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# UPDATING OF CPUE TREND OF SOUTHERN ATLANTIC ALBACORE BY USING GLM ADJUSTMENTS ON TAIWANESE LONGLINE DATA FROM 1968 TO 1995

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## SUMMARY

Generalized linear model (GLM) was used to standardize the CPUE series of south Atlantic albacore. Chinese Taipei Task II data from 1968 to 1995 provided by the Overseas Fisheries Cooperation Council was the basic data source used in this analysis. In order to avoid the dilution of target species catch by deep longline operation, which is aimed at bigeye, an attempt was made to eliminate those records in which the bigeye catch in number exceeds albacore was also applied in this analysis. The factors used in the GLM are: year, quarter, fishing area, bigeye CPUE, yellowfin CPUE, other species CPUE and interaction terms. Five major areas, based on areal-specific size and species composition characteristics, were identified and designated in this study.

The GLM results obtained by using all Chinese Taipei Task I data files showed that: (1) CPUE sharply declined at the beginning of the fisheries from early 1968 to 1973; (2) a declining CPUE trend also appeared in 1977-1990; (3) a slightly increasing trend was observed after 1990, but the CPUE declined again in 1995.

The GLM results obtained by using only those records that in which the albacore catch in number exceed bigeye showed that: (1) the CPUE also declines sharply at the beginning of the fisheries from early 1968 to 1973; (2) the CPUE trend showed a more slightly declining trend in 1977-1990 than the above results obtained in the same period; and (3) a slightly increasing trend was observed in 1991-1995.

There are no significant differences in the two CPUE trends derived from the aforementioned methods, except that the latter one showed a continuous slightly increasing CPUE in 1990-1995.


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## RÉSUMÉ

Le Modèle linéaire généralisé (GLM) a été utilisé pour standardiser les séries de CPUE du germon de l'Atlantique Sud. Les données Tâche II de 1968 à 1995 du Taïpeï chinois transmises par le Overseas Fisheries Cooperation Council ont été la source des données de base utilisées dans ces analyses. Afin d'éviter la dilution de l'espèce ciblée par les opérations de palangre de profondeur, qui sont dirigées contre le thon obèse, on a également essayer dans ces analyses d'éliminer les registres dans lesquels la prise de thon obèse dépassait en nombre celle du germon. Les facteurs utilisés dans le GLM sont l'année, le trimestre, la zone de pêche, la CPUE du thon obèse, la CPUE de l'albacore, les CPUE d'autres espèces et des termes d'interaction. Cinq principale zones, fondées sur la taille spécifique de la zone et les caractéristiques de la composition par espèces ont été identifiées et déterminées dans cette étude.

Les résultats GLM obtenus par l'utilisation de tous les fichiers de données Tâche II du Taïpeï chinois ont montré que : 1) la CPUE a brusquement décliné au commencement des pêcheries, du début de l'année 1968 jusqu'en 1973 ; 2) il y a également eu une tendance au déclin de la CPUE en 1977-1990; 3) une légère tendance à la croissance a été observée après 1990, mais que la CPUE a recommencé à décliner en 1995.

Les résultats GLM obtenus en n'utilisant que les registres dans lesquels les prises de germon dépassaient en nombre celle de thon obèse ont montré que : 1) la CPUE a également brusquement décliné au commencement des pêcheries du début de l'année 1968 jusqu'en 1993 ; 2) la tendance de la CPUE a présenté un déclin légèrement plus élevé en 1977-1990 que dans les résultats ci-dessus obtenus pour la même période ; 3) on a observé une tendance légère à la croissance en 1991-1995.

Il n'y a pas de différence significative entre les deux tendances de la CPUE issues des méthodes sus-mentionnées, si ce n'est que la dernière présentait une CPUE en légère croissance continue en 1990-1995.

## RESUMEN

Se empleó el modelo lineal generalizado (GLM) para estandarizar las series de CPUE del atún blanco del Atlántico sur. Los datos de Taipei Chino de la Tarea II desde 1968 a 1995, facilitados por Overseas Fisheries Cooperation Council constituyeron la fuente de datos básicos empleados en estos análisis. Con el fin de evitar la dilución de la especie objetivo obtenida en operaciones de palangre profundo, que se dirigen al patudo, también se aplicó a este análisis un intento para eliminar aquellos registros donde la captura de patudo en número excedía de la del atún blanco. Los factores empleados en GLM son año, trimestre, zona de pesca, CPUE de patudo, CPUE de rabil, CPUE de otras especies, y términos de la interacción. Se identificaron y determinaron cinco zonas principales, basándose en tamaño específico del área y características de la composición por especies.

Los resultados GLM obtenidos empleando todos los ficheros de datos de la Tarea II de Taipei Chino mostraron que: (1) la CPUE descendió bruscamente a comienzos de la pesquería, desde principio de 1968 a 1973; (2) también tuvo lugar una tendencia de la CPUE al declive en 1977-1990; (3) se observó una tendencia ligeramente ascendente después de 1990, pero la CPUE volvió a declinar en 1995.

