Report of the 12th Session of the IOTC Working Party on Methods (Management Strategy Evaluation Task Force)

Online, 1 - 4 March 2021

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ACRONYMS

ABNJ	Areas Beyond National Jurisdiction
ALB	Albacore
B	Biomass (total)
B_0	Unfished biomass
BET	Bigeye tuna
B_{MSY}	Biomass which produces MSY
CMM	Conservation and Management Measure (of the IOTC; Resolutions and Recommendations)
CPCs	Contracting parties and cooperating non-contracting parties
CPUE	Catch per unit of effort
current	Current period/time, i.e. $F_{current}$ means fishing mortality for the current assessment year.
F	Fishing mortality
FAD	Fish aggregating device
F_{MSY}	Fishing mortality at MSY
IOTC	Indian Ocean Tuna Commission
MP	Management Procedure
MPD	Management Procedures Dialogue
MSE	Management Strategy Evaluation
MSY	Maximum Sustainable Yield
OM	Operating Model
P	Probability
SC	Scientific Committee, of the IOTC
SB	Spawning biomass (sometimes expressed as SSB)
SB_{MSY}	Spawning stock biomass which produces MSY (sometimes expressed as SSB_{MSY})
TCMP	Technical Committee on Management Procedures
WPM	Working Party on Methods
WPNT	Working Party on Neritic Tunas
WPTT	Working Party on Tropical Tunas of the IOTC
YFT	Yellowfin tuna

GLOSSARY OF TERMS

The WPM decided to utilise the MSE Glossary developed by the Joint Tuna RFMO MSE Working Group in 2018**.**

Average Annual Variation - (in catch/TAC) The absolute value of the proportional TAC change each year, averaged over the projection period.

Biomass - Stock biomass, which may refer to various components of the stock. Often spawning stock biomass (SSB) of females is used, as the greatest conservation concern is to maintain the reproductive component of the resource.

Candidate Management Procedure - An MP (defined below) that has been proposed, but not yet adopted.

Conditioning - The process of fitting an Operating Model (OM) of the resource dynamics to the available data on the basis of some statistical criterion, such as a Maximum Likelihood. The aim of conditioning is to select those OMs consistent with the data and reject OMs that do not fit these data satisfactorily and, as such, are considered implausible.

Error - Differences, primarily reflecting uncertainties in the relationship between the actual dynamics of the resource (described by the OMs) and observations. Four types of error may be distinguished, and simulation trials may take account of one or more of these:

- Estimation error: differences between the actual values of the parameters of the OM and those provided by the estimator when fitting a model to the available data;
- Implementation error: differences between intended management actions (as output by an MP) and those actually achieved (e.g. reflecting over-catch);
- Observation error (or measurement error): differences between the measured value of some resource index and the corresponding value calculated by the OM;
- Process error: natural variations in resource dynamics (e.g., fluctuations about a stock-recruitment curve or variation in fishery or survey selectivity /catchability).

Estimator - The statistical estimation process within a population model (assessment or OM); in a Management Strategy Evaluation (MSE) context, the component that provides information on resource status and

productivity from past and generated future resource-monitoring data for input to the Harvest Control Rule (HCR) component of an MP in projections.

Exceptional circumstances - Specifications of circumstances (primarily related to future monitoring data falling outside the range covered by simulation testing) where overriding of the output from a Management Procedure should be considered, together with broad principles to govern the action to take in such an event.

Feedback Control - Rules or algorithms based, directly or indirectly, on trends in observations of resource indices, which adjust the management actions (such as a TAC change) in directions that will change resource abundance towards a level consistent with decision makers' objectives.

Harvest Control Rule - (also Decision Rule) A pre-agreed and well-defined rule or action(s) that describes how management should adjust management measures in response to the state of specified indicator(s) of stock status. This is described by a mathematical formula.

Harvest Strategy - Some combination of monitoring, assessment, harvest control rule and management action designed to meet the stated objectives of a fishery. Sometimes referred to as a Management Strategy (see below). A fully specified harvest strategy that has been simulation tested for performance and adequate robustness to uncertainties is often referred to as a Management Procedure.

Implementation - The practical application of a Harvest Strategy to provide a resource management recommendation.

Kobe Plot - A plot that shows the current stock status, or a trajectory over time for a fished population, with abundance on the horizontal axis and fishing mortality on the vertical axis. These are often shown relative to BMSY and to FMSY, respectively. A Kobe plot is often divided into four quadrants by a vertical line at B=BMSY and a horizontal line at F=FMSY.

Limit Reference Point - A level of biomass below, or fishing mortality above, which an actual value would be considered undesirable, and which management action should seek to avoid.

Management Objectives - The social, economic, biological, ecosystem, and political (or other) goals for a given management unit (i.e. stock). These typically conflict, and include concepts such as maximising catches over time, minimising the chance of unintended stock depletion, and enhancing industry stability through low inter-annual variability in catches. For the purposes of Management Strategy Evaluation (MSE) these objective need to be quantified in the form of Performance statistics (see below).

Management Plan - In a broad fisheries governance context, a Management Plan is the combination of policies, regulations and management approaches adopted by the management authority to reach established societal objectives. The management plan generally includes the combination of policy principles and forms of management measures, monitoring and compliance that will be used to regulate the fishery, such as the nature of access rights, allocation of resources to stakeholders, controls on inputs (e.g. fishing capacity, gear regulations), outputs (e.g. quotas, minimum size at landing), and fishing operations restrictions (e.g. closed areas and seasons). Ideally, the Management Plan will also include the Harvest Strategy for the fishery or a set of principles and guidelines for the specification, implementation and review of a formal Management Procedure for target and non-target species.

Management Procedure - A management procedure has the same components as a harvest strategy. The distinction is that each component of a Management Procedure is formally specified, and the combination of monitoring data, analysis method, harvest control rule and management measure has been simulation tested to demonstrate adequately robust performance in the face of plausible uncertainties about stock and fishery dynamics.

Management Strategy - Synonymous with harvest strategy. (But note that this is also used with a broader meaning in a range of other contexts.)

Management Strategy Evaluation - A process whereby the performances of alternative harvest strategies are tested and compared using stochastic simulations of stock and fishery dynamics against a set of performance statistics developed to quantify the attainment of management objectives.

Maximum Economic Yield - The (typically annual) yield that can be taken continuously from a stock sustainably (i.e. without reducing its size) that maximizes the economic yield of a fishery in equilibrium. This yield occurs at the effort level that creates the largest positive difference between total revenues and total costs of fishing (including the cost of labor, capital, management and research etc.), thus maximizing profits.

Maximum Sustainable Yield - The largest (typically annual) yield that can be taken continuously from a stock sustainably (i.e. without reducing its size). In real, and consequently stochastic situations, this is usually estimated as the largest average long-term yield that can be obtained by applying a constant fishing mortality F, where that F is denoted as FMSY.

Observation Model - The component of the OM that generates fishery-dependent and/or fishery-independent resource monitoring data from the underling true status of the resource provided by the OM, for input to an MP.

Operating Model(s) - A mathematical–statistical model (usually models) used to describe the fishery dynamics in simulation trials, including the specifications for generating simulated resource monitoring data when projecting forward in time. Multiple models will usually be considered to reflect the uncertainties about the dynamics of the resource and fishery.

Performance statistics/measures - A set of statistics used to evaluate the performance of Candidate MPs (CMPs) against specified management objectives, and the robustness of these MPs to important uncertainties in resource and fishery dynamics.

Plausibility (weights) - The likelihood of a scenario considered in simulation trials representing reality, relative to other scenarios also under consideration. Plausibility may be estimated formally based on some statistical approach, or specified based on expert judgement, and can be used to weight performance statistics when integrating over results for different scenarios (OMs).

Precautionary Approach - An approach to resource management in which, where there are threats of serious irreversible environmental damage, lack of full scientific certainty is not used as a reason for postponing cost-effective measures to prevent environmental degradation.

Reference case - (also termed reference scenario or base case) A single, typically central, conditioned OM for evaluating Candidate MPs (CMPs) that provides a pragmatic basis for comparison of performance statistics of the CMPs.

Reference set - (also termed base-case or evaluation scenarios) A limited set of scenarios, with their associated conditioned OMs, which include the most important uncertainties in the model structure, parameters, and data (i.e. alternative scenarios which have both high plausibility and major impacts on performance statistics of Candidate MPs).

