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).

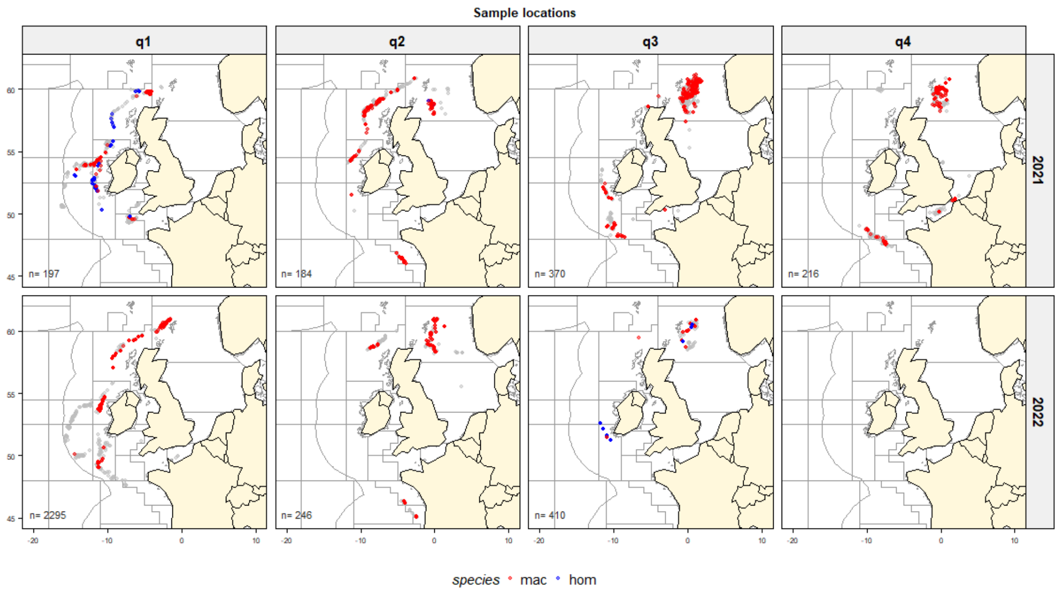

Figure 1.4.8.2 Overview of PFA gonad sampling for mackerel and horse mackerel during 2021 and 2022.

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.

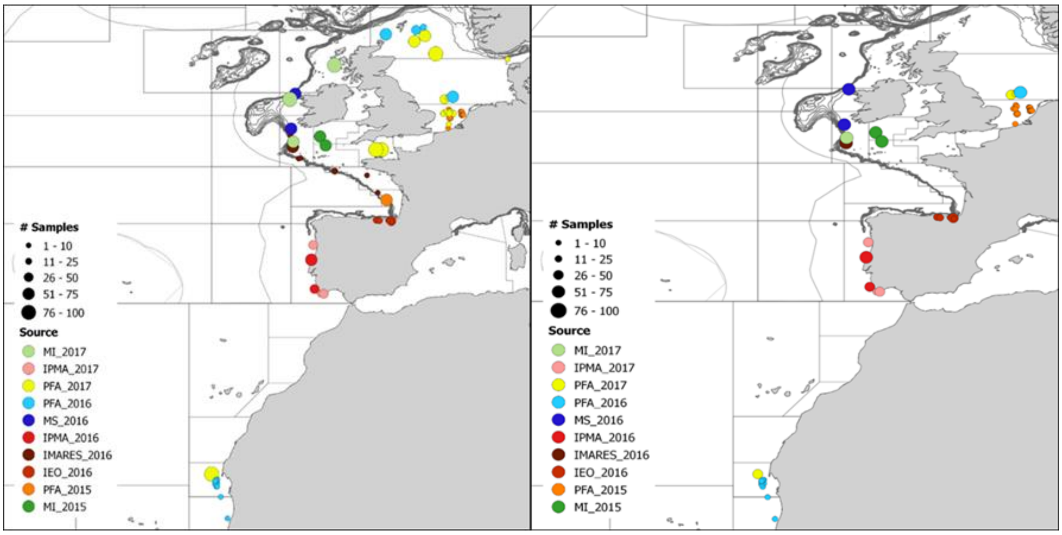

Figure 1.4.8.2. (left panel) The horse mackerel samples collected from 2015 to 2017 and (right panel) those included in the baseline dataset.

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).

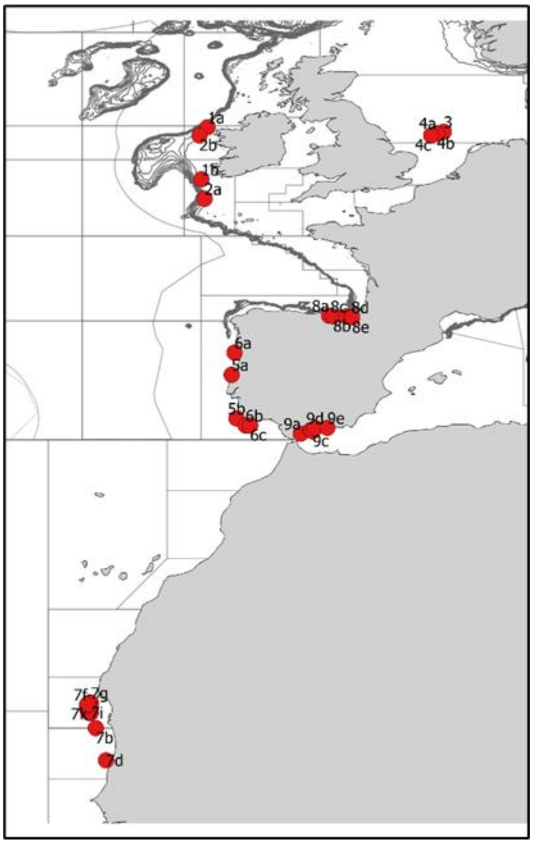

Figure 1.4.8.3. Sampling locations of the Atlantic horse mackerel included in this study. (Left) Sample batches collected at each location.

