Report of the 7th Session of the IOTC Working Party on Methods

Victoria, Seychelles, 11–13 November 2016

DISTRIBUTION:
Participants in the Session
Members of the Commission
Other interested Nations and International Organizations
FAO Fisheries Department
FAO Regional Fishery Officers

BIBLIOGRAPHIC ENTRY
IOTC–WPM07 2016. Report of the 7th Session of the IOTC Working Party on Methods. Victoria, Seychelles 11-13 November 2016.
IOTC–2016–WPM07–R[E]:39 pp.

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

Contact details:

Indian Ocean Tuna Commission
Le Chantier Mall
PO Box 1011
Victoria, Mahé, Seychelles
Ph: +248 4225 494
Fax: +248 4224 364
Email: secretariat@iotc.org
Website: http://www.iotc.org

ACRONYMS

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; F_{2011} is the fishing mortality estimated in the year 2011
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
WPTT	Working Party on Tropical Tunas of the IOTC
YFT	Yellowfin tuna

GLOSSARY OF TERMS

Control measure: the unit used to control the amount of fishing or resource extraction allowed (e.g. catch or effort) according to some indicator (e.g. stock status)

Harvest control rule (HCR): agreed response that management must make under pre-defined circumstances regarding stock status.

Harvest strategy: Strategy outlining how the catch in a fishery will be adjusted from year to year depending on the size of the stock, the economic or social conditions of the fishery, conditions of other interdependent stocks and uncertainty of biological knowledge. Well-managed fisheries have an unambiguous (explicit and quantitative) harvest strategy that is robust in the unpredictable biological fluctuations to which the stock may be subject. A harvest strategy sets out the management actions necessary to achieve defined biological and economic objectives in a given fishery. Harvest strategies must contain 1) a process for monitoring and conducting assessments of the biological and economic conditions of the fishery, and 2) rules that control the intensity of fishing activity according to the biological and economic conditions of the fishery (as defined by the assessment). These rules are referred to as harvest control rules.

Limit reference point (LRP): a benchmark which defines undesirable states of the system that should be avoided or achieved with very low probability.

Management objectives: the social, economic, biological, ecosystem, and political (or other) goals specified for a given management unit (e.g. stock).

Management options: alternative management procedures from which recommended management actions will be chosen.

Management procedure (MP): a set of formal actions, usually consisting of data collection, stock assessment, and harvest control rules, to iteratively and adaptively .adjust harvest controls (e.g. catch or effort quotas).

Management strategy evaluation (MSE): procedure whereby alternative management procedures' performance are tested and compared using stochastic simulations of stock and fishery dynamics against a set of management objectives.

Performance statistics: a set of consistent statistics used to evaluate how well management objectives have been achieved under each candidate MP over a pre-defined simulated period.

Simulation: an imitation of a real world system used to gain insight into how the system operates.

Target reference point (TRP): a benchmark which assesses the performance of management in achieving one or more operational management objectives.

Trigger reference point (TrRP): a particular state of the system that triggers a predefined change in the management response.

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**).

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The 7th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Methods (WPM) was held in Victoria, Seychelles 11–13 November 2016. A total of 29 participants (26 in 2015, 34 in 2014) attended the Session. The list of participants is provided at Appendix I. The meeting was opened by the Chairperson, Dr Toshihide Kitakado (Japan) who welcomed participants to Seychelles. The presence of Dr Ana Parma was gratefully acknowledged as the Invited Expert for the WPM07.

The following are a subset of the complete recommendations from the WPM07 to the Scientific Committee, which are provided at Appendix VII.

Outcomes of the 20th Session of the Commission

WPM07.01 (para. 9): The WPM **NOTED** the request for advice (IOTC-2016-S20-R, para. 16) on the feasibility of reporting stock status in relation to limit reference points in addition to the target reference points currently used. Further **NOTING** that managing to target reference points is unlikely to yield a stock status that is always in the green zone of the KOBE plot, the WPM **RECOMMENDED** that the Scientific Committee consider this issue further and refers it for discussion at the Technical Committee on Management Procedures.

Visualisation of MSE results

WPM07.02 (para. 59): The WPM **RECOMMENDED** the proposed standardised methods for the presentation of MSE results (Appendix IX) are submitted to SC21 for discussion, revision and endorsement, as appropriate. Subsequently, this should be considered a living document that will benefit from revision based upon feedback received from the TCMP, which will first meet in 2017.

Performance indicators

WPM07.03 (para. 61): The WPM reviewed the performance statistics, used for measuring the performance of alternative management procedures against different objectives, that were endorsed by the SC and **AGREED** the following:

- the measure of catch variability would be more comparable across MPs if expressed as a coefficient of variation (CV)
- arithmetic means should be used for all statistics (rather than geometric means)

The WPM therefore **RECOMMENDED** that the Scientific Committee endorses the revised list of performance statistics provided in Appendix V.

Joint CPUE standardisation

WPM07.04 (para. 75): The WPM **NOTED** that the joint CPUE work undertaken so far has become a critical component for assessments of temperate and tropical species and **RECOMMENDED** that this work continue under the current framework, but that plans should be developed to normalize the process within the IOTC in the near future.

Revision of the WPM Program of work (2017–2021)

WPM07.05 (para. 97): The WPM **NOTED** that the next stock assessment of Indian Ocean swordfish is due to take place in 2017 and **RECOMMENDED** that the development of MSE of swordfish is considered as a high priority in the revised WPM Program of Work and that funding is allocated for this activity, to start the conditioning of an OM for this stock.

1. OPENING OF THE MEETING

1. The 7th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Methods (WPM) was held in Victoria, Seychelles 11–13 November 2016. A total of 29 participants (26 in 2015, 34 in 2014) attended the Session. The list of participants is provided at Appendix I. The meeting was opened by the Chairperson, Dr Toshihide Kitakado (Japan) who welcomed participants to Seychelles. The presence of Dr Ana Parma was gratefully acknowledged as the Invited Expert for the WPM07.

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 WPM07 are listed in Appendix III.

3. THE IOTC PROCESS: OUTCOMES, UPDATES AND PROGRESS

3.1 Outcomes of the 18th Session of the Scientific Committee

3. The WPM **NOTED** paper IOTC–2016–WPM07–03 which outlined the main outcomes of the 18th Session of the Scientific Committee (SC18), specifically related to the work of the WPM.

4. The WPM **NOTED** that in 2015, the SC made a number of endorsements in relation to the WPM06 report. These are provided below for reference.

- ***Presentation and evaluation of MSE results***

  *The SC **ENDORSED** the draft list of performance statistics representing a suite of candidate management objectives, provided in Appendix VI which provides a means of measuring the performance of alternative management procedures against different objectives.*

- ***Albacore MSE update***

  - *The SC **ENDORSED** the Operating Model for albacore as the basis for the provision of advice to the Commission on the performance of alternative Management Procedures, **NOTING** that external reviewers have considered the albacore MSE work and largely endorsed the approach taken, while recommending a number of improvements to be incorporated.*

- ***Skipjack tuna MSE update***

  - *The SC **ENDORSED** the use of the Operating Model for skipjack tuna as the basis for the provision of advice to the Commission on the performance of alternative Management Procedure, **NOTING** that external reviewers have considered the skipjack tuna work MSE and largely endorsed the approach taken, while recommending a number of improvements to be incorporated.*

3.2 Outcomes of the 20th Session of the Commission

5. The WPM **NOTED** paper IOTC–2016–WPM07–04 which outlined the main outcomes of the 20th 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 12 Conservation and Management Measures (CMMs) adopted at the 20th Session of the Commission (consisting of 12 Resolutions and 0 Recommendations) as listed below:

IOTC Resolutions

- Resolution 16/01 *On an interim plan for rebuilding the Indian Ocean yellowfin tuna stock*
- Resolution 16/02 *On harvest control rules for skipjack tuna in the IOTC area of competence*
- Resolution 16/03 *On the second performance review follow-up*
- Resolution 16/04 *On the implementation of a Pilot Project in view of Promoting the Regional Observer Scheme of IOTC*
- Resolution 16/05 *On vessels without nationality*
- Resolution 16/06 *On measures applicable in case of non-fulfilment of reporting obligations in the IOTC*

- Resolution 16/07 *On the use of artificial lights to attract fish*
- Resolution 16/08 *On the prohibition of the use of aircrafts and unmanned aerial vehicles as fishing aids*
- Resolution 16/09 *On establishing a Technical Committee on Management Procedures*
- Resolution 16/10 *To promote the implementation of IOTC Conservation and Management Measures*
- Resolution 16/11 *On port state measures to prevent, deter and eliminate illegal, unreported and unregulated fishing*
- Resolution 16/12 *Working Party on the Implementation of Conservation and Management Measures (WPICMM)*

7. The WPM **NOTED** that pursuant to Article IX.4 of the IOTC Agreement, the above mentioned Conservation and Management Measures became binding on Members, 120 days from the date of the notification communicated by the IOTC Secretariat in IOTC Circular 2016–054 (i.e. **27 September 2016**).

8. The WPM **NOTED** that that the Commission also made a number of general comments and requests on the recommendations made by the Scientific Committee in 2015, which have relevance for the WPM. At the time of writing, the final report has not been approved so all text and paragraph numbers refer to the ***draft*** report of the Commission pending final agreement by all parties (IOTC–2016–S20–R[1]):

   Para. 13. *"The Commission **CONSIDERED** the list of recommendations made by the SC18 (Appendix VI) from its 2015 report (IOTC–2015–SC18–R) that related specifically to the Commission. The Commission **ENDORSED** the list of recommendations as its own, while taking into account the range of issues outlined in this Report (S20) and incorporated within Conservation and Management Measures adopted during the Session and as adopted for implementation as detailed in the approved annual budget and Program of Work".*

   Para. 15. *"The Commission **NOTED** the substantial work underway to develop management procedures and harvest strategies for IOTC stocks and **REQUESTED** the SC to develop a work plan reflecting key elements to be agreed and developed, including roles and responsibilities of each of the Commission, Scientific Committee, Compliance Committee and other subsidiary bodies, and also including decision points on these elements for the Commission".*

   Para. 16. *"The Commission **NOTED** the progress towards development of harvest strategies for key stocks, including the adoption of limit and target reference points for a number of stocks, and **REQUESTED** that the SC provide advice to the 21st Session of the IOTC on the feasibility of reporting stock status in relation to the agreed limit reference points".*

9. The WPM **NOTED** the request for advice (IOTC-2016-S20-R, para. 16) on the feasibility of reporting stock status in relation to limit reference points in addition to the target reference points currently used. Further **NOTING** that managing to target reference points is unlikely to yield a stock status that is always in the green zone of the KOBE plot, the WPM **RECOMMENDED** that the Scientific Committee consider this issue further and refers it for discussion at the Technical Committee on Management Procedures.

Outcomes of the Management Procedures Dialogue (MPD03)

Para 107. "*The Commission **NOTED** the Report of the Third Management Procedures Dialogue, presented by the Chair of the Scientific Committee, where the current status and results of the MSE work on skipjack, albacore, yellowfin and bigeye were reviewed and discussed".*

Para. 108. ***"NOTING** that the MPD needs to focus on presenting the results of ongoing MSE work to the Commission to allow decisions needed prior to the adoption of a management procedure, the Commission **ENDORSED** the recommendation of the Scientific Committee on the modification to the Management Procedures Dialogue process to the performance of alternative management procedures against different objectives".*

On establishing a technical committee on management procedures dialogue

Para. 128. "*The Commission **ADOPTED** Resolution 16/09 On establishing a technical committee on management procedures dialogue (Appendix XXIV). This Resolution aims at enhancing the dialogue and mutual understanding between the Scientific Committee and the Commission on matters relating to management procedures, and the decision making response of the Commission in relation to management procedures, The Resolution addresses the priorities identified in Resolutions 14/03 On enhancing the dialogue*

[1] Provisional until approval of the final version of the S20 report by correspondence

between fisheries scientists and managers, and 15/10 On target and limit reference points and a decision framework or any subsequent resolutions addressing Management Strategy Evaluation and Management Procedures. This Resolution supersedes Resolution 14/03 On enhancing the dialogue between fisheries scientists and managers".

3.3 Review of Conservation and Management Measures relevant to the WPM

10. The WPM **NOTED** paper IOTC–2016–WPM07–05 which aimed to encourage participants at the WPM07 to review some of the existing Conservation and Management Measures (CMM) relevant to the WPM, noting the CMMs referred to in document IOTC–2016–WPM07–04, 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.

11. The WPM **AGREED** that it would consider proposing modifications for improvement to the existing CMMs following discussions held throughout the current WPM meeting.

3.4 Progress on the recommendations of WPM06

12. The WPM **NOTED** paper IOTC–2016–WPM07–06 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 WPM07 as appropriate given any progress.

13. The WPM **RECALLED** that any recommendations developed during a Session, must be carefully constructed so that each contains the following elements:
    - a specific action to be undertaken (deliverable);
    - clear responsibility for the action to be undertaken (i.e. a specific CPC of the IOTC, the IOTC Secretariat, another subsidiary body of the Commission or the Commission itself);
    - a desired time from for delivery of the action (i.e. by the next working party meeting, or other date);
    - if appropriate, an approximate budget for the activity, so that the IOTC Secretariat may be able to use it as a starting point for developing a proposal for the Commission's consideration.

