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Exploring Alternative CPUE Standardisation Approaches for Inclusion in South Pacific Albacore MSE Operating Models

WCPFC-SC19-2023/MI-IP-04

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Executive Summary

Under the workplan for the development of the harvest strategy approach for WCPO stocks and fisheries, SC19 is scheduled to agree upon the operating model (OM) grid for south Pacific albacore. Given the strong dependency of stock assessments on CPUE and the sensitivity of CPUE indices to alternative assumptions and procedures for their development, SC18 recommended that alternative standardisation CPUE approaches could be an important factor to consider when evaluating uncertainty captured within the OM grid. To address this suggestion, we evaluated four alternative approaches for CPUE standardisation to identify whether they provided sufficient additional sources of uncertainty in dynamics to be included within the OM grid. Our results demonstrate that these approaches produce either indistinguishable CPUE index trends, or led to stock status that overlaps with the current OM grid. Furthermore, the initial investigation into the "traditional" CPUE approach did not yield results which demonstrate a perceivable trend over time, prompting the decision to discontinue any further pursuit of this approach. Based on this, we do not recommend that alternative CPUE standardisation approaches be included as an uncertainty axis in the south Pacific albacore OM grid.

We invite SC19 to:

- consider the evaluation of alternative CPUE indices to inform development of the OM grid for the south Pacific albacore MSE;
- support the recommendation that alternative CPUE standardisation approaches should not be included in the OM grid for the south Pacific albacore MSE.

1 Introduction

The harvest strategy approach is widely recognised as best-practice for effective decision-making in fisheries management. It provides a framework for taking the best available information about stocks and fisheries, and applying an evidence- and risk-based approach to setting harvest levels. The management strategy evaluation (MSE) framework allows decision-makers to assess the robustness and sensitivity of different management procedures (MPs) to uncertainties and risks, and to identify the most effective and robust MP for achieving their management objectives, prior to implementation.

Operating models (OMs) are one of the main components of the MSE simulation framework and are used to represent the dynamics of the fish population and its associated fisheries. The OMs allow us to evaluate the consequences of uncertainty in these dynamics by testing management procedures against different hypotheses. Thus, a suite of OMs should typically include a greater level of uncertainty than that considered within a stock assessment, and incorporate all critical sources of uncertainty affecting both past and future states in the evaluation process.

In accordance with the workplan for the development of the harvest strategy approach for WCPO stocks and fisheries, SC19 is scheduled to agree upon the OM grid for south Pacific albacore. Given the strong dependency of stock assessments on CPUE and the sensitivity of CPUE indices to alternative assumptions and procedures for their development, SC18 recommended that alternative CPUE standardisation approaches could be an important factor to consider when evaluating uncertainty captured within the OM grid (WCPFC, 2022). In response to this request, analyses have been conducted to explore alternative approaches to standardise CPUE under the 2021 south Pacific albacore assessment.

In the recent assessment, CPUE standardisation for the index fishery data was conducted using a spatiotemporal modelling approach implemented in the VAST R package (Thorson et al., 2015). The final model used to generate the CPUE indices included targeting cluster and vessel flag as catchability covariates (Vidal et al., 2021). This approach explicitly models the spatial structure in the response variable, based on the reasoning that observations closer in space are more likely to be similar. This allows the spatial autocorrelation to be considered, which increases the precision in estimates and makes it easier to identify a relationship between response and candidate explanatory variables (Castillo-Jordan et al., 2021). This approach has been extensively implemented in recent WCPFC stock assessments.

The objective of exploring the CPUE standardisation approach for stock assessment purposes differs from that needed for MSE OM development. The aim of the assessment is to estimate a single standardised CPUE index from the best fitting model. For OM development, the objective is to identify multiple standardised CPUE indices based upon plausible alternative hypotheses, in order to incorporate additional uncertainties in the OM grid. Therefore, candidate CPUE indices should not only be able to represent stock abundance with probable hypotheses and reasonable diagnostics, but also produce plausible estimates of stock status which may differ from those in the recent assessment.

In this paper, we present four alternative approaches and compare the CPUE indices to those of the recent assessment. Furthermore, the stock status estimates from these alternative approaches are also compared to the stock status of the recent assessment.

