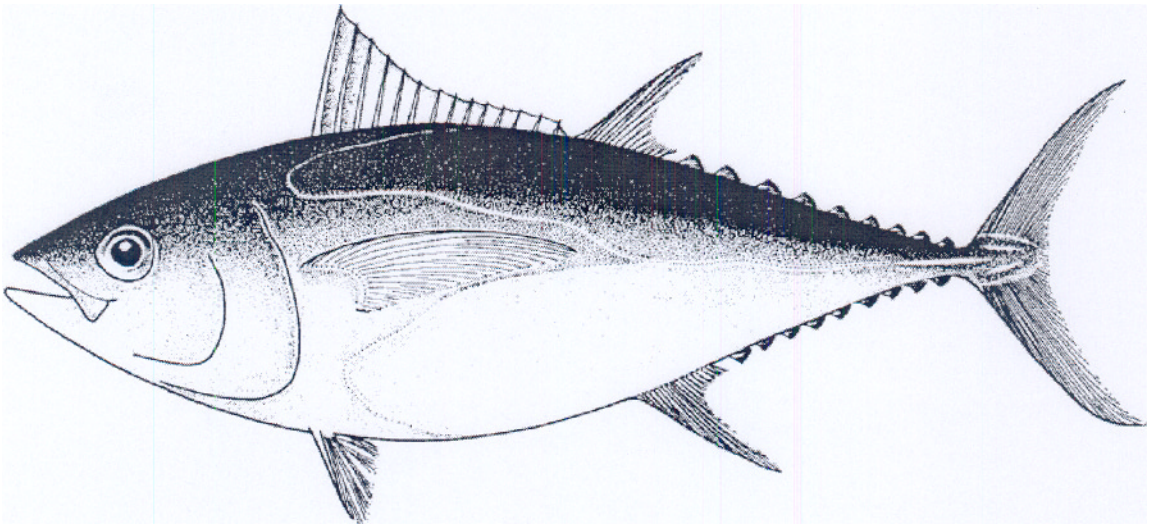
SCTB 14 Working Paper

BET-5

Updated CPUE of Central and Western Pacific Bigeye Tuna From Taiwanese Tuna Longline Fisheries



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Introduction

Taiwan's distant-water tuna longline vessels have been fishing in the Pacific Ocean since 1963. They primarily target albacore but also land significant numbers of yellowfin and bigeye tuna (Sun and Yeh 1992, 1993, 1994, 1997, 1998a, 1998b, 1999,2000). Taiwan's offshore tuna longline fleets based in the fishing ports of western Pacific Island countries have been fishing in the western Pacific since 1988. They target primarily yellowfin and bigeye tuna (Sun and Yeh 1998a, 1999,2000). The purpose of this paper is to update the standardized catch per unit effort (CPUE) series provided by Sun and Yeh (2000) for bigey~: tuna caught by these two fleets. The general linear modeling technique was applied to estimate annual CPUE's of the distant-water and offshore longline data for the periods 1967-1999 and 1980-1999, respectively.

Materials and Methods

Catch was represented as the number of fish taken and effort was expressed in number of hooks used. These variables were presented by month in a 5°x 50 square area during the period 1967-1999 for the distant-water longline fishery, and during the period 1985-1999 for the offshore longline fishery. The nominal CPUE value represented catch in number of big eye per 1000 hooks.

The main variables chosen to implement the general linear model (GLM) analyses (Kimura 1981, Allen and Punsly 1984, Draper and Smith 1981) were year, month, and WPYF area for both fisheries.

The multiplicative model used in this analysis for both fisheries is

$$\ln (CPUE_{ijk}+1) = \mu + Y_i + M_j + A_k + interactions + \varepsilon_{ijk}$$

where

ln	is the natural logarithm;
$CPUE_{ijk}$	is the nominal catch rate (no. of fish / 1000 hooks) in year i, month j, and WPYF area k;
μ	is the overall mean;
Y_i	is year i;
M_j	is month j;
A_k	is WPYF area k;
interactions	is the two-way interactions among main effects except year;
ε_{ijk}	is the error term, NID $(0,\sigma^2)$.

