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Updates to management procedure evaluations for WCPO skipjack and PIMPLE since SMD01.

WCPFC19-2022-11A rev 1

24 November 2022

SPC-OFP

Rev1: Updates to Figures 4, 5, 6 to make colours consistent across HCRs.

Executive Summary

WCPFC19 is scheduled to adopt a management procedure (MP) for WCPO skipjack. To assist in this process, the first Science Management Dialogue (SMD01) of the WCPFC was held in August 2022. SMD01 identified a subset of management procedures comprising HCRs 1,2,5,6 and 9 for further consideration by WCPFC19, and, in addition to the recommendations of SC18, requested a number of revisions to the settings of the MP evaluations as follows.

1	Evaluate HCRs 6 and 9 with a 10% constraint on catch/effort changes between management periods	SMD01
2	Evaluate the use of effort controls for pole and line fisheries using a baseline effort of 2001-04	SMD01
3	Apply catch controls for ID, PH, VN domestic fisheries using a baseline catch of 2016-18	SMD01
4	Determine the status of small scale fisheries (<2000 MT) and fisheries in territorial waters within management procedure controls.	SMD01
5	Perform specific robustness set evaluations (low recruitment scenarios)	SC18
6	Provide additional performance indicators in PIMPLE (pole and line CPUE)	SC18

All of the above tasks have been completed. This paper outlines the updated evaluations and summarises key aspects of the results where these requests have been implemented. Note that the results for all five HCRs are now where a 10% constraint has been applied. The full set of results, including the results of the robustness set analyses, can be interrogated using the interactive web-based tool PIMPLE specific to WCPFC19 (https://ofp-sam.shinyapps.io/pimple_WCPFC19).

In comparison to previous results, the performance of the management procedures is slightly modified under the revised baselines for catch and effort scaling. However, as before, the 5 selected management procedures show very similar results for many of the performance indicators. All 5 result in $SB/SB_{F=0}$ being slightly above the target in the short- to medium-term and at, or very close to, the target in the long-term (where the target is determined as equilibrium stock stock status under baseline fishing levels). All of the MPs perform well in terms of stock sustainability and in terms of maintaining overall stability in the fishery.

The results of specific robustness set low recruitment scenarios are summarised in Appendix A. An analysis of small scale fisheries (< 2000 MT) not considered subject to control by the management procedure is provided in Appendix B, Table 6 of this report.

A more detailed description of the evaluation framework for skipjack is available in WCPFC-SC16-MI-WP-08 and the range of uncertainty over which the MPs are tested is outlined in WCPFC-SC18-MI-WP-01. The basis of the evaluation framework is outlined in WCPFC-SMD01-2022/IP-01.

1 Introduction

In accordance with the updated indicative workplan for the adoption of harvest strategies under CMM2014-06 (WCPFC18, Attachment I), WCPFC19 is tasked to review and adopt a management procedure (MP) for WCPO skipjack. To assist in this process, the first science management dialogue meeting of the WCPFC (SMD01) was held immediately after SC18 and provided an opportunity to further consider the current status of the harvest strategy approach in advance of the annual meeting of the WCPFC.

The primary objectives of the SMD01 were:

1. to promote consistent understanding of the harvest strategy approach amongst CMMs;
2. to initiate discussion on prioritising and identifying skipjack management procedures for the consideration of WCPFC19;
3. to consider future processes that will better inform the Commission decision-making process on management procedures and other harvest strategy components.

The SMD01 reviewed the current status of the development of harvest strategies for WCPO skipjack, taking into account the key outputs from the harvest strategy discussions during SC18. With respect to objective 2 above, SMD01 identified a subset of preferred management procedures comprising HCRs 1,2,5,6 and 9 for further consideration by WCPFC19 and in addition, requested a number of revisions to the settings of the MP evaluations:

1. conduct analyses of HCRs 6 and 9 with a 10% constraint on catch/effort changes between management periods;
2. analyse the use of effort controls for pole and line fisheries, using a baseline effort of 2001-04 average;
3. apply catch controls to the domestic fisheries of ID, PH and VN, using a baseline catch of 2016-18 average;
4. perform specific robustness set evaluations;
5. analyse the status of small-scale fisheries ($<$ 2000 MT) and fisheries in territorial waters within management procedure controls;
6. provide performance indicators for pole and line CPUE in the PIMPLE software tool.

This report briefly outlines the basis of the updated evaluations. It describes the work conducted to date to address the requests of SMD01 and summarises key aspects of the results. The full set of results for both the reference and robustness scenarios are available online and can be interrogated using the interactive web-based tool (`https://ofp-sam.shinyapps.io/pimple_WCPFC19`) which has been updated with the most recent set of results covering points 1, 2, 3, 4 and 6 above.

An addition to the robustness set, requested by SC18, was for low recruitment scenarios to be investigated. An overview of the analysis and summary results are provided in Appendix A of this report. Further results are available in the PIMPLE app.

An analysis of small scale fisheries (< 2000 MT) **not** considered subject to control by the management procedure is provided in Appendix B, Table 6.

A more comprehensive description of the technical details of the evaluation framework for skipjack is provided in WCPFC-SC16-MI-WP-08 and the range of uncertainty over which the MPs are tested is outlined in WCPFC-SC18-MI-WP-01. The basis of the evaluation framework is outlined in WCPFC-SMD01-2022/IP-01.

2 WCPO skipjack MP re-evaluations

The subset of preferred MPs identified by SMD01 (comprising HCRs 1,2,5,6 and 9) were re-evaluated to examine their relative performance under revised assumptions for future catch and effort conditions. The evaluation framework remained unchanged from that used previously.

