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2018 ISSF STOCK ASSESSMENT WORKSHOP "Review of Current t-RFMO Practice in Stock Status Determinations"

Photo: David Itano

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Abstract

This Workshop was convened by the International Seafood Sustainability Foundation (ISSF) to review different approaches currently used by tuna Regional Fisheries Management Organizations' (tRFMOs: CCSBT, IATTC, ICCAT, IOTC and WCPFC) science bodies to determine stock status and disseminate stock status information. Workshop participants from all ocean regions reviewed current methodologies, identified best practices and agreed on a set of recommendations on scientific process, stock assessment, uncertainty characterization, stock status determination and communication of scientific results to managers and stakeholders.

April 2018

The 2018 Stock Assessment Workshop was funded by the International Seafood Sustainability Foundation (ISSF). The report and its results, professional opinions, and conclusions are solely the work of the workshop participants. There are no contractual obligations between ISSF and the participants that might be used to influence the report's results, professional opinions, and conclusions.

ISSF is a global coalition of scientists, the tuna industry and World Wildlife Fund (WWF) — the world's leading conservation organization — promoting science-based initiatives for the long-term conservation and sustainable use of tuna stocks, reducing bycatch and promoting ecosystem health. Helping global tuna fisheries meet sustainability criteria to achieve the Marine Stewardship Council certification standard — without conditions — is ISSF's ultimate objective. ISSF receives financial support from charitable foundations and industry sources.

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Executive Summary

The five tuna RFMOs follow different practices to determine stock status. This includes differences in the models and data used, differences in assumptions, differences in reference points used to define overfishing, and differences in whether a single or combined model runs are used to characterize uncertainty. These differences often make it difficult to compare relative status between different stocks. The objective of the 2018 ISSF Stock Assessment Workshop was to review these practices, with a view to identify best practices and recommend possible steps for harmonization.

After a number of presentations and discussions, the Workshop identified a series of best practices that the RFMOs could consider following. These include best practices for the scientific process, carrying out the stock assessments, the methodology used to characterize uncertainty, determining stock status, and communicating the scientific results to the Commissions. Some of the key best practices identified are as follows:

- Ensuring transparency and reproducibility. Although the input data and software for most tuna stock assessment are stored somewhere, this process should be set up formally to ensure reproducibility of stock assessment used for providing the management advice.
- Pursuing opportunities to improve stock assessments. Improved understanding of tuna biology, and reducing biases in input data, may be enhanced by new sources of information, such as close-kin genetics, FAD echosounder buoy estimates of biomass or new empirical growth estimates.
- Characterizing uncertainty. Best practice for characterizing assessment uncertainty is through a "grid approach" that includes uncertainties related to model specification (e.g., steepness, natural mortality, growth, stock-recruit relationship, selectivity forms, spatial resolution and movement settings) and data inputs (e.g. alternative abundance-indices, catch-history scenarios and size data compilations). Individual models in the grid, representing unique combinations of all uncertainty alternatives, should be biologically plausible, satisfy basic model diagnostics, and be based on characterizing real uncertainty rather than seeking to balance or promote specific model outcomes. Generally, results from different assessment model platforms based on different assumptions should not be combined.
- Adapting the assessment process to demanding assessment models. Tuna stock assessment has evolved toward highly-parameterized, integrated statistical modeling frameworks which offer the flexibility to fit the wide range of data available. However, these models are also more demanding in terms of the work required to set them up properly and thoroughly review diagnostics, etc. Those RFMOs that employ time-limited working group approaches have less capacity to develop and examine in-depth alternative model options. In these cases, best practice is to either hire consultants or set up advisory panels that provide dedicated continuity over time.
- Enhancing capacity by national scientists. There is limited capacity within the tuna RFMO scientific committees with regards to assessment and MSE expertise. Capacity-building initiatives could be used to promote in-depth understanding and, where possible, involvement by national scientists in the assessment/advice process, especially in cases where more demanding integrated assessment models are used. However, it is recognized that full fluency in formulating fully-integrated assessments requires dedicated study along the lines of what might be achieved through a graduate degree program.
- Adapting the Kobe Plots to current circumstances. So-called Kobe plots are often used to report if a stock is overfished or if overfishing is occurring, relative to MSY levels. While these plots have been very useful for managers to visualize status in a user-friendly way, they are overly simplistic and do not reflect the current reality that RFMOs have been formally adopting limit and target reference points (including that SSB_{MSY} is not a usual or required common limit reference point). Kobe plots should be modernized to define overfished status relative to the limit

reference points (if adopted) rather than the target reference points, and provide greater detail about status, including uncertainty, to avoid over-simplification.

- Improving communication of stock status to managers and stakeholders. Scientific committees should consider developing standalone Commissioners-targeted executive summaries to provide stock status and management advice information which, in addition to modernized Kobe plots, could also incorporate plots based on biomass depletion and other useful plots highlighted in this report.

Key Findings:

1. The five tuna RFMOs follow different practices to determine stock status and to characterize uncertainty. These differences can make it difficult to compare relative status between different stocks.
2. The Workshop identified several best practices that RFMOs could consider following on:
   a. scientific process,
   b. stock assessments,
   c. characterizing uncertainty,
   d. determining stock status, and
   e. communicating scientific results to managers and stakeholders.

List of Acronyms

ASPIC	Stock Production Model Including Covariates (assessment software)
ASPM	Age-structured Production Model (assessment software)
CAPAM	Center for the Advancement of Population Assessment Methodology
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CMM	Conservation and Management Measure
F	Fishing mortality rate
FAD	Fish Aggregating Device
FAO	Food and Agriculture Organization of the United Nations
HCR	Harvest Control Rule
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission for the Conservation of Atlantic Tunas
IOTC	Indian Ocean Tuna Commission
ISC	International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean
K2SM	"Kobe-2" Strategy Matrix
LRP	Limit Reference Point
MP	Management Procedure
MSE	Management Strategy Evaluation
MSY	Maximum Sustainable Yield
MULTIFAN-CL	Multiple Length Frequency Analysis (Catch at Length) (assessment software)
OM	Operating Model
tRFMO	Tuna Regional Fisheries Management Organization
SC	Scientific Committee
SS	Stock Synthesis (assessment software)
SSB	Spawning Stock Biomass
SPC-OFP	The Pacific Community - Oceanic Fisheries Programme
SPRFMO	South Pacific Regional Fisheries Management Organisation
VPA	Virtual Population Analysis (assessment software)
WCPFC	Western and Central Pacific Fisheries Commission

1. Background, Objectives and Organization

The tuna RFMOs follow different practices to determine and report stock status. This includes differences in the models and data used, differences in assumptions, differences in reference points used to define overfishing, and differences in whether a single or combined model runs are used to characterize uncertainty. These differences often make it difficult to compare relative status between different stocks.

The objective of the 2018 ISSF Stock Assessment Workshop was to review these practices, with a view to identify best practices and recommend possible steps for harmonization.

The Workshop was held at the Hotel Porto Bay Liberdade in Lisbon, Portugal. Participants included members from the ISSF Scientific Advisory Committee, as well as other experts on the topics being discussed: Paul de Bruyn, Bill Fox, Dan Fu, John Hampton, Ray Hilborn, Jim Ianelli, Susan Jackson, Ana Justel, Dale Kolody, Mark Maunder, Hilario Murua, Shuya Nakatsuka, Graham Pilling, Maite Pons, Ann Preece, Victor Restrepo (Chair), Keith Sainsbury, Josu Santiago, Jerry Scott, Dale Squires and Meryl Williams. Haritz Arrizabalaga and Gorka Merino collaborated in the preparation of background papers.

