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Juvenile index of North Pacific albacore tuna: Japanese longline CPUE standardization using a spatiotemporal model.[1]

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Abstract

At the North Pacific albacore tuna data preparatory meeting, the ALBWG requested that Japanese scientists provide CPUEs for juvenile albacore tuna. We standardized the Japanese longline CPUE in this study. First, we analyzed the first quarter's longline logbook data from Areas 1-3. Using a mixture model, we isolated this data that indicated juvenile albacore fish were being caught. We then built several models using R-INLA and selected the best model by WAIC model selection. The selected best model was a spatiotemporal model with a negative binomial distribution. The standardized CPUE was calculated by the least squares means, and the posterior distribution was obtained from resampling.

Introduction

The ISC Albacore tuna Working Group (ALBWG) conducted a data preparation meeting for the North Pacific albacore stock assessment. At this meeting, a new method of defining fisheries using a mixture model was proposed (Ijima and Tsuda 2022). This method uses the Year-Month-5x5 grid as the grouping factor, which allows for a more rigorous separation of data than the previous 5x5 grid-based cluster analysis results. The ALBWG agreed to adopt this new approach to Area 1-3. In the first quarter of Area 1-3, juvenile fish are caught due to migration, and highly precisely separated data can be used to obtain CPUE for juvenile fish. Therefore, the ALBWG requested that Japanese scientists conduct CPUE standardization with data from the first quarter of Areas 1-3. In this study, we will implement the standardization of CPUE in response to this request and report the results.

Material and methods

Longline logbook data

We used Japanese longline logbook data for this analysis. Of the logbook data, we analyzed areas 1-3 with a mixture model and classified them into adult and juvenile fish using the Year-Month-5x5 grid as a grouping factor (Ijima and Tsuda 2022). We chose only data considered to be catching juvenile fish and summed this data by year, month, 1x1 grid, and vessel name to input into the statistical model (Figure 1 B).

Statistical model

To standardize CPUE, we built a spatiotemporal statistical model using R software package R-INLA (Matsubayashi et al. 2022). To obtain the best model, we constructed the several models and performed model selection by WAIC (Watanabe and Opper 2010). The models we constructed are as follows.

- nb_spde_t_FULL

We assumed that the number of hooks is the offset term and that the number of albacore catches follows a negative binomial distribution. The spatial effects follow the Gaussian Markov Random Fields (GMRF) and vary year by year according to auto-regression (AR1). The year effect is assumed to be a fixed effect, and Hooks Per Basket (HPB) and vessel name are assumed to be random effects.

- nb_spde_t_hpb

This model excluded random effects of HPB from nb_spde_t_FULL.

- znb_spde_t_FULL

The number of hooks was assumed to be the offset term, and the number of albacore catches follows a zero-inflated negative binomial distribution. The year effect is a fixed effect, and H PB and vessel name are assumed to be random effects. The effect in space is year-varying according to AR1 with GMRF.

- znb_spde_t_hpb

Model from znb_spde_t_FULL, excluding random effects of HPB.

We computed the least squares means using the selected model to obtain the standardized CPUE. The HPB and vessel effects are random and should be zero in CPUE standardization. On the other hand, the spatiotemporal effects were computed using estimates for nodes within the range where the data exist (Figure 1 B). The posterior distribution of the standardized CPUE was obtained by resampling these least squares mean.

Result and discussion

Model selection by WAIC resulted that nb_spde_t_FULL being the best. The reason why the zero-inflated model was not selected could be due to the low zero catch rate in the analyzed area. The standardized CPUE showed lower and gentler variability than the nominal CPUE (Figure 1 A). The estimated spatial field tended to be higher off western Japan, consistent with fisheries established by the migration of juvenile albacore (Figure 1C). Correlations among estimated sites are about 0.3 at the maximum (500 km) of the edge (Figure 1 D), and Q-Q plots by Randomized Quantile Residual (RQR) were generally good with some bias (Figure 1 E). The posterior distributions of some estimated fixed effects parameters have means close to zero (Figure 2). On the other hand, the posterior distributions of the hyperparameters are not biased or have a wide distribution (Figure 3). The treatment of year effects as fixed effects is considered to be a future issue.

