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Updated Standardized CPUE for North Pacific Albacore by Japanese Longline by using INLA

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This document (rev1) is a revised version prepared in response to the request from the working group, with some additional results included.

The added content is as follows:

- Comparison of standardized CPUEs based on different area definitions (Fig. 4)

Summary

This document briefly reports on the standardized JPLL (Japanese longline) CPUE estimated using the INLA package as a backup index for the ISC North Pacific albacore stock assessment. Compared to the previous submission in 2023, only the data were updated; the data aggregation method and the standardization model itself were unchanged. Standardized CPUE was successfully estimated without convergence and model diagnostics issues.

Introduction

In the 2023 stock assessment, JPLL CPUE was used as an index of stock abundance (ALBWG, 2023). At the previous ALBWG meeting on March in 2025, standardized CPUE using sdmTMB package was newly considered as the JPLL CPUE (ALBWG, 2025). As a backup plan for the 2026 stock assessment, ALBWG has also proposed the updated standardized CPUE using INLA. This document reports on the standardized CPUE using INLA, with fishery data updated through 2024.

Data and methods

Logbook data

To calculate the standardized CPUE, logbook data from 1994–2024 were used. Details of the data are the same as those submitted for the previous stock assessment (Matsubayashi et al., 2023) and are therefore omitted here. Data extraction also followed the previous assessment submission: records were limited to operations targeting albacore by selecting 10 hpb (Hooks per baskets) data and Area 2 and Quarter 2 operations as referring previous study (Ochi et al., 2016; Ijima et al., 2017). Although the format of Japanese logbook data collection changed in 1994, only data from 1996 onward—judged to be stable and reliable—were used.

Generation of Mesh for spatial model

Following the previous CPUE submission method, geographic coordinates of each data point were transformed from latitude/longitude to meters so that inter-point distances were accurately reflected in the analysis (Matsubayashi et al., 2023). To model data with INLA, it is necessary to generate a mesh that represents artificial neighboring areas within the study region to compute spatial autocorrelation among data points. In this study, the "inla.mesh.2d" function of the INLA package was used, with the "max.edge" parameter (determining the maximum allowed triangle length within the mesh) set to 500 and the "cutoff" parameter (defining mesh resolution) set to 170 (**Figure. 1**).

CPUE standardization

The CPUE standardization model was the same as in the previous submission (Matsubayashi et al., 2023):

$$alb \sim intercept + year + f(fleet, model = iid) + f(hpb, model = iid) + f(vessel\ ID, model = iid) + f(w, model = AR1) + offset(hooks/1000)$$

Here, w represents spatial random effects estimated using the SPDE approach, and *AR1* denotes the autoregressive model. As in the previous submission of CPUE in 2023, the model estimates multiple autoregressive spatial random fields by year. Because spatiotemporal models require enormous computation time, a zero-inflated negative binomial distribution was assumed for the error distribution of the response variable. Since the present work involved only updating three years of data, predictive performance of the model was assumed to remain nearly unchanged; therefore, only the full model including all explanatory variables was fitted, and no model selection was conducted.

Model diagnostics included examination of spatial effects using Matérn correlation, posterior distributions of hyperparameters, randomized quantile residuals, and spatial residual patterns.

Results and Discussion

Generating mesh and Standardized CPUE

The generated mesh and the distribution of effort (hooks) are shown in Fig 1. The mesh was successfully generated to match the Area 2 region used in the stock assessment. The CPUE model converged successfully, and the standardized CPUE trend is shown in **Figure 2**. As in the previous model, a decline of CPUE in 2020 was observed, followed by relatively high values thereafter.

Model diagnostics

Trends of the Matérn correlation are shown in **Figure. 3**(a). The plot of correlation versus distance defined by the Matérn function suggested strong spatial correlation up to about 500 km, with correlation declining to 10% at around 1,600 km (Fig. 3(a). Therefore, the "max.edge" parameter used for triangulation was within a sufficiently correlated distance range.

The plot of randomized quantile residuals indicated consistency with a normal distribution (Fig. 3(b)). This suggests that the zero-inflated negative binomial

distribution defined for the model appropriately fit the data, adequately describing the response variable.
The latent spatial field results indicated higher residuals in areas with more fishing operations (more data) and lower residuals in areas with fewer operations (less data), reflecting spatial imbalance in data availability (Fig. 3(c)).
Posterior distributions of all parameters were unimodal, suggesting that fixed effects, spatial effects, and random effects were appropriately identified (Fig. 3(d)). This indicates that the estimation results of the model are numerically stable and robust for prediction.

In conclusion, the backup CPUE for 1996–2024 was successfully estimated. The CPUE provided in this document is expected to serve as a useful backup index for the North Pacific albacore stock assessment.