2 Alternative CPUE standardisation approaches

In accordance with the 2021 stock assessment's recommendation, we have investigated four alternative approaches for the CPUE standardisation. The first approach, labelled the "geostatistical hooks between floats (HBF)" approach, replaces the targeting cluster with the number of hooks between floats (HBF) as a covariate in the standardisation process. The second approach, referred to as the "geostatistical WCPFC-only data" approach, excludes catch and effort data from the Eastern Pacific Ocean (EPO) to mitigate its potential impact on CPUE standardisation in the WCPFC region. Thirdly, the "geostatistical individual region" approach assumes the independence of catch and effort data in each assessment region and incorporates different regional weights (McKechnie et al., 2014), which are empirical estimates of the vulnerability of the population in each region to fishing gear. Without regional weights, models often have too much flexibility in where they assign recruits and move individuals among regions, leading to unrealistic exchange rates and population sizes among regions. Lastly, we have explored the "geostatistical single flag" approach, which utilises catch and effort data exclusively from the Japanese fleet for standardisation. These approaches offer distinct perspectives in addressing CPUE standardisation and contribute to a comprehensive analysis of the data.

Comparative 2021 south Pacific ablacore stock assessments were conducted. These assessments were run across a range of 72 assessment model grids, each utilising one of the new CPUE indices that were generated from the approaches described above. The settings in each phase of each model remained consistent with those used in the 2021 stock assessment. Each model was refitted starting from phase 1 and run until convergence was achieved. The resulting estimates of stock status, including depletion ($SB_{instant}/SB_{F=0}$) and adult biomass, were then compared with those obtained from the corresponding 2021 stock assessment model.

2.1 Geostatistical hooks between floats (HBF) approach

The number of hooks between floats (HBF) on the longline mainline is considered an important gear characteristic, as it largely determines the fishing depth of the gear. As such, it is frequently used as a covariate in longline CPUE standardisation. In the 2021 assessment, HBF was proposed as an additional catchability covariate to be included with targeting cluster and vessel flag. However, models that included HBF did not converge, ultimately resulting in its exclusion from the assessment. In our analysis, we replaced targeting cluster with HBF since both can represent the targeting behaviour of the fishing fleet. All other model configurations remained consistent with those used in the recent assessment.

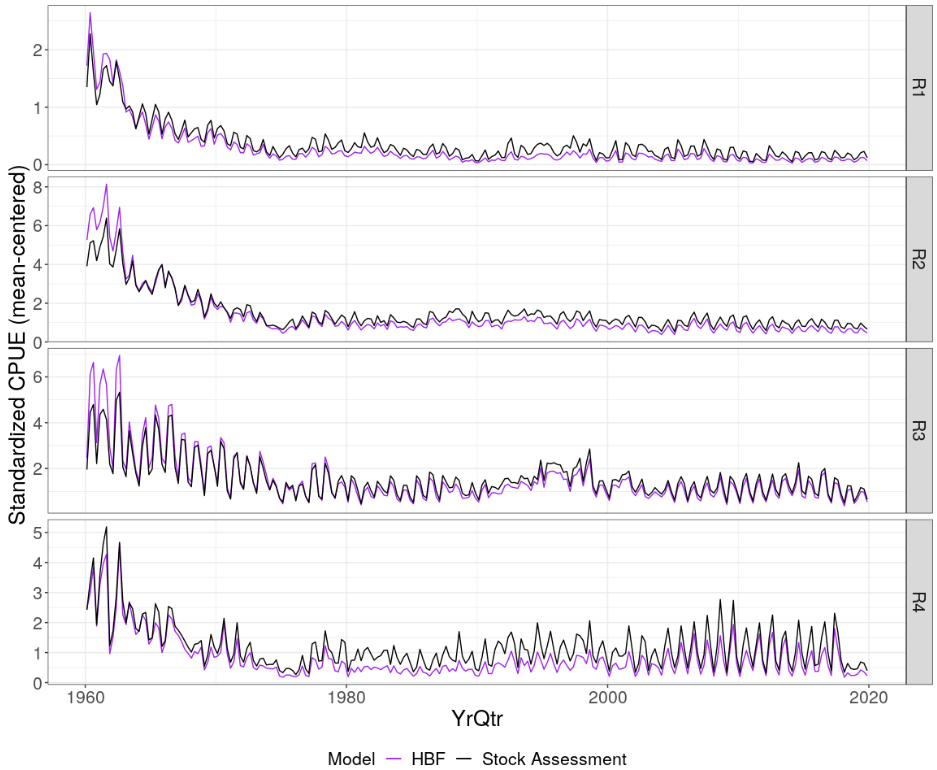

Figure 1: Standardised CPUE indices by region using geostatistical hooks between floats (HBF) approach (violet line) plotted alongside the standardise CPUE from the recent south Pacific albacore assessment (black line), from 1960-2019.

