Report of the 9th Session of the IOTC Working Party on Methods

Eden Island, Seychelles, 25-27 October 2018

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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 9th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Methods (WPM) was held in Eden Island, Seychelles 25–27 October 2018. A total of 23 participants (28 in 2017, 29 in 2016, 26 in 2015) attended the Session. The list of participants is provided in Appendix I. The meeting was opened by the Chairperson, Dr Toshihide Kitakado (Japan) who welcomed participants to Seychelles. Dr Rishi Sharma was welcomed as the Invited Expert.

The following are a subset of the complete recommendations from the WPM09 to the Scientific Committee, which are provided in Appendix V.

Albacore MSE: Update

The WPM **NOTED** that there would be a new assessment in 2019 and, therefore, in case that 2019 assessment result are different from the envelope of the OM grid, the OM may need to be reconditioned to 2019 stock assessment. For example, if the resulting stock assessment results are within the central 50 % of the OM distribution there would not need to recondition the OM, however, if the results are within the extreme bounds of the OM this may require to recondition the OM for ALB. The WPM noted that this is linked to the definition of the "Exceptional Circumstances" and, thus, the WPM **RECOMMENDED** that this is discussed in the Scientific Committee. If reconditioning is required or additional uncertainty dimensions are added the developers should consider using partially confounded factorial design to reduce the computational overhead (para.16).

Skipjack tuna MSE: Update

WPM also **NOTED** that the SKJ 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. Hence the WPM **SUGGESTED** that the review and potential revision required under Res 16/02 be conducted with the aim of fully determining an MP for SKJ, should the Commission desire. The WPM **RECOMMENDED** feedback from TCMP be sought on these issues, considering the future MSE guidelines agreed by the Commission.

The WPM **CONSIDERED** that currently available resources are not sufficient for the required review and possible revision called for under RES 16/02 and **RECOMMENDED** that WPTT and SC develop an appropriate workplan and budget for this work.

Bigeye and yellowfin tuna MSE

The WPM **RECOMMENDED** exploring partially-confounded experimental design as a computationally tractable method for expanding the number of uncertainty dimensions and the main interactions (at the expense of losing higher order interactions). It should be adopted if it is not found to have a significant reduction in full grid uncertainty.

Joint CPUE Standardisations

The WPM **NOTED** that YFT assessment results are sensitive to the target variable in the standardization and **AGREED** that it is important to examine the target effects thoroughly. The WPM **RECOMMENDED** further joint CPUE analysis should continue to explore and test alternative methods for identifying and accounting for targeting.

The WPM congratulated the authors of WPM09-12 and WPM09-13 which are responsive to prior recommendations made by WPM and SC. It was again noted that the process has greatly improved the ability of the SC to provide management advice to the Commission. Unfortunately, the lack of access to the operational level longline CPUE, except during the limited time available for joint meetings between authors, greatly reduces the efficiency of the process and limits the degree of capacity building for participating scientists, because these data are only available for analysis and quality assurance for a limited time. In the interest of normalizing the process for producing joint longline CPUE for future assessments, the WPM again **RECOMMENDED** that the Secretariat continue discussions with the affected CPCs to develop a confidential operational LL data repository at the IOTC that would permit more detailed evaluation of these data as well as assuring the confidential nature of the information. The WPM also **REQUESTED** that these meetings are also open to any interested scientists to participate in the discussions held, although the data will remain confidential and accessed only by pre-agreed experts.

Stock Status Guidance

The WPM **RECOGNIZING** that such a definition does not imply that no management action should take place until after a stock breaches the biomass limit, the WPM **RECOMMENDED** considering alternative formulations to indicate an appropriate buffer zone below BMSY to account for natural variations in biomass (for example, using the figures below). As such, WPM **REQUESTED** that this topic be considered by other WPs and subsequently by the SC when formulating the scientific management advice to the Commission. Ideally this type of modified display should be coordinated with other tRFMOs through a KOBE process.

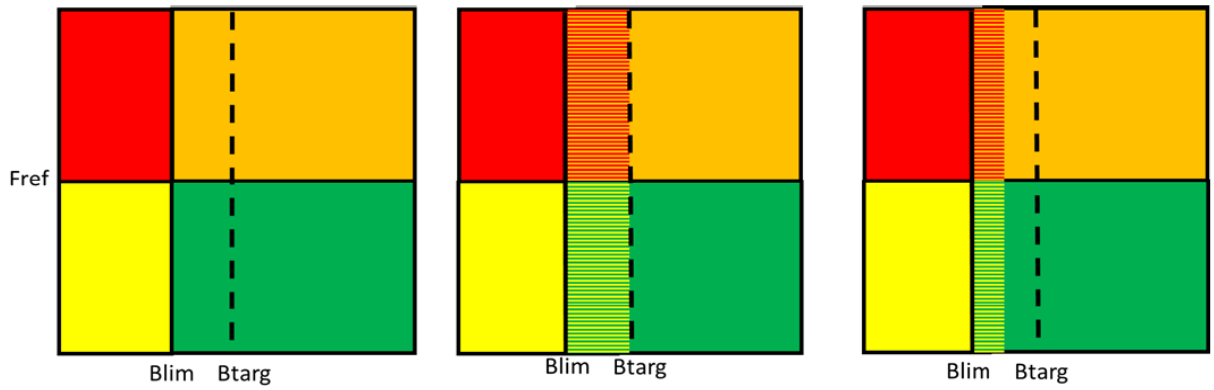

Figure 1. Three examples of modified Kobe Plots in which there is a target biomass, Btarg, and a reference F (Fref) such as FMSY. In each plot. The red quadrant is based on biomass being below the limit (Blim) rather than below a target biomass. The plot in the middle retains the four colours, but contains red-orange and yellow-green "buffer zones" between the target and limit. In the plot on the right, the buffer zone starts somewhat below the target biomass to account for natural fluctuations of the stock around the target. Note: This figure is from the ISSF Stock Assessment Workshop report (IOTC-2018-WPM09-INF06). It is not the recommendation of the WPM.

Revision of the WPM Program of work (2019–2023)

WPM09.09: 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 **RECOMMENDED** additional work to address the reviewed comments made (para. 91).

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

WPM09.10: 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. The WPM **NOTED** the difficulty in adequately funding through the Commission budget, work in support of the TCMP, which, in part, relates to the timing of the SCAF and TCMP meetings. WPM **RECOMMENDS** that the budgetary needs to support these activities be considered during the next SCAF meeting (para. 97).

1. OPENING OF THE MEETING

1. The 9th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Methods (WPM) was held at the Eden Bleu Hotel, Seychelles 25–27 October 2018. A total of 23 participants (28 in 2017, 29 in 2016, 26 in 2015) attended the Session. The list of participants is provided in Appendix I. The meeting was opened by the Chairperson, Dr Toshihide Kitakado (Japan) who welcomed participants to Seychelles. Dr Rishi Sharma was welcomed as the Invited Expert.

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 WPM09 are listed in Appendix III.

3. THE IOTC PROCESS: OUTCOMES, UPDATES AND PROGRESS

3.1 Outcomes of the 20th Session of the Scientific Committee

3. The WPM **NOTED** paper IOTC–2018–WPM09–03 which outlined the main outcomes of the 20th Session of the Scientific Committee (SC20), specifically related to the work of the WPM.

