Development toward the New Management Scheme for Southern Bluefin Tuna

Sachiko TSUJI

Fishery Information, Data and Statistics Unit (FIDI),
Food and Agriculture Organization of the United Nations (FAO)
Viale delle Terme di Caracalla, 00100 Rome, Italy
e-mail: sachiko.tsuji@fao.org

Abstract

Historically, management of the southern bluefin tuna had been a great dispute among relevant parties. However, the situation is improving in recent years, mainly due to the introduction of the independent Advisory Panel to the scientific process of the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) and its agreement to adopt a management scheme based on the Management Procedure, a set of pre-specified TAC adjustment rules evaluated with thorough simulations. Concepts and the progress of developing Management Procedures under the CCSBT are introduced. Some of the advantages of Management Procedure are: 1) avoids continuous and consistent struggle in selecting appropriate management action by choosing pre-specified rule beforehand, and 2) chooses management plan by examining effectiveness for multiple or even contradictory objectives with clear understanding on trade-off. Limitations in Management Procedures are: 1) underestimates the uncertainty intrinsic to stock assessment model in general, especially on absolute stock level and projections, and 2) only valid within the uncertainty range that is examined.

Key words: adaptive management, CCSBT, decision rule, Management Procedure, Southern bluefin tuna (*Thunnus maccoyii*), stock assessment, trade-off

1. Introduction

The southern bluefin tuna, *Thunnus maccoyii,* is a temperate tuna species distributed in the southern hemisphere with high commercial value. This species may have gained a reputation as the center of severe conflicts among relevant parties regarding its management, especially through an international legal dispute relating to the field experiment conducted in 1999 and 2000 by Japan. The species was originally managed through an informal management scheme established in 1983 among Australia, Japan and New Zealand. This trilateral management scheme succeeded to implement substantial and sequential TAC (Total Allowable Catch) reductions during 1985 and 1989 and the post-1989 TAC became about one third of the early 1980s' level. The scheme was formalized as the CCSBT (Convention for the Conservation of Southern Bluefin Tuna) in 1994.

Around the same time, however, the discrepancies in views among the parties on the stock status and how to manage the stock became more distinct and the CCSBT started having a difficulty in resolving management issues. This was also the time when the stock started showing sign of recovery in young fish as a combined result of substantial TAC reduction and several relatively high recruitments. Generally speaking, an absolute stock abundance and a recent trend of the stock are the two most difficult components to estimate accurately in stock assessment. However, those are the key components controlling overall future stock dynamics under a given catch scenario and information directly linking to management decisions. It should be noted that it is even harder to assess and evaluate data and information obtained from stock when the stock is at a turning point such as the beginning of a recovery. Thus, the scientists involved in the CCSBT at that time eventually failed to resolve the difference in views on stock status and could not deliver a unified recommendation for management as a Scientific Committee. The managers fought bitterly, with one seeking an immediate TAC increase in a response to a sign of stock recovery and another doubting the credibility of the sign of stock recovery and insisting to defer the TAC increase until the time the stock recovery would become a solid fact. They sought different way to resolve the uncertainties in stock assessment and this led to a legal dispute at the

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end. For those who are interested in the dispute, an overall description of the case is available at *http://www.rikkyo.ne.jp/~kanehara/article.htm* and all the legal documents for the provisional measures at *http://www.itlos.org/start2_en.html* and for the arbitration at *http://www.oceanlaw.net/cases/tuna2.htm*.

The dispute ended with the denial of ITLOS (International Tribunal for the Law of the Sea) jurisdiction by the Arbitral Tribunal, indicating that the ITLOS should not and could not override disputes and decisions within the RFMO (Regional Fishery Management Organization) if other dispute settlement measures were agreed on beforehand among the RFMO members. This meant that the CCSBT members had to sit down again and resolve the issues by themselves. Gradually though, the members re-established good collaboration, even stronger than before the dispute, and took several measures to improve the impasse at the scientific forum. Most effective among them was the introduction of an independent Advisory Panel who would act as arbitrators and could report directly to the Commission when there were conflicts among member scientists.

