1 Introduction

1.1 Terms of References (ToRs)

The Working Group on Widely Distributed Stocks (WGWIDE), chaired by Andrew Campbell, Ireland, met virtually from 26 August – 1 September 2020. A virtual meeting replaced the planned physical meeting at ICES Headquarters due to restrictions resulting from the COVID-19 emergency. The terms of reference for the meeting consisted of re-prioritised generic Regional and Species Working Group ToRs:

High Priority

c) Conduct an assessment on the stock(s) to be addressed in 2020 using the method (analytical, forecast or trends indicators) as described in the stock annex and produce a brief report of the work carried out regarding the stock, summarising where the item is relevant. **Check the list of the stocks to be done in detail and those to roll over**.

   i) Input data and examination of data quality;

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

   iii) For relevant stocks (i.e., all stocks with catches in the NEAFC Regulatory Area) estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2019.

   v) The developments in spawning stock biomass, total stock biomass, fishing mortality, catches (wanted and unwanted landings and discards) using the method described in the stock annex;

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

   vii) Catch scenarios for next year(s) 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 quality issues with these. For the analytical performance of category 1 and 2 age-structured assessments, report the mean Mohn's rho (assessment retrospective (bias) analysis) values for R, SSB and F. 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. Check list to confirm whether the stock requires a concise advice sheet or a traditional advice sheet.

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

j) Audit all data and methods used to produce stock assessments and projections.

Medium Priority

a) Consider and comment on Ecosystem and Fisheries overviews where available;

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

  i) descriptions of ecosystem impacts of fisheries
  ii) descriptions of developments and recent changes to the fisheries
  iii) mixed fisheries considerations, and
  iv) emerging issues of relevance for the management of the fisheries;
  e) Review progress on benchmark processes of relevance to the Expert Group; High for application;

Low Priority

c iv) Estimate MSY proxy reference points for the category 3 and 4 stocks

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

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

i) Take 15 minutes, and fill a line in the audit spread sheet ‘Monitor and alert for changes in ecosystem/fisheries productivity’; for stocks with less information that do not fit into this approach (e.g. higher categories >3) briefly note in the report where and how productivity, species interactions, habitat and distributional changes, including those related to climate-change, have been considered in the advice. ACOM would encourage expert groups to carry out this term of reference later in the year through a WebEx.

1.1.1 The WG work 2020 in relation to the ToRs

The WG considered update assessments for all eight stocks within its remit. Based upon these assessments and associated short term forecasts, the group produced full draft advice sheets for Northeast Atlantic mackerel and blue whiting and abbreviated advice sheets for Norwegian spring spawning herring, western horse mackerel and striped red mullet. 2021 catch advice for the remaining three stocks (North Sea horse mackerel, boarfish and red gurnard) was issued previously and therefore not required this year although update assessments were presented to the group. All draft advice sheets were agreed in plenary. Advice sheets, report sections and assessments were audited with 3 working group members assigned to each stock. In addition, five stock annexes were updated and the productivity audit was completed for each stock.

1.2 Participants at the meeting

WGWIDE 2020 was attended by 39 delegates from the Netherlands, Ireland, Spain, Norway, Germany, Portugal, Iceland, UK (England and Scotland), Faroe Islands, France, Denmark, Greenland, Russia 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 prevent them from acting with scientific independence, integrity, and impartiality.

1.3 Overview of stocks within the WG

Eight stocks are assessed by WGWIDE. In 2020, the group drafted 2021 advice sheets for 5 stocks. Full advice sheets were drafted for Northeast Atlantic Mackerel and Blue Whiting with abbreviated sheets for Norwegian Spring Spawning Herring, Western Horse Mackerel and Striped Red Mullet. 2021 advice for the remaining stocks was issued previously although the relevant data series and stock assessments were updated and considered at WGWIDE 2020. 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	2021 Advice Sheet
Boarfish	boc.27.6-8	3.2	Bayesian Schafer surplus production model	2	2019	NA
Red gurnard	gur.27.3-8	6.2	No assessment	2	2019	NA
Norwegian spring-sp. herring	her.27.1-24a514a	1	XSAM	1	2019	Abbreviated
Western horse mackerel	hom.27.2a4a5b6a7a-ce-k8	1	Stock Synthesis	1	2019	Abbreviated
North Sea horse mackerel	hom.27.3a4bc7d	3.2	Survey trends based	2	2019	NA
NE-Atlantic mackerel	mac.27.nea	1	SAM	1	2019	Full
Striped red mullet	mur.27.67a-ce-k89a	5	No assessment	3	2017	Abbreviated
Blue whiting	whb.27.1-91214	1	SAM	1	2019	Full

1.4 Quality and Adequacy of fishery and sampling data

1.4.1 Sampling Data from Commercial Fishery

The working group again carried out a review of the 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. 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 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 limited. Prior to 1977, red gurnard catches were not reported. Since this time, landings of gurnards have often been reported as mixed gurnards. With the exception of Portugal, there is no detail provided to the WG on the methodology used to estimate the proportion of red gurnards.

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 *et al.* 2009, 2010, van Overzee *et al.* 2011, 2013, Ulleweit *et al.* 2016, van Overzee *et al.* 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. Nevertheless, the majority of these estimates were associated with very large variances and composition estimates of ´slippages´ are liable to strong biases and are therefore open to criticism.

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

1.4.4 Age-reading

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

1.4.4.1 Mackerel

The most recent workshop on age reading of Atlantic mackerel otoliths (WKARMAC2) took place in October 2018 and was attended by 23 participants from 14 separate laboratories (ICES 2019c).

Through on-screen discussion, the workshop identified a number of issues leading to differences in age determination between readers for difficult and/or old otoliths and calibration. This resulted in revisions to ageing guidelines with modifications agreed and adopted by the workshop participants. As a result, the workshop indicates an improvement in the agreement between readers (66.8% agreement, 31.4% CV), and particularly for expert readers (73.2% agreement, 16.4% CV). However, the agreement between readers for otoliths with older ages (from age 6) continues to be very low (40-58% for all readers; 53-71% for expert readers). This increasing reduction in agreement for older ages was also confirmed by an exercise with quasi age validated Norwegian otoliths from tag-recaptured experiments.

An image collection of agreed age otoliths was assembled on the WKARMAC2 SharePoint and the Age Forum site. This otolith collection includes the otoliths with > 80% agreement between expert readers from the WKARMAC2 calibration exercise. In addition, the images of the otoliths from the exchange with Norwegian otoliths from the tag-recapture experiments will also be included in the reference otolith collection.

A further, small scale exchange on NE A mackerel otoliths is scheduled for the 4th quarter 2020.

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.

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.

1.4.4.4 Blue Whiting

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

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

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

Recurrent issues among age readers were the identification of the position of the first annual growth ring, false rings and interpretation of the edge. In order to overcome those problems, age validation studies on blue whiting otoliths were further recommended and should be conducted until the next age reading workshop. An age reading inter-calibration exchange commenced in May 2020 and will conclude by November 2020. A further age validation study on this species is being conducted together with the preparation of the 2021 age reading workshop planned to be carried out in June 2021.

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.

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 12.7.

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.

1.5 Quality Control and Data Archiving

1.5.1 Current methods of compiling fisheries assessment data

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

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

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

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

Official Catch	Catches as reported by the official statistics to ICES
Unallocated Catch	Adjustments (positive or negative) to the official catches made for any special knowledge about the fishery, such as under- or over-reporting for which there is firm external evidence.
Area misreported Catch	To be used only to adjust official catches which have been reported from the wrong area (can be negative). For any country the sum of all the area misreported catches should be zero.
BMS landing	Landings of fish below minimum landing size according to landing obligation
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

1.5.2 Quality of the Input data

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

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

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

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

There exist gaps in some 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.

Stock data problems relevant to data collection 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 the deadline. Data should include length distributions split by area and quarter. Should the data submitter be unavailable after the data has been submitted (e.g. vacation) an alternative contact should be available who can be contacted in the event of any queries.	National laboratories
Northeast Atlantic Mackerel	Discard and slippage information	Discard and slippage information is incomplete. All fleets, including demersal fleets should be monitored and sampled for discards and slipping. Data should be supplied to the coordinator by the submission deadline, accompanied by documentation describing the sampling protocol.	National laboratories, RCG NA, RCG NS&EA
Northeast Atlantic Mackerel	Sampling deficiencies– general	All countries involved should provide sampling information. Increased cooperation between countries would help reduce redundancy and increase coverage.	National laboratories, RCG NA, RCG NS&EA
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 (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	To ensure the sampling of age and length information from all catch fractions and all areas and within all quarters from all commercial	National institutes

Stock	Data Problem	How to be addressed in	By who
	the age and length distribution of catches	fleets with a distribution of sampling effort over the year and areas in the North Sea	
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	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

1.5.3 Quality control of data and assessments, auditing

As a quality control of the data and the assessment, three 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 5). Issues identified in the audit reports were followed up by the appropriate stock coordinator/assessor with updates made where appropriate.

1.5.4 Information from stakeholders

The procedure for the submission of inputs from stakeholders into the scientific advice has changed in 2020. Instead of contributing information directly into the Advice Drafting Groups, the procedure is now that the information from stakeholders should be submitted to the expert groups who will then consider the information for inclusion into the advice, if applicable.

For WGWIDE stocks there are several instances of strong cooperation between research institutes and fishing industries 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. In WGWIDE 2020, the following contributions from fishing industry research activities have been reported to the working group:

1. PFA self-sampling report 2015-2020
2. Gonad sampling for mackerel and horse mackerel 2019-2020
3. Inventory of industry acoustic data for blue whiting
4. Evaluation of a potential rebuilding plan for Western horse mackerel
5. Genetic stock identification of horse mackerel

1.5.4.1 PFA self-sampling report 2015-2020 (WD01)

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 is presented in the text table below (number of vessels, trips, days, hauls, catch (tonnes), catch per day (tonnes), %non-target catch and number of fish measured. * denotes incomplete year).

