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CPUE standardization for bigeye tuna caught by Korean tuna longline fisheries in the Indian Ocean (1978-2011)

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Abstract

CPUE (catch per unit effort) standardization for bigeye tuna of Korean longline fisheries in the Indian Ocean was conducted by GLM using fisheries data (1978-2011), i.e., catch (number of fishes), effort (number of hooks) and number of hooks between floats (HBF) by year, month and 5°× 5° (Lat. and Long.) area. The standardized CPUE was about 10 in 1978, but since then it had showed the declining trend until the early of 2000s except one jump in 1996, and showed a steady trend with a level of 2-3 in recent years.

Contents

1. Introduction

Bigeye tuna in the Indian Ocean has been one of the highest catch in Korean tuna longline fisheries along with yellowfin tuna. Bigeye catch considerably increased from the mid-1960s and peaked at about 33 thousands mt in 1978, but had decreased with a fluctuation to a few hundred tons in recent years (Fig. 1). In this study, bigye CPUE (catch per unit effort) standardization of Korean tuna longline fisheries in the Indian Ocean (1978-2011) was conducted using Generalized Linear Model (GLM) to assess the proxy of the abundance index.

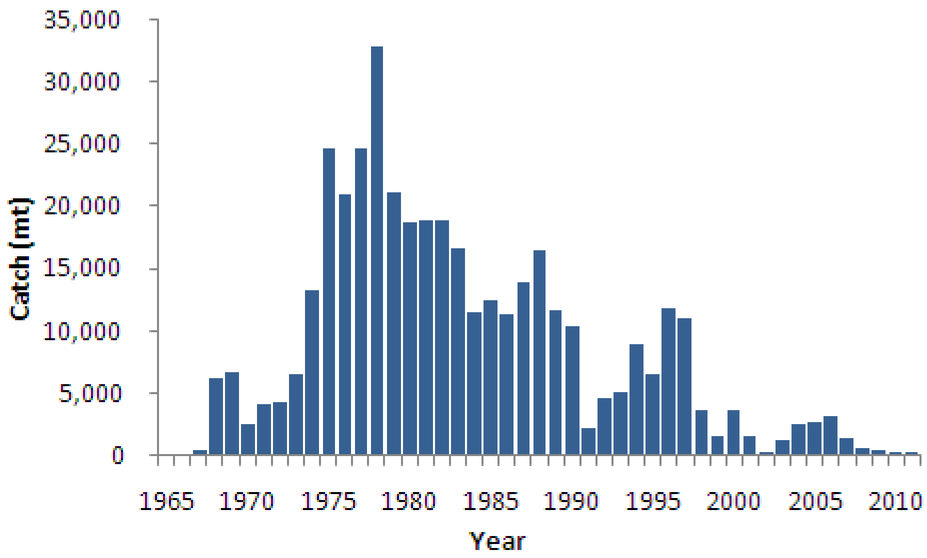

Fig. 1. Annual catch of bigeye caught by Korean tuna longline fisheries in the Indian Ocean, 1965-2011 (data source: IOTC data base).

2. Data and Methods

2.1 Area

Based on the fishing patterns of Korean tuna longline fisheries, only 2 areas, that is, West (area 1, 3 and 6) and East (areas 2, 4, 5, 6 and 7) were used for standardizing bigeye CPUE of Korean tuna longline fisheries (Fig. 2). Another significant reason to combine to 2 large areas is that if we use sub-areas, there are a lot of missing values (no operations) in some sub-areas in some seasons, which make it difficult to run GLM. And area 67 was not used in this study.

