ISC/06/MARWG&SWOWG-2/06

Standardization of Taiwanese Tuna Longline catch rates for striped marlin in the North Pacific Ocean[1]

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[1]Working document submitted to the ISC Marlin Working Group Workshop, November 8-15, 2006, Shimizu, Shizuoka, Japan. Document not to be cited without authors' written permission.

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Abstract

Catch rate of striped marlin for Taiwanese longline fishery in the North Pacific Ocean was standardized using the general linear model (GLM). The standardized CPUE had been very low since 1969 until 1977 except for 1973 when CPUE was about 0.31 fish per thousand hooks. The standardized CPUE reached its maximum of 0.37 fish per thousand hooks in 1982 and has been stable since 1995 within a range between 0.09 and 0.16 fish per thousand hooks. The nominal CPUE in 1979 and 1980 (1.31 and 1.41 fish per thousand hooks, respectively) are extremely high compared to other years, which need to be further checked.

Introduction

Taiwan's distant-water tuna longline, or Taiwan's 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, 1999). Striped marlin and other billfishes were incidental catches of Taiwan's longline. The purpose of this paper is to standardize the catch rates of striped marlin caught by Taiwan's longline vessels in the North Pacific Ocean during the period of 1969 to 2003 using the general linear model (GLM) procedure, and to provide a preliminary description of the patters or trends of abundance of the striped marlin in the North Pacific Ocean.

Materials and Methods

[1] A working paper submitted to the Intercessional Meeting of the Swordfish and Marlin Working Groups of ISC. November 8-15 2006, Shimizu, Japan.

The data were provided by Oversea Fisheries Development Council (OFDC) and were presented as catch, the number of fish taken and effort, the number of hooks used, in an area of 5^o x 5^o square per month during the period 1969-2003. The nominal CPUE value represented catch in number of striped marlin 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, area (Fig. 1), and the catch rates of albacore, yellowfin, and bigeye tuna treated as class variables.

The multiplicative model used in this analysis is

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

where

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

Data preparation and calculation employing SAS Statistical Software, Version 8.2, were performed on personal computer.

Results and Discussion

Fig. 2 shows the yearly CPUE distribution of striped marlin during the period from

1969 to 2003. The total number of observations for GLM analysis was 1,792. The frequency distribution of the standardized residuals for all variables combined effects is approximately close to that of the normal distribution (Fig. 3).

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, yellowfin and bigeye tunas, and their interactions) are shown in Table 1. All of the main variables as well as the whole model are statistically significant ($p<0.05$). The fraction of sum of squares explained by the model (i.e. R^2) is 0.38.

Fig. 4 shows the least square mean (LSM) estimates of annual CPUE (standardized CPUE) and the nominal CPUE. The standardized CPUE had been very low since 1969 until 1977 except for 1973 when CPUE was about 0.31 fish per thousand hooks. The standardized CPUE reached its maximum of 0.37 fish per thousand hooks in 1982 and has been stable since 1995 within a range between 0.09 and 0.16 fish per thousand hooks. The nominal CPUE in 1979 and 1980 (1.31 and 1.41 fish per thousand hooks, respectively) are extremely high compared to other years, which need to be further checked.

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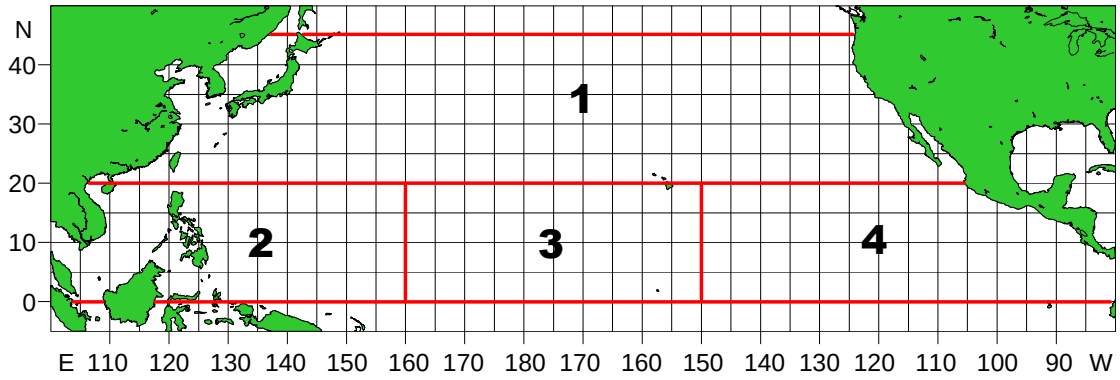

Fig. 1. Map of North Pacific Ocean showing the statistical areas for the GLM model in this study.