The first stock assessment after the dispute was conducted in 2001 (CCSBT, 2001a). Although the Scientific Committee delivered a report with unified view mainly due to the efforts by the Advisory Panel and the general attitude of national scientists to accept the wordings proposed by the Panel, this did not mean that the wide diversion in views on the stock status was somehow narrowed. Given a large uncertainties around stock assessment, the Panel strongly urged the CCSBT to move toward a new management scheme called the Management Procedure, which was a set of pre-determined TAC adjustment rules whose effects and robustness were evaluated with thorough simulations beforehand. The CCSBT adopted that proposal.

The most well known and most intensively worked example of the management procedures will be the 'Revised Management Procedure' adopted by the International Whaling Commission, though they were evaluated but not yet implemented. The scheme was also applied to various commercial stocks (*e.g.*, Germont *et al.*, 1999; Butterworth & Punt, 1999; Kell *et al.*, 1999; Parma, 2002). Still, the concept was relatively new and the southern bluefin tuna will be the first case in which this idea is applied to a highly migratory large pelagic species managed within an international setting, if successively implemented. We are now in the final phase of developing the Management Procedure. I would like to take this opportunity to briefly review the development process with some of my own insights.

The purpose here is to introduce the overall concept of management procedures with consideration on their merits and demerits as well as the practical difficulties encountered during a development process. Technical details of the model structures, assumptions, and mathematical specifications are not included unless they are critical. Most of the description is based on the reports of the CCSBT meetings that are available at *http://www.ccsbt.org/docs/meeting_r.html*. The technical details discussed are usually available in the attachments of the relevant reports.

2. Concept of Management Procedures

What are the 'management procedures'? At the CCSBT, the Management Procedure is defined as 'a set of rules that are agreed in advance, that dictate how the Total Allowable Catch (TAC) for the fishery will be adjusted as new data are collected' (CCSBT, 2001a). Frequently, the term of 'management procedure' also indicates the whole process including pre-specified TAC adjustment rules and evaluation of the performance of those rules through simulations. Here, the term 'management procedure' is used to indicate the whole process and the pre-specified TAC adjustment rules are referred to as 'decision rules.'

Figure 1 illustrates the three components required

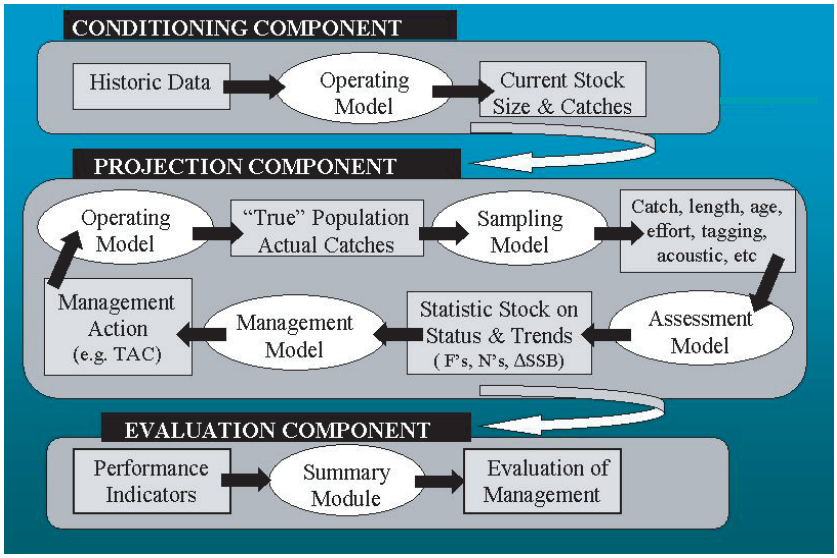

Fig. 1 Overall scheme of Management Procedure concept (from the presentation by R. Hilborn).

in management procedure evaluation. This figure is borrowed from the slides that Ray Hilborn, one of the Panel members, used to explain the concept of Management Procedure to managers and industries at a very early stage of development. It should be noted that the terminology in this drawing is not exactly the same as those developed within the CCSBT at a later stage (see Annex 1).

