REPORT OF THE 2018 ICCAT BLUEFIN TUNA SPECIES GROUP MSE INTERSESSIONAL MEETING

(Madrid, Spain 16-20 April 2018)

"The results, conclusions and recommendations contained in this Report only reflect the view of the Species/Working Group/Sub-Committee. Therefore, these should be considered preliminary until the SCRS adopts them at its annual Plenary meeting and the Commission revise them at its Annual meeting.

Accordingly, ICCAT reserves the right to comment, object and endorse this Report, until it is finally adopted by the Commission."

1. Opening, adoption of Agenda and meeting arrangements

The meeting was held at the ICCAT Secretariat in Madrid, 16-20 April 2018. Dr. Douglas Butterworth (Professor Emeritus, University of Cape Town) served as Chair for both the West and East-Mediterranean bluefin tuna, opened the meeting and welcomed participants. Dr. Miguel Neves dos Santos (ICCAT Assistant of the Executive Secretary) addressed the Group on behalf of the ICCAT Executive Secretary, welcomed the participants and highlighted the importance of the meeting for the ICCAT Management Strategy Evaluation (MSE) process regarding bluefin. The Chair proceeded to review the Agenda, which was adopted with changes (**Appendix 1**).

The List of Participants is included in **Appendix 2**. The List of Documents presented at the meeting is attached as **Appendix 3**. The abstracts of all the SCRS documents presented at the meeting are included in **Appendix 4**. The following served as Rapporteurs:

Sections	*Rapporteur*
Items 1 and 15	M. Neves dos Santos
Item 2	D. Die
Item 3	P. de Bruyn, C. Fernandez
Item 4	P. de Bruyn, C. Fernandez
Item 5	A. Gordoa, P. de Bruyn
Item 6	C. Fernandez, C. Brown
Item 7	N. Duprey, G. Diaz
Item 8	J. Walter, J.J. Maguiere
Item 9	A. Kimoto, S. Miller
Item 10	G. Merino
Item 11	G. Melvin, N. Abid
Item 12	S. Nakatsuka
Item 13	D. Butterworth, D. Die
Item 14	P. De Bruyn

2. Introduction to MSE/Management Procedures (MP) issues

The discussion concerning this agenda item was held together with the Swordfish Species Group.

2.1 Where is ICCAT with MSE?

The Chair of the SCRS summarized (SCRS/P/2018/019) the context around which the MSE work is being conducted by ICCAT. He noted that ICCAT recommendations (Rec. [15-04] and Rec. [15-07]) adopted in 2015 cemented the decision of the Commission regarding committing to an MSE process to support the development of harvest control rules. The Commission identified priority stocks, and Rec [15-04] tasked the SCRS with the development of a harvest control rule specifically for northern albacore. Rec [15-07] identified North albacore, bluefin tuna, North swordfish and tropical tunas stocks as priority and established a work plan and timetable that were subsequently modified every year since by the SCRS and the Commission. Changes to the timetable were again adopted in 2017 by the SCRS which also defined the major steps for the technical work to be completed as part of the MSE. These steps were detailed in a timetable chart in the 2017 SCRS report and reflected the earliest dates that the SCRS could provide enough information to the Commission to consider harvest control rule options for each stock: 2019 for Bluefin tuna, 2020 for northern swordfish and 2021 for tropical tunas. The SCRS provided advice on a variety of HCRs for northern albacore in 2017 and the Commission adopted an interim harvest control rule in 2017 [Rec. 17-04]. The SCRS Chair also pointed out that in May 2018 the Standing Working Group on Dialogue between Scientists and Managers (SWGSM) will focus on MSE and that a synthesis of the results of the current meeting would be provided to that meeting to facilitate discussions.

The Group thanked the Chair for this summary, and agreed that this information would be taken into account throughout the rest of the meeting.

2.2 What makes an MP an MP and an MSE an MSE

Presentation SCRS/P/2018/020 provided a summary of what the potential uses of MSE might be what types of Management Strategy are available as well as advice on MSE best practice.

The Group welcomed the presentation made on behalf of the author and acknowledged its relevance to the ICCAT MSE process. The Group stressed that the best practices and caveats regarding the MSE process and associated Management Procedures (MPs) highlighted in this presentation are important to take into account to move forward in this process. Of particular importance was the key observation that any MPs discussed and proposed should be clearly and fully specified so as to ensure complete reproducibility and reduce potential divergence in application.

2.3 Improving communication: the key requirement to improve the effectiveness of MSE processes

Presentation SCRS/P/2018/018 advised that the use of MSE to design and test candidate fisheries management approaches is expanding globally. Participation of managers, scientists and stakeholders should be an integral component of the MSE process. Open and effective communication among these groups is essential for the success of the MSE and the adoption of the management approach based on it. The highly technical nature of MSE and newness of the approach to many audiences present considerable communication challenges and have, unfortunately, slowed progress in some cases. The presentation drew on diverse experiences with MSE to identify two areas in which the implementation of MSE in multilateral fora may be improved: a) the use of formally constituted "dialogue groups" as a forum for exchange at the management-science interface, and b) the development of engaging, yet uncomplicated, visual communication tools for conveying key results to different audiences at each stage. While the presentation's focus was on the MSE processes underway in the Regional Fisheries Management Organizations (RFMOs) for tunas and tuna-like species, the advice provided is also pertinent for other fisheries pursuing MSE, international and domestic alike.

It was acknowledged that the need for a clear definition of MSE-related terms to be used by the Group is of fundamental importance, and as indeed these terms need to be standardized across RFMOs. There is great uncertainty in the use of certain terms, which in many cases mean different things to different people. It was noted that this presentation provided a draft glossary of terms targeted at managers and stakeholders. This glossary is not exhaustive, however, and advice was given that it is envisioned that at the Joint Tuna RFMO MSE Working Group meeting to be held in June, this glossary will be expanded and more technical definitions be added.

The structure and composition of the various groups that need to work to develop an MSE is also important and advice on this was provided. These groups occur at four levels: a) Sub groups conducting highly technical work providing summarized scientific information to b) a larger scientific body for review (like the SCRS) with discussion in c) both formal and informal dialogue-type intermediary group(s) (incorporating input from stakeholders) before very summarized recommendations are passed on to d) the Commission. The Commission's Secretariat has a role to play in this process as well as ensuring fluid communications between these groups and the dissemination of vital information. It was noted that the SWGSM and Panel meetings may not be adequate intermediary groups to allow true dialogue among scientists, managers and stakeholders, potentially necessitating the formation of additional informal groups, especially for more complicated MSE processes like that for Atlantic bluefin tuna.

To facilitate the ongoing MSE process, it was strongly suggested that there is a need to develop an MSE specific webpage for ICCAT, providing background information on the progress and developments, including information such as MSE-related management recommendations and timelines, as well as technical MSE development. A timeline for this will be discussed later.

The need to standardize the presentation of MSE outputs was also discussed.

The Group considered that the definition of management (including economic) objectives should be a primary step in the MSE process, although these objectives should start very broad and then be refined iteratively as data and analyses become available and are integrated into the process. In other RFMOs it has been generally accepted that the performance of the MP or underlying HCR is more important to managers than the internal details of the MSE operating and MP models. The objectives and outputs may be defined at the decision-making level, but the technical aspects of the modelling should not be constrained from the outset.

2.4 The MSE/MP Trials Specification document

The ICCAT GBYP Core modelling Group external Contractor presented the Bluefin tuna Trials Specifications document, and elaborated thereon based on the work thus far of the Core modelling Group. It was stressed that the Trial Specifications document is a living document that will evolve over time and should be constantly updated. The Group agreed that in this case, the Bluefin tuna Trials Specification Document will be updated based on the recommendations arising from this meeting. This document as presented to the Group is included as **Appendix 7.** The Group stressed that trial specification documents should be developed for all species undergoing an MSE process (including one for the northern albacore MSE, which was used to provide advice to the Commission in 2017). In order to facilitate this, it was recommended that a template for a trial specification document be created, based on the current example, as this could be used for other species.

2.5 An example of initial CMP results and their graphical presentation

Document SCRS/2018/047 provided details on an initial exploratory exercise in which simple fixed proportion MP control rules are applied using composite abundance indices for the East and West areas, where these composites take weighted averages over standardized values of the agreed indices and are then averaged over the last three years for which they would be available.

The Group noted that the simplicity of presenting results is key. Too many outputs can be confusing and complicate the recommendations and outputs. Zeh plots, worm plots and basic projections are very useful to communicate information among scientists, but more simplified graphics showing the tradeoffs among key performance metrics (e.g., catch and stock status) are likely a sufficient level of detail for the Commission. Intermediate levels of detail are required for the intermediary bodies previously identified.
The need to reduce the volume of model results was also discussed. Models that show very similar results should be removed as duplication is not beneficial. In addition, it may often be necessary to integrate results across models, although this should be done with caution so as not to hide or mask any uncertainties or key outcomes. In addition, the weighting of models is also important, based on relative plausibility. There are a number of ways of doing this with several examples available from other fora, and these should be discussed and defined. When presenting results, it was agreed that it is best not to disaggregate all the information but instead beneficial to cluster outputs to the extent possible (to make them simpler), but ensuring no important details are masked or omitted.

2.6 LRPs in assessments and in MSE/MPs (related to SWO agenda)

The Group was informed that the Swordfish Species Group were looking at methods to better define limit reference points or to verify that the currently adopted Limited Reference Points (LRP) for this species is suitable. The Group acknowledged that it is important to define exactly what is meant by an LRP as differences in definition in different fora can and has led to confusion. Furthermore it was agreed that an LRP is necessary at this stage, but how it can be estimated needs further discussion, possibly at the species-specific meetings.

2.7 Multi-year support for MSE

The Group strongly stressed that it is clear that MSE is a multi-year process (2-3 years minimum) that requires funding and technical support throughout its duration. The Commission needs to be made aware of this requirement and the necessary resources must be made available for the process to succeed.