The CPUE indices obtained from the spatiotemporal model with HBF and vessel flag as covariates exhibit trends that are almost indistinguishable from those of the recent assessment (Figure.1). As a result, these CPUE indices do not introduce additional uncertainty into the south Pacific albacore OM grid, and therefore, this approach is not considered further.

2.2 Geostatistical WCPFC-only data approach

In the 2021 assessment, catch and effort data in the EPO is predominantly from a single flag (Japanese), while the WCPO data included contributions from fleets representing multiple countries. Consequently, there may be variations in behavior of vessels under different flags between the EPO and WCPO regions. To mitigate the potential influence of the EPO data, this analysis exclusively utilized catch and effort data from the WCPFC region while maintaining consistency with other model configurations employed in the recent assessment.

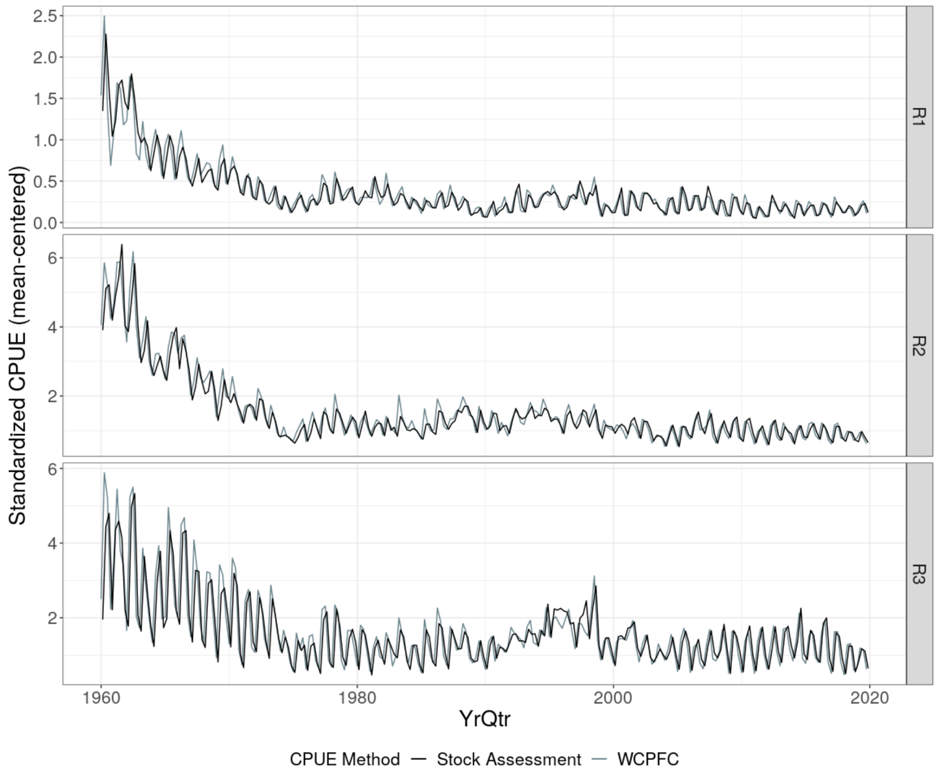

Figure 2: Standardised CPUE indices by region using geostatistical WCPFC-only data approach (gray line) plotted alongside the standardise CPUE from the recent south Pacific albacore assessment (black line), from 1960-2019.

The results show that the CPUE indices obtained from the geostatistical model utilising WCPFC-only data show remarkably similar trends to those obtained from the recent assessment for the corresponding regions (Figure.2). This indicates that adopting this CPUE approach would not introduce increase uncertainty into the OM grid for south Pacific albacore.

2.3 Geostatistical individual region approach

Another alternative hypothesis for the standardisation of the CPUE indices is to assume that catch and effort data in each model region are independent from each other. Under this assumption, a spatiotemporal model with the same configurations as the assessment was conducted separately for each assessment region.

While geostatistical models that include the entire region enable the estimation of regional weights directly as part of the modelling procedure, this is not the case for individual single region models. Therefore, an additional step is required before they can be used in the assessment. Three alternative regional weights were developed, using the method described in Tremblay-Boyer et al. (2018a). These regional weights were 1. 2021VAST, which is derived from the regional VAST model used in the recent assessment (Vidal et al., 2021), 2. Catch, the average catch proportion of south Pacific albacore for each region, calculated as the average from 1970 to 2019, and 3. SEAPODYM, average south Pacific albacore density estimates from the SEAPODYM model. (Senina et al., 2020).

