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Evaluation of candidate management procedures for bigeye tuna

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REVISIONS

*Corrected x-axis label for Figure 1 (the HCRs plot) to "SB/SBF=0 relative to 2012-2015" (was "...relative to 2019-2021").

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Executive summary

** Revisions **

- Corrected x-axis label for Figure 1 (the HCRs plot) to "SB/SBF=0 relative to 2012-2015" (was "... relative to 2019-2021").

This report presents preliminary evaluations of candidate management procedures (MPs) for bigeye tuna in the WCPFC-CA, including an overview of the management strategy evaluation (MSE) framework and the assumptions made. Three candidate MPs are tested that have been been designed to achieve performance in terms of median long-term $SB/SB_{F=0}$ at the three candidate TRPs specified at WCPFC21. Each MP has the same data collection, estimation method and meta-rule, and differ only in their HCR shape.

Under the proposed mixed fishery approach, the bigeye MP defines the level of fishing of the tropical longline fisheries (operating in the WCPFC-CA, 20N to 10S), and adjusts that level as needed to achieve management objectives. To run the bigeye candidate MP evaluations several assumptions need to be made on the future level of fishing by fisheries not managed by the bigeye MP.

The proposed mixed fishery approach specifies that the future fishing pressure of purse seine, pole and line and the domestic fisheries of Vietnam, Indonesia and the Philippines is managed through the skipjack MP, while the longline fisheries operating south of 10S in the WCPFC-CA (referred to as the southern longline fishery - SLL) are managed through the south Pacific albacore MP. Previous analyses have investigated how the MP evaluations of individual stocks can be linked together in a mixed fishery modeling framework, through the transfer of effort from one model to another. In this preliminary set of bigeye MP evaluations a simpler approach is taken whereby future catch and effort of model fisheries not managed by the bigeye MP are fixed at an appropriate constant level.

The future activity of the purse seine fisheries is consistent with the skipjack MP scenario in the recent Tropical Tuna Measure (TTM) evaluations for bigeye presented to WCPFC21. The future purse seine effort is held constant at 2012 levels, following the objectives of the interim skipjack MP. The settings assume the shorter FAD closure period as described in CMM 2023-01 (one and half month annual FAD closure period in EEZs and high seas, with an additional month in the high seas).

Ideally, the domestic fisheries in the bigeye evaluations would be projected on levels of effort consistent with that required to take their skipjack catch limit from the skipjack MP evaluations (using a baseline of 2016-2018 average catch levels). However, this would require transferring effort from the domestic fisheries in the skipjack MP evaluations to the corresponding fisheries in the bigeye evaluations, which is currently limited by available data. Instead, here the future bigeye catch levels of the domestic fisheries are held constant at 2016-2018 levels. Similarly, under the skipjack MP the pole and line fishing effort would be held constant at 2001-2004 levels. However, for these

preliminary evaluations recent average levels are used.

Ideally the fishing effort of the SLL fisheries in these evaluations would be determined by the south Pacific albacore MP. However, as the south Pacific albacore MP is not yet agreed, and given that the proportion of recent total bigeye catches taken by this fishery is relatively small, here the future catches of bigeye taken by the SLL are fixed at the average 2019-2021 level, with an additional 12%, consistent with the Table 3 settings in the recent TTM bigeye projections presented to WCPFC21. The same assumption is made for the nothern longline fishery (operating north of 20N).

Six performance indicators are calculated to assess the perfomance of the candidate MPs, including expected $SB/SB_{F=0}$, probability of being above the Limit Reference Point and bigeye catches taken by the tropical longline fishery.

WCPFC21 supported a 'sequenced approach' to the target reference points (TRPs) for bigeye and yellowfin, whereby the Commission first addresses the TRP for bigeye and then evaluates its implications for achieving management objectives for yellowfin. Three candidate TRPs for bigeye were specified at WCPFC21 at 1x, 0.94x and 1.06x the 2012-2015 average spawning biomass depletion. The Commission noted that these candidate TRPs may in future be specified as threshold targets for which associated probabilities of being 'at or above' would need to be specified. In these evaluations, the specified TRP levels are used as long-term objectives for the candidate MP performance.

We note these are preliminary analyses, demonstrating the utility of the bigeye MSE framework and providing results based upon the request of WCPFC21. However, further guidance will be needed from managers on the assumptions made on key settings within the analyses to progress the work.

SC21 is invited to:

- Note the baseline assumptions made about future catches of bigeye by the northern and southern longline fisheries and domestic fisheries of Vietnam, Indonesia and Philippines, as well as the future fishing effort of the pole and line and purse seine fisheries for these preliminary evaluations.
- Provide feedback on consequences of the long-term objectives, noting the selected target reference points and WCPFC21 discussions on thresholds, and request guidance from WCPFC22 on these issues.
- Provide feedback on the suite of performance indicators used.

