Update Japanese longline abundance index of Pacific blue marlin (*Makaira nigricans*) estimated by the habitat model.

Hirotaka Ijima[1]

[1]Highly Migratory Resources Division, Fisheries Stock Assessment Center, Fisheries Resources Institute (FRI), Japan Fisheries Research and Education Agency. 2-12-4 Fukuura, Kanazawa-ku, Yokohama, Kanagawa, 236-8648, JAPAN

Email: ijima@affrc.go.jp

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Abstract

This paper reports the updated Japanese CPUE indices used in the previous Pacific blue marlin stock assessment in 2016. Data sets were used from Japanese longline logbook data and NOAA oceanic environmental data. The habitat model was used to standardize Pacific blue marlin CPUE as in the previous analysis. Differences from the previous analysis are; 1. Coastal longline data were removed following the SS3 fishery definition, 2. All years of environmental data were updated, and 3. a part of aggregation methods of environmental data was changed, and errors were fixed. The standardized CPUE showed a flat trend as before, but the range of variability increased. The changes in logbook data had the biggest impact on the CPUE standardization. Looking at Japanese offshore and distant water longliners' size selectivity, it is reasonable that CPUE of Pacific blue marlin would fluctuate from year to year because the Japanese longline mainly catches an immature blue marlin. The 2019 data is very preliminary, and the BILLWF needs consideration when using CPUE for the stock assessment.

Introduction

The ISC BILLWG conducted the Pacific blue marlin stock assessment in 2016 used the Japanese Habitat-based standardized CPUE. This standardized CPUE was calculated using the Habitat-based standardization model. This paper attempted to standardize the Pacific black marlin CPUE using the same method and updated data as Kai et al., 2016.

Material and Methods

Data sets

The present analysis was conducted using the same data sources and methodology as in Kai et al., 2016. The details are as follows.

- Catch and effort data

Catch and effort data were used for the Japanese longline logbook data (1994-2018). In the previous analysis, the logbook data of the Coastal longline and Offshore-Distant water longline were used. In this study, however, the Offshore-Distant water longline logbook was used to follow the fishery definition in SS3. The Japanese logbook was recorded by a 1°×1° degree level of resolution with detailed information for each fishing operation. In the data screening, the range of 30°N to 30°S latitude was chosen and excluded those listed as targeting swordfish or sharks.

In addition, those operations where the SST is more than 20 degrees Celsius are extracted and used for the analysis.

- Oceanic environmental data

The mixed layer depth data (MLD) was from NOAA NCEP EMC CMB GODAS monthly ocean_mixed_layer_bot. The water temperature by hierarchical depth was from NOAA NCEP EMC CMB GODAS monthly Below Sea Level POT. Potential temperature data (POT) was aggregated into the same periods and areas as the longline logbook data. These two data sets were used to obtain the MLD water temperature. The -1 to -6 degrees celsius depth from MLD was estimated using the interpolation at 1° latitude, 1° longitude, and monthly resolution. The data appear to have been interiorized by SAS's function, but the R software package of spline function was used since the details of methods are unclear. These data seem to be frequently updated and slightly different from the data set of previous analysis. Also, some errors were fixed in the previous tabulation of environmental data.

Habitat-based CPUE standardization

In the first step, the appropriate hook depths were calculated by the "Gear model," and then the vertical distribution of blue marlin was estimated from the "Habitat preference model". Finally, the Habitat model was used to calculate the standardized CPUE for the Pacific black marlin. The details of each model are shown as follows.

