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(Revised title)

Bigeye tuna CPUE standardization of the Korean tuna longline fisheries in the Indian Ocean (1977-2009)

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Abstract

CPUE standardization for bigeye tuna of the Korean longline fisheries in the Indian Ocean was conducted by GLM using fisheries data (1977-2009), i.e., catch (number), effort (number of hooks) and number of hooks between floats (NHF) by year, month and 5°× 5° (Lat. and Long.) area. Explanatory variables for the GLM analysis are year, quarter, area and NHF. Standardized (STD) CPUE showed the declining trend in general except one jump in 1996. STD CPUE between Korea and Japan are similar, while STD CPUE of Taiwan shows the flat trend, which is different from those of Korea and Japan. This difference is likely caused by the fact that Taiwan used species ratios as for the targeting correction factor, while Korea and Japan, number of hooks between float. This is the first attempt to estimate the India Ocean bigeye tuna STD CPUE of the Korean tuna longline fisheries. As we have some difficulty to run GLM by R program (initial attempt) due to the large number in the data set, we switched to SAS to run GLM analyses. We need some suggestion how to run GLM for a large number of the data set by R.

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1. Introduction

Bigeye tuna in the Indian Ocean has been one of the highest catch in the Korean tuna longline fisheries along with yellowfin tuna. Bigeye catch considerably increased from the beginning of the mid-1960s and peaked at about 34 thousands mt in 1978, but had decreased with fluctuation to a few hundred tons in recent years (Fig. 1). In this study, bigeye CPUE standardization of the Korean longline fisheries in the Indian Ocean (1977-2009) was conducted using Generalized Linear Model (GLM) by R program to assess the proxy of the abundance index.

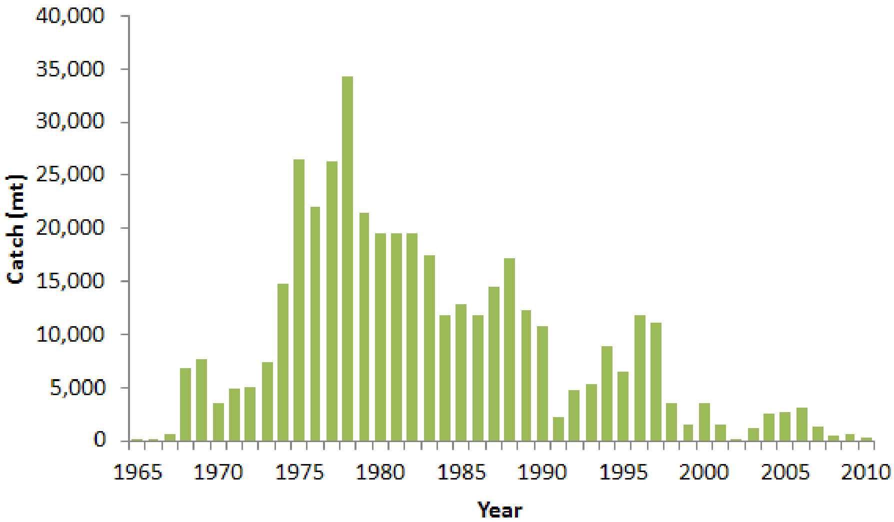


Fig. 1. Annual catch of bigeye caught by the Korean tuna longline fisheries in the Indian Ocean (data source: IOTC database).

2. Data and Methods

2.1 Area

Based on the area defined by Okamoto and Shono (2006), only two areas were used for bigeye CPUE standardization of the Korean tuna longline fisheries, i.e., East (areas 1, 3 and 6) and West (areas 2, 4, 5 and 7) (Fig. 2). This was because there were insufficient number of fisheries data in areas 1, 2, 5, 6 and 7. Area 67 was not used in this study.

