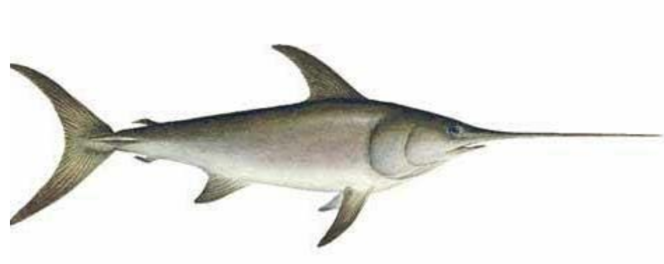
Standardization of Taiwanese distant water tuna longline catch rates for swordfish in the North Pacific Ocean[1]

Su-Zan Yeh[2], Chi-Lu Sun[2], Sheng-PingWang[3], and Yi-Jay Chang[2]

[2] Institute of Oceanography
National Taiwan University
Taipei, Taiwan

[3] Department of Environmental Biology and Fisheries Science
National Taiwan Ocean University
Keelung, Taiwan



[1]Working document submitted to the ISC Billfish Working Group Workshop, 16-26 March 2007, Chinese Taipei. Document not to be cited without author's written permission.

Standardization of Taiwanese distant water tuna longline catch rates for swordfish in the North Pacific Ocean*

Su-Zan Yeh[1], Chi-Lu Sun[1], Sheng-Ping Wang[2], and Yi-Jay Chang[1]

[1] Institute of Oceanography, National Taiwan University, Taipei 106, Taiwan

[2] Department of Environmental Biology and Fisheries Science, National Taiwan Ocean University, Keelung 202, Taiwan

Abstract

Catch rate of swordfish for Taiwanese longline fishery in the North Pacific Ocean was standardized using the general linear model (GLM). The standardized CPUE had been stable during 1995-2000 within a range between 0.08 and 0.19 fish per thousand hooks. The standardized CPUE increased to 0.3 fish per thousand hooks in 2001, decreased again to 0.2 fish per thousand hooks in 2003, and increased to its maximum of 0.32 fish per thousand hooks in 2004. The nominal CPUE in 2002 and 2003 (0.9 and 0.8 fish per thousand hooks, respectively) are 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, 1999). Swordfish and other billfishes were incidental catches of Taiwan's longline. The purpose of this paper is to standardize the catch rates of swordfish caught by Taiwan's longline vessels in the North Pacific Ocean during the period of 1995 to 2004 using the general linear model (GLM) procedure, and to provide a preliminary description of the patters or trends of abundance of the swordfish in the North Pacific Ocean.

* A working paper submitted to the Joint Intercessional Meeting of the Swordfish and Marlin Working Groups of ISC. March 19-26, 2007, Taipei, Taiwan.

Materials and Methods

The catch/effort data during the period 1995-2004 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. The nominal CPUE value represented catch in number of swordfish per 1000 hooks. Monthly average data of sea surface temperature (SST) on the scale of 1˚ x 1˚ square over the Pacific Ocean were obtained from the NCEP Reynolds Optimally Interpolated Sea Surface Temperature database (http://poet.jpl.nasa.gov/) and compiled to 5^o x 5^o square.

The main variables chosen to implement the general linear model (GLM) analyses (Kimura 1981, Allen and Punsly 1984, Draper and Smith 1981) were year, season, area (Fig. 1), and the SST, the catch rates of albacore, yellowfin, and bigeye tuna treated as class variables.

