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Further consideration on the development and testing of new Management Procedures for SBT

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Contents

Abstract

The CCSBT has agreed to develop a new Management Procedure (MP) to guide the setting of the global Total Allowable Catch (TAC) as part of the Commission's rebuilding plan for the stock and fishery. This paper provides an overview of the MP development and testing process that lead to the adoption of the "Bali Procedure" and its implementation as context for the ESC's consideration of the work plan for development of a new MP. We note the results of the most recent reconditioning of the CCSBT Operating Models (OMs) indicate incremental improvement in the stock status since the last full stock assessment and preliminary projections suggest substantially higher productivity (and rate of rebuilding) than estimated when the Bali Procedure was adopted and for the 2014 full stock assessment. These results have implications both for what might be considered desirable attributes and behaviours of a new MP, in terms of "post-rebuilding" behaviour and performance, and for the likely consultation and engagement requirements between the ESC, Extended Commission and stakeholders to ensure that the tuning criteria and performance measures used to test likely performance of Candidate MPs (CMPs) adequately reflect the objectives of the Commission. In light of this, we suggest that the ESC may wish to recommend extending the process for the development of a new MP for one year to allow for sufficient iteration between i) the technical development of CMPs and ESC review and direction; and, ii) dialogue between the ESC and EC on desirable behaviour and performance measures for CMP to meet the objectives of the rebuilding strategy and longer-term goals for the management of the SBT fishery.

1 Background

At its 2015 meeting the Extended Commission (EC) agreed to implement a new recruitment monitoring program, using gene-tagging, to estimate absolute abundance of 2 year olds. The impetus for this decision revolved around the cost and logistic frailty of the existing recruitment monitoring series, derived from the scientific aerial survey (Eveson and Farley 2017). The aerial survey provides the current recruitment index of relative abundance of 2-4 year olds, which is used in combination with the standardised longline CPUE in the CCSBT "Bali Procedure". The change in the method used to estimate recruitment means it will be necessary to develop a revised, or new, Candidate Management Procedures (CMP) (Anon. 2016, 2017).

1.1 The *Bali Procedure*

A management procedure (MP) is the *combination* of monitoring data, method for analyses of those data, the decision rule (also known as Harvest Control Rule (HCR)) and implementation of a management measure to achieve the specified change in the level of fishing (Figure 1).

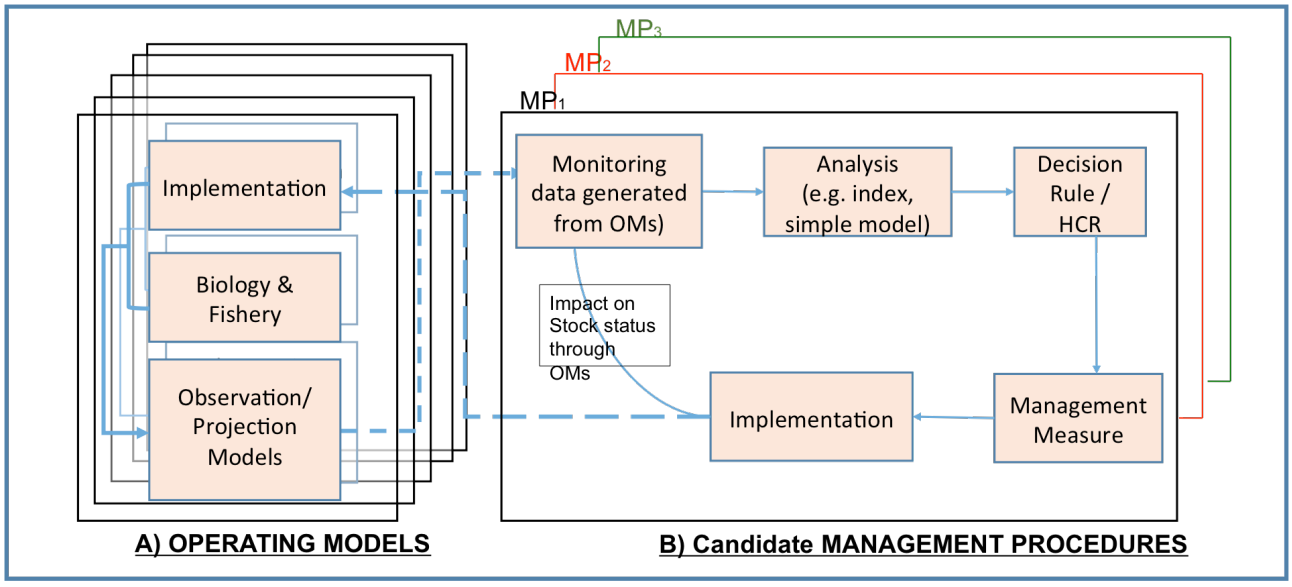

Figure 1: Schematic representation of the components of a) the Operating Models and b) candidate Management Procedures used as part of Management Strategy Evaluation (MSE). The MSE process starts with development of multiple Operating Models, which define the status and dynamics of the stock, fisheries and monitoring data, including the plausible uncertainty in them. Multiple candidate MPs are developed, and their relative performance compared across a range of criteria, given that each candidate MP has been "tuned" to meet the CCSBT rebuilding objective.