References

Ijima, H. and Tsuda, Y., 2022. Additional analysis for Japanese longline data using finite mixture model. ISC/22/ALBWG-02/03.

Matsubayashi, J. Ijima, H. Matsubara, N. Aoki, Y. and Tsuda, Y. 2022. CPUE standardization for North Pacific albacore caught by Japanese longline fishery from 1996 to 2021: the GLMM analysis using R-INLA. ISC/22/ALBWG-02/04.

Watanabe, S. and Opper, M., 2010. Asymptotic equivalence of Bayes cross validation and widely applicable information criterion in singular learning theory. Journal of machine learning research, 11(12).

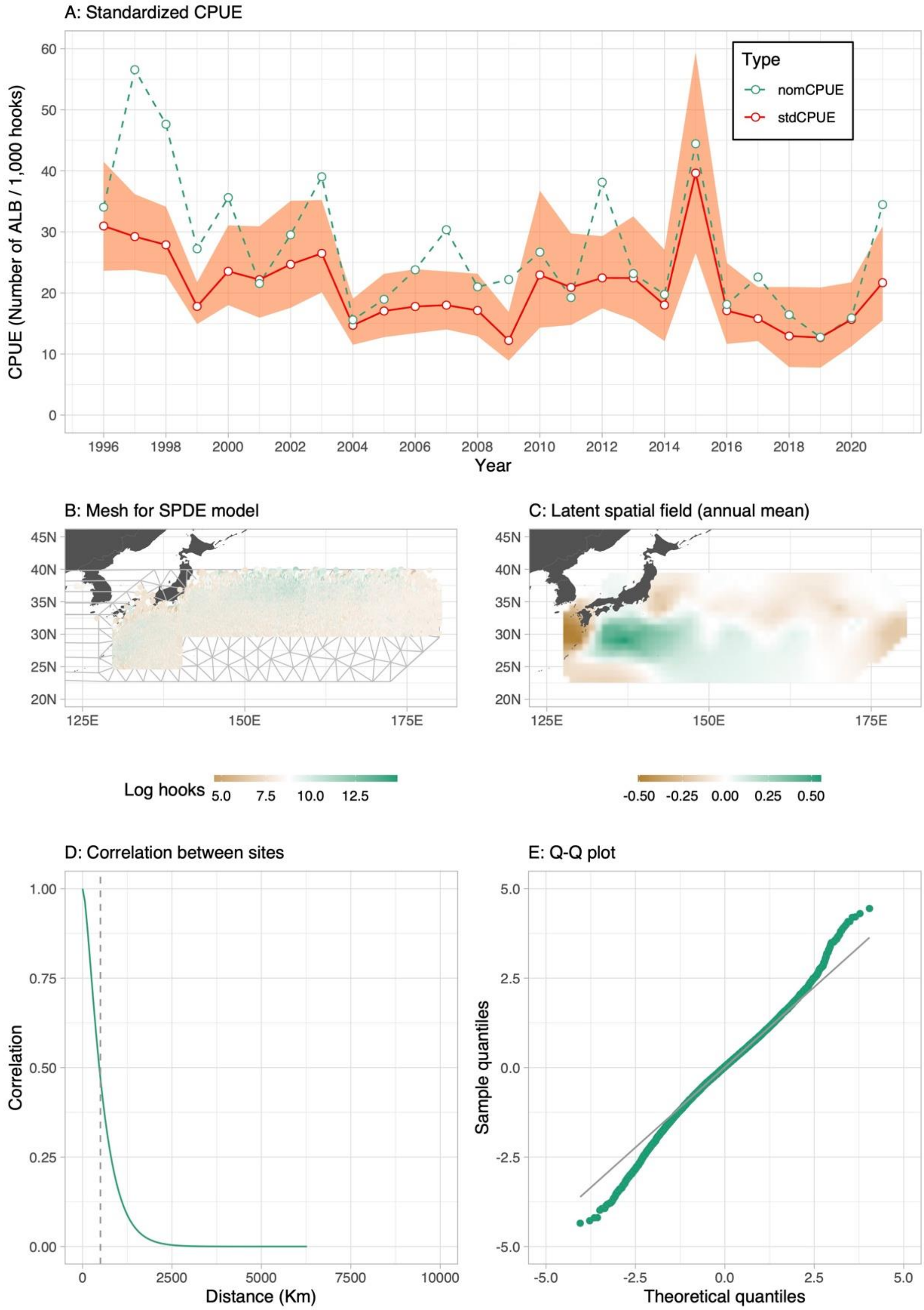

Figure 1. Japanese longline logbook analysis results using R software package INLA.