2. Presentations and background documents

Presentations were made by A. Preece (CCSBT), M. Maunder (IATTC), P. de Bruyn (ICCAT), D. Fu (IOTC), G. Pilling (WCPFC) and S. Nakatsuka (ISC) for each tuna RFMO on how the assessment and management process is structured in each tuna RFMO. J. Ianelli also made a similar presentation about SPRFMO.

Presentations were also made by H. Murua on three background papers that were prepared by G. Merino *et al.* to facilitate discussions at the workshop (these will be published at a later date separately from this report):

"Overview of current stock assessment practices across tuna RFMOs"

"Review of approaches used to characterize and address uncertainty in each RFMO"

"Communication of stock status and management advice to tuna RFMOs"

The presentations are summarized in Appendix 1. Summaries of tuna RFMO practices from the background papers are presented in Appendix 2.

3. Discussion and recommended best practices

3.1. Assessment models

Examination of the stock assessment models used within tRFMOs indicated that, while integrated models such as MULTIFAN-CL and Stock Synthesis are commonly used, in ICCAT in particular a wide range of assessment approaches had been used, with different software packages being used for a single stock (see Appendix A2.2, A2.3, A2.4). For clarity of description, this ‘multiple model’ approach is distinguished from an individual stock assessment using a single modelling platform that presented multiple model runs under different input assumptions (e.g. the model grid approach described in Section 3.2).

Participants noted that a key avenue to improving the stock assessments was through the available data and parameter estimates. Improved understanding of tuna biology, and reducing biases in input data, may be enhanced by new sources of information now available. As examples, the development of close-kin genetics (Bravington et al. 2016), and availability of new technologies such as FAD echosounder buoys (Moreno et al. 2016), offer novel data sources with the potential to improve our knowledge of tuna biology and dynamics. While many Scientific Committees highlight areas of research to improve data inputs and better understand uncertainty in order to enhance future stock assessments, this should be expanded and strengthened across the tRFMOs. It was also noted that research to improve stock assessment methodology and software (e.g. CAPAM workshops) should also be a priority.

3.2. Characterizing uncertainty

The situation where multiple assessment model platforms (e.g. ASPIC, ASPM, VPA, SS) are used for a stock and the resulting status estimates given equal plausibility when developing management advice (Appendix A2.6, A2.7) was noted to have issues (e.g., difficulties in comparing fits to data). Similar issues can also arise when a single nested-model framework is used and processes and other elements of uncertainty are ignored. It was also noted that factors other than their technical merit can influence the use of diverse modeling platforms. Ideally, scientists are able to carefully examine diagnostics of all different model runs and avoid using or appropriately down-weighting those runs or models that seem implausible.

The issue of conflicting data sets was highlighted, using an example of conflicting abundance time series model inputs. In this situation, an approach of joint analysis was considered appropriate to identify why CPUE series might be different. A further example was discussed where examination of oceanographic influences on catch rates led to a better understanding of the differences in indices. If no further clarity in conflicting inputs could be gained, the abundance series should be included as different elements of a specific axis of uncertainty.

Best practices for using a grid approach to characterize assessment uncertainty include the treatment of uncertainties related to model specification and data inputs. The former would include the use of appropriate ranges of fixed parameter settings (e.g., steepness, natural mortality, growth) and structural alternatives (e.g., stock-recruit relationship, selectivity forms, spatial resolution and movement settings). Uncertainties in data inputs might include alternative abundance-indices, catch-history scenarios and size data compilations. Individual models in the grid, representing unique combinations of all uncertainty alternatives, should be biologically plausible, satisfy basic model diagnostics (e.g., model convergence, uncorrelated residuals and minimal data conflict), and be based on characterizing real uncertainty rather than seeking to balance or promote specific model outcomes. If possible, models should be weighted for relative plausibility, which will likely require expert judgement. The use of models of the same general class (e.g., integrated statistical catch-at-age models, biomass dynamic models) is generally preferred to ensure comparability of results. The group noted the distinction between MSE Operating Model development versus assessment application and that they may relate to how management measures are adopted (e.g., through an MP or based on a stock status report from the assessment). Generally, an OM will be more complex than assessments and, in both settings, the practice of implementing a grid to represent uncertainty requires extensive planning, preparation, and computation.

In considering the uncertainty to include in an MSE Operating Model (e.g. the uncertainty grid) compared to the treatment of uncertainty in a stock assessment model it is necessary to recognize the different purposes of the two types of model.

- An assessment model is used tactically to identify the current stock status, and often as the basis of relatively short-term projections (e.g. effect of different catch levels). The context of application is usually that there will be an assessment performed reasonably frequently to provide an opportunity to detect and respond to errors or changed circumstances, and in multi-cohort populations the short-term projections are strongly driven by events that have already happened and are reflected in the current stock status. So, the focus of uncertainty in assessment models is on processes that influence the interpretation of past information, and in this the intent is to represent the uncertainties considered to have a substantial effect on those interpretations.
- An MSE Operating Model is used strategically to identify elements of a harvest strategy (e.g. control rules, data and analyses) that will robustly achieve management objectives. The context of application is that the chosen harvest strategy is expected to be applied for several years (e.g. 5-15y) before being substantially re-evaluated and that the OM is used for long-term projections because some management objectives usually relate to long-term performance. The uncertainties that need to be included in the MSE Operating Model are those relevant to the assessment model, as above, plus those relevant to long-term projections including the range of future real-world circumstance that the selected harvest strategy is intended to be robust against.

3.3. The assessment process

For many tuna stocks, stock assessment has evolved toward highly-parameterized, integrated statistical modeling frameworks which offer the flexibility to fit the wide range of data available Appendix A2.1). The different tRFMO scientific committee structures imply varying capacities to perform multiple alternative model runs. Those that employ time-limited working group approaches have less capacity to develop and examine in-depth alternative model options. Also, the Working Group model is not ideal in terms of providing continuity over time if there are frequent changes in participants and the software platforms they are familiar with. In contrast, those tRFMOs that use scientific staff, science service providers or consultants, and have continuity of national scientists with the expertise to develop the assessments, have greater potential to allow both more extensive ‘uncertainty grid’ analyses (Section 3.2), longer-term development of assessments and more thorough examination of diagnostics. Nevertheless, both CCSBT and IOTC, which follow some aspects of the Working Group model, have introduced changes to improve their use of integrated statistical models. In the case of CCSBT, an Advisory Panel provides independent overview of the assessment process over time. IOTC contracts external experts that carry out the assessments over several months (much longer than a working group meeting would last), with assistance from the Secretariat (the secretariat assessment expert has primary responsibility for some assessments). The SAW identified continuity of scientific expertise, diversity of views/teams within the group, plus independent advice as contributing factors to good practice.