2.8 Roadmap

The Group noted the SCRS MSE calendar was included as part of the MSE budget proposal (Appendix 13 2017 SCRS report). Although such calendar provides more details than the Commission MSE roadmap (ICCAT Report of Biennial Period 2016-2017, Part I, 2016 (Vol. 1), Annex 7.2) the Group agreed that more details are needed for each MSE process and also that the calendar has to be extended for a longer period. The final roadmap must include other stocks and realistic deadlines for each key milestone for advancing the MSE processes (including guillotines dates: dates by which final decisions must be made where re-visiting these decisions will not be entertained). In addition, clear objectives/deliverables should be defined for the various groups and planned meetings well in advance to allow CPCs to plan their participation. It is important to understand that each group has different responsibilities and will provide decisions and recommendations of varying technical levels and complexities. The role of each Working Group needs to be clearly defined, and their decision-making responsibilities defined and agreed upon. The Group stressed that more time and dedicated meetings are required to advance the MSE process, and that this should not be conducted on the periphery of other meetings. A proposal is required to define the flow of the MSE process, which can be based on experiences in other RFMOs/organizations in which MSE has been successfully conducted.

Finally, the Group agreed that the roadmap contains two key schedules: a short-term schedule to complete the current implementation of MSEs, and a schedule of the frequency of the revisions of the MPs (i.e. reviews of the MSE). Review schedules may be agreed and finalized, but there should be a clearly defined process to allow earlier reviews/revisions of the MSE (i.e. “exceptional circumstances” provisions).

3. Review of available documents on Bluefin tuna MSE and MSE trials specifications document update

Several of these documents were presented during the meeting. The Summaries of these documents can be found in **Appendix 4**. The discussions surrounding these documents are included in the relevant sections that follow. Document SCRS/2018/041 was not fully discussed during the meeting, as a response document was submitted by some core modelling group members. The authors of SCRS/2018/041 who were present at the meeting provided a Working Paper summarizing some of their proposals for changes to the Trials Specification document. Discussions in the meeting were based on this Working Paper, though as it was not possible to consider all the proposals made, their further consideration was deferred to a following meeting (see also section 7 of this report for detailed discussions).

4. Specification (prioritized) of further OM conditioning and comparative presentations of initial Candidate Management Procedure (CMP) results to be attempted by ICCAT GBYP modelling expert during the meeting

The ICCAT GBYP modelling expert noted that he should be advised as soon as possible of any CMP that should be run during the meeting. Five CMPs were presented to the meeting. Each CMP developer gave the ICCAT GBYP modelling expert their “preferred” CMP attempt thus far, and it was agreed that the expert would run these during the meeting and prepare a comparative display of results. This was considered as priority 1.

The ICCAT GBYP modelling expert was requested to prepare a common format for plots, so as to facilitate comparison of results from different CMPs.

There was a request to try to implement an “F0.1 MP”, in order to have a scenario representing “status quo” (i.e. current) management. Such an MP depends on the stock assessment model used to assess the stock. In the current MSE round it is not possible to implement MPs based on a VPA or other age-based assessment methodology, because simulating age-structured or length-structured catch data is a complex issue. Some approximation could be considered and a subgroup was requested to propose how to address this in the simulation. The subgroup suggested implementing two approaches, based on OM-independent and OM-dependent on interpretations of F0.1, respectively; details are provided in **Appendix 5**. In plenary discussions with the entire Group, there were a variety of views expressed as to whether or not the subgroup's suggestions were appropriate. The Group concluded that attempting an "F0.1 MP" mimicking the F0.1 strategy implemented in 2017 (based on VPA in the east and VPA/SS in the west) was not appropriate at this stage due to the lack of OM generated age-structured data needed to construct such models within the MP. Consideration of the generation of such data will not be part of the current MSE process.

A concern was raised that, for the West area, the results of conditioning some OMs graphed in document Carruthers T., and Butterworth 2017 (obtained from fitting the M3 model, which includes stock mixing) looked quite different from the accepted stock assessment for the West, with non-matching SSB trends. For this reason, the ICCAT GBYP modelling expert was requested to prepare an OM that resulted in a closer match to the accepted stock assessment for the West. Before doing this work, in order to better understand the historic range of variability encompassed by all 12 OMs fitted in Carruthers T., and Butterworth 2017, a plot overlaying the time series of SSB estimates resulting from this set of OMs was prepared; separate plots were produced for the East and West areas, as well as for the East and West stocks. These plots showed that the 12 OMs result in a variety of trends in the historic time series of SSB estimates for the West, including some with recent increasing trends, and this reduced the concern initially raised about non-matching trends. It was agreed to include the accepted 2017 stock assessments biomass trends (VPA in the east and VPA and SS3 in the west) in the plots, and to start the plots at an earlier year than 1983. The final decision on an OM specification matching results from the agreed stock assessments was deferred to Agenda Item 8.

It was noted that all 12 OMs in document Carruthers T., and Butterworth 2017 estimated that the West stock has been above SSB_{MSY} in all years since 1983 (as indicated by Figure 4 of that document); this does not agree with the general perception scientists have of stock history. The Group was later informed that the SSB_{MSY} values calculated so far by the software package were not correct, so that any SSB_{MSY} calculations from OMs presented to date should be disregarded. The calculation of SSB_{MSY} will be corrected in a later version of the package. This is to be done after this meeting.

It was noted the residuals of the fit to the indices shown in Figure 3 of Carruthers T., and Butterworth 2017 appeared to be very similar across all 12 OMs fitted. Although the comment was made focusing on the CAN_CMB_RR index, it seemed to apply to all indices and was a feature already noted by the Core Modelling Group in their 2017 report. The ICCAT GBYP modelling expert noted that it should be kept in mind that in the OMs each of these indices is taken to represent bluefin biomass in a particular quarter of the year and spatial area, rather than bluefin biomass in the entire West or East areas; therefore the residuals of a given index also correspond to a particular quarter and spatial area. This, however, does not explain the similarity of residuals across OMs. The ICCAT GBYP modelling expert conducted some preliminary investigation of this issue during the meeting, but indicated that more time was needed to fully examine the issue. Providing the plots of actual fits to the data, and not only the residuals, might be informative.

Concerns were raised that some of the unexpected results from the fit of the 12 OMs to historic data (i.e. the results shown in Carruthers T., and Butterworth 2017) might be due to the fact that these stock assessments only start in 1983, so that information from earlier years was not taken into account (this could, e.g., affect estimates of stock productivity). The ICCAT GBYP modelling expert clarified that for the 12 OMs, calculations start from year 1864, with biomass and recruitment before 1983 being estimated using Stock Reduction Analysis due to the absence of sufficient age or length composition data to fit statistical catch-at-age or catch-at-length models. The Group later decided to try to extend the age-structured assessment back to 1975 in order to make better use of available information. This is to be done after this meeting.

The Group discussed whether it is important that the OMs used in the MSE (obtained from fitting the M3 model, with stock mixing) should match the historic results from the agreed stock assessments. The conclusions from this discussion are reported under Agenda Item 7.

5. Initial review of experiences with and comments on the coding package

The participants to the meeting were requested to share their experiences from using the software package developed by the ICCAT GBYP modelling expert. The participants that had tried out the package before the meeting indicated that in general they found it very good and easy to use. General comments included:

- The package generates future values of indices for use in MPs. It is not clear how far back in time those indices go.
- A better introduction in the software manual on how to design an MP could be helpful; currently, this is somewhat buried in the manual (in Section 7 of the manual). This was considered advantageous, but of low priority.
- The model is extremely complex and therefore computationally intensive. Problems with computational memory requirements were experienced by some users. This is not surprising because the M3 model contains 2 stocks, 14 fleets, 3 age groups, quarterly time step and 10 spatial areas. Routines and modifications are being developed to reduce the memory requirements, but the time taken to run the model is unavoidable.
- It is important to display performance across OMs in a way that is simple and facilitates understanding of results and comparisons between CMPs. A shiny application will be added to the software package. Appropriate ways of weighting across OMs should be considered and included in the package apart from the shiny app, to be able to add those results to the ones obtained from single OMs.
- Regarding the conditioning of OMs, more information is required to understand all the behaviour and properties of the M3 model. The ICCAT GBYP modelling expert noted that a report pdf file can already be generated with the software for each OM fitted to historical data. The file displays fit and diagnostic information for the OM fits to historic data. The ICCAT GBYP modelling expert requested that the Group indicate if additional elements, e.g. additional diagnostics, should be displayed in the file.
- Clarification was sought about how the data (indices) are used to condition OMs, as well as how the software generates them in the MSE when used in MPs. This is addressed in the discussion on abundance indices reported below.
- When a TAC is set for year *y*, the last year of finalised data at the time of setting the TAC is *y*-2 for surveys and CPUE indices and *y*-3 for catch data. For years *y*-2 and *y*-1 the catch can be assumed to be equal to the TAC. Therefore the software package should not allow the use of data for any year after *y*-2 in the TAC computations by CMPs, as in reality these data would not be available at the time TAC computations were conducted. Once a CMP is available, it is important to show the benefit of having more recent information. This can be done by showing how the catch changes for the same level of risk.
- The B_{MSY} calculation in the software package version available for the meeting was not correct. A corrected version will be produced as soon as possible.
- Options for reporting depletion statistics when the stock-recruitment regime changes through time need to be clarified. The discussion and conclusions are summarised below.

5.1 Abundance indices used to condition OMs and to specify MP

The Group requested clarification on the abundance indices used to condition the OMs. The key questions and discussions were as follows:

Which indices are used to condition (i.e. fit to historical data) OMs?

The indices included were those shown in Table 1 (commercial CPUE) and 2 (survey indices) of the Trial Specifications Document (**Annex 1 to Appendix 7**). It was stressed that each index was linked to the abundance of BFT in a particular quarter of the year and spatial area. The so-called "master index" in the Trial specifications document can be interpreted as a prior on the spatial distribution of bluefin, but the OMs are then fitted using the indices in Tables 1 and 2 of **Annex 1 to Appendix 7**. It was noted that CPUEs were fitted from 1983 onwards only. The Group stated that it may be worth adding the age groups to which each CPUE applies to the table for easy reference.

