COMMISSION
SIXTEENTH REGULAR SESSION
Port Moresby, Papua New Guinea
5 – 11 December 2019

RESULTS OF INITIAL EVALUATIONS OF MANAGEMENT PROCEDURES FOR SKIPJACK

WCPFC16-2019-16
25 July 2019

SPC-OFP

[This paper was submitted to SC15 as
SC15-2019 MI-WP05 Results of Initial Evaluations of Management Procedures for Skipjack
Scott, R., F. Scott, N. Yao, G. Pilling and J. Hampton.]

SCIENTIFIC COMMITTEE
FIFTEENTH REGULAR SESSION
Pohnpei, Federated States of Micronesia
12–20 August 2019

Results of Initial Evaluations of Management Procedures for Skipjack

WCPFC-SC15-2019/MI-WP-05

R. Scott[1], F. Scott, N. Yao, G. M. Pilling, and J. Hampton

[1]Oceanic Fisheries Programme, The Pacific Community

Contents

1 Introduction **4**

2 The MSE Framework for Skipjack **4**

2.1 MSE Uncertainty Grid 5

3 Evaluations of Candidate Management Procedures **6**

3.1 Harvest Control Rules 6

3.2 Performance Indicators 6

3.3 Results 7

3.3.1 PIMPLE 7

4 Next Steps **8**

5 Acknowledgments **10**

Executive Summary

This paper, along with the information presented in supporting papers to this SC, provides the latest information on the management strategy evaluation (MSE) framework for skipjack. It presents a summary of the results of recent evaluations and considers the next steps that will need to be taken as scheduled in the harvest strategy work-plan. This paper should be considered alongside a number of other papers presented to this SC, specifically MI-IP-02, MI-WP-06 and MI-WP-09.

In particular, MI-IP-02 details a number of specific technical developments to the skipjack MSE framework that have not previously been presented to SC including the development, testing and validation of an estimation model; refinement of the procedures for generating pseudo data, and modifications to the MSE uncertainty grid.

This paper presents early outputs for the skipjack harvest strategy, based upon the latest MSE framework for the stock. It represents a significant step forward in the development of management procedures for skipjack. It provides only a brief summary of the results of the evaluations and we encourage members to use the web-based tool PIMPLE to interrogate the results in more detail.

To progress this work, we consider the short-term priority areas for key decisions for skipjack to be the definition and calculation of performance indicators and the specification of the monitoring strategy, which will include consideration of exceptional circumstances.

We seek advice from SC on:

- Feedback on the content and status of the evaluation framework,
- Input into candidate harvest control rules (HCRs),
- Feedback on presentational approaches to enhance decision making,
- Discussion on how advice on the scientific aspects of candidate HCRs should be delivered to managers.

To progress the development of harvest strategies for the skipjack/tropical purse seine fishery, SC may wish to seek advice from the Commission on the following issues:

- Definition of fisheries and fishery controls within the harvest strategy,
- Input into candidate HCRs,
- Feedback on presentational approaches to enhance decision making,
- Procedures for selecting the 'best performing' management procedure (MP).

1 Introduction

In accordance with the work-plan for the adoption of harvest strategies under CMM2014-06, SC15 is scheduled to provide advice on the performance of candidate harvest control rules (HCRs) for skipjack. This paper along with the information presented in supporting papers to this SC provides the latest information on the MSE framework for skipjack and the work undertaken to test candidate HCRs. It presents a summary of the results of recent evaluations and considers the next steps that will need to be taken as scheduled in the harvest strategy work-plan. This paper should be considered alongside a number of other papers presented to this SC:

MI-IP-02 describes the current status of the management strategy evaluation (MSE) modelling framework for skipjack in the WCPO. The framework continues to be developed and modified with work currently focussed on refining the models that comprise the robustness set. However the main components of the technical framework are now relatively well established and are expected to form the basis of future evaluations.

MI-WP-06 outlines on-going work to investigate key uncertainties in the skipjack MSE framework and specifically to define the set of models that comprise the robustness set. Ongoing work in this area is required to fully characterise uncertainty within the framework and to inform future consideration and definition of exceptional circumstances.

MI-WP-09 describes the interactive software developed specifically to allow members to review and compare the results of evaluations conducted for WCPFC harvest strategies.

We note that a new stock assessment for WCPO skipjack is presented to SC15 and that the interim TRP for skipjack is scheduled to be reviewed in 2019. The outcome of the stock assessment and the considerations of SC15 are not known at the time of writing. It remains to be seen if any modifications to the skipjack evaluation framework will be necessary as a consequence of these events.

