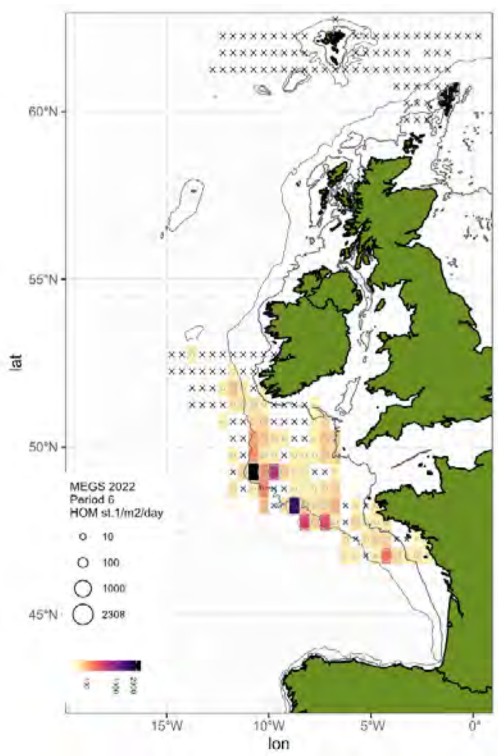

Figure 7.2.1.4: Western Horse mackerel egg production by half rectangle for period 6 (June 1st – 30th, 2022). Circle areas and colour scale represent horse mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

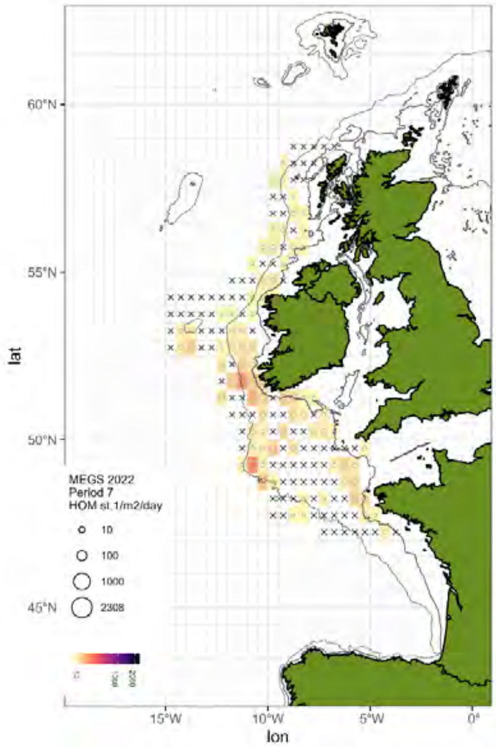

Figure 7.2.1.5: Western mackerel egg production by half rectangle for period 7 (July 1st – July 31st, 2022). Circle areas and colour scale represent horse mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values

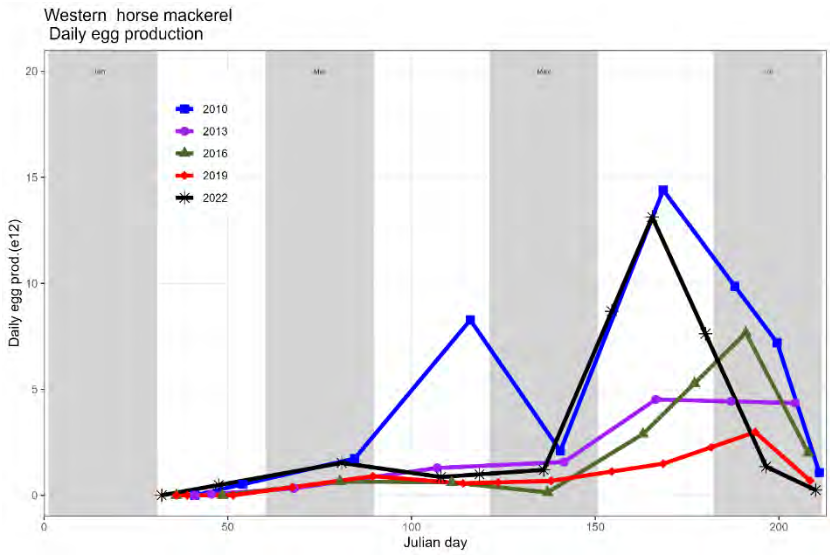

Figure 7.2.1.6: Provisional annual egg production curve for western horse mackerel for 2022, (black line). The curves for 2010, 2013, 2016 and 2019 are included for comparison

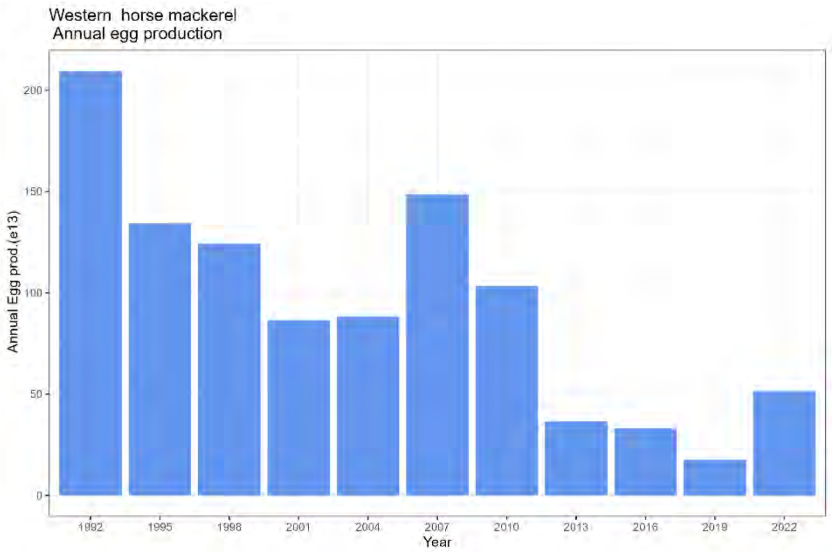

Figure 7.2.1.7. Provisional total annual egg production for western horse mackerel. Production figures back to 1992 are included for comparison.

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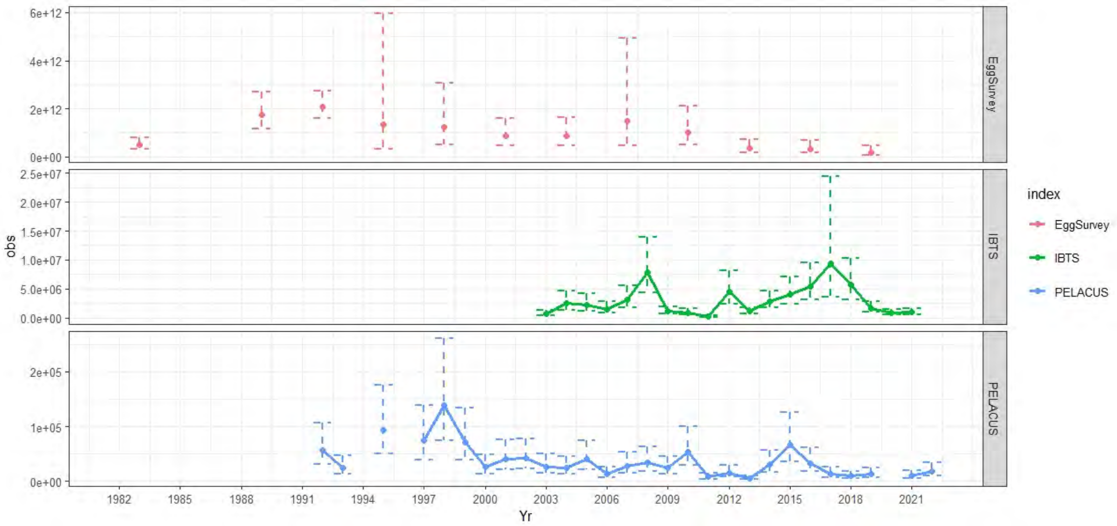


Figure 7.2.2.1: Western horse mackerel. Trend of the fisheries independent indices of abundance used in the assessment of Western Horse mackerel. Top: Spawning index from egg survey; middle: recruitment index from IBTS survey; bottom: biomass estimates from PELACUS acoustic survey. Confidence intervals are shown as well.

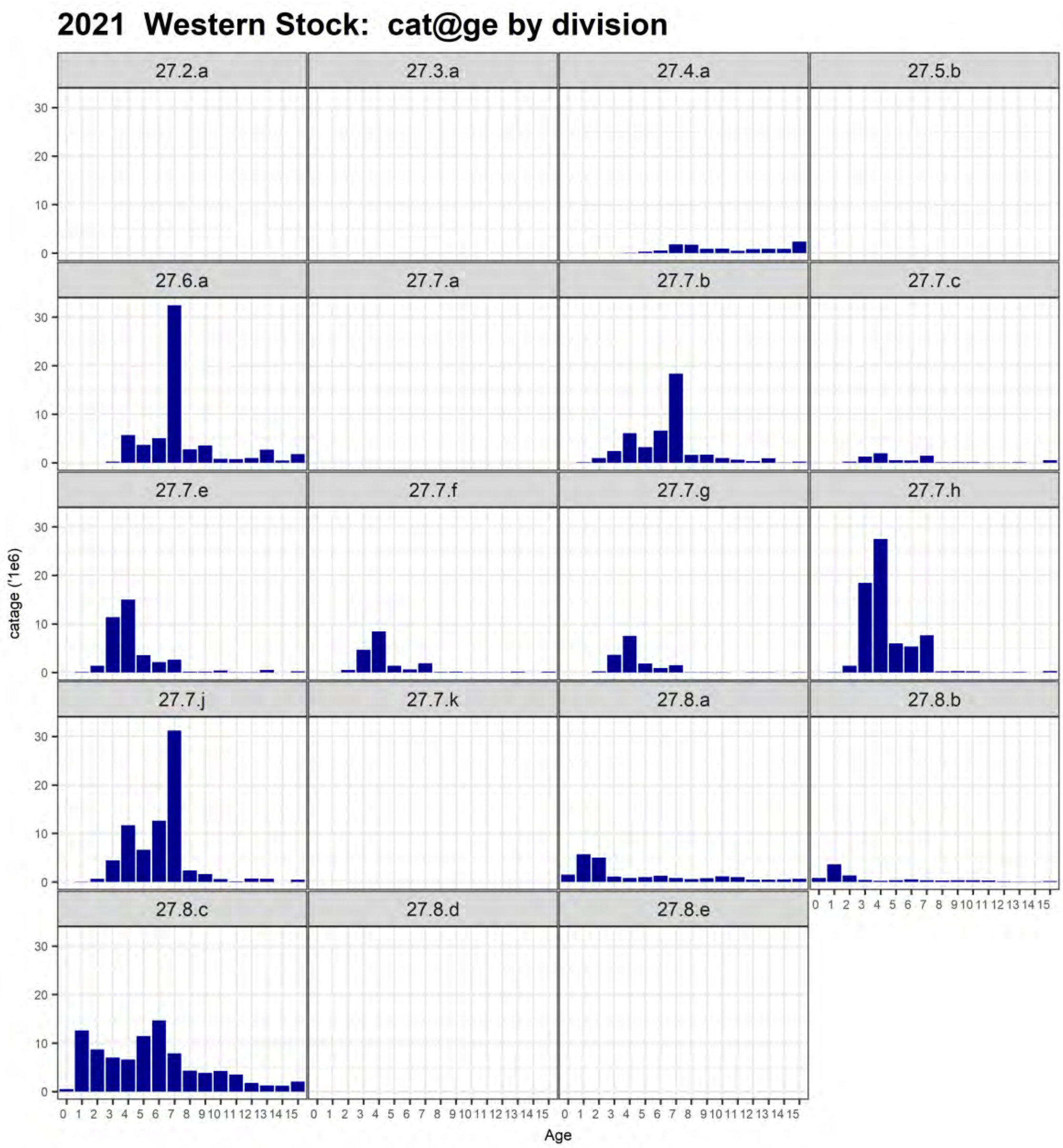


Figure 7.2.4.1: Western horse mackerel. Catch-at-age (millions) by ICES division in 2021.

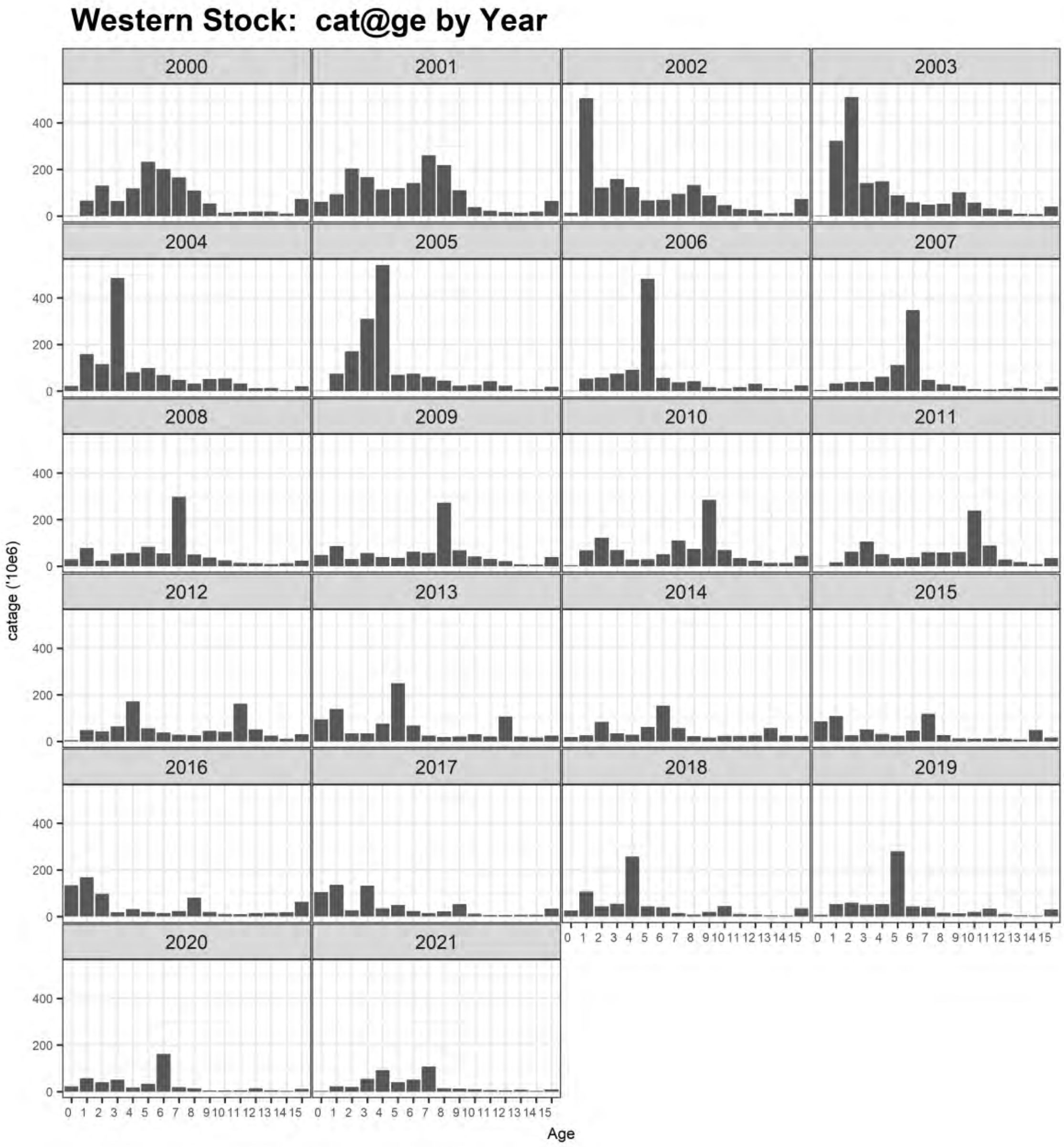


Figure 7.2.4.2: Western horse mackerel. Catch-at-age (millions) by Year.

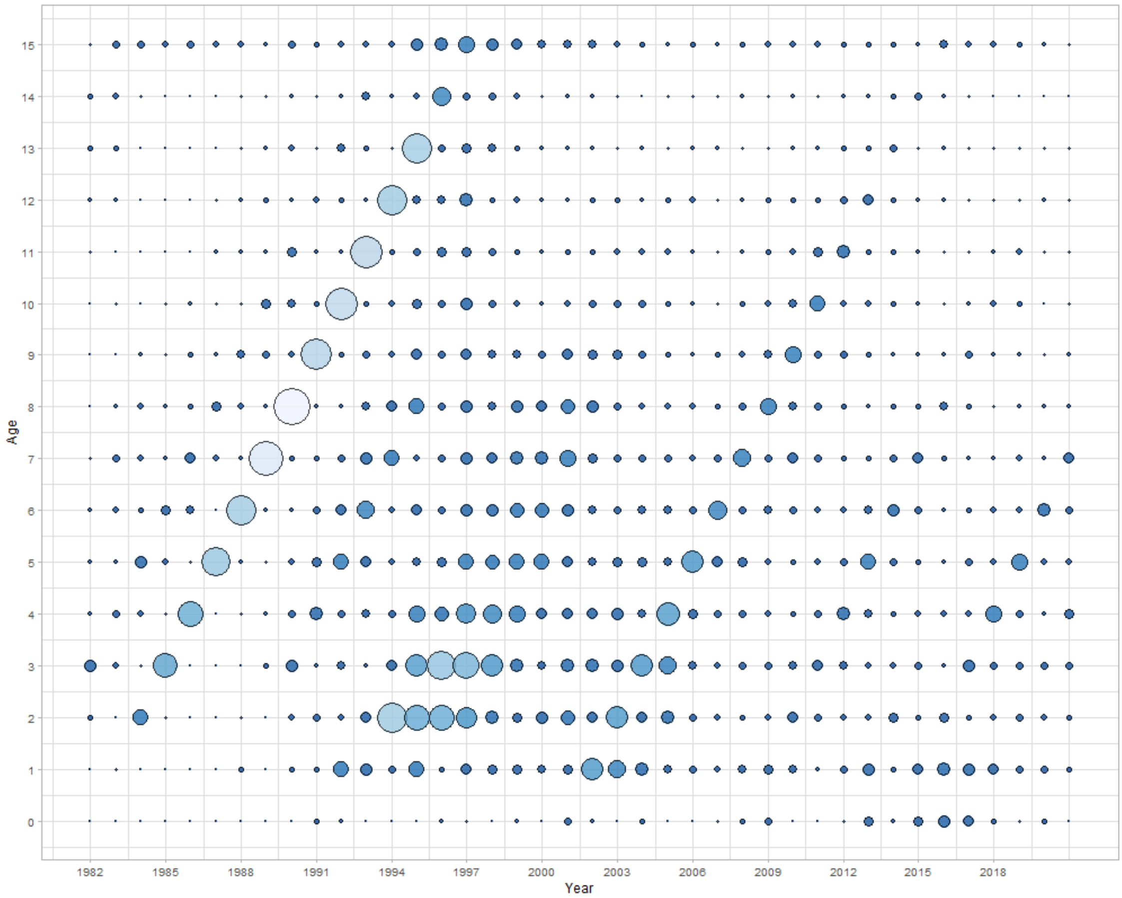


Figure 7.2.4.3: Western horse mackerel. Catch-at-age - the area of bubbles is proportional to the catch number. Age 15 is a plus group.

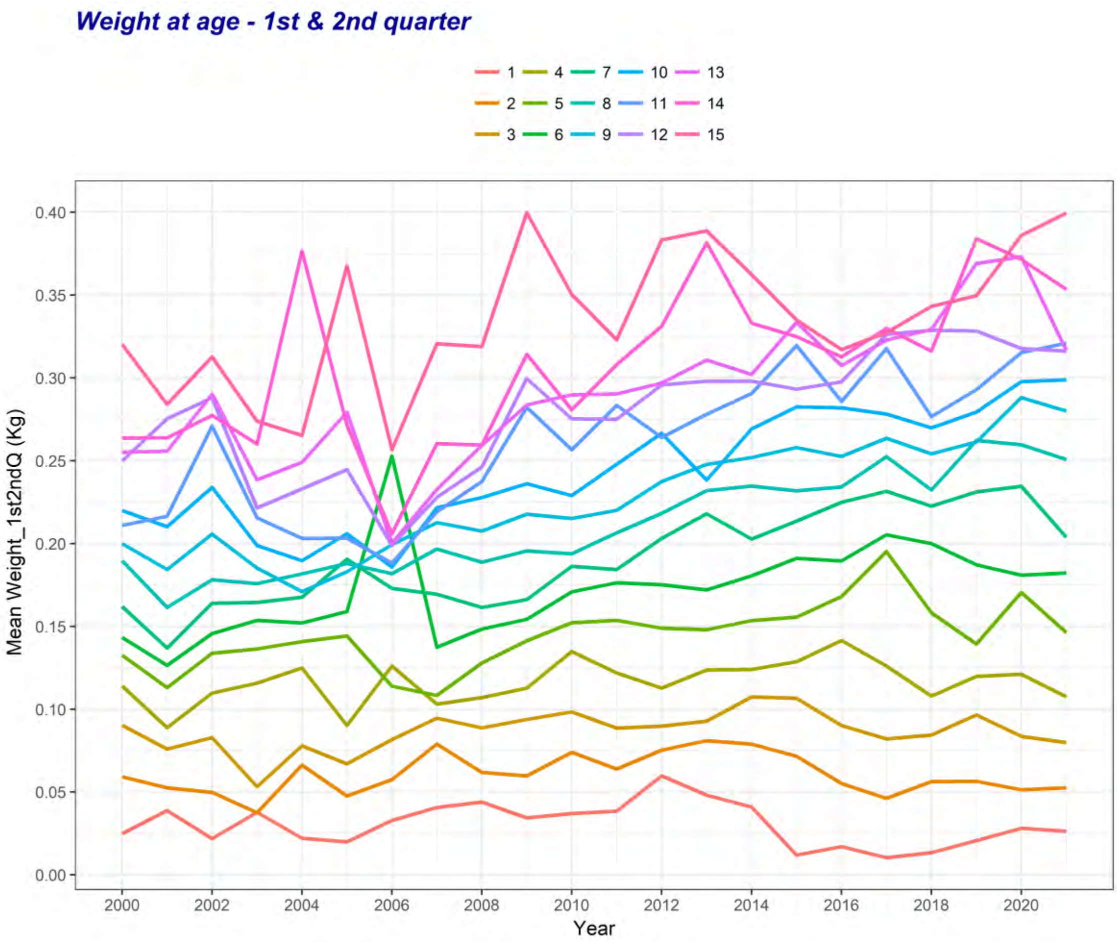


Figure 7.2.5.1: Western horse mackerel. Weight at age in the catch (kg) by year.

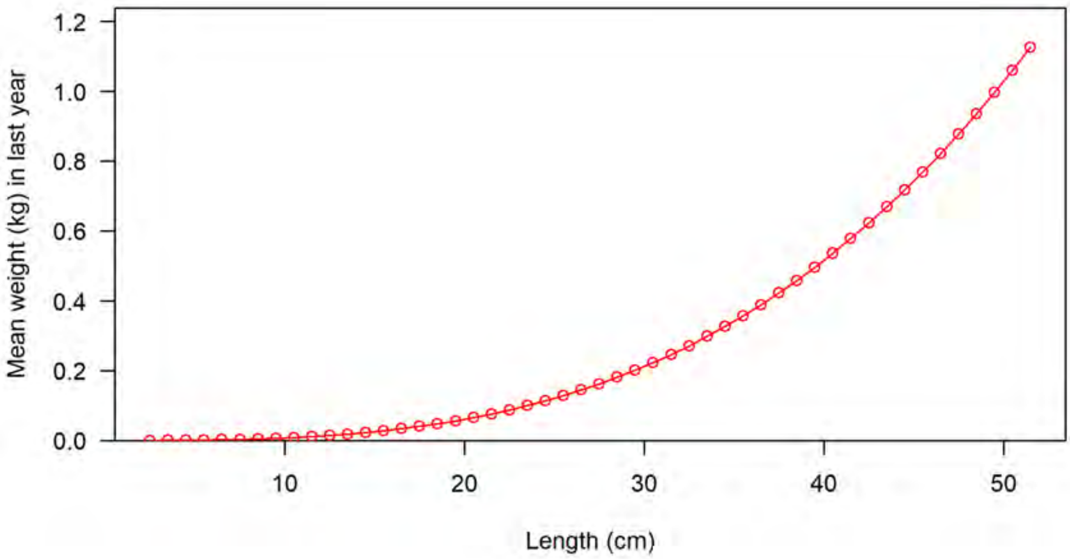


Figure 7.2.5.2: Western horse mackerel. Weight at length in the stock (kg) as estimated by the stock assessment.

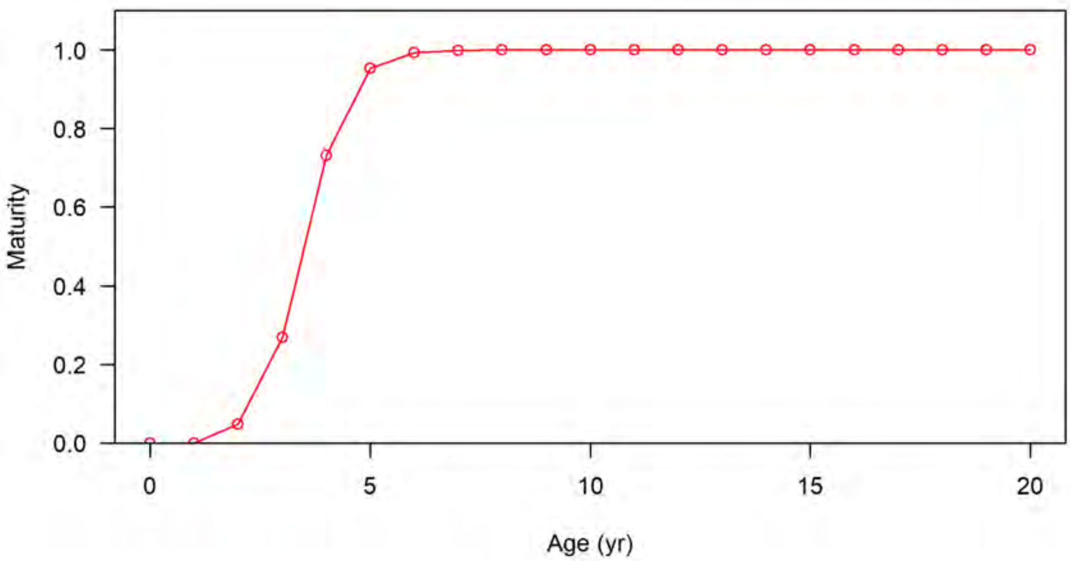


Figure 7.2.6.1: Western horse mackerel. Maturity at age as used in the assessment model.

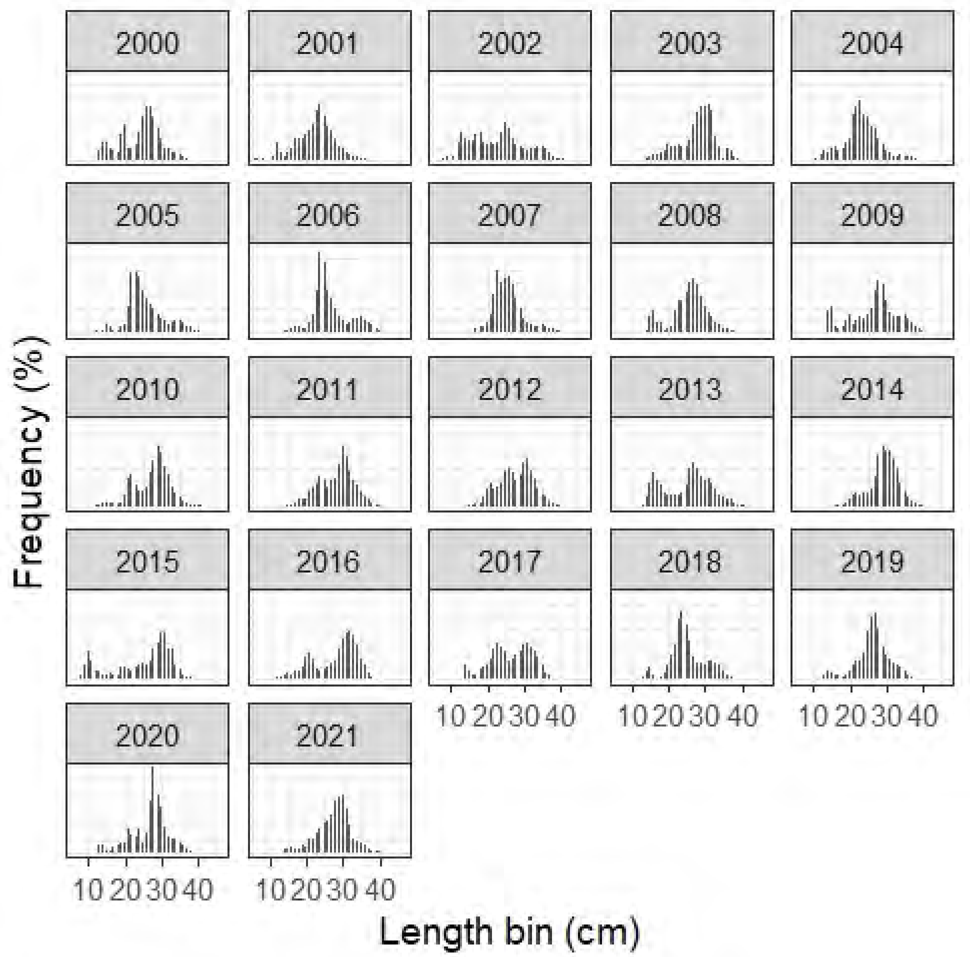


Figure 7.2.10.1: Western horse mackerel. Length frequency distribution of the landing data as used in the assessment model.

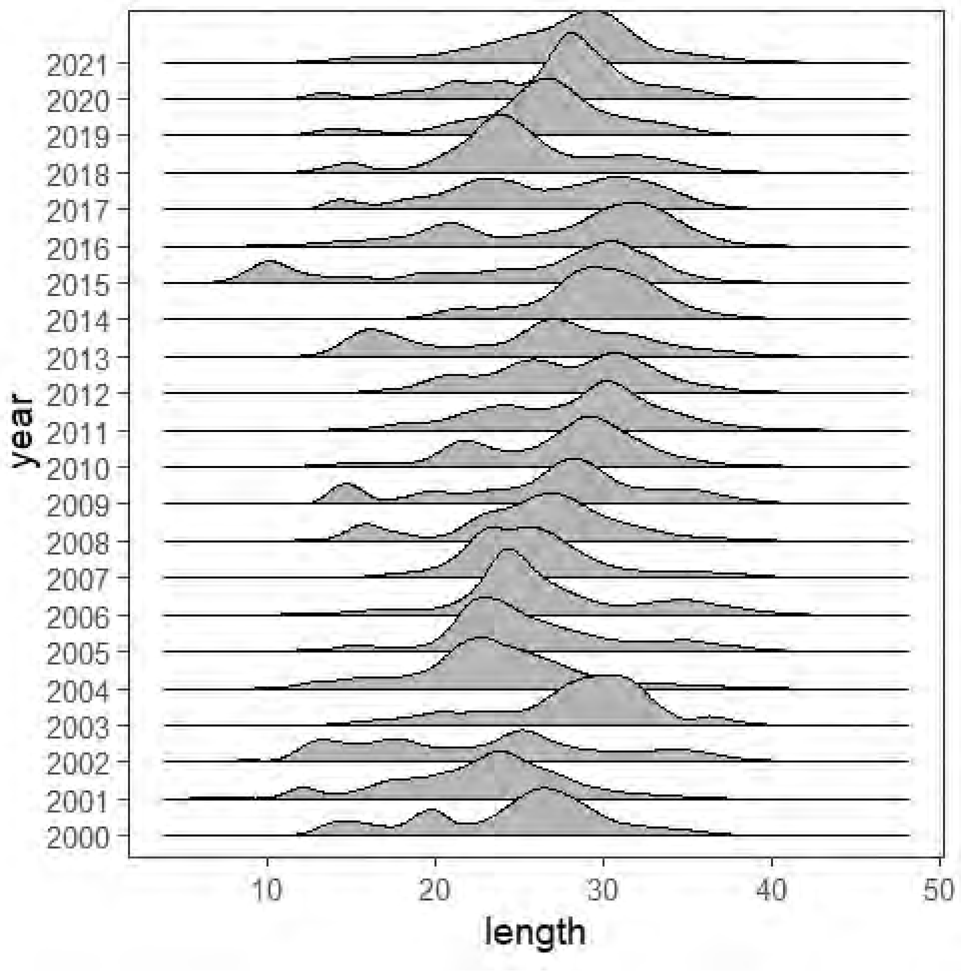


Figure 7.2.10.2: Western horse mackerel. Stacked length frequency distribution of the landing data as used in the assessment model.

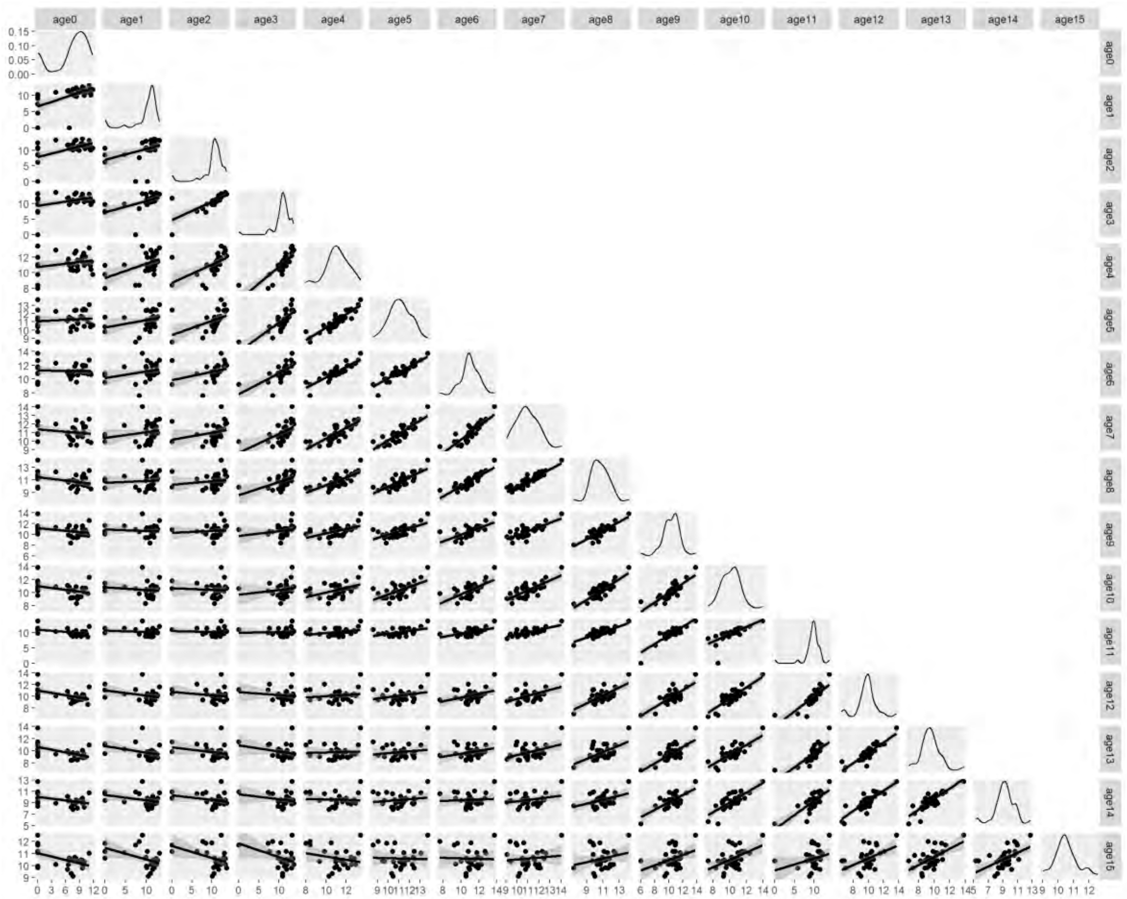


Figure 7.2.10.3: Western horse mackerel. Within-cohort consistency in the catch-at-age matrix, shown by plotting the log-catch of a cohort at a particular age against the log-catch of the same cohort at subsequent ages.

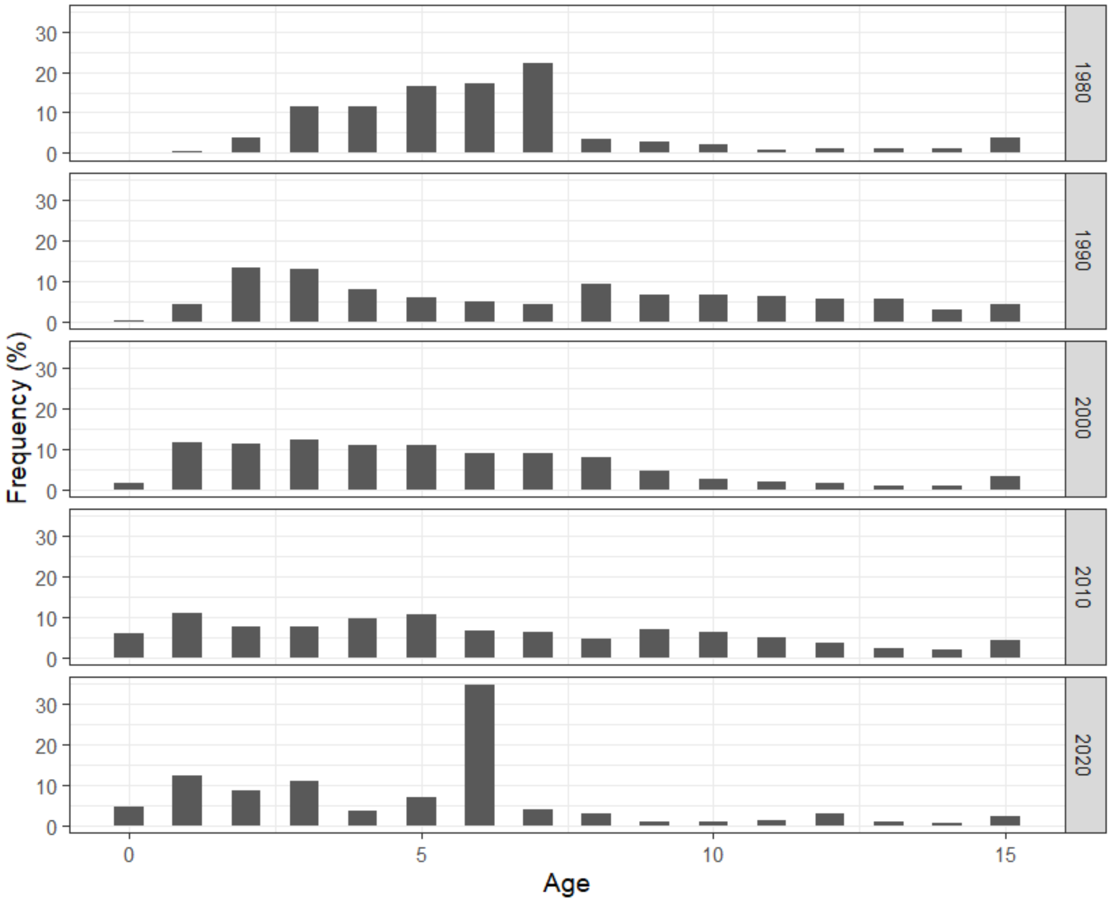


Figure 7.2.10.4: Western horse mackerel. Catch numbers at age composition by decade (*year* specifies start of decade i.e., 1980 = 1980-1999, also note that 2020 only includes years 2020-2021).

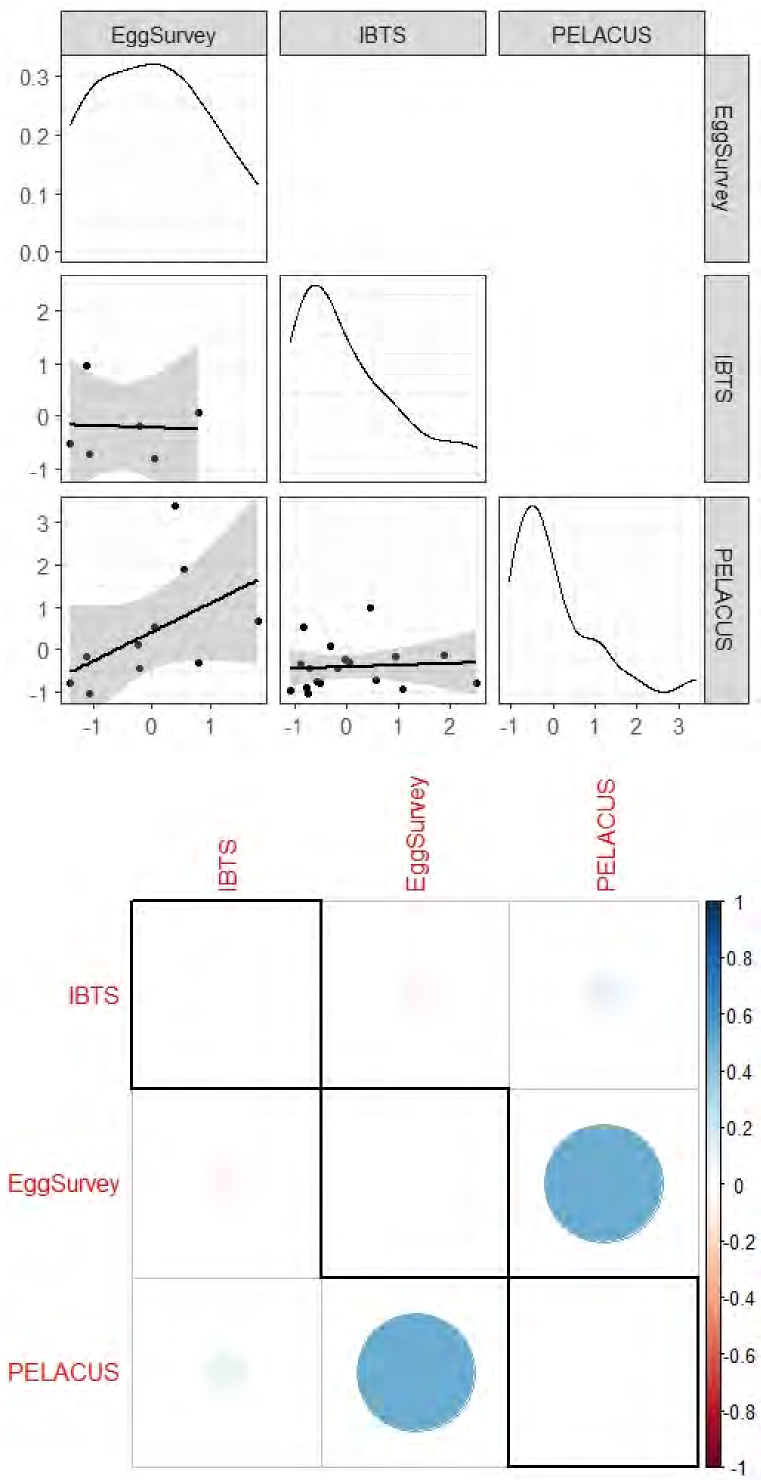


Figure 7.2.10.5: Western horse mackerel. Data exploration. Correlation plots between indices of abundance (including 2021 data points). Size and shade of circle indicates magnitude of correlation and color indicated sign (blue positive, red negative).

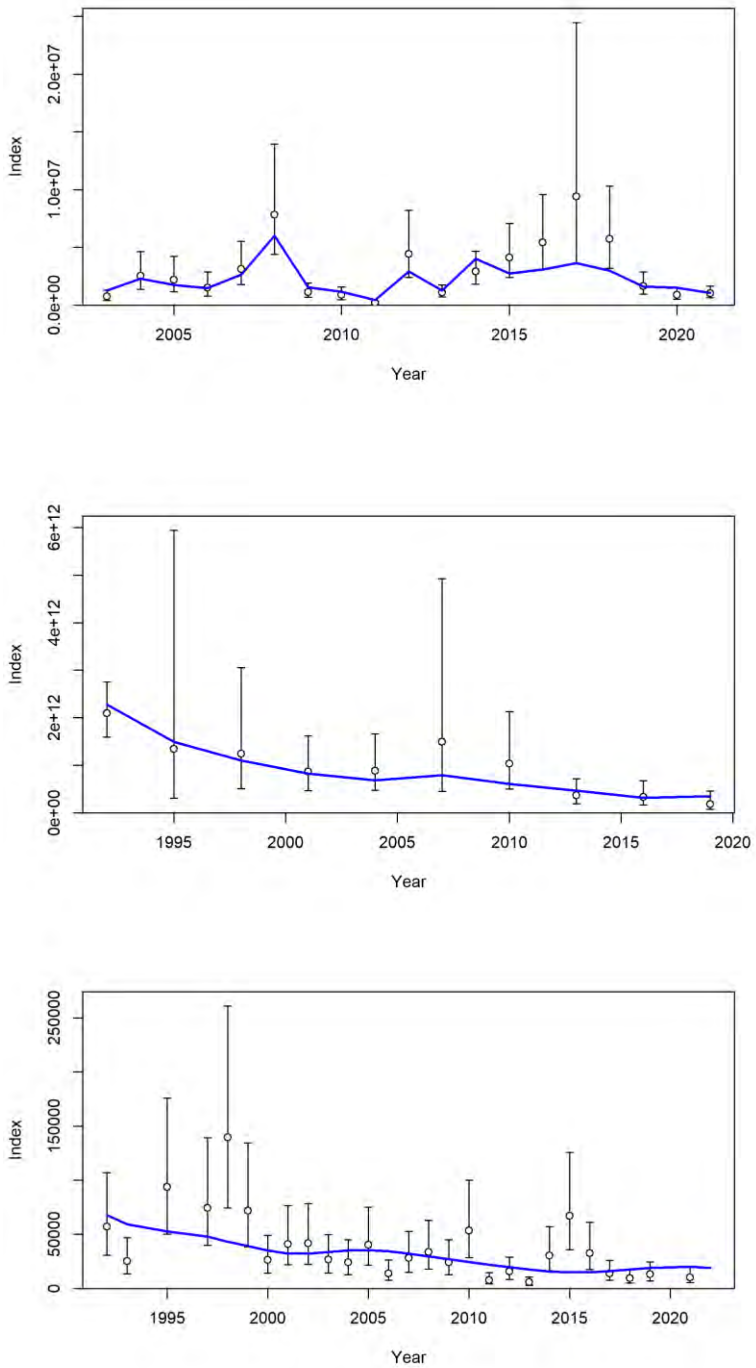


Figure 7.2.11.1: Western horse mackerel. Model fitting. Fitting of the model to the fisheries-independent indices. From top to bottom: IBTS, egg survey, PELACUS. Dots represent observations (with confidence intervals) and blue line the model.

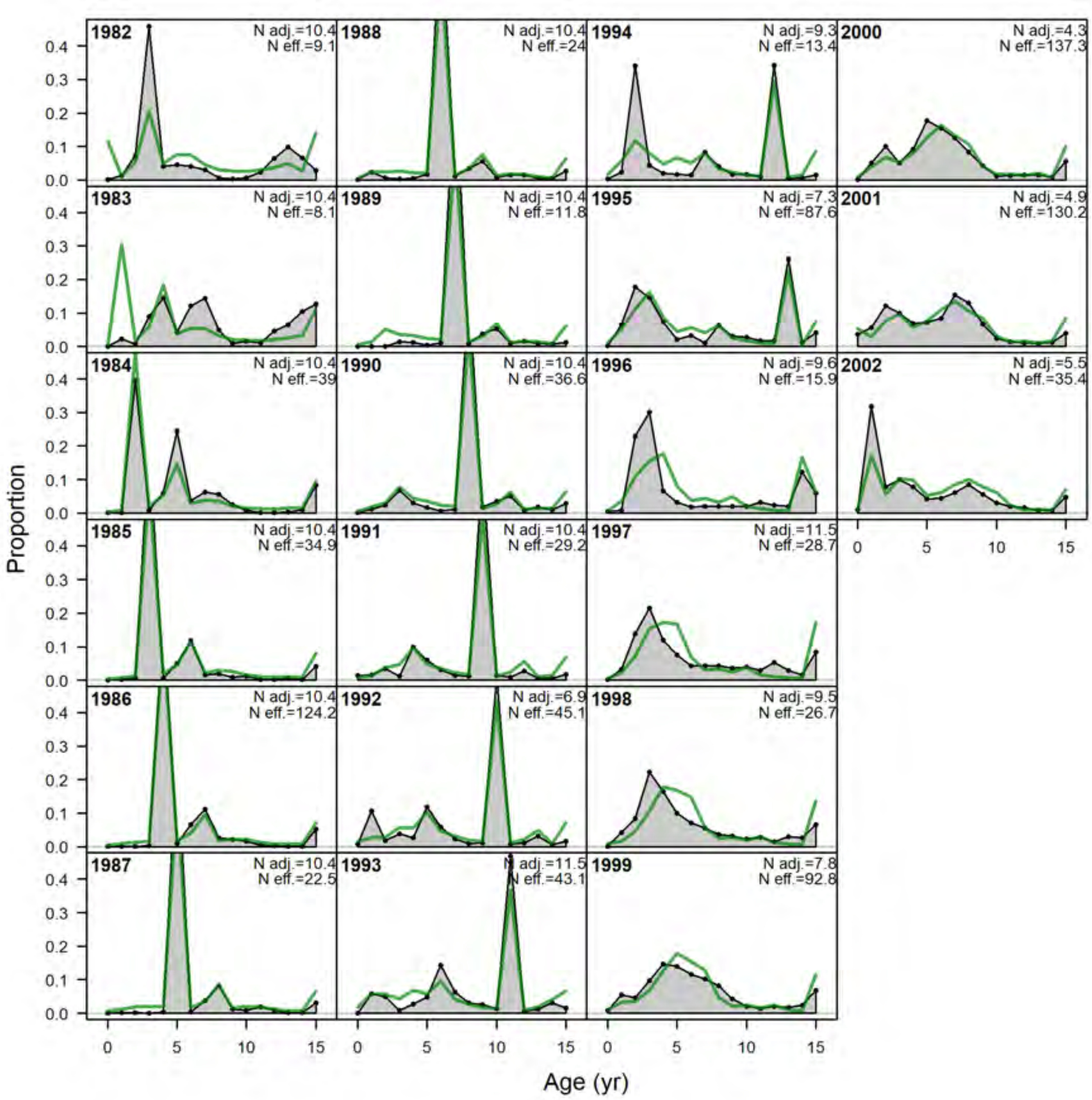


Figure 7.2.11.1 cont.: Western horse mackerel. Model fitting. Fitting of the model to the catch at age matrix from 1982 to 2002. Black joined dots represent observations and green line represents model.

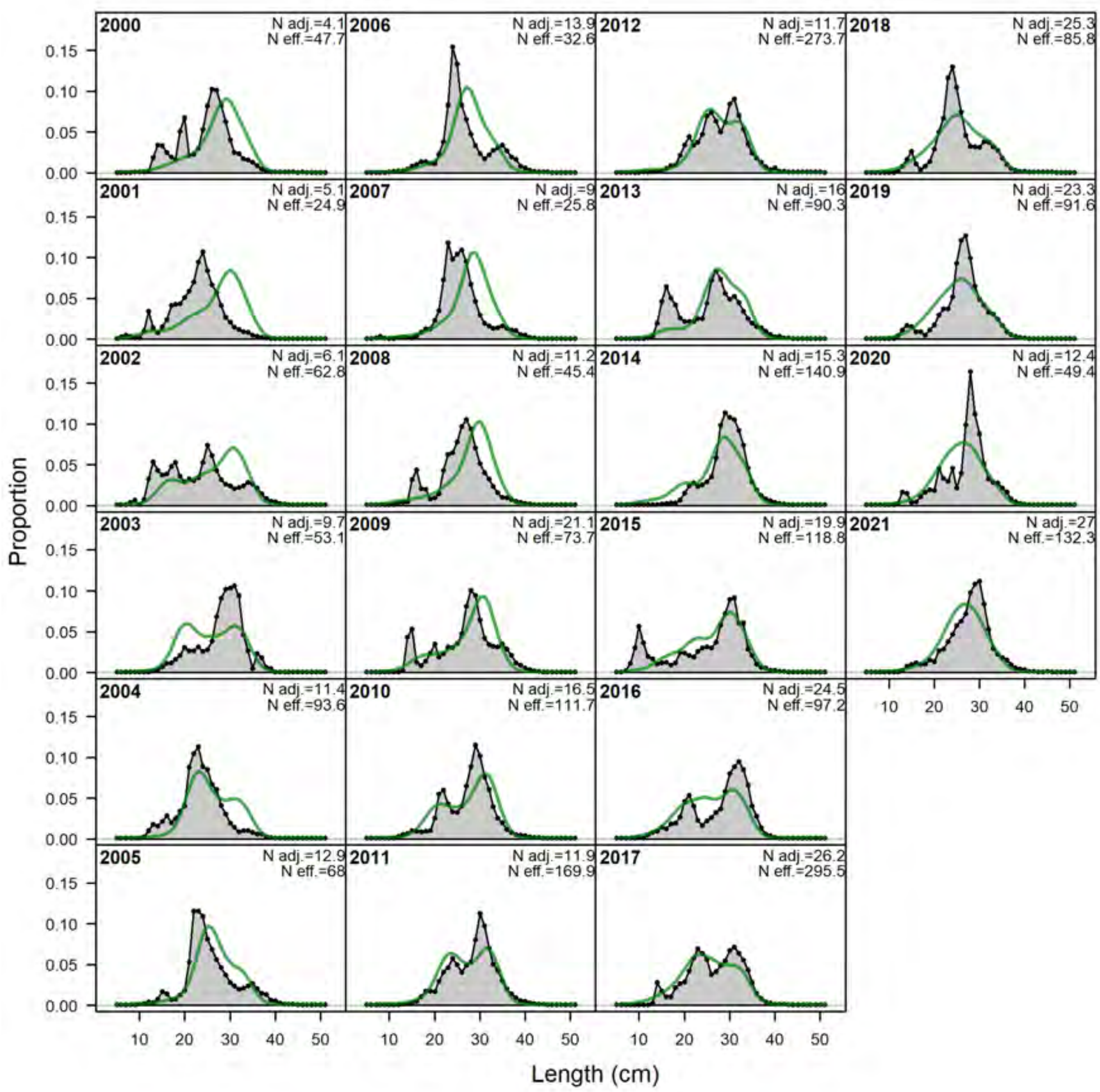


Figure 7.2.11.1 cont.: Western horse mackerel. Model fitting. Fitting of the model to the length composition of the landing data from 2000 to 2021.

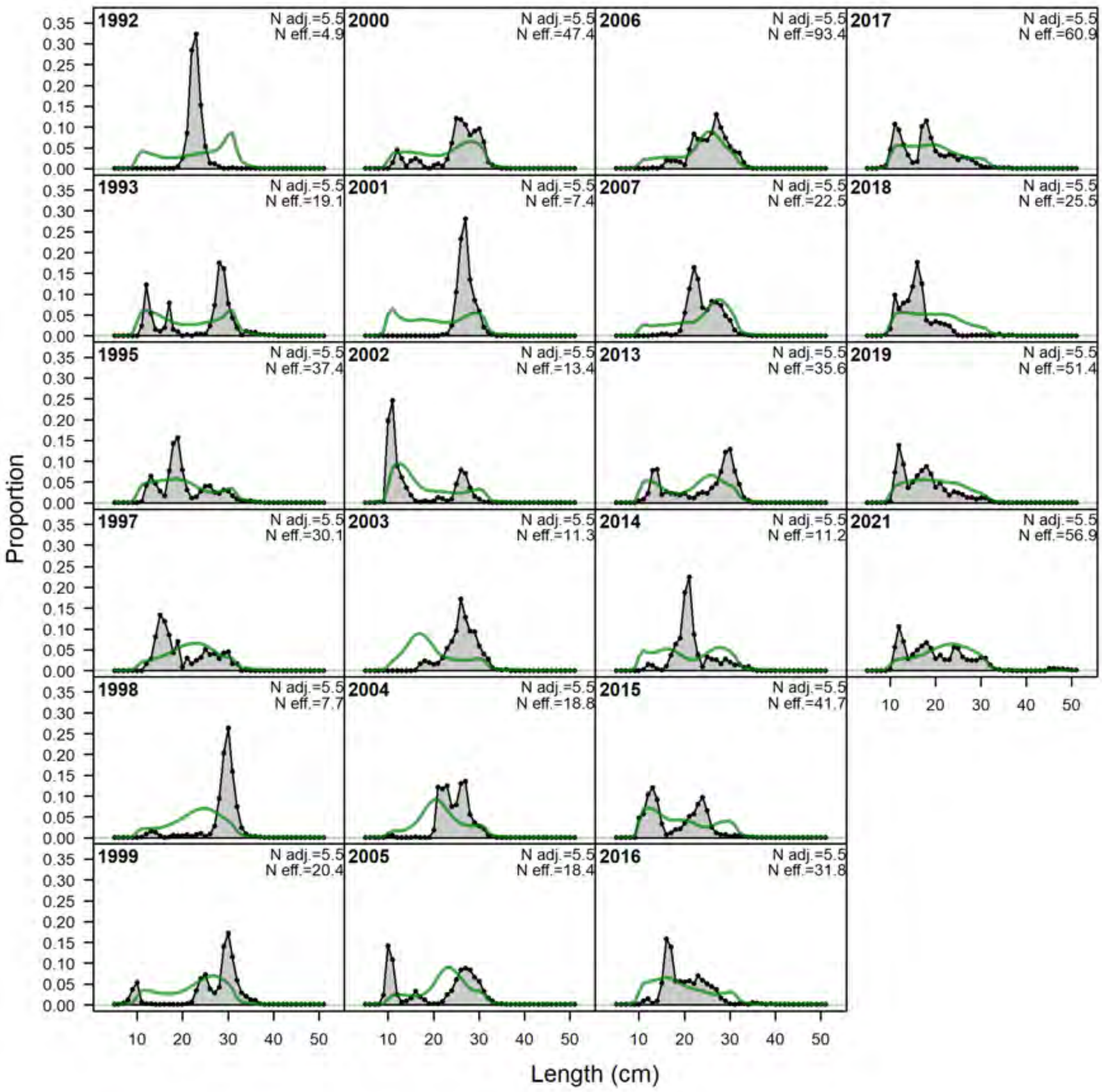
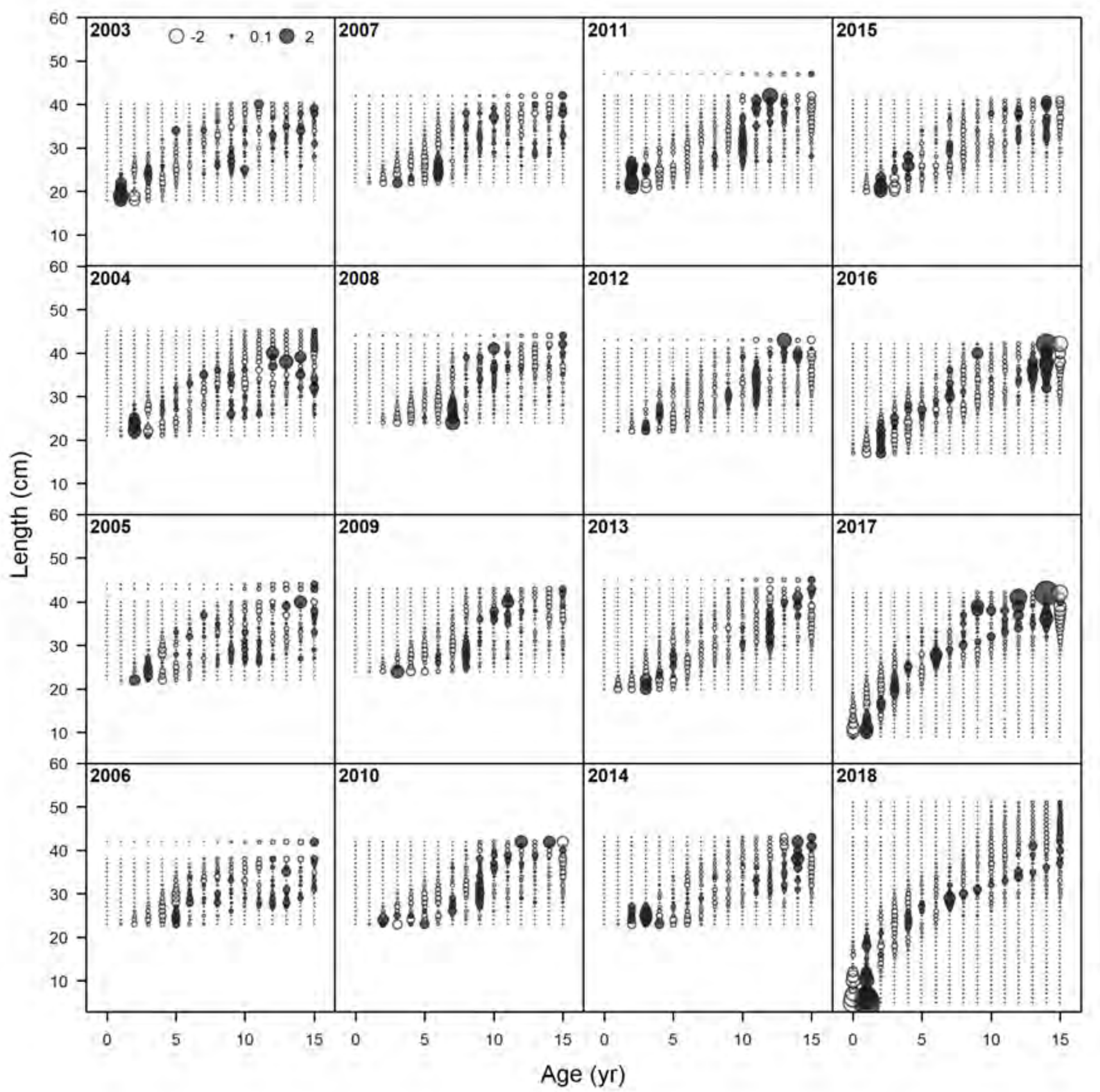


Figure 7.2.11.1 cont.: Western horse mackerel. Model fitting. Fitting of the model to the length composition of the acoustic survey.


2003
-2
0.1
2
2007
2011
2015
2004
2008
2012
2016
2005
2009
2013
2017
2006
2010
2014
2018
Length (cm)
Age (yr)

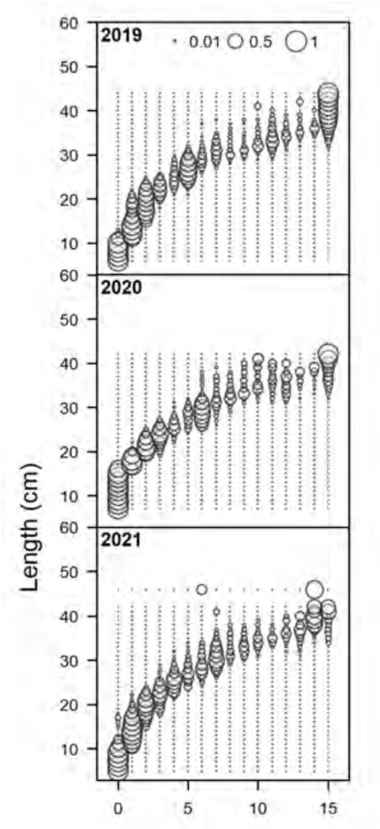


Figure 7.2.11.1 cont.: Western horse mackerel. Model fitting. Fitting of the model to the Age length comp of the catch.

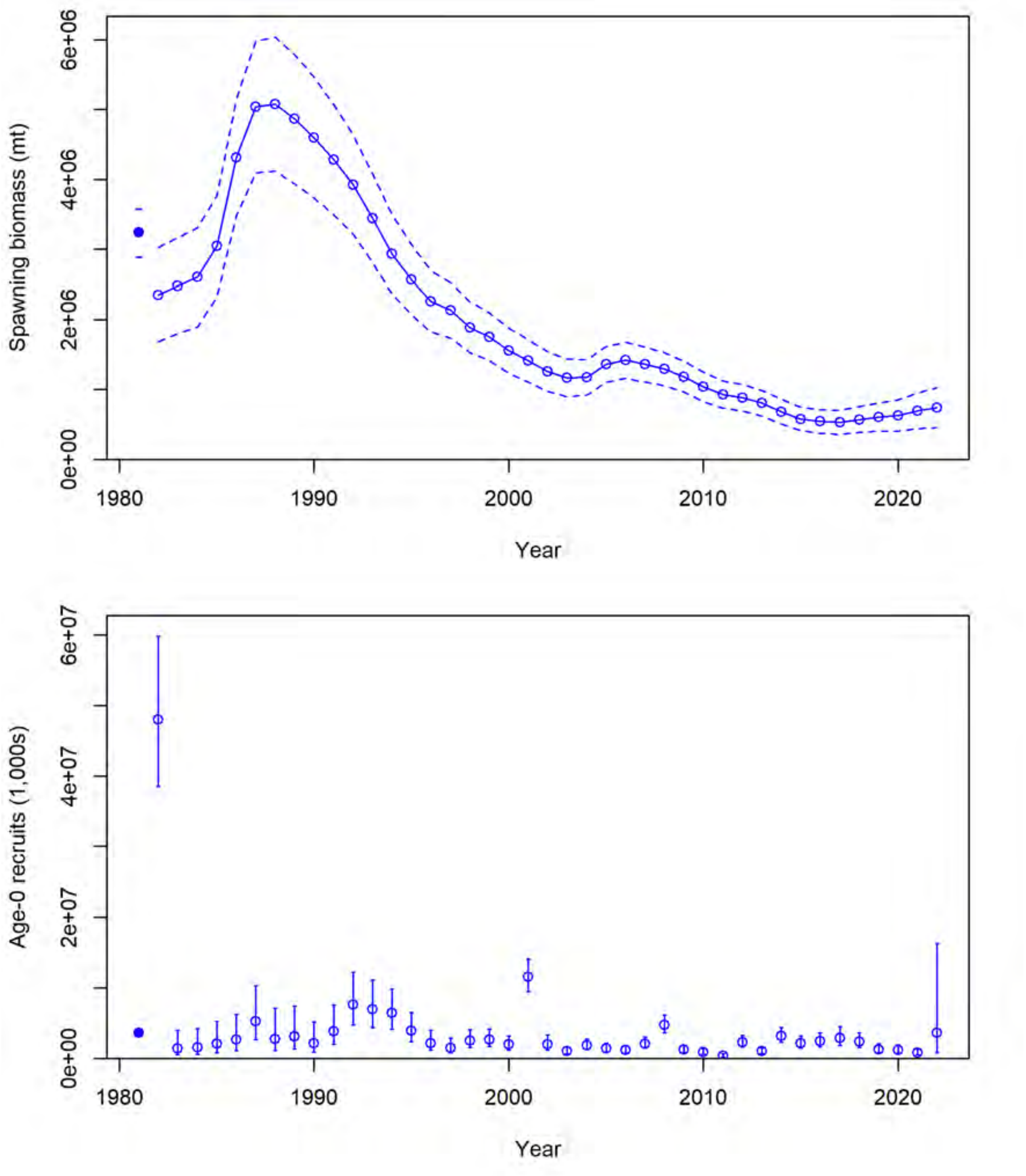


Figure 7.2.11.2: Western horse mackerel. Model results. Spawning stock biomass (0.5 of the overall SSB only is shown; plot on the top) and recruitment estimates (plot on the bottom) from the assessment model from 1982 to 2022. 95% CI are shown. Note this figure is a standard SS output. Whilst the y-axis 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.

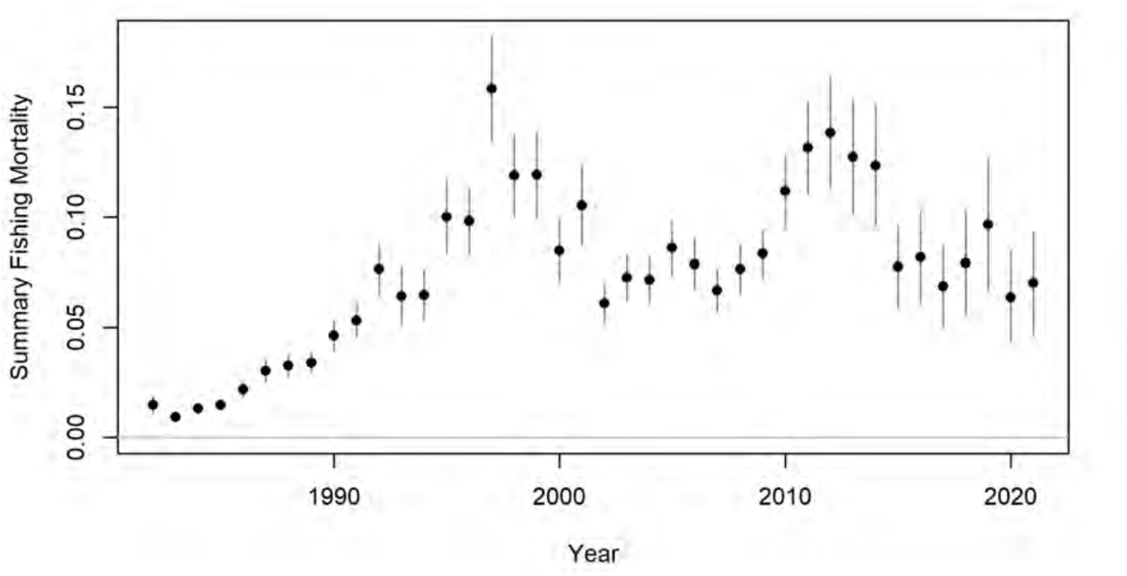


Figure 7.2.11.2 cont.: Western horse mackerel. Model results. Fishing mortality estimates (Fbar ages 1-10) from the assessment model from 1982 to 2021. 95% CI are shown.

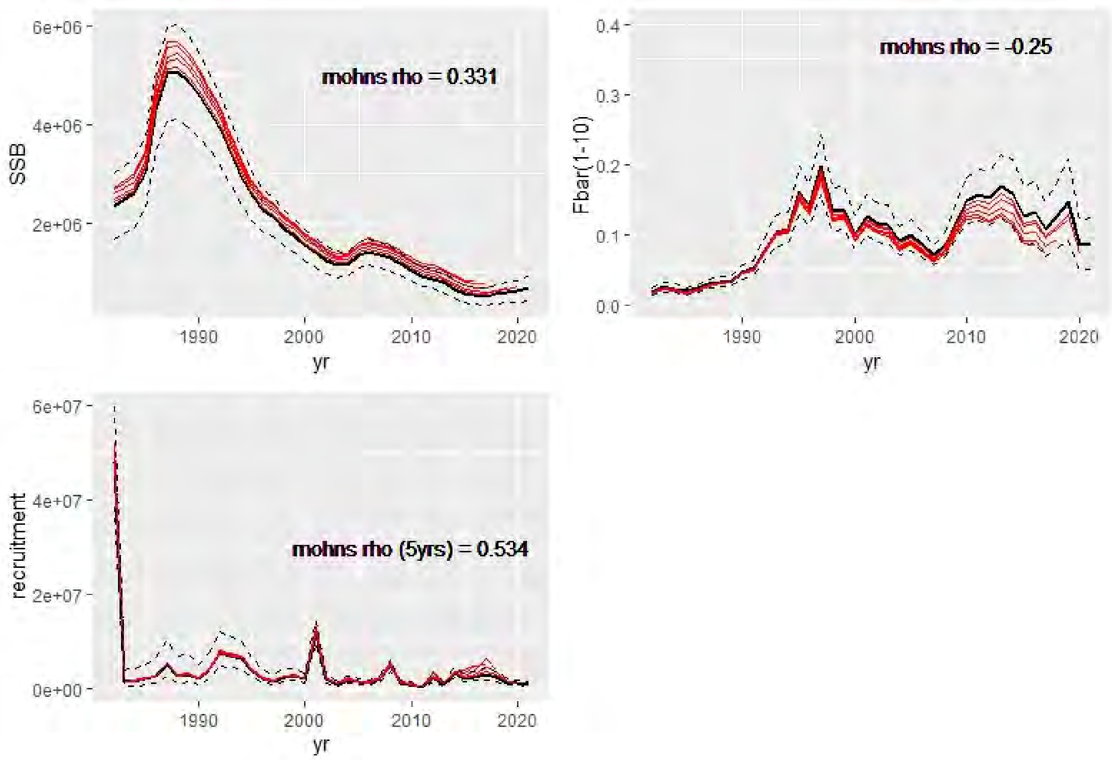


Figure 7.2.11.3: Western horse mackerel. 5 years of retrospective analysis for SSB, F and Recruitment. Dash lines are the 2022 assessment confidence intervals.

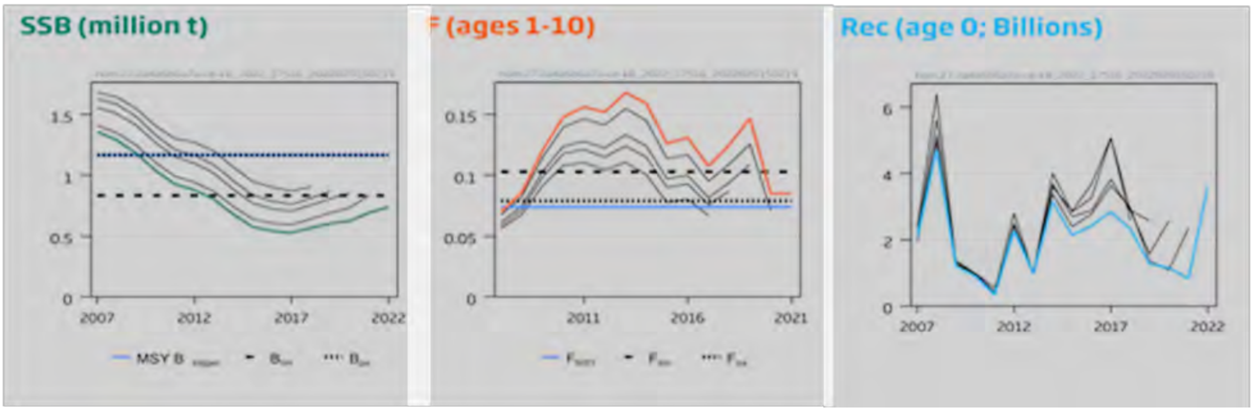


Figure 7.2.11.4: Western horse mackerel. Historical model assessment results. Note: since the 2017 assessment, SSB is estimated on 1st of January. Prior to 2017 SSB has been estimated in May (spawning time).

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.

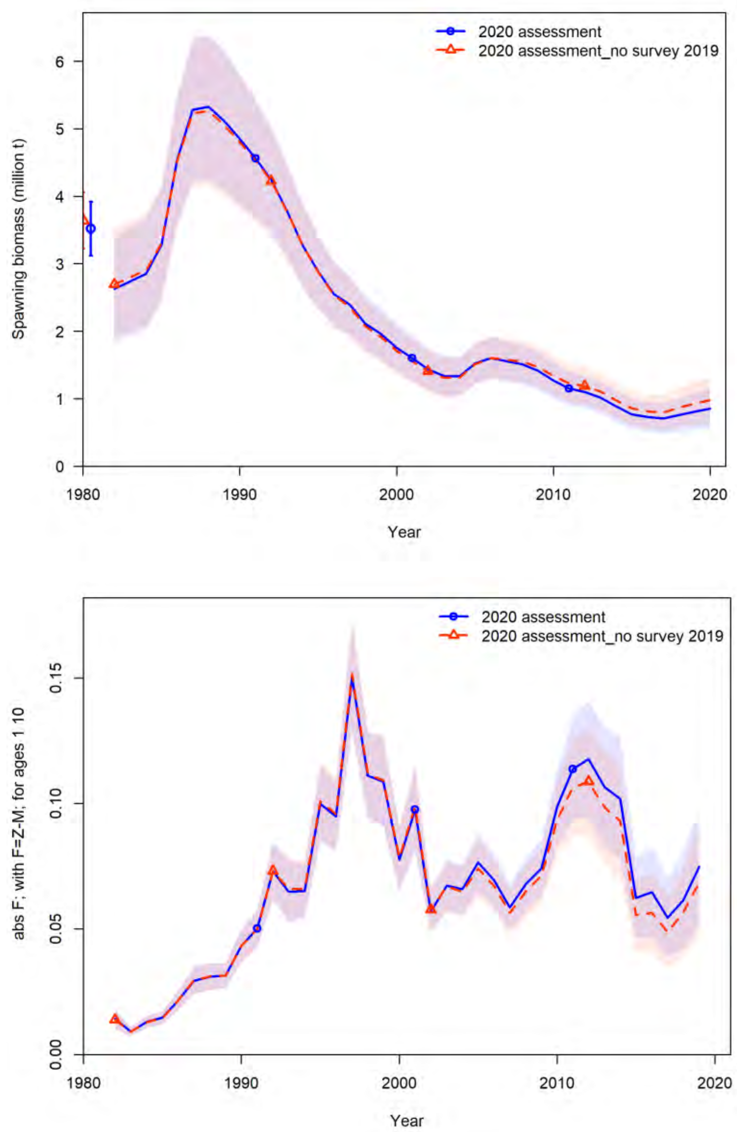


Figure 7.13.1. Sensitivity of the model to the PELACUS data. Spawning biomass and fishing mortality (ages 1-10) as estimated in the model conducted in 2020 (in blue) and in a model with the same setup but excluding the PELACUS data for 2019 (in red).

8 Northeast Atlantic Mackerel

8.1 ICES Advice and International Management Applicable to 2021

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 for 2021 and 2022. Despite various agreements, the total declared quotas in each of the years 2015 to 2021 all exceeded the TAC advised by ICES. An overview of declared quotas and transfers for 2022, as available to WGWIDE, is given in the text table below. An estimate of the expected quota uptake in 2022 was carried out based on the fishery up to the end of August 2022 and knowledge of the fishery development from September to December 2021. Total removals of mackerel are expected to be approximately 1.1 million tonnes in 2022, exceeding the ICES advice for 2022 by approximately 336 500 tonnes (30%).

The quota figures and transfers in the text table below were based on national regulations, official press releases, and discard estimates.

Various international and national measures to protect mackerel are in operation throughout the mackerel catching countries. Refer to the stock annex for an overview.

Estimation of 2022 catch (t)	Unilateral quotas	Reference	Expected uptake	Justification
EU quota	183 359	Record of fisheries consultations between the United Kingdom and the European Union for 2022	183 359	Full uptake
UK quota	210 820	Footnote [1]	210 820	Full uptake
Norwegian quota	278 222	NEAFC HOD 04/2022	278 222	Full uptake
Inter-annual quota transfer to 2022	23 763	NEAFC HOD 04/2022	23 763	Full uptake
Russian expected catches 2022	-	Last year's quota	112 319	Russian expected catch [3]
Icelandic quota	120 210	Footnote [2]	120 210	Icelandic expected catch [4]
Inter-annual quota transfer to 2022 plus special quota	28 026	Footnote [2]	9 790	Icelandic expected catch [4]
Faroese quota	155 804	Faroese Fisheries Ministry regulations No. 182/2022	155 804	Faroese expected catch [4]
Inter-annual quota transfer to 2022	20 905	Faroese Fisheries Ministry regulations No. 182/2022	0	

Estimation of 2022 catch (t)	Unilateral quotas	Reference	Expected uptake	Justification
Greenland quota	51 670	Ministry of Fisheries, Hunting and Agriculture, Greenland	34 000	Greenland expected catch [4]
Discards	3 129	Previous years estimate	3 129	Previous years estimate
Total expected catch (incl. discards) [5, 6]			1 131 416	tonnes

[1]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1059641/Out-comes_of_annual_negotiations_for_UK_fishing_opportunities_in_2021_and_2022.pdf
[2]https://www.fiskistofa.is/veidar/aflaupplysingar/heildaraflamarksstada/?tima-bil=2122&fyrirsp=4&lang=is&landhelgi=U
[3] **The Russian estimated uptake in 2022 was set as the Russian quota in 2021 scaled by the reduction of the ICES advised TAC from 2021 to 2022 (-6.7%).**
[4] **The estimated catch of mackerel in 2022 was obtained by summing recorded catches as of August 25th 2022 and the catches from that date to end of the fishing season 2021, assuming a similar development in the fishery for the remainder of the 2022 season as in 2021.**
[5] **Quotas refer to claims by each party for 2022 and include exchange to other parties.**
[6] **No estimates of banking from 2022 to 2023 are available.**

8.2 The Fishery

8.2.1 Fleet Composition in 2021

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 Fleet Behaviour in 2021

The northern summer fishery in Subarea 2 continued and increased significantly in 2021 with Norway reporting 80% of their catches in Division 2.a quarter 3. There was no fishery in Subarea 14 and a reduced fishery in Subarea 5. The Russian freezer trawler fleet operates over a wide area in northern international waters. This fleet targets herring and blue whiting in addition to mackerel. In 2021 the Russian vessels took the vast majority of their catch in Division 2.a.

Total catches from Icelandic vessels were similar to those in recent years and were in excess of 100 kt. The majority of the catch was taken in Division 2.a in quarter 3 of 2021, with very small catch also taken in Divisions 5.a and 5.b. In 2021 Greenland targeted mackerel in Division 2.a with no catch taken from Division 14.b. In 2019 Greenland fished in Division 14.b and in 2018 both Greenland and Iceland reported landings from this area. Catches from Greenland have increased in 2021 to 33kt up from 27 kt in 2021 but lower than the peak of 63 kt in 2018. The Faroese fleet targeted mackerel during quarters 2,3 and 4 with 96% of the catches taken in Division 2.a. The remaining catch was taken in Division 5.b in quarter 2. No catch was reported from Divisions 4.a or 6.a as had been in previous years.

Fishing in the North Sea and west of the British Isles followed a traditional pattern, targeting mackerel on their spawning migration from the Norwegian deep in the northern North Sea, westwards around the north coast of Scotland and down the west coast of Scotland and Ireland. The majority of the Irish mackerel fishery took place in quarter 1 along the west coast of Scotland and Ireland, with the Scottish fleet operating in the same area at this time. The Scottish fishery in quarter 4 was more concentrated in the North Sea where 51% of the Scottish catch was taken.

In 2021 the Spanish fishery started at the beginning of March, as in previous years.

8.2.3 Recent Changes in Fishing Technology and Fishing Patterns

Northeast Atlantic mackerel, as a widely distributed species, is targeted by a number of different fishing métiers. Most of the fishing patterns of these métiers have remained unchanged during the most recent years (see stock annex), although the variation in timing of the spawning migration and geographical distribution can change from year to year and this affects the fishery in various areas. The most important changes in recent years are related to the geographical expansion of the northern summer fishery (Subareas 2, 5 and 14) and changes in southern waters due to stricter TAC compliance by Spanish authorities. In 2020 and 2021 the northern summer fishery did not extend as far west as in previous years. In 2021 the summer fishery in Division 2.a increased substantially. The annual fishing pattern by statistical rectangle from 2003-2021 is shown in Section 1.8.

8.2.4 Recent regulations and management

Currently there is no agreement on a management strategy covering all parties fishing mackerel.

An overview of the technical measures, effort controls and management plans are given in the stock annex. Note that there may be additional existing international and national regulations that are not listed.

8.3 Quality and Adequacy of sampling Data from Commercial Fishery

The sampling of the commercial catch of Northeast Atlantic mackerel is summarised below:

Year	WG Total Catch (t)	% catch covered by sampling programme*	No. Samples	No. Measured	No. Aged
1992	760000	85	920	77000	11800
1993	825000	83	890	80411	12922
1994	822000	80	807	72541	13360
1995	755000	85	1008	102383	14481
1996	563600	79	1492	171830	14130
1997	569600	83	1067	138845	16355
1998	666700	80	1252	130011	19371
1999	608928	86	1109	116978	17432
2000	667158	76	1182	122769	15923
2001	677708	83	1419	142517	19824
2002	717882	87	1450	184101	26146

Year	WG Total Catch (t)	% catch covered by sampling programme*	No. Samples	No. Measured	No. Aged
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
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

Overall sampling effort in 2021 was lower than previous years with 79 % of the catch sampled. It should be noted that this proportion is based on the total sampled catch and in 2021 there was no sampling reported from Russia. Nations with large, directed fisheries are capable of sampling 100 % of their catch which may conceal deficiencies in sampling elsewhere.

The 2021 sampling levels by country are shown below.

Country	Official catch	% WG catch covered by sampling programme	No. Samples	No. Measured	No. Aged
Belgium	110	0%			
Denmark	32813	93%	5	111	111
Faroe Islands	105096	98%	20	1001	960

Country	Official catch	% WG catch covered by sampling programme	No. Samples	No. Measured	No. Aged
France	16686	0%			
Germany	11996	92%	34	6389	310
Greenland	33360	100%	23	1768	138
Iceland	132109	96%	108	2823	4810
Ireland	60795	96%	51	8971	1899
Lithuania	6655	0%			
Netherlands	24594	92%	34	2450	844
Norway	270653	96%	92	2423	2336
Poland	1779	0%			
Portugal	4723	20%	77	2287	897
Russia	136176	0%			
Spain	30085	99%	1134	32868	3207
Sweden	3514	0%			
UK (England & Wales)	22094	54%	154	9533	1747
UK (Northern Ireland)	16464	50%	1	164	50
UK (Scotland)	171840	92%	50	5537	1427

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. Russia, Sweden, Lithuania and Poland did not supply sampling information in 2021. 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 below.

Division	Official Catch (t)	WG Catch (t)	No. Samples	No. Measured	No Aged
1	0.03	0.03	0	0	0
2.a	657905	657905	238	7828	8095
3.a	439	439	0	0	0
3.b	19	19	0	0	0

Division	Official Catch (t)	WG Catch (t)	No. Samples	No. Measured	No Aged
3.c	24	24	0	0	0
3.d	59	59	0	0	0
4.a	216985	216985	96	12866	2244
4.b	2837	2837	0	0	0
4.c	1078	1078	1	92	25
5.a	933	933	1	34	25
5.b	4273	4273	2	102	75
6.a	146583	146583	75	10372	2250
6.b	52	52	0	0	0
7.a	11	11	0	0	0
7.b	2778	2778	3	366	102
7.c	124	124	1	46	25
7.d	6180	6180	1	59	25
7.e	808	808	71	3747	1466
7.f	258	258	75	5016	82
7.g	12	12	0	0	0
7.h	38	38	1	111	25
7.j	2740	2740	6	476	168
8.a	1096	1096	1	54	1
8.b	4338	4338	196	3950	66
8.c	29120	29120	569	22553	2504
8.d	40	40	0	0	0
8.e	0.0096	0.0096	0	0	0
9.a	2807	2807	446	8653	1558

In general, areas with insufficient sampling have relatively low levels of catch.

8.4 Catch Data

8.4.1 ICES Catch Estimates

Missing 2021 data

In 2022, WGWIDE did not receive a data submission from Russia with the 2021 catch and sampling information. Preliminary catch data were available for 2021 from Russia and were reported by ICES division by year. From 2018-2020 the Russian catch accounted for an average of 13% of the total working group catch. The preliminary figure for 2021 also represents 13% of the total working group catch. Historically, preliminary catches are comparable to ICES final estimated catch.

The majority of the Russian catch was from ICES division 2.a and a three year average (2018-2020) was used to distribute the data by quarter. This resulted in the data assigned 7% in quarter 2, 92% in quarter 3 and 1% in quarter 4. The remaining data was from Division 5.b and was all assumed to be taken in quarter 3 as has been the case in previous years by the Russian fleet.

Catch maps were produced by country to determine the fishing pattern particularly in Division 2.a quarter 3. The Russian fishery is concentrated mainly in Division 2.a with an average of 90% of the catch from Division 2.a.1 and a consistent distribution of the fishery in the last three years. Iceland and the Faroes also fish in a similar area to the Russian fleet and use similar gear. Comparisons of the age and length data from Division 2.a quarter 3 were presented and a decision made to use samples from Iceland and the Faroes to allocate to the Russian catches.

Total Catch 2021

The total ICES estimated catch for 2021 was 1 081 540 tonnes, an increase from 1 039 513 tonnes in 2020.

The combined 2021 TAC, arising from agreements and autonomous quotas, amounts to 1 199 103 tonnes. The ICES catch estimate (1 081 540 tonnes) represents an undershoot of this but is still above the ICES advice of 852 284 tonnes for 2021. The combined fishable TAC for 2022, as best ascertained by the Working Group (see Section 8.1), amounts to 1 131 416 tonnes.

Catches reported for 2021 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 2021, discard data for mackerel were provided by France, Ireland, Spain, Denmark, England, Scotland and Sweden. Total discards amounted to 3 129 tonnes which is a decrease from 2020. 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 Distribution of Catches

A significant change in the fishery took place between 2007 and 2009 with a greatly expanded northern fishery becoming established. This fishery has continued to the present but with a clear tendency for an eastern retraction, especially from the Greenlandic area and also western parts of the Icelandic area in the most recent three years. In 2021 there was only a small amount of catch from southern Iceland with the fishery moving further east. Of the total catch in 2021, Norway accounted for the greatest proportion (25%) followed by Scotland (16%), Russia (13%), Iceland (12%), Faroes (10%) and Ireland (6%). In the absence of sharing arrangements, the fishing parties declared unilateral quotas for 2021.

In 2021, catches in the northern areas (Subareas 1, 2, 5, 14) increased significantly and amounted to 663 111 tonnes (see Table 8.4.2.1), an increase of 306 126 tonnes on the 2020 catch. Norwegian catches were over 270 kt and Icelandic, Russian, Scottish and Faroese catches were all over 100 kt. Catches from Division 2.a accounted for 61% of the total catch in 2021. The wide geographical distribution of the fishery noted in previous years has continued.

The time series of catches by country from the North Sea, Skagerrak and Kattegat (Subarea 4, Division 3.a) is given in Table 8.4.2.2. Catches in 2021 decreased to 221 340 tonnes from 457 211 tonnes in 2020. The majority of the catch is from Subarea 4 with small catches were also reported in Divisions 3.a-d.

Catches in the western area (Subareas 6, 7 and Divisions 8.a, b, d and e) decreased in 2021 to 165 060 tonnes. This is a decrease of around 22 000 t from 2020. The catches are detailed in Table 8.4.2.3.

Table 8.4.2.4 details the catches in the southern areas (Divisions 8.c and 9.a) which are taken almost exclusively by Spain and Portugal. The reported catch in 2021 of 31 928 tonnes represents a decrease of almost 5 600 tonnes from 2020. The catch is above the long-term average.

The distribution of catches by quarter (%) is described in the text table below:

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

Year	Q1	Q2	Q3	Q4
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
2019	28	5	42	26
2020	31	4	34	31
2021	19	5	56	20

The quarterly distribution of catch from 2010- 2020 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 2010-2020 is 46%. In 2021 this proportion increased to 56% and is higher than the quarter 1 and quarter 4 catches which when combined account for 39% of the total. The proportion of the catch taken in quarter 2 has remained stable.

Catches per ICES statistical rectangle are shown in Figures 8.4.2.1 to 8.4.2.4. It should be noted that these figures are a combination of official catches and ICES estimates and may not indicate the true location of the catches or represent the location of the entire stock. These data are based on catches reported by all the major catching nations and represents almost the entire ICES estimated catch except Russia.

- First quarter 2021 (208 190 tonnes – 19%)

The distribution of catches in the first quarter is shown in Figure 8.4.2.1. The proportion of the fishery taken in quarter 1 has decreased in 2021 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 2021 (55 707 tonnes – 5%)

The distribution of catches in the second quarter is shown in Figure 8.4.2.2. The quarter 2 fishery is traditionally the smallest and this was also the case in 2021. The most significant catches where those in Division 8.c and at the start of the summer fishery in northern waters by Icelandic, Norwegian and Russian fleets in Division 2.a.

- Third quarter 2021 (599 548 tonnes – 56%)

Figure 8.4.2.3 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 2021 (218 186 tonnes – 20%)

The fourth quarter distribution of catches is shown in Figure 8.4.2.4. The proportion of the catch taken in the fourth quarter has decreased from 31 % in 2020 to 20% in 2021. 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.

8.4.3 Catch-at-Age

This catch in numbers relates to a total ICES estimated catch of 1 081 540 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 Denmark, England, Germany, Faroes, Iceland, Ireland, the Netherlands, Norway, Portugal, Scotland, Northern Ireland and Spain. There remain gaps in the age sampling of catches, notably from France (length samples were provided), Russia, Sweden, Lithuania 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 85 % of the catch in numbers in 2021 consists of 2 to 10-year olds with the 2016-year class 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 2 years old accounts for 13% of the catch numbers at age and were not evident in the fishery before. The 2015 year-class does not look as strong as the other year classes and represents 7 % of the total. In 2021 there is a decrease in the proportion of fish in the plus group from 7% in 2020 to 5% in 2021. Year classes from 2009 and earlier are now in the plus group.

There is a small presence of juvenile (age 0) fish within the 2021 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 2021 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 180mm-222 mm. 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 2021 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). These variations in weight-at-age are consistent with the changes noted in length in Section 8.5.1.

The Working Group used weight-at-age in the stock calculated as the average of the weight-at-age in the three spawning components, weighted by the relative size of each component (as estimated by the 2022 egg survey for the southern and western components and the 2017 egg survey for the North Sea component). Mean weight-at-age in 2021 for the western component are estimated from Dutch, Irish and German commercial catch data, the biological sampling data taken during the egg surveys and during the Norwegian tagging survey. Only samples corresponding to mature fish, 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 component. For the North Sea spawning component, mean weight-at-age in 2021 were calculated from samples of the commercial catches collected from Divisions 4.a and 4.b in the second quarter of 2021 and samples collected during the 2021 egg survey conducted in the North Sea. Stock weights for the southern component, 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 component and in the stock in 2021 are shown in the text table below.

As for the stock 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).

Age	North Sea Component	Western Component	Southern Component	NEA Mackerel 2021 Weighted mean*
0				0.000
1	0.132		0.103	0.064
2	0.224	0.186	0.163	0.186
3	0.280	0.267	0.218	0.261
4	0.328	0.278	0.277	0.281
5	0.360	0.316	0.344	0.323
6	0.407	0.343	0.379	0.352
7	0.412	0.389	0.395	0.392
8	0.444	0.414	0.415	0.416
9	0.463	0.417	0.437	0.423
10	0.510	0.438	0.459	0.446
11	0.509	0.447	0.493	0.458
12+	0.535	0.487	0.523	0.496
Component Weighting	7.1%	78.6%	14.3%	
Number of fish sampled	800	646	1123	

*** Missing value of mean weight-at-age per component are replaced by component mean value in the calculation of the stock weights**

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 2021 was calculated as the average of the ogives of the three spawning components weighted by the relative size of each component calculated as described above for the stock weights. The ogives for the North Sea and Southern components are fixed over time. For the Western component the ogive is updated every year, using maturity data from commercial catch samples from Germany, Ireland, the Netherlands and the UK collected during the first and second quarters (ICES, 2014 and Stock Annex). The 2021 maturity ogives for the three components and for the mackerel stock are shown in the text table below.

Age	North Sea Component	Western Component	Southern Component	NEA Mackerel
0	0	0	0	0
1	0	0.15	0.02	0.12
2	0.37	0.59	0.54	0.57
3	1	0.98	0.70	0.94
4	1	1	1	1
5	1	1	1	1
6	1	1	1	1
7	1	1	1	1
8	1	1	1	1
9	1	1	1	1
10	1	1	1	1
11	1	1	1	1
12+	1	1	1	1
Component Weighting	7.1%	78.6%	14.3%	

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 since then and the proportion of fish mature at age since 2018 are now markedly lower than in the previous years and at levels comparable with the ones observed at the end of the 2000s (Figure 8.5.3.1).

8.6 Fishery Independent Data

8.6.1 International Mackerel Egg Survey

The ICES Triennial Mackerel and Horse Mackerel Egg Survey 2022 was carried out during January – July. The results have been used in the assessment for mackerel since 1977. Since 2004 and subsequent to demands for up-to-date data for the assessment, WGMEGS aims to provide a preliminary estimate of NEA mackerel biomass and western horse mackerel egg production in time for the assessment meetings within the same calendar year as the survey.

WGMEGS provided the preliminary results of the 2022 mackerel and horse mackerel egg survey for WGWIDE in August 2022. The final survey results will be available following the next WGMEGS meeting (April 2023). This is due to the extremely large numbers of plankton and fecundity samples to be analysed following the surveys as well as the tight deadline set by WGWIDE for delivering these estimates. A Working Document (WD07: O'Hea et al. 2022) with the preliminary results of the 2022 survey was presented to the WGWIDE 2022 meeting.

The 2022 survey was split into 6 separate sampling periods. Maximum deployment of effort in the Western area was during periods 3-6. 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, survey effort allocation focuses on achieving full area coverage and delineation of the spawning boundaries.

Analyses 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).

8.6.1.1 Data analysis for mackerel annual egg production

Stage 1 egg counts were converted to daily egg production using the development equations given in the survey manual. Procedures to estimate the total annual egg production are described in the WGMEGS Survey Manual (ICES, 2019a). Plots of the distribution of egg production for the western area are presented in Figures 8.6.1.1.1-8.6.1.1.5. The area coverage is described in detail in WD07 (O'Hea et al. 2019).

Figure 8.6.1.1.6 presents the egg production curve for the western area for the 2022 survey, along with those for the previous surveys for comparison. 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. 2019 followed that of 2016 with no early peak spawning being recorded. The 2022 egg production curve is very similar to that of 2016, with peak spawning again occurring during Period 5. The expansion observed in western and northwestern areas during Periods 5 and 6 in 2016 was once again reported during 2022. During these periods it was not possible to fully delineate the northern and north-western boundaries, however the production in Periods 5 and 6 in the current survey year was lower in these northwestern areas. (Figures 8.6.1.1.4-5).

Due to the cancelation of the Irish survey in June the area from 53N to 61N, and 3.5W to 21W could not be covered in period 6. In order to estimate the egg production in this uncovered area WGMEGS estimated the spawning area that was missed and also estimated mean daily egg production for the period. Positive stations (spawning area) were selected where stage 1 eggs were found in a rectangle on at least two occasions over last three MEGS surveys. MEGS estimated this amounted to 127 missed stations during the period and also estimated mean daily egg production for period 6 in 2022 at 19.58 stage 1 eggs/m^2/day (WD07: O'Hea et al. 2022).

The inclusion of the estimated egg abundance for the missing stations in Period 6 accounts for 10% of the annual egg production estimate in the western area for the 2022 survey.

The nominal end of spawning date of the 31st July is the same as used during previous survey years and the shape of the egg production curve for 2022 does not suggest that the end date needs to be altered. The provisional total annual egg production (TAEP) for the western area in 2022 was as 1.795 x 10^{15}. This is a 47% increase on the 2019 TAEP estimate which was 1.22 x 10^{15}.

Figure 8.6.1.1.7 shows the egg production curve for the southern area for the 2022 survey, along with those from previous surveys for comparison. The start date for spawning in the southern area was the 23rd January. 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 the 17th July was used again this year and the spawning curve suggests that there is no reason for this to change. As in 2019 the survey periods were not completely contiguous and this has been accounted for. The provisional total annual egg production (TAEP) for the southern area in 2022 was calculated as 3.21 x 10^{14}. This is a 25% decrease on the 2019 TAEP estimate of 4.23 x 10^{14}. A comparison of the total annual egg production (TAEP) for the western and southern area since 1998 is given below:

Year	Western TAEP	Southern TAEP
2022	1.795 x 10^{15} #	3.21 x 10^{14} #
2019	1.22 x 10^{15}	4.19 x 10^{14}
2016	1.55 x 10^{15}	2.25 x 10^{14}
2013	2.20 x 10^{15}	5.06 x 10^{14}
2010	1.92 x 10^{15}	4.59 x 10^{14}
2007	1.42 x 10^{15}	3.48 x 10^{14}
2004	1.36 x 10^{15}	1.38 x 10^{14}
2001	1.35 x 10^{15}	3.18 x 10^{14}
1998	1.54 x 10^{15}	4.79 x 10^{14}

The total annual egg production (TAEP) in 2022 for the western and southern components combined is 2.116 x 10^{15}. This is an increase in production of 29% compared to the 2019 estimate of 1.64 x 10^{15} (Figure 8.6.1.1.8).

8.6.1.2 Mackerel fecundity and atresia estimation

Estimates of fecundity are given as preliminary realised fecundity which is the potential fecundity minus the atresia rate (for details see WD07: O'Hea et al. 2022). Atlantic mackerel samples were collected during survey periods 2-7 over an area bounded by 59.36˚N 14.20˚W – 36.54˚N 2.32˚W. The analysis of potential fecundity is carried out by nine participating institutes. Preliminary fecundity results are based on 169 samples from periods 2 and 3. The number of samples is higher than in 2019, when only 62 samples were available for the preliminary potential fecundity. The preliminary relative potential fecundity in 2022 is 1253 oocytes/gram female which is slightly higher than the preliminary estimate in 2019 of 1224 oocytes /gram female (Table 8.6.1.2.1). Due to time constraints no samples were analysed for atresia at the time of WGWIDE. For the preliminary estimation of the realised fecundity the mean atresia rate based on the previous seven surveys (6%) was used. This resulted in a preliminary realised fecundity estimate for 2022 of 1178 oocytes/gram female fish.

8.6.1.3 Quality and reliability of the 2022 egg survey

The surveys in 2010 and 2013 were dominated by the issue of an early peak of western mackerel spawning and its close proximity to the nominal start date. In 2016 peak spawning reverted to May/June, a time that would traditionally be considered normal. In 2019, peak spawning in the western area was found to have occurred slightly earlier in Period 4 (Fig. 8.6.1.1.6). For 2022 the spawning pattern is remarkably similar to that reported for 2016.

The bulk of the spawning activity reported during historical surveys resulted from several egg production hotspots on and around the continental shelf edge and usually around the Celtic Sea and Porcupine Bank region. During 2016, high levels of spawning were recorded over a large area of the Northeast Atlantic with a large number of the stations being reported over deep water and well away from the continental shelf. In 2019 numbers of stage 1 eggs recorded on these northerly and western boundary stations were much reduced, although still present (Figures 8.6.1.1.4-5). This expansion was repeated in 2022 during Periods 5 and 6, however spawning densities recorded in these areas were significantly lower than reported in 2016 and 2019. Available surveys deployed during these periods were unable to fully delineate all boundaries. However, WGMEGS is satisfied that significant additional egg production is not being missed in these northern and western areas. Despite the inability to secure a northern spawning boundary for western area mackerel during periods 5 and 6, results from the recent exploratory MEGS surveys undertaken within these regions and reported to WGWIDE in 2021 (ICES, 2021a) provide reassurance that the fraction of spawning missed is a minor one and that the survey has indeed been successful in capturing the majority of spawning activity. An approach to estimate and account for the egg production missed as a result of the Irish survey cancellation in period 6 was developed and is detailed in WD07 (O'Hea et al. 2022).

8.6.1.4 Mackerel biomass estimates.

Based on the procedures of the WGMEGS Survey Manual (ICES, 2019a) & Fecundity manual (ICES, 2019b) the preliminary spawning stock biomass (SSB) by components and components combined have been estimated as shown below using a preliminary fecundity estimate of 1178 oocytes/g female:

- 3.292Mt for western component (2019: 2.29Mt).
- 0.589Mt for southern component (2019: 0.80Mt).
- 3.881Mt for western and southern components combined (2019: 3.09Mt)

8.6.1.5 2022 North Sea mackerel egg survey

The North Sea Mackerel Egg Survey (NSMEGS) is designed to estimate the spawning stock biomass (SSB) of mackerel of the North Sea component of the Northeast Atlantic stock on a triennial basis. Prior to 2017 this survey was done utilizing the annual egg production method (AEPM). At the 2018 WGMEGS meeting, it was agreed to switch to the Daily Egg Production Method (DEPM) for the following survey NSMEGS (ICES, 2018b). The DEPM requires only one full sweep, in a short time period, over the entire mackerel spawning area, preferably during peak spawning time. A disadvantage of the DEPM is that it requires many more mackerel ovary samples to be collected in order to estimate batch fecundity and spawning fraction.

In 2022, the UK, Denmark and Norway conducted the North Sea survey between 5th–24th June. The spawning area (between 54˚N and 62˚N) in the North Sea was surveyed with a single sweep. A total of 259 plankton stations and 38 pelagic trawl hauls were performed for the collection of mackerel adult and ichthyoplankton samples (O'Hea et al, WD08). The total area sampled in 2022 was slightly smaller than the area sampled during the previous survey in 2021.

The spatial daily egg production distribution is shown in Fig. 8.6.1.5.1. Procedures to estimate the Daily egg production are described in the WGMEGS Survey Manual (ICES, 2019a).

The DEP was calculated for the total investigated area. Provisional mackerel daily egg production for 2022 for the North Sea was estimated as 0.67 x 10^{13} eggs. This is a 50% decrease on that reported for the 2021 survey.

Adult parameters

Denmark sampled 1180 mackerel and collected ovary samples from 364 females. England sampled 225 mackerel and collecting ovary samples of 74 females. Norway collected 239 female mackerel (O'Hea et al, WD08). These samples were collected in June 2022 and at the time of writing, no analysis has yet been carried out. Analysis will take place before the end of 2022, with the results to be delivered prior to the WGMEGS meeting in April 2023.

8.6.1.6 2021 North Sea mackerel egg survey

In 2021 a North Sea Mackerel Egg Survey (NSMEGS, I1582) was carried out to estimate the spawning stock biomass (SSB) of mackerel of the North Sea component of the Northeast-Atlantic stock using DEPM methodology. The survey was designed to cover the whole spawning area in the North Sea (53°N to 62°N).

The NSMEGS was carried out from 25th May to 12th June by The Netherlands, Denmark and Scotland (van Damme *et al*., WD03). The samples were collected and analysed according to the WGMEGS manuals (ICES 2019a, 2019b). A total of 294 plankton stations ,23 pelagic trawl hauls and 283 collected female samples were performed for the collection of mackerel adult and ichthyoplankton samples.

The spatial egg production distribution is shown in Fig. 8.6.1.6.1. The Daily egg production was calculated as 128 x 10^{13} mackerel eggs for the total investigated area (Table 8.6.1.6.1).

The DEPM adult parameters were estimated with the data provided by the Netherlands (van Damme et al., WD03). Batch fecundity was estimated 18735 eggs/g. Corrected mean female weight was estimated as 331g. Spawning fraction in the North Sea was calculated as 18% and sex ratio was 0.53. Adult parameters are presented in Table 8.6.1.6.2.

Using the DEP (stage Ia) for the entire sampled area and the estimated adult parameters for the North Sea component leads to an estimated SSB of 2380x10^3 t in 2021.

8.6.2 Demersal trawl surveys in October – March (IBTS Q4 and Q1)

An index of survivors in the first autumn-winter (recruitment index) is normally 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 collection in 2022 Q1 was incomplete as two Scottish surveys (IBTS-NS Q1 and SWC Q1) were cancelled due to technical issues with R/V Scotia.

The area covered by IBTS-NS Q1 and SWC Q1 have historically been an important nursery area. A major fraction of the total estimated recruits are in this area in Q1 (Figure 8.6.2.1). The fraction varies from year to year and it was considered too uncertain to interpolate or assume that the same fraction was in the area as in Q1 2021. As a result, the recruitment index (survivors in the first autumn-winter) has not been updated in 2022 to estimate the value for the 2021 year-class. The time series from ICES (ICES, 2021b) that is used for this years' assessment is shown in Figure 8.6.2.2.

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 and was successfully conducted in 2022. Major survey results worth mentioning is that survey coverage expanded 32%, compared to 2021, as Greenlandic waters, north of 62°N, were surveyed again and mackerel distribution south of Iceland demanded southward expansion of survey to latitude 61°15' in the Iceland basin and on the Reykjanes ridge. Value of the mackerel index was impacted by two extremely large catches, 103 and 70 tonnes km^{-2}, which contributed 33% of the biomass index value. Extreme catches also impacted index calculations in 2017, 2019 and 2020. Analytical work to develop index calculation method less sensitive to extreme catches will be undertaken at ICES Working Group on Improving use of Survey Data for Assessment and Advice (WGISDAA) annual meeting in October 2022. The western part of the northern Norwegian Sea (stratum 9) was over-sampled as three surface trawl stations were added, at the dynamic stratum boundary, at only half the distance from next station, 35 nm instead of 70 nm. Mackerel was caught at two of these stations and the maximum catch per station was approximately one ton. All three stations were included in the index calculations and the dynamic stratum boundary extended 35 nm westward of these three stations. The zero-line for mackerel abundance was reached south and north of Iceland and in Greenlandic waters. It was not reached in the north-western and north-eastern part of the Norwegian Sea but given that the polar front with water too cold for mackerel is usually found close to the north-westernmost catches, we assume that the zero-line was practically reached there. Towards the Barents Sea the zero-line was not reached but this is considered of less quantitative importance based on low catch rates. The zero-line was not reached on the European shelf, where mackerel are present west of the British Isles and in the southern North Sea. 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 increased 43% compared to 2021. When the two extreme catches are excluded from index calculations in 2022, biomass and abundance is similar to 2021 values. Internal consistency increased compared to 2021, particularly for ages 5-8 years which had lower consistency than other ages in 2021. 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, with and without two extreme catches in 2022, for the time series. Figures 8.6.3.3-4 show the internal consistency and catch curves for abundance at age from 2010 to 2022. Figures 8.6.3.6-7 display swept area trawl catch rate and mean mackerel density per rectangle for 2022, and mean mackerel density per rectangle for years 2010 and from 2012 to 2022.

8.6.4 Tag Recapture data

The following is a summary of the most important information on tag recapture data, more detailed info can be found in a working document attached to this report (Slotte and Hølleland, WD09). 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 in Norway, Scotland and Iceland 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 were considered to be 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.

An overview of all RFID tagging data in terms of numbers tagged, biomass scanned, and numbers recaptured per year, and geographical distributions of data are shown in Figures 8.6.4.1-3. The exclusion of recapture years 3 and longer after release is due to potential tag loss over time, which seem evident in the RFID data (WD09). The exclusion of release years 2011-2012 is mainly based in lack of distributional coverage of scanned fishery, which changed significantly when more countries joined the program from 2014 onwards (Figure 8.6.4.2). The exclusion of ages 1-4, was mainly because early in the time series these age groups were relatively few 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 8.6.4.4).

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 (Figure 8.6.4.5). Note that an alternative assessment at WGWIDE 2021 using these indices for the selected ages 5-11 instead of the regular data table resulted in negligible differences in SSB trend and same leave out RFID data effects; i.e. higher SSB in most recent years when excluding RFID data. Translating these abundance indices into different age-aggregated biomass indices also show comparable time trend with SSB from WGWIDE 2022 from release years 2013 onwards (Figure 8.6.4.5). Especially the marked decrease in SSB from 2017-2020 seem to follow the decline in the RFID biomass estimates, which may explain why leave out RFID runs from WGWIDE 2022 tends to lift the SSB upwards.

The signals of total mortality rate (Z) in fully mature fish ages 4-12 for year classes 2003-2014 tend to be higher in the RFID data than in the catch data with the data from final WGWIDE2022 assessment in between, whereas estimated Z from the international trawl survey (IESSNS) is sticking out as the lowest of all sources (Figure 8.6.4.6).

The overall conclusion is that the RFID time series is slowly developing, but still is a very short time series. Nevertheless, the data seem quite informative for stock assessment, although showing higher total mortality rate signals than the other input data. 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 near future.

This especially counts for the inclusion of younger ages 2-4 that may be informative for incoming year classes to the stock.

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).

The spatial distribution pattern of mackerel in 2022 was quite similar to previous years, with mackerel present in the south-eastern Norwegian Sea. However, there were small catches of mackerel as far north as 68°N in 2021, but this year the catches only extended north to about 64°N. This is the lowest northward extent of mackerel catches during IESNS after 2007 (first year with data from all participating vessels).

The IESNS survey provides valuable, although limited, quantitative information on mackerel. It is an acoustic survey and the trawl hauls are mainly targeting acoustic registrations of herring and blue whiting. Thus, the survey does not provide proper mackerel sampling in the vertical dimension and has too low trawl speed for representative sampling of all size groups of mackerel. Therefore, no further quantitative information can be drawn from these data.

8.6.5.2 Acoustic estimates of mackerel in the Iberian Peninsula and Bay of Biscay (PELACUS, A2548)

PELACUS survey data have not been processed on time for WGWIDE 2022 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 2022

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 fit to catch-at-age data for ages 0 to 12 (plus group) for the period 1980 to 2021 (with a strong down-weighting of the catches for the period 1980-1999) and three surveys:

1) SSB estimates from the triennial Mackerel Egg survey (every three years in the period 1992-2022),
2) a recruitment index from the western Europe bottom trawl IBTS Q1 and Q4 surveys (1998-2020, could not be updated for 2021) and
3) the abundance estimates for ages 3 to 11 from the IESSNS survey (2010, 2012-2022).

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 2021 (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 2021 catch-at-age (0-12+), weights-at-age in the catch and in the stock and maturity ogive, proportions of natural and fishing mortality occurring before spawning.
- Addition of the 2022 abundance-at-age (3-11) index from IESSNS.
- Addition of the 2022 SSB index (preliminary value) from the 2022 mackerel egg survey
- The inclusion of the tag recaptures from 2021

Input parameters and configurations are summarized in Table 8.7.1.1. The input data are given in tables 8.7.1.2-9. 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 that from the catches. The IESSNS age 3 is very poorly fit 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 estimated to be 1.17, greater than 1, which implies that the assessment considers the egg survey index to be an overestimate of SSB. The catchabilities at age for the IESSNS increase from 0.79 for age 3 to 1.96 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 ages 4 to 11. The post tagging mortality estimate is higher for the steel tags (~40%) than for the RFID tags (~16%).

The process error standard deviation (ages 1-11) is moderate as are the standard deviations 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 has a slightly higher standard deviation, except for age 3 which is significantly higher. 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 in 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.

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=0.82), decreasing exponentially with age difference (figure 8.7.2.3.). This high error correlation implies that the weight of this survey in the assessment is 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 show some weak patterns in the residuals, with a prevalence of positive residuals for ages 3 to 10 between 2008 and 2014 and again in the last 2 years (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 show 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) 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 indicate a different trend to the other available observations.

Residuals for the IESSNS indices are relatively well balanced for most 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 for the recruitment index show no particular pattern, and appear to be relatively randomly distributed in the earlier years although positive residuals are consistently observed over the most recent 5 years, indicating that the model has difficulties agreeing with the sustained period of high values in the index.

Finally, inspection of the residuals for the tag recaptures (figure 8.7.2.8) did not show any specific pattern for the RFID data. 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 impact of individual surveys on the estimated stock trajectories, the assessment was run leaving out successively each of the survey data sources (figure 8.7.2.9).

All leave one out runs showed parallel trajectories in SSB and Fbar, except for the run that excluded the RFID tag information, which shows a less steep decline in SSB since 2014. For recruitment, all runs also resulted in similar trajectories, except for the run without the recruitment index, in which recruitment decreased from high levels in the mid-2010s to historically low levels in the terminal assessment year.

Excluding the IESSNS survey resulted in estimates very close to the base case run, with slightly lower SSB and higher Fbar for the period covered by this survey. Removing the recruitment index had a similar effect on the estimated stock trajectories, but with a larger discrepancy in SSB for the most recent years. Without the recruitment index, the estimates of age 0 abundance are only informed by the catch data, which are considered uninformative by the model. 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 an effect on SSB estimates. The exclusion of SSB estimates from 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. The magnitude of the effect of removing the RFID data is similar to that of removing other surveys.

As in previous years, the update assessment appears to trade-off the information coming from the IESSNS which leads to a more optimistic perception of the stock, and the information from the egg survey and the tags which suggests a more pessimistic perception of the stock.

Additional sensitivity runs

A series of additional sensitivity runs were carried out to explore the potential influence of the additional uncertainty in some of the new data included in the 2022 update assessment namely the 2022 SSB index from the mackerel egg survey and the possible higher uncertainty in the 2021 catch-at-age data as a consequence of the missing Russian data.

- Sensitivity to assumption made for missing coverage in the 2022 egg survey index

The egg production assumed for the missing coverage in period 6 accounted for 9.4% of the 2022 SSB index from the mackerel egg survey. An alternative SAM assessment was run with a 2022 SSB index decreased by 9.4% (3.51Mt) compared to the value used in the update assessment (3.88Mt). The stock estimates for this run are almost identical to the update assessment (figure 8.7.2.10) which indicates that the current assessment is fairly robust to a 9.4% difference in the 2022 egg survey index of SSB

- Effect of increased uncertainty for 2021 catch-at-age

The current SAM assessment uses the same observation variance for all years, thereby considering that level of uncertainty in the catches does not vary over time. However, given the lack of sampling data from the Russian catch for 2021, and the uncertainty on the total catch value provided, the 2021 catches-at-age for the stock are potentially more uncertain than in normal years. In order to test the effect this potential larger uncertainty has on the assessment, the observation variance for the catch-at-age data for 2021 was increased by 50% compared to other years. This had no noticeable effect on the assessment (figure 8.7.2.11)

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 5.9 million tonnes in 2014 and 2015 and subsequently declined to reach a level just above 3.6 million tonnes in 2020 and increased slightly in 2021 to 3.9 million tonnes. The fishing mortality has declined from levels between F_{pa} (0.36) and F_{lim} (0.46) in the mid-2000s to levels at or below F_{MSY} (0.26) between 2010 to 2019 and increased sharply in the last two years to 0.31 in 2021. 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 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, as 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 8.7.4.1 and figure 8.7.2.7). 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 confidence intervals become narrower from the early 1990s to the mid-2000s, corresponding to the period where information is available from the egg survey index, the tagging data and (partially) catches. The uncertainty increases slightly in the most recent years and the SSB estimate for 2021 is estimated with a precision of +/- 24.8% (figure 8.7.4.1). There is generally also a corresponding large uncertainty on the fishing mortality, especially before 1995. The estimate of $F_{bar4\text{-}8}$ in 2021 has a precision of +/- 27.4%.

Model instability

The retrospective analysis was carried out for 8 retro years, (or peels) by fitting the assessment using the 2022 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 -4 to current year -8) with a systematic downwards revision. The was also a pattern in the opposite direction for the SSB. However, this pattern is not apparent in the most recent peels (current -1 to -3), and the Mohn's rho value calculated over the last 5 years is of 0.18 for Fbar and -0.11 for SSB. Recruitment appears to be quite consistently estimated for the older peels (current -3 to -8), but the perception changed for the last 2 peels. This change is associated with an increase in the observation variance for the recruitment index, meaning that the recruitment estimates were more influenced by the recruitment index in the older peels, which was less the case in the last 2 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 is shown in figure 8.7.4.3 which shows indications of some pattern across time and ages. There is a predominance of positive deviations in the recent years for ages 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 years.

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 estimates larger global 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 (e.g. in 2013 - almost equivalent to the total catch weight). The reason for this aspect of model behaviour 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 that derived at older ages. While the age 0 abundances indicate very high recruitment for the year-classes 2012 to 2019, some 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 ages 0 and 2 and 3, exploitation is not likely to explain these changes in the 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 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 of year-class strength, and should not be used to make assumptions on stock development in the near future. The implications of starting the assessment at age 0 for the short term forecast done to compute the catch advice, however, are relatively limited, with the last estimated recruitment value (R2021 this year) contributing to around 6% of the catch in the advice year.

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 appropriate to use age 0 or 1 as the youngest age in the assessment. 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 retaining the remainder of the data and an unchanged model configuration).

Both the update and exploratory assessments give a very similar perception of the SSB and Fbar trajectories (figure 8.7.5.2), with only small differences in the last 2 years for both SSB and Fbar. 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 more 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.

In conclusion, both models are in broad agreement in terms of fit to the available data and stock trajectories such that the model starting at age 2 could be considered as potential alternative to the current model at the next benchmark workshop for this stock.

8.8 Short term forecast

The short-term forecast provides estimates of SSB and catch in 2023 and 2024 (given an assumed catch for the current (intermediate) year) and a range of management options for the catch in 2023.

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 (2022) 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 (2021) was 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 normally replaced by predictions from the RCT3 software (Shepherd, 1997). The RCT3 software evaluates the historical performance of the IBTS recruitment index, by performing a linear regression between the index and the SAM estimates over the period 1998 to the year before the terminal year. The recruitment is then calculated as a weighted mean of the prediction from this linear regression based on the IBTS index value, and a time tapered geometric mean of the SAM estimates from 1990 to the year before the terminal year. The time tapered geometric mean gives the latest years more weight than a geometric mean. This is done because the recent productivity of the stock appears different than in the 1990’s.

However, no IBTS index data point is available for 2021 and therefore the time tapered geometric mean was used without adjustments. This is as close to the standard procedure as practicable and leads to an expected recruitment of 5 844 million.

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 constraints in 2023.

Assuming catches for 2022 of 1 131 kt, F was estimated at 0.36 (above F_{MSY}) and SSB at 3.77 Mt (above B_{pa}) in spring 2022. If catches in 2023 equal the assumed catch for 2022, F is expected to increase to 0.40 (above F_{pa}) in 2023 with a corresponding decrease in SSB to 3.60 Mt in spring 2023. Assuming an F of 0.40 again in 2024, the SSB will further decrease to 3.33 Mt in spring 2024.

Following the MSY approach, exploitation in 2023 shall be at F_{MSY} (0.26). This is equivalent to catches of 782 kt and a decrease in SSB to 3.68 Mt in spring 2023 (2% decrease). During the subsequent year, SSB will remain at a similar level (3.65 Mt) in spring 2024.

8.9 Biological Reference Points

A management strategy evaluation Workshop on northeast Atlantic mackerel (MKMSEMAC) 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, 2019c)	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 assessment and forecast

Stock assessment output

The last available assessment used for providing advice was carried out in 2021 during the WGWIDE. The 2022 WGWIDE assessment gives a slightly different perception of the development of the stock, with a higher SSB estimated for the period 2014-2017 and a lower Fbar estimated over the period 2009-2018 (figure 8.10.1). The differences in the 2020 TSB, SSB and Fbar estimates between the 2021 and 2022 assessments are -7.0%, -9.35% and 15.4% respectively.

	TSB 2020	SSB 2020	Fbar4-8 2020
Assessment			
2021 WGWIDE Update	5 131 499 tonnes	3 938 555 tonnes	0.249
2022 WGWIDE Update	4 772 765 tonnes	3 570 188 tonnes	0.287
Revision	-7.0%	-9.35%	15.4%

The addition of a new year of data modified only marginally the model parameters compared to last year (figure 8.10.2). The observation standard deviation has increased slightly for the IESSNS survey while it remained unchanged for the other data. Process variances all increased slightly, except the process error on abundances at age 1-11 which remained unchanged. There was also a minor change in the catchabilities for the age 4 to 6 in the IESSNS survey.

The uncertainty on the estimates of the process variances have decreased slightly (especially for the recruitment random walk) but the uncertainty on other parameters is very similar to last year. The uncertainty on SSB and $F_{bar4\text{-}8}$ in this year's assessment is lower for the recent period (for the estimates since 2010), but has increased slightly for the terminal year estimates (figure 8.7.4.1).

Short term forecast

The estimation for the intermediate year (2021) catch used for the short-term forecast in the advice given last year was 10.87% higher than the actual catches as reported to WGWIDE 2022 (table below). 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, several countries were not able to catch their national TAC, due to restrictions on access to UK waters, and this could not be anticipated at the time of the working group. The undershoot of some of the national TACs lead to an assumed intermediate year catch that was too large. As the situation with regard to access to UK waters is still ongoing, an assumption regarding TAC undershoot is made in this year calculation of the intermediate year catch (see section 8.1).

Since the intermediate year catch was overestimated, the 2021 short-term forecast produced an underestimate of the 2021 SSB (by 9.78%) and 13.6% overestimation of Fbar 2021.

	Catch (2021)	SSB (2021)	$F_{bar4\text{-}8}$ (2021)
2021 WGWIDE forecast	1 199 103 t	3 510 849 t	0.35
2022 WGWIDE assessment	1 081 541 t	3 891 546 t	0.31
% difference	10.87%	-9.78%	13.60%

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. There has been no new agreement on a new Management Strategy or share of the stock since then. Despite agreeing to abide by the ICES advice, the total declared quotas in each of the years 2015 to 2021 all exceed the advised catch by ICES (figure 8.11.1).

The mackerel in the Northeast Atlantic is traditionally characterised as three distinct 'spawning components': the southern component, the western component and the North Sea component. The basis for the components is derived from tagging experiments (ICES, 1974). However, the methods normally used to identify stocks or components (*e.g.*, ectoparasite infections, blood phenotypes, otolith shapes and genetics) have not been able to demonstrate significant differences between animals from different components. 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.

Since the mid-1970s, ICES has continuously recommended conservation measures for the North Sea component of the Northeast Atlantic mackerel stock (*e.g.,* ICES, 1974; ICES, 1981). The measures advised by ICES to protect the North Sea spawning component (*i.e.,* closed areas and minimum landing size) aimed to promote the conditions that make a recovery of this component possible.

The minimum landing size (MLS) for mackerel is currently set at 30 cm for the North Sea and 20 cm in the western area. The MLS of 30 cm in the North Sea was originally introduced by Norway in 1971 and was intended to protect the very strong 1969 year-class from exploitation in the industrial fishery (Pastoors, 2015). In the early 1990s, ICES recommended that, because of mixing of juvenile and adult mackerel on western waters fishing grounds, the adoption of a 30 cm minimum landing size for mackerel was not desirable as it could lead to increased discarding (ICES, 1990; 1991). A substantial part of the catch of (western) NEA mackerel is taken in ICES Division 4.a during the period October until mid-February to which the 30 cm MLS applies even though there is limited understanding on the effectiveness of minimum landing sizes in achieving certain conservation benefits (STECF, 2015).

8.12 Ecosystem considerations

An overview of the main ecosystem drivers possibly affecting the different life-stages of Northeast Atlantic mackerel and relevant observations are given in the Stock Annex. The discussion here is limited to recent features of relevance.

Production (recruitment and growth)

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 northeastern areas since 2016 (ICES, 2016; Nøttestad *et al*., 2018; Bjørdal, 2019; Bjørdal et al. in press). 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)).

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), 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. Distribution range peaked in 2014 and was positively correlated to Spawning Stock Biomass (SSB) (ICES 2020). 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, mainly towards western and northern regions of the Nordic seas (Nøttestad *et al.*, 2016). The distribution area was stable around 2.8-2.9 mill km^2 during 2017-2019 (Nøttestad *et al.*, 2017; 2019; ICES, 2018a). However, we witnessed a substantial shift in mackerel concentrations and distribution during summers of 2020-2021, 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.*, 2020b; WD09 in ICES 2021b). Overall, we have witnessed that mackerel had a much more eastern distribution in 2018-2022 compared to 2014-2017 (ICES, 2018a; Nøttestad *et al.*, 2019; 2020b; 2021). Most of the surveyed mackerel still appears to be in the Norwegian Sea, but were more westerly distributed in 2022 than in the last 2 years. The survey coverage area was 2.9 million km^2 in 2022, which is 32% larger coverage compared to 2021. Survey coverage was increased in the western areas (Iceland and Greenland waters) compared to in 2021. Furthermore, 0.28 million km^2 was surveyed in the North Sea in July 2022.

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; 2020b; 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.

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; 2020; 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). 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 (2019-2022, IESSNS; Nøttestad *et al*., 2019; 2020b; 2021; 2022) 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

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Table 8.4.1.1. NE Atlantic Mackerel. ICES estimated catches by area (t). Discards not estimated prior to 1978 (data submitted by Working Group members).

Year	Subarea 6			Subarea 7 and Divisions 8.abde			Subareas 3 and 4			Subareas 1 2 5 and 14			Divisions 8.c and 9.a			Total		
	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch
1969	4800		4800	47404		47404	739175		739175	7		7	42526		42526	833912		833912
1970	3900		3900	72822		72822	322451		322451	163		163	70172		70172	469508		469508
1971	10200		10200	89745		89745	243673		243673	358		358	32942		32942	376918		376918
1972	13000		13000	130280		130280	188599		188599	88		88	29262		29262	361229		361229
1973	52200		52200	144807		144807	326519		326519	21600		21600	25967		25967	571093		571093
1974	64100		64100	207665		207665	298391		298391	6800		6800	30630		30630	607586		607586
1975	64800		64800	395995		395995	263062		263062	34700		34700	25457		25457	784014		784014
1976	67800		67800	420920		420920	305709		305709	10500		10500	23306		23306	828235		828235
1977	74800		74800	259100		259100	259531		259531	1400		1400	25416		25416	620247		620247
1978	151700	15100	166800	355500	35500	391000	148817		148817	4200		4200	25909		25909	686126	50600	736726
1979	203300	20300	223600	398000	39800	437800	152323	500	152823	7000		7000	21932		21932	782555	60600	843155
1980	218700	6000	224700	386100	15600	401700	87931		87931	8300		8300	12280		12280	713311	21600	734911
1981	335100	2500	337600	274300	39800	314100	64172	3216	67388	18700		18700	16688		16688	708960	45516	754476
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

Year	Subarea 6			Subarea 7 and Divisions 8.abde			Subareas 3 and 4			Subareas 1 2 5 and 14			Divisions 8.c and 9.a			Total		
	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch
1985	388140	2735	390875	75043	1800	76843	46790	3656	50446	78000		78000	18111		18111	606084	8191	614275
1986	104100		104100	128499		128499	236309	7431	243740	101000		101000	24789		24789	594697	7431	602128
1987	183700		183700	100300		100300	290829	10789	301618	47000		47000	22187		22187	644016	10789	654805
1988	115600	3100	118700	75600	2700	78300	308550	29766	338316	120404		120404	24772		24772	644926	35566	680492
1989	121300	2600	123900	72900	2300	75200	279410	2190	281600	90488		90488	18321		18321	582419	7090	589509
1990	114800	5800	120600	56300	5500	61800	300800	4300	305100	118700		118700	21311		21311	611911	15600	627511
1991	109500	10700	120200	50500	12800	63300	358700	7200	365900	97800		97800	20683		20683	637183	30700	667883
1992	141906	9620	151526	72153	12400	84553	364184	2980	367164	139062		139062	18046		18046	735351	25000	760351
1993	133497	2670	136167	99828	12790	112618	387838	2720	390558	165973		165973	19720		19720	806856	18180	825036
1994	134338	1390	135728	113088	2830	115918	471247	1150	472397	72309		72309	25043		25043	816025	5370	821395
1995	145626	74	145700	117883	6917	124800	321474	730	322204	135496		135496	27600		27600	748079	7721	755800
1996	129895	255	130150	73351	9773	83124	211451	1387	212838	103376		103376	34123		34123	552196	11415	563611
1997	65044	2240	67284	114719	13817	128536	226680	2807	229487	103598		103598	40708		40708	550749	18864	569613
1998	110141	71	110212	105181	3206	108387	264947	4735	269682	134219		134219	44164		44164	658652	8012	666664
1999	116362		116362	94290		94290	313014		313014	72848		72848	43796		43796	640311		640311
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

Year	Subarea 6			Subarea 7 and Divisions 8.abde			Subareas 3 and 4			Subareas 1 2 5 and 14			Divisions 8.c and 9.a			Total		
	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch
2002	136847	12931	149778	102484	2260	104744	375708	8583	394878	73929		73929	49576		49576	749131	23774	772905
2003	135690	1399	137089	90356	5712	96068	354109	11785	365894	53883		53883	25823	531	26354	659831	19427	679288
2004	134033	1705	134738	103703	5991	109694	306040	11329	317369	62913	9	62922	34840	928	35769	640529	19962	660491
2005	79960	8201	88162	90278	12158	102436	249741	4633	254374	54129		54129	49618	796	50414	523726	25788	549514
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

Table 8.4.2.1. NE Atlantic Mackerel. ICES estimated catch (t) in Subareas 1, 2, 5 and 14, 2000 – 2021 (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		
Russia	49101	41566	45811	40026	49489	40491	33580	35408	32728	414141	58613
Misreported			-570		-553						
Unallocated				-44	32	-2393		-10	-18		

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
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**
Denmark	269		391	2345	4321	1	2	289			0.691
Estonia			13671								
Faroe Islands	121499	107198	142976	103896	76889	61901	66194	52061	37418	33291	105096
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
Iceland	159263	149282	151103	172960	169333	170374	167366	168330	128008	151534	132109
Ireland	90			1725	6	2					
Latvia											
Lithuania				1082		1931				2	
Netherlands	178	5	1	5887	6996	8599	7671	2697	13	0.73	
Norway	43168	110741	33817	192322	204574	153228	167739	46853	22605	15937	256124
Poland								2		0.044	8.2
Sweden		4	825	3310	740	730	1720	910		220	228
United Kingdom			2	5534	7851	5240	4601	2009		426	

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Russia	73601	74587	80812	116433	128433	121614	138061	118255	126543	128805	136176
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

Table 8.4.2.2. NE Atlantic Mackerel. ICES estimated catch (t) in the North Sea, Skagerrak and Kattegat (Subarea 4 and Division 3.a), 2000-2021 (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
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					

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
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**
Belgium	21	39	62	56	38	99	107	110	13	75	77
Denmark	32800	36492	31924	21340	35809	21696	27457	22207	25374	34375	28295
Faroe Islands	543	432	25	42919	25672	18193	12915	15475	17460	32860	
France	1416	5736	1788	4912	7827	3448	5942	6714	5455	8959	5041
Germany Fed. Rep.	52911	4560	5755	4979	6056	10172	11185	12091	7778	15946	9939
Iceland											
Ireland	15810	20422	13523	45167	34167	24437	35957	24567	1678	15395	11021
Lithuania				8340		596				813	6655
Netherlands	9881	6018	4863	24536	17547	11434	17401	13844	8957	18425	15983
Norway	162878	64181	130056	85409	36344	55089	51960	135715	135083	195515	14518

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Poland					24		0.721	4041	1394	16	559
Sweden	32481	4560	2081	1112	3190	2933	1981	3056	2152	3451	3277
United Kingdom	69858	75959	70840	145119	129203	99945	104499	103707	101890	130650	125553
Russia			4						0.12		
Misreported (Area 6.a)											
Unallocated											
Discards	1906	1089	337	334	34	559	400	620	812	732	423
Total	303652	219489	261258	384221	295911	248611	269804	342147	308047	457211	221340

Table 8.4.2.3. NE Atlantic Mackerel. ICES estimated catch (t) in the Western area (Subareas 6 and 7 and Divisions 8.a,b,d,e), 2000−2021 (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
Estonia											
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	
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**
Belgium					14	44	21	58	53	49	34
Denmark	2889	8	903	18538	6741	19443	12569	8194	5189	4110	4463
Estonia											

Faroe Islands	8			3421	5851	13173	20559	13543	7787	2913	
France	11304	14448	12438	16627	17820	16634	16925	13974	12371	12816	11308
Germany	18792	14277	15102	23478	19238	9740	9608	7214	8936	8878	2049
Greenland										22	
Guernsey	10	5	9	9	4			12	9		
Iceland									69		
Ireland	45696	42627	42988	56286	54571	52087	48957	42181	51635	58720	49731
Isle of Man	11	11	8	3		8	2	3	3	2	
Jersey	7	8	8	7	3	3	0.003	3	2	5	
Lithuania	23			176	554	13					
Netherlands	18336	19794	16295	16242	15264	17896	18694	13851	13727	11895	8611
Norway	2019	1101	734		1313	1035	2657	4639	1420	221	11
Poland								14	2312	5286	1155
Portugal									46	35	32
Russia						30			1	10	
Spain	1257	773	635	1796	951	1253	786	4471	1220	1784	704
Sweden									805		
United Kingdom	111103	93775	92957	137195	110932	112268	116308	84309	50253	72637	84323

Unallocated	399	16	-144		34			13			
Discards	7153	10654	2105	1742	3185	2126	2142	1701	6046	8405	2640
Total	219007	197496	183857	275519	236475	245754	249229	194180	161883	187788	165060

Table 8.4.2.4. NE Atlantic Mackerel. ICES estimated catch (t) in Divisions 8.c and 9.a, 2000−2021 (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	4867.9437
Portugal	9.a	2289	1509	2620	2605	2381	1753	2363	962	824
Spain	8.c			43063	53401	50455	91043	38858	14709	17768
Spain	9.a			7025	6773	6855	14569	7347	2759	845
Discards	8.c	928	391	3606	156	73	725	4408	563	2187
Discards	9.a		405	1	916	677	241	232	1245	1244
Unallocated	8.c	28429	42851						4691	4144
Unallocated	9.a	3946	5107					108	871	1076
Total	9.a	6234	7021	9646	10293	9913	16562	10049	5836	3989
Total		35768	50414	56358	63906	60609	108713	55466	28146	33239

Country	Div	2013	2014	2015	2016	2017	2018	2019	2020	2021
France	8.c	220	171	21	106	83	50	43	96	93
Portugal	8.c	5134	7334	6836	6069	3697	3709	3188	4189	3738
Portugal	9.a	254	618	1456	619	634	855	706	575	953
Spain	8.c	14617	33783	29726	26553	30893	27190	19148	31143	25272
Spain	9.a	1162	2227	3853	2229	1206	1656	747	1379	1807

Russia									2	
Discards	8.c	1428	2821	4724	2469	84	324	760	28	18
Discards	9.a	1027	1463	2409	751	143	194	172	115	47
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
Total		27322	57874	50867	42276	36740	34279	24764	37529	31928

Table 8.5.1.1. NE Atlantic Mackerel. Mean length (mm) -at-age by area for 2021 (Q1-Q4).

Age	1	2.a	3.a	3.b	3.c	3.d	4.a	4.b	4.c
0									
1	292	279	293	292	292	289	289	278	286
2	322	312	322	319	316	318	317	323	317
3	338	335	340	343	336	326	341	333	333
4	348	345	350	350	347	352	350	351	354
5	356	355	358	359	355	360	359	358	363
6	364	366	372	372	372	361	373	368	368
7	370	372	378	376	377	359	376	372	377
8	376	377	381	381	380	378	380	380	383
9	381	381	385	383	384	387	382	384	390
10	386	383	389	388	388	389	385	387	383
11	390	388	391	386	389	377	387	389	384
12	394	393	399	400	398	386	399	398	392
13	398	395	400	399	396	398	397	397	397
14	402	396	406	406	399	404	392	396	389
15	399	398	412				402	407	398

Age	5.a	5.b	6.a	6.b	7.a	7.b	7.c	7.h
0								
1		289	209	207	231			103
2	302		290	287	168			304
3	341	342	324	327	97	352	354	314
4	348	360	342	346	128	350	342	302
5	354	353	353	358	172	356	359	341
6	370	372	366	371	143	364	384	347
7	376	378	372	373	132	379	396	373
8	381	379	380	381	162	390	391	383
9	381	377	382	383	256	385	400	387

10	380	389	385	386	367	389	399	390
11	386	386	391	391	274	390	409	400
12	390	364	394	393	409	405	399	393
13	388		398	399	358	401	395	395
14	392		399	404	404	410	410	405
15	396		399	418	404	435	435	415

Table 8.5.1.1. NE Atlantic Mackerel. Mean length (mm) -at-age by area for 2021 (Q1-Q4) continued.

Age	7.j	8.a	8.b	8.c	8.d	9.a	9.a.N	All
0		181	180	217		206	222	178
1	178	247	216	225	278	258	256	195
2	295	295	294	315	326	317	279	306
3	338	316	323	341	324	329	310	328
4	349	347	347	354	346	340	338	343
5	356	363	360	364	366	368	357	354
6	367	376	372	373	375	385	379	368
7	374	382	379	377	379	390	383	373
8	382	391	389	383	385	395	389	379
9	379	389	387	386	388	413	394	382
10	387	393	392	391	393	411	395	384
11	388	396	393	399	400	470	401	388
12	392	415	416	403	406	410	414	395
13	400	406	406	408	406	440	409	396
14	395	405	415	422	405		423	396
15	415							399

Table 8.6.1.2.1. Fecundity and atresia for the assessment years, from 1998 to 2022 (Preliminary values). n is the number of samples used, n/g refers to the number of oocytes or atretic oocytes by gram of fish (*) means median not mean relative for potential fecundity.

	Survey year							
	2001	2004	2007	2010	2013	2016	2019	2022 Prel.
Fecundity samples (n)	187	205	176	74	132	97	62	169
Prevalence of atresia (n)	290	348	416	511	732	713	895	559
Intensity of atresia (n)	290	348	416	511	56	66	64	
Relative potential fecundity (n/g)	1097	1127	1098	1140	1257*	1159*	1191*	1253*
Prevalence of atresia	0.2	0.28	0.38	0.33	0.22	0.3	0.28	0.28
Geometric mean intensity of atresia (n/g)	40	33	30	26	27	30	20	
Potential fecundity lost per day (n/g)	1.07	1.25	1.48	1.16	0.8	1.2	0.73	
Potential fecundity lost (n/g)	64	75	89	70	48	72	44	75
Relative potential fecundity lost (%)	6	7	9	6	4	6	4	6
Realised fecundity (n/g)*	1033	1052	1009	1070	1209	1087	1147	1178

Table 8.6.1.6.1. Daily egg production estimate (stage Ia) for mackerel in the North Sea using the DEPM in 2021.

