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UPDATED STANDARDIZED CPUE FOR ALBACORE CAUGHT BY JAPANESE LONGLINE FISHERY IN THE ATLANTIC OCEAN

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ABSTRACT

The standardized CPUE for Atlantic albacore caught by Japanese longline fishery was updated, using a Generalized Linear Model (GENMOD), including the preliminary data of 1993. The data for the period from 1959 to 1993 were divided into 3 periods, Target, Transition, and By-catch periods, according to Uozumi (1996). The trend of CPUEs which was standardized in each period was similar to those standardized using GLM (Uozumi 1994a).

RESUME

La CPUE standardisée pour le germon de l'Atlantique capturé par la pêcherie palangrière japonaise a été actualisée en utilisant le Modèle Linéaire Généralisé (GENMOD) avec les données provisoires de 1993. Les données pour la période 1959-1993 ont été divisées en trois groupes : Cible, Transition et Prise accessoire, d'après Uozimi (1996). Les tendances des CPUE standardisées pour chaque période étaient similaires à celles qui ont été standardisées en utilisant GLM (Uozimi 1994a).

RESUMEN

Usando el Modelo Lineal Generalizado (GENMOD) se actualizó la CPUE estandarizada del atún blanco atlántico capturado por la pesquería japonesa de palangre, incluyendo los datos preliminares de 1993. Los datos correspondientes a los años 1959 a 1993 se dividieron en tres períodos: Objetivo, Transición y Captura Fortuita, de acuerdo con Uozumi (1996). La tendencia de las CPUEs que fue estandarizada en cada uno de los períodos, era similar a las que habían sido estandarizadas usando GLM (Uozumi 1994a).

1. INTRODUCTION

Standardization of *CPUE* using General Linear Model (GLM) for albacore in the Atlantic Ocean had been carried out (Uosaki 1994, Uozumi 1996). However, some problems with the application of GLM were noted, i.e., the treatment of zero catch observation and the interaction with Year-effect. Nishida *et al.* (1994) and Miyabe (1995) used the model with Poisson distribution to solve the zero catch problem. To solve the problems of Year-interaction, the following procedures are applied in this study. The expected *CPUE* in each cell is calculated using the estimated parameters including interaction terms and then the annual abundance index is calculated as the weighted mean of expected *CPUE* by area.

2. MATERIAL AND METHOD

Catch and effort data used in the analysis were obtained from the Japanese longline fishery statistics, compiled at the National Research Institute of Far Seas Fisheries (NRIFSF), for 1959-1993. Two kinds of database were used. The Database-I is the same database submitted to ICCAT as TASK-II. The Database-II contains sample statistics including information on the number of branch lines between floats. Observations of less than 3,000 hooks were excluded and observations with no catch of albacore were retained in the analysis.

Uozumi (1996a) reported there were three periods of "Target", "Transition" and "By-catch" in the history of Japanese longline fishery in the Atlantic Ocean based on their fishery strategy. In this report, *CPUEs* were calculated separately for the periods 1959-69, 1969-75 and 1975-92, according to Uozumi (1996).

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The models for the Target and Transition periods included main effects of year, fishing season, area, and *CPUEs* of other species. Furthermore the model added a gear configuration for the By-catch period. Quarter of a year was selected as the fishing season. Sub-areas were selected according to Uozumi (1996). With regard to gear configuration, 3 to 20 hooks between floats were observed in Database-II. These 18 levels were categorized to 4 levels (3-7, 8-11, 12-15 and 16-20 hooks between float). *CPUEs* of yellowfin, bigeye and bluefin tunas were used as the species effect in the north Atlantic Ocean. *CPUEs* of yellowfin, bigeye and southern bluefin tunas were used as the species effect in the south Atlantic Ocean. The model for Target and Transition periods is shown below :

$$Ex(\mathrm{C}) = \mathrm{E} \bullet \exp(\mu + \mathrm{YR} + \mathrm{QT} + \mathrm{AR} + \mathrm{YFT} + \mathrm{BET} + \mathrm{BFT} + \mathrm{interaction}) \quad \text{North Atlantic}$$
$$[+\mathrm{SBT}] \quad \text{South Atlantic}$$

The model for By-catch period is :

$$Ex(\mathrm{C}) = \mathrm{E} \bullet \exp(\mu + \mathrm{YR} + \mathrm{QT} + \mathrm{AR} + \mathrm{YFT} + \mathrm{BET} + \mathrm{BFT} + \mathrm{GE} + \mathrm{interaction}) \quad \text{North Atlantic}$$
$$[+\mathrm{SBT}] \quad \text{South Atlantic}$$

where *Ex*(C): expectation of catch
E : number of hooks
μ : intercept
YR : effect of year — YFT : effect of yellowfin tuna
QT : effect of quarter — BFT : effect of bigeye tuna
AR : effect of subarea — BFT : effect of bluefin tuna
GE : effect of gear — SBT : effect of southern bluefin tuna
Interaction : any combination of two way interaction includes for year term

Interaction was added whenever it was estimable, and selection of model was made using AIC.