The Group noted that the indices in Tables 1 and 2 **Annex 1 to Appendix 7**. of the Trial Specifications document do not exactly coincide with those used in the agreed stock assessments, nor are they all being used in the same way (e.g. some indices time-series are split in the 2017 assessment but have not been split in the OM conditioning). This is partly due to the fact that the indices used for conditioning OMs were decided before the final stock assessment decisions were made in 2017.

A subgroup was tasked with reviewing the indices used in the final assessments and proposing which of those indices (series and time periods) should be used in conditioning OMs. It was noted that the OM is a spatial assessment and that the indices used in such an assessment are not necessarily the same ones that may be appropriate in spatially-aggregated assessments. It was also noted that the agreed stock assessments split some abundance index series in two periods, but that that splitting could sometimes be problematic in the MSE context because it could make some abundance indices look better than they actually are (which has implications for how the indices are then generated if used to provide inputs to MPs). The conclusions from the entire Group after reviewing the subgroup's proposal on indices are presented below, with the final series to be used included in **Annex 1 to Appendix 7.**

1. If the index was used in any of the agreed 2017 stock assessments (West: SS or VPA; East: VPA) then use it in the OM conditioning (except where specifically stated otherwise), in the same manner that it was used in either SS or VPA. The sub-list below highlights specific indices that needs to be changed or added to the set of indices used in OM conditioning:

   a) Split French Aerial survey index
   b) Add US RR >177 index
   c) Include the Japanese LL GOM 1974-1981 index

2. Changes relative to the indices used in the agreed stock assessments:

   a) Remove the Canada Combined index, and replace it with two indices: SWNS (assign it to WATL) and Gulf of St Lawrence (assign it to GSL) as these separate indices contain spatially specific information.
   b) Move the start date of all indices to 1975
   c) In the development of CMPs developers are permitted to use data for all indices prior to 1975 in their management procedures; this maintains consistency with data provided to previous assessments.

3. Sensitivity/Robustness test OM

   a) Alt. OM: split Med Larval index

4. At the 2018 September Species Group meeting consider recommending advancing the terminal year of indices datasets to 2016 or 2017 for MSE OM conditioning, provided first that these data updates are accepted by the bluefin session.

After this meeting, the OMs will be reconditioned using the indices agreed during this meeting. It was also agreed that the "master index" should be recalculated based on the new choices of indices.

How are the indices projected from the OMs?

A subset of the indices in Tables 1 and 2 of the Trial Specifications document **Annex 1 to Appendix 7** are projected into the future in each OM and can be used to develop CMPs. The statistical properties (variance and autocorrelation) of the residuals from the OM fits are used to generate data in the future years in the MSE assuming a log-normal distribution.

How are the indices selected that will be projected from the OMs (and therefore be available for CMP construction)?

Clarification was provided that the main criteria were:

1. Likely only 3-4 indices can be projected for each of the East and West as more become computationally burdensome.

2. They should each be a series that is very likely to continue in the future.

3. The statistical properties of the residuals from the OM fits should be understood, so that indices with realistic behaviour can be generated for the MSE. Indices showing time-trends in residuals should be avoided.

4. Longer time-series are preferable.

It was noted that in the East there are very few indices that meet all aspects of the selection criteria listed above for being included as projected indices by the OMs and being made available for use in CMPs. Should too strict a selection be placed on the eastern indices, it is likely none would remain available for being projected from OMs and therefore some flexibility must be used in the selection process.

The Group considered the implications of survey indices being selected for use in a CMP if these are then discontinued in the future. If such a situation were to occur, the MP may need to be re-evaluated earlier than initially planned. A useful exercise, which should be conducted at a later stage, is to retune the CMP assuming none of the 3 surveys for the East are available (so that only 1 fishery dependant index remains); the CMP would then be re-evaluated so as to keep the same level of risk and the Group could then examine how much the catch would need to be reduced in the absence of these 3 surveys. This would better justify the necessity for supporting the continuation of these surveys to managers.

Further conclusions from the Group after reviewing the subgroup's proposal on indices is presented below,

1. Alternative projected indices from the OMs made available for CMPs input (beyond those listed in the Trials Specification document).

    a) Include Canada Acoustic index as a western projected index from OMs available for CMP input.

    b) Once the new, corrected, residual plots are available for eastern and western indices, re-evaluate the indices to be projected in the OMs and be available for CMP input.

5.2 Reporting depletion statistics when the stock-recruitment regime changes through time

The Chair of the meeting suggested that a dynamic B0 concept[1] could be used for reporting depletion. This dynamic B0 would be obtained by projecting BFT abundance from 1864 onwards assuming zero catch in all years. If the stock-recruitment relationship changes at a particular time, the dynamic B0 approach will change biomass values gradually over a period of several years, and depletion statistics (B/B0_dynamic) will not show (e.g. step function) behaviour which renders interpretation problematic. It was noted that a similar "dynamic B_{MSY}" concept could be used, with the dynamic B_{MSY} being a constant (i.e. time-invariant) fraction of the dynamic B0 (this holds for all the models being considered, as projections fix the selectivities-at age at their current values). The ICCAT GBYP modelling expert was requested to prepare an illustrative plot for the next meeting to help understand the idea.

6. Presentation of initial CMPs and associated results by each developer/set of developers

IMPORTANT NOTE: all initial results of CMPs were explored only as early examples; this is especially important to appreciate as the OMs will be re-conditioned with different indices (see section 4) and the indices will extend back to 1975 (no longer 1983). Therefore any results were explored for discussion purposes only, and it is expected that any trends in the results could well change.

Brief presentations were provided by the 5 scientists that had prepared CMPs in advance of the meeting. The idea was to get an overview of the CMPs considered so far and to see the format of the comparative plots that the ICCAT GBYP modelling expert had been requested to prepare. Results from applications of CMPs will be different in September, after the planned OM-reconditioning and other expected developments. Therefore, results at this stage were considered for illustrative purposes only.

[1] Some CPCs used the term dynamic B0 differently from what is defined here.

All of the CMPs presented are directly based on abundance indices used in the stock assessments, i.e. they are empirical rather than estimation/model-based. It was noted that developing some model-based MPs is possible with the existing structure of the OMs (e.g. MPs based on surplus production models, as was done for North albacore).

The technical details of some of the CMPs are provided in **Appendix 6** of this report and additional details can be found in the documents SCRS/2018/P_15; SCRS/2018/P_16; SCRS/2018/P_47; SCRS/2018/55; SCRS/2018/59.

Some lessons learnt from this work so far include the following.

The ICCAT GBYP modelling expert explained that models in the software package refer to precision and bias in catch data, but they do not refer to how the abundance indices used in MPs are generated; the generation of abundance indices is based on the statistical properties of the residuals from the OM fits. The "Perfect" observation model is used for testing by developers and not really intended for their final presentation of results; if a CMP fails under the "Perfect" data, it should not be developed further. The "Good" model is the one to be used by default and the "Bad" model is mostly intended as a robustness test.

Discontinuities in HCRs (such as the existence of thresholds that have appreciable impacts on resulting TAC recommendations depending on which side of the threshold a certain variable falls) should be avoided. Such discontinuities are often problematic because noise in data or in results can end up strongly impacting on TAC recommendations. Instead, a linear relationship from slightly above to slightly below the intended threshold should be used.

Explanation was provided that certain parameters in HCRs (e.g. a target index value that may be used in the rule) often become tuning parameters in the MP and are chosen so as to achieve a particular performance. The number of years in a management period (the time period over which a TAC is set each time) could be of the order of 2 or 3 years, but this is to be discussed with the Commission.

For this initial development of the OMs, a 20% limit on interannual TAC changes was imposed when running all the CMPs, whether specified explicitly within the CMP or not. The Group agreed that imposing such a constraint by default in all CMPs was not appropriate at this stage, and should be removed from the running of CMPs. Managers should be asked to provide feedback on desired level of interannual TAC changes, although this feedback is likely better requested at a later date after initial results have been presented to the Commission.

Comments pertaining to the comparison plots presented by the ICCAT GBYP modelling expert were as follows.

The plots prepared by the ICCAT GBYP modelling expert to compare performance of different CMPs under different OMs were found to be very useful, although it was noted that it could be difficult to interpret the results across large numbers of OMs. A sub-group (N. Duprey, G. Merino, H. Arrizabalaga, S. Miller, J. Walter, S. Nakatsuka, A. Gordoa, D. Butterworth and A. Kimoto) was organized to work by correspondence on how best to present results in upcoming scientific meetings. The subgroup will be providing a report to the next meeting of this Bluefin MSE Group.

Some initial thoughts included the following:

- For the CMPs considered, the differences in performance across OMs were usually greater than the differences across CMPs. The Group reviewed plots on overall catch level, interannual catch variability and resulting stock depletion. Catch and variability of catch should be reported by area, whereas depletion statistics should be reported by stock. Reporting abundance of bluefin by area may also be of interest.

- Interannual catch variability should be considered when examining the results, as this may have important operational and management impacts; often the fishing industry is in favour of low interannual TAC changes, although this is not always the case. The information shown in the plots was based on averages over the modelled 30 year projection period. The Group considered it would be useful to include additional plots showing Annual Average Variation information separately for interannual increases and decreases in catch, i.e. taking into account the sign as well as the magnitude of the changes.

- Among the OMs for which results were displayed, the OM that incorporated a regime shift implied the highest risk for the East stock; this is why considering the regime shift scenario is crucial for identifying appropriate CMPs for bluefin tuna.

- The plots should be inspected for results that look suspect according to the experts' understanding of bluefin dynamics and productivity, e.g. MPs leading to high catches at a level that has been seen to be unsustainable in the past should lead to careful investigation of the associated OMs.

- There were some instances where probability intervals on the projected average catch were very small and developers should examine the MPs concerned carefully to try to understand what causes this. Conversely, CMPs with large probability intervals on the projected average catch, or which cover a large range of potential catches/depletion levels, might be problematic, and the CMP developer should explore further what attributes of their CMP might be causing this.