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			

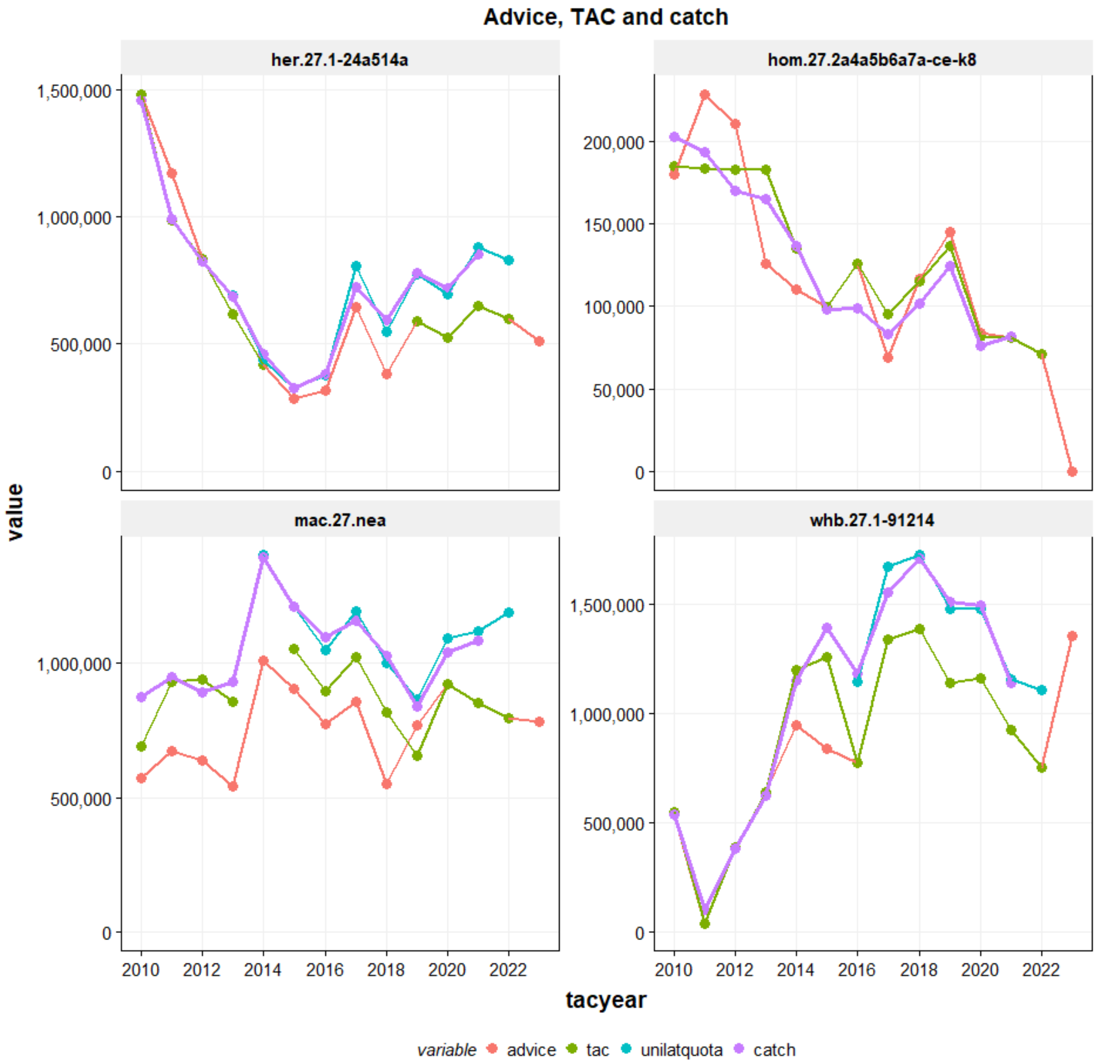

Figure 1.7.3.1: Overview of scientific advice, agreed TAC (or sum of unilateral quota) and catch

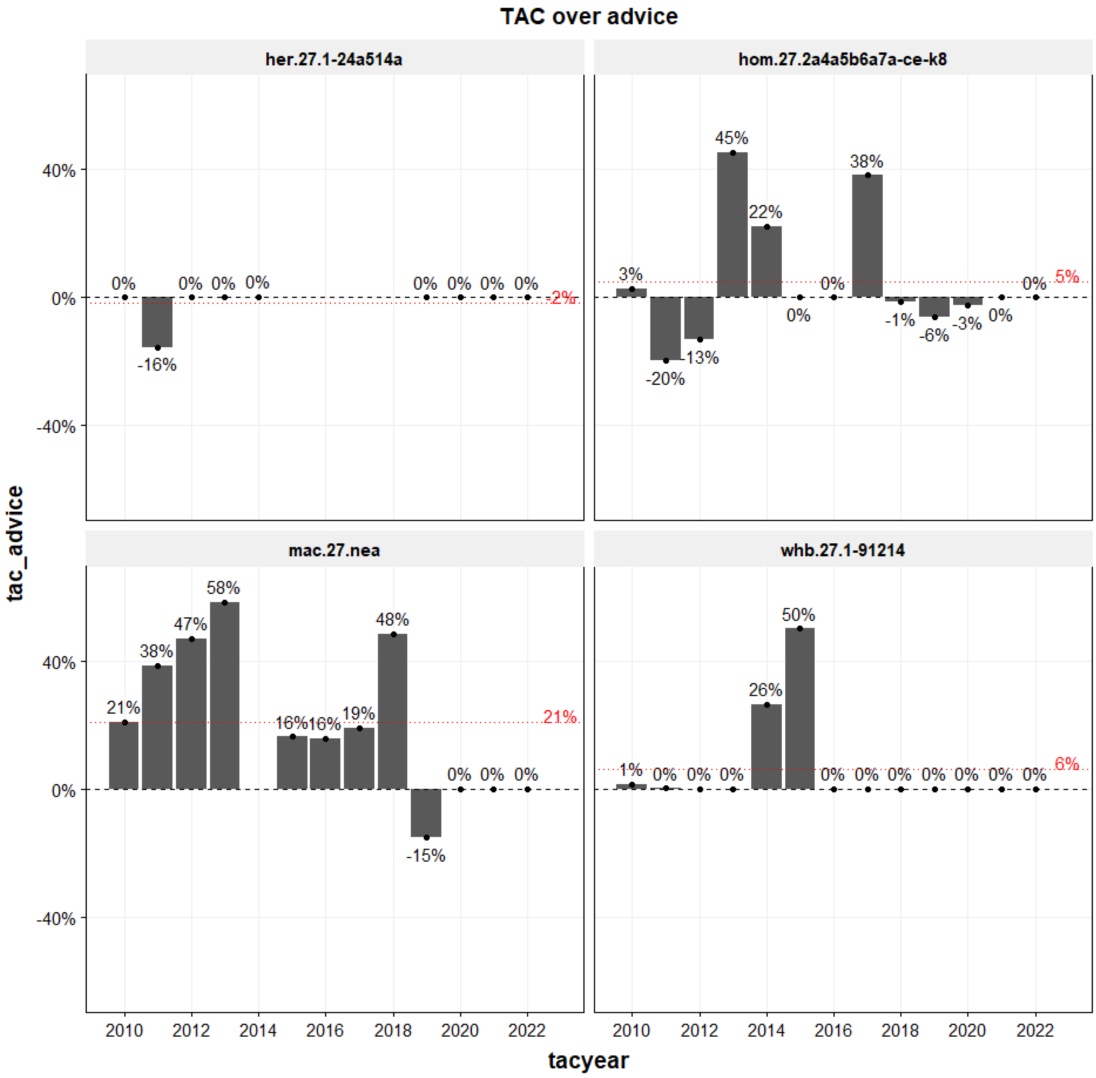

Figure 1.7.3.2: Relative deviations of TAC over advice. Red line indicates average relative deviation over the time series shown.