4. ALBACORE MSE: UPDATE

14. The WPM **NOTED** paper IOTC–2016–WPM07–08 describing progress on the MSE for Indian Ocean albacore tuna, including the following abstract provided by the author:

"*This document presents the development of the technical platform and initial results for Management Strategy Evaluation for Indian Ocean albacore tuna. The work includes the development of a reference case Operating Model for the stock, an open source computational platform for the evaluation of alternative Management Procedures, an initial set of simulations for two MPs, and the presentation and output for inspection and analysis of the results. The Operating Model is based around the Stock Synthesis stock assessment conducted by WPTmT and incorporates the main sources of uncertainty identified in the estimation of population trajectories and dynamics according to the data available at IOTC.*"

4.1 Conditioning of operating models

15. The WPM **THANKED** the author for the continued progress on the albacore MSE.

16. The WPM **NOTED** that the biomass trajectories from the 72 model OM grid from 2014 did not encompass either the 2014 or 2016 reference case assessment results. This was a consequence of the fact that the 72 model subset used for MP development did not include the specific 2014 assessment specification. The full model grid was not included in the latest round of MP testing because many factors did not appear to be important. However the group **NOTED** that the full grid of models with plausible biomass, including the 2016 reference case assessment, would be carried forward in the next phase of MP evaluations.

17. The WPM **NOTED** that a fractional factorial experimental design could be used to test the importance of a large number of factors in a model grid. However, the fully balanced grid of the more influential factors should subsequently be calculated to properly describe the interactions among assumptions.

18. The WPM **NOTED** that there is a risk in rejecting grid elements solely on the basis of overlapping stock status estimates. Two models with similar stock status estimates might have very different projection behaviour, e.g. if there is non-stationary biology or environmental variability.

19. The WPM **NOTED** that uncertainty in growth should be included in the grid, because there are no growth studies available for the Indian Ocean, and the assessments used studies from other oceans.

20. The WPM **SUGGESTED** that models with unrealistically high biomass might be identifiable through the long term negative trends in recruitment that must be required to explain declining CPUE if the fishery is estimated to have a negligible impact on the stock size. However, it was **NOTED** that this criteria is not necessarily a sufficient criteria for identifying implausible models.

21. The WPM **NOTED** that the upper bound (99.95%) of the carrying capacity analysis corresponded to a biomass of about double the 2014 assessment model reference case, which appears to be a reasonable upper limit.

22. The WPM **NOTED** that a large grid is going to have some correlated interactions that will probably result in some models that fit the data very poorly. The WPM **SUGGESTED** that some likelihood-based weighting may be useful to constrain the projections to a reasonable parameter space. This weighting would need to be stratified within model combinations that are in principle comparable on the basis of the likelihood (i.e. those combinations that use the same data inputs in the same statistical framework). As shown in the CCSBT case, some factors might be better weighted on the basis of the prior.

23. The WPM **AGREED** that the changes to the assessment in 2016 were substantial enough to justify re-conditioning of the albacore OM and **AGREED** to the grid of input assumptions in Table 1, subject to the K-based filtering of implausible biomass estimates.

Table 1. Grid of assumptions for albacore assessment for the next iteration.

Factor	Levels
Natural mortality	0.2, 0.3, 0.4, 0.4-0.3, 0.4-0.2
Standard deviation of the recruitment deviates (sigmaR)	0.4, 0.6
Steepness of the stock-recruits relationship	0.7, 0.8, 0.9
Coefficient of variation of the CPUE series	0.2, 0.3, 0.4, 0.5
Effective Sampling Size of each length data point	20, 50, 100
Quarterly % increase in catchability trends in the CPUE Longline fleet	1.0000, 1.0025
Form of the selectivity curve for the CPUE fleet	Logistic, Double-normal
Growth parameters	TBD

4.2 Simulation platform

24. The WPM **NOTED** that the current simulation platform and software is available at the development website, http://github.com/iotcwpm/ALB, and can be readily installed.

25. The WPM **NOTED** that it is usually preferable to maintain consistency between conditioning and projection assumptions, e.g. CPUE CVs. If systematic lack-of-fit issues arise during conditioning (e.g. CPUE series or recruitment deviations) a reasonably smooth transition between historical estimates and projections might be achieved by adding auto-correlation to the error structure.

26. The WPM **NOTED** that the MSE simulator should not synthesize historical observations for the MP, because these data may provide additional information about the stock history that is not available in the real world, e.g. alternative CPUE series may be used in different OM conditioning scenarios to admit alternative possible abundance histories, but the MP must only use one CPUE series because we do not know what series is closer to reality. The WPM **REQUESTED** that the MSE simulator be changed to only provide a single data series to the MP in the next iteration.

27. The WPM **NOTED** that the albacore projections to-date were conducted using a single aggregate fishery selectivity vector, which can differ somewhat from fixed-allocation, quota-based management. The author indicated that new software was soon to be implemented that overcomes this limitation.

4.3 Tentative Harvest Control Rules

28. The WPM **NOTED** that different MP approaches were being used for the different species. The adopted SKJ management strategy consists of a HCR only, with the assumption that a reasonable consensus stock assessment

will be available with which to apply the HCR. ALB, YFT and BET are all conducting MSE in the spirit of a formal MP that requires pre-specification of data inputs and analyses, and a unique algorithm for calculating the quota. The specific MPs explored to date have differed and the WPM **AGREED** that going forward, the selected MP classes should be applied to each of ALB, YFT and BET to simplify communication. The MP classes should not differ unless there are management performance differences (or different computational situations).

5. SKIPJACK TUNA MSE: UPDATE

29. The WPM **NOTED** that a brief summary of the process that led to the adoption of IOTC Resolution 16/02, *On Harvest Control Rules for skipjack tuna in the IOTC area of competence*, was presented. The main elements of the Resolution were reviewed, especially those that led to discussions during adoption that could be of interest for the presentation of future MSE exercises.

30. The WPM **NOTED** paper IOTC–2016–WPM07–15 Rev_1 reporting on the MSE work for Indian Ocean skipjack tuna, including the following abstract provided by the authors:

"This report describes work towards Management Strategy Evaluation (MSE) for the Indian Ocean skipjack tuna (Katsuwonus pelamis) fishery. MSE is the simulation-based evaluation of alternative fisheries management policies. This research was initiated by the Maldives pole-and-line fishery in partial fulfilment of the conditions of its Marine Stewardship Council (MSC) certification (Adam et al 2013) and developed as part of the work programme of the Working Party on Methods (WPM) of the Indian Ocean Tuna Commission (IOTC). A simulation model of the skipjack fishery in the Indian Ocean was developed to use as the basis for MSE. The model attempts to capture the complexities of the fishery whilst remaining simple enough to be both understandable and computationally tractable. The model is spatially explicit with an age structured fish population and four fishing gears in each of three regions (West, East and Maldives). Several classes of management procedure were developed and preliminary evaluations done. These classes were intended to be illustrative of the diversity of potential MPs and their relative performance. These classes included MPs based on regular estimates of total mortality (e.g. from tagging), relative catch-per-unit-effort (CPUE) and estimates of stock status from stock assessments…" - see paper for full abstract.

31. The WPM NOTED that the current simulation platform and software is available at the development website, http://github.com/iotcwpm/SKJ, and can be readily installed.

32. The WPM **NOTED** that the documentation for the software has been improved, and additional performance statistics can now be computed. A series of future developments and extensions were also listed, including the reliability of the CPUE series used as input to the HCR, the sensitivity to uncertainty in certain parameters, and the multi-species nature of the fishery, which were all mentioned as possible future avenues of work.

33. The WPM **THANKED** the authors for this work and this update and **NOTED** that future work on the tropical tuna MSE simulation would greatly benefit from the involvement of the lead scientist.

34. The WPM **NOTED** that the quality and quantity of data from the Maldives pole and line fishery is a key element in both stock assessment and HCR for this stock and that potentially more informative data from logbooks has been collected since 2012. The WPM **NOTED** that these data could be used in the future to inform an alternative MP once the current HCR is up for revision (2019), and that further work needs to be conducted to ensure its usefulness.

35. The WPM **NOTED** that data for anchored FADs will be used in the standardization process and could be further improved in conjunction with the new data available from the logbooks.

36. The WPM **NOTED** that methods could be developed to complement the Maldivian series with information coming from the length distributions of catches from the purse seine fleets and PS CPUE, when the skipjack MP is reviewed (2019).

37. The WPM **RECALLED** that the conditioning procedure for the skipjack OM has evolved over time. The different structures of the stock assessment model and the OM, such as the spatial dynamics around the Maldives, led to a move to internal conditioning of the OM. A first attempt was made through the calculation of likelihoods for the various data sets: CPUE, length data and Z-estimates from tagging. These likelihoods were

used for conditioning based on the "differential evolution Markov chain Monte Carlo" method[2]. Results, however, did not appear reliable: the posterior distributions of some parameters seemed overly precise and suggested that it may have converged on a local minimum. The final method used is that of "Feasible Stock Trajectories"[3], as it appears to be internally consistent but not artificially precise.

6. BIGEYE TUNA AND YELLOWFIN TUNA MSE: UPDATE

38. The WPM **NOTED** paper IOTC–2016–WPM07–09 which provided an update on the bigeye tuna and yellowfin tuna management strategy evaluation development framework, including the software, documentation, demonstration Operating Model cases, and evaluation of candidate Management Procedures for both bigeye tuna and yellowfin tuna. The following abstract was provided by the authors:

> *"The IOTC has opted to use MSE to help meet its management objectives for the main commercial species, with the target of having MSE results presented to the Commission by 2018 for bigeye and yellowfin tunas. Working Paper IOTC–2016–WPTT18–32 is the final report and user manual from the completed first phase project, conducted with funds provided by the EU through FAO, and CSIRO, Australia. In addition to a general introduction to MSE, the document describes i) the simulation software, ii) demonstration case Operating Models (OMs) conditioned using SS3 assessment software, iii) candidate Management Procedures (MPs), iv) MSE results for the demonstration case OMs and range of MPs, and v) a critique of issues that were identified during the first phase that need to be reviewed and endorsed by the appropriate IOTC technical working parties to facilitate the next phase of the work. The presentation to the WPM highlighted key issues in the OM development process, and sought expert feedback from the WPM participants and endorsement for the next phase. The approach used in the IWC, CCSBT and for IOTC albacore was adopted, in which the OM for each species represents an ensemble of stock assessment models. Each individual model within the ensemble is fit to the assessment data, and they vary in terms of structural assumptions, input data and/or fixed values for parameters that are known to be difficult to estimate. The ensemble represents a balanced cross of interacting assumptions (the demonstration case consisted of 54 models for YFT and 18 for BET) …"* - see paper for full abstract.

39. The WPM **NOTED** that the project concluded in June 2016 and the software to make projections with the BET and YFT MSE is openly available for downloading, installing and running (https://github.com/pjumppanen/MSE-IO-BET-YFT).

40. The WPM **AGREED** to proceed with the next phase of the YFT and BET tunas MSE in the IOTC (noting that funding is available from the ABNJ project).

41. With regards to the technical features of the MSE, the WPM **NOTED** the following:
    - The software for the Operating Models of both YFT and BET has been adapted from the R-based projection software developed for Atlantic bluefin tuna.
    - The diverse feature set includes age-structure, seasonal dynamics, multiple fleets, multiple regions and multiple populations (i.e. with independent biological parameters). A number of modifications were required for the bigeye tuna and yellowfin tuna applications, and a numerically efficient C++ sub-routine was coded in parallel to reduce memory constraints, computation time, and provide independent error checking.

Yellowfin tuna MSE

42. The WPM **REQUESTED**:
    - the OM grid is updated in relation to the 2016 assessment (Table 2).

43. The WPM discussed the range of OMs that would cover the existing uncertainties on IOTC YFT stock assessment and provided a series of recommendations:
    - Weighting factors (lambdas) for both tag likelihoods would need to be modified in the uncertainty grid (i.e. the abundance estimator and the movement estimator).

44. The following robustness scenarios were proposed but specific model structures to examine these scenarios have yet to be developed:

[2] Ter Braak, C.J.F. 2006. A Markov Chain Monte Carlo version of the genetic algorithm Differential Evolution: easy Bayesian computing for real parameter spaces. *Statistics and Computing*, 16: 239-249.

[3] Bentley, N. & Langley, A. 2012. Feasible stock trajectories: a flexible and efficient sequential estimator for use in fisheries management procedures. *Canadian Journal of Fisheries and Aquatic Science*, 69: 161-177.

- Testing for the effect of changing selectivity over time (e.g. to check for a shift towards younger selected ages over time).
- A model structure that would permit accommodating the CPUE information prior to 1979 should be considered.
- Tag λ=1.5. This was proposed on the basis that the tags might be more informative and reliable than the other data, despite the fact that the tags are known to violate mixing assumptions and are expected cause biases.

45. The WPM **NOTED** that there will likely be a demand for yet another assessment of YFT in 2017, and there will be an opportunity to decide on the data and sets of assumptions to be used. The group **AGREED** that the 2016 stock assessment is used for the new conditioning of the OMs of YFT but that there are no further OM updates until the MP process has progressed sufficiently to reach MP adoption and review (unless extreme new evidence comes to light to indicate that the assessment is badly formulated).

46. The WPM **NOTED** the problems with the movement estimates on the SS3 models in this and other tuna stocks, but no suggestions were made on how to improve this. The models used so far do not fit the tagging information very well and the range of options currently explored may not capture the real movement dynamics of YFT stocks. Given the confounding of mortality, selectivity, recruitment and movement, it is expected that there may be very different model parameters that would fit the data reasonably well and are not recognised.

Bigeye tuna MSE

47. The WPM **NOTED** that a grid of OMs similar to the YFT was proposed (Table 2). Weighting factors (lambdas) for both tag likelihoods would need to be modified in the uncertainty grid (i.e. the abundance estimator and the movement estimator).

48. The WPM **AGREED** that the new OM grid is based on the 2016 stock assessment. However, a series of robustness tests were also proposed including:
    - Tag λ=1.5. This was proposed on the basis that the tags might be more informative and reliable than the other data, despite the fact that the tags are known to violate mixing assumptions and are expected cause biases.
    - Testing for the effect of changing selectivity over time (e.g. to check for a shift towards younger selected ages over time).

