CPUE STANDARDIZATION ON NORTHERN ATLANTIC ALBACORE CAUGHT BY CHINESE TAIPEI LONGLINERS, 1967 TO 2015

Feng-Chen Chang¹

SUMMARY

Both the logbooks (since 1981) and the task2 (since 1967) data sets of Taiwanese longliners were scrutinized, by three periods and 5o-square block, for the geographical distribution characters of four major tuna species (albacore, bigeye, yellowfin, and swordfish) and identified appropriate sampling areas for obtaining the better abundance indices for albacore resource. This paper used only those Taiwanese fisheries data sets within proposed sampling areas for the generalized linear model (GLM) standardization analyses and hopefully able to minimize most noises of non-albacore-targeting data. The Taiwanese longline catch per unit effort (CPUE) in appropriate albacore sampling areas was separately standardized into three periods. The GLM with lognormal error distribution was adopted for the standardized CPUE continuously declined up to mid-1980s, highly fluctuated before early 2000s, thereafter, it increased since early 2000s up to 2015. The new fishing managements inevitably affected the understanding the status of the stock, as compared to those collected through traditional setup. Similar trends were also obtained for the quarterly standardized CPUE series.

RÉSUMÉ

Les carnets de pêche (depuis 1981) ainsi que les jeux de données de la tâche II (depuis 1967) des palangriers du Taipei chinois ont été minutieusement examinés, en trois périodes et en carré de 5°, afin de déterminer les caractéristiques de la distribution géographique des quatre principales espèces thonières (germon, thon obèse, albacore et espadon) et d'identifier les zones d'échantillonnage idéales pour obtenir les meilleurs indices d'abondance de la population du germon. Le présent document n'a utilisé que les jeux de données des pêcheries du Taipei chinois provenant des zones d'échantillonnage proposées pour les analyses de standardisation du modèle linéaire généralisé (GLM) et qui devraient, on l'espère, minimiser la plupart des bruits des données ne ciblant pas le germon. La prise par unité d'effort (CPUE) des palangriers du Taipei chinois dans les zones appropriées d'échantillonnage du germon a été standardisée séparément en trois périodes. Le modèle GLM avec une distribution d'erreur log-normale a été adopté pour la standardisation des tendances annuelles et trimestrielles de la CPUE. Les résultats ont fait apparaître que la CPUE annuelle standardisée descendait de manière continue jusqu'à la moitié des années 80, avant de fluctuer considérablement avant le début des années 2000. Par la suite, elle a augmenté depuis le début des années 2000 jusqu'en 2015. Les nouvelles dispositions en matière de gestion des pêches ont inévitablement affecté la compréhension de l'état du stock par rapport aux données recueillies au moyen de systèmes traditionnels. Des tendances similaires ont également été obtenues pour les séries des CPUE trimestrielles standardisées.

RESUMEN

Se examinaron tanto los cuadernos de pesca (desde 1981) como los conjuntos de datos de Tarea II (desde 1967) de los palangreros de Taipei Chino para tres periodos y por cuadrículas de 5°, para determinar las características de la distribución geográfica de cuatro especies principales de túnidos (atún blanco, patudo, rabil y pez espada) y se identificaron las áreas de muestreo más adecuadas para obtener mejores índices de abundancia para el recurso de atún blanco. Este documento utilizó únicamente los conjuntos de datos de las pesquerías de Taipei Chino dentro de las áreas de muestreo propuestas para análisis de estandarización mediante un modelo lineal

¹ Overseas Fisheries Development Council, Taipei 106, Taiwan; E-mail: fengchen@ofdc.org.tw; d93241008@ntu.edu.tw.

generalizado (GLM) y se espera poder minimizar la mayoría de los ruidos de los datos no dirigidos al atún blanco. La captura por unidad de esfuerzo (CPUE) del palangre de Taipei Chino en las áreas de muestreo de atún blanco adecuadas fue estandarizada por separado en tres periodos. Se adoptó un modelo lineal generalizado (GLM) con una distribución de error lognormal para estandarizar las tendencias de la captura por unidad de esfuerzo (CPUE) tanto anuales como trimestrales. Los resultados mostraron que la CPUE estandarizada anualmente descendía de forma continua hasta mediados de los 80, fluctuaba mucho antes de principios de los 2000 y posteriormente aumentaba desde principios de los 2000 hasta 2015. La nuevas disposiciones de ordenación de la pesca afectaron inevitablemente a la comprensión del estado del stock, en comparación con los datos recopilados mediante sistemas tradicionales. Se obtuvieron tendencias similares para la serie de CPUE estandarizada trimestralmente.

KEYWORDS

Albacore, CPUE standardization, longline, GLM, North Atlantic

1. Introduction

1.1 Historical fisheries activities

In the Atlantic Ocean, two stocks of albacore (*Thunnus alalunga*), separated by 5°N latitude, were assumed for the fishery management. Taiwan is one of the main fishing nations utilizing the North Atlantic albacore resource, and contributes a significant part to the total landings. As one of the main fishing nations, it is equally our responsibility to acquire the catch and effort statistics for the purpose of monitoring its status.

Chinese Taipei longliners operated in the Atlantic Ocean were mainly composed of two types of fishing gears, i.e., regular longliner and deep longliner. The former, which was also called traditional longliner, was mainly targeting

albacore, whereas the latter equipped with -70°C freezing capability was mainly targeting bigeye tuna and yellowfin tuna. Unfortunately, it was not possible until mid-1990s when the logbook reporting system was able to directly distinguish their major identities by the addition of 'the number of hooks per basket used' in new reporting logbooks. Nevertheless, historic Task II data series compiled by Chinese Taipei fisheries managerial sectors and reported to the ICCAT since late 1960s thus became one of the important data sources to investigate the long-term abundance fluctuation of this resource.

1.2 Chinese Taipei Fisheries management

The new fishing managements of Chinese Taipei fleets have been launched for abide by the new regulation requirement set by ICCAT recommendations. The Fisheries Agency announced:

(1) fishing only allowed as prior authorization by area and group; initial vessel quota are pre-set, yet later modification will be allowed as long as total catch limits as a whole is not exceed;

(2) for best controlling the fishing procedure not to cross the pre-set red-line, several further management tools are also implemented parallel to the progressive fishing activities, such as: VMS-reporting continuously for monitoring its fishing location; daily fill in catch logbook as well as weekly reporting its weekly total; prior permission for at sea transshipment; verification of catch documents versus weekly reporting;

(3) on-board observer; at-sea inspection; and e-logbook system are also organized and implemented for a better abide by the requests from ICCAT.

These new establishments inevitably will affect the understanding the status of the stock, as compared to those collected through traditional setup. As a result, how to standardize the information is something we have to concern.

1.3 Standardization CPUE of Chinese Taipei fleets

Although Catch Per Unit Effort (CPUE) standardization, using only three subareas of whole North Atlantic Ocean (North of 5°N latitude) as subarea factor in the Generalized Linear Model (GLM), had been carried out for Chinese Taipei longliners data dating of 1967-2012 (Chang *et al.*, 2014); how to properly sort out the entanglements of albacore information reported from the regular longliner (targeting albacore) and the deep longliner (targeting bigeye tuna) remained the major difficulty in obtaining a better indicator for albacore abundance. Undertaking this problem, as the attempt, an appropriate area or the best sampling area was investigated and proposed in this analysis for obtaining the better albacore abundance indices.

