Standardizations of CPUE of striped marlin caught by Japanese offshore and distant water longliners in the north west and central Pacific[1]

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Introduction

Striped marlin in the north Pacific is one of important target/by catch fish for Japanese longline fishermen. This study is first trial to standardize CPUE of striped marlin caught by Japanese longliners at ISC marlin working group. Last study about estimation of abundance index of striped marlin in the north Pacific is done by Uozumi (1995), which standardized CPUE of striped marlin with traditional GLM methods. This study reports results of CPUE standardizations of striped marlin in the north west and central Pacific with both traditional GLM and the Habitat model (Hinton and Nakano, 1996).

Materials and Methods

(1)GLM

Basic catch and effort data used in the estimation of effective fishing effort was obtained from the Japanese longline fishery statistics compiled at the National Research Institute of Far Seas Fisheries for 1952-2002. Two kinds of Databases were used. The Database-I has the information of catch number and number of hooks aggregated by month and 5x5 blocks and rose to 100 percent coverage, while the new Database-II, starting from 1975, contains additional information for the gear configuration, i.e. the number of branch lines between floats. Standardizations of CPUE are conducted separately for the periods of 1952 – 1975 and 1975-2002, as difference in data quality. They are connected in 1975 after the standardization.

The standardization of CPUE conducted by the GLM method with the model as follows;

Database-I

$$\ln(CPUE_{ijk}+const)=\ln(\mu)+\ln(YR_i)+\ln(QT_j)+\ln(AR_k)+\ln(INTER)+\varepsilon$$

Database-II

$$\ln(CPUE_{ijkl}+const)=\ln(\mu)+\ln(YR_i)+\ln(QT_j)+\ln(AR_k)+\ln(GE_l)+\ln(INTER)+\varepsilon_{ijkl}$$

where ln: natural logarithm, $CPUE_{ijk}$: nominal CPUE (catch in number per 1,000 hooks, in year i, quarter j, area k), const: 1/20 of overall mean, μ: overall mean, YR_i: effect of year i, QT_j: effect of quarter j, AR_k: effect of area k, GE_l: effect of gear configuration l, INTER: interaction terms between YR*AR, YR*QT and AR*QT for Database-I, and YR*AR, YR*QT, AR*QT, and GE*QT. , and ε: normal error term. Analysis was made though the GLM procedure of computer software, “SAS Ver. 8.02”.

Area stratification used in this study is shown in Fig. 1. The effect of gear configuration is represented with the number of hooks between floats (NHF) classified into five categories (3-4, 5-6, 7-9, 10-11, 12-15, and 16=<).

Because interaction term between AR and YR is significant, abundance index of each area is weighted by the approximate size of area and summed up to get total abundance index.

(2) Habitat model

Same method as Yokawa (2004) is used for the estimation of effective fishing effort of striped marlin except for the vertical distribution pattern of fish and effect of operational time. Vertical distribution pattern of striped marlin used in this study is estimated by Dr. M. Hinton (unpublished) using data reported by Brill *et. al.* (1993). The pattern is shown in Fig. 2.

CPUE of striped marlin calculated by the effective effort is adjusted seasonal and areal effect using GLM with following model;

CPUE=μ+Year+Area+Quarter+Area*Quarter+Year*Area+Year*Quarter+e.

Because Year*Area interactions were significant, the weighted mean of CPUE in each year by the size of areas are summed up to get total abundance index.

In a longline research in autumn 2001 in the Atlantic, almost all catch (>90%) of billfishes except for swordfish caught during daytime based on data by the time, depth and temperature recorders (Yokawa and Saito, unpublished). Effective efforts of operations with NHF=3-4 (all night setting) are assumed to be 50% of that of day setting, and effective efforts of operations with NHF=5 and all operations in the period before 1975 (part of them are night setting but its ration unknown) are assumed to be 70% of that of day setting. This is rather rough hypothesis based on limited information, and should be improved in future.

Because number of observation in areas 7 and 8 were quite few or 0 for the periods before 1964, abundance indices estimated in two ways as one for the periods of 1952 – 2002 using data of areas 1-6, and the other for periods of 1964-2002 using data of areas 1-8, in both GLM and the habitat model.