1 Introduction

The WCPFC harvest strategy workplan schedules the consideration and refinement of bigeye management procedures (MPs) in 2025, with the adoption of the bigeye tuna management procedure by the end of 2026 (WCPFC, 2024). This report describes the initial evaluations of candidate MPs for bigeye tuna in the WCPFC-CA. The relative performance of the MPs is summarised through the calculated performance indicators.

An important consideration when developing harvest strategies for tuna stocks in the WCPO is to account for mixed fishery interactions (Table 1).

Table 1: Proportion of mean catch by weight (2020-2022) in the WCPFC-CA (south of the equator for albacore) of the four main tuna stocks by fishery. 'Other' fisheries are the domestic fisheries of Vietnam, Indonesia and the Phillipines. The figures include catches in archipelagic waters.

Stock	Tropical longline	Southern longline	Northern longline	Pole and line	Purse seine	Troll	Other
Skipjack	0.00	0.00	0.00	0.09	0.83	0.00	0.08
South Pacific albacore	0.12	0.81	0.00	0.00	0.00	0.07	0.00
Bigeye	0.27	0.05	0.06	0.01	0.45	0.00	0.15
Yellowfin	0.08	0.02	0.01	0.03	0.55	0.00	0.31

Under the proposed mixed fishery harvest strategy approach, fisheries would be managed through single stock management procedures (MPs) for skipjack, south Pacific albacore and bigeye (Scott et al., 2023, 2021, 2020). Each single stock MP only considers the status of a single stock and sets the fishing opportunities, e.g. catch or effort limits, for one or more fisheries. Additionally, a fishery is only managed through one single stock MP. For example, the effort limits of the purse seine fishery are only managed through the skipjack MP, which only considers the stock status of skipjack.

This mixed fishery approach proposes that longline fisheries operating between 20N and 10S, referred to as the tropical longline (TLL) fishery, will be managed through the bigeye MP. Other fisheries that also catch bigeye will be managed through the single stock MPs for skipjack (purse seine, pole and line, domestic fisheries of Indonesia, Vietnam and the Philippines - excluding archipelagic waters), and south Pacific albacore (southern longline fishery that operates south of 10S). The stock status of bigeye is, therefore, influenced not just by the bigeye MP, but also by the skipjack MP and, to a lesser extent, the south Pacific albacore MP.

WCPFC21 supported a 'sequenced approach' to the target reference points (TRPs) for bigeye

and yellowfin, whereby the Commission first addresses the TRP for bigeye and then evaluates its implications for achieving management objectives for yellowfin (WCPFC, 2024). Three candidate TRPs for bigeye were specified at WCPFC21 at 1x, 0.94x and 1.06x the 2012-2015 average spawning biomass depletion. The Commission noted that these candidate TRPs may in future be specified as threshold targets for which associated probabilities of being 'at or above' would need to be specified. In these evaluations, the specified TRP levels are used as long-term objectives for the candidate MP performance.

To run the evaluations several assumptions need to be made, including on the management strategy evaluation (MSE) simulation framework and the MPs. Assumptions also need to be made about the future level of fishing pressure on bigeye by the fisheries not managed by the bigeye MP. These assumptions made for these preliminary evaluations are described below.

2 Management strategy evaluation framework

2.1 Operating models

The evaluations use the initial operating model (OM) grid described in Scott et al. (2025), with 32 extraction fisheries (purse seine, longline, pole and line and the domestic fisheries of Vietnam, Indonesia and the Phillipines) operating in 9 model regions (Figure 4). The OM grid includes uncertainty in steepness, tag mixing, future levels of effort creep on purse seine and longline fisheries and future recruitment variability. Further development may consider additional sources of uncertainty (see WCPFC-SC21-2025/MI-WP-05 for details).

The projections are stochastic through the inclusion of recruitment variability, implemented as the application of randomly selected historical recruitment deviates.

2.2 Fisheries not managed through the bigeye management procedure

Under the proposed mixed fishery approach, the bigeye MP defines the level of fishing of the tropical longline fisheries (those operating in the WCPFC-CA, 20N to 10S), and adjusts that level as needed to achieve management objectives. To run the bigeye candidate MP evaluations several assumptions need to be made on the future level of fishing by fisheries not managed by the bigeye MP.

The proposed mixed fishery approach specifies that the future fishing pressure of purse seine, pole and line and the domestic fisheries of Vietnam, Indonesia and the Philippines is managed through the skipjack MP, while the longline fisheries operating south of 10S in the WCPFC-CA (referred to as the southern longline fishery - SLL) are managed through the south Pacific albacore MP. Previous analyses have investigated how the MP evaluations of individual stocks can be linked together in a mixed fishery modeling framework through the transfer of effort between model fisheries (Scott et al., 2021, 2022). In this preliminary set of bigeye MP evaluations a simpler approach is taken whereby future catch and effort of model fisheries not managed by the bigeye MP are fixed at an

appropriate constant level (Table 2).