Both the logbooks (since 1981) and the Task II (since 1967) data sets of Chinese Taipei longliners were scrutinized, by three periods (1967-1987, 1987-1999 and 1999-2015) and 5°-square block, for the geographical distribution characters of four major tuna species (albacore, bigeye tuna, yellowfin tuna, and swordfish) and identified the appropriate sampling area for obtaining the better abundance indices for albacore resource. This paper used only those Chinese Taipei fisheries data sets within the proposed sampling areas for the GLM standardization analyses and hopefully able to minimize most noises of non-albacore-targeting data.

2. Materials and methods

2.1 Data

(1) Task I from 1962 to 2015

Task1 is compiled based on the data of weekly catch report; the total catch from the recovered logbooks; statistical documents reported to the Fisheries Agency; monthly traders' sales records; the verification on settlement of fish sales from the Fisheries Agency; and trading data from the Organization for the Promotion of Responsible Tuna Fishery (OPRT). The historical catch of North Atlantic albacore was showed in **Figure 1**.

(2) Logbook from 1981 to 2015

The logbooks data, aggregated by per vessel's year-monthly catch from 1981 to 2015, were compiled. The catches in weight (kg) of albacore, bigeye tuna, yellowfin tuna and swordfish of logbooks were used to conduct the k-means model cluster analysis to determine the albacore fleet. It was used Euclidean distances, so the cluster centers were based on least squares estimation. After confirmation operating distribution of the albacore fleet from logbooks, thus it can supplement the appropriate albacore sampling subareas which are applied to the Task II data.

(3) Task II from 1967 to 2015

Chinese Taipei longline catch and effort data, compiled by month and 5° square block, from 1967 to 2015 were compiled. The logbook and Task II data were the major sources of data used in this analysis. These data were kindly provided by the Overseas Fisheries Development Council (OFDC), Chinese Taipei fisheries managerial sector.

2.2 Three periods

The Chinese Taipei regular longline fishery which commenced since 1960s in the North Atlantic Ocean has reached the peak of its development between mid-1970s and mid-1980s and reached a historical high North Atlantic albacore catch in 1986 which was 19,646 t in **Figure 1**. Since mid-1980s, some operators began to build new vessels and switch to super freezer longline fishing. As a consequence, the proportion of albacore of the overall catches was decreased, and surpassed by bigeye tuna and yellowfin tuna caught by deep longliners. The aforementioned period (1987-1999) of situation can be viewed as the transitional phase of the Chinese Taipei longline fisheries in the North Atlantic Ocean. The catch decreased and remained in low levels after 1987 and fluctuated between 800 t to 6700 t. From 2002, the Fisheries Agency has requested that longliners shall apply to the statistical documents for catches of bigeye tuna, southern bluefin tuna and swordfish prior to their export to foreign countries. Furthermore, several measures of fisheries management and monitoring, such as VMS and e-logbook, have gradually carried out. Thus, three periods were 1967-1987, 1987-1999 and 1999-2015.

2.3 The appropriate albacore sampling subareas

In order to find the appropriate albacore sampling subareas for Chinese Taipei longline fishery, distribution maps of albacore CPUE, albacore catch, effort, proportion of catch by species, and amount of catch by species for three periods (1967-1987, 1987-1999 and 1999-2015) by Chinese Taipei longline fishery were used to examine.

2.4 Models of GLM

Three constants for the periods of 1967-1987, 1987-1999 and 1999-2015 respectively, which were obtained by averaging all Chinese Taipei longliners' nominal albacore CPUE reported in the appropriate albacore sampling subareas of the North Atlantic Ocean and dividing by 10, were determined and added to each nominal albacore CPUE before using SAS solver for the purpose of avoiding zero albacore catch rate problem (ICCAT, 1996). In the appropriate albacore sampling subareas, the GLM with normal error structure (Robson, 1966; Gavaris, 1980; Kimura, 1981) was used in the present study to standardize yearly and quarterly CPUE trends, based on Chinese Taipei longline fisheries data set, for the North Atlantic albacore. Factors of year, quarter, subareas by 5° latitude x 5° longitude, bycatch effects of bigeye tuna, yellowfin tuna and swordfish, and interactions will be constructed for obtaining yearly standardized CPUE trend. Factors of quarter-series, subareas by 5° latitude x 5° longitude, and bycatch effects of bigeye tuna, yellowfin tuna and swordfish will be constructed for obtaining quarterly standardized CPUE trend. Bycatch effects of bigeye tuna, yellowfin tuna and swordfish were evaluated by quartile. The subareas by 5° latitude x 5° longitude were adopted in the model to minimize variations caused by fishing location. The Chinese Taipei longline CPUE was separately standardized into three periods (1967-1987, 1987-1999 and 1999-2015). The GLM models thus constructed for both yearly and quarterly standardizations are:

Yearly generalized linear model with normal error structure:

 $Log (U_{ijklmn} + C) = \mu + Y_i + Q_j + A_k + BET_l + YFT_m + SWO_n + interactions + \varepsilon_{ijklmn}$

where *Log*: natural logarithm;

U_{ijklmn}: nominal CPUE in year i, quarter j, subarea k, with bycatch level of BET₁, YFT_m, SWO_n, and interactions; μ : intercept; C: constant (10% of the overall mean of nominal albacore CPUE); Y_i: effect of year i; Q_j: effect of quarter j; A_k: effect of subarea k; BET₁: bycatch effect of bigeye tuna in quartiles of CPUE (Wt./1000hooks); YFT_m: bycatch effect of yellowfin tuna in quartiles of CPUE (Wt./1000hooks); SWO_n: bycatch effect of swordfish in quartiles of CPUE (Wt./1000hooks); Interactions are the interactions between main effects; ϵ : error term with distribution character of $N(0, \sigma^2)$.

Quarterly generalized linear model with normal error structure:

 $\textit{Log}~(U_{jklmn} + C) = \mu + YQ_j + A_k + BET_l + YFT_m + SWO_n + \epsilon_{jklmn}$

where *Log*: natural logarithm;

U_{jklmn}: nominal CPUE in quarter-series j, subarea k, and with bycatch level of BET₁, YFT_m, SWO_n; μ : intercept; C: constant (10% of the overall mean of nominal albacore CPUE); YQ_j: effect of quarter-series j; A_k: effect of subarea k; BET₁: bycatch effect of bigeye tuna in quartiles of CPUE (Wt./1000hooks); YFT_m: bycatch effect of yellowfin tuna in quartiles of CPUE (Wt./1000hooks); SWO_n: bycatch effect of swordfish in quartiles of CPUE (Wt./1000hooks); ϵ : error term with distribution character of $N(\theta, \sigma^2)$.

SAS (Statistical Analysis Software) Ver. 9.4 package was used to find solutions.

3. Results and discussion

3.1 Cluster analysis

The cluster analysis was used to allocate sets to a main target species, with the goal of removing non-albacoretargeting sets and ensure that albacore catchability was the same across sets retained for the analysis. This approach is further justified by examining trends in regional nominal CPUE by cluster, which shows important contrasts between albacore and non-albacore-targeting clusters.