4. The WPM **NOTED** that in 2017, the SC made a number of endorsements and recommendations in relation to the WPM08 report. These are provided below for reference

- ***Presentation and evaluation of MSE results***
    - *The SC **ENDORSED** the proposed revisions to the standardised protocol for the presentation of MSE results (Appendix VIb). This should still be considered a living document that will benefit from revision based upon feedback received from the TCMP.*
- ***Update on the status of the joint CPUE indices (yellowfin tuna, bigeye tuna & albacore)***
    - *The SC recognised the importance of normalizing these procedures and approaches into the various Working Party stock assessments making use of longline catch rate indices, **ENDORSED s**uch joint analyses, and **RECOMMENDED** these continue into the future as a normal course of business. It was noted that additional time for more detailed analysis is still needed and SC **REQUESTED** that methods to increase analysis time, such as the use of secure, cloud-based data exchange and increased use of electronic communication between analysts be investigated.*
    - *The SC congratulated the WPM for the investigation of catchability/selectivity changes and spatial size patterns of bigeye and yellowfin tuna in the early years of the Japanese longline fishery and **AGREED** that this work is important in terms of improving understanding of the trends in CPUE. Noting that various issues have been identified that could be explored further, the SC **RECOMMENDED** that this work is continued.*
- ***Priorities for future development of the joint CPUE indices***
    - *The SC noted that a substantial amount of work has already been completed for the tropical tunas and that it may be more worthwhile to focus on some other species for which this approach would be useful. The SC therefore **RECOMMENDED** that a similar joint analysis approach is explored for key IOTC billfish and shark species.*
- ***Presentation of stock status advice for data limited stocks***
    - *The SC **AGREED** that work on the presentation of stock status advice for data limited stocks will need to be carried out inter-sessionally, and that this will require some level of preparation and planning. The SC **REQUESTED** the WPM Chairperson liaise with the Chairs of the species WPs (WPNT and WPB) in order to draft a study proposal on this issue and **RECOMMENDED** the Commission allocates funding to this project.*

3.2 Outcomes of the 22nd Session of the Commission

5. The WPM **NOTED** paper IOTC–2018–WPM09–04 which outlined the main outcomes of the 22nd Session of the Commission, specifically related to the work of 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.

6. The WPM **NOTED** the 10 Conservation and Management Measures (CMMs) adopted at the 22nd Session of the Commission (consisting of 10 Resolutions and 0 Recommendations) as listed below:

IOTC Resolutions

- Resolution 18/01 *On an interim plan for rebuilding the Indian Ocean yellowfin tuna stock in the IOTC Area of Competence*
- Resolution 18/02 *On management measures for the conservation of blue shark caught in association with IOTC fisheries*
- Resolution 18/03 *On establishing a list of vessels presumed to have carried out illegal, unreported and unregulated fishing in the IOTC Area of Competence*
- Resolution 18/04 *On bioFAD experimental project*
- Resolution 18/05 *On management measures for the conservation for the conservation of billfish, striped marlin, black marlin, blue marlin and Indo-Pacific sailfish*
- Resolution 18/06 *On establishing a programme for transhipment by large-scale fishing vessels*
- Resolution 18/07 *On measures applicable in case of non-fulfilment of reporting obligations in the IOTC*
- Resolution 18/08 *Procedures on a fish aggregating devices (FADs) management plan, including a limitation on the number of FADs, more detailed specifications of catch reporting from FAD sets, and the development of improved fad design to reduce the incidence of entanglement of non-target species*
- Resolution 18/09 *On a scoping study of socio-economic indicators of IOTC fisheries*
- Resolution 18/10 *On vessel chartering in the IOTC Area of Competence.*

7. The WPM **NOTED** that these Conservation and Management Measures shall become binding on Members 120 days from the date of the notification communicated by the IOTC Secretariat in IOTC Circular 2018–026 (i.e. 4 October 2018)[1].

8. The WPM **NOTED** that the Commission also made a number of general comments and requests regarding the recommendations made by the Scientific Committee in 2017, which have relevance for the WPM (details as follows: paragraph numbers refer to the report of the Commission IOTC–2018–S22–R).

- ***On the status of billfish***
  - *(Para 50): The Commission **NOTED** that, in accordance with the MSE work program endorsed at the 21st Session of the Commission, the swordfish MSE was initiated in 2017.*
- ***Report of the 2nd Session of the Technical Committee on Management Procedures (TCMP02)***
  - *(Para 74): The Commission **NOTED** that the Harvest Control Rule was implemented for skipjack tuna through Resolution 16/02 and **ENCOURAGED** CPCs to begin to develop management proposals for other IOTC species that are based on TCMP outputs and advice once the results of the current MSE analyses are reviewed and endorsed. .*

3.3 Review of Conservation and Management Measures relevant to the WPM

9. The WPM **NOTED** paper IOTC–2018–WPM09–05 which aimed to encourage participants at the WPM09 to review some of the existing Conservation and Management Measures (CMM) relevant to the WPM, noting the CMMs referred to in document IOTC–2018–WPM09–04, 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 WPM08

10. The WPM **NOTED** paper IOTC–2018–WPM09–06 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 WPM09 as appropriate given any progress.

[1] As per Article IX.4 of the IOTC Agreement

3.5 Review of intersessional meetings related to the IOTC MSE process

11. The WPM **NOTED** the presentation of the report of the 7th MSE workshop of IOTC WPM scientists that took place in Portugal from 13-16 March 2018 (IOTC–2018–WPM09–INF03).

12. The WPM **THANKED** the participants of this workshop for their informative discussions on the technical aspects of MSE and related topics The WPM **NOTED** the need to hold a further *ad hoc* meeting of this group to prepare materials for TCMP03 in advance of the TCMP meeting in 2019. The WPM **AGREED** that the timing and location of this meeting will be further discussed and refined in advance of the SC21 meeting. The WPM **STRESSED** that the ad hoc meeting only address issues requested by the SC as it was noted that the outcomes of this meeting will be presented directly to the TCMP without the results having been discussed by the SC. This is not the usual procedure for presenting scientific outputs to bodies of the Commission.

4. ALBACORE MSE: UPDATE

13. The WPM **NOTED** paper IOTC–2018–WPM09–08 had been withdrawn by the author as the analysis had not been completed in time for presentation to the WPM. It was clarified, however, that this analysis would be made available to the Scientific Committee meeting in 2018 and discussions regarding the outcomes could be conducted at that stage.

14. The WPM noted the development of a complete grid of OMs (1,440 conditioning models) for albacore based around the 2016 stock assessment, with data up to 2014. The WPM **NOTED** the description of the process being used to select the final conditioning models to be included in the final reference case OM using (i) convergence criteria, (ii) selecting conditioning models that are able to explain the 2015-2017 nominal catches, but (iii) do so without large increase in fishing mortality (=< 50 %). This leaves a reference set OM of around 500 conditioning models. The WPM **NOTED** that the selected final conditional models are biased in favour of those assuming a double normal selectivity of the longline fleet, but very few conditioning models including the usually expected longline logistic selectivity.

15. The WPM **NOTED** the workplan of the albacore MSE will now focus on testing both model-based and CPUE-based MPs to achieve the 4 tuning criteria [SSB(2019-2038) >= SSBmsy with 50%probability, and the probability of being in green (2019-2038) equal to 50, 60 and 70 %] agreed by the 2nd Technical Committee on Management Procedure (TCMP). The WPM also noted that Pella-Tomlinson production shape will be considered as a parameter in the MP, as for bigeye and yellowfin, and that different value for the Pella-Tomlinson shape parameter will be tested. The WPM also noted that some robustness tests reflecting scenarios of recruitment failure and CPUE bias will be explored.

16. The WPM **NOTED** that there would be a new assessment in 2019 and, therefore, in case that 2019 assessment result are different from the envelope of the OM grid, the OM may need to be reconditioned to 2019 stock assessment. For example, if the resulting stock assessment results are within the central 50 % of the OM distribution there would not need to recondition the OM, however, if the results are within the extreme bounds of the OM this may require to recondition the OM for ALB. The WPM noted that this is linked to the definition of the "Exceptional Circumstances" and, thus, the WPM **RECOMMENDED** that this is discussed in the Scientific Committee. If reconditioning is required or additional uncertainty dimensions are added the developers should consider using partially confounded factorial design to reduce the computational overhead.