Los resultados GLM obtenidos utilizando únicamente los registros en los cuales la captura de atún blanco en número excedían de la de patudo mostraron que: (1) la CPUE descendió bruscamente a comienzos de las pesquerías, desde comienzos de 1968 a 1973; (2) la tendencia de la CPUE experimentó un ligero declive en 1977-1990 que los resultados arriba indicados obtenidos en el mismo período; (3) se observó una tendencia ligeramente ascendente en 1991-1995.

No hay una diferencia significativa entre las dos tendencias de la CPUE deducida de los métodos mencionados, excepto que la última mostraba una CPUE con un ligero incremento sostenido en 1990-1995.


## INTRODUCTION

The Southern Atlantic albacore fishery is one of the most important distant water tuna fisheries around the entire world. Standardization of fishing effort is essential before the CPUE can be considered as a index of relative abundance. Generalized linear model methods have been extensively applied to standardize the fishing effort of South Atlantic albacore ( Yeh et al., 1993; Wu et al., 1994; Sun and Yeh, 1996). Factors, such as: year, season, fishing area block , target species and CPUE of the other's species are commonly to considered in GLM for adjusting albacore CPUE.

The purpose of this paper is thus to investgate the relevant factors of historic Taiwanese longline data series into GLM methods to standardize the CUPE trend of southern Atlantic albacore stock.

## MATERIALS AND METHODS

Taiwanese task II data from 1968 to 1995 provided by the Overseas Fisheries Cooperation Council of the Republic of China was the basic data source used in this analyses. In order to avoid the dilution of target species catch by deep longline operation, which is aimed at bigeye, an attempt of eliminating those records that bigeye catch in number exceeds albacore was also applied in this analyses.

CPUE was calculated as catch in number per 1000 hooks. Records with less then 1000 hooks were excluded from this two analysis. Generalized linear model was used to standardize the CPUE series of southern Atlantic albacore. Six main factors used in GLM are year (yr), quarter (qt), fishing area (area), nominal CPUE of bigeye (bybet), nominal CPUE of yellowfin tuna (byyft) and nominal CPUE of the others (byoth). Some interaction terms are also included in GLM model. According the suggestion of Wu et al. (1994), species composition (Fig. 1) and the length composition (Fig.2), the fishing area are subdivided into five blocks (Fig. 3). The formula of GLM is followed:

$$LN(cpue+1.0) = u + yr + qt + area + bybet + byyft + byoth + qt * area + qt*bybet + qt*byyft + qt*byoth + area*bybet + area*byyft + area*byoth + E$$

where CPUE is albacore catch in number per 1000 hooks, u is overall mean, E is error term with N(0,S). F-test were conducted on all main

effects and interactions terms to determine whether not each contributed significantly to the model. Two data sets are conducted. separately.

## RESULTS

Table 1 and 2 show the ANOVA tables of GLM analysis of all Taiwanese task II data file and only those records that albacore catch in number exceed bigeye, respectively. All the factors considered in first data set are significant. The interaction term between area and byoth in latter data set is not significant, since this term is excluded and GLM was conducted again.

The standardized residual plots of the GLM model for two data sets were showed in Fig. 3 and 4. A normal approximated distribution could be noted for two data sets.

The least-square adjusted CPUE and its 95% confidence interval along with the nominal CPUE are separately plotted in Fig.4 and 5 for two data sets. Their values estimated are tabulated in Table 3 and Table 4.

The GLM results obtained by using all Taiwanese task II data file showed that: (1) the CPUE sharply declined at the beginning of the fisheries from the early 1968 to 1973;(2) a declined CPUE trend also appeared in 1977-1990;(3) a slightly increase trend was observed after 1990, but the CPUE declined again in 1995.

The GLM results obtained by using only those records that albacore catch in number exceed bigeye showed that: (1) the CPUE also sharply declines at the beginning of the fisheries from the early 1968 to 1973;(2) the CPUE trend appeared a more slightly declined in 1977-1990 then the above results obtained in the same period; (3) a slightly increase trend was observed in 1991-1995.

There are no significant difference in two CPUE trends derived from the aforementioned methods except the latter one appeared a continuous slightly increasing CPUE in 1990-1995.

