Received: 12 & 19 August, 2012
IOTC–2012–WPTmT04–17 Rev_1

Standardization of albacore catch rates of Korean tuna longline fisheries in the Indian Ocean (1986-2010)

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Abstract

CPUE standardization for albacore of Korean longline fisheries in the Indian Ocean was conducted by GLM using fisheries data (1986-2010), i.e., catch (number), effort (number of hooks) and number of hooks between floats (HBF) by year, month and 5°× 5° (Lat. and Long.) area. Albacore standardized CPUE showed the declining trend from the mid-1980s to the beginning of 2000s, and started to increase thereafter. Albacore standardized CPUE between Korea and Japan was similar, while Korean standardized CPUE showed a large increasing in 2010.

Contents

1. Introduction

Albacore has been one of major important commercial species of the Korean tuna longline fisheries in the Indian Ocean, Albacore catch had considerably increased from the mid-1960s and peaked at about 9 thousands mt in 1973 and 1974, but had sharply decreased to below a hundred tons and has increased about 4 hundreds in recent years (Fig. 1). In this study, albacore CPUE standardization of Korean tuna longline fisheries in the Indian Ocean (1986-2010) was conducted using Generalized Linear Model (GLM) to assess the proxy of the abundance index.

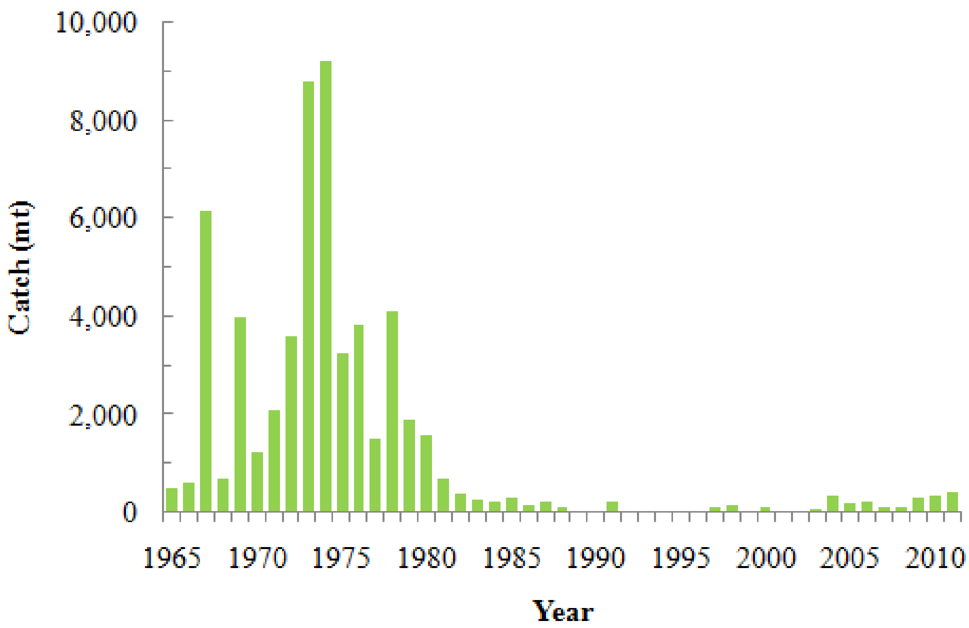

Fig. 1. Annual catch of albacore caught by the Korean tuna longline fisheries in the Indian Ocean (data source: IOTC data base).

2. Data and Methods

2.1 Area

Based on the fishing patterns of Korean tuna longline fisheries and biology for albacore, only 2 areas (modified from Matsumoto and Uosaki, 2011), that is, Areas 1 and 2 were used for standardizing albacore CPUE of the Korean tuna longline fisheries (Fig. 2). Another significant reason to reduce to 2 large areas is that if we used 8 sub areas, there were a lot of missing values (no operations) in some sub areas in some seasons, which make it difficult to run GLM.