Importantly, the development and implementation of effective MPs is generally very context specific (Anon. 2013a, Punt et al., 2016). In the case of CCSBT, the development of MPs has been influenced by the available monitoring series, the depleted nature of the stock and low levels of recruitment at the turn of the century, and the objectives agreed by the EC to rebuild the stock to a specified level (20%) within a defined period (2035) and given level of confidence (70%). An

important element of the Bali Procedure is the implementation framework that specifies the schedule of activities, including: TAC recommendations (every 3 years), assessment of stock status (every 3 years) and evaluation of meta-rules (annual), examination of evidence of exceptional circumstances (annual), and periodic review of MP performance (every 6 years). This implementation framework serves to ensure, to the extent possible, that operation of the MP is consistent with the conditions and manner in which it was tested. The full specification of the Bali Procedure is given in Appendix 13 of the report of the ESC, Anon. 2013b. Hillary et al (2016a) provide a summary of the background and development of the Bali Procedure. Table 1 summarises the main steps in the MP development, testing, adoption and implementation to date.

1.2 What has changed since the adoption of the Bali Procedure

In 2011, when the Bali Procedure was adopted by the CCSBT, the depletion level was estimated to be between 3-8 percent of its unfished level (Anon. 2011), mean recruitment at ~50% of that estimated for the unfished state and four very low year classes around the turn of the century had been confirmed across all major monitoring series. The first reconditioning of the CCSBT operating models (OMs) post-implementation of the MP (Anon. 2014), included updated data and the first inclusion of close-kin mark-recapture (CKMR) parent-offspring pair (POP) data. The results indicated an improvement in stock status (6-9% SSB10+, 8-12% SSB using a new definition), current estimates of fishing mortality and, potentially, underlying productivity. The improved stock status reflected a combination of i) rescaling of depletion as a result of the abundance of spawners of the CKMR data, and ii) total mortality on the spawning stock being lower than previously assumed. The more optimistic assessment of productivity was inferred from results of projections of the MP, which showed the probability of meeting the interim rebuilding target of the CCSBT was 0.74 under the reference set of OMs, relative to 0.70 at the time of adoption of the Bali Procedure.

Sensitivity tests aimed at estimating the impact of plausible levels of uncounted mortality, demonstrated that the rebuilding would be compromised if such levels of unaccounted catches were, in fact, occurring (0.49, relative to 0.74 under the reference set in 2014). The ESC noted *"… that if total mortalities are as large as those considered in the added-catch scenario, then impacts on the rebuilding plan may be substantial. The ESC is concerned about the implications and impacts of the unaccounted mortality scenarios and requests the Extended Commission and Compliance Committee urgently provide detailed information and data to properly assess impacts of unaccounted mortalities."* (paragraphs 93-95, Anon. 2014). In addition, the index from the 2014 aerial survey was considered (at the time) unusually high and on the margin of invoking exceptional circumstances. The ESC retained the 2014 estimate from the aerial survey in the reference set as it did not have a substantial impact on stock status.

The timetable for testing and selection of a new MP was developed at the Operating Model and Management Procedure (OMMP) technical meeting in 2015, and subsequently recommended by the ESC to the EC (Anon. 2015a, Anon. 2015b), in response to the decision by the CCSBT not to continue the aerial survey. The process of testing and selecting candidate MPs (known as Management Strategy Evaluation, MSE) involves reconditioning the CCSBT OMs with updated and/or new data, defining data generation methods for monitoring series for use in projections,

defining performance measures for testing of the candidate MPs and tuning the individual MPs to the same objective so that the MP performances can be compared across a range of performance measures (Table 1) (see Anon. 2009, 2010 and 2011 for most recent round of MP development, testing and selection).

Table 1: Summary of steps in development, adoption (2009-2011) and implementation (2011-2020) of the Bali Procedure. SFMWG = Strategy and Fisheries Management Working Group.