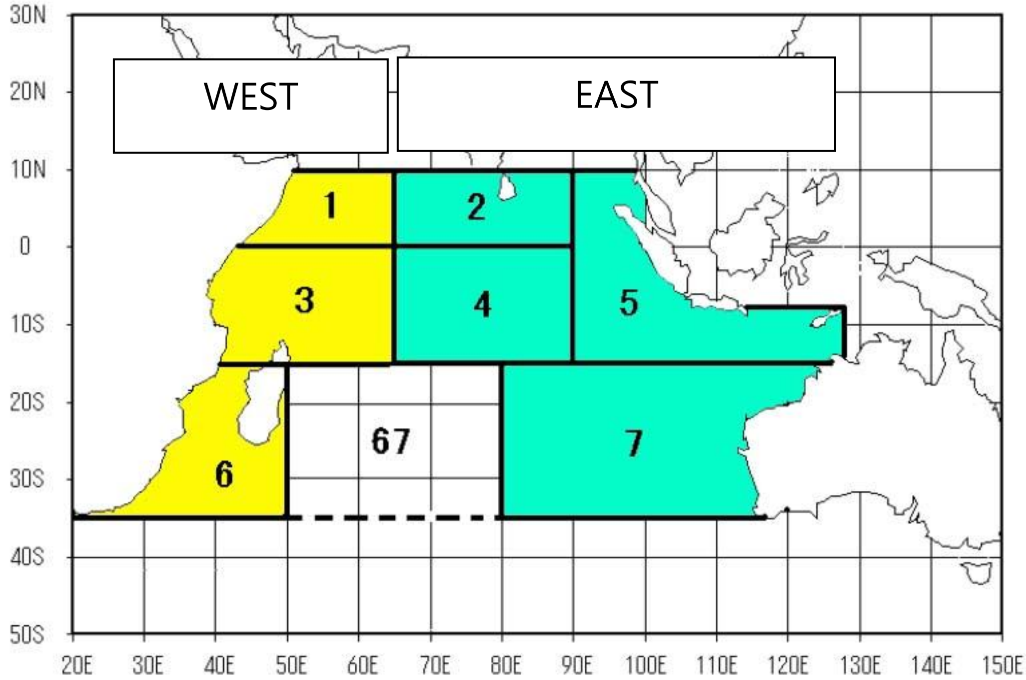

Fig. 2. Map showing areas used for bigeye CPUE standardization of Korean tuna longline fisheries in the Indian Ocean (modified from Okamoto and Shono, 2006). (West=1+3+6, East=2+4+5+7).

2.2 Catch and effort data

Bigeye catch (number of fishes) and effort (number of hooks), HBF (number of hooks between floats) by year, month and Lat. 5°×Long. 5° area for Korean tuna longline fisheries (1978-2011) were used for the CPUE standardization. The data before 1977 were not used because there were many missing information in the dataset to conduct GLM. In addition, the targeting factor (HBF) was not available in 1988-1989, hence the data of these two years were not included in this study. The HBF was divided into 5 classes (class 1 : below 8, class 2 : 9-11, class 3 : 12-14, class 4 : 15-17, class 5 : above 18) based on the fishing operational patterns of Korean tuna longline fisheries (Fig. 3).