Year	DEP $*10^{13}$	CV DEP
2021	1.28	16%

Table 8.6.1.6.2. Estimated adult parameters and SSB for mackerel in the North Sea using the DEPM in 2021

Year	2021
Batch fecundity	18735
Relative batch fecundity (N/g)	42.7
CV Batch fecundity	0.87
Spawning fraction	0.18
Sex ratio	0.53
Female weight (g)	331.4
SSB (* 103 tonnes)	2380

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 -2021		Yes
Catch-at-age in numbers	1980 -2021	0-12+	Yes

Weight-at-age in the commercial catch	1980 –2021	0-12+	Yes
Weight-at-age of the spawning stock at spawning time.	1980 –2021	0-12+	Yes
Proportion of natural mortality before spawning	1980 -2021	0-12+	Yes
Proportion of fishing mortality before spawning	1980 -2021	0-12+	Yes
Proportion mature-at-age	1980 -2021	0-12+	Yes
Natural mortality	1980 -2021	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	Age 0
Survey (abundance index)	International Ecosystem Summer Survey in the Nordic Seas (IESSNS)	2010, 2012-2022	Ages 3-11
Tagging/recapture	Norwegian tagging program	Steel tags : 1980 (release year)-2006 (recapture years) RFID tags : 2013 (release year) 2021 (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 0/0/0/5/6/6/6/6/6/6/6/6/0	Separate observation variances for age 0 and 1 than for the older ages in the catches One observation variance for the egg survey One observation variance for the recruitment index 2 observation variances for the IESSNS (age 3 and ages 4 and older)
Stock recruitment model	0	No stock-recruiment model
Correlation structure	"ID", "ID", "ID", "AR"	Auto-regressive correlation structure for the IESSNS index, independent observations assumed for the other data sources

Table 8.7.1.2. NE Atlantic Mackerel. CATCH IN NUMBER

Units : thousands

age \ year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
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

age										
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

age \ year	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
0	6443	2332
1	52637	29202
2	107302	326976
3	182163	217298
4	266760	281925
5	166627	366644
6	270154	182783
7	246268	300014
8	274182	208961
9	311215	228236
10	241775	198134
11	128294	128957
12	179703	118150

Table 8.7.1.3. NE Atlantic Mackerel. WEIGHTS AT AGE IN THE CATCH

Units : Kg

age \ year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
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	2016	2017	2018	2019	2020	2021
0	0.035	0.018	0.066	0.057	0.057	0.049
1	0.154	0.178	0.147	0.112	0.174	0.163
2	0.240	0.266	0.247	0.260	0.285	0.277
3	0.297	0.311	0.320	0.297	0.322	0.338
4	0.329	0.356	0.355	0.360	0.360	0.374
5	0.356	0.377	0.397	0.388	0.389	0.406
6	0.383	0.397	0.410	0.429	0.417	0.441
7	0.411	0.415	0.426	0.441	0.444	0.457
8	0.438	0.444	0.446	0.453	0.459	0.477
9	0.453	0.465	0.469	0.472	0.471	0.486
10	0.479	0.484	0.492	0.497	0.495	0.501
11	0.499	0.497	0.507	0.514	0.519	0.514
12	0.520	0.531	0.537	0.537	0.554	0.548

Table 8.7.1.4. NE Atlantic Mackerel. WEIGHTS AT AGE IN THE STOCK

Units : Kg

age	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	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	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	2016	2017	2018	2019	2020	2021
0	0.000	0.000	0.000	0.000	0.000	0.000
1	0.059	0.058	0.064	0.070	0.069	0.064
2	0.182	0.204	0.190	0.191	0.209	0.186
3	0.238	0.237	0.266	0.250	0.252	0.261
4	0.282	0.278	0.283	0.293	0.289	0.281
5	0.298	0.308	0.314	0.311	0.348	0.323
6	0.340	0.308	0.327	0.346	0.363	0.352
7	0.368	0.338	0.346	0.365	0.376	0.392
8	0.385	0.377	0.364	0.371	0.394	0.416
9	0.404	0.394	0.389	0.397	0.400	0.423
10	0.424	0.426	0.419	0.428	0.423	0.446
11	0.440	0.430	0.437	0.431	0.445	0.458
12	0.473	0.499	0.491	0.481	0.488	0.496

Table 8.7.1.5. NE Atlantic Mackerel. NATURAL MORTALITY

Units : NA

year

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

year

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

year

age	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
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
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
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
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
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
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
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
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
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
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
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
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
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

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
0	0.000	0.000	0.000	0.000	0.000	0.000
1	0.127	0.125	0.105	0.105	0.105	0.119
2	0.633	0.606	0.464	0.534	0.519	0.569
3	0.937	0.945	0.902	0.910	0.915	0.943
4	0.997	0.998	0.998	0.999	0.998	0.999
5	0.999	1.000	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000	1.000	0.999
7	0.999	0.999	0.999	1.000	1.000	0.999
8	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
10	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
12	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
0	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
2	0.224	0.153	0.179	0.183	0.184	0.090
3	0.224	0.153	0.179	0.183	0.184	0.090
4	0.224	0.153	0.179	0.183	0.184	0.090
5	0.178	0.295	0.196	0.301	0.317	0.233
6	0.178	0.295	0.196	0.301	0.317	0.233
7	0.178	0.295	0.196	0.301	0.317	0.233
8	0.178	0.295	0.196	0.301	0.317	0.233
9	0.178	0.295	0.196	0.301	0.317	0.233
10	0.178	0.295	0.196	0.301	0.317	0.233
11	0.178	0.295	0.196	0.301	0.317	0.233
12	0.178	0.295	0.196	0.301	0.317	0.233

Table 8.7.1.8. NE Atlantic Mackerel. FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

age \ year	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

age \ year	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

age \ year	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

age \ year	2016	2017	2018	2019	2020	2021
0	0.343	0.327	0.312	0.296	0.312	0.329
1	0.343	0.327	0.312	0.296	0.312	0.329
2	0.343	0.327	0.312	0.296	0.312	0.329
3	0.343	0.327	0.312	0.296	0.312	0.329
4	0.343	0.327	0.312	0.296	0.312	0.329
5	0.343	0.327	0.312	0.296	0.312	0.329
6	0.343	0.327	0.312	0.296	0.312	0.329
7	0.343	0.327	0.312	0.296	0.312	0.329
8	0.343	0.327	0.312	0.296	0.312	0.329
9	0.343	0.327	0.312	0.296	0.312	0.329
10	0.343	0.327	0.312	0.296	0.312	0.329
11	0.343	0.327	0.312	0.296	0.312	0.329
12	0.343	0.327	0.312	0.296	0.312	0.329

Table 8.7.1.9. NE Atlantic Mackerel. SURVEY INDICES

Some random text

103

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		

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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              3880895.853
R-idx

1998           2021

1              1              0              0

0              0

1              0.012476066
1              0.01862673
1              0.013289745
1              0.020583855
1              0.026244937
1              0.012684229
1              0.029582367
1              0.038157763
1              0.034722557
1              0.022670008
1              0.02064922
1              0.014607073
1              0.02237237
1              0.037563703
1              0.02733911
1              0.029964112
1              0.022348323
1              0.024720467
1              0.0432534
1              0.043849281
1              0.039094593
1              0.04381569
1              0.036397234
1              -1
Swept-idx