- Evaluation criteria for CMPs: A CMP that results in depleting the stock to very low levels is obviously a failure. However guidance on additional depletion level(s) of concern (e.g. limit reference points, thresholds) has not yet been developed, nor have other objective criteria to determine what constitutes a failure (or success). It was considered that it would be better to wait until the changes planned to OMs and CMPs are implemented (i.e. until September 2018, at least) so that the space of what is feasible is better understood before setting more specific guidelines.

7. Development of a standard format for ready comparison of key results across CMPs and across trials

Due to time restrictions, the Group agreed to postpone the discussion of this particular issue. To facilitate this future discussion, the Group requested that Dr. Carruthers and the following members of the Group: N. Duprey, G. Merino, H. Arrizabalaga, S. Miller, J. Walter, S. Nakatsuka, A. Gordoa, D. Butterworth and A. Kimoto work intersessionally to develop a proposal to be presented at the next meeting of the Group.

8. Possible amendments to the coding package and its associated trials (SCRS/2018/041) and response, and WP in preparation

As noted in Section 4, the set of OMs presented to the meeting in the Trial Specifications document and Carruthers T., and Butterworth 2017 will be reconditioned after this meeting using the abundance indices agreed during the meeting. There were concerns in the Group that the behaviour of OMs was not sufficiently understood and that the OMs could benefit from some changes to input specifications (SCRS-2018/041). After review of the existing OMs, the Group made several recommended modifications to better capture the nature of uncertainties (Table 7.1). The Group also discussed and agreed changes that would be implemented in the Reference set of OMs and in the Robustness trials (using the terminology of Section 9 of the Trials Specification Document).

These changes are provided in the following sections:

8.1 General OM conditioning

To be able to use the whole series of the GOM larval index (1977-present) and to better capture a longer time period of the stock dynamics, the Group agreed that OM conditioning should start in 1975.

8.2 Recruitment scenarios used in OMs

- For the West, the "high recruitment" scenario (level 2 of uncertainty axis 1 "future recruitment" in Reference set of OMs in the Trials Specification document) was not captured correctly in the OM and must be re-specified. Any results seen for that scenario should, therefore, be dismissed. The problem was that a very high value of steepness (*h*) was being estimated, leading to very little difference between the hockey-stick and the High stock-recruitment (SR) dynamics. The meeting agreed to use *h*=0.6 which was generally within the range of steepness estimated in previous stock assessments of Western Bluefin tuna. It was stressed that the recruitment scenarios considered in the Reference set of OMs are meant to capture a representative range of uncertainties, but do not imply any particular relative weighting between the different scenarios (this is a matter that would be discussed at a subsequent meeting). It is also essential to ensure that the stock recruitment relationship for the high recruitment scenario has a virgin recruitment (R0) that is substantially higher than that for the hockey-stick.

- It was also agreed to fix the hinge point of the hockey-stick SR used for the West according to specifications similar to those used in previous stock assessments, e.g. the SSB threshold (hinge) has been set to the average SSB during a time period (usually 1990-1995) with the lowest estimated SSB, and R0 was calculated as the geometric mean recruitment during the time period after 1976 (Anon. 2014).

- It was also pointed out that level 3 of uncertainty axis 1 "future recruitment" in the Reference set of OMs is meant to capture a possible regime shift in recruitment. In the West, a regime shift could have occurred in 1975 and in East from 1987 to 1988. In the West, the hockey-stick (level 1) is a scenario meant to capture that a regime shift to a lower recruitment regime had occurred, whereas the Beverton-Holt form (level 2) assumes that recruitment can still become potentially very high. Explanation was provided that past experience indicated that the regime-shift scenario (level 3) is crucial to ensure MPs with good performance are identified. The methodological implications of regime shifts for performance evaluations of MPs were already discussed under the "dynamic B0" paragraph earlier in this report.

- The Group agreed that appropriate text is needed in the Trials Specification document, and plots of the stock-recruitment fits, as well as of the recruitment trends considered for each OM to explain the basis for the recruitment scenarios chosen for the Reference set of OMs.

- It was also noted that the SSB_{MSY} calculations needed to be redone as part of the OM reconditioning.

Abundance scenarios and extent to which results from conditioning OMs should match those from the agreed stock assessments:

Uncertainty axis 2 ("Abundance") in the Reference set of OMs presented by the ICCAT GBYP modelling expert, contains scenarios (levels B and C) in which the results from conditioning the OMs were "forced" to match certain features of the 2017 stock assessments. The Group discussed if such matching is appropriate, and additionally considered potential modifications to the scenarios examined under this factor. There was general agreement that differences between the OMs and the agreed stock assessments should be expected because the OMs contain many more features, such as spatial disaggregation and stock mixing, which are not included in the 2017 stock assessments. However, the results from conditioning OMs should be carefully inspected to check if there are substantial discrepancies with scientists' broad understanding of the overall stock dynamics of bluefin tuna. In particular, it is easier to obtain acceptance of the results if at least some of the OMs reflect the public perception of stock trends to some extent. For instance, some OMs for both stock areas should show that overfishing has occurred and that the stocks have been overfished during some periods. Another example would be in the eastern Atlantic, where OMs would not be expected to show increases in biomass at times when catches were in the order of 50,000 t per year.

Hence the Group recommends three proposals for abundance.

PROPOSALS: It was agreed that the Reference set of OMs should contain at least 3 scenarios for uncertainty axis 2 "abundance":

A. Best estimate OM fit. If this implies large differences with the accepted assessments, the reason(s) for the differences should be identified.

B. The trends and scales in SSB resulting from OM conditioning for both East and West are simultaneously forced to follow the results of the 2017 stock assessments closely in terms of both absolute magnitude and trend (the final assessments agreed by SCRS in 2017 should be used for this). This should help identify the reasons for any possible differences identified in A.

C. This is similar to scenario A but including some broad constraints to prevent the results of the OM conditioning from diverging from the current general knowledge of past stocks dynamics. The Group considered that it would be appropriate to require that the results of the OM for both East and West BFT show that they were overfished at some point in the past. This means not just spawning stock biomass being lower than SSB_{MSY}, but also a low relative SSB level in certain time periods. Preventing SSB increases during past periods of high catches may also be considered and should be clearly explained if it is included in the scenario. These ideas are meant to reflect public perception of BFT being at low level (particularly in the east) around the turn of the century. The ICCAT GBYP modelling expert was given flexibility here, depending on outcomes found from various explorations.

The ICCAT GBYP modelling expert requested that the Group indicate the kinds of diagnostics that it would need to see and discuss to be comfortable with an OM. Many current diagnostics are available in operating-model specific reports that will be provided by the ICCAT GBYP modelling expert.

8.3 Movement and stock mixing

Substantial discussions were held to clarify how movement is modelled in the OMs (the OMs have an age and stock of origin-dependent movement probability between spatial areas that changes from quarter to quarter but is the same for all years). There was substantial discussion concerning the extent to which this assumption can be considered realistic, while understanding that the data available to estimate time-varying movement is limited. While movement rates for a given age, stock and quarter are assumed to be constant from year to year in the OMs, the stock composition in any particular region, quarter and year is variable. The OM uses the fits to the available electronic tag data as well as genetic and otolith micro-chemistry information to estimate movement rates; it should be noted that all data used to fit the OMs contribute to some extent to the estimation of movement rates. It is noteworthy that stock composition data obtained for the Canadian GSL region from genetics show increased representation of eastern stock bluefin tuna in recent years.

Other movement scenarios could be considered in the OMs such as increasing the weight of GSL in the gravity model, or allowing time-varying movement rates but, given time constraints and information content in the data, it was agreed to keep the baseline movement scenario used so far (e.g. same movement probabilities in all years). The increasing percentage of eastern origin fish in the GSL was noted, for which separating the GSL and SWNS indices in the OMs (see section 4) may address this issue.

There is a concern that movement rates may be overestimated by the fitting to the observed stock composition data, as the composition data always has some element of uncertainty and often has some non-negligible fraction of a much smaller stock, even in areas where it has previously been assumed that no mixing occurs. Hence movement rates may be overestimated and the spatial models, in order to improve fits, may put biomass in areas that are not currently fished, based on electronic tag information.

The Group had a strong preference that the Reference set of OMs encompass alternative mixing scenarios. Given the complexity of developing alternative scenarios, the Group outlined several proposals. Initially some were proposed to be included in the axis of uncertainty in developing the Reference set of OMs; however due to concerns around increasing the number of OMs (making the presentation of the results and running of the MSE difficult), the proposal was modified to include them as part of the robustness tests. There is, however an expectation that, provided the alternative mixing OMs meet performance criteria, they may be upgraded to the Reference set at a later meeting.

PROPOSALS: The Group agreed to two mixing scenarios (i and ii below) and one change to the treatment of tagging data (iii below):

i) Halve the rates of mixing, e.g. if the observed fraction of Western fish in an assumed eastern year/area/quarter is 40%, this scenario will assume that it is only 20%. Such changes will reduce the estimated rates of movement between the East and West and may represent a plausible scenario. This set of OMs will be used for the robustness set, with high priority.

ii) Condensing the 10-area model into a 7-area model, merging areas 6+7, 5+9 and 1+2. This is also recommended to be added as a robustness test; however noting this also corresponds to a structural change in the model which has major coding implications, it is therefore given a relatively low priority.

iii) The Group also agreed that tagging of juveniles by AZTI in the Bay of Biscay will be used to estimate movement rates, assuming that those fish are of Eastern origin, based on previous otolith chemistry studies suggesting this is the case (Fraile *et al.* 2014). This change will be made across all OMs.

The Group considered several other options for different mixing scenarios such as use of only one source of mixing information at a time (e.g. only microchemistry or only DNA) or to allow time-varying movement or average mixing rates (Hazin *et al.* 2018), but these were not considered for alternative OMs at this point in time.

The Group also discussed the fact that the agreed VPA stock assessments are known to be sensitive to the assumed Fratio, which points to an unknown level of cryptic biomass. Concern was expressed that large amounts of cryptic biomass could impact the OMs, by moving large quantities of fish outside the range of the fishery. To address this, the Group agreed that the spatial distribution of the vulnerable and non-vulnerable (cryptic) biomass by stock in each area should be plotted over time.

