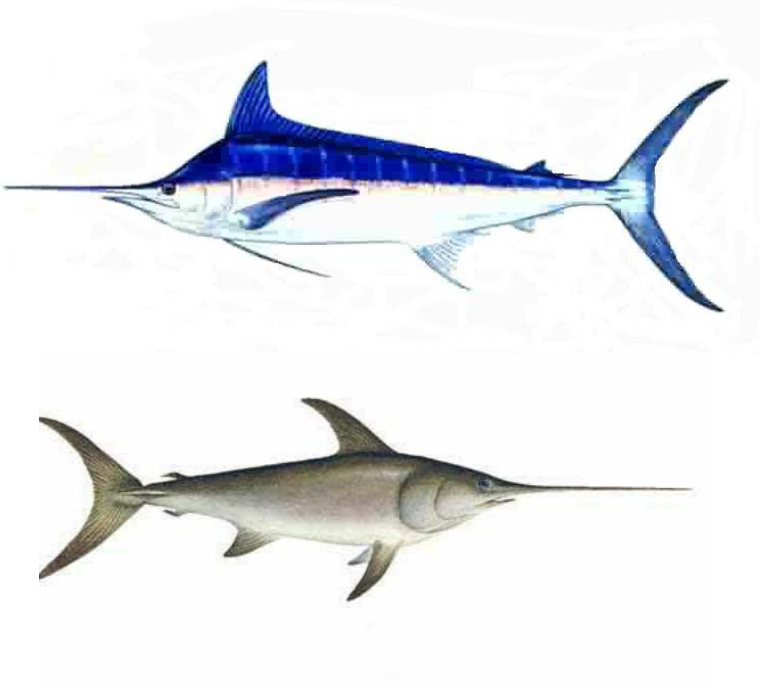
Standardized catch-rates for striped marlin *(Kajikia audax)* for Taiwanese distant-water longline fishery in the North Pacific Ocean for 1967-2009

Chi-Lu Sun
Nan-Jay Su
Su-Zan Yeh
Yi-Jay Chang
National Taiwan University
Institute of Oceanography
1, Sect. 4, Roosevelt Road, Taipei, Taiwan 106



Working document submitted to the ISC Billfish Working Group Workshop, 19-27 January 2011, Honolulu, Hawaii, USA. Document not to be cited without author's written permission.

Standardized catch-rates of striped marlin (*Kajikia audax*) for Taiwanese distant-water longline fishery in the North Pacific Ocean for 1967-2009*

Chi-Lu Sun, Nan-Jay Su, Su-Zan Yeh, and Yi-Jay Chang

Institute of Oceanography, National Taiwan University

Taipei, Taiwan

Abstract

Catch and effort data of the Taiwanese tuna longline fisheries in the North Pacific Ocean for 1967-2009 were collected in this study. The catch-rates of striped marlin caught in this fishery were standardized using generalized linear models based on a two-stock scenario in the North Pacific Ocean, the WCPO and EPO stocks. Results show that the standardized catch-rates of striped marlin are stable over 1967-2009 in general, but have shown a slightly decreased trend since 2005 for both stocks in the North Pacific Ocean.

Keywords: striped marlin, standardized catch-rate, GLM, Taiwanese longline fishery

Introduction

Striped marlin (*Kajikia audax*) are widely distributed throughout tropical, subtropical, and temperate waters of the Pacific and Indian Oceans (Nakamura, 1985). They occur occasionally in the Atlantic Ocean near the Cape of Good Hope (Penrith and Cram, 1974). Striped marlin are recreationally important species and commercial resource (McDowell and Graves, 2008). Most of them are caught as a bycatch in the pelagic longline fisheries targeting tunas (Hinton and Maunder, 2003). Based on the results of genetic studies and the larvae of striped marlin occurring in spatially discrete regions in the Pacific Ocean in the same season, there are four stocks of striped marlin in the Pacific Ocean (McDowell and Graves, 2008). Striped marlin are highly abundant in the central North Pacific and the eastern tropical Pacific, but less abundant in the southern and western Pacific, as inferred from Japanese longline data (Ueyanagi and Wares, 1975). The objectives of this study are to standardize catch and effort data of the Taiwanese distant-water tuna longline fishery for striped marlin in the North Pacific Ocean based on a two-stock scenario. The standardized catch-rates of striped marlin can provide basic, necessary input data for stock assessment of this species.

