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Evaluation of candidate management procedures for South Pacific albacore

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SPC-OFP

Executive summary

This report presents recent evaluations of candidate management procedures (MPs) for South Pacific albacore (SPA) and updates WCPFC-SC21-2025/MI-WP-04 REV1.

Following the mixed fishery harvest strategy approach, the SPA MP applies to longline and troll fisheries operating in the region south of 10°S in the WCPFC-CA. In previous evaluations, presented to SMD02 and WCPFC21 in 2024, the MP applied to longline and troll fisheries operating in the WCPFC-CA, south of the equator. As requested by SC21, additional information to support this change, including Commission decisions, are provided in this report.

To run the evaluations it is necessary to make an assumption about future albacore fishing levels in the equator to 10°S region of the WCPFC-CA, known as the tropical longline (TLL) fishery, and the EPO (excluding the overlap area). For the TLL fishery, the baseline assumption is that the future catches of albacore are fixed at 9000 mt per annum (approximately the average of 2014-2023 catches). The assumed future catch levels of albacore in the EPO are fixed at 18,000 mt per annum (approximately the average of 2014-2023 catches). In the previous evaluations they were fixed at 22,500 mt per annum. As requested by SC21, information is provided to support these assumptions.

Four candidate MPs are evaluated using these baseline EPO and TLL assumptions. Three are catch-based, i.e. output a catch limit, and the other is effort-based, i.e. outputs an effort limit. It should be noted that the allocation of the catch or effort limit, and how those allocations are managed in practice (e.g. through effort if the allocation is in terms of catch, or catch if the allocation is in terms of effort) is external to the MP. The candidate MPs are designed to achieve the interim target reference point (iTRP) or the proposed upper or lower TRP range in the long-term. Constraints are applied to how much the output of an MP can change between management periods.

Sensitivity tests are performed for one of the candidate MPs in which the future SPA catches in the EPO and in the equator to 10°S region of the WCPFC-CA are set at 22,500 and 12,000 mt per annum respectively, i.e. higher than the baseline assumptions. These tests show that the performance of the candidate MP is not strongly affected by the alternative catch assumptions.

The estimation method (EM) of the MPs is an age-structured production model, implemented in Multifan-CL, as presented to SC20, SMD02 and WCPFC21 that uses the longline indices in the WCPFC-CA and EPO. The EM outputs a relative indicator of stock status (average $SB/SB_{F=0}$ in the last three estimated years relative to the average $SB/SB_{F=0}$ in 2017-2019), as agreed by SMD02. SC21 recommmeded the continued use of this EM.

Six performance indicators are calculated to evaluate the relative performance of the candidate MPs, including expected $SB/SB_{F=0}$ (to be compared to candidate TRP levels), expected catch levels, and expected vulnerable biomass (a proxy for catch rates).

SC21 made additional requests, including:

- Provide sufficient explanation and additional information as necessary (such as historical catch trajectory in the EPO and the area bounded by 0-10°S) to the SPAMWS01 (September 2025) and to WCPFC22 to assist decision makers.
- Three additional MPs be developed for the Commission's consideration that more fully explore EPO (excluding overlap area) catch consequences as well as the use of a fixed effort assumption in the WCPFC-CA from the equator to 10°S.
    1. EPO (excluding the overlap area) set to 22,500 mt (being the approximate average of catches in the years 2021-22), WCPFC-CA 0-10°S set to 9,000t (being the approximate average in the period 2014-2023), using a catch control HCR 'tuned' to achieve the adopted iTRP.
    2. EPO (excluding the overlap area) set to 13,500 mt (being the approximate catch in the year 2020), WCPFC-CA 0-10°S set to 9,000t (being the approximate average in the period 2014-2023), using a catch control HCR 'tuned' to achieve the adopted iTRP.
    3. EPO (excluding the overlap area) set to 18,000 mt (being the approximate average for the period 2014-2023), WCPFC-CA 0-10°S set to average effort levels in the period 2014-2023, using a catch control HCR 'tuned' to achieve the adopted iTRP.
- The results of this expanded set of seven candidate MP evaluations and all candidate MP evaluations in WCPFC21-2024-30 (those applied to longline and troll fisheries operating in the WCPFC-CA, south of the equator) be provided to the SPAMWS01 in September 2025 and to the Commission for their consideration and decision.
- Reporting the median time series of vulnerable biomass from the OMs for the historical period and to develop a table with the average nominal CPUE (kg/100 hooks) for the reference period (2020-2022) by CCMs with South Pacific albacore catches.

All of these requests have been completed and are presented in this report.

1 Introduction

This report describes the most recent evaluations of candidate management procedures (MPs) for South Pacific albacore following feedback and outcomes from SC20, SMD02, WCPFC21 and SC21 (WCPFC, 2024a,b,c; SPC-OFP, 2024a; WCPFC, 2025b). The relative performance of the MPs is summarised through the calculated performance indicators.

The analyses presented within this paper are based on different assumptions from those presented to the Commission in WCPFC21-2024-30 (REV1) (SPC-OFP, 2024a). Primarily, fishing for South Pacific albacore is now being controlled within the southern WCPFC-CA below 10°S, rather than from the equator. This change was highlighted within WCPFC Circular 2025/17, distributed on the 4th April 2025 (WCPFC, 2025a). Following presentation to SC21, the SSP was encouraged to "provide sufficient explanation for the change and additional information as necessary (such as historical catch trajectory in the EPO and the area bounded by 0-10°S) to the SPAMWS01 and to WCPFC22 to assist decision makers". We therefore provide a summary of the decisions made by the Commission and its subsidiary bodies that underpin the changes made.

The mixed fishery framework has had several names and has been discussed over many years. WCPFC-SC14-MI-WP-05 noted the need to develop 'multi-species approaches' to harvest strategies, given many of the fisheries under consideration affect more than one key tuna stock (SPC, 2018). This was expanded upon in WCPFC-SC15-MI-WP-04, and a tentative framework put forward where MPs for skipjack, South Pacific albacore and bigeye interacted to achieve objectives for all four stocks (including yellowfin), and the MP for South Pacific albacore would relate to the southern longline and troll fisheries (operating south of 10°S) (Scott et al., 2019). SC15 endorsed the use of this 'hierarchical approach' based on single species operating models as a way forward and recommended that WCPFC16 note the approaches and associated challenges (SC15 summary report, para 457) (WCPFC, 2019). WCPFC16 duly tasked the SC and SSP with progressing work on the 'multispecies approach' (WCPFC16 summary report, para 195) (WCPFC, 2018). While discussion was limited during the COVID period, SC17 reviewed a proof-of-concept of the 'multi-species modelling framework for mixed fishery interactions', endorsed the proposed work, and recommended the Commission take note of the progress (SC17 summary report, paras 127-128) (WCPFC, 2021). WCPFC18 incorporated the 'the mixed fishery (multispecies) approach' within the agenda for the first Science-Management Dialogue meeting (WCPFC, 2022a). Updates on progress within the mixed fishery framework have subsequently been given to the SC18 and SC19 meetings (Scott et al., 2022c,b,a, 2023).

As noted in WCPFC Circular 2025/17, the adjustments to the area of control for South Pacific albacore arose from WCPFC21 outcomes, to incorporate the request for parallel development and adoption of the South Pacific albacore and bigeye tuna MPs under the mixed fishery framework within the next two years (WCPFC, 2025a). These changes are consistent with the long-term development of the mixed fishery framework. We note that while the MP for South Pacific albacore

may control the level of fishing specifically south of 10°S - and catch levels between the equator and 10°S are assumed - the implementing measure may specify how the total southern Convention Area catch or effort is set and managed.

This paper also presents a reduced number of South Pacific albacore MPs compared to the 20 in WCPFC21-2024-30 (REV1) and WCPFC21-2024-30a (19 original MPs plus a supplementary request) (SPC-OFP, 2024a,b). As presented to WCPFC21, the level of constraint (the amount by which effort or catch was allowed to change up or down between management periods) had little impact on the performance of the candidate MPs. To simplify presentation, therefore, MPs with specific constraints are provided herein (+10% -5% for catch-based MPs, +-5% for the effort-based MP), reducing the number of MPs being presented from 20 (WCPFC21) to 4. If alternative constraints are desired, they can be evaluated.

The original 20 MPs, including their results, are described in WCPFC21-2024-30 (REV1) and WCPFC-2024-30a. The results can also be explored in the 2024 version of the online app: https://ofp-sam.shinyapps.io/SPAMPLE-WCPFC-2024. Note that this older version of the app does not contain the results presented in this report.

The main differences between the evaluations presented here and at WCPFC21 therefore is that fisheries operating in the area between the equator and 10°S within the WCPFC-CA are no longer managed through the South Pacific albacore MP. Under the mixed fishery harvest strategy framework, it is proposed that longline fisheries operating in this area, referred to as the tropical longline (TLL) fishery, will be managed through the bigeye MP, i.e. their fishing levels will not consider the stock status of South Pacific albacore. Catch levels of albacore in the equator to 10°S region of the WCPFC-CA make up about 12% of recent (2020-2022) total South Pacific albacore catch in the WCPFC-CA. It is therefore important that any adopted South Pacific albacore MP is robust to different levels of albacore catch by the TLL.

To run the candidate South Pacific Albacore MP evaluations, assumptions need to be made about the future level of albacore catches taken by the TLL, noting those albacore catches would vary dependent upon the bigeye MP output. These assumptions are described below (Section 2). The impact of alternative catch assumptions are explored in a series of sensitivity tests (Section 5.5). In this way, mixed fishery considerations are included in the evaluations.

Additional MP evaluations address requests made by SC21 (Section 6). Other requests from SC21 (see Executive Summary for details) have also been addressed.

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 Appendices.

Fisheries operating in the EPO (excluding the overlap) and WCPFC-CA 0-10°S areas of the OMs are not managed through the South Pacific albacore MP. The South Pacific albacore MP therefore defines the level of fishing by longline and troll fisheries in the WCPFC-CA, south of 10°S, and adjusts that level as needed to achieve management objectives.

To run the South Pacific albacore candidate MP evaluations assumptions are made on the level of future albacore catch in the EPO and the WCPFC-CA 0-10°S areas. For the evaluations presented here, the future catches in these areas are fixed at the approximate average levels in the years 2014-2023:

- Future level of albacore catch in the 0-10°S area of WCPFC-CA (the TLL fishery) is fixed at 9000 mt.
- Future level of albacore catch in the EPO area (excluding the overlap) is fixed at 18,000 mt.