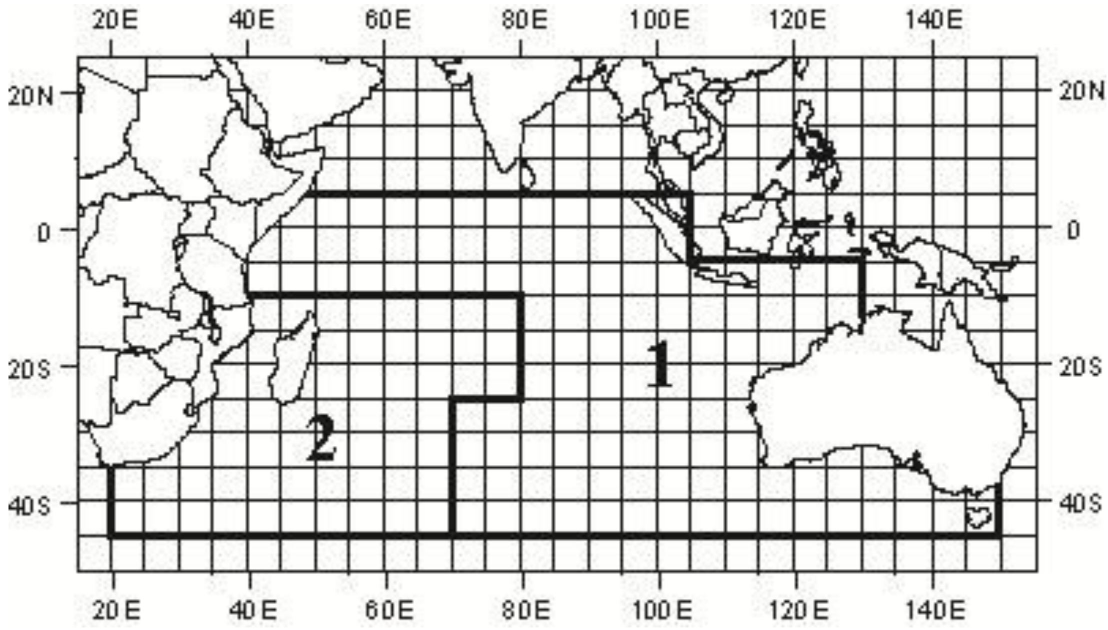

Fig. 2. Map showing areas used for the albacore CPUE standardization of Korean tuna longline fisheries in the Indian Ocean (modified from Matsumoto and Uosaki, 2011).

2.2 Catch and effort data

Albacore catch (number) 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 (1986-87, 1990-2010) were used for the CPUE standardization. The data before 1985 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 in these two years were not included this study. The HBF was divided into 4 classes (class 1 : 5-8, class 2 : 9-14, class 3 : 15-17, class 4 : 18-22) based on the fishing operational pattern of Korean tuna longline fisheries (Fig. 3) (Kim et al., 2012).

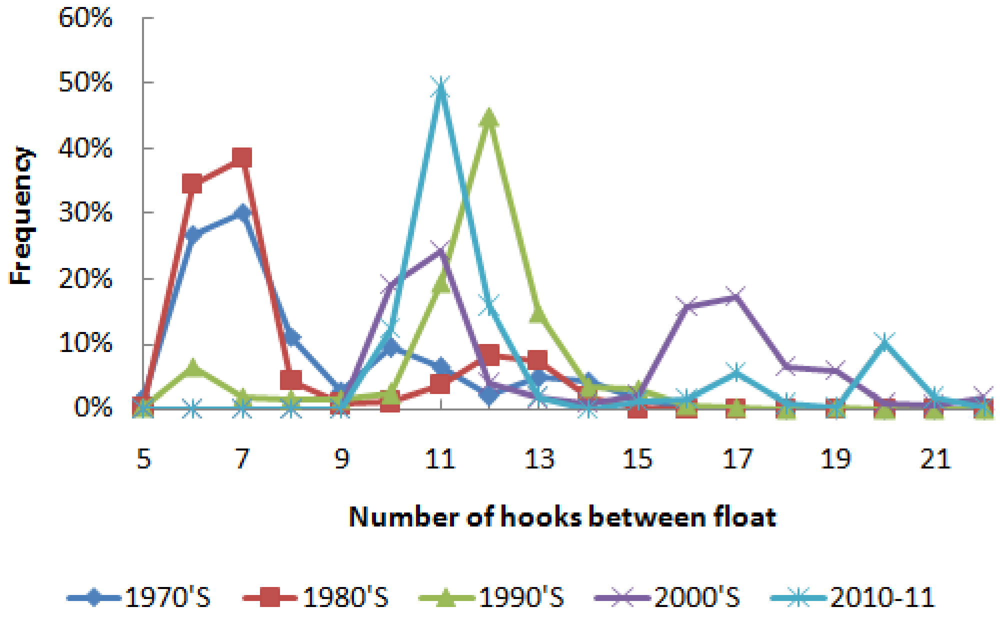

Fig. 3. Changes in the number of hooks between float (HBF) used in Korean tuna longline fisheries by decade.