Year	Vessels	Trips	Days	Hauls	Catch	Catch/Day	Non-target	Lengths
2015	4	26	390	869	65 899	168	1.10%	69 680
2016	9	47	647	1 456	126 997	196	0.50%	78 708
2017	12	64	887	1 886	184 460	207	0.20%	95 190
2018	16	88	1 330	2 901	272 416	204	0.20%	176 455
2019	16	101	1 423	3 109	252 973	177	0.30%	150 806
2020*	13	65	908	2 092	215 627	237	0.40%	178 114
ALL		391	5 585	12 313	1 118 372			748 953

***incomplete**

The Mackerel fishery takes place from October through to March of the subsequent year. Minor bycatches of mackerel may also occur during other fisheries. Overall, the self-sampling activities for the mackerel fisheries during the years 2015 – 2020 (up to August) covered 323 fishing trips with 4,725 hauls, a total catch of 286,957 tonnes and 91,000 individual length measurements. The main fishing areas are ICES division 27.4.a (between 27% and 54% of the catch) and division 27.6.a (between 25% and 44% of the catch). Compared to the previous years, mackerel in the catch have been relatively large in 2020 with median length of 36.4 cm compared to 32.4-35.4 in the preceding years. Also, the median weight has been somewhat higher with median weight of 417 gram compared to 379-400 gram the preceding years. Average annual fat content ranges from 17 to 21% with individual measurements reaching up to 30%

The horse mackerel fishery takes place from October through to March of the subsequent year. Overall, the self-sampling activities for the horse mackerel fisheries during the years 2015 – 2020 (up to August) covered 457 fishing trips with 3,454 hauls, a total catch of 140,633 tonnes and 125,000 individual length measurements. The main fishing areas are ICES division 27.6.a (between 21% and 40% of the catch), division 27.7.b (7%-22%) and division 27.7.d (19%-34%, note that this is considered as the North Sea horse mackerel stock). Horse mackerel have a wide range in the length distributions in the catch. Median lengths have fluctuated between 22.8 cm and 30.0 cm. In 2019 and 2020 there are some indications of a stronger year class being available to the fishery, with a narrower length distribution. For example, in 27.6.a, the mode was 26.6 cm in 2019 and 27.5 cm in 2020. Average annual fat content ranges from 5 to 7.5% with individual measurements reaching up to 15%.

The blue whiting fishery takes place from February through to May although some minor fisheries for blue whiting may remain over the other months. Overall, the self-sampling activities for the blue whiting fisheries during the years 2015 – 2020 (up to August) covered 365 fishing trips with 5,836 hauls, a total catch of 561,888 tonnes and 128,000 individual length measurements. The main fishing areas are ICES division 27.6.a (between 41% and 65% of the catch), division 27.7.c (6%-36%) and division 27.7.k (2%-32%). Blue whiting have a wide range in the length distributions in the catch. Median lengths have fluctuated between 23 cm (2016) and 30 cm (2015). During the period 2016 - 2020, the median length is consistently increasing (from 23 cm to 28 cm), indicating that the fishery is probably concentrating on a strong year class going without new year classes coming in. Fat content for blue whiting is generally low (on average less than 1%).

The fishery for Atlanto-Scandian herring (ASH) is a relatively small fishery for the PFA and takes place mostly in October. Overall, the self-sampling activities for the ASH fisheries during the years 2015 – 2020 (up to August) covered 27 fishing trips with 406 hauls, a total catch of 30,234 tonnes and 8,918 individual length measurements. Only the herring fishery in ICES division 27.2.a is considered for ASH. Note that there are herring catches in other divisions within the selected trips. These are trips where North Sea herring has been fished with some bycatches of mackerel for example. Atlanto-Scandian herring have a narrow range in the length distributions in the catch. Median lengths have fluctuated between 32 and 36 cm. Average annual fat content for ASH has been between 17 and 20% with individual measurements going up to 25%).

1.5.4.2 Gonad sampling for mackerel and horse mackerel 2019-2020 (WD08)

Working Document 08 summarizes the status of the industry-science collaboration aimed at improving the knowledge on gonad development of mackerel and horse mackerel. The work is based on samples taken by the fishing industry (PFA vessels) on both targeted and by-catches of mackerel and/or horse mackerel. The overall aim of the Year of the Mackerel project is to gain insight in the gonad development of female and male mackerel throughout the year in order to gain improved understanding of the spawning strategy. For horse mackerel, the aim is to investigate the period during which spawning occurred in 2020 for the Western horse mackerel. To date, 1365 individual mackerel and 197 horse mackerel have been sampled (horse mackerel sampling only started in 2020). Preliminary results of the analysis on mackerel are presented in the working document. Final results for mackerel are expected in October 2020 and for horse mackerel in the first half of 2021.

1.5.4.3 Inventory of industry acoustic data for blue whiting (WD07)

Since 2012 the Dutch pelagic industry (PFA) has been engaged in the collection of acoustic data at a large scale. Working document 07 presents an overview of the acoustic data with a focus on blue whiting. Further work will be carried out to (automatically) analyse the acoustic data and couple those results with the PFA self-sampling data. The ambition is to explore the development of an index of abundance from commercial acoustic data that could aid the blue whiting acoustic survey in case of missing surveys or bad weather conditions.

1.5.4.4 Evaluation of a potential rebuilding plan for Western horse mackerel (WD02)

Working document 02 summarises a number of analyses conducted in an attempt to develop a potential rebuilding plan for the Western horse mackerel. Even though western horse mackerel was not classified by ICES as in need of rebuilding in their latest advice (ICES, 2019a), the general perception within the fishing industries has been that the stock has been in a poor state recently although there are some positive signals in recent recruitment. Ensuring that these recent recruitments can lead to improvements in stock status requires a careful management approach. The Pelagic Advisory Council (PELAC) has been a proponent of developing management plans for all stocks in their remit. In the case of Western horse mackerel, the PELAC has adopted a rebuilding plan approach because of the current stock status of the stock. The working document summarizes the progress on horse mackerel stock ID (Farrell et al., 2020), issues around the length compositions in the catch, spawner per recruit analysis, the development of an alternative assessment (SAM) and associated reference points.

A key point in the context of WGWIDE is the evaluation of potential harvest control rules (HCRs) for Western horse mackerel. The HCR analyses represent two different assessment methods (SS3 and SAM) and two different HCR evaluation tools (EqSim and SAM HCR). Both HCR evaluation tools are of the type 'short-cut' with appropriate conditioning of the uncertainties in the assessment based on historical CV and autocorrelation in line with the recommendations from WKMSYREF3 and WKMSYREF4. The evaluations followed the guidelines from WKGMSE2 (ICES, 2019c) and WKREBUILD (ICES, 2020b).

Three different types of harvest control rules were evaluated:

- Constant F strategy: fixed F_{target} independent of biomass level
- ICES Advice Rule: breakpoint at $B_{trigger}$ and linear reduction in F to zero when below $B_{trigger}$.
- Double Breakpoint rule: a breakpoint at $B_{trigger}$ and linear reduction in F to 20% of F_{target} at B_{lim}. Below B_{lim} continued fishing at F = 0.2 * F_{target}.

For each of the HCRs, a number of different F_{target} values were explored (0.0, 0.05, 0.075, 0.1, 0.125, 0.15). No evaluation of different $B_{trigger}$ values was carried out, so that all evaluations used MSY $B_{trigger}$ as the trigger point. All HCRs where evaluated with three variants:

- Without any additional constraints
- With a minimum TAC of 50 kt
- With a maximum 20% inter-annual variation (IAV) in TAC, but only when the stock is above $B_{trigger}$)

Two simulation tools were used: the EqSim simulator and the SAM HCR forecast. The EqSim simulator is a modified version of the SimpSIM approach that was used for the blue whiting MSE in 2016 (ICES, 2016). The code was further developed by Andrew Campbell and Martin Pastoors to improve standardization, documentation and visualization of results. EqSim makes use of an Operating Model (OM) and a Management Procedure (MP). The SAM HCR forecast is a simple stochastic forecast with HCR to evaluate management for fish stocks that need rebuilding in the short-term. The stochastic forecasts start from the currently perceived stock, *i.e.* the assessment estimates currently used for tactical management advice, but incorporating consideration of the uncertainty in these estimates. Rebuilding is evaluated by forward projection for a specified number of years and for different target fishing mortality values.

The EqSim with SS3 results indicate that the constant F strategy is the least cautious rule and the double breakpoint rule is the most cautious rule. Under the F strategy rule with a Ftarget of 0.075, rebuilding to B_{pa} is only just being achieved (probability just above 50%) by 2025, while in the double breakpoint rule this is expected to be achieved in 2024 with substantially higher probabilities of remaining above B_{pa}. The first year of rebuilding to B_{pa} in the double breakpoint rule with target fishing mortalities up to 0.1 is the same as the first year of rebuilding under the zero fishing scenarios.

Similar results have been obtained with the EqSim with SAM evaluations although the levels of SSB are slightly higher and risk to B_{lim} is slightly lower. According to these evaluations, rebuilding to Bpa could be obtained by 2022 in all scenarios.