2010           2022

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
```

Table 8.7.1.10. NE Atlantic Mackerel. RFID recapture data for the year 2021

Release Yr	Recapture Yr	Year-class	age at release	Numbers scanned in recapture Yr	Numbers Released in Release Year	Numbers recaptured
2019	2021	2008	11	28671260	2556	19
2019	2021	2009	10	32424008	2871	22
2019	2021	2010	9	73535492	4728	37
2019	2021	2011	8	91009636	9483	79
2019	2021	2012	7	54099631	6785	57
2019	2021	2013	6	43820959	8040	70
2019	2021	2014	5	82980291	5824	51
2020	2021	2009	11	32424008	2191	28
2020	2021	2010	10	73535492	5001	67
2020	2021	2011	9	91009636	5081	70
2020	2021	2012	8	54099631	5474	76
2020	2021	2013	7	43820959	2665	36
2020	2021	2014	6	82980291	4339	68
2020	2021	2015	5	35012724	1509	28

Table 8.7.2.1. NE Atlantic Mackerel. SAM parameter estimates for the 2022 update.

	estimate	std.dev	confidence interval lower bound	confidence interval upper bound
observation standard deviations				
Catches age 0	0.89	0.18	0.63	1.28
Catches age 1	0.35	0.25	0.21	0.58
Catches age 2-12	0.11	0.15	0.08	0.15
Egg survey	0.32	0.25	0.20	0.53
Recruitment index	0.26	0.31	0.14	0.48
IESSNS age 3	0.66	0.23	0.41	1.04
IESSNS ages 4-11	0.45	0.14	0.34	0.60
Recapture overdispersion tags	1.25	0.24	1.40	1.15

random walk standard deviation				
F age 0	0.28	0.43	0.12	0.68
F age 1	0.18	0.46	0.07	0.45
F age 2+	0.15	0.14	0.11	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	1.17	0.11	0.94	1.47
recruitment index	4.99E-09	0.11	3.97E-09	6.28E-09
IESSNS age 3	0.79	0.22	0.51	1.22
IESSNS age 4	1.19	0.17	0.85	1.66
IESSNS age 5	1.64	0.17	1.18	2.29
IESSNS age 6	1.75	0.17	1.25	2.45
IESSNS age 7	1.94	0.17	1.37	2.73
IESSNS age 8	1.83	0.17	1.30	2.58
IESSNS age 9	1.96	0.17	1.39	2.77
IESSNS ages 10-11	1.88	0.17	1.34	2.63
post tagging survival steal tags	0.40	0.11	0.35	0.45
post tagging survival RFID tags	0.16	0.11	0.13	0.19

Table 8.7.3.1. NE Atlantic Mackerel. STOCK SUMMARY.

Year	Recruitment (age 2)			SSB at spawning time			Total catch	F (ages 4–8)		
	Low	Value	High	Low	Value	High		Low	Value	High
1980	741662	2256379	6864651	1931692	4095763	8684237	734950	0.13	0.21	0.33
1981	1483866	3954164	10536946	1908690	3610917	6831242	754045	0.13	0.21	0.33
1982	2251174	4258180	8054508	2034611	3475244	5935937	716987	0.13	0.21	0.32
1983	2476430	4189394	7087228	2412006	3685894	5632577	672283	0.14	0.21	0.31
1984	1048672	1945021	3607518	2800858	3989717	5683201	641928	0.14	0.21	0.31
1985	911867	1761799	3403932	2949017	4015844	5468602	614371	0.15	0.21	0.31
1986	2414771	4075432	6878145	2709488	3608231	4805089	602201	0.15	0.22	0.31
1987	1645418	2713304	4474253	2689623	3575982	4754438	654992	0.16	0.22	0.31
1988	1704717	2668074	4175837	2719049	3526114	4572730	680491	0.17	0.23	0.32
1989	2626296	3859714	5672396	2586241	3297725	4204941	585920	0.18	0.24	0.33
1990	1615372	2352987	3427412	2703312	3381620	4230127	626107	0.19	0.26	0.34
1991	1806495	2640685	3860081	2648612	3278987	4059393	675665	0.21	0.27	0.36
1992	1255408	1959426	3058250	2453803	3005914	3682253	760690	0.22	0.29	0.38
1993	1667703	2400478	3455227	2192074	2665757	3241797	824568	0.24	0.31	0.39
1994	1937535	2792997	4026163	1924591	2323071	2804054	819087	0.25	0.32	0.40
1995	1447844	2068160	2954245	1914732	2290278	2739483	756277	0.25	0.31	0.39
1996	1465444	2062647	2903224	1825764	2174598	2590081	563472	0.25	0.30	0.37

Year	Recruitment (age 2)			SSB at spawning time			Total catch	F (ages 4–8)		
	Low	Value	High	Low	Value	High		Low	Value	High
1997	1220370	1738105	2475486	1824264	2144607	2521204	573029	0.24	0.30	0.36
1998	1445736	2299083	3656118	1799608	2120261	2498049	666316	0.25	0.30	0.37
1999	1262250	1918742	2916672	1958221	2301530	2705027	640309	0.27	0.32	0.38
2000	1646261	2242303	3054147	1970480	2266622	2607272	738606	0.29	0.34	0.39
2001	1930231	2565296	3409305	1874159	2147511	2460732	737463	0.32	0.37	0.43
2002	863381	1152032	1537189	1778419	2054100	2372516	771422	0.33	0.39	0.46
2003	3687488	4794496	6233834	1718635	1993516	2312361	679287	0.34	0.41	0.48
2004	5011045	6668900	8875242	2204914	2608232	3085323	660491	0.32	0.38	0.45
2005	1745850	2356809	3181573	2013569	2404435	2871174	549514	0.26	0.31	0.36
2006	2532416	3427824	4639829	1888395	2242585	2663208	481181	0.24	0.28	0.33
2007	3624149	4994825	6883900	2021689	2380749	2803579	586206	0.27	0.31	0.37
2008	3651784	5064453	7023604	2354473	2800351	3330667	623165	0.25	0.30	0.36
2009	2640841	3641939	5022536	2915680	3480016	4153581	737969	0.23	0.27	0.33
2010	2971798	4083427	5610870	3290915	3901258	4624797	877272	0.22	0.26	0.32
2011	2520467	3464819	4762994	3791504	4504765	5352206	948963	0.22	0.26	0.31
2012	4214540	5786958	7946034	3548472	4225513	5031731	899551	0.20	0.24	0.29
2013	4871399	6709016	9239829	3935828	4705814	5626437	938299	0.19	0.24	0.29

Year	Recruitment (age 2)			SSB at spawning time			Total catch	F (ages 4–8)		
	Low	Value	High	Low	Value	High		Low	Value	High
2014	2729554	3753792	5162367	4924869	5898500	7064615	1401788	0.20	0.24	0.29
2015	2437757	3352679	4610983	4928398	5928946	7132621	1215827	0.18	0.22	0.27
2016	3652137	5035066	6941658	4638104	5598144	6756902	1100135	0.16	0.20	0.25
2017	1541675	2141687	2975221	4469022	5404599	6536037	1159641	0.17	0.21	0.25
2018	3434902	4853899	6859101	3859967	4667166	5643167	1023144	0.17	0.21	0.26
2019	2020927	2923019	4227783	3233573	3945436	4814014	839727	0.18	0.22	0.27
2020	1816780	2698510	4008168	2888782	3570188	4412324	1039513	0.23	0.29	0.36
2021	4313470	6801162	10723570	3044947	3891546	4973528	1081540	0.23	0.31	0.40
2022	2148239	4317473	8677141		3769326†					

† 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	4977824	4592946	3796286	3630479	4120760	4018388	3996884	4085430	3714031	3542109
1	4770227	4667307	4444600	2747095	2554680	4153858	3337149	3297715	4020185	2989130
2	2256379	3954164	4258180	4189394	1945021	1761799	4075432	2713304	2668074	3859714
3	912180	1820022	3310754	4041761	4235132	1338773	1230503	4005081	2150334	2331117
4	1566134	705301	1375181	2796871	3678706	3995572	998216	837570	3714427	1671198
5	3406968	1168826	510471	949136	2140450	3017436	3135126	783356	528198	2969366
6	2631794	2415970	846616	379243	656491	1605024	2219979	2159711	600448	343216
7	822419	1788183	1638596	578072	268789	459973	1078736	1503046	1411112	463388
8	309077	572320	1245878	1138797	397837	195390	311847	770217	1046138	1067708
9	848340	215083	397825	867613	789693	278639	139301	210575	547400	732107
10	233382	590713	149594	276223	603333	546635	196960	96371	141292	376120
11	341202	162433	410639	104016	191710	418065	376311	135405	66188	92257
12	690723	718841	612445	708530	561998	521034	644266	694742	562107	422472

year

age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	3297094	3318561	3327308	3098419	2964293	2859040	2952257	2923500	2987978	3289960
1	3097593	2570564	2856940	3087202	2565454	2505469	2258676	2639679	2400853	2618309
2	2352987	2640685	1959426	2400478	2792997	2068160	2062647	1738105	2299083	1918742
3	3890784	2115127	2534665	1621187	1967779	2382272	2153403	1924846	1227717	2350070
4	1827221	3033337	1514054	2017745	1086566	1416848	1800381	1772730	1630353	1239955
5	1073211	1243666	1917567	979620	1372311	673445	964445	1200871	1508741	1265166
6	1973779	775220	945978	1153956	583882	966540	489028	724376	855047	899888
7	214236	1223334	473593	569829	648711	343790	572199	320013	479077	614420
8	351975	137286	732262	309748	336390	280329	212476	344773	262374	310595
9	731514	249257	88556	410862	181936	175936	135539	150472	211003	180762
10	478615	497774	159923	52759	214721	108449	92183	85476	101841	131487
11	252493	302692	312443	97205	29473	129461	62308	49031	52952	63338
12	342343	388796	440913	466489	339941	219549	209528	169160	140089	124666

year

age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
0	3144960	4433789	5064730	4013211	4940011	6087928	6119559	5148658	4756583	4639324
1	3035680	1857761	5101748	6175998	2832192	3897654	5945414	5618783	4333207	4134463
2	2242303	2565296	1152032	4794496	6668900	2356809	3427824	4994825	5064453	3641939
3	1790222	1727766	2474397	798852	3936615	5336987	1738772	2564331	4591346	5210179
4	1819767	1279107	1516076	1553732	750904	1902452	3240215	1511773	2043494	4067468
5	1010369	1237307	970982	902493	996705	540476	1055644	2123609	1264672	1661329
6	859823	660339	800265	568797	472792	482143	376210	757409	1140265	931368
7	619464	600842	404644	376524	265228	233351	284819	255528	426786	710562
8	375412	410741	343916	238702	183557	135455	133426	184948	179036	270518
9	191120	238796	226933	192419	115881	87835	74299	95034	102742	111945
10	113685	126738	126615	116014	91545	62816	53326	47505	59034	53904
11	70379	68495	62601	65601	46922	31568	32450	34341	22259	29446
12	122286	126402	111017	80331	56491	40612	39033	39894	31628	21099

year

age	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	5520852	6360676	5704912	5490274	5587694	5154715	5999571	6307925	6367101	7176591
1	4273885	5587697	6415242	4551906	4222134	5704906	3528918	5217025	4291009	4229297
2	4083427	3464819	5786958	6709016	3753792	3352679	5035066	2141687	4853899	2923019
3	3515562	3836598	2860930	5634314	7160193	3007330	2663718	4323592	1345459	3459984
4	4900988	3206377	3179936	2539120	5288131	4883570	2789692	2085552	2773684	904800
5	3065295	3582228	2550450	2653768	2532000	3851455	3615558	2164113	1356115	1440392
6	1322833	2226928	2584252	2393429	2527420	2092277	3059819	3088656	1481157	972355
7	584975	951404	1432488	1727766	2164657	1975678	1678923	2744688	2330127	1046798
8	391333	429065	634372	925526	1446550	1628395	1450473	1350611	1926895	1629024
9	175392	215371	282202	434894	648104	1042218	973051	1143531	1041363	1332009
10	76179	98128	130947	176676	286800	493250	571416	704991	709220	605128
11	26303	47692	55031	86098	98402	148441	246010	388856	490368	436225
12	32975	40716	51979	72920	71228	109057	146957	280765	354142	451171

year

age	2020	2021	2022
0	6610775	6333542	6333542
1	6919855	5097986	5442078
2	2698510	6801162	4317473
3	2019484	2072539	5459511
4	2203869	1865960	1413880
5	733129	1694067	1344203
6	1008745	533527	989652
7	831732	991559	350945
8	850646	675470	542972
9	1081500	769063	399065
10	923342	698265	557747
11	437216	503532	472776
12	620191	465215	581817

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	0.008	0.008	0.008
1	0.033	0.033	0.033	0.033	0.033	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
2	0.058	0.058	0.057	0.057	0.058	0.057	0.057	0.057	0.057	0.058	0.058	0.059	0.059
3	0.106	0.106	0.105	0.106	0.107	0.109	0.111	0.113	0.116	0.119	0.122	0.126	0.129
4	0.174	0.174	0.175	0.175	0.176	0.180	0.184	0.191	0.197	0.205	0.211	0.218	0.222
5	0.193	0.194	0.194	0.196	0.198	0.201	0.206	0.210	0.217	0.222	0.227	0.234	0.244
6	0.238	0.238	0.240	0.241	0.245	0.249	0.255	0.261	0.268	0.281	0.293	0.304	0.314
7	0.213	0.213	0.213	0.213	0.214	0.218	0.223	0.230	0.239	0.253	0.275	0.304	0.335
8	0.213	0.213	0.213	0.213	0.214	0.218	0.223	0.230	0.239	0.253	0.275	0.304	0.335
9	0.213	0.213	0.213	0.213	0.214	0.218	0.223	0.230	0.239	0.253	0.275	0.304	0.335
10	0.213	0.213	0.213	0.213	0.214	0.218	0.223	0.230	0.239	0.253	0.275	0.304	0.335
11	0.213	0.213	0.213	0.213	0.214	0.218	0.223	0.230	0.239	0.253	0.275	0.304	0.335
12	0.213	0.213	0.213	0.213	0.214	0.218	0.223	0.230	0.239	0.253	0.275	0.304	0.335

year

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	0.032	0.032	0.032	0.032	0.032	0.031	0.031	0.031	0.029	0.029	0.025	0.020	0.018
2	0.060	0.061	0.062	0.063	0.065	0.066	0.067	0.069	0.069	0.068	0.066	0.069	0.062
3	0.133	0.136	0.138	0.141	0.144	0.149	0.158	0.168	0.161	0.161	0.143	0.148	0.135
4	0.225	0.228	0.228	0.228	0.228	0.233	0.243	0.258	0.270	0.267	0.238	0.223	0.192
5	0.251	0.254	0.259	0.268	0.281	0.300	0.317	0.341	0.327	0.334	0.328	0.314	0.275
6	0.322	0.326	0.326	0.324	0.325	0.330	0.344	0.366	0.413	0.406	0.412	0.388	0.340
7	0.367	0.385	0.376	0.349	0.328	0.329	0.343	0.355	0.411	0.475	0.529	0.480	0.360
8	0.367	0.385	0.376	0.349	0.328	0.329	0.343	0.355	0.411	0.475	0.529	0.480	0.360
9	0.367	0.385	0.376	0.349	0.328	0.329	0.343	0.355	0.411	0.475	0.529	0.480	0.360
10	0.367	0.385	0.376	0.349	0.328	0.329	0.343	0.355	0.411	0.475	0.529	0.480	0.360
11	0.367	0.385	0.376	0.349	0.328	0.329	0.343	0.355	0.411	0.475	0.529	0.480	0.360
12	0.367	0.385	0.376	0.349	0.328	0.329	0.343	0.355	0.411	0.475	0.529	0.480	0.360

year

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	0.014	0.014	0.013	0.013	0.013	0.013	0.014	0.013	0.011	0.010
2	0.054	0.044	0.038	0.036	0.037	0.037	0.038	0.039	0.041	0.042	0.045	0.047	0.050
3	0.111	0.101	0.099	0.098	0.096	0.093	0.087	0.086	0.098	0.099	0.109	0.117	0.116
4	0.176	0.169	0.167	0.173	0.173	0.169	0.160	0.167	0.171	0.156	0.173	0.182	0.163
5	0.246	0.254	0.246	0.235	0.234	0.222	0.215	0.212	0.234	0.210	0.203	0.217	0.230
6	0.327	0.323	0.293	0.288	0.268	0.261	0.243	0.231	0.249	0.244	0.217	0.213	0.241
7	0.334	0.413	0.401	0.338	0.324	0.320	0.285	0.283	0.270	0.250	0.207	0.208	0.214
8	0.334	0.413	0.401	0.338	0.324	0.320	0.285	0.283	0.270	0.250	0.207	0.208	0.214
9	0.334	0.413	0.401	0.338	0.324	0.320	0.285	0.283	0.270	0.250	0.207	0.208	0.214
10	0.334	0.413	0.401	0.338	0.324	0.320	0.285	0.283	0.270	0.250	0.207	0.208	0.214
11	0.334	0.413	0.401	0.338	0.324	0.320	0.285	0.283	0.270	0.250	0.207	0.208	0.214
12	0.334	0.413	0.401	0.338	0.324	0.320	0.285	0.283	0.270	0.250	0.207	0.208	0.214

year

age	2019	2020	2021	2022
0	0.001	0.001	0.001	0.001
1	0.010	0.009	0.008	0.008
2	0.048	0.047	0.051	0.051
3	0.114	0.109	0.116	0.116
4	0.152	0.150	0.166	0.167
5	0.247	0.262	0.264	0.264
6	0.277	0.329	0.400	0.407
7	0.213	0.348	0.355	0.342
8	0.213	0.348	0.355	0.342
9	0.213	0.348	0.355	0.342
10	0.213	0.348	0.355	0.342
11	0.213	0.348	0.355	0.342
12	0.213	0.348	0.355	0.342

Table 8.8.3.1. NE Atlantic Mackerel. Short-term prediction: INPUT DATA

	Stock Numbers	M	Maturity ogive	Prop of F before spw.	Prop of M before spw.	Weights in the stock	Exploitation pattern	Weights in the catch
2022								
0	4497060	0.15	0.000	0.000	0.312	0.000	0.001	0.054
1	5025194	0.15	0.110	0.433	0.312	0.068	0.009	0.150
2	4317473	0.15	0.541	0.152	0.312	0.195	0.049	0.274
3	5459511	0.15	0.922	0.152	0.312	0.254	0.115	0.319
4	1413880	0.15	0.999	0.152	0.312	0.288	0.159	0.365
5	1344203	0.15	1.000	0.284	0.312	0.328	0.262	0.394
6	989652	0.15	1.000	0.284	0.312	0.354	0.335	0.429
7	350945	0.15	1.000	0.284	0.312	0.378	0.302	0.447
8	542972	0.15	1.000	0.284	0.312	0.394	0.302	0.463
9	399065	0.15	1.000	0.284	0.312	0.406	0.302	0.476
10	557747	0.15	1.000	0.284	0.312	0.432	0.302	0.498
11	472776	0.15	1.000	0.284	0.312	0.445	0.302	0.516
12+	581817	0.15	1.000	0.284	0.312	0.488	0.302	0.546
2023								
0	4497060	0.15	0.000	0.000	0.312	0.000	0.001	0.054
1	-	0.15	0.110	0.433	0.312	0.068	0.009	0.150
2	-	0.15	0.541	0.152	0.312	0.195	0.049	0.274
3	-	0.15	0.922	0.152	0.312	0.254	0.115	0.319
4	-	0.15	0.999	0.152	0.312	0.288	0.159	0.365
5	-	0.15	1.000	0.284	0.312	0.328	0.262	0.394
6	-	0.15	1.000	0.284	0.312	0.354	0.335	0.429
7	-	0.15	1.000	0.284	0.312	0.378	0.302	0.447
8	-	0.15	1.000	0.284	0.312	0.394	0.302	0.463
9	-	0.15	1.000	0.284	0.312	0.406	0.302	0.476
10	-	0.15	1.000	0.284	0.312	0.432	0.302	0.498
11	-	0.15	1.000	0.284	0.312	0.445	0.302	0.516
12+	-	0.15	1.000	0.284	0.312	0.488	0.302	0.546
2024								
0	4497060	0.15	0.000	0.000	0.312	0.000	0.001	0.054
1	-	0.15	0.110	0.433	0.312	0.068	0.009	0.150
2	-	0.15	0.541	0.152	0.312	0.195	0.049	0.274
3	-	0.15	0.922	0.152	0.312	0.254	0.115	0.319
4	-	0.15	0.999	0.152	0.312	0.288	0.159	0.365
5	-	0.15	1.000	0.284	0.312	0.328	0.262	0.394
6	-	0.15	1.000	0.284	0.312	0.354	0.335	0.429

	Stock Numbers	M	Maturity ogive	Prop of F before spw.	Prop of M before spw.	Weights in the stock	Exploitation pattern	Weights in the catch
7	-	0.15	1.000	0.284	0.312	0.378	0.302	0.447
8	-	0.15	1.000	0.284	0.312	0.394	0.302	0.463
9	-	0.15	1.000	0.284	0.312	0.406	0.302	0.476
10	-	0.15	1.000	0.284	0.312	0.432	0.302	0.498
11	-	0.15	1.000	0.284	0.312	0.445	0.302	0.516
12+	-	0.15	1.000	0.284	0.312	0.488	0.302	0.546

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.

2022			
TSB	**SSB**	**F_{bar}**	**Catch**
5 011 502	3 769 326	0.361	1 131 416

2023				2024		
TSB	**SSB**	**Fbar**	**Catch**	**TSB**	**SSB**	**Implied change in the catch**
4703613	3834187	0	0	5260647	4442903	-100%
-	3827916	0.01	33188	5232934	4408097	-97%
-	3821661	0.02	66109	5205449	4373667	-94%
-	3815422	0.03	98764	5178190	4339610	-91%
-	3809199	0.04	131156	5151155	4305920	-88%
-	3802991	0.05	163288	5124341	4272593	-86%
-	3796799	0.06	195161	5097748	4239624	-83%
-	3790623	0.07	226780	5071371	4207009	-80%
-	3784463	0.08	258145	5045210	4174744	-77%
-	3778318	0.09	289260	5019263	4142824	-74%
-	3772188	0.1	320127	4993527	4111245	-72%
-	3766074	0.11	350747	4968000	4080003	-69%
-	3759975	0.12	381124	4942680	4049094	-66%
-	3753892	0.13	411260	4917566	4018513	-64%
-	3747824	0.14	441156	4892655	3988258	-61%
-	3741771	0.15	470816	4867945	3958323	-58%

-	3735734	0.16	500241	4843435	3928704	-56%
-	3729712	0.17	529434	4819123	3899399	-53%
-	3723704	0.18	558397	4795006	3870403	-51%
-	3717712	0.19	587132	4771083	3841712	-48%
-	3711735	0.2	615640	4747353	3813322	-46%
-	3705773	0.21	643925	4723812	3785231	-43%
-	3699826	0.22	671989	4700460	3757434	-41%
-	3693894	0.23	699832	4677295	3729928	-38%
-	3687977	0.24	727458	4654314	3702709	-36%
-	3682074	0.25	754869	4631517	3675774	-33%
-	3676187	0.26	782066	4608901	3649119	-31%
-	3670314	0.27	809052	4586464	3622741	-28%
-	3664456	0.28	835827	4564206	3596637	-26%
-	3658612	0.29	862396	4542124	3570803	-24%
-	3652783	0.3	888758	4520217	3545237	-21%
-	3646969	0.31	914917	4498482	3519934	-19%
-	3641169	0.32	940874	4476920	3494891	-17%
-	3635384	0.33	966631	4455527	3470106	-15%
-	3629613	0.34	992190	4434302	3445576	-12%
-	3623856	0.35	1017552	4413244	3421297	-10%
-	3618114	0.36	1042720	4392350	3397266	-8%
-	3612386	0.37	1067695	4371621	3373481	-6%
-	3606673	0.38	1092479	4351053	3349939	-3%
-	3600973	0.39	1117074	4330646	3326635	-1%
-	3595288	0.4	1141482	4310398	3303569	1%
-	3589617	0.41	1165704	4290308	3280736	3%
-	3583960	0.42	1189741	4270373	3258135	5%
-	3578317	0.43	1213597	4250594	3235762	7%
-	3572688	0.44	1237271	4230967	3213615	9%
-	3567073	0.45	1260767	4211492	3191690	11%

-	3561472	0.46	1284085	4192167	3169986	13%
-	3555885	0.47	1307228	4172992	3148499	16%
-	3550312	0.48	1330196	4153964	3127228	18%
-	3544752	0.49	1352992	4135082	3106169	20%
-	3539207	0.5	1375617	4116345	3085321	22%
-	3533675	0.51	1398072	4097752	3064680	24%
-	3528157	0.52	1420360	4079300	3044244	26%
-	3522652	0.53	1442481	4060990	3024010	27%
-	3517161	0.54	1464437	4042819	3003978	29%
-	3511684	0.55	1486230	4024787	2984143	31%
-	3506220	0.56	1507861	4006892	2964504	33%
-	3500769	0.57	1529332	3989132	2945058	35%
-	3495332	0.58	1550643	3971507	2925803	37%
-	3489909	0.59	1571797	3954015	2906737	39%
-	3484499	0.6	1592795	3936656	2887858	41%
-	3479102	0.61	1613639	3919427	2869163	43%
-	3473718	0.62	1634329	3902328	2850651	44%
-	3468348	0.63	1654867	3885357	2832319	46%
-	3462991	0.64	1675254	3868514	2814165	48%
-	3457647	0.65	1695492	3851797	2796187	50%
-	3452316	0.66	1715583	3835205	2778383	52%
-	3446998	0.67	1735527	3818737	2760751	53%
-	3441693	0.68	1755325	3802392	2743289	55%
-	3436402	0.69	1774980	3786168	2725995	57%
-	3431123	0.7	1794492	3770065	2708867	59%
-	3425857	0.71	1813863	3754081	2691903	60%
-	3420605	0.72	1833093	3738216	2675101	62%
-	3415365	0.73	1852185	3722468	2658460	64%
-	3410137	0.74	1871139	3706836	2641977	65%
-	3404923	0.75	1889957	3691320	2625652	67%

-	3399721	0.76	1908639	3675917	2609481	69%
-	3394533	0.77	1927188	3660628	2593463	70%
-	3389356	0.78	1945604	3645451	2577596	72%
-	3384193	0.79	1963888	3630385	2561880	74%
-	3379042	0.8	1982041	3615429	2546311	75%
-	3373903	0.81	2000065	3600582	2530888	77%
-	3368778	0.82	2017962	3585844	2515611	78%
-	3363664	0.83	2035731	3571212	2500476	80%
-	3358563	0.84	2053374	3556687	2485482	81%
-	3353475	0.85	2070892	3542267	2470628	83%
-	3348399	0.86	2088287	3527952	2455912	85%
-	3343335	0.87	2105559	3513740	2441333	86%
-	3338283	0.88	2122709	3499630	2426889	88%
-	3333244	0.89	2139739	3485622	2412578	89%
-	3328217	0.9	2156649	3471714	2398399	91%
-	3323202	0.91	2173442	3457907	2384351	92%
-	3318200	0.92	2190116	3444198	2370432	94%
-	3313209	0.93	2206675	3430587	2356641	95%
-	3308231	0.94	2223118	3417074	2342975	96%
-	3303264	0.95	2239446	3403657	2329434	98%
-	3298310	0.96	2255662	3390335	2316017	99%
-	3293368	0.97	2271765	3377108	2302722	101%
-	3288437	0.98	2287757	3363974	2289547	102%
-	3283519	0.99	2303638	3350934	2276491	104%
-	3278612	1	2319410	3337986	2263554	105%
-	3273718	1.01	2335073	3325129	2250733	106%
-	3268835	1.02	2350629	3312362	2238027	108%
-	3263964	1.03	2366078	3299685	2225435	109%
-	3259104	1.04	2381422	3287098	2212956	110%
-	3254257	1.05	2396660	3274598	2200589	112%

-	3249421	1.06	2411795	3262186	2188331	113%
-	3244596	1.07	2426827	3249860	2176183	114%
-	3239783	1.08	2441756	3237621	2164143	116%
-	3234982	1.09	2456585	3225466	2152209	117%

Table 8.8.3.3. NE Atlantic Mackerel. Short-term prediction: Management option table for 1 131 416 t catch in 2022 and a range of catch options in 2023.

Rationale	Catch (2023)	F_{bar} (2023)	SSB (2023)	SSB (2024)	% SSB change *	% catch change **	% advice change ***
Catch(2023) = Zero	0	0.000	3834187	4442903	2%	-100%	-100%
Catch(2023) = 2022 catch -20%	905133	0.306	3649147	3494839	-3%	-20%	14%
Catch(2023) = 2022 catch	1131416	0.396	3597636	3333051	-5%	0%	42%
Catch(2023) = 2022 catch +25%	1414270	0.517	3529667	3131128	-6%	25%	78%
Fbar(2023) = 0.26 (Fmsy)	782066	0.260	3676187	3649119	-2%	-31%	-2%
Fbar(2023) = 0.36 (Fpa)	1042720	0.360	3618114	3397266	-4%	-8%	31%
Fbar(2023) = 0.46 (Flim)	1284085	0.460	3561472	3169986	-6%	13%	62%

*** SSB 2023 relative to SSB 2022.**

**** Catch in 2023 relative to assumed catches in 2022 (1 131 416 t). There is no internationally agreed TAC for 2022.**

***** Catch in 2023 relative to the advice value for 2022 (794 920 t).**

8.14 Figures

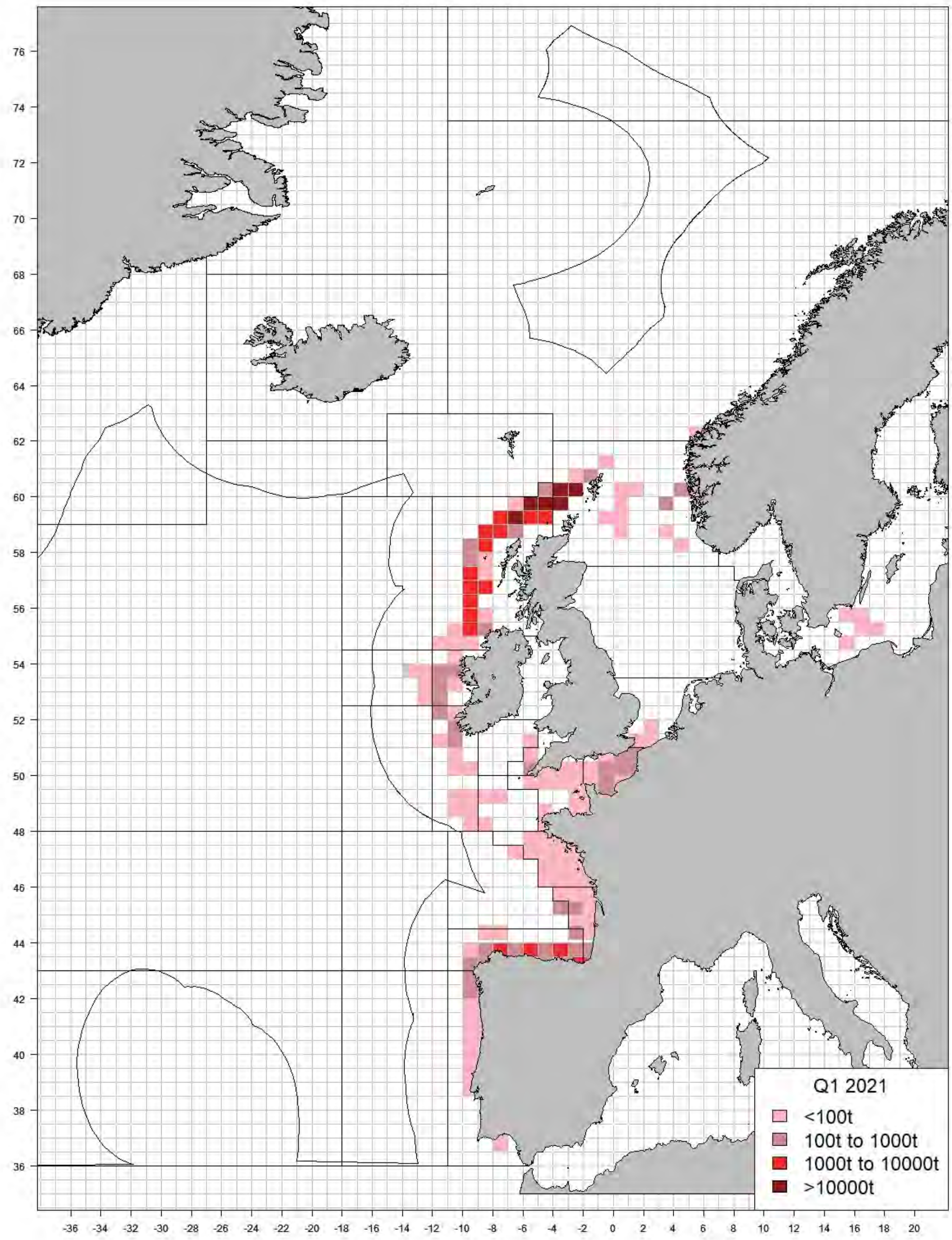


Figure 8.4.2.1. NE Atlantic Mackerel. Commercial catches in 2021, quarter 1.

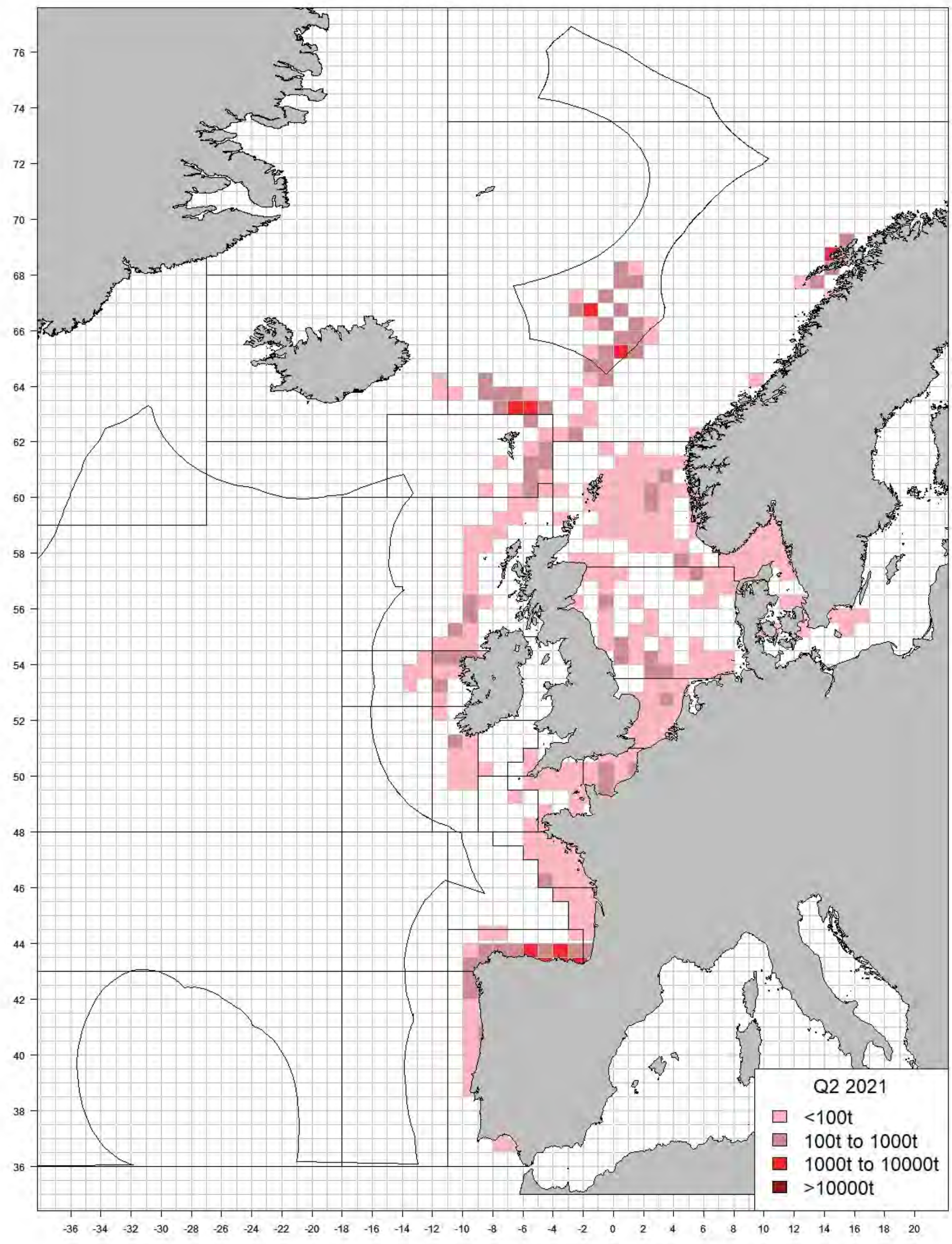


Figure 8.4.2.2. NE Atlantic Mackerel. Commercial catches in 2021, quarter 2.

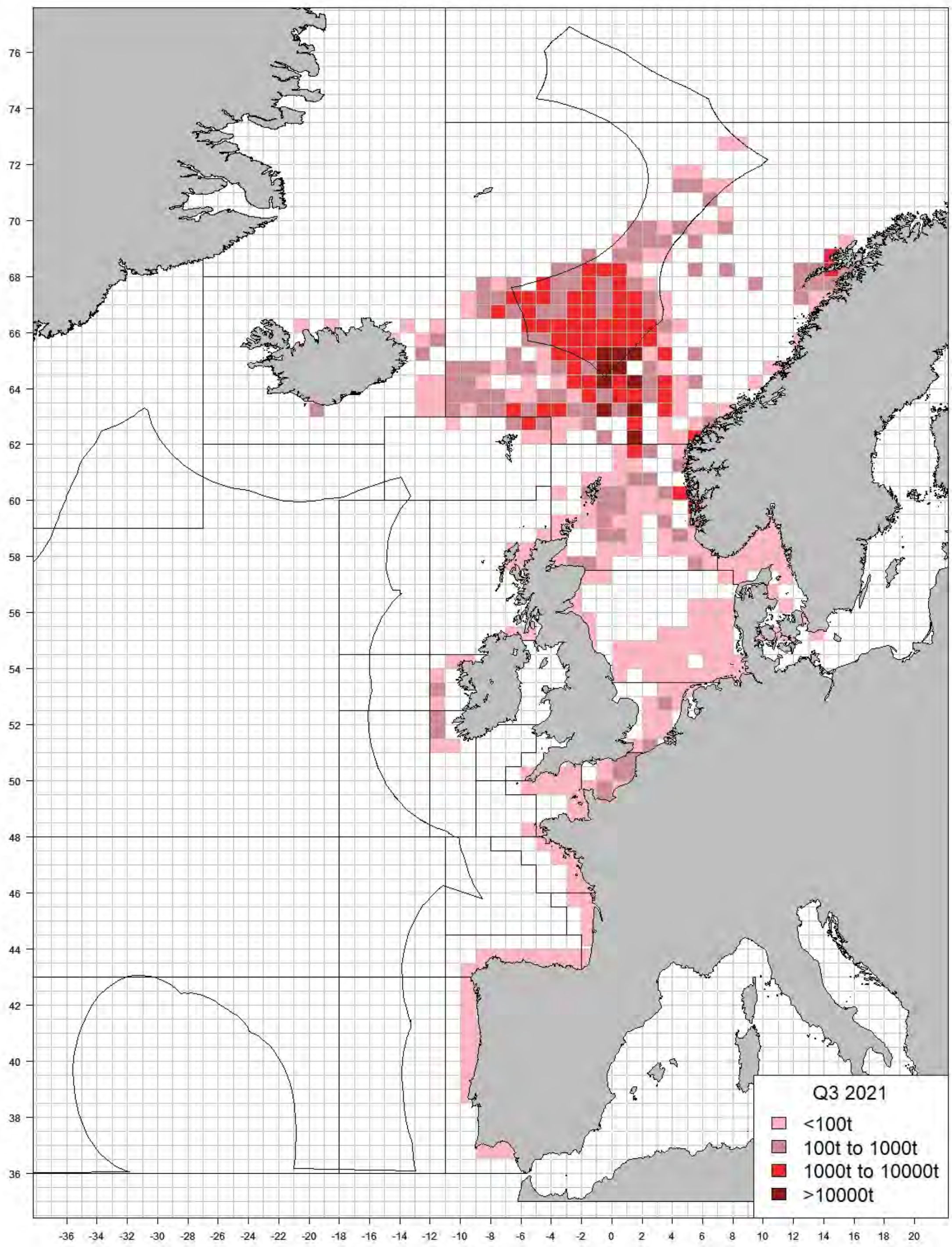


Figure 8.4.2.3. NE Atlantic Mackerel. Commercial catches in 2021, quarter 3.

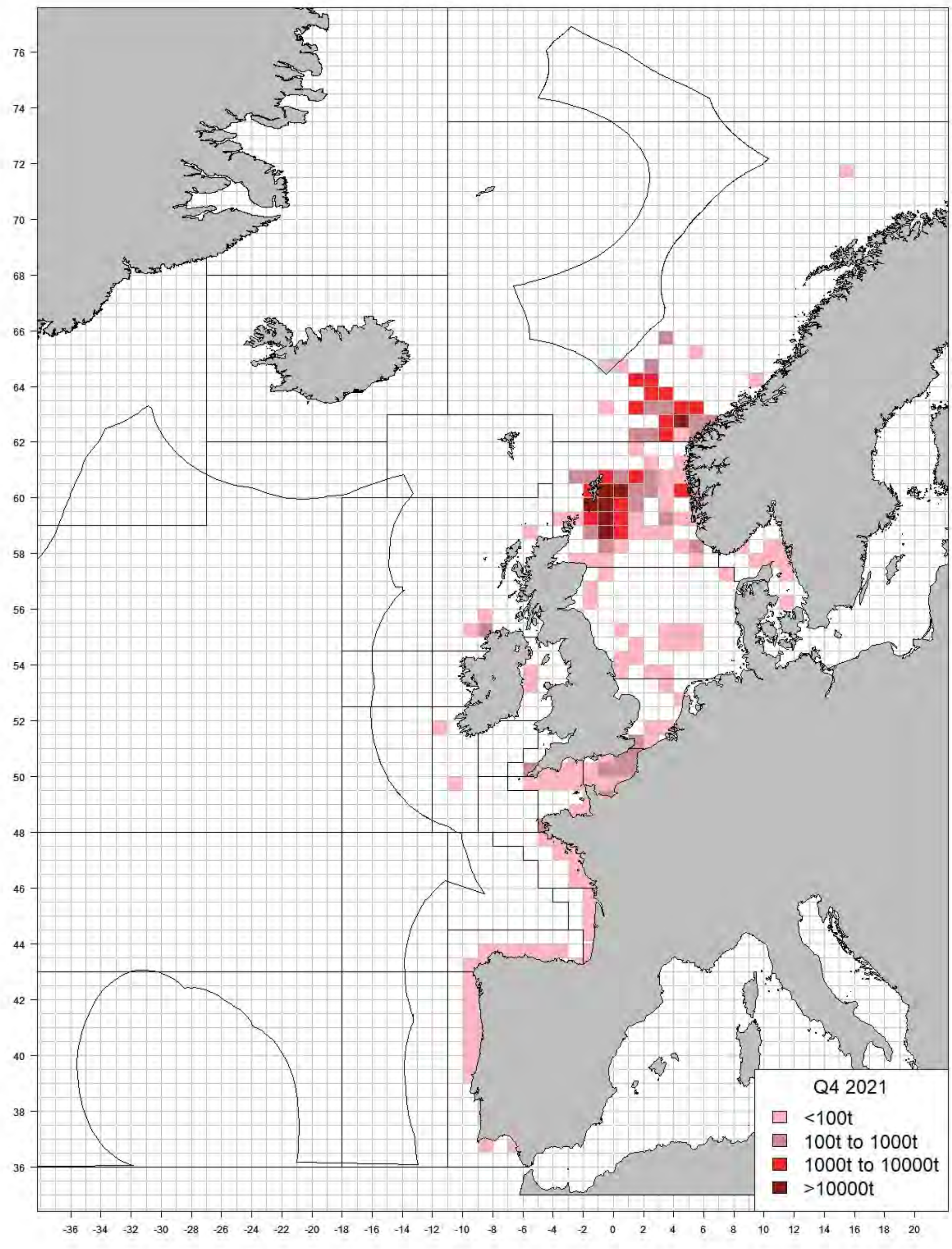


Figure 8.4.2.4. NE Atlantic Mackerel. Commercial catches in 2021, quarter 4.

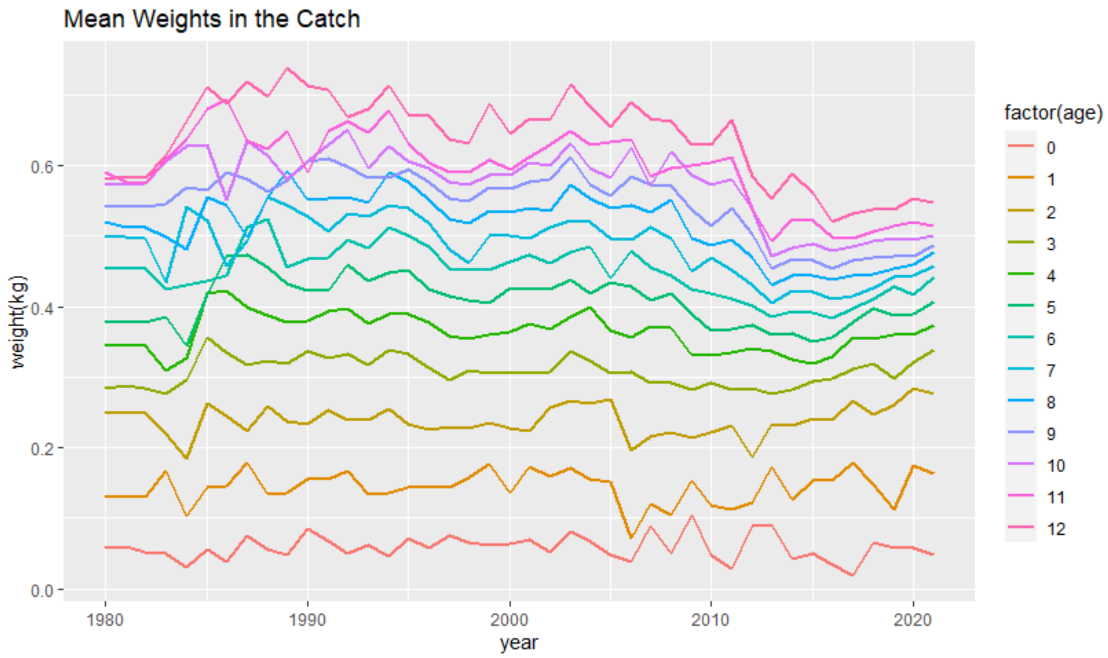


Figure 8.5.2.1. NE Atlantic mackerel. Weights-at-age in the catch.

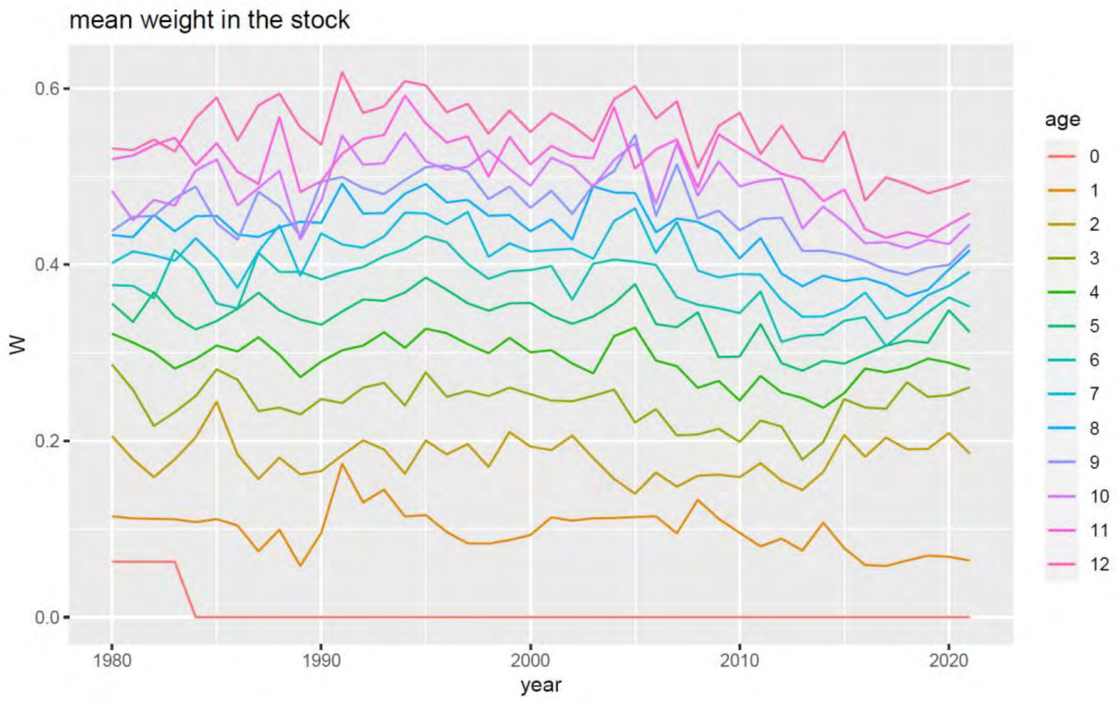


Figure 8.5.2.2. NE Atlantic mackerel. Weights-at-age in the stock.

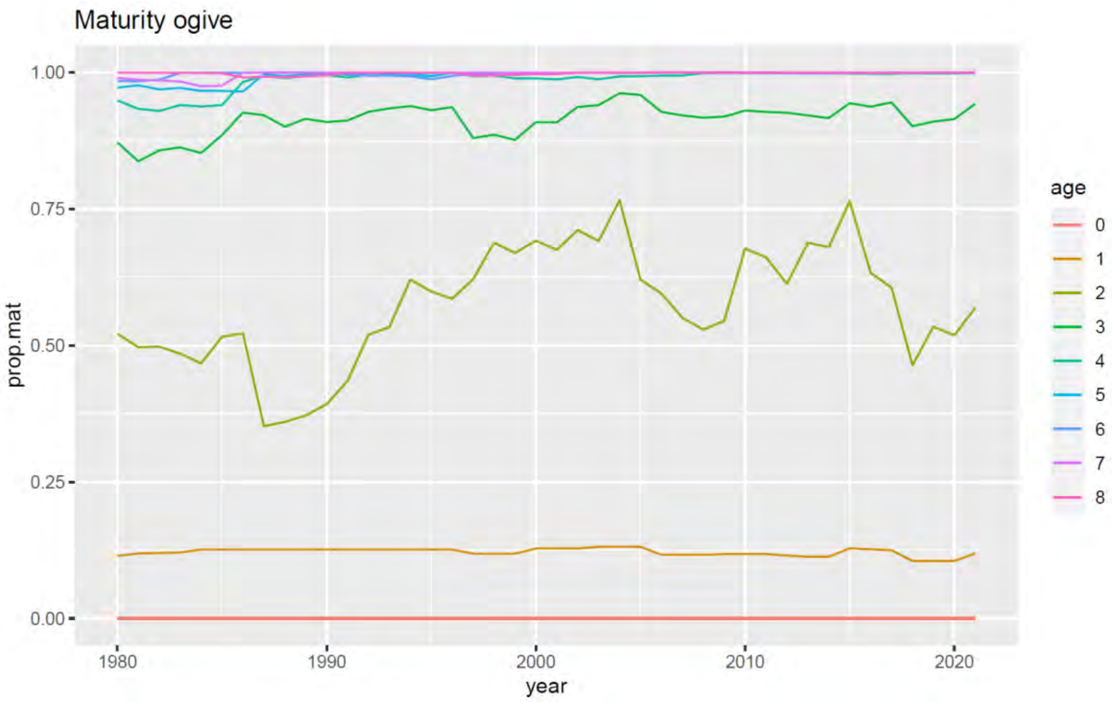


Figure 8.5.3.1. NE Atlantic mackerel. Proportion of mature fish at age.

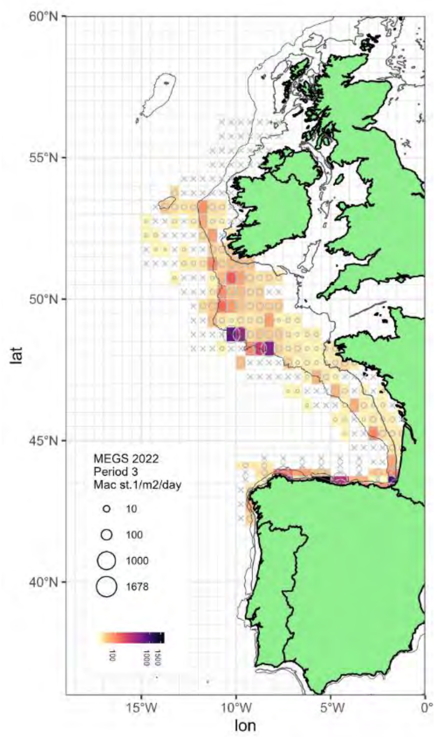


Figure 8.6.1.1.1. Mackerel egg production by half rectangle for period 3 (Mar 4th–Apr 8th). Circle areas and colour scale represent mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

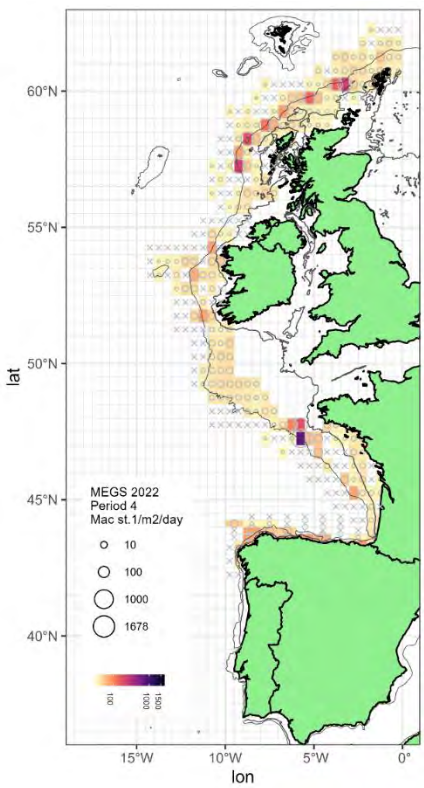


Figure 8.6.1.1.2. Mackerel egg production by half rectangle for period 4 (Apr 9th –29th). Circle areas and colour scale represent mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

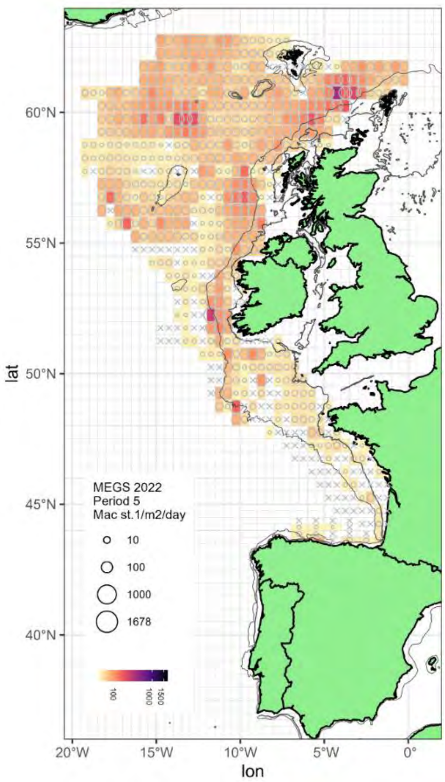


Figure 8.6.1.1.3. Mackerel egg production by half rectangle for period 5 (Apr 30th–May 31st). Circle areas and colour scale represent mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

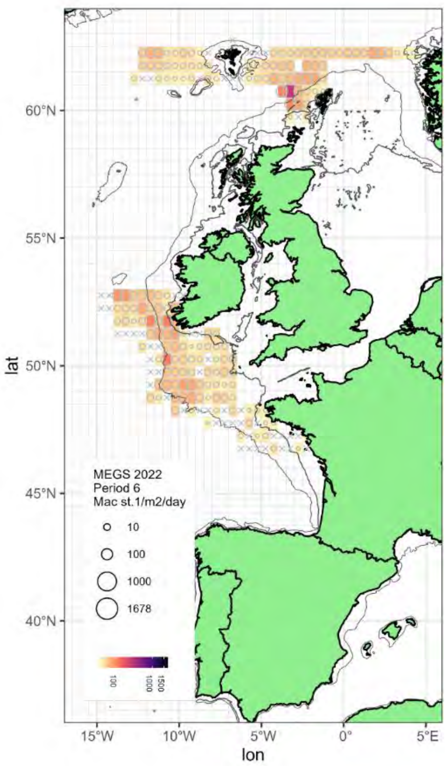


Figure 8.6.1.1.4. Mackerel egg production by half rectangle for period 6 (June 1st–30th). Circle areas and colour scale represent mackerel stage I eggs/m^2/day by half rectangle. Crosses represent zero values.

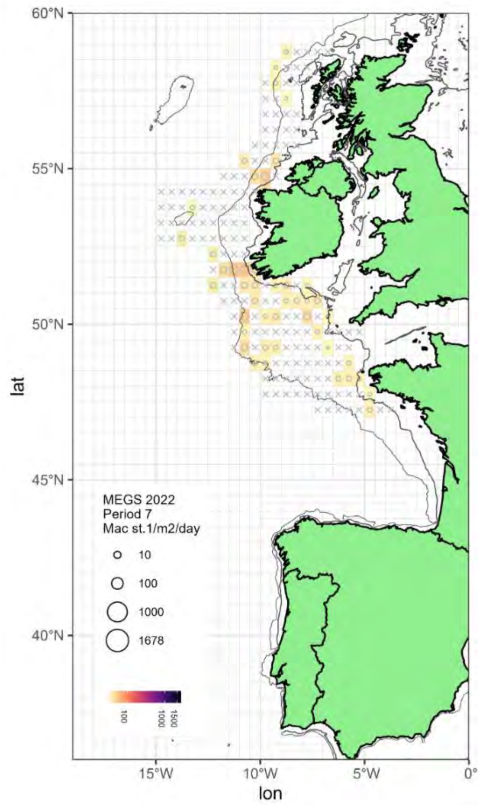


Figure 8.6.1.5. Mackerel egg production by half rectangle for period 7 (July 1st – 31st). Circle areas and colour scale represent mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

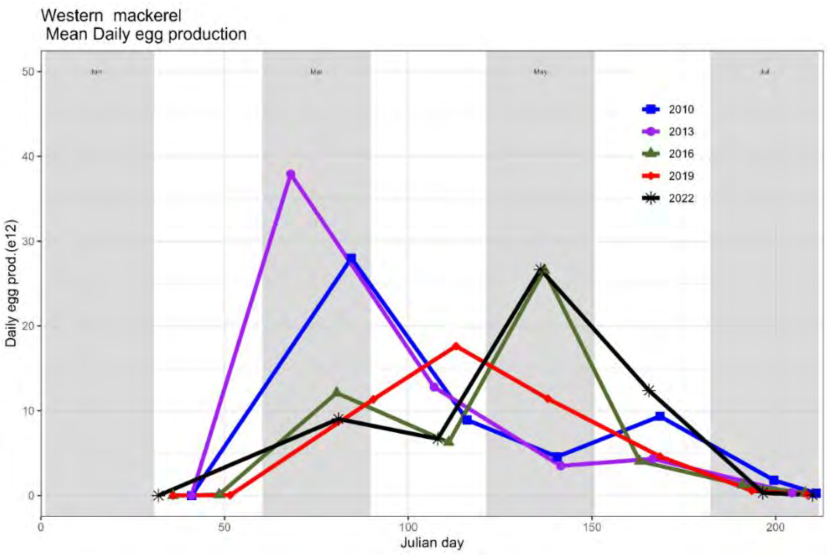


Figure 8.6.1.1.6. Provisional annual egg production curve for mackerel in the western component in 2022, (black line). The curves for 2007, 2010 2013 2016 and 2019 are included for comparison.

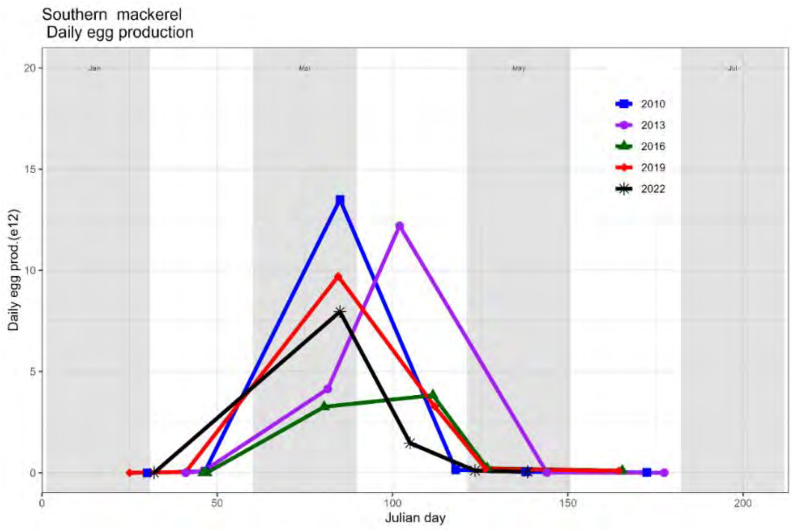


Figure 8.6.1.1.7. Provisional annual egg production curve for mackerel in the southern component in 2022, (black line). The curves for 2007, 2010 2013 2016 and 2019 are included for comparison.

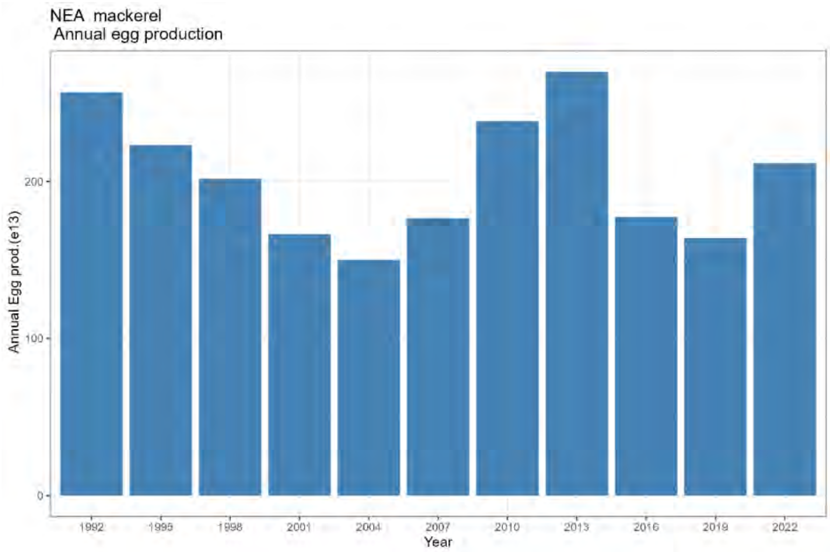


Figure 8.6.1.1.8. Combined mackerel TAEP estimates (*10^{13}) - 1992 – 2022.

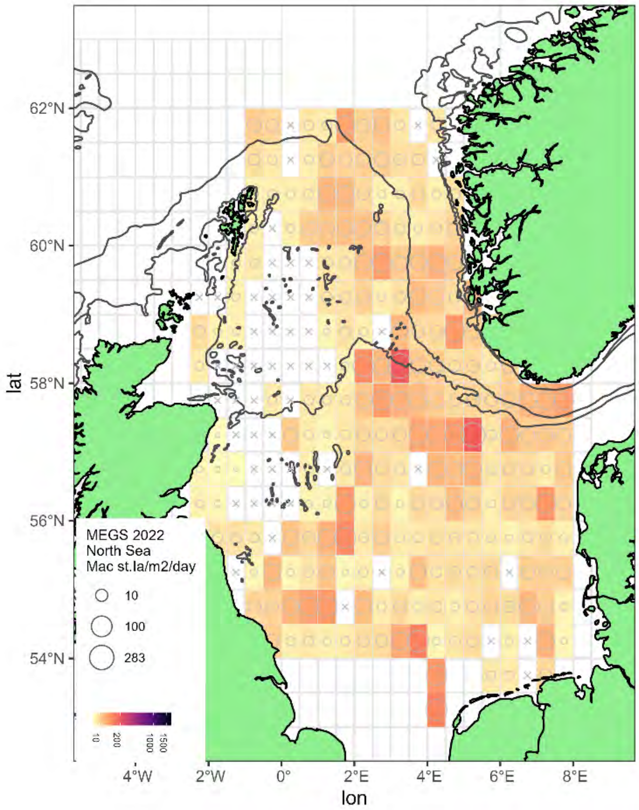


Fig. 8.6.1.5.1. Stage 1a mackerel egg production (eggs/m2/day) by half rectangle for NSMEGS 2022. Circle areas and colour scale represent mackerel stage 1 eggs/m2/day by half rectangle. Crosses represent zero values.

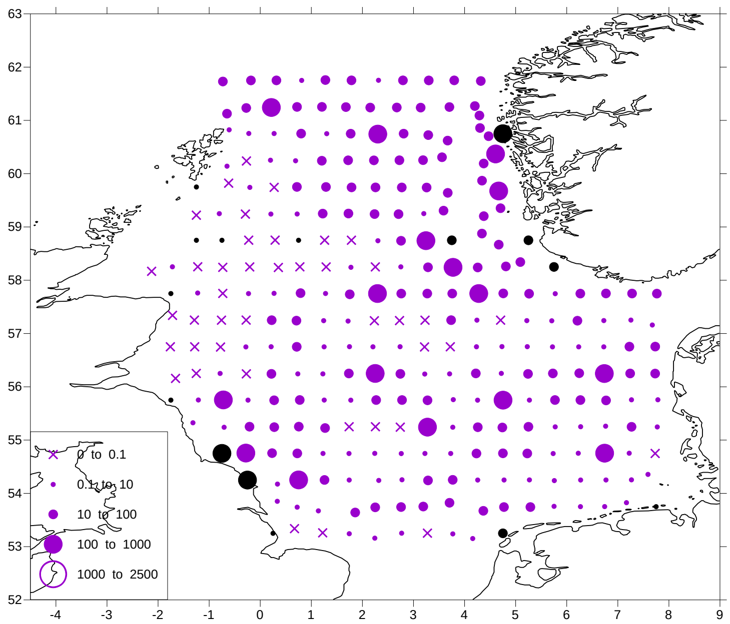


Figure 8.6.1.6.1. Stage Ia mackerel egg production (eggs/m²/day) by half rectangle for NSMEGS 2021. Purple circles represent observed values, black circles represent interpolated values, and crosses represent observed zeros.

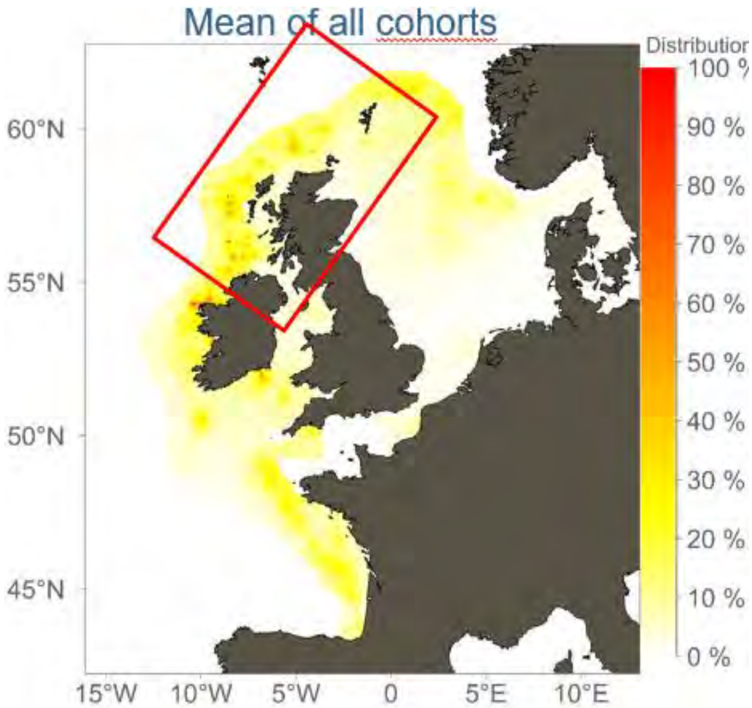


Figure 8.6.2.1. Spatial distribution of mackerel juveniles at age 0 in October to March. Average for cohorts from 1998-2020. Mackerel squared catch rates by trawl haul (circle areas represent catch rates in kg/km2) overlaid on modelled squared catch rates per 10 x 10 km rectangle. Each rectangle is coloured according to the expected squared catch rate in percent of the highest value for that year. See Jansen *et al.* (2015) for details. Red box indicates the approximate typical coverage of the IBTS-NS Q1 and SWC Q1 surveys.

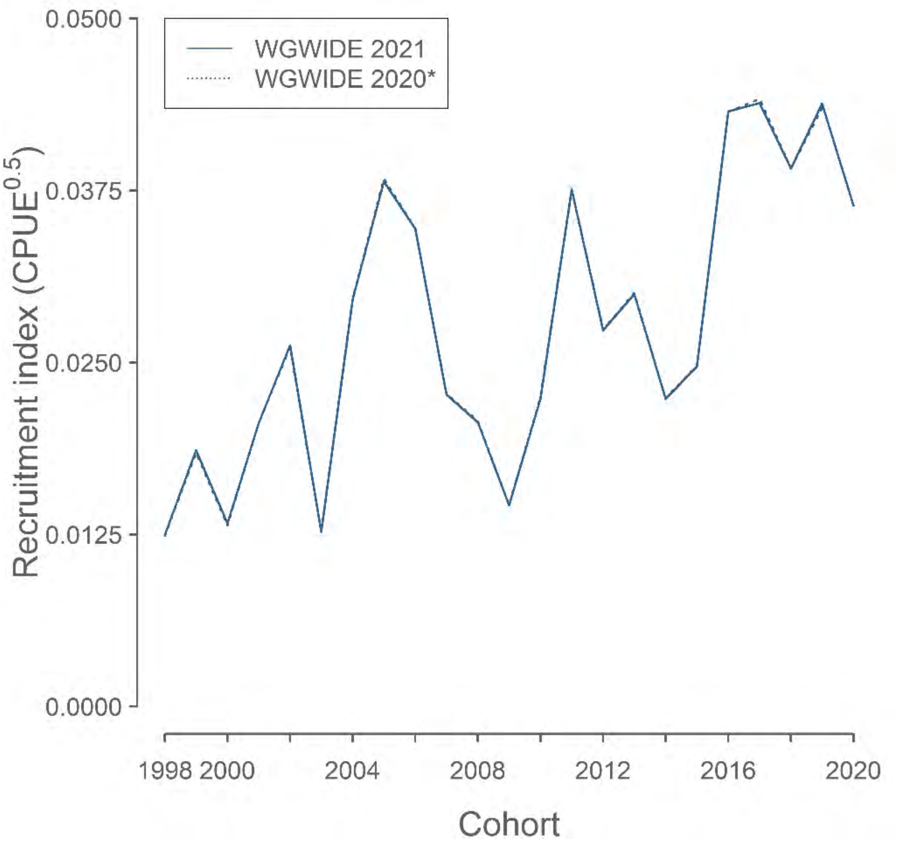


Figure 8.6.2.2. Index of mackerel juveniles at age 0 in October to March proxied by annual integration of square root of expected catch in demersal trawl surveys (Blue lines). See Jansen *et al.* (2015) for details. * Rescaled

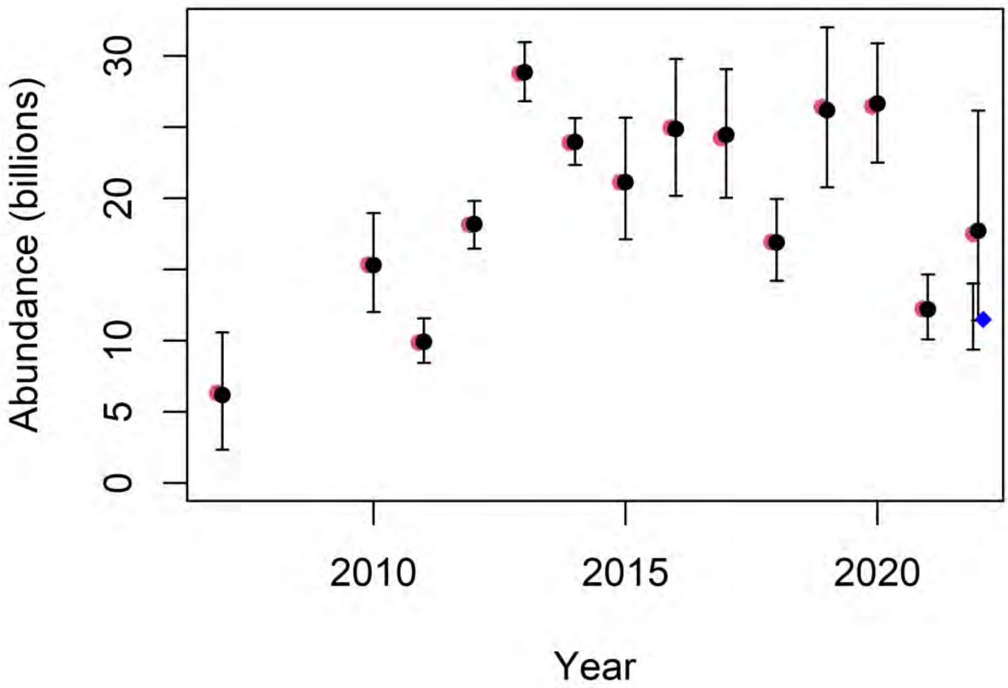


Figure 8.6.3.1. Estimated total stock numbers (TSN) of mackerel from IESSNS calculated using StoX for the years 2007 and from 2010 to 2022. Displayed is StoX baseline estimate (red dot) and a bootstrap estimate (black dot), calculated using 1000 replicates, with 90% confidence intervals (vertical line) based on the bootstrap. Analysis excludes the North Sea and survey coverage was incomplete in 2007 and 2011. For 2022, index value is also calculated excluding the two extreme catches (filled blue diamond) including 90% confidence interval.

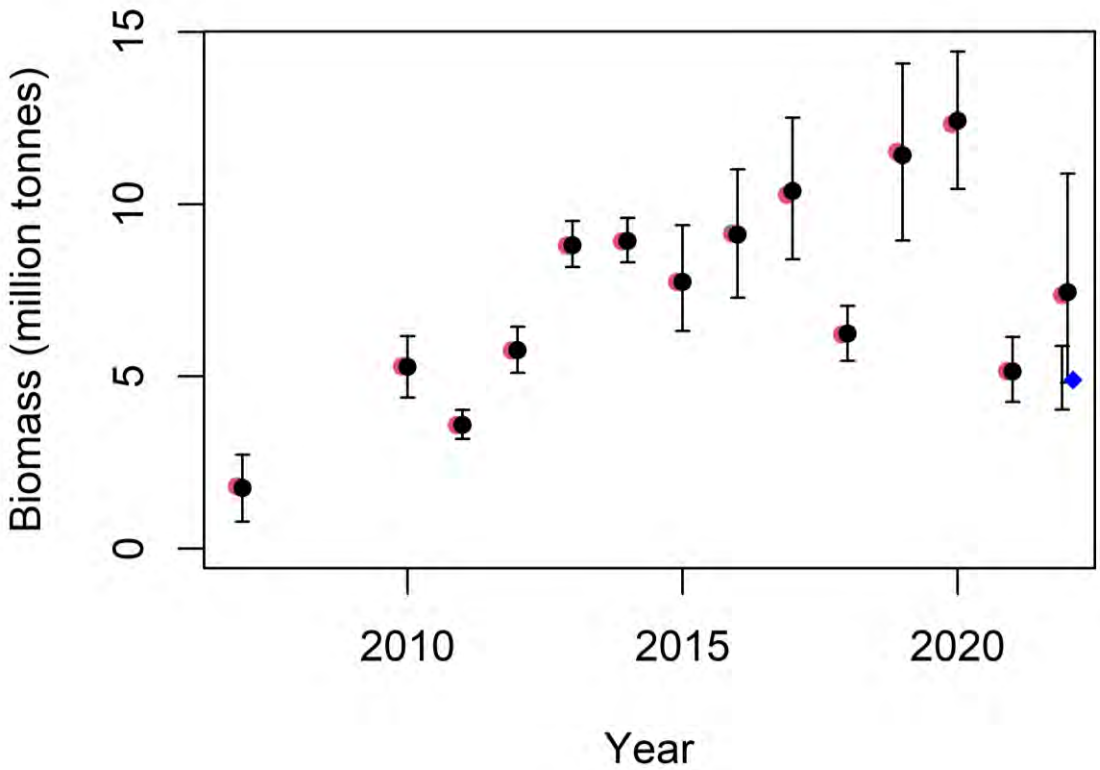


Figure 8.6.3.2. Estimated total stock biomass of mackerel from IESSNS calculated using StoX for the years 2007 and from 2010 to 2022. Displayed is StoX baseline estimate (red dot) and a bootstrap estimate (black dot), calculated using 1000 replicates, with 90% confidence intervals (vertical line) based on the bootstrap. Analysis excludes the North Sea and

survey coverage was incomplete in 2007 and 2011. For 2022, index value is also calculated excluding the two extreme catches (filled blue diamond) including 90% confidence interval.

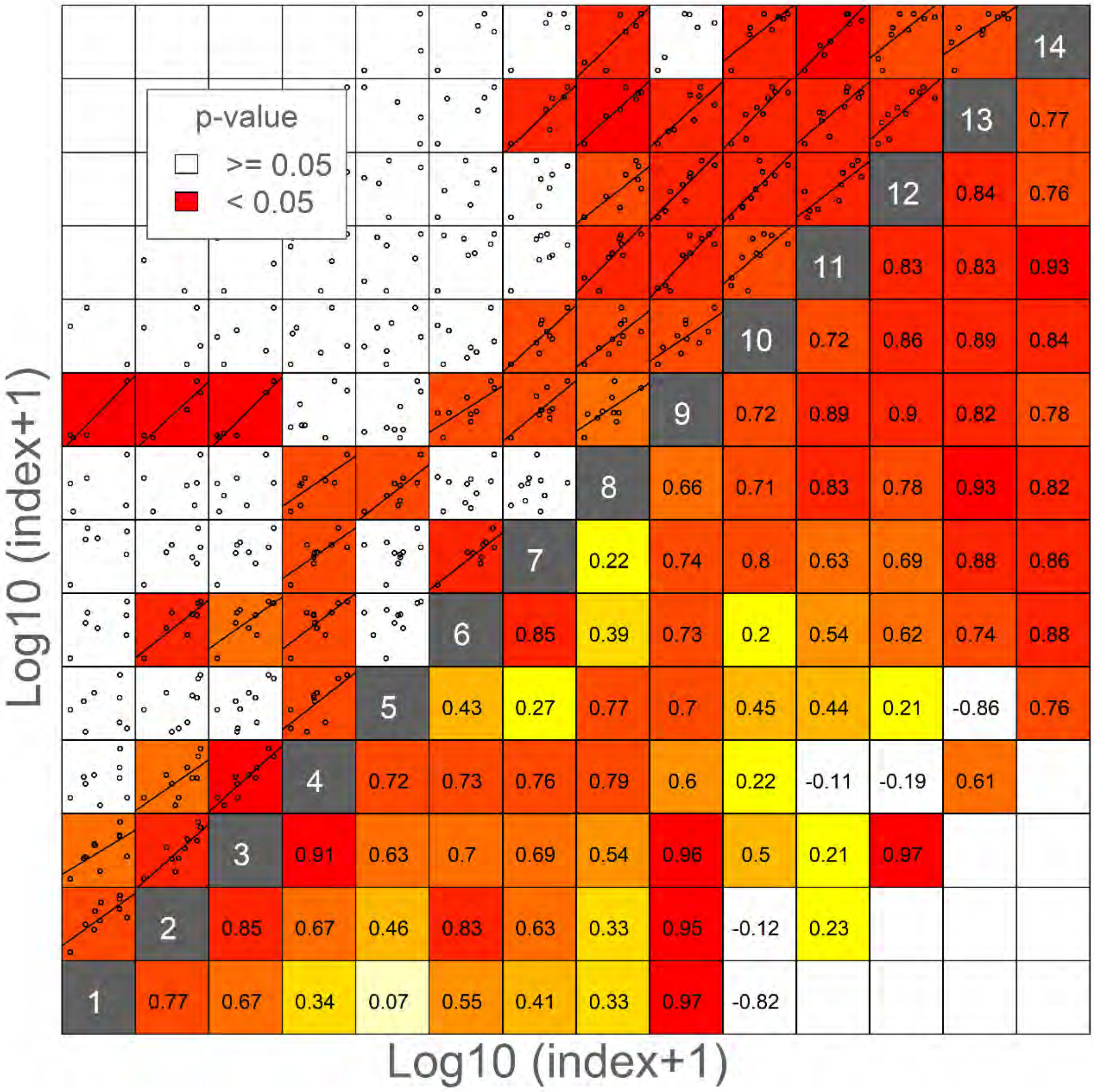


Figure 8.6.3.3. Internal consistency of the mackerel abundance index from the IESSNS survey including data from 2012 to 2022, excluding North Sea. Ages indicated by white numbers in grey diagonal cells. Statistically significant positive correlations (*p<0.05*) are indicated by regression lines and red cells in upper left half. Correlation coefficients (r) are given in the lower right half.

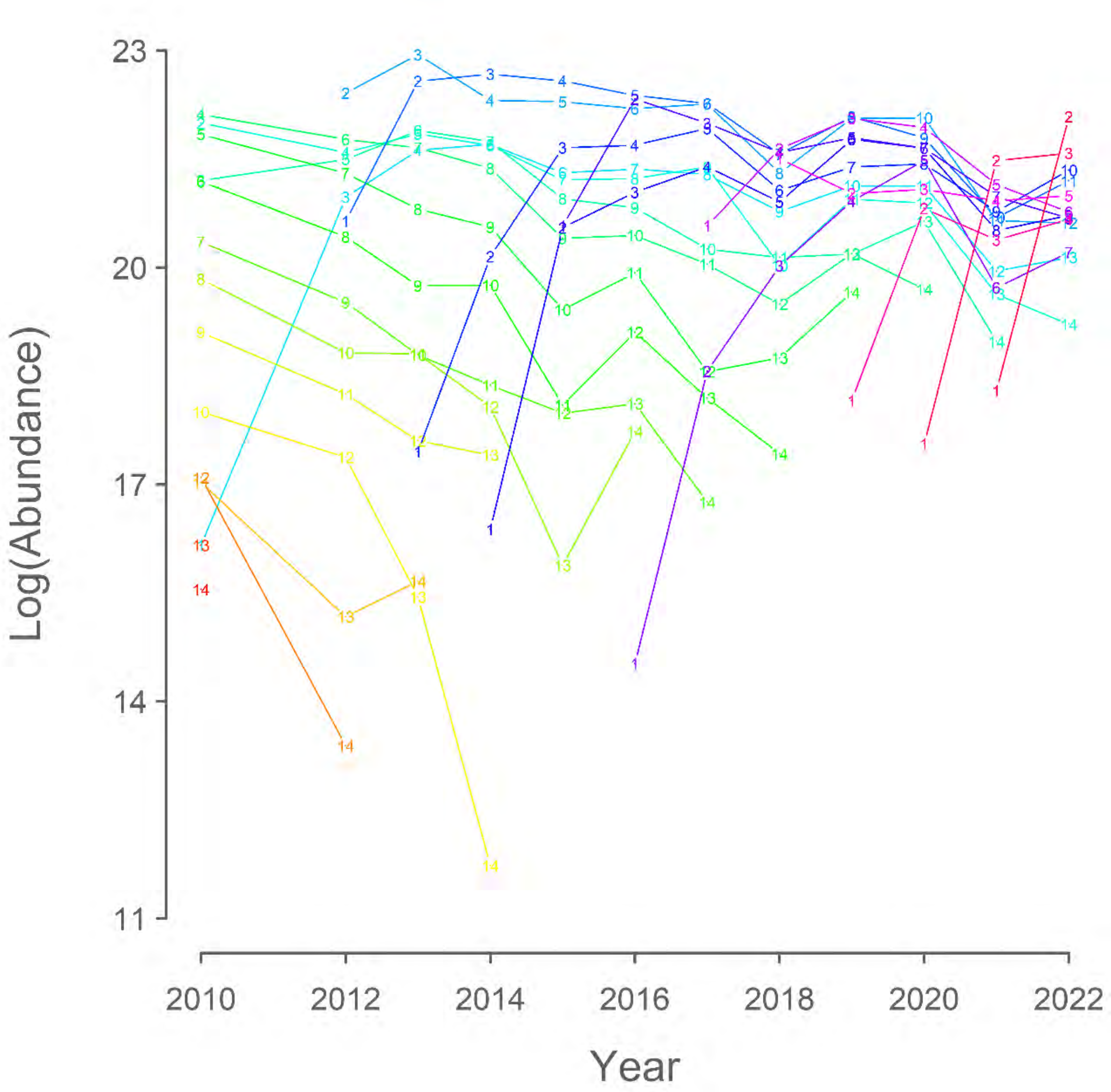


Figure 8.6.3.4. Mackerel catch curves from the estimate stock size at age from the IESSNS in 2010 and from 2012 to 2022, excluding the North Sea. Each cohort is marked by a uniquely coloured line that connects the estimates indicated by the respective ages.

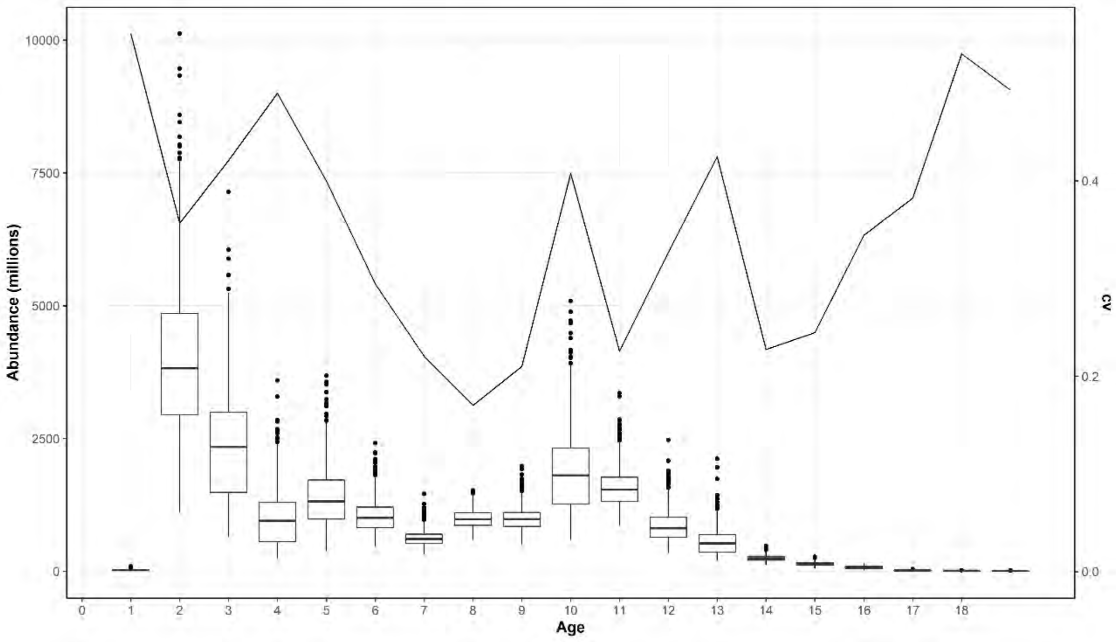


Figure 8.6.3.5. Mackerel numbers by age from the IESSNS survey in 2022, excluding North Sea. Boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 1000 replicates using StoX version 3.5.0.

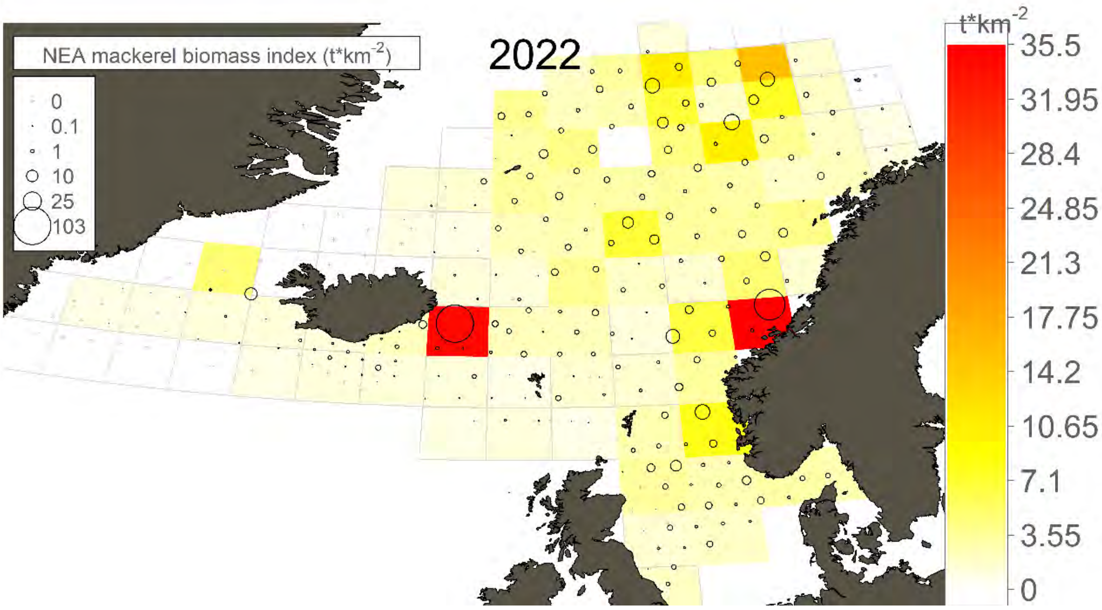


Figure 8.6.3.6. Mackerel catch rates from predetermined surface trawl stations (circle size represents catch rate in kg/km2) overlaid on mean catch rate per standardized rectangle (2° lat. x 4° lon.) from the 2022 IESSNS, including North Sea. Zero mackerel catches are displayed as grey crosses.

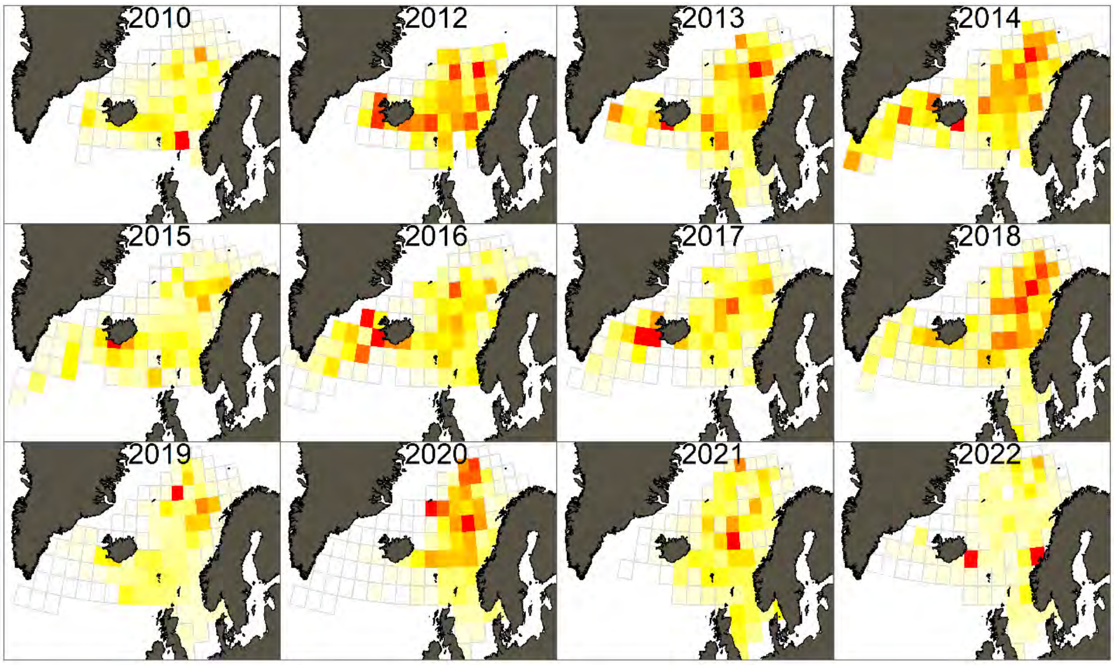


Figure 8.6.3.7. Mackerel annual distribution proxied by the absolute distribution of mean mackerel catch rates per standardized rectangles (2° lat. x 4° lon.), from predetermined surface trawl stations from IESSNS in 2010 to 2022, including North Sea. Colour scale goes from white (= 0) to red (= maximum value for the given year).

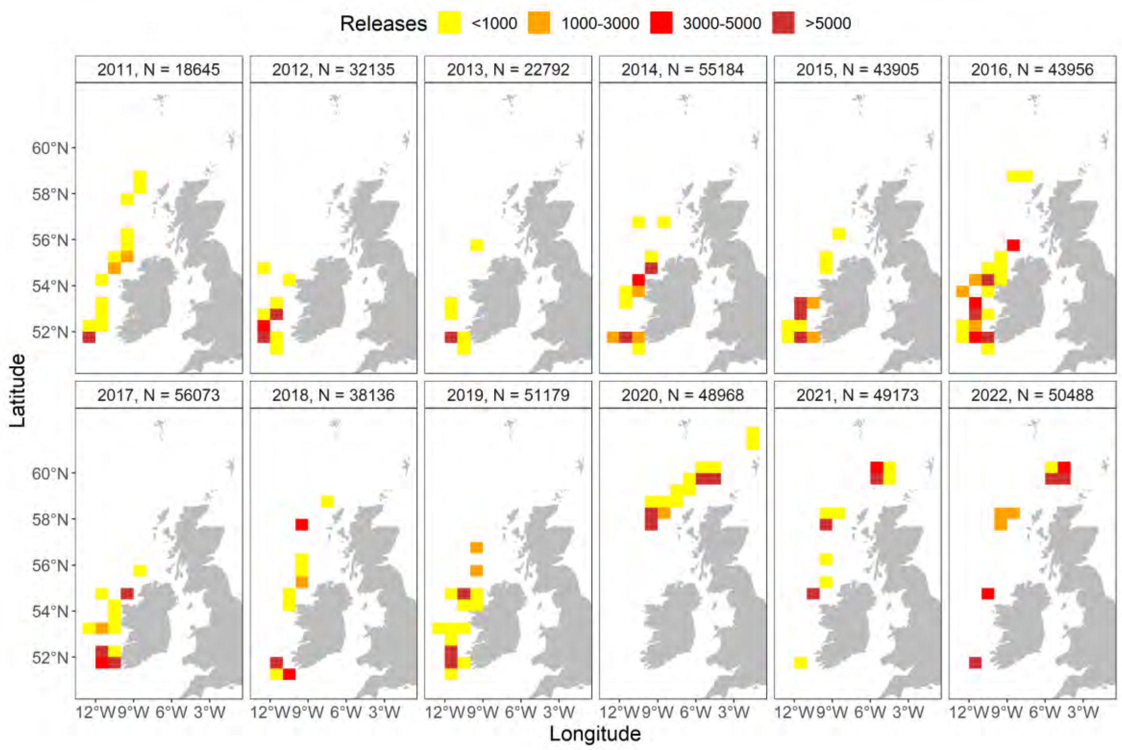


Figure 8.6.4.1. Number and distribution of RFID tagged mackerel from experiments west of Ireland and British Isles during 2011-2022. Note that data from releases 2011-2012 are not used in the stock assessment, based on decisions in the ICES IBPNEAMac 2019 meeting (ICES 2019c), and data from experiments in 2021-2022 are not included as there are no full years with recaptures yet.

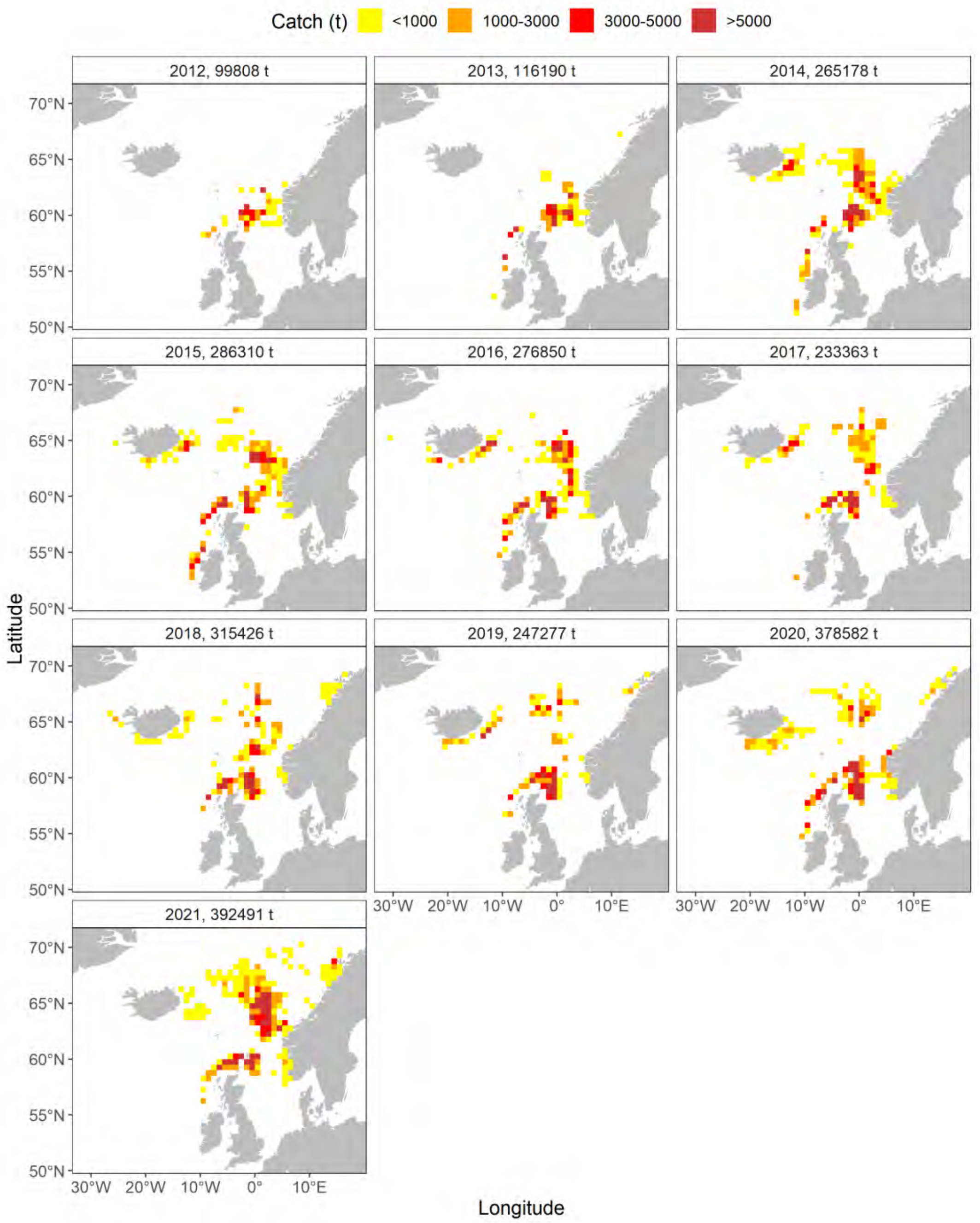


Figure 8.6.4.2. Biomass and distribution of catches scanned for RFID tagged mackerel during 2012-2021. Note that data from scanned catches in 2012-2013 are not used in the stock assessment based on decisions in the ICES IBPNEAMac 2019 meeting (ICES 2019c).

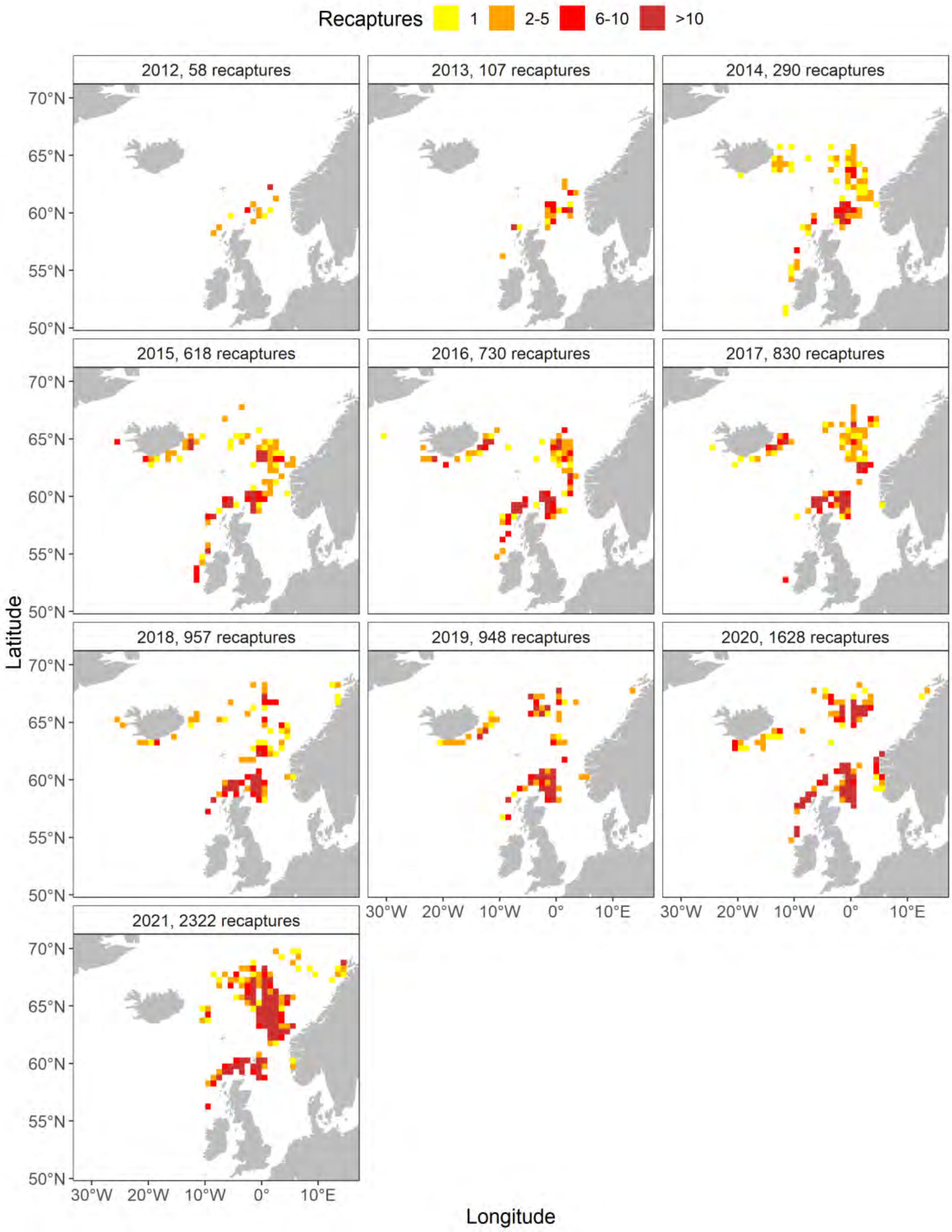
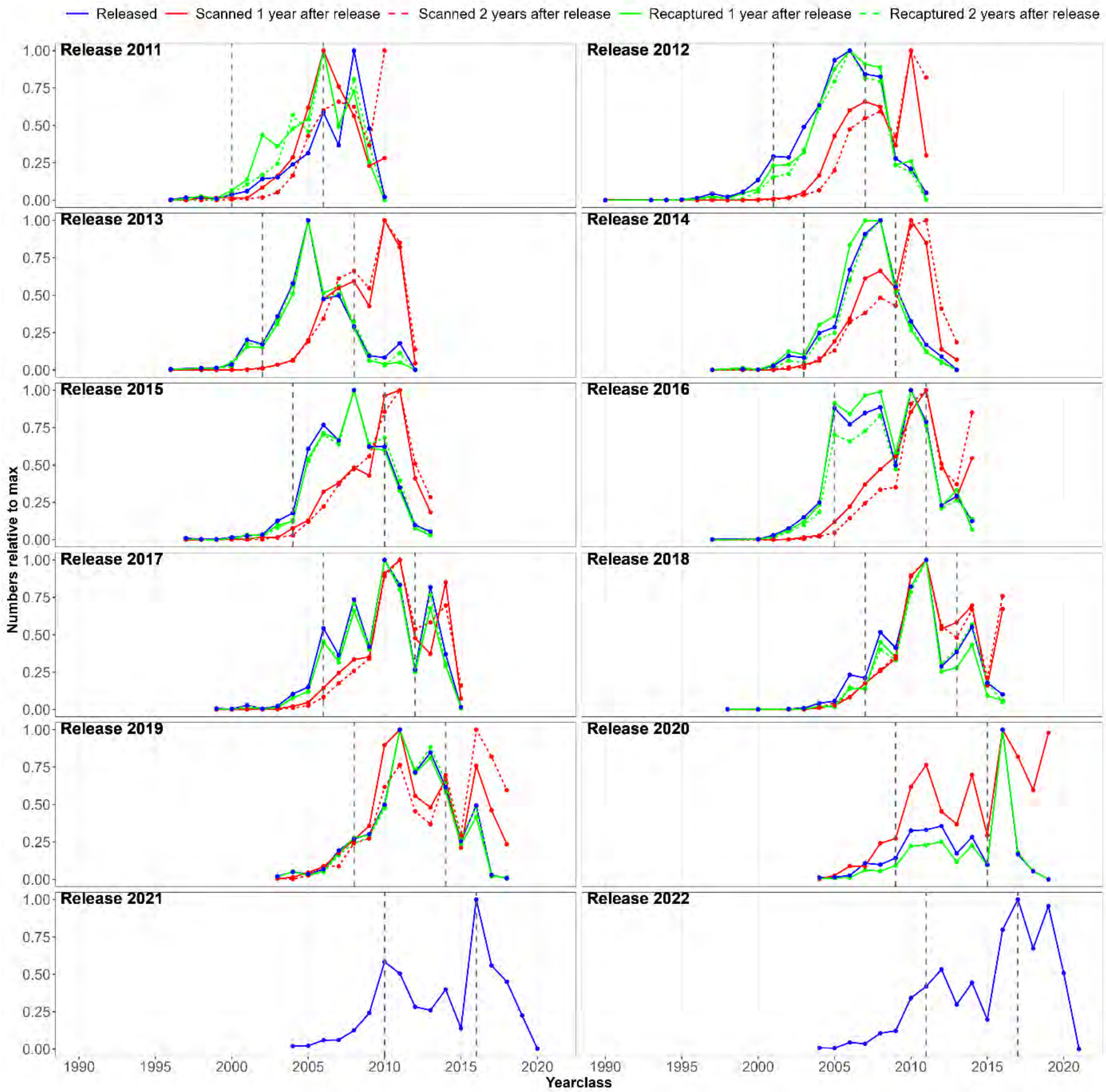


Figure 8.6.4.3. Distribution of recaptures of RFID tagged mackerel during 2012-2021. Note that data on recaptures in 2012-2013 are not used in the stock assessment based on decisions in the ICES IBPNEAMac 2019 meeting (ICES 2019c).



8.6.4.4. Overview of the relative year class distributions among RFID tagged mackerel per release year from experiments west of Ireland and British Isles in May-June compared with scanned and recaptured fish 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.

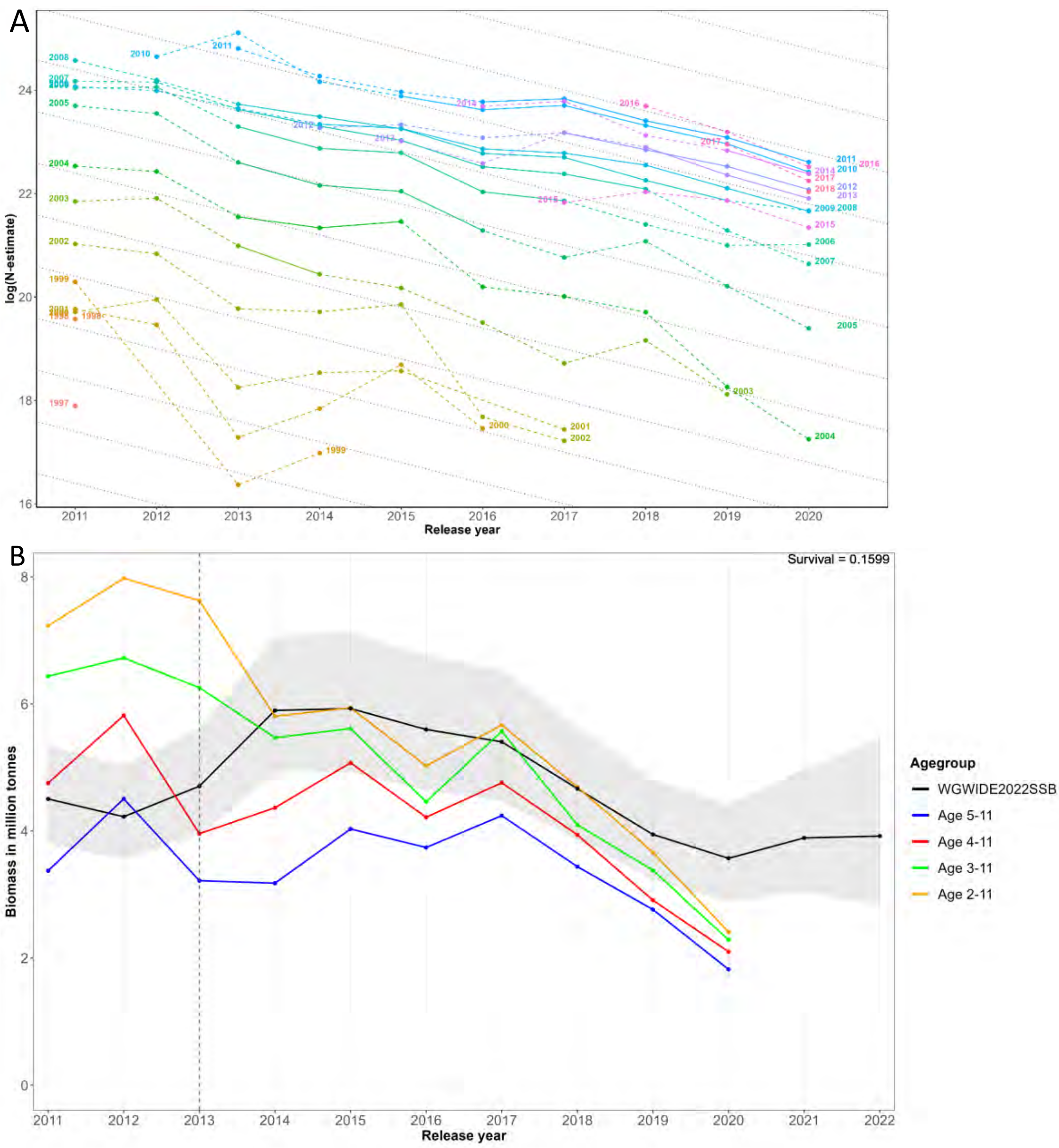


Figure 8.6.4.5. (A) Trends in year class abundance (N=numbers released/numbers recaptured*numbers scanned) from RFID tag-recapture data based on aggregated data on recaptures and scanned numbers in year 1 and 2 after each release year. Data excluded in the stock assessment based on decisions in the ICES IBPNEAMac 2019 meeting (ICES 2019c), release years 2011-2012 and ages 2-4 and 12+, are marked with dotted lines in year class trends. (B) Trends in various age aggregated biomass indices from RFID tag-recapture data compared with the SSB (±95 confidence intervals) from the WGWIDE 2022 stock assessment. Data are based on a combination of estimated numbers by year class (A) scaled by survival parameter (0.1599) and weight at age in stock from WGWIDE 2022. Vertical dotted line marks the starting year where RFID tagging experiments are used in the stock assessment. Note that final year with RFID biomass estimates in 2020 is only based on recapture year 2021 and will likely change when adding recapture year 2022 in WGWIDE 2023.

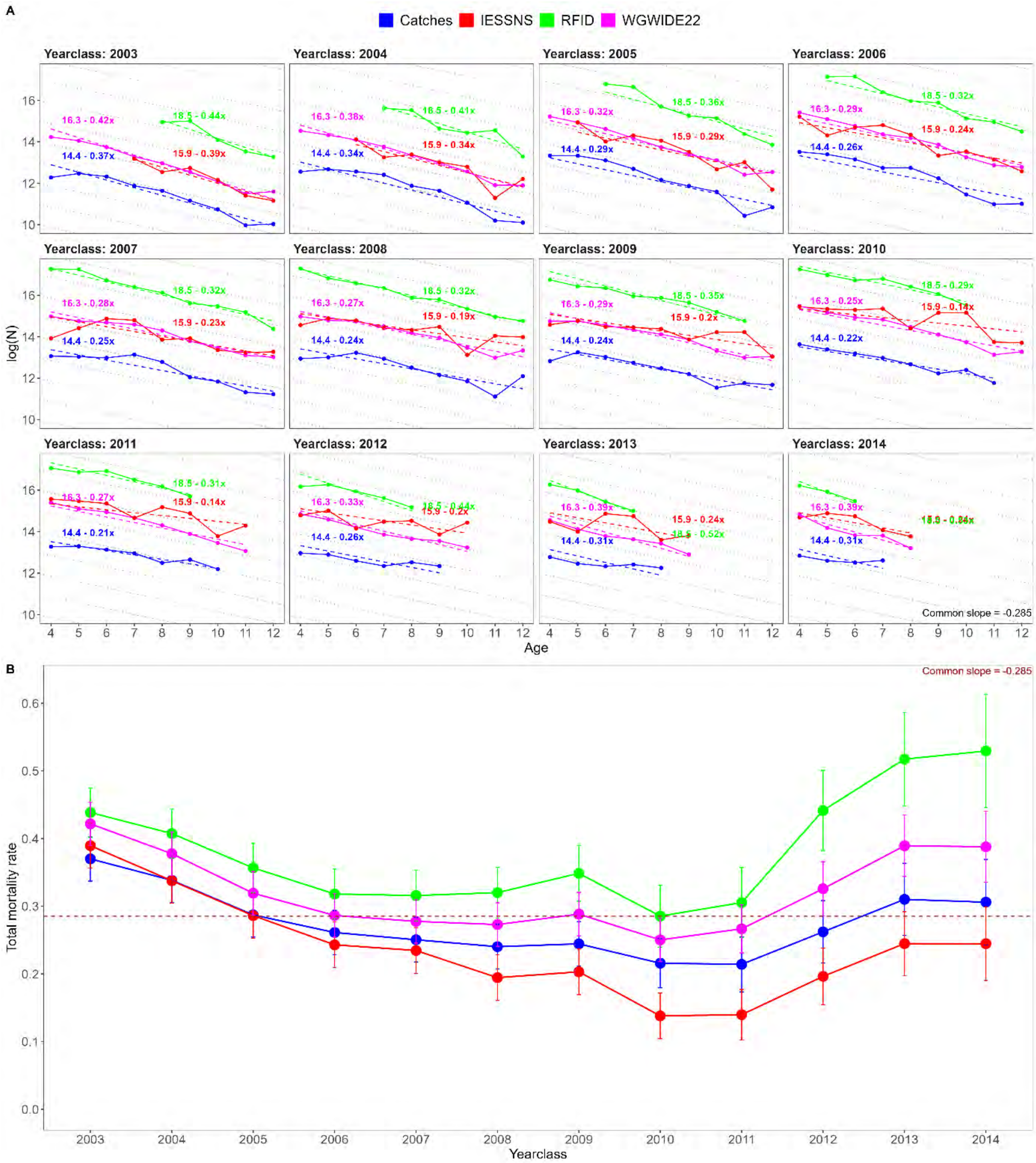


Figure 8.6.4.6. Signals of total mortality rate (Z). (A) Trends in abundance of year classes 2003-2014 from unscaled input data (RFID, IESSNS and catches) and the WGWIDE2022 stock assessment. The estimated slope of decrease from the age 4 when it is fully recruited to the spawning stock until age 12 is interpreted as signal Z, grey dotted lines is Z=0.4. (B) The estimated year class differences in Z (with 95% confidence intervals), and corresponding differences between the various data sources.

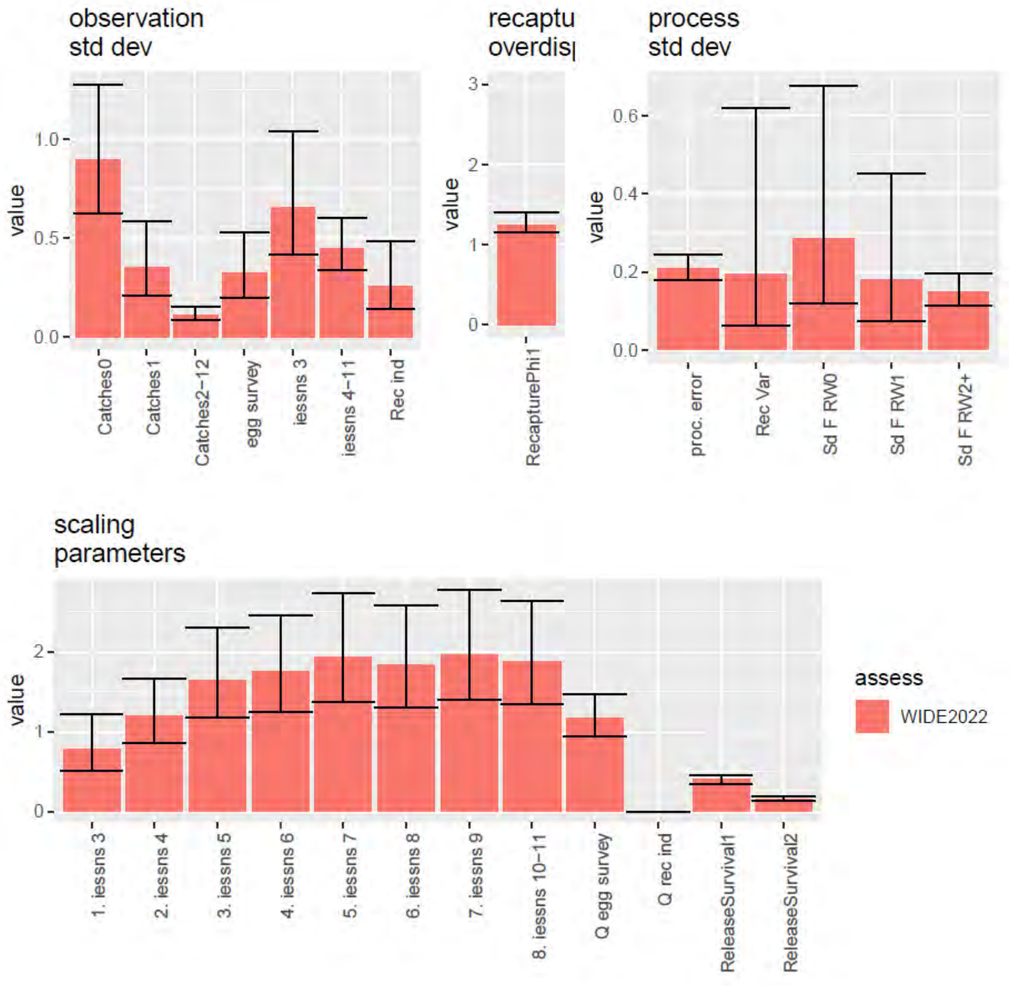


Figure 8.7.2.1. NE Atlantic mackerel. Parameter estimates from the SAM model (and associated confidence intervals) for the WGWIDE 2022 update assessment. top left : estimated standard deviation for the observation errors, top centre : estimated overdispersion for the errors on the tag recaptures, top right : standard deviation for the processes, bottom : survey catchabilities and post-release survival of tagged fish.

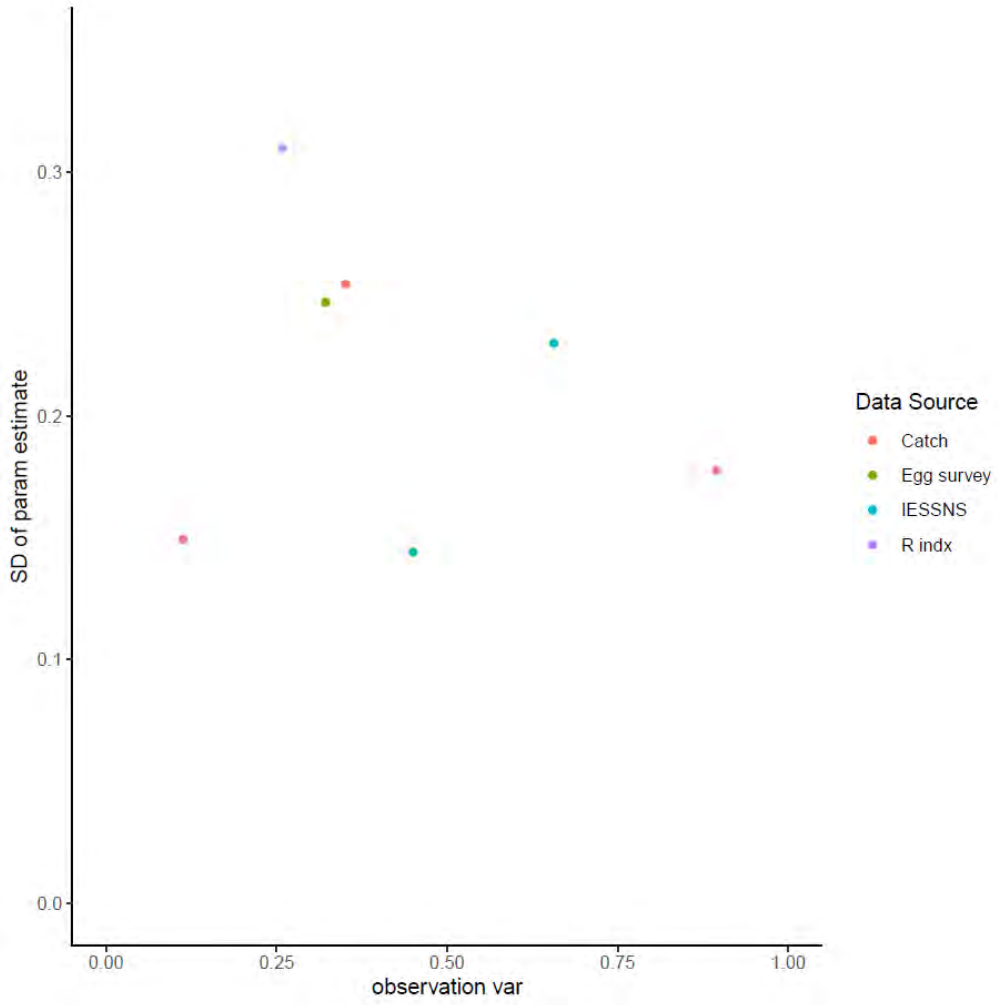


Figure 8.7.2.2. NE Atlantic mackerel. Parameter uncertainty (standard deviation of estimate) versus parameter value for the observation variances.

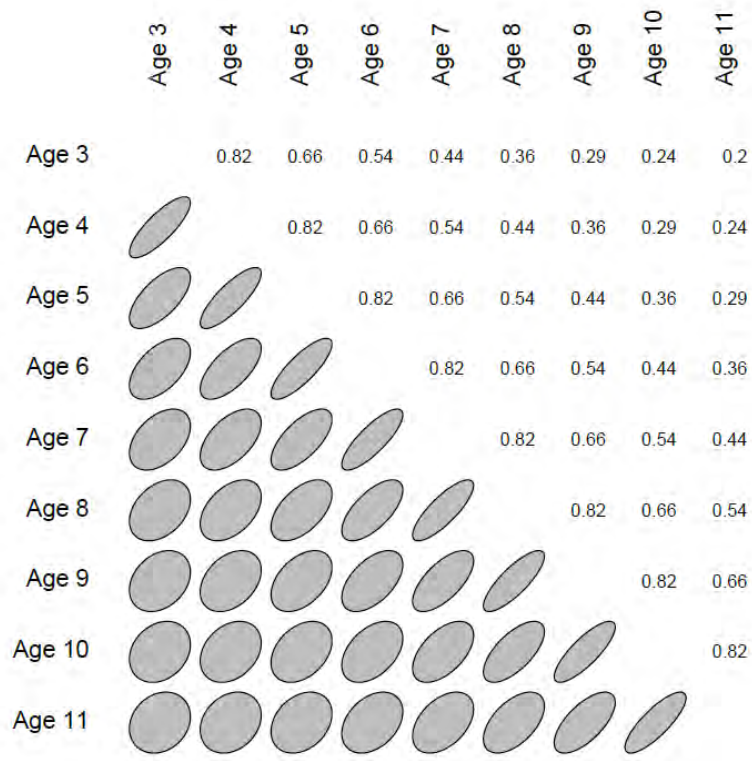


Figure 8.7.2.3. NE Atlantic mackerel. Estimated AR1 error correlation structure for the observations from the IESSNS survey age 3 to 11.

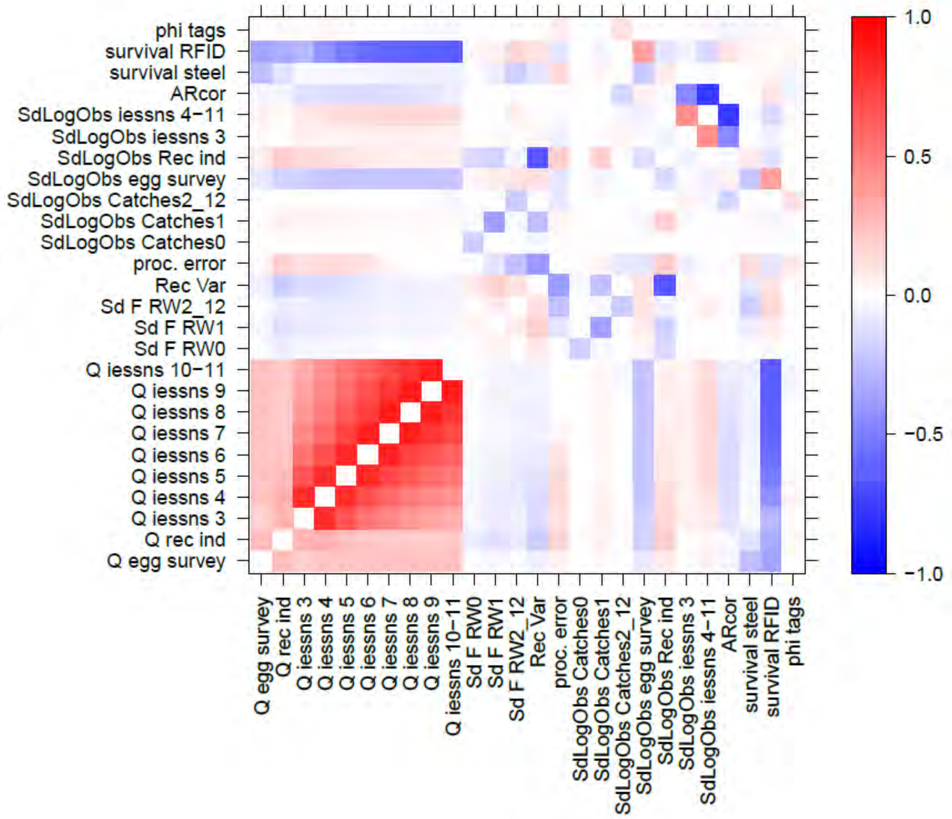


Figure 8.7.2.4. NE Atlantic mackerel. Correlation between parameter estimates from the SAM model for the WGWIDE 2022 update assessment

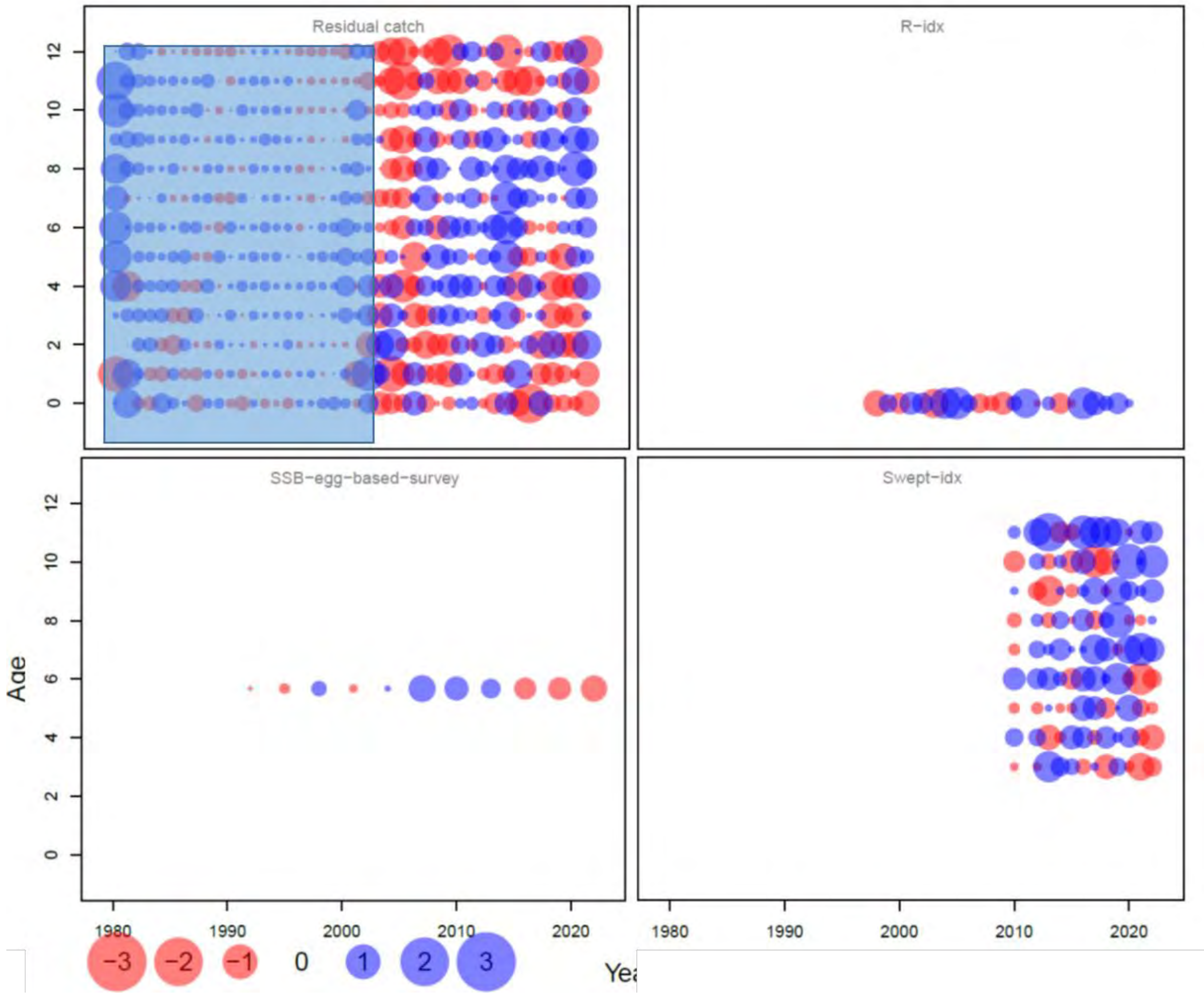


Figure 8.7.2.5. NE Atlantic mackerel. One Step Ahead Normalized residuals for the fit to the catch data (catch data prior to 2000 in blue rectangle were not used to fit the model). Blue circles indicate positive residuals (observation larger than predicted) and filled red circles indicate negative residuals.

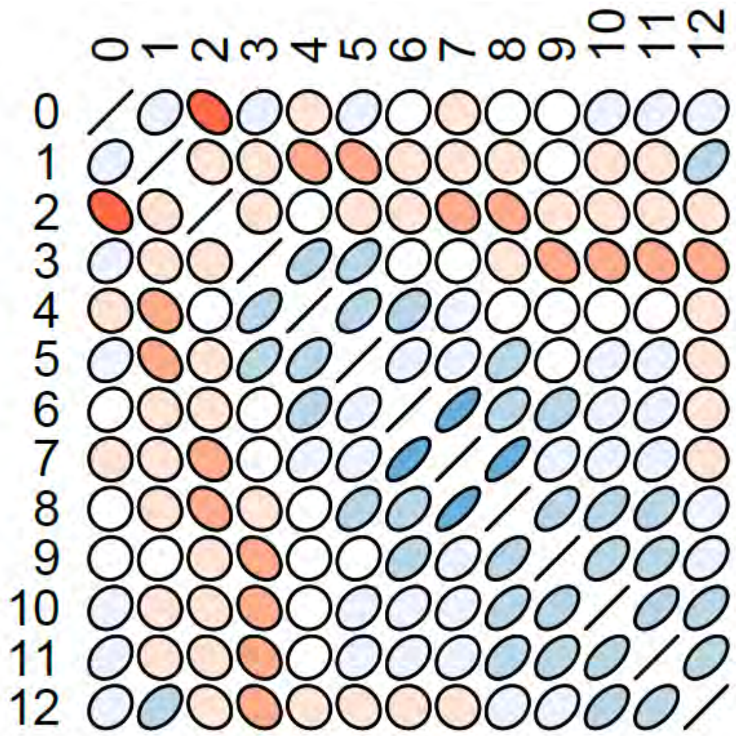


Figure 8.7.2.6. NE Atlantic mackerel. Empirical correlations between ages in the One Step Ahead residuals for the catch-at-age data.

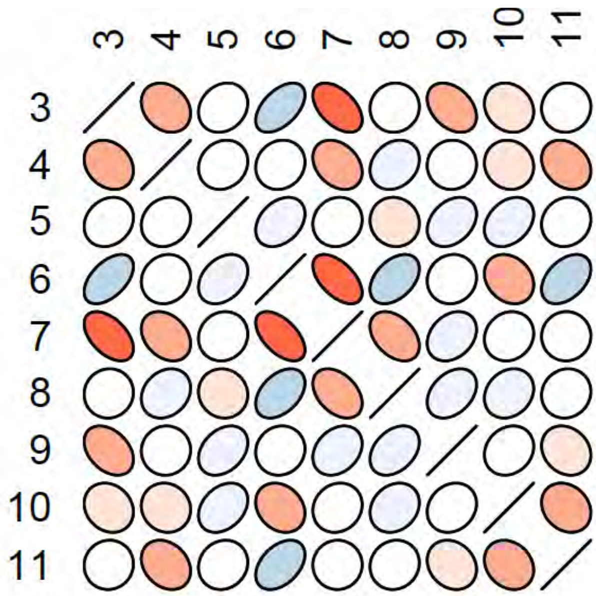


Figure 8.7.2.7. NE Atlantic mackerel. Empirical correlations between ages in the One Step Ahead residuals for the IESSNS abundances-at-age.

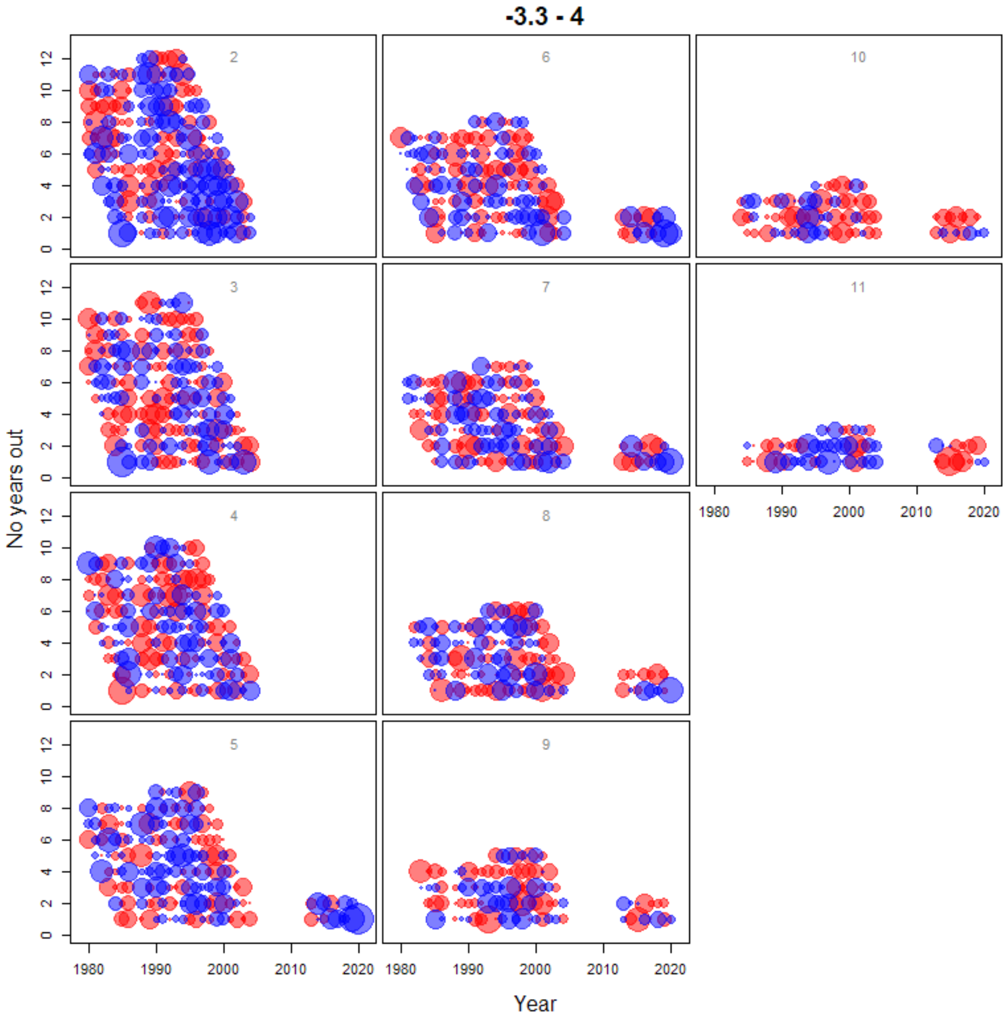


Figure 8.7.2.8. NE Atlantic mackerel. One step ahead residuals for the fit to the recaptures of tags in the final assessment. The x-axis represents the release year, and the y-axis is the number of years between tagging and recapture. Each panel correspond to a given age at release. Blue circles indicate positive residuals (observation larger than predicted) and filled red circles indicate negative residuals.

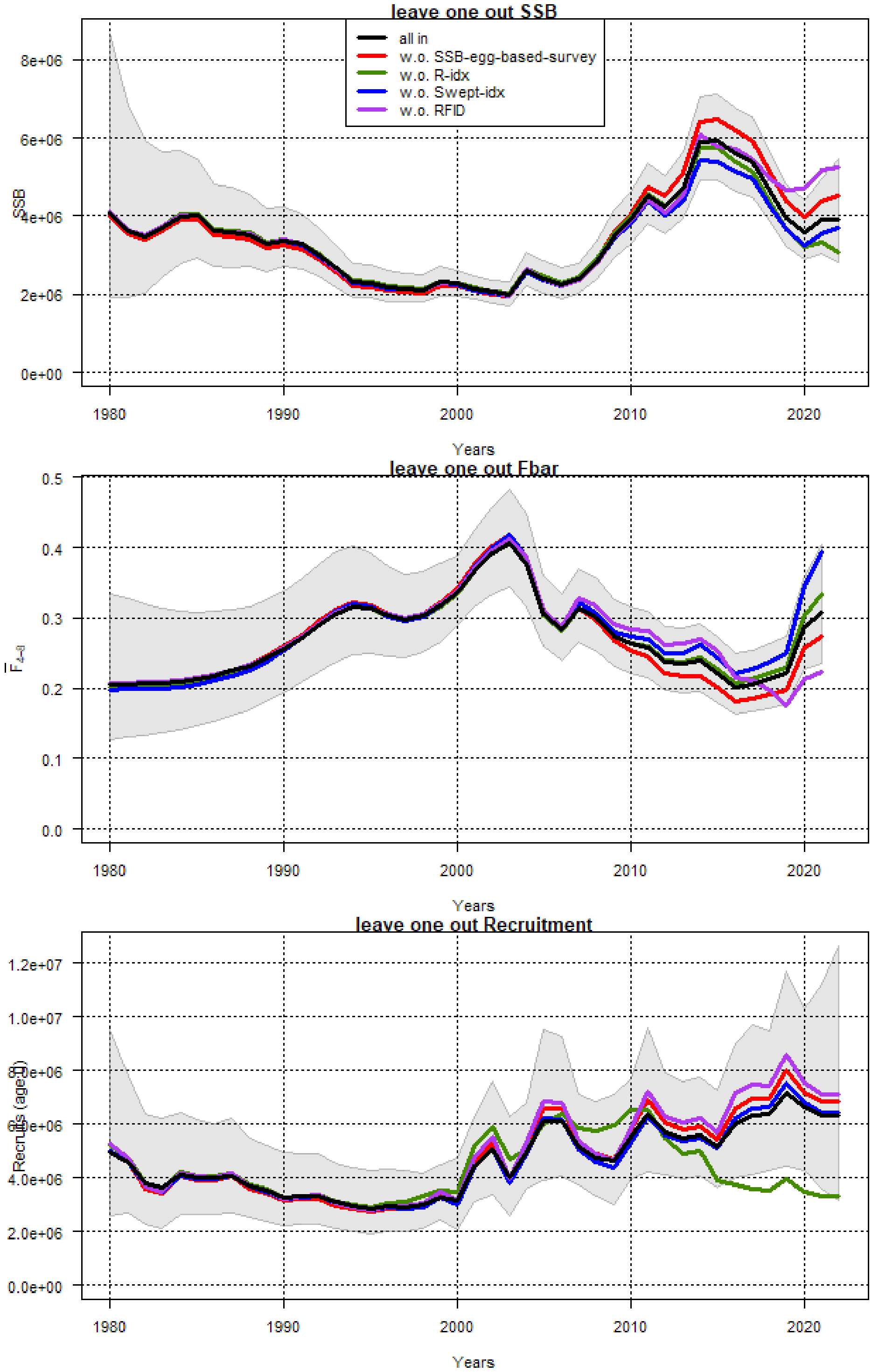


Figure 8.7.2.9. NE Atlantic mackerel. Leave one out assessment runs. SAM estimates of SSB , Fbar and recruitment, for assessments runs leaving out one of the observation data sets.

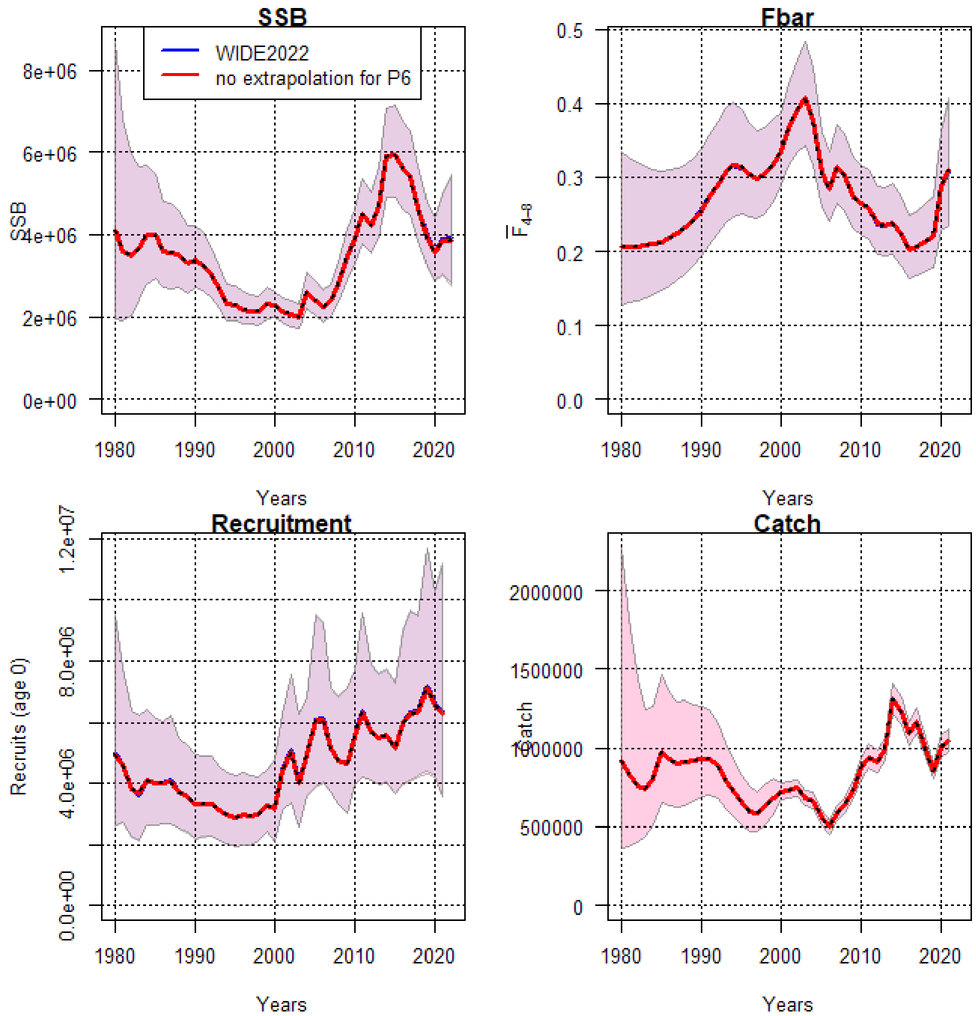


Figure 8.7.2.10. NE Atlantic mackerel. Sensitivity of the estimated stock trajectories to a 9.4% reduction of the 2022 SSB index from the egg survey (proportion of the total annual egg production corresponding to the interpolation done for the missing coverage in period 6 of the survey).

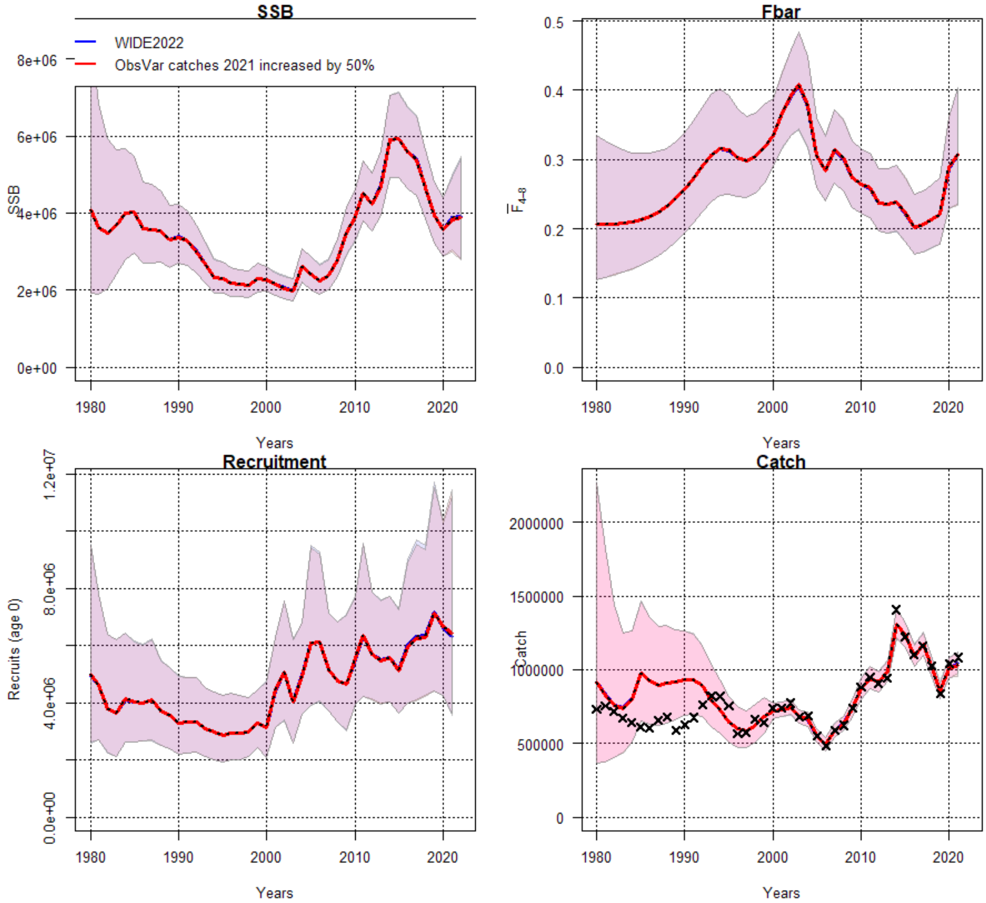


Figure 8.7.2.11. NE Atlantic mackerel. Sensitivity of the estimated stock trajectories to a 50% increase in the observation error variance for the catches-at-age for the year 2021 (to account for a potential higher uncertainty due to the lack of data from Russia).

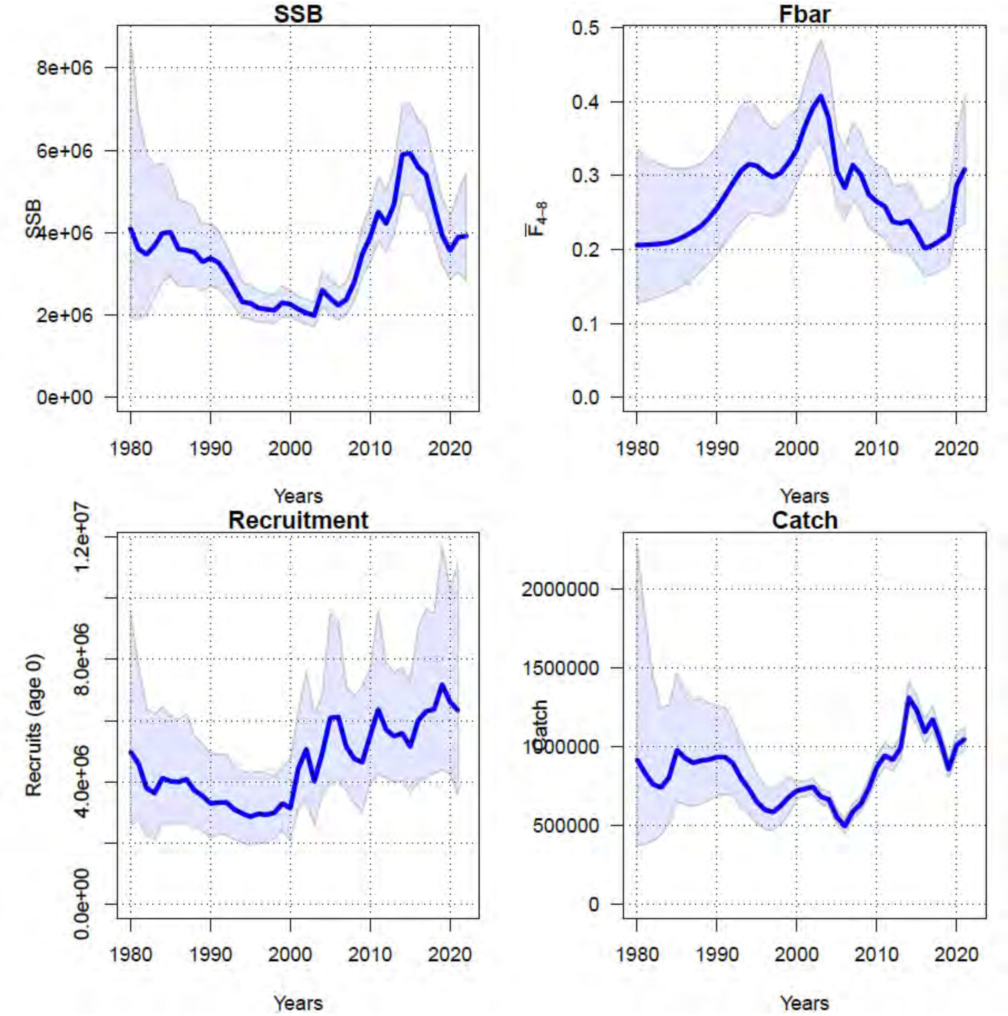


Figure 8.7.3.1. NE Atlantic mackerel. Perception of the NEA mackerel stock, showing the SSB, F_{bar}4-8 and recruitment (with 95% confidence intervals) from the SAM assessment.

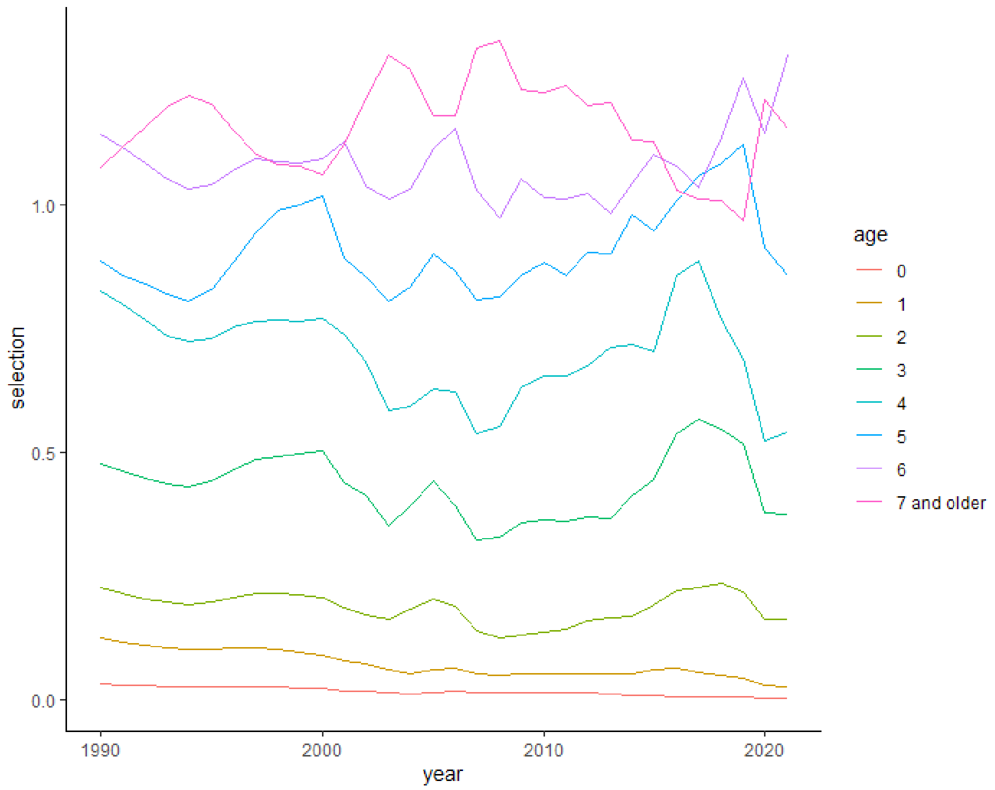


Figure 8.7.3.2. NE Atlantic mackerel. Estimated selectivity for the period 1990 to 2021, calculated as the ratio of the estimated fishing mortality-at-age and the Fbar4-8 value in the corresponding year.

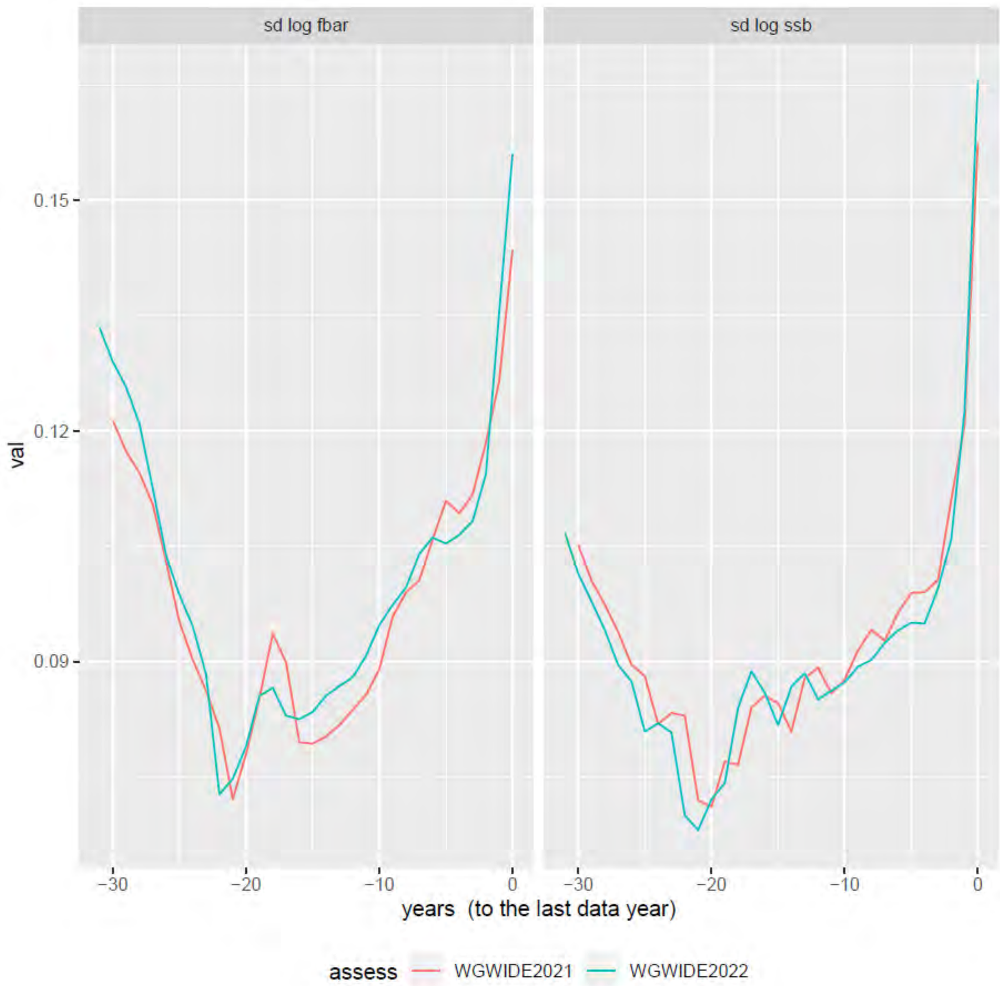


Figure 8.7.4.1. NE Atlantic mackerel. Uncertainty (standard deviation of the log values) of the estimates of SSB and Fbar from the SAM for the 2021 and 2022 WGWIDE assessments.

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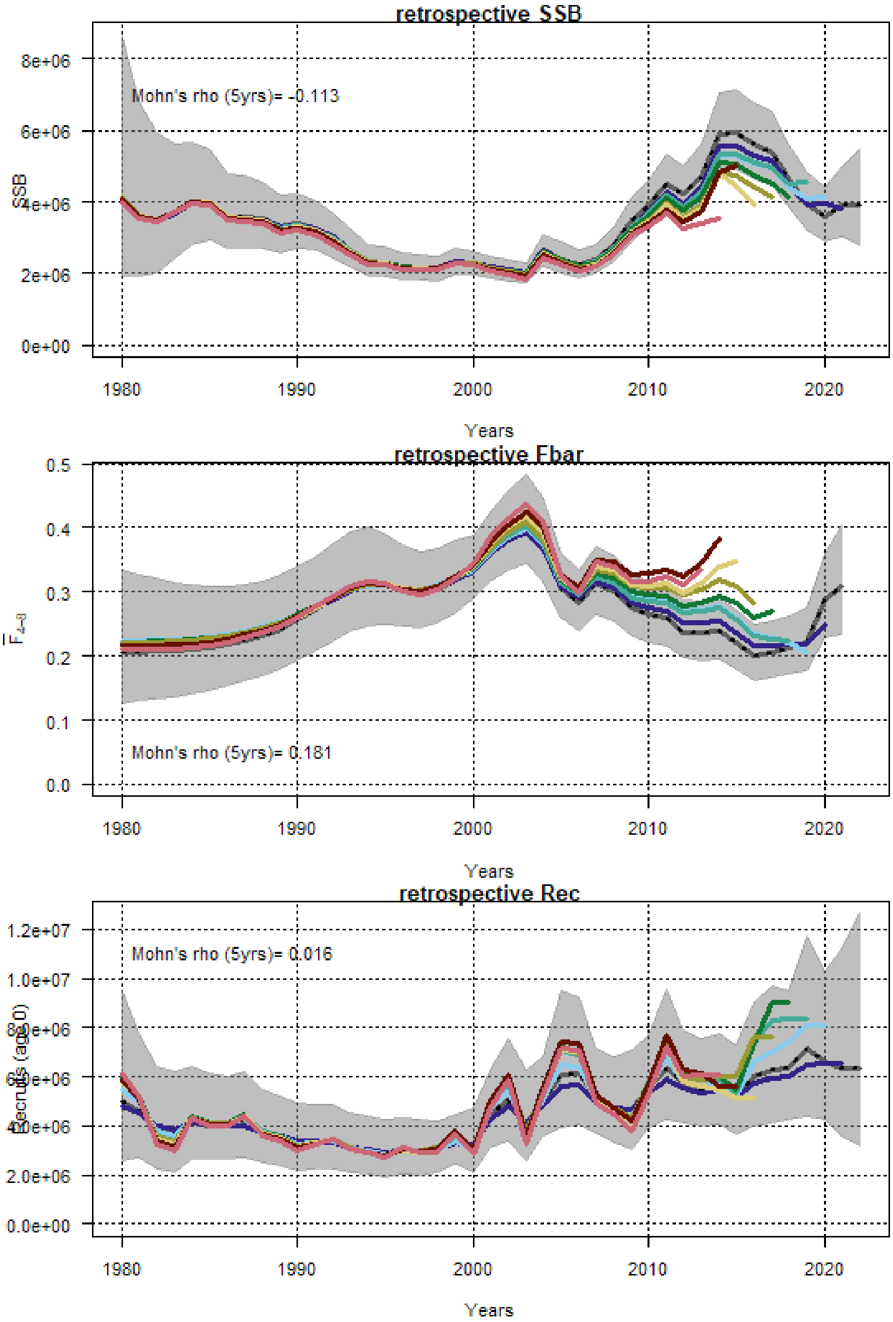

Figure 8.7.4.2. NE Atlantic mackerel. Analytical retrospective patterns (8 years back) of SSB, F_{bar}4-8 and recruitment from the WGWIDE 2022 update assessment. the Mohn's rho values are calculated based on 5 retro years.

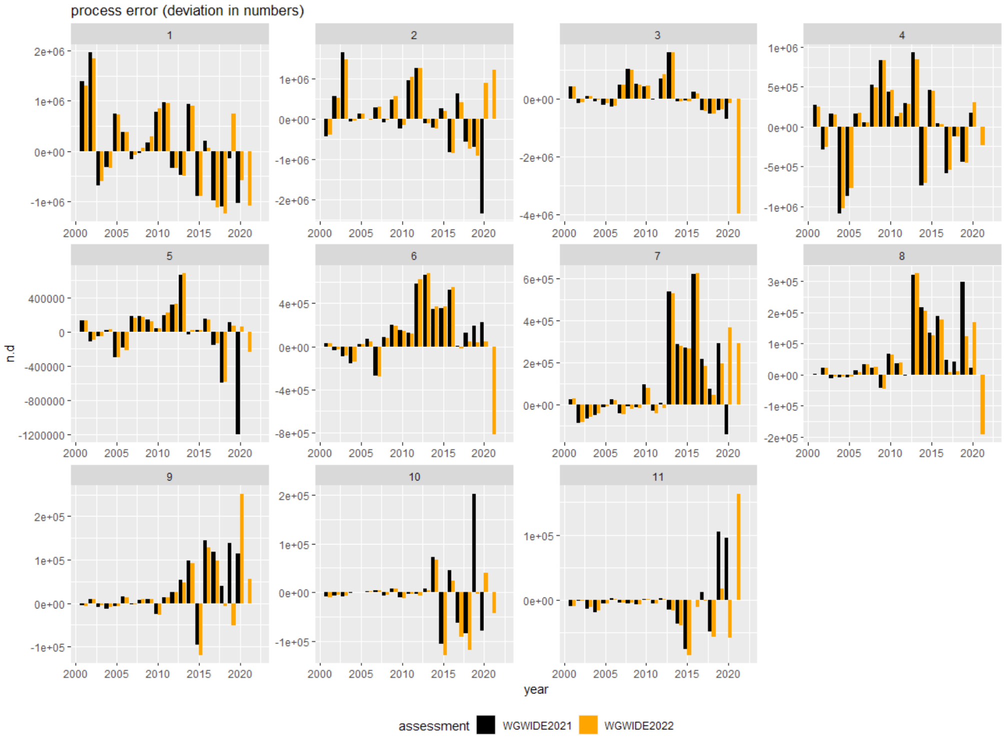

Figure 8.7.4.3. NE Atlantic mackerel. Process error expressed as annual deviations of abundances at age, for the 2022 WGWIDE assessment and from the 2021 WGWIDE assessment.

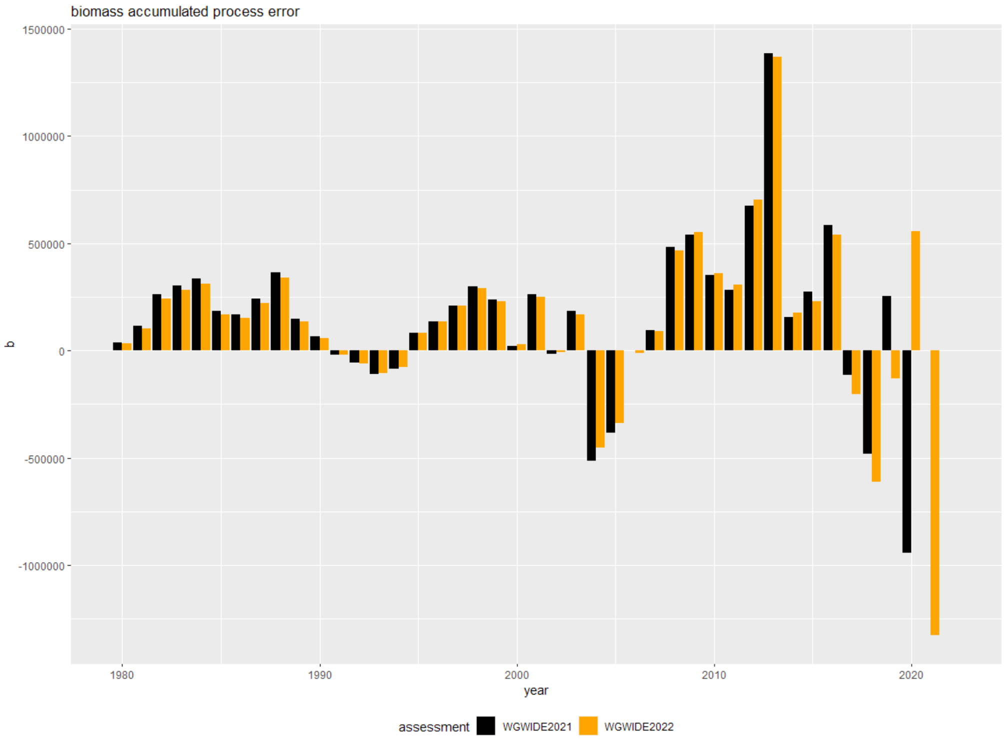

Figure 8.7.4.4. NE Atlantic mackerel. Model process error expressed in biomass cumulated across age-group for the 2022 WGWIDE assessment and for the 2021 WGWIDE assessment.

Figure 8.7.5.1. NE Atlantic mackerel. Model comparison of the cohort signal based on SAM estimates at age 0, 2 and 3.

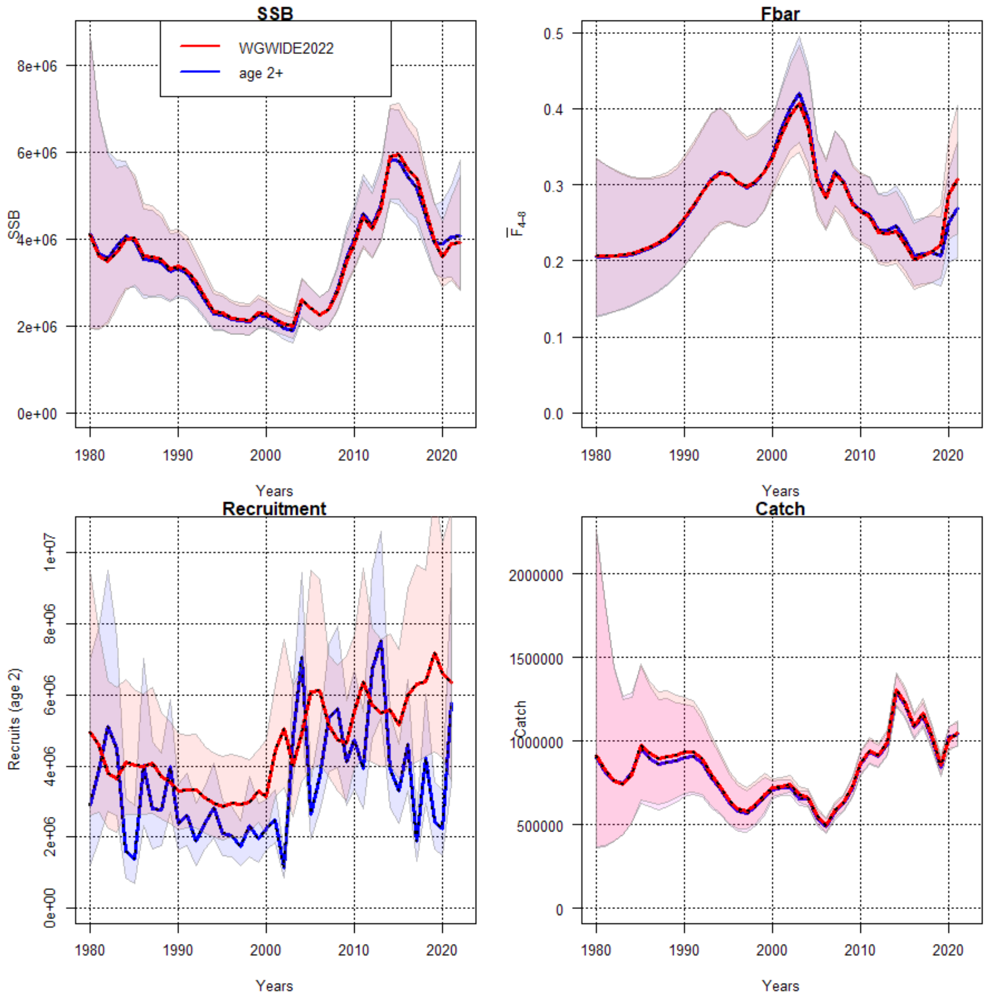

Figure 8.7.5.2. NE Atlantic mackerel. Model. comparison of the perception of the stocks from the WGWIDE 2022 assessment, and the assessment starting at age2.

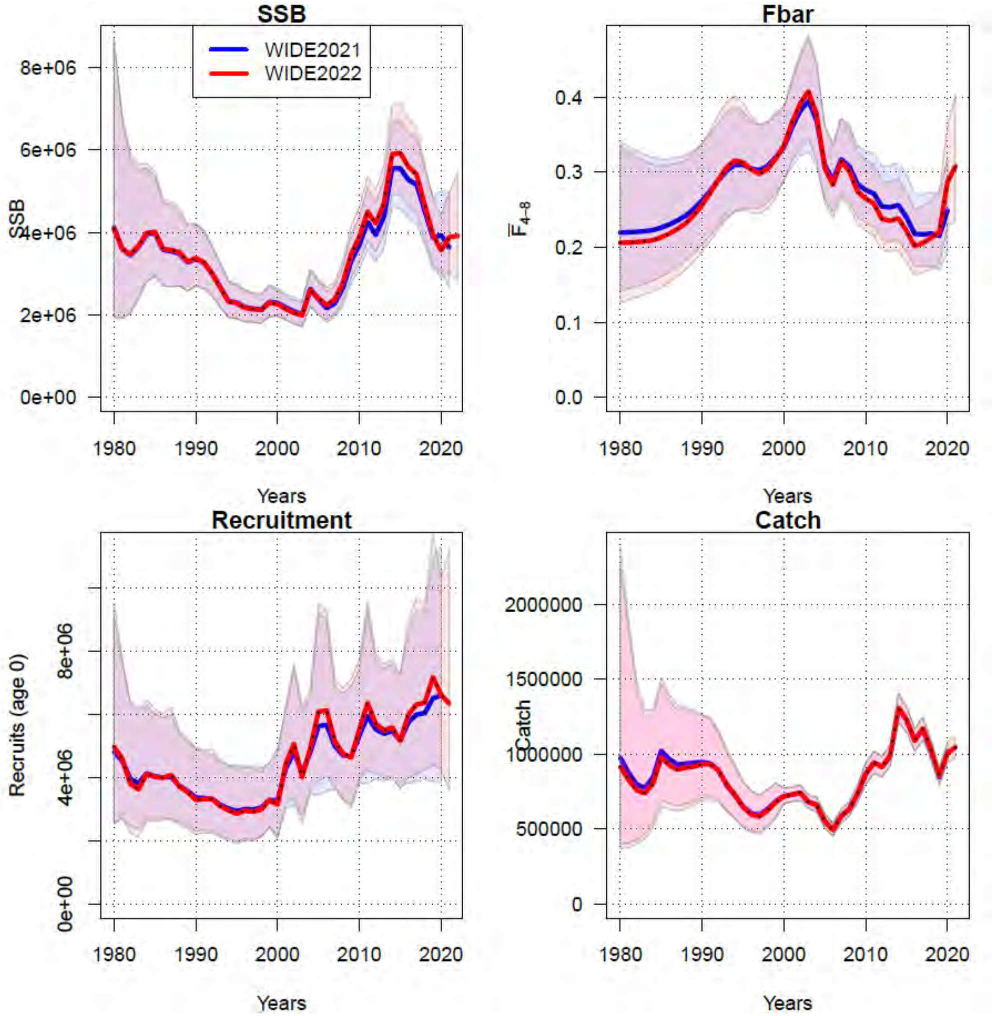

Figure 8.10.1. NE Atlantic mackerel. Comparison of the stock trajectories from the WGWIDE 2021 (blue) and 2022 (red) update assessments.

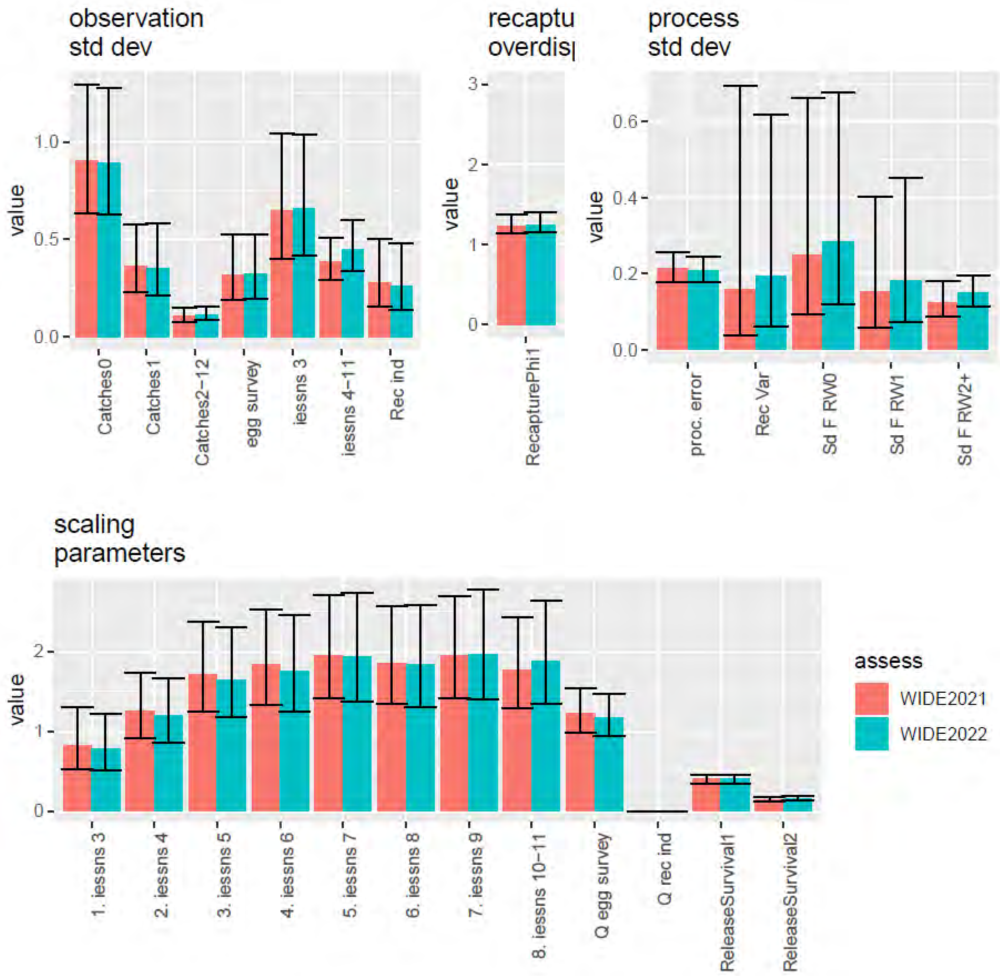

Figure 8.10.2. NE Atlantic mackerel. Comparison of model parameters and their uncertainty for the 2022 WGWIDE and the 2021 WGWIDE assessment

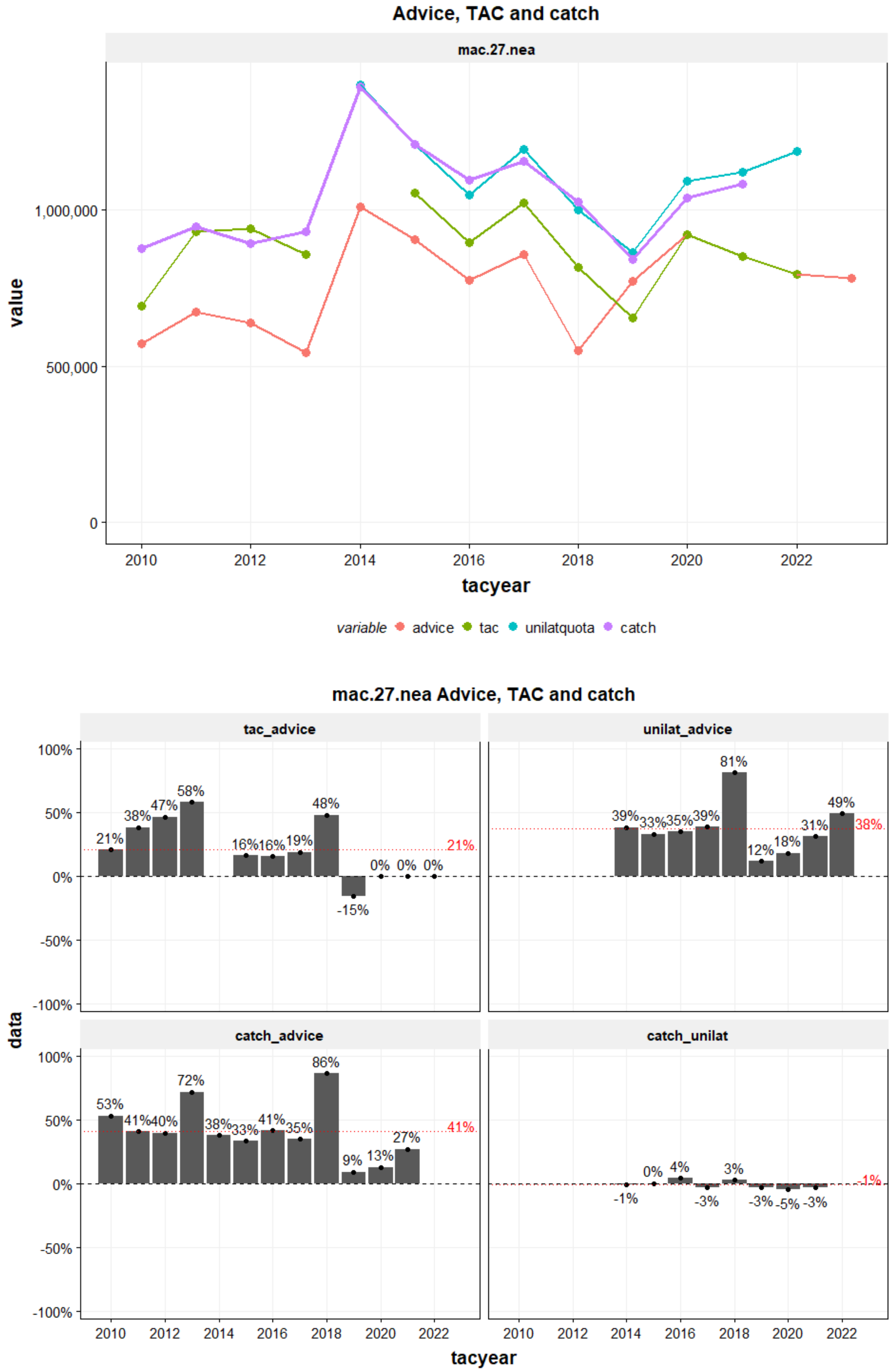

Figure 8.11.1. NE Atlantic mackerel. Top: comparison of the ICES advice, the agreed TAC, the sum of the unilateral quota and total catch. Bottom: calculated percentage of TAC over Advice, Sum of unilateral quota over Advice, Catch over Advice and Catch over Sum of unilateral quota.

9 Red gurnard in the Northeast Atlantic

9.1 General biology

The main biological features known for red gurnard (*Aspitrigla (Chelidonichthys) cuculus*) are described in the stock annex. This species is widely distributed in the 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 ~25cm at 3 years old (Dorel, 1986).

9.2 Stock identity and possible assessments areas

A compilation of datasets from bottom-trawl surveys undertaken within the project 'Atlas of the marine fishes of the northern European shelf' has produced a distribution map of red gurnard. Higher occurrences of red gurnard with patchy distribution have been observed along the Western approaches from the Shetlands Islands to the Celtic Seas and the Channel.

A continuous distribution of fish crossing the Channel and the area West of Brittany does not suggest a separation of the divisions 7d from 7e and 7h. Therefore, a split of the population between 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 SA 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 fig. 9.1.

International landings have fluctuated between 3452 - 5171 tonnes between 2006-2019. Landings in the most recent year (2021) were 2903 tonnes – the lowest on record. France is the main contributor of 'red gurnard' landings, with around 80% of landings from subarea 7d-h (Celtic Sea/English Channel). In the North Sea red gurnard landings are variable, but roughly evenly distributed between divisions 4a, b and c. Landings from the west of Scotland and Ireland, and the Irish Sea (subarea 6a-b, 7a-c, 7j) and Bay of Biscay (division 8) have been consistently low.

9.4.2 Discards

Discard data for red gurnard has been provided for 2015 - 2021 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 SC-IBTS), Irish Groundfish Survey (IGFS), English Channel Beam Trawl Survey (BTS), and French Q4 surveys EVHOE in the Celtic Sea and Bay of Biscay and CGFS in division 7d. 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 CGFS-Q4 and (for some years) from IGFS.

SCO-WCGFS and SC-IBTS.

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 value for 2020 was sharply up on 2019, however it fell back in 2021(figs 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 2021 were down (fig 9.4).

EVHOE (Q4).

Over the period 1997—2020, the CPUE has fluctuated. It has been on an increasing trend since 2017, and 2020 is the second highest value in the series. 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. Values in 2021 were down (fig. 9.4).

IGFS.

The CPUE of red gurnard in the IGFS series has varied around the series mean without trend between 2002 and 2020. Values in 2021 were down (fig 9.5).

BTS.

CPUE in this relatively short series has fluctuated without apparent trend since 2006. Values in 2021 were down (fig 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 (figs 9.6-7) and the log-normal part of the model has an adjusted r^2 value of 0.32.

After a period of relative stability, the biomass indicator declined in 2019, before recovering strongly in 2020 (fig. 9.8). The indicator 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.

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Table 9.1. Red gurnard in subareas 3-8. Official landings by country in tonnes.

Year	Belgium	Spain	France	Jersey	Guernsey	Ireland	IM	Netherlands	Portugal	UK	Total
2006	313	0	4552	0	10	0	0	57	125	115	5172
2007	328	0	4494	1	4	0	0	66	127	156	5176
2008	352	0	4045	0	8	0	0	92	112	166	4775
2009	227	0	3310	0	6	0	1	160	150	263	4117
2010	237	0	3437	0	2	0	0	251	115	362	4404
2011	306	0	3176	1	2	0	1	295	134	257	4172
2012	306	0	2706	3	4	26	0	329	148	257	3779
2013	288	576	3154	3	9	16	2	267	113	329	4757
2014	263	399	3782	3	6	0	5	241	108	283	5090
2015	187	91	2919	2	3	0	0	210	122	341	3875
2016	238	87	2598	3	2	9	1	224	106	381	3646
2017	265	104	2396	0	1	9	4	226	113	335	3454
2018	314	89	2968	0	1	1	1	306	114	347	4141
2019	289	84	2448	1	5	3	0	247	117	478	3672
2020*	211	105	2335	0	0	10	1	235	123	254	3273
2021*	123	69	2240		0	8	0	160	117	370	2968
2021**	90	31	2251		0	8	0	158		365	2903

***preliminary data**

****Intercatch data**

Table 9.2. Red gurnard in subareas 3-8. Official landings by area in tonnes.

Year	4a	4b	4c	5b	6a	6b	7a	7b	7c	7d	7e	7f	7g	7h	7j	7nk	8a	8b	8c	8d	9a	9nk	10a	12c	10nk	14a	Total
2006	13	83	64	0	32	1	11	9	12	1101	2803	229	16	446	5	0	153	60	1	5	9	115	0	0	1	0	5054
2007	12	120	55	2	21	0	7	7	15	1229	2674	246	15	437	4	0	139	59	3	2	125	0	0	0	2	0	5174
2008	34	64	54	0	28	3	5	7	16	1236	2451	249	9	408	5	0	66	24	3	1	109	0	3	0	0	0	4772
2009	58	59	92	0	94	2	4	8	6	1293	1557	112	22	510	7	0	98	40	1	3	148	0	1	0	0	0	4115
2010	79	63	86	0	101	46	13	8	10	1531	1608	132	23	433	9	0	100	33	0	2	114	0	0	0	1	0	4392
2011	66	29	51	0	69	54	13	5	6	1295	1753	124	20	372	9	0	112	46	1	3	133	0	1	0	0	1	4163
2012	83	71	78	0	51	7	8	2	5	1244	1441	145	53	294	2	0	83	50	8	1	136	4	1	0	0	1	3768
2013	88	109	60	0	47	0	10	2	6	1193	1692	170	58	477	2	0	79	72	532	1	155	0	2	0	0	0	4755
2014	102	52	68	0	47	3	7	1	2	1294	1642	115	19	1069	1	0	82	75	363	3	139	0	3	0	0	0	5087
2015	133	102	53	0	58	1	4	3	1	790	1553	87	6	703	1	0	95	70	81	2	128	0	2	0	0	0	3873
2016	112	83	117	0	76	1	11	3	1	906	1270	114	16	608	1	0	87	63	56	1	120	0	1	0	0	0	3645
2017	53	44	90	0	27	1	14	1	0	874	1424	83	38	473	3	0	78	48	59	1	142	0	1	0	0	0	3454
2018	109	40	113	0	43	0	7	0	0	903	1785	164	28	631	4	0	80	43	62	2	116	0	1	0	0	0	4131
2019	128	19	75	0	84	0	12	1	0	959	1516	75	24	477	5	5	73	38	65	0	109	0	0	2	0	0	3663
2020	58	13	65	2	53	4	10	1	4	680	1504	90	19	425	4	0	69	51	87	1	128	0	0	8	0	0	3273
2021*	60	18	75	0	113	4	4	2	1	602	1390	46	15	471	4	0	62	40	62	0	119	0	1	8	0	0	3096

***preliminary data**

Table 9.3. Red gurnard in subareas 3-8. Discards (t) by country, 2015 – 2021.

Country	2015	2016	2017	2018	2019	2020	2021
France	1323	2249	2232	770	3132	292	623
Ireland	10	147	93	251	180	76	56
Spain		286	272	189	122	161	128
UK (ENG)	74	30		207	506	110	708
UK (SCO)	649	411	198	512	331	117	
Total	2056	3123	2795	1929	4270	757	1515

Table 9.4. Red gurnard in subareas 3-8. Discarding of Red gurnard in the Northeast Atlantic, as a percentage of catch, by country, 2017-2021.

Country	Discard rate (%)				
	2017	2018	2019	2020	2021
France	48	21	56	11	22
Ireland	91	95	95	88	87
Spain	72	68	78	91	80
UK (England)			67	51	83
UK (Scotland)	68	92	60	45	

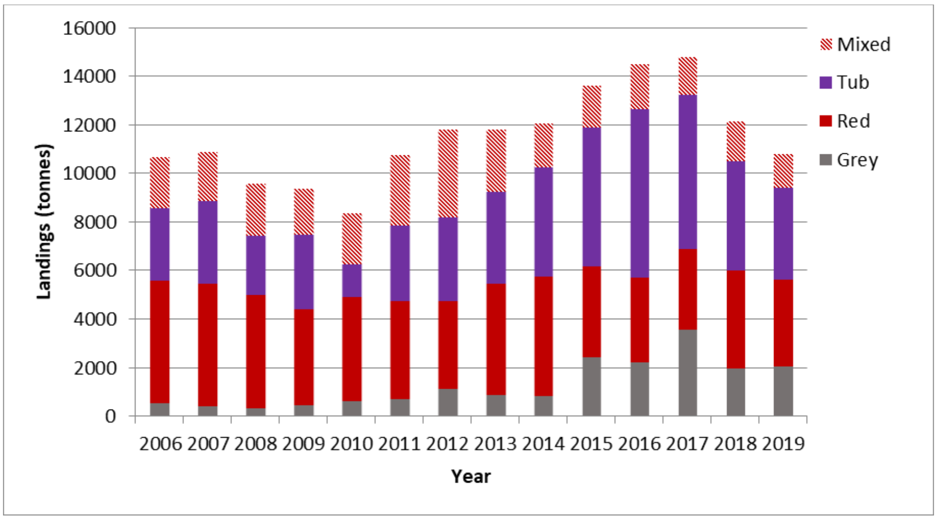

Figure 9.1. Red gurnard in subareas 3-8. Official landings of red, grey, tub and mixed gurnards from SA3-8, 2006-2019.

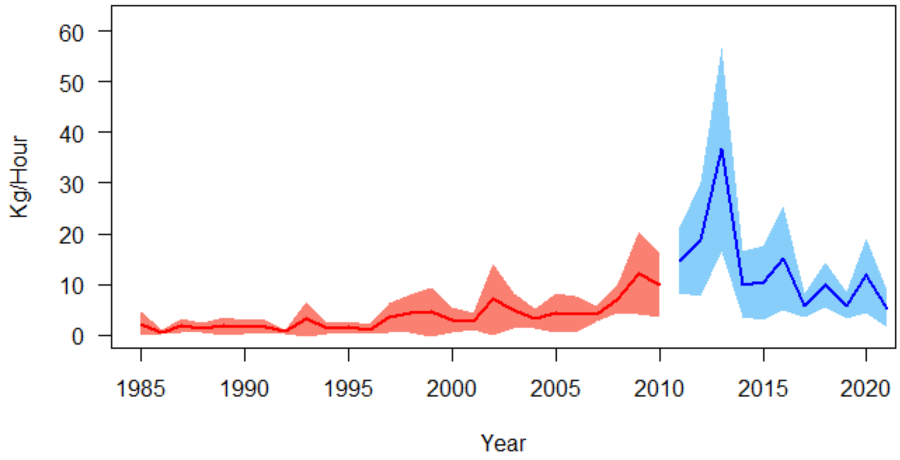

Figure 9.2. Red Gurnard in subareas 3-8. Trends in mean abundance (kg/hr) in the Q1 Scottish IBTS (1985 - 2010) and Q1 Scottish West Coast Groundfish Survey (2011 - 2021)

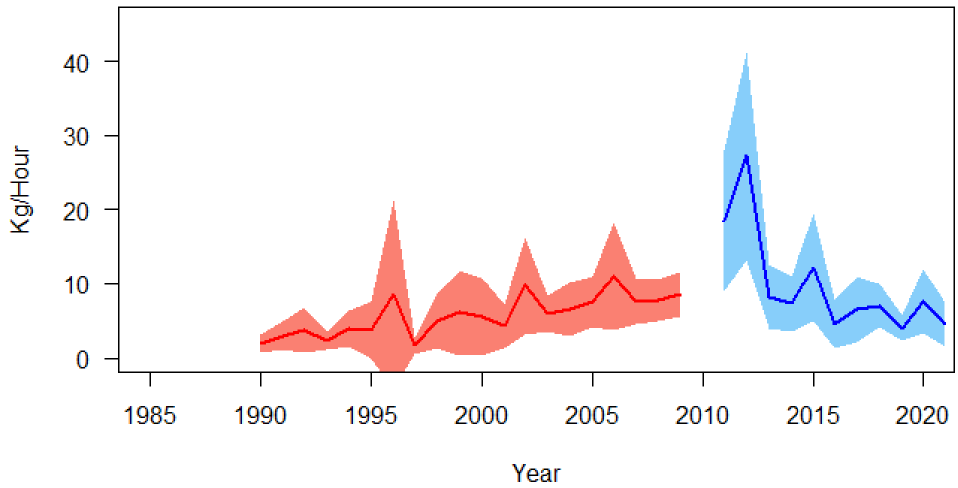

Figure 9.3. Red Gurnard in subareas 3-8. Trends in mean abundance (kg/hr) in the Q4 Scottish IBTS (1990 - 2009) and Q4 Scottish West Coast Groundfish Survey (2011 - 2021)

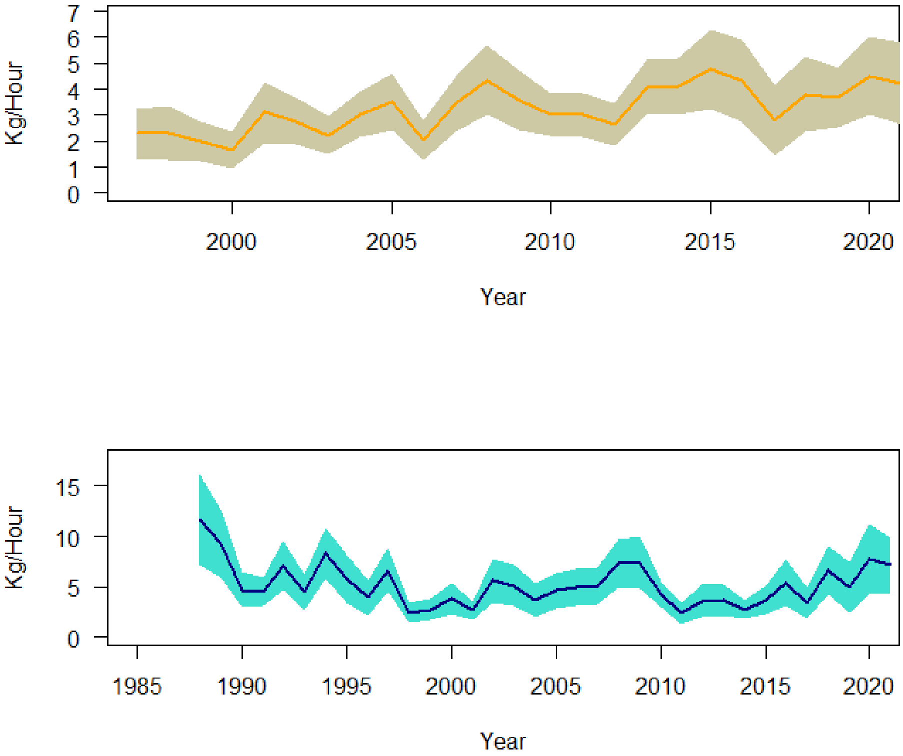

Figure 9.4. Red Gurnard in subareas 3-8. Trends in mean abundance (kg/hr) in the EVHOE (top) and French Channel Groundfish Survey (bottom)

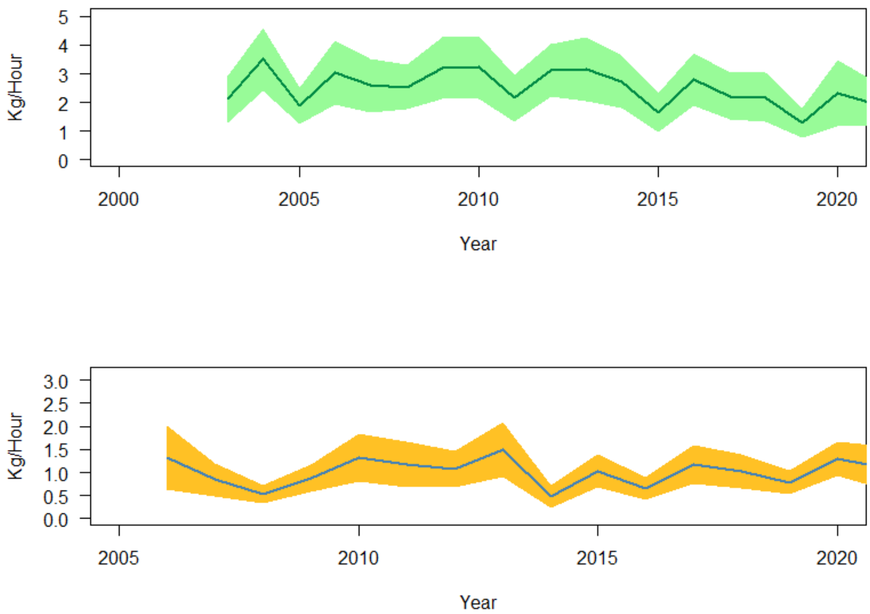

Figure 9.5. Red Gurnard in subareas 3-8. Trends in mean abundance (kg/hr) in the Irish Groundfish Survey (top) and English Channel Beam Trawl Survey (bottom)

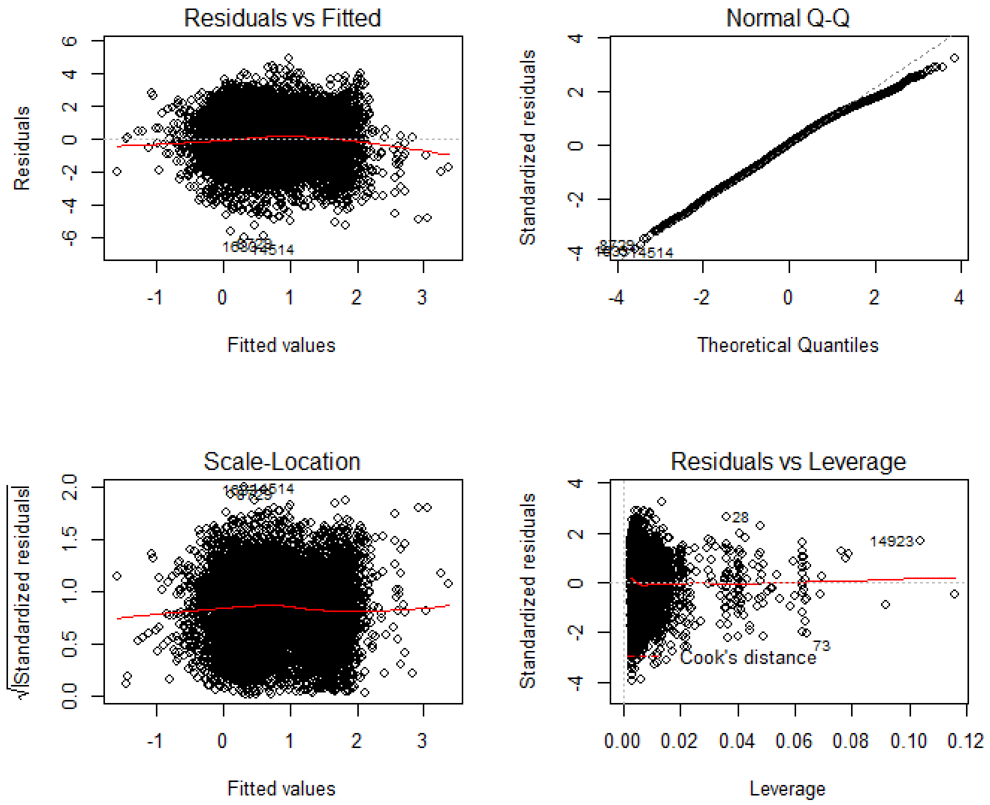

Figure 9.6. Red Gurnard in subareas 3-8. Measures of goodness of fit of the lognormal part of the assessment model.

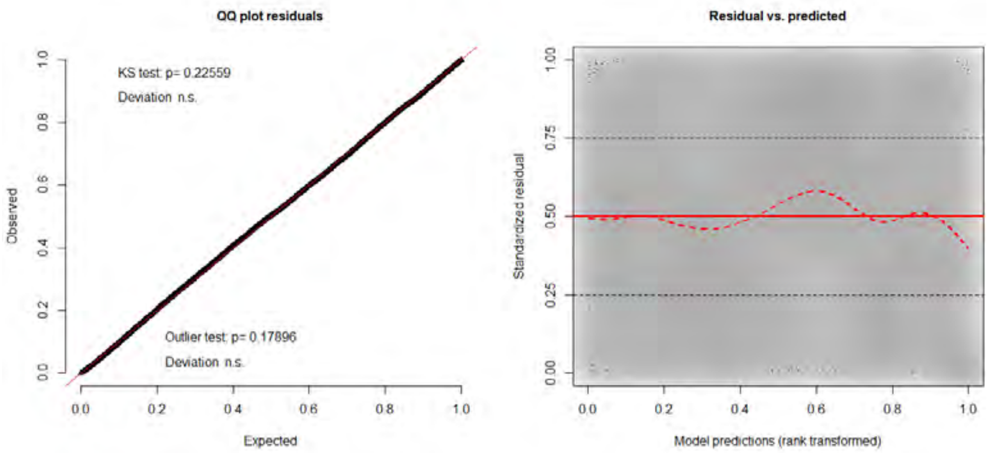

Figure 9.7. Red gurnard in subareas 3-8. Measures of goodness of fit of the binomial part of the assessment model.

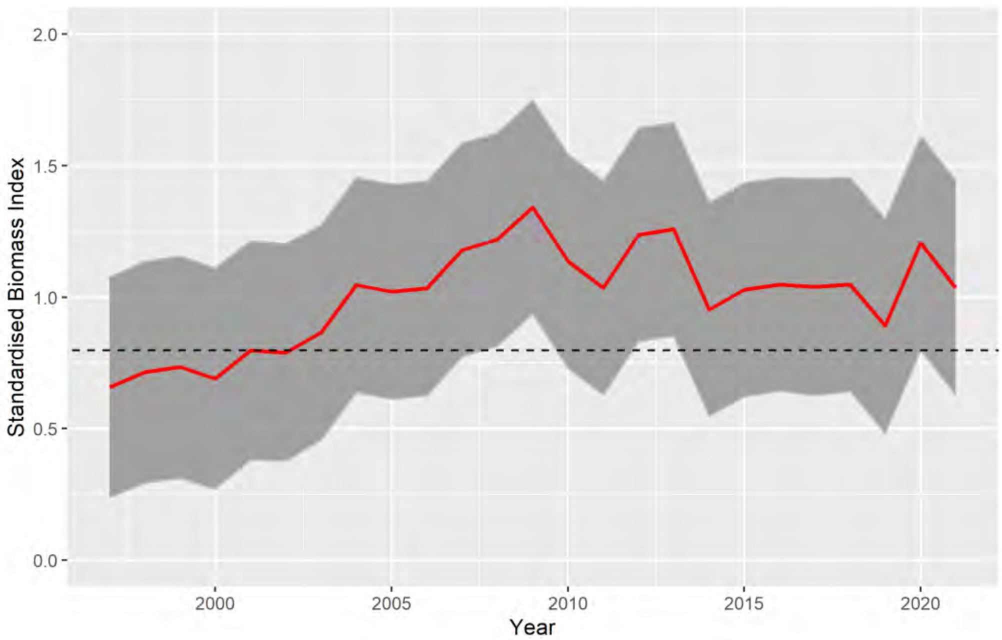

Figure 9.8. Red gurnard in subareas 3-8. Results of the assessment model. Shading corresponds to 2 standard errors around the estimate. The dashed line represents MSY $B_{trigger}$ (0.81).

10 Striped red mullet in Subareas and Divisions 6, 7a–c, e–k, 8, and 9a

10.1 General biology

Striped red mullet (*Mullus surmuletus*) is a predominantly benthic species found along the coasts of Europe, southern Norway, and northern Scotland (northern Atlantic, Baltic Sea, North Sea, and the English Channel), up to the Northern part of West Africa, in the Mediterranean Basin, and in the Black Sea (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. As a consequence, 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 mullet are sea basses, pollacks, barracudas, monkfish, congers, and sharks (Caill-Milly *et al.*, 2017).

Sexual maturity is reached at the beginning of the second year for males, followed by a marked decrease in growth rates, and at the end of the second or beginning of the third year for females which therefore continue their rapid growth a little longer (Déniel, 1991). In the English Channel, this species matures at approximately 16 cm (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.

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 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 rate of growth declines sharply in October due to the cooling of water and the scarcity of trophic resources in the environment. These conditions contribute to the initiation of migration of red mullets to greater depths offshore. Until the age of two, there is no significant difference in size between males and females; they then measure 20-23cm. Sexual dimorphism is observed from the age of first maturity due to growth rates that will then differ between the two sexes. From age three, females exceed males in length by 4 cm on average and 7cm beyond 5 years (N'Da *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).

10.1 Management regulations

Prior to 2002, France enforced a minimum landing size of 16 cm. Since 2013 minimal size requirement has been established to 15 cm (France, 2013). There is no TAC for this stock.

10.2 Stock ID and possible management areas

In 2004 and 2005, a study using fish geometrical morphometry was carried out in the Eastern English Channel and the Bay of Biscay. It pointed out a morphological difference on striped red mullets between those from the Eastern English Channel and those from the Bay of Biscay (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 10.3.1). Examination of catch from surveys suggests striped red mullet in division 9a are geographically distinct, with an area of higher abundance between Cabo Sao Vicente and the Tagus estuary, and an area where this species is mostly absent to the north. This assessment treats these putative components as one population. At present there are no management measures in place, however this structuring should be taken into account if measures are considered.

10.3 Fisheries data

Official landings have been recorded since 1975 and after early increases they have declined in recent years. Landings are mainly taken from Subarea 7 and 8 and France accounts for the majority of removals (Table 10.4.1-2). The striped red mullet is one species among set of benthic (demersal) species targeted by the French fleet, and is mainly caught by bottom trawlers with a mesh size of 70—99mm. In the Western English Channel striped red mullet is also caught by gillnets. Danish seine appeared in 2008 as a result of some trawlers converting to use seine gears.

The average characteristics of vessels in French fleets that caught red mullet from 2000 to 2015 are: 41.1 GRT, 191.1kW engine power, 12.9m length and 22 years of service. Net vessels are made up of the smallest units (85% are less than 12m long), while 52% of bottom trawlers are less than 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 (8a, b) and the south (8c) of the Bay of Biscay.

Discarding represented between 3% and 18% of the total catches in 2014–21 (Table 10.4.3). Since 2018, the discard rates are reported below 5%. However, there are concerns about how these discards have been estimated due to the lack of discards data for some countries. From the data provided to Intercatch in 2020, discards are essentially composed of individuals measuring less than 18 cm (Figure 10.2).

10.4 Survey data, recruit series

Exchange data is available in DATRAS during 1997-2021 for the French EVHOE survey, covering the Bay of Biscay and Celtic Sea (fig. 10.5.1), 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. Relative total biomass in the EVHOE survey (fig. 10.5.2) are variable around the series mean between 1997 – 2011, before falling to a lower level thereafter. Similarly, catch rates in the PT-IBTS are at a low level in 2005, peak in 2010, before falling back to near the series mean in recent years. The mean stratified abundance from the Spanish NSGFS follows a similar trend: high variability around the mean before 2017, then low level since 2017. (fig. 10.5.3).

Biological sampling in the Bay of Biscay of sexual maturity and length measures were taken in 2009 by AZTI. French sampling started in 2004 in the Eastern Channel and in the south North Sea, and since 2008 in the Bay of Biscay. Since 2004, data (age, length, sexual maturity) are usually collected by France for the Eastern English Channel and the southern North Sea. France started to collect data for 8a, b at the end of 2007. In 2007—2008, the striped red mullet otolith exchange had for goal to optimize age estimation between countries. In 2011, an Otolith Exchange Scheme was carried out, which was the second exercise for the Striped red mullet (Mullus surmuletus). Four readers of this exchange interpreted an images collection coming from the Bay of Biscay, the Spanish coasts and the Mediterranean coasts (Spain and Italy). A set of Mullus surmuletus otoliths (N=75) from the Bay of Biscay presented highest percentage of agreement (82%). On 75 otoliths, 34 were read with 100% agreement (45%) and thus a CV of 0%. Modal age of these fishes was comprised between 0 and 3 years (Mahe *et al.*, 2012).

10.5 10.6 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) extend the analysis presented in
Caill-Milly *et al.* (2017) and Caill-Milly *et al.* (2019) and computes 4 abundances indices from 2005 to 2021 based on the landings per unit effort for 4 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 done in 2021. The final results will be published in 2022/2023 and the references will be added in the next report.

10.6 Analysis of stock trends/ assessment

Currently, an age structured analytical stock assessment has not been developed due to a short time-series of available data.

Data requirements - regular sampling of biological parameters of striped red mullet catches must be continued under DCF. Sampling in the Celtic Sea and in the Bay of Biscay started in 2008. In 2010 and 2011, sampling for age and maturity data was reduced compared to 2009, due to the end of the Nespman project. Since 2009, a concurrent sampling design carried out, should provide more data (length compositions) than in recent years.

10.7 References

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Table 10.4.1: 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
2006	33	1947	8	16	1	115	10	387	170	2688
2007	43	1941	9	23	1	148	222	398	194	2978
2008	26	1394	9	22	0	165	169	394	165	2345
2009	20	1562	5	16	0	110	199	520	134	2567
2010	20	1743	5	8	0	128	276	479	133	2793
2011	21	1740	0	8	0	130	245	508	155	2806
2012	37	1342	0	7	1	125	217	332	122	2183
2013	28	932	5	4	0	50	187	246	71	1522
2014	12	926	5	2	0	2	221	265	53	1487
2015	23	1215	5	3	0	111	282	248	102	1989
2016	28	1179	0	4	0	69	204	194	83	1761
2017	36	997	0	10	0	13	154	327	64	1601
2018	37	896	0	0	0	95	122	321	67	1538
2019	30	1358	0	12	0	91	159	267	55	1973
2020	50	965	0	6	0	82	109	261	89	1562
2021	53	836	0	18	0	54	117	274	93	1445

Table 10.4.2: Striped red mullet in Subareas and Divisions 6, 7a-c, e-k, 8 and 9a. Official landings by area in tonnes.

Year	6a	6b	7a	7b	7c	7e	7f	7g	7h	7j	7k	8a	8b	8c	8d	8e	9a	Total
2006	0	0	1	1	0	869	50	24	103	11	0	1,023	468	71	28	0	39	2688
2007	1	0	1	1	1	1047	54	22	104	24	0	861	473	90	32	0	267	2978
2008	0	0	1	1	0	880	46	16	72	26	0	639	246	86	35	0	296	2345
2009	2	0	1	2	2	592	25	9	74	35	0	879	460	156	88	0	243	2567
2010	2	0	1	3	2	642	26	10	59	32	1	1,033	467	146	38	0	331	2793
2011	1	1	1	0	0	665	20	10	55	11	0	970	513	214	35	0	310	2806
2012	0	0	0	0	0	493	23	7	34	9	0	696	387	200	53	0	280	2183

Year	6a	6b	7a	7b	7c	7e	7f	7g	7h	7j	7k	8a	8b	8c	8d	8e	9a	Total
2013	0	0	0	1	0	232	23	7	36	4	0	473	328	166	12	0	241	1522
2014	1	0	0	0	0	192	15	3	40	3	0	523	240	151	23	0	297	1487
2015	0	0	0	1	0	595	10	2	36	2	0	506	327	126	15	0	369	1989
2016	0	0	0	2	0	417	21	7	35	5	0	548	311	117	21	0	277	1761
2017	0	0	0	1	0	277	27	21	37	3	0	514	324	160	5	0	231	1601
2018	0	0	0	0	0	361	26	7	39	1	0	453	276	144	2	0	226	1538
2019	0	0	1	1	0	377	23	20	35	1	0	770	388	123	4	0	229	1973
2020	0	0	2	1	0	386	43	18	40	4	0	502	265	128	3	0	170	1562
2021	0	0	1	0	0	302	52	30	54	3	0	416	281	114	2	0	188	1445

Table 10.4.3: 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	Netherlands	Total
2013	0							0 (0%)
2014		98						98 (6.2%)
2015	77	115						192 (8.8%)
2016	171	213	1	0	8			394 (18.3%)
2017	11	74	2	0	0	0		87 (5.1%)
2018	14	35	3	0	2	0		53 (3.3%)
2019	29	67	3		1	0		100 (4.8%)
2020	39	28	4		1	9	0	82 (5%)
2021	9	49	4		0	6	0	67 (4.5%)

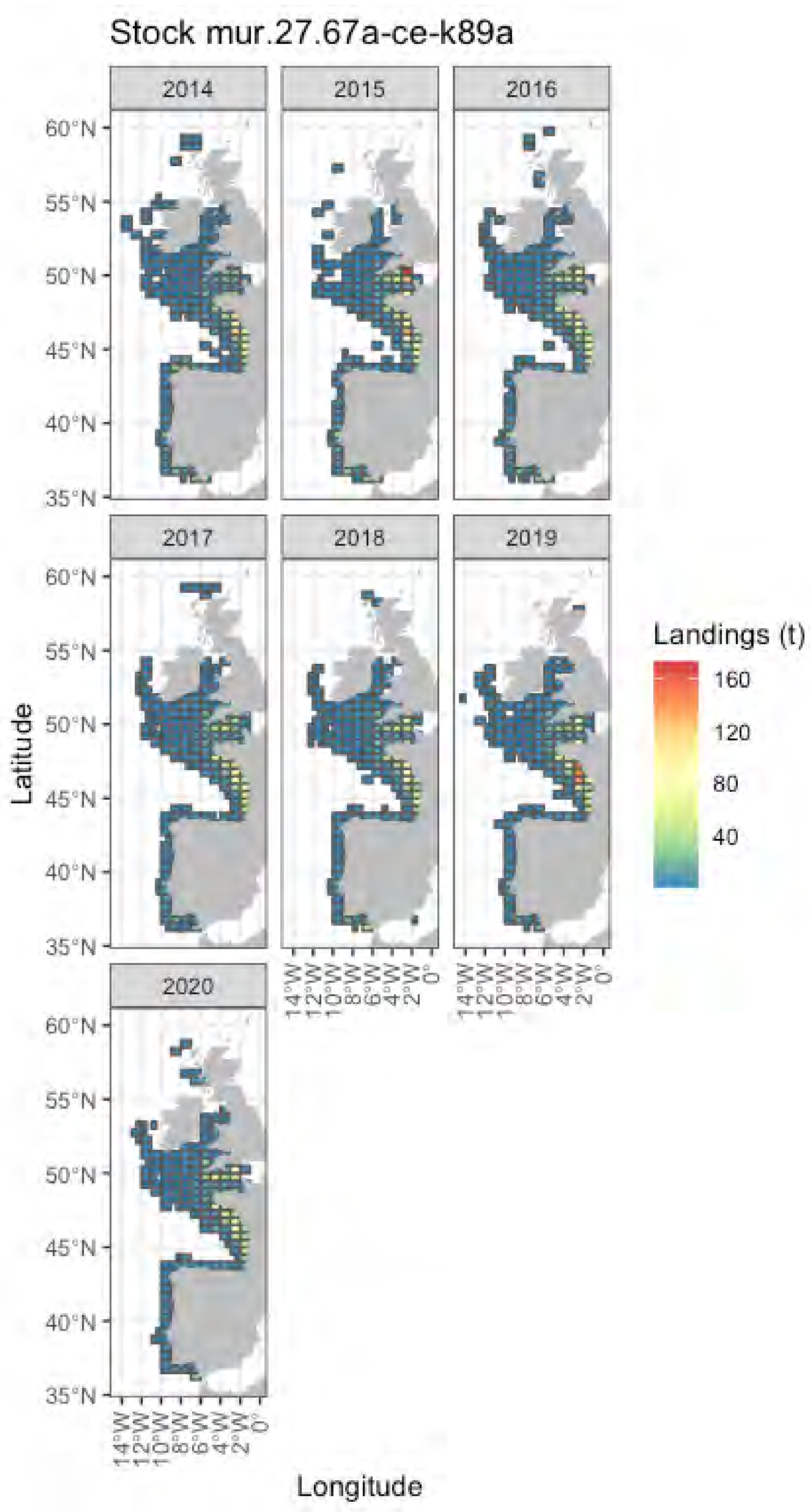

Figure 10.3.1: Striped red mullet in Subareas and Divisions 6, 7a-c, e-f, 8 and 9a. Landings by statistical rectangle for BEL, FRA, IRE, PT, UK (E&W), UK (SCO) from 2014 to 2020 (Fishery Dependent Information database 2021).

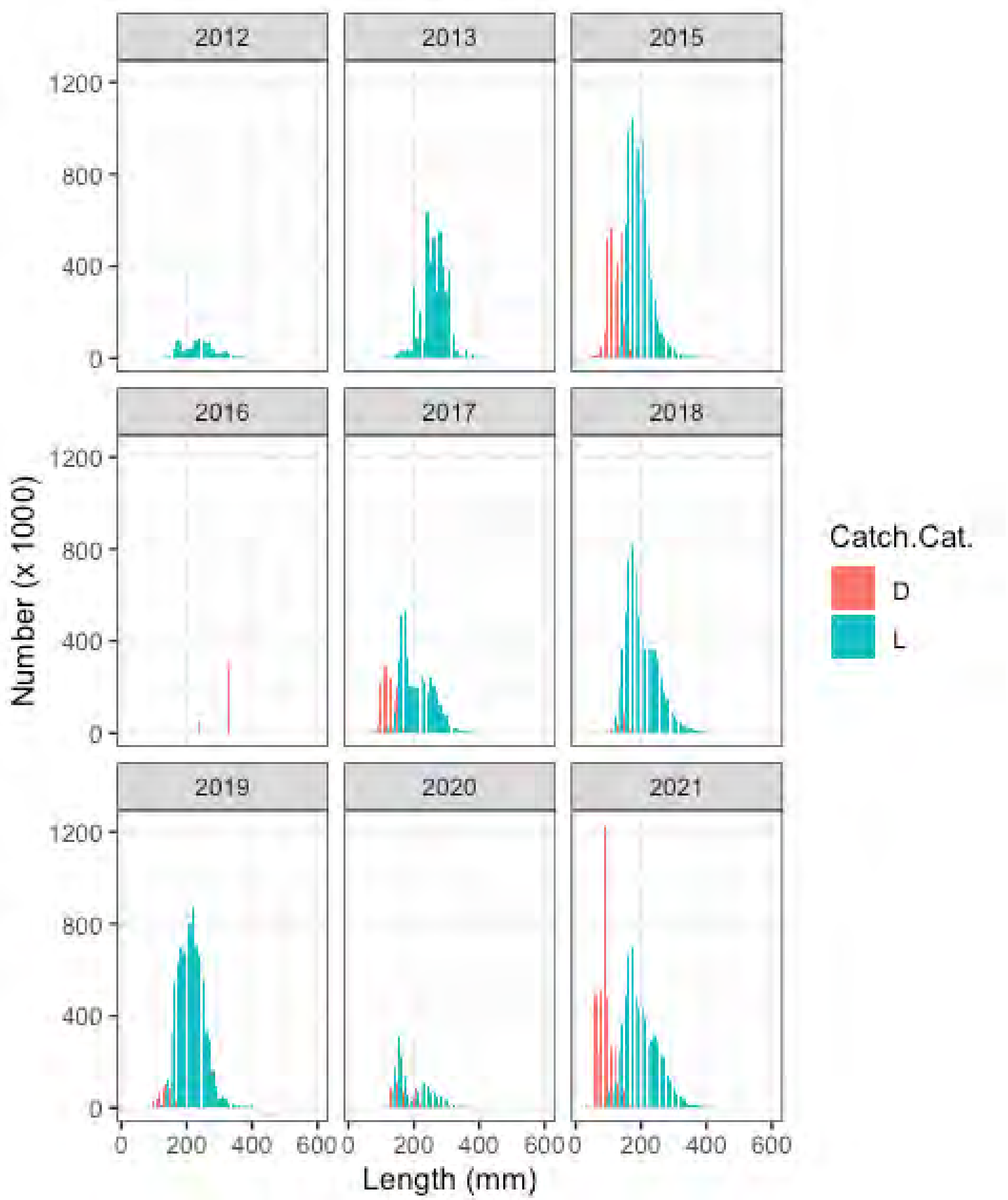

Figure 10.2: Striped red mullet in Subareas and Divisions 6, 7a-c, e-f, 8 and 9a. Length distribution from 2014 to 2021 from Intercatch (D: Discards, L: Landings)

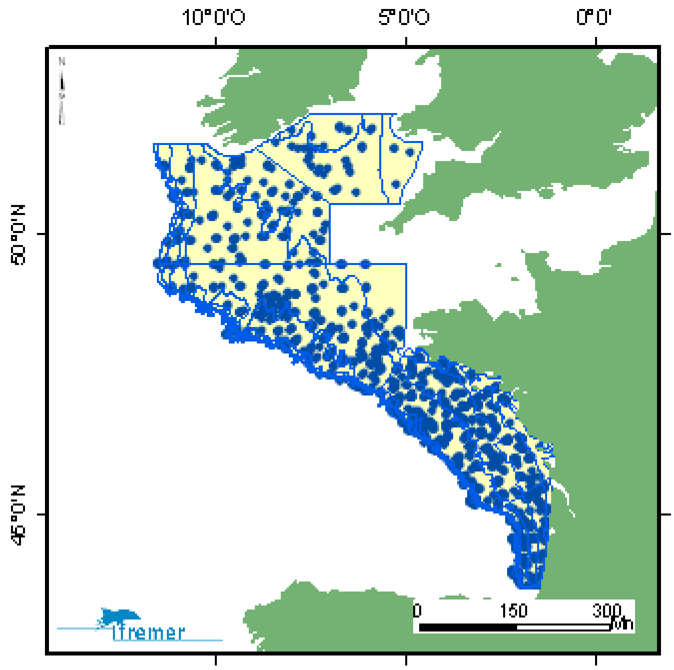

Figure 10.5.1: EVHOE survey station map

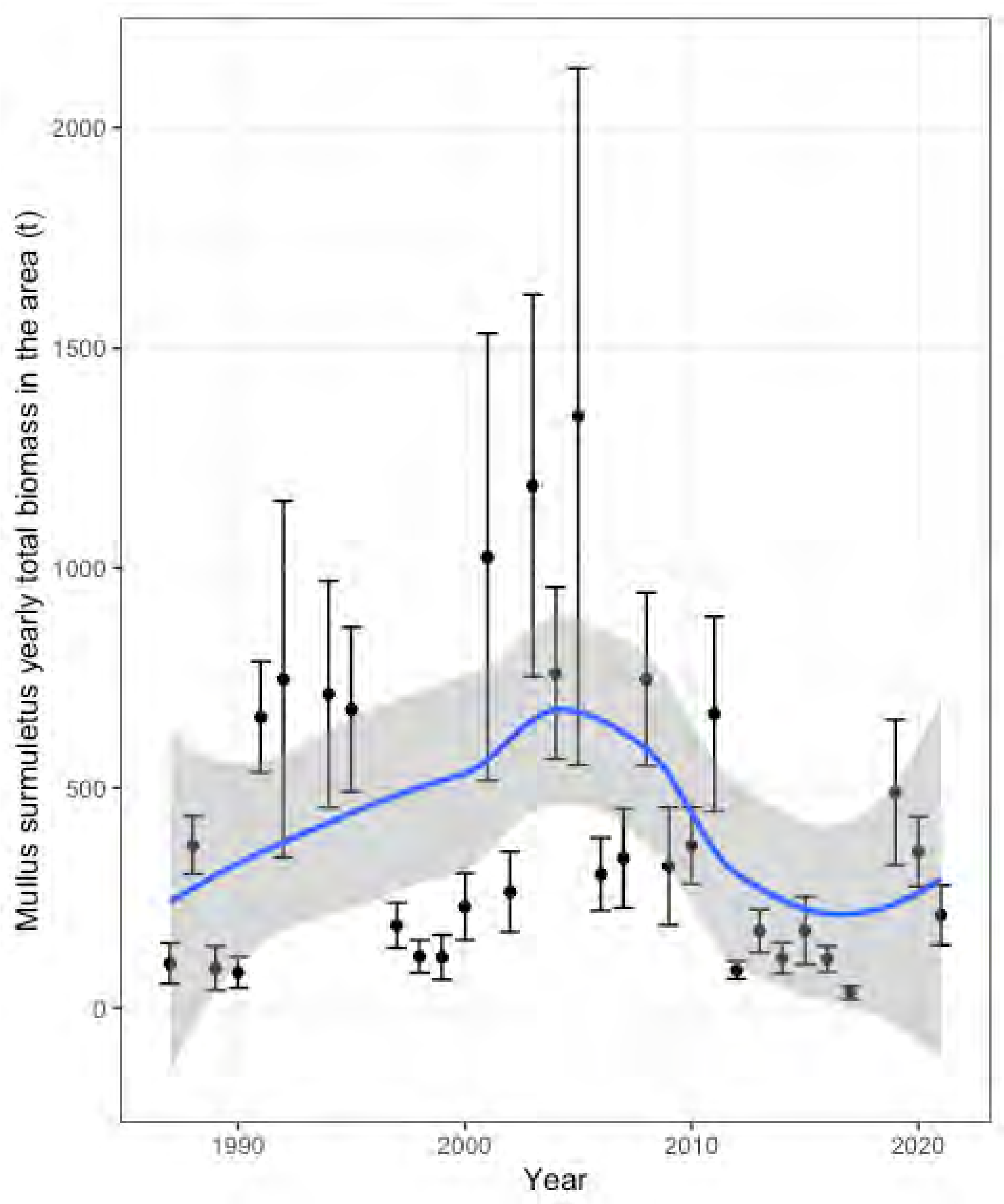

Figure 10.5.2: Total biomass of striped red mullet in Subareas and Divisions 6, 7a-c, e-f, 8 and 9a., estimated from the EVHOE survey in tons, 1997-2021

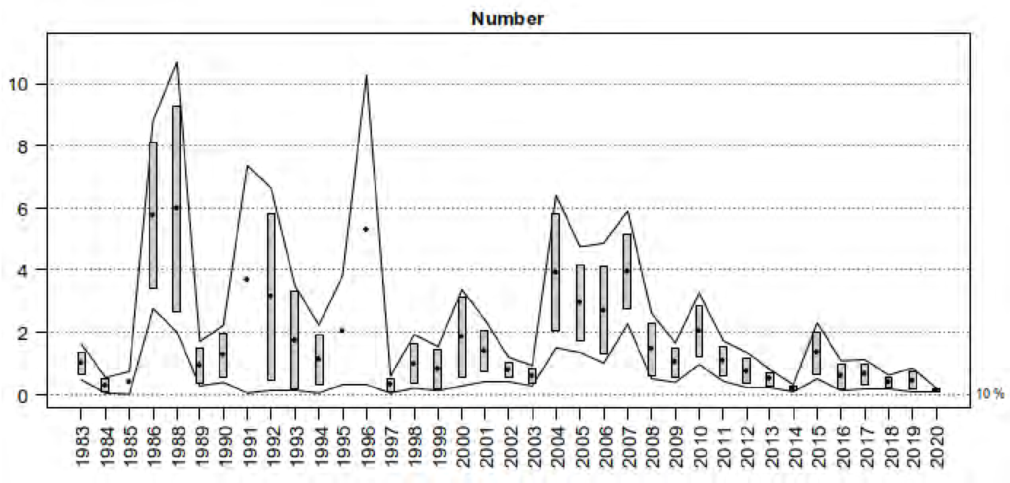

Figure 10.5.3: Striped red mullet in Subareas and Divisions 6, 7a-c, e-f, 8 and 9a. Spain NSGFS mean stratified abundance in northern Spanish Shelf 1983-2020

Annex 1: List of participants

Name	Institute	Country (of institute)	Email	Participation
Aaron Brazier	Cefas	England	aaron.brazier@cefas.co.uk	In person
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Åge Høines	Institute of Marine Research	Norway	aageh@hi.no	In person
Alessandro Orio	Institute of Marine Research	Sweden	alessandro.orio@slu.se	In person
Andrew Campbell (chair)	Marine Institute	Ireland	andrew.campbell@marine.ie	In person
Anna Ólafsdóttir	Marine and Freshwater Research Institute	Iceland	anna.olafsdottir@hafogvatn.is	In person
Are Salthaug	Institute of Marine Research	Norway	are.salthaug@hi.no	In person
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Axelle Cordier	Copenhagen University	Denmark	axelle.cordier@sund.ku.dk	In person
Brendan O'Hea	Marine Institute	Ireland	brendan.ohea@marine.ie	In person (MEGS)
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David Miller	ICES	Denmark	david.miller@ices.dk	In person
Edward Farrell	Marine Institute	Ireland	edward.d.farrell@gmail.com	In person
Ellie MacLeod	Marine Scotland Science	Scotland	eleanor.macleod@gov.scot	Online
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Gersom Costas	CO Vigo - Instituto Español de Oceanografía- CSIC	Spain	gersom.costas@ieo.csic.es	In person
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Name	Institute	Country (of institute)	Email	Participation
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Annex 2: Terms of Reference

WGWIDE– Working Group on Widely Distributed Stocks

Approved in November 2021

2021/2/FRSG20 The **Working Group on Widely Distributed Stocks** (WGWIDE), chaired by Andrew Campbell, Ireland, will meet 24–30 August 2022 in ICES HQ in Copenhagen 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 for the meeting must be available to the group no later than 14 days prior to the starting date.

WGWIDE will report by 2 September 2022 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

Approved in November 2021

2021/2/FRSG01 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 where available;

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

  i) descriptions of ecosystem impacts on fisheries

  ii) descriptions of developments and recent changes to the fisheries

  iii) mixed fisheries considerations, and

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

c) Conduct an assessment on the stock(s) to be addressed in 2022 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 COVID-

19 pandemic disruption 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 2021.

iv) For category 3 and 4 stocks requiring new advice in 2022, 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

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 of https://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/Fisheries%20Resources%20Steering%20Group/2020/WKFORBIAS_2019.pdf) 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, consider whether it is possible and feasible to resolve the issue through an interbenchmark. If this is not possible, consider providing advice using an appropriate Category 2 to 5 approach.;

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

Consistent with ACOM's 2020 decision, the basis for Fpa should be Fp.05.

1) 1. Where Fp.05 for the current set of reference points is reported in the relevant benchmark report, replace the value and basis of Fpa with the information relevant for Fp.05

2) 2. Where Fp.05 for the current set of reference points is not reported in the relevant benchmark report, compute the Fp.05 that is consistent with the current set of reference points and use as Fpa. A review/audit of the computations will be organized.

3) 3. Where Fp.05 for the current set of reference points is not reported and cannot be computed, retain the existing basis for Fpa.

vii) 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;

viii) 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.

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

   i. In the section 'Basis for the assessment' under input data match the survey names with the relevant "SurveyCode" listed ICES survey naming convention *(restricted access)* and add the "SurveyCode" to the advice sheet.

e) 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 2023 for conclusion in 2024;
   iii) determine the prioritization score for benchmarks proposed for 2023–2024;
   iv) as necessary, document generic issues to be addressed by the Benchmark Oversight Group (BOG)

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

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

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

i) If not completed in 2020, 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.

Information of the stocks to be considered by each Expert Group is available here.

Annex 4: List of Stock Annexes

The table below provides an overview of the WGWIDE Stock Annexes. Stock Annexes for other stocks are available on the ICES website Library under the Publication Type "Stock Annexes". Use the search facility to find a particular Stock Annex, refining your search in the left-hand column to include the year, ecoregion, species, and acronym of the relevant ICES expert group.

STOCK ID	STOCK NAME	LAST UPDATED	LINK
boc.27.6-8	Boarfish (*Capros aper*) in Sub areas 6– 8 (Celtic Seas, English Channel, and Bay of Biscay)	September 2020	boc.27.6-8_SA
gur.27.3-8	Red gurnard (*Chelidonichthys cuculus*) in subareas 3–8 (Northeast Atlantic)	September 2021	gur.27.3-8
her.27.1-24a514a	Herring (*Clupea harengus*) in subareas 1, 2, and 5, and in divisions 4.a and 14.a, Norwegian spring-spawning herring (the Northeast Atlantic and Arctic Ocean)	September 2021	her.27.1-24a514a_SA
hom.27.3a4bc7d	Horse mackerel (*Trachurus trachurus*) in divisions 3.a, 4.b-c, and 7.d (Skagerrak and Kattegat, southern and central North Sea, eastern English Channel)	September 2021	hom.27.3a4bc7d_SA
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)	September 2021	hom.27.2a4a5b6a7a-ce-k8_SA
mac.27.nea	Mackerel (*Scomber scombrus*) in subareas 1-7 and 14 and divisions 8.a-e, 9.a (the Northeast Atlantic and adjacent waters)	September 2021	mac.27.nea_SA
whb.27.1-91214	Blue whiting (*Micromesistius poutassou*) in subareas 1-9, 12, and 14 (Northeast Atlantic and adjacent waters)	September 2021	whb.27.1-91214_SA

Annex 4: Audits

1 Audit of Norwegian spring spawning herring (her.27.1-24a514a)

Date: 05.09.2022
Auditor: Afra Egan, Anna Olafsdottir, Axelle

General

The Norwegian springs-pawning herring is carried out using the XSAM model. This audit focuses on input data for the assessment and the WGWIDE report chapter.

For single stock summary sheet advice:

1) **Assessment type:** update/SALY
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: XSAM with 3 survey fleets
5) **Data issues:** 2022 assessment input data are available on SharePoint in the folder "07.Software – 2022_her.27.1-24a514a_assessment".

Input data files were checked against the working group report tables
Data were the same in tables except for 2 instances:

Table 4.4.3.1 Catch numbers at age for 2020 differ from the input file – correction done.
Table 4.4.4.1 Mean weights in the catch at age 1 does not match the input file (not used in the assessment)

The only available catch data from Russian Federation for 2021 was total catch by ICES division from ICES preliminary catch database, and no Russian catch samples were available. Historically, preliminary catches are comparable to ICES final estimated catch. There were adequate samples from other fishing nations operating in the same areas which were used to estimate catch at age and weight at age.

6) **Consistency**: This years' assessment is consistent with last years' assessment and the WG accepted the assessment.
7) **Stock status**: The fishing pressure on the stock is above F_{MSY}, 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 2018: the TAC shall be fixed to a fishing mortality of Fmgt = 0.14, with a constraint of maximum 20% reduction and 25% increase relative to the TAC in the preceding year. If SSB is forecast to be lower than MSY $B_{trigger}$ in the beginning of the quota year, F decreases linearly from F_{mgt} to F = 0.05 over the biomass range from $B_{trigger}$ to B_{lim}. The long-term management strategy has been evaluated by ICES and found to be consistent with the precautionary approach.

General comments

The input data and assessment are documented as described in the stock annex and the report sections are well ordered. A table summarising the assessment settings in the stock annex would be useful and would make the audit easier.

The advice sheet was clearly and concisely written. Numbers and tables in the advice sheet were compared to the same information in the report and rounding differences highlighted and comments forwarded to the responsible person.

Technical comments
To the best of our knowledge, the assessment has been performed correctly according to the stock annex.

Table and figure numbers and references to them in the text have been checked.

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? I think so?
- 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?
- 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

Audit of Western Horse Mackerel data and assessment

Date: 07/09/2022

Auditor: Alessandro Orio, Sólvá Káradóttir Eliasen, Eleanor MacLeod, Richard Nash

General

Western horse mackerel is assessed as a Category 1 stock. An 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:

9) **Assessment type:** update
10) **Assessment**: analytical.
11) **Forecast**: presented
12) **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.
13) **Data issues:** No data issues.
14) **Consistency**: The view of the WG was that the assessment should be accepted. The Stock annex needs to be updated for the F and M before spawning used in the forecast (assumed at the beginning of the year in the current forecast) and for the new F_{pa} value due the changed basis.
15) **Stock status**: Fishing pressure on the stock is above F_{MSY} and between F_{pa} and F_{lim}; spawning-stock size is below MSY $B_{trigger}$, B_{pa} and B_{lim}.
16) **Management Plan**: No management plan

General comments

The assessment and forecast have been available for review. Input and output data were correct. A few inconsistencies were found in the advice sheet but these have been already corrected.

Technical comments

Few inconsistencies are present in the stock annex. F and M before spawning in the forecast needs to be updated in the stock annex since in the forecast the spawning time is assumed to happen at the beginning of the year. The section on reference points needs to be updated with the new F_{pa} due to the change of basis.

A thorough revision of the number of samples used for the different age and length frequency distributions in the assessment is suggested for the next benchmark iteration. There is a need to inspect the potential problems caused by the reweighting of both age length keys and age frequency distribution of the commercial catches using the same parameter. The fishing mortality estimated by the model is weighted by the population numbers but now the unweighted F can be obtained so it would be preferable to switch to that in the future to avoid extra calculations. Forecasts run directly in SS should be also considered during the next benchmark.

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).

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.

2 Audit of the Blue whiting assessment (whb.27.1-91214)

Date: 01.09.2022

Auditor: Martin Pastoors, Leif Nottestad, Ed Farrell, Jessica Tingvall

General

The blue whiting assessment is carried out using the SAM model and available on Stockassessment.org (WHB-2022). This audit focuses on input data, assessment, forecast and draft advice document.

For single stock summary sheet advice:

17) **Assessment type: update/SALY**
18) **Assessment**: analytical
19) **Forecast**: presented; derived directly from the outputs of the SAM model. Appropriate settings according to Stock Annex.
20) **Assessment model**: SAM with 1 survey fleet
21) **Data issues:** Estimation of preliminary catch in 2022 difficult because of absence of Russian information. The tables in the report have been checked in relation to the input files used for the assessment and in relation with the tables in the advice summary.
22) **Consistency**: This years' assessment is consistent with last years' assessment, although there is very different outlook due to an incoming new year class. The WG accepted the assessment.
23) **Stock status**: The fishing pressure on the stock is above FMSY, FMGT and Fpa (but below Flim). Spawning-stock size is above MSY Btrigger, Bpa, and Blim.
24) **Management Plan**: Agreed by the Coastal States in October 2016 after evaluation of the management plan by ICES. The long-term management strategy was found to be consistent with the precautionary approach. However, the management plan was modified subsequent to the evaluation by ICES by including a clause to lift the limit on TAC change if the change was more than 40% (Clause 6). This modification has not been evaluated by ICES. Despite the agreement on the management plan by the Coastal States, the plan has not been effective due to a lack of agreement on the sharing of the TAC.

General comments

The input data and assessment are documented as described in the stock annex and the report sections are well ordered.

Technical comments

The code for the short term forecast is embedded in a large collection of code (_job_to_do_it_all.R) that is not running on stockassessment.org. If the stock is not being entered into TAF, it could be beneficial to at least include the forecast methodology directly on stockassessment.org. The text on the forecast in the stock annex needs updating as it is referring to code being available on stockassessment.org which is currently not the case.

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 (in some cases the SA will need minor updates)
- 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? The management plan has been agreed by the Coastal States in October 2016 after evaluation of the management plan by ICES. The long-term management strategy has been evaluated by ICES and was consistent with the precautionary approach. However, the management plan was modified subsequent to the evaluation by ICES by including a clause to lift the limit on TAC change if the change was more than 40% (Clause 6). This modification has not been evaluated by ICES. Despite the agreement on the management plan by the Coastal States, the plan has not been effective due to a lack of agreement on the sharing of the TAC.
- 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**

Checking of Blue whiting report tables.

Green = checked and ok. NO highlight = can't find the source data. Yellow = potential issue

1. **Table 2.3.1.1. Blue whiting. ICES estimated catches (tonnes) by country for the period 1988–2021.**
2. **Table 2.3.1.2. Blue whiting. ICES estimated catches (tonnes) by country and ICES division for 2021.**
3. **Table 2.3.1.3. Blue whiting. ICES estimated catches (tonnes) by quarter and ICES division for 2021.**
4. **Table 2.3.1.4. Blue whiting. ICES estimated catches (tonnes) from the main fisheries 1988–2021 by area.**
5. **Table 2.3.1.5. Blue whiting. ICES estimates (tonnes) of catches, landings and discards by country for 2021.**
6. **Table 2.3.1.6. Blue whiting. ICES estimated catches (tonnes) inside and outside NEAFC regulatory area for 2021 by country.**
7. **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 2000-2021.**
8. **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 2021.

9. **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 2021.**

10. **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 2021.**

11. **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 2021.**

12. **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 2021.**

13. **Table 2.3.2.1. Blue whiting. ICES estimated preliminary landings (tonnes) in 2022 by quarter and ICES division. Data submitted to InterCatch.**

14. **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 2022 preliminary data (quarters 1 and 2). Data submitted to InterCatch.**

15. **Table 2.3.2.3. Blue whiting. ICES estimates of catches (tonnes) in 2022, based on (initial) declared quotas and expected uptake estimated by WGWIDE.**

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

17. **Table 2.3.3.1. Blue whiting. Catch-at-age numbers (thousands) by year. Discards included since 2014. Values for 2022 are preliminary.**
    a. From 2011 onwards the data file (cn.dat) numbers are given to a few decimal places which is not show in the report tables.
    b. There is a difference in how some of these decimals are rounded when at 0.5 in data. In some cases rounded up and in some rounded down.
        i. 2016 age 3 in data is 2933271.5 and 2933271 in table
        ii. 2018 age 9 in data is 90387.5 and 90387 in table
        iii. 2021 age 7 in data is 1360104.5 and 1360104 in table

18. **Table 2.3.4.1. Blue whiting. Individual mean weight (kg) at age in the catch. Preliminary values for 2022.**
    a. cw.dat. Checked. OK.

19. **Table 2.3.5.1. Blue whiting. Natural mortality and proportion mature.**
    a. From mo.dat. OK

20. **Table 2.3.7.1.1. 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 2004-2022) are used as input to the assessment**
    a. survey.dat. OK

21. **Table 2.3.7.2.1. Blue whiting. Estimated abundance of 1 and 2 year old blue whiting from the International Ecosystem Survey in Nordic Seas (IESNS), 2003–2022.**

    Compare report table to table in BW_RecruitmentRank22.xls. There is one disagreement in the table in 2014. In the report age 1 and 2 in 2014 are 3893 and 2048 but in the xl table they are 3937 and 2030, respectively.

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

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

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

25. **Table 2.4.1.1. Blue whiting. Parameter estimates, from final assessment (2022) and retrospective analysis (2018-2021).**

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

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

    a. The 2023 data is in the model output but not in the report table. Is this correct??

28. **Table 2.4.1.4. Blue whiting. Estimated stock numbers-at-age (thousands). Preliminary catch data for 2022 have been used.**

    a. The 2023 age 1 figure is missing from the report table but is in the model output table. Is this correct?

29. **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 (TBS) in tonnes. Preliminary catch data for 2022 are included.**

    a. Some of the 2023 values that are in the model output are not in the report table. Is this correct?

30. **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.**

31. **Table 2.8.2.1.1. Blue whiting. Input to short-term projection (median values for exploitation pattern and stock numbers).**

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

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

Some checking of the assessment inputs and settings:

1. "# preliminary year catches, the best guesses on total catch in the current (full) year (the catch of O-groups should be subtracted, but not done)" – JT: Has this been dealt with or not?
   MV: The 0-group catch at age is very small in the preliminary Q1 and Q2 catches (they are mainly caught in the second half-year), however our best guess on the total catch weight is transformed to catch at age without taking account of the 0-group. This will provide (an insignificant) bias, but we ignore that, for the preliminary data.
2. #totalyield<- 1233169 ## best guess for 2021 – JT: Cannot find this number anywhere?
   EB: this is the value the preliminary catches for 2021 used in last year's assessment, so I think this is not relevant anymore - we could have even deleted this line as we're not using it in this year's assessment.
   totalyield<- 1107529 ## best guess for 2022 - ok!
3. **Fpa<-0.32** in stock annex it says Fpa= 0.53. – JT: Not sure if this is a typo in the code or if 0.32 is correct, but in the stock annex it is Fpa = 0.53 (refer to table in stock annex on page 23). The other BRFs are ok.
   EB: thanks a lot for spotting, this is an old value! We'll change it to 0.32 in the stock annex.

4. JT: Configuration looks ok. I'm guessing that 1's in stock annex is equivalent to 0's in the script? See example below:

Coupling of fishing mortality STATES

Rows represent fleets.

Columns represent ages.

1 2 3 4 5 6 7 8 9 10 # Age

1 2 3 4 5 6 7 8 9 9 # **Catch –** stock annex

$keyLogFsta - in script
0 1 2 3 4 5 6 7 8 8

MV: The configuration file was made for the ADMB version of SAM, but now where we use the TMB version it is fine to change the configuration to that (and maybe add a sentence that the configuration file is for use with the TMB version of SAM).

EB: I'll make this change in the stock annex.

Audit of (Northeast Atlantic mackerel (mac.27.nea))

Date: 8th September, 2022

Auditor: Eydna í Homrum, Sondre Hølleland, Esther Beukhof

- *Audience to write for: ADG, ACOM, benchmark groups and EG next year.*
- *Aim is to audit (check if correct):*
  - *the stock assessment– concentrate on the input data, settings and output data from the assessment*
  - *the correct use of the assessment output in the forecast, and check if forecast settings are applied correctly*
- *Any deviations from the stock annex should be described sufficiently.*
- *By the conclusion of the working group, all update assessments should be audited successfully.*
- *Store all audits on SharePoint for future reference.*

General

This audit focuses on the advice sheet and the WGWIDE report section on NEA Mackerel. The advice sheet is generally consistent with the report section. Some small inconsistencies in catch tables were identified between the advice sheet and the report. The assessment model performance was good, and a systematic downward revision in the retrospective pattern for F in recent years seems to be improved.

For single stock summary sheet advice:

25) **Assessment type:** updated assessment (inter-benchmarked in 2019)
26) **Assessment**: analytical
27) **Forecast**: presented
28) **Assessment model**: A modified state-space Assessment Model (SAM) that is able to incorporate tag/recapture data – both historical steel tags (1980-2006) and recent RFID tags (2014-2021) together with three additional survey indices.
29) **Data issues:** For the IBTS age 0 index, no value for 2021 could be calculated due to technical issues with one survey vessel covering an historically important area. Therefore, the stock assessors had to deviate from the methodology in the stock annex for estimating recruitment for 2021 in the short-term forecast. The time-tapered geometric mean was estimated without the weighting procedure that uses the IBTS index and the SAM recruitment estimates combinedly. Instead, the time-tapered geometric mean was estimated using the SAM estimates only.
    There was no submission of Russian data to WGWIDE this year, yet both preliminary catches for 2021 and final catches from 2018-2020 indicated a Russian proportion of the catches of 13%. It is therefore considered appropriate to use the historic average (2018-2020) to assign catches to Russia in 2021 and to use samples from Iceland and the Faroes to allocate the Russian catches, as these countries fish largely within the same area and time of year.
30) **Consistency**: The retrospective bias (8 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.
31) **Stock status**: SSB is above all reference points (MSY $B_{trigger}$, B_{pa}, and B_{lim}) and F is above F_{MSY} but below F_{pa} and F_{lim}.
32) **Management Plan**: There is no management strategy agreed for the stock, therefore ICES based its advice on the MSY approach. No agreement on the share of the stock has

been reached for 2022. Despite the acceptance of ICES advice, the total declared quotas in each of the years 2015 to 2021, all exceed the maximum catch advised by ICES.

General comments

The report section reads well and most information is there. However, the report is not entirely updated to the fact that Russian catch data (catch at age and catch by rectangle) were not submitted to WGWIDE; smaller edits have been reported to the team responsible for the report chapter to be included in this year's report.

The advice sheet is well documented. WGWIDE decided to present the recruitment in the advice sheet as age 2 rather than as age 0, as abundances of age 0 and age 1 do not reflect year class strength very well. Explanation for this is briefly stated in the figure captions of Figure 1 and 2 in the advice sheet, though not in the text of the sheet.

Technical comments

The code and input data for the analysis (assessment, and short-term forecast) are all available on SharePoint. An auditor reran the assessment and short-term forecast, reproducing the reported results. Some adjustments were necessary to achieve this (e.g., adjusting paths, installing specific versions of R packages etc.).

To the best of our knowledge, the assessment has been performed correctly according to the stock annex.

The report is rather long. Particularly the sections on surveys (used and unused) could be considerably shortened; at the time of reviewing the text, one survey-section (not used in the assessment) had not been updated.

Table and figure numbers and references to them in the text have been checked.

Conclusions

The assessment has been performed correctly according to the stock annex.

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 (Stock name)

Date: 02/09/2022
Auditor: Are Salthaug

General

Advice was provided in 2021 for both 2022 and 2023, thus this year's assessment is exploratory.

For single stock summary sheet advice:

33) **Assessment type: update/SALY**
34) **Assessment**: trends - Category 3 with biennial advice
35) **Forecast**: not presented
36) **Assessment model**: Bayesian state space surplus production model fitted using catch data, 6 delta-lognormal estimated IBTS survey indices, and 1 acoustic survey estimate.
37) **Data issues:** No data issues
38) **Consistency**: This updated assessment is consistent with the assessment carried out in 2021
39) **Stock status**: Reference points are undefined**.**
40) **Management Plan**: A management strategy proposed by the Pelagic Advisory Council was evaluated and found to be precautionary (ICES, 2015). ICES provides advice for this stock following the precautionary approach, which in this case corresponds to the management strategy from the PelAC.

General comments

The chapter is easy to follow and interpret.

Technical comments

None

Conclusions

The assessment has been performed correctly according to the procedure.

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 Red Gurnard stock assessment

Date: 02.09.2022
Auditor: Patricia Gonçalves

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 2021, discard data has been provided for 2015 - 2021 through Intercatch, 6 survey abundances index for the species area presented from around 1990 to 2021, with a combined biomass index built on these series.

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 very 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 has been correctly computed. There is no assessment for this stock.

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?

Working Document to

ICES Working Group on Widely Distributed Stocks (WGWIDE, No. 1)
ICES HQ, Copenhagen, Denmark, (hybrid meeting) 24. – 30. August 2022

Cruise report from the International Ecosystem Summer Survey in the Nordic Seas (IESSNS) 1st July – 3rd August 2022

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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 2022 using six vessels from Norway (2), Iceland (1), Faroe Islands (1), Greenland (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 seven years (2016-2022).

The survey coverage area included in calculations of the mackerel index was 2.9 million km^2 in 2022, which is 32% larger coverage compared to 2021. Survey coverage was increased in the western areas (Iceland and Greenland waters) compared to in 2021. Furthermore, 0.28 million km^2 was surveyed in the North Sea in July 2022, but those stations are excluded from the mackerel index calculations.

The total swept-area mackerel index in 2022 was 7.37 million tonnes in biomass and 17.51 billion in numbers, an increase by 43% for biomass and 43% for abundance compared to 2021. In 2022, the most abundant year classes were 2020, 2019, 2010, 2011, respectively. The cohort internal consistency improved compared to last year, particularly for ages 5-8 years.

Most of the surveyed mackerel still appears to be in the Norwegian Sea. The mackerel were more westerly distributed than in the last 2 years.

The zero-line was reached south and north of Iceland and in the west in Greenland waters. It was not reached in the north-western and north-eastern part of the Norwegian Sea but given that the polar front with water too cold for mackerel is usually found close to the northwesternmost catches, we assume that the zero-line was practically reached here as well. Towards the Barents Sea the zero-line was not reached but considered of less quantitative importance based on low catch rates. The zero-line was not reached on the European shelf, where mackerel are present west of the British Isles and in the southern North Sea

Total number of NSSH recorded during IESSNS 2022 was 25.0 billion and the total biomass index was 7.14 million tonnes, or 22% (abundance) and 17% (biomass) higher than in 2021. The 2016 year-class (6-year-olds completely dominated in the stock and contributed to 58% and 56% to the total biomass and total abundance, respectively, whereas the 2013 year-class (9-year-olds) contributed 8% and 7% to the total biomass and total abundance, respectively. The 2016 year-class is fully recruited to the adult stock.

The zero-line of the distribution of the mature part of NSSH was considered to be reached in all directions. The group considered the acoustic biomass estimate of herring in 2022 to be of the similar quality as in the previous survey years. The herring was mainly observed in the upper surface layer as relatively small schools.

Total biomass of blue whiting registered during IESSNS 2022 was 2.2 million tons, which is to the same as in 2021. Estimated stock abundance (ages 1+) was 27.5 billion compared to 26.2 billion in 2021. Age 1 and 2 respectively, dominated the estimate in 2022 as they contributed to 44% and 33% (abundance) and 30% and 33% (biomass), respectively. The group considered the acoustic biomass estimate of blue whiting to be of good quality in the 2022 IESSNS as in the previous survey years.

As in previous years, there was overlap in the spatio-temporal distribution of mackerel and herring. This overlap occurred between mackerel and North Sea herring in the North Sea and partly in the southernmost part of the Norwegian Sea. There were also some overlapping distributions of mackerel and Norwegian spring-spawning herring (NSSH) particularly in the western, north-western part of the Norwegian Sea.

Other fish species also monitored are lumpfish (*Cyclopterus lumpus*) and Atlantic salmon (*Salmo salar*). Lumpfish was caught at 71% of surface trawl stations distributed across the surveyed area from southwestern part of Iceland, central part of North Sea to southwestern part of the Svalbard. Abundance was greater north of latitude 72°N compared to southern areas. A total of 60 North Atlantic salmon were caught in 38 stations both in coastal and offshore areas from 61°N to 76°N in the upper 30 m of the water column. The salmon ranged from 0.028 kg to 4.1 kg in weight, dominated by post-smolt and 1 sea-winter individuals. We caught from 1 to 6 salmon during individual surface trawl hauls. The length of the salmon ranged from 15 cm to 74 cm, with the highest fraction between 20 cm and 30 cm

Satellite measurements of sea surface temperature (SST) in the Northeast Atlantic in July 2022 show that parts of central Norwegian Sea and areas east and north of Iceland were slightly cooler than the long-term average for July 1990-2009. The northern regions of the Nordic Seas were slightly warmer than the average while the East Greenland Current was cooler that the long-term average. The SST in the Irminger Sea and Iceland Basin were slightly warmer than the average.

The zooplankton biomass varied between areas with a patchy distribution throughout the area. In the Norwegian Sea areas, the average zooplankton biomass was at similar level as last year, slightly lower in Icelandic waters, and higher in Greenlandic waters.

2 Introduction

During approximately four weeks of survey in 2022 (1st of July to 3rd of August), six vessels; the M/V "Eros" and M/V "Vendla" from Norway, "Jákup Sverri" operating from Faroe Islands, the R/V "Árni Friðriksson" from Iceland; R/V "Tarajoq" from Greenland 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. 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 when 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 and Atlantic salmon. Opportunistic whale observations are also recorded from Norway, Iceland, 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).

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 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 but was back in 2022 with their new research vessel R/V "Tarajoq".

The North Sea was included in the survey area for the fifth time in 2022, 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 - 2021 results).

3 Material and methods

Coordination of the IESSNS 2022 was done during the WGIPS 2022 virtual meeting in January 2022, and by correspondence in spring and summer 2022. The participating vessels together with their effective survey periods are listed in Table 1.

Overall, the weather conditions were rougher than usual for the Norwegian vessels in the first part of the survey. However, in the second part, the weather conditions and progress were good. The Icelandic vessel, operating in Icelandic waters, experienced calm weather for duration of the survey with no survey delay, and no CTD or WP2-net sampling was skipped due to high winds. The weather was worse than what is has been previous years for the Faroese vessel which operated in Faroese and Icelandic waters. This resulted in slow progression and the Icelandic vessel had to cover the northernmost transect line for R/V Jakup Sverri. 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 also 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 2022. 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	4-21/7	4082	48/46	46	46
Jákup Sverri	1-17/7	2768	33/27	28	28
Ceton	3-12/7	1905	38/34	34	-
Vendla	5/7-3/8	5369	74/60	59	59
Eros	5/7-3/8	5233	67/57	56	56
Tarajoq	21/7-1/8	1522	19/19	19	19
Total	1/7-3/8	20879	275/247	242	208

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. Tarajoq used a SEABIRD SBE 19plus. Ceton used a Seabird SeaCat offline CTD. The CTD-sensors were used for recording temperature, salinity, and pressure (depth) from the surface down to 210 m, or to the bottom when at shallower depths.

Zooplankton was sampled with a WP2-net on 4 of 5 vessels, excluding Ceton which operates in the North Sea. Mesh sizes were 180 µm (Eros and Vendla) and 200 µm (Árni Friðriksson, Jákup Sverri and Tarajoq). 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).

Two planned CTD and plankton stations 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. 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 Icelandic and 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). 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 2018, 2019, 2020, 2021 and 2022.

Table 2. Trawl settings and operation details during the international mackerel survey in the Nordic Seas from 1st July to 3rd August 2022. 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	Tarajoq	Influ-ence
Trawl producer	Hampiðjan new 2017 trawl	Egersund Trawl AS	Egersund Trawl AS	Vónin	Egersund Trawl AS	Hampiðjan	0
Warp in front of doors	Dynex-34 mm	Dynex -34 mm	Dynex	Dynex – 38 mm	Dynex-34 mm	Dynex-34 mm	+
Warp length during towing	350	350	290-305	350	350-400	350	0
Difference in warp length port/starb. (m)	16	2-10	10	0-7	5-10	10-20	0
Weight at the lower wing ends (kg)	2×400 kg	2×400	2×400	2×400	2×400	2×500	0
Setback (m)	14	6	6	6	6	6	+
Type of trawl door	Jupiter	Seaflex 7.5 m² adjustable hatches	Thybron type 15	Vónin Twister	Seaflex 7.5 m² adjustable hatches	T-20vf Flipper	0
Weight of trawl door (kg)	2200	1700	1970	1650	1700	2000	+
Area trawl door (m²)	6	7.5 with 25% hatches (effective 6.5)	7	4.5	7 with 50% hatches (effective 6.5)	7 with 50% hatches (effective 6.5)	+
Towing speed (knots) mean (min-max)	5.3 (4.6-5.7)	4.6 (4.1-5.5)	5.1 (4.5-5.6)	4.4 (3.6-6)	4.7 (4.1-5.725)	4.9 (4.4-5.4)	+
Trawl height (m) mean (min-max)	32 (26-41)	28-37	30 (25-35)	43 (35–50)	25-32	-	+
Door distance (m) mean (min-max)	107 (95 - 115)	121.8 (118-126)	131.2 (126-137)	115 (107 – 135)	135 (113-140)	105.4 (92-109)	+
Trawl width (m)*	63.75	63.8	72.0	63.4	67.5	61.4	+
Turn radius (degrees)	5-10	5-12	5-10	5 BB turn	5-8 SB turn	6-8 SB turn	+
Fish lock front of cod-end	Yes	Yes	Yes	Yes	Yes	Yes	+
Trawl door depth (port, starboard, m) (min-max)	3-21, 4-8	6-22, 8-23	6-15, 8-20	7-26, 7-20	(6-20)	-	+
Headline depth (m)	0	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 on each wingtip	Kite + 2 buoy on each wingtips	Kite + 1 buoy on each wingtips	+

Weighing of catch	All weighted	All weighted	All weighted	Catch < 12 tonnes weighed	All weighted	All weighted	+

* calculated from door distance (Table 6)

Table 3. Protocol of biological sampling during the IESSNS 2022. Numbers denote the maximum number of individuals sampled for each species for the different determinations.

	Species	Faroes	Iceland	Norway	Denmark	Greenland
Length measurements	Mackerel	200/100*	150	100	≥ 125	100/50*
	Herring	200/100*	200	100	75	100/50*
	Blue whiting	200/100*	100	100	75	100/50*
	Lumpfish	all	all	all	all	All
	Salmon	-	all	all	-	All
	Capelin		100/50^^	25-30		25/25
	Other fish sp.	20-50	50	25	As appropriate	25
Weight, sex and maturity determination	Mackerel	15-25	50	25	***	25
	Herring	25-50	50	25	0	25
	Blue whiting	15-50	50	25	0	
	Lumpfish	10	1^	25	0	
	Salmon	-	0	25	0	0
	Capelin		100/50^^			25
	Other fish sp.	0	0	0	0	25
Otoliths/scales collected	Mackerel	15-25	25	25	***	25
	Herring	25-50	25	25	0	0
	Blue whiting	15-50	50	25	0	0
	Lumpfish	0	1^	0	0	0
	Salmon	-	0	0	0	50
	Capelin		100/50^^			0
	Other fish sp.	0	0	0	0	50
Fat content	Mackerel	0	10	0	0	0
	Herring	0	10**	0	0	0
	Blue whiting	0	10	0	0	0
Stomach sampling	Mackerel	5	10	10	0	0
	Herring	5	10**	10	0	0
	Blue whiting	5	10	10	0	0
	Other fish sp.	0	0	10	0	0
Tissue for genotyping	Mackerel	0	0	0	0	0
	Herring	0	0	25	0	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.
^^Numbers changed from 100 to 50 during survey.

This year's survey was well synchronized in time and was conducted over a relatively short period (less than 5 weeks) given the large spatial coverage of around 2.9 million km^2 (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 July. The main argument for this time period was to make the 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 4 and 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 70 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 5th July and 2nd August 2022 onboard M/V "Eros" and M/V "Vendla", and onboard R/V Árni Friðriksson from 4th until 21st July 2022. On board Jákup Sverri (1st – 17th 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" and R/V Tarajoq 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 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 4th July 2022 for 18, 38, 70, 120 and 200 kHz. Árni Friðriksson was calibrated 28th of May 2022 for frequencies 18, 38, 70, 120 and 200 kHz. Jákup Sverri was calibrated on 24th April 2022 for 18, 38, 120, 200 and 333 kHz. Tarajoq was calibrated on 20th May 2022 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). Acoustic measurements were not conducted onboard Ceton in the North Sea. 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 = 20.0 log(L) – 71.9 dB

Table 4. Acoustic instruments and settings for the primary frequency (38 kHz) during IESSNS 2022.

	R/V Árni Friðriksson	M/V Vendla	Jákup Sverri	Eros	Tarajoq*
Echo sounder	Simrad EK80	Simrad EK60	Simrad EK80	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	18, **38**, 70, 120, 200, 333
Primary transducer	ES38-7	ES38B	ES38-7	ES38B	ES38-7
Transducer installation	Drop keel	Drop keel	Drop keel	Drop keel	Drop keel
Transducer depth (m)	9.6	8	6-9	6	7
Upper integration limit (m)	15	15	15	15	
Absorption coeff. (dB/km)	10.5	9.9	9.5	9.3	
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Band width (kHz)	2.425	2.43	3.064	2.43	
Transmitter power (W)	2000	2000	2000	2000	2000
Angle sensitivity (dB)	18	21.90	21.9	21.9	
2-way beam angle (dB)	-20.30	-20.70	-20.6	-20.7	
TS Transducer gain (dB)	27.03	25.22	27.27	25.22	
s_A correction (dB)	-0.04	-0.73	-0.01	-0.72	
3 dB beam width alongship:	6.43	6.88	6.86	6.85	
3 dB beam width athw. ship:	6.43	6.76	6.89	6.79	
Maximum range (m)	500	500	500	500	750
Post processing software	LSSS v.2.12.0	LSSS 2.12.0	LSSS 2.12.0	LSSS 2.12.0	LSSS 2.12.0

M/V Ceton: No acoustic data collection because other survey in the same area in June/July (HERAS).

*Acoustic data collected but not post-processed at the time of report writing.

Multibeam sonar

Both M/V Eros and M/V Vendla were equipped with the Simrad fisheries sonar SH90 (frequency range: 111.5-115.5 kHz), 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 six 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 35-90 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 2022 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.

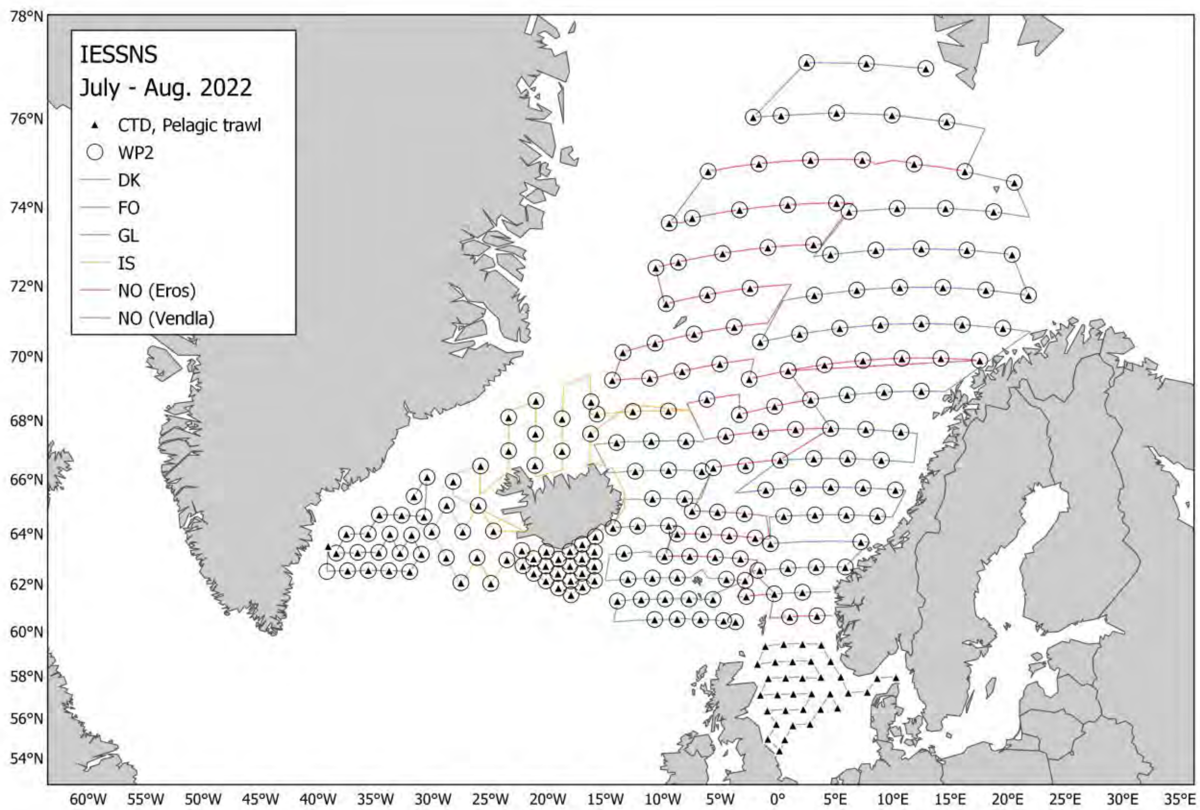

Figure 1. Fixed predetermined trawl stations (shown for CTD and WP2) included in the IESSNS from July 1st to August 3rd 2022. At each station a 30 min surface trawl haul, a CTD station (0-500 m) and WP2 plankton net samples (0-200 m depth) was performed.

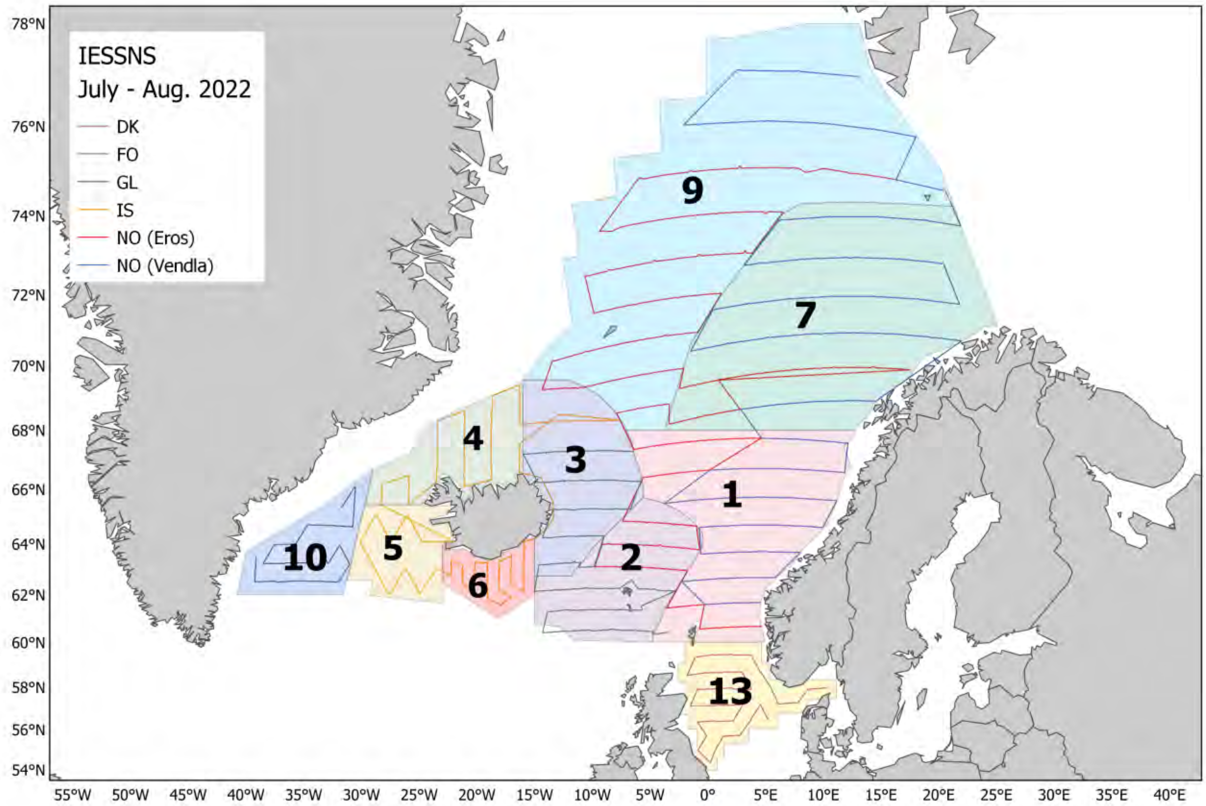

Figure 2. Permanent and dynamic strata used in StoX for IESSNS 2022. The survey area is split into 10 strata, of which 6 are permanent (1, 2, 3, 7, 10 and 13) and four dynamic (4, 5, 6 and 9). The former stratum 8 (along the Norwegian coast) was merged into adjacent strata 1 and 7. The former stratum 11 (southern Greenland) has not been surveyed the last few years. 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).

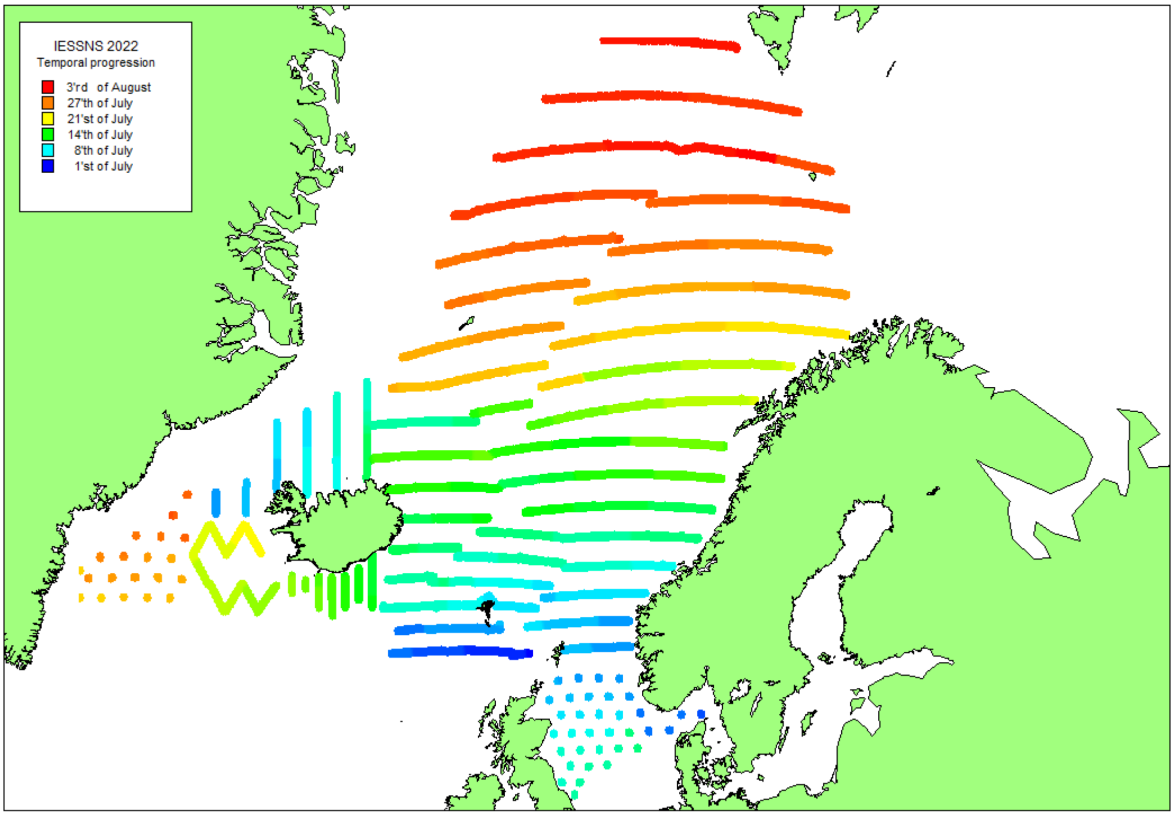

Figure 3. Temporal survey progression by vessel along the cruise tracks during IESSNS 2022: Blue represents effective survey start (1'st of July) progressing to red representing a five-week span (survey ended 3rd of August). As Ceton and Tarajoq did not submit acoustics, they have been represented by 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 3.5.0. The herring and blue whiting acoustic abundance indices were calculated using StoX version 3.4.0.

3.7 Swept area index and biomass estimation

This year the input data for the swept area calculations were taken from the ICES database in contrast to previous years where 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 2022. 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 2022 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	Tarajoq
Trawl doors horizontal spread (m)						
Number of stations	27	44	57	60	34	19
Mean	115	107	122	112	131.2	105.4
max	125	115	136	120	136.7	109.4
min	107	95	115	100	126.4	92.4
st. dev.	4.1	3.9	4.8	4.0	2.7	
Vertical trawl opening (m)						
Number of stations	27	45	59	60	34	-
Mean	43	31.7	35	32.5	29.5	-
max	47	25.8	33	37.0	35.5	-
min	35	41.3	25	18.8	24.9	-
st. dev.	3.8	3.0	2.9	4.33	2.2	-
Horizontal trawl opening (m)						
Mean	63.4	63.75	67.5	63.8	72.0	61.4
Speed (over ground, nmi)						
Number of stations	27	45	57	60	34	19
Mean	4.4	5.3	4.5	4.7	5.1	4.9
max	6	5.7	5.3	5.6	5.6	5.4
min	3.4	4.6	3.0	4.1	4.5	4.4
st. dev.	0.5	0.2	0.5	0.3	0.2	0.2

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 knots. 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	56.6	57	57.2	57.7	58.2	58.7	59.2	59.7	60.2	60.7	61.1	61.6	62.1
101	56.9	57.3	57.6	58.1	58.6	59.1	59.6	60.1	60.6	61.1	61.5	62	62.4
102	57.3	57.7	58.1	58.6	59	59.5	60	60.5	60.9	61.4	61.9	62.4	62.8
103	57.7	58.1	58.5	59	59.5	59.9	60.4	60.9	61.3	61.8	62.3	62.7	63.2
104	58.2	58.6	59	59.4	59.9	60.3	60.8	61.3	61.7	62.2	62.6	63.1	63.5
105	58.6	59	59.4	59.9	60.3	60.8	61.2	61.7	62.1	62.6	63	63.5	63.9
106	59	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	62.5	62.9	63.3	63.8	64.2	64.6
108	59.9	60.3	60.7	61.1	61.6	62	62.4	62.9	63.3	63.7	64.1	64.6	65
109	60.4	60.8	61.2	61.6	62	62.4	62.8	63.2	63.7	64.1	64.5	64.9	65.3
110	60.8	61.2	61.6	62	62.4	62.8	63.2	63.6	64.1	64.5	64.9	65.3	65.6
111	61.3	61.6	62	62.4	62.8	63.2	63.6	64	64.4	64.8	65.2	65.6	66
112	61.7	62.1	62.5	62.9	63.3	63.7	64	64.4	64.8	65.2	65.6	66	66.3
113	62.2	62.5	62.9	63.3	63.7	64.1	64.4	64.8	65.2	65.6	65.9	66.3	66.6
114	62.6	63	63.4	63.7	64.1	64.5	64.9	65.2	65.6	66	66.3	66.6	67
115	63.1	63.5	63.8	64.2	64.5	64.9	65.3	65.6	66	66.3	66.7	67	67.3
116	63.6	63.9	64.3	64.6	65	65.3	65.7	66	66.4	66.7	67	67.3	67.6
117	64	64.4	64.7	65	65.4	65.7	66.1	66.4	66.8	67.1	67.4	67.7	68
118	64.5	64.8	65.1	65.5	65.8	66.1	66.5	66.8	67.2	67.5	67.8	68	68.3
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	68.6
120	65.4	65.7	66	66.3	66.6	67	67.3	67.6	67.9	68.2	68.5	68.7	68.9
121	65.8	66.1	66.5	66.8	67.1	67.4	67.7	68	68.3	68.6	68.8	69	69.3
122	66.2	66.5	66.9	67.2	67.5	67.8	68.1	68.4	68.7	69	69.1	69.4	69.6

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 2022 were slightly cooler than the long-term average for July 1990-2009 based on SST anomaly plots (Figure 4). The northern regions of the Nordic Seas were slightly warmer than the average while the East Greenland Current was cooler that 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 4-5). However, since the anomaly is based on the average for the whole month of July, it should give representative results of the surface temperature.

In situ measurements from the survey showed that the upper layer (10 m depth) in 2022 generally was slightly cooler than 2021, except for the northern areas with slightly warmer surface layer (Figure 5, upper left panel). However, in the deeper layers (50 m and deeper; Figure 5, upper right panel and bottom panels), the hydrographical features in the area were similar to previous years. The increased presence of the East Icelandic Current visible in the surface might be due to the relatively cold July month in 2022 with less summer stratification in the that area. 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.

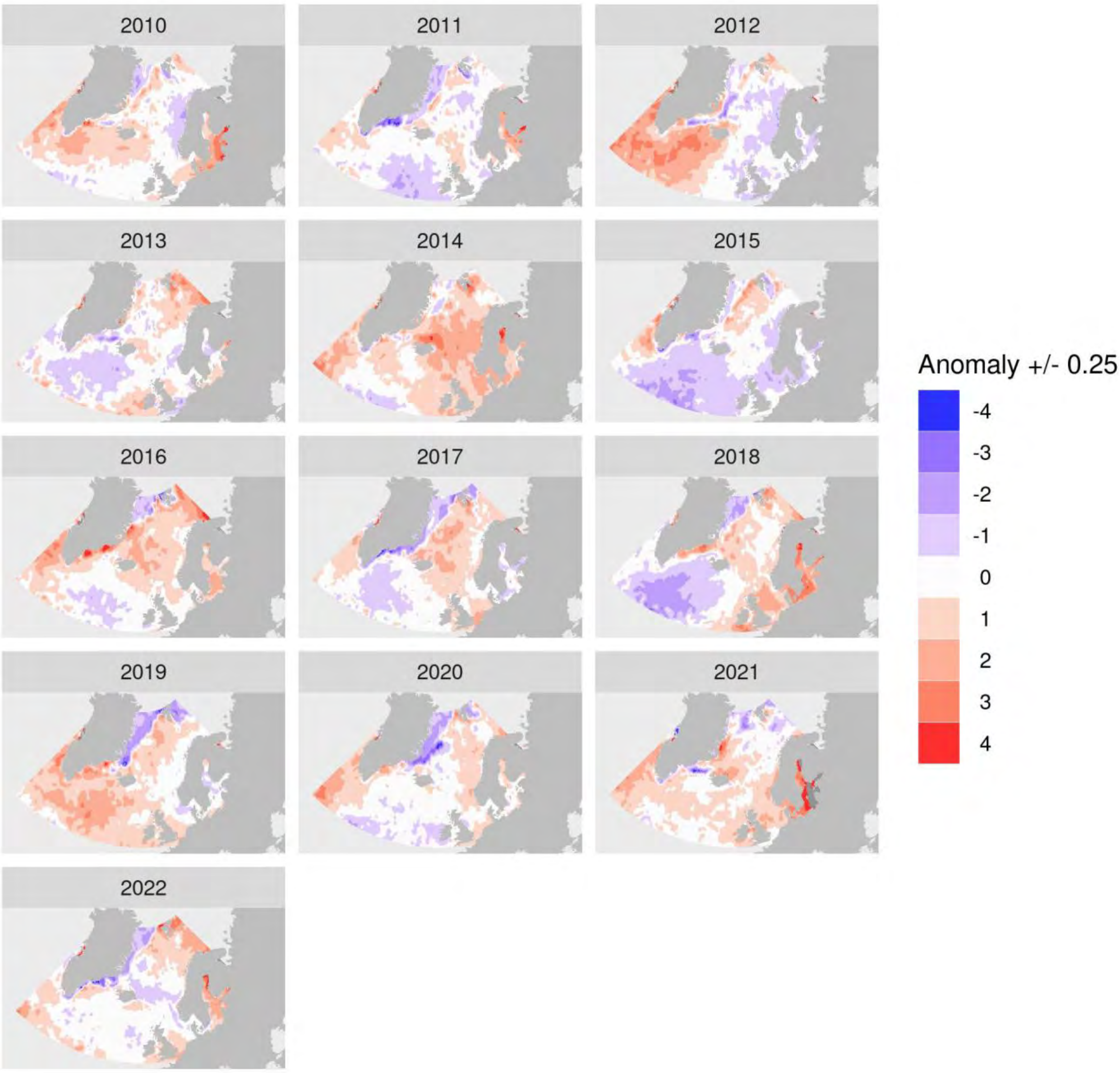

Figure 4. Annual sea surface temperature anomaly (-4 to +4°C) in Northeast Atlantic for the month of July from 2010 to 2022 showing warm and cold conditions in comparison to the average for July 1990-2009. Based on monthly averages of daily Optimum Interpolation Sea Surface Temperature (Ver. 2.1 NOAA OISST, AVHRR-only, Banzon et al. 2016, https://www.ncdc.noaa.gov/oisst).

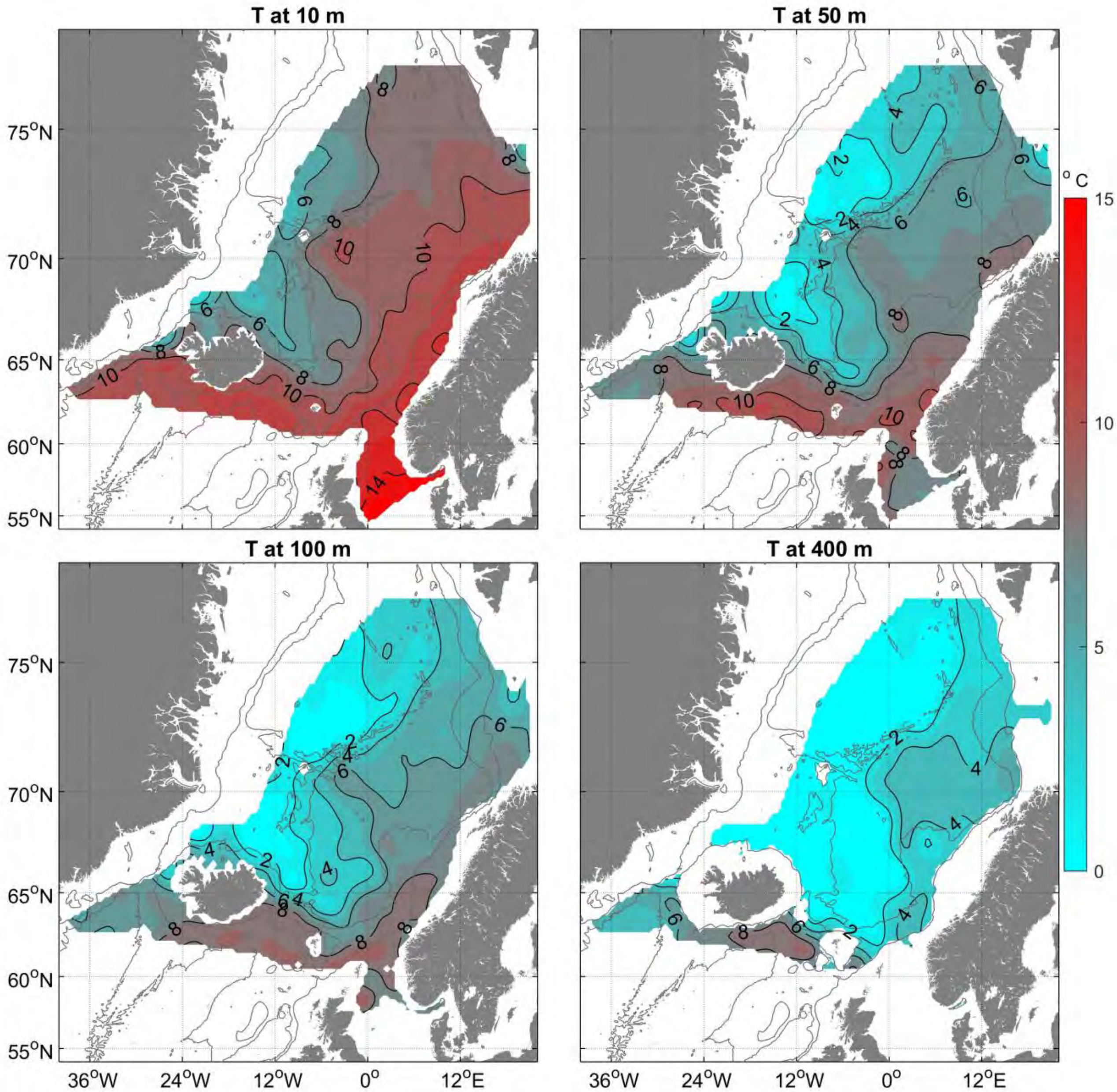

Figure 5. Temperature (°C) at 10, 50, 100 and 400 m depth in Nordic Seas and the North Sea in July-August 2022. 500 m and 2000 m depth contours are shown in light grey.

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 at the same level as last year.

The time-series of average zooplankton biomass averaged by three subareas: Greenland region, Iceland region and the Norwegian Sea region is shown in Figure 6b (see definitions in legend). In the Greenland area an increase was observed in 2022 compared to the low 2020 value (not surveyed in 2021). In the Icelandic region the level was the same as in 2021. The Greenland and Iceland time-series co-vary (2014-2020, 2022 r = 0.89). The biomass index in the Norwegian Sea varied less compared to the other two indices, and showed a slight decrease in 2022 from a relatively stable level since 2013 (Figure 6b). The lower variability 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.

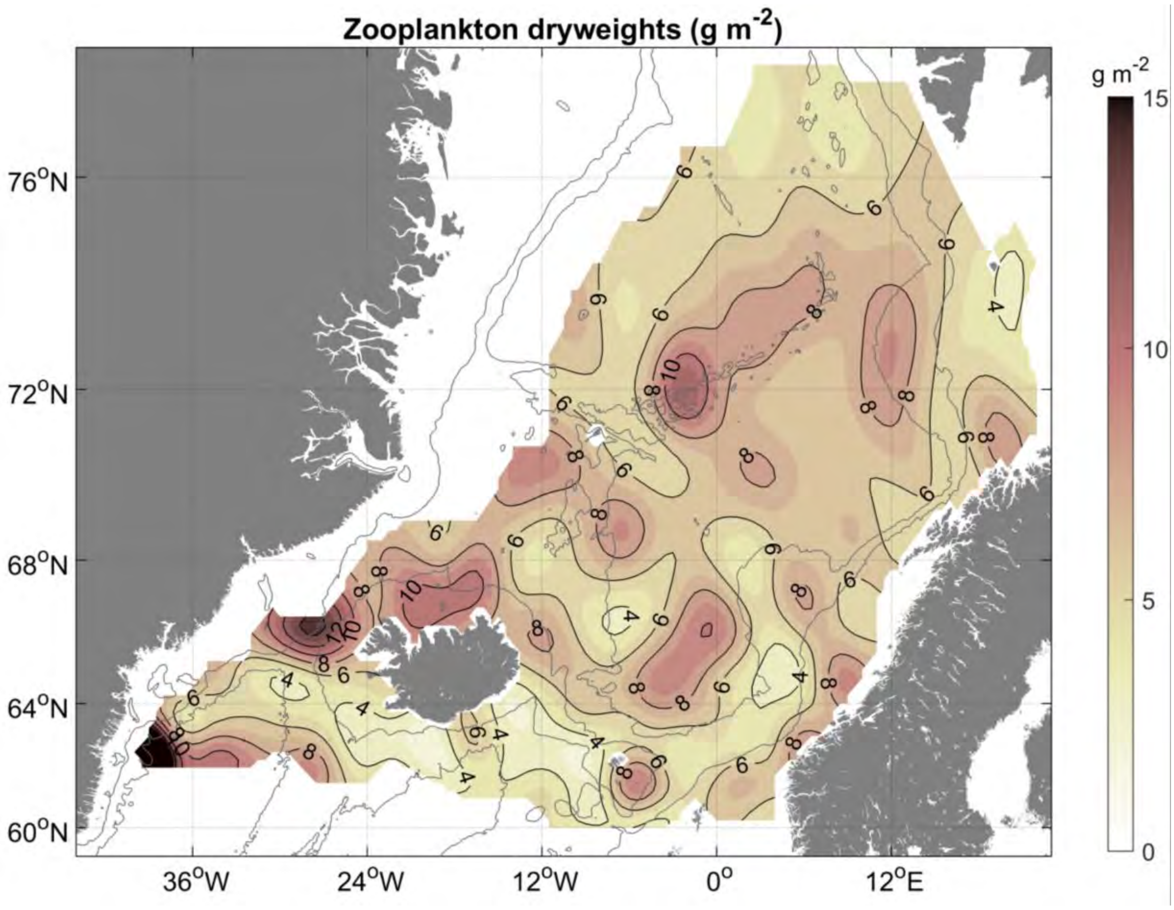

Figure 6a. Zooplankton biomass (g dw/m2, 0-200 m) in Nordic Seas in July-August 2022. 500 m and 2000 m depth contours are shown in light grey.

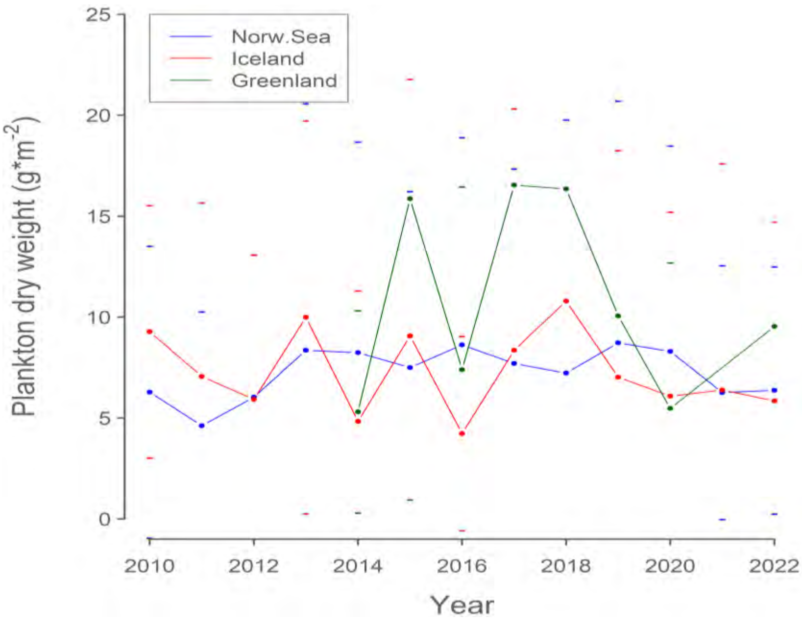

Figure 6b. Zooplankton biomass indices (g dw/m2, 0-200 m). Time-series (2010-2022) of mean zooplankton biomass for three subareas within the survey range: Norwegian Sea (between 14°W-17°E & north of 61°N), Icelandic waters (14°W-30°W) and Greenlandic waters (2014-2022, west of 30°W).

4.3 Mackerel

The total swept-area mackerel index in 2022 was 7.37 million tonnes in biomass and 17.51 billion in numbers, an increase of 43% for biomass and 43% for abundance compared to 2021. The survey coverage area (excl. the North Sea, 0.28 million km^2) was 2.9 million km^2 in 2022, which is 32% larger compared to 2021. The mackerel catch rates varied from zero to 103 tonnes/km^2 (mean = 2.3 tonnes/km^2, with two very large values (70 and 103, see CPUE by station in Figure 7 together with the mean catch rates per 2° lat. x 4° lon. rectangles). These two hauls contributed with 33% of the total biomass index (Appendix 3). This is also explains the very high uncertainty of the estimate. It is worth noting that western part of the northern Norwegian Sea (stratum 9) was oversampled as three surface trawl stations were added, at the dynamic stratum boundary, at only half the distance from next station, 35 nm instead of 70 nm. Mackerel was caught at all these station and max catch per station was about one ton. All three stations were included in the index calculations and the dynamic stratum boundary extended 35 nm westward of these three stations.

Most of the surveyed mackerel still appears to be in the Norwegian Sea. The mackerel were more westerly distributed than in the last 2 years.

The zero-line was reached south and north of Iceland and in the west in Greenland waters. It was not reached in the northwestern and northeastern part of the Norwegian Sea but given that the polar front with water too cold for mackerel is usually found close the northwestern most catches, we assume that the zero-line was practically reached here as well. Towards the Barent Sea the zero-line was not reached but considered of less quantitative importance based on low catch rates. The zero-line was not reached on the European shelf, where mackerel are present west of the British Isles and in the southern North Sea (Campbell, 2021).

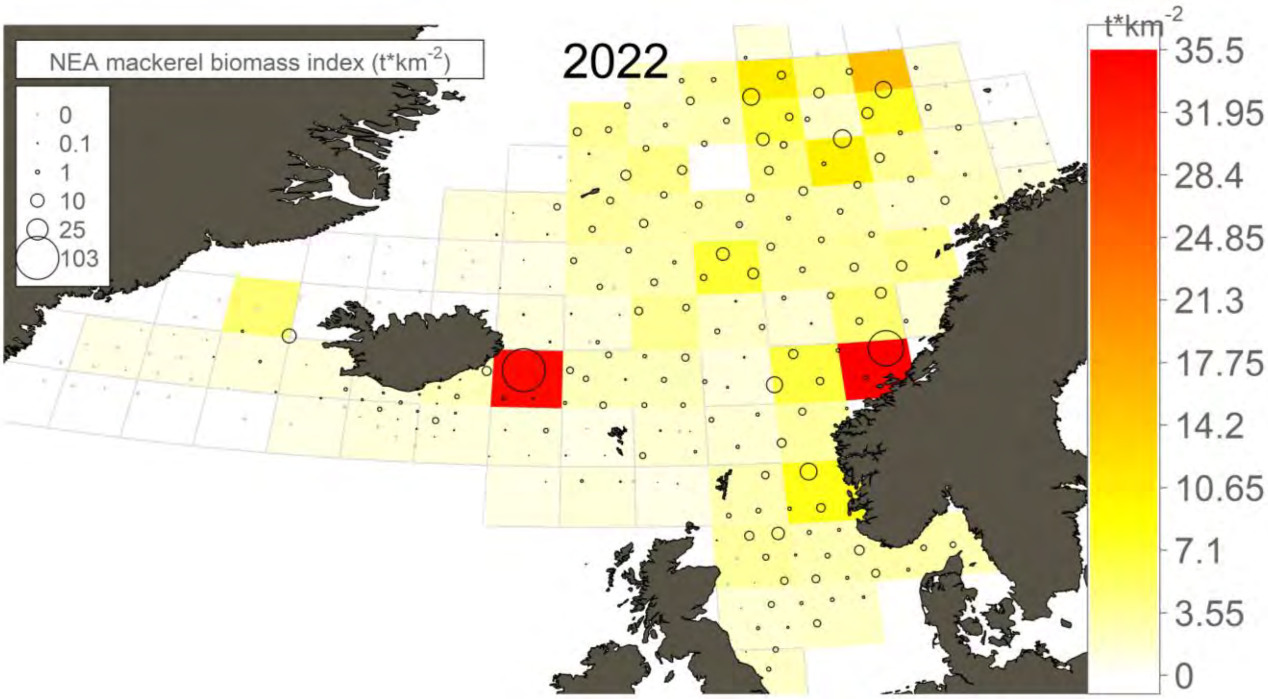

Figure 7. Mackerel catch rates by Multpelt 832 pelagic trawl haul at predetermined surface trawl stations (circle areas represent catch rates in kg/km^2) overlaid on mean catch rates per standardized rectangles (2° lat. x 4° lon.) in Nordic Seas in July-August 2022.

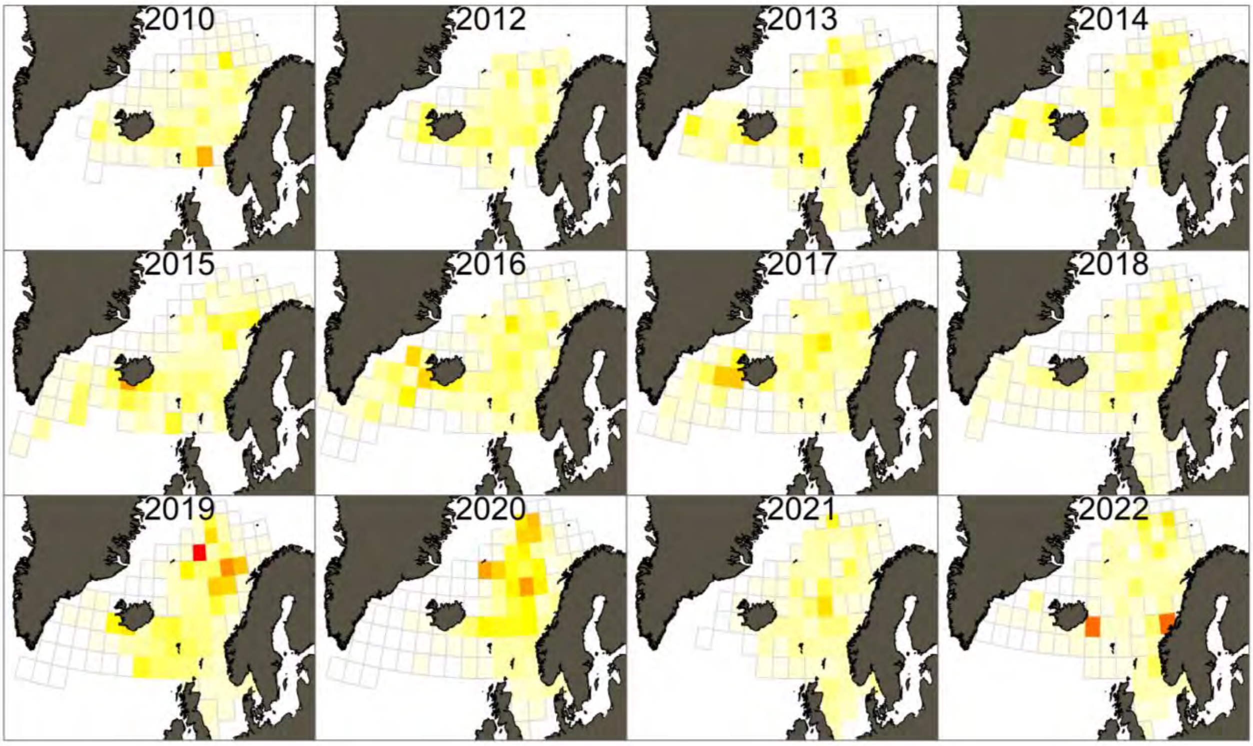

Figure 8. Annual distribution of mackerel proxied by the absolute distribution of mean mackerel catch rates per standardized rectangles (2° lat. x 4° lon.), from Multpelt 832 pelagic trawl hauls at predetermined surface trawl stations in Nordic Seas in June-August 2010-2022. Colour scale goes from white (= 0) to red (= maximum value for the highest year).

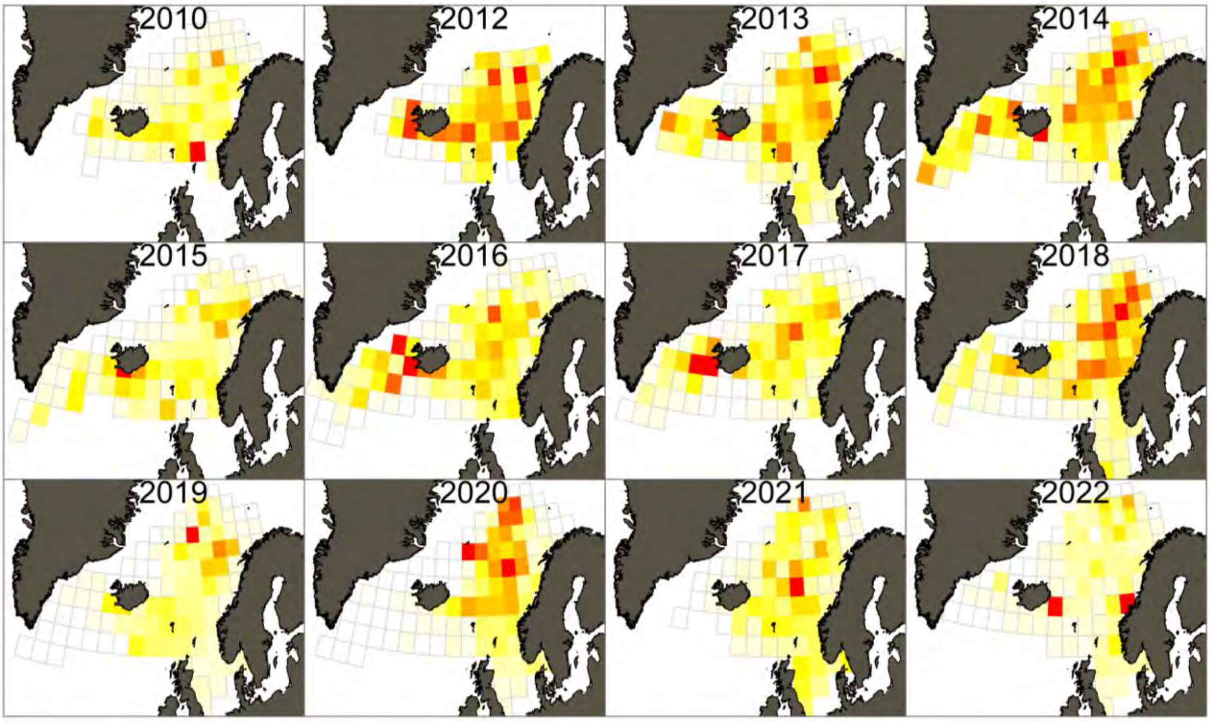

Figure 9. Annual distribution of mackerel proxied by the relative distribution of mean mackerel catch rates per standardized rectangles (2° lat. x 4° lon.), from Multpelt 832 pelagic trawl hauls at predetermined surface trawl stations stations in Nordic Seas in June-August 2010-2022. Colour scale goes from white (= 0) to red (= maximum value for the given year).

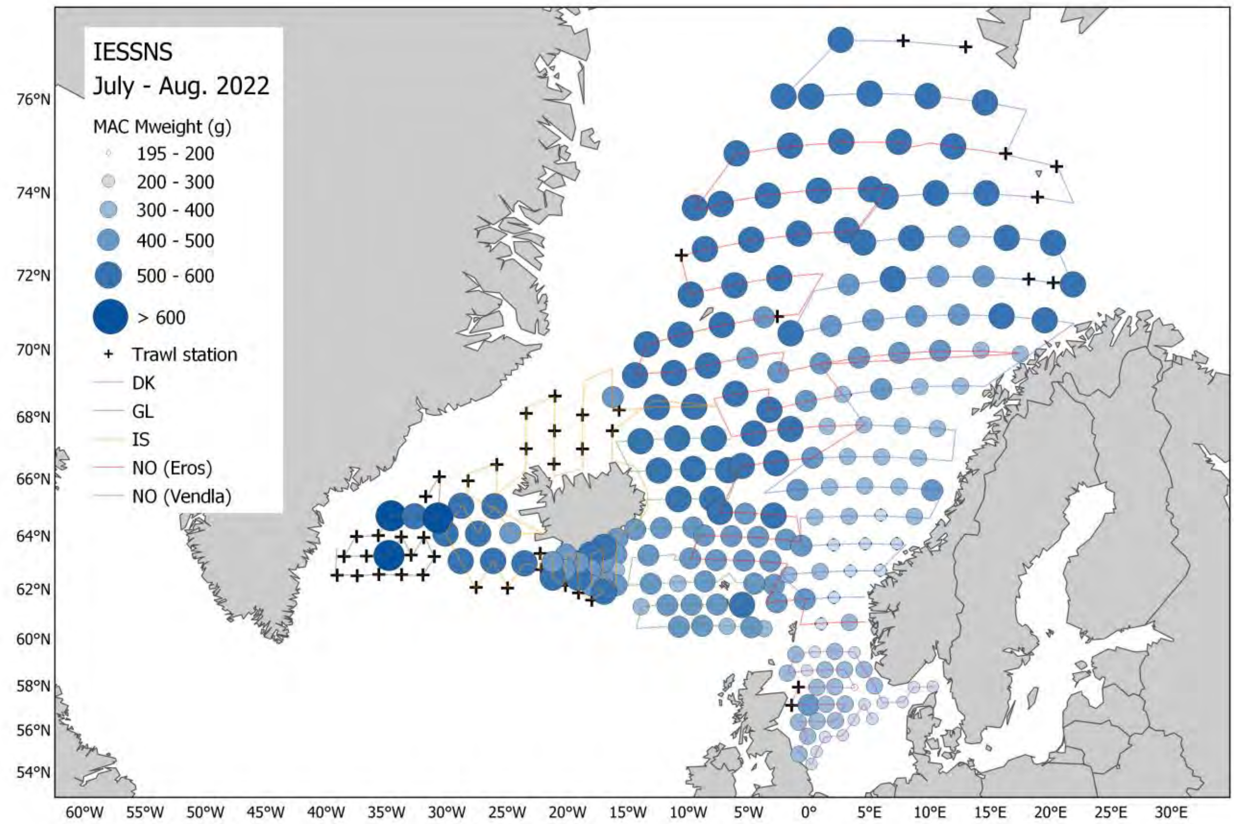

Figure 10. Average weight of mackerel at predetermined surface trawl stations during IESSNS 2022.

The mackerel weight varied between 48 to 872 g with an average of 388 g. The length of mackerel caught in the pelagic trawl hauls onboard the five vessels varied from 18 to 46 cm, with an average of 33 cm. Individuals in the length range 30-31 cm and 36-40 cm dominated in numbers and biomass. 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 2022 according to surface trawl catches is shown in Figure 11.

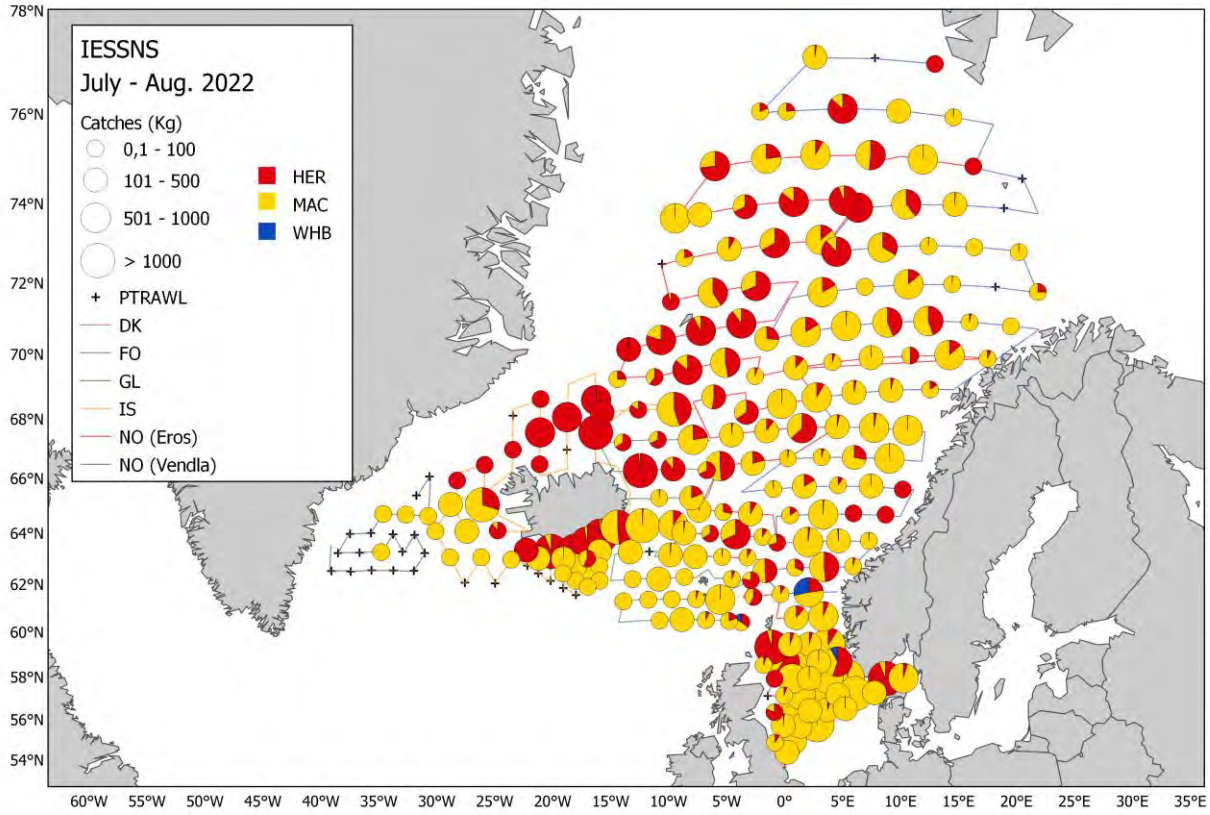

Figure 11. Distribution and spatial overlap between mackerel, herring, and blue whiting, at all surface trawl stations during IESSNS 2022. Vessel tracks are shown as continuous lines and predetermined surface trawl stations with no catch of the three species is displayed as +.

Swept area analyses from standardized pelagic trawling with Multpelt 832

The swept area estimates of mackerel biomass from the 2022 IESSNS were based on abundance of mackerel per stratum (see strata definition in Figure 2) and calculated in StoX version 3.5.0. Mackerel abundance index in 2022 was slightly lower than the time series mean of 18.9 billion (Table 7a; Figure 12) and the biomass index was slightly higher than the mean of 7.28 million tons (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 2022, the most abundant year-classes were respectively 2020 (age 2), 2019 (age 3), 2012 (age 10), and 2011 (age 11) (Figure 13). Mackerel of age 1, 2 and to some extent also age 3 are not completely recruited to the survey (Figure 15), information on recruitment is therefore uncertain. Variance in age index estimation is provided in Figure 14.

The overall internal consistency was slightly improved 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 0.70 and 0.91. However, the internal consistency is more variable between age 5 to 9, with r=0.43 between 5 and 6 years (r=0.43) and r=0.22 between 7 and 8 years. The reason for the relatively low consistency for these year groups are not clear.

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).

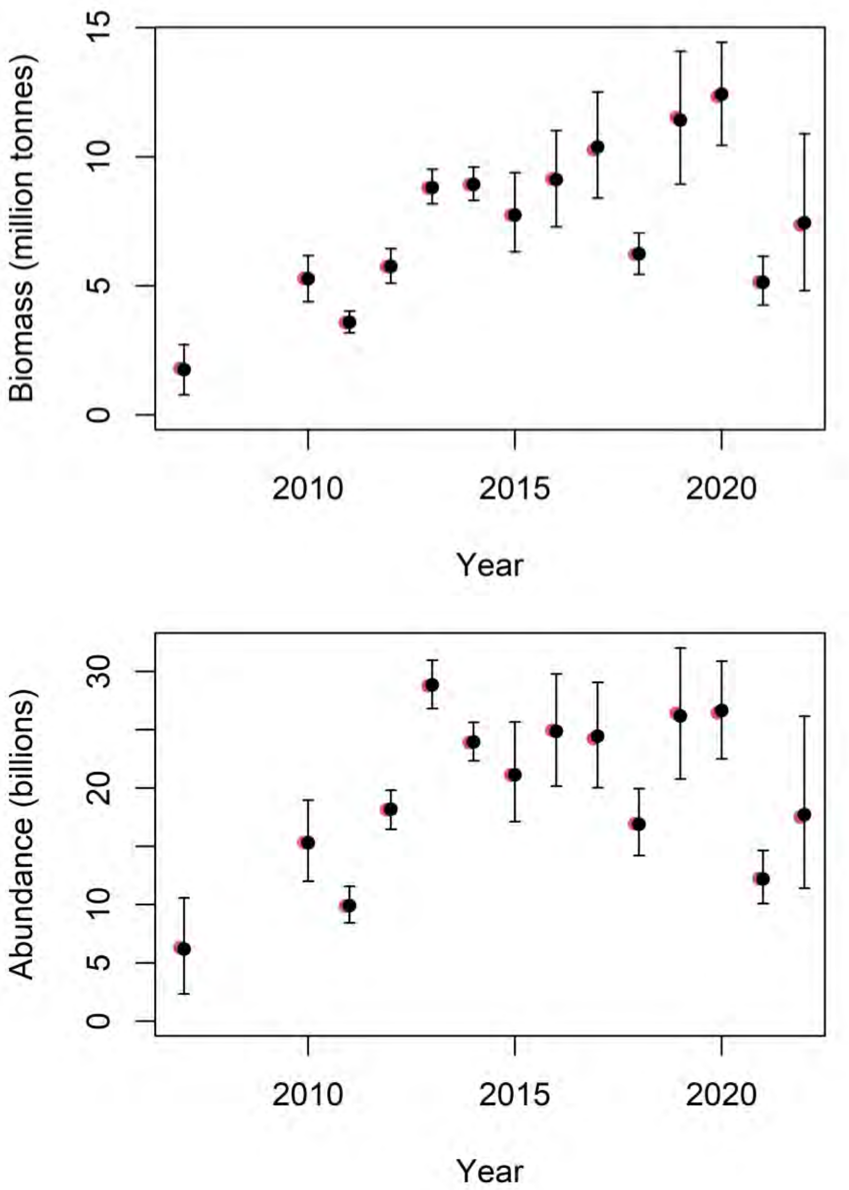

Figure 12. Estimated total stock biomass (upper panel) and total stock numbers (lower panel) of mackerel from StoX for the years 2007 and from 2010 to 2022. The red dots are baseline estimates, the black dots are mean of 1000 bootstrap replicates while the error bars represent 90 % confidence intervals based on the bootstrap.

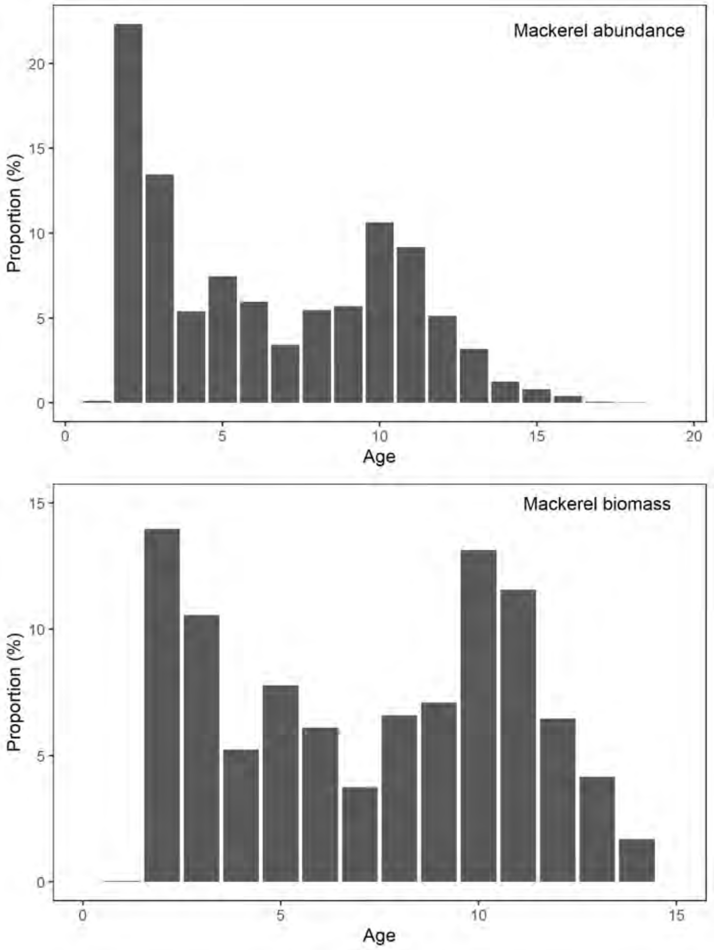

Figure 13. Mackerel age distribution in numbers (%) and in biomass (%) from IESSNS 2022.

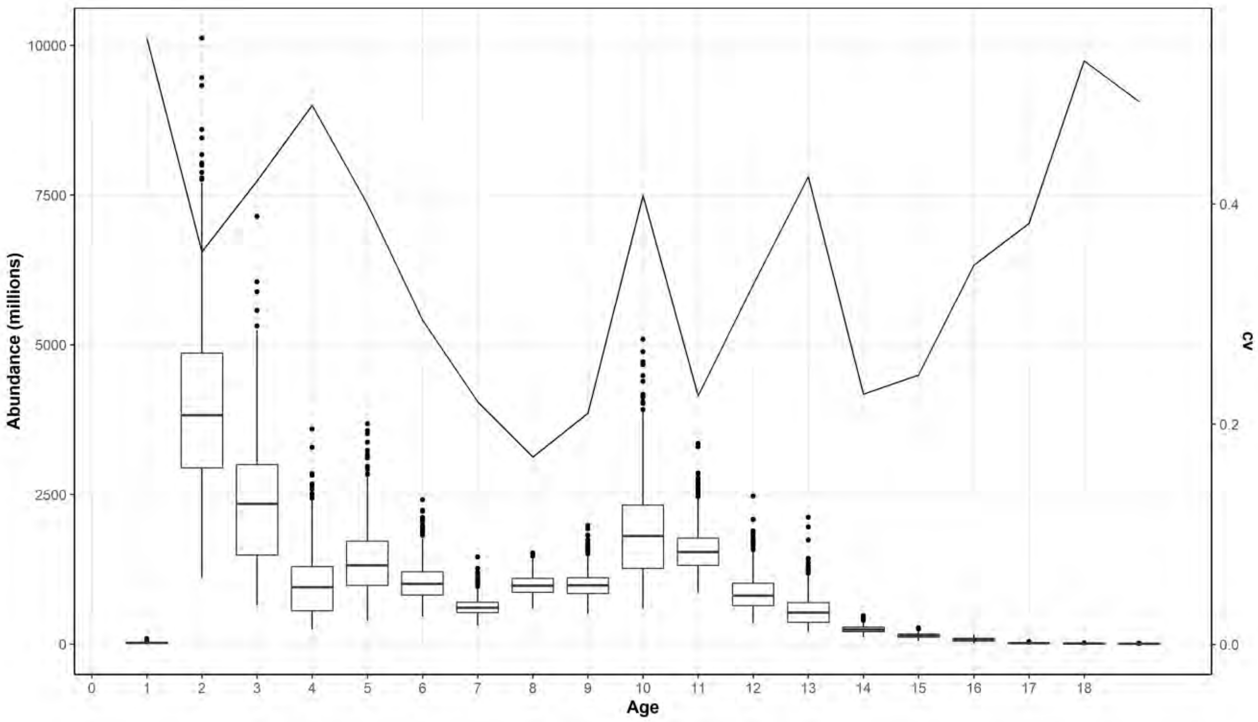

Figure 14. Number by age for mackerel in 2022. Boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 1000 replicates using the StoX software.

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 2022, 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

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

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

d) Length (cm)	Age in years (year class) 1 2021	2 2020	3 2019	4 2018	5 2017	6 2016	7 2015	8 2014	9 2013	10 2012	11 2011	12 2010	13+	NA	Number (10^6)	Biomass (10^6 kg)	Mean weight (g)
18-19	1														1	0	46.7
19-20	8														8	0	58.1
20-21	3														3	0	66.4
21-22	3														3	0	74.5
22-23														0	0	0	88.0
23-24															0	0	
24-25														0	0	0	126.0
25-26															0	0	
26-27	0														0	0	166.0
27-28															0	0	
28-29	8	64													72	15	214.4
29-30		805	30	3											838	200	239.1
30-31		1 809	9		4	3									1 825	471	258.1
31-32		993	353	2	34	5									1 386	390	281.7
32-33		178	637	25	5	5									851	265	311.5
33-34		34	711	96	43	10	3		0	0					896	301	336.3
34-35	0	16	384	95	133	52	0					0			681	248	363.6
35-36		3	204	70	104	279	125	13	7	3	2				808	313	387.6
36-37			26	477	219	236	77	38	1	17	26	0	4		1 120	471	420.5
37-38		4	1	168	439	269	153	127	84	403	97	43	11		1 799	835	464.1
38-39			1	7	171	161	158	461	195	435	527	295	226		2 639	1321	500.5
39-40		4	0	1	157	17	41	198	511	465	497	301	188		2 382	1256	527.5
40-41					0	3	28	111	174	493	341	159	297		1 606	910	566.5
41-42				0		4	12	4	19	40	98	82	203		464	280	606.3
42-43								2	5	6	17	8	56		94	61	642.4
43-44								3			1	9	21		33	22	687.6
44-45													3		3	2	704.0
45-46														1	1	1	803.8
46-47														0	0	0	872.0
TSN(mill)	23.4	3 909.5	2 355.9	944.4	1 307.8	1 043.4	598.2	956.1	995.9	1 862.0	1 605.7	897.6	1 011.3	2.2	17 513.5	7365	
TSB(1000 t)	2.9	1 028.7	777.1	385.4	572.3	449.4	276.5	485.8	522.7	967.2	851.5	476.6	567.8	1.4	7 365.3		
Mean length(cm)	22.7	30.2	32.7	35.5	36.4	36.2	37.1	38.2	38.8	38.6	38.9	39.0					
Mean weight(g)	125	263	330	408	438	431	462	508	525	519	531	531					

Table 8. Bootstrap estimates from StoX (based on 1000 replicates) of mackerel in 2022. 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	3.9	20.3	41.5	21.3	12.0	0.56
2	1945.0	3822.1	6590.4	3974.3	1416.0	0.36
3	1019.0	2341.4	4200.5	2384.2	1002.9	0.42
4	382.1	950.4	1858.6	988.8	483.8	0.49
5	575.8	1311.0	2357.8	1380.1	551.4	0.40
6	617.4	1006.7	1609.3	1043.2	306.7	0.29
7	434.8	602.8	845.6	618.9	136.3	0.22
8	704.6	972.9	1250.1	980.5	166.5	0.17
9	696.4	977.0	1367.3	991.6	207.9	0.21
10	874.3	1801.7	3269.0	1872.5	763.0	0.41
11	1068.4	1534.8	2206.6	1567.8	353.6	0.23
12	487.9	808.9	1340.7	849.8	277.5	0.33
13	283.9	522.3	983.6	556.4	236.2	0.42
14	162.4	241.0	343.9	245.3	55.7	0.23
15	88.7	141.7	201.7	142.8	34.9	0.24
16	33.6	78.2	112.2	74.5	25.6	0.34
17	6.5	14.1	25.4	14.8	5.6	0.38
18	1.1	6.0	12.7	6.6	3.6	0.55
19	0.0	2.5	7.6	2.7	2.7	1.03
TSN	11388	17196	26156	17719	4558	0.26
TSB	4.82	7.23	10.89	7.44	1.87	0.25

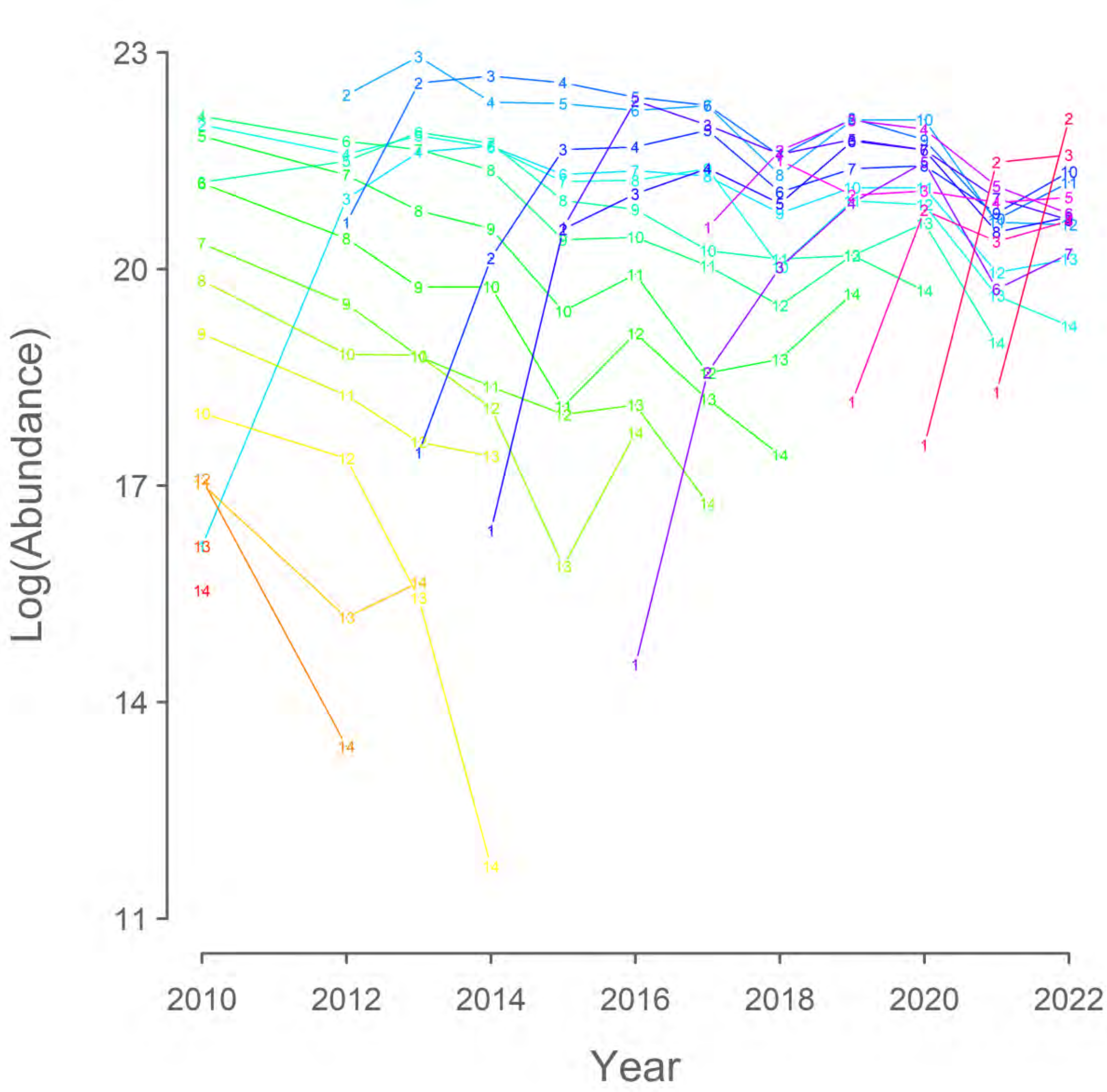

Figure 15. Catch curves for the years 2010; 2012-2022. Each cohort of mackerel is marked by a uniquely coloured line that connects the estimates indicated by the respective ages.

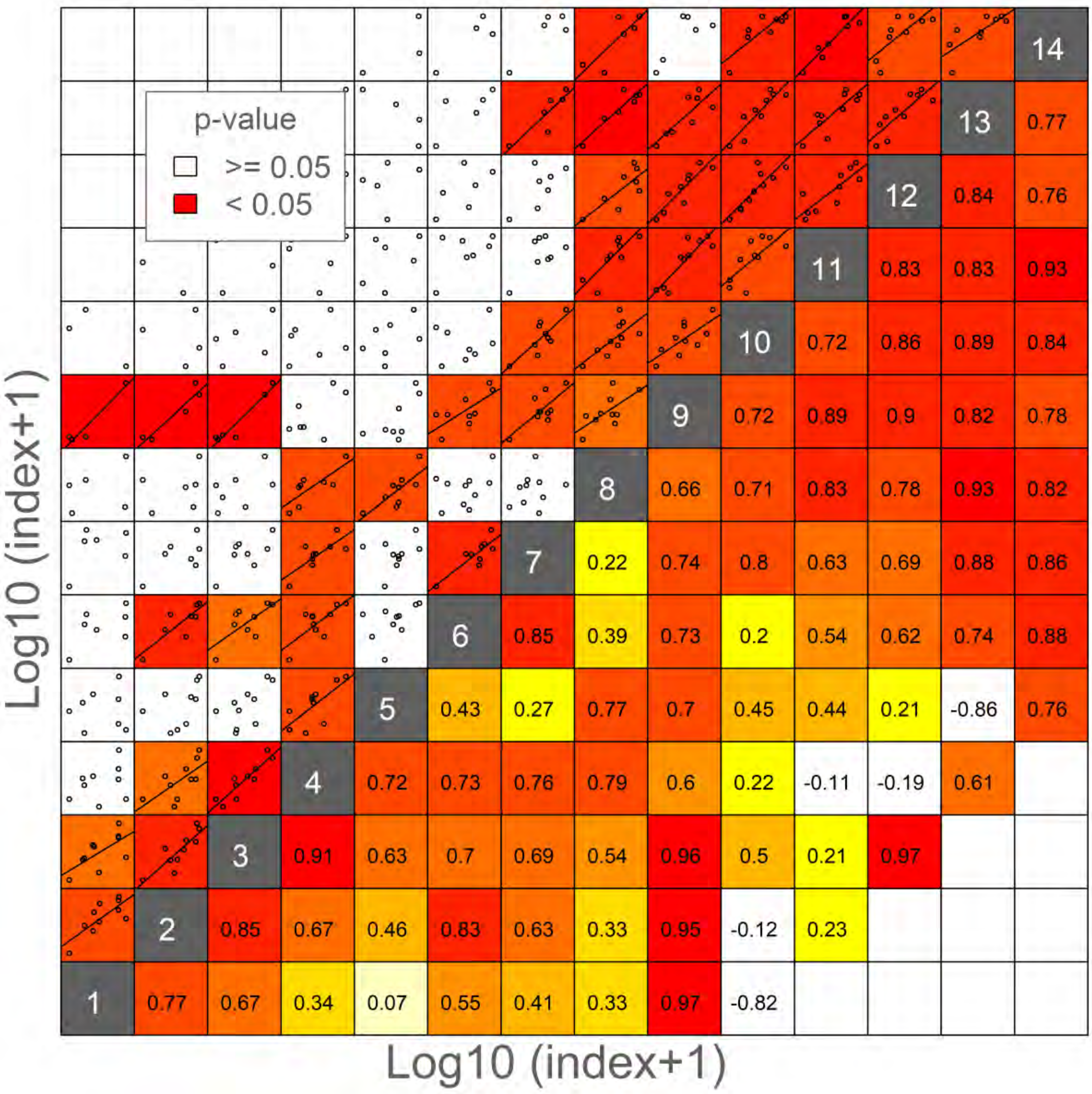

Figure 16 Internal consistency of the of mackerel density index from 2012 to 2022. Ages indicated by white numbers in grey diagonal cells. Statistically significant positive correlations (*p<0.05*) are indicated by regression lines and red cells in upper left half. Correlation coefficients (r) are given 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 56.6.5-75.4 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