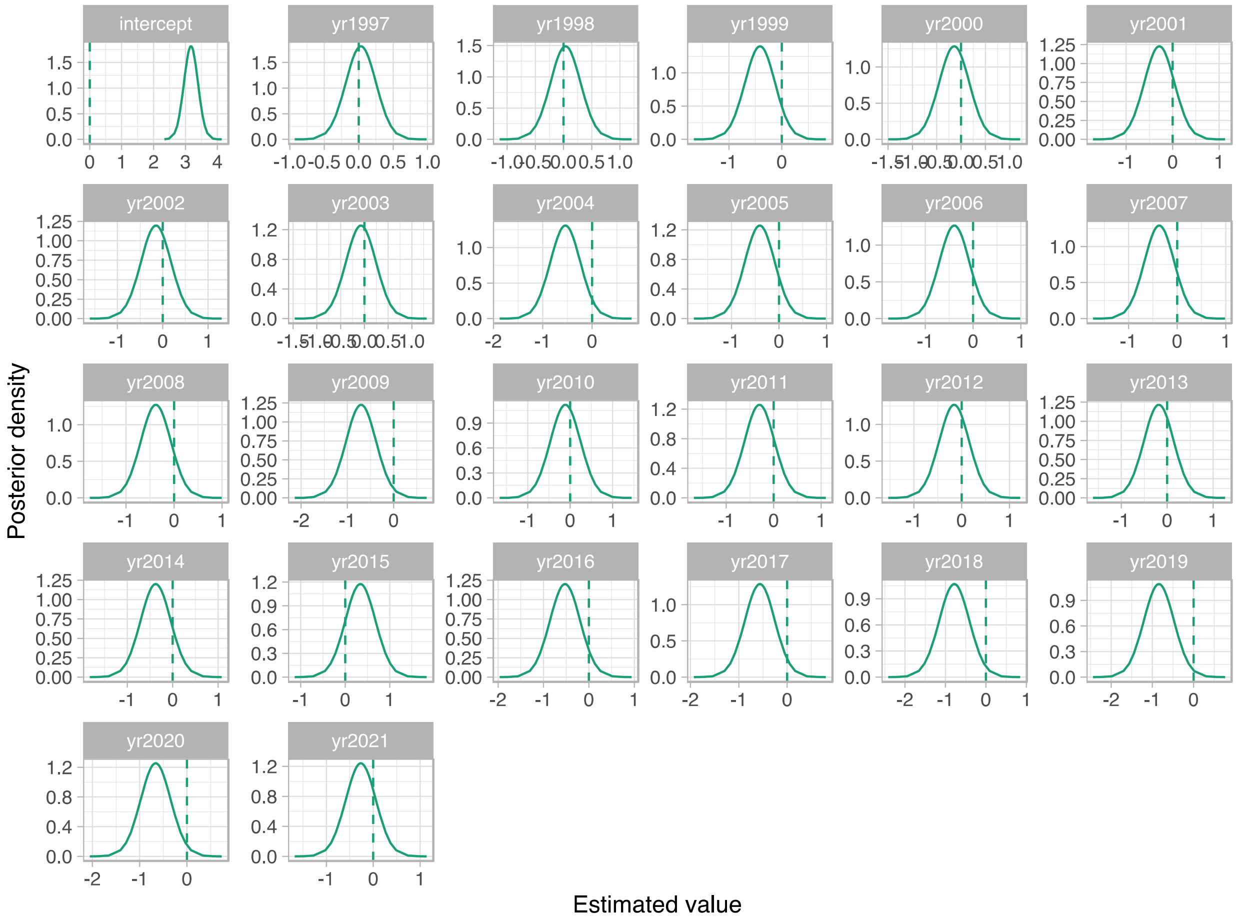

Figure 2. Posterior distribution of the fixed effect.

