STANDARDIZATION OF BIOMASS CPUE FOR SWORDFISH CAUGHT BY JAPANESE LONGLINE FISHERY IN THE SOUTH ATLANTIC

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SUMMARY

The swordfish biomass CPUE of the Japanese longline fishery from 1975 to 1995 was standardized by Generalized Linear Model in the south Atlantic Ocean. The effects of area, season, and gear configuration were incorporated in the models. The standardized CPUE had increased gradually in the 1970s and then became relatively stable in the 1980s, but then continued to decrease with some fluctuations since the late 1980s.

RÉSUMÉ

La CPUE de la biomasse d'espadon des pêcheries japonaises à la palangre de 1975 à 1995 a été standardisée à partir du modèle linéaire généralisé dans l'Atlantique Sud. On a incorporé aux modèles les effets des facteurs zone, saison et configuration de l'engin. La CPUE standardisée a augmenté graduellement au cours des années 70 et s'est ensuite relativement stabilisée dans les années 80 ; cependant, à partir de la fin des années 80, elle a continué à décroître avec quelques fluctuations.

RESUMEN

Por medio del Modelo Lineal Generalizado, se estandarizó la CPUE de la biomasa de pez espada, de la pesquería palangrera japonesa en el Atlántico sur, de 1975 a 1995. Se incorporaron a los modelos los efectos de zona, temporada y configuración del arte. La CPUE estandarizada aumentó gradualmente en los años 70, permaneciendo relativamente estable en la década de los 80, aunque desde finales de la misma ha ido en descenso con algunas fluctuaciones.

Introduction

The CPUE of longline is only one source of information on the historical changes in stock abundance for swordfish in the south Atlantic. But there are many factors which seem to affect CPUE such as environmental (season, water temperature, salinity, depth, current, moon phase etc.); biological (maturation, migration, food availability etc.), and operational ones (gear configuration, soaking time, target species, regulation, kind of bait, hook size etc.). Then standardization becomes essential for the purposes of monitoring the stock abundance using the CPUE, though the data availability of such factors generally are very limited and only some of them are possible to be incorporated into the analysis.

In the present study, a multiplicative model with log-normal error assumption is applied to standardize CPUE expressed by catch in ton per 1000 hooks, considering year, season, area, and gear configuration.

Materials and methods

A. Basic data

The basic data for this study were obtained from the Japanese longline fishery statistics compiled at the National Research Institute of Far Seas Fisheries for 1975-1995. The catch and effort statistics in the present study is a sample statistics aggregated by year, month, five-degree area, i.e.,

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TASK II database submitted to ICCAT with an additional item of number of branch lines per basket, which approximates the gear configuration such as regular and deep longlines. This sample statistics was started to collect since 1975. The catch in this database is expressed by number. In the present study, the catch in number is converted to catch in weight (ton) using the size composition by year, ICCAT swordfish area, and quarter. Observations with less than 3,000 hooks were excluded from the analysis.

B. Standardization

Year, season, area, and gear configuration were incorporated as the main effects. Quarter-of-the-year was selected as season. Based on the distribution of fishing efforts and CPUE of swordfish (Appendix figs. 1 and 2), six subareas were selected as shown in Fig. 1. With regard to the gear configuration, 3 to 20 hooks between floats were observed in the statistics used. These 18 levels were categorized to 4 levels (4-8, 9-11, 12-15, and 16-20 hooks between floats) arbitrarily.

The fittings for the model, CPUE model with log-normal distributions, was done through GLM procedure of SAS/STAT statistical package (Ver. 6.11).

The multiplicative CPUE model with log-normal distribution is as follows:

$$\log(CPUE_{ijkl}+\text{Constant}) = \mu + YR_i + QT_j + Area_k + Gear_l + \text{Interactions} + e_{ijkl} \quad \cdots\cdots (1)$$

where log : natural logarithm,

$CPUE_{ijkl}$: nominal CPUE (catch in ton per 1000 hooks, in year i, quarter j, subarea k and effect of gear l),

μ : overall mean, YR_i : effect of year i, QT_j : effect of quarter j, $Area_k$: effect of subarea k, $Gear_l$: effect of gear l, Interactions : two-way interactions, e_{ijkl} : normal error term.