The SAW also noted that there is limited capacity within the tuna RFMO scientific committees with regards to assessment and MSE expertise. This is an important issue that reduces participatory involvement and potentially transparency in the quantitative aspects of the provision of management advice. It also may affect the quality of assessments in some cases. Capacity-building initiatives could be used to promote in-depth understanding and, where possible, involvement by national scientists in the assessment/advice process. This capacity building should occur at two levels: (1) Non-technical courses that increase the ability of participating scientists to understand and contribute to discussions on the quantitative aspects of assessments without the need to do any actual modelling, and, (2) Technical quantitative training to increase the number of scientists who can provide quality assessments. The first courses would ideally be week-long workshops where the principles and basics of modelling are discussed and the assumptions and outputs of specific assessments are presented. This would enable scientists without a quantitative background to provide input into the assumptions and comment on the results of the models thus increasing the buy-in and acceptance of these methods and advice. The second level of training would be formal postgraduate work such as funding Masters, PhD or Post-Doctoral studies, or 'on-the-job' type training via internships or similar medium to longer-term arrangements. This level of training would be highly technical and increase the number of scientists competent to provide the highly quantitative modelling to support assessments.

Although the input data and stock assessment software for most tuna stock assessments are stored somewhere (e.g. in tRMFO internal servers or web pages), tRFMOs should adopt procedures to do so routinely. This would ensure transparency and reproducibility of stock assessments used for providing the management advice.

3.4. Stock status determination

Many organizations use the terms "overfished" (or "overexploited") and "overfishing" to indicate that the abundance is too low or the fishing mortality is too high relative to some benchmarks, explicit or implicit. Current practice in the tuna RFMOs is summarized in Table 1. "Overfishing" is generally equated with a fishing mortality that is above that which achieves MSY (Appendix A2.5). Similarly, "overfished" is generally equated with spawning biomass being below the SSB that is achieved on average when fishing at F_{MSY}. One exception is WCPFC, which considers a stock to be overfished when it is below the LRP. CCSBT does not have formal definitions for "overfished" or "overfishing". The CCSBT reports depletion of SSB (SSB/SSB_0) and has defined 20% SSB_0 as the interim rebuilding objective for the Management Procedure. The CCSBT also reports the range of fishing mortality relative to F_{MSY} estimates from the reference set of assessment models.

Table 1. Current practice for stock status determination by the tuna RFMOs. Note: The LRP for tuna stocks managed by WCPFC is 20% of the unfished SSB.

tRFMO	OVERFISHED	OVERFISHING	REF.
CCSBT	N/A	N/A	CCSBT (2017)
IATTC	$SSB < SSB_{MSY}$	$F > F_{MSY}$	IATTC (2017)
ICCAT	$SSB < SSB_{MSY}$	$F > F_{MSY}$	ICCAT (2017)
IOTC	$SSB < SSB_{MSY}$	$F > F_{MSY}$	IOTC (2017)
WCPFC	$SSB < SSB_{LRP}$	$F > F_{MSY}$	WCPFC (2017)

The Kobe Plot (Figure A2.8), a type of phase plot, is used to represent status relative to the MSY-based reference points. Although there are earlier uses of similar plots (e.g., Garcia and De Leiva Moreno, 2005), its use in tRFMOs resulted from a recommendation in the "Kobe Process", a series of informal meetings of the tRFMOs, which first met in 2007. Early in the process, it was agreed that stock assessment results across all five tuna RFMOs should be presented in the "four quadrant, red-yellow-green" format. The Kobe Plot was widely embraced as a practical, user-friendly method for presenting stock status information (tRFMO, 2009). It should be noted that, at that time, none of the tRFMOs had adopted explicit target and limit reference points, and it made sense to refer stock status relative to B_{MSY} and F_{MSY} as a default, since MSY or "optimum yield" are enshrined in the RFMO Conventions. Today, however, most of the tRFMOs have adopted or are in the processes of adopting explicit target and limit reference points (Anonymous, 2015). Because of this, it would be useful to adapt the determination of stock status to current circumstances. If target and limit reference points have been adopted for a stock, the aim should be to convey where SSB and F are in relation to the target(s) and limit(s). There are a range of ways the plots could be constructed depending on the purpose (i.e. showing status re targets, limits or both), and the reference points need not be MSY-based necessarily.

Participants agreed that determining stock status in discrete binary categories was over-simplified and it could be misleading (e.g., in a Kobe Plot, a miniscule decrease in SSB can move the status from "not-overfished" to "overfished" and may create a false perception of ecological catastrophe and bad management). If F_{MSY} is the target, the stock is expected to breach B_{MSY} 50% of the time, and this should not be sufficient cause for alarm. Participants considered different best practice options for expressing the stock status continuum:

- The Kobe Plot "Red" zone should be defined with respect to the LRP rather than target. A probabilistic interpretation should be adopted to identify whether the limit is breached.
- The upper right-hand side and the lower left-hand side quadrants of the Kobe Plot should not use the same color (yellow is used for both in some reports). In the lower left, fishing mortality is being managed and the stock is rebuilding; in the upper right, fishing mortality is too high.
- The usefulness of the plots would be enhanced if they included the projected trajectory of SSB and F in the near-term, given current levels and CMMs.
- Transitional "buffer zones" should be added to Kobe plots (possibly with new colors), to distinguish additional stock status categories between targets and limits, thus increasing the level of detail in the plots.
- If F_{MSY} is the target, B_{MSY} should not be used as the default biomass below which the stock is considered to be Overfished (the reference biomass should be lower than B_{MSY}, by an amount that depends in part on recruitment variability for the stock).
- Thought should be given to what "current" status represents. In some assessment reports, the last year of F and B are plotted, while in others it is a recent (e.g. 3-year) average.
- Additional plots of catch time series expressed relative to the potential yield, in which the deviation from potential yield is attributed to either over-fishing or under-fishing, would add valuable insight.
- Assumptions about the steepness of the stock recruitment relationship can greatly affect estimates of MSY-based reference points. Stock depletion estimates (SSB/SSB_0), are more robust to this uncertainty. Majuro plots (Figure A2.8), which are based on stock depletion, would bring additional information on stock status.

3.5. Communicating status to managers and stakeholders

The tuna RFMO SCs use similar ways to communicate stock status to their Commissions Appendix A2.8). This includes Executive Summaries, Kobe Plots and other graphs (it was noted that CCSBT does not use a Kobe Plot, but it produces one that is used by FAO and other RFMOs). Noting the differences between RFMOs, participants highlighted the following as best practice:

- Different stock status summary formats should be developed for different audiences (i.e. scientific/technical, Commission and general public).
- The more important information for Commissioners should be presented at the top of the summaries (e.g. for those longer than 2 pages).
- Kobe plots should be consistent in using 4 colors (not the 3 colors initially recommended in the Kobe Process), including the distinction between orange for the top right and yellow for the bottom left. Alternative candidate formats, potentially including additional buffer zones and colors could be used to provide better insight into the stock status continuum (see examples in Figure 1).

- Depletion-based and MSY-based plots (Majuro and/or Kobe plots) could both be included in summaries (especially if assumptions about the steepness of the stock recruitment relationship affects estimates of MSY-based reference points; see Section 3.4). Stationary and dynamic SSB Reference Points should be presented in the plots if they differ appreciably.
- If reference points have been adopted by the tRFMO, they should be included on the Kobe plots.
- Fishery impact plots (e.g., Wang et al., 2009) are useful to compare the relative effect of the different fisheries and should be included in summaries.
- Time series plots of F and SSB should also be included.

Participants also discussed the management recommendations provided with the stock status advice. It was noted that the scientific advice should be framed in terms of management options and consequences, rather than explicitly or implicitly advocating for management objectives that are not defined (e.g. rebuilding timeframes). It was noted that all tRFMOs have moved in the direction of developing Management Procedures (harvest strategies) to provide management advice. The CCSBT adopted a management procedure in 2011 to provide TAC advice. ICCAT and IOTC have adopted HCRs for their North Atlantic albacore and skipjack stocks respectively. Unlike the CCSBT MP, the simulation testing for these latter HCRs did not predefine the data and analysis -- the simulation testing assumed that a consensus assessment would be available with known estimator characteristics.

