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Retrospective CPUE forecasting of South Pacific albacore

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N. Yao, R. Scott, F. Scott, and J. Singh

Oceanic Fisheries Programme, The Pacific Community

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Executive Summary

To support the development of the harvest strategy approach for South Pacific albacore, SC14 endorsed an initial focus on empirical based MPs that use CPUE as the primary indicator of stock status. The initial development of the framework along with the initial set of performance indicators were presented at SC15. Noting the comments of CCMs concerning the stability of the simulated CPUE, a retrospective forecasting was performed to test model predictions using existing historical data. The approach is based on a retrospective analysis with the additional step that each assessment is then projected through to the end of the original time series. The results of the retrospective forecasts show that no significant retrospective pattern was detected among the simulated CPUE. Therefore, we suggest that the current South Pacific albacore framework is stable enough to be used in the management strategy evaluations to test candidate management procedures.

1 Introduction

Initial work on the harvest strategies for South Pacific albacore has focused on developing empirical management procedures (MPs) that use CPUE as the primary indicator of stock status. In this framework, future fishing opportunities are set according to harvest control rules (HCRs) that are "driven" by CPUE. Therefore, the stability and robustness of the CPUE time series used in the framework is of particular concern. A highly variable and noisy CPUE index may reduce the effectiveness of the MP. However, a greater concern is that the CPUE index may be biased in some way resulting in a systematic over- or under-estimation of stock status by the MP. When testing candidate MPs we use a modeling framework based on the stock assessment to simulate future conditions within the fishery. Likely values of future catch and effort, subject to the MP under evaluation, are generated from projections of the modeling framework.

Whilst it is unreasonable to expect that stock assessments will be 100% accurate, it is not unreasonable to expect that they should provide consistent estimates from one year to the next, and specifically that model estimates do not show persistent trends of under- or over-estimation over time. When updated parameter estimates display a persistent trend in relation to previous estimates it suggests that something may be misspecified in the model. Systematic error of this kind is typically referred to as retrospective bias (Sinclair et al., 1991). For this reason a retrospective analysis is typically conducted for each new assessment whereby the final assessment model is refitted to a progressively truncated time series of data (ie. the terminal year of the assessment is iteratively moved backward).

The validity of projections made from assessments that are subject to retrospective bias is a significant concern since catch and effort limits that are designed to meet management targets can be systematically under- or over-estimated, ultimately leading to drastic management revisions eventually being required. Such revisions reduce the ability of managers to manage risk because they indicate a source of uncertainty that has not been fully accounted for. Retrospective forecasting (Brooks and Legault, 2015), also known as hindcasting and backtesting, is a method for testing the performance of a predictive model using existing historic data. The approach is based on a retrospective analysis with the additional step that each assessment is then projected through to the end of the original time series. A similar analysis has previously been presented to SC12 to investigate the performance of short term projections for WCPO bigeye tuna (Scott et al., 2016).

Noting the comments of CCMs at SC15 concerning the stability of the simulated CPUE for South Pacific albacore, retrospective forecasting was performed to test model predictions using existing historical data.

2 Retrospective Stock Assessment Models Set-up

The first step for the retrospective forecasting analysis was to re-fit the diagnostic case of the most recent South Pacific albacore stock assessment (Tremblay-Boyer et al., 2018) to input data that had been successively truncated by one year from 2016 to 2012.

In general, the settings in each phase of each model was consistent with the settings in the stock assessment diagnostic case. The only difference was the period to estimate the Beverton and Holt stock-recruitment relationship (SRR) over, which ranged from 1970 to the final year in each retrospective assessment.

All of the retrospective runs successfully converged. In addition, the adult biomass of each retrospective run displayed a similar trend to the adult biomass estimated from the stock assessment (Figure 6). No significant retrospective pattern was detected in the terminal estimates of the model fits.

3 Simulation Settings

The assessment models described above were used for forecasting. Each projection was run from the terminal year of each model through to 2016. The projections were based on catch for all fisheries using the actual catches that had been observed in each of the projection years. The fisheries projected are listed in Table 1 and are consistent with the fisheries definition for the 2018 South Pacific albacore stock assessment (Tremblay-Boyer et al., 2018). With the exception of the two driftnet fisheries (fisheries 15,16), which no longer operate, all other fisheries were projected. Catchability was assumed to remain constant for the projection at the level estimated for the terminal year of each retrospective assessment. In addition, The coefficient of variation (CV) for both the simulated catch and effort were set to 0 (i.e. no observation error was added to the forecasting process). In each case, 200 projections were performed with variability in future recruitment implemented by randomly re-sampling from the historical recruitment estimates of the retrospective assessment from 1970 to the last year of the model. The simulated CPUE in each projection was calculated by fishery simply as $CPUE = Catch/Effort$. An average CPUE was also calculated across the five regions by weighting the CPUE with the adult biomass of each region. The adult biomass used here was estimated in each retrospective stock assessment run.

