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Estimation of adult and immature abundance indices of North Pacific albacore caught by Japanese longline fisheries over a long period of time, from 1976 to 2018

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Summary

In this document, we attempted to develop adult and immature abundance indices (i.e. standardized CPUEs) using Japanese longline fisheries data over a long period of time from 1976 to 2018. The standardized CPUE was calculated separately for two periods of 1976-1993 and 1994-2018, based on the information about historical operational patterns and albacore catch-availability of the fisheries. In the recent period (1994-2018), the operational patterns and catch-availability of adult and immature albacore were mostly stable, and the three-year-time lags between prominent peaks of the immature and adult abundance indices were observed regularly, thus the indices in the period would be reasonable to input to the model for the stock analysis in 2020. Those abundance indices obtained from the early period (1976-1993), on the other hand, may need further investigation on the validity as the fishery information during the period still remain largely unstudied.

Introduction

The abundance index (i.e. standardized CPUE) is one of the most important parameters of the stock assessment model as an input data. In the past stock assessment in 2017, standardized CPUE for adult albacore was calculated using longline operational data from 1996 to 2015, and the results accepted for the stock analysis. However, prior to 1996, the standardized CPUE was not used in the stock analysis in terms of reliability due to lack of information on historical changes in the fishery targeting albacore.

This document outlines information on historical longline operation patterns and their long-term data changes, and based on that, the standardized CPUE for both adult and immature albacore were calculated over two periods divided before and after 1994. And also, although the immature abundance indices have been estimated based on the pole-and-line fishery data as shown in the stock assessment in 2017 (Kinoshita et al. 2016), the CPUE trends based on the longline fishery would provide a comprehensive perspective for this species.

Methods and Results

Standardized CPUE was calculated based on the same dataset, procedures and assumptions as previous studies (Ochi et al. 2017; Fujioka et al. 2019). Considering the migration patterns of this species, longline operational data recorded in Japanese logbook was used for the calculation of the adult abundance index in area 2 and juvenile abundance index in area 1 & 3 (Fig. 1). The data season selected for the analysis was based on the quarter 1 with higher albacore catches compared to other the quarters for both abundance indices (Fujioka et al. 2019). In order to analyze long-term longline fishery data from 1976, the main points of the changes in the reported items in the logbook database and in the operational patterns and catch patterns are listed below.

- Longline operational data from 1976 are useful for the analysis because of the number of hooks per basket and vessel IDs are available.

- Longline operational data format and target range of the data collection was changed in 1994. The location type of all fleet (Distant (≥120 GRT, gross register tonnage), Offshore (20-120 GRT), Coastal (<20 GTR)) are available from 1994, but there is no information of the Coastal fleet before 1994.

- From beginning to 1989-1990, trunk ropes and branch ropes which are logline fishing gear changed from polyester ropes such as tetoron to nylon (Uosaki, 1999).

- Frequency of zero catch operation of albacore in the logbook changed significantly around the 1990s, and the zero catch rate was higher in early period than in the recent period (Fig. 2).

- The hooks per basket gradually increased from 5 to 20, and the trend stabilized since 1994 or 1996 (Fig. 3)

- The trend of catch composition by fish species was changed greatly in the 1990s. Yellowfin and bigeye were frequently caught by logline in the early period, while albacore mainly caught recently (Fig. 4). During 1994-1995, the catch composition seems to be transition period.

- Historical change in the length composition of albacore caught by longline fishery has occurred since 1994. From the 1980s to 1993, Larger albacore (> 30kg) were caught, and much smaller albacore have been caught until recently (Ijima et al. 2017; Ohashi et al. 2019).

Discussion

This study provides evidence that longline operation patterns and catch-availability for targeting ALB would change in the middle of 1990s. Consequently, it was considered appropriate to calculate the data separately at least two periods of the early (1976-1993) and recent (1994-2018). For both adult and immature indices, Figure 5a, b, c, d are shown the distribution of albacore catch, annual change of hooks per basket, frequency of fleet type, nominal and standardized CPUE and 95% Bayesian credible interval, scatter plot between fitted value of the GLMM and Pearson residuals, and distribution of Pearson residuals in each year period, respectively. Calculated values of the standardized CPUEs and CVs were given in Table 1. In the recent period (1994-2018), the standardized CPUE for adult albacore calculated in this document shows similar fluctuation trends with previous study (Ochi et al. 2017) (Fig. 6). When we examined the timing of prominent peaks of the CPUE between juvenile and adult abundance indices (Fig. 7a), it was detected five peaks showing that an adult peaks appearance after 3 years from a juvenile peak. While in the early period (1976-1993), there was no prominent peaks with a time lag between juvenile and adult abundance indices (Fig. 7b). Therefore, in the early period, those abundance indices may not be a reasonable because an increase in the abundance of adult fish is generally detected as a result of an increase in the abundance of immature fish. Further investigation will be required for that calculation of robust abundance index, especially in the early period.

Reference

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Ochi, D., Ijima, H. and Kiyofuji, H. (2017) Abundance indices of albacore caught by Japanese longline vessels in the North Pacific during 1976-2015. ISC/17/ALBWG/01

