Col.Vol.Sci.Pap. ICCAT, 46 (3) : 95-100 (1997)

UPDATED STANDARDIZED CPUE FOR ALBACORE CAUGHT BY JAPANESE LONGLINE FISHERY IN THE ATLANTIC OCEAN, 1959-95

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SUMMARY

CPUEs of Atlantic albacore *(Thunnus alalunga)* caught by the Japanese longline fishery for 1959-1995 were standardized using two kinds of models with different error structures (log-normal and Poisson distribution). The standardization was carried out for the three periods according to Uozumi (1994b) under the hypotheses of north and south stocks. The trend of standardized CPUEs between the two models were similar except for that for the period 1959-1975 in the south Atlantic.

RÉSUMÉ

Les CPUE du germon de l'Atlantique *(Thunnus alalunga)* capturé par les palangriers japonais entre 1959 et 1995 ont été standardisées avec deux types de modèles comportant différentes structures de l'erreur (lognormale et Poisson). la standardisation a été effectuée pour les trois périodes dénifies par Uozimi (1994b) dans l'hypothèse de stocks Nord et Sud. La tendance des CPUE standardisées entre les deux modèles était similaire, sauf pour la période 1959-1975 dans l'Atlantique Sud.

RESUMEN

Se estandarizaron CPUE (1959-1995) de atún blanco atlántico (*Thunnus alalunga*) capturado por la pesquería de palangre de Japón, empleando dos clases de modelos con diferentes estructuras de error (distribución logarítmica normal y de Poisson). La estandarización se llevó a cabo para los tres períodos, de acuerdo con Uozumi (1994) bajo la hipótesis de stocks norte y sur. La tendencia de las CPUE estandarizadas entre los dos modelos fue similar, excepto la que se refiere al período 1959-1975 en el Atlántico sur.

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Introduction

For Atlantic albacore caught by Japanese longline fishery, the CPUE standardization using the General Linear Model (GLM) with the assumption that the error structure belongs to log-normal had been carried out (Uozumi 1994a). Uosaki (1996) carried out the standardization assuming error structure with Poisson distribution using the Generalazed Linear Model (GENMOD) to overcome a problem of zero CPUE treatment. In the present study the standardized CPUE for the Atlantic albacore was updated using the two models up to 1995.

Materials and methods

1. Basic data

The data used in this study were obtained from the Japanese longline fishery statistics based on the logbooks and compiled at the National Research Institute of Far Seas Fisheries. Two kinds of dataset were used in this report, one is the Task II catch and effort data for 1959-1975, another is the same dataset as the Task II but additionally including gear configuration information i.e., number of hooks per basket, for 1975-1995, with the preliminary data in 1995. CPUE was defined as the number of catch of albacore per 1,000 hooks. Observations with less than 3,000 hooks

were excluded from this analysis. In addition, observations which belong to the EEZ was also excluded to avoid inconsistency of data coverage during a long histric period.

Uozumi (1994b) classified three periods of "Target", "Transition" and "Bycatch" in the history of the Japanese longline fishery on the Atlantic Ocean based on their fishery strategy. In this study, CPUEs were calculated separately for the 1959-69, 1969-75 and 1975-92 periods according to Uozumi (1994b).

2. Standardization

In order to standardize CPUE of albacore, two different models were used, i.e., CPUE model with the assumption of log-normal error structure, and Catch model with the assumption of Poisson error structure, using GLM and GENMOD procedures of SAS package (Ver. 6.11), respectively. Year, season, subarea and gear configuration were incorporated as main effects. Quarter was used for fishing season. Sixteen for Target period, seventeen for Transition period and eighteen subareas for Bycatch period were defined based on the spatial distribution pattern of nominal CPUE of albacore (Fig. 1). The gear configuration were categorized to four levels (3-7, 8-11, 12-15 and 16-20 hooks between float). Two stocks, north and south Atlantic, were assumed.

