Preliminary analysis of additional future projections for Pacific bluefin tuna requested by WCPFC NC and IATTC

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Summary

Stochastic projections of Pacific bluefin tuna requested by the Northern Committee of the Western and Central Pacific Fisheries Commission and Inter-American Tropical Tuna Commission in August and December 2016 were preliminary conducted. There were 32 projections which were based on the current results of the stock assessment in 2016 and contained alternative harvesting (several combinations of fishing mortality and catch limit) and recruitment (randomly resampled from the whole stock assessment period or from the relatively low recruitment period) scenarios. Performance measures were examined for all scenarios, such as achieving probabilities of rebuilding targets ($SSB_{MED1952\text{-}2014}$ at 2024, $150\%SSB_{MED1952\text{-}2014}$ at 2030, $200\%SSB_{MED1952\text{-}2014}$ at 2030, $20\%SSB_{current,\ F=0}$ at 2030, and $20\%SSB_{F=0}$ at 2034) and expected annual yield by flag or area. Trajectories of spawning stock biomass and total yield during 2015-2035 were shown, which were comparable to each scenario, as well as the table of performance measures, providing a material for further discussion towards the next conservation and management measures. The results are expected to be presented to the ISC PBF stakeholder meeting in April.

1. Introduction

Pacific bluefin tuna (*Thunnus orientalis*) (PBF) is a highly migratory species from the western North Pacific Ocean (WPO) to the eastern North Pacific Ocean (EPO). PBF is an economically important fish stock with a long history of harvest by multiple Pacific Ocean nations, stock status determination and conservation advice for PBF are provided by both the Western and Central Pacific Fisheries Commission (WCPFC) and the Inter-American Tropical Tuna Commission (IATTC).

The Joint Meeting of the Northern Committee (NC), which is one of subsidiary bodies in the WCPFC, and the IATTC has adopted a request to the International Science Committee for Tuna and Tuna-like Species in the North Pacific (ISC) to conduct multiple projections to compare various candidates for the next rebuilding target of PBF (**Appendix A**, WCPFC 2016a). Furthermore, extraordinary NC during WCPFC13 in December 2016 (WCPFC 2016b) have requested ISC to conduct additional projections, as noted in **Appendix B**.

There were 32 projections demonstrated in this document, including a combination of twelve harvesting scenarios (one of them, scenario 10, contains five scenarios) and two recruitment scenarios. First, basic information for conducting projections in PBF were provided. Second, we made interpretations of Attachment D in NC12 summary report to implement what NC12 has requested ISC, such as a setting of rebuilding targets and definitions of performance measures. Third, we showed trajectories of spawning stock biomass (SSB) and total yield. Forth, the performance of each scenario was evaluated by several indices. Finally, we discussed the stock status in future, which would provide a material towards the next conservation and management measures

(CMMs).

2. Method

2.1 Basic information

Projections were conducted by a method basically the same as used in the 2016 ISC PBF assessment. Details are as follows;

Software: 'ssfuturePBF' with version 1.07, updated version of 'ssfuture' (Ichinokawa 2012; Takeuchi 2014), was used for conducting projections. This software was distributed as an R-package and has been used for projections in the current stock assessment of PBF. Details were documented in Akita et al (2015) and Akita et al (2016).

Model structure: This software can simulate quarterly age-structured population dynamics in a forward direction, which is identical in model structure used in the stock assessment model of PBF ('Stock Synthesis' (SS), Method and Wetzel 2013).

Randomness: Each projection was conducted from 300 bootstrap replicates (i.e. report files generated by SS) followed by 20 stochastic simulations, aggregating 6,000 runs in total for an analysis of single scenario. While process uncertainty is driven by a resampling of recruitment, parameter uncertainty of the stock assessment model is related to bootstrap runs in which fishery data are generated with a parametric resampling of residuals from the expected values.

Duration years: The period 2015-2034 in calendar year was requested from the NC. However, due to a technical reason, the starting period was set to the fishing year (FY) 2014 of the first quarter (July 1st of 2014 in calendar year), conditional on the value of both recruitment and catch in 2014.

Fleet grouping and age class: Catch limit was imposed on several categories which are classified by both fleet groups and age classes. Firstly, 19 fleets which were used in the current stock assessment in PBF were recognized into seven groups, such as:

- 1st group: **F1**-JPLL;
- 2nd group: **F2**-JPSPPS_Q134, **F4**-JPTPSJS, **F5**-JPTPSPO, **F18**- JPSPPS_Q2;
- 3rd group: **F6**-JPTroll_Q234, **F7**-JPPL, **F8**-JPSetNet_Q123, **F9**-JPOthers_Q4, **F10**-JPTroll_HK_AM, **F11**-JPOthers, **F16**-JPTroll4Pen, **F19**-JPTroll_Q1;
- 4th group: **F3**-KROLPS;
- 5th group: **F12**-TWLLS, **F17**-TWLLN;
- 6th group: **F13**-USCOMM, **F14**-MXCOMM;
- 7th group: **F15**-EPOSP.

Then, each group in the WPO is further divided into two classes: age0-2 and age3+. This

age class reflects a boundary as to whether the catch of fish is less than 30 kg or not (Weight at Age 2.75 = 29.3 kg, Weight at Age 3.0 = 34.5 kg), which maintains consistency with past work (ISC 2014, 2016).

2.2 Harvesting scenario

In the current CMMs, a combination of both a constant effort strategy and a setting catch limit has been taken into consideration in harvesting processes. Constant effort strategy can be interpreted as management of fishing mortality (F); therefore, averaged seasonal F (e.g. average during 2002-2004, denoted by F2002-2004) in a specified period is used for determining catch levels for each quarter. Then, by each quarter, the amount of catch is subtracted from catch limit that is allocated every calendar year; when the amount of catch with the F excesses the remaining catch limit, the F is modified to meet the catch limit with an error below 10% (see details in Akita et al. 2015). **Figure 1** illustrates F2002-2004 and F2010-2012 at quarter-age based on the current assessment (ISC 2016).

While the WPO has adopted a combination of effort-base and catch limit management, the EPO has adopted catch limit management alone, reflecting on a setting of harvesting scenarios, as shown in **Table 1**. **Appendix A** and **B** describe the details of harvesting scenarios made by the NC. Followings are technical aspects of setting up a harvesting scenario.

