SCIENTIFIC COMMITTEE
NINETEENTH REGULAR SESSION
Koror, Palau
16–24 August 2023

Evaluations of skipjack management procedures for the robustness set

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WCPFC-SC19-2023/MI-IP-01
18th July 2023

F. Scott[1], R. Scott, N. Yao and R. Natadra

[1]Oceanic Fisheries Programme, The Pacific Community

Executive Summary

A management procedure (MP) is typically adopted after testing it against a 'reference' set of plausible uncertainties. The 'robustness' set provides an additional round of testing and is used to test a reduced list of preferred candidate MPs against more extreme, but still plausible, uncertainties. The uncertainties are considered one at a time as a 'stress test'. This identifies whether the performance of the MP is substantially worse when exposed to the additional uncertainties of the robustness set. Judgement can then be made on whether to retain that MP given that it performs poorly against a scenario that is considered less likely, though still plausible.

The results of the robustness set evaluations for the adopted WCPO skipjack interim MP, along with the other candidate MPs, are available under the **Robustness set** tab in the PIMPLE app at https://ofp-sam.shinyapps.io/PIMPLE_WCPFC19/.

The results currently include three robustness scenarios:

- increased hyperstability in the purse seine fisheries;
- lower than average future recruitment;
- increased effort creep in the purse seine fisheries.

The performance of the candidate MPs in each of the robustness scenarios is measured by performance indicators similar to those used to evaluate the reference set, including expected catches and relative CPUE. Performance of the candidate MPs varies across the robustness scenarios. None of the indicators suggest a failure of the adopted MP and that none of the scenarios have flagged up areas of concern. For example, the probability of being above the LRP is always close to 1, the lowest being in the long-term of the extreme hyperstability scenario with a value of 0.92.

It is possible to continue to develop the robustness set and test new scenarios as new information about the stock and the fishery is presented and this report discusses other potential scenarios to include. Not all potential robust set scenarios have yet been evaluated, for example effort creep in the pole and line fishery. These evaluations are closely linked to the monitoring strategy, in particular the identification and evaluation of exceptional circumstances.

1 Introduction

A key element of developing a harvest strategy for WCPO tuna stocks is evaluating proposed management procedures (MPs) through a simulation process known as management strategy evaluation (MSE) (Punt et al., 2014). Each candidate MP should be tested against a range of alternative scenarios that represent appropriate levels of uncertainty in stock and fishery dynamics. A 'grid' of OMs should be identified, each one representing a specific plausible hypothesis on uncertainty in stock biology or fishery dynamics. This grid should cover all plausible and important sources of uncertainty, against which the performance of candidate MPs should be evaluated. The preferred MP should be the one that has the highest chance of achieving the objectives while also being robust to uncertainty.

The OMs are divided into a reference set, considered to reflect the most plausible hypotheses on uncertainty, and a robustness set, considered to reflect less likely but still plausible hypotheses and which may have a stronger impact on the performance of the MP (Rademeyer et al., 2007).

The reference set forms the primary basis for selecting the 'best performing' MP. The relative performance of candidate MPs is evaluated from performance indicators calculated across all combinations of uncertainty in the reference set. The results should not be disaggregated by the different OM grid factors of the reference set as all are considered to be equally plausible.

The robustness set contains more extreme, but still plausible, uncertainties than the reference set of OMs and is used to give a secondary indication of performance of a reduced subset of MPs, for example in situations where the final selection must choose between two very similarly performing MPs. Instead of testing candidate MPs against all combinations of uncertainties in the robustness set, the MPs are tested against specific uncertainties to see how it impacts their performance, i.e. the uncertainties are considered one at a time, similar to the 'one-off' assessment runs conducted for the stock assessments. This tests whether the performance of the MP is substantially worse when exposed to the additional uncertainties of the robustness set. Judgement can then be made on whether to retain that MP given that it performs poorly against a scenario that is considered less likely. It is recommended that the robustness set includes a smaller number of scenarios than the reference set (Scott et al., 2019).

Evaluations of robustness scenarios are closely linked to the monitoring strategy. After adoption, a management procedure can be re-tested and evaluated when new information about the stock and the fishery is presented to ensure that it remains appropriate and provides the best opportunities for achieving management objectives. In particular, any exceptional circumstances that are identified may form the basis of new scenarios to be tested in the robustness set (Scott et al., 2023).

2 The robustness scenarios

SC18 agreed to accept the reference set of 96 OMs for WCPO skipjack as currently specified in SC18-MI-WP-01, noting the broad range of uncertainty encompassed by the grid axes, and recommended this reference set be adopted by WCPFC19 (Scott et al., 2022c; SPC-OFP, 2022).

SC18 also agreed, and recommended to WCPFC19, to provisionally adopt a robustness set of OMs, noting that SC18 also discussed longer-term work to expand this set of models to include additional uncertainties including models that could account for effort-creep in the Japanese pole and line fisheries; likely changes on skipjack productivity due to the impacts of climate change, and a lower productivity 'stress test', modelled as lower than average future recruitment (Scott et al., 2022a,c; SPC-OFP, 2022).

The robustness set scenarios to be considered are:

- Impact of climate change on skipjack productivity;
- High level of hyperstability in the purse seine fishery;
- High level of effort creep in the purse seine fishery;
- Effort creep in the pole and line fishery;

Of these scenarios, the first three also feature in the reference set at more moderate levels. In the robustness set they have more extreme levels.