Given that the EqSim with SS3 evaluation is closest methodologically to the ICES advisory practice, this was used as the basis for the preferred rebuilding plan by the PELAC. The PELAC preferred options are:

- Target fishing mortality at F_{MSY} = 0.074 (approximated by 0.075 in the simulations)
- B_{lim} at ICES B_{lim} (834 480 t)
- $B_{trigger}$ at ICES MSY $B_{trigger}$ (1 168 272 t)
- Double breakpoint rule with 20% constraint on IAV above $B_{trigger}$
- Minimum F when stock is below B_{lim} at 20% of F_{MSY} = 0.015

The selected rebuilding plan has a 50% probability of rebuilding to B_{lim} by 2021 (similar to zero catch option) and a 50% probability of rebuilding to B_{pa} /MSY $B_{trigger}$ by 2024 (similar to the zero-catch option). Furthermore, the probability of being below B_{lim} remains well below 5% for the duration of the simulation. This has formed the basis of the rebuilding plan proposed by PELAC to the EC, with a request to have the evaluation reviewed by ICES.

1.5.4.5 Genetic stock identification of horse mackerel (WD11)

Atlantic horse mackerel is currently assessed and managed as three distinct stocks: the Western, the North Sea and the Southern. Despite the commercial importance of the horse mackerel, the accuracy of alignment of these stock divisions with biological units is remains uncertain. The aims of this study were to identify informative genetic markers for the stock identification of horse mackerel and to estimate the extent of genetic differentiation among populations distributed across the distribution range of the species. For this we used modern sequencing techniques that allowed us to assess genetic variants in the entire genome. We discovered that while the populations differ in a small fraction of their DNA (< 1.5%), such genetic differences are significant as they likely represent natural selection and might be involved in local adaptation. We validated a small fraction of these highly differentiated genetic variants by a SNP assay and demonstrated that they can be used as informative molecular markers for the genetic identification of the main stock divisions of the Atlantic 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 indicate that a further large-scale analysis of samples, with a greater temporal and spatial coverage, with the newly identified molecular markers is required to test and reassess the current stock delineations.

1.6 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 benchmark that took place in January 2017 (ICES 2017a) and NEA mackerel on an inter-benchmark that took place in 2019 (ICES 2019b).

Norwegian spring spawning herring was assessed using the XSAM implementation benchmarked in 2016. A minor update to the historic acoustic survey time series following development of the StoX software was implemented. Data from a juvenile survey in the Barents Sea was unavailable this year (2020) due to technical difficulties with the vessel.

The Blue whiting assessment also used an updated acoustic survey StoX time series. In addition, due to disruption to the survey programme as a result of the COVID-19 emergency, no 2020 survey was conducted. As in 2019, the stock weights in the assessment year were determined from preliminary catch data rather than using the average of the most recent three years.

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

1.7 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. The WG considers that both stocks should be benchmarked in 2022 with considerable scope for development of these assessments.

The current implementation of the Stock Synthesis model for the assessment of Western horse mackerel has been used since the benchmark in 2017. The working group considers that there are sufficient issues in relation to the input data and model configuration and proposes a new benchmark in 2022. In particular, the length frequency information from the commercial catch should be reviewed and expanded to include information from the discarded component (unavailable in 2017). The assessment configuration with respect to the dynamics of the fishery should be reviewed to investigate the inclusion of time varying selectivity and spatial dynamics (multi-fleet). The relative weight of the various data sources should also be reviewed, in particular with regard the use of both ALKs and age composition data. The re-weighting scheme employed should also be explored following model stability issues in 2020. The fishery independent data, in particular the utility of a number of acoustic surveys and the egg survey should be evaluated. Advances with regard to data collected by industry, the development of an alternative assessment model (SAM) and the SS model itself since 2017 should also be considered.

The assessment of Norwegian spring spawning herring makes use of an acoustic survey time series conducted on the spawning grounds in February and March. This survey was not conducted between 2006 and 2014 and, when included in the assessment following the 2016 benchmark exercise, was treated as a single time series despite changes in the survey design on its resumption in 2015. There are now 6 data points the recent time series (2015-2020) and WGWIDE proposes that an inter-benchmark be conducted to investigate the splitting of this survey time series within the assessment. It is also proposed that the inter-benchmark explore the implementation of the assessment within the SAM model (which has been updated and now supports the XSAM model), review and (if necessary) update the MSY and PA reference points and update the stock annex.

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

Stock	Benchmark History	WGWIDE 2020 Proposal
Boarfish	Never benchmarked	Full benchmark
Red gurnard	Full benchmark scheduled 2021 (WKWEST)	
Norwegian Spring Spawning herring	Full benchmark 2016	Inter-benchmark
Western horse mackerel	Full benchmark 2017 Reference point inter-benchmark 2019	Full benchmark
North Sea horse mackerel	Full benchmark 2017	
Northeast Atlantic mackerel	Full benchmark 2014 Full benchmark 2017 Inter-benchmark 2019	
Striped red mullet	Never benchmarked	Full benchmark
Blue whiting	Benchmarked 2012 Inter-benchmark 2016	

1.8 Special Requests to ICES regarding stocks within WGWIDE

During 2020 a request to evaluate long-term management strategies for Northeast Atlantic mackerel using a full feedback approach was considered by ICES (WKMSEMAC, (ICES, 2020c)) with advice released on August 3rd 2020 (https://doi.org/10.17895/ices.advice.7446). The advice identified combinations of F_{target} and $B_{trigger}$ that maximize median annual yield in the long term and simultaneously minimise the risk of falling below B_{lim}. At the time of WGWIDE 2020, the requesting parties had yet to on a candidate set of HCR parameter values and it was therefore not possible to include the corresponding catch option in the draft advice sheet.

1.8.1 Request to ICES from EU, Norway and the Faroe Islands on the long-term management strategies for Northeast Atlantic mackerel (full feedback approach).

The European Union, Norway and the Faroe Islands jointly request ICES to advise on the longterm management strategies on Northeast Atlantic Mackerel. A request is provided below.

ICES is requested to identify appropriate precautionary combinations in the Tables given in its response to the EU, Norway and the Faroe Islands request to ICES to evaluate a multi-annual management strategy for mackerel in the North East Atlantic (ICES 2017), using:

- *A range of Btrigger from two to five million tonnes with an appropriate range of target Fs*
- *A harvest control rule with a fishing mortality equal to the target F when SSB is at or above $B_{trigger}$*

- *In the case that the SSB is forecast to be less than $B_{trigger}$ at spawning time in the year for which the TAC is to be set, the TAC shall be fixed consistently with a fishing mortality that is given by: $F = F_{target}*SSB/B_{trigger}$*

All alternatives should be evaluated with and without a constraint on the inter-annual variation of TAC. When the rules would lead to a TAC, which deviates by more than 20% below or 25% above the TAC of the preceding year, the Parties shall fix a TAC that is respectively no more than 20% less or 25% more than the TAC of the preceding year. The TAC constraint shall not apply if the SSB at spawning time in the year for which the TAC is to be set is less or equal to Btrigger.

The constraint mechanism shall be tested separately from and in combination with 10% banking and borrowing mechanism.

Evaluation and performance criteria

Each alternative shall be assessed in relation to how it performs in the short term (5 years), medium term (next 10 years) and long term (next 25 years) in relation to:

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

The approach should follow the same full feedback methodology that has been recently used to evaluate stocks in the North Sea (ICES, 2019). The evaluation should be conducted to identify options that are robust to alternative operating models including but not limited to:

A. Investigating alternative plausible recruitment dynamics and scenarios,

B. Alternative natural mortality assumptions,

C. The potential impact of density dependent growth.

Following initial consideration of the request by ICES, the requesting parties confirmed that the strategy should also be evaluated with a banking and borrowing scheme representative of recent behaviour. The requesters furthermore confirmed that banking and borrowing should be suspended when SSB is below $B_{trigger}$, and that implications of any future catch scenario that exceeds the advised catch should not be evaluated.

References:

ICES, 2017. EU, Norway, and the Faroe Islands request concerning long-term management strategy for mackerel in the Northeast Atlantic. ICES Special Request Advice. https://10.17895/ices.pub.3031

ICES, 2019. EU and Norway request concerning the long-term management strategy of cod, saithe, and whiting, and of North Sea autumn-spawning herring. In Report of the ICES Advisory Committee, 2019. ICES Advice 2019, sr.2019.06, https://doi.org/10.17895/ices.advice.4895

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

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

Analytical (category 1) type of assessments are available for the four 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 are shown in Figure 1.9.1.