Management Procedures

49. Both empirical and model-based types of MP were implemented and described. The first would adjust future catches based on the observed CPUE trends (and level relative to a desirable target CPUE). The model-based MP includes fitting a surplus production model, from which key estimates are plugged into a 10:40 type Harvest Control Rule. Demonstration MP results were presented along with an attempt to identify an MP "tuning" range within which MP performance should be targeted to reflect the stated Commission objectives. Some particular comments to the MPs were **NOTED** by the WPM:

    - The group **NOTED** that the MSE framework is complete with respect to the feature set required from the previous assessments, though minor modifications will be required for 2016 assessments.
    - The group **NOTED** that the PT4010 MP included an HCR that defined control parameters that could be interpreted as reference points. The group **AGREED** to re-name the control parameters to avoid confusion.
    - The group **NOTED** that the size data could be used to try to make recruitment inferences within MPs.
    - The group **REQUESTED** that the Irate and Brule MPs (tested for albacore) also be applied to YFT and BET to reduce options and simplify communication with the Commission if MP performance is similar.

50. The WPM **NOTED** the uncertainty associated with the historical catch data reported by many CPCs, particularly the large artisanal component of the catch and **AGREED** that methods to incorporate this into the MSE process should be explored in the future.

Table 2. Summary of the grids agreed by the WPM for YFT and BET OM ensembles.

YFT OM ensemble	3 x 3 x 3 x 2 x 2 x 2 options = 216 configurations			
Grid Dimension	Levels			Notes
Natural mortality	0.6	0.8	1.0	Multiplier relative to 2015 reference case assessment
Steepness	0.7	0.8	0.9	Beverton-Holt relationship
Tag lambdas	0.0	0.1	1.0	weighting factor for both components of tag likelihood
Tag Mixing period	3	8		Quarters
Relative abundance (CPUE) bias	0.0	1.0		Historical and future catchability trend (percent per annum compounded)
CPUE analysis for tropical tuna targeting	CLU	HBF		CLU = cluster analysis (no HBF) HBF = hooks between floats
BET OM ensemble	**3 x 3 x 3 x 1 x 2 x 2 options = 108 configurations**			
Grid Dimension	Levels			Notes
Natural mortality	0.6	0.8	1.0	Multiplier for M(a=4) relative to 2013 reference case
Steepness	0.7	0.8	0.9	Beverton-Holt relationship
Tag lambdas	0.0	0.1	1.0	weighting factor for both components of tag likelihood
Tag Mixing period	4			Quarters
Relative abundance (CPUE) bias	0.0	1.0		Historical and future catchability trend (percent per annum compounded)
CPUE analysis for tropical tuna targeting	CLU	HBF		CLU = cluster analysis (no HBF) HBF = hooks between floats

7. PRESENTATION AND EVALUATION OF MSE RESULTS

7.1 Visualisation of MSE results

51. The WPM **WELCOMED** paper IOTC–2016–WPM07–10 which proposed some standardised approaches for providing MSE results in an easier understood format for non-technical audience. The following abstract was provided by the authors:

"*The Indian Ocean Tuna Commission (IOTC) management strategy evaluation (MSE) work program was initiated following adoption of the proposal to implement the precautionary approach for managing IOTC species in 2012 (Resolution 12/01). From this Resolution, the IOTC Scientific Committee (SC) was instructed to assess the performance of candidate management procedures (MP) through MSE, and provide the Commission with advice on their performance against Commission objectives. The IOTC Working Party on Methods (WPM) leads the technical development of MSEs for key IOTC species. Outputs from an MSE can be extensive and complicated, and the entire MSE process is often not well-understood by non-technical audiences. Effective and consistent communication of MSE results is important to ensure that decision makers are clearly informed about the likely consequences of implementing different MPs or harvest control rules (HCR). Communication of MSE results for IOTC stocks has been relatively ad hoc to date, with no established guidelines for presenting MSE results to the Commission. The use of standardised terminology and presentation formats for MSE results would facilitate a better understanding and maximise the engagement of all partners in the MP dialogue. The proposal to establish a Technical Committee on Management Procedures (TCMP) was adopted at the 20th Session of the IOTC. This committee will provide a forum in which MSE results are presented and discussed in a manner that assists the Commission to consider possible adoption of candidate MPs. This paper outlines some of the key considerations, and presents some potential options, for developing a standardised approach for communicating MSE results to the TCMP and Commission. The intent of this paper is to provide a basis for a recommendation to the SC and TCMP for further feedback. The ultimate goal is to develop a set of guidelines for the communication of MSE results in the IOTC".*

52. The WPM **WELCOMED** the initiative taken by the authors as a positive step forward and **AGREED** to share the approach with practitioners in other tRFMOs, through the Joint Tuna RFMO Management Strategy Evaluation Working Group (Agenda item 11.2).

53. The WPM **NOTED** that ranking MPs should allow discrimination of performance rather than a simple ordinal ranking which may mask very small differences in performance. Further applying an overall rank needs further consideration regarding weighting across different performance indicators.

54. The WPM **NOTED** that the proposed Kobe plot with uncertainty ranges seems to be a useful way to demonstrate status outcomes and is a familiar way of communicating assessment outcomes. Further, the WPM **NOTED** the importance of informing on the trade-offs resulting from the competing MPs under evaluation.

55. The WPM **RECOGNISED** the need to provide both graphical and text summaries of the outcomes of the MSE testing of the MPs and **AGREED** the text format proposed, with some definition of terms, will be a quite useful summary of results.

56. The WPM **CONSIDERED** advice provided regarding lessons learned at CCSBT and IWC and **ACKNOWLEDGED** that providing too many summary statistics from the MSE outcomes can result in unnecessary confusion. The WPM further **ACKNOWLEDGED** that the number of MPs evaluated should be limited to those judged to meet the policy guidelines established by the Commission, such as those provided in Resolution 15/10.

57. The WPM **NOTED** that MP "tuning" should be used to reduce the dimensionality of the MP selection process. Tuning involves adjusting the control parameters of each MP to achieve the same management objective (the highest priority objective). This reduces the amount of information presented and allows MPs to then be selected with respect to secondary or tertiary objectives. Since the Commission has not yet defined an objective clearly enough to define a unique tuning objective, it is suggested that ~3 tuning objectives might be defined initially, and refined with feedback from the TCMP and Commission.

58. The WPM **AGREED** to develop a proposal for a succinct set of summary graphics and text formats to be used in communicating MSE outcomes, considering both those proposed in IOTC–2016–WPM7–10, the views of MP, and those identified in the 2016 Tokyo Meeting (IOTC-2016-WPM07-INF01).

59. The WPM **RECOMMENDED** the proposed standardised methods for the presentation of MSE results (Appendix IX) are submitted to SC21 for discussion, revision and endorsement, as appropriate. Subsequently, this should be considered a living document that will benefit from revision based upon feedback received from the TCMP, which will first meet in 2017.

60. The WPM was advised of the ABNJ Tuna Project plan for its second capacity building workshop in the Indian Ocean region in the first quarter of 2017 (possibly March). These workshops are global in nature and are overseen by FAO, but led by WWF which has engaged a consultant group that has developed and delivers curriculum and participatory exercises to promote better understanding of the use of MSE for guiding selection of MPs. The WPM **NOTED** that this workshop could be a very useful test bed for using the summary formats proposed in Appendix IV and **REQUESTED** that the workshop organizers be made aware of these formats and incorporate them into the curriculum, to the degree possible.

7.1 Performance statistics

61. The WPM reviewed the performance statistics, used for measuring the performance of alternative management procedures against different objectives, that were endorsed by the SC and **AGREED** the following:
    - the measure of catch variability would be more comparable across MPs if expressed as a coefficient of variation (CV)
    - arithmetic means should be used for all statistics (rather than geometric means)

    The WPM therefore **RECOMMENDED** that the Scientific Committee endorses the revised list of performance statistics provided in Appendix V.

8 JOINT CPUE STANDARDISATION

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

62. The WPM **NOTED** paper IOTC–2016–WPM07–11 which described the collaborative study of tropical tuna CPUE from multiple Indian Ocean longline fleets in 2016. This paper was presented in two parts to discuss two distinct issues: (i) the use of the joint CPUE indices in the MSE process and (ii) priorities for future analysis/development of the joint CPUE index.

63. The WPM **NOTED** the presentation of the first part of paper IOTC-2016-WPM07-11, which dealt with the use of the joint CPUE indices in the MSE process, including the following summary provided by the authors:

"*The paper presents the results of a collaborative study between national scientists with expertise in Japanese, Taiwanese, and Korean longline fleets, and an independent scientist to address several important issues related to albacore, bigeye and yellowfin tuna CPUE indices in the Indian Ocean, to validate and improve methods for developing indices of abundance for tropical tunas. The use of CPUE indices in MSE was discussed, particularly systematic errors likely to remain in CPUE indices, such as catchability trends, hyper depletion and hyperstability; appropriate CVs for fitting OMs; and ways to express uncertainty in OM conditioning and future projections*"

64. The WPM **NOTED** that for the MSE process it will be important to focus on factors that vary over the long term and could therefore substantially bias the CPUE index, such as changes in spatial structure, effort creep, or changes in targeting. The WPM **NOTED** that efficiency creep and increasing catchability will be investigated in the MSE process through scenarios with either no effort creep or 1% effort creep.

65. The WPM **NOTED** that declines in CPUE in the early stages of fisheries may be associated with juvenilization of the population (i.e. the older and larger mature individuals were more vulnerable to capture in the early time periods of the fishery) and that selectivities may also change when fishing practices change. The WPM **AGREED** that this should be investigated in parallel with the CPUE standardization and MSE processes.

66. Although it was suggested that the ratio in catches between species could be included to deal with targeting issues, the WPM **NOTED** that this could cause mathematical problems as the catch of the species to be standardized appears on both sides of the standardization equation (i.e. response variable and predictors). Thus, the WPM **NOTED** that cluster approach presented is a better choice to address the targeting issue in the standardization.

8.2 Priorities for future development of the joint CPUE indices

67. The WPM **NOTED** the presentation of the second part of paper IOTC-2016-WPM07-11, which discussed priorities for future analysis of the joint CPUE index, including the following summary provided by the authors:

"*The author described in more detail the methods used in the collaborative study of Japanese, Taiwanese, and Korean CPUE for albacore, bigeye and yellowfin tuna in the Indian Ocean. He identified areas of uncertainty and potential bias, and suggested a number of potential approaches for further research to help to make the indices more reliable and representative*"

68. The WPM **NOTED** that information on the identification of Japanese vessels is available from the beginning of the time series, but these data are stored in paper documents and compilation of the data could take some time. The WPM **ENCOURAGED** Japan to assemble these data as soon as possible so that they might be included in the standardization process.

69. The WPM **NOTED** that skipper behaviour could affect catchability and, thus skipper identity should be included in the standardization process. However, the WPM **NOTED** that the recovery of these data could be more difficult and time consuming than recovering vessel identity data.

70. The WPM **NOTED** that Japanese size data was investigated last year and that a paper on size data of Japanese longliners will be presented to the upcoming IOTC WPDCS. Summaries of the raw data identified no major differences between size composition of longliners operating in different areas and times. However, the WPM also **NOTED** that different methods are available to account for different size distribution by area/time in the standardization process.

71. Although Sea Surface Temperature (SST) can be included in the standardization process, the WPM **NOTED** that 5 degree cell areas are already included in the standardisation process and including SST in addition to 5 degree cells does not significantly change the outcomes.

72. The WPM **NOTED** that variable selection for the CPUE standardization is based on the variance explained by the factor rather than by variable selection using statistical significance, because most of the factors are significant in the standardization due to the very large sample sizes and lack of independence between sets.

73. The WPM **NOTED** that the change in number of hooks between floats (HBF) from 5 to 10 in the late 70s is related to changes in targeting, while the change in HBF in the late 90s (from around 10 to 20) is related to changes in the line material to monofilament. The change in material density causes the longline to float higher, and thus more hooks are included to allow the longline to sink to fishing depths.

74. The WPM **NOTED** that it would be good to include soak time, haul time, branch-line material and other operational variables in the CPUE standardization, but the WPM **RECOGNISED** that these data are available neither for all the fleets nor for the whole time period, precluding their use in the CPUE estimation.

75. The WPM **NOTED** that the joint CPUE work undertaken so far has become a critical component for assessments of temperate and tropical species and **RECOMMENDED** that this work continue under the current framework, i.e. supported by a consultant, but that plans should be developed to normalize the process within the IOTC in the near future.

76. The WPM **NOTED** the research priorities identified in the presentation of the CPUE standardization, ranked as follows: (i) improve the understanding of the fishery including the discontinuity of CPUE 1976-80 and size data, (ii) explore the spatial variation and time-area interactions within regions, (iii) prepare indices for each fleet separately, (iv) set up hardware and software for grid computation to speed up the analysis, (v) develop a simulator to allow development and testing of code while joint data are unavailable, and (vi) the analysis of factors affecting changes in targeting.

77. The WPM **NOTED** that the spatial structure of the BET/YFT CPUE standardization is different to that developed for the 2016 bigeye stock assessment and so **AGREED** to realign the spatial structure of CPUE analysis to match that of the stock assessment of bigeye (and, if necessary in 2017, yellowfin tuna).

78. The WPM **CONGRATULATED** the authors on the MSE work that has been completed and **THANKED** ISSF for supporting this important study.