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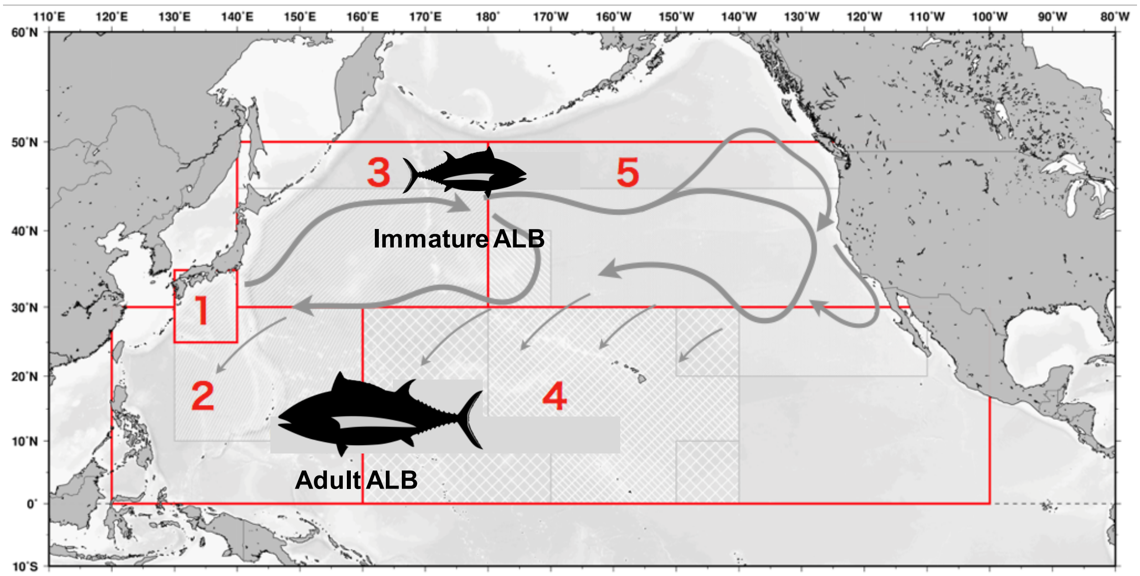
Uosaki, K. (1990) Increase in albacore catch by small tuna longline fishery. Enyo (Far Seas) Fisheries Research Laboratory News 105, pp. 19-24 (only in Japanese), National Research Institute of Far Seas fisheries, Shizuoka, Japan.

(a)



(b)

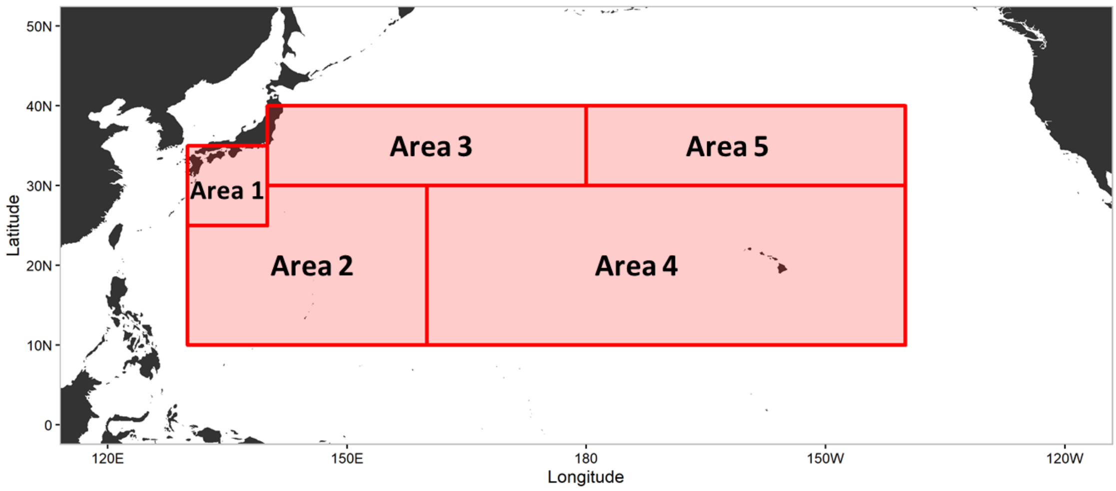


Figure 1. (a) A schematic model of migration pathways of immature and adult albacore (*Thunnus alalunga*), and the five areas used in the stock assessment models in 2017. (b) The area definition of Japanese longline fisheries and target areas of this study which are considered as core areas of albacore distribution.

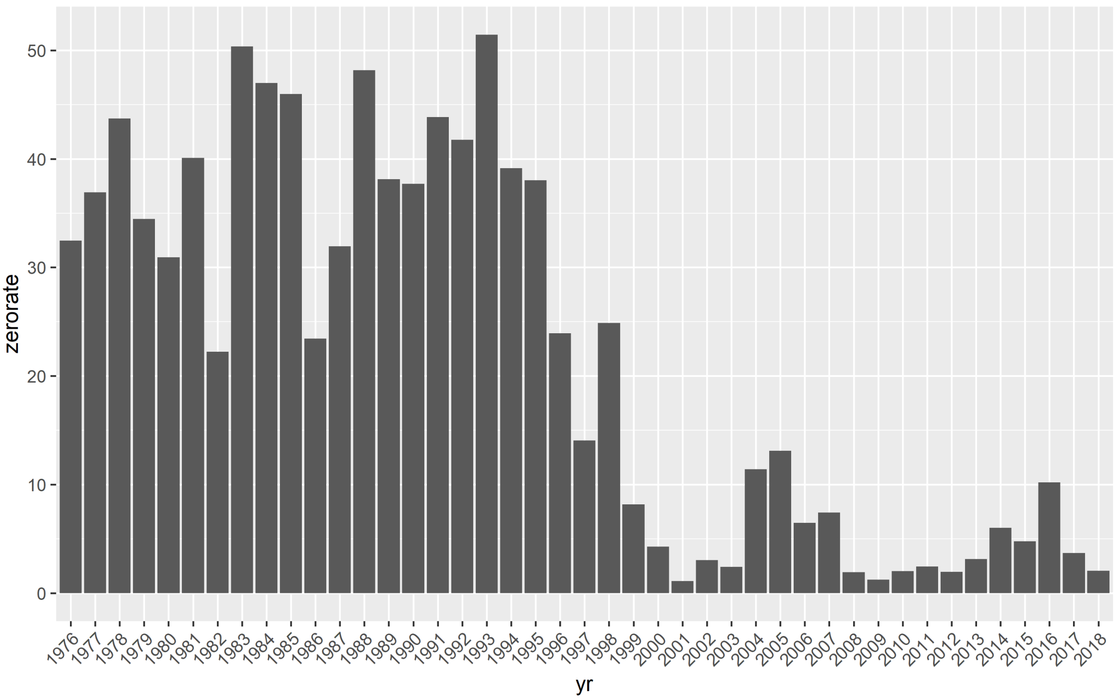


Figure 2. Historical changes on zero catch rate (%) of albacore caught by Japanese longline fisheries which the number of no albacore catch operations divided by the number of total operations in area 2.

