SOUTH PACIFIC ALBACORE ROADMAP INTERSESSIONAL WORKING GROUP (SPA-RM-IWG05)

ELECTRONIC MEETING
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Evaluation of Candidate Management Procedures for South Pacific Albacore - DRAFT

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Evaluation of candidate management procedures for South Pacific albacore - DRAFT 10/10/24

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SPC-OFP

Executive Summary

This report describes the most recent results from evaluating candidate management procedures (MPs) for South Pacific albacore.

Candidate MPs are developed based on a fixed estimation method and several harvest control rule (HCR) shapes, combined with different levels of constraint on how much the HCR output can change between management periods, consistent with candidate MPs that have been shown before. Only troll and longline fisheries operating in the WCPFC-CA are managed through any of the alternative MPs.

At the request of the WCPFC SMD02, the MPs are evaluated with fisheries managed through the setting of either catch or effort limits. The HCRs for the catch-based MPs are different to the HCRs for the effort-based MPs as performance is affected by the management method but have been designed to achieve similar performance in terms of long-term $SB/SB_{F=0}$.

These evaluations have assumed that the output of an MP will be either the total annual catch for the next 3 year management period, or total annual effort, dependent upon the MP. Allocation of that total, and how those allocations are managed in practice (e.g. through effort if that allocation is in terms of catch, or catch if the allocation is in terms of effort) is external to the MP.

Following discussion at WCPFC SC20 and WCPFC SMD02, the input to the HCR from the estimation method is a relative measure of stock status, defined as the mean estimated $SB/SB_{F=0}$ in the last three years relative to the mean estimated $SB/SB_{F=0}$ in 2017-2019.

The HCR baselines are the average catch or effort level in the period 2020-2022 for each fishery group. Different combinations of HCR shape, constraint and management method (catch- or effort-based) result in 16 candidate MPs.

Six performance indicators (PIs) are calculated over the 30 year projection period: $SB/SB_{F=0}$; the probability of $SB/SB_{F=0}$ being above the limit reference point (LRP); total catch in the WCPFC-CA; vulnerable biomass (a proxy for catch rates) relative to the vulnerable biomass in 2020-2022; the variability of catches in the WCPFC-CA; and the variability of longline effort in the WCPFC-CA.

An updated online app is available to explore the results: https://ofp-sam.shinyapps.io/spample

Three one-off sensitivity tests are run based on a single MP to explore potential impacts of: an alternative HCR baseline of 2000-2004 catches for troll fisheries in the WCPFC-CA; an alternative baseline catch level for fisheries in the EPO; EPO fisheries being managed through the MP.

Finally, a dry run analysis is performed in which a single candidate MP is evaluated using the most recent data up to 2022 to explore what the resulting catch limits would be under different HCR constraints.

1 Introduction

This report describes the most recent evaluations of candidate management procedures (MPs) for South Pacific albacore (SPA) following feedback and outcomes from WCPFC SC20 and WCPFC SMD02 (See Appendices) (WCPFC, 2024a,c,b).

The relative performance of the MPs is summarised, including the impact of the choice of harvest control rule (HCR), and the impact of various constraints on how much the output of the HCR (i.e. catch or effort limits) can change from one management period to the next.

The main differences between the evaluations presented here and at SMD02 are:

- The HCR input is a relative measure of stock status: mean estimated $SB/SB_{F=0}$ in the last three years relative to the mean estimated $SB/SB_{F=0}$ in 2017-2019. The absolute measure of mean estimated $SB/SB_{F=0}$ in the last three years as an HCR input has been dropped following discussions at SMD02.
- The estimation method now only uses the two longline CPUE index fisheries and no longer uses the troll CPUE index fishery (see Appendix).
- Both catch- and effort-based candidate MPs are evaluated (SMD02 request).
- An additional performance indicator for WCPFC-CA longline effort variability is calculated (SMD02 request).
- Additional MPs with alternative HCR shapes have been evaluated (SMD02 request).
- The impact of excluding fisheries operating in archipelagic waters has been investigated.

2 Management strategy evaluation framework

Full details of the management strategy evaluation (MSE) framework, including the operating models (OMs) can be found in WCPFC-SMD02-2024/SMD02-BP-02 (Scott et al., 2024b). A summary of the main assumptions, including a description of the OMs, can be found in the Appendix.

Under the WCPFC harvest strategy approach, fisheries operating in archipelagic waters are not managed through an MP. Using the most recently available data, the proportion of SPA catch taken in archipelagic waters in the WCPFC-CA is calculated to be less than 1% of the total SPA WCPFC-CA catch. Excluding fisheries operating in archipelagic waters from MP management in the MSE simulations would require some technical work and a number of assumptions to be made. Given the small proportion of catches in archipelagic waters, and the negligible impact they will have on the performance of the candidate MPs, in the current MP evaluations fisheries operating in archipelagic waters are still under MP control.

3 Performance indicators

Six performance indicators (PIs) are calculated.

- $SB/SB_{F=0}$ in the WCPFC-CA (measured as $SB_{latest}/SB_{F=0}$, i.e. SB in year y relative to the average $SB_{F=0}$ in years y-10 to y-1). This can be compared to the interim target reference point (TRP) and any proposed alternative TRPs.
- Probability of the stock status being above the limit reference point (LRP), noting that the WCPFC requires the probability to be greater than 0.8.
- Total catch in the WCPFC-CA.
- Vulnerable biomass available to longline fisheries in the WCPFC-CA. This is a proxy for CPUE and is calculated as relative to the average vulnerable biomass in the period 2020-2022.
- Catch variability, calculated as the absolute annual difference in total WCPFC-CA catch.
- Effort variability, calculated as the absolute annual difference in total WCPFC-CA longline effort, measured in hooks (as requested by SMD02).

The average values of the PIs are calculated over three time periods:

- Short (2026-2034)
- Medium (2035-2043)
- Long (2044-2052)

4 Candidate management procedures

An MP comprises three components:

- Data collection
- Estimation method (EM)
- Harvest control rule (HCR)

For each candidate MP examined in this paper the data collection is the same and is assumed to be similar to current data collection processes. The EM and HCRs are explored below.

The current key assumptions for the MPs are:

- All fisheries in the WCPFC-CA are managed either through the setting of catch or effort limits, depending on the candidate MP, i.e. all are managed through catch limits, or all are managed through effort limits.
- The HCR of each MP outputs a scaler that is applied to the baseline catch or effort for each fishery group managed by the MP.
- The current baseline for each HCR is the average catch or effort in the period 2020-2022 within the WCPFC-CA, i.e. an output scaler of 1 sets the catch or effort limit for the next management period to the average of 2020-2022 catches or effort by fishery group.
- All fisheries managed by the MP are affected equally, e.g. if the MP specifies a 10% increase in catch, all fisheries managed by the MP have their catch limits increased by 10% relative to the baseline for the next management period.

These evaluations have assumed that the output of an MP will be either the total annual catch for the next 3 year management period, or total annual effort, dependent upon the MP. Allocation of that total, and how those allocations are managed in practice (e.g. through effort if that allocation is in terms of catch, or catch if the allocation is in terms of effort) is external to the MP.

4.1 Estimation method

The estimation method (EM) is an age-structured production model, implemented in Multifan-CL, with two index fisheries: a longline index in the WCPFC-CA model region and a longline index in EPO model region. This is an update to that presented to SC20 as it has removed the reliance on a WCPFC-CA troll fishery index which helps to 'future proof' the MP (Scott et al., 2024a,b). An investigation into the performance of the updated EM is presented in the Appendix. The updated EM performs well and the resulting performance indicators have not substantially changed.

Following discussion at SC20 and SMD02, the HCR input is a relative measure of stock status: mean estimated $SB/SB_{F=0}$ in the last three years relative to the mean estimated $SB/SB_{F=0}$ in 2017-2019. The absolute measure of HCR input (mean estimated $SB/SB_{F=0}$ in the last three years) that was presented to SMD02 has been dropped.

$SB/SB_{F=0}$ is measured as $SB_{latest}/SB_{F=0}$, i.e. SB in year y relative to the average $SB_{F=0}$ in years y-10 to y-1, and is averaged over the last three years in the calculations above.

4.2 Harvest control rules

The candidate MPs are split into two groups: those that define total future fishery level in terms of catch limits and those that do so through setting effort limits. The HCRs for the catch-based MPs are different to the HCRs for the effort-based MPs as performance is affected by the management method (catch or effort).

The catch-based candidate MPs have five basic HCR shapes (HCRs 1, 2, 3, 5 and 6) and the effort-based candidate MPs have three basic HCR shapes (HCRs 7, 8 and 9) (Figure 1, Table 1). Each HCR has a similar shape to the HCR in the adopted interim skipjack MP, with a Hillary step.

The HCR shapes for the two management methods are different but have been designed to achieve similar performance in terms of long-term $SB/SB_{F=0}$, e.g. HCR 1 (catch-based) achieves approximately the same long-term $SB/SB_{F=0}$ as HCR 7 (effort-based). HCRs 2 and 8 have a higher maximum output and are designed to achieve lower stock levels than HCRs 1 and 7, whereas HCRs 3 and 9 have a lower maximum output and are designed to achieve higher stock levels than HCRs 1 and 7.

HCRs 5 and 6 were specific requests from SMD02 and have been evaluated using catch-based management only. Following discussion at SMD02 HCR 4 was dropped and does not feature here.

Testing the EM suggested that there is a positive bias between the EM estimates of stock status compared to the true stock status of the OMs (Scott et al., 2024a). To compensate for these differences the shapes of HCRs (except HCR 5, following the SMD02 request) have been transformed using the fitted linear relationships in Table 1 of Scott et al. (2024a), noting that without the troll index in the EM, the fitted linear relationship may be slightly different (see Appendix: Estimation method update). For these HCRs the relative $SB/SB_{F=0}$ coordinates are therefore higher than if the true relative stock status was known.

Most of the candidate MPs have constraints on how much the output of the HCR can change between management periods (Table 2). HCR 1 has an example of an asymmetrical constraint where the output can increase by up to 10% from the previous management period, but can only decrease by up to 5%, as well as an option with no constraint.

Table 1: Parameter values of the HCR shapes, split by absolute and relative input.