The results of cluster analysis based on the logbook catches in weight of albacore, bigeye tuna, yellowfin tuna and swordfish for three periods (i.e., 1981-1987, 1987-1999, and 1999-2015) showed a clear separation of 4 clusters (**Table 1**). Chinese Taipei longline fisheries operated in these 4 clusters had apparently different catch composition of main species. The fleets targeting albacore for three periods were as follows: Period_1 of 1981-1987: albacore (clusters 2, 3 and 4); Period_2 of 1987-1999: albacore (clusters 1 and 4); and Period_3 of 1999-2015: albacore (cluster 3). **Figures 2-5** showed the geographical distribution maps of the albacore fleet, albacore mostly distributed in subtropical and temperate waters of the North Atlantic Ocean. After confirmation operating distribution of the albacore fleet from logbooks, thus it can supplement the appropriate albacore sampling subareas which are applied to the Task II data.

For elucidating geographical distribution characteristics of the North Atlantic albacore resource, for three periods of geographic distribution maps of nominal albacore CPUE in weight were shown in **Figure 6**. As shown in **Figure 6**, significant area aggregation with different level of catch rate was observed. In particular, an aggregation with higher catch rate appeared between 15°N and 45°N of the North Atlantic Ocean. The same pattern was also observed in **Figures 6-9**, which was obtained exactly the same procedure used to obtain **Figure 6**. In **Figures 2-10**, three areas (**Figure 11**) were proposed for the periods of 1967-1987, 1987-1999 and 1999-2015 respectively as the appropriate albacore sampling subareas. These figures showed the areas located in subtropical and temperate waters of the North Atlantic Ocean were always the most dominate fishing grounds of albacore by Chinese Taipei longline fishery.

The subareas (**Figure 11**) by 5° latitude x 5° longitude were adopted in the model to minimize variations caused by fishing location. Longline catch in temperate waters, which were also the traditional fishing ground for North Atlantic albacore, was mainly comprised of albacore. As for subtropical waters, there often appeared mixture catches of albacore, bigeye and yellowfin tunas with various area-time intensities. To divide appropriately the North Atlantic albacore's entire habitat into subareas is one of the attempts used in the present study for providing corrections stemmed from area contrast. The character of subareas from the data set reflects that temperate waters are the main fishing areas of albacore, and subtropical waters are a mixture of albacore, bigeye and yellowfin tunas.

3.2 Standardization CPUE

In the appropriate albacore area, the standardized CPUE trends for both the yearly series and quarterly series were constructed by the GLM models. The results of ANOVA test for the yearly series show that either the model itself or the effects considered are significant at 0.0001 confidence level (**Table 2**). As shown in the table, the effect of subarea plays the most important role in explanation of the model variation. Comparatively, effects of quarter, yellowfin tuna and swordfish play less important roles as their sum of squares are relatively low, but they are still statistically significant. Similar results of ANOVA are obtained for the quarterly series, and importance of the effects in explanation of the model variation ranks from subareas, year-season/bigeye tuna, swordfish and yellowfin tuna (**Table 3**).

In the appropriate albacore sampling subareas, the yearly nominal CPUE trend and its respective standardized CPUE series thus obtained were tabulated in **Table 4** and plotted in **Figure 12**. The yearly standardized CPUE series continuously declined up to mid-1980s, highly fluctuated before early 2000s, thereafter, it increased since early 2000s up to 2015. The normalized residual pattern from this model was shown in **Figure 13**. As shown in the figure, main distributions of residuals ranged from -1.65 to +1.65 and obviously centered at zero as mode. The Q-Q plots of those residuals were also shown in **Figure 14** indicating the fitting was not far from normal distribution.

In the appropriate albacore sampling subareas, the quarterly standardized CPUE series were also tabulated in **Table 5** and plotted in **Figure 15**. In the period of 1967-1987, the quarterly standardized CPUE series continuously declined within a range between 156 and 615 Wt. (kg)/1000 hooks. Then a high fluctuation from late 1980s to early 2000s was apparently observed. Thereafter, the CPUE trend increased since early 2000s up to 2015. The new

fishing managements inevitably affected the understanding the status of the stock, as compared to those collected through traditional setup. The trend appeared in quarterly CPUE series was very similar with those obtained in yearly CPUE trend. The normalized residual pattern from this model was shown in **Figure 16**. As shown in **Figure 16**, main distributions of residuals ranged from -1.65 to +1.65 and obviously centered at zero as mode. The Q-Q plots of those residuals were shown in **Figure 17** indicating the fitting was not far from normal distribution.

3.3 Discussion

Comparisons were made visually as in **Figure 12** and **Figure 15** among the yearly and quarterly nominal CPUE series respectively, which were evaluated in the appropriate albacore sampling subareas and in whole areas (Chang et al., 2014). They were similar to those in whole areas of the North Atlantic Ocean from 1977 to 1987. However, the series revealed a different tendency with those in whole areas since early 1990s. The new fishing managements inevitably affected the understanding the status of the stock, as compared to those collected through traditional setup. Although the true meaning of this difference is still needs further investigation, the proposed appropriate albacore sampling subareas do appear its own significance in this regard.

The appropriate albacore sampling subareas (**Figure 11**) were proposed in this analysis mainly for minimizing those non-albacore-targeting noises. Although the boundary of such a subarea was only based on Chinese Taipei longliners historic data sets, Chinese Taipei longliners fishing albacore in the North Atlantic Ocean have been longstanding since early 1960s, the three appropriate albacore sampling subareas thus proposed in this paper have its right implications.

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Table 1. The result of cluster analysis based on the logbook catches in weight (kg) of albacore, bigeye tuna, yellowfin tuna and swordfish for three periods: 1981-1987, 1987-1999 and 1999-2015.

1981-	1987
1701	1/0/

cluster	ALB_wt	BET_wt	YFT_wt	SWO_wt
1	108	31,214	6,710	1,578
2	27,708	571	1,047	248
3	50,774	823	1,330	354
4	10,176	349	651	122

1987-1999

cluster	ALB_wt	BET_wt	YFT_wt	SWO_wt
1	28,436	495	1,286	401
2	1,089	24,804	7,152	2,262
3	1,350	4,193	1,660	542
4	76,948	589	1,751	248

1999-2015

cluster	ALB_wt	BET_wt	YFT_wt	SWO_wt
1	-	646	90,421	1,731
2	4,079	3,393	2,143	338
3	42,421	824	1,405	172
4	204	23,266	3,717	839

Remark: ALB: Albacore, BET: Bigeye tuna, YFT: Yellowfin tuna, and SWO: Swordfish.

Table 2. Analysis of variance on the yearly standardized CPUE based on northern Atlantic albacore data (in the appropriate albacore sampling subareas) of Chinese Taipei longline fishery from 1967 to 2015 (three periods: 1967-1987, 1987-1999 and 1999-2015).