First, it is necessary to develop a virtual world to describe stock dynamics including the catch and data provision processes. This virtual world will be used to evaluate the performance of various decision rules. To make the virtual world as similar as possible to the reality, the model should be adjusted using the available historical data. This process is called 'conditioning' and is illustrated as the top box named the 'conditioning component.' Conditioning is identical to stock assessment in a sense, except that the purpose here is not to find the most credible value but to identify a whole plausible range of uncertainties. Thus the outcome from the conditioning components is an assemblage of estimation results spread throughout a reasonably plausible range.

In the second box named the 'projection component,' various decision rules, TAC adjustment rules, are applied to the virtual world controlled with the 'operating model.' Although the projection part of operating model carries the same parameters and model structures that are determined in the 'conditioning component' in principle, further uncertainties are added to incorporate unknown features of future projections such as recruitment fluctuations and observation errors. Types of errors to be considered have been reviewed by Butterworth & Punt (1999).

This illustration shows a case using an assessment model to provide a TAC for the next term. Decision rules, however, can be either model-based or empirically based. In the case of empirical decision rules, information obtained from the 'sampling model' directly goes into the 'management model' to determine the TAC for the next time step.

Through simulation in the 'projection component,' information on how well the rules work in managing the stock is collected. This information is called 'performance indicators' or 'performance statistics' as shown in the bottom box. In fisheries management, there are generally three objectives: i) maximizing catches, ii) minimizing the risk of stock collapse, and iii) maximizing the stability of industry. Performance statistics are set separately for each objective. Apparently i) and ii) are contradictory and cannot be attained simultaneously. The capability to examine the performance of various decision rules with multiple axes of objectives is one of the strong benefits of management procedures. Quick and simple examples of performance statistics include an average catch for a certain period for i), a proportion of stock below a certain level for ii) and an average level of TAC changes in an absolute term for iii).

This whole process is repeated to make sure that the plausible uncertainty space is reasonably covered. Then, in theory, it should be possible to select such a rule that works reasonably well wherever the real stock status is, as long as it is within the examined range of uncertainty. It should be noted that this process is consistent with the precautionary approach to fisheries management determined by the FAO (Food and Agriculture Organization of the United Nations) in 1996.

3. Progress under the CCSBT

This section briefly describes the development process of management procedures at the CCSBT.

The CCSBT agreed to develop the Management Procedure as the highest priority among its scientific tasks in 2001 (CCSBT, 2001b). Although the model specification was to be determined through discussion among national scientists and the Advisory Panel, the CCSBT decided to hire an independent technical consultant for developing code for all necessary programs. The national scientists' role would be to explore a range of candidate decision rules using their own judgment on the relative priority of different management objectives and own preference for the nature and complexity of the rules. This decision was made to be sure to avoid trouble with minor discrepancies in outputs when multiple groups are engaged in program coding of the operating model.

The original target for completion of development was set at two years with a working schedule as shown in Table 1. Development of management procedures requires intensive efforts by the national scientists involved in stock assessment. The CCSBT desired to complete the development within as minimum time frame as possible and in order to concentrate its scientists' efforts on this task, it agreed to accept a suspension of the full stock assessment in 2002 unless an examination of updated fisheries indicators suggested a drastic and negative change in the stock (CCSBT, 2001a, b). The same decision was made later for 2003 (CCSBT, 2002c, d).

Ana Palma was appointed to the overall coordinator and Vivian Haist, to the consultant for developing codes who was replaced by Trever Branch in 2005. At the first Management Procedure Workshop held in March 2002, the overall structure of operating model was determined. The Workshop decided to use the model structure developed in 1996 as a basis of the operating model (Butterworth *et al.*, 2003). Single global stock with age specific natural mortalities, high during young and low for old, was assumed. The age specific population dynamics model with natural and fisheries mortalities treated as discrete events was adopted. Five fisheries, one surface fishery and four longline fisheries specified with targeting sizes and operating areas, were defined. The selectivity of these fisheries was age-specific and estimated in the model.