9 OTHER MATTERS

9.1 Online collaborative environment for stock assessment models

79. The WPM **NOTED** paper IOTC–2016–WPM07–13 Rev_1 which described an approach that has been used to run ICCAT bluefin stock assessments in a collaborative online environment. The following summary was provided by the authors:

> *"In this note, we present an approach which has been recently used to execute online the set of codes used for eastern bluefin tuna (BFT-E) stock assessment at ICCAT. We aim at discussing the possible interest of the approach to the IOTC Community for focusing on Indian Ocean tuna and tuna-like stocks and running other assessment models such as Stock Synthesis 3 (SS3).*
>
> *In 2014, ICCAT BFT-E working group has been able to execute thousands of model runs by using parallelization of R and Fortran codes on a supercomputer. This approach has a lot of scientific benefits, in particular for better including the multiple sources of uncertainty in assessment results and associated scientific advice. However, very few participants would be able to reproduce it without specific technical skills.*
>
> *Since November 2015, a WebSite or VRE for Virtual Research Environment has been set up within the H2020 BlueBridge project to enable users to easily parametrize and execute various steps of the BFT-E stock assessment workflow. By repackaging codes provided by ICCAT BFT-E working group, the same codes are now executable online. They can be parametrized, executed and edited by anybody from a simple web page and data outputs are delivered in standard data format. At this stage, this VRE comes with various collaborative Web Services: (i) a workspace to share documents or data, (ii) Web pages or RStudio server to process data online, and (iii) an automated report service to dynamically generate documents packaging these results. Such a collaborative environment enables to store and access the whole set of data and source codes to replicate past results or to try new parametrizations of the model with usual tools or simple web forms. Such an approach might bring more transparency and collaboration within working groups".*

80. The WPM **WELCOMED** the interesting online approach for running stock assessment models presented by the authors, and **NOTED** that it may be one towards which the IOTC progresses towards over time.

81. The WPM **NOTED** the absence of a method for storing and accessing the files used for historical assessments which are often useful for replicating previous assessments. The WPM **RECOGNISED** that the approach presented by the authors demonstrates an effective way of storing and archiving historical assessment files and that storage in netCDF files is useful for transparency.

82. The WPM **NOTED** that the online collaborative approach presented by the authors is also being extended to species other than bluefin, including albacore, and that the approach could also be extended to the development and presentation of MSEs.

83. The WPM **NOTED** that the IOTC Secretariat is working towards providing better online access to IOTC data, and that the approach presented by the authors could be applied to facilitate this process.

84. The WPM **NOTED** the varying levels of expertise and knowledge across CPCs, and the need to develop a broader understanding of the process of a collaborative online approach across other working parties before such a system could be adopted in the IOTC.

I.R. Iran purse seine fishery

85. The WPM **NOTED** paper IOTC–2016–WPM07–16 which described the Iranian tuna fisheries, including recent trends in catch and effort and fish size in the Oman Sea and Indian Ocean, including the following abstract provided by the authors:

    "About 550000 Mt. of various fishes have been harvested in 2015 from Persian Gulf, Oman Sea and Indian Ocean by 10.600 vessels including boats, Dhows and ships. These vessels are equipped with different fishing gears to harvest variety of aquatics e.g. Large and small pelagic, Reversal species, Lantern fish and Shrimp, within allowed areas. Following diagram demonstrates harvest geographical position, capture type and method of harvest as well".

86. The WPM **WELCOMED** the collection of logbook data and size data in Iran, especially from the gillnet fishery, and **ENCOURAGED** Iran to continue this valuable data collection. The WPM **NOTED** that these data have not yet been reported to the IOTC Secretariat and **REQUESTED** the submission of these data by Iran with assistance from the IOTC Secretariat, where necessary.

Indonesia: enumeration methods for estimating yellowfin tuna production

87. The WPM **NOTED** paper IOTC–2016–WPM07–17 Rev_1 which described catch, effort and size data for yellowfin tuna collected from a monitoring program in Bali, Indonesia. The following summary was provided by the authors:

    "*Yellowfin tuna (Thunnus albacares) is one of the important catch for the fishing industry in Indonesia. The objectives of this study is to investigate the production of yellowfin tuna in Indian Ocean. Data were collected from enumeration data in Benoa Port, Indonesia from January 2010 to December 2015. The methods used in this study was enumeration methods where we collected data from sampled vessels. The estimation values were calculated from sampled data multiplied by covered percentage vessels. Total of 5,105 vessels were landed during that periods and 2,711 vessels were covered (54.74%). More than 200,000 yellowfin tuna were measured its weight (kg) and around 36,000 were measured its fork length (cm). Generally, the estimation of landed yellowfin tuna decreased during that periods. The number was sharply declined from nearly 1,000 tons in June 2010 to only less than 100 tons in December 2015. It means that the decreasing level was around 10 times in 5 years. However, the average CPUE fluctuated monthly with the average around 3 tons/trip. Moreovver, the average length and weight of yellowfin tuna were tend to be stagnant from year to year with 131 cm of fork length and 42 kg of weight. The findings from this study provide fundamental information for management of yellowfin tuna stock and population.*"

88. The WPM **WELCOMED** the collection of catch and effort data and size sampling of yellowfin tuna in Indonesia, and **ENCOURAGED** Indonesia to continue this valuable sampling and data collection.

89. The WPM **WELCOMED** any updates on results from this data collection and sampling and **REQUESTED** that any further analysis of these data are presented at future WPM meetings.

9.2 Future considerations for WPM: methods to investigate management advice across multiple model structures for assessing stock status

90. The WPM **NOTED** the request from the WPTT18:

"The WPTT NOTED that there were results from several assessment models presented, and it was not clear whether or how to synthesize all of the results. Some of the analyses were much more detailed than others and used more of the available data. Additionally, some of the models were very similar and did not seem to provide new insight. The WPTT REQUESTED the WPM to provide guidance on the most appropriate models to use in the future, and how to provide advice when multiple models are presented" [WPTT18, para. 91]

and **AGREED** to add this to the WPM program of work.

10 WPM PROGRAM OF WORK

10.1 Revision of the WPM Program of work (2017–2021)

91. The WPM **NOTED** paper IOTC–2016–WPM07–12 which provided a propose programme of work for the development of harvest strategies for key species in the IOTC, including the following abstract provided by the authors:

"Resolution 15/10 notes that the objectives of the Commission are 'to maintain stocks in perpetuity and with high probability, at levels not less than those capable of producing their maximum sustainable yield'. To that end, interim and alternate interim limit and target reference points have been adopted by the Commission, and the Scientific Committee has been instructed to 'develop and assess, through the management strategy evaluation process, the performance of harvest control rules to achieve target reference points on average and avoid limit reference points with a high probability'. The development of management procedures for key IOTC species is underway. The development and review of management procedures through the IOTC committees and sub-committees, and the adoption of management procedures by the Commission, is a complex and iterative process that will likely require several rounds of advice, consideration and review. The 20th Session of the IOTC Commission noted the substantial work underway in developing management procedures for IOTC stocks and requested 'the SC to develop a work plan reflecting key elements to be agreed and developed, including roles and responsibilities of each of the Commission, Scientific Committee, Compliance Committee and other subsidiary bodies, and also including decision points on these elements for the Commission'. The following draft schedule of work has been developed to address this request from the Commission…" - see paper for full abstract.

92. The WPM **NOTED** that definition of the MPs is an iterative process requiring communication between the WPM and the Commission through its various subsidiary bodies.

93. The WPM **NOTED** the schedules proposed in Resolution 15/10 (Annex I, para. 4) are quite ambitious and more time may be required. Nevertheless, the WPM **NOTED** that it is currently unclear how many iterations will be needed, given the adoption of the HCR for skipjack and **AGREED** that the work plan and scheduling must remain responsive according to the needs of the Commission.

94. The WPM **NOTED** that the Compliance Committee does not necessarily need to be involved in the MSE development process, but may potentially be able to provide information on the uncertainty regarding implementation aspects.

95. The WPM **NOTED** paper IOTC–2016–WPM07–07 presenting the draft WPM Program of Work (2017–2021).

96. 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)

97. The WPM **NOTED** that the next stock assessment of Indian Ocean swordfish is due to take place in 2017 and **RECOMMENDED** that the development of MSE of swordfish is considered as a high priority in the revised WPM Program of Work and that funding is allocated for this activity, to start the conditioning of an OM for this stock.

98. The WPM **AGREED** to hold an informal meeting of the MSE development team in early 2017, prior to the TCMP session, as in previous years.

99. 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 high priority projects detailed on the WPM Program of Work (2017–2021) that are yet to be funded, for circulation to potential funding bodies.

100. The WPM **RECOMMENDED** that the Scientific Committee consider and endorse the WPM Program of Work (2017–2021), as provided at Appendix VI.

10 OTHER BUSINESS

10.1 Tier approach for providing stock status advice

101. The WPM **NOTED** the tier approach has been in discussion for a number of years and paper IOTC–2015–WPM06–13 provided a way forward to develop a tier approach for providing stock status advice and was previously discussed by WPM.

102. The WPM previously **NOTED** that tiered approaches can be used to facilitate the selection of appropriate stock assessment methods and encourage consistency in the provision of stock status advice derived from those methods. The WPM also **NOTED** that it may be a non-trivial exercise to generalize the degree of accuracy and precision to be expected from tiers. Experience in other fora has suggested that the assumed relationship between a tier hierarchy and uncertainty has not always translated into the desired level of precautionary management.

103. The WPM also **AGREED** that there are of course a number of details that must be addressed in developing these tiers, particularly in relation to the preferred method for estimating the probability density.

104. The WPM incorporated the tier approach into its Program of Work for 2016, but it was **NOTED** that there was not sufficient funding to permit addressing this issue in 2016.

10.2 Joint t-RFMO Management Strategy Evaluation working group

105. The WPM NOTED the summary of the outcomes of the recent meeting on MSE approaches across the tRFMOs:

"The Joint MSE Technical Working Group was created during the Third Joint Tuna RFMOs meeting of the Kobe process (San Diego, 2012) to support the implementation of the Precautionary Approach for tuna fisheries management. A previous output of the group was a review of the Kobe advice framework and how the adoption of MSE would change the dialogue on risk and uncertainty. The group met for the first time in Madrid Nov 1-3, 2016 with support of the ABNJ Tuna project.
The objectives of the meeting were to:

- *Review current practice, successes, failures and potential areas for collaboration.*
- *Openly discuss progress on MSE*
- *Identify future actions focusing on areas for collaboration*

The workshop was organized around five themes: 1) MSE process and stakeholder dialogue, 2) Conditioning operating models, 3) Albacore case study, 4) Computational aspects and 5) Dissemination of results.

The meeting concluded, based upon the experiences communicated at the workshop, that in conducting dialogues or similar meetings, technical jargon and the tendency to lecture needs to be avoided in communicating the concepts related to development and testing of MPs. Further, communicating trade-offs with respect to the most likely main issues of concern to the tRFMO Commissions (safety, stability, and yield) is critical and adding a large number of dimensions in terms of MP performance trade-offs at that level can lead to confusion and lack of acceptance. Although only CCSBT has agreed and fully implemented an MP for TAC setting of SBT, the other tRFMOs are at various stages of development and are expected to progress over the next few years, although likely at different paces.

The Workshop considered the range of operating models (OM) examined across tRFMOs were primarily based on the assessment models and judged this practice to be a good starting point, though further processes (observation error and time series and ecological) should be accounted for in OM designs. Getting agreement on the scenarios examined should be discussed from the onset. The process of eliminating unrealistic scenarios of OMs needs standardization to the degree possible, and should be clearly documented so one tRFMO can learn from another. The Workshop tabled the range of OM conditioning approaches and

assumptions used across the different tRFMOs that can be used to inform future developments and identify best practices. Progress on an Albacore case study, which takes advantage of the relative advancement of the MSE for several of the Albacore stocks across several tRFMOs, including the IOTC, and the relative simplicity of the operating models required in the development of MSE simulations, was summarized. Other discussions on computation aspects which could assist in speeding up the process of simulation and means of disseminating the results were also held".

106. The WPM **WELCOMED** the information on these recent developments and encouraged the Joint Technical Working Group to maintain momentum in further progressing the work on these issues.

107. The WPM **NOTED** the positive progress made by the IOTC in advancing the dialogue and MP evaluations for some priority stocks in the Indian Ocean, especially considering the ongoing work of WPM, WPTT and the SC, leading to the adoption of Resolutions 16/02 and 16/09 by the Commission.

108. The WPM **NOTED** the common feature of conditioning OMs on assessment models. More complicated model structures that accommodate broader hypotheses regarding underlying stock dynamics are desirable in some cases, such as for Bluefin tuna.

109. The WPM **NOTED** that it may be desirable to standardize not only the OM conditioning approach, but also the HCRs considered in MPs. While there is some standardization in classes of HCRs that have been or are undergoing evaluation in the MSEs in the IOTC, such an approach might not be globally acceptable due to the multiple and differing objectives across tRFMOs, fisheries, and memberships.

110. The WPM further **NOTED** the intent of the Joint Technical Working Group to develop and maintain an MP software code archive through the group and **ENCOURAGED** the group to continue to develop this archived tool set.

10.3 Date and place of the 8th and 9th sessions of the WPM

111. The WPM **REQUESTED** that the IOTC Secretariat liaise with CPCs to determine if they would be able to host the 7th and 8th sessions of the WPM respectively (Table 3), in conjunction with the WPTT.

112. The WPM **RECOMMENDED** that the WPM should be held in conjunction the WPTT in 2017, with a day's break in between meetings and slightly earlier in the year (October).