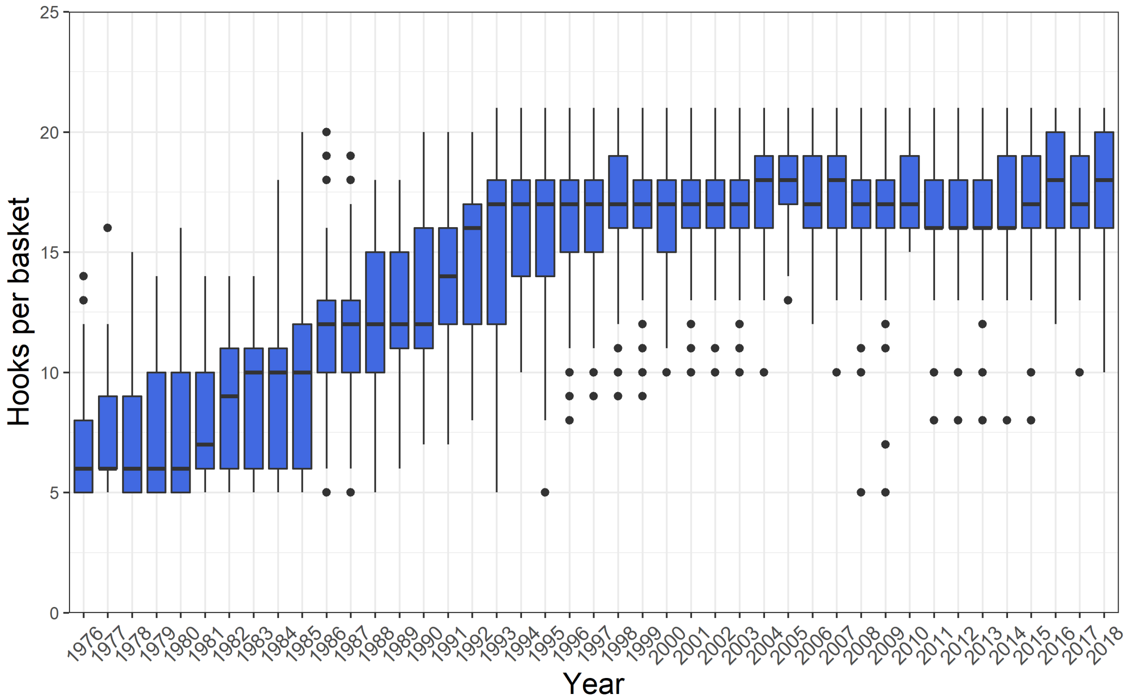


Figure 3. Historical changes on hooks per basket of Japanese longline fisheries in area 2.

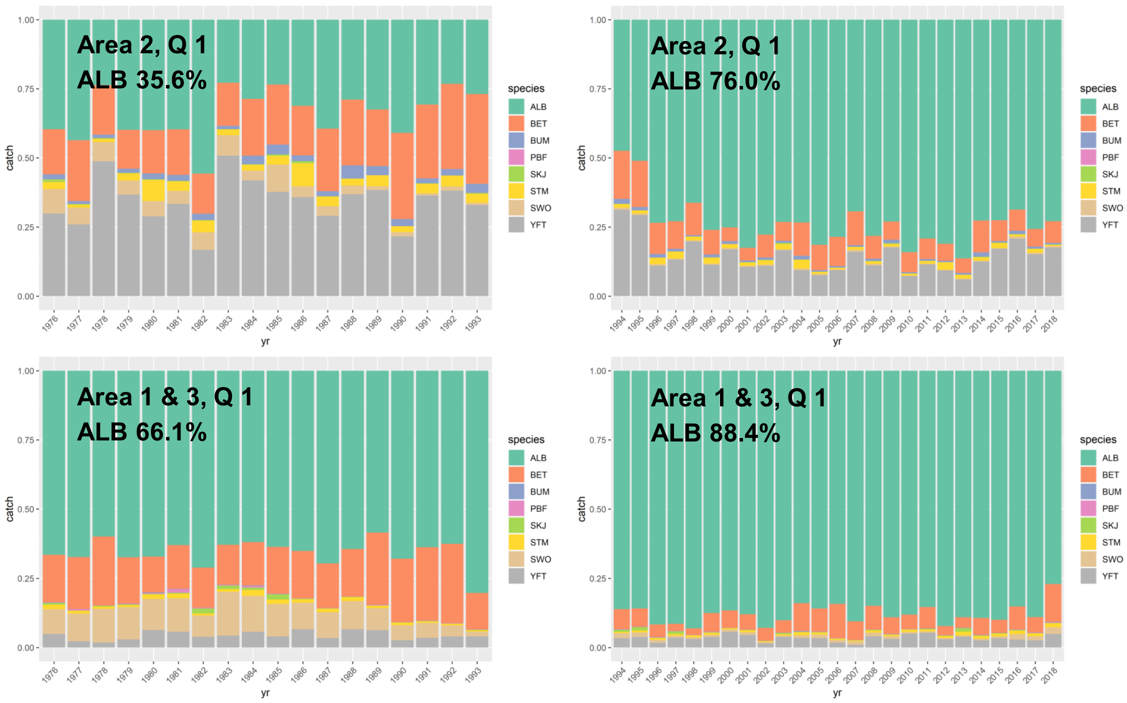


Figure 4. Historical changes on species composition caught by Japanese longline fisheries in area 2 of quarter 1 (top) and in area 1 & 3 of quarter 1 (bottom) with average catch rate of albacore both 1976-1993 (left) and 1994-2018 (right).