The CPUE model used were :

$\ln(CPUE+1.0)=\mu+Y+Q+A+Interactions+e$ for Target and Transition Periods

$\ln(CPUE+0.1)=\mu+Y+Q+A+G+Interactions+e$ for By-catch Period

where μ : overall mean Y : effect of year

Q : effect of quarter A : effect of subarea

G : effect of gear e : error term

Interactions : any combinations of two way interaction between main factor

In order to include observations with fishing effort but no catch of albacore, the natural logarithm of CPUE+1.0 for Target and Transition Period, CPUE+0.1 for Bycatch Period were used. The constants, 1.0 and 0.1 were selected as approximate 0.1*mean CPUE of albacore. The 0.1*mean CPUE as the constant was recommended in Bluefin Species Group (ICCAT, 1996).

The Catch model is:

$E(C)=H\cdot\exp(\mu+Y+Q+A+ Interactions)$ for Target and Transition Period

$E(C)=H\cdot\exp(\mu+Y+Q+A+G+Interactions)$ for By-catch Period

where E(C): expectation of catch in number which belong to Poisson distribution.

H: number of hooks used.

In GENMOD analysis, overdispersion was observed, therefor DSCALE option which estimates dispersion parameter was included. All statistics were adjusted according to the dispersion parameter appropriately.

For the CPUE and Catch models, all of the combinations of two-way interactions was attempted to fit except for the interactions which had lack of observations. Model selection was made using Akaike's Information Criterion (AIC):

for the CPUE model $AIC=X\cdot\ln(MSE) + 2\cdot Y$

for the Catch model $AIC=-2\cdot\ln(LF) + 2\cdot X$

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

Standardized CPUE weighted by area is :

$$CPUE_i = \exp\left(\mu + P_{Y_i} + \frac{1}{4}\sum_j P_{Q_j} + \frac{A_k}{\sum_k A_k}\sum_k P_{A_k} + \frac{1}{4}\sum_l P_{G_l} + \frac{1}{4}\sum_j P_{YQ_{ij}}\ldots\right) - \text{constant}$$

where $CPUE_i$: standardized CPUE 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 uarter term in *j* year

P_{A_k}: estimated parameter for area term in *k* year

P_{G_l}: estimated parameter for gear term in *l* year

$P_{YQ_{ij}}$: estimated parameter for interaction term between year and quarter

Results and Discussion

The obtained AICs were shown in Table 1. The final model chosen for each stock and period is:

for the CPUE model

North Atl. Target(1959-69) $\ln(CPUE+1.0)= \mu+Y+Q+A +Y*Q+Q*A$

Transition(1969-75) $\ln(CPUE+1.0)= \mu+Y+Q+A +Q*A$

Bycatch(1975-93) $\ln(CPUE+0.1)= \mu+Y+Q+A+G+Q*A+Q*G$

South Atl. Target(1959-69) $\ln(CPUE+1.0)= \mu+Y+Q+A +Q*A$

Transition(1969-75) $\ln(CPUE+1.0)= \mu+Y+Q+A +Q*A$

Bycatch(1975-93) $\ln(CPUE+0.1)= \mu+Y+Q+A+G+Y*Q+Q*A+Q*G+A*G$

for the Catch model

North Atl. Target(1959-69) $E(C)=H\cdot\exp(\mu+Y+Q+A+Y*Q+Q*A)$

Transition(1969-75) $E(C)=H\cdot\exp(\mu+Y+Q+A+Y*Q+Q*A)$

Bycatch(1975-93) $E(C)=H\cdot\exp(\mu+Y+Q+A+G+Y*Q+Q*A+Q*G)$

South Atl. Target(1959-69) $E(C)=H\cdot\exp(\mu+Y+Q+A+Y*Q+Q*A)$

Transition(1969-75) $E(C)=H\cdot\exp(\mu+Y+Q+A+Y*Q+Q*A)$

Bycatch(1975-93) $E(C)=H\cdot\exp(\mu+Y+Q+A+G+Y*Q+Q*A+Q*G+A*G)$

The ANOVA for the CPUE model using GLM procedure and goodness of fit for the Catch model using GENMOD procedure are shown in Table 2 and 3. F value in Table 2 and scaled Pearson χ^2 in Table 3 show the models are highly significant. However, Q effect for 1959-1969 in south Atlantic CPUE model (F=1.01, P=0.39) and G effect for 1975-1995 in north and south Atlantic Catch model (χ^2=1.64, 3.02, P=0.65, 0.38) were not significant. On the CPUE model, the R-square for 1975-1995 in South Atlantic (0.350) was relatively low compared with that for the others. The distribution of the standardized residuals of CPUE model for each period in each stock is shown in Fig. 2. The distribution of the standardized residuals appear roughly normal.