1. Dependent Variable. Logepie w_aib												
DF	Sum of Squares	Mean Square	F Value	Pr > F								
104	277.37123	2.66703	13.13	<.0001								
2564	520.71061	0.20309										
2668	798.08184											
Coeff Var	Root MSE	Logcpuew_alb Mean										
7.59339	0.45065	5.93477										
DF	Type III SS	Mean Square	F Value	Pr > F								
20	68.79311	3.43966	16.94	<.0001								
3	6.89174	2.29725	11.31	<.0001								
57	106.45921	1.86771	9.20	<.0001								
3	6.87895	2.29298	11.29	<.0001								
3	9.61068	3.20356	15.77	<.0001								
9	5.87268	0.65252	3.21	0.0036								
9	6.34611	0.70512	3.47	0.0007								
	DF 104 2564 2668 Coeff Var 7.59339 DF 20 3 57 3 3 3 9 9	DF Sum of Squares 104 277.37123 2564 520.71061 2668 798.08184 Coeff Var Root MSE 7.59339 0.45065 DF Type III SS 20 68.79311 3 6.89174 57 106.45921 3 6.87895 3 9.61068 9 5.87268 9 6.34611	DF Sum of Squares Mean Square 104 277.37123 2.66703 2564 520.71061 0.20309 2668 798.08184 Coeff Var Root MSE Logcpuew_alb Mean 7.59339 0.45065 5.93477 DF Type III SS Mean Square 20 68.79311 3.43966 3 6.89174 2.29725 57 106.45921 1.86771 3 6.87895 2.29298 3 9.61068 3.20356 9 5.87268 0.65252 9 6.34611 0.70512	DF Sum of Squares Mean Square F Value 104 277.37123 2.66703 13.13 2564 520.71061 0.20309 2668 2668 798.08184								

1. Dependent Variable: Logcpuew_alb

2. Dependent Variable: Logcpuew_alb

	Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model		85	251.42844	2.95798	5.96	<.0001
Error		803	398.50418	0.49627		
Corrected Total		888	649.93262			
	R-Square	Coeff Var	Root MSE	Logcpuew_alb Mean		
	0.38685	12.29840	0.70446	5.72809		
Source		DF	Type III SS	Mean Square	F Value	Pr > F
year		12	25.79907	2.14992	4.33	<.0001
quarter		3	11.20353	3.73451	7.53	<.0001
subarea		52	73.11101	1.40598	2.83	<.0001
codebet		3	26.00773	8.66924	17.47	<.0001
codeyft		3	10.89056	3.63019	7.31	<.0001
codeswo)	3	7.63373	2.54458	5.13	0.0016
quarter*	codebet	9	27.34704	3.03856	6.12	<.0001

3. Dependent Variable: Logcpuew_alb													
	Source	DF	Sum of Squares	Mean Square	F Value	Pr > F							
Model		81	410.68712	5.07021	16.22	<.0001							
Error		1462	456.92899	0.31254									
Correcte	d Total	1543	867.61611										
	R-Square	Coeff Var	Root MSE	Logcpuew_alb Mean									
	0.47335	9.87096	0.55905	5.66359									
Source		DF	Type III SS	Mean Square	F Value	Pr > F							
year		16	230.87838	14.42990	46.17	<.0001							
quarter		3	15.72735	5.24245	16.77	<.0001							
subarea		50	50.72510	1.01450	3.25	<.0001							
codebet		3	27.72468	9.24156	29.57	<.0001							
quarter*	codebet	9	17.16214	1.90690	6.10	<.0001							

Table 3. Analysis of variance on the quarterly standardized CPUE based on northern Atlantic albacore data (in the appropriate albacore sampling subareas) of Chinese Taipei longline fishery from 1967 to 2015 (three periods: 1967-1987, 1987-1999 and 1999-2015).

1		0	1 —			
	Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model		144	321.44571	2.23226	11.82	<.0001
Error		2524	476.63613	0.18884		
Correcte	ed Total	2668	798.08184			
	R-Square	Coeff Var	Root MSE	Logcpuew_alb Mean		
	0.40277	7.32226	0.43456	5.93477		
Source		DF	Type III SS	Mean Square	F Value	Pr > F
yq		81	135.93689	1.67823	8.89	<.0001
subarea		57	99.16513	1.73974	9.21	<.0001
codebet		3	7.34067	2.44689	12.96	<.0001
codeswo)	3	10.18472	3.39491	17.98	<.0001

1. Dependent Variable: Logcpuew_alb

2. Dependent Variable: Logcpuew_alb

Source	e DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	109	254.01260	2.33039	4.59	<.0001
Error	779	395.92002	0.50824		
Corrected Total	888	649.93262			
R-Square	coeff Var	Root MSE	Logcpuew_alb Mean		
0.39083	12.44586	0.71291	5.72809		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
yq	48	73.40810	1.52934	3.01	<.0001
subarea	52	73.85570	1.42030	2.79	<.0001
codebet	3	18.45274	6.15091	12.10	<.0001
codeyft	3	11.92611	3.97537	7.82	<.0001
codeswo	3	5.92061	1.97354	3.88	0.009

3. Dependent Variable: Logcpuew_alb

	Source	DF	Sum of Squares	Mean Square	F Value	Pr > F	
Model		117	457.22439	3.90790	13.58	<.0001	
Error		1426	410.39173	0.28779			
Correcte	ed Total	1543	867.61611				
	R-Square	Coeff Var	Root MSE	Logcpuew_alb Mean			
	0.52699	9.47214	0.53646	5.66359			
Source		DF	Type III SS	Mean Square	F Value	Pr > F	
yq		64	341.70845	5.33919	18.55	<.0001	
subarea		50	52.64958	1.05299	3.66	<.0001	
codebet		3	29.83620	9.94540	34.56	<.0001	

Vaar	Nominal	Nominal	Nominal	Standardized	CV	Standardized	CV	Standardized	CV
i eai	CPUE 1	CPUE 2	CPUE 3	CPUE 1	CV	CPUE 2	CV	CPUE 3	CV
1967	295.58			294.6791	0.0302				
1968	508.84			509.5313	0.0108				
1969	595.80			409.4818	0.0090				
1970	447.53			389.2505	0.0074				
1971	503.22	~~~~~~		317.8628	0.0095	~~~~~~			~~~~~~
1972	482.38		~~~~~~	311.4597	0.0096		~~~~~~		********
1973	469.94	******	******	305.3485	0.0090				******
1974	453.98			317.9450	0.0071				
1975	471.44			294.2251	0.0075				
1976	362.64			291.7729	0.0071				
1977	351.84			287.0757	0.0067				
1978	333.71			256.3453	0.0075				
1979	440.88	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		295.9886	0.0088				~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
1980	471.67		~~~~~~	329.5752	0.0078		~~~~~~		**********
1981	486.70	******	******	383.6085	0.0069				******
1982	558.78			458.9732	0.0063				
1983	521.38			432.0405	0.0060				
1984	477.45			366.9191	0.0055				
1985	392.17			310.7035	0.0057				*****
1986	340.03			274.2483	0.0056				********
1987	275.14	273.38		235.7245	0.0078	283.9162	0.0149		*****
1988		442.06				353.0965	0.0271		******
1989		380.82				342.1148	0.0317		
1990		343.38				301.7633	0.0377		
1991		193.27				285.1749	0.0227		
1992		467.95				226.0827	0.0417		
1993		417.17				424.6678	0.0227		
1994		486.71				345.4850	0.0156		
1995		564.56				398.5791	0.0175		
1996		479.38				234.5771	0.0195		
1997		556.96				312.8780	0.0193		
1998		520.49				431.8790	0.0140		
1999		280.29	289.43			245.1944	0.0136	220.9084	0.0081
2000			257.01					175.4527	0.0094
2001			220.92					170.0116	0.0090
2002			223.53					158.9563	0.0098
2003			228.42					199.2920	0.0106
2004			301.07					281.6502	0.0173
2005			240.42					281.8669	0.0095
2006			347.02					404.8764	0.0100
2007			319.58					320.8192	0.0122
2008			330.21					305.1050	0.0134
2009			379.39					375.2456	0.0141
2010			524.79					448.5055	0.0126
2011			412.05					347.5100	0.0134
2012			553.02					456.7708	0.0129
2013			690.12					706.7904	0.0115
2014			1012.62					1263.3011	0.0152
2015			758.32					492.6446	0.0106