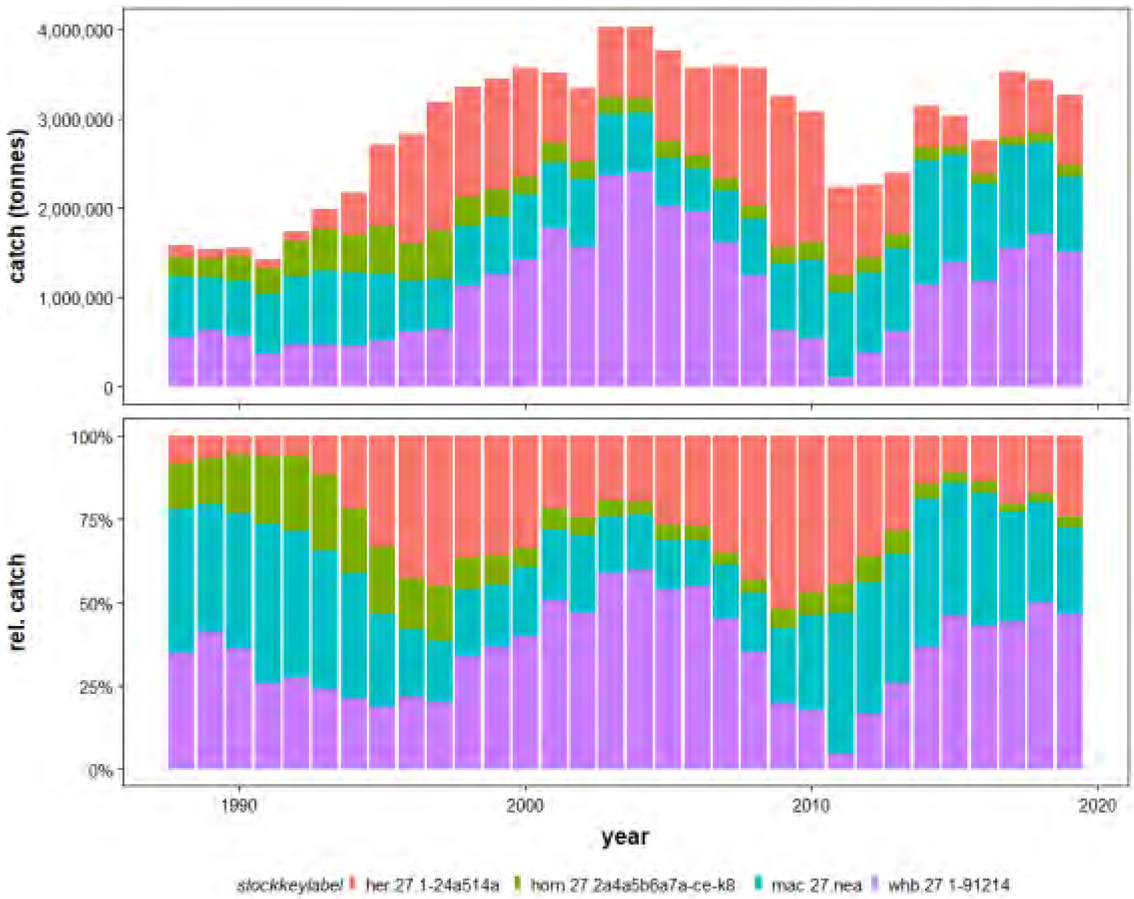

Figure 1.9.1: Catch of mackerel, western horse mackerel, blue whiting and Norwegian spring spawning herring

The trends in SSB of the four stocks are shown in Figure 1.9.2, first in historical perspective (assessments 2017-2020) with the uncertainty estimates from the most recent assessment, then for the current assessment (2020) in absolute biomass (tonnes) and in relative proportions. At the maximum, the total pelagic biomass of these species has been just above 15 million tonnes. In 2019, the pelagic biomass is estimated to be around 13.5 million tonnes. The relative contributions of Norwegian Spring-spawning herring and Western horse mackerel has decreased in recent years while blue whiting and Northeast Atlantic mackerel have increased.

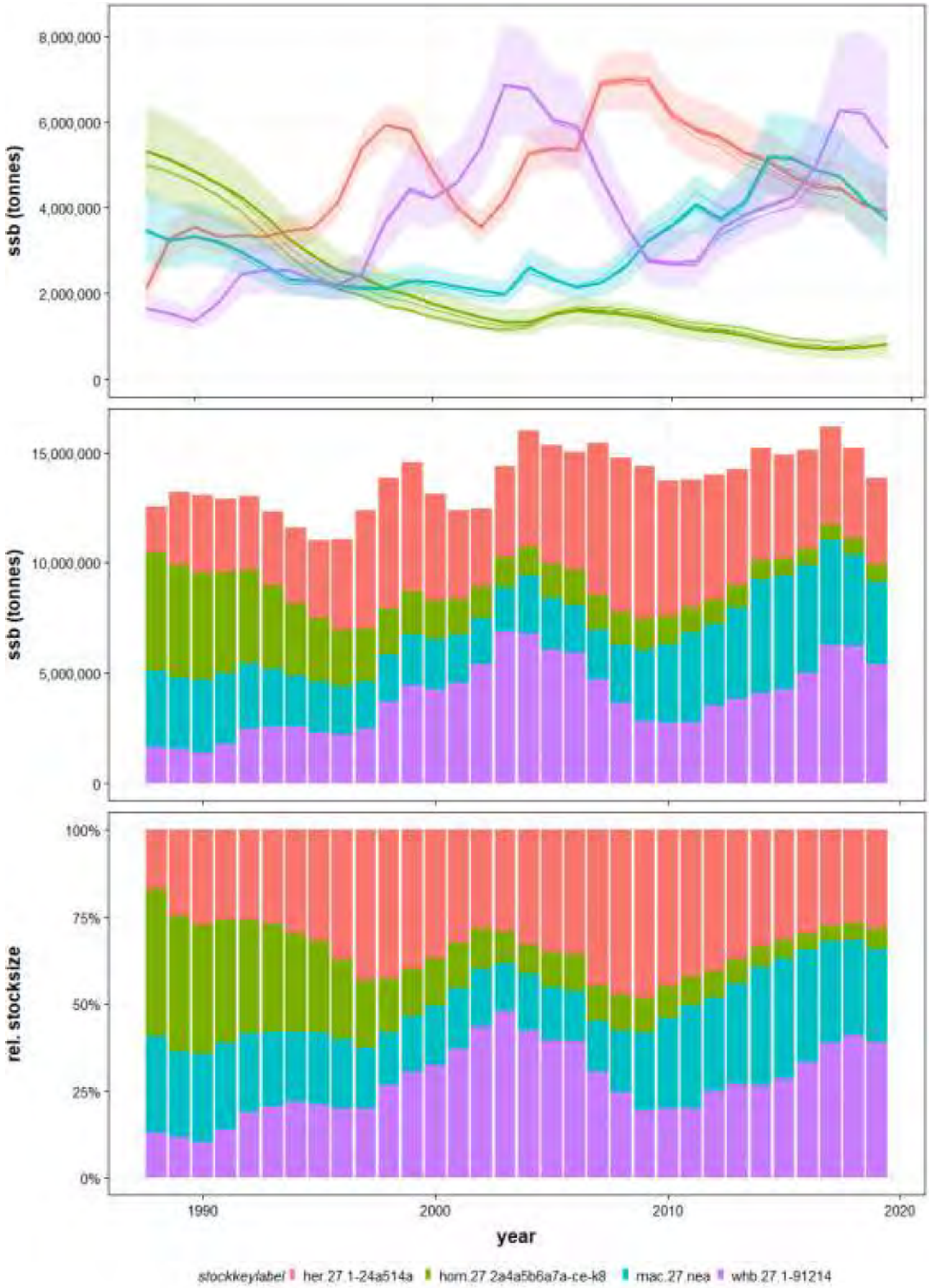

Figure 1.9.2: SSB of mackerel, western horse mackerel, blue whiting and Norwegian spring spawning herring. The top figure has the most recent assessment in bold and with confidence intervals and the two previous estimates. The bottom two graphs refer only to the most recent assessment.

An overview of the key variables for each of the stocks (stock size, fishing mortality and recruitment), in historical perspective (assessments 2017-2020) with the uncertainty estimates from the most recent assessment, is shown in Figure 1.9.3. From these comparisons it can be concluded that the fishing mortality of mackerel and blue whiting has generally been higher than the fishing mortality of horse mackerel and herring. Recruitment levels of blue whiting and herring are on a comparable scale and substantially higher than horse mackerel (except for the 1982 year-class) and mackerel. Biomass trends of the different stocks are somewhat on the same level but show very different tendencies.

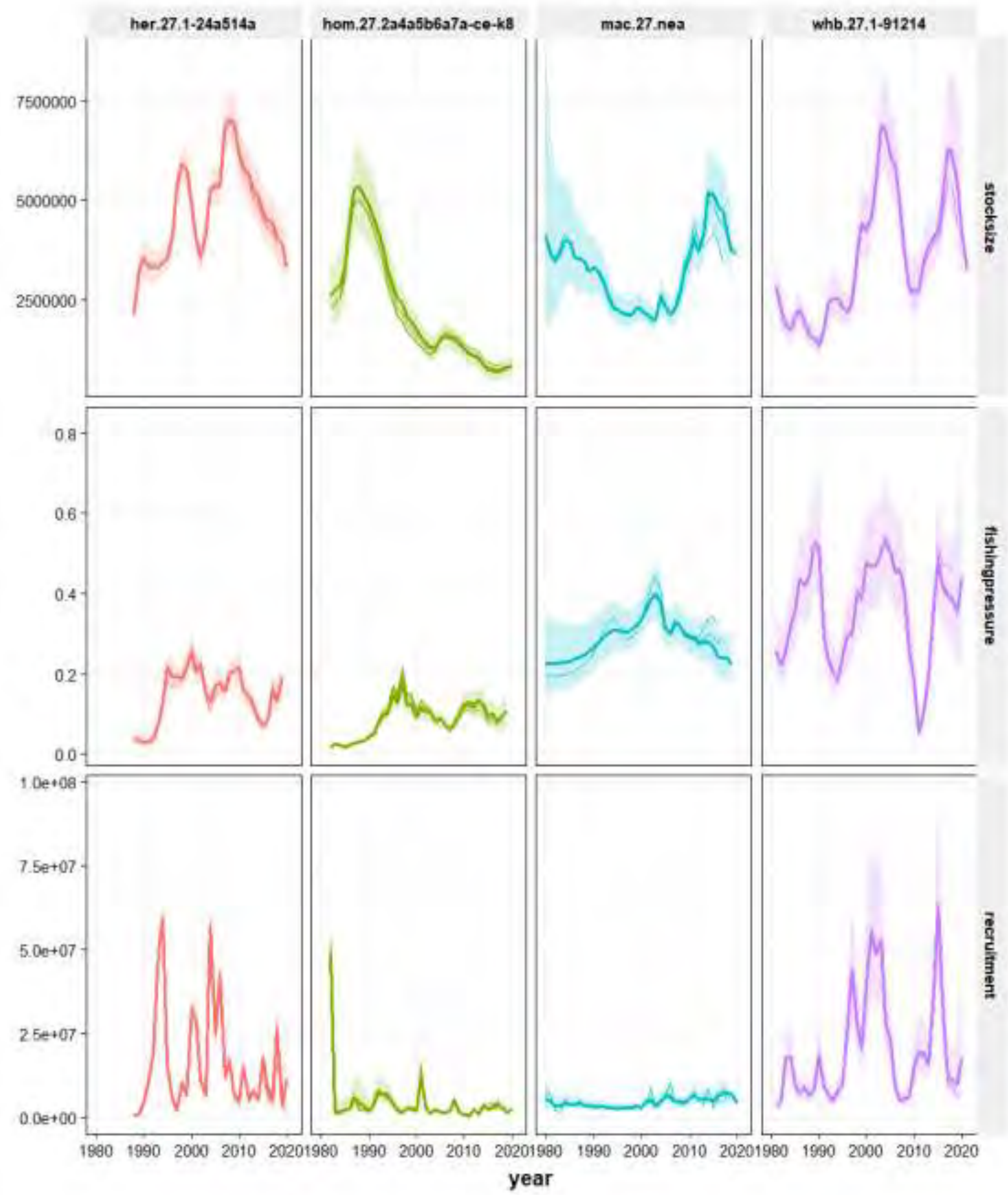

Figure 1.9.3: SSB of mackerel, western horse mackerel, blue whiting and Norwegian spring spawning herring

An overview of stock weight at age for mackerel and blue whiting is shown in figures 1.9.4 and 1.9.5. 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.