As requested by SC21, the historical catches in these regions can be seen in Figure 1. Note that the 18,000 mt in the EPO area is less than the level of 22,500 mt used in the evaluations presented to WCPFC21 (SPC-OFP, 2024a).

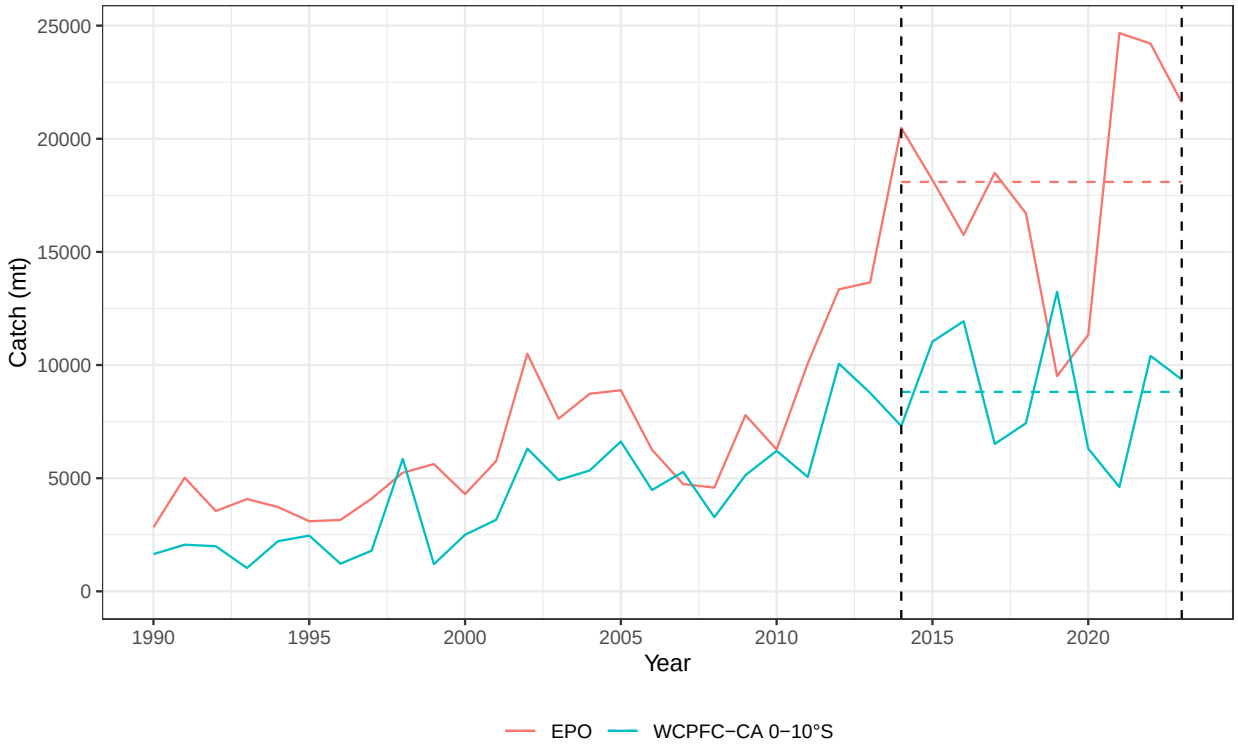

Figure 1: Time series of total albacore catches in the WCPFC-CA 0-10°S and EPO (excluding the overlap) areas. The time period used for the EPO and TLL catch assumptions (2014-2023), and corresponding average catch, is shown by the dashed lines.

Sensitivity tests are performed whereby candidate MPs are tested against alternative future catch levels in these two areas. As the adoption of an South Pacific albacore MP is conditional upon

the assumptions made about future catches in these areas, catches in these regions will need to be monitored as part of the South Pacific albacore MP monitoring strategy to determine if these assumptions are still valid.

Another assumption is the catches of albacore in the WCPFC-CA, south of 10°S in the period 2023-2025, i.e. between the start of the evaluations and when the MP is first applied (the 'transient' period). In these evaluations the catches in the transient period are set to the 2017-2022 average of approximately 58,800 mt per annum. Data for 2023 and 2024 show the actual catches in the south of 10°S area are approximately 51,500 and 57,300 mt respectively, supporting this assumption.

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 South Pacific albacore catch taken in archipelagic waters in the WCPFC-CA is calculated to be less than 1% of the total South Pacific albacore 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 under MP control. Following implementation of an MP for South Pacific albacore, the level of catch in archipelagic waters would be monitored within the monitoring strategy.

3 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 key assumptions for the MPs are:

- All fisheries in the WCPFC-CA, south of 10°S, 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 scalar that is applied to the baseline catch or effort. Associated catch limits are shown for the catch-based MPs.
- The current baseline for each HCR is the average catch or effort in the period 2020-2022 within the WCPFC-CA, south of 10°S, i.e. an output scalar of 1 sets the catch or effort limit for the next management period to the average of 2020-2022 catches or effort.

- 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.

The evaluations assume that, dependent on the MP, the output will be either the total annual catch or total annual effort of longline and troll fisheries in the WCPFC-CA south of 10°S, for the next 3 year management period. Allocation of that total, and how those allocations are managed in practice (e.g. through effort if the allocation is in terms of catch, or catch if the allocation is in terms of effort) is external to the MP.

As described in the introduction, four candidate MPs are evaluated here. The candidate MPs are split into two groups: those that define the total future fishing level through setting catch limits and those that do so through setting effort limits.

3.1 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 the 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).

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) 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.

The updated EM performs well and SC21 recommmeded its continued use (SPC-OFP, 2024a; WCPFC, 2025b) .

3.2 Harvest control rules

The catch-based candidate MPs have 3 basic HCR shapes (HCRs 7, 10 and 13) and the effort-based candidate MP has one basic HCR shape (HCR 9) (Figure 2, Table 1). Each HCR has a similar shape to the HCR in the adopted interim skipjack MP, with a 'Hillary step' (WCPFC, 2022b). The HCR parameters for the catch-based MPs are different to the HCR for the effort-based MP as performance is affected by the management method (catch or effort).

Table 1: Parameter values of the HCR shapes.

HCR		Limit	Step start	Step end	Maximum
Catch-based MPs					
HCR 7	Relative $SB/SB_{F=0}$	0.37	0.94	1.29	1.59
	HCR output	0.2	1.05	1.05	1.25
	Catch output	10550	55370	55370	65920
HCR 10	Relative $SB/SB_{F=0}$	0.45	0.93	1.52	1.88
	HCR output	0.2	1.31	1.31	1.51
	Catch output	10550	69090	69090	79630
HCR 13	Relative $SB/SB_{F=0}$	0.33	0.95	1.15	1.43
	HCR output	0.2	0.82	0.82	1.02
	Catch output	10550	43510	43510	54060
Effort-based MPs					
HCR 9	Relative $SB/SB_{F=0}$	0.45	0.85	1.09	1.88
	HCR output	0.2	1.46	1.46	1.66

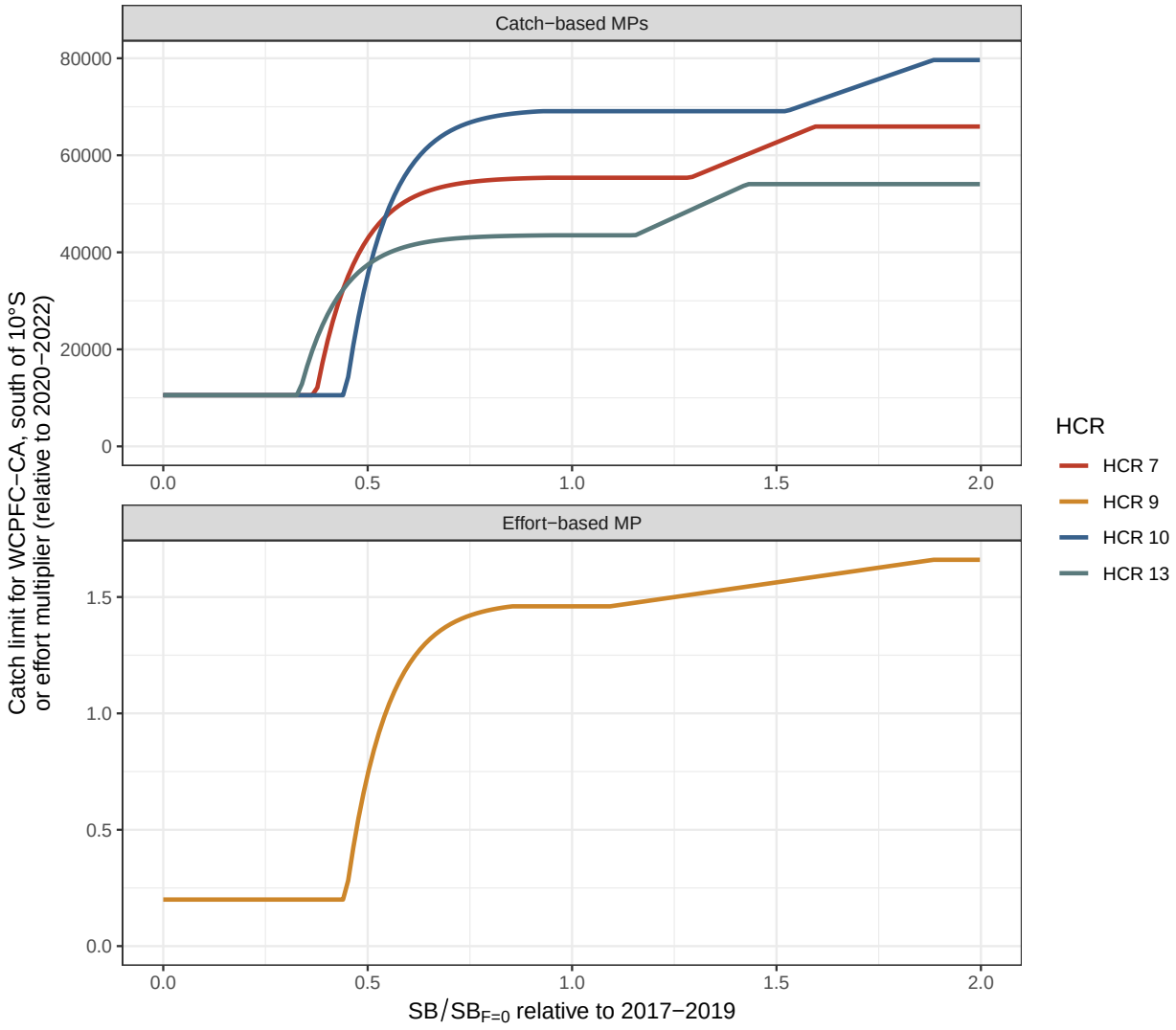

Figure 2: The basic HCR shapes. The MPs are split into two groups based on management output: catch- or effort-based. The input to the HCR is the mean $SB/SB_{F=0}$ of the last three years relative to 2017-2019. The output is a scalar applied to 2020-2022 levels of catch or effort, depending on the MP. For catch-based MPs, the associated catch limit for WCPFC-CA, south of 10°S is also shown in mt.

