UPDATED BIOMASS CPUE FOR ALBACORE CAUGHT BY JAPANESE LONGLINE FISHERY IN THE ATLANTIC OCEAN STANDARDIZED BY GENERAL LINEAR MODEL

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ABSTRACT

The albacore biomass CPUEs of the Japanese longline fishery are standardized by General Linear Model (GLM) for north and south Atlantic. The data period from 1975 to 1993 was used for the present analysis. The CPUE in the north Atlantic continued to decrease through the years observed with some fluctuations. In the south Atlantic the standardized CPUE was stable with some fluctuations. In both of the areas, CPUE was stable in the recent several years.

RESUME

Les CPUE de la biomasse du germon de la pêcherie palangrière japonaise ont été standardisées par GLM pour l'Atlantique Nord et Sud. Les données de la période 1975-1993 ont été utilisées pour la présente analyse. La CPUE de l'Atlantique Nord continue à diminuer au fil des années observées avec quelques fluctuations. Dans l'Atlantique Sud, la CPUE standardisée est stable, avec quelques fluctuations. Dans les deux zones, la CPUE a été stable au cours des dernières années.

RESUMEN

Las CPUEs de la biomasa del atún blanco correspondientes a la pesquería de palangre japonés se estandarizan por el Modelo Lineal Generalizado (GLM), para el Atlántico Norte y Sur. En este análisis se ha usado el período de datos de 1975 a 1993. La CPUE en el Atlántico norte siguió decreciendo durante los años observados, con algunas fluctuaciones. En el Atlántico sur, la CPUE permaneció estable, con algunas fluctuaciones. En ambas zonas, la CPUE se mantuvo estable en los últimos años.

1. INTRODUCTION

Uozumi (1996a) standardized albacore *CPUE* by the Japanese longline fishery. The period from 1959 to 1992 was divided into three periods, the Target, Transition, and By-catch periods. The *CPUE*s in weight were standardized independently in each period using General Linear Model (GLM). In the present study, standardized *CPUE*s of the Japanese longline fishery were updated to 1993.

2. MATERIALS AND METHODS

2.1 Basic data

The data from 1975 to 1993 was used, which is similar to TaskII data with information on gear configuration, i.e., the number of branch lines per basket (between floats), but not raised to the total operations.

In the data base, the catch is expressed in number. Using the catch at size of Japanese albacore catch submitted to ICCAT, and length-weight relationship, the catch in weight was estimated to the corresponding catch in number. For the north Atlantic the length-weight relationship by Santiago (1993) was used and for the south Atlantic the relationship by Penney (1994) was used. *CPUE* was calculated as catch (kg) per 1000 hooks. Observations with less than 3,000 hooks were excluded from the analysis.

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2.2 Selection of the model

Year, fishing season, fishing area, gear configuration, and *CPUE*s of other species were included as the main effects in the model. Quarter-of-the-year was selected as fishing season. The same subareas were used in the present analysis as were used in Uozumi (1996a).

*CPUE*s of yellowfin, bigeye, and bluefin tunas were used as the species effect in the north Atlantic. *CPUE*s of yellowfin, southern bluefin, and bigeye were used in the south Atlantic. With regard to the gear configuration, 3 to 20 hooks between floats were observed. These 18 levels were categorized into 4 levels (3-7, 8-11, 12-15, and 16-20 hooks between floats) arbitrarily.

The multiplicative model was selected. The model is:

$$\mathrm{LOG}(CPUE_{ijklmnop}+1)=f\hat{E}+Y_i+Q_j+A_k+YFT_l+BET_m+BF_n+SBT_o+G_p+\ \text{Interactions}\ +e_{ijklmop}$$

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),
$f\hat{E}$: 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,
SBT_o : effect of southern bluefin o,
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.

3. 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 terms shown in Tables 1 and 2 in the north and south Atlantic. The final models in the north and south Atlantic were the same as those in Uozumi (1996a). The analyses of variance (Tables 1 and 2) revealed that all main effects and almost all interactions were significant at 0.1% level in both the north and south Atlantic. The overall histograms of standardized residual from the final models were shown in Figure 1. The distribution of residuals was not far from normal distributions, though there was some skewness. The rate of variability explained by the final model (i.e. R-Square) was 0.53 and 0.47 in north and south Atlantic, respectively.

The standardized *CPUE*s are shown in Table 3 and Figure 2 with lower and upper 95% confidence limit. The *CPUE* in the north Atlantic (Figure 2) continued to decrease with some fluctuations. But the *CPUE* became relatively stable in the recent years. In the south Atlantic, the *CPUE* has been relatively stable with some fluctuations. The *CPUE* fluctuated at about 8 kg/ 1000 hooks from 1975 to 1987 periodically. Then the level of *CPUE* decreased to around 5 kg/1000 hooks and has stabilized in the last six years.

Table 1. Analysis of variance for North Atlantic from 1975 to 1993. R-square=0.53, CV=68.7.

