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Requested Future projection based on the new CMMs proposed in 2024

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Introduction

The Ninth meeting of the IATTC-WCPFC NC Joint Working Group (JWG) on Pacific Bluefin Tuna (PBF) management held in July 2024 discussed about a new management measure after seeing the results of ISC 2024 PBF stock assessment. Then, the JWG adopted a draft resolution for IATTC and a draft CMM for WCPFC (IATTC-WCPFC JWG 2024). Those management measures are basically similar with one of the harvesting scenarios of projection (scenario 15) conducted by the ISC (ISC 2024). However, there were several tweaks from the scenario 15, which were made after intensive discussion and negotiation, in the form of additional catch allocations to some countries and the JWG requested ISC to conduct projection based on the specifications of the recommended measures. This document provides a result of the future projection with a new harvesting scenario based on the newly adopted draft management measures.

Model configuration for the future projection

Base case assessment model

The 2024 PBF assessment base case model was developed using the Stock Synthesis (SS) version 3.30.22. The base case model files were shared among the attendees of the stock assessment meeting on March 9th, 2024. This base case model was used as a basis of all analysis in this document.

Future projection model

The future projection platform for PBF was developed and compiled as an R-package 'ssfuture', and it was firstly introduced in the 2012 assessment (ISC 2012). This software can simulate quarterly age-structured population dynamics in a forward direction, which has similar population dynamics structure with the SS (Methot and Wetzel 2013).

Bootstrap

Each projection is conducted based on the 300 bootstrap replicates of assessment base case followed by twenty stochastic simulations for the recruitment resampling, thus 6,000 runs in total were estimated for each scenario. These replicates were produced by the bootstrapping function of the SS, and those were anticipated to incorporate parameters and observation uncertainty. From this assessment, PBFWG updated the version of the SS from 3.30.14 to 3.30.22. This update included the change in the bootstrapping procedure for the size composition data, but we confirmed that the difference by this update for the estimated demography was not critical. In Fukuda et al. (2020), biases of the output variables between the point estimates of the assessment base case and the median of bootstrap replicates were pointed out. These biases were also confirmed in the 2024 assessment base case. Lee et al. (2021) identified possible sources of biases during the bootstrapping procedure, and a method for bootstrapping procedure to reduce the biases was suggested. This method was applied in

the procedure of bootstrapping for the 2024 assessment.

Recruitment

In the base case model, recruitment fluctuated during the stock assessment period without apparent trend. The recruitment in 2021 fishing year of the assessment had a large uncertainty and a possible bias mainly due to the lack of information in the input data. The WG assumed that the future recruitment would fluctuate as it was in the past period during 1983-2020, thus it was resampled from that period, in the 2024 assessment. We followed the same procedure in this analysis.

Initial Condition and Time Frame

In the March 2024 stock assessment meeting, the WG agreed to start the projection from the beginning of 2021 fishing year (one year before the terminal year of assessment) ending in 2041. The reason for this procedure was that a couple of recruitments in 2021 and 2022 FY estimated by the assessment had a large uncertainty and a possible bias mainly due to the lack of information about those cohorts in the input data. The numbers at age at the beginning of the 2021 FY from each of the bootstrap replicates were applied as an initial age structure of the projection, and the recruitment in 2021 FY was resampled from the past time series.

Twenty years of future dynamics of PBF stock was simulated in this projection. Catches for 2021-2022 FY were given based on the reported catch. Catches after 2022 are based on the allocation defined in the new resolution (IATTC) and the CMM (WCPFC).

Grouping of the fleets

In the 'ssfuture', the fishery fleets in the assessment can be lumped into groups of fleets to apply a mutual catch upper limit for the group of fleets. Common age-based fishing mortality (F at Age from the assessment) and size-based catch quota are applied among the fleets in a group. Number of groups should be equal or smaller than number of fleets. The basic groups of the fishing fleet in the projection were defined as;

Group 1 (Japanese longline) ; Fleet 1,2
Group 2 (Japanese Purse seine) : Fleet 5-10
Group 3 (Japanese coastal fisheries) : Fleet 12-19
Group 4 (Korea) : Fleet 11
Group 5 (Chinese-Taipei) : Fleet 3,4
Group 6 (EPO commercial fisheries) : Fleet 20,21
Group 7 (EPO Sport) : Fleet 22,23
Group 8 (Unaccounted mortality) : Fleet 24-26.