As a constant used in this model, 10% of the overall mean CPUE (0.008) was selected which was recommended in bluefin species group (ICCAT, 1996).

All combinations of two-way interactions were tested for the selection of the best CPUE model, except for the two-way interactions of year and gear configuration (YR*Gear) due to the lack of sufficient data combinations for this two-way interaction. The best CPUE model was selected by the AIC (Akaike's Information Criterion). AIC is:

$$AIC = X \log(MSE) + 2Y \quad \cdots\cdots (2)$$

where X is the number of observation, MSE is mean square error and Y is number of parameters.

Results and discussions

The obtained AICs are listed in Table 1. The final model in the south Atlantic included all main effects (year, area , and quarter) and all available two-way interactions.

The result of ANOVA for the CPUE model by GLM procedure is shown in Table 2. F-values in Table 2 shows the model is highly significant. Fig. 2 shows the standardized residuals. The distribution of the standardized residuals is reasonably symmetrical and not far from normal distribution.

The standardized biomass CPUEs, which is expressed as relative one (re-scaled to overall mean), is shown in Fig. 3. The standardized CPUE gradually increased during the mid and late 1970s and then became relatively stable in the 1980s with some fluctuations. Then it has continued to decrease since the late 1980s.

The distribution of the fishing effort of the Japanese longline fishery has been limited in the tropical eastern part of the south Atlantic, compared with the distribution pattern of swordfish CPUE (see Appendix figs. 1 and 2). In the present study the data only in the eastern Atlantic were used, because of the sufficient observations by time-area strata. As the result, the resulted CPUE may reflects one part of the south Atlantic swordfish.

References

ICCAT 1996: Report of the bluefin tuna methodology session (Madrid, Spain -April 16 to 19, 1996). 28pp.

Table 1. Estimates of AIC for each model. The value of AIC with under line shows the best model.

Model	AIC
yr qt area gear	-6248.583
yr qt area gear yr*qt	-6580.945
yr qt area gear area*qt	-6905.642
yr qt area gear area*gear	-6532.645
yr qt area gear qt*gear	-6466.246
yr qt area gear area*gear area*qt	-7149.841
yr qt area gear yr*qt area*qt	-7152.935
yr qt area gear yr*qt area*gear	-6854.546
yr qt area gear yr*qt qt*gear	-6740.609
yr qt area gear area*qt qt*gear	-6909.346
yr qt area gear area*gear qt*gear	-6724.830
yr qt area gear yr*qt area*qt area*gear	-7398.999
yr qt area gear yr*qt area*qt qt*gear	-7155.114
yr qt area gear yr*qt area*gear qt*gear	-6994.373
yr qt area gear area*qt area*gear qt*gear	-7153.354
yr qt area gear yr*qt area*qt area*gear qt*gear	-7401.564

Table 2. The results of ANOVA.

R-square : 0.519

Source	DF	SS	MS	F Value	Pr > F
Model	130	7768.546	59.758	107.99	0.0001
Error	12996	7191.716	0.553		
Corrected Total	13126	14960.262			

Source	DF	SS	MS	F Value	Pr > F
YR	20	582.752	29.138	52.65	0.0001
QT	3	51.718	17.239	31.15	0.0001
AREA	5	688.138	137.628	248.70	0.0001
GEAR	3	103.492	34.497	62.34	0.0001
YR*QT	60	265.859	4.431	8.01	0.0001
QT*AREA	15	262.342	17.489	31.60	0.0001
AREA*GEAR	15	171.521	11.435	20.66	0.0001
QT*GEAR	9	23.892	2.655	4.80	0.0001