17. The WPM **FURTHER NOTED** that a study on ALB growth is being conducted in Indian Ocean and should be available in 2019. This will provide Indian Ocean specific growth parameters, which may affect the assessment results. This ongoing study, as well as the initiative to develop joint CPUE analysis may need to be taken into account in future OM conditioning should they prove to be influential on the assessment results or incorporated in robustness trials.

5. SKIPJACK TUNA MSE: UPDATE

18. The WPM **REVIEWED** the current status of the Skipjack MSE and subsequent Harvest Control Rule (HCR) adopted by the Commission (Res 16/02). The WPM **NOTED** that the first iteration of the HCR was implemented in 2018 subsequent to the 2017 Skipjack Stock Assessment and a TAC was established for 2018-2020. WPM further **NOTED** that Res 16/02 required review and, if necessary, revisions to the HCR by 2021.

19. The WPM **CONSIDERED** that the review and possible revision of the SKJ HCR will need to consider if the outcome of the 2017 assessment, which was appreciably less optimistic than the OM grid used for testing robustness of the HCR, might represent an exceptional circumstance that should be evaluated further.

20. WPM also **NOTED** that the SKJ 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. Hence the WPM **SUGGESTED** that the review and potential revision required under Res 16/02 be conducted with the aim of fully determining an MP for SKJ, should the Commission desire. The WPM **RECOMMENDED** feedback from TCMP be sought on these issues, considering the future MSE guidelines agreed by the Commission.

21. The WPM **CONSIDERED** that currently available resources are not sufficient for the required review and possible revision called for under RES 16/02 and **RECOMMENDED** that WPTT and SC develop an appropriate workplan and budget for this work.

6. BIGEYE TUNA AND YELLOWFIN TUNA MSE: UPDATE

6.1 Review of Operating Models based on WPM and SC feedback, including possible robustness tests

22. The WP **NOTED** that the MSE for both species is being pursued in the strict sense of MP in which the MP consists of simulation-tested combination of data collection, analysis methods and HCR (which makes this work different to the SKJ assessment, where no specification on data and analyses methods was made)

Bigeye tuna

23. The WPM **NOTED** paper IOTC–2018–WPM09–09 which provided an update on the IOTC Bigeye Tuna MSE Operating Model Development. The following abstract was provided by the authors:

> *"This paper summarizes progress on the development of Operating Models (OMs) for IOTC bigeye (BET) tuna. Additional background detail on recent software developments is provided in the yellowfin (YFT) companion paper (Kolody and Jumppanen 2018f). MP evaluation updates for BET and YFT are described in Kolody and Jumppanen (2018a). This paper builds on the work presented and reviewed at the IOTC informal MSE Working Group in March 2018 (Kolody and Jumppanen 2018d,e), and represents the first time that the formal IOTC WPTT and WPM have the opportunity to review the substantial BET OM developments since the phase 1 work was completed in 2016. (See paper for full abstract):*

24. The WPM **SUGGESTED** the following changes to the reference case OM grid, and expected that the WPTT would refine these recommendations:

- CPUE variability set to a level that would result in an annual CV of 0.2 (retaining auto-correlation of 0.5)
- Extend bridging catches, with first TAC in 2021
- Additional uncertainty dimensions:
    i. alternative growth function (noting the large effect on the recent WCPFC bigeye assessment). WPTT was asked to review and specify the most appropriate alternative. This could be a robustness scenario.
    ii. alternative regional CPUE scaling factors. Specific scenarios will be proposed by the CPUE consultant.
    iii. alternative historical catch series. Proposals were discussed, but the options were thought to either not represent a large change from the preferred series, or were difficult to justify as plausible.

25. The WPM **RECOMMENDED** exploring partially-confounded experimental design as a computationally tractable method for expanding the number of uncertainty dimensions and the main interactions (at the expense of losing higher order interactions). It should be adopted if if it is not found to have a significant reduction in full grid uncertainty.

26. The WPM **SUGGESTED** the following priorities for robustness scenarios:

- Annual aggregated CPUE CV = 0.3 (auto-correlation = 0.5) in the projections only. [High priority]
- 10% reported over-catch (projections only; reference case conditioning) [High priority]
- 10% unreported over-catch (projections only; reference case conditioning) [High priority]
- 2% and 3% LL catchability trend (projections only; reference case conditioning) [High priority]
- Non stationary M, linf and K in the projections. [Low priority]

And the WPM discussed that Stock Structure (based on ongoing IO stock structure project) will guide Spatial Structure- possibly additional area around eastern INDONESIA, another in the Bay of Bengal Region and the area around Oman (other area stratification as is).

27. The WPM **NOTED** that some of these robustness tests should be considered long-term ambitions, which would require more specific definitions and input from the secretariat and external parties, and would likely delay the current development timeline.

28. The WPM **NOTED** that some of the effects tested separately in the Robustness scenarios could eventually happen simultaneously and at least some scenarios should consider these effects in combination (e.g. catch misreporting and recruitment failure in the same simulation). However, it was further noted that an MP cannot be expected to handle every adverse situation and "exceptional circumstances" procedures are applicable in the worst cases.

Yellowfin tuna

29. The WPM **NOTED** paper IOTC–2018–WPM09–10 which provided an update on the IOTC Yellowfin Tuna Operating Model Development. The following abstract was provided by the authors:

> *"This paper summarizes progress on the development of Operating Models (OMs) for IOTC yellowfin (YFT) tuna. MP evaluation updates for yellowfin and bigeye tunas are described in Kolody and Jumppanen (2018a). This paper builds on the work presented and reviewed at the IOTC informal MSE Working Group in March 2018 (Kolody and Jumppanen 2018d,e).*
>
> *The latest version of the MSE software is publicly available from github, with a recently updated technical description and user manual (https://github.com/pjumppanen/niMSE-IO-BET-YFT/).The BET and YFT MSE projection software has undergone several changes in the past year, with a substantial rewrite to improve memory usage and parallel processing, which greatly improves MP evaluation speed. Most of these changes to the computational engine are not visible to the end user. (See paper for full abstract):"*

30. The WPM **NOTED** the high uncertainty and large number of implausible models in the uniformly weighted grid of the YFT Reference set OMs. It was recognised that the proposed approach of sampling the uniform grid with respect to the central tendency of the assessment was not ideal, but represented a pragmatic path forward.

31. The WPM **DISCUSSED** the alternative option of filtering plausible models in relation to habitat constraints as was used for albacore, and noted the following disadvantages in this case:

    - It is not obvious that a meta-analysis of the productivity of 3 or 4 other YFT populations would provide more valuable insight about productivity than the arguments employed within the IOTC assessment process.
    - The YFT MSY distribution forms a long-tailed continuum, unlike the disjointed polymodal distribution for ALB
    - Unlike ALB, the YFT distribution also had many models that were implausibly unproductive (not only over-productive)

32. The WPM **SUGGESTED** the following changes to the YFT reference set OM grid, and expected that the WPTT would refine these recommendations, particularly with respect to insights from the new YFT assessment:

    - CPUE variability set to a level that would result in an annual CV of 0.2 (retaining auto-correlation of 0.5)
    - Extend bridging catches, with first TAC in 2021
    - Additional uncertainty dimensions:
        i. alternative growth function (noting the large effect on the recent WCPFC bigeye assessment). WPTT will be asked to review and specify the most appropriate alternative. This could be a robustness scenario.
        ii. alternative regional CPUE scaling factors Specific scenarios will be proposed by the CPUE consultant.
        iii. alternative historical catch series. Proposals were discussed, but the options were thought to either not represent a large change from the preferred series, or were difficult to justify as plausible.
        iv. It was noted that a new YFT catch data series will be discussed for the assessment at the WPTT, which is probably appropriate for the OM as well

- Sample the OM grid using the bi-variate sampling approach (sampling with respect to the central tendency of MSE and SB(current)/SB(MSY), but with variance assumptions that are compatible with the distributional characteristics of the BET grid (for consistency)

33. The WPM **RECOMMENDED** exploring partially-confounded experimental design as a computationally tractable method for expanding the number of uncertainty dimensions and the main interactions (at the expense of losing higher order interactions). It should be adopted if if it is not found to have a significant reduction in full grid uncertainty.

