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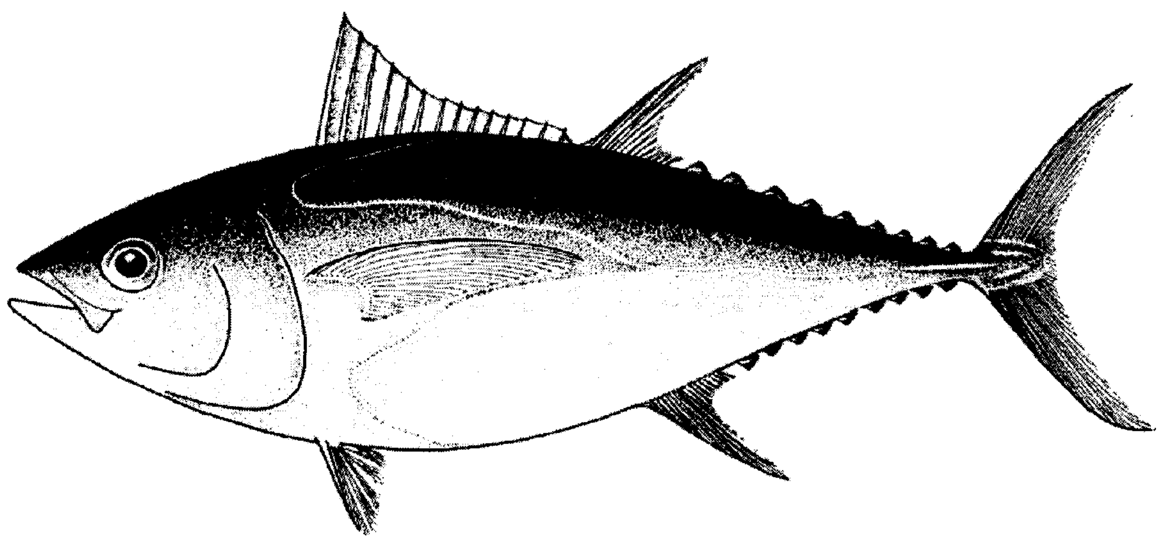
Updated CPUE of Central and Western Pacific Bigeye Tuna from Taiwanese Tuna Longline Fisheries.



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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, 1993a, 1994, 1997, 1998a, 1998b, 1999). 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). The purpose of this paper is to standardize the catch per unit effort (CPUE) of bigeye tuna caught in the central and western Pacific by these two fleets. The standardized CPUE may then find possible use in the stock assessments of the Western Pacific Bigeye Tuna Research Group.

The general linear modeling technique was applied to estimate annual CPUE's of the distant-water and offshore longline data for the periods 1964-1998 and 1980-1999, respectively. The distant-water longline data were recently revised by OFDC by checking with the catch and effort information obtained from NMFS Honolulu Lab.

Materials and Methods

Distant-water longline fishery

Catch was represented by the number of fish taken and effort was expressed in number of hooks used. These variables were presented by month in a 5°x 5° square area during the period 1964-1998. The nominal CPUE value represented catch in number of bigeye 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, WPYF area, and the catch rates of albacore and yellowfin tuna treated as class variables.

The multiplicative model used in this analysis is

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

where

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

Offshore longline fishery

Catch was represented by the number of fish taken, and effort was expressed in number of hooks used. These variables were presented by month in a 5°x 5° square area during the period 1980-1999. The nominal CPUE value represented catch in number of bigeye per 1000 hooks.

The main effects chosen to implement the GLM analyses were year, month, WPYF area, and the catch rates of yellowfin tuna treated as a class variable.

The multiplicative model used in this analysis is

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

where

ln	is the natural logarithm;
$CPUE_{ijkl}$	is the nominal catch rate (no. of fish / 1000 hooks) in year i, month j, WPYF area k, and yellowfin catch rate l;
μ	is the overall mean;
Y_i	is year i;
M_j	is month j;
A_k	is WPYF area k;

YFT_l	is yellowfin catch rate l;
interactions	is the two-way interactions among main effects except year;
ε_{ijkl}	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 9,399. 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, the catch rates of albacore and yellowfin tuna, and their interactions) 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 0.48.

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 2.74 to 1.23 fish per thousand hooks during the period of 1965 to 1971. The CPUE increased to 1.77 fish per thousand hooks in 1972. Another downward trend of the CPUE from 1.77 to 0.44 fish per thousand hooks occurred during the period of 1972 to 1988. The CPUE increased to 0.80 in 1989 and then maintained stable and fluctuated between 0.95 and 0.55 fish per thousand hooks in recent ten years.

The nominal CPUE have similar trend although the nominal CPUE were generally higher before 1981 and lower after 1981 than the standardized CPUE.