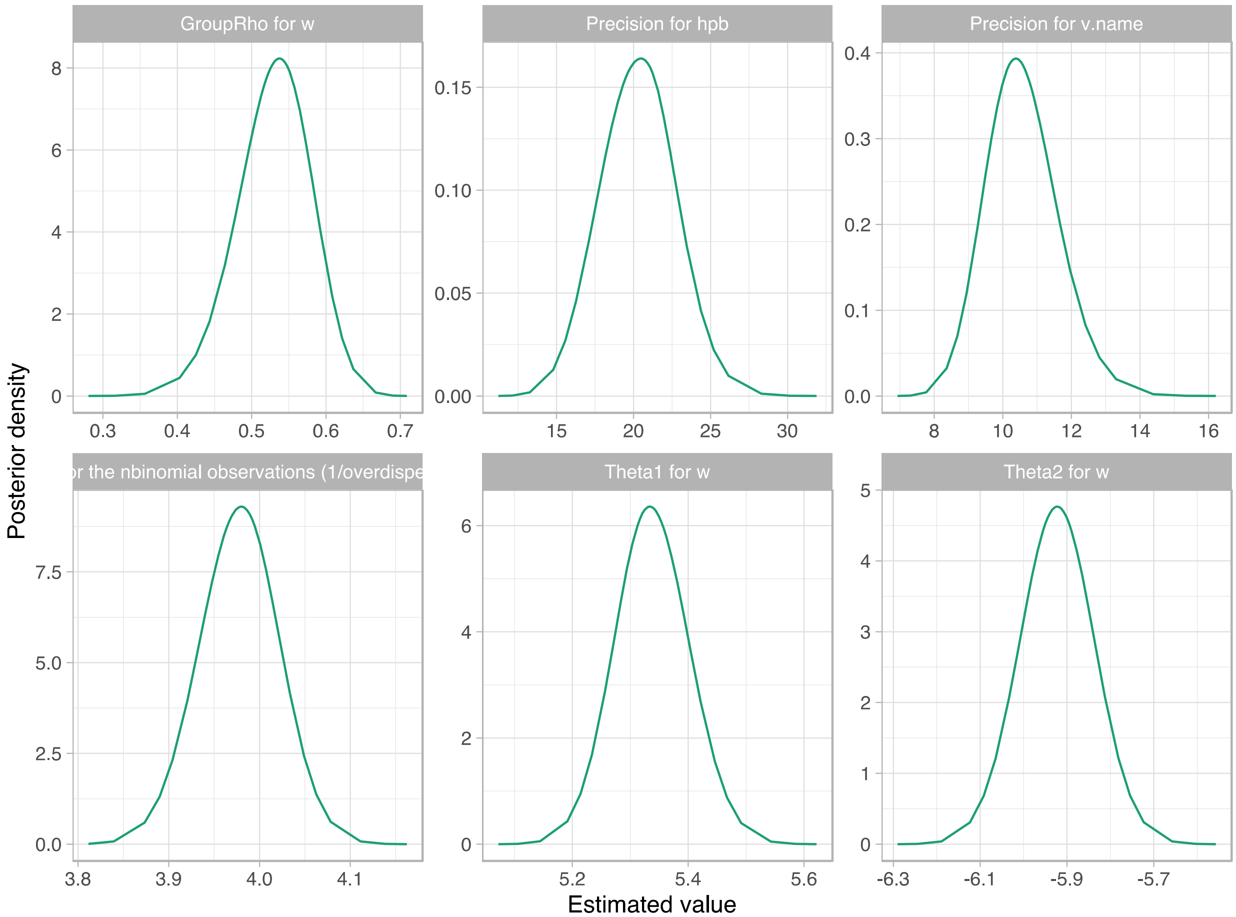

Figure 3. Posterior distribution of the hyper parameter.