References

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Ochi, D., Ijima, H., Kinoshita, J. and Kiyofuji, H. (2016) New fisheries definition from Japanese longline North Pacific albacore size data. ISC/16/ALBWG-02/03.

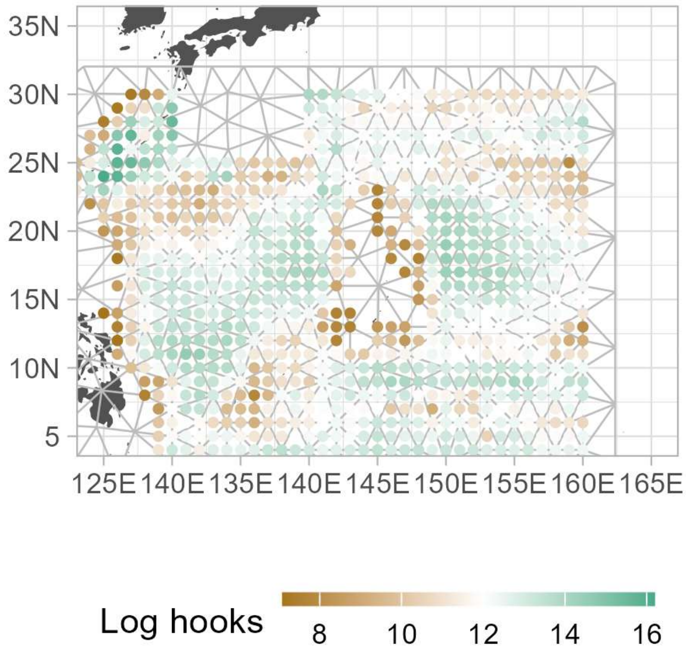


Figure 1 The mesh generated by using Japanese longline logbook data. The color of each point indicates the number of hooks.

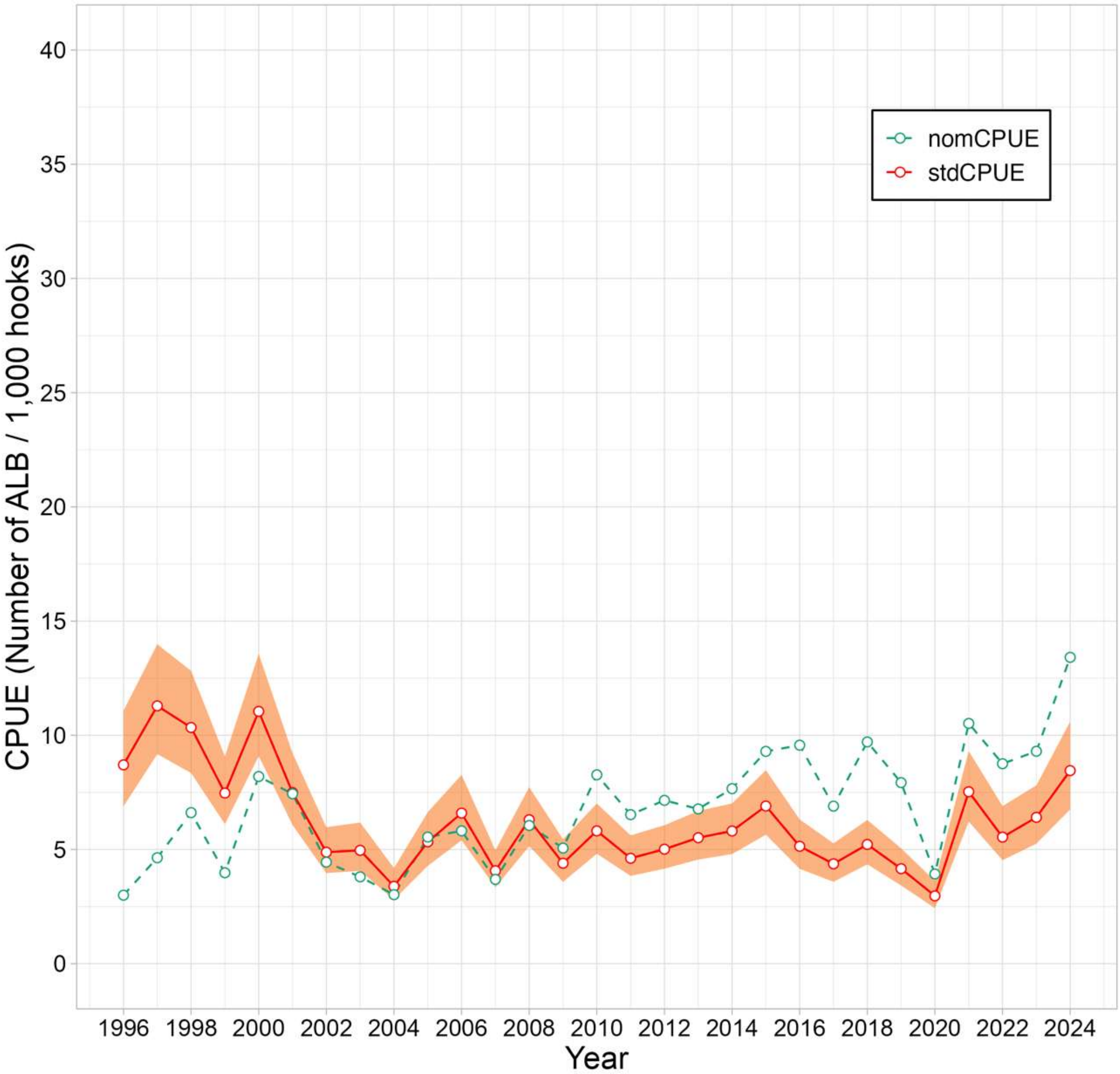
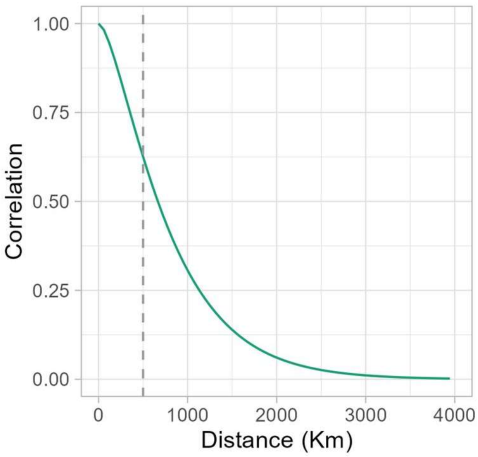
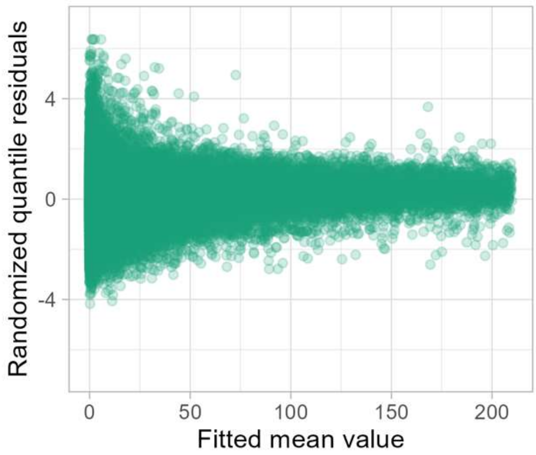