Offshore longline fishery

The total number of observations for this analysis was 2,248. The results of ANOVA for the final model are shown in Table 2. The rate of variability explained by the model (i.e. R^2) was fairly low (0.27). 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 except in 1991. The CPUE increased gradually from 0.68 fish per thousand hooks in 1986 to the maximum of 4.12 fish per thousand hooks in 1994. Since then, the CPUE decreased again and remained between 2.3 to 3.0 fish per thousand hooks during 1995 to 1997. The CPUE was 2.4 fish per thousand hooks in 1999.

The CPUE for the offshore longline fishery was 3.9 times in average 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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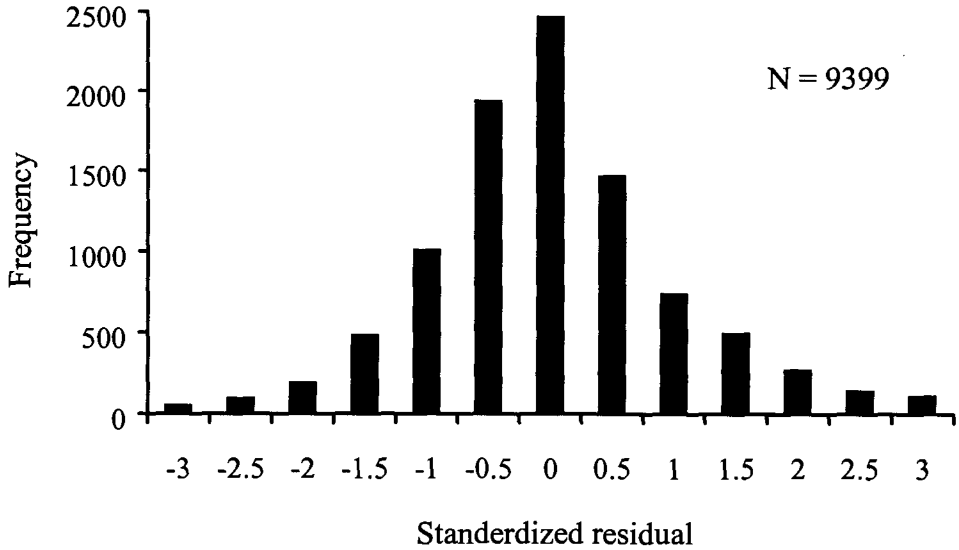

Figure 1a. Distribution of standerdized residuals of the models fitted to the bigeye CPUE data from Taiwanese distant-water longline fishery in the western Pacific.

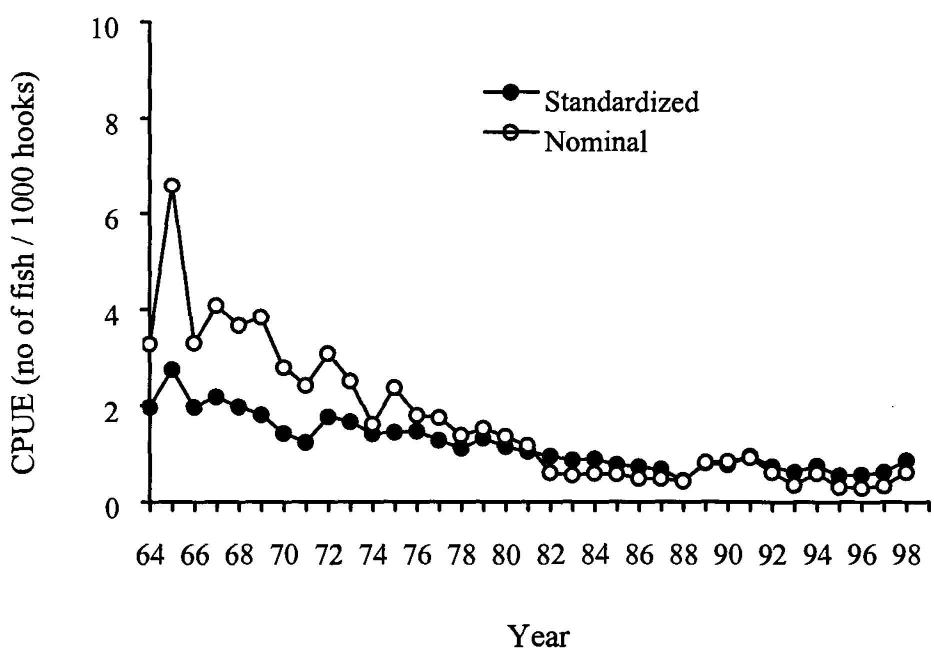

Figure1b Standardized and nominal bigeye CPUE for Taiwanese distant-water longline fishery in the western Pacific, 1964-1998.