Table 1 Original time table for development of management procedure (from CCSBT 2002a).

	Task:	Completion by:
9.1	Compile conditioning data	May 1, 2002
9.2	Prepare/debug computer code	August, 2002
9.3	Estimate model parameters by conditioning on historical data	August, 2002
9.4	Conduct first set of simulation trials using a few simple MP candidates	August, 2002
9.5	Meet inter-sessionally to examine model fits and consider the choice of operating models	SAG meeting, September 2002
9.6	Make code and input parameters (for different operating models) available to national scientists so that they can test different MPs using chosen set of operating models	2 weeks after SAG meeting (may not include the posterior distributions for Step 4 initially)
9.7	Continue with MP trials and document results	
9.8	Hold Workshop II – update data for final conditioning estimations, produce final specifications of operating models (robustness tests), and consider results for initial candidate MPs	Feb/March, 2003
9.9	Continue with MP trials and document results	
9.10	Inter-sessional meeting – evaluate conditioning and assign weights to alternate hypotheses (new Step 5, old step 4.5) and consider results for penultimate candidate MPs	SAG meeting, September 2003?
9.11	Continue with MP trials and document results	
9.12	Hold Workshop III – consider results for final candidate MPs and evaluate results, formulate conclusions and provide advice	March 2004

The selectivity of the two major fisheries, surface and high-sea longline, was allowed to change gradually every four years. The relationship between recruitments and spawning stock size was assumed to be a stochastic Beverton-Holt relationship with autocorrelation in residuals. Technical details of the model equations and inputs are described in the Attachment D of CCSBT (2002a). The Workshop also decided that the operating model would be developed based on the data available in 2002, current when the model development began, and would not be updated in terms of data during the development period.

The first version of the operating model was developed based on the specifications decided on at the First Management Procedure Workshop. The limited results of conditioning were presented at the Third Meeting of the Stock Assessment Group for determination of models to be used for the first phase of decision rule testing as well as for further discussion on more generalized model specifications. Examination of results under various settings revealed that stock productivity, represented with steepness value (h) in the stock-recruit relationship, and natural mortality for adults are the two key parameters controlling stock dynamics. Since the available data was not informative enough to estimate either of these parameters, it was decided to use nine sets of conditioning results with a combination of three steepness values and three natural mortality values for the first testing of candidate decision rules. Consideration was also made on generalization of the operating models, specification of the relationship between stock and CPUE (catch per unit effort, used as stock abundance indicator) and how to handle catches and selectivity in the projection part (see CCSBT, 2002b).

The code needed for the first trials of decision rules was distributed after the completion of the Third Meeting of the Stock Assessment Group, and subsequently national scientists explored possible decision rules. Those results were presented to the Second Meeting of the Management Procedure Workshop held in April 2003 (CCSBT, 2003a). The decision rules presented were categorized into model-based ones, using stock assessment results to determine future TAC, and empirical ones, determining future TAC based simply on CPUE trends. There was no discussion of relative performances among the rules presented. In fact, at that time, a rather large group of participants including our national scientists was still struggling to understand the whole concept of management procedures. The majority of the time during the Meeting was devoted again for the further specification of the operating model. For the model to be used for the secondary trial of decision rule evaluation, it was agreed to maintain natural mortality and productivity as the two uncertainty dimensions in conditioning. In addition, a future increase of catchability was incorporated as the third main uncertainty axis. Further, a series of scenarios were identified for 'robustness trials' to examine impacts of events such as nonlinearity of the stock relationship, alternative assumptions in targeting and regime shift.

