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MINIMUM TRPS FOR WCPO YELLOWFIN AND BIGEYE TUNA CONSISTENT WITH ALTERNATIVE LRP RISK LEVELS

WCPFC15-2018-13[1]
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(Update of WCPFC-SC14-2018/MI-WP-01)

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[1] Revision 1 replaces the original issued on 6th November 2018. The only change made was to clarify that the authorship of the paper is SPC-OFP, this change was made to avoid confusion.

Executive Summary

SC14 reviewed information on what would be the minimum setting for a candidate spawning-biomass-depletion-based TRP for yellowfin tuna that avoids breaching the agreed LRP with a specified level of probability under the current uncertainty framework (SC14-MI-WP-01). While SC14 noted that the main biological consideration for a TRP is that it should be sufficiently above the LRP, SC14 also noted that the choice of a TRP can be based on a combination of biological, ecological and socio-economic considerations. … SC14 recommended that the analyses be repeated for bigeye tuna taking account of the updated 2018 bigeye stock assessment, and with both 'recent' and 'long term' recruitment assumptions. The additional bigeye analyses are contained within this update of the SC14 paper.

In this paper, we compute median levels of spawning biomass depletion ($SB/SB_{F=0}$) that are consistent with specified risk levels of breaching the limit reference point (LRP) of $0.2SB_{F=0}$. To do this, we used:

- the structural uncertainty grid of models used by SC13 for advice from the 2017 yellowfin tuna assessment, and
- the structural uncertainty grid containing only 'updated new growth' models used by SC14 as the basis for advice from the 2018 update bigeye tuna assessment, under both the 'recent' and 'long term' assumptions for future bigeye recruitment,

to generate 30 year projections that included stochastic variability in future recruitment under a variety of fishing levels scaled to the 2013-2015 averages. The main results are summarised in the following table:

Median levels of $SB_{2045}/SB_{F=0}$ for the four nominated levels of risk of breaching the LRP.

Risk level	Yellowfin tuna	Bigeye tuna	
		'Recent' recruitment	'Long-term' recruitment
5%	0.36	0.33	0.38
10%	0.34	0.30	0.34
15%	0.31	0.29	0.32
20%	0.29	0.28	0.29

These are values of $SB/SB_{F=0}$ that if achieved on average are predicted to result in the specified levels of risk of breaching the LRP, and thus may be interpreted as minimum levels of $SB/SB_{F=0}$ consistent with those risk levels, under the current uncertainty framework.

SC14 recommended that WCPFC15 take note of these results in consideration of management objectives upon which any candidate TRPs for yellowfin tuna and bigeye tuna should be based, and in so doing clarify the management objectives for these species (including the selection of risk levels) so that additional work identified by SC14 can be undertaken.

Introduction

The specification of target and limit reference points (TRPs and LRPs) are a critical part of the harvest strategy approach. LRPs are places we want to stay away from, while TRPs represent places we want to be. The choice of a LRP is based primarily on biological considerations relating to the resilience of the stock in question, i.e. what is the level of spawning biomass where the risk of recruitment overfishing becomes unacceptable. WCPFC has decided that the LRP for key tuna stocks is 20% of the unfished spawning biomass (0.2 $SB_{F=0}$). The choice of TRP is normally based on a combination of biological, ecological and socio-economic considerations. The main biological consideration is that a TRP should be sufficiently above the LRP so that if the TRP is achieved on average, the risk of breaching the LRP will be acceptably small. To inform WCPFC's consideration of potential TRPs for yellowfin and bigeye tuna, this paper attempts to answer the question "what is the minimum setting for a spawning-biomass depletion-based TRP that avoids breaching the LRP with a specified level of probability?"

