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Developing management procedures for South Pacific albacore

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Executive Summary

A management procedure (MP) is a key component of a harvest strategy that determines how much fishing can take place given the status of the target stock, using a pre-agreed rule. It is designed to achieve specific management objectives and is decided on and agreed by members. The WCPFC harvest workplan has scheduled the adoption of an MP for South Pacific albacore at the end of 2024. This paper describes the key issues that need to be considered when developing an MP for South Pacific albacore (SPA).

MPs are normally designed to have a high probability of keeping a stock above the Limit Reference Point. If a Target Reference Point exists then the MP should be designed to keep stock around the TRP on average. This makes designing an MP that is acceptable to all members difficult as many different options are available. For this reason, it is greatly preferred that a stock has a TRP that can be used to facilitate MP design. Without an agreed TRP, members will need to use a range of performance indicators to help choose an MP.

The estimation method plays a critical role in the MP for assessing the status of the stock and providing an input to the harvest control rule (HCR). The method should work well across a range of stock statuses, not just when the stock is healthy and around the TRP. In particular, the method selected should be capable of detecting when the stock is declining or approaching the LRP, enabling timely and appropriate management actions.

Various operational factors for the MP need to be considered. These include the frequency with which to run the SPA MP. The skipjack interim MP runs every three years, and it is suggested that SPA MPs also follow the same schedule for evaluation. Decisions need to be made about which fisheries to include in the SPA MP, for example, all longline and troll fisheries. The method of control, such as catch limits or both catch and effort limits, should be determined. The SPA MP can potentially cover the WCPFC-Convention Area only or also include the Eastern Pacific Ocean (EPO). Analyses undertaken so far have assumed the MP controls all fisheries in the WCPFC-CA.

A harvest control rule (HCR) sets the management action and fishing opportunities to be applied given the estimate of stock status from the estimation method. Different shapes of HCRs for the SPA MP are discussed, using the skipjack HCR as an example. A key consideration will be the use of a 'catch constraint' meta-rule which will limit the amount the HCR output can change each management period.

We invite WCPFC-SC to provide feedback on management procedure design considerations including:

- The agreement of a Target Reference Point for South Pacific albacore;
- Management procedure operational considerations such as the controlled fisheries and controlled mechanism, the geographic area of application, and baseline fishing conditions, noting current interim settings; and

- HCR shape and design.

1 Introduction

A management procedure (MP) is a key component of a harvest strategy that determines how much fishing can take place given the status of the target stock, using a pre-agreed rule. It is designed for the purpose of achieving specific management objectives and is decided and agreed by members.

An MP has three components: a data collection program that ensures that appropriate and sufficient information is available to monitor the stock and determine its status; an estimation method (EM) that follows a pre-specified and fixed procedure to determine the status of the stock; and a harvest control rule (HCR) that sets the management action to be applied given the estimate of stock status. The performance of the HCR is conditional on the stock status estimation method which in turn depends on the data collection program. Therefore, all three components are considered as a whole when designing, evaluating, and implementing an MP (Butterworth et al., 1997; Yao et al., 2020).

During the harvest strategy development process WCPFC members are required to make a range of informed decisions, such as those related to the desired management objectives, performance indicators and Target and Limit reference points (TRP and LRP). In particular, the development of candidate MPs, including the shape of the HCR and operational issues such as how often the MP is used, needs to be carefully considered. Some of the design issues surrounding MP development are amongst the most technical that members will decide on. Many of these decisions require a two-way dialogue between scientists and decision-makers from member countries and territories.

The current roadmap for South Pacific albacore (SPA) indicates that the MP for SPA will be adopted at the end of 2024 (WCPFC, 2022c). This report explores some of the design considerations for the SPA MP, including the development of the reference points, estimation method, and shape of the HCR.

2 Reference Points

WCPFC members recognize the importance of reference points in guiding management decisions because they serve as benchmarks or indicators against which stock assessments and fishing effort/activities are evaluated. Target and Limit reference points are used for the management of key tuna species. A limit reference point (LRP) is a threshold or limit that, if reached or exceeded, can trigger targeted management actions to prevent the further depletion of fish stocks. A target reference point (TRP) is the desired level of stock biomass that fisheries management aims to achieve (objectives). It is often set to support sustainable fishing practices while maximizing economic and social benefits and act as a guide when managers decide on catch limits and adjusting fishing effort.