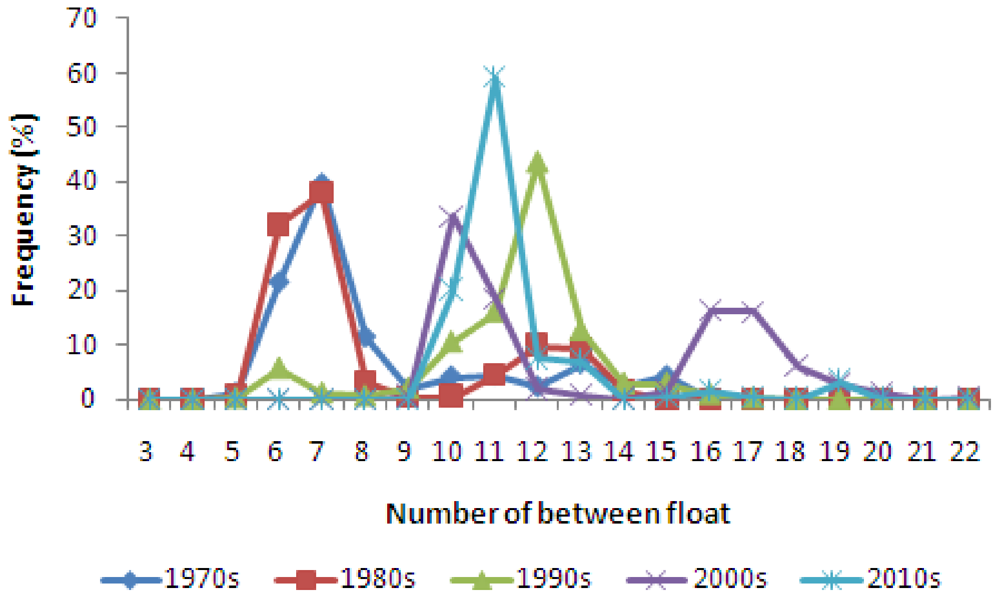

Fig. 3. Changes in the number of hooks between floats (HBF) used in Korean tuna longline fisheries in the Indian Ocean by decade.

2.3 Generalized Linear Model (GLM)

Generalized Linear Model (GLM) for bigeye CPUE standardization is as follows, and the analysis was conducted by SAS program (ver. 9.2).

$$\ln(CPUE + c) = \mu + Y + Q + A + HBF + Y\times A + Q\times A + Q\times HBF + A\times HBF + Q\times A\times HBF + error$$

where, CPUE : catch in number of bigeye per 1,000 hooks

c : 10% of average overall nominal CPUE (0.54)

Y : effect of year

Q : effect of quarter (season)

A : effect of area (Areas 1 and 2)

HBF : effect of targeting (5 classes)

Y×A : interaction term between year and area

Q×A : interaction term between quarter and area

Q×HBF : interaction term between quarter and HBF

A×HBF : interaction term between area and HBF

Q×A×HBF : interaction term among quarter, area and HBF

error : error term

3. Results and Discussion

Fig. 4 shows the standardized (STD) CPUE trends for bigeye with nominal CPUE in real and relative scales. The STD CPUE was about 10 in 1978, but since then it had showed the declining trend until the early of 2000s except one jump in 1996, and showed a steady trend with a level of 2-3 in recent years.

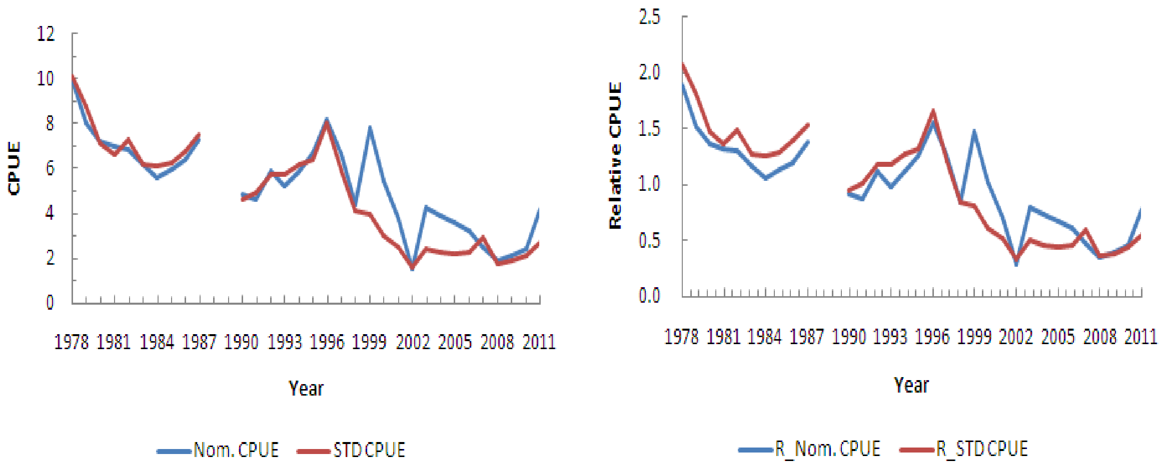

Fig. 4. Standardized (STD) and nominal CPUEs in real (left) and relative (right) scales for bigeye of Korean tuna longline fisheries in the Indian Ocean (1978-2011).