The multiplicative model used in this analysis is

$$\ln\,(CPUE_{ijklmno} + 0.1) = \mu + Y_i + S_j + A_k + SST_l + ALB_m + YFT_n + BET_o + \varepsilon_{ijklmno}$$

where

ln	is the natural logarithm;
$CPUE_{ijklmno}$	is the nominal catch rate (no. of fish / 1000 hooks) in year *i*, season *j*, area *k*, SST *l*, albacore catch rate *m*, yellowfin catch rate *n*, and bigeye catch rate *o*;
μ	is the overall mean;
Y_i	is year *i*;
S_j	is season *j*;
A_k	is area *k*;
SST_l	is sea surface temperature *l*;
ALB_m	is albacore catch rate *m*;
YFT_n	is yellowfin catch rate *n*;
BET_o	is yellowfin catch rate *o*;
ε_{ijklmo}	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

Figs. 2 and 3 show the yearly distribution of the fishing effort and the swordfish CPUE during the period from 1995 to 2004. The total number of observations for GLM analysis was 1,629. The frequency distribution of the standardized residuals for all variables combined effects is close to that of the normal distribution (Fig. 4).

The results of using the GLM analysis of variance (ANOVA) to examine the logged catch rate for differences among variables (year, season, area, SST, and the catch rates of albacore, yellowfin and bigeye tunas) are shown in Table 1. All of the variables except albacore catch rate 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 0.43.

Fig. 5 shows the least square mean (LSM) estimates of annual CPUE (standardized CPUE) and the nominal CPUE. The standardized CPUE had been stable during 1995-2000 within a range between 0.08 and 0.19 fish per thousand hooks. The standardized CPUE increased to 0.3 fish per thousand hooks in 2001, decreased again to 0.2 fish per thousand hooks in 2003, and increased to its maximum of 0.32 fish per thousand hooks in 2004. The nominal CPUE in 2001 and 2002 (0.9 and 0.8 fish per thousand hooks, respectively) are high compared to other years, which need to be further checked.

References cited

Allen R. and R. Punsly. 1984. Catch rate as indices of abundance of yellowfin tuna, in the eastern Pacific Ocean. IATTC Bull. 18(4): 303-379.

Draper, N.R. and H. Smith. 1981. Applied regression analysis. John Wiley and Sons, Inc., New York. 708 pp.

Kimura, D.K. 1981. Standardized measures of relative abundance based on modeling log(CPUE) and their application to Pacific Ocean perch. J. Cons. Int. Explor. Mer. 39: 211-218.

Sun, C.L. and S.Z. Yeh. 1999. Standardized catch rates of yellowfin and bigeye tunas from the Taiwanese tuna fisheries in the western Pacific. Working Document SCTB12/RG-3, 15 pp.

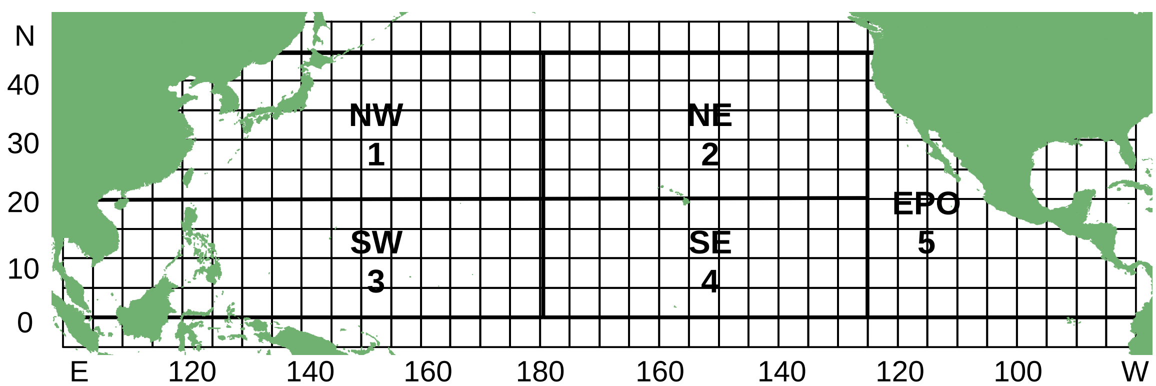


Fig. 1. Map of North Pacific Ocean showing the statistical areas for the GLM model in this study.

