Updated Methodology to Calculate Total Allowable Catch for Candidate Management Procedures with a 70:30 WCPO:EPO Impact Ratio

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Abstract

This working paper recalculates the potential 2026-2028 Total Allowable Catch (TAC) for the candidate Management Procedures (MPs) 9 to 16 for Pacific Bluefin Tuna (PBF), addressing an inconsistency in the previous calculation presented in the ISC PBF Working Group's Management Strategy Evaluation (MSE) report. We update the relative apical fishing mortality (RelF) for MPs 9 to 16 used to allocate the TAC among the three fleet segments: Eastern Pacific Ocean (EPO), Western Central Pacific Ocean (WCPO) small fish, and WCPO large. The same RelF employed in the TAC calculation of MPs 1 to 8 (80:20 WCPO:EPO impact ratio) is used, adjusted to reach the target 70:30 WCPO:EPO impact ratio. This updated 2015-2022 RelF was estimated from an ASPM-R+ estimation model fitted to new data up to fishing year (FY) 2023 and with updated fixed parameters derived from a full dynamics stock assessment model fitted to new data up to FY 2023. The original TAC calculation for MPs 9-16 used a 2015-2022 RelF from the MSE estimation model based on older data. Recalculating the TAC for MPs 9-16 using the updated RelF resulted in a decrease in the WCPO small fish TAC and an increase in the WCPO large fish TAC. The EPO TAC remained largely unchanged. The overall WCPO:EPO impact ratio remained close to the target 70:30 regardless of whether the fixed or updated RelF was used, suggesting the changes were mostly between the large and small WCPO segments. We argue that using the updated RelF for MPs 9-16 is more precise and consistent with the approach for MPs 1-8. We recommend changing the workflow for generating the TAC for MPs 9 to 16 to use the updated RelF informed by new data.

Introduction

In June 2025 the ISC Pacific Bluefin tuna (PBF) working group (WG) completed the Management strategy evaluation (MSE) for Pacific Bluefin tuna, as tasked by the Western and Central Pacific Fisheries Commission’s Northern Committee (WCPFC NC) and the Inter American Tropical Tuna Commission (IATTC) Joint Working Group (JWG) on PBF management. The analysis assessed performance of 16 candidate management procedures (MPs) put forward by the JWG relative to a set of management objectives defined by the JWG (ISC 2025). All the MPs set a Total Allowable Catch (TAC) for three fleet segments: the Eastern Pacific Ocean (EPO), the Western Central Pacific Ocean (WCPO) fleet small fish, and the WCPO fleet large fish.

The MSE simulated application of each candidate MP over a period of 23 years to assess if management objectives are met when the stock is managed using each of the candidate MP. Each MP uses a stock assessment (i.e., the estimation model, EM) to derive inputs to a harvest control rule (HCR) that sets an annual TAC that is kept constant for three years until the next stock assessment. The first simulated annual TAC is for calendar years 2026 to 2028 and is based on output from a first EM that uses simulated data up to fishing year (FY, July-June) 2023. The second TAC for 2029-2031 is based on a second EM that uses simulated data updated to FY 2026, and so on until the last EM with data up to FY 2044. This is similar to what is done in the real world. For example, the current PBF catch limits were informed by the latest PBF stock assessment model completed in 2024, which used data up to FY 2022 (ISC 2024). However, the stock assessment (i.e, EM) used with each MP in the MSE is simpler than the latest PBF stock assessment. It is an Age-Structured Production Model with Recruitment, ASPM-R+, where the + indicates use of some size composition data. All of the ASPM-R+ parameters except the R1 offset, the R0, the initial F, and the main and early recruitment deviations were fixed to those of a full dynamics integrated model based on the latest PBF stock assessment model which used data up to FY 2022 (ISC 2025).

In the calculation of the simulated TAC, the allocation between fleet segments is driven by the relative apical fishing mortality (RelF) used for each fleet. The apical fishing mortality (F) is the fully selected fishing mortality for each fleet. The RelF is the ratio of each fleet apical F to the total apical F, and can be expressed as a fraction or a percentage. The RelF for the fleet operating in the EPO and fleets operating in the WCPO are set to meet the WCPO:EPO fisheries impact ratio set by the JWG for each MP (WCPFC 2023). MPs 1 to 8 have a WCPO:EPO fisheries impact ratio of 80:20, while MPs 9 to 16 have a 70:30 fisheries impact ratio. For MPs 1 to 8, the JWG agreed to use the average 2015-2022 RelF in the TAC calculation (WCPFC 2023), which leads to a WCPO:EPO impact ratio of about 80:20 in the terminal year of the MSE simulation across all iterations and operating models (ISC 2025). To obtain an impact ratio of 70:30 for MPs 9 to 16, the PBF WG developed a method to estimate by how much to tune the baseline 2015-2022 RelF to obtain a desired WCPO:EPO impact ratio (Tommasi and Lee 2024). For a 70:30 WCPO:EPO impact ratio, the baseline 2015-2022 EPO RelF is modified to have 6.5% more of the total apical F, and the WCPO RelF to have 6.5% less (ISC 2025). While the RelF between the EPO and WCPO fleets is controlled by the fisheries impact ratios put forward