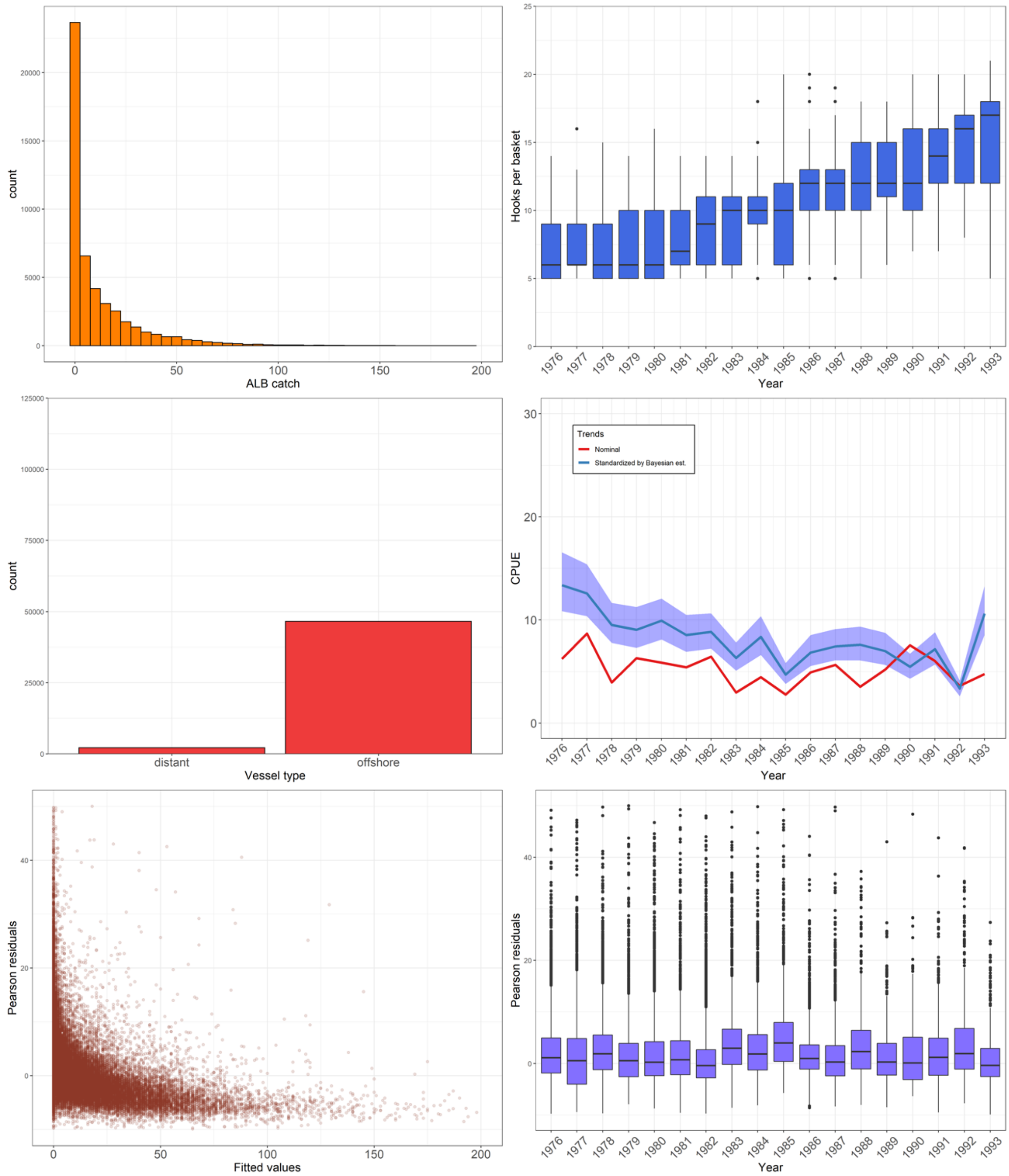


Figure 5a. Data summary and result standardized CPUE in the analysis during 1976-1993 in area 2 of quarter 1. Distribution of albacore catch (left top), annual change of hooks per basket (right top), frequency of fleet type (left middle), nominal and standardized CPUE and 95% Bayesian credible interval (blue shaded area; right middle), scatter plot between fitted value of the GLMM and Pearson residuals (left bottom), and distribution of Pearson residuals in each year (right bottom).