2.2 Catch and effort data

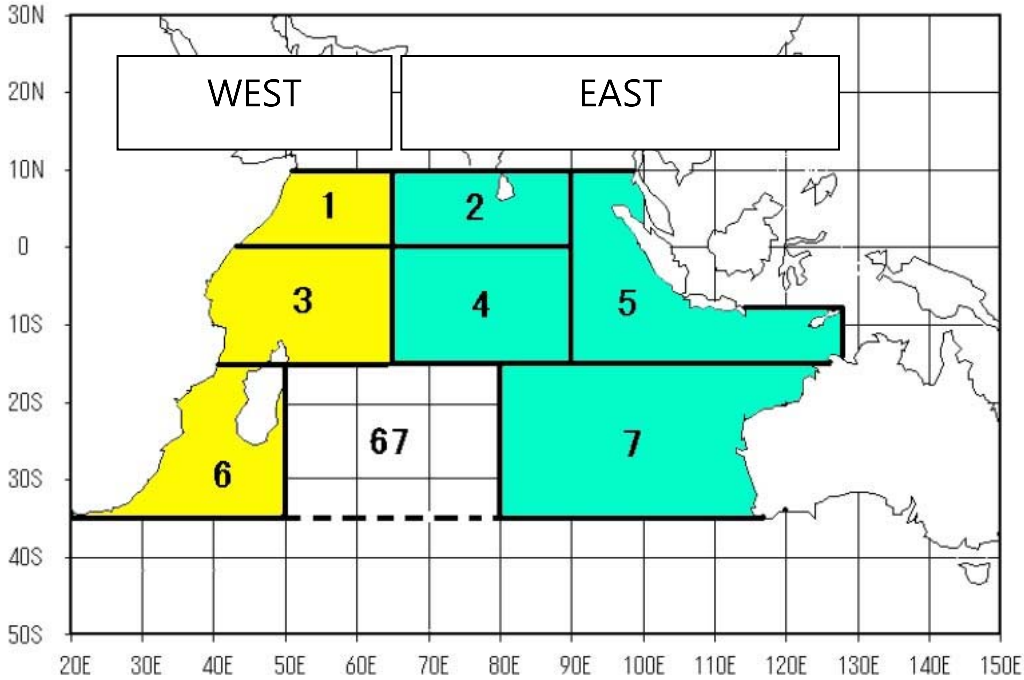


Fig. 2. Map showing two areas (West=1+3+6 and East=2+4+5+7) used for the bigeye CPUE standardization of the Korean longline fisheries in the Indian Ocean.

Bigeye catch (number) and effort (number of hooks), NHF (number of hooks between floats) by year, month and Lat. 5°×Long. 5° area for the Korean tuna longline fisheries (1977-2009) were used for the CPUE standardization. The data before 1976 was not used because there was no 5°×5° catch and effort information. In addition, the targeting factor (NHF) was not available in 1988-1989, hence the data in these two years were not included this study. The NHF was divided into 5 classes (class 1 : 4-7, class 2 : 8-10, class 3 : 11-13, class 4 : 14-16, class 5 : 17-20).

2.3 Generalized Linear Model (GLM) by R

Generalized Linear Model (GLM) available in the R program was initially applied for bigeye CPUE standardization (next page).

$$Ln(CPUE + c) = \mu + Y + Q + A + NHF + Q\times A + Q\times NHF + Y\times A + A\times NHF + error$$

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

c : 10% of average overall nominal CPUE

Y : effect of year

Q : effect of quarter (season)

A : effect of area (East and West)

NHF : effect of targeting (5 classes)

Q×A : interaction term between quarter and area

Q×NHF : interaction term between quarter and NHF

Y×A : interaction term between year and area

A×NHF : interaction term between area and NHF

error : error term

At the initial attempt, R could not accept the large number of the data set (n= 8,163). Then we reduced the number of the data set by making quarterly average data set (n=4,172) as the proxy of the GLM analyses as a reference. Appendix A shows the results. We need some suggestion how to handle GLM for the large data set.