* A working paper submitted to the Intercessional Workshop of the Billfish Working Groups of ISC. 19-27 January 2011, Hawaii, USA.

Materials and methods

Fishery data

Task II data of striped marlin catch (number of fish) and fishing effort (number of hooks) for 1967-2009 were collected from Oversea Fisheries Development Council (OFDC, Taiwan) for the Taiwanese tuna longline fleets in the North Pacific Ocean. This data set contains information on time (year and month) and location (latitude and longitude), but this data set was separated into two data sets at 140°W based on a two-stock scenario of North Pacific striped marlin as defined by ISC (see Fig. 1). Catch-rates (CPUE) are expressed as number of fish caught per 1000 hooks in this study.

Statistical model

Generalized linear models (GLMs) are a standard and most commonly used approach for standardizing catch and effort data (Maunder and Punt, 2004), assuming that the expected value of a transformed response variable is related to a linear combination of exploratory variables (Guisan et al., 2002). The catch and effort data of Taiwanese distant-water tuna longline fishery in the North Pacific Ocean were standardized for striped marlin using GLMs. The GLM model is expressed as follows:

$$MLS \sim Year + Month + Lat + Lon + Lat:Lon \quad (1)$$

where MLS is the nominal catch-rates of striped marlin, added with a constant;
Year is the year effect;
Month is the month effect;
Lat is the latitude effect;
Lon is the longitude effect; and
Lat:Lon is the interaction between Lat and Lon.

Diagnostic analysis

Diagnostic plots, i.e. the distribution of residuals and quantile-quantile (Q-Q) plots, were used to assess the error distribution (assuming lognormal distribution), as well as the model fitting for standardizing the catch-rates of striped marlin.

Results and discussion

Most of striped marlin catches was caught in the western and central Pacific Ocean, while small amount of the catches were taken in the Eastern Pacific Ocean, for the Taiwanese distant-water longline fisheries (Fig. 2). There are totally 4,382 (1967-2009) and 828 (1979-2008) catch-effort records in 5 by 5 grid of the Taiwanese tuna

longline fisheries available for the WCPO and EPO stocks of striped marlin respectively. The effects considered in the GLM modesl are statistically significant ($p < 0.05$), except for the interaction term between latitude and longitude for the EPO stock of striped marlin (Table 1). The deviance explained by the model for standardizing catch-rates of striped marlin is 24.3% for the WCPO stock and 25.7% for EPO stock respectively (Table 1).

The residual distributions from log-normal error distribution based on the GLM analysis appear normal for not only the WCPO stock but also the EPO stock of striped marlin in the North Pacific Ocean (Fig. 3). This result confirms the assumption of error model for log-normal distribution to standardize catch and effort data of the Taiwanese tune longline fleets for striped marlin in the North Pacific Ocean. According to Q-Q plots, this assumption is also suitable to model the catch-rates of striped marlin for each stock in the North Pacific Ocean (Fig. 4). Therefore, analyses of standardizing swordfish catch-rates in this study are consequently based on the log-normal error distribution.

The standardized catch-rates of striped marlin caught by Taiwanese distant-water tuna longline fleets in the North Pacific Ocean are generally stable over 1967-2009, although nominal catch-rates of striped marlin vary greatly for few years (Fig. 5). This is because the sample sizes of catch-effort data are small for several years before 1997, while the sample sizes of observations are largely increased in recent 10 years. The standardized catch-rates of striped marlin for both WCPO and EPO stocks in the North Pacific Ocean seem to slightly decrease in recent years, especially for those after 2005 (Fig. 5). The catches of striped marlin caught in the North Pacific Ocean also decline, for both WCPO and EPO stocks of striped marlin in the North Pacific Ocean, during those years (Fig. 2). Table 2 lists the values of catches and standardized catch-rates of striped marlin caught by Taiwanese longline fleets in the North Pacific Ocean for the WCPO and EPO stocks.

References

Guisan, A., Edwards Jr., T.C., Hastie, T. (2002). Generalized linear and generalized additive models in studies of species distributions: setting the scene. *Ecol. Model.*, **157:** 89-100.

Hinton, M.G., Maunder, M.N. (2003). Status of striped marlin in the eastern Pacific Ocean in 2002 and outlook for 2003–2004. Report 4. Inter-American Tropical Tuna Commission, La Jolla, Calif.