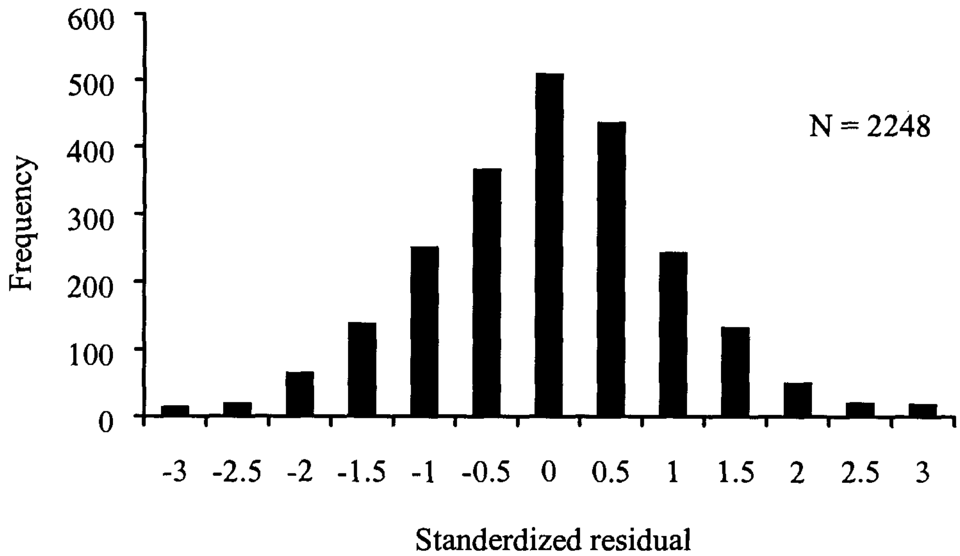

Figure 2a. Distribution of standerdized residuals of the models fitted to the bigeye CPUE data from Taiwanese offshore longline fishery in the western Pacific.

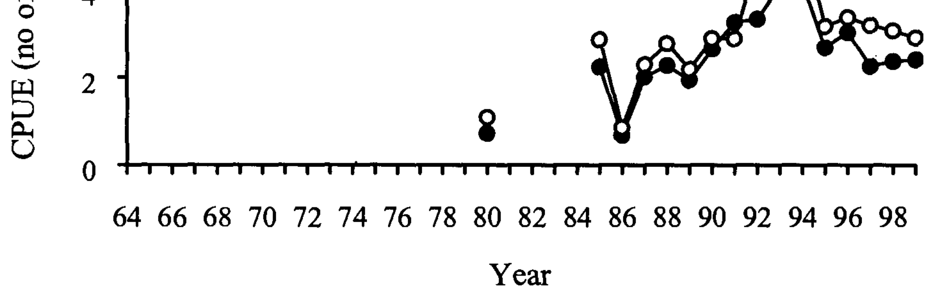

Figure2b. Standardized and nominal bigeye CPUE for Taiwanese offshore longline fishery in the western Pacific, 1980-1999.

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	35	1964 1965 1966 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
MONTH	12	1 2 3 4 5 6 7 8 9 10 11 12
AREA	7	1 2 3 4 5 6 7
ALB	5	0 1 2 3 4
YFT	6	0 1 2 3 4 5

Number of observations in data set = 9399

Dependent Variable: LNCPUE

Source	DF	Sum of Squares	F Value	Pr > F
Model	179	1885.16341748	47.51	0.0001
Error	9219	2043.69690171		
Corrected Total	9398	3928.86031919		

R-Square	C.V.	LNCPUE Mean
0.479824	63.92505	0.73653822

Source	DF	Type III SS	F Value	Pr > F
YEAR	34	256.40785973	34.02	0.0001
MONTH	11	9.28845814	3.81	0.0001
AREA	6	62.89534774	47.29	0.0001
ALB	4	15.28863493	17.24	0.0001
YFT	5	230.48442708	207.94	0.0001
MONTH*ALB	44	21.70142095	2.22	0.0001
MONTH*YFT	55	29.74980504	2.44	0.0001
ALB*YFT	20	23.24012895	5.24	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	2	3 4
YFT	5	1 2 3 4 5

Number of observations in data set = 2248

Dependent Variable: LNCPUE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	79	226.07138	2.86166	10.25	0.0001
Error	2168	605.36058	0.27923		
Corrected Total	2247	831.43196			

R-Square	C.V.	Root MSE	LNCPUE Mean
0.271906	40.25326	0.5284	1.3127

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	15	79.191958	5.279464	18.91	0.0001
MONTH	11	8.143873	0.740352	2.65	0.0022
AREA	1	4.097147	4.097147	14.67	0.0001
YFT	4	28.913890	7.228473	25.89	0.0001
MONTH*YFT	44	22.170815	0.503882	1.80	0.0010
AREA*YFT	4	12.059002	3.014751	10.80	0.0001