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STANDARDIZATION OF SPECIES COMBINED CPUE FOR SAILFISH AND SPEARFISH CAUGHT BY JAPANESE LONGLINE FISHERY IN THE ATLANTIC OCEAN

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SUMMARY

The sailfish and spearfish combined CPUE of the Japanese longline fishery are standardized by General Linear Model (GLM) for the east and west Atlantic. The effects of area, season, and target species are included in the model. For data after 1975, the effect of gear configuration is also included. In both the east and west Atlantic, the CPUE peaked in 1968 and then decreased continuously until 1992 with some fluctuations.

RESUME

Les CPUE combinées des voiliers et des "spearfish" de la pêcherie palangrière du Japon sont standardisées avec le Modèle Linéaire Généralisé (GLM) pour l'Atlantique Est et Ouest. Les effets de zone, de saison et d'espèces ciblées sont pris en compte dans le modèle. Les données de la période après 1975 tiennent également compte de l'effet de la configuration de l'engin. Dans l'Atlantique Est et Ouest, la CPUE a atteint son maximum en 1968 et n'a cessé de diminuer depuis cette date jusqu'en 1992, avec des fluctuations.

RESUMEN

Las CPUE combinadas de pez vela y *Tetrapturus pfluegeri* + *T. belone* de la pesquería palangrera de Japón se estandarizan mediante Modelo Lineal Generalizado (GLM) para el Atlántico este y oeste. Se incluyen en el modelo los efectos zonales, estacionales y de especies-objetivo. Para los datos posteriores a 1975, también se incluye el efecto de la configuración de los artes. En el Atlántico este y oeste, la CPUE alcanzó un pico en 1968 y descendió después de manera contínua hasta 1992, con algunas fluctuaciones.

Introduction

The Japanese longline fishery has a long history, initiated from 1956 in the western equatorial Atlantic Ocean. After the commencement of the operation, the Japanese longline fishery expanded its fishing ground rapidly and covered almost entire tropical waters in the early 1960's. Since then, the longline vessels shifted their operations toward the temperate waters due to the change in target species from yellowfin and albacore to bigeye, southern bluefin and bluefin tunas. According to the change of target species, the deep longline operations have been introduced in the tropical Atlantic Ocean since the late-1970's. Sailfish and spearfish have been caught as bycatch species throughout the history, because the price of these species are low in the Japanese fish market.

The catch of sailfish and spearfish by Japanese longline fishery peaked at about 2,500 tons in 1965 and then decreased sharply to less than 100 tons in the 1980's. The catch of these species were not reported by species, but presented as a species combined catch since the beginning of the fishery in the Atlantic. But in 1993, the reporting system of the Japanese longline fishery was changed and the catch of sailfish and spearfish began to be reported separately.

The Japanese longline fishery has changed in the long history as mentioned above, especially the effect of the change of target species on CPUE is critical for monitoring the trend of stock abundance. The main fishing ground has been changed according to the change of target species. Furthermore, the deep longline operations were introduced since the late-1970's and the catchability on sailfish and spearfish probably changed. Therefore, in this study CPUEs of the Japanese longline fishery were standardized using General Linear Model (GLM) in the east and west Atlantic, accounting the effects of the areas, time, gear configurations, and other species.

Although the effect on the CPUE derived from other changes than population size may be eliminated by the standardizing procedure, the historical and spatial change of species composition should have serious effect on the species combined CPUE trend. The application of the resultant CPUE time series should be done cautiously.

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 1956-1992. Two kinds of databases were used. The Database-I is the same database submitted to ICCAT as the TASK-II. The Database-II was sample statistics including additional information on gear configuration, i.e., the number of branch lines per basket (between floats), which is obtained from logbook records, but not raised to the total operations.

CPUE was calculated as catch (number) per 1000 hooks. Observations with less than 3,000 hooks were excluded from the analysis. Database-I from 1959 to 1975 and Database-II from 1975 to 1992 were used in the present analysis, because Database-II has been collected since 1975 when deep longlining started in the Pacific.