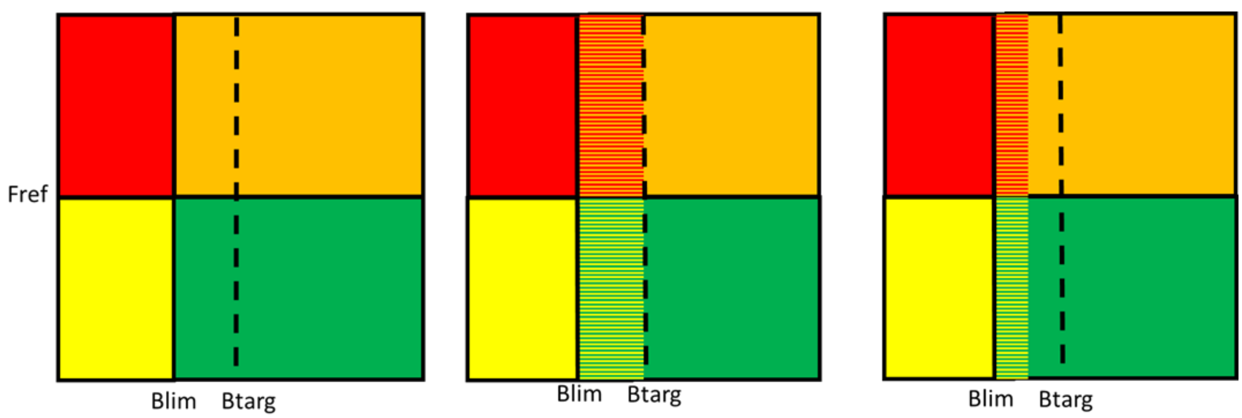

Figure 1*. Three examples of modified Kobe Plots in which there is a target biomass, Btarg, and a reference F (Fref) such as F_{MSY}. In each plot, the red quadrant is based on biomass being below the limit (Blim) rather than below a target biomass. The plot in the middle retains the four colors, but contains red-orange and yellow-green "buffer zones" between the target and limit. In the plot on the right, the buffer zone starts somewhat below the target biomass to account for natural fluctuations of the stock around the target.*

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Appendix 1. Summaries of the presentations made during the workshop

A1.1 CCSBT

(Ann Preece)

The CCSBT adopted a management procedure (the Bali Procedure) in 2011 to provide management advice to the Commission on Total Allowable Catch (TAC). The Bali Procedure has been used to set the TAC from 2011-2020 in 3-year blocks. The Bali Procedure was tested (Management Strategy Evaluation) to ensure that it is robust to a range of uncertainties and plausible and more extreme potential future conditions. Management procedures fully specify the monitoring data, method for analyses of those data, and the decision rule (also known as Harvest Control Rule (HCR)). For the Bali Procedure the specified components are (i) monitoring data to be used, (ii) method to analyze the data, and (iii) application of the Decision Rule.

The CCSBT members' scientists and Advisory Panel of independent experts review the data inputs to the MP and run the code to calculate the TAC. No changes are made to the MP model or decision rule. The TAC recommendation is presented to the Commission for adoption and implementation.

The ESC has a schedule of activities for providing scientific advice to the Commission:

1. Management advice: The Bali Procedure is run every three years to provide the management advice on a recommended TAC for the next 3-year block.
2. Stock status advice: A full stock assessment is completed every three years, off-set from the years in which the MP TAC management advice is provided, to provide advice on current stock status (depletion of SSB), whether the stock is rebuilding, and current stock size and fishing mortality relative to commonly used reference points. The stock assessment is not used to provide management advice, run the MP, or recommend the TAC. It uses a reference set of operating models to provide a plausible range of estimates of stock size. Sensitivity tests explore more extreme assumptions about the stock and fishery. The Operating Model and Management Procedure (OMMP) technical working group examines a preliminary reconditioning of the operating models for the stock assessment, prior to the Scientific Committee meeting, to review structure of the models, fits to data, weights and to revise the reference set (grid of uncertainties) and sensitivity tests.
3. Annual review of implementation of MP: An annual review of the implementation of the MP considers any evidence for exceptional circumstances, and through the formal meta-rules process recommends principles and a process for action. The actions that may be considered include a more precautionary TAC, collection of additional data or other management actions.
4. Full review of the MP: After 6 years of implementation (having set TAC for 9 years), review performance of MP.

The members' scientists and Advisory Panel undertake the technical modelling work of the ESC and OMMP working group and draft the agreements of the ESC. The Chair of the Scientific Committee presents the scientific advice from the ESC, the management recommendation from the MP and updates on stock status from the stock assessment, to the Commission.

A1.2 IATTC

(Mark Maunder)

The IATTC is unique among tuna RFMOs because it has a secretariat with dedicated staff that conduct data collection, stock assessment, scientific research, and provide policy advice. Data collection includes 100% observer coverage on large purse seines through the IATTC and national programs and purse seine port sampling for species and length composition. Stock assessments for the tropical tunas are conducted regularly by secretariat staff, while other species are conducted less frequently or by collaborating with other organizations and CPCs. Stock assessment results and management advice are reviewed in-house and through the Scientific Advisory Committee (SAC). In addition, the yellowfin and bigeye tuna assessments have had independent reviews. Interim reference points and a harvest control rule have been adopted (see Resolution C-16-02). The main conservation measure is through seasonal closures, in combination with capacity limits, for the purse seine fishery, which are set to achieve the fishing mortality that corresponds to MSY for the species with the highest fishing mortality. Adjustments are made for any increase in the fishing capacity. Catch quotas are used for the longline fishery and are set to be consistent with management taken for the purse seine fishery. Catch quotas were recently tried for the purse seine fishery, but were found to be inappropriate for fisheries that catch juveniles with stocks like tropical tunas that show considerable annual variability, unless short term or in-season predictions of biomass can be made. Other management measures for the purse seiner fishery include, but are not limited to, a spatial closure, FAD limits, and full retention. The scientific coordinator drafts the advice in collaboration with the staff, which is then discussed with the Director and presented at the SAC. CPCs initially receive scientific advice through their representatives at the SAC and then directly at the Annual Meeting. Both the Secretariat Staff and the SAC produce management advice that is presented at the Annual Meeting. One or more proposals for conservation measures developed by the CPCs are considered at the annual meeting and, through discussions and negotiations, a final proposal is presented and adopted as a Resolution.

A1.3 ICCAT

(Paul de Bruyn)

The International Commission for the Conservation of Atlantic Tunas is responsible for the conservation of tunas and tuna-like species in the Atlantic Ocean and adjacent seas. The convention was signed into force in 1969 and there are currently 52 contracting parties and 5 Cooperating Non-Contracting Party, Entity or Fishing Entities. There are about 30 species are of direct concern to ICCAT which include mainly principle tuna species and billfish, but also increasingly by-catch species as well. The SCRS, on which each member of the Commission may be represented, is responsible for developing and recommending to the Commission all policy and procedures for the collection, compilation, analysis and dissemination of fishery statistics. It is the SCRS' task to ensure that the Commission has available at all times the most complete and current statistics concerning fishing activities in the Convention area as well as biological information on the stocks that are fished. The SCRS is composed of individual species groups, a working group on assessment methods and the Sub-committees on Statistics and Ecosystems. The ICCAT Secretariat facilitates the work carried out by the SCRS and the in turn the Commission but does not conduct the scientific assessments for studies, rather providing support and expert assistance.