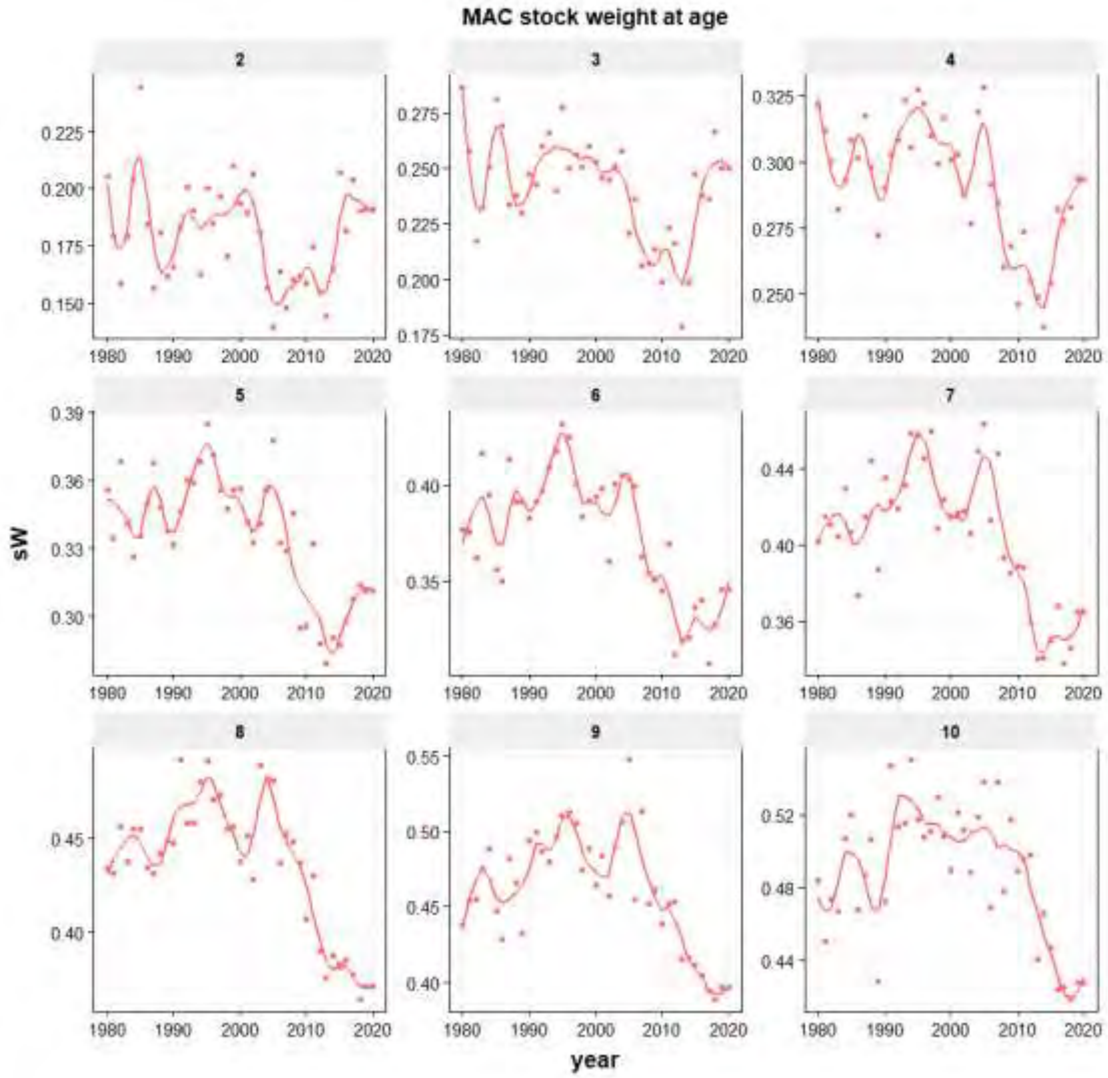

Figure 1.9.4: Stock weight at age of NEA mackerel

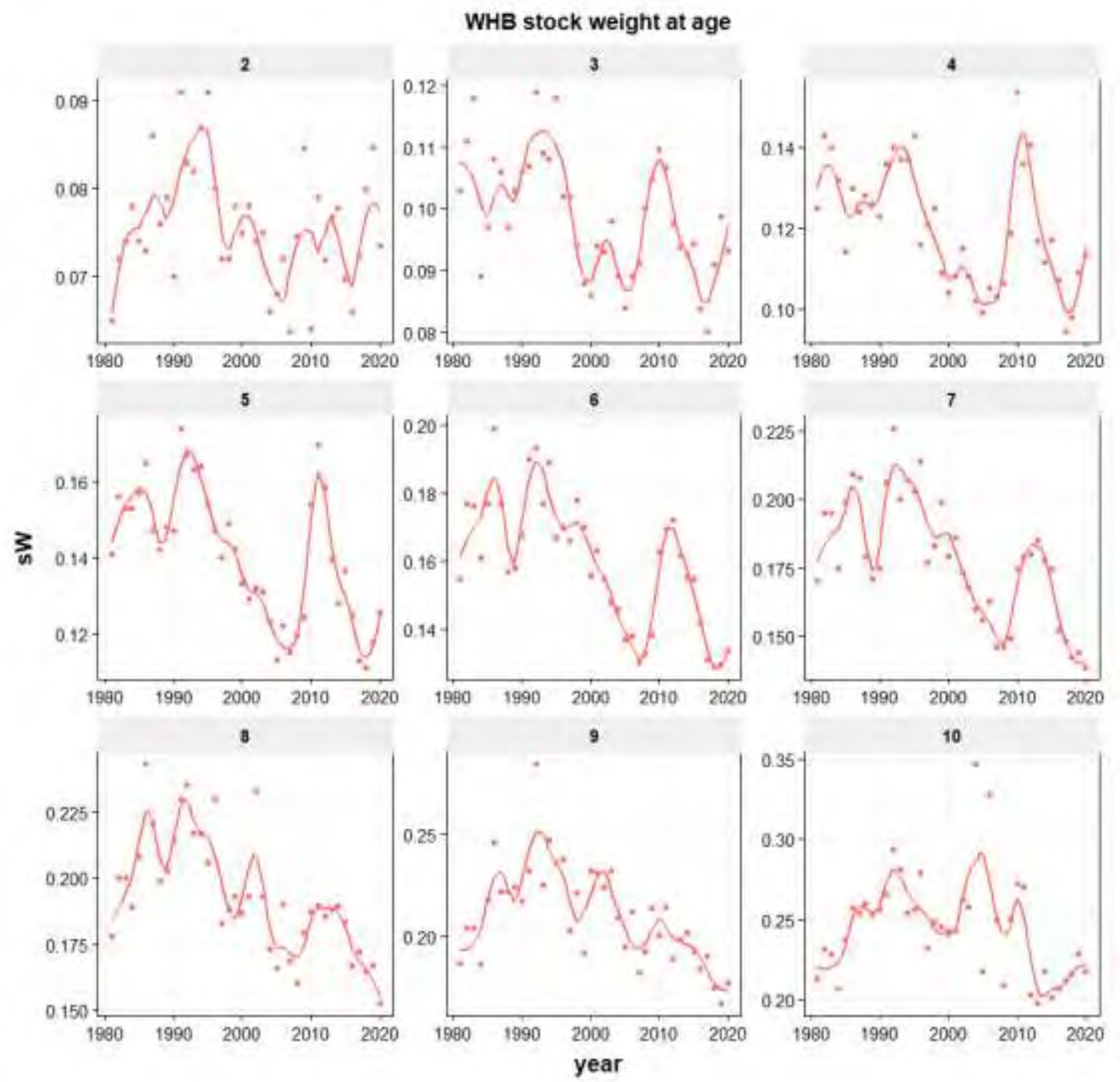

Figure 1.9.5: Stock weight at age of blue whiting

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 a WG estimate of total catch per 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. 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 (HOM) and 1998 (MAC). The time series for herring and blue whiting are shorter (starting in 2011) although additional information could still be derived from earlier WG reports.

