ADJUSTED TAIWANESE LONGLINE CPUE OF NORTH ATLANTIC ALBACORE STOCK FROM TARGET SPECIES SEGREGATED CATCH DATA

Shui-Kai Chang[1] and Chien-Chung Hsu[2]

ABSTRACT

Variations in fishing effort make the standardization of fishing effort essential for properly deriving the CPUE. Two standardizations by GLM were performed for the north Atlantic albacore longline fisheries in this study. One used the original logbook data and included all the possible effects pertaining to the data sets: fishing year, season, area, catch composition, surface temperature and bait used. The other used data segregated through catch composition information (albacore-targeted longline data) and included only fishing year, season and area effects.

The results showed that the main effects in the first GLM model were the catch composition of albacore and the fishing year. As to the second model, with the effects of catch composition of target species eliminated in the data already used, the main effect was the fishing year and season.

RESUME

Les variations de l'effort de pêche rendent essentielle la standardisation de l'effort de pêche pour calculer la CPUE de façon adéquate. Deux standardisations par GLM sont effectuées dans cette étude sur les pêcheries de germon nord-atlantique. L'une d'entre elles utilisait les données originales des carnets de pêche, et comprenait tous les facteurs possibles des jeux de données : année, saison, zone, composition de la prise, température de surface et appât utilisé. L'autre utilisait des données isolées au moyen de l'information sur la composition de la prise (données sur la pêche à la palangre visant le germon) et ne comprenait que les facteurs année, saison et zone.

Les résultats ont montré que les principaux facteurs du premier modèle GLM étaient la composition de la prise et l'année. Quant au deuxième modèle, le facteur de composition de la prise étant déjà éliminé des données utilisées, les principaux facteurs étaient l'année et la saison.

RESUMEN

Las variaciones en el esfuerzo de pesca hacen esencial la estandarización del esfuerzo de pesca para derivar adecuadamente la CPUE. En este estudio se llevaron a cabo dos estandarizaciones con GLM para las pesquerías de palangre de atún blanco del Atlántico norte. Una empleaba los datos originales de los cuadernos de pesca e incluía todos los efectos posibles relativos a los conjuntos de datos: año pesquero, área, composición de la captura, temperatura de la superficie y cebo utilizado. La otra utilizaba datos segregados a través de información sobre composición de la captura (datos de atún blanco perseguido con palangre) e incluía sólo los efectos del año de la pesca, temporada y área.

Los resultados mostraron que los efectos principales del primer modelo GLM eran la composición de la captura y el año de pesca. Con respecto al segundo modelo, habiendo eliminado el efecto de la composición de la captura en los datos empleados, el efecto principal era el año de pesca y la temporada.

[1] Taiwan Fisheries Research Institute, 199 Hou-Ih Rd., Keelung, Taiwan

[2] Institute of Oceanography, National Taiwan University, P.O. Box 23-13, Taipei, Taiwan

1. INTRODUCTION

Standardization of fishing effort is essential before the catch per unit effort (*CPUE*) can be properly derived, since there could be many variations involved in the fishing effort. These variations may include fishing area, fishing strategy, fishing season, and even target species.

For the Atlantic albacore stock, standardization of longline fishing effort previously performed (Tsou 1989; Hsu and Chang 1993; Hsu 1994) concentrated mainly on the fishing area and fishing season effects. However, the target species effect has become more and more important ever since the Atlantic longliners changed their target species (Chang *et al.* 1996; Nakano 1996). Stocker and Fournier (1984), Nakano (1996) and Uozumi (personal communication 1994) suggested that the target species effect should be included in the standardization model. Chang *et al.* (1993; 1996) suggested that standardization might be applied to the data that have been segregated for catches targeting albacore.

In this study, we performed two standardizations for the north Atlantic albacore stock. The first used the unsegregated logbook data and included all the possible effects pertaining to the data sets: fishing year, season, area, target species index, catch composition index, surface temperature and bait used. The other used the segregated "species-specified regluar longline" (SRL, albacore-targeted longline) data (Chang *et al.* 1996) and included only year, season and area effects. Some comparisons between and discussions on these two results were made.