The scaled CPUEs which were adjusted to 1.0 in 1975, for 1959-1995 are shown in Table 4. and Fig. 3. For the north Atlantic stock there is no significant difference in the CPUE trend between the models throughout the period 1959-95. The CPUEs rapidly declined from around 6 to 1 between the early 1960s and the early 1970s in the north stock. After that, it continued to decline to around 0.2 in recent years. For the south Atlantic stock there was a difference in CPUE trend, in term of degree of decline, between the models for the period 1959-1975, but not for the period 1975-1995. Both CPUEs declined rapidly for the period 1959-1975, but the rate of decrease for the CPUE of the Catch model is around three times higher than that of CPUE model. There were no clear trend since the mid-1970s.

The reason of the difference between the two models in CPUE trend in south Atlantic is suspected to be (a) the difference of the interactions used in each model and (b) the difference of CPUE model and Catch model. In order to compare between the CPUEs of the CPUE model and that of Catch model themselves, the standardization was attempted to examine by the Catch model using the model with the same interaction term as the final CPUE model. The result was shown as "Catch model (2)" in Fig. 3. For north Atlantic there was no significant difference between two CPUEs of the Catch models. For south Atlantic the decrease pattern of the CPUE of the Catch model (2) was similar to the Catch model, but the rate of decrease was much close to that of the CPUE model. On Catch model, the rate of decrease of CPUE was affected very much by removing the interaction Y*Q from the model for the period 1959-1975 in south Atlantic. It is apparent that the most part of different between the final CPUE and Catch models was caused by the interaction Y*Q for the period 1959-1975 in south Atlantic

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Table 1. AICs for the CPUE model and the Catch model for Target (1959-69), Transition (1969-75), and Bycatch (1975-95) period in north and south Atlantic.

North 1959-69 Obs=2049			CPUE model		Catch model	
Model		Par.#	MSE	AIC	Log likelihood	AIC
Y Q A		24	0.805	-397.55	52554	-105060
Y Q A	YQ	68	0.774	-388.04	58314	-116492
Y Q A	QA	60	0.749	-471.05	61048	-121976
Y Q A	YQ QA	104	0.716	**-477.12**	67257	**-134306**

North 1969-75 Obs=1401			CPUE model		Catch model	
Model		Par.#	MSE	AIC	Log likelihood	AIC
Y Q A		20	0.518	-882.79	26306	-52572
Y Q A	YQ	48	0.515	-833.32	27916	-55736
Y Q A	QA	56	0.463	**-966.49**	29128	-58144
Y Q A	YQ QA	84	0.458	-925.22	30838	**-61508**

North 1975-95 Obs=8820			CPUE model		Catch model	
Model		Par.#	MSE	AIC	Log likelihood	AIC
Y Q A G		38	1.257	1980.81	61221	-122366
Y Q A G	YQ	122	1.233	1989.48	67289	-134334
Y Q A G	QA	74	1.181	1532.24	66910	-133672
Y Q A G	QG	54	1.219	1756.94	61524	-122940
Y Q A G	YQ QA	158	1.164	1577.06	74366	-148416
Y Q A G	YQ QG	138	1.204	1817.38	67968	-135660
Y Q A G	QA QG	90	1.174	**1518.08**	67122	-134064
Y Q A G	YQ QA QG	174	1.160	1580.61	74834	**-149320**

South 1959-69 Obs=2633			CPUE model		Catch model	
Model		Par.#	MSE	AIC	Log likelihood	AIC
Y Q A		22	0.960	-62.41	69780	-139516
Y Q A	YQ	66	0.933	-49.77	77479	-154826
Y Q A	QA	50	0.788	**-527.79**	98690	-197280
Y Q A	YQ QA	94	0.775	-484.17	102391	**-204594**