Unlimited F: The NC has requested to use enough high value of F for several scenarios to fulfill their catch limit, leading to a replicate of catch limit management alone. In the EPO commercial fisheries, however, the value of F in a recent period has been enough high to fulfill the catch limits considering here, thus we used the F as it is. Contrary to the EPO, the F in the WPO under catch limit management alone (i.e. scenario 2) was multiplied by two. It should be noted that using a higher multiplier (i.e. ten, denoted by the NC) drastically changes the nature of a fishery structure, such as exceeding the limit immediately after allocating quota, thus, we did not use this option. See "Summary of harvest scenarios" of **Appendix A** in page 16.

Scenario 4 and 7: These scenarios require different periods for F-level between the WPO and the EPO. However, due to technical reason that multiple periods of F-level among groups were not possible, F-multiplier was explored for adjusting the F2002-2004 to F2010-2012 and applied to the 6th group. The value used here was 1.3451 that minimizing the difference of both Fs at quarter-age. See **Table 1**.

Scenario 10: This scenario is unique compared to other scenarios: multiplier to F was used such that the F achieves a rebuilding target with 60% at a specific year. In this document, five rebuilding targets were adopted as explained later, leading to five harvesting sub-scenarios, called as scenario 10-**a**, 10-**b**, 10-**c**, 10-**d**, and 10-**d'**. F2011-13 was used for the F and the value of a multiplier was explored by 0.001 intervals. See

Table 2.

Scenario 11 and 12: These scenarios imply a transfer of quota from small size to large size catch such that total yield is the same to 2002-04 level: 25% and 50% yield of small size in 2002-2004 was transferred into quota in the large size under scenario 11 and 12, respectively. In those runs, the peculiar situation of the 4th group (i.e. **F3**-KROLPS) should be noted: it is reported that an operating for large size fish by this fleet in 2016 was recognized (460 t, WCPFC 2016a) and this type of targeting was theoretically allowed for this fleet in those scenarios. However, the referenced F is based on 2002-2004 (or even other stock assessment periods) level, which does not reflect the catch of large fish by this fleet (i.e. $F_{age>3} = 0$, as shown in **Fig. 1**), thus the fleet cannot materialize its given catch limit for large size fish and this will lead to optimistic results in projections of those scenarios. See **Table 1**.

2.3 Recruitment scenario

Future recruitment is randomly resampled from the whole stock assessment period (1952-2014) for the average recruitment scenario (mean: 13.5 million fish, CV: 0.54), and also resampled from the relatively low recruitment period (1980-1989) for the low recruitment scenario (mean: 8.2 million fish, CV: 0.25). **Figure 2** illustrates a histogram of resampled number of recruitment. Contrary to the average recruitment scenario, the low recruitment scenario showed a smaller variance of recruitment and thus is not expected to produce a very large recruitment, suggesting the scenario is precautionary.

2.4 Performance indices

While performance indices are requested as in **Attachment A**, here we describe how the indices were examined.

Probability of achieving each of the candidate rebuilding targets: We set five targets as follows:

a. 41,000 t, Initial rebuilding target ($SSB_{MED1952-2014}$) by 2024;
b. 61,500 t, 150% of initial rebuilding target by 2030;
c. 82,000 t, 200% of initial rebuilding target by 2030;
d. 141,454 t, 20%$SSB_{current,F=0}$ by 2030;
d'.128,893 t, 20%$SSB_{F=0}$ by 2034.

$SSB_{MED1952-2014}$ was defined by the median of point estimates for the stock assessment periods (1952-2014) and 41,000 t was used (Plenary report 2016 p.34). $SSB_{current,F=0}$ was defined by the decade average of recruitment (2004-2013) multiplied by $SPR_{F=0}$ and 707,270 t was used, in a same manner calculated in WCPFC, as requested by Attachment

A; thus, $20\%SSB_{current,F=0}$ was 141,454. $SSB_{F=0}$ was defined as the theoretical unfished SSB and reflects the recruitments in the whole stock assessment periods (1952-2014). The estimated value was 644,466 t (ISC 2016) and 128,893 t was used as $20\%SSB_{F=0}$. $SPR_{F=0}$ was calculated from the values (weight, death rate, and maturity rate) at the fourth quarter in fishing years since the value of yearly SSB is conventionally used in that term.

ISC does not usually use $SSB_{currnet\ F=0}$ as done by WCPFC. Therefore, for the target-**d'** we used our standard calculation of $SSB_{F=0}$ as the basis instead of $SSB_{current\ F=0}$.

Probability of achieving the target-**a** was calculated as follows: we surveyed the value of SSB at the fourth quarter in FY 2024 for the 6,000 runs, and the number of runs such that SSB_{2034} is more than 41,000 t divided by 6,000 was used for the probability. Calculations of the other probabilities were the same way. Multipliers used in scenario 10 were selected such that these probabilities are approximately 60%.

The time expected to achieve each of the candidate rebuilding target SSB levels with 60% probability: Similar to the above probability, we surveyed the value of SSB at the fourth quarter for all runs, and the first fishing year such that 60% of runs satisfying SSB > target was used. It should be noted that 60% of runs simultaneously achieved a target for a given fishing year.

Probability of SSB falling below the historical lowest at any time during the projection period: The value 11,500 t was used for calculating this probability as the historical lowest value of SSB. This level of (estimated) SSB was observed in 1984, 1985, and 2010.

Probability of catch falling below the historical lowest at any time during the projection period: The value 8,653 t was used for calculating this probability as the historical lowest value of total yield. This level of total yield was observed in 1990.

Median SSB at 2034: Median value of SSB at the last year of projection.

Expected annual yield by area and size category: We showed the mean annual (calendar year) yield in 2019, 2024, and 2030. In the WPO, the values were presented by flag, and by size only in Japan. In the EPO, aggregated values (i.e. both commercial and sport) were presented.

