Food and Agriculture Organization of the United Nations

Indian Ocean Tuna Commission
Commission des Thons de l'Ocean Indien
iotc ctoi

Report of the 11th Session of the IOTC Working Party on Methods

Microsoft Teams Online, 14 - 15 October 2020

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 (WPM) was held online on Microsoft Teams from 14 - 15 October 2020. A total of 55 participants (37 in 2019, 23 in 2018 and 28 in 2017) 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 WPM11 to the Scientific Committee, which are provided in Appendix VI.

Revision of the WPM Program of work (2021–2025)

WPM11.01: The WPM **RECOMMENDED** that the Scientific Committee consider and endorse the WPM Programme of Work (2021–2025), as provided in Appendix IV (para. 77).

Date and place of the 12th and 13th sessions of the WPM

WPM11.02: The WPM **NOTED** that the global Covid-19 pandemic has complicated international travel and with no clear end to the pandemic in sight, it was not possible to finalise arrangements for the meeting in 2021. The Secretariat will continue to liaise with CPCs to determine their interest in hosting these meetings in the future when this becomes feasible. The WPM **RECOMMENDED** the SC consider mid October 2021 as a preferred time period to hold the WPM12 in 2021. As usual it was also **AGREED** that this meeting should continue to be held back-to-back with the WPTT, with the WPM taking place before the WPTT (Para. 81)

Development of priorities for Invited Expert(s) at the next WPM meeting

WPM11.03: Given the importance of external peer review, the WPM **RECOMMENDED** that the Commission continues to allocate sufficient budget for a regular invited expert to be invited to meetings of the WPM (para. 83).

Review of the draft, and adoption of the Report of the 11th Session of the WPM

WPM10.04: The WPM **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPM11, provided in Appendix VI (para. 85)

1. OPENING OF THE MEETING

1. The 11th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Methods (WPM) was held online on Microsoft Teams from 14 - 15 October 2020. A total of 55 participants (37 in 2019, 23 in 2018 and 28 in 2017) 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. ADOPTION OF THE AGENDA AND ARRANGEMENTS FOR THE SESSION

2. The WPM **ADOPTED** the Agenda provided at Appendix II. The documents presented to the WPM11 are listed in Appendix III.

3. THE IOTC PROCESS: OUTCOMES, UPDATES AND PROGRESS

3.1 Outcomes of the 22nd Session of the Scientific Committee

3. The WPM **NOTED** paper IOTC–2020–WPM11–03 which outlined the main outcomes of the 22nd Session of the Scientific Committee (SC22), specifically related to the work of the WPM.

4. The WPM **NOTED** that in 2019, the SC made a number of endorsements and recommendations in relation to the WPM10 report. These are provided below for reference

- *Management Strategy Evaluation Progress*
  - o *(Para 87) The SC NOTED paper IOTC–2019–SC22–15 which provided an updated schedule of work for the development of management procedures for key species in the IOTC Area. The SC AGREED to the schedule of work (Appendix 6), noting it is a living document to provide an indicative timeframe to guide the IOTC MSE development and may subject to change. The SC ENCOURAGED the schedule to be resubmitted to TCMP and Commission for final endorsement.*

- *Albacore MSE*
  - o *(Para 88) The SC NOTED that the 2019 albacore stock assessment results fall outside the range of uncertainty captured by the current operating model (OM) and therefore reconditioning of the OM is required based on the 2019 assessment. The SC AGREED that if the proposed update of the assessment can be achieved in 2020, the new OMs may be conditioned on the new assessment.*

- *Skipjack tuna MSE*
  - o *(Para 89) The SC NOTED that catches of skipjack in 2018 and 2019 have both exceeded the catch limit established under Resolution 16/02 using the harvest control rule (HCR). The SC recalled that Resolution 16/02 included a provision to review the skipjack tuna harvest control rule. The SC NOTED that an MSE expert has been contracted to undertake review of the skipjack tuna harvest control rule with a view towards developing the management procedures. It is anticipated that current HCR will be replaced by the alternative MP subject the result of the review.*

- *Yellowfin tuna MSE*
  - o *(Para 90) The SC NOTED the attempt to conduct a full assessment of the yellowfin tuna has not been achieved this year and the current yellowfin OM is based on the 2018 yellowfin assessment. However, the SC AGREED that further OM development may take into consideration the progress made so far in addressing the yellowfin workplan.*

- *Bigeye tuna MSE*
  - o *(Para 91) The SC NOTED that the 2019 bigeye assessment results are more pessimistic than in previous assessments and that there were changes in the fishery characteristics, which are likely to have an impact on the evaluation of the management procedures performance. The SC AGREED that the bigeye OMs may need reconditioning on the new assessment.*

- *Swordfish MSE*
  - o *(Para 92) The SC NOTED that the initial OM conditioning and preliminary testing of MP performance have been started. The SC ACKNOWLEDGED the good progress made in the MSE exercises for swordfish.*

3.2 Outcomes of the 23rd Session of the Commission

5. The WPM **NOTED** paper IOTC–2020–WPM11–04 which provided the main outcomes of the 23rd Session of the Commission specifically related to the work of the WPM. The WPM further **NOTED** that the 24th Session of the Commission which was due to be held in June 2020 had been postponed until November and therefore no new outcomes or Resolutions are available since the 23rd session.

6. Participants to WPM11 were **ENCOURAGED** to familiarise themselves with the previously adopted Resolutions, especially those most relevant to the WPM and **AGREED** to consider how best to provide the Scientific Committee with the information it needs, in order to satisfy the Commission's requests, throughout the course of the current WPM meeting.

3.3 Review of Conservation and Management Measures relevant to the WPM

7. The WPM **NOTED** paper IOTC–2020–WPM11–05 which aimed to encourage participants at the WPM11 to review some of the existing Conservation and Management Measures (CMM) relevant to the WPM and as necessary to 1) provide recommendations to the Scientific Committee on whether modifications may be required; and 2) recommend whether other CMMs may be required.

3.4 Progress on the recommendations of WPM10

8. The WPM **NOTED** paper IOTC–2020–WPM11–06 which provided an update on the progress made in implementing the recommendations from the previous WPM meeting which were endorsed by the Scientific Committee and **AGREED** to provide alternative recommendations during the WPM11 as appropriate given any progress.

