STANDARDIZATION OF THE JAPANESE LONGLINE CATCH RATES OF ADULT YELLOWFIN TUNA (*THUNNUS ALBACARES*) IN THE WESTERN INDIAN OCEAN BY GENERAL LINEAR MODEL (1975-98)

Tom Nishida

tnishida@enyo.affrc.go.jp

National Research Institute of Far Seas Fisheries (NRIFSF)

5-7-1, Orido, Shimizu-City, Shizuoka, Japan 424-8633

ABSTRACT

This paper attempted the GLM standardization of CPUE of adult yellowfin tunas in the Japanese longline fishery of the western Indian Ocean. The study used longline logbook data from 1975 to 1998. The western Indian Ocean was subdivided into four sub-areas, which were included as factors of the model. Additional factors were type of gear, year and season. It was noted that the fitted GLM only explained a relatively low proportion of the variance. While bearing this in mind, the paper also reported that (a) the factors most affecting nominal CPUEs in order of importance were area, number of hooks between floats, season, year and the interaction between season and area, (b) after a peak in 1977, the standardized CPUE shows a sharp decrease until 1980, after which it becomes stable(with a small reduction in 1988) and (c) The catch rates in most recent years (1995-1998) have stabilized at the lowest levels observed during the period 1975-1998.

INTRODUCTION

Yellowfin tuna is one of Thunnus species and distributes in tropical waters. Juvenile and young fish are often form pure or mixed school with other tunas near sea surface where the surface fisheries such as purse seine exploit them. On the other hand, the adult inhabits in deeper water around the thermocline and is mostly caught by longline gear.

In the late 1970s, there were some changes in the number of hooks between floats in the longline operations, i.e., before 1977, most of Japanese longline vessels used the basket sets with from five to eight hooks (regular longline) and after 1978, more hooks between floats (from nine to thirteen hooks: deep longline) became common (up to about fifty percent in early 1980s) (see Appendix A). The deep longline improves to catch bigeye tuna by deploying hooks deeper waters than those of the regular longline. Positive effects on catch rates for bigeye and negative effect for yellowfin tuna, were reported by Suzuki et al. (1977) and Koido (1985). Because of use of the deep longline, nominal catch rates of yellowfin tuna need be adjusted in standardizing them.

In this paper, two major yellowfin tuna stocks (west and east) is assumed in the Indian Ocean and standardization of yellowfin catch rates in the western stock from 1975-98 is attempted by applying

General Linear Model (GLM).