- Gear model

The catenary curve model was used to estimate hooks' vertical distribution in the water column (Yoshihara 1951; Suzuki et al. 1977). The depth of j the hook (D_i) can be defined by the length of the branch line(h_a), the float line length (h_b), half of the mainline's length (L), and the number of intervals between the branch lines in the unit basket (n). The catenary angle ($\varphi = 72\pi/180$) between the horizontal and tangential lines of the mainline at the connecting points of mainline and float lines,

$$D_i = h_a + h_b + L\left\{\left(1 + \frac{1}{\tan(\varphi)^2}\right)^{0.5} - \left[\left(1 - 2\frac{j}{n}\right)^2 + \frac{1}{\tan(\varphi)^2}\right]^{0.5}\right\}. \qquad (1)$$

Following the previous analysis, the depth at 85% of the theoretical depth was derived from equation (1). Each variable is the mean value from logbook data, and data were pooled by prefecture, area, a quarter), the mainline's material, and the hooks per basket (3-5, 6-9, 10-14, 15-17, 18-25).

- Habitat preference model

Brill et al. 1993 and Block et al. 1992 estimated the blue marlin population's vertical distribution using acoustic telemetry data. The time at temperature relative to the mixed-layer on the range of Δ_t= (0, -1, -2, …,-8°C) can estimate the population. This study used the result of Hinton and Nakano (1996) (Table 1).

- Habitat model

The standardized CPUE was defined as the total catch of blue marline over the total effective fishing effort (the joint probability of the vertical distribution of hooks in the water column, and blue marlin distribution). The total catch was weighted by the relative size of the area (Table 2). Annual relative abundance indices were derived from the mean of standardized CPUEs. Bootstrap methods calculated the uncertainties of standardized CPUE.

Result and discussion

The trend in the standardized CPUE fluctuated around the historical mean (Table. 3, Figure 1). In recent years, the trend shows a sharp increase in 2014, the last year of the last stock assessment, followed by a decreasing trend through 2018 (Table. 3, Figure 1). Comparing the previous standardized CPUE and the updated CPUE, both indices show a flat trend, but the current results show a more extensive variation (Figure 2 B). These differences can be attributed to different data sets. As mentioned above, there are three differences between the previous and current analyses. Specifically;

1. Coastal longline data were removed following the SS3 fishery definition.
2. Environmental data for all years were updated.
3. Some of the environmental data aggregation methods were changed, and errors were corrected.

The most impactful change was logbook data (Figure 2 A, B). These revisions are considered to be scientifically valid. Also, This large variability in CPUE is considered to be a reasonable explanation for the stock assessment model because Japanese longline vessels catch a mainly juvenile blue marlin. In terms of the environmental data, since they are estimates, updates and changes are likely to occur in the future. Therefore, it should be noted that standardization using the Habitat model is difficult to maintain consistency.

The 2019 data is very preliminary, and most of the data has not yet been digitized. Therefore, due consideration must be given when using CPUE for the stock assessment.

References

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Table 1. The percentage (P) and that 90% confidence interval (C.I.) of the population of blue marlin temperatures. ³t is relative temperature of the mixed layer (Hinton and Nakano 1996).

³t	0	-1	-2	-3	-4	-5	-6	-7	-8
P	75.9	13.8	5.8	2.1	1.2	0.5	0.5	0.2	0.02
C.I	69.9,	7.3,	4.3,	1.4,	0.5,	0.1,	0.03,	0.01,	0.01,
	81.9	20.5	8.4	3.2	2.2	1.2	1.2	0.3	0.03

Table 2. The area weighting values to estimate standardized CPUE (Kai et al., 2016)

