Sensitivity analysis with different unseen mortality assumptions based on the 2024 stock assessment model

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Introduction

Since the beginning of the strict management for the Pacific Bluefin tuna (PBF), the unseen mortality became the necessary topic to discuss. In the ISC PBF stock assessment, the WG assumed “unaccounted mortality” fleets including the management issues since 2020. The unseen mortality for catch amount in WPO was 5%, it for catch number in WPO was same number, and it for EPO recreational fishery was 6%. In the 2024 stock assessment, PBFWG performed some sensitivity analysis with increased catch amount and number in unseen mortality fleets (F24-26) and it showed insensitivity of the model to the alternative catch scenarios.

In this document, the authors provided comparisons among the models with different unseen mortality settings.

Model and Data

The base case model from 2024 stock assessment model was used as the base case model in this document. From the base case model, the catch in weight and number for the unaccounted mortality fleets (Fleets 24, 25 and 26) were multiplied by 0.5, 2 and 3 for the model with unseen mortality x0.5, x2 and x3.

Biomass scale

The log R0 showed a higher value as the model assumed a higher unseen mortality (Figure 2). Doubling and tripling the unseen catch assumption resulted in a difference of about 30,000 tons in the unfished SSB (Figure 1). However, the log R0 median estimated by the models with each unseen mortality scenario was within the distribution of R0 estimated by the base case model. There is no strong impact by changing the unseen mortality assumptions to the estimated population scale.

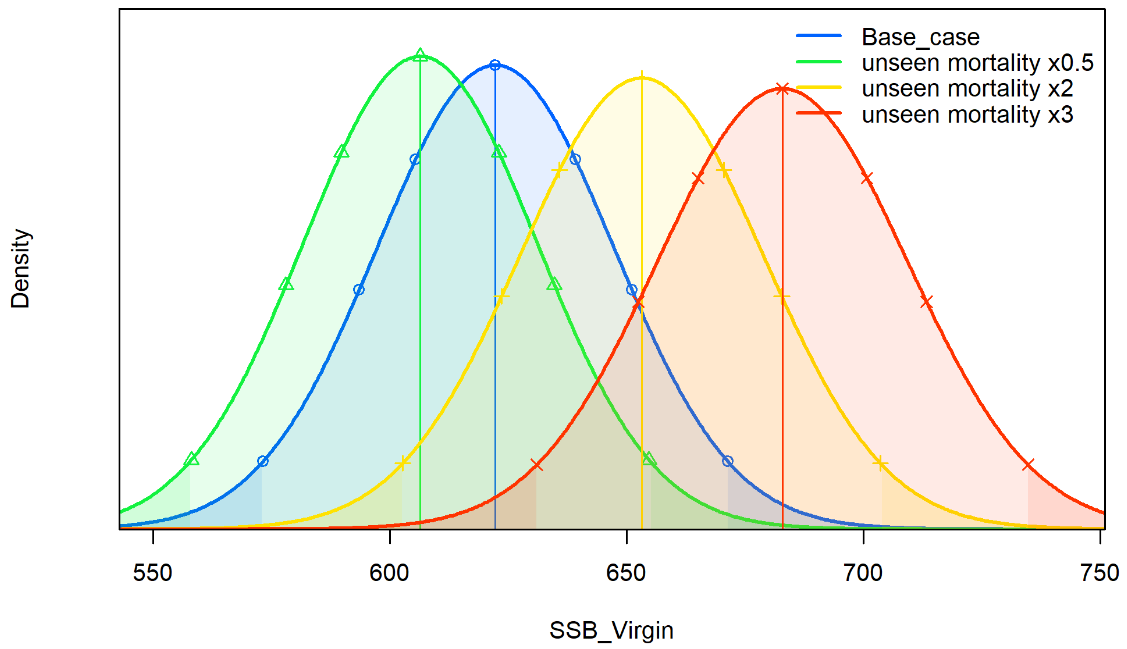

Figure 1 $SSB_{F=0}$ comparison between base case (blue), unseen mortality with half (green), twice (yellow) and three times (red).