Table 2: Assumptions about future catch or effort in the bigeye model fisheries for these preliminary evaluations.

Fishery	MP	Assumption
Northern longline		2019-2021 average catch + 12%
Tropical longline	Bigeye MP	Catch set by bigeye MP
Southern longline	SPA MP	2019-2021 average catch + 12%
Purse seine	Skipjack MP	2012 effort
Pole and line	Skipjack MP	2019-2021 average effort
Domestic	Skipjack MP	2016-2018 average catch

The future activity of the purse seine fisheries is consistent with the skipjack MP scenario in the recent Tropical Tuna Measure (TTM) evaluations for bigeye presented to WCPFC21 (Pilling et al., 2024). The future purse seine effort is held constant at 2012 levels, following the objectives of the interim skipjack MP. These settings assume the shorter FAD closure period as described in CMM 2023-01 (one and half month annual FAD closure period in EEZs and high seas, with an additional month in the high seas).

Ideally, the domestic fisheries in the bigeye evaluations would be projected on levels of effort consistent with that required to take their skipjack catch limit from the skipjack MP evaluations (using a baseline of 2016-2018 average skipjack catch levels). However, this would require transferring effort from the domestic fisheries in the skipjack MP evaluations to the corresponding fisheries in the bigeye evaluations, which is currently limited by available data. Instead, here the future bigeye catch levels of the domestic fisheries are held constant at 2016-2018 levels. Similarly, under the skipjack MP the pole and line fishing effort would be held constant at 2001-2004 levels. However, for these preliminary evaluations recent average levels are used.

Ideally the fishing effort of the SLL fisheries in these evaluations would be determined by the south Pacific albacore MP. However, as the south Pacific albacore MP is not yet agreed, and given that the proportion of recent total bigeye catches taken by this fishery is relatively small (about 5%, see Table 1), for the sake of simplicity in the preliminary evaluations here the future catches of bigeye taken by the SLL are fixed at the average 2019-2021 level, with an additional 12%, consistent with the Table 3 settings in the recent TTM bigeye projections.

Catches taken by longline fisheries operating in the area north of 20N in the WCPFC-CA (known as northern longline fisheries - NLL) make up only a small proportion of recent total bigeye catch

(Table 1). In the OMs, model fisheries 1, 2 and 3 operate in model regions 1 and 2 (see Scott et al. (2025)). These model regions range from 10N to 50N, i.e. include both TLL and NLL components (Figure 4). Only the TLL component of the future catches of these model fisheries are managed by the bigeye MP (approximately 15%, 80% and 60% of the catches of fisheries 1, 2 and 3 respectively in the period 2019-2021). The catches of the NLL components are held constant at their average 2019-2021 levels, with an additional 12%, consistent with the Table 3 settings in the TTM bigeye projections.

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 bigeye catch taken in archipelagic waters in the WCPFC-CA is calculated to be 17% of recent total bigeye WCPFC-CA catch (2020-2022). The catch taken in archipelagic waters by the purse seine, domestic and pole and line fisheries has already been accounted for in the evaluations through the assumptions made about their future fishing levels. The Indonesia flagged longline fishery in the Indonesia EEZ partially operates in archipelagic waters. To accommodate the archipelagic waters catch component, the MP output should only affect a portion of the catches of this fishery. This will implemented in later versions of the MSE framework. Following implementation of an MP for bigeye, the level of catch in archipelagic waters would be monitored within the monitoring strategy.

As the adoption of the bigeye MP would be conditional on the assumptions made about future fishery pressure by fisheries not managed through the bigeye MP, catches and effort by these fisheries will need to be monitored as part of the bigeye MP monitoring strategy to determine if these assumptions are still valid.

2.3 Transient period

The evaluations start in 2022 and the MP is first used in 2026 to set fishing opportunities for the TLL fishery in 2027. The level of catches taken by the TLL fishery in the period 2022-2026, i.e. the transient period before the MP is first applied, is set to the 2019-2021 average with an additional 12%, consistent with the Table 3 settings in the TTM bigeye projections. The level of catches and effort for the other fisheries in the transient period is as described above.

3 Candidate management procedures

An MP comprises three components:

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

These components for the bigeye MP are discussed in more detail in Wickens et al. (2025). 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 candidate MPs are:

- The tropical longline fisheries in the WCPFC-CA, operating between 10S and 20N, are managed by the bigeye MP through the setting of a catch limit.
- The HCR of each MP outputs a scalar that is applied to the baseline catch.
- The baseline catch for each HCR is the average tropical longline catch within the WCPFC-CA, between 10S and 20N, in the period 2012-2015 (the year range used to specify the candidate bigeye TRPs), i.e. an output scalar of 1 sets the catch limit for the next management period to the average of 2012-2015 catches.
- 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 (TLL fisheries) have their catch limits increased by 10% relative to the baseline for the next management period.
- The management period is three years, i.e. the catch limit output by the MP is set for the following three years.