3. Results and Discussion

Stochastic projections of SSB and total yield for each harvesting scenario were demonstrated, as shown in **Figure 3** (low recruitment) and **Figure 4** (average recruitment). Horizontal lines in **Fig. 3a** and **Fig. 4a** show the level of SSB targets, providing a rough guide as to whether the target is achieved or not. The trajectories could be used to grasp the performance measures, summarized in **Table 2**. These results tell us the following

points:

- Different recruitment scenarios forecast an entirely different level of SSB in future.
- Achieving 20%$SSB_{current,F=0}$ during the projection period is difficult in the most of low recruitment scenarios.
- Probability of SSB falling below the historical lowest at any time during the projection period is basically low (less than the level of 1%) in all the projections.
- By further reducing the catch limit of small size fish, the stock can recover even with the increase of catch of large fish in WPO more than the reduction of catch of small fish (scenarios 5, 8, 12). On the other hand, if the catch limit of EPO is simultaneously eliminated, the stock would recover less than current measures (scenarios 4 and 7) even with the further reduction of the catch of small fish.
- For the implementation of scenario 10s, it is necessary to calculate appropriate catch level that will maintain a certain F for each fleet. However, such a management scheme may be difficult for PBF given its high harvest of juvenile before assessment and complexity of fisheries.

Moreover, it should be pointed out that an apparent inconsistency exists between the model assumption and the target-setting:

- The probability of achieving target-**d** (20%$SSB_{current\ F=0}$) is calculated based on different recruitment assumptions to calculate the target.

In addition to above mentioned results based on the requested scenarios, we demonstrated an example of scenario, which was finely adjusted from current management measures, to illustrate the effect of reallocation of catch to fisheries from the current management measures to that catching large fish while keeping its total catch limit. There were several scenarios in which a shift in targeting from small fish to large one seems to work well for both the stock and the yield, such as scenario 5, 8, and 12. We also examined that even a relatively low amount of reallocation of quota from a fishery catching small fish to that of large one still could show a significant contribution for rebuilding (e.g. 250 t from purse seine targeting small fish to purse seine targeting large fish would improve from the current 62% to 73% for target-**a**). To evaluate the effect of this kind of reallocation, it may be desirable that showing trajectory of YPR which is affected by stock status followed by changes of fishing mortality, although the current software cannot handle YPR due to the lack of an availability of modified F after approaching a catch limit (noted in the section **2.2**). In addition, if such a modified F can be handled during a projection period, trajectory of target reference point, such as $F_{\%SPR}$, can be evaluated, providing a demonstration of rebuilding effects in terms of not only a biomass-based stock status but also fishing mortalities.

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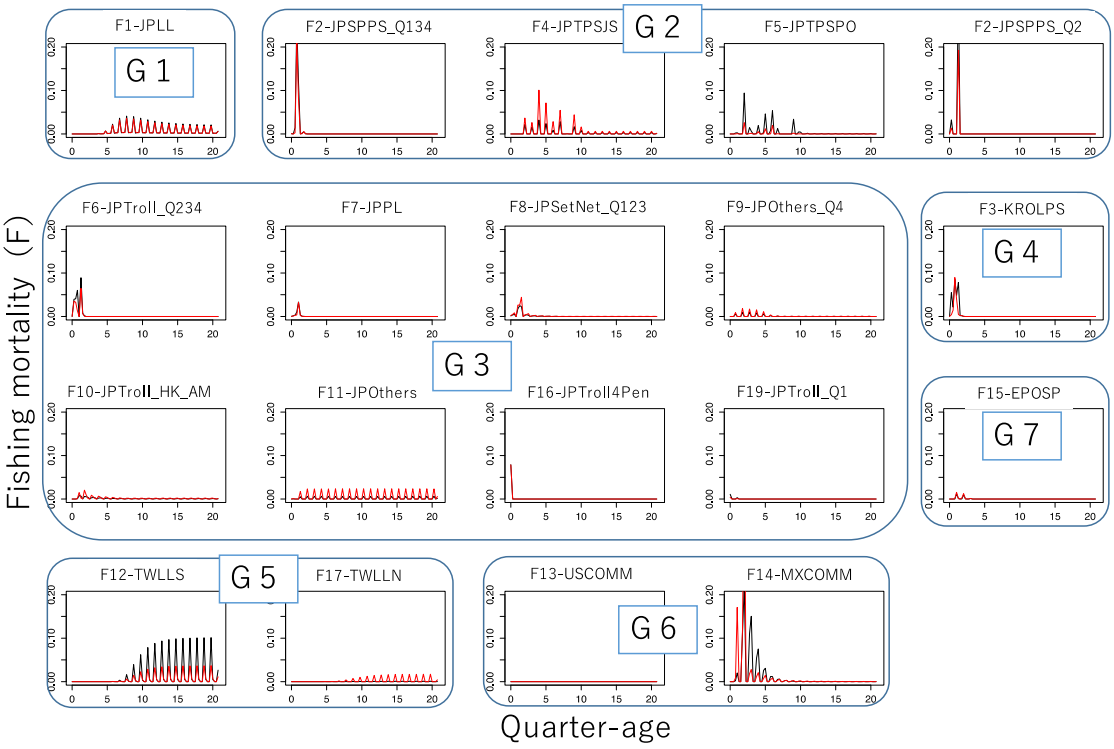

Figure 1: Fishing mortality by the fleet group. F2002-2004 (denoted by black line) and F2010-2012 (denoted by red line) were shown. Abbreviations from G1 to G7 correspond to the fleet groups from the 1st to 7th group in **p.3**.

