Cause of the high fluctuation of SSB in base case OM

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Abstract

In PBFWG meeting held in November 2022, the calculation results from base case OM were showed. The PBFWG raised the concerns regarding the larger fluctuation in the future trajectory of TAC and SSB than expected. To clarify the cause of this large fluctuation in the base case of OM, the output of base case OM was examined. During the assessment period, number at age time-series showed that a stronger cohort was more heavily caught at young age than weak cohorts. It suggested that a strong year class was exposed to stronger fishing mortality than weaker cohorts, thus disappears quickly. On the other hand, the catch in projection period was assigned to each fleet to be consistent with the currently introduced catch upper limit. Due to the constant catch scenario without time varying selectivity, F during the projection period were negatively correlated with the recruitment size. Therefore, recruitment fluctuation during the projection period can be maintained even at age 10.

Introduction

Based on the Western and Central Pacific Fisheries Commission (WCPFC) request, the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) Pacific Bluefin Tuna working group (PBFWG) is constructing overall framework of the management strategy evaluation (MSE) to evaluate management procedures (MPs) for PBF. The dynamics of base-case operating model (OM) was presented in PBFWG meeting held on November 2022 (Tomassi and Lee 2022). During the 2022 November meeting, the WG noted the base-case OM showed short-term fluctuation in Spawning Stock Biomass (SSB) in projection period and consequently shorter-term fluctuation in the generated longline index in the future period than that was observed in the past (Fig,1, ISC 2022a). The base case model for stock assessment showed longer-term fluctuation, thus the cause of this fluctuation observed in the base-case OM was not clear.

To identify cause(s) of the high fluctuation observed in SSB trajectories, we examined outputs from the base-case OM.

Methods

To examine the cause of the fluctuation we used outputs from a scenario with recruitment deviations sampled randomly of the base-case OM with constant catch reported in Tomassi et al., 2022 (ISC 2022b). R package “r4ss” was used to pick up number at age and fishing mortality.

To confirm the fishing mortality that exerted on each year class, F at age by cohort were summarized from F at age in the Report file. We categorized the year classes into 3 groups, 1983-2000, 2001-2020, 2021-2050 cohorts. Based on F at age by cohort, the total fishing mortality in age 0-4 for each cohort were summed.

Results

Number at age

Figure 2 shows the Number at age time-series. In the stock assessment period, fluctuation of the number at age was observed at age-0 as a fluctuation of recruitment, but it disappears at age 2 and older. Only slight peaks could be observed at age 4. In contrast, over the future projection period, the fluctuation of each recruitment year classes could be observed more clearly even at age 10.

Fishing mortality by cohort

Figure 3 shows the fishing mortality by cohorts. Cohorts born before 2010 was exposed to strong fishing mortality during age 0-5, especially at age 0-2. The fishing mortality at age 0-5 gradually decreased in 2010-2016 cohorts and this might be an outcome of the fishery management to reduce fishing mortality for small PBF (< 30 kg), which was firstly introduced in 2011 and strengthened in 2014 and 2015.

Contrarily, in the projection period, the fishing mortality for age 0-5 were maintained relatively constant at very low level.

F at age v.s. Recruitment

Total F for each cohort from age 0 to 4 and the strength of that recruitment was summarized in figure 4. Before 2010-year class, the strong cohorts encountered stronger fishing mortality than weak cohorts (blue points in fig. 3). Cohorts in 2011-2014 encountered weaker fishing mortality during age 0-4 (green points). Cohorts in 2015-2020, which recruited after the introduction of the most strict management, encountered very low fishing mortality. However, the 2016 year-class, which was assessed as one of the strong year classes after 2010 by the 2022 stock assessment, encountered the stronger fishing mortality during age 0 to 4 than any other cohorts in the projection period. Contrary to this, the total fishing mortality for the cohorts recruited in the projection period during age 0-4 were decreased as the recruitment increased (yellow points).