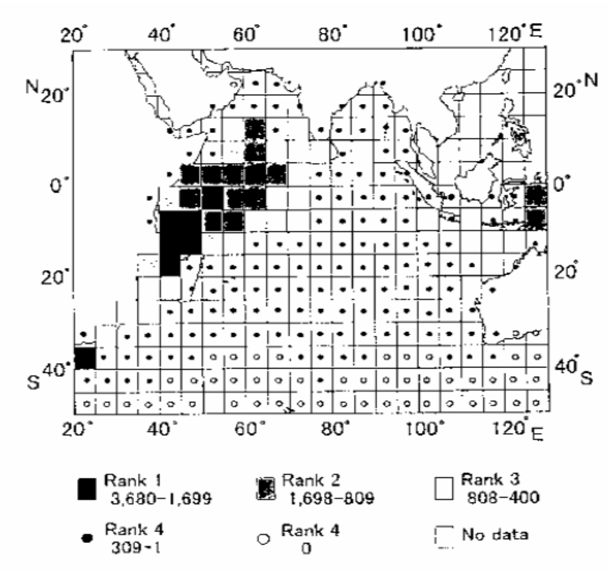
MATERIALS AND METHODS

Data

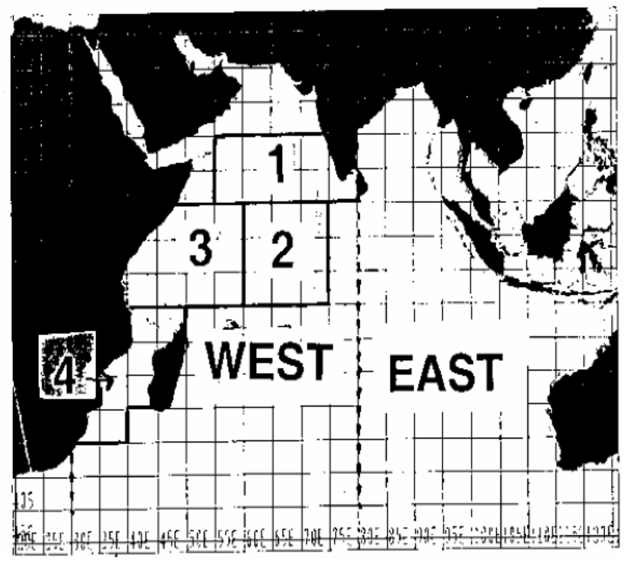
The Japanese longline catch and effort statistics from 1975 to 1998 were used, which were aggregated by month, 5x5 area and number of hooks between floats (NHF). Although there were data from 1952 to 1974, it was not used because it did not include the information on NHF.

GLM

Map 1 shows distribution of adult yellowfin tuna in the Indian Ocean based on the Japanese longline catch data (1975-98) (Mohri and Nishida, 2000). The major habitat area of the western stock is assumed to be in the tropical waters between 30°E and 80°E in latitudes. In the fishing ground of the western stock region, four sub-areas are defined for the GLM analyses as depicted in Map.2.



Map 1 Japanese yellowfin tuna longline fishing ground in the western Indian Ocean. (annual average catch by 5x5x area are ranked by 4 classes)



Map 2 Four sub-areas defined for the GLM analyses for the western yellowfin stock in the Indian Ocean.

For the GLM analyses, NHF is separated into 4 classes (class 1: 5-8, class 2: 9-12, class 3: 13-17, class 4:18-22). This classification was determined by considering the estimated parameter values of NHF effect derived from preliminary GLM analysis using the model in which only main effects were included.

Then, following GLM (log normal error structure) model is applied for the analyses:

$$\text{Log}\ (CPUE_{ijkl} + \text{const}) = \mu + Y_{(i)} + M_{(j)} + A_{(k)} + G_{(l)} + M{*}A_{(m...)} + A{*}G(n) + e_{(ijk)}$$

, where

Log : natural logarithm

CPUE : number of yellowfin catch per 1000 hooks

Const : 10% of overall mean of CPUE

μ : overall mean

$Y_{(i)}$: effect of year

$M_{(j)}$: effect of fishing season (month)

$A_{(k)}$: effect of area

$G_{(l)}$: effect of gear type (NHF)

M*A(j,k) : interaction term between fishing season and area,

A*G (k,l) : interaction term between area and gear type,

$e_{(ijkl..)}$: error term.

RESULTS

Table 1 shows the resultant ANOVA table and Table 2 shows the result of F-test of each effect term in GLM. Fig. 1 depicts the distribution of the residuals, which indicated appropriateness of the selected model (log normal error structure). Fig. 2 shows the trends of the nominal catch rates and standardized catch rates.

Table 1 Resultant ANOVA table

Source	DF	Sum of Squares	F Value	Pr > F
Model	115	916.5	15.63	0.0001
Error	3535	1802.5		
Corrected Total	3650	2719.0		

R-Square	C.V.	LCPUE Mean
0.337082	40.04853	1.78299897

Table 2 Result of F-test of each effect term in GLM of finally cited model

Source	DF	Type III SS	F Value	Pr > F
YR	23	157.29232216	13.41	0.0001
MO	11	122.55462435	21.85	0.0001
AREA	3	223.69790138	146.24	0.0001
EDA	3	47.26235376	30.90	0.0001
MO*AREA	33	164.31697001	9.77	0.0001
AREA*EDA	9	10.50120936	2.29	0.0148
MO*EDA	33	32.23938488	1.92	0.0013