2 The MSE Framework for Skipjack

To try to reduce the length of papers, the technical details of the evaluation framework that underpins the results presented here have been documented in a separate information paper, SC-MI-IP-02 (Scott et al., 2019c). That paper details a number of specific technical developments to the skipjack MSE framework that have not previously been presented to SC. These recent modifications to the framework include the development, testing and validation of an estimation model that provides an estimate of stock status for the management procedure; refinement of the procedures for generating pseudo data and in particular the generation of future tag recapture data, and modifications to the MSE uncertainty grid to ensure greater model stability across the range of models that comprise the reference set. In this paper we briefly outline the skipjack MSE

uncertainty grid across which the technical framework for skipjack has been applied. More detailed information on the basis of the grid and other technical elements of the framework are provided in SC15-MI-IP-02.

2.1 MSE Uncertainty Grid

The skipjack MSE uncertainty grid (Table 1) is similar to that presented to SC14 except that, at the request of members, alternative scenarios for effort creep and hyper-stability have been moved from the robustness set to the reference set and the parameter value for tag overdispersion of 8 has been replaced with a value of 6 (see SC15-MI-IP-02). The robustness set comprises scenarios that are considered less likely though still plausible and are used to give a secondary indication of the performance of a candidate subset of management procedures. Work continues to finalise the outstanding elements of the robustness set (Scott et al., 2019b).

Axis	**Levels**		**Options**		
	Reference	Robustness	**0**	**1**	**2**
Process Error					
Recruitment variability	**2**		**1982-2014**	**2005-2014**	
Recruitment autocorrelation	**2**		**0**	**estimated**	
Observation Error					
Catch and effort	**1**	1	**20%**	30%	
Size composition	1		all models (see Scott et al. (2018b))		
Tag recaptures	**1**	2	**status quo**	low	none
Model Error					
Steepness ‡	**3**		**0.8**	**0.65**	**0.95**
Mixing period (qtr) ‡	**2**		**1**	**2**	
Tag overdispersion ‡	**3**		**4**	**2.5**	**6**
Movement	**1**	1	**estimated**	El Nino/La Nina	
DD catchability (k) ‡	**2**		**0**	**-0.5**	-0.9
Implementation Error					
Effort creep	**2**	1	**0%**	**2% cont.**	3%

Table 1: Skipjack OM uncertainty grid. Scenarios shown in bold are proposed for the reference set. ‡denotes those scenarios for which a dedicated fit of MULTIFAN-CL is required.

Performance indicators are calculated for the reference set of model scenarios and are the primary source of information for selecting the 'best' management strategy (see Section 3).

Factorial expansion of the reference set results in 288 model combinations. Four iterations for each combination have been run resulting in 1,152 evaluations for each HCR (see Section 3.1). A unique set of random number seeds and stochastic recruitment values has been used for each evaluation. Each HCR has been tested with the same unique set of 1,152 model combinations, random seeds and recruitment values to ensure that all HCRs are tested under the same conditions and can be directly compared.

3 Evaluations of Candidate Management Procedures

We provide here, only a brief summary of the results of the evaluations and encourage members to use the web-based tool PIMPLE (described below) to interrogate the results in more detail.

3.1 Harvest Control Rules

The HCRs considered in this report have been selected on the basis of previous analyses, along with additional designs that try to show a range of potential outcomes and to achieve some contrast in the performance indicators. The results for five HCRs (Table 2, Figure 1) are presented. Two constant scaler HCRs were also evaluated, the results for which are available in the app. In each case, the output of the HCR scales the 2012 catch or effort to determine fishing opportunities in the next management period. The scaler resulting from the HCR has been applied equally to effort for purse seine fisheries and to catch for all other fisheries, reflecting current management approaches.

The assumption has currently been made that all fisheries are subject to the HCR, with the exception of fisheries in archipelagic waters (specifically within assessment region 5) for which status quo effort has been assumed. We seek further guidance and advice from SC15 on the design and scope of candidate HCRs to be considered in future evaluations, and WCPFC16 on the control mechanism (e.g. effort) and the fisheries being controlled (e.g. all key fisheries taking skipjack).

3.2 Performance Indicators

Currently six performance indicators (PIs) are calculated for the skipjack evaluations (Scott et al., 2018a) and a further four indicators, requested by members, remain under consideration pending further discussion on how they might best be calculated or approximated. The six PIs presented here are listed in Table 3. The full list of PIs currently being developed for skipjack are listed in the companion information paper (MI-IP-02).