Table 3. Draft meeting schedule for the WPM (2017 and 2018)

	2017			2018		
Meeting	**No.**	**Date**	**Location**	**No.**	**Date**	**Location**
Working Party on **Methods** (WPM)	8th	Third week in October (3 d) (with WPTT)	TBD	9th	Third week in October (3 d) (with WPTT)	TBD

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

113. The WPM **THANKED** the invited expert, Dr Ana Parma, for her excellent contributions to the meeting.

114. 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 2017, by an Invited Expert(s):

- **Expertise**: Management Strategy Evaluation.
- **Priority areas for contribution**: Evaluation of management procedures, communication of fisheries advice.

10.5 Review of the draft, and adoption of the Report of the 7th Session of the WPM

115. The WPM **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPM07, provided at Appendix VII.

116. The report of the 7th Session of the Working Party on Methods (IOTC–2016–WPM07–R) was **ADOPTED** on 13 November 2016.

APPENDIX I
LIST OF PARTICIPANTS

Chairperson
Dr Toshihide **Kitakado**
Tokyo University of Marine Science & Technology
Japan
Email: kitakado@kaiyodai.ac.jp

Vice Chairperson
Dr Iago **Mosqueira**
European Commission Joint Research Centre
Email:
iago.mosqueira@jrc.ec.europa.eu

Invited Expert
Dr Ana **Parma**
CONICET
Argentina
Email:
parma@cenpat-conicet.gob.ar

Other Participants
Dr M.Shiham **Adam**
Ministry of Fisheries & Agriculture
Maldives
Email: msadam@mrc.gov.mv

Ms Cindy **Assan**
Seychelles Fishing Authority
Seychelles
Email: cassan@sfa.sc

Dr Julien **Barde**
IRD
France
Email: julien.barde@ird.fr

Dr Sylvain **Bonhommeau**
IFREMER
Seychelles
Email:
sylvain.bonhommeau@ifremer.fr

Dr. Yin **Chang**
National Cheng Kung University
Taiwan, China
Email: yinchang@mail.ncku.edu.tw

Dr Emmanuel **Chassot**
IRD
France
Email: emmanuel.chassot@ird.fr

Mr James **Geehan**
Indian Ocean Tuna Commission,
Seychelles
Email: james.geehan@iotc.org

Dr Sisira **Haputhantri**
National Aquatic Resources Research and Development Agency (NARA)
Sri Lanka
Email:
sisirahaputhantri@yahoo.com

Dr Simon **Hoyle**
Hoyle Consulting
New Zealand
Email: simon.hoyle@gmail.com

Ms Juliette **Lucas**
Seychelles Fishing Authority
Seychelles
Email: jlucas@sfa.sc

Mr Prasit **Luesrithawornsin**
Department of Fisheries
Thailand
Email: prasit_kim@hotmail.com

Dr Gorka **Merino**
AZTI
Spain
Email: gmerino@azti.es

Mr Gholamali **Moradi**
Iran Fisheries Organization
Iran
Email: moradi54ali@gmail.com

Mr Stephen **Ndegwa**
State Department of Fisheries
Kenya
Email: ndegwafish@yahoo.com

Dr Tsutomu **Nishida**
National Research Institute of Far Seas Fisheries
Japan
Email: aco20320@par.odn.ne.jp

Dr Gerald **Scott**
International Seafood sustainability Foundation, USA
Email:
gpscott_fish@hotmail.com

Dr Ashley **Williams**
Department of Agriculture
Australia
Email: ashley.williams@jcu.edu.au

Mr Irwan **Jatmiko**
Research Institute for Tuna Fisheries
Indonesia
Email: irwan.jatmiko@gmail.com

Dr Hilario **Murua**
AZTI
Spain
Email: hmurua@azti.es

Dr Takayuki **Matsumoto**
National Research Institute of Far Seas Fisheries
Japan
Email: matumot@affrc.go.jp

Dr Dale **Kolody**
CSIRO
Email: dale.kolody@csiro.au

Mr Muhammad Farhan **Khan**
Ministry of Ports and Shipping,
Government of Pakistan
Email: farhankhan704@gmail.com

Mr Abdi Ali **Yare**
Ministry of Fisheries and Marine Resources
Somalia
Email: abdialiyare@gmail.com

Mr Jiang Feng **Zhu**
Shanghai Ocean University
China
Email: jfzhu@shou.edu.cn

Dr Sarah **Martin**
Indian Ocean Tuna Commission,
Seychelles
Email: Sarah.martin@iotc.org

Dr Alejandro **Anganuzzi**
Indian Ocean Tuna Commission/
ABNJ Project
Rome
Email: Alejandro.anganuzzi@fao.org

APPENDIX II
AGENDA FOR THE 7TH WORKING PARTY ON METHODS

Date: 11-13 November 2016
Location: Victoria, Seychelles
Venue: International Conference Centre, Seychelles
Time: 09:00 – 17:00 daily
Chairperson: Dr. Toshihide Kitakado; **Vice-Chairperson**: Dr. Iago Mosqueira

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 18th Session of the Scientific Committee (IOTC Secretariat)
   - 3.2 Outcomes of the 20th 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 WPM06 (IOTC Secretariat and Chairperson)
4. **ALBACORE MSE: UPDATE** (Vice-Chairperson)
   - 4.1 Conditioning of operating models
   - 4.2 Simulation platform
   - 4.3 Tentative Harvest Control Rules
5. **SKIPJACK TUNA MSE: UPDATE** (Chairperson and Consultant)
   - 5.1 Conditioning of operating models
   - 5.2 Simulation platform
   - 5.3 Tentative Harvest Control Rules
6. **BIGEYE TUNA AND YELLOWFIN TUNA MSE: UPDATE** (Chairperson and Consultant)
7. **PRESENTATION AND EVALUATION OF MSE RESULTS** (Chairperson and Vice-Chairperson)
   - 7.1 Visualisation of MSE results
   - 7.2 Performance indicators
8. **JOINT CPUE STANDARDISATION** (Chairperson and Consultant)
   - 8.1 Update on the status of the joint CPUE indices (yellowfin tuna, bigeye tuna & albacore).
   - 8.2 Priorities for future development of the joint CPUE indices.
9. **OTHER MATTERS (**Chairperson)
   - 9.1 Other matters
   - 9.2 Future considerations for WPM: methods to investigate management advice across multiple model structures for assessing stock status
10. **WPM PROGRAM OF WORK** (Chairperson and IOTC Secretariat)
    - 10.1 Revision of the WPM Program of Work (2017–2021)
11. **OTHER BUSINESS**
    - 11.1 Tier approach for providing stock status advice (Chairperson)
    - 11.2 Meeting of the Joint t-RFMO Management Strategy Evaluation working group (Chairperson)
    - 11.3 Date and place of the 8th and 9th Sessions of the WPM (Chairperson and IOTC Secretariat)
    - 11.4 Development of priorities for Invited Expert(s) at the next WPM meeting (Chairperson)
    - 11.5 Review of the draft, and adoption of the Report of the 7th Session of the WPM (Chairperson)

APPENDIX III
LIST OF DOCUMENTS

Document	Title	Availability
IOTC–2016–WPM07–01a	Draft: Agenda of the 7th Working Party on Methods	✓17 August ✓20 September ✓14 October ✓11 November
IOTC–2016–WPM07–01b	Draft: Annotated agenda of the 7th Working Party on Methods	✓11 November
IOTC–2016–WPM07–02	Draft: List of documents of the 7th Working Party on Methods	✓14 October ✓11 November
IOTC–2016–WPM07–03	Outcomes of the 18th Session of the Scientific Committee (IOTC Secretariat)	✓24 October
IOTC–2016–WPM07–04	Outcomes of the 20th Session of the Commission (IOTC Secretariat)	✓24 October
IOTC–2016–WPM07–05	Review of Conservation and Management Measures relating to methods (IOTC Secretariat)	✓24 October
IOTC–2016–WPM07–06	Progress on the recommendations of WPM06 (IOTC Secretariat, Chair & Vice-Chair)	✓25 October
IOTC–2016–WPM07–07	Revision of the WPM Program of Work (2017–2021) (IOTC Secretariat, Chair & Vice-Chair)	✓25 October
IOTC–2016–WPM07–08	Management Strategy Evaluation for Indian Ocean albacore tuna (I.Mosqueira)	✓28 October
IOTC–2016–WPM07–09	IOTC Yellowfin and Bigeye Tuna Management Strategy Evaluation: Phase 1 Technical Support Project Final Report (D. Kolody and P. Jumppanen)	✓14 October
IOTC–2016–WPM07–10	Standardising the presentation of MSE results to provide clear advice for managers (A. J. Williams, J. Larcombe, H. Patterson)	✓27 October
IOTC–2016–WPM07–11	Collaborative study of tropical tuna CPUE from multiple Indian Ocean longline fleets in 2016 (S. D. Hoyle, D. N. Kim, S. I. Lee, T. Matsumoto, K. Satoh, and Y. Yeh)	✓24 October
IOTC–2016–WPM07–12	Schedule of work for the development of harvest strategies for key species in the IOTC (A. J. Williams, J. Larcombe, H. Patterson)	✓27 October
IOTC–2016–WPM07–13 Rev_1	Online collaborative environment to run stock assessment models (T. Imzilen, S. Bonhommeau, T. Rouyer, L.T. Kell, J. Barde)	✓27 October ✓10 November
IOTC–2016–WPM07–14	tunadata, an R package for easy access to the tRFMO datasets (I.Mosqueira)	*[withdrawn]*
IOTC–2016–WPM07–15 Rev_1	Management strategy evaluation for the Indian Ocean skipjack tuna fishery (N. Bentley and M.S. Adam)	✓27 October ✓11 November
IOTC–2016–WPM07–16	Tuna purse seiner fishing in Iran (G. Moradi)	✓24 October
IOTC–2016–WPM07–17 Rev_1	Enumeration methods used to investigate the production of yellowfin tuna (*Thunnus albacares*) in Indian Ocean; Case study of tuna monitoring in Benoa Port, Bali, Indonesia (I. Jatmiko, A. Widodo, B.Setyadji, F. Rochman & Z. Fahmi)	✓20 October ✓31 October
Information Papers		
IOTC-2016-WPM07-INF01	Report of the 5th workshop on MSE, WPM	✓11 November

APPENDIX IV
PROPOSED STANDARDISED METHODS FOR THE PRESENTATION OF MSE RESULTS

Introduction

The Indian Ocean Tuna Commission (IOTC) management strategy evaluation (MSE) work program was initiated following adoption of the proposal to implement the precautionary approach for managing IOTC species in 2012 (Resolution 12/01). From this Resolution, the IOTC Scientific Committee (SC) was instructed to assess the performance of candidate management procedures (MP) through MSE, and provide the Commission with advice on their performance against Commission objectives. The IOTC Working Party on Methods (WPM) leads the technical development of MSEs for key IOTC species.

Effective and consistent communication of MSE results is important to ensure that decision makers are clearly informed about the likely consequences of implementing different MPs or harvest control rules (HCR). The use of standardised terminology and presentation formats for MSE results would facilitate a better understanding and maximise the engagement of all partners in the MP dialogue.

This proposal outlines some guidelines for standardising the communication of MSE results to the Technical Committee on Management Procedures (TCMP) and Commission.

Proposal for presenting MSE results

It is important that decision makers are presented with a selection of candidate MPs (or HCRs) from which to evaluate the relative performance against the Commission objectives. However, consideration needs to be given to limit the number of MPs (or HCRs) and performance measures that are presented to avoid saturation and confusion. As a guide, a maximum of 6 candidate MPs (or HCRs) and 6 performance measures would seem to allow sufficient coverage of the range of potential MPs of interest whilst limiting the amount of information to communicate.

The key elements of the presentation material are as follows:

1. **Illustrate the MPs** that have been evaluated in a figure and/or briefly define them in text.
2. Present the results for the performance of each MP in:
    a. **Boxplots** for a representative subset of performance measures
    b. **A summary table** that ranks the performance of each MP against a subset of performance measures
    c. **Trade-off plots** for a representative subset of performance measures
    d. **A Kobe plot** for the B/B_{MSY} and F/F_{MSY} performance measures
    e. **Time series plots** for stock size and fishing intensity performance measures.
3. Provide a clear and **succinct summary** of the performance of each MP.
4. Provide the numerical results for each MP across all 16 performance measures endorsed by the SC in a table in an appendix.

1. Illustrate the Management Procedures

It will be important that decision makers have a clear understanding of the MPs (or HCRs) that have been evaluated. To achieve this, a clear description of each MP (or HCR) should be presented prior to the MSE results, along with an explanation of the relevant decision steps involved. Example figures are illustrated in Figures 1 and 2.

2. Performance of Management Procedures

a. Boxplots

The key plots for communicating MSE results should clearly indicate the relative performance of each MP (or HCR) against a representative subset of performance measures from the categories of status, safety, yield, abundance and stability. These plots should clearly indicate the uncertainties in the MSE using error bars to represent percentiles. Example boxplots are illustrated in Figure 3. The summary period(s) which were used to generate the results should be clearly indicated.

b. Summary table

A summary table that ranks the performance of each MP against the key performance measures is shown in Table 1. The numbers in the table indicate the performance of each MP while the colours represent the relative ranking.

c. Trade-off plots

Trade-off plots provide useful information for evaluating the trade-off between different performance measures, particularly between yield (catch) and other performance measures. Example trade-off plots are illustrated in Figure 4. The summary period(s) which were used to generate the results should be clearly indicated.

d. Kobe plot

An example Kobe plot indicating the performance of MPs is illustrated in Figure 5. Consistent with the adopted guidelines for presenting stock assessment results, the Kobe plot indicates target and limit reference points. The summary period(s) which were used to generate the results should be clearly indicated.

e. Time series plots

Example time series plots are illustrated in Figure 6 for the stock size performance measure and in Figure 7 for the fishing intensity performance measure. Time series plots for additional performance measures may also be relevant. The key elements depicted in these figures are the median of all runs and the 75^{th} and 90^{th} percentiles and the target and limit reference points. A sample of individual realizations should be included in the projections to illustrate the typically erratic nature of individual trajectories.

