WORKSHOP ON A RESEARCH ROADMAP FOR MACKEREL (WKRRMAC)

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WORKSHOP ON A RESEARCH ROADMAP FOR MACKEREL (WKRRMAC)

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i   Executive summary

Fisheries managers, researchers and fishers participated in the ICES Workshop on a Research Roadmap for Mackerel (WKRRMAC) co-chaired by Carl O'Brien (UK) and Mark Dickey-Collas (ICES) at its meeting held in Bremerhaven, Germany on 7–9 May 2019. The main aim of the workshop was to produce a roadmap for the delivery of future research needs for the management of fisheries on mackerel in the Northeast Atlantic. The fishery is one of the biggest in the North Atlantic, with first sale value over €1 billion, and recent catches of approximately 1 million tonnes.

The workshop was convened to address the challenges to the evidence base for the provision of ICES advice and took place against a backdrop of another revision to the fishing opportunities advice which resulted from an inter-benchmark review of the performance of the stock assessment model earlier in 2019. The output of the workshop is a list of suggested further research and methods intended to improve the evidence base for the fisheries management of mackerel. The list is pragmatic and operational; and addresses the data and knowledge needs and the resourcing.

Participants had to consider the trade-offs between resourcing and the quality of science. The time-line for the proposed research and application of the findings is the next 3-5 years. The workshop felt that either a reapportioning of resources or an increase in resources was necessary to improve the science evidence base. Greater industry/science partnerships were seen as important approaches to improving the evidence base. Overall, ICES needs improve the quality assurance of ICES assessments, forecasts and advice.

The workshop felt that the development of new ideas to support research and fisheries advice for Northeast Atlantic mackerel should be explored. There is a need for an analysis of what key skills/expertise is missing from the research community. Various models to invest in expertise were discussed including industry funded research positions and industry/academic partnerships.

This workshop report should be considered the Chairs' summary and synopsis of the workshop but the text has been written in a manner to highlight where issues had full support of all participants, and where some only partial support.

The key recommendations of the workshop were:

1. Explore new funding mechanisms of research for the management the fishery and invest and better coordinate building fisheries science expertise.
2. Evaluate management and advisory mechanisms that will result in more robust, quality assured advice on optimised yield (the trade-off between MSY and stability in TAC).
3. Explore which surveys contribute the strongest signal into the stock assessment, and reconcile survey information.
4. Where relevant, explore expanding existing surveys to seasons and areas they currently do not cover.
5. Extend the winter acoustic survey time series and contribute ship time and researchers to these efforts.
6. Build mechanisms to incorporate industry sampling of biological information into the formal stock assessment process and develop approaches for formalising the flow of information of industry perceptions of the state of the stock into the assessment process.
7. Develop credible methods for industry surveys.

ii Expert group information

Expert group name	The Workshop on a Research Roadmap for Mackerel (WKRRMAC)
Expert group cycle	Annual
Year cycle started	2019
Reporting year in cycle	1/1
Chair(s)	Carl O'Brien, UK
	Mark Dickey-Collas, ICES
Meeting venue(s) and dates	7–9 May 2019, Bremerhaven, Germany

1   Introduction

Fisheries managers, researchers and fishers were invited to participate in the ICES workshop on a research roadmap for mackerel (WKRRMAC). The objective of the workshop was to produce a roadmap for the delivery of future research needs for the management of fisheries on mackerel in the NE Atlantic. The workshop took place over three days and was hosted by the Thünen Institute of Sea Fisheries, in Bremerhaven, Germany. The fishery is one of the biggest in the North Atlantic, with first sale value over €1 billion, and recent catches of approximately 1 million tonnes.

Figure 1.1. The participants of WKRRMAC on day 1 of the workshop (Annex 1).

1.1 Background

Since 2013, in addition to the regular annual cycle of advice for the management of the fisheries on Northeast Atlantic mackerel, there have been changes almost every year to the fisheries advice, due to revisions, corrections or changes to management (Table 1.1). This was considered a failing by ACOM (the ICES Advisory Committee) and WKRRMAC was set-up to help improve the evidence base and approach for the advice.

Table 1.1 Changes to mackerel fisheries advice from ICES since 2013.

Year	Issue
2013	Assessment method (ICA) rejected – historical catches uncertain
	Advice for 2014 based on precautionary approach (≤ 889,886 t)
2014	**Benchmark** - New assessment method (SAM) – down-weighed historical catch data, included swept area survey (IESSNS), IBTS and tagging data
	Advice for 2014 revised based on MP (927,000 – 1,011,000 t)
	Advice for 2015 based on MP (831,000 – 906,000 t)
2015	Advice for 2016 based on MSY (≤ 667,385 t)
	Advice in response to Coastal State request on LMP – reference points, F_{target}
	Advice in response to Coastal State request on management of mackerel - F_{range}
2016	Advice for 2016 revised (≤ 773,846 t) – IBTS recruitment index used incorrectly
	Advice for 2017 based on MSY (≤ 944,302 t)
2017	**Benchmark**, estimating lower SSB and higher F in recent years
	MSE of EU/Faroes/Norway management plan
	Advice for 2017 revised (≤ 857,185 t) – IESSNS index incorrectly calculated
	Advice for 2018 based on MSY (≤ 550 948 t)
2018	Downward revision of SSB in 2016 & 2017 but within confidence of 2017 assessment.
	Request for inter-benchmark as issues with model performance & tagging data.
	Advice for 2019 based on MSY (≤ 318,403 t)
2019	Advice for 2019 is revised upwards (≤770 358 tonnes) due to adaption of method proposed by an **inter-benchmark**. Advice for 2019 based on MSY.