Results and Discussions

(1) Abundance index by GLM

Figure 3 shows estimated abundance indices by GLM. For periods before 1975, two series were calculated, one is using data of areas 1-6 and the other is using data of areas 1-8 (starting in 1964). Historical trends of two indices are quite similar.

Residual patterns are shown in Fig. 4. In both three analyses, patterns are roughly the normal distribution. Tables 1-3 show results of ANOVA.

(2) Standardization of effect of gear configuration in GLM

In the Atlantic, vertically and horizontally unbalanced distribution and shortage of data caused unrealistic results about estimation of effect of gear configuration in the CPUE standardization of marlins (Yokawa, 2003). Standardized effect of gear configuration estimated in this study is roughly examined if it reasonably standardized or not.

Figure 5 shows standardized CPUEs (n/1000 hooks) by quarter and by gear configuration (left), and its residual patterns. Residual patterns are roughly the normal distribution but CPUE by gear configuration show clear different pattern among seasons. CPUEs decrease as NHF increase in

2nd and 3rd quarters – this may not so unrealistic because striped marlin stayed mostly in near surface layers (Brill et. al., 1993), and night setting operations conducted relatively lower latitude (around 30N) and gear started setting 3-4 hours before sun set. In 1st and 4th quarters, CPUEs go up as NHF increase and this result is very hard to explain by existing information about underwater movement of striped marlin.

Figure 6 shows historical changes of gear effects. All values obtained by adding year*gear interaction terms on the GLM model for Database-II. All values are expressed as relative values to the one of NHF=5-6 in corresponding year (set at 1.0). Data in area 6 and years of 1997, 1998 were deleted from analysis because of shortage of data coverage.

As shown in Fig. 6, pattern of gear effect remarkably changed by year in the periods after 1990. This may one of the reason for unrealistic results of estimated gear effect by GLM which shown in Fig. 5.

In the present study, reliability of the estimated effect of gear configurations is roughly examined. Results of analysis show the fact that estimated values about gear effect are biased. Further investigation should be necessary to get more reliable abundance index of striped marlin.

(3) Abundance index by the habitat model

Figure 7 shows contrast between two type of effort (nominal and effective effort), and between un-standardized trends of catch number and effective effort. In compare to the trend of nominal effort, the trend of effective effort showed significant decrease for period between 1955 and 1975. This can partly be attributed to the effect of change of length of float and branch lines in this period as well as change of speed of gear retrieving (speed in the period of 1955-1969 assumed to be 1/3 of the one of 1970-2005, as branch lines retrieved by hand in former period; Yokawa, 2004). Catch number is also dropped markedly in the first half of 1970's.

Effect of operation time of day and night setting introduced to the model in this study is quite preliminary one. Figure 8 shows contrast of effective effort with and without effect of operation time. Introduction of effect of operation time decreased yearly total amount of effective effort by 10-40%.

Abundance indices estimated by the habitat model (adjusted area and season effect by GLM) are shown in Fig. 9. Difference of trends between a index estimated using data in areas 1-6 (1955-2002) and in areas 1-8 (1964-2002) is minor. Residual patterns in the adjustment of area and season effect by GLM are shown in Fig. 10. In both indices, the patterns are not so different from the normal distribution. Results of ANOVA are shown in Tables 4 and 5.

Figure 11 shows abundance indices estimated by the habitat model with and without effect of operation time. Introduction of effect of operation time in the model gives quite minor effects on the historical trend of the abundance index.

(4) Regional trends of abundance indices

To compare regional trends of abundance indices, eight areas divided into four regions (areas 1-3, area 5, areas 4 & 6, and areas 7-8). Figure 12 shows comparison between four regions by both habitat model and GLM. In both cases, no clear differences in historical pattern of trends between regions are observed.

Conclusion

In the present study, abundance index of striped marlin in the north west and central Pacific (north of 10N and west of 130W) is estimated using the GLM method and the habitat model. Trends of two abundance indices are different (Fig. 13). The one by the habitat model indicates that current stock level is larger than that in 1950's while the other by GLM indicates that current stock level is about half of that in 1950's.

