STANDARDIZED CATCH PER UNIT EFFORT OF TAIWANESE LONGLINE FISHERY AS ABUNDANCE INDEX OF ALBACORE STOCK IN THE ATLANTIC

SCRS/1996/080 Rev.

Col.Vol.Sci.Pap. ICCAT, 46 (3) : 123-130 (1997)

Hsu[1], *C.C.*

SUMMARY

The abundance index for the north and south Atlantic albacore stocks was derived from the catch and effort data of the Taiwanese longline fishery using general linear model techniques. The factors used were: year, quarter, fishing area and two-way interactions, year-quarter and quarter fishing area. Based on changes in the fishing pattern, the northern abundance index is comprised of two segments, the 1968-1987 segment and the 1988-1994 segment. Consequently, the standardized CPUE series for the northern stock continued to decrease from 1984, when the series has increased since 1972; the decreasing trend seems to cease in 1987, and then widely fluctuated downward from then onwards. Comparatively, the standardized CPUE series for the southern stocks shows a decreasing trend from 1968 to 1972, and a slight, but continuous decreasing trend occurs from 1973 to 1990, abruptly increasing to a high level in 1993, and then decreases again. Both northern and southern abundance indices were compared with the corresponding results of previous studies. The comparison indicated that the new standardized abundance series are significantly related to previous estimates.

RÉSUMÉ

Les indices d'abondance des stocks de germon de l'Atlantique Nord et Sud ont été élaborés à partir des données de prise et d'effort de la pêcherie palangrière taïwanaise, avec un modèle linéaire généralisé. Les facteurs retenus comprenaient notamment : l'année, le trimestre, la zone de pêche, ainsi qu'une interaction année-trimestre et année-zone. L'indice d'abondance de l'Atlantique Nord était divisé en deux segments : 1968-1987 et 1988-1994, pour tenir compte des changements intervenus dans les modes de pêche. Les séries de CPUE standardisées du stock Nord indiquent en effet une augmentation entre 1972 et 1984, suivie d'une diminution jusqu'en 1987 qui semble s'arrêter, puis reprendre progressivement à partir de cette date. Les CPUE standardisées du stock Sud indiquent une tendance à la baisse entre 1968 et 1972, suivie d'une légère mais certaine tendance à la baisse entre 1973 et 1990, puis d'une augmentation brusque jusqu'en 1993, suivie d'une nouvelle diminution. La comparaison entre les indices d'abondance du Sud et du Nord et les résultats des précédentes recherches indique que les nouvelles séries d'abondance standardisées sont très semblables aux précédentes estimations.

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

RESUMEN

Se derivaron índices de abundancia para los stocks de atún blanco del Atlántico norte y sur a partir de datos de captura y esfuerzo de la pesquería de palangre de Taiwan, utilizando técnicas de modelo lineal generalizado. Los factores empleados fueron año, trimestre, zona de pesca e interacciones de doble sentido, año-trimestre y trimestre-zona de pesca. Basándose en cambios de esquema pesquero, el índice de abundancia del norte se compone de dos segmentos, el segmento 1968-1987 y el segmento 1988-1994. En consecuencia, la serie estandarizada de CPUE para el stock norte continuó decreciendo desde 1984, cuando aumentado desde 1972; esta tendencia descendente parece cesar en 1987, fluctuando después grandemente, y descendiendo a partir de entonces. Comparativamente, la serie estandarizada de CPUE para los stocks del sur muestra una tendencia decreciente desde 1968 a 1972, y una ligera pero estable tendencia al descenso tuvo lugar de 1973 a 1990, con incrementos bruscos a un alto nivel en 1993, y descendiendo nuevamente. Se compararon los índices de abundancia del norte y del sur con el resultado correspondiente de las tareas previas,. La comparación indica que las nuevas series de abundancia estandarizadas están relacionadas de forma significativa con las estimaciones anteriores.

INTRODUCTION

Albacore, *Thunnus alalunga*, has been one of the important targets for Taiwanese longline fishery in the Atlantic since early 1960's. The time series of catch per unit effort of Taiwanese longline fishery for albacore in the Atlantic seems to be appropriately used as abundance index for assessing the stock, although the data quality were uncertain before the two longline data preparatory meetings held in

Taipei, Taiwan in 1989 and 1994 (Anon. 1993; 1996a). Some known disadvantages existed in Taiwanese data bases have been partially solved (Anon. 1996b).

Furthermore, the catch of Atlantic albacore by Taiwanese longline fishery peaked around 30,000 MT in the 1970's and 1980's, and reached its historically highest catch 47,000 MT in 1986, when Taiwanese longline vessels targeted mainly the albacore, and from 1988 onward, the catches of albacore, influenced by the partial transformation of target by Taiwanese longline fleets installed super-cold freezer facility, has declined, in particular for the northern stock, but the order of 25,000 MT has continued to maintain since then.