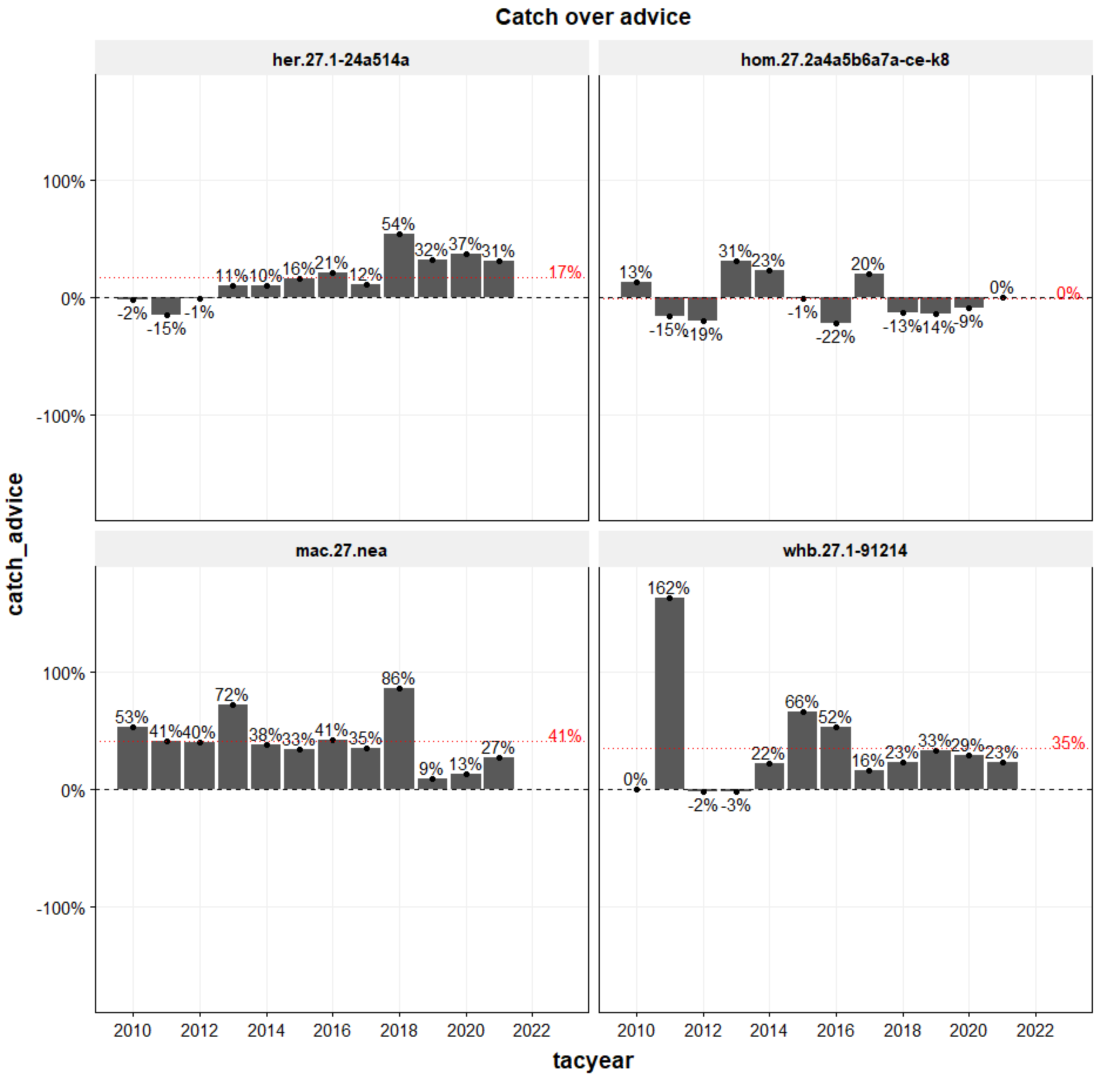

Figure 1.7.3.3: Overview of catch over advice

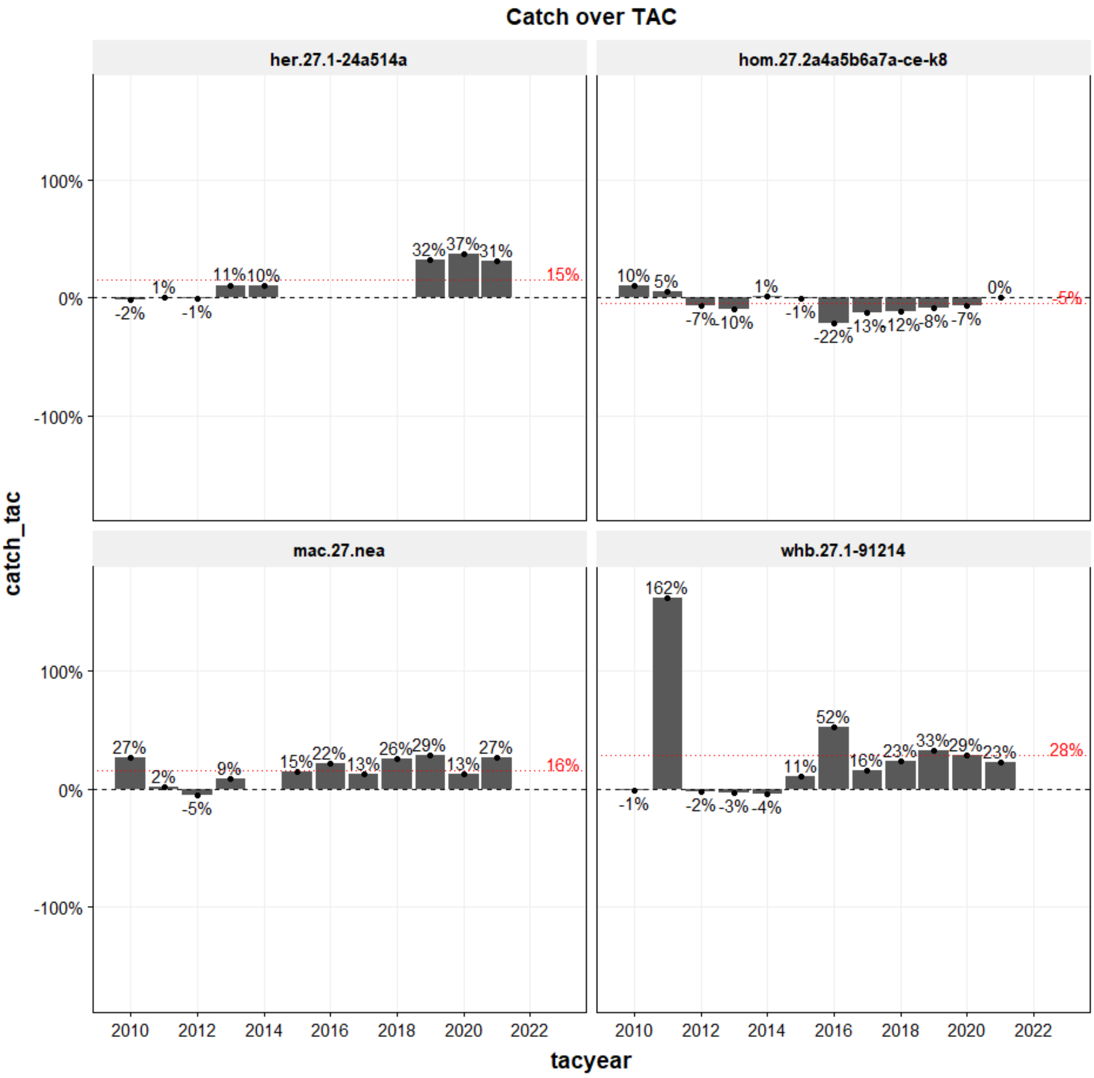

Figure 1.7.3.4: Overview of catch over TAC

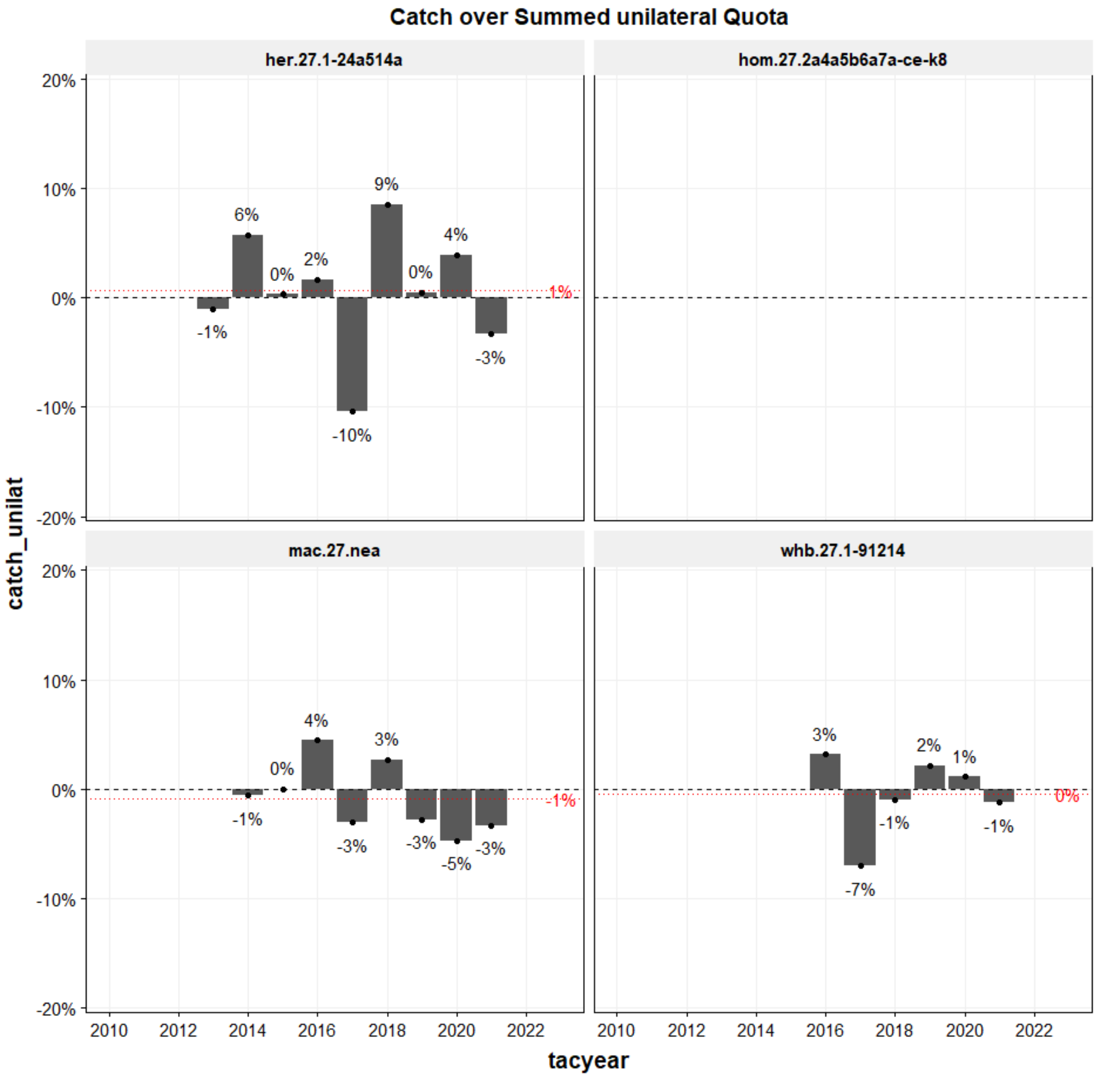

Figure 1.7.3.5: Overview of catch over sum of unilateral quotas.