In the GLM model, effect of gear configuration seems not to be standardized correctly. Relatively higher CPUE of deep setting than shallow setting observed in 2nd and 3rd quarters (Fig. 5) would results in the underestimate of current stock level, because ratio of deep setting operation increased after 1980's. Estimation of more reliable effect of gear configuration in GLM would not be possible when one use only information from logbook because coverage of data is limited. Only breakthrough would be introduce the effect of gear configuration from outside of GLM, or introduce other adequate information such as some oceanographic data into the model.

The habitat model is one of ways to estimate effect of gear configuration directly. This method can estimate effective fishing effort in set by set scale if proper information about under water movement of fish and gear were available. Though some of input parameters, such as vertical distribution pattern of striped marlin, for the habitat model are preliminary and they should be improved for conducting more precise stock assessment, estimated abundance indices by the habitat model also indicates that the GLM method underestimates current stock status of striped marlin.

Both indices show decreasing trends since mid 1990's, which should be reviewed in near future.

Reference

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Hinton, G.M. & Nakano, H. (1996) 'Standardizing catch and effort statistics using physiological, ecological, or behavioral constrains and environmental data, with application to blue marlin (*Makaira nigricans*) catch and effort data from Japanese longline fisheries in the Pacific'

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Uozumi (1995); Stock of striped marlin in the Pacific (in Japanese), Kaiyo Monthly, Vol. 27, No. 2, 96-101.

Yokawa (2003); Preliminary results of study on the effect of gear configuration in CPUE standardization by GLM methods. ICCAT SCRS DOC, SCRS/2003/035, 19pp.

Yokawa. 2004; Estimation of abundance index of swordfish caught by Japanese longliners by the habitat model. ISC/04/SWO-WG/___, 17pp.

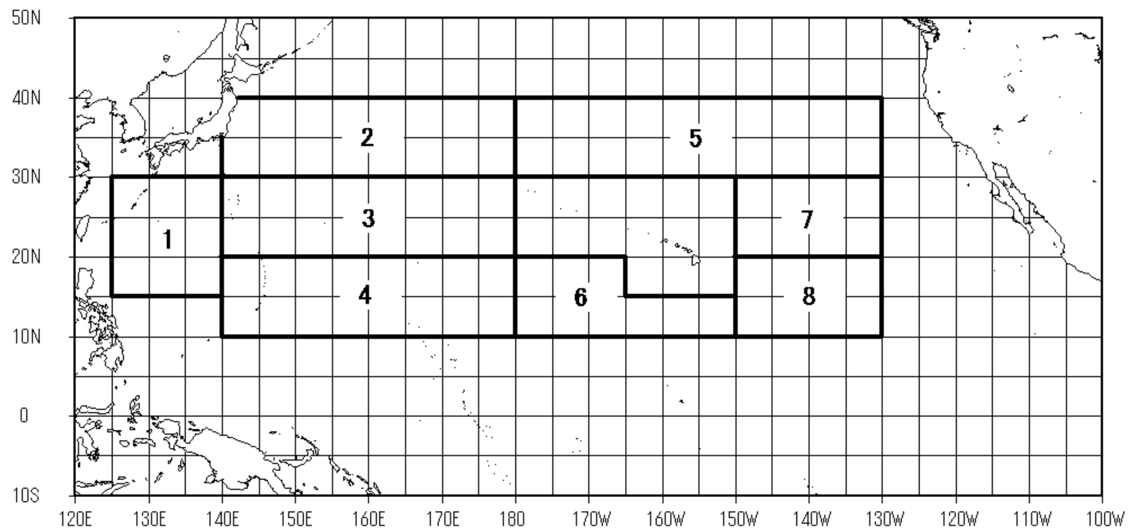

Fig. 1. Area stratification used in this study.

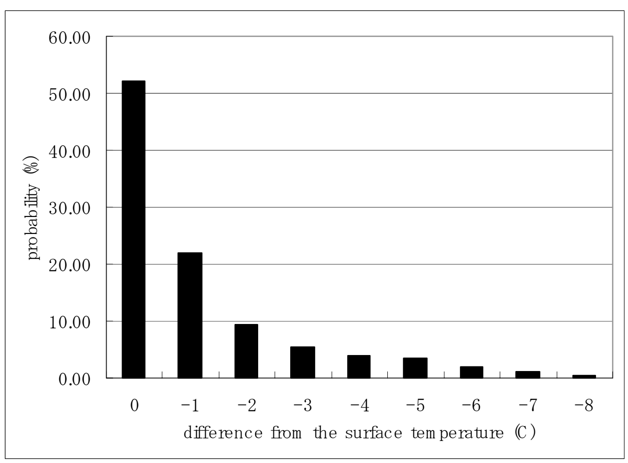

Fig. 2. Vertical distribution pattern of striped marlin used in the estimation of the effective effort. Values are estimated by Dr. M. Hinton (unpublished) using data reported by Brill *et. al.* (1993). 0% is assumed for layer of <-8 C.