HCR		Limit	Step start	Step end	Maximum
Catch-based MPs					
HCR 1	SB/SBF=0	0.37	0.94	1.29	1.59
	HCR output	0.2	1	1	1.2
HCR 2	SB/SBF=0	0.37	0.77	1.09	1.59
	HCR output	0.2	1.27	1.27	1.47
HCR 3	SB/SBF=0	0.37	1.07	1.39	1.59
	HCR output	0.2	0.85	0.85	1.05
HCR 5	SB/SBF=0	0.37	0.82	1.29	1.59
	HCR output	0.2	1	1	1.2
HCR 6	SB/SBF=0	0.36	0.67	0.85	1.45
	HCR output	0.2	1.5	1.5	1.7
Effort-based MPs					
HCR 7	SB/SBF=0	0.37	0.94	1.29	1.59
	HCR output	0.2	0.93	0.93	1.13
HCR 8	SB/SBF=0	0.37	0.76	1.09	1.59
	HCR output	0.2	1.34	1.34	1.54

HCR		Limit	Step start	Step end	Maximum
HCR 9	SB/SBF=0	0.37	1.07	1.39	1.59
	HCR output	0.2	0.63	0.63	0.83

Table 2: The constraint options for the candidate MPs

HCR shape	Constraint
Catch-based MPs	
HCR 1	None; +-5%; +-10%; +10%, -5%
HCR 2	+-5%; +-10%
HCR 3	+-5%; +-10%
HCR 5	+-20%
HCR 6	+-5%
Effort=based MPs	
HCR 7	+-5%; +-10%
HCR 8	+-5%; +-10%
HCR 9	+-5%; +-10%

Considering the different combinations of HCR shape, management method and constraint option there are 16 candidate MPs: 10 catch-based MPs and 6 effort-based MPs.

For MPs with a constraint, the first time the MP is used (in 2025), the constraint is applied to the catch or effort in 2023 (assuming a two year data lag), i.e. the catch or effort limit set by the MP in 2025 cannot change by more than X% from the catch or effort level in 2023. The assumed levels of catch or effort in 2023 can therefore impact the performance of an MP with a constraint, particularly in the first few management periods. For the current evaluations the catch or effort in 2023-2025 are set to the average level in 2017-2022. These assumed catch and effort levels are higher than the baseline (2020-2022) catch and effort.

5 Results

800 stochastic simulations (known as iterations) are performed for each MP. In some of the simulations the projected stock crashes due to a combination of low recruitment, life history parameters

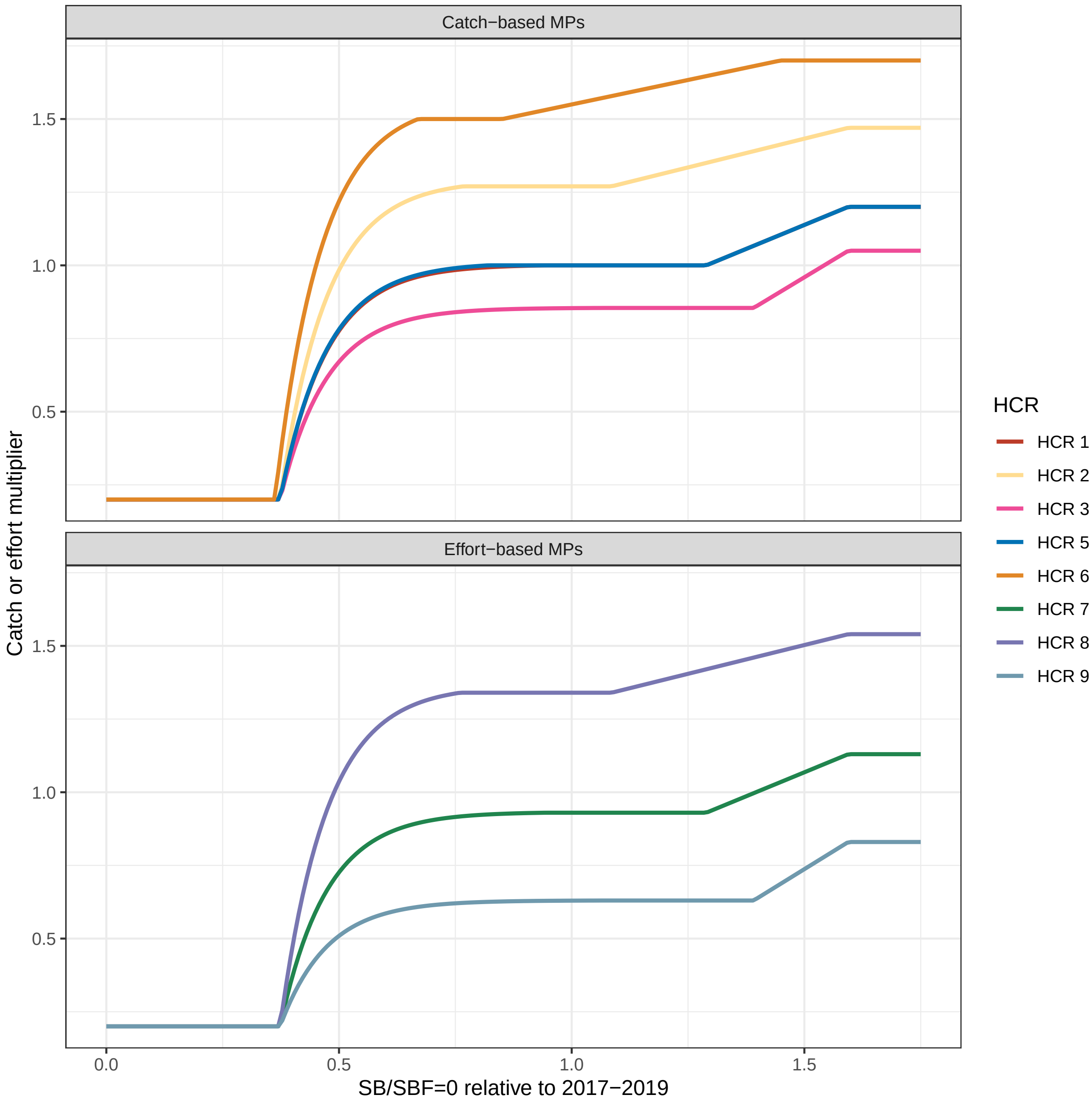

Figure 1: The basic HCR shapes. The MPs are split into two groups based on management method: catch- or effort-based. The input to the HCR is the mean $\mathrm{SB}/\mathrm{SB}_{\mathrm{F}=0}$ of the last three years relative to 2017-2019. The output is a scaler applied to 2020-2022 levels of catch or effort, depending on the management method of the MP.

implying a less productive stock, and high fishing pressure. In these cases, the expected catch, effort and stock status for the remainder of the simulation are set to zero.

The large number of MPs evaluated can make it difficult to fully analyse and discuss the results in a report. A brief summary is presented here.

A potential method for narrowing down the initial suite of 16 candidate MPs to something more manageable would be to first decide whether a catch- or effort-based management method is preferred. The preferred level of constraint, if any, can then be considered, along with the most important performance indicators (which may be different among members). Noting that in practice, if, for example, an effort-based MP was chosen, it may be possible to convert the recommended effort levels to catches or vice versa for operational management.

Performance is summarised briefly below by performance indicator, but the interactive use of the online app, SPAMPLE, is recommended for exploring the results and may assist in selecting preferred MPs: https://ofp-sam.shinyapps.io/spample.

5.1 Stock depletion and LRP risk

The range of expected $SB/SB_{F=0}$ for each candidate MP can be seen in Figure 2. WCPFC20 agreed an interim TRP as 0.96 x mean $SB/SB_{F=0}$ in 2017-2019. A TRP range of 0.42 to 0.56 was also proposed at WCPFC20 for examination. These values have been rescaled for the current OM grid and are shown as the top three horizontal dashed lines, the middle line being the iTRP. The bottom dashed line is the LRP.

Generally, for MPs with HCR 1 (catch-based) and HCR 7 (effort-based) the median expected $SB/SB_{F=0}$ is close to the iTRP in the medium- and long-term time periods. For MPs with HCR 2 (catch-based) and HCR 8 (effort-based) the median $SB/SB_{F=0}$ is close to the lower proposed TRP, while for MPs with HCR 3 (catch-based) and HCR 9 (effort-based) the median $SB/SB_{F=0}$ is close to the upper proposed TRP.

This could help inform which MPs to focus on. For example, if being at the iTRP is considered to be important then only MPs based on HCR 1 and 7 should be considered, depending on the preferred management method. The other MPs could then be eliminated making the selection of preferred MPs easier.

The new MP with HCR 5 (catch-based) performs similarly to MPs with HCR 1 (the shapes are similar), resulting in median depletions close to the iTRP.

The new MP with HCR 6 (catch-based) leads to a long-term decline in stock biomass and, in the long-term, results in a median depletion below the proposed TRPs, and a wide range of stock depletion outcomes.

With regards the probability of remaining above the LRP, MPs based upon HCRs 1, 3 and 5 (catch-based) and all effort-based MPs (HCRs 7 to 9) show high probability. MPs based on HCR 2 show a lower probability but remain above the 0.8 threshold. The MP with HCR 6 is, in the long-term, the only MP with a less than 0.8 probability of being above the LRP i.e. it falls below the WCPFC's requirement of a probability of higher than 0.8 (i.e. there is a greater than 20% chance of falling below the LRP).

5.2 Longline vulnerable biomass

The relative vulnerable biomass (Figure 2) follows a similar pattern to the $SB/SB_{F=0}$ results, with MPs based on HCR 3 and HCR 9 having the highest levels of vulnerable biomass in the medium- and long-term, and therefore CPUE. The MP with HCR 6 has the lowest $SB/SB_{F=0}$ and vulnerable biomass in the medium- and long-term.

Effort-based equivalent MPs tend to show slightly lower average vulnerable biomass levels (HCR 1 vs HCR 7; HCR 3 vs HCR 9), but are less uncertain.