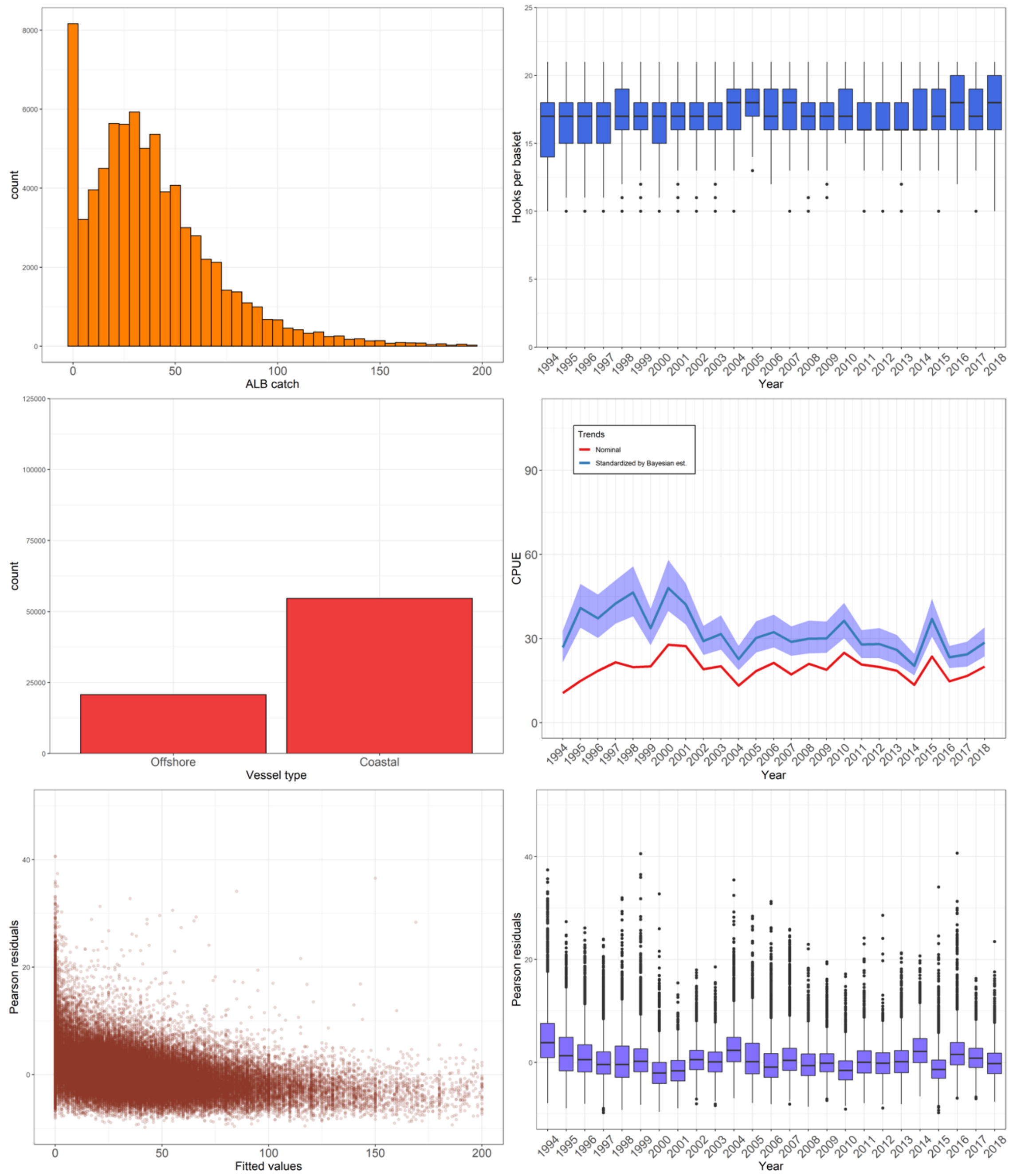


Figure 5b. Data summary and result standardized CPUE in the analysis during 1994-2018 in area 2 of quarter 1. Distribution of albacore catch (left top), annual change of hooks per basket (right top), frequency of fleet type (left middle), nominal and standardized CPUE and 95% Bayesian credible interval (blue shaded area; right middle), scatter plot between fitted value of the GLMM and Pearson residuals (left bottom), and distribution of Pearson residuals in each year (right bottom).