Fishery	Nationality	Gear	Region	Longline group
1.DWFN LL 1	Distant-water Fishing Nations	Longline	1	Tropical
1.PICT.AZ LL 1	Pacific Island Countries and Territories	Longline	1	Tropical
3.DWFN LL 2	Distant-water Fishing Nations	Longline	2	Sub-tropical
4.PICT LL 2	Pacific Island Countries and Territories	Longline	2	Sub-tropical
5.AZ LL 2	Australia/New Zealand	Longline	2	Sub-tropical
6.DWFN LL 3	Distant-water Fishing Nations	Longline	3	Temperate
7.PICT LL 3	Pacific Island Countries and Territories	Longline	3	Temperate
8.AZ LL 3	Australia/New Zealand	Longline	3	Temperate
9.DWFN LL 4	Distant-water Fishing Nations	Longline	4	Sub-tropical
10.PICT LL 4	Pacific Island Countries and Territories	Longline	4	Sub-tropical
11.DWFN LL 5	Distant-water Fishing Nations	Longline	5	Temperate
12.PICT LL 5	Pacific Island Countries and Territories	Longline	5	Temperate
13.All TR 3	All nationalities	Troll	3	-
14.All TR 5	All nationalities	Troll	5	-
15.All DR 3	All nationalities	Driftnet	3	-
16.All DR 5	All nationalities	Driftnet	5	-
17.Index LL 1	Index fishery	Longline	1	-
18.Index LL 2	Index fishery	Longline	2	-
19.Index LL 3	Index fishery	Longline	3	-
20.Index LL 4	Index fishery	Longline	4	-
21.Index LL 5	Index fishery	Longline	5	-

Table 1: Definition of fisheries for the MULTIFAN-CL South Pacific albacore tuna retrospective forecasting

In summary, the assumptions used in the simulations were:

- All the fisheries (except two driftnet fisheries) were projected from the terminal year of each assessment through to 2016 based on the observed catch for the projection period.
- Catchability was assumed to remain constant for the projection at the level of the terminal year of each retrospective assessment.
- The recruitment for the projection was determined by randomly re-sampling from the historical recruitment estimates during the assigned period (i.e. 1970 to the terminal year of the retrospective assessment).
- No observation error was added to the catch and effort simulations.

4 Results

The projected CPUE from each simulation showed very similar trends for both DWFN longline fisheries (Figure 1) and PICT longline fisheries (Figure 2) over time. No significant retrospective pattern was detected among them except for fishery 9 and 10 (the DWFN and PICT longline fisheries in region 4). We also noted that CPUE of fishery 4 (the CPUE time series used to "drive" the HCR in the current framework) has a tendency to be over-estimated. The use of this fishery is further discussed in SC16-MI-IP05.

The DWFN and PICT longline CPUE were also further aggregated across the five regions by weighting the CPUE with the adult biomass of each region. No significant retrospective pattern was detected among the aggregate DWFN (Figure 3) and PICT (Figure 4) longline CPUE.

In addition, the DWFN and PICT longline CPUE were further aggregated into one CPUE time series. Similar to the previous result, no retrospective pattern was detected (Figure 5).

5 Discussion

The period over which the retrospective analysis could be run was restricted to just 5 years because age-length data included in the 2018 South Pacific albacore stock assessment were collected in 2010. These data influenced the biomass estimates of the model in all years and their omission resulted in poor convergence and dramatically revised model estimates. Therefore, the retrospective runs were only conducted back to 2012 in order to include these age-length data and ensure reasonable model convergence.

The results of the retrospective forecasting analysis are difficult to interpret given the relatively short period over which it was possible to run the analysis. Retrospective estimates of biomass (Figure 6) are very consistent and show little evidence of persistent retrospective bias. However, at the individual fishery level, the projected CPUE is much more variable (Figures 1 and 2), although aggregated CPUE showed greater consistency (Figures 3 and 4). While variable, the projected CPUE showed little evidence of persistent retrospective bias that would preclude it from use within the harvest strategy evaluations.