Analysis was made though the computer software, 'SAS Ver. 6.09'. The fitting of Poisson distribution to the catch model was done by the GENMOD procedure of SAS/STAT statistical package (Ver. 6.09), which fits Generalized Liner Model. Under this procedure, many other distributions of exponential family such as normal, binomial, gamma and inverse Gaussian can be included in a model. Parameters are obtained by maximum likelihood estimation with the algorithm of a ridge-stabilized Newton-Raphson method (SAS 1993). In most cases, over-dispersion was observed, and the DSCALE option which estimates dispersion parameter was included. All statistics were adjusted according to the dispersion parameter appropriately.

3. RESULT AND DISCUSSION

The final model and factors chosen for each period in the north and south Atlantic were as follows:

North	Target(1959-69):	YR+QT+AR+YFT+BET+BFT	+YR*QT+QT*AR
	Transition(1969-75):	YR+QT+AR+YFT+BET+BFT	+YR*QT
	By-catch(1975-93):	YR+QT+AR+YFT+BET+BFT+GR	+YR*QT+QT*AR
South	Target(1959-69):	YR+QT+AR+YFT+BET+SBT	+YR*QT+QT*AR
	Transition(1969-75):	YR+QT+AR+YFT+BET+SBT	+YR*QT+QT*AR
	By-catch(1975-93):	YR+QT+AR+YFT+BET+SBT+GR	+YR*QT+QT*AR

The goodness of fit for the model is shown in Table 1. Deviance is much larger than the degree of freedom. The χ square statistics of effects for these models are statistically significant (Table 2). The χ square of Area for each period was the greatest effect. The χ square of bigeye effect for the By-catch period in the south Atlantic was an important effect of other species. This result is consistent with the strategy of Japanese longline fishery which has targeted bigeye tuna in the south Atlantic since about the late 1970s. The distribution of residual for each model is shown in Figure 1.

Since interaction term including Area became significant except for the north Atlantic in the Transition period, annual abundance indices were calculated with weighting by Area. The equation of the area-weighting abundance index as follows:

$$Ex(CPUE_i) = \sum_j \sum_k \sum_{...} \frac{\mathrm{A}_k}{\sum_k \mathrm{A}_k} . \exp(\mu + P_{Y_i} + P_{Q_j} + P_{A_k} + ... + P_{inter} + ...)$$

where $Ex(CPUE_i)$:abundance index in i year

A_k :area which excludes land and adjusted latitude in area k
μ :estimated intercept
P_{Y_i} :estimated parameter for year term in i year
P_{Q_j} :estimated parameter for quarter term in j th quarter
P_{A_k} :estimated parameter for area term in area k
P_{inter} :estimated parameter for interaction term

Figure 2 shows the scaled annual index which calculate the volume of 1959 as 1.0 with GLM result (Uozumi 1996). The values of scale index are shown in Table 3.

The trend of the scaled index in the north Atlantic decreased until the late 1970, and then it became stable for the 1980s and 90s. The result by GENMOD is similar to that by GLM. The scaled index in the south Atlantic decreased sharply in the 1960s, and continued to decline until the end of 1970s. Then it became stable for the 1980s and 90s. There is some difference in *CPUE* trend estimated by the two methods. For the north Atlantic between 1959 and 1963 GENMOD estimates showed a bigger fluctuation than that by the GLM. For the south Atlantic, the trend of index by GENMOD is different to that by GLM during the period between 1973 and 1979, i.e., the index continued to decrease in the GENMOD but not in GLM.

Table 1. Criteria for assessing goodness of fit.

