REPORT OF THE PROJECT "EXTERNAL REVIEW OF THE OVERALL ICCAT MSE PROCESS

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SUMMARY

This report summarizes the review of the five MSE activities that ICCAT has been involved in since 2015. The review was based on the available working group reports, SCRS documents, and dialogue with relevant *ICCAT experts.* For each case study, *individual meetings were held including species working group chairs, technical working group chairs, contractors and current and former SCRS chairs (not all of them participated in all the meetings). Additionally, a general meeting was held that included all these participants plus the methods working group chair and relevant ICCAT Secretariat members. In the species-specific meetings, processes were discussed in detail to complement the knowledge gained from existing reports and documents. Furthermore, the perception of the process by the chairs and the contractors was obtained. Conclusions and recommendations were presented and discussed in the joint meeting with all case studies. This report reflects what was presented and discussed in the join meeting. Some recommendations resulted from assessing consistency across case studies and reviewing materials, while many arose from dialogue with relevant experts.*

KEYWORDS

Atlantic bluefin tuna, Management procedure, Management strategy evaluation, Multi-stock tropical tunas, North Atlantic albacore, North Atlantic swordfish, Western skipjack

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1. Introduction

International Whaling Commission was pioneer on the implementation of management strategy evaluation (MSE) to manage whale populations at the end of the last century (Punt and Donovan, 2007). MSE, also referred to as management procedure approach, formalizes the inclusion of uncertainty in the decision-making process in a structured framework with the aim of identifying management strategies that are robust to uncertainty (Punt et al., 2016). But the MSE approach goes beyond the application of mathematical models and promotes the inclusion of stakeholders in the process of defining and selecting management strategies (Goethel et al., 2019).

Since the implementation of a MSE approach in the IWC, its use has been expanded worldwide and it is now used to provide advice for Southern bluefin tuna (Hillary et al., 2016), various stocks in South Africa (de Moor et al., 2022) or anchovy in the Bay of Biscay (Sánchez et al., 2018). In all the tuna Regional Fisheries Management Organizations (RFMOs) there is ongoing work to advance in the implementation of operational management procedures. With the purpose of sharing experiences, joining efforts, and defining best practices, two join workshops on MSE took place in the past (Anon., 2018). The Conservation of Southern Bluefin Tuna (CCSBT) was the first one to adopt an operational management procedure (Hillary et al., 2016), and the Indian Ocean Tuna Commission (IOTC) has three adopted management procedures already: bigeye tuna, skipjack and swordfish (https://ec.europa.eu/commission/presscorner/detail/en/ip_24_2683). The Western and Central Pacific Fisheries Commission (WCPFC) is scheduled to adopt a management procedure for South Pacific albacore in 2024. In the Inter-American Tropical Tuna Commission (IATTC) there is ongoing work in the MSE for bigeye tuna and there are plans to expand the MSE work to skipjack and yellowfin.

In 2015, the International Commission for the Conservation of Atlantic Tunas (ICCAT) recommended developing harvest control rules (HCRs) for North Atlantic albacore, Atlantic bluefin tuna, North Atlantic swordfish, and multi-stock tropical tunas (Rec. 15-07). For North Atlantic albacore the work started already before 2015 and it was adopted by the Commission in 2017 (Rec. 17-04), becoming the first management procedure in ICCAT. Management procedure for Atlantic bluefin tuna was adopted 5 years later in 2022 (Rec. 22-09). In November 2024, for the first time in its history, ICCAT has adopted a Management Procedure for North Atlantic swordfish, setting a TAC for the period 2025-2027, and a protocol for the selection of a MP from a set of Candidate Management procedures (CMPs) for Western skipjack aiming to set the TAC for 2026 and beyond. In tropical tunas' multi-stock case, the objective, according to the last roadmap, is to adopt the management procedure in 2026 (at the earliest), as there is still much work to do. The management objectives for the multi-stock case were agreed at the last Commission meeting, the operating models are under development and CMPs need to be selected and evaluated, among other things.

In 2022, the Standing Committee on Research and Statistics (SCRS) formally recommended an overall review of the ICCAT MSE activities by an external expert and, in 2024, ICCAT launched a call for tenders to do the work. This report is the main deliverable of this study. It provides a full description of the work carried out and summarizes the main outcomes and conclusions. The project was conducted from August to November 2024 in collaboration with Species Group Rapporteurs, MSE technical working group chairs, developers of the models to conduct the MSE simulations ('the contractors'), current and former SCRS chairs, the Working Group on Stock Assessment Methods (WGSAM) Rapporteur and several members of the ICCAT secretariat. This report is based on the dialogue with the experts at those meetings, information available in the SCRS reports, Panel meeting reports and Commission reports, presentations used in those meetings, and other available information on the Internet.

2. Case studies

2.1. North Atlantic albacore

The MSE for North Atlantic albacore started in 2010 with a research plan that sets key objectives and goals, including assessing management strategies against uncertainties. In 2017, a harvest control rule (Rec. 17-04) and in 2021, a Management Procedure (MP) based on MSE were adopted for the first time in ICCAT (Rec. 21-04), marking significant milestones within ICCAT. The MP was revised in 2021 and is currently under further revision. As the revision is still in its initial phase, this project is focused on the process that led to the adoption of the MP currently in place.

The MSE process for this stock laid the foundation for other stocks' MSEs, transferring elements like performance metrics, the presentation of MSE results and exceptional circumstances protocols. However, it can still benefit

from other case studies, such as incorporating formal ambassadors' meetings. Compared to other tuna MSE processes, there were fewer formal intersessional MSE meetings and dialogue meetings with stakeholders; instead, everything was coordinated from the Species Group.

The European Union is responsible for over 75% of North Atlantic albacore catches, with four European Union countries (Spain, France, Ireland and Portugal), and Chinese Taipei, accounting for around 90% of the total. As a case study involving a small number of countries in the fishery, the number of people actively participating in the development of the MSE was also small (. While North Atlantic albacore may not be the most prominent species within ICCAT, the Contracting Parties, and Cooperating non-Contracting Parties, Entities or Fishing Entities (CPCs) closely monitored the North Atlantic albacore MSE process, recognizing its pioneering role and anticipating that more significant species' MSEs will follow.

2.2. Atlantic bluefin tuna

The socio-economic relevance of Atlantic bluefin tuna created a great interest in the development of the MP for this stock (**Table 1**). Apart from its socio-economic relevance, what made this case study special was the existence of two stocks, in the eastern and western North Atlantic, that had previously been assessed and managed independently. Scientists and managers agreed that the MP for the two populations should be developed jointly. This required the development of a multi-area, multi-fleet and multi-stock operating model (OM) that allowed different degrees of mixing between areas. Work on the MSE of Atlantic bluefin tuna started before the ICCAT recommendation in 2015 to initiate an MSE process for the five cases. In 2016, the contractor developed the first model to condition the OMs, and few experts started to test CMPs afterwards. At that time, there were many problems with the assessment model of the stock, and it was not until those were solved that the process received real attention from many of the experts involved in the BFT species working group. In 2021, there were around seven group of experts testing different CMPs. This case study introduced the figure of the “ambassadors” which main task was to present the progress in the MSE to stakeholders in the three ICCAT official languages. These meetings, that were purely informative, were very well accepted by the stakeholders. In the end, the process took too long, and this led to the need of updating the OMs with new data, which at the same time lengthened the process. The case study received considerable attention from experts and stakeholders, which on the one hand enriched the process, but at the same time created challenges in communication and delayed it.

Fifteen countries contribute to the total catch of Atlantic bluefin tuna with more than a 1%. Three EU countries contribute with more than 10% of the total catch, and afterwards Maroc, Japan, Tunisia, Türkiye and Libya, in this order, are the main contributors (> 5%). USA contributes with less than 4% to the total catch of Atlantic bluefin tuna, but it is the main contributor (~50%) to the catches of the western stock.

2.3. Western skipjack

A first demonstration of the MSE framework for Western skipjack was presented in 2020 and capacity building occurred along 2021. Since then, the development of MSE has taken place within a short time frame. The initial operating models were conditioned in 2022 and updated based on the stock assessment results conducted in that year. Management objectives were adopted in 2022 (Res 22-02), while operational management objectives were agreed by Panel 1 in 2023 and 2024. CMPs were developed and discussed in 2023 and 2024, which led to final adoption by the commission in November 2024 of a MP to set the TAC for 2026. The first ambassador meeting took place in October 2024, although communication with managers also benefited from the training workshops.

In contrast to the other case studies, a single country is responsible for more than 95% of the catches of Western skipjack. Therefore, the number of people actively engaged in the development has also been smaller than in other case studies. While this has facilitated a faster development, it has also implied less interaction with other experts.

2.4. North Atlantic swordfish

The first studies on HCR and MSE for North Atlantic swordfish started before 2015. In 2017, a Stock Synthesis (SS) stock assessment model was configured for this stock, already thinking on a future implementation of an MSE. The first contract for the development of an MSE started in 2018 and ended in 2019, when a new contract with a different contractor was established. This second contract was the starting point of the process that has been extended until now. In this case, they learnt from the process of North Atlantic albacore and Atlantic bluefin tuna which facilitates the process. During 2019, work was carried out mainly in the development of an R package for this MSE, a Shiny app, and the first set of OMs. In the following year, the development of OMs continued with the focus on the impact of uncertainty. A large set of uncertainties was proposed initially, which was reduced to

two main uncertainty axes at the end. The candidate performance indicators were discussed in 2021 and CMPs were evaluated. The code was reviewed in 2021, and the corresponding suggestions were addressed. In 2022, in addition to the stock assessment model, the work on testing CMPs continued. In the workplan 3 meetings with Panel 4 were initially identified, which were held during 2023. Several robustness tests were requested by the Panel before taking a decision to adopt an MP, that was finally adopted in November 2024. Exceptional circumstances will be investigated in 2025. A schedule for reviews on assessment and MSE has been provided. During the process two ambassador meetings were held to communicate the main results.

Fourteen CPCs contribute to the total catch of North Atlantic swordfish. The EU countries contribute with nearly 50% of the total catch, and afterwards United States, Canada, Marocco and Japan are the main contributors (> 5%). There are other nine CPCs contributing with less than a 2% of the total catch.

2.5. *Multi-stock tropical tunas*

The MSE process for the multi-stock tropical tunas started some years after the recommendation from the Commission to develop an MSE for the different species (REC 15-07). In 2018, the first conditioning of the operating model (OM) was presented at the intersessional Panel 1 meeting as a basis for discussion. In the following years, little progress was made (focus was on the identification of main uncertainties and OM conditioning). Consequently, a new revised roadmap for MSE and HCR development was developed, after recognizing the need to link the MSE plan to stock assessment schedule which was limiting the availability of experts. Finally, in 2023, a multispecies OM which main characteristic was the incorporation of an observation error model to simulate the abundance indices was made available. However, this OM still did not include all identified uncertainties.

The process is still under development and little work has been carried out regarding communication (just some MSE training workshops in different languages). The plan is to follow a similar approach to the rest of MSEs (external advisor, code review, communication with stakeholders through Panel 1, ambassador meetings…). In the short term, documentation of the work is scheduled, and external advisors will be included in the process to guide on the next steps.

Sixteen CPCs contribute to the total catch of Atlantic bigeye tuna, Atlantic yellowfin tuna, and Eastern skipjack. The European Union is responsible for over 25% of these catches, with two European Union countries (Spain and France), Ghana, Senegal, Belize and Panama, accounting for around 70% of the total. As a case study involving a large number of countries in the fishery, the number of people actively participating in the development of the MSE was quite small (**Table 1**).

3. Methodology

The review for each of the MSE activities (here after 'the case studies') was led by a different expert. This expert reviewed the resources available on the Internet, such as SCRS reports, Panel meeting reports and Commission reports, presentations used in those meetings, interactive applications available for some of the stocks and other relevant information accessible.

Along October, case study meetings with the technical working group chairs, contractors and current and former SCRS chairs were conducted. For all the case studies the species and technical working group chairs attended the meeting, except for the multi-stock tropical tunas, where both the species and the technical working group chairs were missing, but the multi-stocks tropical tunas' coordinator was available. In some cases, two meetings were held to ensure participation of key experts, as it was not possible to find a date that suited all the relevant people. The number of participants in the meetings for each of the case studies is shown in **Table 2**. The main objective of these meetings was to get information about the perception of the participants on the MSE activity in each of the case studies in relation to the resources available, the quality check, the definition of operating models and testing of management procedures, the inclusiveness of the process and communication with stakeholders (**Figure 1**).

In November, a general meeting was held with the species and the technical working group chairs, contractors, the current and former SCRS chairs and relevant ICCAT experts. The meeting was attended by 14 experts. In this meeting a summary of the case studies was presented together with the main conclusions and recommendations.

3.1. Meeting with the technical working group and species working group chairs

In all the meetings the same template was employed for the presentation, used to guide the dialogue between the participants. After a general presentation, the meeting was structured around six elements (**Figure 1**), the process, available resources (personal and economic), stakeholders, communication tools, model conditioning and management procedures, with special focus on the first four topics.

Table 3 shows a list of key elements of the MSE process that were present at least in one of the case studies, together with the availability of the element in each of the case studies.

North Atlantic albacore

A unique North Atlantic albacore meeting was held, attended by three individuals (**Table 2**): the species working group chair, the contractor, and the former SCRS chair. Note that in this case, there was no technical MSE chair; instead, the MSE technical meetings were conducted as part of the species working group meetings. A presentation guided the conversation, and the minutes of the meeting can be found in **Annex 1**. Participants highlighted the importance of the Standing Working Group on Dialogue between Fisheries Scientists and Managers (SWGSM) for the initial transition of ICCAT into MSE management and for the North Atlantic albacore MSE process. They emphasized that the North Atlantic albacore MSE process deserves recognition for being the first of its kind and for setting the foundations for other MSE processes within ICCAT. Additionally, they noted the exceptional circumstances protocol established for North Atlantic albacore, which has proven effective and will be maintained. Furthermore, while communication during the meetings was fluid even without formal ambassadors, participants mentioned that more formal ambassador meetings would be valuable. However, this would require additional resources and funding.

Atlantic bluefin tuna

Two meetings were conducted that were attended by 4 people (**Table 2**). The first meeting was attended by the BFT species working group chairs and the technical working group chair, and the second by the contractor. The minutes for the two meetings were presented in a single document (**Annex 2**). The same presentation was used in the two meetings to guide the conversation. The participants were active in explaining the details of how the MSE process worked and making recommendations to improve future MSE activities in ICCAT. In this case study one of the main complaints was related to the length of the process, motivated primarily by: the problems with the stock assessment of the stocks, the lack of knowledge on MSE among managers and experts at that time, and the lack of hard deadlines for some of the milestones in the process (e.g. incorporation of new data and definition of new operating models). Panel 2 meetings were considered too formal and the need to have more frequent and less formal meetings with managers was identified. “Intermediary group” meetings formed by stakeholders and scientists as proposed by (Miller et al., 2019). A type of meeting less formal than the Panel 2 meeting, that meets routinely and provide guidance to the scientist.

Western skipjack

The case study meeting for Western skipjack took place in two different days and was attended by 3 people (**Table 2**), including the species working group chair (who is also contractor), the current SCRS chair and a former SCRS chair. Both sessions were guided by the same presentation. The joint minutes can be found in **Annex 3**. Being a small case study in terms of countries involved in the fishery. The number of people actively involved in the development of the MSE was also small (**Table 1**). Participants in the meetings commented that more interaction with other experts and earlier feedback from Panel 1 would have been desirable. Apart from the ambassador meetings, capacity-building workshops were considered very useful to communicate with managers in a less formal atmosphere.

North Atlantic swordfish

The meeting for this case study was conducted in a single day with 3 participants involved in the MSE process for North Atlantic swordfish: the species working group chair, the former chair and the contractor (**Table 2**). A presentation was used to guide the meeting including the main parts of the MSE process. The minutes from the meeting are available in **Annex 4**. They noted that this process had a roadmap since the beginning, that was updated every year and helped to achieve a successful MSE. However, it was suggested that a more formal technical roadmap with deadlines could be helpful in order to be more efficient and avoid having lots of intermediate updates (mainly on data). During the MSE process, there was the feeling that most of the time was spent working on OMs

and robustness tests and the available time for CMPs had been shorter. It was commented that, for future processes, dedicating more time to CMPs development would be desirable. Regarding communication with stakeholders, it was done through the Panel 4 and Ambassadors' meetings, which they found very useful. Some concerns were expressed during the meeting about the computational power and the hosting of the Shiny application, that was handled by the contractor, which can be an issue for the future.

Multi-stock tropical tunas

The meeting for this case study was conducted in a single day with 3 participants involved in the MSE process for the tropical tunas: the multi-stocks tropical tunas' species coordinator, the contractor and the former SCRS chair (**Table 2**). A presentation was used to guide the meeting including the main parts of the MSE process. The minutes from the meeting are available in **Annex 5**. Participants identified the lack of feedback from the Commission as one of the main shortcomings of the process. Communication with the Commission through Panel 1 is key, but very challenging, especially for multi-stock tropical tuna, due to its complexity. Time allocated to this specific subject in the Panel 1 meetings has been very limited. Additionally, they consider necessary an increase in technical support with the recruitment of at least one technical expert. Moreover, the number of MSEs happening at the same time at ICCAT should be limited to ensure that technical experts can contribute to the process. In this specific case, the MSE process overlaps with three stock assessment processes, which is really challenging in terms of finding a period where the experts can focus on the development of the MSE exclusively. Moreover, adequate funding should be provided for the WGs and, even after adoption, strategic plans should also consider providing a budget for the review of implemented management plans.

3.2. General meeting

The general meeting with all species working group chairs, technical working group chairs, contractors, methods working group chair, current and former SCRS chairs and relevant ICCAT secretariat experts was held online on the 6th of November. A date that suited all the pool participants (14) except one was selected to have the meeting, as it was not possible to find a date that suited all of them. Fortunately, this person was at the end able to participate in the meeting. A couple of people that filled in the doodle did not attend the meeting and the other way around. Thus, finally the meeting was attended by ICCAT 14 experts and the five AZTI experts involved in the project. All the MSE technical working group chairs attended the meeting (note that in the case of North Atlantic albacore, there was not a technical MSE meeting, and those meetings were conducted as part of the species working group), along with most of the species working group chairs, three ICCAT secretariat experts, the methods working group chair and the current SCRS chair. None of the contractors attended the meeting.

The contractors of the project first presented a summary of the MSE processes of each of the case studies. Then they introduced the main findings in relation to available resources, inclusiveness, consistency between MSEs, communication, review and quality control and they finished the meeting with the conclusions and the identified potential improvements. There was active participation in the meeting, with ICCAT experts clarifying and elaborating more some of the topics introduced by the contractors and suggesting improvements to the material presented to be included in this report. The meeting minutes were circulated among the participants to have their final agreement (**Annex 6**).

