Received: 9 & 15 October, 2012

CPUE standardization for yellowfin 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 yellowfin 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 showed the level of 3-4 from 1978 to 1987 except in 1980, but dropped to 2.3 in 1990. After then it had the declining trend with a fluctuation till 2002 when had the lowest value. And it showed somewhat of increasing in 2004 through 2007, but decreased again to 0.7 in 2008 and showed a low level in recent years.

Contents

1. Introduction

Yellowfin tuna in the Indian Ocean has been one of the highest catch in Korean tuna longline fisheries along with bigeye tuna. Yellowfin catch considerably increased from the mid-1960s and peaked at about 31 thousands mt in 1977, but had decreased with a fluctuation to a few hundred tons in recent years (Fig. 1). Yellowfin catch showed the similar trend to that of bigeye (Lee et al., 2012). In this study, yellowfin 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.

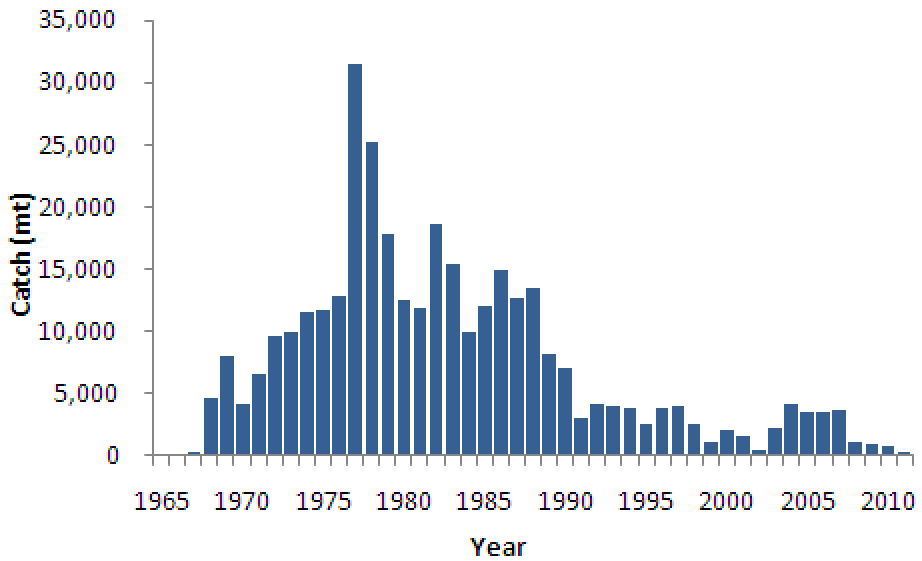

Fig. 1. Annual catch of yellowfin caught by Korean tuna longline fisheries in the Indian Ocean, 1966-2011 (data source: IOTC data base).

2. Data and Methods

2.1 Area

Based on the fishing patterns of Korean tuna longline fisheries, only 2 areas, that is, West (areas 1, 2 and 3) and East (areas 4 and 5) were used for standardizing yellowfin 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 91 was not used in this study.