2.1 MSE uncertainty grid

The performance of each management procedure is tested against a range of alternative scenarios for future stock and fishery conditions. The scenarios are grouped into those representing the most plausible scenarios (the reference set), and those representing scenarios that are less likely but still possible (the robustness set). Performance indicators are calculated from the results of evaluations across the reference set of model scenarios and form the primary basis for selecting an MP. The sources of uncertainty included in the reference set (Table 2) are unchanged from previous evaluations.

The robustness set provides a secondary indication of MP performance. Proposed scenarios for the robustness set are outlined in WCPFC-SC18-MI-WP-01. In addition, SC18 requested an additional low recruitment scenario also be considered.

SC18 agreed to accept the reference set of 96 OMs 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. SC18 agreed, and recommended to WCPFC19, to provisionally adopt the robustness set of OMs as listed in Table 1 of SC18-MI-WP-01, noting that SC18 also discussed longer-term work to expand this set of models to include additional uncertainties. These included 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 (lower recruitment) 'stress test'. This further work is an integral part of the MSE and will be presented to SC19 next year, and where possible key elements will be presented to WCPFC19.

2.2 WCPO skipjack management procedures

Of the 12 MPs presented to SC18, 5 were selected by SMD01 for further consideration. These included MPs with HCRs 1, 2, 5, 6 and 9 (Figure 5). All of these 5 HCRs now include a constraint that limits the maximum change in catch or effort between management periods to 10% or less as requested by SMD01.

SMD01 requested that the baseline catch and effort values that set the fishery-specific level of future fishing be revised. In particular that pole and line fisheries be managed through effort controls (rather than catch) with a baseline effort of the 2001-04 average and that the domestic fisheries of Indonesia, Philippines and Vietnam (region 5) be managed through catch controls with a baseline catch of the 2016-18 average. This assumption has been implemented in the analyses of all five MPs. The baseline starting conditions, prior to any scaling by the HCR, for the purse seine fisheries, pole and line fisheries and the domestic fisheries of Indonesia, Philippines and Vietnam (Figure 2) show the assumed catch and effort levels for the interim period (2019-2022) for which 2016-18 average values have been applied for all fisheries, after which the purse seine fisheries are scaled on 2012 effort; the pole and line fisheries are scaled on 2001-04 average effort, and the domestic fisheries in region 5 are scaled on 2016-18 average catch (Table 1).

A 3-year management cycle has been assumed, whereby the MP will run once every 3 years and the management action determined from the harvest control rule (HCR) will apply for the following 3 years until the MP is run again. This assumed management cycle replicates, more or less, the timescale of the current assessment cycle for WCPFC tuna stocks and fisheries. Note that the modelling implementation also preserves the time lag that occurs between the last year of available data (year y-1), running the estimation model to determine stock status (year y) and implementing the management action (year y+1).

2.3 Performance indicators

Currently six performance indicators (PIs) are calculated for the skipjack evaluations along with two additional indicators recently requested by members showing effort levels relative to 2012 effort and CPUE for pole and line fisheries. A further four indicators, requested by members, remain under consideration pending further discussion on how they might best be calculated or approximated. The PIs presented in the most recent version of PIMPLE are listed in Table 3. The list of PIs currently being developed for skipjack is detailed in Scott et al. (2018).

Noting that a monitoring strategy for skipjack tuna is scheduled to be adopted by the Commission in 2023, SC18 supported further discussion on this issue at SC19, including on mechanisms for the collection of data for the range of agreed performance indicators not generated by the MSE framework (e.g. economic PIs).

3 Results

The results of the most recent evaluations, that have been updated for the revised baseline catch and effort levels, can be viewed on latest version of the web-based app PIMPLE (https://ofp-sam.shinyapps.io/PIMPLE_WCPFC19). At the request of SC18, the boxplot panel is now the default page for the "compare performance" tab and 3 additional plots are shown for pole and line CPUE; $SB/SB_{F=0}$ relative to the target depletion level and for effort relative to the baseline effort levels (Figure 4).

In comparison to previous results, the performance of the management procedures is slightly modified under the revised baselines for catch and effort scaling. However, as before, the 5 selected management procedures show very similar results for many of the performance indicators. All 5 result in $SB/SB_{F=0}$ being slightly above the target in the short- to medium-term and at, or very close to, the target in the long-term (where the target is determined as equilibrium stock stock status under baseline fishing levels, Figure 5). We note that the revised effort baselines for some fisheries represent a substantial increase on current effort levels and it is unclear whether all sectors of the fishery will in fact fish to their limits.

Perhaps the greatest contrast between the 5 selected MPs is in effort stability (Figure 5), HCR 5 being the most effective at maintaining effort at the baseline levels. This HCR has a threshold of $SB/SB_{F=0} = 0.37$ below which point effort levels are reduced with further declines in stock status. HCRs 6 and 9 have a similar lower threshold for effort reduction (0.37) but, in contrast to HCR 5, they also allow for increased effort at high stock status. These increases in effort when the stock increases contribute to the overall effort variability and result in the performance indicator showing increased effort variability (i.e. decreased effort stability).

Effort levels, relative to baselines (Figure 5), show the opposite trend to $SB/SB_{F=0}$ with effort very slightly below the baseline in the short term and generally increasing slightly in the medium- to long-term. HCR 9 is the most effective at maintaining effort around the baseline in the short-term but overall differences between HCRs in the short-, medium- and long-term are very small.

All of the MPs perform well in terms of stock sustainability (maintaining $SB/SB_{F=0} >$ LRP with high probability) and in terms of maintaining overall stability in the fishery. Figure 6 shows the expected catch and effort scalars resulting from each of the 5 MPs for each management period across the 30 year evaluations. The median scalar value is at or close to 1 in almost all cases with the exception of HCRs 1 and 2 for which median scalars are lower than 1 for the first two management periods and and HCRs 6 and 9 for which median scalars are slightly above 1 for the final management period.

4 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". In addition we thank the Center for High Throughput Computing (CHTC, UW-Madison) for generously providing access to their computing resources.