The workshop was convened to address the challenges to the evidence base for the provision of that advice (Annex 2). It took place against a backdrop of another change to the fishing opportunities advice, resulting from an inter-benchmark review of the performance of the stock assessment model in 2019.

The output of the workshop is a list of suggested further research and methods that are thought to improve the evidence base for the fisheries management of mackerel. The list is pragmatic and operational; and addresses the data and knowledge needs and the resourcing. Participants had to consider the trade-offs between resourcing and the quality of science. The time-line for the proposed research and application of the findings is the next 3-5 years. Participants were asked to consider resourcing from international and national/administration projects, industry partnerships, PhDs, postdocs etc.

1.2   Methods and approach

The workshop was framed around two main activities:

1. Addressing questions or statements relevant to the provision of the evidence base for fisheries management in subgroups and through plenary discussion.
2. Invited statements and presentations relevant to the general discussion given to plenary.

Subgroup work.

The subgroups were designed to be comprised of a mix of managers, researchers and fisheries representatives. The subgroups addressed various questions and statements throughout the three days, reporting back to plenary after each discussion. The subgroups lasted just over an hour. Four subgroups, with the same membership throughout the workshop, had 8- 10 participants. A rapporteur was chosen to report back to plenary after each session (see Annex 3 for the agenda). The work was aimed to set the context, review the challenges and then suggest improvements to the provision of fisheries advice (Figure 1.2).
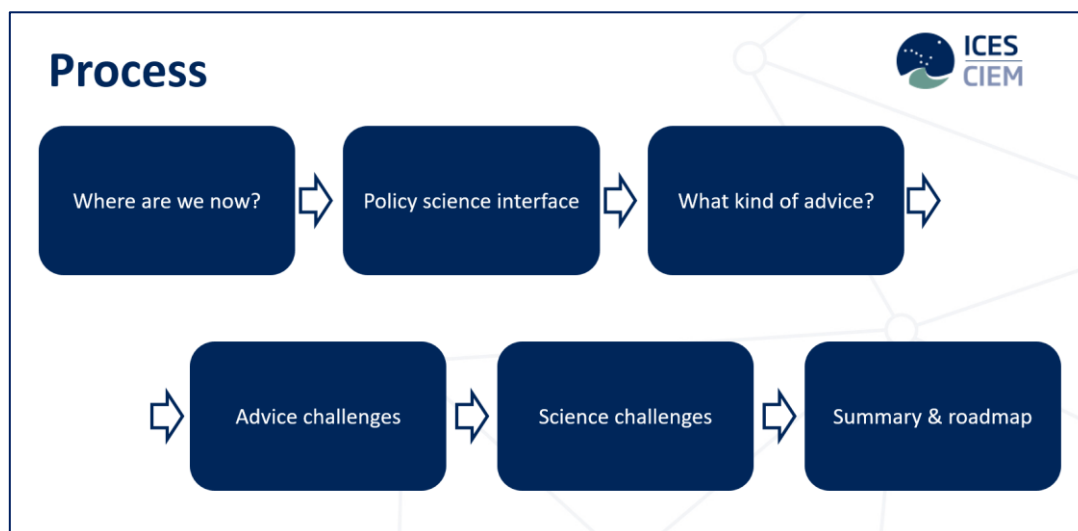
Figure 1.2. Subgroup process on questions or statements relevant to the provision of the evidence base for fisheries management.

Invited statements and presentations

Managers from Coastal States, representatives of fishers and researchers were invited at various stages in the meeting to make statements on their views and work. These statements were encouraged to be candid. The presenters were invited and briefed before the workshop. The presentations took place at the opening of the workshop and the close of the workshop (from both managers' and fishers' representatives), and in the middle of the workshop (from researchers and advisers).

1.3   ICES code of conduct/conflict of interest

WKRRMAC is seen as a scoping workshop and participants are expected and encouraged to speak from their own experiences and positions. Thus this workshop is considered to be covered by the code of conduct as '*ICES may run meetings which are intended to solicit stakeholder views. For these meetings, … participants will be asked to represent specific professional interests*.'

1.4 Nature of consensus in this report

The workshop was tasked with developing a research roadmap for mackerel. This report should be considered the Chairs' interpretations of the workshop. Most of what is documented was agreed by the participants of the workshop during plenary. However, some issues did not receive full consensus agreement; e.g. the nature of text about 'ecosystem approach' in the policy-science interface section (3), nor the nature of the text about 'cost benefit analysis' in the science challenges section (5). The text has been written in a manner to highlight when some issues had full support, and some only partial support.

1.5 Scope of the workshop

The workshop was designed to address the evidence needs for ICES for the provision of fishing opportunities advice (catch). There are many issues that challenge the fisheries and management of Northeast Atlantic mackerel (e.g. zonal attachment, marketing, sustainability accreditation, catch sharing). The workshop agreed that its work would only focus on evidence needs for the ICES advice. Some freedom was given to aid discussion when issues outside the scope were raised in the subgroups or plenary, but the workshop agreed that the main drive, and the workshop report should only reflect the discussions within the scope of evidence needs to improve ICES advice.