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.

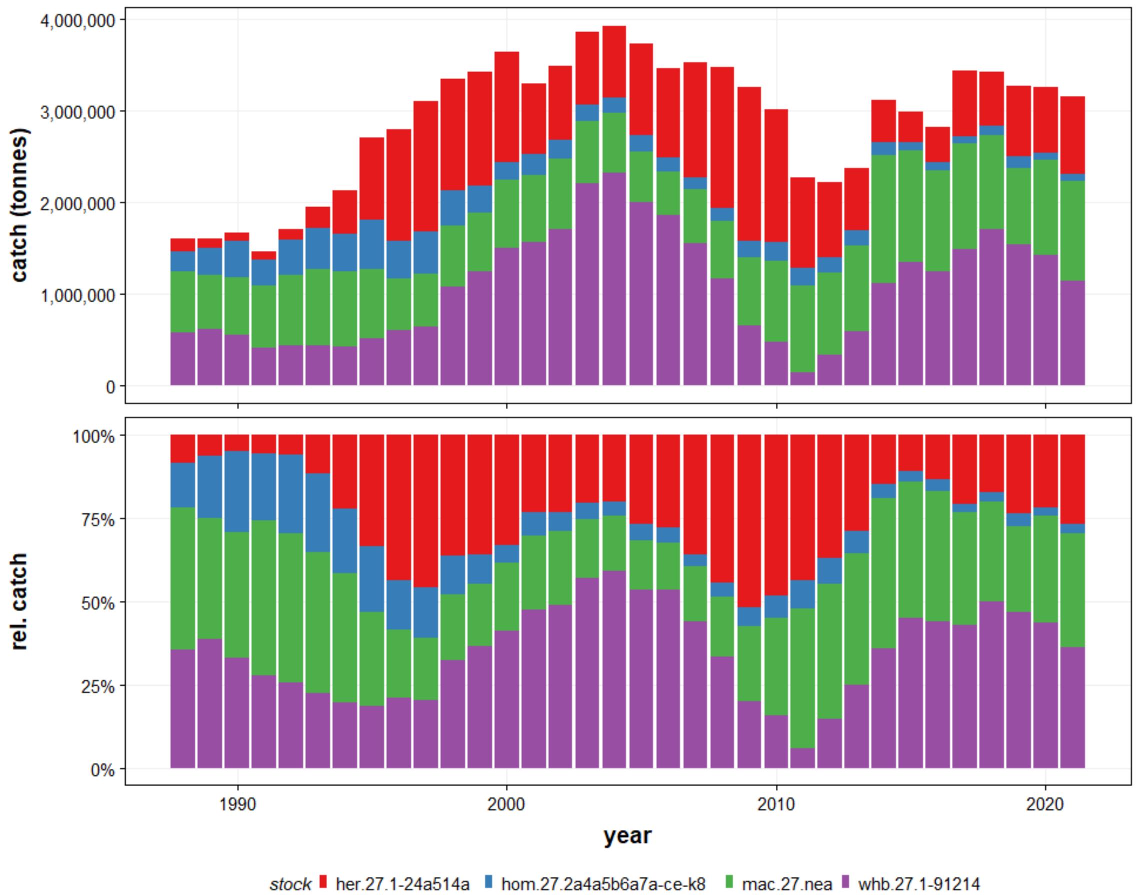

Figure 1.8.1: Catch of blue whiting, mackerel, western horse mackerel and Norwegian spring spawning herring

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.