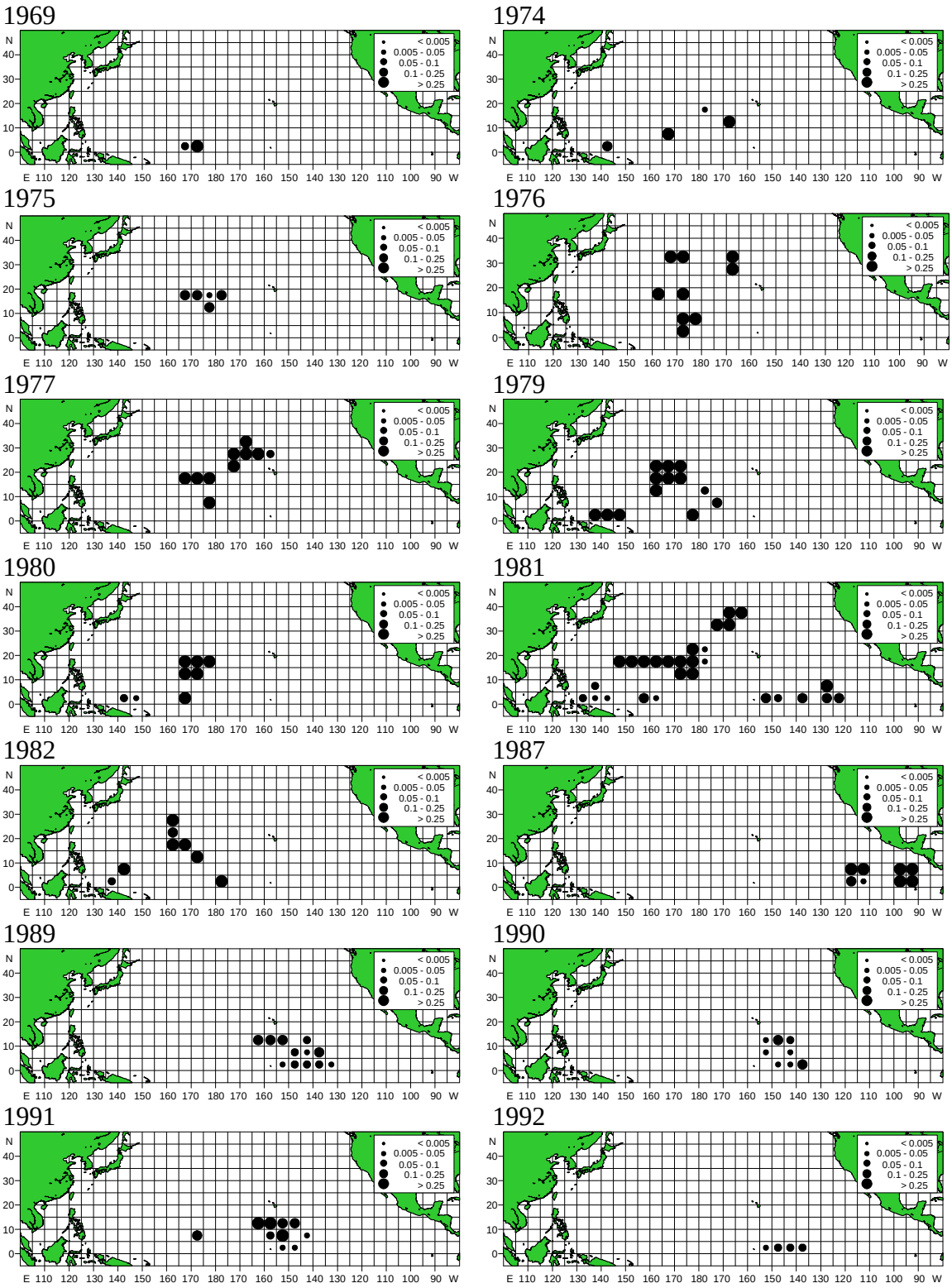

Fig. 2. The yearly distribution of striped marlin CPUE for Taiwan's longline fishery in the North Pacific Ocean during the period from 1969 to 2003.