Each of the MSE activities in ICCAT have its own peculiarities that were highlighted in the meeting:

- The initial North Atlantic albacore work was groundbreaking in that it succeeded in alerting the Commission, getting the Commission to be responsive, and getting an MP adopted. But during the review, the SCRS identified several areas for potential improvement that are being looked at and implemented right now.
- A main difference of Atlantic bluefin tuna case study is that it includes development of a new model considering two different stocks (eastern and western) with some mixing between them and different management of the two sides of the Atlantic, while other MSEs are based on existing assessment models. This added considerable complexity to the process in terms of the implementation of the OMs and the definition and testing of the combined CMPs.
- Western skipjack case study is different from others because there were no regulations for this fishery prior to this work, and few stakeholders have an interest, with one country accounting for 95% of the catch.
- The North Atlantic swordfish case study is an example of how experience from the previous case studies was used to build a more efficient process. The Atlantic bluefin tuna had started before, and they could learn from it. They anticipated to the MSE process and worked on a SS stock assessment model

configuration already thinking on the future MSE implementation. They also could learn from indicators and presentation of results from the previous works, and during this MSE process the contractor was able to develop a wide framework for MSE results visualization, that can now be used, not only for North Atlantic swordfish, but for other case studied.

- Tropical tuna multi-stock case study represents a groundbreaking exercise because it involves three different stocks, and no similar exercise has been carried out in tuna RFMOs before. While in the case of Atlantic bluefin tuna, the managers wanted a mixed stock MSE, in this case it is not clear what type of MSE needs to be developed. If a typical single stock MSE takes 1-2 years, one would expect this case study to take 5 years or more.

4. Available resources

All the case studies, except North Atlantic albacore, received funding to develop and condition the operating models and to test the CMPs. The North Atlantic albacore work was initially funded internally, and it received some funds from the European Commission. The MSE contracts for North Atlantic albacore began in 2021, alongside those for Atlantic bluefin tuna. In general, the feeling was that the contractors were well supported economically. However, they complained about the annual financing scheme that created uncertainty about the continuity of the contracts and was detrimental to the efficient planning of the task. Having contractors doing the work of implementing the MSE simulation model is a double-edged sword. On the one hand, it is positive because they work very efficiently and are independent experts. Moreover, when the model is implemented by interested parties, there could be a lower level of trust in the product. But on the other hand, it does not directly contribute to the capacity building of the ICCAT community, and when the contract ends, the contractors are, in principle, no longer available and the expertise does not remain within ICCAT. The participants identified the need for a permanent position in the ICCAT Secretariat to support all the MSE activities. This person could help to give continuity to the work of the contractors when the contract finishes and would have institutional memory related to MSE. In other tuna RFMOs this profile already exists.

At country level there were problems supporting the work of experts. Even if in many cases they were public servants, in many cases they had other commitments that precluded them from participating actively in the MSE processes. For example, it is very difficult to participate in both an assessment and MSE process simultaneously, as demonstrated in the case of Atlantic bluefin tuna. The number of experts actively participating in the MSE process varied across case studies (**Table 1**), primarily driven by the number of countries participating in the fishery and the socio-economic relevance of the stock. In general, the definition of OMs received the most attention from the experts. The most active experts were from Brazil, Canada, European countries and United states. The language, the expertise and the available resources in the country could be a barrier for experts from less developed countries to participate actively. While commission meetings have interpreting service in the three official ICCAT languages, the working language in technical meetings is English. This could be a handicap for some experts.

In terms of computational resources, the contractors hosted the Shiny apps, and when the contract ended, the apps were not available anymore. Additionally, in some cases the simulations were very time demanding and more efficient code and/or better computing facilities would have facilitated the work.

In some case studies in person MSE dedicated meetings have been funded, but this has not been the case in all the case studies. In cases without funding for dedicated meetings, it has been necessary to have those meetings jointly with data preparatory or stock assessment meetings.

5. Review the inclusiveness of the MSEs

Some countries are more actively engaged than others. For example, in the cases of Atlantic bluefin tuna, North Atlantic swordfish or the tropical tunas' multi-stock case study, there are many countries involved in the fishery, but only experts from few countries contribute to the SCRS. Language, and lack of expertise and resources are barriers. However, when training workshops were organized in relation to multi-stock tropical tuna case study, to reach out primarily to people from developing countries, it failed to attract new participants beyond the people that normally participate in the Commission meetings and contribute with SCRS papers. In terms of stakeholders, it must be borne in mind that there has not been direct interaction with stakeholders in this project. The feedback obtained came from the meetings with the ICCAT experts and contractors, and the review of the SCRS documents and Panel and Commission meeting reports. The impression is that communication with individual stakeholders is somehow hidden amongst the CPCs in Panel meetings. Thus, communication depends on how well the CPCs

interact with their members. In general, dialogue and ambassador meetings worked well to facilitate communication. On top of that, some countries have meetings at country level. In the case of Western skipjack, the MSE training workshops were a good place to get informal input from stakeholders.

6. Assess the appropriateness of the degree of consistency between MSEs

6.1. Management objectives

The management objectives in all the case studies (**Table 4**) have been operationalized through four management objectives related to different dimensions of the system: stock status, safety, yield and stability. The numeric target is decided by the Commission for each case study based on the results of the simulation which goes against the essence of MSE (Punt et al., 2016). For Western skipjack, for example, the objective for the probability of being at the Kobe green quadrant (PGK, i.e. $SSB \geq SSB_{MSY}$ and $F < F_{MSY}$) was updated from 70% to 60% in the last Commission meeting in 2024. In order to be fully consistent across case studies, save time and have agreed management objectives early in the process, and given the quantitative objectives that have already been agreed are the same, or similar, in many cases, it would make sense to set them as generic management objectives. In the Northeast Atlantic, ICES for example, has a common objective for all data rich stocks (~70 stocks) for safety (precaution in the ICES vocabulary) of $p(SSB < B_{lim}) < 5\%$. However, it must be noticed that if uncertainty is not characterized with the same accuracy across case studies, having the same numeric target would not ensure risk equivalence across case studies.

6.2. Performance indicators

Although qualitative operative management objectives are the same, and quantitative ones are the same or similar, performance indicators defined in each case study to measure if the objectives are achieved differ. **Tables 5 to 8** show the performance indicators used in each case study where examples of these differences can be found. Some examples:

- What is measured is different: To check if the stock falls into the red Kobe plot area, in the North Atlantic albacore they measured the number of years this happens, while in the Atlantic bluefin tuna they measured the probability.
- The same thing is measured in a different time-period: To evaluate if yield is maximized for the North Atlantic albacore, mean catch in the first 15 and 30 years was measured, in the Atlantic bluefin tuna the median over 1-10 and 1-30 years and in the North Atlantic swordfish the median over short (1-3), medium (4-10) and long term (10-30).
- Different notations are used to refer to the same thing: to refer to average biomass in the North Atlantic albacore they used 'BMEAN', while in the Atlantic bluefin tuna they used 'AvgBr'.

To facilitate better communication and understanding, it would be adequate to have the same performance indicators measuring the same operational management objectives and using the same notations. In the Western skipjack and North Atlantic swordfish case studies, where most of the work has happened after the North Atlantic albacore and Atlantic bluefin tuna work, the performance indicators are much more homogeneous, and the main differences are in the time-period used to compute short, medium and long-time indicators and the notation used to refer to them. The time period used could be related to the life history of the stocks, for example, and consequently having a different time-period would make sense. However, using different notations is not justified and using the same one would not imply a big job and would facilitate communication enormously, even across scientists.

6.3. Graphical representation

Regarding graphical representations of MSE outputs, using the same figures across case studies and throughout each specific process is desirable to facilitate understanding. In the case studies that went through an MSE process (North Atlantic albacore and Atlantic bluefin tuna), this was difficult because they were learning along the process. However, currently there is considerable good material from these case studies and consequently graphical representations could build on existing work and experience. Additionally, when it comes to graphical representations, the objective is not to produce the prettiest plot, but the one that is easiest to understand. **Figures 2 to 5** show examples of areas for improvement:

Figure 2 shows two different types of plots used to show the change in TAC between periods. The one for Western

skipjack (on the left) uses a boxplot on top of a scatter plot; but this can be confusing because points in traditional boxplots are used to show outliers. On the other hand, the violin plot for North Atlantic swordfish (on the right) is a beautiful plot but requires thinking about the shape of the probability distribution underlying the data, and this is probably something which is difficult for stakeholders. Thus, in this particular case, the recommendation would be to always use boxplots.

Two examples for Worm plots are shown in **Figure 3**; these plots are recommended to show the variability of individual replicates in MSEs. The plot for Atlantic bluefin tuna (on the right) is very good, with few iterations on top of the confidence interval. Thus, it shows what it is intended, the individual trajectory variability in contrast to the stability of the quantiles. It would be even more informative to plot also the median in a way that is differentiated from the individual trajectories. However, in the case of North Atlantic swordfish (on the right) all the single iterations are plotted which difficult to see the real variability in single trajectories. The recommendation in this case is to learn from the past and use the Worm plots as they were used for Atlantic bluefin tuna.

In **Figure 4** the most recent plot from Western skipjack case study (on the left) outperforms the Atlantic bluefin tuna example (on the right). It shows the trade-offs between different objectives, and in the case of Western skipjack it does not show confidence intervals which makes the plot clearer. Usually, scientists try to incorporate as much information as possible in a graph, and for the person that produces it, is probably a good think, as figures allow identification of important things easily. However, adding too much information into one figure could scare a person that is not too familiar with the analysis and probably makes she/him not even try to understand it.

The last example found in one of the presentations made to Panel 2 is an example of a complex plot too (**Figure 5**). A plot which encapsulates too much information and does not have all the information required to understand the plot. In this case, the middle column would probably be enough to understand the message and it is difficult to see how the histograms in the right contribute to the story about individual variability.

The participants noted that, although having the same performance indicators and figures could be desirable, homogenizing them is a very difficult task and, in some cases, having different performance indicators or figures could be necessary. Homogenization of performance indicators and/or figures should be done carefully and the ICCAT's method working group should address this.

7. Evaluate the communication of the MSE processes to stakeholders

A variety of channels and tools have been used in the five case studies to communicate with stakeholders: panel meetings, ambassador meetings, dialogue meetings, the trial specification document, executive summary, short summary document, the interactive application (Shiny), detailed technical SCRS reports, and documents and MSE (training/capacity building) workshops.

In Atlantic bluefin tuna, Panel 2 meetings were considered too formal and "intermediary meetings" were recommended by participants in this process. While Panel 2 is the right place to take decisions, in some cases during the MSE process what was needed from managers was just quick guidance, and for that Panel 2 was considered too formal. In the general meeting some participants suggested to use subgroup of Panel 2 for this purpose.

Ambassadors' meetings are considered a very useful tool to communicate with stakeholders in a more informal way. They were introduced in the Atlantic bluefin tuna MSE process. For North Atlantic albacore they had meetings of the SWGSM to interact exclusively with managers. Ambassador meetings were used also for North Atlantic swordfish and are planned in the tropical tuna multi-stock case. In the Western skipjack process, MSE workshops were introduced to build capacity, they were highly valued as a place to have informal input from managers. However, it must be considered that this is a very special case study with 95% of the catch coming from a single country. In other case studies such as Atlantic bluefin tuna with many countries contributing to the catch, this may not work. In the tropical tuna multi-stock case two MSE workshops were held but as mentioned before they did not reach new people.

The trial specification document, executive summary and short summary documents are useful, but they are not easy to find among the SCRS documents and on the Internet. Thus, centralising all this documentation somewhere would be useful. The interactive applications are useful to explore results, but it is necessary to institute some kind of training for non-experts.

8. Review and quality control

Most of the case studies have gone through a review of the code or are going through it, except in the case of the multi-stock tropical tunas, for which the review is planned for the near future. After the review the contractors addressed the recommendations of the reviewers, at least partially. As the review comes late in the process, it is already too late to implement some of the recommendations. The timing for the review must be planned adequately so there is enough time to implement recommendations, if required. Additionally, the contractors had their own mechanisms to ensure that the code does what it is supposed to do. In principle, the code review has been satisfactory in all the cases.

In the Atlantic bluefin tuna case study, there was an external advisor following the last part of the process. It came late into the process and the experts thought that it would be preferable to have this person from an early stage of the process. This advisor figure was not present in other case studies. In tropical tunas' multi-stock case study, the species group is expecting to have three advisors in the coming months.

9. Conclusions

Several conclusions were derived from the reports and the conversations with the species and technical working group chairs, contractors and SCRS chairs.

Related with the availability of human resources, all the experts agreed that conducting five MSE processes simultaneously in ICCAT is unmanageable because the capacity of the community is limited. They suggested that there should not be more than two simultaneous processes. Furthermore, the MSE process should not overlap with the stock assessment because experts cannot actively contribute two both tasks. The MSE should be planned to be conducted between the period of two consecutive assessments. Now that managers and scientist are familiar with MSE, and related elements such as operational management objectives and performance indicators have been agreed and are similar for all the implemented case studies, the MSE process should not take more than 2 years. Thus, adopting a MP between assessments should be feasible.

Having all ICCAT Panels discussing in parallel about the same thing for different species was inefficient in the past, but now that the operational management objectives have been defined with associated quantitative target and performance indicators agreed, the discussions in future case studies should be more efficient.

Large case studies have more diversity and experts contributing actively but lengthen the process and complicate the dialogue. However, in small cases studies, with few countries involved in the fishery, the problem is just the opposite, the process can run quickly but there can be a lack of discussion and critical opinions. Two clear opposite examples are Atlantic bluefin tuna and Western skipjack.

In terms of resources, communication, inclusiveness, review and quality control, the five case studies are relatively consistent. There were important differences in some cases, but they can be explained by the idiosyncrasy of each case study and the natural evolution in the scientific community and stakeholders since the first North Atlantic albacore MP to the recently approved North Atlantic swordfish one. However, despite being relatively consistent, there is room for improvement and standardization among case studies, principally in terms of performance indicators and how they are presented.

In the Panel meetings with stakeholders, it is important to show tangible results and to have 'closed-ended' questions to ensure an effective communication. To facilitate the communication and understanding it is important to use the same language, performance indicators, figures and tables all along the MSE process. It is something that could have been challenging in the first case studies, that learned from their own experience, but now the new case studies can learn from others and develop definitive material since the beginning. In the presentations there is considerable technical information, and they should be kept as simple and as standard as possible across case studies. When producing figures, beautiful does not mean easy to understand, and for communication with stakeholders is better to limit the amount of information encapsulated in a single graph.

Stakeholders and managers appreciate having informal discussion venues such as capacity building MSE workshops and ambassadors' meetings. In big case studies, such as Atlantic bluefin tuna, having guidance meetings with a group of managers and scientist would have helped to dynamize the work. However, now that management objectives and respective operational objectives are clearer, this could not be necessary even in large

case studies. But it is something that should be considered if the case studies are groundbreaking in some sense, for example the multi-stock tropical tunas case study. On the contrary, in small case studies, enough diversity is not ensured. In such cases a minimum participation should be guaranteed to ensure that the final product is not bias to the thinking of individual persons.

In this project the feedback has been obtained through documents and dialogue with scientist. Thus, we have not obtained direct input from stakeholders.

10. Recommendations

In this section we list the recommendations derived from the meetings with ICCAT experts and the reading of relevant documents. Some of the recommendations come from the experts themselves. Most of the recommendations are for the SCRS and few of them for the Commission.

The idea of having a dedicated MSE webpage within the ICCAT web is a good recommendation that appeared in one of the early SCRS documents. There is already an MSE webpage within the ICCAT web, but it does not have much information. Having it as a place to centralize information could be helpful. Some ideas in relation to the webpage:

- Update the glossary. The available glossary comes from the second joint tuna RFMO MSE workshop (Anon., 2018). This glossary could be complemented with terms that are used in ICCAT, for example to refer to specific type of figures and tables (e.g. quilt plot). The glossary should be updated by the methods working group and it should be made it clear that it represents an extension to the glossary agreed in 2018.
- Create a document with a standardized list of performance indicators and add a link to that document I the webpage. In the North Atlantic swordfish and Western skipjack case studies they are already fairly similar, so they represent a good starting point. However, this is not a straightforward task, and it should be coordinated by the methods working group.
- Create a document with standard figures, their interpretation and the type of data for which they are used. The list of figures should be based on those used in the existing case studies and the work should be coordinated by the methods working group.
- Add links to important information for each case study, such as the Shiny app or relevant reports and documents.

To facilitate the communication, the material used should be as standard as possible. There are several possibilities towards accomplishing this:

- Homogenize operational management objectives and the associated performance statistics. Operational management objectives are the same for the five case studies and the differences are in the quantitative targets. In order to be fully consistent across case studies, save time and have agreed management objectives early in the process, and given the quantitative objectives that have already been agreed are the same, or similar, in many cases, it would make sense to set them as generic management objectives. However, it must be noticed that if uncertainty is not characterized with the same accuracy across case studies, having the same numeric target would not ensure risk equivalence across case studies. As commented in the previous paragraph, in the North Atlantic swordfish and Western skipjack case studies they are already fairly similar, so they represent a good starting point. However, this is not a straightforward task, and it should be coordinated by the methods working group.
- The trial specification document is useful to know how the simulations have been set up. The document could be standardized, to some extent, to facilitate the exchange between ICCAT experts.
- Build a standard presentation template to communicate with stakeholders. This was a recommendation already in one of the Atlantic bluefin tuna MSE reports. Such a presentation could facilitate the work of scientists and facilitate the understanding of the stakeholders.
- Use the same performance indicators, figures and tables throughout the whole process and for all cases as far as possible. This was challenging in the pioneer case studies, but it should be achievable in the new case studies where a lot of good material is already available from other case studies. If some of the recommendations listed above were followed, this one would be relatively straightforward.
- In general, in order to standardize things, there is much good material already available, and it is a matter of putting it together.

In terms of roadmaps and processes:

- Some experts commented on the need to have more detailed roadmaps containing details on responsibilities, expected outcomes and deadlines to make the process more efficient. Specifically, hard deadlines are needed at least for data and operating models, so respectively after these time limits no new data are included and no new OMs are implemented. The roadmap should clearly identify for which specific parts of the MSE process feedback from managers (or stakeholders in general) is needed.
- Assessment models should not be updated in the MSE process to avoid having to recondition the OMs. The OM process should start immediately after the assessment, and the process should finish in less than three years, so that the next catch advice is given using the MP and there is no need to recondition the OMs.
- In the interaction with stakeholders very directed questions to guide discussions should be used.
- At the beginning of the processes capacity should be built through MSE (training) for experts and stakeholders.
- External advisors should be incorporated earlier in the process, to support the case-specific experts doing the work and avoid that their recommendations cannot be implemented because they come too late in the process.

General recommendations:

- The interaction and communication among experts in different case studies should be promoted to ensure consistency and exchange of ideas.
- Conduct a survey to get feedback from stakeholders and identify improvement points.
- ICCAT should host and maintain Shiny apps and other applications, or material related to the MSE activities.
- Transparent and reproducible coding should be promoted to facilitate code review and interchangeability.
- The trial specifications document should be very clear on the settings used to implement the OMs.

Finally, some recommendations for the Commission have been identified:

- ICCAT should not develop more than two MSE processes simultaneously.
- ICCAT should have a permanent position in ICCAT Secretariat to support all the MSE activities. This person could help to ensure consistency across case studies, to give continuity to the work of the contractors when the contract finishes and would have institutional memory related to MSE. In other tuna RFMOs this profile already exists.
- The MSE developments should not rely on external funding and stability for several years is required.

