# NEW ESTIMATES OF THE ADJUSTED NORTH ATLANTIC ALBACORE CPUE FROM TAIWANESE LONGLINE CATCH DATA OF 1968-1993

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*ABSTRACT*

*An adjusted CPUE for north Atlantic albacore stock using new Task II estimates of 1981-1993 of Taiwanese longline fishery was re-estimated. Generalized linear model (GLM) was applied to the present re-estimation. Factors included in the model were fishing year, season, area, and a target species index. This estimation was used to replace the last series presented at the final meeting of the Albacore Research Program at Sukarrieta (Chang and Hsu 1996).*

*RESUME*

*Une CPUE ajustée du stock de germon de l'Atlantique Nord, qui prend en compte les nouvelles estimations Tâche II de la période 1981-1993 de la pêcherie palangrière taïwanaise, a été estimée à nouveau. On a utilisé la méthode du Modèle Linéaire Généralisé (GLM) pour cette ré-estimation. Les facteurs pris en compte dans le modèle sont : l'engin, la saison, la zone et l'indice espèce cible. Cette estimation a été utilisée pour remplacer les dernières séries présentées à la réunion finale du Programme de Recherche sur le Germon de Sukarrieta (Chang et Hsu 1996).*

*RESUMEN*

*Se efectuó una nueva estimación de una CPUE ajustada para el stock de atún blanco del Atlántico norte, con nuevas estimaciones de la Tarea II correspondientes a la pesquería taiwanesa de palangre en el período 1981-1993. A esta nueva estimación se aplicó el modelo lineal generalizado (GLM). Los factores incluidos en el modelo eran: año de pesca, temporada, zona y un índice de especie objetiv. esta estimación se usó para reemplazar la última serie presentada en la reunión final del Programa de Investigación sobre el Atún Blanco, que tuvo lugar en Sukarrieta (Chang y Hsu 1996)*

## 1. INTRODUCTION

Catch per unit effort (*CPUE*) has always been treated as an abundance index of fish stock. The fishing effort component of the *CPUE*, however, is subject to the variations caused by factors from the non-static fisheries. Adjusting *CPUE* from those factors therefore becomes essential before stock assessment can be properly performed.

An adjusted *CPUE* for north Atlantic albacore stock using 1980-1993 logbook data of Taiwanese longline fishery has been estimated and was presented at the final meeting of the Albacore Research Program (Chang and Hsu 1996). The present paper re-estimated the *CPUE* using the revised and recovered new estimates of 1981-1993 by generalized linear model (GLM). Factors included in the model were fishing year, season, area, and a target species index.

## 2. MATERIALS AND METHODS

Data used were 1968-1980 time series catch data and 1981-1993 recovered data which were revised in October of 1994 by the Tuna Research Center. Four factors were designed in the GLM model: fishing year (*YEAR*), season (*QUAT*), area (*AREA*), and a target species index (*TARGET*). The fishing year was divided into three time periods according to the *CPUE* trend of north Atlantic albacore (Figure 1): 1968-1971, 1972-1989, 1990-1993; and the *CPUE*s

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were estimated separately for the three periods since they were considered to have different catchability. Fifteen subareas altogether were defined in the fishing area (Figure 2). The target species index was defined as the class of *CPUE* of bigeye and yellowfin tunas together [$U_{BET+YFT}$ = (number of bigeye tuna caught + number of yellowfin tuna caught) / total fishing effort]. Four classes were separated by 0.5, 1.5 and 2.0 in number per 1000 hooks. Thus, the GLM model was built as:

$$LOG(U_{ALB}+1)=\mu+YEAR+QUAT+AREA+TARGET+(INTERACTION)+\xi$$

where the $U_{ALB}$ is albacore catch in number per 1000 hooks, $\mu$ is overall mean, $\xi$ is error term, and *(INTERACTION)* is the interaction term of every two of the variables.

## 3. RESULTS

Table 1 is the ANOVA table of the final GLM models of the three time periods. Only eight subareas (subarea 7 to 11 and 13 to 15) were without missing data and therefore included in the final model for the 1968-1971 period. Similarly, only seven subareas (subarea 6 to 11 and 13 to 14) were included for 1972-1989, and five subareas (subarea 6, 9, 10, 13 and 14) for 1990-1993. For the first and third periods (1968-1971 and 1990-1993), the *INTERACTION* terms were excluded as being insignificant or missing data.

Figure 3 is the standardized residuals histogram for the final GLM models. A normal approximated distribution could be noted for the three time periods.

The least-square adjusted *CPUE* together with the nominal *CPUE* are plotted in Figure 1. Their estimated values are tabulated in Table 2.