ISC, (2010). Report of the Billfish Working Group Workshop. 15-22 April 2010, Hokkaido University, Hakodate, Hokkaido, Japan. 28 pp.

Maunder, M.N. Punt, A.E.(2004). Standardizing catch and effort data: a review of recent approaches. *Fish. Res.*, **70:** 141-159.

McDowell, J.R., Graves, J.E. (2008). Population structure of striped marlin (*Kajikia audax*) in the Pacific Ocean based on analysis of microsatellite and mitochondrial DNA. *Can. J. Fish. Aquat. Sci.*, **65:** 1307-1320.

Nakamura, I. (1985). FAO species catalogue. Vol. 5. Billfishes of the world. An annotated and illustrated catalogue of marlins, sailfishes, spearfishes and swordfishes known to date. FAO Fisheries Synopses 125, Rome, Italy.

Penrith, M.J., Cram, D.L. (1974). The Cape of Good Hope: a hidden barrier to billfishes. In Proceedings of the International Billfish Symposium Kailua–Kona, Hawaii, 9–12 August 1972. Part 2. Edited by R.S. Shomura and F. Williams. National Marine Fisheries Service, Seattle, Wash. NOAA Tech. Rep. NMFS SSRF-675. pp. 175–187.

Ueyanagi, S., Wares, P.G. (1975). Synopsis of biological data on striped marlin, *Tetrapturus audax* (Philippi, 1887). In Proceedings of the International Billfish Symposium, Kailua–Kona, Hawaii, 9–12 August 1972, Part 3. Species synopses. Edited by R.S. Shomura and F. Williams. National Marine Fisheries, Service, Seattle, Wash. NOAA Tech. Rep. NMFS SSRF-675. pp. 132–159.

Table 1. Analysis of deviance table for the models selected to standardize the catch-rates of striped marlin caught in the Taiwanese distant-water tuna longline fisheries in the North Pacific Ocean. The WCPO and EPO stocks of North Pacific striped marlin defined by ISC (2010) are shown in Fig. 1.

	WCPO			EPO		
	Degree of freedom	Deviance explained	*P*-value	Degree of freedom	Deviance explained	*P*-value
Year	38	403	<0.01	19	69	<0.01
Month	11	55	<0.01	11	50	<0.01
Lat	9	323	<0.01	8	31	<0.01
Lon	22	176	<0.01	11	17	0.01
Lat:Lon	115	261	<0.01	19	19	0.11
R^2		0.243			0.257	

Table 2. Catches and standardized catch-rates of striped marlin for the WCPO and EPO stocks caught by the Taiwanese longline fleets in the North Pacific Ocean.

	Catch		CPUE			Catch		CPUE	
Year	WCPO	EPO	WCPO	EPO	Year	WCPO	EPO	WCPO	EPO
1961					1986				
1962					1987	0	31	0.030	0.120
1963					1988		7		0.059
1964					1989	7	1	0.076	0.107
1965					1990	2	0	0.063	0.269
1966					1991	36		0.113	
1967	2		0.085		1992	1	0	0.064	0.139
1968	1		0.074		1993	5		0.127	
1969	2		0.086		1994				
1970	0		0.066		1995	27		0.121	
1971	0		0.083		1996	0	0	0.095	0.045
1972	9		0.102		1997	59		0.079	
1973	0		0.105		1998	90		0.088	
1974	24		0.060		1999	66	0	0.091	0.060
1975	64		0.066		2000	126	27	0.090	0.169
1976	32		0.122		2001	40	81	0.073	0.161
1977	17		0.105		2002	154	97	0.119	0.127
1978	0		0.128		2003	179	62	0.117	0.115
1979	26	0	0.143	0.042	2004	242	19	0.157	0.155
1980	61	0	0.121	0.039	2005	186	13	0.152	0.271
1981	16	1	0.128	0.245	2006	163	41	0.111	0.247
1982	7	0	0.200	0.042	2007	98	4	0.101	0.148
1983	0		0.066		2008	76	2	0.092	0.129
1984	0		0.061		2009	37		0.081	
1985					2010				