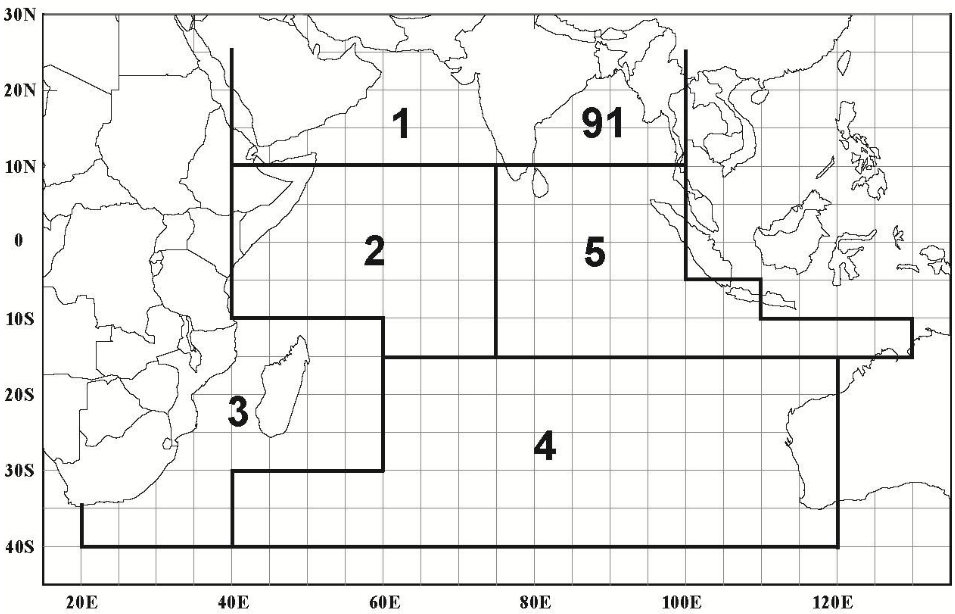

Fig. 2. Map showing areas used for yellowfin CPUE standardization of Korean tuna longline fisheries in the Indian Ocean (modified from Okamoto, 2011). (West=1+2+3, East=4+5).

2.2 Catch and effort data

Yellowfin 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) alike used in the bigeye CPUE standardization (Lee et al., 2012).

2.3 Generalized Linear Model (GLM)

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

$$\mathrm{Ln}(CPUE + c) = \mu + Y + Q + A + HBF + Y\times A + Q\times A + Q\times HBF + A\times HBF + Q\times A\times HBF + error$$

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

c : 10% of average overall nominal CPUE (0.42)

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. 3 shows the standardized (STD) CPUE trends for yellowfin with nominal CPUE in real and relative scales. The STD CPUE showed the level of 3-4 from 1978 to 1987 except in 1980, but dropped to 2.3 in 1990. After then it had the declining trend with a fluctuation till 2002 when had the lowest value. And it showed somewhat of increasing in 2004 through 2007, but decreased again to 0.7 in 2008 and showed a low level in recent years.

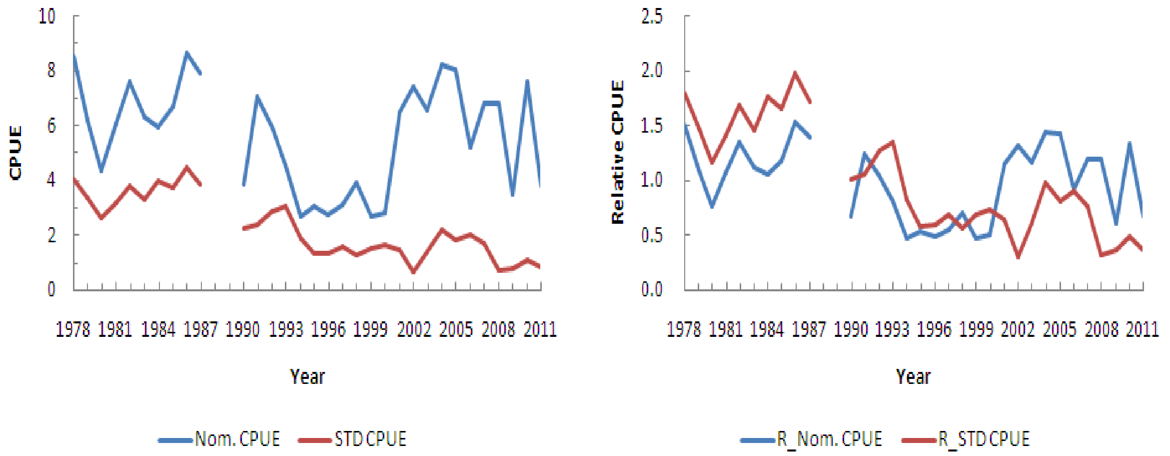

Fig. 3. Standardized (STD) and nominal CPUEs in real (left) and relative (right) scales for yellowfin of Korean tuna longline fisheries in the Indian Ocean (1978-2011).