2.3 Generalized Linear Model (GLM)

Generalized Linear Model (GLM) for albacore 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 albacore per 1,000 hooks

c : 10% of average overall nominal CPUE (0.15)

Y : effect of year

Q : effect of quarter (season)

A : effect of area (Areas 1 and 2)

HBF : effect of targeting (4 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

The ANOVA (type 3) results for the GLM are shown in Table 1, and it suggests that year, area and HBF effects are the largest factors affecting the nominal CPUE. Fig. 4 shows the estimated STD CPUE with 95% confidence interval. The albacore standardized CPUE had decreased from 1986 to the beginning of 2000s, but it showed the increasing trend thereafter (Fig. 4). Figs. 5, 6 and 7 shows 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 albacore CPUE standardization

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	75	1949.1463	25.988617	22.58	<.0001
Error	4351	5007.7138	1.150934		
Corrected Total	4426	6956.8601			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.280176	-211.5419	1.072816	-0.507141

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Y	22	376.01324	17.091511	14.85	<.0001
Q	3	3.4548644	1.1516215	1	0.3915
A	1	36.815208	36.815208	31.99	<.0001
HBF	3	57.778322	19.259441	16.73	<.0001
Q×A	3	25.572203	8.5240676	7.41	<.0001
Q×HBF	9	39.127816	4.3475351	3.78	<.0001
A×HBF	3	20.803054	6.9343513	6.02	0.0004
Y×A	22	234.19649	10.645295	9.25	<.0001
Q×A×HBF	9	54.750936	6.0834373	5.29	<.0001

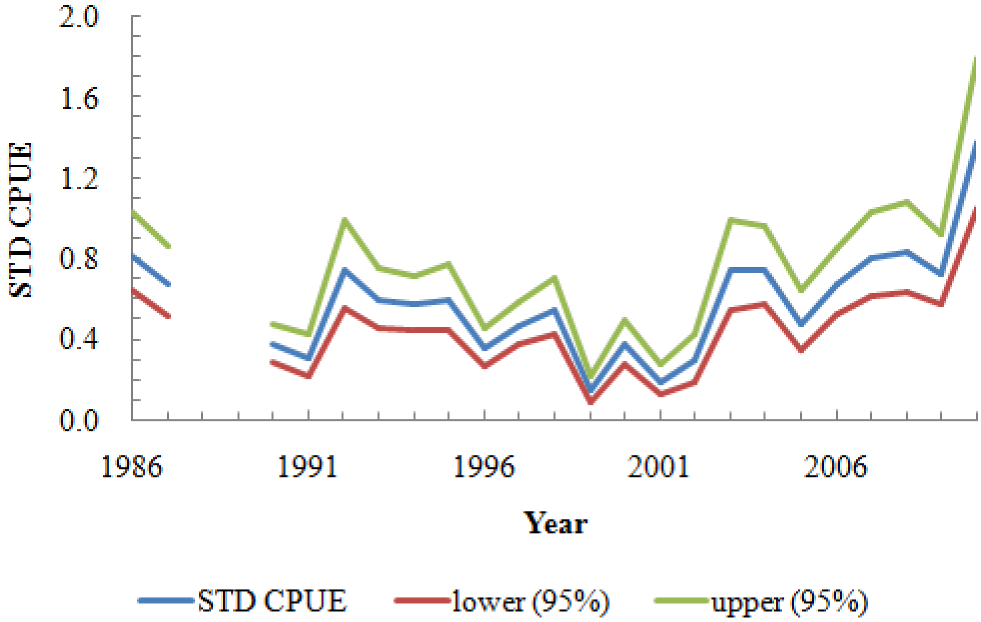

Fig. 4. Standardized CPUE with 95% confidence interval for albacore of Korean tuna longline fisheries in the Indian Ocean (1986-87 and 1990-2010).