Harvesting scenario

The harvesting scenario for this projection basically followed the method conducted at the 2024 PBF stock assessment (Nishikawa et al., 2024). For all scenarios, the catch is controlled based on the age specific fishing mortality in the average of 2002-2004 FY as well as the catch upper limit for each fishery group to reflect the effort and catch controls prescribed in the WCPFC CMM. If the calculated catch from the fishing mortality and the numbers at age in any given year exceeds their catch limit, the catch at that year was re-calculated to be settled within its catch upper limit (Akita et al., 2015). The catch limit was assigned for small and large PBF categories (i.e. <30kg or ≥30kg) for the fisheries in western Pacific except for the Korean fleet, which have a different fishing pattern in recent years. In the case of Korean fishery, the catch upper limit not by the size category but a total quota was assigned, and the average fishing mortality at age during 2014-2016, when they caught both the small PBF and large PBF, was applied. The quota in small fish category for Japanese Purse Seine was transferred 250 t to the quota in large fish category for the same fishery. Because there is no resolution for effort management in the measure of the IATTC, the same fishing patterns for the eastern Pacific fisheries are simulated (e.g. F2002-04). Also, because the EPO commercial fishery fleets in the assessment (fleet 20 and 21) combined both of the Mexican and the U.S. commercial fisheries, the projection could not separate those fisheries but combining into a single "EPO commercial fishery group". The EPO recreational fishery was treated as an independent group without any catch upper limit since there is no written catch upper limit but a kind of the effort control (bag limit).

In this document, 4 harvesting scenarios were compared. The first scenario was the status quo scenario, which is identical one from one of the projections conducted at the 2024 stock assessment (scenario 1). The second scenario was scenario 15 from the 2024 stock assessment (ISC 2024), which raised catch quotas in the IATTC convention area for 50% from the status quo, as well as 10% and 50% for the small and large PBF quotas in the WCPFC convention area, respectively. The third scenario was a new harvesting scenario which applied some tweaks on scenario 15 to be consistent with the adopted draft management measures discussed by the JWG (IATTC- WCPFC JWG 2024). Differences between scenario 2 (scenario 15 in 2024 stock assessment) and scenario 3 (the new CMMs) as well as the modeling method to deal with those were as below.

- No increase of small PBF quota from the status quo scenario for Korean fleet (Fleet 11 in the assessment) while, additional 471 t was allocated to large PBF quota.
  - To reflect the observed size distribution of catch by Korean fleet in recent years, which catches more PBF in large size category than their original quota (only small fish category), an annual catch upper limit without size category with a recent fishing pattern ($F_{2014\text{-}2016}$) were applied in the projection calculation. 2014-2016 were the years been started to catch larger category fish by the Korean fleet.

- Countries located in the southern hemisphere were allocated with new catch quota (200 t for New Zealand and 40 t for Australia).
  - Because catch by countries located in the southern hemisphere was included in the Chinese Taipei longline southern fishing ground fleet (fleet 3) in the stock assessment, those catch allocations for countries in the southern hemisphere were also assigned to fleet 3 in this projection.
- Catch limit for commercial fisheries in the EPO (fleet 21) was increased by 300 t additionally.
  - Catch upper limit for the EPO commercial fishery in recent years (fleet 21) was simply raised for 300 tons from that of the scenario 2.

There were several detailed provisions such as "2-years block quota", "Carry-over" and "quota transfer from the quota for small PBF category to large one" in the CMMs, however, this projection didn't consider those detailed provisions. Also, the stock assessment considered unseen mortality in each convention area, but the future projection didn't assume the unseen mortality.

Furthermore, based on the JWG request (IATTC-WCPFC JWG 2024), the projection scenario with maximum transfer with conversion factor from WPO small fish catch limits to WPO large fish catch limits was calculated as scenario 4 additionally.

Harvesting scenarios were available in table 1.