Research-conditional option - Temporary application of an MP that does not satisfy conservation performance criteria, accompanied by both a research programme to check the plausibility of the scenarios that gave rise to this poor performance and an agreed subsequent reduction in catches should the research prove unable to demonstrate implausibility.

Robustness tests - Tests to examine the performance of an MP across a full range (i.e. beyond the range of the Reference Set of models alone) of plausible scenarios. While plausible, robustness test OMs are typically considered to be less likely than the reference set OMs, and often focus on particularly challenging circumstances with potentially negative consequences to be avoided.

Scenario- A hypothesis concerning resource status and dynamics or fishery operations, represented mathematically as an OM.

Simulation trial/test - A computer simulation to project stock and fishery dynamics for a particular scenario forward for a specified period, under controls specified by a HS or MP, to ascertain the performance of that HS or MP. Such projections will typically be repeated a large number of times to capture stochasticity.

Spawning Biomass, initial - Initial spawning biomass prior to fishing as estimated from a stock assessment.

Spawning Biomass, current - Spawning biomass (SSB) in the last year(s) of the stock assessment.

Spawning Biomass at MSY - The equilibrium spawning biomass that results from fishing at FMSY. In the presence of recruitment variability, fishing a stock at FMSY will result in a biomass that fluctuates above and below SSBMSY.

Stationarity - The assumption that population parameter values are fixed (at least in expectation), and not varying systematically, over time. This is a standard assumption for many aspects of stock assessments, OMs and management plans.

Stock assessment - The process of estimating stock abundance and the impact of fishing on the stock, similar in many respects to the process of conditioning OMs.

Target Reference Point - The point which corresponds to a state of a fishery and/or resource which is considered desirable and which management aims to achieve.

Trade-offs - A balance, or compromise, achieved between desirable but conflicting objectives when evaluating alternative MPs. Trade-offs arise because of the multiple objectives in fisheries management and the fact that some objectives conflict (e.g. maximizing catch vs minimizing risk of unintended depletion).

Tuning - The process of adjusting values of control parameters of the Harvest Control Rule in a Management Procedure to achieve a single, precisely-defined performance statistic in a specified simulation test. This reduces confounding effects to allow the performance of different candidate MPs to be compared more readily with respect to other management objectives. For example, in the case of evaluating rebuilding plans, all candidate MPs might be tuned to meet the rebuilding objective for a specified simulation trial; then the focus of comparisons among MPs is performance and behaviour with respect to catch and CPUE dimensions.

Weight(s) - Either qualitative (e.g. high, medium, low) or quantitative measures of relative plausibility accorded across a set of scenarios.

Worm plot - Time series plots showing a number of possible realizations of simulated projections of, for example, catch or spawning biomass under the application of an MP for a specific OM or weighted set of OMs.

STANDARDISATION OF IOTC WORKING PARTY AND SCIENTIFIC COMMITTEE REPORT TERMINOLOGY

SC16.07 (para. 23) The SC **ADOPTED** the reporting terminology contained in Appendix IV and **RECOMMENDED** that the Commission considers adopting the standardised IOTC Report terminology, to further improve the clarity of information sharing from, and among its subsidiary bodies.

HOW TO INTERPRET TERMINOLOGY CONTAINED IN THIS REPORT

Level 1: ***From a subsidiary body of the Commission to the next level in the structure of the Commission:***
RECOMMENDED, RECOMMENDATION: Any conclusion or request for an action to be undertaken, from a subsidiary body of the Commission (Committee or Working Party), which is to be formally provided to the next level in the structure of the Commission for its consideration/endorsement (e.g. from a Working Party to the Scientific Committee; from a Committee to the Commission). The intention is that the higher body will consider the recommended action for endorsement under its own mandate, if the subsidiary body does not already have the required mandate. Ideally this should be task specific and contain a timeframe for completion.

Level 2: ***From a subsidiary body of the Commission to a CPC, the IOTC Secretariat, or other body (not the Commission) to carry out a specified task:***
REQUESTED: This term should only be used by a subsidiary body of the Commission if it does not wish to have the request formally adopted/endorsed by the next level in the structure of the Commission. For example, if a Committee wishes to seek additional input from a CPC on a particular topic, but does not wish to formalise the request beyond the mandate of the Committee, it may request that a set action be undertaken. Ideally this should be task specific and contain a timeframe for the completion.

Level 3: ***General terms to be used for consistency:***
AGREED: Any point of discussion from a meeting which the IOTC body considers to be an agreed course of action covered by its mandate, which has not already been dealt with under Level 1 or level 2 above; a general point of agreement among delegations/participants of a meeting which does not need to be considered/adopted by the next level in the Commission's structure.
NOTED/NOTING: Any point of discussion from a meeting which the IOTC body considers to be important enough to record in a meeting report for future reference.

Any other term: Any other term may be used in addition to the Level 3 terms to highlight to the reader of and IOTC report, the importance of the relevant paragraph. However, other terms used are considered for explanatory/informational purposes only and shall have no higher rating within the reporting terminology hierarchy than Level 3, described above (e.g. **CONSIDERED**; **URGED**; **ACKNOWLEDGED**).

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EXECUTIVE SUMMARY

The 11th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Methods Management Strategy Evaluation Task Force (WPM(MSE)) was held online on Microsoft Teams from 1-4 March 2021. A total of 41 participants attended the Session. The list of participants is provided in Appendix I. The meeting was opened by the Chairperson, Dr Hilario Murua (ISSF) who welcomed participants.

The following are the recommendations from the WPM12(MSE) to the Scientific Committee, which are provided in Appendix V.

Other Issues

WPM12(MSE).01: Finally, the WPM(MSE) **NOTED** that many scientists from developing countries are not familiar with MSE concepts and it would be necessary to plan some sort of capacity building with developing countries to give opportunity to all scientists to know about these concepts. The WPM(MSE) **RECOMMENDED** that this capacity is made both at TCMP but also intersesionally facilitated by the IOTC Secretariat should funding be available (para. 89).

1. OPENING OF THE MEETING

1. The 11th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Methods Management Strategy Evaluation Task Force (WPM(MSE)) was held online using Zoom from 1-4 March 2021. A total of 41 participants attended the Session. The list of participants is provided in Appendix I. The meeting was opened by the Chairperson, Dr Hilario Murua (ISSF) who welcomed participants.

2. REVIEW OF MP PROCESS IN IOTC

2. The WPM(MSE) **ADOPTED** the Agenda provided at Appendix II. The documents presented to the WPM(MSE) are listed in Appendix III.

2.1 Review outcomes of TCMP03 and COM (S23/S24) in 2019/2020

3. The WPM **NOTED** a presentation by the Chair regarding the updates from the 2020 Session of the Commission (S24) as well as a recap of the deliberations during the 2019 TCMP03 and S23 meetings. The presentation summarised the information related to MSE found in documents IOTC-2019-TCMP03-R, IOTC-2029-S23-R and IOTC-2020-S24-R.

4. The WPM(MSE) **NOTED** that no TCMP or WPM MSE meeting were held in 2020 due to the Covid-19 crisis. In addition, the WPM(MSE) **NOTED** that no new CMMs were agreed by the Commission in 2020 and therefore no new guidance for the WPM(MSE) regarding MSE is available since 2019.

5. The WPM(MSE) **NOTED** that the revised schedule for MSE progress in IOTC had been endorsed by the SC in 2019 and is included as appendix 6 of the meeting report (IOTC-2019-SC22-R)

6. The WPM(MSE) were **INFORMED** that the deadline for the submission of documents for the TCMP meeting had been extended to 30 days before the meeting commences. This deadline has been extended to give all participants sufficient time to review the highly technical information prior to the start of the TCMP meeting.

2.2 Review outcomes of WPM, WPTT and SC in 2019/2020

7. The WPM(MSE) **NOTED** a brief summary provided by the Secretariat on the discussions held at the 2019 and 2020 sessions of the WPM, WPTT and SC all of which had taken place since the last WPM MSE Task Force meeting. The Secretariat summarised the information related to MSE contained in the documents IOTC-2019-WPM10-R, IOTC-2020-WPM11-R, IOTC-2019-WPTT21-R, IOTC-2020-WPTT22(AS)-R, IOTC-2019-SC22-R and IOTC-2020-SC23-R.