11. Acknowledgments

This work was carried out under the provision of the ICCAT. The contents of this document do not necessarily reflect the point of view of ICCAT, which has no responsibility over them, and in no ways anticipate the Commission's future policy in this area.

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Tables

Table 1. Approximate number of experts involved in the MSE process of the five case studies.

Number of experts	North Atlantic albacore	Atlantic bluefin tuna	Western skipjack	North Atlantic swordfish	Multi-stock tropical tunas
Developing code	3	1	2	1	3
Defining operating models	10	20	5	8	3
Testing candidate management procedures	3	13	5	8	3

Table 2. Number of participants in the meetings with the species and technical working group chairs, contractors and the current and former SCRS chairs.

Case Study	Date	Number of participants
North Atlantic albacore (ALB)	16 Oct	3
Atlantic bluefin tuna (BFT)	8 Oct & 16 Oct	4
Western skipjack (SKJ)	25 Oct & 30 Oct	3
North Atlantic swordfish (SWO)	24 Oct	3
Multi-stock tropical tunas	10 Oct	3
General Meeting	6 November	14

Table 3. List of key elements in the MSE process identified in the review. For each case study the presence of the element is shown in columns. Question mark indicates that it is suppose to exist but has not been found.

Key elements in the MSE process	North Atlantic albacore	Atlantic bluefin tuna	Western skipjack	North Atlantic swordfish	Multi-stock tropical tunas
Trial Specification documment	Yes	Yes	?	Yes	No
Reference & Robustness sets	Yes	Yes	Yes	Yes	Not yet
Plausability weighting	No	Yes	No	No	No
Specific MSE working groups	No	Yes	Yes	Yes	Yes
Ambasadors (industry/NGO-s + scientist)	No	Yes	Yes	Yes	No
Dialogue meetings (managers + scientist)*	Yes	No	No	No	No
External code review	Yes	Yes	Not yet	Yes	Not yet
MSE process reviewer	No	Yes	No	No	Not yet
Formal process to obtain feedback from stakeholders	No	No	No	No	No
1-pager document	No	Yes	Not yet	Yes	No
4-pager document	Yes	Yes	Not yet	Yes	No
Standardized presentation	Yes	No	No	No	Not yet
Roadpmap	Yes	Yes	Yes	Yes	Yes
Exceptional circumstances protocol	Yes	Yes	No	Not yet	No
Fully implemented management procedure	Yes	Yes	No	No	No
MSE Workshop(s)	No	No	Yes	No	Yes

* Dialogue meetings are ICCAT meetings to promote the dialogue between managers and scientists that were stablished during the North Atlantic albacore MSE process and that were used to discuss other matters.

Table 4. Operational objectives that were agreed or that are being tested in each case study, for four elements: stock status, safety, yield and stability. Stability refers to the change in percentage of the total allowable catch (TAC) between management periods and the values in the table set the bounds to this percentage. PGK denotes the probability of being in the green quadrant of the Kobe plot, i.e. p(SSB ≥ SSBMSY & F < FMSY).

	North Atlantic albacore	Atlantic bluefin tuna	Western skipjack	North Atlantic swordfish	Multi-stock tropical tunas
Status	PGK ≥ 60%	PGK ≥ 60%	PGK ≥ 60%*	PGK ≥ 60%	PGK ≥ 50%
Safety	-	$p(SSB < B_{lim}) \leq 15\%$	$p(SSB < B_{lim}) \leq 10\%$	$p(SSB < B_{lim}) \leq 15\%$	$p(SSB < B_{lim}) \leq 15\%$
Yield	Maximize catches	Maximize catches	Maximize catches	Maximize catches	Maximize catches
Stability	+25%/-20%	+20%/-35%	+25%/-25%	Minimize variability	+25%/-25%

* In 2023 a value of 70% was agreed and the agreement was revised by the Commission in 2024.

Table 5. Performance indicators used for North Atlantic albacore to measure if the status, safety, yield and stability objectives had been achieved.

	North Atlantic albacore	
	Primary	**Secondary**
Status	**pGr%**: Proportion of years [1-15] that B≥BMSY & F≤FMSY	**BMIN**: Min(SSB/ SSBMSY) over 1-15 years **BMEAN:** Mean(SSB/ SSBMSY) over 1-15 years **FMEAN:** Mean(F/ FMSY) over 1-15 years **pRed%:** Proportion of years [1-15] that B≤BMSY & F≥FMSY
Safety	**pBINT%**: Proportion of years [1-15] that BLIM<B <BTHRESH	**pBLIM%:** Proportion of years [1-15] that B>BLIM
Yield	**LongY (kt)**: Mean catch in 15 and 30 years	**ShortY (kt)**: Mean catch over 1-3 years **MediumY (kt)**: Mean catch over 5-10 years
Stability	**MAP%**: Mean absolute proportional change in catch over 1-15 years	**var**: Variance in catch over 1-15 years **Pshut:** Proportion of years that TAC=0 **P10%:** Prop.of mngt. cycles when the ratio of change (TACn-TACn-1)/TACn-1>10% **MaxTACc:** Maximum amount of TAC change between management periods

Table 6. Performance indicators used for Atlantic bluefin tuna to measure if the status, safety, yield and stability objectives had been achieved.

	Atlantic bluefin tuna	
	Primary	**Secondary**
Status	**PGK** (SSB >= Dynamic SSBmsy & U<= UMSY) in year 30)	**Br30**: Br = SSB/SSBmsy in year 30 **AvgBr**: Average Br over years 11-30 **Br20** **POF**: Probability of overfishing in year 30 (U>Umsy) **PNRK**: Probability of not being in the red Kobe kuadrant **OFT**: Overfished trend, SSB trend if Br30< 1
Safety	**LD*15%**: 15% percentile of lowest SSB/SSBmsy over years 11-30	**LD*5%** **LD*10%**
Yield	**AvC10**: Median TAC over years 1-10 **AvC30**: Median TAC over years 1-30	**C1**: TAC in first 3 years of MP **AvC20**: Median TAC over years 1-20
Stability	**VarC:** Variation in TAC (%) between management cycles	

Table 7. Performance indicators used for Western skipjack to measure if the status, safety, yield and stability objectives had been achieved.

	Western skipjack
	Performance indicators
Status	**PGKshort:** Probability of being in Kobe green quadrant (i.e., SSB≥SSBMSY and F<FMSY) in years 1-3
	PGKmedium: Probability of being in Kobe green quadrant (i.e., SSB≥SSBMSY and F<FMSY) in years 4-10
	PGKlong: Probability of being in Kobe green quadrant (i.e., SSB≥SSBMSY and F<FMSY) over years 11-30
	PGKall: Probability of being in Kobe green quadrant (i.e., SSB≥SSBMSY and F<FMSY) over years 1-30
	POF: Probability of F>FMSY over years 1-30
	PNOF: Probability of F<FMSY over years 1-30
Safety	**LRPshort:** Probability of breaching the limit reference point (i.e., SSB<0.4*SSBMSY) over years 1-3
	LRPmedium: Probability of breaching the limit reference point (i.e., SSB<0.4*SSBMSY) over years 4-10
	LRPlong: Probability of breaching the limit reference point (i.e., SSB<0.4*SSBMSY) over years 11-30
	LRPall: Probability of breaching the limit reference point (i.e., SSB<0.4*SSBMSY) over years 1-30
	nLRPshort: Probability of not breaching the limit reference point (i.e., SSB<0.4*SSBMSY) over years 1-3
	nLRPmedium: Probability of not breaching the limit reference point (i.e., SSB<0.4*SSBMSY) over years 4-10
	nLRPlong: Probability of not breaching the limit reference point (i.e., SSB<0.4*SSBMSY) over years 11-30
	nLRPall: Probability of not breaching the limit reference point (i.e., SSB<0.4*SSBMSY) over years 1-30
Yield	**AvCshort**: Median catches (t) over years 1-3
	AvCmedium: Median catches (t) over years 4-10
	AvClong: Median catches (t) over years 11-30
Stability	**VarCmedium**: Variation in TAC (%) between management cycles over years 4-10
	VarClong: Variation in TAC (%) between management cycles over years 11-30
	Varall: Variation in TAC (%) between management cycles over years 1-30

Table 8. Performance indicators used for North Atlantic swordfish to measure if the status, safety, yield and stability objectives had been achieved.

	North Atlantic swordfish Performance indicators
Status	**PGKSHORT**: Probability of being in Kobe green quadrant (i.e., SB≥SBMSY and F<FMSY) in years 1-10 **PGKMED**: Probability of being in Kobe green quadrant (i.e., SB≥SBMSY and F<FMSY) in years 11-20 **PGKALL**: Probability of being in Kobe green quadrant (i.e., SB≥SBMSY and F<FMSY) over years 1-30 **PNOF**: Probability of not overfishing (F<FMSY) over years 1-30
Safety	**LRPALL[1]**: Probability of breaching the limit reference point (i.e., SB<0.4*SBMSY) in any of years 1-30
Yield	**TAC1**: TAC in the first management cycle (2025-27) **AvTACSHORT**: Median TAC (t) over years 1-10 **AvTACMED**: Median TAC (t) over years 11-20 **AvTACLONG**: Median TAC (t) over years 21-30
Stability	**VarC**: Mean variation in TAC (%) between management cycles over years 1-30

Figures

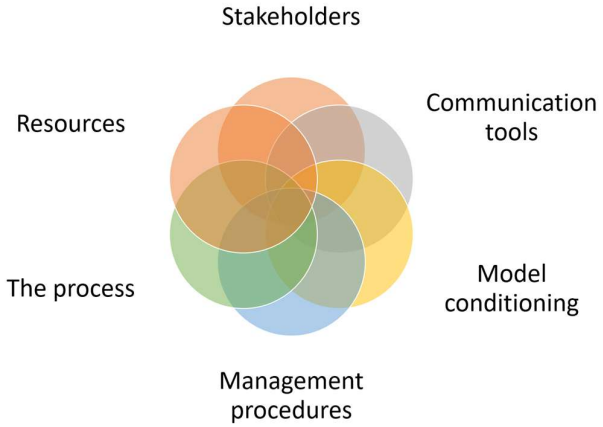

Figure 1. The six topics around which the meeting was structured.

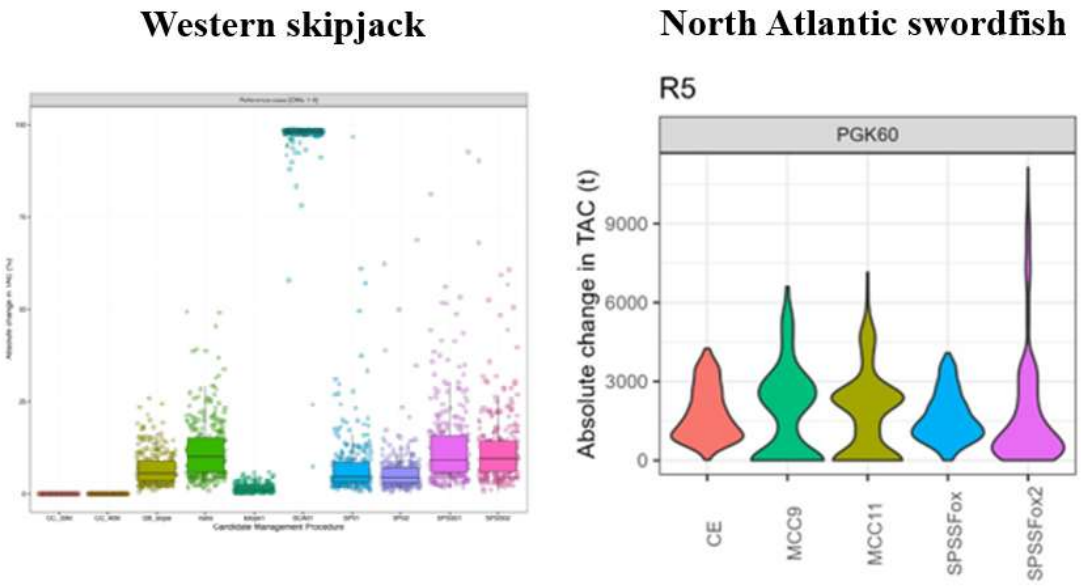

Figure 2. Figures used in Western skipjack (left) and North Atlantic swordfish (right) case studies to show the anticipated absolute change in TAC between management periods.

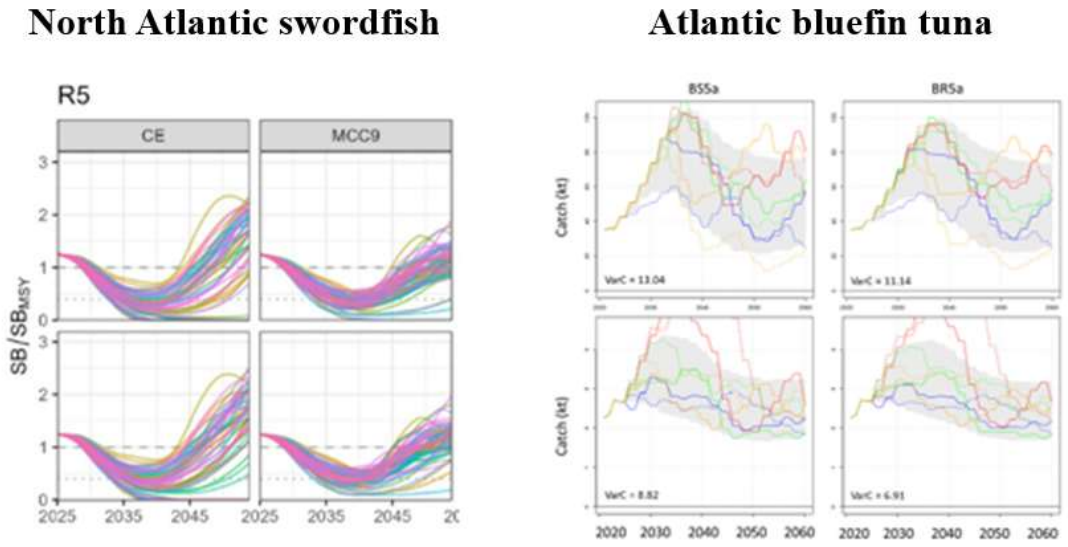

Figure 3. Examples of Worm plots used in North Atlantic swordfish (left) and Atlantic bluefin tuna (right) case studies.

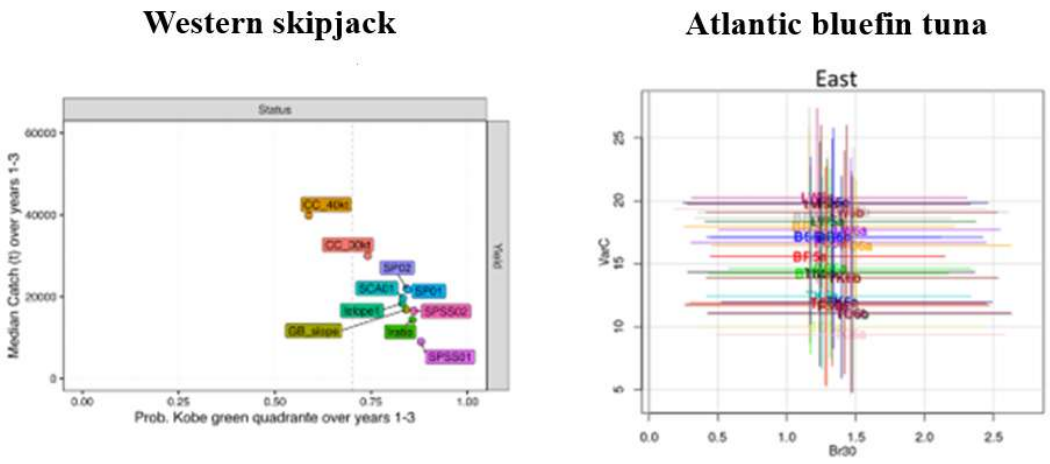

Figure 4. Figures used in Western skipjack (left) and Atlantic bluefin tuna (right) case studies to show trade-offs in different management procedure performances.

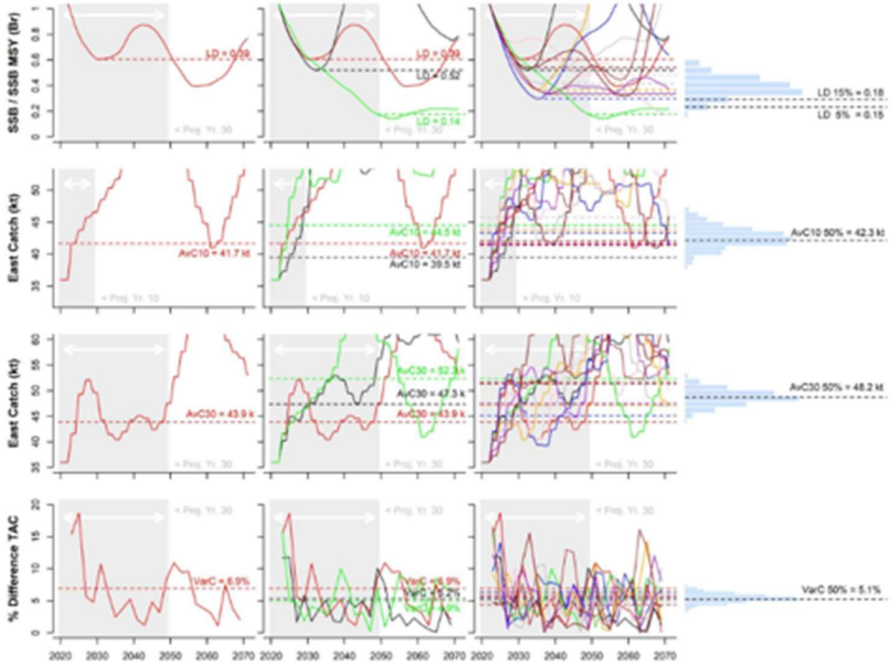

Figure 5. Worm plot used in Atlantic bluefin tuna case study.

Annex 1

North Atlantic albacore Management Strategy Evaluation process review

Date: 16th October 2024

Format: Online (Teams)

Participants:

- Gary Melvin (Fisheries and Oceans Canada, former chair of SCRS)
- Haritz Arrizabalaga (AZTI, chair of the species working group)
- Gorka Merino (AZTI, contractor for the next MSE)
- Dorleta Garcia (AZTI, project coordinator)
- Leire Ibaibarriaga (AZTI, project participant)
- Miren Altuna (AZTI, project participant)

Invited, but couldn't finally attend:

- David Die (former chair of SCRS)

The project coordinator begins the meeting by introducing the project, outlining its general objectives, and presenting the team members who will be involved. Following this, the project participants introduce themselves and describes their role within the project.

The meeting was structured around six topics related to North Atlantic Albacore (ALB) management strategy evaluation (MSE) process implementation (**Figure 1**).

1. The process

The main milestones of the ALB MSE process are summarised in **Figure 2**. There was no written roadmap, but the theoretical process was understood. Learning and adaptation occurred over time.