Tables

Table 1: Fishery controls within the management procedure: showing the system of control (catch or effort), the baseline year range for catch or effort scaling.

	Gear	Code	Flag	Area	Metric	Baseline	MP control
1	Pole and line	P-ALL-1	ALL	1	effort	2001-04	full
2	Purse seine	PS-ALL-1	ALL	1	effort	2012	full
3	Longline	LL-ALL-1	ALL	1	-	-	none
4	Pole and line	P-ALL-2	ALL	2	effort	2001-04	full
5	Purse seine	PS-ALL-2	ALL	2	effort	2012	full
6	Longline	LL-ALL-2	ALL	2			none
7	Pole and line	P-ALL-3	ALL	3	effort	2001-04	full
8	Purse seine	PS-ALL-3	ALL	3	effort	2012	full
9	Longline	LL-ALL-3	ALL	3	-	-	none
10	Domestic	Z-PH-5	PH	5	catch	2016-18	full
11	Domestic	Z-ID-5	ID	5	catch	2016-18	none - AW
12	Purse seine	S-ID-PH-5	ID-PH	5	effort	2012	partial - AW
13	Pole and line	P-ALL-5	ALL	5	effort	2001-04	partial - AW
14	Purse seine	PS-ASS-5	DW	5	effort	2012	full
15	Purse seine	PS-UNASS-5	DW	5	effort	2012	full
16	Domestic	Z-VN-5	VN	5	catch	2016-18	full
17	Longline	LL-ALL-5	ALL	5	-	-	none
18	Pole and line	P-ALL-6	ALL	6	effort	2001-04	full
19	Purse seine	PS-ASS-6	ALL	6	effort	2012	partial - AW
20	Purse seine	PS-UNASS-6	ALL	6	effort	2012	partial - AW
21	Longline	LL-ALL-6	ALL	6	-	-	none
22	Pole and line	P-ALL-4	ALL	4	effort	2001-04	full
23	Longline	LL-ALL-4	ALL	4	-	-	none
24	Pole and line	P-ALL-7	ALL	7	effort	2001-04	full
25	Purse seine	PS-ASS-7	ALL	7	effort	2012	full
26	Purse seine	PS-UNASS-7	ALL	7	effort	2012	full
27	Longline	LL-ALL-7	ALL	7	-	-	none
28	Pole and line	P-ALL-8	ALL	8	effort	2001-04	full
29	Purse seine	PS-ASS-8	ALL	8	effort	2012	full
30	Purse seine	PS-UNASS-8	ALL	8	effort	2012	full
31	Longline	LL-ALL-8	ALL	8	-	-	none

Table 2: Skipjack OM uncertainty grid (reference set, 96 model scenarios). ‡ denotes those scenarios for which a dedicated fit of MULTIFAN-CL is required. Settings for the robustness set shown in bold

Axis	**Reference Set**			**Robustness Set**
	0	**1**	**2**	
Process Uncertainty				
Recruitment	below average	above average		very low
Observation Uncertainty				
Catch and effort	average levels			greater uncertainty
Size composition (ESS)	estimated			
Tag recaptures	status quo			
Model Uncertainty				
Steepness ‡	moderate	lower	higher	
Mixing period (qtr) ‡	short	long		
Growth ‡		low	high	
Movement	estimated			
Hyperstability in CPUE (k) ‡	none	moderate		extreme
Implementation Uncertainty				
Effort creep	none	moderate		high

Table 3: Performance indicators examined

Indicator 1	Maintain SKJ, YFT, BET biomass at or above levels that provide fishery sustainability throughout their range.
Indicator 3	Expected catch relative to average 2013-15 levels.
Indicator 4	CPUE in purse seine fisheries.
Indicator 6	Catch stability.
Indicator 7	Effort stability.
Indicator 8	Proximity of $SB/SB_{F=0}$ to the average $SB/SB_{F=0}$ in 2012.
Indicator 9	Purse seine effort relative to 2012 effort levels
Indicator 11	CPUE in pole and line fisheries

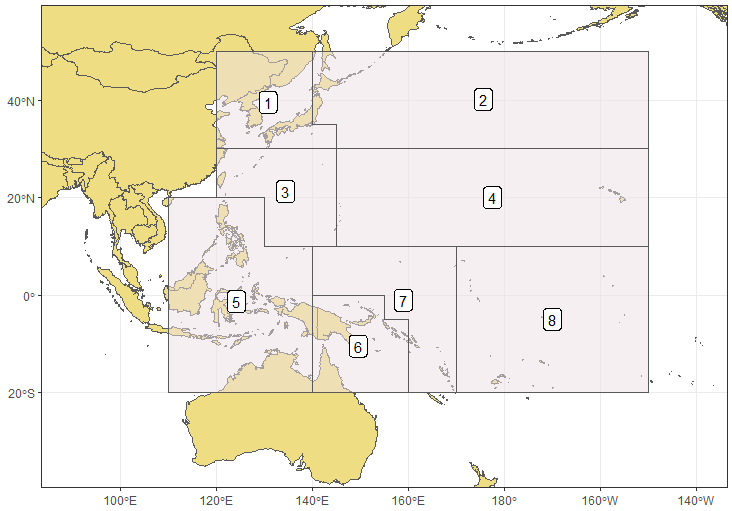

Figure 1: Spatial structure of the WCPO skipjack operating model.