2. MATERIALS AND METHODS

2.1 GLM model 1, using unsegregated data

The original logbook data included fishing date, fishing area, surface temperature, bait used, vessel name, hooks deployed and catches of 13 species. After the segregation for SRL was performed (Chang *et al.* 1996), a target species index (RD) on whether the record belonged to SRL (targeting albacore) or SDL (targeting species other than albacore) was also included in the data sets.

We divided the north Atlantic Ocean into two subareas by latitude of 30^0 N, according to the effort distribution plotted in Chang *et al.* (1996), with the variable referred to as ARNDX. Chang *et al.* (unpublished data) reported that the surface temperature had a close relationship with the catch composition of albacore in the Taiwanese longline catch data. Therefore, we classified the surface temperature into two groups (TEMPNDX) by 24.5^0 C, with an extra group for those without temperature data recorded.

A bait index (BAITNDX) and a catch composition index (SPNDX) were also included in the GLM model. BAITNDX was coded as 1, if saury baits were used; 2, if other baits were used; and 3, if no bait information was available; SPNDX was coded as 1, for albacore catches higher than 70% of the daily total catches; and the rest were coded as 2.

Seven variables in all were chosen for the initiation of GLM analysis; the model was built as:

$$\mathrm{LOG}(CPUE+1.0)=\mu+\mathrm{YEAR}_i+\mathrm{QUAT}_j+\mathrm{ARNDX}_k+\mathrm{RD}_l+\mathrm{SPNDX}_m+\mathrm{TEMPNDX}_n+\mathrm{BAITNDX}_p+(\mathrm{INTERACTION})+\xi_{ijklmnp}$$

where *CPUE* is albacore catch in number per 1000 hooks, μ is overall mean, $\xi_{ijklmnp}$ is error term with N(0,s), and (INTERACTION) is interactions of every two variables.

F-tests were conducted on all main effects and interactions to determine whether or not each contributed significantly to the model.

2.2 GLM model 2, using segregated SRL data

The segregated SRL data of the north Atlantic Ocean were obtained from Chang *et al.* (1994), of which the albacore catch compositions were all higher than 90%. Since the SPNDX, TEMPNDX, BAITNDX were highly correlated with the target species, these and the RD variables were not necessary for this standardization. Therefore, the GLM model was built as:

$$\mathrm{LOG}(CPUE+1.0)=\mu+\mathrm{YEAR}_i+\mathrm{QUAT}_j+\mathrm{ARNDX}_k+(\mathrm{INTERACTION})+\xi_{ijk}$$

3. RESULTS

Table 1 is the ANOVA table of the GLM model 1. It shows that only 5 out of the 20 items have significant meaning at the significant level of 1%. The others contributed little to the variances. Furthermore, the main variables in the 5 items are YEAR, RD and SPNDX. This indicated that the target species effect (catch composition effect) contributed the most to the overall variances of GLM model 1. If no allowances for the target species effect for north Atlantic albacore stock were made, misleading *CPUE* estimates could result.

Since the model was fully unbalanced, the least-square estimation of the annual adjusted *CPUE* was unavailable. Therefore, the adjusted *CPUE* series could not be plotted.

When running the GLM model 2, we found that the area effect was not significant. From Table 1 we find that the area effect is not significant either. This might suggest that the segregations through catch composition have already explained the effect of fishing area. Therefore, we discarded the area variable from the GLM model 2. The obtained ANOVA table is tabulated in Table 2; the residual histogram is plotted in Figure 1, which shows a normal approximated distribution. The least-square *CPUE* (ADJUSTED) estimates with the nominal *CPUE* (SRL) are plotted in Figure 2. The figure shows that the difference is insignificant between the nominal and the adjusted *CPUE*, except for the last two years. These two *CPUE* series, however, differed considerably from 1989 onward with the series of overall nominal longline data on which no segregation was performed (OVERALL).

Table 1. ANOVA table of the GLM model 1.