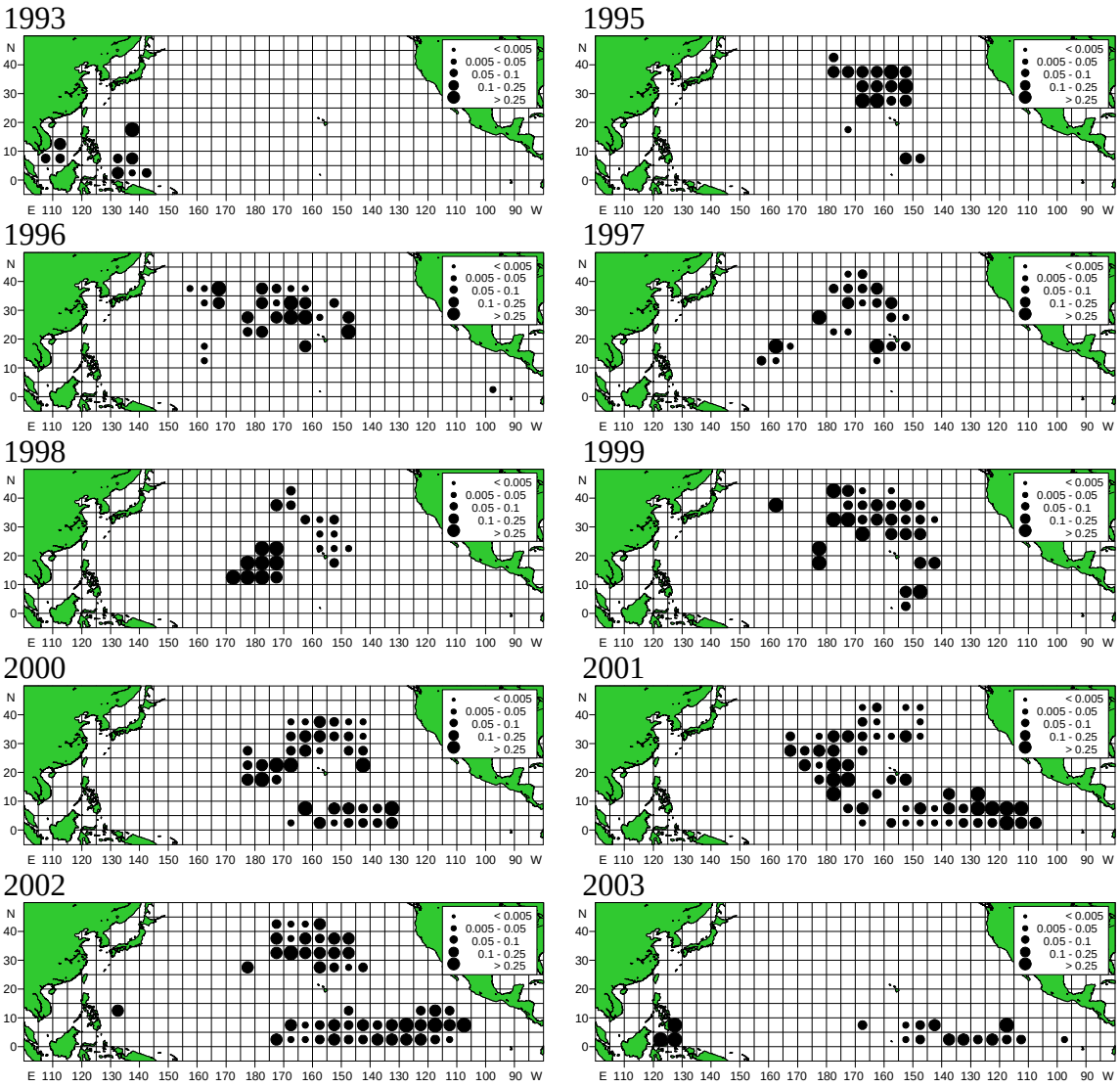

Fig. 2. The yearly distribution of striped marlin CPUE for Taiwan's longline fishery in the North Pacific Ocean during the period from 1969 to 2003 (continued).

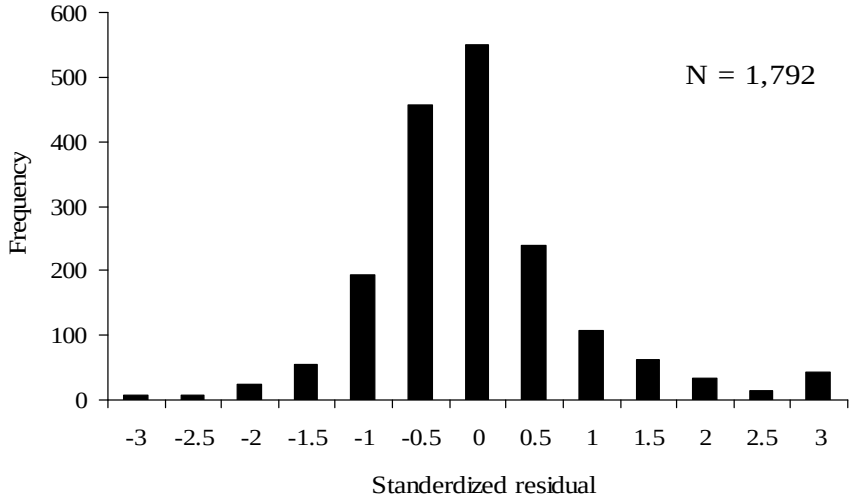

Fig. 3. Distribution of standerdized residuals of the models fitted to the striped marlin CPUE data from Taiwanese distant-water longline fishery in the North Pacific Ocean.