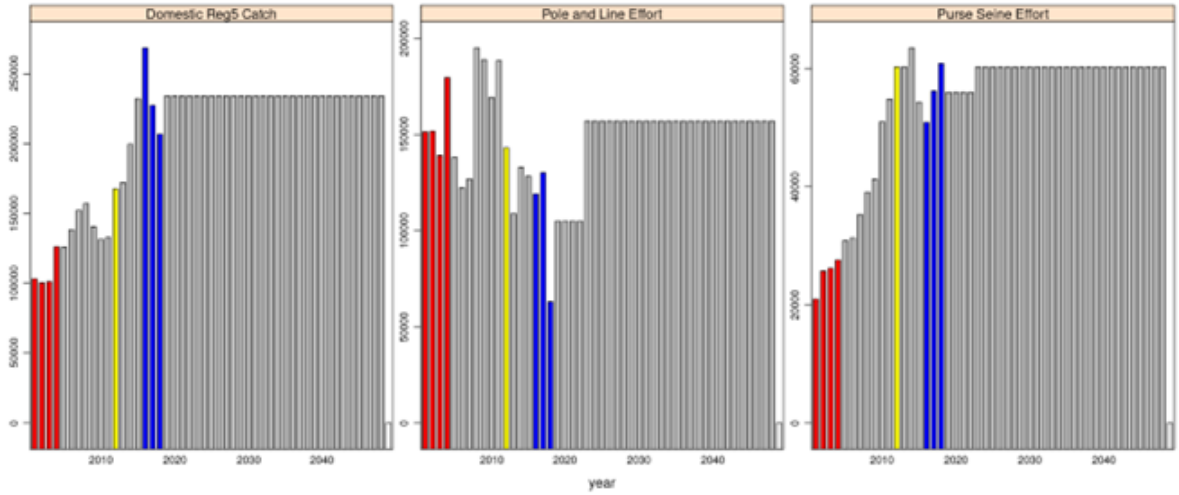

Figure 2: Catch and effort levels for purse seine (2012, yellow), pole and line (2001-04, red) and region 5 domestic (2016-18, blue) fisheries used as the baseline for catch and effort scaling by the management procedure. The interim period (2019-2022) prior to first running the management procedure is set to 2016-18 levels.

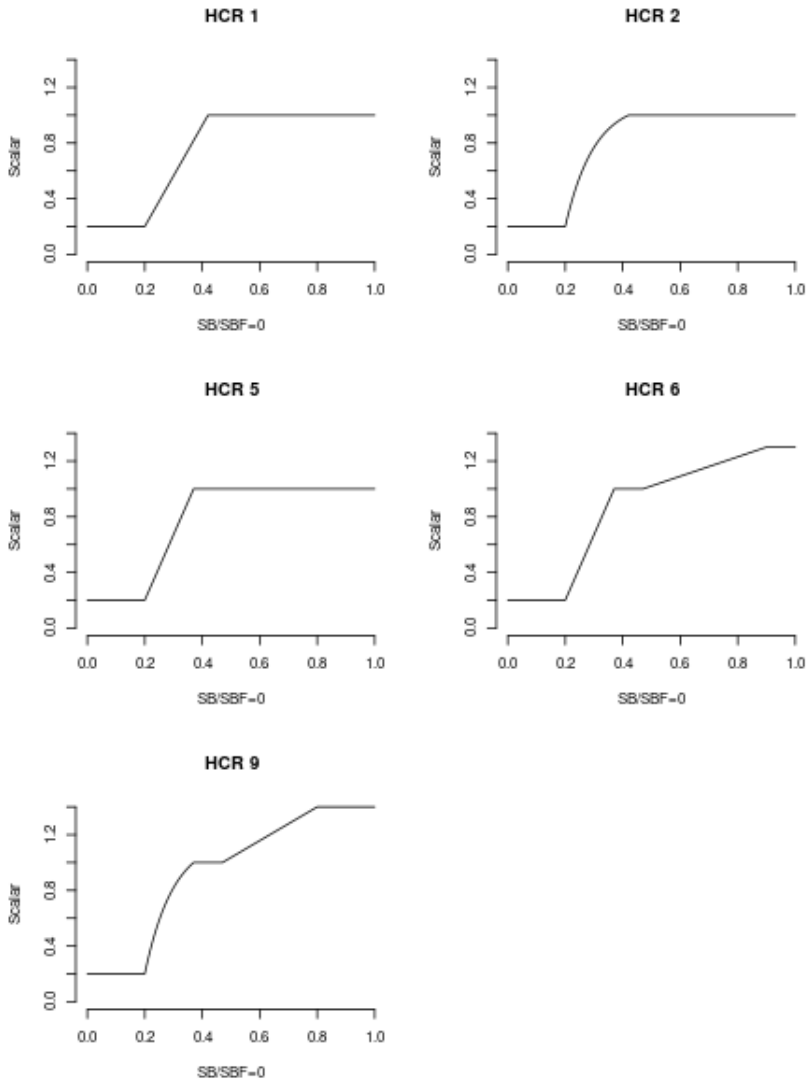

Figure 3: Harvest control rules identified by SMD01 for further consideration by WCPFC19. Each HCR includes a 10% constraint on changes in the catch/effort scalar from one management period to the next.