3.5 Review of intersessional meetings related to the IOTC MSE process

9. The WPM **NOTED** that the 9th MSE workshop of IOTC WPM scientists (MSE Task Force) as well as the TCMP04 due to be held in 2020 had both been cancelled due to the Covid-19 crisis. The WPM **EXPRESSED** its hope that these meetings would once again take place in 2021, even if it required using online tools to facilitate them.

4. ALBACORE MSE: UPDATE

4.1 Review of the progress on development new Operating Models based on 2019 ALB stock assessment

10. 7.The WPM **NOTED** paper IOTC-2020-WPM11-08, describing progress on the ALB MSE, with the following summary provided by the authors:

> *"This document presents the first steps in the developments for the conditioning of a new Operating Model (OM) for Indian Ocean albacore. A contract has been recently signed between the Indian Ocean Tuna Commission (IOTC) and Wageningen Marine Research (WMR), under which further development of a Management Strategy Evaluation for this stock will take place. Work has started on updating the simulation platform to the new model structure and software. A proposal for a new OM grid is presented, together with a preliminary exploration of the extremes (corners) of this grid. Initial metrics for weighting of model runs are discussed."*

11. The WPM **THANKED** the author and **NOTED** that ALB progress had been delayed until the recent signature of a contract for this work.

4.2 Feedback on MSE/OM development

12. The WPM **NOTED** that the 0% vs 1% per year catchability trend assumption is one of the most influential OM options and **AGREED** that this remains an important uncertainty dimension in the OMs for all species.

13. The WPM **NOTED** that the extreme down-weighting of the Catch-at-Length scenarios might result in unrealistic selectivity functions and **SUGGESTED** that these scenarios should be checked and possibly deleted.

14. The WPM **NOTED** that there were conflicting CPUE trends in different regions, and there is not enough structural flexibility in the OM spatially-aggregated population to fit all series simultaneously. The group **SUGGESTED** that further analysis should be undertaken on the relative importance of the different CPUE series and how they should be weighted in the OM ensemble. Alternatively, the group **SUGGESTED** that non-stationary selectivity might be able to explain the conflicting trends.

15. The WPM **NOTED** that the application of model diagnostics is important to ensure that the scenarios selected to be included in the OMs (for all species) are robust, however, the specific suite of diagnostics and criteria to select the models remains a work in progress.

4.3 Future steps and timeline

16. The WPM **ENDORSED** the reference set OM uncertainty dimensions defined in Table 1, subject to further investigation of the issues identified in 4.2. Other elements (e.g. NW CPUE) are to be included only as part of the robustness OMs.

Table 1. ALB Reference Set Operating Model

Factor	Values
Natural mortality (M)	0.3, 0.35 or 0.4 for all ages
Standard deviation of recruitment residuals (sigmaR)	0.4, 0.6 or 0.8
Steepness (h)	0.7, 0.8 or 0.9
Likelihood weighting of LL length frequency data	0.1 or 1
LL catchability increase	0% or 1% per year
LL CPUE series	Southwest (14)

17. The WPM **NOTED** that the current contract will support ALB MSE work until November 2021, and the revised OM and candidate MP evaluation results should be ready for TCMP 2021.

5. SKIPJACK TUNA MSE: UPDATE

18. The WPM **RECALLED** that the first iteration of the skipjack HCR was implemented in 2017 and an annual Catch Limit was established for 2018-2020. The WPM also **RECALLED** that the skipjack HCR is not a fully specified Management Procedure (MP), since the underlying data required, and assessment methodology are not fully specified under Res 16/02. The WPM **NOTED** that in response to the request from the SC, the IOTC initiated a project to review and potentially revise the HCR as required Res 16/02, with the aim of developing a full skipjack MP.

19. The WPM further **NOTED** that the overarching objectives of the Skipjack MSE project include (1) develop an Operating Model based on Stock Synthesis III; (2) develop a simple stock assessment model that can be fitted to simulated data from the skipjack stock assessment grid, and (3) Simulation test model-based Management Procedures with input from stakeholders.

20. The WPM **NOTED** paper IOTC–2020–WPM11–09 which described applications of a Bayesian biomass dynamic model to Indian Ocean Skipjack Tuna. The following abstract was provided by the authors:

   "*An MP includes the assessment or estimation method on which the HCR is based, as well as the data inputs and the HCR itself. To be fully specified therefore, a suitable assessment method is required: one that is capable of forming the basis for implementation of the HCR but simple enough to simulation test. A biomass dynamic model could fulfill these requirements. Developing such a model provides the motivation and basis for the current work*. (See paper for full abstract)"

21. The WPM **NOTED** that the biomass dynamic model (BDM) developed in the paper is intended to be used as the assessment method in the MP for providing inputs for the HCR. The model is in the form of a combined Fletcher-Schaefer hybrid model, which compensates the more flexible, generalised production model with an ecologically consistent parameter for the intrinsic growth rate r.

22. The WPM **NOTED** that a surplus production model-based HCR would also enable the implementation of catch-based constraints. The flexible implementation of the Schaefer-Fletcher hybrid model enables the formulation of alternative candidate MPs for tuning, i.e. adjusting values of control parameters (r prior, shape, fixed observation error) in a Management Procedure to achieve precisely defined performance statistics.

23. The WPM **NOTED** attempts to obtain an informative prior for r using skipjack life-history parameters yielded anomalously large values (r > 1.5). Therefore, the current application of the BDM adopted the r values from the Fishbase. The WPM also NOTED the observation error was fixed at a moderate value of 0.2.

24. The WPM **NOTED** that the BDM generally estimated well the depletion-based indicators and MSY, but estimated poorly the absolute biomass values, harvest rates, and related reference points. However, aggregated biomass and harvest rates are usually not compatible in scale with SSB and F from integrated age-structured models, and more importantly, these values are not used directly in an HCR. The WPM further NOTED that the exploitation rate E/E40%SSB0 employed in the current HCR could be easily converted into F/Fmsy or F/F40%SSB0.

25. The WPM **NOTED** that the presented state-space surplus production formulation appears sufficiently flexible and promising to be included in the MP, albeit dependent on making it computationally more efficient e.g. by implementing it within a Maximum Likelihood framework (e.g. TMB).