Activity	Date	Items relating to MP development and implementation
Development to Adoption		
ESC13	2008	Aerial survey included in OM reference set.
OMMP	July 2009	Recondition OMs for stock status advice and MP development
ESC14	Sept 2009	Initial discussion on forms of potential MPs
SFMWG2	Apr 2010	
OMMP3	June 2010	OM conditioning and robustness tests Tuning and testing of initial testing of candidate MPs Performance measures and operational constraints based on SFMWG advice
ESC15	2010	Reviewed final candidate MP performance Two candidate MPs recommended to EC Range of implementation options for each candidate MP
EC17	2010	EC requests refinements and simplified choice of MP
ESC16	July 2011	Reconditioning of OMs Retuning and review of two candidate MP, combination into single preferred MP Recommendation of Bali Procedure with small set of implementation choices
Special EC meeting	Aug 2011	EC adopted Bali Procedure and select implementation option
Inter-sessional	Sep 2011	Bali Procedure checked, retuned and run to EC specification and TAC recommended.
EC18	Oct 2011	EC adopted Bali Procedure, including meta-rules and implementation framework Sets TAC for initial quota block (2012-2014) lower than MP recommended TAC as a precautionary measure.
Implementation		
ESC17	Aug 2012	Review of fisheries indicators; MP monitoring series; new data sources, including CKMR stand-alone model and initial results of incorporating POPs in OMs
OMMP4	July 2013	Evaluate approaches for incorporating CK data in OMs and revisions to grid
ESC18	Sep 2013	Review of fisheries indicators and MP monitoring series; Review results of incorporating POPs in OMs and revisions to grid; Finalised re-instatement of CCSBT Scientific Research Program; Operation of MP for 2015-17 TAC recommendation to EC.
EC20	Oct 2013	MP recommended TAC for 2015-2017 adopted by Extended Commission.
OMMP5	Jun 2014	Reconditioning of OMs with updated and new data (POPs) in preparation for first full assessment of stock status following MP adoption. Review of info on UAM.
ESC19	Sep 2014	Review of fisheries indicators and MP monitoring series; Full assessment of stock status. Recommendation on SRP project, including CKMR and preliminary GT design. Review of information to estimate UAM.
OMMP7	Aug 2015	Technical implications of changes in aerial survey on MP; reconsideration of OM structure
ESC20	Sep 2015	Review of fisheries indicators; MP monitoring series; Advice to EC on implications of discontinuing aerial survey for OM and MP; Estimation of UAM; Review of CKMR design (POPs+HSP) and full GT design study.
EC22	Oct 2015	EC agreed to continue aerial survey to 2017, GT pilot and transition to new MP
OMMP7	Sep 2016	Review and define OM structure for 2017 stock assessment; initial form of MPs using GT recruitment index, in lieu of aerial survey.
ESC21	Sep 2016	Review of fisheries indicators; MP monitoring series; review of 2017 TAC in light of UAM estimates; Operation of MP for 2018-2020 TAC recommendation; review of MP development work plan.

2 Identified monitoring series and potential forms of MPs

2.1 Candidate monitoring series

Recruits

The second round of MP development (2009-2011) included the requirement for candidate MPs to include an index of recruitment, given the low status of the stock and the historically low recruitments at the turn of the century (Anon. 2009). While there have been positive indications in recruitment and the status of the spawning stock in recent years (Hillary et al., 2017a), the ESC continues to consider a fishery independent index of recruitment an essential monitoring series for candidate MPs (Anon. 2015). This is a function of the late maturity of SBT and the current selectivity of the majority of the fleets being focussed predominantly on juvenile and sub-adult fish. The combination of these two factors results in a substantial delay between catches being taken and the impacts propagating through to the spawning stock.

Sub-adults

Longline CPUE data are used in the current MP as an index of the abundance of sub-adult, or "harvested" component of the population. The actual CPUE input data series used in the Bali Procedure is the average of two standardised CPUE indices that have been adjusted for an agreed unreported catch scenario (for the historical period where that applies). The CPUE combines data across age classes from age 4 upwards and is assumed to represent the relative abundance of sub-adult fish, as these have been the dominant age classes in this component of the fishery over the past few decades.

Spawning adults

Until recently, there was no direct monitoring of the abundance of the spawning stock. The advent of the CKMR methods has filled this gap to some extent, providing the biological sampling and quality control programs that underpin the approach can be maintained. Bravington et al. (2017) describes the processing of ~17,000 samples of adults and juveniles to identify 77 Parent-Offspring Pairs (POPs) and 140 Half-Sibling Pairs (HSP) which have been incorporated into the most recent reconditioning of the CCSBT OMs (Hillary et al. 2017c).

The history and characteristics of the candidate series were reviewed at OMMP8 (Anon. 2017) and are summarised in Table 2. Hillary et al. (2016b,c and 2017c) provide detailed specifications and diagnostics for the generation of simulated data for each series using the CCSBT OMs.