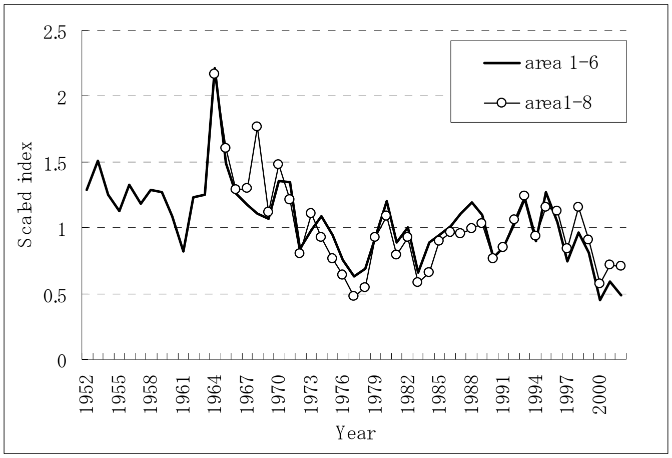

Fig. 3. Estimated two abundance indices by GLM, one is using data of area 1-8 (1964-2002), and the other using data of areas 1-6 for periods of 1952-1974 and data of areas 1-8 for periods of 1975-2002. All values are scaled to the average of 1964-2002, which set at 1.0.

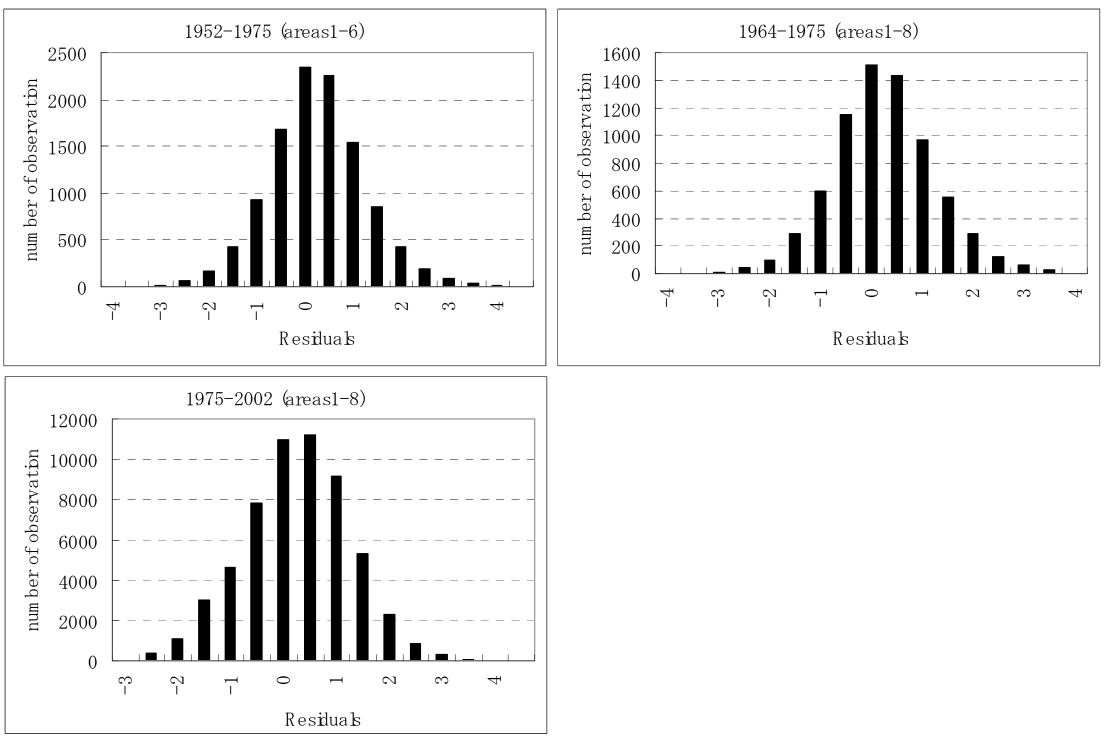

Fig. 4. Pattern of residuals in GLM analysis. Left top panel is the one for the periods of 1952-1975 (areas 1-6), right top for the periods of 1964-1975 (areas 1-8), and left bottom for the periods of 1975-2002 (areas 1-8).