Conclusion

By examining number at age time-series, it was shown that a stronger cohort was more heavily caught at young age than weak cohorts during the assessment period. Consequently, the recruitment fluctuation disappears at age 2 and older. This indicated that a strong year class was targeted by multiple fleets during their young stage. Under the ideal constant fishing mortality, the stronger cohorts should appear in the size composition of the multiple fleets over multiple years since the availability of those cohorts are higher than a weak cohort. However, the PBF assessment suggested that in reality a strong year class was exposed to stronger fishing mortality than weaker cohorts, thus disappears (in a relative sense) quickly. The estimated time varying selectivity by the assessment, observed size composition data, and a somewhat smooth longline abundance index consistently supports this targeting of stronger cohorts.

In the MP on the other hand, the catch in projection period was assigned to each fleet to be consistent with the currently introduced catch upper limit. Because of the constant catch scenario without time varying selectivity, Fs during the future period were negatively correlated with the recruitment size. Therefore, Recruitment fluctuation during the projection period can be maintained even at age 10, which is considered to be causing shorter-term SSB fluctuation in the projection period. This kind of phenomena was not observed in the stock assessment since the fishery seems to target the abundant cohorts, which would be easier to explore in the sea, so that the gap between the assumption in the MP (constantly assigned catch and constant selectivity/constant shape of F at Age) and the those for the actual fishery should be examined very carefully.

References

ISC. 2022a. Report of Pacific Bluefin Tuna Working Group Intersessional Workshop. 1–8 November 2022, webinar

ISC. 2022b. Stock Assessment of Pacific Bluefin Tuna in the Pacific Ocean in 2022. ISC/22/ANNEX/13, July 2022, Kona, USA

Tomassi D. and H.-H. Lee. 2022. Overview of the preliminary Pacific bluefin tuna management strategy evaluation framework. ISC/22/PBFWG-2/05. 1–8 November 2022, webinar

Figure 1. The top figure is Spawning stock biomass from stock assessment result (ISC 2022b). Worm plots of spawning stock biomass during the projection period for individual runs. The middle figure is the result for the CMM Catch Limit simulation with the base case operating model. The bottom figure is the result for harvest control rule 15 in with the base case operating model. The middle and bottom figures are from Tomassi et al. (2022).