Source	DF	Sum of Squares	Mean Square	F Value	Pr>F
Model	92	314.56493042	3.41918403	16.19	0.0001
Error	264	55.74946557	0.21117222		
Corrected Total	356	370.31439599			

R-Square	C.V.	Root MSE	LOG(CPUE+1.0) Mean
0.849454	17.97371	0.4595348	2.5567047

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	13	12.5296	0.9638	4.56	0.0001
QUAT	3	1.2111	0.4037	1.91	0.1280
ARNDX	1	0.0894	0.0894	0.42	0.5157
RD	1	19.7092	19.7092	93.33	0.0001
SPNDX	1	14.2105	14.2105	67.29	0.0001
TEMPNDX	2	0.3976	0.1988	0.94	0.3914
BAITNDX	2	0.4059	0.2030	0.96	0.3838
YEAR*ARNDX	8	4.3524	0.5440	2.58	0.0101
YEAR*RD	5	6.3952	1.2790	6.06	0.0001
YEAR*SPNDX	6	4.1658	0.6943	3.29	0.0039
YEAR*TEMPNDX	14	2.6939	0.1924	0.91	0.5472
QUAT*ARNDX	3	1.0950	0.3650	1.73	0.1615
QUAT*RD	3	1.1925	0.3975	1.88	0.1329
QUAT*SPNDX	3	0.4314	0.1438	0.68	0.5644
QUAT*TEMPNDX	6	3.4966	0.5828	2.76	0.0128
RD*TEMPNDX	2	1.6519	0.8259	3.91	0.0212
RD*BAITNDX	1	0.0497	0.0497	0.24	0.6281
SPNDX*TEMPNDX	2	1.3323	0.6661	3.15	0.0443
SPNDX*BAITNDX	1	0.0573	0.0573	0.27	0.6027
TEMPNDX*BAITNDX	2	0.0844	0.0422	0.2	0.8189

Table 2. ANOVA table of GLM model 2.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	16	3.77828123	0.23614258	13.11	0.0001
Error	34	0.61241008	0.01801206		
Corrected Total	50	4.39069132			

R-Square	C.V.	Root MSE	LOG(CPUE+1.0) Mean
0.860521	4.196346	0.1342090	3.1982354

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	13	2.2771	0.1751	9.72	0.0001
QUAT	3	1.2630	0.4210	23.37	0.0001