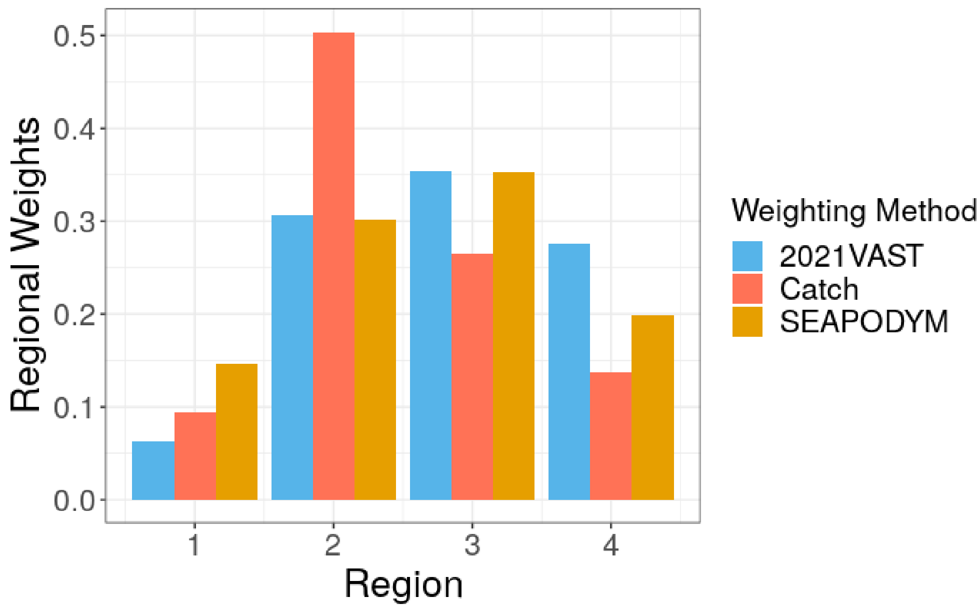

Figure 3: Comparison of the three regional weights (2021VAST, Catch and the SEAPODYM) estimated for the geostatistical individual region approach. All regional weights sum up to one under this method.

The three methods used to derive the regional weights result in different weight patterns across the four regions (Figure.3). Regions 2 and 3 have similar weight predictions from the 2021VAST and SEAPODYM methods, while the weights for regions 1 and 4 differ. On the other hand, the Catch method predicts significantly higher weights in region 2 than the other two methods.

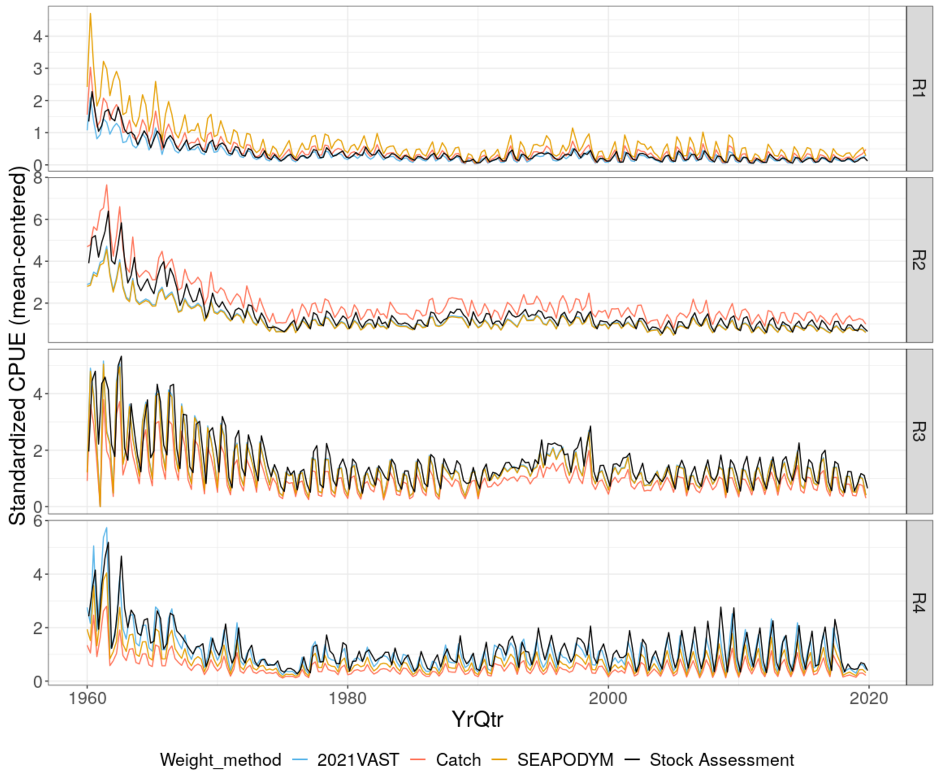

Figure 4: Standardised CPUE indices by region using the geostatistical individual region approach with three different regional weights (color lines) plotted alongside the standardise CPUE from the recent south Pacific albacore assessment (black line), from 1960-2019.