Future candidate MPs could output a total effort for the TLL, instead of a total catch limit. 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.

3.1 Estimation method

The estimation method (EM) is an age-structured production model, implemented in Stock Synthesis 3, using a consensus index fishery from each OM model area (Wickens et al., 2025). This EM is expected to be further developed to improve performance. Only catch data and CPUE indices are required to run the EM. Tagging data and size composition data are not needed.

In the evaluations observation error is applied to catches, simulated as normally distributed noise with a c.v. of 20%.

There is a two year data lag in the running of the EM. For example, the first time it is evaluated in 2026, only data up to 2024 is available.

The HCR input is a relative measure of stock status: estimated $SB/SB_{F=0}$ in the final year relative to the mean estimated $SB/SB_{F=0}$ in 2012-2015.

3.2 Harvest control rules

The candidate MPs have 3 basic HCR shapes (HCRs 1, 2 and 3) (Figure 1, Table 3). Each HCR has a similar shape to the HCR in the adopted interim skipjack MP, with a 'Hillary step' (WCPFC, 2022). Alternative HCR options are discussed in Wickens et al. (2025).

As noted earlier, candidate target reference points (TRPs) for bigeye were specified at WCPFC21 at 1x, 0.94x and 1.06x the 2012-2015 average spawning biomass depletion (WCPFC, 2024). The HCRs have been designed to achieve performance in terms of median long-term $SB/SB_{F=0}$ at these candidate TRPs, e.g. HCR 1 achieves approximately the same long-term $SB/SB_{F=0}$ as the 2012-2015 average spawning biomass depletion.

The HCRs can continue to be tuned and refined to better achieve their objectives.

Table 3: Parameter values of the HCR shapes.

HCR		Limit	Step.start	Step.end	Maximum
HCR 1	Relative SB/SBF=0	0.19	0.47	1.12	2.77
	HCR output	0.20	1.00	1.00	1.20
HCR 2	Relative SB/SBF=0	0.24	0.45	1.14	2.99
	HCR output	0.20	1.15	1.15	1.35
HCR 3	Relative SB/SBF=0	0.14	0.49	1.10	2.58
	HCR output	0.20	0.87	0.87	1.07

3.3 Meta-rules and constraints

Meta-rules allow for additional constraints to be placed on the HCR output. In these evaluations the candidate MPs have constraints on how much the output of the HCR can change between management periods. Here, only a single constraint option is currently evaluated for each HCR: +-10%.

The first time the MP is used (in 2026), the constraint is applied to the TLL catch in 2024 (assuming a two year data lag), i.e. the catch limit set by the MP for 2027 cannot change by more than 10% from the catch or effort level in 2024. The assumed levels of catch in 2024 can therefore impact the performance of an MP with a constraint, particularly in the first few management periods.

4 Performance indicators

Six performance indicators (PIs) are calculated. Note that the $SB/SB_{F=0}$ and probability of being above the LRP indicators are based on the biomass in the WCPFC-CA, whereas the vulnerable biomass and catch indicators focus on the TLL fishery.

- $SB/SB_{F=0}$ 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 candidate TRPs.