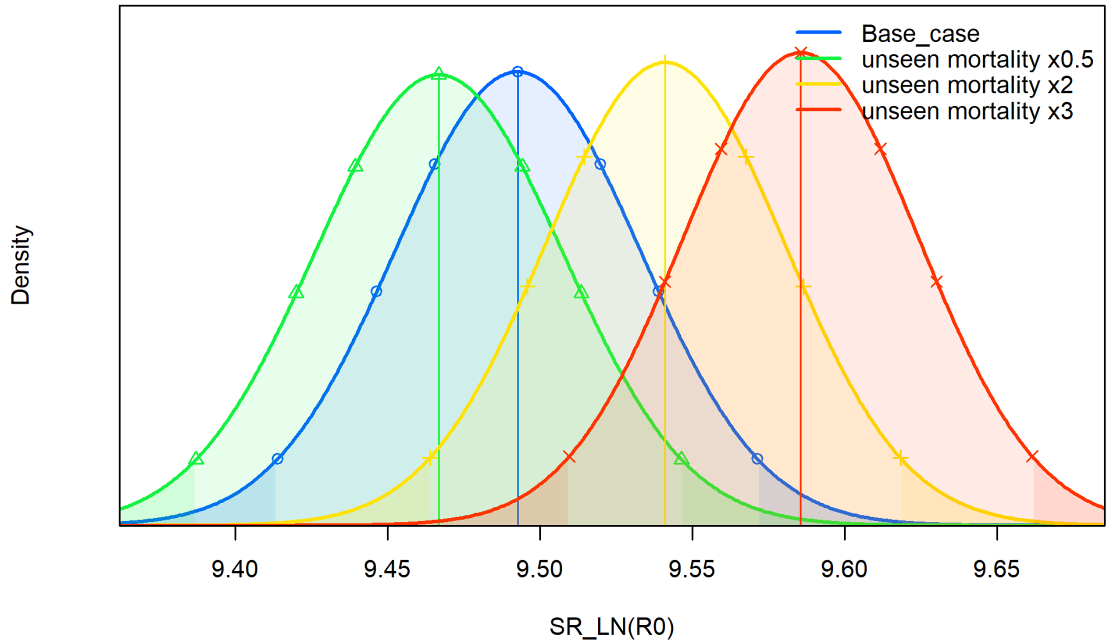

Figure 2 R_0 comparison between base case (blue), unseen mortality with half(green), twice (yellow) and three times (red).

Spawning Stock Biomass (SSB)

There was little difference between 4 models with different unseen mortality assumptions (Figure 3). Due to the difference of $SSB_{F=0}$, the models with higher unseen mortality showed slightly lower relative SSB than others during 1990-2002 and after 2020 (Figure 4). From the comparisons of SSBs and relative SSBs, the SSBs didn't affect from the different setting of the unseen mortality.

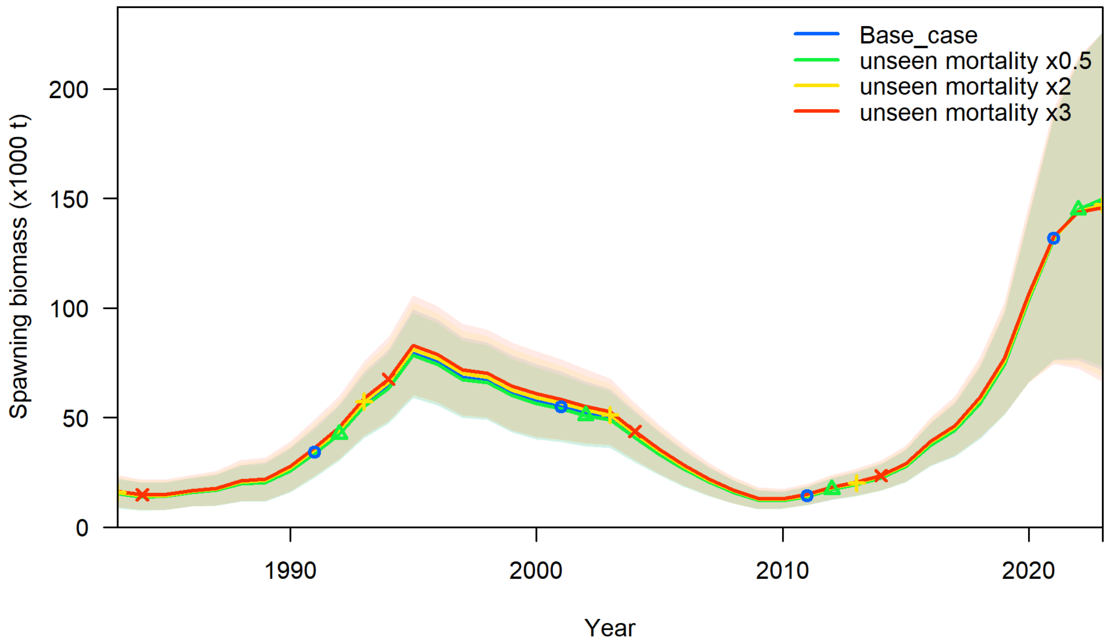

Figure 3 SSB (mt) comparison between base case (blue) , unseen mortality with half(green), twice (yellow) and three times (red).