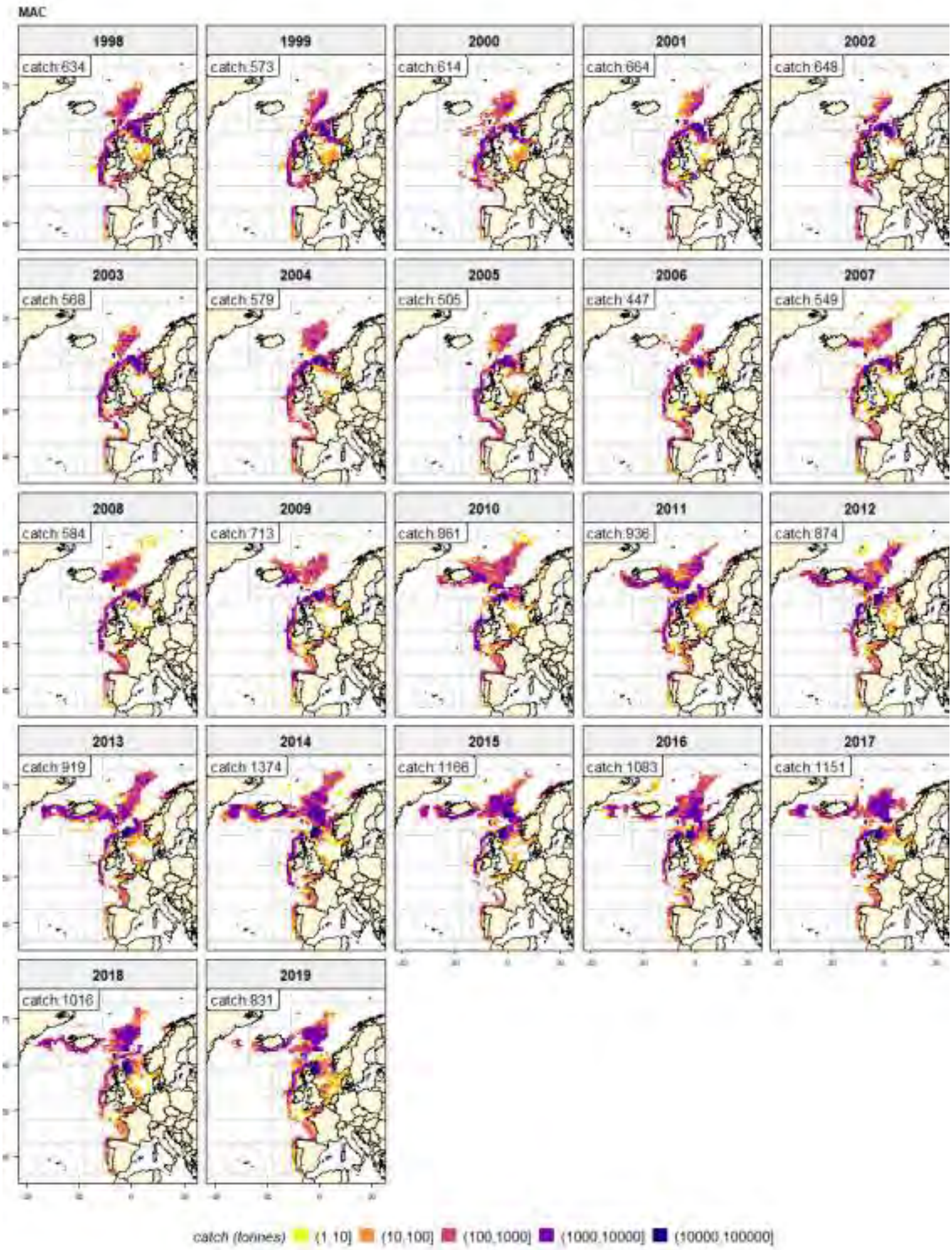

Figure 1.9.6: Catch of mackerel (tonnes) by year and rectangle. Catch by rectangle data do not represent the official catches and cannot be used for management purposes. In general, the total annual catches by rectangle are within 10 % from the official catches.

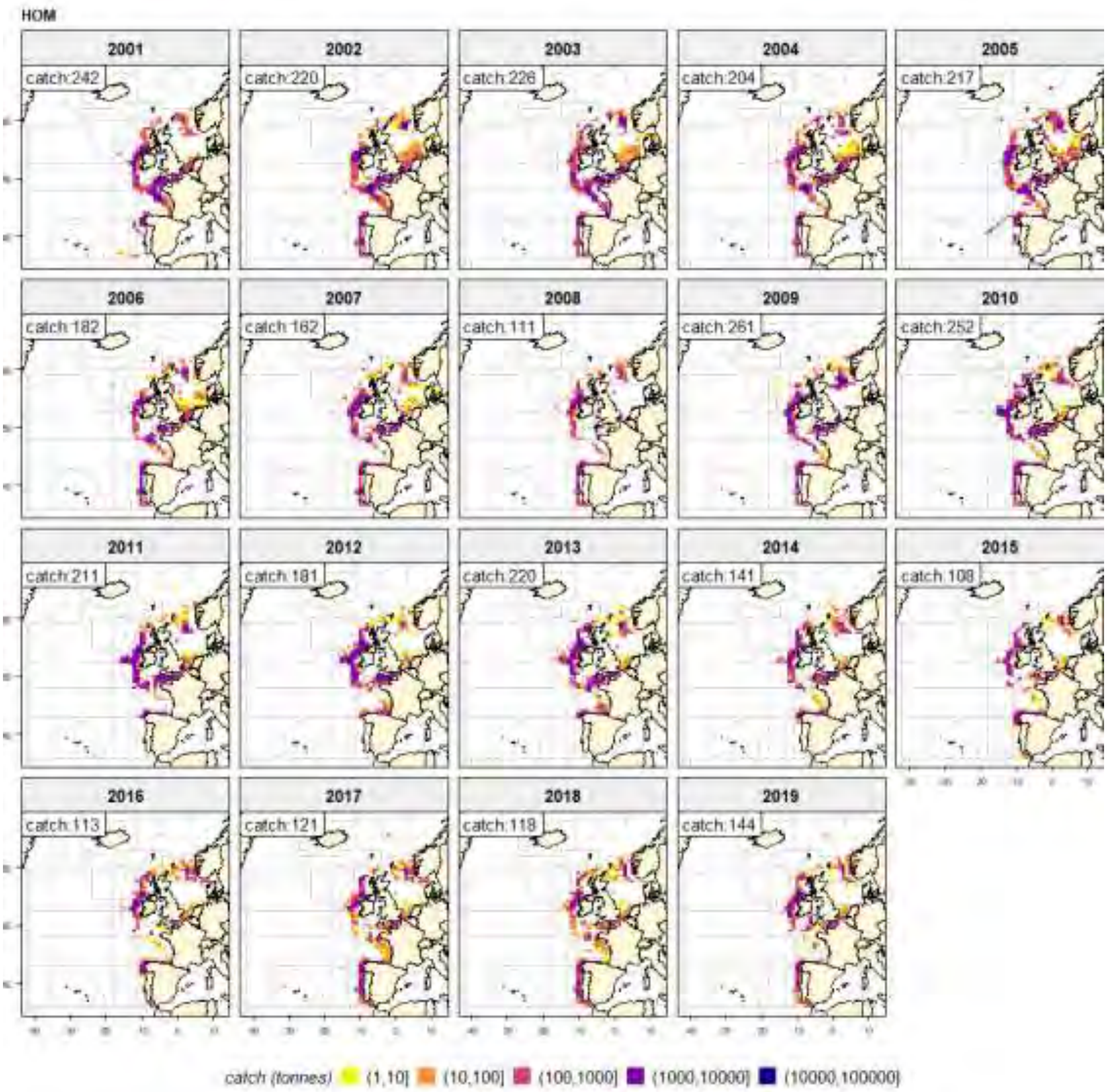

Figure 1.9.7: Catch of horse mackerel (tonnes) by year and rectangle. Catch by rectangle data do not represent the official catches and cannot be used for management purposes. In general, the total annual catches by rectangle are within 10 % from the official catches.