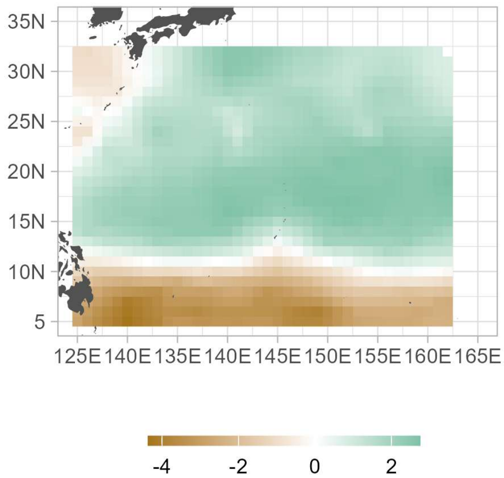
Figure 2 Annual trends in nominal and standardized CPUE estimated by using SPDE model in this study. The red ranges indicate the 5% and 95% quantile intervals of the estimated standardized CPUE.



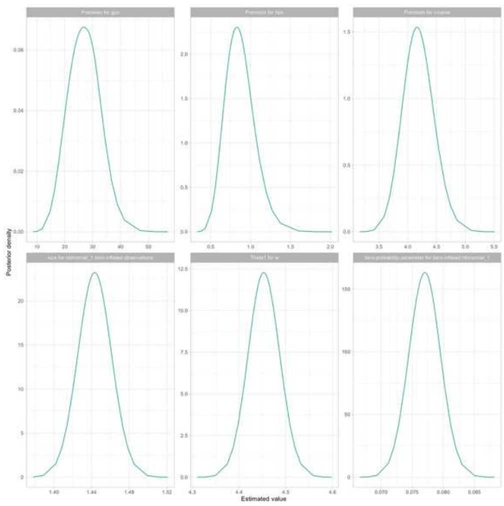
(a) Matérn Correlation



(b) Random quantile residuals



(c) Latent spatial field



(d) Posterior distribution for each parameter

Figure 3 Model diagnostics for standardized JPLL CPUE. (a) Matérn correlation indicated the strong spatial correlation up to about 500 km, with correlation declining to 10% at around 1,600 km. (b) Random quantile residuals indicated consistency with a normal distribution. (c) Latent spatial field for residuals indicated the reflecting spatial imbalance in data availability. (d) The posterior distribution of each parameter showed the unimodal distribution, suggesting that fixed effects, spatial effects, and random effects were appropriately identified.