Table 4. The nominal CPUE and its respective yearly standardized CPUE of the appropriate northern Atlantic albacore area based on the Chinese Taipei catch statistics from 1967 to 2015.

Chill Chill <th< th=""><th>Year*Ouarter</th><th>Nominal</th><th>Nominal</th><th>Nominal</th><th>Standardized</th><th>CV</th><th>Standardized</th><th>CV</th><th>Standardized</th><th>CV</th><th>Year*Ouarter</th><th>Nominal</th><th>Nominal</th><th>Nominal</th><th>Standardized</th><th>CV</th><th>Standardized</th><th>CV</th><th>Standardized</th><th>CV</th></th<>	Year*Ouarter	Nominal	Nominal	Nominal	Standardized	CV	Standardized	CV	Standardized	CV	Year*Ouarter	Nominal	Nominal	Nominal	Standardized	CV	Standardized	CV	Standardized	CV
Image 10.14 10.13 10.14 10.15 <th< td=""><td></td><td>CPUE 1</td><td>CPUE 2</td><td>CPUE 3</td><td>CPUE 1</td><td>0.0000</td><td>CPUE 2</td><td></td><td>CPUE 3</td><td></td><td></td><td>CPUE 1</td><td>CPUE 2</td><td>CPUE 3</td><td>CPUE 1</td><td></td><td>CPUE 2</td><td></td><td>CPUE 3</td><td>0.0154</td></th<>		CPUE 1	CPUE 2	CPUE 3	CPUE 1	0.0000	CPUE 2		CPUE 3			CPUE 1	CPUE 2	CPUE 3	CPUE 1		CPUE 2		CPUE 3	0.0154
1994 127.0 23.55% 80.00 2001 2012 21.54 80.00 1995 143.63 334.125 30.00 2001 20.0	19841	533.01			425.4215	0.0098					20011			221.31					155.6291	0.0154
1984 49.5 11.158 64.07 64.07 1983 69.55 52.07 52.07 198.0 198.1	19843	427.71			333.2979	0.0103					20012	******		204.47				*****	192.3244	0.0152
1985 23.13 33.12.27 2007 127.29 <td>19844</td> <td>419.26</td> <td></td> <td></td> <td>311.3586</td> <td>0.0111</td> <td></td> <td></td> <td></td> <td></td> <td>20014</td> <td></td> <td></td> <td>211.58</td> <td></td> <td></td> <td></td> <td></td> <td>164.0076</td> <td>0.0196</td>	19844	419.26			311.3586	0.0111					20014			211.58					164.0076	0.0196
IMBS 135.2 135.37 <td>19851</td> <td>424.58</td> <td></td> <td></td> <td>358.1227</td> <td>0.0095</td> <td></td> <td></td> <td></td> <td></td> <td>20021</td> <td></td> <td></td> <td>262.09</td> <td></td> <td></td> <td></td> <td></td> <td>187.5587</td> <td>0.0176</td>	19851	424.58			358.1227	0.0095					20021			262.09					187.5587	0.0176
IDEA IDEA <thidea< th=""> IDEA IDEA <thi< td=""><td>19852</td><td>372.42</td><td></td><td></td><td>365.1925</td><td>0.0112</td><td></td><td></td><td></td><td></td><td>20022</td><td></td><td></td><td>185.22</td><td></td><td></td><td></td><td></td><td>143.8327</td><td>0.0185</td></thi<></thidea<>	19852	372.42			365.1925	0.0112					20022			185.22					143.8327	0.0185
1963 1963 1973 20279 20299 1964 1964 1979 1985 1987	19853	332.36			255.4856	0.0110					20023			208.47					140.8034	0.0183
1963 140.8 294.84 0.099 1963 37.99 231.84 0.016 1964 37.15 255.39 0.010 2001 2013 213.84 114.091 0.016 1967 252.15 255.39 0.016 2001 232.37 213.091 0.016 1967 27.01 22.58 255.99 0.016 2001 232.37 22.374 0.029 1967 27.01 22.58 255.99 0.016 2001 2001 135.59 23.577 0.225.778 0.029 1968 30.42 25.399 0.024 0.056 2001 17.04 111.045 0.057 1983 30.52 25.399 0.024 0.057 2002 20.51 13.52 0.051 10.53 10.051 10.051 10.051 10.051 10.051 10.051 10.051 10.051 10.051 10.051 10.051 10.051 10.051 10.051 10.051 10.051 10.051 1	19854	369.13			293.4043	0.0098					20024			235.08					197.5741	0.0200
Image 307.99 22.94.80 0.010 1.003 32.6.8 1.86.400 0.86.40 1986 37.12 27.6.6 29.5.50 0.075	19862	340.88			298.8864	0.0098					20032			233.95					188.5163	0.0179
1964 31.25 225.59 0.0120 20014 212.67 211.061 0.010 1987 25.25 210.8 226.09 0.014 20014 <td< td=""><td>19863</td><td>307.99</td><td></td><td></td><td>283.9463</td><td>0.0101</td><td></td><td></td><td></td><td></td><td>20033</td><td></td><td></td><td>203.68</td><td></td><td></td><td></td><td></td><td>186.4030</td><td>0.0166</td></td<>	19863	307.99			283.9463	0.0101					20033			203.68					186.4030	0.0166
Her 125.3 213.8 244.05 0.016 20.02 1997 202.3 25.39 22.59 22.59 22.59 22.59 22.59 22.59 22.59 22.59 22.59 22.59 22.59 25.59	19864	321.25			229.5350	0.0120					20034			282.87					213.6981	0.0291
1971 27.01 25.2531 25.599 0.014 25.577 0.028 1981 27.92 27.99 27.99 0.014 25.597 0.014 1981 30.642 25.599 0.014 20.518 25.547 0.014 1983 30.642 25.599 0.014 20.518	19871	275.23	273.68		244.0455	0.0108	279.6750	0.0196			20041			252 57					227.2054	0.0260
1974 27.99 22.399 0.202 24.447 0.014 2044 36.18 203.540 0.037 1983 506.65 -07.317 0.093 2005 32.5.0 33.4370 0.015 1983 -47.5.5 30.317 0.091 2005 17.3.0 17.4.68 0.015 1983 -47.5.5 30.317 0.051 32.5.0 32.146 0.015 1983 -72.5.5 30.317 0.051 32.5.0 32.146 0.213 0.146 201.11 0.11.11 0.051 32.5.0 32.5.0 32.5.0 32.5.0 32.5.0 32.5.0 32.5.0 32.5.0 32.5.0 32.5.0 32.5.1 0.017 30.5.1 32.5.2 32.5.0 30.5.1 32.5.2 32.5.0 30.5.1 32.5.2 32.5.0 30.5.5 30.5.5 30.5.5 30.5.5 30.5.5 30.5.5 30.5.5 30.5.5 30.5.5 30.5.5 30.5.5 30.5.5 30.5.5 30.5.5 30.5.5 30.5.5 30.5.5 30.	19872	267.01	262.58		225.4455	0.0144	400.2894	0.0263			20042			255.49					225 4778	0.0259
1981 30.42 30.901 2001 32.30 32.4379 0.017 1982 50.65 47.319 0.003 2005 17.20 17.148 0.017 1983 47.136 0.001 2005 17.20 21.1421 0.017 1982 77.06 47.7461 0.057 2006 25.32 0.017 1983 350.37 55.656 0.058 2006 25.32 0.017 1993 49.41 13.1841 0.054 2006 35.23 0.018 2005 1994 49.41 13.1841 0.044 2007 30.33 23.599 0.001 1994 30.22 25.997 0.702 2007 39.53 20.44 20.97 39.54 0.025 1991 20.22 32.429 0.001 2007 39.56 0.021 20.7 39.57 0.035 1991 20.22 32.349 30.414 2004 40.14 20.35.7 0.035.1	19874	272.99	272.99	~~~~~~	225.3919	0.0240	244.6447	0.0414			20044			336.18					205.3640	0.0357
1982 504.65 470.317 0.091 2002 177.20 171.48 0013 1983 371.65 370.37 370.66 311.22 0.017 300.51 310.52 311.22 0.017 19993 39.947 515.645 0.0637 20051 312.460 351.31 0.017 0.017 19993 39.947 515.645 0.0685 20061 451.11 411.421 0.027 19901 404.41 311.801 0.0685 20071 360.32 31.595 0.0301 19901 30.427 41.4240 0.114 20072 366.31 320.595 0.0301 19912 18.16 34.4443 0.0352 20072 366.31 366.00271 20972 366.31 366.00271 20972 366.31 366.00271 20972 366.31 366.00271 20072 366.31 366.00271 20072 366.31 366.00271 20072 366.31 366.00271 20072 366.31 366.00271 200.01	19881		380.42				305.9810	0.0503			20051			382.50					354.3779	0.0176