Table 2: Candidate monitoring series for recruits, sub-adult and spawning adult life-history stages of SBT for potential inclusion in MPs (modified from Table 9 of OMMP8 report; Anon. 2017). *The concept of a recruitment index based on relative CPUE of 4-year olds from LL1 was proposed at OMMP8, but the statistical properties of this index are yet to be evaluated. ** Ongoing collection and sequencing of tissue samples is funded under the CCSBT SRP. At present, there is no plan to genotype and identify kin from these samples.

Life-history stage	Candidate monitoring series	Index	Date Available	Times series available by 2018, 2019	
Recruits	Gene-tagging	Absolute abundance 2yo	March 2018 March 2019	N_2, 2016 N_2, 2017	Fishery independent
	*CPUE LL rec	Relative abundance 4yo	June 2018 June 2019	1969-2017 1969-2018	Fishery dependent
Sub-adults	CPUE LL	Relative abundance 4-8yo or 4-11yo	June 2018 June 2019	1969-2017 1969-2018	Fishery dependent
Spawning Adults	**POPs	Abundance/trend of spawners.	May 2018 May 2019	2002-2013 2002-2014	Fishery independent
	**HSP	Abundance and trend in mortality of spawners	May 2018 May 2019	2002-2013 2002-2014	Fishery independent

Table 3. Activity plan and timelines for OMMP technical group leading to TAC recommendation in 2020 for 2021-2023. Source: Table 11, Report of OMMP8, Anon. (2017).

Activity	Dates	Notes
2017		
Web meeting	July 20th/21st	Decision on whether to include HSPs in 2017 stock assessment model based on fits and impact.
One-day OM meeting	Aug 27th	In Yogyakarta prior to ESC; main purpose to refine MP testing process and consultation schedule. Specify list of robustness tests for MP development.
ESC22	Aug 28-Sep 2nd	Focus on stock assessment/status, with some projections done to initially inform on tuning and rebuilding targets
2018		
Update data for OM	May	Include update of CPUE and gene tagging data.
Intersessional	May	MP developers interact and coordinate/discuss with each other.
OMMP9	June	• Review of candidate MP (CMP) performance • Finalize robustness tests • Improve CMPs • Informal dialogue with Commissioners on preliminary results of CMPs
Intersessional	Prior to ESC	Refine reduced set of CMPs.
ESC	Sept	Includes presentation of refined CMPs and a session for interaction with stakeholders.
Commission	October	Confirms or amends broad recovery objectives etc. based on advice from ESC.
2019		
OMMP	June	Review final versions of CMPs to develop limited set to put forward to ESC.
ESC	September	Select final set of CMP options.
Commission	October	Selects and adopts MP.
2020		
ESC	September	Implementation of agreed MP to provide TAC advice for 2021 (i.e., no standard 1-year lag) Note, this implementation will include data to June 2020, rather than just to 2019. Update assessments including projections using adopted MP
Commission	October	Agrees TAC advice for 2021. Perhaps with option to have MP implemented sooner, e.g., via a special meeting should the Commission desire.

2.2 Potential Forms of MPs

Initial development of a wide variety of candidate MPs is useful to demonstrate contrasting performance and behaviours of different candidates that may be more or less attractive to CCSBT members and their stakeholders (Davies et al, 2016). We encourage wide participation in development and trials of candidate MPs and make suggestion here for some of the variants that could be considered individually or in combination. Full development and review of candidate MPs will occur after the ESC22 according to the revised ESC work plan (Table 3).

Candidate MPs can vary in the following ways.

Data inputs

Candidate MPs can explore performance using any combination of the identified monitoring series as inputs. The ESC has recommended that a recruitment index is "essential" in development of a new MP, because when using the existing MP, greater catches and earlier rebuilding were achieved when the recruitment index was included (Anon. 2015). It has been a concern, of the ESC and trilateral scientific committee, since the early 1980's that because of the timespan from birth to maturity, that the stock is vulnerable to recruitment over-fishing. The CPUE index is focused on the main harvested component of the stock. There are identified issues associated with the interpretation of this CPUE series as a relative abundance index for which a range of sensitivity and robustness tests have been developed to address. The adult abundance monitoring series provide direct information on the component of the stock, which is the target of current management (at least in terms of the current rebuilding objective). These monitoring series can also be individual tested, in relation to their level of fishery independence, statistical properties, potential biases, availability and cost prior to inclusion in candidate MPs and MSE (e.g. Hillary et al 2016b).

Use of absolute estimates or relative trends in data

Some of the monitoring series may be used as absolute or relative indices of abundance in candidate MPs (Hillary et al 2016c and 2017b). Gene-tagging estimates of abundance can provide both absolute (i.e. individual estimates of absolute abundance for each cohort in each year) and relative information (the trend and/or relative level of X years of estimates, relative to a reference level, as in the Bali Procedure for the CPUE). As the gene-tagging abundance estimates' times-series accumulates, it will become informative on the trend and variation in mean recruitment, in addition to the absolute values. CPUE data provides relative abundance trends, and close-kin POPs and HSPs data can be combined to provide relative abundance of adults (Hillary et al., 2016b,c), which are separate from the absolute estimates of abundance derived from the close-kin assessment model (see Bravington et al., 2017).