8. The WPM(MSE) **NOTED** that progress had been made since the last WPM MSE Task Force meeting, but that it had been affected by the cancellation of the 2020 Task Force and TCMP meetings as well as delays in finalising contracts to carry out the work for several species. The WPM(MSE) further **NOTED** that most of these issues have now been resolved and progress is expected to be made through 2021. Discussions held at the 2020 WPM and WPTT were particularly useful and had resulted in agreement on the Model Grids to be used for Albacore, Bigeye and Yellowfin tunas.

3. STATUS OF WORK ON ALBACORE OMS AND MPS

3.1 Review progress and difficulties

9. The WPM(MSE) **NOTED** the presentation on the ongoing work for the development of MSE for Indian Ocean albacore, carried out by Dr. Iago Mosqueira (WMR-EU). Work has continued on the reconditioning of the operating model based on the 2019 albacore stock assessment. Based on learnings from the previous grid, that consisted of 1,440 model runs, a new reduced grid is proposed for this iteration.

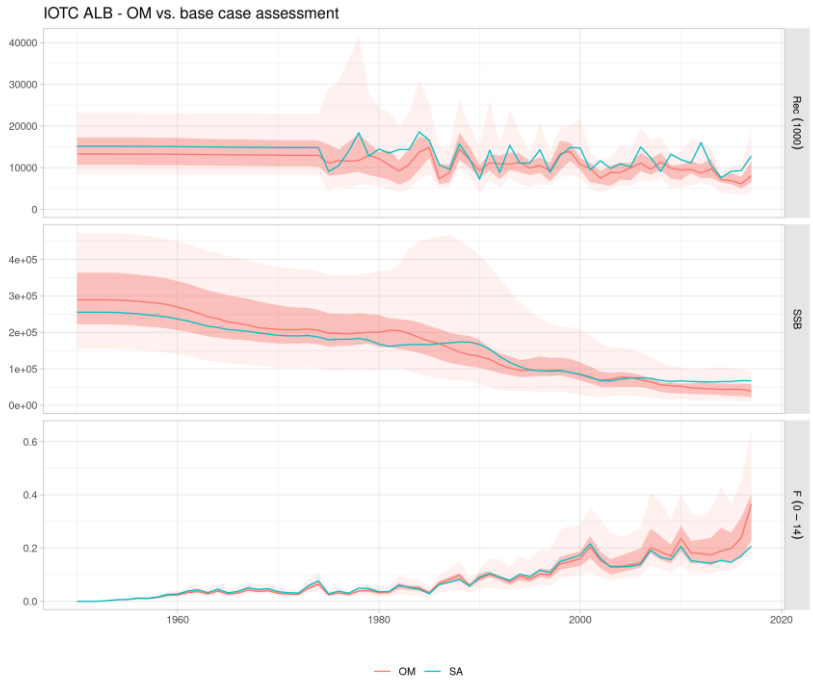
10. The WPM(MSE) **NOTED** the proposed updated grid of model runs (Table 1).

to

Table 1: Proposed Grid of alternative model setups for the constructions of the new albacore operating model.

Factor	Values
M, natural mortality	0.20, 0.25, 0.30 or 0.35, for all ages
H, SRR steepness	0.7, 0.8, 0.9
Sigma R, std dev in recruitment residuals	0.4, 0.6, 0.8
Longline CPUE series (cpue)	Northwest or Southwest
Length frequency data likelihood weighting (lfreq)	0.01, 0.1 or 1
Catchability increase	0%, 1% / year

11. The WPM(MSE) **NOTED** the results of running the OM grid corners instead of the full set of OM scenarios, that resulted on 64 model runs. Based on exclusion of runs with very high biomass, high convergence level and a MASE score for the Season 1 Area 1 CPUE higher than 1, 53 model runs were finally accepted.



12. The WPM(MSE) **NOTED** the proposal of selecting runs if the relevant CPUE MASE is less than 1, and then using the p-value of the Diebold-Mariano test to weight model runs when resampling. The DM test compares a naïve prediction (equal to the previous year observation) with the model 1-step-ahead predictions of CPUE, to determine if the model prediction skill is better than a naïve prediction.

13. The WPM(MSE) **NOTED** the initial projections at F=FMSY. The WMP(MSE) **NOTED** that estimated recruitments over the last few years of the series are lower than half of the long-term average value and discussed how recruitment should be modelled during the projection period. One suggestion is that the projected recruitment should be informed by the recent trends.

14. The WPM(MSE) **NOTED** that the South West region CPUE series creates a bump in SSB in the 1980s compared to the North West region CPUE series that shows a declining trend over the entire period. This could be further investigated with the collaboration of the WPTmT.

15. The WPM(MSE) **NOTED** the analysis of the hindcast MPs on the 2016 grid using three production function shapes and the F_{MSY} multipliers. The Pella function seems to better compare to the OM productivity shape, however the Schaeffer function performs better on the MP, especially if target is set at 70% of the estimated F_{MSY}. A similar effect should be obtained by the tuning of the HCR. This result indicates that MP performance should not be seriously affected by the assumption of production curve in the biomass dynamics model

16. The WPM(MSE) **NOTED** that the OM in the FLR platform, is simplified to a yearly, single sex and area, dynamic. FLR could now support a 2 sex, seasonal and multiple fleets model, but all checks and tests so far have been coherent between the two dynamics. Also, management is planned to be carried out on a yearly cycle, and the differences in growthw between sexes are not large enough to affect the results.

17. The WPM(MSE) **NOTED** the proposed robustness tests:
    - Continuing recruitment decline at recent levels
    - CPUE overcompensation bias
    - 10% reported overcatch
    - 10% unreported overcatch

18. The WPM(MSE) **WELCOMED** the presentation and the progress in the development of the third iteration of the OM for albacore.

19. The WPM(MSE) **NOTED** that the OM stock status is more pessimistic than the stock assessment (SA). Although this is not a problem in itself and should not affect the performance of the MP, it might impact the management objectives, as the starting point will be different, and makes the results more difficult to be communicated.

20. The WPM(MSE) **NOTED** that CPUEs used in the stock assessment are per season and per area, but only one yearly index is used in the operating models (and management procedure). Although it would be possible to have the OM conditioned with both CPUEs there might be an added dimension of uncertainty by keeping the two series separate.

21. The WPM(MSE) **NOTED** that there has been relatively little feedback from the WPTmT into the MSE development. The WPTmT group meets only every 3 years and usually the stock assessment modeller has been an external contract, which makes the interaction between the MSE and SA developers difficult. The WPM(MSE) **SUGGESTED** the MSE developer to explore with the SC chair avenues for increasing this communication in the near future, for example, through online meetings.

22. The WPM(MSE) **NOTED** that the CPUE prediction skill is being investigated as a possibility for model weighting. Although, prediction skill of length can also be estimated, the focus has been on the CPUE as this will be used in the MPs. The WPM(MSE) **NOTED** that there should be consistent approaches to weighting amongst different MSEs and AGREED to further discuss this under the general discussion of OMs and MPs.

23. The WPM(MSE) **NOTED** that although the analysis of the grid corners scenarios seem to cover the same range of as the full grid analysis, there could be a reduction of the density of the central tendencies while highlighting the extremes of the OM grid. This could make MP testing more robust to the extreme tendencies but could also impact the probabilities of the performance statistics to achieve the management objectives. An alternative configuration was thus proposed by the developer, the Central Composite Design pattern, a factorial grid that combines the extreme values (i.e. the corners of the grid) with the values that includes the center values of each factor.

24. The WPM(MSE) **REQUESTED** the developer to present a comparison of the corners and the full grid, using the 2016 grid. Upon this request the developer presented a comparison of key quantities. Of these the recruitment deviations were the most impacted when using only the grid corners.

25. The WPM(MSE) **SUGGESTED** that for consistency the partial factorial design applied to YFT and BET should also be investigated for ALB and SWO, but **ENCOURAGED** the developers to further investigate other options (e.g. grid corners, central composite design pattern).

3.2 Future Work

26. The WPM(MSE) **REQUESTED** the developer to present the status of work to the upcoming 4th session of the TCMP. The WPM(MSE) **NOTED** that the contract for work on albacore is active until the end of 2021. The developer will update the model and analysis after the feedback from TCMP, and from the planned session with WPTmT, and submit the final analysis and platform to the WPM 2021.