B. Selection of the model

Year, fishing season, fishing area, and CPUEs of other species were included as the main effects for Database-I, and gear configuration was added as the main effect for Database-II. Quarter-of-the-year was selected as fishing season. Based on the distribution of efforts, subareas were selected for the east and west Atlantic as shown in Fig. 1.

CPUEs of yellowfin, bigeye, albacore and bluefin tunas were used as the species effect. With regard to the gear configuration, 3 to 20 hooks between floats were observed in Database-II for Bycatch period from 1975 to 1992. These 18 levels were categorized to 4 levels (3-7, 8-11, 12-15, and 16-20 hooks between floats) arbitrarily.

The multiplicative model was selected. For Database-I is:

$$LOG(CPUE_{ijklmn}+1)=\mu+Y_i+Q_j+A_k+YFT_l+BET_m+BF_n+Interactions+e_{ijklmn}$$

For Database-II, the model is:

$$LOG(CPUE_{ijklmnop}+1)=\mu+Y_i+Q_j+A_k+YFT_l+BET_m+BF_n+G_p+Interactions+e_{ijklmop}$$

where LOG : natural logarithm,

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

μ : overall mean. Y_i : effect of year i, Q_j : effect of quarter j, A_k : effect of subarea k,

YFT_l : effect of yellowfin l, BET_m : effect of bigeye m, BF_n : effect of bluefin n,

G_p : effect of gear p,

Interactions : any combinations of two way interaction except for year term,

$e_{ijklmnop}$: error term.

Analysis was made through computer software, 'SAS Ver. 6.09'.

Results and discussions

Various runs with any combinations of the two way interactions indicated that the estimates could be obtained with the model including significant interaction term shown in Tables 1-4 for each Database in the east and west Atlantic. Then the model composed of main effects and an interaction term were selected for the east and west Atlantic (Tables 1 -4).

The analyses of variance (Tables 1-4) revealed that all main effects and almost all of interactions were significant at 0.1% level in both of east and west Atlantic. The overall histograms of standardized residual from the final models were shown in Fig. 2. The distribution of residuals in the four cases were not far from normal distributions, though there were some skews. R-Square ranged from 0.25 to 0.36, except for Database-II in the west Atlantic which was very low (0.07).

The scaled annual abundance indices (calculated the value of 1975 as 1.0) were shown in Fig. 3

with lower and upper 95% confidence limits. The abundance index in the east Atlantic peaked in 1968 and decreased sharply till the early 1970s. Then it decreased gradually with some fluctuations. In the late 1980s the rate of decrease increased again, but became stable since 1989. The abundance index in the west Atlantic peaked in 1968 and decreased sharply till the late 1970s. Then it became stable during the 1980s, but gradual decrease was observed in the late 1980s.

In the present analysis, the species combined catch data of sailfish and spearfish was used. The abundance indices obtained in the present analysis should be affected by the yearly and spatial change in the species composition. Therefore, the application of the result in this analysis should be done cautiously.

Table 1. Analysis of variance for Database-I in the east Atlantic from 1959-1975. R-square=0.36. CV=122.3.

Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	42	384.47921	9.154267	54.9	0.0001
Error	3987	664.78105	0.166737		
Corrected Total	4029	1049.2603			
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
YR	18	99.578251	5.5321251	33.18	0.0001
QT	3	9.9481466	3.3160489	19.89	0.0001
AREA	3	60.322762	20.107588	120.59	0.0001
ALB	3	19.510577	6.5035255	39	0.0001
BET	3	40.037668	13.345889	80.04	0.0001
YFT	3	16.689212	5.5630707	33.36	0.0001
QT*AREA	9	7.1539506	0.7948834	4.77	0.0001

Table 2. Analysis of variance for Database-II in the east Atlantic from 1975-1992. R-square=0.07 CV=270.5

Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	41	17.045661	0.4157478	18.86	0.0001
Error	9580	211.20107	0.022046		
Corrected Total	9621	228.24673			
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
YR	17	6.213468	0.3654981	16.58	0.0001
QT	3	1.6347294	0.5449098	24.72	0.0001
AREA	3	2.0374716	0.6791572	30.81	0.0001
GEAR	3	1.0882541	0.3627514	16.45	0.0001
ALB	3	0.2556672	0.0852224	3.87	0.0089
YFT	3	2.5686067	0.8562022	38.84	0.0001
QT*AREA	9	2.560901	0.2845446	12.91	0.0001

Table 3. Analysis of variance for Database-I in the west Atlantic from 1959-1975. R-square=0.26. CV=111.3

Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	47	495.67392	10.546254	32.85	0.0001
Error	4414	1417.2497	0.321081		
Corrected Total	4461	1912.9237			
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
YR	19	110.34124	5.807434	18.09	0.0001
QT	3	17.852989	5.950996	18.53	0.0001
AREA	4	139.69991	34.924978	108.77	0.0001
ALB	3	9.908258	3.302753	10.29	0.0001
BET	3	17.799909	5.933303	18.48	0.0001
YFT	3	37.42927	12.476423	38.86	0.0001
QT*AREA	12	57.989089	4.832424	15.05	0.0001

Table 4. Analysis of variance for Database-II in the west Atlantic from 1975-1992. R-square=0.25 CV=244.5

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	46	103.56273	2.251364	46.6	0.0001
Error	6450	311.61134	0.048312		
Corrected Total	6496	415.17406			
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
YR	17	8.8860199	0.5227071	10.82	0.0001
QT	3	2.7075732	0.9025244	18.68	0.0001
AREA	4	13.456261	3.3640652	69.63	0.0001
GEAR	1	0.0818755	0.0818755	1.69	0.193
ALB	3	1.9426316	0.6475439	13.4	0.0001
BET	3	2.0112511	0.670417	13.88	0.0001
YFT	3	11.149058	3.7163528	76.92	0.0001
QT*AREA	12	16.780956	1.398413	28.95	0.0001

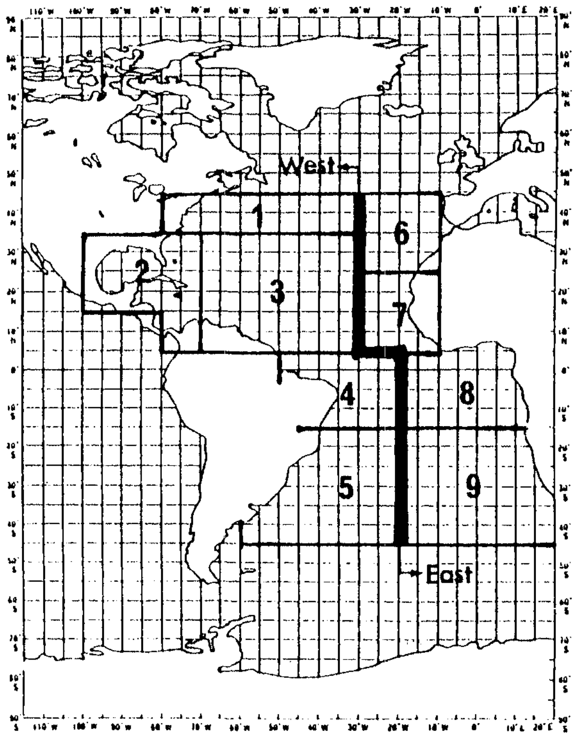

Fig. 1. Subareas used for GLM analysis. Subareas 1 to 5 are used for the west Atlantic and subareas 6 to 9 are used for the east.