Source	DF	Sum of Square	Mean Square	F Value	Pr > F
Model	93	17500.2600	188.1749	117.24	0.0001
Error	9573	15364.8000	1.6050		
Corrected Total	9666	32865.0600			

Source	DF	Sum of Square	Mean Square	F Value	Pr > F
YR	18	707.2585	39.2921	24.48	0.0001
QT	3	748.3538	249.4513	155.42	0.0001
AREA	8	7156.6230	894.5778	557.36	0.0001
GEAR	3	35.6503	11.8834	7.40	0.0001
BF	4	97.6061	24.4015	15.20	0.0001
BET	3	354.0250	118.0083	73.52	0.0001
YFT	3	409.8955	136.6319	85.13	0.0001
QT*AREA	24	650.5085	27.1045	16.89	0.0001
QT*YFT	9	94.4590	10.4954	6.54	0.0001
BET*YFT	9	117.8755	13.0973	8.16	0.0001
QT*BET	9	51.2492	5.6944	3.55	0.0002

Table 2. Analysis of variance for South Atlantic from 1975 to 1993 R-square=0.47, CV=95.1.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	96	14448.7700	150.5080	100.27	0.0001
Error	11433	17160.4500	1.5010		
Corrected Total	11529	31609.2200			

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
YR	18	432.1868	24.0104	16.00	0.0001
QT	3	247.1287	82.3763	54.88	0.0001
AREA	8	7355.2330	919.4041	612.55	0.0001
GEAR	3	223.7214	74.5738	49.68	0.0001
BET	3	1386.4450	462.1482	307.90	0.0001
YFT	3	304.0152	101.3384	67.52	0.0001
SBT	4	66.3070	16.5767	11.04	0.0001
QT*BET	9	48.8258	5.4251	3.61	0.0002
QT*AREA	24	746.6909	31.1121	20.73	0.0001
QT*SBT	12	42.5332	3.5444	2.36	0.0050
BET*YFT	9	41.4307	4.6034	3.07	0.0011

Table 3. Standardized Biomass CPUEs (kg/1000 hooks) for albacore during 1975/93 in the Atlantic.

Year	North Atlantic			South Atlantic		
	Mean CPUE	Lower 95% limit	Upper 95% limit	Mean CPUE	Lower 95% limit	Upper 95% limit
75	9.9	8.2	11.9	7.2	5.1	9.9
76	9.0	7.5	10.8	9.9	6.9	14.1
77	6.2	5.0	7.7	9.1	6.4	12.8
78	5.1	4.1	6.3	8.7	6.3	12.0
79	5.6	4.5	6.9	6.2	4.5	8.5
80	3.8	3.1	4.7	5.8	4.3	7.8
81	5.6	4.7	6.7	8.9	6.6	11.8
82	4.7	3.9	5.6	8.5	6.3	11.2
83	4.2	3.4	5.2	6.1	4.5	8.3
84	3.7	3.0	4.6	6.3	4.6	8.4
85	5.4	4.5	6.5	9.2	6.9	12.1
86	3.1	2.5	3.8	9.2	6.9	12.2
87	2.7	2.1	3.3	6.0	4.4	8.1
88	3.7	3.0	4.6	4.1	3.0	5.6
89	3.7	3.0	4.4	5.3	3.9	7.1
90	2.5	2.0	3.1	5.3	3.9	7.1
91	2.3	1.9	2.9	5.4	4.0	7.2
92	2.3	1.8	2.9	4.8	3.5	6.4
93	3.0	2.4	3.6	5.0	3.7	6.7