1983 4713.6 36.0127 0.061 20051 214.96 231.121 0.015 1984 313.6 0.050 20041 31.622 387.71 0.005 1993 393.97 555.658 0.069 20061 353.53 431.871 0.015 1994 345.45 322.292 0.089 20061 353.53 431.871 0.015 1994 345.45 322.292 0.089 20061 353.53 341.871 0.016 1992 304.7 404.348 0.064 20071 30.028 360.55 360.607 1991 202.4 204.4 20072 286.31 232.5501 0.021 1991 202.1 345.907 0.0761 20031 353.3 431.968 0.021 1991 20.18 314.160 0.031 2033 23.537 343.960 0.015 1991 20.18 314.967 0.038 2033 23.537 343.960 0.015 1991 20.18 314.967 0.038 2004 35.357 30.413 <td< td=""><td>19882</td><td></td><td>504.65</td><td></td><td></td><td></td><td>470.3171</td><td>0.0391</td><td></td><td></td><td>20052</td><td></td><td></td><td>177.20</td><td></td><td></td><td></td><td></td><td>171.4618</td><td>0.0153</td></td<>	19882		504.65				470.3171	0.0391			20052			177.20					171.4618	0.0153
IP08 J314 J2314 0.058 J2061 3425 J2072 J2072 J993 J9947 S55.658 0.0897 J2062 J2535 J31181 0.012 J9943 J9947 S55.658 0.0897 J2062 J2535 J31181 0.012 J9944 J3144 J311801 0.0484 J2071 J6023 J21191 0.012 J9943 J3247 J424260 0.191 J2072 J6031 J21595 0.021 J9941 J3247 J424260 0.191 J2072 J6031 J2055 J2056 J2056 J2056 J2056 J2056 J2056 J2057 J2051 J2056 J2056 J2057 J2058 J2058 J2056 J2056 J2057 J2057<	19883		473.36				380.3127	0.0621			20053			214.96					231.8221	0.0176
1992 27806 47.7443 0.057 1993 339.37 55.565 0.069 1994 344.56 322.982 0.0853 1991 409.41 33.181 0.0453 1992 30.47 40.1342 0.0572 20071 30.28 281.595 0.058 19902 30.47 40.1342 0.0572 20071 30.65 36.061 0.010 19913 2013 36.64 0.1194 20071 36.65 36.010 0.010 19913 2018 31.467 0.035 20032 22.27 24.540 0.019 19913 210.18 31.467 0.035 20032 22.057 0.044 0.015 19923 56.75.0 31.1967 0.032 20092 35.157 0.033 19924	19884		353.02	~~~~~~			292 8154	0.0530			20054			454.25		~~~~~			465 5723	0.0205
1993 39937 355.668 0.0897 2005 352.35 41.878 0.011 19901 409.41 331.8014 0.0484 20071 300.28 321.507 321.507 321.507 320.507 321.507 320.507 320.505 0.021 321.507 320.505 0.021 321.507 320.505 0.021 321.507 321.507 320.505 0.021 320.57 325.505 0.0210 0.0216	19892		378.06				427.3643	0.0557			20062			263.92					306.1327	0.0178
1994 384.56 322.982 0.585 2004 4.511 41.1421 0.0237 19901 40.41 31.804 0.6648 20071 3.06.28 381.595 0.034 19902 320.47 40.4342 0.0572 20072 286.31 325.591 0.0201 19913 0.122 265.997 0.0702 286.31 325.591 0.0216 19911 20.23 324.190 0.401 20081 296.95 41.1648 0.0216 19912 1.13 31.6160 0.0356 20082 242.27 24.97.84 0.0186 19921 1.013 31.6107 0.0483 20091 41.118 27.517.9 0.025 19922 34.99 32.0421 0.0483 20092 30.14 29.6563 0.0256 19923 467.53 59.0796 0.0378 20012 44.757 48.87.257 0.0189 19933 422.03 59.10864 0.0415 20101 452.48 0.0237	19893		389.87				535.6658	0.0689			20063			352.35					431.8781	0.0163
19901 40941 331401 0.0648 20071 360.25 281.5955 0.054 19903 304.29 424.2466 0.0572 286.51 332.555 0.064 19913 2012 286.51 329.555 0.064 0.016 0.017 39.565 0.064.01 0.016 0.016 0.017 39.565 0.064.01 0.016 0.016 0.017 39.555 0.004.01 0.016 0.017 0.016 0.016 0.016 0.017 0.016 0.017 0.016 0.016 0.017 0.016 0.017 0.016 0.017 0.016 0.017 0.016 0.017 0.016 0.017 0.017 0.017 0.017 0.017 0.017 0.017 0.017 0.017 0.017 0.017 0.017 0.017 0.017 0.017 0.017 0.017 0.011	19894		384.56				322.2982	0.0585			20064			465.11					411.4421	0.0237
19902 120.47 441.442 00.572 206.31 209.21 206.31 209.33 00.01 209.73 305.05 365.03 0.01 209.73 305.05 365.03 0.01 209.73 305.05 345.09 0.01 209.73 305.05 345.09 0.01 209.73 305.05 345.09 0.01 209.73 305.05 345.09 0.00 209.73 305.05 345.04 0.01 209.73 209.74 209.74 209.75 209.74 20.77 20.77	19901		409.41				331.8014	0.0648			20071			360.28					281.5995	0.0364
19904 20722 245.997 20722 2074 2751 248.991 2072 19911 20223 21229 0401 2072 2074 2751 248.991 2075 19912 183.04 344.643 0356 20031 226.55 306.413 0021 19914 169.22 359.832 0.044 20081 461.16 375279 0.034 19921 - 20091 411.18 351.515 0.029 305.14 298.563 0.027 19922 334.99 332.0421 0.0483 20092 305.14 298.563 0.027 19924 - - 20041 125.12 236.3424 0.053 19931 - - 20101 826.95 671.207 0.022 19933 420.3 591.644 0.033 20114 353.37 266.200 0.022 19934 360.15 279.486 0.033 20111 454.46 380.000.0233 0.0211	19902		320.47				404.3482	0.0572			20072			286.31					329.5501	0.0201
19911 20228 324,1209 0.0401 20081 396,93 431,9668 0.0272 19913 210.18 318,1667 0.0382 20083 226,27 249,7514 0.018 19914 16922 358,352 0.0434 20083 226,95 306,4103 0.027 19921 - - 20091 411.18 351,517 0.0352 19922 334,99 332,0421 0.0483 20092 351,41 298,64 0.025 19923 567,50 311,9192 0.0643 20093 461,17 646,242 0.021 19931 - - 20091 82,657 671,2707 0.022 19933 452,033 591,0790 0.031 20101 82,657 671,2707 0.022 19934 300,15 279,4466 0.034 20103 354,38 388,3947 0.021 19941 393,62 334,0700 0.021 20111 454,66 380,300 0.023	19903		307.22				265.9937	0.0762			20073			379.51					248,9901	0.0109
19912 183.04 344.643 0.0336 20082 26.27 249.7814 0.0184 19914 10.022 359.8352 0.0434 20083 236.95 36.04.00.0224 19921	19911		202.28				324.1209	0.0401			20081			396.93					431.9668	0.0273
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	19912		183.04				344.6443	0.0336			20082			262.27					249.7814	0.0189
19914 16922 359 8352 0.0343 20084 461.16 375 5279 0.035 19921 334.99 332.0421 0.0483 20092 305.14 298.8663 0.0205 19923 567.50 31.1912 0.0463 20092 305.14 298.8663 0.0205 19931 20094 125.12 23.6424 0.053 61.17 64.6248 0.0231 19933 432.03 59.10844 0.0415 20102 447.75 438.7235 0.0189 19934 360.15 279.4686 0.0343 20104 392.67 28.8333 0.0428 19943 452.78 517.2939 0.0317 20112 30.337 266.500 0.0224 19944 452.78 517.2393 0.037 20112 30.337 266.500 0.0234 19943 405.70 241.7943 0.0257 20113 498.63 604.675 0.0230 19944 405.70 241.7943 0.0257 20114 55.01 172.2387 0.0317 19954 401.46 211.5014 0.0255 20122 307.77 305.7535 0.0237 19955 604.52 597.914 0.0235 2013 <	19913		210.18				318.1667	0.0382			20083			236.95					306.4103	0.0234