26. The WPM **NOTED** paper IOTC–2020–WPM11–10 which described the developments toward an MSE framework for Indian Ocean skipjack tuna using Stock Synthesis III. The following abstract was provided by the authors:

> "*An MP includes the assessment or estimation method on which the HCR is based, as well as the data inputs and the HCR itself. Simulation evaluation requires an operating model (OM), to describe dynamics of the resource and how it responds to harvesting, plus a computational framework that will generate artificial observations, apply the MP to estimate a management recommendation, and then simulate the implementation of that recommendation in a closed loop forward projection. The current report describes initial developments of such a framework, specifically implementing Stock Synthesis III as the OM. Closed loop simulation evaluations of the current HCR are performed so as to demonstrate the framework's functionality.* (See paper for full abstract)"

27. The WPM **NOTED** that the proposed OM is based on SS3 models as opposed to independently coded applications (e.g. C++), which is expected to improve the accessibility, and reproducibility of the MSE.

28. The WPM **NOTED** that in the projection to examine the limiting property of the HCR, the terminal F differs slightly to F40%SSB0 (the target F estimated from the 2017 assessment models). The WPM suggested that this may be due to F40%SSB0 being an extrapolated value approximating the true equilibrium. However, The WPM agreed that the difference is very minor and not a concern.

29. The WPM **NOTED** the current HCR relies on the input of the median SSB estimates from the Stock Synthesis assessment grid. This makes it computationally difficult to implement a feedback control loop and condition the HCR. Another issue is that the HCR is not clearly defined considering that the "best" stock assessment models can change significantly in terms of data input, weighting and assumptions. Moving towards a simpler, fully simulation-tested MP, whether empirical or model-based (SPM), would therefore be beneficial.

30. The WPM **ENCOURAGED** the continued development of the MP for skipjack and **NOTED** that future iterations of the project should focus on the development of a full MP, which includes an assessment model for setting of the catch limit in the closed-loop simulations, which shall include the simulation of future abundance data and automation model fit. The OM is also expected to be updated based on the 2020 stock assessment and further expanded to account for a wider range of uncertainty.

6. BIGEYE TUNA AND YELLOWFIN TUNA MSE: UPDATE

Yellowfin Assessment Update

31. The WPM **NOTED** paper IOTC-2020-WPTT22(AS)-21 which explained the progress made in 2020 with regards to the yellowfin workplan. There is a proposal to update the current scientific advice on stock status and management for this stock. It was clarified that the work carried out in 2020 aimed at finalising the yellowfin assessment that was not agreed in the last moment of the 2019 WPTT due to concerns on the growth equation and tagging data, that needed further exploration. The following abstract was provided by the authors:

> "*In 2018 the advice of yellowfin tuna in the Indian Ocean (YFT) was based on a grid of 24 models, where all models were based on the age and length structured integrated assessment model Stock Synthesis (SS). However, due to several issues in the data inputs and model assumptions, the Science Committee of IOTC (SC) recommended a workplan to improve the YFT assessment. Therefore, in this document, based on the comments of the WPTT21, two different processes were conducted: i) some of the basic assumptions on the assessment model were analyzed in details and ii) a new procedure on how to select the models to be included in the final grid used for the advice is presented.*" – See paper for full abstract

32. The WPM **NOTED** that the work in 2020 was carried out along two research lines: First, the "seasons as years" is being transformed into a seasonal model ("years with seasons"). The technical details of this process were presented to the WP. Starting from a base case from the grid agreed by the 2019 WPTT, two alternatives for the

model configuration have been evaluated (one with a similar setting but in annual scale and another simplified version to analyze the assumptions and components within the model). The WPTT **NOTED** that the main difference between models refers to the recruitment process and the associated method for assigning tag release ages. In the annual model the recruitment is distributed between areas and then between seasons, contrary to what happens with the "seasons as years" model. The WPTT **ACKNOWLEDGED** that the diagnostics between the model configurations are somewhat similar and despite that it is considered an adequate path to follow, the annual model still needs further work before using it in the assessment.

33. The WPM **NOTED** that with regards to the second research line, it has consisted of a series of steps to reduce the number of models in a reference grid looking at their performance using diagnostic tests. The diagnostics were presented to the WPM and also the process followed to rank the models based on their performance. The authors clarified that the idea behind this approach is to reduce the number of models to characterize uncertainty, identify model configurations that show a poor diagnostic performance and to select the best performing models. The WPM **NOTED** that a 70% score threshold was somewhat arbitrary, but it was chosen as a compromise between including models that represent all options agreed in 2019 but discarding models that do not perform with the available data.

34. The WPM **NOTED** the progress made and requested clarification on the diagnostics made and how the annual model deals with the tagging data and in particular, how the assignment of tag ages in seasonal vs non-seasonal model should be compared. The WPM **SUGGESTED** one additional diagnostic to check that the bound on fishing mortality is not hit in the estimation process. The Authors clarified that the fits to tagging data have not been compared between both "seasonal" and "annual" but this will be looked at.

6.1 Review of Operating Models based on WPM, SC feedback, and latest stock assessment results

35. The WPM **NOTED** paper IOTC-2020-WPM11-12 which contains the updates on the progress of the yellowfin MSE. The OM of the yellowfin MSE are based on the 2018 and 2019 assessments with additional assumptions on environmental indices, recruitment and a wider dimension uncertainty grid. The following abstract was provided by the authors:

> "*This paper describes developments on the Indian Ocean yellowfin (YFT) reference set operating models (OMs), since the 2019 Working Party on Tropical Tunas (WPTT) and Working Party on Methods (WPM). There were requests for a number of YFT OM developments from the 2019 WPM and WPTT. The requests were made during a particularly busy WPTT meeting schedule, under the assumption that the OM changes would reflect the improvements realized through the YFT stock assessment update that was happening in parallel. However, the 2019 YFT assessment was aborted near the end of the formal WPTT meeting, and there was not time to discuss the implications or appropriateness of assessment innovations for either future assessments or OM conditioning.* (See paper for full abstract)*".*

36. The WPM **NOTED** that the update of the grid of the OMs has been complicated by the cancelled meetings and the lack of discussions with the updates on the yellowfin stock assessment. The unresolved issues were presented to the WPM which included the natural mortality and growth options proposed in 2019, among others. The presentation included requests for feedback from the WPM (and possibly the WPTT) to help the way forward.

37. The WPM **NOTED** the progress made in 2020. Also, the WPM **DISCUSSED** the use of some of the diagnostic tools provided in the SSdisag R package (Winker et al. 2019) for the screening of OMs. In particular, the WPM **NOTED** that the 'run' tests are non-parametric tests to test for non-random distribution of residuals (sequence positive/negative), but they do not provide a measure of the scale of errors. Therefore, the runs tests are useful to detect misspecifications in the observation process of models (Carvalho et al. 2016), but may not be suitable for examining how well the model "fits" are. The WPM further **NOTED** the metrics such as Mean Squared Errors can measure the scale of the errors, but they are influenced by the fixed sample size or assumed observation error and, therefore, may not necessarily work well.