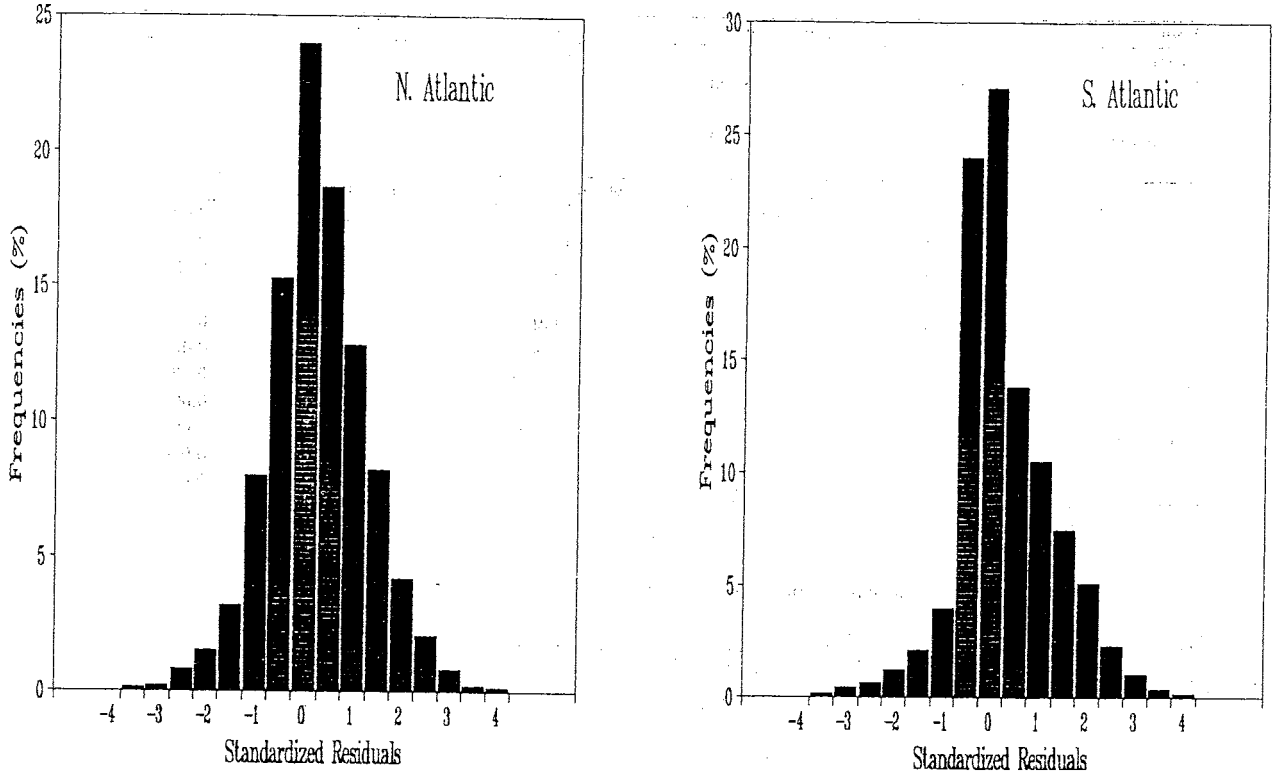

Fig. 1. **Overall histograms of standardized residuals from the final model.**

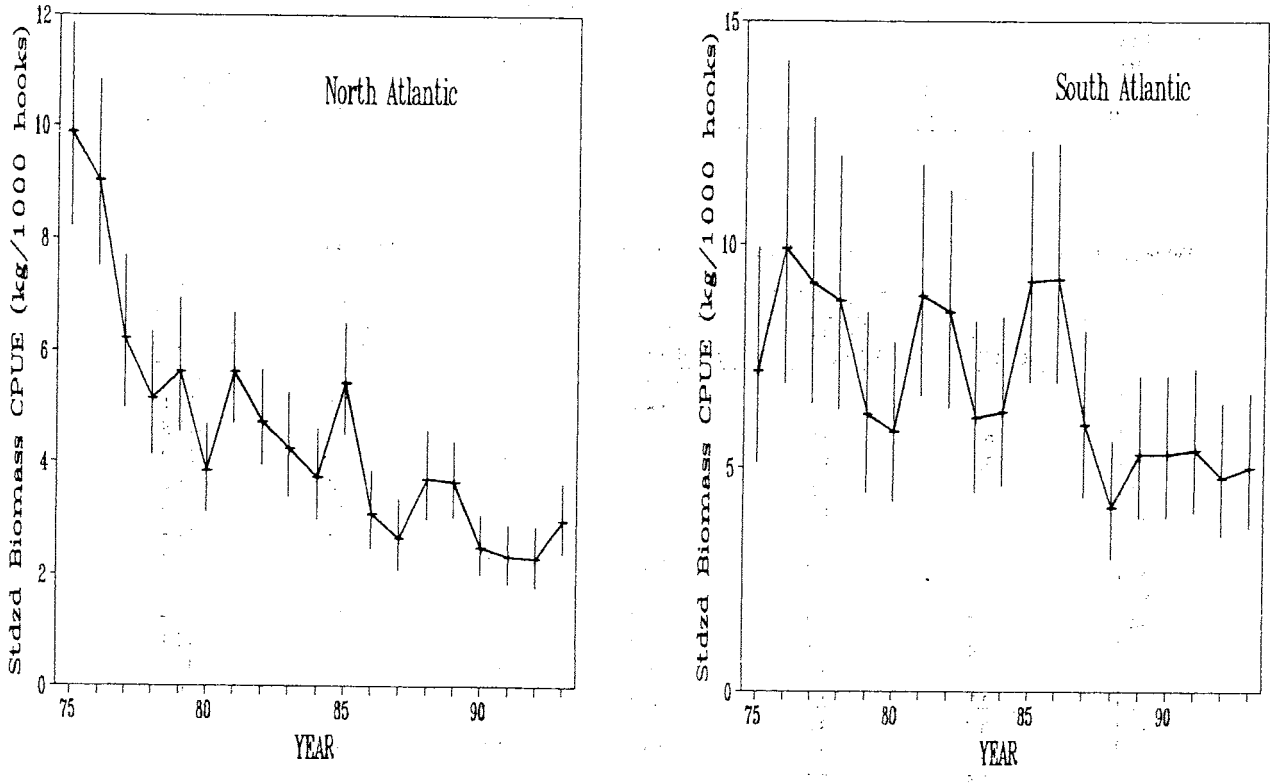

Fig. 2. **Standardized biomass CPUE (kg/1000 hooks) for albacore by the Japanese longliners in the Atlantic Ocean, with 95% confidence intervals.**