6 Conclusions

The results of the retrospective forecasting showed that no significant retrospective pattern was detected among the simulated CPUE. Therefore, we suggest that the current South Pacific albacore framework is stable enough to be used in the management strategy evaluations to test candidate management procedures

Acknowledgments

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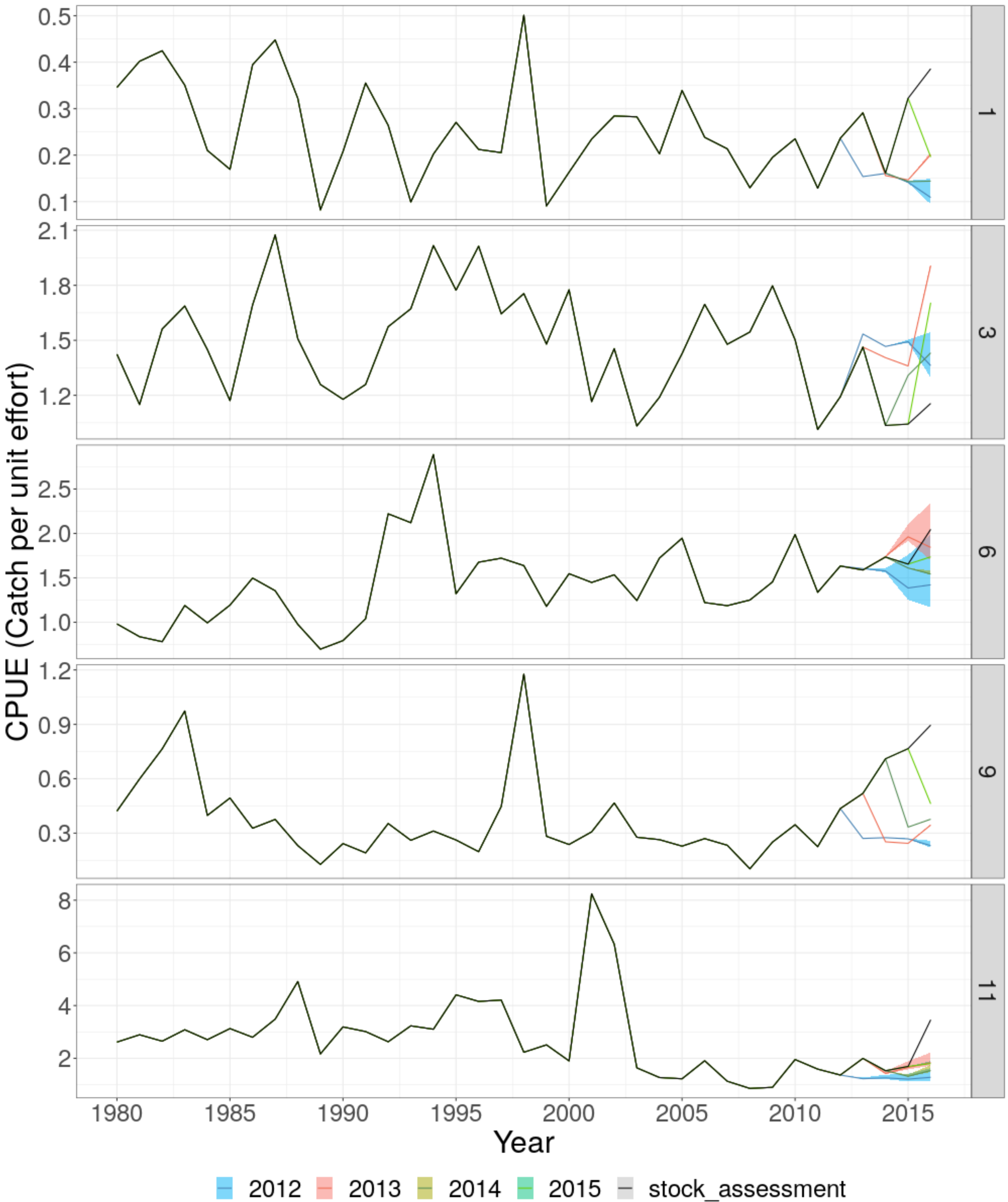

Figure 1: CPUE determined from retrospective forecasting for the individual DWFN longline fleets for 2012 to 2015. The shaded area shows the approximate 95th percentile range for each retrospective forecasting run. The DWFN CPUE from the stock assessment is the black line.