34. The WP **SUGGESTED** the following priorities for robustness scenarios:

- Annual aggregated CPUE CV = 0.3 (auto-correlation = 0.5) (projections only) [High priority]
- 10% reported over-catch (projections only) [High priority]
- 10% unreported over-catch (projections only) [High priority]
- 2%, 3% LL catchability trend (projections only) [High priority]
- dome-shaped longline selectivity (noting potential for interaction with M and growth) (conditioning and projections) [Low priority]
- Recruitment shock (projections only) [High priority]
- Ricker recruitment (conditioning and projections) [Low priority]

35. The WPM **NOTED** that some of these robustness tests should be considered long-term ambitions, which would require more specific definitions and input from the secretariat and external parties, and would likely delay the current development timeline.

36. The WPM **NOTED** that some of the effects tested separately in the Robustness scenarios could eventually happen simultaneously and at least some scenarios should consider these effects in combination (e.g. catch misreporting and recruitment failure in the same simulation). However, it was further noted that an MP cannot be expected to handle every adverse situation and "exceptional circumstances" procedures are applicable in the worst cases

37. The WPM **NOTED** that alternative MP tuning levels should be added to increase contrast to the results for the TCMP03.

38. The WPM **NOTED** that funding to continue this work to December 2019 has been identified from the Common Oceans ABNJ tuna project and CSIRO but not confirmed. No source of funding beyond 2019 has been identified.

6.2 Revision of Management Procedures and Indicators

39. The WPM **NOTED** paper IOTC–2018–WPM09–11 which provided an update on the IOTC Bigeye and Yellowfin Management Procedure Evaluation. The following abstract was provided by the authors:

> *"This document presents MP evaluation results for bigeye and yellowfin tunas, using the new operating models (OMs) proposed in Kolody and Jumppanen (2018a, b) and the new tuning levels requested by TCMP (2018). The results of various robustness scenarios are included, at this point largely to help facilitate the discussion of their role in the MP development and selection process and how they should be presented to the TCMP."*

40. The WPM **NOTED** that this paper was presented in conjunction with the previous two papers and so the comments provided above apply to this document as well.

7. SWORDFISH MSE: UPDATE

7.1 Conditioning of operating models

41. The WPM **NOTED** the summary provided by the chair regarding the progress on the Swordfish MSE to date. This included a presentation on the grid of uncertainties in the OM parameters which are mostly based on the 2017 WPM recommendations. It was **NOTED** that 1,296 conditioning models were identified based on previous WPM recommendations, of which 864 have already been carried out although one of the natural mortality options, and the alternative selectivity scenario, are yet to be implemented

42. The WPM **NOTED** the distribution of estimates for virgin biomass in the current OM grid are concentrated, in decreasing numbers, around three values. These groupings originate from the combination of two elements in the grid, the scaling by area of the CPUEs and the CPUE used, sometimes helped by the choice of catchability

hypothesis. This is problematic as starting from those large abundances naturally leads to stocks that remain at very close to virgin levels, despite the long history of exploitation.

43. The WPM **ACKNOWLEDGED** the observation that the final grid of runs should not include those runs starting from biomasses above a certain level, still to be determined, as they will not provide a useful testing ground on which to test management procedures for the Indian Ocean swordfish stock. For testing purposes a filter was applied on those runs were virgin biomass is greater than 1.5 Mt resulting in 576 conditioning models remaining after the filter is applied.

44. The WPM **NOTED** a workshop is planned to be held at the EC JRC in Ipsra, Italy from the 5th to 8th November with the objectives to i) Evaluate the OM grid; ii) Identify implausible model runs through diagnostics; iii) Tuning and determining the final operating model configuration and iv) Testing of generic candidate management procedures (MPs). In addition ongoing future objectives are being planned for 2019/2020, namely the development of evaluation MPs and consideration of an independent review of the MSE (pending funding).

45. If reconditioning is required or additional uncertainty dimensions are added the developers should consider using partially confounded factorial design to reduce the computational overhead.

8. JOINT CPUE STANDARDISATION

8.1 Update on the status of the joint CPUE indices (yellowfin tuna, albacore).

46. The WPM **NOTED** paper IOTC–2018–WPM09–12 which reported on a collaborative study of yellowfin tuna CPUE from multiple Indian Ocean longline fleets in 2018. The following abstract was provided by the authors:

> *"In May and June 2018 a collaborative study was conducted between national scientists with expertise in Japanese, Korean, Seychelles, and Taiwanese longline fleets, an independent scientist, and an IOTC scientist. The meetings addressed Terms of Reference covering several important issues related to yellowfin and albacore tuna CPUE indices in the Indian Ocean. The study was funded by the Indian Ocean Tuna Commission (IOTC). (See paper for full abstract)"*

47. The WPM **NOTED** the 2018 collaborative CPUE analysis was carried out during the 5th IOTC longline CPUE workshop held in Keelung (May 28th to June 1st, 2018). The WPM further **NOTED** that the analysis developed standardized CPUE indices by fleet (Japanese, Taiwanese, Korean, and Seychelles Longline fleet), species (yellowfin and albacore tuna), and regional structure.

48. The WPM **NOTED** that a generic package (cpue.rfmo) has been developed for the joint analysis to improve transparency and code sharing, and that the package is available for download from GitHub for participants in the analyses.

49. The WPM **NOTED** that the joint analysis proposed a modification to current YFT regional structure (by further subdividing the western equatorial region into two regions – the area south of the equator and the area north of the equator. The WPM further **NOTED** that this subdivision is consistent with the regional stratification used for recent assessment of IOTC bigeye tuna. The WPM **AGREED** that if there are different trends between sub-regions, it would be more appropriate to combine indices for sub-regions using appropriate regional weighting to obtain indices for the whole region.

50. The WPM **NOTED** that data included in the yellowfin CPUE standardizations dated back to 1950s however the indices prior to 1972 have not been included in the assessment. The WPM suggested that further analysis could examine the effect of the excluding early data from the standardizations.

51. The WPM **NOTED** that the recent trend in the yellowfin CPUE indices for western tropical region depends on whether cluster or hooks between float (HBF) was included in the standardizations (a flatter trend if cluster was used). The WPM **NOTED** that in tropical regions, bigeye and yellowfin tuna are usually targeted together and therefore it is possible that clusters are confounded with abundance trends.

52. The WPM **NOTED** that YFT assessment results are sensitive to the target variable in the standardization and **AGREED** that it is important to examine the target effects thoroughly. The WPM **RECOMMENDED** further joint CPUE analysis should continue to explore and test alternative methods for identifying and accounting for targeting.

53. The WPM **NOTED** that ICCAT was recently notified of the likely discarding of small yellowfin by Taiwanese albacore targeting vessels since 2004. This practice will most likely result in the change of the size structure of the catch, and as well as the change in catch rates.

54. The WPM **NOTED** that Indian scientists should be engaged to share their LL survey data as part of an analyses to develop CPUE indices.