HCR	**type**	**Parameters**			
		$sbsbf0_{min}$	$sbsbf0_{max}$	out_{min}	out_{max}
0	constant	-	-	1.0	1.0
1	threshold	0.2	0.6125	0.2	1.3
2	threshold	0.2	0.4	0.2	1.0
3	threshold	0.15	0.25	0.2	1.5
4	threshold	0.2	0.8	0.2	1.2
5	threshold	0.2	0.4	0.5	1.0
6	constant	-	-	1.1	1.1

Table 2: HCR settings

Indicator 1	Maintain SKJ, YFT, BET biomass at or above levels that provide fishery sustainability throughout their range.
Indicator 3	Maximise economic yield from the fishery (average expected catch)
Indicator 4	Maintain acceptable CPUE.
Indicator 6	Catch stability.
Indicator 7	Stability and continuity of market supply (effort variation relative to a reference period).
Indicator 8	Stability and continuity of market supply (probability of and deviation from $SB/SB_{F=0} > 0.5$).

Table 3: Performance indicators examined

3.3 Results

We provide a short commentary on the preliminary results, to highlight particular features for SC consideration. This commentary is not comprehensive, and as noted we encourage the use of PIMPLE (Section 3.3.1) to explore these further.

None of the HCRs that we considered resulted in the stock crashing (Figure 2) although HCR3 reduced adult biomass to very low levels with relatively high probability of being below the LRP. HCR3 is a relatively 'aggressive' HCR that maintains catch or effort at a high level even when biomass is relatively low (Figure 1). This HCR maintained catch or effort at a high level throughout the short- medium- and long-term periods (Figure 3). However, as the risk of falling below the LRP is greater than 20% by the end of the time series (Figures 2 and 5), this HCR would be considered unacceptable under the decisions of WCPFC13 (paragraph 296) and discarded.

In contrast, HCR4 is perhaps the least aggressive HCR, increasing catch or effort very slowly as biomass increases. HCR4 resulted in the highest values for $SB/SB_{F=0}$, maintaining the stock well above the TRP (Figure 4). Interestingly, both HCR3 and HCR4 performed relatively poorly in terms of total catch (PI 3, Figure 4).

HCRs 1 and 2 both performed relatively well across the range of PIs. HCR1 providing slightly higher stock biomass and relative CPUE (PI 4, Figure 5) at the cost of less stability in catch and effort (PIs 6 and 7) particularly in the short-term.

3.3.1 PIMPLE

PIMPLE is an interactive web-based tool for exploring and comparing the performance of alternative candidate HCRs (Scott et al., 2019a). It facilitates the exploration of the results of evaluations using a range of different plots and tables, allowing trade-offs between the different HCRs to be examined. The app graphically displays the results for performance indicators 1,3,4,6,7 and 8 for the short- medium- and long-term, similar to the figures shown in this paper, but additionally allows the user to select / de-select particular options to aid selection of the 'best performing' HCR.

The results of the evaluations described in this paper can be accessed and interrogated using the PIMPLE app at the following address https://ofp-sam.shinyapps.io/pimple. Further information about PIMPLE is provided in SC15-MI-WP-09. A demonstration of the software will be given to SC15 and a user guide is also available. In the meantime, we encourage members to access the app using the above link and to trial the software. We welcome feedback from members on their experience of interrogating the evaluation results using this web-based tool and suggestions for improving its utility for MP selection.

4 Next Steps

This paper presents early outputs for the skipjack harvest strategy, based upon the latest MSE framework for the stock. It represents a significant step forward in the development of management procedures for skipjack.

As drivers of the harvest strategy process, fishery managers and the wider stakeholder group need to define key aspects of the process. The key decisions for scientists and managers have previously been outlined in OFP (2018). In general, the Scientific Committee will need to consider more technical issues relating to the evaluation and testing of candidate HCRs whilst the Commission will need to consider the overall objectives for the fishery, methods for selecting the 'best performing' HCR and approaches for its implementation. There will, however, be considerable overlap in the issues addressed by the two bodies and discussions around many of these key decisions will need to involve both scientists and managers. These discussions would be supported through the 'science-management dialogue' process, the consultative draft Terms of Reference for which is presented in SC15-MI-IP-08.