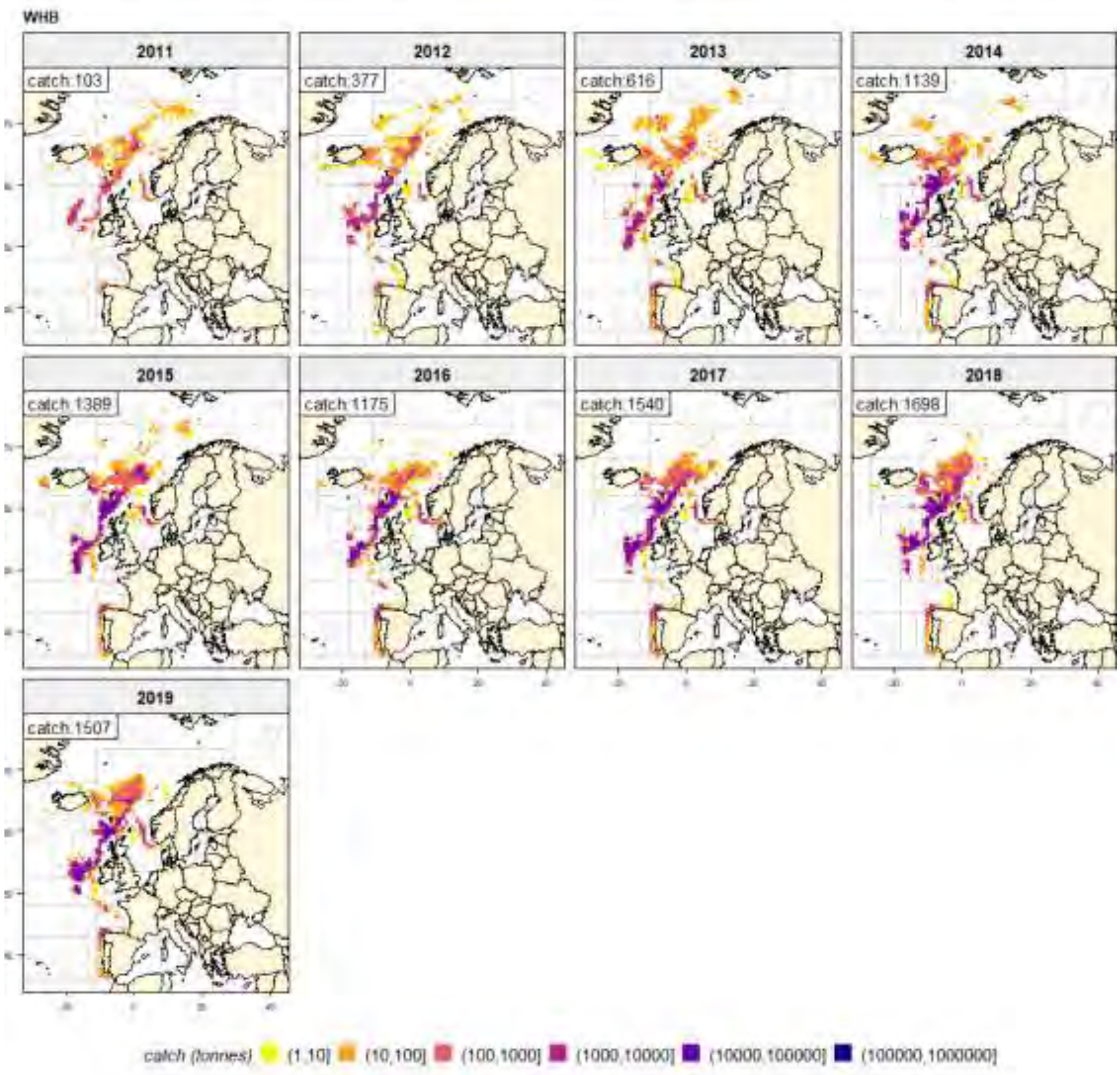

Figure 1.9.8: Catch of blue whiting (tonnes) by year and rectangle. Catch by rectangle data do not represent the official catches and cannot be used for management purposes. In general, the total annual catches by rectangle are within 10 % from the official catches.

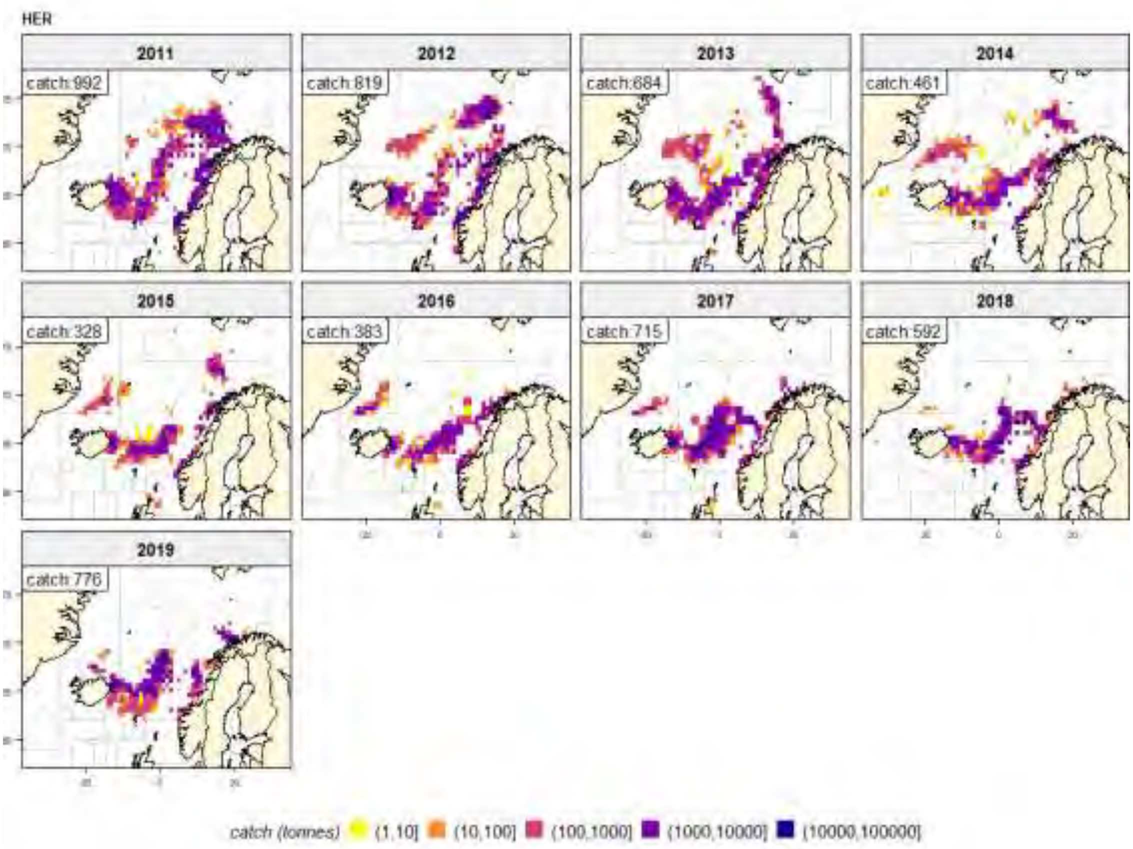

Figure 1.9.9: Catch of Norwegian spring-spawning (Atlanto-scandian) herring (tonnes) by year and rectangle. Catch by rectangle data do not represent the official catches and cannot be used for management purposes. In general, the total annual catches by rectangle are within 10 % from the official catches.

1.10 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 2018a), and hopefully other relevant Integrated Assessment groups within ICES in the near future, will help in operationalizing ecosystem approach for the widely distributed pelagic stocks assessed by WGWIDE. The text below was largely provided by WGINOR (ICES 2016e; 2018a; 2019a).

1.10.1 Climate variability and climate change

The North Atlantic Oscillation (NAO) corresponds with the alternating periods of strong and weak differences between Azores high and Icelandic low pressure centres. Variations in the

NAO influence winter weather over the North Atlantic and have a strong impact on oceanic conditions (sea temperature and salinity, Gulf Stream intensity, and wave height). The 2015 winter NAO index was high, and simultaneously cold/freshwaters on the Canadian site of the Atlantic that winter and spring because of increase advection resulted in relative low temperatures in the Sub Polar Gyre (SPG) and low temperatures at all depths in 2015 in the large part of the Northeast Atlantic in comparison to the 20-year long-term mean (ICES, 2015). The NAO index has been positive throughout the period 2014-2018. Such an extended period without the NAO index changing sign is very unusual. The last comparable period during which the NAO index was consistently positive was in the period 1992–1995.

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

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

1.10.2 Circulation pattern

The circulation of the North Atlantic Ocean is characterized by two large gyres: the Subpolar Gyre (SPG) and subtropical gyre (Rossby, 1999). When the SPG is strong it extends far eastwards bringing cold and fresh Subarctic water masses to the NE Atlantic, while a stronger SPG allows warmer and more saline subtropical water to penetrate further northwards and westwards over the Rockall plateau area. Changes in the oceanic environment in the Porcupine/Rockall/Hatton areas have been shown to be linked to the strength of the Subpolar Gyre (Hátún *et al.*, 2005). The large oceanographic anomalies in the Rockall region spread directly into the Nordic Seas, regulating the living conditions there as well as further south. Such changes are likely to have an impact on the spatial distribution of spawning and feeding grounds and on migration patterns of widely distributed pelagic fish species.

1.10.3 Recent trends in oceanography and zooplankton in Norwegian Sea

The time-series of ocean heat content in the Atlantic Water of the Norwegian Sea starting in 1951 show that the recent warm period continues (Figure 1.11.1). However, during the last two years, 2017 and 2018 the basic covariance between cold/fresh and warm/salt condition are lost (Figure 1.11.1). Instead, the situation is now that the temperature is still relative warm, but that the salinity has a marked decrease. For example, the salinity in 2018 in the Svinøy section, was the lowest value since "The Great Salinity Anomaly" of the late 1970s (ICES 2019a).

The changes in the Norwegian Sea in 2017 and 2018 with relative warm but with low salinity are unusual. This affects the vertical stability of the water column, of importance both for biological production and as well as for the conversion to denser water that contribute to the large-scale thermohaline circulation. Observations upstream in the North Atlantic Current, in the Icelandic Basin, in 2016 and 2017 show a prominent freshwater anomaly (about -0.1 in salinity). Under the assumption that circulation patterns do not change, this situation with anonymously fresh Atlantic water in the Norwegian Sea is expected to continue and even increase in the coming years. Although the temperature upstream in the Atlantic is also relatively low in the period 2013-2017, this has been compensated by reduced heat loss inside the Norwegian Sea, linked to a coincidence with the positive NAO index. If, on the other hand, we get a winter with a negative NAO index, we can expect a decrease in the temperature in the Norwegian Sea. However, this is not very predictable because the atmosphere is largely stochastic on time scales beyond about 5-10 days (ICES 2019a).

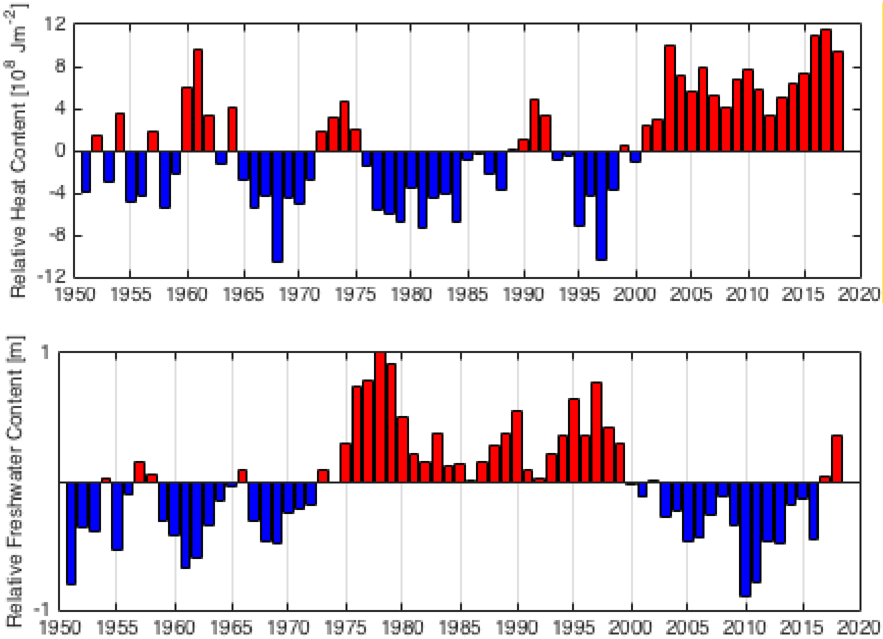

Figure 1.11.1. Time-series of anomalies of heat content (upper panel) and salinity (lower panel) of and the Atlantic waters in Norwegian Sea for the years 1951–2018(ICES 2019a).