3. Summary performance of Management Procedures and management advice

To assist with decisions on adopting candidate MPs, the Commission will require some guidance on the performance of each candidate MP, in addition to the figures and tables provided. A clear and succinct summary statement comparing the relative performance of each MP against the performance measures would allow the Commission to evaluate the trade-offs among alternative MPs when making such decisions.

The following statement provides an example summary of the performance for a hypothetical MP.

- MP1 performed very well for maintaining high catches, and performed average for maintaining low catch variability. However, MP1 performed very poorly at maintaining biomass and fishing mortality away from limit reference points and close to target reference points. There is a 20% risk that MP1 will cause the spawning biomass to fall below the limit reference point and a 50% risk that MP1 will cause the fishing mortality to exceed the limit reference point over the next 20 years.

4. Full set of results for each Management Procedure

While the main presentation of MSE results should focus on a selection of key performance measures summarised for a single time period, it is possible that the Commission will have interest in seeing the results for other performance measures or the same performance measures for a different summary time period. Therefore, the numerical results for each MP across all 16 performance measures and for the different time periods evaluated should be provided for reference in a table in an appendix, but not

reported or presented in the main results. Table 2 provides an example table of MSE outputs comparing the performance of 6 MPs against all IOTC performance measures for 4 time periods (1, 5, 10, and 20 years). Additional information, such as percentiles ranges, could be added in parentheses for each value.

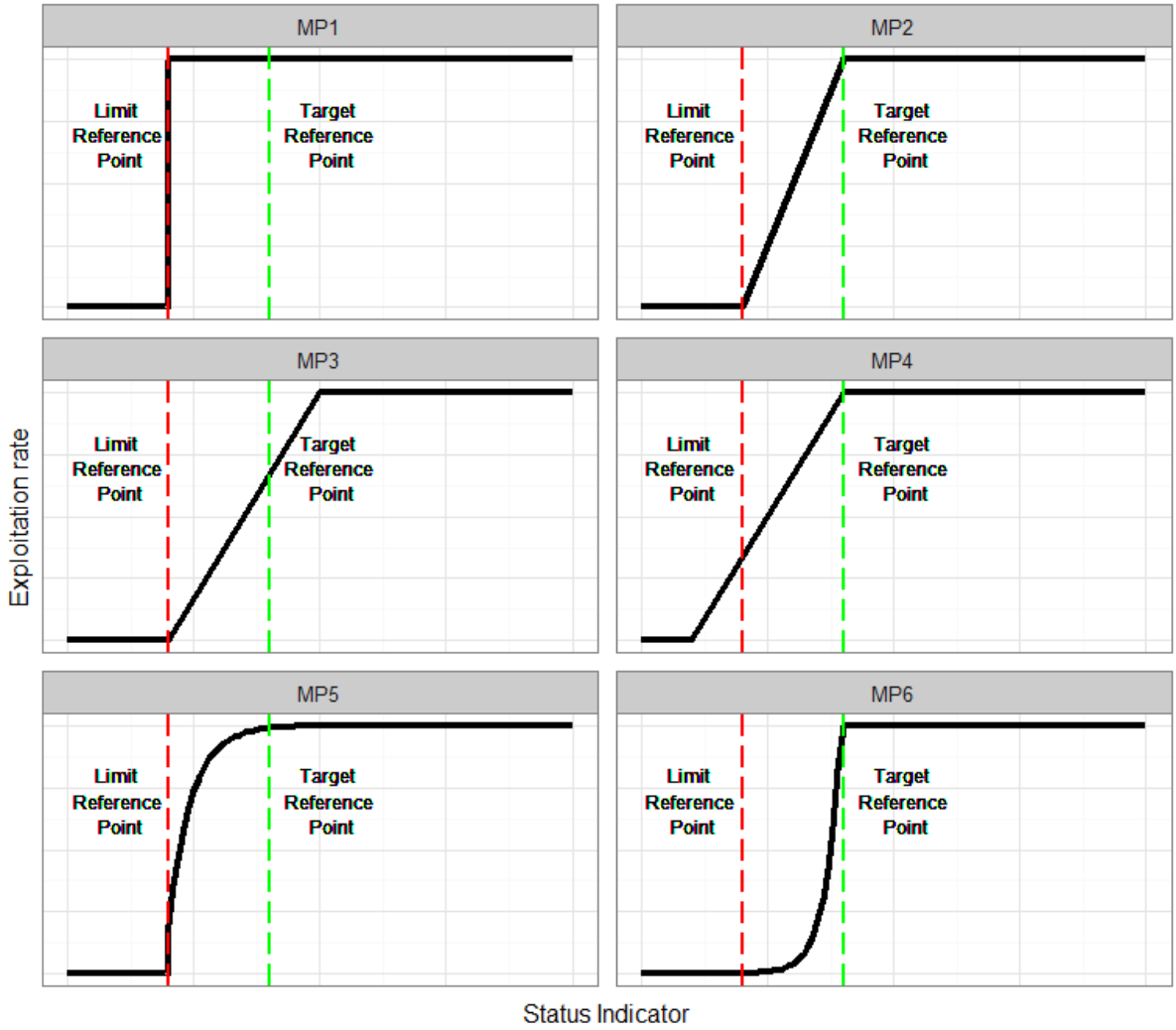

Figure 1. Illustration of six hypothetical example management procedures (MPs) relating the recommended exploitation rate to status indicator. The limit and target reference points are indicated by red and green dashed lines respectively.

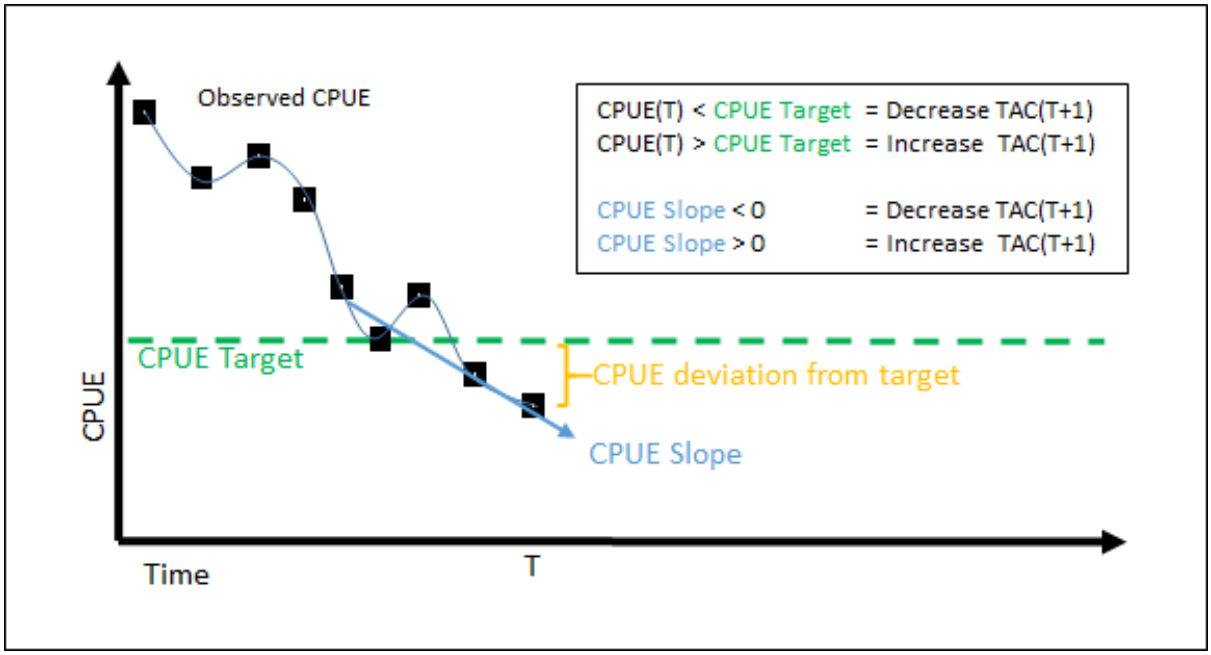

Figure 2. Illustration of an example catch per unit effort (CPUE) management procedure (MP) relating changes in the recommended TAC to changes in the CPUE over time. The target CPUE reference point are indicated by the green dashed line.

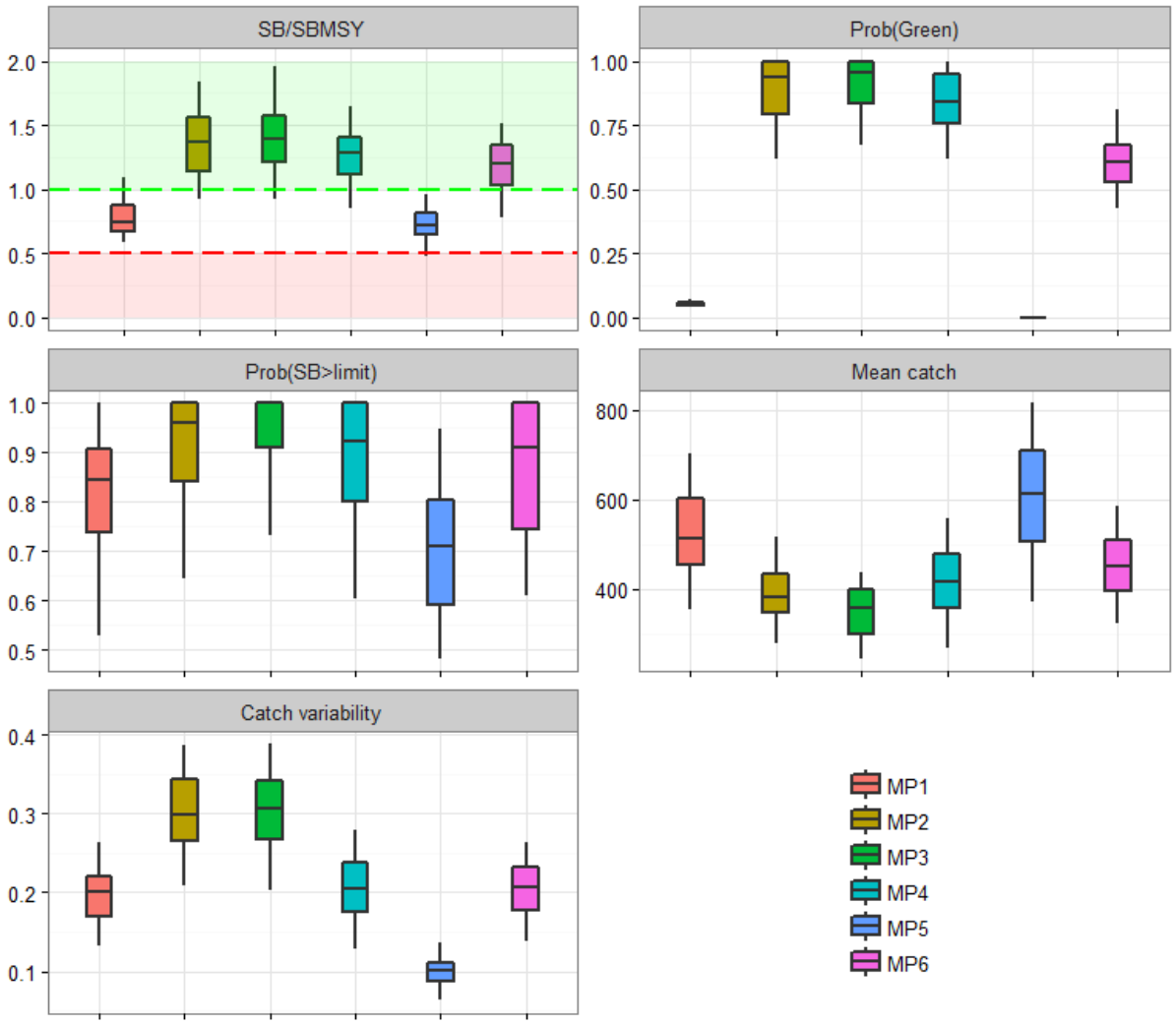

Figure 3. Example of MSE outputs comparing the performance of 6 management procedures (MPs) against 5 performance measures. Each data point represents the median over the last 20 years of the projection period as the horizontal line, 25th -75th percentiles as coloured bars, and 5th -95th percentiles as thin lines. Limit and target reference points for the biomass performance measure are indicated by red and green dashed lines respectively.

