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Joint standardized abundance index of US and Canada albacore troll fisheries in the North Pacific[1]

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ABSTRACT

The US and Canadian troll fisheries operate in similar ways, and have overlapping fishing areas and similar size compositions. Previous stock assessments have only used data from the US fishery to derive a standardized abundance index but the ALBWG suggested developing a joint US/Canada index for the upcoming assessment. We developed and compared the joint US/Canada index with US-only and Canada-only indices. The main sources of data used in this paper were catch-effort information from logbooks of the US (1966-2008) and Canadian troll fisheries (1995-2008). For both US and Canadian logbook data, we aggregated catch and effort data into 1° x 1° spatial blocks by month. A lognormal generalized linear model was used to standardize CPUE and 1000 bootstrap runs were used to estimate confidence intervals. The joint US-Canada standardized abundance index was comparable to the US-only and Canada-only indices for their respective periods. Based on the results of this study, we recommend that the ALBWG use the merged US-Canada abundance index in the upcoming stock assessment model.

INTRODUCTION

The US and Canadian troll fisheries are important fisheries targeting albacore tuna in the North Pacific (Anonymous, 2010). Both fisheries use jigs to target juvenile albacore in surface waters and range throughout the North Pacific. However, their primary fishing grounds in recent years have been the Northeast Pacific, especially off the coasts of Oregon, Washington, and British Columbia (Holmes and Zhang, 2010; Teo, et al., 2010a). Under the bilateral Canada/US Pacific Albacore Tuna Treaty, a portion of the Canadian fleet is allowed to operate in US EEZ waters, and likewise a portion of the US fleet may fish in Canadian EEZ waters (Holmes and Zhang, 2010). In addition, size compositions from the catch of both fleets are also highly similar, which suggests that both fleets are catching the same subset of the North Pacific albacore stock and have similar selectivities (Holmes and Zhang, 2010; Teo, et al., 2010a).

In previous stock assessments, a standardized abundance index was derived from US troll fishery data only and used in the stock assessment models (McDaniel, et al., 2006). Due to the similarity of operations, spatiotemporal overlap, and size compositions of both troll fleets, the Albacore Working Group (ALBWG) of the ISC suggested developing a standardized abundance index based on data from both US and Canadian troll fisheries for the upcoming stock assessment using Stock Synthesis 3 (SS3) (Anonymous, 2010).

Our primary objectives in this paper are to develop and compare standardized CPUE indices from 1) US-only, 2) Canada-only, and 3) merged US-Canada troll fisheries data. These comparisons should assist the ALBWG in choosing the most appropriate source of data for this abundance index in the SS3 model. In addition, this document will describe the processes and data sources used to develop the standardized troll fishery abundance index used in the assessment.

MATERIALS AND METHODS

Data Sources

The main sources of data used in this paper were catch-effort information from logbooks of the Canadian (1995-2008) and US (1966-2008) troll fisheries (see Holmes and Zhang, 2010; Teo, et al., 2010b for country-specific details). The respective databases for US and Canadian troll fisheries are maintained by the Southwest Fisheries Science Center and the Pacific Biological Station, respectively. For both US and Canadian logbook data, we aggregated catch and effort data into 1° x 1° spatial blocks by month. Only logbook data where the location was recorded at

≤1 ° resolution and the vessel was actively fishing were used in this study. Effort was calculated as the number of boat days in each time-area block and catch was the total number of fish caught in that block (sum of retained and discarded albacore). Three datasets were developed: 1) US-only, 2) Canada-only, and 3) merged US-Canada. Since the Canadian logbook data is from a shorter period, the US-only and merged datasets were identical from 1966-1994. For all three datasets, strata (1° x 1° spatial block by month) with less than three boat days of effort (57-60% of strata) were removed from the analysis, which reduced the influence of peripheral fishing areas with minimal effort.

Standardization of CPUE

A generalized linear model (GLM) approach was used to standardize abundance indices based on the datasets defined above. In order to maintain continuity and comparability, we developed our GLMs to be consistent with those developed for previous stock assessments (cf. McDaniel, et al., 2006).