2.4 Generalized Linear Model (GLM) by SAS

At the second trial we used SAS program for the same model stated in the previous section and we could obtain the results without any problem.

3. Results

Box 1 shows the ANOVA (type 3) table for the GLM results which suggest that year and area effect is the largest factor affecting the nominal CPUE. Fig 2 shows the estimated STD CPUE with 95% confidence interval which suggest that STD CPUE (1977-2009) generally shows the declining trend except one jump in 1996. Figs. 3-5 shows box plot, QQ-plots and percent frequency distribution of the standardized residuals respectively which suggested the data fit to the GLM fairly well.

Box 1 ANOVA Table

	DF	SS	Mean sq	F	Pr > F
Model	87	760.675159	8.743393	31.45	<.0001
Error	7386	2053.640075	0.278045		
Corrected Total	7473	2814.315234			

R2	CV	Root MSE	Mean CPUE
0.270288	31.29069	0.527300	1.685165

Type III

	DF	SS	Mean Sq	F	Pr > F
Y	30	298.4871948	9.9495732	35.78	<.0001
Q	3	14.5908094	4.8636031	17.49	<.0001
a	1	32.6453404	32.6453404	117.41	<.0001
G	4	19.4675670	4.8668917	17.50	<.0001
Q*a	3	20.7584638	6.9194879	24.89	<.0001
Q*G	12	4.7903710	0.3991976	1.44	0.1415
Y*a	30	27.0309717	0.9010324	3.24	<.0001
a*G	4	9.4497278	2.3624319	8.50	<.0001

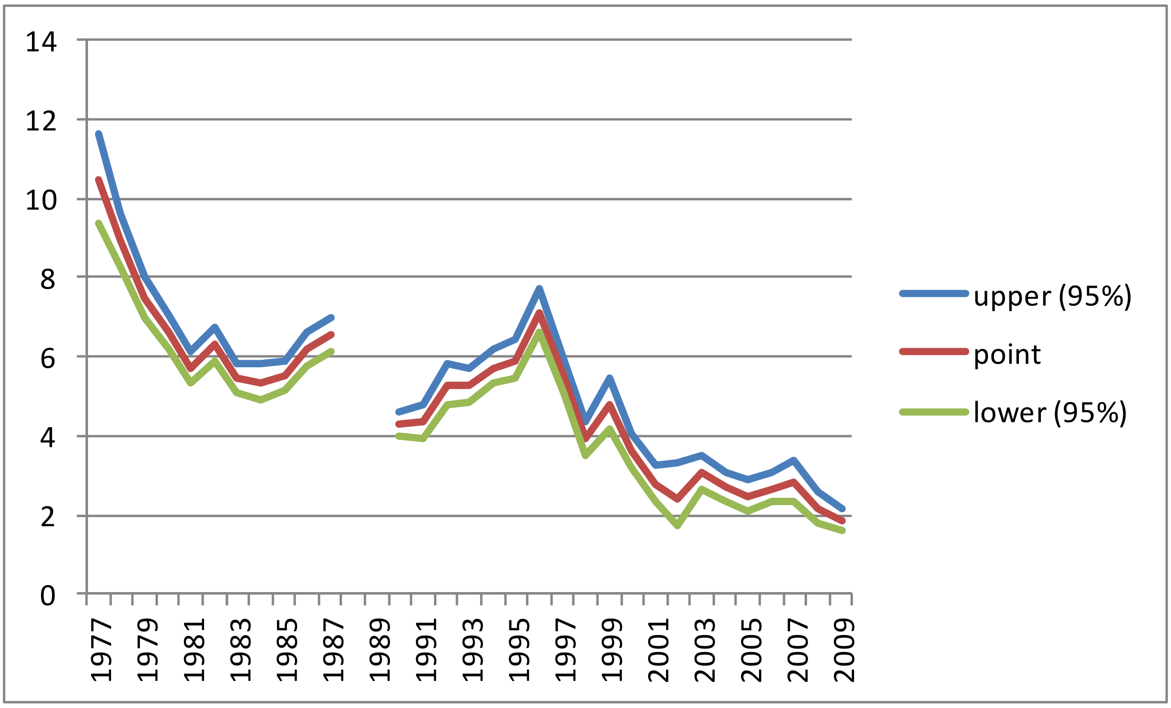
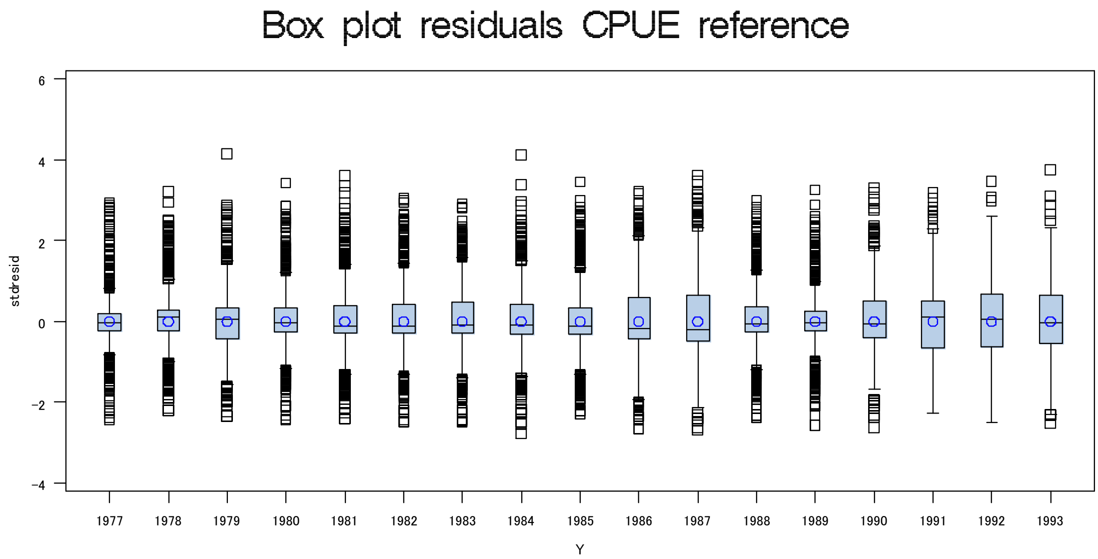