The SCRS provides the scientific advice to the commission at its annual meeting in November. The majority of this information is provided to the 4 panels of the commission that are responsible for keeping under review the species, group of species, or geographic area under its purview, and for collecting scientific and other information relating thereto. Based on investigations from the SCRS, Panels may propose to the Commission recommendations for joint action by the Contracting Parties. Recommendations, which are binding and are adopted by consensus and resolutions which are non-binding are then finalized by the end of the commission meeting and enacted in the following year. Presentation of scientific advice by the SCRS has been semi-standardized, and the SCRS has greed on certain figures and tables that must be presented for each species, however the content of these reports may be variable in their presentation. ICCAT provides advice based on MSY where it is implicit that MSY (both relative to biomass and fishing mortality rate) is a target. The trend of the stock as well as the outputs of all final models used for management advice are plotted on Kobe plots and where possible, projections are made and compiled in Kobe 2 Strategy matrices. Although ICCAT has committed to conducting MSE analyses in order to develop Management Procedures (or harvest control rules) for key species, only one HCR has currently been adopted (for Northern Albacore tuna). The SCRS has yet to develop a standard for presenting the results from MSE analysis to the commission. This work has been advanced at intersessional panel meetings, as well as at the recently created Standing Working Group on Dialogue between Fisheries Scientists and Managers (SWGSM), which is an intermediary group to enhance communication between all stakeholders.

A1.4 IOTC

(Dan Fu)

Indian Ocean Tuna Commission was established in 1996 under Article XIV of the FAO Constitution. The IOTC is mandated to manage 16 species tuna and tuna-like species in the Indian Ocean with its primary objective the conservation and optimum utilization of the stocks for long-term sustainability. The IOTC science process involves the commission, the scientific committee, the working groups, and the secretariat. The commission has annual meetings; the SC coordinates research and provides management advice; the working parties are organized by species groups and are responsible for drafting recommendations on management options; the secretariat supports commission activities at all levels. IOTC doesn’t have a dedicated science provider. The stock assessments are conducted by CPC scientists, consultants, and the secretariat (which has a stock assessment expert on staff). To date status reports based on qualitative stock assessments have been produced for 12 out of the 16 IOTC species, among which fully integrated models are used for bigeye, yellowfin, skipjack, albacore, and swordfish assessments. The assessments are usually conducted every 3 years, but can vary depending on status of the stock and uncertainty of the assessment. The stock assessments are reviewed by the species working parties. IOTC aims to have one invited expert for each working party to review and improve the assessment but there has been no formal external peer review on stock assessments. The management recommendations are drafted by the working parties and reviewed and endorsed by the scientific committee. The main management recommendations are provided in forms of species executive summaries which consist of fairly standard structure including sections on stock status, stock outlook, management advice, data quality and assessment limitations, and supporting information. Management advice are provided for every species in every year to the commission. Since 2013, IOTC has adopted interim target and limit reference points for key tuna and billfish species based on MSY-related reference points, and requires stock status to be reported against these species specific reference points. Alternative reference points, such as those based on deletion can be used if the MSY-related reference points cannot be established reliably. The species is considered to be overfished if the biomass falls below the target (B_{MSY}) and overfishing has occurred if the fishing mortality is above the target (F_{MSY}). IOTC also requires the Kobe plots to be used to present stock estimates. To date IOTC has adopted 53 active conservation management measures which include binding resolutions and non-binding recommendations. In managing stocks, IOTC has implemented both input controls through limitations on fishing capacity, and output controls through catch limits on major commercial tuna species. The IOTC has adopted a Harvest Control Rule for skipjack, such that the TAC recommendation now forms the key part of the scientific advice (the first TAC recommendation was endorsed by the SC, and became active Jan 2018, without Commission deliberation since the Commission meeting will not take place until later in the year). MPs are under development for albacore, bigeye, yellowfin and swordfish.

A1.5 WCPFC

(Graham Pilling)

Unlike many other tuna RFMOs, for non-northern stocks WCPFC contracts OFP, SPC as an independent science and data management service provider, with a particular focus on developing the inputs to and performing stock assessments for key tuna species, as well as billfish and some shark stocks. The review process for these assessments was described, including the SPC ‘pre-assessment workshop’, discussions at the WCPFC Scientific Committee, and external peer review. The move toward the use of the agreed biomass limit reference point (20% SBF=0) to define overfished status, as well as FMSY to define an overfishing state was presented, and discussions on weighting particular models within the assessment ‘structural uncertainty grid’ and moves towards using these grid results to provide probabilistic advice were also covered. The content of binding WCPFC ‘Conservation and Management Measures’, which have historically been adopted through consensus at the Commission meeting, were presented, particularly those for tuna management which include the use of purse seine FAD closure periods and longline catch limits, capacity management and limits on active FAD numbers. Finally, the potential consequences of WCPFC’s move toward a ‘harvest strategy’ approach to management were discussed.

A1.6 ISC

(Shuya Nakatsuka)

ISC provides scientific advice on certain species to WCPFC as well as IATTC. Its members are Canada, Chinese Taipei, Japan, Republic of Korea, Mexico, People's Republic of China and USA. It is not a formally (legally) established organization but has an MOU with WCPFC and IATTC for scientific advice on “northern stocks”, which are Pacific bluefin, north Pacific albacore and north Pacific swordfish. ISC’s stock assessments are conducted by species working groups, which consist of scientists from member countries and sometimes from cooperating organizations such as IATTC. Management advice is usually based on the results of “base case” model and stock status is evaluated against reference points agreed by relevant RFMOs if available. If no LRP is agreed, evaluation against various potential reference points is provided. The presentation of the results usually includes summary table, Kobe chart, impact analysis, F-at-age. Projections are conducted based on the current measures in place by RFMOs and other scenarios can also be tested as requested. Recommendations are fed into mainly to the Northern Committee in the case of WCPFC and SAC in the case of IATTC.

A1.7 SPRFMO

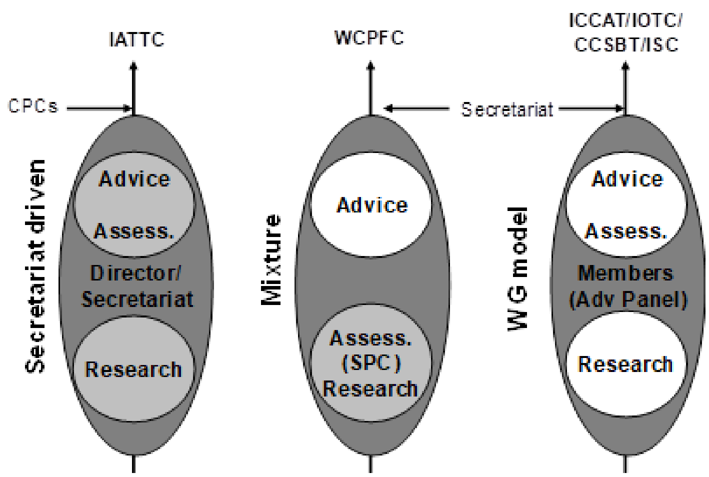
(Jim Ianelli)

The South Pacific Regional Fisheries Management Organisation (SPRFMO) is an intergovernmental organisation headquartered in Wellington, New Zealand established in 2012 by the Convention on the Conservation and Management of High Seas Fishery Resources in the South Pacific Ocean. This Convention closed one of the last remaining gaps for conserving and managing high seas straddling fish stocks (except for tunas) and gives SPRFMO responsibility for an area covering more than 15% of the world’s oceans. The main target species in the SPRFMO Convention Area are Jack mackerel (*Trachurus murphyi*), jumbo flying squid (*Dosidicus gigas*) and deep-sea species such as orange roughy (*Hoplostethus atlanticus*). The Commission has currently 15 Members from Asia, Europe, the Americas, and Oceania and one of the first immediate objectives was to set firm TACs (using CMMs) for rebuilding the Jack mackerel stock with catch allocations among participating members. Presently the SPRFMO SC considers a “full assessment” every other year with data updates only in the intervening years.

