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Impact of setting of catch limits on stock assessment results of Pacific bluefin tuna

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Summary

In order to rebuild Pacific bluefin tuna (PBF) stock, WCPFC CMM 2014-04 and IATTC Resolution C-14-06 came into effect in 2015 and placed catch limits on the overall growth stages of PBF in the North Pacific Ocean. These measures will accomplish a significant reduction of catch of PBF less than 30 kg. This study aimed to examine whether setting of the catch limits would have an effect on stock assessment results such as estimates of recruitment and spawning stock biomass by conducting sensitivity and retrospective analyses based on past data by introducing hypothetical catch limit. It was found that that the catch limits set for fisheries targeting PBF younger than six years old would result in underestimate of recruitment. In addition, annual accumulation of catch information under catch restriction of young fish caused a further bias of recruitment estimates. Consequently, it is important to note for the future stock assessments that the recruitment of the year classes protected by the catch restrictions based on the current management measures could be underestimated during the several years after birth.

Introduction

In order to ensure the rebuilding of PBF stock, WCPFC Conservation and Management Measure 2014-04 (CMM 2014-04) and IATTC Resolution C-14-06 came into effect in 2015. Towards the interim target of rebuilding spawning stock biomass (SSB) to the historical median (42,592 mt) within 10 years with at least 60% probability, WCPFC CMM 2014-04 included the following measures:

1) Total fishing effort by CCM's vessels fishing for Pacific bluefin tuna shall stay below the 2002–2004 annual average levels;
2) To reduce to 50% of the 2002-2004 average levels of all catches of PBF less than 30 kg;
3) Not to increase catches of PBF of 30 kg or larger from the 2002-2004 annual average levels.

On the other hand, IATTC Resolution C-14-06 specified the measures taken against the EPO commercial fishery for 2015 and 2016 not to exceed 6,600 metric tons, for an effective annual catch of 3,300 metric tons each year. As a result of those measures, upper limits of catch (catch limits) were placed on all fisheries harvesting overall growth stages of PBF in the North Pacific Ocean from this year.

In the stock assessment of PBF, not only the abundance indices such as CPUE but also catch and size composition data provide information on recruitment strength of target species. Therefore, the artificial decrease catch may create a bias in the assessment results. The catch limits specified by WCPFC CMM 2014-04 and IATTC Resolution C-14-06 will accomplish a significant reduction of catch of PBF less than 30 kg than that was expected under the past management measures in case strong recruitment comes. The purpose of this working paper is to examine whether setting of the catch limits would have an effect on the stock assessment results such as estimates of recruitment and SSB by conducting sensitivity analysis based on the past data by introducing hypothetical catch limit.

Materials and methods

Sensitivity analysis

The ISC PBFWG (2014) concluded that, among the future projections conducted under seven harvesting scenarios, only the scenario of 50% reduction of juvenile catches from the 2002-2004 annual average levels achieved increase of SSB above the historical median at the probability of more than 80% within ten years. WCPFC CMM 2014-04 and IATTC Resolution C-14-06 generally line with the ISC PBFWG's recommendation and are expected to contribute to the stock rebuilding. However, information on SSB recovery obviously will not be available until a year class grew up to the size entering the selectivity of abundance index of large fish as a result of the protection by the management measures. Hence, we focused the short-term (period before recruitment entering SSB) impacts of the catch limits on the stock assessment results.

Impacts of the setting of the catch limits on the stock assessment results were tested through the sensitivity run using the base case run of the SS3 model applied in the 2014 stock assessment (PBFWG, 2014). In the sensitivity run, the catch limits were incorporated into input data of the base case run, such as quarterly catch data, in recent six years of 2007-2012, because the 2007 year class in the terminal year, equivalent to age 5, is the youngest year class which might have small contribution to CPUE from Japanese and Taiwanese longliners used as abundance indices for adult PBF in the stock assessment. The catch limits assigned for each fleet were calculated as if WCPFC CMM 2014-04 and IATTC Resolution C-14-06 had been implemented in those years (Table 1). The quarterly catch data by fleet after 2006 were modified in accordance with the fleet-specific catch limits through the following procedure.

1) The quarterly catch data, where fishing year starting from July and ending in June was applied, were rearranged in calendar year.

2) If an annual catch of fleet was equivalent to or below the catch limit, the quarterly catches of that year were not changed.

3) In the case of the annual catch is larger than the catch limit, the catch of a quarter when cumulative catch from the first quarter exceeds the limit was reduced and the catches of subsequent quarters were set at zero so that the annual catch equated to the limit.