Result

The results were shown in table 2, 3 and figure 1, 2. Estimated SSB at 2034 of the projection for new CMM scenario was 224,029 tons (36.0% SSB_0) and it was slightly lower than the scenario 15, but there was only little difference between them (table 2 and figure 1). The SSB had gradually increased to achieve 93% probability to 20%SSB_0 in 2041. Due to a higher catch amount for new CMM scenario, the probability of overfishing relative to each candidate reference point in 2041 became slightly higher than the scenario 15 (table 2 and figure 2). A scenario with maximum transfer from WPO small fish catch limits to WPO large fish catch limits (scenario 4) showed a slight decrease in a couple of the initial years of projection, but it showed more rapid increase thereafter. The decreasing trend in the earlier period was caused by a massive increase of catch for large fish category. And the increasing trend in the later period was caused by a higher surplus production caused by no catch in small fish category than a massive catch increase for the large fish category. The small fish were protected from the fishery and allowed to grow up to large size in this scenario.

The expected future catches by country were shown in Table 3. The commercial catches in the EPO realized their quota in 2029 and 2034, and the recreational fishery group caught 1210 and 1298 tons of PBF in 2029 and 2034. Chinese Taipei longline group, which included quota for New Zealand and Australia, also consumed their catch limits in 2029 and 2034. Korean fisheries fleet has both size categories, and this fleet was assigned with a single size-combined quota to reflect recent fishing

pattern. Korean fishery was expected to catch about 700 and 500 tons of small and large PBF, respectively, and those were reasonably similar with their catch upper limits.

All fishery groups, which were sub-divided by country, area, size category and gear, caught PBF up to their catch limits. Thus, the scenarios of this projection could replicate the new management measure drafted by the RFMOs.

Another request from the Northern Committee of the WCPFC said that the ISC was asked to seek the potential impact of the maintaining catch for young of the year PBF (YOY; smaller than 2kg body weight) less than 50% of 2002-2004 average level (WCPFC NC 2024). Because the projection result confirms that the YOY catch by Japanese fleets were less than 50% of 2002-2004 average level for scenario 3 (Table 3), we did not calculate further scenarios.

There were several unmodeled provisions in this projection. Among them the “Block-quota” and “Carry-over” provisions potentially affect to the stock condition negatively. Also, as shown in the scenario 4, “Quota transfer from small PBF category to large one with conversion factor” will only work on the stock condition positively. Although those unmodelled measures could make our projections a little bit imprecisely, the authors believed those would have a limited impact on the results by canceling each of positive and negative effects.

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Table 1. Future projection scenarios for PBF.

Harvesting scenarios												
Reference No	Scenarios				Catch limit in the projection							Note
	WCPO		EPO		WCPO					EPO		
	Small	Large	Small	Large	JPN		KOR		TWN	Commercial		
					Small	Large	Small	Large	Large			
1	Status quo (WCPFC CMM2023-02, IATTC Resolution 21-05)				4,007	5,614	718	30	1,965	3,995		JWG 8's request 1(NC19 Summary Report, Attachment E; Maintaining the current CMM)
2	Status quo +10%	Status quo +50%	Status quo +50%		4,407	8,421	790	45	2,948	5,993		Additional request scenario 3 from JWG co-chairs.
3	New CMM (Resolution and CMM adopted)				4,407	8,421	718	501	3,187	6,292		New CMM adopted in JWG 9. Update points from s2 are as below. /Korea no increase for small fish, add 471 ton to original large fish quota /EPO got additional 300t /NZ and AU got 200 and 40t respectivly. For FP calculation, these amount assigned to Taiwanese group.
4	No catch	New CMM for large fish +New CMM for small fish *1.47	New CMM		0	14,899	0	1,556	3,187	6,292		Based on the new CMM adopted by JWG,all small fish catch limits in WPO are transferred with conversion factor to large fish catch limits.

Table 2. Future projection scenarios for PBF and their probability of achieving various target levels by various time schedules based on the base-case model.