In the WCPFC, both the TRP and LRP are typically defined using $SB/SB_{F=0}$. WCPFC9 adopted

the use of the biomass-based LRP of $20\%SB_{F=0}$ which has been subsequently used in management advice for WCPO target tuna stocks. As a TRP is based on objectives, it may be challenging to agree, as members can have different objectives based on national interests and future fisheries aspirations.

CMM 2022-03 establishes that individual harvest strategies for each key tuna stock will need objectives and reference points (WCPFC, 2022b). For instance, the objective of the interim MP for SKJ adopted in 2022 is to ensure that: a) the spawning potential depletion ratio of SKJ is maintained on average at a level consistent with the TRP; and b) the spawning potential depletion ratio of SKJ is maintained above the LRP with a risk of the LRP being breached no greater than 20%; in a manner that achieves the objective of relative stability in fishing levels between management periods and in the longer term. Thus, having the SKJ TRP greatly helped design the MP and facilitated its adoption as the MP was designed to keep stock around the TRP on average (WCPFC, 2022a).

For SPA, WCPFC15 agreed on an interim TRP (iTRP) at 56% of spawning stock biomass in the absence of fishing ($0.56SB_{F=0}$) with the objective of meeting an 8% increase CPUE for the southern longline fishery (SLL) as compared to 2013 levels, and where the timeline to achieving the iTRP was for no longer than 20 years (WCPFC, 2019: para 207). A recalibrated iTRP depletion level of 68% was presented at WCPFC18, but was not agreed. The results of the 2021 assessment were consistent with the 2018 assessment in that the iTRP will not be achieved under recent catch levels in the southern WCPFC-CA. However, the recalibrated iTRP no longer serves the purpose it was set out to achieve in 2018 which was to "maintain an economically viable SPA fishery". The work presented to WCPFC18 based upon the 2021 stock assessment has identified that even further reductions of catch are required to achieve the recalibrated iTRP than for the agreed iTRP of 56% (Castillo Jordan et al., 2021). WCPFC-SC19-2023/MI-WP-03 discusses further work on a potential TRP for SPA (SPC-OFP, 2023).

MPs are normally designed to have a high probability of keeping stock above LRP (WCPFC requires a harvest strategy that results in at least an 80% chance of being above the LRP). If a TRP exists then the MP should be designed to keep stock around the TRP on average. Without an agreed TRP, members have to use a range of performance indicators to help choose an MP which is very challenging (WCPFC, 2012). This makes designing an MP that is acceptable to all members difficult as many different options are available. For this reason, it is greatly preferred that a stock has a TRP that can be used to facilitate MP design. Although agreeing a TRP may not be easy, without one the same arguments and negotiations will need to happen so that the range of performance indicators on which to base the selection of the preferred MP can be agreed.

3 Estimation Methods

The estimation method is a component of the MP that estimates the status of the stock using the collected data and provides an input to the HCR. The selection of an appropriate estimation method is a key decision in the harvest strategy development process, and one of the most technical.

Estimation methods can be broadly split into two schools: an empirical approach (where the level or trend in CPUE is used to drive future decisions) or a model-based approach (where stock status is estimated through a simple model, such as a surplus production model, although more complex approaches may be considered based upon experience with the interim skipjack MP) (Pilling et al., 2018).

There are several important qualities of an effective estimation method that must be considered. The estimation method should work well for a range stock statuses. For example, an estimation method that only provides an accurate measure of stock status when the stock is healthy and around the TRP is of limited use. It is particularly important that it is able to detect when the stock is declining or approaching the LRP so that appropriate management action can be taken in a timely manner. Additionally, it is necessary to know if the stock status is higher than desired so that fishing opportunities can potentially be increased. The estimation method should be robust to different sources of uncertainty. This includes being robust to sources of process error, such as variations in stock-recruitment processes, and observation uncertainty, such as in the collected catch and effort data (Scott et al., 2023a).

Initial work to develop the management procedures for SPA focused on developing empirical procedures that used longline catch per unit effort (CPUE) as the primary indicator of stock status, consistent with the noted objectives. Results of those preliminary analyses highlighted the difficulty of using CPUE as the primary measure of stock status with this empirical method. SC17 supported the continued investigation of simple model-based alternatives that could address some of these problems. Consequently, more recent work has focused on the development of model-based estimation methods that use estimates of total stock abundance from a relatively simple stock assessment model as a measure of stock status. While these model-based approaches also depend on CPUE to estimate stock status, they typically provide more reliable and more stable estimates through the use of additional information (e.g. catches) (Scott et al., 2019; Yao et al., 2019).