South 1969-75 Obs=1364			CPUE model		Catch model	
Model		Par.#	MSE	AIC	Log likelihood	AIC
Y Q A		19	1.037	87.35	9776	-19514
Y Q A	YQ	47	1.007	104.13	10686	-21278
Y Q A	QA	51	0.900	**-41.53**	12007	-23912
Y Q A	YQ QA	79	0.891	1.26	12500	**-24842**

South 1975-93 Obs=12645			CPUE model		Catch model	
Model		Par.#	MSE	AIC	Log likelihood	AIC
Y Q A G		38	1.362	3982.17	16363	-32650
Y Q A G	YQ	122	1.324	3791.58	18612	-36980
Y Q A G	QA	74	1.254	3009.16	19933	-39718
Y Q A G	QG	54	1.349	3891.37	16694	-33280
Y Q A G	AG	74	1.323	3690.28	17793	-35438
Y Q A G	YQ QA	158	1.224	2869.68	22787	-45258
Y Q A G	YQ QG	138	1.309	3682.61	19670	-39064
Y Q A G	YQ AG	158	1.285	3485.41	20446	-40576
Y Q A G	QA QG	90	1.247	2968.76	20080	-39980
Y Q A G	QA AG	110	1.223	2767.11	21097	-41974
Y Q A G	QG AG	90	1.310	3597.03	18287	-36394
Y Q A G	YQ QA QG	174	1.219	2855.68	22924	-45500
Y Q A G	YQ QA AG	194	1.193	2617.11	24048	-47708
Y Q A G	YQ QG AG	174	1.270	3367.17	21259	-42170
Y Q A G	QA QG AG	126	1.215	2719.24	21223	-42194
Y Q A G	YQ QA QG AG	210	1.187	**2586.91**	24107	**-47794**

Table 2. ANOVA for the final CPUE model for Target (1959-69), Transition (1969-75), and Bycatch (1975-95) period in north and south Atlantic.

North Atlantic Target period from 1959 to 1969

Source	DF	SS	Mean Sq.	F Value	Pr > F
Model	75	2410.54	32.14	44.90	0.0001
Error	1973	1412.25	0.72		
Corr. Tot.	2048	3822.79			

R-sq.= 0.631 C.V.= 38.22

Source	DF	Type III SS	Mean Sq.	F Value	Pr > F
Y	10	61.73	6.17	8.62	0.0001
Q	3	33.81	11.27	15.75	0.0001
A	8	1176.01	147.00	205.37	0.0001
Q*A	24	134.09	5.59	7.81	0.0001
Y*Q	30	88.83	2.96	4.14	0.0001

South Atlantic Target period from 1959 to 1969

Source	DF	SS	Mean Sq.	F Value	Pr > F
Model	37	3261.46	88.15	111.88	0.0001
Error	2595	2044.51	0.79		
Corr. Tot.	2632	5305.97			

R-sq.= 0.615 C.V.= 36.43

Source	DF	Type III SS	Mean Sq.	F Value	Pr > F
Y	10	288.56	28.86	36.63	0.0001
Q	3	2.39	0.80	1.01	0.3870
A	6	1760.27	293.38	372.37	0.0001
Q*A	18	465.00	25.83	32.79	0.0001

North Atlantic Transition period from 1970 to 1975

Source	DF	SS	Mean Sq.	F Value	Pr > F
Model	41	1885.09	45.98	99.28	0.0001
Error	1359	629.36	0.46		
Corr. Tot.	1400	2514.45			

R-sq.= 0.750 C.V.= 36.58

Source	DF	Type III SS	Mean Sq.	F Value	Pr > F
Y	6	149.51	24.92	53.81	0.0001
Q	3	49.15	16.38	35.38	0.0001
A	8	837.24	104.66	225.99	0.0001
Q*A	24	86.40	3.60	7.77	0.0001

South Atlantic Transition period from 1970 to 1975

Source	DF	SS	Mean Sq.	F Value	Pr > F
Model	37	1526.53	41.26	45.84	0.0001
Error	1326	1193.55	0.90		
Corr. Tot.	1363	2720.09			