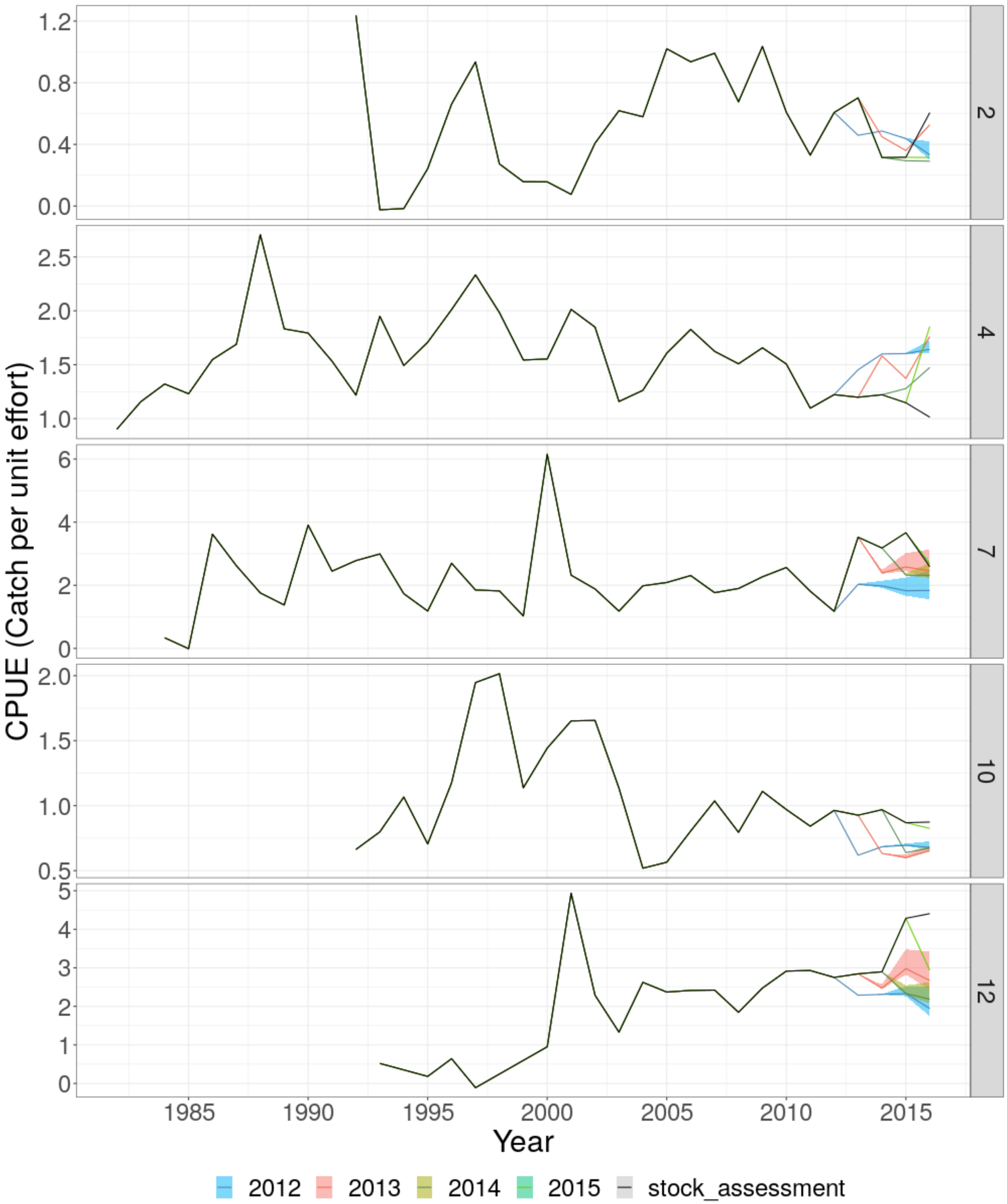

Figure 2: CPUE determined from retrospective forecasting for the individual PICT longline fleets for 2012 to 2015. The shaded area shows the approximate 95th percentile range for each retrospective forecasting run. The PICT CPUE from the stock assessment is the black line.