55. The WPM **NOTED** the importance of exploring joint CPUE analysis for other gear types, such as PS, gillnets and Hand line/pole and line.

56. The WPM **NOTED** paper IOTC–2018–WPM09–13 which provided Indian Ocean tropical tuna regional scaling factors that allow for seasonality and cell areas. The following abstract was provided by the authors:

> *"Indian Ocean tuna assessments are spatially structured, with regions that contain separate but linked subpopulations. In such multi-region assessments we must determine the relative abundances among regions. Regional scaling, which has been used since 2005 in tuna assessments, estimates the abundance distribution from regional catch rates and areas. We describe the method and explore potential improvements to the current practice. Supported improvements included using cell ocean areas in scaling calculations; adjusting statistical weights in the standardization model based on the density of samples; including fleet effects in the standardization model; and using a region-season interaction term in the standardization model rather than a year-season term."*

57. The WPM **NOTED** that regional weighting factors determine relative abundance among regions and are important to tropical tuna assessments which are typically structured spatially.

58. The WPM **NOTED** that a previous version of regional scaling factors for yellowfin tuna has been used for yellowfin assessments since 2008.

59. The WPM **NOTED** that the method used relative catch rate as a proxy for fish density and has accounted for fleet and seasonal effects. The WPM **NOTED** that one of the major differences from previous estimates is that the revised method has also taken into consideration the ocean areas of 5x5 grid cells using a GIS approach.

60. The WPM **NOTED** that the author has recommended that the estimates using method '8' from data period 1979-1994 should be used for the 2018 yellowfin assessment (and future assessments). The WPM **NOTED** that the revised estimates were based on a period with good data coverage and relatively stable catch rates and targeting strategy. The WPM **NOTED** that the 2018 yellowfin assessment examined alterative regional scaling factor estimates derived in the paper.

61. The WPM **NOTED** that the GAM approach has been used to extrapolate catch rates for cells with no data.

62. The WPM **AGREED** that future revision of the method should consider the use of operational-level data that allows for targeting effect, and exploration of information from other fleets to estimate abundance outside the standard regions

63. The WPM congratulated the authors of WPM09-12 and WPM09-13 which are responsive to prior recommendations made by WPM and SC. It was again noted that the process has greatly improved the ability of the SC to provide management advice to the Commission. Unfortunately, the lack of access to the operational level longline CPUE, except during the limited time available for joint meetings between authors, greatly reduces the efficiency of the process and limits the degree of capacity building for participating scientists, because these data are only available for analysis and quality assurance for a limited time. In the interest of normalizing the process for producing joint longline CPUE for future assessments, the WPM again **RECOMMENDED** that the Secretariat continue discussions with the affected CPCs to develop a confidential operational LL data repository at the IOTC that would permit more detailed evaluation of these data as well as assuring the confidential nature of the information. The WPM also **REQUESTED** that these meetings are also open to any interested scientists to participate in the discussions held, although the data will remain confidential and accessed only by pre-agreed experts.

9. STOCK STATUS GUIDANCE

9.1 Guidance on most appropriate models – different structures

64. The WPM reviewed prior requests of the WPM regarding methods appropriate for provision of management advice across multiple models when they are applied in assessment.

65. The WPM **NOTED** that this has been added to the programme of work, but so far, no funding has been made available to progress on the work plan.

66. The WPM briefly discussed a range of diagnostics that have been used for guiding model selection including - several residual plots with quantitative measures, R0 or other parameter profiling, etc.

67. The WPM **RECALLED** a paper presented in 2017 which provided overview of one potential method that may also be used to assess the appropriateness of different models, and indicated that more intersessional work would be needed to further address this issue. The WPM **NOTED** that a paper under preparation for WPTT20 is intended to further address this issue, but that paper was not discussed at WP09.

68. The WPM **WELCOMED** a presentation on additional diagnostics useful for evaluating the appropriateness of models being applied. In this case, hind-casting, which is a kind of retrospective cross validation approach based on CPUE to evaluate the predictability of model, was proposed to be used to compare between assessment models. It was mentioned that CPUE might not a good indicator of the stock size. Also, as the assessment is run every 3 years, hindcasting might not be useful as the model configuration might be changed. Other diagnostic tools are available, and hind-casting is only one of them.

9.2 Synthesis of results from multiple model outputs

69. The WPM **NOTED** that WPTT (YFT, BET, SKJ), WPTmT (ALB), and WPB (SWO), currently mainly rely on SS3, but that other methods, such as SCAA and production models have been used as supporting evidence. This approach is viewed favourably as a method to confirm similarity of results between SS3 and other less data intensive and less parameterized models. The WPM also noted that production models are frequently applied in model-based Management Procedures evaluated through Management Strategy Evaluation procedures.

70. The WPM **NOTED** that this topic was broadly discussed in WP09-INFO6 which indicated that in terms of characterizing assessment uncertainty, a grid approach as applied in some IOTC assessments, is preferred although it was recognized that some tRFMOs make use of multiple model formulations and software to achieve the same objective. In both approaches, it is important to consider the plausibility of the model formulation and assumptions in using them for providing management advice

9.3 Review the approach used to provide management advice – relative to reference points

71. The WPM **ACKNOWLEDGED** the TCMP02 recommendation that discussion on potential refinements to the KOBE plots and definitions of "overfished" and "overfishing" in relation to target and limit reference points be conducted in collaboration with other t-RFMOs, ideally through the KOBE process.

72. The WPM **NOTED** the outcomes and suggestions made by participants of a recent (March 2018) ISSF Stock Assessment Workshop (IOTC-2018-WPM09-INF06) which summarized the practices across the tRFMO regarding the use KOBE plots and some alternative presentations that characterized stock status relative to different target and limit reference points.

73. The WPM **NOTED** that IOTC provides indications of stock status relative to limit reference points as well as Convention Objectives of BMSY and FMSY. The WPM further **NOTED** that WCPFP uses both the KOBE and Majuro plots to characterize stock status and the Majuro plot only considers a stock "overfished" when biomass falls below limit reference points (i.e. below the 20% of the unfished level; WCPFC limit biomass reference point).

74. The WPM **RECOGNIZING** that such a definition does not imply that no management action should take place until after a stock breaches the biomass limit, the WPM **RECOMMENDED** considering alternative formulations to indicate an appropriate buffer zone below BMSY to account for natural variations in biomass (for example, using the figures below). As such, WPM **REQUESTED** that this topic be considered by other WPs and subsequently by the SC when formulating the scientific management advice to the Commission. Ideally this type of modified display should be coordinated with other tRFMOs through a KOBE process.