R-sq.= 0.561 C.V.= 68.63

Source	DF	Type III SS	Mean Sq.	F Value	Pr > F
Y	6	90.24	15.04	16.71	0.0001
Q	3	45.33	15.11	16.79	0.0001
A	7	875.07	125.01	138.88	0.0001
Q*A	21	203.07	9.67	10.74	0.0001

North Atlantic By-catch period from 1975 to 1995

Source	DF	SS	Mean Sq.	F Value	Pr > F
Model	67	11555.79	172.47	146.85	0.0001
Error	8252	9691.82	1.17		
Corr. Tot.	8319	21247.61			

R-sq.= 0.544 C.V.= -126.68

Source	DF	Type III SS	Mean Sq.	F Value	Pr > F
Y	20	712.96	35.65	30.35	0.0001
Q	3	53.27	17.76	15.12	0.0001
A	8	5007.66	625.96	532.96	0.0001
G	3	11.58	3.86	3.29	0.0198
Q*A	24	398.23	16.59	14.13	0.0001
Q*G	9	64.56	7.17	6.11	0.0001

South Atlantic by-catch period from 1975 to 1995

Source	DF	SS	Mean Sq.	F Value	Pr > F
Model	151	8026.64	53.16	44.79	0.0001
Error	12492	14827.05	1.19		
Corr. Tot.	12643	22853.70			

R-sq.= 0.351 C.V.= -81.73

Source	DF	Type III SS	Mean Sq.	F Value	Pr > F
Y	20	417.05	20.85	17.57	0.0001
Q	3	71.84	23.95	20.18	0.0001
A	8	2086.74	260.84	219.76	0.0001
G	3	15.04	5.01	4.22	0.0054
Y*Q	60	429.30	7.15	6.03	0.0001
Q*A	24	1064.25	44.34	37.36	0.0001
A*G	24	434.27	18.09	15.24	0.0001
Q*G	9	83.84	9.32	7.85	0.0001

Table 3. Goodness of fit for the final catch model for Target (1959-69), Transition (1969-75), and Bycatch (1975-95) period in north and south Atlantic.

North Atlantic Target period from 1959 to 1969

Source	NDF	DDF	F	Pr>F	ChiSquare	Pr>Chi
Y	10	1973	13.27	0.0001	132.66	0.0001
Q	3	1973	6.83	0.0001	20.49	0.0001
A	8	1973	392.90	0.0001	3143.21	0.0001
Y*Q	30	1973	7.67	0.0001	229.97	0.0001
Q*A	24	1973	13.53	0.0001	324.75	0.0001

South Atlantic Target period from 1959 to 1969

Source	NDF	DDF	F	Pr>F	ChiSquare	Pr>Chi
Y	10	2565	24.88	0.0001	248.84	0.0001
Q	3	2565	4.93	0.0020	14.80	0.0020
A	6	2565	430.32	0.0001	2581.92	0.0001
Y*Q	30	2565	4.19	0.0001	125.67	0.0001
Q*A	18	2565	46.37	0.0001	834.62	0.0001

North Atlantic Transition period from 1970 to 1975

Source	NDF	DDF	F	Pr>F	ChiSquare	Pr>Chi
Y	6	1341	60.44	0.0001	362.66	0.0001
Q	3	1341	13.63	0.0001	40.88	0.0001
A	8	1341	194.08	0.0001	1552.63	0.0001
Y*Q	18	1341	5.31	0.0001	95.57	0.0001
Q*A	24	1341	6.78	0.0001	162.84	0.0001

South Atlantic Transition period from 1970 to 1975

Source	NDF	DDF	F	Pr>F	ChiSquare	Pr>Chi
Y	6	1308	26.34	0.0001	158.05	0.0001
Q	3	1308	7.41	0.0001	22.23	0.0001
A	7	1308	105.99	0.0001	741.90	0.0001
Y*Q	18	1308	3.70	0.0001	66.53	0.0001
Q*A	21	1308	10.94	0.0001	229.69	0.0001