2 Where are we now?

Managers (EU, Norway and the Faroe Islands) and fisheries representatives (from the EU Pelagic AC and Norway) were invited to make a statement to open the workshop. They were asked to address two questions:

1. What evidence is required to manage the Northeast Atlantic mackerel fishery?
2. Is the advice robust for long-term fisheries management?

The invited statements emphasised that management of the fisheries on Northeast Atlantic mackerel is through a voluntary, loose coastal states framework. Management plans are owned by the managers, and evaluation of plans by scientists against objectives and criteria is important. Instability and fluctuations are a key natural property of fish stocks but the advice needs more stability than has recently occurred. There is a perception that the scientific advice adds to the uncertainty that managers and fishers face. Mackerel advice in the past was more stable, but perhaps 'less right'. More resources are needed for analysis and assessment. If the advice is considered too poor to be delivered, ICES should not necessarily give poor advice, 'parking the advice' could be appropriate in some circumstances.

The temporal and spatial distribution and coverage of the surveys relative to that distribution should be addressed. There may be a need to consider the trade-off between the information provided by each of the surveys, and how effective each survey is as evidence for the stock assessment. Substantial progress has been made in recent years, with the incorporation of more survey indices into the stock assessment model.

Every speaker concluded that the current advice was **not robust** enough, with frequent revisions, volatile stock assessments and unpredictable advice. The 2018 advice highlighted concern about the performance of the model, and yet the advice was still published. One speaker noted that concerns about the model were raised in 2017, and clearly stated in 2018 (leading to the review of methods), so the process appeared to work, but at too slow a pace.

This was against a backdrop of the fishing industry vociferously reporting that they did not recognise the trends in the stock being advised by ICES. One participant said that there is "… a need to hear the voices from the sea". The advice sheet hides the quality of the advice section away from the main headline advice.

3   Policy-science interface

Researchers do not determine management objectives, however they need to be informed of the needs of managers and the expectations of fishers. Societally-determined management objectives are used by scientists to evaluate strategies for fisheries management; to assess the current situation relative to those objectives and to determine the likelihood of successful delivery of those objectives. The workshop explored and listed, through subgroup work and plenary discussion, the key management objectives for the Northeast Atlantic mackerel fishery with the aim of informing researchers.

Figure 3.1. Word cloud of management objectives suggested by the subgroups.

After plenary consideration of the subgroup suggestions, the workshop constrained the management objectives to a few concepts:

- Optimisation of yield: this phrase recognises that there is a trade-off between the MSY objective and inter-annual stability in the TAC. Both MSY and stability in TAC were seen as the key objectives for fisheries management, and it is unlikely that both can be maximised simultaneously, thus an optimisation is required.
- Understanding trade-offs between short- and long-term objectives: that the management objectives reflect the short- and long-term expectations of society and fishers.
- A consideration of the impact of the fishery on the ecosystem, and the impact of the ecosystem on the fishery: the workshop could not further refine this objective. Some felt that it was a key component of 'optimisation of yield', others felt that it was a stand-alone objective.

The workshop agreed that maintaining sustainability certification, and managing to maximise the size of fish in the catch, were not management objectives for the Coastal States when seeking advice from ICES.

4   Advice: its properties and the challenges

4.1   Properties of advice

The participants were asked to explore the key properties of robust advice for the management of Northeast Atlantic mackerel. They were asked to synthesise their key concerns and expectations about the way advice is provided for the management of mackerel. A list of properties of advice was provided and each group was asked to rank the properties (Figure 4.1).

- certainty
- credible methods
- legitimacy of governance
- responsiveness to stakeholder concerns
- engagement in risk choices
- integrated with ecosystem effects
- stability
- international standards
- conforming to rules
- multi-annual advice
- fleet-based
- trusted
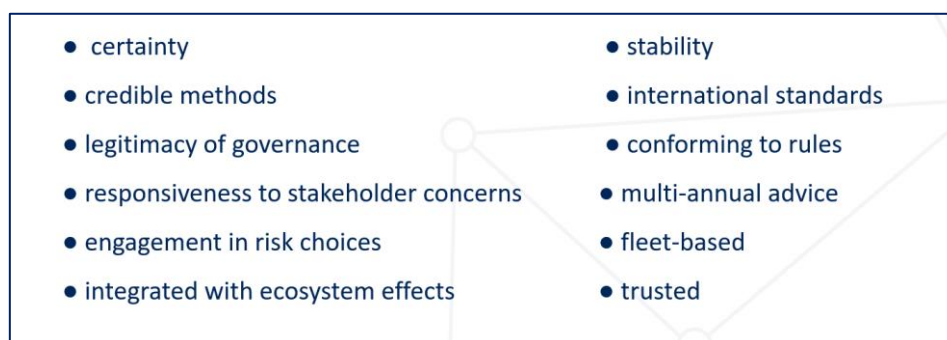
Figure 4.1. The examples of properties of advice that was circulated to the subgroups.

The four subgroups ranked the following properties:

1.	Credible (transparency/traceability)	1.	Stable
2.	Stable	2.	Credible (transparent & trusted)
3.	Reported certainty/uncertainty	3.	Responsive to stakeholder
4.	Responsive to stakeholder	4.	Clear description of risk
		5.	Legitimate governance
		6.	Ecosystem approach
1.	Quality assurance and adherence to standards	1.	Trust (credible & certain)
2.	Credible	2.	Inclusive & responsive to stakeholders
3.	Full transparency	3.	Stable
		4.	Legitimate governance (international standards)

In the plenary discussion the key messages were:

1.   A credible approach (both methods and process) is a key property. This is linked to ensuring fit-for-purpose analytical methods, quality control of data and quality assurance of the advisory process.