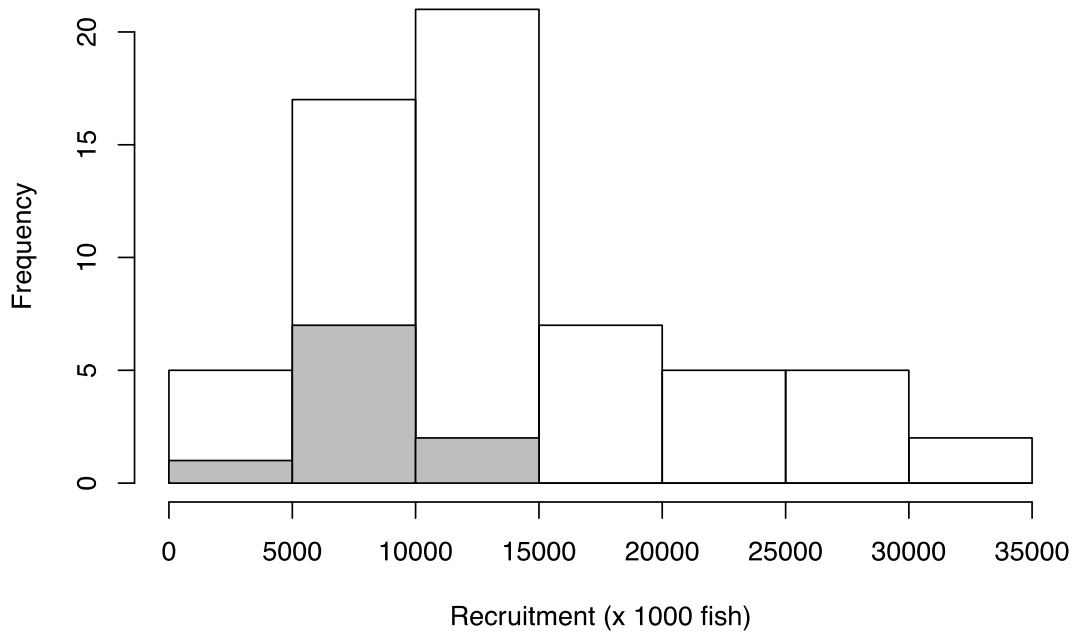

Figure 2: Overlaying histograms of recruitment. Open and filled area indicates averaged recruitment of 1952-2014 and low recruitment of 1980-1989, respectively.

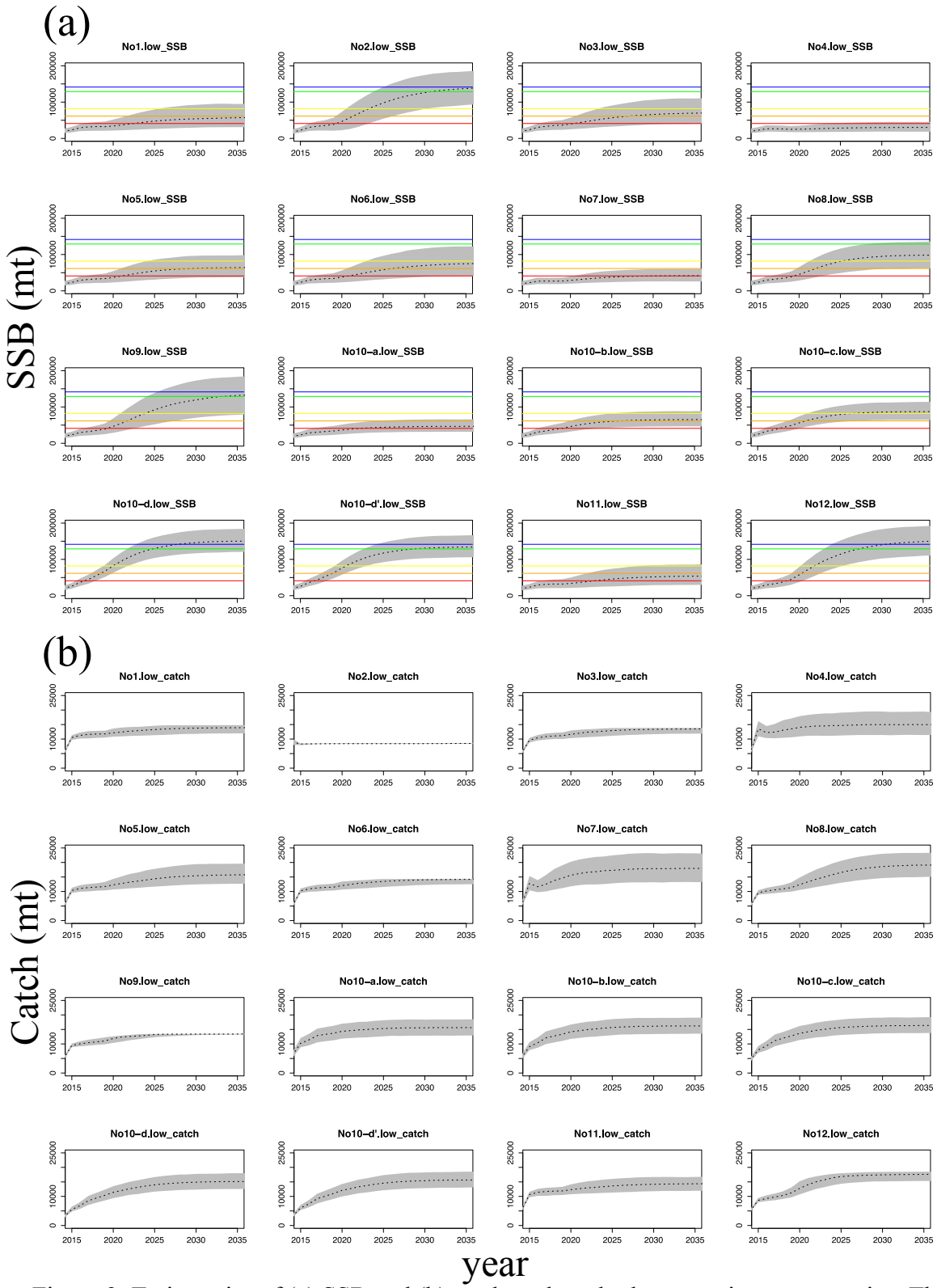

Figure 3: Trajectories of (a) SSB and (b) total catch under low recruitment scenarios. The dotted line refers to the median; and the gray shaded area refers to 90% confidence interval. Horizontal lines in (a) show the level of SSB targets (41,000 t, denoted by red; 61,500 t, denoted by orange; 82,000 t, denoted by yellow; 128,893 t, denoted by green; 141,454 t, denoted by blue).