by the JWG, within the WCPO, the RelFs of the WCPO small and large fleets are proportional to those in the 2015-2022 baseline no matter the WCPO:EPO impact ratio used.

The 2015-2022 RelF is thus a key component of the TAC calculation. In the MSE simulation, for MPs 1 to 8, the 2015-2022 RelF used in the calculation of the simulated TAC is re-estimated by each EM (Table 1). Thus, it changes slightly over the simulation time period as the EM is updated with new data and fitted every three years. By contrast, the RelF for MPs 9 to 16 stays fixed to the 2015-2022 RelF estimated by the first EM under operating model 1 and adjusted by 6.5% to reach an impact ratio of 70:30 (ISC 2025, Table 1). Modifying the estimated 2015-2022 RelF at each simulated EM would have added more computational time to the already long simulation, and thus the fixed RelF approach was adopted.

In addition to presenting the output of the MSE simulation, the ISC PBF WG MSE report also showed what the 2026-2028 annual TAC for each of the three fleet segments (i.e., WCPO small fish, WCPO large fish, and EPO) and candidate MPs would be when using the updated and re-fitted ASPM-R+ stock assessment model (i.e, the EM) using new data available as of spring 2025. In this calculation of the 2026 TAC outside the MSE simulation, the potential TAC for MPs 1 to 8 used the 2015-2022 RelF from the updated ASPM-R+ model based on a full dynamics model also updated with data until FY 2023 (Table 1). While the TAC calculation for MPs 9 to 16 also used the output of the updated ASPM-R+ model, unlike MPs 1 to 8, it employed the fixed RelF from the MSE simulation, which was not based on an ASPM-R+ model updated with new data (Table 1). The two 2015-2022 RelFs in the MSE report, one used for the TAC of MPs 1-8 and one for the TAC of MPs 9 to 16, are inconsistent with each other as they are derived from models with different end years (Table 1).

In the PBF stock assessment, there is uncertainty in the estimation of recruitment in the final years of the model, particularly for cohorts born in the last 6–7 years, since the abundance of those cohorts was not calibrated by any abundance index in the model (ISC 2024). As there are significant fisheries targeting juveniles (age 2 or less), this can lead to uncertainty in estimated parameters such as selectivity and fishing mortality and also in the RelF for the final years of the assessment. As more years of data are added to the assessment we would expect the estimate of 2015-2022 RelF to change and become more precise. Here we recalculate the potential 2026 TAC for MPs 9 to 16 using the 2015-2022 RelF from the updated ASPM-R+ model as it is more precise and consistent with the one that was used for MPs 1 to 8 (Table 1).

Table 1. Summary detailing how the 2015-2022 relative apical fishing mortality (RelF) used in the TAC calculation is computed for MPs 1 to 8 and MPs 9 to 16 in the MSE simulation, and in the computation of the 2026-2028 TAC in the MSE Report and in this working paper.

MP Type	**2015-2022 RelF Calculation Details**		
	MSE Simulation	*2026-2028 TAC in MSE Report*	*2026-2028 TAC in this paper*
MPs 1 to 8	Estimated every three years from ASPM-R+ stock assessment model updated with new data	Estimated from ASPM-R+ stock assessment model updated with new data and fixed parameters from full dynamics stock assessment model updated with new data	No change from MSE Report
MPs 9 to 16	Fixed to 2015-2022 RelF from EM1 of MPs 1 to 8 under operating model 1 and adjusted to reach a 70:30 EPO:WCPO impact ratio	Fixed to the same RelF used in the MSE simulation	Same as that used by MPs 1 to 8 in the 2026-2028 TAC calculation but adjusted to reach a 70:30 EPO:WCPO impact ratio