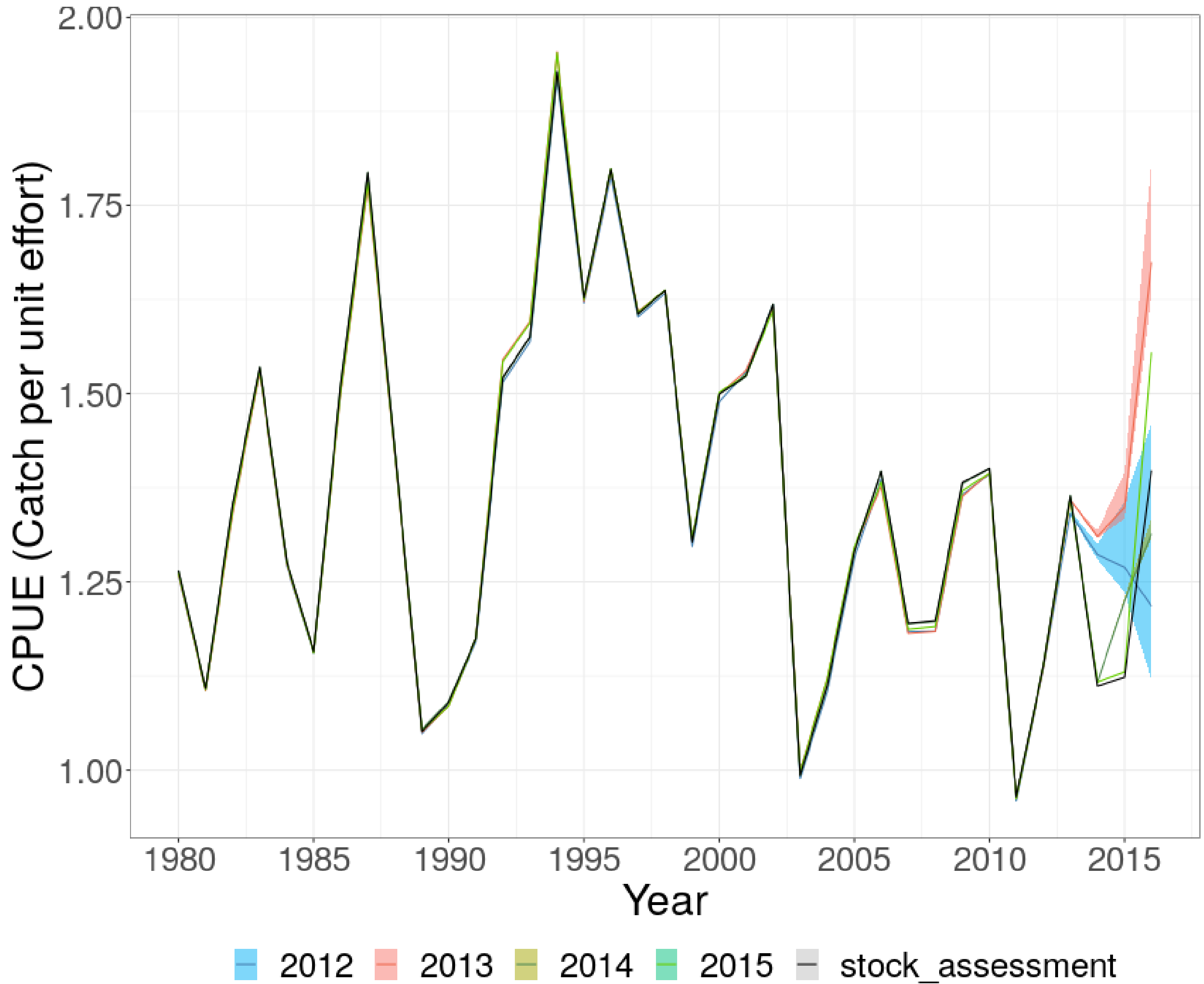

Figure 3: Aggregated CPUE determined from retrospective forecasting for the DWFN longline fleets for 2012 to 2015.The aggregated DWFN CPUE from the stock assessment is the black line. The shaded area shows the approximate 95th percentile range for each retrospective forecasting run. The CPUE of each fishery was weighted by the biomass of its region that was estimated from the retrospective stock assessment run.