During the first longline data preparatory meeting in 1989, the main discrepancy in size measurements between on board and on port sampling were compared graphically and well resolved, also the TASK I landings of albacore for Taiwanese longline fishery in the Atlantic were verified. Further those data have become whichsoever the following assessments of Atlantic albacore stock based on. However, the Albacore Working Group reviewed and found that two keypoints in the TASK II data of Taiwanese longline fishery still exist, one is lower recovery rate observed from the beginning of 1990's, and other is great discrepancy investigated between the TASK I and those converted from catch in numbers and catch at size. The latter was verified in the second longline data preparatory meeting in 1994, and an appropriate substitution of catch at size has been used in raising the catch in numbers in order to fix the TASK I; and the former was improved in the previous year, therefore, the TASK II of 1981 to 1990 which are with size data has been raised incorporating suitable time-area substitution (Anon. 1996a), those results were prepared for the abundance index which were the assessment basis in 1994 and 1995 Species Group Sessions (Chang and Hsu 1996a; 1996b; Punt et al. 1996; Sun 1995; Wu et al. 1996), and those of 1991 to 1993 have been refined with increasing logbooks recovery, the new data base have not ever been processed for any assessment and management purposes.

The present report aims to use those verified TASK II data to compute catch per unit effort which standardized type could be used as abundance index properly.

MATERIAL AND METHOD

1. Basic data

The basic data for the present study were obtained from two sources, those who compiled Taiwanese longline fishery statistics, the Institute of Oceanography, National Taiwan University for the data of 1968-1990, and the Oversea Fishery Development Council for the refined data of 1991-1994.

The data base contains monthly 5 x 5 square block catch and effort for the year 1968-1994, and quarterly 1cm class size distribution for the year 1981-1994. Because not well compatibility of TASK I and TASK II converted from size distribution and catch in numbers in 1981 to 1990 provided by Oversea Fishery Development Council, those catch and effort have been modified again using the similar procedure and substitution verified in the Second Data Preparatory Meeting (Anon. 1996a). The catch and effort in 1991-1994 were reraised by the Oversea Fishery Development Council, and no fine scale (monthly 5 x 5 square block) size measurements available, the 1991-1994 catch and effort data provided by Oversea Fishery Development Council were used in case of the low compatibility of TASK I and TASK II converted from size distribution. Consequently, the present study uses three segments data, data of 1968-1980 from the Institute of Oceanography, National Taiwan University, which are traditional data used in assessment, data of 1981-1994 from Oversea Fishery Development Council, and data of 1981-1990 were modified in according to the procedure adopted in the Second Data Preparatory Meeting (Anon. 1996a).

Where are in size and catch conversion, the Santiago's length-weight relationship (Santiago 1993) was used for the northern stock, and Penny's (Penny 1994) for the southern stock.

2. Nominal catch per unit effort computation

In the data bases, nominal catch per unit effort (nominal-CPUE) was calculated by catch in number divided by effort (per 1000 hooks) for monthly 5 by 5 square block, and then multiplying annual mean weight to obtain catch per unit effort in weight. Therefore, catch per unit effort in number was used in standardization, and using the same procedure to obtain catch per unit effort in weight.

3. The GLM model

Referring the past GLM model building, year, quarter, fishing area were included as the main effect and two way interactions, year-quarter and quarter-fishing area were also used in the present GLM model, however, by-catch factor was not used in the present analysis because no very reliable by-catch data (catches of bigeye tuna and yellowfin tuna) are available and the stratification of subarea may possibly eliminate the target problem in standardization.

In order to layout the similar pattern of fishing area as possible in the analysis, based on the change of fishing pattern and raw catch data treatment, three segments of catch per unit effort and fishing effort distribution, 1968-1979, 1980-1987 and 1988-1994, were mapped for total Atlantic. Those results are given in Fig. 1 to Fig. 6, accordingly, a map of fishing subarea stratification was given as Fig. 7 that almost

reflects the change of fishing pattern and targeted species. There are 7 subareas to be separated for the northern and southern Atlantic, respectively. Those subareas were used in the fishing area effect in the present analysis.

Due to no hooks per basket information available, the gear configuration was not used in the present analysis, and the stratification of fishing area may eliminate the effect of target, so the effect of other species such as bigeye tuna and yellowfin tuna that are targeted recently after 1990 by Taiwanese longline fleets installed super cold freezer facility was also not considered.

Consequently, the multiplicative GLM model was selected as:

$LOG(CPUE+0.001)=\mu+Y+Q+A+(\text{quarter-area+year-quarter})\ \text{interactions}+\varepsilon$

where

μ =overall mean;

Y=yearly effect;

Q=quarterly effect;

A=fishing subarea effect; and

ε =error term assumed as normal distribution with zero mean and σ^2.

The independent variable for logarithmic transformation of catch per unit effort in number with 0.001 additional constant was chosen by referring Uojumi (1996) used in the 3rd ICCAT Billfishes Workshop, a good normalized assumption was met in its model attribute using the 0.001 constant.

Analyses included 1968-1987 and 1988-1994 time series TASK II data of Taiwanese longline fisheries for the northern Atlantic, and 1968-1994 TASK II data for the southern Atlantic, and the computation was made through computer software SAS ver.6.08.