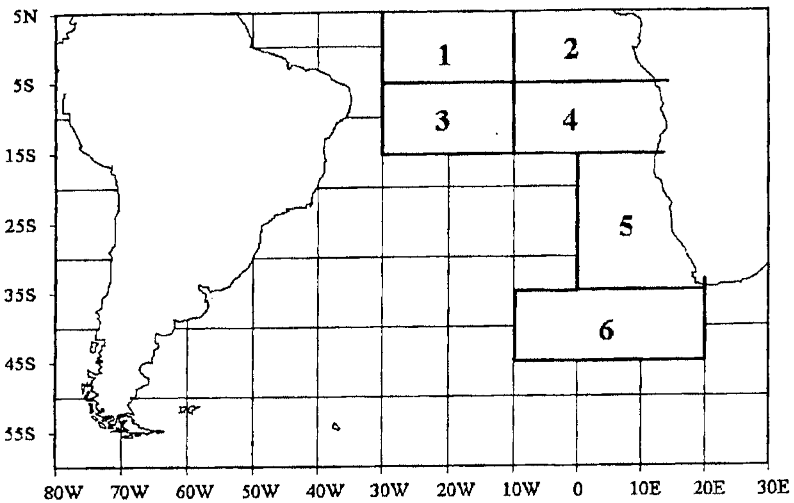


Fig. 1. Subareas used in the standardization of CPUE for swordfish.

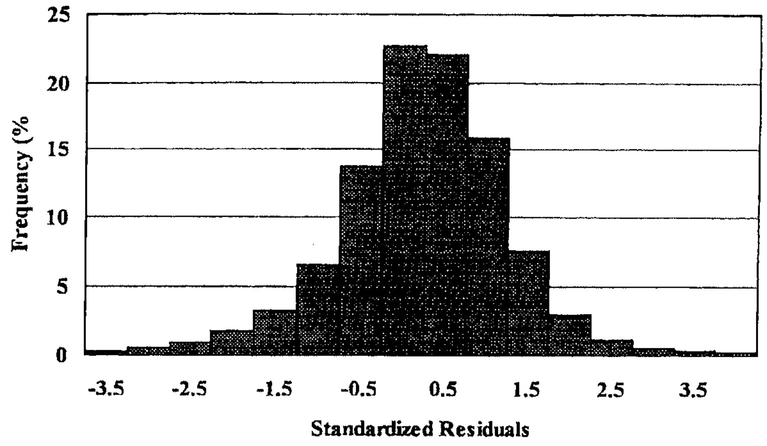


Fig. 2. Distribution of standardized residuals.