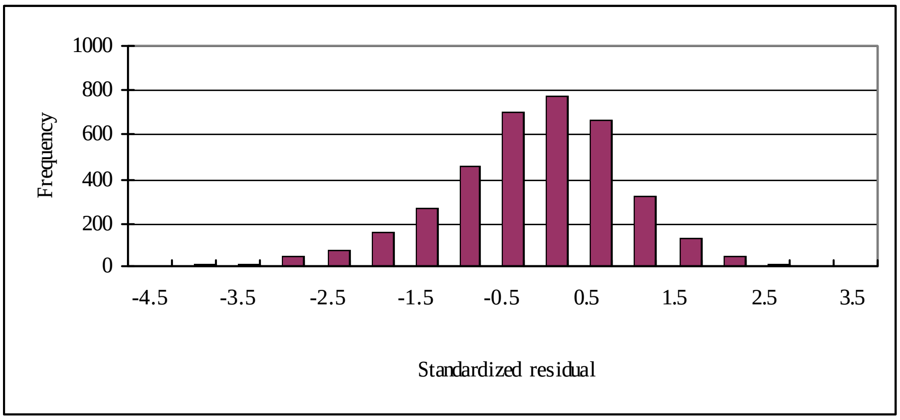


Fig. 1 Distribution of the residuals

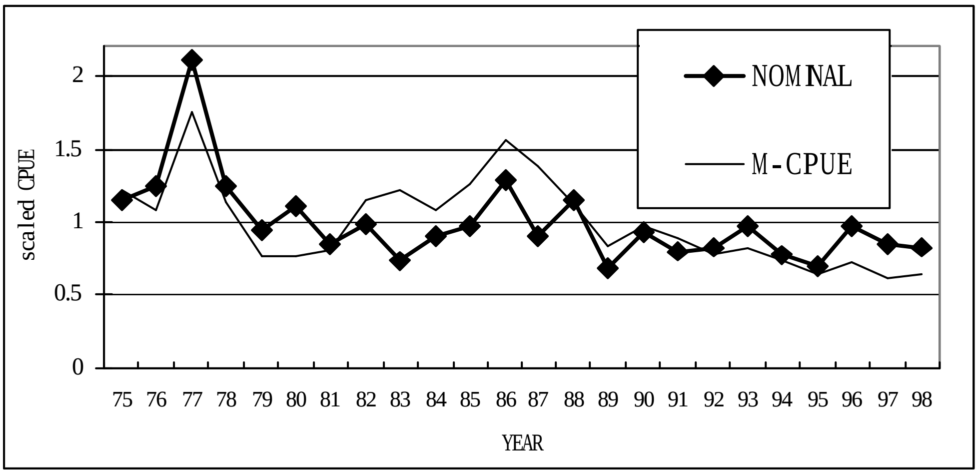


Fig. 2 Trends of the nominal and the standardized catch rates(M-CPUE).

DISCUSSION

In the past, all the GLM analyses for the longline catch rates standardization have been providing poor fitness to the models (R^2 range from 20-40% and CV range from 30-70%), no matter what sophisticated models were applied. The result of this study also showed very poor correlation and accuracy (R^2=34% and CV=40%). Thus, the RIGOROUS analyses and results are IMPOSSIBLE to expect, as long as we use the UNCERTAIN quality of the fishery information.

Therefore, no conclusions are made if RIGOROUS analyses and results are required.

However, if it is agreed that RIGOROUS results are not possible to obtain by the UNCERTAIN quality of the fishery information, following conclusion might be stated, although they are not highly accurate:

(1) Factors affecting the nominal catch are (in order of higher significant effect):

area, NHF, season (month), year and interaction term (month*area).