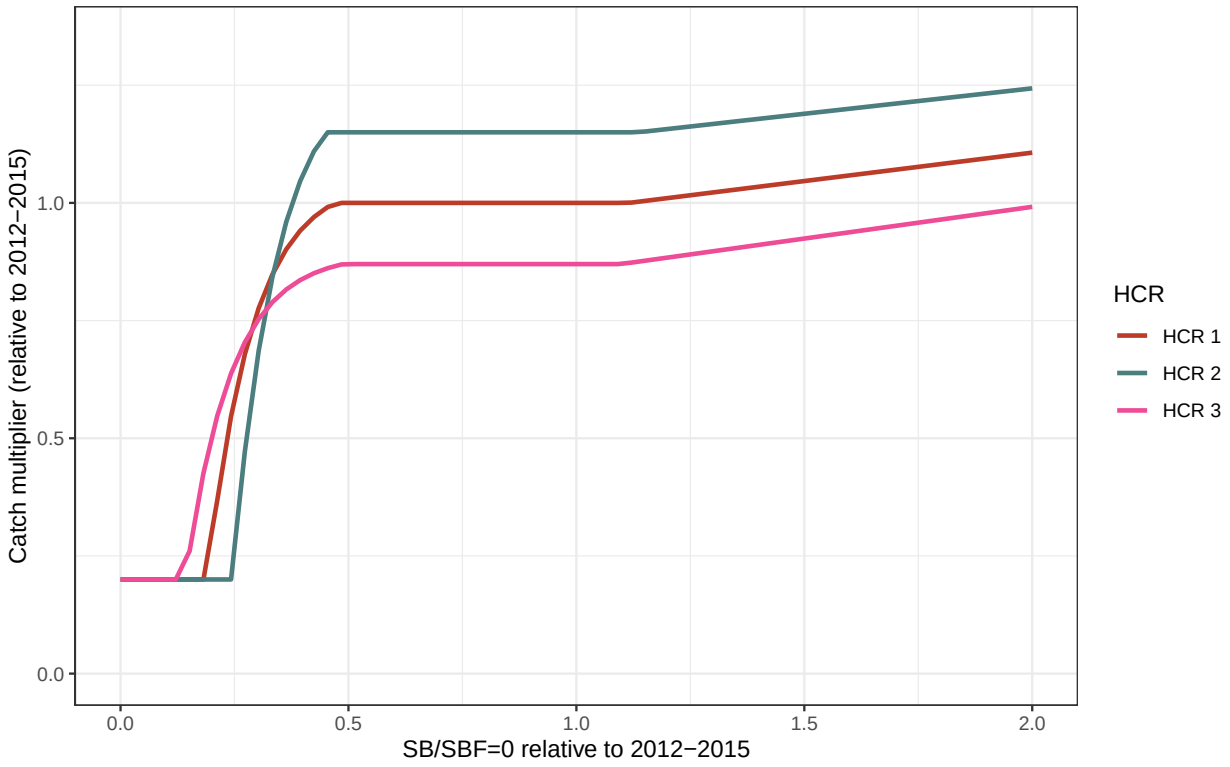

Figure 1: The basic HCR shapes. The input to the HCR is the estimated $SB/SB_{F=0}$ in the last year relative to the estimated average in 2012-2015. The output is a scalar applied to 2012-2015 levels of catch.

- 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.
- Vulnerable biomass available to TLL fisheries in model areas 3, 4 and 8. This is a proxy for CPUE and is calculated as relative to the average vulnerable biomass in the period 2019-2021.
- Total catch by the TLL fishery (10S to 20N), relative to 2019-2021.
- Total catch in the WCPFC-CA, relative to 2019-2021.
- Relative catch variability of the TLL fishery, calculated as the absolute annual difference in relative TLL catch.

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

- Short (2027-2035)
- Medium (2036-2044)
- Long (2045-2053)

5 Results

480 stochastic simulations (known as iterations) are performed for each MP. Each simulation completed successfully without the stock crashing, or the EM failing to converge.

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

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. WCPFC21 proposed candidate TRPs of 1x, 0.94x and 1.06x mean $SB/SB_{F=0}$ in 2012-2015, shown as the top three horizontal dashed lines. Note that these values were proposed on the basis of projections based on the 2023 stock assessment grid. The OM grid is different to the stock assessment grid and so the values have been rescaled accordingly. The bottom dashed line is the LRP.

The three MPs each achieve a median $SB/SB_{F=0}$ value equal to one of the proposed TRPs in the long-term. All current candidate MPs have a probability of being above the LRP greater than the WCPFC threshold of 0.8. As expected, the MP that achieves the lowest long-term $SB/SB_{F=0}$ has the lowest probability of being above the LRP.

5.2 Longline vulnerable biomass, tropical longline fisheries.

Vulnerable biomass is a proxy for CPUE (catch rates). The relative vulnerable biomass of tropical longline fisheries in the WCPFC-CA (10S to 20N) follows a similar pattern to the $SB/SB_{F=0}$ results (Figure 2).

Each of the MPs suggest that the future vulnerable biomass will be lower than the average 2019-2021 level (represented by the dashed line on the plot). This is consistent with the analyses to

inform discussions on candidate bigeye TRPs presented to WCPFC21, although the values are different as the OM grid and evaluation assumptions are different (see Table 5 of SPC-OFP, 2024).

In these evaluations, the expected vulnerable biomass is sensitive to changes in overall $SB/SB_{F=0}$, i.e. a large change in vulnerable biomass may only reflect a relatively small change in $SB/SB_{F=0}$. The $SB/SB_{F=0}$ indicator is calculated across all model areas, whereas the vulnerable biomass indicator only includes the tropical model areas 3, 4 and 8. Changes in stock abundance in only these areas will therefore impact the vulnerable biomass in these areas, while only having a small impact on the overall stock wide $SB/SB_{F=0}$, which is buffered by the biomass other areas.