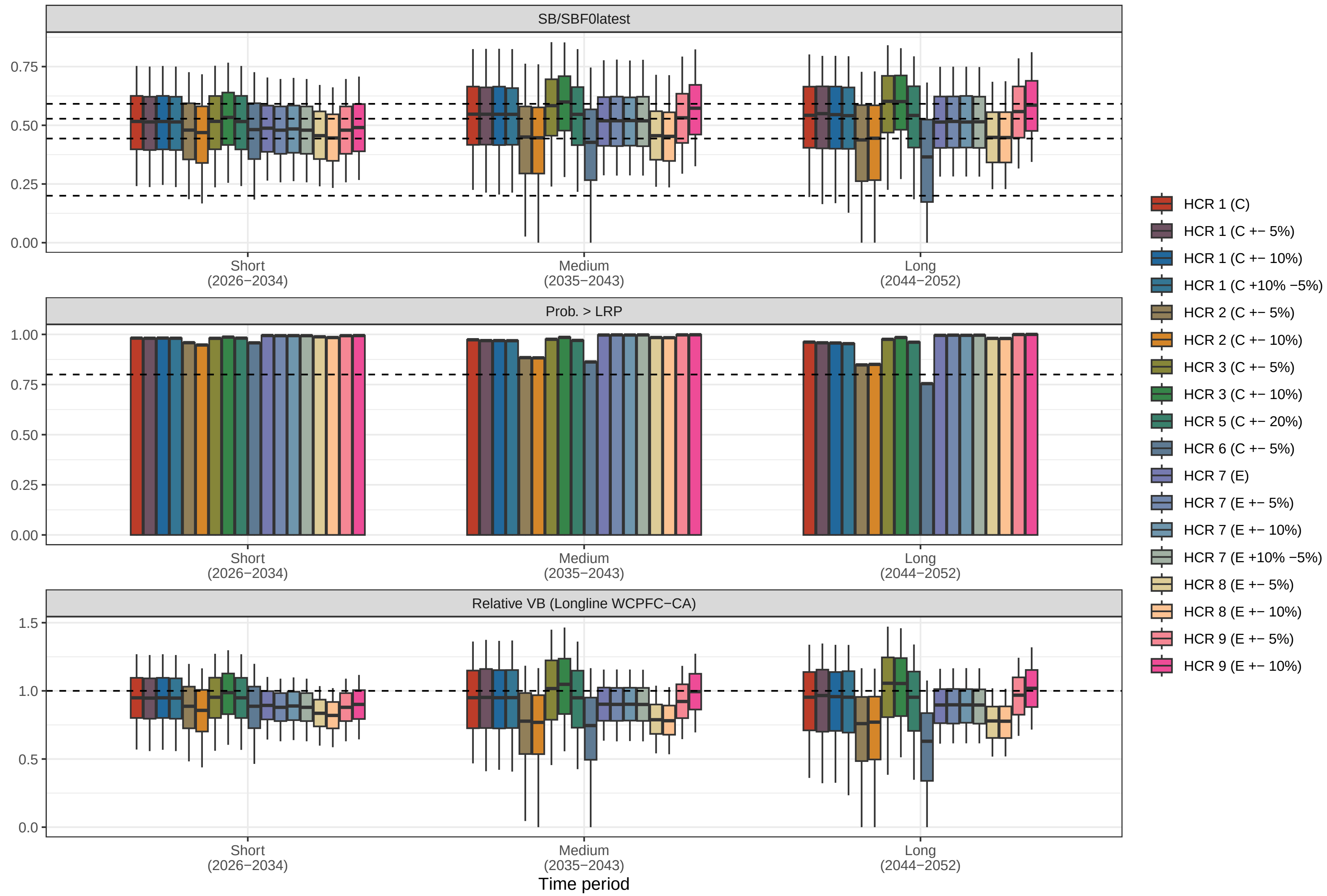

Figure 2: Box plots of $SB/SB_{F=0}$ and vulnerable biomass for the longline fisheries relative to the level in 2020-2022, and a bar plot (middle) of probability of being above the LRP for each of the candidate management procedures across the three time periods. The whiskers show the 95th percentile range, the box shows the 60th percentile range, and the horizontal line is the median value. Horizontal lines on the $SB/SB_{F=0}$ plot are the iTRP, proposed TRPs from WCPFC20 and the LRP. The horizontal line on the Prob. > LRP plot is at 0.8, the minimum required by WCPFC.

5.3 Expected catches and catch variability

The median level of expected catches are conditional on the shape of the HCR and also the presence of any constraint on the MP output (Figure 3). The larger the box and the longer the whiskers, the greater the uncertainty in the expected catches. For more detail on the potential impact of constraints, see the relevant section in Scott et al. (2024b).

MPs based on HCR 2, HCR 6 (both catch-based) and HCR 8 (effort-based comparable to HCR 2) have higher median levels of catch. The long whiskers seen for MPs based on HCR 2 and HCR 6 in the medium- and long-term are a result of the stock crashing in some iterations, due to a combination of high catches, less productive stock assumptions, and low recruitment. For these iterations the catches are set to 0 for the remainder of the simulation.

MPs that are effort-based have much higher uncertainty in the catches, and higher catch variability than catch-based MPs. Generally, the higher the resulting catches, the greater the uncertainty about them.

HCR 5 has a similar shape to HCR 1 (both catch-based) and the median catch levels for MPs with these HCRs are similar. The catch variability for MPs with these HCRs is determined by the level of constraint.

5.4 Effort variability

Longline effort variability is strongly affected by the management method (Figure 4). These are shown in two separate panels for catch- and effort-based MPs as the scales can be quite different, with catch-based MPs resulting in higher effort variability. MPs with HCR 2 and HCR 6 have particularly high effort variability. This is driven by these MPs having a higher proportion of iterations in which the stock crashed.

The evaluations for the catch-based MPs assumed that the catch limit is always caught where possible (i.e. when there are enough fish). If the stock is very low it can require unrealistically high levels of fishing effort to take the catch limit. The effort then goes to 0 if the stock crashes, leading to a high degree of effort variability (from very high effort in one year to nothing in the next). In reality the maximum effort would be limited, and the realised catches resulting from that effort would be lower than the catch limit set by the MP.

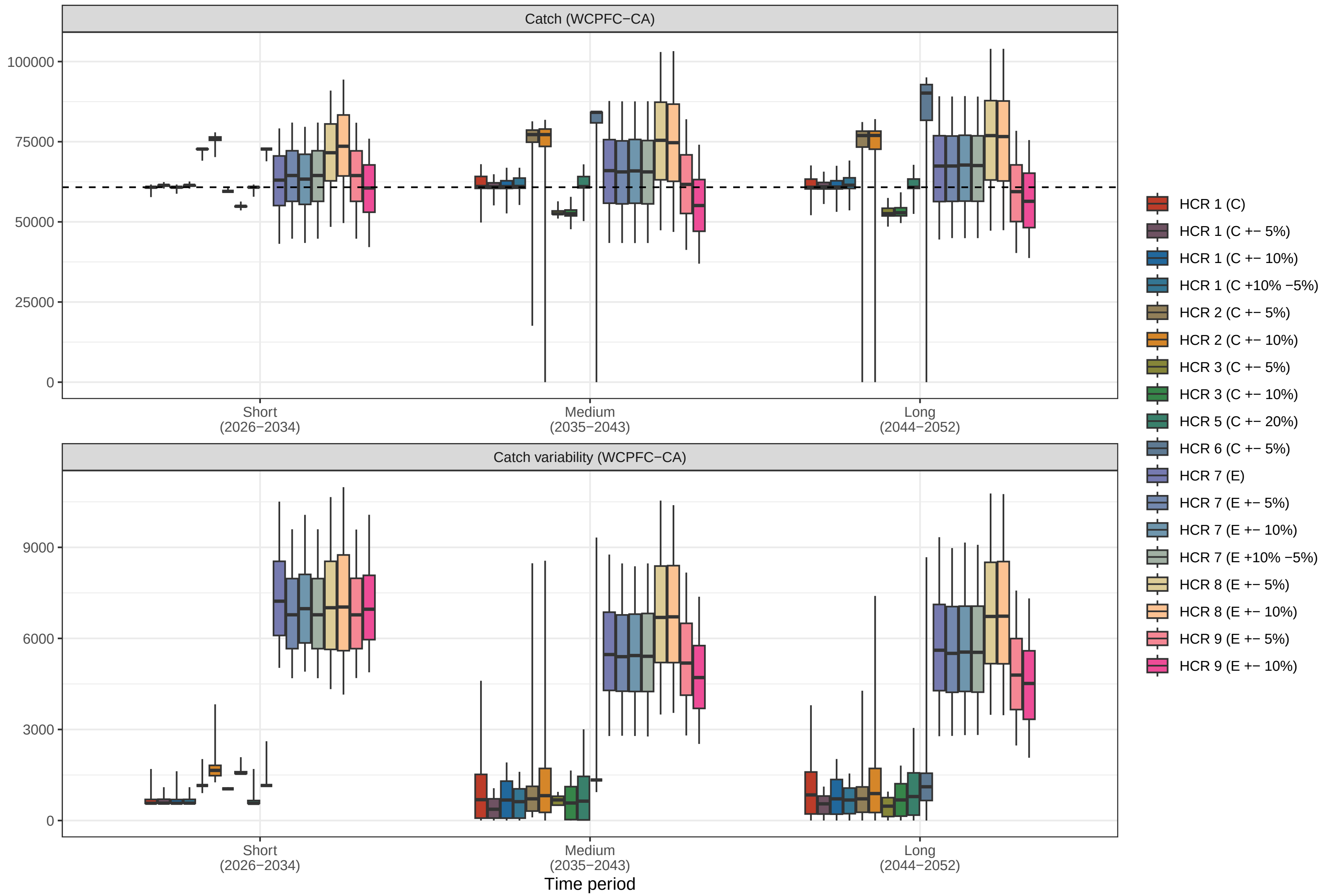

Figure 3: Box plots of total WCPFC-CA catch and associated average annual WCPFC-CA catch variability (both in mt) for each of the candidate management procedures across the three time periods. The whiskers show the 95th percentile range, the box shows the 60th percentile range, and the horizontal line is the median value. The horizontal line on the catch plot is the HCR baseline, the average catch in 2020-2022.