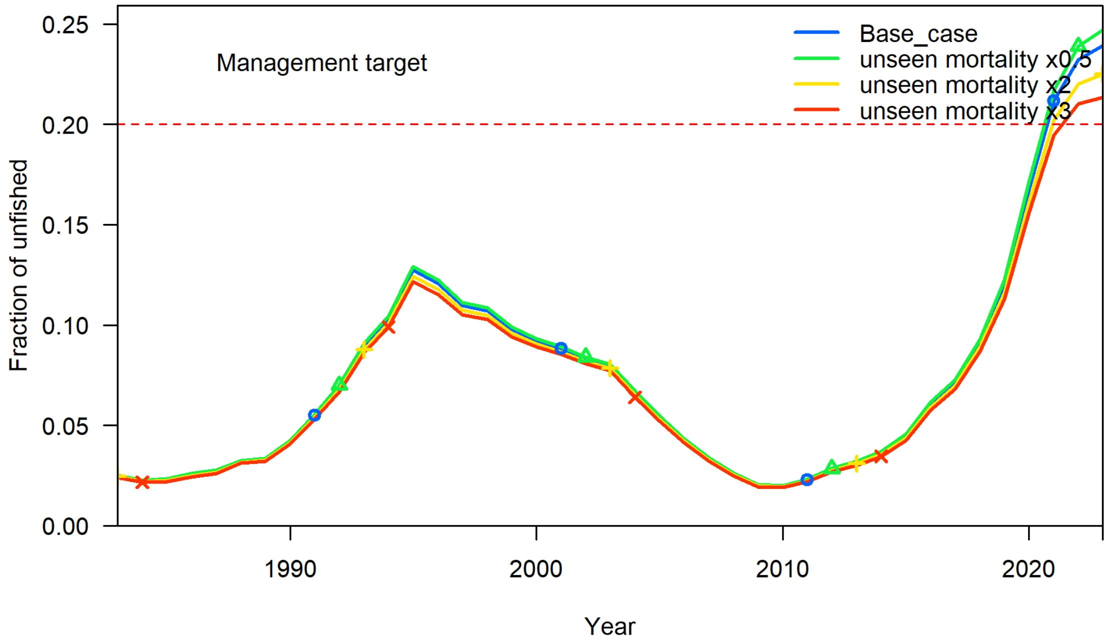

Figure 4 Relative SSBs comparison between base case (blue) , unseen mortality with half (green), twice (yellow) and three times (red).

Recruitment (R)

There were some differences in recruitment after 2000, and the models with a higher unseen mortality showed a higher recruitment value (Figure 5). Although all models have narrow confidence intervals, especially during 2000-2009, recruitments estimated by the model with 3 times higher unseen mortality were out of confidence intervals estimated by the base case model. On the other hand, there was no clear difference in the estimated recruitment deviation among the models with different unseen mortality assumptions except during 2000's (Figure 6). Those results indicated that the models with a higher unseen mortality basically explained its additional catches by mimicking the population scale but maintained the shape of the relative strength of the recruitment.

A difference in the absolute recruitment during 2000-2009 could be a compensation of the additional unseen mortality given a large amount of the removal of young fish at that period. Since 1993, catch at age 0 were rapidly increased until the management introduction (Figure 7). The recruitment deviations might be increased to make some more fish, which would be removed by a additional unseen mortality assumption. The scale of recruitment (R0) was also in a higher level as assuming a higher unseen mortality. It is reasonable that the recruitment deviations in 1990s when there are no unseen mortality were not affected by the unseen mortality assumptions.

Although there were some differences in the recruitment estimates to compensate the unseen catch, the recruitment estimates were not critically affected by the unseen mortality assumption.