With specific regard to progressing the development of harvest strategies for the skipjack/tropical purse seine fishery, key decisions and considerations for SC15 are outlined in table 4. A substantial body of work covering many of these issues is documented in the scientific papers presented to

Issue	**Doc Ref**	**Status**
Operating model (OM) refinement and development	SC14-MI-WP03, SC15-MI-IP02	advanced
Define candidate estimation methods (EMs)	SC15-MI-IP02	advanced
Refine and evaluate performance indicators	SC14-MI-WP04	advanced
Provide advice on scientific aspects of candidate HCRs	SC15-MI-WP05	intermediate
Support TRP definition		-
Review approaches to support the monitoring strategy	SC12-MI-WP05	developing
Evaluate economic indicators	SC14-MI-WP04	developing
Define exceptional circumstances	SC12-MI-WP05	developing
Develop multi-species approaches	SC15-MI-WP04	developing

Table 4: Key SC decisions for skipjack harvest strategy development

Issue	Doc Ref
Identify management objectives	WCPFC14 Attach. C
Agree procedure for selection of the 'best performing' MP	SC15-MI-WP09
Approach for implementing the agreed procedure	
Adopting Target Reference Points (TRPs)	CMM 2015-06
Definition of fisheries and fishery controls within the harvest strategy	
Input into candidate harvest control rules (HCRs)	
Feedback on presentational approaches to enhance decision making	SC15-MI-WP09
Development of the monitoring strategy	
Definition of exceptional circumstances	SC15-MI-WP06

Table 5: Key WCPFC decisions for skipjack harvest strategy development

this and previous sessions of the Scientific Committee. Other aspects of the process have yet to be addressed in detail. In Table 4 we provide references for the scientific papers that specifically address these key issues along with an estimation (from our perspective) of the status of the discussions around them.

For skipjack, we consider the short-term priority areas for key decisions to be the less developed items associated with the definition and calculation of performance indicators and the specification of the monitoring strategy which will include consideration of exceptional circumstances.

Key decisions for managers, as outlined in OFP (2018), are listed in Table 5 and again we provide references for recent scientific papers and related documents that address some of these issues, or at least provide relevant information.

We seek advice from SC on:

- Feedback on the content and status of the evaluation framework;
- Input into candidate HCRs;
- Feedback on presentational approaches to enhance decision making;
- Discussion on how advice on the scientific aspects of candidate HCRs should be delivered to managers.

To progress the development of harvest strategies for the skipjack/tropical purse seine fishery SC may wish to seek advice from the Commission on the following issues:

- Definition of fisheries and fishery controls within the harvest strategy;
- Input into candidate HCRs;
- Feedback on presentational approaches to enhance decision making;
- Procedures for selecting the 'best performing' MP.

5 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" and from the European Union through their funding support for WCPFC Project 75 "Technical Support for the Development of Harvest Strategies". In addition we thank the Center for High Throughput Computing (CHTC UW-Madison) for generously providing access to their computing resources.