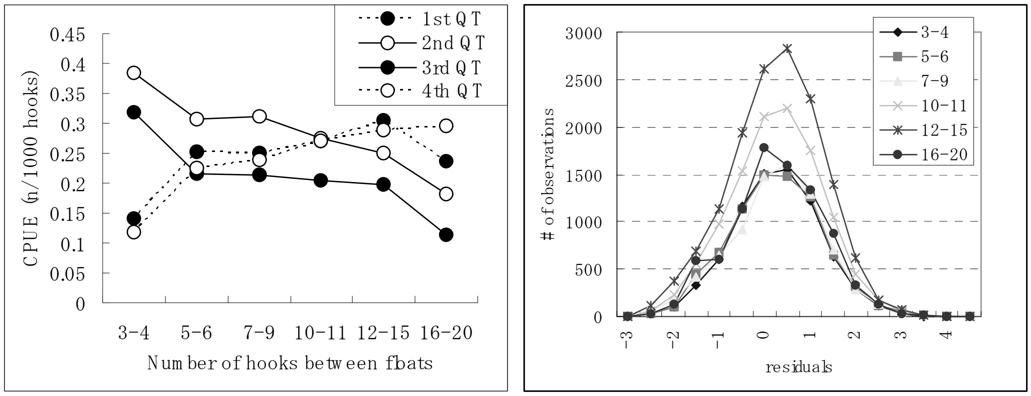

Fig. 5. Standardized CPUE (n/1000 hooks) by quarter and by gear configuration (left) and its residual patterns.

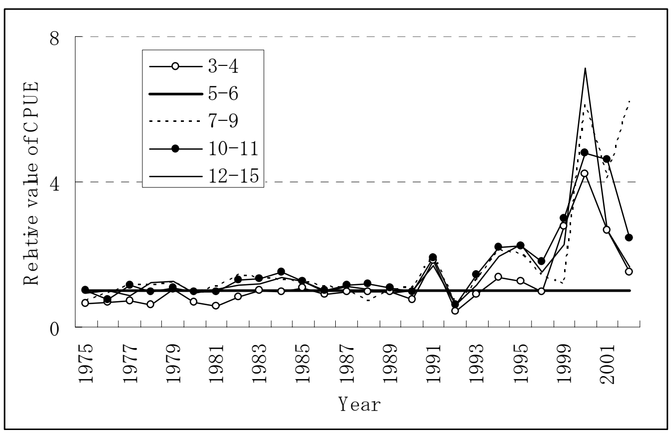

Fig. 6. Historical trends of standardized CPUE by gear configuration. All values scaled to the one of NHF=5-6 in corresponding year (set at 1.0). Data in area 6 and years of 1997, 1998 were deleted from analysis.