38. With regards to other diagnostics, the authors clarified that "jittering" can also be added to the list of diagnostics in future model configurations. In this regard, the WPM **NOTED** that the Jittering analysis is important diagnostics to ensure model stability and convergency, but it would not be feasible to perform it all the models in the OM. Jittering is probably best placed for a representative subset of the final candidate models.

39. The WPM **NOTED** that there is a need for a common definition of "plausibility" to separate models that are "plausible" for the grid of OMs and those that are "not plausible", that could be discarded or moved to a

robustness grid. The WPTT further **NOTED** that the role of Operating Models and assessment models differ. Since the OM should encompass more uncertainty, it is not clear that the application of diagnostics should be identical.

40. The WPM noted that CPUE error (and recruitment deviation) auto-correlation is not included in the conditioning assumptions, but is included in the MSE projections to partially account for systematic lack of fit issues and possible time series discontinuities in transitioning   from historical to projected dynamics.

41. The WPM **NOTED** that the OM has tested two alternative growth models from the Dortel et al. 2015[1]. However, the variance structure from Dortel log-normal model (model 3) cannot be adequately represented in SS3. The WPM discussed this further and it was not completely clear which of the two curves is more adequate. The WPM further **NOTED** that the options of platoons and growth morphs have more flexibility in modelling the growth and representing size-based fishery selectivity more realistically, but these options are computationally slow and cannot be represented in the OM code at present.

42. The WPM **NOTED** the problematic retrospective pattern observed in the reference model and discussed some of the possible causes. The WPM **NOTED** that one mechanism for introducing this retrospective pattern might be a non-linearity between CPUE and abundance, but the investigation conducted so far has not been very conclusive. The WPM further noted the retrospective pattern are mainly in the scale of the biomass, but not in the trend, and thus queried whether this might be related to changes in dome-shaped fishery selectivity.

43. The WPM **NOTED** that the Stock Synthesis (SS) maximum fishing mortality setting used in the assessment (Fmax = 2.9) results in a "non-trivial" catch likelihood term for the majority of OM specifications, indicating a harvest rate of 95% (for the most highly selected age/quarter/region strata). This issue affects YFT and BET Operating Models.   The number of models affected by this problem can be decreased by raising the F constraint (e.g. Fmax = 6.0 results in a harvest rate of 99.5%), but the question remains as to whether a harvest rate > 95% is plausible, whether the arbitrary bound has serious implications for model inferences, or whether it is a minor problem that does not have misleading consequences (e.g. a transient effect caused by poor seasonal movement representation).

44. The WPM NOTED that the YFT (and BET) reference set OM does not include quota implementation errors or catch reporting errors.   Robustness scenarios have been agreed for both situations individually, but not simultaneously.

45. The WPM **NOTED** that how to account for potential overcatches of CPCs is something that could be referred to the TCMP.

46. The WPM **NOTED** that the revised Operating Models for YFT and BET were modified to include i) recruitment deviation constraints for the most recent 12 quarters during conditioning (with error introduced back into the initial age structure for the projections), and ii) auto-correlated CPUE errors in the projections, which describe the scenario-specific systematic lack-of-fit estimated from the conditioning. Together, these changes remove the occasional problem of a large CPUE series discontinuity in the first year of projections.

Bigeye MSE

47. The WPM **NOTED** papers IOTC-2020-WPM11-11 and IOTC-2020-WPM11-13. These included updates on bigeye MSE. The OMs were updated from the 2019 stock assessment. Also, a Pella-Tomlinson Random Effects surplus production model that admits process and observation errors was presented as a candidate for the MP. The model is spatially-aggregated and operates in an annual time-step, fitting to catch and CPUE observations. The following abstracts were provided by the authors for papers IOTC-2020-WPM11-11 and IOTC-2020-WPM11-13 respectively.

> Paper IOTC-2020-WPM11-11- "*The paper describes developments on the Indian Ocean bigeye (BET) reference set and robustness test operating models (OMs), with key Management Procedure (MP) evaluation results, since the 2019 Working Parties on Tropical Tunas (WPTT) and Methods (WPM). The BET OM was updated with respect to the WPTT/WPM 2019 requests, using the new 2019 assessment for the core data and structural assumptions, subject to a number of small modifications for technical reasons.   Many model configurations have very high F estimates in some time/area/age strata that remain questionable and may be an artefact of the poor seasonal representation of movement* (See paper for full abstract)""

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[1] Dortel E, Sardenne F, Bousquet N, Rivot E, Million J, Le Croizier G, Chassot E (2015) An integrated Bayesian modeling approach for the growth of Indian Ocean yellowfin tuna. Fish Res 163:69–84. doi:10.1016/j.fishres.2014.07.006

Paper IOTC-2020-WPM11-13 – "*In this paper, we explore a Pella-Tomlinson Random Effects surplus production model (PTRE) that admits joint process and observation error, as a potential estimation model for use within IOTC Management Procedures. The model is spatially-aggregated and operates on an annual time-step, fitting to catch and CPUE observations. Model parameters include carrying capacity (k), intrinsic population growth rate (r), initial biomass, PT production curve "shape" (p - determines B(MSY)/k), CPUE variance and productivity process error variance.* (See paper for full abstract)""

48. The WPM **NOTED** that the BET OM shares the issues of retrospective pattern, high F, and revised treatment of recruitment and CPUE auto-correlation, as described in the YFT section above.

49. The WPM **NOTED** that the updated BET OM was slightly more pessimistic than the previous iteration, but MP evaluation performance remained qualitatively consistent with 2019, including minor catch increases expected to reach the TCMP 2019 tuning objectives, and similar responses to robustness tests.

50. The WPM further **NOTED** that the MP based on the Pella-Tomlinson Random Effects model appears to respond more quickly to incoming data, and lowers the MP overfishing risk, relative to previous MPs that are data-based or include an observation-error only production model.