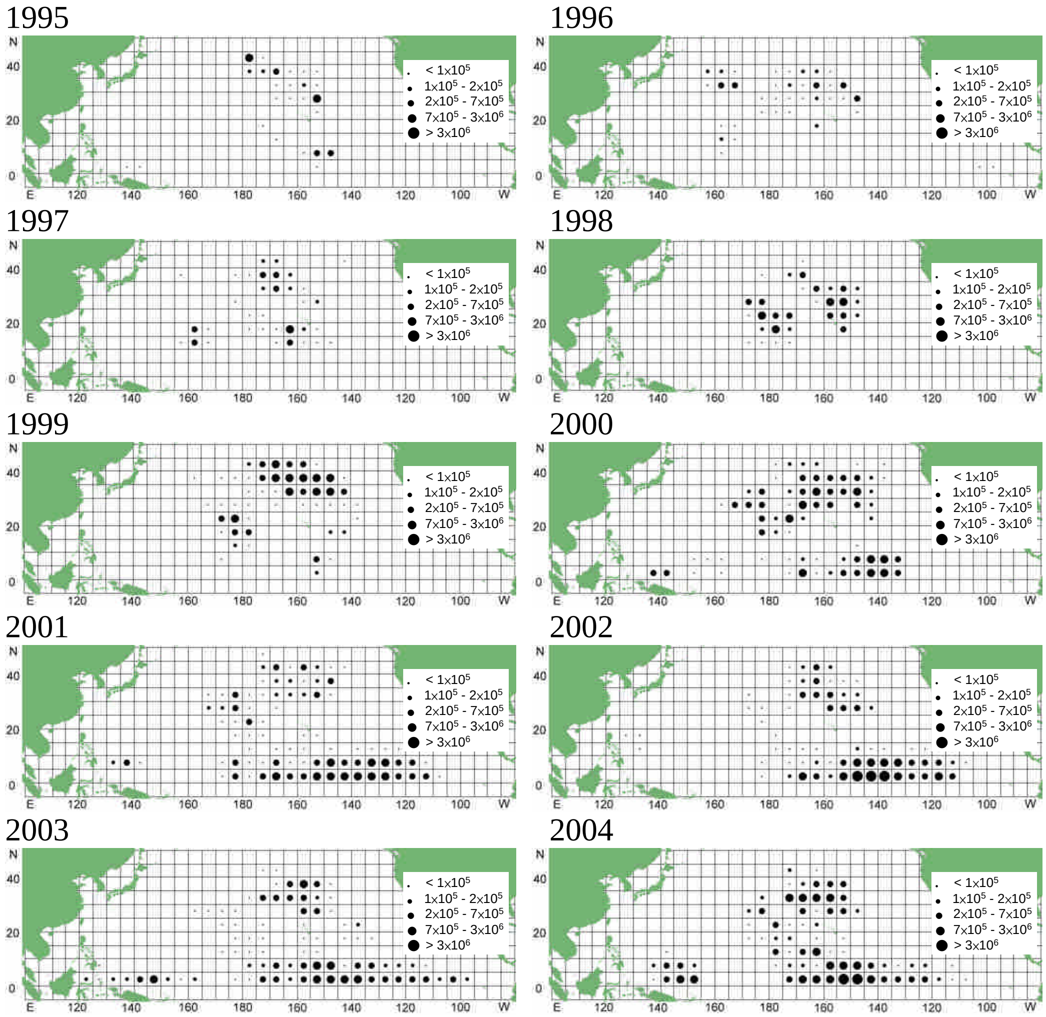


Fig. 2. The yearly distribution of fishing effort for Taiwan's longline fishery in the North Pacific Ocean during the period from 1995 to 2004 (Unit: hooks).