Development of decision rules continued and the results of the secondary trials were presented at the Fourth Meeting of the Stock Assessment Group in August 2003 (CCSBT, 2003b). At this stage, the characteristics of the rules presented varied widely, reflecting the developers' arbitrary criteria of 'good' performance, especially on the relative priority between catch maximization and stock risk minimization. On the other hand, it was also noted that the rules presented could be adjusted to attain a certain target, *e.g.*, stock level. There was a clear trade-off between the catch amount taken and the attainable stock level. In order to make candidate rules more comparable, it was agreed to adjust the rules to attain a pre-specified median stock level ('tuning level') relative to the current after 20 years and three tuning levels of 0.7, 1.1, and 1.5 were selected. Another focus of discussion was how to synthesize results obtained from multiple

operating model scenarios and an integrative approach using the MCMC (Monte Carlo Markov Chain) was adopted. Mortality and steepness were maintained as key uncertainty axes and a non-linear relationship between stock and CPUE was incorporated as an additional uncertainty axis. An increase in catchability was now incorporated for both conditioning and projection parts but to a reduced extent.

The Third Meeting of the Management Procedure Workshop in April 2004 was aimed at selecting the final decision rules among the candidates presented (CCSBT, 2004a). First, the upper and lower limits of the tuning levels were noted as unrealistic with an unacceptably high probability of stock collapse for 0.7 and an unrealistically severe TAC reduction for 1.5, irrespective to the rules, so alternative limits of 0.9 and 1.3 were accepted. Four groups presented their own candidate rules whose characteristics again reflected the developers' criteria of 'good' performances. In general, those rules that reduce TAC substantially in the early period tended to lead to a TAC increase at the end of the simulation period, but those rules that maintained a gradual TAC reduction in the early period led to a continuous decline of TAC at the end of the simulation year. A comparison of performance among candidate rules revealed that the characteristics of the rules were clustered by developer-group, so four rules, one from each cluster, were selected for further consideration by the Commission.

However, the Meeting also noted that the CPUEs realized in the last two years were outside the range expected from the operating model. This implied that the operating model based on data up to 2002 could not predict the actual situation that occurred in 2002 and 2003. This problem was first examined by updating the data, but could not be resolved. Then, the Fourth Meeting of the Stock Assessment Group examined the performance of the operating model extensively and concluded that the MCMC favored a possibly unrealistically high natural mortality value (CCSBT, 2004b). Because there was no sound and quick way to fix this problem, the Meeting decided not to pursue the MCMC but to return to a simple approach of selecting key uncertainties in a grid with pre-specified weightings. The final specification of the operating model was determined at the Special Management Procedure Technical Meeting held in February 2005 (CCSBT, 2005a) and distributed to the members for refinement of four selected candidate rules for the final selection at the Fourth Meeting of the Management Procedure Workshop in May 2005. The Fourth Meeting of the Management Procedure Workshop (CCSBT, 2005b) examined improved versions of the four candidate rules selected at the Third Meeting. Again, the performance characteristics were more similar within the developer-groups than among them. Subsequently, four rules, one improved version of each originally selected candidate, were selected and presented to the Commission. Those rules will be further examined after incorporating the most updated information, especially on recent recruitments, at the forthcoming Stock Assessment Group Meeting and Scientific Committee and recommendations will be made for the final decision at the Commission.

Consultations with managers and industries were extremely important in developing the management procedures for two reasons: one, for developing good understanding of procedures and rules that will govern their ways of living and two, for obtaining feedback on their preferred options regarding stock management. At the CCSBT, the first consultation with managers and industries was held at the end of the Second Meeting of the Management Procedure Workshop in April 2003, where the general concept of management procedures and the work schedule were explained. In response to the request from the industries, one of the Panel members made trips for individual consultation in the member countries to explain the concept of the management procedures and seek feedback on what kind of management decisions would be preferable from the industries' point of view. It was noted that there was no strong desire for an immediate increase of TAC, but all were strongly opposed to sudden or substantial reductions in catch. All industries expressed sensitivity to prices as well as high desirability of stability in catch levels (CCSBT, 2003b, c). At the Tenth Annual Meeting of the CCSBT, the scientists explained the progress made and stated that there were two key trade-offs in managing the stock, the trade-off between catch levels and rebuilding of the stock and the trade-off between TAC stability and the magnitude of TAC changes, and asked guidance from managers. The Tenth Meeting of the CCSBT agreed to TAC changes every three years as preferred, with a need to limit the magnitude of TAC changes and preference for some lead time prior to the first implementation of TAC changes based on the Management Procedure, and requested to a one-year delay between decision and implementation of TAC changes with the time schedule illustrated Fig. 2 as an example. Addi-