4. Comparison with previous works

The recent works of standardized catch per unit effort have been done in 1994 for the Final Meeting of the ICCAT Albacore Research Program and further ICCAT/SCRS Species Group Session (Anon. 1996b). Four standardized series were presented in the Meeting, Taiwanese longline series for the north stock (Chang and Hsu 1996a; 1996b), for the south stock (Punt 1996), and Japanese longline series for both stocks (Uojumi 1996), however, the Japanese longline series has not any numeric values attached in the paper, therefore, the figures tabulated in Punt's paper (Punt 1996) were adopted in the present comparison.

The comparisons include, for north stock, Chang and Hsu's series with the present standardized series, and for south stock, Punt's Taiwanese longline series (Punt 1996), Japanese longline series and the present standardized series, among those, a correlation analysis was made to understand how they related each other in the same stock.

RESULTS AND DISCUSSION

The statistics of GLM analyses for the series of 1968-1987, 1988-1994 for the northern stock and 1968-1994 for the southern stock are given in Tables 1, 2, and 3, respectively. All the effects and two way interactions shows significance tested by the analysis of variance, and those factors in the GLM model explain 0.669 (Table 1), 0.627 (Table 2) and 0.606 (Table 3) total variations resepectively for the three time series data.

The histograms of standardized residual show likely normality as assumed in the model (Fig. 8).

The relative nominal-CPUE and relative standard-CPUE for the northern and southern stocks are given in Table 4.

The nominal-CPUE and standardized catch per unit effor (standard-CPUE) of the 1968-1987, 1988-1994 for the northern Atlantic stock and 1968-1994 for the southern Atlantic stock are, respectively given in Figs. 9 and 11. The standard-CPUEs with lower and upper 95% confidence limit are given in Figs. 10 and 12 for the northern and southern Atlantic stocks.

The standardized CPUE series for the northern stock continued to decrease from 1984, when the series has increased since 1972, this decreasing trend seems to cease in 1987, and then greatly fluctuated decreasing onward (Figs. 9 and 10). Comparatively, the standardized CPUE series for the southern stock shows decreasing trend from 1968 to 1972, and a slightly but stably decreasing trend occurs from 1973 to 1990, abruptly increases to a high level in 1993, then decreases again (Figs. 11 and 12).

For the nothern stock, the comparison between standardized longline series by Chang and Hsu (1996) and the present study is given in Fig. 13, a 0.667 correlation coefficient shows that both series is in its coincident trend, however the trend after 1990 indicates that both series seem not well trended, this perhaps results from the discrepancy between TASK I and TASK II that is not raised and substituted by suitable size data. For the southern stock, the comparison was made among Punt's Taiwanese longline series (Punt 1996), Japanese longline series (Punt 1996) and the present standardized series, the result is given in Fig. 14, and correlation coefficients 0.777 between Punt's Taiwanese longline series and the present study, 0.869 between Japanese longline series and the present study, and 0.608 between Punt's Taiwanese

longline series and Japanese longline series were found. The result also indicates that the present standardized Taiwanese longline catch per unit effort is coincident more or less with the result from previous works.

LITERATURE CITED

Anon. 1993. Documentation of albacore stock assessment work carried out at the special session. International Commission for the Conservation of Atlantic Tunas, Coll. Vol. Sci. Paps. XL(2):217-305.

Anon. 1996a. Final Report of the Data Preparatory Meeting for atlantic Pelagic Tuna Longline Fisheries. Institute of Oceanography, national Taiwan University, Taipei, Taiwan, 11-15 May, 1994. International Commission for the Conservation of Atlantic Tunas, *Coll. Vol. Sci. Paps.*, XLIII, pp. 147-158.

Anon. 1996b. Report of the Final Meeting og the ICCAT Albacore Reséarch Program. Sukarrieta, Vizcaya, Spain, 1-8, June, 1994. International Commission for the Conservation of Atlantic Tunas, *Coll. Vol. Sci. Paps.* XLIII, pp. 1-24.

Chang, S. K. and C. C. Hsu. 1996a. adjusted Taiwanese longline CPUE of north Atlantic albacore stock from target species segregated catch data. International Commission for the Conservation of Atlantic Tunas, *Coll. Vol. Sci. Paps.*, XLIII, pp. 277-282.

Chang, S. K. and C. C. Hsu. 1996b. New estimates of the adjusted north Atlantic albacore CPUE from Taiwanese longline catch data of 1968-93. International Commission for the Conservation of Atlantic Tunas, *Coll. Vol. Sci. Paps.*, XLIII, pp. 283-288.

Penny, A. J. 1994. Morphometric relationships, annual catch-at-size for south African caught South Atlantic albacore (*Thunnus alalunga*). International Commission for the Conservation of Atlantic Tunas, *Coll. Vol. Sci. Paps.* XLII(1):371-382.