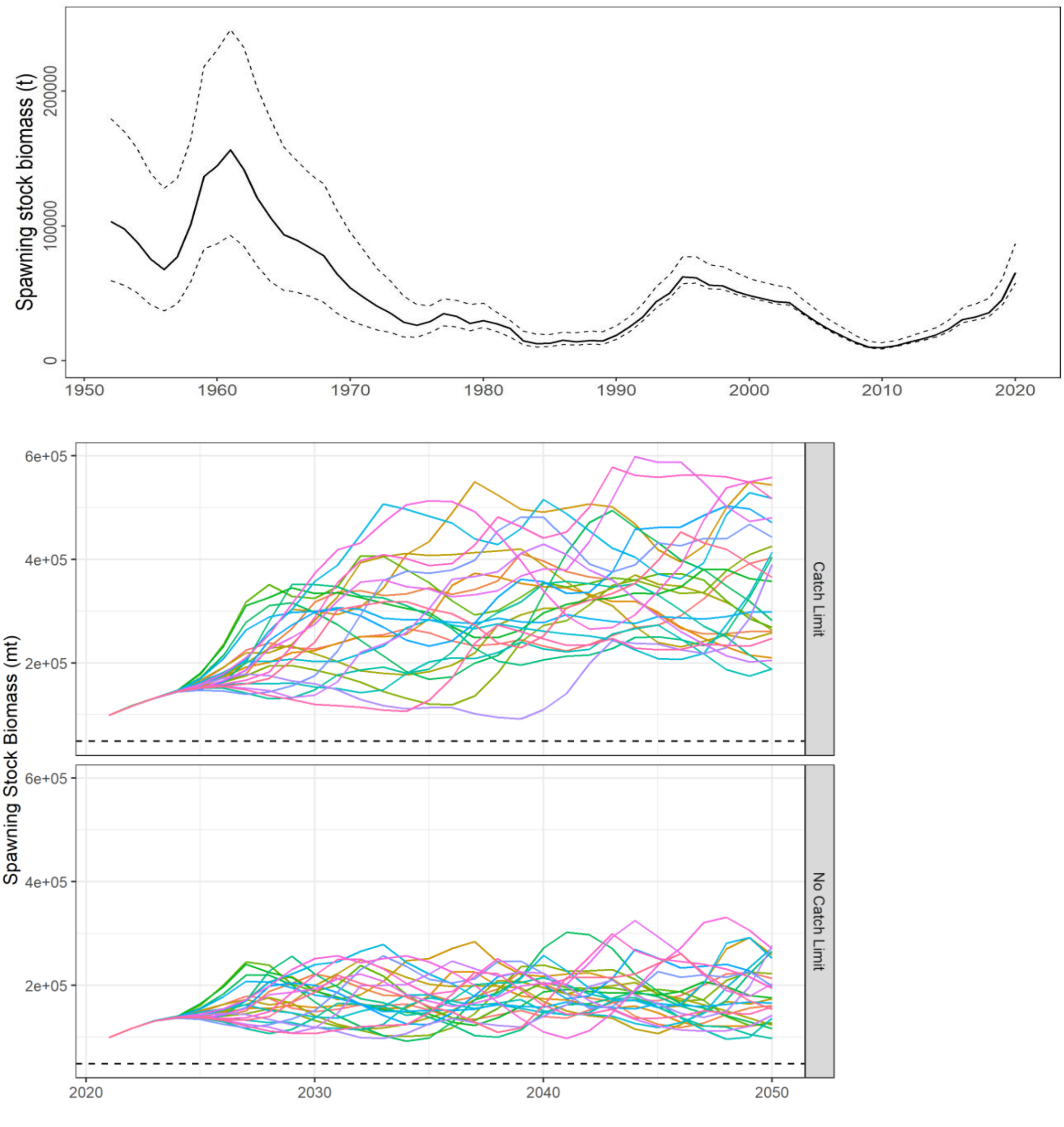

Figure 2. Number at age time-series from 1983 to 2050 in age 0-10.