The ANOVA (type 3) results for the GLM are shown in Table 1, and it suggests that area and year effects are the largest factors affecting the nominal CPUE. Figs. 5, 6 and 7 show frequency distribution, Q-Q plots, and box plots of the standardized residuals, respectively. They indicate that the GLM applied in this study was not largely biased and the data fitted to the GLM fairly well.

Table 1. ANOVA results of the GLM for bigeye CPUE standardization

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	101	990.48378	9.80677	31.2	<.0001
Error	7214	2267.838	0.314366		
Corrected Total	7315	3258.3218			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.303986	34.13362	0.560684	1.642614

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Y	31	338.30655	10.913114	34.71	<.0001
Q	3	9.7806861	3.2602287	10.37	<.0001
A	1	21.450554	21.450554	68.23	<.0001
HBF	4	32.624833	8.1562081	25.94	<.0001
Y*A	31	45.529602	1.4686968	4.67	<.0001
Q*A	3	8.0508254	2.6836085	8.54	<.0001
Q*HBF	12	8.9891605	0.7490967	2.38	0.0046
A* HBF	4	3.5131088	0.8782772	2.79	0.0247
Q*A* HBF	12	9.0881735	0.7573478	2.41	0.0041

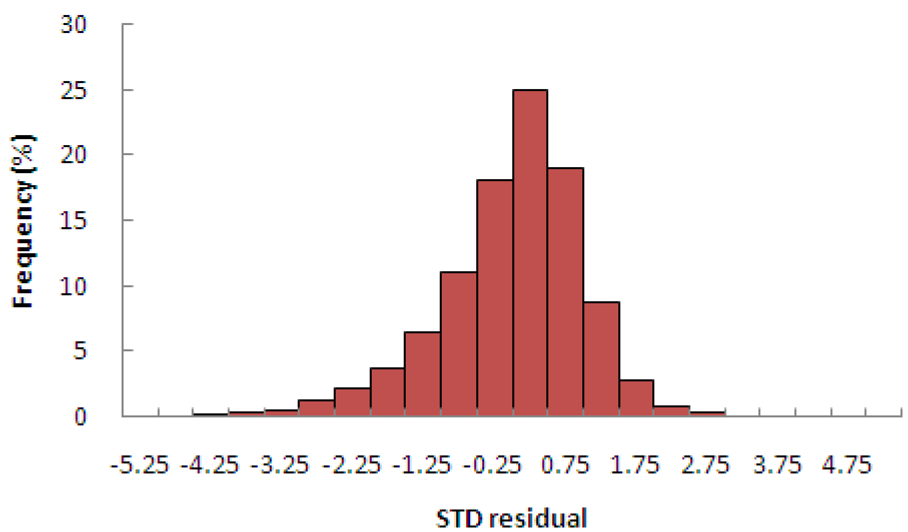

Fig. 5. Distribution of the standardized residual for the GLM analysis.