Punt, A. E., R. W. Leslie and A. J. Penny. 1996. A preliminary examination of the Taiwanese longline catch and effort data (1967 to 1992) for south Atlantic albacore (*Thunnus alalunga*). International Commission for the Conservation of Atlantic Tunas, *Coll. Vol. Sci. Paps.*, XLIII, pp. 301-310.

Santiago, J. 1993. A new length-weight relationship for the north Atlantic albacore. International Commission for the Conservation of Atlantic Tunas, *Coll. Vol. Sci. Paps.* XL(2):316-319.

Sun, C. L. 1995. Stock assessment and fishery management of the south Atlantic albacore (*Thunnus alalunga*). Ph.D. Dissertation, University of Miami, 330pp.

Uojumi, Y. 1996. Standardization of CPUE for white marlin caught by Japanese longline fishery in the Atlantic. Document submitted to the 3rd ICCAT Billfishes Workshop, 11-20 July, 1996, Miami laboratory, Southeast Fisheries Center, NOAA, Miami, Fl. (SCRS/96/94).

Wu, C. L., S. Y. Yeh and H. C. Liu. 1996. Standardization of south Atlantic albacore CPUE by using GLM with area-time species adjustments on Taiwanese data. International Commission for the Conservation of Atlantic Tunas, *Coll. Vol. Sci. Paps.*, XLIII, pp. 289-294.

Table 1 Analysis of variance for northern Atlantic albacore from 1968 to 1987.

R-square=0.669, Coefficient of Variation=48.910

Source	DF	Sum of Square	Mean Square	F value	Pr>F
Model	103	7887.8907	76.5815	58.42	0.0001
Error	2976	3901.0737	1.3108		
Corrected total	3079	11788.9644			

Source	DF	Sum of Square	Mean Square	F value	Pr>F
Year	19	207.2316	10.9069	8.32	0.0001
Quarter	3	55.1627	18.3876	14.03	0.0001
Area	6	4279.9525	713.3254	544.17	0.0001
Quarter*Area	18	338.0490	18.7805	14.33	0.0001
Year*Quarter	57	200.3798	3.5154	2.68	0.0001

Table 2 Analysis of variance for northern Atlantic albacore from 1988 to 1994.

R-square=0.627, Coefficient of Variation=158.689

Source	DF	Sum of Square	Mean Square	F value	Pr>F
Model	55	2818.0804	51.2378	20.67	0.0001
Error	677	1677.7865	2.4783		
Corrected total	732	4495.8669			

Source	DF	Sum of Square	Mean Square	F value	Pr>F
Year	7	147.4322	21.0617	8.50	0.0001
Quarter	3	37.4318	12.4773	5.03	0.0019
Area	6	890.9777	148.4963	59.92	0.0001
Quarter*Area	18	450.8915	25.0495	10.11	0.0001
Year*Quarter	21	144.9456	6.9022	2.79	0.0001

Table 3 Analysis of variance for southern Atlantic albacore from 1968 to 1994.

R-square=0.606, Coefficient of Variation=58.637

Source	DF	Sum of Square	Mean Square	F value	Pr>F
Model	131	18497.2166	141.2001	79.41	0.0001
Error	6772	12040.7833	1.7780		
Corrected total	6903	30537.9999			

Source	DF	Sum of Square	Mean Square	F value	Pr>F
Year	26	1212.0877	46.6188	26.22	0.0001
Quarter	3	29.9816	9.9939	5.62	0.0008
Area	6	11561.1378	1926.8563	1083.71	0.0001
Quarter*Area	18	626.1884	34.7882	19.57	0.0001
Year*Quarter	78	530.9040	6.8065	3.83	0.0001

Table 4 The relative nominal catch per unit effort and standardized catch per unit effort, where the relative nominal catch per unit effort is scaled by the overall mean of the time series from 1968 to 1994 for both stocks (i.e., 176.4216 kg/1000 hooks for the north and 199.0916 kg/1000 hooks for the south), the standardized catch per unit effort for the north stocks was scaled by 1987 standardized level (56.0088 kg/1000 hooks for the 1968-1987 series, and 51.51699 kg/1000 hooks for the later series) then rescaled to the overall mean (1.5084), the relative standardized catch per unit effort for the south stock was scaled by the overall mean (147.5175 kg/1000 hooks).

Year	North Stock		South stock	
	Nominal CPUE	Standardized CPUE	Nominal CPUE	Standardized CPUE
1968	0.876887	1.840418	0.777039	2.324904
1969	0.750713	2.048852	0.665231	2.487810
1970	0.792656	1.516287	0.702399	1.465719
1971	0.548223	0.538673	0.485798	1.584452
1972	1.200254	0.810158	1.063584	0.770541
1973	1.280538	1.298674	1.134727	0.800709
1974	1.262192	1.042777	1.118470	1.086523
1975	1.192983	0.755736	1.057142	1.042789
1976	1.432357	1.007773	1.269258	0.835671
1977	1.003365	0.858540	0.889114	0.950366
1978	1.348636	1.113268	1.195071	1.077230
1979	1.368051	0.934304	1.212275	1.101276
1980	1.396644	0.985548	1.237612	1.115248
1981	1.388639	1.226290	1.230519	0.807674
1982	1.620464	1.160271	1.435947	0.962266
1983	1.515292	1.481453	1.342750	1.023231
1984	1.363554	1.333027	1.208290	0.837756
1985	1.211557	1.174304	1.073601	0.874944
1986	1.045583	1.048917	0.926526	0.934612
1987	0.642426	0.662943	0.569275	0.832246
1988	1.083641	0.825713	0.960249	0.775222
1989	0.865671	0.835111	0.767099	0.631015
1990	0.248464	0.336015	0.220173	0.396915
1991	0.289514	0.934142	0.256548	0.515289
1992	0.197589	0.382383	0.175090	0.840308
1993	0.417534	0.596174	0.369991	0.466046
1994	0.656578	0.252255	0.581815	0.459231

