Estimating Impacts on the Spawning Stock Biomass by Fleets in Pacific Bluefin Tuna Future Projection

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Summary

Introduction

Pacific bluefin tuna (PBF) is born in the western North Pacific Ocean (WPO) but some portion of juvenile migrates to the Eastern Pacific Ocean (EPO) to spend several years before returning to WPO to spawn. As a result, PBF is caught in both WPO and EPO by various types of fishing gears. The relative impacts on the spawning stock biomass (SSB) of PBF by different fishing gear varies due to the difference of the selectivity; 1 ton of catch by fleets targeting juvenile will have a larger impact on future SSB than 1 ton catch by other fleets targeting adult fish. Therefore, given its stock status, ISC has been promoting to reduce fishing mortality of juvenile PBF to recover the stock.

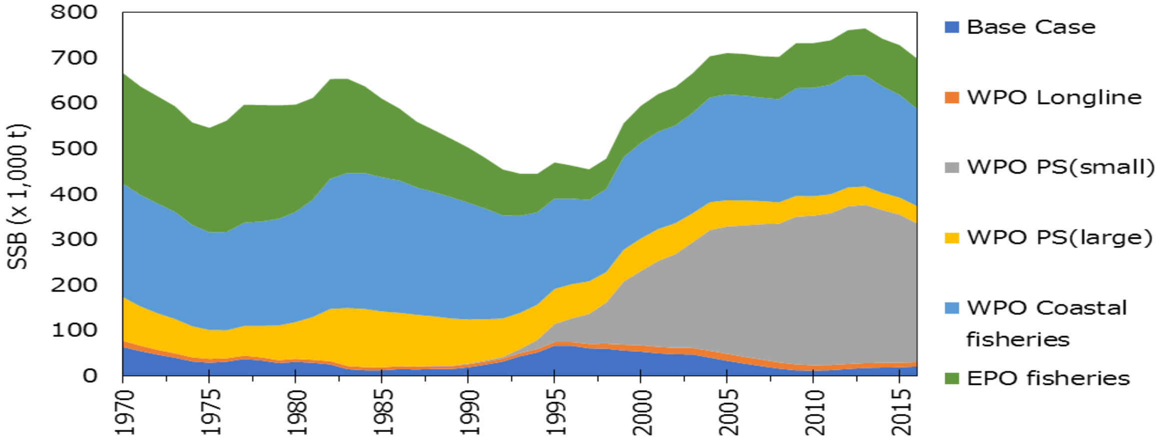
In order to illustrate the point, ISC has been providing “impact plot” (Fig. 1 (ISC, 2018)) which illustrates the historical impact on SSB by fleets. The method is described in Appendix F, Appendix 2, Annex 14 (PBFWG meeting report) of ISC 13 Plenary Report (ISC, 2013) as follows.

(1) Set the S-R steepness parameter to 1.0 to fix the recruitment without any re-estimation of other parameters with this steepness value.

(2) Set the catch for all fisheries and the initial F parameters to zero. Simulate the dynamics of the stock using the parameters of the base-case run to estimate the dynamic unexploited stock size (dynamic virgin SSB).

(3) Set the catch and the initial F parameters for a fishery group to zero. Simulate the dynamics from the parameters of the base-case run to estimate the exploited stock size in the absence of particular fishery group.

(4) Repeat Step 3 for every fishery groups. (The sum of the fishery impacts by all the fishery groups will not be equal to the dynamic virgin SSB that was estimated in Step 2). Assign the impact from dynamic virgin SSB to each fishery group by using the ratios of the impacts obtained in Step 3.