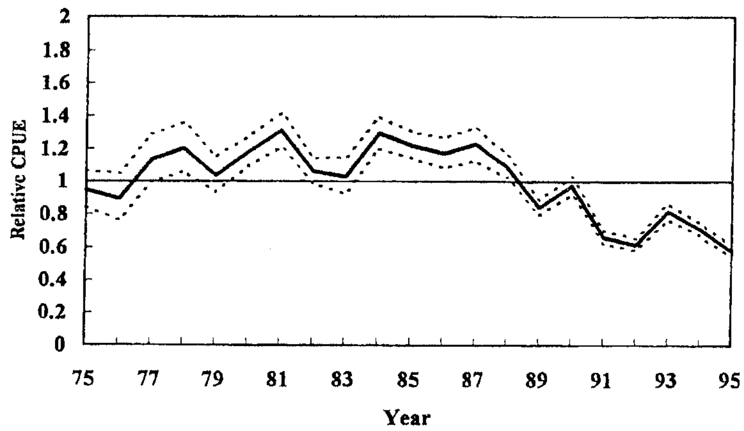
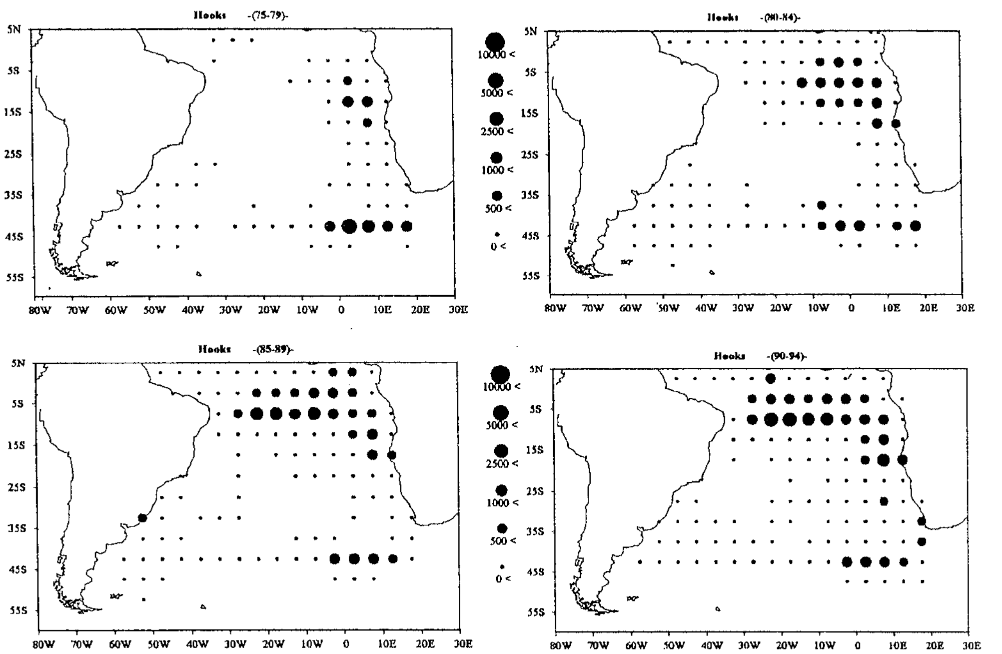
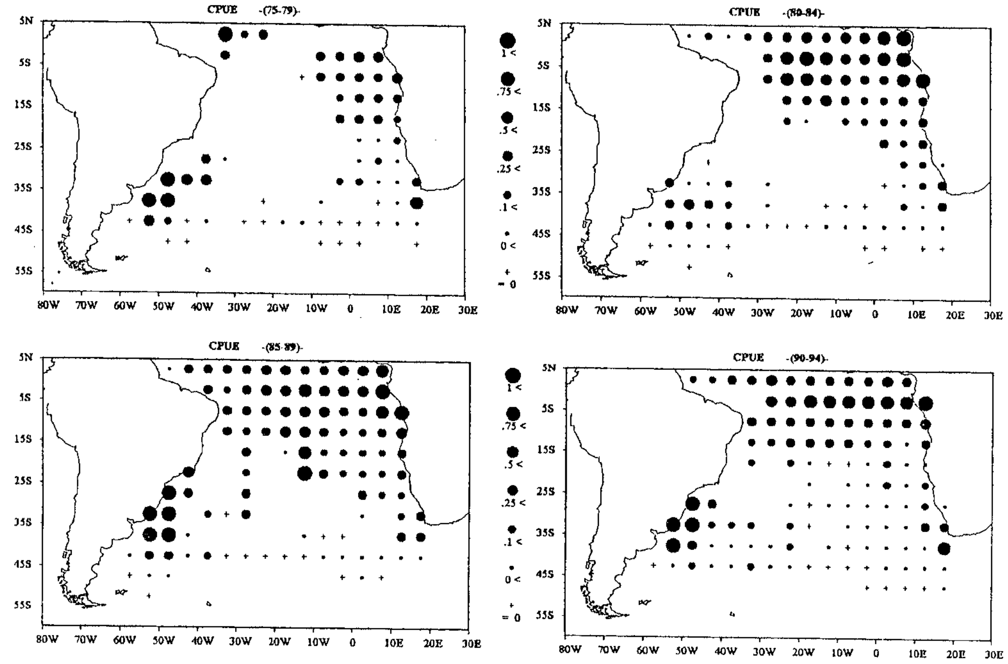


Fig. 3. Standardized biomass CPUE (re-scaled to overall mean) of swordfish caught by the Japanese longline fishery in the south Atlantic Ocean.



Appendix fig. 1. Distribution of fishing effort (No. of hooks in thousand) of Japanese longline fishery by five years from 1975 to 1994 in the south Atlantic.



Appendix fig 2. Distribution of swordfish CPUE (ton/1000 hooks) caught by Japanese longline fishery by 5 years from 1975 to 1994 in the south Atlantic.