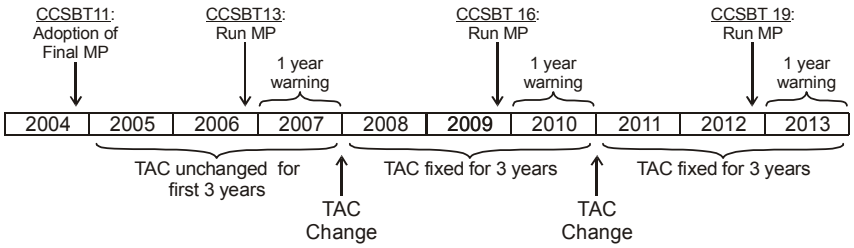

Fig. 2 An example of Management Procedure implementation schedule proposed by the Tenth Meeting of the CCSBT (from CCSBT, 2003c).

tional performance statistics were also requested from the managers (CCSBT, 2003c).

Three management objectives were identified at the First Meeting of the Management Procedure Workshop in 2002: maximizing catches, safeguarding the resource, and minimizing inter-annual variation in catches and efforts. Performance statistics corresponding to each objective were also identified. Originally, it was tried to minimize the total number of performance statistics. However, the total number of statistics kept increasing, especially for stock management objectives, mainly for two reasons. One was that with a lack of pre-specified agreed management target under the CCSBT, the parties wanted to see the performance of the rules relative to their own chosen targets. Also, the resource safeguarding objective involves two aspects: one, to reach and maintain a target level and two, to minimize the risk for the stock declining to a truly undesirable low level, and separate statistics are needed to examine both aspects. At this moment, a total of 17 statistics have been identified, with two for catch maximization, seven for tracing stock trajectories relative to potential management targets, two for examining the lowest stock level and four for examining stability of TACs. Statistics are also established to examine how often the initial direction of TAC change is reversed later, or whether a stock trajectory and TAC trajectory show contradictory patterns, though there are concerns about the interpretation of those statistics.

4. Points Noted and Some Considerations

We are now at the final stage of developing the Management Procedure for the CCSBT. At this moment, although we are still waiting for the final selection of decision rules and their adoption by the Commission, most of the tasks required to the scientists have been completed. With this opportunity, I would like to highlight some of the points that I noted throughout this experience.

The advantages of management procedures can be summarized as follows:

a) to be able to avoid a constant struggle to select appropriate management action by choosing pre-specified rules beforehand,
b) to be able to take action even when there are substantial uncertainties with regard to the understanding of stock status,
c) to be able to evaluate the effectiveness of those actions through intensive simulations, and
d) to be able to choose management plans by examining the effectiveness of multiple, even contradictory, objectives with a clear understanding of trade-offs.

Points b) and c) have been emphasized on many occasions as aspects in line with the FAO precautionary approach to fisheries management (1996), so here I will comment on a) and d). In conventional fisheries management, it is not easy to reach an agreement on management actions, especially in the international management schemes for several reasons. Members generally have different social, economical, and industrial backgrounds and different priorities, even when gathering to manage one common stock. In addition, most stock assessment can only provide reasonably reliable estimates of the stock trends but not of the absolute level of the stock and the future behavior of the stock. The reliability of the latter two is generally much worse than that of the estimated relative trends. Even worse, because the level of precision that managers desire to have, *e.g.*, distinction of impact on stock caused by 1,000 mt differences in catch, is far outside that scientists can provide. Unfortunately, scientists do not answer managers' questions precisely and often the two groups use different, mutually incomprehensible languages. The development process of management procedures gives some opportunity to achieve better communication between the two. When we asked managers to examine the trajectories of 20 scenarios controlled by four candidate rules and to express their preferences among the four, we found a high level of commonality among managers from various countries, especially regarding the least desirable patterns. In this practice, we found that most managers consider multiple factors and objectives simultaneously in making their judgments. The fact that they only need to choose the rules also seems to contribute in facilitating their decisions, by obscuring a linkage between their decisions and TAC that have direct impact on their industries.