Rules that respond to limits, trends or targets

MP decision rules are designed to move away from limits, towards targets and, or, respond to positive and negative trends. For example, the Bali Procedure MP includes limit reference levels for the aerial survey. One part of the decision rule compares historical estimates of the

very lowest recruitment from the operating models (1999-2002) to current estimates. This part of the rule is designed to reduce TACs quite rapidly to minimise the impact of very low recruitments on rebuilding. Changing the TAC in response to the slope of a trend (for example in CPUE) has been used in the Australian Eastern Tuna and Billfish Fishery (ETBF) harvest control rule for swordfish and striped marlin (Kolody et al 2010). Target based rules (e.g. rebuilding a depleted stock to a target CPUE level) can be used in combinations with others. Care is needed in the design of the responsiveness of target based rules when close to the target, as oscillation around the target can be associated with this form of decision rule (e.g., Basson and Dowling, 2008 Kolody et al., 2010).

Empirical, model based or fuzzy logic decision rules

Candidate MPs developed as part of the most recent CCSBT MSE process (Anon. 2010) included all three of these types of rules; empirical rules that respond directly to values and trend in the input data; model based rules that use an estimation model to transform the input data from the monitoring series into a population (i.e. spawning biomass) or fishery parameter (e.g. F) for use in the harvest control rule (the TAC calculation part of the MP); and fuzzy logic MPs, a form of model based rules. Empirical rules are the simplest to follow in that any integration, smoothing or standardisation of the monitoring inputs occurs before the series are used in the MP (e.g., CPUE standardisation), and the values of the monitoring series are used directly in the decision rule to make TAC recommendations. Being both simple to follow and describe to stakeholders, is considered one of the strengths of empirical rules and aids transparency of TAC decisions. There is a growing body of examples that indicate that relatively simple empirical MPs can perform as effectively as those that include more complex models (see Carruthers et al, 2016; Geromont and Butterworth, 2015). Model-based rules can be relatively “simple” (like the Bali Procedure) or more complex, i.e. the “assessment/analysis” component of the MP can be equivalent to a full stock assessment. The disadvantages of these more complex model-based MPs are: 1) the data requirements (more data series to collect and model in simulation testing), 2) the difficulties of selecting a model that will not need to be changed when new data become available (i.e. the MP model needs to be fixed and operational for a long period of time before a new MP needs to be developed, unlike stock assessments which can change from assessment to assessment), and 3) the practicality of MSE testing, where the full data and TAC decision each year is iterated across thousands of replicates, different scenarios and robustness test (i.e. the time required, or consistent convergence of the assessment model in the MP, makes the MP untestable). Fuzzy logic and other branches of mathematics and decision support systems may have methods worth exploring in candidate MPs. Combinations of model and empirical components in an MP are also possible, as was the case for the Bali Procedure.

Different types of responses in rules (e.g. asymmetry to positive/negative trends, hierarchical decision tree type structures, more or less reactive gain factor)

Candidate MPs that use the same monitoring series, limits or targets and type of rule, can be quite different in their responses to the inputs in the decision rule, which in turn can have a substantial impact on their overall performance. For example, an asymmetrically response is

embedded in the Bali Procedure, for rapid TAC decreases when current recruitment estimates approach the limit reference levels for recruitment, and proportionally slower and smaller TAC changes when further from the limit. The strength of responses in the decision rules affect the overall performance of the MP (e.g. risk of increasing TAC and then having to decrease it quickly, and average annual variation in catches (AAV), stability of catches objectives). Therefore, the objectives and performance measures that the Commission defines for the new MP will influence the types and strengths of responses included in the decision rules. Hence, this iterative process between the Commission, members' stakeholders and the ESC to identify desirable attributes and behaviours of MPs has been an essential part of the MP development process and highlights the importance of the including sufficient opportunities for formal and informal dialogue in the MP development process.

Another possibility explored elsewhere is the use of hierarchical decision tree in the decision-rule. The main advantage of this type of rules (besides their relative ease of communication) is that they can use multiple indices and provide for multiple conditions of action. Additionally, they can be imbued with potentially attractive features – such as delaying action until pre-specified triggers are breached, which are often harder to reproduce in the kinds of rules explored in a lot of MP work (Carruthers et al, 2016; Geremont and Butterworth, 2013). A less desirable feature of this form of rule is that there can often be hidden discontinuities embedded within the rules that can cause problems that may not be immediately obvious at the design, or even the testing stage, but post-implementation.