4. STATUS OF WORK ON BIGEYE OMS AND MPS

4.1 Review progress and difficulties

27. The WPM(MSE) **NOTED** paper IOTC-2021-WPM12(MSE)-04, which provides a progress update on key technical elements of the bigeye tuna MSE, with the following summary provided by the authors:

    This working paper briefly describes developments on the Indian Ocean Tuna Commission (IOTC) bigeye (BET) Management Procedure (MP) evaluation project, since the 2020 Working Party on Tropical Tunas (WPTT) and Working Party on Methods (WPM). Some concerns about the BET OMs were identified and discussed in 2020, but the issues were of a generic nature affecting multiple IOTC species, with potential solutions being explored by multiple parties (e.g. the yellowfin stock assessment and OM are affected to a greater and more urgent extent). No changes were proposed for the bigeye reference set OM grid presented in 2020, while one additional robustness test was added (5% reported overcatch, on top of 5% unreported overcatch during the projection period). MP evaluation results were presented for a suite of candidate MPs and two tuning objectives. Outcomes were slightly more pessimistic, but generally very similar to the results presented to the 2019 TCMP.

28. The WPM(MSE) NOTED that the OMs were updated from the 2019 stock assessment, which is a spatially structured model fitting to CPUE, size composition, and tag observations. The WPM(MSE) further **NOTED** that the OM included the following uncertainty axis:

    - Stock-recruit steepness (3 levels)
    - Natural mortality multiplier (3 levels)
    - Tag recapture data weighting (3 levels)
    - Assumed longline CPUE catchability trend (2 levels)
    - longline CPUE Regional-scaling factors (2 levels)
    - Longline fishery selectivity (2 levels)
    - Size composition input Effective Sample Sizes (2 levels)

29. The WPM(MSE) **NOTED** that running a full combination of the above uncertainty axis would produce more than 400 models. As such, a fractional factorial design was used to reduce the total number of models to 72 which captured most of the structural uncertainty of the full grid. It was further noted that uncertainty from higher order interactions generally do not have an appreciable impact on the MP evaluations.

30. The WPM(MSE) **NOTED** that a number of models in the OM have trigged a significant level of catch penalties, which was mostly caused by PS fisheries frequently exceeding the maximum exploitation rate of 0.99+. The WPM(MSE) **NOTED** that the reason for this is not clear, but may have been attributed to the seasonality of the dynamics.

31. The WPM(MSE) **NOTED** that nine MPs were tested against the reference set OM, including constant catch projections, data-based MPs, and model-based MPs. The WPM(MSE) also **NOTED** that the results were presented for the two TCMP tuning objectives (See Figure 1 for results against tuning objective B2):
    - **B2:** Pr(Kobe green zone 2030:2034) = 0.6.
    - **B3:** Pr(Kobe green zone 2030:2034) = 0.7.

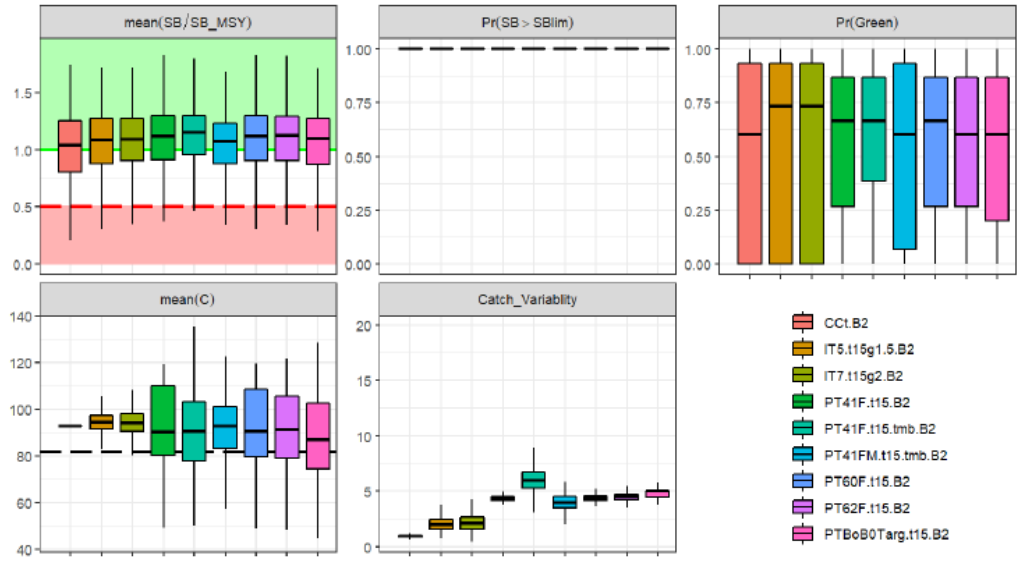


Figure 1: Boxplots comparing (B2 tuned) candidate MPs with respect to key performance measures averaged over the period 2021 -2035. Horizontal line is the median, boxes represent 25th - 75th percentiles, thin lines represent 10th - 90th percentiles. Red and green horizontal lines represent the interim limit and target reference points for the mean SB/SB_{MSY} performance measure. The horizontal dashed black line is 2020 catch.

32. The WPM(MSE) **NOTED** that the model-based MP implements a Pella-Tomlinson (PT) Random Effects surplus production model that incorporated both process and observation errors. The observations errors were applied to CPUE indices, and the process errors correspond the stochastic deviations from the production function. The tuning of MPs towards the predefined management objectives can correct to some extent the bias inherent in the model. The WPM(MSE) also **NOTED** that the Pella-Tomlinson model employed priors on key production parameters that become increasingly restrictive to improve the convergency performance, and that the priors and penalties are an integral part of the MP that must be specified in advance and MSE tested.

33. The WPM(MSE) **NOTED** that the random effects PT model implemented in Template Model Builder is fast and efficient. The uncertainty may not have been estimated as well as a full Bayesian estimator but this is not expected to have much impact on the MP evaluations. It was suggested that it might be useful to examine how well the PT model estimates the stock status by comparing it to the OM.

34. The WPM(MSE) **NOTED** that the CPUE-based MPs are generally not as robust as model-based MPs as they appear not to be very responsive to the data. Further investigation during the meeting revealed that this might be improved by increasing the MP responsiveness control parameters, as the CPUE-based MPs rarely invoked the TAC change constraints.

35. The WPM(MSE) **QUERIED** whether it might be useful to examine factors (e.g. regional scaling) that influence the regional recruitment distribution trends which can affect the projections. The WPM **REQUESTED** the developer to investigate this option when possible. Investigations undertaken during the meeting indicated that the MP evaluation results were not sensitive to the specific regional scaling factors represented in the current OM grid (though the effect on recruitment distribution was not examined).

36. The WPM(MSE) **NOTED** that for bigeye the OM has been tested against a robust set in which of all ages are assumed to be uniformly redistributed among regions and quarters, but the assumption does not appear to influence the performance of the MP tested.

37. The WPM(MSE) **NOTED** that trends in catchability can cause divergence in MP performance. However, a catchability change of 3% per year over a 20 year period seems unlikely to be a realistic assumption. The WPM(MSE) **NOTED** that it may be necessary to further examine and quantify the trend of catchability changes, perhaps in the CPUE standardisation process.

38. The WPM(MSE) **NOTED** that a new MP was tested, that combines a Pella-Tomlinson Random Effects model with constant catch internal projections to attain a target depletion level. The WPM(MSE) **NOTED** that MP resembles the manner how the Commission appears to interpret the Kobe 2 Strategy Matrix but suggested that clear communication is needed to present the MP to avoid possible confusion.

39. The WPM(MSE) **SUGGESTED** that it is important not to over-interpret the performance of the MP beyond the tuning period.

40. The WPM(MSE) **SUGGESTED** that statistics of how often the cap of 15% TAC changes are reached be presented as this might be a question stakeholders and managers want to know. Investigations undertaken during the meeting indicated that the model-based MPs hit the TAC change constraint more often than not.

4.2 Future Work

41. The WPM(MSE) **DISCUSSED** issues related to operationalization of the MP. One important question is to decide how often the OM should be updated, noting that the current practice appears to be that the OM is revisited when the assessment is updated. The WPM(MSE) **AGREED** that it is not feasible to change the OM indefinitely and it is essential to establish when an OM can be considered adequate to encompass all major source of the uncertainty for the concerned stock ("the Butterworth Guillotine"). The WPM(MSE) **AGREED** that the Scientific Committee should bear the responsibility to establish the conditions and criteria for the OM updates and to communicate this with the candidate MPs to the TCMP/Commission so that an agreement to be achieved with fishery managers. It would then be up to the CPCs to operationalize the MP through a suitable CMM.