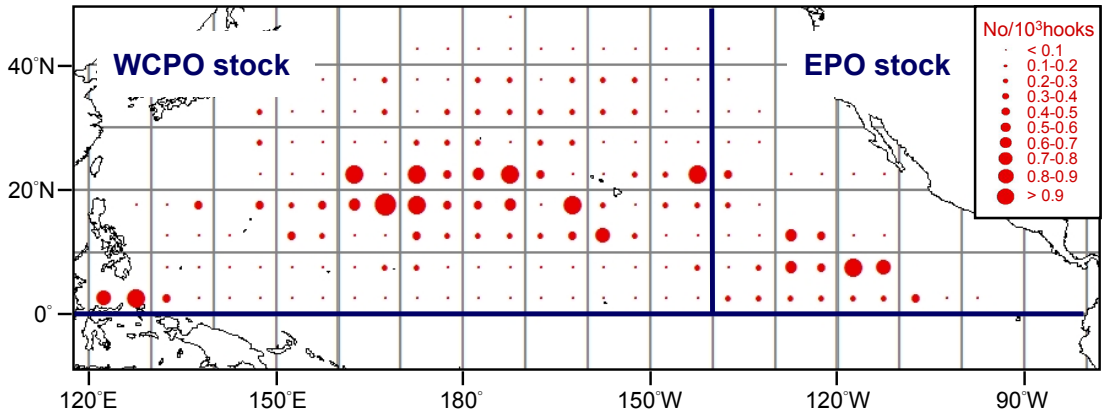


Fig. 1. Nominal catch-rates (number of fish caught per 1000 hooks) distribution for striped marlin caught in the Taiwanese tuna longline fisheries. The two regions are shown for the WCPO and EPO stocks of striped marlin in the North Pacific Ocean.

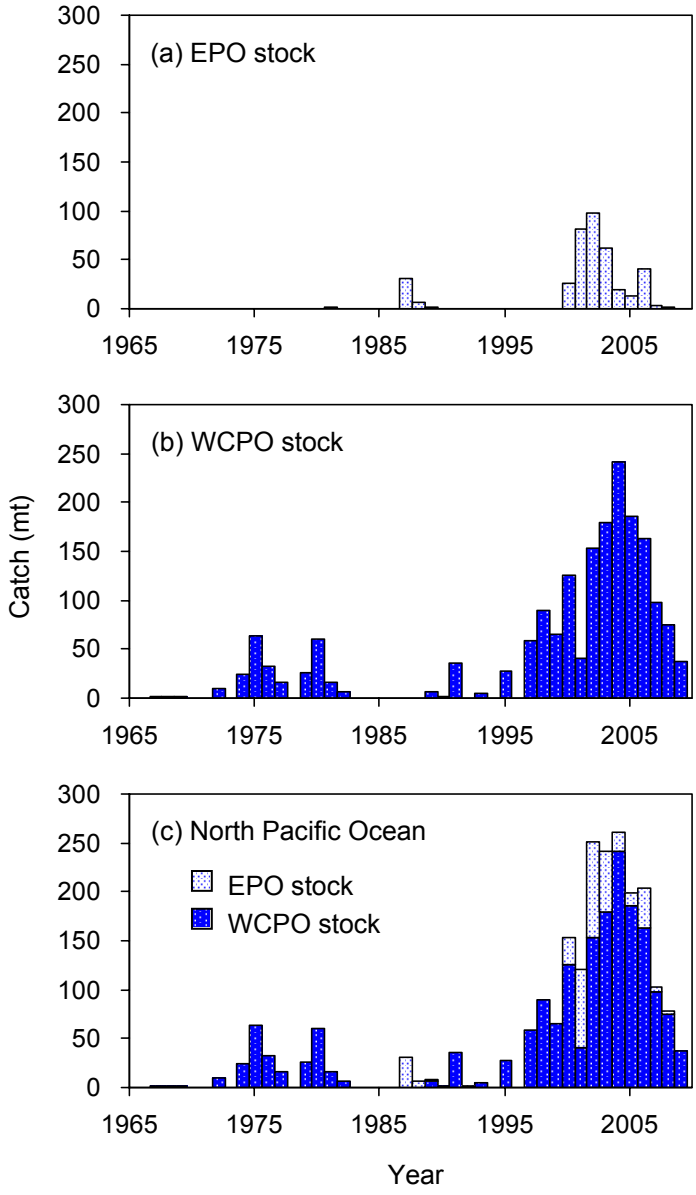


Fig. 2. Annual catches of striped marlin caught in the Taiwanese fisheries in the North Pacific Ocean for (a) the EPO (Eastern Pacific Ocean) stock, (b) the WCPO (western and central Pacific Ocean) stock, and (c) the two stocks of striped marlin combined.