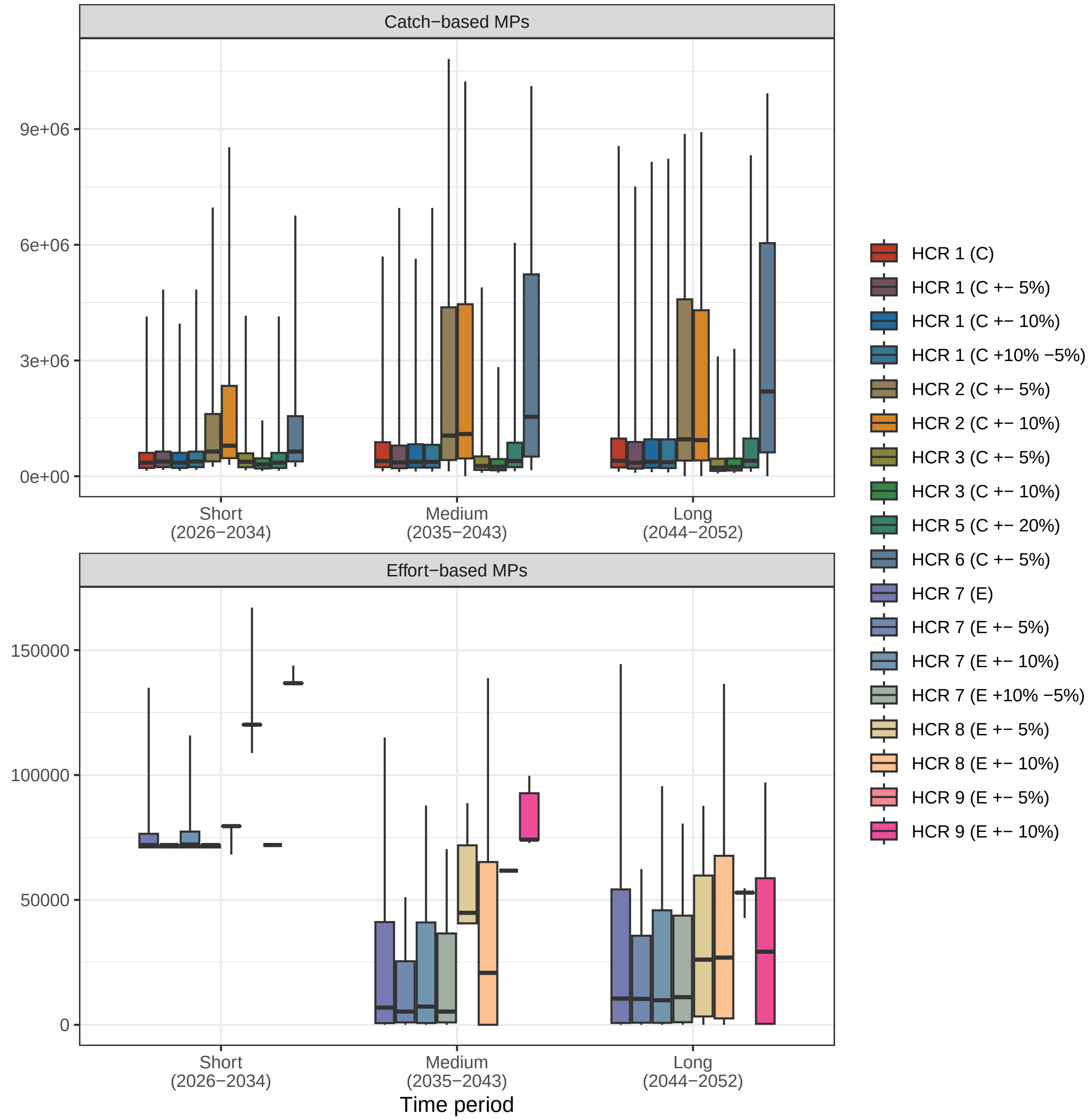

Figure 4: Box plots of average annual WCPFC-CA longline effort variability for each of the candidate management procedures across the three time periods. The whiskers show the 95th percentile range, the box shows the 60th percentile range, and the horizontal line is the median value. The plot is presented in two windows as the results from catch- and effort-based MPs have different scales.

5.5 Comparison of catch- and effort-based MPs

Here the performances of a catch-based MP and effort-based MP are compared. The comparison focuses only on the resulting performance indicators and does not consider any practicalities involved in implementing the different management methods, e.g. data collection, allocation etc.

The two MPs have HCRs that result in comparable long-term median stock status (HCR 3, catch-based and HCR 9, effort-based), and have the same level of constraint (+- 10%) (Figure 5). This pair of MPs have been chosen to highlight the potential differences in performance by the two management methods. Further comparisons between catch- and effort-based MPs can be undertaken using the SPAMPLE app.

Although the median $SB/SB_{F=0}$ values are comparable in all three time periods, the range of expected $SB/SB_{F=0}$ is slightly larger under the catch-based MP. The catch-based MP has a slightly lower probability of being above the LRP, although the probability is well above the 0.8 threshold. The vulnerable biomass shows a similar pattern to the $SB/SB_{F=0}$ results, with comparable median values in the medium- and long-term but higher uncertainty for the catch-based MPs.

The median catches are slightly lower for the catch-based MP but catch uncertainty is close to zero compared to the effort-based MP, i.e. the results suggest greater certainty in the level of catch that would be expected under the catch-based MP. As expected, catch variability is much lower for the catch-based MP, and effort variability is much lower for the effort-based MP.

This comparison illustrates potential trade-offs between using a catch- or effort-based MP.

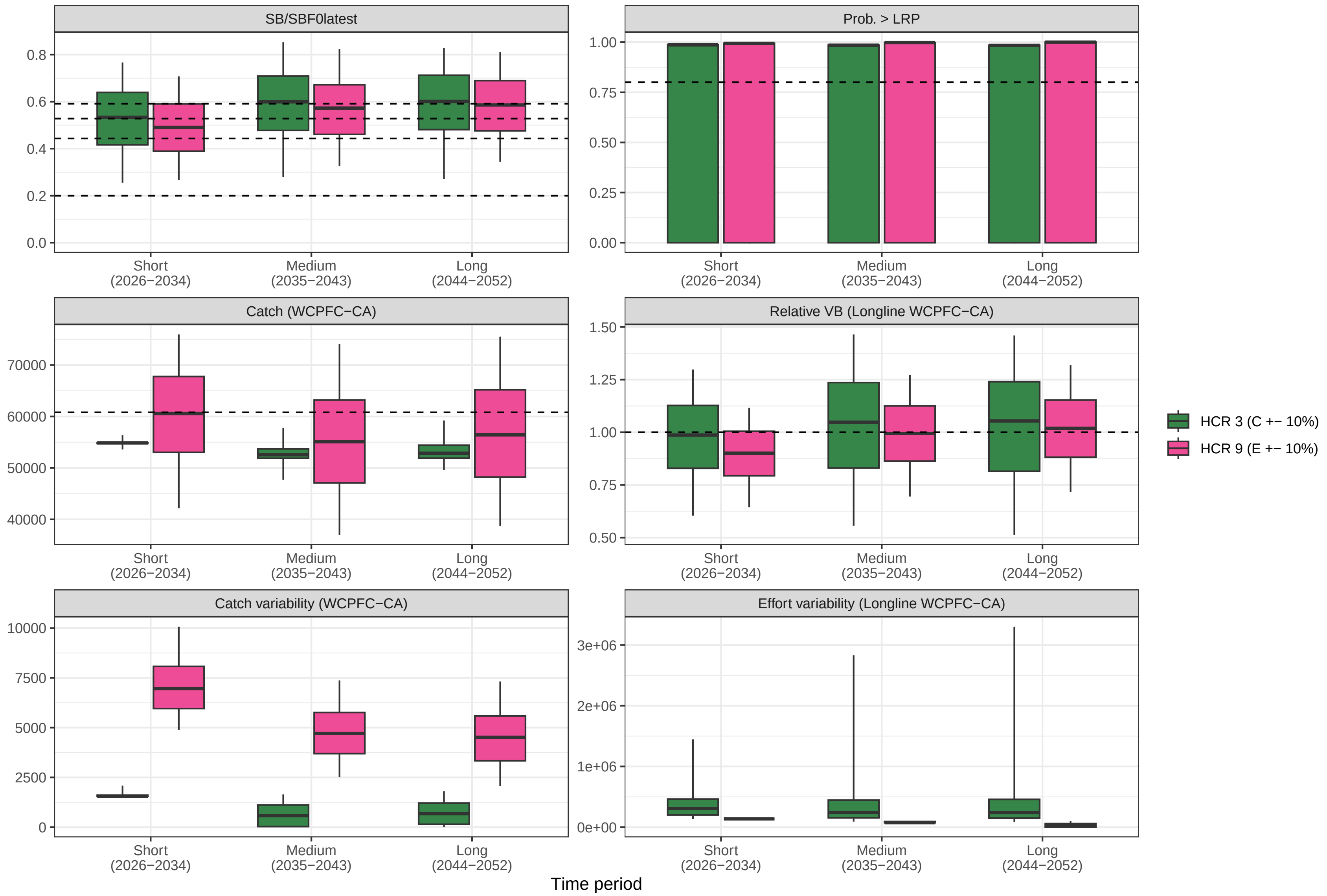

Figure 5: Box plots of all six performance indicators for two MPs. The whiskers show the 95th percentile range, the box shows the 60th percentile range, and the horizontal line is the median value.

5.6 Sensitivity tests

Various one-off sensitivity tests were performed. These evaluations only use a catch-based MP with HCR 1 and a +- 10% constraint. The results of the single change are then compared to the results from that original MP.

Troll fishery with different baseline

The catch-based MP evaluations performed above use an HCR baseline of average catches in the period 2020-2022 for all fisheries in the WCPFC-CA. In this one-off sensitivity test, the baseline period for the troll fisheries in the WCPFC-CA is changed to 2000-2004, i.e. an output scaler of 1 sets the troll fisheries in the WCPFC-CA to the average catch level in 2000-2004, but for all other fisheries sets it to the average catch level in 2020-2022 (Figure 6).

In the OM grid the average troll fishery catch in the WCPFC-CA in the period 2000-2004 is 5240 mt compared to 4783 mt in the period 2020-2022. The difference in the baseline levels results in only small differences in the results (Figure 6). For example, the expected catches are slightly higher with the troll baseline as 2000-2004.

EPO baseline

In the evaluations performed above the fisheries in EPO are not managed through the MP and their future catches are fixed at 22,500 mt per annum. As a sensitivity test the future catches are fixed at a lower level of 15,000 mt per annum (Figure 7).

Lower catches in the EPO result in higher expected stock status and vulnerable biomass in the WCPFC-CA. The catches in the WCPFC-CA are also higher, with lower variability.

EPO included in the MP

In the evaluations above only fisheries in the WCPFC-CA are managed through the MP and the fisheries in the EPO have a constant level of future catches of 22,500 mt per annum. In this sensitivity test, the EPO fisheries are also managed through the MP. This can be interpreted as a 'compatible measures' scenario. The HCR baseline for the EPO fisheries is 22,500 mt, i.e. an output MP scaler of 1 means that the catch limit for EPO fisheries is set to 22,500 mt.

The EM only estimates the stock status in the WCPFC-CA, not the combined model area. As with the other results presented in this paper, the PIs are calculated from the OMs and are based on exclusively on the WCPFC-CA, i.e. the reported catches are catches in the WCPFC-CA only.

The results for this test are broadly the same as when only the WCPFC-CA fisheries are managed through the MP (Figure 8).