8.4 Catchability and indices

Noting that recommendations for indices used in the historical OM conditioning are captured in section 4, only aspects of future index specifications are discussed in this section of the report.

PROPOSAL:

A. Apply a 2% increase in catchability for projected fishery-dependent CPUE indices in a robustness test.

This proposal is to apply a 2% increase in catchability for the forecast components of OMs to protect against undetected depletion. This is to be applied as a robustness test. This would apply only to fishery-dependent indices of stock sizes. It is assumed that fishery-independent indices of stock size will have constant catchability. If the methods to collect the fishery independent indices of stock size are changed in future, it is assumed that a calibration coefficient will be derived at the time that occurs. The two percent value is based on estimated change in catchability for one of the stock size indices over a 45-year period.

The Group noted that catchability will not necessarily always increase. For some indices, environmental factors may decrease catchability and changes in catchability are not necessarily expected to be monotonic. The Group suggested that these changes, including step changes in catchability, be included in robustness tests as a second priority.

A proposal was considered for including index-specific variance, autocorrelation and non-linearity in the projected indices. There were concerns that the method of estimation of the autocorrelation and non-linearity may have been inappropriate and that these estimates should be re-examined for a revised Trials specification document. Once the estimation procedure has been finalised and reconditioning completed according to decisions made at this meeting, the Group agreed to re-run the estimation of autocorrelation and non-linearity and, if statistically justified, use those in a robustness test.

8.5 Summary of recommended OM changes

Overall, the following changes are recommended by the Group to the OMs (**Table 1** below); they are denoted according to whether they apply to all OMs, the Reference set OMs only or the robustness set OMs only.

Reference set

Three major uncertainty axes: future recruitment, abundance and natural mortality/maturity (in combination) for conditioning and projections. These axes assume that the options of East and West are linked across the rows of the table below. This is done with the intention of capturing extremes.

Table 1. Recommended changes to Reference set OMs.

	West	East
Future recruitment		
1	Hockey-stick with fixed hinge point starting from 1975	88+ B-H with *h*=0.98
2	B-H with h=**0.6** fixed, **high R0***	88+ B-H with *h*=0.70
3	Hockey-stick changes to B-H after 10 years	88+ B-H with *h*=0.98 changes to 50-87 B-H with *h*=0.98 after 10 years
Abundance		
A	Best estimate	
B	East-West area spawning biomasses match 2017 VPA assessment	
C	**Prior on trend** and/or depletion **to match perception of heavy exploitation**	
Spawning fraction both stocks		Natural Mortality rate both stocks
I	Younger	High
II	Younger	Low
III	Older	High
IV	Older	Low

*High recruitment should reflect higher R0 than for hockey-stick.

Combinations for Reference Set

A full cross of (1, 2, 3) x (A, B, C) x (I, II, III, IV), i.e. 36 scenarios in total.

Recommended changes to robustness set OMs (Appendix 7 section 9b)

High priority

1. Robustness to less mixing (50%): crossed design with 4 tests, corresponding to 1A, 2A, 1B, 2B in **Table 1** above.
2. Future catches in both the West and the East + Med are each year 20% bigger than the TAC as a result of IUU fishing (of which the MP is not aware)
3. An undetected increase in future catchability for CPUE-based abundance indices of 2% per annum
4. Non-linear index-abundance relationships: revise estimates based on more appropriate statistical estimation and revise projection components of OMs
5. Robustness to more mixing crossed design with 4 tests, corresponding 1A, 2A, 1B, 2B in **Table 1** above).

Low priority

1. Future recruitment change as in 3), but with probability of 0.05 for each of the first 20 years of projection.
2. Alternative assignments to stock of origin of historical catches from the South Atlantic (off Brazil).
3. Seven area model. Condensing the 10-area model into a 7-area model, merging areas 6+7, 5+9 and 1+2.

"Second round" issues (not in this current MSE process)

The following aspects of uncertainty are recommended to be postponed at this time for consideration rather in a "second round":

1. More than two stocks
2. Use of CAL (CAS in ICCAT) data in an MP
3. TACs allocated on a spatially more complex basis than the traditional West and East + Med
4. Changes in technical measures affecting selectivity
5. Changes in stock distributions in the future
6. Future changes in proportional allocation of TACs amongst fleets

9. Presentation of results of possible refinements of CMPs developed during the meeting

Due to meeting time constraints and the need to first make amendments to the OMs in the coding package, there were no further refinements to the CMPs presented made during the meeting.

10. Agreement of a tuning specification (possibly more than one) to facilitate comparison of future results presented (e.g. median target level of biomass at the end of the projection period for each of the West and the East populations for a single specified trial)

A fuller explanation of tuning is provided in **Appendix 8.**

The Group noted that the development tuning control parameter value will be specific for each of the two stocks.

Every developer will be able to decide their own preferred tuning. The separate development tuning is to help differentiate the performance of two CMPs in conditions where their median depletion after 30 years is the same.

For the development tuning, in one particular trial every developer will tune to get median $SSB/SSB_{MSY}=1$ in projection year 30 for a central OM in addition to their own preferred tuning. This exercise will be for internal use between the developers and the MSE Group.

When presenting results to decision makers, performance metrics will be averaged across OMs.

11. Initial discussion and specification of aspects where input from Commission/stakeholders will likely assist future refinement of CMPs (this will relate, in part, to increased detail regarding objectives and trade-offs)

The Standing Working Group on Dialogue between Scientists and Managers (SWGSM) meeting (21-23 May 2018) will have an agenda item specific to bluefin tuna MSE (item 6.2). The objective is to initiate input from stakeholders to assist in future refinement of CMPs. Furthermore, there is a need for guidance on the general ICCAT MSE roadmap and the recommendations on MSE to be provided to the Commission.

Input to be provided to the SWGSM will be in the form of a synthesis of the report of this meeting. The SCRS Chair will prepare this synthesis and circulate it to all participants of this meeting by 28 April. Feedback on this synthesis will be required by 5 May. After that the SCRS Chair will modify the report and make it available to all (including SWGSM participants) by 9 May[2].

The Synthesis will have the following goals:

- *Status update on MSE-related work by the SCRS*

  - Summarize work progress to date, and demonstrate the importance of continued resourcing of the GBYP MSE work
  - Provide sufficient and understandable information to ensure useful feedback from the SWGSM participants and increase SWGSM participants' engagement in the MSE work conducted by the SCRS
  - To convey to Commission a realistic schedule for completing the MSE. Based on experiences elsewhere, even in a very optimistic situation the Bluefin tuna Species Group will likely need at least four more one-week meetings dedicated to this MSE. The current schedule which suggests completing MSE by 2019 needs to be revised accordingly.

- *Consideration of candidate management procedures (CMPs)*

  - Describe the general types of characteristics of the MPs being proposed so that SWGSM participants can provide feedback on:
    - The acceptability of such types of MPs
    - Possible TAC constraints
    - General objectives for MPs in broad terms (e.g. priorities amongst resource conservation, maximizing catches and minimizing the extent of TAC changes made, with advice on the intervals between TAC changes which are preferred)
  - Understand when further input on more detailed MP objectives will be required and useful.

- *Transparency and communication of MSE results*

  - Obtain guidance on possible modifications to the current MSE process to improve the communication of MSE results and the engagement of SWGSM participants in the MSE development.

12. Work programme for further CMP refinement, with deadlines, leading to results sought for presentation at the September 2018 Bluefin Species Group meeting

Tentatively the following near-term work schedule was suggested by the Group. The Group discussed intensively the feasibility of the September meeting of the Group (item 5) and many concerns were expressed about the heavy meeting schedule. It was explained by the Secretariat that moving the date of the meeting would require re-writing of the contract for GBYP modelling. The general purpose of the meeting was understood to be for further discussion of re-conditioning of OMs and review of results of revised CMPs, continuing building upon the discussions of the current meeting.

1. End of May – Completion of updates to the OM based on this meeting (the ICCAT GBYP modelling expert)
2. Mid-June – Comments on updated OMs
3. Early July – ICCAT GBYP modelling expert circulates updated package on the basis of finalised revisions
4. Mid July to early September:

   a) Developers rerun adjusted CMPs on updated package;
   b) documents prepared on further conditioning issues requiring attention

[2] This report was finalized on 9/5/2018, by which time these deadlines had not been met and the draft synthesis document was yet to be produced by the Chair of the SCRS.

5. Activities occurring after early September are driven by the recommendations in section 13. Decisions in this regard will be made by the SCRS Chair, BFT Rapporteurs and the Secretariat.

13. Recommendations

The Group identified a number of challenges faced by the Bluefin tuna Species Group in effectively participating and engaging in the Bluefin tuna MSE process:

- The need for mechanisms, including well planned meetings, which facilitate the engagement of the Bluefin Species Group at different levels and which ensure maintaining the momentum of the MSE process.
- The difficulties encountered by Bluefin Species Group members to engage effectively in the process earlier because of the demands put by the 2017 Bluefin Stock Assessment.
- The fact that further engagement of the Bluefin tuna Species Group in the MSE process is best achieved by meetings of the Species Group that are substantial in length (3+ days) and focused on the single topic of MSE.
- The difficulties faced by many CPCs to effectively engage in the multiple concurrent sessions occurring during the species Group week in September because of the limited number of scientists in the respective CPC delegations.
- The additional length of periods away from home generated by adding meeting days prior to the species Group week.

Given these challenges the Group recommends that:

- The decision of the number of days allocated to the Bluefin Species Group meeting of September, the agenda of such meeting, and the timing of the next core modelling Group meeting should consider the challenges above.
- Future core modelling Group meetings should encourage participation of anybody interested in providing input into the MSE process.
- The objectives and agenda of any core modelling Group meeting be widely circulated to all of the SCRS well in advance to help participation of all interested scientists in such a meeting.
- In early 2019 the SCRS conducts a one week intersessional meeting of the Bluefin tuna Species Group focusing on MSE.