42. The WPM(MSE) **NOTED** that for bigeye tuna the average spawning biomass at the end of the 20 year projection period tends to be below SB_{MSY} (the stock assessment estimated that the current SB is above SB_{MSY}), and that the pessimism of the OM relative to the stock assessment is mainly due to there being 1% catchability increase in 50% of the runs. The WPM(MSE) discussed to what extent the OM should be consistent with the stock assessment. The WPM(MSE) **NOTED** that OM usually expanded the uncertainty axis of the assessment model in a symmetric manner therefore, while it might be expected that the median of the OM is in line with the stock assessment, in practice this is often not the case and the assessment estimates tend to be misaligned with the OM predictions. WPM(MSE) **RECALLED** that the yellowfin tuna OM had investigated a procedure using bivariate sampling to filter the OM to match key reference quantities with the assessment model. The WPM(MSE) **AGREED** that differences between OM and stock assessment results for the terminal year are unavoidable, and it is important to communicate it clearly to the fishery managers to avoid confusion.

43. The WPM(MSE) **NOTED** the R package (*ss3diags*) for the proposed new diagnostics to rank and select stock assessment runs based on a set of criteria such as retrospective and hindcasting metrics is currently not available for the yellowfin and bigeye model structure and require considerable adaptation which is not expected to be done within a short term.

5. STATUS OF WORK ON SKIPJACK OMS AND MPS

5.1 Review progress and difficulties

44. The WPM(MSE) **NOTED** the considerable progress made on the development of an OM and MP for skipjack tuna and thanked the developer for his efforts.

45. The WPM(MSE) **NOTED** that the OM was developed in SS3 and currently assumes a single stock with no spatial structure.

46. The WPM(MSE) **NOTED** that empirical-based MPs may be a better option for skipjack than stock assessment-based MPs that require some inferences to be made about stock status. Recruitment variability is high for skipjack tuna and the time lag in receiving catch and effort data may make it impractical to estimate stock status from a production model. The WPM(MSE) **SUGGESTED** that the developer communicate with the southern bluefin tuna scientists at CCSBT to explore options for empirical-based MPs.

47. The WPM(MSE) **NOTED** that the CPUE series for the 2020 stock assessment were very different to those used for the 2017 stock assessment, but both SS3 assessments estimated similar depletion levels. This is likely a result of including both the PS and PL CPUE in the assessments, and conflicting trends in these series, leading to a compromise in the depletion estimates. Furthermore, the assessments also include tagging data which has the effect of anchoring the recent biomass estimates.

48. The WPM(MSE) **NOTED** that the depletion estimates from a Biomass Dynamic Model (BDM) fitted to the 2020 CPUE series are much lower (i.e. higher relative biomass) than the 2020 stock assessment depletion levels. This is in contrast to the outputs of the BDM when applied to the 2017 CPUE data, which estimated a depletion similar to the 2017 SS3 assessment. The WPM(MSE) **AGREED** that the additional data in the stock assessment models

(i.e. tagging and length frequency data) were likely providing additional information on depletion that was not available to the BDM.

49. The WPM(MSE) **NOTED** that the differences observed between SS3 and the BDM are likely to come from the length frequency data in SS3, which are known to have some biases. The **WPM(MSE) SUGGESTED** that the developer evaluate this issue by giving lower weight to the length frequency data in some SS3 model runs.

50. The WPM(MSE) **NOTED** that catch levels for all the projections remained at or below the target catch level (Ctarg; the catch level estimated to maintain the biomass on average at B40) and that biomass initially increased above the target level (B40). The developer clarified that these preliminary results were deterministic projections, and that it was not possible for the catches to exceed Ctarg (the maximum catch that could be output by the HCR) because implementation error had not been included. When stochastic variability in implementation of the recommended catch is added, the results will be more variable.

51. The WPM(MSE) **NOTED** that Ctarg is a tuning parameter for the HCR that is currently derived from the SS3 model outputs, and discussed at length whether Ctarg should be derived from other sources such as the MP or OM. The WPM(MSE) **NOTED** that the current approach is analogous to the implementation of an empirical MP (e.g. CPUE-based MPs) whereby a sensible target level is selected initially, which can be adjusted to achieve the overall tuning objective of the MP. The WPM(MSE) also **SUGGESTED** that alternative approaches, such as the projection-based MPs being evaluated for yellowfin and bigeye tuna, could be explored in future for skipjack tuna.

52. The WPM(MSE) **NOTED** that the value for Ctarg varies for each individual model run and that using the median values produces estimates of Ctarg that are too high for approximately half of the model runs. That is, strong fluctuations in projected catches are observed for those model runs that assume a lower productivity of the stock, due to the HCR reducing catches when the biomass is depleted below the target. The WPM(MSE) **NOTED** that a possible solution to this problem is to use a lower quantile of the Ctarg estimates from the SS3 model, which would be a more conservative approach and should reduce significant fluctuations in catches.

53. The WPM(MSE) **NOTED** that sensitivity runs for the BDM showed that estimates of depletion were far more robust than estimates of absolute biomass to the input assumptions (prior on the intrinsic growth rate and assumed depletion at MSY), and **AGREED** that depletion estimates are a better input for the HCR than estimates of absolute biomass.

54. The WPM(MSE) **NOTED** that the output from the existing HCR is expressed as an exploitation rate (i.e. fishing intensity), but that an exploitation rate cannot be reliably converted into a catch since the exploitable biomass from the BDM is poorly estimated, being dependent on the assumed intrinsic growth rate and shape of the production function. As a result, the catches (i.e. TACs) output from the current HCR, when implemented within an MP, would be unreliable.

55. The WPM(MSE) **NOTED** that the Kobe colours used in the HCR figure may be misleading as they link to specific definitions of overfished and overfishing, which are not necessarily linked to the depletion based reference points and catch outputs of the HCR. Furthermore, it was noted that the reference point indicated in the HCR at 10% depletion should be labelled as the safety limit, rather than the limit reference point (which is at 20% depletion). The WPM(MSE) **REQUESTED** that the developer revise these figures to facilitate clearer communication of this work to the TCMP and Commission, and ensure that the distinction between the definitions of control parameters of the HCR and the Commission's reference points are made clear.

56. The WPM(MSE) **NOTED** that the BDM does not distinguish between exploitable biomass and spawning biomass, so the outputs from the BDM, used as inputs in the OM, are expressed as exploitable biomass.

57. The WPM(MSE) **NOTED** that the recently developed Bayesian JABBA model (Winker et al. 2018) may provide more reliable estimates of biomass and run more quickly than the BDM, and **SUGGESTED** that this model could be explored as an alternative in future.

58. The WPM(MSE) **NOTED** that the updated CPUE series for the 2020 stock assessment have less information on depletion than the 2017 CPUE series (as evidenced by the vastly different depletion estimates from the BDM model between the 2017 and 2020 CPUE series) and that we need to understand better where the signal for depletion is coming from in order to build a model that incorporates these data sources.

59. The WPM(MSE) **AGREED** that reverting to the 2017 CPUE series was not advisable, and **SUGGESTED** that the BDM could be fit to a single 2020 CPUE series at a time, as the MP Model does not need to be conditioned on the same data as the stock assessment model. However, the large differences in the trajectories of the different CPUE series present challenges in deciding which series better reflects abundance.

5.2 Future Work

60. Given the problems identified with estimating depletion from the BDM, using the updated CPUE timeseries, the WPM(MSE) **AGREED** that it would be useful to explore the performance of empirical MPs, such as CPUE-based MPs, as an alternative to the BDM, and **REQUESTED** that the developer explore these options.

6. STATUS OF WORK ON SWORDFISH OMS AND MPS

6.1 Review progress and difficulties

61. The WPM(MSE) **NOTED** the presentation on the ongoing work for the development of MSE for Indian Ocean swordfish. Work has recently started to recondition the operating model based on the most recent stock assessment for the stock (WPB, 2020). The grid of model runs considered is the same as applied in the previous version.

62. The WPM(MSE) **NOTED** the grid of model runs (Table 2)

Table 2: Grid of alternative model setups for the constructions of the new swordfish operating model.