The HCRs have been designed to achieve performance in terms of long-term $SB/SB_{F=0}$, e.g. HCR 7 (catch-based) achieves approximately the same long-term $SB/SB_{F=0}$ as the iTRP, under baseline assumptions for future EPO and TLL catch levels (Table 2). The HCRs can continue to be tuned and refined to better achieve their objectives.

3.3 Meta-rules and constraints

The candidate MPs have constraints on how much the output of the HCR can change between management periods. Results presented in 2024 suggested that alternative constraint options had only a limited impact on the long-term results. As such, only a specific constraint option is currently evaluated for each HCR (Table 2). An additional constraint option is evaluated as a sensitivity test.

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 for 2026 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 assumed catch or effort in the 2023-2025 'transient period' is set to the average level in 2017-2022. These assumed catch and effort levels are higher than the baseline (2020-2022) catch and effort.

Table 2: The constraint options for the candidate MPs, and their overall long-term objective under baseline EPO and TLL catch assumptions (18,000 mt EPO and 9000 mt TLL per annum).

HCR shape	Constraint	Objective under baseline assumptions
Catch-based MPs		
HCR 7	+10 -5%	iTRP
HCR 10	+10 -5%	Lower TRP range
HCR 13	+10 -5%	Upper TRP range
Effort-based MPs		
HCR 9	+-5%	Lower TRP range

4 Performance indicators

Six performance indicators (PIs) are calculated. Note that the biomass indicators ($SB/SB_{F=0}$, probability of being above the LRP) are based on the biomass in WCPFC-CA, whereas the catch and effort indicators are based on the area in which the SPA MP operates, i.e. the WCPFC-CA, south of 10°S.

- $SB/SB_{F=0}$ 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 (iTRP) and any proposed alternative TRPs.

- Probability of the stock status in the WCPFC-CA 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, south of 10°S.
- Vulnerable biomass available to longline fisheries in the WCPFC-CA, south of 10°S. 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 WCPFC-CA catch, south of 10°S.
- Effort variability, calculated as the absolute annual difference in WCPFC-CA longline effort, south of 10°S, measured in 100s of hooks.

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

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

SC21 requested that the SSP report the median time series of vulnerable biomass from the OMs for the historical period and to develop a table with the average nominal CPUE (kg/100 hooks) for the reference period (2020-2022) by CCMs with SPA catches. These can be seen in the Appendices (Table 6).

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 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.

A brief summary of the results is presented here using box plots in the three different time periods. The box and whiskers show the 60th and 95th percentile ranges respectively. The larger the box and the longer the whiskers, the greater the uncertainty in the expected values.

Performance is summarised below. The main results include the baseline scenarios for future EPO and TLL catches (18,000 mt and 9000 mt, respectively). Sensitivity tests for different EPO and TLL future assumptions are shown below, including three additional MP evaluations requested by SC21 (Section 5.5; Section 6).

The interactive app, SPAMPLE, is recommended for exploring the results and may assist in selecting preferred MPs: https://ofp-sam.shinyapps.io/SPAMPLE. [1]

[1]The 2024 MPs, when the MP operated south of the equator, are described in WCPFC21-2024-30 (REV1) and WCPFC-2024-30a. The results can also be explored in the 2024 version of the online app: https://ofp-sam.shinyapps.io/SPAMPLE-WCPFC-2024.

5.1 Stock depletion and LRP risk

The range of expected $SB/SB_{F=0}$ for each candidate MP can be seen in Figure 3. WCPFC20 agreed an interim TRP (iTRP) 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 are shown as the top three horizontal dashed lines, the middle line being the iTRP. Note that these values were proposed on the basis of projections based on the 2024 stock assessment grid. The OM grid is different to the stock assessment grid and so the TRP values have been rescaled accordingly. The bottom dashed line is the LRP.

All current candidate MPs have a probability of being above the LRP greater than the WCPFC threshold of 0.8. The MP based on HCR 10, which achieves the lower range of the proposed TRP, shows the lowest probability (greatest risk).

5.2 Longline vulnerable biomass, south of 10°S

Vulnerable biomass is a proxy for CPUE (catch rates). The relative vulnerable biomass of longline fisheries in the WCPFC-CA, south of 10°S, follows a similar pattern to the $SB/SB_{F=0}$ results (Figure 3). The MP based on HCR 13, which achieves the upper TRP range in the long-term, has the highest vulnerable biomass, but in the short- and medium-term it is not much higher than the MP based on HCR 7. The effort based MP with HCR 9 has the narrowest range of anticipated outcomes, and like it's catch-based equivalent (the MP with HCR 10), implies larger reductions in vulnerable biomass.

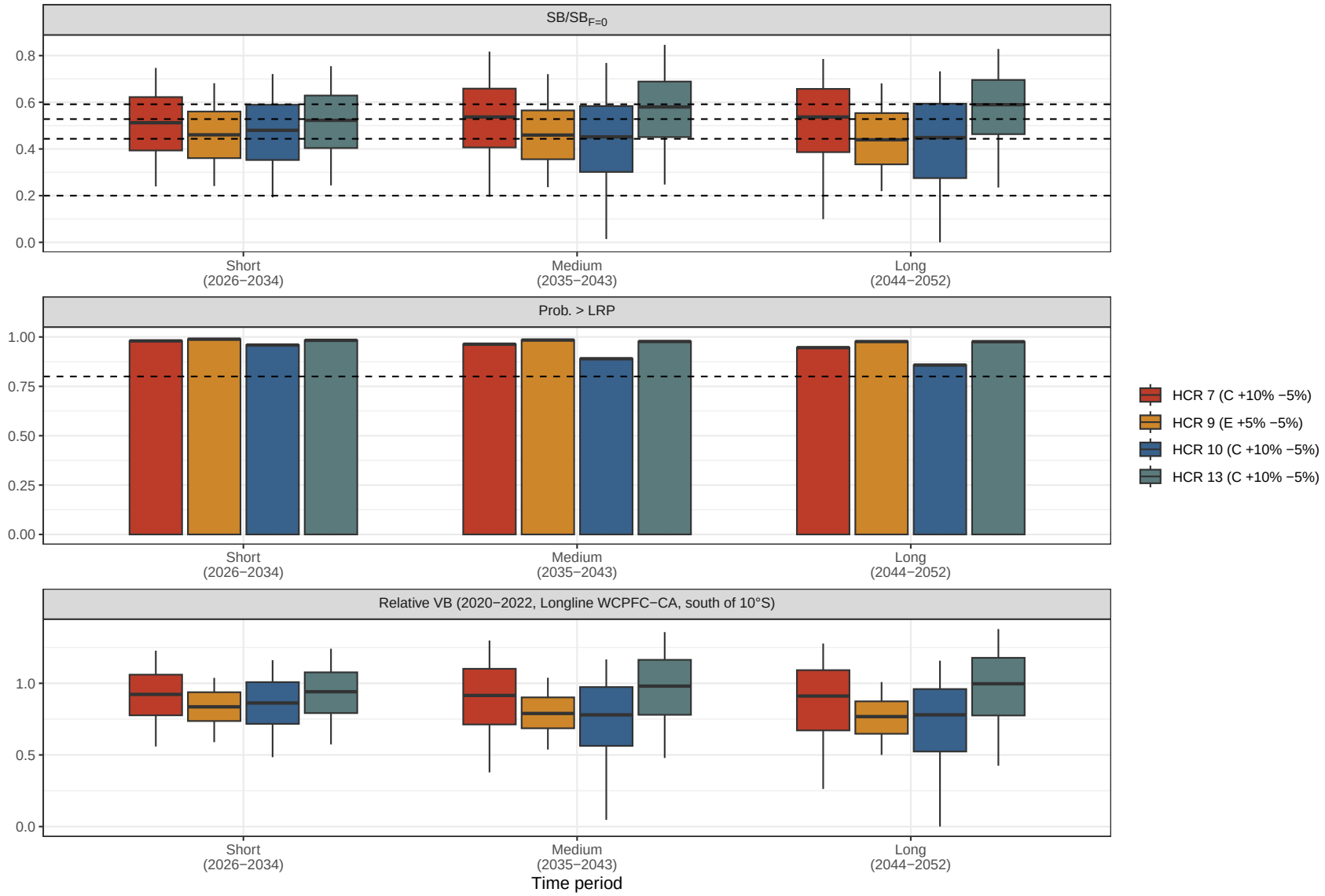

Figure 3: Box plots of SB/SB$_{F=0}$ in the WCPFC-CA and vulnerable biomass (VB) for the longline fisheries in the WCPFC-CA, south of 10°S, relative to the level in 2020-2022, and a bar plot (middle) of probability of being above the LRP. The whiskers show the 95th percentile range, the box shows the 60th percentile range, and the horizontal line is the median value. Horizontal lines on the SB/SB$_{F=0}$ plot are the iTRP (second from top), proposed TRPs from WCPFC20 and the LRP (bottom). 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 is conditional on the shape of the HCR (Figure 4). Only catches in the WCPFC-CA, south of 10°S are considered here.

The candidate MP with HCR 13 has the lowest expected catches, and is the only one which has catches lower than the 2020-2022 average level. This MP also achieves the highest level of stock status and vulnerable biomass, an example of the known trade-off choice between high catches and high catch rates.

Some of the advantages of having a catch-based MP setting can be seen in the low uncertainty in future catches, and also low levels of catch variability. The catch variability for the catch-based MPs will be partially determined by the constraint (here +10% -5%).

The long whiskers seen for the MP based on HCR 10 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 (Figure 4). For these iterations the catches are set to 0 for the remainder of the simulation. For this MP, 6% of the 800 iterations resulted in the stock crashing at the end of the time series. However, as the whiskers show the 95th percentile range (almost the full range of results), this is enough to result in the whisker reaching 0.