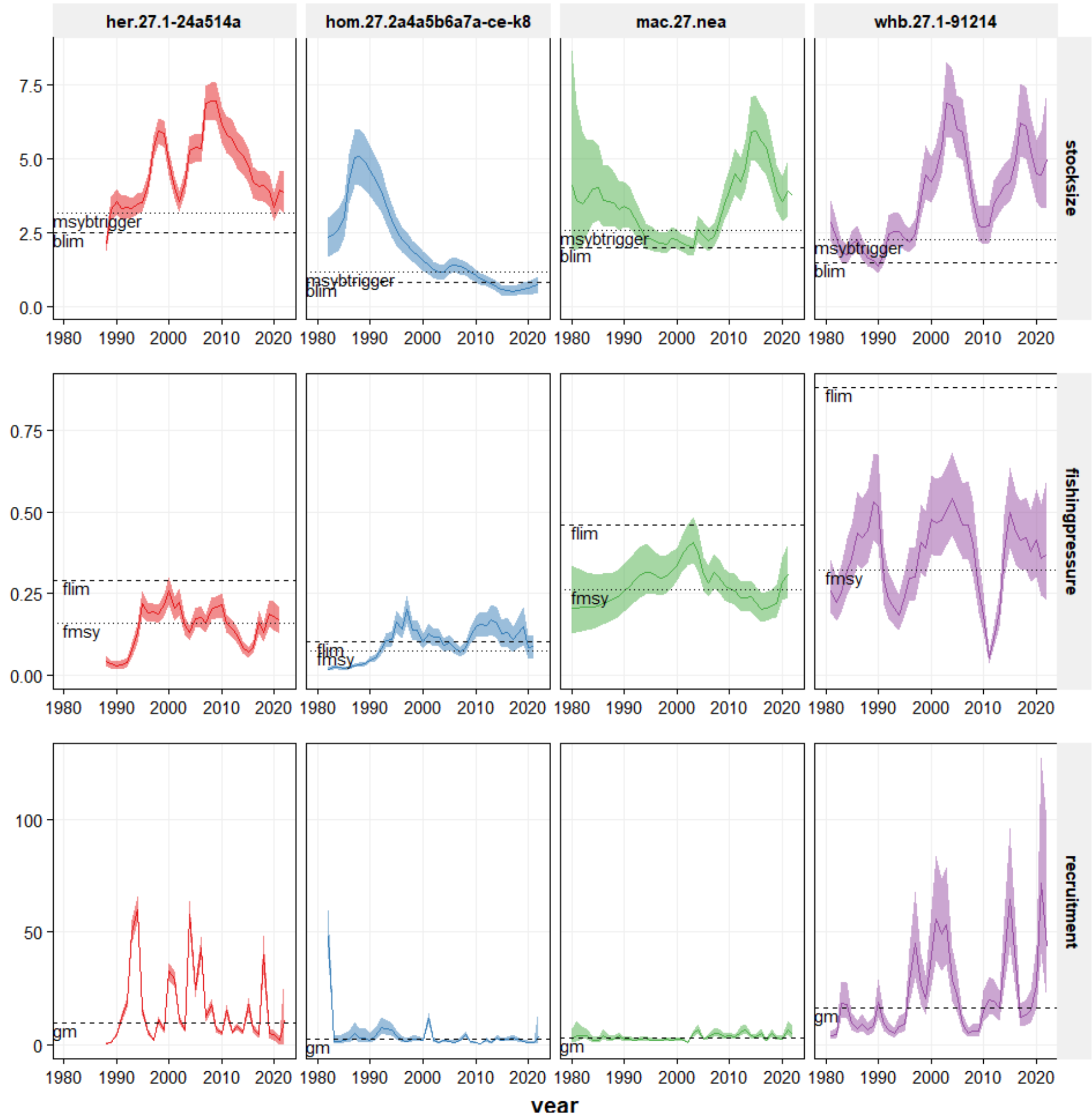

Figure 1.8.2: top - SSB (million tons), middle - fishing mortality and bottom - recruitment (billions) of Norwegian spring spawning herring, western horse mackerel, Northeast Atlantic mackerel and blue whiting from the WGWIDE 2022 update assessments.

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

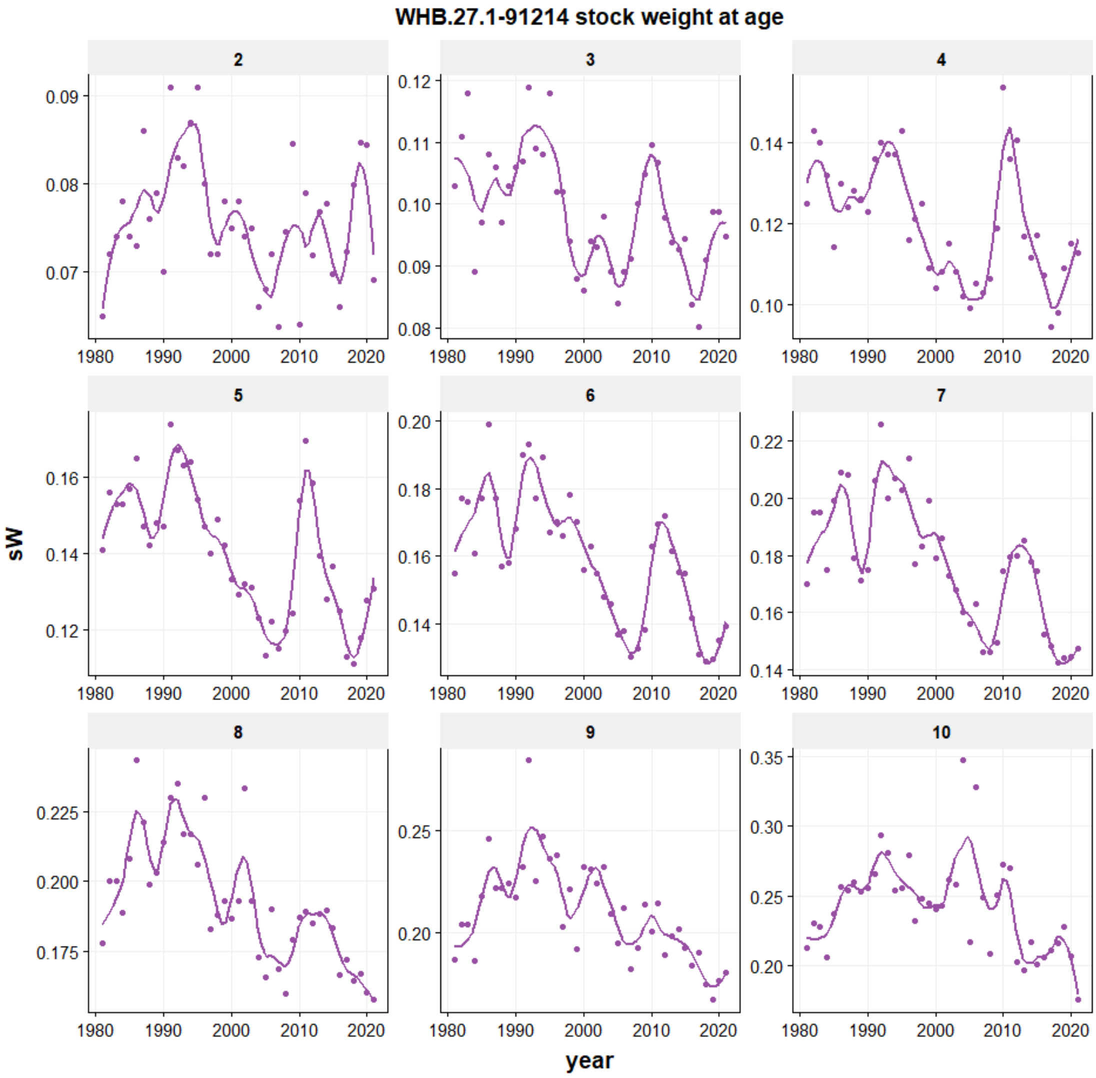

Figure 1.8.4: Stock weight at age of blue whiting

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.