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	19914		169.22				359.8352	0.0434			20084			461.16					375.5279	0.0345
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	19921		334.99				332.0421	0.0483			20091			305.14					298.5663	0.0205
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	19923		567.50				311.9192	0.0643			20093			461.17					646.2482	0.0231
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	19924										20094			125.12					236.3424	0.0563
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	19931										20101			826.95					671.2707	0.0229
19933 422.03 391.0844 0.0343 20103 534.38 386.3944 0.0121 19941 395.62 334.0710 0.0321 20111 454.46 380.800 0.0223 19942 452.78 517.2393 0.0317 20112 303.37 266.2500 0.0224 19943 605.88 463.6491 0.0249 20113 498.63 604.0575 0.0230 19944 405.70 241.7943 0.0224 20114 539.01 177.2387 0.0417 19951 951.54 678.2497 0.0447 2012 307.77 305.7353 0.0237 19953 604.52 597.8342 0.0234 20123 416.30 459.4897 0.0200 19954 401.46 211.5014 0.0265 20124 1131.35 712.8440 0.0533 19961 576.65 270.203 0.0333 20133 877.00 1074.3217 0.014 19964 463.42 175.9421 0.0421 20134	19932		477.53				593.0790	0.0378			20102			447.75					438.7235	0.0189
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	19933		360.15				279 4686	0.0343			20103			392.67					268 3233	0.0212
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	19941		393.62				334.0710	0.0321			20104			454.46					380.3800	0.0223
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	19942		452.78				517.2393	0.0317			20112			303.37					266.2500	0.0224
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	19943		605.88				463.6491	0.0249			20113			498.63					604.0575	0.0230
19951 951.34 678.249 0.0447 20121 790.24 654.4809 0.0237 19952 726.52 830.2380 0.0324 20122 307.77 305.7353 0.0237 19953 604.52 597.8342 0.0293 20123 416.30 459.4987 0.0203 19954 401.46 211.5014 0.0265 20124 1131.35 712.8340 0.0583 19961 57.665 270.2903 0.0273 20131 817.17 751.6398 0.0203 19963 312.26 237.1058 0.0393 20132 434.73 394.1183 0.0201 19964 463.42 175.9421 0.0421 20144 668.61 776.7322 0.0408 19971 497.69 397.9611 0.0238 20141 826.88 1002.4454 0.0193 19973 366.59 185.7517 0.0512 2014 2014 20152 802.67 522.8554 0.0160 19981 645.21 458.157 0.0234 20151 428.58 350.7210 0.0220 19982	19944		405.70	~~~~~~	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		241.7943	0.0257			20114			539.01		~~~~~			172.2387	0.0419
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	19951		726.52				830 2380	0.0447			20121			307.77					305 7353	0.0200
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	19953		604.52				597.8342	0.0293			20122			416.30					459.4987	0.0203
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	19954		401.46				211.5014	0.0265			20124			1131.35					712.8340	0.0583
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	19961		576.65				270.2903	0.0273			20131			817.17					751.6398	0.0208
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	19962		262.29				308.7386	0.0333			20132			434.73					394.1183	0.0200
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	19963		312.26				237.1058	0.0393			20133			877.00					10/4.3217	0.0174
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	19964		497.69				397.9611	0.0238			20134			826.88		~~~~~			1002.4454	0.0193
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	19972		420.70				429.0478	0.0323			20142			1379.64					1619.0792	0.0196
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	19973		366.59				185.7517	0.0512			20143									
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	19974		1156.30				300.1045	0.0443			20144			12						
17702 102.30 100.030 100030 0.0210 20132 802.57 502.834 0.0100 19983 474.36 502.1251 0.0214 20153 736.77 603.1052 0.0208 19994 436.591 460.1218 0.0235 132.771 0.0163 20154 929.16 491.0174 0.0228 19993 234.54 244.23 166.5971 0.0235 132.7721 0.0163 19994 316.21 331.76 200.0077 0.0242 2183.3622 0.0162 20001 314.13 239.4808 0.0152 239.4808 0.0152 20002 268.48 150.9946 0.0161 168.5291 0.0240 20004 226.39 168.5291 0.0240 168.5291 0.0240	19981		645.21				458.1537	0.0284			20151			428.58					350.7210	0.0220
19984 434.54 460.1218 0.038 2015 1907 492.16 491.0174 0.0228 19991 336.92 349.40 338.0023 0.0210 369.4184 0.0140 20154 929.16 491.0174 0.0228 19992 244.23 244.23 168.5971 0.0235 132.7721 0.0163 312.7721 0.0163 19993 234.54 248.69 258.4677 0.0205 189.1771 0.0162 20047 229.408 0.0152 20001 314.13 239.4808 0.0152 239.4808 0.0152 2004 266.39 150.2477 0.0183 20002 268.48 150.9496 0.0161 130.2477 0.0183 165.291 0.0240 20004 226.39 165.5291 0.0240 165.5291 0.0240	19982		402.38				466.0582	0.0216			20152			736.77					603.1052	0.0209
19991 336.92 349.40 338.0023 0.0210 369.4184 0.0140 19992 244.23 244.23 168.5971 0.0235 132.7721 0.0163 19993 234.54 248.69 258.4677 0.0205 189.1771 0.0134 19994 316.21 331.76 200.0077 0.0242 218.3362 0.0162 20001 314.13 239.4808 0.0152 20002 268.48 150.9946 0.0161 20003 171.79 130.2247 0.0183 20004 236.39 168.5291 0.0240	19984		434.54				460.1218	0.0238			20153			929.16					491.0174	0.0228
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	19991		336.92	349.40			338.0023	0.0210	369.4184	0.0140										
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	19992		244.23	244.23			168.5971	0.0235	132.7721	0.0163										
19994 316.21 331.70 200.007 0.0242 218.350 0.0162 20001 314.13 239.480 0.0152 20002 268.48 150.496 0.0161 20003 171.79 130.2247 0.0183 20004 236.39 168.5291 0.0240	19993		234.54	248.69			258.4677	0.0205	189.1771	0.0134										
20002 26848 150.496 0.0161 20003 171.79 130.2247 0.0183 20004 236.39 168.5291 0.0240	20001		316.21	331.76			200.0077	0.0242	218.3362	0.0162	-									
20003 171.79 130.2247 0.0183 20004 236.39 168.5291 0.0240	20001			268.48					150.9496	0.0152										
20004 236.39 168.5291 0.0240	20003			171.79					130.2247	0.0183	***									
	20004			236.39					168.5291	0.0240										