The effort-based MP with HCR 9 shows high levels of catch variability. This is because the level of realised catches is a product of the fishing effort and the vulnerable biomass. As biomass levels can vary due to natural processes (here modelled through recruitment variability) as well as fishing pressure, an effort-based MP can therefore result in variable catches, with a high level of uncertainty.

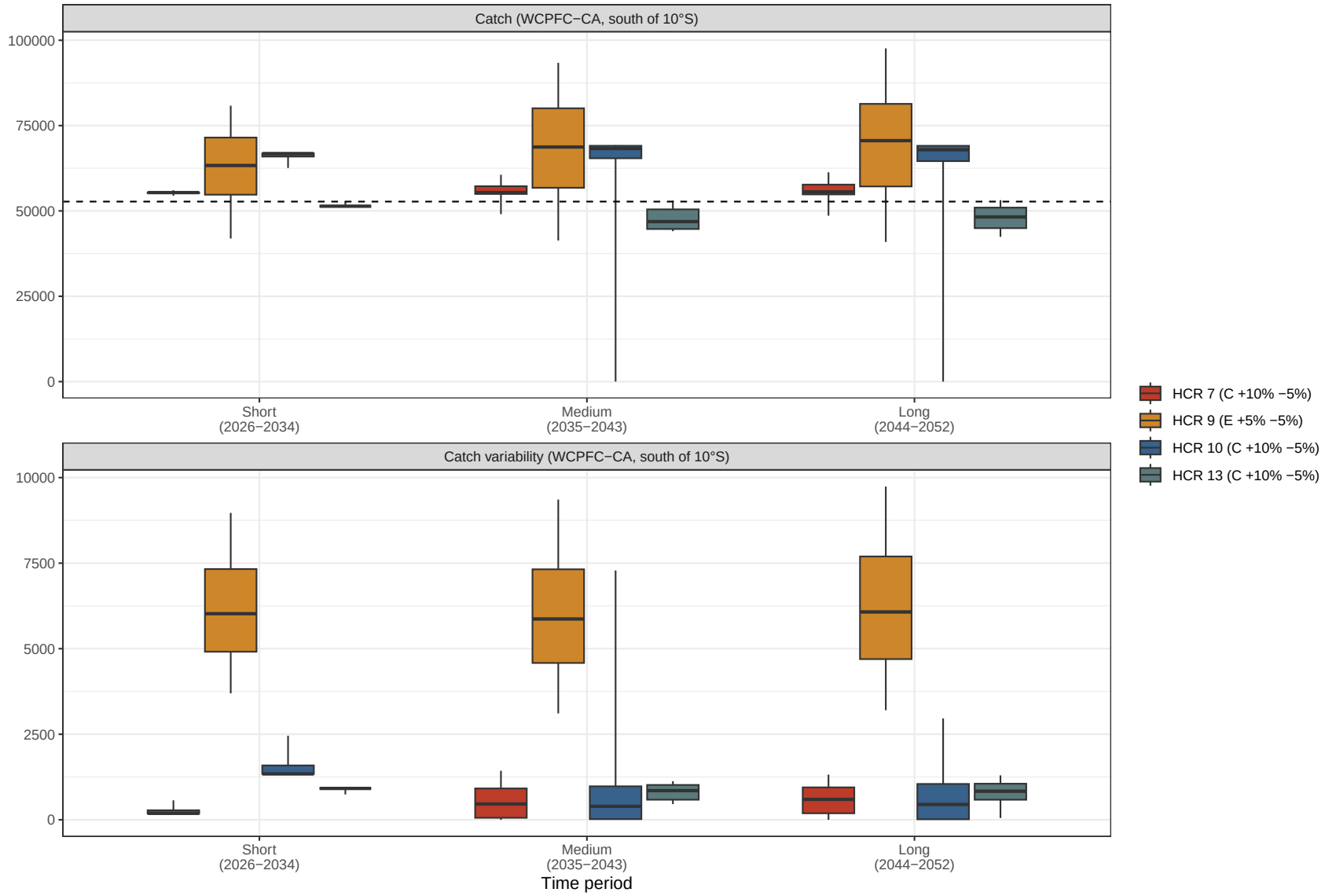

Figure 4: Box plots of total catch in the WCPFC-CA, south of 10°S, and associated average annual catch variability (both in mt). The whiskers show the 95th percentile range, the box shows the 60th percentile range, and the horizontal line is the median value. The dashed horizontal line on the catch plot is the HCR baseline, the average catch in 2020-2022 in the WCPFC-CA, south of 10°S.

5.4 Effort variability

As seen for catch variability, longline effort variability is strongly affected by the management method (Figure 5).

Catch-based MPs have higher effort variability than effort-based MPs. The amount of effort needed to take a set catch limit depends on the biomass available to the fishery. As noted above, biomass levels vary due to natural processes as well as fishing pressure. Therefore, the amount of effort needed to take a set catch limit varies over time, resulting in higher effort variability for the catch-based MPs.

The whiskers seen in Figure 5 are long for the catch-based MPs. 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. 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. This would greatly limit the effort variability.

As noted above, the output type of the MP is not necessarily how the limit set by the MP will be implemented, e.g. the catch limits specified by a catch-based MP may be implemented through effort limits. To implement a catch limit set by a catch-based MP as an effort limit requires a conversion between catch and effort. This conversion will likely be based on recently observed catch rates. Therefore, the effort limits that would be implemented would be expected to be as stable as the catch limits set by the catch-based MP, and subject to the same constraint on how much the output can change between management periods.

The average long-term effort variability for the effort-based MP with HCR 9 is lower than in the other two periods. The level of variability in that period is, however, less certain, i.e. there is more uncertainty in the expected effort variability. However, the change in effort between management periods is still constrained by the +-5% constraint.

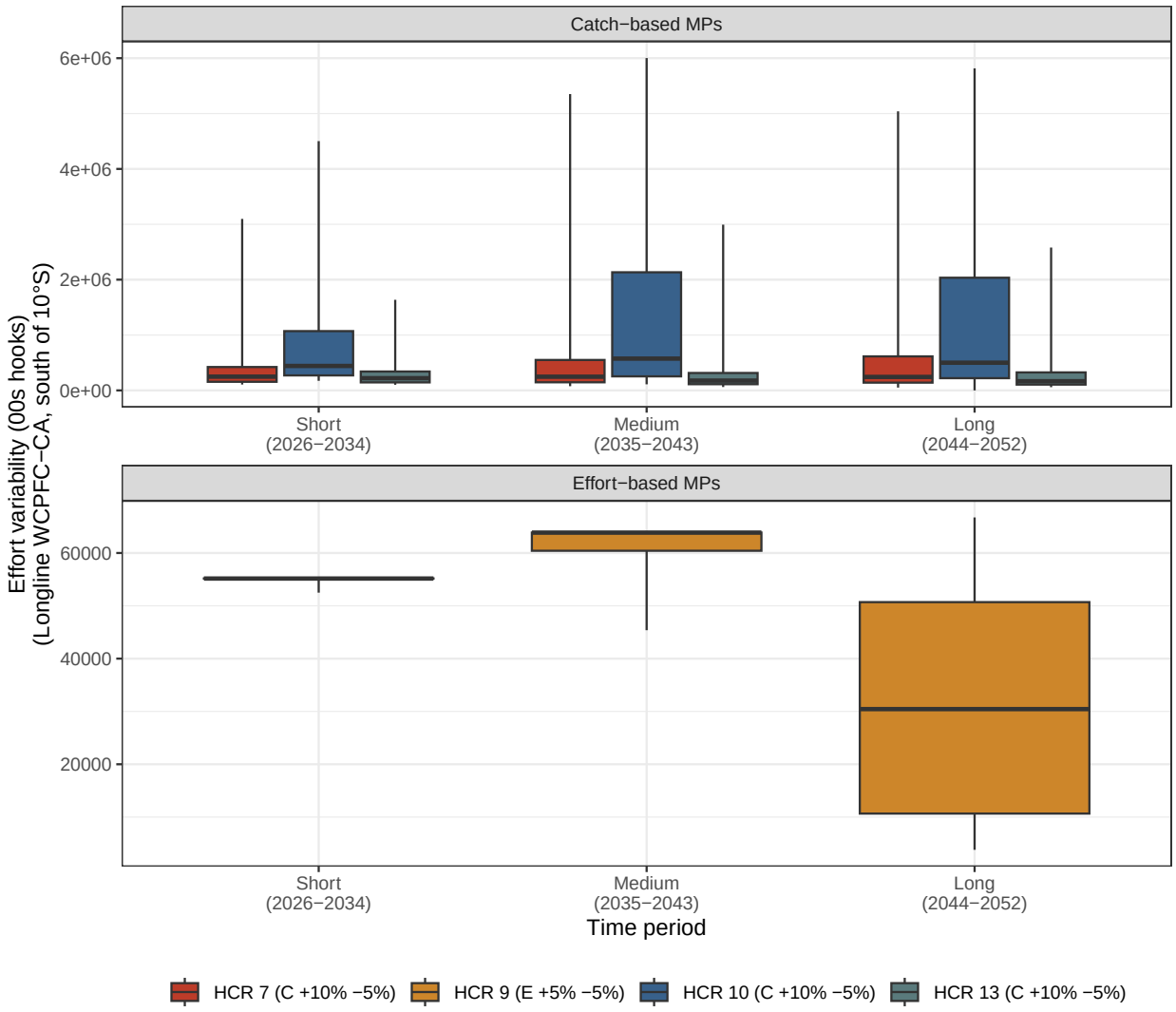

Figure 5: Box plots of average annual WCPFC-CA longline effort variability (00s of hooks), south of 10°S. The whiskers show the 95th percentile range, the box shows the 60th percentile range, and the horizontal line is the median value. The plot is presented in two windows as the results from catch- and effort-based MPs have different scales.

5.5 Sensitivity tests

One-off sensitivity tests were performed, including alternative assumptions about the future levels of albacore catches in the EPO and in the region between the equator and 10°S in the WCPFC-CA. An alternative constraint option of +-10% is also included.

These evaluations use a catch-based MP with HCR 7 and a +10% -5% constraint as the base case. The results of the single change are then compared to the results from the base case.