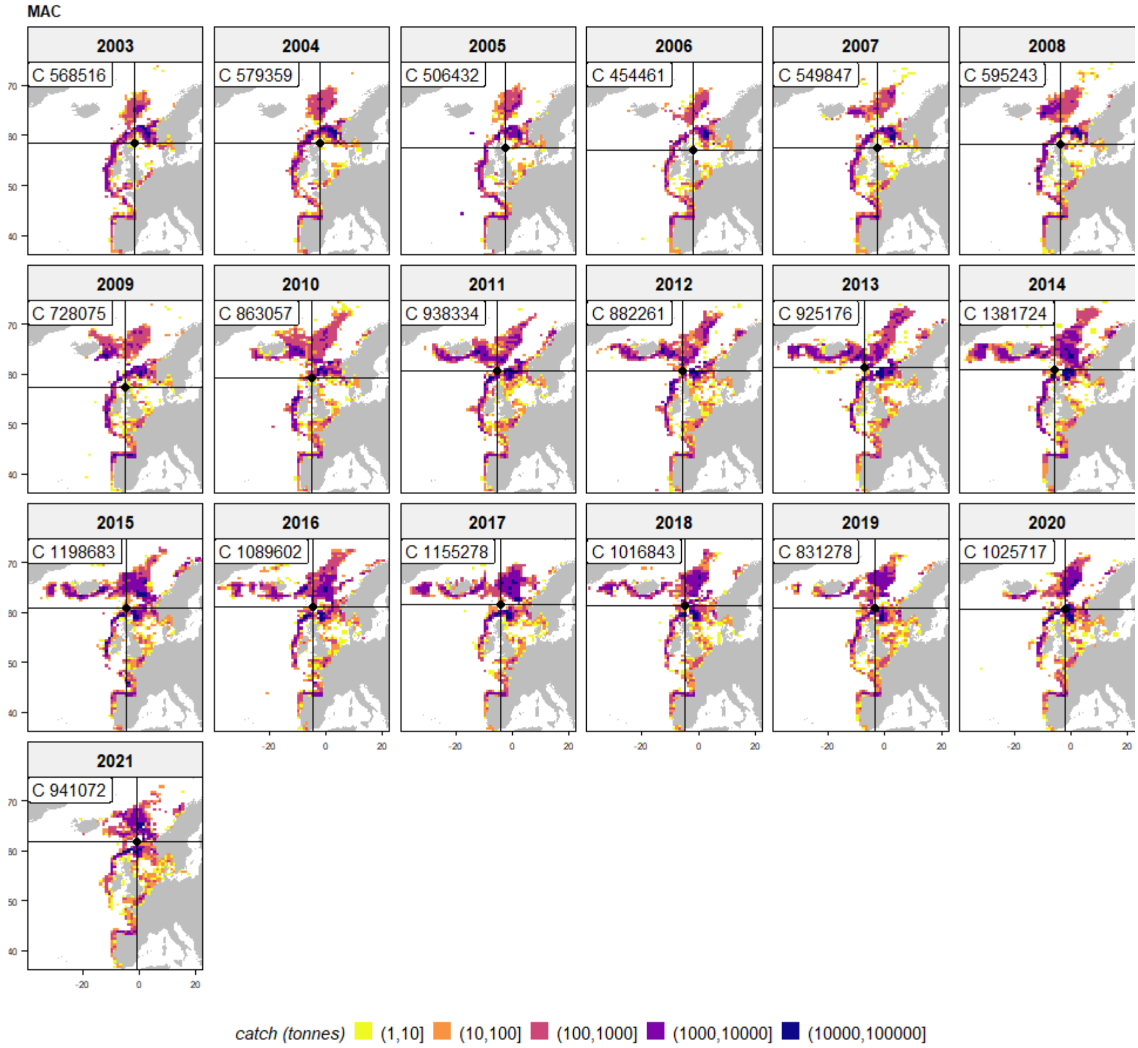

Figure 1.8.5: Catch of mackerel (tonnes) by year and rectangle. Catch by rectangle data do not represent the official catches and cannot be used for management purposes. In general, the total annual catches by rectangle are within 10% from the official catches.

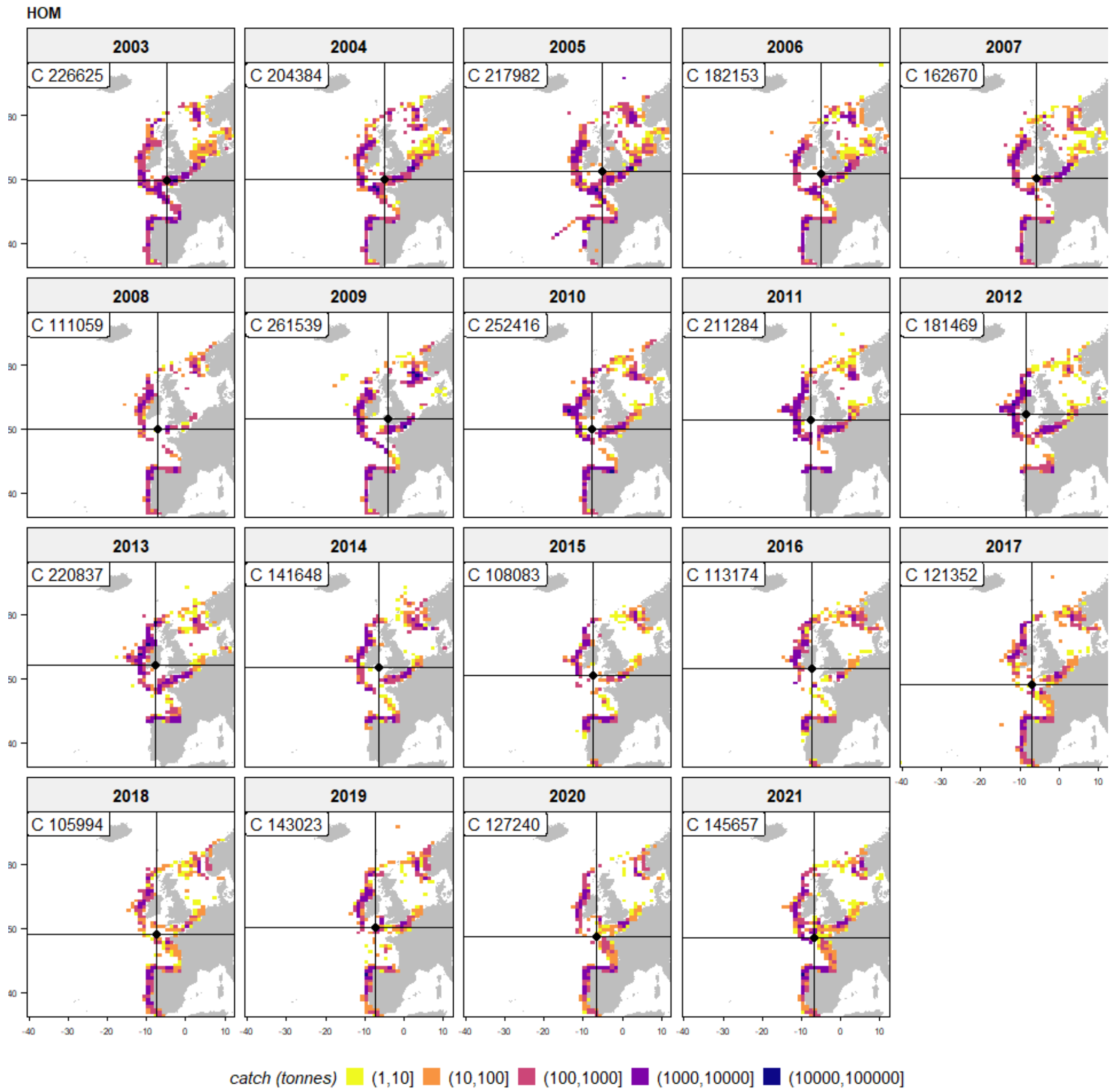

Figure 1.8.6: Catch of horse mackerel (all stocks, tonnes) by year and rectangle. Catch by rectangle data do not represent the official catches and cannot be used for management purposes. In general, the total annual catches by rectangle are within 10% from the official catches.