Factor	Values
M, natural mortality	0.2, 0.3, Lorenzen
H, SRR steepness	0.6, 0.75, 0.9
Sigma R, std dev in recruitment residuals	0.2, 0.6
Growth & maturity	Farley et al., 2016, Wang et al., 2010
ESS, effective sample size length data	2, 20
CPUE	JPNlate+PRT, JPNlate, TWNlate+PRT
CPUE area scaling	Biomass, catch, area
Selectivity LL	Double normal, logistic

63. The WPM(MSE) **NOTED** the results of running the OM grid main effects, where a single factor is changed at a time, in both the estimates of virgin biomass) and relative stock status (final year SB over SB_{MSY}) (Figure 2)

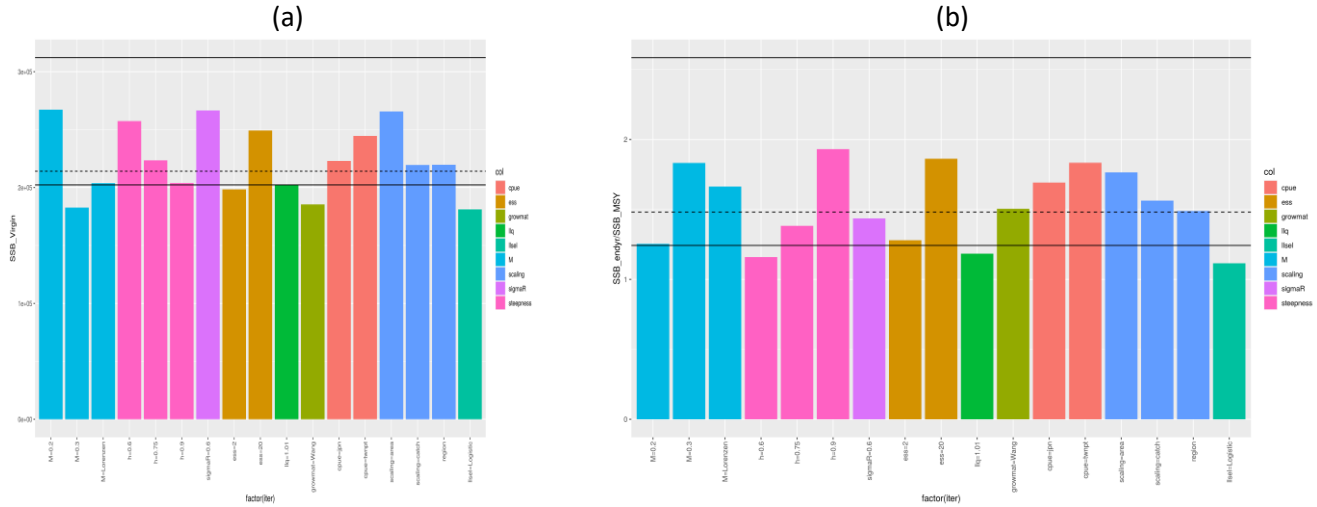


Figure 2: Swordfish OM grid main effects, where a single grid factor is changed at a time, on the estimates of virgin biomass (a) and relative stock status (b).

64. The WPM(MSE) **WELCOMED** the presentation and the progress made in such a short period to condition the OM to the new assessment model.

65. The WPM(MSE) **NOTED** that the set of robustness tests is to be defined and a number of participants **AGREED** on discussing the matter intersessionally. The WPM(MSE) **NOTED** the large number of model runs in the OM and **SUGGESTED** methods are explored to decrease this, given the workload involved. Either the partial factorial design applied to BET and YFT, or some alternative method, should be considered. The WPM(MSE) also **NOTED** the intention to consider some approach to select and weight the model runs in the final set OM, and **AGREED**, as this is a general issue to all MSE work, to extend the discussion to all species MSEs.

66. The WPM(MSE) **NOTED** that the scaling of CPUE series in the four-area model is carried out in a slightly different way that it is done in tropical tunas. The current OM grid considers this as one of the factors, although the differences in stock dynamics that the scaling methods introduce appear to be small (e.g. biomass scaling vs catch scaling).

67. The WPM(MSE) **NOTED** that the development of this MSE is being carried out through staff time and resources provided by one CPC, as the work is part of the postgraduate studies of the main developer. Some support on the use of the software platform is provided by the main developer that covers the work on albacore tuna.

6.2 Future Work

68. The WPM(MSE) **SUGGESTED** the work to be presented at the WPB and **REQUESTED** the developer to present the status of work to the upcoming 4th session of the TCMP.

7. STATUS OF WORK ON YELLOWFIN OMS AND MPS

7.1 Review progress and difficulties

69. The WPM(MSE) **NOTED** paper IOTC-2021-WPM12(MSE)-03 was presented, describing recent developments in the YFT MP evaluation project, with the following summary provided by the authors:

> *The Operating Model OM) was updated with the revised assumptions and grid combinations requested by WPM and WPTT 2020. Additional investigations were undertaken to explore the implications of the 2 area vs: 4 area structure. The stock status and Management Procedure MP evaluation results of the two spatial grids were very similar. The two area structure was slightly more optimistic, and less prone to the numerical problem of (at least one) age/región/quarter strata hitting the fishing mortality bound limit (corresponding to a harvest rate of 95%). It appears that the inclusion of the tags in the 4 area model (but not the 2 area model), is the biggest factor driving the divergence in stock status. Unfortunately, a satisfactory Operating Model (OM) could not be identified with which to provide (MP) advice to the 2021 TCMP. The OMs are extremely pessimistic (i.e. require very large catches to hit the 2034 rebuilding objective), but there are good reasons to dismiss most or all of the OM grid as implausible. The data used to condition the OMs stopped in 2017. The MP evaluations indicate that a large portion of the OM ensemble cannot remove the catches subsequently reported in 2018 and 2019. Additional analyses are discussed in the report* - (see document for full abstract*).*

70. The WPM(MSE) **THANKED** the analyst for the work carried out for the yellowfin MSE and noted that it is unfortunate that the many problems encountered with the stock assessment model are transferred to the OM/MPs producing delays on the MSE process for yellowfin.

71. Noting the many problems found with the grid of Operating Models the WPM(MSE) **DISCUSSED** the next steps for the yellowfin MSE with regards to communication to the TCMP and possible ways to progress in the technical work. For the first, the group discussed what material should be presented in the next TCMP and noted that caution needs to be placed on how to communicate the results presented in this meeting emphasizing the reasons for delays and potential needs for progressing. Noting the interest in the yellowfin MSE, it is important to clarify the critical issues with the model.

72. Despite the delay in the YFT MSE process, the WPM(MSE) **NOTED** the work done with the MSE framework, once the assessment is accepted by the WPTT and SC, the steps for reconditioning the grid of OMs for MSE of candidate MPs that achieve objectives identified by TCMP should be straightforward and further delays should not be significant. However, it should be noted that the MSE framework does not have the full flexibility of Stock Synthesis, and the ease of updating depends on how the new assessment is structured (e.g. the OM does not support size-based selectivity, or sex disaggregation, and includes one CPUE series per area). The WPM(MSE) **NOTED** the need to communicate that even after an MP is implemented by the Commission, the MSE is regularly reviewed and adjustments made if unanticipated unusual circumstances are identified.

73. The WPM(MSE) **NOTED** that the MSE has also contributed to the workplan that is aiming to improve the yellowfin stock assessment in recent years. In this regard, the WPM(MSE) **NOTED** that the current grid of OMs includes models with two areas (East and West) and the main reason for this was to reduce the number of parameters and to account for the possibility that the currently available data do not provide enough information about movements between 4 areas. Also, with the 2 area model a more simplified configuration is possible. It was

NOTED that the 2-area model was not divided in North and South areas because there is no information on fish movement between the north and the south. It was further **NOTED** that inferences from the recent stock structure project should be reviewed in this context as they are suggesting a latitudinal stock structure (eg North vs South).

74. The WPM(MSE) also **DISCUSSED** ways to improve the yellowfin assessment (and the uncertainty grid for the OM). In this regard, the WPM(MSE) **NOTED** that all models of the stock assessment uncertainty grid and all OMs are based on a single (but region-specific) abundance indicator, the Joint Longline index CPUE. The WPM(MSE) **NOTED** that other possibilities to inform the model on abundance trends remain to be explored, for example FAD buoy indices, Maldivian pole and line CPUE, EU purse seine CPUE (in the short term). Other possible solutions are long-term exercises such as the use of Close-Kin Mark Recapture (CKMR)-based abundance estimator, and the Commission should be aware that they will require decisions to be made and resources allocated for those projects to start.