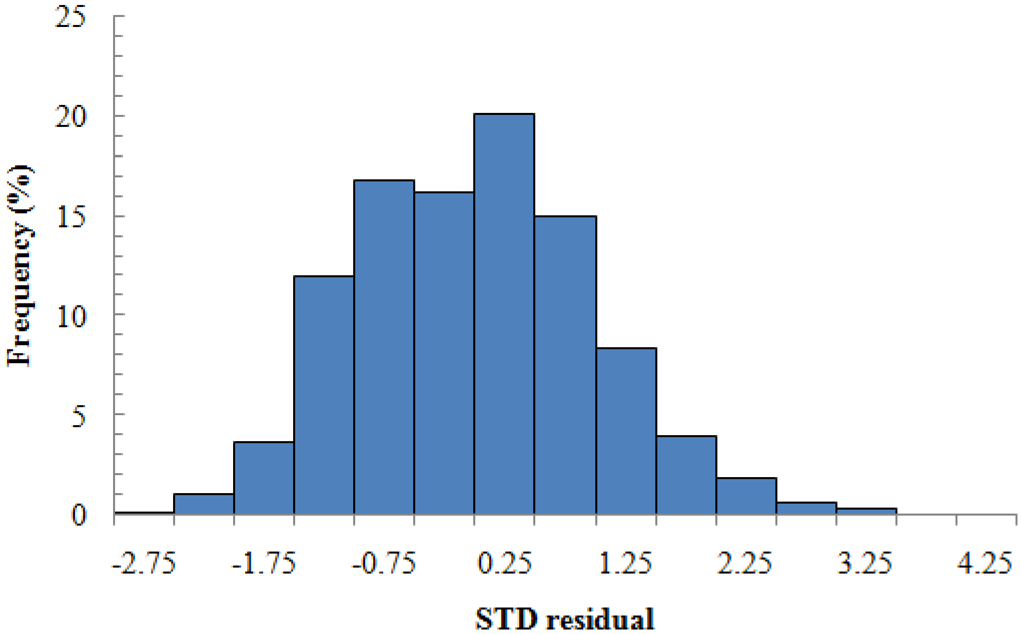

Fig. 5. Distribution of the standardized residual for the GLM analysis.

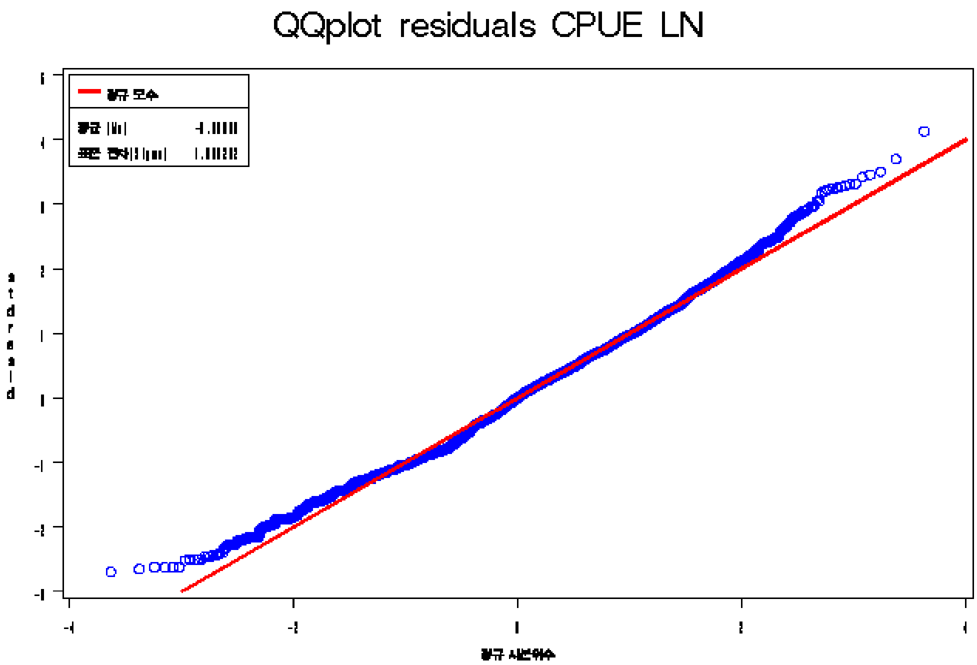

Fig. 6. QQ-plots of the standardized residual for the GLM analysis.