North Atlantic By-catch period from 1975 to 1995

Source	NDF	DDF	F	Pr>F	ChiSquare	Pr>Chi
Y	20	8231	71.33	0.0001	1426.60	0.0001
Q	3	8231	30.36	0.0001	91.09	0.0001
A	8	8231	763.86	0.0001	6110.91	0.0001
G	3	8231	0.55	0.6499	1.64	0.6499
Y*Q	60	8231	15.90	0.0001	953.70	0.0001
Q*A	24	8231	33.70	0.0001	808.74	0.0001
Q*G	9	8231	6.40	0.0001	57.63	0.0001

South Atlantic By-catch period from 1975 to 1995

Source	NDF	DDF	F	Pr>F	ChiSquare	Pr>Chi
Y	20	12502	35.71	0.0001	714.29	0.0001
Q	3	12502	20.05	0.0001	60.16	0.0001
A	8	12502	107.77	0.0001	862.18	0.0001
G	3	12502	1.01	0.3885	3.02	0.3884
Y*Q	60	12502	22.74	0.0001	1364.41	0.0001
Q*A	24	12502	54.83	0.0001	1315.81	0.0001
Q*G	9	12502	3.50	0.0002	31.46	0.0002
A*G	24	12502	21.95	0.0001	526.87	0.0001

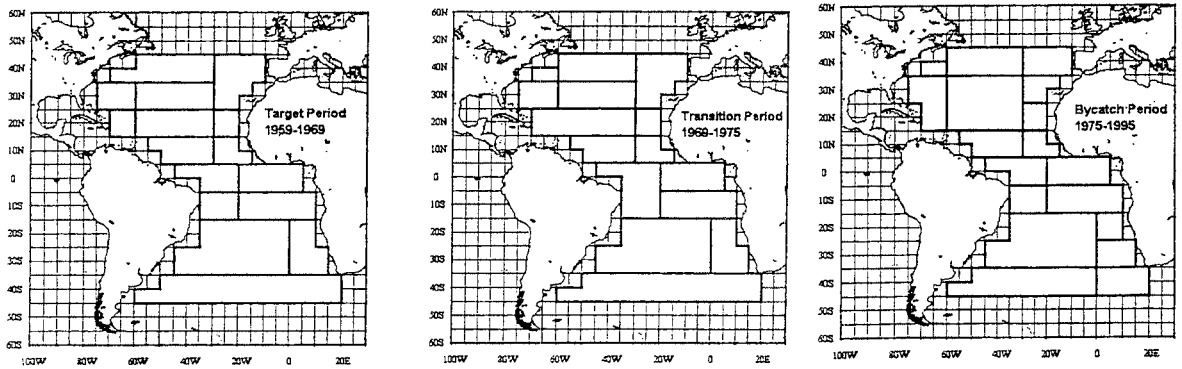

Figure 1. Subarea used in standardization of CPUE for albacore, for Target (1959-69), Transition (1969-75), and Bycatch periods (1975-95)

Table 4. Scaled CPUEs with the 95 % confidence intervals for the CPUE model and scaled CPUEs for Catch model in north and south Atlantic. The value of CPUE was adjusted to 1.0 in 1975,