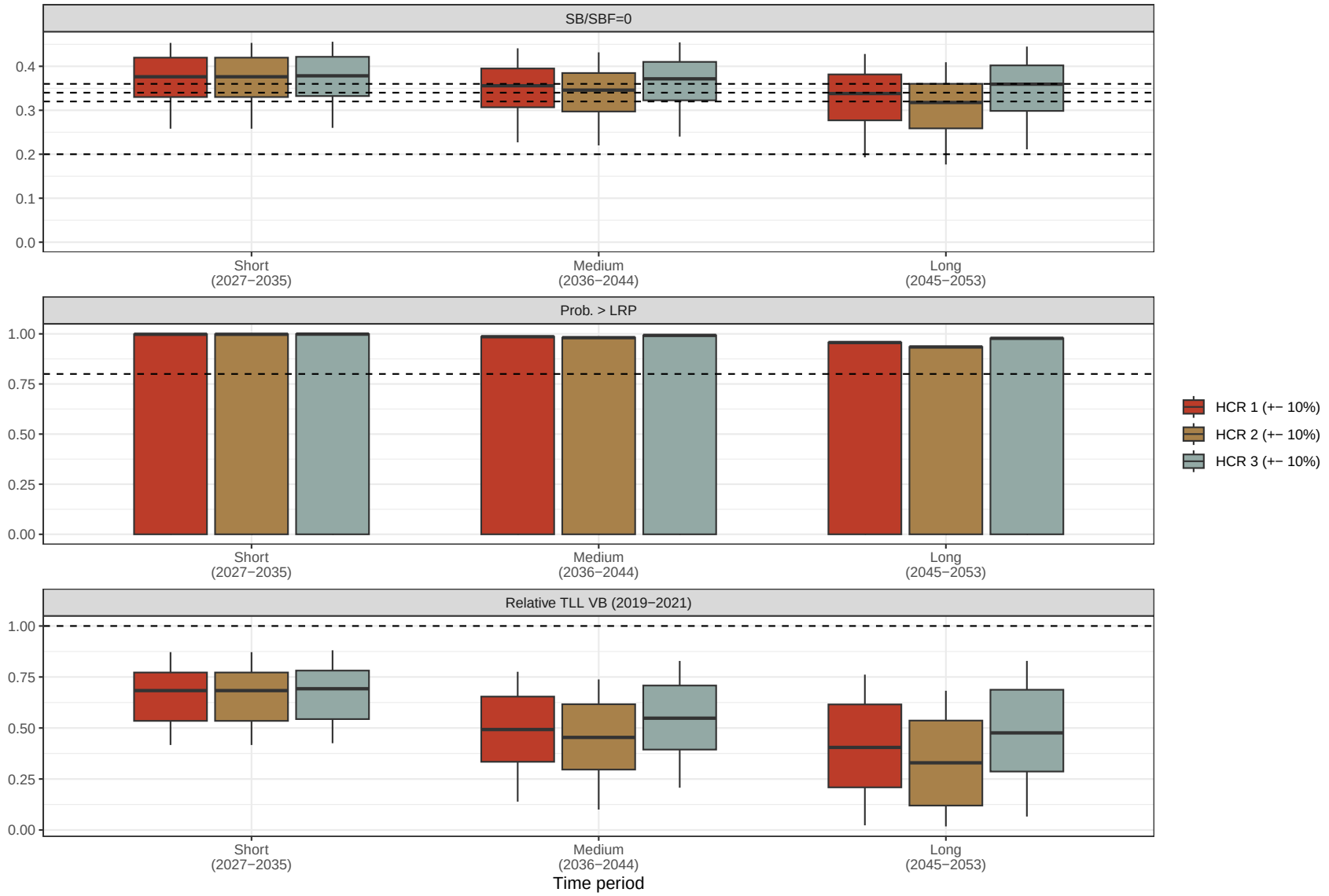

Figure 2: Box plots of $SB/SB_{F=0}$ in the WCPFC-CA and vulnerable biomass for the tropical longline fisheries in the WCPFC-CA (10S to 20N) relative to the level in 2019-2021, and a bar plot (middle) of probability of being above the LRP. The whiskers show the 95th percentile range, the box shows the 60th percentile range, and the horizontal line is the median value. Horizontal lines on the $SB/SB_{F=0}$ plot are the candidate TRPs from WCPFC21 (top three lines) and the LRP (bottom line). 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 catches are presented as relative to the average level in 2019-2021. The median level of expected catches are conditional on the shape of the HCR: the higher the height of the Hillary step, the higher the median catches (Figure 3). All MPs evaluated here show catches by the TLL fishery to be above the 2019-2021 average in all time periods.

A similiar pattern is seen for catches across the WCPFC-CA. However, the difference between the MPs is smaller than when only considering catches taken by the TLL. This is because the MP only manages the TLL fisheries, which make up only a portion of total WCPFC-CA catch. Differences in the MPs therefore have only a limited impact on the total WCPFC-CA catch.