51. The WPM **NOTED** process error is difficult to estimate quantity in State-Space implementations of production models and fixing the process error to minimal realistic value may therefore be a sensible option to improve convergence rates. Setting the process error too high could be problematic as it enables the model to fit the data through a random walk process, resulting in loss of information about the scale. The WPM **NOTED** that the current prior mode is located at the upper range expected for bony fishes (process error parameter = 0.15). A possible way to objectively derive the adequate level of process error is to sample the expected process error on SSB based on the expected surplus for SSB across the OMs. However, the WPM further **NOTED** that the MSE provides an objective measure of OM-specific model performance, such that demonstrably better MP performance should take precedence over theoretical correctness.

7. SWORDFISH MSE: UPDATE

7.1 Progress on the development of Swordfish MSE/MP

52. The WPB **NOTED** that limited progress had been made on the Swordfish MSE. The secretariat **CLARIFIED** that both the MSE Task Force meeting (a technical expert group of the WPM) and the TCMP meetings in 2020 were cancelled due to the covid pandemic. In addition, the modeller working on the MSE was currently not available. As such, very little progress had been made since the 2019 SC meeting. The work is expected to resume in late 2020, early 2021.

53. The WPM **NOTED** that the new assessment conducted for SWO in 2020 will need to be reviewed to determine if subsequent reconditioning of the SWO OM is required.

54. The WPM also **NOTED** that the grid of models being used for the SWO MSE was very large, presenting significant computational challenges. The WPM **AGREED** that this grid should be reviewed and reduced where possible.

8. GENERAL MSE ISSUES

8.1 General discussion

55. The WPM **NOTED** that a number of technical issues under discussion during the presentations for individual stocks were common to all or most of them. The WPM **AGREED** that work would benefit from a continuation of the existing communication among MSE developers and the stock assessment teams. The WPM **NOTED**, for example, that work on surplus production models (including its state-space version) that are appropriate for use in management procedures is being carried out by multiple researchers.

56. The WPM **NOTED** that uncertainty exists around the catch data and there was discussion around whether to include that uncertainty in the reference grid or to keep it only in the robustness tests. The WPM **AGREED** that this issue should be referred to the TCMP for further discussion.

57. The WPM **NOTED** that there is a need for deciding on how and when to stop re-visiting the conditioning of the OMs with new assessments.

58. The WPM **NOTED** that there are some criteria for exceptional circumstances (i.e. new stock assessment dynamics are outside the bounds considered in the MSE) that would recommend updating the grid of OMs.

8.2 Consideration of reconditioning OMs based on recent stock assessments

59. The WPM **NOTED** that a set of robust guidelines were needed on what circumstances call for the revision of a conditioned operating model. The WPM **AGREED** that a new stock assessment should not lead automatically to a new operating model, as this increases considerably the MSE development workload and obviates the role of an OM as a representation of potential past and future dynamics. The WPM **AGREED** that the current general recommendation to check whether a new assessment model falls within the uncertainty of an existing OM needs to have clear criteria. The WPM **AGREED** that a small group will work intersessionally on developing an initial set of guidelines on when an OM needs to be reconditioned based on new assessments as well as on the definition of exceptional circumstances, and will report back to WPM in 2021.

8.3 Consideration of Exceptional Circumstances

60. The WPM **NOTED** that a similar exercise should be carried out more generally on the definition of exceptional circumstances. The WPM **NOTED** that future resolutions implementing management procedures should contain a precise definition of the circumstances under which the procedure should not be applied. The WPM **AGREED** that work should be carried out intersessionally on those elements that relate to the elements in a management procedure being tested by WPM. The WPM **AGREED** the group should report back to WPM in 2021.

8.4 Internal and External Peer review

61. The WPM **NOTED** that a peer-review process for the MSE work has been discussed in the past. The WPM **AGREED** that such a process would be beneficial for the MSE work at IOTC, and for its acceptance by all parties involved. The WPM **ACKNOWLEDGED** that such a process will need to go beyond the participation of an invited expert at WPM meeting, given that the work required to review and evaluate the MSE work is quite substantial. The WPM **REQUESTED** the Secretariat to explore with the WPM chair possible mechanisms and sources of funding to carry out these reviews.

9. JOINT CPUE STANDARDISATION

9.1 Update on the development of the joint CPUE indices for 2020 & 2021.

62. The WPM **NOTED** paper IOTC–2020–WPTT22(AS)–09 which provided the plan of a trilateral collaborative study among Japan, Korea and Taiwan,China for producing joint abundance index with longline fisheries data for the tropical tuna species in the Indian Ocean. The following abstract was provided by the authors:

> *"Three distant-water tuna longline fleets, Japan, Korea and Taiwan,China have started a collaborative study for improving the joint abundance index using integrated fishery data of these fleets for tropical tuna species in the Indian and Atlantic Oceans. In addition to some preliminary steps to confirm similarity and dissimilarity of fishery operation, nominal CPUE, length frequency and spatio-temporal coverage, we planned three tasks to produce the joint CPUE; 1) investigation of better approaches to account for changes in target within each country; 2) analyses using conventional regression models with geographical, environmental and fishery (including target) information; and 3) analysis using an advanced spatio-temporal model (e.g. VAST) for developing abundance indices with additional consideration of spatio-temporal correlations* (See paper for full abstract)*"*

63. The WPM **NOTED** the plan for conducting joint longline CPUE standardization for next year yellowfin stock assessment using the GLM approach used in previous stock assessment (e.g. continuity joint CPUE) as well as to explore using advance spatio-temporal models (e.g VAST) to improve standardization. The WPM also NOTED that the research is focused on investigating several methods to appraise targeting within each country.

64. The WPM **NOTED** that for, both yellowfin and bigeye, MSE different hypothesis of CPUE (e.g. targeting using cluster or hooks between floats) are needed to account for uncertainty related to CPUE standardization. Thus, the WPM REQUESTED that CPUE joint working group to develop and produce different CPUE series, using different methods for targeting and/or different standardization methods, to be included in yellowfin and bigeye OMs.