Table 1. ANOVA table of the GLM model of the three time periods: 1968-1971, 1972-1989, 1990-1993.

A. 1968-1971

| Source | DF | Sum of Squares | Mean Square | F value | Pr>F |
|---|---|---|---|---|---|
| Model | 16 | 785.481 | 49.09256 | 97.93 | 0.0001 |
| Error | 593 | 297.2627 | 0.501286 | | |
| Corrected Total | 609 | 1082.744 | | | |

R2 = 0.7254

| Source | DF | Type I SS | Mean Square | F value | Pr>F |
|---|---|---|---|---|---|
| AR | 3 | 43.66629 | 14.55543 | 29.04 | 0.0001 |
| QUAT | 3 | 7.703891 | 2.567964 | 5.12 | 0.0017 |
| AREA | 7 | 711.8709 | 101.6958 | 202.87 | 0.0001 |
| TARGET | 3 | 22.23997 | 7.413323 | 14.79 | 0.0001 |

| Source | DF | Type II SS | Mean Square | F value | Pr>F |
|---|---|---|---|---|---|
| YEAR | 3 | 24.7351 | 8.245033 | 16.45 | 0.0001 |
| QUAT | 3 | 3.260506 | 1.086835 | 2.17 | 0.0907 |
| AREA | 7 | 366.6091 | 52.37273 | 104.48 | 0.0001 |
| TARGET | 3 | 22.23997 | 7.413323 | 14.79 | 0.0001 |

B. 1972-1989

| Source | DF | Sum of Squares | Mean Square | F value | Pr>F |
|---|---|---|---|---|---|
| Model | 74 | 490.3172 | 6.625908 | 26.4 | 0.0001 |
| Error | 1591 | 399.3784 | 0.251024 | | |
| Corrected Total | 1665 | 889.6956 | | | |

R2 = 0.551107

| Source | DF | Type I SS | Mean Square | F value | Pr>F |
|---|---|---|---|---|---|
| YEAR | 17 | 66.9954 | 3.940906 | 15.70 | 0.0001 |
| QUAT | 3 | 42.83517 | 14.27839 | 56.88 | 0.0001 |
| AREA | 6 | 165.0903 | 27.51506 | 109.61 | 0.0001 |
| TARGET | 3 | 112.833 | 37.611 | 149.83 | 0.0001 |
| QUAT*AREA | 18 | 52.91144 | 2.939525 | 11.71 | 0.0001 |
| QUAT*TARGET | 9 | 8.014847 | 0.890539 | 3.55 | 0.0002 |
| AREA*TARGET | 18 | 41.63704 | 2.313169 | 9.21 | 0.0001 |

| Source | DF | Type II SS | Mean Square | F value | Pr>F |
|---|---|---|---|---|---|
| YEAR | 17 | 39.57245 | 2.327791 | 9.27 | 0.0001 |
| QUAT | 3 | 11.29414 | 3.764714 | 15.00 | 0.0001 |
| AREA | 6 | 38.56966 | 6.428276 | 25.61 | 0.0001 |
| TARGET | 3 | 72.9558 | 24.3186 | 96.88 | 0.0001 |
| QUAT*AREA | 18 | 38.33903 | 2.129946 | 8.49 | 0.0001 |
| QUAT*TARGET | 9 | 11.58471 | 1.28719 | 5.13 | 0.0001 |
| AREA*TARGET | 18 | 41.63704 | 2.313169 | 9.21 | 0.0001 |

C. 1990-1993

| Source | DF | Sum of Squares | Mean Square | F value | Pr>F |
|---|---|---|---|---|---|
| Model | 13 | 128.4901 | 9.88385 | 59.93 | 0.0001 |
| Error | 89 | 14.67734 | 0.164914 | | |
| Corrected Total | 102 | 143.1674 | | | |

R2 = 0.897481

| Source | DF | Type I SS | Mean Square | F value | Pr>F |
|---|---|---|---|---|---|
| YEAR | 3 | 3.503281 | 1.16776 | 7.08 | 0.0003 |
| QUAT | 3 | 33.04173 | 11.01391 | 66.79 | 0.0001 |
| AREA | 4 | 87.78628 | 21.94657 | 133.08 | 0.0001 |
| TARGET | 3 | 4.158762 | 1.386254 | 8.41 | 0.0001 |

| Source | DF | Type II SS | Mean Square | F value | Pr>F |
|---|---|---|---|---|---|
| YEAR | 3 | 2.067587 | 0.689196 | 4.18 | 0.0081 |
| QUAT | 3 | 2.95812 | 0.98604 | 5.98 | 0.0009 |
| AREA | 4 | 6.473865 | 1.618466 | 9.81 | 0.0001 |
| TARGET | 3 | 4.158762 | 1.386254 | 8.41 | 0.0001 |