In 2010, a research plan for ALB was presented. In that meeting/document, the main objectives and research aims for ALB were defined. Although the MSE was not explicitly mentioned, one of the research aims was to evaluate the robustness of alternative management strategies to uncertainties, which is the purpose of the MSE.

In 2011, the principles of decision making for conservation and management measures were recommended. In addition, there was a request by the commission to establish limit reference points.

In 2013 a HCR for ALB was proposed. Additionally, the Standing Working Group on Dialogue between Fisheries Scientists and Managers (SWGSM) was stablished, meeting three times in 2014, 2015 and 2018. The group's goal is to enhance communication and foster mutual understanding between fisheries managers and scientists, particularly regarding management strategies, data collection, research needs and the establishment of limit and target reference points. It also aims to promote the efficient use of scientific resources and information. Although the initial aim was to have "open" meetings, there were concerns that managers dominated the discussions, limiting scientists' opportunities to speak. There were also uncertainties about how these discussions would translate into decisions compared to Panel discussions. Despite these challenges, the dialogue meetings were beneficial for the ALB MSE process and the initial transition of ICCAT into MSE management. The ALB was the first MSE process in ICCAT and the first MP adopted.

In 2016, the multiannual management and conservation programme for ALB was established with the objective of maintaining the stock in the green zone of the Kobe plot, with at least a 60% probability, while maximizing long-term yield from the fishery (Rec. 16-06).

In 2017, during the intersessional ALB species group meeting, the presentation of the MSE results was discussed, the need for an external reviewer was identified, and the ALB work plan and MSE were updated. Compared to the

work presented in 2016, the new MSE included more OMs and MP options to test. The first HCR based on MSE was adopted (Rec. 17-04).

In 2018, the MSE was updated and reviewed by an independent expert. An external reviewer was brought in to ensure that the code functioned as intended. Our contract marked the first review of the process.

In 2020, during the intersessional meeting of Panel 2, a draft protocol was proposed to detect and respond to exceptional circumstances for ALB. Based on this draft, the Protocol on Exceptional Circumstances was defined in 2021.

In 2021, MP based on MSE was adopted for the first time in ICCAT (Rec. 21-04).

The next MSE, incorporating the new OM reference set among other changes, is currently under development and will be presented by the end of 2024.

Lessons and recommendations:

- The ALB MSE needs recognition. The ALB was the first MSE process in ICCAT and the first MP adopted. ALB MSE set the foundations for other stocks. Many of the things were transferred to other MSE processes. For example, 1) the presentation of the MSE results was discussed along many conversations with the commission and then used for other MSE processes 2) the performance metrics used for ALB and some have become standard for other stocks, 3) exceptional circumstances protocol established for ALB was adapted to other MSEs.

1. Involvement of stakeholders

The ALB is not the species that attracts most attention in ICCAT. However, it is a major species for the EU, and CPCs paid attention to the process, knowing that other more interesting species' MSE would follow up.

The main instruments in the MSE process have been the species working group and the methods working group, the SWGSM and the Panel 2. The meetings of these groups are publicly announced, allowing anyone to participate. Communication is actively maintained through email exchanges, among other methods, inviting as many interested parties as possible. In addition, each country has its own mechanisms for handling stakeholders and NGOs.

While the management objectives are defined by the commission, contributions from anyone are welcomed in other aspects. Stakeholder representation was open throughout the process, allowing managers, NGOs, scientists, and other stakeholders to follow and contribute. The final representation depended on interest, availability, and motivation. For example, NGOs showed significant interest from the beginning, actively following and contributing to the process.

Lessons and recommendations:

- The MSE process is clearly open.
- The process allowed anyone interested to follow and contribute.

2. Communication

There are dialogue meetings (between scientists and managers), panel meetings, CPCs, species working group meetings, and methods working group meetings. Additionally, extra-meetings are held as needed.

Compared to other tuna MSE processes, there are less formal intersessional MSE meetings and ambassadors' meetings. Instead, for ALB, everything went through the species working group. For ALB, the group of interested people is smaller than for other stocks like BFT, and communication was fluid even without formal/structured meetings. However, the lack of translation to/from English in scientific working groups can be a deterrent for many people, limiting attendance due to language barriers, although this might not have impacted significantly in the case of ALB.

Standardizing the presentation of results is crucial to facilitate stakeholder understanding and avoid repeatedly deciphering figures and tables. The foundational format of figures and tables was established during the ALB MSE process and served as a basis to other tuna MSEs. Figures and tables were not adapted depending on the audience, keeping the plots simple and common.

Apart from the results presented in the meetings, ICCAT maintains a repository for the code, where the code is submitted after contracts. Additionally, there is an executive summary document that provides a concise and clear overview of the stock status and management advice for ALB. Furthermore, there is a "living document", a document that can be continuously updated as new information becomes available and as the ALB MSE evolves.

Lessons:

- It is mentioned that formal ambassadors' meetings might start being held in 2026. These meetings are considered valuable but require additional resources and funding.
- A Github repository has been created for the next MSE.
- The next MSE will be simulated using FLBEIA, and the plan is to also use the FLBEIA Shiny app to present the results in the meetings.

3. Model conditioning

The ALB MSE include 132 OMs, accounting for uncertainties in biology (natural mortality, steepness), data (size, cpue, tagging) and modelling options (time period, catchability). Additionally, decreasing catchability scenarios, and implementation error scenarios (such as bank and borrow and catches below TAC) are included as robustness tests. The population is projected using an observation error model. These data are then used to fit the surplus production stock assessment model.

Diagnostics have been applied for each OM, but no weighting is based on the plausibility of the OMs; all OMs are considered equally plausible.

The current MP is robust to the impact of global changes in productivity (growth, natural mortality, and recruitment). Within ICCAT, there are now groups focused on climate change and discussions on how to incorporate climate change into MSE for different species. It is likely that the approach used to include the impact of global change in the ALB MSE (Merino et al., 2019) will be followed.

In the MP, all parameters are fixed.

Lessons and recommendations:

- The next MSE will be based on Stock Synthesis assessment model rather than Multifan-CL, and the OM reference set will change.

4. Management procedure

In 2017 a harvest control rule specifically tailored to the stock assessment was used. However, since 2021, with the indices, the model, and other components in place, a full management procedure is used in the MSE.

A series of HCRs, which decrease fishing mortality depending on spawning stock biomass thresholds and trigger points, has been evaluated. The management objective was clear and selected by the commission.

Lessons and recommendations:

- It is a fully implemented management procedure.
- The FLBEIA model will be used to simulate the MSE process in the next MSE.

5. Resources

Since the beginning (2010), around 20 -30 people are actively involved in the ALB MSE process. Initially, the ALB MSE process was funded by European projects and internal CPC funds. The ICCAT MSE contracts for ALB began in 2021, alongside the contracts for MSE for BFT. In some cases, the EU provided direct funding, which was then removed from the ICCAT budget. The contracts are usually for less than one year, two at most.

6. Final remarks

MSE is an evolution. Single species and single stock assessment. Things are changing slowly. Overall, the MSE is a good and slow process.

Things to improve: Include formal ambassadors' meetings.

Things to highlight: 1) ALB set the foundations for other stocks MSE. 2) Exceptional circumstances protocol established for ALB was adapted to other MSEs. This is something that worked well and it will be maintained.

Figures

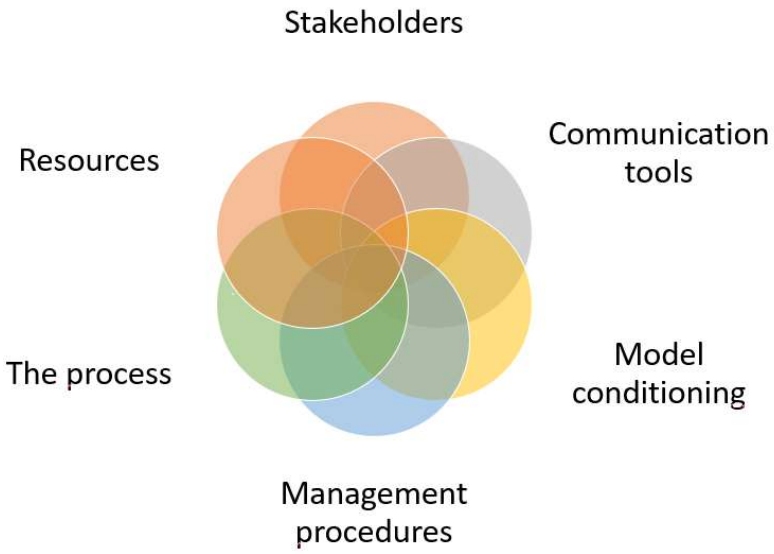

Figure 1. The six topics around which the meeting was structured.

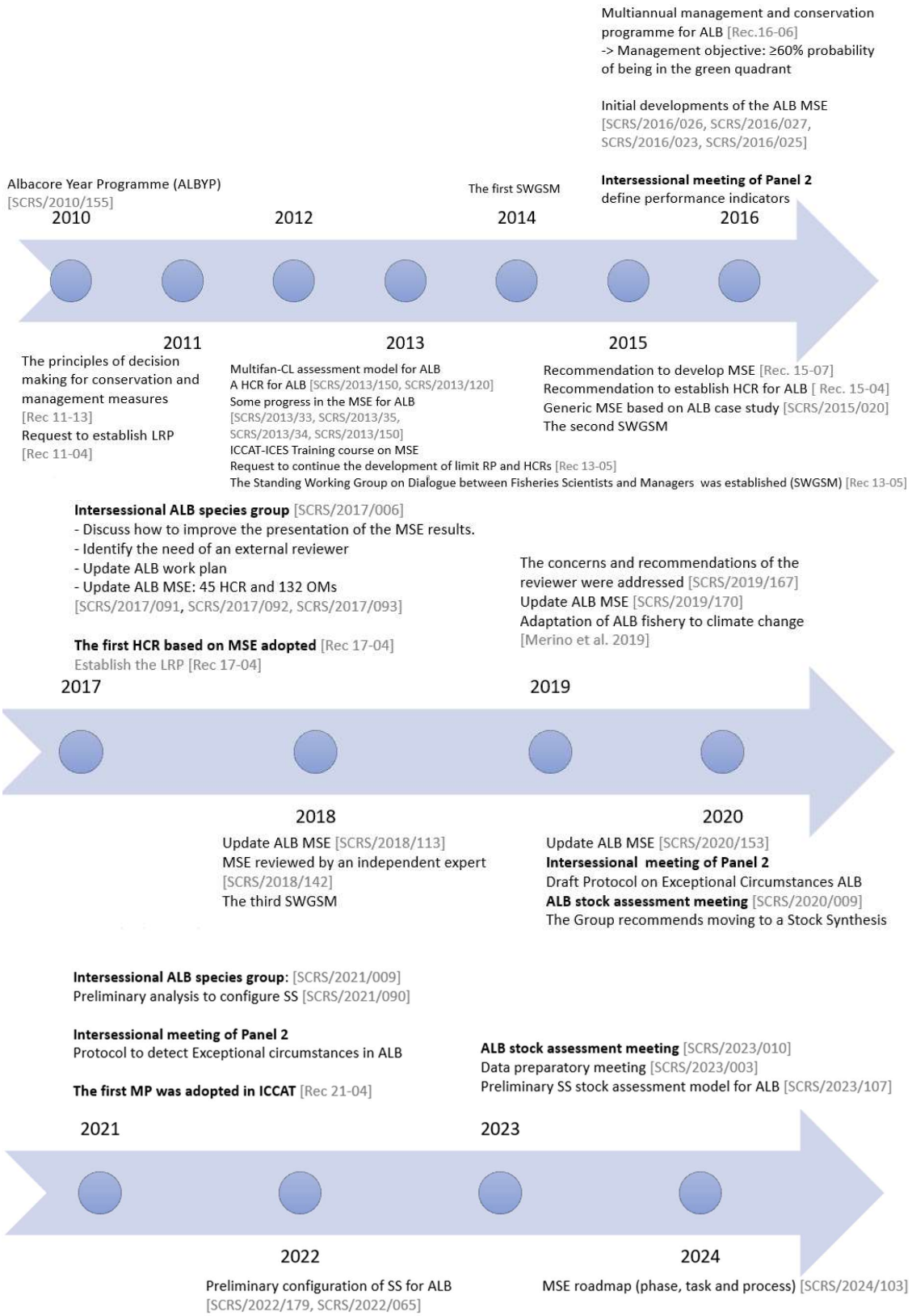

Figure 2. Key milestones in the ALB MSE process over the years.

Annex 2

Atlantic bluefin tuna Management Strategy Evaluation process review

Dates: 8th and 16th of October 2024

Format: Online (Teams)

Participants:

- Doug Butterworth (Japanese delegation, Technical WG chair, 8/10)
- Tom Carruthers (Blue Matters Science, contractor, 16/10)
- Enrique Rodriguez-Marin (IEO, Species Working group chair, 8/10)
- John Walter (NOAA, Species Working group chair, 8/10)
- Miren Altuna (AZTI, Project participant, 8/10)
- Leire Citores (AZTI, Project participant, 16/10)
- Dorleta Garcia (AZTI, Project coordinator, 8/10 and 16/10)

The participants introduced themselves and commented on their role in the Bluefin (BFT) Tuna management strategy evaluation (MSE) process. One of the participants made a general recommendation based on the International Whaling Commission (IWC) experience that no more than two MSE development processes should be running at the same time because there is a lack of experience and expertise in the community to support more than two processes simultaneously.

The meeting was structured around six topics related to MSE process implementation (**Figure 1**).

1. The process

The MSE process in BFT (**Figure 2**) started before 2015 (around 2013) with a meeting in Gloucester (Massachusetts)that set the seed to the future adoption of a management procedure (MP) for the stock. However, until 2018 only a core group was working actively in the MSE. There were many problems with the stock assessment of the stocks so that most of the experts were fully engaged on the assessment and the MSE did not receive as much attention. Meetings focused on the stock assessments rather than MSE, which diverted attention. An inflexion point took place around 2020/2021 where the stock assessments received some harsh peer review elevating the need for MSE. At this time, the core modelling team was expanded to allow for greater participation and inclusiveness.

During the process all participants learned a lot about what worked and what did not work with respect to presenting material to managers (e.g. Panel 2). Informational meetings with managers without no results proved unproductive; some results on likely MSE performance are needed to get their attention (in the sense of useful quantitative feedback on objectives and trade-offs). Managers expect to see decisions points. Furthermore, options must be given in the specific form of what is preferred: A or B, rather than simply ask for preferences in broad general terms. Once CMPs were well-developed and concrete results available, then Managers and stakeholders were keenly involved in the process and requested meetings. In the year prior to adoption (2022), the different meetings related to the BFT MSE summed up around 38 working days.

The Bluefin tuna model (conditioning and simulation) represented new science. It was a bespoke set of operating models that encompassed numerous sets of hypotheses around stock structure, movement, mixing and stock dynamics.

At the time, MSE was relatively new to many of the participants (both scientists and managers) so it took a long time to develop an understanding the approach so they could collaborate/contribute effectively.

The BFT experience was lengthy and time consuming and provides numerous lessons for how the process can be accelerated at ICCAT. For example, it is critical to have a clear roadmap, hard deadlines for each step in the process and a clear set of roles and responsibilities for each decision-making entity. For BFT, specifically the OM models had to be reconditioned on a number of occasions as new data became available and this lengthened the process too, which could have been solved by hard data deadlines.

External code review happened late in the process and it is challenging for an external person to do a real in depth review when the code is so long. However, the model was coded in 3 different languages and the 3 of them provided the same results, which provided reasonable confirmation that there were no coding errors. Furthermore, a scientist involved in the process did review the code line by line.

Lessons and recommendations:

- Be careful with when the process is set up, the buyin of the species working group is needed. Thus, need to ensure that the experts in the group are available to engage in such a time demanding process.
- The assessment and MSE processes are too related that running both in parallel is difficult. Prioritize the main priority- which should be the MSE.
- To have the attention of managers results are needed.
- External reviewers must be involved in the entire process itself because MSE takes a long time.
- After the stakeholders have reasonably understood what the MSE exercise involves, the process should not take more than 1-2 year(s), thus avoiding the need for multiple reconditionings. Two interactions with the Commission and another 2 with the Panel 2 should be enough.
- Two deadlines (or "guillotines") are essential for the process: a "data" deadline after which no new data may be considered (before the first occasion a few years on when a review and possible revision is first entertained); and an "operating model") deadline after which no further models may be considered in the concluding simulation testing component of the process. Failure to enforce these deadlines leads to lengthy delays in completing the process.
- The role of people needs to be clear, even within the scientists, so the collaboration is efficient.
- As far as possible, the code used should be generic and have been used in other case studies to be sure that it works well.

2. Involvement of stakeholders

In 2022, the meetings related to the BFT MSE summed up around 38 working days. The meetings with managers to ask them questions in the abstract and without showing results were unproductive. Some results or something tangible is needed to get their attention and useful feedback. They need to see the space the scientists are talking about. Asking them to select among options instead of making open questions can result in more useful feedback.

Regional groups were formed to interact with stakeholders at local level. At this level feedback from industry and other interested parties was obtained. However, the activity (or existence) of these regional groups was constrained by the capacity of the countries. There is differing degrees of scientific and stakeholder engagement capacity among the countries involved in bluefin tuna fishery. Language is one of the barriers, but expertise is also a limitation. Thus, the process was dominated by the countries that had the capacity to participate actively in the process. However, the BFT process was the first to develop the Ambassador process of providing common materials in the three official ICCAT languages as well as Arabic.

There was a lack of rapid and efficient feedback between scientists and stakeholders. In other processes with fewer countries involved (NAFO, CCSBT) such interaction is easier. An intermediate level group between experts and Panel 2 would be needed that combines both type of professionals, scientist and stakeholders. In ICCAT Panel 2 is too formal to get feedback from all groups of stakeholders. Panel 2 is largely a deliberative body where rather than a collaborative body, which impedes the necessary interaction and iteration between scientists and managers that is most effective to developing MSE. As a deliberative body tasked with making recommendations on political decisions such as allocations and catch quotas, the Panels are necessarily formal and do not foster communication and a common trust in the MSE process. Panel 2 is a place to make decisions but in the process of MSE implementation what is usually needed is guidance. Panel 2 is good to reach agreements but not to get feedback from different parties. The meetings are very formal, and people are not 'free' to participate. This is way a lot of informal meetings were arranged.

ICCAT has no way to interact with individual members within the CPCs. This is why the ambassador concept was created, to ensure interaction with regional communities and stakeholders. One of the objectives of the ambassadors' meetings was to help stakeholders to understand the MSE approach, because to be able to provide useful feedback, understanding the approach is essential. However, this worked very differently from country to country.

Lessons and recommendations:

- The meetings with stakeholders need something tangible (i.e. results, options between which to choose) to have their attention and to obtain useful feedback.
- An "Intermediary group" needed to get feedback from stakeholders efficiently (Miller, Anganuzzi et al. 2019).
- Capacity building in all the countries involved.

2. Communication

The main tools were Github, the shiny app and the 4-pager document. The 3 tools had their own role, and they were useful.