NORTH ATLANTIC

Target Period (59-69)

Observations Used	2746		
Criterion	DF	Value	Value/DF
Deviance	2652	753890.7294	284.2725
Scaled Deviance	2652	2652.0000	1.0000
Pearson Chi-Square	2652	885111.2276	333.7523
Scaled Pearson X2	2652	3113.6011	1.1741
Log Likelihood	-	84190.6388	-

Transition Period (69-75)

Observations Used	2040		
Criterion	DF	Value	Value/DF
Deviance	1992	485495.2988	243.7225
Scaled Deviance	1992	1992.0000	1.0000
Pearson Chi-Square	1992	589416.6589	295.8919
Scaled Pearson X2	1992	2418.3921	1.2141
Log Likelihood	-	30648.0223	-

Bycatch Period (75-93)

Observations Used	9667		
Criterion	DF	Value	Value/DF
Deviance	9546	541205.3522	56.6945
Scaled Deviance	9546	9546.0000	1.0000
Pearson Chi-Square	9546	1043063.9846	109.2671
Scaled Pearson X2	9546	18397.9866	1.9273
Log Likelihood	-	85610.5678	-

SOUTH ATLANTIC

Target Period (59-69)

Observations Used	3161		
Criterion	DF	Value	Value/DF
Deviance	3083	1599250.7839	518.7320
Scaled Deviance	3083	3083.0000	1.0000
Pearson Chi-Square	3083	1715708.1518	556.5060
Scaled Pearson X2	3083	3307.5039	1.0728
Log Likelihood	-	122552.9429	

Trasition Period (69-75)

Observations Used	1749		
Criterion	DF	Value	Value/DF
Deviance	1683	563365.7638	334.7390
Scaled Deviance	1683	1683.0000	1.0000
Pearson Chi-Square	1683	804315.1801	477.9056
Scaled Pearson X2	1683	2402.8128	1.4277
Log Likelihood	-	24724.7193	-

Bycatch Period (75-93)

Observations Used	11530		
Criterion	DF	Value	Value/DF
Deviance	11409	510869.2505	44.7777
Scaled Deviance	11409	11409.0000	1.0000
Pearson Chi-Square	11409	1200066.2493	105.1859
Scaled Pearson X2	11409	26800.5088	2.3491
Log Likelihood	-	41436.0060	-

Table 2. Likelihood ratio statistics for type 3 analysis.

NORTH ATLANTIC

Target Period (59-69)

Source	NDF	DDF	F	Pr>F	ChiSquare	Pr>Chi
YR	10	2652	16.6219	.0000	166.2194	0.0000
QT	3	2652	13.7979	.0000	41.3937	0.0000
AREA	10	2652	263.6834	.0000	2636.8345	0.0000
BF	4	2652	82.9700	.0000	331.8800	0.0000
BET	3	2652	11.4743	.0000	34.4228	0.0000
YFT	3	2652	23.0440	.0000	69.1319	0.0000
QT*AREA	30	2652	13.8554	.0000	415.6609	0.0000
YR*QT	30	2652	8.8228	.0000	264.6846	0.0000

Transition Period (69-75)

Source	NDF	DDF	F	Pr>F	ChiSquare	Prf>Chi
YR	6	1992	64.731	.0000	388.3910	0.0000
QT	3	1992	93.1024	.0000	279.3071	0.0000
AREA	10	1992	233.3503	.0000	2333.5028	0.0000
BF	4	1992	25.0836	.0000	100.3343	0.0000
BET	3	1992	50.4644	.0000	151.3933	0.0000
YFT	3	1992	54.6254	.0000	3.8762	0.0000
YR*QT	18	1992	5.6592	.0000	101.8651	0.0000

Bycatch Period (75-93)

Source	NDF	DDF	F	Pr>F	ChiSquare	Pr>Chi
YR	18	9546	59.6567	.0000	1073.8207	0.0000
QT	3	9546	78.4501	.0000	235.3503	0.0000
AREA	8	9546	646.7356	.0000	5173.8848	0.0000
GEAR	3	9546	4.8363	.0023	14.5090	0.0023
BF	4	9546	42.6606	.0000	170.6423	0.0000
BET	3	9546	93.9521	.0000	281.8564	0.0000
YFT	3	9546	39.0524	.0000	117.1572	0.0000
QT*AREA	24	9546	37.5673	.0000	901.6140	0.0000
YR*QT	54	9546	15.9374	.0000	860.6197	0.0000

SOUTH ATLANTIC

Target Period (59-69)