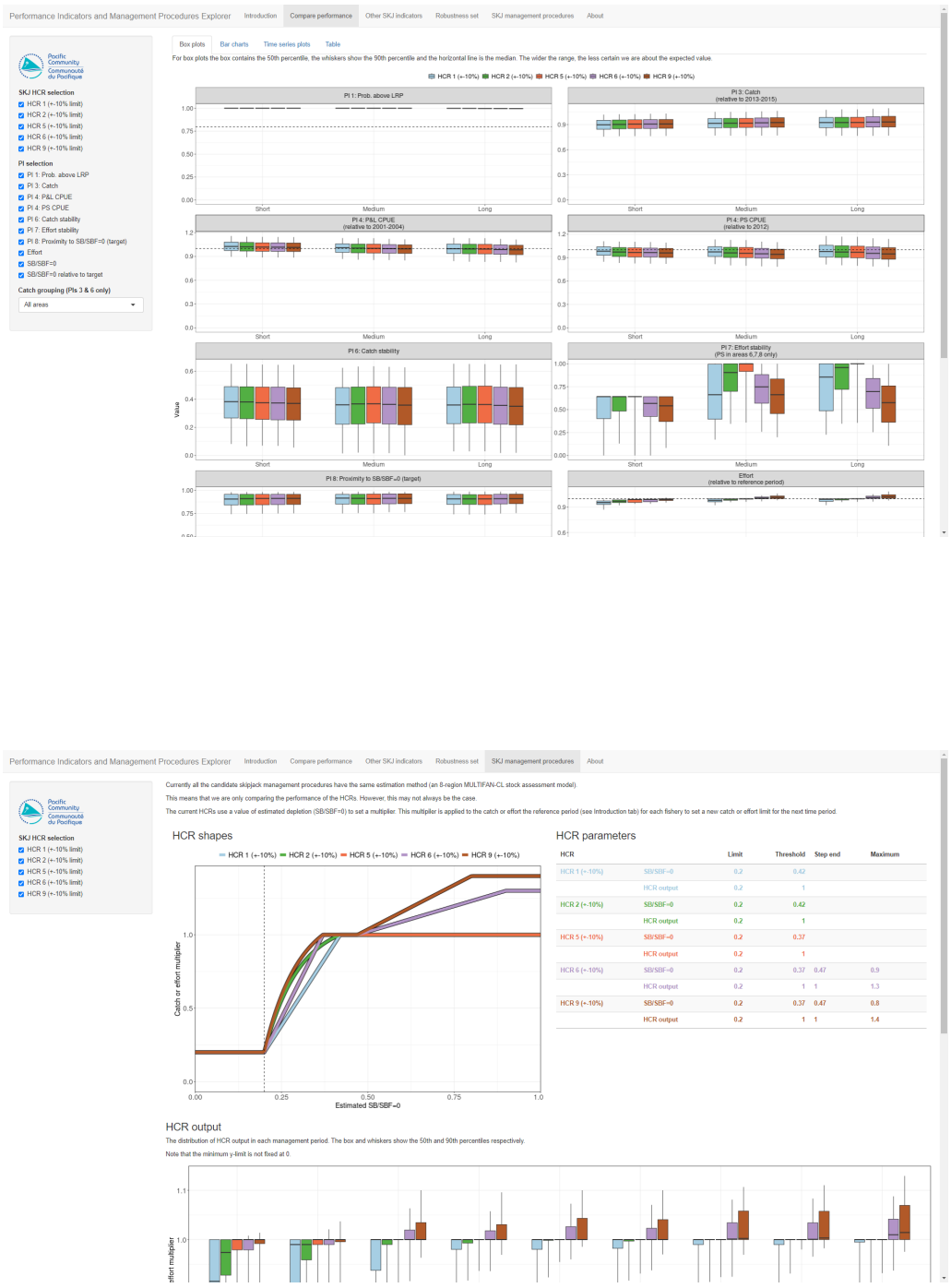

Figure 4: PIMPLE screen grabs showing the 'Compare performance' and 'SKJ management procedures' pages. The updated PIMPLE app can be accessed at https://ofp-sam.shinyapps.io/PIMPLE_WCPFC19/