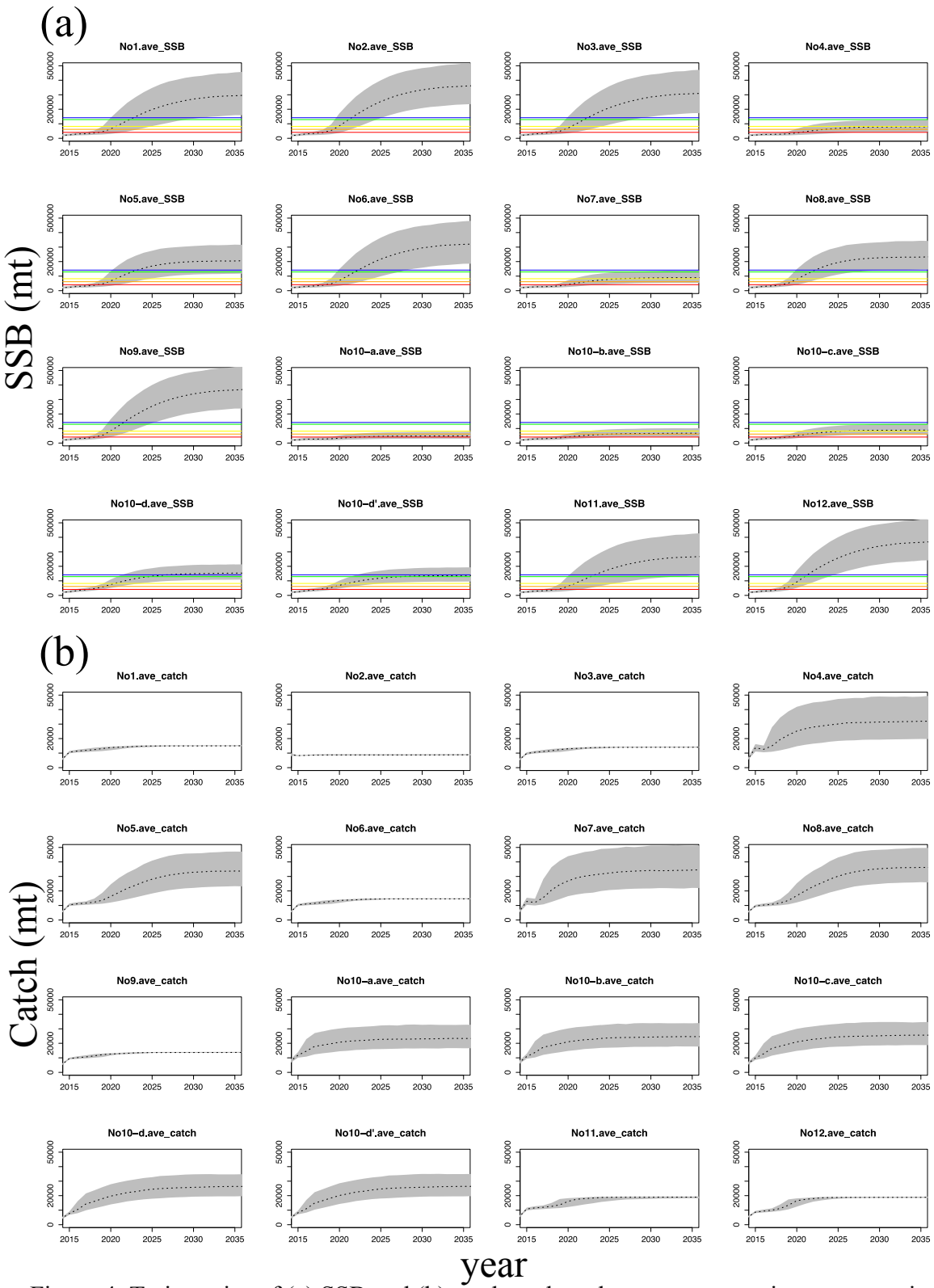

Figure 4: Trajectories of (a) SSB and (b) total catch under average recruitment scenarios. The details are the same in Figure 3, except that the scale of y-axis is changed.

Table 1: Fishing mortality and catch limit for each scenario.

Harvesting Scenario #	Fishing mortality in WPO	Catch limit in WPO		Fishing mortality in EPO	Catch limit in EPO	Catch limit by country (mt)							
						Japan		Korea		Taiwan		EPO commercial	EPO sports
		Small	Large			Small	Large	Small	Large	Small	Large		
1	F2002-2004	50% 2002-2004	Average 2002-04	F2002-2004	3,300 mt comm.	4,007	4,882	718		0	1,700	3,300	-
2	Enough high value to fullfill its catch limit (multiply F2010-2012 by two)	50% 2010-2012	50% 2010-12	F2002-2004	50% 2010-12	3,192	1,393	553		0	155	2,884	-
3	F2002-2004	50% 2002-2004	Average 2002-04	F2002-2004	50% 2002-04	4,007	4,882	718		0	1,700	2,329	-
4	F2002-2004	45% 2002-2004	No catch limit	F2010-2012 (multiply F2002-2004 by 1.3451)	No catch limit	3,606	-	646	-	0	-	-	-
5	F2002-2004	45% 2002-2004	No catch limit	F2002-2004	3,300 mt comm.	3,606	-	646	-	0	-	3,300	-
6	F2002-2004	45% 2002-2004	Average 2002-04	F2002-2004	3,300 mt comm.	3,606	4,882	646		0	1,700	3,300	-
7	F2002-2004	35% 2002-2004	No catch limit	F2010-2012 (multiply F2002-2004 by 1.3451)	No catch limit	2,805	-	503	-	0	-	-	-
8	F2002-2004	35% 2002-2004	No catch limit	F2002-2004	3,300 mt comm.	2,805	-	503	-	0	-	3,300	-
9	F2002-2004	35% 2002-2004	Average 2002-04	F2002-2004	3,300 mt comm.	2,805	4,882	503		0	1,700	3,300	-
10	Fullfill a target with 60%	No catch limit		Fullfill a target with 60%	No catch limit	-	-	-	-	0	-	-	-
11	F2002-2004	50% 2002-2004	"Average 2002-04 catches in WPO (all sizes)" minus "50% 2002-04 catches in WPO (<30 kg)"	F2002-2004	3,300 mt comm.	4,007	8,889	718	718	0	1,700	3,300	-
12	F2002-2004	25% 2002-2004	"Average 2002-04 catches in WPO (all sizes)" minus "25% 2002-04 catches in WPO (<30 kg)"	F2002-2004	3,300 mt comm.	2,003	10,893	359	1,077	0	1,700	3,300	-

Table 2: Performance measures for each scenario.