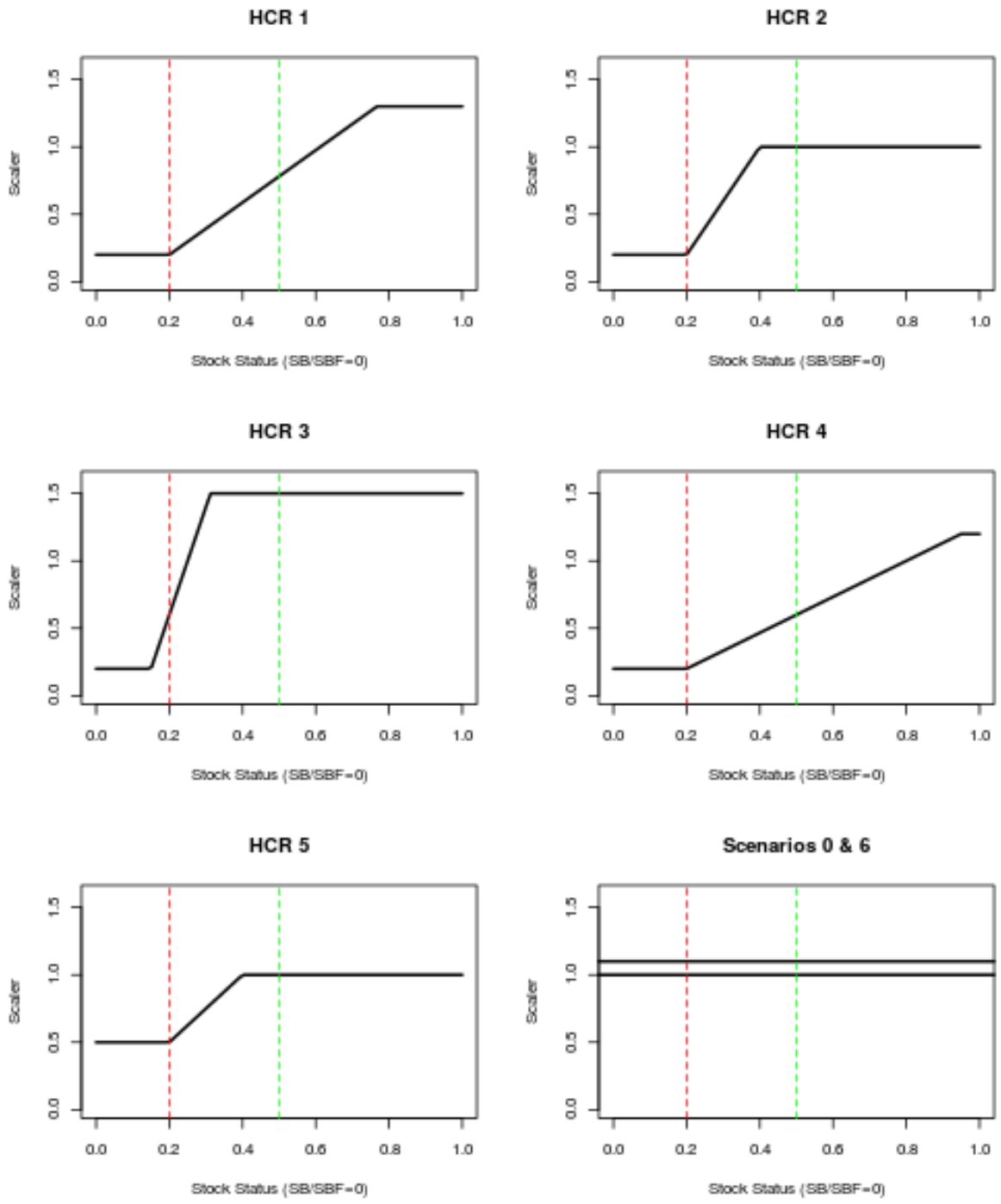

Figure 1: The five harvest control rules considered in this report and the two constant scaler scenarios that were also evaluated, the results for which are available online. Vertical lines show the limit (red) and interim target (green) reference points.