Methods

First, we compare the average 2015-2022 RelF for the small WCPO fleet segment, mixed WCPO fleet segment, large WCPO fleet segment, and EPO fleet segment estimated by the updated ASPM-R+ to the fixed RelF used in the MSE and the 2026-2028 TAC computation for MPs 9-16 in the MSE report (ISC 2025). The Stock Synthesis software (Methot et al. 2020) automatically computes the RelF by season for each fleet as specified in the ASPM-R+ model, which uses a fleet notation finer than fleet segments to account for changes in gear selectivity and local availability to fleets operating in different regions and seasons. To obtain the RelF for each fleet segments from that of the more highly resolved fleets, we summed the RelF of the fleets belonging to each fleet segments across seasons. In the WCPO, Japanese set-net and Korean purse seiners catch a mix of sizes and thus we report a separate RelF for mixed fleets for

ease of computation, rather than a RelF solely for the WCPO small and large fleets. However, the TAC, as requested by the JWG, is computed for the WCPO large and small fleet segments only. This is done by adding the TAC of ages 0 to 2 from the WCPO mixed fleets to the WCPO small fish TAC, and the TAC for ages 3 and older of the WCPO mixed fleets to the WCPO large fish fleets TAC.

The potential TAC for MPs 9 to 16 was calculated following the same approach as in the current MP TAC calculation (Section 5.6 of ISC 2025) but with the 6.5% adjustment applied to the updated 2015-2022 RelF from the ASPM-R+ model updated with FY 2023 observations. The workflow to obtain the potential TAC for MPs 9 to 16 with the updated ASPM-R+ was as follows:

1. Update the 2024 PBF stock assessment, which has data up to FY 2022, with any new available observations. Available observations were catches for all fleets updated to FY 2023, and the index of abundance from the Chinese Taipei longline fleet updated with FY 2023 data. No updated size composition data was available.
2. Fit the full dynamics model to the updated dataset and check model diagnostics.
3. Develop an ASPM-R+ version of the full dynamics model by fixing all parameters to the value from the updated full dynamics model except for the 1982 recruitment offset, log R0, initial F for fleet 1, main recruitment deviations, and early recruitment deviations.
4. Fit the ASPM-R+ to the updated dataset and estimate parameters.
5. Extract the average 2015-2022 RelF.
6. Adjust the average 2015-2022 RelF so that the EPO RelF has 6.5% more of the total apical F, and the WCPO RelF has 6.5% less.
7. Specify the adjusted RelF from step 6 directly in the forecast file, fix all the parameters and run the ASPM-R+ model again to obtain the F multiplier, biomass at age, and spawning stock biomass relative to unfished and calculate the TAC based on the HCR of each MP (see section 4.2.3 of ISC 2025 for more details).
8. Compare the TAC to the current catch limit (WCPFC's CMM24-01 for WCPO fleets and the one-year maximum of IATTC's Resolution C-24-02 for the EPO fleet), and, as specified in each MP, if the HCR TAC is 25% higher or lower than the current catch limit and SSB is above the limit reference point, set the TAC to ±25% of the current catch limit instead.

Note that the current MP TAC for MPs 1 to 8 followed the same steps described above, but the updated ASPM-R+ model was run with a forecast file where the RelF was set to the average of 2015-2022 rather than to that adjusted to obtain a WCPO:EPO 70:30 impact ratio. The R code to compute the TAC and associated Stock Synthesis EM files are at https://github.com/detommas/PBFTAC. The new TAC for MPs 9 to 16 was compared to the TAC for MPs 9 to 16 computed previously with the fixed RelF from the MSE simulation (Table ES4 in ISC 2025).

Finally, we wanted to assess if the 70:30 WCPO:EPO set by the JWG would be met using either RelF. Using the MSE framework (see ISC 2025 for details), we run 100 iterations of MP 9 under operating model 1 and the EM with the updated RelF. We then compared the terminal year fishery impact ratio to that obtained for MP 9 during the MSE simulation with the fixed RelF.

Results

The updated 2015-2022 RelF of the ASPM-R+ for MPs 9-16 (Table 1) was estimated to 59% for the WCPO small fleet segment, 28% for the WCPO large fleet segment, 6% for the WCPO mixed fleet segment, and 7% for the EPO fleet segments. This is a 1 percentage point decrease for the RelF of the EPO and WCPO mixed fleet relative to the fixed RelF used in the previous TAC computation for MPs 9-16 (Table 2). Changes in the RelF of the WCPO large and small fleets were higher. The WCPO small fleet segment 2015-2022 RelF decreased by 5 percentage points, while the WCPO large fleet segment RelF increased by 7 percentage points (Table 2). Since the largest changes in RelF between the two estimates are within the WCPO between the large and small fish fleet segments, the WCPO:EPO fisheries impact was similar notwithstanding which 2015-2022 baseline RelF is used (Table 3).