Harvesting Scenario #		Fishing mortality in the WPO	Catch limit in WPO		Fishing mortality in EPO	Catch limit in EPO	Multiplier to F2011-2013	Recruitment scenario	Probability of achieving each of the candidate rebuilding targets					The time expected to achieve each of the candidate rebuilding target SSB levels with 60% probability					Probability of SSB falling below the historical lowest at any time during the projection period	Probability of Catch falling below the historical lowest at any time during the projection period	Median SSB at 2034	Expected annual yield in 2019, by area and size category					Expected annual yield in 2024, by area and size category					Expected annual yield in 2030, by area and size category				
									41,000 t @2024	61,500 t @2030	82,000 t @2030	141,454 t @2030	128,893 t @2034										Japan					Japan					Japan				
			Small	Large					a	b	c	d	d'	a	b	c	d	d'				Small	Large	Korea	Taiwan	EPO	Small	Large	Korea	Taiwan	EPO	Small	Large	Korea	Taiwan	EPO
Scenario1 (the current measures)		F2002-2004	50% 2002-2004	Average 2002-2004	F2002-2004	3,300 mt comm.	-	Low	61.5%	35.2%	10.5%	0.1%	0.5%	10	-	-	-	-	0.0%	0.7%	56466	3958	3073	719	618	3361	3969	3915	719	989	3396	3966	4154	719	1362	3400
								Average	99.4%	99.9%	99.4%	94.0%	98.0%	6	7	8	10	9	0.0%	0.3%	291478	4025	3990	720	622	3597	4027	4884	720	1504	3620	4025	4909	720	1722	3624
Scenario2		Enough high value to fullfill its catch limit (multiply F2010-2012 by two)	50% 2010-2012	50% 2010-12	F2002-2004	50% 2010-12	-	Low	96.8%	98.9%	94.6%	29.1%	60.0%	6	8	10	-	20	1.4%	100.0%	136132	3204	1400	554	158	3074	3205	1404	554	159	3089	3205	1404	554	158	3092
								Average	100.0%	100.0%	100.0%	99.8%	100.0%	5	6	7	8	8	1.0%	100.0%	355928	3247	1418	556	158	3361	3244	1416	556	157	3373	3245	1415	556	158	3377
Scenario3		F2002-2004	50% 2002-2004	Average 2002-2004	F2002-2004	50% 2002-04	-	Low	81.4%	58.9%	23.0%	0.5%	1.3%	8	17	-	-	-	0.0%	2.1%	69186	3967	3385	719	630	2445	3977	4283	719	1141	2449	3975	4473	719	1524	2449
								Average	99.8%	100.0%	99.8%	96.1%	99.1%	5	6	7	10	9	0.0%	1.3%	305244	4025	4196	720	634	2640	4026	4896	721	1568	2657	4025	4912	720	1724	2661
Scenario4		F2002-2004	45% 2002-2004	No catch limit	F2010-2012	No catch limit	-	Low	6.0%	0.2%	0.0%	0.0%	0.0%	-	-	-	-	-	1.0%	0.7%	30192	3592	2493	647	578	6316	3594	2912	647	691	6919	3592	3098	647	793	6987
								Average	88.8%	75.2%	42.8%	1.7%	4.3%	7	11	-	-	-	0.0%	0.1%	78608	3623	3442	648	578	15469	3624	7254	648	988	17911	3624	8160	648	2011	17954
Scenario5		F2002-2004	45% 2002-2004	No catch limit	F2002-2004	3,300 mt comm.	-	Low	77.7%	51.3%	14.9%	0.0%	0.4%	8	-	-	-	-	0.0%	0.8%	63808	3604	3454	647	610	3401	3609	5453	647	1021	3425	3609	6315	647	1620	3426
								Average	99.7%	99.9%	99.1%	84.7%	91.5%	5	7	8	11	10	0.0%	0.5%	203902	3628	5589	648	612	3621	3628	16982	649	1855	3641	3628	20203	649	5207	3643
Scenario6		F2002-2004	45% 2002-2004	Average 2002-2004	F2002-2004	3,300 mt comm.	-	Low	80.6%	65.5%	30.6%	1.2%	3.3%	8	15	-	-	-	0.0%	0.7%	74204	3604	3236	647	619	3401	3609	4310	647	1082	3425	3609	4532	647	1530	3426
								Average	99.8%	100.0%	99.9%	97.2%	99.3%	5	7	7	9	9	0.0%	0.5%	316301	3628	4111	648	623	3621	3628	4902	649	1550	3642	3627	4916	649	1725	3646
Scenario7		F2002-2004	35% 2002-2004	no catch limit	F2010-2012	No catch limit	-	Low	30.9%	3.8%	0.1%	0.0%	0.0%	-	-	-	-	-	0.1%	1.2%	41645	2810	2764	504	578	8166	2810	3865	504	770	9267	2810	4238	504	1061	9373
								Average	95.5%	88.0%	58.8%	3.2%	8.0%	7	9	18	-	-	0.0%	0.7%	88936	2829	3783	505	578	17898	2829	8216	505	1086	20076	2829	9176	505	2274	20222
Scenario8		F2002-2004	35% 2002-2004	No catch limit	F2002-2004	3,300 mt comm.	-	Low	97.4%	94.1%	72.3%	2.3%	7.9%	6	9	13	-	-	0.0%	2.1%	97792	2813	4022	504	611	3461	2813	7946	504	1226	3470	2813	9479	504	2404	3471