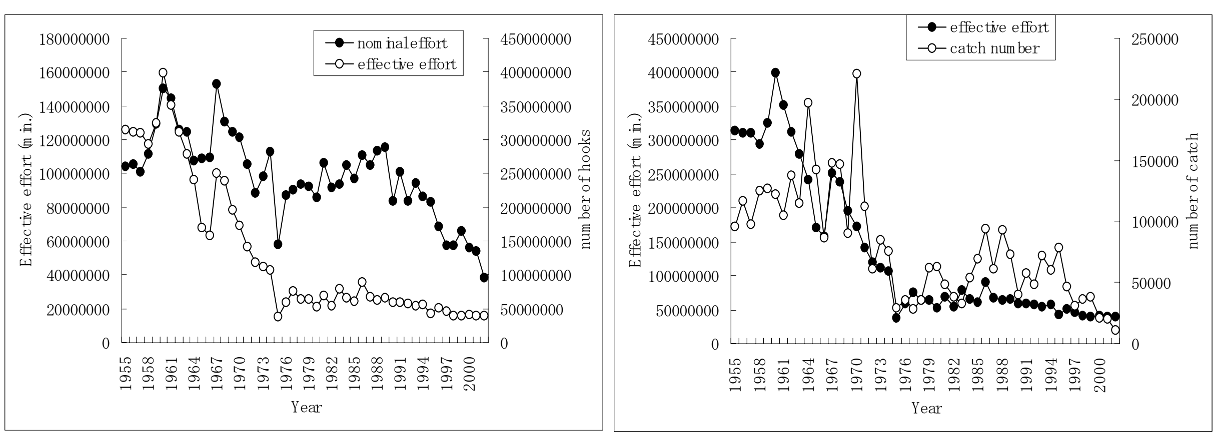

Fig. 7. Contrast between amount of total hooks and total effective effort by year (left), and amount of total effective effort and total catch number by year (right).

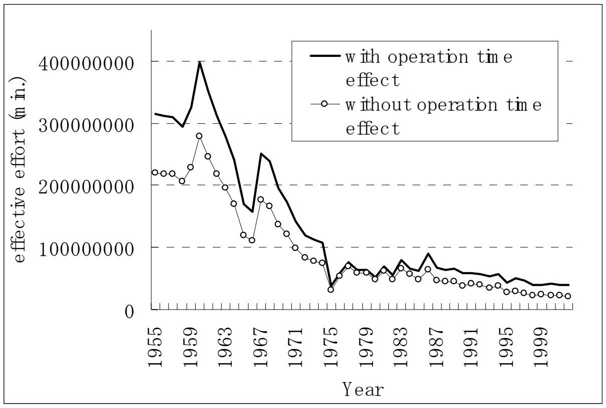

Fig. 8. Contrast between effective efforts estimated with and without effect of operation time.

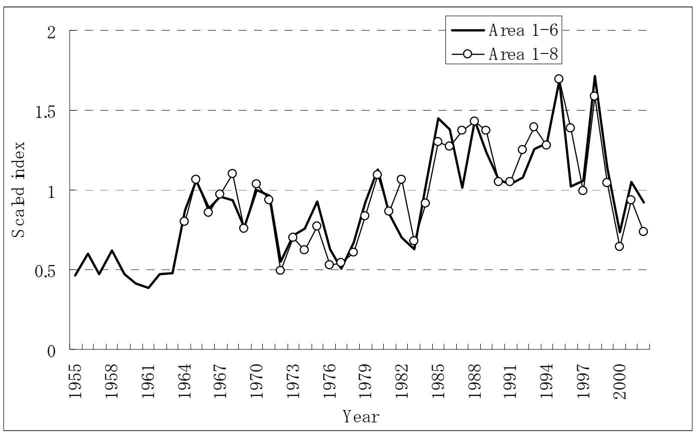

Fig. 9. Two abundance indices estimated by the habitat model. One is estimated using data of areas 1-6 for periods of 1955-2002 and the other using data of areas 1-8 for periods of 1964-2002. All values are scaled to the average of 1964-2002, which set at 1.0.

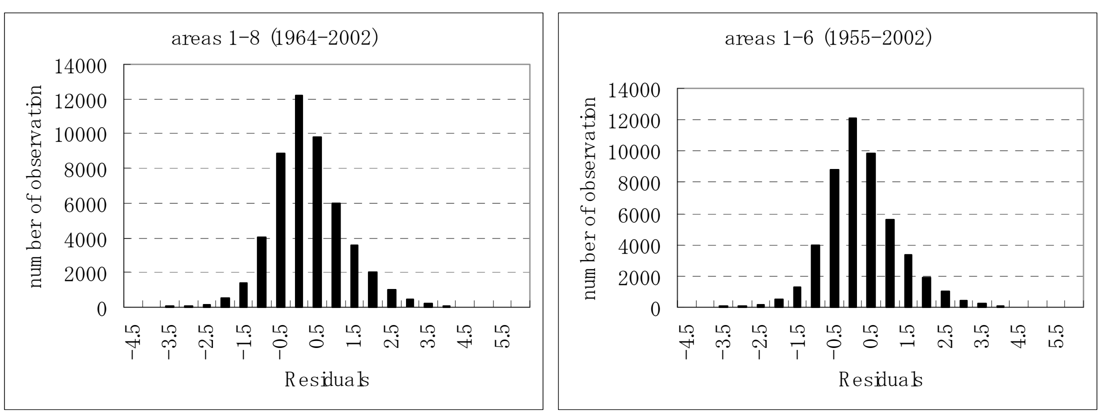

Fig. 10. Patterns of residuals for two abundance indices estimated by the habitat model when they adjusted area and season effect by GLM.