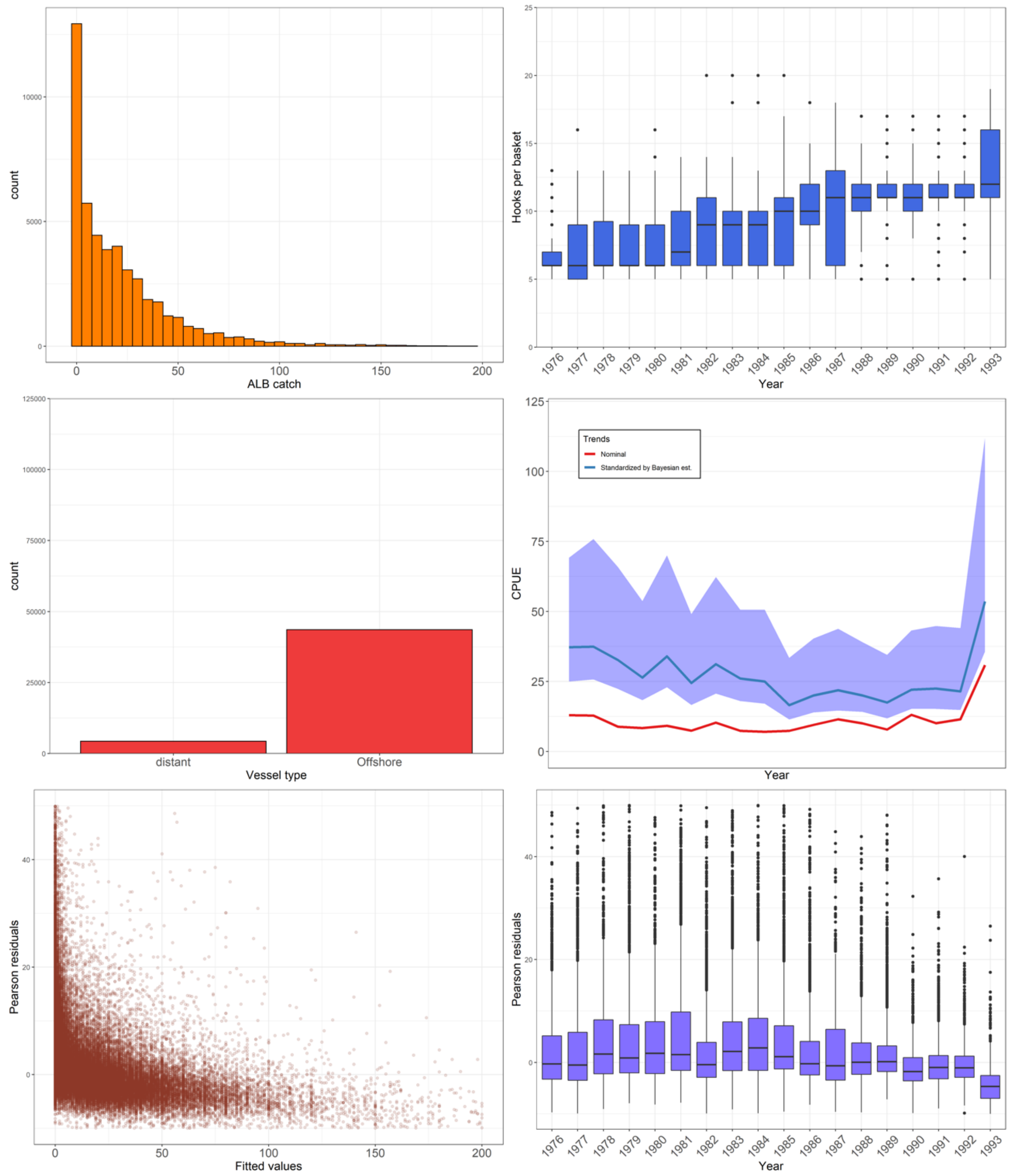


Figure 5c. Data summary and result standardized CPUE in the analysis during 1976-1993 in area 1 & 3 of quarter 1. Distribution of albacore catch (left top), annual change of hooks per basket (right top), frequency of fleet type (left middle), nominal and standardized CPUE and 95% Bayesian credible interval (blue shaded area; right middle), scatter plot between fitted value of the GLMM and Pearson residuals (left bottom), and distribution of Pearson residuals in each year (right bottom).

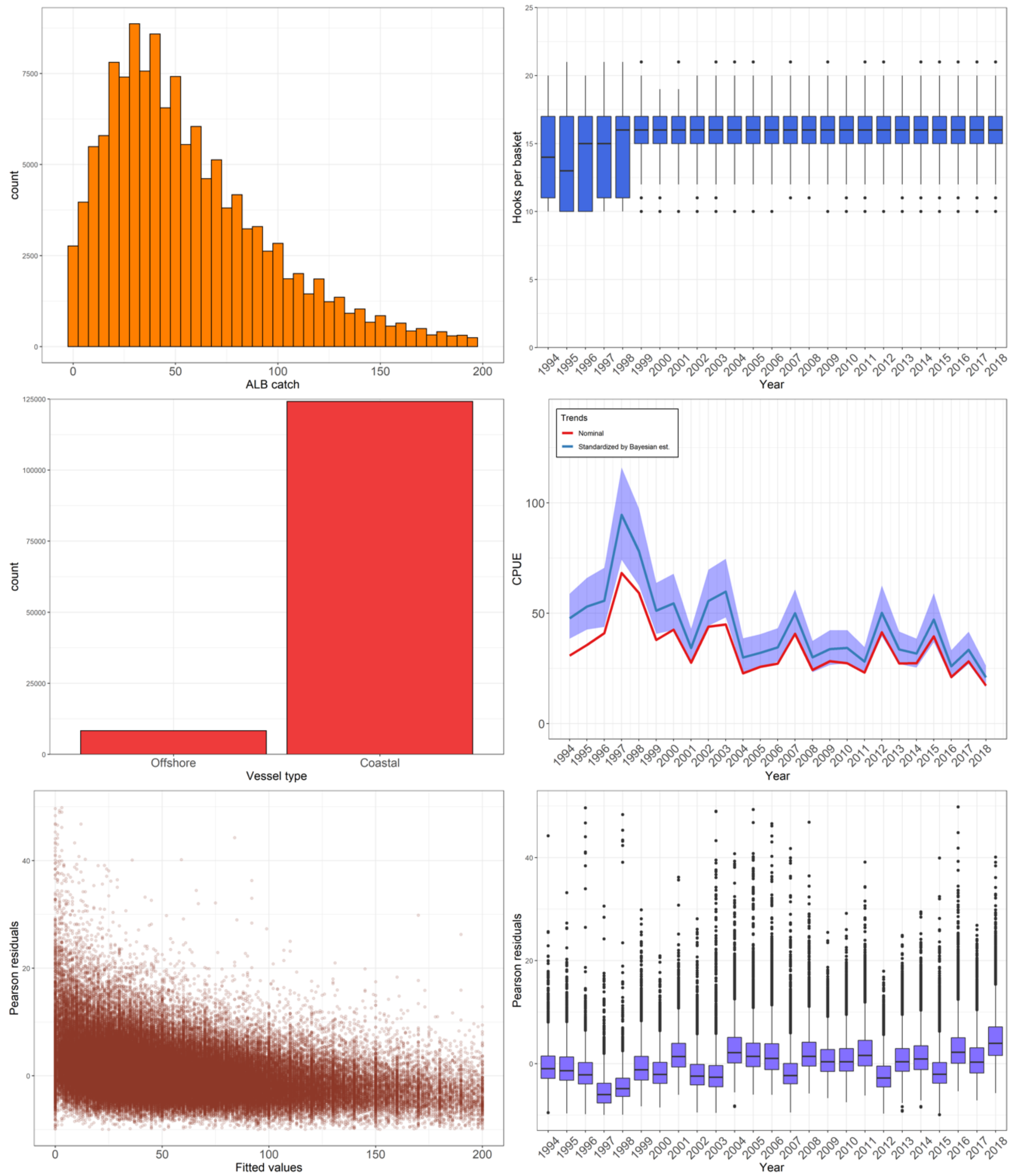


Figure 5d. Data summary and result standardized CPUE in the analysis during 1994-2018 in area 1 & 3 of quarter 1. Distribution of albacore catch (left top), annual change of hooks per basket (right top), frequency of fleet type (left middle), nominal and standardized CPUE and 95% Bayesian credible interval (blue shaded area; right middle), scatter plot between fitted value of the GLMM and Pearson residuals (left bottom), and distribution of Pearson residuals in each year (right bottom).