Norwegian spring-spawning herring (NSSH) was recorded in the southwestern (east and north of Iceland), central and northern part of the Norwegian Sea basin (Figure 17a). The acoustic registrations in the eastern parts of the Norwegian Sea were low in July 2022. A relatively large part of the adult NSSH stock was distributed north of 68°N (Figure 17a). Herring registrations south of 62°N in the eastern part were allocated to a different stock, North Sea herring, while the herring to the south and west in Icelandic waters (west of 14°W south of Iceland) were allocated to Icelandic summer-spawners – these were removed from the biomass estimation of NSSH, except some putative North Sea herring in the southeastern area north of Shetland (Figure 17b).

The total number of NSSH recorded during IESSNS 2022 was 25.0 billion and the total biomass index was 7.14 million tonnes, or 22% (abundance) and 17% (biomass) higher than 2021 (Table 10 and 11).

The 2016 year-class (6 year-olds) completely dominated in the stock and contributed 58% and 56% to the total biomass and total abundance, respectively, whereas the 2013 year-class (9 year-olds) contributed 8% and 7% to the total biomass and total abundance, respectively (Figure 18 and Table 9). The 2016 year-class is fully recruited to the adult stock.

Bootstrap estimates of numbers by age are shown in Figure 18. The uncertainty (CV) around the age disaggregated abundance indices from the 2022 survey was very low, except for the highly dominating 6 year-olds (2016 year class) (Figure 18).

The internal consistency among year classes was generally very high for age classes 4 years and older, with the lowest correlation, for the youngest year classes, as expected since they are not fully recruited into the survey (Figure 19).

The 0-boundary of the distribution of the adult part of NSSH was considered to be reached in all directions. The herring was mainly observed in the upper surface layer as relatively small schools. This shallow distribution of herring might have led to an unknown portion of herring being in the "blind zone" above the transducer depth of the vessels (i.e. shallower than 10-15 m, Table 4), and therefore not being registered by the vessels. The group considered the acoustic biomass estimate of herring in 2022 to be of the similar quality as in the previous survey years.

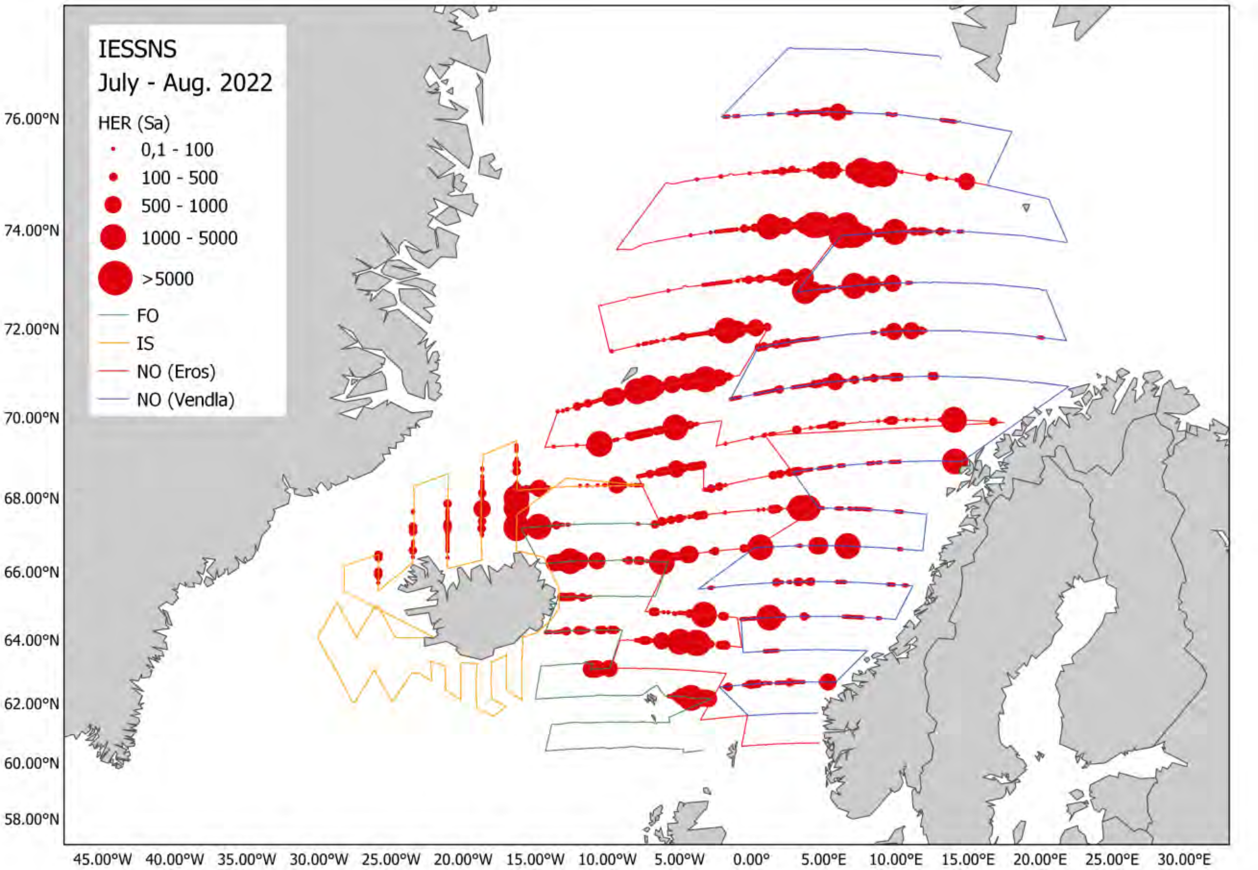

Figure 17a. The sA/Nautical Area Scattering Coefficient (NASC) values of herring along the cruise tracks in 2022 presented as contour lines. Values north of 62ºN, and east of 14ºW, are considered to be Norwegian spring-spawning herring. South and west of this area the herring observed are other stocks, *i.e.* Icelandic summer spawners, Faroese autumn spawners and North Sea herring in the southeast.

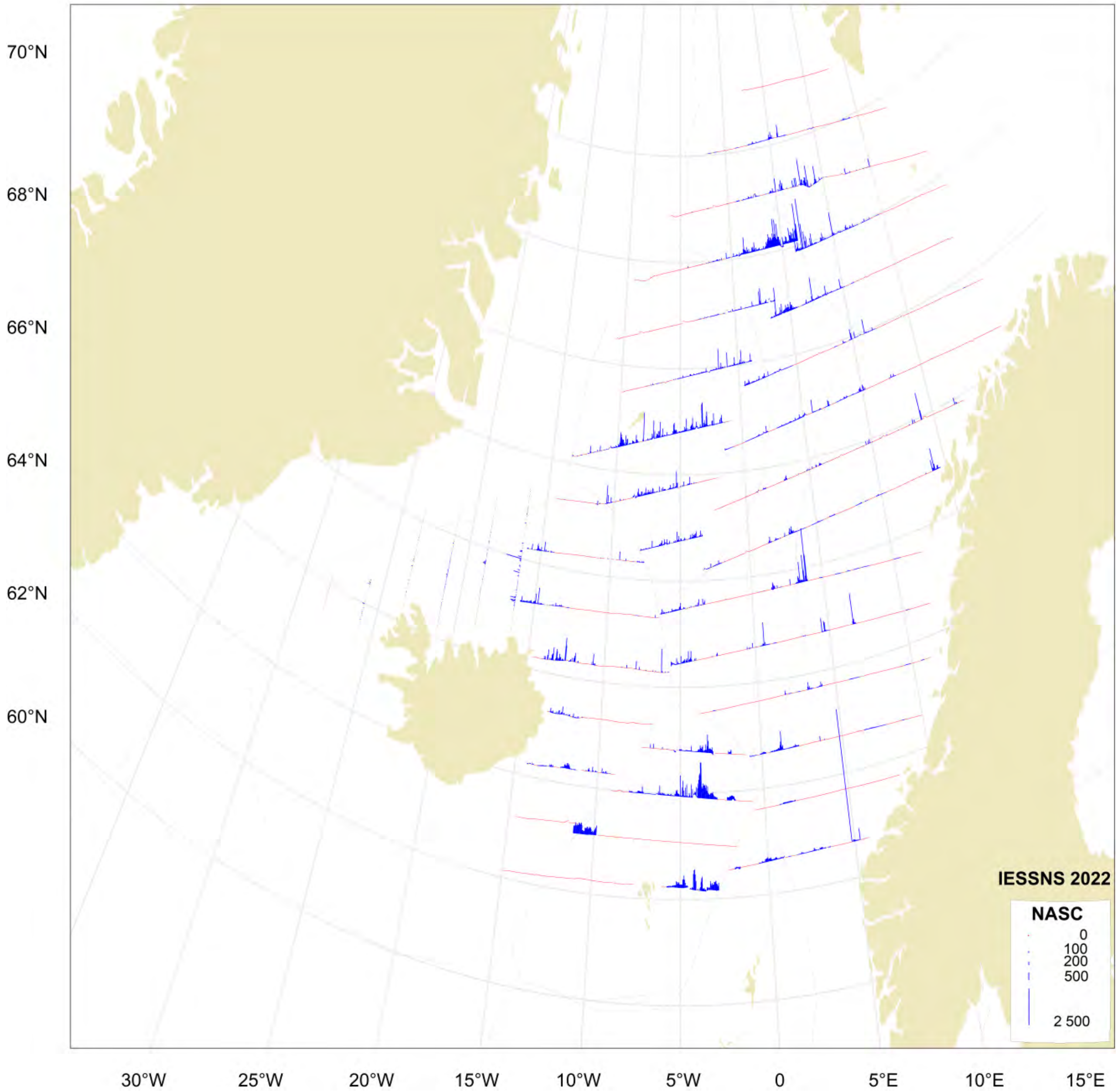

Figure 17b. The sA/Nautical Area Scattering Coefficient (NASC) values of Norwegian spring-spawning herring along the cruise tracks in 2022, presented as bar plot.

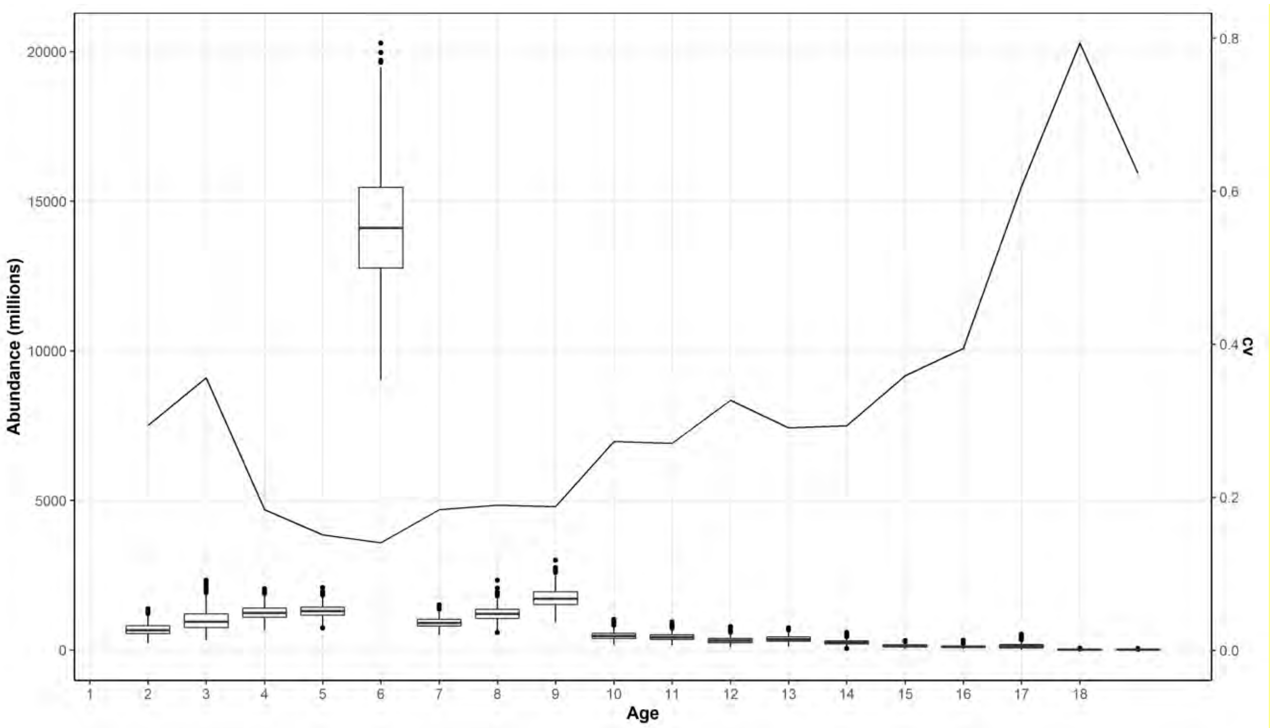

Figure 18. Abundance by age for Norwegian spring-spawning herring during IESSNS 2022. Boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 500 replicates using the StoX software.

Table 9. Estimates of abundance, mean weight and mean length of Norwegian spring-spawning herring based on calculation in StoX (bootstrap) for IESSNS 2022.

Length	Age in years (year class)																		Number	Biomass	Mean weight
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18			
(cm)	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	(10^6)	(10^6 kg)	(g)
15-16																					
16-17																					
17-18																					
18-19																					
19-20			30.1																30.1	2.6	85.0
20-21		17.7	26.7																44.3	3.4	70.7
21-22		9.0	82.6																91.6	8.5	89.6
22-23		149.0	45.6																194.6	19.5	100.4
23-24		217.2	143.0	4.4															364.6	41.6	114.8
24-25		156.8	55.5	9.6															221.9	29.1	131.1
25-26		86.0	108.8	93.4	7.4														295.7	44.7	150.2
26-27		45.4	68.8	222.9	73.2														410.4	68.6	167.1
27-28			70.3	225.9	57.9	51.9			6.5										412.5	78.5	186.4
28-29			143.3	228.1	113.2	67.0	24.1	15.3	60.7	22.7									674.2	145.7	213.0
29-30			135.9	191.7	141.3	117.0	43.6	3.6	218.8	3.1		11.8							866.9	207.5	238.7
30-31			39.4	127.1	337.6	857.1	24.2	42.5	141.5	55.1	47.3	21.1	12.3	24.7	10.5				1 740.3	454.0	259.0
31-32			55.8	119.6	264.1	3301.7	37.3	94.8	82.4	73.6	32.6	19.9	3.5						4 085.2	1142.3	278.0
32-33				23.2	252.2	5232.2	134.8	120.5	46.7	28.4	36.0	2.2		21.8					5 898.0	1748.0	296.1
33-34			2.3		49.8	3249.0	217.9	184.0	58.5	14.7	10.8			21.2	11.0				3 819.3	1199.2	313.1
34-35				4.8		1107.3	259.0	355.6	371.5	45.6	21.3		17.0			10.5			2 192.5	738.5	335.9
35-36						141.1	126.0	300.9	448.1	48.4	40.3	20.8	47.7	22.1		12.2	2.2		1 209.8	440.0	361.7
36-37					4.2		22.7	84.2	233.8	112.1	88.3	24.7	81.9	65.7	5.3	5.0	3.4		731.3	278.8	376.2
37-38						10.8	13.0	9.3	65.6	61.7	109.1	91.8	136.5	25.6	47.1	29.3	22.2	5.1	627.2	251.8	402.4
38-39							11.6			11.7	33.8	90.9	48.1	37.3	41.8	43.4	48.8	4.8	372.2	156.9	422.0
39-40											13.8	19.3	12.6	16.5	19.1	5.3	43.8	4.1	134.6	60.5	445.9
40-41												12.7	3.6	18.3	6.3		5.3		46.2	20.7	454.9
41-42																1.1	4.8		5.9	20.7	489.3
42-43																		0.6	0.6	2.8	510.9
TSN(mill)		681.2	1008.0	1250.7	1301.0	14135.1	914.3	1210.8	1734.0	477.1	433.3	315.1	363.1	253.2	141.1	106.9	130.5	14.6	25 009.4		
cv (TSN)		0.29	0.36	0.18	0.15	0.14	0.18	0.19	0.19	0.27	0.27	0.33	0.29	0.29	0.36	0.39	0.61	0.82	0.12		
TSB(1000 t)		82.2	171.4	262.4	332.5	4 190.8	294.3	399.0	571.1	161.4	158.4	121.4	141.4	95.8	55.4	42.4	57.2	6.4	7 143.4		
cv (TSB)		0.29	0.29	0.18	0.15	0.14	0.19	0.20	0.20	0.26	0.29	0.34	0.30	0.30	0.37	0.40	0.61	0.80	0.13		
Mean length(cm		23.5	26.1	28.3	30.1	32.1	33.4	33.8	33.9	34.9	35.2	37.1	36.5	37.0	37.2	37.3	38.2	39.1			
Mean weight(g)		123.3	175.1	215.6	256.3	296.6	324.3	330.7	341.4	363.0	367.3	400.8	393.0	402.9	401.2	406.3	437.4	480.0			

Table 10. IESSNS bootstrap time series (mean of 1000 replicates) from 2016 to 2022. StoX abundance estimates of Norwegian spring-spawning herring (millions).

	Age												
Year	1	2	3	4	5	6	7	8	9	10	11	12+	TSB(1000 t)
2016	38	119	747	577	1 622	1 636	1 967	1 588	1 274	2 001	2 164	6 245	6 676
2017	1 232	240	1 318	4 653	1 003	1 184	795	1 716	1 004	1 115	1 657	4 040	5 821
2018	0	587	656	864	3 054	924	1 172	746	971	1 078	663	2 704	4 379
2019	0	143	1 910	616	1 101	3 487	814	751	510	780	470	4 660	4 794
2020	0	15	117	8 280	1 710	2 367	4 087	696	520	305	594	1 827	5 991
2021	1	4	184	398	12 117	1 045	1 398	2 226	502	361	393	1 641	6 103
2022	0	681	1 008	1 251	1 301	14 135	914	1 211	1 734	477	433	1 325	7 143

Table 11. IESSNS baseline time series from 2016 to 2022. StoX abundance estimates of Norwegian spring-spawning herring (millions).

	Age												
Year	1	2	3	4	5	6	7	8	9	10	11	12+	TSB(1000 t)
2016	41	146	752	604	1 637	1 559	2 010	1 614	1 190	2 023	2 151	6 467	6 753
2017	1 216	248	1 285	4 586	1 056	1 188	816	1 794	1 022	1 131	1 653	4 119	5 885
2018	0	577	722	879	3 078	931	1 264	734	948	1 070	694	2 792	4 465
2019	0	153	1 870	590	1 067	3 475	859	702	520	700	463	4 808	4 780
2020	0	7	111	8 082	1 697	2 335	4 102	714	491	294	590	1 833	5 930
2021	1	3	196	388	11 988	1 109	1 342	2 292	491	365	386	1 649	6 085
2022	0	724	984	1 225	1 339	14 071	960	1 172	1 762	434	432	1 329	7 135

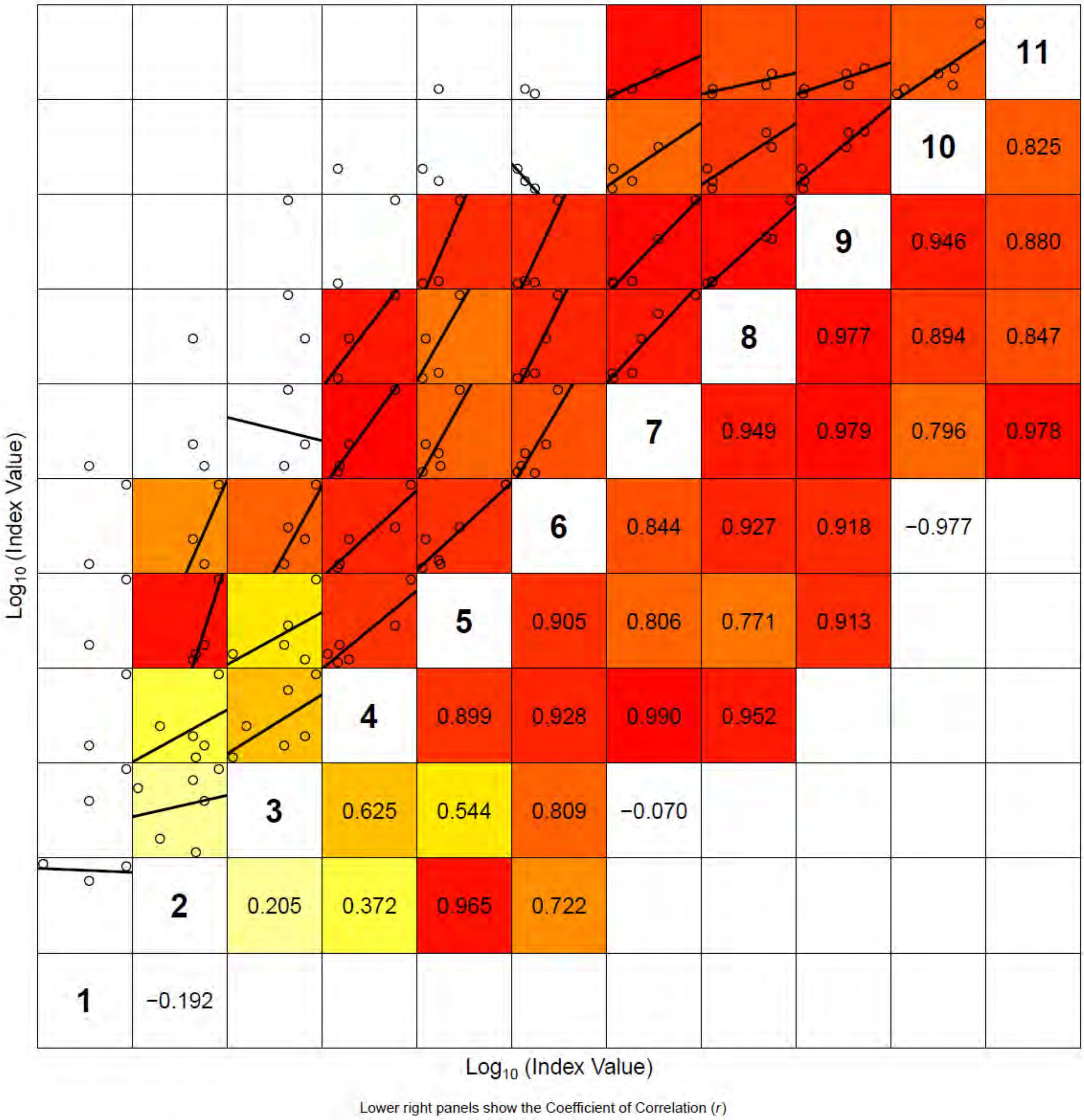

Figure 19. Internal consistency for Norwegian spring-spawning herring within the IESSNS 2022. The upper left part of the plots shows the relationship between log index-at-age within a cohort. Linear regression line shows the best fit to the log-transformed indices. The lower-right part of the plots shows 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.

4.5 Blue whiting

Blue whiting was distributed in parts of the survey area dominated by warm Atlantic waters and had a continuous distribution from the southern boundary of the survey area (60 °N) to Spitsbergen (72 °N). High blue whiting density (sA-values) was observed in the southern part of the Norwegian Sea, along the Norwegian continental slope, around the Faroe Islands, and southeast of Iceland. Concentrations of older fish (age2+) were low, and they were mainly observed on the continental slopes, both in the eastern and the southern part of the Norwegian Sea (Figure 20). The distribution in 2022 is comparable to the last two years with juvenile blue whiting recorded south and southwest of Iceland. As in previous years no blue whiting was registered in the cold East Icelandic Current, between Iceland and Jan Mayen.

The total biomass of blue whiting registered during IESSNS 2022 was 2.2 million tons (Table 12), which is about the same level as in 2021. Estimated stock abundance (ages 1+) was 27.5 billion compared to 26.2 billion in 2021. Age 1 and 2 respectively, dominated the estimate in 2022 as they contributed to 44% and 33% (abundance) and 30% and 33% (biomass), respectively.

Bootstrap estimates of numbers by age, with uncertainty estimates, for blue whiting during IESSNS 2022 are shown in Figure 21. The baseline point estimates from 2016-2022 are shown in Table 13. The internal consistency among year classes is shown in Figure 22 and indicates very good internal consistency for ages 3-5, and moderate to good fit for other ages.

The group considered the acoustic biomass estimate of blue whiting to be of good quality in the 2022 IESSNS as in the previous survey years.

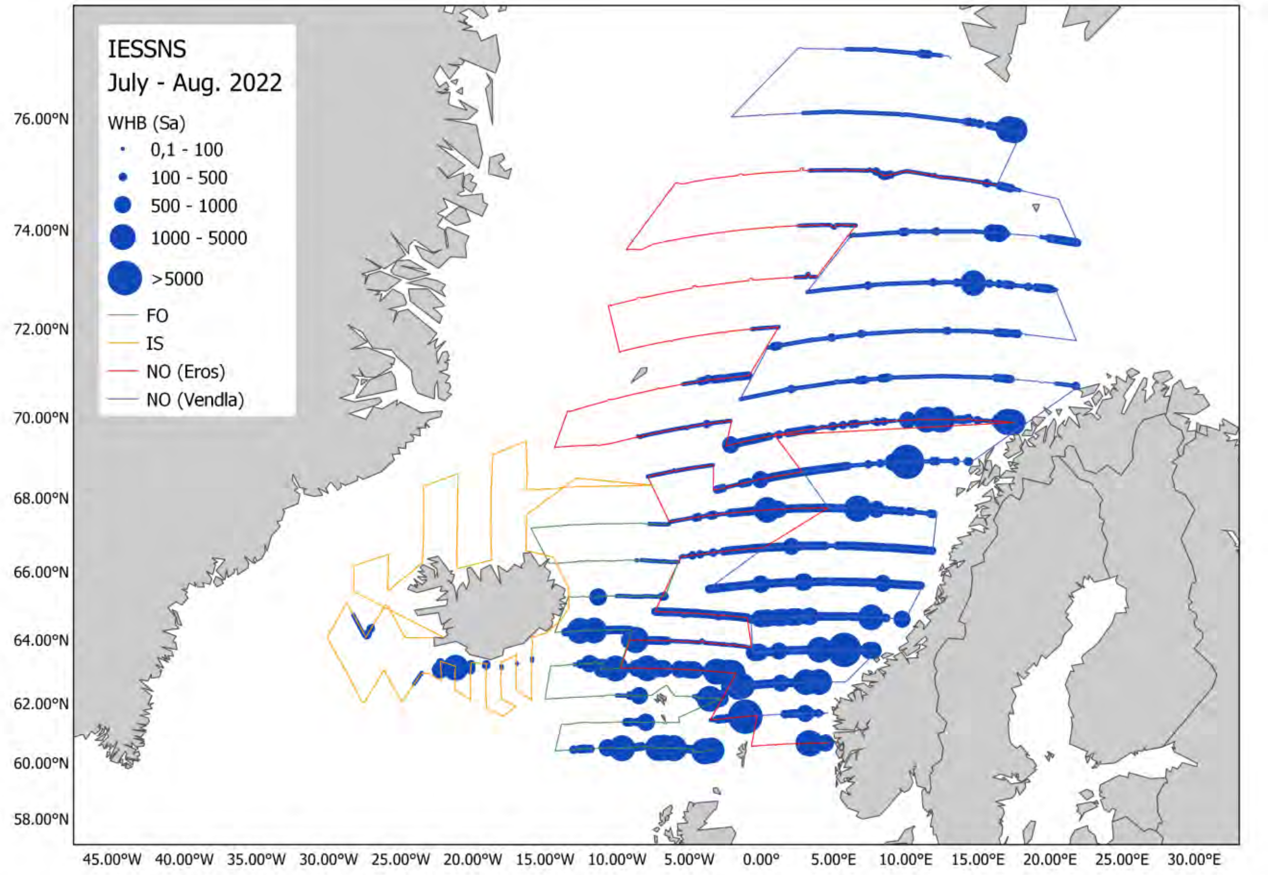

Figure 20a. The sA/Nautical Area Scattering Coefficient (NASC) values of blue whiting along the cruise tracks in IESSNS 2022.

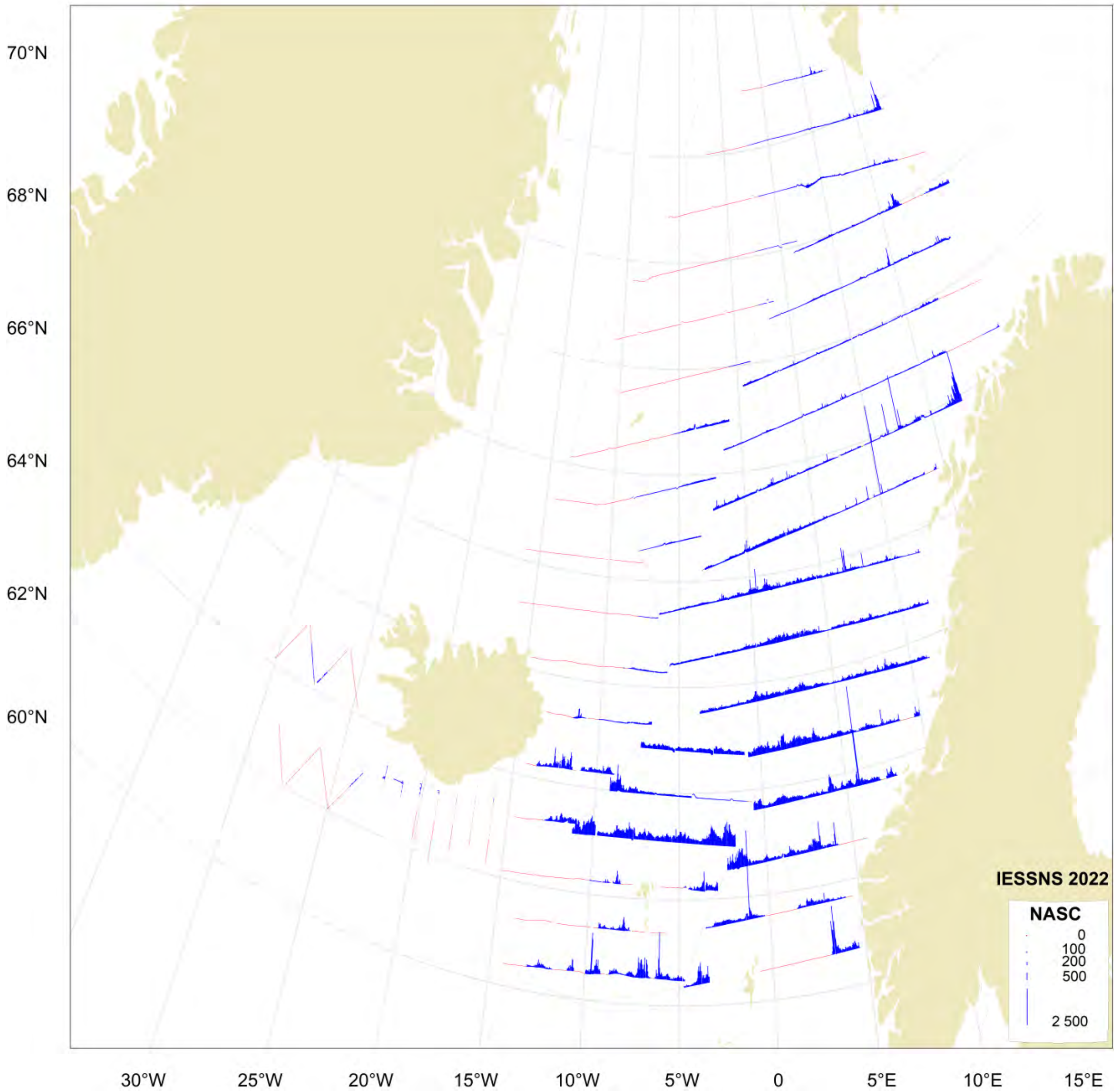

Figure 20b. The sA/Nautical Area Scattering Coefficient (NASC) values of blue whiting along the cruise tracks in IESSNS 2022. Presented as bar plot.

Table 12. Estimates of abundance, mean weight and mean length of blue whiting based on calculation in StoX (bootstrap) for IESSNS 2022.

	Age in years (year class)											Number	Biomass	Mean
Length	0	1	2	3	4	5	6	7	8	9	10			weight
(cm)	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	(10^6)	(10^6 kg)	(g)
10-11														
11-12	135.2											135.2	1.1	8.2
12-13	414.1											414.1	4.7	11.3
13-14	236.6											236.6	3.5	14.9
14-15	169.0											169.0	2.9	17.1
15-16													0.2	22.0
16-17														
17-18													0.4	30.0
18-19		152.9										152.9	6.2	37.2
19-20		1567.2										1 567.2	68.3	44.1
20-21		4498.5										4 498.5	225.8	50.8
21-22		4136.4	277.3	44.9								4 458.5	251.9	57.1
22-23		1687.7	902.5									2 590.2	166.9	64.0
23-24		484.9	2723.7	21.6								3 230.2	244.4	76.6
24-25		84.2	2921.4	101.8								3 107.4	263.9	85.7
25-26		5.9	1837.0	336.5								2 179.4	207.8	95.5
26-27		4.0	729.4	396.6	19.4	6.8						1 156.3	121.6	106.5
27-28			243.2	564.3	144.2	6.5						958.2	107.7	115.1
28-29		1.1	99.4	437.5	151.5	11.7		46.8	26.3			774.4	95.5	127.3
29-30				81.2	240.6	34.8	67.3	65.6	101.5	54.1	54.1	699.3	90.1	133.3
30-31			14.4	190.4	8.9	19.7	125.3	43.1	249.8			651.7	96.1	154.1
31-32					174.0	26.1	178.4	36.0	64.3	74.0		552.8	89.0	167.6
32-33					97.6	43.9	53.9	26.7	145.2			367.3	66.5	187.2
33-34					47.2	65.8	66.9	35.7	72.8		6.4	294.8	58.3	200.8
34-35						64.9	7.0	49.6	18.4			139.8	29.7	221.0
35-36						24.4	10.9		11.9			47.2	11.8	244.2
36-37						7.8				19.5	6.4	33.7	8.7	267.6
37-38														
38-39													0.5	285.0
39-40									0.7			0.7	0.2	282.6
TSN(mill)	955	12623	9748	2175	883	313	510	303	691	148	67	28 503.1		
cv (TSN)	1.04	0.18	0.17	0.27	0.35	0.36	0.37	0.34	0.34	0.50	0.79	0.11		
TSB(1000 t)	12.2	683.9	826.3	240.1	127.5	58.4	81.9	48.5	111.4	22.9	9.0	2 223.7		
cv (TSB)	1.04	0.18	0.17	0.27	0.36	0.38	0.37	0.35	0.34	0.46	0.71	0.12		
Mean length(cm)	12.5	21.3	24.0	26.8	29.6	32.0	31.0	31.1	31.0	31.6	32.3			
Mean weight(g)	13	60	87	114	152	190	167	173	167	168	180			

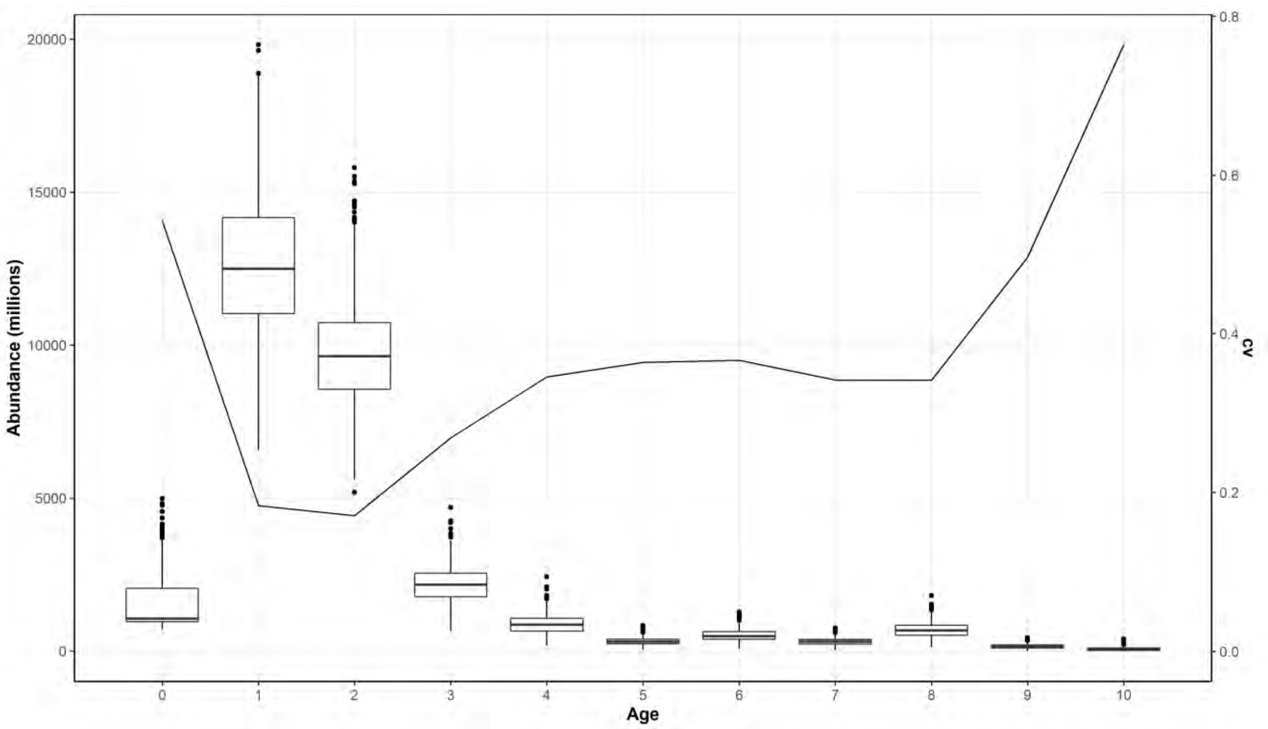

Figure 21. Number by age with uncertainty for blue whiting during IESSNS 2022. Boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 1000 replicates using the StoX software.

Table 13. IESSNS baseline time series from 2016 to 2022. StoX abundance estimates of blue whiting (millions).

	Age										
Year	0	1	2	3	4	5	6	7	8	9	10+	TSB(1000 t)
2016	3 869	5 609	11 367	4 373	2 554	1 132	323	178	177	8	233	2 283
2017	23 137	2 558	5 764	10 303	2 301	573	250	18	25	0	25	2 704
2018	0	915	1 165	3 252	6 350	3 151	900	385	100	52	41	2 039
2019	2 153	640	1 933	2 179	4 348	5 434	1 151	209	229	5	8	2 028
2020	4 066	5 804	2 996	1 629	1 205	1 718	1 990	939	201	21	30	1 806
2021	4 023	18 056	2 300	1 664	841	982	1 543	609	60	91	74	2 238
2022	978	12 454	9 773	2 279	904	314	520	303	678	177	71	2 241

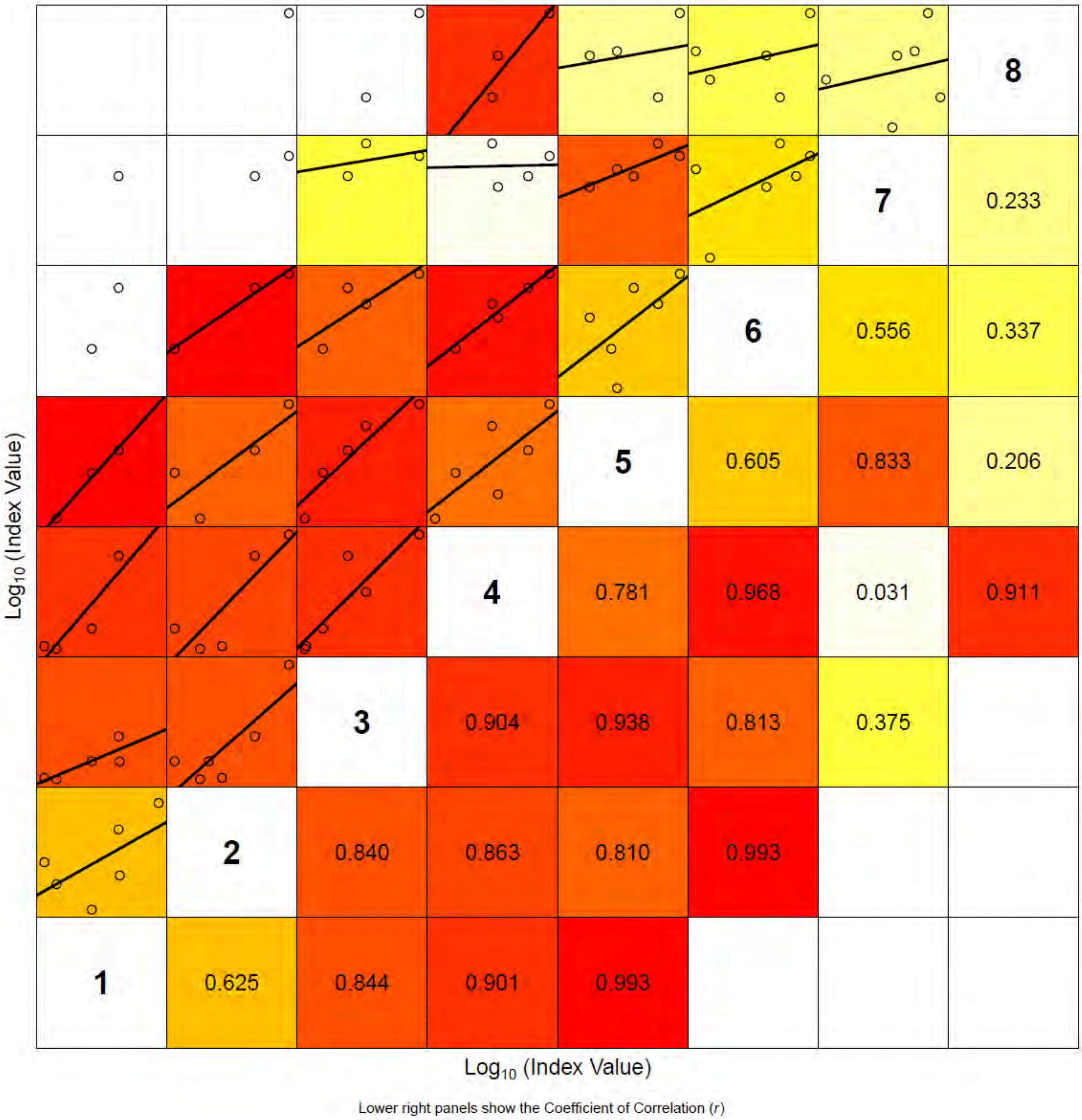

Figure 22. Internal consistency for blue whiting within the IESSNS. The upper left part of the plots shows the relationship between log index-at-age within a cohort. Linear regression line shows the best fit to the log-transformed indices. The lower-right part of the plots shows the correlation coefficient (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.

4.6 Other species

Lumpfish (*Cyclopterus lumpus*)

Lumpfish was caught in 71% of trawl stations across the five vessels (Figure 23) and where lumpfish was caught, 69% of the catches were ≤10kg. Lumpfish was distributed across the entire survey area, from east of Greenland to the Barents Sea in the northeast 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 southwest of the survey so it is likely that the distribution of lumpfish extends beyond the survey coverage. The length of lumpfish caught varied from 5 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). For fish ≥20 cm in which sex was determined, the males exhibited a unimodal distribution with a peak around 25-27 cm. The females also exhibited a bimodal distribution but with a peak around 24-30 cm and another around 35-45 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 294 fish (67 by R/V "Árni Friðriksson", 83 by M/V "Eros", 96 by M/V Vendla and 48 by Tarajoq) between 5 and 52 cm were tagged during the survey (Figure 25).

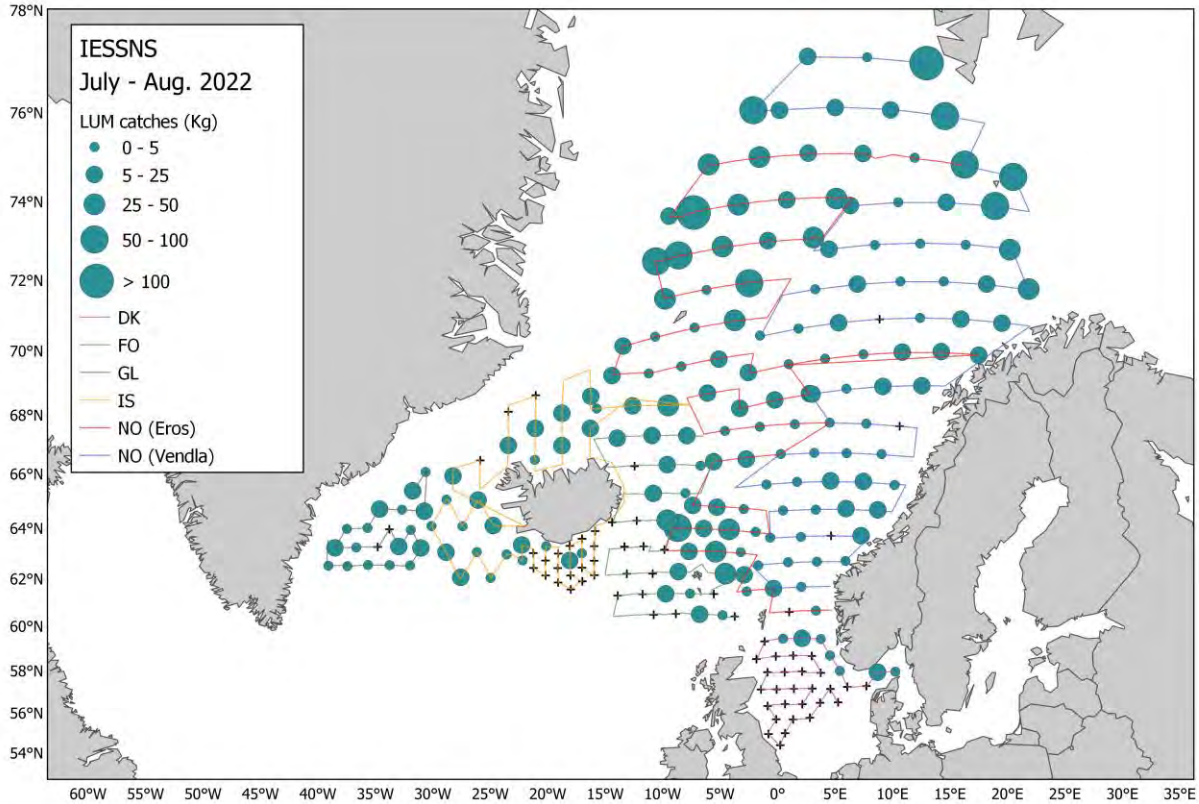

Figure 23. Lumpfish catches at surface trawl stations during IESSNS 2022.

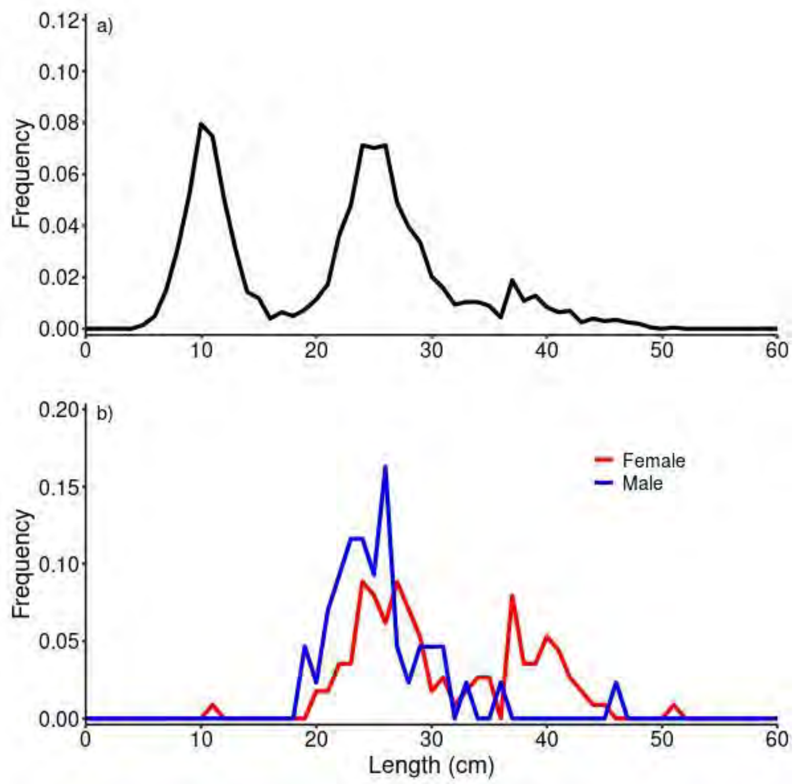

Figure 24. Length distribution of a) all lumpfish caught during the survey and b) length distribution of fish in which sex was determined.

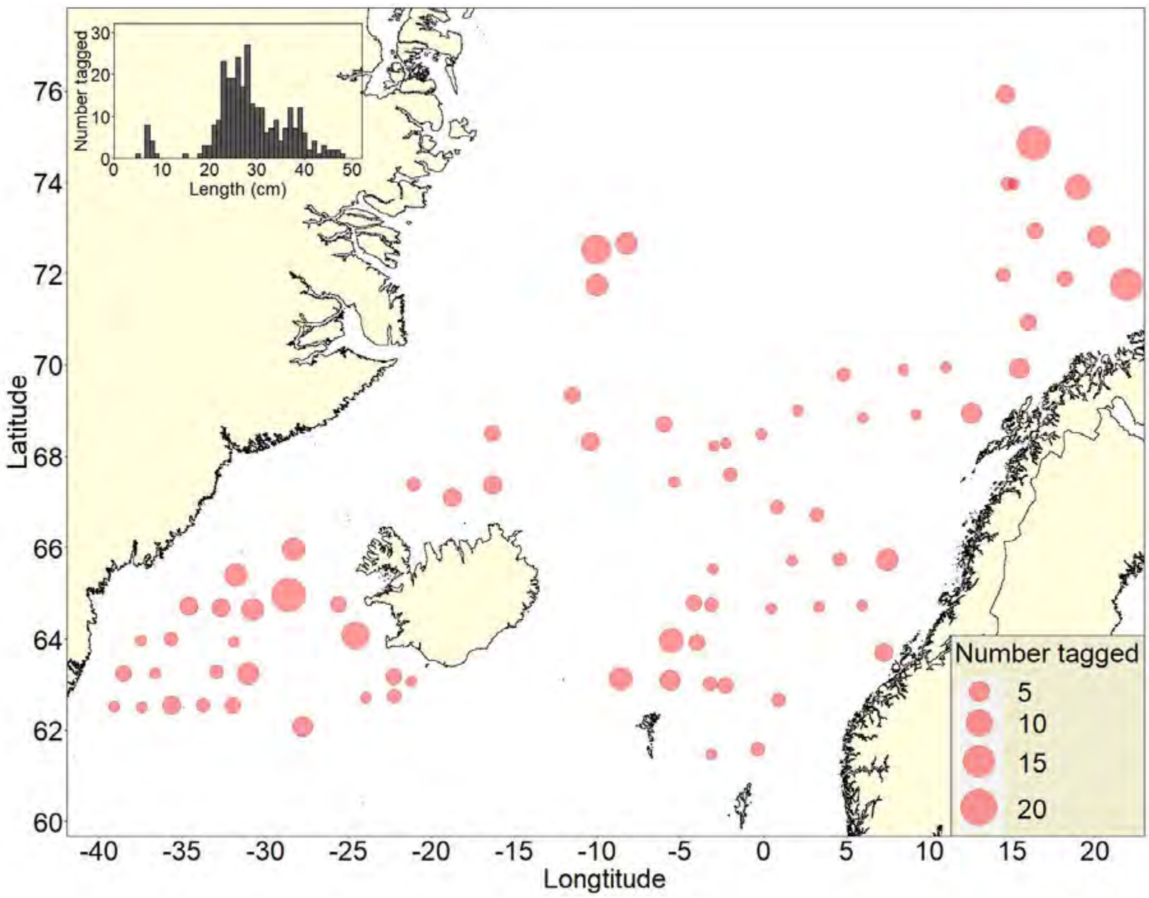

Figure 25. Number tagged, and release location, of lumpfish. Insert shows the length distribution of the tagged fish.

Salmon (*Salmo salar*)

A total of 60 North Atlantic salmon were caught in 38 stations both in coastal and offshore areas from 61°N to 76°N in the upper 30 m of the water column during IESSNS 2022 (Figure 26). The salmon ranged from 0.028 kg to 4.1 kg in weight, dominated by post-smolt and 1 sea-winter individuals. We caught from 1 to 6 salmon during individual surface trawl hauls. The length of the salmon ranged from 15 cm to 74 cm, with the highest fraction between 20 cm and 30 cm.

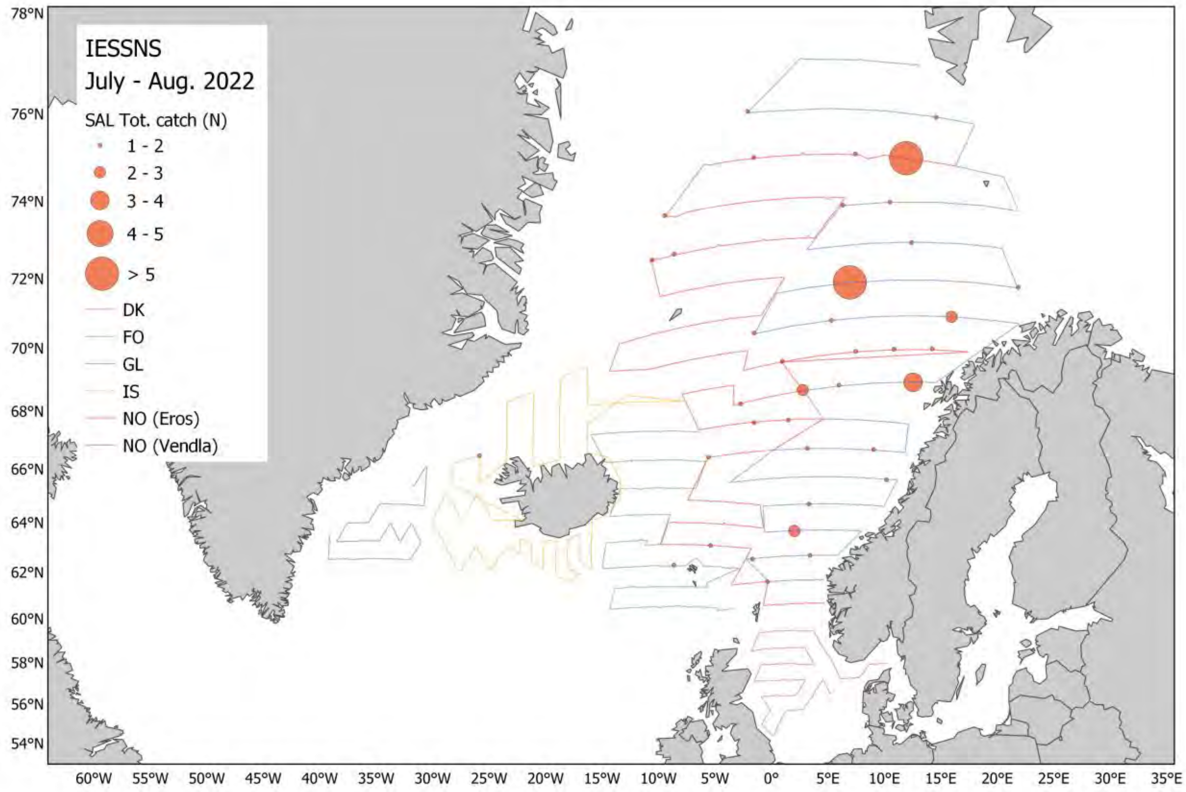

Figure 26. Catches of salmon at surface trawl stations during IESSNS 2022.

Capelin (*Mallotus villosus*)

Capelin was caught in the surface trawl on 22 stations primarily along the cold fronts: Between East Greenland and Iceland, west and North of Jan Mayen and at the entrance to the Barents Sea (Figure 27). This is 10 stations more than in 2021 partly because of the lack of Greenland coverage in 2021 and partly because of more stations with capelin around Iceland this year (11 in 2022, 6 in 2021).

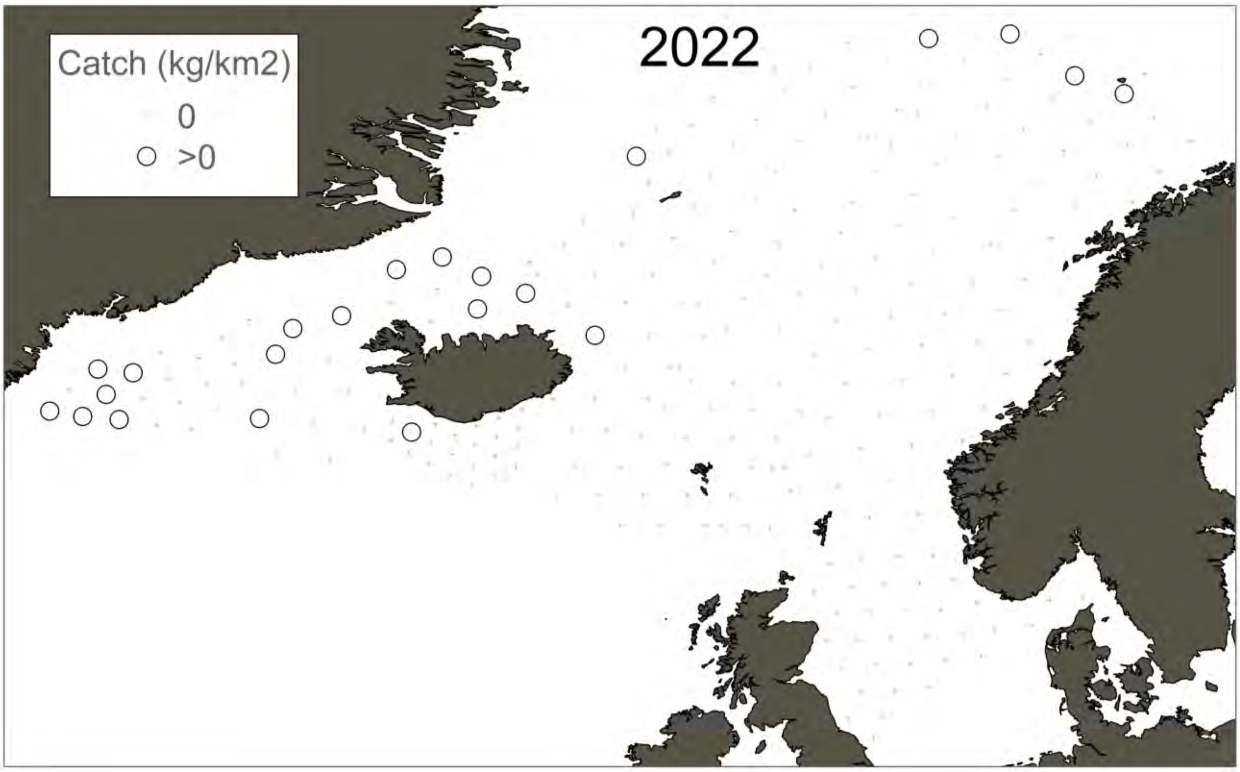

Figure 27. Presence of capelin in surface trawl stations during IESSNS 2022.

4.7 Marine Mammals

Opportunistic whale observations were done by M/V "Eros" and M/V "Vendla" from Norway in addition to R/V "Árni Friðriksson" from Iceland and R/V "Jákup Sverri" from Faroe Islands in from 1st July to 3rd August 2022 (Figure 28). Overall, 711 marine mammals of 11 different species were observed, which was a decrease from an overall 1029 marine mammals and eight species observed in 2021.

The species that were observed included 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*), harbour porpoise (*Phocoena phocoena*). A basking shark (*Cetorhinus maximus*) was also observed during the survey. The dominant number of marine mammal observations were found around Iceland, Faroe Islands and along the continental shelf between the north-eastern part of the Norwegian Sea and in a line between Finnmark to southwest of Svalbard. We observed very few marine mammals in the central part of the Norwegian Sea in July 2022. Fin whales (n = 48, group size = 1-12 (average group size = 2.5)) and humpback whales (n = 44, group size = 1-30 (average group size = 3.9)) dominated among the large whale species, and they were present west and northwest of Iceland and from Norwegian coast outside Finnmark stretching north/northwest via Bear Island to southwest of Svalbard. Very few sperm whales (n = 8, group size = 1 (average group size = 1.0)) where observed. Killer whales (n = 121, group size = 1-30 (average groups size = 10.1)) dominated in the southern, northern and north-eastern part of the Norwegian Sea, partly overlapping and presumably feeding on NEA mackerel in the upper water masses. Pilot whales (n = 30, group size = 5-15 (average groups size = 10)) where mostly observed in Faroese waters during IESSNS 2022. A sei whale and one northern bottlenose whale were observed in Icelandic waters, whereas a basking shark was observed in Faroese waters. White beaked dolphins (n = 229, group size = 1-22 (average groups size = 8.5)) were present in the northern part of the Norwegian Sea. Two pods of white sided dolphins (group size = 15) were observed in the southern part of the Norwegian Sea. Minke whales (n = 53, group size = 1-10 (average group size = 1.7)) were distributed over large areas from western coast of Norway to western part of Iceland, and from 60°N to 75°N, including overlapping and likely feeding on NSS herring in the upper 40 m of the water column. There is available a new 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)

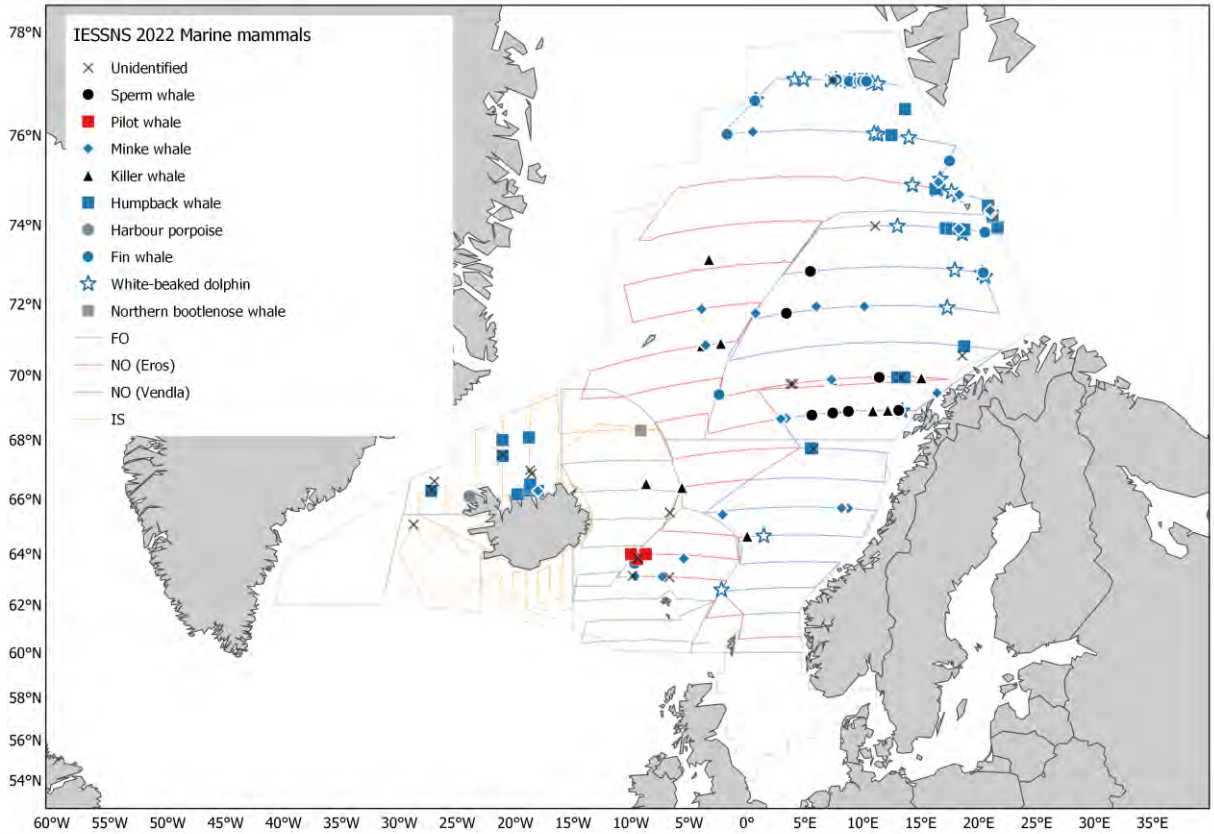

Figure 28. Overview of all marine mammals sighted during IESSNS 2022.

5 Recommendations

The group suggested the following recommendation from WGIPS	To whom
The occasional large catches of mackerel have a relatively large impact on the overall results and possibly bias the stock indices. WGIPS recommends that the ability of the present and alternative methods (such as more advanced statistical models) to represent this overdispersion is evaluated, preferably at the WGISDAA meeting 25.-27.October, 2022.	National institutes and WGISDAA
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
It is recommended that WGIPS contacts the country representatives for the IESSNS survey to update the respective sections (e.g. trawl performance, trawl station data collection) in the survey manual prior to the WGIPS meeting 23.-27.January 2023.	WGIPS

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
All survey participants are encouraged to continue the international tagging of lumpfish.	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 2022 the IESSNS survey in the North Sea has been conducted for five consecutive years (2018-2022). 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 the internal consistency between years in the survey for selected age groups is also evaluated. 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)

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We greatly appreciate and thank skippers and crew members onboard M/V "Vendla", M/V "Eros", R/V " Jákup Sverri", R/V "Árni Friðriksson", R/V "Tarajoq" and M/V "Ceton" for outstanding collaboration and practical assistance during the joint mackerel-ecosystem IESSNS cruise in the Nordic Seas from 1st of July to 3rd of August 2022.

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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.

In 2022, 34 stations were taken (PT and CTD. The locations of stations differed slightly from the previous year focussing on the area north and west of Doggerbank and extended into the eastern Skagerrak. However, due to shortage of available survey time only 34 out of the planned 38 stations were covered.

Average mackerel catch in 2022 amounted 1689 kg/km^2, which was considerably lower than in the previous year (2021: 2429 kg/km^2) but higher or similar than in the period 2018-2020 (2020: 1318 kg/km^2, 2019: 1009 kg/km^2, 2018: 1743 kg/km^2). The length and age composition indicate a relative low amount of small (< 25 cm) individuals whereas the abundance of older (≥ age 2) mackerel was on a similar level than in the previous year (Fig. A.1.).

StoX (version 3.5.0) estimate of mackerel biomass in the North Sea for 2022 is 471 948 tonnes (Table A1-1) which is the second highest biomass values in the time series. The biomass and abundance estimates are based on a preliminary defined polygon for the surveyed area covered in all years since 2018 in which the northern border was set to 60 °N (border to stratum 1; Fig. 2), and the eastern, southern, and western limits were either the coastline or extrapolated using half the longitudinal or latitudinal distance between the adjacent stations. The area of this polygon is 278 525 km^2.

For 11 out of 35 individuals in the size range of 18 to 20 cm the first wintering was not visible applying the standard age reading procedure. These fish should be attributed to the 2021-year class rather than be treated as 0-group fish considering the spawning period of mackerel in the North Sea. However, the aspect of the non-visible first age ring, which might be related to the presently prevailing warm winter conditions in the North Sea, warrants further investigations.

Based on the experiences made in the previous years, new limits for the stratum in the North were defined which shall be used for the station allocation for future surveys (Fig. A2). 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 were 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.

Table A1-1. StoX (version 3.5.0) baseline estimates of age segregated and length segregated mackerel indices for the North Sea in 2022.

Length	Age in years / Year class															Number	Biomass	Mean weight
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14			
(cm)	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	(10^6)	(ton)	(g)
17-18		0.1														0.1	4	40
18-19	15.5	15.3														30.8	1488	48
19-20	36.3	87.1														123.4	6753	55
20-21	1.8	120.4														122.1	8024	66
21-22		42.0														42.0	3162	75
22-23		12.6														12.6	1153	92
23-24		11.3														11.3	1237	109
24-25		26.7														26.7	3318	124
25-26		12.6														12.6	1747	139
26-27		7.4														7.4	1161	157
27-28		15.3								0.8						16.1	3013	187
28-29		147.9	23.2													171.1	36138	211
29-30		496.5	23.2													519.7	126715	244
30-31		204.9	160.3													365.2	97338	266
31-32		26.2	134.1	13.3												173.6	49252	284
32-33			103.7	13.1	0.6											117.4	36622	312
33-34			35.2	30.1	5.4	0.6										71.3	23661	332
34-35			3.6	29.6	18.9	2.3										54.3	19943	367
35-36				5.7	13.5	7.6	6.6	4.4								37.8	14858	393
36-37				0.7	8.9	11.3	7.1	0.2	0.5	0.8						29.5	12106	410
37-38					1.5	6.3	9.4	3.9	0.1							21.1	9138	433
38-39						1.2	0.7	4.1	2.4	0.5						8.9	4416	498
39-40					1.1	4.2	2.5	0.7	0.9	0.5						9.8	4963	504
40-41						1.1	0.8	1.3	0.5	0.3	0.7					4.6	2537	549
41-42								1.1		0.1						1.3	699	542
42-43								0.4					0.4		0.1	1.0	648	675
43-44										1.8						1.8	1250	682
44-45							1.3									1.3	1281	950
TSN (mill)	53.6	1226.4	483.3	92.4	49.8	34.4	28.5	16.3	4.3	4.8	0.7	0.0	0.4	0.0	0.1	1,995	472626	
TSB (ton)	2913	242385	136351	30981	19206	14533	13103	7731	2195	2535	345	0	259	0	90	472,626		
Mean length (cm)	18.7	26.8	30.8	33.0	34.7	36.3	36.9	37.4	38.2	38.1	40.0		42.0		42.0			
Mean weight (g)	54	198	282	335	385	422	460	474	511	525	525		638		746			

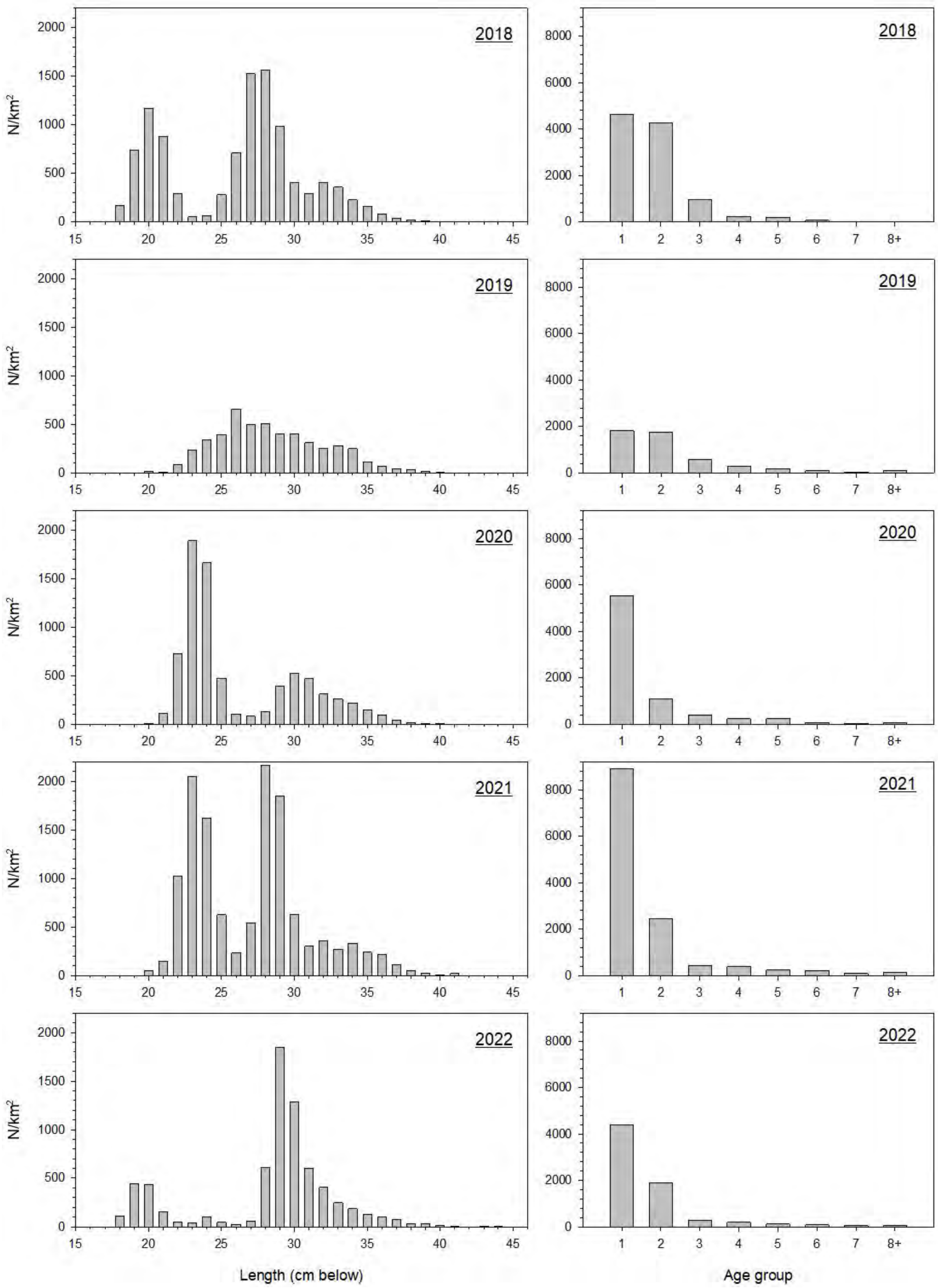

Fig. A1-1. Comparison of length and age distribution of mackerel in the North Sea 2018 to 2022.

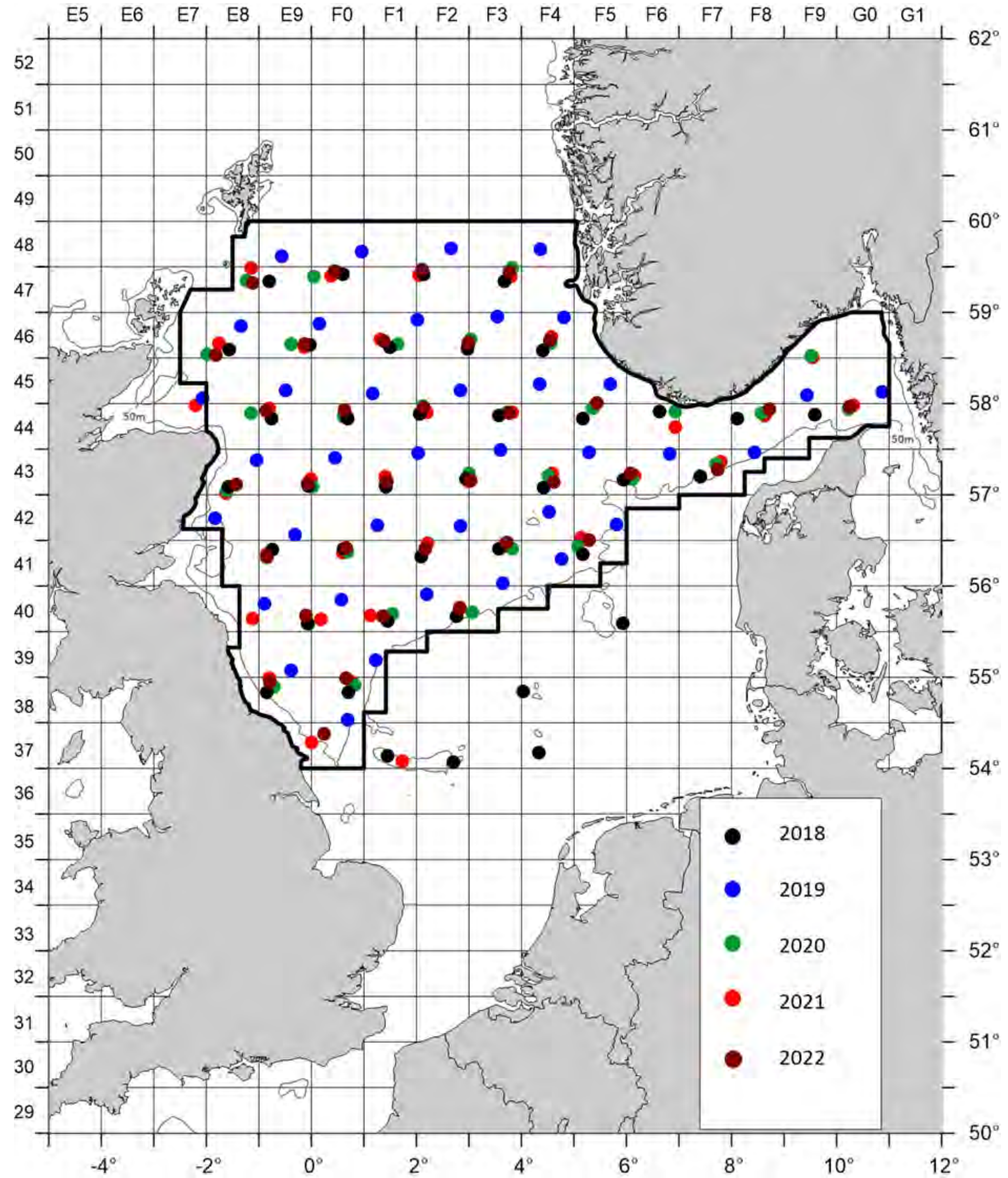

Fig. A1-2. Limits of the North Sea stratum for future surveys and sampling positions achieved in the period 2018-2022.

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 2022 (Table A2-1). Map of included and excluded trawl stations displayed in Figure A2-1.

Table A2-1: Trawl station exclusion list and average horizontal trawl opening per vessel for IESSNS 2022 for calculating the mackerel abundance index.

Vessel	Country	Horizontal trawl opening (m)	Exclusion list Cruise	Stations
Vendla	Norway	67.5	2022816	60, 75, 80, 82, 85, 88, 90, 91, 95, 104, 109, 113, 120, 124
Eros	Norway	63.5	2022817	28, 30, 44, 46,51, 55, 59, 63, 72, 73, 91
R/V Árni Friðriksson	Iceland	63.75	A8-2022	295, 311
R/V Jákup Sverre	Faro Islands	63.4	2230	5, 23, 24, 35, 46, 61*
R/V Tarajoq	Greenland	61.4	TA-2022-04	none
Ceton	Denmark	72.0	IESSNS2022	none

* Observe that in PGNAPES and the national database station numbers are 4-digit numbers preceded by 2230 (e.g. ‘22300005’)

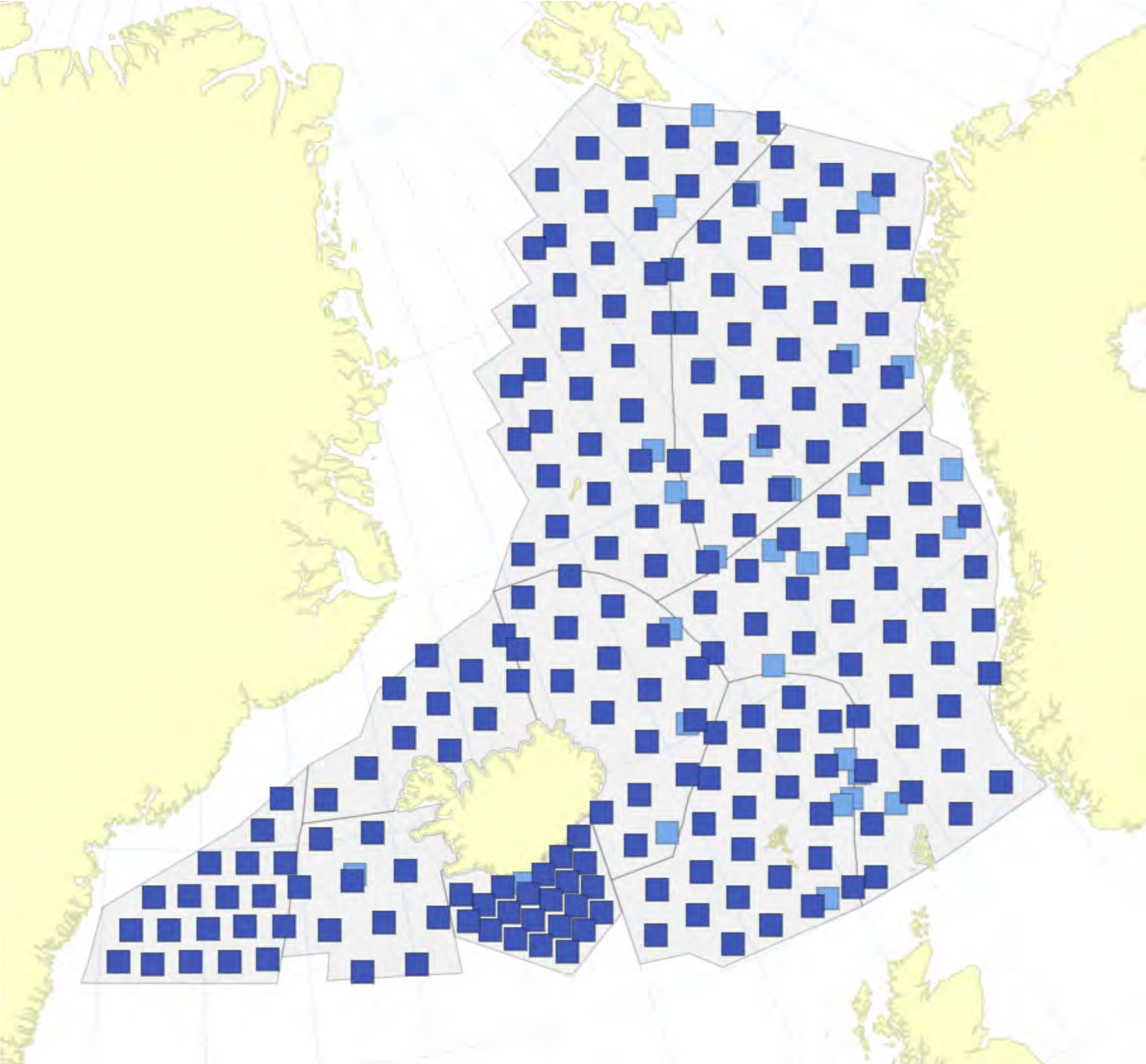

Figure A2-1. IESSNS 2022. Surface trawl stations included (filled dark blue rectangle) and excluded (filled light blue rectangle) in calculations of mackerel age segregated index used in the assessment. Strata boundary also displayed (grey solid lines).

Appendix 3: Impact of large hauls on abundance and biomass estimates

In 2022 there were two large mackerel hauls. In order to investigate the effect of these on the StoX estimates, an additional run of StoX was made without these hauls (Figure A3-1).

If the two stations with the highest catches (slightly above 20 tons on each) are removed, the baseline estimate of total abundance is reduced by 34 % and the baseline estimate of total biomass is reduced by 33 % (from 7.37 to 4.91 million tons). Moreover, the relative standard error of total abundance from 1000 bootstrap replicates is 26 % when all stations are used, while becomes reduced to 12 % when the two highest stations are removed. The relative standard error of total biomass from 1000 bootstrap replicates is 25 % when all stations are used, while becomes reduced to 11 % when the two highest stations are removed.

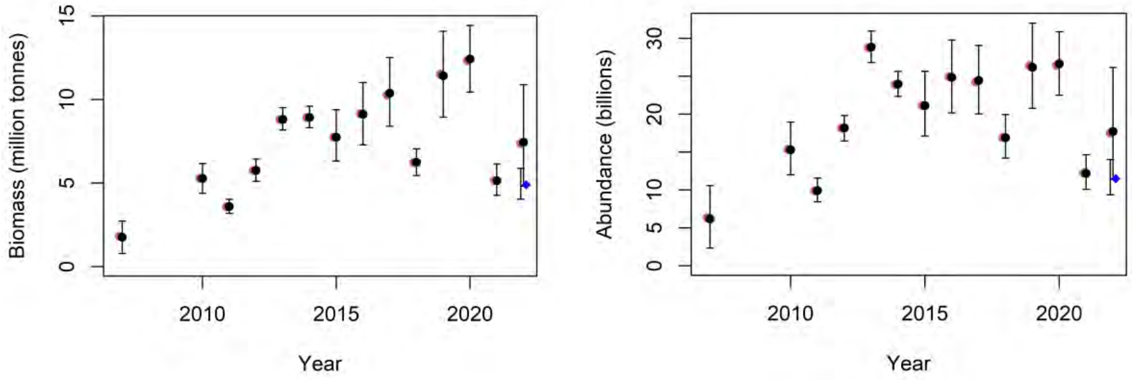

Figure A3-1. StoX runs with (black/red 2022 dot) and without (blue 2022 dot) large hauls. Biomass (left panel) and abundance (right panel).

Appendix 4:

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.

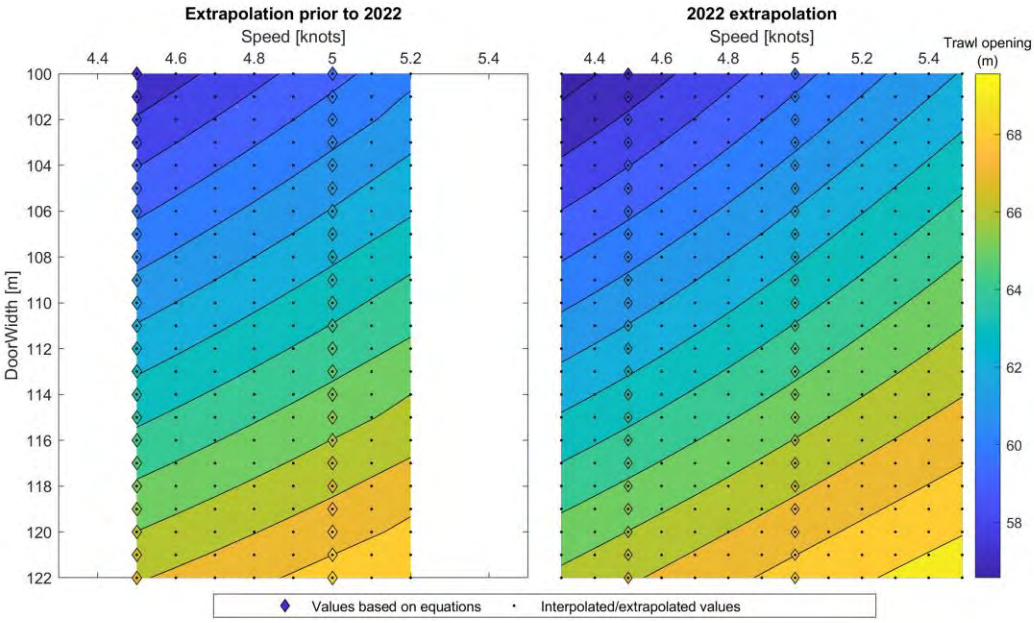

Figure A3-1. Table 6 in the report shown as a plot.

Working document 02, WGWIDE 2022

PFA self-sampling report for WGWIDE 2022

Martin Pastoors, 24/08/2022 12:41:15 (v2)

PFA report 2022_07

Executive summary

The Pelagic Freezer-trawler Association (PFA) is an association that has nine member companies that together operate 15 (in 2021) 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 Martin Pastoors (PFA chief science officer) with support of 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 2016 up to 11/08/2022 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, 22% German trawlers, 14% UK trawlers and 16% other countries. Blue whiting constitutes the majority of the catch in those trips (54%), followed by mackerel (23%) and horse mackerel (12%). Atlanto-scandian herring only constitutes around 3% 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 2016 - 2022 (up to 11/08/2022) covered 465 fishing trips with 6352 hauls, a total catch of 386474 tonnes and 103745 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 2021 have been relatively large with a median length of 36.4 cm compared to 33.6-36.2 in the preceding years. Also, the median weight has been somewhat higher with median weight of 435 gram compared to 385-422 gram in the 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 2016 - 2022 (up to 11/08/2022) covered 250 fishing trips with 3316 hauls, a total catch of 128553 tonnes and 130146 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 in divisions 27.6.a, 27.7.b and 27.7.j have fluctuated between 25.2 and 31.9 cm (with one low median length of 22.7 cm in 27.6.a in 2018). In ICES division 27.7.h, median lengths in the catch have been smaller and fluctuated between 20.7 and 24.5 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 2016 - 2022 (up to 11/08/2022) covered 109 fishing trips with 900 hauls, a total catch of 46322 tonnes and 38983 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 in division 27.7.d have fluctuated between 20.7 and 24.3 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 2016 - 2022 (up to 11/08/2022) covered 320 fishing trips with 8234 hauls, a total catch of 810714 tonnes and 466229 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 27.8 cm compared to 24.1-24.5 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 horse mackerel fisheries during the years 2016 - 2022 (up to 11/08/2022) covered 32 fishing trips with 297 hauls, a total catch of 17705 tonnes and 5147 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 and 35 cm.

In this 2022 self-sampling report, a standardized CPUE calculation has been included for the first time 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)

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 Martin Pastoors (PFA chief science officer) with support of 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 Floor Quirijns and/or Martin Pastoors, 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 2016 - 2022 (up to 11/08/2022).

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. 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
2016	9	45	591	1,307	113,900	193	0.50%	65,212	0
2017	12	62	840	1,781	177,887	212	0.26%	91,357	0
2018	16	86	1,219	2,677	253,237	208	0.22%	170,306	641
2019	16	97	1,226	2,658	224,886	183	0.29%	124,288	1,055
2020	17	112	1,424	3,038	305,282	214	0.36%	163,955	2,379
2021	19	119	1,398	2,874	282,097	202	0.52%	138,481	1,411
2022*	18	62	733	1,694	144,718	197	0.84%	65,457	4,004
(all)		583	7,431	16,029	1,502,007			819,056	9,490

*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	2016	2017	2018	2019	2020	2021	2022*	all	perc
27.6.a	34,822	75,493	126,130	116,241	125,729	113,522	57,044	648,981	43.2%
27.4.a	24,771	23,842	36,129	39,494	63,061	61,135	13,684	262,116	17.5%
27.7.c	7,516	29,371	30,524	26,772	44,548	28,885	20,835	188,451	12.5%
27.7.k	7,489	96	7,646	2,036	11,339	16,684	29,327	74,616	5.0%
27.2.a	11,784	20,469	18,096	4,607	10,000	2,595	0	67,551	4.5%
27.7.j	4,822	663	3,648	8,635	16,322	14,976	14,801	63,868	4.3%
27.7.d	10,456	8,404	9,853	10,373	10,763	9,934	2,303	62,086	4.1%
27.7.b	4,614	8,605	5,324	10,530	11,649	13,205	5,997	59,924	4.0%
27.5.b	5,721	8,061	7,933	3,925	10,277	8,689	514	45,120	3.0%
27.7.h	1,381	1,330	6,571	1,236	111	9,012	212	19,851	1.3%
27.4.c	523	1,555	1,385	1,036	1,483	3,460	0	9,442	0.6%
(all)	113,900	177,887	253,237	224,886	305,282	282,097	144,718	1,502,007	100.0%

division	2016	2017	2018	2019	2020	2021	2022*	all	perc
27.6.a	411	668	1,267	1,281	1,209	966	711	6,513	40.6%
27.4.a	194	191	374	436	548	560	139	2,442	15.2%
27.7.c	87	255	243	252	328	255	159	1,579	9.8%
27.7.d	162	153	187	187	187	206	55	1,137	7.1%
27.7.j	52	17	60	137	208	289	273	1,036	6.5%
27.7.b	101	139	88	175	207	202	86	998	6.2%
27.2.a	129	237	207	86	142	24	0	825	5.1%
27.7.k	77	3	59	17	95	131	244	626	3.9%
27.5.b	57	66	82	38	87	54	5	389	2.4%
27.7.h	25	30	94	24	6	144	22	345	2.2%
27.4.c	12	22	16	25	21	55	0	151	0.9%
(all)	1,307	1,781	2,677	2,658	3,038	2,886	1,694	16,041	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	2016	2017	2018	2019	2020	2021	2022*	all	perc
Jan	12,789	28,644	25,647	35,499	37,485	51,537	41,028	232,629	15.5%
Feb	10,196	19,369	32,600	32,829	28,300	31,967	28,025	183,285	12.2%
Mar	16,154	29,388	32,673	27,992	47,769	36,936	40,093	231,004	15.4%
Apr	14,420	28,510	58,665	28,857	66,042	29,472	25,878	251,844	16.8%
May	7,763	12,367	30,227	21,332	29,189	14,466	8,521	123,866	8.2%
Jun	1,649	0	6,866	1,498	4,219	2,467	0	16,699	1.1%
Jul	1,977	665	791	6,185	1,566	12,330	1,174	24,688	1.6%
Aug	886	6,545	4,551	3,844	4,234	4,779	0	24,839	1.7%
Sep	1,990	9,898	8,334	7,775	12,586	9,134	0	49,717	3.3%
Oct	18,517	17,478	22,975	25,417	27,648	39,924	0	151,960	10.1%
Nov	18,307	21,875	20,385	22,205	27,061	30,033	0	139,865	9.3%
Dec	9,251	3,148	9,522	11,453	19,184	19,052	0	71,610	4.8%
(all)	113,900	177,887	253,237	224,886	305,282	282,097	144,718	1,502,007	100.0%

month	2016	2017	2018	2019	2020	2021	2022*	all	perc
Jan	174	311	309	452	355	568	482	2,651	16.5%
Feb	142	206	325	362	287	344	301	1,967	12.3%
Mar	160	226	297	314	410	333	389	2,129	13.3%
Apr	114	201	494	289	574	240	359	2,271	14.2%
May	105	145	372	250	312	167	144	1,495	9.3%
Jun	14	0	77	23	97	42	0	253	1.6%
Jul	25	12	10	75	26	113	19	280	1.7%
Aug	5	58	39	41	53	33	0	229	1.4%
Sep	38	130	145	149	154	187	0	803	5.0%
Oct	204	198	232	299	295	398	0	1,626	10.1%
Nov	223	269	291	315	331	305	0	1,734	10.8%
Dec	103	25	86	89	144	156	0	603	3.8%
(all)	1,307	1,781	2,677	2,658	3,038	2,886	1,694	16,041	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	2016	2017	2018	2019	2020	2021	2022*	all	perc
DEU	27,803	27,500	55,468	40,385	69,108	54,075	26,246	300,585	20.0%
FR	0	0	11,936	19,356	14,506	12,257	9,128	67,184	4.5%
LIT	0	0	0	1,414	13,744	23,150	6,467	44,775	3.0%
NL	68,790	114,844	139,403	106,898	117,284	124,171	69,345	740,736	49.3%
POL	0	0	15,966	28,022	54,615	29,675	13,599	141,877	9.4%
UK	17,306	35,543	30,464	28,811	36,026	35,341	19,932	203,423	13.5%
NA	0	0	0	0	0	3,428	0	3,428	0.2%
(all)	113,900	177,887	253,237	224,886	305,282	282,097	144,718	1,502,007	100.0%

flag	2016	2017	2018	2019	2020	2021	2022*	all	perc
DEU	340	276	637	456	623	463	269	3,064	19.1%
FR	0	0	236	357	243	205	165	1,206	7.5%
LIT	0	0	0	34	142	165	36	377	2.4%
NL	807	1,177	1,403	1,314	1,374	1,385	886	8,346	52.1%
POL	0	0	111	183	322	187	113	916	5.7%
UK	160	328	290	314	334	394	225	2,045	12.8%
NA	0	0	0	0	0	75	0	75	0.5%
(all)	1,307	1,781	2,677	2,658	3,038	2,874	1,694	16,029	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	2016	2017	2018	2019	2020	2021	2022	all	perc
whb	blue whiting	Micromesistius poutassou	48,666	79,108	154,733	113,262	174,647	149,325	90,974	810,715	54.0%
mac	mackerel	Scomber scombrus	33,544	63,026	55,756	54,005	84,290	69,094	26,569	386,283	25.7%
hom	horse mackerel	Trachurus trachurus	21,808	20,853	28,497	31,565	25,061	33,995	13,096	174,876	11.6%
her	herring	Clupea harengus	4,509	6,870	7,851	17,286	9,154	19,912	3,123	68,704	4.6%
arg	argentines	Argentina spp	1,560	2,596	4,097	4,566	7,036	5,457	9,595	34,906	2.3%
her_ash	NA	NA	2,109	4,913	1,367	3,373	3,563	2,379	0	17,706	1.2%
boc	boarfish	Capros aper	226	245	153	288	603	844	680	3,039	0.2%
pil	pilchard	Sardina pilchardus	719	61	371	155	32	325	140	1,805	0.1%
hke	hake	Merluccius merluccius	266	107	270	197	181	239	333	1,593	0.1%
spr	sprat	Sprattus sprattus	382	0	0	0	415	138	0	934	0.1%
sqr	squid	Loligo vulgaris	0	0	8	8	26	133	55	229	0.0%
had	haddock	Melanogrammus aeglefinus	11	5	15	46	42	66	37	222	0.0%
brb	black seabream	Spondyliosoma cantharus	29	2	22	3	83	5	3	148	0.0%
bor	boarfish	Caproidae	0	0	0	0	0	59	73	132	0.0%
whg	whiting	Merlangius merlangus	13	0	24	31	31	30	2	130	0.0%
oth	NA	NA	57	101	74	102	119	95	37	585	0.0%
(all)	(all)	(all)	113,900	177,887	253,237	224,886	305,282	282,097	144,718	1,502,007	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.

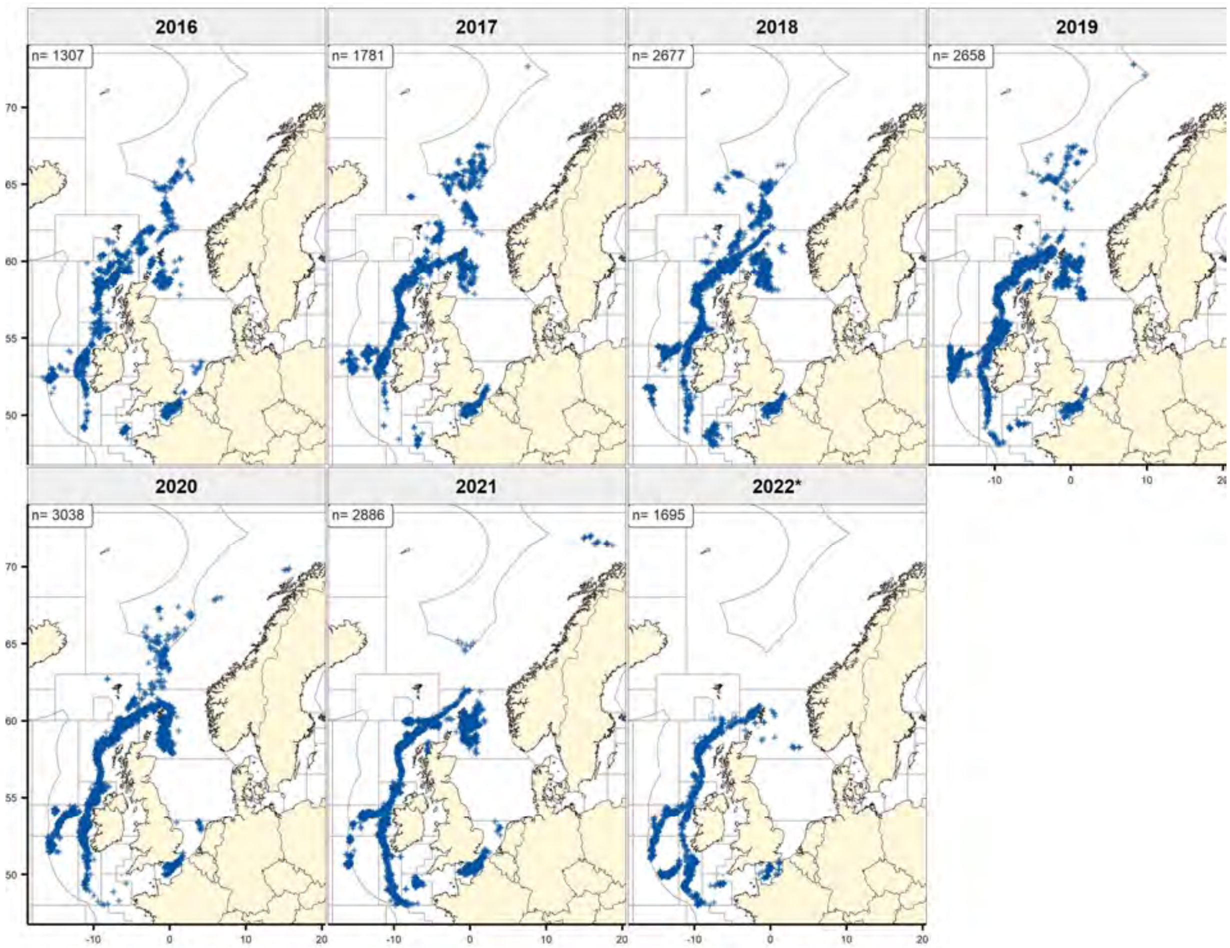

Figure 3.1.1: PFA fisheries for widely distributed species Self-sampling haul positions. N indicates the number of hauls.

Catches for the main target species

Summed catches (tonnes) of the main target species aggregated in rectangles.

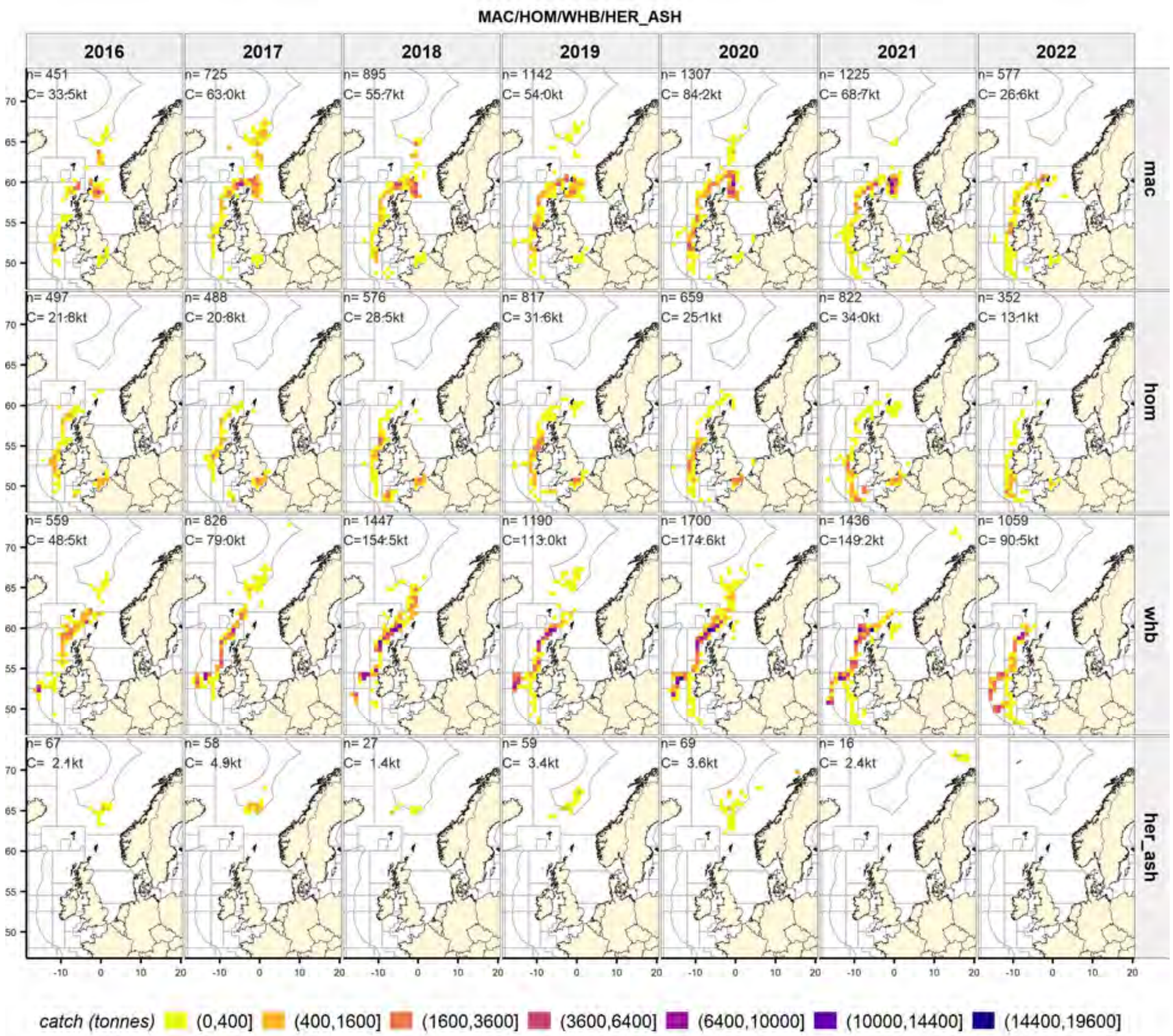

Figure 3.1.2: PFA fisheries for widely distributed species Self-sampling catch per species and per rectangle. N indicates the number of hauls. Catch refers to the total catch per year.

Catch rates (catch/day) for the main target species

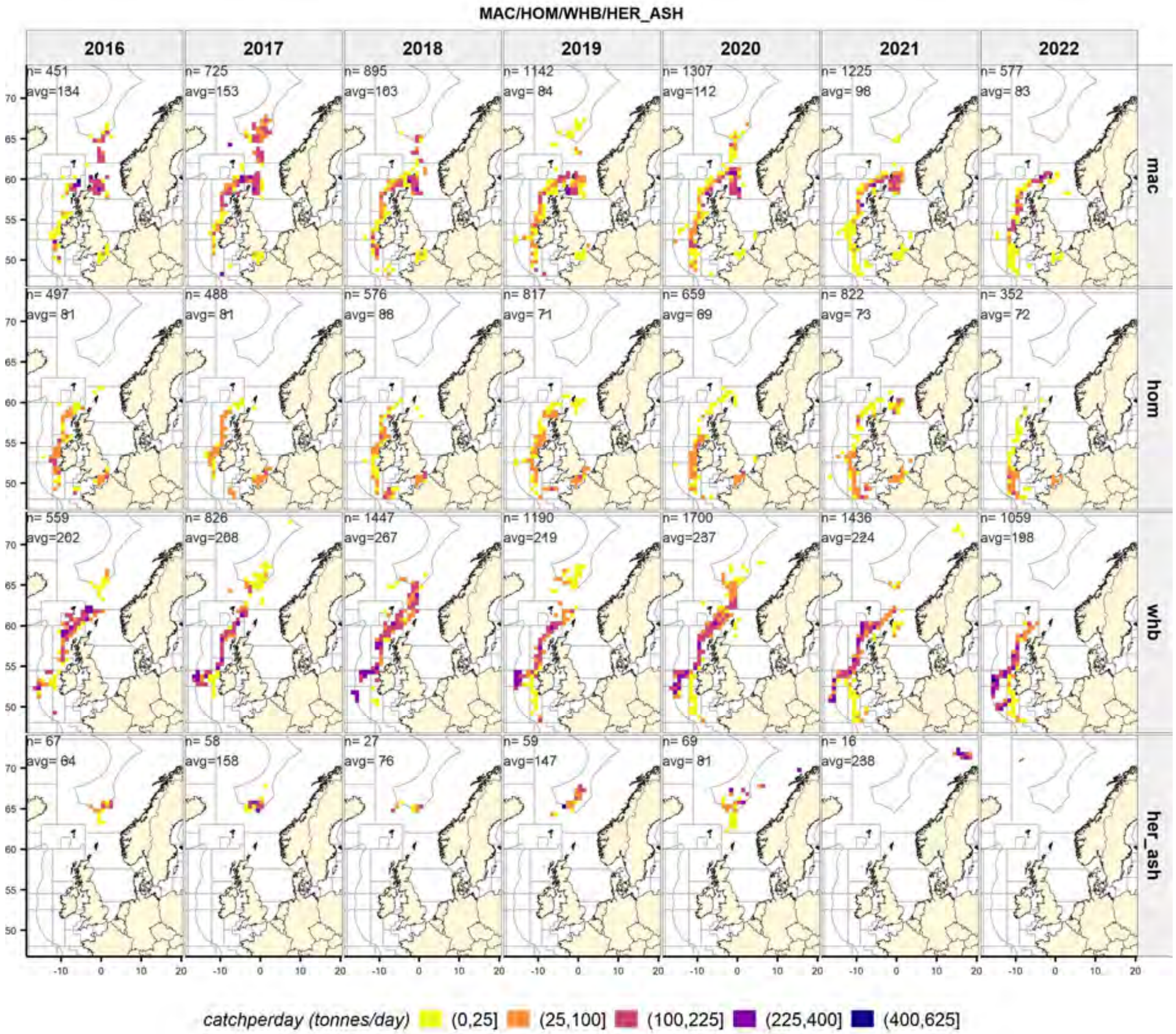

Figure 3.1.3: Average catch per day, per species and per rectangle. N indicates the number of hauls; avg refers to the average catch per day.

Average surface temperature by quarter and by rectangle.

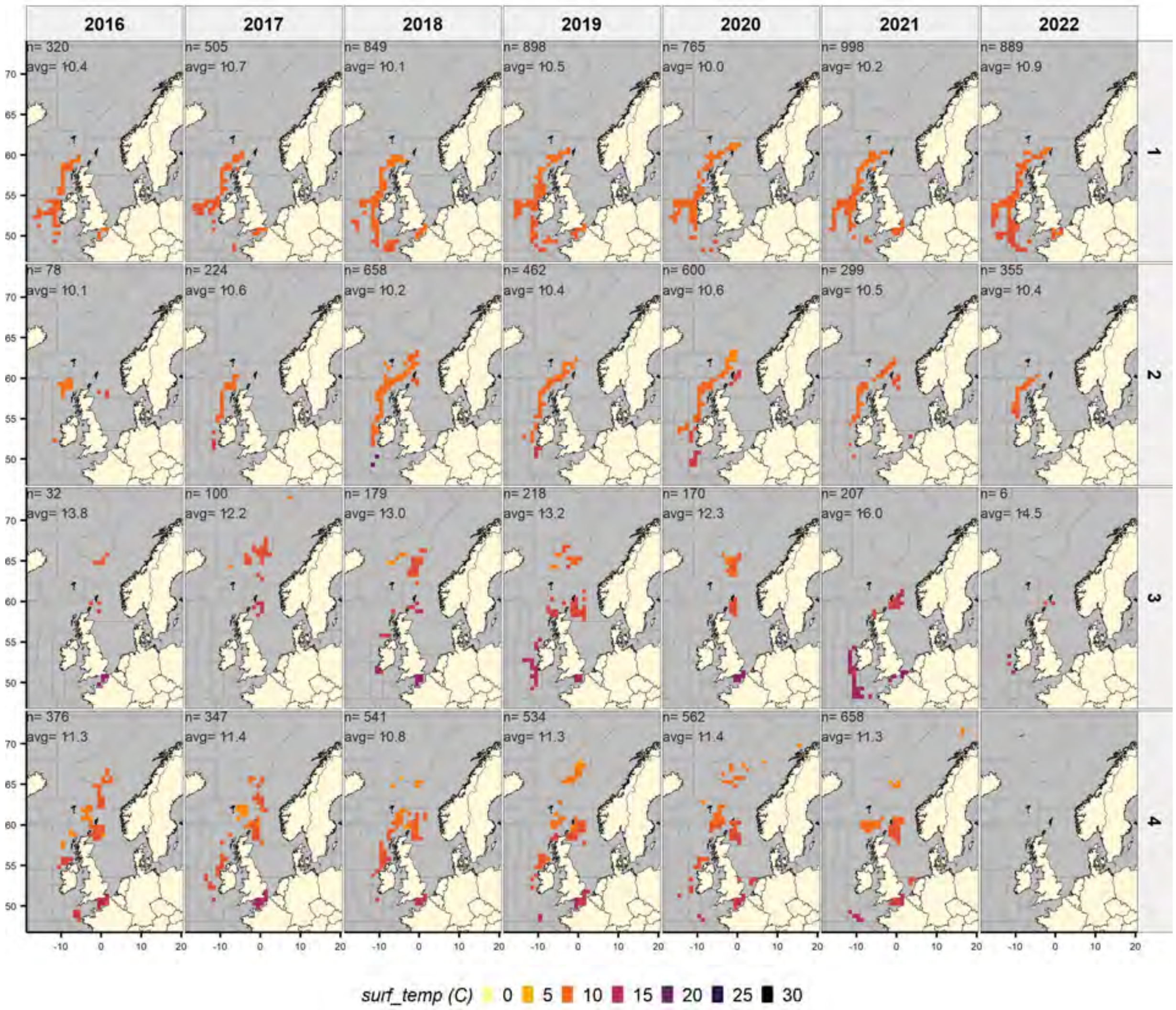

Figure 3.1.4: PFA fisheries for widely distributed species Average surface temperature (C) by year and quarter. N indicates the number of hauls. Avg refers to the average temperature.

Average fishing depth.

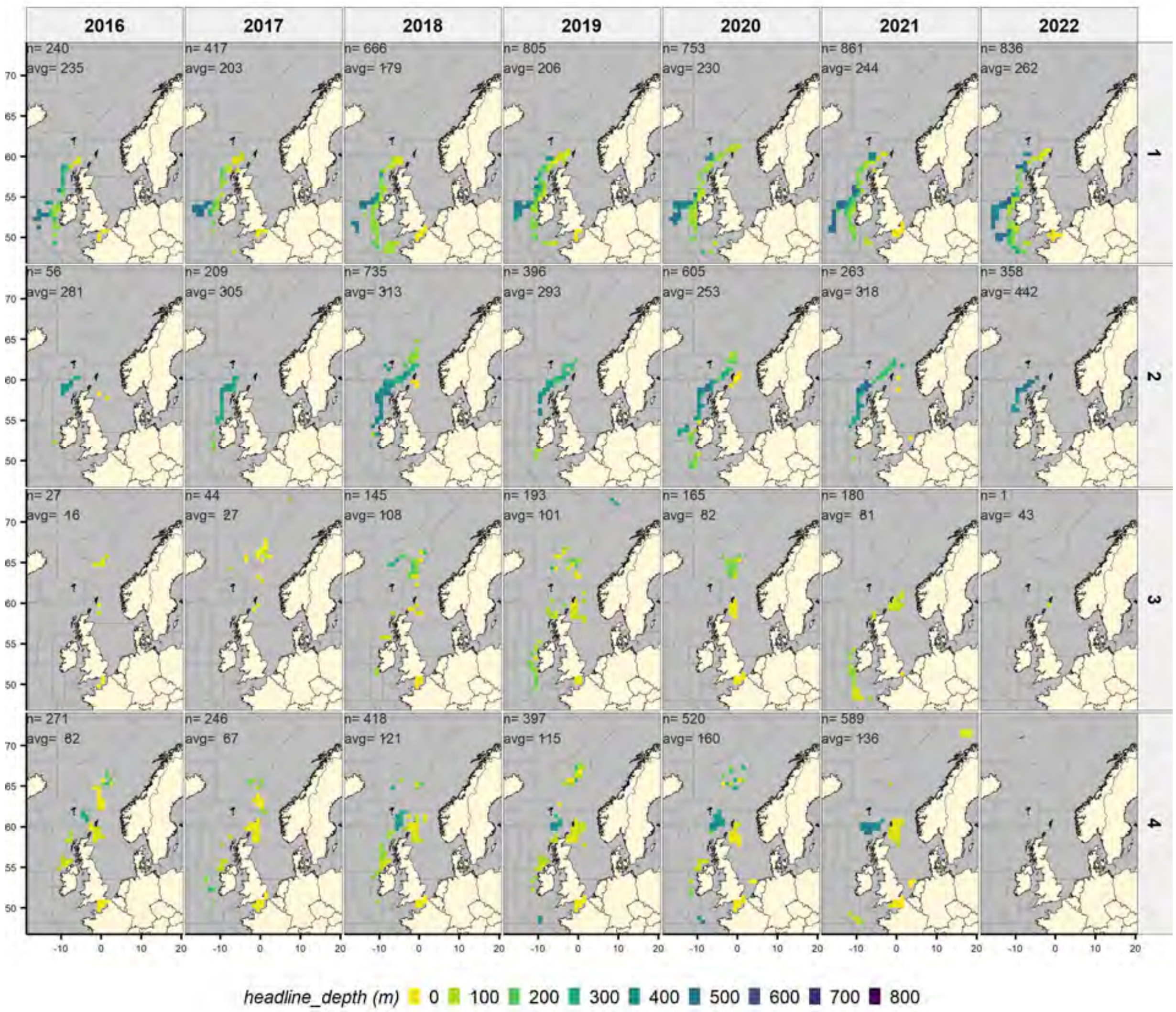

Figure 3.1.5: PFA fisheries for widely distributed species Average fishing depth (m) by year and quarter. N indicates the number of hauls. Avg refers to the average fishing depth.

Average wind force.

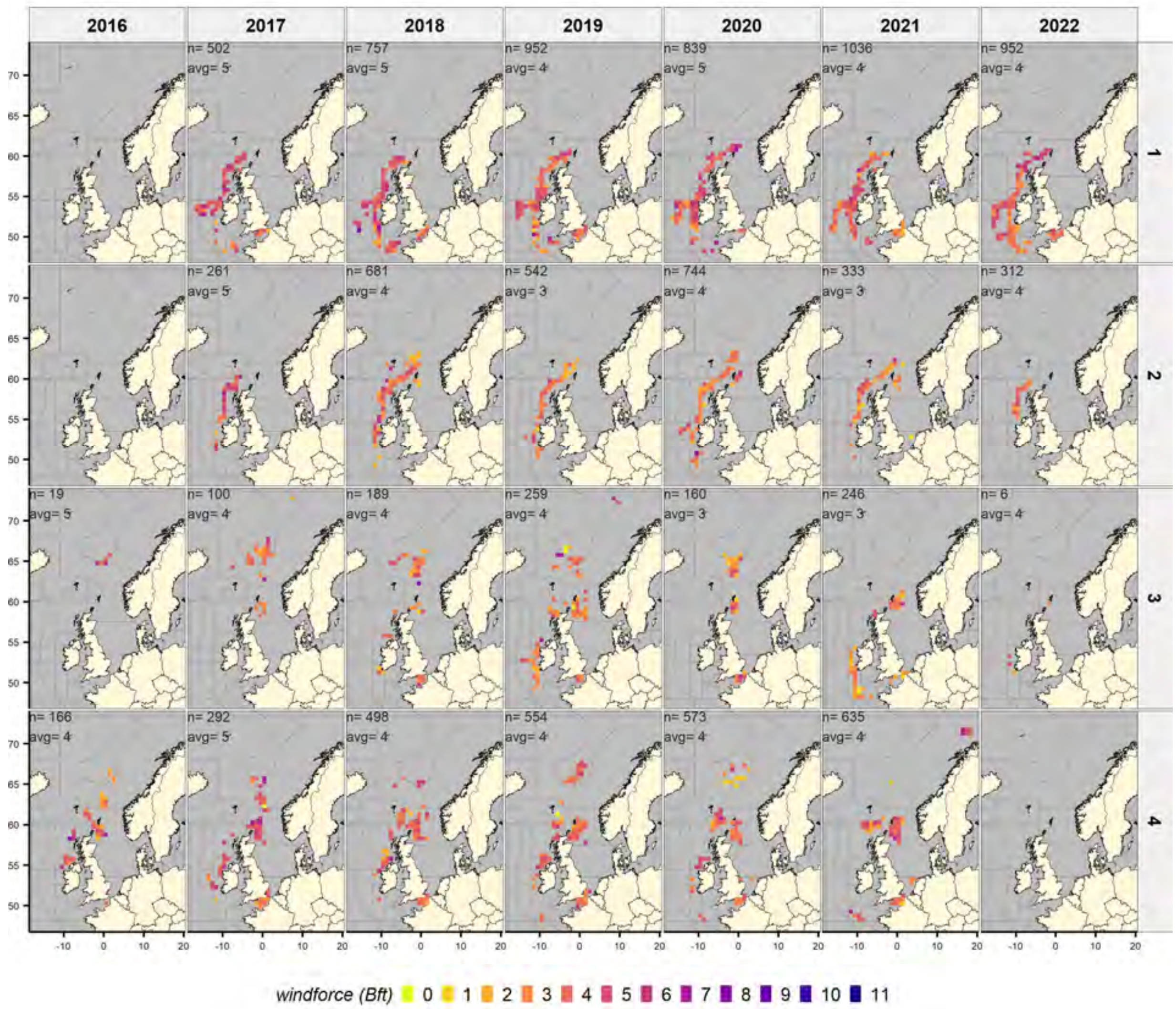

Figure 3.1.6: PFA fisheries for widely distributed species Average windforce (Bft) by year and quarter. N indicates the number of hauls. Avg refers to the average windforce.

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	2016	9	30	213	395	32,894	154	6,964	0
mac	2017	11	48	386	690	62,715	162	11,614	0
mac	2018	16	56	501	841	55,186	110	13,700	32
mac	2019	15	72	615	1,105	53,525	87	17,894	476
mac	2020	17	84	712	1,258	83,876	118	31,381	646
mac	2021	18	78	606	1,054	68,466	113	11,294	684
mac	2022	14	40	296	538	26,515	90	6,591	3,733
(all)	(all)		408	3,329	5,881	383,176		99,438	5,571

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	2016	2017	2018	2019	2020	2021	2022*	all	perc
mac	27.2.a	7,381	12,967	4,803	204	706	9	0	26,069	6.8%
mac	27.4.a	15,291	17,325	28,511	24,293	50,545	44,514	11,715	192,194	50.2%
mac	27.6.a	8,678	28,288	18,071	21,298	15,847	21,989	9,854	124,025	32.4%
mac	27.7.b	186	3,640	1,111	5,386	6,044	1,094	4,539	21,999	5.7%
mac	27.7.j	1,359	496	2,689	2,345	10,734	861	406	18,889	4.9%
(all)	(all)	32,894	62,715	55,186	53,525	83,876	68,466	26,515	383,176	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	2016	2017	2018	2019	2020	2021	2022*	all	perc
mac	Jan	7,848	18,550	11,546	18,715	20,750	14,806	12,735	104,950	27.4%
mac	Feb	1,189	8,199	7,297	11,862	19,376	5,678	6,942	60,544	15.8%
mac	Mar	139	4,469	1,292	4,374	5,114	2,840	6,613	24,841	6.5%
mac	Apr	701	955	1,226	1,326	604	366	98	5,276	1.4%
mac	May	30	288	192	489	1,239	97	71	2,406	0.6%
mac	Jun	124	0	60	96	173	35	0	489	0.1%
mac	Jul	192	89	0	262	83	907	55	1,588	0.4%
mac	Aug	120	237	59	431	296	360	0	1,503	0.4%
mac	Sep	943	9,096	4,779	3,039	6,284	2,624	0	26,765	7.0%
mac	Oct	13,857	7,866	19,437	11,457	20,161	30,743	0	103,521	27.0%
mac	Nov	7,625	11,595	8,934	1,473	9,461	10,009	0	49,097	12.8%
mac	Dec	128	1,370	363	0	334	0	0	2,195	0.6%
(all)	(all)	32,894	62,715	55,186	53,525	83,876	68,466	26,515	383,176	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	2016	2017	2018	2019	2020	2021	2022*	all	perc
mac	DEU	6,127	6,934	9,760	8,735	22,795	10,305	7,859	72,515	18.9%
mac	FR	0	0	8,096	8,962	6,375	7,086	2,997	33,516	8.7%
mac	LIT	0	0	0	0	827	6,876	0	7,704	2.0%
mac	NL	16,107	29,171	12,670	14,885	27,424	20,674	5,035	125,966	32.9%
mac	POL	0	0	4,051	3,601	5,502	1,771	0	14,926	3.9%
mac	UK	10,660	26,610	20,608	17,341	20,952	19,704	10,815	126,691	33.0%
mac	NA	0	0	0	0	0	2,049	0	2,049	0.5%
(all)	(all)	32,894	62,715	55,186	53,525	83,876	68,466	26,707	383,368	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

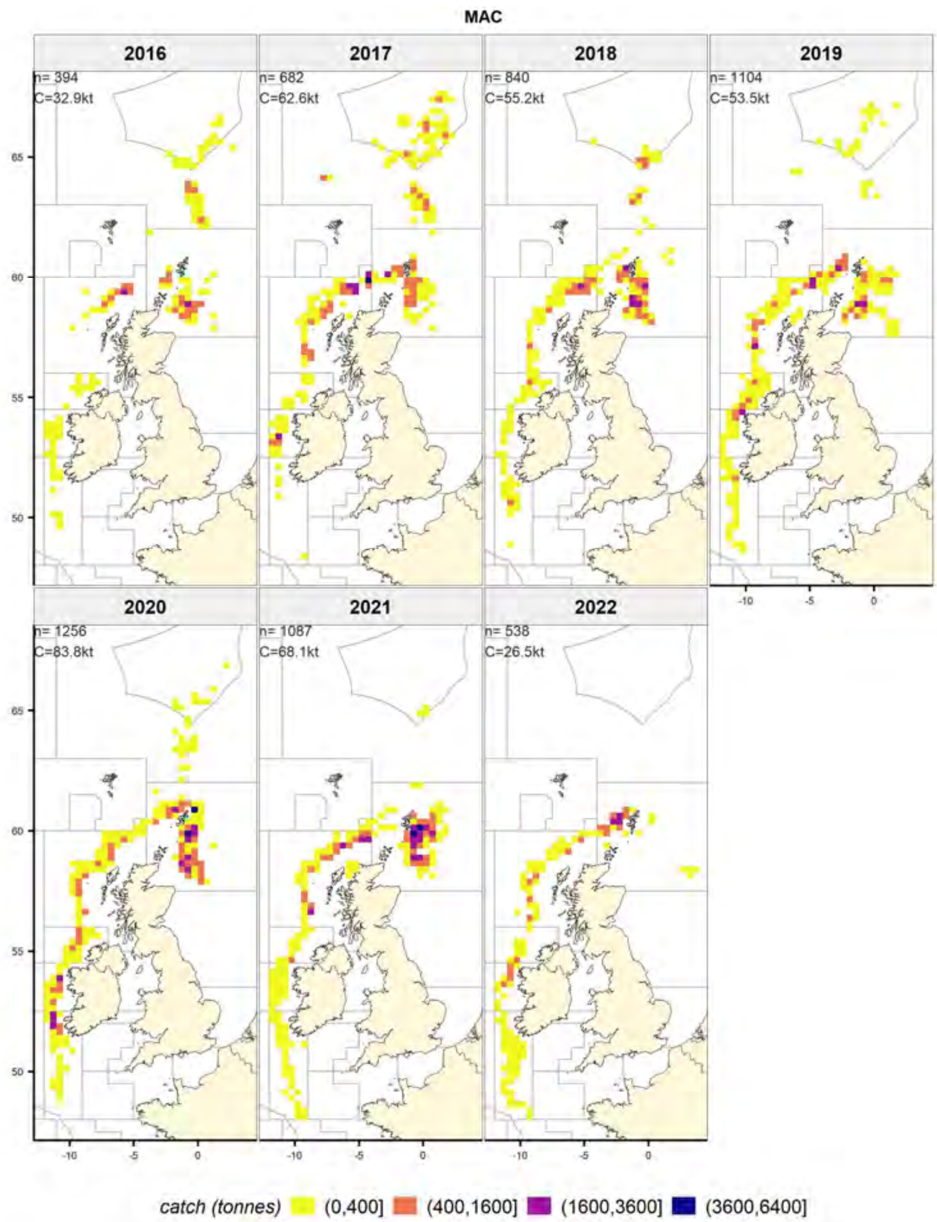

Figure 3.2.1: Northeast Atlantic mackerel. Catch per per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

Northeast Atlantic mackerel. Catchrate (ton/day) by rectangle

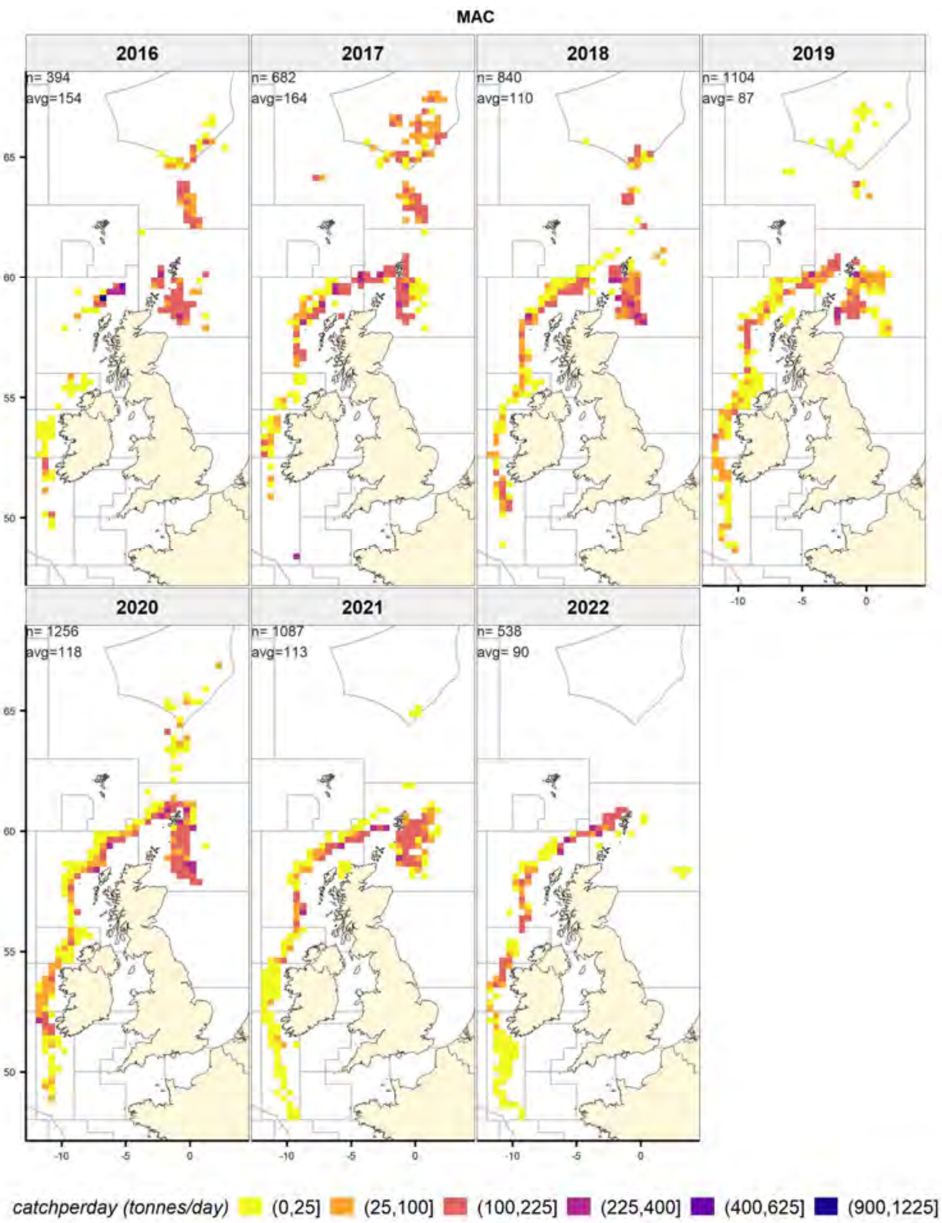

Figure 3.2.2: Northeast Atlantic mackerel. Catchrate (ton/day) per rectangle. N indicates the number of hauls; Avg refers to the average catchrate per rect.

Northeast Atlantic mackerel. Spatio-temporal evolution of catch by month and rectangle

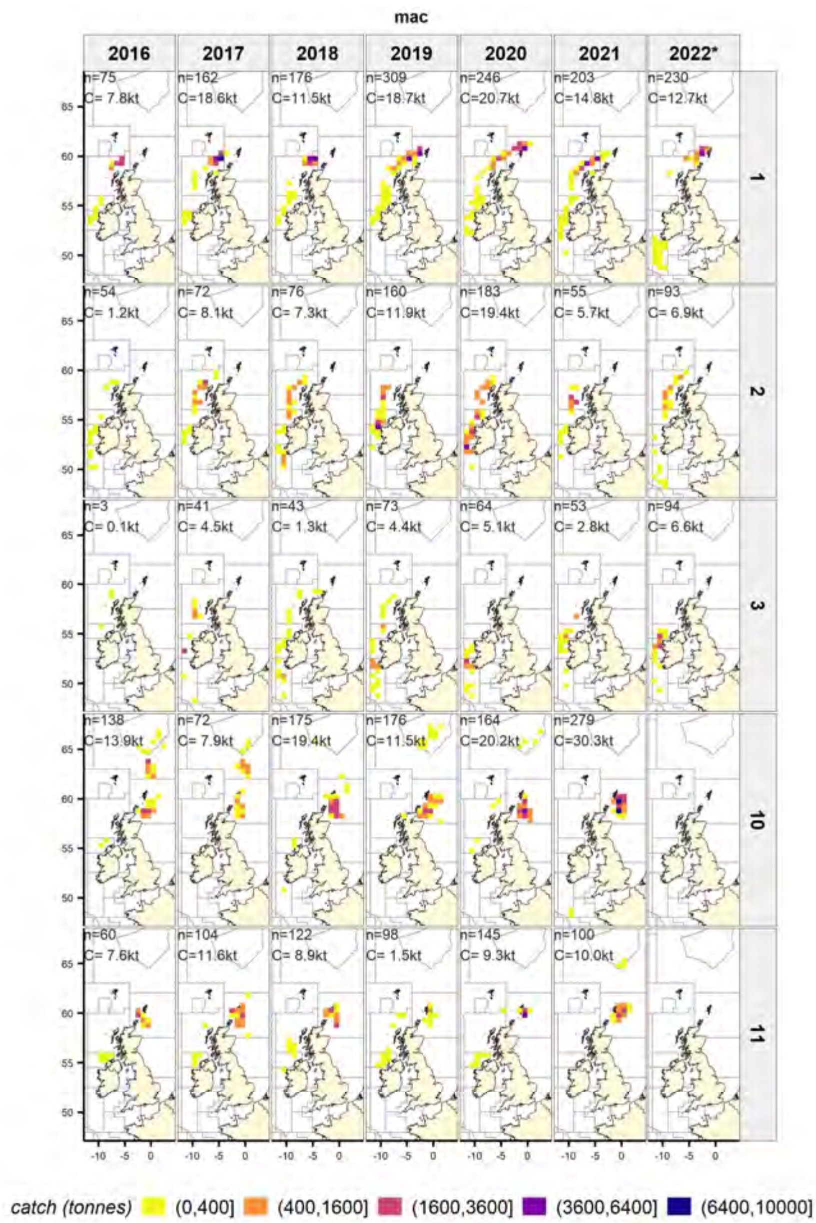

Figure 3.2.3: Northeast Atlantic mackerel. Spatio-temporal evolution of the catches per rectangle and month. N indicates the number of hauls; C refers to the total catch by year and month.

Northeast Atlantic mackerel. Catch proportion at depth

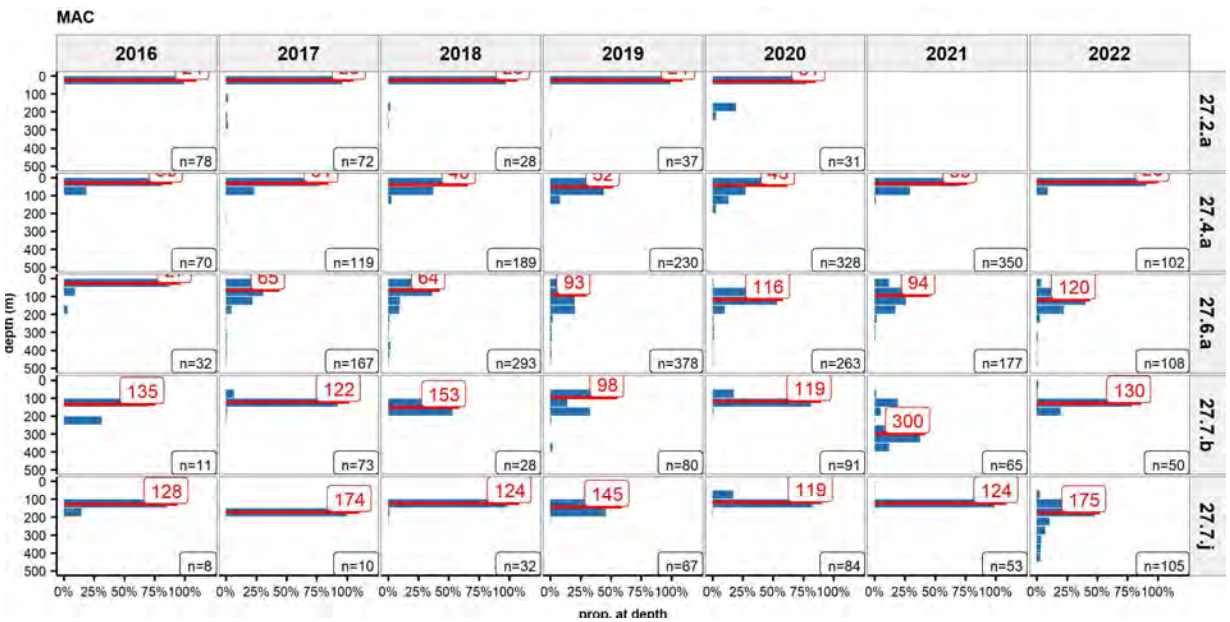

Figure 3.2.4: Northeast Atlantic mackerel. Catch proportion at depth. N indicates the number of hauls.

Northeast Atlantic mackerel. Length distributions of the catch

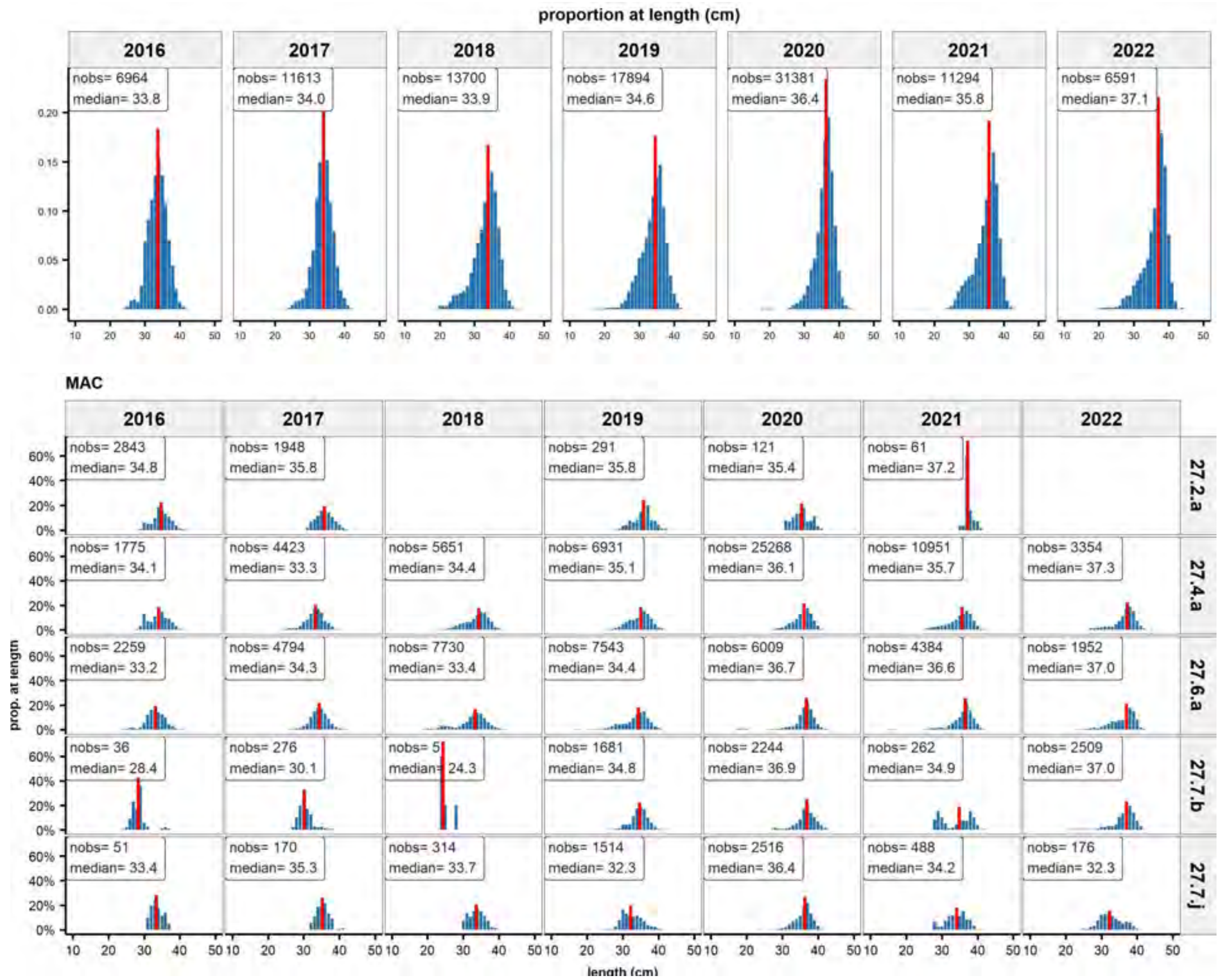

Figure 3.2.5: Northeast Atlantic mackerel. Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

Northeast Atlantic mackerel. Length distributions as proportions by (large) rectangle

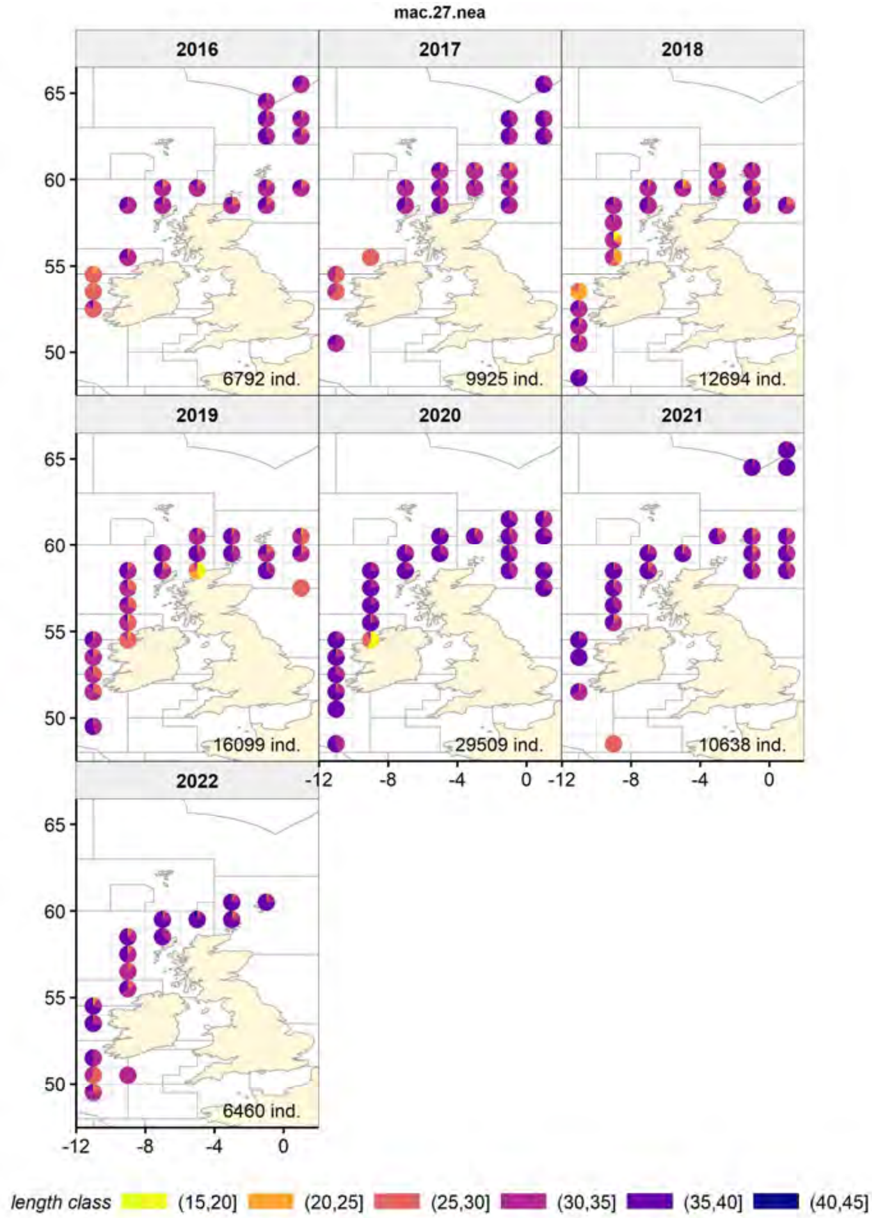

Figure 3.2.6: Northeast Atlantic mackerel. Length distributions as proportions by large rectangle. Ind. refers to the number of length measurements

Northeast Atlantic mackerel. Average length, weight and fat content by year and month

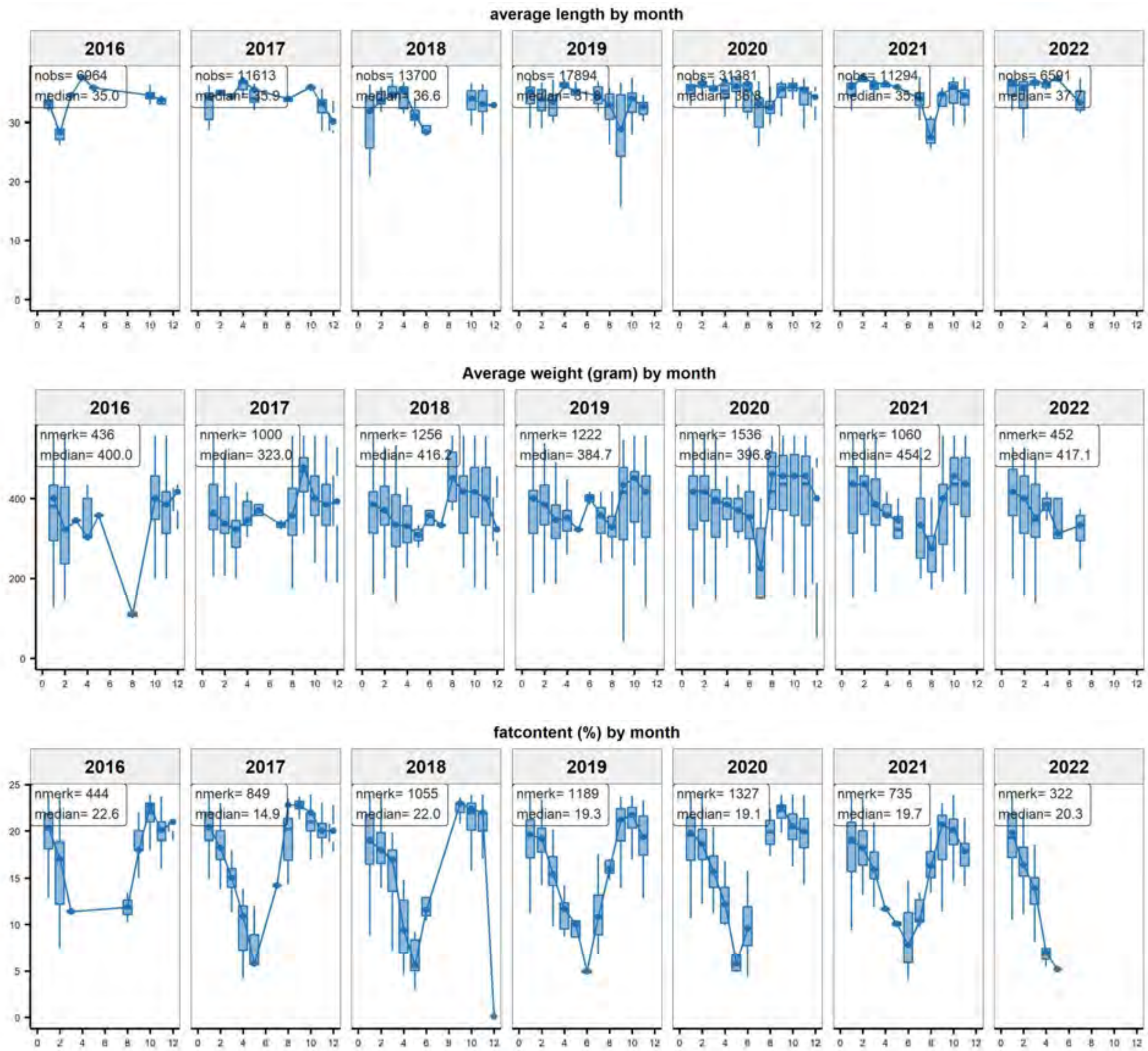

Figure 3.2.7: Northeast Atlantic mackerel. Average length, average weight, and average fat content. Nobs indicates the number of measurements, median indicates the median values

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).

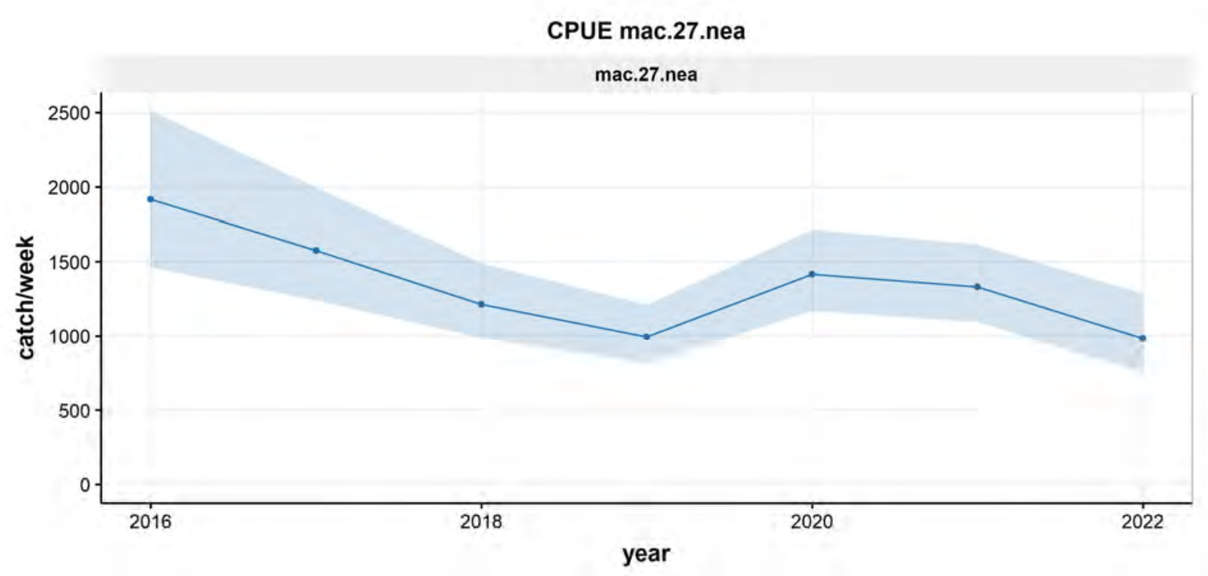

Figure 3.2.8: Northeast Atlantic mackerel. Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset

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	2016	7	21	171	314	13,382	78	11,154	0
hom	2017	10	25	161	304	11,578	72	8,176	0
hom	2018	13	35	244	431	21,412	88	21,756	0
hom	2019	15	47	363	668	24,022	66	14,172	25
hom	2020	14	40	268	508	16,334	61	13,531	203
hom	2021	17	53	366	643	26,576	73	24,753	59
hom	2022	14	28	166	330	12,183	73	8,976	269
(all)	(all)		249	1,739	3,198	125,486		102,518	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	2016	2017	2018	2019	2020	2021	2022*	all	perc
hom	27.4.a	7	6	0	11	13	1,007	9	1,054	0.8%
hom	27.6.a	4,751	5,343	12,067	13,849	5,901	1,564	552	44,027	35.1%
hom	27.7.b	4,313	4,741	2,250	4,176	5,226	4,743	335	25,784	20.5%
hom	27.7.h	1,297	1,329	6,282	984	55	8,551	197	18,695	14.9%
hom	27.7.j	3,015	159	813	5,002	5,138	10,712	11,089	35,927	28.6%
(all)	(all)	13,382	11,578	21,412	24,022	16,334	26,576	12,183	125,486	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	2016	2017	2018	2019	2020	2021	2022*	all	perc
hom	Jan	3,350	6,666	10,627	9,610	7,017	4,894	10,232	52,397	41.8%
hom	Feb	5,361	3,052	5,392	3,257	4,774	6,634	1,264	29,734	23.7%
hom	Mar	60	212	3,027	1,284	1,237	245	413	6,478	5.2%
hom	Apr	174	0	31	45	0	6	0	257	0.2%
hom	May	176	156	7	42	529	2	0	911	0.7%
hom	Jun	2	0	227	1,357	642	0	0	2,228	1.8%
hom	Jul	1,728	112	15	5,342	420	5,809	274	13,699	10.9%
hom	Aug	0	0	0	8	0	1,005	0	1,013	0.8%
hom	Sep	0	0	429	335	0	4,300	0	5,065	4.0%
hom	Oct	27	15	126	259	1	831	0	1,259	1.0%
hom	Nov	1,608	1,262	1,410	2,483	1,713	2,629	0	11,105	8.8%
hom	Dec	896	103	120	0	0	221	0	1,340	1.1%
(all)	(all)	13,382	11,578	21,412	24,022	16,334	26,576	12,183	125,486	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	2016	2017	2018	2019	2020	2021	2022*	all	perc
hom	DEU	3,710	1,803	4,069	2,602	977	4,155	725	18,042	14.4%
hom	FR	0	0	622	864	1,370	788	1,400	5,043	4.0%
hom	NL	9,211	9,239	14,617	18,011	11,535	18,234	9,605	90,452	72.1%
hom	POL	0	0	0	4	1,005	1,210	0	2,219	1.8%
hom	UK	461	535	2,104	2,541	1,447	2,014	452	9,555	7.6%
hom	NA	0	0	0	0	0	175	0	175	0.1%
(all)	(all)	13,382	11,578	21,412	24,022	16,334	26,576	12,183	125,486	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

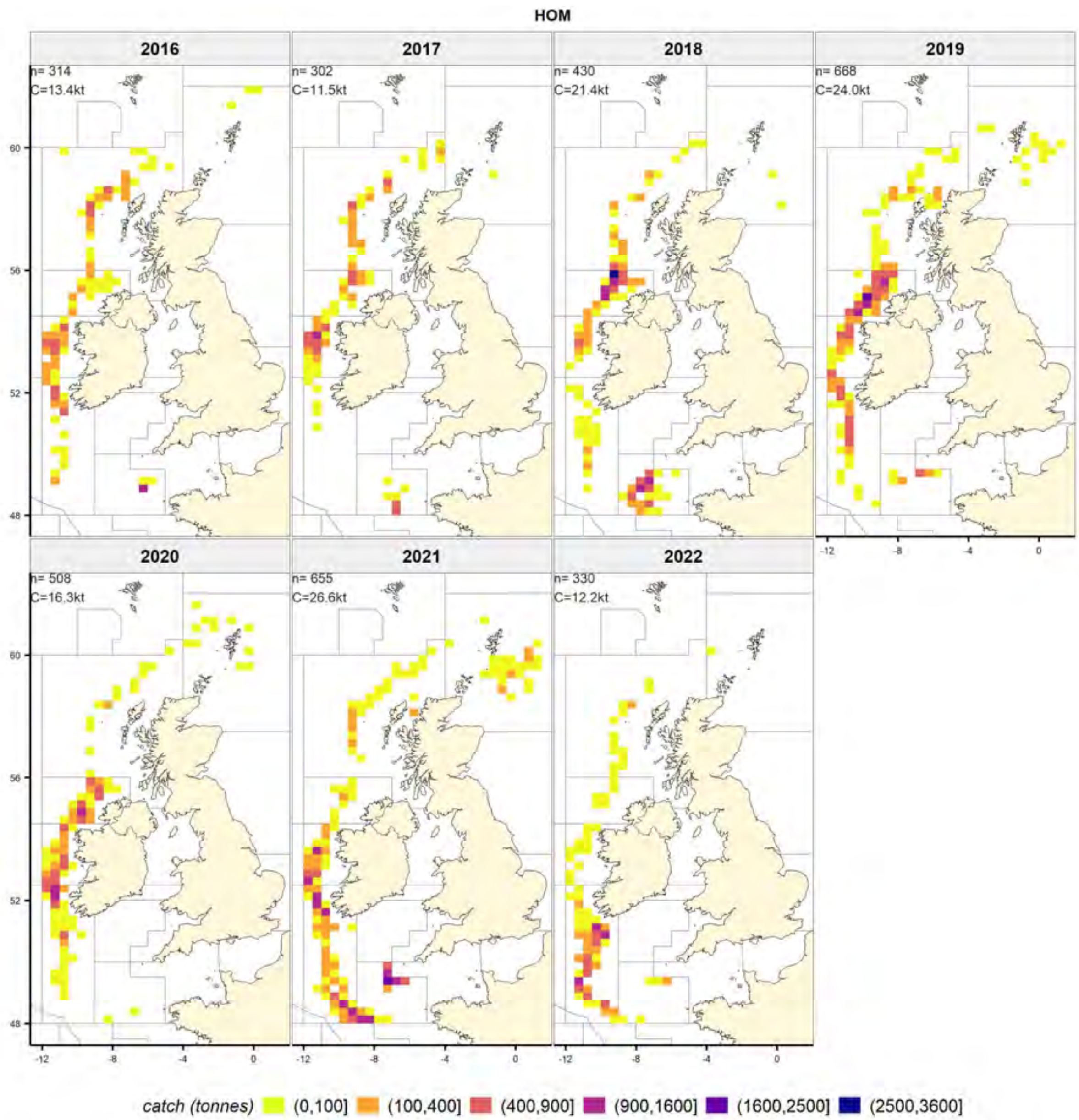

Figure 3.3.1: Western horse mackerel. Catch per per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

Western horse mackerel. Catchrate (ton/day) by rectangle

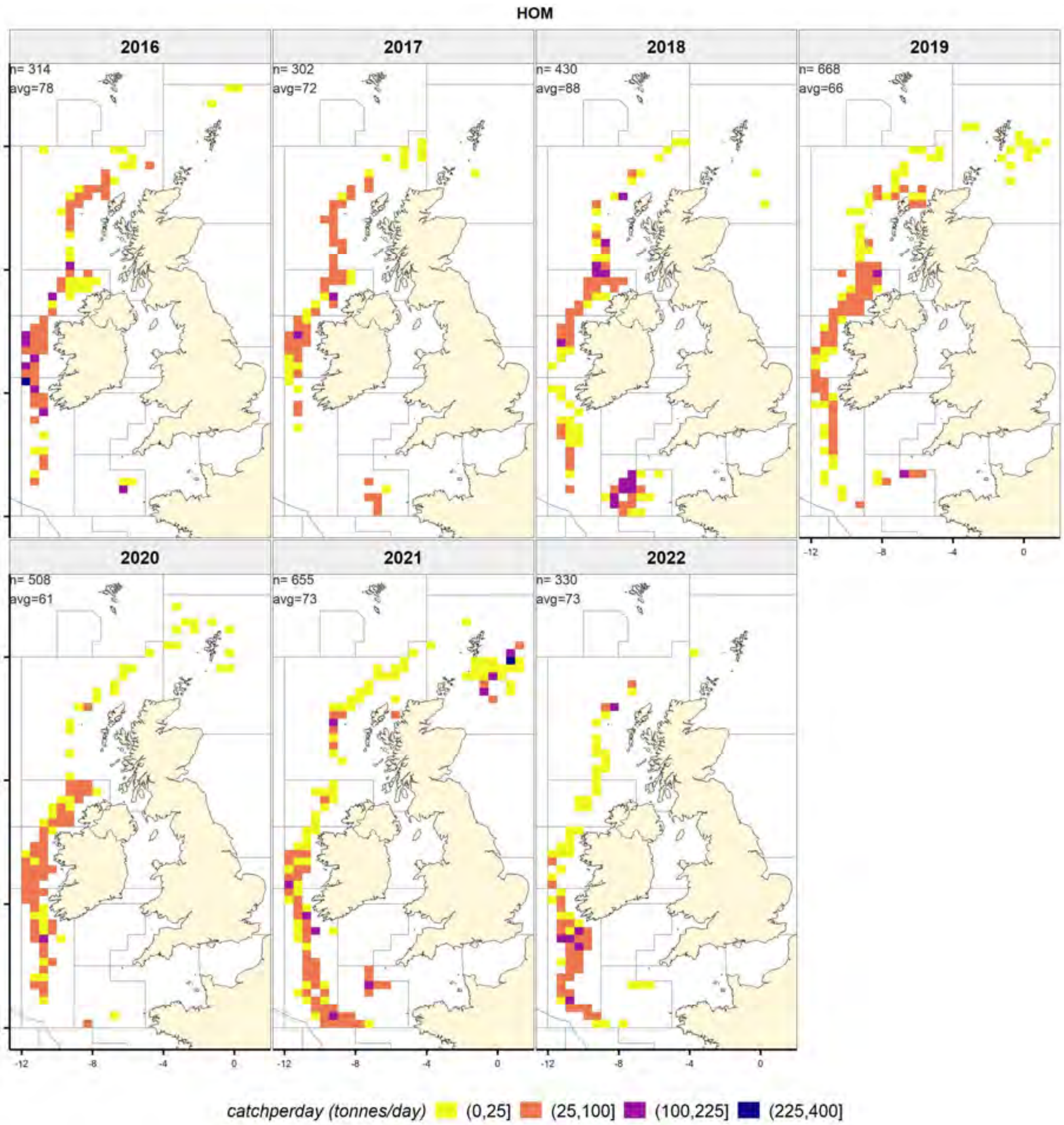

Figure 3.3.2: Western horse mackerel. Catchrate (ton/day) per rectangle. N indicates the number of hauls; Avg refers to the average catchrate per rect.

Western horse mackerel. Spatio-temporal evolution of catch by month and rectangle

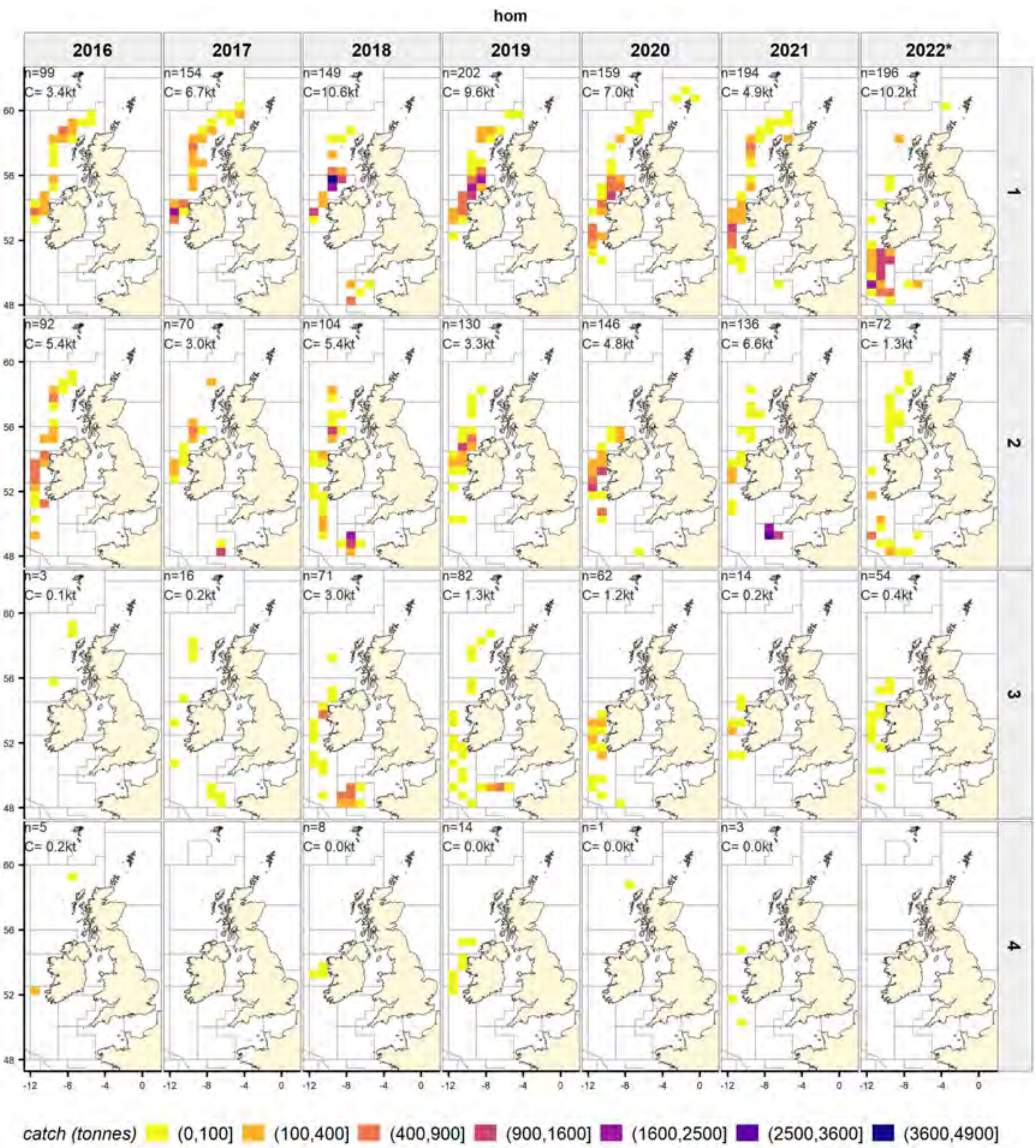

Figure 3.3.3: Western horse mackerel. Spatio-temporal evolution of the catches per rectangle and month. N indicates the number of hauls; C refers to the total catch by year and month.

Western horse mackerel. Catch proportion at depth

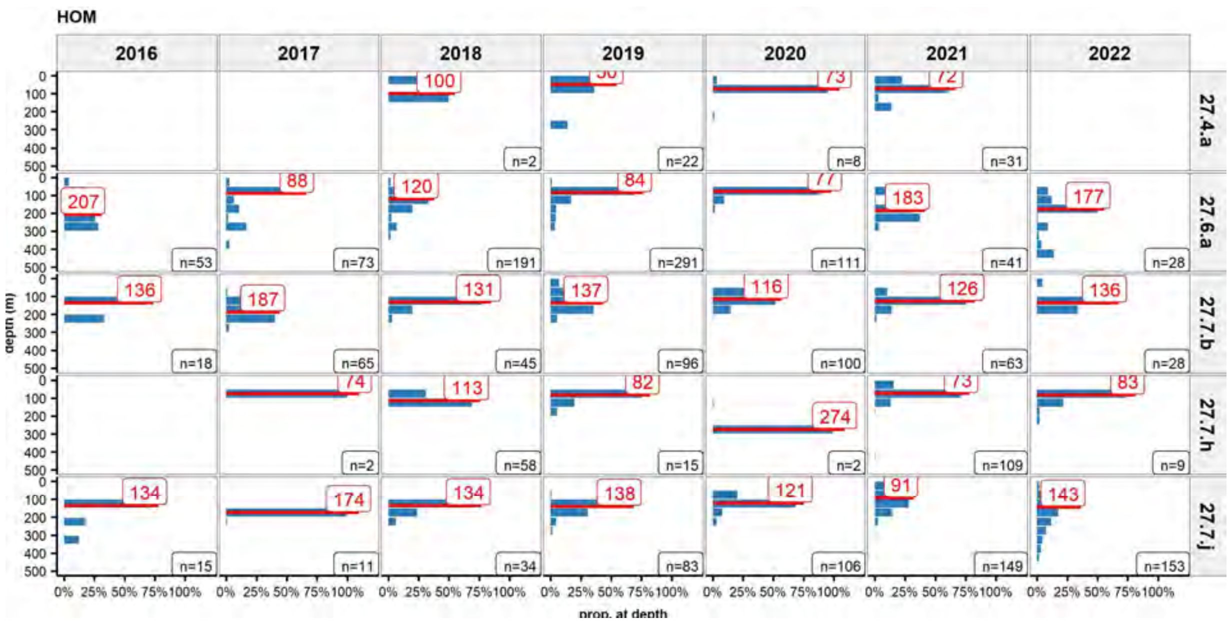

Figure 3.3.4: Western horse mackerel. Catch proportion at depth. N indicates the number of hauls.

Western horse mackerel. Length distributions of the catch

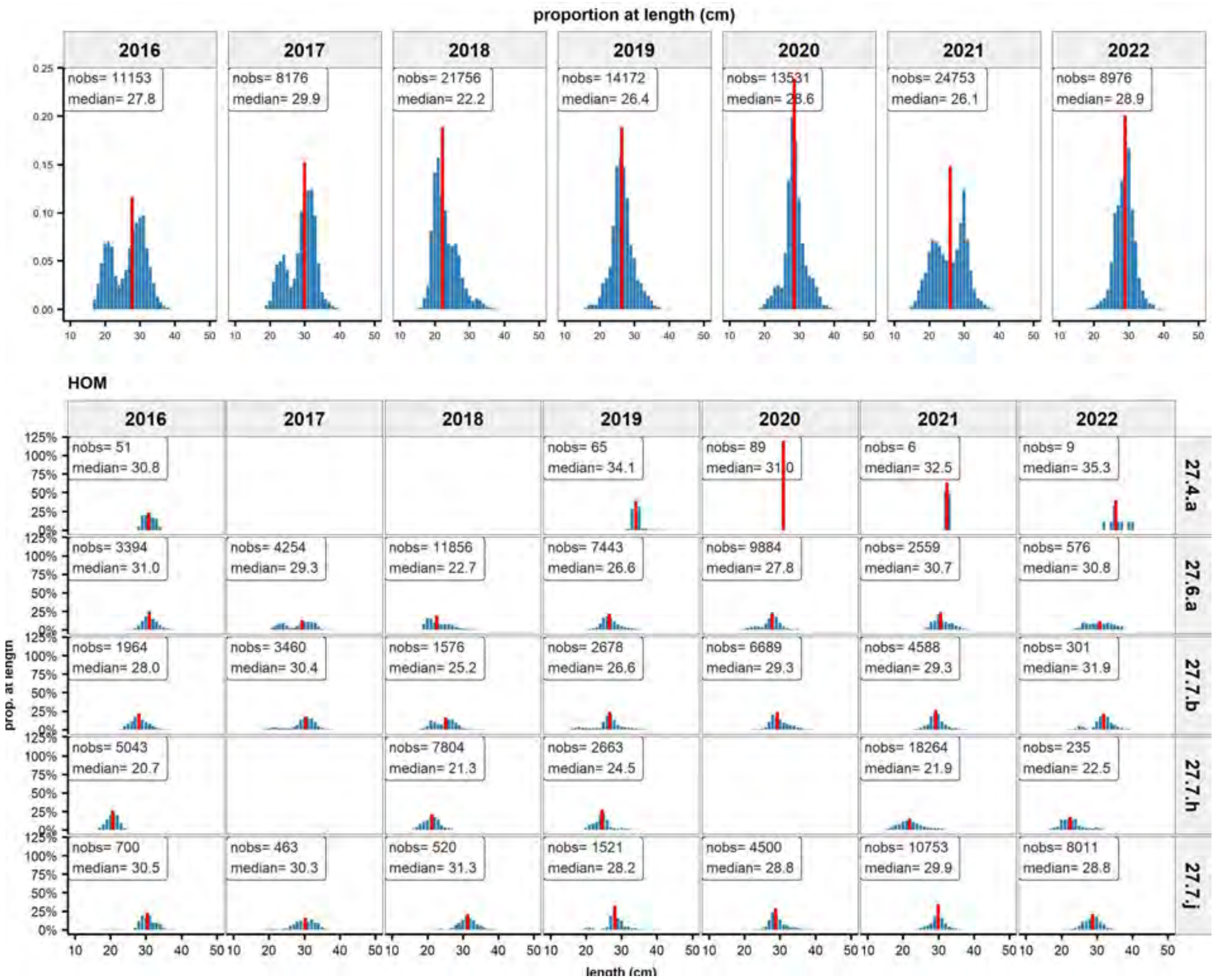

Figure 3.3.5: Western horse mackerel. Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

Western horse mackerel. Length distributions as proportions by (large) rectangle

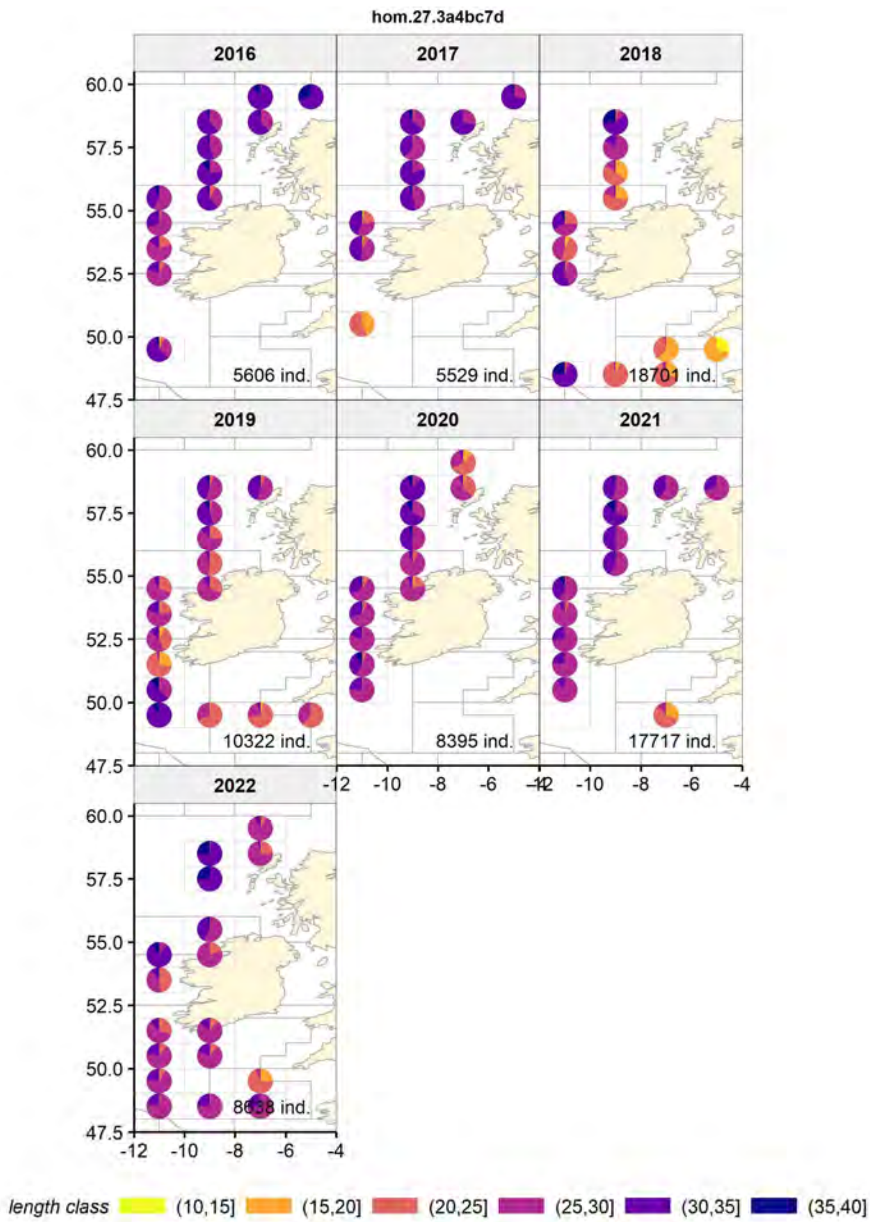

Figure 3.3.6: Western horse mackerel. Length distributions as proportions by large rectangle. Ind. refers to the number of length measurements

Western horse mackerel. Average length, weight and fat content by year and month

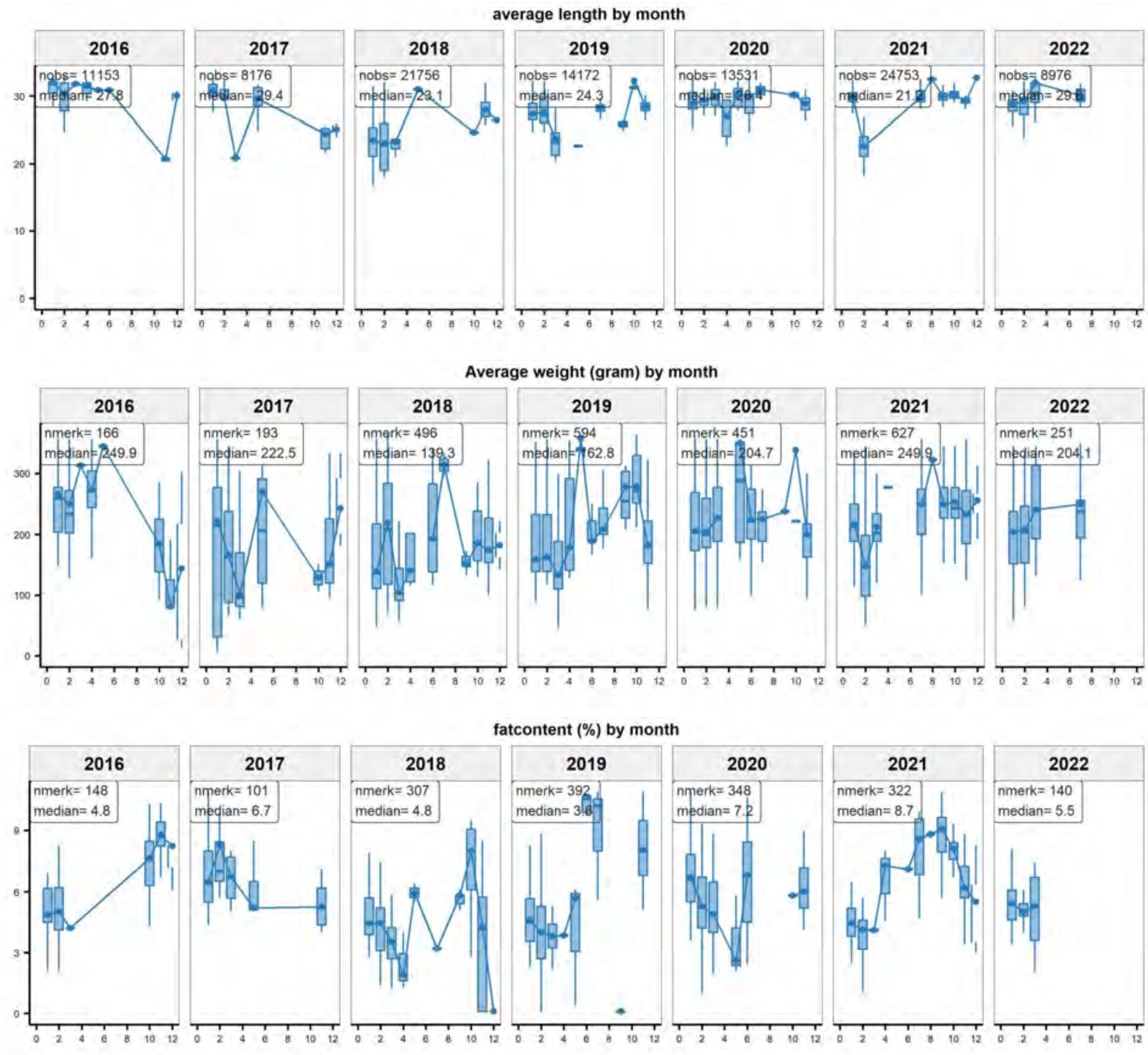

Figure 3.3.7: Western horse mackerel. Average length, average weight, and average fat content. Nobs indicates the number of measurements, median indicates the median values

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).

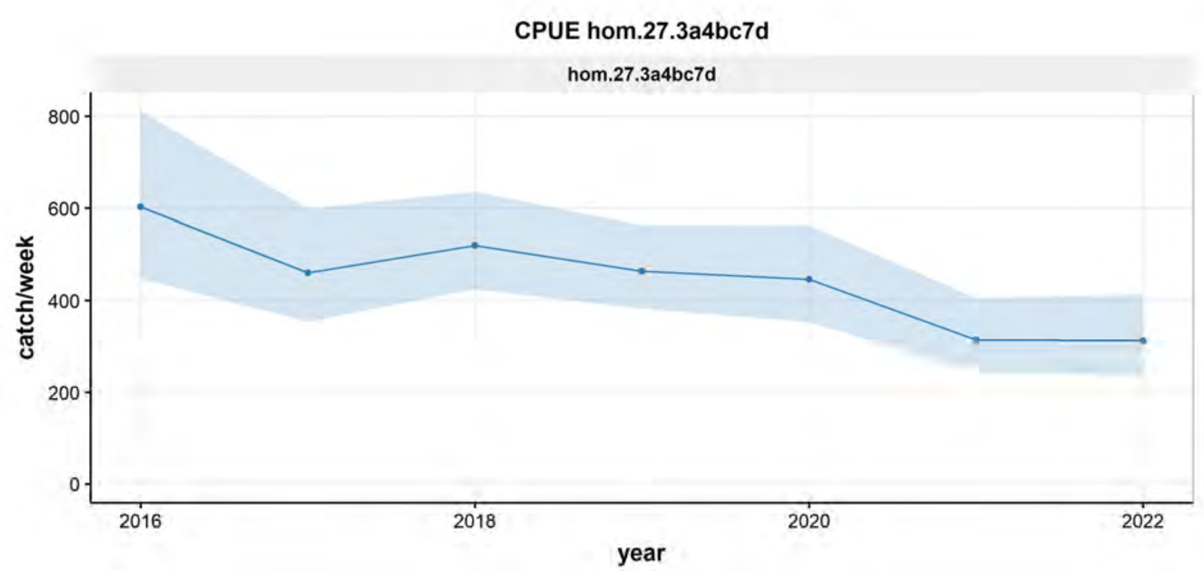

Figure 3.3.8: Western horse mackerel. Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset

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	2016	5	16	77	130	6,359	83	6,313	0
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	9,448	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	5	9	17	22	914	54	855	0
(all)	(all)		109	521	900	46,322		38,983	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	2016	2017	2018	2019	2020	2021	2022*	all	perc
hom	27.4.c	0	1,371	853	369	898	1,149	0	4,640	10.0%
hom	27.7.d	6,358	7,198	6,226	7,048	7,829	6,111	914	41,682	90.0%
(all)	(all)	6,359	8,568	7,079	7,417	8,726	7,259	914	46,322	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	2016	2017	2018	2019	2020	2021	2022*	all	perc
hom	Jan	0	2,362	892	1,382	2	1,013	538	6,189	13.4%
hom	Feb	879	0	310	0	0	97	376	1,662	3.6%
hom	Mar	38	0	0	0	0	0	0	38	0.1%
hom	Jun	0	0	0	0	6	25	0	31	0.1%
hom	Jul	0	0	0	0	0	0	0	0	0.0%
hom	Aug	6	0	0	0	0	0	0	6	0.0%
hom	Sep	447	135	1,471	2,009	3,860	422	0	8,344	18.0%
hom	Oct	1,802	4,490	1,391	1,967	1,834	2,349	0	13,833	29.9%
hom	Nov	2,873	1,581	2,018	1,110	1,463	1,218	0	10,263	22.2%
hom	Dec	312	0	998	949	1,561	2,134	0	5,954	12.9%
(all)	(all)	6,359	8,568	7,079	7,417	8,726	7,259	914	46,322	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	2016	2017	2018	2019	2020	2021	2022*	all	perc
hom	DEU	593	0	1,378	958	0	0	0	2,930	6.3%
hom	FR	0	0	422	400	238	202	0	1,261	2.7%
hom	LIT	0	0	0	1,373	0	0	0	1,373	3.0%
hom	NL	2,383	4,887	1,578	1,682	4,167	2,356	436	17,487	37.8%
hom	UK	3,383	3,682	3,701	3,004	4,322	3,674	478	22,243	48.0%
hom	NA	0	0	0	0	0	1,028	0	1,028	2.2%
(all)	(all)	6,359	8,568	7,079	7,417	8,726	7,259	914	46,322	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

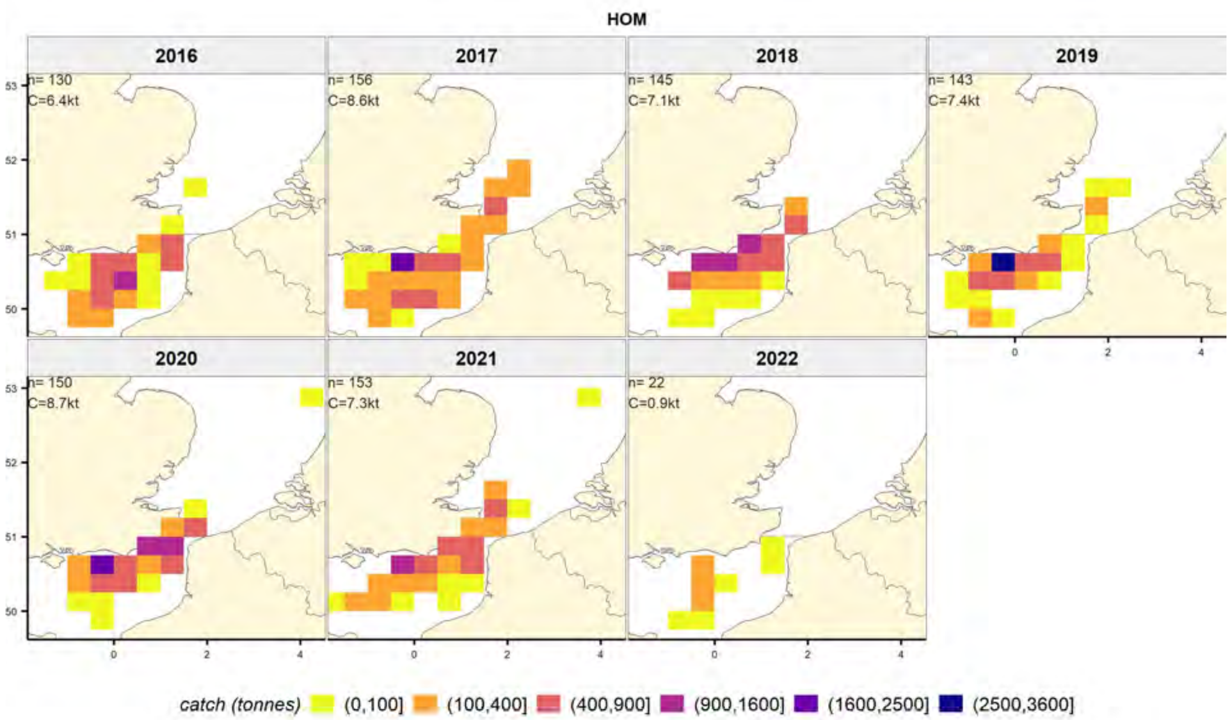

Figure 3.4.1: North Sea horse mackerel. Catch per per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

North Sea horse mackerel. Catchrate (ton/day) by rectangle

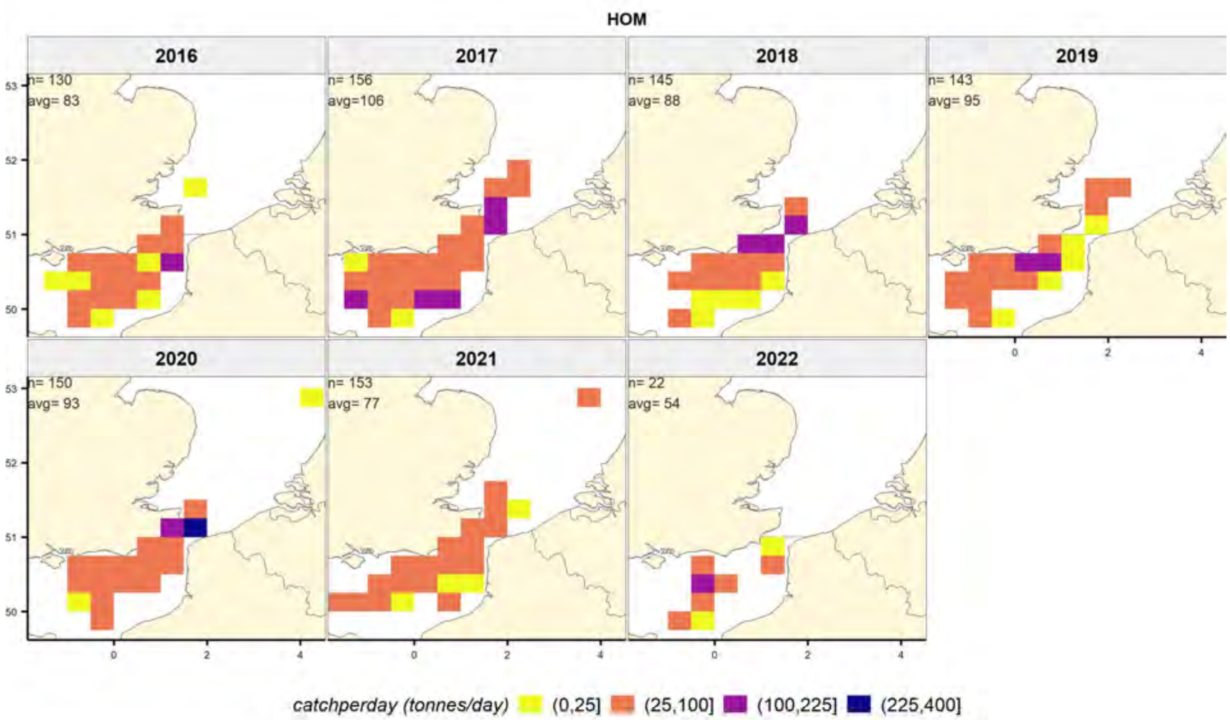

Figure 3.4.2: North Sea horse mackerel. Catchrate (ton/day) per rectangle. N indicates the number of hauls; Avg refers to the average catchrate per rect.

North Sea horse mackerel. Spatio-temporal evolution of catch by month and rectangle

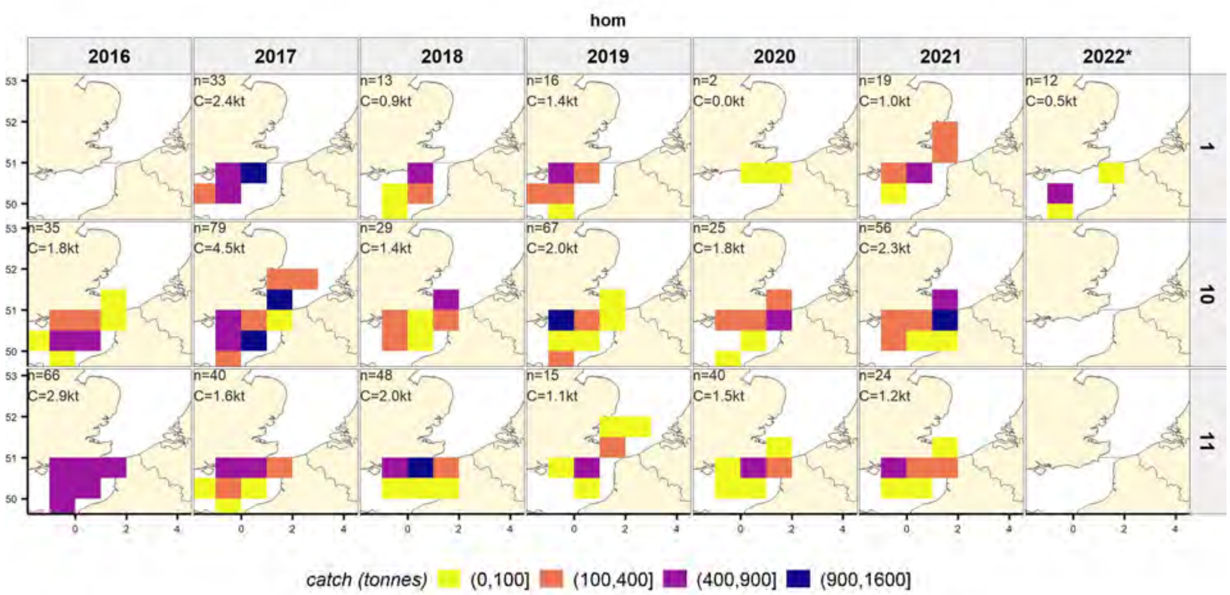

Figure 3.4.3: North Sea horse mackerel. Spatio-temporal evolution of the catches per rectangle and month. N indicates the number of hauls; C refers to the total catch by year and month.

North Sea horse mackerel. Catch proportion at depth

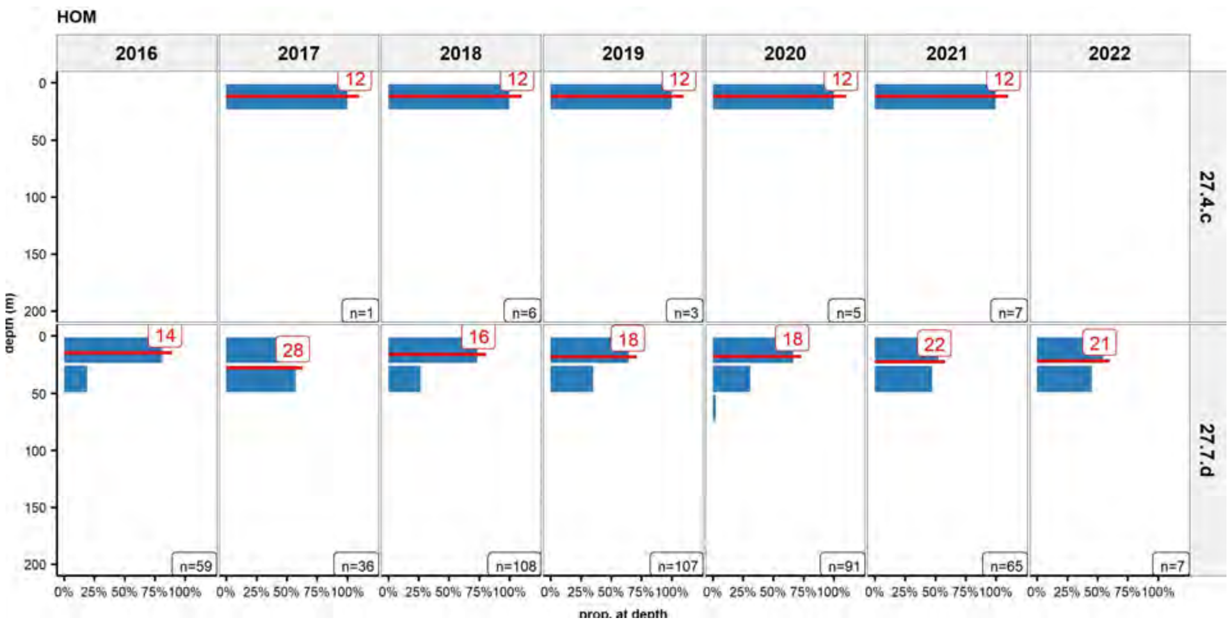

Figure 3.4.4: North Sea horse mackerel. Catch proportion at depth. N indicates the number of hauls.

North Sea horse mackerel. Length distributions of the catch

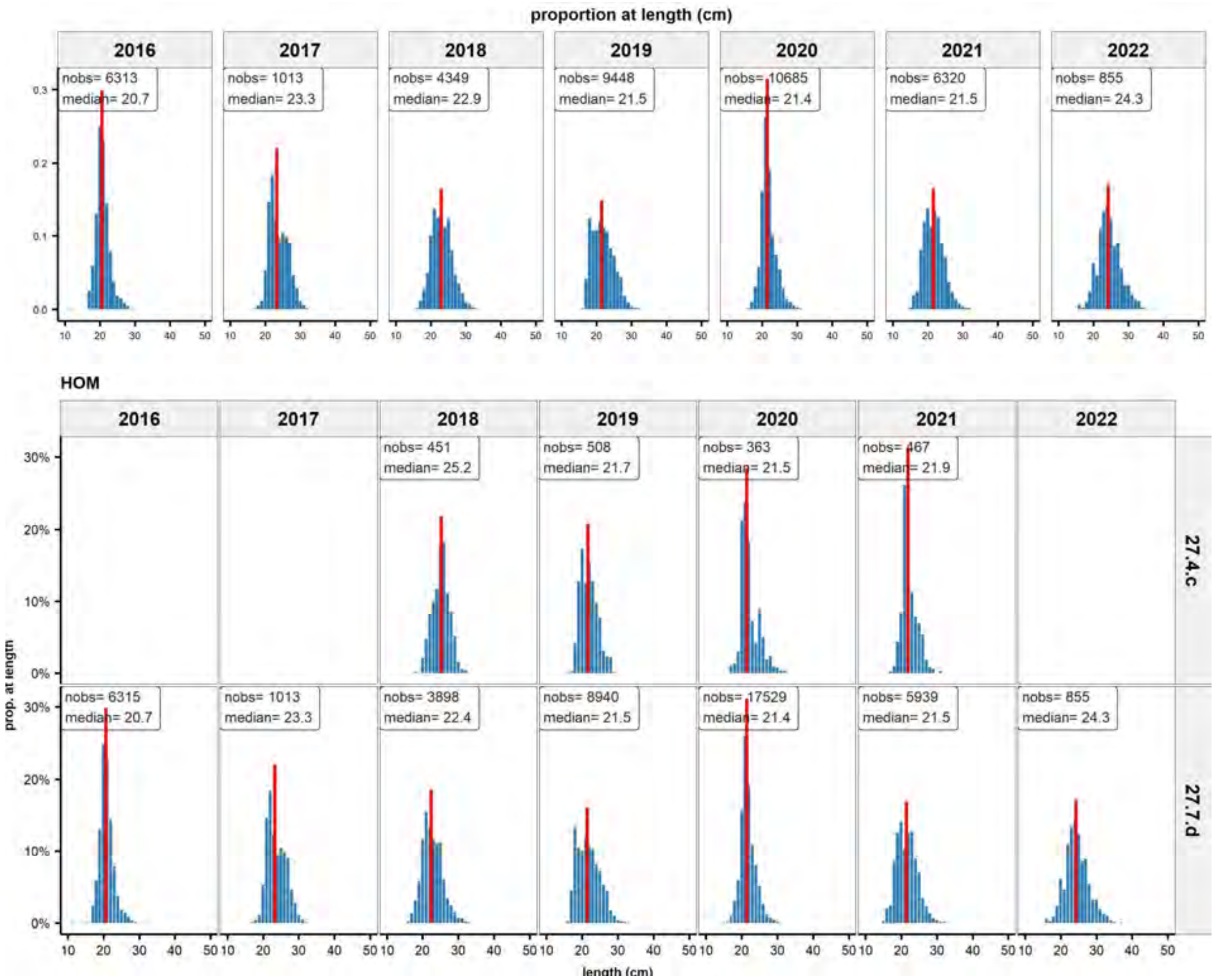

Figure 3.4.5: North Sea horse mackerel. Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

North Sea horse mackerel. Length distributions as proportions by (large) rectangle

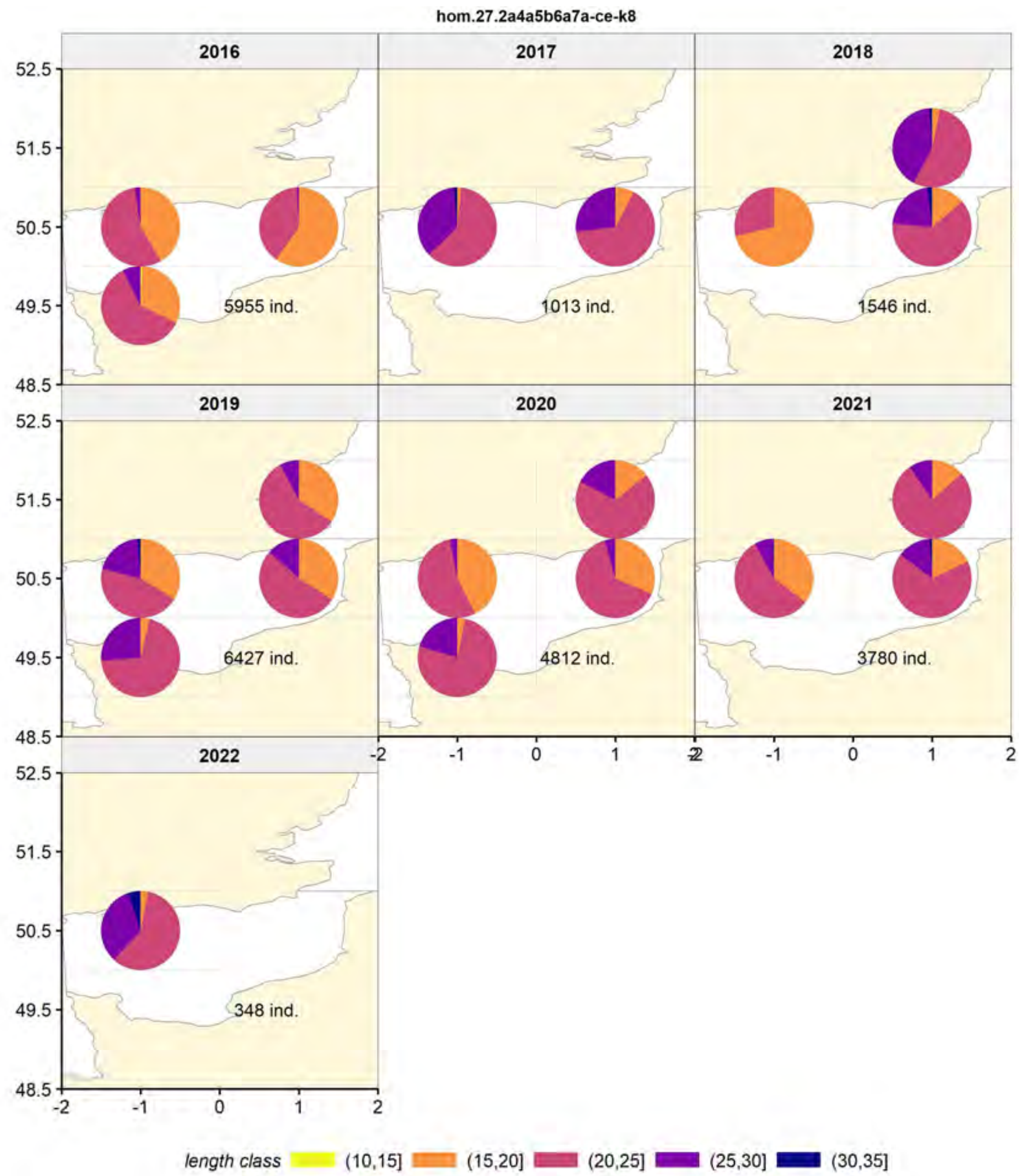

Figure 3.4.6: North Sea horse mackerel. Length distributions as proportions by large rectangle. Ind. refers to the number of length measurements

North Sea horse mackerel. Average length, weight and fat content by year and month

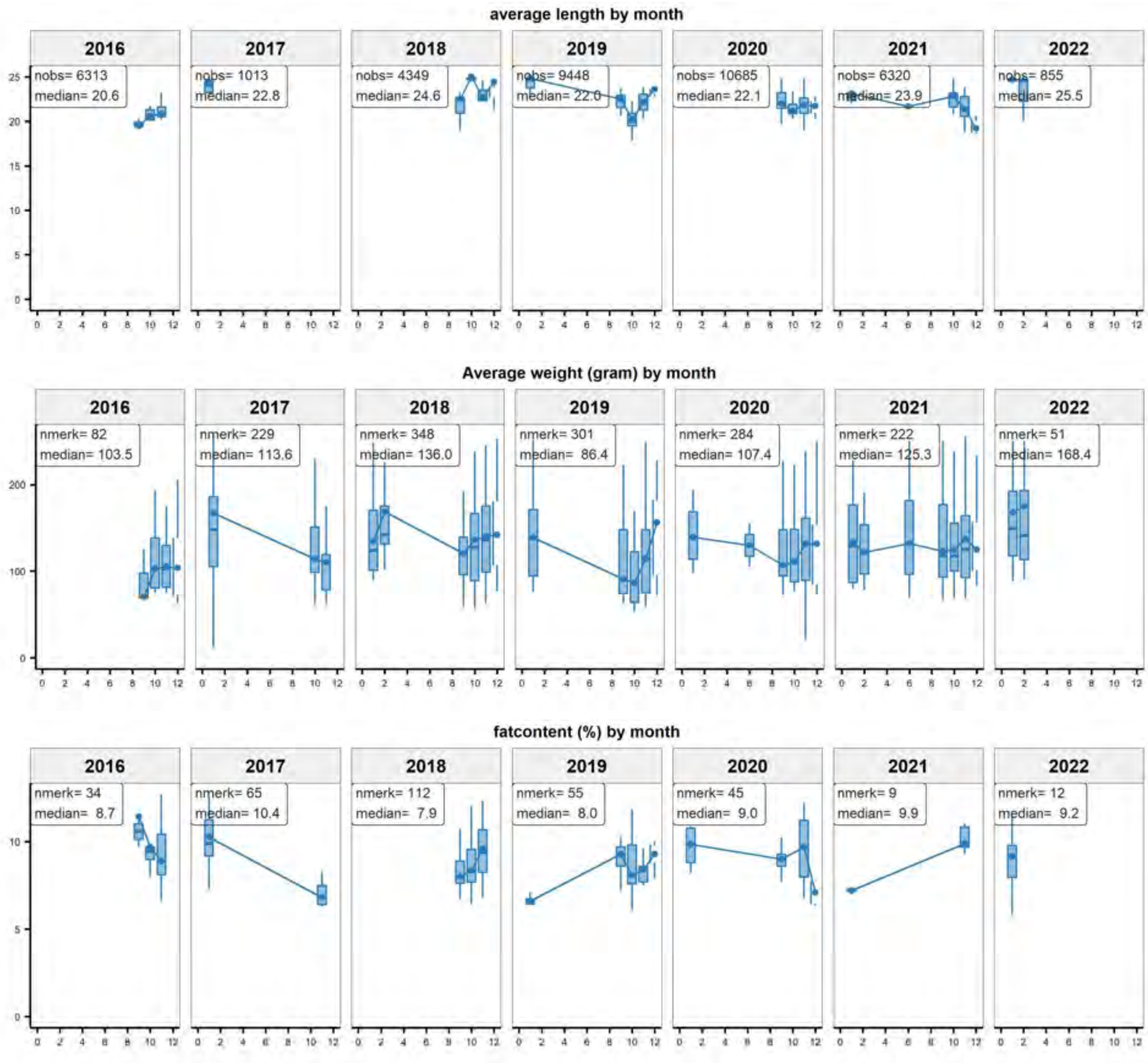

Figure 3.4.7: North Sea horse mackerel. Average length, average weight, and average fat content. Nobs indicates the number of measurements, median indicates the median values

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).

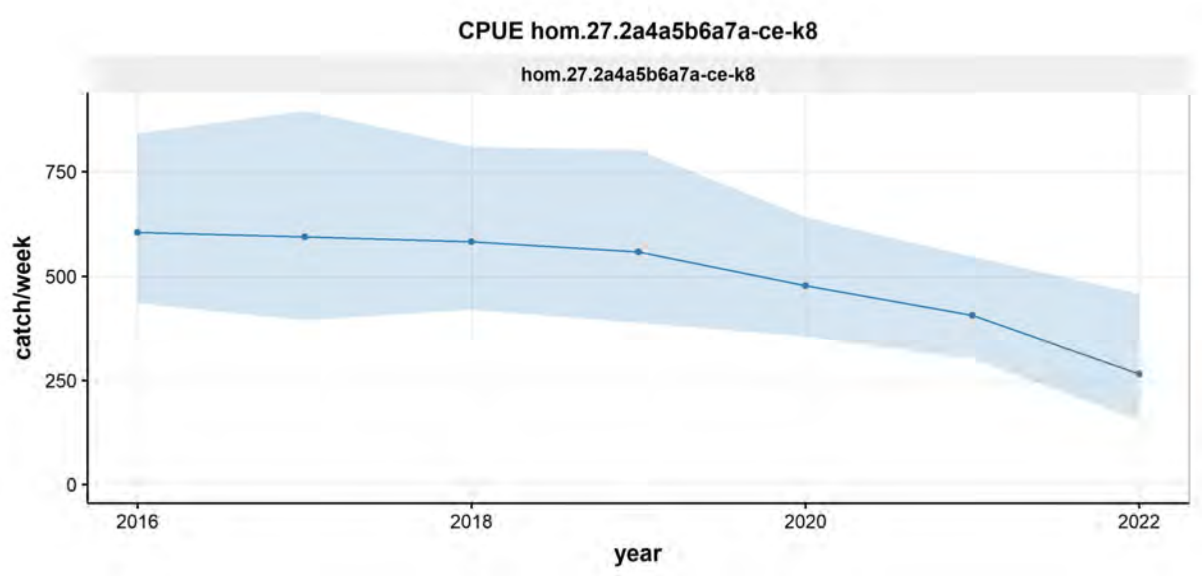

Figure 3.4.8: North Sea horse mackerel. Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset

3.5 Blue whiting (WHB, Micromesistius pouttasseu)

Blue whiting self-sampling summary.

species	year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nlength	nbio
whb	2016	8	22	198	462	40,535	205	27,315	0
whb	2017	8	32	343	753	78,325	228	63,682	0
whb	2018	12	42	550	1,375	149,723	272	112,492	0
whb	2019	14	46	457	1,089	109,234	239	50,057	0
whb	2020	13	57	670	1,581	168,786	252	83,177	178
whb	2021	14	52	532	1,185	138,946	261	58,391	0
whb	2022	15	33	406	962	87,325	215	34,068	0
(all)	(all)		284	3,156	7,407	772,874		429,182	178

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	2016	2017	2018	2019	2020	2021	2022*	all	perc
whb	27.2.a	2,294	2,550	11,907	998	5,718	190	0	23,657	3.1%
whb	27.5.b	5,577	7,960	7,928	3,905	10,220	8,665	514	44,769	5.8%
whb	27.6.a	19,730	39,085	91,738	75,707	97,232	84,794	36,680	444,967	57.6%
whb	27.7.c	5,445	28,731	30,504	26,587	44,309	28,613	20,803	184,993	23.9%
whb	27.7.k	7,489	0	7,646	2,036	11,307	16,684	29,327	74,488	9.6%
(all)	(all)	40,535	78,325	149,723	109,234	168,786	138,946	87,325	772,874	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	2016	2017	2018	2019	2020	2021	2022*	all	perc
whb	Jan	85	185	957	4,287	9,527	29,603	14,391	59,034	7.6%
whb	Feb	1,683	8,027	19,108	17,504	4,051	18,915	16,468	85,755	11.1%
whb	Mar	15,317	24,683	26,954	21,389	41,128	30,134	32,907	192,513	24.9%
whb	Apr	13,328	27,316	55,518	26,391	61,978	25,146	19,539	229,216	29.7%
whb	May	5,001	9,390	24,093	15,465	22,506	8,571	4,020	89,045	11.5%
whb	Jun	697	0	5,004	0	697	0	0	6,398	0.8%
whb	Jul	10	0	0	7	13	0	0	30	0.0%
whb	Aug	0	1,265	4,219	337	2,043	0	0	7,864	1.0%
whb	Sep	50	538	414	246	1,327	2	0	2,576	0.3%
whb	Oct	266	39	92	407	2,401	4	0	3,209	0.4%
whb	Nov	1,665	5,623	6,413	13,841	7,283	11,275	0	46,099	6.0%
whb	Dec	2,432	1,260	6,952	9,361	15,834	15,296	0	51,135	6.6%
(all)	(all)	40,535	78,325	149,723	109,234	168,786	138,946	87,325	772,874	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	2016	2017	2018	2019	2020	2021	2022*	all	perc
whb	DEU	13,545	15,914	35,831	23,479	39,647	33,190	16,635	178,240	23.1%
whb	FR	0	0	1,625	4,892	5,069	2,786	4,188	18,561	2.4%
whb	LIT	0	0	0	0	10,146	15,807	6,467	32,421	4.2%
whb	NL	26,940	59,027	98,499	53,538	60,454	52,365	41,147	391,969	50.7%
whb	POL	0	0	11,764	23,192	45,791	26,288	11,237	118,273	15.3%
whb	UK	50	3,385	2,004	4,133	7,678	8,510	7,650	33,410	4.3%
(all)	(all)	40,535	78,325	149,723	109,234	168,786	138,946	87,325	772,874	100.0%

Table 3.5.4: Blue whiting. Self-sampling summary with the catch (tonnes) by year and country

Blue whiting. Catch by rectangle

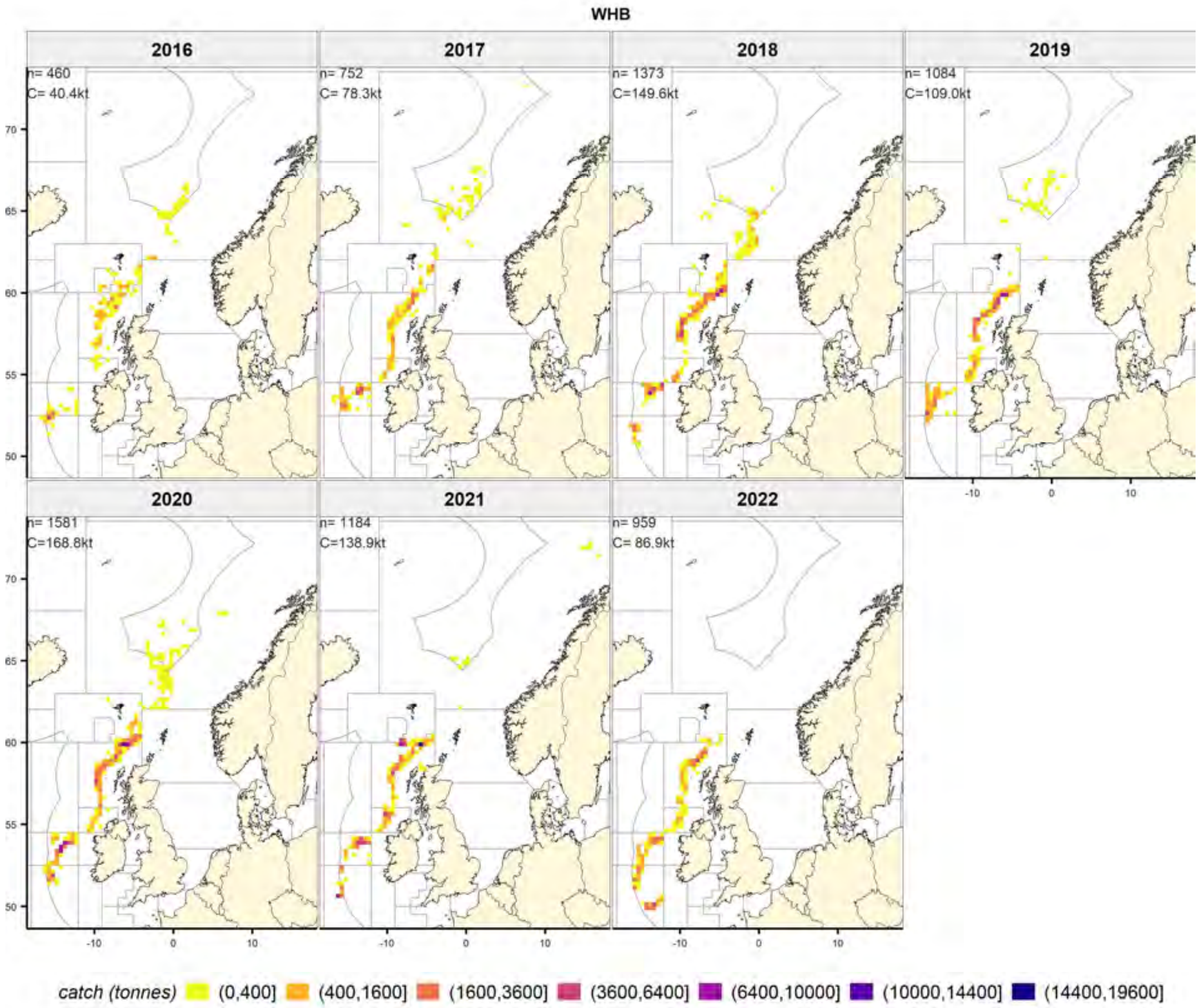

Figure 3.5.1: Blue whiting. Catch per per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

Blue whiting. Catchrate (ton/day) by rectangle

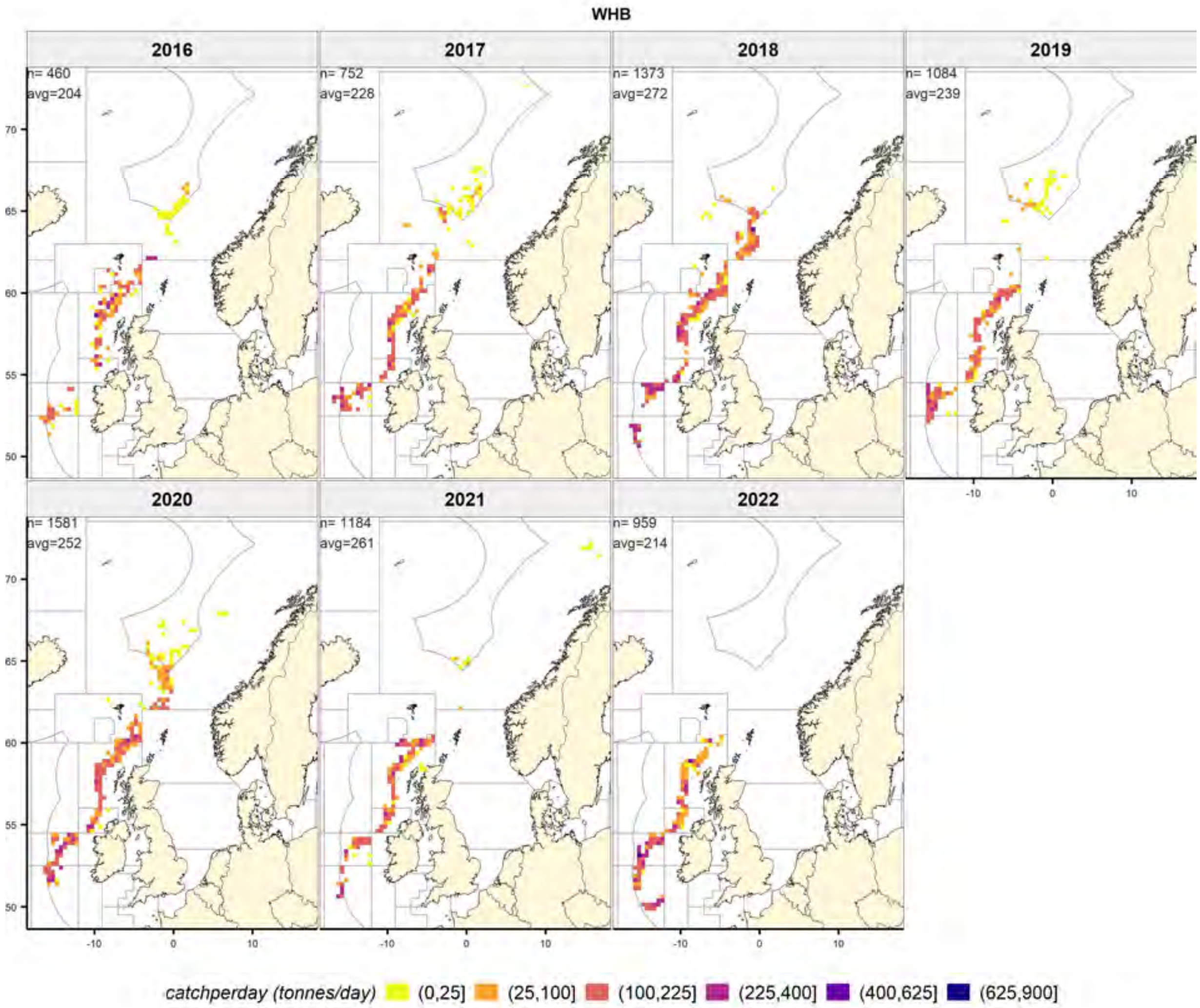

Figure 3.5.2: Blue whiting. Catchrate (ton/day) per rectangle. N indicates the number of hauls; Avg refers to the average catchrate per rect.

Blue whiting. Spatio-temporal evolution of catch by month and rectangle

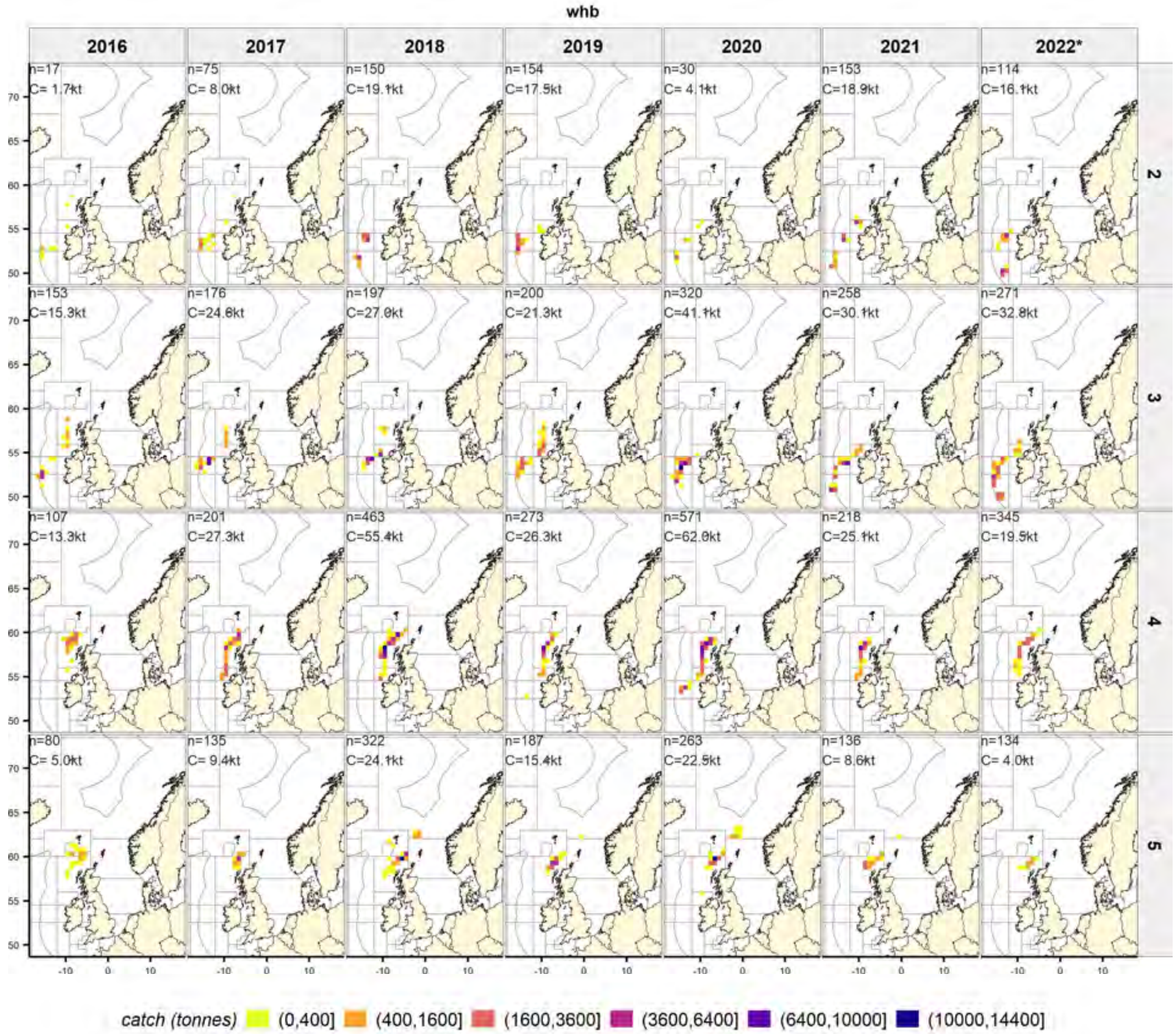

Figure 3.5.3: Blue whiting. Spatio-temporal evolution of the catches per rectangle and month. N indicates the number of hauls; C refers to the total catch by year and month.

Blue whiting. Catch proportion at depth

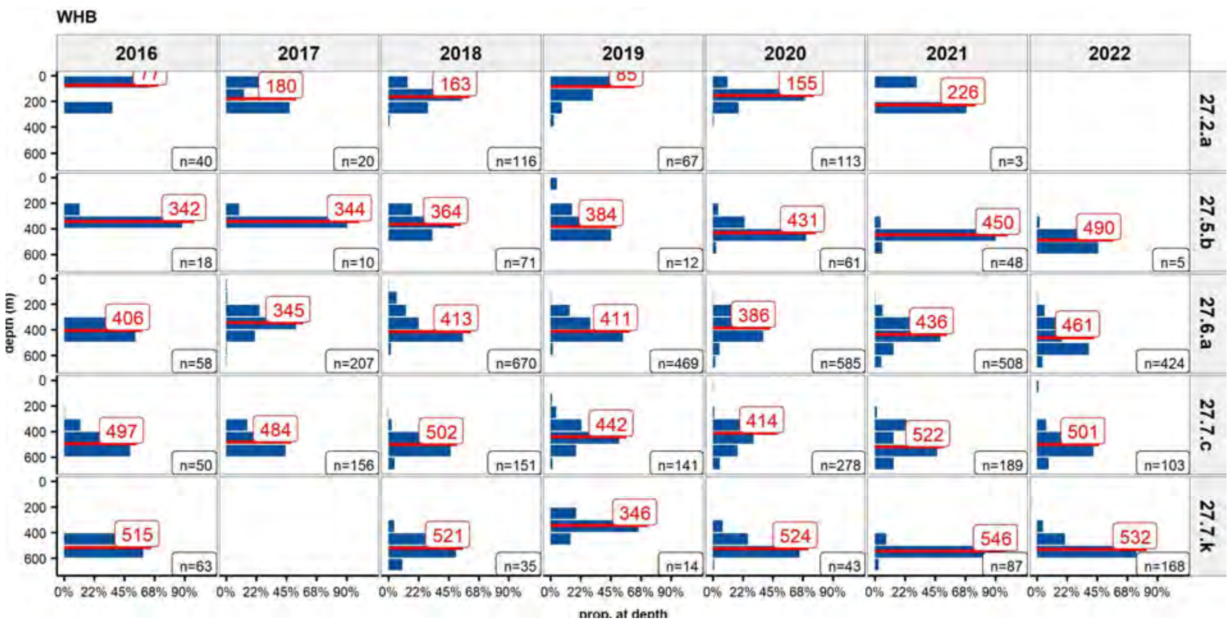

Figure 3.5.4: Blue whiting. Catch proportion at depth. N indicates the number of hauls.

Blue whiting. Length distributions of the catch

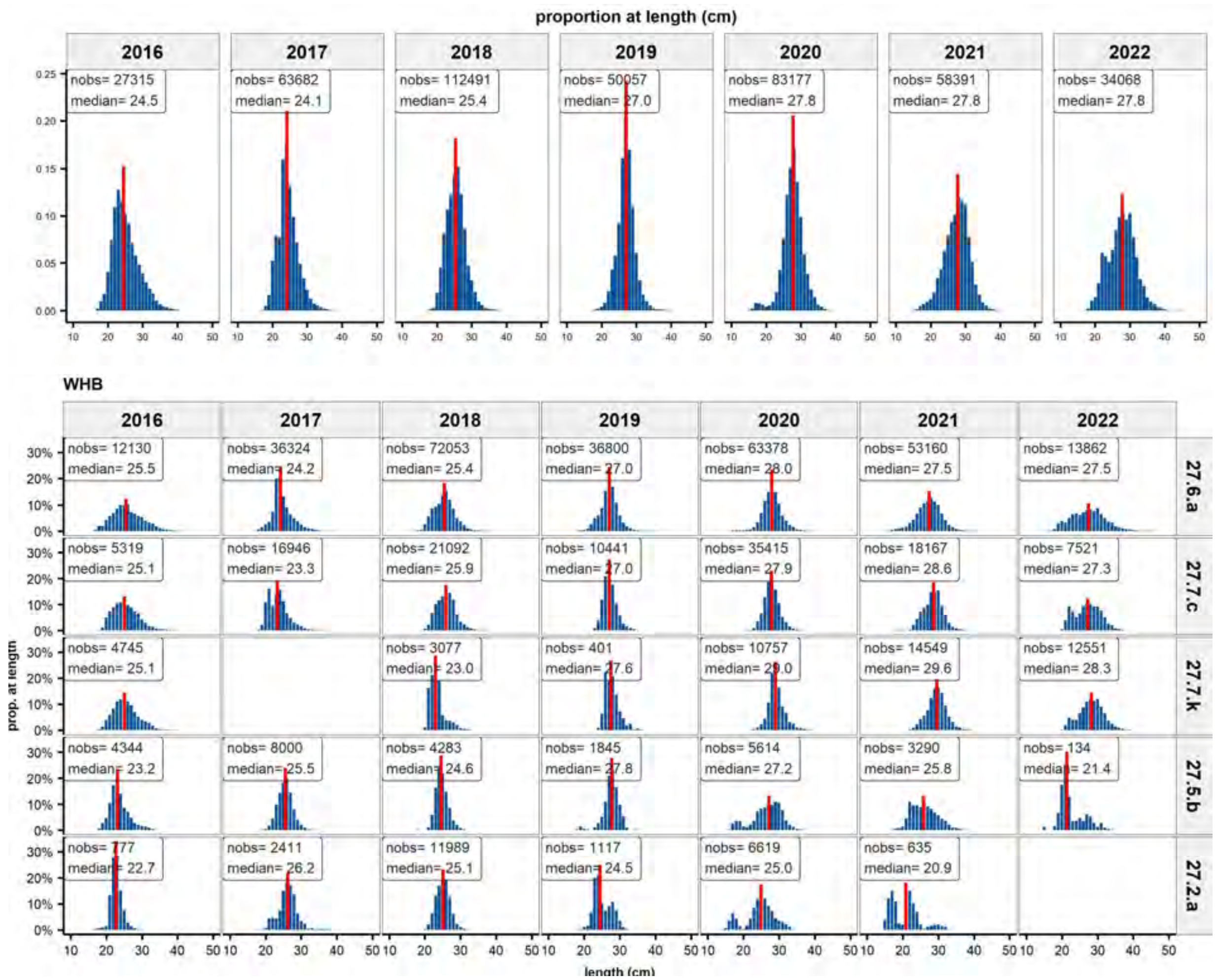

Figure 3.5.5: Blue whiting. Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

Blue whiting. Length distributions as proportions by (large) rectangle

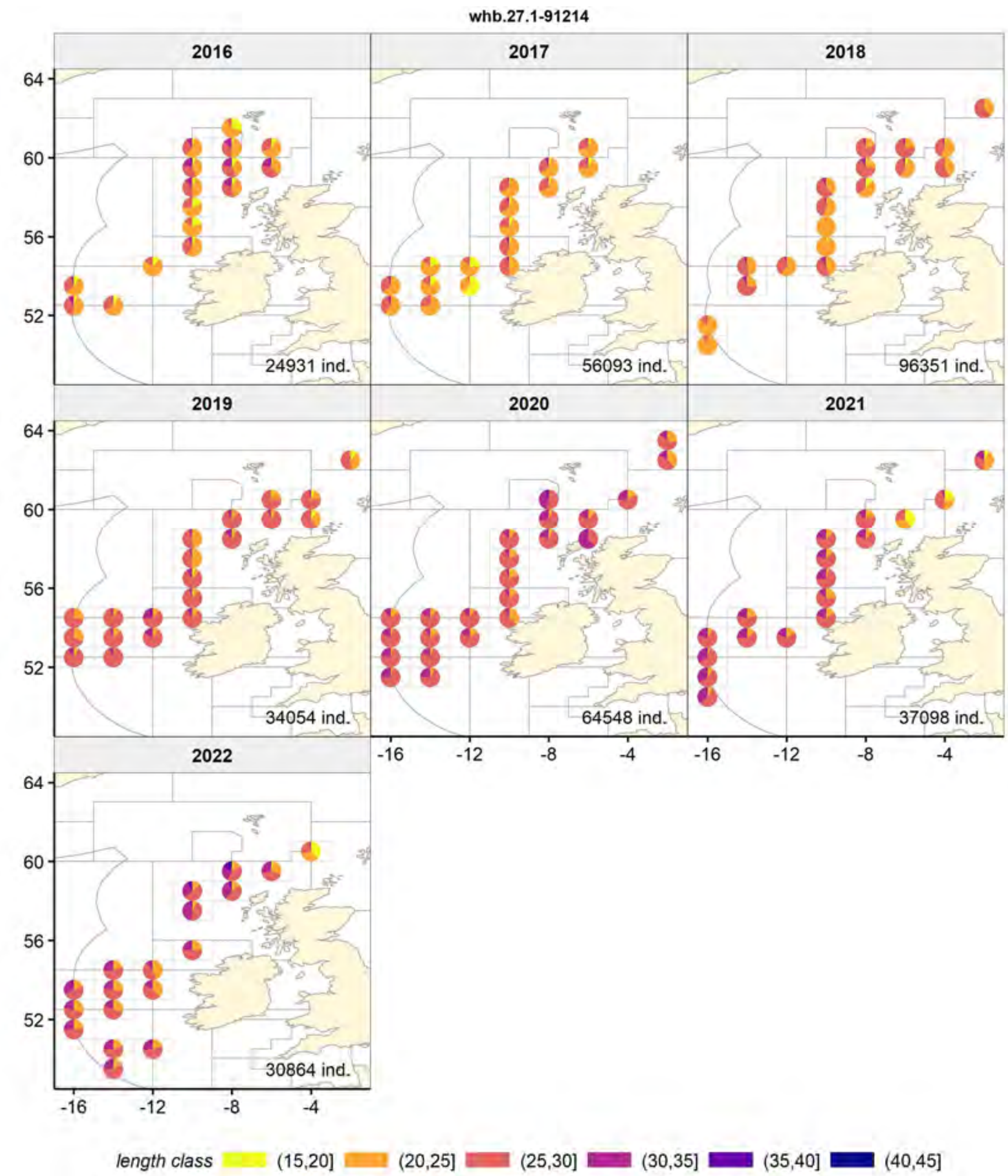

Figure 3.5.6: Blue whiting. Length distributions as proportions by large rectangle. Ind. refers to the number of length measurements

Blue whiting. Average length, weight and fat content by year and month

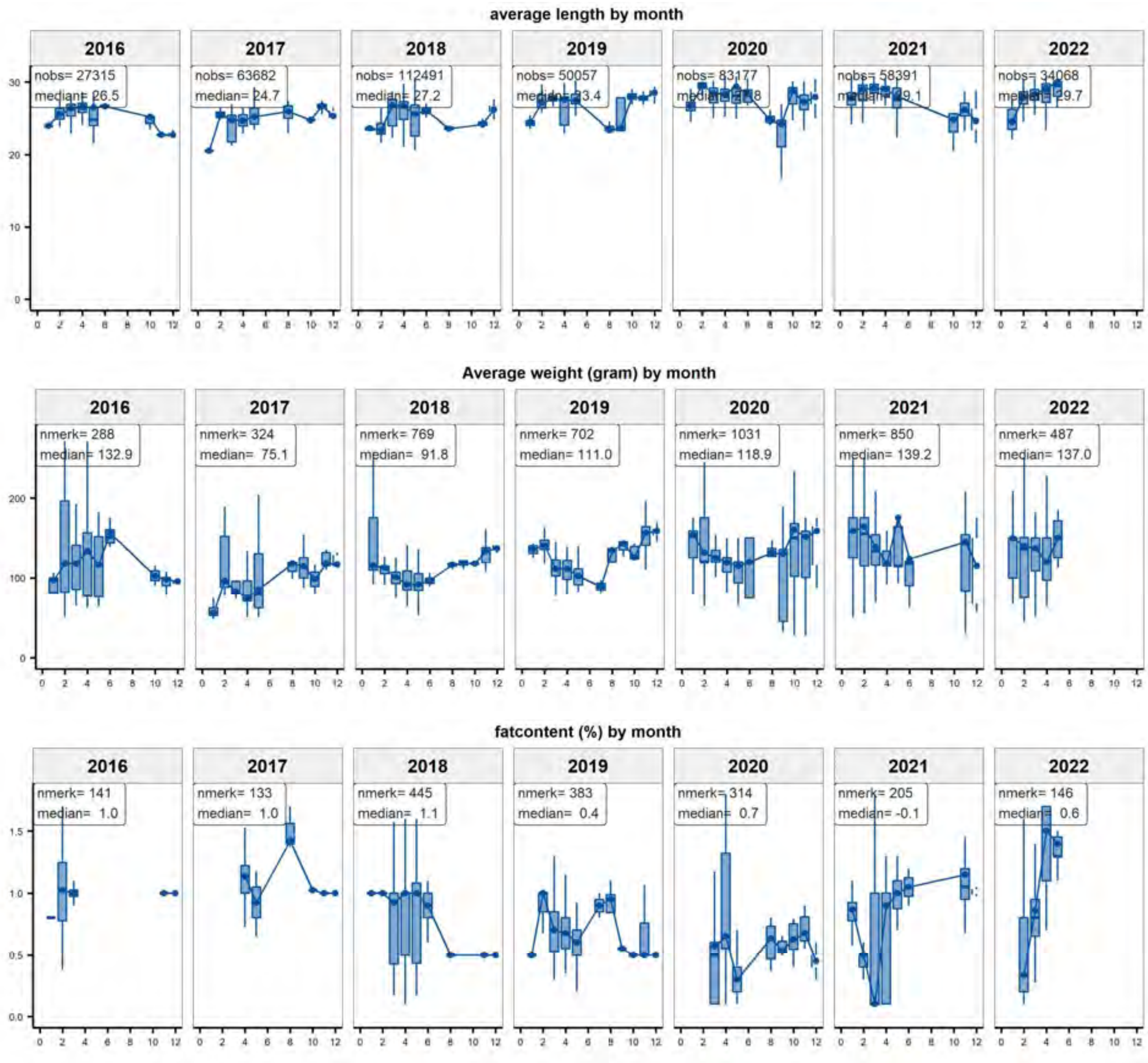

Figure 3.5.7: Blue whiting. Average length, average weight, and average fat content. Nobs indicates the number of measurements, median indicates the median values

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).

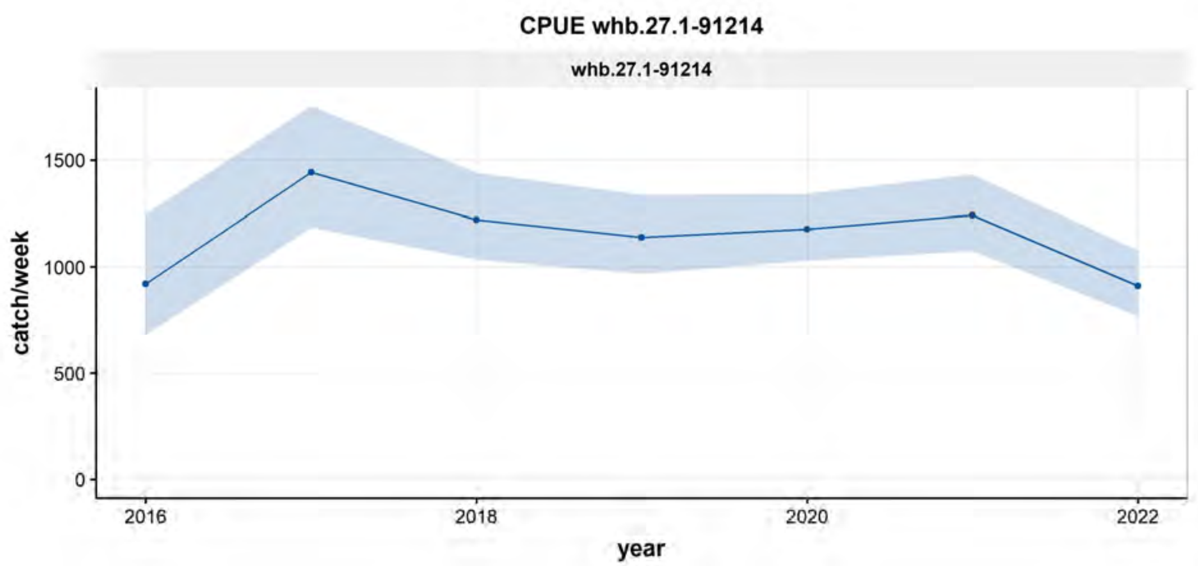

Figure 3.5.8: Blue whiting. Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset

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	2016	6	7	33	68	2,109	64	1,206
her_ash	2017	4	7	31	58	4,913	158	678
her_ash	2018	2	3	18	27	1,367	76	2
her_ash	2019	3	4	23	59	3,373	147	817
her_ash	2020	6	8	44	69	3,563	81	976
her_ash	2021	3	3	10	16	2,379	238	1,469
(all)	(all)		32	159	297	17,706		5,148

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	2016	2017	2018	2019	2020	2021	all	perc
her_ash	27.2.a	2,109	4,913	1,367	3,373	3,563	2,379	17,706	100.0%
(all)	(all)	2,109	4,913	1,367	3,373	3,563	2,379	17,706	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	2016	2017	2018	2019	2020	2021	all	perc
her_ash	May	0	0	0	0	26	0	26	0.1%
her_ash	Aug	0	118	52	0	61	0	232	1.3%
her_ash	Sep	54	7	405	362	53	0	881	5.0%
her_ash	Oct	2,055	4,788	910	2,184	2,480	1,659	14,076	79.5%
her_ash	Nov	0	0	0	828	942	721	2,491	14.1%
(all)	(all)	2,109	4,913	1,367	3,373	3,563	2,379	17,706	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	2016	2017	2018	2019	2020	2021	all	perc
her_ash	DEU	1,237	707	0	719	1,036	721	4,419	25.0%
her_ash	LIT	0	0	0	0	1,098	0	1,098	6.2%
her_ash	NL	775	4,185	1,367	2,654	524	1,659	11,164	63.1%
her_ash	POL	0	0	0	0	859	0	859	4.9%
her_ash	UK	97	21	0	0	48	0	166	0.9%
(all)	(all)	2,109	4,913	1,367	3,373	3,563	2,379	17,706	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

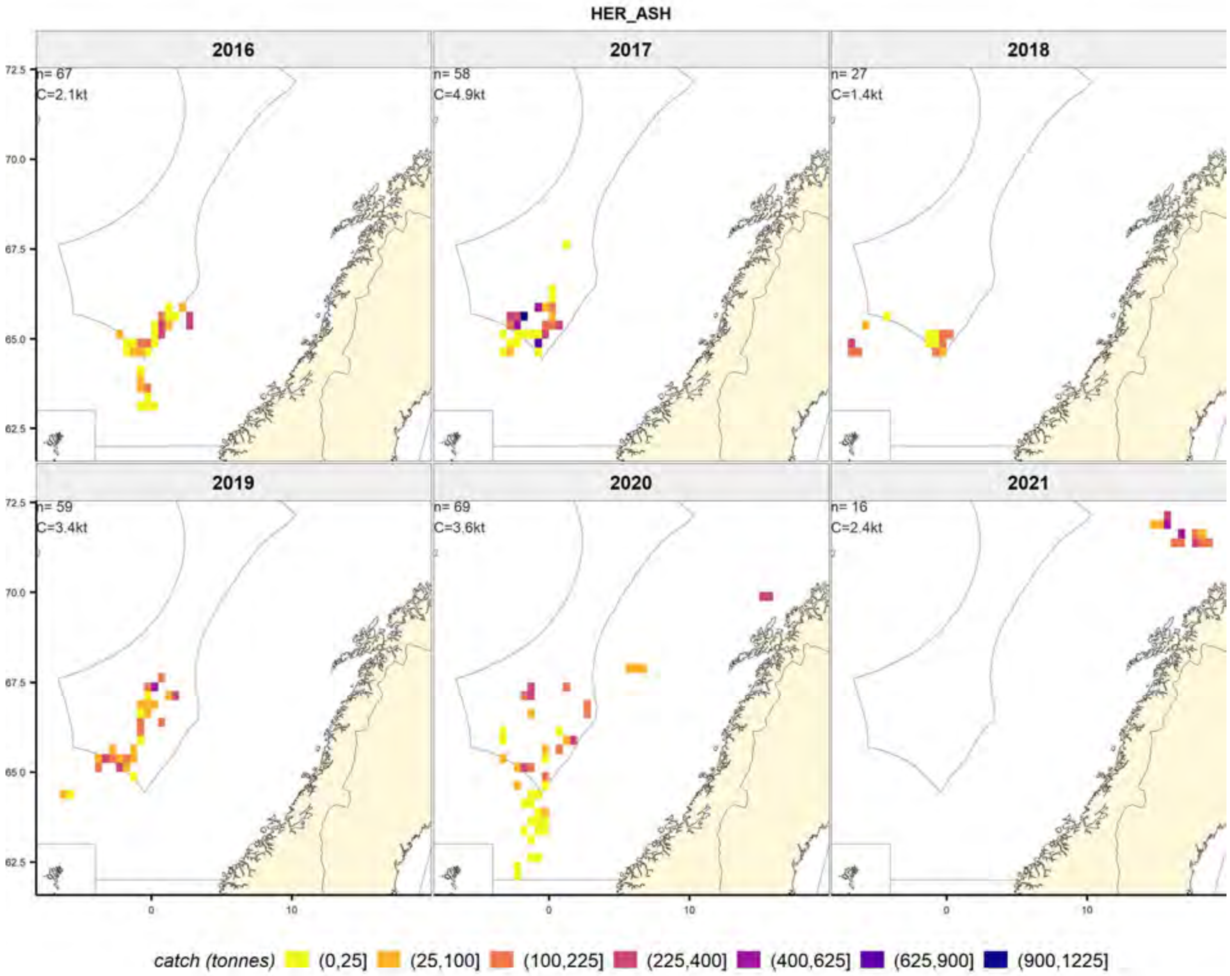

Figure 3.6.1: Atlanto-scandian herring. Catch per per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

Atlanto-scandian herring. Catchrate (ton/day) by rectangle

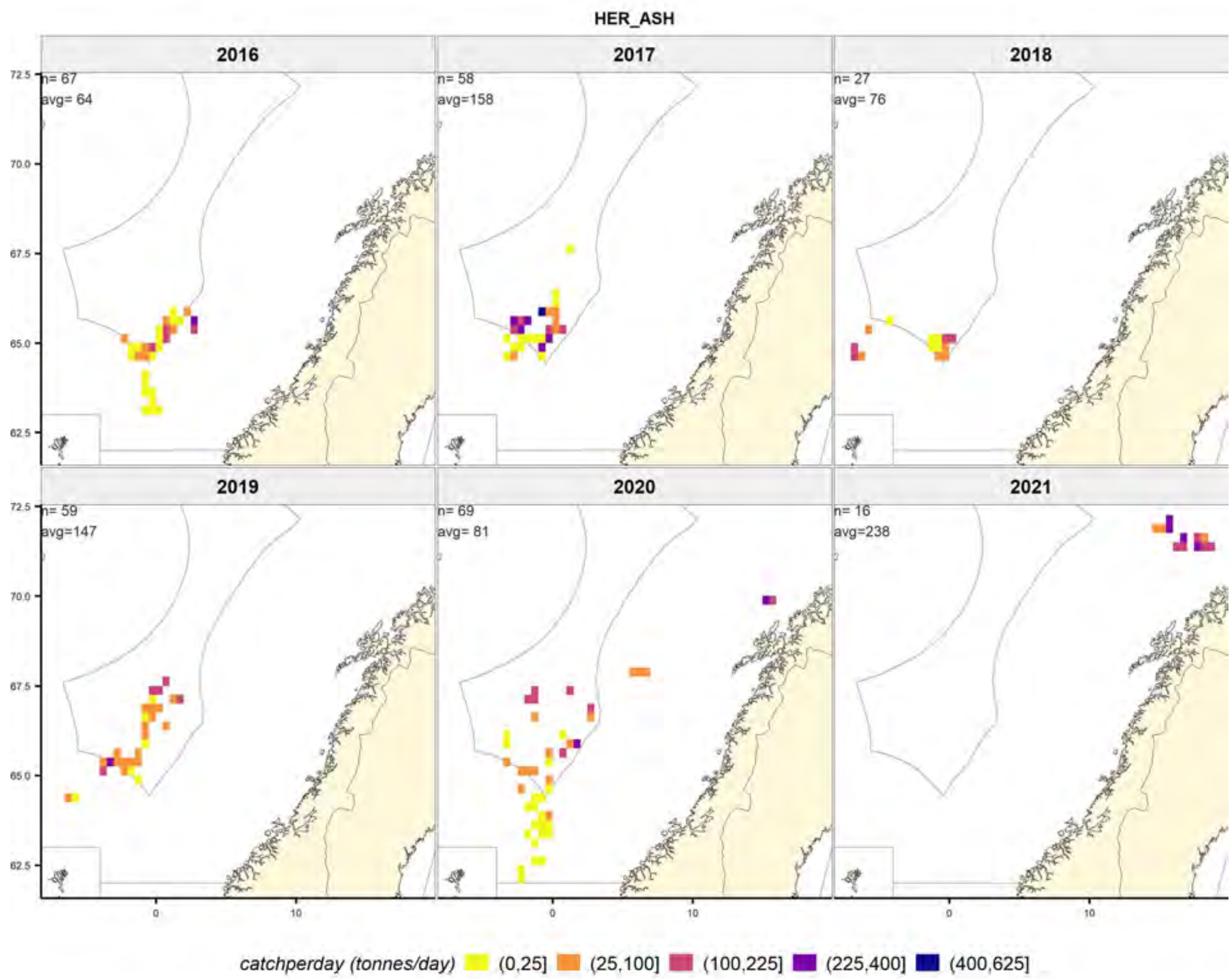

Figure 3.6.2: Atlanto-scandian herring. Catchrate (ton/day) per rectangle. N indicates the number of hauls; Avg refers to the average catchrate per rect.

Atlanto-scandian herring. Spatio-temporal evolution of catch by month and rectangle

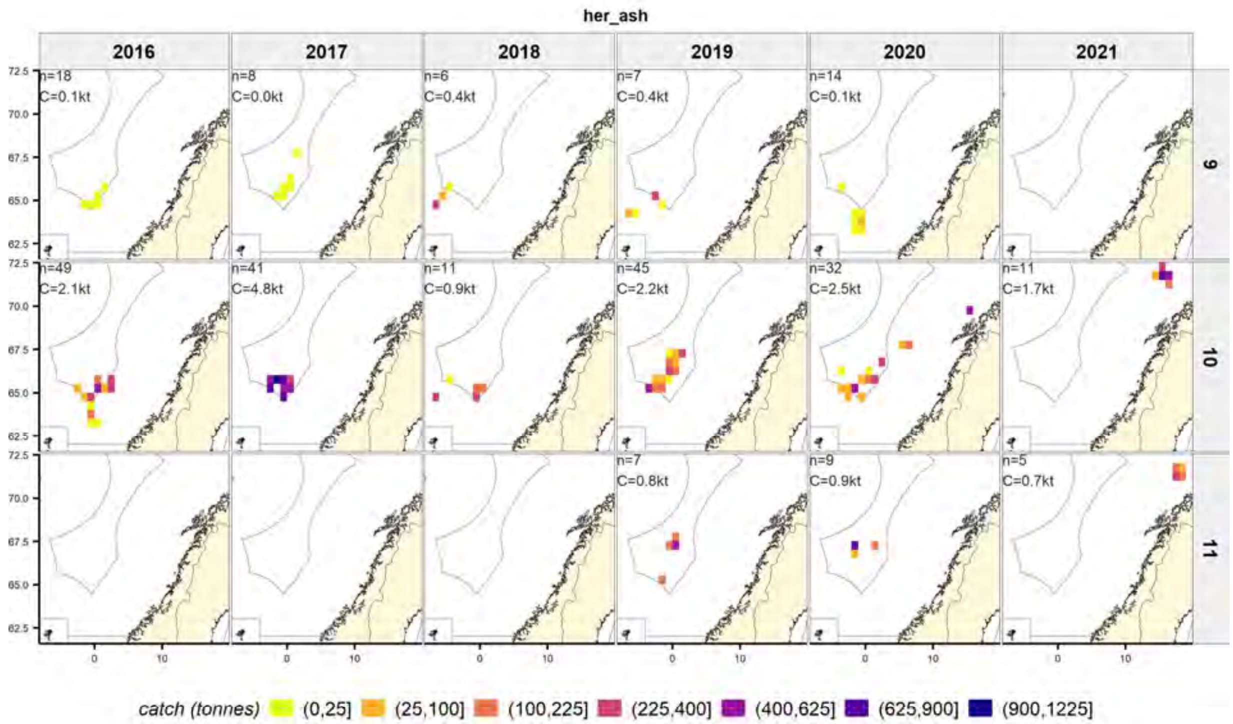

Figure 3.6.3: Atlanto-scandian herring. Spatio-temporal evolution of the catches per rectangle and month. N indicates the number of hauls; C refers to the total catch by year and month.

Atlanto-scandian herring. Catch proportion at depth

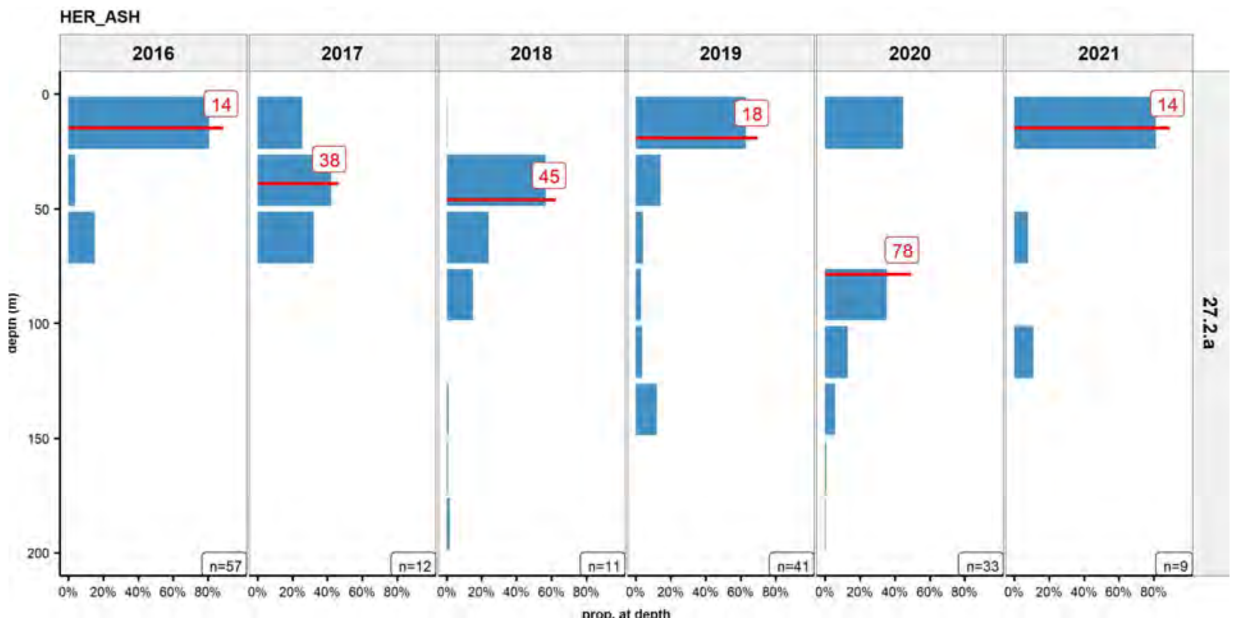

Figure 3.6.4: Atlanto-scandian herring. Catch proportion at depth. N indicates the number of hauls.

Atlanto-scandian herring. Length distributions of the catch

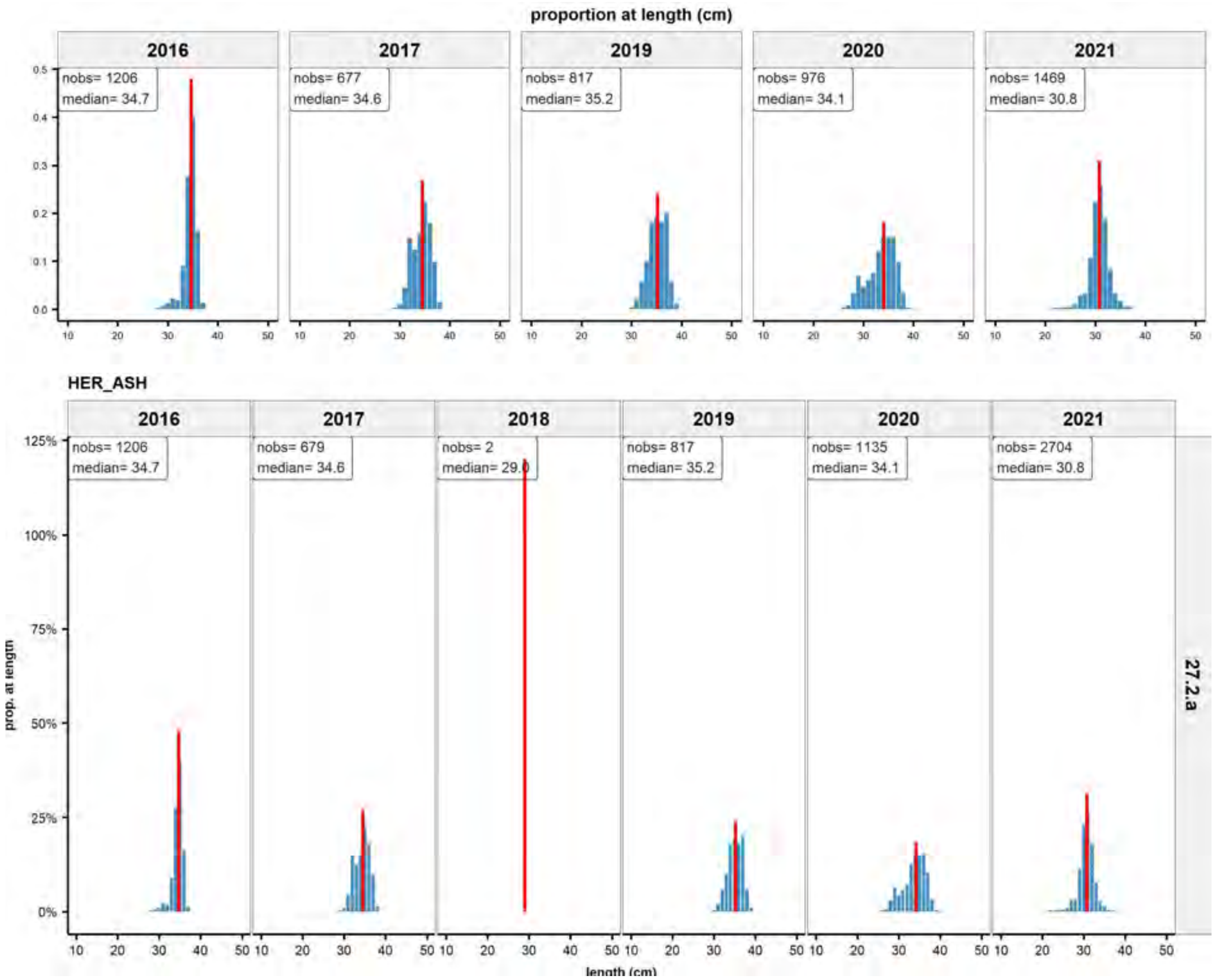

Figure 3.6.5: Atlanto-scandian herring. Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

Atlanto-scandian herring. Length distributions as proportions by (large) rectangle

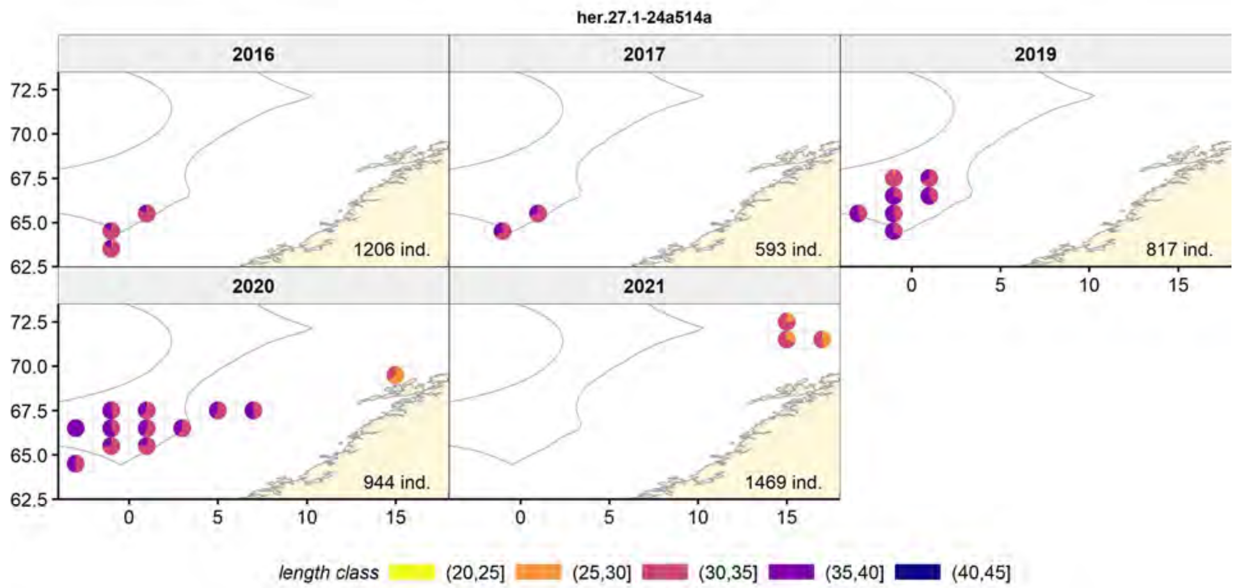

Figure 3.6.6: Atlanto-scandian herring. Length distributions as proportions by large rectangle. Ind. refers to the number of length measurements

Atlanto-scandian herring. Average length, weight and fat content by year and month

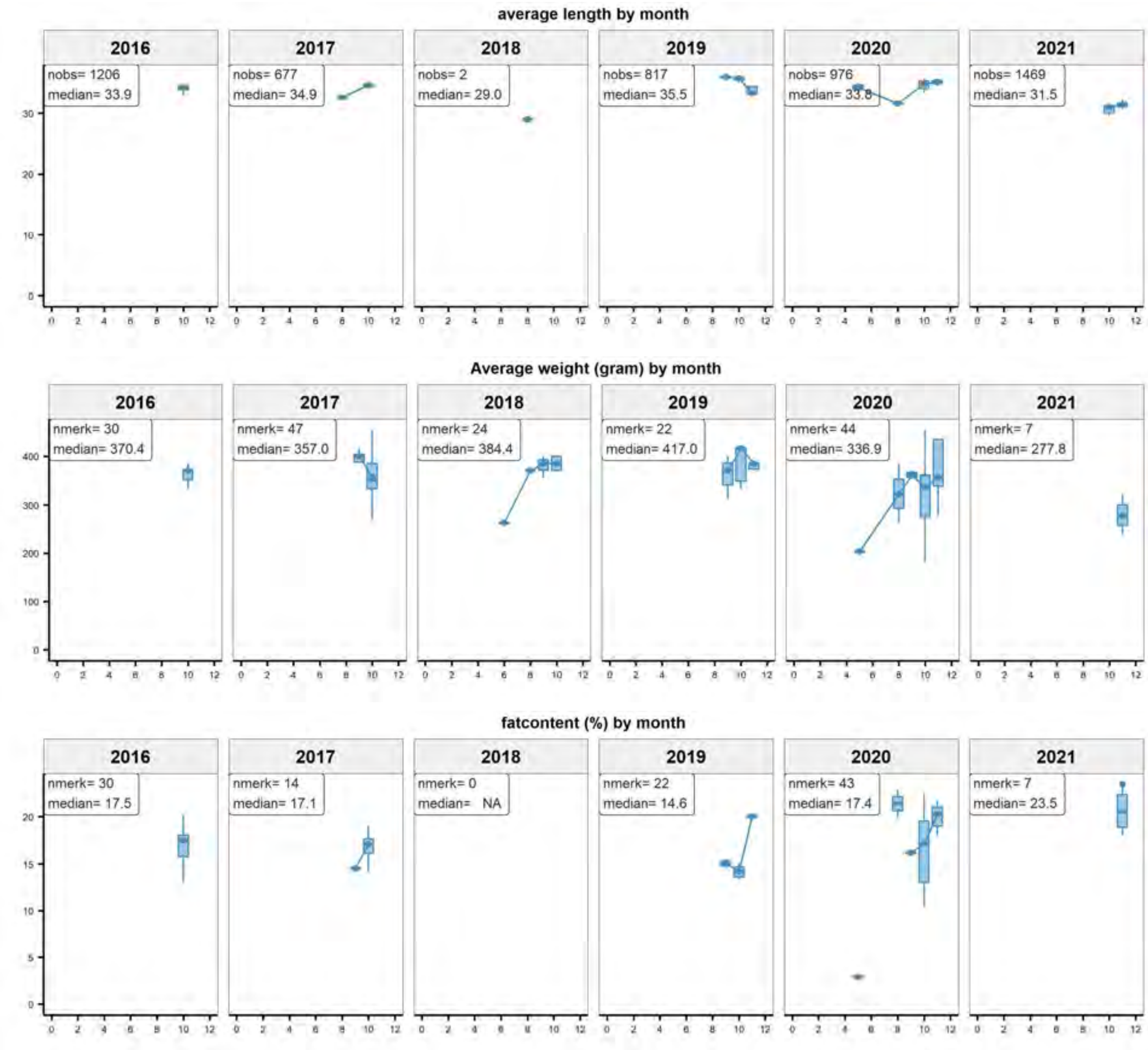

Figure 3.6.7: Atlanto-scandian herring. Average length, average weight, and average fat content. Nobs indicates the number of measurements, median indicates the median values

4 Discussion and conclusions

The PFA self-sampling program has been carried out for the seventh year in a row (2015-2021). Here, results have been presented for the years 2016-2022 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.

Trips from 2016 up to 11/08/2022 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, 22% German trawlers, 14% UK trawlers and 16% other countries. Blue whiting constitutes the majority of the catch in those trips (54%), followed by mackerel (23%) and horse mackerel (12%). Atlanto-scandian herring only constitutes around 3% 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 2016 - 2022 (up to 11/08/2022) covered 465 fishing trips with 6352 hauls, a total catch of 386474 tonnes and 103745 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 2021 have been relatively large with a median length of 36.4 cm compared to 33.6-36.2 in the preceding years. Also, the median weight has been somewhat higher with median weight of 435 gram compared to 385-422 gram in the 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 2016 - 2022 (up to 11/08/2022) covered 250 fishing trips with 3316 hauls, a total catch of 128553 tonnes and 130146 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 in divisions 27.6.a, 27.7.b and 27.7.j have fluctuated between 25.2 and 31.9 cm (with one low median length of 22.7 cm in 27.6.a in 2018). In ICES division 27.7.h, median lengths in the catch have been smaller and fluctuated between 20.7 and 24.5 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 2016 - 2022 (up to 11/08/2022) covered 109 fishing trips with 900 hauls, a total catch of 46322 tonnes and 38983 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 in division 27.7.d have fluctuated between 20.7 and 24.3 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 2016 - 2022 (up to 11/08/2022) covered 320 fishing trips with 8234 hauls, a total catch of 810714 tonnes and 466229 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 27.8 cm compared to 24.1-24.5 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 horse mackerel fisheries during the years 2016 - 2022 (up to 11/08/2022) covered 32 fishing trips with 297 hauls, a total catch of 17705 tonnes and 5147 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 and 35 cm.

In this 2022 self-sampling report, a standardized CPUE calculation has been included for the first time 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).

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

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7 More information

Please contact Martin Pastoors (mpastoors@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	2021	1	27	27.4.a	739	20	1	49	370
mac	2021	1	27	27.6.a	21577	490	69	2483	22508
mac	2021	1	27	27.7.b	672	28	6	67	452
mac	2021	1	27	27.7.j	334	26	2	76	1325
mac	2021	2	27	27.4.a	38	NA	NA	NA	NA
mac	2021	2	27	27.6.a	406	25	6	64	883
mac	2021	2	27	27.7.b	53	0	1	2	12
mac	2021	3	27	27.4.a	2991	46	20	252	1742
mac	2021	3	27	27.6.a	4	1	1	42	148
mac	2021	3	27	27.7.b	368	24	9	87	909
mac	2021	3	27	27.7.j	525	73	27	208	1394
mac	2021	4	27	27.2.a	8	29	3	61	31
mac	2021	4	27	27.4.a	40743	2269	201	7902	74412
mac	2021	4	27	27.7.j	0	0	1	1	1
mac	2022	1	27	27.4.a	11645	1045	72	3281	23588
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	402	58	22	162	513
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	27.4.a	238	77	12	259	3116
mac	2022	3	27	27.7.b	3	5	1	12	10
mac	2022	3	27	27.7.j	3	4	4	14	103

Northeast Atlantic mackerel Length frequencies 2021

species	year	quarter	area	division	lengthtype	length	count	catchnumber	prop
mac	2021	1	27	27.4.a	TL	27	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	28	3	22662	0.0612
mac	2021	1	27	27.4.a	TL	29	2	15108	0.0408
mac	2021	1	27	27.4.a	TL	30	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	31	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	32	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	33	2	15108	0.0408
mac	2021	1	27	27.4.a	TL	34	4	30216	0.0816
mac	2021	1	27	27.4.a	TL	35	7	52878	0.1429
mac	2021	1	27	27.4.a	TL	36	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	37	5	37770	0.1020
mac	2021	1	27	27.4.a	TL	38	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	39	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	40	4	30216	0.0816
mac	2021	1	27	27.6.a	TL	20	1	7036	0.0003
mac	2021	1	27	27.6.a	TL	21	1	5983	0.0003
mac	2021	1	27	27.6.a	TL	22	2	12764	0.0006
mac	2021	1	27	27.6.a	TL	24	2	10452	0.0005
mac	2021	1	27	27.6.a	TL	25	9	47828	0.0021
mac	2021	1	27	27.6.a	TL	26	10	61280	0.0027
mac	2021	1	27	27.6.a	TL	27	25	245675	0.0109
mac	2021	1	27	27.6.a	TL	28	16	198136	0.0088
mac	2021	1	27	27.6.a	TL	29	30	303481	0.0135
mac	2021	1	27	27.6.a	TL	30	43	331822	0.0147
mac	2021	1	27	27.6.a	TL	31	36	222011	0.0099
mac	2021	1	27	27.6.a	TL	32	88	746047	0.0331
mac	2021	1	27	27.6.a	TL	33	145	1154437	0.0513
mac	2021	1	27	27.6.a	TL	34	193	1641334	0.0729
mac	2021	1	27	27.6.a	TL	35	270	2158065	0.0959
mac	2021	1	27	27.6.a	TL	36	372	3205188	0.1424
mac	2021	1	27	27.6.a	TL	37	498	4794277	0.2130
mac	2021	1	27	27.6.a	TL	38	386	3699361	0.1644
mac	2021	1	27	27.6.a	TL	39	195	2138953	0.0950
mac	2021	1	27	27.6.a	TL	40	110	1122308	0.0499
mac	2021	1	27	27.6.a	TL	41	40	322748	0.0143
mac	2021	1	27	27.6.a	TL	42	8	58488	0.0026
mac	2021	1	27	27.6.a	TL	43	2	11590	0.0005
mac	2021	1	27	27.6.a	TL	46	1	9415	0.0004
mac	2021	1	27	27.7.b	TL	31	1	158	0.0003

mac	2021	1	27	27.7.b	TL	32	1 158	0.0003
mac	2021	1	27	27.7.b	TL	33	1 9116	0.0202
mac	2021	1	27	27.7.b	TL	34	3 27349	0.0605
mac	2021	1	27	27.7.b	TL	35	1 5243	0.0116
mac	2021	1	27	27.7.b	TL	36	7 44463	0.0983
mac	2021	1	27	27.7.b	TL	37	11 69334	0.1534
mac	2021	1	27	27.7.b	TL	38	18 125023	0.2765
mac	2021	1	27	27.7.b	TL	39	15 112427	0.2487
mac	2021	1	27	27.7.b	TL	40	7 44475	0.0984
mac	2021	1	27	27.7.b	TL	41	1 5243	0.0116
mac	2021	1	27	27.7.b	TL	42	1 9116	0.0202
mac	2021	1	27	27.7.j	TL	28	1 21375	0.0161
mac	2021	1	27	27.7.j	TL	29	1 21375	0.0161
mac	2021	1	27	27.7.j	TL	30	1 21375	0.0161
mac	2021	1	27	27.7.j	TL	31	6 128253	0.0968
mac	2021	1	27	27.7.j	TL	32	12 256507	0.1935
mac	2021	1	27	27.7.j	TL	33	9 192380	0.1452
mac	2021	1	27	27.7.j	TL	34	8 171004	0.1290
mac	2021	1	27	27.7.j	TL	35	8 106877	0.0806
mac	2021	1	27	27.7.j	TL	36	11 149629	0.1129
mac	2021	1	27	27.7.j	TL	37	9 85502	0.0645
mac	2021	1	27	27.7.j	TL	38	7 149629	0.1129
mac	2021	1	27	27.7.j	TL	39	3 21375	0.0161
mac	2021	2	27	27.6.a	TL	32	1 19069	0.0216
mac	2021	2	27	27.6.a	TL	33	3 54106	0.0613
mac	2021	2	27	27.6.a	TL	34	7 77064	0.0873
mac	2021	2	27	27.6.a	TL	35	9 115011	0.1303
mac	2021	2	27	27.6.a	TL	36	14 180151	0.2040
mac	2021	2	27	27.6.a	TL	37	11 161067	0.1824
mac	2021	2	27	27.6.a	TL	38	8 99500	0.1127
mac	2021	2	27	27.6.a	TL	39	6 94816	0.1074
mac	2021	2	27	27.6.a	TL	40	4 66247	0.0750
mac	2021	2	27	27.6.a	TL	42	1 15967	0.0181
mac	2021	2	27	27.7.b	TL	38	1 6127	0.5000
mac	2021	2	27	27.7.b	TL	40	1 6127	0.5000
mac	2021	3	27	27.4.a	TL	24	1 9442	0.0054
mac	2021	3	27	27.4.a	TL	25	5 43353	0.0249
mac	2021	3	27	27.4.a	TL	26	12 97836	0.0561
mac	2021	3	27	27.4.a	TL	27	2 10111	0.0058
mac	2021	3	27	27.4.a	TL	28	2 9810	0.0056
mac	2021	3	27	27.4.a	TL	29	10 98209	0.0563
mac	2021	3	27	27.4.a	TL	30	23 131613	0.0755
mac	2021	3	27	27.4.a	TL	31	16 127653	0.0732
mac	2021	3	27	27.4.a	TL	32	28 166532	0.0955
mac	2021	3	27	27.4.a	TL	33	23 149258	0.0856
mac	2021	3	27	27.4.a	TL	34	26 179596	0.1030
mac	2021	3	27	27.4.a	TL	35	23 173859	0.0998
mac	2021	3	27	27.4.a	TL	36	25 179053	0.1027
mac	2021	3	27	27.4.a	TL	37	24 155003	0.0889
mac	2021	3	27	27.4.a	TL	38	19 123471	0.0708
mac	2021	3	27	27.4.a	TL	39	11 74916	0.0430
mac	2021	3	27	27.4.a	TL	40	2 13203	0.0076
mac	2021	3	27	27.6.a	TL	14	4 14157	0.0952
mac	2021	3	27	27.6.a	TL	15	17 60167	0.4048
mac	2021	3	27	27.6.a	TL	16	14 49549	0.3333
mac	2021	3	27	27.6.a	TL	17	5 17696	0.1190
mac	2021	3	27	27.6.a	TL	18	2 7078	0.0476
mac	2021	3	27	27.7.b	TL	28	9 112126	0.1232
mac	2021	3	27	27.7.b	TL	29	13 203625	0.2238
mac	2021	3	27	27.7.b	TL	30	11 141073	0.1550
mac	2021	3	27	27.7.b	TL	31	7 76669	0.0843
mac	2021	3	27	27.7.b	TL	32	4 25451	0.0280
mac	2021	3	27	27.7.b	TL	33	6 23804	0.0262
mac	2021	3	27	27.7.b	TL	34	4 35446	0.0390
mac	2021	3	27	27.7.b	TL	35	13 115133	0.1265
mac	2021	3	27	27.7.b	TL	36	8 64557	0.0710
mac	2021	3	27	27.7.b	TL	37	2 23926	0.0263
mac	2021	3	27	27.7.b	TL	38	7 66987	0.0736
mac	2021	3	27	27.7.b	TL	39	2 17577	0.0193
mac	2021	3	27	27.7.b	TL	40	1 3499	0.0038
mac	2021	3	27	27.7.j	TL	27	1 2840	0.0020
mac	2021	3	27	27.7.j	TL	28	16 151373	0.1086
mac	2021	3	27	27.7.j	TL	29	11 47096	0.0338
mac	2021	3	27	27.7.j	TL	30	9 53242	0.0382
mac	2021	3	27	27.7.j	TL	31	12 62300	0.0447
mac	2021	3	27	27.7.j	TL	32	6 27933	0.0200
mac	2021	3	27	27.7.j	TL	33	18 116680	0.0837
mac	2021	3	27	27.7.j	TL	34	14 154071	0.1105
mac	2021	3	27	27.7.j	TL	35	29 191132	0.1371
mac	2021	3	27	27.7.j	TL	36	32 259037	0.1858

mac	2021	3	27	27.7.j	TL	37	32	150305	0.1078
mac	2021	3	27	27.7.j	TL	38	15	80969	0.0581
mac	2021	3	27	27.7.j	TL	39	7	70033	0.0502
mac	2021	3	27	27.7.j	TL	40	5	16515	0.0118
mac	2021	3	27	27.7.j	TL	41	1	10581	0.0076
mac	2021	4	27	27.2.a	TL	35	4	1061	0.0337
mac	2021	4	27	27.2.a	TL	36	4	1141	0.0362
mac	2021	4	27	27.2.a	TL	37	14	18943	0.6011
mac	2021	4	27	27.2.a	TL	38	19	5141	0.1631
mac	2021	4	27	27.2.a	TL	39	10	2534	0.0804
mac	2021	4	27	27.2.a	TL	40	8	2202	0.0699
mac	2021	4	27	27.2.a	TL	41	2	490	0.0155
mac	2021	4	27	27.4.a	TL	23	1	11982	0.0002
mac	2021	4	27	27.4.a	TL	24	9	108983	0.0015
mac	2021	4	27	27.4.a	TL	25	21	231669	0.0031
mac	2021	4	27	27.4.a	TL	26	76	793340	0.0107
mac	2021	4	27	27.4.a	TL	27	138	1561556	0.0210
mac	2021	4	27	27.4.a	TL	28	138	1922592	0.0258
mac	2021	4	27	27.4.a	TL	29	190	2253457	0.0303
mac	2021	4	27	27.4.a	TL	30	253	2750277	0.0370
mac	2021	4	27	27.4.a	TL	31	318	3004111	0.0404
mac	2021	4	27	27.4.a	TL	32	392	4157073	0.0559
mac	2021	4	27	27.4.a	TL	33	482	5170802	0.0695
mac	2021	4	27	27.4.a	TL	34	651	6524440	0.0877
mac	2021	4	27	27.4.a	TL	35	902	8714365	0.1171
mac	2021	4	27	27.4.a	TL	36	1037	9457713	0.1271
mac	2021	4	27	27.4.a	TL	37	1253	11146124	0.1498
mac	2021	4	27	27.4.a	TL	38	1084	8877236	0.1193
mac	2021	4	27	27.4.a	TL	39	603	4858841	0.0653
mac	2021	4	27	27.4.a	TL	40	263	2138178	0.0287
mac	2021	4	27	27.4.a	TL	41	69	522747	0.0070
mac	2021	4	27	27.4.a	TL	42	17	176805	0.0024
mac	2021	4	27	27.4.a	TL	43	3	24148	0.0003
mac	2021	4	27	27.4.a	TL	44	2	5576	0.0001
mac	2021	4	27	27.7.j	TL	30	1	1413	1.0000

Northeast Atlantic mackerel Length frequencies 2022

species	year	quarter	area	division	lengthtype	length	count	catchnumber	prop
mac	2022	1	27	27.4.a	TL	26	9	33098	0.0014
mac	2022	1	27	27.4.a	TL	27	52	340439	0.0144
mac	2022	1	27	27.4.a	TL	28	44	336042	0.0142
mac	2022	1	27	27.4.a	TL	29	54	396568	0.0168
mac	2022	1	27	27.4.a	TL	30	59	388841	0.0165
mac	2022	1	27	27.4.a	TL	31	62	440724	0.0187
mac	2022	1	27	27.4.a	TL	32	68	505194	0.0214
mac	2022	1	27	27.4.a	TL	33	84	482556	0.0205
mac	2022	1	27	27.4.a	TL	34	159	1033678	0.0438
mac	2022	1	27	27.4.a	TL	35	241	1684979	0.0714
mac	2022	1	27	27.4.a	TL	36	392	2663419	0.1129
mac	2022	1	27	27.4.a	TL	37	576	4055936	0.1719
mac	2022	1	27	27.4.a	TL	38	626	4511764	0.1913
mac	2022	1	27	27.4.a	TL	39	481	3759345	0.1594
mac	2022	1	27	27.4.a	TL	40	256	1875541	0.0795
mac	2022	1	27	27.4.a	TL	41	92	770072	0.0326
mac	2022	1	27	27.4.a	TL	42	21	243746	0.0103
mac	2022	1	27	27.4.a	TL	43	2	7439	0.0003
mac	2022	1	27	27.4.a	TL	44	3	58790	0.0025
mac	2022	1	27	27.6.a	TL	17	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	18	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	19	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	23	4	15424	0.0010
mac	2022	1	27	27.6.a	TL	24	5	30313	0.0020
mac	2022	1	27	27.6.a	TL	25	8	34891	0.0023
mac	2022	1	27	27.6.a	TL	26	12	85246	0.0057
mac	2022	1	27	27.6.a	TL	27	14	137644	0.0091
mac	2022	1	27	27.6.a	TL	28	24	273784	0.0182
mac	2022	1	27	27.6.a	TL	29	22	150308	0.0100
mac	2022	1	27	27.6.a	TL	30	45	398239	0.0265
mac	2022	1	27	27.6.a	TL	31	64	554722	0.0368
mac	2022	1	27	27.6.a	TL	32	84	782862	0.0520
mac	2022	1	27	27.6.a	TL	33	120	1156090	0.0768
mac	2022	1	27	27.6.a	TL	34	95	882994	0.0586
mac	2022	1	27	27.6.a	TL	35	115	1091725	0.0725
mac	2022	1	27	27.6.a	TL	36	105	1096835	0.0728
mac	2022	1	27	27.6.a	TL	37	209	2050525	0.1362

mac	2022	1	27	27.6.a	TL	38	274	2565070	0.1704
mac	2022	1	27	27.6.a	TL	39	214	2171710	0.1442
mac	2022	1	27	27.6.a	TL	40	117	1193579	0.0793
mac	2022	1	27	27.6.a	TL	41	29	282289	0.0187
mac	2022	1	27	27.6.a	TL	42	7	89517	0.0059
mac	2022	1	27	27.7.b	TL	20	3	34527	0.0034
mac	2022	1	27	27.7.b	TL	21	5	57545	0.0056
mac	2022	1	27	27.7.b	TL	22	7	80563	0.0079
mac	2022	1	27	27.7.b	TL	23	7	80563	0.0079
mac	2022	1	27	27.7.b	TL	24	4	46036	0.0045
mac	2022	1	27	27.7.b	TL	25	5	57545	0.0056
mac	2022	1	27	27.7.b	TL	26	4	46036	0.0045
mac	2022	1	27	27.7.b	TL	27	4	35245	0.0035
mac	2022	1	27	27.7.b	TL	28	3	31860	0.0031
mac	2022	1	27	27.7.b	TL	29	7	84735	0.0083
mac	2022	1	27	27.7.b	TL	30	25	216377	0.0212
mac	2022	1	27	27.7.b	TL	31	24	196195	0.0192
mac	2022	1	27	27.7.b	TL	32	31	296552	0.0291
mac	2022	1	27	27.7.b	TL	33	45	315556	0.0310
mac	2022	1	27	27.7.b	TL	34	72	507485	0.0498
mac	2022	1	27	27.7.b	TL	35	162	1101891	0.1081
mac	2022	1	27	27.7.b	TL	36	203	1318078	0.1293
mac	2022	1	27	27.7.b	TL	37	201	1323574	0.1298
mac	2022	1	27	27.7.b	TL	38	270	1866023	0.1831
mac	2022	1	27	27.7.b	TL	39	211	1395078	0.1369
mac	2022	1	27	27.7.b	TL	40	110	751821	0.0738
mac	2022	1	27	27.7.b	TL	41	34	283483	0.0278
mac	2022	1	27	27.7.b	TL	42	6	46318	0.0045
mac	2022	1	27	27.7.b	TL	43	3	9300	0.0009
mac	2022	1	27	27.7.b	TL	44	1	10778	0.0011
mac	2022	1	27	27.7.j	TL	25	2	6604	0.0129
mac	2022	1	27	27.7.j	TL	26	1	3302	0.0064
mac	2022	1	27	27.7.j	TL	27	3	14565	0.0284
mac	2022	1	27	27.7.j	TL	28	6	20668	0.0403
mac	2022	1	27	27.7.j	TL	29	10	46168	0.0899
mac	2022	1	27	27.7.j	TL	30	20	74332	0.1448
mac	2022	1	27	27.7.j	TL	31	16	73536	0.1432
mac	2022	1	27	27.7.j	TL	32	13	59549	0.1160
mac	2022	1	27	27.7.j	TL	33	15	55851	0.1088
mac	2022	1	27	27.7.j	TL	34	15	44410	0.0865
mac	2022	1	27	27.7.j	TL	35	16	30610	0.0596
mac	2022	1	27	27.7.j	TL	36	17	21822	0.0425
mac	2022	1	27	27.7.j	TL	37	11	26273	0.0512
mac	2022	1	27	27.7.j	TL	38	8	18422	0.0359
mac	2022	1	27	27.7.j	TL	39	6	12616	0.0246
mac	2022	1	27	27.7.j	TL	40	3	4754	0.0093

mac	2022	2	27	27.6.a	TL	34	4	20848	0.1319
mac	2022	2	27	27.6.a	TL	35	5	31786	0.2011
mac	2022	2	27	27.6.a	TL	36	5	28235	0.1786
mac	2022	2	27	27.6.a	TL	37	6	27219	0.1722
mac	2022	2	27	27.6.a	TL	38	6	28043	0.1774
mac	2022	2	27	27.6.a	TL	39	3	14125	0.0894
mac	2022	2	27	27.6.a	TL	40	1	2102	0.0133
mac	2022	2	27	27.6.a	TL	41	1	2102	0.0133
mac	2022	2	27	27.6.a	TL	42	1	3602	0.0228

mac	2022	3	27	27.4.a	TL	26	1	3261	0.0010
mac	2022	3	27	27.4.a	TL	29	9	102965	0.0330
mac	2022	3	27	27.4.a	TL	30	68	847404	0.2719
mac	2022	3	27	27.4.a	TL	31	65	831571	0.2668
mac	2022	3	27	27.4.a	TL	32	53	568987	0.1825
mac	2022	3	27	27.4.a	TL	33	36	409378	0.1313
mac	2022	3	27	27.4.a	TL	34	11	109308	0.0351
mac	2022	3	27	27.4.a	TL	35	4	54797	0.0176
mac	2022	3	27	27.4.a	TL	36	4	67573	0.0217
mac	2022	3	27	27.4.a	TL	37	5	74347	0.0239
mac	2022	3	27	27.4.a	TL	38	3	47380	0.0152
mac	2022	3	27	27.7.b	TL	32	1	873	0.0833
mac	2022	3	27	27.7.b	TL	34	5	4369	0.4168
mac	2022	3	27	27.7.b	TL	35	1	873	0.0833
mac	2022	3	27	27.7.b	TL	36	1	873	0.0833
mac	2022	3	27	27.7.b	TL	37	2	1747	0.1667
mac	2022	3	27	27.7.b	TL	38	1	873	0.0833
mac	2022	3	27	27.7.b	TL	40	1	873	0.0833
mac	2022	3	27	27.7.j	TL	31	1	4751	0.0457
mac	2022	3	27	27.7.j	TL	32	2	17221	0.1656
mac	2022	3	27	27.7.j	TL	33	1	12469	0.1199
mac	2022	3	27	27.7.j	TL	34	1	9293	0.0894
mac	2022	3	27	27.7.j	TL	35	3	14255	0.1371
mac	2022	3	27	27.7.j	TL	36	2	9503	0.0914
mac	2022	3	27	27.7.j	TL	37	1	13494	0.1298

mac	2022	3	27 27.7.j	TL	38	2 18246	0.1755
mac	2022	3	27 27.7.j	TL	39	1 4751	0.0457

9 Western horse mackerel: detailed tables

Western horse mackerel Sampling overview

species	year	quarter	area	division	catch	sampleweight	nsamples	count	catchnumber
mac	2021	1	27	27.4.a	739	20	1	49	370
mac	2021	1	27	27.6.a	21577	490	69	2483	22508
mac	2021	1	27	27.7.b	672	28	6	67	452
mac	2021	1	27	27.7.j	334	26	2	76	1325
mac	2021	2	27	27.4.a	38	NA	NA	NA	NA
mac	2021	2	27	27.6.a	406	25	6	64	883
mac	2021	2	27	27.7.b	53	0	1	2	12
mac	2021	3	27	27.4.a	2991	46	20	252	1742
mac	2021	3	27	27.6.a	4	1	1	42	148
mac	2021	3	27	27.7.b	368	24	9	87	909
mac	2021	3	27	27.7.j	525	73	27	208	1394
mac	2021	4	27	27.2.a	8	29	3	61	31
mac	2021	4	27	27.4.a	40743	2269	201	7902	74412
mac	2021	4	27	27.7.j	0	0	1	1	1
mac	2022	1	27	27.4.a	11645	1045	72	3281	23588
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	402	58	22	162	513
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	27.4.a	238	77	12	259	3116
mac	2022	3	27	27.7.b	3	5	1	12	10
mac	2022	3	27	27.7.j	3	4	4	14	103

Western horse mackerel Length frequencies 2021

species	year	quarter	area	division	lengthtype	length	count	catchnumber	prop
mac	2021	1	27	27.4.a	TL	27	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	28	3	22662	0.0612
mac	2021	1	27	27.4.a	TL	29	2	15108	0.0408
mac	2021	1	27	27.4.a	TL	30	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	31	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	32	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	33	2	15108	0.0408
mac	2021	1	27	27.4.a	TL	34	4	30216	0.0816
mac	2021	1	27	27.4.a	TL	35	7	52878	0.1429
mac	2021	1	27	27.4.a	TL	36	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	37	5	37770	0.1020
mac	2021	1	27	27.4.a	TL	38	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	39	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	40	4	30216	0.0816
mac	2021	1	27	27.6.a	TL	20	1	7036	0.0003
mac	2021	1	27	27.6.a	TL	21	1	5983	0.0003
mac	2021	1	27	27.6.a	TL	22	2	12764	0.0006
mac	2021	1	27	27.6.a	TL	24	2	10452	0.0005
mac	2021	1	27	27.6.a	TL	25	9	47828	0.0021
mac	2021	1	27	27.6.a	TL	26	10	61280	0.0027
mac	2021	1	27	27.6.a	TL	27	25	245675	0.0109
mac	2021	1	27	27.6.a	TL	28	16	198136	0.0088
mac	2021	1	27	27.6.a	TL	29	30	303481	0.0135
mac	2021	1	27	27.6.a	TL	30	43	331822	0.0147
mac	2021	1	27	27.6.a	TL	31	36	222011	0.0099
mac	2021	1	27	27.6.a	TL	32	88	746047	0.0331
mac	2021	1	27	27.6.a	TL	33	145	1154437	0.0513
mac	2021	1	27	27.6.a	TL	34	193	1641334	0.0729
mac	2021	1	27	27.6.a	TL	35	270	2158065	0.0959
mac	2021	1	27	27.6.a	TL	36	372	3205188	0.1424
mac	2021	1	27	27.6.a	TL	37	498	4794277	0.2130
mac	2021	1	27	27.6.a	TL	38	386	3699361	0.1644
mac	2021	1	27	27.6.a	TL	39	195	2138953	0.0950
mac	2021	1	27	27.6.a	TL	40	110	1122308	0.0499
mac	2021	1	27	27.6.a	TL	41	40	322748	0.0143
mac	2021	1	27	27.6.a	TL	42	8	58488	0.0026
mac	2021	1	27	27.6.a	TL	43	2	11590	0.0005
mac	2021	1	27	27.6.a	TL	46	1	9415	0.0004
mac	2021	1	27	27.7.b	TL	31	1	158	0.0003

mac	2021	1	27	27.7.b	TL	32	1 158	0.0003
mac	2021	1	27	27.7.b	TL	33	1 9116	0.0202
mac	2021	1	27	27.7.b	TL	34	3 27349	0.0605
mac	2021	1	27	27.7.b	TL	35	1 5243	0.0116
mac	2021	1	27	27.7.b	TL	36	7 44463	0.0983
mac	2021	1	27	27.7.b	TL	37	11 69334	0.1534
mac	2021	1	27	27.7.b	TL	38	18 125023	0.2765
mac	2021	1	27	27.7.b	TL	39	15 112427	0.2487
mac	2021	1	27	27.7.b	TL	40	7 44475	0.0984
mac	2021	1	27	27.7.b	TL	41	1 5243	0.0116
mac	2021	1	27	27.7.b	TL	42	1 9116	0.0202
mac	2021	1	27	27.7.j	TL	28	1 21375	0.0161
mac	2021	1	27	27.7.j	TL	29	1 21375	0.0161
mac	2021	1	27	27.7.j	TL	30	1 21375	0.0161
mac	2021	1	27	27.7.j	TL	31	6 128253	0.0968
mac	2021	1	27	27.7.j	TL	32	12 256507	0.1935
mac	2021	1	27	27.7.j	TL	33	9 192380	0.1452
mac	2021	1	27	27.7.j	TL	34	8 171004	0.1290
mac	2021	1	27	27.7.j	TL	35	8 106877	0.0806
mac	2021	1	27	27.7.j	TL	36	11 149629	0.1129
mac	2021	1	27	27.7.j	TL	37	9 85502	0.0645
mac	2021	1	27	27.7.j	TL	38	7 149629	0.1129
mac	2021	1	27	27.7.j	TL	39	3 21375	0.0161
mac	2021	2	27	27.6.a	TL	32	1 19069	0.0216
mac	2021	2	27	27.6.a	TL	33	3 54106	0.0613
mac	2021	2	27	27.6.a	TL	34	7 77064	0.0873
mac	2021	2	27	27.6.a	TL	35	9 115011	0.1303
mac	2021	2	27	27.6.a	TL	36	14 180151	0.2040
mac	2021	2	27	27.6.a	TL	37	11 161067	0.1824
mac	2021	2	27	27.6.a	TL	38	8 99500	0.1127
mac	2021	2	27	27.6.a	TL	39	6 94816	0.1074
mac	2021	2	27	27.6.a	TL	40	4 66247	0.0750
mac	2021	2	27	27.6.a	TL	42	1 15967	0.0181
mac	2021	2	27	27.7.b	TL	38	1 6127	0.5000
mac	2021	2	27	27.7.b	TL	40	1 6127	0.5000
mac	2021	3	27	27.4.a	TL	24	1 9442	0.0054
mac	2021	3	27	27.4.a	TL	25	5 43353	0.0249
mac	2021	3	27	27.4.a	TL	26	12 97836	0.0561
mac	2021	3	27	27.4.a	TL	27	2 10111	0.0058
mac	2021	3	27	27.4.a	TL	28	2 9810	0.0056
mac	2021	3	27	27.4.a	TL	29	10 98209	0.0563
mac	2021	3	27	27.4.a	TL	30	23 131613	0.0755
mac	2021	3	27	27.4.a	TL	31	16 127653	0.0732
mac	2021	3	27	27.4.a	TL	32	28 166532	0.0955
mac	2021	3	27	27.4.a	TL	33	23 149258	0.0856
mac	2021	3	27	27.4.a	TL	34	26 179596	0.1030
mac	2021	3	27	27.4.a	TL	35	23 173859	0.0998
mac	2021	3	27	27.4.a	TL	36	25 179053	0.1027
mac	2021	3	27	27.4.a	TL	37	24 155003	0.0889
mac	2021	3	27	27.4.a	TL	38	19 123471	0.0708
mac	2021	3	27	27.4.a	TL	39	11 74916	0.0430
mac	2021	3	27	27.4.a	TL	40	2 13203	0.0076
mac	2021	3	27	27.6.a	TL	14	4 14157	0.0952
mac	2021	3	27	27.6.a	TL	15	17 60167	0.4048
mac	2021	3	27	27.6.a	TL	16	14 49549	0.3333
mac	2021	3	27	27.6.a	TL	17	5 17696	0.1190
mac	2021	3	27	27.6.a	TL	18	2 7078	0.0476
mac	2021	3	27	27.7.b	TL	28	9 112126	0.1232
mac	2021	3	27	27.7.b	TL	29	13 203625	0.2238
mac	2021	3	27	27.7.b	TL	30	11 141073	0.1550
mac	2021	3	27	27.7.b	TL	31	7 76669	0.0843
mac	2021	3	27	27.7.b	TL	32	4 25451	0.0280
mac	2021	3	27	27.7.b	TL	33	6 23804	0.0262
mac	2021	3	27	27.7.b	TL	34	4 35446	0.0390
mac	2021	3	27	27.7.b	TL	35	13 115133	0.1265
mac	2021	3	27	27.7.b	TL	36	8 64557	0.0710
mac	2021	3	27	27.7.b	TL	37	2 23926	0.0263
mac	2021	3	27	27.7.b	TL	38	7 66987	0.0736
mac	2021	3	27	27.7.b	TL	39	2 17577	0.0193
mac	2021	3	27	27.7.b	TL	40	1 3499	0.0038
mac	2021	3	27	27.7.j	TL	27	1 2840	0.0020
mac	2021	3	27	27.7.j	TL	28	16 151373	0.1086
mac	2021	3	27	27.7.j	TL	29	11 47096	0.0338
mac	2021	3	27	27.7.j	TL	30	9 53242	0.0382
mac	2021	3	27	27.7.j	TL	31	12 62300	0.0447
mac	2021	3	27	27.7.j	TL	32	6 27933	0.0200
mac	2021	3	27	27.7.j	TL	33	18 116680	0.0837
mac	2021	3	27	27.7.j	TL	34	14 154071	0.1105
mac	2021	3	27	27.7.j	TL	35	29 191132	0.1371
mac	2021	3	27	27.7.j	TL	36	32 259037	0.1858

mac	2021	3	27	27.7.j	TL	37	32	150305	0.1078
mac	2021	3	27	27.7.j	TL	38	15	80969	0.0581
mac	2021	3	27	27.7.j	TL	39	7	70033	0.0502
mac	2021	3	27	27.7.j	TL	40	5	16515	0.0118
mac	2021	3	27	27.7.j	TL	41	1	10581	0.0076
mac	2021	4	27	27.2.a	TL	35	4	1061	0.0337
mac	2021	4	27	27.2.a	TL	36	4	1141	0.0362
mac	2021	4	27	27.2.a	TL	37	14	18943	0.6011
mac	2021	4	27	27.2.a	TL	38	19	5141	0.1631
mac	2021	4	27	27.2.a	TL	39	10	2534	0.0804
mac	2021	4	27	27.2.a	TL	40	8	2202	0.0699
mac	2021	4	27	27.2.a	TL	41	2	490	0.0155
mac	2021	4	27	27.4.a	TL	23	1	11982	0.0002
mac	2021	4	27	27.4.a	TL	24	9	108983	0.0015
mac	2021	4	27	27.4.a	TL	25	21	231669	0.0031
mac	2021	4	27	27.4.a	TL	26	76	793340	0.0107
mac	2021	4	27	27.4.a	TL	27	138	1561556	0.0210
mac	2021	4	27	27.4.a	TL	28	138	1922592	0.0258
mac	2021	4	27	27.4.a	TL	29	190	2253457	0.0303
mac	2021	4	27	27.4.a	TL	30	253	2750277	0.0370
mac	2021	4	27	27.4.a	TL	31	318	3004111	0.0404
mac	2021	4	27	27.4.a	TL	32	392	4157073	0.0559
mac	2021	4	27	27.4.a	TL	33	482	5170802	0.0695
mac	2021	4	27	27.4.a	TL	34	651	6524440	0.0877
mac	2021	4	27	27.4.a	TL	35	902	8714365	0.1171
mac	2021	4	27	27.4.a	TL	36	1037	9457713	0.1271
mac	2021	4	27	27.4.a	TL	37	1253	11146124	0.1498
mac	2021	4	27	27.4.a	TL	38	1084	8877236	0.1193
mac	2021	4	27	27.4.a	TL	39	603	4858841	0.0653
mac	2021	4	27	27.4.a	TL	40	263	2138178	0.0287
mac	2021	4	27	27.4.a	TL	41	69	522747	0.0070
mac	2021	4	27	27.4.a	TL	42	17	176805	0.0024
mac	2021	4	27	27.4.a	TL	43	3	24148	0.0003
mac	2021	4	27	27.4.a	TL	44	2	5576	0.0001
mac	2021	4	27	27.7.j	TL	30	1	1413	1.0000

Western horse mackerel Length frequencies 2022

species	year	quarter	area	division	lengthtype	length	count	catchnumber	prop
mac	2022	1	27	27.4.a	TL	26	9	33098	0.0014
mac	2022	1	27	27.4.a	TL	27	52	340439	0.0144
mac	2022	1	27	27.4.a	TL	28	44	336042	0.0142
mac	2022	1	27	27.4.a	TL	29	54	396568	0.0168
mac	2022	1	27	27.4.a	TL	30	59	388841	0.0165
mac	2022	1	27	27.4.a	TL	31	62	440724	0.0187
mac	2022	1	27	27.4.a	TL	32	68	505194	0.0214
mac	2022	1	27	27.4.a	TL	33	84	482556	0.0205
mac	2022	1	27	27.4.a	TL	34	159	1033678	0.0438
mac	2022	1	27	27.4.a	TL	35	241	1684979	0.0714
mac	2022	1	27	27.4.a	TL	36	392	2663419	0.1129
mac	2022	1	27	27.4.a	TL	37	576	4055936	0.1719
mac	2022	1	27	27.4.a	TL	38	626	4511764	0.1913
mac	2022	1	27	27.4.a	TL	39	481	3759345	0.1594
mac	2022	1	27	27.4.a	TL	40	256	1875541	0.0795
mac	2022	1	27	27.4.a	TL	41	92	770072	0.0326
mac	2022	1	27	27.4.a	TL	42	21	243746	0.0103
mac	2022	1	27	27.4.a	TL	43	2	7439	0.0003
mac	2022	1	27	27.4.a	TL	44	3	58790	0.0025
mac	2022	1	27	27.6.a	TL	17	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	18	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	19	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	23	4	15424	0.0010
mac	2022	1	27	27.6.a	TL	24	5	30313	0.0020
mac	2022	1	27	27.6.a	TL	25	8	34891	0.0023
mac	2022	1	27	27.6.a	TL	26	12	85246	0.0057
mac	2022	1	27	27.6.a	TL	27	14	137644	0.0091
mac	2022	1	27	27.6.a	TL	28	24	273784	0.0182
mac	2022	1	27	27.6.a	TL	29	22	150308	0.0100
mac	2022	1	27	27.6.a	TL	30	45	398239	0.0265
mac	2022	1	27	27.6.a	TL	31	64	554722	0.0368
mac	2022	1	27	27.6.a	TL	32	84	782862	0.0520
mac	2022	1	27	27.6.a	TL	33	120	1156090	0.0768
mac	2022	1	27	27.6.a	TL	34	95	882994	0.0586
mac	2022	1	27	27.6.a	TL	35	115	1091725	0.0725
mac	2022	1	27	27.6.a	TL	36	105	1096835	0.0728
mac	2022	1	27	27.6.a	TL	37	209	2050525	0.1362

mac	2022	1	27	27.6.a	TL	38	274 2565070	0.1704
mac	2022	1	27	27.6.a	TL	39	214 2171710	0.1442
mac	2022	1	27	27.6.a	TL	40	117 1193579	0.0793
mac	2022	1	27	27.6.a	TL	41	29 282289	0.0187
mac	2022	1	27	27.6.a	TL	42	7 89517	0.0059
mac	2022	1	27	27.7.b	TL	20	3 34527	0.0034
mac	2022	1	27	27.7.b	TL	21	5 57545	0.0056
mac	2022	1	27	27.7.b	TL	22	7 80563	0.0079
mac	2022	1	27	27.7.b	TL	23	7 80563	0.0079
mac	2022	1	27	27.7.b	TL	24	4 46036	0.0045
mac	2022	1	27	27.7.b	TL	25	5 57545	0.0056
mac	2022	1	27	27.7.b	TL	26	4 46036	0.0045
mac	2022	1	27	27.7.b	TL	27	4 35245	0.0035
mac	2022	1	27	27.7.b	TL	28	3 31860	0.0031
mac	2022	1	27	27.7.b	TL	29	7 84735	0.0083
mac	2022	1	27	27.7.b	TL	30	25 216377	0.0212
mac	2022	1	27	27.7.b	TL	31	24 196195	0.0192
mac	2022	1	27	27.7.b	TL	32	31 296552	0.0291
mac	2022	1	27	27.7.b	TL	33	45 315556	0.0310
mac	2022	1	27	27.7.b	TL	34	72 507485	0.0498
mac	2022	1	27	27.7.b	TL	35	162 1101891	0.1081
mac	2022	1	27	27.7.b	TL	36	203 1318078	0.1293
mac	2022	1	27	27.7.b	TL	37	201 1323574	0.1298
mac	2022	1	27	27.7.b	TL	38	270 1866023	0.1831
mac	2022	1	27	27.7.b	TL	39	211 1395078	0.1369
mac	2022	1	27	27.7.b	TL	40	110 751821	0.0738
mac	2022	1	27	27.7.b	TL	41	34 283483	0.0278
mac	2022	1	27	27.7.b	TL	42	6 46318	0.0045
mac	2022	1	27	27.7.b	TL	43	3 9300	0.0009
mac	2022	1	27	27.7.b	TL	44	1 10778	0.0011
mac	2022	1	27	27.7.j	TL	25	2 6604	0.0129
mac	2022	1	27	27.7.j	TL	26	1 3302	0.0064
mac	2022	1	27	27.7.j	TL	27	3 14565	0.0284
mac	2022	1	27	27.7.j	TL	28	6 20668	0.0403
mac	2022	1	27	27.7.j	TL	29	10 46168	0.0899
mac	2022	1	27	27.7.j	TL	30	20 74332	0.1448
mac	2022	1	27	27.7.j	TL	31	16 73536	0.1432
mac	2022	1	27	27.7.j	TL	32	13 59549	0.1160
mac	2022	1	27	27.7.j	TL	33	15 55851	0.1088
mac	2022	1	27	27.7.j	TL	34	15 44410	0.0865
mac	2022	1	27	27.7.j	TL	35	16 30610	0.0596
mac	2022	1	27	27.7.j	TL	36	17 21822	0.0425
mac	2022	1	27	27.7.j	TL	37	11 26273	0.0512
mac	2022	1	27	27.7.j	TL	38	8 18422	0.0359
mac	2022	1	27	27.7.j	TL	39	6 12616	0.0246
mac	2022	1	27	27.7.j	TL	40	3 4754	0.0093
mac	2022	2	27	27.6.a	TL	34	4 20848	0.1319
mac	2022	2	27	27.6.a	TL	35	5 31786	0.2011
mac	2022	2	27	27.6.a	TL	36	5 28235	0.1786
mac	2022	2	27	27.6.a	TL	37	6 27219	0.1722
mac	2022	2	27	27.6.a	TL	38	6 28043	0.1774
mac	2022	2	27	27.6.a	TL	39	3 14125	0.0894
mac	2022	2	27	27.6.a	TL	40	1 2102	0.0133
mac	2022	2	27	27.6.a	TL	41	1 2102	0.0133
mac	2022	2	27	27.6.a	TL	42	1 3602	0.0228
mac	2022	3	27	27.4.a	TL	26	1 3261	0.0010
mac	2022	3	27	27.4.a	TL	29	9 102965	0.0330
mac	2022	3	27	27.4.a	TL	30	68 847404	0.2719
mac	2022	3	27	27.4.a	TL	31	65 831571	0.2668
mac	2022	3	27	27.4.a	TL	32	53 568987	0.1825
mac	2022	3	27	27.4.a	TL	33	36 409378	0.1313
mac	2022	3	27	27.4.a	TL	34	11 109308	0.0351
mac	2022	3	27	27.4.a	TL	35	4 54797	0.0176
mac	2022	3	27	27.4.a	TL	36	4 67573	0.0217
mac	2022	3	27	27.4.a	TL	37	5 74347	0.0239
mac	2022	3	27	27.4.a	TL	38	3 47380	0.0152
mac	2022	3	27	27.7.b	TL	32	1 873	0.0833
mac	2022	3	27	27.7.b	TL	34	5 4369	0.4168
mac	2022	3	27	27.7.b	TL	35	1 873	0.0833
mac	2022	3	27	27.7.b	TL	36	1 873	0.0833
mac	2022	3	27	27.7.b	TL	37	2 1747	0.1667
mac	2022	3	27	27.7.b	TL	38	1 873	0.0833
mac	2022	3	27	27.7.b	TL	40	1 873	0.0833
mac	2022	3	27	27.7.j	TL	31	1 4751	0.0457
mac	2022	3	27	27.7.j	TL	32	2 17221	0.1656
mac	2022	3	27	27.7.j	TL	33	1 12469	0.1199
mac	2022	3	27	27.7.j	TL	34	1 9293	0.0894
mac	2022	3	27	27.7.j	TL	35	3 14255	0.1371
mac	2022	3	27	27.7.j	TL	36	2 9503	0.0914
mac	2022	3	27	27.7.j	TL	37	1 13494	0.1298

mac	2022	3	27 27.7.j	TL	38	2 18246	0.1755
mac	2022	3	27 27.7.j	TL	39	1 4751	0.0457

10 North Sea horse mackerel: detailed tables

North Sea horse mackerel Sampling overview

species	year	quarter	area	division	catch	sampleweight	nsamples	count	catchnumber
mac	2021	1	27	27.4.a	739	20	1	49	370
mac	2021	1	27	27.6.a	21577	490	69	2483	22508
mac	2021	1	27	27.7.b	672	28	6	67	452
mac	2021	1	27	27.7.j	334	26	2	76	1325
mac	2021	2	27	27.4.a	38	NA	NA	NA	NA
mac	2021	2	27	27.6.a	406	25	6	64	883
mac	2021	2	27	27.7.b	53	0	1	2	12
mac	2021	3	27	27.4.a	2991	46	20	252	1742
mac	2021	3	27	27.6.a	4	1	1	42	148
mac	2021	3	27	27.7.b	368	24	9	87	909
mac	2021	3	27	27.7.j	525	73	27	208	1394
mac	2021	4	27	27.2.a	8	29	3	61	31
mac	2021	4	27	27.4.a	40743	2269	201	7902	74412
mac	2021	4	27	27.7.j	0	0	1	1	1
mac	2022	1	27	27.4.a	11645	1045	72	3281	23588
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	402	58	22	162	513
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	27.4.a	238	77	12	259	3116
mac	2022	3	27	27.7.b	3	5	1	12	10
mac	2022	3	27	27.7.j	3	4	4	14	103

North Sea horse mackerel Length frequencies 2021

species	year	quarter	area	division	lengthtype	length	count	catchnumber	prop
mac	2021	1	27	27.4.a	TL	27	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	28	3	22662	0.0612
mac	2021	1	27	27.4.a	TL	29	2	15108	0.0408
mac	2021	1	27	27.4.a	TL	30	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	31	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	32	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	33	2	15108	0.0408
mac	2021	1	27	27.4.a	TL	34	4	30216	0.0816
mac	2021	1	27	27.4.a	TL	35	7	52878	0.1429
mac	2021	1	27	27.4.a	TL	36	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	37	5	37770	0.1020
mac	2021	1	27	27.4.a	TL	38	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	39	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	40	4	30216	0.0816
mac	2021	1	27	27.6.a	TL	20	1	7036	0.0003
mac	2021	1	27	27.6.a	TL	21	1	5983	0.0003
mac	2021	1	27	27.6.a	TL	22	2	12764	0.0006
mac	2021	1	27	27.6.a	TL	24	2	10452	0.0005
mac	2021	1	27	27.6.a	TL	25	9	47828	0.0021
mac	2021	1	27	27.6.a	TL	26	10	61280	0.0027
mac	2021	1	27	27.6.a	TL	27	25	245675	0.0109
mac	2021	1	27	27.6.a	TL	28	16	198136	0.0088
mac	2021	1	27	27.6.a	TL	29	30	303481	0.0135
mac	2021	1	27	27.6.a	TL	30	43	331822	0.0147
mac	2021	1	27	27.6.a	TL	31	36	222011	0.0099
mac	2021	1	27	27.6.a	TL	32	88	746047	0.0331
mac	2021	1	27	27.6.a	TL	33	145	1154437	0.0513
mac	2021	1	27	27.6.a	TL	34	193	1641334	0.0729
mac	2021	1	27	27.6.a	TL	35	270	2158065	0.0959
mac	2021	1	27	27.6.a	TL	36	372	3205188	0.1424
mac	2021	1	27	27.6.a	TL	37	498	4794277	0.2130
mac	2021	1	27	27.6.a	TL	38	386	3699361	0.1644
mac	2021	1	27	27.6.a	TL	39	195	2138953	0.0950
mac	2021	1	27	27.6.a	TL	40	110	1122308	0.0499
mac	2021	1	27	27.6.a	TL	41	40	322748	0.0143
mac	2021	1	27	27.6.a	TL	42	8	58488	0.0026
mac	2021	1	27	27.6.a	TL	43	2	11590	0.0005
mac	2021	1	27	27.6.a	TL	46	1	9415	0.0004
mac	2021	1	27	27.7.b	TL	31	1	158	0.0003

mac	2021	1	27	27.7.b	TL	32	1	158	0.0003
mac	2021	1	27	27.7.b	TL	33	1	9116	0.0202
mac	2021	1	27	27.7.b	TL	34	3	27349	0.0605
mac	2021	1	27	27.7.b	TL	35	1	5243	0.0116
mac	2021	1	27	27.7.b	TL	36	7	44463	0.0983
mac	2021	1	27	27.7.b	TL	37	11	69334	0.1534
mac	2021	1	27	27.7.b	TL	38	18	125023	0.2765
mac	2021	1	27	27.7.b	TL	39	15	112427	0.2487
mac	2021	1	27	27.7.b	TL	40	7	44475	0.0984
mac	2021	1	27	27.7.b	TL	41	1	5243	0.0116
mac	2021	1	27	27.7.b	TL	42	1	9116	0.0202
mac	2021	1	27	27.7.j	TL	28	1	21375	0.0161
mac	2021	1	27	27.7.j	TL	29	1	21375	0.0161
mac	2021	1	27	27.7.j	TL	30	1	21375	0.0161
mac	2021	1	27	27.7.j	TL	31	6	128253	0.0968
mac	2021	1	27	27.7.j	TL	32	12	256507	0.1935
mac	2021	1	27	27.7.j	TL	33	9	192380	0.1452
mac	2021	1	27	27.7.j	TL	34	8	171004	0.1290
mac	2021	1	27	27.7.j	TL	35	8	106877	0.0806
mac	2021	1	27	27.7.j	TL	36	11	149629	0.1129
mac	2021	1	27	27.7.j	TL	37	9	85502	0.0645
mac	2021	1	27	27.7.j	TL	38	7	149629	0.1129
mac	2021	1	27	27.7.j	TL	39	3	21375	0.0161
mac	2021	2	27	27.6.a	TL	32	1	19069	0.0216
mac	2021	2	27	27.6.a	TL	33	3	54106	0.0613
mac	2021	2	27	27.6.a	TL	34	7	77064	0.0873
mac	2021	2	27	27.6.a	TL	35	9	115011	0.1303
mac	2021	2	27	27.6.a	TL	36	14	180151	0.2040
mac	2021	2	27	27.6.a	TL	37	11	161067	0.1824
mac	2021	2	27	27.6.a	TL	38	8	99500	0.1127
mac	2021	2	27	27.6.a	TL	39	6	94816	0.1074
mac	2021	2	27	27.6.a	TL	40	4	66247	0.0750
mac	2021	2	27	27.6.a	TL	42	1	15967	0.0181
mac	2021	2	27	27.7.b	TL	38	1	6127	0.5000
mac	2021	2	27	27.7.b	TL	40	1	6127	0.5000
mac	2021	3	27	27.4.a	TL	24	1	9442	0.0054
mac	2021	3	27	27.4.a	TL	25	5	43353	0.0249
mac	2021	3	27	27.4.a	TL	26	12	97836	0.0561
mac	2021	3	27	27.4.a	TL	27	2	10111	0.0058
mac	2021	3	27	27.4.a	TL	28	2	9810	0.0056
mac	2021	3	27	27.4.a	TL	29	10	98209	0.0563
mac	2021	3	27	27.4.a	TL	30	23	131613	0.0755
mac	2021	3	27	27.4.a	TL	31	16	127653	0.0732
mac	2021	3	27	27.4.a	TL	32	28	166532	0.0955
mac	2021	3	27	27.4.a	TL	33	23	149258	0.0856
mac	2021	3	27	27.4.a	TL	34	26	179596	0.1030
mac	2021	3	27	27.4.a	TL	35	23	173859	0.0998
mac	2021	3	27	27.4.a	TL	36	25	179053	0.1027
mac	2021	3	27	27.4.a	TL	37	24	155003	0.0889
mac	2021	3	27	27.4.a	TL	38	19	123471	0.0708
mac	2021	3	27	27.4.a	TL	39	11	74916	0.0430
mac	2021	3	27	27.4.a	TL	40	2	13203	0.0076
mac	2021	3	27	27.6.a	TL	14	4	14157	0.0952
mac	2021	3	27	27.6.a	TL	15	17	60167	0.4048
mac	2021	3	27	27.6.a	TL	16	14	49549	0.3333
mac	2021	3	27	27.6.a	TL	17	5	17696	0.1190
mac	2021	3	27	27.6.a	TL	18	2	7078	0.0476
mac	2021	3	27	27.7.b	TL	28	9	112126	0.1232
mac	2021	3	27	27.7.b	TL	29	13	203625	0.2238
mac	2021	3	27	27.7.b	TL	30	11	141073	0.1550
mac	2021	3	27	27.7.b	TL	31	7	76669	0.0843
mac	2021	3	27	27.7.b	TL	32	4	25451	0.0280
mac	2021	3	27	27.7.b	TL	33	6	23804	0.0262
mac	2021	3	27	27.7.b	TL	34	4	35446	0.0390
mac	2021	3	27	27.7.b	TL	35	13	115133	0.1265
mac	2021	3	27	27.7.b	TL	36	8	64557	0.0710
mac	2021	3	27	27.7.b	TL	37	2	23926	0.0263
mac	2021	3	27	27.7.b	TL	38	7	66987	0.0736
mac	2021	3	27	27.7.b	TL	39	2	17577	0.0193
mac	2021	3	27	27.7.b	TL	40	1	3499	0.0038
mac	2021	3	27	27.7.j	TL	27	1	2840	0.0020
mac	2021	3	27	27.7.j	TL	28	16	151373	0.1086
mac	2021	3	27	27.7.j	TL	29	11	47096	0.0338
mac	2021	3	27	27.7.j	TL	30	9	53242	0.0382
mac	2021	3	27	27.7.j	TL	31	12	62300	0.0447
mac	2021	3	27	27.7.j	TL	32	6	27933	0.0200
mac	2021	3	27	27.7.j	TL	33	18	116680	0.0837
mac	2021	3	27	27.7.j	TL	34	14	154071	0.1105
mac	2021	3	27	27.7.j	TL	35	29	191132	0.1371
mac	2021	3	27	27.7.j	TL	36	32	259037	0.1858

mac	2021	3	27	27.7.j	TL	37	32	150305	0.1078
mac	2021	3	27	27.7.j	TL	38	15	80969	0.0581
mac	2021	3	27	27.7.j	TL	39	7	70033	0.0502
mac	2021	3	27	27.7.j	TL	40	5	16515	0.0118
mac	2021	3	27	27.7.j	TL	41	1	10581	0.0076
mac	2021	4	27	27.2.a	TL	35	4	1061	0.0337
mac	2021	4	27	27.2.a	TL	36	4	1141	0.0362
mac	2021	4	27	27.2.a	TL	37	14	18943	0.6011
mac	2021	4	27	27.2.a	TL	38	19	5141	0.1631
mac	2021	4	27	27.2.a	TL	39	10	2534	0.0804
mac	2021	4	27	27.2.a	TL	40	8	2202	0.0699
mac	2021	4	27	27.2.a	TL	41	2	490	0.0155
mac	2021	4	27	27.4.a	TL	23	1	11982	0.0002
mac	2021	4	27	27.4.a	TL	24	9	108983	0.0015
mac	2021	4	27	27.4.a	TL	25	21	231669	0.0031
mac	2021	4	27	27.4.a	TL	26	76	793340	0.0107
mac	2021	4	27	27.4.a	TL	27	138	1561556	0.0210
mac	2021	4	27	27.4.a	TL	28	138	1922592	0.0258
mac	2021	4	27	27.4.a	TL	29	190	2253457	0.0303
mac	2021	4	27	27.4.a	TL	30	253	2750277	0.0370
mac	2021	4	27	27.4.a	TL	31	318	3004111	0.0404
mac	2021	4	27	27.4.a	TL	32	392	4157073	0.0559
mac	2021	4	27	27.4.a	TL	33	482	5170802	0.0695
mac	2021	4	27	27.4.a	TL	34	651	6524440	0.0877
mac	2021	4	27	27.4.a	TL	35	902	8714365	0.1171
mac	2021	4	27	27.4.a	TL	36	1037	9457713	0.1271
mac	2021	4	27	27.4.a	TL	37	1253	11146124	0.1498
mac	2021	4	27	27.4.a	TL	38	1084	8877236	0.1193
mac	2021	4	27	27.4.a	TL	39	603	4858841	0.0653
mac	2021	4	27	27.4.a	TL	40	263	2138178	0.0287
mac	2021	4	27	27.4.a	TL	41	69	522747	0.0070
mac	2021	4	27	27.4.a	TL	42	17	176805	0.0024
mac	2021	4	27	27.4.a	TL	43	3	24148	0.0003
mac	2021	4	27	27.4.a	TL	44	2	5576	0.0001
mac	2021	4	27	27.7.j	TL	30	1	1413	1.0000

North Sea horse mackerel Length frequencies 2022

species	year	quarter	area	division	lengthtype	length	count	catchnumber	prop
mac	2022	1	27	27.4.a	TL	26	9	33098	0.0014
mac	2022	1	27	27.4.a	TL	27	52	340439	0.0144
mac	2022	1	27	27.4.a	TL	28	44	336042	0.0142
mac	2022	1	27	27.4.a	TL	29	54	396568	0.0168
mac	2022	1	27	27.4.a	TL	30	59	388841	0.0165
mac	2022	1	27	27.4.a	TL	31	62	440724	0.0187
mac	2022	1	27	27.4.a	TL	32	68	505194	0.0214
mac	2022	1	27	27.4.a	TL	33	84	482556	0.0205
mac	2022	1	27	27.4.a	TL	34	159	1033678	0.0438
mac	2022	1	27	27.4.a	TL	35	241	1684979	0.0714
mac	2022	1	27	27.4.a	TL	36	392	2663419	0.1129
mac	2022	1	27	27.4.a	TL	37	576	4055936	0.1719
mac	2022	1	27	27.4.a	TL	38	626	4511764	0.1913
mac	2022	1	27	27.4.a	TL	39	481	3759345	0.1594
mac	2022	1	27	27.4.a	TL	40	256	1875541	0.0795
mac	2022	1	27	27.4.a	TL	41	92	770072	0.0326
mac	2022	1	27	27.4.a	TL	42	21	243746	0.0103
mac	2022	1	27	27.4.a	TL	43	2	7439	0.0003
mac	2022	1	27	27.4.a	TL	44	3	58790	0.0025
mac	2022	1	27	27.6.a	TL	17	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	18	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	19	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	23	4	15424	0.0010
mac	2022	1	27	27.6.a	TL	24	5	30313	0.0020
mac	2022	1	27	27.6.a	TL	25	8	34891	0.0023
mac	2022	1	27	27.6.a	TL	26	12	85246	0.0057
mac	2022	1	27	27.6.a	TL	27	14	137644	0.0091
mac	2022	1	27	27.6.a	TL	28	24	273784	0.0182
mac	2022	1	27	27.6.a	TL	29	22	150308	0.0100
mac	2022	1	27	27.6.a	TL	30	45	398239	0.0265
mac	2022	1	27	27.6.a	TL	31	64	554722	0.0368
mac	2022	1	27	27.6.a	TL	32	84	782862	0.0520
mac	2022	1	27	27.6.a	TL	33	120	1156090	0.0768
mac	2022	1	27	27.6.a	TL	34	95	882994	0.0586
mac	2022	1	27	27.6.a	TL	35	115	1091725	0.0725
mac	2022	1	27	27.6.a	TL	36	105	1096835	0.0728
mac	2022	1	27	27.6.a	TL	37	209	2050525	0.1362

mac	2022	1	27	27.6.a	TL	38	274	2565070	0.1704
mac	2022	1	27	27.6.a	TL	39	214	2171710	0.1442
mac	2022	1	27	27.6.a	TL	40	117	1193579	0.0793
mac	2022	1	27	27.6.a	TL	41	29	282289	0.0187
mac	2022	1	27	27.6.a	TL	42	7	89517	0.0059
mac	2022	1	27	27.7.b	TL	20	3	34527	0.0034
mac	2022	1	27	27.7.b	TL	21	5	57545	0.0056
mac	2022	1	27	27.7.b	TL	22	7	80563	0.0079
mac	2022	1	27	27.7.b	TL	23	7	80563	0.0079
mac	2022	1	27	27.7.b	TL	24	4	46036	0.0045
mac	2022	1	27	27.7.b	TL	25	5	57545	0.0056
mac	2022	1	27	27.7.b	TL	26	4	46036	0.0045
mac	2022	1	27	27.7.b	TL	27	4	35245	0.0035
mac	2022	1	27	27.7.b	TL	28	3	31860	0.0031
mac	2022	1	27	27.7.b	TL	29	7	84735	0.0083
mac	2022	1	27	27.7.b	TL	30	25	216377	0.0212
mac	2022	1	27	27.7.b	TL	31	24	196195	0.0192
mac	2022	1	27	27.7.b	TL	32	31	296552	0.0291
mac	2022	1	27	27.7.b	TL	33	45	315556	0.0310
mac	2022	1	27	27.7.b	TL	34	72	507485	0.0498
mac	2022	1	27	27.7.b	TL	35	162	1101891	0.1081
mac	2022	1	27	27.7.b	TL	36	203	1318078	0.1293
mac	2022	1	27	27.7.b	TL	37	201	1323574	0.1298
mac	2022	1	27	27.7.b	TL	38	270	1866023	0.1831
mac	2022	1	27	27.7.b	TL	39	211	1395078	0.1369
mac	2022	1	27	27.7.b	TL	40	110	751821	0.0738
mac	2022	1	27	27.7.b	TL	41	34	283483	0.0278
mac	2022	1	27	27.7.b	TL	42	6	46318	0.0045
mac	2022	1	27	27.7.b	TL	43	3	9300	0.0009
mac	2022	1	27	27.7.b	TL	44	1	10778	0.0011
mac	2022	1	27	27.7.j	TL	25	2	6604	0.0129
mac	2022	1	27	27.7.j	TL	26	1	3302	0.0064
mac	2022	1	27	27.7.j	TL	27	3	14565	0.0284
mac	2022	1	27	27.7.j	TL	28	6	20668	0.0403
mac	2022	1	27	27.7.j	TL	29	10	46168	0.0899
mac	2022	1	27	27.7.j	TL	30	20	74332	0.1448
mac	2022	1	27	27.7.j	TL	31	16	73536	0.1432
mac	2022	1	27	27.7.j	TL	32	13	59549	0.1160
mac	2022	1	27	27.7.j	TL	33	15	55851	0.1088
mac	2022	1	27	27.7.j	TL	34	15	44410	0.0865
mac	2022	1	27	27.7.j	TL	35	16	30610	0.0596
mac	2022	1	27	27.7.j	TL	36	17	21822	0.0425
mac	2022	1	27	27.7.j	TL	37	11	26273	0.0512
mac	2022	1	27	27.7.j	TL	38	8	18422	0.0359
mac	2022	1	27	27.7.j	TL	39	6	12616	0.0246
mac	2022	1	27	27.7.j	TL	40	3	4754	0.0093
mac	2022	2	27	27.6.a	TL	34	4	20848	0.1319
mac	2022	2	27	27.6.a	TL	35	5	31786	0.2011
mac	2022	2	27	27.6.a	TL	36	5	28235	0.1786
mac	2022	2	27	27.6.a	TL	37	6	27219	0.1722
mac	2022	2	27	27.6.a	TL	38	6	28043	0.1774
mac	2022	2	27	27.6.a	TL	39	3	14125	0.0894
mac	2022	2	27	27.6.a	TL	40	1	2102	0.0133
mac	2022	2	27	27.6.a	TL	41	1	2102	0.0133
mac	2022	2	27	27.6.a	TL	42	1	3602	0.0228
mac	2022	3	27	27.4.a	TL	26	1	3261	0.0010
mac	2022	3	27	27.4.a	TL	29	9	102965	0.0330
mac	2022	3	27	27.4.a	TL	30	68	847404	0.2719
mac	2022	3	27	27.4.a	TL	31	65	831571	0.2668
mac	2022	3	27	27.4.a	TL	32	53	568987	0.1825
mac	2022	3	27	27.4.a	TL	33	36	409378	0.1313
mac	2022	3	27	27.4.a	TL	34	11	109308	0.0351
mac	2022	3	27	27.4.a	TL	35	4	54797	0.0176
mac	2022	3	27	27.4.a	TL	36	4	67573	0.0217
mac	2022	3	27	27.4.a	TL	37	5	74347	0.0239
mac	2022	3	27	27.4.a	TL	38	3	47380	0.0152
mac	2022	3	27	27.7.b	TL	32	1	873	0.0833
mac	2022	3	27	27.7.b	TL	34	5	4369	0.4168
mac	2022	3	27	27.7.b	TL	35	1	873	0.0833
mac	2022	3	27	27.7.b	TL	36	1	873	0.0833
mac	2022	3	27	27.7.b	TL	37	2	1747	0.1667
mac	2022	3	27	27.7.b	TL	38	1	873	0.0833
mac	2022	3	27	27.7.b	TL	40	1	873	0.0833
mac	2022	3	27	27.7.j	TL	31	1	4751	0.0457
mac	2022	3	27	27.7.j	TL	32	2	17221	0.1656
mac	2022	3	27	27.7.j	TL	33	1	12469	0.1199
mac	2022	3	27	27.7.j	TL	34	1	9293	0.0894
mac	2022	3	27	27.7.j	TL	35	3	14255	0.1371
mac	2022	3	27	27.7.j	TL	36	2	9503	0.0914
mac	2022	3	27	27.7.j	TL	37	1	13494	0.1298

mac	2022	3	27 27.7.j	TL	38	2 18246	0.1755
mac	2022	3	27 27.7.j	TL	39	1 4751	0.0457

11 Blue whiting: detailed tables

Blue whiting Sampling overview

species	year	quarter	area	division	catch	sampleweight	nsamples	count	catchnumber
mac	2021	1	27	27.4.a	739	20	1	49	370
mac	2021	1	27	27.6.a	21577	490	69	2483	22508
mac	2021	1	27	27.7.b	672	28	6	67	452
mac	2021	1	27	27.7.j	334	26	2	76	1325
mac	2021	2	27	27.4.a	38	NA	NA	NA	NA
mac	2021	2	27	27.6.a	406	25	6	64	883
mac	2021	2	27	27.7.b	53	0	1	2	12
mac	2021	3	27	27.4.a	2991	46	20	252	1742
mac	2021	3	27	27.6.a	4	1	1	42	148
mac	2021	3	27	27.7.b	368	24	9	87	909
mac	2021	3	27	27.7.j	525	73	27	208	1394
mac	2021	4	27	27.2.a	8	29	3	61	31
mac	2021	4	27	27.4.a	40743	2269	201	7902	74412
mac	2021	4	27	27.7.j	0	0	1	1	1
mac	2022	1	27	27.4.a	11645	1045	72	3281	23588
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	402	58	22	162	513
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	27.4.a	238	77	12	259	3116
mac	2022	3	27	27.7.b	3	5	1	12	10
mac	2022	3	27	27.7.j	3	4	4	14	103

Blue whiting Length frequencies 2021

species	year	quarter	area	division	lengthtype	length	count	catchnumber	prop
mac	2021	1	27	27.4.a	TL	27	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	28	3	22662	0.0612
mac	2021	1	27	27.4.a	TL	29	2	15108	0.0408
mac	2021	1	27	27.4.a	TL	30	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	31	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	32	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	33	2	15108	0.0408
mac	2021	1	27	27.4.a	TL	34	4	30216	0.0816
mac	2021	1	27	27.4.a	TL	35	7	52878	0.1429
mac	2021	1	27	27.4.a	TL	36	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	37	5	37770	0.1020
mac	2021	1	27	27.4.a	TL	38	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	39	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	40	4	30216	0.0816
mac	2021	1	27	27.6.a	TL	20	1	7036	0.0003
mac	2021	1	27	27.6.a	TL	21	1	5983	0.0003
mac	2021	1	27	27.6.a	TL	22	2	12764	0.0006
mac	2021	1	27	27.6.a	TL	24	2	10452	0.0005
mac	2021	1	27	27.6.a	TL	25	9	47828	0.0021
mac	2021	1	27	27.6.a	TL	26	10	61280	0.0027
mac	2021	1	27	27.6.a	TL	27	25	245675	0.0109
mac	2021	1	27	27.6.a	TL	28	16	198136	0.0088
mac	2021	1	27	27.6.a	TL	29	30	303481	0.0135
mac	2021	1	27	27.6.a	TL	30	43	331822	0.0147
mac	2021	1	27	27.6.a	TL	31	36	222011	0.0099
mac	2021	1	27	27.6.a	TL	32	88	746047	0.0331
mac	2021	1	27	27.6.a	TL	33	145	1154437	0.0513
mac	2021	1	27	27.6.a	TL	34	193	1641334	0.0729
mac	2021	1	27	27.6.a	TL	35	270	2158065	0.0959
mac	2021	1	27	27.6.a	TL	36	372	3205188	0.1424
mac	2021	1	27	27.6.a	TL	37	498	4794277	0.2130
mac	2021	1	27	27.6.a	TL	38	386	3699361	0.1644
mac	2021	1	27	27.6.a	TL	39	195	2138953	0.0950
mac	2021	1	27	27.6.a	TL	40	110	1122308	0.0499
mac	2021	1	27	27.6.a	TL	41	40	322748	0.0143
mac	2021	1	27	27.6.a	TL	42	8	58488	0.0026
mac	2021	1	27	27.6.a	TL	43	2	11590	0.0005
mac	2021	1	27	27.6.a	TL	46	1	9415	0.0004
mac	2021	1	27	27.7.b	TL	31	1	158	0.0003

mac	2021	1	27	27.7.b	TL	32	1	158	0.0003
mac	2021	1	27	27.7.b	TL	33	1	9116	0.0202
mac	2021	1	27	27.7.b	TL	34	3	27349	0.0605
mac	2021	1	27	27.7.b	TL	35	1	5243	0.0116
mac	2021	1	27	27.7.b	TL	36	7	44463	0.0983
mac	2021	1	27	27.7.b	TL	37	11	69334	0.1534
mac	2021	1	27	27.7.b	TL	38	18	125023	0.2765
mac	2021	1	27	27.7.b	TL	39	15	112427	0.2487
mac	2021	1	27	27.7.b	TL	40	7	44475	0.0984
mac	2021	1	27	27.7.b	TL	41	1	5243	0.0116
mac	2021	1	27	27.7.b	TL	42	1	9116	0.0202
mac	2021	1	27	27.7.j	TL	28	1	21375	0.0161
mac	2021	1	27	27.7.j	TL	29	1	21375	0.0161
mac	2021	1	27	27.7.j	TL	30	1	21375	0.0161
mac	2021	1	27	27.7.j	TL	31	6	128253	0.0968
mac	2021	1	27	27.7.j	TL	32	12	256507	0.1935
mac	2021	1	27	27.7.j	TL	33	9	192380	0.1452
mac	2021	1	27	27.7.j	TL	34	8	171004	0.1290
mac	2021	1	27	27.7.j	TL	35	8	106877	0.0806
mac	2021	1	27	27.7.j	TL	36	11	149629	0.1129
mac	2021	1	27	27.7.j	TL	37	9	85502	0.0645
mac	2021	1	27	27.7.j	TL	38	7	149629	0.1129
mac	2021	1	27	27.7.j	TL	39	3	21375	0.0161
mac	2021	2	27	27.6.a	TL	32	1	19069	0.0216
mac	2021	2	27	27.6.a	TL	33	3	54106	0.0613
mac	2021	2	27	27.6.a	TL	34	7	77064	0.0873
mac	2021	2	27	27.6.a	TL	35	9	115011	0.1303
mac	2021	2	27	27.6.a	TL	36	14	180151	0.2040
mac	2021	2	27	27.6.a	TL	37	11	161067	0.1824
mac	2021	2	27	27.6.a	TL	38	8	99500	0.1127
mac	2021	2	27	27.6.a	TL	39	6	94816	0.1074
mac	2021	2	27	27.6.a	TL	40	4	66247	0.0750
mac	2021	2	27	27.6.a	TL	42	1	15967	0.0181
mac	2021	2	27	27.7.b	TL	38	1	6127	0.5000
mac	2021	2	27	27.7.b	TL	40	1	6127	0.5000
mac	2021	3	27	27.4.a	TL	24	1	9442	0.0054
mac	2021	3	27	27.4.a	TL	25	5	43353	0.0249
mac	2021	3	27	27.4.a	TL	26	12	97836	0.0561
mac	2021	3	27	27.4.a	TL	27	2	10111	0.0058
mac	2021	3	27	27.4.a	TL	28	2	9810	0.0056
mac	2021	3	27	27.4.a	TL	29	10	98209	0.0563
mac	2021	3	27	27.4.a	TL	30	23	131613	0.0755
mac	2021	3	27	27.4.a	TL	31	16	127653	0.0732
mac	2021	3	27	27.4.a	TL	32	28	166532	0.0955
mac	2021	3	27	27.4.a	TL	33	23	149258	0.0856
mac	2021	3	27	27.4.a	TL	34	26	179596	0.1030
mac	2021	3	27	27.4.a	TL	35	23	173859	0.0998
mac	2021	3	27	27.4.a	TL	36	25	179053	0.1027
mac	2021	3	27	27.4.a	TL	37	24	155003	0.0889
mac	2021	3	27	27.4.a	TL	38	19	123471	0.0708
mac	2021	3	27	27.4.a	TL	39	11	74916	0.0430
mac	2021	3	27	27.4.a	TL	40	2	13203	0.0076
mac	2021	3	27	27.6.a	TL	14	4	14157	0.0952
mac	2021	3	27	27.6.a	TL	15	17	60167	0.4048
mac	2021	3	27	27.6.a	TL	16	14	49549	0.3333
mac	2021	3	27	27.6.a	TL	17	5	17696	0.1190
mac	2021	3	27	27.6.a	TL	18	2	7078	0.0476
mac	2021	3	27	27.7.b	TL	28	9	112126	0.1232
mac	2021	3	27	27.7.b	TL	29	13	203625	0.2238
mac	2021	3	27	27.7.b	TL	30	11	141073	0.1550
mac	2021	3	27	27.7.b	TL	31	7	76669	0.0843
mac	2021	3	27	27.7.b	TL	32	4	25451	0.0280
mac	2021	3	27	27.7.b	TL	33	6	23804	0.0262
mac	2021	3	27	27.7.b	TL	34	4	35446	0.0390
mac	2021	3	27	27.7.b	TL	35	13	115133	0.1265
mac	2021	3	27	27.7.b	TL	36	8	64557	0.0710
mac	2021	3	27	27.7.b	TL	37	2	23926	0.0263
mac	2021	3	27	27.7.b	TL	38	7	66987	0.0736
mac	2021	3	27	27.7.b	TL	39	2	17577	0.0193
mac	2021	3	27	27.7.b	TL	40	1	3499	0.0038
mac	2021	3	27	27.7.j	TL	27	1	2840	0.0020
mac	2021	3	27	27.7.j	TL	28	16	151373	0.1086
mac	2021	3	27	27.7.j	TL	29	11	47096	0.0338
mac	2021	3	27	27.7.j	TL	30	9	53242	0.0382
mac	2021	3	27	27.7.j	TL	31	12	62300	0.0447
mac	2021	3	27	27.7.j	TL	32	6	27933	0.0200
mac	2021	3	27	27.7.j	TL	33	18	116680	0.0837
mac	2021	3	27	27.7.j	TL	34	14	154071	0.1105
mac	2021	3	27	27.7.j	TL	35	29	191132	0.1371
mac	2021	3	27	27.7.j	TL	36	32	259037	0.1858

mac	2021	3	27	27.7.j	TL	37	32	150305	0.1078
mac	2021	3	27	27.7.j	TL	38	15	80969	0.0581
mac	2021	3	27	27.7.j	TL	39	7	70033	0.0502
mac	2021	3	27	27.7.j	TL	40	5	16515	0.0118
mac	2021	3	27	27.7.j	TL	41	1	10581	0.0076
mac	2021	4	27	27.2.a	TL	35	4	1061	0.0337
mac	2021	4	27	27.2.a	TL	36	4	1141	0.0362
mac	2021	4	27	27.2.a	TL	37	14	18943	0.6011
mac	2021	4	27	27.2.a	TL	38	19	5141	0.1631
mac	2021	4	27	27.2.a	TL	39	10	2534	0.0804
mac	2021	4	27	27.2.a	TL	40	8	2202	0.0699
mac	2021	4	27	27.2.a	TL	41	2	490	0.0155
mac	2021	4	27	27.4.a	TL	23	1	11982	0.0002
mac	2021	4	27	27.4.a	TL	24	9	108983	0.0015
mac	2021	4	27	27.4.a	TL	25	21	231669	0.0031
mac	2021	4	27	27.4.a	TL	26	76	793340	0.0107
mac	2021	4	27	27.4.a	TL	27	138	1561556	0.0210
mac	2021	4	27	27.4.a	TL	28	138	1922592	0.0258
mac	2021	4	27	27.4.a	TL	29	190	2253457	0.0303
mac	2021	4	27	27.4.a	TL	30	253	2750277	0.0370
mac	2021	4	27	27.4.a	TL	31	318	3004111	0.0404
mac	2021	4	27	27.4.a	TL	32	392	4157073	0.0559
mac	2021	4	27	27.4.a	TL	33	482	5170802	0.0695
mac	2021	4	27	27.4.a	TL	34	651	6524440	0.0877
mac	2021	4	27	27.4.a	TL	35	902	8714365	0.1171
mac	2021	4	27	27.4.a	TL	36	1037	9457713	0.1271
mac	2021	4	27	27.4.a	TL	37	1253	11146124	0.1498
mac	2021	4	27	27.4.a	TL	38	1084	8877236	0.1193
mac	2021	4	27	27.4.a	TL	39	603	4858841	0.0653
mac	2021	4	27	27.4.a	TL	40	263	2138178	0.0287
mac	2021	4	27	27.4.a	TL	41	69	522747	0.0070
mac	2021	4	27	27.4.a	TL	42	17	176805	0.0024
mac	2021	4	27	27.4.a	TL	43	3	24148	0.0003
mac	2021	4	27	27.4.a	TL	44	2	5576	0.0001
mac	2021	4	27	27.7.j	TL	30	1	1413	1.0000

Blue whiting Length frequencies 2022

species	year	quarter	area	division	lengthtype	length	count	catchnumber	prop
mac	2022	1	27	27.4.a	TL	26	9	33098	0.0014
mac	2022	1	27	27.4.a	TL	27	52	340439	0.0144
mac	2022	1	27	27.4.a	TL	28	44	336042	0.0142
mac	2022	1	27	27.4.a	TL	29	54	396568	0.0168
mac	2022	1	27	27.4.a	TL	30	59	388841	0.0165
mac	2022	1	27	27.4.a	TL	31	62	440724	0.0187
mac	2022	1	27	27.4.a	TL	32	68	505194	0.0214
mac	2022	1	27	27.4.a	TL	33	84	482556	0.0205
mac	2022	1	27	27.4.a	TL	34	159	1033678	0.0438
mac	2022	1	27	27.4.a	TL	35	241	1684979	0.0714
mac	2022	1	27	27.4.a	TL	36	392	2663419	0.1129
mac	2022	1	27	27.4.a	TL	37	576	4055936	0.1719
mac	2022	1	27	27.4.a	TL	38	626	4511764	0.1913
mac	2022	1	27	27.4.a	TL	39	481	3759345	0.1594
mac	2022	1	27	27.4.a	TL	40	256	1875541	0.0795
mac	2022	1	27	27.4.a	TL	41	92	770072	0.0326
mac	2022	1	27	27.4.a	TL	42	21	243746	0.0103
mac	2022	1	27	27.4.a	TL	43	2	7439	0.0003
mac	2022	1	27	27.4.a	TL	44	3	58790	0.0025
mac	2022	1	27	27.6.a	TL	17	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	18	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	19	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	23	4	15424	0.0010
mac	2022	1	27	27.6.a	TL	24	5	30313	0.0020
mac	2022	1	27	27.6.a	TL	25	8	34891	0.0023
mac	2022	1	27	27.6.a	TL	26	12	85246	0.0057
mac	2022	1	27	27.6.a	TL	27	14	137644	0.0091
mac	2022	1	27	27.6.a	TL	28	24	273784	0.0182
mac	2022	1	27	27.6.a	TL	29	22	150308	0.0100
mac	2022	1	27	27.6.a	TL	30	45	398239	0.0265
mac	2022	1	27	27.6.a	TL	31	64	554722	0.0368
mac	2022	1	27	27.6.a	TL	32	84	782862	0.0520
mac	2022	1	27	27.6.a	TL	33	120	1156090	0.0768
mac	2022	1	27	27.6.a	TL	34	95	882994	0.0586
mac	2022	1	27	27.6.a	TL	35	115	1091725	0.0725
mac	2022	1	27	27.6.a	TL	36	105	1096835	0.0728
mac	2022	1	27	27.6.a	TL	37	209	2050525	0.1362

mac	2022	1	27	27.6.a	TL	38	274	2565070	0.1704
mac	2022	1	27	27.6.a	TL	39	214	2171710	0.1442
mac	2022	1	27	27.6.a	TL	40	117	1193579	0.0793
mac	2022	1	27	27.6.a	TL	41	29	282289	0.0187
mac	2022	1	27	27.6.a	TL	42	7	89517	0.0059
mac	2022	1	27	27.7.b	TL	20	3	34527	0.0034
mac	2022	1	27	27.7.b	TL	21	5	57545	0.0056
mac	2022	1	27	27.7.b	TL	22	7	80563	0.0079
mac	2022	1	27	27.7.b	TL	23	7	80563	0.0079
mac	2022	1	27	27.7.b	TL	24	4	46036	0.0045
mac	2022	1	27	27.7.b	TL	25	5	57545	0.0056
mac	2022	1	27	27.7.b	TL	26	4	46036	0.0045
mac	2022	1	27	27.7.b	TL	27	4	35245	0.0035
mac	2022	1	27	27.7.b	TL	28	3	31860	0.0031
mac	2022	1	27	27.7.b	TL	29	7	84735	0.0083
mac	2022	1	27	27.7.b	TL	30	25	216377	0.0212
mac	2022	1	27	27.7.b	TL	31	24	196195	0.0192
mac	2022	1	27	27.7.b	TL	32	31	296552	0.0291
mac	2022	1	27	27.7.b	TL	33	45	315556	0.0310
mac	2022	1	27	27.7.b	TL	34	72	507485	0.0498
mac	2022	1	27	27.7.b	TL	35	162	1101891	0.1081
mac	2022	1	27	27.7.b	TL	36	203	1318078	0.1293
mac	2022	1	27	27.7.b	TL	37	201	1323574	0.1298
mac	2022	1	27	27.7.b	TL	38	270	1866023	0.1831
mac	2022	1	27	27.7.b	TL	39	211	1395078	0.1369
mac	2022	1	27	27.7.b	TL	40	110	751821	0.0738
mac	2022	1	27	27.7.b	TL	41	34	283483	0.0278
mac	2022	1	27	27.7.b	TL	42	6	46318	0.0045
mac	2022	1	27	27.7.b	TL	43	3	9300	0.0009
mac	2022	1	27	27.7.b	TL	44	1	10778	0.0011
mac	2022	1	27	27.7.j	TL	25	2	6604	0.0129
mac	2022	1	27	27.7.j	TL	26	1	3302	0.0064
mac	2022	1	27	27.7.j	TL	27	3	14565	0.0284
mac	2022	1	27	27.7.j	TL	28	6	20668	0.0403
mac	2022	1	27	27.7.j	TL	29	10	46168	0.0899
mac	2022	1	27	27.7.j	TL	30	20	74332	0.1448
mac	2022	1	27	27.7.j	TL	31	16	73536	0.1432
mac	2022	1	27	27.7.j	TL	32	13	59549	0.1160
mac	2022	1	27	27.7.j	TL	33	15	55851	0.1088
mac	2022	1	27	27.7.j	TL	34	15	44410	0.0865
mac	2022	1	27	27.7.j	TL	35	16	30610	0.0596
mac	2022	1	27	27.7.j	TL	36	17	21822	0.0425
mac	2022	1	27	27.7.j	TL	37	11	26273	0.0512
mac	2022	1	27	27.7.j	TL	38	8	18422	0.0359
mac	2022	1	27	27.7.j	TL	39	6	12616	0.0246
mac	2022	1	27	27.7.j	TL	40	3	4754	0.0093
mac	2022	2	27	27.6.a	TL	34	4	20848	0.1319
mac	2022	2	27	27.6.a	TL	35	5	31786	0.2011
mac	2022	2	27	27.6.a	TL	36	5	28235	0.1786
mac	2022	2	27	27.6.a	TL	37	6	27219	0.1722
mac	2022	2	27	27.6.a	TL	38	6	28043	0.1774
mac	2022	2	27	27.6.a	TL	39	3	14125	0.0894
mac	2022	2	27	27.6.a	TL	40	1	2102	0.0133
mac	2022	2	27	27.6.a	TL	41	1	2102	0.0133
mac	2022	2	27	27.6.a	TL	42	1	3602	0.0228
mac	2022	3	27	27.4.a	TL	26	1	3261	0.0010
mac	2022	3	27	27.4.a	TL	29	9	102965	0.0330
mac	2022	3	27	27.4.a	TL	30	68	847404	0.2719
mac	2022	3	27	27.4.a	TL	31	65	831571	0.2668
mac	2022	3	27	27.4.a	TL	32	53	568987	0.1825
mac	2022	3	27	27.4.a	TL	33	36	409378	0.1313
mac	2022	3	27	27.4.a	TL	34	11	109308	0.0351
mac	2022	3	27	27.4.a	TL	35	4	54797	0.0176
mac	2022	3	27	27.4.a	TL	36	4	67573	0.0217
mac	2022	3	27	27.4.a	TL	37	5	74347	0.0239
mac	2022	3	27	27.4.a	TL	38	3	47380	0.0152
mac	2022	3	27	27.7.b	TL	32	1	873	0.0833
mac	2022	3	27	27.7.b	TL	34	5	4369	0.4168
mac	2022	3	27	27.7.b	TL	35	1	873	0.0833
mac	2022	3	27	27.7.b	TL	36	1	873	0.0833
mac	2022	3	27	27.7.b	TL	37	2	1747	0.1667
mac	2022	3	27	27.7.b	TL	38	1	873	0.0833
mac	2022	3	27	27.7.b	TL	40	1	873	0.0833
mac	2022	3	27	27.7.j	TL	31	1	4751	0.0457
mac	2022	3	27	27.7.j	TL	32	2	17221	0.1656
mac	2022	3	27	27.7.j	TL	33	1	12469	0.1199
mac	2022	3	27	27.7.j	TL	34	1	9293	0.0894
mac	2022	3	27	27.7.j	TL	35	3	14255	0.1371
mac	2022	3	27	27.7.j	TL	36	2	9503	0.0914
mac	2022	3	27	27.7.j	TL	37	1	13494	0.1298

mac	2022	3	27 27.7.j	TL	38	2 18246	0.1755
mac	2022	3	27 27.7.j	TL	39	1 4751	0.0457

12 Atlanto-scandian herring: detailed tables

Atlanto-scandian herring Sampling overview

species	year	quarter	area	division	catch	sampleweight	nsamples	count	catchnumber
mac	2021	1	27	27.4.a	739	20	1	49	370
mac	2021	1	27	27.6.a	21577	490	69	2483	22508
mac	2021	1	27	27.7.b	672	28	6	67	452
mac	2021	1	27	27.7.j	334	26	2	76	1325
mac	2021	2	27	27.4.a	38	NA	NA	NA	NA
mac	2021	2	27	27.6.a	406	25	6	64	883
mac	2021	2	27	27.7.b	53	0	1	2	12
mac	2021	3	27	27.4.a	2991	46	20	252	1742
mac	2021	3	27	27.6.a	4	1	1	42	148
mac	2021	3	27	27.7.b	368	24	9	87	909
mac	2021	3	27	27.7.j	525	73	27	208	1394
mac	2021	4	27	27.2.a	8	29	3	61	31
mac	2021	4	27	27.4.a	40743	2269	201	7902	74412
mac	2021	4	27	27.7.j	0	0	1	1	1
mac	2022	1	27	27.4.a	11645	1045	72	3281	23588
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	402	58	22	162	513
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	27.4.a	238	77	12	259	3116
mac	2022	3	27	27.7.b	3	5	1	12	10
mac	2022	3	27	27.7.j	3	4	4	14	103

Atlanto-scandian herring Length frequencies 2021

species	year	quarter	area	division	lengthtype	length	count	catchnumber	prop
mac	2021	1	27	27.4.a	TL	27	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	28	3	22662	0.0612
mac	2021	1	27	27.4.a	TL	29	2	15108	0.0408
mac	2021	1	27	27.4.a	TL	30	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	31	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	32	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	33	2	15108	0.0408
mac	2021	1	27	27.4.a	TL	34	4	30216	0.0816
mac	2021	1	27	27.4.a	TL	35	7	52878	0.1429
mac	2021	1	27	27.4.a	TL	36	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	37	5	37770	0.1020
mac	2021	1	27	27.4.a	TL	38	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	39	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	40	4	30216	0.0816
mac	2021	1	27	27.6.a	TL	20	1	7036	0.0003
mac	2021	1	27	27.6.a	TL	21	1	5983	0.0003
mac	2021	1	27	27.6.a	TL	22	2	12764	0.0006
mac	2021	1	27	27.6.a	TL	24	2	10452	0.0005
mac	2021	1	27	27.6.a	TL	25	9	47828	0.0021
mac	2021	1	27	27.6.a	TL	26	10	61280	0.0027
mac	2021	1	27	27.6.a	TL	27	25	245675	0.0109
mac	2021	1	27	27.6.a	TL	28	16	198136	0.0088
mac	2021	1	27	27.6.a	TL	29	30	303481	0.0135
mac	2021	1	27	27.6.a	TL	30	43	331822	0.0147
mac	2021	1	27	27.6.a	TL	31	36	222011	0.0099
mac	2021	1	27	27.6.a	TL	32	88	746047	0.0331
mac	2021	1	27	27.6.a	TL	33	145	1154437	0.0513
mac	2021	1	27	27.6.a	TL	34	193	1641334	0.0729
mac	2021	1	27	27.6.a	TL	35	270	2158065	0.0959
mac	2021	1	27	27.6.a	TL	36	372	3205188	0.1424
mac	2021	1	27	27.6.a	TL	37	498	4794277	0.2130
mac	2021	1	27	27.6.a	TL	38	386	3699361	0.1644
mac	2021	1	27	27.6.a	TL	39	195	2138953	0.0950
mac	2021	1	27	27.6.a	TL	40	110	1122308	0.0499
mac	2021	1	27	27.6.a	TL	41	40	322748	0.0143
mac	2021	1	27	27.6.a	TL	42	8	58488	0.0026
mac	2021	1	27	27.6.a	TL	43	2	11590	0.0005
mac	2021	1	27	27.6.a	TL	46	1	9415	0.0004
mac	2021	1	27	27.7.b	TL	31	1	158	0.0003

mac	2021	1	27 27.7.b	TL	32	1	158	0.0003
mac	2021	1	27 27.7.b	TL	33	1	9116	0.0202
mac	2021	1	27 27.7.b	TL	34	3	27349	0.0605
mac	2021	1	27 27.7.b	TL	35	1	5243	0.0116
mac	2021	1	27 27.7.b	TL	36	7	44463	0.0983
mac	2021	1	27 27.7.b	TL	37	11	69334	0.1534
mac	2021	1	27 27.7.b	TL	38	18	125023	0.2765