Harvesting scenarios							Performance indicators								
Reference No	Scenarios				Specified fishery impact at 2034		Median SSB at 2034	Fishery impact ratio of WPO fishery at 2034	Fishery impact ratio of EPO fishery at 2034	Probability of achiving the 2nd rebuilding target at 2041	Risk to breach $SSB_{7.7\%F=0}$ at least once by 2041	Probability of overfishing compared to 20%SSB0 at 2041	Probability of overfishing compared to 25%SSB0 at 2041	Probability of overfishing compared to 30%SSB0 at 2041	Probability of overfishing compared to 40%SSB0 at 2041
	WCPO		EPO												
	Small	Large	Small	Large	WCPO	EPO									
1	Status quo (WCPFC CMM2023-02, IATTC Resolution 21-05)				-	-	287,844	78%	22%	100%	0%	0%	1%	4%	20%
2	Status quo +10%	Status quo +50%	Status quo +50%		-	-	237,663	79%	21%	96%	0%	4%	11%	22%	50%
3	New CMM				-	-	224,029	79%	21%	93%	1%	7%	15%	27%	57%
4	No catch	New CMM for large fish +New CMM for small fish *1.47	New CMM		-	-	360,888	72%	28%	100%	0%	0%	0%	0%	5%

Table 3. Expected yield for PBF under various harvesting scenarios based on the base-case model.

	Harvesting scenarios				Expected catch																				Number of fish under 2kg (x1,000 fish) caught by Japan	
Reference No	Scenarios				Catch limit in the projection						2029							2034								
	WCPO		EPO		WCPO					EPO	WCPO					EPO		WCPO					EPO			
	Small	Large	Small	Large	JPN		KOR		TWN	Commercial	JPN		KOR		TWN	Commercial	Sport	JPN		KOR		TWN	Commercial	Sport	50% 2002-2004: 818(x1,000 fish)	
					Small	Large	Small	Large	Large		Small	Large	Small	Large	Large			Small	Large	Small	Large	Large			2029	2034
1	Status quo (WCPFC CMM2023-02, IATTC Resolution 21-05)				4,007	5,614	718	30	1,965	3,995	3,766	5,902	418	337	1,980	4,010	1,797	3,766	5,904	413	342	1,986	4,011	2,005	-	-
2	Status quo +10%	Status quo +50%	Status quo +50%		4,407	8,421	790	45	2,948	5,993	4,161	8,733	483	358	2,954	5,990	1,238	4,161	8,730	478	363	2,952	5,992	1,318	-	-
3	New CMM				4,407	8,421	718	501	3,187	6,292	4,162	8,722	714	513	3,198	6,286	1,210	4,162	8,721	705	522	3,191	6,290	1,298	426	426
4	No catch	New CMM for large fish +New CMM for small fish *1.47	New CMM		0	14,899	0	1,556	3,187	6,292	0	15,049	0	1,552	3,219	6,300	1,554	0	15,066	0	1,559	3,202	6,296	1,921	-	-

1. Japan transfers 250 t from catch limit for small fish to for large fish in all scenarios.
2. Catch for each size category in Korean fisheries is based on fishing mortality during 2014-2016.
3. In new CMM, Taiwanese catch limit includes catch limit for New Zealand (200 t) and for Australia (40 t).

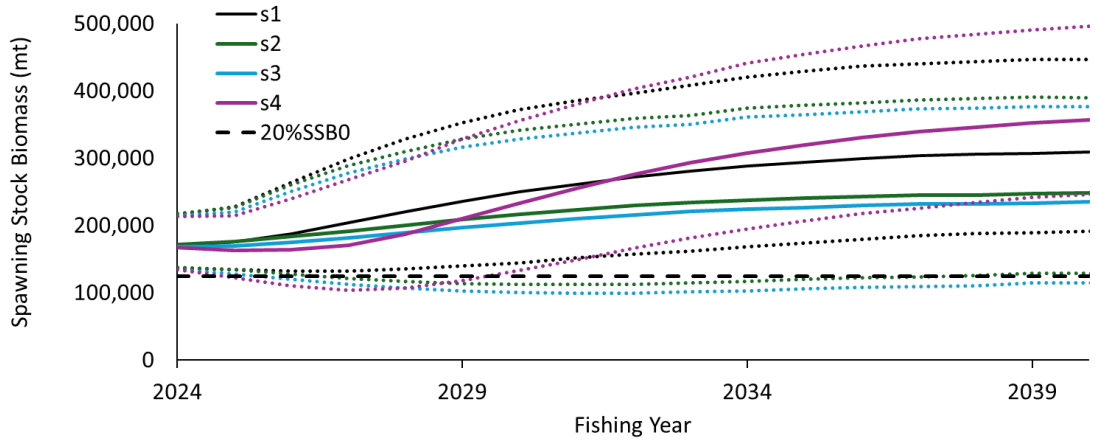

Figure 1. Comparisons of various projected median SSB for 3 harvest scenarios examined for PBF obtained from projection result.