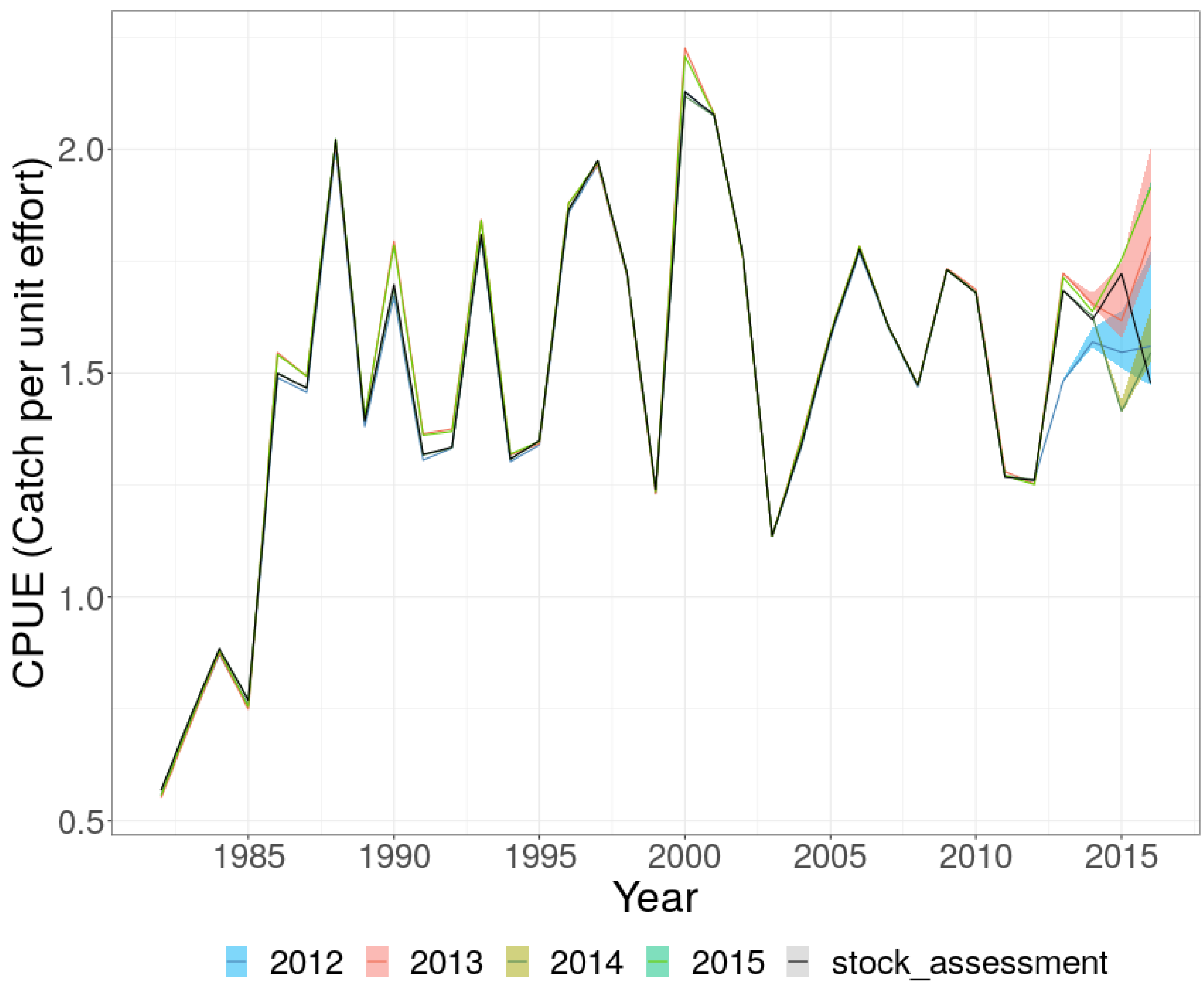

Figure 4: Aggregated CPUE determined from retrospective forecasting for the PICT longline fleets for 2012 to 2015. The aggregated PICT CPUE from the stock assessment is the black line. The shaded area shows the approximate 95th percentile range for each retrospective forecasting run. The shaded area shows the approximate 95th percentile range for each retrospective forecasting run. The CPUE of each fishery was weighted by the biomass of its region that was estimated from the retrospective stock assessment run.

Figure 5: Aggregated CPUE determined from retrospective forecasting for all longline fleets for 2012 to 2015 of all fisheries. The aggregated CPUE from the stock assessment is the black line. The shaded area shows the approximate 95th percentile range for each retrospective forecasting run. The CPUE of each fishery was weighted by the biomass of its region.