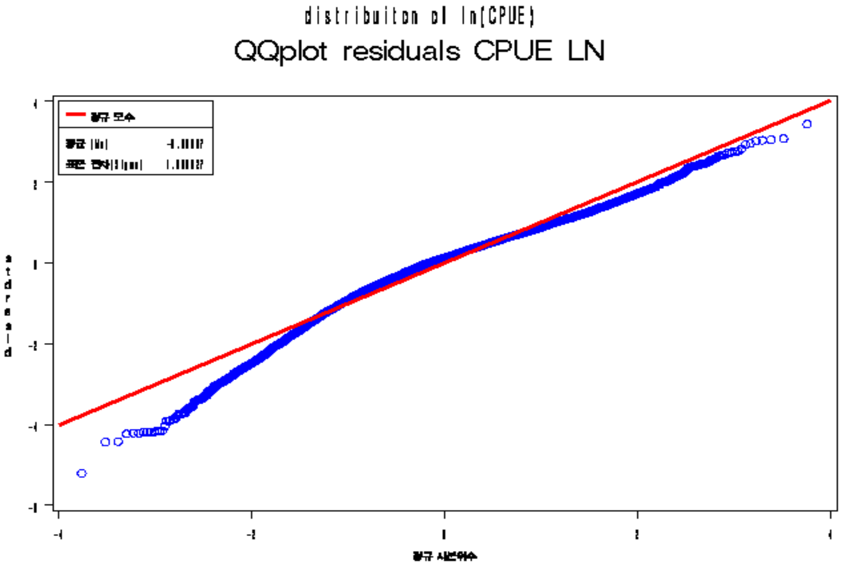

Fig. 6. QQ-plots of the standardized residual for the GLM analysis.

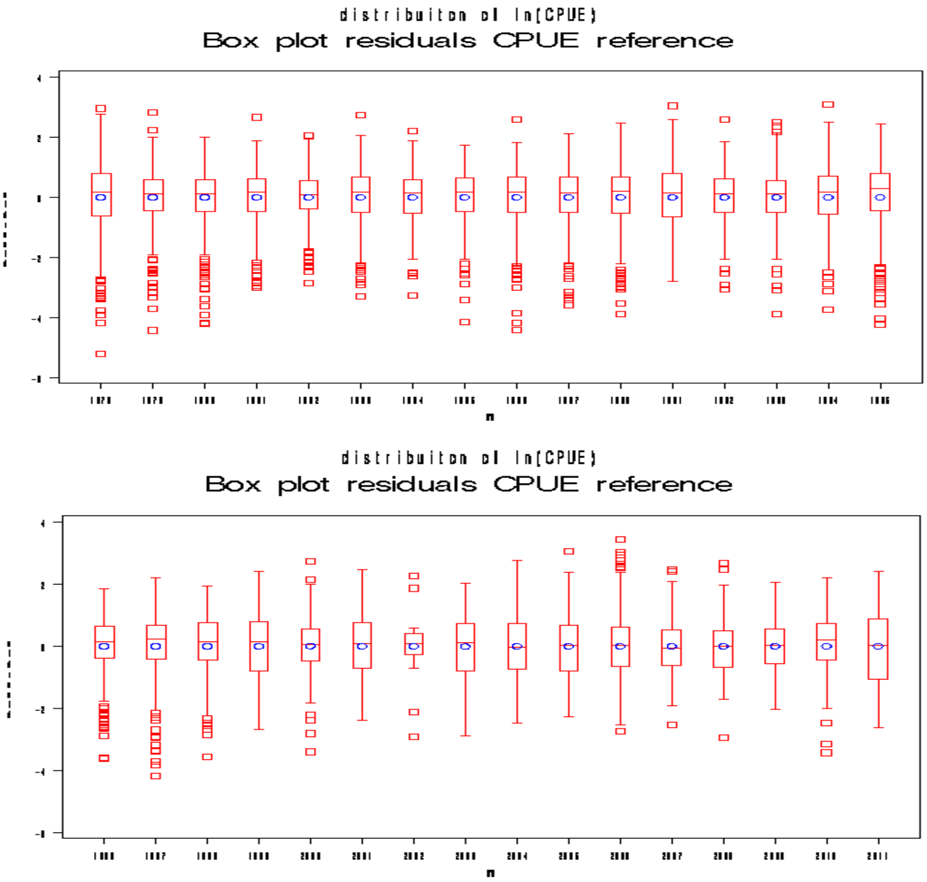

Fig. 7. Box plot of the standardized residual by year for the GLM analysis. Circle: mean, box: 25th and 75th percentile, horizontal line in the box: median, bars: maximum and minimum observation between 1.5 IQR (interquartile range) above 75th percentile and 1.5 IQR below 25th percentile, squares: outliers.

References

Okamoto, H. and H. Shono, 2006. Japanese longline CPUE for bigeye tuna in the Indian Ocean up to 2004 standardized by GLM applying gear material information in the model. IOTC-2006-WPTT-1, pp. 17.