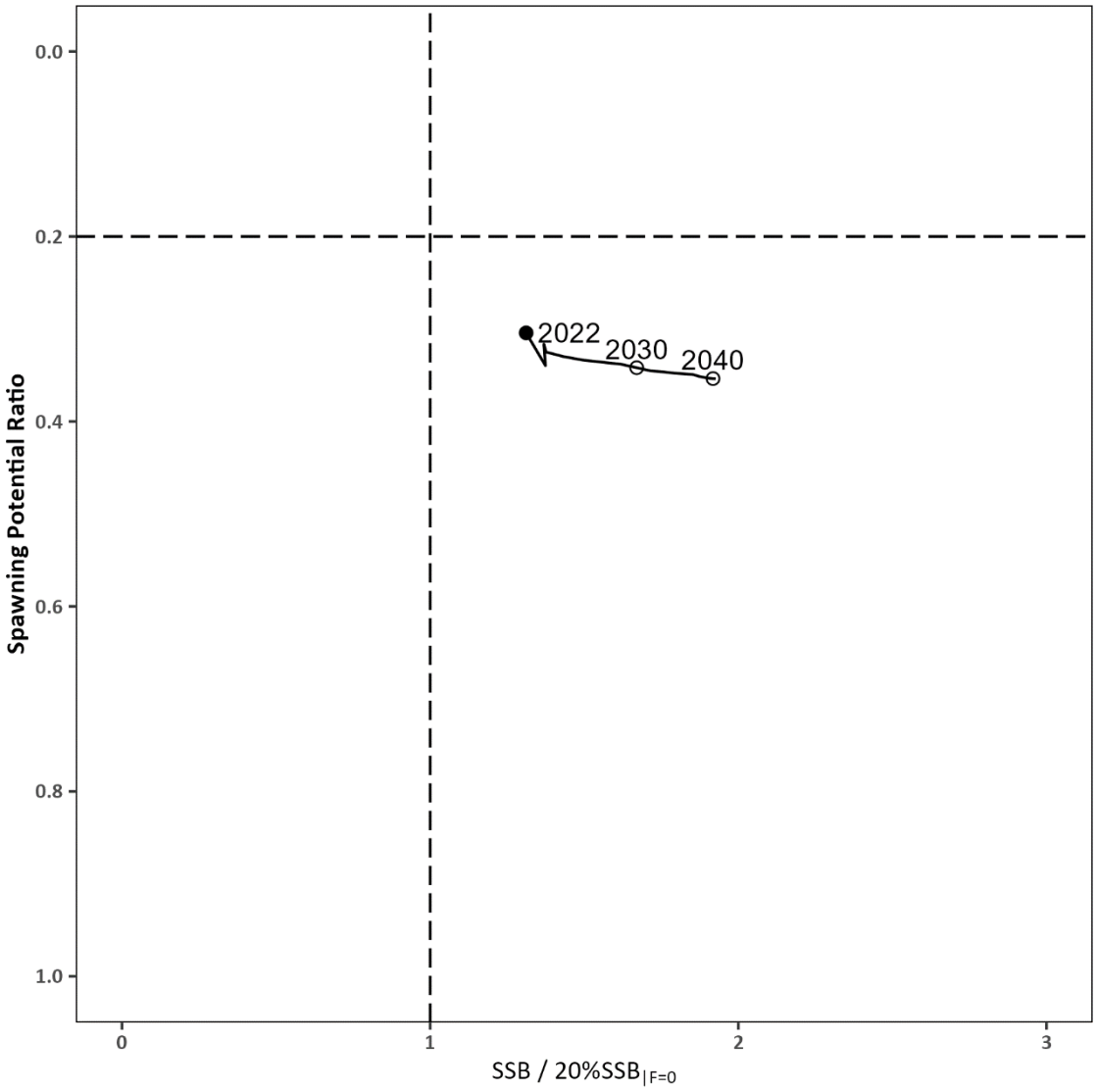

Figure 2. "Future Kobe Plot" of projection results for PBF from the new CMM. Vertical and horizontal dashed lines show 20%SSBF=0 (which corresponds to the second biomass rebuilding target) and the corresponding fishing mortality that produces SPR, respectively.