10. STOCK STATUS GUIDANCE

10.1 Review the approach used to provide stock status and management advice relative to reference points

65. The WPM **NOTED** paper IOTC–2020–WPM11–14 which provided guidance on defining stock status against conservation and management reference points with a global review for informing the process of status determination for key IOTC stocks. The following abstract was provided by the authors:

> "When providing advice on stock status relative to MSY-based reference points, stocks are currently considered to be overfished and subject to overfishing when the target MSY-based reference points are breached (i.e., SSB < SSBMSY anf F > FMSY). However, there is no further change to stock status when limit reference points are breached. This approach may not consistent with the intended application of target and limit reference points. For example, when managing stocks to MSY-based target reference points (the agreed/desired state of the stock) it is expected that the stock will fluctuate around that target, sometimes above and sometimes below, due to natural fluctuation in recruitment, stock abundance or other sources of variability (See paper for full abstract)"

66. The WPM **NOTED that** with regards to stock status determination, in the 2019 report of the TCMP stated:

> "The TCMP AGREED that progress on this issue should continue intersessionally within a small working group and be presented to relevant working groups throughout the year with final presentation to the TCMP in 2020. Terms of reference for this group are provided in Appendix VI. These deliberations could then be used to revise Resolution 15/10"

67. The WPM further **NOTED** that in accordance with the Terms of Reference provided in Appendix VI of the 2019 TCMP report, document IOTC–2020–WPM11–14 was drafted after consulting all focal points provided by CPCs and accredited observers, which constitute the membership of the *ad hoc* Reference Point Working Group.

68. The WPM **THANKED** the former SC chair, who was named as the convenor of this working group, for coordinating the development of this document and **AGREED** that it is a living document that should continue to be discussed and revised as required.

69. The WPM **DISCUSSED** whether it was appropriate to determine a stock's status as being overfished relative to the limit reference point rather than relative to the target reference point, or whether status should continue to be shown relative to Bmsy and Fmsy, or proxies thereof, to be more consistent with the IOTC Agreement. No clear agreement was reached on this point as there was concern that limit reference points may not be set at conservative levels and, therefore, only consider an overfished status once the stock is at a very low level. Moreover, current management framework triggers management action once the stock is overfished and, thus, it was noted that this could provide a confusing signal to managers so as to trigger management actions when stock is below limit reference points.

70. The WPM **SUGGESTED** that it may be more appropriate to present depletion-based reference points and presenting the stock status using alternative figures to the standard Kobe plots, such as Majuro plots.

71. Due to the concerns raised with a substantial change in how the stock status advice is provided to managers, the WPM **AGREED** that a good compromise would be to include in the standard Kobe plots (or any other plot) the stock status relative to limit reference points. As such, either Majuro or Kobe plots would indicate both target and limit reference points.

72. The WPM **REQUESTED** that for the SKJ assessment in 2020 the outcome of assessment would be presented as whether the stock is above or below the target reference point based on depletion levels, whether the stock is above or below B_{MSY} and F_{MSY} (so showing traditional overfished or overfishing status) and whether it is above or below the limit reference point. All of these will be presented alongside their associated probabilities.

73. The WPM **REQUESTED** that further meetings/correspondence of the ad hoc Reference Point Working Group take place to continue to address these important issues and provide advice to the 2021 TCMP meeting.

11. WPM PROGRAM OF WORK

11.1 Revision of the WPM Program of work (2021–2025)

74. The WPM **NOTED** paper IOTC–2020–WPM11–07 presenting the draft WPM Programme of Work (2021–2025).

75. The WPM **RECALLED** that the SC, at its 17th Session, made the following request to its working parties:

"*The SC **REQUESTED** that during the 2015 Working Party meetings, each group not only develop a Draft Program of Work for the next five years containing low, medium and high priority projects, but that all High Priority projects are ranked. The intention is that the SC would then be able to review the rankings and develop a consolidated list of the highest priority projects to meet the needs of the Commission. Where possible, budget estimates should be determined, as well as the identification of potential funding sources.*" (SC17, Para. 178)

76.   The WPM **REQUESTED** that the Chairperson and Vice-Chairperson of the WPM, in consultation with the IOTC Secretariat, develop Terms of Reference (ToR) for each of the projects detailed on the WPM Programme of Work (2021–2025) that are yet to be funded, for circulation to potential funding bodies.

77.   The WPM **RECOMMENDED** that the Scientific Committee consider and endorse the WPM Programme of Work (2021–2025), as provided in Appendix IV.

78.   The WPM reviewed the progress of the MSE work conducted to date, and subject to the comments held in this report, endorsed the MSE conducted thus far and **REQUESTED** additional work to address the reviewed comments made.

79.   The WPM **NOTED** that with regards to the schedule of work for the development of management procedures for key species in the IOTC Area, at the 22nd session of the SC, a revised schedule was presented

> *"(Para 87) The SC NOTED paper IOTC–2019–SC22–15 which provided an updated schedule of work for the development of management procedures for key species in the IOTC Area. The SC AGREED to the schedule of work (Appendix 6), noting it is a living document to provide an indicative timeframe to guide the IOTC MSE development and may subject to change. The SC ENCOURAGED the schedule to be resubmitted to TCMP and Commission for final endorsement."*

80.   The revised schedule from IOTC-2019-SC22-15 (Schedule of work for the development of management procedures for key species in the IOTC area) is provided in Appendix V, although it is still pending approval by the Commission.

12. OTHER BUSINESS

12.1 Date and place of the 12th and 13th sessions of the WPM

81.   The WPM **NOTED** that the global Covid-19 pandemic has complicated international travel and with no clear end to the pandemic in sight, it was not possible to finalise arrangements for the meeting in 2021. The Secretariat will continue to liaise with CPCs to determine their interest in hosting these meetings in the future when this becomes feasible. The WPM **RECOMMENDED** the SC consider mid October 2021 as a preferred time period to hold the WPM12 in 2021. As usual it was also **AGREED** that this meeting should continue to be held back-to-back with the WPTT, with the WPM taking place before the WPTT.

82.   The WPM also **NOTED** the informal MSE task force meeting to be held in 2021 should take place after its cancellation in 2020. If physical meetings are still not possible, this meeting should take place virtually. The WPM AGREED that this task force meeting is crucial for providing technical feedback to the TCMP.

12.2 Development of priorities for Invited Expert(s) at the next WPM meeting

83.   Given the importance of external peer review, the WPM **RECOMMENDED** that the Commission continues to allocate sufficient budget for a regular invited expert to be invited to meetings of the WPM.

84.   The WPM **AGREED** to the following core areas of expertise and priority areas for contribution that need to be enhanced for the next meeting of the WPM in 2021, by an Invited Expert(s):

- **Expertise**: Management Strategy Evaluation.

12.3 Review of the draft, and adoption of the Report of the 11th Session of the WPM

85.   The WPM **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPM11, provided in Appendix VI.

86.   The WPM **THANKED** the Chair for his excellent running of the meeting as well as his contributions to the intersessional work conducted to expedite the MSE of the Indian Ocean stocks.