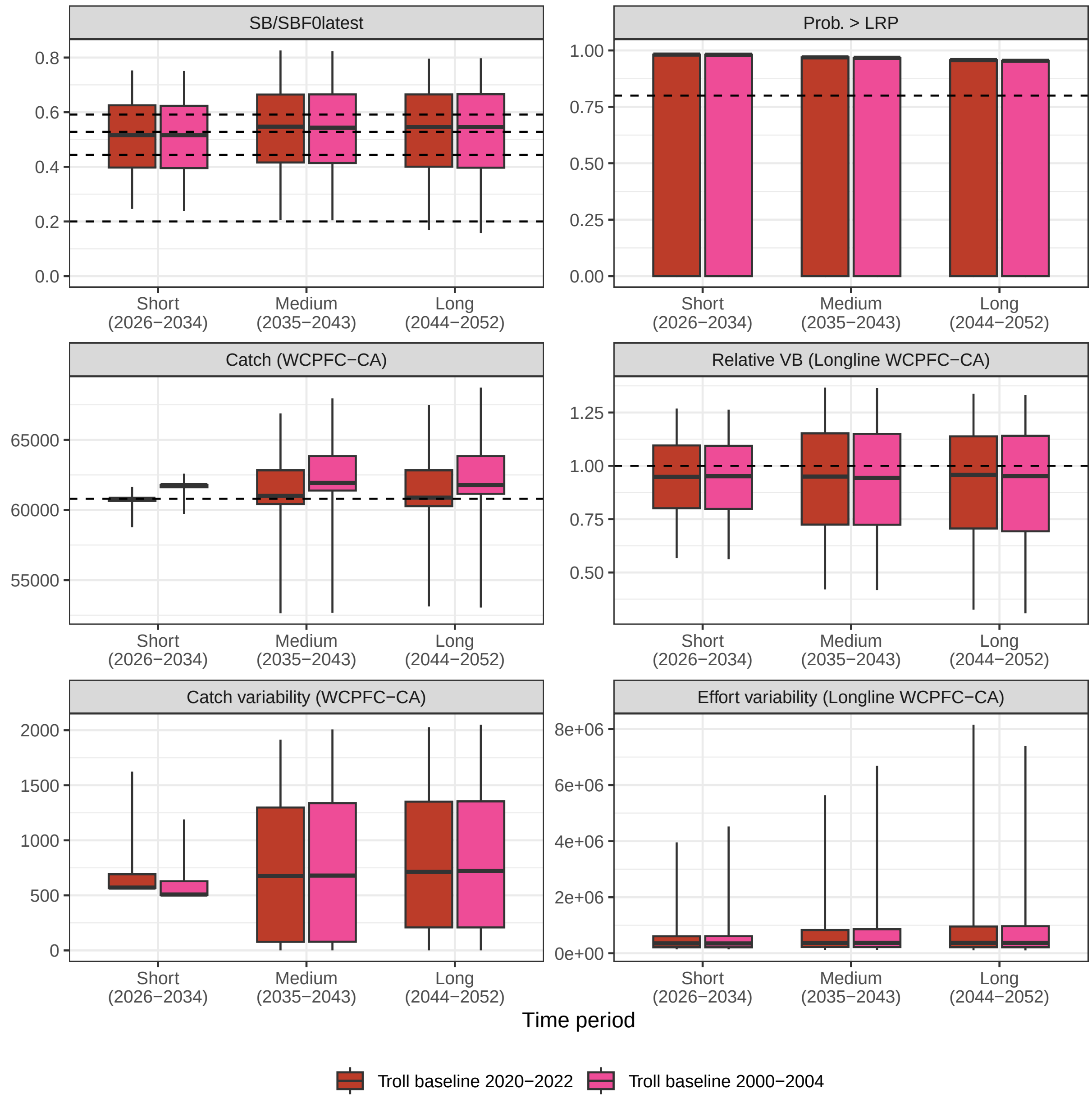

Figure 6: The performance indicators for when the HCR baseline for all fisheries in the WCPFC-CA is 2020-2022 catches and when the HCR baseline for the troll fisheries in the WCPFC-CA is 2000-2004 catch (others at 2020-2022 catches). A catch-based MP with HCR 1 is used, with +-10% constraint. The whiskers show the 95th percentile range, the box shows the 60th percentile range, and the horizontal line is the median value. The probability of being above LRP is shown as a bar plot.

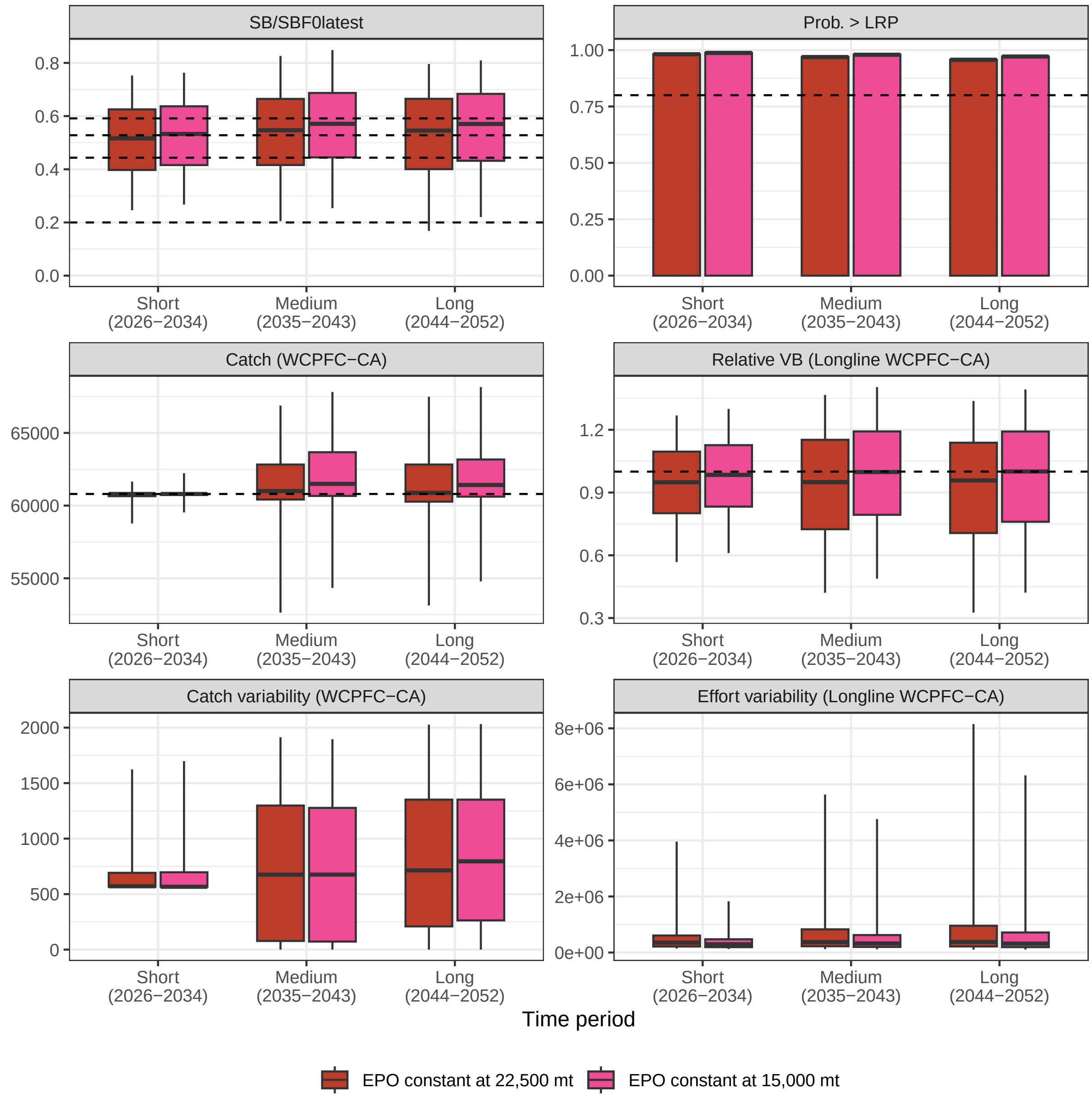

Figure 7: The performance indicators for when the constant catch level in the EPO is 22,500 mt and 15,000 mt. A catch-based MP with HCR 1 is used, with +- 10% constraint. The whiskers show the 95th percentile range, the box shows the 60th percentile range, and the horizontal line is the median value. The probability of being above LRP is shown as a bar plot.

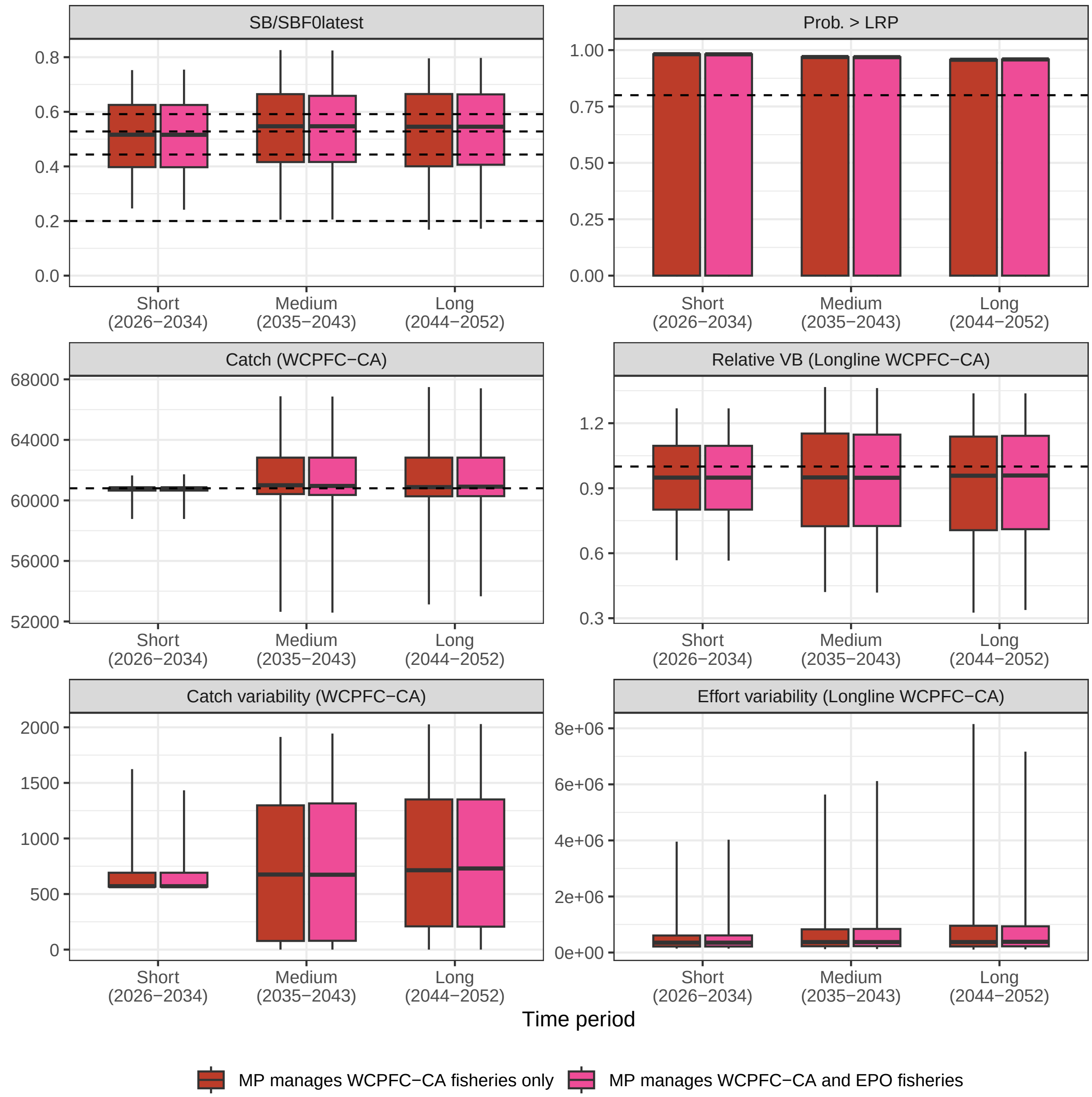

Figure 8: The performance indicators for when the EPO fisheries are also managed through the MP, with a baseline of 22,500 mt. A catch-based MP with HCR 1 with +- 10% constraint is used. The whiskers show the 95th percentile range, the box shows the 60th percentile range, and the horizontal line is the median value. The probability of being above LRP is shown as a bar plot.