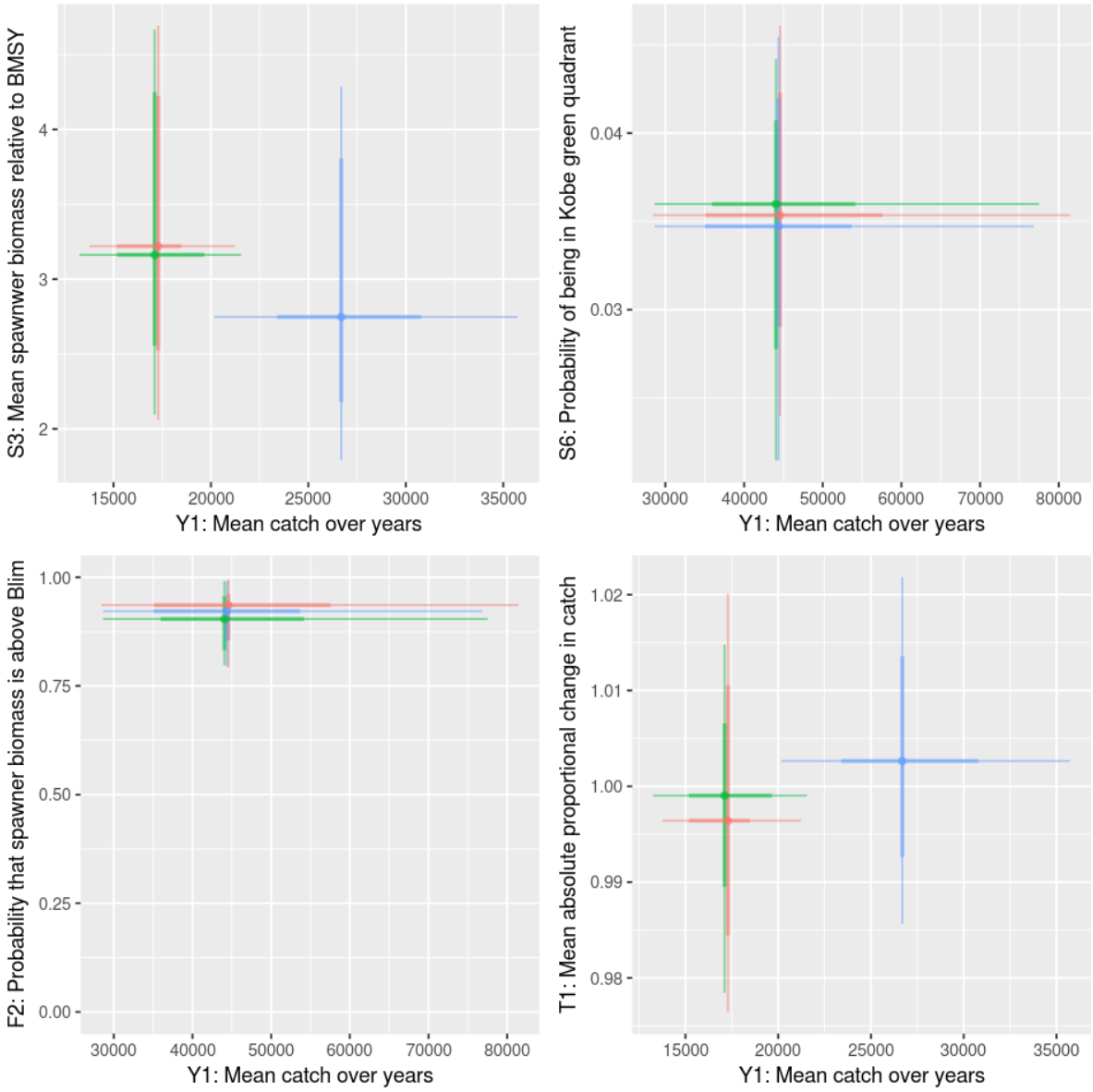

Figure 4. Example trade-off plots indicating the trade-offs in performance of 3 management procedures (MPs) between yield (catch) and 4 performance measures. Each data point represents the median over the last 20 years of the projection period and the errors bars represent the 25th -75th percentiles as thick lines, and 5th -95th percentiles as thin lines.

Table 1. Performance of six hypothetical example MPs against five key performance measures averaged over the last 20 years of the projection period. Colours indicate the relative performance for each MP (light = highest, dark = lowest). See Figures 2 and 3 for more detail on performance of each MP.

Management Procedure	**Performance Measure**				
	SB/SB_{MSY}	Prob(Green)	Prob(SB>limit)	Mean Catch	Catch variability
MP1	0.82	0.05	0.8	520	0.2
MP2	1.36	0.95	0.98	390	0.3
MP3	1.42	1	0.99	350	0.3
MP4	1.24	0.85	0.95	430	0.2
MP5	0.71	0	0.7	600	0.1
MP6	1.15	0.6	0.9	460	0.2

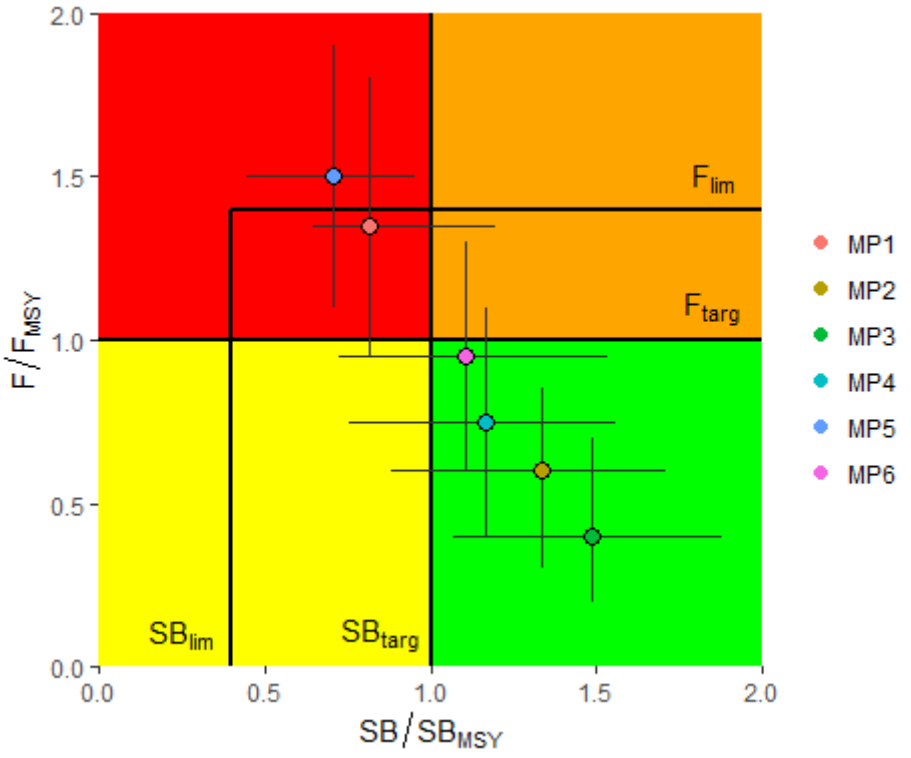

Figure 5. Kobe plot for hypothetical example of MSE outputs comparing 6 management procedures (MPs) against performance measures for SB/SB_{MSY} and F/F_{MSY}. Each data point represents the median in the final year of the projection period and the error bars represent the 95th percentiles. Target (SB_{targ} and F_{targ}) and limit (SB_{lim} and F_{lim}) reference points are indicated by black lines.

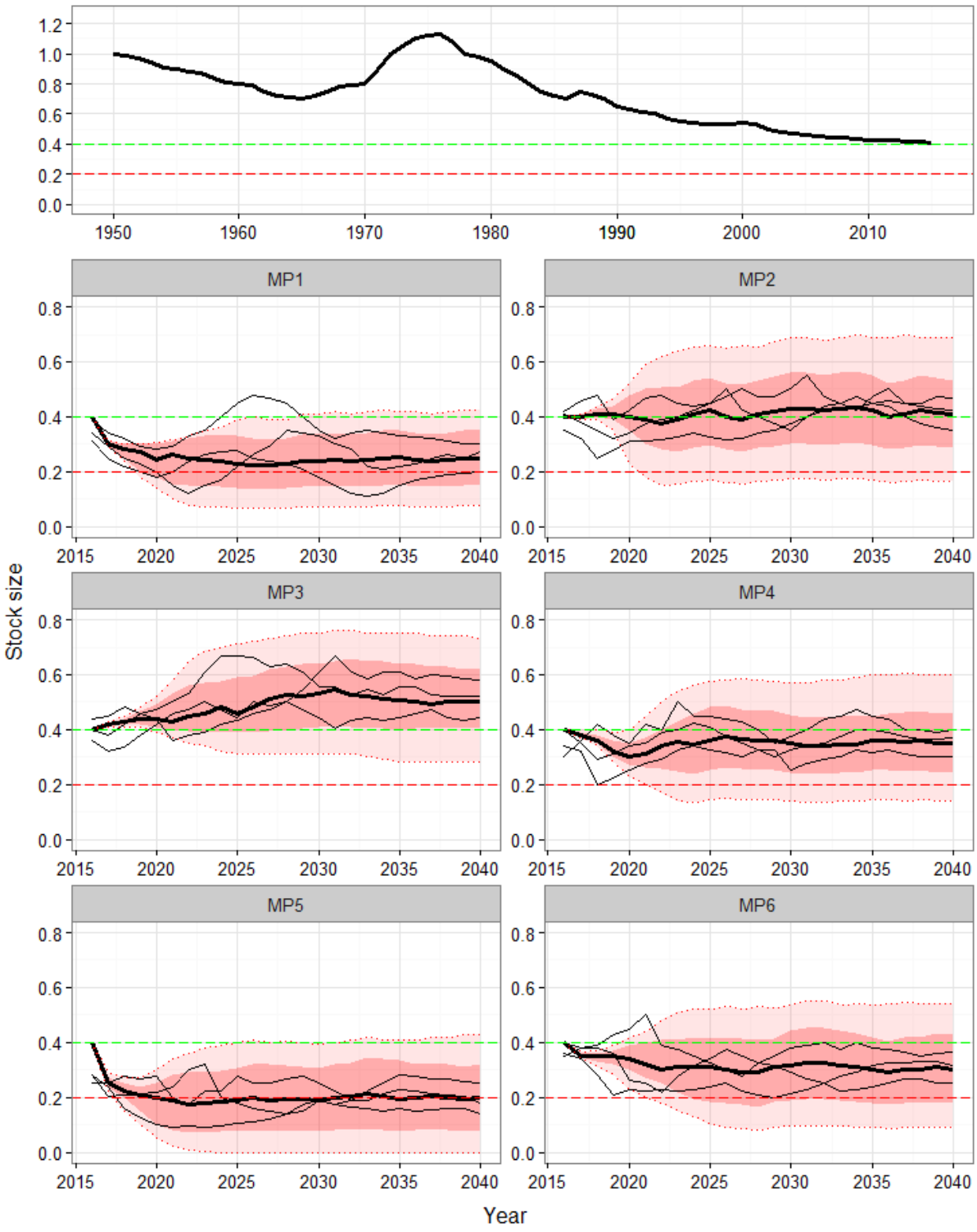

Figure 6. Time series plots for a hypothetical example of the performance of 6 MPs against the stock size performance measure. The top panel represents the historical period (1950-2015) and the bottom 6 panels represent the projection years (2016-2040). The median for each MP is represented by the bold black lines, a dark ribbon shades the 25th-75th percentile region and a light ribbon shades the 10th-90th percentile region. Three additional thin black lines show individual realizations. Horizontal lines indicate depletion-based target (green) and limit (red) reference points.

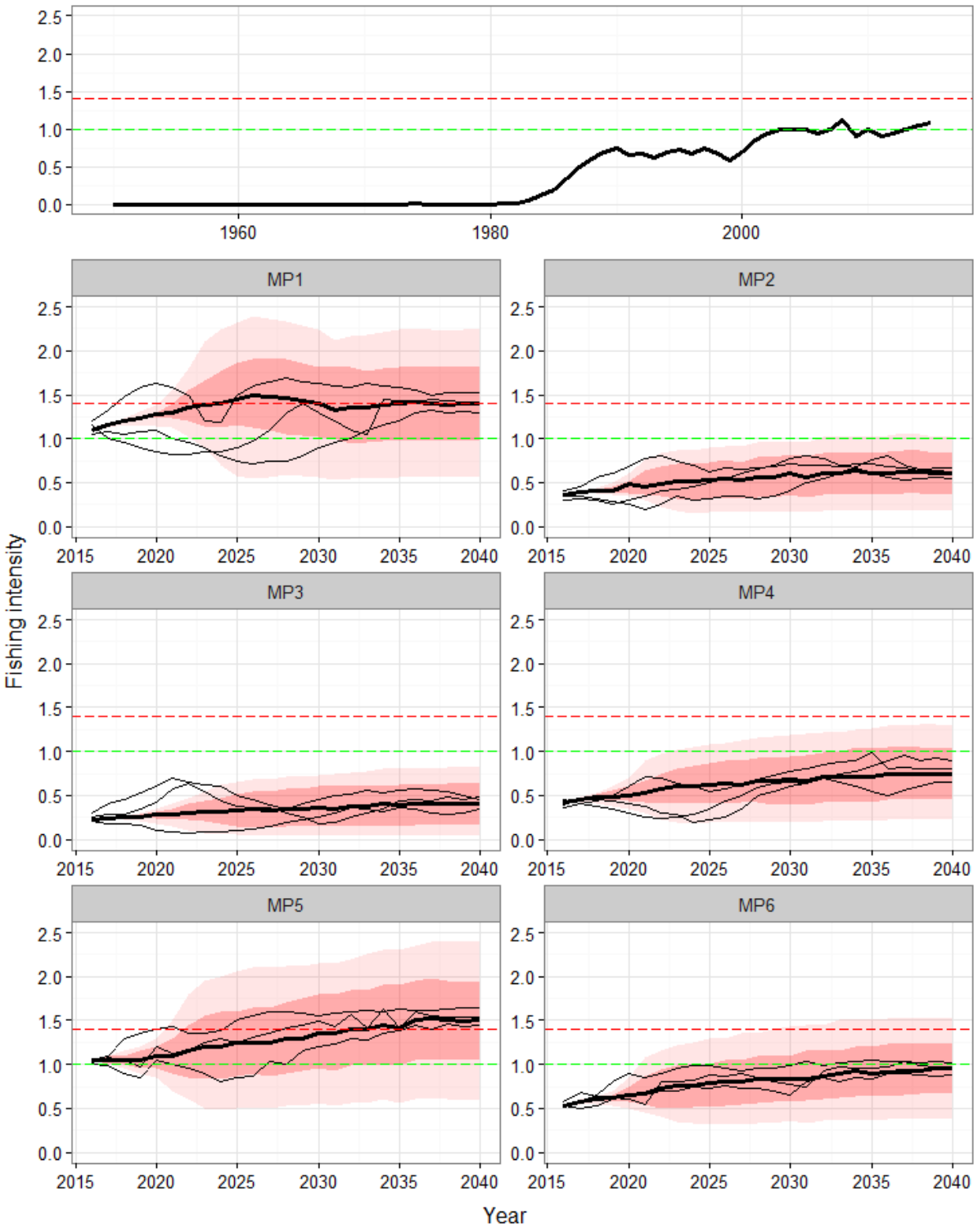

Figure 7. Time series plots for a hypothetical example of the performance of 6 MPs against the fishing intensity performance measure. The top panel represents the historical period (1950-2015) and the bottom 6 panels represent the projection years (2016-2040). The median for each MP is represented by the bold black lines, a dark ribbon shades the 25th-75th percentile region and a light ribbon shades the 10th-90th percentile region. Three additional thin black lines show individual realizations. Horizontal lines indicate depletion-based target (green) and limit (red) reference points.