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. 4, 5 and 6 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 yellowfin CPUE standardization

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	101	2672.7084	26.462459	50.76	<.0001
Error	7718	4023.9783	0.521376		
Corrected Total	7819	6696.6866			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.399109	60.45177	0.722064	1.194446

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Y	31	555.84683	17.930543	34.39	<.0001
Q	3	8.4223561	2.807452	5.38	0.0011
A	1	89.575352	89.575352	171.81	<.0001
HBF	4	16.795411	4.1988527	8.05	<.0001

Y*A	31	207.35173	6.6887656	12.83	<.0001
Q*A	3	15.501358	5.1671192	9.91	<.0001
Q*HBF	12	49.163165	4.0969304	7.86	<.0001
A*HBF	4	78.763908	19.690977	37.77	<.0001
Q*A*HBF	12	8.3112089	0.6926007	1.33	0.1942

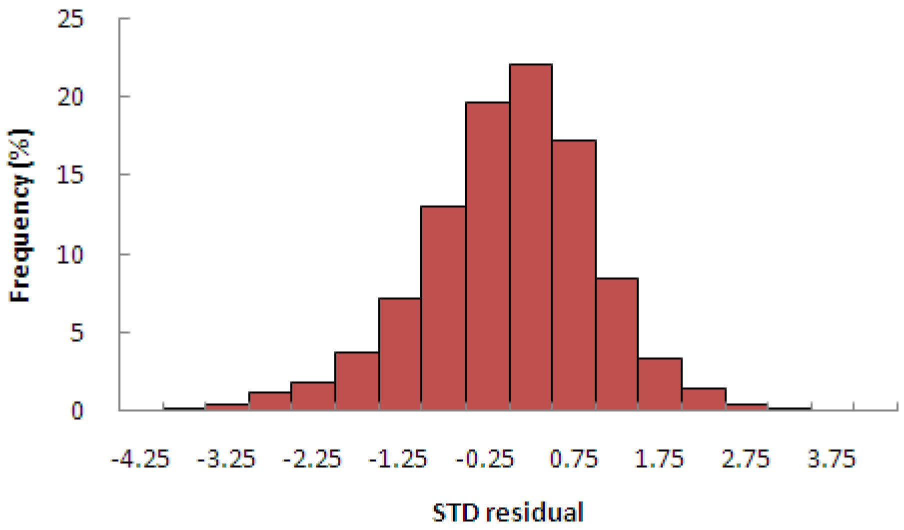

Fig. 4. Distribution of the standardized residual for the GLM analysis.

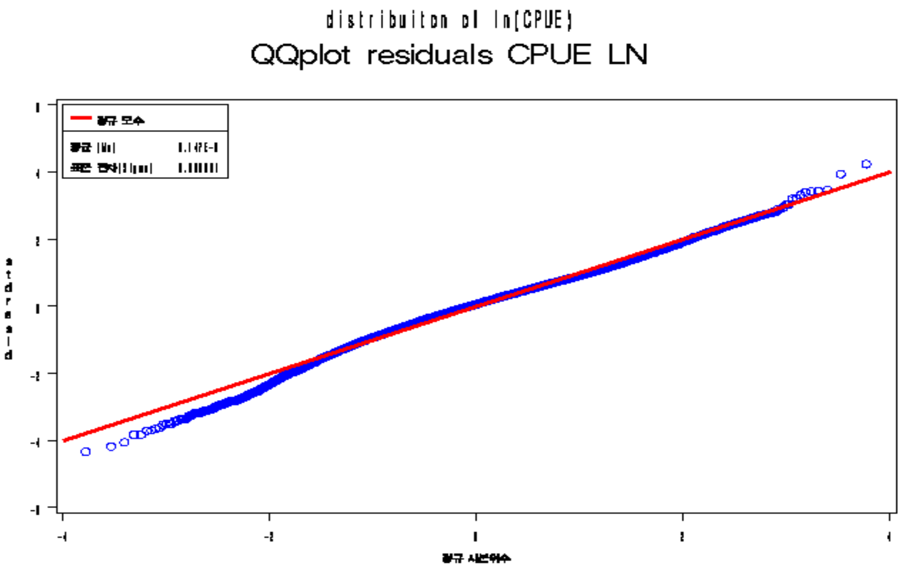

Fig. 5. QQ-plots of the standardized residual for the GLM analysis.