Appendix 2. Summary of current RFMO practices in stock assessment and stock status determination

A2.1 Process of scientific advice provision across tuna RFMOs.

Three types of approaches are generally followed by the RFMOs: (1) "Secretariat driven" (IATTC), where the scientific staff from the Secretariat carries out the stock assessment and produces the management advice, which is presented to the Commission; (2) "Working Group model" (CCSBT, ICCAT, IOTC and ISC), where technical working groups assisted by each Commissions' Secretariat produce the stock assessment, decide upon the modelling choices and agree on the stock status and management recommendation. This is then communicated to SCs, which review/endorse the work by the technical working groups and communicate the main results to the Commissions (CCSBT follows aspects of this approach with a technical group that reviews preliminary reconditioning of assessment models, but assessments are produced by member scientists and the SC agrees on stock assessment status advice or management recommendations from the MP); and, (3) "Mixed approach" (WCPFC) where an independent Science Provider carries out the assessments. An SC agrees on stock status and management recommendations to the Commission.



A2.2 Types of models used for providing scientific advice.

For the 23 stocks of major commercial tunas, fully-integrated models are most commonly used (primarily Stock Synthesis). ICCAT is the only RFMO that sometimes uses the results of several types of models to determine stock status.

RFMO	stockname	INDICATORS	CATCH M & F (2012)	BIOMASS PRODUCTION				AGE/SIZE BASED		FULLY INTEGRATED		
				ASPIC	BSP	Biodyn	JABBA	ASPM	VPA	MFCL	SS	SBT OM
ICCAT	Atlantic_yellowfin			●				●	●		●	
	Atlantic_bigeye			●							●	
	East_Atlantic_skipjack*	●	●									
	West_Atlantic_skipjack			●								
	North_Atlantic_albacore					●						
	South_Atlantic_albacore			●	●							
	Mediterranean_albacore						●					
	East_Atlantic_bluefin								●			
	West_Atlantic_bluefin								●		●	
IOTC	Indian_Ocean_albacore										●	
	Indian_Ocean_bigeye										●	
	Indian_Ocean_yellowfin										●	
	Indian_Ocean_skipjack										●	
CCSBT	Southern_bluefin											●
IATTC	East_Pacific_yellowfin										●	
	East_Pacific_bigeye										●	
	East_Pacific_skipjack	●										
WCPFC	Pacific_bigeye									●		
	Pacific_yellowfin									●		
	South_Pacific_albacore									●		
	Pacific_skipjack									●		
ISC	Pacific_bluefin										●	
	North_Pacific_albacore										●	

(*) The stock status for East Atlantic skipjack was qualitative.

A2.3 Structure of the models used to provide scientific advice.

In general, there is considerable diversity in the data and model structure used. Alternative scenarios (different data and/or assumptions) are used in many cases to characterize uncertainty.

RFMO	Stock	Model	Regions	Year 0	N. Fisheries	N. CPUEs	Length (yrs) of CPUE*	Indep Indx/Tag	Length of Idx/tag*	Year classes	Plus group	CAA/CAS	Time steps in a year	Scenarios
ICCAT	A-YFT	ASPM	1	1965	6	6	50	0	-	6	yes	yes	1	2
	A-YFT	ASPIC	1	1950	4	4	50	0	-	-	-	-	1	1
	A-YFT	VPA	1	1970	10	8	45	0	-	6	yes	yes	1	2
	A-YFT	SS	1	1950	17	8	38	0	-	11	yes	yes	4	2
	A-BET	ASPIC	1	1950	3	3	39	0	-	-	-	-	1	3
	A-BET	SS	3	1950	15	7	53	0	-	10	yes	yes	4	12
	EA-SKJ	Catch based	1	1950	1	0	-	0	-	-	-	-	1	1
	WA-SKJ	Catch based	1	1952	1	0	-	0	-	-	-	-	1	1
	WA-SKJ	ASPIC	1	1950	4	4	31	1	18	-	-	-	1	1
	NA-ALB	Biodyn	1	1930	5	5	35	0	-	-	-	-	1	1
	SA-ALB	BSP	1	1956	3	3	48	0	-	-	-	-	1	4
	SA-ALB	ASPIC	1	1956	3	3	48	0	-	-	-	-	1	4
	Med-ALB	JABBA	1	1980	2	2	11	1	6	-	-	-	1	1
	EA-BFT	VPA	1	1968	7	7	55	2	9	10	yes	yes	1	1
	WA-BFT	VPA	1	1974	10	10	34	2	38	16	yes	yes	1	1
	WA-BFT	SS	1	1950	13	11	22	2	38	35	yes	yes	1	1
IOTC	IO-ALB	SS	1	1950	11	3	35	0	-	14	yes	yes	4	1
	IO-BET	SS	4	1975	15	4	46	1	16	10	yes	yes	4	6
	IO-YFT	SS	4	1950	21	4	32	2	10	7	yes	yes	4	1
	IO-SKJ	SS	4	1950	4	2	30	2	6	9	yes	yes	4	36
CCSBT	SBT	SBT OM	1	1930	6	1	48	4	21	31	yes	yes*	2	432
IATTC	EPO-YFT	SS	1	1975	16	5	42	0	-	7	yes	yes	4	1
	EPO-BET	SS	1	1975	23	2	42	0	-	10	yes	yes	4	1
WCPFC	P-BET	MFCL	9	1952	32/33	9	63	3	11	10	yes	yes	4	72
	P-YFT	MFCL	9	1952	32/33	12	63	3	9	7	yes	yes	4	72
	SP-ALB	MFCL	8	1960	14	8	53	2	12	-	yes	yes	4	36
	P-SKJ	MFCL	5	1972	23	5	46	4	17	4	yes	yes	4	1
ISC	P-BFT	SS	1	1952	19	3	35	0	-	20	yes	yes	1	1
	NP-ALB	SS	1	1993	29	1	22	0	-	15	yes	yes	4	1

(*) Length of longest CPUE or independent index available. Note that these tables refer specifically to those model runs used for scientific advice.

(**) SBT is the only stock that uses direct age composition data.

A2.4 Biological and fishery information.

Usually, the more complex models require more data inputs and/or assumptions, as reflected below (in the table the value of 0 is used for Fixed parameters and 1 for Estimated parameters). Steepness, a parameter that is highly influential in determining MSY-related values, is most commonly fixed at a single value or a range of values. Note that these tables refer specifically to those model runs used for scientific advice. Also, when 'Fleet' level is indicated, it can contain amalgamation of fleets information.