The paper MOW3-WP-02 (SPC-OFP, 2014) provided preliminary answers to this question for skipjack, yellowfin, bigeye and South Pacific albacore, at 5%, 10%, 15% and 20% levels of probability of breaching the LRP. For that analysis, a small number of models from the respective structural uncertainty grids presented for the 2014 assessments for skipjack, yellowfin and bigeye and the 2012 assessment for South Pacific albacore were used. The models were run in projection mode with future recruitment sampled from the historical estimated time series. Various scalars of fishing effort and/or catch were applied and the results for runs that produced the specified levels of risk of breaching the LRP were recorded, in particular the median level of $SB/SB_{F=0}$. In other words, based on the assessments and their uncertainty frameworks available at the time, it was possible to specify median levels of $SB/SB_{F=0}$ that were consistent with breaching the LRP with the specified probabilities. These median levels could then be interpreted as minimum settings for a spawning-biomass-depletion-based TRP, for each probability level of breaching the LRP. In this paper we repeat the MOW3-WP-02 analysis using the latest yellowfin and bigeye tuna assessments.

Methods

We used the most recent yellowfin stock assessment presented in 2017 (Tremblay-Boyer *et al.*, 2017) and updated bigeye stock assessment presented in 2018 (Vincent *et al*., 2018).

For yellowfin tuna, SC13 chose a grid of 48 models to represent the structural uncertainty in the assessment, consisting of five axes – regional structure (2), steepness (3), tag over-dispersion (2), tag mixing (2) and size composition weighting (2).

For bigeye tuna, SC14 chose a grid of 36 models to represent the structural uncertainty. The grid consisted of four axes – regional structure (2), steepness (3), tag over-dispersion (2) and size composition weighting (3). SC14 agreed that the 'updated new growth' model, which incorporated new age-at-size information collected since 2017, represented the best available science on bigeye growth and that the 'old growth' model should not be used to provide management advice.

For both stocks, the analysis proceeded as follows:

- Run simulations for 30 years (2016-2045) for each model in the grid – each simulation representing a possible 'future' trajectory for recruitment, under a specific level of fishing effort or catch;
- Recruitment trajectories were constructed by computing a mean recruitment resulting from the estimated stock-recruitment relationship and adding recruitment deviations randomly sampled from:
    - For both yellowfin and bigeye, the last 10 years of the assessment (2005-2014, 'recent recruitment'), with recruitments then distributed to seasons and regions according to the average distributions within the same 10-year period;
    - For bigeye, an alternative 'long-term' recruitment assumption where recruitments were sampled across the period used to estimate the stock recruitment relationship (1963-2014).
- Combine the results across model runs and calculate the % of projections that had a terminal (final year) biomass that was below the agreed LRP (20% of the average spawning biomass that would have occurred in the absence of fishing over the penultimate 10-year period of the projections (2035-2044)). Also calculate the median level of terminal spawning biomass compared to $SB_{F=0}$ ($SB_{2045}/SB_{F=0}$); and
- Repeat the above steps with different scalars of effort/catch until the future fishing levels that resulted in risk levels of 5, 10, 15, and 20% were identified. Scalars were applied to the seasonal average of the catch or effort for the last three years of the assessment period for each fishery. The same scalars were applied to all fisheries simultaneously. Future scenarios for longline fisheries were expressed as constant catch[2], while scenarios for all other fisheries were expressed as constant effort. In order to determine the specific multipliers associated with the four levels of risk of breaching the LRP in the last year of the projection (2045), a wide range of multipliers were considered to identify those that achieved the risk level of interest.

Results

The median $SB_{2045}/SB_{F=0}$ associated with each of the four levels of risk of breaching the LRP for yellowfin and bigeye are provided in Table 1. These values can be interpreted as the minimum levels of $SB/SB_{F=0}$ that, if achieved on average, would be consistent with remaining above the LRP at each level of risk. Figure 1 presents the distributions of $SB_{2045}/SB_{F=0}$ for each risk level.