2.   When considering the independence of the advice from managers and stakeholders and the responsiveness to stakeholder concerns, the workshop recognised that there was a trade-off. However, the independence of the advice takes primacy over responsiveness to stakeholders. This is to maintain the legitimacy and credibility of ICES as a provider of scientific evidence and advice.

3.   The word stable, or stability, was interpreted as 'no surprises' in the advice, that the advice was as predictable as possible.

4.   Many subgroups felt that the ecosystem approach was now as fundamental as the precautionary approach, so they had not ranked it in their lists.

5.   A distinction should be made between stakeholder information and stakeholder concerns. There was no effective mechanism for introducing either into the ICES advice system. The workshop felt there should be a mechanism to reflect divergent perceptions of

the status of a stock, while maintaining the independence of ICES. Currently, the stake-holder message is getting lost.

## 4.2 Current challenges and weaknesses for advice

There is a large investment in data collection, which is not that well-coordinated overall, and much less resourcing of data compilation and analysis, and the production of advice. The workshop found this relative allocation of resources inappropriate. There is a sense of inertia in provision of advice and scientific evidence. Changing the system is difficult as is reapportioning resources.

There are challenges to the transparency of the system caused by lack of access to high resolution input data; some participants highlighted a lack of transparency in some of the advice processes.

The current system results in volatile TACs and variable perception in the state of the stock relative to reference points. This is caused by the use of one stock assessment model that is very sensitive to annual changes in the data. This sensitivity is linked to the lack of maturity of data time series. The advice process needs to account for this with flexibility in the advice approach until stability builds.

As a result of the complexity of the stock assessment model, it is difficult to reconcile the biological understanding with the outputs of the model. The lack of overview metrics of the data mean that the screening of data before incorporation into the stock assessment model is not carried out well. The poor-quality assurance of the advice process (including quality control of the data) hinders the credibility of the advice. Despite a substantial section in the advice sheet on the quality of the advice, it appears that warnings about the quality of the advice from ICES are not picked up by many users of the advice. There are no clear indicator tags on quality of advice and there is a perception that the presentation of advice appears too certain, especially when the advice is provided to so many decimal places.

The system is very poor at incorporating information derived by commercial sampling and accounting for discrepancies in the perception of the state of the stock between scientists and stakeholders. The provision of data into the RDBES, following agreed protocols and collection standards should improve the inclusion of sampling by industry of the catch, but another stage is required to reconcile potential divergent perceptions of the state of the stock (Figure 4.2).
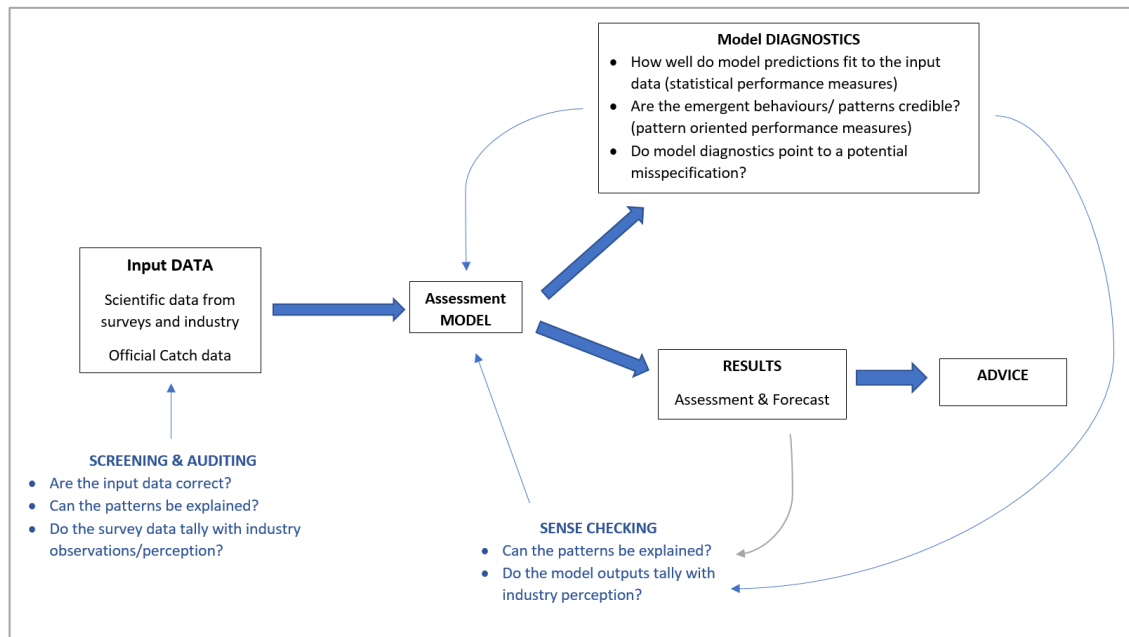
Figure 4.2. WKRRMAC analysis of the difference between checking model diagnostics and ground-truthing input data and stock assessment model outputs.