In terms of frequency, for efficiency, in a process like these meetings should happen every one or two months. The 'intermediary group" cited above is a (not too large) group of scientists, managers and other stakeholder representatives which provides the input from the "decision level" to scientists regarding preferred options in terms of management procedures, so that the scientists can implement their simulation testing more efficiently by having the guide of stakeholders on this.

Again, without results it makes no sense to have meetings. It is necessary to make people time worthwhile and have the meetings when there is something to show them.

Quilt plots to present the results (including the shading colours used) worked very well. Time trajectories of individual realisations of catch and abundance time series (in addition to medians and quantiles) show real variability in a way that many stakeholders may not comprehend properly from tables of performance statistics alone. The quantiles can hide the extent of inter-annual variability that is likely to occur in reality.

Standardizing how the results are presented (both within a single organisation (e.g. RFMO) and amongst such organisations) is important, to facilitate the understanding of stakeholders, and even scientists, and not to lose time with multiple explanations being required to assist understand plots and tables.

ICCAT should have a server to host the shiny apps. Running the apps locally is possible and requires only one line of code. However, this would not be straightforward for people not familiar with R.

3. Model conditioning

A key difficulty when specifying the operating models is to decide on who does the selection. If a specific operating model does not make a difference in terms of management outcomes, it is not necessary to include it in the analysis. From previous experiences it was already known that it was not worthwhile to consider some operating models, but some experts nevertheless wanted to test them to be sure about this. The need to include them slowed down the process substantially. Given the complexity of BFT and the long history of scientific research, there was substantial attention to many details of the population dynamics that were not critical to MP performance. A key recommendation regarding model conditioning would be to create an initial model with a simple MP to be able to quickly 'show' rather than tell when a particular scenario has little impact on the results. This would greatly speed up the process.

Given the non-linearity of biological responses, it remains uncertain how the increase in temperature derived from climate changes scenarios will impact the biology and population dynamics (including productivity) of the stocks. The BFT process could have added substantial additional complexity to include explicit climate-change scenarios, however most impacts of climate change on population dynamics can be abstracted to several parameters within the operating models. Typically, these include only the stock recruitment relationships, growth, mortality or catchability. In the absence of such explicit climate incorporation, the regime shifts in the BFT MSE convey a high degree of 'climate' readiness in that the MPs were specifically tuned to reference grid OMs with non-stationarity and also use dynamic reference points to evaluate stock status within the OMs.

4. Management procedure

In an MSE process, ideally anyone should be able to propose a management procedure. Then, the discussion on acceptance/rejections should not be based on the a priori formulation of the management procedure but on how it performs.

For Atlantic bluefin in ICCAT, here were (originally) 8 groups each testing their different CMPs; in other cases probably there are not as many groups. There was a friendly competition to find the MP that had the best performance. This competition facilitated a better search of the space of different possible MP options. The groups learnt from each other which made the process more efficient. Without the 8 groups competing among themselves it would not have been possible to search the space as thoroughly as was done. This is not possible when all the work is in the hands of a single consultant for example.

Model based rules were tested, but there was more focus on empirical rules. The assessment models for BFT have been problematic in the past and this was a major reason why empirical MPs received more attention.

Assessment models assume stationarity in many processes, while we know the future is not stationary. This problem is less problematic with empirical MPs that are based on far fewer assumptions.

Criteria to discard CMPs that didn't work well and keep those that did were clear and useful.

However, the MP eventually probably uses too many indices, and it could perhaps have been improved by using only the most informative ones.

If managers would have specified what is a meaningful change for a specific indicator (i.e changes in catches), experts could have worked on many options for the CMPs and only presented those that resulted on a meaningful change.

5. Resources

In general resources and computational power were more accessible in this case because of the support of the Atlantic-wide Bluefin Tuna Research Programme (GBYP). But at country level there were some problems. For example, some groups faced difficult because they were not familiar with the code, and had to run it externally due to its computational complexity.

An annual cycle funding scheme is a problem for the contractors. Longer term funding would facilitate the planning and more efficient conduct of the work.

6. Final remarks

The process of implementing MSEs in ICCAT is taking too long and it should be simplified. Ideally it should be done in a two-year period. There is a flowchart from the IWC that could help on this.

At the beginning of the process set a timeline that is clear about the end goal and that aligns the expectations with reality in terms of available resources.

The BFT experience expended considerable time and resources following numerous paths which, in hindsight, could be made much more efficient for future MSEs at ICCAT.

Having all panels discussing in parallel about the same thing (i.e. management procedures) for different species has been inefficient. For example, a default set of operational management objectives and their thresholds could be adopted by ICCAT and simply modified rather than developed de novo for each species. Probably some elements do not need to be discussed again, and the ones already agreed for some species can be directly adopted for other species, unless there is something that makes the species very different.

7. Recommended literature

Miller, S. K., A. Anganuzzi, D. S. Butterworth, C. R. Davies, G. P. Donovan, A. Nickson, R. A. Rademeyer and V. Restrepo (2019). "Improving communication: the key to more effective MSE processes." Canadian Journal of Fisheries and Aquatic Sciences 76(4): 643-656.

Figures

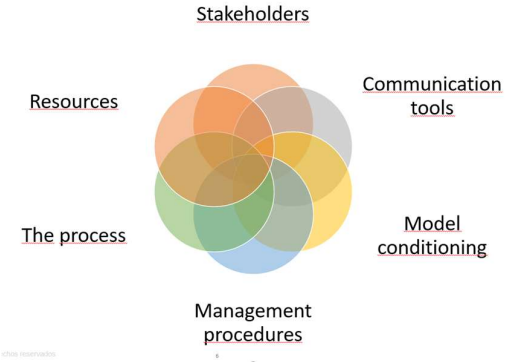

Figure 1. The six topics around which the meeting was structured.

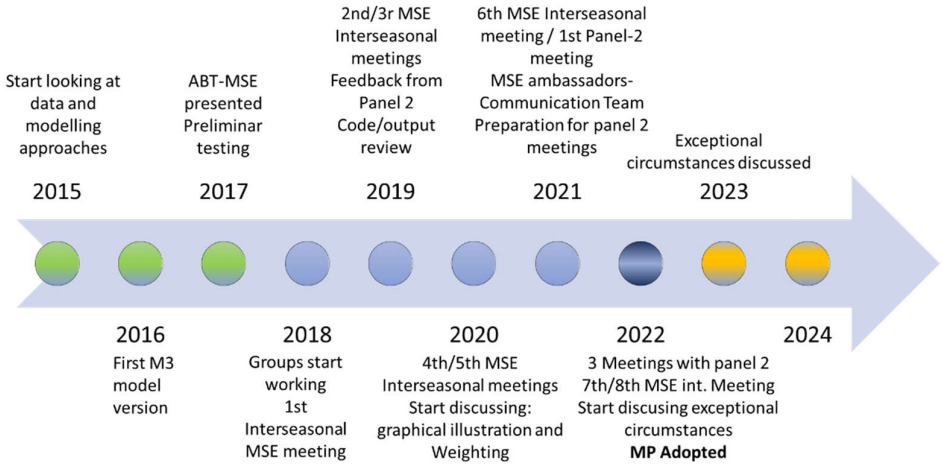

Figure 2. The bluefin tuna MSE process along years.

Annex 3

Western skipjack Management Strategy Evaluation process review

Dates: 25th and 30th of October 2024

Format: Online (Teams)

Participants:

- Craig Brown (SCRS chair 2023-onwards, 25/10)
- Gary Melvin (former SCRS chair 2019-2022, 25/10)
- Rodrigo Sant'Ana (contractor, 30/10)
- Leire Ibaibarriaga (AZTI, Project participant, 25/10 and 30/10)
- Dorleta Garcia (AZTI, Project coordinator, 25/10)

Invited, but couldn't finally attend:

- Bruno Mourato (contractor)
- David Die (former SCRS chair 2015-2018)
- Shannon Cas-Calay (chair Technical MSE subgroup)

To ensure participation of both contractors and SCRS chairs, two meetings were organised. Both were recorded to facilitate the minutes writing. At the beginning of each of the meetings, the participants introduced them and their role in the W-SKJ MSE process. Then, AZTI introduced the external review of the overall ICCAT Management Strategy Evaluation (MSE) process and explained the six topics that were going to be covered in the meeting: process, involvement of stakeholders, communication, model conditioning, management procedure and resources. The comments for each of the topics are summarised below.

1. The process

The main milestones of the W-SKJ MSE process are summarised in **Figure 1**. A first demonstration of the MSE framework for this stock was conducted in 2020, but the process really started in 2022.

- Albacore was the first MSE. Bluefin was the second one and is the one that has had most of the attention. Other case studies in development, not full process finalised.
- In comparison to other case studies in ICCAT, W-SKJ was maybe simpler, with less countries in the fishery and less people involved.
- Success or failure of the MSE process depends on the people involved. The work for W-SKJ was conducted by enthusiastic people that could allocate the time and resources needed. They started from zero, learning the basics of MSE. Learning by doing. They tried to take advantage of and learn from the processes of the other stocks.
- At the beginning, there was a lack of attention from the TT (tropical tunas) group. Development was slow until they agreed to officially support the MSE process for W-SKJ.
- One of the disadvantages of having few people involved is that the process could not benefit from comments of experts. It is difficult to have other case study experts involved, and this hinders the transference of knowledge and interactions across case studies. As a result, feedback on some issues arrived later than would have been desirable. This sometimes can imply starting again the work, slowing down the process.
- It would have been good if the technical group was earlier.
- It is important to improve communication across case studies: learn from others' experience and not repeat past errors. Although there are ICCAT reports and SCRS documents available, active discussions and interaction are needed.
- The work is now ready to be presented and discussed by the Commission. According to the roadmap, a MP should be adopted this year. However, the catches are lower than expected to be in the green area of the Kobe

plot. It is not clear what will happen. They could ask for more work, revise the management objectives or something else.

2. Involvement of stakeholders

- The level of stakeholder participation is very different. They have different levels of training and not everyone is sufficiently competent on technical aspects like MSE. As a result, they may attend the meeting but are not very active providing feedback.
- The covid pandemic was a challenge, but it allowed to improve the online communication. Some meetings are now online and has facilitated participation. On the contrary, the advantage of the physical meetings is that it is easier to have informal conversations in the corridor (sometimes people are afraid of asking/talking in plenary).
- For some case studies, they have tried to keep political and technical discussions separate. And not everyone was welcome to participate in the technical meetings.
- ICCAT has a very good instantaneous translation system, which facilitates stakeholder involvement. The language is not considered to be a problem.
- Panel 1 reached agreement on operational management objectives, but did not have time to discuss the uncertainty sources.
- Very few MSE meetings. It would have been good to have more frequent meetings.
- The MSE-tropical tuna was considered very useful, but it started in 2024. Maybe if this would have started earlier, the MSE process would be more mature. In 2024 this group discussions occurred within the yellowfin tuna data preparation and stock assessment group.
- Given that not all the stakeholder participate actively in the meetings, it is difficult to assess if the views of all the stakeholders are well reflected. However, CPC delegations are structured to give a balanced view.
- It is also difficult to separate industry and managers involvement. NGO's always present.
- In any case, the overall view is that the process for W-SKJ was not hampered by lack of stakeholder involvement.
- First ambassador meeting took place in October 2024. Very good feedback.
- MSE training workshops have been very successful for this case study. The W-SKJ was used as an example in the workshops. For scientists they provided more detailed material. For managers they learned how to make decisions based on objectives. Among others, EU, African and Caribbean CPCs involved. Very interesting discussions. These meetings are more informal and without the responsibility of making decisions, the atmosphere is more relaxed. People feel free to ask and participate, facilitating communication and learning. Using the W-SKJ as an example provided an opportunity to discuss about this particular case study.
- For W-SKJ the main CPCs are Brazil, Venezuela and US. Always same participants in meetings.

3. Communication

- SCRS and ICCAT meeting documents are available in a relatively short time frame. Therefore, all the process is well documented.
- Slick used for communication (code needs to be updated)
- The more standardised approach for presenting results, the better
- Github available
- It is important to have unified plots/tables. They need to improve the plots/tables to present results in a similar way to other case studies. Having the same type of results facilitates communication, comprehension and presentation of results to the commission.
- The living document not ready yet, but they plan to do it shortly. Right now information is separated in several SCRS documents.
- The same for the 4-pager document. It is pending.
- Very low frequency of meetings. This could be improved. But 2024 was good in that sense, they got feedback.

4. Model conditioning

- Uncertainty sources were identified by experts. The process relies on the experts participating in the process.
- In this case, the uncertainty were based on the stock assessment. It could be debated if the uncertainty sources in a MSE process should be the same as in the stock assessment.
- All scenarios are equally weighted (bluefin is the only case study that has weighted scenarios, weights given by experts). All scenarios are plausible, but some may be a bit extreme and less likely. There is the need to think better about what are "realistic" uncertainties. Maybe some OMs could be dropped down. The plausibility of the OMs should be discussed early in the MSE process.
- They refer to the SCRS document by Tom Carruthers on the MSE process as something interesting that should be looked at.
- There are reference and robustness OMs. Eventually, some robustness tests can be moved to reference OMs.
- Global change is a hot issue and there are discussions on how to account for it in the OMs. The idea is that global change is not explicitly considered, but a "worse productivity" scenario representing worse conditions attributed to global change will be tested. This is planned for 2025.
- The low catches resulting from the MSE process compared to actual catches, may be a result of the uncertainty sources considered. This may need to be revised in the future.

5. Management procedure

- The constant catch MPs were used to check the code and test if the results were meaningful.
- They have empirical and model-based HCRs.
- Exceptional circumstances will be developed after the MP is approved.

6. Resources

- Primarily 2 experts (contractors) + additional 5 people (participating in discussions)
- Funding restricted to people availability. This case study was anticipated to be "less complex", although there is never a simple case study.
- Tool used: OpenMSE. It is in continuous development.
- Computation power was an issue. Five days for each OM for 300 iterations. Tuning process more than one week. Need to improve the code efficiency.
- Financial funding considered to be sufficient by the contractors.
- It could be interesting to compare the budgets across countries. Maybe the same budget is sufficient in some countries, but insufficient in others.

7. Others

- A lot of code testing/checking was done to ensure everything was correct.
- No external code review done yet, but there is budget allocated for next year.
- There is a proposal to have MSE work done by external people, but they do not think this will work.
- THINGS TO IMPROVE:
    - To have more engagement with other analysts and more feedback since the beginning.
    - More experience on MSE is needed. ICCAT is learning by doing. A lot of experience has been gained but more needed (scientists, managers, etc).
    - Selection of uncertainty sources (stock assessment vs MSE). Plausibility of scenarios. Drop off some uncertainty cases.
- TO ADOPT:
    - Spirit of exploration and improving. Initiative by the experts.

Figures

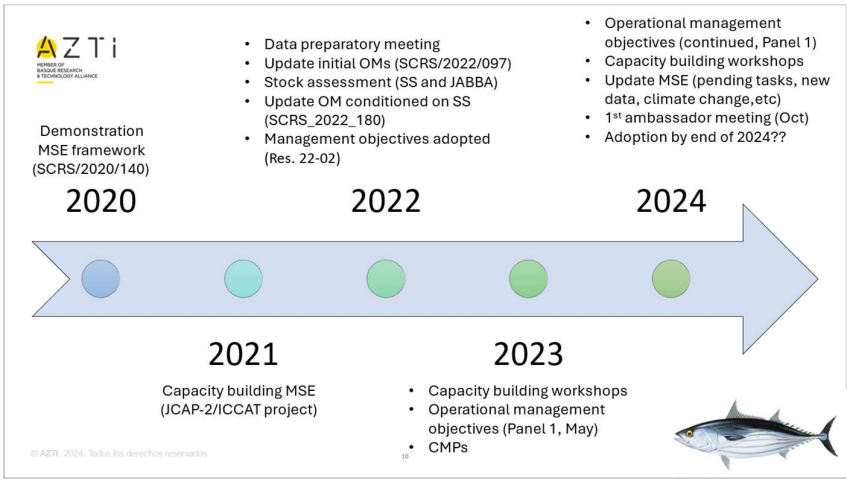

Figure 1. Main milestones of the W-SKJ MSE process.

Annex 4

North Atlantic swordfish Management Strategy Evaluation process review

Date: 24th of October 2024

Format: Online (Teams)

Participants:

- Kyle Gillespie (SWO coordinator and Chair of Technical MSE sub-group)
- Adrian Hordyk (MSE Contractor)
- Rui Coelho (previous SCRS vice-chair and previous SWO coordinator)
- Leire Citores (AZTI, Project participant)
- Dorleta Garcia (AZTI, Project coordinator)

Presentations and introduction (about the project and the six topics related to the MSE implementation to be discussed during the meeting) by Dorleta.

1. The process

First recommendations to work on HCRs were around 2013 with a general recommendation to develop MSEs, including the North Atlantic Swordfish stock in the list, in 2015. In 2017 a Stock Synthesis (SS) stock assessment model was configured for this stock, already thinking on an MSE for future implementation. The first contract to work on an MSE came in 2018 and ended in 2019, with no satisfactory results. In 2019 a new contract with a different contractor was established, which was the starting point of the process that has been carried out until now (**Figure 1**).

This process had a roadmap since the beginning that was updated every year. Most of the times it was too optimistic, and it needed to be adjusted accordingly. Having such roadmap helped to have the work structured for the various steps that need to happen in order to achieve a successful MSE. The participants don't have the feeling of the process being too long, the MSE process for the BFT stock had started before, and learning from that stock helped to have a more efficient process for the SWO case. It was also noted that the SWO case was likely simpler than BF due to the species biology and stock mixture characteristics of SWO. However, the SWO process could be more efficient; as the process takes longer, new data comes and the OMs need to be updated. It would be better if no data updates need to be done after a certain point, shortening the process.

There was not an external reviewer for the whole process until now. The reviewing process was done in 2021 for the code and algorithms part.

All countries have same right to be involved in the process, but it may happen that not all have the same presence due to different reasons, such as interest in the stock or "technical background".

2. Involvement of stakeholders

Countries are mainly represented by CPCs, that give their feedback and express their desires and views trough the ICCAT panels (panel 4 in the case of SWO).

The technical group is a smaller group (around 8 persons), where everyone is invited to participate but a high level of understanding of MSE technical aspects is preferable in order to fully follow this group. The technical group takes technical decisions on MSE, never decisions related to management. When the technical group needs information in biological or other aspects, those are requested to the SWO-Species Group during the regular intersessional or species groups meetings.

It was decided that it was better not to include the industry or other stakeholders in the technical group. Most of the scientist in the technical group have contact with stakeholders (e.g., NGOs, administration, sector, …) in their countries but the official feedback or requests have to be done through the ICCAT panel 4. Although all the CPCs have the same right to discuss and make such management decisions, there are some specific CPCs that are more actively involved. For example, due to less specific interest in SWO fisheries, language or other issues some of the countries may have a less active participation.

3. Communication

Communication during the MSE process was done in different ways. Each year, several SCRS papers and presentations are shared with detailed information on the works done. The most useful communication documents have been the summary document, of 4-10 pages, with short descriptions and summaries of all assumptions and results using simple terminology, along with a ppt presentation. This documentation is provided before the panel 4 or the regular annual ICCAT meeting, so that people can have a look and prepare questions or comments.