The impact of climate change on skipjack productivity is a long-term proposal that is not yet complete. It will require careful consideration on which scenarios to actually implement, for example changes in future movement rates, noting that they may pose considerable technical challenges. Here, climate change impacts on productivity have been evaluated through changes in future recruitment. In the evaluations future recruitment variability is modelled through the application of randomly sampled historical recruitment residuals. In the reference set there are two historical periods from which the residuals are sampled: 1982-2018 (that includes lower recruitment residuals observed in the 1980s) and 2005-2018 (that assumes recent, higher recruitment levels will continue in the future). For the robustness set low recruitment scenario, future recruitment residuals have been sampled from the first 10 years (1972 to 1981) representing the period of the lowest observed residuals in the assessment. Recruitment levels for the low recruitment scenario were on average 33% lower than recruitment levels assumed in the reference set (see Figure 7 in WCPFC19-2022-11A) (SPC-OFP, 2022).

Hyperstability arises when the CPUE does not increase or decrease linearly with stock size, i.e. the stock may become depleted but the CPUE remains high. This can be a feature of schooling stocks, such as skipjack. The true level of hyperstability can be very hard to estimate. To account for this uncertainty a range of values are used in the OM grid. Hyperstability is implemented through density-dependent catchability in the MULTIFAN-CL model, applied to the purse seine fisheries only. The reference set has two levels: none (k=0) and moderate (k=-0.5). The robustness set

includes an additional, more extreme, value of k=-0.9 (Scott et al., 2022a). At this stronger level of hyperstability, CPUE remains relatively constant across a broad range of stock abundance (see Figure 1 in WCPFC-SC18-2022/MI-IP-12).

Effort creep, where fishing operations become more efficient over time, can be problematic in effort managed fisheries as it may reduce the effectiveness of management measures designed to constrain fishing mortality. In the reference set, future effort creep in the purse seine fishery had two values: 0% and 2% per annum. In the robustness set, a more extreme value of 3% is used (Scott et al., 2022a).

Effort creep in the pole and line fishery has not yet has not been simulated. A Japanese project has been proposed to investigate the levels of effort creep in the pole and line fisheries. The robustness set testing can be conducted pending these results.

A robustness scenario of catch and effort observation error higher than implemented in the reference set was explored (the reference set has a CV of 20%, the robustness set proposed a CV of 30%). Initial explorations showed that this resulted in insufficient additional variability in the OM grid and was unlikely to be a useful component of the robustness set (Scott et al., 2022a). It has not been considered further.

WCPFC-SC18-2022/MI-IP-12 discussed alternative assumptions for archipelagic waters catches (Scott et al., 2022a). Fisheries operating in archipelagic waters are managed through domestic arrangements and are not subject to control by the MP. Three alternative scenarios for future catches from all fisheries in archipelagic waters were investigated: 100% (the base assumption of the evaluations), 125% and 150% of 2012 catches. These alternative catches were selected to investigate the sensitivity of the MP to increased catches in archipelagic waters rather than to represent expected catches for those fisheries. The results (see Figure 5 in WCPFC-SC18-2022/MI-IP-12) showed the increased catches have little or no impact on stock status and future catches, but there is increased potential for greater effort reductions throughout the evaluation period.

An additional robustness scenario could be alternative assumptions about tag mixing. The reference set contains two levels (1 and 2 quarters) which provide a range of uncertainty. An alternative scenario could be tag mixing by release group (Scutt Phillips et al., 2022). However, any scenarios included in the robustness need to be more extreme than those included in the reference set.

3 Results

The results of the robustness set evaluations are available, under the **Robustness set** tab, in the PIMPLE app at https://ofp-sam.shinyapps.io/PIMPLE_WCPFC19/.

The results currently include three robustness set scenarios:

- Increased hyperstability in the purse seine fisheries;

- Lower than average future recruitment;
- Increased effort creep in the purse seine fisheries.

These scenarios were evaluated using the same MSE framework as for the reference set (Scott et al., 2022b).

The results are available for the seven management procedures considered at WCPFC19, including the one that was adopted. It should be noted that the results from the robustness set evaluations should not be compared between scenarios, e.g. do not compare the increased hyperstability results to the increased effort creep results. Additionally, they should not be compared to the reference set evaluations as the OMs are different. Instead, the relative performance of the candidate MPs should be compared within each robustness set scenario. As noted above, the purpose of the robustness are one off 'stress tests' and do not form the primary basis for selecting the 'best performing' MP.

Ten performance indicators are calculated for each robustness set scenario, similar to those in the reference set:

- Probability of $SB/SB_{F=0}$ being above the Limit Reference Point;
- Expected catches (relative to 2013-2015 average), available for different fishery groupings;
- Pole and line CPUE (relative to 2001-2004 average);
- Purse seine CPUE (relative to 2012);
- Catch stability;
- Effort stability;
- Proximity of $SB/SB_{F=0}$ to the target value;
- Fishing effort of purse seine and pole and line fisheries (relative to reference period);
- $SB/SB_{F=0}$;
- $SB/SB_{F=0}$ relative to the target value.

The indicators are presented as box plots over three time periods: short- (2022-2030), medium- (2031-2039) and long-term (2040-2048) For further details of these indicators see the PIMPLE app.

Note that for the 'low recruitment' scenario, the low recruitment affects the spawning biomass (SB) as well as the spawning biomass in the absence of fishing ($SB_{F=0}$) so that the $SB/SB_{F=0}$ may not be affected as expected.

Performance of the candidate MPs varies across the robustness scenarios. It is worth noting that none of the indicators suggest a failure of the adopted MP and that none of the scenarios have flagged up areas of concern. For example, the probability of being above the LRP is always close to 1, the lowest being in the long-term of the extreme hyperstability scenario with a value of 0.92.

Acknowledgments

We gratefully acknowledge funding for this work from the New Zealand Ministry of Foreign Affairs and Trade (MFAT) funded project “Pacific Tuna Management Strategy Evaluation”.

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