5 Science challenges

5.1 What science do we need?

To provide robust advice on optimisation of yield (MSY and stability in catch) for Northeast Atlantic mackerel, the evidence base should be credible, quality assured, stable and trusted. The degree of certainty/uncertainty of the advice needs to be better communicated. Information is needed on the impact of fishing on the stock, and this is derived from stock assessments, estimation of reference points and management strategy evaluations. Currently this is provided using research institute sampling of commercial catches, egg surveys, recruitment series, tagging information and swept area surveys. Many of these survey time-series can be challenged due to their lack of spatial coverage of the whole stock, the shortness of the time series, and a paucity of understanding in the processes that create the time series. The use of one assessment model to provide advice can also be challenged, and the failure to use alternative operating models when carrying out MSEs of proposed management measures.

Data are required that reflect the dynamics of the whole stock. There should be a stronger link between reviews of the assessment methods (benchmarks) and MSEs. Exploring the potential dynamics of the stock using various models (either through ensemble approaches, or the use of one main model and comparing the results to supplementary models) could improve the evaluation of uncertainty by providing more than one perception of reality.

There are improvements to the existing surveys and their coverage (see section 5.2) that would enhance the coverage (spatial and temporal) of the stock. Efforts should be international and carried out in collaboration with all nations that fish for mackerel. Evidence of the changes in distribution is as important as evidence on the stock status.

There is also a large programme of biological sampling being carried out and reported from commercial catch by the commercial fisheries themselves. This is being supervised by industry-hired scientists following protocols. Many more fish are being weighed and measured by commercial efforts than by the fisheries institutes. Approaches to incorporate this information into the ICES system are still at a very preliminary stage.

5.2 Resourcing and science

There are trade-offs between the resourcing and the quality of science. The workshop was asked to address how to improve the science underpinning the advice (data and knowledge) in two scenarios; *status quo* resourcing (the workshop considered this synonymous with being under-resourced) and improved resourcing. The time-line for these improvements was the next 3–5 years. Resourcing could be from international and national/administration projects, industry partnerships, PhDs, postdocs etc.

5.2.1 Funding mechanisms

The workshop felt that either a reapportioning of resources or an increase in resources was necessary to improve the science evidence base. Mechanisms that were discussed were a scientific quota, a levy on fish sales and/or a Coastal States science fund. Greater industry/science partnerships were also seen as useful approaches to improving the evidence base. The workshop felt that the development of new ideas to support research and fisheries advice for Northeast Atlantic mackerel should be explored.

5.2.2   Expertise

There is a need for a thorough analysis of what key skills/expertise is missing from the research community. ICES reports a lack of expertise in certain research areas, especially MSEs and advanced stock assessment modelling. The workshop was unclear as to how many new experts are needed and in what areas capacity building was necessary. Various models to invest in expertise were discussed including industry funded research positions and industry/academic partnerships.

5.2.3   Stable advice from a multiannual process

The objective of optimised yield (MSY and stability) could be delivered through a multiannual process of advice. This has been discussed for decades but little movement has occurred. The workshop was not opposed to the idea but there were no strong proponents for the idea. There would be a trade-off between risk and yield, if advice was delivered every three years, but the instability created through annual advice has not resulted in a robust process.

5.2.4   The stock assessment, forecast and MSE

One best fit model approach

Throughout the workshop, a number of issues with the current 'one model best fit' approach were highlighted. An unrealistic perception of certainty was being given in the current advice, reflecting an assumption that the one stock assessment method (as agreed by the benchmark) represents the best version of reality. The uncertainty from one model does not reflect the true uncertainty in the assessment, or the uncertainty caused by the assumptions incorporated into the model settings. There were calls for supplementary assessment models to be run alongside the main model, or to explore ensemble approaches within the stock assessment. Methods need to be developed to address this weakness in the stock assessment, forecasts and advice. Linked to this is the use of one operating model within the MSEs for the mackerel fisheries. It is unreasonable to assume that the full uncertainty of the management system is characterised by assuming that the one stock assessment (with its assumptions) represents reality.

Review and interpretation of inputs to, and outputs from, models

Methods need to be found to allow biologists, stakeholders and managers to review and interpret the inputs and outputs of a stock assessment and forecast. These could include visualisation tools, indicator times series, and the development of biologically relevant outputs in the diagnostics. It is best that high resolution data are input into the model, this enables more realistic uncertainty to be incorporated into the analysis. But the input of raw data makes pre-screening more difficult. Developing such methods will have numerous advantages, including scanning for errors in the input data, reconciling perceptions of the state of the stock, verifying assumptions in the model, reconciling ecological understanding with statistical analysis and overall building trust and legitimacy in the assessment. An example of this is the ongoing work to create metrics for the mackerel tagging information.

Auditing of model code

Continuing efforts need to be maintained to provide full transparency of the model codes. The ICES Transparent Assessment Framework (TAF) is a large contributor to this process. However, making the code open and auditable is only half the process. Further resources are required to make the actual audits of the code. Having openly available code alone does not prevent errors, the code should be actively audited too.

5.2.5   Tagging

The assessment uses coded wire tagging data (1980–2006) and RFID tagging data (2014–2017). The tagging data caused the recent problems for the stock assessment, leading to the inter-benchmark and reissuing of the advice in 2019. More research is needed into the performance of the RFID tags. The perception of the workshop was that this data source was of value and it was a good investment to further research its performance. The workshop suggested that it would be advantageous for further countries to begin tagging mackerel with RFID tags, and for scanners to be installed across the region, potentially in the south.