Marked decreases of catch resulted from setting of the catch limit were found in Fleets 2, 5, 7-10, 12 and 14 (Fig 1).

Retrospective analysis

Retrospective analysis was carried out by sequentially dropping data from the terminal year using the same model configuration of the sensitivity run mentioned above in order to examine whether retrospective patterns appeared in estimates of recruitment and SSB. In this analysis, up to five years of data were removed.

Results and discussion

The sensitivity run was converged, because maximum gradient was 3.9×10^{-6}. Total negative likelihood increased from 2412 for the base case run to 2424 for the sensitivity run. The increase in negative likelihood of abundance indices contributed to the increase in total negative likelihood (Fig. 2).

Japanese troll CPUE (JpnTroll CPUE) works as recruitment abundance index of age-0 fish in the stock assessment model. Fit of CPUE predicted by the sensitivity run to JpnTroll CPUE (observed) got worse than that by the base case run after 2005 (Fig. 3). Residuals of the sensitivity run increased and were biased upwards after 2005. Poor fit of the sensitivity run after 2005 might have a large effect on the increase of total negative likelihood and negative likelihood of abundance indices mentioned above.

It was found that the catch limits resulted in clear decrease in estimates of recruitment after 2005 except for 2012, although the differences in SSB between the base case run and the sensitivity run was not significant (Fig. 4). The largest decrease of ratio, which was 50% reduction of the recruitment from the base case run, was recorded in 2007 when the second strongest year class in the 2000s occurred and 46% reduction of the recruitment was detected in 2008 when the strong cohort next to 2007 was occurred. On average the recruitment of 2006-2012 estimated by the sensitivity run was decreased to 67% of that of the base case run. The variability of estimated recruitment deviations of the sensitivity run was mostly within input recruitment variability (σ=0.6), although there were differences in recruitment deviations between the base case run and the sensitivity run after 2004 (Fig. 5).

In general, catch limit management in each fleet cumulated a bias in estimation of recruitment and, in particular, the data at the second and third years after birth, which is the time they experience fishing pressures from several fleets, resulted in marked decline of estimates of recruitment (Fig. 6). The recruitment estimated for 2009-2012 was decreased with data of additional year. In contrast, no particular tendency of estimation in the SSB during 2007-2012 was observed.

A clear retrospective pattern was found in predicted CPUE of JpnTroll (Fig. 7). The CPUE predicted for the terminal year except for 2007 was larger than the observed ones. The sequential addition of data made the fit of CPUE worse with decreasing predicted value.

In summary, it was found that the catch limits set for fisheries targeting PBF younger than six years old would result in the underestimate of recruitment. In addition, annual accumulation of catch information under catch restriction of young fish caused a further bias of recruitment estimates. Consequently, it is important to note the above results for the future stock assessments that the recruitment of the year classes protected by the catch restrictions based on the current management measures could be underestimated during the several years after birth.

It is necessary that the impact of the catch limits on the stock assessment result is adequately assessed before and after the stock recovery of PBF in future. In this study, changes in size composition resulted from the current management measures and CPUE after the stock recovery were not considered, because this information was not available. In order to evaluate the impacts of the catch limits using virtual input data, development of operating model (OM) for PBF stock is essential for the future stock assessment.

References cited

PBFWG. 2014. Stock assessment of Bluefin tuna in the Pacific Ocean in 2014. Available at: http://isc.ac.affrc.go.jp/pdf/2014_Intercessional/Annex4_Pacific%20Bluefin%20Assmt%20Report%202014-%20June1-Final-Posting.pdf

Table 1 Catch limit set for all fleets except for Fleet 13.

Region	Fleet #	Fleet name	Catch limit (mt/year)		
			PBF less than 30 kg	PBF of 30 kg and over	Total
WPO	1	JLL	-	1,317	1,317
	2	SPelPS	2,718	-	2,718
	3	TPSJS	-	2,000	2,000
	4	TPSPO	500		500
	5	JpnTroll	1,299	-	1,299
	6	JpnPL	156	-	156
	7	JpnSetNet	423	173	596
	8				
	9				
	10				
	11	TWLL	-	1,700	1,700
EPO	12	EPOCOMM	3,300		3,300
	13	EPOSP	-		-
WPO	14	Others	129	294	423

