Received: 5 October 2015
IOTC-2015-WPM06-13

# Base document for the development of a multiple-tier system for stock-assessment-based advice in IOTC

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IOTC-2015-WPM05-13 – 19-21 October 2015

## Introduction

The IOTC Working Party on Billfish, as its 12th session in 2014, made a proposal for the adoption of a 'tier' approach for the provision of stock status advice. The text (IOTC, 2014, Appendix XII), in Appendix C of this document, provided a very valuable first attempt at defining such a classification in terms of data quantity and quality, and the stock assessments methods to be applied. A third element to be expanded is the kind of management advice that could be provided in each case. The IOTC Scientitic Committee (IOTC, 2014b), after discussion of the proposal, requested the Working Party on Methods to work on the issue of establishing such guidelines to help species Working Parties in their work.

Unfortunately, and given the current workload and the limited availability of expertise at the WPM, it was not possible to build upon the WPB proposal and present to the next session of the SC a more complete proposal. Instead, what I suggest in this document is the establishment of a small project, lead by an expert in stock assessment methods and advice, that should also involve the participation of the chairs of the IOTC species Working Parties.

This study would attempt to create a classification of data and knowledge currently available across IOTC stocks, along a four level category outlined below, identify models being use and of possible interest in each, and assemble some guidelines on the interpretation of results for those models given the known caveats and limitations in their use. Particular needs in terms of adaptation of methods to the IOTC setting could also be identified for future development. The final outcome would be a set of guidelines on stock assessment methods adapted to the needs of IOTC. A software

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toolset to help applying these guidelines could be created, for example as an R package that provides the diagnostics and graphical outputs deemed useful for each method, if they are not already available.

# Tiers and levels of knowledge

The study proposed here could use as starting point the four-tier approach proposed by WPB (IOTC, 2014), although with some changes in its scope and detail. First, the lowest tier should include stocks for which even data on catch rates are not available but we can make use of existing knowledge on life history to evaluate risk levels given current catches. Second, the separation of robust and preliminary quantitative stock assessment is a difficult one, given that models considered of good quality can be found to be flawed when new data is available.

The classification across tiers should thus be based on the different types of data, methods applied, and type of advice generated, rather than on the quality of data sources and results, which instead needs to be well considered and communicated.

### Tier 1: Quantitative stock assessment and forecast

The tier 1 and 2 in the WPB proposal (IOTC, 2014) would be merged into a single one. Robustness, either perceived or measured in some way, as a basis for qualifying an stock assessment appears to be too subjective and bound to constant changes. If the results provided by the model are deemed not appropriate for advice, this should be reflected in the executive summary for the species.

The analysis should provide estimates of current biomass (total or exploitable) and fishing mortality levels, time series of changes to both, and provide estimates of reference points, of the basis for its calculation.

Ideally it should allow for short term forecasting of stock dynamics under a range of scenarios as required by the Kobe 2 Strategy Matrix.

### Tier 2: Estimates of F from catch curves or catch-at-length methods

The main source of data should be a catch-at-age matrix. Data exists, or sufficient knowledge from similar stocks can be used, to ascertain the basic biological parameters: e.g. natural mortality, age-length relationships, length/weight relationships, stock recruitment relationship steepness, age at maturity and age at recruitment to the fishery. The estimation of fishing mortality is then carried out using all this information. The time period used to estimate fishing mortality is the same as that used to estimate current catch.

#### Tier 3: Trends in standardized CPUE

Catch rates for fleets known to have changed relatively little over the period under analysis can be used to infer trends in relative abundance and provide indications of negative signals in stock status.

#### Tier 4: Life history-based and risk analysis

Tier 4 would be applied to any stock for which any of the data requirements above does not apply. A time series of nominal catches provides the only indication of the history of the stock. Risk-based analyses, like Ecological Risk Assessments, also making strong use of available knowledge on the life history of the species or others closely related, should be use to establish a series of indicators for these stocks.

## Risks and uncertainties

Quantifying and communicating precisely the level of uncertainty in any stock assessment is generally difficult (Rosenberg and Restrepo, 1994), and much needs to be done at IOTC in making statements on uncertainty more clear and coherent. For example, ranges for stock status indicators or reference points may come from uncertainty estimates around a single model or from the extremes of values obtained by very different models. Those two methods will always provide very different statements about the uncertainty in results, and guidelines on how to assemble alternative estimates, when appropriate, and how to express those to managers, could and should be developed with wide agreement. Generally, the ways used to convey uncertainty should be formalized (National Aquarium, 2015) as this facilitates the conversation with managers, as they become familiar with the language employed.

Acceptable levels of risk are commonly defined for each of the levels on a multiple-tier system, as they tend to span all the way to management procedures. See, for example, the Australian Commonwealth Fisheries Harvest Strategy Policy and Guidelines (DAFF, 2007) for a full development of this approach. Although the objective of the proposed study is by not means not to develop such a system, consideration should be given to the links between data and knowledge quantity and quality, ads reflected in the classification of stock advice under each tier, and the risks that exploitation under those circunstances mighhtr entail. This could be used, for example to inform future extension of the Management Strategy Evaluation approach for analysing Management Procedures to all IOTC stocks on acceptable the levels of risk and error in management. This is an important element of the Precautionary Approach, that of exploiting less when less is known of its effect.

## Evaluation of IOTC stock advice

The latest summary table on the status of IOTC stocks, (IOTC, 2014b, Table 1) includes 23 stock of tunas and sharks for which IOTC attempts to provide advice, and for 13 of them this includes some estimate of current stock status and reference points. These numbers reflect the significant effort that has gone into the quantitative basis for management advice in IOTC. As more stocks are added to this list, it could be beneficial to review the range of approaches that have been taken. A simple comparison across Working Parties could be useful in identifying common problems, differences in approaches, and highlight areas of improvement that could benefit more stocks and WPs.