Lat	Lat (km)	Lon (km)	Area (1x1)	Relative value	Lat	Lat (km)	Lon (km)	Area 1x1	Relative value
0.00	110.57	111.32	12308.43	1.05	16.00	110.65	107.04	11843.85	1.01
1.00	110.57	111.30	12306.66	1.05	17.00	110.66	106.49	11784.17	1.00
2.00	110.57	111.25	12301.13	1.05	18.00	110.68	105.91	11721.15	1.00
3.00	110.57	111.17	12291.96	1.05	19.00	110.69	105.29	11654.57	0.99
4.00	110.74	111.05	12297.23	1.05	20.00	110.70	104.65	11584.54	0.99
5.00	110.58	110.90	12262.88	1.04	21.00	110.71	103.97	11510.95	0.98
6.00	110.58	110.72	12242.86	1.04	22.00	110.73	103.26	11433.91	0.97
7.00	110.58	110.50	12219.20	1.04	23.00	110.74	102.52	11353.41	0.97
8.00	110.59	110.25	12191.88	1.04	24.00	110.75	101.75	11269.56	0.96
9.00	110.60	109.96	12160.92	1.03	25.00	110.77	100.95	11182.25	0.95
10.00	110.60	109.64	12126.40	1.03	26.00	110.78	100.12	11091.48	0.94
11.00	110.61	109.29	12088.24	1.03	27.00	110.80	99.26	10997.58	0.94
12.00	110.62	108.90	12046.52	1.02	28.00	110.82	98.36	10900.21	0.93
13.00	110.62	108.49	12001.16	1.02	29.00	110.83	97.44	10799.58	0.92
14.00	110.63	108.04	11952.35	1.02	30.00	110.85	96.49	10695.50	0.91
15.00	110.64	107.55	11899.99	1.01					

Table 3. The results of update analysis of the habitat model for the Pacific blue marlin CPUE standardization.

Year	Nominal CPUE (Relative scale)	Area weighted Standardized CPUE (Relative scale)	CV of the standardized CPUE
1994	1.58	1.43	0.02
1995	1.13	1.35	0.02
1996	0.86	0.69	0.02
1997	1.46	2.01	0.02
1998	1.14	1.13	0.02
1999	1.00	0.76	0.03
2000	1.09	0.84	0.02
2001	1.04	0.77	0.02
2002	0.94	0.84	0.02
2003	0.88	0.99	0.02
2004	1.58	1.45	0.02
2005	0.88	0.66	0.03
2006	1.25	1.70	0.03
2007	0.91	0.58	0.03
2008	0.96	0.63	0.03
2009	1.37	1.31	0.03
2010	0.82	0.62	0.03
2011	0.76	0.64	0.03
2012	1.05	1.13	0.03
2013	0.74	0.73	0.03
2014	1.00	1.38	0.04
2015	0.97	1.40	0.03
2016	0.83	1.26	0.03
2017	0.74	0.70	0.03
2018	0.67	0.62	0.03
2019	0.35	0.36	0.13