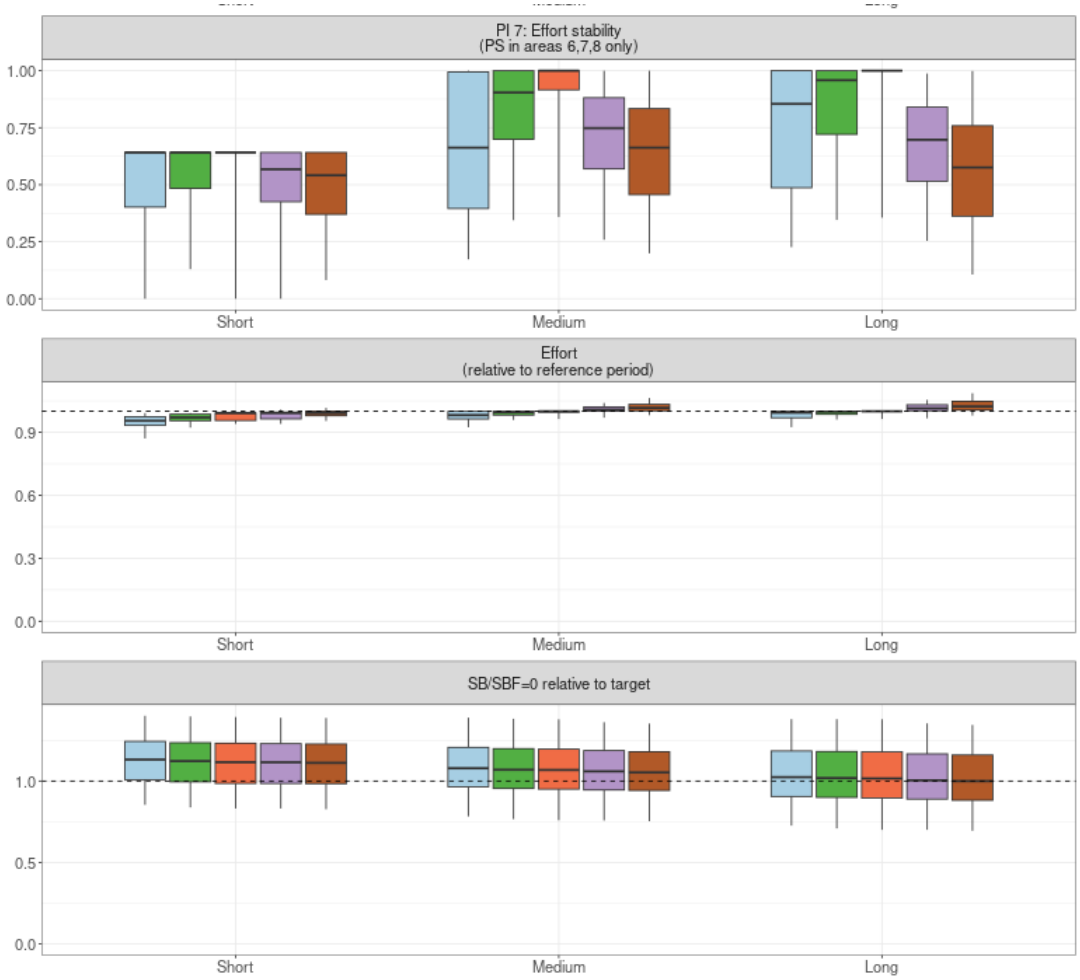

Figure 5: PIMPLE screen grabs showing selected 'Compare performance' panels for effort stability, $SB/SB_{F=0}$ relative to the target and effort relative to baseline effort levels for the 5 HCRs identified by SMD01.

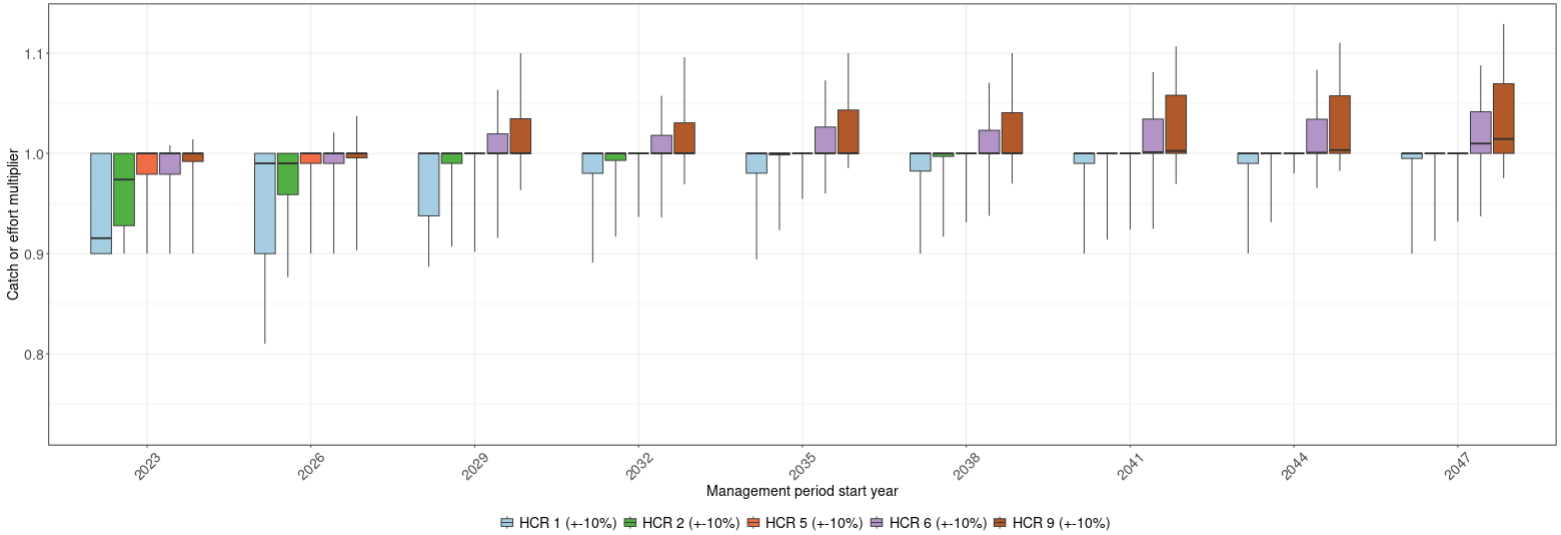

Figure 6: PIMPLE screen grab showing the HCR output (catch or effort multiplier) in each management period for each of the five selected MPs. Black bar shows the median, boxes show the 80th %ile range and whiskers extend to the 95 %ile range.

A Robustness Set: low recruitment scenarios

The reference set of operating models for WCPO skipjack (Table 2) includes two recruitment scenarios. One representing a lower recruitment scenario in which recruitment residuals are drawn from the long-term period (1982 to 2018) and one representing a higher recruitment scenario with recruitment residuals drawn from a more recent period (2005 to 2018). A difference in recruitment between these two periods has been apparent in earlier assessments, however, the difference has become less marked in more recent assessments. At the request of SC18 a low recruitment scenario was added to the robustness set to provide a further 'stress test' for investigating the performance of candidate management procedures.

For the robustness set low recruitment scenario, future recruitment values have been sampled from the first 10 years (1972 to 1981) representing the period of the lowest observed recruitment in the assessment. Recruitment levels for the low recruitment scenario were on average 33% lower than recruitment levels assumed in the reference set (Figure 7).

Under the low recruitment scenario all of the MPs continue to perform relatively well. Stock status is maintained around the TRP and away from the LRP, although the stock level is slightly lower and the risk of breaching the LRP is higher than for the reference set evaluations (Figure 8). Other performance indicators, specifically catch and CPUE, show marked reductions, however, all five MPs perform as expected, reducing fishing as the stock declines toward the LRP, to achieve stock sustainability.

For the reference set evaluations, there are very few instances where the evaluations have not run to completion either due to the population declining to zero (operating model) or failure of the estimation model (management procedure). However, for the low recruitment robustness scenario, there is a higher incidence of incomplete evaluations (Table 4). The recruitment levels assumed under the low recruitment 'stress test' scenario represent a substantial reduction from recent levels and this reduction can be more pronounced in some regions of the assessment than others. In assessment region 5, recruitment is estimated to be above average for the most recent years and the marked reduction in recruitment coupled with larger 2016-18 catch levels makes this region in particular more susceptible to significant stock decline. The precise reason for the failure of some evaluations is still being investigated but appears to be caused by the management procedure failing to determine a scalar to set future fishing levels. This result would clearly indicate failure of the management procedure and would trigger exceptional circumstances.