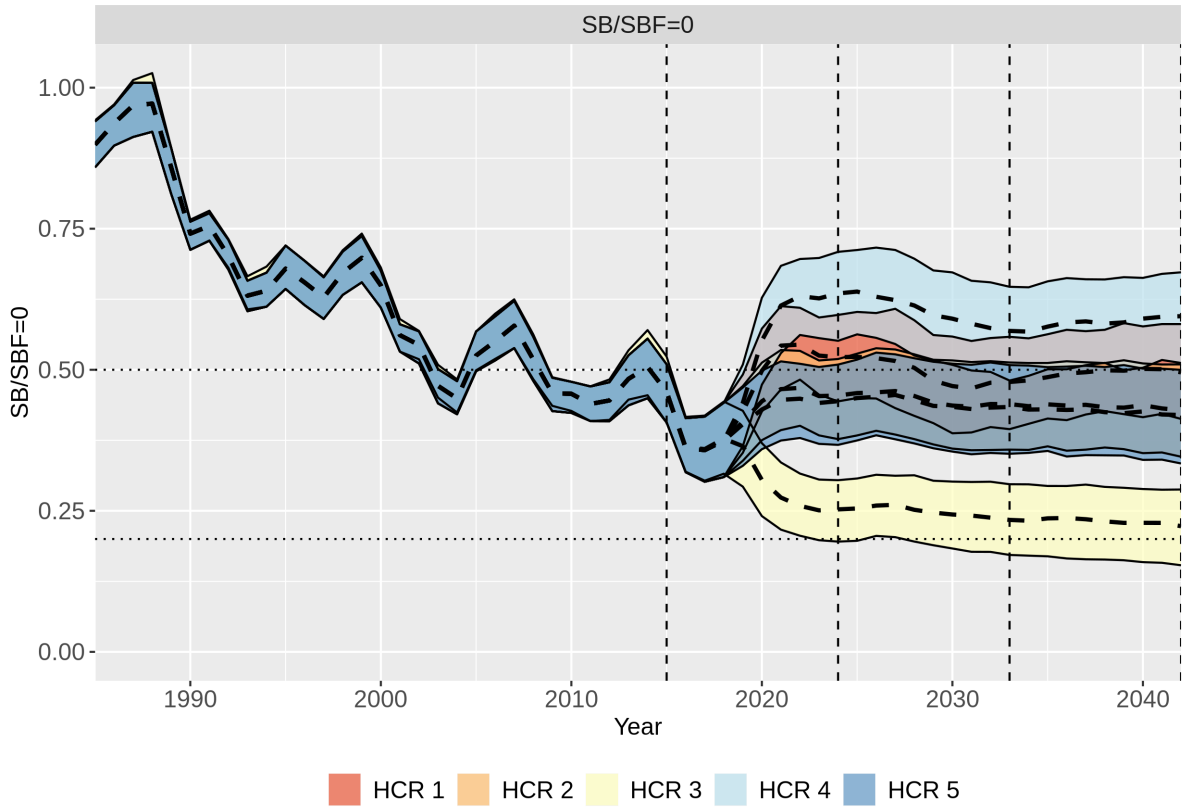

Figure 2: Time series of $SB/SB_{F=0}$ showing the results of evaluations of the 5 HCRs. Horizontal dotted lines show the target and limit reference points. Vertical dotted lines show the short-, medium- and long-term periods over which performance indicators have been calculated. Shaded bands show the 20th and 80th percentiles.

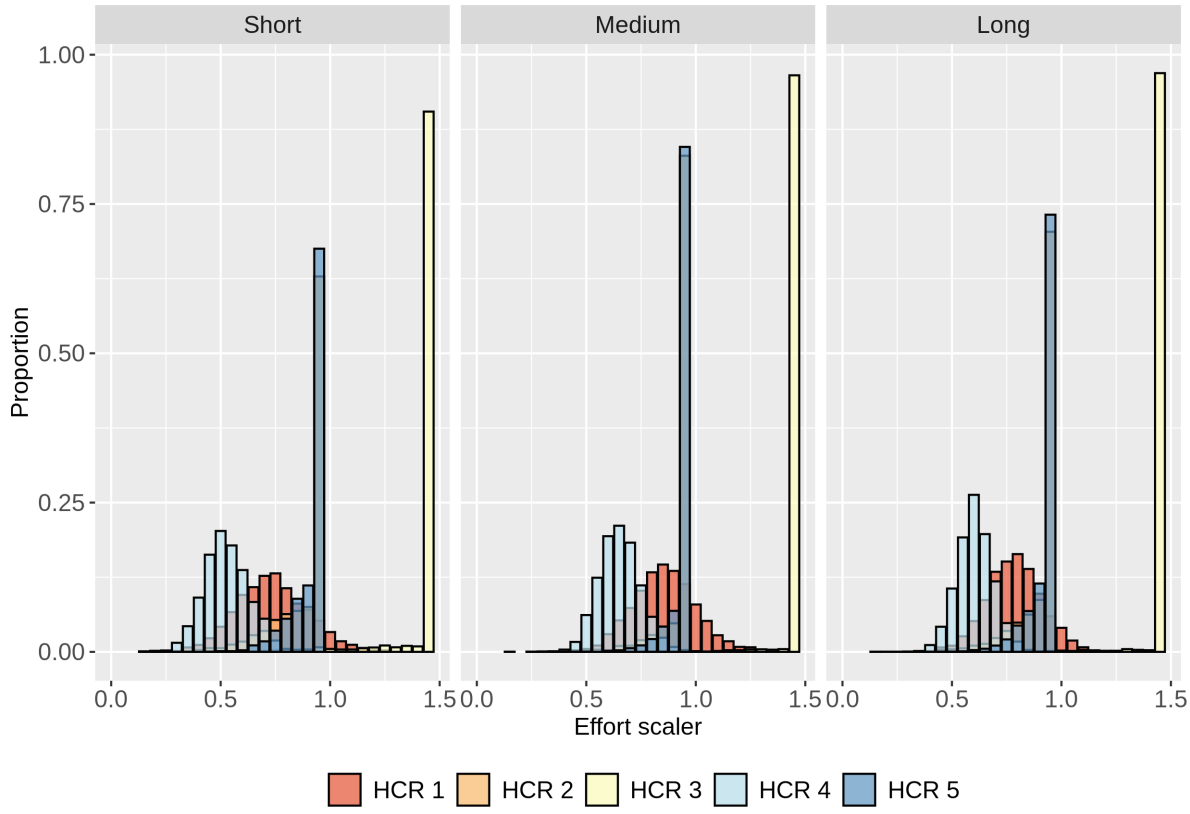

Figure 3: Histograms of the effort scaler values determined by each of the 5 HCRs throughout the evaluations in the short- medium- and long-term.