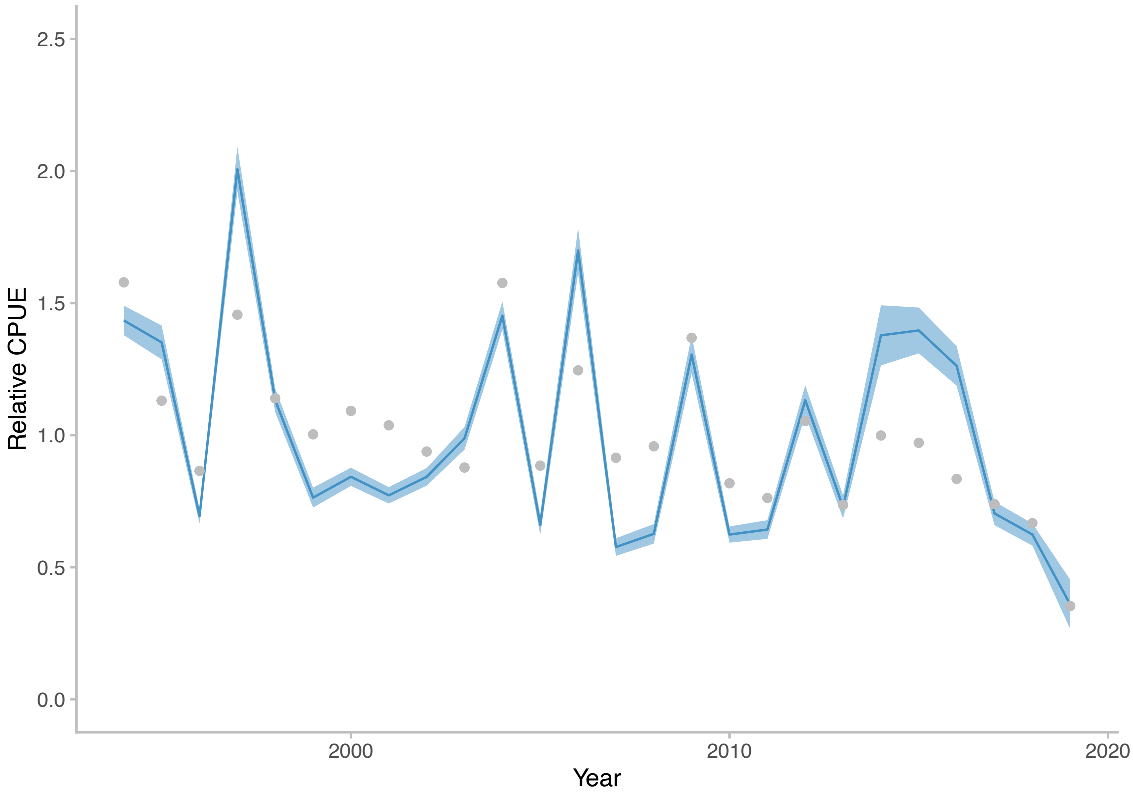

Figure 1. The estimated the abundance index of Pacific blue marlin. Gray points denote nominal CPUE, the blue line is the estimated relative CPUE, and blue tiles are 95% confidence intervals, respectively.

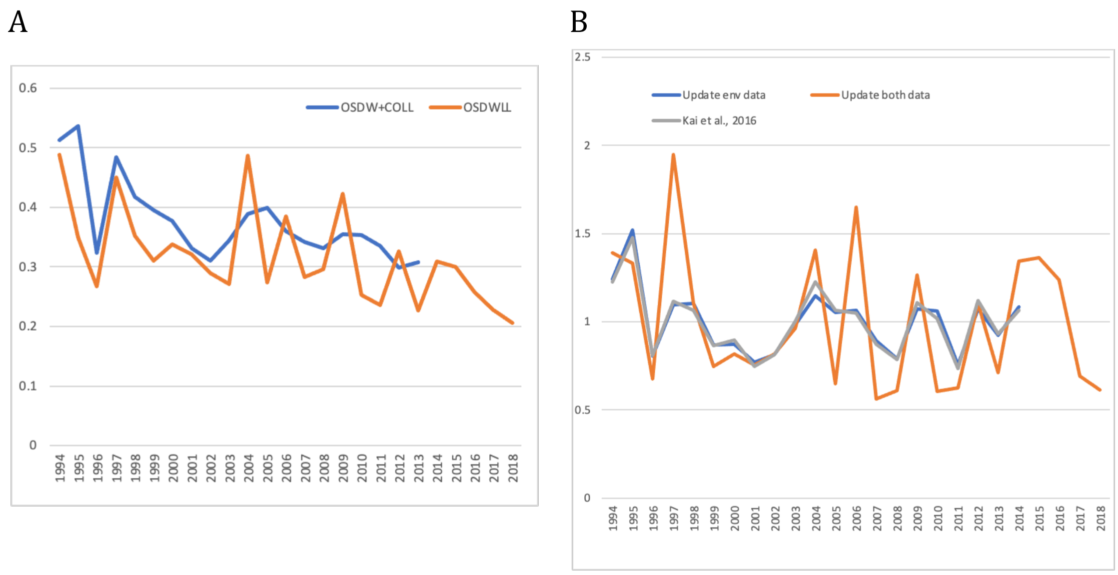

Figure 2. Comparison of the CPUE of Pacific blue marlin used in the previous stock assessment with the results of the current estimate. A: Difference of the logbook data. This study used OSDWLL data only. B: Comparison of standardized CPUEs.