								Average	100.0%	100.0%	99.9%	94.8%	97.7%	5	6	7	9	9	0.0%	1.9%	230687	2832	6331	506	614	3667	2832	19516	506	2121	3681	2833	22844	506	5954	3682
Scenario9		F2002-2004	35% 2002-2004	Average 2002-2004	F2002-2004	3,300 mt comm.	-	Low	97.9%	97.7%	89.0%	24.8%	51.2%	6	9	11	-	-	0.0%	2.2%	130078	2813	3641	504	621	3461	2813	4802	504	1311	3470	2813	4872	504	1691	3471
								Average	100.0%	100.0%	100.0%	99.7%	99.9%	5	6	7	8	8	0.0%	1.9%	363095	2832	4366	506	625	3667	2832	4923	506	1629	3684	2833	4924	506	1729	3687
Scenario10	a	Constant F to achive "target a" with 60% of its probability.	No catch limit		Constant F to achive "target a" with 60% of its probability.	No catch limit	0.798	Low	60.4%	8.7%	0.2%	0.0%	0.0%	10	-	-	-	-	0.0%	3.0%	46453	3818	3898	681	446	4895	3822	4849	682	724	5110	3813	5050	679	898	5146
							0.965	Average	60.3%	19.0%	2.9%	0.0%	0.0%	10	-	-	-	-	0.0%	0.2%	48950	6691	4504	1262	474	7475	6672	6417	1259	740	7911	6664	6719	1255	1058	7958
	b	Constant F to achive "target b" with 60% of its probability.	No catch limit		Constant F to achive "target b" with 60% of its probability.	No catch limit	0.666	Low	96.1%	60.6%	9.7%	0.0%	0.0%	6	16	-	-	-	0.0%	28.9%	65149	3512	4008	597	413	4864	3516	5399	598	810	5166	3508	5710	595	1104	5216
							0.841	Average	90.5%	60.1%	19.3%	0.1%	0.4%	7	16	-	-	-	0.0%	1.2%	66924	6359	4788	1151	455	7639	6339	7315	1148	851	8204	6333	7757	1144	1320	8267
	c	Constant F to achive "target c" with 60% of its probability.	No catch limit		Constant F to achive "target c" with 60% of its probability.	No catch limit	0.554	Low	100.0%	96.9%	60.6%	0.1%	0.7%	5	8	16	-	-	0.0%	82.1%	87110	3196	3983	519	376	4722	3190	5755	518	866	5098	3188	6144	518	1280	5142
							0.729	Average	99.1%	92.1%	60.3%	2.1%	5.6%	6	8	16	-	-	0.0%	6.7%	88965	5979	4981	1039	430	7664	5960	8094	1036	951	8351	5954	8690	1034	1586	8433
	d	Constant F to achive "target d" with 60% of its probability.	No catch limit		Constant F to achive "target d" with 60% of its probability.	No catch limit	0.347	Low	100.0%	100.0%	100.0%	60.4%	87.0%	3	5	7	16	15	0.0%	100.0%	149949	2357	3518	351	278	3917	2360	5705	352	874	4366	2355	6294	350	1485	4452
							0.519	Average	100.0%	100.0%	99.8%	60.2%	78.5%	4	6	7	16	15	0.0%	87.4%	152558	5000	5032	800	362	7224	4982	9149	798	1100	8112	4979	10080	796	2097	8236
	d'	Constant F to achive "target d'" with 60% of its probability.	No catch limit		Constant F to achive "target d'" with 60% of its probability.	No catch limit	0.390	Low	100.0%	100.0%	100.0%	27.7%	60.6%	3	6	7	-	20	0.0%	100.0%	133800	2557	3680	388	301	4147	2559	5824	389	889	4589	2554	6386	387	1467	4672
							0.562	Average	100.0%	100.0%	98.6%	39.4%	60.2%	4	6	8	-	20	0.0%	69.6%	136490	5234	5068	853	379	7381	5216	9008	850	1077	8234	5212	9869	848	1999	8350
Scenario11		F2002-2004	50% 2002-2004	"Average 2002-2004 catches in WPO (all sizes) " minus "50% 2002-2004 catches in WPO (<30 kg)"	F2002-2004	3,300 mt comm.	-	Low	57.8%	29.0%	6.1%	0.0%	0.2%	11	-	-	-	-	0.0%	0.6%	53683	3956	3228	719	609	3356	3967	4389	719	955	3395	3965	4816	719	1308	3398
								Average	99.3%	99.8%	99.0%	89.1%	95.6%	6	7	8	11	10	0.0%	0.3%	263027	4024	5101	720	612	3598	4027	8493	720	1461	3619	4025	8781	720	1717	3622
Scenario12		F2002-2004	25% 2002-2004	"Average 2002-2004 catches in WPO (all sizes) " minus "25% 2002-2004 catches in WPO (<30 kg)"	F2002-2004	3,300 mt comm.	-	Low	99.9%	100.0%	99.5%	48.0%	79.4%	5	7	9	20	19	0.0%	49.7%	148029	2013	4775	361	613	3502	2014	8803	361	1475	3507	2014	9579	361	1709	3508
								Average	100.0%	100.0%	100.0%	99.9%	100.0%	5	6	6	8	8	0.0%	49.4%	362590	2034	6956	362	615	3712	2035	10808	362	1663	3721	2035	10961	362	1728	3724