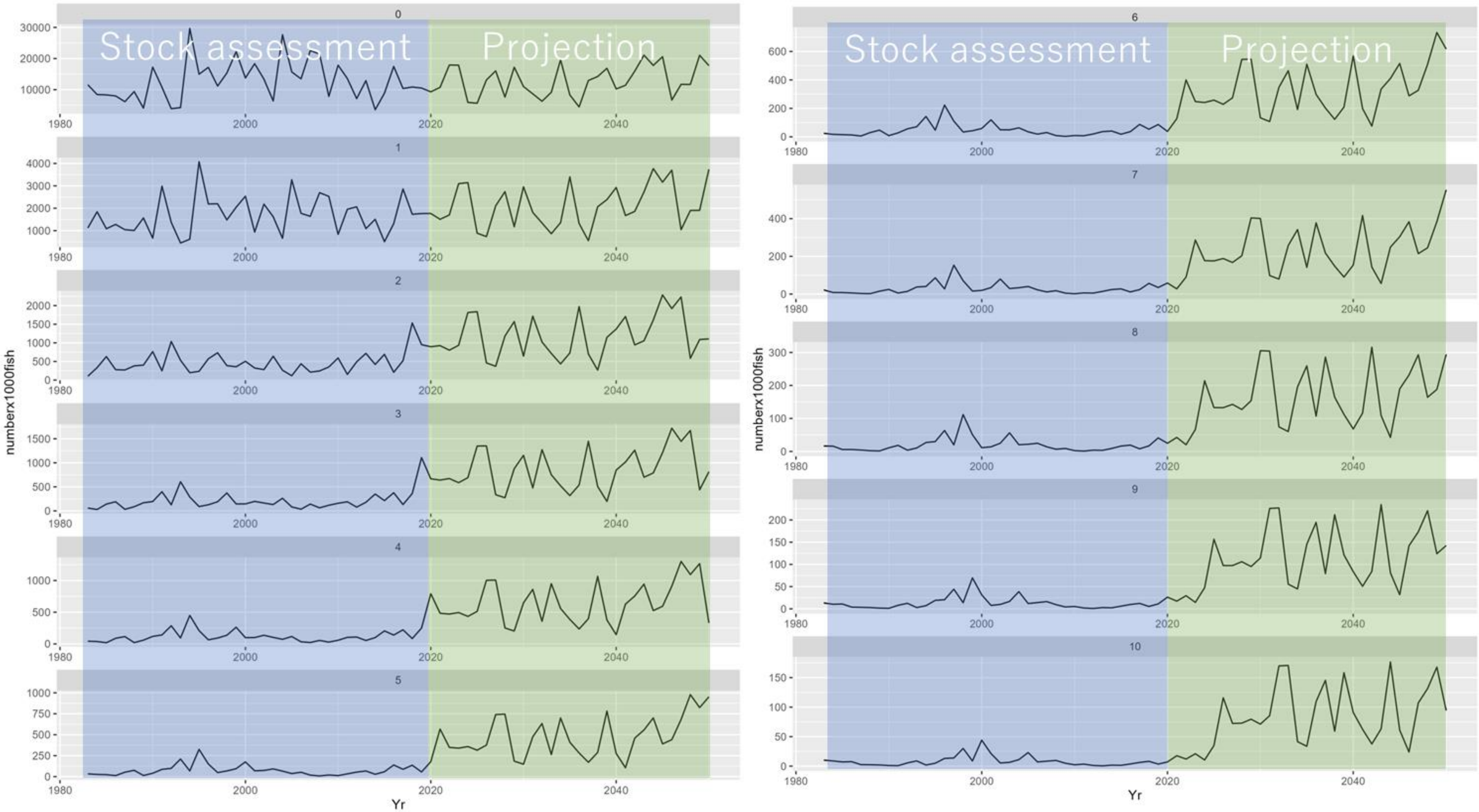

Figure 3. F at age by cohort. Left panel is for 1983-2000 year classes, middle panel is for 2001-2020 year classes and right panel is for 2021-2050 year classes.

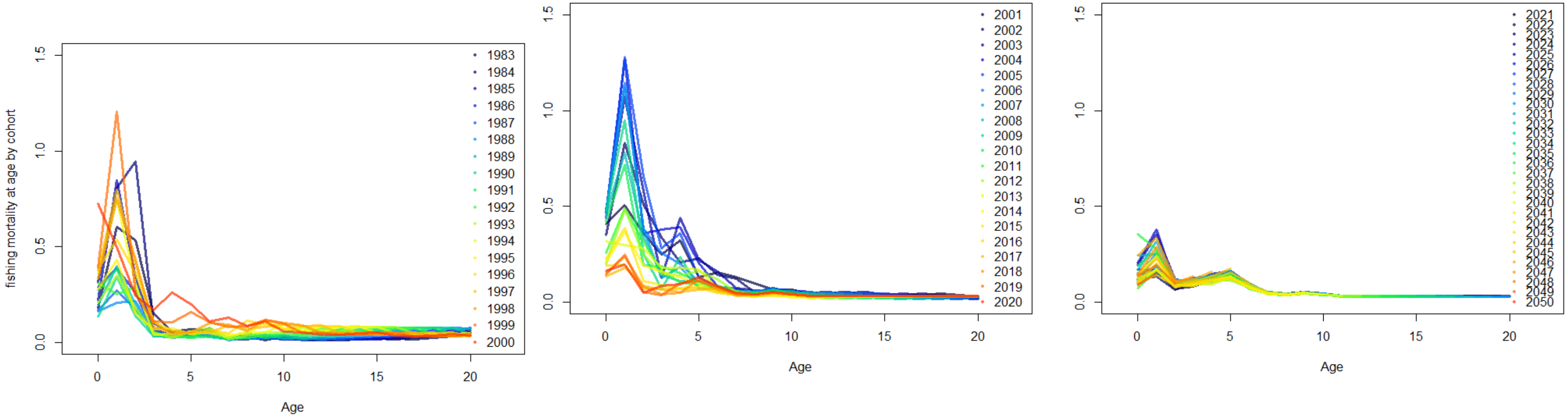

Figure 4. Relationship between total F at age 0-4 and recruitment. Blue points are for non-management year classes, green points are for year classes in management period with reducing young fish catch, red points are for strict management period and yellow points are for projection period.