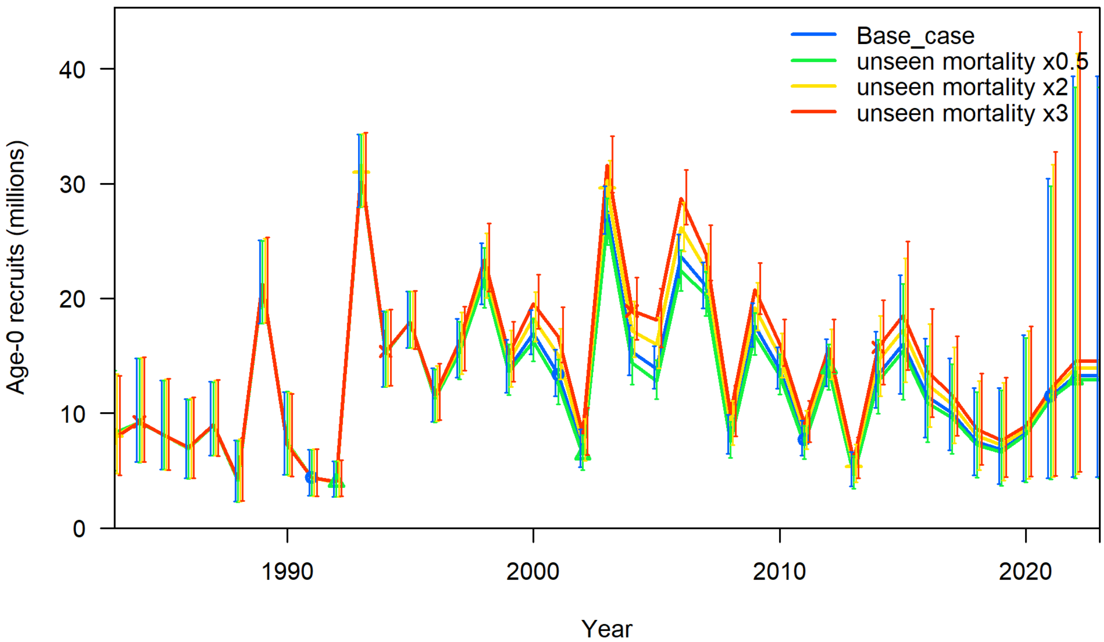

Figure 5 Recruitment (x millions) comparison between base case (blue) , unseen mortality with half(green), twice (yellow) and three times (red).

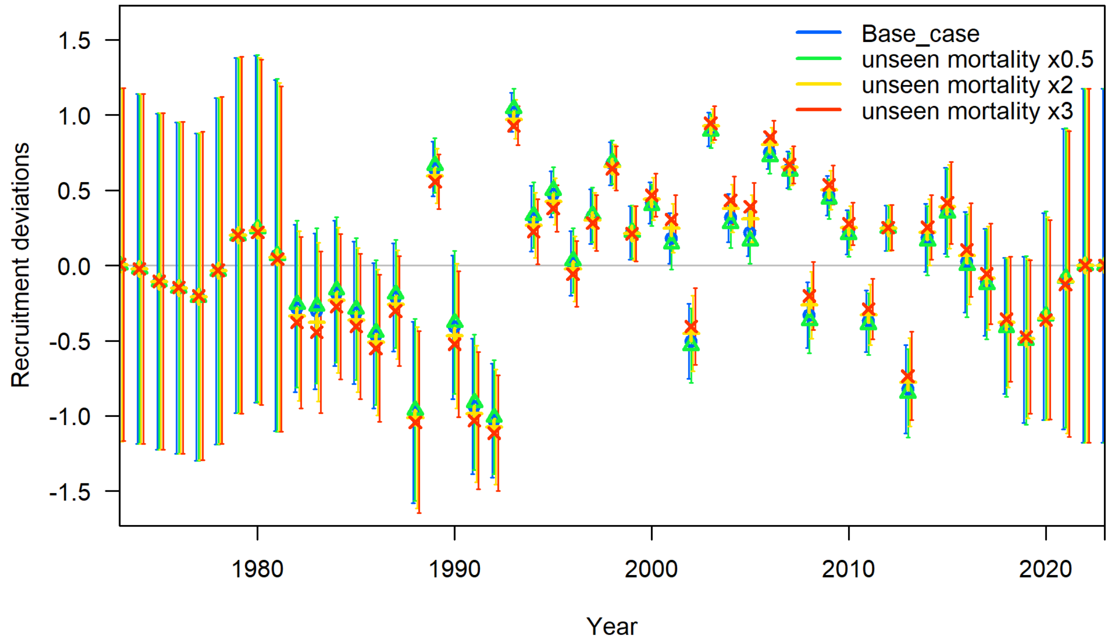

Figure 6 Recruitment deviations comparison between base case (blue), unseen mortality with half(green), twice (yellow) and three times (red).