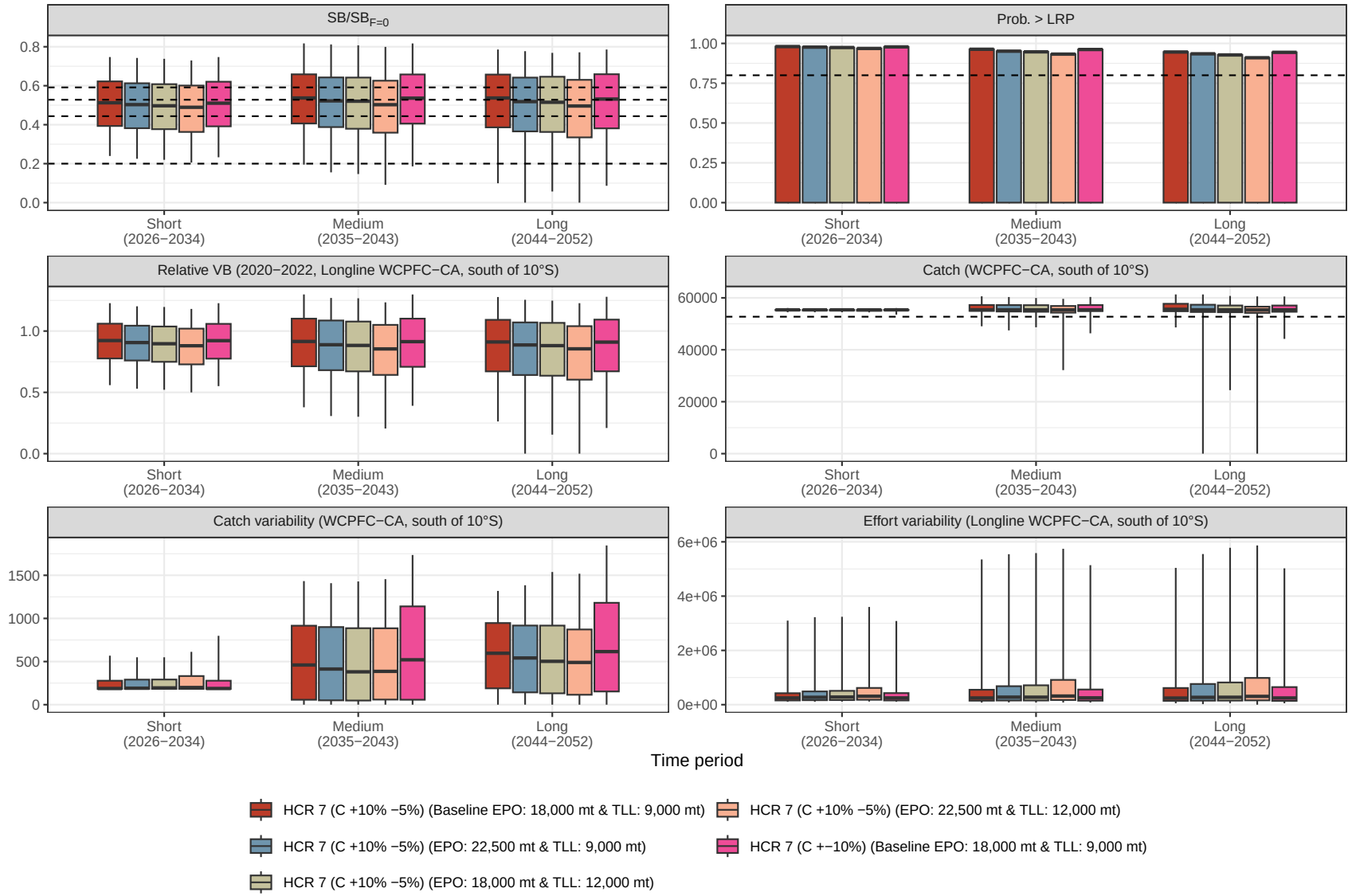

Figure 6: The performance indicators for the same MP with alternative constant annual catch levels in the EPO and in the region between the equator and 10°S in the WCPFC-CA (the TLL fisheries) compared to baseline levels of 18,000 mt and 9000 mt respectively. A catch-based MP with HCR 7 is used, with +10% -5% constraint. An additional constraint option of +-10% is also included. 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.

EPO baseline

In the evaluations performed above, the fisheries in the EPO (excluding the overlap area) are not managed through the MP and their future catches are fixed at 18,000 mt per annum. In this sensitivity test the future catches of albacore in the EPO are fixed at the higher level of 22,500 mt per annum, consistent with the assumptions in SPC-OFP (2024a) (Figure 6).

Higher catches in the EPO result in slightly lower expected stock status and vulnerable biomass in the WCPFC-CA. Catches in the WCPFC-CA, south of 10°S, are largely unaffected by the increase in catches in the EPO, even though expected biomass is lower, suggesting that the stock status is on the 'Hillary step' part of the HCR, i.e. the stock status is fluctuating but is still on the step so that the output catch limit does not change frequently. This demonstrates that the HCR is working as expected.

TLL baseline

In the evaluations performed above the longline fisheries in WCPFC-CA, equator to 10°S (tropical longline - TLL), are not managed through the MP and their future catches are fixed at 9,000 mt per annum. Under the mixed fishery approach it is proposed that these fisheries will be managed through the bigeye MP which will not consider the stock status of South Pacific albacore. It is therefore important that the performance of the South Pacific albacore MP is robust to future South Pacific albacore catch levels by the TLL fishery. In this sensitivity test the future catches of albacore by the TLL fishery are fixed at a higher level of 12,000 mt per annum (approximately the highest one year catch by the TLL fishery in the last ten years) (Figure 6).

As with the alternative EPO catch scenario above, under the higher TLL catch scenario, the average long-term $SB/SB_{F=0}$ and vulnerable biomass are slightly lower. Also as above, the catches in the WCPFC-CA, south of 10°S, are largely unaffected by the increase in catches by the TLL fisheries, suggesting that the stock status is on the 'Hillary step' and the HCR is performing as expected.

EPO and TLL baseline

In this sensitivity test, the future South Pacific albacore catches of the EPO region and TLL fisheries are both set at higher levels to the baseline (22,5000 mt and 12,000 mt) (Figure 6).

This scenario represents the biggest change from the baseline assumptions about TLL and EPO future catches. The average long-term $SB/SB_{F=0}$ is lower than the objective of the iTRP, and the vulnerable biomass (CPUE) is also lower. However, catches in the WCPFC-CA, south of 10°S, are largely unaffected and are still higher than the 2020-2022 average.

Alternative constraint

In the main results, the MP with HCR 7 has a constraint of +10% -5%. Here the same HCR is tested but with an alternative constraint of +-10% (Figure 6). Baseline values for future EPO and

TLL catches of albacore are used. The alternative constraint has little impact on the performance of the MP. The main differences are increased catch variability and slightly less uncertainty in the expected catches with the looser constraint, in the long-term.

For more detail on the potential impact of constraints, see the relevant section in Scott et al. (2024b).

6 Additional management procedure evaluations

SC21 requested evaluations for three additional candidate MPs that more fully explore future EPO (excluding overlap area) catch consequences as well as the use of a fixed effort assumption in the WCPFC-CA 0-10°S.

1. Future EPO catches (excluding the overlap area) set to 22,500 mt (being the approximate average of catches in the years 2021-22), WCPFC-CA 0-10°S future catches set to 9,000t (being the approximate average in the period 2014-2023), using a catch control HCR 'tuned' to achieve the adopted iTRP.
2. Future EPO catches (excluding the overlap area) set to 13,500 mt (being the approximate average of catches in the year 2020), WCPFC-CA 0-10°S future catches set to 9,000t (being the approximate average in the period 2014-2023), using a catch control HCR 'tuned' to achieve the adopted iTRP.
3. Future EPO catches (excluding the overlap area) set to 18,000 mt (being the approximate average for the period 2014-2023), WCPFC-CA 0-10°S future effort set to average effort levels in the period 2014-2023, using a catch control HCR 'tuned' to achieve the adopted iTRP.

The first two MPs use alternative assumptions about future EPO catches (excluding the overlap area) at 22,500 mt and 13,500 mt per annum respectively, while maintaining future TLL catches at baseline levels of 9000 mt per annum. The third MP uses the baseline assumption of future EPO catches (excluding the overlap area) of 18,000 mt per anuum, while fixing future TLL effort at average 2014-2023 levels (approximately 144 million hooks) instead of fixing future TLL catches at baseline catch levels (Figure 7).

Note these additional evaluations are not equivalent to the sensitivity tests in the previous section. Those sensitivity tests evaluate the robustness of the same MP to alternative EPO and TLL assumptions, i.e. they reflect the expected change in performance should the EPO and TLL fishing levels differ to the baseline assumptions. Here, HCRs are 'tuned' to achieve the same long-term performance under alternative EPO and TLL assumptions. If the EPO or TLL fishing levels differ to those assumptions, then the expected performance would be different to that reported here.

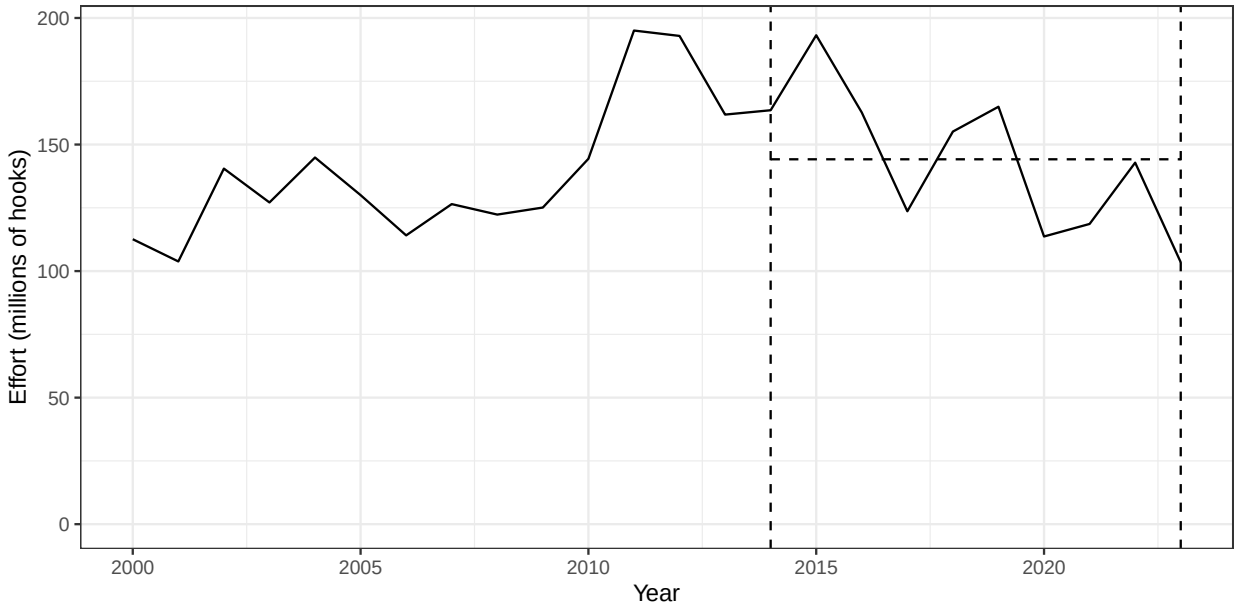

Figure 7: Time series of total longline effort in the equator to 10°S model region. The time period of 2014-2023, and the average effort over that time period, are shown as dashed lines.