Specific recommendations to the developer of the BFT MSE framework and the core modelling Group are included elsewhere in this report. There are a few general recommendations to the SCRS relevant to experiences from the Bluefin MSE:

- Other MSE processes in the SCRS should consider the advantages that the MSE framework developed by the ICCAT GBYP project may have for their own MSE processes. Such advantages include the current application of this framework to an ICCAT stock, the power and flexibility of the different modules of the framework and the experience acquired by several SCRS scientists in the use of this framework.
- The input from the Bluefin tuna Species Group to the SWGSM meeting (21-23 May 2018) should be in the form specified and following the process described in section 12 of this report.
- The establishment of a section solely dedicated to MSE in the ICCAT webpage. This section should contain descriptions of all MSE processes and the most important scientific outputs from such processes.
- Rapporteurs or designated representatives from Species Groups engaged in MSE processes should do everything possible to attend SCRS meetings that focus on MSE, even if the meeting is not a meeting of their respective Species Group.
- The SCRS should ask the Commission to identify a dedicated source of funding for the MSE processes, because all require a longer commitment than the typical 2-year funding cycle used by the Commission.
- A trial specification document should be developed and maintained for any MSE process initiated within the Commission. A template for such document should be developed.

14. Other matters

No other matters were discussed.

15. Adoption of the report and closure

The report was adopted by the Group and the meeting was adjourned.

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Appendix 1

Adopted Agenda MSE Bluefin Tuna

1. Opening, adoption of Agenda and meeting arrangements
2. Introduction to Management Strategy Evaluation (MSE)/ Management Procedures (MP) issues
3. Review of available documents on Bluefin tuna MSE and MSE trials specifications document update
4. Specification (prioritized) of further OM conditioning and comparative presentations of initial Candidate Management Procedure (CMP) results to be attempted by GBYP modelling expert during the meeting
5. Initial review of experiences with and comments on the coding package
   - 5.1. Abundance indices used to condition OMs and to specify MPs
   - 5.2. Reporting depletion statistics when the stock-recruitment regime changes through time
6. Presentation of initial CMPs and associated results by each developer/set of developers
7. Development of a standard format for ready comparison of key results across CMPs and across trials
8. Possible amendments to the coding package and its associated trials (SCRS/2018/041) and response, and WP in preparation.
   - 8.1. General OM conditioning
   - 8.2. Recruitment scenarios used in Oms
   - 8.3. Movement and stock mixing
   - 8.4. Catchability and indices
   - 8.5. Summary of proposed OM changes
9. Presentation of results of possible refinements of CMPs developed during the meeting
10. Agreement of a tuning specification (possibly more than one) to facilitate comparison of future results presented (e.g. median target level of biomass at the end of the projection period for each of the west and the east populations for a single specified trial)
11. Initial discussion and specification of aspects where input from stakeholders will likely assist future refinement of CMPs (this will relate, in part, to increased detail regarding objectives and trade-offs)
12. Work programme for further CMP refinement, with deadlines, leading to results sought for presentation at the September Bluefin Species Group meeting.
13. Recommendations
14. Other matters
15. Adoption of the report and closure

Appendix 2

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Appendix 3

List of Papers and Presentations

Reference	Title	Authors
SCRS/2018/041	Potential further considerations on the conditioning of Operating Models of Atlantic bluefin tuna	Kimoto A., Walter J., Lauretta M., Sharma R., and Rouyer T.
SCRS/2018/047	Results for initial explorations of simple candidate “fixed proportion” MPs for Atlantic Bluefin tuna based on the operating models package circulated	Butterworth D.S., Miyagawa M., and Jacobs M.R.A.
SCRS/2018/055	Designing and testing a multi-stock spatial management procedure for Atlantic bluefin tuna	Carruthers T.
SCRS/2018/059	A candidate Management Procedure for bluefin tuna	Hanke A.
SCRS/P/2018/015	Preliminary evaluation of MPs for Atlantic bluefin using MSE	Merino G., Arrizabalaga H., Rouyer T., and Gordoa A.
SCRS/P/2018/016	An extremely preliminary evaluation of some empirical management procedures	Walter J.
SCRS/P/2018/017	Overview of a MSE reference document: ‘Specifications for MSE Trials’	Carruthers T., and Butterworth D.
SCRS/P/2018/018	Improving communication: the key requirement to improve the effectiveness of MSE processes	Miller S., Anganuzzi A., Butterworth D., Davies C., Donovan G., Nickson A., Rademeyer R., and Restrepo V.
SCRS/P/2018/019	Current state of MSE/HCR Process in ICCAT	Die D.
SCRS/P/2018/020	What makes an MP an MP and an MSE an MSE?	Punt A.E.

Appendix 4

SCRS Documents and Presentations Abstracts as Provided by the Authors

SCRS/2018/041 - ICCAT BFTWG completed the stock assessment using multiple stock assessment methods in 2017, and they are going to proceed the MSE process: development of MP in 2018. It is well recognized that the performance results of MPs often depend on the design of the OM and its conditioning that capture the range of potential population dynamics. It is therefore critical to consider them carefully before moving to the development of MP, but this has been monumental task given the complexity of ABFT. ICCAT GBYP core modelling group has developed the OM by incorporating the mixing between two stocks, and the trial specifications. However, the 2017 stock assessment raised a number of issues that may require further consideration for the OMs, particularly related to time varying catchability and selectivity, effective sample sizes for composition data and stock mixing dynamics that are limited information. Overall, we commend the work of the ICCAT GBYP Core modelling group for producing the current OM and framework for evaluating MPs. Our purpose in this document is not to criticize this work but to foster clarification and further discussion about key uncertainties that have emerged during the 2017 assessment.

SCRS/2018/047 - In an initial exploratory exercise, simple fixed proportion MP control rules are applied using composite abundance indices for the East and West areas, where these composites take weighted averages over standardised values of the agreed indices and are then averaged over the last three years for which they would be available. These candidate MPs (CMPs), which also impose a 20% cap on biennial TAC changes, show ready ability to achieve median depletion close to the MSY spawning biomass for each stock within a 30-year projection period for a number of members of the Reference Set of Operating Models (OMs). Two insights from the analyses are first that discussion is needed regarding the most appropriate statistic to use to measure resource depletion in circumstances where some OMs allow for changes in stock recruitment relationships at some time during the projection period considered. The second is that resource depletion can at times be too great for the OM for which the historical abundance of the East stock shows a large increase over recent years. Typical TAC changes are also greater than desirable for adequate stability from an industrial viewpoint. Suggestions are made for further work towards improving MP performances in these respects.

SCRS/2018/055 - A candidate management procedure to set total allowable catch advice from indices of abundance was designed that has two novel aspects. Firstly, it combines catch rate indices by area and spawning biomass indices by stock to infer regional abundance. This configuration has the advantage that TACs are set according to multiple sources of information and mixing is accounted for, for example allowing TACs in the western area to respond to fluctuations in productivity in the Eastern stock. Secondly, the MP implements a harvest control rule that accounts for both stock status (B/B_{MSY}) and exploitation rate (F/F_{MSY}). The advantage of this approach is that for example, a stock that is overfished and recovering (underfishing) does not necessarily incur a TAC reduction. These two features are intended to maintain a 'steady hand' in the face of potentially large fluctuations in the productivity of both East and West stocks. A preliminary test of the MP was carried out for 8 reference operating models.

SCRS/2018/059 - A management strategy evaluation framework developed for Bluefin tuna (ABTMSE version 2.7.0) was used to test the performance of a management procedure (MP) developed following consultation with stakeholders in the Canadian Bluefin tuna fishery. The single DFO MP and several constant catch MPs applied in the western stock management area were evaluated against a single constant catch scenario for the east.

SCRS/P/2018/015 - Not provided by the author.
SCRS/P/2018/016 - Not provided by the author.
SCRS/P/2018/017 - Not provided by the author.
SCRS/P/2018/018 - Not provided by the author.
SCRS/P/2018/019 - Not provided by the author.
SCRS/P/2018/020 - Not provided by the author.

Appendix 5

Approximate F0.1 CMP Proposal from the Subgroup

Two approaches were put forward by the subgroup. These are options 1 and 2 below.

OPTION 1. This uses an F0.1 interpretation which is OM-independent. From the agreed VPA assessments, we have F0.1-based TACs for 2018 and a few additional future years. The idea is to take these projections at F=F0.1 forward for 30 years from these agreed VPAs. Then use those 30-year future catches as fixed catch values to input to all different OMs.

OPTION 2: This uses an F0.1 interpretation which is OM-specific. Option 2A is preferred to 2B but may not be doable, particularly because the stock mixing may complicate the calculation. If 2A is not doable, then 2B will be used.

A) Calculate the true F0.1 (by age) for 2018 for each OM (OM-dependent). Characterize uncertainty in biomass estimates in stock assessments by using a fixed CV (to be determined) and apply F0.1 (30 years into the future) to these noisy estimates of stock biomass.

B) Calculate the F-at-age in each OM that corresponds to the 2018 TAC and interpret that as F0.1 (OM-dependent). Project 30 years into the future using the F-at-age identified in this way to compute anual catches to which error is added as for A) above.

Note: As regards the CV mentioned in Option 2 as to be determined, one suggestion made was to use the estimate from Ralston et al. (2011) "A meta-analytic approach to quantifying scientific uncertainty in stock assessments", Fish. Bull. 109:217–231). This suggests a lower bound of 37%.