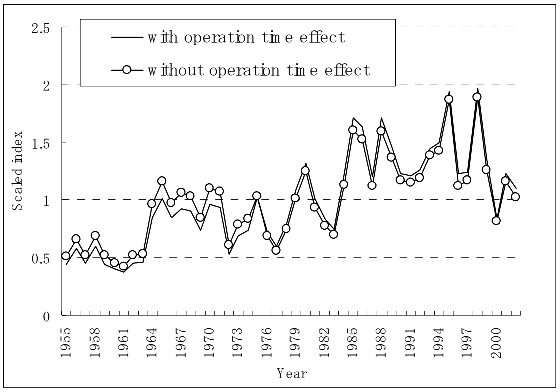

Fig. 11. Abundance indices estimated by the habitat model with and without effect of operation time. All are values scaled to their average, which set at 1.0.

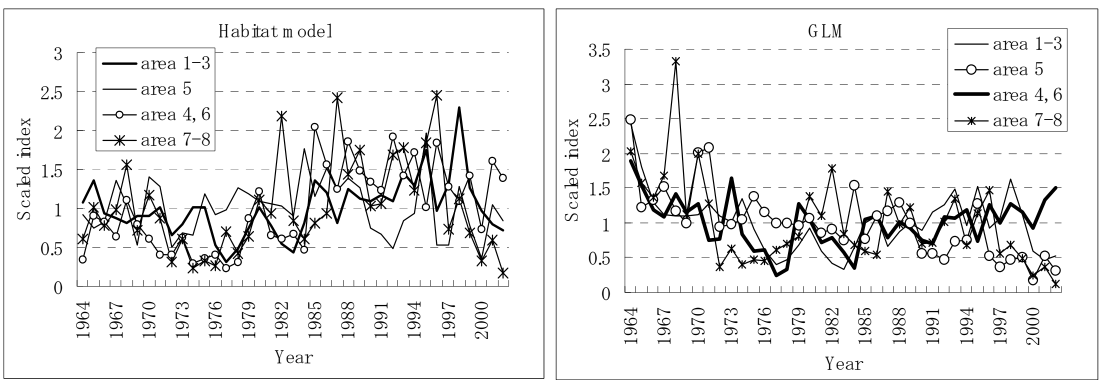

Fig. 12. Trends of abundance indices by region. Left panel shows the one by the habitat model and right shows the one by GLM. All are values scaled to their average, which set at 1.0.

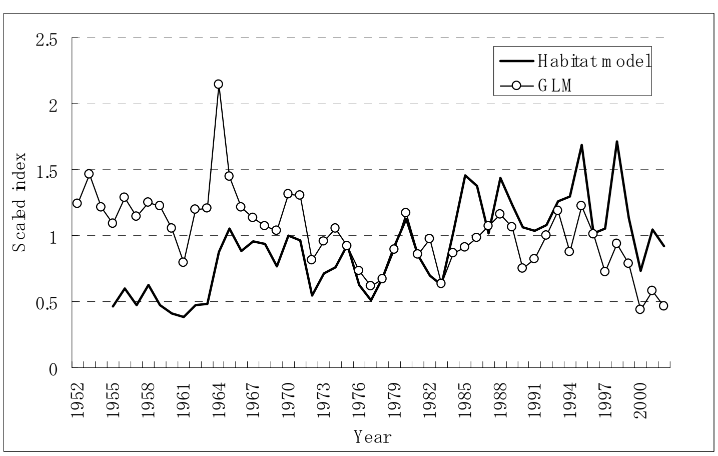

Fig. 13. Estimated abundance indices of striped marlin in the north west and central Pacific (north of 10N and west of 130W) by GLM and the habitat model. All values are scaled to the average of 1955-2002, which set at 1.0.