Fig.2 Estimated STD CPUE (1977-2009)



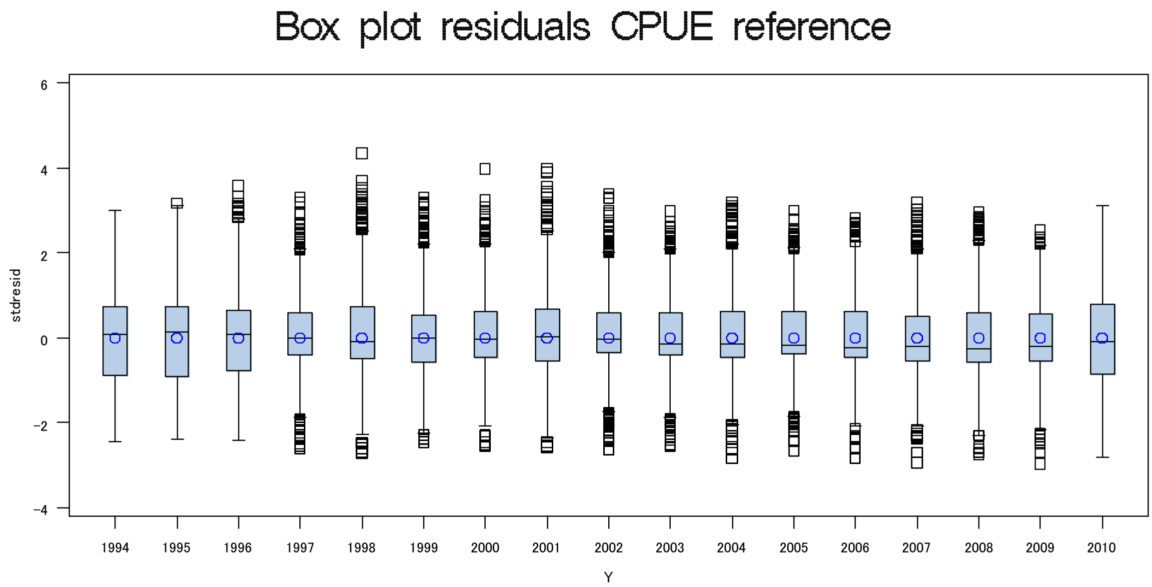


Fig. 3 Box plot of the standardized residual by year for the GLM analysis. Circle: mean, box: 25th and 75th percentile, horizontal line in the box: median, bars: maximum and minimum observation between 1.5 IQR (interquartile range) above 75th percentile and 1.5 IQR below 25th percentile, squares: outliers.

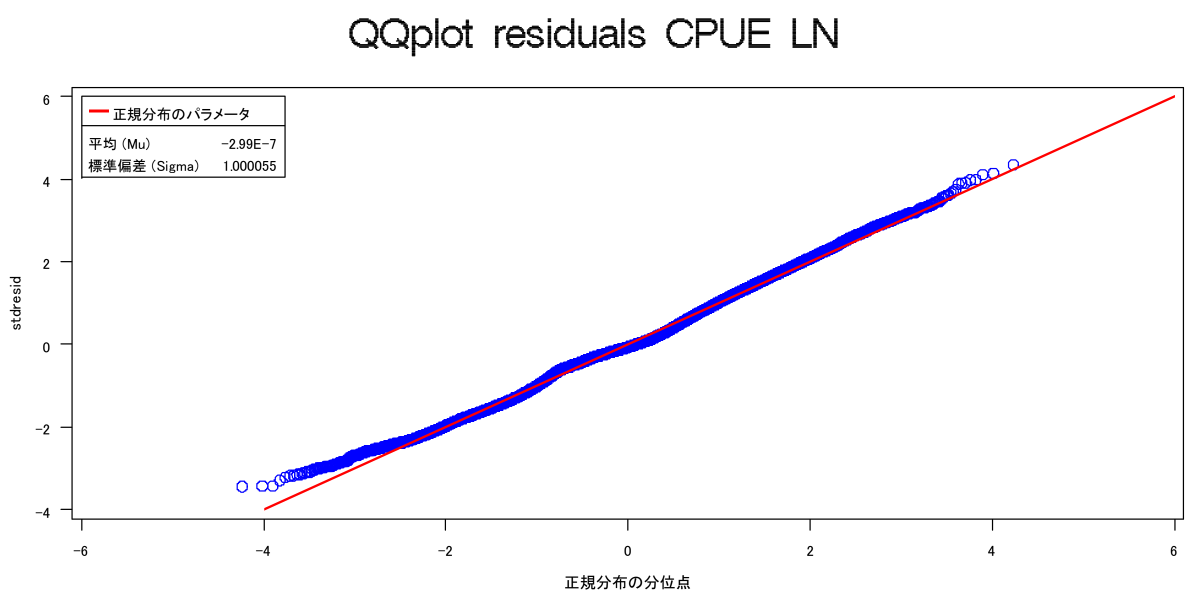


Fig. 4 QQ-plots of standardized residual.