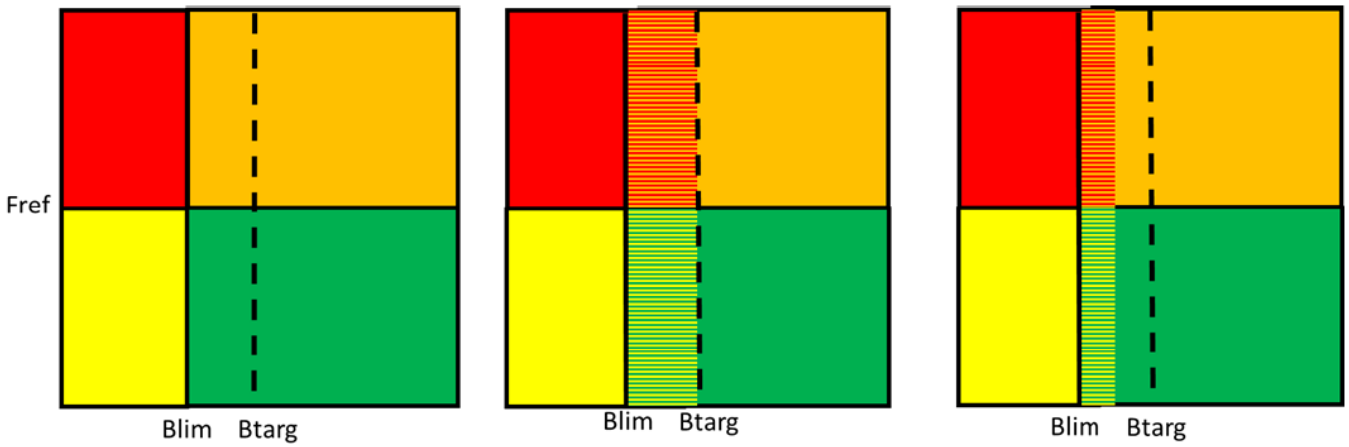

***Figure 1**. Three examples of modified Kobe Plots in which there is a target biomass, Btarg, and a reference F (Fref) such as F_{MSY}. In each plot. The red quadrant is based on biomass being below the limit (Blim) rather than below a target biomass. The plot in the middle retains the four colours, but contains red-orange and yellow-green "buffer zones" between the target and limit. In the plot on the right, the buffer zone starts somewhat below the target biomass to account for natural fluctuations of the stock around the target. **Note**: This figure is from the ISSF Stock Assessment Workshop report (*IOTC-2018-WPM09-INF06). *It is not the recommendation of the WPM.*

9.4 Stock status advice for data limited stocks

75. The WPM NOTED the request from the SC to investigate alternative stock assessment methods to be used in data-limited situations and for an evaluation of alternative methods of presenting advice from data-limited assessments to managers:

*"The SC **NOTED** the importance of exploring alternative data poor stock assessment methods and **RECOMMENDED** that the Commission allocates funding for work to explore methods based on different data sources, such as catch curve estimation of mortality from length-frequency data. A range of data sources should be explored, including data from observer programmes, the sport fisheries project, and non-state actor (e.g. WWF) projects for suitability". (SC19, Para. 32)*

*"The SC **RECALLED** the recommendation of the WPNT05 for the SC to request the Working Party on Methods evaluate a proposed alternative methodology for presenting management advice for data poor methods in 2016. The SC **REQUESTED** that the WPM evaluate the possibility of using different colours to distinguish between stocks which have not been assessed (e.g., white) and stocks which have been assessed but the status is considered to be uncertain (e.g., grey)". (SC19, Para. 33)*

76. The WPM **RECALLED** that the Chair of WPM and Chairs of the species WPs (WPNT and WPB, in particular) liase in order to develop a study plan on the issue and to identify resources needed for this task. The Chair of WPM indicated such a discussion was anticipated during SC21.

77. The WPM **NOTED** that funding has been received to conduct this work, particularly for the WPNT, from an EU grant and that it should commence in 2019. The WPM welcomed this information and **REQUESTED** that the WPB also be included in this planning and review

9.5 Other Stock Status Advice Issues

78. The WPM **REQUESTED** the assumption of the recruitment used in the short and medium term forecast to be added in the stock assessment report and in the executive summaries (either in the main summary or supplementary information).

79. The WPM **REQUESTED** the level of risk (probability of failure to achieve the KOBE 'green' zone) used in the short and medium term forecast to be added in the stock assessment report and in the executive summary.

80. The WPM **REQUESTED** that the trends in SSB, recruitment and F as estimated by the assessment model are to be added in the supplementary information of the executive summary.

10. OTHER MATTERS

10.1 Other matters

Iran gillnet challenges

81. The WPM **NOTED** paper IOTC–2018–WPM09–14 which discussed considerations and challenges of changing gillnet to long line fishing method for tuna catch in Iran providing updates on the improved data sharing processes that are currently being developed by the IOTC Secretariat including the following summary provided by the authors:

" There are different Fishing methods for catching fish in Iran, but Gillnet is a common fishing method between all fishermen. Approximately more than 93% of the fish species are caught by using gillnet method in Iran and other methods like purse seine, long line, and trawl have a small share of total catch. In relation to catching tuna fish, a high percentage of catches are made by the Gillnet method, and in recent years some boats in the coastal areas have been using trolling to catch fish. According to the recommendations of IOTC to the member countries for using Long Line method in catching tuna fish and also in line with the Iranian fisheries policy to change the way of gillnet to long line, there have been attempts by the Iranian fishery to encourage the fishermen to use this method. Nevertheless, running this program faced with some problems and requires a medium to long-term planning to achieve this goal. In this article we will consider the situation of fishery in Iran with emphasis on gillnet fishery and Long Line method and also the efforts made by the Iranian fisheries organization to attract the fishermen to change their Gillnet fishing method, also we will have a review on existing challenges and problems in this matter."

82. The WPM **NOTED** that gillnets are currently more profitable than longlines in Iran due to similar domestic market price for tuna caught by both gear types but gillnets have higher catch rates than longliners. Plans to develop the mechanised LL fleet, create more employment, catch fish of high quality and achieve the export markets are the main incentives for Iranian fishers to change from gillnets to longlines.

83. The WPM **ENCOURAGED** future analyses to characterize changes in catchability resulting from the shift from gillnets to longline gear, including the development of standardized CPUE series.

Andaman Sea tuna statistics

84. The WPM **NOTED** paper IOTC–2018–WPM09–15 which discussed data collection methodology in the Andaman Sea and statistic on tuna fisheries including the following summary provided by the authors:

> *"Thai marine fishery consists of two segments, the coastal fisheries, and oversea fisheries. The coastal fishery along the Andaman Sea is multi-gear and not exclusively for tuna fishery except for tuna-like by purseine. The organization's collectings coastal marine fisheries data are Upper Andaman Sea Fisheries Research and Development Center(Phuket) and others organizations along the Andaman Sea in fisheries department. Over sea fisheries in Thailand has conducted and reported tuna catches from two sources. The first one from Thai fishing vessels that go fishing in the high sea or water under the jurisdiction of the other country. The second, data comes from fishing boats on board at fishing ports. However, tuna fisheries from Thai vessels are not active during 2016-2017. So, the tuna data from Thailand has only been reported by tuna from foreign tuna vessel and tuna-like from purse seine landing in Phuket ports and along the Andaman Sea. The tuna vessel comes to landing at Phuket ports. There must be a procedure for reporting the type and amount of harboring. Follow the steps set by Fish Quarantine and Inspection Division. This is consistent with international principles. Operated by Phuket fish inspection office. Therefore, the sampling program can only be compiled by the record of Fish Quarantine and Inspection Division, such as Flag state, fishing area, trip date, port of loading, fishing gear, type and amount of each species. However, Thailand has collected data on catches of marine fisheries and report as the fisheries statistics of the country."*

85. The WPM **NOTED** that the data collection process described in this paper should provide useful information on catches from Thailand and **ENCOURAGED** the authors to undertake some analyses of the data for future presentation to the WPM or other relevant working parties.

11. WPM PROGRAM OF WORK

11.1 Revision of the WPM Program of work (2019–2023)

86. The WPM **NOTED** paper IOTC–2018–WPM09–07 presenting the draft WPM Programme of Work (2019–2023).

87. 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)

88. 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 (2019–2023) that are yet to be funded, for circulation to potential funding bodies.

89. The WPM **RECOMMENDED** that the Scientific Committee consider and endorse the WPM Programme of Work (2019–2023), as provided in Appendix IV.

90. The WPM **NOTED** the need to review the MSE analyses being conducted. Experts to conduct an internal review of the code were identified. The WPM **ACKNOWLEDGED** that the MSE software for BET and YFT has already had a double check for consistency in that the main projection code was independently implemented in R and C++. The catch equations are implemented differently, with R using something similar to Pope's approximation and C++ using the Baranov equations.