For context, current stock status:

- the 2017 stock assessment for yellowfin tuna (Tremblay-Boyer *et al.* 2017) estimated the median recent four-year average $SB/SB_{F=0}$ to be 0.32 and the 2015 level to be 0.35. These estimated levels of spawning biomass depletion would be consistent with long-term risks of breaching the LRP of 5-15%.
- the 2018 updated stock assessment for bigeye tuna (Vincent *et al.* 2018) estimated the median recent four-year average $SB/SB_{F=0}$ to be 0.36 and the 2015 level to be 0.46. These estimated levels of spawning biomass depletion would be consistent with risks of breaching the LRP of 0-10% under the long-term recruitment scenario (zero risk under recent recruitments).

[2] In a number of projections, the constant-catch scenarios for longline fisheries resulted in some age-classes in some regions tending towards zero abundance. In such cases, the catches of the longline fisheries in those regions were reduced to avoid negative numbers-at-age.

We note that the scalar on future effort or catch is applied equally to all fisheries within the yellowfin and bigeye assessments. The gear specific combination of harvest, along with the overall pattern of recruitment, will therefore be different to that estimated in 2015. The results also cannot therefore be directly compared to those of the tropical tuna CMM evaluation; in the current analysis, consistent scalars are applied to both purse seine effort and longline catch, while the CMM evaluation applies different scalars on each fishery component.

Conclusions

The method used here to estimate 'limiting' TRPs is consistent with that used in the past (MOW3-WP-02) and seems to be generally accepted by WCPFC. However, it should be noted that the results of such analyses are conditioned on the uncertainty framework used. In the analysis reported here, the structural uncertainty frameworks used in the 2017 yellowfin and 2018 bigeye tuna assessments, plus stochastic variability in future recruitment, were used. The amount of uncertainty recognised will impact the 'spread' of the distributions of $SB/SB_{F=0}$, which in turn will affect the estimated risks of breaching the LRP. In general, more uncertainty = greater risk, and higher median levels $SB/SB_{F=0}$ would be required to meet a particular risk of breaching the LRP.

The median values of $SB_{2045}/SB_{F=0}$ estimated here can be interpreted as 'limiting' TRP's for the two tuna stocks, consistent with the nominated levels of risk of breaching the LRP. In order to recommend a specific level of $SB/SB_{F=0}$ as a TRP, it is therefore necessary to:

- Agree on an acceptable level of risk of breaching the LRP in order to define the <u>minimum</u> TRP in terms of $SB/SB_{F=0}$. This issue was summarised previously (SPC-OFP, 2014) in the following terms:
    - "The acceptable level of risk is a management decision and will be strongly influenced by the severity of the consequences of exceeding the LRP, be those consequences biological, economical, ecological or social. Low stock size is likely to be associated with lower production (catches) and higher variability in productivity, along with the increased potential for other unexpected but bad consequences that we have not experienced in the past ('unknown unknowns'). When considering the acceptable level of risk, the importance of the stock to the people of the region and to the ecosystem may be important factors to consider."
- Consider other ecological and socio-economic factors that might be relevant in recommending specific TRPs that may be more conservative than the risk-based 'limiting' levels described in this paper.

References

SPC-OFP (2014). Consideration of acceptable levels of risk of exceeding Limit Reference Points for the four main tuna stocks: uncertainty and implications for Target Reference Points and Harvest Control Rules. MOW3-WP-02.

Tremblay-Boyer L., S. McKechnie, G. Pilling and J. Hampton (2017). Stock assessment of yellowfin tuna in the western and central Pacific Ocean Rev 1 (26 July 2017). WCPFC-SC13-2017/SA-WP-06.

Vincent, M.T., Pilling, G. and Hampton, J. (2018). Incorporation of updated growth information within the 2017 WCPO bigeye stock assessment grid, and examination of the sensitivity of estimates to alternative model spatial structures. WCPFC-SC14-2018/SA-WP-03.

Tables and figures

Table 1. Median levels of $SB_{2045}/SB_{F=0}$ for the four nominated levels of risk of breaching the LRP, for yellowfin and for bigeye (under the two future recruitment assumptions of 'recent' (sampling from the last 10 years) and 'long term' (sampling across 1962 to 2014)).