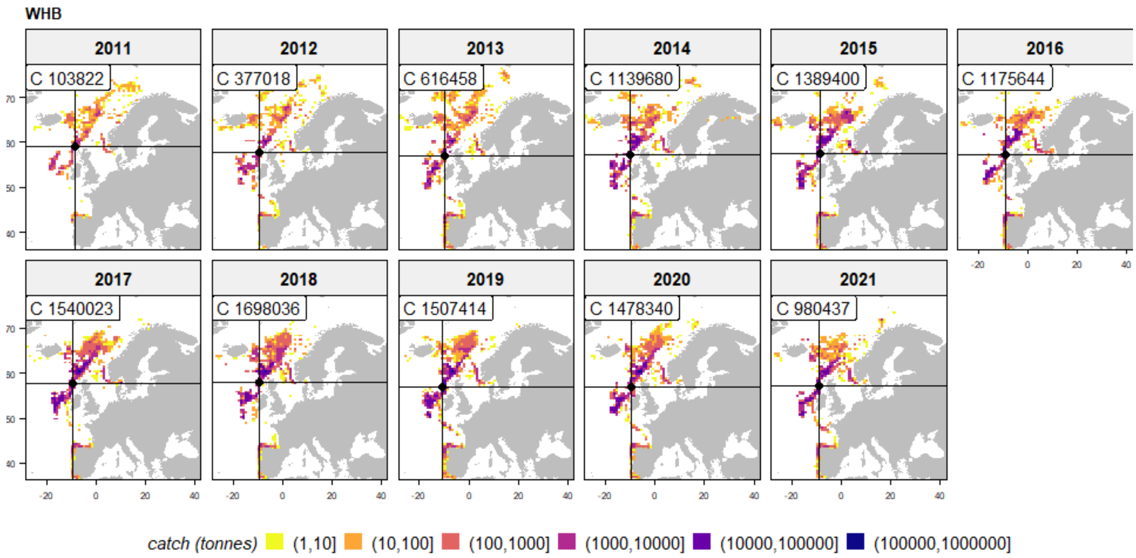

Figure 1.8.7: Catch of blue whiting (tonnes) by year and rectangle. Catch by rectangle data do not represent the official catches and cannot be used for management purposes. In general, the total annual catches by rectangle are within 10% from the official catches.

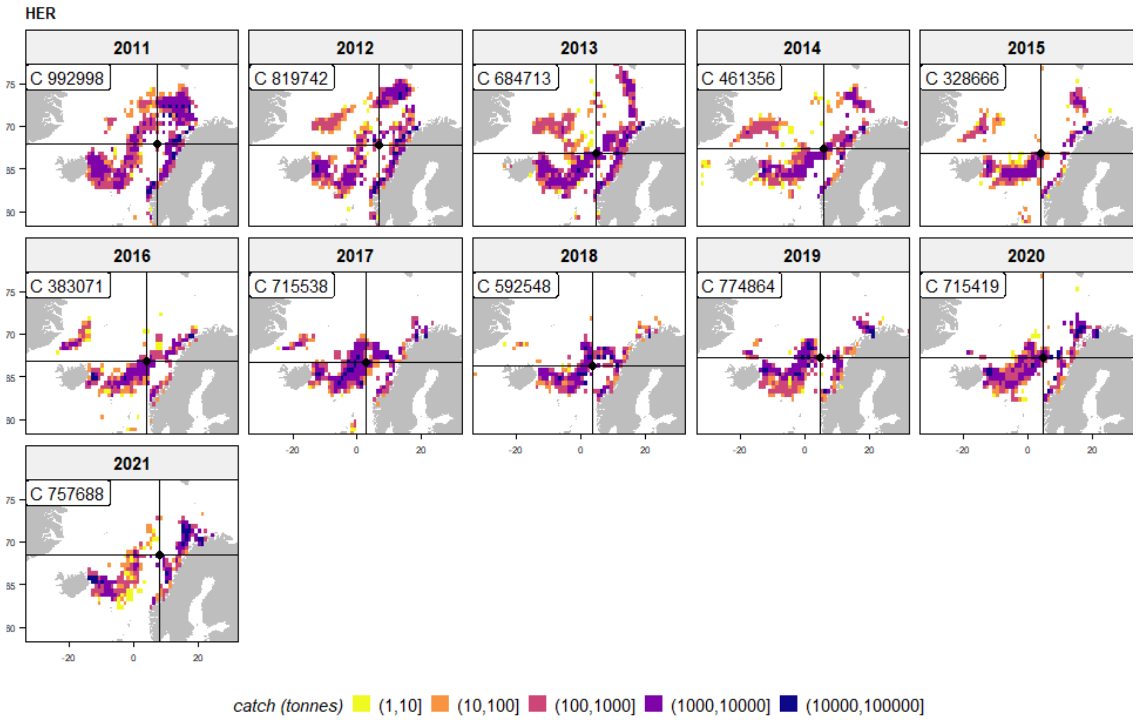

Figure 1.8.8: Catch of Norwegian spring-spawning (Atlanto-scandian) herring (tonnes) by year and rectangle. Catch by rectangle data do not represent the official catches and cannot be used for management purposes. In general, the total annual catches by rectangle are within 10% from the official catches.

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.