6 Dry run analysis

In this section a 'dry run' of a candidate MP is performed, using the most recently available data up to 2022. For this analysis, a catch-based MP based on HCR 1 is used. The output of the MP is a catch limit that would be applied for the period 2025-2027. The potential impacts of different constraints are explored.

The EM ran successfully to convergence with a maximum gradient of $8.7e^{-7}$. The predicted CPUE of the two index fisheries tracks the observed CPUE, noting that there is no longer a WCPFC-CA troll CPUE index for the EM (Figure 9).

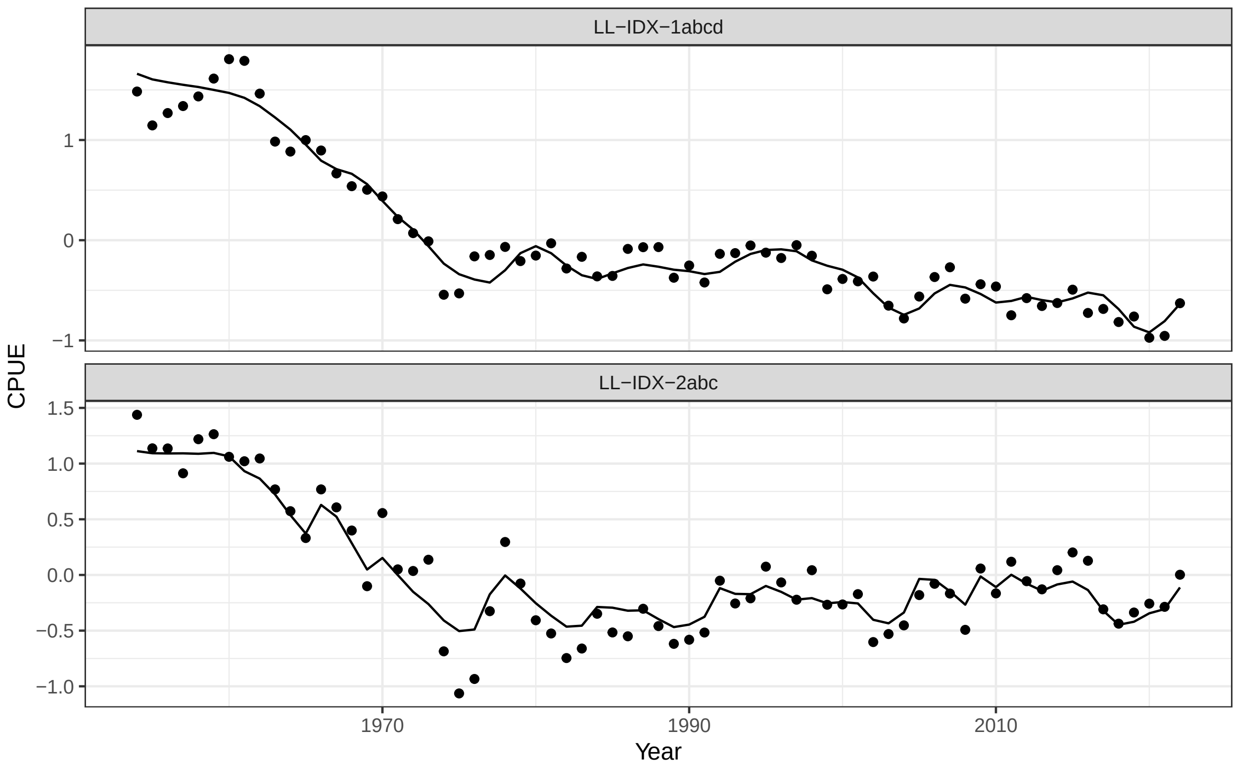

Figure 9: Observed (points) and predicted (lines) CPUE for the index fisheries (top panel is WCPFC-CA, bottom panel is EPO) from the EM for the dry run analysis.

The relative HCR input, as estimated by the EM, is calculated as 1.2184. The output scaler, with no constraint, from the MP is therefore 1, i.e. without a constraint the new catch limit would be set to the baseline catch level of 2020-2022 catches (60,700 mt) (Figure 10). Here any constraint is applied to the catches in the last data year of 2022 (67,400 mt), i.e. with a constraint, the new catch limit would not be able to change by more than X% from this catch level. The new catch limit for various constraints is shown in Table 3.

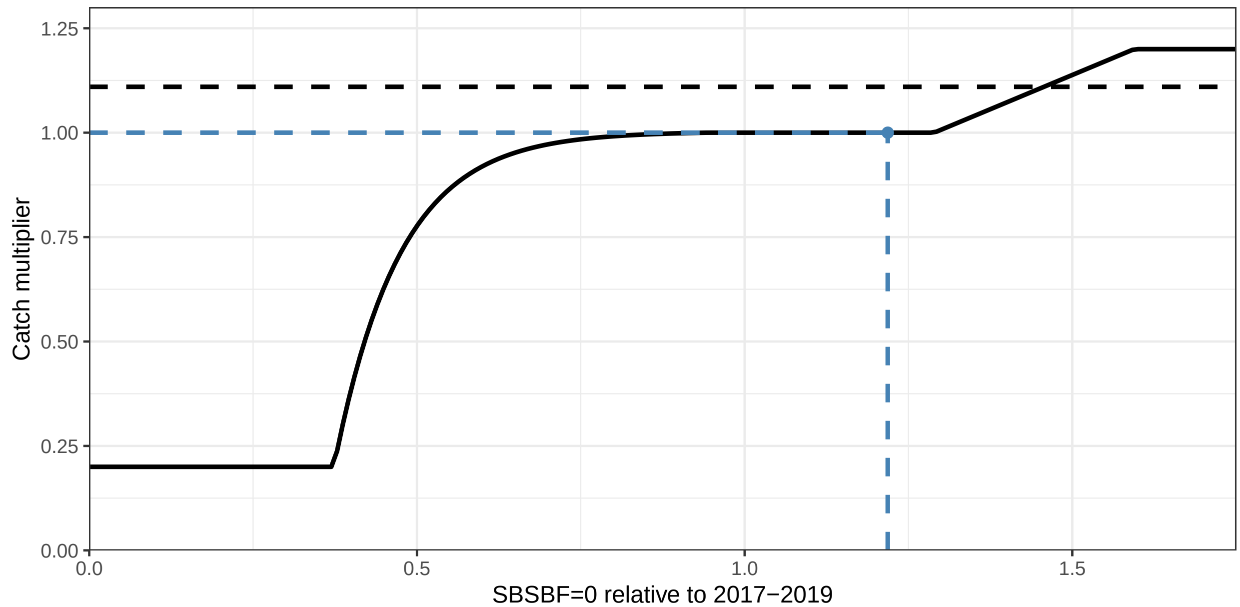

Figure 10: The result from the dry run analyses, using input data up to 2022 and a catch-based MP with HCR 1. The estimated stock status from the EM is used as the input to the HCR (vertical blue dashed line). The horizontal blue dashed line shows the resulting scaler with no constraint. The horizontal black dashed line shows the effective scaler from the previous time period, i.e. the catch level in 2022, relative to the baseline catch level (the average of 2020-2022).

Table 3: Resulting catch limit set by catch-based MPs with HCR 1 and different constraint options using data up to 2022 (dry run analysis). The baseline catch in WCPFC-CA (average of 2020-2022 levels) is 60,700 mt. The constraint is applied to the 2022 catch level of 67,400.

Constraint	New catch limit (mt)
None	60,700
+- 5%	64,000
+- 10%	60,700
+10%, -5%	64,000

Acknowledgments

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Appendix: Summary of relevant SC20 outcomes

The following are relevant outcomes from SC20 (numbering follows the SC20 Outcomes Document).

5.1.2 South Pacific albacore tuna

5.1.2.1 Target reference points

106. SC20 recognized that WCPFC20 adopted an interim TRP for South Pacific albacore, defined as 4% below the estimated average spawning potential depletion of the stock over the period 2017-2019 (0.96 SB2017- 2019/SBF=0). SC20 recommended the Commission note that the biomass depletion associated with the adopted interim TRP has been re-estimated to be 50% according to the 2024 SPA stock assessment outcomes. This biomass depletion when the interim TRP was adopted by WCPFC20 was previously estimated at 47% based on the 2021 SPA stock assessment.

5.1.2.2 South Pacific albacore operating models

110. SC20 adopted the operating model reference set, together with the proposed robustness set (Table 2, SC20-MI-WP-04), for the evaluation of candidate south Pacific albacore MPs.

111. SC20 noted there are concerns about the range of uncertainty covered by the current operating model set. SC20 recommended that future work to elaborate the OM sets be conducted through the monitoring strategy and could include:

- development of scenarios for the impacts of climate change
- consideration of potential effects of effort creep and/or hyperstability in CPUE
- development of models that address uncertainties around stock structure to the robustness set.

112. SC20 recommended that simulations be conducted to explore the implications of assuming a single stock OM when there could be multiple stocks. If ongoing genetics work confirms the presence of multiple-stocks and the simulations indicate that the single-stock assumption made in the OMs is problematic, then exceptional circumstances should be considered and the OM sets should be revised to account for multiple reproductive stocks in the South Pacific.