91. 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 **RECOMMENDED** additional work to address the reviewed comments made.

12. OTHER BUSINESS

12.1 Meeting of the Joint t-RFMO Management Strategy Evaluation working group

92. The WPM **NOTED** document IOTC-2018-WPM09-INF04 which provided a list of recommendations resulting from the 2nd meeting of the Joint Tuna RFMO MSE Working Group.

93. The WPM **NOTED** the recommendations and glossary provided in the document and **AGREED** to take them into consideration in future deliberations of the Working Party.

12.2 Date and place of the 10th and 11th sessions of the WPM

94. The WPM **REQUESTED** that the IOTC Secretariat liaise with CPCs intersessionally to determine if they would be willing to host the 10th and 11th sessions of the WPM in conjunction with the WPTT (Table 1.).

Table 1. Draft meeting schedule for the WPM (2019 and 2020)

	2019			2020		
Meeting	**No.**	**Date**	**Location**	**No.**	**Date**	**Location**
Working Party on **Methods** (WPM)	10th	Third week in October (3 d) (with WPTT)	San Sebastian, Spain	11th	Third week in October (3 d) (with WPTT)	Maldives

95. The WPM also **NOTED** the informal MSE technical working group meeting to be held at the European Commission Joint Research Centre (EC JRC) in, Italy in 2019 (para. 12).

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

96. The WPM **THANKED** the invited expert, Dr Rishi Sharma, for his excellent contributions to the meeting.

97. 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. The WPM **NOTED** the difficulty in adequately funding through the Commission budget, work in support of the TCMP, which, in part, relates to the timing of the SCAF and TCMP meetings. WPM RECOMMENDS that the budgetary needs to support these activities be considered during the next SCAF meeting

98. 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 2019, by an Invited Expert(s):

- **Expertise**: Management Strategy Evaluation.

12.4 Review of the draft, and adoption of the Report of the 9th Session of the WPM

99. The WPM **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPM09, provided in Appendix V.

100. 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.

101. The Chair **THANKED** the all the participants for their dedicated discussion during the session.

102. The report of the 9th Session of the Working Party on Methods (IOTC–2018–WPM09–R) was **ADOPTED** on 27 October 2018.

APPENDIX I
LIST OF PARTICIPANTS

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Absent

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APPENDIX II
AGENDA FOR THE 9TH WORKING PARTY ON METHODS

Date: 25-27 October 2018
Location: Seychelles
Venue: Eden Bleu Hotel, Eden Island
Time: 09:00 – 17:00 daily
Chairperson: Dr. Toshihide Kitakado; **Vice-Chairperson**: Absent

1. **OPENING OF THE MEETING**
2. **ADOPTION OF THE AGENDA AND ARRANGEMENTS FOR THE SESSION**
3. **THE IOTC PROCESS: OUTCOMES, UPDATES AND PROGRESS**
   - ***3.1*** Outcomes of the 20th Session of the Scientific Committee
   - ***3.2*** Outcomes of the 22nd Session of the Commission
   - ***3.3*** Review of Conservation and Management Measures relevant to the WPM
   - ***3.4*** Progress on the recommendations of WPM08
   - ***3.5*** Review of intersessional meetings related to the IOTC MSE process
4. **ALBACORE MSE: UPDATE**
5. **SKIPJACK TUNA MSE: UPDATE**
6. **BIGEYE TUNA AND YELLOWFIN TUNA MSE: UPDATE**
   - ***6.1*** Review of Operating Models based on WPM and SC feedback, including possible robustness tests
   - ***6.2*** Revision of Management Procedures and Indicators
7. **SWORDFISH MSE: UPDATE**
   - ***7.1*** Conditioning of operating models
8. **JOINT CPUE STANDARDISATION**
   - ***8.1*** Update on the status of the joint CPUE indices (yellowfin tuna, albacore).
9. **STOCK STATUS GUIDANCE**
   - ***9.1*** Guidance on most appropriate models – different structures
   - ***9.2*** Synthesis of results from multiple model outputs
   - ***9.3*** Review the approach used to provide management advice – relative to reference points
   - ***9.4*** Stock status advice for data limited stocks
   - ***9.5*** Other stock status advice issues
10. **OTHER MATTERS**
    - ***10.1*** Other matters
11. **WPM PROGRAM OF WORK**
    - ***11.1*** Revision of the WPM Program of work (2019–2023)
12. **OTHER BUSINESS**
    - ***12.1*** Meeting of the Joint t-RFMO Management Strategy Evaluation working group
    - ***12.2*** Date and place of the 10th and 11th sessions of the WPM
    - ***12.3*** Development of priorities for Invited Expert(s) at the next WPM meeting
    - ***12.4*** Review of the draft, and adoption of the Report of the 9th Session of the WPM

APPENDIX III
LIST OF DOCUMENTS

Document	Title	Availability
IOTC–2018–WPM09–01a	Agenda of the 9th Working Party on Methods	✓ 25 September
IOTC–2018–WPM09–01b	Annotated agenda of the 9th Working Party on Methods	✓ 12 October
IOTC–2018–WPM09–02	List of documents of the 9th Working Party on Methods	✓ 11 October
IOTC–2018–WPM09–03	Outcomes of the 20th Session of the Scientific Committee (IOTC Secretariat)	✓ 9 October
IOTC–2018–WPM09–04	Outcomes of the 22nd Session of the Commission (IOTC Secretariat)	✓ 10 October
IOTC–2018–WPM09–05	Review of Conservation and Management Measures relating to methods (IOTC Secretariat)	✓ 10 October
IOTC–2018–WPM09–06	Progress made on the recommendations and requests of WPM08 and SC20 (IOTC Secretariat)	✓ 11 October
IOTC–2018–WPM09–07	Revision of the WPM Program of Work (2019–2023) (IOTC Secretariat & Chairpersons)	✓ 10 October
IOTC–2018–WPM09–08	Update on the development of MSE analysis of candidate Management Procedures for Indian Ocean albacore (Mosqueira I)	✓ WITHDRAWN
IOTC–2018–WPM09–09	Update on IOTC Bigeye Tuna Operating Model Development October 2018 (Kolody D and Jumppanen P)	✓ 11 October
IOTC–2018–WPM09–10	Update on IOTC Yellowfin Tuna Operating Model Development October 2018 (Kolody D and Jumppanen P)	✓ 11 October
IOTC–2018–WPM09–11	IOTC Bigeye and Yellowfin Management Procedure Evaluation Progress October 2018 (Kolody D and Jumppanen P)	✓ 11 October
IOTC–2018–WPM09–12	Collaborative study of yellowfin tuna CPUE from multiple Indian Ocean longline fleets in 2018 (Hoyle S D, Chassot E, Fu D, Kim D N, Lee S I, Matsumoto T, Satoh K, Wang S-P, Yeh Y-M, and Kitakado T)	✓ 11 October
IOTC–2018–WPM09–13	Indian Ocean tropical tuna regional scaling factors that allow for seasonality and cell areas (Hoyle S D)	✓ 11 October
IOTC–2018–WPM09–14	Considerations and challenges of changing gillnet to long line fishing method for tuna catch in Iran (Azadi M.)	✓ 12 October
IOTC–2018–WPM09–15	Data collection methodology in the Andaman Sea and statistic on tuna fisheries (Maeroh K, Hoimuk S, Somkliang N, and Rodpradit S)	✓ 11 October
Information Documents		
IOTC-2018-WPM09-INF01	Update on IOTC Bigeye Tuna Management Procedure Evaluation March 2018 (Kolody D)	✓ 12 October
IOTC-2018-WPM09-INF02	Update on IOTC Yellowfin Tuna Management Procedure Evaluation March 2018 (Kolody D)	✓ 12 October
IOTC-2018-WPM09-INF03	Report of the 7th Workshop on Management Strategy Evaluation in Working Party on Methods of Indian Ocean Tuna Commission (Anon)	✓ 25 October
IOTC-2018-WPM09-INF04	Report of the 2nd meeting of the Joint Tuna RFMO MSE Working Group (Anon)	✓ 22 October
IOTC-2018-WPM09-INF05	Report of the Fifth IOTC CPUE Workshop on Longline Fisheries	✓ 16 October
IOTC-2018-WPM09-INF06	2018 ISSF STOCK ASSESSMENT WORKSHOP "Review of Current t-RFMO Practice in Stock Status Determinations"	✓ 25 October