However, the management procedures are not perfect and there are several fundamental limitations. First, the virtual world used to evaluate rules, the operating model, is only an extension of the stock assessment process and has the same problems, i.e., less reliability regarding absolute estimates and projections. The current operating model developed in the CCSBT seems to underestimate the absolute stock abundance, at least in recent years, judging from the fact that a substantial number of the scenarios fail to explain the actual catch taken in 2004, the most updated catch record that was not included in the operating model conditioning. Regarding to this specific problem, there was agreement to refine the results of those scenarios giving a lower stock number than the catch for 2004 when making the final presentation to the Commission. However, it should be noted that overall underestimation of absolute stock levels may lead to an overestimation of sensitivity of stock responses to decision rules.

It should also be noted that management procedures are only valid within the uncertainty range examined. The current process under the CCSBT does not consider social factors or drastic changes in fishing patterns. In principle, it was decided that when those unexpected events arouse, there would be an evaluation of whether the same rules could be main-

tained or not. Substantial TAC reductions easily trigger a shift of fishing efforts into a more profitable area, or a change in targeting size. Shifts in fishing patterns generally occur much more swiftly than any scientific and management process can respond to them and those changes may have critical impacts on the performance and credibility of the management procedures. Both managers and scientists need to be prepared to handle this problem before implementing TAC changes based on the management procedure.

Some evidence indicates that some of the recent recruitments were substantially lower than previous levels. Because of these potentially low recruitments, the overall recognition of the stock status of southern bluefin tuna and future stock behaviors has shifted toward serious concern, in contrast with the previous recognition of the current catch level as being close to sustainable yield. The situation is not easy but we believe that the Management Procedure will be the only possible way to take prompt actions in response to stock behavior. We sincerely hope that the CCSBT will select and adopt one management rule this year as planned and implement it at the earliest possible time.

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Annex 1

Definitions of Terminology Used to Discuss Management Procedures

(copied from Attachment 5 of CCSBT(2004b))

Operating model:

The operating model is used to represent the population dynamics of SBT based on fits to available data (to 2000). These estimates (and the uncertainty) are used as a set of simulations for stock and fishery trajectories in order to test management procedures.

Nautical analogy: a simulation of ocean and vessel conditions

Reference case:

Is the main configuration of the operating model used for testing MPs as agreed at the 2003 SAG held in Christchurch.

Nautical analogy: the best estimate of ocean and vessel conditions (and the associated unpredictability of the weather)

Robustness trials:

Tests conducted using more challenging scenarios than the reference set.

Nautical analogy: course made good under real (planetary) magnetic anomalies… adding previously unspecified ocean currents…placing uncharted islands in the ocean…

Decision rule:

A rule that specifies how future TACs will change based on data collected. The decision rule specifies the TAC change but not the magnitude. An **Empirical decision rule** is driven by data directly. Example: CPUE goes up, TAC goes up. A **Model-based decision rule** uses a model (typically a simple model) to analyze the data and set TACs.

Nautical analogy: the autopilot as purchased (before the voyage).

Management Procedure:

In our context, a MP is a decision rule that has a specified rebuilding target (on average). The MP fully specifies how TACs will be modified as a function of the new data.

Example: a decision rule adjusted to achieve a spawning biomass in 2022 that is 10% above current.

Nautical analogy: the autopilot set to a specific course.

Metarules:

Rules for evaluating whether or not the implemented MP is performing as anticipated and, if not, what to do. It includes rules to apply when unexpected circumstances occur.

Nautical analogy: an unexpected reef appears on the bow… The compass was found to be in error…