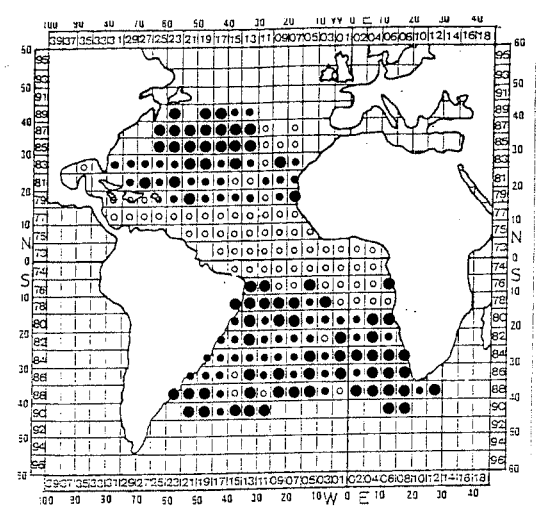

Fig. 1 The nominal catch per unit effort (CPUE) distribution of averaging each annual 5x5 square block for albacore by Taiwanese longline fishery in the Atlantic from 1968 to 1979, where open circle denotes CPUE is less than 10 individuals/1000 hooks, small solid circle denotes CPUE is between 10 individuals/1000 hooks and 20 individuals/1000 hooks, and large solid circle for greater than 20 individuals/1000 hooks.

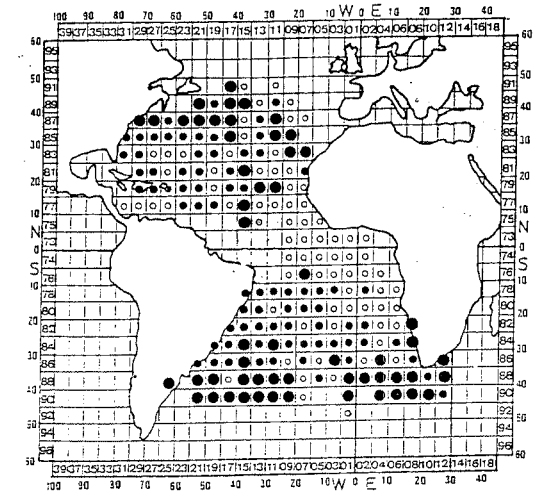

Fig. 2 The nominal catch per unit effort (CPUE) distribution of averaging each annual 5x5 square block for albacore by Taiwanese longline fishery in the Atlantic from 1980 to 1987, where open circle denotes CPUE is less than 10 individuals/1000 hooks, small solid circle denotes CPUE is between 10 individuals/1000 hooks and 20 individuals/1000 hooks, and large solid circle for greater than 20 individuals/1000 hooks.

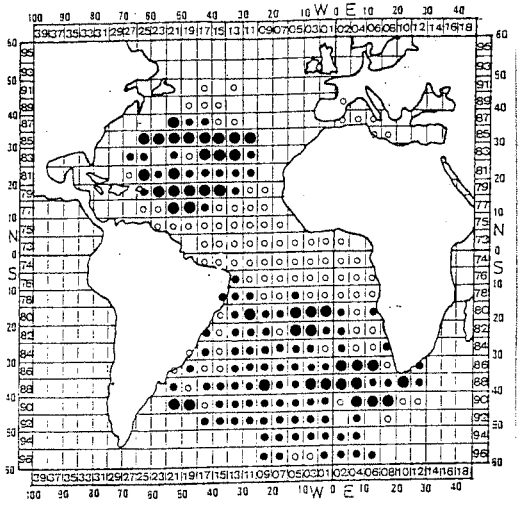

Fig. 3 The nominal catch per unit effort (CPUE) distribution of averaging each annual 5x5 square block for albacore by Taiwanese longline fishery in the Atlantic from 1988 to 1994, where open circle denotes CPUE is less than 10 individuals/1000 hooks, small solid circle denotes CPUE is between 10 individuals/1000 hooks and 20 individuals/1000 hooks, and large solid circle for greater than 20 individuals/1000 hooks.