Data preparation and calculation employing SAS Statistical Software, Version 6.12, were performed on personal computer.

Results and Discussion

Distant-water longline fishery

The total number of observations for this analysis was 8,745. The frequency distribution of the standardized residuals for all variables combined effects is approximately close to that of the normal distribution (Fig. 1a).

The results of using the GLM analysis of variance (ANOVA) to examine the logged catch rate for differences among variables (year, month, area) are shown in Table 1. All of the main variables as well as the whole model are statistically significant ($p<0.01$). The fraction of sum of squares explained by the model (i.e. R^2) is 0.32.

Figure 1b shows the least square mean (LSM) estimates of annual CPUE (standardized CPUE) and the nominal CPUE. There is a downward trend of standardized CPUE from 2.53 to 0.26 fish per thousand hooks during the period from 1967 to 1988. The CPUE increased in 1989 and then maintained stable between 0.56 and 0.72 fish per thousand hooks during 1989-1992. The CPUE decreased to 0.34 fish per thousand hooks in 1993 and thereafter fluctuated between 0.44 and 0.26 fish per thousand hooks.

The nominal CPUE have a similar trend although the nominal CPUE were generally higher than the standardized CPUE, especially in the years before 1977 and during 1989-1991.

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The total number of observations for this analysis was 2,360. The results of ANOV A for the final model are shown in Table 2. All of the main variables as well as the whole model are statistically significant (p<O. 0 1). The rate of variability explained by the model (i.e. R1 was fairly low (0.17). The overall distribution of standardized residual (Figure 2a) is close to the normal curve.

Figure 2b shows the trend of standardized and nominal CPUE. The nominal CPUE is always higher than standardized CPUE. The standardized CPUE increased gradually from 0.57 fish per thousand hooks in 1986 to the maximum of3.68 fish per thousand hooks in 1993. Since then, the CPUE decreased gradually and reduced to 1.5 fish per thousand hooks in 1999.

The CPUE for the offshore longline fishery was several times higher than the CPUE for distant-water longline fishery. The reasons are that bigeye tuna is the target species by offshore longline fleets while the albacore is the target species by distant-water longline fleet.

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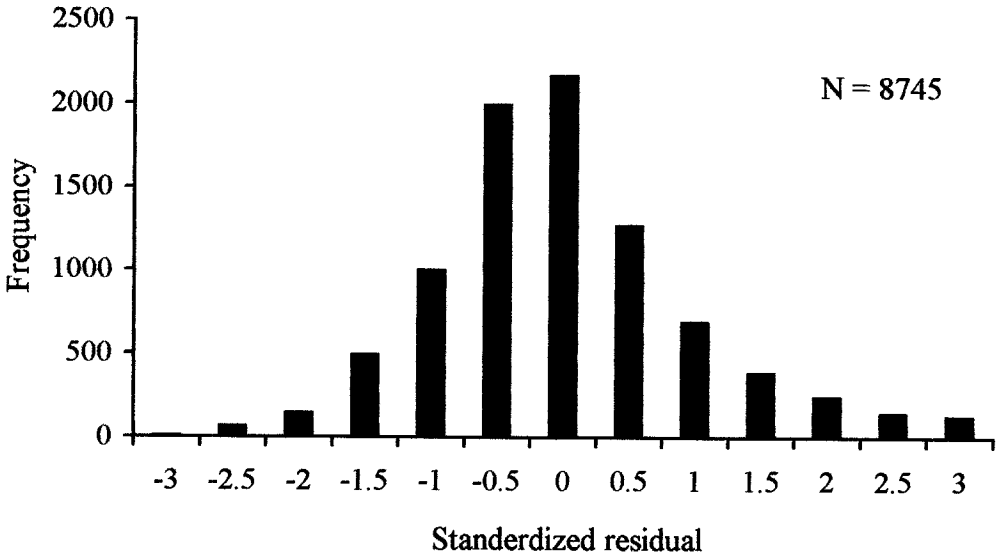

Figure 1a. Distribution of standerdized residuals of the models fitted to the bigeye CPUE data from Taiwanese distant-water longline fishery in the western Pacific.