Combinations of these components of MPs and different ideas within these categories led to a large range of candidate MPs being specified and tested during the development process (Anon. 2009) that led to the final selection and adoption of the current Bali Procedure MP (e.g. Anon. 2010). Some of these candidates, or components thereof, may be useful to reconsider and update with ideas from our collective experience with the Bali Procedure and/or other MP/MSE work and the new data series that are now available.

Broad suggestions for candidate MPs and potential decision rules, based on the information content of the agreed monitoring series, were described in Hillary et al (2017c). These were intended to stimulate consideration of initial forms of MPs which can then be further specified, extended/refined and tested.

One form of MP outlined in Hillary et al (2017c), as an example for further exploration, considers methods using multiple monitoring series and analyses which are combined in the decision rule to set TAC:

1) Calculate the ratio of recent absolute recruitment from the gene-tagging index relative to the limit level (very low recruitments in the 1999-2002 period) and linearly reducing the TAC as this ratio falls below 1.0; leave TAC unchanged when ratio above 1.0.
2) Use the trend in recruitment (from a time series of gene-tagging recruitment estimates) and increase or decrease TAC if the mean recruitment is positive or negative. The size of the change in TAC is controlled by a gain parameter.
3) Use the recent trend in CPUE (e.g. 7 years is used in the Bali Procedure) and a gain parameter to increase or decrease TAC in proportion to the change in the trend in CPUE.

4) Use the close-kin POPs and HSPs data, combined into an index of relative adult abundance, to increase and decrease TAC relative to a limit/target ratio rule.

5) Combine the recommended TAC changes from each component using appropriate weightings for each component. In this way, the weighting of the components can be explored to give different performance outcomes.

As noted above and observed in 2011, a variety of candidate MPs can be informative; the MP adopted in 2011 was a combination of two MPs, which used the same monitoring series, but different analysis and forms of decision-rule and had slightly different performance attributes. The combination of the two candidate MPs improved the overall performance.

3 Desirable attributes and behaviour for a new MP

The Bali Procedure was developed and adopted as a central component of the CCSBT's plan to rebuild the stock and reduce the risk of further declines in the spawning stock. As noted, at the time of development and adoption, the spawning stock was estimated to be at a very low level, there had been several very low recruitments which had yet to work their way into the spawning stock and the impact of the 2006 and 2009 quota reductions, in terms of rebuilding, remained unclear. Since 2011, there is evidence that fishing mortality has been reduced to below F_{msy} , the state of the spawning stock is estimated to be higher (0.13, 0.11-0.17), with evidence of an increasing trend, and there have been a number of year classes have been above average levels of recruitment (Hillary et al. 2017b).

In addition, the successful implementation of CKMR provides a basis to monitor the spawning stock directly, which was not the case previously. The 2017 reconditioned OMs and projections using the Bali MP also indicate that the productivity of the stock may be substantially higher than previously thought. While these results are encouraging and consistent with the combined actions of CCSBT over the last decade, or so, having reduced fishing mortality sufficiently to allow for rebuilding, several more years of monitoring of recruitment and the spawning stock will be required before a firm conclusion on the updated estimates of stock productivity. There remain substantial challenges to meeting the Commission's rebuilding goal; including addressing various sources of fishing mortality that are not currently included in the reported catches, or managed under the global TAC.

Notwithstanding this, the changed understanding of the status and productivity of the stock, relative to 2009-2011, does change the nature of consideration of desirable attributes and behaviours for the design and selection of a new MP. Between 2009 and 2011, relatively little consideration was given to the likely behaviour of candidate MPs beyond the rebuilding target. The focus was firmly on the ability of an MP to:

i) achieve the rebuilding target;

ii) respond sufficiently rapidly to further low recruitment events to avoid further declines in the spawning stock;

iii) robustness to biases (known and potential) in CPUE and AS indices;

iv) trade-offs between likely catch levels in the short/long term;

v) stability of direction in TAC changes (i.e. likelihood of TAC decrease, after an increase.)

The most recent assessment of stock status results require that consideration will need to be given to the following issues by both the ESC and EC in the MP development process:

i) The level of confidence in new estimates of population dynamics, in particular, long-term productivity and influence of recent recruitments, and how the level of confidence might be improved in the short term;

ii) Review and re-interpretation of current specification of the CCSBT rebuilding plan;

iii) Desirable behaviour of candidate MPs pre- and post-rebuilding; and

iv) Specification of objectives for post-rebuilding phase, since the projections using the Bali Procedure indicate that the rebuilding target may be reached in the next 1 or 2 TAC blocks.

The CCSBT strategic plan (Anon. 2015) provides some guidance for the ESC to consider these issues as a basis for early advice to the EC, starting with the objective of the Convention:

"The objective of the Convention is to ensure, through appropriate management, the conservation and optimum utilisation of the global SBT fishery."