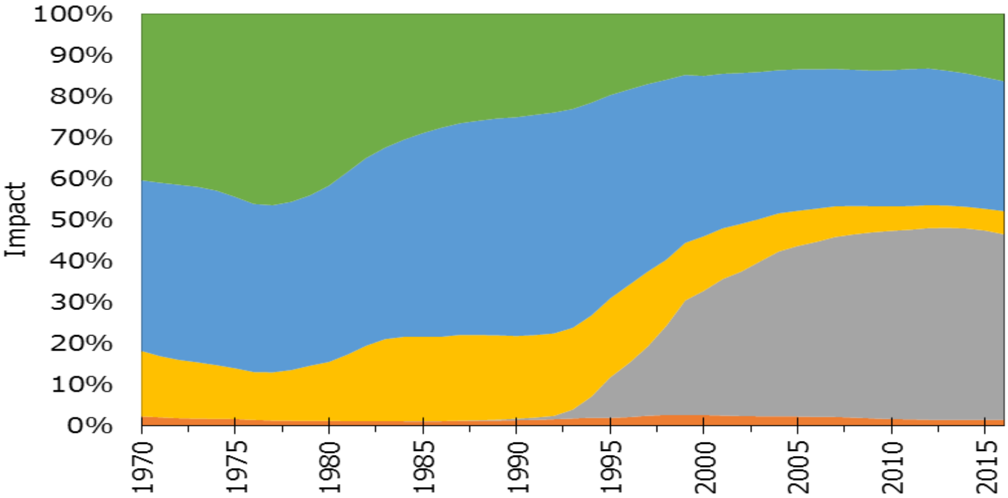


Fig. 1. "Impact plot" from 2018 PBF stock assessment (ISC, 2018). Trajectory of the spawning stock biomass of a simulated population of Pacific bluefin tuna (*Thunnus orientalis*) when zero fishing mortality is assumed, estimated by the base-case model. (top: absolute impact, bottom: relative impact). Fleet definition; WPO longline: F1, F12, F17. WPO purse seine for small fish: F2, F3, F18. WPO purse seine: F4, F5. WPO coastal fisheries: F6-11, F16, F19. EPO fisheries: F13, F14, F15.

The relative impacts on PBF SSB from WPO as well as EPO fisheries has been discussed in RFMOs. WCPFC Harvest Strategy for PBF (HS2017-02) stipulates as one of management objectives "to seek cooperation with IATTC to find an equitable balance between the fisheries in the western and central Pacific Ocean (WCPO) and those in the eastern Pacific Ocean (EPO)" (WCPFC, 2017). In 2019, the IATTC-WCPFC NC Joint Working Group requested ISC "to provide fishery impact on the SSB under recent conditions taking into account the difference in age caught. Provide a matrix of conversion values across age classes" (WCPFC, 2019).

It is therefore considered useful for the discussion at RFMOs to provide "impact plot" for future projection as well, taking a similar approach to create historical impact plot. Future projection was conducted in accordance with the method applied at the 2018 assessment (Nakayama et al., 2018).

Materials and Methods

The following approach was taken to develop a "future impact plot".

(i) All the variables (F at age by quarter, Number at age at the terminal year, recruitment estimates) required for this analysis were brought from 2018 base-case assessment model. Obtain future SSB (2016-) based on current management measures as done in 2018 assessment (Nakayama et al., 2018). As an example, future recruitments up to 2024 were fixed to the average of the annual recruitment of 1980-1989 (low recruitment period) and for 2025 and thereafter were fixed to the average of the annual recruitment from whole period (average recruitment period).

(ii) Conduct procedures (1) to (3) of impact analysis for the assessment period above for each fishery group, i.e. set initial F and catch at zero only for that fishery group and run the base-case assessment model to prepare "starting condition" for future impact plot.

(iii) To calculate future impact of a fishery group, take the model run of (ii) above for that group as the "starting condition" and run future projection with zero F and catch for the fishery group. Recruitment scenario is as specified in (i) above. Repeat the procedure for all the fishery groups.

(iv) Run projection with zero catch for all fleets, starting from the dynamic virgin SSB in 2016 as obtained from procedure (2) of impact analysis for the assessment period. Divide the difference between the dynamic virgin SSB and the estimated remaining SSB from (i) by the annual proportion of impact among fishery groups obtained through (iii) above.

(v) Fishery groups used here were the same as used for historical impact plot, i.e. WPO longline: F1, F12, F17, WPO purse seine for small fish: F2, F3, F18, WPO purse seine: F4, F5, WPO coastal fisheries: F6-11, F16, F19, and EPO fisheries: F13, F14, F15.

Results and Discussions

Estimated "future impact plot" is shown as Fig. 2. Note that relative impacts among fishery groups of a particular year does not represent the relative instantaneous impact of each fishery group being given on SSB that year. Rather, it shows the cumulative impact that a fishery group has given on the stock up to the year by a certain harvesting rule. It also assumes a particular future constant recruitment scenario (low until 2024 and average afterwards) and that selectivities of fleets remain constant to simplify the calculation. The WG is invited to consider if it is useful to include this "future impact plot" for providing conservation advice at the upcoming benchmark assessment.