We first calculated the nominal CPUE (fish per boat day) of each stratum and log-transformed the CPUE by ln(CPUE+1) in order to accommodate strata with zero catch. Less than 1% of the strata used had zero catch. Previous studies have found the results of the GLM to be robust to the choice of constant (McDaniel, et al., 2006) and we found that to be true as well. The analysis was repeated using additive constants of 0.1, 1, and 8.1 (10% of mean CPUE), and we found the resultant indices to be highly and significantly correlated ($R > 0.99$, $p << 0.0001$). Each stratum was assigned to one of two areas (inshore: ≤130 °W; offshore: >130 °W), which was used as a factor in the GLM. The year and quarter (three months = one quarter, starting in January) of each stratum were also used as factors in the GLM. Due to the low number of albacore caught by this fishery between January and March, similar to previous studies, we did not include the first quarter in the model. No interaction terms were included in the model because during preliminary explorations of the models, the addition of interaction terms did not improve model fit substantially (Table 1). In addition, this is consistent with previous CPUE indices derived from the US troll fishery, which also did not include any interaction terms (McDaniel, et al., 2006). The log-transformed CPUE was related to three main factors – year (Y), quarter (Q), and area (A) by,

$$\ln(CPUE_{ijk} + 1) = X + Y_i + Q_j + A_k + \varepsilon_{ijk}$$

where $CPUE_{ijk}$ is the CPUE (fish per boat day) in year i, quarter j, and area k, and X is the intercept, and ε_{ijk} is the random error term. The standardized CPUE indices, I_t, were obtained by calculating the population marginal means (Searle, et al., 1980) of the above model for each given year and back-transforming the result using,

$$I_t = \exp(\hat{\alpha}_t + \hat{\sigma}_t^2/2)$$

where, $\hat{\alpha}_t$, is the estimated year factor and $\hat{\sigma}_t$, is the standard error of $\hat{\alpha}_t$, which reduces the log-transformation bias. Confidence intervals of the abundance indices were estimated from 1000 bootstrap runs.

RESULTS AND DISCUSSION

Trends in the joint US-Canada, US-only, and Canada-only standardized abundance indices were comparable for their respective periods (Fig. 1). For the 1995-2008 period, the joint US-Canada index was highly and significantly correlated with both the US-only (R = 0.98, p<<0.001) and Canada-only (R = 0.93, p<<0.001) indices. The model fits for all three indices were highly similar, with R^2 ranging from 0.149 to 0.185. The diagnostics of the GLM for the joint US-Canada abundance index is shown in Fig. 2, and is also representative of the other indices. In comparison with the nominal CPUE (Fig. 3), the standardization of the joint US-Canada index appeared to reduce the variability of the index, which might have been due to changes in the fishing area and season. Based on the results of this study, we recommend that the ALBWG use the merged US-Canada troll abundance index in the upcoming North Pacific albacore stock assessment.

However, it is important to note potential drawbacks of using a merged US-Canada abundance index in future assessments. For example, if the operations, fishing areas, and size distributions of the US and Canada troll fisheries diverge in the future, continued use of a merged US-Canada abundance index could lead to misleading assessment results. It is therefore important for the ALBWG to continue monitoring the operations, fishing areas, and size compositions of both fleets. It should also be noted that future improvements to the index would likely be developed using the data from one fishery before being extended to a merged dataset. It is therefore essential for fishery scientists from both countries to collaborate closely in the collection, preparation, and analysis of data in order to continue using and improving the abundance index.

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Table 1. ANOVA of merged US/Canada dataset.

	DF	SS	Mean SS	F	Pr(>F)
Year	42	825.2	19.647	31.112	< 2.2e-16
Season	2	118.0	59.010	93.445	< 2.2e-16
Area	1	230.9	230.916	365.667	< 2.2e-16
Residuals	9463	5975.8	0.631		