**Table. 2.** **Adjusted *CPUE* (ACPUE) and its 95% lower (LCPUE) and upper bounds (UCPUE), nominal *CPUE* (NCPUE), total effort in hook (EFFORT), and total albacore catches (CATCH) in number for the north Atlantic albacore fishery.**

| YEAR | ACPUE | LCPUE | UCPUE | NCPUE | EFFORT | CATCH |
|---|---|---|---|---|---|---|
| 68 | 10.1338 | 8.1896 | 12.4893 | 16.0668 | 6140788 | 98663 |
| 69 | 9.8809 | 8.0643 | 12.0616 | 13.4850 | 9060480 | 122181 |
| 70 | 9.2300 | 7.6646 | 11.0782 | 14.0167 | 16804609 | 235546 |
| 71 | 5.5099 | 4.4995 | 6.7059 | 10.4190 | 14991908 | 156200 |
| 72 | 9.6343 | 8.2720 | 11.1967 | 25.6773 | 10389525 | 266775 |
| 73 | 11.7622 | 10.0100 | 13.7922 | 26.5542 | 21025594 | 558317 |
| 74 | 11.9696 | 10.5659 | 13.5437 | 25.4768 | 21331164 | 543449 |
| 75 | 9.3057 | 8.1728 | 10.5785 | 27.1367 | 19242740 | 522184 |
| 76 | 13.4195 | 11.4455 | 15.7067 | 34.0050 | 29283846 | 995797 |
| 77 | 9.1076 | 7.7999 | 10.6096 | 21.5000 | 38697190 | 831991 |
| 78 | 10.7368 | 9.0912 | 12.6507 | 31.4471 | 19543627 | 614591 |
| 79 | 10.3594 | 8.7290 | 12.2631 | 30.7613 | 14501486 | 446085 |
| 80 | 11.8168 | 10.2718 | 13.5737 | 32.4886 | 14518811 | 471696 |
| 81 | 11.5604 | 10.0733 | 13.2471 | 27.8906 | 13470021 | 375687 |
| 82 | 14.1595 | 12.4408 | 16.0979 | 34.4511 | 18363893 | 632657 |
| 83 | 13.9378 | 12.2857 | 15.7954 | 31.6339 | 26745768 | 846074 |
| 84 | 11.3461 | 10.0632 | 12.7777 | 27.6076 | 30969120 | 854982 |
| 85 | 10.2650 | 9.1399 | 11.5149 | 22.4648 | 34854320 | 782997 |
| 86 | 8.0502 | 7.1199 | 9.0871 | 19.6358 | 53126687 | 1043183 |
| 87 | 8.4684 | 7.2861 | 9.8195 | 16.5018 | 29116222 | 480471 |
| 88 | 13.8253 | 9.6877 | 19.5647 | 28.0662 | 5492231 | 154146 |
| 89 | 13.7148 | 9.9398 | 18.7926 | 19.0700 | 4256033 | 81165 |
| 90 | 5.4417 | 4.2148 | 6.9573 | 4.7790 | 18836708 | 90021 |
| 91 | 5.2140 | 3.8883 | 6.8992 | 4.3963 | 32470897 | 142753 |
| 92 | 3.9054 | 2.8644 | 5.2268 | 4.4107 | 33982917 | 149888 |
| 93 | 2.2321 | 1.0913 | 3.9952 | 3.9567 | 95320348 | 377155 |

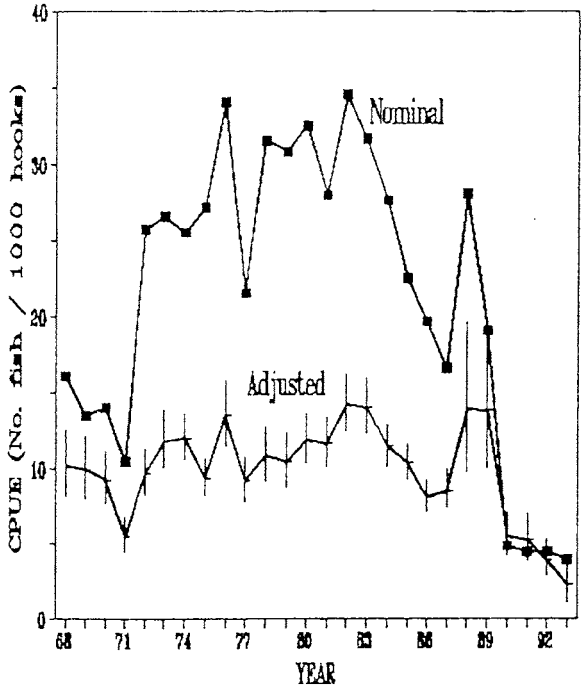


Fig. 1. Nominal and least-square adjusted CPUEs of North Atlantic albacore. The adjusted CPUE trends were estimated from three GLM models for three time periods separately: 1968-1971, 1972-1989 and 1990-1993.