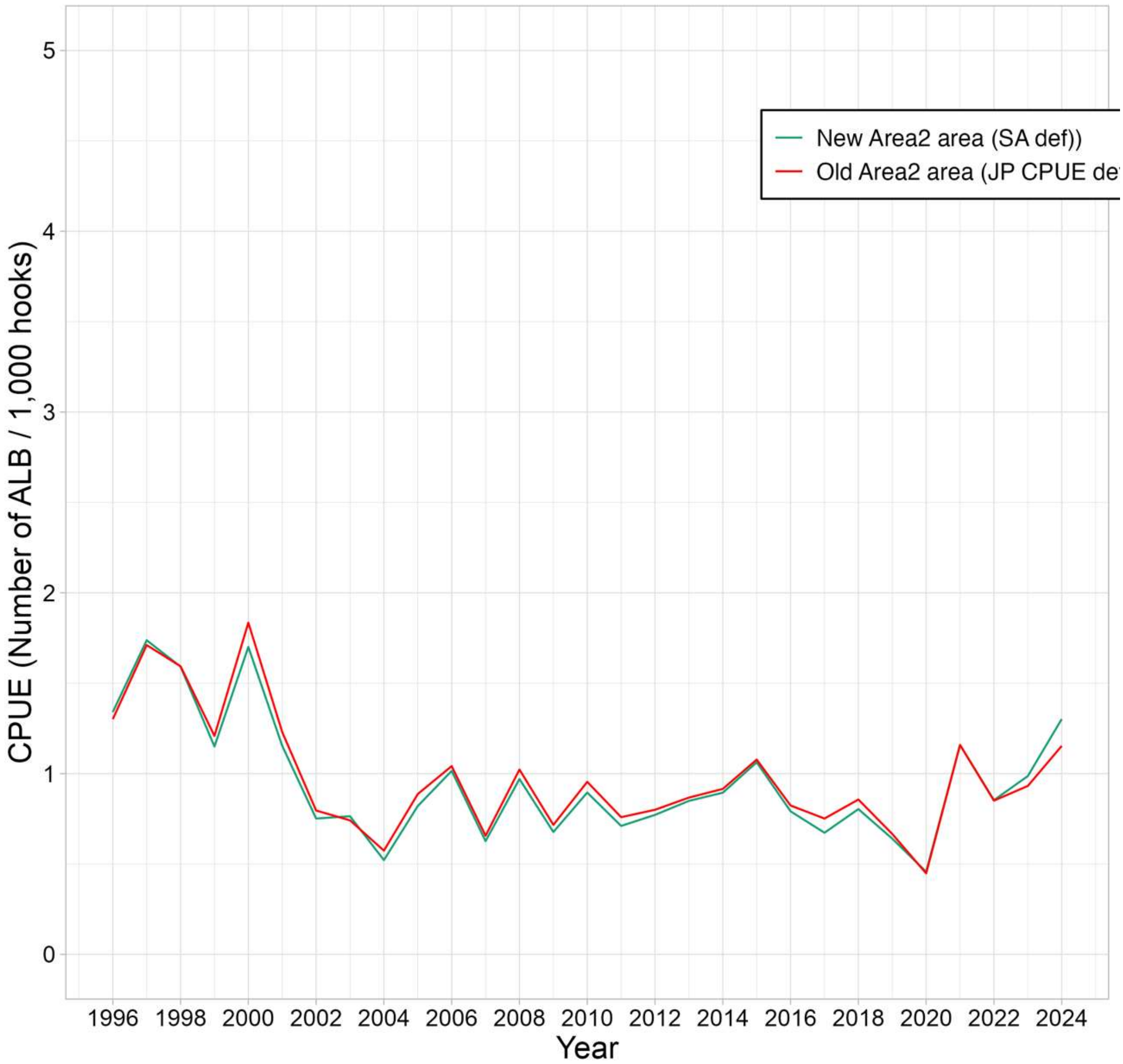


Figure 4. Comparison of two standardized CPUEs based on different area definitions. The New Area2 corresponds to Area 2 defined in the stock assessment model (ALBWG, 2023), while the Old Area2 represents CPUE estimated using the previous Area 2 defined from historical Japanese longline data.