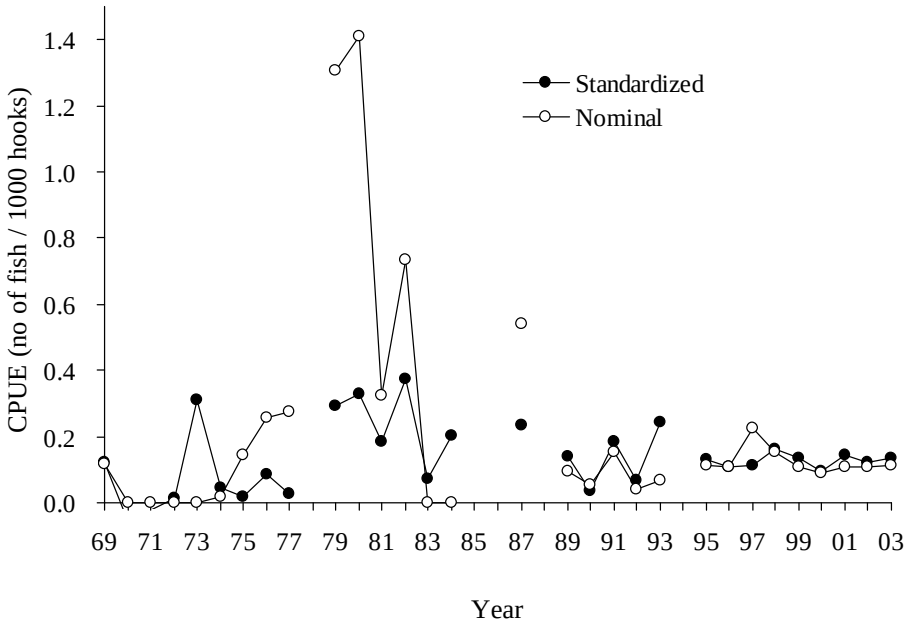

Fig. 4. Standardized and nominal striped marlin CPUE for Taiwanese distant-water longline fishery in the North Pacific Ocean, 1969-2003.

Table 1. Analysis of variance results for the GLM model fitted to the striped marlin CPUE data from Taiwanese distant-water longline fishery in the North Pacific Ocean.

Class Level Information

Class	Levels	Values
YEAR	30	1969 1970 1971 1972 1973 1974 1975 1976 1977 1979 1980 1981 1982 1983 1984 1987 1989 1990 1991 1992 1993 1995 1996 1997 1998 1999 2000 2001 2002 2003
MONTH	12	1 2 3 4 5 6 7 8 9 10 11 12
AREA	4	1 2 3 4
alb	3	0 1 2
yft	5	0 1 2 3 4
bet	5	0 1 2 3 4

Number of observations 1792

Dependent Variable: LNCPUE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	258	33.29923678	0.12906681	3.72	<.0001
Error	1533	53.24461348	0.03473230		
Corrected Total	1791	86.54385027			

R-Square	Coeff Var	Root MSE	LNCPUE Mean
0.384767	166.3768	0.186366	0.112014

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	29	3.50392266	0.12082492	3.48	<.0001
MONTH	11	0.95163363	0.08651215	2.49	0.0042
AREA	3	0.57431414	0.19143805	5.51	0.0009
alb	2	0.24197509	0.12098755	3.48	0.0309
yft	4	0.42917718	0.10729430	3.09	0.0152
bet	4	0.98264997	0.24566249	7.07	<.0001
MONTH*AREA	33	2.76052464	0.08365226	2.41	<.0001
MONTH*alb	22	1.97925581	0.08996617	2.59	<.0001
MONTH*yft	44	3.10325436	0.07052851	2.03	<.0001
MONTH*bet	44	3.90241503	0.08869125	2.55	<.0001
AREA*yft	12	1.13576975	0.09464748	2.73	0.0012
AREA*alb	6	0.42064730	0.07010788	2.02	0.0602
AREA*bet	12	2.04524092	0.17043674	4.91	<.0001
alb*yft	8	0.55324774	0.06915597	1.99	0.0442
alb*bet	8	1.06608153	0.13326019	3.84	0.0002
yft*bet	16	1.10519376	0.06907461	1.99	0.0111