Scott et al. (2019) noted that initial development of model-based MPs for SPA has been undertaken using relatively simple biomass dynamic models to provide an estimate of stock status to provide an input to the HCR. Many implementations of biomass dynamic models exist. Initial trials have been conducted using JABBA (Just Another Bayesian Biomass Assessment (Winker et al., 2018)) and the SPiCT (Stochastic Production model in Continuous Time (Pederson and Berg, 2016)) R-package for fitting surplus production models to fisheries catch data and biomass indices.

WCPFC-SC19-2023/MI-IP-02 notes that the use of an Age-Structured Production Model (ASPM), implemented in Multifan-CL, as a candidate estimation method shows encouraging results and

should be considered by members (Scott et al., 2023b).

4 Management procedure operational considerations

Several decisions need to be made regarding the operational aspects of the SPA MP. These include:

- The frequency of running the SPA, e.g. every three years or five years. The adopted interim skipjack MP is scheduled to be run every three years. This seems like a suitable time frame for SPA as well, and is consistent with the current stock assessment cycle. The current evaluation of candidate SPA MPs adopts this approach (Scott et al., 2023b).
- Which fisheries will be managed under the SPA MP. For example, all longline and troll fisheries. While this has been discussed at Commission and subsidiary body meetings, no final decision has been made. Currently the outputs of the MP are applied to both longline and troll fisheries.
- The control mechanism through which the fisheries will be managed under the SPA MP, e.g. catch or limits (or both). Additionally, appropriate monitoring systems will need to be in place. At present, controls are modelled in terms of catch.
- The geographical scope of the SPA MP, e.g. will it be limited to fisheries operating in the WCPFC-CA only, or extend to include fisheries operating in the Eastern Pacific Ocean. It is worth nothing that the mixed-fishery harvest strategy approach suggests that longlines south of 10 South are managed through the SPA MP, those north to the equator being controlled through the BET MP (Scott et al., 2023b).

5 HCR design

A harvest control rule (HCR) sets the management action and fishing opportunities to be applied given the estimate of stock status from the estimation method. Ideally, the HCR should be designed so that the stock has a high probability of avoiding the LRP while keeping the stock around the TRP on average. This section discusses aspects of HCR design, using the adopted skipjack HCR as an illustration.

5.1 HCR input and output

The skipjack HCR uses $SB/SB_{F=0}$ as the input. However, this is not a requirement of the SPA HCR and the input signal will depend on the selection of the estimation method. For example, a simple surplus production model will provide an estimate of total biomass, whereas an empirical estimation method may provide an estimate of CPUE. The choice of input signal will impact the shape of the HCR.

The skipjack HCR outputs a scalar, where a value of 1 means 2012 PS effort, pole and line effort at average 2001-2004 levels, and the domestic fisheries of Indonesia, Vietnam and the Philippines

(in model region 5) at average 2016-2018 levels. Similar baseline decisions will need to be made for the output SPA HCR. It is possible that the HCR output is specified in terms of absolute catches (numbers or tonnes) or effort, depending on how the fisheries managed through the SPA MP are managed. Alternatively, the HCR output could be a scalar, applied to baseline fishing levels in a previous period, similar to the skipjack HCR. Recent work on the SPA TRP and MP investigations has used the years 2015-2018 or 2017-2019 as a baseline. Another consideration is whether all fisheries will be affected equally by the HCR, as is the case for the skipjack HCR.

5.2 HCR shape

Here, different possible shapes of HCR are discussed, using the adopted skipjack as an example.

One of the simplest shapes of HCR is the typical 'hockey stick' (Figure 1). The shape is defined by four parameters:

- The minimum and maximum HCR outputs (i.e. the heights of the flat sections); and
- The two values of the estimated stock status where the inflection points occur (i.e. at the top and bottom of the sloping section).

The HCR shape is normally determined so that the stock status spends most of the time, on average, on the top flat section near the top of the slope, i.e., the TRP (if it exists) is achieved on average on the flat bit. The slope ensures that fishing pressure declines if the stock status falls below the TRP. The gradient of the slope determines the strength of the response - the steeper, the more rapid the response. Ideally, there should be a low probability of falling below the LRP. A minimum output is set as it is assumed that some fishing will always be present, e.g., those not directly controlled by the MP.