5.2.6   Surveys

All of the current, and some potential new, surveys were considered by the workshop.

Relative contributions of surveys to advice

The workshop felt that an analysis of the contributions (in terms of value of the information into the advice) should be carried out. Some called this a 'cost-benefit analysis'; i.e. which existing surveys are making substantial contributions to the advice process. Are there surveys that could be dropped, without substantially disrupting that quality and certainty of the advice? The workshop estimated that approximately €10 million a year is spent on surveying/sampling Northeast Atlantic mackerel. Drawing conclusions on the suitability of current resources, or the need for greater resources, might be aided by such an analysis. This assessment of the contribution should be to the advice, not just the stock assessment, as knowledge on the distribution of the stock is as important as an assessment of the dynamics. The workshop agreed that if an analysis was to take place, it should be carried out by individuals/institutes not directly involved in the sampling/surveying of mackerel.

Triennial egg survey

The stock assessment uses an SSB index from the triennial egg survey (1992–2016). The workshop felt that there was little benefit in surveying the western waters and the North Sea in separate years. Better justification was needed to maintain this practice. The workshop suggested that if the egg survey was found to contribute substantially to the information in the advice, then the frequency and methods could be adapted. Innovations such as the daily egg production method (DEPM) rather than the annual egg production methods (AEPM) should be explored further. The applicability of CUFES should also be investigated.

Recruitment indices from IBTS

The workshop had little comment about this survey (IBTS combined Q1 and Q4; age 0, 1998–2017). The nature of the IBTS (International Bottom Trawl Survey) is that many stocks are surveyed and thus the indices are easily attainable. The workshop did however express the need for a better survey of the abundance and distribution of age 1 and 2 mackerel.

Swept area IESSNS

As with the egg survey, if the IESSNS (International Ecosystem Summer Survey in the Nordic Sea, ages 3–11, 2010, 2012–2018) was found to contribute substantially to the information in the advice, then the frequency and methods could be adapted. There were suggestions in the workshop that other nations should join the survey and thus increase the southern coverage of the survey. Others said that more research was needed to support this action, because preliminary evidence suggests that the mackerel in more southern areas and the North Sea congregate lower in the water column than in the northern more oceanic regions. Thus, verification of the suitability of the method was required.

Winter acoustic survey

Research and technology for acoustic surveying of mackerel has advanced since 2005 (see Annex 4). Marine Scotland and the University of Aberdeen suggested to the workshop that a credible acoustic survey, in winter, of mackerel will now be of value. The technological challenges have been overcome. Previous surveys can be re-analysed using a new approach to target strength, and new surveys can be designed and enhanced through international cooperation.

Industry surveying using acoustics

The use of commercial fishing vessels as ocean observing platforms was highlighted to the workshop. Innovations by the PFA (Pelagic Freezer-trawler Association) and Sustainovate using Oceanbox, are developing robust bottom detection plus ES80 storage, allowing fast calibration of acoustic systems, improving data storage. The use of Oceanbox is being spread out across the PFA fleet. Combined with the innovations in acoustic sensing (section 5.2.9 and Annex 4), this offers strong potential to improve the evidence base for advice, in the medium- to long-term.

5.2.7   Commercially sampled biological data from the catch

Many of the participants of WKRRMAC are developing methods to collect, to scientific standards, biological information from their catches. The work of SPFA (Scottish Pelagic Fishermen's Association) on the issue was presented and it listed the conditions that allow industry to contribute useful and useable information for science. Data should be collected using protocols and fed through into the ICES RDBES (Regional Database and Estimation System). This is seen as a very important innovation and results from these initiatives should flow into the ICES system in the medium-term.

5.2.8   Generic spatial information

Stakeholders and scientists need to find value for money approaches to map the annual changes in mackerel distribution across the North and Northeast Atlantic. Collaboration is key, and many of the upcoming innovations listed above can be used, combined with individual based modelling (IBM).

5.2.9   Future innovation

The workshop also highlighted that technological advances have been made in the field of genetics (e.g. eDNA), the use of sail drones, and moorings for ocean observing. ICES, industry and fisheries institutes should stay alert to innovations arising from these research fields.