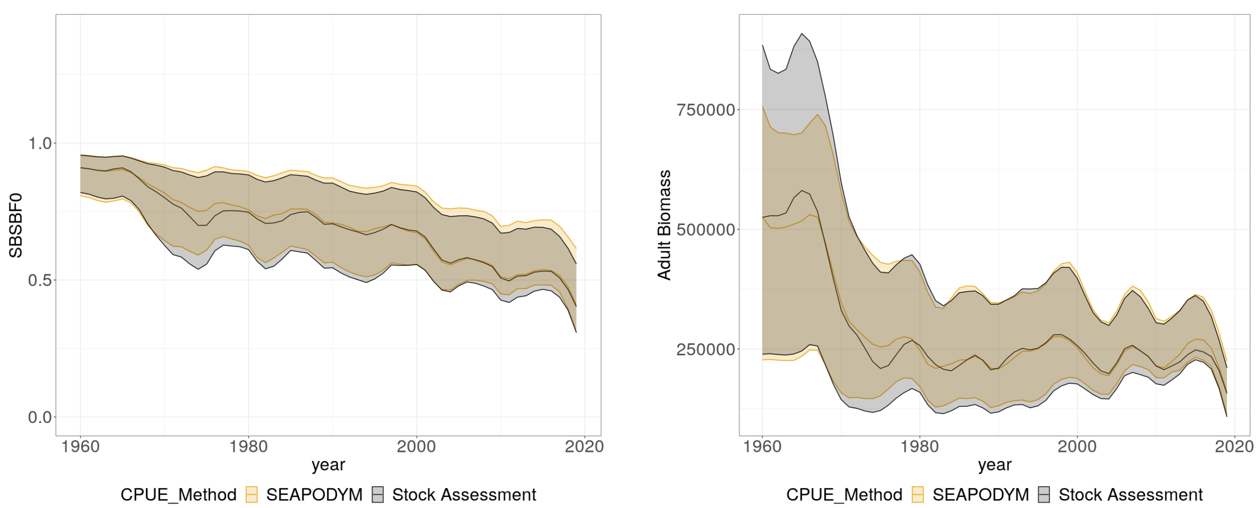

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Figure 5: Stock status estimated using the CPUE indices from the individual single region approach with SEAPODYM regional weights (yellow area), alongside the stock status from the recent south Pacific albacore assessment (gray area). Shaded area shows the 90th percentile range for each summary diagnostic. The solid line shows the median value across the replicates. A.Depletion. B.Adult biomass.

After incorporating the regional weights into the individual region models, we observe notable differences among the CPUE indices in regions 1 and 2 (Figure.4). However, the stock status estimated using these CPUE indices overlap with those of the current assessment (Figure.5; Appendix: Figure.9-10). Thus, we conclude that incorporating geostatistical individual single region approach does not introduce additional uncertainties in the assessment and hence, it is not necessary to consider them further.

2.4 Geostatistical single flag approach

In the recent assessment, there is a concern around potential confounding of the abundance signal with the flag effect because there are strata in which the Japanese fleet is the only fleet fishing (Vidal et al., 2021). To address this issue, we investigated using catch and effort data from a single flag for the standardisation. In the 2021 assessment, only data from the Japanese fleet were retained for the CPUE standardisation in the EPO. Hence, we used Japan-only data for this single flag analysis. The remaining model configurations were consistent with the recent assessment.