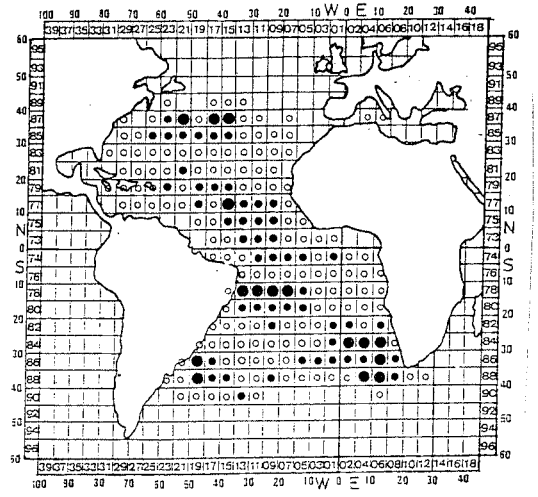

Fig. 4 The effort distribution of averaging each annual 5x5 square block for albacore by Taiwanese longline fishery from 1968 to 1979, where open circle denotes effort employed is less than 10,000 hooks, small solid circle denotes CPUE is between 10,000 and 20,000 hooks, and large solid circle for greater than 20,000 hooks.

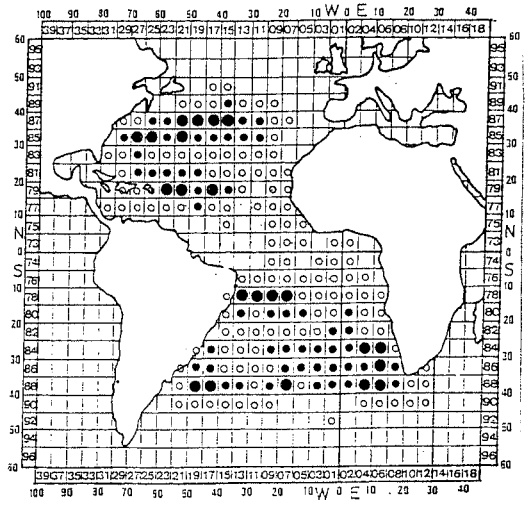

Fig. 5 The effort distribution of averaging each annual 5x5 square block for albacore by Taiwanese longline fishery from 1980 to 1987, where open circle denotes effort employed is less than 10,000 hooks, small solid circle denotes CPUE is between 10,000 and 20,000 hooks, and large solid circle for greater than 20,000 hooks.

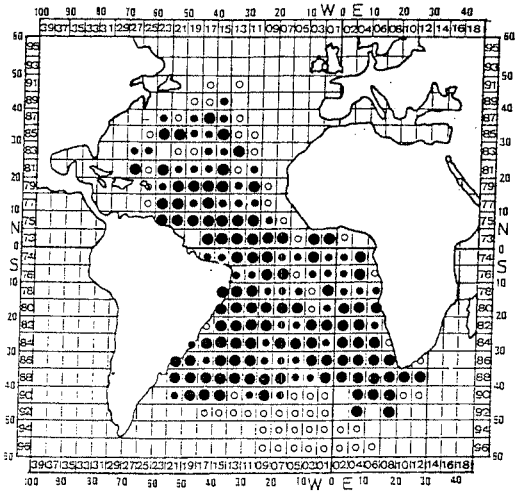

Fig. 6 The effort distribution of averaging each annual 5x5 square block for albacore by Taiwanese longline fishery from 1988 to 1994, where open circle denotes effort employed is less than 10,000 hooks, small solid circle denotes CPUE is between 10,000 and 20,000 hooks, and large solid circle for greater than 20,000 hooks.

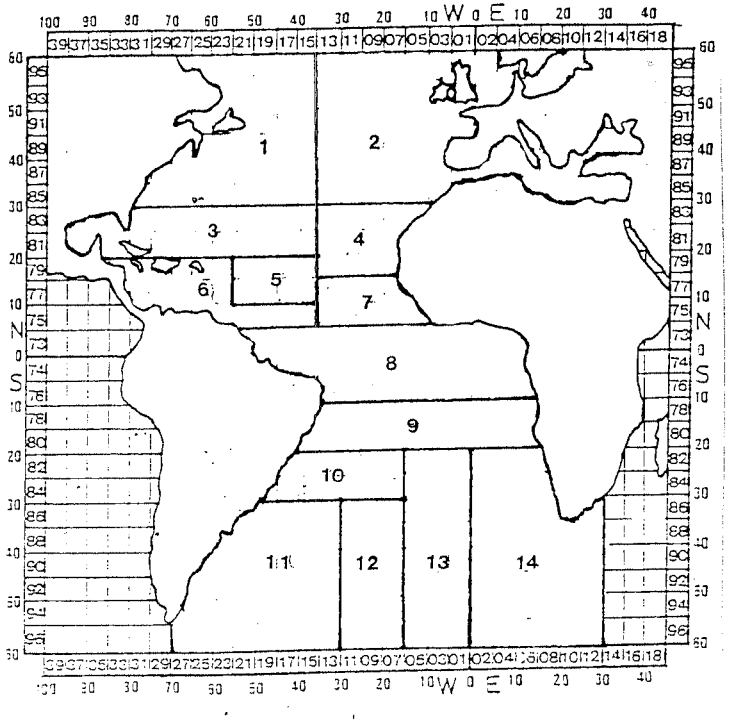

Fig. 7 The subarea stratification dependin on the catch per unit effort and effort distributions shown in Figs. 1 to 6 for applying in standardizing the Taiwanese longline fishery for albacore in the Atlantic.