Table 3: Parameter values of the additional HCR shapes (HCRs 14, 15 and 16) requested by SC21. HCR 7 is included for comparison. Each HCR achieves the iTRP in the long-term under the EPO and TLL assumptions noted in the table.

HCR		Limit	Step start	Step end	Maximum
HCR 7	Relative $SB/SB_{F=0}$	0.37	0.94	1.29	1.59
(EPO: 18,000 mt; TLL: 9000 mt)	HCR output	0.20	1.05	1.05	1.25
	Catch output	10,550.00	55,370.00	55,370.00	65,920.00
HCR 14	Relative $SB/SB_{F=0}$	0.37	0.94	1.29	1.59
(EPO: 22,500 mt; TLL: 9000 mt)	HCR output	0.20	1.00	1.00	1.20
	Catch output	10,550.00	52,740.00	52,740.00	63,280.00
HCR 15	Relative $SB/SB_{F=0}$	0.37	0.94	1.29	1.59
(EPO: 13,500 mt; TLL: 9000 mt)	HCR output	0.20	1.10	1.10	1.30
	Catch output	10,550.00	58,010.00	58,010.00	68,560.00
HCR 16	Relative $SB/SB_{F=0}$	0.37	0.94	1.29	1.59
(EPO: 18,000 mt; TLL: 2014-2023 effort)	HCR output	0.20	1.02	1.02	1.22
	Catch output	10,550.00	54,060.00	54,060.00	64,600.00

The three additional MPs are catch-based and have new HCRs that have been 'tuned' to achieve the iTRP in the long-term. The HCRs are based around HCR 7 (which achieves the iTRP in the long-term under baseline EPO and TLL catch assumptions), with the height of the Hillary step adjusted to achieve the iTRP under the new assumptions (Table 3, Figure 8). A constraint of -5%

+10% is applied to each of the new MPs.

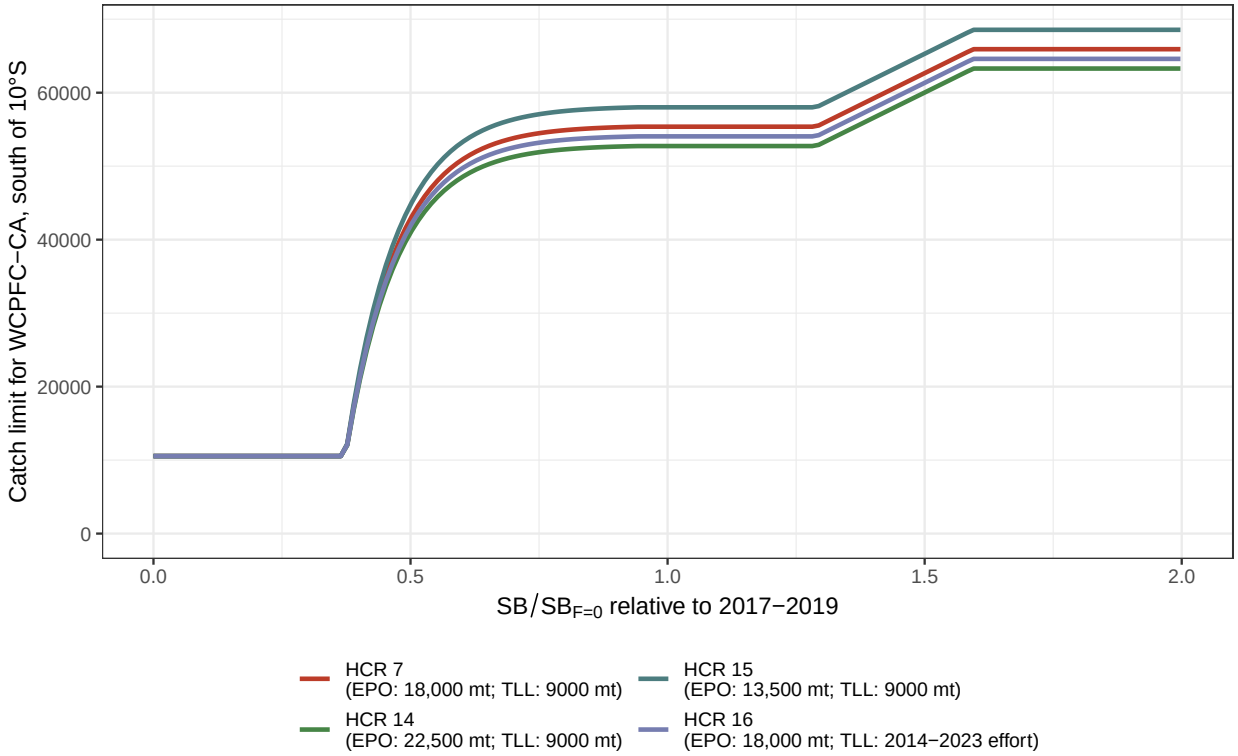

Figure 8: The additional HCR shapes (HCRs 14, 15, 16) requested by SC21. HCR 7 is included for comparison. The input to the HCR is the mean $SB/SB_{F=0}$ of the last three years relative to 2017-2019. The output is a scalar applied to 2020-2022 levels of catch.

6.1 Results

The performance indicators from the three additional MPs, plus an MP with HCR 7 for comparison, are shown in Figure 9. The assumptions about the future EPO and TLL albacore catch or fishing effort are different for each of the MPs so care must be taken when comparing them. The differences between the results are a combination of the HCR shape and the EPO and TLL assumptions.

The three additional MPs have HCRs that have been 'tuned' to achieve the iTRP in the long-term. Consequently, the expected $SB/SB_{F=0}$ and the relative vulnerable biomass are very similar across MPs and EPO and TLL assumptions. The MP with HCR 16 (where future TLL effort is fixed at 2014-2023 average) is slightly more certain in these indicators (the box and whiskers are slightly shorter). The probability of being above the LRP is very similar for all MPs, and well above the 0.8 minimum required by WCPFC.

The expected catches in the WCPFC-CA, south of 10°S, are affected by the MP and the EPO and TLL assumptions. MPs with HCRs 14 and 15 differ from the baseline assumptions used for the MP with HCR 7 in terms of the level of future EPO catches of albacore (22,500 and 13,500

mt per annum respectively, with the baseline assumption being 18,000 mt per annum). To achieve the same level of long-term $SB/SB_{F=0}$, the resulting catches in WCPFC-CA, south of 10°S, are increased or decreased relative to the baseline assumption. The median level of catches is above the recent level (average of 2020-2022 period) for all MPs and time periods.

For the MP with HCR 16, future fishing effort of the TLL is fixed at 2014-2023 effort levels instead of future catches of albacore being fixed at 9000 mt per annum (the approximate average catch in the 2014-2023 period). The resulting average catches of albacore in the future period of the evaluations by the TLL for the effort based assumption is approximately 10,500 mt per annum. This is above the 9000 mt baseline assumption, but lower than in the sensitivity test presented in Section 5.5.

Catch variability across all MPs is similar in the medium- and long-term. The differences in the short-term are a result of the evaluations moving from the 'transient period' (2023-2025) to when the MP is first applied. The different MPs attempt to set the catch limit to different levels, as determined by the HCR. The bigger the difference from the catches assumed in the transient period (set to 2017-2022 average levels) to the catch limit first set by the MP, the bigger the catch variability. The difference will be restricted by the constraint applied to the MPs. In all time periods the catch variability is relatively small for all MPs and EPO and TLL assumptions.

The effort variability is similar across MPs and EPO and TLL assumptions. The long whiskers are the result of a small proportion of iterations crashing, leading to catches being set to 0 for the remainder of the iteration.

A table of results can be found in the Appendices.