An important consideration for the monitoring strategy will be the definition of exceptional circumstances, which represent the occurrence of events that are outside the range of scenarios considered for testing the MP. The performance of the estimation model will be an important consideration when running the MP. The MP trial run analysis conducted for SC18 (WCPFC-SC18-MI-WP03) outlined the approach and suitable diagnostics for determining whether the estimation model had run successfully or not.

Table 4: Number of low recruitment scenarios evaluations that either ran successfully, or failed. Failed runs are shown by the management period in which the failure occurred.

Run Status	**HCR1**	**HCR2**	**HCR5**	**HCR6**	**HCR9**
Success	379	379	385	378	375
fail-1	40	46	41	45	52
fail-2	25	20	26	19	21
fail-3	15	17	10	13	14
fail-4	5	8	4	9	8
fail-5	8	7	8	6	6
fail-6	4	2	5	3	2
fail-7	2	1	1	2	0
fail-8	0	0	2	1	1
fail-9	1	0	0	2	1
fail-10	1	0	0	2	0

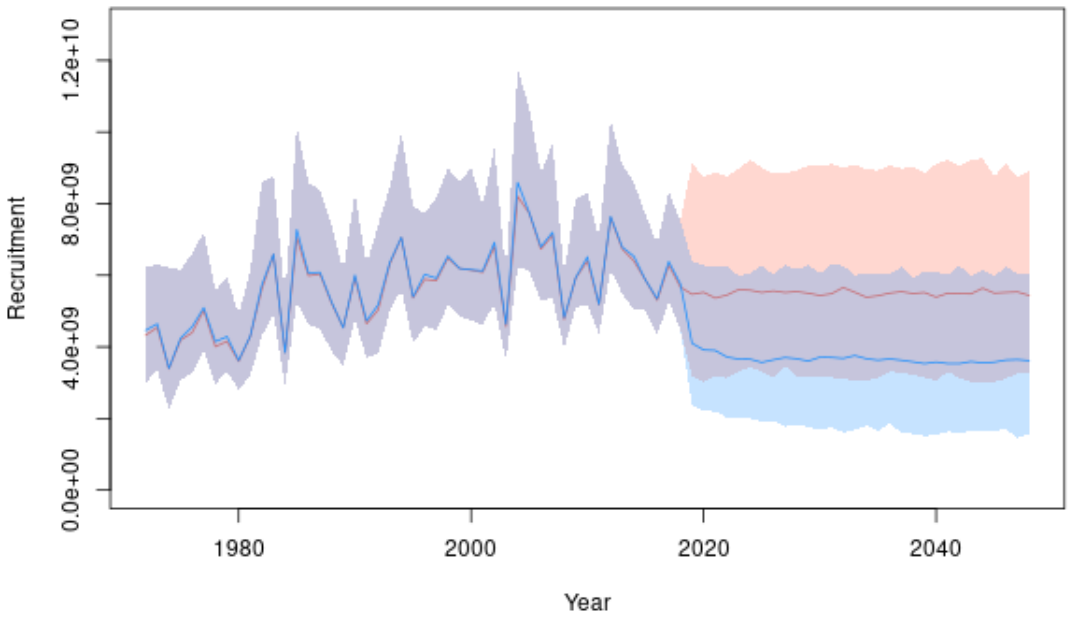

Figure 7: Median and 95 %ile range of historical and future recruitment under the reference set (red) and robustness set low recruitment (blue) scenarios.