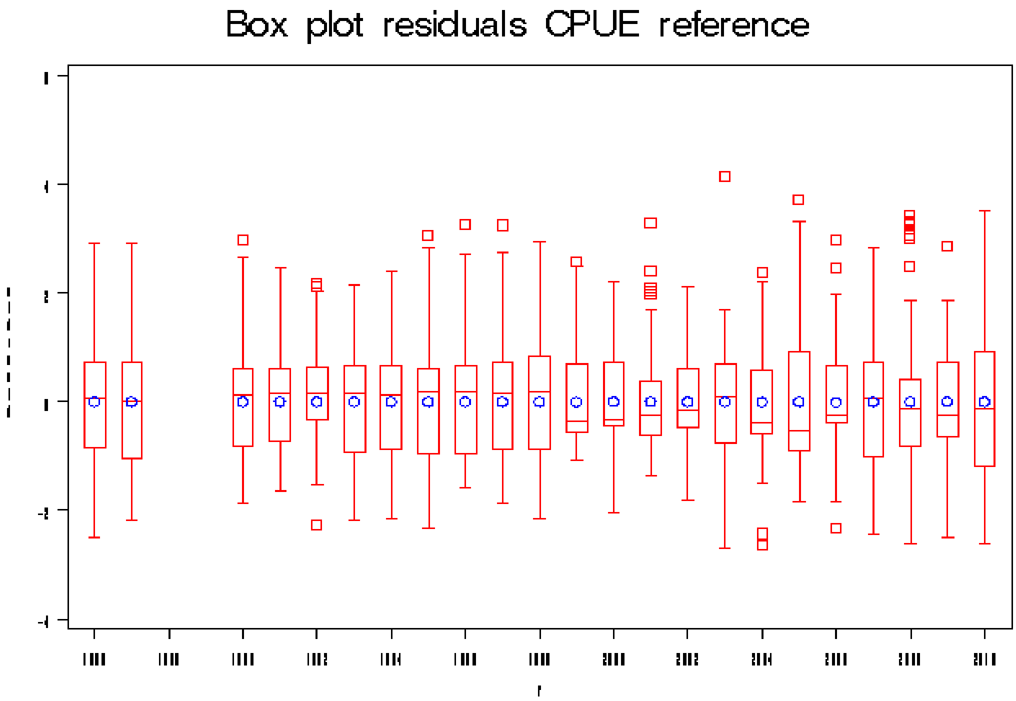

Fig. 7. Box plot of the standardized residual by year for the GLM analysis. Circle: mean, box: 25th and 75th percentile, horizontal line in the box: median, bars: maximum and minimum observation between 1.5 IQR (interquartile range) above 75th percentile and 1.5 IQR below 25th percentile, squares: outliers.

Fig. 8 shows comparisons of the standardized CPUE estimates among Korea and Japan. Both Korean and Japanese standardized CPUE showed decreasing trend from the mid-1980s to the beginning of 2000s, and they have increased thereafter. But Korean standardized CPUE showed a largely increasing in 2010. This is because the Korean tuna longline fisheries have targeted albacore since 2010 due to small TAC of southern bluefin tuna.