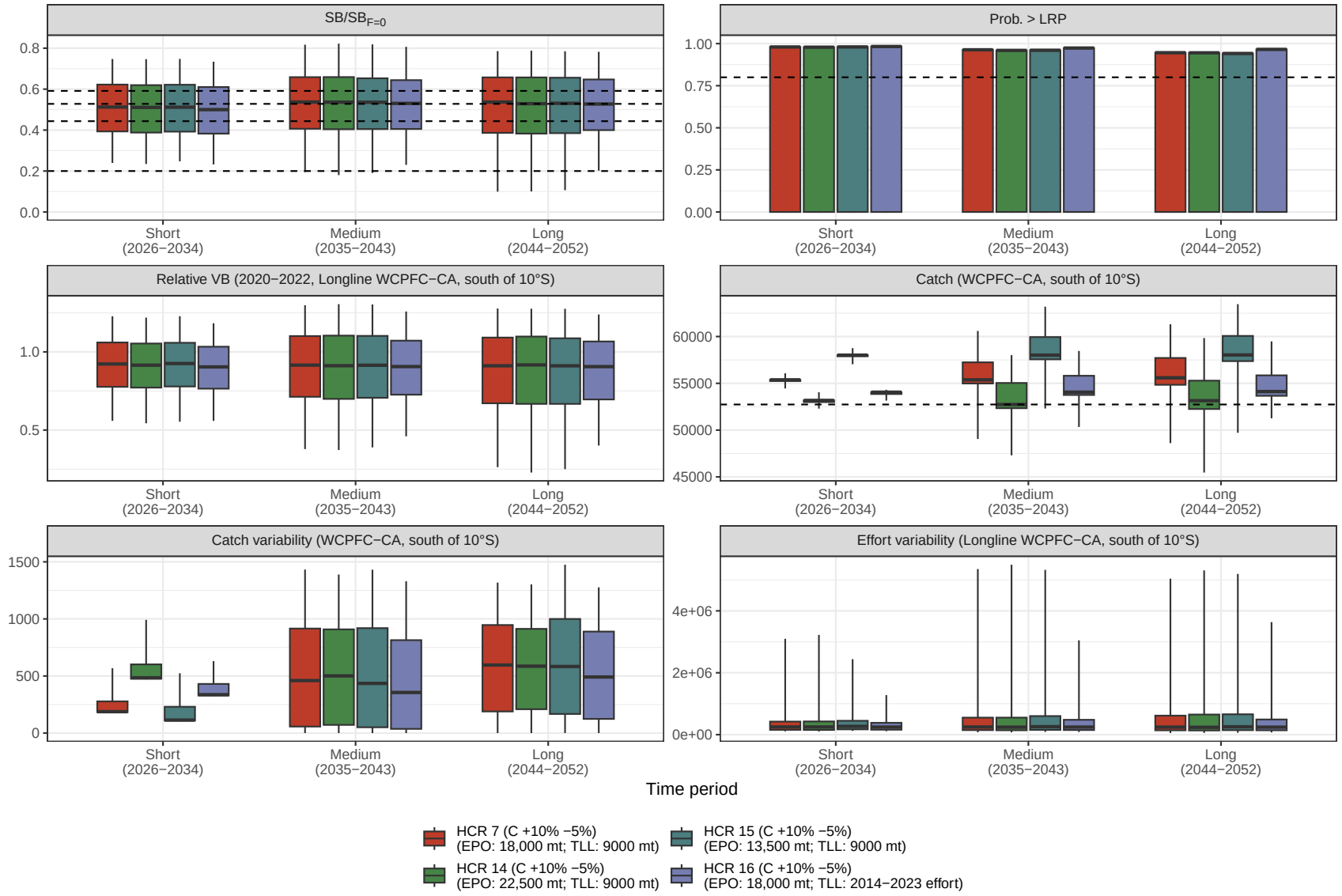

Figure 9: Performance indicators for the three additional MPs (with HCRs 14, 15, 16) as well as for the MP with HCR 7. Each MP has different assumptions about the future EPO and TLL albacore catch or fishing effort, described in the legend. The whiskers show the 95th percentile range, the box shows the 60th percentile range, and the horizontal line is the median value. The probability of being above LRP is shown as a bar plot. The horizonal dashed line on the catch plot is the average catch in the 2020-2022 period.

Acknowledgments

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Appendix: Main assumptions behind the SPA MSE framework

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

The key difference to those assumptions is that the SPA MP no longer applies to fisheries operating in the equator to 10°S region of the WCPFC-CA. Instead the future catches of SPA in the equator to 10°S region are fixed at 9000 mt per annum (approximate the average of 2014 to 2023 catches). Additionally, the future catches of fisheries operating in the EPO region of the model (which excludes the overlap area) are fixed at 18,000 mt per annum (approximate the average of 2014 to 2023 catches)

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, south of 10°S, 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, south of 10°S, 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 10°S.
- 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 future catches of fisheries operating in the EPO region of the model are fixed at 18,000 mt per annum.
- The MP does not apply to fisheries operating in the equator to 10°S region of the WCPFC-CA.
- The total future catches of fisheries operating in the equator to 10°S region of the WCPFC-CA are fixed at 9000 mt per annum.

Operating models

The operating model (OM) grid is based on the 2024 South Pacific wide stock assessment, with additional uncertainty scenarios (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, south of 10°S) are managed either through 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 method settings

Following the update presented in SPC-OFP (2024a), the esimation method now only uses two index fisheries: the longline indices in the WCPFC-CA and the EPO. The troll index has been removed. This removes the reliance on the troll index and helps to 'future proof' the MP. This change was not found to impact the performance of the esimation method. The estimation method and CPUE standardisation settings can be seen in Table 4 and Table 5.

Table 4: Settings for the estimation method

Model setting	Value
Regional structure	2 regions
Number of fisheries	19
Longline	13
Troll / Driftnet	4
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

Table 5: Model settings and post-processing steps used in the CPUE standardisation for south Pacific albacore estimation method.

Model Setting	Description
Model Type	Spatiotemporal delta-gamma generalized linear mixed model (delta-GLMM).
Spatial Knot Configuration	A mesh with 166 spatial knots.
Model Equations	$$y_i \sim \text{Bernoulli}(p_i)$$ $$\log\left(\frac{p_i}{1-p_i}\right) = \text{Year}_i + \omega_1(s_i) + \phi_1(s_i, t_i) + s(\text{HBF}_i) + \text{Flag}_i + \varepsilon_1$$ $$c_i \sim \Gamma(\log \mu_i, \sigma^{-2}, \eta_i \sigma^2)$$ $$\log \eta_i = \text{Year}_i + \omega_2(s_i) + \phi_2(s_i, t_i) + s(\text{HBF}_i) + \text{Flag}_i + \varepsilon_2$$ where σ is the coefficient of variation for positive catch rate measurement errors, y is the encounter probability, c is the CPUE, and i indexes individual records. *Year* is the year effect; ω is the spatial random effect at location x; ϕ is the spatiotemporal random effect at location x and time t; $s(\textit{HBF})$ is a spline function for hook-based fishing effort; and *Flag* is the additive effect of the flag group. The spatial variation terms $\omega_2(x_i)$ are modeled as a Gaussian random field with a Matérn covariance function to account for spatial autocorrelation.
HBF Imputation	Missing HBF values are predicted using a random forest approach (Breiman, 2001) implemented via the `randomForest` R package (Liaw and Wiener, 2002). The model uses predictors including year, month, latitude, longitude, number of hooks fished, vessel flag, the proportional catch of the four main species (albacore, yellowfin, bigeye, swordfish), and total catch value, with 500 trees.
Implementation Platform	`sdmTMB` version 0.3.0 (R package).
Normalisation Method	CPUE values are mean-centered using absolute values.
Penalty Term Calculation	Penalty terms are applied as the coefficient of variation (CV) for the catch-conditioned model.

Appendix: Nominal catch rates and historical vulnerable biomass

SC21 requested that the SSP report the median time series of vulnerable biomass from the OMs for the historical period and to develop a table with the average nominal CPUE (kg/100 hooks) for the reference period (2020-2022) by CCMs with South Pacific albacore catches. These are presented in Figure 10 and Table 6. Note that these consider the area WCPFC-CA, south of 10°S, only, i.e. the area of application of the South Pacific albacore MP.

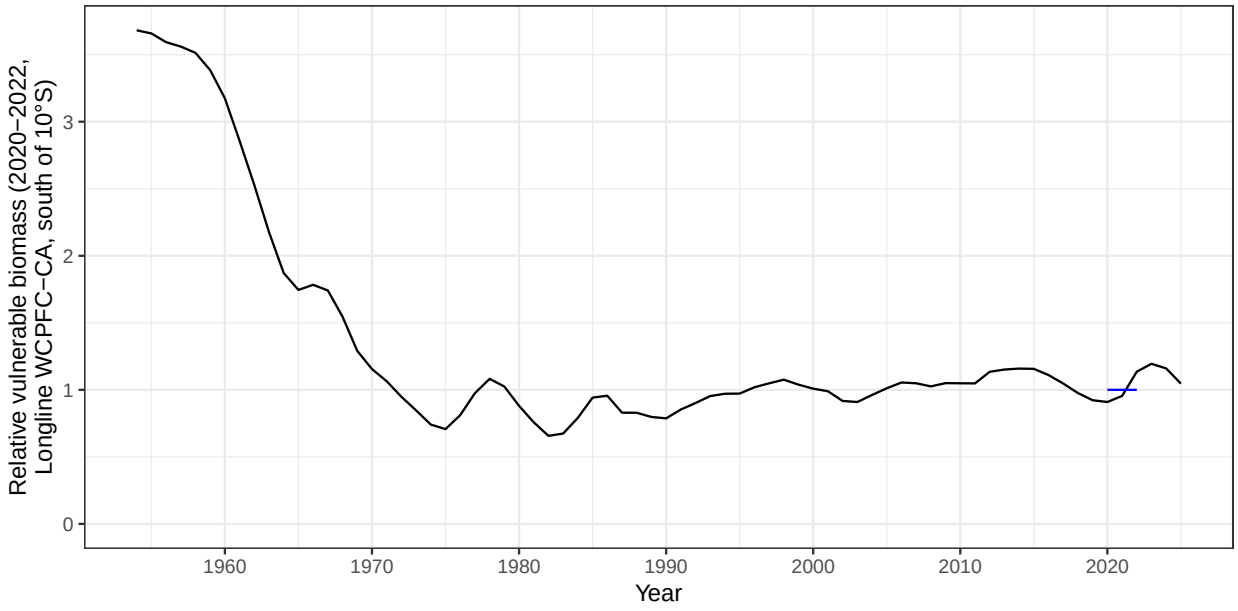

Figure 10: Median historical vulnerable biomass across the operating models, relative to the corresponding average in the period 2020-2022, of the longline fisheries in the WCPFC-CA, south of 10°S. The solid blue line highlights the average in the 2020-2022 period.

Table 6: Average nominal albacore catch-per-unit-effort (CPUE, kg / 100 hooks) for the period 2020-2022 in the WCPFC-CA, south of 10°S by flag.

Flag	CPUE (kg / 100 hooks)
AU	13.97
CK	14.94
CN	18.16
ES	2.56
FJ	19.35
FM	16.34
JP	16.11
KI	21.21
KR	7.30
NC	31.65
NZ	11.26
PF	17.11
PG	15.69
SB	17.91
TO	3.38
TV	32.25
TW	21.17
US	20.90
VU	31.67
WS	15.57

Appendix: Tables of results

Tables of the median results for the short-, medium- and long-term can be seen Table 7, Table 8 and Table 9. The results are separated into the main results, sensitivity results and the additional MP requests from SC21.

Table 7: Results of the baseline and sensitivity scenarios in the short-term (2026-2034). The value shown is the median. Values in parenthesis are the 95th percentile range. $SB/SB_{F=0}$ is shown as relative to the mean $SB/SB_{F=0}$ in 2017-2019, noting that the iTRP is defined as the 0.96 x mean $SB/SB_{F=0}$ in 2017-2019. Relative vulnerable biomass (VB), catch, catch variability and effort variability are for the WCPFC-CA, south of 10°S. Relative VB and effort variability are for longline fisheries only.