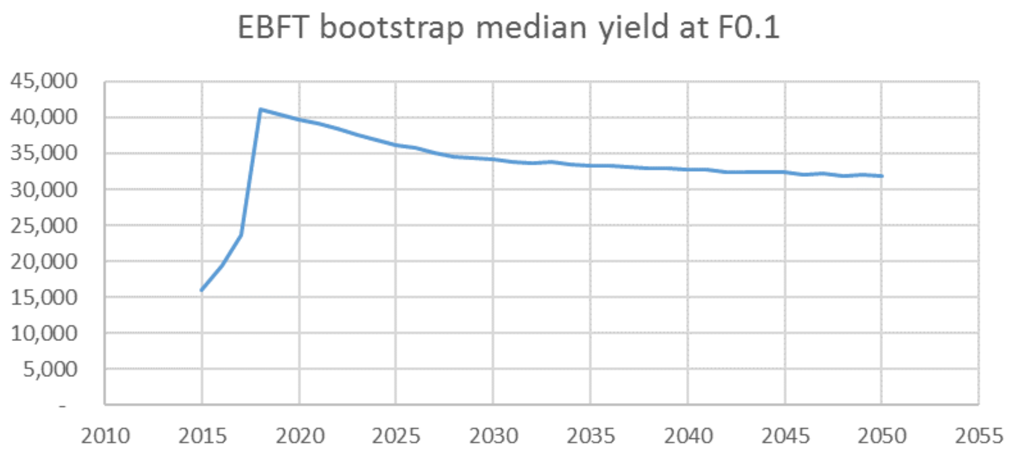

Figure 1. Catch series for Option 1 for EBFT. This comes from projecting the EBFT VPA forward at constant F=F0.1, using the 6-year average recruitment (constant mean, but with some variability) into the future.

Appendix 6

Technical details of some of the CMPs

A. The DMM (Doug, Mitsuyo and Melissa) initial Candidate Management Procedure

The DMM initial CMP is in essence a constant fishing mortality approach. It is applied separately to composite indices aggregated over those abundance indices available for each of the East and the West areas respectively. The control parameters setting this mortality may differ for the two areas, and each aggregate abundance index is averaged over the last three years for which data would be available so as to reduce variability in the index and consequently in TACs. TACs for each area are restricted not to change by more than 20% when the TAC is revised every second year. Details are provided below.

Aggregate abundance indices

An aggregate abundance index is developed for each of the East and the West areas by first standardising each index available for that area to an average value of 1 over the past years for which the index appeared reasonably stable[1], and then taking a weighted average of the results for each index, where the weight is inversely proportional to the variance (σ^2) shown by that standardised index over the chosen years. The mathematical details are as follows.

J_y is an average index over *n* series (*n*=4 for the East area and *n*=3 for the West area)

$$J_y = \frac{\sum_i^n w_i \times I_y^{i*}}{\sum_i^n w_i} \qquad (1)$$

where $w_i = \frac{1}{(\sigma^i)^2}$

and where the standardised index for each index series (i) is:

$$I_y^{i*} = I_y^i \Big/ Average\ of\ historical\ I_y^i$$

The actual index used in the CMPs, J_{av}, is the average over the last three years for which data would be available at the time the MP would be applied, hence[2]:

$$J_{av,y} = \frac{1}{3}\left(J_{y-2} + J_{y-3} + J_{y-4}\right) \qquad (2)$$

where the J applies to either to the East or to the West area[3].

CMP specifications

The CMP sets the TAC every second year simply as a multiple of the J_{av} value for the area at the time, but subject to the change in the TAC for each area being restricted to a maximum of 20% (up or down). The formulae are given below.

For the East area:

$$TAC_{E,y} = \left(\frac{TAC_{E,2018}}{J_{E,2016}}\right) \cdot \alpha \cdot J^E_{av,y-2} \quad ^4 \qquad (3a)$$

If $TAC_{E,y} \geq 1.2 * TAC_{E,y-1}$ then $TAC_{E,y} = 1.2 * TAC_{E,y-1}$

[1] These years commence from 2012 (JPN_LL_NEAtl2), 2010 for FR_AER_SUV, 2013 for MED_LAR_SUV, 2011 for MED_AER_SUV and JPN_LL2, 1994 for US_RR_115_144, and 1984 for GOM_LAR_SUV.

[2] For the French and Mediterranean aerial survey, there is no value for 2014 and 2015 respectively. These years are omitted from this averaging where relevant.

[3] The reason that the subscript on J_{av} is *y*-2 here is that one would set a TAC for year *y* during year *y*-1, at which time the most recent abundance indices available would be for year *y*-2.

If $TAC_{E,y} \leq 0.8 * TAC_{E,y-1}$ then $TAC_{E,y} = 0.8 * TAC_{E,y-1}$

For the West area:

$$TAC_{W,y} = \left(\frac{TAC_{W,2018}}{J_{W,2016}}\right) \cdot \beta \cdot J^{W}_{av,y-2} \qquad (3b)$$

If $TAC_{W,y} \geq 1.2 * TAC_{W,y-1}$ then $TAC_{W,y} = 1.2 * TAC_{W,y-1}$

If $TAC_{W,y} \leq 0.8 * TAC_{W,y-1}$ then $TAC_{W,y} = 0.8 * TAC_{W,y-1}$

B. The DFO Candidate Management Procedure

A.R. Hanke

The DFO western MP (DFO7_40_10) uses index 7 (GOM_LAR_SUV) to predict stock status and derive a TAC recommendation. Healthy, cautious, critical and super critical zones are defined by the reference values 1.0, 0.4 and 0.1. The stock status at the conclusion of a management cycle is determined by comparing the ratio of the index value at the end of a cycle to a base value of the index. The base value is the mean of the index values in the last 3 years of the historical period.

In addition to an evaluation of status based on the index, the MP also determines the trend in the index over the most recent 4 years in order. The magnitude and direction of the trend affects the TAC recommendation conditional on stock status and comprise the control rules.

These control rules are as follows:

1. When the stock is in the healthy zone and the trend is positive, the TAC is increased by a scalar of 0.3 applied to the magnitude of the trend. Thus a slope of 1.0 increases the TAC by 30%. Otherwise, if the trend is negative there is no adjustment in the TAC.

2. When the stock is in the cautious zone and the trend is negative, the TAC is decreased by a scalar of 0.1 applied to the magnitude of the trend. Thus a slope of -1.0 decreases the TAC by 10%. Otherwise, if the trend is positive there is no adjustment in the TAC.

3. When the stock is in the critical zone, the TAC is decreased by a scalar of 0.1 applied to the magnitude of the trend 50%. In the event that the status falls below the critical zone, the TAC is set to 0.

In mathematical terms the MP works as follows:

$$I_{base} = \sum_{y=2012}^{2015} I_y / 4$$

$$I_{ratio} = I_n / I_{base}$$

$$\beta = I_j - \alpha / Y_j, \qquad j = y_{n-3}, \dots, y_n$$

Healthy Zone

$$I_{ratio} \geq 1 \ \wedge \ \beta \geq 0, \qquad TAC_{y_{n+1}} = (1 + \beta \times 0.3) \times TAC_{y_n}$$

$$I_{ratio} \geq 1 \ \wedge \ \beta < 0, \qquad TAC_{y_{n+1}} = TAC_{y_n}$$

Cautious Zone

$$I_{ratio} < 1 \ \wedge \ I_{ratio} \geq 0.4 \ \wedge \ \beta < 0, \qquad TAC_{y_{n+1}} = (1 + \beta \times 0.1) \times TAC_{y_n}$$

$$I_{ratio} < 1 \ \wedge \ I_{ratio} \geq 0.4 \ \wedge \ \beta \geq 0, \qquad TAC_{y_{n+1}} = TAC_{y_n}$$

Critical Zone A

$$I_{ratio} < 0.4 \ \wedge \ I_{ratio} \geq 0.1 \, , \qquad TAC_{y_{n+1}} = 0.5 \times TAC_{y_n}$$

Critical Zone B

$$I_{ratio} < 0.1 \, , \qquad TAC_{y_{n+1}} = 0$$

If $TAC_{W,y} \leq 0.8 * TAC_{W,y-1}$ then $TAC_{W,y} = 0.8 * TAC_{W,y-1}$

A constant catch MP (CurEC100) was developed for the eastern stock that set the TAC according to the management recommendations for 2016 through 2020 (Rec [14-04]; Rec [17-07]). The resulting schedule of removals for the eastern stock was 19,296 MT, 23,155 MT, 28,200 MT, 32,240 MT and 36,000 MT in years 2016 to 2020. Following 2020 the TAC was fixed at 36,000 MT. However, when a greater than 1 year management cycle is invoked, ABT-MSE will adjust this schedule by omitting TAC recommendations that do not fall on the terminal year of the cycle and repeat those that do.

C. EU Candidate Management Procedure (CMP)

Gorka Merino, Haritz Arrizabalaga, Tristan Rouyer, Ana Gordoa

The CMPs first attempted for the East and Western areas are empirical and are only different on the indices used and the targets. In particular, for the Eastern stock three indices were tested: JPN-LL-NEAtl12, FRE-AER-SUV, MED-AER-SUV and an average of the three. For the West we tried the GOM-LAR-SUV index. For both areas we tried two targets (100% and 75% of current values).

At a later stage, the average indices for the East and the target of 100% for both areas were selected for further testing.

Thus, the CMP consists on TAC adaptations as a response to the following indices' dynamics:

- East: Average of the JPN-LL-NEAtl12, FRE-AER-SUV and MED-AER-SUV.
- West: GOM_LAR_SUV

The CMP calculates the relation of the average value of the index in each management period of the simulation (curI) with a target (Targ), which is set relative to its value at the beginning of the simulation (I0). In this case the target is set at the value at the beginning of the simulation, Targ=1.

Targ= x * I0
Irat= curI/Targ

The new TAC is set proportionally to the relation between the current value and the target:
newTAC=oldTAC * Irat

In addition, this CMP includes a stability constraint that allows only for small increases of TAC in each management period (Irat < +5%) and moderate reductions (Irat> -20%).

D. The MPx (MP with optional mixing, Tom Carruthers) initial Candidate Management Procedure

The MPx CMP aims to maintain a constant fishing mortality rate at biomass approximately at B_{MSY} levels. To achieve this the MP uses calibrated regional indices to infer regional biomass from which TACs are adjusted depending on both stock status (regional biomass levels relative to a target level) and the implied fishing rate (current catch levels divided by the estimated regional biomass relative to a target fishing rate). The MPx CMP has a highly flexible harvest control rule that allows for either no adjustment relative to target fishing rate or no adjustment relative to target biomass (or varying levels of sensitivity to these). Optionally, the MPx CMP can also use Atlantic-wide indices to infer regional mixing by including mixing parameters in the set of control parameters.