Ambassador meetings have been also a very effective way of communication. Technical results and taken decisions are presented in three languages. This presentation is usually before the panel 4 meeting so people can get familiar with the process and results. The Ambassadors meetings are only to present results and decisions, but it is not the place for stakeholders to give feedback, this is done in the panel.

A shiny app was also developed, which is accessible to everyone. This is useful to respond to specific questions as well as to explore general results. Some stakeholders, including administrations from CPCs, can use them to explore the results. Some people are also more familiar with the tool as it is similar to the BFT.

More than one type of representation is used to communicate results, not to restrict to a single plot. They (the contractor) are working on the standardization of visual results.

The communication in the panel was effective; they learned to ask very specific questions and to express the exact decisions the technical group needed from the panel. The communication within the technical group was very frequent, sometimes as often as weekly meetings. This was easier to manage as it was a small group.

4. Model conditioning

A set of reference OMs were set and then robustness tests were performed. At the beginning of the conditioning process a large grid of uncertainties was designed with 7-8 uncertainty axes. This original grid was first proposed and agreed by the wider SWO-Species Group, after the 2017 stock assessment that used SS3 for evaluating the stock. After some discussion it was decided that such a large grid was not needed and it was reduced to the 2 main uncertainty axes, with 3 different values each, giving a total of 9 reference OMs. Additionally, various robustness tests were built over time, with 7 robustness tests presented in the final results, and from those there is more focus on the main 3 robustness test. This selection was done as those are the tests that provide better discriminatory results for the various CMPs. Implementation error was also tested. No weighting was applied to OMs.

For next year, there are plans to continue work on more robustness tests, namely, to advance the climate change test and initiate the minimum size test. They commission may ask for more work on this or may take a decision that those are no longer needed.

5. Management procedure

Two workshops for the development of MPs were carried out. In these workshops people were able to give ideas and to develop several CMPs. The contractor then coded the developed options. The group was told to develop CMPs with no specific requirements or restrictions, so they had freedom to explore on a wide range of MPs. There were no groups to explore CMPs as in BFT, rather, the technical team worked collaboratively to develop a variety of CMPs.

Three tunings were proposed at first (0.5, 0.6 and 0.7 PGK, in the short, mid and long term). 0.5 was eliminated and the 0.6 and 0.7 tunings were retained. CMPs were not tuned to the biomass limit reference point (0.4 BMSY) as all CMPs showed good performance with respect to the avoiding biomass levels that approached this LRP.

Some CMPs were discarded when the minimum criteria were not met. For the CMPs that met the minimum criteria, the best version of each CMP was developed and presented to the panel 4. It is the ICCAT panel 4 that needs to decide between trade-offs and choose the best MP (so an order of preference was not provided by the technical group, they just proposed the various options).

For the simulations the R package SWOMSE was developed. It is a specific package for this MSE process based on OpenMSE (and other more generic R packages). The review of the code and algorithms was done to the whole code in 2021, including the equations on the OpenMSE simulation tool.

The bulk of the work was done by the technical group (around 8 people), with the contractor in charge of implementing everything.

6. Resources

The computational power was handled by the contractor. There were no problems regarding the computational power, everything could be run in time and the shiny app for results works well. However, they note that both things are dependent on the contractor and that it will be very difficult to reproduce the simulations by individual CPC scientists or someone in ICCAT with their own laptops (many days will be needed to run everything).

The participants comment that it would be good that ICCAT could provide the needed computational power as well. Similarly, for the shiny app that is hosted by the contractor, they comment that it would be good that ICCAT could host it, given that if the contract is finished the shiny app will no longer be maintained. Alternatively, it is also proposed, that ICCAT could have some internal or external group of maintenance for these kind of services.

The financial resources covered the contractors. It was renewed yearly; a quantity was requested every year and then it was accepted by the “financial Panel”. No mayor extra requests were needed during the process.

They pointed out that it is important that involved scientist have enough time to the dedicate to the process, which is not the usual case, if not it can take longer and be less efficient. It is a problem in ICCAT the limited number of people involved.

7. Final remarks

A more formal technical roadmap with deadlines could be helpful. Some developments where tricky as data became outdated, and updates were needed during the process. Deadlines could help to not extend much the process, so that new data don’t come in and the process is more efficient without all these intermediate updates.

There was the feeling that most of the time was spent working on OMs and robustness test and the available time for CMPs had been shorter. For future processes, dedicating more time to CMPs development would be interesting (and doing faster the OM part, avoiding the data updates as mentioned above).

In this line, it was noted that for CMP exploration, having a longer data-lag, could avoid some data updates and allow being more efficient in CMP testing.

Figures

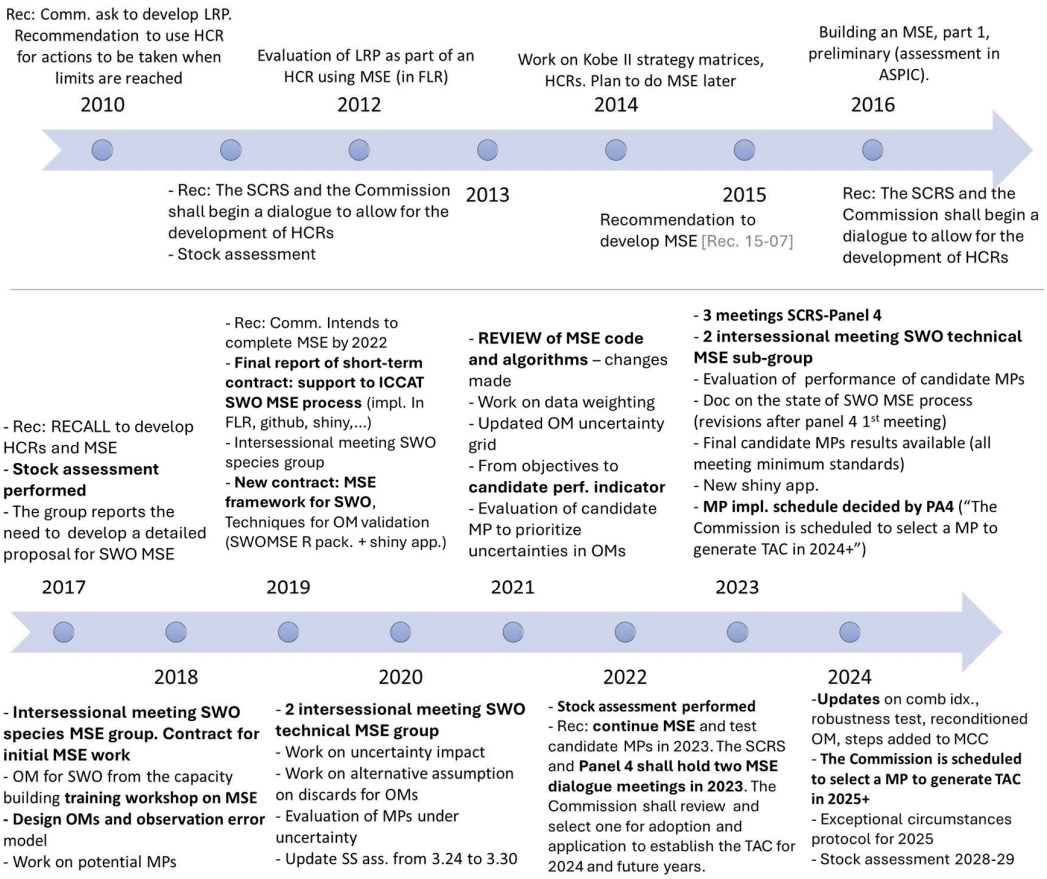

Figure 1. North Atlantic swordfish process along years (generated by Leire Citores, based on ICCAT documentation and presented in the meeting).

Annex 5

Multi-stocks tropical tunas Management Strategy Evaluation process review

Date: 10th of October 2024

Format: Online (Teams)

Participants:

- Gary Melvin (Department of Fisheries and Oceans - Canada, Chair of the SCRS 2018-2022)
- Serena Wright (CEFAS, Tropical tuna coordinator, supporting intersessional ad-hod tropical tuna MSE meetings)
- Gorka Merino (AZTI, Contractor – coordinating projects for MSE process for tropical tunas & stock assessor of tropical tunas)
- Miren Altuna-Etxabe (AZTI, Project participant)
- Sonia Sánchez- Maroño (AZTI, Project participant)

Firstly, the aim of the project and the team were presented. Next, the participants introduced themselves and commented on their role in the multi-stocks tropical tunas (TRO) Tuna management strategy evaluation (MSE) process. Afterwards, the meeting was structured around six topics related to MSE process implementation (**Figure 1**).

1. The process

The MSE process in TRO (**Figure 2**) started some years after the recommendation from the Commission to develop an MSE for the different species (REC 15-07). After a couple of meetings to set some of the basis of the work. These are, a Tuna Regional Fisheries Management Organizations' MSE working group (t-RFMO MSE WG), where MSE performance indicators were reviewed, and at an intersessional tropical tuna species working group (SCRS/2017/011), where a fist single stock MSE for bigeye tuna (BET) and yellowfin tuna (YFT) was made available (SCRS/2017/198) and Carruthers (2017) carried out an analysis on the assessment uncertainties and the effect of data processing.

But it was not until 2018, when the TRO MSE started and a first conditioning of the operating model (OM) was presented at the 1st intersessional Panel 1 meeting as a basis for discussion (SCRS/2018/112, SCRS/2018/146-147, SCRS/P/2018/053). This initial OM only included bigeye tuna (BET) and yellowfin tuna (YFT), still missing eastern skipjack (SKJ) which was included some time after. At the same time, the graphs for presenting MSE results were harmonised and best practices for communication were defined at the t-RFMO MSE WG.

In the next years, the main uncertainties in the MSE process were identified (SCRS/2019/033, SCRS/2019/015) and the need to link the MSE plan to stock assessment schedule was recognised. Therefore, a new revised roadmap for MSE and harvest control rule development was defined (SCRS/2020 Annex10). However, small progresses were made (SCRS/2021/001, Forrestal *et al*, 2021, SCRS/2021/16, SCRS/2021/55, SCRS/2022/007), while new BET and SKJ are carried out (in 2021 and 2022, respectively), as the assessment work was limiting the expert's availability for working on the MSE process.

In 2023, a multispecies OM conditioned with modified fleet structure with observation error model of an abundance index was available, but still now including all uncertainties (SCRS/2023/002, SCRS/2023/017, SCRS/2023/020, SCRS/2023/P/007). During 3rd Panel 1 intersessional meeting, the operational objectives were presented and a request for including climate change robustness test was made. Finally, in 2024, a new yellowfin tuna assessment is available.

Regarding communication, in 2021 some capacity building programs were developed (the figure of ambassadors and MSE courses in different languages) and that same year the 1st MSE training workshop was carried out (in

Portuguese and Spanish), In the following years and additional ones are being planned (in all ICCAT official languages) for scientist and other stakeholders for next year.

In the short term (probably 2024), a documentation of the work is scheduled, and 3 external advisors will be included in the process (budget has been already planned), to guide on the next steps of the process. In the medium-term (2025-206) an external review of code, scripts and results is expected. And, although not yet occurred, ambassador meetings for the TRO MSE are planned for the near future.

In the opinion of the experts, the roadmaps have been weak in describing the steps forward. It needs to be more detailed, and specific enough about what and when should be presented each year, in order to avoid misinterpretation or not supplying expected outcomes on time. There is a need to define clearly who is doing what, as there are multiple players, and it is not clear who is going to provide results to the specific WG or Committee.

It is difficult to get dedicated time on the MSE subject on Panel 1 to get effective feedback from the Commission and this has provoked that the process has been pushed back frequently. To overcome this, at the latest SCRS meeting there was a discussion on having a general MSE lead across species to help on the connection between Panel 1 and the species working groups. But it is still not clear whether this will be implemented next year or just discussed further.

Lessons and recommendations:

- The process roadmap has been periodically reviewed and adapted. But additionally, should be more detailed containing details on responsibilities, expected outcomes and deadlines.
- MSE process is highly dependent on the assessment outcomes. And experts' availability is very limited during the assessment working groups and sometime before while they are being prepared. This has led to a lengthening of the process.
- There is limited feedback in the Pannel 1 meetings when MSE results are presented.
- A figure that assures effective feedback between the different Panels and species working groups could help on getting more effective feedback from the Commission.

2. Involvement of stakeholders

Main stakeholders are contracting parties (CPCs), which are the only ones that have the voting rights (consisting of countries' representatives, i.e. managers), and others, such as NGOs, industry or scientist, that attend Panel meetings as observers. However, they can influence decisions through their CPC representative, as the CPC gathers inputs and provides information to a wide range of stakeholders.

The feedback from the Commission is very important, so for an effective communication, scientist should make very concise and directed questions, to correctly get what they are requesting without deviating the focus. Workshops are also critical so that all stakeholders (not only scientists) can understand the MSE approach (moving from a single stock perspective) and allow them to contribute effectively to the process.

There has been scarce communication between scientists and stakeholders in the case of the TRO MSE, although ICCAT has several ways to easy communication (e.g. WG for dialogs between scientist and managers or the ambassadors' meetings).

Up to now, the MSE process has been driven by scientists. Due to the limited communication between scientists and the Commission, most of the decisions has been made by scientists. As the MSE results were presented and discussed within the scientific working group, but nothing has been presented to the commission yet.

MSE objectives and performance statistics have been discussed globally for all MSEs, but not specifically for the TRO MSE. Similarly, the exceptional circumstances protocols are globally defined, but not specifically for tropical tuna. However, this will be addressed in the near future.

Lessons and recommendations:

- Limited communication between scientist and Commission or other stakeholders. Consequently, the MSE process has been driven by scientists.
- There are available mechanisms within ICCAT that could aid at improving communication, such as MSE workshops, the WGs for dialogs between scientists and managers or ambassadors.

3. Communication

The only communication tool available at the moment is the Shiny app (FLBEIA). However, the results have not yet been communicated outside the working group.

Once the work is considered ready for revision, it will be uploaded to a GitHub repository.

Additionally, communication tools will be prepared in the future, similar to those existing for other ICCAT MSEs.

4. Model conditioning

There has been carried out a wide analysis carried out on assessment uncertainties. For the OM conditioning, the biological and fishery components (harmonised compatible fleet structure between the 3 stocks, BFT, YFT and SKJ) were taken from stock-specific assessment results. Where it is assumed that all OMs are equally plausible. Although there was discussion about weighting different OMs differently, the scientific working group concluded that all OMs should be given the same weight.

Observation errors have also been included based on the assessment. But the implementation error will be addressed in the near future.

Reference scenarios are currently being used, with plans to examine different robustness tests in the future. Additionally, global change uncertainties are to be considered in the following steps (SCRS/2024/118).

5. Management procedure

There has not been yet decided on the specific management strategies to be tested. However, some of the potential ones has been already discarded as they do not comply with the basic objectives (e.g. keeping all the stocks at the green Kobe area), as for example multispecies MSY or the pretty good yield. And idea could be managing the stock that is in poorer condition (BET) and being this stock that sets the effort level for most of the fleets.

The idea is to replicate the full management process (observation of an abundance index and fitting of a production model, JABBA or SPiCT, to inform the harvest control rule). However, but still under development. The idea is to give advice based on a model-free HCR and use the stock assessment just to periodically evaluate if management in place is being effective. Nevertheless, model-based HCRs will also be tested.

6. Resources

There have been mainly a group of 10 experts involved in the TRO MSE process (including 2 or 3 developers). Now, they are recruiting 3 additional experts on the figure of external advisors, to give some guidance on the process. At the beginning 3-4 experts from NOAA were giving guidance and helping the development team. None of them having full dedication to this work.

7. Final remarks

The process of implementing a tropical tuna multi-stocks MSE has been a learning exercise. But has a great advantage over the other MSEs because it is the most recent one.

The main shortcomings of the process have been the lack of feedback from the Commission. Communication with the Commission through Panel 1 is key, but very challenging, especially for multi-stock tropical tuna, due to its complexity.

It would be advisable an increase in the technical support, so the recruitment of at least one technical expert probably would help. Otherwise, the number of MSEs happening at the same time at ICCAT should be limited to ensure that technical experts can contribute to the process.

Adequate funding should be provided for the WGs. Even after adoption strategic plans should also consider providing budget also to allow the review or implemented management plans.

David Die and Shannon Calay were identified during the interviews as potential actors to give some extra useful feedback of the process, but unfortunately, they were not available to meet. No extra information was provided by them by other means.

Minutes were circulated to all the scientist invited to the meeting: David Die, Serena Wright, Shannon Calay, Davy Angueko, Rodrigo Sant'Ana, Gorka Merino, Gary Melvin, Miguel Santos, Dorleta Garcia and Miren Altuna for their approval. No remarkable comments were received.

Figures

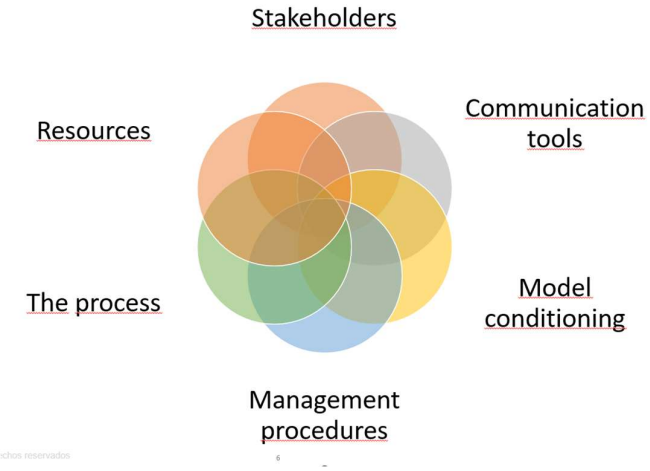

Figure 1. The six topics around which the meeting was structured.

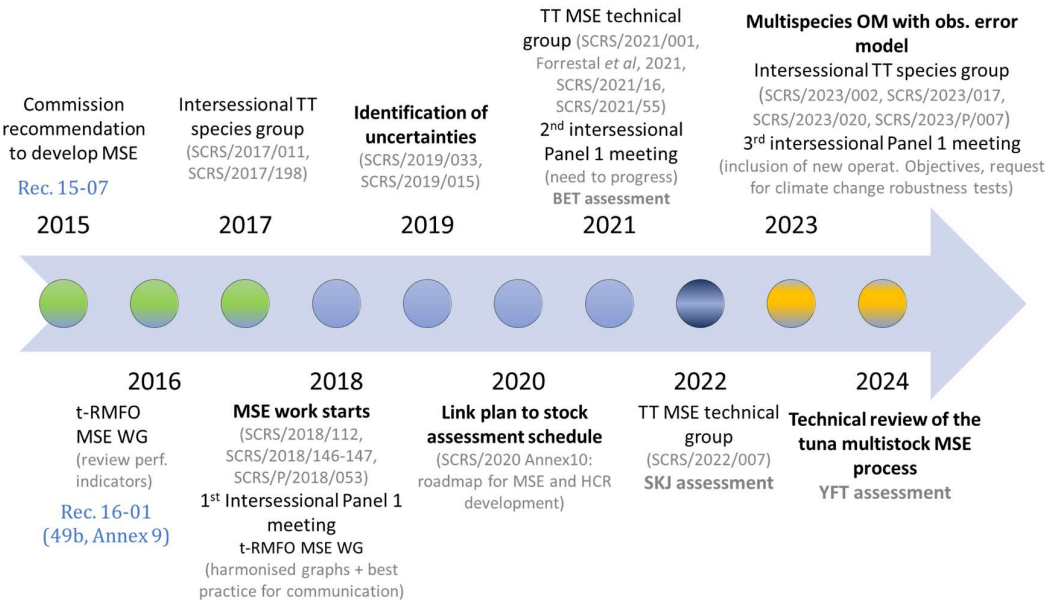

Figure 2. The multi-stocks tropical tunas MSE process along years.