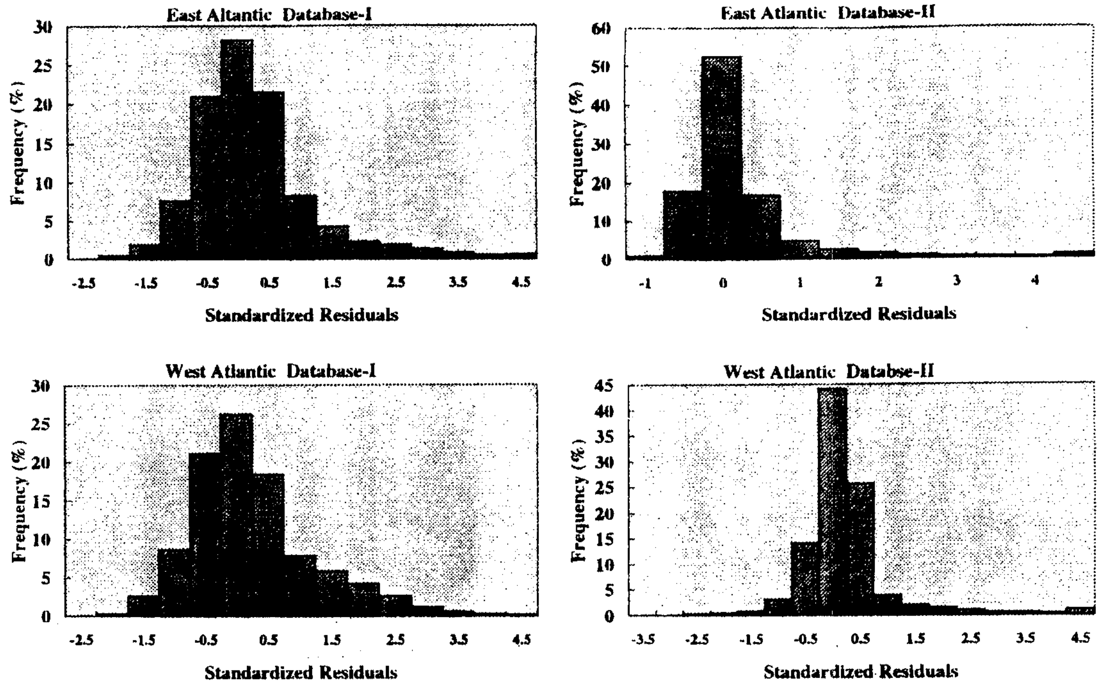

Fig. 2 Overall histograms of standardized residuals from the final model.

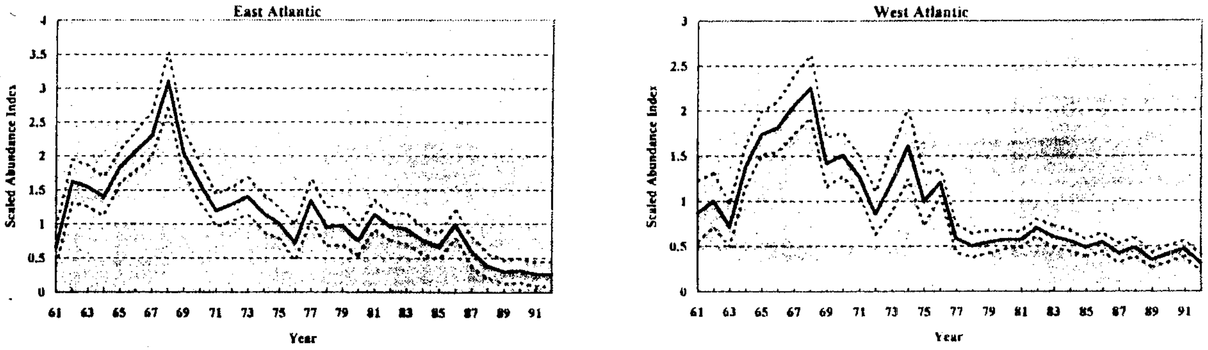

Fig. 3 Scaled annual abundance index for sailfish and spearfish caught by the Japanese longliners. Dotted lines show 95% confidence limits.