APPENDIX IV
WORKING PARTY ON METHODS PROGRAM OF WORK (2019–2023)

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	Research Priority	Funding Priority	Lead	Est. budget (potential source)	Timing				
						2019	2020	2021	2022	2023
1. Management Strategy Evaluation	1.1 Albacore	High	1	EU (JRC)	Funded (EC JRC)					
	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 (2018 or date TBD)				US$15,000					
	1.1.5 Evaluation of new set of Management Procedures (if required)									
	1.2 Skipjack tuna	High	5	Maldives						
	1.2.1 Review of model implementation and participation in MSE process				US$75,000 (EC) to be finalised					
	1.3 Bigeye tuna	High	3							
	1.3.1 Update OM & present preliminary MP results to TCMP, WPTT/WPM review of new OM			Australia (CSIRO)	$75,000 (ABNJ/CSIRO) pending					

	1.3.2 External peer review (2018 or date TBC)				US$15,000					
	1.3.3 Present revised MP results to TCMP with target adoption date of 2019				$30,000 (Jan - Jun 2018)					
	1.3.4 Additional iterations if required				(TBD)					
	1.4 Yellowfin tuna	High	2							
	1.4.1 Update OM & present preliminary MP results to TCMP, WPTT/WPM review of new OM			Australia (CSIRO)	$75,000 (ABNJ/CSIRO) pending)					
	1.4.2 External peer review (2018 or date TBD)				US$15,000					
	1.4.3 Present revised MP results to TCMP with target adoption date of 2018; iteratively update development if required)				US$30,000 (Jan-Jun 2018)					
	1.4.4 additional iterations if required				(TBD)					
	1.5 Swordfish	High	4	TBD	USD$2,500 (EC)					
	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				US$15,000					
2. 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)	Medium	7	Consult.	US$30,000 (EC)					

3. 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*)	Medium	6	$?? (TBD)					

APPENDIX V
CONSOLIDATED RECOMMENDATIONS OF THE 9TH SESSION OF THE WORKING PARTY ON METHODS

Note: Appendix references refer to the Report of the 9th Session of the Working Party on Methods (IOTC–2018–WPM09–R)

Albacore MSE: Update

WPM09.01: 16. The WPM **NOTED** that there would be a new assessment in 2019 and, therefore, in case that 2019 assessment result are different from the envelope of the OM grid, the OM may need to be reconditioned to 2019 stock assessment. For example, if the resulting stock assessment results are within the central 50 % of the OM distribution there would not need to recondition the OM, however, if the results are within the extreme bounds of the OM this may require to recondition the OM for ALB. The WPM noted that this is linked to the definition of the "Exceptional Circumstances" and, thus, the WPM **RECOMMENDED** that this is discussed in the Scientific Committee. If reconditioning is required or additional uncertainty dimensions are added the developers should consider using partially confounded factorial design to reduce the computational overhead (para.16).

Skipjack tuna MSE: Update

WPM09.02: WPM also **NOTED** that the SKJ 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. Hence the WPM **SUGGESTED** that the review and potential revision required under Res 16/02 be conducted with the aim of fully determining an MP for SKJ, should the Commission desire. The WPM **RECOMMENDED** feedback from TCMP be sought on these issues, considering the future MSE guidelines agreed by the Commission (para. 20)

WPM09.03: The WPM **CONSIDERED** that currently available resources are not sufficient for the required review and possible revision called for under RES 16/02 and **RECOMMENDED** that WPTT and SC develop an appropriate workplan and budget for this work (para. 21).

Bigeye and yellowfin tuna MSE

WPM09.04: The WPM **RECOMMENDED** exploring partially-confounded experimental design as a computationally tractable method for expanding the number of uncertainty dimensions and the main interactions (at the expense of losing higher order interactions). It should be adopted if it is not found to have a significant reduction in full grid uncertainty (para. 25).

Joint CPUE Standardisations

WPM09.05: The WPM **NOTED** that YFT assessment results are sensitive to the target variable in the standardization and **AGREED** that it is important to examine the target effects thoroughly. The WPM **RECOMMENDED** further joint CPUE analysis should continue to explore and test alternative methods for identifying and accounting for targeting. (para. 52).

WPM09.06: The WPM congratulated the authors of WPM09-12 and WPM09-13 which are responsive to prior recommendations made by WPM and SC. It was again noted that the process has greatly improved the ability of the SC to provide management advice to the Commission. Unfortunately, the lack of access to the operational level longline CPUE, except during the limited time available for joint meetings between authors, greatly reduces the efficiency of the process and limits the degree of capacity building for participating scientists, because these data are only available for analysis and quality assurance for a limited time. In the interest of normalizing the process for producing joint longline CPUE for future assessments, the WPM again **RECOMMENDED** that the Secretariat continue discussions with the affected CPCs to develop a confidential operational LL data repository at the IOTC that would permit more detailed evaluation of these data as well as assuring the confidential nature of the information. The WPM also **REQUESTED** that these meetings are also open to any interested scientists to participate in the discussions held, although the data will remain confidential and accessed only by pre-agreed experts. (para. 63).

Stock Status Guidance

WPM09.07: The WPM **RECOGNIZING** that such a definition does not imply that no management action should take place until after a stock breaches the biomass limit, the WPM **RECOMMENDED** considering alternative formulations to indicate an appropriate buffer zone below BMSY to account for natural variations in biomass (for example, using the figures below). As such, WPM **REQUESTED** that this topic be considered by other WPs and subsequently by the SC when formulating the scientific management advice to the Commission. Ideally this type of modified display should be coordinated with other tRFMOs through a KOBE process.

Figure 1. Three examples of modified Kobe Plots in which there is a target biomass, Btarg, and a reference F (Fref) such as FMSY. In each plot. The red quadrant is based on biomass being below the limit (Blim) rather than below a target biomass. The plot in the middle retains the four colours, but contains red-orange and yellow-green "buffer zones" between the target and limit. In the plot on the right, the buffer zone starts somewhat below the target biomass to account for natural fluctuations of the stock around the target. Note: This figure is from the ISSF Stock Assessment Workshop report (IOTC-2018-WPM09-INF06). It is not the recommendation of the WPM. (para. 74).

Revision of the WPM Program of work (2019–2023)

WPM09.08: The WPM **RECOMMENDED** that the Scientific Committee consider and endorse the WPM Programme of Work (2019–2023), as provided in Appendix IV (para. 89).

WPM09.09: 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 **RECOMMENDED** additional work to address the reviewed comments made (para. 91).

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

WPM09.10: 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. The WPM **NOTED** the difficulty in adequately funding through the Commission budget, work in support of the TCMP, which, in part, relates to the timing of the SCAF and TCMP meetings. WPM **RECOMMENDS** that the budgetary needs to support these activities be considered during the next SCAF meeting (para. 97).

Review of the draft, and adoption of the Report of the 8th Session of the WPM

WPM09.11: The WPM **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPM09, provided in Appendix V (para. 99).