75. The WPM(MSE) also **NOTED** that a filtering exercise based on OM/MP realizations (i.e. retaining only those that attain observed 2019 catch, with no more than doubling recent effective effort) distorts the original OM grid. Notably, models with lower weighting on the CPUE, lower weight on the tagging data, and high natural mortality were disproportionately retained.

76. The WPM(MSE) then **DISCUSSED** the mixing scenarios developed in the MSE and noted that when uniform mixing is assumed, it is like simulating a one area model. In the case of bigeye tuna, this does not have a major impact, and the results are similar to the model where migration between areas is estimated. However, the case of the yellowfin is different. When movement is estimated within the stock assessment model, the catches estimated by the model cannot reach the observed (and assumed catches) for the first 4 years before the MP is implemented, indicating insufficient abundance in some of the areas modelled in which fishing effort is projected. In contrast, the models with uniform mixing do. This is because the uniform mixing completely redistributes the fish every quarter, so the effect of spatial refugia is minimized. Increased capacity to remove the early catches is also associated with a higher probability of crashing the stock.

77. The WPM(MSE) **SUGGESTED** that unreported/underestimated catch in the OM conditioning could contribute to the problems of the stock assessment model and should be further considered in analysis. In this regard, the group briefly discussed the alternative catch reporting scenarios developed in the MSE and noted that these are used to estimate the impact of implementation errors when projecting the model into the future, but they were not used to recondition the OMs, and thus, are independent of the stock assessment model.

7.2 Future Work

78. The WPM(MSE) **NOTED** that there are still problems with the stock assessment model which impede the conditioning of a plausible set of OMs. In this regard, the WPM(MSE) **NOTED** that it will be necessary to communicate potential needs for resources and an estimated timeline for the improvement of the models. For this, the WPM(MSE) **NOTED** that the next steps will depend upon the new stock assessment model that is going to be developed in the WPTT in 2021 and later reviewed by SC.

8. GENERAL DISCUSSION ON OMS AND MPS

8.1 Consideration of multi-species OMs/MPs

79. The WPM(MSE) **NOTED** that substantial work had been conducted on single species OMs and that this was a priority in the short and medium term. The WPM(MSE) **AGREED** that it was premature to discuss multi-species models and that this could be looked at in the future.

8.2 Internal and external peer-review

80. The WPM(MSE) **DISCUSSED** various merits of external peer-review and agreed that external review at both technical (e.g. code inspection) and process levels can greatly benefit the MSE development (e.g. addressing issues that are not able to be resolved by the internal review; providing credibility to the MP development). The WPM(MSE) **SUGGESTED** that the external review could be conducted independently and in parallel to the TCMP process, preferably to species for which the MP evaluation is close to completion (such as BET), and when resources and expertise are available.

81. The WPM(MSE) **NOTED** the suggestion that clear instructions and terms of references should be provided for the external review given the complexity of the MSE process. It was also suggested a standard set of diagnostics for the OM development should be made available to assist the review.

82. The WPM(MSE) **ACKNOWLEDGED** that arranging an external peer review will not be trivial due to the complexity of the process as well as the limited number of experts able to conduct the work. An external peer review could be an expensive process and the exact scope should be decided and potential candidates could be contacted to ascertain their availability.

8.3 Workload, priorities, and resources

83. The WPM(MSE) **DISCUSSED** the funding prospects for the IOTC MSE work. It was noted that for yellowfin and bigeye tuna, the current funding will finalise mid-2021, and after that external funding is required for the work to continue (Australia has expressed interest providing further funding to support the yellowfin and bigeye tuna MSE); for skipjack and albacore tuna, the current funding (from IOTC) can support the MSE development until mid and late 2021 respectively; Swordfish is funded externally as part of a PhD grant and no further funding is required currently although some support to the developer is included in the albacore contract.

84. The WPM(MSE)MSE WS **NOTED** that continued MSE work had been listed as a priority for funding during WPM 2020 meeting which was endorsed by the 2020 SC. As such it is hoped that the Commission will discuss and approve funding for MSE work at its 2021 session and these funds could then be available from 2022 onwards.

8.4 Workplan and roadmap 2021-2023

85. The WPM(MSE) **NOTED** the discussion of the MSE workplan for each species. The WPM(MSE) **SUGGESTED** that it would be useful to provide a revision and update to the "Proposed Schedule of Work for the Development of Management Procedures for Key IOTC Species" (Appendix 6, IOTC–2019–SC22–R) after the discussion taken place at the upcoming TCMP and Commission meetings to be presented to the next WPM.

8.5 Other issues

86. The WPM(MSE) **DISCUSSED** the most appropriate methods for developing the model grids used in the MSEs and **NOTED** the utility of conducting a comparison of fractional factorial design, or other approaches, that seek to balance computational intensity while adequately reflecting the underlying uncertainty distribution being represented, understanding that it is not only the central tendency, but also the shape of the distribution that influences the probability statements about future performance under different management objectives.

87. The WPM(MSE) **NOTED** that although it is beneficial to standardise the approaches between species, in order to reduce variation and confusion when presenting the results to managers, that flexibility would be provided to the developers to investigate different options.

88. The WPM(MSE) **NOTED** the discussion regarding model selection and weighting and the potential to weight models based on their predictive ability. Two different techniques (Mohn's Rho and MASE) were discussed as potential methods for investigating this issue. The WPM(MSE) further **NOTED** that model selection and weighting is an ongoing process and it is difficult to decide on a final method at this stage. This can be accommodated in the mid to longer term once more work is done on evaluating the methods and their implications.

89. Finally, the WPM(MSE) **NOTED** that many scientists from developing countries are not familiar with MSE concepts and it would be necessary to plan some sort of capacity building with developing countries to give opportunity to all scientists to know about these concepts. The WPM(MSE) **RECOMMENDED** that this capacity is made both at TCMP but also intersesionally facilitated by the IOTC Secretariat should funding be available.

9. PREPARATION OF TCMP04 AND COMMISSION (S25)

9.1 Agenda for TCMP04

90. The WPM(MSE) **DISCUSSED** the agenda for the TCMP04 and **AGREED** to the version provided in Appendix IV of this report.

9.2 Organization, tasks and responsibilities

91. The WPM(MSE) **DISCUSSED** the organization of TCMP04 meeting with associated tasks and responsibilities prior to and during the meeting and **AGREED** that introductory presentations and materials on the MSE would be useful to facilitate subsequent discussions. The WPM(MSE) asked SC Chair to prepare such introductory products by liaising with the WPM(MSE) Chair and Secretariat, and present them at the TCMP04. The WPM(MSE) also **AGREED** that it would be beneficial to circulate in advance to the TCMP04 some MSE documents used in the previous IOTC's meeting such as the glossary of MSE, the document for the guideline of standard presentation of MSE results as well as some key published references on MSE.

9.3 Presentations of results

92. The WPM(MSE) **DISCUSSED** the contents of the presentations for the various species and provided the following guidance for the developers.

Bigeye tuna

93. The WPM(MSE) **SUGGESTED** that the presentation should consist of the standard agreed format of MP performance summary graphics (time-aggregated performance statistics and time series plots) and tables as presented to the TCMP03 in 2019. The specific MPs to present will be decided by a sub-group of the MSE Task Force, including the Chairs of the SC, WPTT and WPM, MP developers and the IOTC Secretariat. The MPs should be selected to provide sufficient contrast to allow the TCMP to express preferences in management objective trade-offs. The WPM(MSE) **SUGGESTED** that no more than 6 MPs should be presented, 3 for each tuning objective and that more MPs could be included as an annex to the documentation presented to the TCMP for interested CPCs.

Yellowfin tuna

94. The WPM(MSE) **NOTED** that the OM suffers from structural problems, such that recent data demonstrate that the MP evaluation results are clearly not plausible. The problems arise from the stock assessment models, upon which the OM is based. As such the WPM(MSE) **SUGGESTED** that showing MP projection results should probably be avoided, as this may provide a misleading message about the perception of the stock status and productivity. Alternatively, the WPM(MSE) **SUGGESTED** to focus on the issues and shortcomings of OM development.

95. The WPM(MSE) **NOTED** that both the stock assessment and OM will need to be updated in 2021, likely including an expanded range of assumptions. While the YFT OM is fully operational at this time, there could be major revisions to the stock assessment model that cannot by represented by the OM software at present. The need for additional development time and resources will be assessed after WPTT and WPM 2021 (or earlier if there are clear indications from the preliminary stock assessment activities).