mac	2021	1	27 27.7.b	TL	39	15	112427	0.2487
mac	2021	1	27 27.7.b	TL	40	7	44475	0.0984
mac	2021	1	27 27.7.b	TL	41	1	5243	0.0116
mac	2021	1	27 27.7.b	TL	42	1	9116	0.0202
mac	2021	1	27 27.7.j	TL	28	1	21375	0.0161
mac	2021	1	27 27.7.j	TL	29	1	21375	0.0161
mac	2021	1	27 27.7.j	TL	30	1	21375	0.0161
mac	2021	1	27 27.7.j	TL	31	6	128253	0.0968
mac	2021	1	27 27.7.j	TL	32	12	256507	0.1935
mac	2021	1	27 27.7.j	TL	33	9	192380	0.1452
mac	2021	1	27 27.7.j	TL	34	8	171004	0.1290
mac	2021	1	27 27.7.j	TL	35	8	106877	0.0806
mac	2021	1	27 27.7.j	TL	36	11	149629	0.1129
mac	2021	1	27 27.7.j	TL	37	9	85502	0.0645
mac	2021	1	27 27.7.j	TL	38	7	149629	0.1129
mac	2021	1	27 27.7.j	TL	39	3	21375	0.0161
mac	2021	2	27 27.6.a	TL	32	1	19069	0.0216
mac	2021	2	27 27.6.a	TL	33	3	54106	0.0613
mac	2021	2	27 27.6.a	TL	34	7	77064	0.0873
mac	2021	2	27 27.6.a	TL	35	9	115011	0.1303
mac	2021	2	27 27.6.a	TL	36	14	180151	0.2040
mac	2021	2	27 27.6.a	TL	37	11	161067	0.1824
mac	2021	2	27 27.6.a	TL	38	8	99500	0.1127
mac	2021	2	27 27.6.a	TL	39	6	94816	0.1074
mac	2021	2	27 27.6.a	TL	40	4	66247	0.0750
mac	2021	2	27 27.6.a	TL	42	1	15967	0.0181
mac	2021	2	27 27.7.b	TL	38	1	6127	0.5000
mac	2021	2	27 27.7.b	TL	40	1	6127	0.5000
mac	2021	3	27 27.4.a	TL	24	1	9442	0.0054
mac	2021	3	27 27.4.a	TL	25	5	43353	0.0249
mac	2021	3	27 27.4.a	TL	26	12	97836	0.0561
mac	2021	3	27 27.4.a	TL	27	2	10111	0.0058
mac	2021	3	27 27.4.a	TL	28	2	9810	0.0056
mac	2021	3	27 27.4.a	TL	29	10	98209	0.0563
mac	2021	3	27 27.4.a	TL	30	23	131613	0.0755
mac	2021	3	27 27.4.a	TL	31	16	127653	0.0732
mac	2021	3	27 27.4.a	TL	32	28	166532	0.0955
mac	2021	3	27 27.4.a	TL	33	23	149258	0.0856
mac	2021	3	27 27.4.a	TL	34	26	179596	0.1030
mac	2021	3	27 27.4.a	TL	35	23	173859	0.0998
mac	2021	3	27 27.4.a	TL	36	25	179053	0.1027
mac	2021	3	27 27.4.a	TL	37	24	155003	0.0889
mac	2021	3	27 27.4.a	TL	38	19	123471	0.0708
mac	2021	3	27 27.4.a	TL	39	11	74916	0.0430
mac	2021	3	27 27.4.a	TL	40	2	13203	0.0076
mac	2021	3	27 27.6.a	TL	14	4	14157	0.0952
mac	2021	3	27 27.6.a	TL	15	17	60167	0.4048
mac	2021	3	27 27.6.a	TL	16	14	49549	0.3333
mac	2021	3	27 27.6.a	TL	17	5	17696	0.1190
mac	2021	3	27 27.6.a	TL	18	2	7078	0.0476
mac	2021	3	27 27.7.b	TL	28	9	112126	0.1232
mac	2021	3	27 27.7.b	TL	29	13	203625	0.2238
mac	2021	3	27 27.7.b	TL	30	11	141073	0.1550
mac	2021	3	27 27.7.b	TL	31	7	76669	0.0843
mac	2021	3	27 27.7.b	TL	32	4	25451	0.0280
mac	2021	3	27 27.7.b	TL	33	6	23804	0.0262
mac	2021	3	27 27.7.b	TL	34	4	35446	0.0390
mac	2021	3	27 27.7.b	TL	35	13	115133	0.1265
mac	2021	3	27 27.7.b	TL	36	8	64557	0.0710
mac	2021	3	27 27.7.b	TL	37	2	23926	0.0263
mac	2021	3	27 27.7.b	TL	38	7	66987	0.0736
mac	2021	3	27 27.7.b	TL	39	2	17577	0.0193
mac	2021	3	27 27.7.b	TL	40	1	3499	0.0038
mac	2021	3	27 27.7.j	TL	27	1	2840	0.0020
mac	2021	3	27 27.7.j	TL	28	16	151373	0.1086
mac	2021	3	27 27.7.j	TL	29	11	47096	0.0338
mac	2021	3	27 27.7.j	TL	30	9	53242	0.0382
mac	2021	3	27 27.7.j	TL	31	12	62300	0.0447
mac	2021	3	27 27.7.j	TL	32	6	27933	0.0200
mac	2021	3	27 27.7.j	TL	33	18	116680	0.0837
mac	2021	3	27 27.7.j	TL	34	14	154071	0.1105
mac	2021	3	27 27.7.j	TL	35	29	191132	0.1371
mac	2021	3	27 27.7.j	TL	36	32	259037	0.1858

mac	2021	3	27	27.7.j	TL	37	32	150305	0.1078
mac	2021	3	27	27.7.j	TL	38	15	80969	0.0581
mac	2021	3	27	27.7.j	TL	39	7	70033	0.0502
mac	2021	3	27	27.7.j	TL	40	5	16515	0.0118
mac	2021	3	27	27.7.j	TL	41	1	10581	0.0076
mac	2021	4	27	27.2.a	TL	35	4	1061	0.0337
mac	2021	4	27	27.2.a	TL	36	4	1141	0.0362
mac	2021	4	27	27.2.a	TL	37	14	18943	0.6011
mac	2021	4	27	27.2.a	TL	38	19	5141	0.1631
mac	2021	4	27	27.2.a	TL	39	10	2534	0.0804
mac	2021	4	27	27.2.a	TL	40	8	2202	0.0699
mac	2021	4	27	27.2.a	TL	41	2	490	0.0155
mac	2021	4	27	27.4.a	TL	23	1	11982	0.0002
mac	2021	4	27	27.4.a	TL	24	9	108983	0.0015
mac	2021	4	27	27.4.a	TL	25	21	231669	0.0031
mac	2021	4	27	27.4.a	TL	26	76	793340	0.0107
mac	2021	4	27	27.4.a	TL	27	138	1561556	0.0210
mac	2021	4	27	27.4.a	TL	28	138	1922592	0.0258
mac	2021	4	27	27.4.a	TL	29	190	2253457	0.0303
mac	2021	4	27	27.4.a	TL	30	253	2750277	0.0370
mac	2021	4	27	27.4.a	TL	31	318	3004111	0.0404
mac	2021	4	27	27.4.a	TL	32	392	4157073	0.0559
mac	2021	4	27	27.4.a	TL	33	482	5170802	0.0695
mac	2021	4	27	27.4.a	TL	34	651	6524440	0.0877
mac	2021	4	27	27.4.a	TL	35	902	8714365	0.1171
mac	2021	4	27	27.4.a	TL	36	1037	9457713	0.1271
mac	2021	4	27	27.4.a	TL	37	1253	11146124	0.1498
mac	2021	4	27	27.4.a	TL	38	1084	8877236	0.1193
mac	2021	4	27	27.4.a	TL	39	603	4858841	0.0653
mac	2021	4	27	27.4.a	TL	40	263	2138178	0.0287
mac	2021	4	27	27.4.a	TL	41	69	522747	0.0070
mac	2021	4	27	27.4.a	TL	42	17	176805	0.0024
mac	2021	4	27	27.4.a	TL	43	3	24148	0.0003
mac	2021	4	27	27.4.a	TL	44	2	5576	0.0001
mac	2021	4	27	27.7.j	TL	30	1	1413	1.0000

Atlanto-scandian herring Length frequencies 2022

species	year	quarter	area	division	lengthtype	length	count	catchnumber	prop
mac	2022	1	27	27.4.a	TL	26	9	33098	0.0014
mac	2022	1	27	27.4.a	TL	27	52	340439	0.0144
mac	2022	1	27	27.4.a	TL	28	44	336042	0.0142
mac	2022	1	27	27.4.a	TL	29	54	396568	0.0168
mac	2022	1	27	27.4.a	TL	30	59	388841	0.0165
mac	2022	1	27	27.4.a	TL	31	62	440724	0.0187
mac	2022	1	27	27.4.a	TL	32	68	505194	0.0214
mac	2022	1	27	27.4.a	TL	33	84	482556	0.0205
mac	2022	1	27	27.4.a	TL	34	159	1033678	0.0438
mac	2022	1	27	27.4.a	TL	35	241	1684979	0.0714
mac	2022	1	27	27.4.a	TL	36	392	2663419	0.1129
mac	2022	1	27	27.4.a	TL	37	576	4055936	0.1719
mac	2022	1	27	27.4.a	TL	38	626	4511764	0.1913
mac	2022	1	27	27.4.a	TL	39	481	3759345	0.1594
mac	2022	1	27	27.4.a	TL	40	256	1875541	0.0795
mac	2022	1	27	27.4.a	TL	41	92	770072	0.0326
mac	2022	1	27	27.4.a	TL	42	21	243746	0.0103
mac	2022	1	27	27.4.a	TL	43	2	7439	0.0003
mac	2022	1	27	27.4.a	TL	44	3	58790	0.0025
mac	2022	1	27	27.6.a	TL	17	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	18	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	19	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	23	4	15424	0.0010
mac	2022	1	27	27.6.a	TL	24	5	30313	0.0020
mac	2022	1	27	27.6.a	TL	25	8	34891	0.0023
mac	2022	1	27	27.6.a	TL	26	12	85246	0.0057
mac	2022	1	27	27.6.a	TL	27	14	137644	0.0091
mac	2022	1	27	27.6.a	TL	28	24	273784	0.0182
mac	2022	1	27	27.6.a	TL	29	22	150308	0.0100
mac	2022	1	27	27.6.a	TL	30	45	398239	0.0265
mac	2022	1	27	27.6.a	TL	31	64	554722	0.0368
mac	2022	1	27	27.6.a	TL	32	84	782862	0.0520
mac	2022	1	27	27.6.a	TL	33	120	1156090	0.0768
mac	2022	1	27	27.6.a	TL	34	95	882994	0.0586
mac	2022	1	27	27.6.a	TL	35	115	1091725	0.0725
mac	2022	1	27	27.6.a	TL	36	105	1096835	0.0728
mac	2022	1	27	27.6.a	TL	37	209	2050525	0.1362

mac	2022	1	27	27.6.a	TL	38	274	2565070	0.1704
mac	2022	1	27	27.6.a	TL	39	214	2171710	0.1442
mac	2022	1	27	27.6.a	TL	40	117	1193579	0.0793
mac	2022	1	27	27.6.a	TL	41	29	282289	0.0187
mac	2022	1	27	27.6.a	TL	42	7	89517	0.0059
mac	2022	1	27	27.7.b	TL	20	3	34527	0.0034
mac	2022	1	27	27.7.b	TL	21	5	57545	0.0056
mac	2022	1	27	27.7.b	TL	22	7	80563	0.0079
mac	2022	1	27	27.7.b	TL	23	7	80563	0.0079
mac	2022	1	27	27.7.b	TL	24	4	46036	0.0045
mac	2022	1	27	27.7.b	TL	25	5	57545	0.0056
mac	2022	1	27	27.7.b	TL	26	4	46036	0.0045
mac	2022	1	27	27.7.b	TL	27	4	35245	0.0035
mac	2022	1	27	27.7.b	TL	28	3	31860	0.0031
mac	2022	1	27	27.7.b	TL	29	7	84735	0.0083
mac	2022	1	27	27.7.b	TL	30	25	216377	0.0212
mac	2022	1	27	27.7.b	TL	31	24	196195	0.0192
mac	2022	1	27	27.7.b	TL	32	31	296552	0.0291
mac	2022	1	27	27.7.b	TL	33	45	315556	0.0310
mac	2022	1	27	27.7.b	TL	34	72	507485	0.0498
mac	2022	1	27	27.7.b	TL	35	162	1101891	0.1081
mac	2022	1	27	27.7.b	TL	36	203	1318078	0.1293
mac	2022	1	27	27.7.b	TL	37	201	1323574	0.1298
mac	2022	1	27	27.7.b	TL	38	270	1866023	0.1831
mac	2022	1	27	27.7.b	TL	39	211	1395078	0.1369
mac	2022	1	27	27.7.b	TL	40	110	751821	0.0738
mac	2022	1	27	27.7.b	TL	41	34	283483	0.0278
mac	2022	1	27	27.7.b	TL	42	6	46318	0.0045
mac	2022	1	27	27.7.b	TL	43	3	9300	0.0009
mac	2022	1	27	27.7.b	TL	44	1	10778	0.0011
mac	2022	1	27	27.7.j	TL	25	2	6604	0.0129
mac	2022	1	27	27.7.j	TL	26	1	3302	0.0064
mac	2022	1	27	27.7.j	TL	27	3	14565	0.0284
mac	2022	1	27	27.7.j	TL	28	6	20668	0.0403
mac	2022	1	27	27.7.j	TL	29	10	46168	0.0899
mac	2022	1	27	27.7.j	TL	30	20	74332	0.1448
mac	2022	1	27	27.7.j	TL	31	16	73536	0.1432
mac	2022	1	27	27.7.j	TL	32	13	59549	0.1160
mac	2022	1	27	27.7.j	TL	33	15	55851	0.1088
mac	2022	1	27	27.7.j	TL	34	15	44410	0.0865
mac	2022	1	27	27.7.j	TL	35	16	30610	0.0596
mac	2022	1	27	27.7.j	TL	36	17	21822	0.0425
mac	2022	1	27	27.7.j	TL	37	11	26273	0.0512
mac	2022	1	27	27.7.j	TL	38	8	18422	0.0359
mac	2022	1	27	27.7.j	TL	39	6	12616	0.0246
mac	2022	1	27	27.7.j	TL	40	3	4754	0.0093

mac	2022	2	27	27.6.a	TL	34	4	20848	0.1319
mac	2022	2	27	27.6.a	TL	35	5	31786	0.2011
mac	2022	2	27	27.6.a	TL	36	5	28235	0.1786
mac	2022	2	27	27.6.a	TL	37	6	27219	0.1722
mac	2022	2	27	27.6.a	TL	38	6	28043	0.1774
mac	2022	2	27	27.6.a	TL	39	3	14125	0.0894
mac	2022	2	27	27.6.a	TL	40	1	2102	0.0133
mac	2022	2	27	27.6.a	TL	41	1	2102	0.0133
mac	2022	2	27	27.6.a	TL	42	1	3602	0.0228

mac	2022	3	27	27.4.a	TL	26	1	3261	0.0010
mac	2022	3	27	27.4.a	TL	29	9	102965	0.0330
mac	2022	3	27	27.4.a	TL	30	68	847404	0.2719
mac	2022	3	27	27.4.a	TL	31	65	831571	0.2668
mac	2022	3	27	27.4.a	TL	32	53	568987	0.1825
mac	2022	3	27	27.4.a	TL	33	36	409378	0.1313
mac	2022	3	27	27.4.a	TL	34	11	109308	0.0351
mac	2022	3	27	27.4.a	TL	35	4	54797	0.0176
mac	2022	3	27	27.4.a	TL	36	4	67573	0.0217
mac	2022	3	27	27.4.a	TL	37	5	74347	0.0239
mac	2022	3	27	27.4.a	TL	38	3	47380	0.0152
mac	2022	3	27	27.7.b	TL	32	1	873	0.0833
mac	2022	3	27	27.7.b	TL	34	5	4369	0.4168
mac	2022	3	27	27.7.b	TL	35	1	873	0.0833
mac	2022	3	27	27.7.b	TL	36	1	873	0.0833
mac	2022	3	27	27.7.b	TL	37	2	1747	0.1667
mac	2022	3	27	27.7.b	TL	38	1	873	0.0833
mac	2022	3	27	27.7.b	TL	40	1	873	0.0833
mac	2022	3	27	27.7.j	TL	31	1	4751	0.0457
mac	2022	3	27	27.7.j	TL	32	2	17221	0.1656
mac	2022	3	27	27.7.j	TL	33	1	12469	0.1199
mac	2022	3	27	27.7.j	TL	34	1	9293	0.0894
mac	2022	3	27	27.7.j	TL	35	3	14255	0.1371
mac	2022	3	27	27.7.j	TL	36	2	9503	0.0914
mac	2022	3	27	27.7.j	TL	37	1	13494	0.1298

mac	2022	3	27 27.7.j	TL	38	2 18246	0.1755
mac	2022	3	27 27.7.j	TL	39	1 4751	0.0457

North Sea mackerel daily egg production and spawning stock biomass estimation in 2021

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Introduction

The North Sea Mackerel Egg Survey (NSMEGS) is designed to estimate the spawning stock biomass (SSB) of mackerel of the North Sea spawning component of the Northeast-Atlantic stock on a triennial basis. Up to and including 2017 this was undertaken utilizing the annual egg production method (AEPM). This method estimates and combines total annual egg production (TAEP), realized fecundity per gram female, and sex (male to female) ratio to calculate SSB.

Spatial and temporal coverage in the North Sea was reduced with the withdrawal of Norway from the NSMEGS in 2014, with the Netherlands left as the sole survey participant in 2015 and 2017. In 2020 Denmark was recruited as a new participant for the NSMEGS, but due to the Covid-19 pandemic and the implementation of associated measures it was not possible to complete the survey in 2020. After consultation with WGMEGS chairs and the mackerel assessor it was agreed to postpone the survey to 2021.

An issue for the NSMEGS is that since 1982 it has been impossible to collect and sample pre-spawning mackerel, which are necessary in order to estimate the potential fecundity. For SSB estimation using the AEPM, the realized fecundity value used was from the 1982 estimate (Iversen and Adoff, 1983). Also, the planned coverage for 2020 (which was postponed to 2021) of the mackerel spawning in the North Sea, both temporally and spatially, was far from ideal for the Annual Egg Production Method (AEPM; ICES 2018). Consequently, WGMEGS discussed utilizing the Daily Egg Production Method (DEPM) for the NSMEGS. The DEPM requires only one full sweep, in a short time period, of the entire mackerel spawning area, and preferably during peak spawning time, in order to estimate the Daily Egg Production (DEP). A disadvantage of the DEPM is that it requires many more mackerel ovary samples to be collected to estimate batch fecundity and spawning fraction. Considering the pros and cons of the AEPM and DEPM for the NSMEGS, at the 2018 meeting WGMEGS decided to switch to the DEPM for the NSMEGS in 2020 (which was then postponed to 2021; ICES 2018).

Survey

In 2021 Netherlands and Denmark conducted the NSMEGS. Whilst completing an exploratory egg survey along the Norwegian Sea, similar to those in 2017 and 2018 to the west of Faroes, Scotland was also able to contribute several additional survey transects within the Northern North Sea that were then incorporated into the 2021 NSMEGS dataset.

During 2021, Covid 19 measures continued to pose significant challenges that impeded the execution of the survey plan. The Dutch vessel was not permitted to enter foreign harbours during survey breaks, instead being required to undertake the long steam back to a Dutch harbour. As a consequence the Netherlands was unable to sample the most northerly transect. However, Scotland was able to complete this transect during their exploratory survey.

The samples were collected and analysed according to the WGMEGS manuals (ICES 2019a, 2019b). The Netherlands and Scotland sampled eggs with a Gulf VII plankton sampler while Denmark used a Nackthai sampler. The Netherlands and Denmark utilised a 500 µm plankton net whereas Scotland used a 250 µm plankton net. At each station a double oblique haul was performed from the surface to 5 m above the bottom, a maximum depth of 200 m, or 20 m below the thermocline in case of stratification of the water column. Temperature and salinity were measured during the haul with a CTD mounted on top of the plankton sampler. Electronic flowmeters were mounted on the plankton sampler to monitor flow.

The NSMEGS was carried out from 25th May to 12th June (Table 1). During this period the spawning area between 53ºN and 62ºN was surveyed once, receiving a single coverage (Fig. 1). The survey is designed to cover the entire spawning area with samples collected every half ICES statistical rectangle (ICES, 2014). In total 294 plankton stations were sampled. In 26 of the half rectangles more than one plankton sample was collected (Fig. 1a). These rectangles were used to estimate the CV and variance of the DEP. On each transect at least one pelagic trawl haul was performed for the collection of mackerel adult samples (Fig. 1b).

Following the WGMEGS manual temperature at 5m depth was used to estimate egg development (ICES 2019a). For the DEPM only the mackerel eggs in development stage 1A are used to estimate daily egg production.

Results

Mackerel daily egg production

During the survey the weather was fine. Denmark and Scotland managed to sample all their planned plankton stations. The Netherlands missed 4 plankton stations due to technical issues and limited sampling time.

The spatial egg distribution is shown in Fig. 2. The standard MEGS interpolation rules (ICES, 2019a) were applied where needed (see interpolated stations in Fig. 2). The interpolated egg production accounted for 7.3% of the DEP. The egg distribution is comparable to previous surveys in the same area and period, with the highest numbers of eggs found in the south western area. Previous surveys did not sample above 59ºN and no comparison with previous years is available for this area.

The DEP was calculated for the total investigated area (Table 2). For comparison with the previous survey, a DEP was also calculated for the area between 53.5 and 59ºN and 0.5ºW and 5.5ºE, which was the area sampled in 2017 in the same period of the year (extended period 2 of 2017; see Fig. 2 for sampled area in 2017). DEP of 2021 was 10% higher compared to 2017 (Table 3), however the sampled area in 2021 was also larger (9%) due to coastal stations not sampled or interpolated in 2017.

Adult parameters

Denmark sampled 817 mackerel and collected ovary samples of 119 females. Of these 34 were suitable for estimating batch fecundity, and 112 for POF analyses for spawning fraction estimation. The Netherlands sampled 524 mackerel during the survey and collected ovary samples of 164 females. Of these 164 ovaries 73 qualified for batch fecundity estimation, and 108 for POF analyses.

Denmark did not deliver the results of the batch fecundity and POF analyses. In agreement with the chairs of WGMEGS, the DEPM adult parameters were therefore estimated with the data provided by the Netherlands. Adult parameters are presented in Table 4.

Of the samples analysed for batch fecundity 54 could be used for batch fecundity estimation. In these samples the batch was clearly separated from the standing stock of vitellogenic oocytes. In the remaining 19 samples the new batch of oocytes was not separated from the standing stock. Batch fecundity was 18735 eggs (Table 4). This is higher compared to the estimate of 12391 in the Atlantic in 2019 (ICES, 2021). Corrected female weight was lower compared to the Atlantic in 2019, 331 and 346 grammes respectively. Spawning fraction in the North Sea was 18%, while this was 23% in the Atlantic in 2019. Sex ratio was 0.53 and this was similar compared to the Atlantic.

SSB

Using the stage 1A (stage duration of 1A is 1 day) egg data and the estimated adult parameters, the DEP for the entire sampled area in 2021 amounts to an SSB of 2380 * 10^3 tonnes (Table 4). This estimate is an order of magnitude higher compared to the estimates of previous surveys in the North Sea using the AEPM. The SSB estimated in 2017 using the AEPM was 287 * 10^3 tonnes.

The total area sampled in 2021 was much larger compared to the area sampled in 2017 (Fig. 2). In 2017 sampling was only conducted south of 59ºN. In 2021 sampling was carried out as far as 62ºN with substantial numbers of eggs being found in this northern area (Fig. 2). In the area above 59ºN there maybe overlap with the western component.

For comparison between 2021 and 2017 a DEPM estimation of SSB was done using the egg production in the area between 53.5 and 59ºN. No adult parameters were available for 2017, so these were assumed to be same as in 2021. The SSB in the area between 53.5 and 59ºN is substantially lower compared to the entire sampled area in 2021 and would be 915 * 10^3 tonnes (Table 5). In 2017 the SSB would be 821 * 10^3 tonnes. For 2017 this is 3 times higher compared to the AEPM estimate of 287 * 10^3 tonnes. Kraus *et al*. (2012) and Köster *et al*. (2020) compared the AEPM and DEPM methods for a time-series of cod in the Baltic. They found the trend and SSB in most years were similar using both methods and similar to the ICES estimate of SSB. However, in years with high SSB the two methods diverged (Kraus *et al*. 2012, Köster *et al*. 2020).

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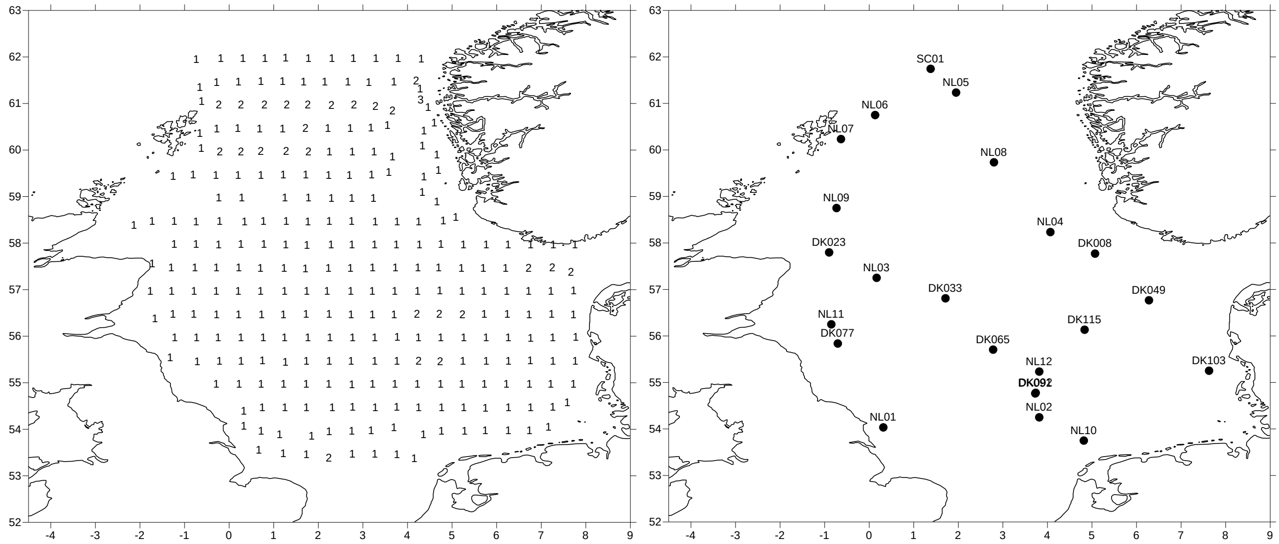

Figure 1. Number of samples for NSMEGS 2021; plankton samples per half ICES rectangle (left) and pelagic trawl hauls for mackerel adult samples (right; all hauls included).

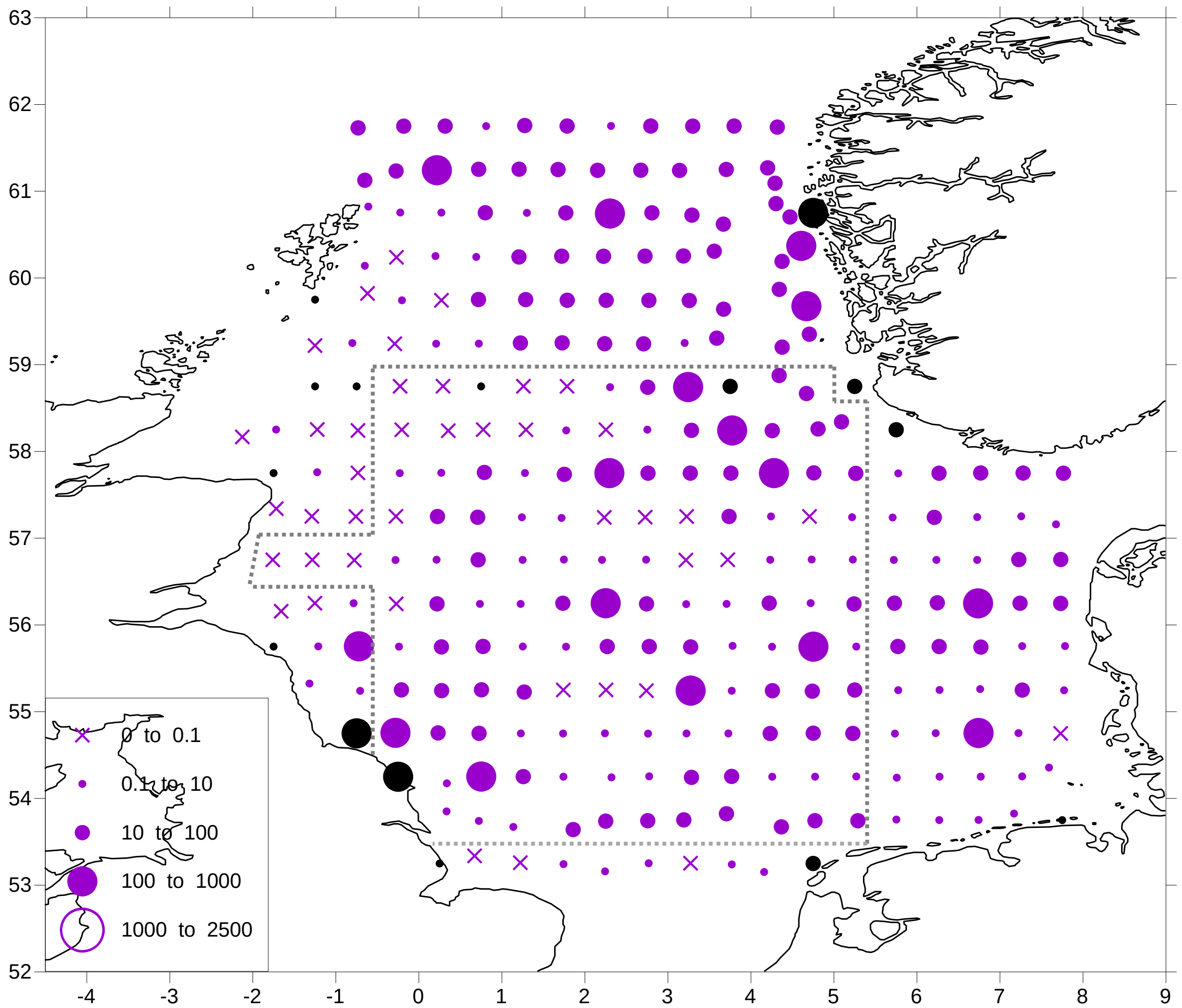

Figure 2. Stage 1A mackerel egg production (eggs/m²/day) by half rectangle for NSMEGS 2021. Purple circles represent observed values, black circles represent interpolated values, and crosses represent

observed zeros. Dashed line shows sampled area in extended period 2 in 2017 which was used for comparison calculation between the years.

Table 1. NSMEGS surveys cruise dates in 2021 (For Scotland only stations used in the NSMEGS DEP calculation are shown.)

Country	NL	DK	SCO
Period	1	1	1
Dates	25.05-12.06	31.05-9.06	8.06-11.06
Plankton stations sampled	174	91	29
Pelagic trawl hauls	12	10	1

Table 2. Daily egg production estimate (stage 1A) in the North Sea.

Year	DEP $*10^{13}$	CV DEP
2021	1.28	16%

Table 3. Comparison of Daily Egg production (stage 1) between 2021 and 2017, in the area between 53.5 and 59ºN.

Year	2021	2017 Extended period 2
DEP $*10^{12}$	4.94	4.43
Area sampled ($*\ 10^{11}\ m^2$)	2.25	2.01

Table 4. Adult parameters and SSB.

Year	2021
Batch fecundity	18735
Relative batch fecundity (N/g)	42.7
CV Batch fecundity	0.87
Spawning fraction	0.18
Sex ratio	0.53
Female weight (g)	331.4
SSB ($*\ 10^3$ tonnes)	2380

Table 5. Comparisons EPM calculation of stage 1 eggs between 2021 and 2017 (extended period 2). (For 2017 the same batch fecundity, S and R are used as for 2021, as these data were not available for 2017.)

Year	DEP $*10^{12}$	SSB ($*10^{3}$) tonnes		
		AEPM	DEPM (below **59⁰N)**	DEPM (total area)
2021	4.94	-	915	2380
2017 Extended period 2	4.43	287	821	-

DISTRIBUTION AND ABUNDANCE OF NORWEGIAN SPRING-SPAWNING HERRING DURING THE SPAWNING SEASON IN 2022

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Cruise leader(s): Are Salthaug and Erling Kåre Stenevik (IMR)

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No.2 2022

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Summary (English):

During the period 14-27th of February 2022 the spawning grounds of Norwegian spring-spawning herring from Møre (62º15´N) to Troms (71ºN) were covered acoustically by the commercial vessels MS Eros and MS Vendla. The estimated biomass was about 18 % lower, and the estimated total number was about 29 % lower this year compared to the last year's survey. The uncertainty of the estimates in 2022 was approximately equal to last year. The surveyed population of NSS herring was dominated by the 2016 year class; 52 % in numbers and 46 % in biomass. The 2016 year class was reduced by 37 % in numbers from last year's survey. Most of the spawning stock was found outside Lofoten and Vesterålen this year, further north and more concentrated than usual. The observed maturity indicates a bit later spawning compared to last year and like last year a more northern spawning than normal. As usual, the herring in the southern part of the spawning area were older than those found in the northern part. The estimates of relative abundance from the survey in 2022 are recommended to be used in this year's ICES stock assessment of Norwegian spring-spawning herring.

Summary (Norwegian):

I perioden 14. - 27. Februar 2022 ble gytefeltene til norsk vårgytende sild fra Møre (62º15´N) til Troms (71ºN) dekket akustisk med de kommersielle fartøyene MS Eros og MS Vendla. Den estimerte biomassen var omtrent 18 % lavere, og det estimerte antallet omtrent 29 % lavere sammenlignet med fjorårets tokt. Usikkerheten i årets estimat er på samme nivå som i fjor. Gytebestanden var dominert av 2016-årsklassen med 52 % i antall og 46 % i vekt. Sammenlignet med toktet i fjor var antallet av 2016-årsklassen redusert med 37 %. Mesteparten av gytebestanden befant seg vest av Lofoten og Vesterålen i år. Sammenlignet med tidligere år stod silda lenger nord og var mer konsentrert. Sammenlignet med toktet i fjor var silda kommet noe senere i modningsprosessen i år. I likhet med tidligere år så var det mer eldre sild i den sørlige delen av gyteområdet og silda i nord var yngre. Det anbefales å bruke estimatene av relativ mengde fra toktet i 2022 i ICES sin bestandsvurdering av norsk vårgytende sild.

Content

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 fishermen'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 2022 was to continue the time series of abundance estimates, both mean 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 also presented: spatial distribution of biomass and acoustic densities, total biomass and stock numbers with sample uncertainty, spatial patterns in age and maturity and variations in temperature.

2 - Material and methods

2.1 - Survey design

During the period 14-27th of February 2022 (same period as in 2017-2021) the spawning grounds from Møre (62º15´N) to Troms (71ºN) were covered acoustically by the commercial fishing vessels MS *Eros* and MS *Vendla*. The survey was planned based on information from the previous spawning cruises and the distribution of the herring fishery during the autumn 2021 up to the survey start February 14th 2022 (Figure 1). The fishery prior to the survey in 2022 indicated that the herring wintering in the Norwegian Sea were entering the coast in the Træna deep south of Røst as observed in previous years. However, unlike previous years the fishery did not move south of Røst before the survey started. Like in the last winter season an extensive fishery in October-February 2021/2022 occurred along the continental slope north of Andenes in addition to the fishery in the Kvænangen fjord area that also have been taking place the five previous years. Biological samples from catches from the northern fishery indicate that the 2016 year class dominated in this area. The survey coverage was therefore planned to also take account of a potentially large flux of herring entering the spawning area from the north. As seen from Figure 1, the fishery during the survey in 2022 mainly took place between Røst and Træna (66.3-67.4°N) which is farther 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 except the northernmost one 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. At the start of the survey in 2022 the fishing fleet was located west of Røst and it was estimated that the fleet had moved south to the Træna area around 66.5°N when the survey entered this area. Hence, the survey coverage (see Aglen 1989) was planned to be relatively low south of 65°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.

2.2 - Biological sampling

Trawl sampling was planned to be carried out on a regular basis during the survey to confirm the acoustic observations 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 measured in up to 50 individuals per sample. Some genetic samples and otoliths were also collected to be used in later research projects.

2.3 - Additional data collection

CTD casts (using Seabird 911 systems) were taken by both vessels, spread out haphazardly in the survey area. ADCP data was recorded on Eros as described in Annex 2 in Salthaug et al. (2020). These data will later be used to analyse swimming speed and direction of herring below the vessel.

2.4 - Acoustic data processing

Echosounder data from the 38 kHz transducers was, as usual, the basis for measurement of fish density. The software

LSSS version 2.12.0 was use 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” and “air bubbles” (upper 20 meters from the transducer near field).

2.5 - Abundance estimation methods

The acoustic density values were stored by species category in nautical area scattering coefficient (NASC) [m^2 $n.mi.^{-2}$] 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. To estimate the mean and variance of NASC, we use the methods established by Jolly and Hampton (1990) and implemented in the software Stox version 3.3 (Johnsen et al. 2019). The primary sampling unit is the sum of all elementary NASC samples of herring along the transect multiplied with the resolution distance. The transect (*t*) has NASC value (*s)* and distance length *L* . The average NASC (S) in a stratum (*i*) is then:

$$\hat{S}_i = \frac{1}{n_i} \cdot \sum_{i=1}^{n_i} w_{it} s_{it} \quad (1)$$

where $w_{it} = L_{it} / L_t$ (t= 1,2,.. n_i) are the lengths of the n_i sample transects, and

$$L_i = \frac{1}{n_i} \sum_{t=1}^{n_i} L_{it} \quad (2)$$

The final mean NASC is given by weighting by stratum area, A;

$$\hat{S} = \frac{\sum_i A_i \hat{S}_i}{\sum_i A_i} \quad (3)$$

Variance by stratum is estimated as:

$$\hat{V}\left(\hat{S}_i\right) = \frac{n}{n_i - 1} \sum_{t=1}^{n} w_{it}^2 \left(s_t - \overline{s}\right)^2 \quad \text{with} \quad \overline{s}_i = \frac{1}{n_i} \cdot \sum_{t=1}^{n_i} s_t \quad (4)$$

Where $w_{it} = L_{it} / L_t$ (t= 1,2,.. n_i) are the lengths of the n_i sample transects.

The global variance is estimated as

$$\hat{V}(\hat{S}) = \frac{\sum_i A_{i=1}^2 \hat{V}(\hat{S})}{\left(\sum_i A\right)^2} \quad (5)$$

The global relative standard error of NASC

$$RSE = 100 \sqrt{\frac{\hat{V}(\hat{S})}{N}} / \hat{S} \quad (6)$$

where N is number of strata.

In order to verify acoustic observations and to analyse year class structure over the surveyed area, trawling was carried out regularly along the transects. All trawl stations with herring were used to derive a common length distribution for all transect within the respective strata. All stations had equal weight.

Relative standard error by number of individuals by age group was estimated by combining Monto Carlo selection from estimated NASC distributions by stratum with bootstrapping techniques of the assigned trawl stations.

The acoustic estimates presented in this report use the 38 kHz NASC, and the mean was calculated for data scrutinized as herring and collected along the transects (acoustic recordings taken during trawling, and for experimental activity are excluded). The number of herring (*N*) in each length group (*l*) within each stratum (*i*) is then computed as:

$$N_l = \frac{f_l \cdot \hat{S}_i \cdot A_i}{\langle \sigma \rangle}$$

Where

$$f_l = \frac{n_l L_i^2}{\sum_{l=1}^{m} n_l L_l}$$

is the ”acoustic contribution” from the length group L_l to the total energy and <s_i>is the mean nautical area scattering coefficient [m^2/nmi^2] (NASC) of the stratum. A is the area of the stratum [nmi^2] and σ is the mean backscattering cross section at length L_l . The conversion from number of fish by length group (*l)* to number by age is done by estimating an age ratio from the individuals of length group *(l)* with age measurements. Similar, the mean weight by length and age grouped is estimated.

The mean target strength (TS) is used for the conversion where $\sigma = 4\pi\ 10^{(TS/10)}$ is used for estimating the mean backscattering cross section. Traditionally, TS = 20logL – 71.9 (Foote 1987) has been used for mean target strength of herring during the spawning surveys, however, several papers question this mean target strength. Ona (2003) describes how the target strength of herring may change with changes with depth, due to swimbladder compression. He measured the mean target strength of herring to be TS = 20logL – 2.3 log(1 + z/10) – 65.4 where z is depth in meters. Given that previous surveys were estimated using Foote (1987), the estimation this year was also done with this TS, for direct comparison and possible inclusion in the stock assessment by ICES WGWIDE 2021 as another year in the time series.

3 - Results and discussion

3.1 - Survey coverage

The cruise tracks of the NSSH spawning survey in 2022, together with pelagic trawl stations and CTD stations are shown in Figure 2. As mentioned above, the coverage south of 65°N was fairly low 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 65°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 four next strata with zigzag transects. The northernmost stratum with parallel transects 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 34 CTD casts were carried out in the surveyed area (Fig. 2). Nautical area scattering coefficients (NASC) allocated to herring from acoustic transects by each nautical mile are shown in Figure 3. Significant herring marks on the echosounders started to occur slightly north of 66°N, which is unusually far north in mid-February, and herring was observed in the entire area north of this. South of Lofoten the herring was mainly distributed around the shelf edge of the Røst bank, but outside Lofoten and Vesterålen herring was also observed on the banks nearer land. North of Vesterålen the herring was distributed along the shelf edge as usual, and the zero-line was established in the north around 70.9°N. Capelin marks started to appear around 69.7°N (confirmed by trawl samples) and was observed regularly north of this, in particular around the shelf edge area in the northernmost part. The herring schools appeared to be deeper and clearly separated from the more shallow capelin schools, an observation that the trawl sampling also supported. No more capelin results are presented in this report as the focus is on herring.

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. The 2016 year class (age 6) dominated both in numbers (52 %) and biomass (46 %), followed by the 2013 year class (age 9) which contributed 12 % in numbers and 15 % in biomass. Compared with the point estimates from last year (see Salthaug et al. 2021) the 2016 year class was reduced by 37 % in numbers and the 2013 year class by 22 %. The point estimate of total stock biomass (TSB) in the survey area was 3.302 million tons which is 18 % lower than last year's estimate (mean of 1000 bootstrap replicates). The time series 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 12.2 billion which is 29 % lower than last year's estimate. The time series of total stock number from the survey is shown in Figure 5. This year's estimates of TSB and TSN are slightly below the respective means of the time series. The relative standard error (CV) of the TSB and TSN estimates in 2021 are both 17 % (Tab. 1 and 2). These estimates of sample uncertainty are quite similar to those from the two previous surveys. The CV per age (Tab.1 and 2) shows the normal pattern with high uncertainty for the very young and old year classes and moderate (20-30 %) for the most abundant ages in the survey. Figure 6 shows estimates of number per year class in the eight most recent surveys. The estimated numbers from the survey in 2022 seems to decline as excepted for the year classes that are fully recruited to the survey. In addition, like in the most recent surveys the 2016 and 2013 year classes are estimated to be the most abundant which shows that this survey is internally consistent. Mean weight and length from the 2021 spawning survey are shown in Table 3. The Stox project used to calculate abundance and related parameters is openly available and can be found here:

http://metadata.nmdc.no/metadata-api/landingpage/2870f9f21da64f3a01641dfe12512b33

3.3 - Spatial distribution of the stock

The relative distribution of the estimated biomass per stratum is shown in Figure 7. This year most of the biomass

(84%) was found in the two strata west of Lofoten and Vesterålen, while only a small fraction was found in the strata to the north and south of these. The spawning stock was much more concentrated and further north than usual this year. Age compositions per stratum are shown in Figure 8. The southernmost stratum where herring was recorded was dominated by herring older than eight years, which is consistent with earlier observations; the largest and oldest fish are in the front of the spawning migration. The 2016 year class dominated in the rest of the strata, and the proportion of younger herring was as usual highest in the north.

The pattern with large and old fish in the southern part of the spawning area and younger and older herring in the north has been thoroughly discussed in Slotte and Dommasnes, 1997, 1998, 1999, 2000; Slotte, 1998b; Slotte, 1999a, Slotte 2001, Slotte et al. 2000, Slotte & Tangen 2005, 2006). The main hypothesis is that this could be due to the high energetic costs of migration, which is relatively higher in small compared to larger fish (Slotte, 1999b). Large fish and fish in better condition will have a higher migration potential and more energy to invest in gonad production and thus the optimal spawning grounds will be found farther south (Slotte and Fiksen, 2000), due to the higher temperatures of the hatched larvae drifting northwards and potentially better timing to the spring bloom (Vikebø et al. 2012).

Figure 9 shows the proportion of different maturation stages in each stratum. Most of the herring was classified as maturing or ripe, and the proportions of maturing herring were larger than last year which indicates later spawning this year. The old herring in the southernmost stratum was dominated by maturing individuals indicating that these fish would swim further south before spawning. The fishery also indicated that this was the case since catches moved further south after the survey covered the area (see Fig. 1). A small fraction of the herring outside Lofoten and Vesterålen were spawning and this, together with the large proportion of ripe individuals, indicate that much of the 2016 year class spawned in this area. Like last year this shows a very northern spawning this year, which also was confirmed through the fishery that was very low at the historically important spawning grounds off Møre.

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 67ºN, for the years after 2016 when the survey has been carried out in the same period (latter half of February). The temperatures in 2022 varied from 7.7°C at 250 m depth south of 67 ∞ N to 5.4°C at 5 m depth north of 67ºN. The temperatures near the surface were quite low this year, and also varied more with depth compared to earlier years. 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

In 2022 both vessels were equipped with multifrequency equipment on a drop keel. The weather conditions were exceptionally good this year so that acoustic data with good quality was recorded and trawling on registrations could be carried out all of the time. No correction for air bubble attenuation (as described in Annex 3 in Slotte et al. 2019) had to be carried out this year due to the nice weather. As opposed to 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 2022 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 2022.

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5 - Tables

Table 1. Abundance estimates (mill ion individuals) of Norwegian spring-spawning herring during the spawning survey 14.-27. February 2022 , based on 1000 bootstrap replicates.

Age	5th percentile	Median	95th percentile	Mean	SD	CV
2	1	23	62	27	19	0.72
3	13	71	134	72	36	0.50
4	51	154	310	162	78	0.48
5	406	738	1148	760	234	0.31
6	4473	6314	8475	6393	1256	0.20
7	205	308	458	317	76	0.24
8	377	557	788	563	126	0.22
9	1066	1500	2063	1515	298	0.20
10	174	294	458	301	89	0.30
11	303	477	707	486	122	0.25
12	175	297	439	301	79	0.26
13	137	247	393	255	80	0.31
14	206	380	584	385	119	0.31
15	37	71	122	73	26	0.36
16	227	384	602	395	117	0.30
17	18	52	109	57	29	0.50
18	36	86	157	89	37	0.41
20	0	13	42	15	15	1.04
TSN	8910	12126	15591	12183	2051	0.17

Table 2 . Abundance estimates (thousand tons) of Norwegian spring-spawning herring during the spawning survey 14.-27. February 2022 , based on 1000 bootstrap replicates.

Age	**5th percentile**	**Median**	**95th percentile**	**Mean**	**SD**	**CV**
2	0	1	4	2	1	0.77
3	1	8	18	9	5	0.59
4	7	23	44	24	11	0.48
5	76	131	204	136	41	0.30
6	1083	1511	2035	1533	303	0.20
7	57	87	128	89	22	0.24
8	115	169	239	171	38	0.22
9	336	478	660	481	96	0.20
10	58	102	160	104	31	0.30
11	104	165	245	168	42	0.25
12	64	108	158	109	29	0.26
13	51	92	147	95	30	0.32
14	75	138	213	140	43	0.31
15	14	27	46	28	10	0.36

Age	5th percentile	Median	95th percentile	Mean	SD	CV
16	87	148	232	151	45	0.30
17	6	19	41	21	11	0.51
18	13	33	60	34	14	0.41
20	0	5	16	6	6	1.03
TSB	2424	3291	4246	3302	557	0.17

Table 3 . Estimated length and weight of individuals by age group of Norwegian spring-spawning herring during the spawning survey 14.-27. February 2022 , based on 1000 bootstrap replicates.

Age	mean weight (g)	CV weight	mean length (cm)	CV length
2	56.7	0.063	21.2	0.017
3	105.7	0.230	24.9	0.053
4	137.6	0.066	27.4	0.017
5	171.3	0.026	29.1	0.006
6	230.0	0.012	31.3	0.003
7	277.0	0.021	33.0	0.005
8	301.1	0.018	34.1	0.005
9	315.2	0.010	34.3	0.003
10	343.4	0.018	35.6	0.007
11	342.3	0.019	35.6	0.006
12	362.1	0.017	36.6	0.003
13	371.7	0.021	36.9	0.004
14	362.5	0.017	36.5	0.005
15	373.7	0.023	37.1	0.006
16	380.9	0.014	37.2	0.003
17	362.5	0.037	37.3	0.008
18	379.1	0.024	37.1	0.011
20	387.6	0.032	37.0	0.000

6 - Figures

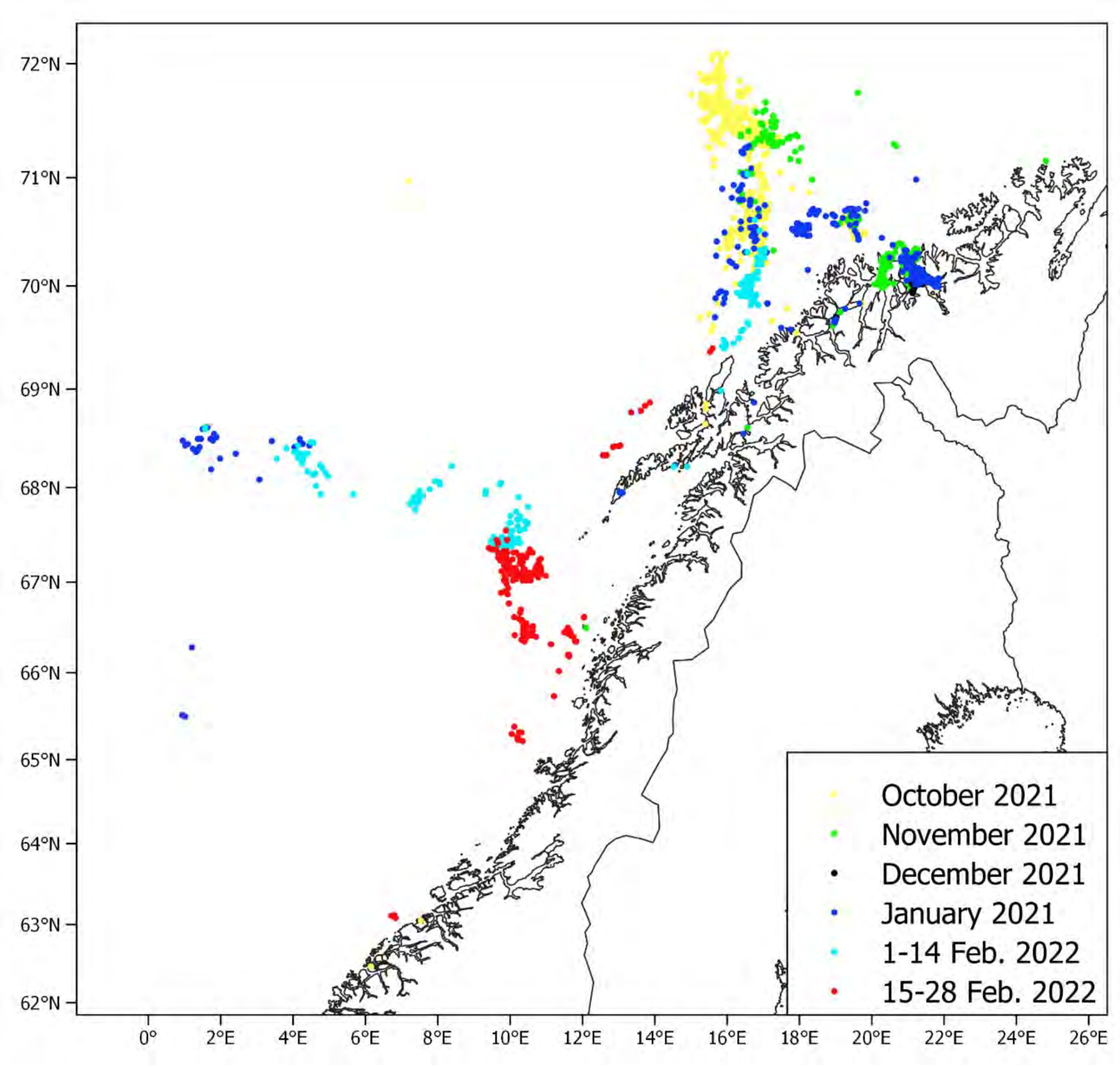

Figure 1. Distribution of commercial catches of Norwegian spring-spawning herring from October 2021 until February 2022, based on electronic logbooks. Each point represent one catch, only catches larger than 10 tons are shown.

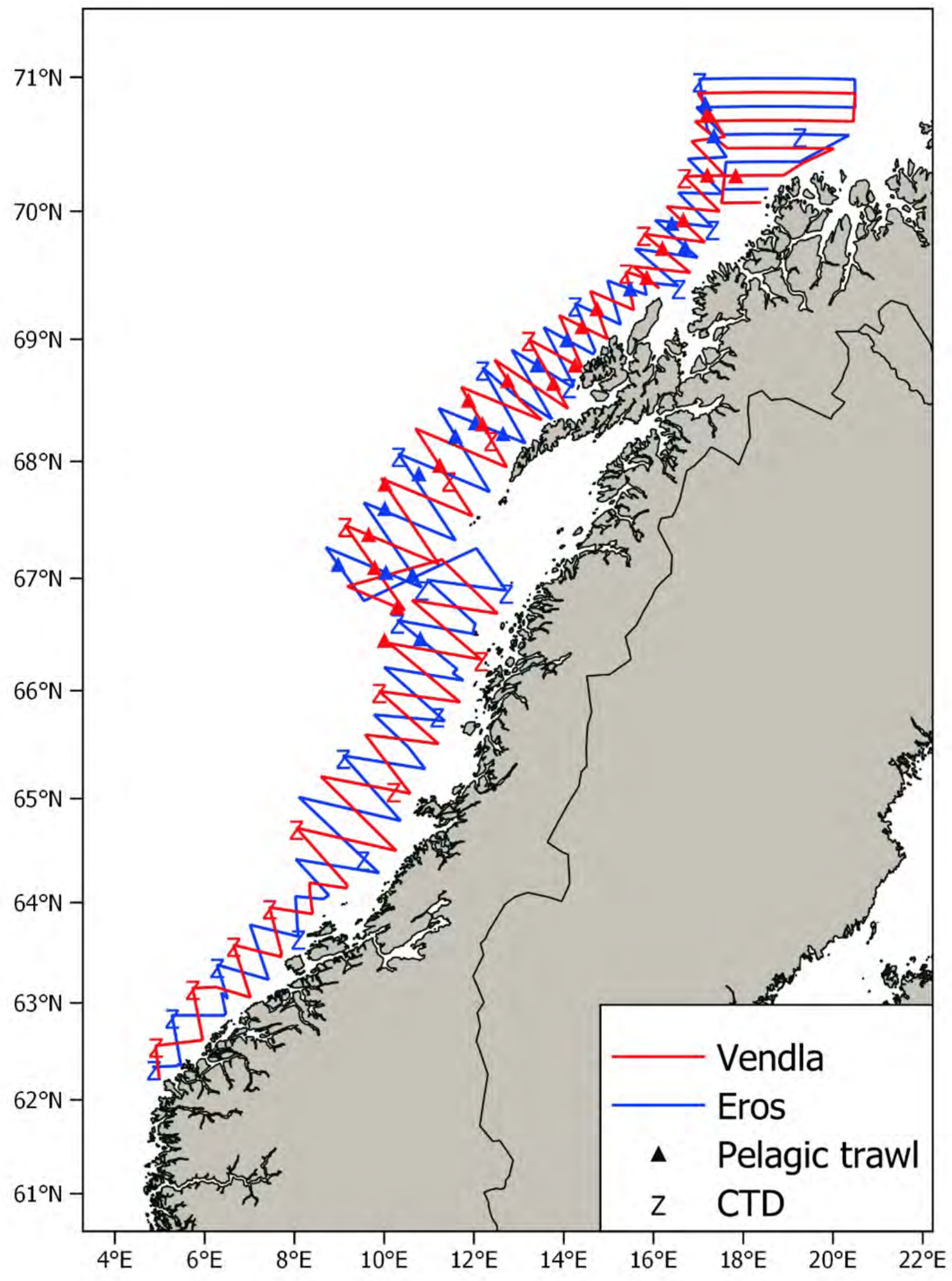

Figure. 2. Cruise tracks (mostly acoustic transects), pelagic trawl stations (triangles), and CTD stations (Z) covered by Eros and Vendla on the Norwegian spring-spawning herring spawning survey 14.-27. February 2022.

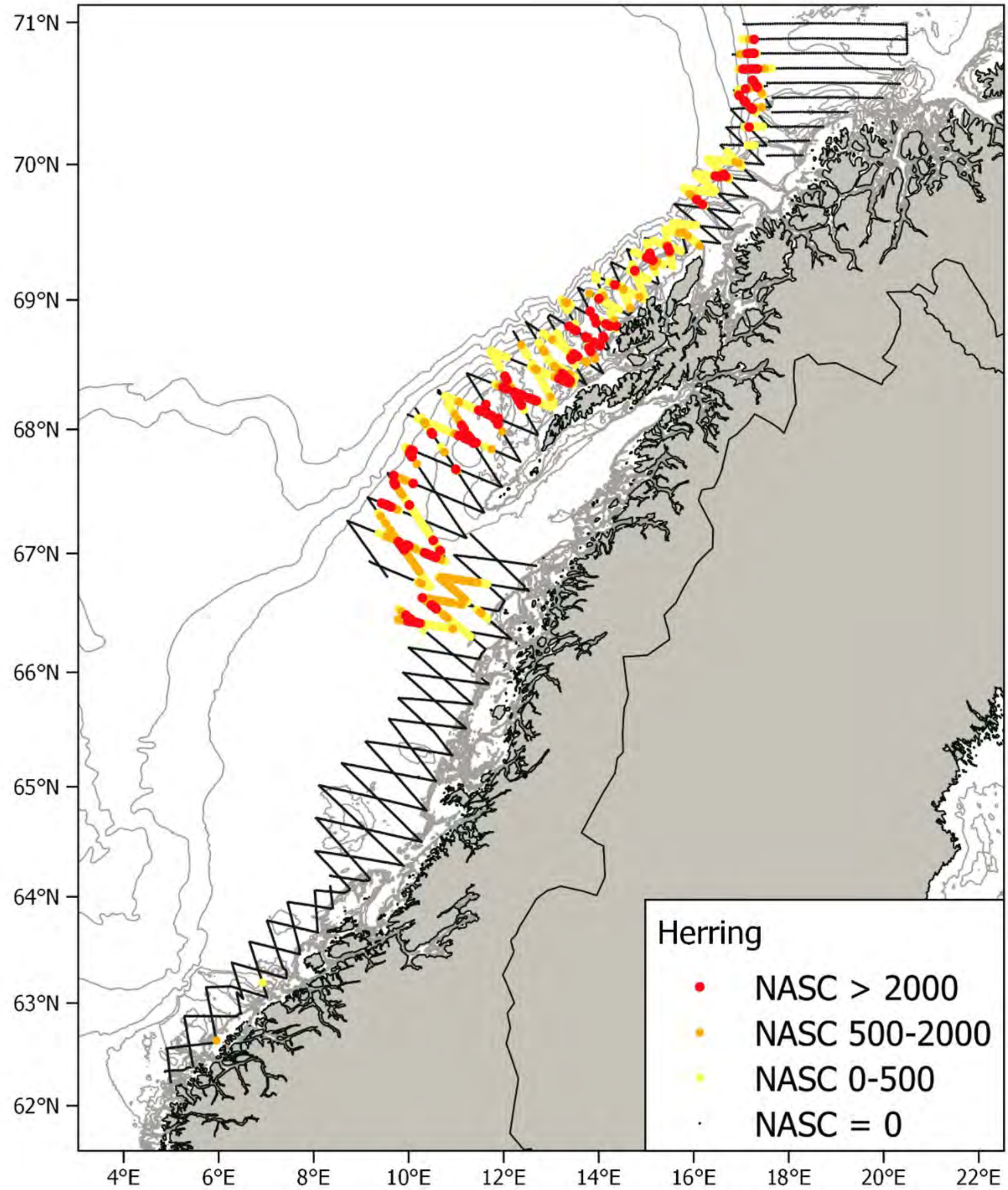

Figure 3. Acoustic densities (NASC) of herring recorded during the Norwegian spring-spawning herring spawning survey 14.-27. February 2022. Points represent NASC values per nautical mile. Depth contours are shown for 50 m, 100 m, 150 m, 200 m, 500 m, 1000 m, 1500 m and 2000 m.

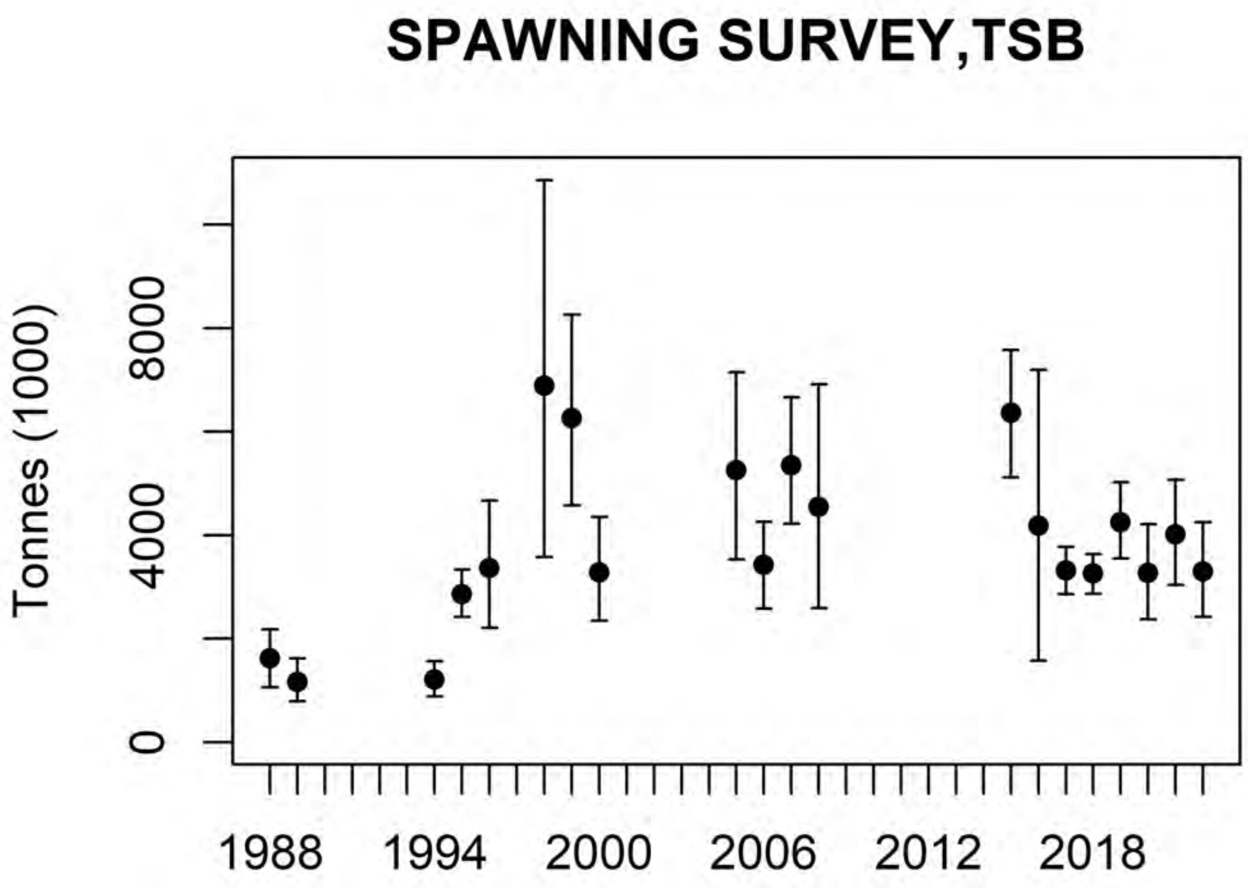

Figure 4. Estimates of total biomass from the Norwegian spring-spawning herring spawning surveys during1988-2022. The estimates are mean of 1000 bootstrap replicates and the error bars represent 90 % confidence intervals.

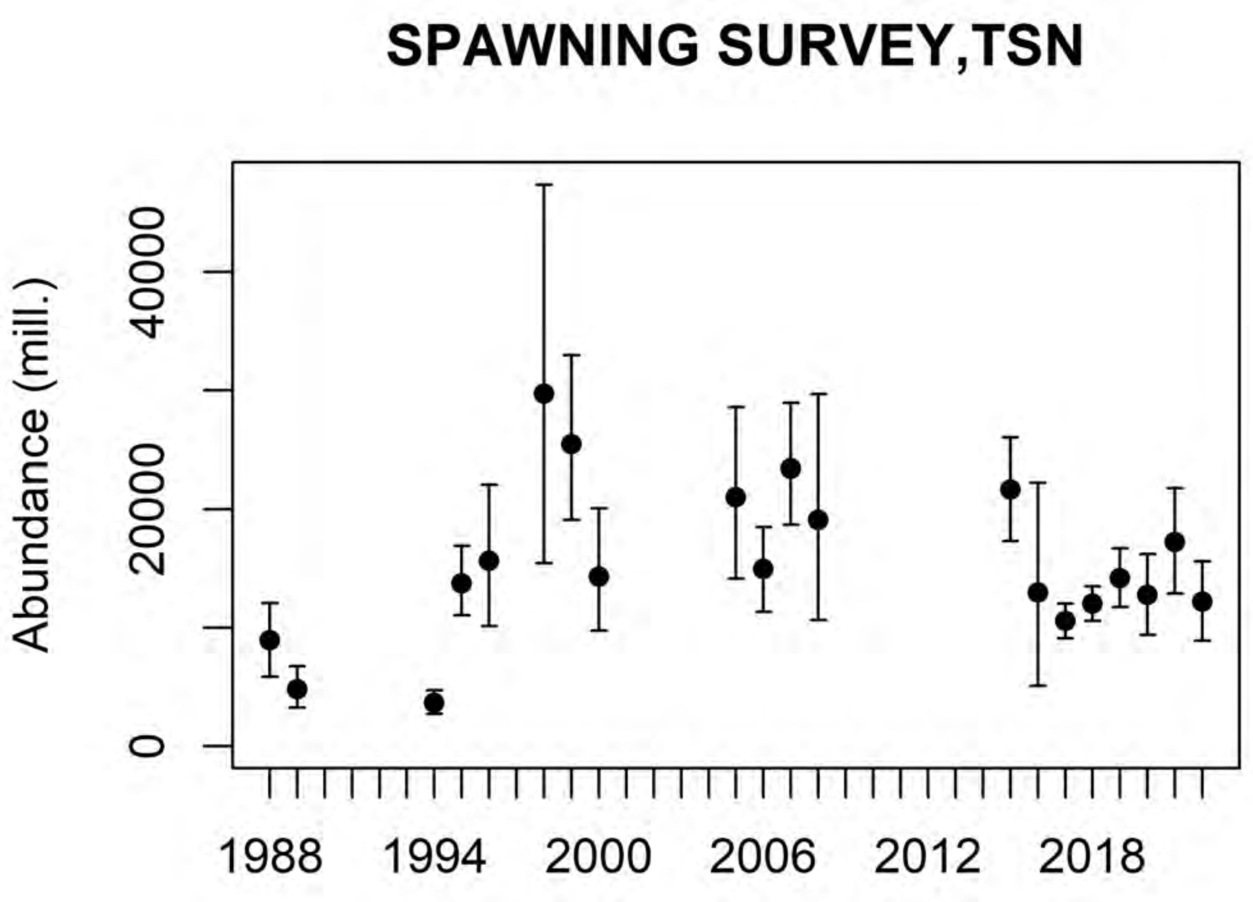

Figure 5. Estimates of total number from the Norwegian spring-spawning herring spawning surveys during1988-2022. The estimates are mean of 1000 bootstrap replicates and the error bars represent 90 % confidence intervals.

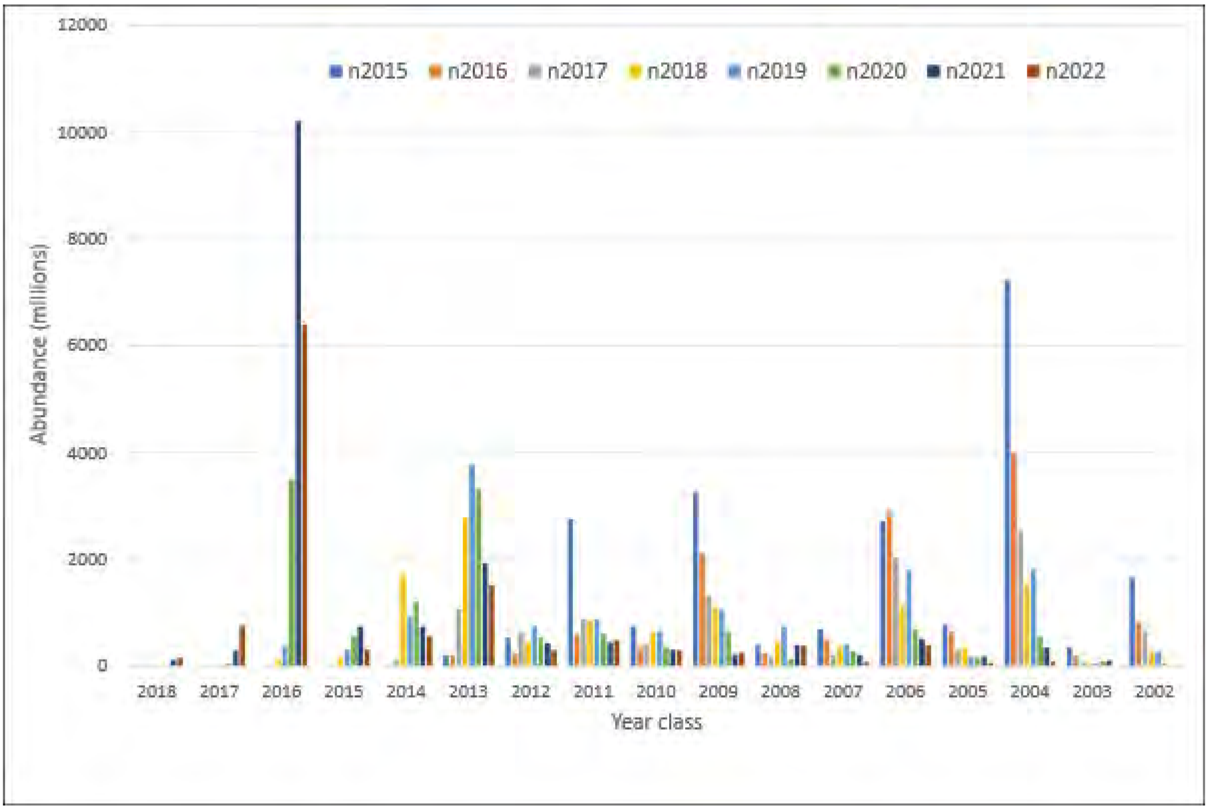

Figure 6. Abundance by year class estimated during the Norwegian spring-spawning herring spawning surveys 2015-2022 (mean of 1000 bootstrap replicates). Legend: Separate colour for each survey year.

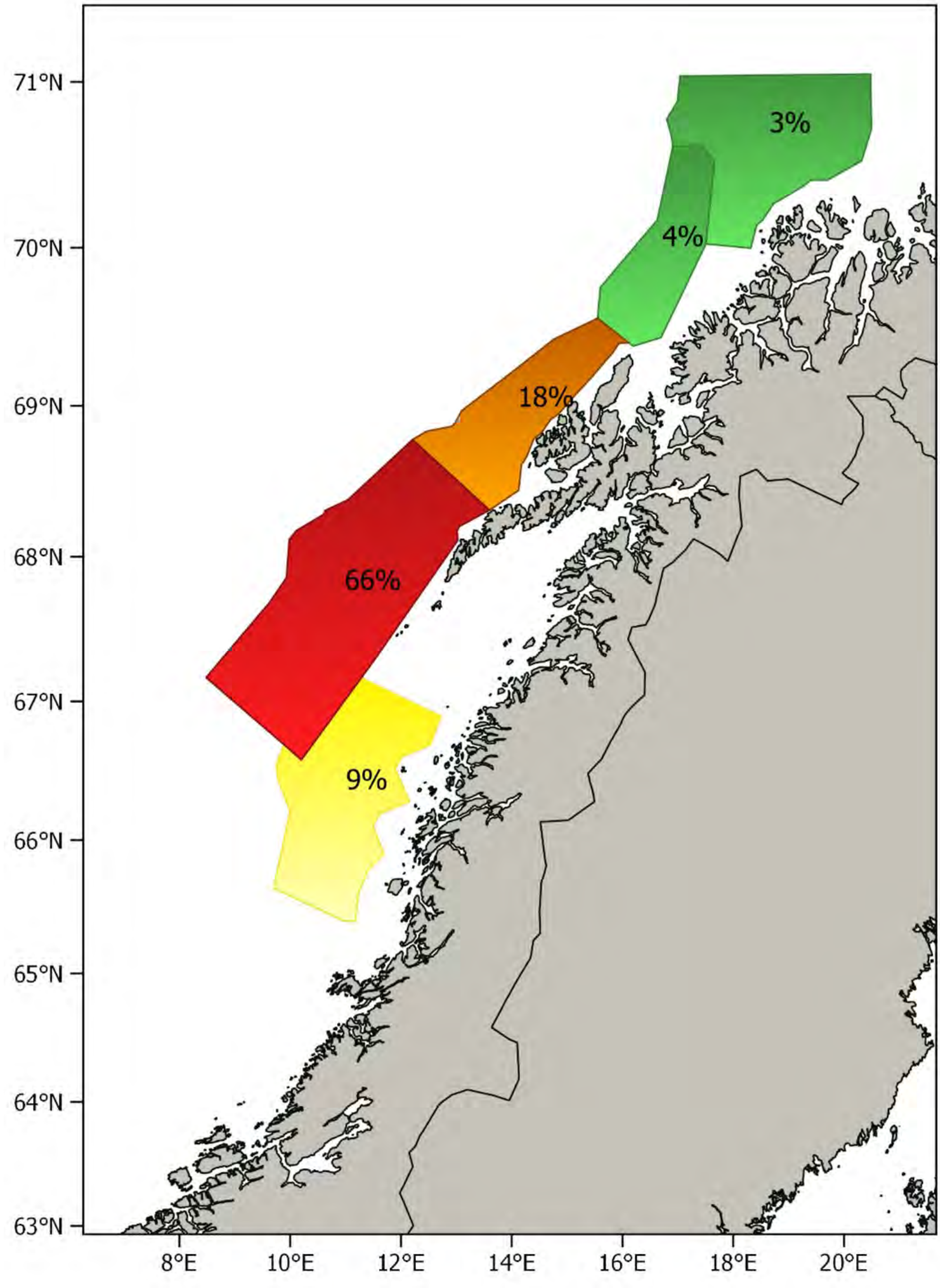

Figure 7. Relative distribution by stratum of the biomass of herring from the Norwegian spring-spawning herring spawning survey 14.-27. February 2022 .

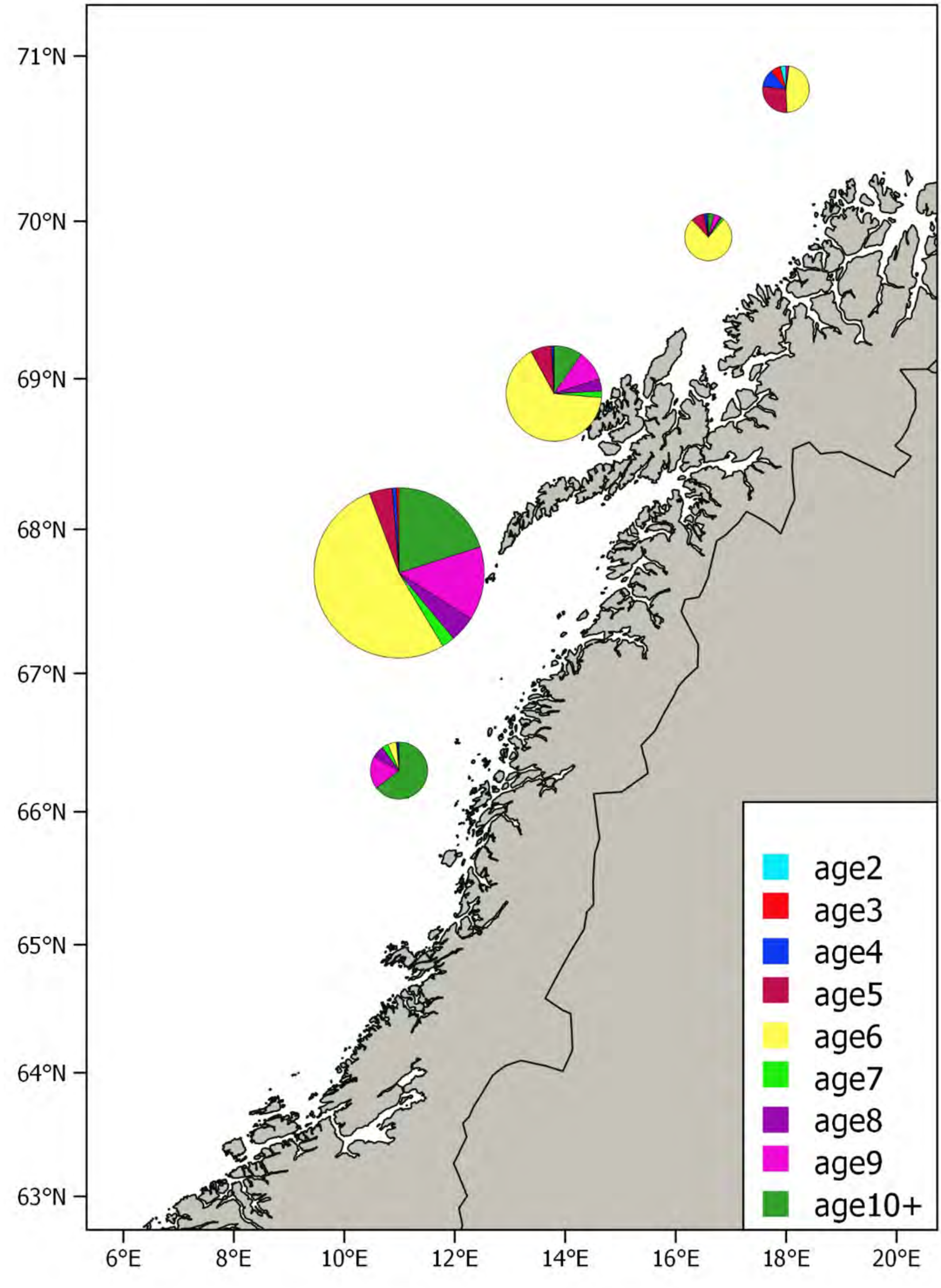

Figure 8. Age distribution per stratum from the Norwegian spring-spawning herring spawning survey 14.-27. February 2022 . The area of the bubbles is scaled with the total number estimated in each stratum.

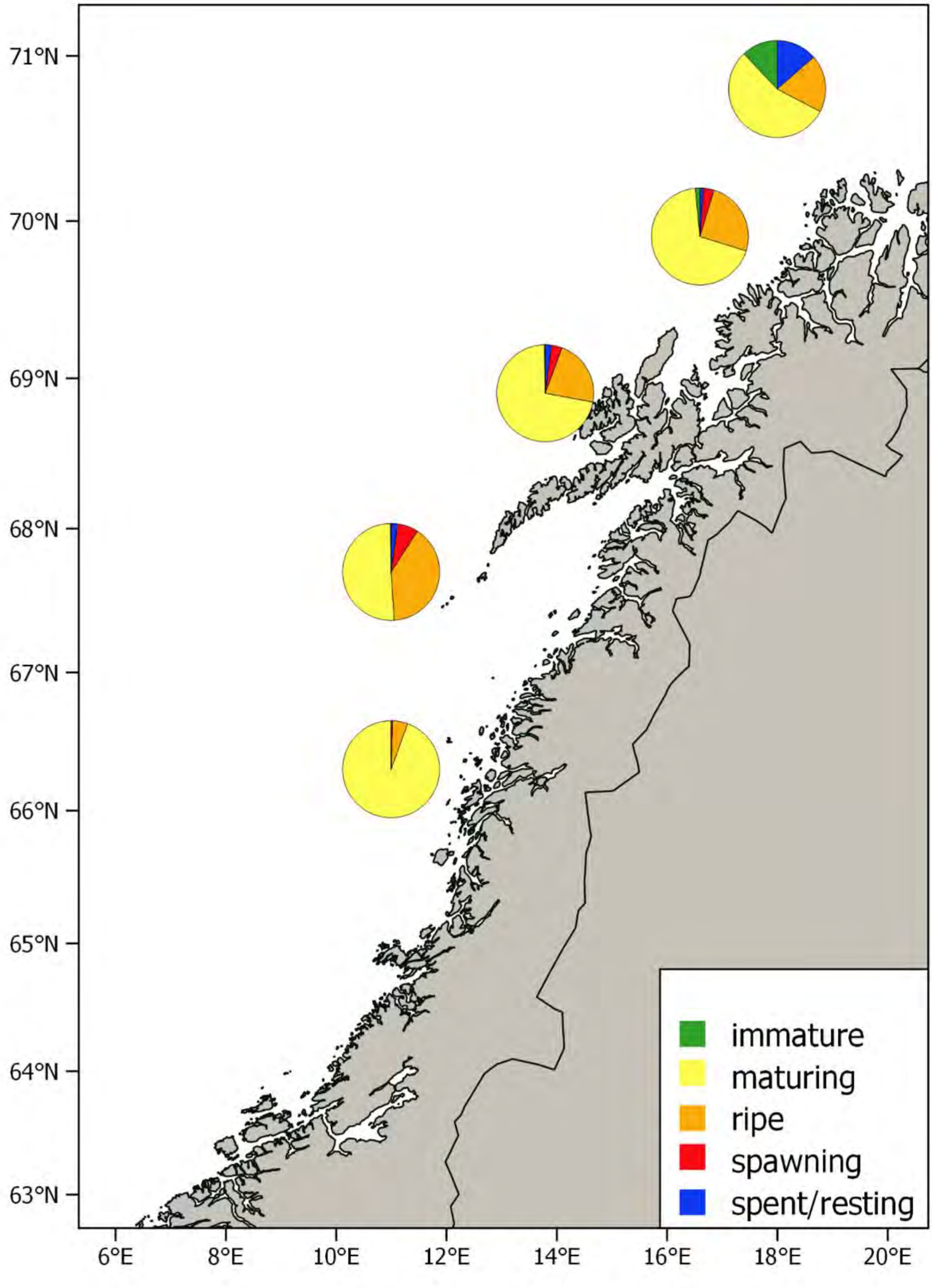

Figure 9. Proportions of different maturity stages from the Norwegian spring-spawning herring spawning survey 14.-27. February 2022 .

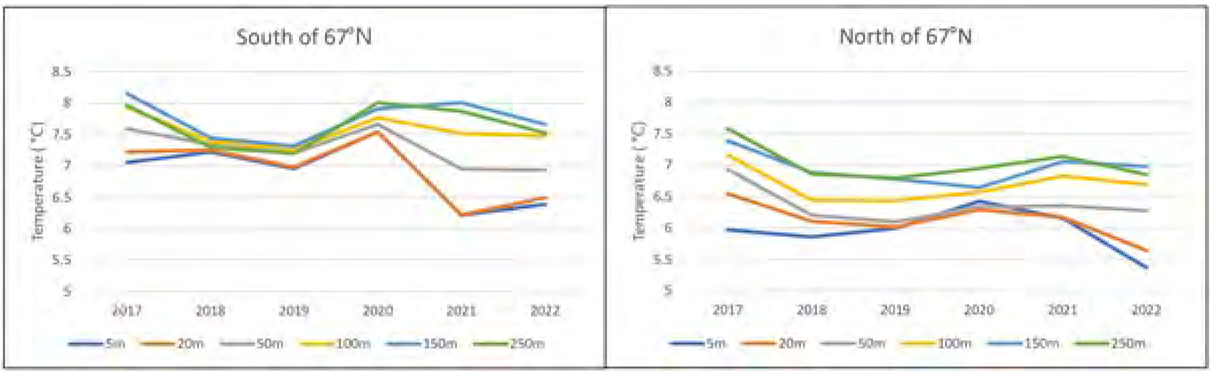

Figure 10. Mean temperatures at 5, 20, 50, 100, 150, 250 m in the area covered during the Norwegian spring-spawning herring spawning surveys in 2017-2022.

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Working Document to

Working Group on International Pelagic Surveys (WGIPS)
23 – 27 January 2023
and
Working Group on Widely Distributed Stocks (WGWIDE)
24 – 30 August 2022

INTERNATIONAL ECOSYSTEM SURVEY IN NORDIC SEA (IESNS) in April - May 2022

Post-cruise meeting on Teams, 14-16 June 2022

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Introduction

In April-May 2022, four research vessels and one hired commercial vessel participated in the International ecosystem survey in the Nordic Seas (IESNS); R/V Dana, Denmark (joint 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). It should be noted that this was the first year that UK participated in the survey, and the plan is to continue the participation in the coming years. The Barents Sea is usually surveyed by a Russian research vessel, but that was not possible in 2022. 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 also the EU participated (except 2002 and 2003) and from 2004 onwards it was more integrated into an ecosystem survey.

This report represents analyses of data from this International survey in 2022 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 03/2022. International Ecosystem survey in the Nordic Seas (IESNS) in 2022, Árni Friðriksson: Report on Survey A5-2022, Bjarnason, 2022, Jákup Sverri: Preliminary Report Cruise no. 2216).

Material and methods

Coordination of the survey was done during the WGIPS meeting in January 2022 and by correspondence. Planning of the acoustic transects and 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:

Vessel	Institute	Survey period
Dana	DTU Aqua - National Institute of Natural Resources, Denmark	22/04-20/05
G.O. Sars	Institute of Marine Research, Bergen, Norway	26/04-30/05
Jákup Sverri	Faroe Marine Research Institute, Faroe Islands	28/04-08/05
Árni Friðriksson	Marine and Freshwater Research Institute, Iceland	04/05-23/05
Resolute	CEFAS, United Kingdom	24/04-06/05

Note that Resolute covered the UK EEZ in the southernmost part of the IESNS survey area, but this area was also covered by G.O. Sars and Dana. The reason for this double coverage was to ensure consistency with previous year's surveys (the UK coverage went well and these data were used in the abundance estimation). 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. UK also covered an area south of the IESNS survey area and this is described in Annex A.

In general, the weather conditions did not affect the survey even if there were some days that were not favourable and trawling, WP2 and Multinet sampling at some stations were prevented. 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	8	6-9	6
Upper integration limit (m)	10	15	15	15	10
Absorption coeff. (dB/km)	10.05	10.1	10.5	10.3	10
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Band width (kHz)	2.425	2.43	2.425	3.06	
Transmitter power (W)	2000	2000	2000	2000	2000
Angle sensitivity (dB)	21.9	21.9	18	21.9	18
2-way beam angle (dB)	-20.5	-20.7	-20.3	-20.4	-20.7
Sv Transducer gain (dB)	25.31				
Ts Transducer gain (dB)		26.12	27.03	26.94	26.62
s_A correction (dB)	-0.61	-0.13	-0.04	-0.13	-0.04
3 dB beam width (dg)					
alongship:	6.98	6.42	6.43	6.47	6.35
athw. ship:	6.94	6.29	6.43	6.54	6.54
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 a 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 2022 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
<u>Trawl dimensions</u>					
Circumference (m)		496	832	832	972
Vertical opening (m)	20-30	25-30	20–35	44–55	30-50
Mesh size in codend (mm)	20/40	24	20	45	100
Typical towing speed (kn)	3.5-4.5	3.0–4.5	3.1–5.0	3.7 (3–4.5)	3.5-5
<u>Plankton sampling</u>					
Sampling net	WP2	WP2	WP2	WP2	WP2
Standard sampling depth (m)	200	200	200	200	200
<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 a coming age reading and stock identity workshop, genetic samples were collected of herring. 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	100-300	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	50	50
	Blue whiting	50	25-30	50	25-50	50
	Mackerel	0	25-30	50	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			25	50

* Number of weighed individuals significantly higher.

Acoustic data were analysed using the StoX software package (version 3.4.0) 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: 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: $TS = 20 \log(L) - 65.2$ 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 WPII 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 mg total dry weight per m^2. 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. This front was sharper below 50 m than above. 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 6 °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 in most of the Norwegian Sea (Figure 7a). Below 50 m depth, the patterns were more fragmented, but the Norwegian Sea was still in general colder than the long-term mean (Figures 7b-c). Largest negative temperature anomalies were between Iceland and Faroe Islands due to a more southern located Iceland-Faroe front compared to the long-term mean. This was found for all depths, and the temperatures in this region were in some locations 3 °C lower than the mean (Figures 7a-c). Also, in the centre of the Norwegian Basin, the temperatures were 1 °C lower than the mean, probably because of a more eastern located Arctic front. Warmest regions, relative to the long-term mean, were in the eastern Greenland Sea, with temperatures 2 °C higher than the mean, and in some areas below 50 m depth in southern and southwestern parts of the Norwegian Sea.

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) in the upper 200 m is shown in Figure 8. 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 eastern and southeastern parts. Within the eastern area, several locations had high biomass and a large patch was found at ca. 3°W and 64.5°N. Lower biomasses were found in central and western parts of the Norwegian Sea.

Figure 9 shows the zooplankton 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 Sea Basin (covering the southern Norwegian Sea). The zooplankton biomass index for 2022 was respectively: 4563, 6627, 9237 and 9962 mg dry weight m^{-2}, and while the subareas east of Iceland and Jan Mayen arctic front showed a decrease compared to last year, the Lofoten- and Norwegian Basin increased. The zooplankton biomass indices for the Norwegian Sea in May have been estimated since 1995. All subareas had a high biomass period until mid-2000, and a lower period thereafter. The decrease was most pronounced in the Iceland Sea, where the reduction was 59 %. 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). 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.

Norwegian spring-spawning herring

Survey coverage in the Norwegian Sea was considered adequate in 2022. 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 2022 can be used for assessment purpose. The herring was primarily distributed in the central and southwestern area (Figure 10). In the westernmost area old herring dominated, but in general, the 2016-year-class was the most abundant year class throughout the survey area. 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).

Six-year-old herring (2016-year class) dominated both in terms of number (49%) and biomass (48%) on basis of the StoX bootstrap estimates for the Norwegian Sea (Table 2). The abundance of the 2016 year-class decreased by 19 % compared to last year's estimate which could be expected since this year-class was fully recruited to the survey last year (Figure 12). The second largest year-class in the survey was the 2013 year-class (10% in numbers), and older age groups (10-18 years old) contributed with less than 10% to the abundance estimate. 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 21 % both for the total biomass and for the total numbers estimate, and the relative standard error for the dominating age groups is around 20-30 % (Figure 13).

The total estimate of herring in the Norwegian Sea from the 2022 survey was 19.8 billion in number and the biomass was 4.4 million tonnes. The biomass estimate is 13 % lower than the 2021 survey estimate and also the estimated number is about 13% lower than in 2021. The biomass estimate decreased significantly from 2009 to 2012 and has since then been rather stable at 4.2 to 5.9 million tonnes with similar confidence interval (Figure 14), with the lowest abundance occurring in 2017. The 2016 year class now appears to be fully recruited, distributed widely in the feeding area and more dominant than the older year classes.

There was no coverage of juvenile herring in strata 5 (the Barents Sea) in May 2022.

In the last 6 years, there have been concerns regarding age reading of herring, because the age distributions from the different participants have showed differences – particularly older specimens appear to have uncertain ages. A scale and otolith exchange has been ongoing for some time, where scales and otoliths for the same fish have been sampled. As a follow-up on that work, a new exchange and following workshop are currently being planned for April 2023. The survey group emphasizes the necessity of having this workshop before next year’s survey takes place.

With respect to age-reading concerns in the recent years, the comparison between the nations in this year’s survey for the most part appeared to be in good agreement (Figure 15).

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 2022 are shown in Table 3. The estimated biomass was 1.5 million tons (CV=0.13) which is a 76 % increase from last year's estimate, and one of the two highest estimates after 2007 (together with the 2016 estimate). The estimated total abundance was 17.2 billion (CV=0.13) which is a 112 % increase from last year's estimate. The stock is totally dominated by 1 and 2 year old (2021 and 2022 year classes) and the estimates of total abundance, abundance of age 1 and abundance of age 2 are all the highest observed after 2007. 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 2022 is shown in Figure 16. As usual, most of the fish was registered in the eastern part of the Norwegian Sea. However, higher concentrations than in later years were observed in more central areas, in particular around the zero meridian in the southern part. This corresponds well with the high abundance estimate. The largest fish was found in the northwestern part of the of the survey area this year (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. This year the catches did not extend as far north as compared with recent years, only north to circa 64°N. This is the lowest northward extent of mackerel catches during IESNS after 2007 (first year with data from all participating vessels). No further quantitative information can be drawn from these data as this survey is not designed to monitor mackerel.

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.	It is recommended that the the planned age reading workshop in April 2023 also includes a session n how to deal with stock components of herring in the IESNS-survey.	WG

Next year's post-cruise meeting

We will aim for next meeting in 13-15 June 2023. The final decision will be made at the next WGIPS meeting.

Concluding remarks

- The sea temperature in 2022 was generally below the long-term mean (1995-2021) in the Norwegian Sea, but the pattern was more fragmented below 50 m depth. The Arctic front in the southern Norwegian Sea was more southerly and easterly located in 2022 compared to the long-term mean.
- The 2022 indices of meso-zooplankton biomass in the Norwegian Sea and adjoining waters were fairly similar to last year's estimates.
- The total biomass estimate of NSSH in herring in the Norwegian Sea was 4.4 million tonnes, which is a 13 % decrease from the 2021 survey estimate. The estimate of total number of NSSH was 19.8 billion, which is 13 % lower than in the 2021 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 (49%) and biomass (48%). The abundance of the 2016 year-class decreased by 19 % compared to last year's estimate
- The biomass of blue whiting measured in the 2022 survey increased by 76 % from last year's survey and 112 % in terms of numbers. The stock is dominated by the 2020 and 2021 year classes) and the estimates of total abundance, abundance of age 1 and abundance of age 2 are all the highest observed after 2007.

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Tables

Table 1. Survey effort by vessel for the International ecosystem survey in the Nordic Seas in May - June 2022.

Vessel	Effective survey period	Effective acoustic cruise track (nm)	Trawl stations	Ctd stations	Aged fish (HER)	Length fish (HER)	Plankton stations
Dana	26/4-16/5	2495	20	36	253	873	35
Jákup Sverri	28/4-8/5	1464	19	23	325	1093	23
Árni Fridriksson	8/5-23/5	3013	14	40	863	2747	34
G.O. Sars	26/4-30/5	5103	37	60	375	1107	59
Resolute	24/4-06/5	1158	11	22	290	537	22
Total		**13233**	**101**	**181**	**2106**	**6357**	**173**

IESNS post-cruise meeting, Teams 14-16/6 2022

Table 2. IESNS 2022 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
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Unknown			weight
(cm)	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004		(10^6)	(10^6 kg)	(g)
17-18	18.6																		18.6	0.7	38.0
18-19	37.3																		37.3	1.6	42.5
19-20	27.4																		27.4	1.5	56.0
20-21	113.7																	4.2	117.8	7.2	59.5
21-22	107.8																		107.8	7.8	72.6
22-23	116.3																	0.6	116.9	9.7	82.9
23-24	71.4	22.9																	94.3	8.9	93.3
24-25		46.8	142.5		5.9													1.7	197.0	21.3	108.6
25-26		61.2	229.3																290.6	33.6	116.3
26-27		27.1	252.4	49.3															328.9	44.7	134.8
27-28		72.1	134.8	5.8	6.8														219.5	33.0	152.2
28-29		46.7	94.5	168.3	57.5	37.7				12.8									417.3	70.3	168.7
29-30	14.7	46.9	174.7	336.4	304.1	81.4	116.3		58.3										1 132.8	210.4	185.2
30-31		28.4	149.5	297.3	1411.4	239.3	378.3	187.0	29.2	26.0									2 746.4	549.4	199.1
31-32		30.8	24.6	212.9	3210.3	353.7	374.9	411.2	79.3			88.9							4 786.7	1034.1	215.0
32-33			4.7	203.8	2986.8	144.5	138.6	383.8	113.2	29.2	68.7	21.1							4 094.4	956.8	232.9
33-34				12.0	1427.9	98.0	163.1	243.8	121.0	6.9	110.7			6.5					2 189.9	554.7	254.2
34-35					190.5	157.7	213.7	491.8	10.9	4.8									1 069.5	299.5	280.0
35-36					29.5	38.3	197.5	235.6	56.4	77.0	39.2	31.1	10.4		7.2	15.6			737.8	219.3	296.8
36-37					2.7		57.8	99.3	70.3	80.7	60.1	32.4	29.5	35.6	6.1	14.1			488.7	154.9	316.9
37-38								11.1	38.1	60.1	32.6	97.2	72.0	56.7	33.9	10.9			412.5	139.7	338.7
38-39										24.2	13.6	22.7	3.4	28.6	26.1	17.6			136.2	49.7	363.3
39-40										17.1				5.4	7.0	6.0	5.6	0.2	41.5	15.1	366.1
40-41															5.0			2.5	7.5	3.1	408.0
TSN(mill)	507.2	383.0	1207.1	1285.8	9633.2	1150.5	1640.3	2063.6	576.6	338.9	324.9	293.4	115.3	132.9	85.4	64.2	5.6		19 817.1		
cv (TSN)	0.59	0.49	0.45	0.34	0.23	0.36	0.37	0.34	0.40	0.31	0.42	0.40	0.39	0.35	0.44	0.45	1.12		0.21		
TSB(1000 t)	37.7	58.0	182.1	252.4	2 132.2	266.1	400.6	531.5	152.2	102.0	89.7	86.2	37.1	45.1	29.8	20.5	2.0		4 427.0		
cv (TSB)	0.55	0.48	0.41	0.35	0.23	0.34	0.35	0.32	0.38	0.31	0.39	0.35	0.39	0.36	0.46	0.46	1.12		0.21		
Mean length(cm)	21.2	27.6	27.9	30.0	31.5	32.2	33.0	33.6	34.0	35.8	35.2	35.9	36.6	36.9	37.3	36.7	39.0				
Mean weight(g)	76.0	165.2	169.1	199.6	223.0	246.3	262.7	273.6	285.3	314.2	299.6	320.7	321.4	341.9	346.6	319.4	365.4				

Table 3. IESNS 2022 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.

Length	Age in years (year class)									Number	Biomass	Mean
	1	2	3	4	5	6	7	8	Unknown			weight
(cm)	2021	2020	2019	2018	2017	2016	2015	2014		(10^6)	(10^6 kg)	(g)
14-15	7.6								2.6	10.2	0.1	16.0
15-16	232.7									232.7	4.9	20.8
16-17	1304.5	29.8								1 334.3	32.5	24.4
17-18	4114.3	122.2								4 236.5	125.6	29.7
18-19	5637.5	135.3								5 772.8	199.4	34.6
19-20	4229.8	161.9	6.7							4 398.5	173.8	39.9
20-21	1206.1	387.6	66.5							1 660.2	78.4	47.5
21-22	271.7	1526.6	123.7							1 922.0	109.8	57.4
22-23	135.6	2649.2	58.5							2 843.2	183.6	65.5
23-24	1.9	2821.4	207.0							3 030.3	221.0	74.5
24-25	27.0	2116.0	308.7							2 451.8	199.0	83.2
25-26		495.9	277.6	12.9						786.4	72.5	93.1
26-27		117.2	145.7	27.8						290.7	30.4	105.0
27-28		11.7	34.6	25.9	31.6	7.1	9.4			120.2	14.2	118.4
28-29			50.1	13.5			4.9			68.5	9.0	128.6
29-30					2.3	9.2	16.7	12.9	0.0	41.2	5.9	141.6
30-31				17.6	20.8		10.0	17.7		66.1	10.5	159.2
31-32					26.5	20.2	5.7			52.3	9.7	182.3
32-33							46.2	16.4	0.2	62.8	12.6	199.5
33-34							9.5	8.0	0.1	17.7	4.2	239.4
34-35					7.9				3.4	11.3	3.0	271.5
35-36												
36-37					2.2					2.2	0.7	330.0
TSN(mill)	17169	10575	1279	98	91	36	102	55		29 411.9		
cv (TSN)	0.16	0.15	0.20	0.39	0.36	0.51	0.54	0.54		0.13		
TSB(1000 t)	603.3	729.5	105.7	11.9	15.2	5.9	17.7	10.5		1 500.6		
cv (TSB)	0.15	0.16	0.19	0.40	0.38	0.53	0.55	0.53		0.13		
Mean length(cm)	18.2	22.7	24.1	27.2	29.7	29.9	30.6	30.5				
Mean weight(g)	36	72	85	121	167	159	168	183				

Figures

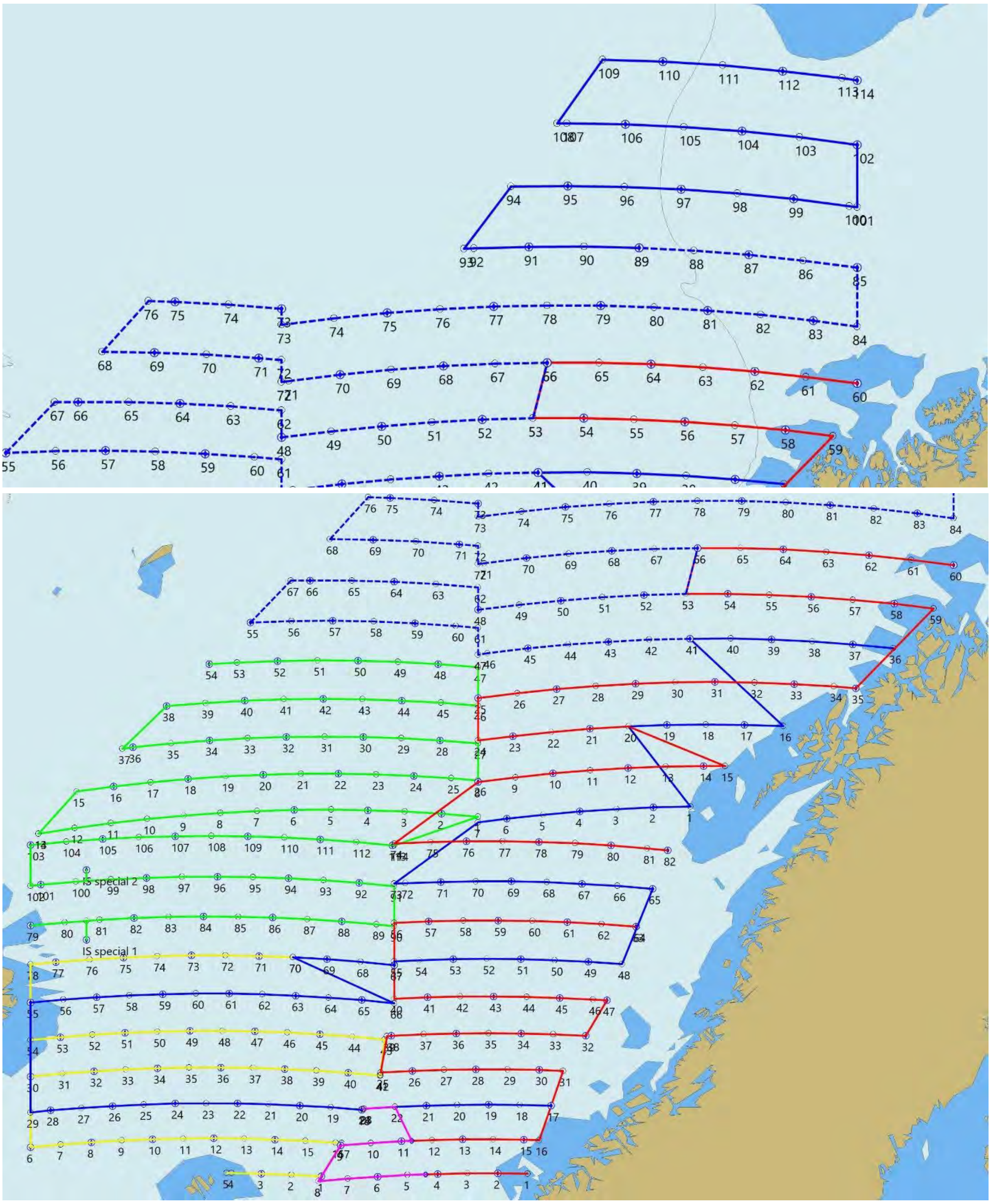

Figure 1. The pre-planned strata and transects for the IESNS survey in 2022 (red: EU, dark blue: Norway, yellow: Faroes Islands, violet: UK, green: Iceland). Hydrographic stations and plankton stations are shown as blue circles with diamonds. All the transects have numbered waypoints for each 30 nautical mile and at the ends**.**

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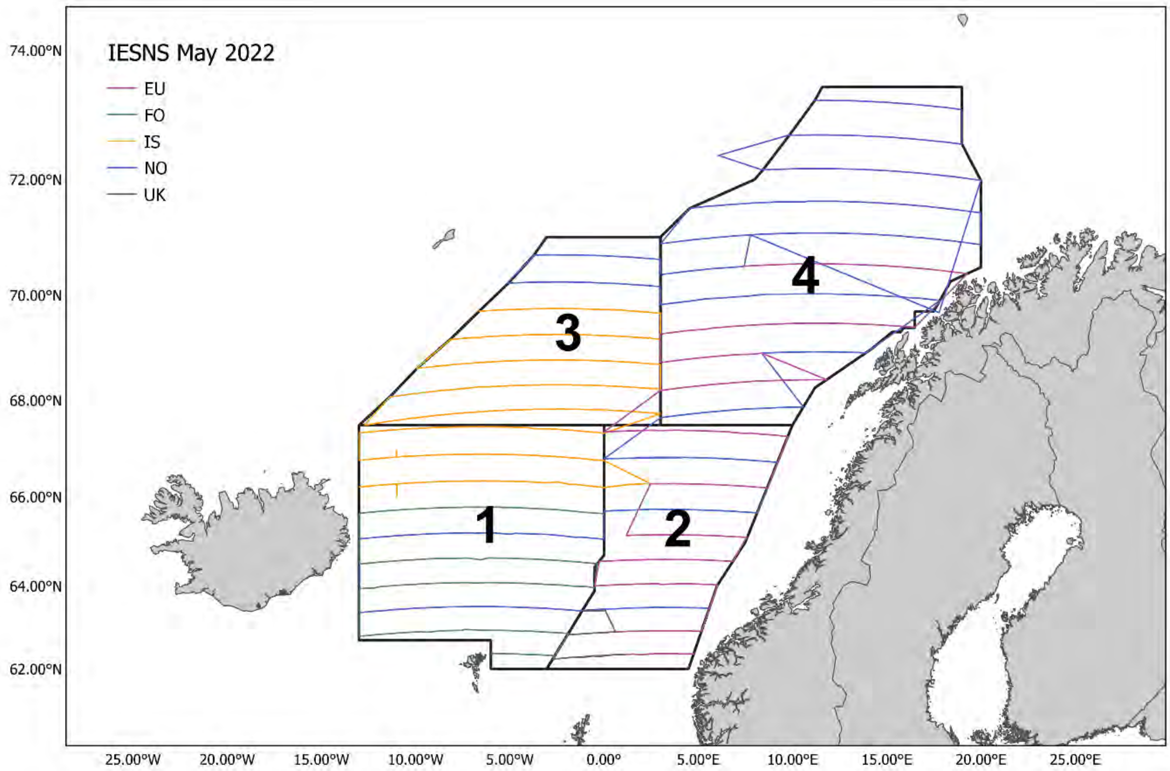

Figure 2. Cruise tracks and strata (with numbers) for the IESNS survey in May 2022.

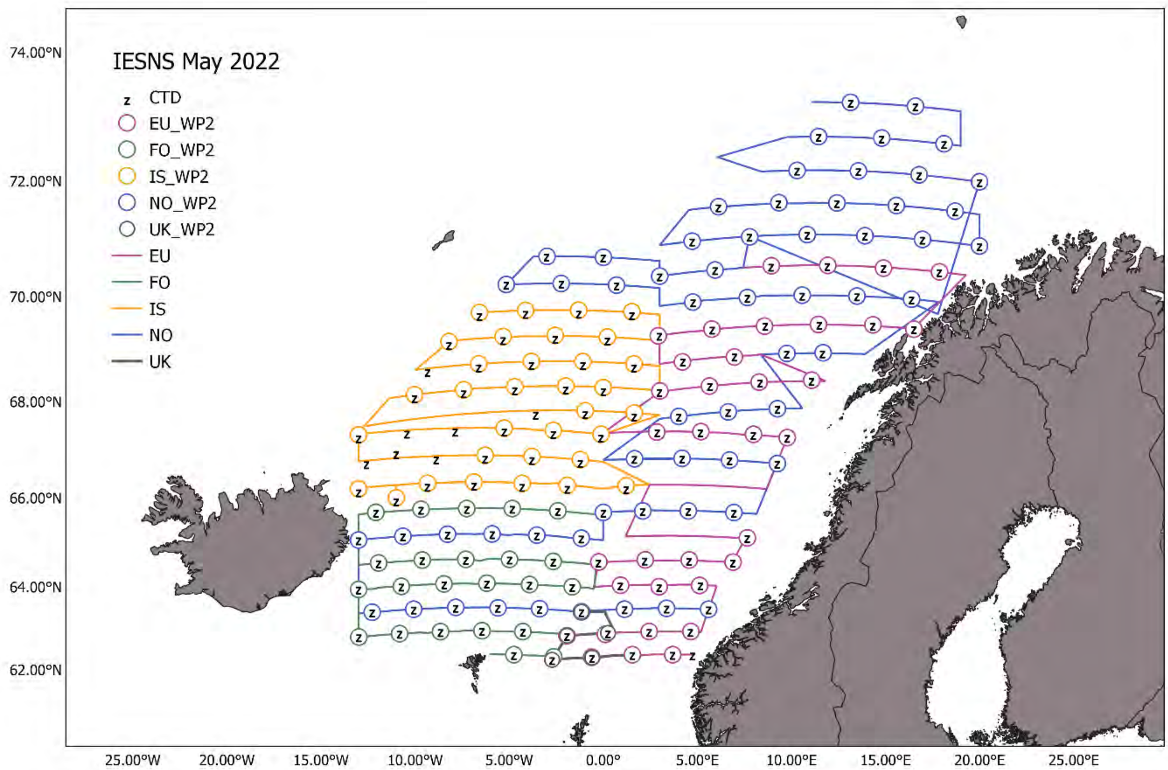

Figure 3. IESNS survey in May 2022: location of hydrographic and WPII plankton stations.

IESNS post-cruise meeting, Teams 14-16/6 2022

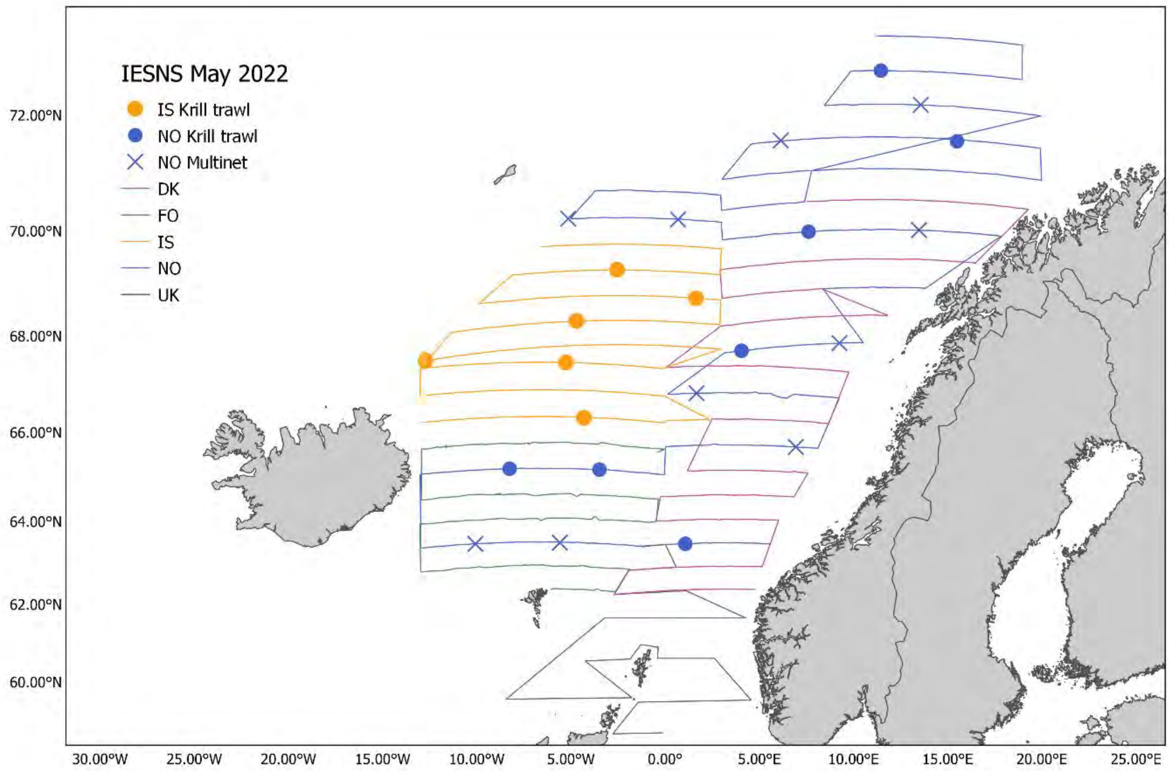

Figure 4. IESNS survey in May 2022: location of Macroplankton/Krill trawl and Multinet stations.

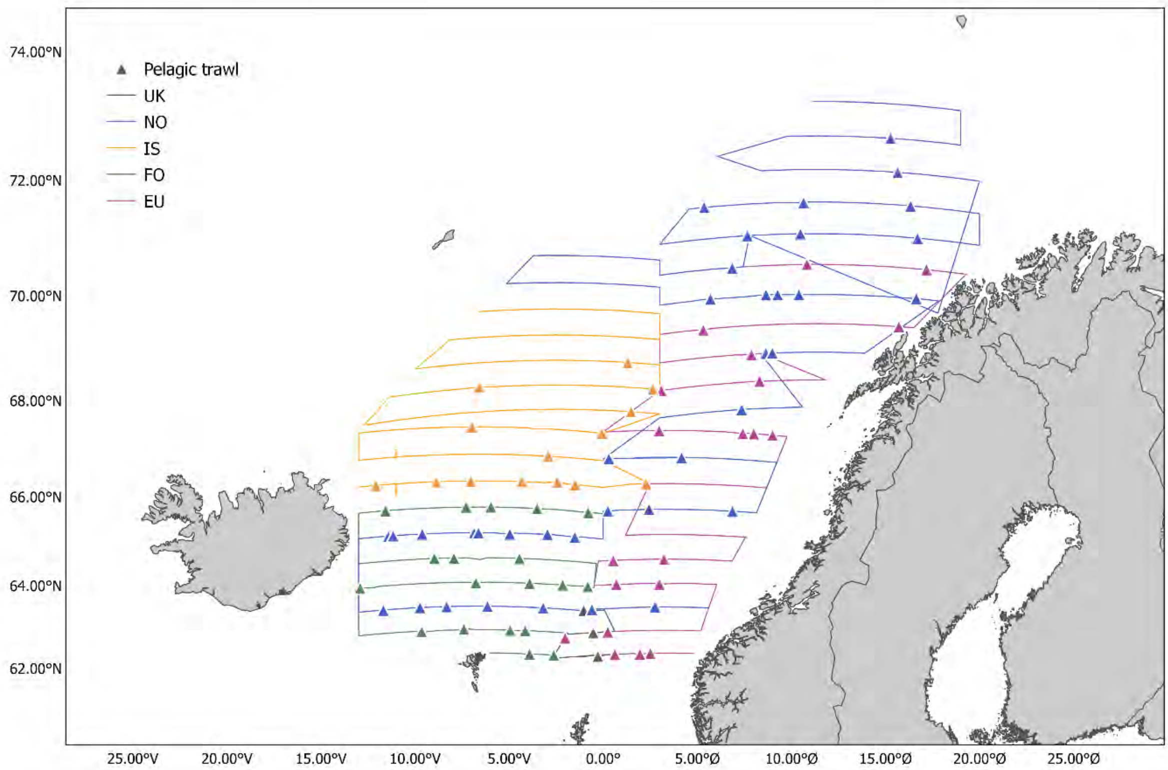

Figure 5. IESNS survey in May 2022: location of pelagic trawl stations.

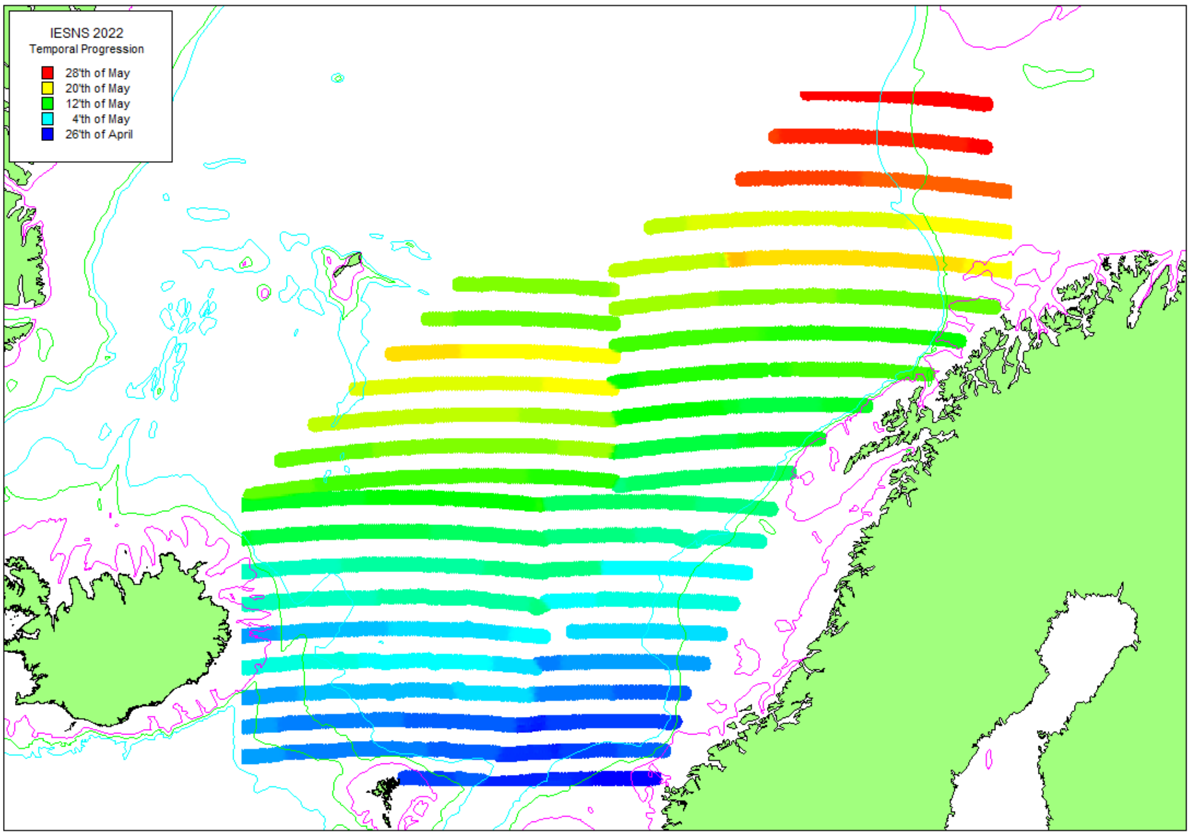

Figure 6. Temporal progression IESNS in April-May 2022.

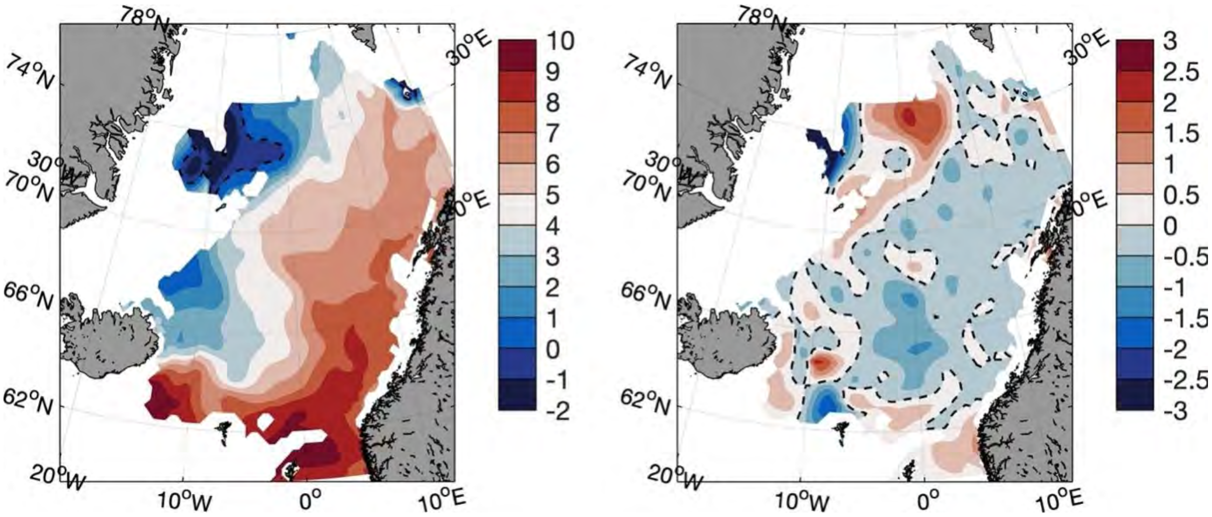

Figure 7a. Temperature (left) and temperature anomaly (right) averaged over 0-50 m depth in May 2021. Anomaly is relative to the 1995-2019 mean.

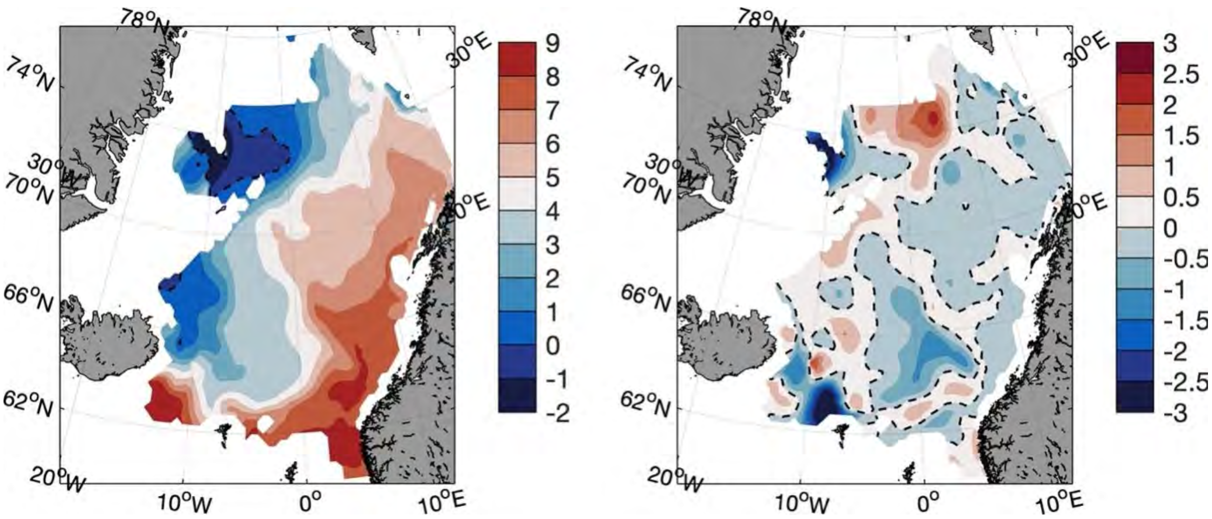

Figure 7b. Same as above but averaged over 50-200 m depth.

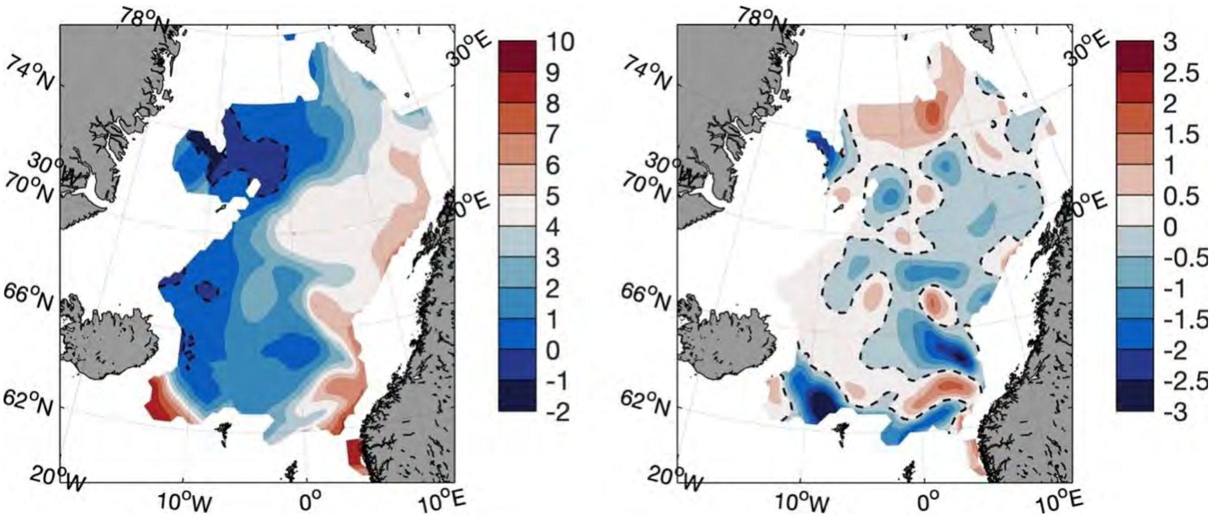

Figure 7c. Same as above but averaged over 200-500 m depth.

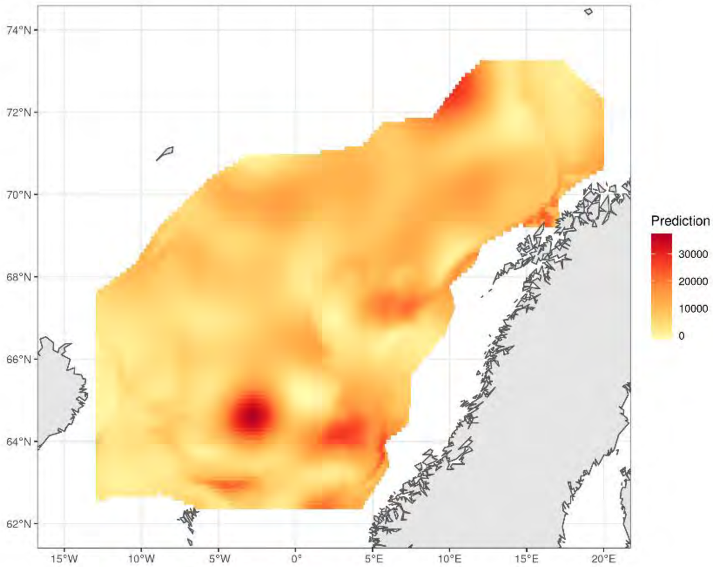

Figure 8. Distribution of zooplankton biomass (mg dry weight m^{-2}) in the upper 200 m in May 2022.

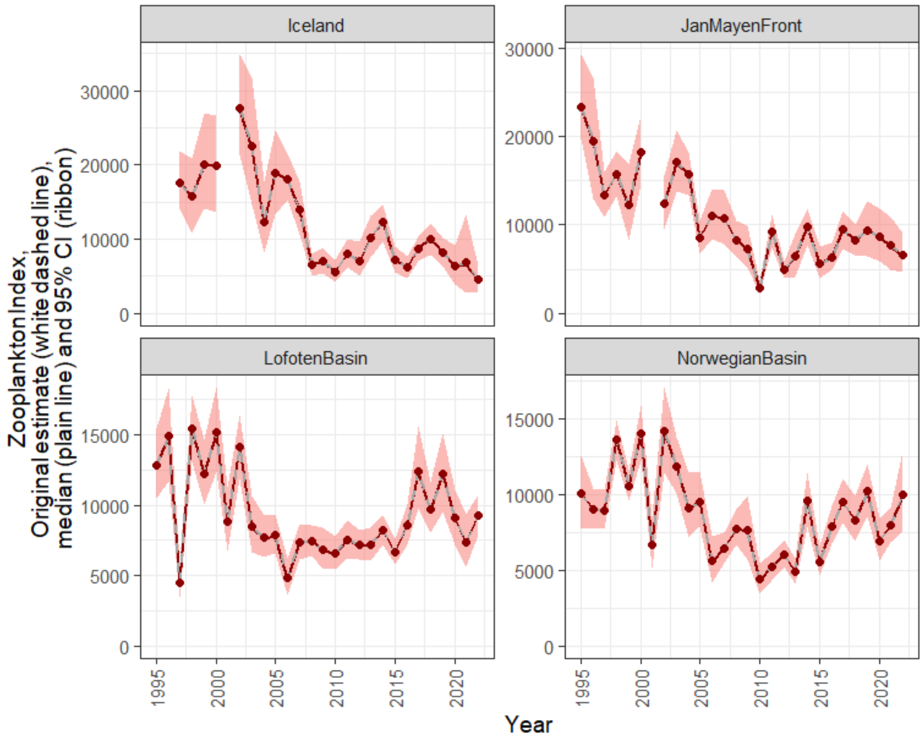

Figure 9. Indices of zooplankton biomass (mg dry weight m^{-2}) sampled by WP2 in May in the Norwegian Sea and adjacent waters from 1995-2022.

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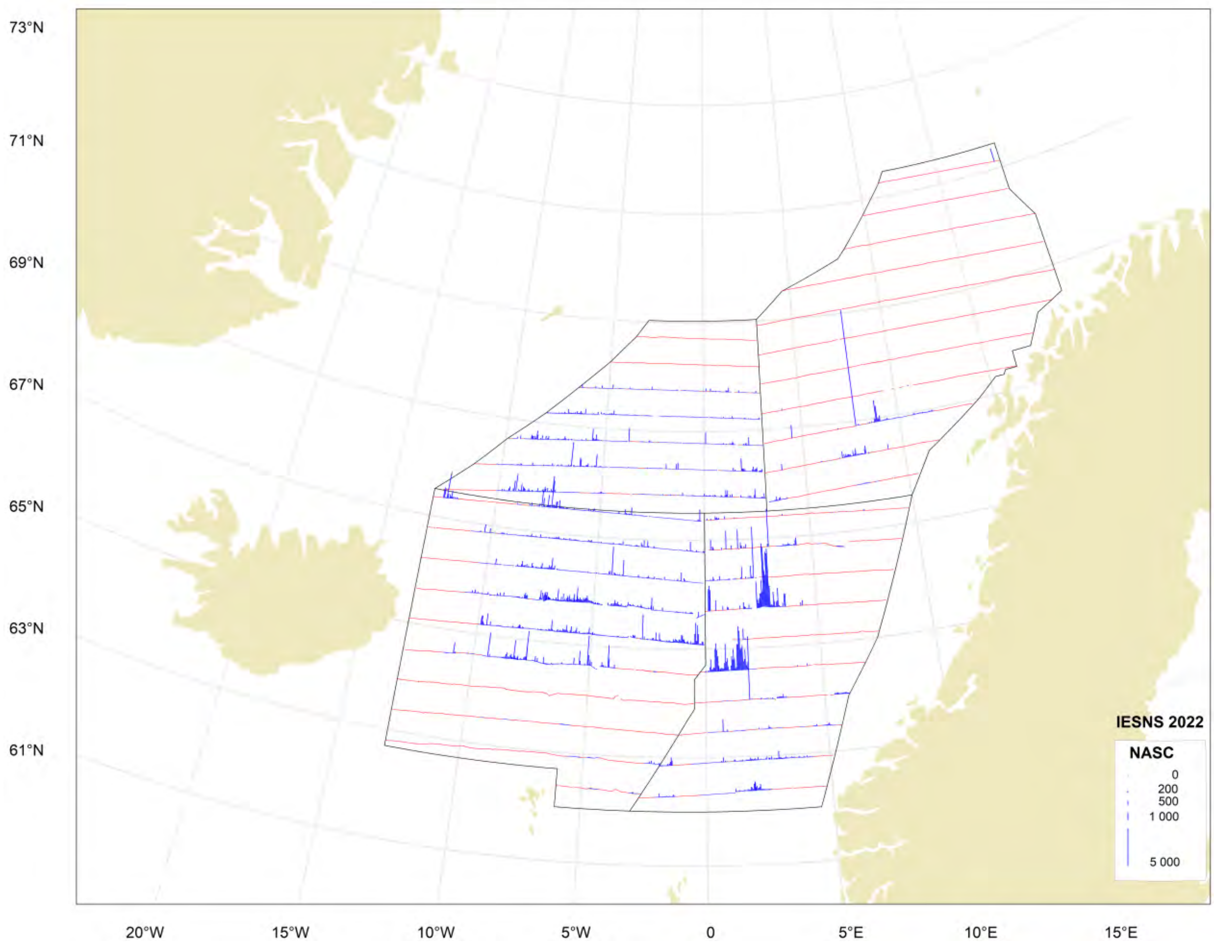
(a)



(b)

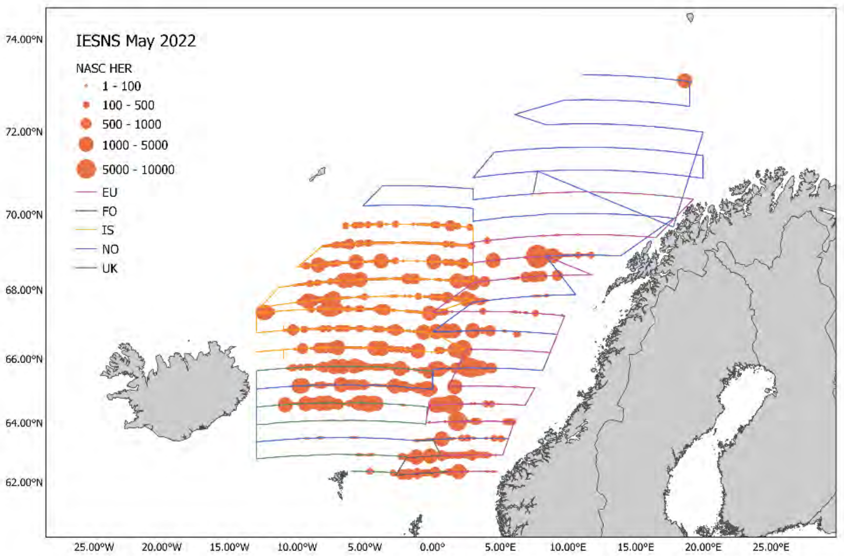


Figure 10. Distribution of Norwegian spring-spawning herring as measured during the IESNS survey in May 2021 in terms of NASC values (m²/nm²) averaged for every 1 nautical mile.

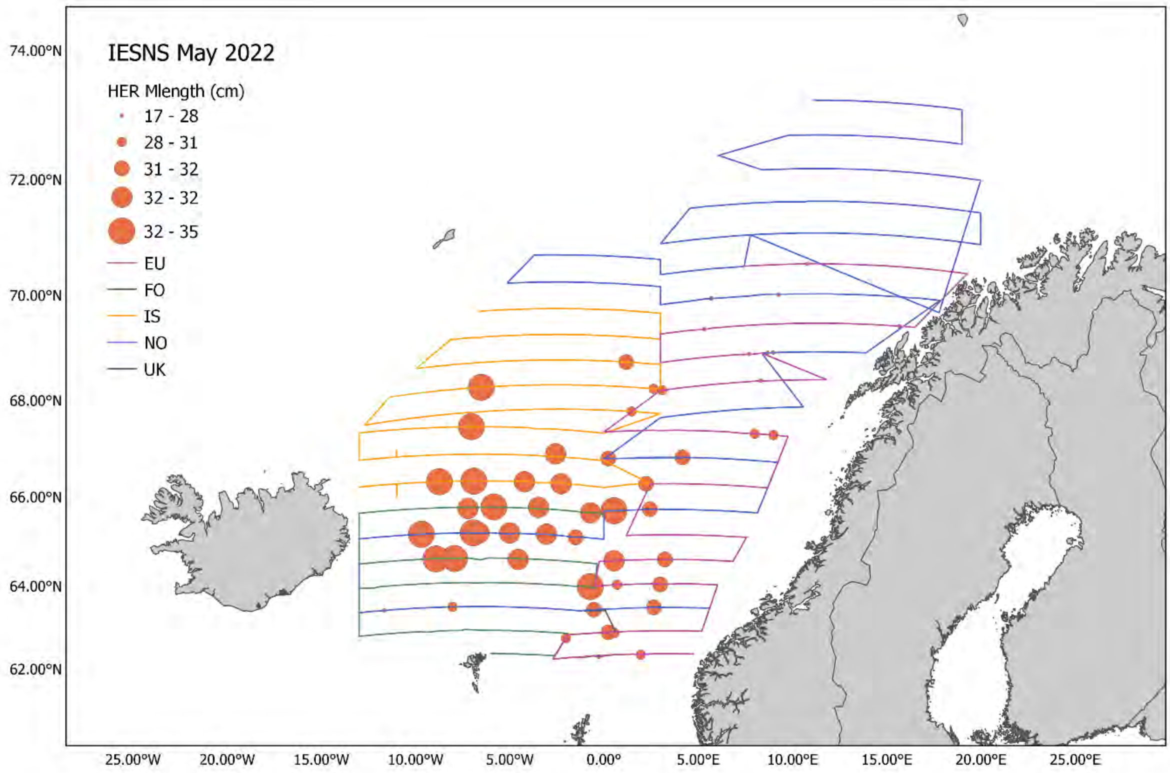


Figure 11. Mean length of Norwegian spring-spawning herring in all hauls in May 2022.

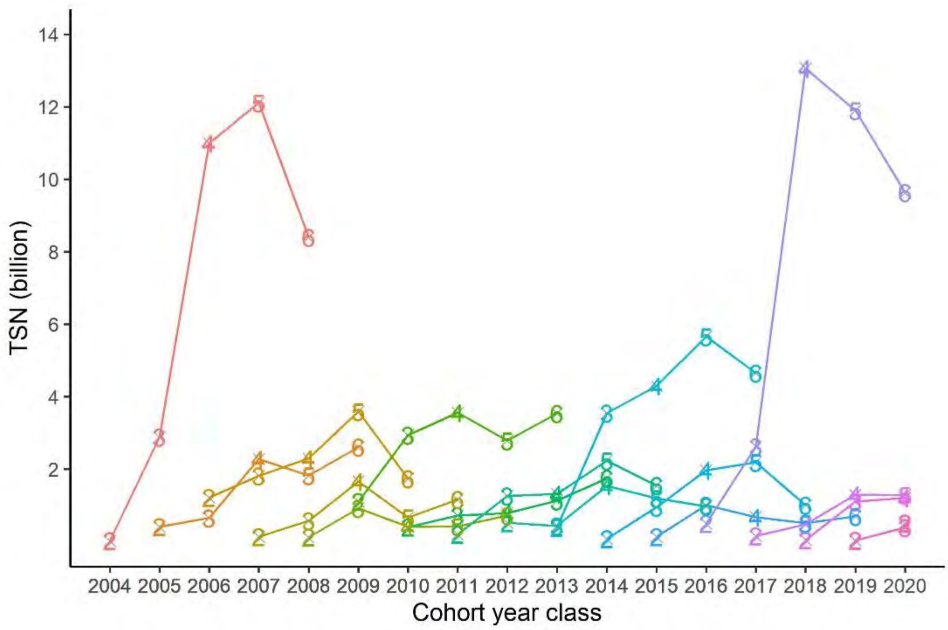


Figure 12. Tracking of the Total Stock Number at age (TSN, in billions) of Norwegian spring-spawning herring for each cohort since 2004 from age 2 to age 6. From 2008, stock is estimated using the StoX software. Prior to 2008, stock was estimated using BEAM.

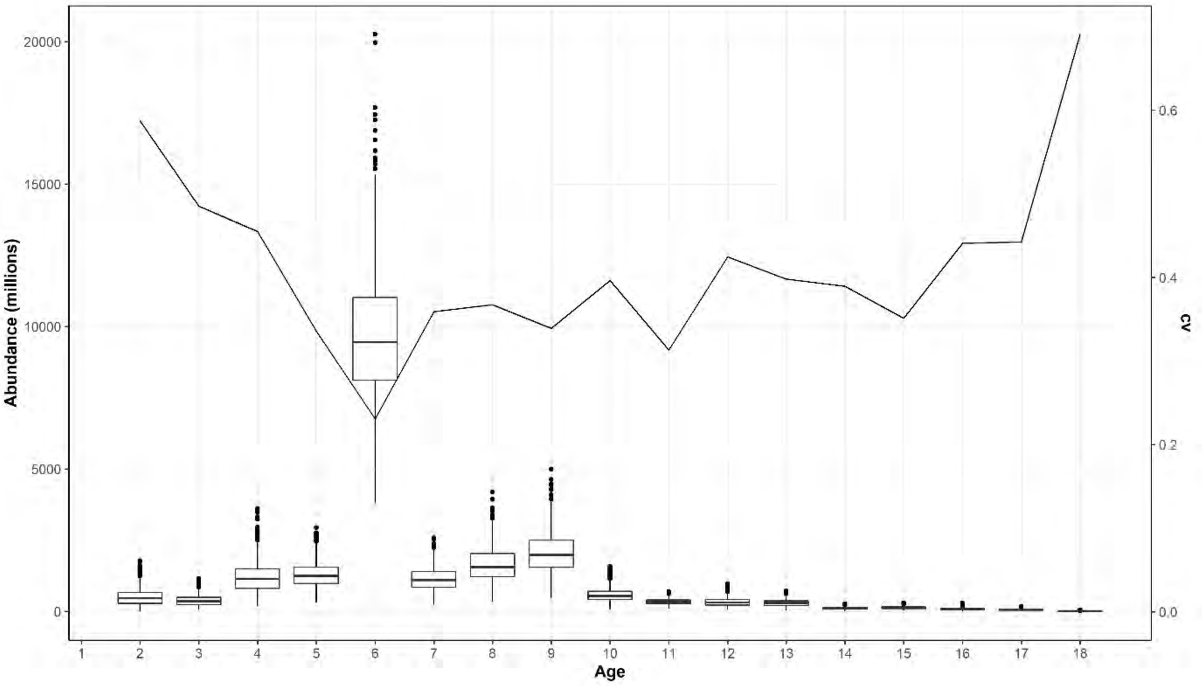


Figure 13. Norwegian spring-spawning herring in the Norwegian Sea: R boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 1000 replicates using the StoX software.

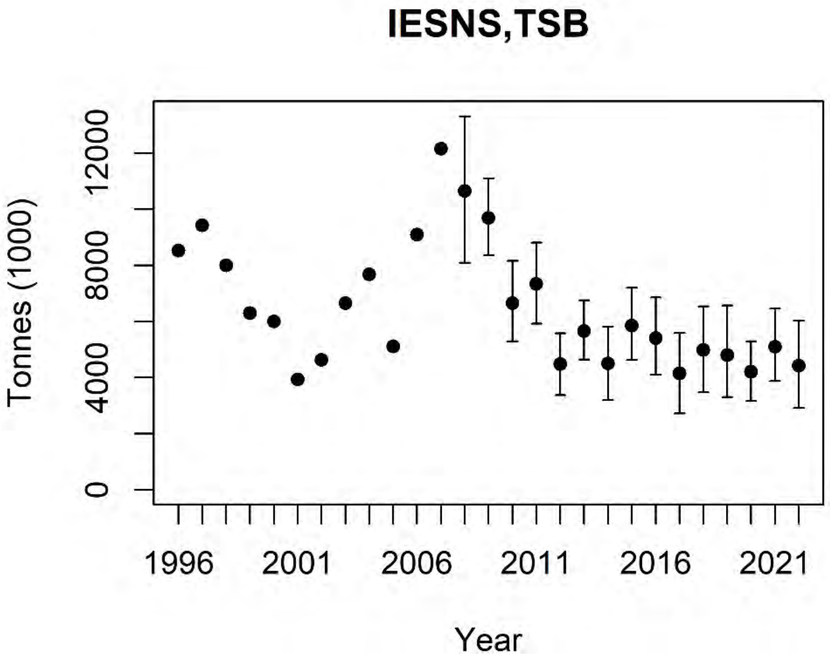


Figure 14. Biomass estimates of Norwegian-spring spawning herring in the IESNS survey (Barents Sea, east of 20°E, is excluded) from 1996 to 2022 as estimated using BEAM (1996-2007; calculated on basis of rectangles) and as estimated with the software StoX (2008-2021; bootstrap means with 90% confidence interval; calculated on basis of standard stratified transect design).

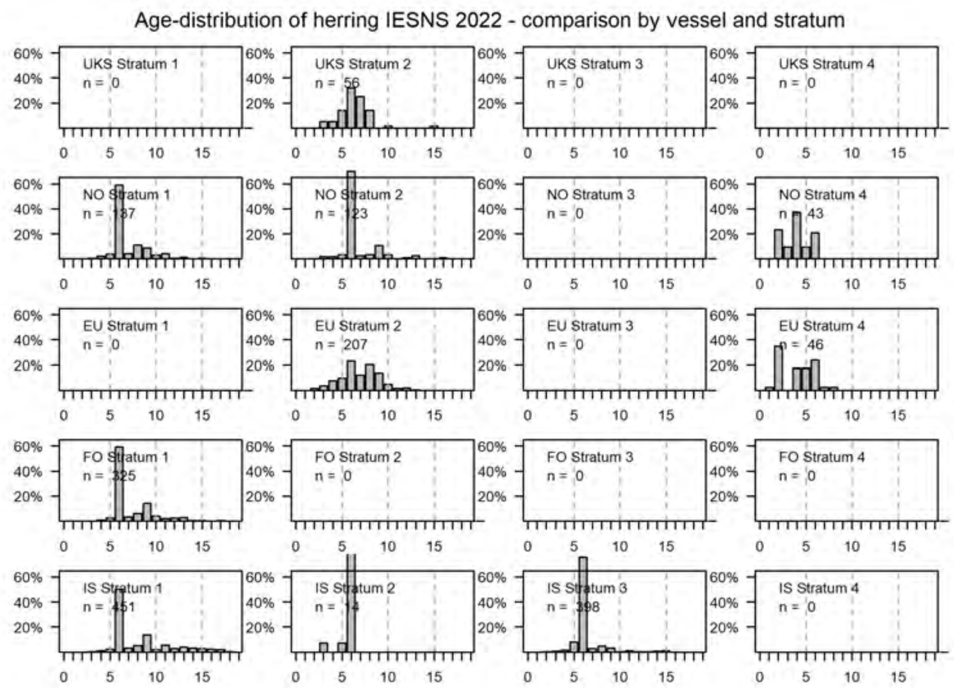
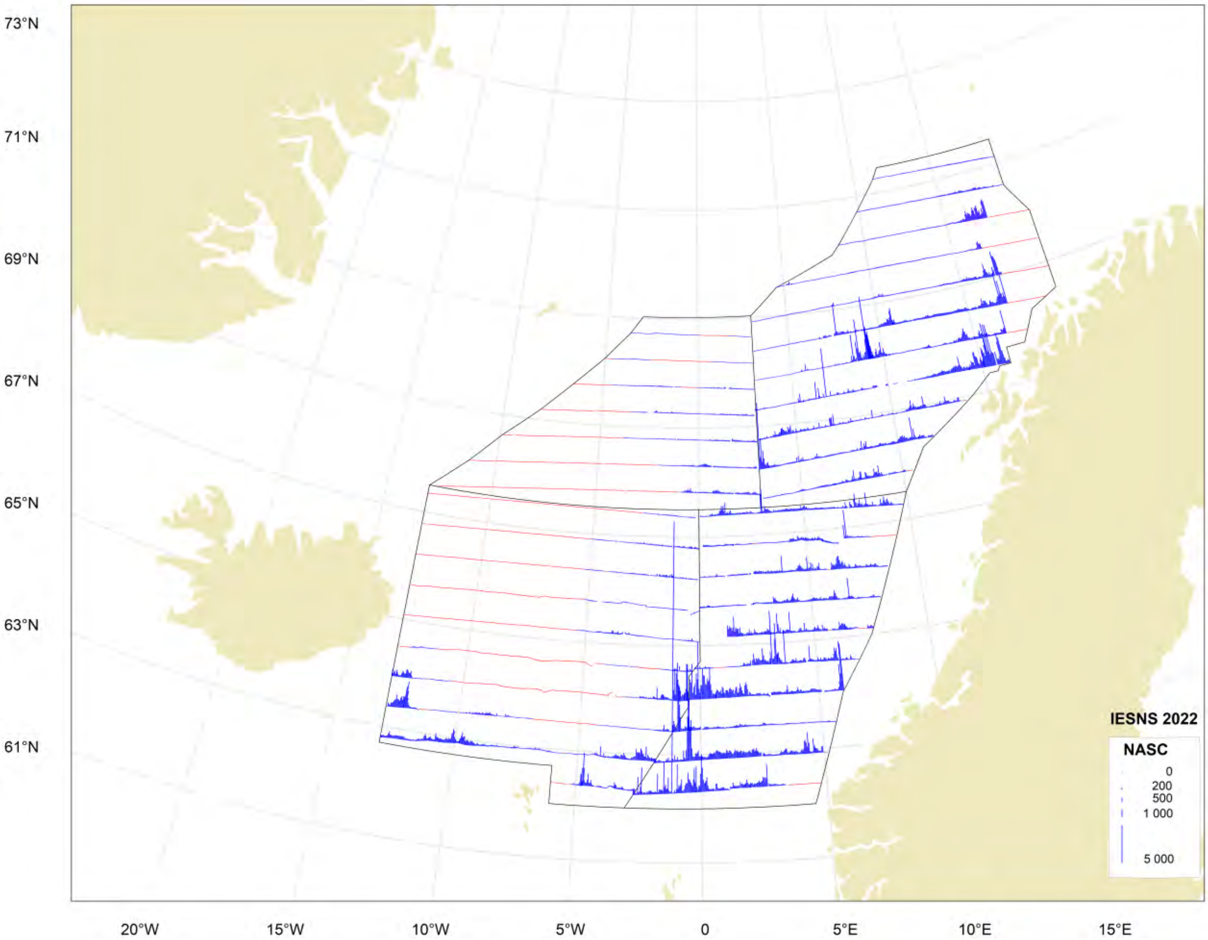


Figure 15. Comparison of the age distributions of NSS-herring by stratum and country in IESNS 2022. The strata are shown in Figure 3.

(a)



(b)

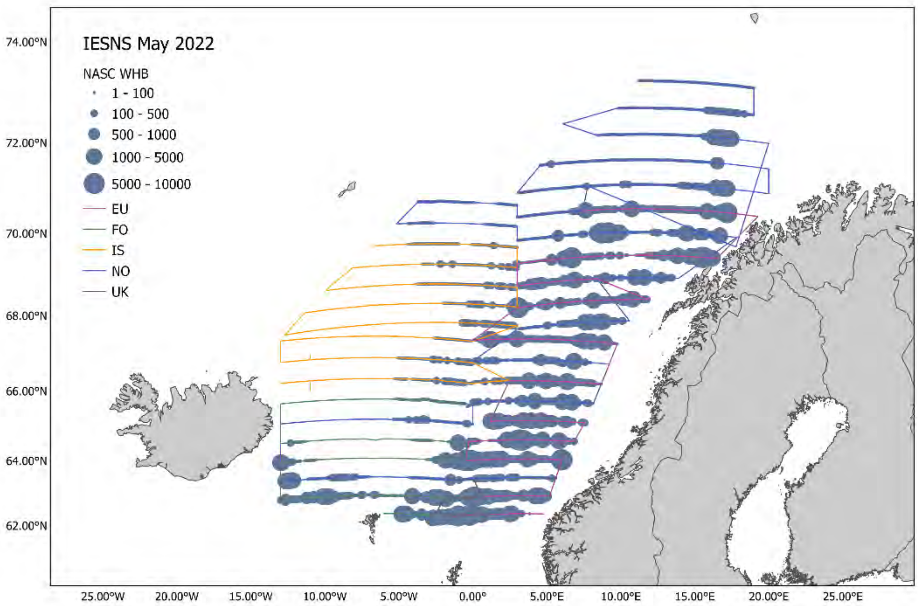


Figure 16. Distribution of blue whiting as measured during the IESNS survey in May 2022 in terms of NASC values (m²/nm²) (a) averaged for every 1 nautical mile.

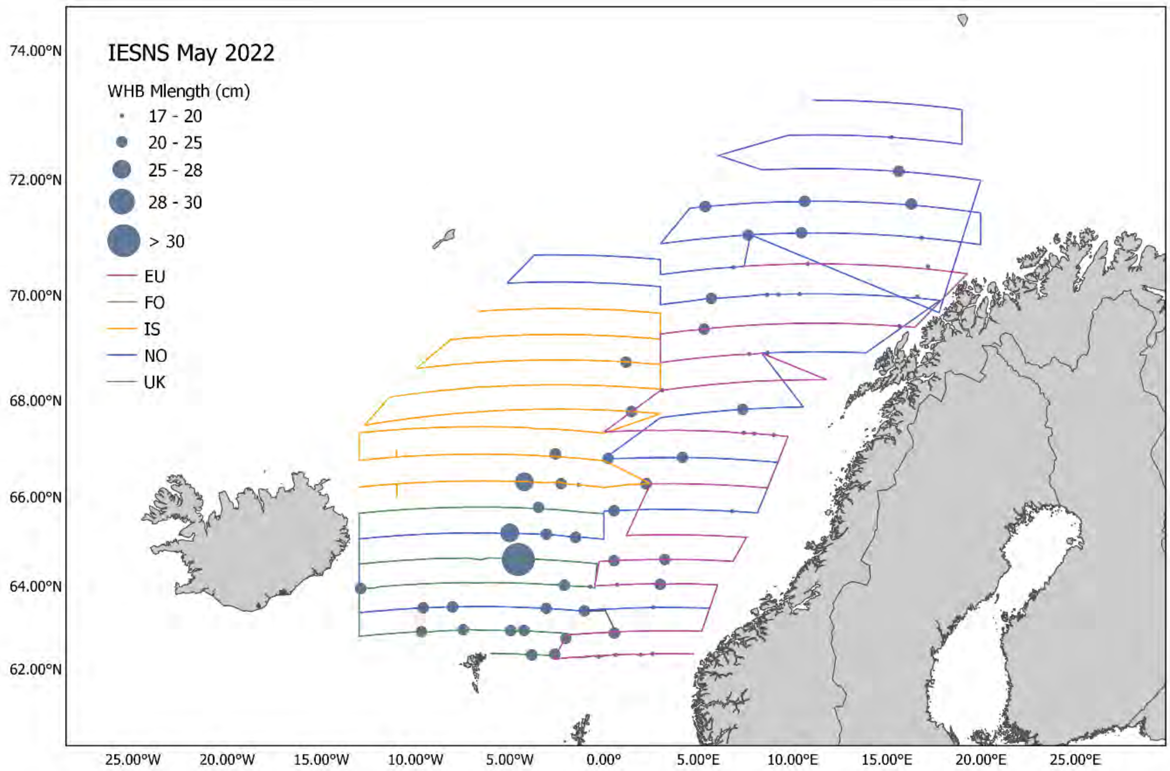


Figure 17. Mean length of blue whiting in all hauls in IESNS 2022. The strata are shown.

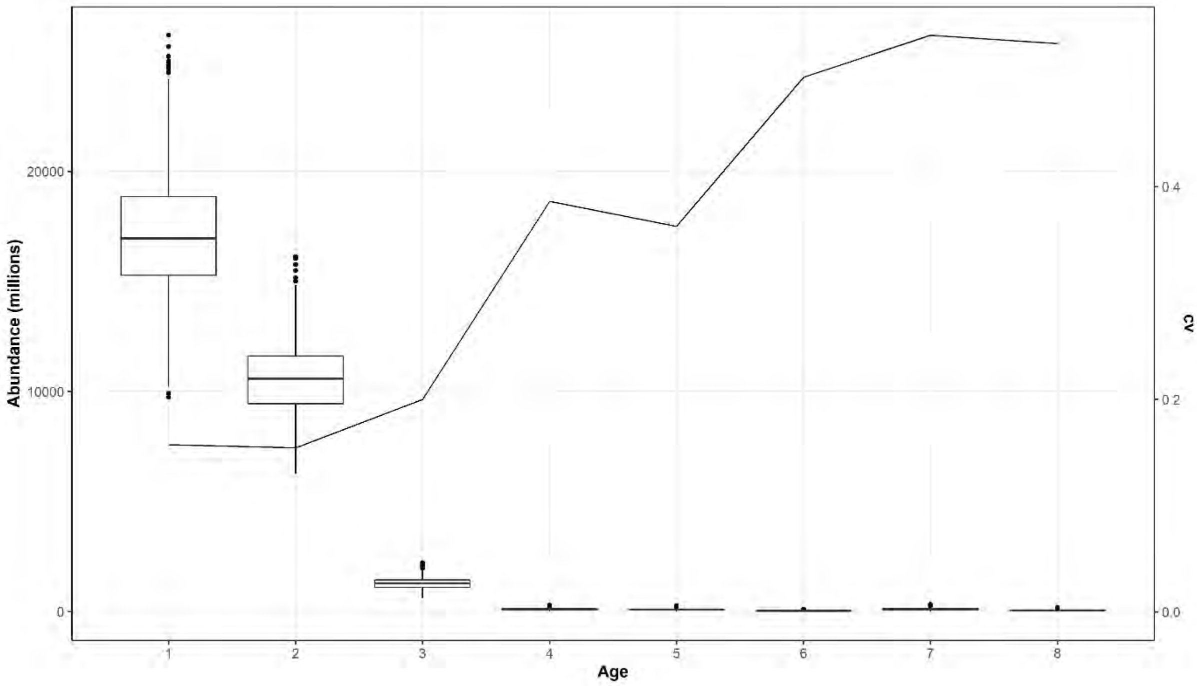


Figure 18. Blue whiting in the Norwegian Sea: R boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 1000 replicates using the StoX software.

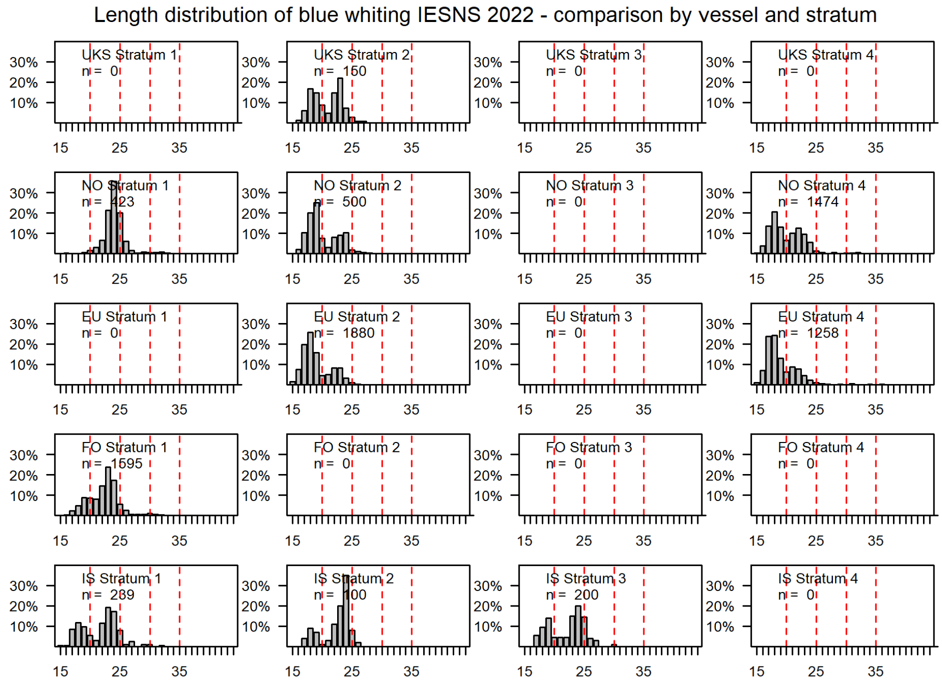


Figure 19. Comparison of the length distributions of blue whiting by stratum and country in IESNS 2022. The strata are shown in Figure 3.

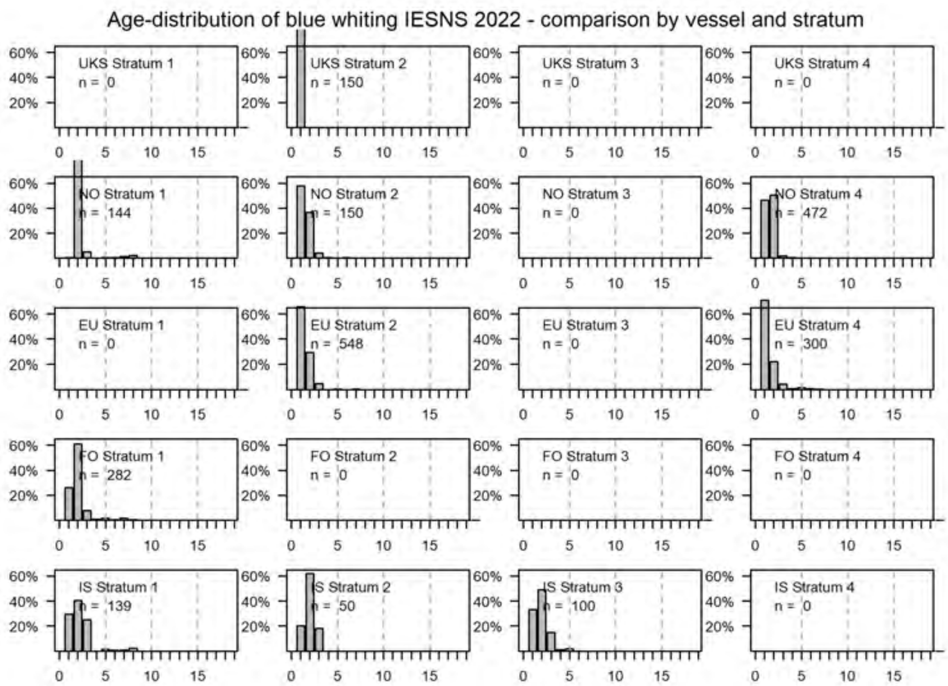


Figure 20. Comparison of the age distributions of blue whiting by stratum and country in IESNS 2022. The strata are shown in Figure 3.

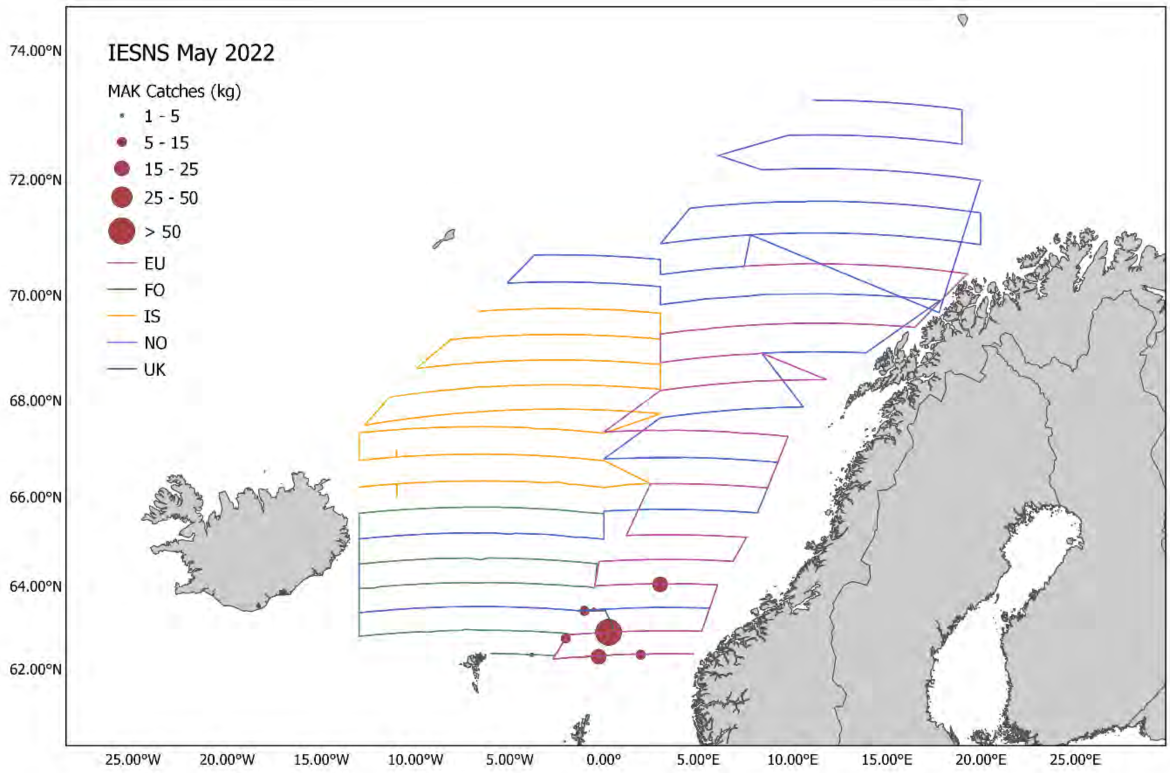


Figure 21. Pelagic trawl catches of mackerel in IESNS 2022.

ANNEX A

UK contribution to IESNS 2022

Background

In 2022 the UK participated to the IESNS survey by running a full survey on a chartered vessel that covered the UK EEZ within the IESNS survey area and an additional area south to 62° N, which is currently considered as the southern boundary of the Norwegian Spring-spawning herring stock. The main objective of the survey was to determine the distribution abundance and age structure of herring and blue whiting in the area south to the IESNS traditional coverage and detect and quantify potential mixing between different herring stocks (e.g. NSSH, NSAS, WoS).

Materials and methods

The survey was conducted onboard the commercial pelagic trawler F/V Resolute from 24/04/2022 to 06/05/2022. All the details about characteristics of the vessel, sampling, acoustic settings used, and data processing are listed in the previous section of this report. The acoustic transects and location of the hydrographic and plankton stations are shown in fig. A1. The survey area was split into 2 strata: a northern stratum that included the area north of 62° N which overlapped with the same area covered by the RV Dana and a southern stratum that covered the rest of the survey area (Fig. A2-a). For blue whiting, the southern stratum was further split into 2 additional strata to account for the habitat preferences of the species (Fig.A2-b).

Results and discussion

In total 9 acoustic transects were completed covering a total of 1158 nmi of acoustic sampling unit. A total of 11 pelagic trawls were carried out to provide groundtruth information about the species and size composition and to collect biological information (Fig. A3). In addition, CTD and plankton sampling were performed on 22 fixed stations.
Herring was patchily distributed over the whole survey area with higher densities located primarily around the Shetlands and at the southernmost transect of the survey located west of Orkney (Fig. A4). Herring size ranged from 21 to 33.5 cm with larger sizes found in the northern part of the survey area (Fig. A5). The total biomass estimate was 450,258 t (northern stratum: 43.550, southern stratum: 406,708) and a total number of 2.89 billion. Three-years-old and four-years-old herring were the most abundant age classes in terms of numbers accounting for 23% and 21% respectively of the total estimate (Fig. A6). The relative standard error (CV) is 40 % for both the total biomass and for the total numbers estimate.
Blue whiting was mainly distributed over the slope area in the north and western part of the survey areas (Fig. A7). Blue whiting aggregations primarily consisted of continuous and dense layers distributed between 200-400 m depth in the water column. Blue whiting size ranged from 16 to 33.5 cm with an overall average of 22.5 cm (Fig. A8). The total biomass

estimate was 449,656 t (northern stratum: 261,872 t, southern stratum: 187,784 t) and a total number of 6.4 billion. Two-years-old was the most abundant age class in terms of numbers accounting for 89% of the total estimate (Fig A9). The relative standard error (CV) is 24 % for both the total biomass and for the total numbers estimate.
Mackerel was caught in almost all the trawls carried out. The size ranged from 18 to 41 cm with an overall average size of 33 cm (Fig. A10). No further quantitative information can be drawn from these data as this survey was not designed to monitor mackerel.

Future work

Genetic analysis is planned to be performed on herring fin clips samples collected during the survey (290 samples collected across 7 locations) to characterise the different stocks present in the survey area and the potential level of mixing with the Norwegian spring spawning herring.

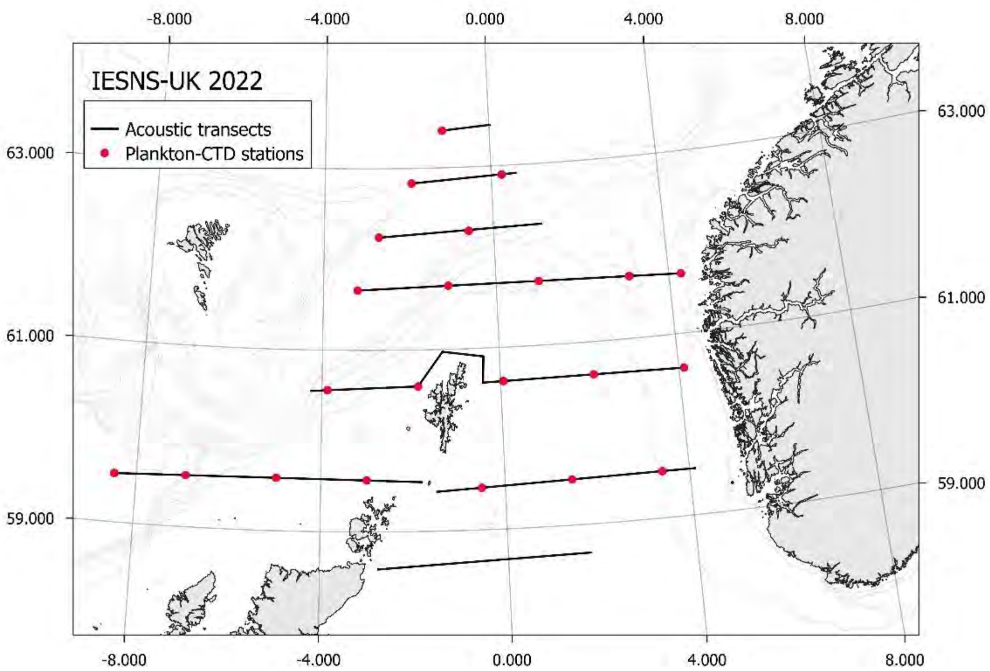


Figure A1 – Acoustic transects and location of hydrographic and plankton stations.

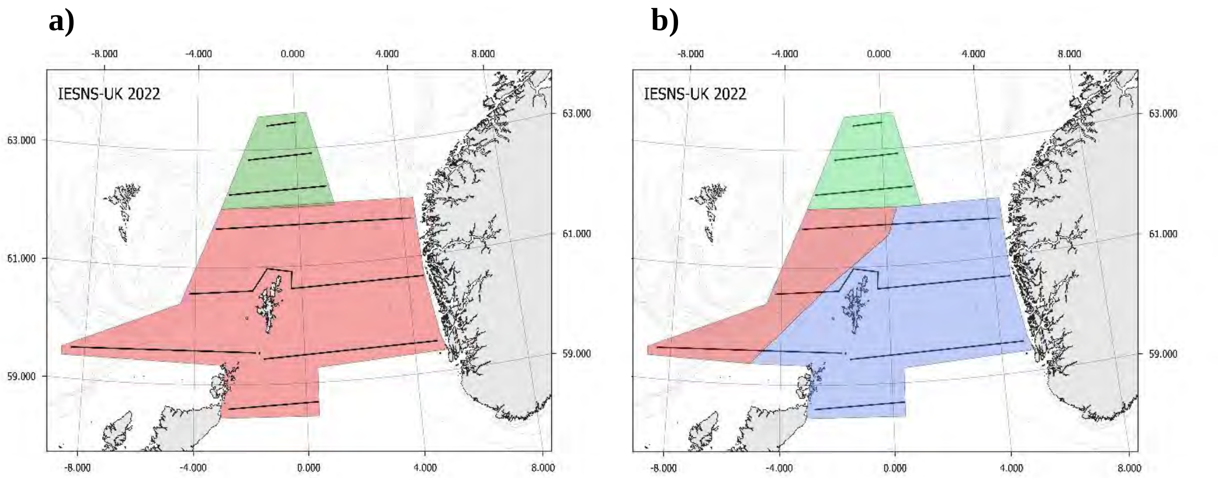


Figure A2 – Strata used for biomass estimation for herring (a) and blue whiting (b).

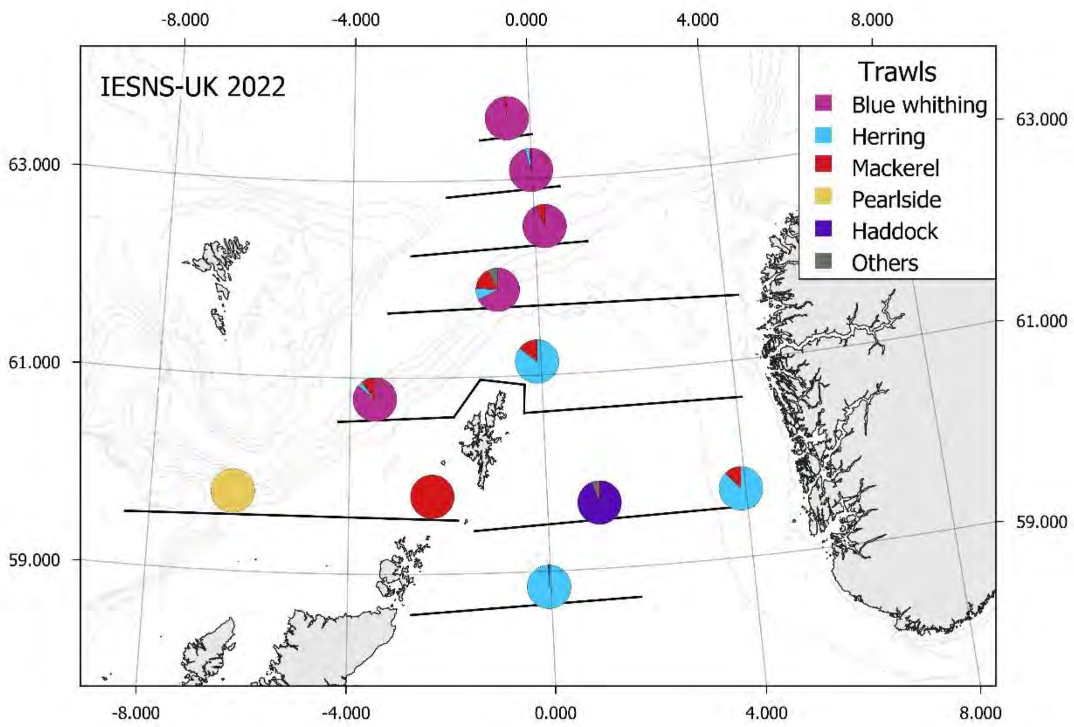


Figure A3 - Location and catch composition of the pelagic trawl stations.

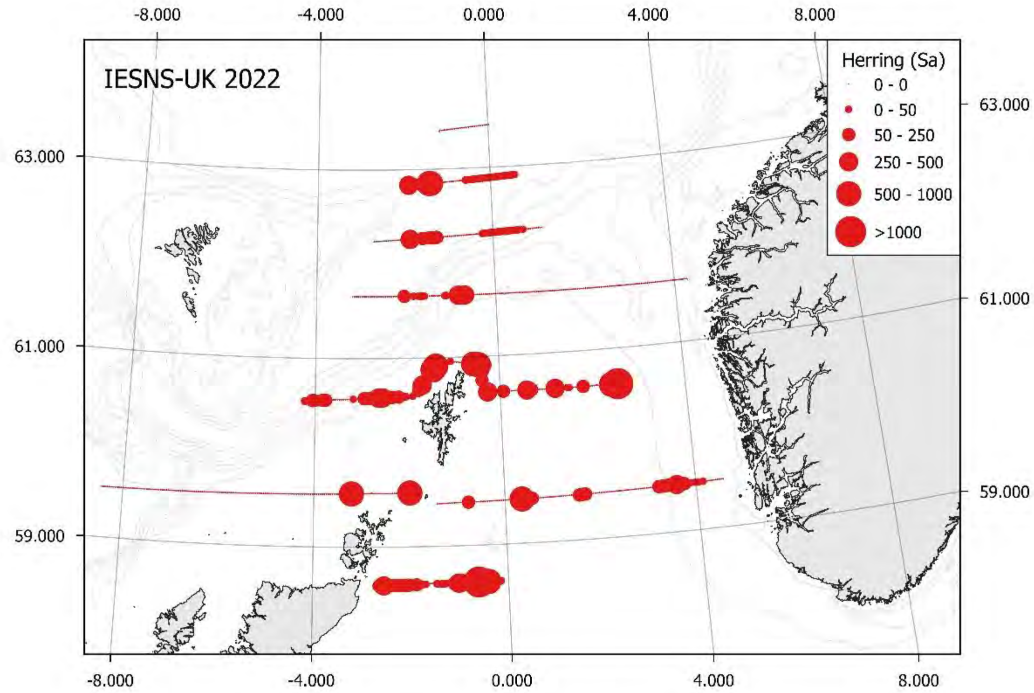


Figure A4 - Distribution of herring in terms of NASC values (m^2/nm^2) averaged for every 1 nautical mile.

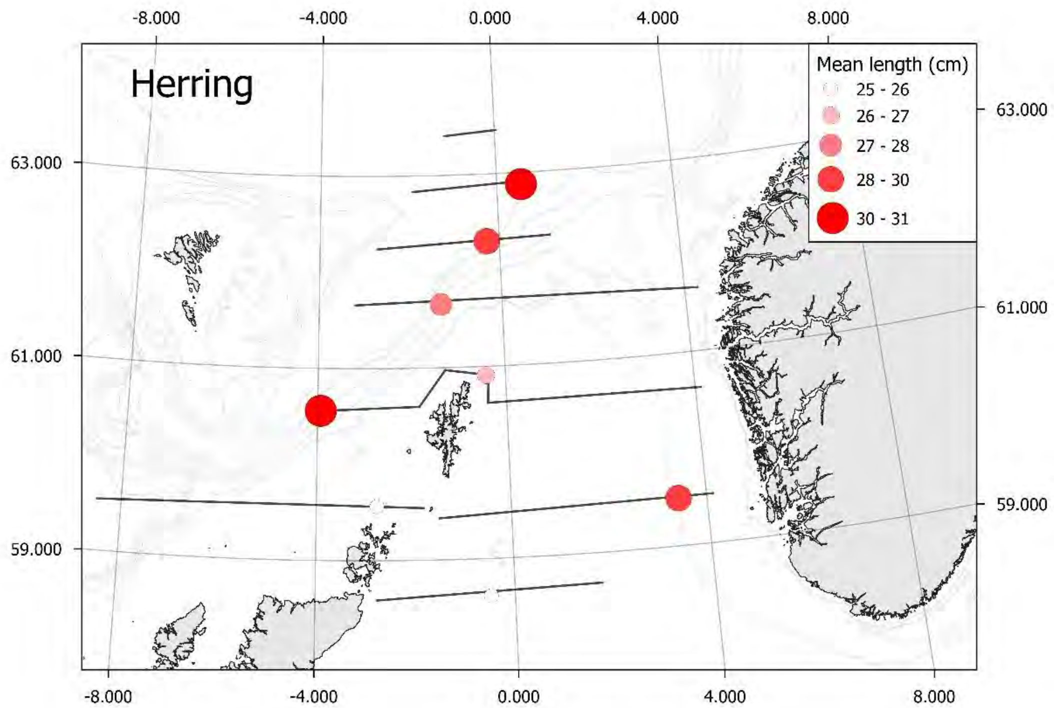


Figure A5 – Distribution of the mean length of herring measured in the pelagic trawl catches.

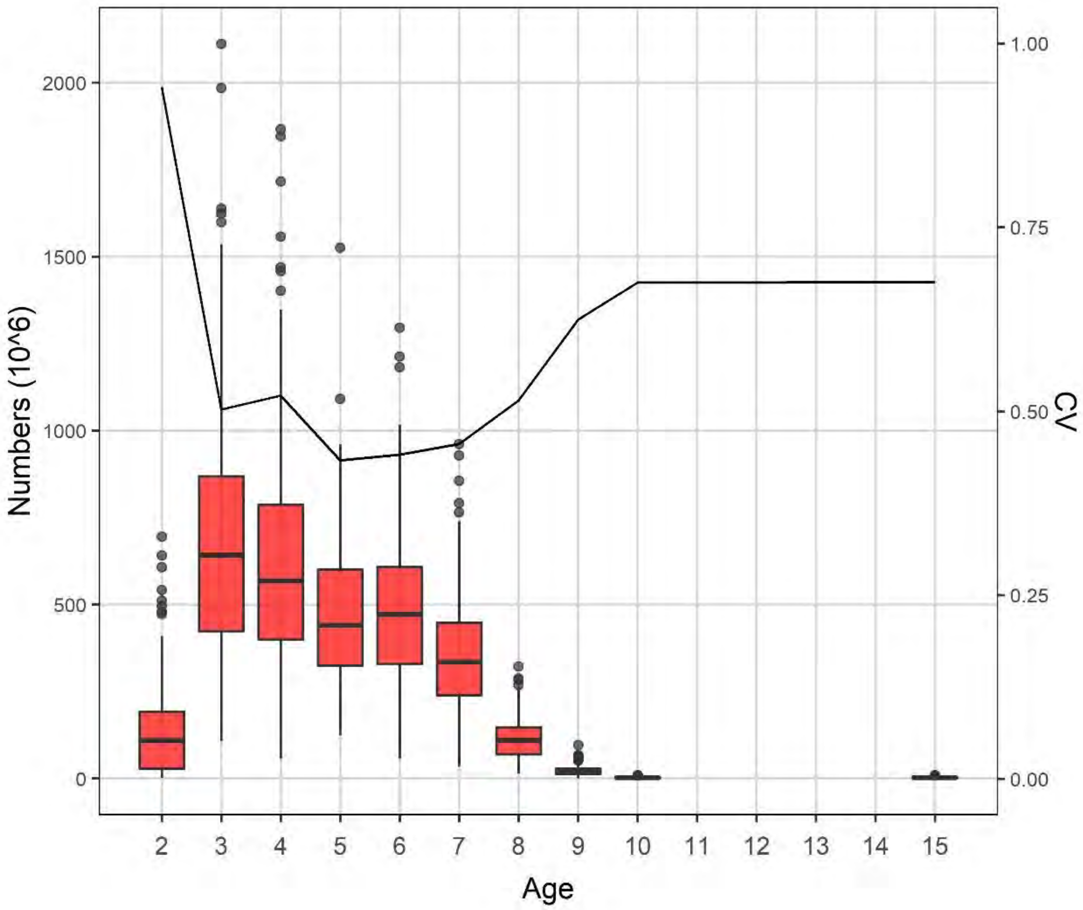


Figure A6 - Boxplot of herring abundance at age and relative standard error (CV) obtained by bootstrapping using the StoX software.

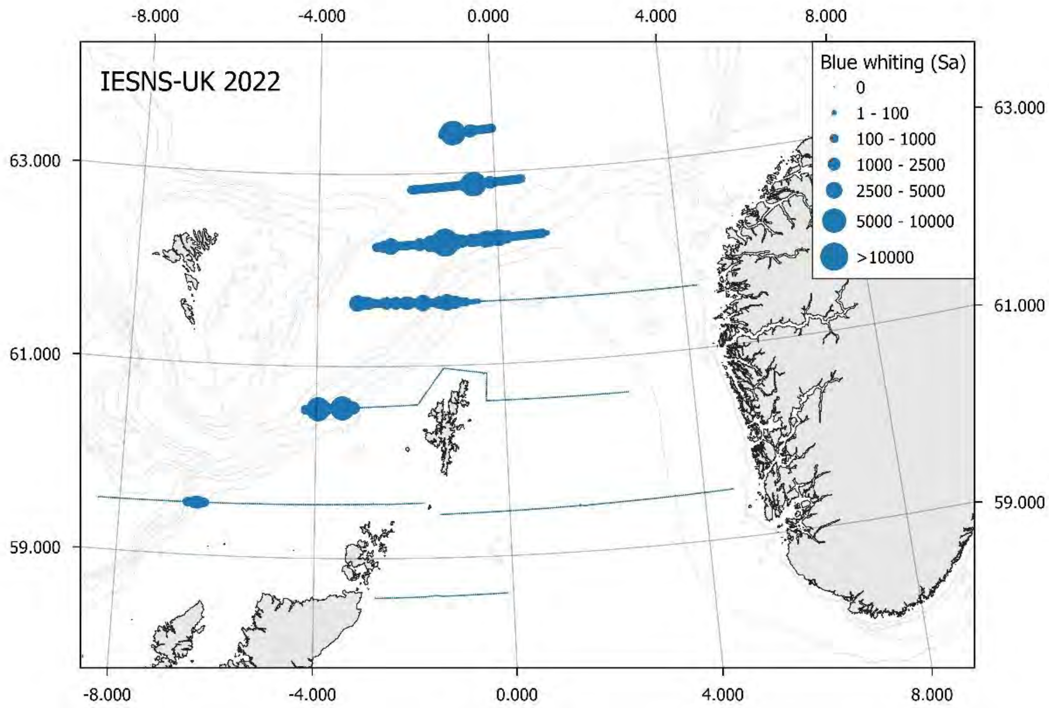


Figure A7 - Distribution of blue whiting in terms of NASC values (m^2/nm^2) averaged for every 1 nautical mile.

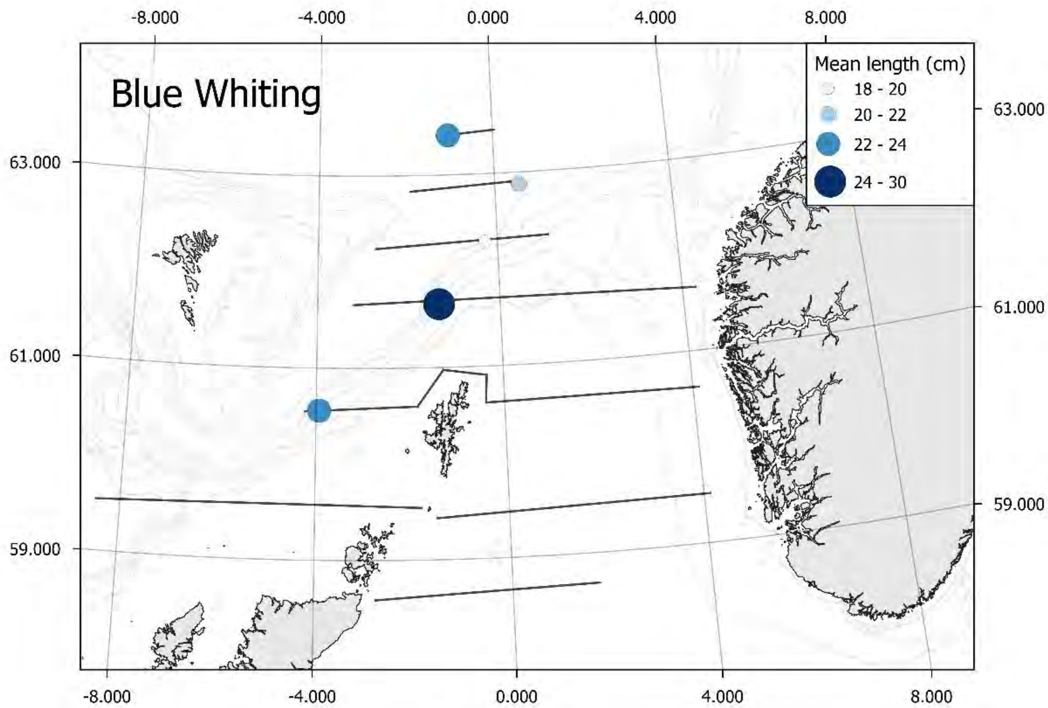


Figure A8 – Distribution of the mean length of blue whiting measured in the pelagic trawl catches.

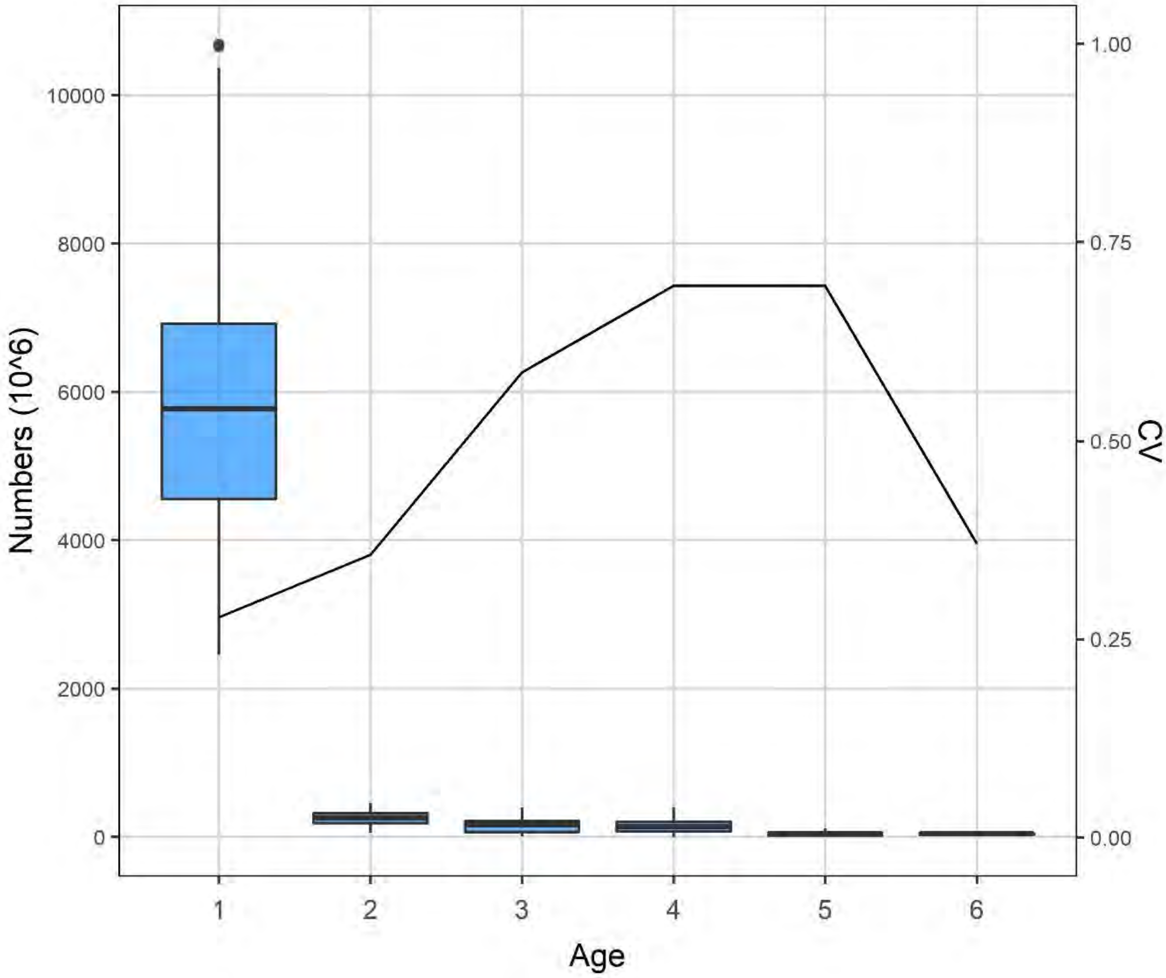


Figure A9 - Boxplot of blue whiting abundance at age and relative standard error (CV) obtained by bootstrapping using the StoX software.

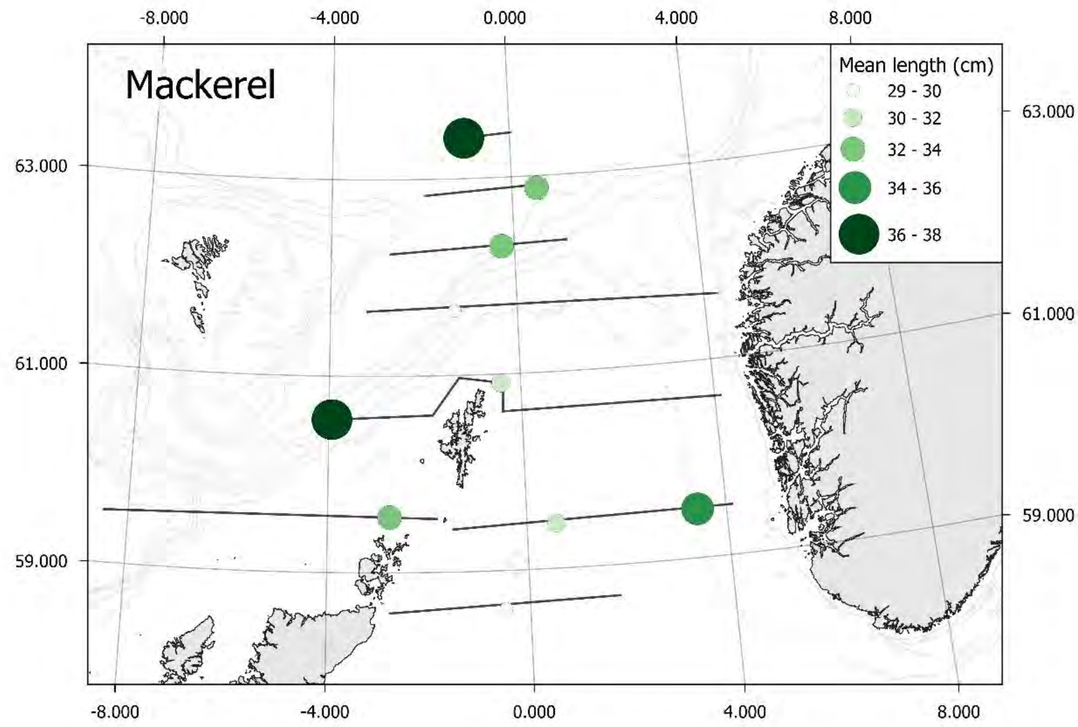


Figure A10 – Distribution of the mean length of mackerel measured in the pelagic trawl catches.

North Sea mackerel total egg production for 2022 using the daily egg production method

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[2] IEO, Vigo, Spain

[3] DTU Aqua, Copenhagen, Denmark

[4] Cefas, Lowestoft, England

[5] IMR, Bergen, Norway

Introduction

The North Sea Mackerel Egg Survey (NSMEGS) is designed to estimate the spawning stock biomass (SSB) of mackerel of the North Sea spawning component of the Northeast-Atlantic stock on a triennial basis. Up to and including 2017 this was undertaken utilizing the annual egg production method (AEPM) and generally undertaken in the year following the survey covering the western components. This method estimates and combines total annual egg production (TAEP), realized fecundity per gram female, and sex (male to female) ratio to calculate SSB.

Spatial and temporal coverage in the North Sea was reduced with the withdrawal of Norway from the NSMEGS in 2014, with the Netherlands left as the sole survey participant in 2015 and 2017. In 2020 Denmark was recruited as a new participant for the NSMEGS, and in 2021 the UK (England) announced that they were willing to participate.

An issue for the NSMEGS is that since 1982 it has been impossible to collect and sample pre-spawning mackerel, which are necessary in order to estimate the potential fecundity. For SSB estimation using the AEPM, the realized fecundity value used was from the 1982 estimate (Iversen and Adoff, 1983). For a number of years it was recognised that an AEPM survey wasn't producing the best results for the North Sea. Therefore, at the WGMEGS meeting in 2018 a decision was made to use the Daily Egg Production Method (DEPM) for future North Sea surveys (ICES 2018). The DEPM requires only one full sweep, in a short time period, over the entire mackerel spawning area, preferably during peak spawning time. A disadvantage of the DEPM is that it requires many more mackerel ovary samples to be collected to estimate batch fecundity and spawning fraction.

Survey

In 2022 the UK and Denmark conducted the North Sea survey. Whilst planning the survey it became apparent that the vessel time available from the two countries would not be sufficient to cover the area. As a result, Norway agreed to survey the four northernmost transects in the North Sea at the start of their period 6 survey.

The samples were collected and analysed according to the WGMEGS manuals (ICES 2019a, 2019b). UK and Norway sampled eggs with a Gulf VII plankton sampler while Denmark used a Nackthai sampler. The UK and Denmark utilised a 500 µm plankton net which is standard protocol for the North Sea due to issues with clogging, while Norway used a 250µm mesh. At each station a double oblique haul was performed from the surface to 5 m above the bottom, a maximum depth of 200 m, or 20 m below the thermocline in case of stratification of the water column. Temperature and salinity were measured during the haul with a CTD mounted on top of the plankton sampler. Either electronic or mechanical flowmeters were mounted on the plankton sampler to monitor flow.

The NSMEGS was carried out from 5th – 24th June (Table 1). During this period the spawning area between 54ºN and 62ºN was surveyed once, receiving a single coverage (Fig. 1). The survey is designed to cover the entire spawning area with samples collected every half ICES statistical rectangle (ICES, 2014). In total 259 plankton stations were sampled, with 19 stations interpolated. On each of the Danish transects at least one pelagic trawl haul was performed for the collection of mackerel adult samples. Due to problems with their fishing gear CEFAS carried out a number of rod and line fishing events.

Following the WGMEGS manual temperature at 5m depth was used to estimate egg development (ICES 2019a). For the DEPM only the mackerel eggs in development stage 1A are used to estimate daily egg production.

Results

Mackerel daily egg production

The spatial egg distribution is shown in Fig. 1. Standard MEGS interpolation rules (ICES, 2019a) were applied where needed. Egg distributions are comparable to 2021, however egg numbers seem to be more evenly distributed throughout the survey area this year.

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 two southern transects were sampled but there were issues with many of the stations re the accuracy of the flow data. This resulted in three valid stations south of 54°N with a further three being interpolated. The invalid stations do give an indication of the presence and absence (qualitative data) of mackerel stage 1A and above over this area.

The DEP was calculated for the total investigated area (Table 2). Total egg production for 2022 was $0.6699*10^{13}$ eggs. This is a 50% decrease on egg numbers reported in 2021 (Table 3).

Adult parameters

Denmark conducted 33 hauls, from which they sampled 1180 mackerel and collected ovary samples from 364 females. England conducted 20 rod and line fishing events of which 9 were positive, biologically sampling 225 mackerel and collecting ovary samples of 74 females. Norway collected 239 female mackerel samples from 5 fishing hauls, (Table 1). As these samples were collected in June no analysis has been carried out on them. Batch fecundity and POF counting will take place before the end of the year, with the results to be delivered prior to the WGMEGS meeting in April 2023.

SSB

As there are no data available from the adult parameters, WGMEGS is just reporting egg production for 2022.

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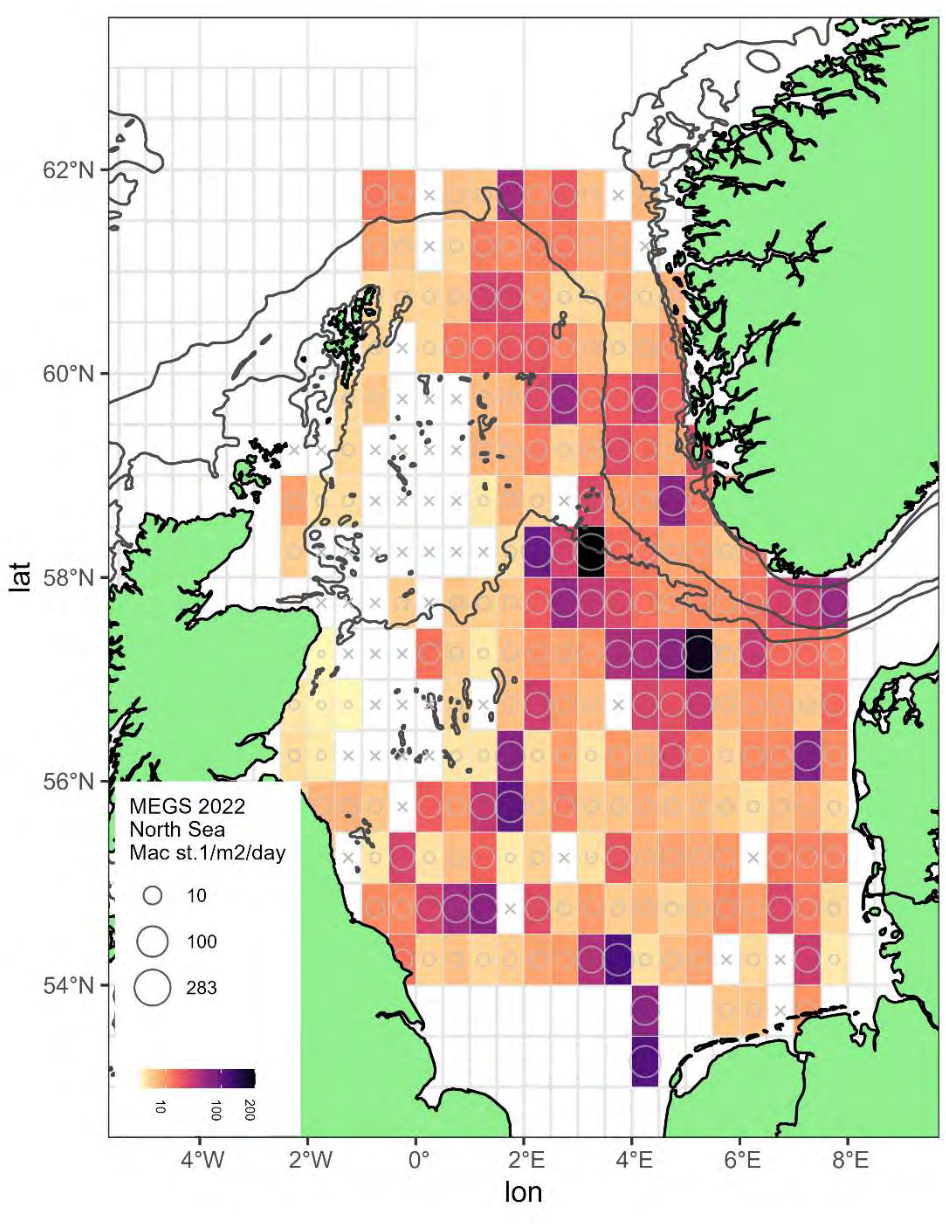

Figure 1. Heat map of Stage 1A mackerel egg production (eggs. m^{-2}. day^{-1}) by half rectangle for the North Sea, 2022. Grey circles represent observed values, crosses represent observed zeros.

Table 1. NSMEGS surveys cruise dates in 2022 (For Norway only stations used in the NSMEGS DEP calculation are shown). UK=UK England, DK=Denmark, NO=Norway.

Country	**UK**	**DK**	**NO**
Period	1	1	1
Dates (2022)	5.06-24.06	08.06-17.06	7.06-19.06
Plankton stations sampled	135	79	45
Pelagic trawl hauls		33	5
Positive rod and line events	9		

Table 2. Total egg production using the Daily egg production estimate (stage 1A abundance) in the North Sea for 2022.

Year	**DEP $*10^{13}$**	**CV DEP**
2022	0.67	

Table 3. Comparison of total stage 1A egg production for 2022 and 2021 in the North Sea estimated by the Daily Egg production method.

Year	**2022**	**2021**
DEP $*10^{13}$	0.67	1.28

2022 Mackerel and Horse Mackerel Egg Survey

Preliminary Results

by

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1 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). Historically a North sea mackerel egg survey is carried out in the year after the western and southern surveys. in 2022, due to the presence of new participants, the all surveys were carried out in the same year

The main objective of this series of individual cruises from January until July is to produce both an index and a direct estimate of the biomass of the north east Atlantic mackerel stock and an index for the southern and western horse mackerel stocks. The results have been used in the assessment for mackerel since 1977 and from 1992 for horse mackerel. The mackerel and horse mackerel egg survey is still a principal 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. In cases where the annual egg production method is applied 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.

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. The 2010 and 2013 MEGS surveys saw peak mackerel spawning in February – March with 2013 also demonstrating a shift in the geographical centre of spawning further south within the southern Biscay region. Since then however 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, as far north as Iceland and the Faroe Islands and in recent years around the Shetland Islands and the Norwegian coast in the Northeast.

This survey report presents the preliminary results of the 2022 mackerel and horse mackerel egg survey provided for WGWIDE in August 2022. The survey report and the analysis will be finalised during the next WGMEGS meeting in April 2023. Although every effort was made to ensure that WGWIDE were provided with the most recent and accurate data-set, WGMEGS cannot guarantee that there will not be changes prior to the analysis being finalised. This is due to the extremely large numbers of plankton and fecundity samples to be analysed following the surveys as well as the tight deadline set by WGWIDE for delivering these estimates. This has resulted in a very limited time within which to process the 2022 MEGS data.

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 18 individual cruises were carried out, 16 in the Atlantic and 2 in the North sea, for a total of 321 at-sea survey days. Individual contributions were; Spain (IEO: 42 days at sea, AZTI: 30 days), Scotland (53 days), the Netherlands (39 days), Ireland (28 days), Portugal (34 days), Germany (23 days), Norway (15 days), Faroe Islands (14 days), England (23 days) and Denmark (14 days). Denmark joined the group in 2020 and participated in the 2021 North Sea survey along with the Netherlands. England rejoined the group in 2021 and in 2022 conducted the North Sea survey in participation with Denmark.

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 15-20 NM, depending on latitude) 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). Portugal were assigned to start the survey in the southern area during 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, Biscay and the Cantabrian Sea. 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 26th	2
Ireland	Celtic Explorer	West of Ireland, Celtic sea, Biscay,	March 2nd – 22nd	2
	Corystes	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 12th – June 1st	5
	Altaire	West of Scotland, west of Ireland, Celtic sea, Biscay	July 4th – 27th	7
Spain (IEO)	Miguel Oliver	Cantabrian sea, Galicia, southern Biscay	March 14th – April 3rd	3
	Vizconde de Eza	Cantabrian sea, Galicia, Biscay	April 4th – April 30th	4
Spain (AZTI)	Ramon Margalef	Northern Biscay	March 10th – 30th	3
	Vizconde de Eza Ramon Margalef	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	Faroes & Norway	June 7th – 20th	6
Faroes	Magnus Heinason	Faroes, Iceland	May 19th – June 1st	5
Denmark	Dana	North Sea	June 7th – 18th	
England	Cefas Endeavour	North Sea	June 4th - 25th	

Processing of samples

The analysis of the plankton and fecundity samples were carried out according to the sampling protocols as described in the WGMEGS Manuals for Survey (ICES, 2019a) and Fecundity (ICES, 2019b).

A total of 1780 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, along with AEPM analysis. Fecundity sampling for horse mackerel only took place during the expected peak spawning Periods, 6 and 7.

In order to increase the number of samples available for fecundity analysis additional mackerel gonads were collected from some Dutch pelagic vessels, and also on the Dutch and Irish Blue whiting surveys in Periods 2, 3 and 4.

After each survey the ovary screening and fecundity samples were shared between the participating research institutes for histological and whole mount analysis to determine the realised fecundity (potential fecundity minus atresia). Screening samples, and fecundity samples, have to be analysed in the laboratory upon return from sea. These procedures are not straightforward and require time. The last histology samples were collected in July and because of the narrow time frame only a selection of the fecundity samples have been analysed up to this date. Samples were therefore only analysed from sampling Periods 2 and 3 for the preliminary estimate.

Horse mackerel is considered to be an indeterminate spawner and therefore since 2007 IPMA has adopted the DEPM methodology for the southern horse mackerel stock (div. 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 areas in order to develop a modified DEPM approach for estimating the biomass of the horse mackerel stocks. Additional samples were collected during the Irish WESPAS survey in the Celtic Sea and west of Ireland in Periods 6 and 7.

Even though the partial processing of the screening samples has identified ovaries to be analysed for DEPM, none of these samples have been analysed yet.

Survey coverage and mackerel egg production by period

Period 2 – Portugal started the 2022 survey series on January 23rd. This is a DEPM survey mainly targeting the southern horse mackerel stock and is designed for this purpose, but it provides mackerel egg samples as well. The survey is usually undertaken between Cadiz and Galicia and is confined to ICES division 9a.

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 starting, however it subsequently linked with the Irish vessel. Both IEO and AZTI suffered difficulties with their vessels, and lost a number of sampling days, however full coverage was achieved (Fig. 1.1).

Egg numbers were quite low to the west of Ireland, however further south large numbers of eggs were found close to the 200m contour line. In Biscay and the Cantabrian Sea IEO and AZTI recorded a number of stations with large egg numbers. 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 (Fig. 1.2).

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 to ensure continuity of sampling 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 egg numbers were recorded to the west of Scotland, however numbers were lower than those reported for 2019 within this area and time period. 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 (Fig. 1.3). 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 westwards 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 numbers in 2022 within this area were lower than reported in 2019 so while the western boundary wasn't delineated, MEGS is happy that major egg production isn't being missed. 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 Shetlands. In total 444 stations were sampled and there were 214 interpolations. No replicate samples were taken.

Period 6 – During period 6 northern Biscay, 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 provide full coverage for the DEPM survey.

Ireland was due to charter a research vessel from Northern Ireland to conduct the survey. One week before the survey was due to depart this vessel had to go to dry dock for emergency repairs. After much searching a smaller Welsh RV was contracted. Once at sea however it quickly became clear that the replacement vessel was not going to be suitable for the survey. Only two successful stations were carried out before a decision was eventually made to abandon the survey. 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 (Fig. 1.4). Similarly in the northern area spawning was persistent at low levels, apart again from the area west of the Shetland. Due to an unavoidable reduction in the number of survey days available Norway was unable to secure either the western or northern boundary in the northern area, however 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 in the south to north of the Hebrides and 59°N (Fig. 1.5). 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. 2 replicate station was 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.

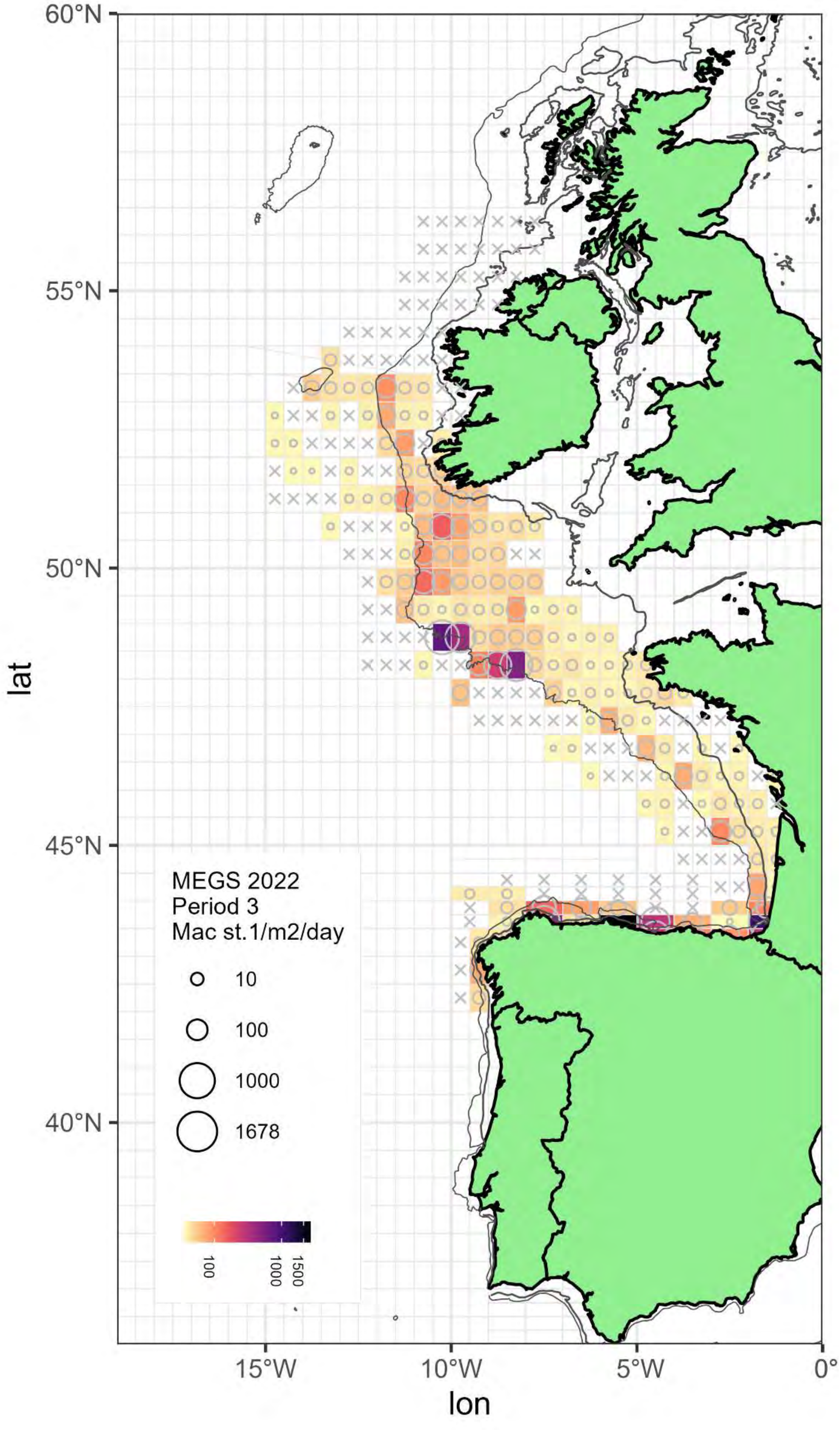

Figure 1.1: Mackerel egg production by half rectangle for period 3 (Mar 4th – Apr 8th). Circle areas and colour scale represent mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

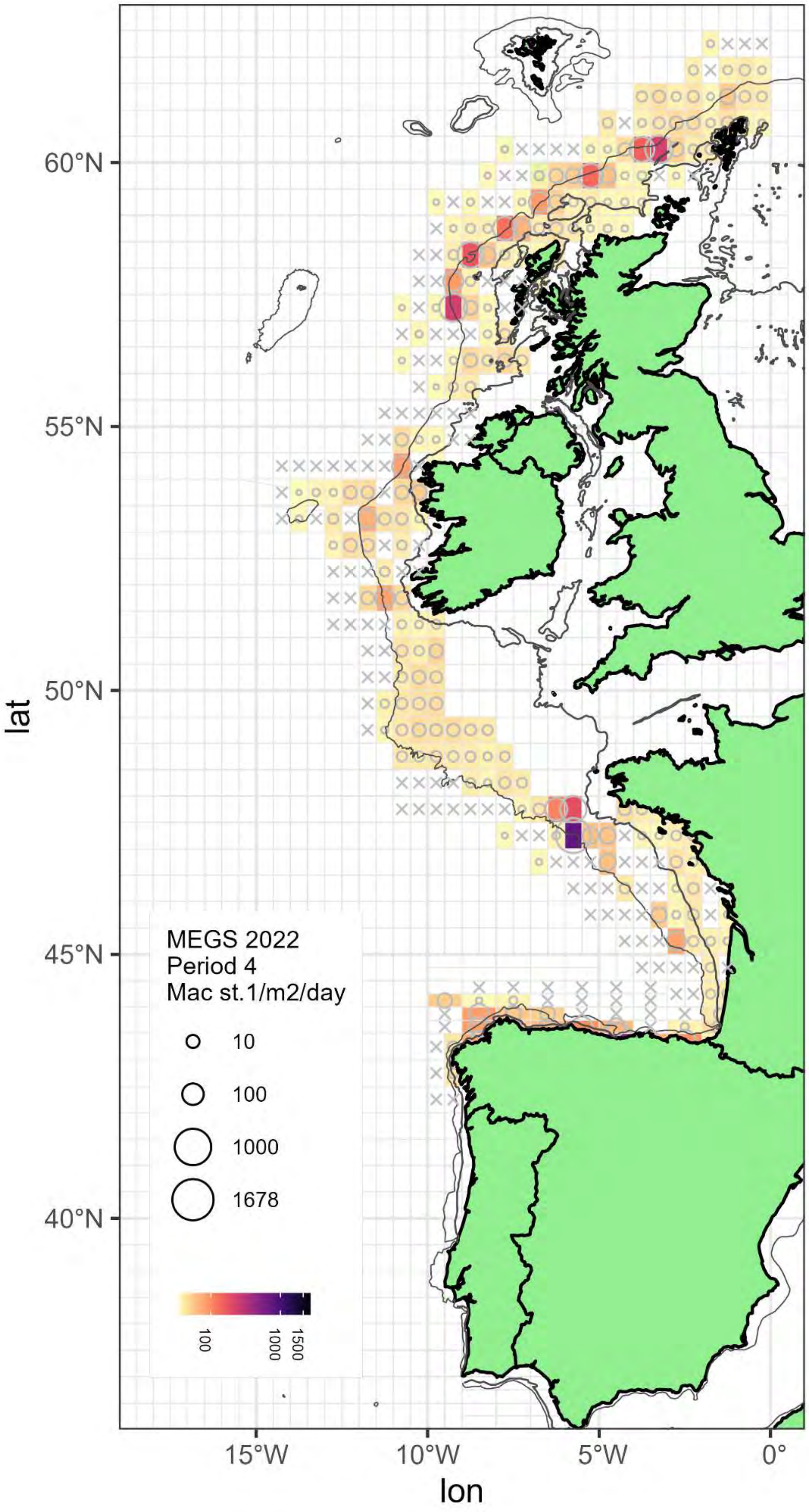

Figure 1.2: Mackerel egg production by half rectangle for period 4 (Apr 9th – 29th). Circle areas and colour scale represent mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

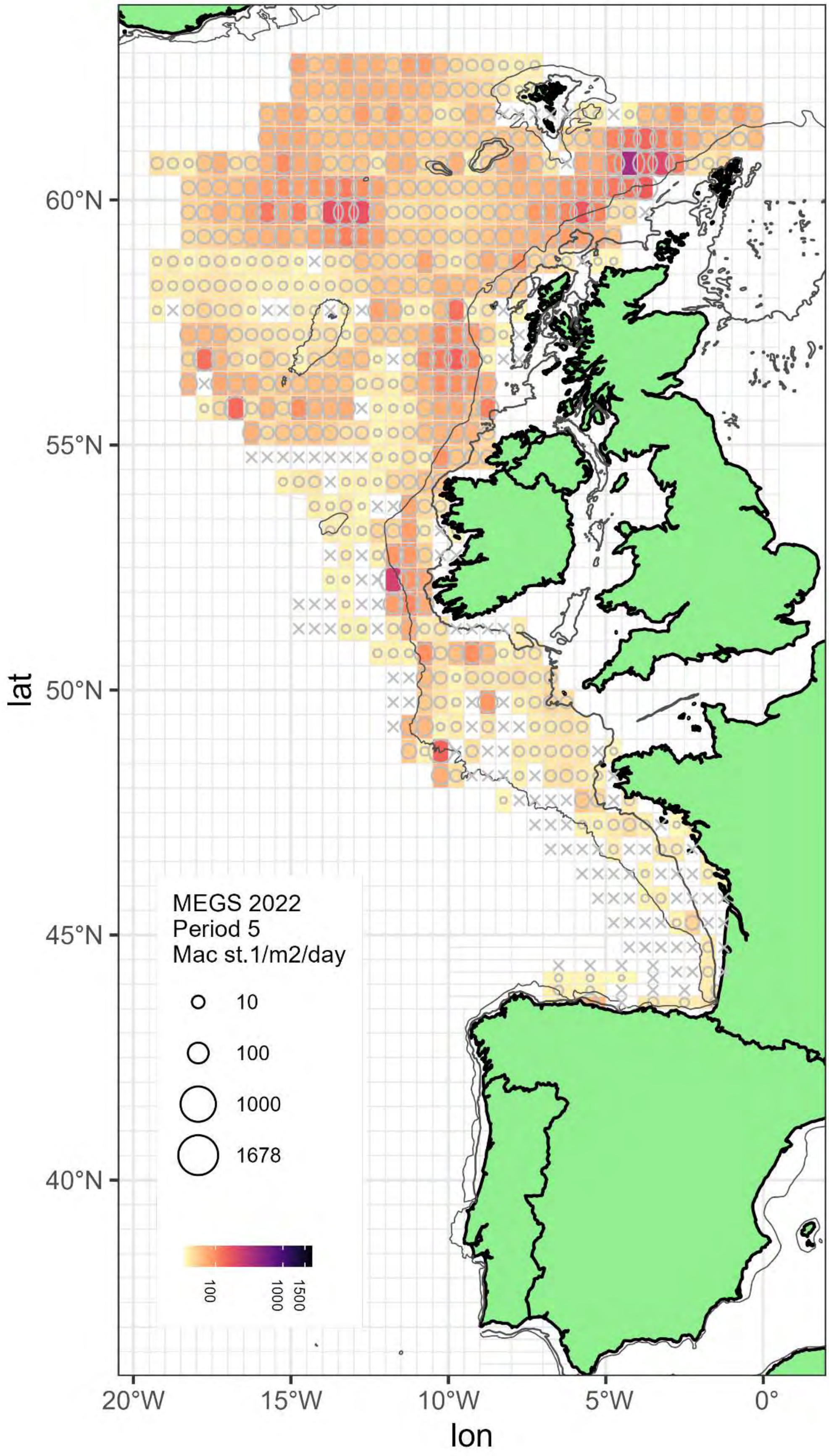

Figure 1.3: Mackerel egg production by half rectangle for period 5 (Apr 30th – May 31st). Circle areas and colour scale represent mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

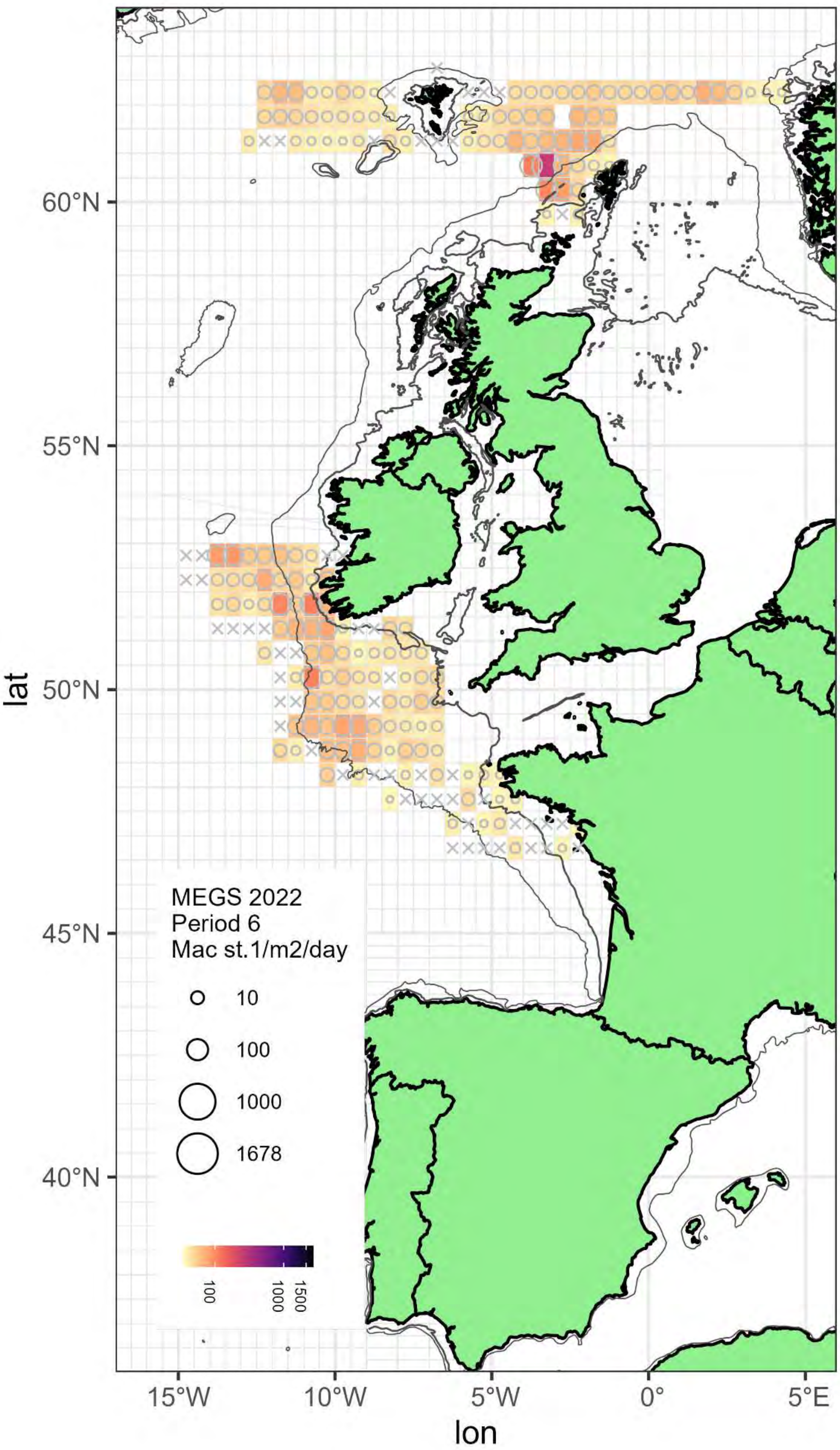

Figure 1.4: Mackerel egg production by half rectangle for period 6 (June 1st – 30th). Circle areas and colour scale represent mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

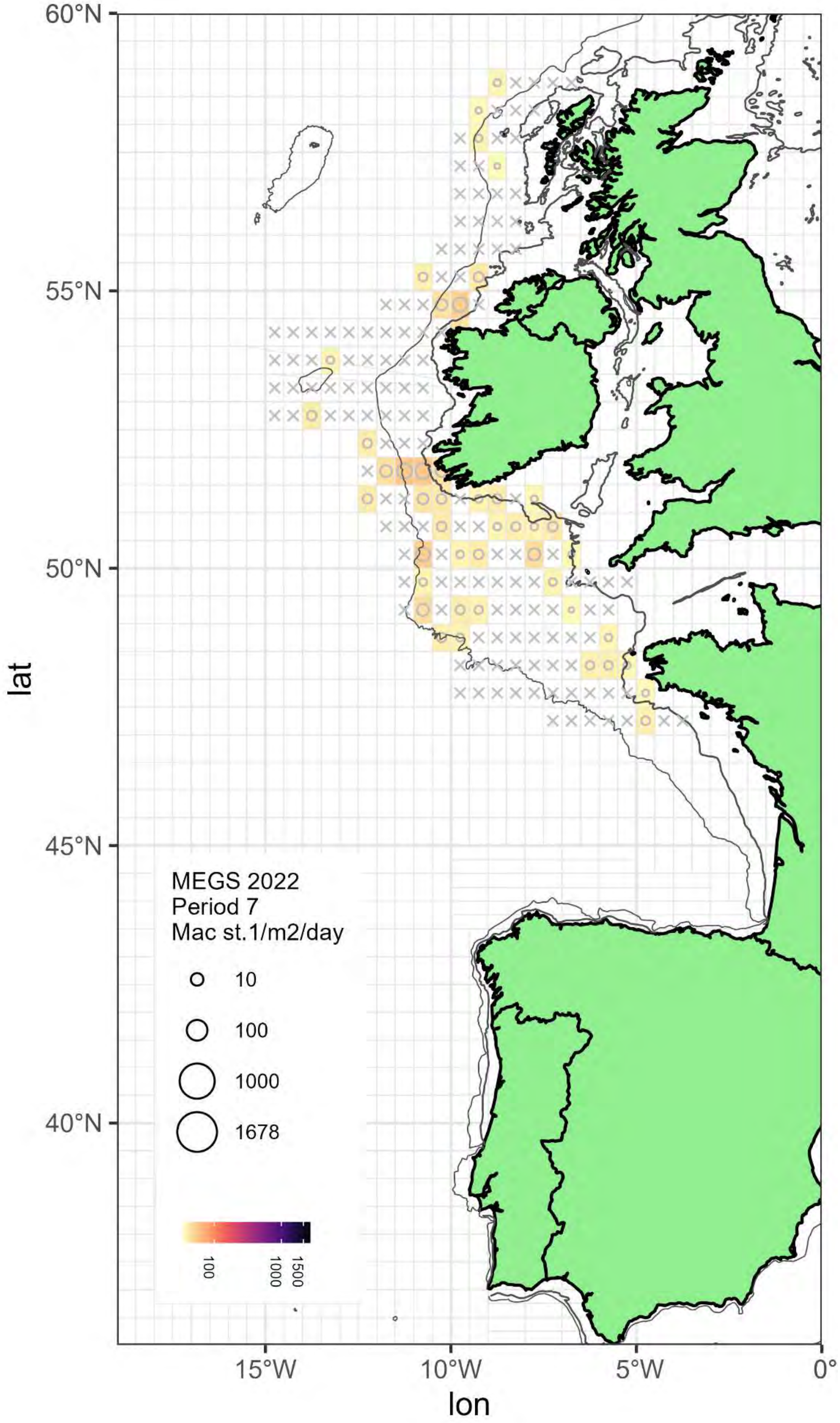

Figure 1.5: Mackerel egg production by half rectangle for period 7 (July 1st – 31st). Circle areas and colour scale represent mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

2 Results - MACKEREL

Stage 1 Egg production in the Western Areas

The cancelling of the Irish survey in period 6 was addressed by MEGS. The group estimated the spawning area that was missed and also estimated mean daily egg production for the period. The survey area from 53N to 61N, and 3.5W to 21W was looked at for the 2013, 2016 and 2019 surveys. Positive stations were selected where stage 1 eggs were found in a rectangle on at least two occasions over these three surveys (Fig. 2.1, blue rectangles). MEGS estimated this amounted to 127 missed stations during the period and also estimated mean daily egg production for period 6 in 2022 at 19.58 stage 1 eggs/m^2/day. Figure 2.2 shows the spawning curve for 2022, with and without the correction for the Irish survey.

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 (Fig. 2.3). 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 (Fig. 2.3 & Table 2).

In 2016 concern was expressed that survey coverage may have underestimated the total egg production estimate. The expansion observed in western and northwestern areas during Periods 5 and 6 in 2016 was once again reported during 2022, however this year production in Periods 5 and 6 was lower in these northwestern areas. The 2022 spawning curve is very similar to that of 2016, with peak spawning again occurring during Period 5. Annual egg production since 1992 is shown in Figure 2.4. Mackerel egg production by period since 2004 is shown in Figure 2.5.

In 2017 and 2018 MEGS organised exploratory egg surveys in this region. These surveys 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.

Overall, the inclusion of the estimated egg abundance for the missing stations in Period 6 has a impact of 10% on the annual egg production 2022.

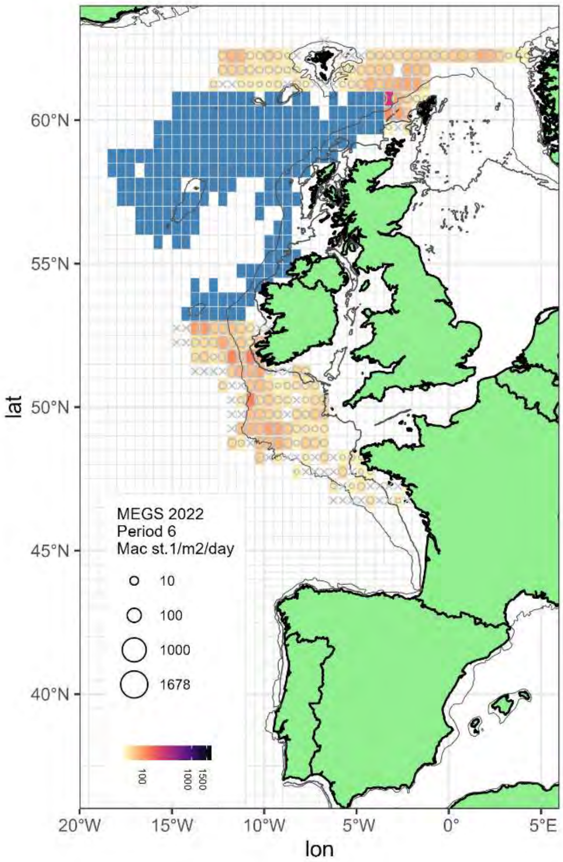

Figure 2.1: Area, blue colour, from period 6 where it is estimated eggs would have been found

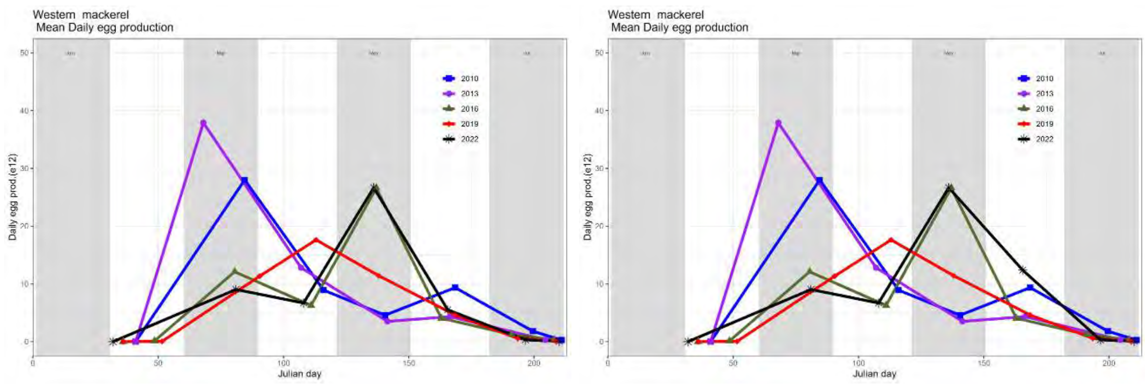

Figure 2.2: 2022 spawning curve showing uncorrected (left) and corrected (right) egg estimates for Period 6 (black line). The left hand plot shows the data from the Netherlands and Norwegian surveys. The right hand plot includes the addition of the estimated egg abundance calculated for the missing Irish Period 6 survey.

The nominal end of spawning date of the 31st July is the same as was 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 **1.795 * 10^{15}** (Table 2). This is a 47% increase on the 2019 TAEP estimate which was 1.22 * 10^{15}.

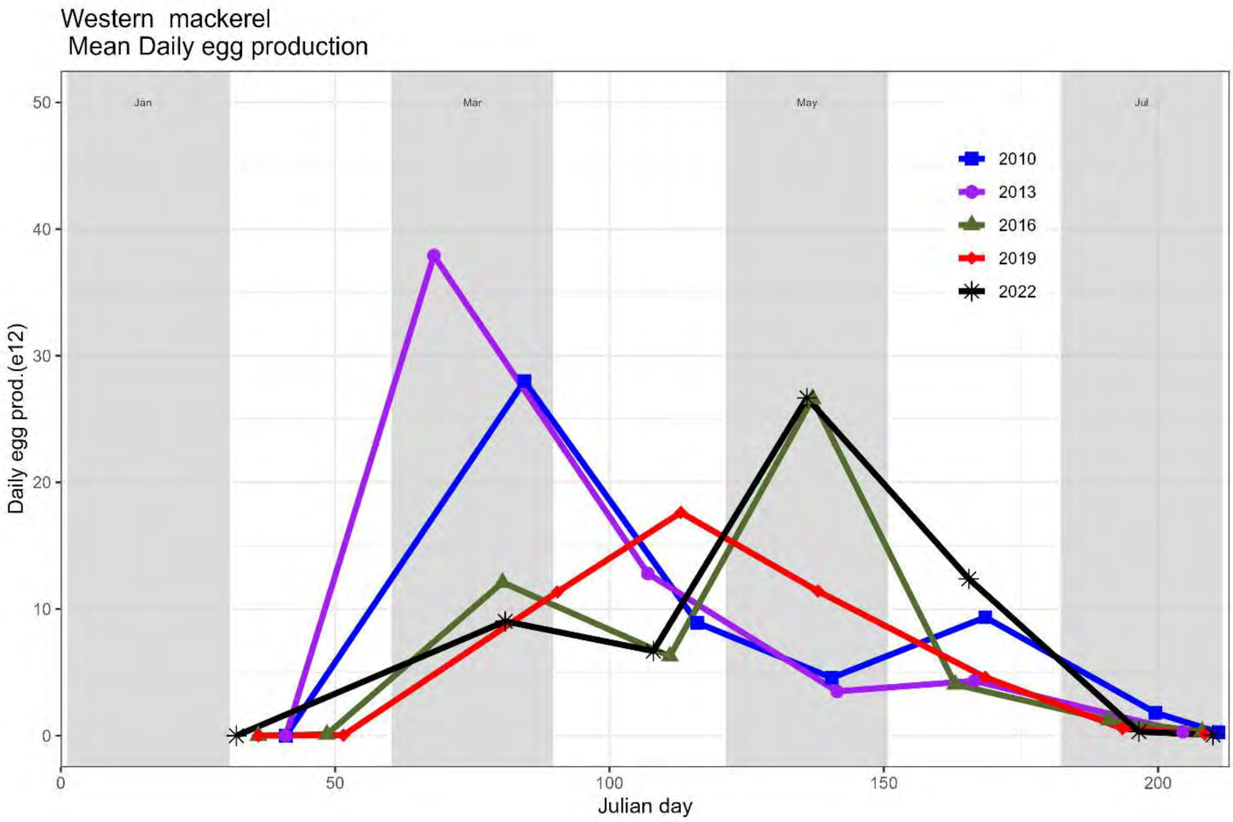

Figure 2.3: Provisional annual egg production curve for mackerel in the western spawning component in 2022, (black line). The curves for 2010, 2013, 2016 and 2019 are included for comparison.

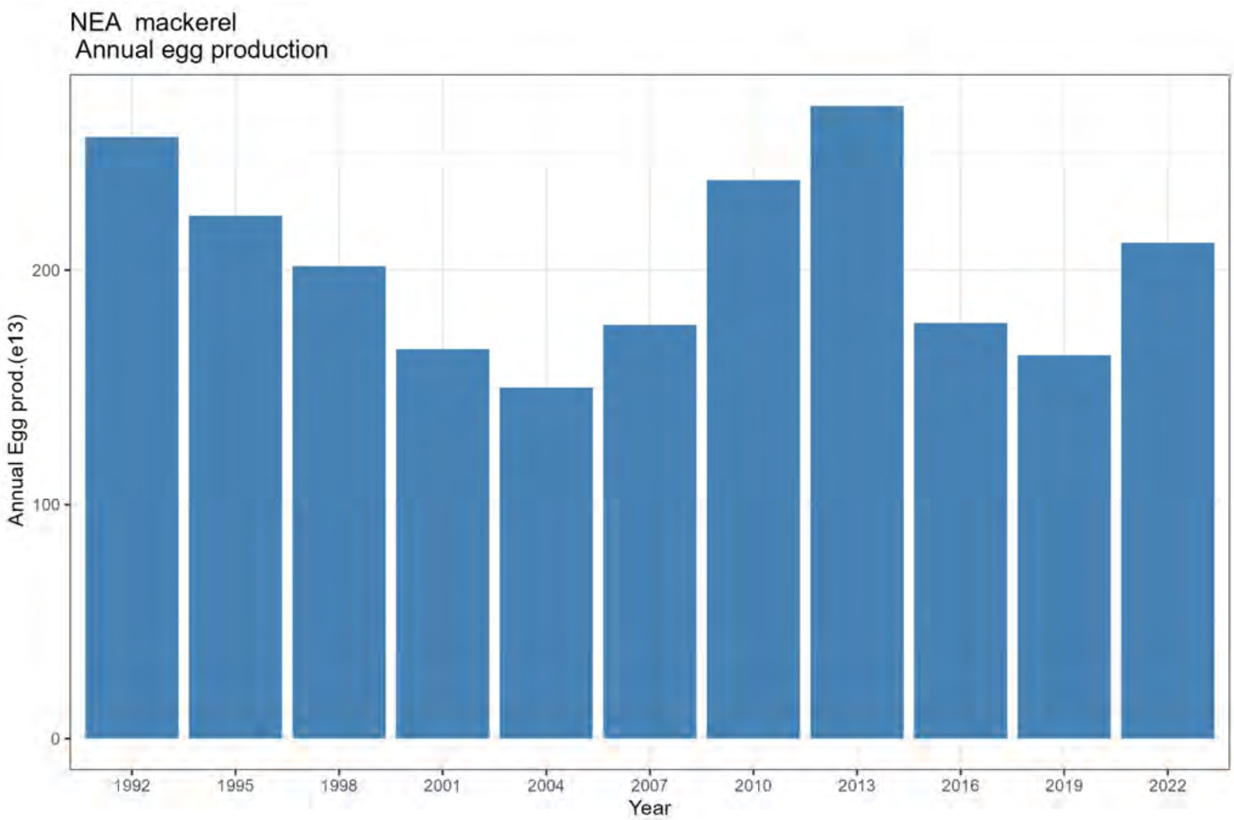

Figure 2.4: Provisional annual egg production for 2022 for the western spawning component.

Bars from 1992 are included for comparison.

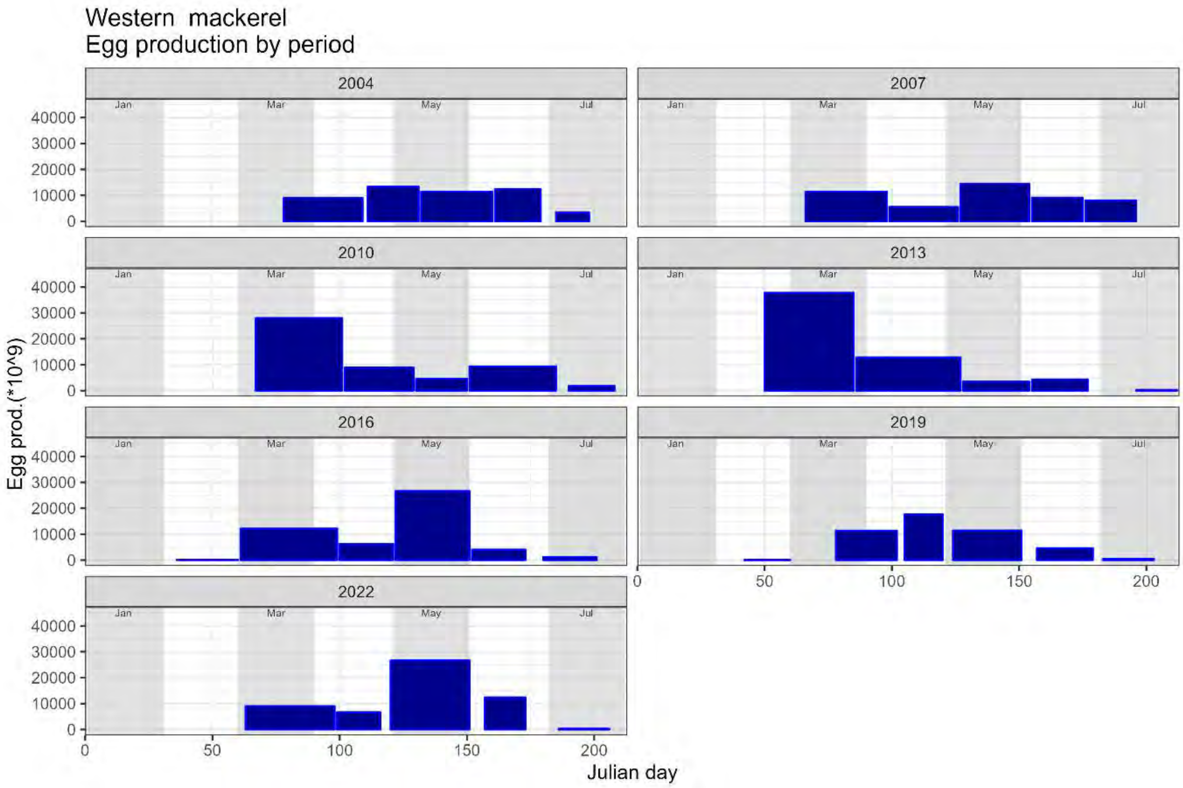

Figure 2.5: Egg production by period for the western spawning component since 2004

Table 2. Western 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	0.09
Mar 4th – April 8th	3	36	0.325
Apr 9th – April 26th	4	18	0.120
April 27th – Apr 29th	4 - 5	3	0.043
Apr 30th – May 31st	5	32	0.853
Jun 1st – 5th	5 - 6	5	0.067
Jun 6th – June 22nd	6	17	0.21
June 23rd – July 4th	6 – 7	12	0.081
July 5th – July 25th	7	21	0.007
July 26th – 31st	Post 7	6	0.0003
Total			1.795

Stage 1 Egg production in the Southern Areas

The start date for spawning in the southern area was the 23rd January (Table 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 the 17th July was used again this year and the spawning curve suggests that there is no reason for this to change (Fig. 2.4). As in 2019 the survey periods were not completely contiguous and this has been accounted for (Table 3). The mackerel egg production by period since 2004 is shown in Figure 2.6. The provisional total annual egg production (TAEP) for the southern area in 2022 was calculated as **$3.21 * 10^{14}$** (Table 3). This is a 25% decrease on the 2019 TAEP estimate which was $4.23 * 10^{14}$ (Fig. 2.5).

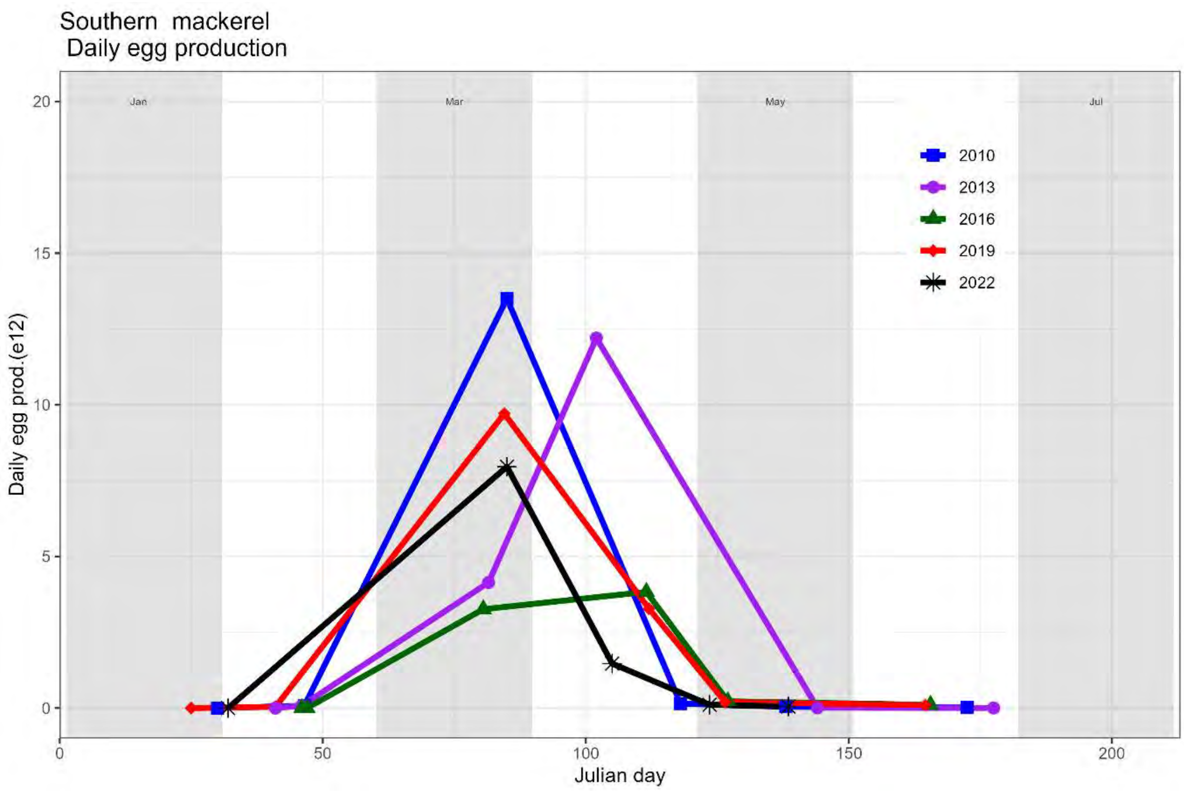

Figure 2.4: Provisional annual egg production curve for mackerel in the southern spawning component for 2022, black line). The curves for 2010, 2013, 2016 and 2019 are included for comparison.

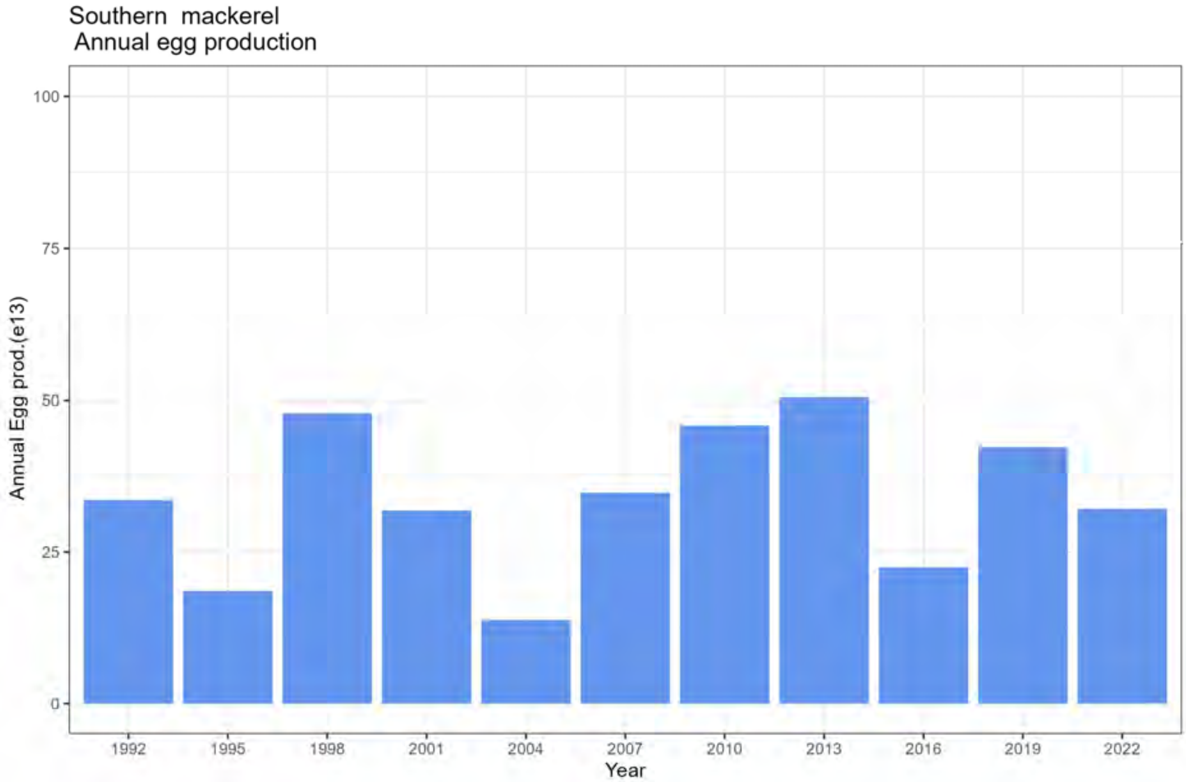

Figure 2.5: Provisional annual egg production for the southern spawning component for 2022. Bars from 1992 are included for comparison.

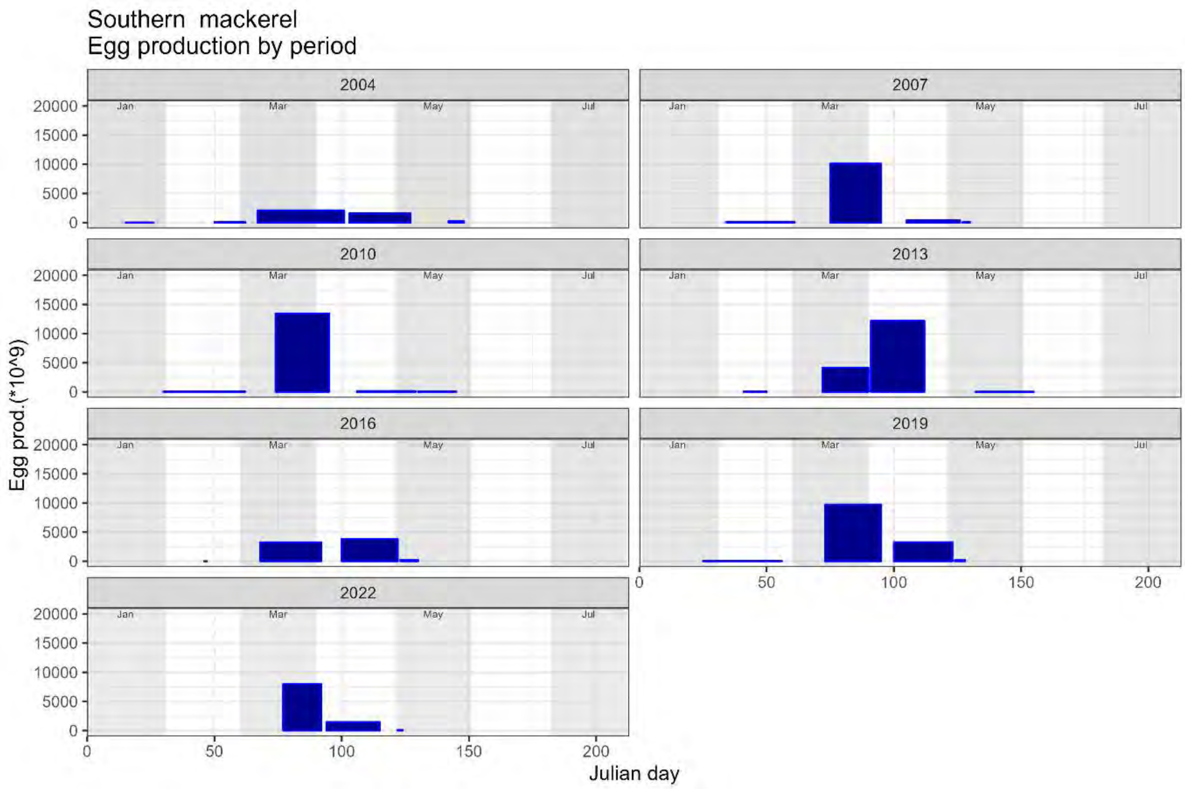

Figure 2.6: Egg production by period for the southern spawning component since 2004

Table 3. Southern estimate of mackerel total stage I egg production by period using the histogram method for 2022.

Dates	Period	Days	Annual stage I egg production x 10^{14}
Feb 1st – Mar 17th	2 - 3	45	1.52
March 18th – April 2nd	3	16	1.27
April 3rd	3 - 4	1	0.052
April 4th – 25th	4	22	0.323
Apr 26th – May 1st	4 - 5	6	0.026
May 2nd – 4th	5	3	0.003
May 5th –July 17th	Post 5	71	0.014
Total	3.212		

Total egg production

Total annual eggs production (TAEP) for both the western and southern components combined in 2022 is **2.116*10^{15}.** (Fig. 2.3). This is an increase in production of **29%** compared to 2019, 1.64*10^{15} (Fig. 2.3).

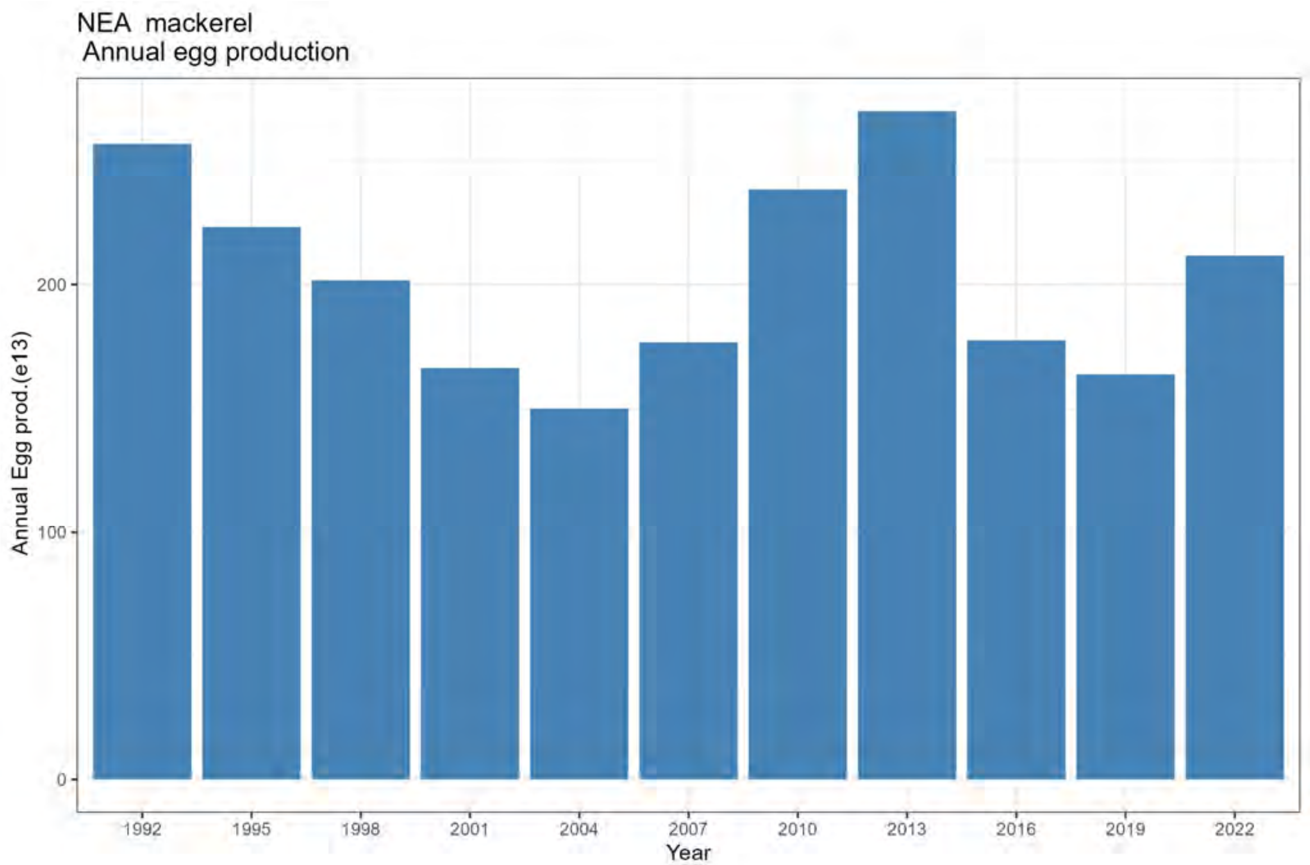

Figure 2.3: Combined mackerel TAEP estimates (*10^{13}) - 1992 – 2022.

Fecundity – Preliminary estimates

Adult Parameters

Fecundity Sample distribution

Atlantic mackerel samples were collected during periods 2-7 spread over an area with a bounding box of 59.36N 14.20W – 36.54N 2.32W. Nine institutes participated. The histological screening of samples was performed by five institutes while fecundity was analysed by six of them.

As usual for the preliminary report, only samples from Periods 2 and 3 were selected. This is because there is not enough time to analyse samples from the other periods. For the final report samples from the other periods will be included also. Experience from earlier surveys is that the preliminary estimate and the final estimate is close.

Screening

Potential fecundity counts were based on whole mount samples taken from maturing females which had not started spawning. To select these samples, a histological screening procedure was used followed by a screening procedure on the selected whole mount samples.

A total of 918 samples were screened, of which 793 were from periods 2 and 3 (
Table). Of those, 482 samples showed spawning markers, i.e. migratory nucleus stage (MIG), hydrated oocytes, eggs, and post ovulatory follicles (POFs). A total of 175 samples from periods 2-3 showed presence of atresia without considering those that were classified as "spent" or having "massive atresia".

From previous survey reports we know that POF scoring has varied considerably between periods. WKFATHOM2 (2018) discussed this issue and came up with more detailed criteria for POF staging. Looking at screening results from 2022, POFs were identified less frequently than in 2019 for periods 2 and 3, i.e. 58 % vs 74% (Table 4).

Table 4. POF scoring using histology by periods 2-3.

Period	Screened	Spawning Markers	POFs	Fecundity Histology	Fecundity Whole mount	Atresia Presence
2	32	24	21	2	2	3
3	675	541	494	38	33	156

Results from previous surveys showed that POF scoring could vary considerably between periods. At WKFATHOM2 (ICES 2018) this issue was discussed and more detailed criteria for POF staging were elaborated. Looking at screening results from 2022, POFs were identified less frequently than in 2019 for periods 2 and 3, i.e. 58 % vs 74% (Table 5).

Table 5. POF scoring using histology (Periods 2-3).

Period	No POF	POF	%POF	%POF 2019
2	66	55	52	66
3	260	404	60	74
2-3	326	459	58	74

A total of 159 samples from periods 2-3 showed presence of atresia without considering those that were classified as "spent" or having "massive atresia" (Table).

Looking at the oocyte stage most of the samples in periods 2-3 were at MIG or hydrated oocyte stage (n = 545) and that less than half (n = 217) were in vitellogenic oocyte stage.

Potential fecundity

For the 2022 preliminary estimate of potential fecundity, 169 samples were available, which represents 21% of all samples screened for periods 2 and 3. This number is much higher than in 2019, when 34 samples were available for the preliminary report.

The potential fecundity estimate is based on samples from pre-spawning fish. The pre-spawning status is confirmed using a detailed histology screening procedure that detects the most advanced oocyte stage (stage 1-5) as well as spawning markers (POF´s, post ovulatory follicles and eggs). This year the fecundity estimate is based on samples that may also include the MIG oocyte stage. This is different from previous surveys (in recent time) where the most advanced oocyte stage included was stage 3 (advanced vitellogenesis). However, the MIG oocyte stage is not a true spawning marker, but a marker that shows that spawning likely will take place within a few days. For previous surveys samples with MIG´s were excluded for precautious reasons.

Since the 2013 MEGS survey, the median has been used for relative fecundity estimation rather than the mean which was used previously. The reason for the change is related to the fact that that unlike the mean, the median is not influenced by extreme values. A posterior analysis showed that the median for relative potential fecundity was close to the arithmetic mean in most years. The largest difference was in 2013, but even then, the median was within the confidence interval of the potential fecundity arithmetic mean. WGMEGS 2018 (ICES 2018) discussed whether to use the trimmed mean instead of the median for the potential fecundity estimate. A trimmed mean is preferred for calculation of confidence intervals. However, until the time-series data is reanalyzed in the near future, it was decided that the relative fecundity estimate should still be based on the median rather than the mean.

The distribution of relative potential fecundity values (Figure 2.4) was close to a normal distribution and ranged from 623 to 1972 (n/g). The distribution was almost similar both for samples with the MIG oocyte stage (stage 4) and stage 3 (Figure 2.4). The median value for stage 3 samples was 1247 (mean 1282, SD 290) while for the MIG stage the median was 1256 (mean 1300, SD 267). This shows that including samples with MIG´s in the fecundity estimate have not significantly changed the median or mean value, and that our previous cautious procedure excluding MIG´s is probably unnecessary.

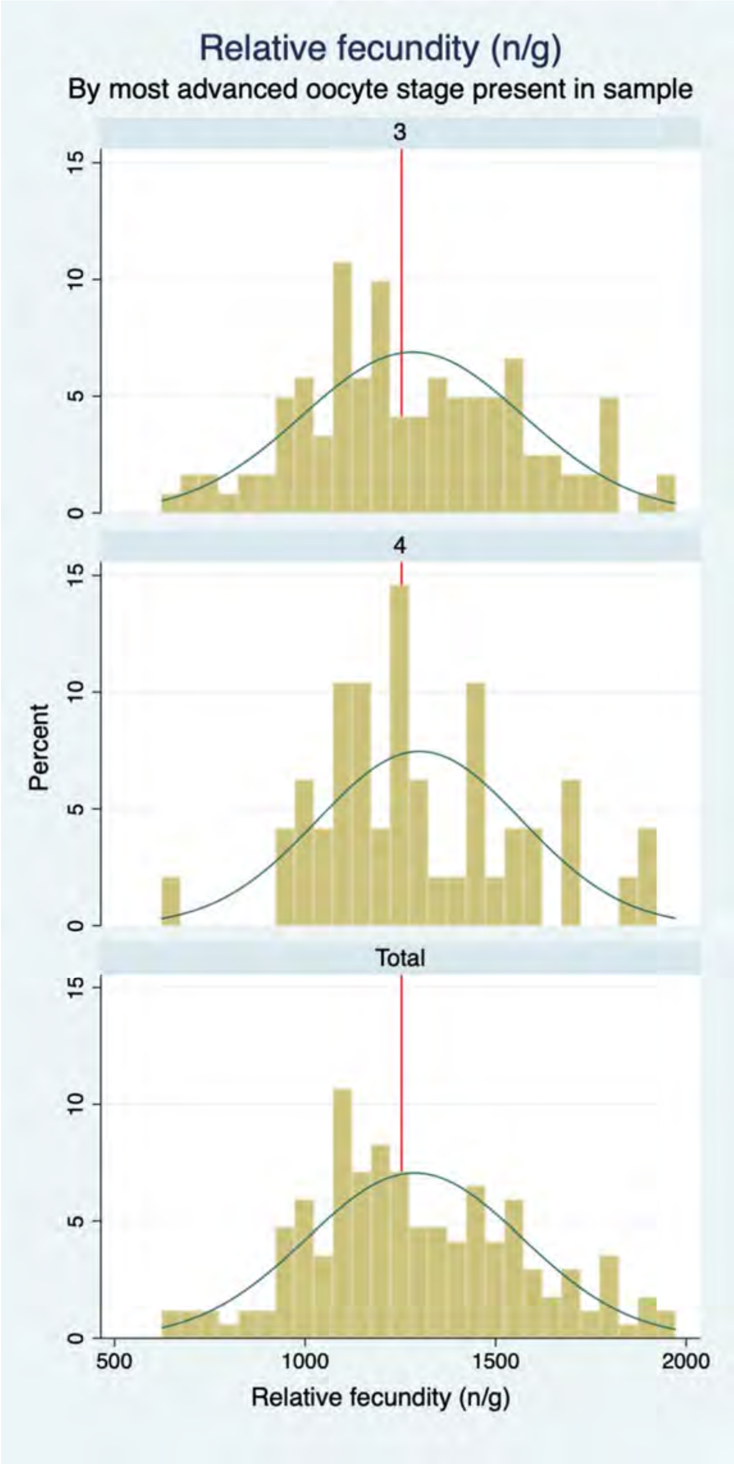

Figure 2.4. Relative fecundity preliminary estimation in 2022. The panels show the distribution (in %) of relative fecundity using samples in which the most advanced oocyte stage present was 3 (advanced vitellogenesis, top panel), samples where the most advanced oocyte stage was MIG (stage 4, middle panel) and the combined histogram (bottom panel).

The preliminary relative potential fecundity in 2022 was slightly higher than in 2019 (1253 and 1191, respectively)

Table 6 Estimate of relative fecundity (n/g fish) and statistics.

Year	N	Median	Mean	sd	Max	Min	95%CI
2022	169	1253	1288	283	1972	623	1252-1324
2019	34	1215	1263	285	2029	564	1163-1362

Biological data of fish samples to fecundity

The distribution of fish length, weight, Fulton's condition factor (100 × weight/length^3), and gonad-somatic index (GSI; 100 × Ovary weight/Fish weight) is shown in Figure 2.5.

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. For this preliminary estimation, no females needed to be excluded from the analysis based on these biological parameters.

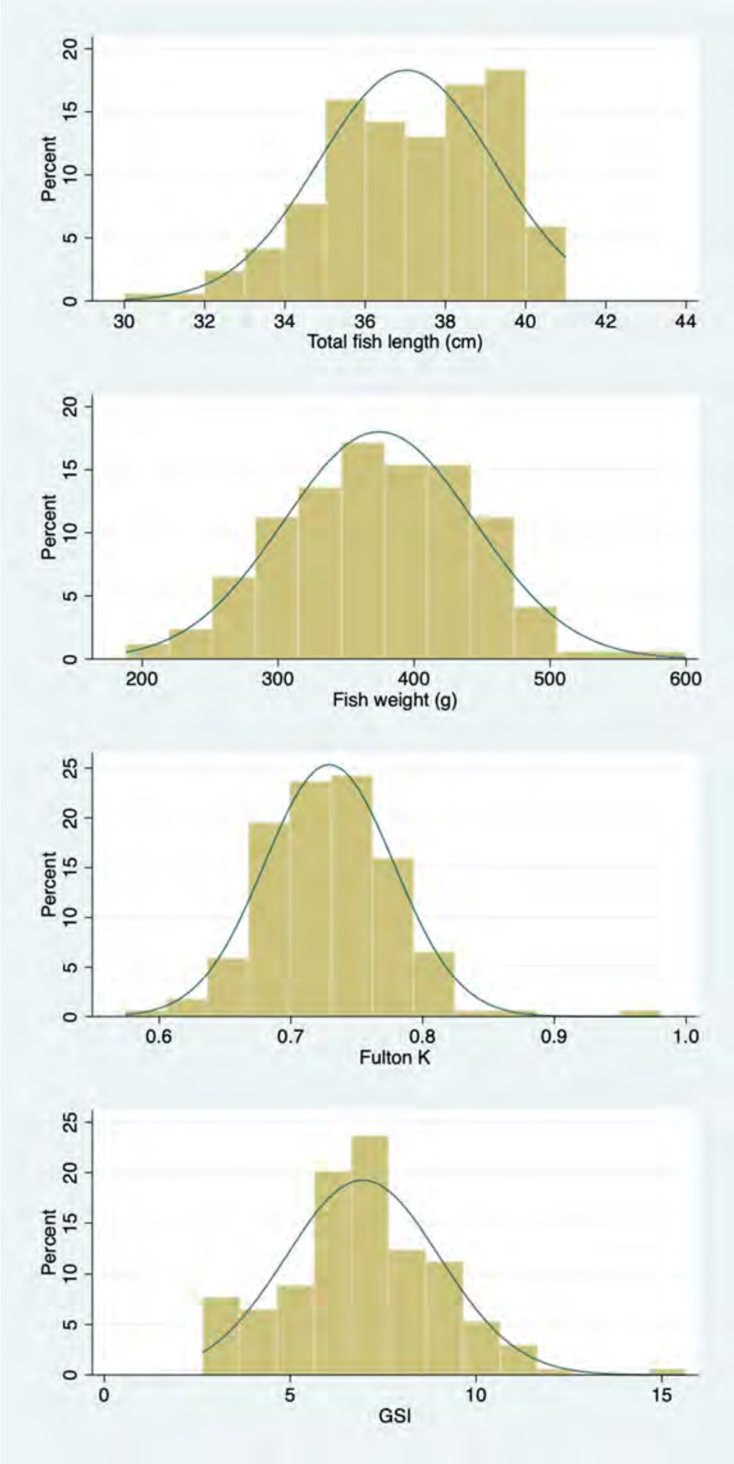

Figure 2.5. Fish length and weight, Fulton's Condition index and GSI of individuals analysed for fecundity.

Atresia

Atresia is the loss of oocytes by reabsorption before spawning and must be subtracted from the potential fecundity (whole mount fecundity counting) to estimate the realised fecundity. In this preliminary report, intensity of atresia can not be presented due to the time consumed for the histology screening.

The prevalence of atresia estimated by histological screening may however be a good indicator of the level of atresia. Prevalence of atresia is defined as the percentage of spawning fish which have early stage atresia (early alpha-atresia). Among the 559 samples considered the prevalence of atresia estimated was 0.28, (fish from period 2-3, excluding spent fish and fish with massive atresia).

Realised fecundity

Realised fecundity is defined as the potential fecundity minus the loss by atresia. The loss by atresia is a function of both intensity of atresia and prevalence of atresia. The intensity of atresia for 2022 is still unavailable, therefore the loss was calculated from the average loss from the surveys since 2001 (Table). The relative loss by atresia from this period (2001-2019) ranged from 6-9% (average 6%).

Based on this, the preliminary realised fecundity-estimate for 2022 was 1178 oocytes/gram female. The estimate is well within the observed range of realized fecundity (1009-1209, average 1087 egg per gram female) from all previous surveys back to 2001 (Table 7). For the three most recent surveys, realized fecundity varied between 1087 and 1209 eggs per gram female (average 1148).

Table 7. Summary table of mackerel fecundity and atresia by survey year.

	Survey year							
	2001	2004	2007	2010	2013	2016	2019	2022 Prel.
Fecundity samples (n)	187	205	176	74	132	97	62	169
Prevalence of atresia (n)	290	348	416	511	732	713	895	559
Intensity of atresia (n)	290	348	416	511	56	66	64	
Relative potential fecundity (n/g)	1097	1127	1098	1140	1257*	1159*	1191*	1253*
Prevalence of atresia	0.2	0.28	0.38	0.33	0.22	0.3	0.28	0.28
Geometric mean intensity of atresia (n/g)	40	33	30	26	27	30	20	
Potential fecundity lost per day (n/g)	1.07	1.25	1.48	1.16	0.8	1.2	0.73	
Potential fecundity lost (n/g)	64	75	89	70	48	72	44	75
Relative potential fecundity lost (%)	6	7	9	6	4	6	4	6
Realised fecundity (n/g)*	1033	1052	1009	1070	1209	1087	1147	1178

*Median not mean relative potential fecundity.

Biomass estimation

Total spawning stock biomass (SSB) was estimated using a preliminary fecundity estimate of 1178 oocytes/g female, a sex ratio of 1:1 and a raising factor of 1.08 (ICES, 1987) to convert pre-spawning to spawning fish. This gave an estimate of spawning stock biomass of:

- 3.292 million tonnes for western component (2019: 2.29).
- 0.589 million tonnes for southern component (2019: 0.80).
- 3.881 million tonnes for western and southern components combined (2019: 3.09)

3 Results – HORSE MACKEREL

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 numbers were still low (Fig. 3.1).

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 (Fig. 3.2).

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 (Fig. 3.3).

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 in this period (Fig. 3.4).

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 (Fig. 3.5).

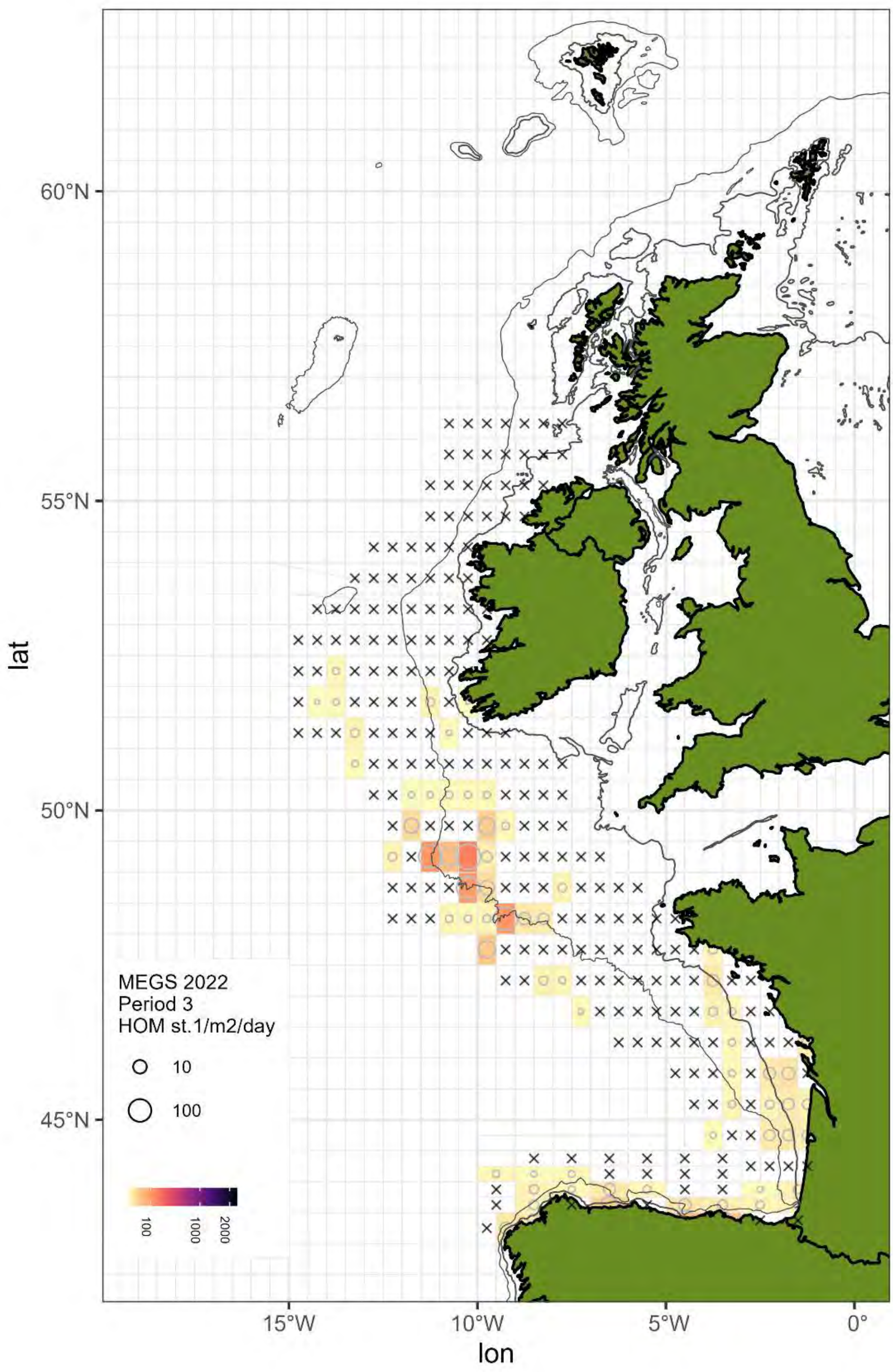

Figure 3.1: Horse mackerel egg production by half rectangle for period 3 (March 4th – April 8th). Circle areas and colour scale represent horse mackerel stage I eggs/m^2/day by half rectangle. Crosses represent zero values.

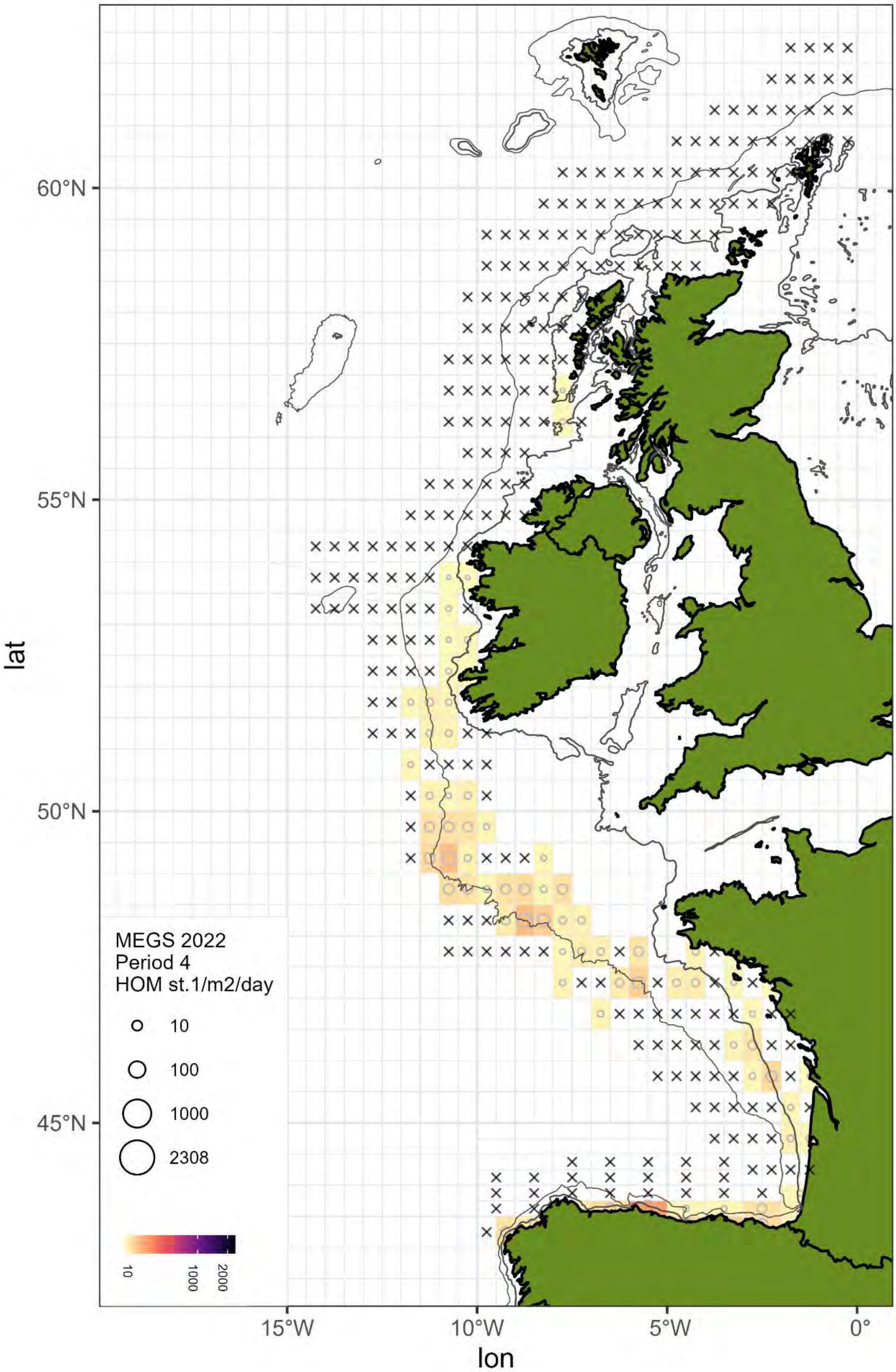

Figure 3.2: Horse mackerel egg production by half rectangle for period 4 (April 9th – 29th). Circle areas and colour scale represent horse mackerel stage I eggs/m^2/day by half rectangle. Crosses represent zero values.

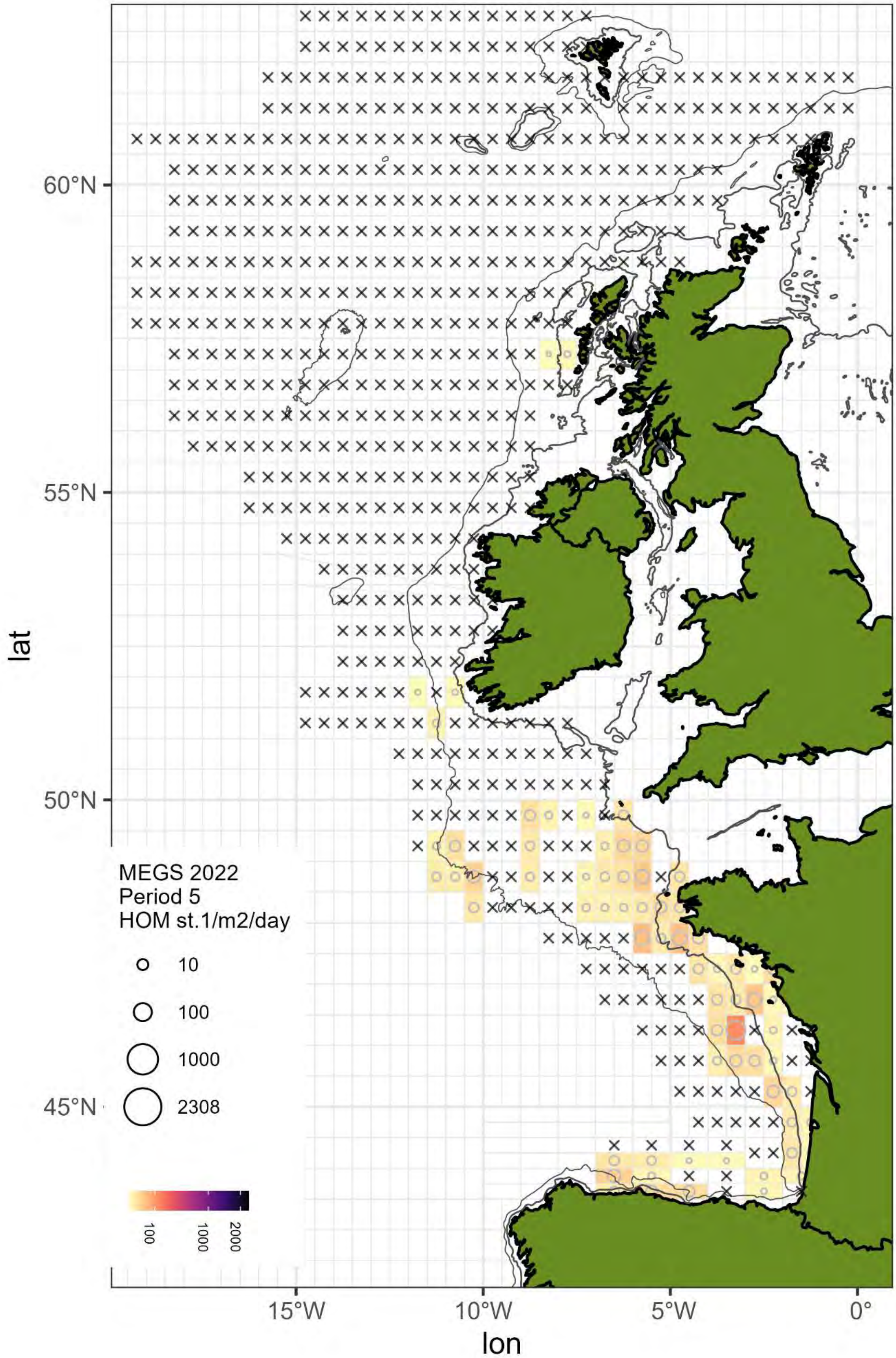

Figure 3.3: Horse mackerel egg production by half rectangle for period 5 (Apr 30th – May 31st). Circle areas and colour scale represent horse mackerel stage I eggs/m^2/day by half rectangle. Crosses represent zero values.

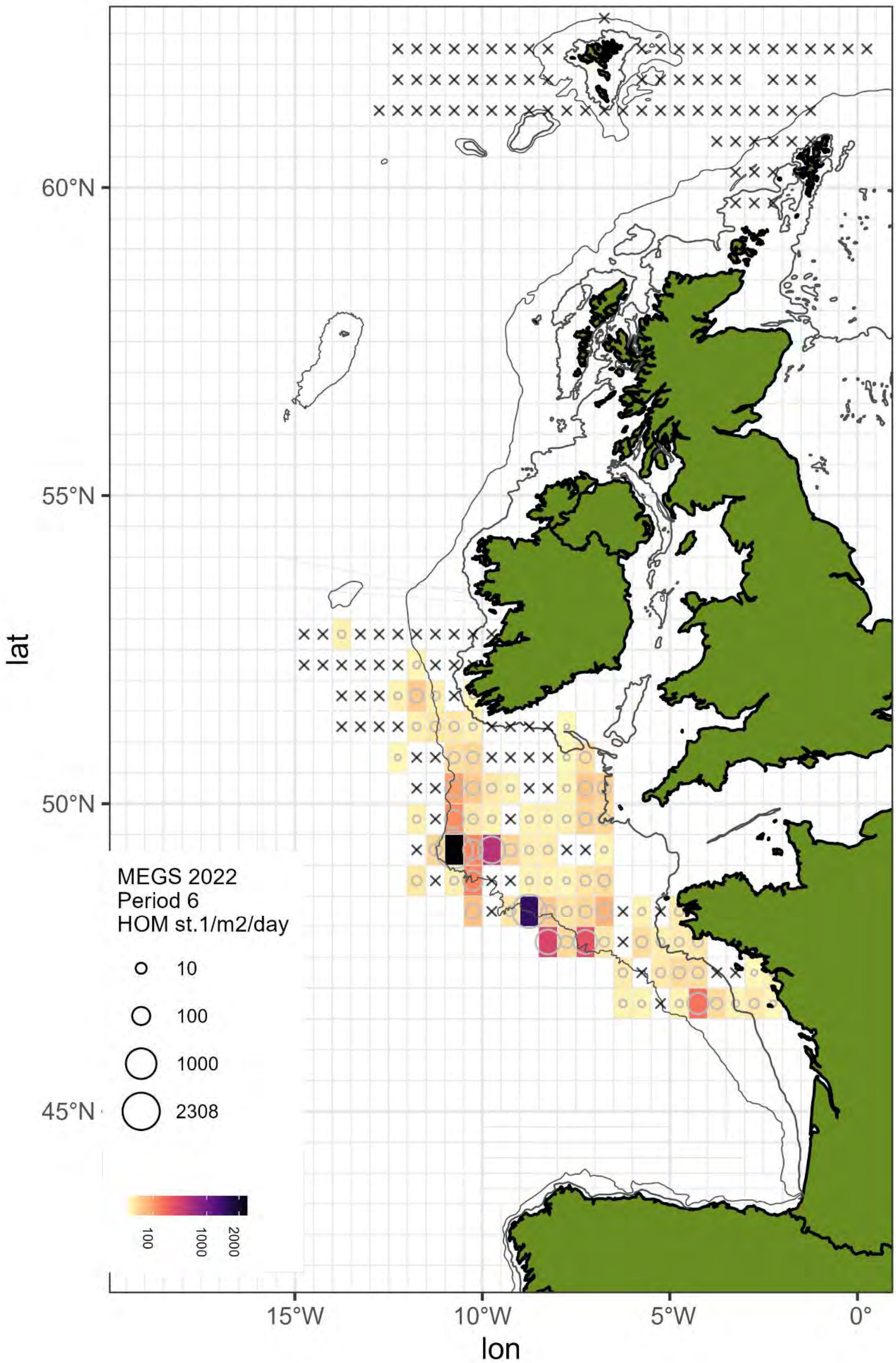

Figure 3.4: Horse mackerel egg production by half rectangle for period 6 (June 1st – 30th). Circle areas and colour scale represent horse mackerel stage I eggs/m^2/day by half rectangle. Crosses represent zero values.

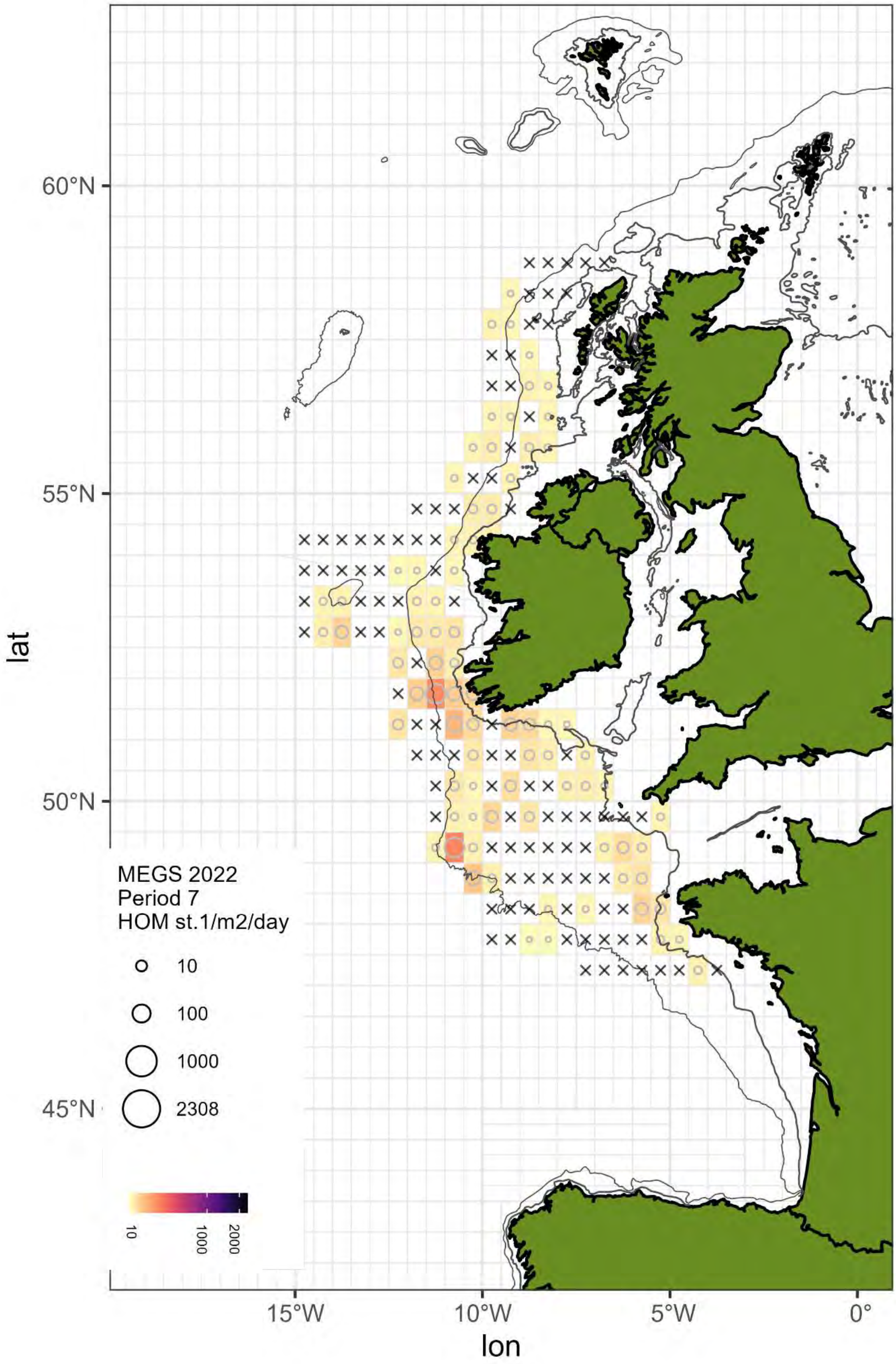

Figure 3.5: Horse mackerel egg production by half rectangle for period 7 (July 1st – July 31st). Circle areas and colour scale represent horse mackerel stage I eggs/m^2/day by half rectangle. Crosses represent zero values.

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 6). The shape of the egg production curve does not suggest that those dates should be altered for 2022 (Fig. 3.6). An exercise, similar to the one carried out for mackerel in period 6, was not carried out for horse mackerel as MEGS feel that the Netherlands period 6 survey delineated the northern boundary of horse mackerel spawning during this period. The total annual egg production was estimated at **5.15 x 10^{14}**. This is almost a threefold increase on 2019 which was 1.78 × 10^{14} which was the lowest estimate of annual egg production ever recorded for this species (Fig. 3.7). Horse mackerel egg production by period since 2007 is shown in Figure 3.8.

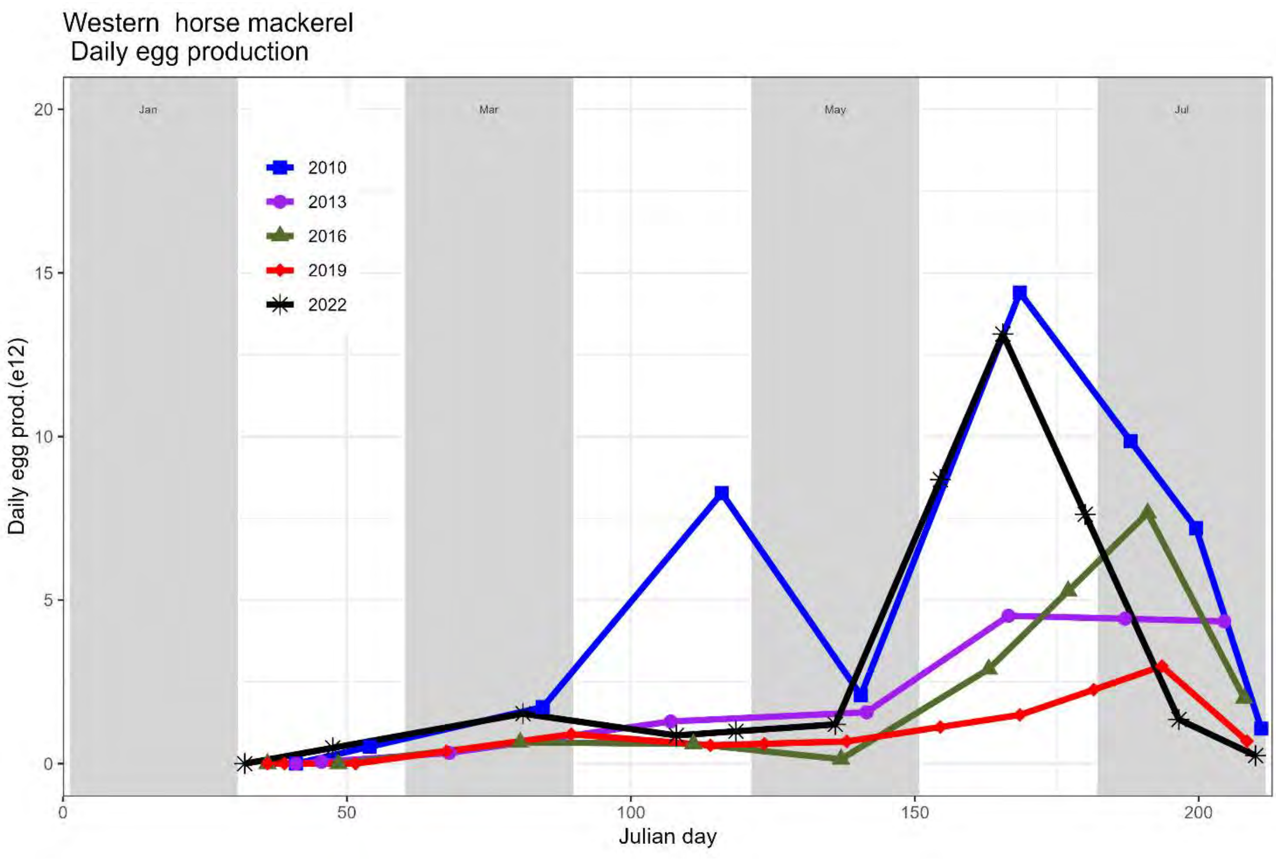

Figure 3.6: Provisional annual egg production curve for western horse mackerel for 2022, (black line). The curves for 2010, 2013, 2016 and 2019 are included for comparison.

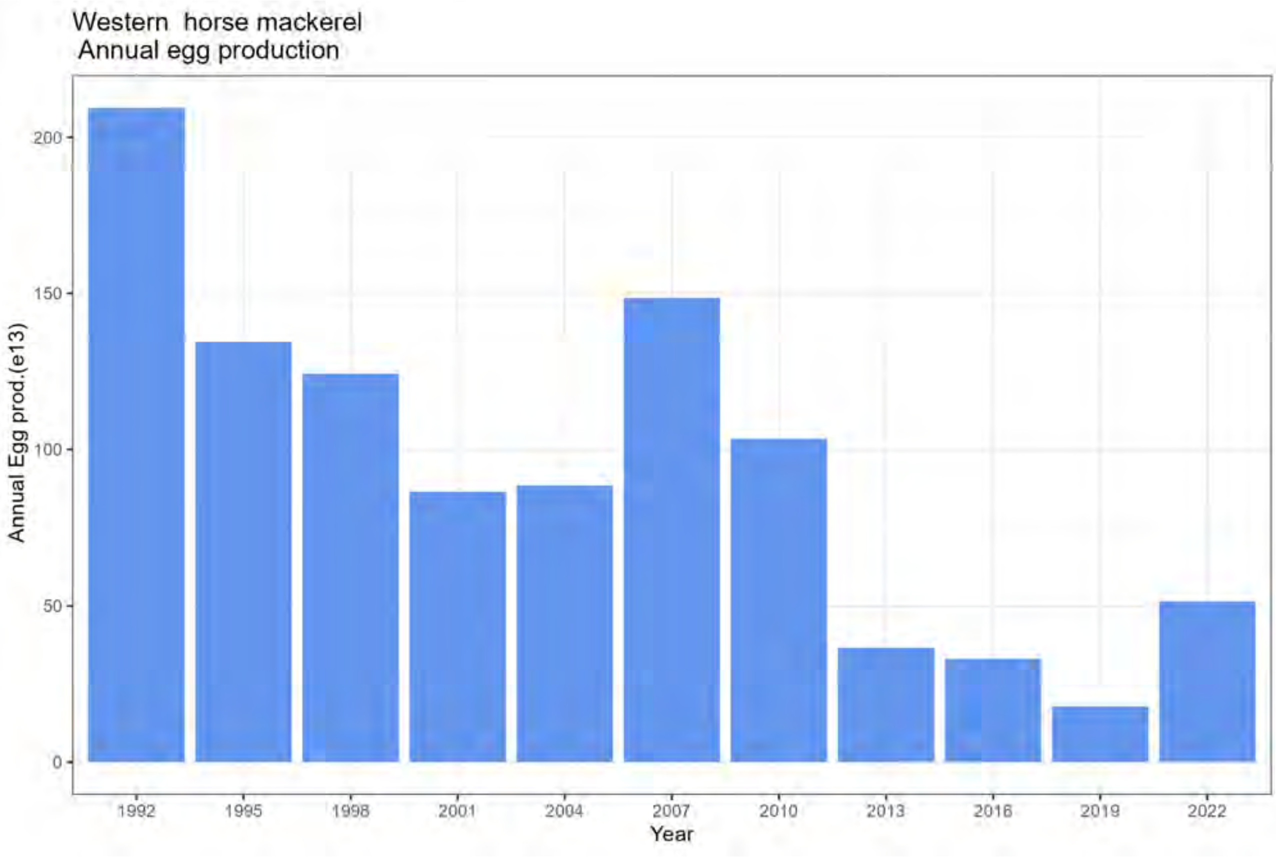

Figure 3.7: Provisional total annual egg production for western horse mackerel. Production figures back to 1992 are included for comparison.

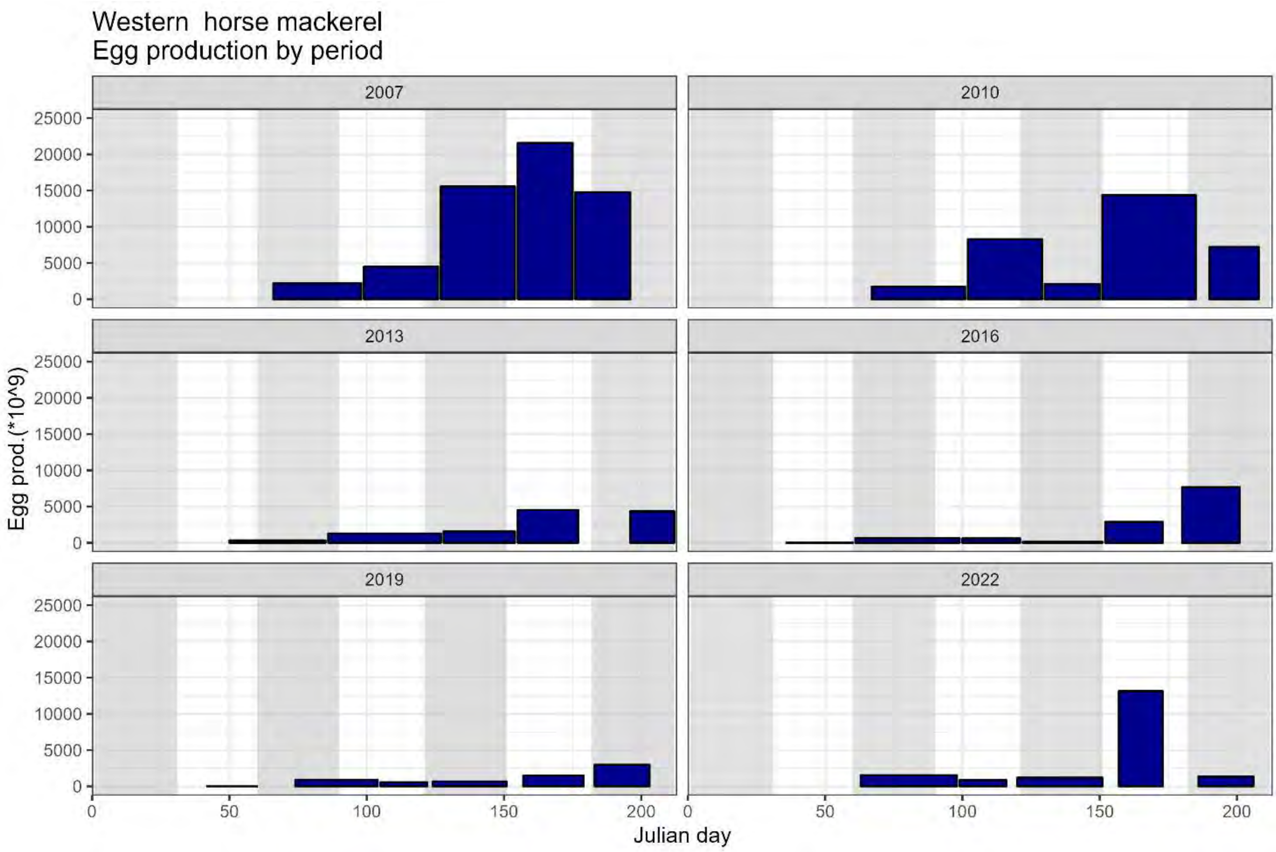

Figure 3.8: Egg production by period for the western horse mackerel spawning component since 2007

Table 6: Western estimate of 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	0.016
Mar 4th – April 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	0.038
Jun 1st – 5th	5 - 6	5	0.043
Jun 6th – 22nd	6	17	0.223
June 5 – July 4th	6 – 7	12	0.091
July 5th – 25th	7	21	0.028
July 26th – 31st	Post 7	6	0.001
Total	0.514		

Fecundity investigations

This year for horse mackerel only DEPM ovary samples were collected during Periods 6 and 7, during peak of spawning. In addition to those samples collected during the MEGS surveys additional samples were collected from the Irish WESPAS surveys in periods 6 and 7. Since horse mackerel fecundity is at this moment not used for estimating the spawning stock biomass the focus of the fecundity analysis has been on mackerel. Therefore, at this time no horse mackerel fecundity results are ready to be presented. All samples will be analysed and results presented at the 2023 WGMEGS meeting.

DEPM results –Western Horse Mackerel

The horse-mackerel egg data of the DEPM survey are still under revision. Samples will be analyzed before and results will be presented to the 2023 WGMEGS meeting.

4 Discussion

Since 2004 and subsequent to demands for up-to-date data for the assessment, WGMEGS has endeavored to provide an estimate of NEA mackerel biomass and western horse mackerel egg production within the same calendar year as the survey and in time for the assessment meetings taking place. This report represents the preliminary results of the 2022 egg survey. WGMEGS cannot guarantee that there will be no changes prior to the presentation of the final survey results at WGMEGS in April 2023. However, despite the tight deadline nearly all plankton samples were analyzed for mackerel (southern and western area) and horse mackerel (western area only) stage 1 eggs. Portugal still has to supply data for their Period 2 survey in division 9a. Historically not many mackerel are caught during this survey therefore only negligible changes in the total egg production values are to be expected

As with 2019 no fecundity samples from Period 1 were available, instead samples from Periods 2 and 3 were included in the potential fecundity estimate. For the final fecundity estimate the later periods will also be included, as was done for previous surveys. No estimate of loss by atresia is yet available for 2022. The realised fecundity estimate is therefore based on the average atretic loss found in the period from 2001-2019. Since the atretic loss has always been a small number compared to the potential fecundity, using this average value will likely not give a large error. The prevalence of atresia for 2022 (28%) is comparable to previous survey estimates, it is thus highly likely that the atretic loss will also be at the same level. Atretic loss will however be analysed and included in the final fecundity estimate at the WGMEGS meeting in 2023.

Previous surveys in 2010 and 2013 were dominated by the issue of the early peak of western mackerel spawning and its close proximity to the nominal start date. In 2016 peak spawning reverted to May / June, a time that would traditionally be considered normal. In 2019, peak spawning in the western area was found to have occurred slightly earlier in Period 4. For 2022 the spawning pattern is remarkably similar to that reported for 2016.

During 2016, high levels of spawning were recorded over a large area of the Northeast Atlantic with a large number of the stations being reported over deepwater and well away from the continental shelf. In 2019 numbers of stage 1 eggs recorded on these northerly and western boundary stations were much reduced, although still present. The expansion was repeated in 2022 during Periods 5 and 6, however spawning densities recorded in these areas were significantly lower than reported in 2016 and 2019. Available surveys deployed during these periods were unable to fully delineate all boundaries however WGMEGS are satisfied that significant additional egg production is not being missed in these northern and western areas.

For the first time in a number of surveys western horse mackerel has shown an increase in egg production.

The MEGS group is confident that this survey accurately reflects the spawning patterns as exhibited by both species and as is presented in this working document. Despite the inability to secure a northern spawning boundary for western mackerel during periods 5 and 6, results from the recent exploratory MEGS surveys undertaken within these regions and reported to WGWIDE in 2021 (ICES,

2021) provide reassurance that the fraction of spawning missed is a minor one and that the survey has indeed been successful in capturing the majority of spawning activity. The potential issue arising from the missing Irish survey has also been satisfactorily addressed.

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ICES, 2021. Working Group on Widely Distributed Stocks (WGWIDE). ICES Scientific Reports. 3:95. 874 pp. http://doi.org/10.17895/ices.pub.8298 (Annex 05, WD 15)

Blue whiting

An updated alternative assessment including more surveys*

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Introduction

During WGWIDE 2020 we saw how vulnerable a stock assessment is when we only have one survey input to base the assessment on, and that survey is cancelled. In 2020 it was due to the covid-19 pandemic, but in the future there might be other unforeseen events that may cause the survey being cancelled or something may go wrong in the data collection so that we do not have reliable data for a specific year. To avoid this issue of potentially having no fishery independent data and make the assessment more robust against problems with the IBWSS, we will in this report consider including the IESNS and IESSNS survey data for blue whiting in the assessment.

Data description

For the IESNS survey we have data from 2008 to 2022 and for the IESSNS from 2016 to 2022. We use ages from 1-4+ and 1-6+ from the two surveys. This age selection was made based on the consistency plots in Figure 4. From the original assessment, we also have catch data (ages 1-10+, 1981-2022) and the IBWSS (ages 1-8, 2004-2022), where 2010 and 2020 is missing. The model has been configured based on data available in 2020, but we will include everything that is available at the time of the WGWIDE 2022 meeting in 24.-30. August 2022. An overview of the data selected for the alternative assessment is found in Figure 5 and each time series is plotted in Figure 6 for each age group and Figure 7 for each year class.

Model description

Today's assessment is using the R package stockassessment and the SAM model. Including additional survey data as input in this framework is a relatively simple task. The effort is mostly needed for deciding how to set up the configuration of the model. The procedure of how we have selected the model configuration is that we have included the two additional survey data sources and start out with a default SAM configuration. Then we start at the top of the configuration and make incremental changes and compare different settings until we get the best model fit in terms of AIC. Then we move on to the next configuration setting. We only consider configurations that are somewhat sensible. For instance, we do not consider putting the same catchability on 1 year old and 8-year-old fish, with some other catchability for those in-between. We only consider cases where neighbouring age groups share the same parameters. The final configuration file is included in the appendix. For details on diagnostic, see appendix.

Model output

Once we have fitted the model, we can look at model output. In Figure 1 we have plotted SSB, Fbar and recruitment for the period 1980-2022 according to the fitted model. The black line with grey confidence

*Updated working document from WD11 for WGWIDE2021 to WGWIDE2022.

interval is the official WGWIDE2022 assessment model for comparison.

In terms of SSB, the two models follow each other closely, with a slightly lower SSB for the alternative model in recent years. The main difference is clearly that we get smaller confidence intervals, i.e. higher accuracy, by adding more data to the model. For Fbar the picture is more or less the same. The two models are close to each other, only the alternative model point estimate is higher than WGWIDE for the last 3-4 years.In recruitment we see a bigger discrepancy. The alternative model gives a higher recruitment in 2016 and also for the last two years, 2021 and 2022. This is most likely due to high values for these years in the two additional survey indices.The confidence intervals are narrower for the alternative model compared to WGWIDE2022. Hence, the alternative assessment is consistent with the WGWIDE2022 assessment, but it has higher accuracy.

Leave-out analysis

A standard diagnostic is to leave out one survey at the time and see what effect this has on the output. This is achieved by taking out one data source at the time and refitting the model. This can give us an idea of how that particular data source affects the total. The leaveout plots are presented in Figure 2.

For the SSB the differences are small and the four curves are close to each other. If we take out IESSNS the SSB is slightly lower and if we take out IESNS it increases in the recent years. Taking out IBWSS increases the uncertainty the most, which is natural as it is the largest survey in terms of observations. We also see a similar pattern for Fbar. For the recruitment, taking out IESSNS will give the lowest recruitment, while if we take out IBWSS we get the highest for 2021. Going back in time, the leaveout scenarios give more or less the same result.

Another interesting scenario we can run is: What if we take out all the surveys and run the SAM model with only catch data. The results of such a model run is presented in Figure 3 compared to the WGWIDE2022 assessment. In short, it gives a lower point estimate for SSB and Recruitment and higher Fbar. It also widens the confidence intervals when taking out all surveys.

Conclusion

This exploratory model run shows that it is possible to include IESNS and IESSNS into the SAM model for Blue Whiting. It reduces the uncertainty and may provide more information about the younger fish. It will certainly reduce the risk for not having any survey to base the assessment on, by having two-three surveys instead of just one. The data is already being collected, and ready to use.

Appendix

Diagnostics

Jit run

A jitter run means that we re-estimate the model using randomly selected initial values and report the maximum difference in each parameter and model output. Ideally there should not be any major changes due to the initial values. The results from the jitter run indicates that there is little effect on the different model parameters due to varying the initial values.