References

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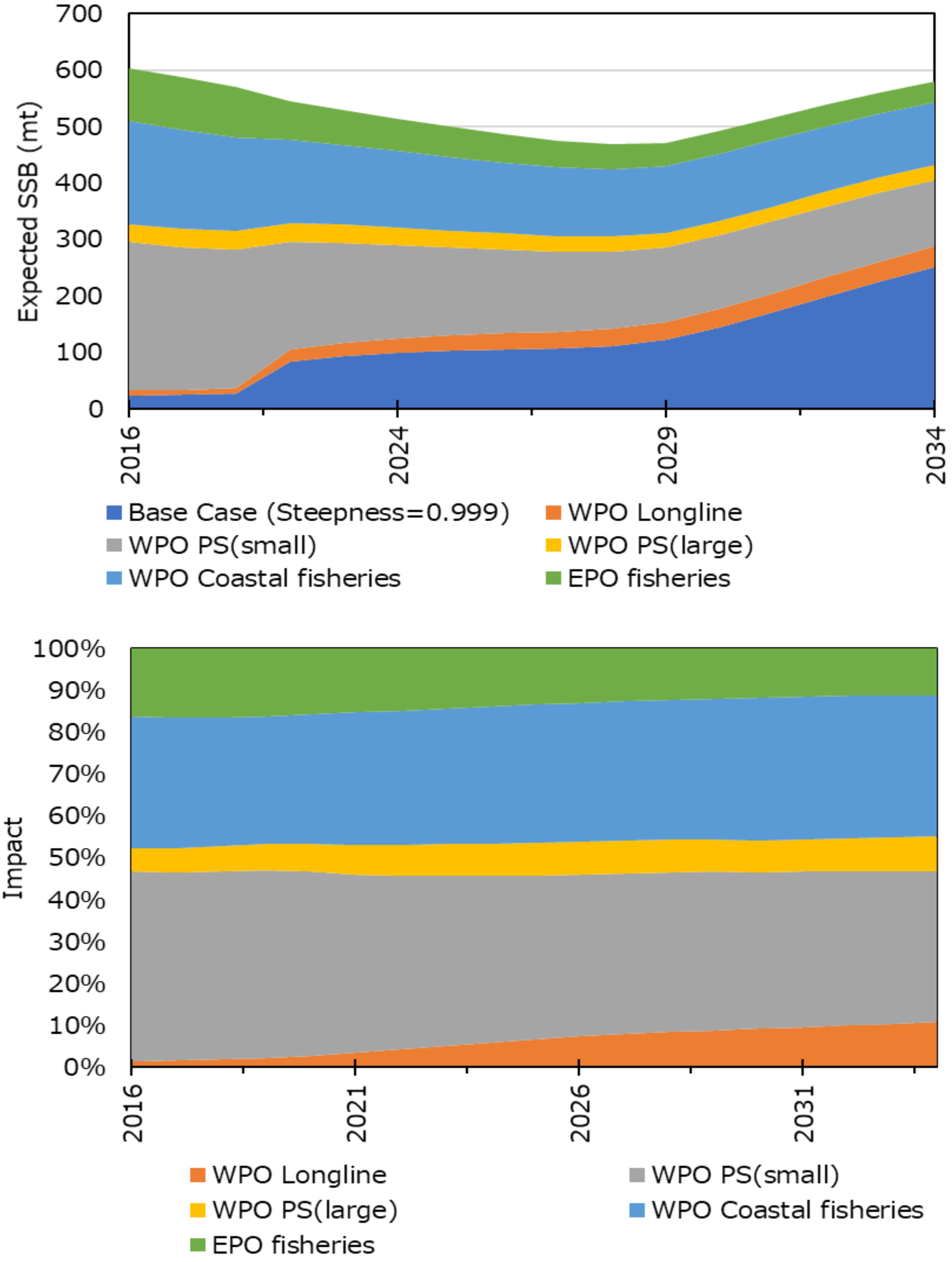

Fig. 2 The result of estimating impacts on Future Projection by fishery groups. Trajectory of the spawning stock biomass of a simulated population of Pacific bluefin tuna (*Thunnus orientalis*) when zero fishing mortality is assumed, estimated by the base-case model. (top: absolute impact, bottom: relative impact). Fleet definition; WPO longline: F1, F12, F17. WPO purse seine for small fish: F2, F3, F18. WPO purse seine: F4, F5. WPO coastal fisheries: F6-11, F16, F19. EPO fisheries: F13, F14, F15.