Albacore, skipjack and swordfish

96. The WPM(MSE) **NOTED** that the current status of the MSE process for each of these three species will be summarised and presented to the TCMP. The presentations will be short (5 – 7 minutes) each and highlight the most relevant developments, issues for discussion and underline the TCMP feedback needed.

General issues

97. The WPM(MSE) **NOTED** that once an OM is considered stable, it might still remain under-utilised for some time, while the discussion on adoption of an MP remains active. The WPM(MSE) **NOTED** that in the past, the TCMP has requested OMs to be updated so simulations start in the most current time step as possible (eg. Albacore given the unusual WPTmT meeting schedule and data revision). OMs would need to be updated, possibly given the most recently known catches. The WPM(MSE) **AGREED** to raise and discuss this issue at the TCMP so that a consistent approach is used when carrying out this update of OMs.

98. The WPM(MSE) **NOTED** that the TCMP should be advised of the status of funding support (e.g. tentative CPC funds and/or Commission budget).

9.4 Capacity building on MSE at IOTC

99. The WPM(MSE) **NOTED** that all the SC, TCMP and Commission have recognized the importance of capacity building with respect to the MSE and the Commission at its session in 2019 requested that these activities be undertaken.

100. The WPM(MSE) **NOTED**, however, that due to the virtual format and limited time available for the TCMP04, that a formal Capacity Building session, as was conducted during the TCMP03, would not be possible. The WPM(MSE) **REQUESTED** that the SC Chair liaise with IOTC Secretariat to prepare a short presentation on capacity building as well as the provision of relevant online videos to the participants to assist them with this process.

10. OTHER ISSUES FOR WPM 2021

10.1 Stock status guidance

101. The WPM(MSE) **NOTED** the progress of the ad hoc Reference Point Working Group which was formed during the last meeting of the TCMP (in 2019).

102. The WPM(MSE) were informed that the progress of this group is provided in document IOTC-2020-WPM11-14 which was presented to the WPM in 2020.

103. The WPM(MSE) **NOTED** that a revised draft taking into consideration the comments and discussions arising from WPM11 would be developed and coordinated by the WPM chair. This revised draft would be presented to the TCMP04.

11. OTHER BUSINESS

104. There was no other business

12. ADOPTION OF REPORT

105. The WPM(MSE) **NOTED** that the report would be adopted via correspondence.

APPENDIX I
LIST OF PARTICIPANTS

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APPENDIX II
MEETING AGENDA

Date: 1-5 March 2021
Location: Online
Venue: Microsoft Teams
Time: 12:00 – 16:00 (Seychelles time) daily
Chairperson: Dr. Hilario Murua; **Vice-Chairperson**: Ms. Daniela Rosa

1. **Opening and adoption of agenda**
2. **Review of MP process in IOTC**
   - 2.1. Review outcomes of TCMP03 and COM (S23/S24) in 2019/2020
   - 2.2. Review outcomes of WPM, WPTT and SC in 2019/2020
   - 2.3. Process of MSE development, discussion and adoption at IOTC
3. **Status of work on Albacore OMs and MPs**
   - 3.1. Review progress and difficulties
   - 3.2. Future work
4. **Status of work on Bigeye OMs and MPs**
   - 4.1. Review progress and difficulties
   - 4.2. Future work
5. **Status of work on Skipjack OMs and MPs**
   - 5.1. Review progress and difficulties
   - 5.2. Future work
6. **Status of work on Swordfish OMs and MPs**
   - 6.1. Review progress and difficulties
   - 6.2. Future work
7. **Status of work on Yellowfin OMs and MPs**
   - 7.1. Review progress and difficulties
   - 7.2. Future work
8. **General discussion on OMs and MPs**
   - 8.1. Consideration of multi-species OMs/MPs
   - 8.2. Internal and external peer-review
   - 8.3. Workload, priorities, and resources
   - 8.4. Workplan and roadmap 2021-2023
   - 8.5. Other issues
9. **Preparation of TCMP04 and Commission (S25)**
   - 9.1. Agenda for TCMP04
   - 9.2. Organization, tasks and responsibilities
   - 9.3. Presentations of results
   - 9.4. Capacity building on MSE at IOTC
   - 9.5. Workplan
10. **Other issues for WPM 2021**
    - 10.1. Stock status guidance
11. **Other business**
12. **Adoption of Report**

APPENDIX III
LIST OF DOCUMENTS

Document	Title
IOTC–2021–WPM12(MSE)–01a	Agenda of the 12th Working Party on Methods Management Strategy Evaluation Task Force
IOTC–2021–WPM12(MSE –03	Indian Ocean Yellowfin Tuna Management Procedure Evaluation Update March 2021 (Kolody D and Jumppanen P)
IOTC–2021–WPM12(MSE –04	Indian Ocean Bigeye Tuna Management Procedure Evaluation Update March 2021 (Kolody D and Jumppanen P)

APPENDIX IV

PROPOSED AGENDA FOR THE TECHNICAL COMMITTEE ON MANAGEMENT PROCEDURES (TCMP)

Date: 4-5 June, 2021

Location: Virtual meeting

Time: 0900–1700 daily

Co-Chairs: Ms. Riley Kim Jung-re (Commission Vice-Chair) and Toshihide Kitakado (SC Chair)

1. OPENING OF THE SESSION AND ARRANGEMENTS (Co-Chairs)

2. ADOPTION OF THE AGENDA AND ARRANGEMENTS FOR THE SESSION (Chairpersons)

3. ADMISSION OF OBSERVERS (Chairpersons)

4. DECISIONS OF THE COMMISSION RELATED TO THE WORK OF THE TECHNICAL COMMITTEE ON MANAGEMENT PROCEDURES (IOTC Secretariat)

- 4.1 Resolution 16/09 – Terms of Reference
- 4.2 Outcomes of the 3rd Session of TCMP
- 4.3 Outcomes of the 23rd and 24th Sessions of the Commission meeting
- 4.4 Outcomes of the 22nd and 23rd Sessions of the Scientific Committee

5. INTRODUCTION TO MSE (SC Chairperson)

- 5.1 Management Procedures and MSE:
  - 5.1.1 Basic principles
  - 5.1.2 Roles and responsibilities, dialogue tools and feedback mechanism
- 5.2 SC proposal for the standard presentation of MSE results

6 STATUS OF THE MANAGEMENT PROCEDURE EVALUATION/OPERATING MODELS (Developers)

- 6.1 Albacore tuna (Iago Mosqueira)
- 6.2 Bigeye tuna (Dale Kolody)
- 6.3 Yellowfin tunas (Dale Kolody)
- 6.4 Skipjack tuna (Charlie Edwards)
- 6.5 Swordfish (Daniela Rosa)

7 DISCUSSION ON THE ACTIONS NEEDED FOR THE ADOPTION OF MANAGEMENT PROCEDURES, INCLUDING BUDGET (Chairpersons and Secretariat)

- 7.1 Albacore tuna
- 7.2 Yellowfin tuna
- 7.3 Skipjack tuna
- 7.4 Bigeye tuna
- 7.5 Swordfish

8 FUTURE DIRECTION OF THE TECHNICAL COMMITTEE ON MANAGEMENT PROCEDURES (Chairpersons)

- 8.1 Workplan (Including new timelines/budget and resources needed)
- 8.2 Priorities
- 8.3 Process and future meetings of TCMP

9 ADOPTION OF REPORT (CHAIRPERSONS)

APPENDIX V
CONSOLIDATED RECOMMENDATIONS OF THE 12TH SESSION OF THE WORKING PARTY ON METHODS (MANAGEMENT STRATEGY EVALUATION TASK FORCE)

Note: Appendix references refer to the Report of the 12th Session of the Working Party on Methods Management Strategy Evaluation Task Force (IOTC–2021–WPM12(MSE)–R)

Other Issues

WPM12(MSE).01: Finally, the WPM(MSE) **NOTED** that many scientists from developing countries are not familiar with MSE concepts and it would be necessary to plan some sort of capacity building with developing countries to give opportunity to all scientists to know about these concepts. The WPM(MSE) **RECOMMENDED** that this capacity is made both at TCMP but also intersesionally facilitated by the IOTC Secretariat should funding be available (para. 89).