6   Research Roadmap

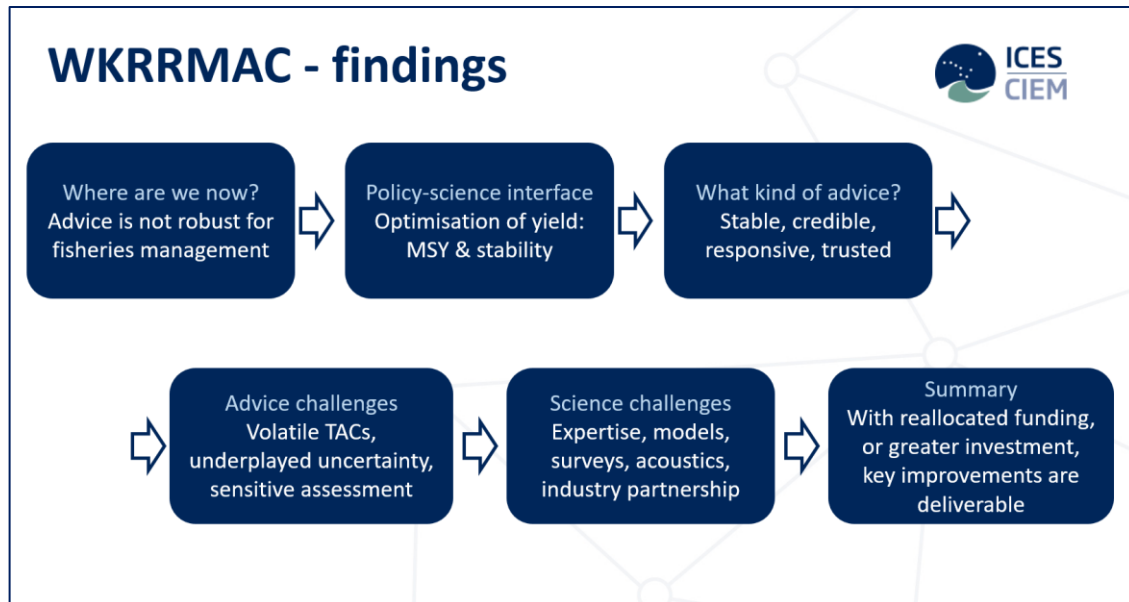The development of ideas by WKRRMAC is summarised in Figure 6.1.

Figure 6.1- summary of conclusions of WKRRMAC.

Based on these conclusions, the priorities for future research (hence the road map) are to:

1.   Explore new funding mechanisms of research for the management of this valuable fishery.
Action: Coastal States ministries and fisheries.

2.   Invest and better coordinate building fisheries science expertise.
Action: Coastal States ministries, national research authorities, fishing industry with support from ICES.

3.   Evaluate management and advisory mechanisms that will result in more robust quality assured advice on optimised yield (the trade-off between MSY and stability in TAC). The evaluation to be done by managers and fishers and facilitated by scientists.
Action: to be facilitated by ICES, managers, fishing industry

4.   Explore which surveys contribute the strongest signal into the stock assessment, and reconcile survey information.
Action: ICES and fishing industry scientists

5.   Explore expanding existing surveys (those with larger contributions to the stock assessment), to seasons and areas they currently do not cover.
Action: national fisheries institutes and academics

6.   Further extend the winter acoustic survey time series and contribute ship time and researchers to these efforts.
Action: national fisheries institutes and academics

7.   Build mechanisms to incorporate industry sampling of biological information into the formal stock assessment process
Action: ICES and fishing industry scientists (workshop planned 2019)

8. Develop pragmatic approaches for formalising the flow of information of industry perceptions of the state of the stock and the fishery into the assessment process.
   <u>Action</u>: ICES and fishing industry scientists

9. Develop methods for industry surveys that maintain credible methods and scientific rigor.
   <u>Action</u>: national fisheries institutes, academics and industry fisheries scientists

Annex 1:   List of participants

Participant	Institute	Email	Country
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Annex 2: Resolution

Terms of Reference

The Workshop on a Research Roadmap for Mackerel (WKRRMAC) co-chaired by Carl O'Brien (UK) and Mark Dickey-Collas (ICES) will be established and will meet in Bremerhaven, 7–9 May 2019 to:

a)   With stakeholders, identify issues necessary for management needs of NE Atlantic mackerel regarding management plans, optimizing yield, distributional shifts, density dependent changes in growth and ecosystem drivers of fisheries productivity;

b)   List additional concerns from fisheries managers and stakeholders which they perceive as suffering from a knowledge deficit:

c)   Prioritize recommendations for research to lead to future improvements of the scientific advice for mackerel;

d)   Consider knowledge and data sources, and potential methods and timetables by which those methods can be incorporated into the advice system;

e)   Produce a roadmap for the delivery of future research needs for the management of fisheries on mackerel in the NE Atlantic.

Annex 3: Agenda

The Workshop on a Research Roadmap for Mackerel (WKRRMAC)

Bremerhaven, 7–9 May 2019

Co-chairs: Carl O'Brien (UK) and Mark Dickey-Collas (ICES)

Agenda

Tuesday

10:00 Welcome and introductions

10:15 Where are we now? (Plenary)

Exercise and discussion to explore the current situation.

11:30 Coffee

12:00 Five 10-minute talks by invitation – managers and fishers (EU, NO, FO, fishers PELAC, fishers NO) (Plenary)

1. What evidence is required to manage the Northeast Atlantic mackerel fishery?

2. Is the advice robust for long term fisheries management?

13:00 Lunch

14:00 **Policy-science interface** (Plenary)

14:15 Policy-science interface (Break-out Groups)

Workshop splits into 4 mixed groups comprising managers, fishing and processing industries, and scientists

Scientists do not determine management objectives, so they need to be informed of the needs of managers and expectations of fishers. This session will explore and list the key management objectives for the mackerel fishery with the aim of informing researchers.

E.g. stability in catch, maximising sustainable yield, size of fish in the catch, minimum environmental impact, trade-offs, broader MSY targets.

Provide the three top management challenges.

15:30 Coffee

16:00 Reporting back to the workshop (Plenary)

17:00 Close first day

Wednesday

09:30   Summary of previous day (Plenary)

09:45   **What kind of advice?** (Break-out Groups)

Workshop splits into 4 mixed groups comprising managers, fishing and processing industries, and scientists

What are the priorities for fisheries management advice? Within the arena of the provision of fisheries advice, what are your key concerns and expectations about the way advice is provided for the management of NE Atlantic mackerel?