```
##                        max(|delta|)
## logFpar                1.708855e-12
## logSdLogFsta           1.119327e-12
## logSdLogN              3.281819e-13
## logSdLogObs            3.246112e-12
## logSdLogTotalObs       5.225820e-12
## transfIRARdist         1.073452e-11
## itrans_rho             2.763567e-12
```

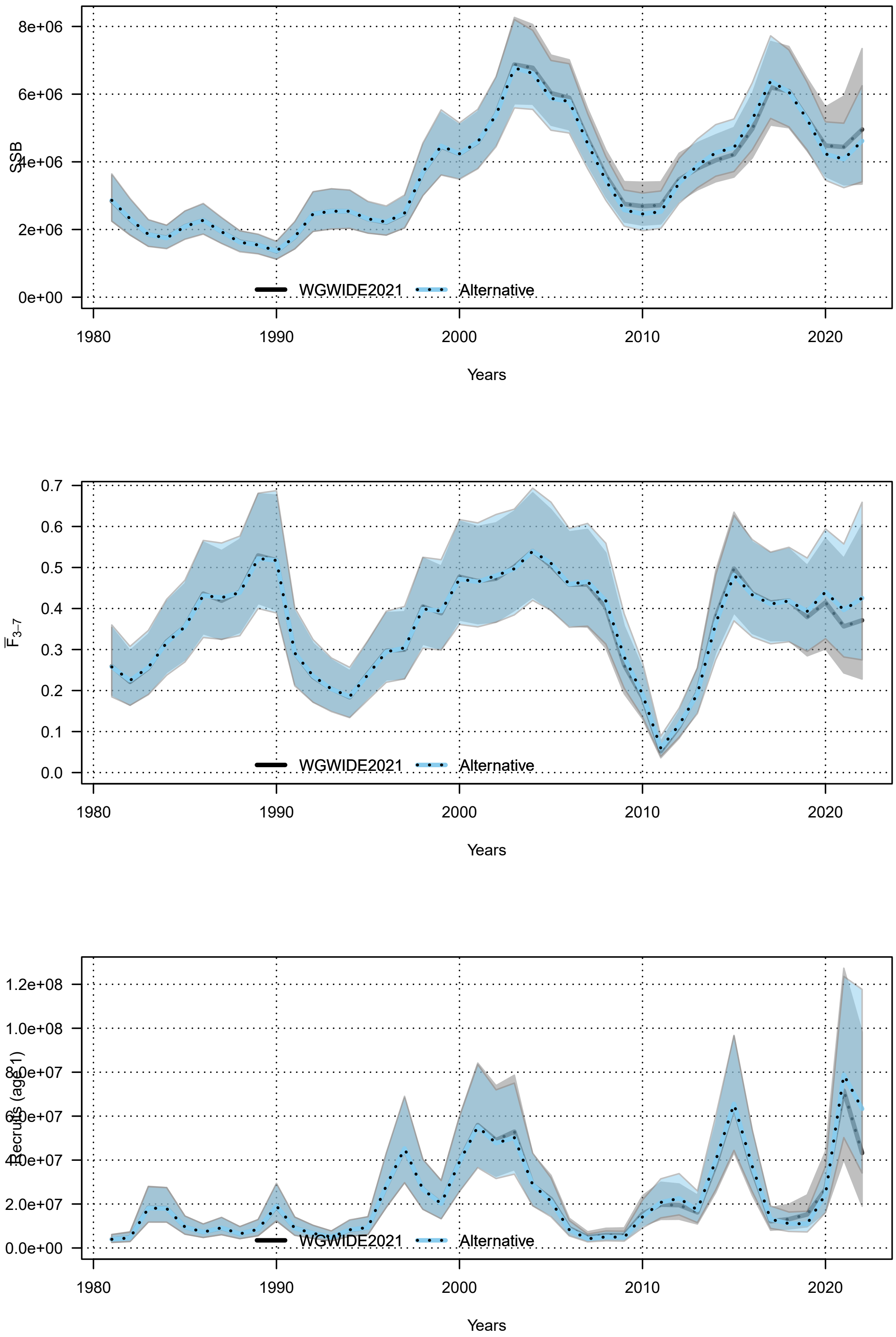


Figure 1: Model output in terms of SSB, Fbar and recruitment with 95 percent confidence intervals.

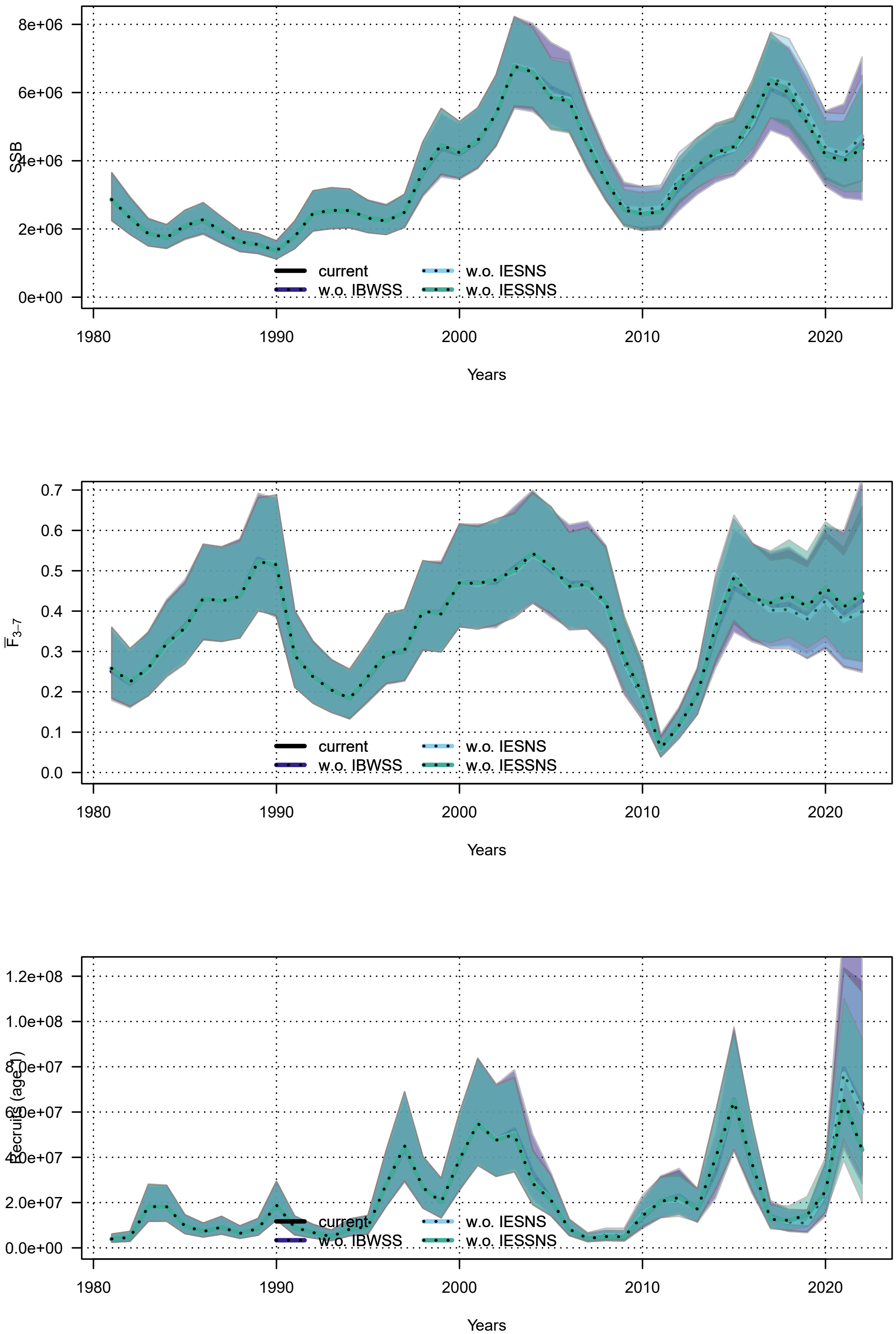
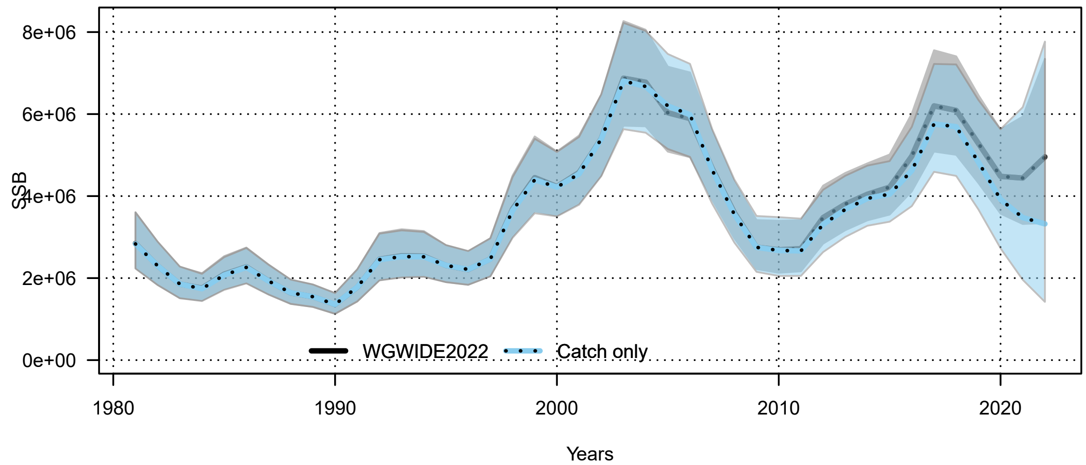
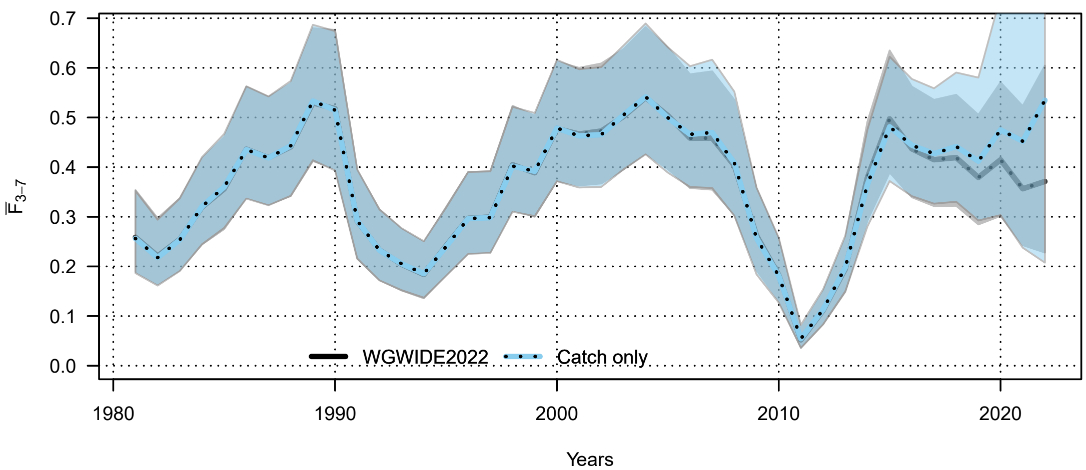


Figure 2: Leaveout plots for alternative assessment.





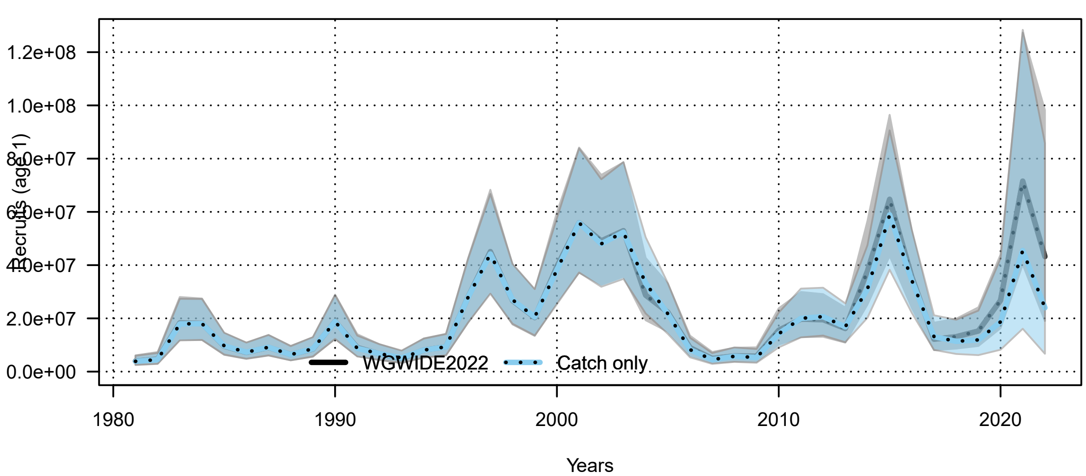


Figure 3: Comparison of assessment with catch only vs WGWIDE2021 assessment.