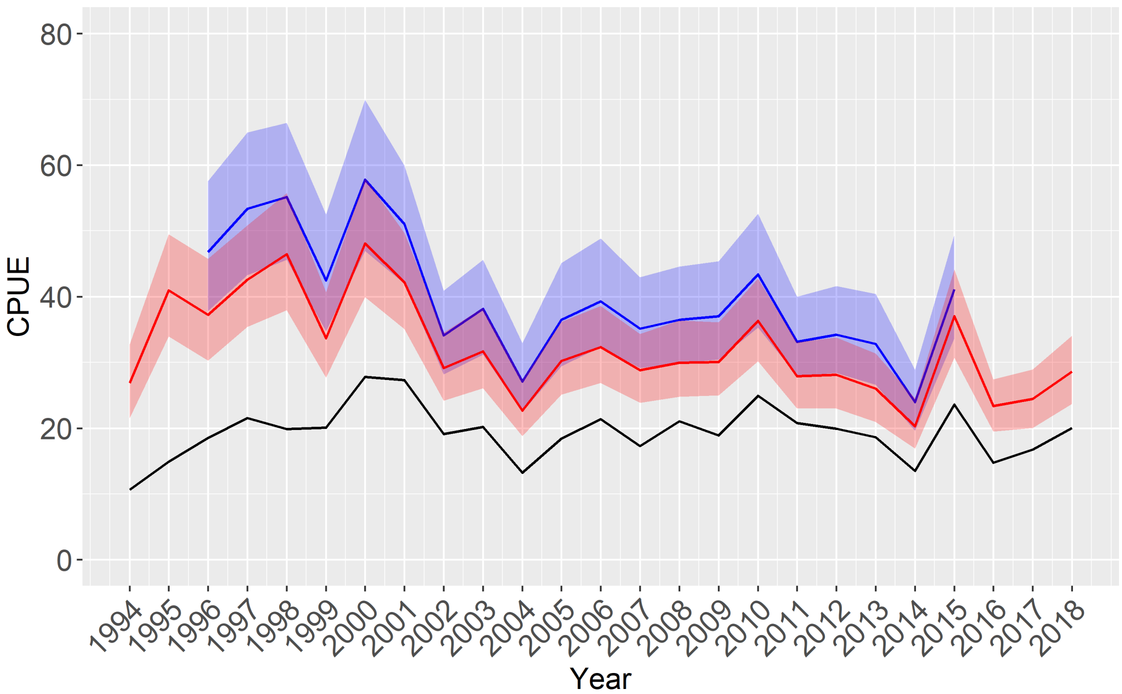


Figure 6. Comparison of two standardized CPUEs with 95% Bayesian credible interval (blue; Ochi et al. 2017, red; the present study) and nominal CPUE (black) in area 2.

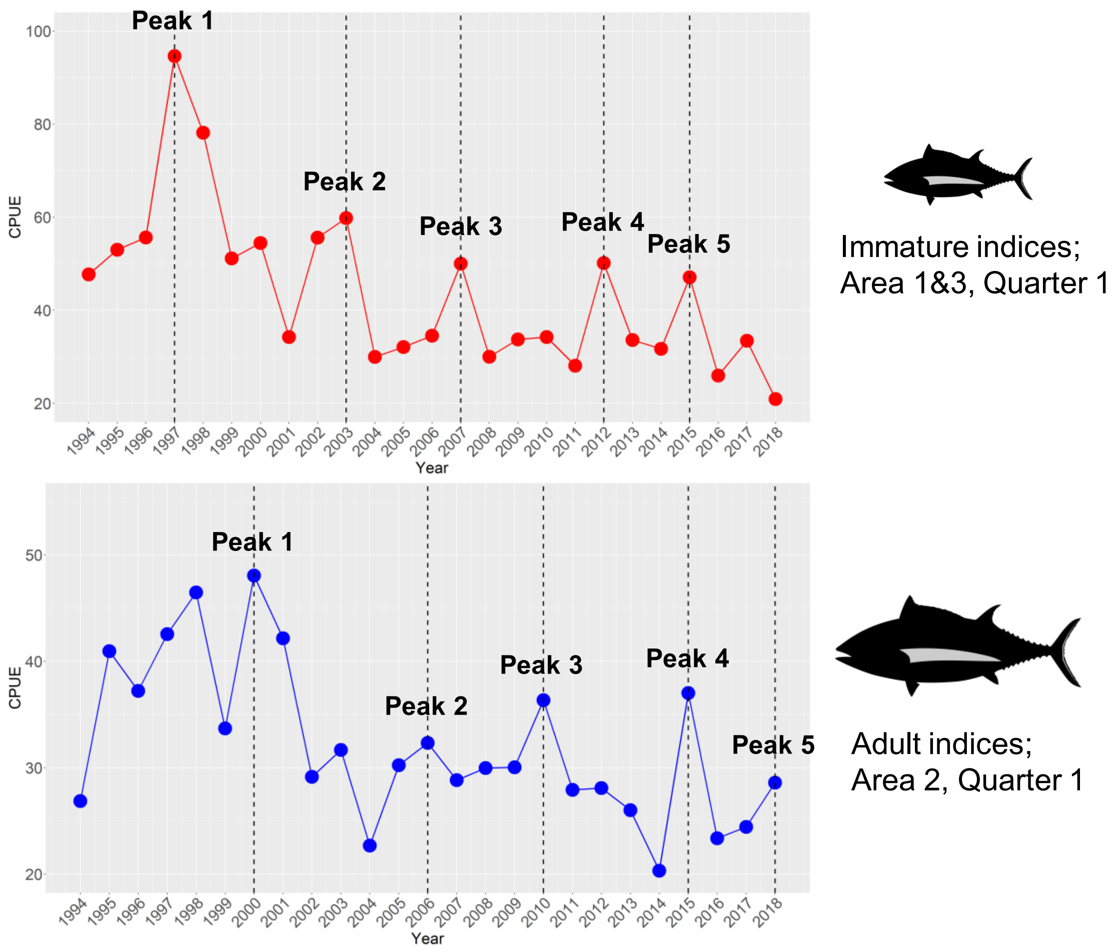


Figure 7a. Comparison of immature abundance index (top) and adult abundance index (bottom) (i.e., standardized CPUEs) in the period 1994-2018. The peaks that correspond to each index with time-lags are numbered.