HCR	EPO catch (mt)	TLL catch (mt)	$SB/SB_{F=0}$ relative to 2017-2019	Prob. > LRP	Relative VB	Catch (mt)	Catch variability (mt)	Effort variability (00s hooks)
Main results								
HCR 7 (C +10% -5%)	18,000	9,000	0.93 (0.43-1.35)	0.98	0.92 (0.56-1.23)	55,400 (54,500-56,100)	188 (183-568)	248,000 (106,000-3,100,000)
HCR 9 (E +5% -5%)	18,000	9,000	0.83 (0.44-1.23)	0.99	0.84 (0.59-1.04)	63,300 (41,900-80,800)	6,020 (3,700-8,970)	55,200 (52,500-55,200)
HCR 10 (C +10% -5%)	18,000	9,000	0.87 (0.35-1.31)	0.96	0.86 (0.48-1.16)	66,800 (62,600-66,800)	1,340 (1,320-2,460)	441,000 (173,000-4,500,000)
HCR 13 (C +10% -5%)	18,000	9,000	0.95 (0.44-1.37)	0.98	0.94 (0.57-1.24)	51,400 (51,400-52,900)	916 (741-958)	221,000 (102,000-1,640,000)
Sensitivity results								
HCR 7 (C +10% -5%)	18,000	12,000	0.9 (0.4-1.34)	0.97	0.9 (0.52-1.2)	55,400 (54,500-55,800)	195 (183-549)	280,000 (114,000-3,240,000)
HCR 7 (C +10% -5%)	22,500	9,000	0.91 (0.41-1.34)	0.98	0.91 (0.53-1.2)	55,400 (54,500-55,900)	191 (183-549)	272,000 (109,000-3,220,000)
HCR 7 (C +10% -5%)	22,500	12,000	0.89 (0.37-1.32)	0.97	0.88 (0.5-1.18)	55,400 (54,400-55,700)	199 (183-613)	311,000 (116,000-3,600,000)
HCR 7 (C +-10%)	18,000	9,000	0.92 (0.42-1.35)	0.98	0.92 (0.55-1.23)	55,400 (53,500-56,100)	188 (183-798)	249,000 (106,000-3,080,000)

HCR	EPO catch (mt)	TLL catch (mt)	$SB/SB_{F=0}$ relative to 2017-2019	Prob. > LRP	Relative VB	Catch (mt)	Catch variability (mt)	Effort variability (00s hooks)
Additional MP requests								
HCR 14 (C +10% -5%)	22,500	9,000	0.93 (0.42-1.35)	0.98	0.92 (0.54-1.22)	53,200 (52,300-54,000)	484 (476-992)	248,000 (100,000-3,220,000)
HCR 15 (C +10% -5%)	13,500	9,000	0.93 (0.45-1.35)	0.98	0.93 (0.55-1.23)	58,000 (57,000-58,800)	114 (110-524)	268,000 (121,000-2,440,000)
HCR 16 (C +10% -5%)	18,000	1,440,000[a]	0.91 (0.42-1.33)	0.98	0.9 (0.56-1.18)	54,100 (53,200-54,300)	336 (330-630)	245,000 (109,000-1,280,000)

[a]The TLL assumption for HCR 16 is effort in 00s hooks, not catch.

Table 8: Results of the baseline and sensitivity scenarios in the medium-term (2035-2043). The value shown is the median. Values in parenthesis are the 95th percentile range. $SB/SB_{F=0}$ is shown as relative to the mean $SB/SB_{F=0}$ in 2017-2019, noting that the iTRP is defined as the 0.96 x mean $SB/SB_{F=0}$ in 2017-2019. Relative vulnerable biomass (VB), catch, catch variability and effort variability are for the WCPFC-CA, south of 10°S. Relative VB and effort variability are for longline fisheries only.

HCR	EPO catch (mt)	TLL catch (mt)	$SB/SB_{F=0}$ relative to 2017-2019	Prob. > LRP	Relative VB	Catch (mt)	Catch variability (mt)	Effort variability (00s hooks)
Main results								
HCR 7 (C +10% -5%)	18,000	9,000	0.97 (0.35-1.48)	0.96	0.92 (0.38-1.3)	55,400 (49,100-60,600)	460 (0-1,430)	247,000 (76,200-5,350,000)
HCR 9 (E +5% -5%)	18,000	9,000	0.83 (0.43-1.31)	0.98	0.79 (0.54-1.04)	68,700 (41,300-93,400)	5,870 (3,110-9,360)	63,900 (45,400-63,900)
HCR 10 (C +10% -5%)	18,000	9,000	0.82 (0.03-1.39)	0.89	0.78 (0.05-1.17)	68,300 (19.8-69,100)	394 (0-7,290)	574,000 (110,000-6,000,000)
HCR 13 (C +10% -5%)	18,000	9,000	1.05 (0.45-1.53)	0.98	0.98 (0.48-1.36)	46,900 (44,100-53,000)	852 (458-1,130)	177,000 (61,200-2,990,000)
Sensitivity results								
HCR 7 (C +10% -5%)	18,000	12,000	0.94 (0.27-1.46)	0.95	0.88 (0.3-1.27)	55,400 (48,700-59,900)	381 (0-1,430)	276,000 (78,400-5,590,000)
HCR 7 (C +10% -5%)	22,500	9,000	0.95 (0.28-1.47)	0.95	0.89 (0.31-1.27)	55,400 (47,500-60,300)	413 (0-1,410)	278,000 (82,800-5,540,000)
HCR 7 (C +10% -5%)	22,500	12,000	0.91 (0.17-1.45)	0.93	0.85 (0.2-1.23)	55,400 (32,200-59,600)	386 (0-1,460)	318,000 (79,600-5,740,000)
HCR 7 (C +-10%)	18,000	9,000	0.97 (0.34-1.48)	0.96	0.91 (0.39-1.3)	55,400 (46,300-60,300)	520 (0-1,740)	250,000 (77,400-5,140,000)

HCR	EPO catch (mt)	TLL catch (mt)	$SB/SB_{F=0}$ relative to 2017-2019	Prob. > LRP	Relative VB	Catch (mt)	Catch variability (mt)	Effort variability (00s hooks)
Additional MP requests								
HCR 14 (C +10% -5%)	22,500	9,000	0.97 (0.33-1.49)	0.96	0.91 (0.37-1.31)	52,700 (47,300-58,000)	501 (0-1,390)	242,000 (73,500-5,490,000)
HCR 15 (C +10% -5%)	13,500	9,000	0.97 (0.35-1.48)	0.96	0.91 (0.39-1.3)	58,000 (52,300-63,200)	435 (0-1,430)	257,000 (86,400-5,330,000)
HCR 16 (C +10% -5%)	18,000	1,440,000[a]	0.96 (0.42-1.46)	0.97	0.91 (0.46-1.26)	54,100 (50,300-58,500)	356 (0-1,330)	245,000 (84,600-3,050,000)

[a]The TLL assumption for HCR 16 is effort in 00s hooks, not catch.

Table 9: Results of the baseline and sensitivity scenarios in the long-term (2044-2052). The value shown is the median. Values in parenthesis are the 95th percentile range. $SB/SB_{F=0}$ is shown as relative to the mean $SB/SB_{F=0}$ in 2017-2019, noting that the iTRP is defined as the 0.96 x mean $SB/SB_{F=0}$ in 2017-2019. Relative vulnerable biomass (VB), catch, catch variability and effort variability are for the WCPFC-CA, south of 10°S. Relative VB and effort variability are for longline fisheries only.

HCR	EPO catch (mt)	TLL catch (mt)	$SB/SB_{F=0}$ relative to 2017-2019	Prob. > LRP	Relative VB	Catch (mt)	Catch variability (mt)	Effort variability (00s hooks)
Main results								
HCR 7 (C +10% -5%)	18,000	9,000	0.97 (0.18-1.42)	0.95	0.91 (0.26-1.28)	55,600 (48,600-61,300)	596 (0-1,320)	243,000 (51,000-5,040,000)
HCR 9 (E +5% -5%)	18,000	9,000	0.8 (0.4-1.23)	0.98	0.77 (0.5-1.01)	70,600 (40,900-97,600)	6,070 (3,200-9,740)	30,400 (3,810-66,700)
HCR 10 (C +10% -5%)	18,000	9,000	0.81 (0-1.33)	0.86	0.78 (0-1.16)	67,900 (0-69,100)	448 (0-2,960)	500,000 (0-5,820,000)
HCR 13 (C +10% -5%)	18,000	9,000	1.07 (0.43-1.5)	0.98	1 (0.42-1.38)	48,200 (42,400-53,200)	834 (52.3-1,300)	166,000 (58,300-2,580,000)
Sensitivity results								
HCR 7 (C +10% -5%)	18,000	12,000	0.93 (0.1-1.39)	0.93	0.88 (0.15-1.25)	55,400 (24,500-60,700)	503 (0-1,540)	274,000 (57,500-5,780,000)
HCR 7 (C +10% -5%)	22,500	9,000	0.94 (0-1.41)	0.93	0.89 (0-1.26)	55,400 (0-61,300)	541 (0-1,380)	271,000 (20,900-5,550,000)
HCR 7 (C +10% -5%)	22,500	12,000	0.9 (0-1.4)	0.91	0.86 (0-1.23)	55,300 (0-60,500)	490 (0-1,520)	306,000 (0-5,870,000)
HCR 7 (C +-10%)	18,000	9,000	0.96 (0.16-1.42)	0.94	0.91 (0.21-1.28)	55,400 (44,200-60,500)	615 (0-1,850)	247,000 (52,500-5,020,000)

HCR	EPO catch (mt)	TLL catch (mt)	$SB/SB_{F=0}$ relative to 2017-2019	Prob. > LRP	Relative VB	Catch (mt)	Catch variability (mt)	Effort variability (00s hooks)
Additional MP requests								
HCR 14 (C +10% -5%)	22,500	9,000	0.96 (0.18-1.43)	0.95	0.92 (0.23-1.28)	53,100 (45,500-59,800)	586 (0-1,300)	237,000 (56,500-5,310,000)
HCR 15 (C +10% -5%)	13,500	9,000	0.96 (0.19-1.42)	0.94	0.91 (0.25-1.28)	58,000 (49,700-63,500)	583 (0-1,470)	253,000 (60,600-5,190,000)
HCR 16 (C +10% -5%)	18,000	1,440,000[a]	0.96 (0.37-1.42)	0.97	0.91 (0.4-1.24)	54,100 (51,300-59,500)	491 (0-1,280)	242,000 (72,200-3,640,000)

[a]The TLL assumption for HCR 16 is effort in 00s hooks, not catch.