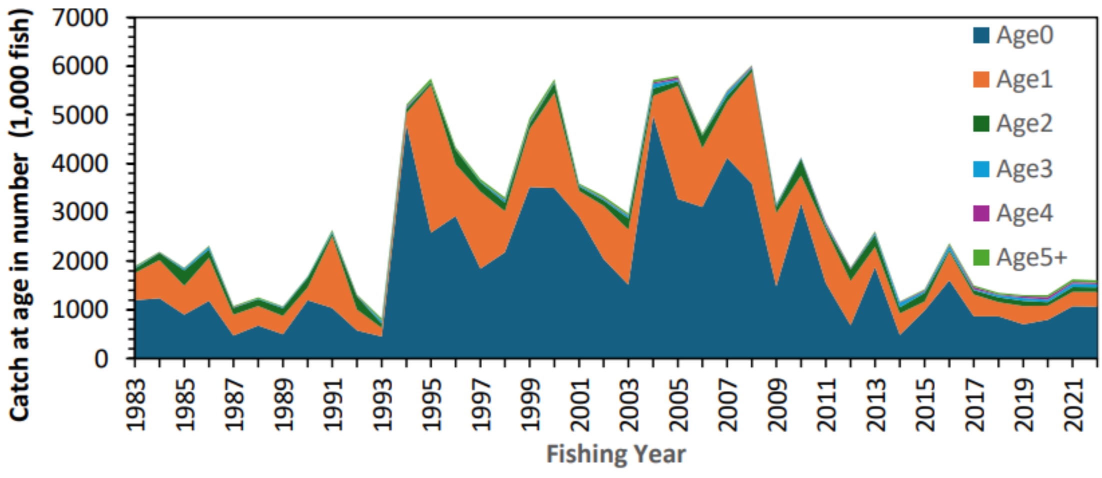

Figure 7. **Estimated annual catch-at-age (number of fish) of Pacific bluefin tuna (*Thunnus orientalis*) by fishing year estimated by the base-case model (1983-2022).**

SPR

About SPR, there are some differences among the models with different unseen mortality after 2010 (Figure 8). During 2000-2010, the recruitment was affected by the difference of the unseen mortality scales (Figure 5), however, the SSB and SPR were not affected (Figure 4 and Figure 7). Average 1-SPR during 2000-2009 was 97.3% in the base case model and the stock was exposed to high fishing intensity. There might be no room to increase SPR by higher unseen catch. Instead, the model might produce higher recruitment for this period to compensate for the catch required due to a higher unseen catch.

After 2010, SPR and relative SSB had some differences among the models with different unseen mortality levels but, as shown in the above sections, there was little difference in the absolute SSB. A difference in SPR in the terminal decade is the result of a higher unseen mortality to make slightly smaller chance for a recruitment to survive at the terminal decade. In addition to Fleet 26, the unseen mortality in WPO (Fleet 25) was assumed to initiate in 2017, and this recently initiated mortality might affect to the survival of a recruitment to be a spawner.

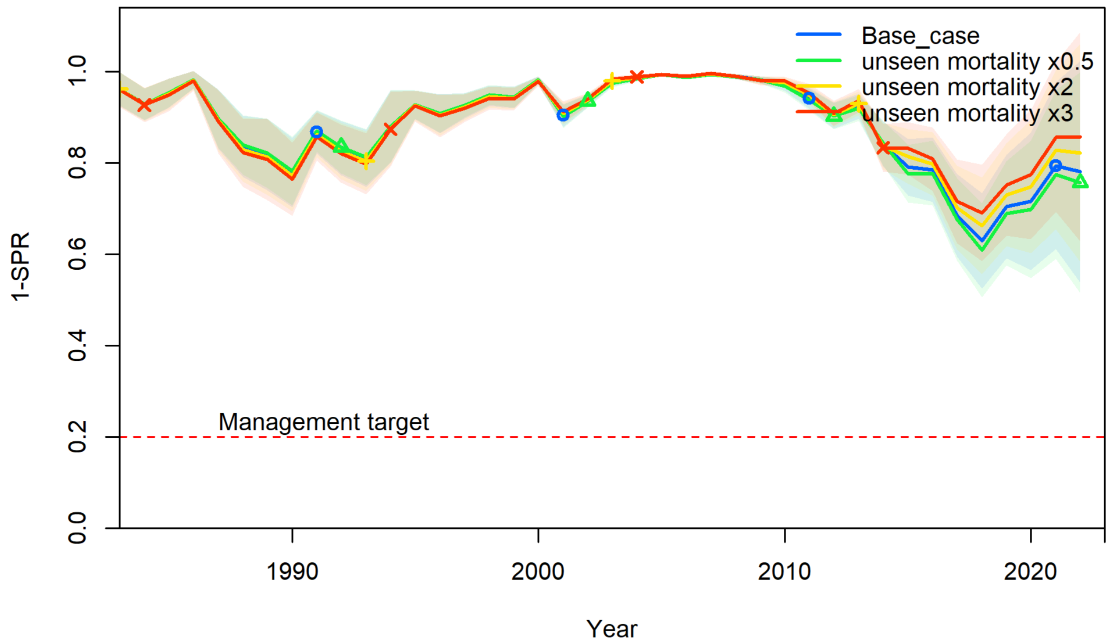

Figure 8 1-SPR comparison between base case (blue) , unseen mortality with half(green), twice (yellow) and three times (red).