5.1.2.3 South Pacific albacore management procedure

113. SC20 recommended that SPC focus primarily on the following two ASPM-derived estimators with a view to having a robust estimator, without obvious future data vulnerabilities:

- A direct biomass depletion approach using mean SB/SBF=0 of the last three years; and
- A ratio approach that uses Mean SB/SBF=0 of the last three year (same as in 1.a) relative to 2019-2022.

114. SC20 noted that there was bias in estimation model performance at low predicted stock sizes. SC20 recommended that this bias be addressed through the design of the HCR and its significance or otherwise will be evaluated through evaluation of candidate MPs. Should the estimation model bias become problematic in the MP design context, then steps will need to be taken to address that issue.

115. SC20 recommended that SPC conduct a Management Strategy Evaluation of a range of candidate MPs, using updated estimators together with HCR and maximum change metarule specifications similar to those presented at SC19 (SC19-MI-WP-06).

116. SC20 recommended that SPC, in addition to running projections assuming a single baseline for all fisheries within the Management Procedure evaluations, explore the potential implications of using different reference periods for different fisheries and gears within the MP.

117. SC20 recommended that EPO catches be assumed to remain constant at recent levels but with an exploration of a case where the EPO is subject to MP controls (in a similar way to SC20-MIWP-03).

118. SC20 noted that it was desirable to constrain the number of candidate MPs evaluated for consideration and recommended that steps be taken to manage this, including using one-off variations from a base-case scenario, rather than a full factorial grid of options.

119. SC20 recommended that, to the extent possible, the results of the above candidate MP evaluations be provided to the SMD and the Commission for their consideration or decision.

Appendix: Summary of relevant SMD02 outcomes

The following are relevant outcomes from SMD02 (numbering follows the SMD02 Outcomes Document).

6.1 4.3 South Pacific Albacore Management Procedures

4.3.1 Interrogation of performance indicators and identification of preferred outcomes

9. SMD02 expressed appreciation for the evaluations undertaken by the SSP of selected candidate Management Procedures for South Pacific albacore (WCPFC-SMD02-2024-BP-02).

10. SMD02 supported maintaining all the current performance indicators noting that those focused on vulnerable biomass and catch stability are critical for South Pacific albacore fisheries.

4.3.2 Settings and Assumptions of the MPs

11. SMD02 supported a 3-year frequency for running the South Pacific albacore Management Procedure (MP), which is in line with the current skipjack MP, the South Pacific albacore assessment schedule, and the biology of South Pacific albacore, and which balances responsiveness to stock status changes and stability for fishery operations.

12. SMD02 supported the removal of candidate MPs that use an absolute estimator, and MPs using Harvest Control Rule (HCR) 4, from the set of candidate MPs provided in WCPFC-SMD02-2024-BP-02.

4.3.3 Additional work to be conducted by the SSP to support decision-making on MPs

1. SMD02 agreed to the additional work set out in Table 1. SMD02 also suggested that other items on the list be further considered by the Commission within the prioritization process of the work of the SSP in 2025 as appropriate.

2. SMD02 noted that there were several requests from WCPFC20 and SC20 regarding SP-ALB TRPs, SP- ALB MP-related analyses, and BET/YFT TRP analyses, which the SSP is currently undertaking. These requests, as well as the SP-ALB MP analysis requests, which do not require additional science units and can be managed within SSP existing resources are outlined in Table 2.

3. SMD02 requested that the data used in SPAMPLE be made available either publicly or on request, in accordance with the Commission's data rules.

Table 1 – List of new SP-ALB MP-related analyses to be prioritised for attention by SSP before WCPFC21, in addition to ongoing analyses requested by WCPFC20 and SC20, or requested by SMD02 which do not require additional science units. **Analyses in the blue shaded cells (12/13 and 14) were selected by ballot of participating CCMs at SMD02 for implementation.**

Subject	Request	Technical feasibility	Science units	SSP Notes
SP-ALB TRPs	1. Perform evaluation setting EPO Catches to 2017-2019 avg levels	OK	2	SC20 request
SP-ALB MPs	3. Evaluate MPs based upon effort	Medium, currently possible for LL fisheries only	10	WCPFC20 request. Run across the reduced grid of 7 MPs that SMD02 defined.
	4. Evaluate MPs with EPO fishing set at 2017-19 levels	OK	-	Done as a one-off sensitivity for SMD02. Could be used as a robustness test for 'adopted' MP.
	5. Provide VB performance indicator relative to 2020-2022	OK	-	Done for SMD02
	11. Exclude archipelagic waters from the MP control	OK	-	Part of the MSE framework that had not been fully developed in time for SMD02 but will be added.
	12/13. Evaluate new MP: HCR where threshold level is to the left of the iTRP Evaluate new MP: HCR where change point is at 0.85 and a constraint of 20%	OK	2*	Modification of HCR1 with a 5% constraint and relative input into the HCR. The absolute change point at $0.45SB_{F=0}$ will be translated into the relative equivalent. **NOTE**: on the assumption that just on catch-based MPs. If also anticipated for effort-based MPs, 4 science units. Modification of HCR1 and relative input into the HCR. **NOTE**: on the assumption that just on catch-based MPs. If also anticipated for effort-based MPs, 4 science units.
	14. Evaluate HCR where Hillary step lies across the range 0.37 to $0.47SB_{F=0}$ after EM bias correction[1]	OK	2*	Modification of HCR2 design with a 5% constraint and relative input into the HCR (see footnote [1]). **NOTE**: on the assumption that just on catch-based MPs. If also anticipated for effort-based MPs, 4 science units.
	15. Make data within SPAMPLE available	OK, dependent upon the format of the data being requested	-	Data underpinning the plots within SPAMPLE are available on request.
BET/YFT TRPs	16. Re-evaluate setting R2 YFT 'miscellaneous fisheries' fishing to more recent levels	OK	4	SC20 request. YFT R2 fishing will be in terms of effort. Implies re-running the 'nuclear grid'.

(Maximum number of points available before WCPFC21, in addition to ongoing work: **4**)

Table 2. List of new SP-ALB MP-related analyses that were *not* prioritized for the work of the SSP before WCPFC21. Analyses with ~~strikethrough~~ (2 and 17) were not included in the ballot because they were considered unnecessary (item 2) or not feasible within the time available prior to WCPFC21 (item 17). The remaining analyses (6, 7, 9, 10, and 17) could be considered by WCPFC21 for implementation in 2025 if still necessary.				
Subject	**Request**	**Technical feasibility**	**Science units**	**SSP Notes**
~~SP-ALB TRPs~~	~~2. Present vulnerable biomass outcomes relative to 2020-2022 levels~~	~~OK~~	~~1~~	~~SMD02 request. Note results within SPAMPLE are presented in this way and were considered sufficient, so no science units were considered necessary.~~
SP-ALB MPs	6. Evaluate the impact of MP not applying to PICT fleets in 1a, 1b, 1c, 1d	OK	3*	Perform as a one-off sensitivity from HCR1 with a 5% constraint using a relative HCR input. Fishing of the uncontrolled 'PICT' fleets set to 2017-2022 average. **NOTE**: if this were across all 7 MPs, this would be 10 science units. Catch-based MPs only. If also on effort, 6 science units are required.
	7. Evaluate the baseline of 2000-2004 for all fisheries (LL + TR)	OK	2*	Perform as a one-off sensitivity from HCR1 with a 5% constraint using a relative HCR input. Assuming HCRs are unadjusted from the current (output of 1 = 2000-2004). **NOTE**: if this were across all 7 MPs, this would be 8 science units. Catch-based MPs only. If also on effort, 6 science units are required.
	9. Add gear specific catch as additional performance indicators	OK	1	LL and TR as a total will be presented in the SPAMPLE tables only.
	10. Add catch and effort variability performance indicators under effort-based runs	Medium	3	As a request, effort variability includes effort-based runs only (linked to the WCPFC20 request above)
BET/YFT TRPs	~~17. Re-evaluate setting R2 BET 'miscellaneous fisheries' fishing to more recent levels~~	~~OK~~	~~8~~	~~Not requested by SC20. YFT R2 fishing may need to be in terms of effort. Implies re-running the 'nuclear grid'. Two recruitment scenarios to be evaluated.~~

Appendix: Main assumptions behind the MSE framework

The MSE framework is described in WCPFC-SMD02-2024/SMD02-BP-02 (Scott et al., 2024b).

6.2 Main MSE assumptions

The key assumptions and settings for the framework are:

- The simulations start in 2023 and run until 2053.
- The MP is first run in 2025 and the output applied in 2026.
- For the evaluations where the MP sets catch limits, the catches for all fisheries in the WCPFC-CA in the period 2023-2025 are set to the average of their 2017-2022 levels.
- For the evaluations where the MP sets effort limits, the effort for all fisheries in the WCPFC-CA in the period 2023-2025 are set to the average of their 2017-2022 levels.
- The management period is three years, i.e. the catch or effort limits set by the MP are applied for the following three years.
- There is a data lag of two years, e.g. when evaluating the MP in 2025, data for the EM is available up to and including 2023.
- The output of the MP is applied in the following year for the remainder of that management period, e.g. when evaluating the MP in 2025, the output fishing levels are applied in 2026-2028.
- That MP output is applied equally to all fisheries (longline and troll) operating within the WCPFC-CA south of the equator.
- The catch or effort limits specified by the MP are always fully utilised (if possible), i.e. there is no implementation error.
- The MP does not apply to fisheries operating in the EPO region of the model, unless otherwise specified.
- The total catches of fisheries operating in the EPO region of the model are fixed at 22,500 mt per annum.

6.3 Operating models

The operating model (OM) grid is based on the 2024 South Pacific wide stock assessment (Scott et al., 2024c; Teears et al., 2024). There are 200 pairs of steepness and natural mortality values, sampled independently from assumed distributions. Two levels of historical recruitment are used on which to base future variability: 1973-2020 and 2000-2020. Two levels of effort creep are applied to the longline fisheries only: 0% and 1% per annum. Note that the inclusion of effort creep in the simulations has been improved since SMD02. A factorial combination of these factors gives 800 OMs.

The fisheries managed through the MP (i.e. those in the WCPFC-CA, model area 1) are managed either through the setting catch limits or effort limits, depending on the MP being evaluated.

Stochasticity is included in the projections by applying randomly sampled recruitment deviates to the recruitment calculated by the stock-recruitment relationship. Each OM uses different samples of recruitment deviates so that the projected recruitment for each of the OMs is different.

Observation error with a CV of 20 is applied to the catch and catch-per-unit of effort (CPUE) data used by the EM.