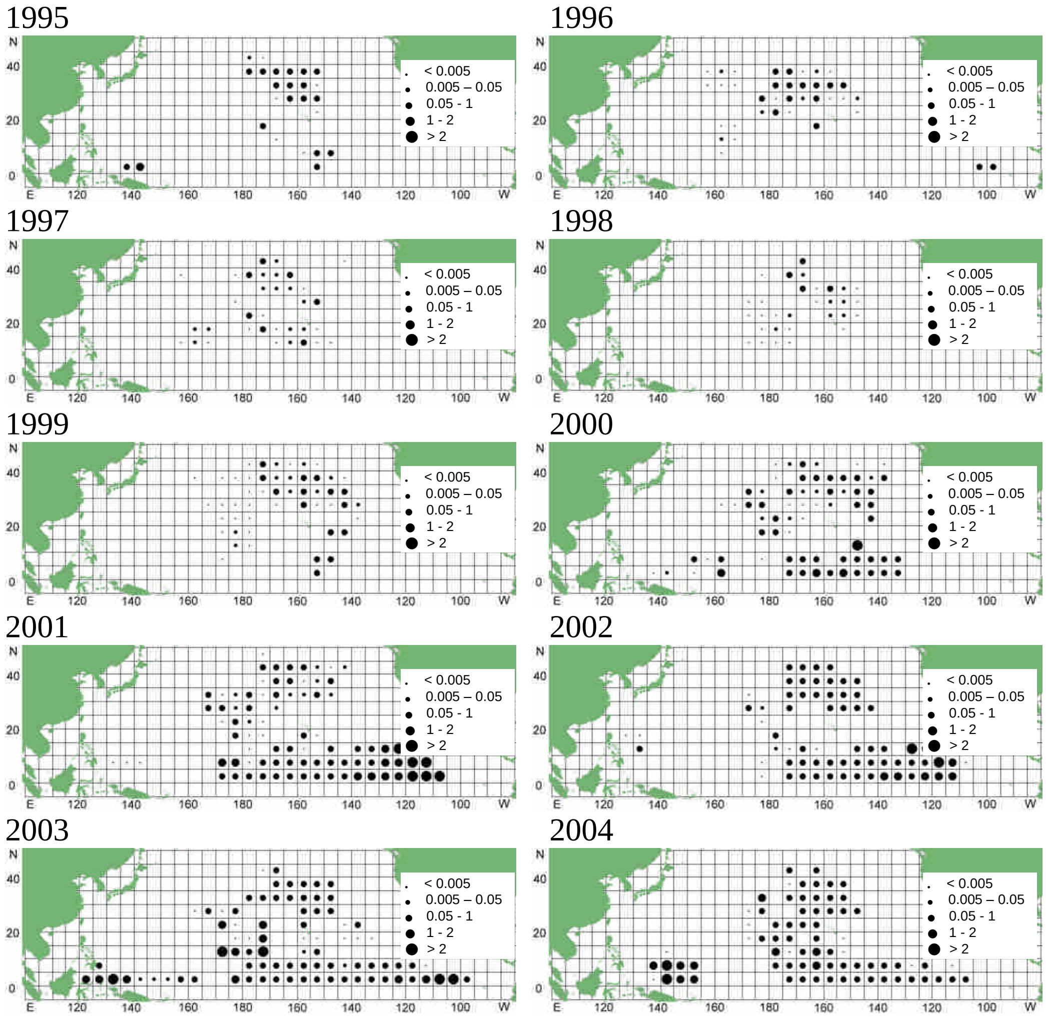


Fig. 3. The yearly distribution of swordfish CPUE for Taiwan's longline fishery in the North Pacific Ocean during the period from 1995 to 2004.