Vulnerable biomass and fishing rate estimation

MPx provides TAC advice in a given time period t using Spawning Stock Biomass indices (I^{SSB}) averaged over two calendar years (indices are available up to the year before current, e.g. 2016), by stock s and Catch Rate Indices (I^{CR}) by area a, calibrated to current stock assessments of vulnerable biomass B (estimates of catchability q for SSB and CR indices). In order to, for example, interpret Eastern area SSB in terms of Western area biomass, an estimate of stock mixing is required $\theta^{mix}_{s=East\_stock,a=West}$ that is the fraction of East stock spawning biomass that can be expected to be vulnerable to fishing in the West.

(1) $$B^{SSB}_{a,t} = \frac{1}{2}\sum_{t=y-2}^{y-1}\sum_{s} I^{SSB}_{s,t}\, q^{SSB}_{s}\, \theta^{mix}_{s,a}$$

(2) $$B^{CR}_{a,t} = \frac{1}{2}\sum_{\mathrm{t=y-2}}^{\mathrm{y-1}} I^{CR}_{a,t}\, q^{CR}_{a}$$

The q parameters are calibrated to 2016 estimates spawning biomass (by stock) θ^{SSB}_{s}, and vulnerable biomass (by area) θ^{B}_{a}:

(3) $$q^{SSB}_{s} = \frac{\theta^{SSB}_{s,2016}}{I^{SSB}_{s,2016}}$$

(4) $$q^{CR}_{a} = \frac{\theta^{B}_{a,2016}}{I^{CR}_{a,2016}}$$

The estimates of vulnerable biomass B arising from the calibrated indices can be used to estimate the fishing mortality rate using observations of catches C

(5) $$F^{CR}_{a,t} = -\ln\left(1 - \frac{C_{a,t}}{B^{CR}_{a,t}}\right)$$

(6) $$F^{SSB}_{a,t} = -\ln\left(1 - \frac{C_{a,t}}{B^{SSB}_{a,t}}\right)$$

Combining inference from SSB and CPUE indices

Assessment estimates of vulnerable biomass at MSY (θ^{BMSY}) can be used to calculate current vulnerable biomass relative to B_{MSY}, here inference from catch rate and spawning indices is equally weighted as the geometric mean:

(7) $$\Delta^{B}_{a,t} = exp\left(\frac{1}{2}\left[ln\left(\frac{B^{SSB}_{a,t}}{\theta^{BMSY}_{a}}\right) + ln\left(\frac{B^{CR}_{a,t}}{\theta^{BMSY}_{a}}\right)\right]\right)$$

The same approach was used to combined estimates of F relative to F_{MSY}:

(8) $$\Delta^{F}_{a,t} = \exp\left(\frac{1}{2}\left[ln\left(\frac{F^{SSB}_{a,t}}{\theta^{FMSY}_{a}}\right) + ln\left(\frac{F^{CR}_{a,t}}{\theta^{FMSY}_{a}}\right)\right]\right)$$

CMP specifications

TACs in the following year are based on TAC in the previous time step multiplied by a factor $\varphi_{a,t}$:

(9) $$TAC_{a,t+1} = TAC_{a,t}\ \varphi_{a,t}$$

where the factor $\varphi_{a,t}$ is determined by adjustments for fishing rate $\delta^F_{a,t}$ and stock status $\delta^B_{a,t}$:

(10) $$\tilde{\varphi}_{a,t} = \delta^F_{a,t}\ \delta^B_{a,t}$$

The adjustment to F is the inverse of F/F_{MSY} ($\Delta^F_{a,t}$) where the magnitude of the adjustment is determined by β^F. The parameter α^F controls the target *F* level where F/F_{MSY} = 1 and B/B_{MSY} = 1. For example, at a value of 0.8, the MP deliberately aims to underfish at 80% of F_{MSY} when the stock is at *BMSY* and current *F* is F_{MSY}. Note that when α^F=1 and β^F = 1 the *F* adjustment $\delta^F_{a,t}$ is the inverse of $\Delta^F_{a,t}$ and hence recommends F_{MSY} fishing rate (and depends on the assumption that biomass will be comparable at t+1).

(11) $$\delta^F_{a,t} = \alpha^F\ exp\left(\ \beta^F\ ln\left(1/\Delta^F_{a,t}\right)\right)$$

The adjustment to biomass is exponentially related to the disparity between current biomass and B_{MSY}. The term $|\Delta^B_{a,t} - 1|$ is the positive absolute difference (modulus). The magnitude of the adjustment for biomass is controlled by the parameter α^B while the (extent of the TAC change for biomass levels far from BMSY) is controlled by the exponent β^B. This is analogous to a traditional harvest control rule (e.g. '40-10') and throttles fishing rates at low stock sizes to speed recovery while also increasing fishing rates at high stock sizes to exploit additional biomass. When α^B = 0 there is no biomass adjustment and $\delta^B_{a,t}$ is invariant to β^B.

(12) $$\delta^B_{a,t} = \begin{cases} exp\left[\left(\alpha^B|\Delta^B_{a,t} - 1|\right)^{\beta^B}\right] & 1 < \Delta^B_{a,t} \\ exp\left[-\left(\alpha^B|\Delta^B_{a,t} - 1|\right)^{\beta^B}\right] & \Delta^B_{a,t} \leq 1 \end{cases}$$

This generalized TAC harvest control rule can accommodate a wide range of control schemes of varying sensitivity to estimates of current exploitation rate and stock status. The default values of the control parameters for the biomass and fishing rate estimation and the harvest control rule are included in **Table Appendix 6** D.1.

TAC adjustment limits

The maximum rate of TAC adjustment is determined by θ^{down} and θ^{up} that control the maximum extent of downward and upward adjustment respectively:

(13) $$\varphi_{a,t} = \begin{cases} \theta^{down} & \tilde{\varphi}_{a,t} < \theta^{down} \\ \tilde{\varphi}_{a,t} & \theta^{down} < \tilde{\varphi}_{a,t} < \theta^{up} \\ \theta^{up} & \theta^{up} < \tilde{\varphi}_{a,t} \end{cases}$$

θ^{down} and θ^{up} are fixed at 20% and the MP updates the TAC every two years.

Table Appendix 6 D.1. Round 1 control parmeter values for biomass estimation, fishing rate estimation and the specification of the harvest control rule.

Description		Value
Biomass calculation		
$I^{SSB}_{East\_stock}$	Spawning stock biomass index for eastern stock	MED_LAR_SUV
$I^{SSB}_{West\_stock}$	Spawning stock biomass index for western stock	GOM_LAR_SUV
I^{CR}_{East}	Vulnerable biomass catch rate index for eastern area	JPN_LL_NEATL2
I^{CR}_{West}	Vulnerable biomass catch rate index for western area	US_RR_115_144
θ^{BMSY}_{East}	Eastern area biomass at maximum sustainable yield	220 kt
θ^{BMSY}_{West}	Western area biomass at maximum sustainable yield	37 kt
θ^{FMSY}_{East}	Eastern area fishing mortality rate at MSY	0.1
θ^{FMSY}_{West}	Western area fishing mortality rate at MSY	0.1
$\theta^{SSB}_{East\_stock,2017}$	Spawning stock biomass of the eastern Stock in 2017	320 kt
$\theta^{SSB}_{West\_stock,2017}$	Spawning stock biomass of the western Stock in 2017	27 kt
$\theta^{B}_{East,2017}$	Vulnerable biomass in the eastern area in 2017	200 kt
$\theta^{B}_{West,2017}$	Vulnerable biomass in the western area in 2017	50 kt
$\theta^{mix}_{West,East}$	Fraction of western stock in eastern area	0.3
$\theta^{mix}_{East,West}$	Fraction of eastern stock in western area	0.2
Harvest control rule		
α^{B}	The magnitude of the adjustment for biomass relative to B_{MSY}	1
β^{B}	Exponent parameter controlling extent of the adjustment for biomass relative to B_{MSY}	2
α^{F}	Target fishing mortality rate (fraction of F_{MSY}) at F/F_{MSY} = 1 and B/B_{MSY} =1	0.8
β^{F}	The magnitude of the adjustment for fishing rate relative to F_{MSY}	0.5

E. A simple index-based CMP (J. Walter)

The MP is exactly the generic index-based MP outlined in the Trial Specifications document. The mathematical details are as follows:

$$I_{curr} = \sum_{i-k}^{y} I_y \Big/ k$$

If $I_{curr} > t^*(1+\Delta)$ then $TAC_y = TAC_{y-1} * (1+\Delta)$

If $I_{curr} < t^*(1-\nabla)$ then $TAC_y = TAC_{y-1} * (1-\nabla)$

else $TAC_y = TAC_{y-1}$

where I_{curr} is the average of the index over the previous k years, t is the target value for the index which if the index is higher than $t^*(1+\Delta)$, then the TAC increases by a factor of 1+ Δ; if I_{curr} is less $t^*(1-\nabla)$ then the TAC in year y decreases by a factor of 1- ∇.

To apply this to an index it is necessary to define the index and the control parameters of the target value, the percentage increase and the percentage decrease and the number of years over which to average the index.

A USRR 115_144 index CMP for East and West areas

A candidate management procedure (CMP) based on the USRR 115_144 index for both East and West areas. It alters the current TAC according to the ratio of the index averaged over *k* years relative to the chosen target value of the index. The concept of using this index for both East and West areas comes from the observation that this index is for ages 4 and 5 year old fish, which are of mixed Eastern and Western origin in the fishery that this index comes from. Hence this index is the first index to see recruits from both stocks and may be useful for tracking recruitment. The CMP exactly follows the example MP in the trial specification document. As such it is it not expressly particularly designed for good performance and further MP development may change control parameter settings or the actual design of any CMP that uses the **USRR 115_144** index.

To create an MP based on the USRR 115_144 index (index 6) as the single index for both East and Western areas we specified the Δ as 0.05 and ∇ as 0.2. Two years were chosen to average the index (k=2) and several different values for the target were explored from 0.25-0.8.