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Tremblay-Boyer, L., J., H., McKechnie, S., and Pilling, G. (2018). Stock assessment of south pacific albacore tun rev 2 (29 july 2018). WCPFC-SC14-2018/SA-WP-05, Busan, Republic of Korea, August 2018.

7 Appendix

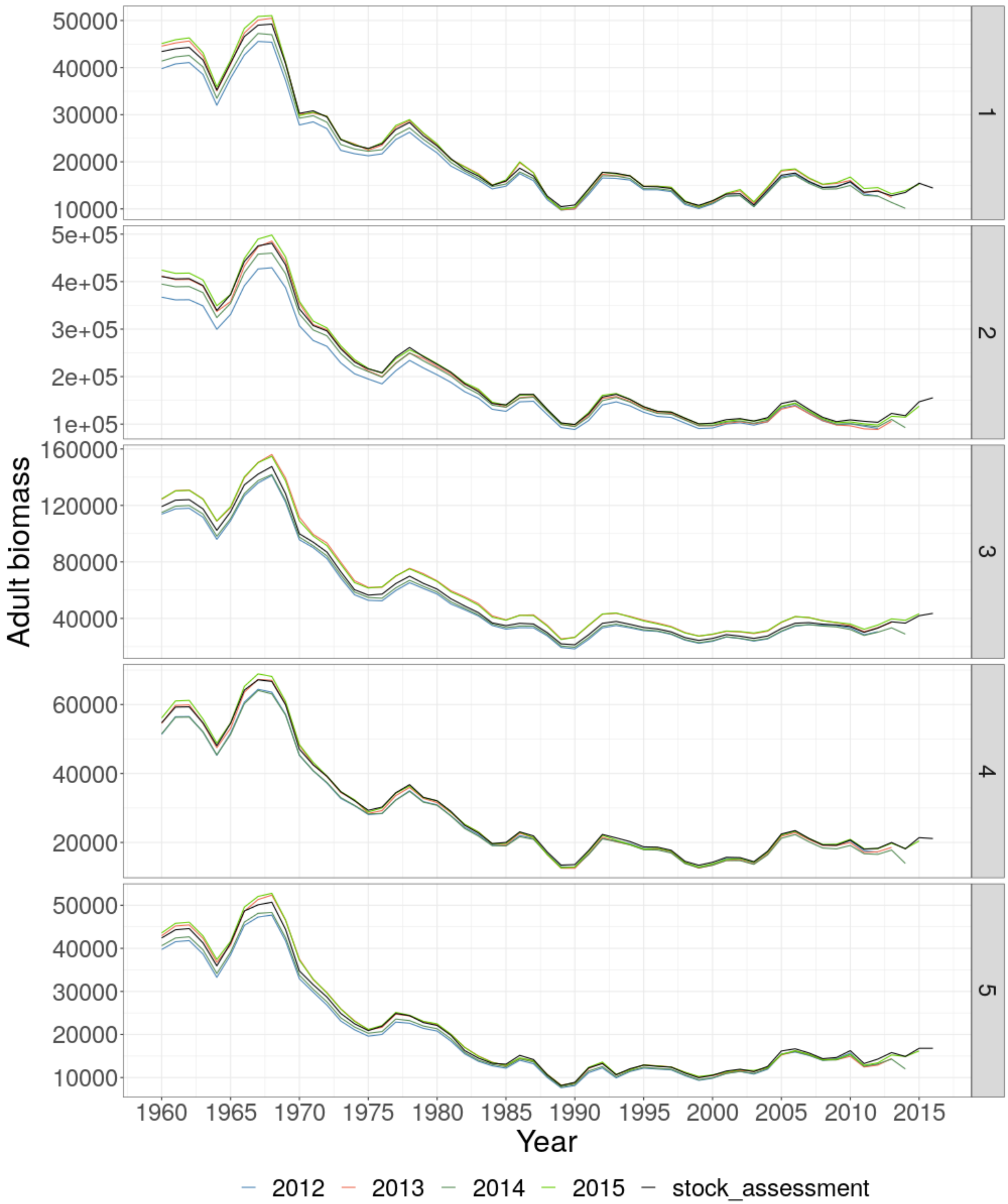

Figure 6: Adult biomass determined from the retrospective stock assessment run for 2012 to 2015 by model region. The adult biomass of the stock assessment diagnostic case is in black.