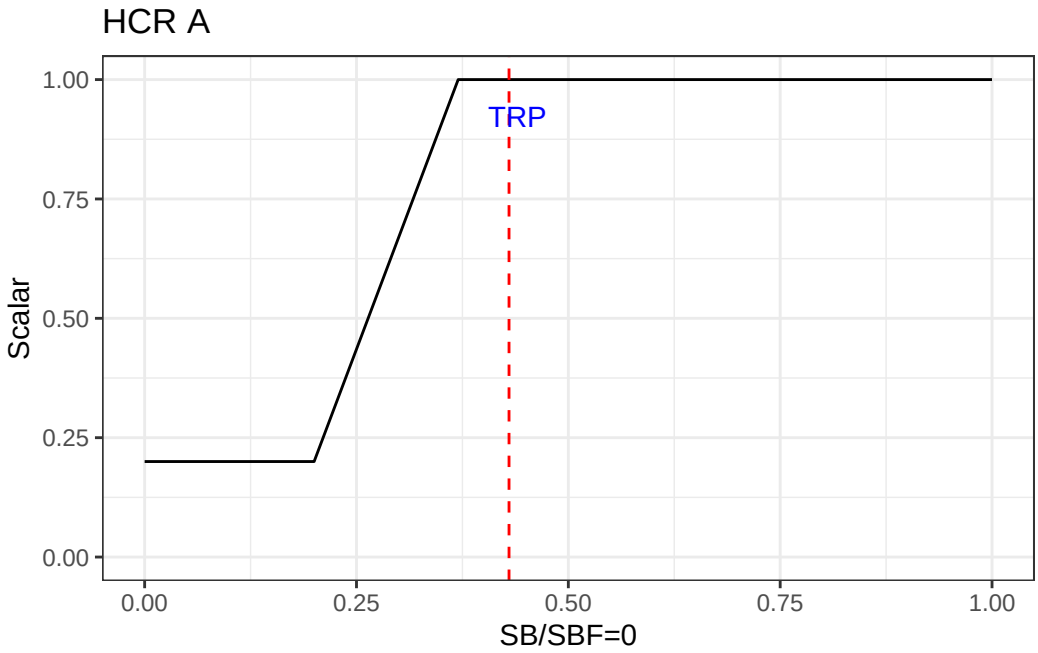

Figure 1: The typical hockey stick design. An example TRP location is identified through the vertical red dotted line.

An alternative to the hockey stick shape is to replace the straight sloping line with a curving line (Figure 2). As with the hockey stick HCR, the shape would normally be defined so that the TRP is positioned on the upper flat part.

The curving line allows for more gradual adjustments in fishing effort or catch limits if the estimated stock status drops slightly below the TRP. This avoids making potentially large reductions in fishing pressure when the population is only marginally below the desired level. However, if the biomass continues to decline, the HCR calls for steeper cuts to address the worsening situation and prevent further depletion.

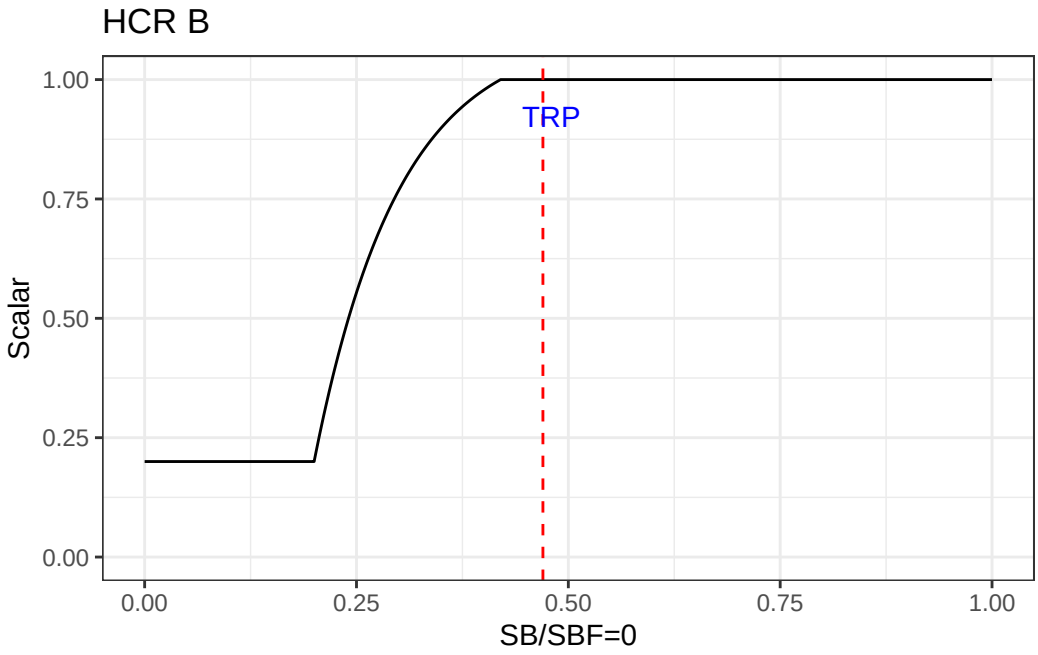

Figure 2: Modified hockey stick design with a curving slope. An example TRP location is identified through the vertical red dotted line.