```
## logFScaleMSY           6.995491e-01
## implicitFunctionDelta 5.901470e-01
## logScaleFmsy           5.912467e-01
## logScaleFmax           5.875044e-01
## logScaleF01            6.409693e-01
## logScaleFcrash         6.993916e-01
## logScaleFext           5.391787e-01
## logScaleFlim           6.193291e-01
## logF                   1.629119e-10
## logN                   2.133138e-10
## missing                2.507221e-10
## ssb                    5.337661e-04
## fbar                   4.384876e-11
## rec                    9.316012e-03
## catch                  8.541672e-05
## logLik                 2.537490e-10
```

Simulation study

Another test is to do a simulation study, where we simulate the processes going into the model and compare this to the model output based on the observations. Ideally, the simulations should stay within the 95% confidence intervals with a probability of 0.95. Here we use 50 simulations. It seems that most of the simulations fall within the confidence intervals, with some exceptions. This is expected.

Retrospective plots

Peeling off one year at the time and fitting the model based on those data. In the retrospective plots (Figure 13) we can see how well the last year's assessment fits with what the model predicts with one more year of data. Mohn's ρ for the retrospective analysis of SSB, Fbar and recruitment is respectively, 0.0069, -0.0094 and -0.0736.

Figures

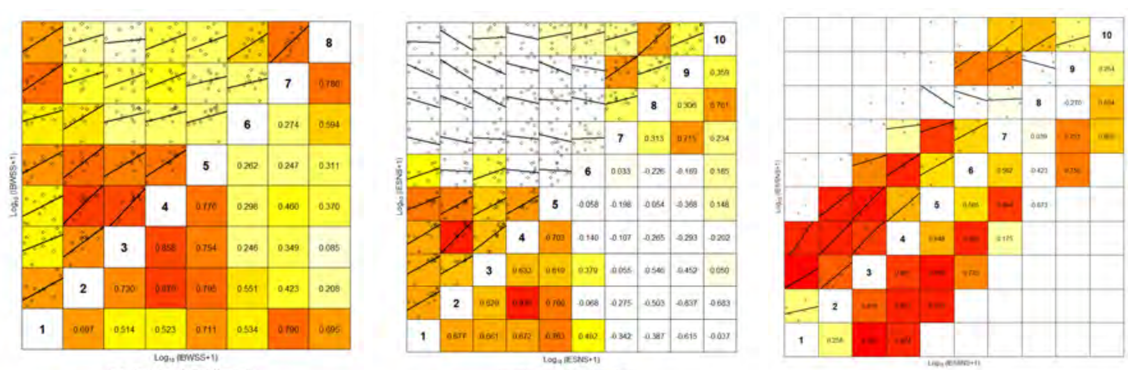


Figure 4: Internal consistency/correlation plots for IBWSS, IESNS and IESSNS. We use $\log(x+1)$ to avoid issues when x is 0. For IBWSS ages 1-8 are used, while in the alternative model 1-4+ and 1-6+ is used for IESNS and IESSNS, respectively.

Figure 5: Dataplot showing for which ages and years we use observations from the different data sources. For all except IBWSS the oldest age group is a plus group.

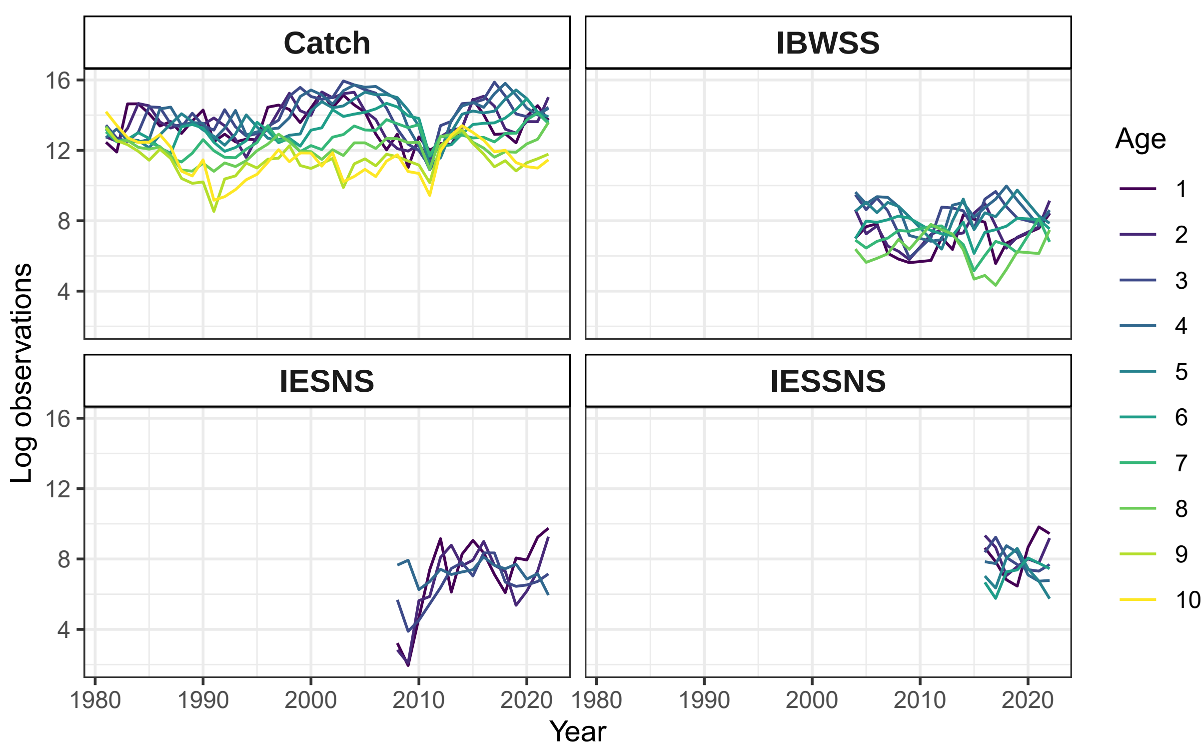


Figure 6: Time series for all data sources on log scale – one line per age group.

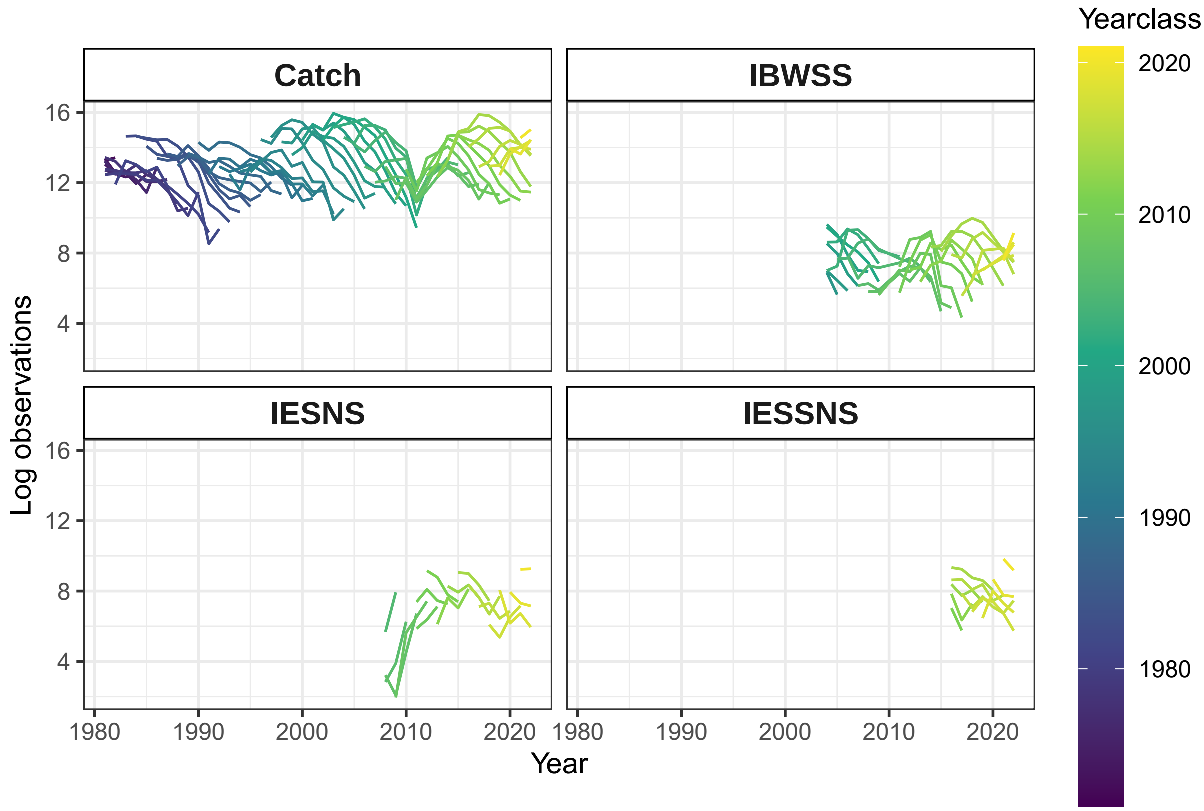


Figure 7: Time series of the different data sources on log scale – one line per year class.

Config

Here we print out the configuration file for the alternative assessment.