Model fitting to the Abundance Indices

There were no differences among all models regarding the model fits to the abundance indices(Figure 9, Figure 10, Figure 12). The RMSE values for the base case and each uncertainty scenarios showed a almost identical values (Table x), and thus, the amount of the unseen mortality would not affect to the model fit to the observed data.

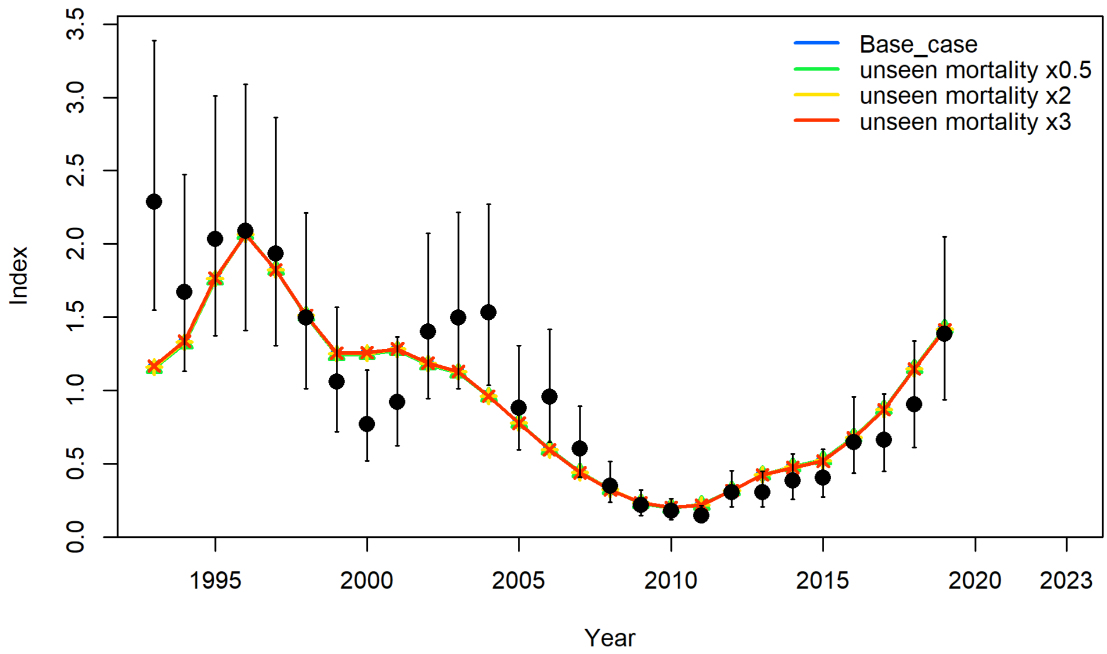

Figure 9 Predicted Japanese Longline CPUE (1993-2019) comparison between base case (blue) , unseen mortality with half(green), twice (yellow) and three times (red).