Annex 6

ICCAT MSE Review - General Meeting

Date: 6th of November 2024

Format: Online (Teams)

Participants:

- Miren Altuna-Etxabe (AZTI, Albacore reviewer)
- Davy Angueko (Gabon, Multi-stocks tropical tunas)
- Haritz Arrizabalaga (AZTI, Albacore species working group chair)
- Doug Butterworth (Univ. Cape Town, BFT Technical working group chair)
- Craig Brown (NOAA, SCRS chair)
- Shannon Calay (NOAA, W-Skipjack MSE technical group chair)
- Leire Citores (AZTI, Swordfish reviewer)
- David Die (NOAA, former SCRS, Multi-stock tropical tunas technical group chair)
- Dorleta García (AZTI, project lead, Bluefin tuna reviewer)
- Kyle Gillespie (DFO, Swordfish species and technical group chair)
- Leire Ibaibarriaga (AZTI, Western skipjack reviewer)
- Ai Kimoto (ICCAT)
- Mauricio Ortiz (ICCAT)
- Enrique Rodriguez (IEO, East-Atlantic and mediterranean Bluefin tuna chair)
- Sonia Sánchez (AZTI, Tropical tunas reviewer)
- Michael Schirripa (Chair of the methods working group)
- Nathan Taylor (ICCAT)
- John Walter (NOAA, Western Bluefin tuna chair, partly)
- Serena Wright (CEFAS, Tropical Tunas Coordinator)

1. Glossary

- ALB: North Atlantic albacore
- BET: bigeye tuna
- BFT: bluefin tuna
- CMP: candidate management procedure
- CPC: Contracting Parties and Cooperating non-Contracting Parties, Entities or Fishing Entities
- HCR: harvest control rule
- MSE: management strategy evaluation
- MP: management procedure
- OM: operating model
- PGK: probability of being in the green area of the Kobe plot
- SKJ: skipjack
- SWO: swordfish
- YFT: yellowfin tuna
- SCRS: Standing Committee on Research and Statistics

2. Introduction

The objective of the meeting was to present the outcome of the overview of the five MSE processes that have been, or are being, carried out in ICCAT.

The meeting was chaired by Dorleta Garcia, with the assistance of the rest of the AZTI team and comments by all the participants.

In the opening slides the aim of the project and the methodology used were presented. To contextualize the case studies and to start the presentation of the results, a table with some high-level attributes of the cases studies was

presented (**Table 1**). The participants agreed that in the table the number of experts needs to be distinguished by the number of experts developing OMs, testing CMPs, and developing the code. Furthermore, the indicators used must be objective and when defining the metric is important to distinguish between being engaged and being involved.

3. Case studies

The presentation continued with a summary of each case study by the person in AZTI responsible for conducting the overview.

3.1. North Atlantic Albacore

The work in MSE for North Atlantic Albacore began in 2010 with a research plan for the species. This plan outlined key objectives and research aims, including the evaluation of the robustness of alternative management strategies to uncertainties, which aligns with the purpose of the MSE. In 2017, a HCR based on MSE, and in 2021, an MP based on MSE were adopted for the management of North Atlantic Albacore. This was the first MSE process in ICCAT and the first MP adopted in ICCAT. The North Atlantic Albacore MSE process set the foundations for other stocks' MSE, with many elements, such as performance metrics, the presentation of MSE results and the exceptional circumstances protocol, being transferred to other stocks' MSEs. The exceptional circumstances protocol, adopted in 2021, has proven effective and will be maintained. However, there are areas for improvement, such as the inclusion of formal ambassadors' meetings, which are anticipated to start in 2026. When the North Atlantic Albacore MSE process started, there was no written roadmap, but the theoretical process was understood, and those developing the MSE learned and adapted over time. Initially, the North Atlantic Albacore MSE process was funded by European projects and internal funds. The ICCAT MSE contracts for North Atlantic Albacore began in 2021. In 2018, the code of MSE was reviewed by an independent expert.

Comments from the participants:

- For albacore ICCAT is currently revising the first MP adopted in 2021. The revision goes beyond the typical updates planned for MPs because major potential improvements have been identified. In the context of this project, AZTI has focused on the currently adopted MP because the revision is still in its initial phase. ICCAT is doing considerable work to update the conditioning of the OMs based on new available data and methods. The conclusions obtained from this MSE process review can be of great help for the new MSE that is underway.
- The initial albacore work was groundbreaking in that it succeeded in alerting the Commission towards the new MSE paradigm, getting the Commission to be responsive to the change in management, and getting an MP adopted. But as other MSEs developed for other species, the SCRS identified several additional alternative ways to conduct MSE that could improve the second round of the North Atlantic Albacore MSE.

3.2. Atlantic bluefin tuna

Work on the MSE of Bluefin tuna started before the ICCAT recommendation in 2015 to initiate an MSE process for the 5 cases. In 2016 the contractor developed the first model to condition the OMs and few experts started to test CMPs afterwards. Although the contractor and few experts started the work in 2016, it was not until the problems with the assessment model were solved that the process received real attention from many of the experts involved in the BFT species working group. In the end the process took too long, and this led to the need of updating the OMs with new data, which at the same time lengthened the process. The case study received considerable attention from experts and stakeholders, which on the one hand enriched the process, but on the other created challenges in communication and lengthened the process.

Comments from the participants:

- A main difference of BFT case study is that it includes two different stocks (eastern and western) with some mixing between them and different management of the two sides of the Atlantic. This added considerable complexity to the process in terms of the implementation of the OMs and the definition and testing of the combined CMPs.
- Proposal to appoint a smaller subgroup of Panel 2 to facilitate communication.

3.3. Western Skipjack

The development of the MSE on western skipjack has taken place within a short time frame. A first demonstration of the MSE framework was presented in 2020. After some capacity building, the first OMs were conditioned in 2022 based on the stock assessment conducted in that year. Since then, the MSE framework has been further refined and developed accounting for the comments from Panel 1. Contrary to other case studies, catches of this stock are taken by very few countries, with a single country only being responsible of over 95% of the catches. Therefore, the number of people actively engaged in the development has also been smaller than in other case studies. While this has facilitated a faster development, it has also meant less feedback from experts. In this case study, capacity building workshops have proven to be very useful to communicate with managers in a less formal atmosphere. The discussion for the adoption of a MP for this stock will take place in the Commission meeting this year.

Comments from the participants:

- This case study is different from others because there were no regulations for this fishery prior to this work, and few stakeholders have an interest with one country accounting for 95% of the catch.
- Managers and scientists participated in the capacity building from the very beginning in 2021, but the group comprised mainly by Brazilian scientists and stakeholders.
- Panel 1 came into this process late, when Brazil had already done considerable work; other stakeholders, from other CPCs, participated late and were reluctant to accept the outcomes of the process.
- The operating model was developed very quickly without the oversight of the scientists from other countries.
- It must be born in mind that the tropical tuna working group has three species that need routine assessment, and there were many MSEs under simultaneous consideration, so there was very limited feedback from the species working group.
- In the species working group, the time dedicated to review the work of the contractors has been very limited. There was not a dedicated team until 2024.
- There are few experts in MSE in the species working group.

3.4. North Atlantic swordfish

The first studies on HCR and MSE for North Atlantic Swordfish started before 2015. In 2017 a Stock Synthesis (SS) stock assessment model was configured for this stock, already thinking at that time about the future implementation of an MSE. The first contract for the development of an MSE started in 2018 and ended in 2019, when a new contract with a different contractor was established, which was the starting point of the process that has been carried out until now. This process had a roadmap since the beginning that was updated every year, and helped to achieve a successful MSE. However, it was suggested that a more formal technical roadmap with deadlines could be helpful to lead to a more efficient process and to avoid having many intermediate updates (mainly of data). During the MSE process, there was the feeling that most of the time was spent working on OMs and robustness tests, and the time available time for CMP development had been too short. The technical MSE group was small (around 8 people), easy to manage and engaged in frequent communications. The code was reviewed in 2021, and the corresponding suggestions were addressed. Regarding the resources, the computational power and the hosting of the shiny application was handled by the contractor, which can be an issue for the future when the contract ends. The Commission is scheduled to select a MP to generate TAC in 2025+, and the exceptional circumstances will be investigated in 2025. A schedule for reviews of the assessment and MSE has been provided.

Comments from the participants:

There were no comments from participants on Swordfish.

3.5. Multi-stock tropical tunas

The MSE process for the multi-stock tropical tunas started some years after the recommendation from the Commission to develop an MSE for the different species (REC 15-07). In 2018 a first conditioning of the operating model (OM) was presented at the intersessional Panel 1 meeting as a basis for discussion. In the following years, little progress was made (focus was on the identification of main uncertainties and OM conditioning). Consequently, a new revised roadmap for MSE and HCR development was developed, after recognising the need

to link the MSE plan to stock assessment schedule which was limiting the availability of experts. Finally, in 2023, a multispecies OM conditioned with observation error model of an abundance index was made available, but this still did not include all identified uncertainties.

The process is still under development and little work has been carried out regarding communication (just some MSE training workshops in different languages). The plan is to follow a similar approach to the rest of MSEs (external advisor, code review, communication with stakeholders through Panel 1, ambassador meetings…). In the short term, a documentation of the work is scheduled, and external advisors will be included in the process to guide on the next steps.

Comments from the participants:

- This case study represents a groundbreaking exercise because it involves three different stocks, and similar exercise has not been carried out in tuna RFMOs before. In the case of Bluefin tuna, the managers wanted a mixed stock MSE, but in this case this was not clear. If a typical single stock MSE takes 1-2 years, one would expect to take 5 years or more in this case.
- Panel 1 is not fully convinced about the multi-stock approach that links the management of the three stocks and reduces independence in setting the individual TACs. The experts are convinced, but not the managers. This is why Panel 1 is not really pushing the process.
- The working group has been instructed to consider climate change, but this needs to be approached with caution as projecting the impact of climate change in stock dynamics into the future is very uncertain.
- Resources and structure are needed in this case. Although the number of countries that participate in the fishery is high, the number of participants in the MSE is limited.
- There has been considerable discussion on how to combine the management of the three stocks, and what the common objectives should be. Until these are clarified, it will be difficult to move forward with the process.

4. Available resources

All the case studies, except northern albacore, received funding to develop and condition the operating models and to test the CMPs. The contractors were well supported economically although they complained about the annual financing scheme that created uncertainty about the continuity of the contracts. However, support of experts by individual countries is not guaranteed. Even if in many cases they are public servants, they can have other commitments that preclude them from participating actively in the MSE processes. For example, it is very difficult to participate in both an assessment and MSE process in parallel. In terms of computational resources, the contractors host the shiny apps, and when the contract ends, the apps do not work anymore. Additionally, in some cases the simulations are very time demanding and more efficient code and/or better computing facilities are needed.

Comments from the participants:

- In some case studies there has been funding for separate in person meetings related to MSE, but this has not been the case in the multi-stock tuna case study for example, where all the work is being conducted jointly with data preparatory or stock assessment meetings.
- The participants agreed that there should be an MSE position in the ICCAT secretariat that is involved actively in all the MSE processes. This person could help to give continuity to the work if the contractor disappears at some point for any reason and such a person would also have institutional memory. Such a person is present in a number of other tuna RFMOs.
- The contractors are very capable people that do the job very efficiently and they are seen as independent of individual countries. In contrast, when the MSE-s are developed primarily by interested countries, there is not the same level of trust. However, the first system has the disadvantage that once the contract ends, the contractor is no longer legally obligated to perform any work.
- ICCAT should set up a permanent MSE team led by a full time ICCAT Secretariat employee. The permanent MSE group should lead all MSE work with support from the species groups.

5. Inclusiveness

In the review of the process, it has been clear that some countries are more actively engaged that others. For example, in the cases of Bluefin tuna, Swordfish or the Tropical tunas multi-stock case study, there are many countries involved in the fishery, but only experts from few countries contribute to SCRS. Language, and lack of expertise and resources are barriers. In terms of stakeholders, it must be born in mind, that there has not been direct interaction with stakeholders in this project. The feedback the reviewers (i.e. AZTI team) obtained came from the meetings with the ICCAT experts and contractors, and the review of the SCRS documents and Panel and Commission meeting reports. The impression is that the communication with individual stakeholders is somehow hidden amongst the CPCs in Panel meetings. Thus, the communication depends on how well the CPCs interact with their members. In general, dialogue and ambassador meetings worked fairly well to facilitate communication. On top of that, some countries have meetings at country level. In the case of skipjack, the MSE Training workshops were very good to get informal input from stakeholders.

Comments from the participants:

- Training workshop participants lack new faces. Apparently, it is difficult to reach new people. Initially these workshops were directed primarily to participants from developing country CPCs, participants from a diversity of CPCs, scientists involved in the SCRS process, and managers involved in the Commission process. However, the participants were mostly the same as the ones at the Commission meetings and writing the SCRS documents. There were some NGOs, but no industry representatives.

6. Consistency between MSEs

Table 2 shows the operational objectives that were agreed or that are being tested in each case study for four elements: stock status, safety, yield and stability. Although these objectives are similar across case studies, the performance indicators defined in each case study to measure if the objectives are achieved differ. In some cases, what is measured is different, in other cases the same thing is measured for different period of times, and in others different notation is used to refer to the same metric. **Tables 3 to 6** show the performance indicators used in each case study where examples of these differences can be found. In order to facilitate better communication and understanding, it would be good to have the same performance indicators measuring the same operational management objective and using the same notation.

Regarding graphical representations of MSE outputs, using the same figures across case studies and throughout each specific process is desirable to facilitate understanding. In the first case studies, North Atlantic Albacore and Bluefin tuna, this was difficult because they were learning along the process. However, now there is considerable good material from these case studies and graphical representations could build on existing work and experience. Additionally, when it comes to graphical representations, the objective is not to produce the prettiest plot, but the one that is easiest to understand. **Figures 1 to 4** show examples of things to improve. In **Figure 1** two different type of plots are used to show the change in TAC. The one for western Skipjack uses a boxplot on top of a scatter plot; this can be confusing because points in traditional boxplots are used to show outliers. On the other hand, the violin plot for Swordfish is a beautiful plot, but requires thinking about the shape of the probability distribution underlying the data, and this is probably something which is difficult for stakeholders. Thus, in this particular case, the recommendation would be to always use boxplots. **Figure 2** shows two examples for Worm plots; these plots are recommended to show the variability of individual replicates in MSEs. The plot for Bluefin tuna is very good, with few iterations on top of the confidence interval. The recommendation in this case would be to learn from the past and use the worm plots as they were used for Bluefin tuna. In the third case (**Figure 3**), the most recent plot from western Skipjack case study outperforms the Bluefin tuna example. It shows the trade-offs between different objectives and in the case of western Skipjack it does not show confidence intervals which makes the plot clearer. The last example, **Figure 4**, shows a plot which encapsulates too much information and could be difficult to interpret.

Comments from the participants:

- PGK (probability of being in the green zone of the Kobe plot) depends on how the uncertainty is characterized and hence is not comparable between cases because this uncertainty depends how the models estimate it, and especially on the range of operating models considered.
- Regarding stability, one participant commented that what appear in the plots are bounds, and bounds do not reflect stability. Thus, how the stability objective is operationalized should be revisited.

- For albacore and bluefin tuna, the objectives in **Table 2** have already been adopted by the commission, but for swordfish and skipjack they are preliminary and for multi-stock tropical tunas there is no proposal as yet.
- The participants noted that, although having the same performance indicators and figures could be desirable, homogenizing them is a very difficult task and, in some cases, having different performance indicators or figures could be necessary. Homogenization of performance indicators and/or figures should be done carefully and the ICCAT's method working group should address this.

7. Communication

There are a variety of channels and tools to communicate with stakeholders: panel meetings, ambassador meetings, dialogue meetings, the trial specification document, executive summary, short summary document, the interactive application (Shiny), detailed technical SCRS reports, and documents and MSE (training/capacity building) workshops. In Bluefin tuna Panel 2 meetings were considered too formal and intermediary meetings were recommended by participants in this process. While Panel 2 is the right place to take decisions, in some cases during the MSE process what was needed from managers was just quick guidance, and for that Panel 2 was considered too formal. During this meeting some participants suggested a subgroup of Panel 2 as a possible option. Ambassadors meetings are considered a very useful tool to communicate with stakeholders in a more informal way. For north Atlantic albacore there were no ambassador meetings, but the group had meetings of the Standing Working Group on Dialogue between Fisheries Scientists and Managers (SWGSM) to interact with managers. The trial, executive summary and short summary documents are useful, but they are not easy to find among the SCRS documents and on the internet. Thus, centralising all this documentation somewhere would be useful. The interactive applications are useful to explore results, but it is necessary to institute some kind of training for non-experts. Finally, the MSE workshops were introduced in the Skipjack case study and were highly valued as a place to have informal input from managers. However, as commented before, although they were open to anyone, they did not reach many people.

There were no comments by participants.

8. Review and quality control

Most of the case studies have gone through a review of the code or are going through it, except in the case of the tropical tunas, for which the review is planned for the near future. After the review the contractors have implemented the recommendations of the reviewers. Additionally, the contractors had their own mechanisms to ensure that the code does what it is supposed to do. So, in principle the code review has been satisfactory in all the cases. In the Bluefin tuna case study, there was an external advisor following the last part of the process. This advisor was not present in other case studies. In the bluefin tuna case study the species group complained that the advisor came late into the process, when there is little room for manoeuvre in case something is suggested to have been carried out incorrectly. It would be preferable to have this person from an early stage of the process. In Tropical tunas' multi-stock case study, the species group is expecting to have three advisors in the coming months.

There were no comments by participants.

9. Conclusions

Several conclusions were derived from the review of the reports and the conversations with the species and technical working group chairs, contractors and SCRS chairs:

- Five simultaneous MSE processes is unmanageable.
- Assessment and MSE processes cannot be run in parallel.
- Having all ICCAT Panels discussing in parallel about the same thing for different species has been inefficient.
- Large case studies have more diversity but lengthen the process and complicate the dialogue.
- The five case studies are consistent in terms of resources, communication, inclusiveness, and review and quality control.
- Despite being consistent, there is room for improvement and standardization among case studies.
- Managers need to see tangible results and 'closed-ended' questions.
- Ambassadors' meetings and MSE (training) workshops very well accepted.

- Difficult to know how each CPC-s work internally.
- Considerable technical information in the presentations.
- Beautiful does not mean easy to understand.