The uncertainty in expected catches across the WCPFC-CA is higher than that for the TLL catches and is mainly driven by the fisheries that are managed on effort, rather than the performance of the catch-based MP. The amount of catch taken by fisheries managed by effort will depend on the stock status. Natural variability in stock status, here driven by recruitment variability, will therefore result in variable catches even when the future effort is fixed.

Relative catch variability is low for all three MPs. This implies that the estimated stock status lies mainly on the Hillary step part of the HCR, i.e. even as estimated stock status changes, the HCR output remains constant. This is also reflected in the relatively low uncertainty in the TLL catches.

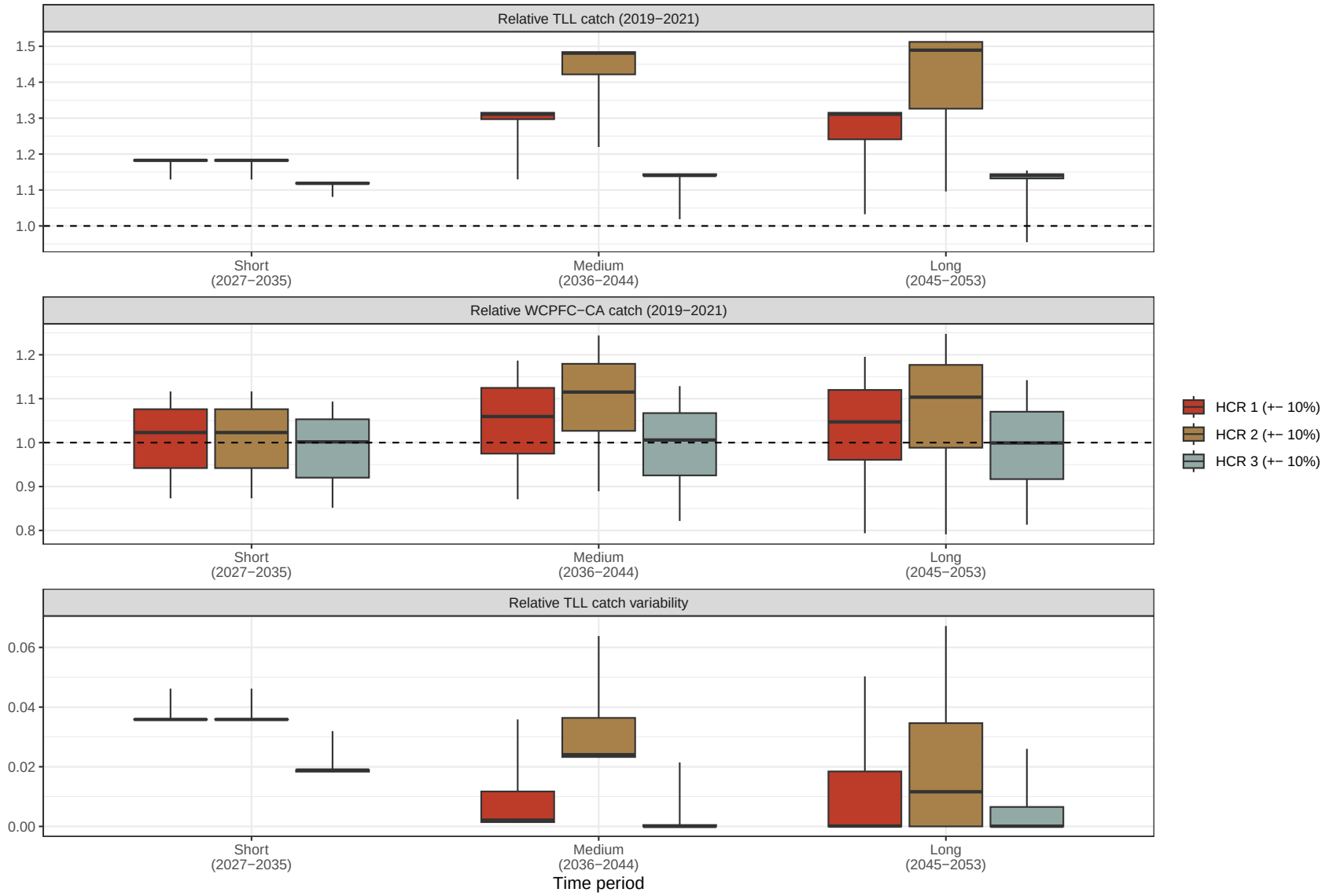

Figure 3: Box plots of catch taken by the tropical longline (TLL) fishery and across the WCPFC-CA, relative to the average 2019-2021 level. The average annual variability of the relative TLL catch is shown in the bottom panel. The whiskers show the 95th percentile range, the box shows the 60th percentile range, and the horizontal line is the median value. The dashed horizontal lines on the catch plots are at a relative catch of 1.0, i.e. 2019-2021 average catch level.