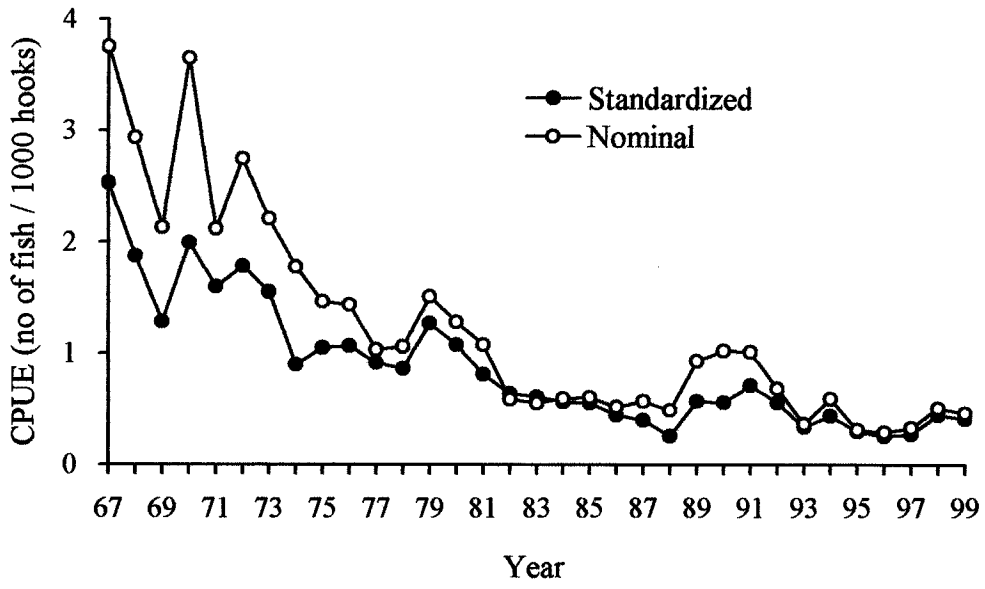

Figure 1b. Standardized and nominal bigeye CPUE for Taiwanese distant-water longline fishery in the western Pacific, 1967-1999.

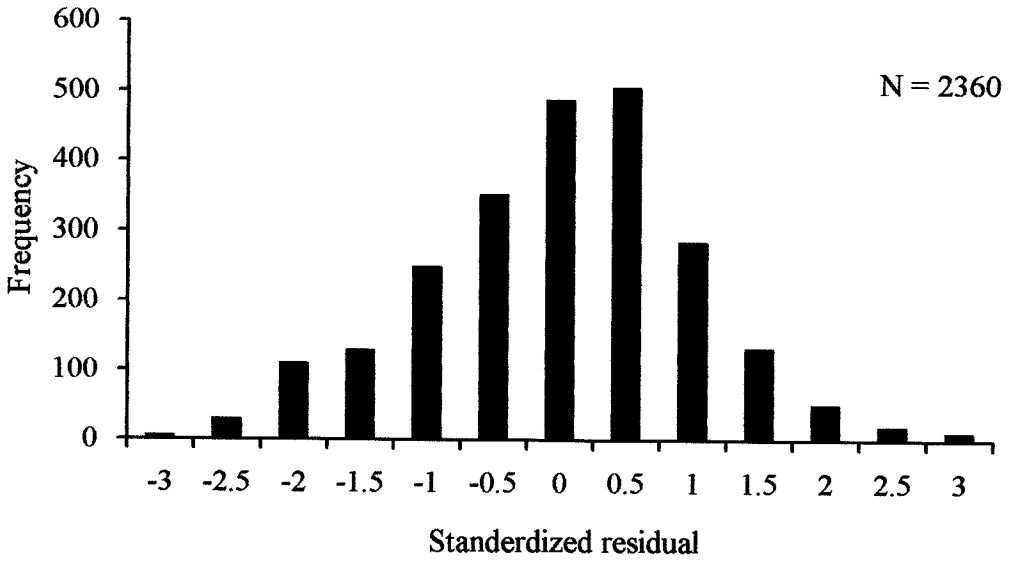

Figure 2a. Distribution of standerdized residuals of the models fitted to the bigeye CPUE data from Taiwanese offshore longline fishery in the western Pacific.