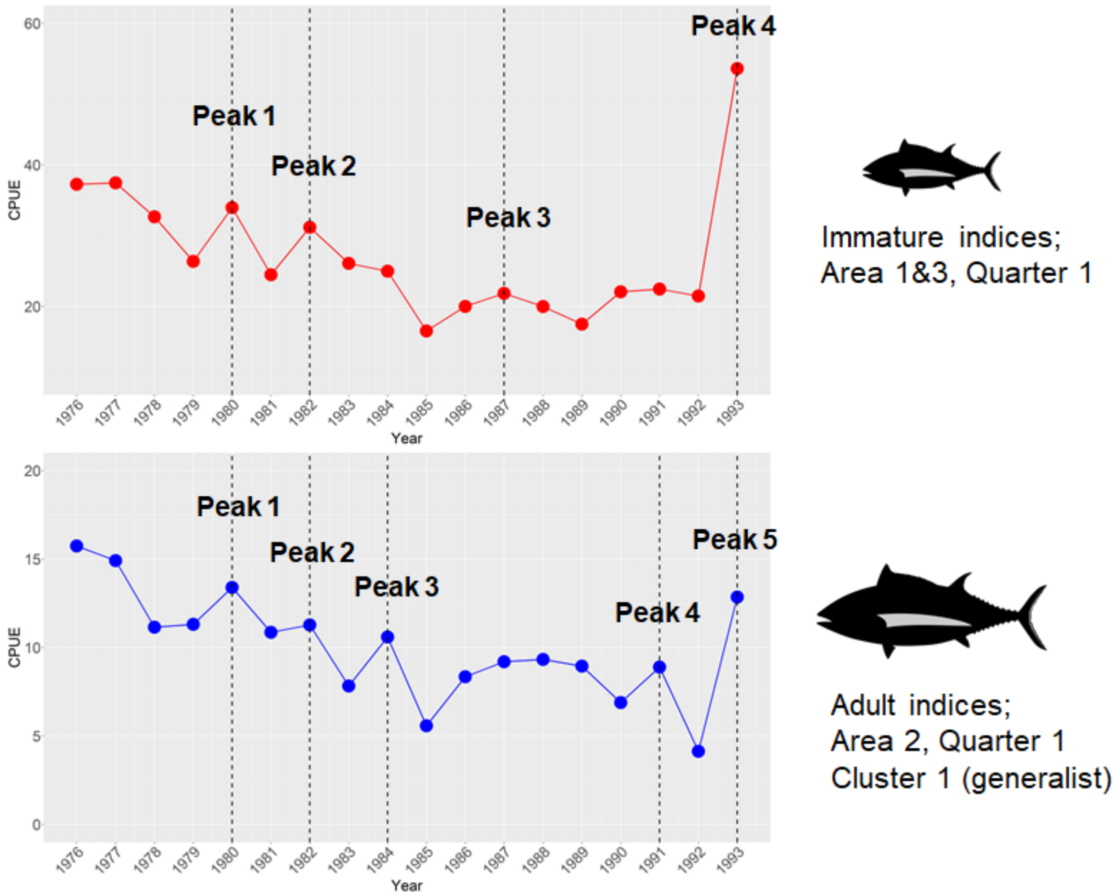


Figure 7b. Comparison of immature abundance index (top) and immature abundance index (bottom) (i.e., standardized CPUEs) in the period 1976-1993. No significant time lag was detected in the peak corresponding to each index.

Table 1 Abundance indices for albacore caught by the Japanese longline fisheries in area 2 and area 1 & 3, which the standardized CPUE for adult and immature albacore in two time-series of 1976-1993 and 1994-2018.

	Adult index		Immature index	
	Area 2, Quarter 1		Area 1 & 3, Quarter 1	
Year	Std. CPUE	CV	Std. CPUE	CV
1976	13.37	0.11	37.25	0.36
1977	12.58	0.10	37.44	0.35
1978	9.52	0.11	32.66	0.34
1979	9.04	0.11	26.36	0.37
1980	9.93	0.10	33.96	0.36
1981	8.54	0.11	24.47	0.36
1982	8.85	0.11	31.17	0.36
1983	6.31	0.11	26.07	0.36
1984	8.36	0.11	24.97	0.35
1985	4.70	0.11	16.51	0.36
1986	6.84	0.11	19.99	0.35
1987	7.44	0.11	21.84	0.37
1988	7.59	0.11	19.97	0.37
1989	6.98	0.11	17.49	0.36
1990	5.47	0.11	22.05	0.35
1991	7.16	0.11	22.45	0.36
1992	3.34	0.12	21.45	0.36
1993	10.62	0.12	53.59	0.37

	Adult index		Immature index	
	Area 2, Quarter 1		Area 1 & 3, Quarter 1	
Year	Std. CPUE	CV	Std. CPUE	CV
1994	26.86	0.11	47.70	0.11
1995	40.96	0.10	53.01	0.12
1996	37.21	0.11	55.64	0.12
1997	42.55	0.09	94.59	0.12
1998	46.47	0.10	78.14	0.12
1999	33.70	0.09	51.13	0.12
2000	48.06	0.10	54.44	0.12
2001	42.17	0.09	34.27	0.11
2002	29.14	0.09	55.60	0.12
2003	31.66	0.10	59.79	0.12
2004	22.69	0.10	29.97	0.13
2005	30.24	0.09	32.11	0.12
2006	32.34	0.09	34.54	0.11
2007	28.84	0.10	50.00	0.11
2008	29.97	0.10	30.02	0.12
2009	30.04	0.10	33.74	0.12
2010	36.34	0.09	34.24	0.11
2011	27.92	0.09	28.09	0.12
2012	28.09	0.10	50.16	0.11
2013	26.01	0.10	33.59	0.11
2014	20.32	0.10	31.73	0.11
2015	37.02	0.09	47.10	0.12
2016	23.36	0.09	25.98	0.13
2017	24.44	0.09	33.45	0.11
2018	28.59	0.09	20.92	0.12