Table 5. The nominal CPUE and its respective quarterly standardized CPUE of the appropriate northern Atlantic albacore area based on the Chinese Taipei catch statistics from 1967 to 2015.



Figure 1. Historical albacore catch of Chinese Taipei longline fishing vessels in the North Atlantic Ocean, 1961-2014. Sources: ICCAT (Task I) and OFDC.



Figure 2. Geographic distribution, by 5o-square block, of nominal CPUE (Wt./1000 Hooks from logbooks) of albacore caught by Chinese Taipei longliners in the North Atlantic Ocean for periods of 1981-1987 (upper left), 1987-1999 (upper right) and 1999-2015 (lower).



Figure 3. The fishing efforts (Number of hooks from logbooks) cast by Chinese Taipeiese longliners in the North Atlantic Ocean for periods of 1981-1987 (upper left), 1987-1999 (upper right) and 1999-2015 (lower).



Figure 4. Geographic distribution, by 5°-square block, of four major species composition, in terms of catch in weight (from logbooks), caught by Chinese Taipei longliners in the North Atlantic Ocean for periods of 1981-1987 (upper left), 1987-1999 (upper right) and 1999-2015 (lower). Four major species are: albacore (ALB in white), bigeye tuna (BET in red), yellowfin tuna (YFT in yellow) and swordfish (SWO in green).



Figure 5. Geographic distribution, by 5°-square block, of catch in weight of four major species (from logbooks), caught by Chinese Taipei longliners in the North Atlantic Ocean for periods of 1981-1987 (upper left), 1987-1999 (upper right) and 1999-2015 (lower). Four major species are: albacore (ALB in white), bigeye tuna (BET in red), yellowfin tuna (YFT in yellow) and swordfish (SWO in green).



Figure 6. Yearly nominal CPUE (Wt./1000 Hooks from task2) of albacore caught by Chinese Taipei longliners in the North Atlantic Ocean for periods of 1967-1987 (upper left), 1987-1999 (upper right) and 1999-2015 (lower).



Figure 7. Yearly catch in weight (from Task II) of albacore caught by Chinese Taipei longliners in the North Atlantic Ocean for periods of 1967-1987 (upper left), 1987-1999 (upper right), and 1999-2015 (lower).



Figure 8. Yearly fishing efforts (Number of hooks from task2) cast by Chinese Taipei longliners in the North Atlantic Ocean for periods of 1967-1987 (upper left), 1987-1999 (upper right) and 1999-2015 (lower).



Figure 9. Geographic distribution of yearly four major species composition (from Task II) caught by Chinese Taipei longliners for periods of 1967-1987 (upper left), 1987-1999 (upper right) and 1999-2015 (lower).



Figure 10. Geographic distribution of yearly catch composition of four major species (from Task II) caught by Chinese Taipei longliners for periods of 1967-1987 (upper left), 1987-1999 (upper right) and 1999-2015 (lower).



Figure 11. There were 58, 53 and 51, by 5°-square block, subareas proposed by this paper for periods of 1967-1987 (upper left), 1987-1999 (upper right) and 1999-2015 (lower) respectively for CPUE standardization on albacore resource in the North Atlantic Ocean.



Figure 12. Yearly nominal and standardized CPUE (Wt./1000 hooks) trends of North Atlantic albacore based on Chinese Taipei longline fishery task2 data set from 1967 to 2015.



Figure 13. Distributions of normalized residuals obtained for periods of 1967-1987 (upper left), 1987-1999 (upper right) and 1999-2015 (lower) from yearly GLM models.



Figure 14. The Q-Q plots for residuals obtained for periods of 1967-1987 (upper left), 1987-1999 (upper right) and 1999-2015 (lower) from yearly GLM models.



Figure 15. Quarterly nominal and standardized CPUE (Wt./1000 hooks) trends of North Atlantic albacore based on Chinese Taipei longline fishery Task II data set from 1967 to 2015.



Figure 16. Distributions of normalized residuals obtained for periods of 1967-1987 (upper left), 1987-1999 (upper right) and 1999-2015 (lower) from quarterly GLM models.



Figure 17. The Q-Q plots for residuals obtained for periods of 1967-1987 (upper left), 1987-1999 (upper right) and 1999-2015 (lower) from quarterly GLM models.