A first step in this review would be a simple tabulated questionnaire, for which a very preliminary draft is presented in Appendix A. The study leader could liaise with WP chairs and scientists responsible for the different stock assessments, and gather this information on what methods are being used, how precisely are they being applied, and in which items scientists feel that the guidelines could be of greater help.

## References

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# Appendix A: Example questionnaire for the classification of IOTC quantitative advice

## 1. Data available

- 1.1 Data sources: e.g. catch-at-age, effort, nominal catch, CPUE, tagging.
- 1.2 Dimensions: e.g. time coverage, fleets, areas. ## 2. Stock assessment methods
- 2.1 Type of model: e.g. statistical catch-at-age, virtual population analysis, biomass dynamics, depletion methods.
- 2.2 Software used

## 3. Inspection of results

- 3.1 Diagnostics generated: e.g. catch fit, CPUE fit, recruitment deviates.

## 4. Estimation of uncertainty

- 4.1 Internal to the model(s): e.g. Bayesian, bootstrap, ...
- 4.2 Obtained from multiple models: GLM, model averaging, extreme ranges, ...

## 5. Use of estimates for advice

- 5.1 Biomass in last year
- 5.2 Fishing mortality in last range
- 5.3 Biomass reference points
- 5.4 Fishing mortality reference points

## 6. Communication of data gaps, model assumptions and result uncertainties

- 6.1 Description of uncertainties and data gaps
- 6.2 Description of methods used for quantifying uncertainty

# Appendix B: WPB proposal

# APPENDIX XII
## OPTIONS FOR A 'TIER' APPROACH TO PROVIDING STOCK STATUS ADVICE

A Tiered approach to providing stock status advice will enable the IOTC working parties and Scientific Committee to better communicate the levels of uncertainty present in the indicators used for monitoring the condition/status of IOTC stocks by categorising the types of assessments conducted, for the development of management advice/actions.

A four tier approach may be designed to apply different types of assessments and cater for different amounts of data available for IOTC stocks. The approach could include increased levels of precaution that correspond to increasing levels of uncertainty about stock status, in order to reduce the level of risk associated with increased uncertainty. In this approach, each stock is assigned to one of four tier levels depending on the amount and type of information available to assess stock status, where Tier 1 represents the highest quality of information available (i.e. a robust quantitative stock assessment) and Tier 4 the lowest.

The four Tier rules are designed to apply to three types of assessments. Tiers 1 and 2 are used for stocks for which there is a quantitative stock assessment that provides estimates of current absolute and relative biomass (Tier 1 if the assessment is regarded as "robust", Tier 2 for a less certain or preliminary assessment).Tier 3 is based on estimates of current fishing mortality derived from catch curves (requiring age and/or length frequency data, but not catch rates or abundance estimates). Tier 4 is based on recent trends in catch rates.

Example of a 4 Tier system:

- Tier 1: robust quantitative assessment
- Tier 2: preliminary quantitative assessment
- Tier 3: estimates of F from catch curves (age/length data)
- Tier 4: trends in standardised CPUE

***Tier 1***

Tier 1 analysis would have a well established and agreed quantitative stock assessment. A robust quantitative assessment that provides estimates of current biomass levels, and estimates of, or appropriate proxies for $B_{LIM}$, $B_{TARG}$ and $F_{TARG}$. The interim target and limit reference points are those set by the Commission.

***Tier 2***

Tier 2 analysis would apply to species and/or stocks which have a less robust quantitative assessment, or a preliminary quantitative assessment. A less robust quantitative assessment should still provide estimates of current biomass levels, and estimates of, or appropriate proxies for $B_{LIM}$, $B_{TARG}$ and $F_{TARG}$. The interim target and limit reference points are those set by the Commission.

***Tier 3***

Tier 3 analysis is not a robust quantitative stock assessment, but is used where information is available on the age structure of annual catches and annual total catch weight, as well as knowledge of basic biological parameters, e.g. natural mortality, age-length relationships, length/weight relationships, stock recruitment relationship steepness, age at maturity and age at recruitment to the fishery. The estimation of fishing mortality is made using all this information. The time period used to estimate fishing mortality is the same as that used to estimate current catch.

***Tier 4***

Tier 4 analysis would apply to species with the least amount of information about current stock status, i.e. there is no reliable information available on either current biomass or current exploitation rate. It is assumed that there is information available on current catch levels and trends in catch rates. The Tier 4 analysis involves the selection of CPUE reference points that are taken as proxies for the estimated $B_{LIM}$ and $B_{TARG}$.

This is done by assuming that the CPUE is proportional to stock abundance, an assumption that is made in most assessments. If the stock was at unexploited equilibrium at the start of fishing, then the initial CPUE level at the start of the time series would correspond to the unexploited biomass or $B_0$, and the other reference points are the appropriate fractions of this (e.g. 20% for $B_{20}$). For most IOTC stocks there is not a full CPUE time series back to the start of fishing, so it is necessary to choose a reference period from the data series that we do have where we think we can make a reasonable estimate of the level of depletion of the stock. Most IOTC species are considered to be fully exploited by a particular year, so a reference period against which current rates are compared is chosen around this time when CPUE levels and catches were relatively stable. A default period may be chosen, but other periods could be used for some species and fisheries which were not fully developed by the default.

It would then be assumed that during the reference period the stock was at the level that would provide maximum sustainable yield, i.e. the CPUE corresponds to $B_{MSY}$. This is why, for these stocks, the Tier 4 rule would use the average CPUE in the reference period as a CPUE target, and the average catch in that period as a catch target.