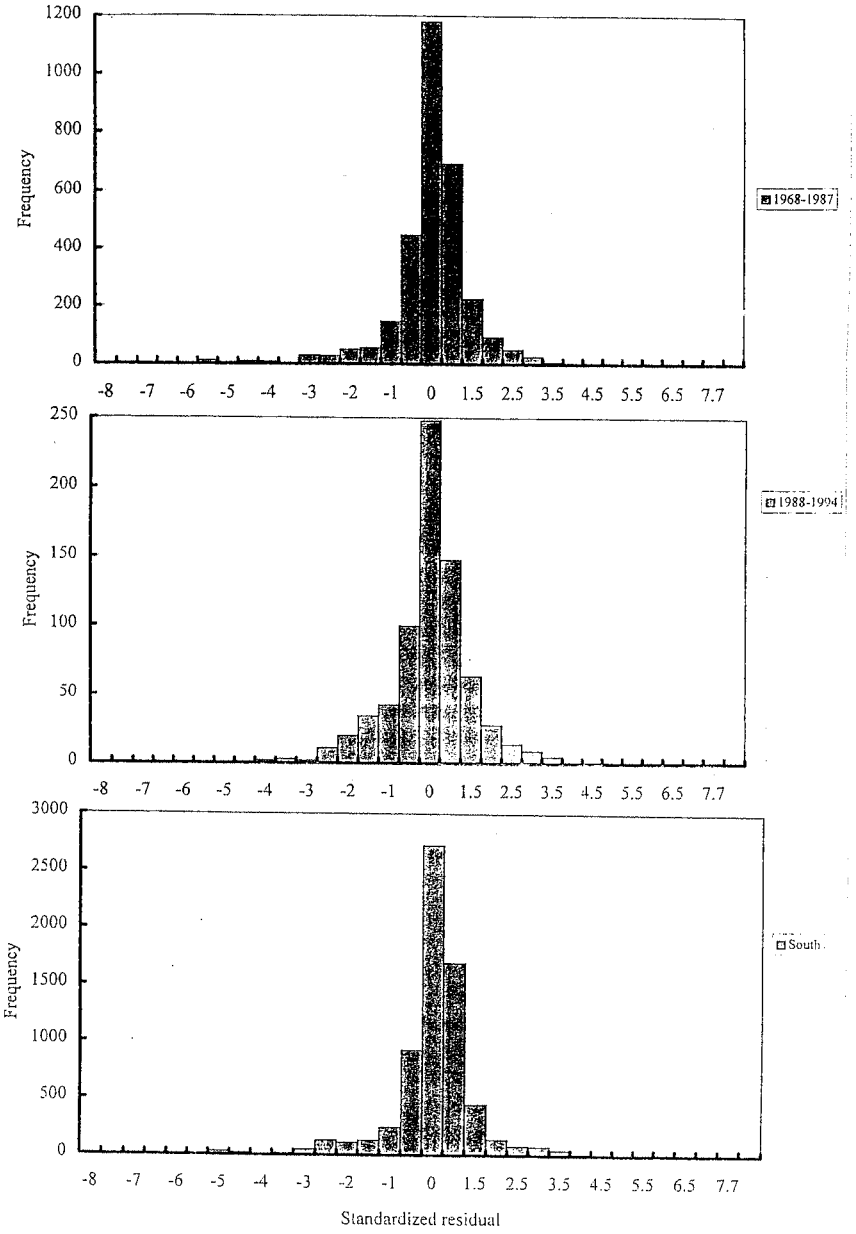

Fig. 8 The histograms of standardized residuals from fitting GLM for showing the normality of standardizing Taiwanese longline fishery for albacore in the Atlantic, the upper panel is 1968-1987 time segment, the middle panel is 1988-1994 segment for the northern stock, and the lower panel for the southern stock.

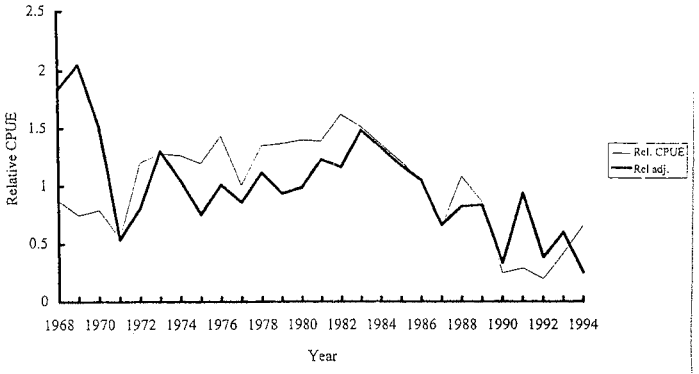

Fig. 9 The comparison of nominal catch per unit effort and standardized catch per unit effort for the northern stock.