Risk level	Yellowfin tuna	Bigeye tuna[1]	
		'Recent' recruitment	'Long-term' recruitment
5%	0.36	0.33	0.38
10%	0.34	0.30	0.34
15%	0.31	0.29	0.32
20%	0.29	0.28	0.29

[1] Note that results in this table cannot be directly compared to those of the tropical tuna CMM evaluation. In the current analysis, consistent scalars are applied to both purse seine effort and longline catch, while the CMM evaluation requires different scalars on each fishery component. As a result, different distributions of $SB/SB_{F=0}$ are obtained here.

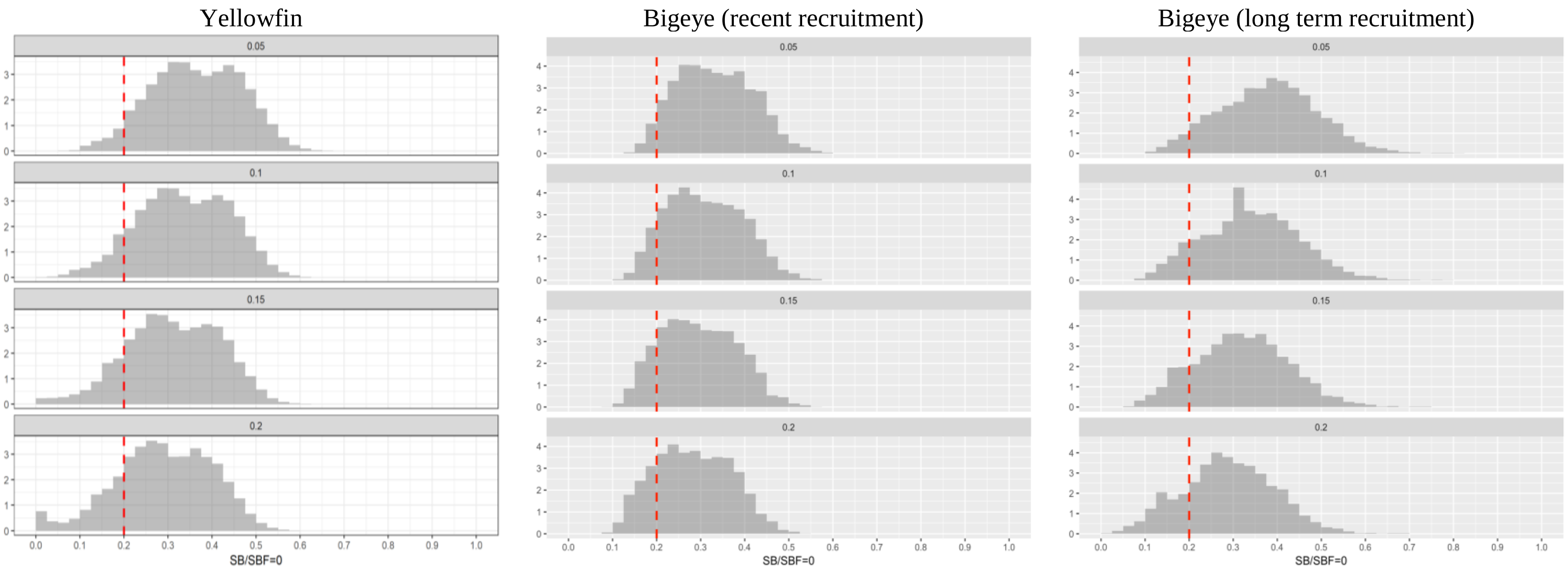

Figure 1. The distribution of $SB_{2045}/SB_{F=0}$ for the four nominated levels of risk of breaching the LRP for yellowfin and bigeye (for the latter, two SRR assumptions). Red vertical line in each panel represents 20% of $SB_{F=0}$