A list of properties of advice will be provided and each group will be asked to rank the properties, the list will include properties such as certainty, stability, credible methods, international standards, legitimacy, conforming to rules, responsiveness to stakeholder concerns etc.

11:00   Coffee

11:30   Report back to the workshop (Plenary)

12:30   Two 15-minute science presentations (By invitation)

13:00   Lunch

14:00   Presentation on perceptions of the challenges for the provision of advice - Mark Dickey-Collas (Plenary)

14:20   **Advice challenges** – what are the key issues in our knowledge base (Break-out Groups)

Workshop splits into 4 mixed groups comprising managers, fishing and processing industries, and scientists. There should be a balance between management objectives, the evidence base & acceptable risk.

Considering the policy-science interface and the prioritises for advice:

1. *What are the weaknesses in the current approach for providing fisheries management advice?*
2. *What evidence so we need to provide robust advice for fisheries management of Northeast Atlantic mackerel?*

Provide your views in up to 6 bullet points.

15:30   Coffee

16:00   Report back (Plenary)

17:00   Close second day

Thursday

09:30   Summary of previous day (Plenary)

09:45   Presentation on science needs for fisheries management - Carl O'Brien: (Plenary)

10:00   **Science Challenges** – How do we resolve the key gaps in our knowledge base? (Break-out Groups)

            Workshop splits into 4 mixed groups comprising managers, fishing and processing industries, and scientists

            Getting operational addressing the data and knowledge needs and resourcing. There are trade-offs between resourcing & quality of science. The time line is the next 3-5 years. Resourcing could be international & national/administration projects, industry partnerships, PhDs, postdocs etc. Each group will determine how to make more robust advice base for the management of the fishery on mackerel assuming:

            1. *Status quo resourcing*
            2. *Improved resourcing*

            Provide three priorities for improvement or initiating science for each scenario.

11:30   Coffee

12:00   Reporting back (Plenary)

12:30   Reflections on progress during workshop - round table discussion with managers (EU, NO, FO, fishers PELAC, fishers NO)

13:00   Lunch

14:00   **Summary of findings and final discussion** (Plenary)

            Insights from the sessions on policy-science interface, what kind of advice, advice challenges and science challenges are brought together.

            Are the priorities right and have we enough for a road map? Have we build a schematic of needs? What are the next steps and indicative timescales?

15:30   Conclusion

16:00   Close

Annex 4: Acoustic surveys for mackerel

Contribution by Paul Fernandes, University of Aberdeen

The stock of North East Atlantic Mackerel gathers in very large schools in the autumn and winter of each year in the northern North Sea. These schools are detected very effectively by fishing vessel sonar and so this is where, and when, mackerel are targeted by fishers from Norway and many European member states. In the mid 2000's this area was surveyed by Scottish and Norwegian research vessels using acoustic-trawl methods, specifically multi-frequency echosounders. These surveys were planned and documented under the auspices of ICES through the Planning Group for Aerial and Acoustic Surveys for Mackerel (ICES PGAAM) (ICES, 2003, 2004, 2005). The survey biomass estimates were very low, lower in fact than the catch: consequently, they were discontinued due to worries about unknown biases.

Marine Scotland, in collaboration with the University of Aberdeen, reinstated the surveys from 2012-2016, with the specific purpose of investigating potential sources of bias in the acoustic-trawl method. One area of investigation concerned the Target Strength (TS) which is a measure of the size of an individual fish echo. ICES PGAAM surveys used estimates of TS based on caged experiments made in the 1980s (Edwards and Armstrong, 1983). New measurements of TS were made based on in-situ measurements of mackerel (using split beam sounders which allow for direct measures of TS to be made under certain conditions). These measurements indicate that mackerel at this time have a much lower TS and when the new TS was applied to estimate the biomass from, for example, the 2014 survey, results were not significantly different from the biomass as estimated by the assessment (Scoulding *et al.*, 2017). The measured [low] TS was supported by video observations, which showed how the mackerel behave when they are in these large schools, effectively diving and exhibiting large tilt angles which accounts for the lower TS (Fernandes *et al.*, 2016). This has since been supported by mathematical scattering models. The video observations also dealt with another source of bias from the PGAAM surveys, that of contamination of mackerel schools by other species, notably herring. No herring were detected in any of the many mackerel schools that were observed over several years. The conclusions of these pieces of work were that the target strength (TS) estimates used in the PGAAM surveys were too high, and that herring are not likely to occur in mackerel schools. There is now ongoing work to revise the earlier time series and to provide estimates at age from the recent time series.

The pelagic industry have long supported the idea of acoustic surveys for mackerel in the northern North Sea in either autumn or winter. Now that some of the major uncertainties of the earlier time series have been resolved, a case could be made to reinstate these surveys. The objective would be to provide an index at age of the entire mackerel stock, given that it is widely acknowledged that the whole stock is present in this region at this time. It would also contribute to our knowledge about the distribution of mackerel at this time of year which would inform any future consideration of zonal attachment. The survey area is large, but could be covered by at least two vessels over 7 to 10 days as per the PGAAM surveys. The survey could take place on either a research vessel or a fishing vessel, but there is also an option to use an autonomous surface vehicle which would operate in conjunction with the fishery. Further details can be examined if there is support for the concept.

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