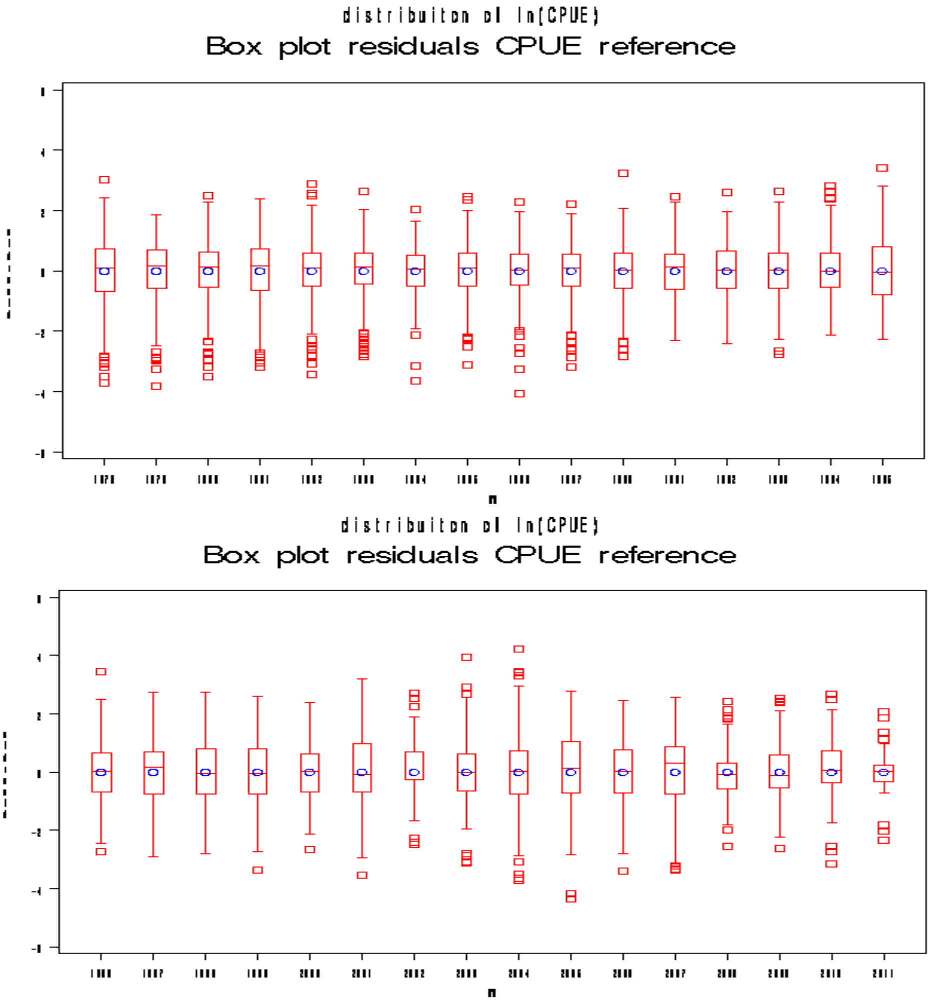

Fig. 6. Box plot of the standardized residual by year for the GLM analysis. Circle: mean, box: 25th and 75th percentile, horizontal line in the box: median, bars: maximum and minimum observation between 1.5 IQR (interquartile range) above 75th percentile and 1.5 IQR below 25th percentile, squares: outliers.

References

Lee, S.I., Z.G. Kim, M.K. Lee, D.-W. Lee and T. Nishida, 2012. CPUE standardization for bigeye tuna caught by Korean tuna longline fisheries in the Indian Ocean (1978-2011). IOTC-2012-WPTT14-25, 1- 8.

Okamoto, H., 2011. Japanese longline CPUE for yellowfin tuna in the Indian Ocean up to 2010 standardized by general linear model. IOTC-2011-WPTT13-34, 1-45.