6 Discussion

This report describes the initial MSE framework for evaluating candidate MPs for WCPO bigeye tuna. Three candidate MPs are tested that have been been designed to achieve performance in terms of median long-term $SB/SB_{F=0}$ at the three candidate TRPs specified at WCPFC21. Each MP has the same data collection, estimation method and meta-rule, and differ only in their HCR shape. The main difference between the HCR shapes is the height of the Hillary step.

The difference between the three candidate TRPs is relatively small (ranging from stock depletions 0.32 to 0.36, across the OM grid). However, the difference in step heights of the HCRs is fairly large (ranging from 0.87 to 1.15 of 2012-2015 catch levels). This is a result of the bigeye MP only managing a subset of fisheries that catch bigeye. In these evaluations, the future catch or effort of fisheries not managed through the bigeye MP is held constant. Consequently, to affect a change in stock status, relatively large changes in fishing pressure by the TLL fishery are needed.

In these evaluations, the shorter FAD closure period described in CMM 2023-01 (one and half month annual FAD closure period in EEZs and high seas, with an additional month in the high seas) is assumed. Future work may include alternative assumptions about the FAD closure period. This may be important, given the impact of FAD fishing on juvenile bigeye. Other future scenarios are discussed in the OMs paper (WCPFC-SC21-2025/MI-WP-05).

We note these are preliminary analyses, demonstrating the utility of the bigeye MSE framework and providing results based upon the request of WCPFC21. However, further guidance will be needed from managers on the assumptions made on key settings within the analyses to progress the work.

Acknowledgments

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Appendix: Operating model area map

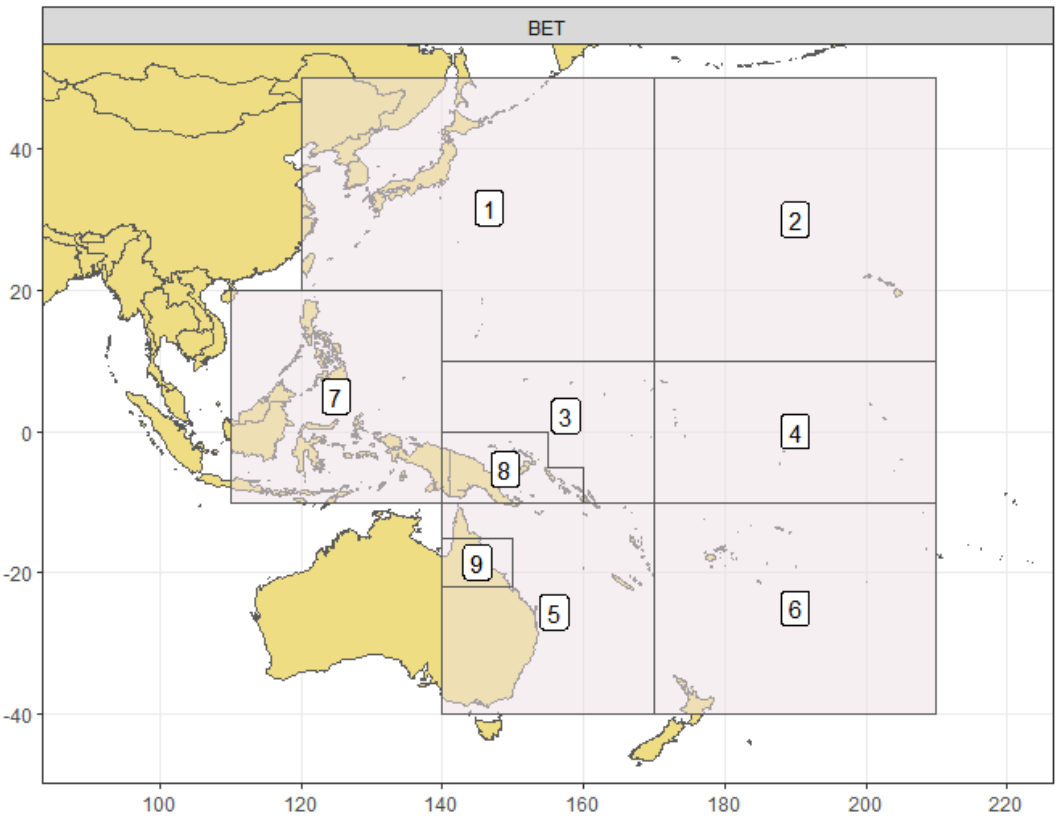

Figure 4: The bigeye operating model area map. Tropical longline fisheries operate in the range 10S to 20N. This includes those operating in areas 3, 4, 7 and 8. Longline fisheries operating in model areas 1 and 2 have a tropical and a northern longline component.