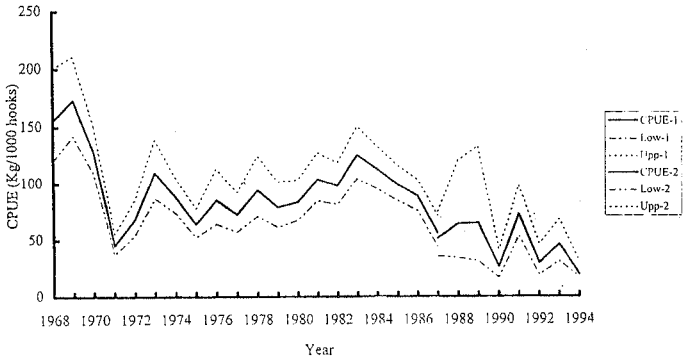

Fig. 10 The standardized catch per unit effort with lower and upper 95% confidence limits for the northern stock from 1968 to 1994.

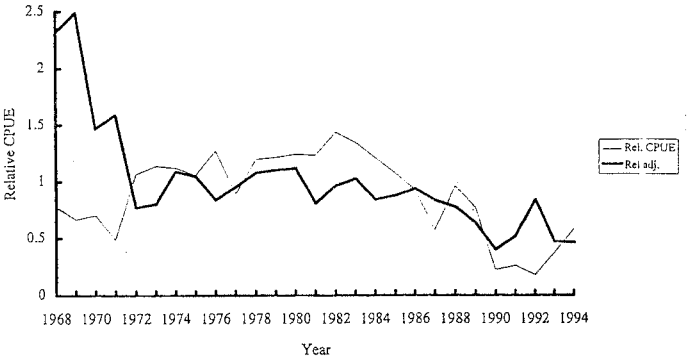

Fig. 11 The comparison of nominal catch per unit effort and standardized catch per unit effort for the southern stock.

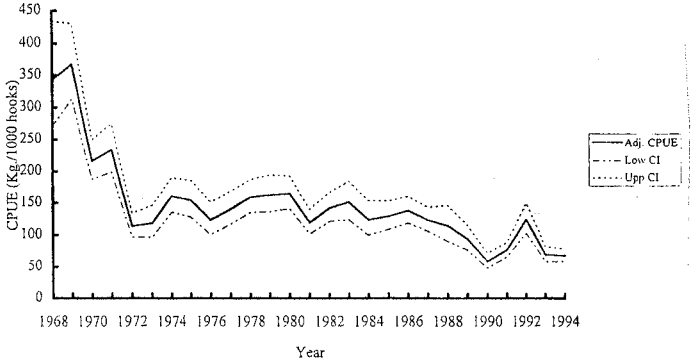

Fig. 12 The standardized catch per unit effort with lower and upper 95% confidence limits for the southern stock from 1968 to 1994.

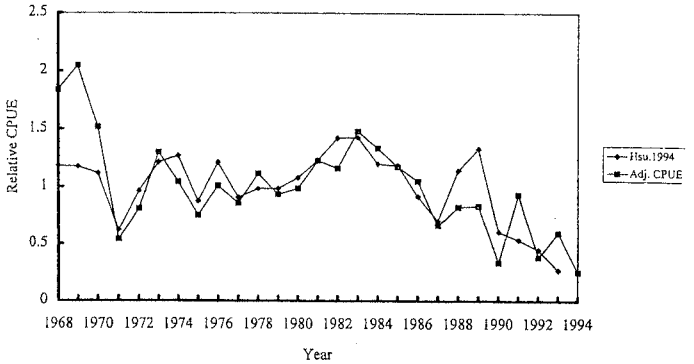

Fig. 13 The comparison of standardized catch per unit effort for the northern Atlantic albacore stock between the results of Taiwanese longline fishery (Chang and Hsu 1996) and the series of the present study.

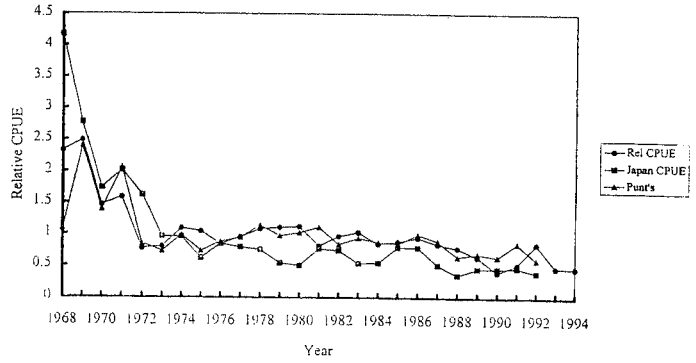

Fig. 14 The comparison of standardized catch per unit effort for the southern Atlantic albacore stock among the results of Taiwanese longline fishery (Punt 1996), Japanese longline fishery (Punt 1996) and the series of the present study.