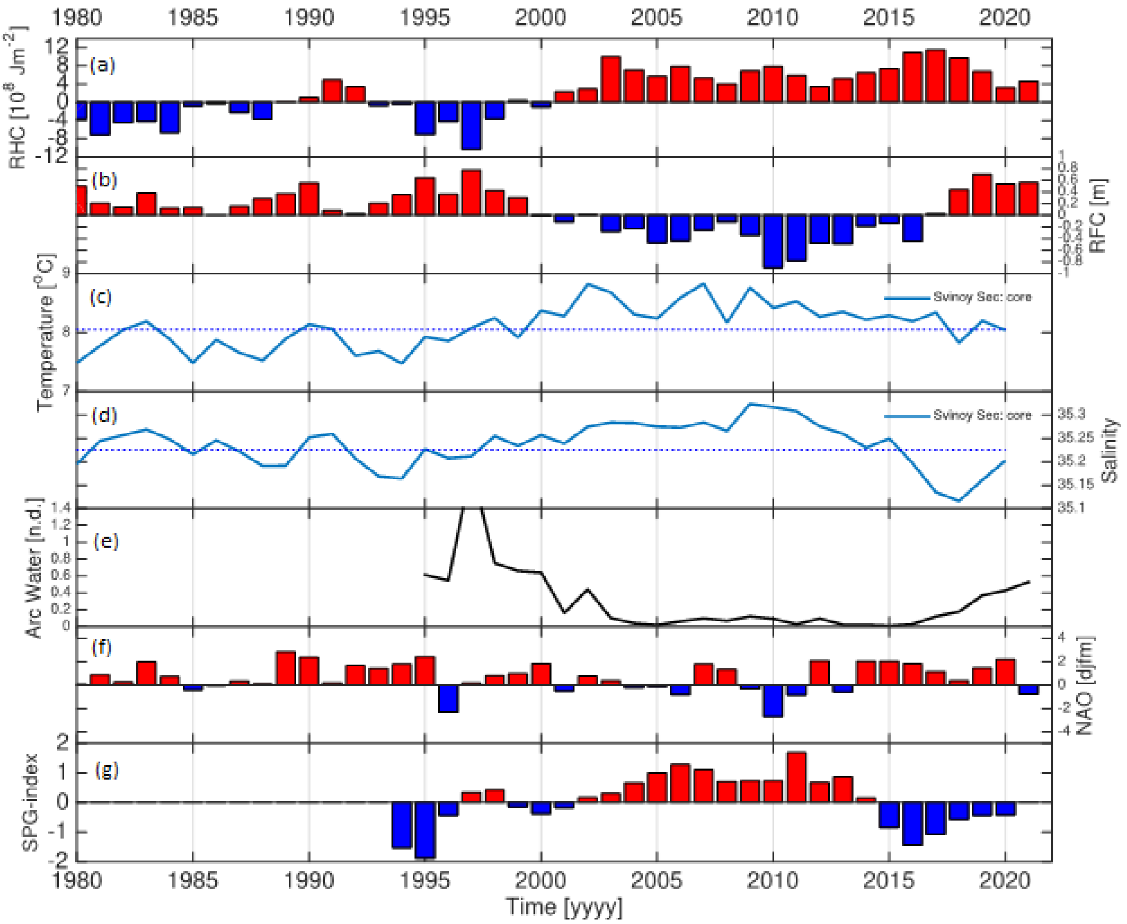

Figure 1.9.1. A subset of climate indicators for the Norwegian Sea: a) Relative heat content (RHC) and b) Relative Freshwater Content (RFC); Svinøy section Atlantic Water core c) temperature and d) salinity; e) Arctic Water amount in the Norwegian Sea, f) The North Atlantic Oscillation (NAO) winter index, 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.

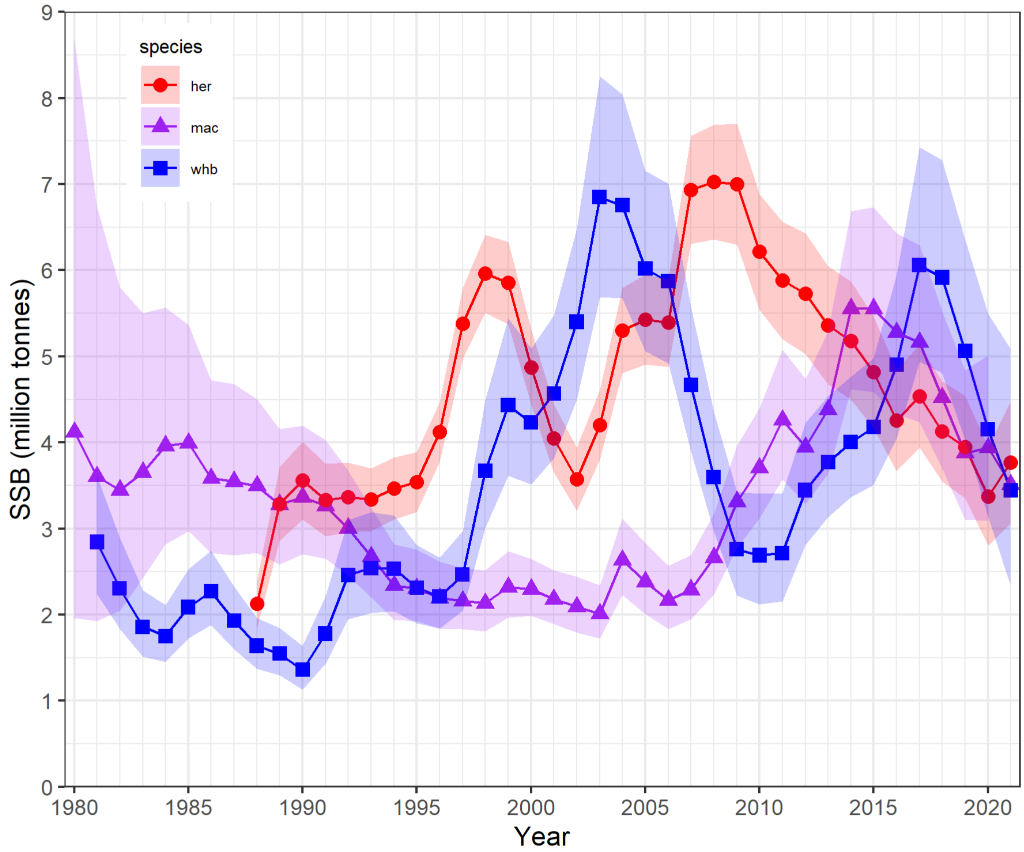

Figure 1.9.2. Estimated spawning stock biomass (lines) including 95% confidence intervals (shaded areas) for Norwegian spring-spawning herring (red filled circles), mackerel (purple filled triangles) and blue whiting (blue filled rectangles) from 1980 to 2021.

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.

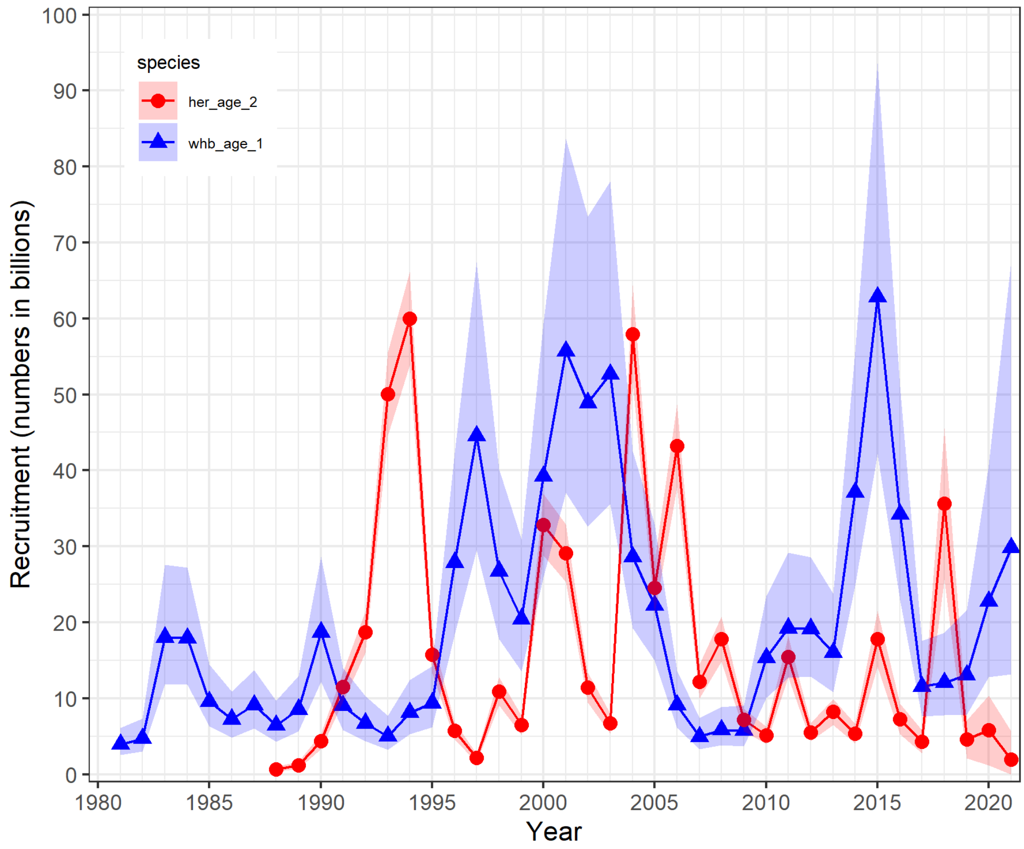

Figure 1.9.3. Estimated year-class size at recruitment for Norwegian spring-spawning herring (age 2; red filled circle) and blue whiting (age 1; blue filled triangle) from 1981 to 2021.

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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