Table 1. ANOVA of GLM analysis using data of areas 1-6 for periods of 1952-1975.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	230	5862.68538	25.48994	30.62	<.0001
Error	10822	9008.18137	0.83240		
Corrected Total	11052	14870.86674			

R-Square	Coeff Var	Root MSE	lcpue Mean
0.394240	-174.4005	0.912357	-0.523139

Source	DF	Type III SS	Mean Square	F Value	Pr > F
yr	23	225.746415	9.815062	11.79	<.0001
area	5	1112.744193	222.548839	267.36	<.0001
qt	3	50.068813	16.689604	20.05	<.0001
yr*area	115	825.121392	7.174969	8.62	<.0001
yr*qt	69	209.941980	3.042637	3.66	<.0001
area*qt	15	2242.193521	149.479568	179.58	<.0001

Table 2. ANOVA of GLM analysis using data of areas 1-8 for periods of 1964-1975.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	152	4150.386888	27.305177	34.11	<.0001
Error	6999	5602.482826	0.800469		
Corrected Total	7151	9752.869714			

R-Square	Coeff Var	Root MSE	lcpue Mean
0.425555	-178.7149	0.894689	-0.500624

Source	DF	Type III SS	Mean Square	F Value	Pr > F
yr	11	297.030782	27.002798	33.73	<.0001
area	7	1392.100214	198.871459	248.44	<.0001
qt	3	19.243371	6.414457	8.01	<.0001
yr*area	77	356.919806	4.635322	5.79	<.0001
yr*qt	33	138.225933	4.188665	5.23	<.0001
area*qt	21	1448.883940	68.994473	86.19	<.0001

Table 3. ANOVA of GLM analysis using data of areas 1-8 for periods of 1975-2002.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	348	30670.60092	88.13391	82.99	<.0001
Error	56781	60303.30043	1.06203		
Corrected Total	57129	90973.90135			

R-Square	Coeff Var	Root MSE	lcpue Mean
0.337136	-86.00173	1.030550	-1.198290

Source	DF	Type III SS	Mean Square	F Value	Pr > F
yr	27	1090.924825	40.404623	38.04	<.0001
area	7	5967.618759	852.516966	802.72	<.0001
qt	3	63.966335	21.322112	20.08	<.0001
gear	5	183.105312	36.621062	34.48	<.0001
yr*area	189	3290.472356	17.409907	16.39	<.0001
yr*qt	81	879.376123	10.856495	10.22	<.0001
area*qt	21	7076.820111	336.991434	317.31	<.0001
qt*gear	15	1314.313257	87.620884	82.50	<.0001

Table 4. ANOVA of GLM analysis using effective effort in areas 1-8 for periods of 1964-2002.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	449	49975.9498	111.3050	102.37	<.0001
Error	50143	54517.5705	1.0872		
Corrected Total	50592	104493.5203			

R-Square	Coeff Var	Root MSE	lcpue Mean
0.478268	91.88580	1.042709	1.134788

Source	DF	Type III SS	Mean Square	F Value	Pr > F
yr	38	1840.70997	48.43974	44.55	<.0001
area	7	5901.52862	843.07552	775.43	<.0001
qt	3	2945.59473	981.86491	903.08	<.0001
yr*area	266	2730.61721	10.26548	9.44	<.0001
yr*qt	114	1049.07059	9.20237	8.46	<.0001
area*qt	21	20822.30762	991.53846	911.98	<.0001

Table 5. ANOVA of GLM analysis using effective effort in areas 1-6 for periods of 1955-2002.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	446	50289.7563	112.7573	105.77	<.0001
Error	49320	52579.3939	1.0661		
Corrected Total	49766	102869.1502			

R-Square	Coeff Var	Root MSE	lcpue Mean
0.488871	97.14705	1.032515	1.062837

Source	DF	Type III SS	Mean Square	F Value	Pr > F
yr	47	2452.47675	52.18036	48.95	<.0001
area	5	4671.67118	934.33424	876.41	<.0001
qt	3	3334.76897	1111.58966	1042.68	<.0001
yr*area	235	2584.73323	10.99886	10.32	<.0001
yr*qt	141	1081.51579	7.67032	7.19	<.0001
area*qt	15	21067.53727	1404.50248	1317.44	<.0001