Source	NDF	DDF	F	Pr>F	ChiSquare	Pr>Chi
YR	10	3083	49.2268	.0000	492.2678	0.0000
QT	3	3083	3.1390	.0244	9.4171	0.0242
AREA	6	3083	318.0162	.0000	1908.0973	0.0000
SBT	4	3083	17.2937	.0000	69.1746	0.0000
BET	3	3083	53.8474	.0000	161.5421	0.0000
YFT	3	3083	80.3449	.0000	241.0348	0.0000
QT*AREA	18	3083	41.5450	.0000	747.8101	0.0000
YR*QT	30	3083	5.1218	.0000	153.6551	0.0000

Transition Period (69-75)

Source	NDF	DDF	F	Pr>F	ChiSquare	Pr>Chi
YR	6	1683	43.9961	.0000	263.9768	0.0000
QT	3	1683	14.4118	.0000	43.2353	0.0000
AREA	7	1683	142.7909	.0000	999.5366	0.0000
SBT	4	1683	109.6733	.0000	438.6931	0.0000
BET	3	1683	51.3227	.0000	153.9681	0.0000
YFT	3	1683	19.0004	.0000	57.0012	0.0000
QT*AREA	21	1683	16.2721	.0000	341.7139	0.0000
YR*QT	18	1683	7.1016	.0000	127.8289	0.0000

Bycatch Period (75-93)

Source	NDF	DDF	F	Pr>F	ChiSquare	Pr>Chi
YR	18	11409	29.7922	.0000	536.2589	0.0000
QT	3	11409	47.7160	.0000	143.1480	0.0000
AREA	8	11409	478.1335	.0000	3825.0677	0.0000
GEAR	3	11409	53.2819	.0000	159.8456	0.0000
SBT	4	11409	124.0283	.0000	496.1133	0.0000
BET	3	11409	684.3811	.0000	2053.1433	0.0000
YFT	3	11409	17.2339	.0000	51.7017	0.0000
QT*AREA	24	11409	39.7934	.0000	955.0405	0.0000
YR*QT	54	11409	18.3604	.0000	991.4623	0.0000

Table 3. Scaled abundance indices estimated by GENMOD.

Year	North	South	Year	North	South
59	1.000	1.000	77	0.093	0.024
60	1.081	0.797	78	0.064	0.017
61	1.123	0.637	79	0.090	0.009
62	2.276	0.416	80	0.069	0.013
63	0.604	0.310	81	0.080	0.019
64	0.584	0.348	82	0.066	0.022
65	0.370	0.287	83	0.092	0.015
66	0.442	0.273	84	0.058	0.013
67	0.489	0.281	85	0.063	0.021
68	0.407	0.248	86	0.036	0.021
69	0.427	0.127	87	0.037	0.011
70	0.354	0.085	88	0.052	0.009
71	0.238	0.112	89	0.047	0.010
72	0.130	0.063	90	0.035	0.010
73	0.190	0.046	91	0.037	0.009
74	0.250	0.044	92	0.036	0.012
75	0.140	0.035	93	0.045	0.010
76	0.136	0.028			