The zooplankton plays an important role in the epipelagic ecosystem of the Norwegian Sea by transferring energy from the phytoplankton to higher trophic levels. The time-series of mesozooplankton biomass in the Norwegian Sea from the International Ecosystem Survey in Norwegian Sea (IESNS) in May shows strong long-term variability (Figure 1.11.2). Following a period with high biomass from mid-1990s to early 2000s, the biomass declined to minimum in 2006. From 2010 the downward trend reversed, and the biomass may have increased after that. Interestingly, all areas show the same long-term trend, however the area east of Iceland had a longer high-biomass period and the decreasing trend started a few years later than the other areas. The biomass has been at about the same level for all the sub-areas the last three years (between 6 and 12 gm^{-2})

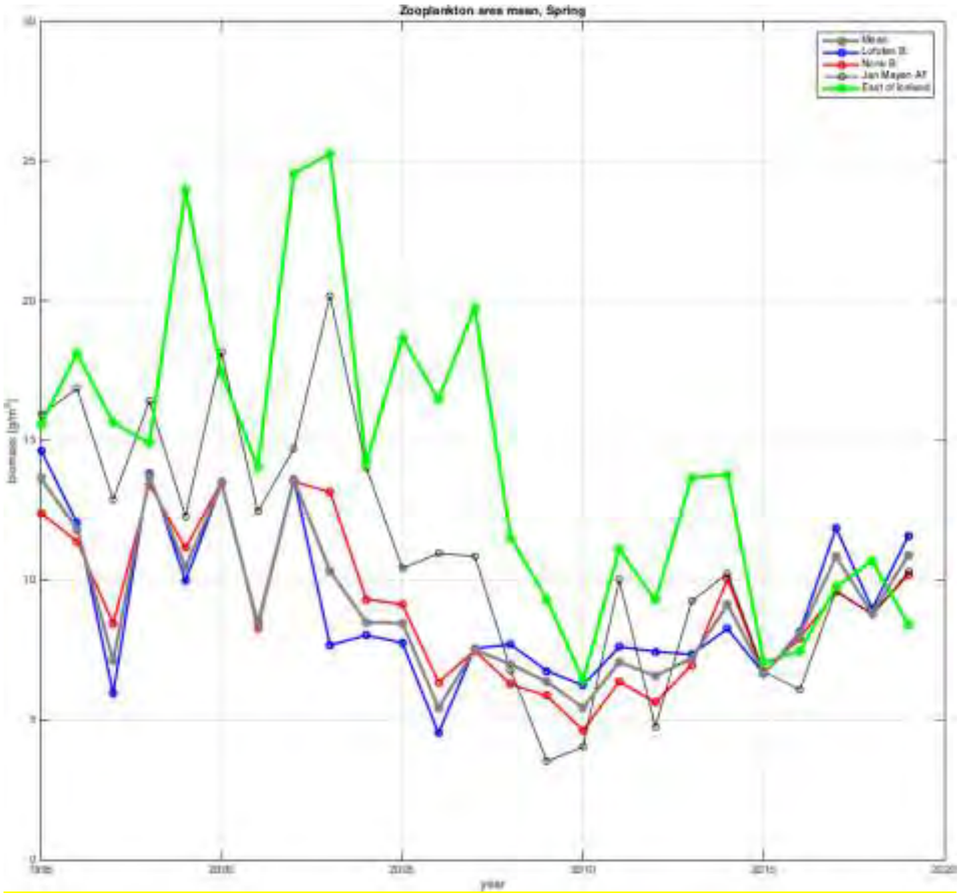

Figure 1.11.2. Indices of zooplankton dry weight (g m^{-2}) sampled by WP2 in May in different areas in and near Norwegian Sea from 1995 to 2019 as derived from interpolation using objective analysis utilizing a Gaussian correlation function (ICES 2019b; see details on methods and areas in ICES 2016a).

1.10.4 Species interactions

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

The Norwegian Sea and adjacent waters are the main summer feeding grounds for the three main small pelagic fish stocks (NSS herring, blue whiting and NEA mackerel; Skjoldal *et al*., 2004; Langøy *et al.* 2012; ICES 2018b). The three stocks are able to adapt their feeding strategy to different conditions, including herring preying in cold water masses, where they show significantly higher feeding incidence and stomach fullness (Bachiller *et al*. 2016). In the later years the geographical distribution overlap between mackerel and herring has been most pronounced in the south-western part of the Norwegian Sea. In 2018 there was very little overlap between mackerel and NSS herring in the central Norwegian Sea (ICES 2019a).

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

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

1.11 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.

1.11.1 NEA Mackerel

In 2019, the ICES Workshop on a Research Roadmap for Mackerel (WKRRMAC, (ICES, 2019f)) 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 which are summarised below (see report of WGWIDE 2019 (ICES, 2019) for additional discussion).

1. Identification of funding mechanisms to improve research capability
2. Investment in and improved co-ordination of available fisheries science expertise, in particular with respect to stock assessment modelling via improvements in collaboration, documentation, training and upskilling.
3. Evaluate management and advisory mechanisms that result in robust, quality assured advice. The rollout of the Transparent Assessment Framework by ICES is an important step in improving quality assurance. A number of WG members have attended ICES

TAF workshops and a number of the stocks assessed by WGWIDE have been trialled in TAF in preparation for full implementation. In addition, WGWIDE recommends the collection of appropriate data and the development of a framework to explore the impacts of uncertainties in assessment inputs (sampling, ageing) and improved documentation for sampling and survey procedures.

4. Explore which surveys contribute the strongest signal into the stock assessment, and reconcile survey information. The SAM assessment currently uses information from 4 separate fishery independent indices (swept area survey, egg survey, tag returns and a recruitment index). The model parameter values and diagnostic leave one out analysis indicates that the relative contribution and influence of each survey on the assessment in recent years has varied due to a number of potential factors including the length of the individual time series the number of data points within each data series and the survey estimates. Additional research is required to investigate the relative weighting of each survey series by the assessment model, to improve process knowledge and investigate contradictory survey indices.
5. Explore the expansion of existing surveys to seasons and areas currently not covered. At its 2020 meeting WGIPS (ICES, 2020a) considered a recommendation from WGWIDE 2019 to consider the feasibility of a southern expansion of the IESSNS. They concluded the existing surveys (HERAS and WESPAS) conducted in July do not currently have the operational capacity to include surface trawling effort alongside the current (acoustic) programme such that additional vessel capacity would be required. July surveys have been conducted in the area in question for several years. Experience indicates that the appropriateness of estimating mackerel abundance on the basis of a surface trawl requires further investigation as mackerel has been encountered at a range of depths over the survey area. Existing acoustic, haul, camera and hydrographic data series from these surveys should be explored (*e.g.* using the most recent developments in acoustic algorithms) to further investigate both the feasibility of the swept area method in this area and the potential of the acoustic data. With regard to the other surveys, the expansion of tagging and scanning into areas not currently covered should also be explored.
6. Further extend the winter acoustic survey time series.
7. Build mechanisms to incorporate industry sampling of biological information into the formal stock assessment process. The contribution of industry data to the WG has continued this year although the mechanisms for incorporation of the this in a quantitate manner in the stock assessment requires further development.
8. Develop approaches to formalise the flow of information of industry perceptions of the state of the stock and the fishery into the assessment process. The process for the submission of information from industry has changed this year with stakeholders requested to submit information in advance of the working group.
9. Develop methods for industry surveys that maintain credible methods and scientific rigour.

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). The workshop will review available information from appropriate methods to infer the stock structure of NEA Mackerel. The draft ToRs for the workshop are detailed in annex 2.

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1.11.2 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.

1.11.3 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.

There are a number of other issues (not proposed for the inter-benchmark) that should be considered in future

The relevance of 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.

Request and incorporate within the assessment information on the uncertainty in catches from all countries submitting catch data (currently only available from Norway).

1.11.4 Western Horse Mackerel

Considering the potential of mixing between Western and North Sea horse mackerel occurring in Division 7.d and 7.e, 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 present it is not yet possible to separate the two stocks when they occur in mixed samples. Therefore, a follow-up project has been initiated to carry out a full genome sequencing of horse mackerel which will allow for future analysis of mixed samples. Results are expected in 2020.

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.

1.11.5 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 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 will be able to reveal the stock identity of individual horse mackerel caught in potential mixing areas. Horse mackerel samples from Division 7.d and 7.e will be collected by the PFA on board of commercial vessels in the Autumn of 2020, while horse mackerel from Division 4.a will be 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.

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, several hundred age readings have not been uploaded to InterCatch since 2012/2013. This information should be uploaded in order to increase (the currently low) confidence in the estimates of catch-at-age.

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

1.11.6 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 should also be explored.

At WGWIDE 2018, an issue list was prepared for the stock and it still applies for potential benchmark in 2022.

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