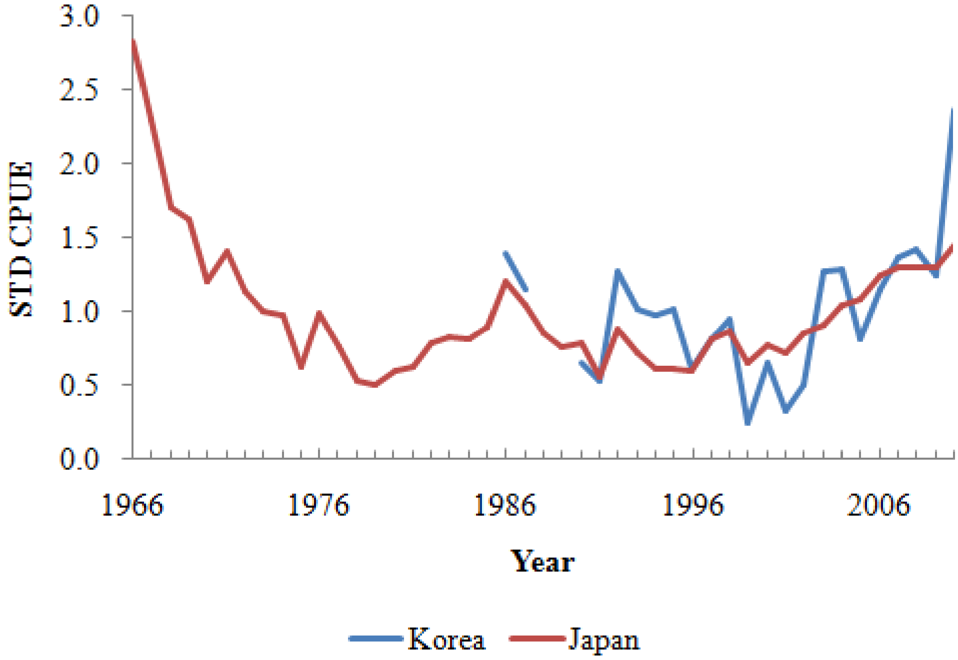

Fig. 8. Comparisons of albacore standardized CPUE between Korea and Japan in the whole Indian Ocean.

References

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Matsumoto, T. and K. Uosaki, 2011. Standardization of albacore CPUE by Japanese longline fishery in the Indian Ocean. IOTC–2011–WPTmT03–15, 1-10.

Appendix: Quarterly standardized CPUE

Table A1. ANOVA results of the GLM for quarterly CPUE standardization

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	141	2661.5014	18.875896	15.61	<.0001
Error	4657	5632.4441	1.209458		
Corrected Total	4798	8293.9455			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.320897	-171.9989	1.099753	-0.639396

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Y	22	475.04507	21.592958	17.85	<.0001
Q	3	8.9533506	2.9844502	2.47	0.0602
A	1	30.290069	30.290069	25.04	<.0001
HBF	3	54.869453	18.289818	15.12	<.0001
Q×A	3	31.202264	10.400755	8.6	<.0001
Q×HBF	9	90.227635	10.025293	8.29	<.0001
A×HBF	3	17.614972	5.8716573	4.85	0.0023
Y×A	22	274.69017	12.485917	10.32	<.0001
Q×A×HBF	9	55.375173	6.1527969	5.09	<.0001
Y×Q	66	482.97535	7.3178084	6.05	<.0001

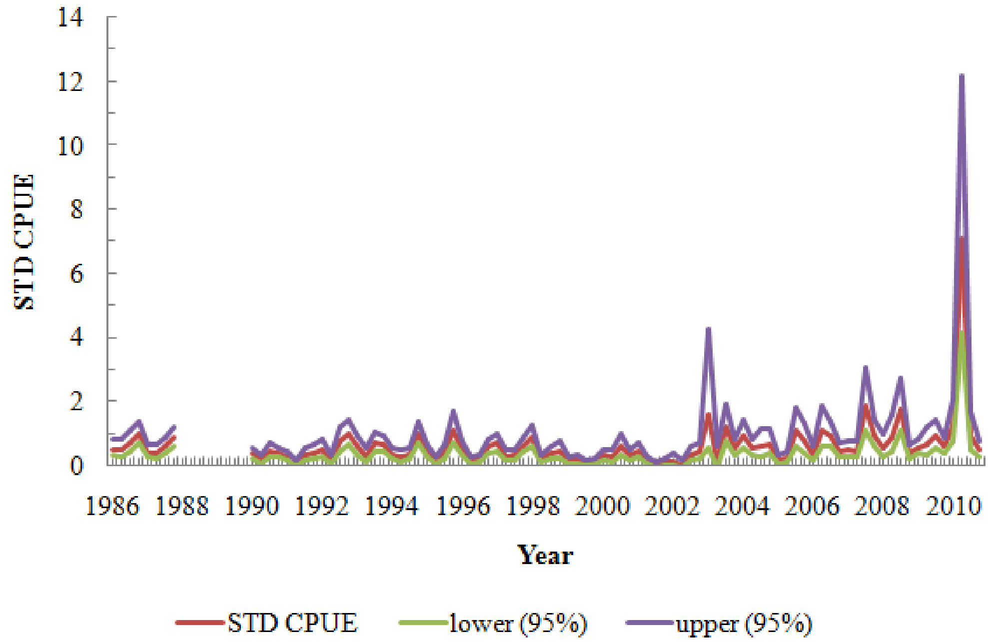

Fig. A1. Quarterly standardized CPUE with 95% confidence interval for albacore of Korean tuna longline fisheries in the Indian Ocean (1986-87 and 1990-2010).