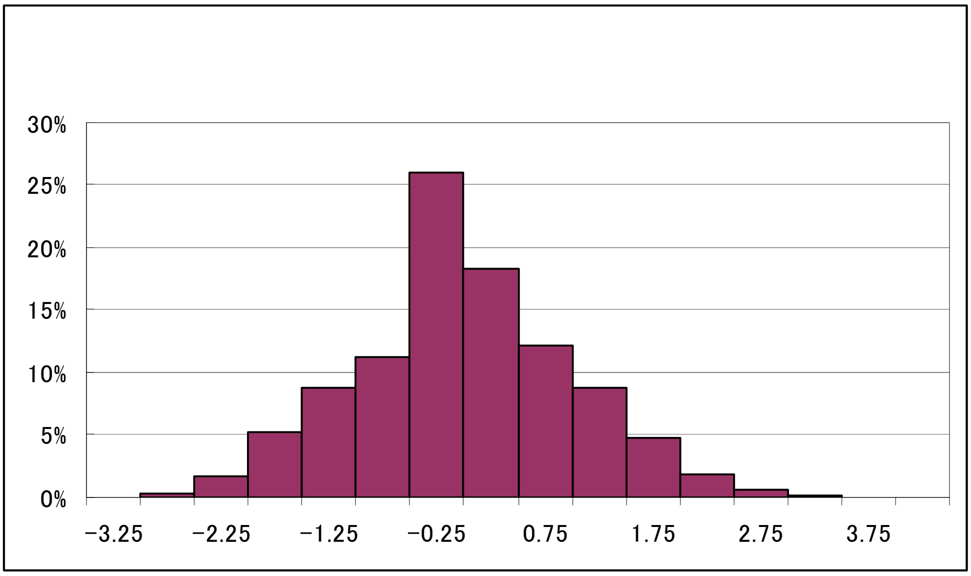


Fig. 5 Frequency distribution of the standardized residuals.

4. Discussion

This is the first attempt to estimate the India Ocean bigeye tuna STD CPUE of the Korean tuna longline fisheries. As we have some difficulty to run GLM by R program (initial attempt) due to the large number in the data set, we switched to SAS to run GLM analyses. We need some suggestion how to run GLM for a large number of the data set by R.

Comparisons of STD CPUE among Japan, Korean and Taiwan

Fig 6 shows comparisons of estimated STD CPUE among Japan, Korean and Taiwan. Both Japanese and Taiwanese STD CPUE show decreasing trend (1977-2009) in general except a big jump in the mid 1990's in Korean STD CPUE. However Taiwan STD CPUE shows the constant trend in general which are different from those of Japan and Korea. This difference is likely caused by the fact that Taiwan used species ratios as for the targeting correction factor, while Korea and Japan, number of hooks between float.

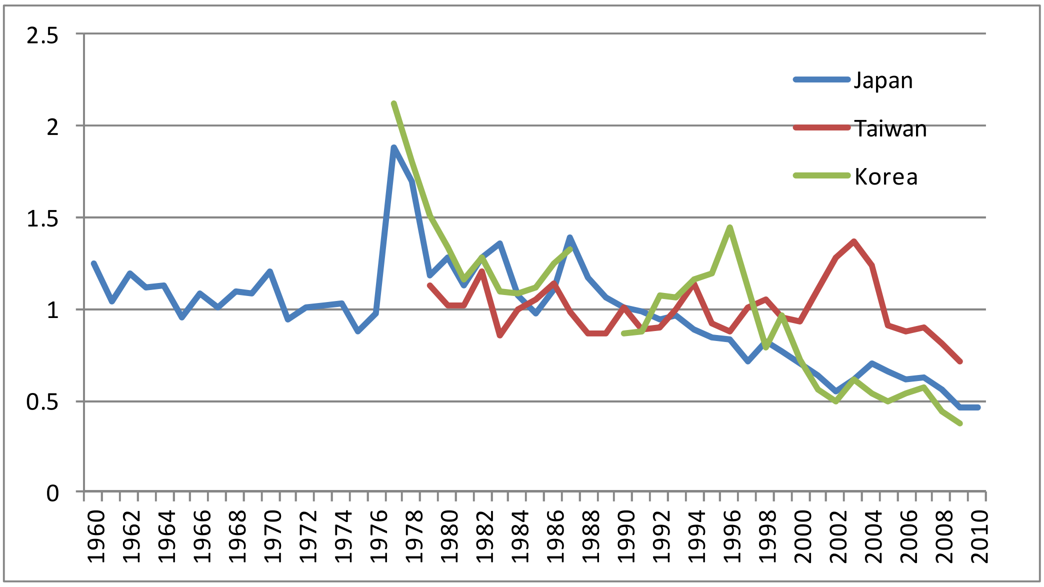


Fig. 6 Comparisons of STD CPUE among Japan, Korean and Taiwan in the whole Indian Ocean

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.