Appendix A: NC12 Summary Report Attachment D, Annex 2

Attachment D, Annex 2

Formulation of a Pacific Bluefin Tuna Rebuilding Strategy

1. The ISC is requested to evaluate the expected performance of each of the following harvest scenarios, and to make the results available to the Northern Committee and IATTC by April 2017.

    - **Harvest scenarios** (see summary table attached)**:** The following scenarios should be evaluated under an appropriate range of assumptions regarding future recruitment (e.g., the "low" and "average" recruitment assumptions used in the ISC's previous set of projections).[1]

        1. 2002-04 fishing effort in all WCPO PBF-directed fisheries; 50% of 2002-04 catches of <30kg PBF in all WCPO fisheries; 2002-04 catches of ≥30kg PBF in all WCPO fisheries; and 3,300 mt/yr in EPO commercial PBF fisheries (i.e., current management measures in WCPO and EPO).
        2. 50% of 2010-2012 catches (all fish sizes) in all EPO and WCPO fisheries.
        3. 2002-04 fishing effort in all WCPO PBF-directed fisheries; 50% of 2002-2004 catches of <30kg PBF in all WCPO fisheries; 2002-04 catches of ≥30kg PBF in all WCPO fisheries; and 50% of 2002-04 catches in all EPO fisheries.
        4. 2002-04 fishing effort in all WCPO PBF-directed fisheries; 45% of 2002-04 catches of <30kg PBF in all WCPO fisheries; F of ≥30kg PBF at 2002-04 average level in all WCPO fisheries; and F of PBF in EPO PBF fisheries at 2010-12 average level.
        5. 2002-04 fishing effort in all WCPO PBF-directed fisheries; 45% of 2002-04 catches of <30kg PBF in all WCPO fisheries; F of ≥30kg PBF at 2002-04 average level in all WCPO fisheries; and 3,300 mt/yr in EPO commercial fisheries.
        6. 2002-04 fishing effort in all WCPO PBF-directed fisheries; 45% of 2002-04 catches of <30kg PBF in all WCPO fisheries; 2002-04 catches of ≥30kg PBF in all WCPO fisheries; and 3,300 mt/yr in EPO commercial fisheries.
        7. 2002-04 fishing effort in all WCPO PBF-directed fisheries; 35% of 2002-04 catches of <30kg PBF in all WCPO fisheries; F of ≥30kg PBF at 2002-04 average level in all WCPO fisheries; and F of PBF in EPO PBF fisheries at 2010-12 average level.
        8. 2002-04 fishing effort in all WCPO PBF-directed fisheries; 35% of 2002-04 catches of <30kg PBF in all WCPO fisheries; F of ≥30kg PBF at 2002-04 average level in all WCPO fisheries; and 3,300 mt/yr in EPO commercial fisheries.
        9. 2002-04 fishing effort in all WCPO PBF-directed fisheries; 35% of 2002-04 catches of <30kg PBF in all WCPO fisheries; 2002-04 catches of ≥30kg PBF in all WCPO fisheries; and 3,300 mt/yr in EPO commercial fisheries.
        10. Constant F in all PBF fisheries, set at the level at which, for a given candidate rebuilding target, the target is achieved at the end of the rebuilding period with 60% probability (relative F among fisheries assumed to be unchanged from the most recent 3-year average).

    - **Performance measures:**

[1] For the fisheries in which *F* is not explicitly limited under a given scenario, the projections should be run such that F in the fishery is not allowed to exceed ten times the 2010-2012 average level in that fishery.

1. Probability of achieving each of the following candidate rebuilding targets:
   a. initial rebuilding target ($SSB_{MED1952-2014}$) by 2024
   b. 150% of initial rebuilding target by 2030
   c. 200% of initial rebuilding target by 2030
   d. $20\%SSB_{current,F=0}$[2] by 2030
2. For all scenarios except 6, the time expected to achieve each of the SSB levels listed above, with 60% probability.
3. Expected annual yield during projection period, by fishery (defined in terms of flag, gear, and area).
4. Probability of SSB falling below the historical lowest at any time during the projection period.
5. Probability of catch falling below the historical lowest at any time during the projection period.

2. Taking into account the objectives of the two Conventions, the results of the evaluations described above, any advice from the IATTC scientific staff and/or Scientific Advisory Committee, and the desire to maintain or enhance fishing opportunities in, and benefits from, PBF-directed fisheries to the extent compatible with the need to rebuild the stock, the WCPFC and IATTC will:

   a. In 2017, agree on a second rebuilding target to be reached by 2030 (not necessarily the ultimate rebuilding target).
   b. Revise their respective management measures as needed to achieve the initial WCPFC rebuilding target by 2024, as appropriate given progress of rebuilding the stock.
   c. Revise or adopt conservation and management measures to achieve the second rebuilding target that would become effective after the initial target is met.

Summary of harvest scenarios

	WCPO			**EPO**	
	F	**Catch**		**F**	**Catch**
		<30kg	**≥30kg**		
1	2002-04	50% 2002-04	2002-04	unlimited	3,300 mt comm.
2	unlimited	50% 2010-12		unlimited	50% 2010-12
3	2002-04	50% 2002-04	2002-04	unlimited	50% 2002-04
4	2002-04	45% 2002-04	unlimited	2010-12	unlimited
5	2002-04	45% 2002-04	unlimited	unlimited	3,300 mt comm.
6	2002-04	45% 2002-04	2002-04	unlimited	3,300 mt comm.
7	2002-04	35% 2002-04	unlimited	2010-12	unlimited
8	2002-04	35% 2002-04	unlimited	unlimited	3,300 mt comm.
9	2002-04	35% 2002-04	2002-04	unlimited	3,300 mt comm.
10	constant – depend on target	unlimited		constant – depend on target	unlimited

[2] The time period to be used for $20\%SSB_{current,F=0}$ shall have a length of 10 years and be based on the years $t_1=y_{last-10}$ to $t_2=y_{last-1}$ where y_{last} is the last year used in the assessment; and the approach used for calculating the unfished biomass levels shall be based on scaled estimates of recruitment according to the stock recruitment relationship.

Appendix B: WCPFC13 draft Summary Report Attachment P

WCPFC13 draft Summary Report Attachment P

Outcomes of extraordinary meeting of NC

1. At its 2017 meeting, NC will develop additional measures to further expedite the recovery of PBF stock.

2. In 2017, NC members will take the following voluntary measures to expedite the recovery of the Pacific Bluefin Tuna Stock in 2017.

(1) Japan
Japan will transfer a part of its catch limit for Pacific Bluefin tuna (PBF) smaller than 30kg (4,007 metric tons) to its catch limit of PBF 30 kg or larger in accordance with a new measure stipulated in paragraph 4 of the draft CMM (Attachment E of the NC Summary Report) if the recommendation from the Northern Committee is endorsed by the Commission. The amount to be used is currently under consideration.

(2) Korea
Korea will make a voluntary payback for its overharvest of PBF 30 kg or larger in accordance with its multi-year plan (see the attached Circular No. 2016/71 dated on December 2, 2016) from its annual catch limit of 718 tons of PBF smaller than 30kg.

3. NC will strengthen cooperation with IATTC to bear shared responsibilities to expedite the recovery of PBF stock.

4. NC requests that the ISC evaluate the following scenarios—in addition to the other ten scenarios already requested—prior to the anticipated ISC sponsored stakeholder meeting in 2017:

Scenario 11: 2002-04 fishing effort in all WCPO PBF-directed fisheries; 2002-04 catches of PBF (of all sizes) in all WCPO fisheries, within which catches of <30kg PBF are 50% of 2002-04 level; and 3,300 mt/yr in EPO commercial fisheries.

Scenario 12: 2002-04 fishing effort in all WCPO PBF-directed fisheries; 2002-04 catches of PBF (of all sizes) in all WCPO fisheries, within which catches of <30kg PBF are 25% of 2002-04 level; and 3,300 mt/yr in EPO commercial fisheries.