Appendix: Estimation model update

The estimation method described in WCPFC-SC20-2024/MI-WP-05, and used for the evaluations presented at WCPFC-SMD02, has three index fisheries: a longline and troll index in the WCPFC-CA model region and a longline index in EPO model region (Scott et al., 2024a,b).

In the evaluations presented here the estimation method has been updated to only use the two longline indices. This removes the reliance on the troll index and helps to 'future proof' the MP.

In this Appendix the performance of the updated estimation method is examined.

The estimated and true HCR inputs from the estimation methods with and without the troll index are compared for evaluations of eight MPs based on HCRs 1, 2 and 3 in Figure 11 (the true input is taken directly from the OMs). The HCR input is the estimated $SB/SB_{F=0}$ of the last three years relative to the estimated $SB/SB_{F=0}$ in the period 2017-2019.

Although more scatter is present without the troll index, it is worth noting that there are 53,000 points in each panel so outlying points may look more frequent than they really are.

The coefficients and R-squared value from fitting a linear regression are shown in Table 4. Without the troll index the R-squared value is slightly lower. However, the relationship between the estimated and true HCR input is still strong, and the the estimated stock status from the estimation method remains a good guide to the true stock status.

Table 4: Coefficients and R-squared value from fitting a linear regression to the estimated and true HCR inputs from the estimation methods with and without the troll index.

Estimation method	Intercept	Slope	R-squared
With troll index	0.06	0.86	0.92
Without troll index	0.13	0.78	0.89

It is worth noting that the HCR shapes evaluated here have been modified to account for perceived bias between the true and estimated stock status. The relationship for that modification is taken from the estimation method with all three indices (Scott et al., 2024a). Without the troll index the perceived bias is slightly different (see the regression coefficients in Table 4).

Performance indicators from using the estimation method with and without the troll index are almost unchanged across the candidate MPs (several examples are shown in Figure 12).

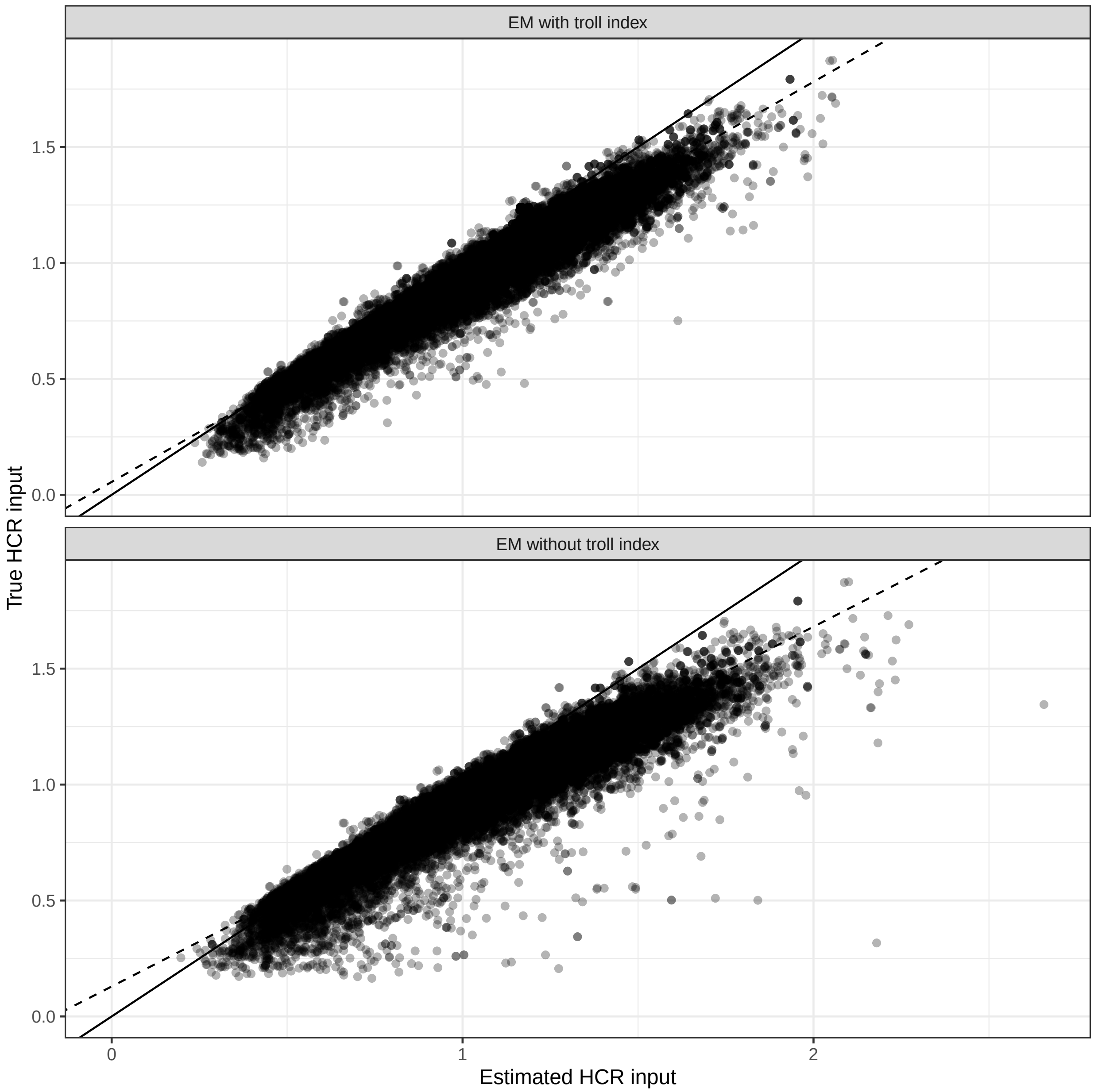

Figure 11: Comparing the estimated and true (from the operating models) HCR inputs from the estimation methods with and without the troll index. The results are taken from evaluations of eight MPs based on HCR 1, 2 and 3 where the MP sets a catch limit. The HCR input is the estimated $SB/SB_{F=0}$ of the last three years relative to the estimated $SB/SB_{F=0}$ in the period 2017-2019. Each panel has the results of over 53,000 evaluations of the estimation method. The solid line is a 1-1 line, the dashed line shows the results from fitting a linear regression.

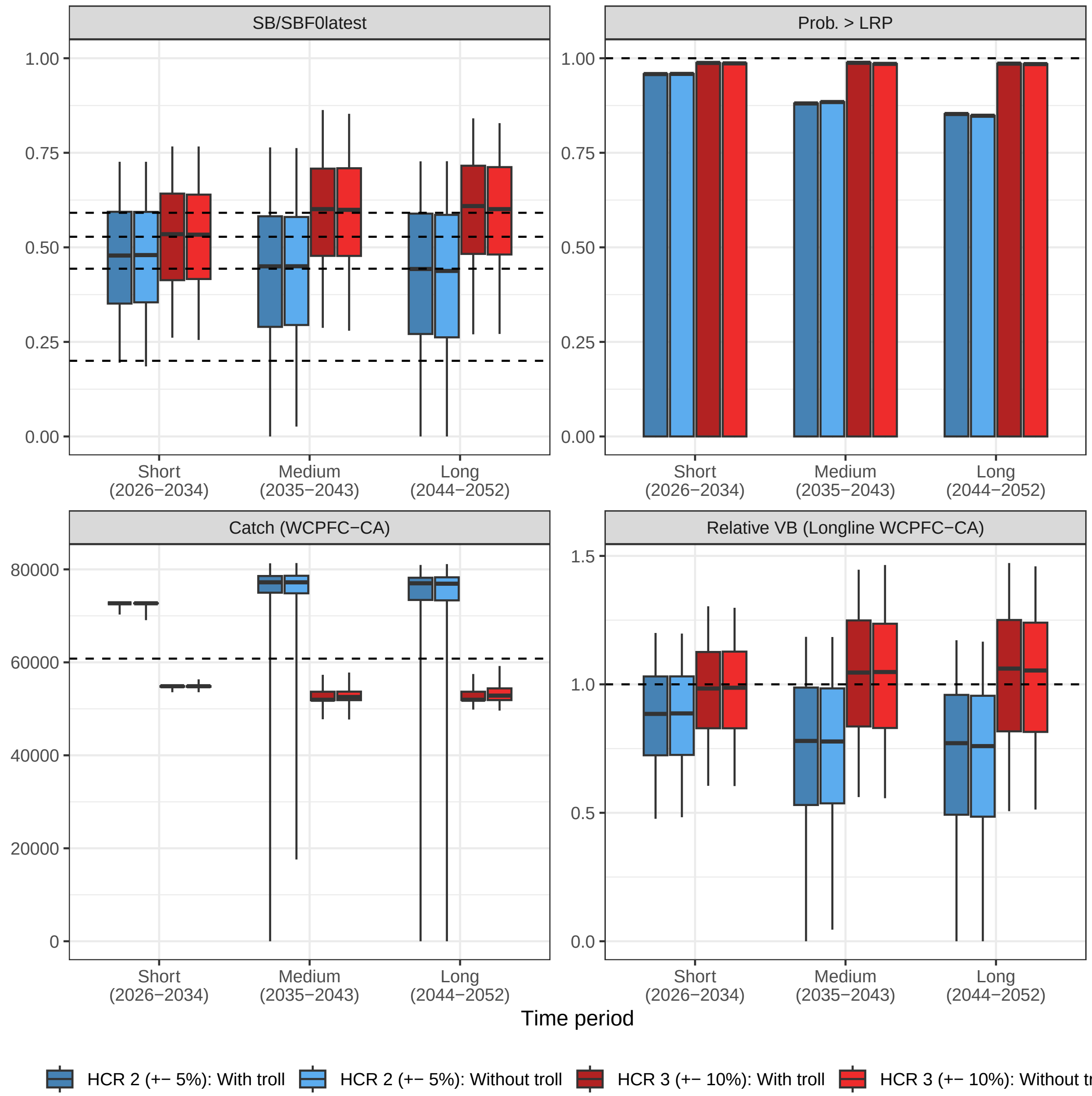

Figure 12: Comparison of four performance indicators for two MPs with and without the troll CPUE index in the estimation method.

Appendix: Estimation model settings

Table 5: Settings for the estimation method

Model setting	Value
Regional structure	2 regions
Number of fisheries	19
Longline	13
Troll / DN	3
Index	2 (longline only)
Steepness	0.8
Natural mortality	Lorenzen, M12=0.36
Growth	Fixed
ML1	45.538
ML2	100.115
K	0.3932
Movement rates	Fixed (2024 assessment)
Selection patterns	Fixed (2024 assessment
Average recruitment	Last 2 years
Recruitment distribution	0.819, 0.181