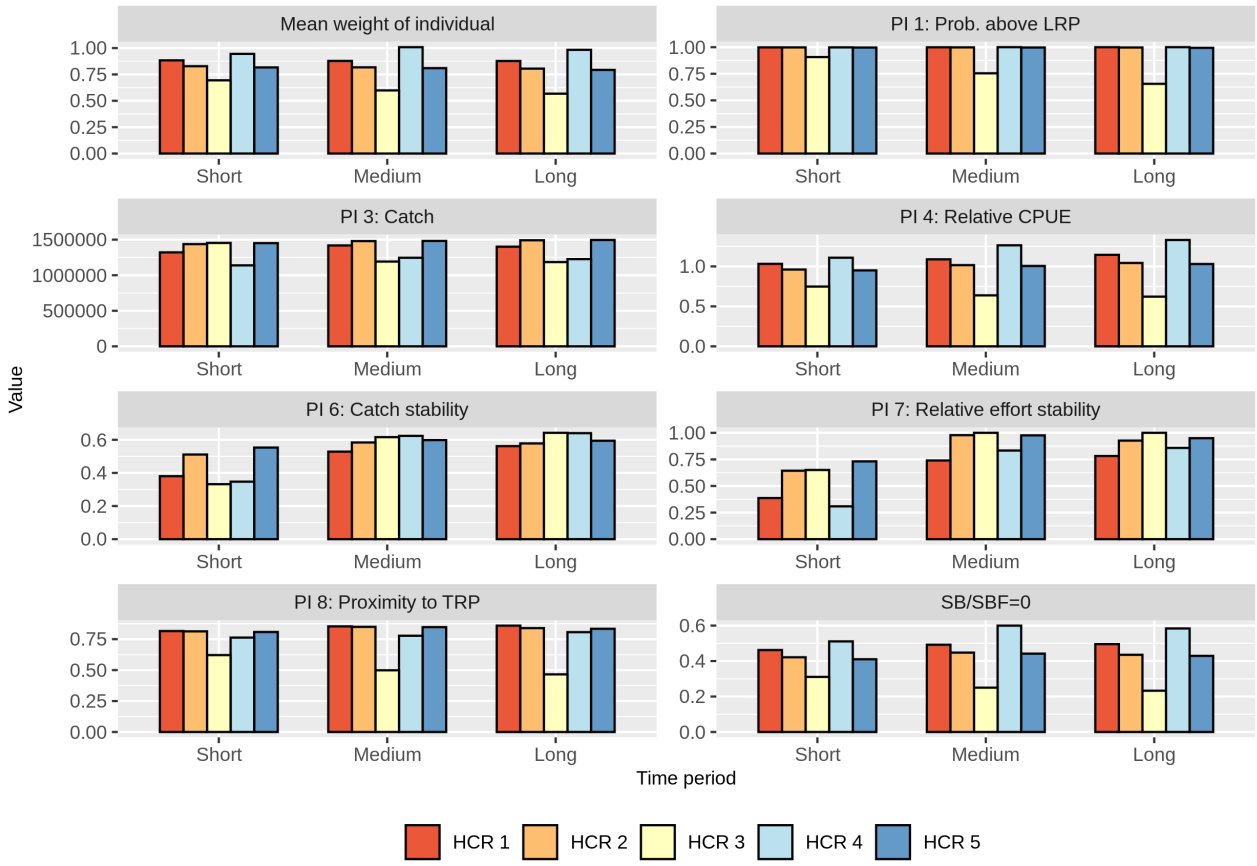

Figure 4: Summary output for the 5 HCRs showing median values for performance indicators 1,3,4,6,7 and 8 for the short- medium- and long-term. $SB/SB_{F=0}$ and the mean weight of an individual in the population are also shown.