There were no comments by participants.

10. Potential improvements

One of the recommendations in an SCRS document was to have a link in the ICCAT webpage dedicated to MSE. We have several recommendations to make it more useful:

- Keep the MSE webpage up to date.
- Update the glossary.
- Add useful information such as:
  - List of performance Indicators, or
  - Plots and their interpretation
  - Centralize important information, presentations and links to relevant documents…

To facilitate the communication, the material used should be as standard as possible. There are several possibilities towards accomplishing this:

- Homogenise operational management objectives and the associated performance statistics.
- Standardize how MSE settings are described.
- Build a standard presentation template (this was a recommendation already in one of the bluefin tuna MSE reports).
- Use the same performance indicators, figures and tables throughout the process and for all cases as far as possible.
- There is much good material already available; it is a matter of putting it together.

In terms of roadmaps and processes:

- More detailed roadmaps containing details on responsibilities, expected outcomes and deadlines are needed.
- Specifically, hard deadlines are needed at least for data and operating models, so respectively after these time limits no new data are included and no new OMs are implemented.
- Assessment models should not be updated in the MSE process to avoid having to recondition the OMs. The OM process should start immediately after the assessment, and the process should finish in less than three years, so that the next catch advice is given using the MP and there is no need to recondition the OMs.
- Clearly define for which specific parts of the MSE process feedback from managers (or stakeholders in general) is needed.
- In the interaction with stakeholders, use very directed questions to guide discussions.

Finally, there are some recommendations:

- ICCAT should not develop more than two MSE processes simultaneously.
- Build capacity through MSE (training) workshops at the beginning of the process for experts and stakeholders.
- Promote interaction/communication among experts in different case studies.
- Incorporate external advisors earlier in the process to support the case-specific experts doing the work.
- Conduct a survey to get feedback on the process from stakeholders.
- ICCAT should host and maintain Shiny apps and other applications or material related to the MSE activities.
- Promote transparent and reproducible coding.

Comments from the participants:

- There is not a dedicated ICCAT webpage for assessments, so it would be weird to have one for MSEs. All the information related to stock assessments can be found in species group reports, and the same happens for MSEs.
- The glossary was agreed in a joint tuna RFMOs MSE meeting in 2018 (https://tuna-org.org/Documents/MSEGlossary_tRFMO_MSEWG2018.pdf), with a wide audience participating and

agreeing to it. Thus, if it needs to be updated, it should be done carefully and led by the methods working group.
- The trial specifications document should be very clear on the settings used to implement the OMs.
- The intention of the web page as initially produced or recommended by the SCRS is to collect all the information generated by the development of the different MSE processes. Now that page is informative and also needs to have links to external resources etcetera.
- Independent reviewers (especially advisors, not code reviewers) should be involved early in the process. Otherwise, it would be very difficult or even impossible to accomplish some of their recommendations on time, because the whole process can't be started again. Code reviewers could be different, depending on what needs to be reviewed.

An ICCAT member made a final statement highlighting that:

- The terms of reference of this project were defined by the SCRS to standardise how ICCAT develops MSE processes, and how results are presented and communicated to the Commission and stakeholders. The Commission strongly endorsed the project.
- When comparing the MSE processes across case studies it is important to identify the similarities and also the differences amongst case studies. Some of the differences in the process can probably be explained by the inherent differences in the case studies.
- In terms of the communication, the most relevant aspect for this project is the communication between MSE development team and the particular SCRS working group, which has improved with time, and between the SCRS and the managers/Commission. Communication with other stakeholders, beyond managers, is a responsibility of the CPCs.
- The report of this project has two audiences, the Commission on the one hand and the SCRS on the other. In the report, the recommendations could be separated based on the target audience.
- It is necessary to include something about the financing support for the MSE developments. This should not rely on external funding and needs some stability for several years.

The minutes for this meeting should be agreed by the participants and finalized before the end of the month, so they can be included in the draft report to be delivered before the 29th of November.

Tables

Table 1. Some attributes of the case studies.

	ALB	BFT	SKJ	SWO	Tropical Tunas
Start	2010	2013	2022	2018	2018
Status	Adopted (2016)	Adopted (2022)	To be adopted by end of 2024	To be adopted by end of 2024	Under development
Countries contributing to the catch	5 countries ~90% of the catch	20 countries 97.5% of the catch	2 countries > 95% catch	~14 countries 97.5% of catch.	23 countries ~99% catch
Approximate catch	31 654 t (2022)	37 800 t (2022)	19 900 t (2021)	10 340t (2022)	373,101t (2022) (BET: 62,513t + YFT: 148,211t + E-SKJ: 271,371t)
Number of Experts	Single medium group (~20p)	8 Groups testing CMPs	Single small group (7p)	Single small group (~8p)	Single small group (~10p)

Table 2. Operational objectives that were agreed or that are being tested in each case study for four elements: stock status, safety, yield and stability. Stability refers to bounds and not to realised averages over time.

	Albacore	Bluefin	Skipjack	Swordfish	Tropical tunas
Stock Status	PGK* ≥ 60%	PGK* ≥ 60%	PGK* ≥ 70%	PGK* ≥ [60, 70]%	-
Safety	-	P(SSB < Blim) ≤ 15%	P(SSB < Blim) ≤ 10%	P(SSB < Blim) ≤ [5, 10, 15]%	-
Yield	Maximize catches	Maximize catches	Maximize catches	Maximize catches	Maximize catches
Stability	+25%/-20%	+20%/-35%	+20%/-20%	+25%/-25%	-

** Probability of being in the green zone of the Kobe plot*

Table 3. Performance indicators used for North Atlantic albacore to measure if the status, safety, yield and stability objectives had been achieved.

North Atlantic Albacore		
	Primary	**Secondary**
Status	**pGr%** = proportion of years [1-15] that B≥BMSY & F≤FMSY	**BMIN** = min(SSB/ SSBMSY) over 1-15 years
		BMEAN* = mean(SSB/ SSBMSY) over 1-15 years
		FMEAN = mean(F/ FMSY) over 1-15 years
		pRed%* = proportion of years [1-15] that B≤BMSY & F≥FMSY
Safety	**pBINT%** = proportion of years [1-15] that BLIM<B <BTHRESH	**pBLIM%*** = proportion of years [1-15] that B>BLIM
Yield	**LongY (kt)** = mean catch in 15 and 30 years	**ShortY (kt)** = mean catch over 1-3 years
		MediumY (kt) = mean catch over 5-10 years
Stability	**MAP%** = mean absolute proportional change in catch over 1-15 years	**var** = variance in catch over 1-15 years
		Pshut = Proportion of years that TAC=0
		P10%* = Prop. of mngt. cycles when the ratio of change (TACn-TACn-1)/TACn-1>10%
		MaxTACc* = Maximum amount of TAC change between management periods

Table 4. Performance indicators used for bluefin tuna to measure if the status, safety, yield and stability objectives had been achieved.

	Bluefin Tuna	
	Primary	**Secondary**
Status	**PGK** (SSB >= Dynamic SSBmsy & U<= UMSY) in year 30)	**Br30**, Br = SSB/SSBmsy in year 30
		AvgBr, Average Br over years 11-30
		Br20
		POF, probability of overfishing in year 30 (U>Umsy)
		PNRK, probability of not being in the red Kobe kuadrant
		OFT, Overfished trend, SSB trend if Br30< 1
Safety	**LD*15%** (15% percentile of lowest SSB/SSBmsy over years 11-30)	**LD*5%**
		LD*10%
Yield	**AvC10** - Median TAC over years 1-10	**C1** - TAC in first 3 years of MP
	AvC30 - Median TAC over years 1-30	**AvC20** - Median TAC over years 1-20
Stability	**VarC** - Variation in TAC (%) between management cycles	

Table 5. Performance indicators used for skipjack to measure if the status, safety, yield and stability objectives had been achieved.

SKIPJACK		
	Management objective	**Proposed performance indicators**
STATUS	The stock should have a 70% or greater probability of occurring in the green quadrant of the Kobe matrix using a 30-year	PGKshort: Probability of being in the Kobe green quadrant (i.e., SSB≥SSBMSY and F<FMSY) in years 1-3
		PGKmedium: Probability of being in the Kobe green quadrant (i.e., SSB≥SSBMSY and F<FMSY) in years 4-1
		PGKlong: Probability of being in the Kobe green quadrant (i.e., SSB≥SSBMSY and F<FMSY) over years 11-3
		PGKall: Probability of being in the Kobe green quadrant (i.e., SSB≥SSBMSY and F<FMSY) over years 1-30
		POF: Probability of F>FMSY over years 1-30
		PNOF: Probability of F<FMSY over years 1-30
SAFETY	There should be no greater than [10%] probability of the stock falling below BLIM (0.4*SSBMSY) at any point during the 30-year projection period.	LRPshort: Probability of breaching the limit reference point (i.e., SSB<0.4*SSBMSY) over years 1-3
		LRPmedium: Probability of breaching the limit reference point (i.e., SSB<0.4*SSBMSY) over years 4-10
		LRPlong: Probability of breaching the limit reference point (i.e., SSB<0.4*SSBMSY) over years 11-30
		LRPall: Probability of breaching the limit reference point (i.e., SSB<0.4*SSBMSY) over years 1-30
		nLRPshort: Probability of not breaching the limit reference point (i.e., SSB<0.4*SSBMSY) over years 1-3
		nLRPmedium: Probability of not breaching the limit reference point (i.e., SSB<0.4*SSBMSY) over years 4-1
		nLRPlong: Probability of not breaching the limit reference point (i.e., SSB<0.4*SSBMSY) over years 11-30
		nLRPall: Probability of not breaching the limit reference point (i.e., SSB<0.4*SSBMSY) over years 1-30
YIELD	Maximize overall catch levels in the short (1-3 years), medium (4-10 years) and long (11-30 years) terms.	AvCshort – Median catches (t) over years 1-3
		AvCmedium – Median catches (t) over years 4-10
		AvClong – Median catches (t) over years 11-30
STABILITY	Any changes in TAC between management periods should be 20% or less.	VarCmedium – Variation in TAC (%) between management cycles over years 4-10
		VarClong – Variation in TAC (%) between management cycles over years 11-30
		Varall – Variation in TAC (%) between management cycles over years 1-30

Table 6. Performance indicators used for swordfish to measure if the status, safety, yield and stability objectives had been achieved.

North Atlantic Swordfish		
	Management objectives	**Corresponding key performance indicators**
Status	The stock should have a [60, 70]% or greater probability of occurring in the green quadrant of the Kobe matrix.	PGKSHORT: Probability of being in the Kobe green quadrant (i.e., SB≥SBMSY and F<FMSY) in years 1-10 PGKMED: Probability of being in the Kobe green quadrant (i.e., SB≥SBMSY and F<FMSY) in years 11-20 PGKALL: Probability of being in the Kobe green quadrant (i.e., SB≥SBMSY and F<FMSY) over years 1-30 PNOF: Probability of not overfishing (F<FMSY) over years 1-30
Safety	There should be a [5, 10, 15]% or less probability of the stock falling below BLIM (0.4*SBMSY) at any point during the 30-year evaluation period.	LRPALL[1]: Probability of breaching the limit reference point (i.e., SB<0.4*SBMSY) in any of years 1-30
Yield	Maximize overall catch levels.	TAC1: TAC in the first management cycle (2025-27) AvTACSHORT: Median TAC (t) over years 1-10 AvTACMED: Median TAC (t) over years 11-20 AvTACLONG: Median TAC (t) over years 21-30
Stability	Any increase or decrease in TAC between management periods should be less than [25]%. [Also test no stability limitation and bifurcated stability when SB<SBMSY.].	VarC: Mean variation in TAC (%) between management cycles over years 1-30

Figures

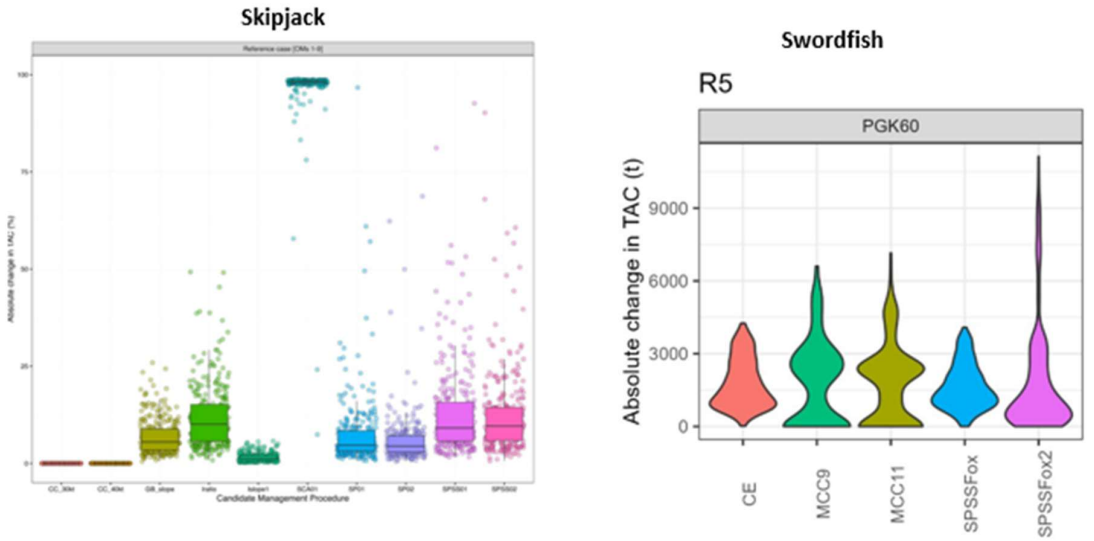

Figure 1. Figures used in Skipjack and Swordfish case studies to show the anticipated absolute change in TAC between management periods.

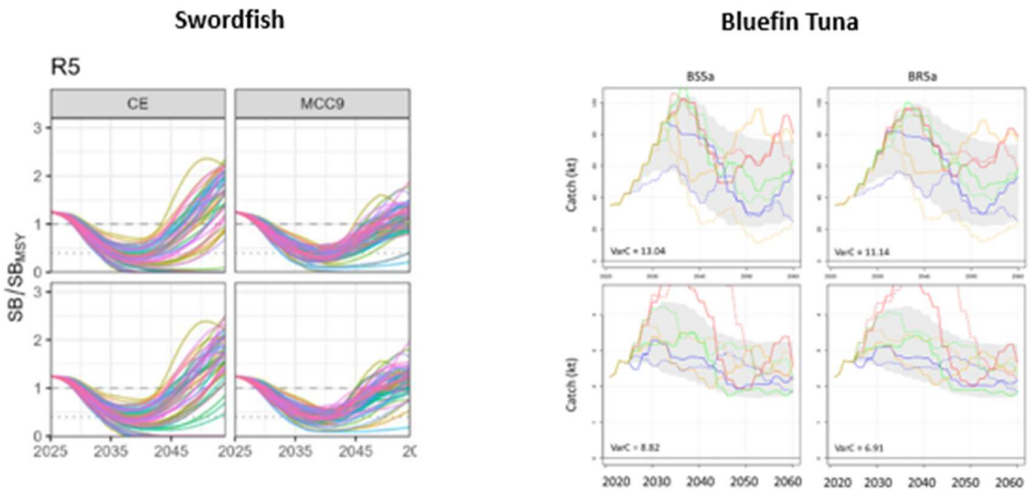

Figure 2. Examples of Worm plots used in Swordfish and Bluefin tuna case studies.

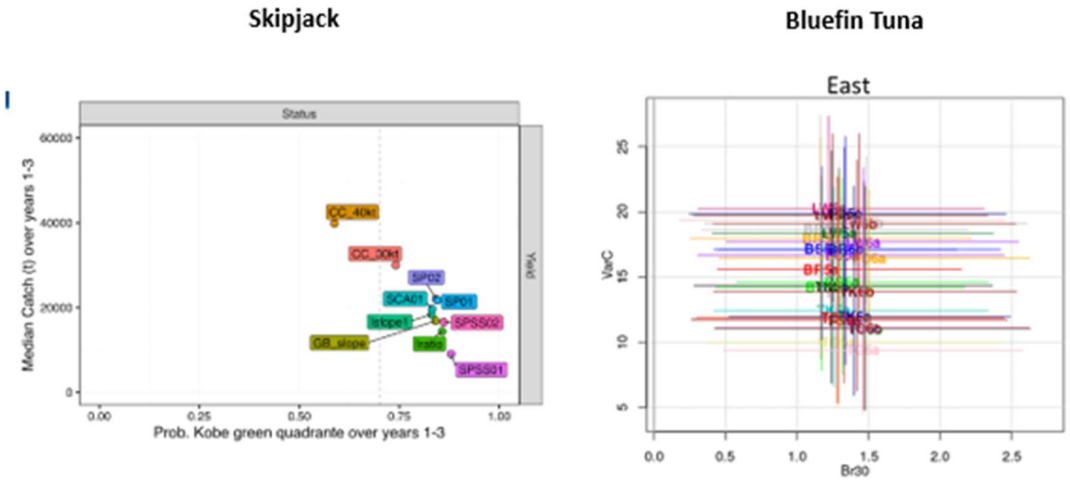

Figure 3. Figures used in Skipjack and Bluefin tuna case studies to show trade offs in different management procedure performances.

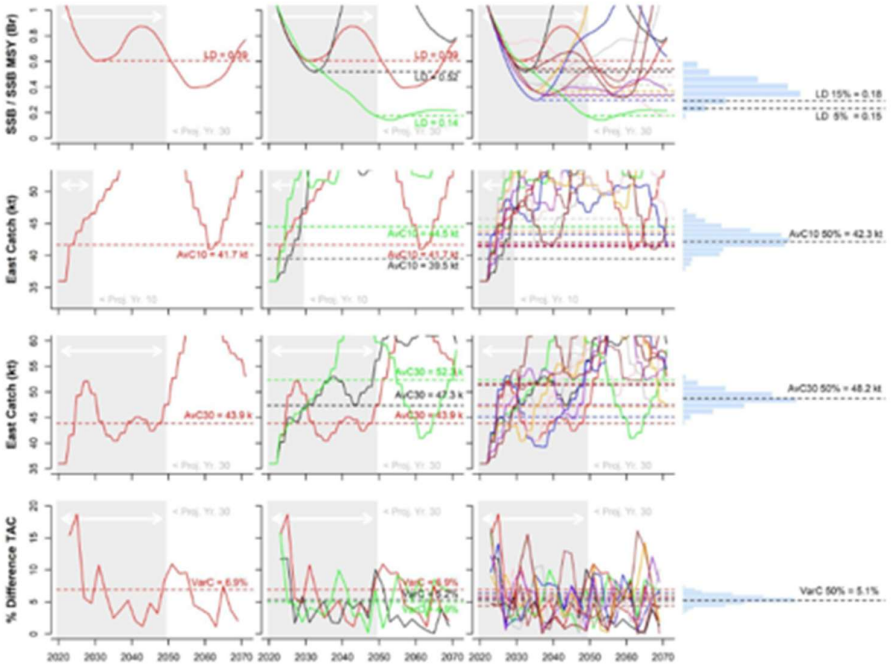

Figure 4. Worm plot used in Bluefin tuna case study.