Year	North				South			
	CPUE model			Catch model	CPUE model			Catch model
	Mean	Lower 95%	Upper 96%		Mean	Lower 95%	Upper 96%	
59	6.330	5.039	7.932	7.243	18.778	15.656	22.499	51.391
60	4.381	3.145	6.060	6.700	14.948	12.548	17.785	44.006
61	5.104	3.123	8.227	5.589	11.377	9.954	12.991	30.737
62	6.599	4.679	9.256	7.677	9.593	8.454	10.875	23.218
63	3.877	2.991	5.000	3.938	8.564	7.558	9.695	19.580
64	4.414	3.851	5.053	3.923	9.092	8.082	10.218	21.378
65	2.784	2.478	3.125	2.518	6.179	5.568	6.851	17.313
66	2.803	2.439	3.215	2.943	6.514	5.817	7.287	16.990
67	3.078	2.652	3.564	3.397	6.928	6.057	7.912	16.239
68	3.490	2.967	4.097	3.150	5.942	5.192	6.788	16.162
69	3.003	2.517	3.572	3.185	3.054	2.629	3.534	7.107
70	3.068	2.758	3.410	2.954	1.888	1.613	2.200	4.807
71	1.731	1.570	1.906	1.806	2.273	1.943	2.648	6.207
72	1.093	0.945	1.260	1.135	1.793	1.498	2.132	3.377
73	1.252	1.063	1.467	1.175	1.096	0.878	1.349	1.674
74	1.063	0.906	1.241	1.420	1.367	1.016	1.801	1.749
75	1.000	0.833	1.197	1.000	1.000	0.782	1.264	1.000
76	0.920	0.758	1.114	1.045	1.105	0.819	1.468	1.324
77	0.559	0.444	0.700	0.709	0.953	0.738	1.214	0.698
78	0.452	0.369	0.552	0.401	1.148	0.904	1.444	0.437
79	0.515	0.422	0.627	0.661	0.748	0.600	0.923	0.299
80	0.400	0.332	0.481	0.518	0.953	0.814	1.111	0.860
81	0.543	0.462	0.637	0.548	1.505	1.294	1.744	1.416
82	0.421	0.358	0.494	0.450	1.274	1.105	1.465	1.497
83	0.397	0.326	0.481	0.455	0.935	0.751	1.153	0.877
84	0.374	0.309	0.450	0.425	0.940	0.802	1.096	0.890
85	0.415	0.351	0.489	0.361	1.482	1.299	1.687	1.360
86	0.271	0.222	0.328	0.214	1.265	1.090	1.463	1.581
87	0.213	0.172	0.260	0.199	0.823	0.686	0.979	0.641
88	0.319	0.264	0.383	0.306	0.585	0.502	0.678	0.477
89	0.310	0.263	0.363	0.257	0.768	0.673	0.873	0.663
90	0.241	0.200	0.288	0.166	0.741	0.651	0.840	0.583
91	0.247	0.205	0.295	0.186	0.798	0.700	0.905	0.701
92	0.210	0.172	0.253	0.158	0.661	0.571	0.760	0.714
93	0.241	0.199	0.289	0.234	0.659	0.573	0.754	0.614
94	0.248	0.206	0.297	0.161	0.818	0.722	0.924	0.657
95	0.218	0.177	0.265	0.120	0.580	0.490	0.680	0.483