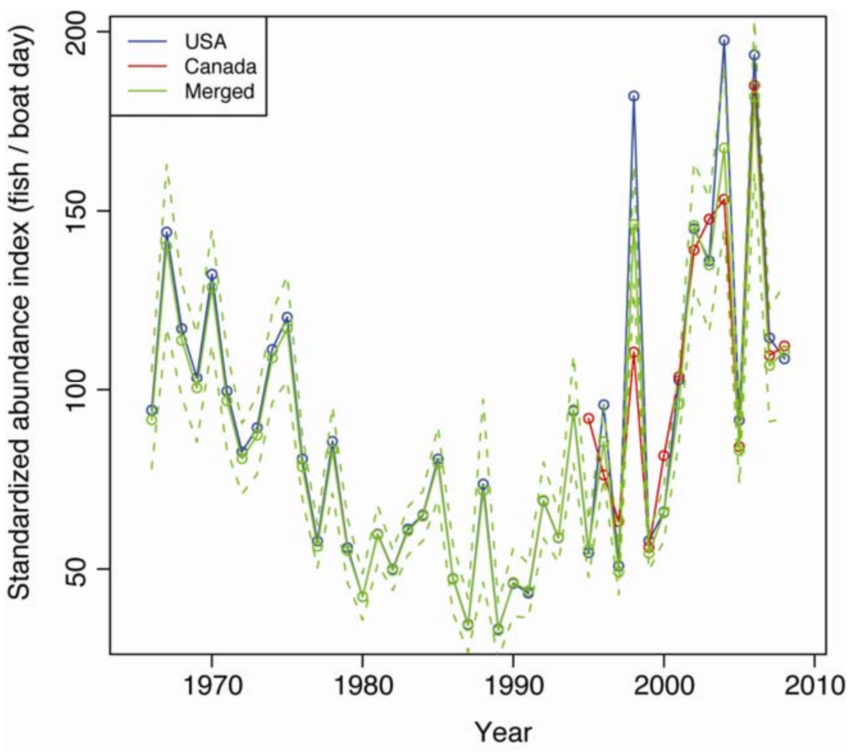

Figure 1. Standardized abundance indices of North Pacific albacore derived from 1) USA-only (blue), 2) Canada-only (red), and 3) merged US-Canada (green) data. Green dashed lines indicate 95% confidence intervals of the joint US-Canada abundance index from 1000 bootstrap samples.

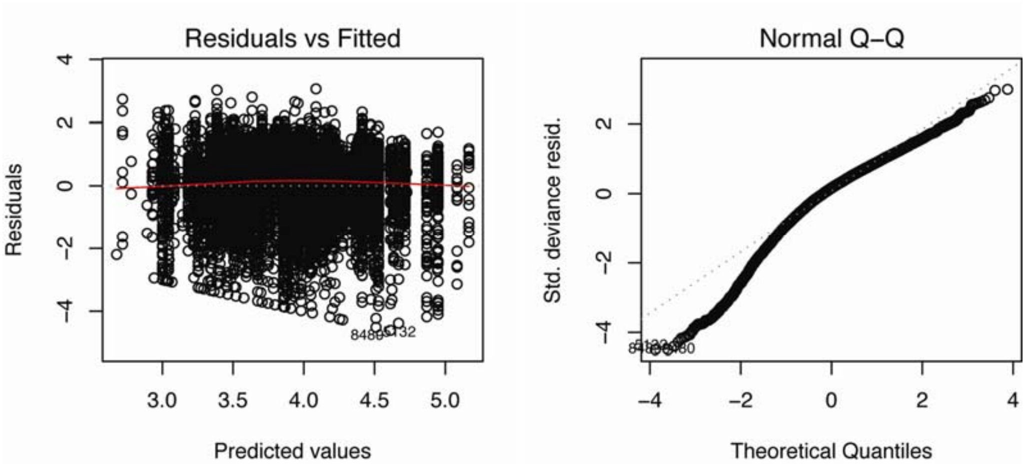

Figure 2. Residuals and Q-Q plots of the GLM using merged US-Canada dataset. Red line indicates the mean of the residuals.

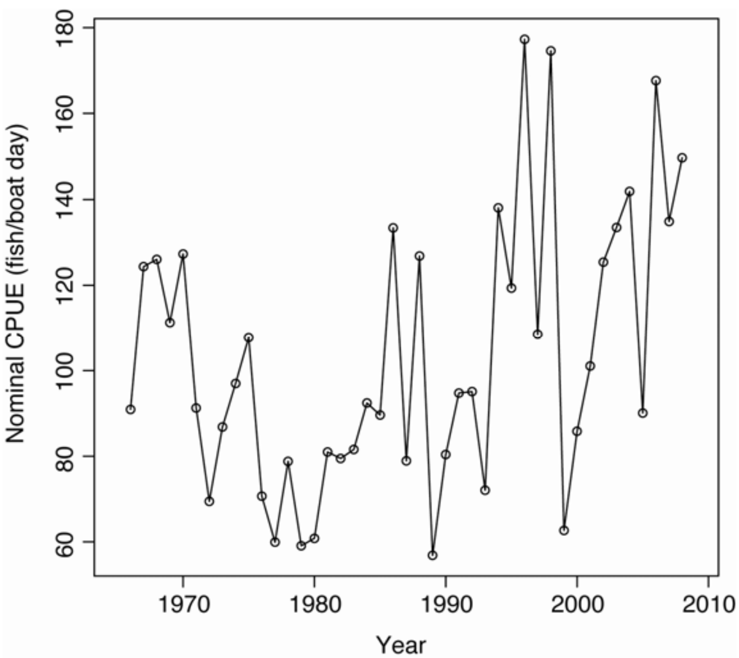

Figure 3. Nominal CPUE of merged US-Canada dataset.