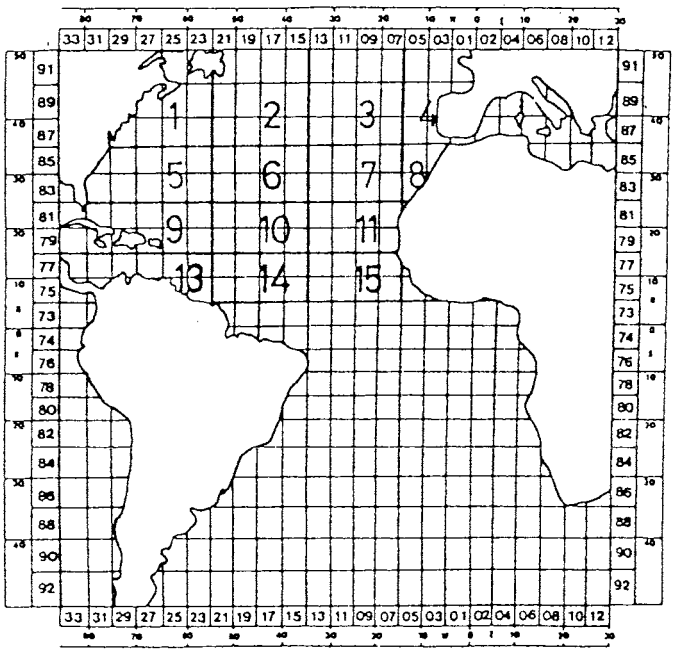

Fig. 2. Map showing the definition of the 15 subareas in the North Atlantic.

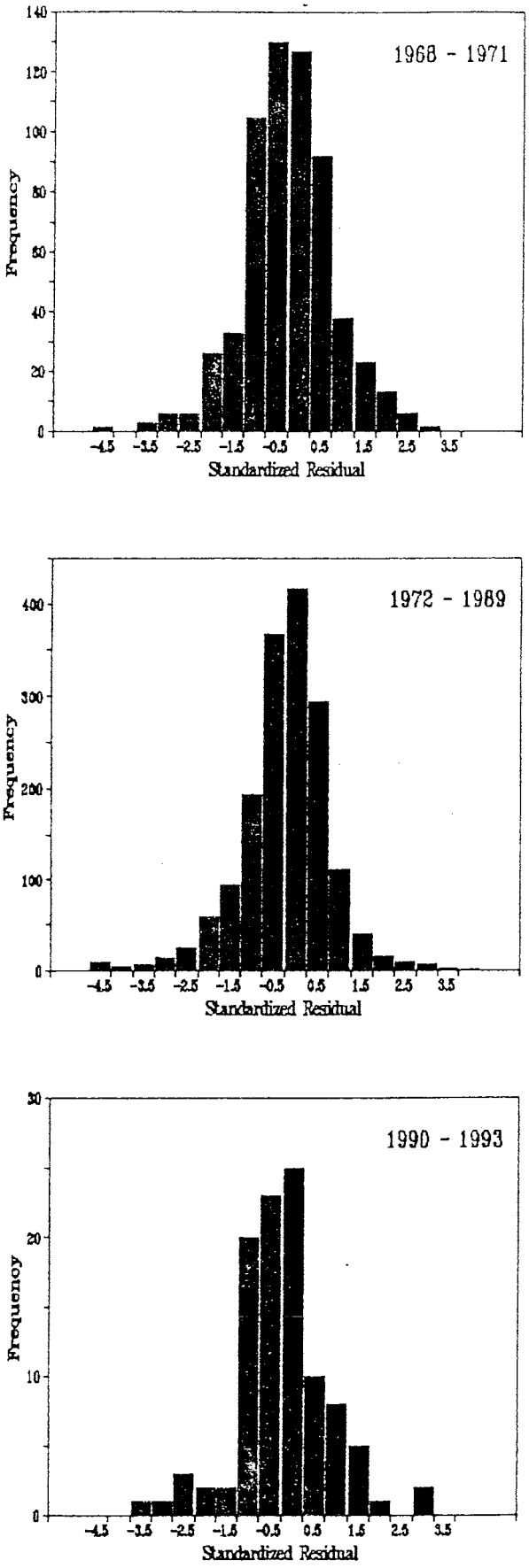


Fig. 3. Standardized residual histogram for the three GLM models.