87. The Chair **THANKED** the all the participants for their dedicated discussion during the session. The Chair also expressed his appreciation to the rapporteurs and Secretariat for their hard work.

88. The report of the 11th Session of the Working Party on Methods (IOTC–2020–WPM11–R) was **ADOPTED** via correspondence.

APPENDIX I
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APPENDIX **II**
MEETING **A**GENDA

Date: 14-15 October 2020
Location: Online
Venue: Microsoft Teams
Time: 12:00 – 16:00 (Seychelles time) daily
Chairperson: Dr. Hilario Murua; **Vice-Chairperson**: Daniela Rosa

1. **OPENING OF THE MEETING** (Chairperson)

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

3. **THE IOTC PROCESS: OUTCOMES, UPDATES AND PROGRESS**
   3.1   Outcomes of the 22nd Session of the Scientific Committee (IOTC Secretariat)
   3.2   Outcomes of the 23rd Session of the Commission (IOTC Secretariat)
   3.3   Review of Conservation and Management Measures relevant to the WPM (IOTC Secretariat)
   3.4   Progress on the recommendations of WPM10 (IOTC Secretariat and Chairperson)
   3.5   Review of intersessional meetings related to the IOTC MSE process (Chairperson)

4. **ALBACORE MSE: UPDATE** (Developers)
   4.1   Review of the progress on development new Operating Models based on 2019 ALB stock assessment
   4.2   Feedback on MSE/OM development
   4.3   Future steps and timeline

5. **SKIPJACK TUNA MSE: UPDATE** (Developers)
   5.1   Progress on the development of Skipjack MSE/MP
   5.2   Review of OM and MP development
   5.3   Discussion on MSE development
   5.4   Future steps and timeline

6. **BIGEYE TUNA AND YELLOWFIN TUNA MSE: UPDATE** (Developers)
   6.1   Review of Operating Models based on WPM, SC feedback, and latest stock assessment results
   6.2   Review of set of simulation runs and results
   6.3   Revision of Management Procedures and Indicators
   6.4   Evaluation of new set of Management Procedures

7. **SWORDFISH MSE: UPDATE** (Developers)
   7.1   Progress on the development of Swordfish MSE/MP
   7.2   Review the conditioning of Operating Models in relation to the new 2020 Stock assessment
   7.3   Discussion on MSE development

8. **GENERAL MSE ISSUES** (Chairperson and Vice-chairperson)
   8.1   General discussion
   8.2   Consideration of reconditioning OMs based on recent stock assessments
   8.3   Consideration of Exceptional Circumstances
   8.4   Internal and External Peer review

9. **JOINT CPUE STANDARDISATION (**Chairperson and Consultant)
   9.1   Update on the development of the joint CPUE indices for 2020 & 2021.
   9.2   Future workplan

10. STOCK STATUS GUIDANCE (Chairperson and Vice-chairperson)

    10.1   Review the approach used to provide stock status and management advice relative to reference points

11. WPM PROGRAM OF WORK (Chairperson and IOTC Secretariat)

    11.1   Revision of the WPM Program of Work (2021–2025)

12. OTHER BUSINESS

    12.1   Date and place of the 12th and 13th Sessions of the WPM (Chairperson and IOTC Secretariat)

    12.2   Development of priorities for Invited Expert(s) at the next WPM meeting (Chairperson)

    12.3   Review of the draft, and adoption of the Report of the 11th Session of the WPM (Chairperson)

APPENDIX III
LIST OF DOCUMENTS

Document	Title
IOTC–2020–WPM11–01a	Agenda of the 11th Working Party on Methods
IOTC–2020–WPM11–01b	Annotated agenda of the 11th Working Party on Methods
IOTC–2020–WPM11–02	List of documents of the 11th Working Party on Methods
IOTC–2020–WPM11–03	Outcomes of the 22nd Session of the Scientific Committee (IOTC Secretariat)
IOTC–2020–WPM11–04	Outcomes of the 23rd Session of the Commission (IOTC Secretariat)
IOTC–2020–WPM11–05	Review of Conservation and Management Measures relating to methods (IOTC Secretariat)
IOTC–2020–WPM11–06	Progress made on the recommendations and requests of WPM10 and SC22 (IOTC Secretariat)
IOTC–2020–WPM11–07	Revision of the WPM Program of Work (2020–2024) (IOTC Secretariat & Chairpersons)
IOTC–2020–WPM11–08	Update of the Indian Ocean albacore Operating Model (Mosqueira I)
IOTC–2020–WPM11–09	Applications of a Bayesian biomass dynamic model to Indian Ocean Skipjack Tuna (Edwards C)
IOTC–2020–WPM11–10	Developments toward an MSE framework for Indian Ocean skipjack tuna using Stock Synthesis III (Edwards C)
IOTC–2020–WPM11–11	Indian Ocean Bigeye Tuna Management Procedure Evaluation Update March 2020 (Kolody D, Jumppanen P and Day J)
IOTC–2020–WPM11–12	Indian Ocean Yellowfin Tuna Management Procedure Evaluation Update April 2020 (Kolody D, Day J and Jumppanen P)
IOTC–2020–WPM11–13	A candidate Management Procedure based on a Joint Process and Observation Error Random Effects Production Model (Kolody D and Jumppanen P)
IOTC–2020–WPM11–14	Definition of stock status against conservation and management reference points: a global review informing IOTC case. (Anon.)
IOTC–2020–WPM11–INF01	Glossary of terms for harvest strategies, management procedures and management strategy evaluation (Anon)
IOTC–2020–WPM11–INF02	Report of the 8th Workshop on MSE of the IOTC Working Party on Methods (Anon)

APPENDIX IV
WORKING PARTY ON METHODS PROGRAM OF WORK (2021–2025)

The Program of Work consists of the following, noting that a timeline for implementation would be developed by the SC once it has agreed to the priority projects across all of its Working Parties:

Table 1. Priority topics for obtaining the information necessary to deliver the necessary advice to the Commission. Resolution 15/10 elements have been incorporated as required by the Commission.