Appendix A: Results of GLM by R

Table 1 shows results of ANOVA of GLM for bigeye CPUE standardization. F-test showed that effects of all explanatory variables except A×NHF and Q×NHF were significant. Fig. 7 shows the standardized CPUE for bigeye of the Korean longline fisheries in the Indian Ocean (1977-2009). It suggests that the highest level was 12 in 1977, since then decreases to approximately 6 in 1980s-1990s and from 2000 further decreased to the level less than 5 in recent years.

Table 1. ANOVA table of GLM for bigeye CPUE standardization

Factor	DF	Deviance	F value	Pr > F
Y	30	12,589	50.2146	<0.0001
Q	3	709.2	28.2858	<0.0001
A	1	1834.4	219.4963	<0.0001
NHF	4	307.2	9.1903	<0.0001
Q×A	3	380.8	15.1903	<0.0001
Y×A	30	746.4	2.9771	<0.0001
A×NHF	4	111.5	3.3346	0.0098
Q×NHF	12	111.4	1.1113	0.3454

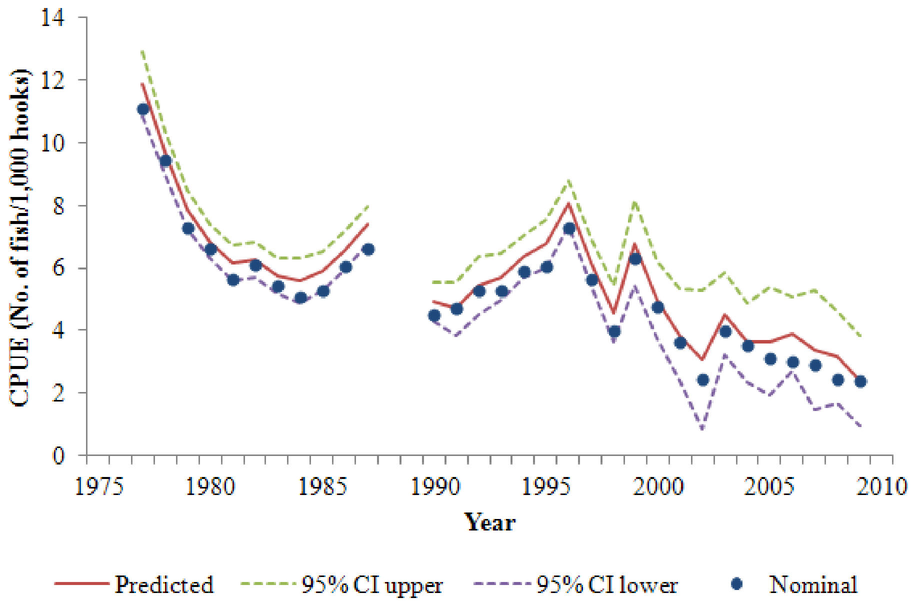


Fig. 7 Standardized CPUE for bigeye of the Korean tuna longline fisheries in the Indian Ocean (1977-2009).

Fig 8 shows the diagnostics of the GLM analyses. The Normal Q-Q plot showed that residuals in the right side in X-axis departed from the normal distribution. The scale-location plot showed some departures from constant variance of residuals. The residuals versus leverage plot showed that while some observations had high leverage, they were reasonably well fitted.