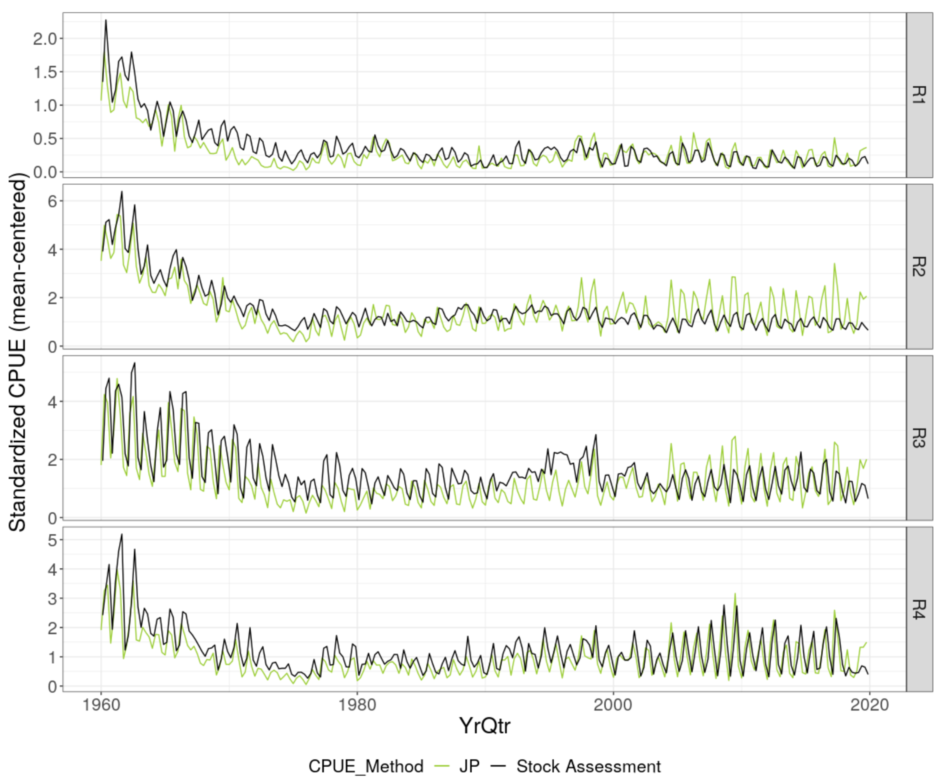

Figure 6: Standardised CPUE indices by region using geostatistical single flag approach (green line) plotted alongside the standardise CPUE from the recent south Pacific albacore assessment (black line), from 1960-2019.

The CPUE indices obtained from Japan-only data show a similar trend in the early period to the recent assessment. However, in the recent period, the Japan-only CPUE indices tend to predict higher values for certain seasons, particular in region 2 (Figure.6).

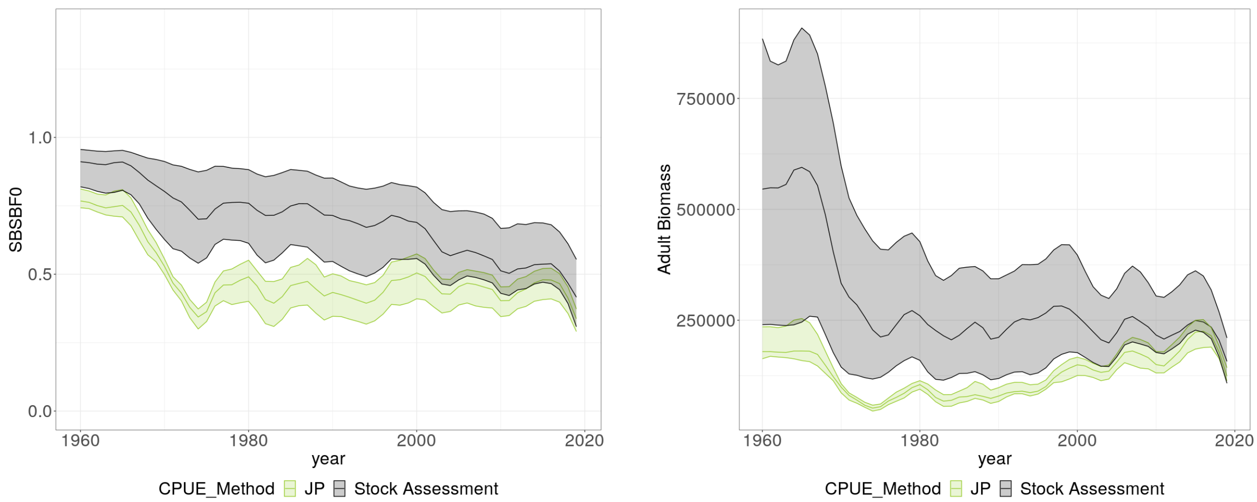

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Figure 7: Stock status estimated using the CPUE indices from the individual single flag approach (green area), alongside the stock status from the recent south Pacific albacore assessment (gray area). Shaded area shows the 90th percentile range for each summary diagnostic. The solid line shows the median value across the replicates. A.Depletion. B.Adult biomass.