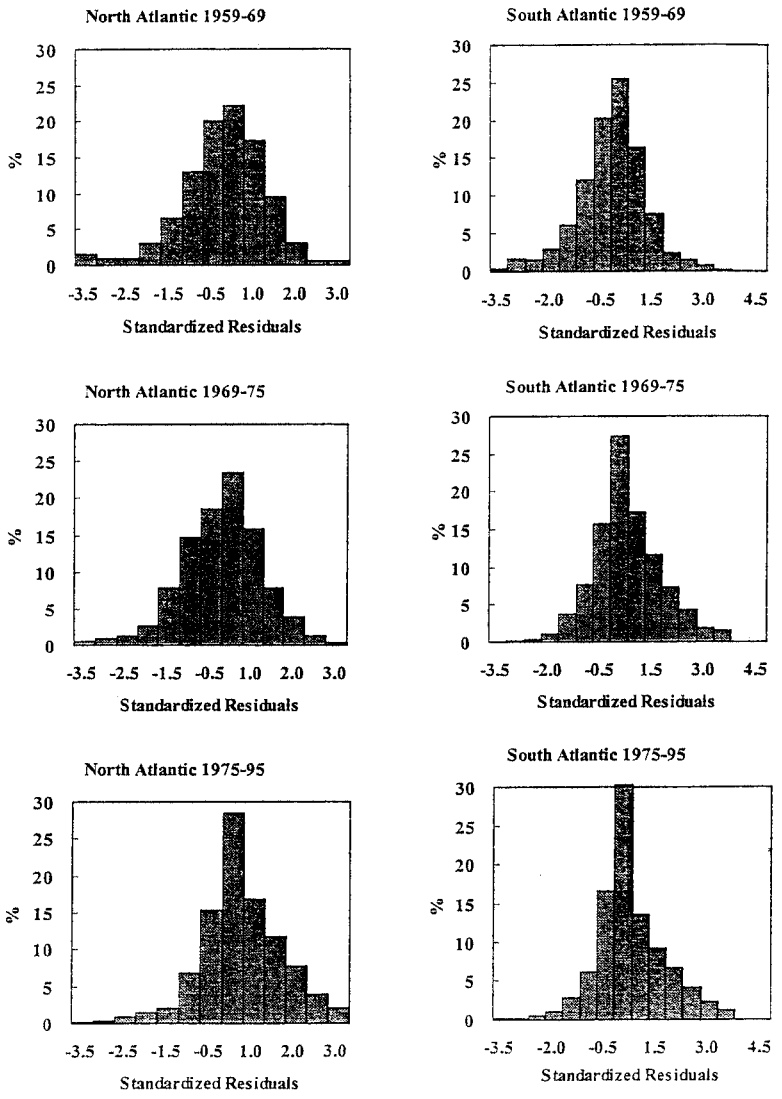

Fig. 2. The distribution of standardized residual of CPUE model for each stock and period.

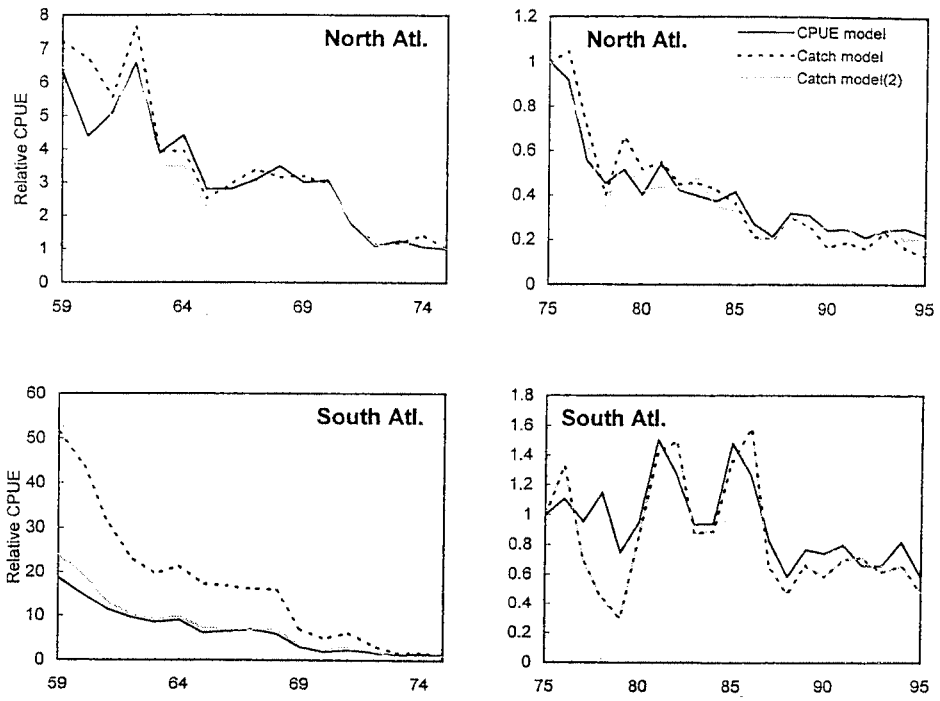

Fig. 3. Scaled standardized CPUE of albacore using two diffent models, CPUE model and catch model for north and south Atlantic. The value of CPUE was adjusted 1.0 in 1975. Catch model(2) indicats the scaled standardized CPUE of the Catch model with the same interactions as the final CPUE model.
The interactions used in each model are as follows.

Stock	Period	CPUE model and Catch model(2)	Catch model
North	1959-69	+Y*Q+Q*A	+Y*Q+Q*A
	1969-75	+Q*A	+Y*Q+Q*A
	1975-95	+Q*A+Q*G	+Y*Q+Q*A+Q*G
South	1959-69	+Q*A	+Y*Q+Q*A
	1969-75	+Q*A	+Y*Q+Q*A
	1975-95	+Y*Q+Q*A+Q*G+A*G	+Y*Q+Q*A+Q*G+A*G