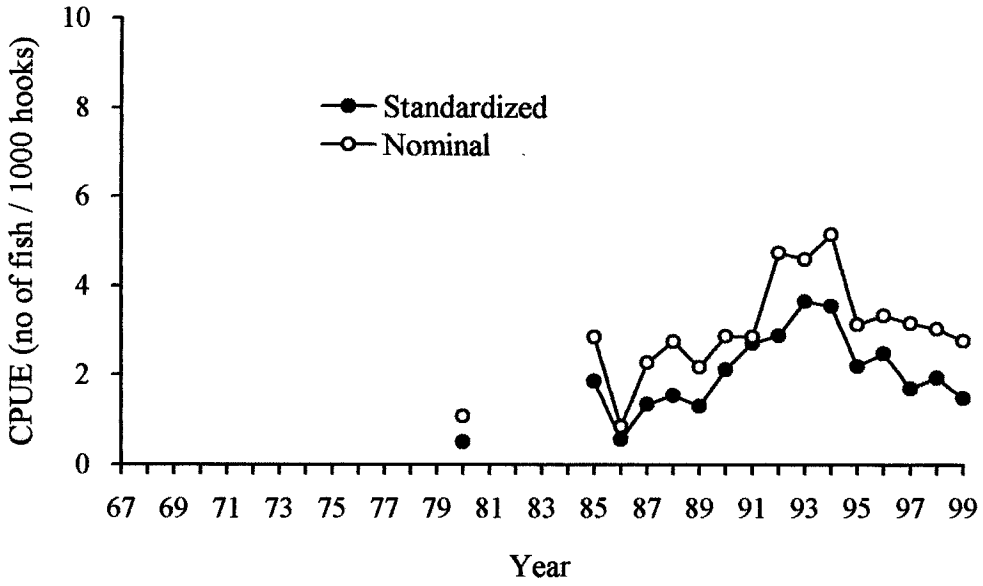

Figure 2b. Standardized and nominal bigeye CPUE for Taiwanese offshore longline fishery in the western Pacific, 1980-1999.

Table 1. Analysis of variance results for the GLM model fitted to the bigeye CPUE data from Taiwanese distant-water longline fishery.

Class Level Information

Class	Levels	Values
YEAR	33	1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999
MONTH	12	1 2 3 4 5 6 7 8 9 10 11 12
AREA	7	1 2 3 4 5 6 7

Number of observations in data set = 8745

Dependent Variable: LNCPUE

Source	DF	Sum of Squares	F Value	Pr > F
Model	49	1040.6221	83.68	0.0001
Error	8695	2206.8018		
Corrected Total	8744	3247.4239		

R-Square	C.V.	LNCPUE Mean
0.3204	76.8273	0.6557

Source	DF	Type III SS	F Value	Pr > F
YEAR	32	558.2469	68.74	0.0001
MONTH	11	31.7636	11.38	0.0001
AREA	6	237.1467	155.73	0.0001

Table 2. Analysis of variance results for the GLM model fitted to the bigeye CPUE data from Taiwanese offshore longline fishery.

Class Level Information

Class	Levels	Values
YEAR	16	1980 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999
MONTH	12	1 2 3 4 5 6 7 8 9 10 11 12
AREA	6	1 3 4 5 6 7

Number of observations in data set = 2360

Dependent Variable: LNCPUE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	31	153.8033	4.9614	15.74	0.0001
Error	2328	733.7987	0.3152		
Corrected Total	2359	887.6020			

R-Square	C.V.	Root MSE	LNCPUE Mean
0.1733	43.4280	0.5614	1.2928

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	15	130.3400	8.6893	27.57	0.0001
MONTH	11	11.3102	1.0282	3.26	0.0002
AREA	5	10.1813	2.0363	6.46	0.0001