RFMO	stock	model	Initial state	r,K	shape	Length-age	M	Maturity	Selectivity	Steepness	Catch	CPUE	Catchabiltiy	Dynamic
ICCAT	A-YFT	ASPM	Estimated	-	-	0	0	0	1	F(0.85)	Fishery	Fleet	Constant	-
	A-YFT	ASPIC	Fixed (0.9)	range	Fox	-	-	-	-	-	Lumped	Fleet	Constant	-
	A-YFT	VPA	Estimated	-	-	0	0	0	1	E	Fishery	Fleet	Constant	-
	A-YFT	SS	Estimated	-	-	1	0	0	1	F(0.9)	Fishery	Fleet	Constant	-
	A-BET	ASPIC	Fixed (1)	range	Fox	-	-	-	-	-	Lumped	Fleet	Constant	-
	A-BET	SS	Estimated	-	-	1	0	0	1	F(0.7,0.8,0.9)	Fishery	Fleet	Dynamic	Estimated
	EA-SKJ	Catch based	-	range	Logistic	-	-	-	-	-	Lumped	Fleet	Constant	-
	WA-SKJ	Catch based	-	range	Logistic	-	-	-	-	-	Lumped	Fleet	Constant	-
	WA-SKJ	ASPIC	Fixed (1)	range	Logistic	-	-	-	-	-	Lumped	Fleet	Constant	-
	NA-ALB	Biodyn	Fixed (1)	range	Fox	-	-	-	-	-	Lumped	Fleet	Constant	-
	SA-ALB	BSP	Fixed (0.9)	priors	Fox/Logistic	-	-	-	-	-	Lumped	Fleet	Constant	-
	SA-ALB	ASPIC	Fixed (0.9)	range	Fox/Logistic	-	-	-	-	-	Lumped	Fleet	Constant	-
	Med-ALB	JABBA	Estimated	priors	Fox	-	-	-	-	-	Lumped	Fleet	Constant	-
	EA-BFT	VPA	Estimated	-	-	0	0	0	1	-	Fishery	Fleet	Constant	-
	WA-BFT	VPA	Estimated	-	-	0	0	0	1	-	Fishery	Fleet	Constant	-
	WA-BFT	SS	Fixed (1)	-	-	0	0	0	1	E	Fishery	Fleet	Constant	-
IOTC	IO-ALB	SS	Fixed (1)	-	-	0	0	0	1	F(0.8)	Fishery	Fleet	Dynamic	Estimated
	IO-BET	SS	Estimated	-	-	0	0	0	1	F(0.7,0.8,0.9)	Fishery	Fleet	Constant	-
	IO-YFT	SS	Estimated	-	-	0	0	0	1	F(0.8)	Fishery	Fleet	Constant	-
	IO-SKJ	SS	Estimated	-	-	0	0/1	0	1	F(0.7,0.8,0.9)	Fishery	Fleet	Dynamic	1%
CCSBT	SBT	SBT OM	Estimated	-	-	0	1	0	1	F(0.6,0.7,0.8)	Fishery	Fleet	Dynamic	0.50%
IATTC	EPO-YFT	SS	Estimated	-	-	0	0	0	1	F(1)	Fishery	Fleet	Constant	-
	EPO-BET	SS	Estimated	-	-	0	0	0	1	F(1)	Fishery	Fleet	Dynamic	Estimated
WCPFC	P-BET	MFCL	Estimated	-	-	0/1	0	0	1	F(0.65,0.8,0.95)	Fishery	Fleet	Dynamic	Estimated
	P-YFT	MFCL	Estimated	-	-	1	0	0	1	F(0.65,0.8,0.95)	Fishery	Fleet	Dynamic	Estimated
	SP-ALB	MFCL	Estimated	-	-	1	0	0	1	F(0.65,0.8,0.95)	Fishery	Fleet	Dynamic	Estimated
	P-SKJ	MFCL	Estimated	-	-	1	1	0	1	F(0.8)	Fishery	Fleet	Dynamic	Estimated
ISC	P-BFT	SS	Estimated	-	-	0	0	0	0	F(1)	Fishery	Fleet	Constant	Estimated
	NP-ALB	SS	Estimated	-	-	0	0	0	1	F(0.9)	Fishery	Fleet	Constant	-

A2.5 Reference points used to provide advice.

For most assessments, MSY-based reference points as well as depletion-based ones (B_0) are estimated. For a few stocks, $F_{0.1}$ is also estimated.

RFMO	stock	model	Benchmark values													Advice
			B/BMSY	SB/SBMSY	F/FMSY	SB/SBF0.1	F/F0.1	SB/SB0	B/B0	B0	SB0	BMSY	SBMSY	FMSY	MSY	
ICCAT	A-YFT	ASPM		√	√					√		√		√	√	Kobe, K2SM
	A-YFT	ASPIC	√		√					√		√		√	√	Kobe, K2SM
	A-YFT	VPA		√	√		√						√	√	√	Kobe, K2SM
	A-YFT	SS		√	√			√		√	√		√	√	√	Kobe, K2SM
	A-BET	ASPIC		√	√					√			√	√	√	Kobe, K2SM
	A-BET	SS		√	√						√		√	√	√	Kobe, K2SM
	EA-SKJ	Catch based								√					√	-
	WA-SKJ	Catch based								√					√	-
	WA-SKJ	ASPIC	√		√					√				√	√	Kobe
	NA-ALB	Biodyn	√		√				√	√		√		√	√	Kobe, K2SM, HCR
	SA-ALB	BSP	√		√				√	√		√		√	√	Kobe, K2SM
	SA-ALB	ASPIC	√		√				√	√		√		√	√	Kobe, K2SM
	Med-ALB	JABBA	√		√				√	√		√		√	√	Kobe, K2SM
	EA-BFT	VPA					√									Kobe, K2SM*
	WA-BFT	VPA					√									Kobe, K2SM*
	WA-BFT	SS					√									Kobe, K2SM
IOTC	IO-ALB	SS		√	√			√			√		√		√	Kobe, K2SM
	IO-BET	SS		√	√						√		√		√	Kobe, K2SM
	IO-YFT	SS		√	√						√		√		√	Kobe, K2SM
	IO-SKJ	SS		√	√			√			√		√	√	√	Kobe, HCR
CCSBT	SBT	SBT OM		√	√			√	√	√**					√	MP
IATTC	EPO-YFT	SS	√	√	√			√	√	√	√	√	√		√	Kobe
	EPO-BET	SS	√	√	√			√	√	√	√	√	√		√	Kobe
WCPFC	P-BET	MFCL		√	√			√			√		√	√	√	Majuro, Kobe
	P-YFT	MFCL		√	√			√			√		√	√	√	Majuro, Kobe
	SP-ALB	MFCL			√		√	√			√				√	Kobe
	P-SKJ	MFCL		√	√			√			√		√	√	√	Majuro, Kobe
ISC	P-BFT	SS			√		√	√			√					Kobe
	NP-ALB	SS			√		√	√			√		√		√	Kobe

(*) For Atlantic bluefin tuna stocks a pseudo-K2SM is provided where the probability of exceeding or not $F_{0.1}$ is shown and not the probability of exceeding or not $SB_{F0.1}$. **B10+.

A2.6 Scenarios considered for structural uncertainty used for providing scientific advice.

For stocks assessed using fully-integrated models, various scenarios are usually considered to provide scientific advice (the table below excludes sensitivity runs, which are often used to examine uncertainty qualitatively). The exception to this are stocks in the eastern Pacific (note that this table contains the scenarios considered to provide scientific advice and excludes the scenarios used as sensitivity runs).