(2) The standardized catch rate shows that after its highest peak in 1977, it sharply decreased to 1980, then gradually increased to 1986 and the catch rate again, gently decreased to 1998. The catch rates in most recent four years (1995-98) are stable at the lowest level in 1975-98.

REFERENCE

KOIDO, T. 1985. Comparison of fishing efficiency between regular and deep longline gears on bigeye and yellowfin tunas in the Indian Ocean. IPTP/TWS/85/25, 62-70.

MOHRI, M. AND T. NISHIDA 2000. Consideration on distribution of adult yellowfin tuna (*Thunnus albacares*) in the Indian Ocean based on Japanese tuna longline fisheries and survey information (IOTC/WPTT/2000/).

SUZUKI, Z., Y. WARASHINA AND M. KISHIDA 1977. The comparison of catches by regular and deep tuna longline gears in the Western and Central Equatorial Pacific. Bull. Far Seas Fish. Res. Lab., 15,51-89

Appendix A Trend of number of hooks per basket (between floats)

Unit: number of hooks (in 1000 hooks)

Year	Number of hooks between floats (NHF)																	
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
1975	692	17637	11110	1679	785	590	275	444	242	0	0	0	0	0	0	0	0	0	
1976	419	13815	4883	575	150	335	9	144	63	0	0	0	0	0	0	0	0	0	
1977	43	9933	3512	306	530	587	456	685	738	0	0	0	0	0	0	0	0	0	
1978	35	8387	4999	1489	256	2960	3237	2426	2523	1681	98	42	0	0	0	0	0	0	
1979	4	5421	5566	1515	408	1391	1902	1193	1218	296	0	0	0	0	0	0	0	0	
1980	0	5776	6497	1604	959	2112	2336	2130	918	308	0	0	0	0	0	0	0	0	
1981	19	6585	8767	3458	792	1945	5510	3236	739	41	0	0	0	0	0	0	0	0	
1982	67	9772	9301	2497	224	1624	6647	7613	2261	470	0	0	0	0	0	0	0	0	
1983	0	5531	10680	2917	458	1157	5541	11660	5068	2344	112	0	0	0	0	0	0	0	
1984	28	5271	14077	3737	628	339	6395	9787	6047	1723	219	0	0	0	0	0	0	0	
1985	19	1588	17618	6813	705	708	7298	12856	7789	2320	97	214	0	0	0	0	0	0	
1986	0	2270	21516	5394	667	446	4051	9974	6608	3146	305	353	0	0	0	0	0	0	
1987	0	1163	17358	8861	903	452	1174	6268	10552	2204	304	418	0	0	0	0	0	0	
1988	0	897	12628	4840	998	701	1781	3703	11410	2177	44	543	0	0	0	0	0	0	
1989	0	173	15483	2932	729	303	2468	1714	6453	1543	166	716	0	27	0	0	0	0	
1990	0	738	8600	6333	997	136	2394	1179	4362	4301	353	531	128	188	26	0	0	0	
1991	0	329	11890	9205	2840	697	957	1304	2964	3647	1232	402	113	63	451	0	31	0	
1992	7	409	15949	8391	2023	932	1581	593	1993	2001	306	784	83	258	726	36	781	0	
1993	0	211	9695	10433	3090	1449	3919	839	2228	1294	929	393	473	705	321	153	1876	346	
1994	4	49	5918	15395	6930	4803	11952	1196	2406	1614	948	784	765	496	1845	351	2081	524	
1995	4	32	2606	14690	8925	9286	20813	2313	2952	2672	634	1152	868	972	1647	585	2766	597	
1996	0	0	469	6441	8216	12793	26548	1920	4746	2567	1509	3995	1521	1082	2922	786	4174	801	42
1997	0	3	197	1921	5108	13310	31009	3490	5617	2155	1930	3010	3678	2749	6970	2072	5747	1048	
1998	0	1	2	532	1639	9496	26412	3461	4345	869	984	2371	2524	3807	8204	2221	8242	2387	7