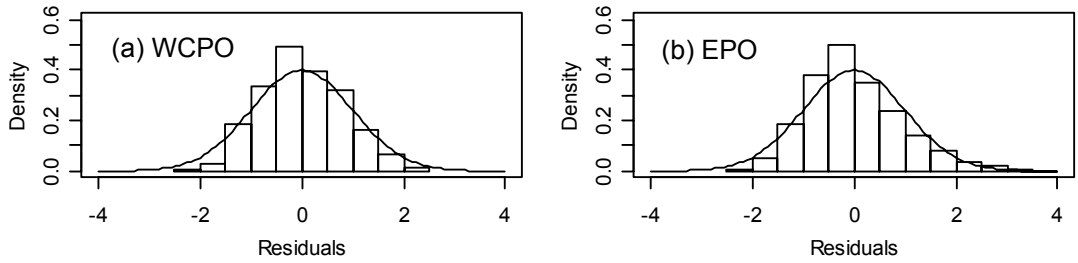


Fig. 3. The residual distribution of standardizing catch-rates of striped marlin caught by Taiwanese tuna longline fleets for the (a) WCPO and (b) EPO stocks.

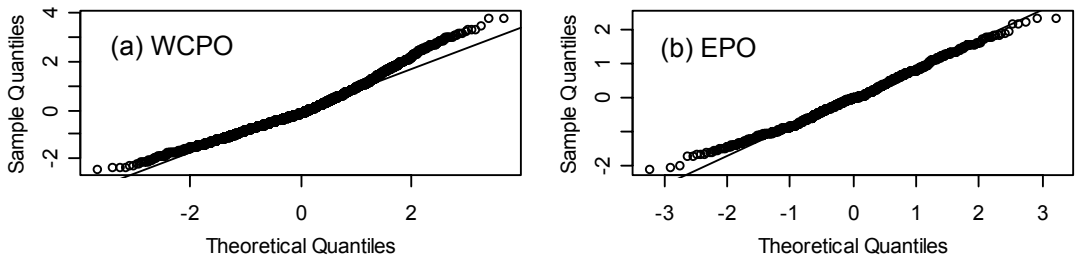


Fig. 4. The diagnostic Q-Q plots of standardizing catch-rates of striped marlin caught by Taiwanese tuna longline fleets for the (a) WCPO and (b) EPO stocks.

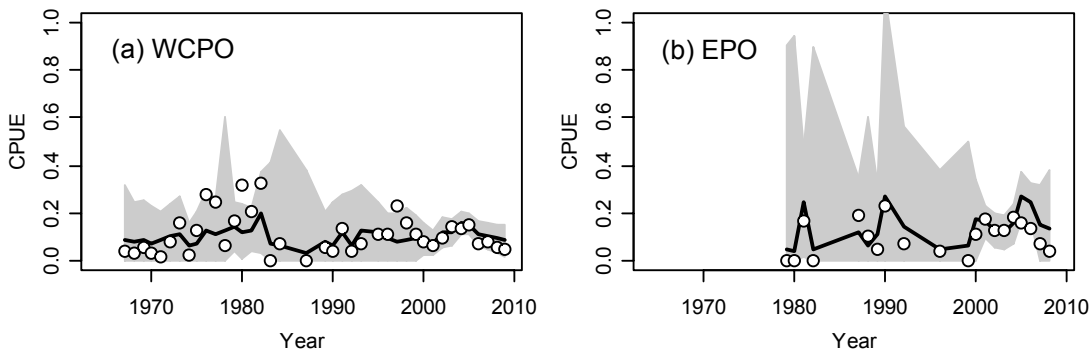


Fig. 5. The nominal (open dots) and standardized (solid lines) catch-rates of striped marlin caught by Taiwanese tuna longline fleets in the North Pacific Ocean for the (a) WCPO and (b) EPO stock. CPUE is expressed as number of fish caught per 1000 hooks. The shadows indicate the point-wise standard errors for the standardized catch-rates of striped marlin.