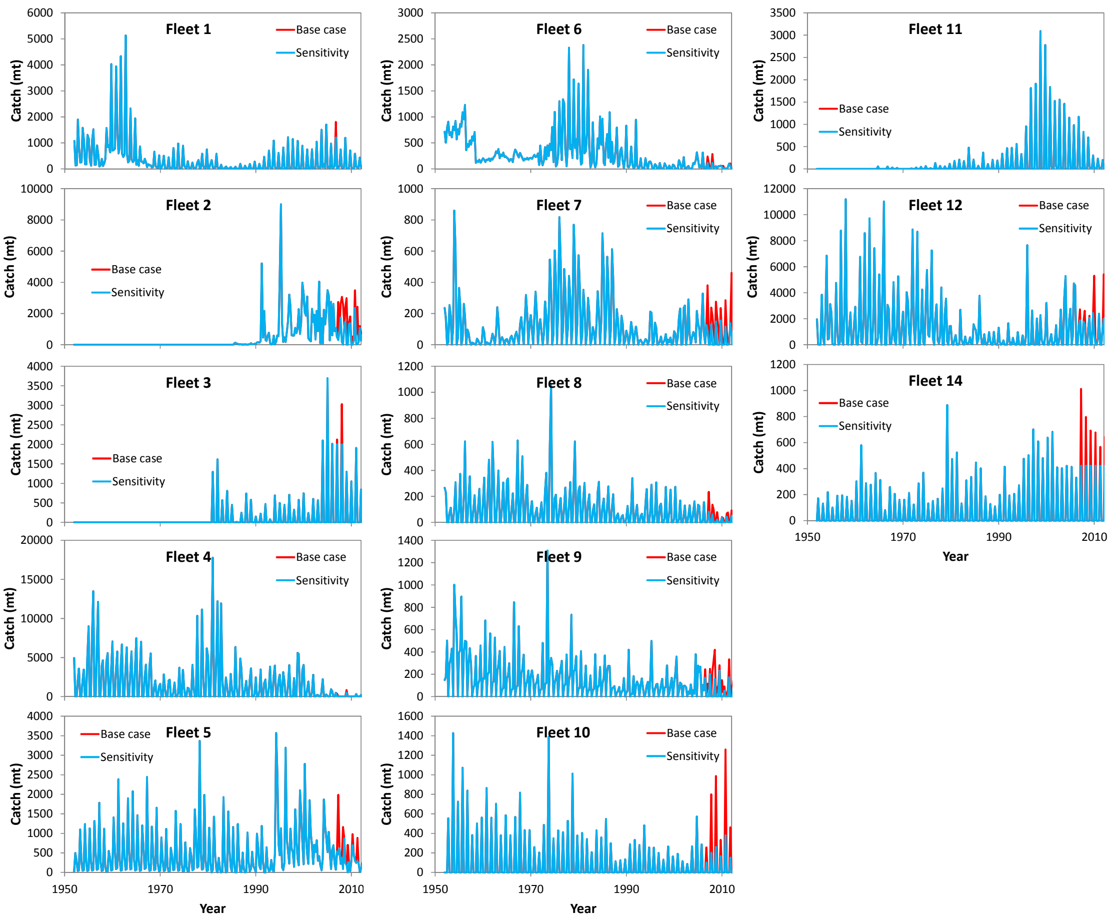


Fig. 1 Historical quarterly catches of base case run of the 2014 stock assessment and sensitivity run with catch limits set after 2006.

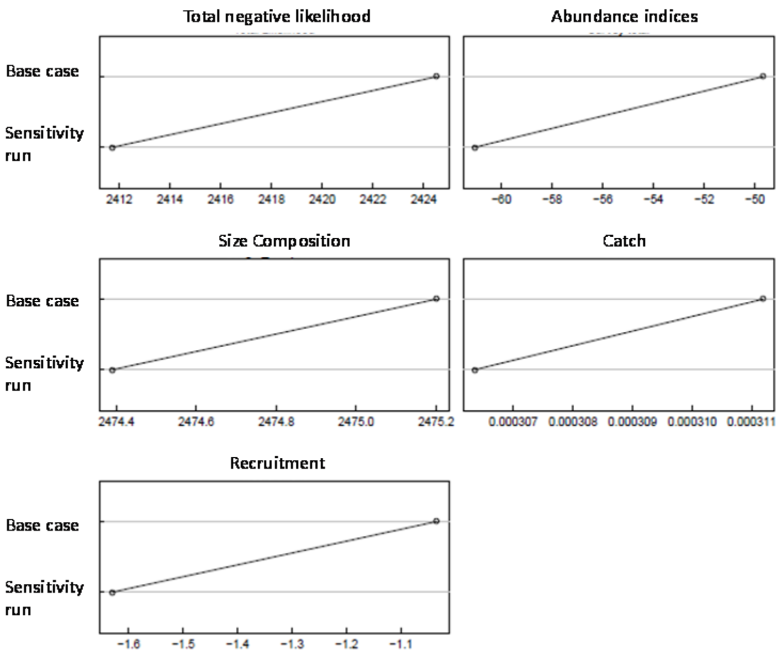


Fig. 2 Total negative likelihood and negative likelihoods for each component calculated from the base case run of the 2014 stock assessment and sensitivity run.