Table 2. Hypothetical example of MSE outputs comparing the performance of 6 management procedures (MPs) against all IOTC performance measures for 2 time periods (1 years and 5 years).

Status : maximize stock status		1 year						5 years					
		MP1	MP2	MP3	MP4	MP5	MP6	MP1	MP2	MP3	MP4	MP5	MP6
1. Mean spawner biomass relative to pristine	SB/SB_0	0.5	0.8	0.9	0.7	0.4	0.6	0.5	0.8	1.0	0.7	0.4	0.6
2. Minimum spawner biomass relative to pristine	SB/SB_0	0.3	0.6	0.6	0.5	0.2	0.4	0.3	0.5	0.6	0.5	0.2	0.4
3. Mean spawner biomass relative to SB_{MSY}	SB/SB_{MSY}	0.8	1.3	1.4	1.2	0.7	1.1	0.9	1.2	1.3	1.1	0.7	1.2
4. Mean fishing mortality relative to target	F/F_{tar}	1.4	0.6	0.4	0.8	1.5	0.9	1.4	0.6	0.4	0.8	1.5	0.9
5. Mean fishing mortality relative to F_{MSY}	F/F_{MSY}	1.4	0.6	0.4	0.8	1.5	0.9	1.5	0.5	0.4	0.8	1.6	0.9
6. Probability of being in Kobe green quadrant	*SB*,*F*	0.5	0.9	1	0.8	0.3	0.7	0.5	0.9	0.9	0.8	0.3	0.7
7. Probability of being in Kobe red quadrant	*SB*,*F*	0.3	0.1	0	0.1	0.5	0.2	0.3	0.1	0.0	0.1	0.5	0.2
Safety : maximize the probability of remaining above low stock status (i.e. minimize risk)													
8. Probability of spawner biomass being above 20% of SB_0	*SB*	0.8	0.9	0.9	0.8	0.7	0.8	0.8	0.8	0.9	0.8	0.7	0.8
9. Probability of spawner biomass being above B_{Lim}	*SB*	0.8	1.0	1.0	0.9	0.7	0.9	0.8	1.0	1.0	0.9	0.7	0.8
Yield : maximize catches across regions and gears													
10. Mean catch (1'000 t)	*C*	520	390	350	430	600	460	551	417	378	434	600	460
11. Mean catch by region and/or gear (1'000 t)	*C*	250	200	180	210	310	220	248	194	176	229	335	218
12. Mean catch relative to MSY	*C/MSY*	1.1	0.7	0.6	0.8	1.2	0.9	1.2	0.6	0.6	0.8	1.3	1.0
Abundance: maximize catch rates to enhance fishery profitability													
13. Mean catch rates (by region and gear) (for fisheries with meaningful catch-effort relationship)	*I*	3.2	3.8	3.9	2.7	2.5	2.6	3.0	3.8	4.0	2.6	2.3	2.8
Stability: maximize stability in catches to reduce commercial uncertainty													
14. Mean absolute proportional change in catch	*C*	0.2	0.3	0.3	0.2	0.1	0.2	0.2	0.3	0.3	0.2	0.1	0.2
15. % Catch co-efficient of variation	*C*	20	25	24	18	12	21	19.4	27.3	26.2	17.6	11.5	21.0
16. Probability of shutdown	*C*	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Table 2. cont. Hypothetical example of MSE outputs comparing the performance of 6 management procedures (MPs) against all IOTC performance measures for 2 time periods (10 years and 20 years).

Status : maximize stock status	10 years	20 years

		MP1	MP2	MP3	MP4	MP5	MP6	MP1	MP2	MP3	MP4	MP5	MP6
1. Mean spawner biomass relative to pristine	SB/SB_0	0.5	0.8	0.9	0.7	0.4	0.6	0.5	0.8	1.0	0.7	0.4	0.6
2. Minimum spawner biomass relative to pristine	SB/SB_0	0.3	0.6	0.6	0.5	0.2	0.4	0.3	0.5	0.6	0.5	0.2	0.4
3. Mean spawner biomass relative to SB_{MSY}	SB/SB_{MSY}	0.8	1.3	1.4	1.2	0.7	1.1	0.9	1.2	1.3	1.1	0.7	1.2
4. Mean fishing mortality relative to target	F/F_{tar}	1.4	0.6	0.4	0.8	1.5	0.9	1.4	0.6	0.4	0.8	1.5	0.9
5. Mean fishing mortality relative to F_{MSY}	F/F_{MSY}	1.4	0.6	0.4	0.8	1.5	0.9	1.5	0.5	0.4	0.8	1.6	0.9
6. Probability of being in Kobe green quadrant	*SB,F*	0.5	0.9	1	0.8	0.3	0.7	0.5	0.9	0.9	0.8	0.3	0.7
7. Probability of being in Kobe red quadrant	*SB,F*	0.3	0.1	0	0.1	0.5	0.2	0.3	0.1	0.0	0.1	0.5	0.2
Safety : m*aximize the probability of remaining above low stock status (i.e. minimize risk)*													
8. Probability of spawner biomass being above 20% of SB_0	*SB*	0.8	0.9	0.9	0.8	0.7	0.8	0.8	0.8	0.9	0.8	0.7	0.8
9. Probability of spawner biomass being above B_{Lim}	*SB*	0.8	1.0	1.0	0.9	0.7	0.9	0.8	1.0	1.0	0.9	0.7	0.8
Yield : maximize catches across regions and gears													
10. Mean catch (1'000 t)	*C*	520	390	350	430	600	460	551	417	378	434	600	460
11. Mean catch by region and/or gear (1'000 t)	*C*	250	200	180	210	310	220	248	194	176	229	335	218
12. Mean catch relative to MSY	*C/MSY*	1.1	0.7	0.6	0.8	1.2	0.9	1.2	0.6	0.6	0.8	1.3	1.0
Abundance: maximize catch rates to enhance fishery profitability													
13. Mean catch rates (by region and gear) (for fisheries with meaningful catch-effort relationship)	*I*	3.2	3.8	3.9	2.7	2.5	2.6	3.0	3.8	4.0	2.6	2.3	2.8
Stability: maximize stability in catches to reduce commercial uncertainty													
14. Mean absolute proportional change in catch	*C*	0.2	0.3	0.3	0.2	0.1	0.2	0.2	0.3	0.3	0.2	0.1	0.2
15. % Catch co-efficient of variation	*C*	20	25	24	18	12	21	19.4	27.3	26.2	17.6	11.5	21.0
16. Probability of shutdown	*C*	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

APPENDIX V
CANDIDATE PERFORMANCE STATISTICS AND TYPES OF MANAGEMENT OBJECTIVES FOR THE EVALUATION OF MANAGEMENT PROCEDURES

Candidate performance statistics	Performance measure/s	Summary statistic
Status: maximize probability of maintaining stock in the Kobe green zone		
Mean spawner biomass relative to unfished	SB/SB_0	Arithmetic mean over years
Minimum spawner biomass relative to unfished	SB/SB_0	Minimum over years
Mean spawner biomass relative to B_{MSY}	SB/SB_{MSY}	Arithmetic mean over years
Mean fishing mortality relative to target	F/F_{targ}	Arithmetic mean over years
Mean fishing mortality relative to F_{MSY}	F/F_{MSY}	Arithmetic mean over years
Probability of being in Kobe green quadrant	SB, F	Proportion of years that $SB \geq SB_{targ}$ & $F \leq F_{targ}$
Probability of being in Kobe red quadrant	SB, F	Proportion of years that $SB < SB_{targ}$ & $F > F_{targ}$
Safety: maximize the probability of the stock remaining above the biomass limit		
Probability that spawner biomass is above 20% of SB_0	SB	Proportion of years that $SB > 0.2SB_0$
Yield: maximize catches across regions and gears		
Mean catch	C	Mean over years
Mean catch by region and/or gear	C	Mean over years
Mean proportion of MSY	C/MSY	Mean over years
Abundance: maximize catch rates to enhance fishery profitability		
Mean catch rates by region and gear	A	Arithmetic mean over years
Stability: maximise stability in catches to reduce commercial uncertainty		
Mean absolute proportional change in catch	C	Mean over years of absolute (C_t / C_{t-1})
Variance in catch	C	CV over years
Variance in fishing mortality	F	Variance over years
Probability of fishery shutdown	C	Proportion of years that C = 0

Note: All the candidate performance statistics are summarised using the XX^{th} percentiles (e.g. XX=5/10/50) of their distributions over multiple stochastic realisations. The summary will include short and long-term time windows (e.g. 1, 3, 5, 10 and 20 years).

APPENDIX VI
WORKING PARTY ON METHODS PROGRAM OF WORK (2017–2021)

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 4. 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				
						2017	2018	2019	2020	2021
1. Management Strategy Evaluation	1.1 Albacore	High	5	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 Evaluation of new set of Management Procedures (if required)					■	■			
	1.2 Skipjack tuna	High	2	Maldives						
	1.2.1 Review of model implementation and participation in MSE process				$?? (TBD)	■	■			
	1.3 Bigeye tuna	High	4	Australia (CSIRO)	$75,000 (ABNJ)					
	1.3.1 Update OM & present preliminary MP results to TCMP, WPTT/WPM review of new OM					■				
	1.3.2 Present revised MP results to TCMP with target adoption date of 2018; iteratively update development if required)				$?? (TBD)		■	■	■	

	1.4 Yellowfin tuna	High	3	Australia (CSIRO)	$75,000 (ABNJ)					
	1.4.1 Update OM & present preliminary MP results to TCMP, WPTT/WPM review of new OM				$??					
	1.4.2 Present revised MP results to TCMP with target adoption date of 2018; iteratively update development if required)				(TBD)					
	1.5 Swordfish	High	1	TBD	$?? (TBD)					
	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									
2. Tier approach for providing stock status advice	2.1 Develop 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	6	Consult.						
	2.2 Review of current practices and recommendation for the consideration at WPM07 and SC19.				$10,000 (TBD)					
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 WPTT18, para.91*)	Medium	7		$?? (TBD)					

APPENDIX VII
CONSOLIDATED RECOMMENDATIONS OF THE 7TH SESSION OF THE WORKING PARTY ON METHODS

Note: Appendix references refer to the Report of the 7th Session of the Working Party on Methods (IOTC–2016–WPM07–R)

Outcomes of the 20th Session of the Commission

WPM07.01 (para. 9): The WPM **NOTED** the request for advice (IOTC-2016-S20-R, para. 16) on the feasibility of reporting stock status in relation to limit reference points in addition to the target reference points currently used. Further **NOTING** that managing to target reference points is unlikely to yield a stock status that is always in the green zone of the KOBE plot, the WPM **RECOMMENDED** that the Scientific Committee consider this issue further and refers it for discussion at the Technical Committee on Management Procedures.

Visualisation of MSE results

WPM07.02 (para. 59): The WPM **RECOMMENDED** the proposed standardised methods for the presentation of MSE results (Appendix IX) are submitted to SC21 for discussion, revision and endorsement, as appropriate. Subsequently, this should be considered a living document that will benefit from revision based upon feedback received from the TCMP, which will first meet in 2017.

Performance indicators

WPM07.03 (para. 61): The WPM reviewed the performance statistics, used for measuring the performance of alternative management procedures against different objectives, that were endorsed by the SC and **AGREED** the following:

- the measure of catch variability would be more comparable across MPs if expressed as a coefficient of variation (CV)
- arithmetic means should be used for all statistics (rather than geometric means)

The WPM therefore **RECOMMENDED** that the Scientific Committee endorses the revised list of performance statistics provided in Appendix V.

Joint CPUE standardisation

WPM07.04 (para. 75): The WPM **NOTED** that the joint CPUE work undertaken so far has become a critical component for assessments of temperate and tropical species and **RECOMMENDED** that this work continue under the current framework, but that plans should be developed to normalize the process within the IOTC in the near future.

Revision of the WPM Program of work (2017–2021)

WPM07.05 (para. 97): The WPM **NOTED** that the next stock assessment of Indian Ocean swordfish is due to take place in 2017 and **RECOMMENDED** that the development of MSE of swordfish is considered as a high priority in the revised WPM Program of Work and that funding is allocated for this activity, to start the conditioning of an OM for this stock.

WPM07.06 (para. 100): The WPM **RECOMMENDED** that the Scientific Committee consider and endorse the WPM Program of Work (2017–2021), as provided at Appendix V.

WPM07.07 (para. 112): The WPM **RECOMMENDED** that the WPM should be held in conjunction the WPTT in 2017, with a day's break in between meetings and slightly earlier in the year (October).

Review of the draft, and adoption of the Report of the 7th Session of the WPM

WPM07.08 (para. 115): The WPM **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPM07, provided at Appendix VII.