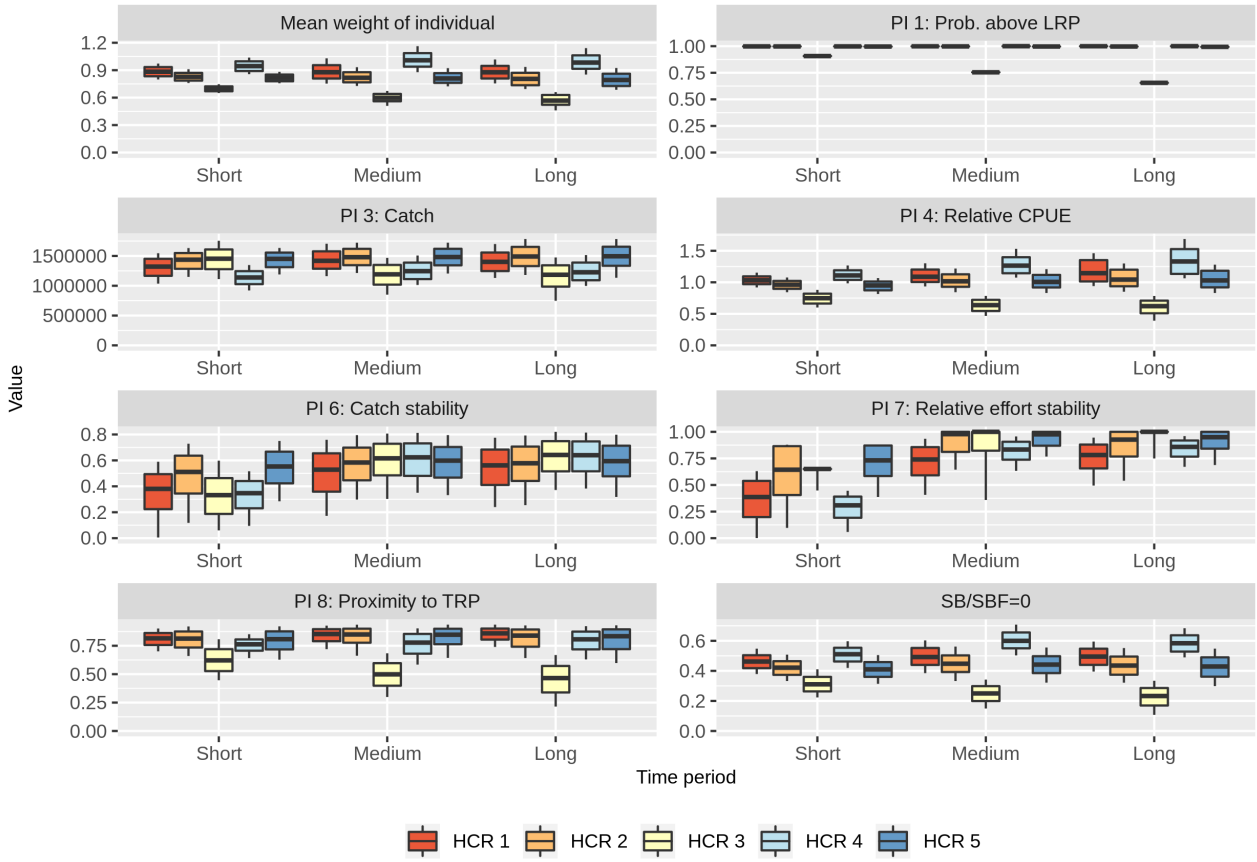

Figure 5: Summary output for the 5 HCRs and. Boxplots show the median and the 20th and 80th percentiles with tails extending to the 5th and 95th percentiles, for performance indicators 1,3,4,6,7 and 8 for the short- medium- and long-term. $SB/SB_{F=0}$ and the mean weight of an individual in the population are also shown.

References

OFP (2018). Key decisions for managers and stakeholders under the harvest strategy approach for WCPO tuna stocks and fisheries. WCPFC-SC14-2018/MI-WP/05, SPC-OFP, Busan, Republic of Korea, 8-16 August 2018.

Scott, F., Scott, R., Yao, N., Pilling, G., and Hampton, J. (2019a). Harvest strategy engagement tools. WCPFC-SC15-2019/MI-WP-09, Pohnpei, Federated States of Micronesia, 12–20 August 2019.

Scott, F., Scott, R., Yao, N., Pilling, G., and Hampton, J. (2019b). Modelling key uncertainties in skipjack management strategy evaluation. WCPFC-SC15-2019/MI-WP-06, Pohnpei, Federated States of Micronesia, 12–20 August 2019.

Scott, F., Scott, R. D., Pilling, G., and Hampton, J. (2018a). Performance indicators for comparing management procedures using the MSE modelling framework. WCPFC-SC14-2018/MI-WP-04, Busan, South Korea, 5–13 August 2018.

Scott, R., Scott, F., Yao, N., Pilling, G., Hampton, J., and Davies, N. (2019c). The WCPO Skipjack MSE Modelling Framework. WCPFC-SC15-2019/MI-IP-02, Pohnpei, Federated States of Micronesia, 12–20 August 2019.

Scott, R. D., Scott, F., Davies, N., Pilling, G., and Hampton, J. (2018b). Selecting and conditioning the operating models for WCPO skipjack. WCPFC-SC14-2018/MI-WP-03, Busan, South Korea, 5–13 August 2018.