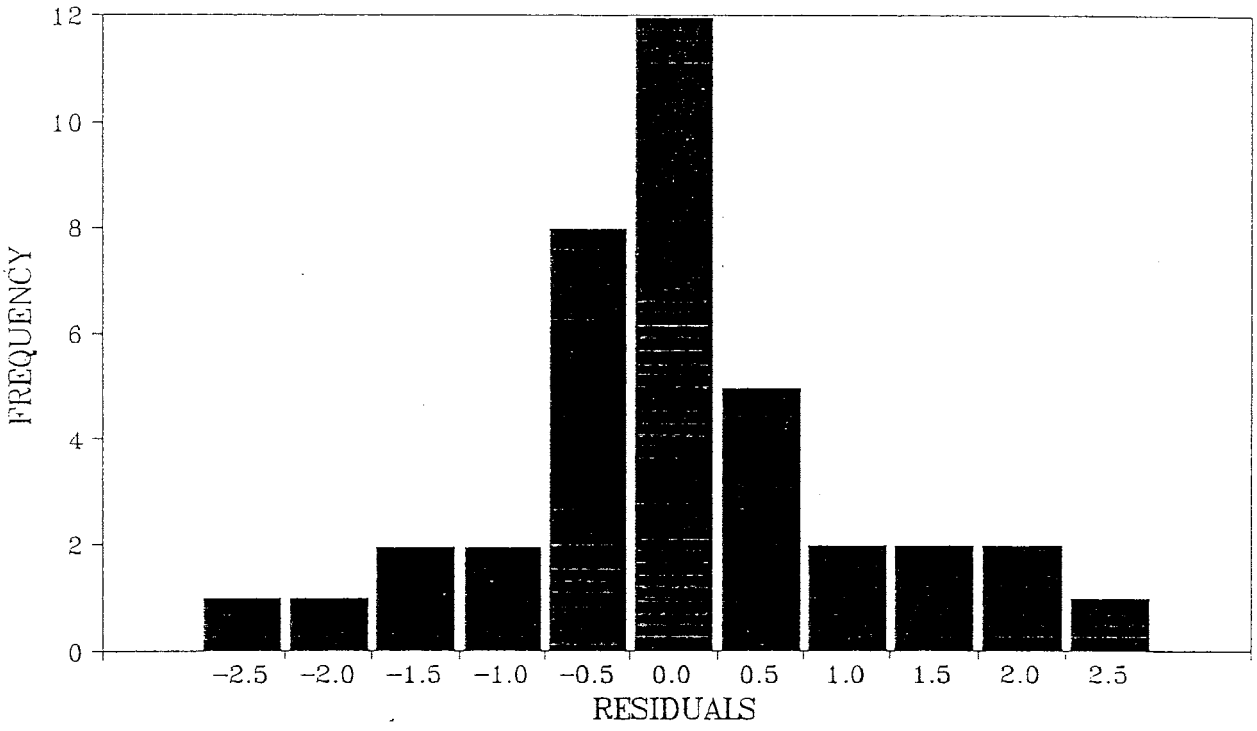

Fig. 1. Residual plot for GLM model 2 (using data segregated for SRL).

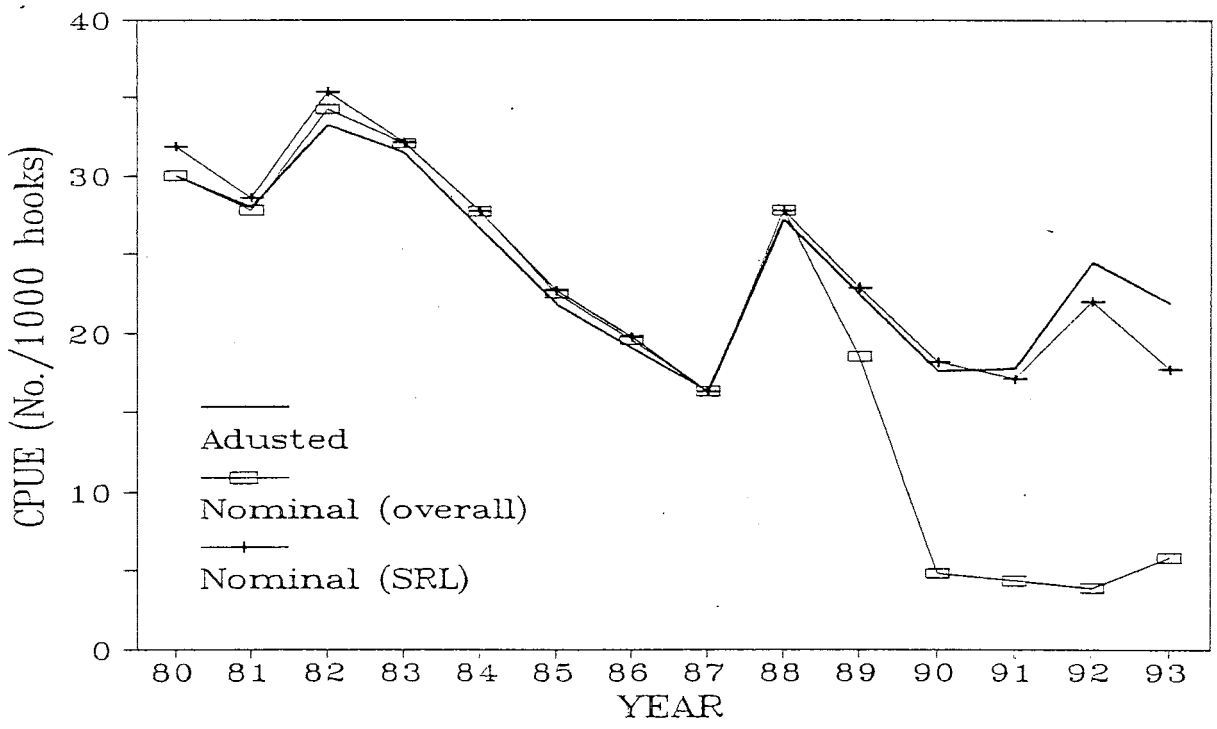

Fig. 2. Nominal and adjusted CPUE series of north Atlantic albacore stock. SRL: segregated albacore-targeted longline data; overall: overall longline data without segregation.