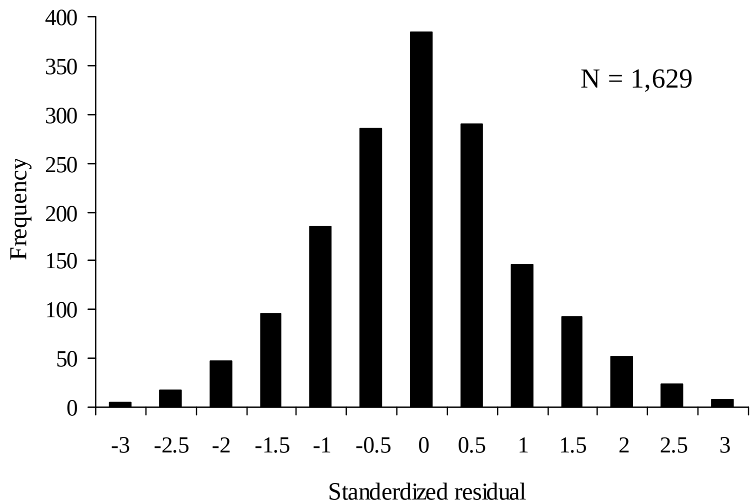


Fig. 4. Distribution of standerdized residuals of the models fitted to the swordfish CPUE data from Taiwanese distant-water longline fishery in the North Pacific Ocean.

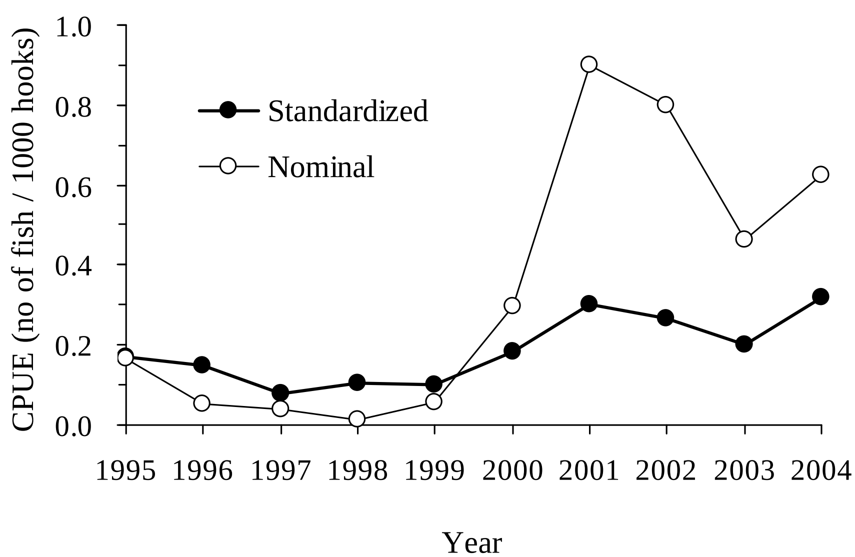


Fig. 5. Standardized and nominal swordfish CPUE for Taiwanese distant-water longline fishery in the North Pacific Ocean, 1995-2004.

Table 1. Analysis of variance results for the GLM model fitted to the swordfish CPUE data from Taiwanese distant-water longline fishery, 1995-2004.

Class Level Information

Class	Levels	Values
year	10	1995 1996 1997 1998 1999 2000 2001 2002 2003 2004
season	4	1 2 3 4
area	5	EPO NE NW SE SW
sst	6	15 20 25 27 28 29
alb	4	0 1 2 3
yft	4	0 1 2 3
bet	4	0 1 2 3

Number of observations 1629

Dependent Variable: LNCPUE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	27	815.966777	30.220992	45.08	<.0001
Error	1601	1073.255352	0.670366		
Corrected Total	1628	1889.222129			

R-Square	Coeff Var	Root MSE	LNCPUE Mean
0.431906	-70.43246	0.818759	-1.162473

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	9	81.9747284	9.1083032	13.59	<.0001
season	3	6.6799174	2.2266391	3.32	0.0191
area	4	70.5263075	17.6315769	26.30	<.0001
sst	5	30.6809011	6.1361802	9.15	<.0001
yft	3	26.1303794	8.7101265	12.99	<.0001
bet	3	117.2815829	39.0938610	58.32	<.0001