Topic	Sub-topic and project	Timing				
		2021	2022	2023	2024	2025
1. Management Strategy Evaluation	Continuation of Management Strategy Evaluation for Albacore, Skipjack, Yellowfin, Bigeye tunas as well as Swordfish					
Future Research Requirements (not in order of priority)						
Management Strategy Evaluation	1.1 Albacore					
	1.1.1 Revision of Operating Models based on WPM and SC feedback, including possible robustness tests					
	1.1.2 Implementation of initial set of simulation runs and results					
	1.1.3 Revision of Management Procedures and Indicators after presentation of initial set to TCMP and Commission					
	1.1.4 External peer review (2022 or date TBD)					
	1.1.5 Evaluation of new set of Management Procedures (if required)					
	1.2 Skipjack tuna					

Task					
1.2.1 Revision and adaptation of framework for simulation evaluations of MPs. Moving from HCR to fully specified MP.	▓	▓	▓	▓	
1.2.2 Develop revised production model for inclusion in simulation framework	▓	▓	▓	▓	
1.2.3 Condition OM on updated assessment model from 2020.	▓	▓	▓	▓	
1.2.4 Revision of Management Procedures and Indicators after presentation of initial set to TCMP and Commission	▓	▓	▓	▓	
1.3 Bigeye tuna					
1.3.1 Update OM & present preliminary MP results to TCMP, WPTT/WPM review of new OM	▓				
1.3.2 External peer review (2021 or date TBC)	▓	▓	▓		
1.3.3 Present revised MP results to TCMP with target adoption date of 2022		▓	▓		
1.3.4 Additional iterations if required		▓	▓		
1.4 Yellowfin tuna					
1.4.1 Update OM & present preliminary MP results to TCMP, WPTT/WPM review of new OM	▓				
1.4.2 External peer review (2020 or date TBD)	▓	▓			
1.4.3 Present revised MP results to TCMP with target adoption date of 2021; iteratively update development if required)		▓			
1.4.4 additional iterations if required			▓	▓	
1.5 Swordfish					
1.5.1 Initial OM	▓	▓	▓	▓	▓
1.5.2 Conditioning and OM set up	▓	▓	▓	▓	▓

	1.5.3	Generic MP tests				
	1.5.4	Final Model with MPs				
	1.5.5	External peer review				
Multiple stock status derived from different model structures	3.1 Develop specific guidance for the most appropriate models to be used or how to synthesize the results when multiple stock assessment models are presented. (*see IOTC-2016-WPTT18-R, para.91*)					
Presentation of stock status advice for data limited stocks	2.1 Explore potential methods of presenting stock status advice to managers from a range of data limited scenarios, e.g. through the development of a 'Tier' approach for providing stock status advice, based on the type of indictors used to determine stock status (e.g. CPUE series, stock assessment model)					

APPENDIX V

PROPOSED SCHEDULE OF WORK FOR THE DEVELOPMENT OF MANAGEMENT PROCEDURES FOR KEY SPECIES IN THE IOTC AREA.

Year	Albacore	Skipjack	Yellowfin	Bigeye	Swordfish
2020	**WPs/SC**: Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs.	**WPs/SC**: Apply harvest control rule (HCR) using results from 2020 stock assessment to calculate total annual catch limit. (Secretariat to advise CPCs of catch limit.) Extend the HCR to develop full candidate MPs and undertake MSE to provide advice on the performance of candidate MPs.	**WPs/SC**: Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs.	**WPs/SC**: Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs.	**WPs/SC**: Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs.
2021	**TCMP**: Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.	**TCMP**: Provide advice to the Commission on outcomes from the application of the HCR. Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.	**TCMP**: Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.	**TCMP**: Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.	**TCMP**: Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.
	Commission: Consider work and advice from subsidiary bodies. Decision and adoption of an MP <u>or</u> provide direction to the WPs/SC on the need for further MSE of candidate or alternative MPs. **WPs/SC**:	**Commission**: Consider work and advice from subsidiary bodies. Decision and adoption of an MP <u>or</u> provide direction to the WPs/SC on the need for further MSE of candidate or alternative MPs. **WPs/SC**:	**Commission**: Consider work and advice from subsidiary bodies. Decision and adoption of an MP.	**Commission**: Consider work and advice from subsidiary bodies. Decision and adoption of an MP <u>or</u> provide direction to the WPs/SC on the need to undertake further MSE of candidate or alternative MPs. **WPs/SC**:	**Commission**: Consider work and advice from subsidiary bodies and provide direction to the WPs/SC on the need to undertake further MSE of candidate or alternative MPs. **WPs/SC**:

	Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs.	Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs.		Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs.	Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs.
2022	**TCMP**: Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.	**TCMP**: Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.		**TCMP**: Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.	**TCMP**: Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.
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	WPs/SC: Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs.	**WPs/SC**: Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs.			**WPs/SC**: Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs.
2023	**TCMP**: Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives. **Commission**:	**TCMP**: Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives. **Commission**:			**TCMP**: Provide advice to the Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives. **Commission**:

Consider work and advice from subsidiary bodies. Decision and adoption of an MP.	Consider work and advice from subsidiary bodies. Decision and adoption of an MP.			Consider work and advice from subsidiary bodies. Decision and adoption of an MP or provide direction to the WPs/SC on the need for further MSE of candidate or alternative MPs.
				WPs/SC: Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs,

APPENDIX VI

CONSOLIDATED RECOMMENDATIONS OF THE 11TH SESSION OF THE WORKING PARTY ON METHODS

Note: Appendix references refer to the Report of the 11th Session of the Working Party on Methods (IOTC–2020–WPM11–R)

Revision of the WPM Program of work (2021–2025)

WPM11.01: The WPM **RECOMMENDED** that the Scientific Committee consider and endorse the WPM Programme of Work (2021–2025), as provided in Appendix IV (para. 77).

Date and place of the 12th and 13th sessions of the WPM

WPM11.02: The WPM **NOTED** that the global Covid-19 pandemic has resulted in international travel being almost impossible and with no clear end to the pandemic in sight, it was impossible to finalise arrangements for the meeting in 2021. The Secretariat will continue to liaise with CPCs to determine their interest in hosting these meetings in the future when this once again becomes feasible. The WPM **RECOMMENDED** the SC consider mid October 2021 as a preferred time period to hold the WPM12 in 2021. As usual it was also **AGREED** that this meeting should continue to be held back-to-back with the WPTT, with the WPM taking place before the WPTT (Para. 81)

Development of priorities for Invited Expert(s) at the next WPM meeting

WPM11.03: Given the importance of external peer review, the WPM **RECOMMENDED** that the Commission continues to allocate sufficient budget for a regular invited expert to be invited to meetings of the WPM (para. 83).

Review of the draft, and adoption of the Report of the 11th Session of the WPM

WPM10.04: The WPM **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPM11, provided in Appendix VI (para. 85).