The stock status produced by the Japan-only CPUE indices is lower than that of the recent assessment (Figure.7). The inclusion of Japan-only CPUE indices may expand the uncertainty of the current OM grid. However, when examining the diagnostics of the assessment model, we observed various indications of unreasonable performance (Figure.8). The plot of model fits (yellow line) to observed standardized CPUE (gray dots) suggests that the assessment model fit the CPUE data poorly, particularly in the recent period (Figure.8). Therefore, caution is advised when interpreting the results from this approach. Based on this issue with the diagnostics, it is not recommended to include this geostatistical single flag index as an additional uncertainty within the OM grid.

3 Discussion

Four alternative approaches are explored in this paper. The geostatistical hooks between floats (HBF) and the geostatistical WCPFC-only data approach both produce similar index trends to the recent assessment. The geostatistical individual region approach with three regional weights scenarios potential produce different CPUE indices, however, the stock status they predict is within the range of 2021 stock assessment. Thus, adding no further uncertainty to the current grid. Furthermore, the CPUE indices standardised from the geostatistical single flag approach should not be included in the south Pacific albacore OM grid due to poor model diagnostics.

In additional to the four approaches mentioned earlier, the "traditional" CPUE approach (GLM) was also explored, following the method described in Tremblay-Boyer et al. (2018a). However, the initial CPUE results produced from this approach indicated no contrast during the stock assessment

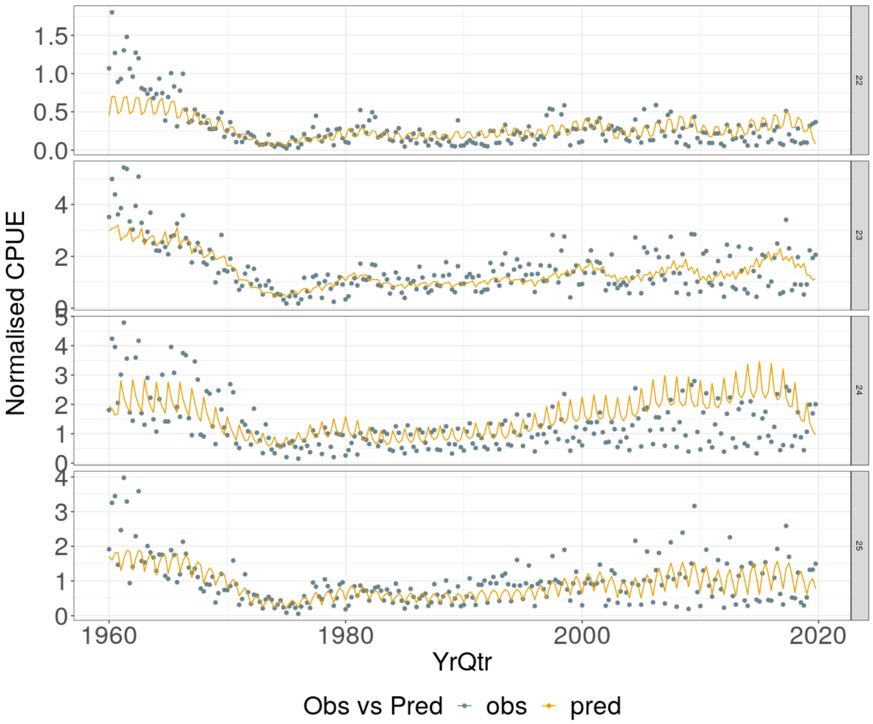

Figure 8: Model fits (yellow line) to observed standardised CPUE (blue dots) for the four index fisheries in the assessment using the CPUE indices from the geostatistical single flag approach.

period, making them inadequate for providing abundance information for the OM grid. Furthermore, the WCPO stock assessment has shifted away from the "traditional" CPUE approach to the geostatistical approach, starting with the 2018 south Pacific albacore assessment (Tremblay-Boyer et al., 2018b). Considering the present circumstances, we have decided not to pursue further investigation with the "traditional" CPUE approach for the OM grid at the current stage. Additional considerations regarding the CPUE approaches will be addressed in the upcoming south Pacific albacore stock assessment.

4 Conclusion

The alternative approaches for CPUE standardisation that have been explored result in either indistinguishable CPUE indices trends or, produce stock status that have the similar range as the recent assessment. Therefore, these results do not suggest that alternative CPUE standardisation approaches should be included in the OM grid of the south Pacific albacore.