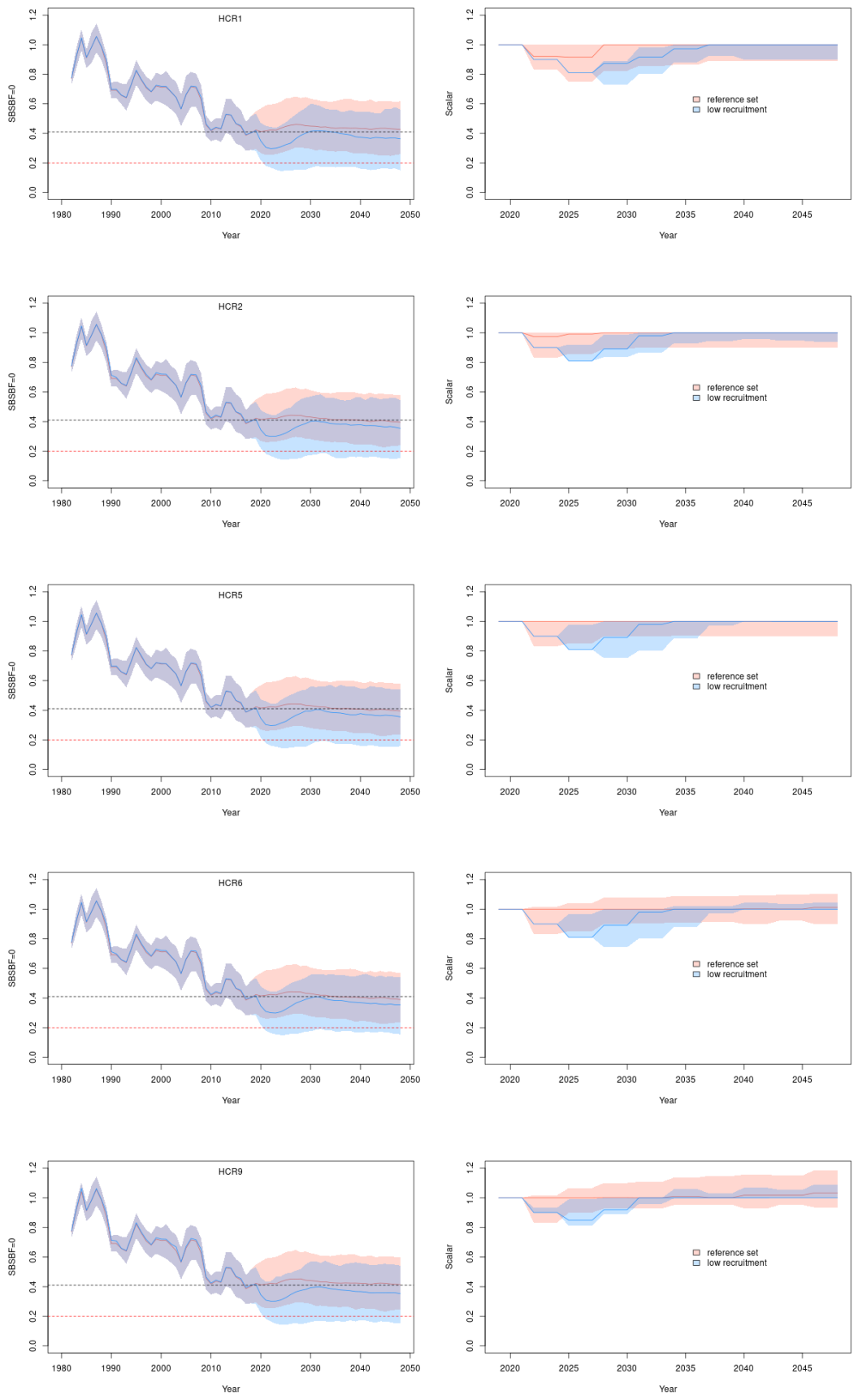

Figure 8: Low recruitment evaluation results: Median and 95%ile range of spawning biomass depletion and HCR output scalar for HCRs 1,2,5,6 and 9 for the reference set (red) and low recruitment robustness set (blue) scenarios.

B Small scale fisheries

Table 5: Total tropical tuna catch estimates for other fisheries (excl. purse seine and longline) in the WCPFC statistical area, that are **not exempt** from CMM 2021-01 other commercial fisheries

Gear	**Flag**	**Tuna catch (MT)**		**notes**	**Included in**	**Total WCPFC**
		2021	**2016-18**		**SKJ assessment**	**SKJ catch 2021**
Handline	ID	-	-	Within EEZ only, exc AW	No, minimal SKJ catch	0
Handline (large fish)	PH	13,343	2,893	Within EEZ only, exc AW	No, minimal SKJ catch	862
Pole and line	ID	41,025	12,734	Within EEZ only, exc AW	Yes	78,402
Pole and line	JP	114,573	59,377		Yes	55,064

Table 6: Total tropical tuna catch estimates for other fisheries (excl. purse seine and longline) in the WCPFC statistical area, that **are exempt** from CMM 2021-01 other commercial fisheries

Gear	**Flag**	**Tuna catch (MT)**		**notes**	**Included in**	**Total WCPFC**
		2021	**2016-18**		**SKJ assessment**	**SKJ catch 2021**
Gillnet	JP	101	101	Less than 2,000t	No, minimal SKJ catch	96
Gillnet	VN	18,059	32,787	Outside WCPFC-CA	Yes	17,365
Handline(large fish)	USA	403	453	Less than 2,000t	No, minimal SKJ catch	5
Hook and line	PH	0	0	Territorial seas/AW only	Yes	13,525
Pole and line	AU	0	0	Less than 2,000t	No, minimal SKJ catch	0
Pole and line	FJ	0	0	Less than 2,000t	No, minimal SKJ catch	0
Pole and line	PF	199	251	Less than 2,000t	Yes	49
Pole and line	KI	0	0	Less than 2,000t	No, minimal SKJ catch	0
Pole and line	NZ	0	0	Less than 2,000t	No, minimal SKJ catch	0
Pole and line	SB	51	61	Less than 2,000t	Yes	1,053
Pole and line	USA	0	0	Less than 2,000t	No, minimal SKJ catch	0
Small scale	AU	0	0	Less than 2,000t	No, minimal SKJ catch	0
Small scale	PF	1,065	1,116	Less than 2,000t	Yes	301
Small scale	ID	46,445	37,599	Territorial seas/AW only	Yes	81,890
Small scale	JP	1,455	1,351	Less than 2,000t	Yes	356
Small scale	KI	4,359	4,359	Territorial seas/AW only	Yes	2,190
Small scale	NZ	0	0	Less than 2,000t	No, minimal SKJ catch	0
Small scale	NU	3	1	Less than 2,000t	No, minimal SKJ catch	1
Small scale	PH	0	0	Territorial seas/AW only	Yes	5,499
Troll	AU	0	0	Less than 2,000t	No, minimal SKJ catch	0
Troll	CA	0	0	Less than 2,000t	No, minimal SKJ catch	0
Troll	CK	157	123	Less than 2,000t	No, minimal SKJ catch	12
Troll	FJ	0	0	Less than 2,000t	No, minimal SKJ catch	14
Troll	JP	3,567	3,446	Territorial seas/AW only	No, minimal SKJ catch	1,387
Troll	NR	20	15	Less than 2,000t	No, minimal SKJ catch	2
Troll	NZ	3	7	Less than 2,000t	No, minimal SKJ catch	3
Troll	TK	51	78	Less than 2,000t	No, minimal SKJ catch	18
Troll	TV	348	348	Less than 2,000t	No, minimal SKJ catch	194
Troll	USA	912	936	Less than 2,000t	No, minimal SKJ catch	514
Troll	VU	115	63	Less than 2,000t	No, minimal SKJ catch	34
Troll	WF	13	11	Less than 2,000t	No, minimal SKJ catch	7