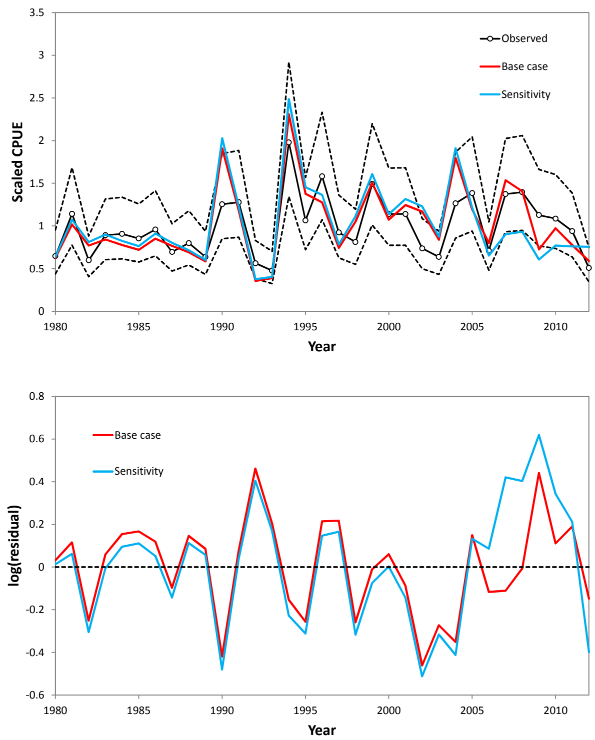


Fig. 3 Time series of observed and predicted CPUE of Japanese Troll (JpnTroll) (upper panel) and residuals by year (lower panel). Red and light blue lines indicated CPUE and residuals of the base case run of the 2014 stock assessment and the sensitivity run, respectively.

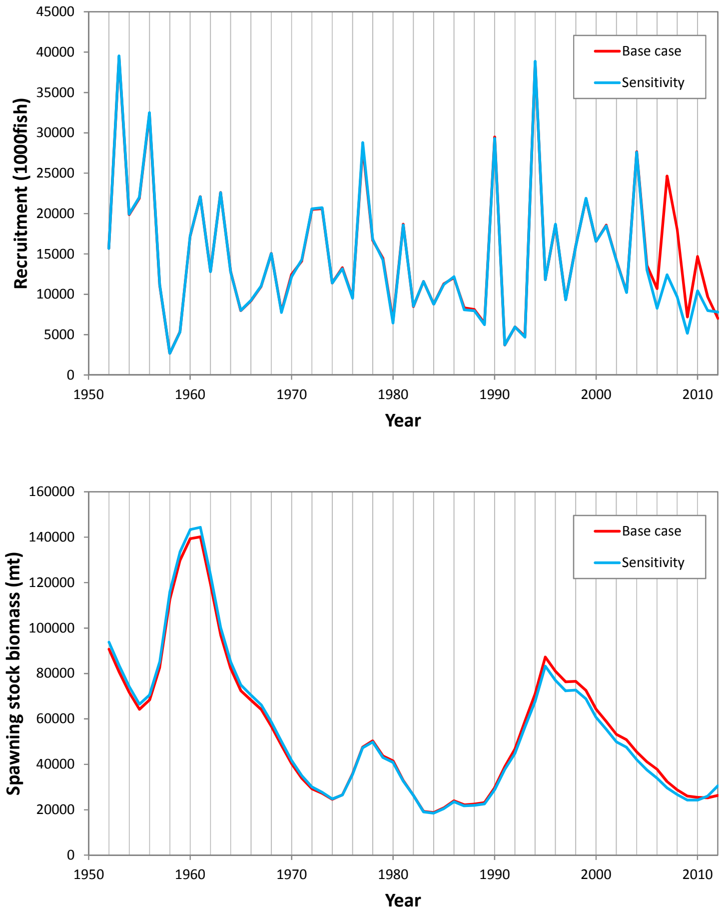


Fig. 4 Historical trends of recruitment (upper panel) and spawning stock biomass (lower panel) estimated by the base case run and the sensitivity run.