We invite SC19 to:

- consider the evaluation of alternative CPUE indices to inform development of the OM grid for the south Pacific albacore MSE;
- support the recommendation that CPUE should not be included in the OM grid for the south

Pacific albacore MSE.

Acknowledgments

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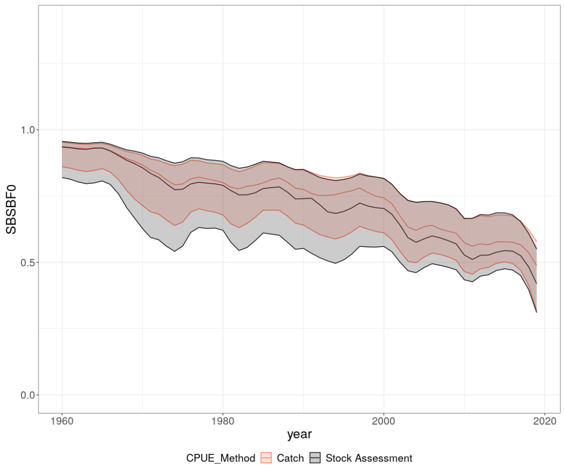
5 Appendix



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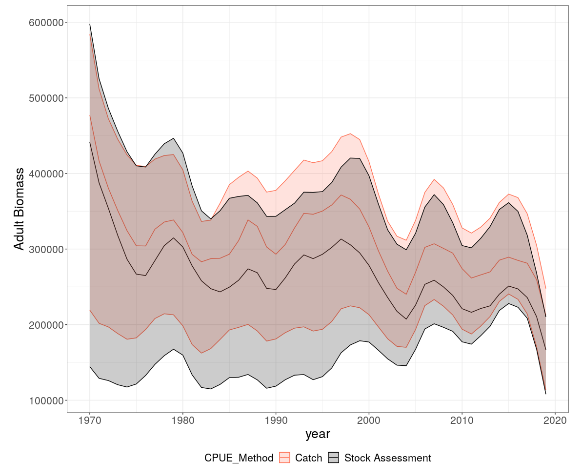

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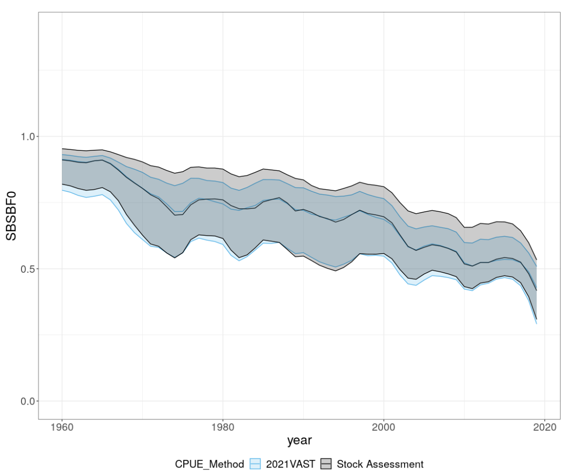
Figure 9: Stock status estimated using the CPUE indices from the individual single region approach with Catch regional weights (red area), alongside the stock status from the recent south Pacific albacore assessment (gray area). Shaded area shows the 90th percentile range for each summary diagnostic. The solid line shows the median value across the replicates. A.Depletion. B.Adult biomass.



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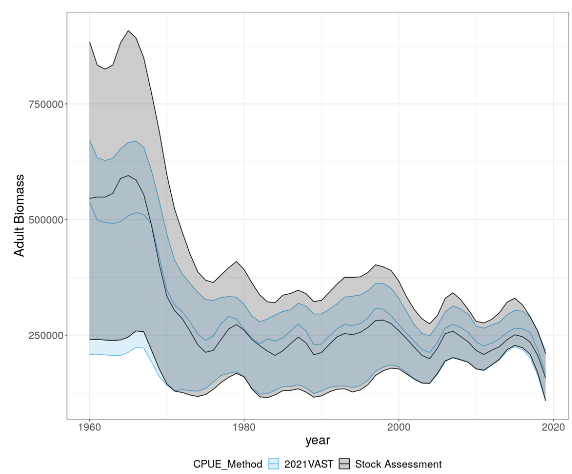

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Figure 10: Stock status estimated using the CPUE indices from the individual single region approach with 2021VAST regional weights (blue area), alongside the stock status from the recent south Pacific albacore assessment (gray area). Shaded area shows the 90th percentile range for each summary diagnostic. The solid line shows the median value across the replicates. A.Depletion. B.Adult biomass.