```
print(conf)
```

```
## $minAge
## [1] 1
##
## $maxAge
## [1] 10
##
## $maxAgePlusGroup
## [1] 1 0 1 1
##
## $keyLogFsta
##      V1 V2 V3 V4 V5 V6 V7 V8 V9 V10
## [1,]  0  1  2  3  4  5  6  7  8   8
## [2,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
## [3,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
## [4,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
##
## $corFlag
## [1] 2
##
## $keyLogFpar
##      V1 V2 V3 V4 V5 V6 V7 V8 V9 V10
## [1,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
```

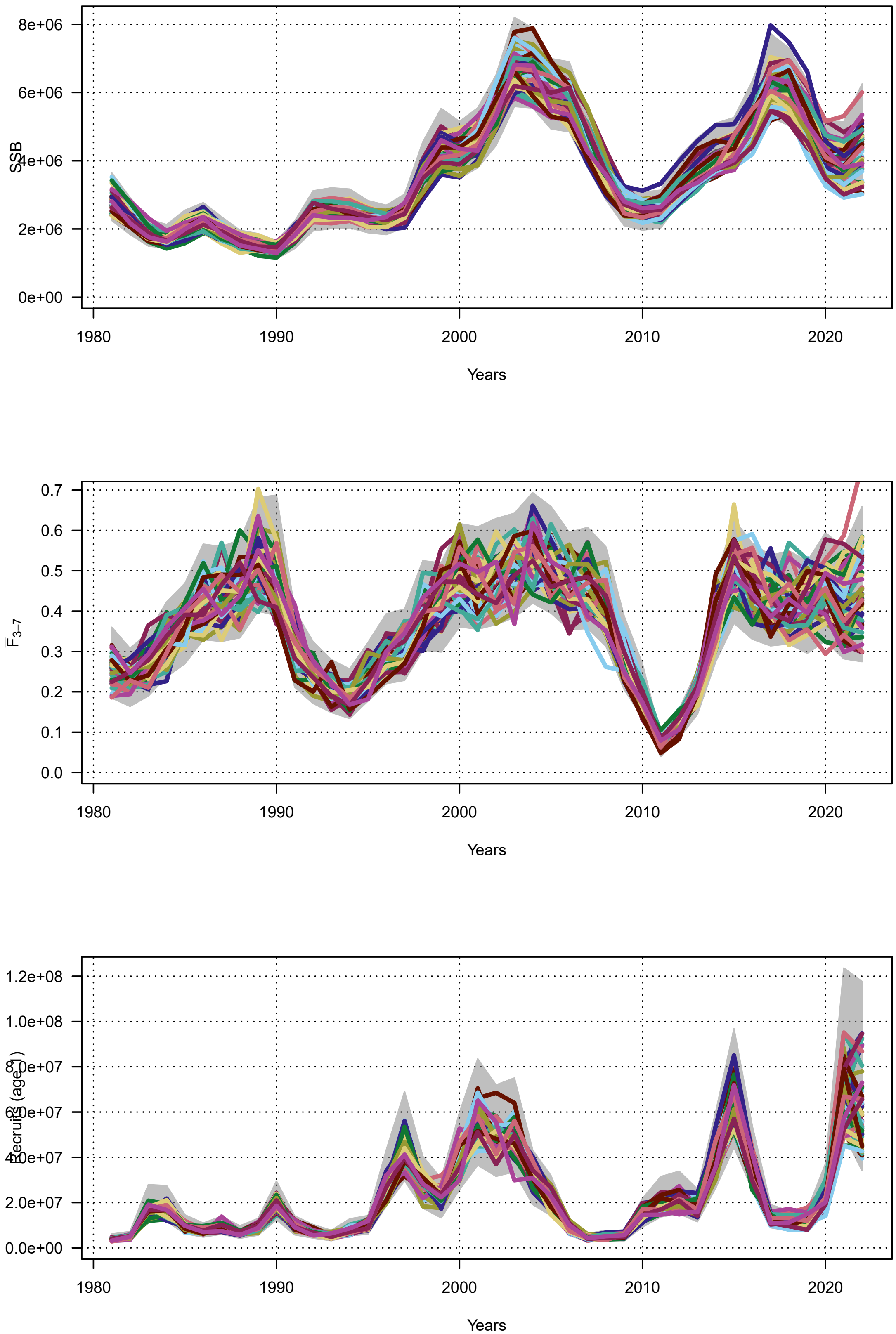


Figure 8: QQ-normality plots for model residuals by data source.

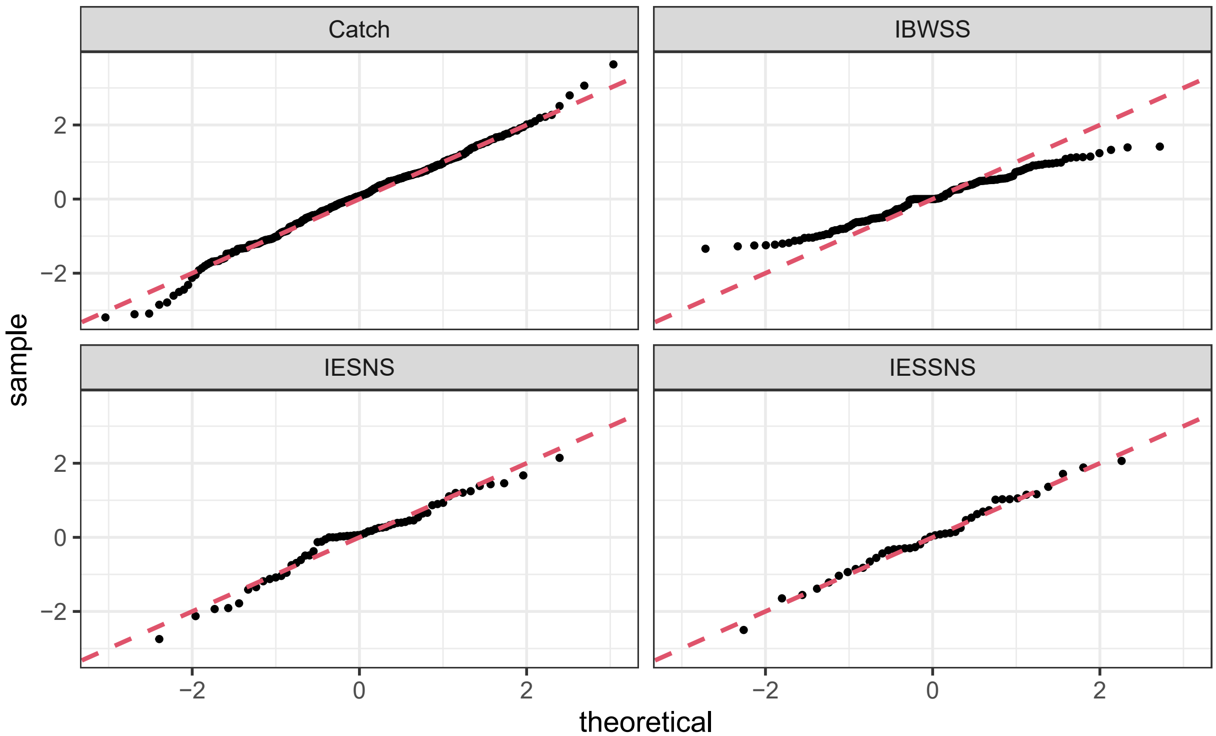


Figure 9: QQ-normality plots for model residuals by data source.

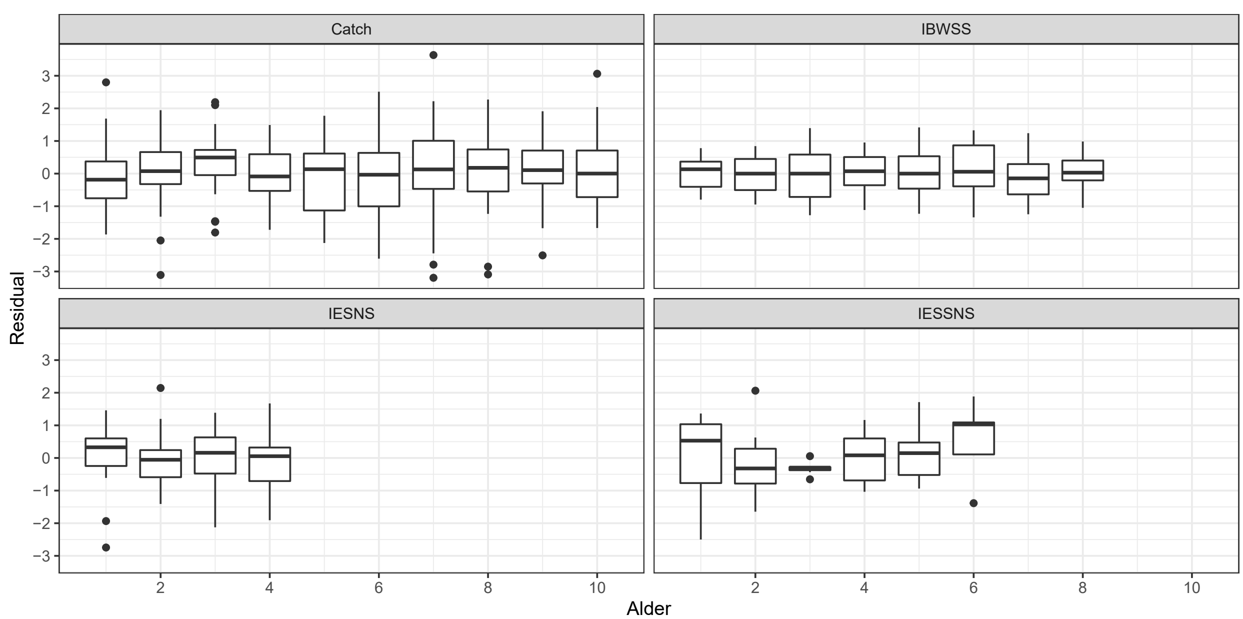


Figure 10: Boxplots of residuals by age for each fleet.

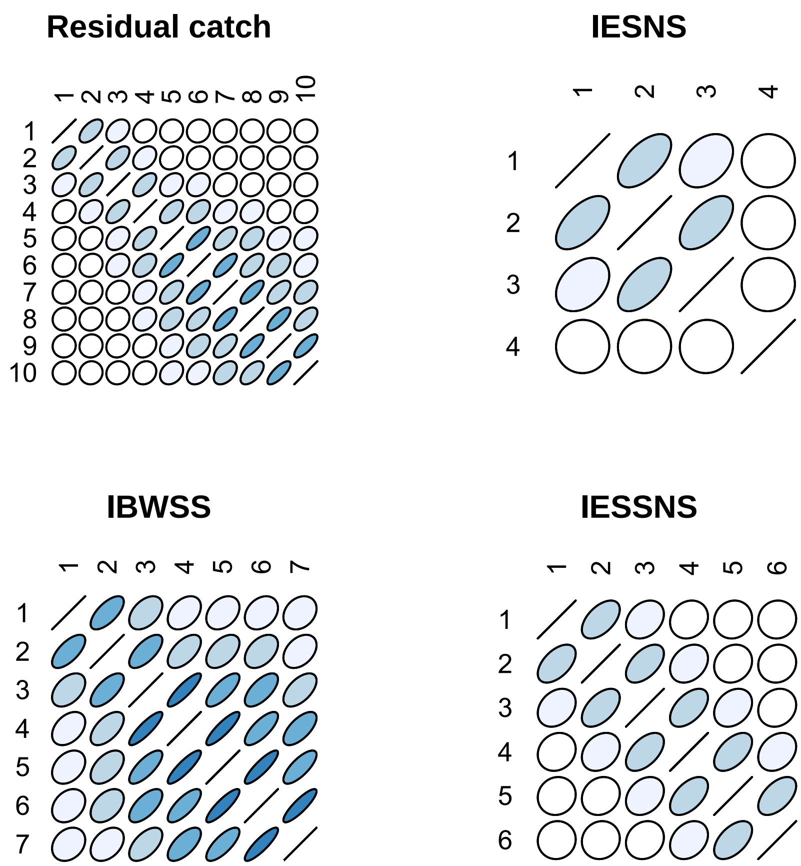


Figure 11: Correlation plot (model estimated).

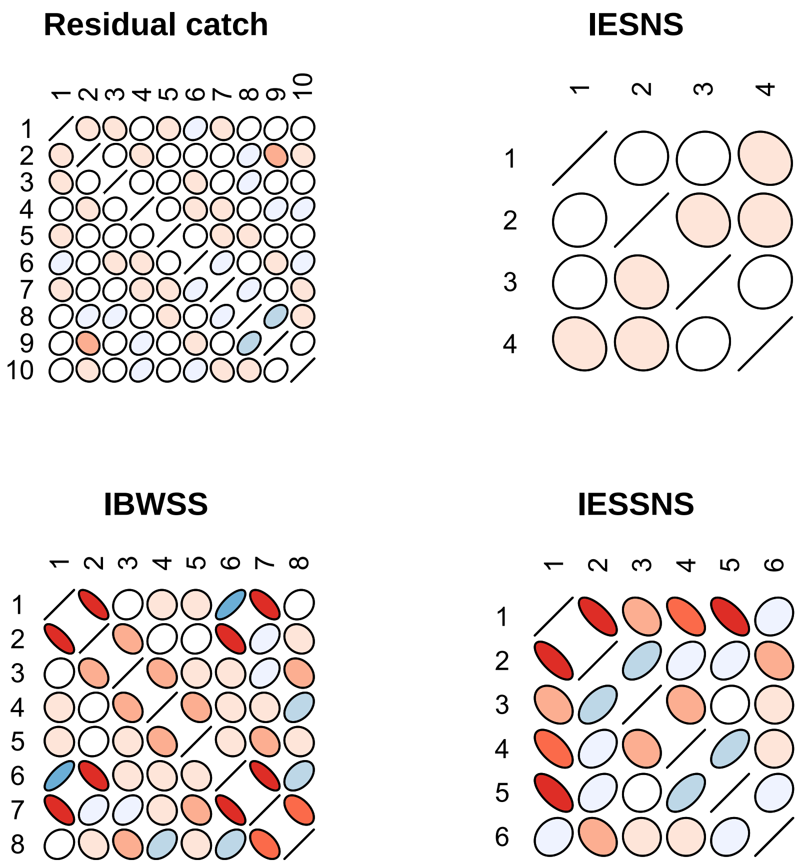


Figure 12: Empirical correlation plot.

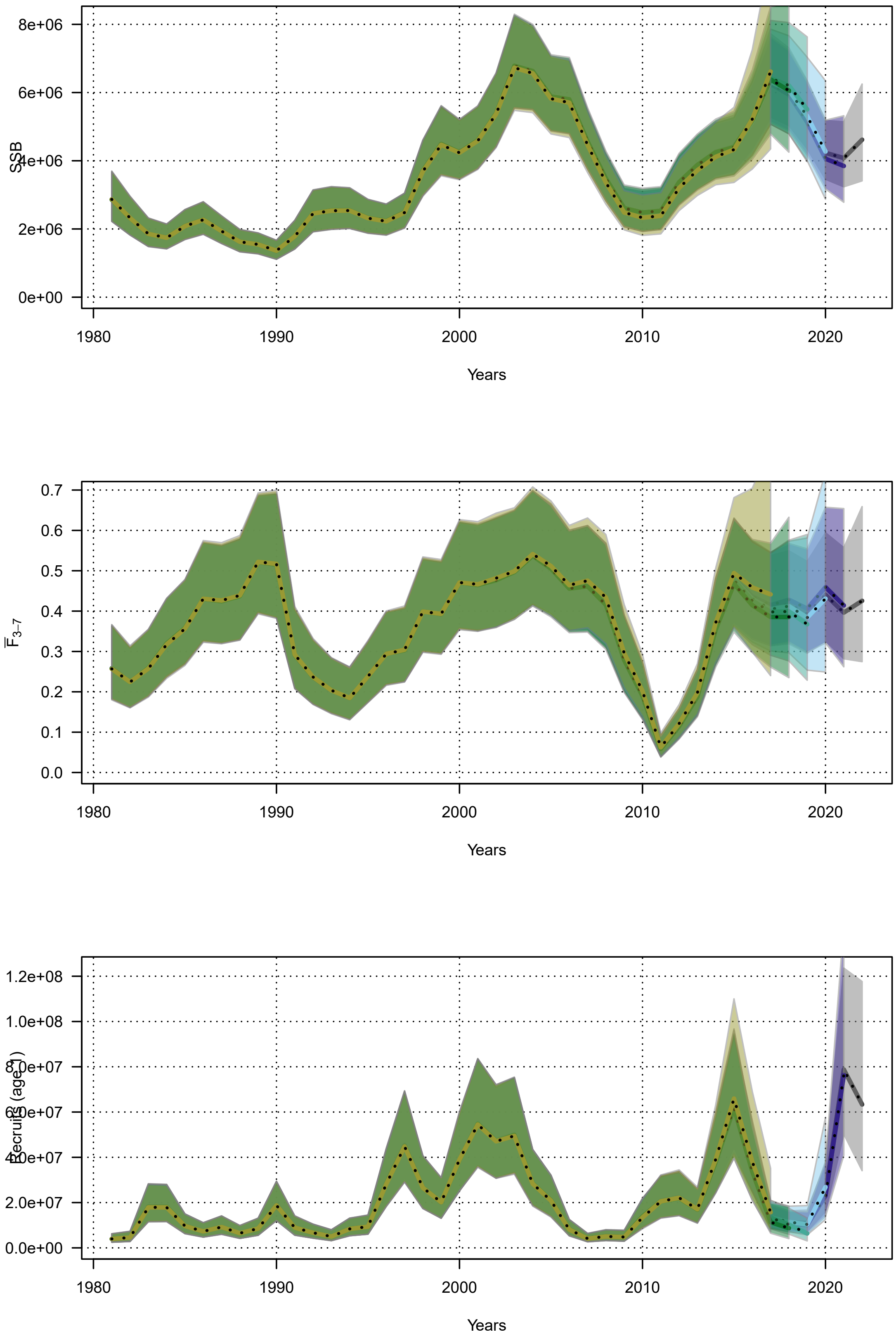


Figure 13: Retrospective plots for SSB, Fbar and Recruitment.

```
## [2,]  0  1  2  3  4  4  4  4 -1  -1
## [3,]  5  6  7  7 -1 -1 -1 -1 -1  -1
## [4,]  8  9 10 10 10 10 -1 -1 -1  -1
##
## $keyQpow
##      V1 V2 V3 V4 V5 V6 V7 V8 V9 V10
## [1,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
## [2,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
## [3,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
## [4,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
##
## $keyVarF
##      V1 V2 V3 V4 V5 V6 V7 V8 V9 V10
## [1,]  0  0  0  0  0  0  0  0  0   0
## [2,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
## [3,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
## [4,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
##
## $keyVarLogN
##  [1] 0 1 1 1 1 1 1 1 1 1
##
## $keyVarObs
##      V1 V2 V3 V4 V5 V6 V7 V8 V9 V10
## [1,]  0  1  2  2  2  2  2  2  3   3
## [2,]  4  5  6  7  7  7  8  8 -1  -1
## [3,]  9  9 10 10 -1 -1 -1 -1 -1  -1
## [4,] 11 11 11 11 11 11 -1 -1 -1  -1
##
## $obsCorStruct
## [1] AR AR AR AR
## Levels: ID AR US
##
## $keyCorObs
##      V1 V2 V3 V4 V5 V6 V7 V8 V9
## [1,]  0  0  0  0  1  1  1  1  1
## [2,]  2  2  3  3  3  3  3 -1 -1
## [3,]  4  4  5 -1 -1 -1 -1 -1 -1
## [4,]  6  6  6  6  6 -1 -1 -1 -1
##
## $stockRecruitmentModelCode
## [1] 0
##
## $noScaledYears
## [1] 0
##
## $keyScaledYears
## numeric(0)
##
## $keyParScaledYA
## <0 x 0 matrix>
##
## $fbarRange
## [1] 3 7
##
```

```
## $keyBiomassTreat
## [1] -1 -1 -1 -1
##
## $obsLikelihoodFlag
## [1] LN  ALN LN  LN
## Levels: LN ALN
##
## $fixVarToWeight
## [1] 0
##
## $fracMixF
## [1] 0
##
## $fracMixN
## [1] 0
##
## $fracMixObs
## [1] 0 0 0 0
##
## $constRecBreaks
## numeric(0)
##
## $predVarObsLink
##      V1 V2 V3 V4 V5 V6 V7 V8 V9 V10
## [1,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
## [2,] -1 -1 -1 -1 -1 -1 -1 -1 NA  NA
## [3,] -1 -1 -1 -1 NA NA NA NA NA  NA
## [4,] -1 -1 -1 -1 -1 -1 NA NA NA  NA
##
## $hockeyStickCurve
## [1] 20
##
## $stockWeightModel
## [1] 0
##
## $keyStockWeightMean
##  [1] NA NA NA NA NA NA NA NA NA NA
##
## $keyStockWeightObsVar
##  [1] NA NA NA NA NA NA NA NA NA NA
##
## $catchWeightModel
## [1] 0
##
## $keyCatchWeightMean
##  [1] NA NA NA NA NA NA NA NA NA NA
##
## $keyCatchWeightObsVar
##  [1] NA NA NA NA NA NA NA NA NA NA
##
## $matureModel
## [1] 0
##
## $keyMatureMean
```

```
##  [1] NA NA NA NA NA NA NA NA NA NA
##
## $mortalityModel
## [1] 0
##
## $keyMortalityMean
##  [1] NA NA NA NA NA NA NA NA NA NA
##
## $keyMortalityObsVar
##  [1] NA NA NA NA NA NA NA NA NA NA
##
## $keyXtraSd
##      [,1] [,2] [,3] [,4]
```

WD ICES WGWIDE 20201

The 2022 updated RFID tag-recapture data on NEA mackerel – Trends in abundance with different filtering

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Summary

A full overview and update of the RFID tagging experiments of mackerel 2011-2022, as well as the recaptures and scanned fish 2012-2021 is given. Since the benchmarking process during ICES IBPNEAMac 2019 and decisions therein, the data included in the SAM stock assessment has been filtered to only include mackerel tagged at ages 5-11, release years 2013 and later and recaptures limited to year 1 and 2 after release. The RFID data set used as input to the SAM stock assessment is a complex one with numbers released per age in a release year, and the numbers scanned and recaptured of these year classes annually in all the years after release; i.e not typical abundance indices per age per year as normally included in age-based stock assessments. Hence, the overview does not only focus on the input data themselves and quality assurance of these, but the actual trends they show for both the different year classes and biomass. Special effort in put on demonstrating trends in actual data included in assessment compared with other ways of filtering the data, such as including more age groups and more years with recaptures after release then the current assessment. Finally, the year class trends, mortality trends in the RFID data are compared with the other age-based input data from commercial catches and the international trawl survey in the Norwegian Sea (IESSNS).

Background

The Institute of Marine Research in Bergen (IMR) has conducted tagging experiments on mackerel on annual basis since 1968, both in the North Sea and to the west of Ireland during the spawning season May–June. Information from steel-tagged mackerel tagged west of Ireland and British Isles was introduced in the mackerel assessment during ICES WKPELA 2014 (ICES, 2014), and data from release years 1980-2004, and recapture years 1986-2006 has been used in the update assessments after this. The steel tag experiments continued to 2009, with recaptures to 2010, but this part of the data was at the time considered less representative and was excluded.

What is used in the SAM stock assessment is a table of data showing numbers of steel 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 steel tag data and the corresponding trends in the data in terms of index of total biomass and year class abundance by year is described in (Tenningen et al., 2011).

The steel tag methodology involved a whole lot of manual processes, demanding a lot of effort and reducing the possibility to scan larger proportions of the landings. The tags were recovered at metal detector/deflector gate systems installed at plants processing mackerel for human consumption. External personnel were hired to monitor the systems during processing. Among the typical 50 fish deflected, they had to find the tagged fish with a hand-hold detector and send the fish to IMR for further analysis. It was decided in the end to go for a change in methodology to radio-frequency identification (RFID), which would allow for more automatic processes and increased proportion of scanned landings.

RFID tag recapture methodology and data quality assurance

The RFID tagging project on NEA mackerel was initiated in 2011 by IMR, and the data were used in update assessments after the ICES WKWIDE2017 benchmark meeting (ICES, 2017b). The data format was the same as for steel tags, but the time series were treated with a different scaling parameter in the assessment.

RFID is a technology that uses radio waves to transfer data from an electronic tag, called an RFID tag, through a reader for the purpose of identifying and tracking the object. The tags used for mackerel are passive, commonly called PIT-tags, specifically developed for tagging fish and animals. They are made of biocompatible glass (specific type used for mackerel is ISO FDX-B 134,3 kHz, 3.85x23mm glass tags) which are equipped with a one-time programmable microchip with a unique ID. Information to the reader is released as it passes an electric field in the antenna system, and information is automatically updated in an IMR database over internet. When tagging and releasing the fish, information is also synced to the IMR database regularly over internet.

There is a web-based software solution (SmartSeaFish) and database that is used to track the different scanning systems at the factories, import data on catch information, and biological sampling data of released fish and screened catches. Based on this information the software is used to allocate the biological data to releases and catches, and to further estimate numbers released every year, and the concurrent numbers screened and recaptured over the next years (by year class).

The development of the tagging data time series is dependent on the work from each country's research institutes, fisheries authorities or the industry it selves to provide additional data about catches screened through the RFID systems, such as total catch weight, position of catch (ICES rectangle), mean weight in catch, etc. Regular biological sampling of the catches landed at these factories is also needed. Altogether, these data are essential for the estimation of numbers screened per year class. Responsible scientists in Norway, Iceland, Faroes and Scotland have been following up the factories, and delivering the catch data and biological data. Currently the responsibilities are as below:

Iceland: Anna Olavsdottir (HAFRO) responsible scientist

- uploading catch data and biological data to SmartSeaFish database
- allocating recaptures and biological samples to the different landings
- testing the 3 Icelandic factories for efficiency, 10 test tags in 10 different landings every year.
- initiates servicing of RFID-antenna systems if needed
-

Scotland: Steve Mackingson (Scottish Pelagic Fishermen's Association) responsible scientist

- uploading catch data to SmartSeaFish database (we still use Norwegian biological data from same period/ICES area)
- allocating recaptures to the different landings
- testing the 5 Scottish factories for efficiency, 10 test tags in 10 different landings every year/season.
- initiates servicing of RFID-antenna systems if needed
-

Norway: Aril Slotte (IMR) responsible scientist for the Norwegian RFID tagging program for mackerel and herring, main responsible for final estimations needed to procuce the data table delivered to ICES WGWIDE

- uploading catch data and biological data to SmartSeaFish database
- allocating recaptures and biological samples to the different landings (including biological data to Scottish landings)
- Norway now has 15 factories with RFID antenna systems for scanning mackerel and herring. All factories are serviced 1 time per year and when there are apparent issues to be solved

A new monitoring system has been developed (Figure 1), which is now placed at all 15 Norwegian factories and the 3 Icelandic factories. This monitoring system is continuously overviewing that RFID antennas and readers are functioning. Voltage variations are measured and every 15 min the reading capabilities are tested automatically with a status tag, and these tests are also stored in the SmartFish database for further analyses of efficiency. This monitoring system has replaced the manual testing with 10 test tags in 10 different landings every year/season. The plan is that same systems are placed out at the Scottish factories, or any new factories installing the system.

Based on results from the online monitoring system in addition to the manual test off recapture efficiencies or the online monitoring, responsible scientists decides if data from a factory have to be excluded from final estimation and data input to ICES WGWIDE assessment. Factories that do not function properly are put in an 'out of order' list (Figure 2), where catch data and recapture data from these 'out of order' periods are excluded during estimation.

To conclude regarding quality assurance, we have made progress and the current monitoring of efficiencies at factories that has been raised as a main issue is now at an acceptable level. Still, there is need for more quality control of both all raw tag-recapture data, biological data and allocations of these to landings, as well as the final estimations of data included in the ICES WGWIDE stock assessment. In the future we potentially need to develop annual sworkshops prior to the assessment, where more scientists go through the new data being updated from new tagging experiments, as well as recaptures from all previous experiments, undertake quality assurance of the data and other analyses of the trends in the data outside of the assessment model. The idea is that this should work similarly as post-cruise meetings where all involved scientists take part in final report.

Status of updated RFID tag recapture data

The RFID tagging technology is clearly a more cost-effective than the old steel tag technology. We are now scanning about 10 times more biomass than during the period with steel tags. An overview of the RFID tagging data in terms of numbers tagged, biomass scanned, and numbers recaptured is given in Tables 1-3, and geographical distributions of data in Figures 3-6.

During the period 2011— 2022 as many as 556953 mackerel have been tagged with RFID (Table 1). This includes an experiment off the Norwegian Coast on young mackerel in September 2011 as well as five experiments carried out in August in Iceland 2015-2019, none of which are included as input data in the assessment. Data from the releases at the spawning grounds in May-June of Ireland and the Hebrides are the only data included in the assessment.

By 26. August 2022 as many as 10124 RFID-tagged mackerel have been recaptured from all experiments. Looking only recaptures 2012-2021 full years and the experiments of Ireland and British Isles used in update asssessments, 8488 mackerel has been recaptured at landings scanned at 25 European factories processing mackerel for human consumption (Tables 2- 3). The project started with RFID antenna reader systems connected to conveyor belt systems at 8 Norwegian factories in 2012. Now there are 5 operational systems at 4 factories in UK (Denholm has 2 RFID systems) and 3 in Iceland. Norway has installed RFID systems at 8 more factories in 2017-2018, most of which with the purpose of scanning Norwegian spring spawning herring catches (IMR started tagging herring in 2016), but some also processing mackerel. Recently one factory, Pelagia Austevoll is terminated, so currently 15 factories are scanning for RFID tags in Norway. More systems are also bought by Ireland (3), which up to now has been non-operational.

During ICES WGWIDE 2018 (ICES, 2018d) meeting bias issues were described for RFID tag data, in addition to potential weighting issues of the tag data inside the model. After the intermediate benchmark meeting ICES IBPNEAMac 2019 (ICES, 2019a), these issues were overcome by using a subset of data for release years (exclude 2011-2012), recapture years (only use recaptures from year 1 and 2 after release) and age groups (exclude youngest fish ages 2-4, use ages 5-11). This is now the subset of data to be used in update assessments.

The exclusion of release years 2011-2012, and recapture years 2012-2013 is mainly based in lack of distributional coverage of scanned fishery, which changed significantly when more countries joined the program and scanned landings from 2014 onwards (Figures 4-5).

The exclusion of recaptures in year 3 or longer after the release year was because data indicated tag loss over time, and that the large majority was recaptured prior to year 3 after release. In year recaptures are not used. However, following recaptures from in year (years out=0) and further through year 1-3+ after tagging, it is apparent that tagged fish are quite quickly distributed in the fishery, and the distributional patterns of recaptures are maintained over time (Figure 6). Hence, potentially more recapture years could be included it one overcame how to adjust for potential tag loss.

The exclusion of ages 1-4, was mainly based in noisy data from these age groups, and the fact that in the early tagging years fish in these age groups were relatively few compared with the scanned fish year 1 and 2 after release. The few fish from these ages were not considered representative for the behaviour of the year classes. However, over time this picture has changed considerable. The age structure of tagged and scanned fish year 1-2 after release are now overlapping, and high proportions of tagged mackerel are now at ages 2-4 (Figure 7). This means that given current filtering we will exclude large proportions of the RFID tag recapture data in coming years, so this is a decision that will have to be revised. Hence, in the following focus is on the actual trends and consistency in the RFID tag data, having in mind that the current filtering may have to be revised in near future.

Status of RFID tag recapture data trends and consistency for use in stock assessment

Estimates of year class abundance for unfiltered RFID tag-recapture data show trends over time that seems informative for stock assessment (Figure 8), and this is also supported by the tests of consistency in the data (Figure 9), implying a potential for including younger age groups in future assessments.

However, the information coming from the RFID tag data is easier to interpret when comparing age aggregated biomass indices estimated from the RFID data (based on year 1-2 with scanning and recaptures) with SSB from the stock assessment, as shown in Figure 10. The decision to exclude release years 2011-2012 is supported by this plot, showing noisy estimates above the confidence intervals of the assessment. However, by including only release years 2013 onwards as in current assessments, the biomass trend in the RFID tag data is more in line with the SSB of the assessment, especially the decrease in SSB from 2017-2020 is also very evident regardless of ages aggregated from RFID data. This again signifies that over time, and in a future benchmark process, information of tag recaptures from younger age groups may be included again if trends are informative for the assessment.

In recent years we have seen a trend that the information from RFID tag recapture data about abundance in a release year increase when adding one more year with recaptures and scanned data. Figures 11-12 illustrates this issue for single year classes as well as various age aggregated abundance estimates. This supports the decision to stick to only using recapture and scanned data for year 1 and 2 after release. Moreover, it also implies the last year included in the stock assessment always based on s will be revised in next update assessment, with a recent clear tendency that adding the second year with data lifts the perception of abundance in a release year.

One more way of looking at the information from RFID tag recapture data relative to the other sources of input data and the stock assessment itself, is to compare signals of total mortality rate (Z) by estimating slope of decrease in abundance of year classes 2003-2014 of fully mature fish aged 4-12

(Figure 13). Here it is apparent that mortality signals from RFID data seem informative following a steady decrease as the catch data, whereas IESSNS data sticks out as a bit noisier trend. When looking at the estimated Z for each data source, it is evident that the RFID data show signals of higher mortality rate than the catch data, whereas Z estimates for the IESSNS data are even lower. Z estimates from the WGWIDE2022 assessment are also above the catch data, but below the tag estimates, signifying that the model put some weight on the tag data. Note that RFID data shows more uncertain estimates of Z for recent year classes with very few years, fewer than the other sources, which means the estimates may change over time.

The overall conclusion is still that the RFID data seems quite informative, and that the current filtering and exclusion of data for use in stock assessment should be revised in near future. Only looking at the relative year class structure in the tag estimates 2019-2020 compared with the structure seen in catch data, IESSNS, and WGWIDE2022 assessment (Figure 14), we see very similar structure. In addition, here it is evident that the RFID-estimates also how large new year classes such as 2016, which is not used yet in assessment because of the exclusion of young fish. Also noticeable is that yearclasses such as 2012-2013 are relatively smaller in the RFID-estimates than in the IESSNS and catch data, which likely may be due to age reading issues. The tag estimates are based on fewer readers.

Finally, on a totally different issue. Do mackerel growing up in the North Sea belong to a specific component? Figure 15 demonstrates that recaptures from very young fish tagged in the North Sea at the western Norwegian coast (Bømlo Island) over the year adapted the same migration pattern as the fish tagged at older ages along Ireland-Hebrides. This supports the hypothesis that mackerel growing up in the North Sea do not belong to a North Sea component, but to a large dynamic mackerel population changing migration pattern and spawning areas as the stock fluctuates in abundance and age structure.

Link to official publication of all raw data needed to produce input data set to the assessment is: Aril Slotte (IMR), Anna Ólafsdóttir (MFRI), Sigurður Þór Jónsson (MFRI), Jan Arge Jacobsen (FAMRI) and Steve Mackinson (SPFA) (2021) PIT-tag time series for studying migrations and use in stock assessment of North East Atlantic mackerel (Scomber Scombrus) http://metadata.nmdc.no/metadata-api/landingpage/f9e8b1cff4261cf6575e70e56c4c3b3e This is the correct citation when using the data. The data are available through this link as various APIs that are updated daily. There is also an R-package https://github.com/IMRpelagic/taggart can be used to download data from the APIs.

Tables

Table 1. Overview of numbers released in the different RFID tagging experiments, and numbers recaptured per year. Recaptures from experiments and recapture years used in 2022 stock assessment, based on decisions in the ICES IBPNEAMac 2019 (ICES 2019) are outlined and marked grey. However, note that these numbers also include recaptures from some factories excluded in the final estimation of tag table used in the stock assessment 2022 (see Tables 2-3), due to low efficiency or misfunctions. Note that recaptures in 2022 are preliminary by 26. August.

Survey	N-Released	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	All years
Iceland 2015	806	0	0	0	6	2	3	0	0	0	0	0	11
Iceland 2016	4884	0	0	0	0	59	48	28	19	13	10	0	177
Iceland 2017	3890	0	0	0	0	0	28	27	9	13	4	5	86
Iceland 2018	1872	0	0	0	0	0	0	5	16	13	8	3	45
Iceland 2019	3614	0	0	0	0	0	0	0	5	25	12	3	45
Norway2011	31253	9	31	24	32	26	16	20	7	13	6	2	186
Ireland-Hebrides 2011	18645	27	24	29	24	17	5	9	7	3	2	0	147
Ireland-Hebrides 2012	32135	31	57	60	64	34	21	12	5	6	5	4	299
Ireland-Hebrides 2013	22792	0	26	89	104	61	30	21	10	8	5	1	355
Ireland-Hebrides 2014	55184	0	0	112	311	277	139	91	44	45	29	3	1051
Ireland-Hebrides 2015	43905	0	0	0	115	217	177	93	49	41	20	9	721
Ireland-Hebrides 2016	43956	0	0	0	0	124	324	183	121	92	48	12	904
Ireland-Hebrides 2017	56073	0	0	0	0	0	134	344	174	146	80	21	899
Ireland-Hebrides 2018	38136	0	0	0	0	0	0	204	248	229	132	37	850
Ireland-Hebrides 2019	51179	0	0	0	0	0	0	0	290	541	435	123	1389
Ireland-Hebrides 2020	48968	0	0	0	0	0	0	0	0	517	811	207	1535
Ireland-Hebrides 2021	49173	0	0	0	0	0	0	0	0	0	755	269	1024
Ireland-Hebrides 2022	50488	0	0	0	0	0	0	0	0	0	0	400	400
All surveys	556953	67	138	314	656	817	925	1037	1004	1705	2362	1099	10124
All Ireland-Hebrides	510634	58	107	290	618	730	830	957	948	1628	2322	1086	9574

Table 2. Overview of numbers of tonnes scanned for RFID tags per factory per year. Data from years used in 2022 stock assessment (2014 and onwards), based on decisions in the ICES IBPNEAMac 2019 (ICES 2019), are outlined and marked grey. Based on an evaluation of efficiency of the scanners, data from some factories are excluded as they were not functioning or having poor data quality, and these are not marked grey.

Factory	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	All years
FO01 Vardin Pelagic	0	0	10460	11565	7895	4844	0	0			34763
GB01 Denholm Coldstore	0	0	0	4377	4710	5365	7806	5191	8809	8957	45215
GB01 Denholm Factory	0	0	14939	17509	18840	17913	13609	12018	13951	6284	115064
GB02 Lunar Freezing Peterhead	0	0	22586	17830	16473	9745	9857	14300	24382	24751	139924
GB03 Lunar Freezing Fraserburgh	0	0	0	8797	14282	12684	9452	5729			50943
GB04 Pelagia Shetland	0	0	21436	41117	40200	26935	25350	15128	22573	18312	211051
GB05 Northbay Pelagic	0	0	0	0	0	0	15353	12667	15478	19377	62875
IC01 Vopnafjord	0	0	18577	18772	21716	22935	18869	18547	21191	15729	156336
IC02 Neskaupstad	0	0	0	6288	21887	19558	16757	26633	28180	32216	151519
IC03 Höfn	0	0	0	0	0	0	0	10592	13488	10087	34167
NO01 Pelagia Egersund Seafood	20930	21442	36724	14375	15905	0	48373	25404	51013	37196	271361
NO02 Skude Fryseri	7546	8250	16719	14172	8671	16760	3108	1285	17661	18611	112783
NO03 Pelagia Austevoll	6405	6134	10314	4203	2216	0	7293	3533	8351		48449
NO04 Pelagia Florø	9986	12838	17379	12592	7749	0	0	0			60544
NO05 Pelagia Måløy	13344	14632	13942	21051	15762	22405	13341	8591	21287	22724	167079
NO06 Pelagia Selje	17731	26878	39525	41209	29897	35416	28972	32047	31678	34835	318189
NO07 Pelagia Liavågen	9442	10968	22395	18144	13911	19989	12398	11888	17487	21515	158138
NO08 Brødrene Sperre	14425	15048	20182	34307	36736	18814	34280	8515	32333	28283	242924
NO09 Lofoten Viking	0	0	0	0	0	0	3380	2457	3823	17924	27584
NO10 Pelagia Træna	0	0	0	0	0	0	0	0		10509	10509
NO11 Nergård Sild	0	0	0	0	0	0	0	0	2	2524	2527
NO12 Pelagia Lødingen	0	0	0	0	0	0	0	0	950	4883	5833
NO13 Pelagia Tromsø	0	0	0	0	0	0	0	0	0	180	180
NO14 Nils Sperre	0	0	0	0	0	0	28304	26272	30265	33901	118742
NO15 Grøntvedt Pelagic	0	0	0	0	0	0	6411	0	0	6778	13190
NO16 Vikomar	0	0	0	0	0	0	12512	6480	15679	16915	51585
All factories	99808	116190	265178	286310	276850	233363	315426	247277	378582	392491	2611475

Table 3. Overview of numbers of RFID tagged mackerel recaptured per factory per year. Only recaptures from Ireland surveys (Table 1) that are used as basis stock assessment are shown. Recaptures from years used in 2022 stock assessment from 2014 and onwards, based on decisions in the ICES IBPNEAMac 2019 (ICES 2019), are outlined and marked grey. Based on an evaluation of efficiency of the scanners, data from some factories are excluded as they were not functioning or having poor data quality, and these are not marked grey. See Table 2 for biomass scanned.

Factory	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	All years
FO01 Vardin Pelagic	0	0	13	35	20	11	0	0	0	0	79
GB01 Denholm Coldstore	0	0	0	10	10	24	36	19	46	61	206
GB01 Denholm Factory	0	0	25	62	77	113	54	53	92	64	540
GB02 Lunar Freezing Peterhead	0	0	32	49	60	38	41	54	123	137	534
GB03 Lunar Freezing Fraserburgh	0	0	0	9	14	7	25	34	0	0	89
GB04 Pelagia Shetland	0	0	21	124	148	137	98	82	134	134	878
GB05 Northbay Pelagic	0	0	0	0	0	0	57	59	81	136	333
IC01 Vopnafjord	0	0	22	55	65	59	62	54	146	180	643
IC02 Neskaupstad	0	0	0	19	65	54	35	114	127	284	698
IC03 Höfn	0	0	0	0	0	0	0	44	65	117	226
NO01 Pelagia Egersund Seafood	10	22	18	7	1	0	137	80	184	184	643
NO02 Skude Fryseri	5	6	21	17	25	51	13	3	34	88	263
NO03 Pelagia Austevoll	1	1	7	4	0	0	28	17	48	0	106
NO04 Pelagia Florø	5	12	27	21	16	0	0	0	0	0	81
NO05 Pelagia Måløy	5	13	18	43	37	77	36	28	97	121	475
NO06 Pelagia Selje	15	27	37	76	59	85	87	153	172	257	968
NO07 Pelagia Liavågen	10	11	29	31	26	97	48	51	111	138	552
NO08 Brødrene Sperre	7	15	20	56	107	77	52	12	0	99	445
NO09 Lofoten Viking	0	0	0	0	0	0	10	3	5	66	84
NO10 Pelagia Træna	0	0	0	0	0	0	0	0	0	67	67
NO11 Nergård Sild Senjahopen	0	0	0	0	0	0	0	0	0	10	10
NO12 Pelagia Lødingen	0	0	0	0	0	0	0	0	1	16	17
NO14 Nils Sperre	0	0	0	0	0	0	109	68	73	80	330
NO15 Grøntvedt Pelagic	0	0	0	0	0	0	11	0	0	18	29
NO16 Vikomar	0	0	0	0	0	0	18	20	89	65	192
All factories	58	107	290	618	730	830	957	948	1628	2322	8488

Figures

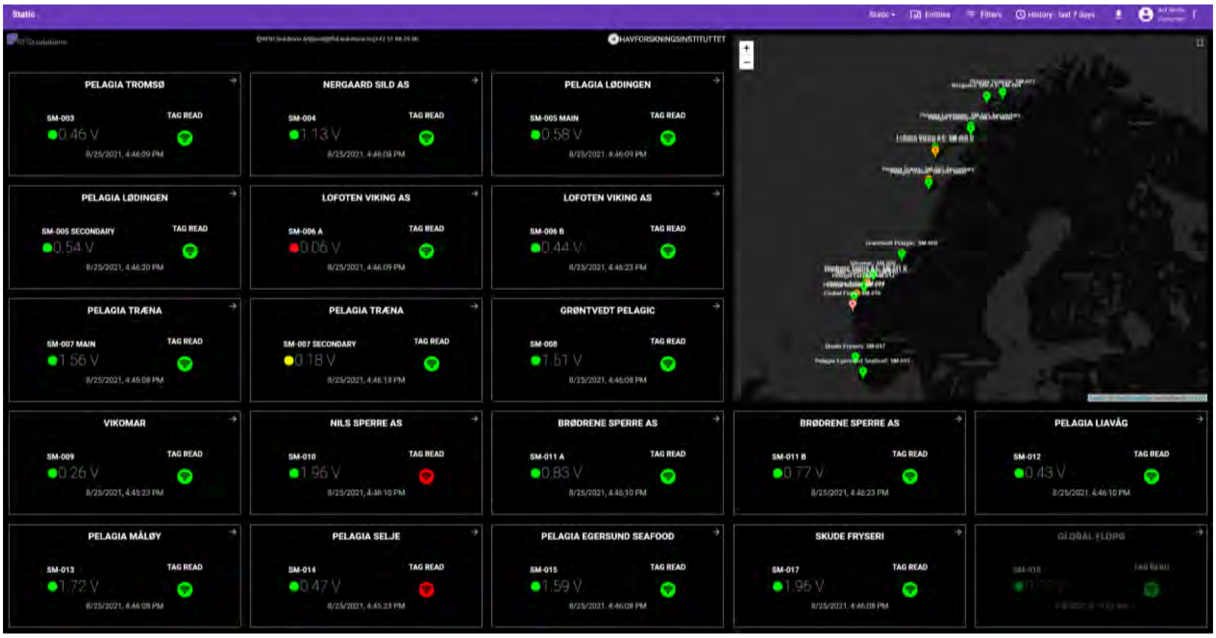

Figure 1. Example of how the new monitoring systems looks like. It follows the traffic light systems, where red implies that we currently may have issues with either voltage variations or reduced efficiency of RFID tags.

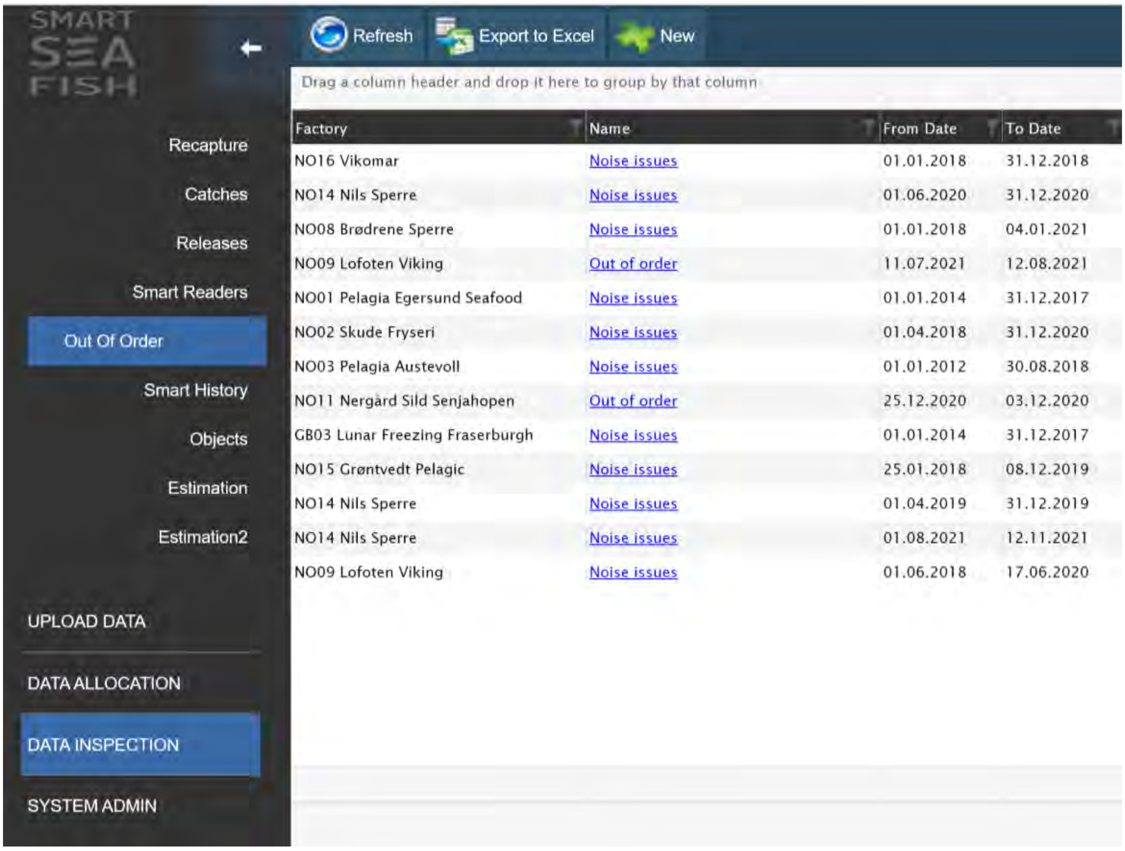

Figure 2. Example of how it looks like in the SmartSeaFish web-based software where factories having issues with recapture efficiency are put in an 'Out of order' list. Catch data and recapture data from these factories and periods are excluded in final estimation of data table being included in the ICES WGWIDE stock assessment.

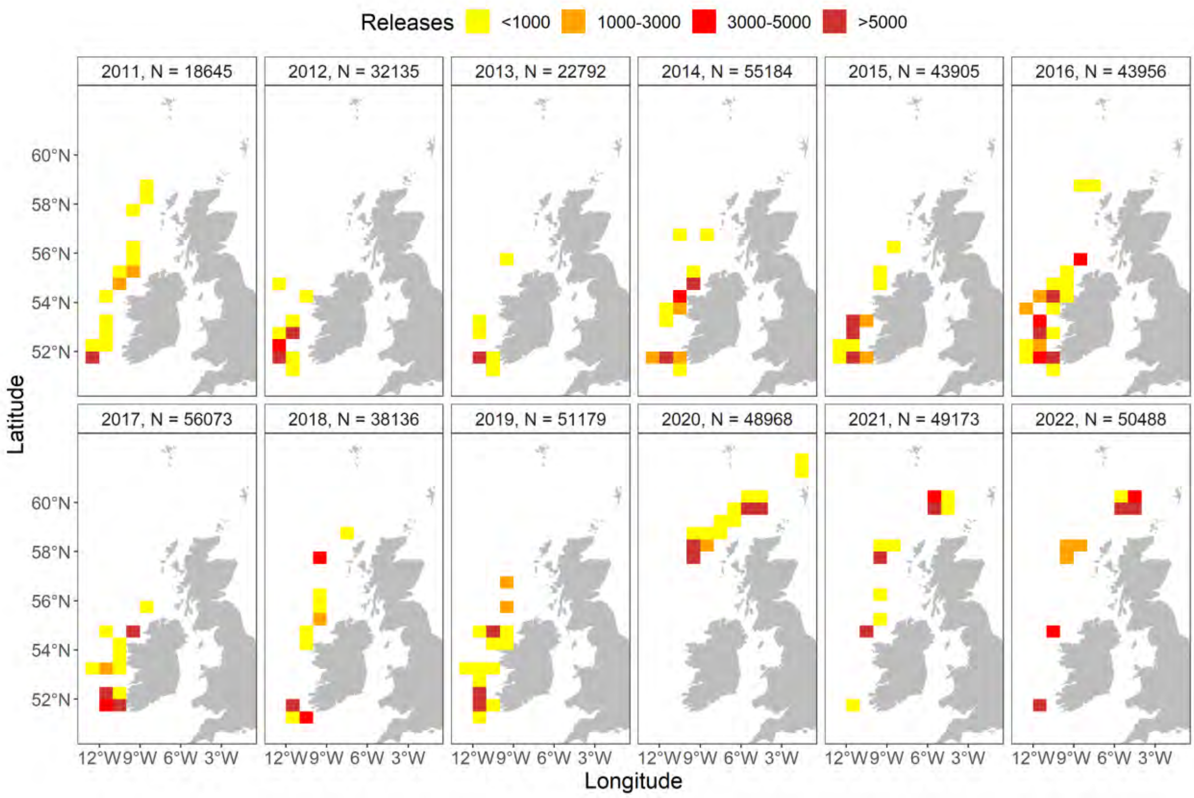

Figure 3. Distribution of RFID tagged mackerel from experiments west of Ireland-Hebrides during 2011-2022. Number of released fish is summed per ICES rectangle. See Table 1 for details on numbers released. Note that data from releases 2011-2012 are not used in the stock assessment, based on decisions in the ICES IBPNEAMac 2019 meeting (ICES 2019), and data from experiments in 2021-2022 are not included as there are no full years with recaptures yet.

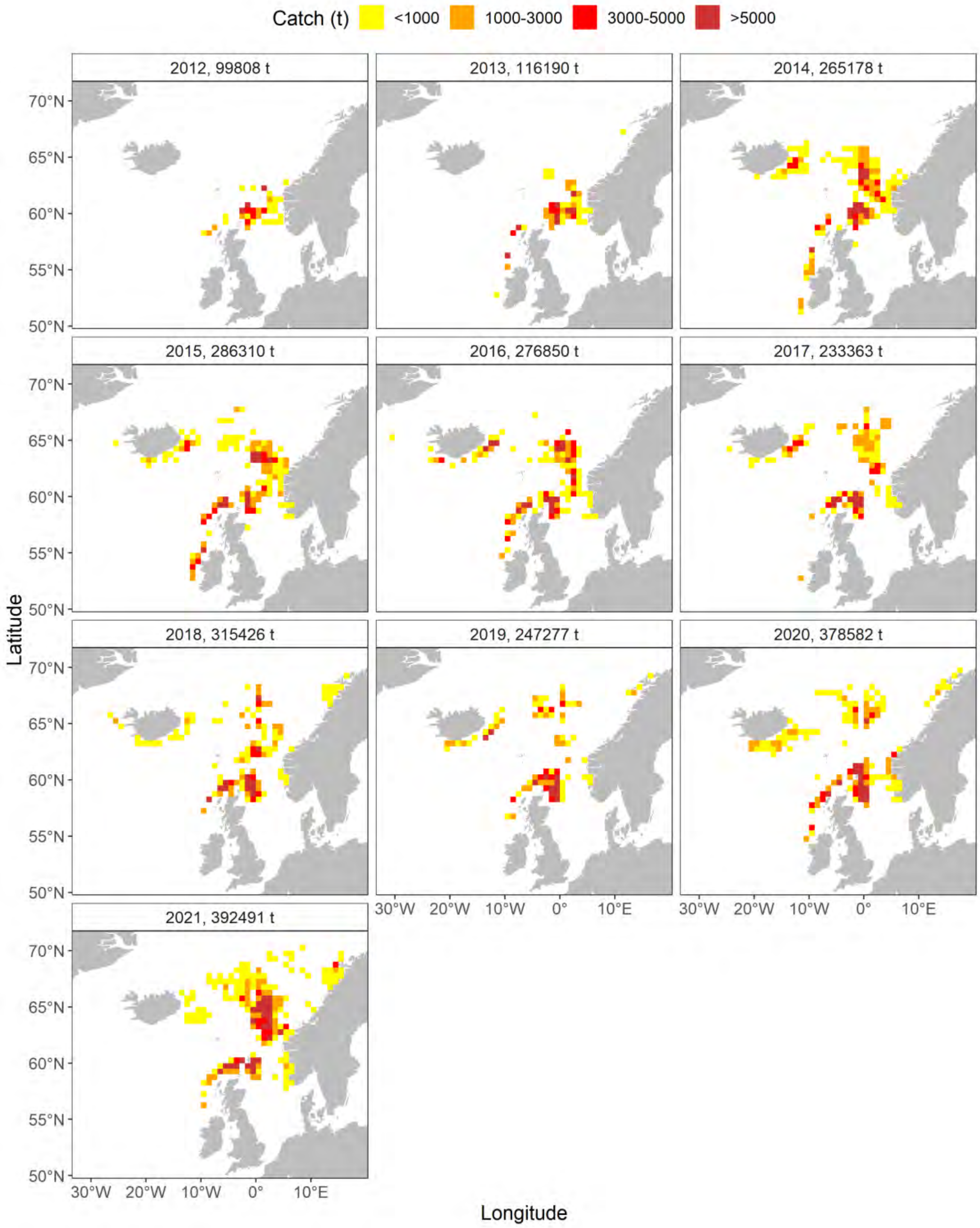

Figure 4. Distribution (summed per ICES rectangle) of catches scanned for RFID tagged mackerel during 2012-2021. Note that data on scanned catches in 2012-2013 are not used in the stock assessment based on decisions in the ICES IBPNEAMac 2019 meeting (ICES 2019). Detailed data on scanned biomass per factory and year are given in Table 2.

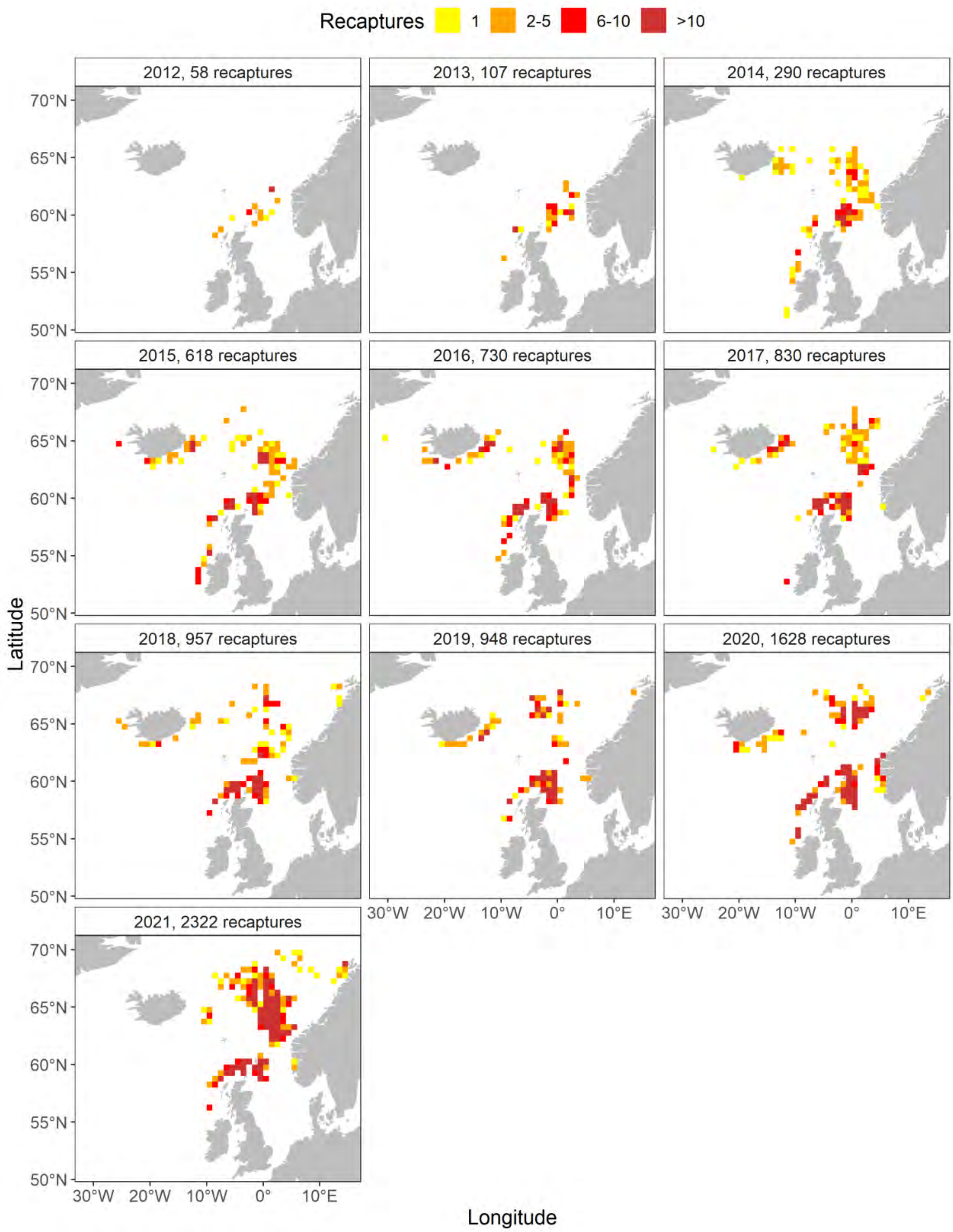

Figure 5. Distribution (summed per ICES rectangle) of recaptures of RFID tagged mackerel during 2012-2021. Note that data on recaptures in 2012-2013 are not used in the stock assessment based on decisions in the ICES IBPNEAMac 2019 meeting (ICES 2019). Detailed data on recaptures per factory and year are given in Table 3.

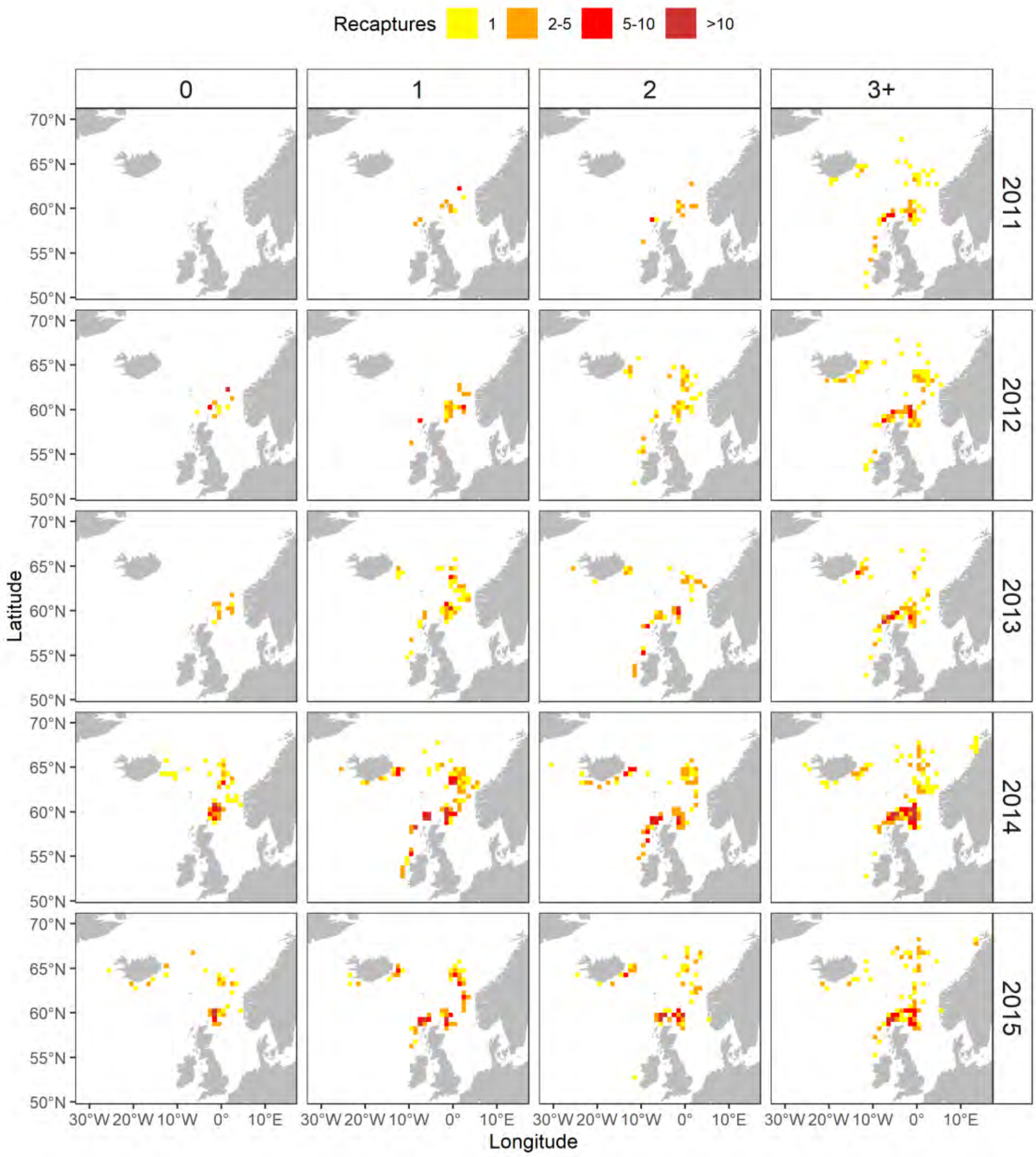

Figure 6. Distribution (summed per ICES rectangle) of recaptures of RFID tagged mackerel related to release years 2011-2015 and years after release (0=same year as tagging, 1= year after tagging etc.). Note that data on recaptures from 2011-2012 release years and from year 0 and 3+ after tagging are not used in the stock assessment based on decisions in the ICES IBPNEAMac 2019 meeting (ICES 2019). Note also tha t in 2011 scanning had not started (Figure 4), so no in year recaptures.

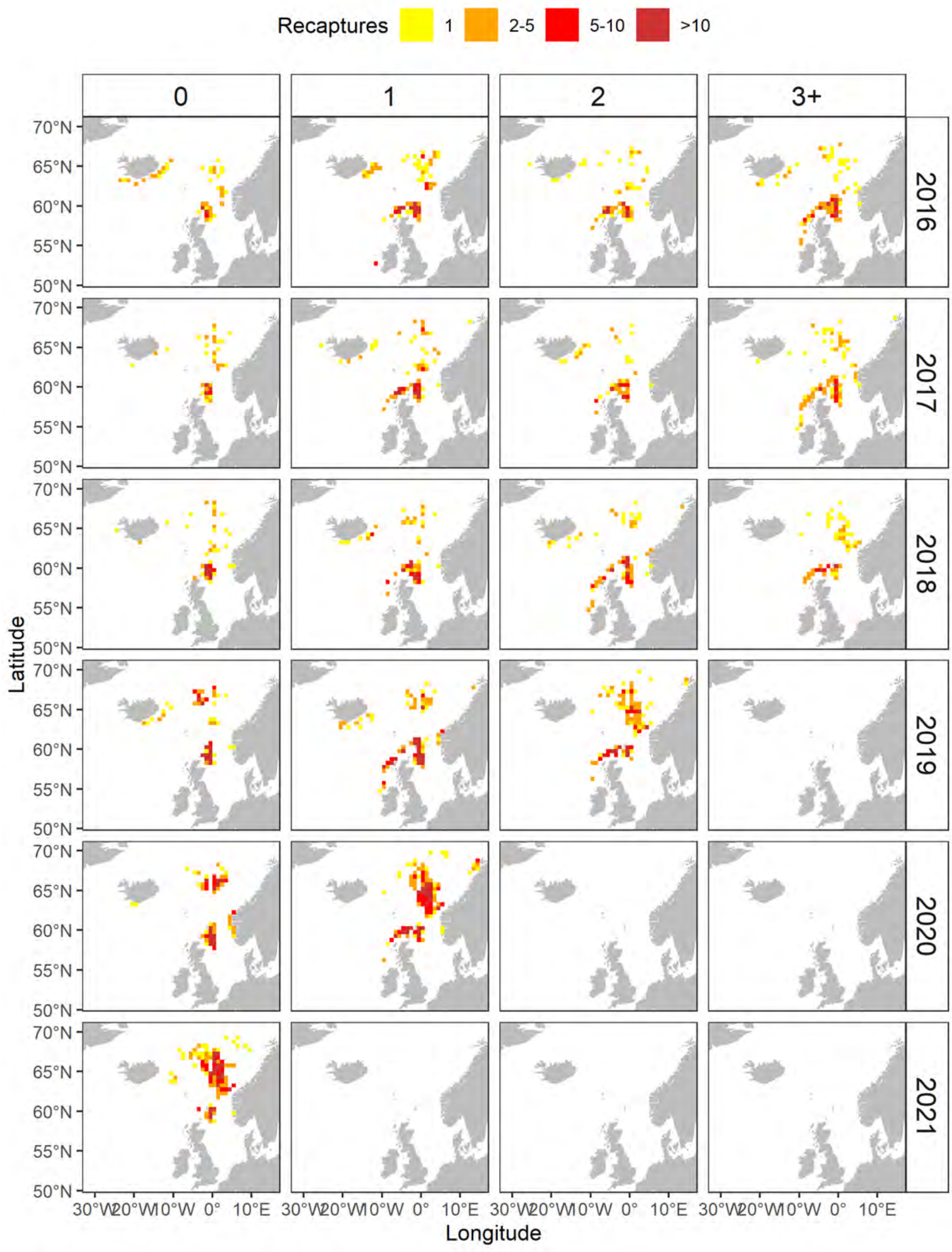

Figure 6 continued for release years 2016-2021. Preliminary recaptures in 2022 are not included as allocations to catches are not completed.

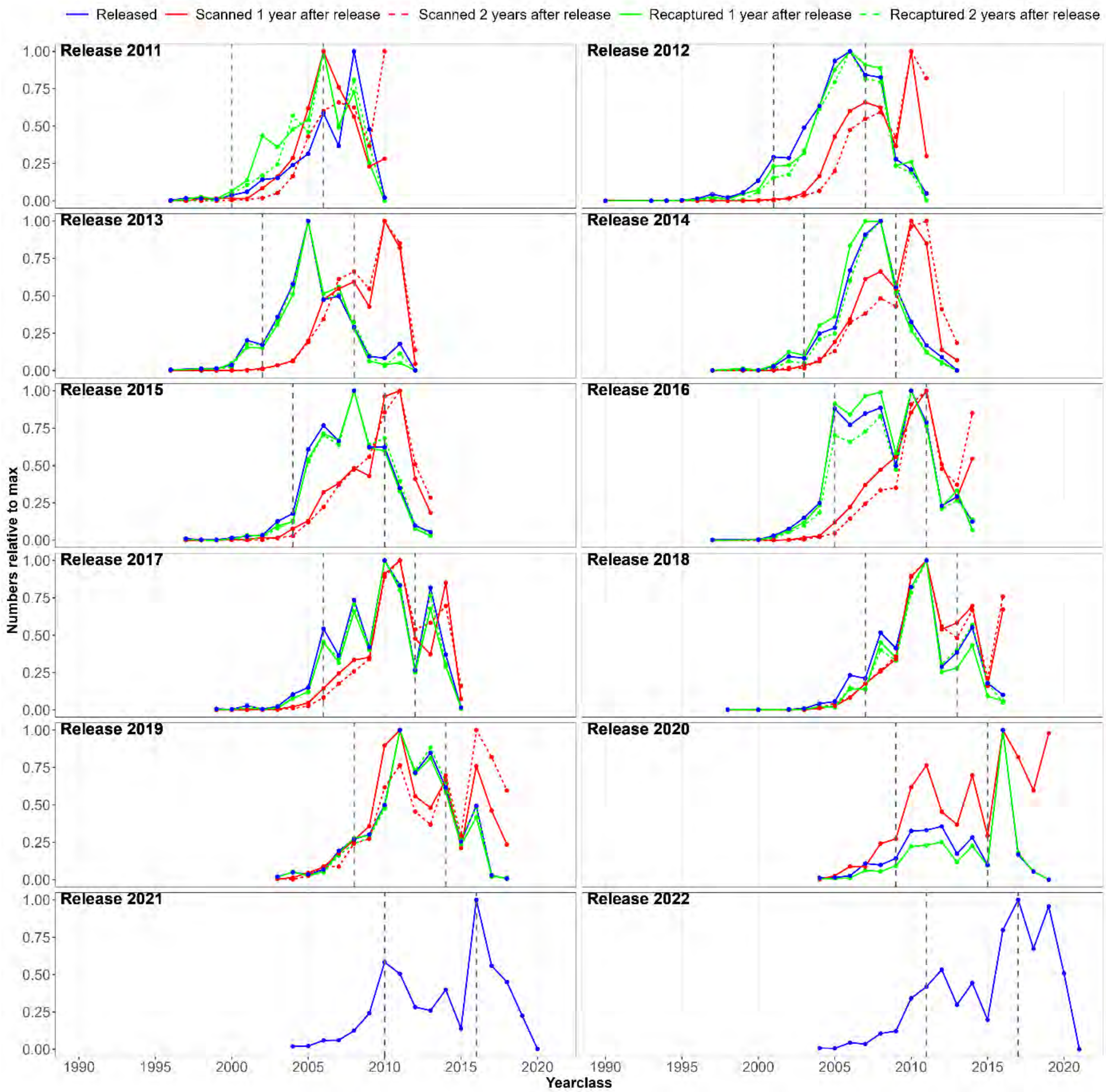

Figure 7. Overview of the relative year class distribution among RFID tagged mackerel per release year from experiments west of Ireland-Hebrides in May-June, compared with the number scanned and recaptured in year 1 and 2 after release of the same year classes. See Figure 3 for distribution of the tagged fish and the respective distribution of recaptures in year 1 and 2 after release in Figures 4-5. 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 2019). 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. Details on actual numbers released and recaptured are given in Table 1 and 3, also for other tagging experiments not included in the stock assessment.

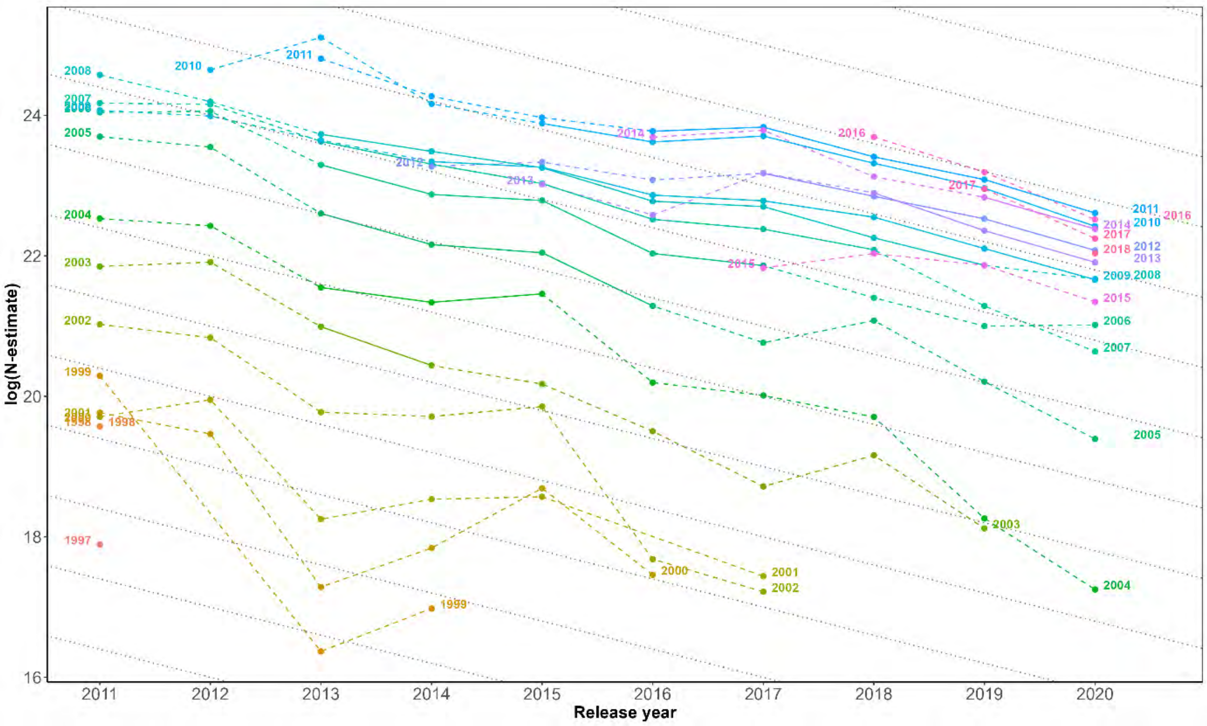

Figure 8. Trends in year class abundance (N=numbers released/numbers recaptured*numbers scanned year 1 and 2 after release) from RFID tag-recapture data based on aggregated data on recaptures and scanned numbers in year 1 and 2 after each release year. Data excluded in the stock assessment based on decisions in the ICES IBPNEAMac 2019 meeting (ICES 2019), release years 2011-2012 and ages 2-4 and 12+, are marked with dotted lines in year class trends. Note that dotted grey lines are showing a total mortality Z=0.4 for comparison with year class trends.

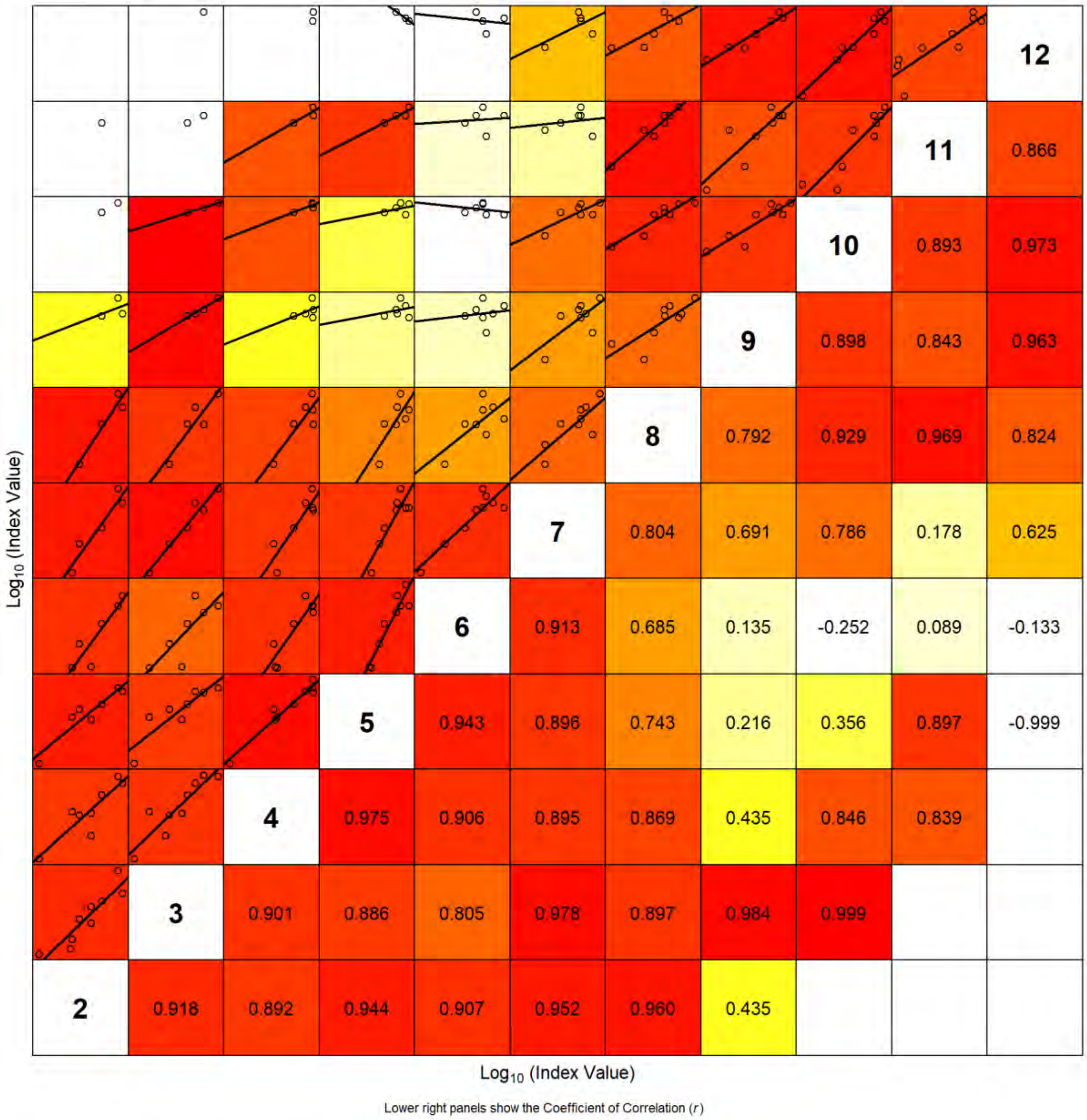

Figure 9. Internal consistency of the of mackerel RFID abundance index from release years 2011 to 2020, based on indices from Figure 8. Ages indicated by white numbers in grey diagonal cells. Statistically significant positive correlations (*p<0.05*) are indicated by regression lines and red cells in upper left half. Correlation coefficients (r) are given in the lower right half.

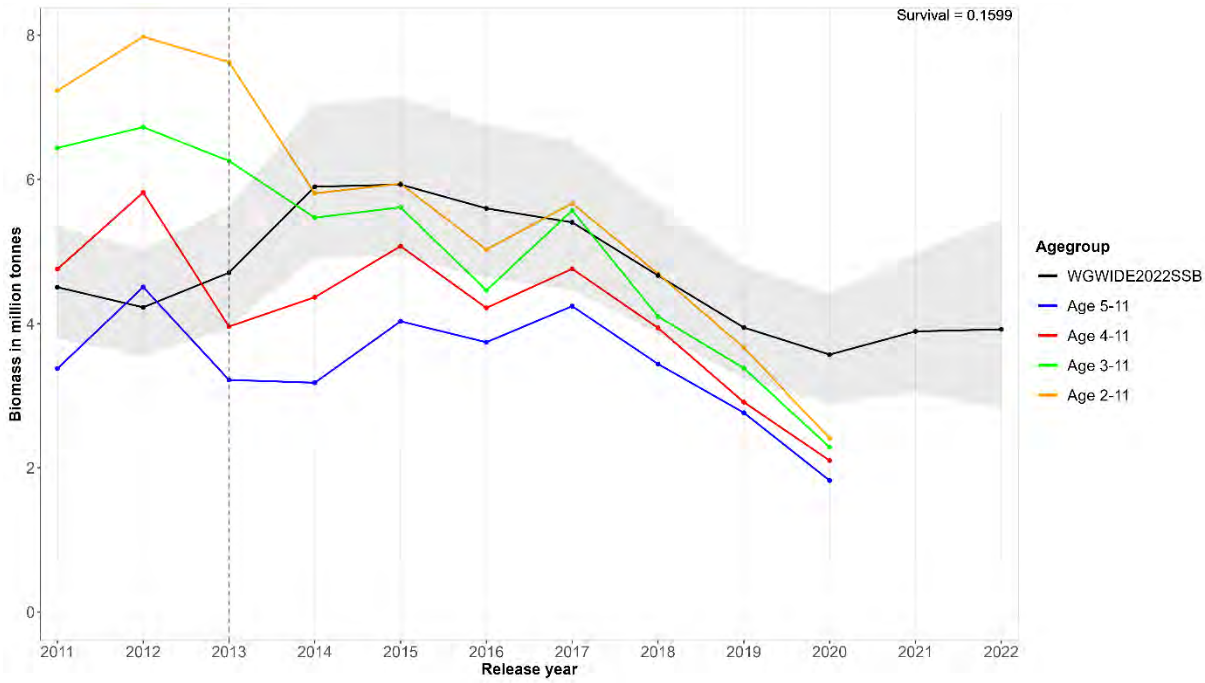

Figure 10. Trends in various age aggregated biomass indices from RFID tag-recapture data compared with the SSB (±95 confidence intervals) from the WGWIDE 2022 stock assessment. Data are based on a combination of estimated numbers by year class from Figure 8 scaled by survival parameter estimated by SAM in WGWIDE 2022 (0.1599) and weight at age in stock form same assessment. Vertical dotted line marks the starting year where RFID tagging experiments are used in the stock assessment based on decisions in the ICES IBPNEAMac 2019. meeting (ICES 2019), and the trend of ages 5-11 is representing the subset of ages used in updated assessments. Note that final year with data 2020 is only based on recapture year 1 after release, whereas the other years are based on recapture year 1-2 after release, i.e. completed. In recent years (2016-2018) the estimates have tended to increase when adding the second recapture year (See Figures 11-12).

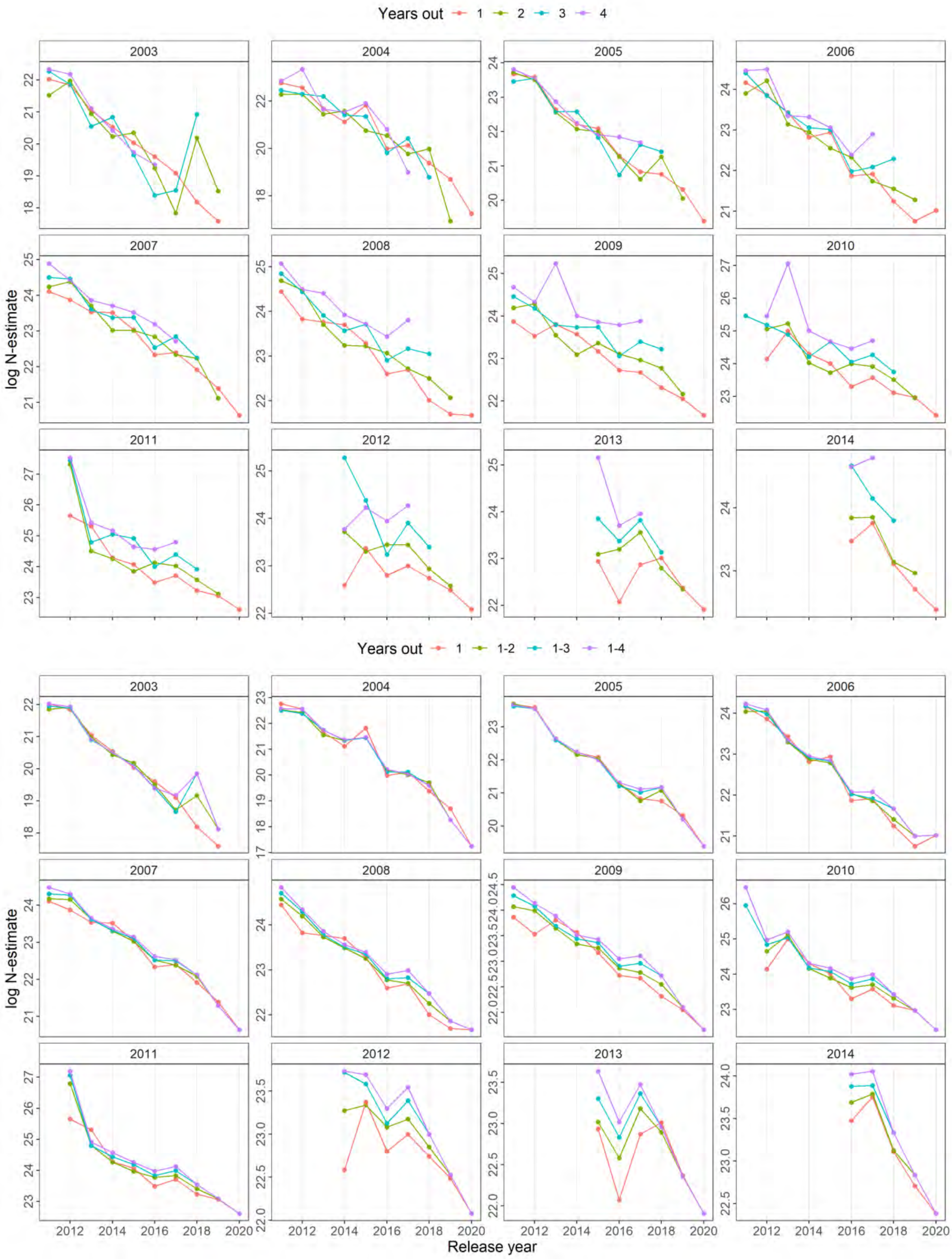

Figure 11. Trends in year class abundance (N=numbers released/numbers recaptured*numbers scanned) from RFID tag-recapture data based on different filtering of recapture year included. Upper panels show the difference between basing the estimate on either year 1, 2, 3, or 4 after release, whereas bottom panels show the difference between using year 1 after release versus various intervals of years after release. Note that data are shown for all ages (1-max 16) with data.

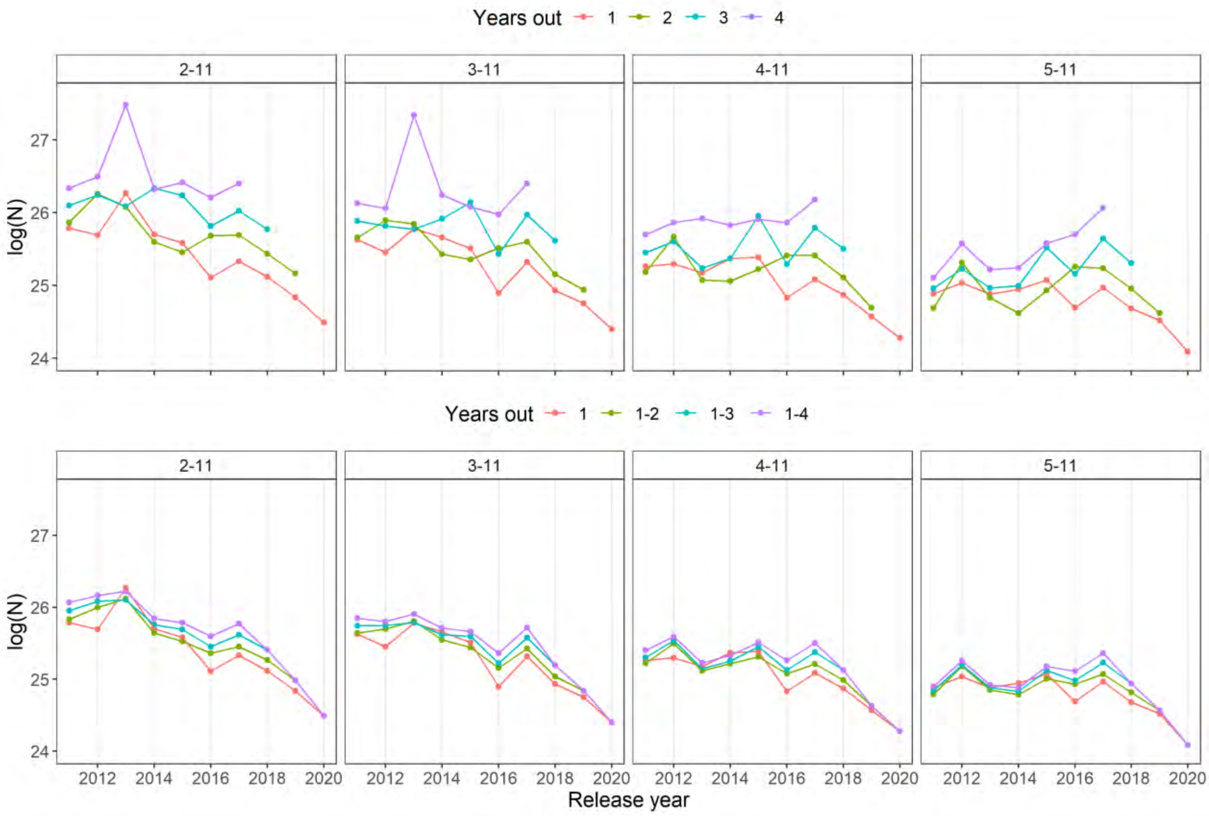

Figure 12. Trends in various age aggregated biomass indices from RFID tag-recapture data based on different filtering of recapture year included. Upper panels show the difference between basing the estimate on either year 1, 2, 3, or 4 after release, whereas bottom panels show the difference between using year 1 after release versus various intervals of years after release.

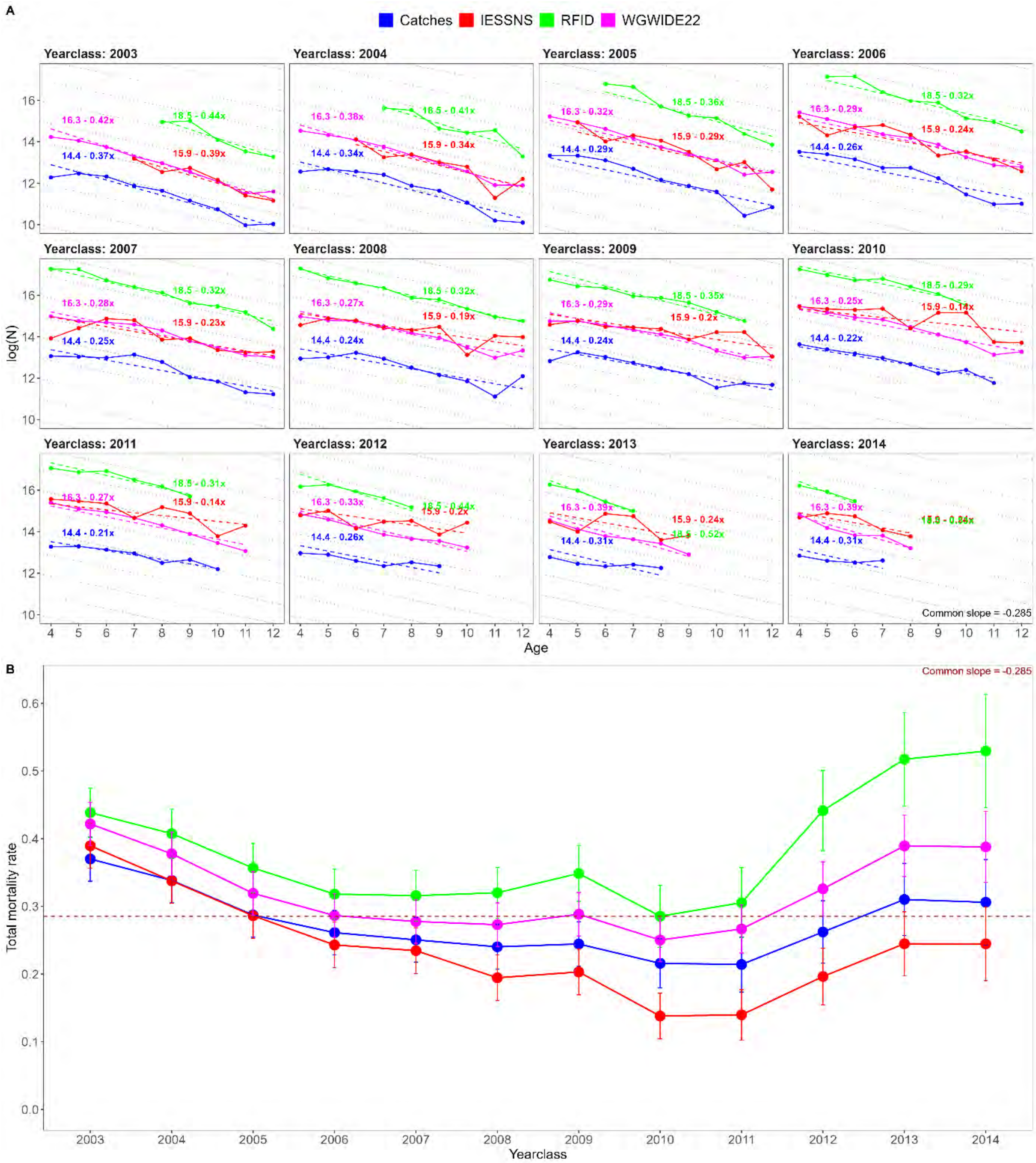

Figure 13. Signals of total mortality rate in input data to the mackerel stock assessment. (A)Upper panels show the trends in year class abundance and estimated slope of decrease from the age 4 when it is fully recruited to the spawning stock until age 12 (interpreted as signal of total mortality), of various sources of unscaled input data to the mackerel stock assessment (RFID, IESSNS and catch data) compared with the final trend estimated in the stock assessment (WGWIDE 2022). (B) Bottom panels summarize the year class differences in estimated total mortality rate (with 95% confidence intervals), and differences between the various data sources.

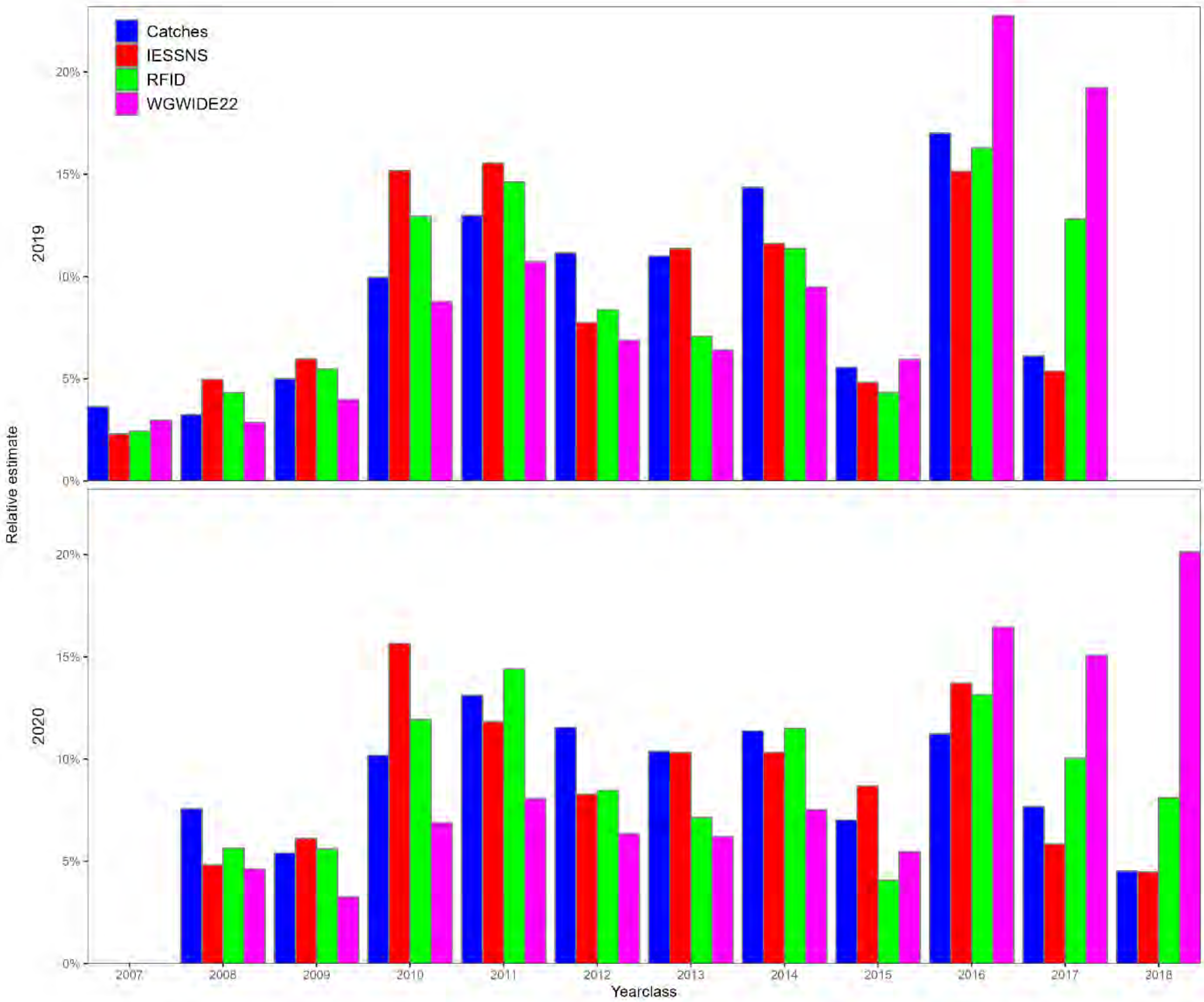

Figure 14. Comparison of relative year class contributions between RFID-tag estimates, catch data, IESSNS data and the WGWIDE2022 stock assessment it self.

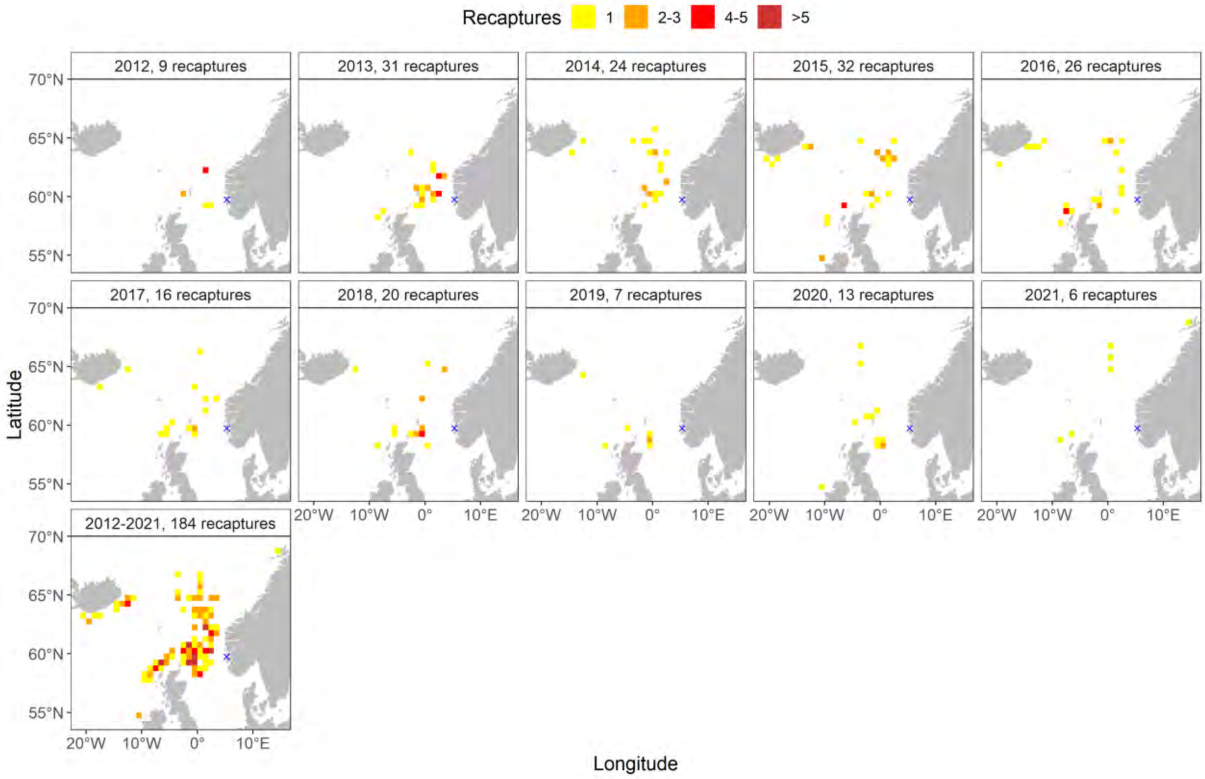

Figure 15. Distribution (summed per ICES rectangle) of recaptures 2012-2022 from an RFID tagging experiment on mackerel in the North Sea at the Norwegian West coast (blue dot) in 2011. This was mainly young mackerel tagged, where 88% were 1 year olds and 6.5% 2 year olds, using the North Sea/Norwegian coast as nursery.