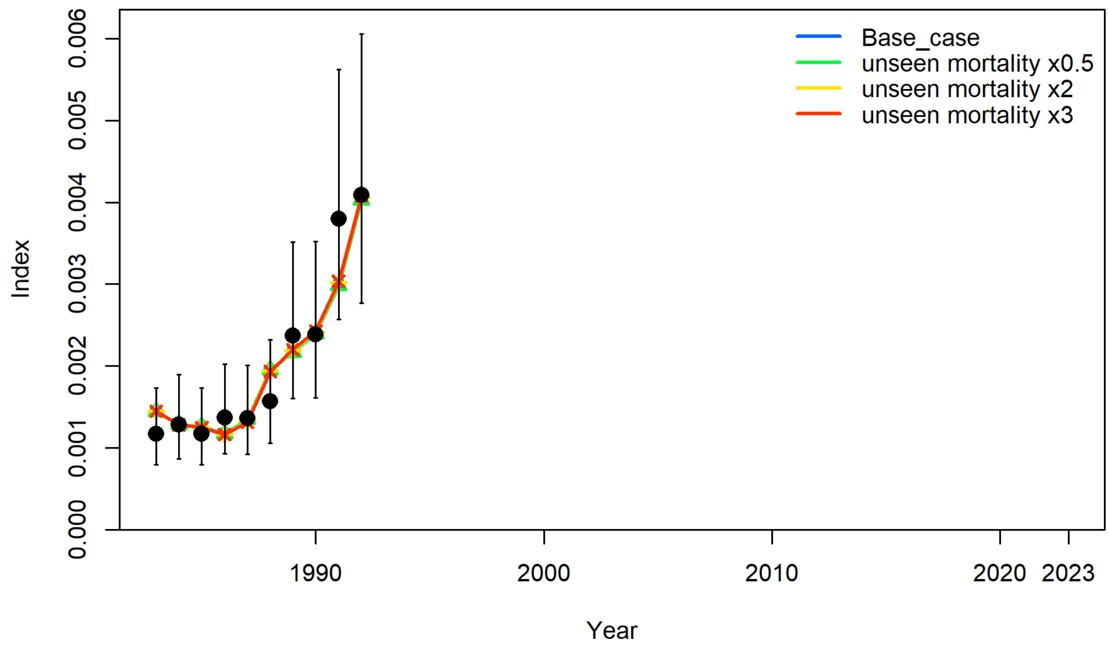

Figure 10 Predicted Japanese Longline CPUE (1982-1992) comparison between base case (blue) , unseen mortality with half(green), twice (yellow) and three times (red).

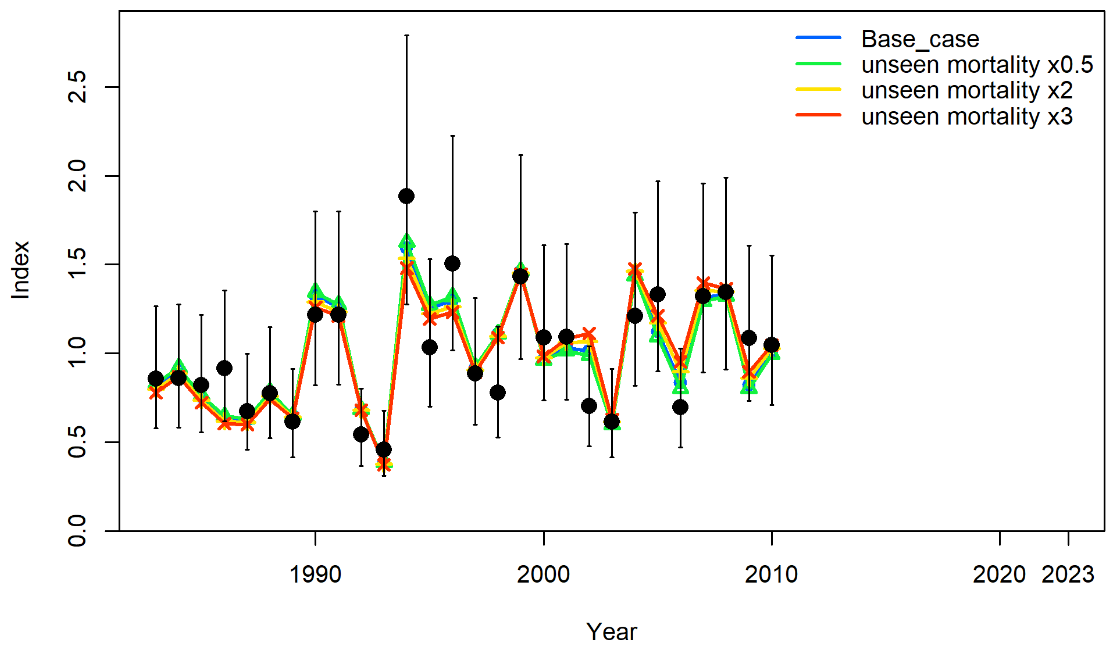

Figure 11 Predicted Japanese Troll CPUE (1982-2010) comparison between base case (blue), unseen mortality with half(green), twice (yellow) and three times (red).