Goal A of the strategic plan "Goals concerning management of SBT" is:

"Southern bluefin tuna stocks are managed at a biomass level that supports the maximum sustainable yield, and the risks of fishing for SBT are mitigated".

This goal includes the following strategies relevant to the development of a new MP, both of which are ranked as "very high" priorities:

Strategy 1. Re-building SBT

1. *Set target and lower limit points for rebuilding the SBT stock, and adopt strategies for achieving the target and avoiding the lower limits*
    - *The interim target reference point is to rebuild the SBT stock to 20% of the original spawning biomass, with 70% probability, by 2035;*
    - *The limit below which stock size should not be allowed to fall is SSB 2010; and*
    - *After reaching each Members' nominal catches, assess the costs and benefits of alternative rebuilding strategies, including those that favour stock rebuilding over short-term catch increase.*

Strategy 2. Sound scientific basis for setting TAC

2. *A Management Procedure is used to provide guidance on TAC setting*

    (i) The Scientific Committee review the function and inputs to the Management Procedure in 2016 and 2017 to ensure it will achieve rebuild targets and timeframes and thereafter at six yearly intervals

    (ii) Continue to use MP as input to setting global TAC

    (iii) Monitor stock status
        - *Review of stock and fishery indicators (annual)*
        - *In depth stock assessment (every 3 years)*

Strategy 2 (above) clearly demonstrates CCSBT's commitment to the *MP Approach* as the basis for rebuilding the spawning stock and managing the fishery into the future. Strategy 1 articulates the goal to rebuild the stock to MSY in the long-term, following rebuilding to the interim rebuilding target of 20% of SSB, with 70% probability by 2035. The last dot point of Strategy 2 also notes the Commission's intention to consider the trade-offs between stock rebuilding and short-term catch increases once Member's nominal catch allocations are restored. As the latter was achieved with the 2016 decision on 2018-2020 TAC, it would seem timely for the ESC to give consideration to this issue for MP design and performance criteria in the context of meeting the interim rebuilding objective and longer-term objectives of the CCSBT.

In particular, the results of the updated OMs indicate the status of the stock has improved gradually, and the rebuilding objective may be achieved substantially earlier than expected. If true, this would be a very positive development, but part of this optimistic outcome is being driven by the very high 2016 aerial survey index, for which there is little additional information at present (i.e. the cohorts observed in the aerial survey, 2-4 year-olds, are not/partially recruited to the long-line fisheries). It is also driven in part by improved information on steepness, abundance and mortality of spawners due to the addition of the close-kin data. The end of the "one-way trip" (sustained decline in SSB) and initial indications of an increase in the spawning biomass are also positive and informing steepness, in particular. The updated OMs appear to have less uncertainty and fewer conflicts between data sources than the 2014 assessment of stock status; but the ESC needs to consider when advising the EC, if this assessment is sufficient to change our perception of stock status and, particularly, productivity. And, in addition, what are the potential risks for the stock and the fishery of developing and tuning MPs based on the current conditioning? In our view, consideration of these questions and the desired attributes of an MP from the previous round of MP development (listed above) should help inform the development of suitable performance measures and robustness tests (in addition to those proposed at OMMP8) and a schedule of events for the coming MSE process.

4 Considerations for MP development and refinement of work plan

It is unlikely the ESC will have sufficient time to consider the relevant technical aspects of the potential change productivity and objectives beyond the interim rebuilding target in detail at ESC22, as the focus of the meeting will be on review of the reconditioned OMs, fisheries indicators, reviewing exceptional circumstances, new close-kin data etc, as part of finalising the 2017 assessment of stock status. Hence, it is likely that advice from the ESC to the EC on the implications of the 2017 assessment for MP development and the Commission's rebuilding plan will be preliminary, with more considered advice requiring guidance from EC24 and sufficient time for inter-sessional analysis and consideration by the ESC23.

The technical working group at OMMP8 considered this situation, following review of the preliminary results of reconditioning the OMs, and recommended a one year delay in the schedule to develop and implement a new MP. In light of the positive stock status and projections, and an agreed TAC for 2018-2020, we consider that there is currently a low risk to the stock associated with a one year delay in the MP development schedule. Given this, we suggest that the ESC should consider recommending a revised work plan for MP development, along the lines of option 3 proposed by the OMMP Technical group at OMMP8 (Table 4), with the following substantive changes:

- 2018: The focus of OMMP and ESC is on design of candidate MPs to meet interim rebuilding target *and* provide satisfactory longer-term performance beyond achievement of the rebuilding target to inform consultation with EC in 2018. This could usefully include a joint session with the EC or SFMWG.
- 2019: The reconditioning of OMs scheduled for 2020 as part of a regular stock assessment be brought forward to 2019 to include the new gene-tagging data (2016, 2017 recruitment), updated CKMR data (trend in spawning stock) and regular updated fishery data. The focus of this activity would be to i) provide up-to-date OMs for tuning candidate MPs; and ii) improved estimation of recent recruitments and their impact on short-term dynamics. The ESC focus would be on testing and tuning MPs, refine performance measures and robustness tests, dialogue with Commissioners and members' stakeholders.
- 2020: Focus is on testing tuned MPs, agreeing primary performance measures for ESC and EC and consultation with EC and stakeholders, prior to ESC recommendation on a preferred MP for adoption by EC and implementation for 2021-23 TAC block.
- 2022: Recondition OMs and full assessment of stock status reverts to three year cycle off-set from TAC decision years.

We consider this option has several benefits including:

- Provides sufficient time for consultation between the ESC and EC and stakeholders on desirable attributes and performance measures for MPs, which are informed by the OMs

reconditioned in 2017, but free from the immediate pressure to select preferred candidate MPs;

- Bringing forward the scheduled 2020 stock assessment will provide updated estimates on the strength of more recent recruitments, which will have entered the longline fisheries, and provide a "data guillotine" for OM reconditioning and MP testing in advance of MP selection and implementation. This also avoids the situation of conducting an updated assessment and selecting and running an MP at the same set of ESC and EC meetings.
- Separating the updating of OMs and the final MP selection and implementation would focus the consultation and advice between the ESC and EC in 2020 on MP performance and allow for iterative refinement. This would be unlikely to be possible if done in combination with reconditioning of OMs.

Table 4. Options considered for MP development work-plan. (Table 12 from OMMP8)

OPTION 1		
2018		
	June	OMMP – first presentation of candidate MPs (CMPs)
	September	ESC - includes presentation of refined CMPs and a session for interaction with stakeholders
	October	Commission – confirms or amends broad recovery objectives etc. based on advice from ESC
2019		
	April	Special ESC session – to review final versions of CMPs and recommend selection to Commission
	June	Special Commission meeting - selects and adopt MP
	September	ESC - Implementation of agreed MP to provide TAC advice
	October	Commission – agrees TAC advice
OPTION 2		
2018		
	June	OMMP – first presentation of candidate MPs (CMPs)
	September	ESC - includes presentation of refined CMPs and a session for interaction with stakeholders
	October	Commission – confirms or amends broad recovery objectives etc. based on advice from ESC
2019		
	June	OMMP – reviews final versions of CMPs to develop limited set to put forward to ESC
	September	ESC – selects final set of CMP options and implements each to provide TAC advice associated with each
	October	Commission – adopts MP and agrees TAC advice
OPTION 3		
2018		
	June	OMMP – first presentation of candidate MPs (CMPs)
	September	ESC - includes presentation of refined CMPs and a session for interaction with stakeholders
	October	Commission – confirms or amends broad recovery objectives etc. based on advice from ESC
2019		
	June	OMMP – reviews final versions of CMPs to develop limited set to put forward to ESC
	September	ESC – selects final set of CMP options
	October	Commission—selects and adopts MP
2020		
	September	ESC - Implementation of agreed MP to provide TAC advice for 2021 (i.e., no standard 1-year lag) Note, this implementation will include data to June 2020, rather than just to 2019. Update assessments including projections using adopted MP
	October	Commission – agrees TAC advice for 2021. Perhaps with option to have MP implemented sooner, e.g., via a special meeting should the Commission desire.

5 Summary

The CCSBT's commitment to the MP approach has resulted in substantial benefits, including: greater certainty and orderly operation of the ESC and EC in the provision of management advice and the setting of the TAC; reduction in fishing mortality and preliminary signs of rebuilding of the spawning stock; and, providing focus and priority for research and monitoring requirements. The development of a new MP to replace the Bali Procedure and the availability of new monitoring series provides an opportunity to consolidate on the progress made with the Commission's rebuilding plan and, in light of the results of reconditioning the OMs, begin to consider the desirable attributes of an MP if and when the rebuilding objective has been met. This was not a substantive consideration in the last round of MP development. It will require the ESC and the EC to give appropriate consideration to the performance measures and tuning criteria for candidate MPs and, also, the measures and criteria to be used, for example, to define when rebuilding has been achieved. While these issues are relative straight-forward on face value, their technical implementation for testing of candidate MPs and in the monitoring of implementation of a new MP will require iterative dialogue at both the technical and policy levels to ensure that the MP selected for implementation reflects the Commission's intentions and allows for a smooth transition between the Bali Procedure and the new MP. We consider the addition of a year to the development schedule to allow for this iterative dialogue will be highly beneficial to the outcome, with relatively low risk to the stock or the fishery.

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