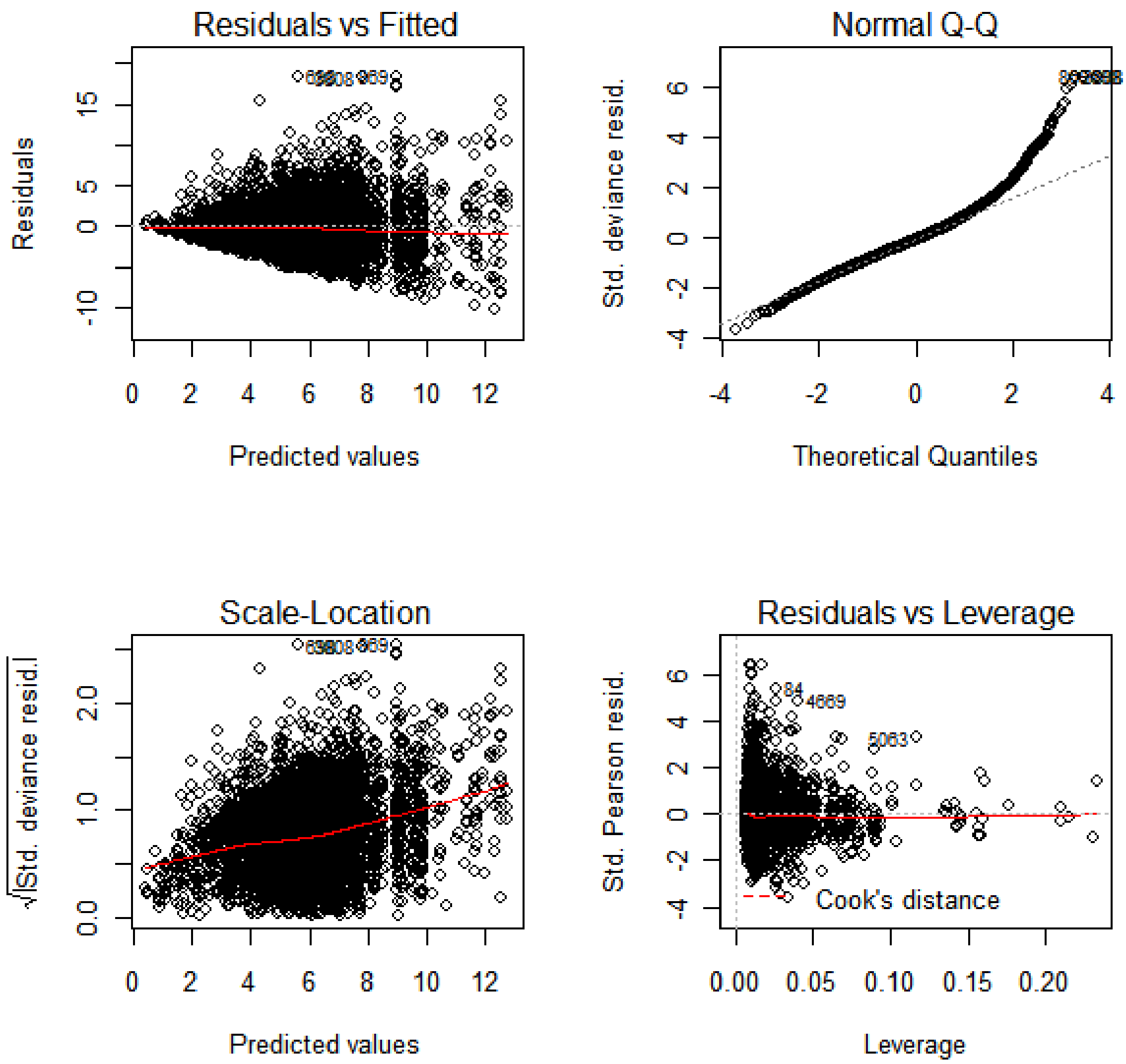


Fig. 8 GLM diagnostic plots for bigeye CPUE standardization of the Korean longline fisheries in the Indian Ocean (1977-2009).