North Atlantic South Atlantic

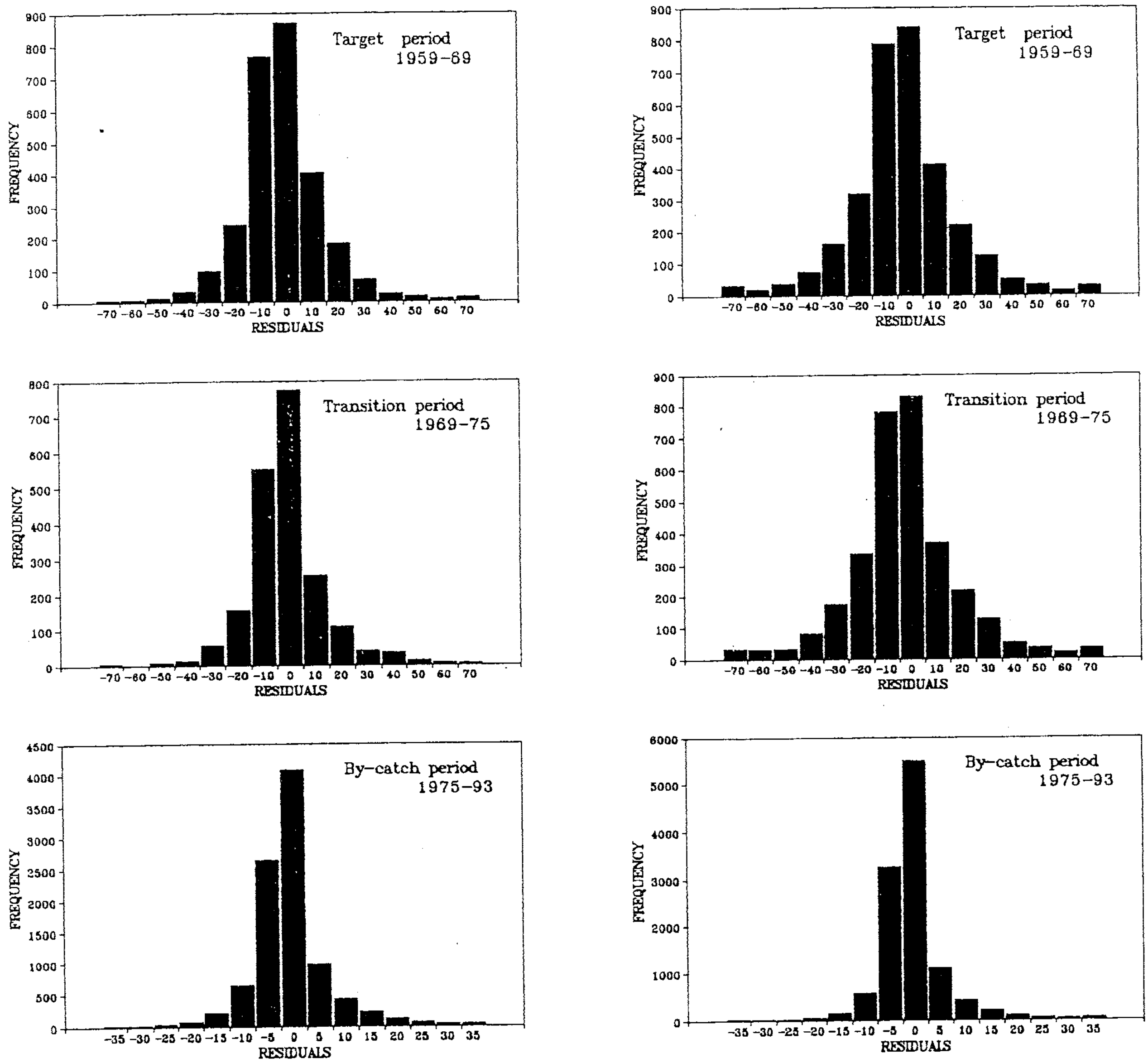

Fig. 1. Residual distribution of the model for each period in the North and South Atlantic.

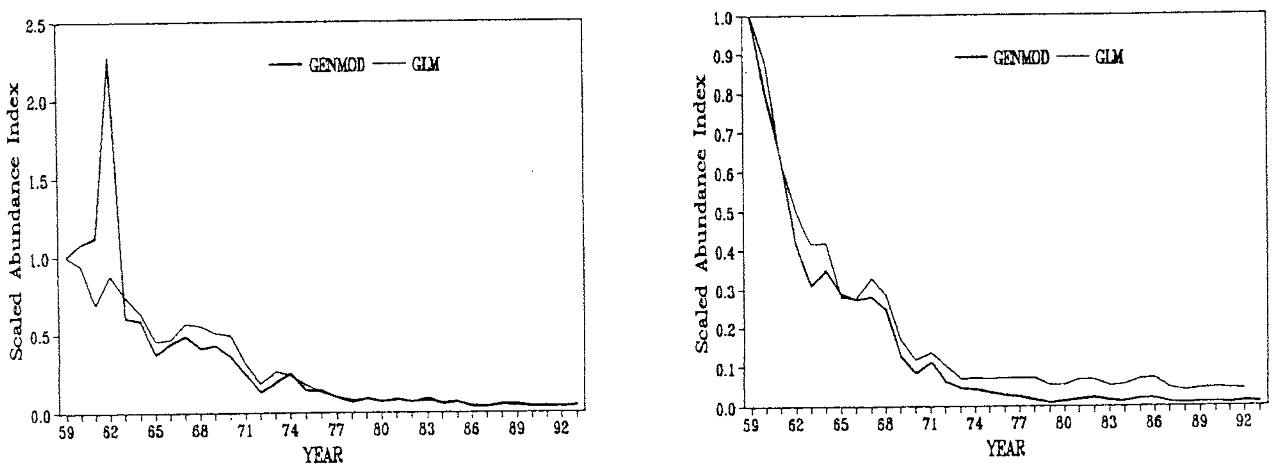

Fig. 2. Scaled annual abundance index for the Atlantic albacore calculated by GENMOD and GLM.