An additional element can be added to the HCR shape that allows the fishing pressure to increase if the estimated stock status increases above a certain threshold (Figure 3). The middle flat section is referred to as the "Hillary Step". Ideally, the TRP sits in the middle of the Hillary step. When the estimated biomass is on the Hillary step, the HCR maintains the baseline fishing effort or catch limits, even if stock status increases or decreases by a limited amount.

If the estimated stock status exceeds the TRP, the HCR allows for an increase in the HCR output. The maximum output (the height of the top section) represents the upper limit of allowed fishing pressure. However, if the HCR and the MP have been well designed, the stock status will not reach this high level, and this maximum output should not be realized.

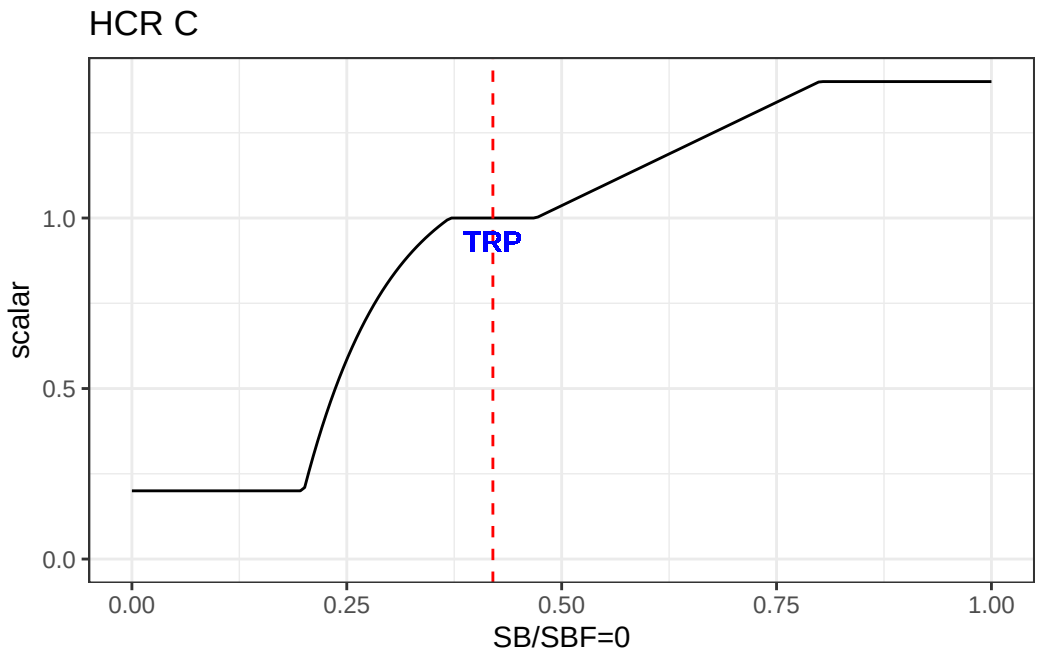

Figure 3: An HCR shape similar to that used in the adopted interim skipjack management procedure. An example TRP location is identified through the vertical red dotted line.

5.3 Additional meta-rules

It is possible to include additional meta-rules that modify the output of an HCR. The main usage is to constrain changes in catch or effort between management periods so that they do not vary by more than the specified amount. This can prevent large fluctuations in fishing levels which may be unattractive to the fishing industry. For example, the adopted skipjack MP has an additional constraint whereby the output the output of the HCR cannot change by more than 10% between management periods. However, the inclusion of such rules may mean that the fishing levels cannot respond fast enough to rapid changes in stock status, potentially leading to problems. This is explored in WCPFC-SC19-2023/MI-WP-06 (Scott et al., 2023b). Furthermore, asymmetrical change constrains can be considered, which allow greater increases (or decreases) than decreases (or increases).

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