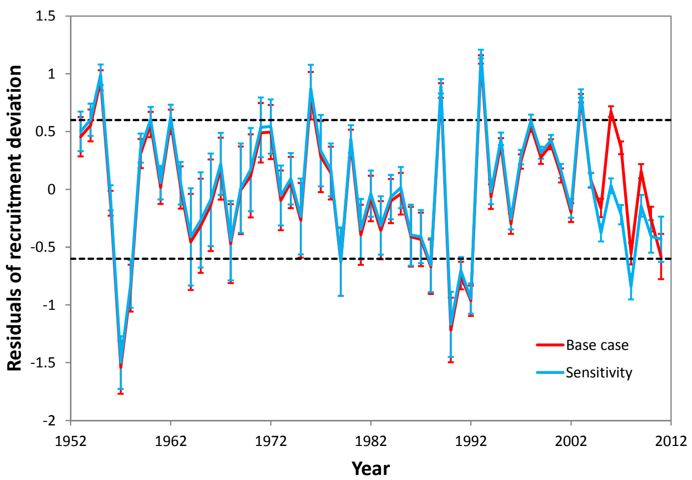
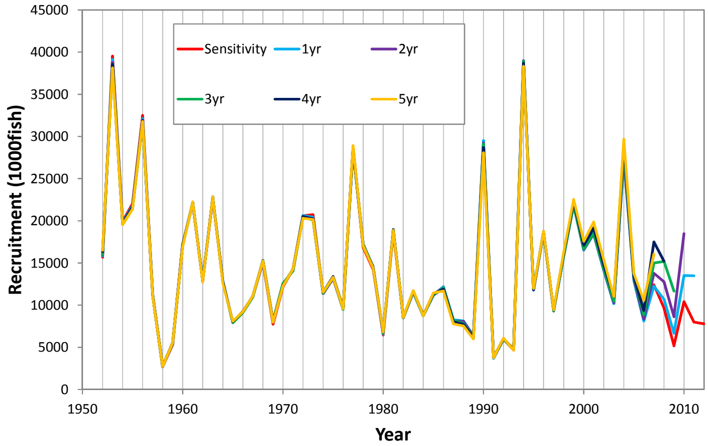


Fig. 5 Annual recruitment deviations derived from the base case run and the sensitivity run. Dotted lines indicate σ and –σ.



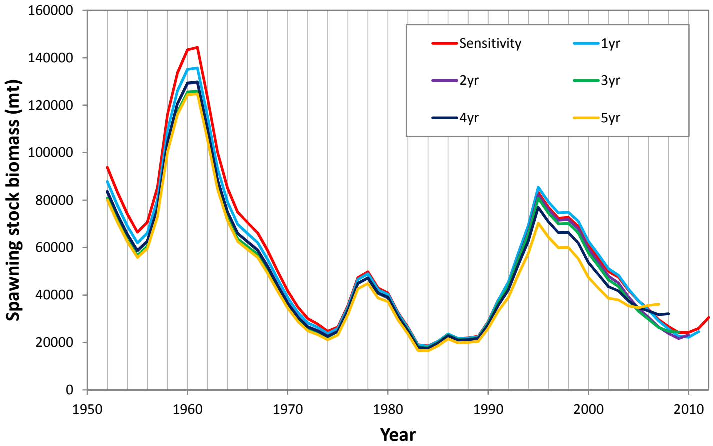


Fig. 6 Plots of recruitment (upper panel) and SSB (lower panel) estimated through retrospective analysis (five years) for sensitivity run.

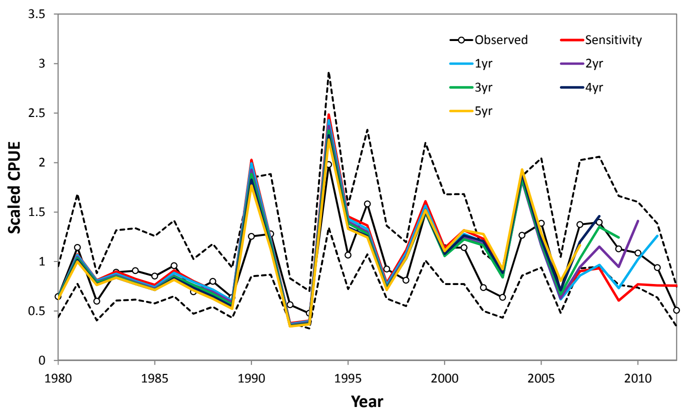


Fig. 7 Plots of Japanese troll CPUE predicted through retrospective analysis (five years) for sensitivity run.