	ICCAT		IOTC		CCSBT	WCPFC				IATTC & ISC
	BET	YFT	BET	SKJ	SBT	BET	YFT	SP-ALB	P-SKJ	All stocks
Steepness	3	1	3	3	3	3	3	3	1	1
Growth	2	1	1	1	1	2	1	1	1	1
M	1	1	1	2	12**	1	1	3	1	1
weight CPUE	1	2	1	1	2	1	1	1	1	1
CPUE age range	1	1	1	1	2	1	1	1	1	1
weight tagging	1	1	2	2*	1	1	1	1	1	1
tag mortality	1	1	1	2	1	1	1	1	1	1
tag mixing period	1	1	1	2	1	1	2	1	1	1
tag data overdispersion	1	1	1	1	1	2	2	1	1	1
size data weight	2	1	1	1	1	3	3	2	1	1
regional structure	1	1	1	1	1	2	2	2	1	1
Psi	1	1	1	1	3	1	1	1	1	1
Total	**12**	**2**	**6**	**48**	**432**	**72**	**72**	**36**	**1**	**1**

* Two tagging program options. **4 options for M at age 0 and 3 options for M at age 10.

A2.7 Sources of uncertainty.

Different types of uncertainty may be considered in determining stock status: Model uncertainty, input uncertainty (uncertainty about input parameters or the quality of the information) and statistical (parameter estimation) uncertainty. One, or a combination of these, are usually considered when determining stock status for providing management advice.

RFMO	Stock	Model U	Input U	Stat U	Advice
ICCAT	A-YFT	4	2	Boot	Model U-Input U- Stat U
	A-BET	2	15*	Boot	Model U-Input U- Stat U
	EA-SKJ	1	1	-	-
	WA-SKJ	1	1	Boot	Stat U
	NA-ALB	1	1	Boot	Stat U
	SA-ALB	4	2	Boot	Model U-Input U- Stat U
	Med-ALB	1	1	Boot	Stat U
	EA-BFT	1	1	Boot	Stat U
	WA-BFT	2	1	Boot	Model U-Input U- Stat U
IOTC	IO-ALB	1	1	Delta	Stat U
	IO-BET	1	6	-	Input U
	IO-YFT	1	1	Delta	Stat U
	IO-SKJ	1	48	-	Input U
CCSBT	SBT	1	432	-	Input U
IATTC	EPO-YFT	1	1	-	-
	EPO-BET	1	1	-	-
WCPFC	P-BET	1	72	Delta	Input U
	P-YFT	1	72	Delta	Input U
	SP-ALB	1	36	-	Input U
	P-SKJ	1	1	Likelihood	Stat U
ISC	P-BFT	1	1	-	-
	NP-ALB	1	1	-	-

A2.8 Communication of stock status to managers.

The tuna RFMOs share some commonalities but also have important differences in terms of how the science bodies communicate stock status to the Commissions.

- Format of communication: In general, tuna RFMOs communicate stock status and management advice through Executive Summaries. The stock status and advice are supported by tables and figures. The length of the different summaries varies considerably.
- Communication of uncertainty: In tuna stock assessments, the different sources of uncertainties are represented through different scenarios and models (Structural or systemic uncertainty) and statistical techniques (statistical uncertainty). Results are usually provided in terms of a central tendency and dispersion measures (e.g. 80% confidence intervals) calculated from different models (if used) and iterations (if used). "Kobe Plots" are often used to visualize stock status relative to MSY-based reference points (the WCPFC also uses "Majuro Plots" to visualize stock status relative to depletion (B_0-based), see Figure A2.8). The probabilistic results shown in the Kobe plots and K2SM are calculated from all the models, scenarios and iterations agreed to represent the plausible dynamics of the fishery for the provision of management advice (K2SM are only used in ICCAT and IOTC). In ICCAT and IOTC, a probability is assigned to each quadrant of the Kobe plots (Green, Red, Yellow or Orange), although in some cases only three colors are used and two quadrants are combined. Additionally, in all RFMOs executive summaries there is a qualitative reference to the existing uncertainties of the stock assessment.
- Summary Tables: All RFMOs summary tables contain a reference to the latest catch and MSY. Stock status in all RFMOs is provided using at least abundance and fishing mortality relative to their MSY values. With them, a qualitative status of the stock is provided (overexploited/not overexploited and subject to overexploitation/not subject to overexploitation). WCPFC provides a wider suite of measures to communicate stock status. These include depletion levels calculated using different methods, last and recent (4 years) stock status, and the estimated values of a number of reference points. Stock depletion levels are included in summary tables in the WCPFC, IOTC and CCSBT.
- Projections: IOTC and ICCAT management advice is supported by the results of constant catch and fishing mortality projections. This allows for the provision of management options in terms of the catch levels that will allow achieving different stock levels in the future. The tables used to illustrate projection results are the Kobe II Strategy Matrices, which estimate probabilities of breaching RPs across the years of the projections (in ICCAT) or in the short and medium terms (3-10 years in the IOTC). In the IATTC, projections using an average of the most recent fishing mortality are also provided.

Harvest strategies change the nature of the management advice where they have been implemented. The CCSBT MP and IOTC-skipjack HCR recommend a TAC, and to date these recommendations have been adopted by the Commissions.

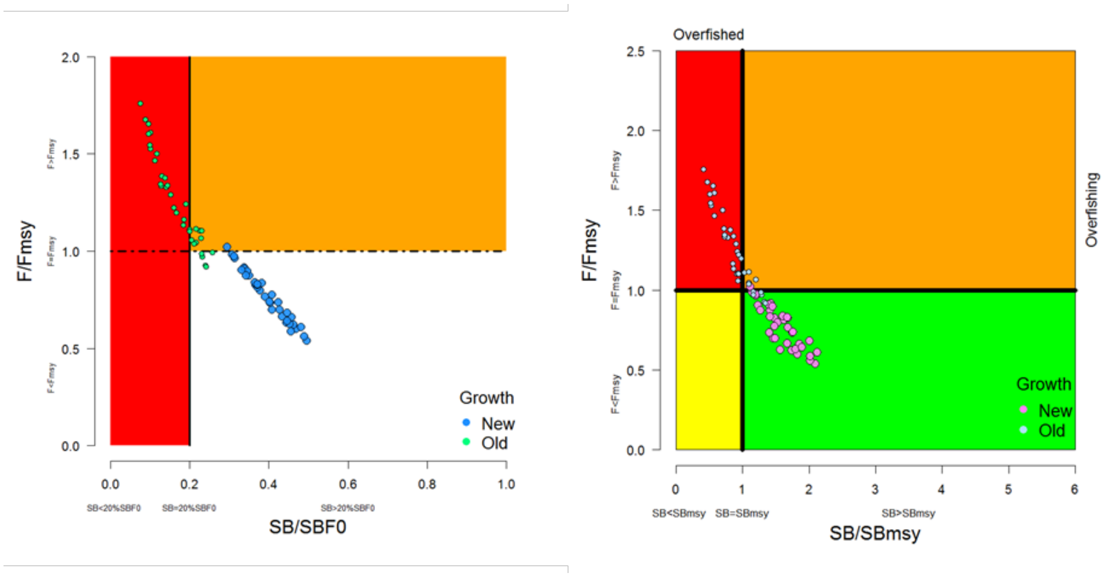


Figure A2.8. Majuro (left) and Kobe (right) plots used to represent stock status and structural uncertainty for WCPFC bigeye.

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