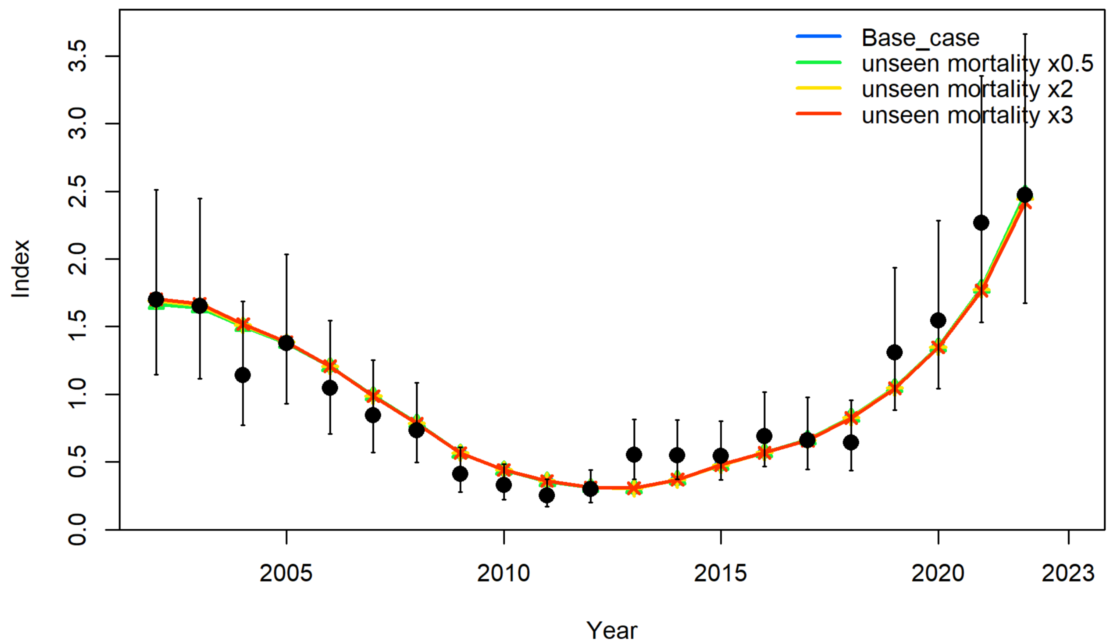

Figure 12 Predicted Taiwanese Longline CPUE comparison between base case (blue), unseen mortality with half(green), twice (yellow) and three times (red).

Conclusion

Based on 2024 stock assessment base case, the sensitivity analysis with half, twice and three times unseen mortality were conducted. There were no strong impact on the estimates of population scale and SSB. About recruitment estimates, recruitments during 1998 to 2015 were slightly affected by the unseen mortality levels. It was suggested that the model compensated the increased unseen mortality by producing some more recruitment to reconcile a large amount of age 0 catch during that period, but that compensation might not be necessary when the strict management of catch limitation was introduced in 2015. SPR timeseries estimated by the models with each unseen mortality had some differences in particular after 2010.–

By assumption of unseen mortality, numbers of fish caught were decreased and increased. This variation in catch was explained by recruitment and fishing mortality. In the case of high unseen mortality, R0 was relatively high and accordingly recruitment was high in overall. In particular 2000s when the catch of age 0 fish was very high, the recruitment deviations were also increased to produce the necessary fish. After 2010s, the model explained the unseen mortality as increasing of fishing mortality, and relative SSB was also decreased in this decade. In 2000s, because the fishing mortality was extremely high, the model couldn’t explain the unseen mortality by increasing the fishing mortality, but created the recruitment as compensation. The number of fish caught was decreased after 2010s when the strict management coming in, the model explained the unseen mortality as the increase of fishing mortality. In either case, there was minor effect to the population dynamics by the assumptions of unseen mortality.

Overall, because the population dynamics estimated by different unseen mortality scenarios were basically robust, the authors do not recommend to conduct conditioning of the OM for different unseen mortality level. Instead, the PBFWG can assume a higher unseen mortality level for the future period as one of the robustness tests. In the current candidate harvest control rules (IATTC-WCPFC JWG 2023), the stock would be maintained above a historic high level with a higher TAC than 2015-2022 (Tommasi and Lee, 2024). A higher TAC in future might reduce the amount of PBF released from the fishing gear since the fisher could have a larger quota. But a higher biomass would also increase the possibility of fishing gear to encounter PBF. Thus, it is always difficult to assume a certain magnification for the unseen mortality. In the current assessment, the unseen mortality in the WPO was assumed 5% of its landings for all fisheries except a fleet (Troll for penning). Because of the nature of the fishery, 100% of the unseen mortality was assumed for the troll for penning. If it is assumed 3 times higher unseen mortality than the current base-case, 300% of reported catch was assumed for the troll for penning and this could be somewhat extreme level. The authors recommend to assume 2 times higher unseen mortality for the robustness test.

Reference

IATTC-WCPFC JWG. 2023. Chairs' Summary of the 8th Joint IATTC and WCPFC-NC Working Group Meeting on the Management of Pacific Bluefin Tuna. IATTC-NC-JWG08-2023-00.