Table 2. Estimates of the average 2015-2022 relative apical fishing morality (RelF) by fleet segments for the two different ASPM-R+ estimation models. The Updated RelF is that from the ASPM-R+ model updated with new data from fishing year (FY) 2023 and new parameters from a full dynamics stock assessment model fit to updated data up to FY 2023. Fixed RelF is that

from the ASPM-R+ model used in the MSE and not updated with FY 2023 observations or new parameters from a full dynamics stock assessment model fit to updated data up to FY 2023

2015-2022 RelF Type	2015-2020 RelF (%)			
	WCPO small	WCPO large	WCPO mixed	EPO
Updated	59	28	6	7
Fixed	64	21	7	8

Table 3. WCPO: EPO Fishery Impact Ratio for the terminal year of an MSE simulation under operating model 1 and MP 9 that uses an EM with the 2015-2022 relative apical fishing morality (RelF) increased by 6.5% for the EPO and decreased by 6.5% for the WCPO to meet a 70:30 WCPO:EPO impact ratio. The "Updated" RelF Type adjusted the 2015-2022 RelF estimated by the ASPM-R+ model updated with fishing year 2023 observations, whereas the "Fixed" RelF Impact Ratio adjusted the 2015-2022 RelF estimated used in the MSE model and conditioned to data up to fishing year 2022.

2015-2022 RelF Type	WCPO:EPO Impact Ratio		
	Median	5th quantile	95th quantile
Updated	71:29	72:28	70:30
Fixed	70:30	72:28	69:31

The differences in 2015-2022 RelF resulted in different 2026 TACs by fleet segment for MPs 9 to 16 as compared to what was calculated using the fixed 2015-2022 RelF, with the largest differences being for the WCPO small and large fleets. The WCPO small fish TAC decreased for all candidate MPs except for MP 11, which already had a TAC set at 3844 mt, the minimum 25% decrease from the current WCPO small fish limit (Table 4). By contrast, the WCPO large fish TAC increased for all candidate MPs except for MPs 13 to 15 which were already at 14836 mt TAC, the maximum 25% increase from the current catch (Table 4). The EPO TAC remained similar, with the TAC for most MPs except MP 11 still being set at 9476 mt, the maximum 25% increase from the current catch limit (Table 4). The EPO TAC for MP 11 was lower with the updated RelF (Table 4).

Table 4. TAC for candidate MPs 9 to 16 calculated based on the updated 2015-2022 RelF baseline or the fixed RelF used in the MSE.

Candidate MP	TAC WCPO small (mt)		TAC WCPO large (mt)		TAC EPO (mt)	
	Fixed RelF	Updated RelF	Fixed RelF	Updated RelF	Fixed RelF	Updated RelF
9	4392	3844	14073	14836	9476	9476
10	4392	3844	14073	14836	9476	9476
11	3844	3844	10724	13031	9085	8576
12	4392	3844	14073	14836	9476	9476
13	5010	4362	14836	14836	9476	9476
14	5749	5023	14836	14836	9476	9476
15	5010	4362	14836	14836	9476	9476
16	4392	3844	14073	14836	9476	9476

Discussion

Our analysis demonstrates that there is uncertainty in the estimate of RelF in the recent years of the ASPM-R+ PBF model used in the MPs, particularly in the large vs. small fish RelF in the WCPO. Thus, when the ASPM-R+ is updated with new data and new parameters from a full dynamics model updated with new data, the RelF changes, particularly between WCPO small and large fleet segments. This is due to lack of information on recruitment in the final years of the assessment model, which leads to uncertain estimates of F on small fish.

We demonstrate that differences in 2015-2022 RelF estimates lead to differences in the estimated TAC for MPs 9 to 16, particularly for the large and small WCPO fleet segments. There is a decrease in the small fish TAC and an increase in the large fish TAC when the updated RelF is used in the TAC calculation. However, since the changes are largely within the WCPO fleets, changes to the WCPO:EPO impact ratio are minimal, with the impact ratio remaining around 70:30 notwithstanding which RelF is used in the TAC calculation.

We recommend that the workflow to generate the TAC for MPs 9 to 16 be changed to use the updated RelF as shown here. This is consistent to how the TAC for MPs 1 to 8 was calculated and is based on a RelF informed by more data.

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