## Reference

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Table 1. ANOVA table of the GLM model of all Taiwanese task II data file. R-Square=0.691

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 105 | 7658.693 | 72.9399311 | 161.23 | 0.0001 |
| Error | 7569 | 3424.213 | 0.4523997 | | |
| Corrected Total | 7674 | 11082.91 | | | |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YR | 27 | 1649.279 | 61.0843974 | 135.02 | 0.0001 |
| QT | 3 | 466.7177 | 155.5725787 | 343.88 | 0.0001 |
| AREA | 3 | 3649.708 | 1216.569441 | 2689.2 | 0.0001 |
| BYBET | 3 | 546.5946 | 182.1982027 | 402.74 | 0.0001 |
| BYYFT | 3 | 666.133 | 222.0443368 | 490.81 | 0.0001 |
| BYOTH | 3 | 43.48313 | 14.4943771 | 32.04 | 0.0001 |
| QT*AREA | 9 | 145.9252 | 16.2139058 | 35.84 | 0.0001 |
| QT*BYBET | 9 | 100.7946 | 11.1993949 | 24.76 | 0.0001 |
| QT*BYYFT | 9 | 29.35066 | 3.2611839 | 7.21 | 0.0001 |
| QT*BYOTH | 9 | 19.46146 | 2.1623847 | 4.78 | 0.0001 |
| AREA*BYBET | 9 | 191.2572 | 21.2508006 | 46.97 | 0.0001 |
| AREA*BYYFT | 9 | 119.0156 | 13.2239506 | 29.23 | 0.0001 |
| AREA*BYOTH | 9 | 30.97264 | 3.4414041 | 7.61 | 0.0001 |

Table 2. ANOVA table of the GLM model of those records that albacore catch in number exceed bigeye. R-Square=0.406

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 96 | 1098.172 | 11.4392909 | 44.12 | 0.0001 |
| Error | 6173 | 1600.393 | 0.2592569 | | |
| Corrected Total | 6269 | 2698.565 | | | |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YR | 27 | 295.0466 | 10.92765103 | 42.15 | 0.0001 |
| QT | 3 | 412.2117 | 137.4038994 | 529.99 | 0.0001 |
| AREA | 3 | 86.16799 | 28.72266466 | 110.79 | 0.0001 |
| BYBET | 3 | 101.6726 | 33.89086231 | 130.72 | 0.0001 |
| BYYFT | 3 | 71.72465 | 23.90821636 | 92.22 | 0.0001 |
| BYOTH | 3 | 30.54068 | 10.18022545 | 39.27 | 0.0001 |
| QT*AREA | 9 | 48.00919 | 5.33435483 | 20.58 | 0.0001 |
| QT*BYBET | 9 | 8.627072 | 0.95856357 | 3.7 | 0.0001 |
| QT*BYYFT | 9 | 6.764621 | 0.75162452 | 2.9 | 0.002 |
| QT*BYOTH | 9 | 9.028735 | 1.00319281 | 3.87 | 0.0001 |
| AREA*BYBET | 9 | 13.17932 | 1.46436891 | 5.65 | 0.0001 |
| AREA*BYYFT | 9 | 15.1988 | 1.68875588 | 6.51 | 0.0001 |

Table 3. Adjusted CPUE (ACPUE) and its 95% lower (LCPUE) and upper bound (UCPUE), nominal CPUE (NCPUE) , total effort in hook (HOOKS), and total albacore catches (CATCH) in number for all Taiwanese task II data file.

| YEAR | ACPUE | LCPUE | UCPUE | NCPUE | HOOKS | CATCH |
|---|---|---|---|---|---|---|
| 1968 | 14.4631 | 12.7031 | 16.4491 | 36.4662 | 19805793 | 722242 |
| 1969 | 15.7869 | 14.2805 | 17.4419 | 31.9235 | 26619269 | 849780 |
| 1970 | 10.1776 | 9.2273 | 11.2162 | 32.0003 | 21012510 | 672406 |
| 1971 | 10.4683 | 9.4196 | 11.6227 | 34.7891 | 36608284 | 1273569 |
| 1972 | 7.3384 | 6.573 | 8.1812 | 29.4183 | 41117775 | 1209617 |
| 1973 | 5.9807 | 5.2073 | 6.8503 | 26.5502 | 41393880 | 1099014 |
| 1974 | 6.386 | 5.6725 | 7.1758 | 27.8128 | 35001226 | 973482 |
| 1975 | 7.879 | 6.9809 | 8.8781 | 33.3248 | 30955169 | 1031575 |
| 1976 | 7.9074 | 7.0517 | 8.8542 | 29.3413 | 31619459 | 927755 |
| 1977 | 9.4089 | 8.4696 | 10.4414 | 34.6997 | 30944846 | 1073778 |
| 1978 | 8.5538 | 7.7195 | 9.4679 | 35.6167 | 40208489 | 1432092 |
| 1979 | 8.4168 | 7.5075 | 9.4232 | 33.2201 | 32391000 | 1076032 |
| 1980 | 7.9989 | 7.1932 | 8.8839 | 32.6668 | 34094000 | 1113741 |
| 1981 | 6.3276 | 5.6811 | 7.0365 | 28.0824 | 38874695 | 1091696 |
| 1982 | 6.3723 | 5.738 | 7.0663 | 29.4201 | 49611261 | 1459568 |
| 1983 | 6.3314 | 5.6149 | 7.1254 | 28.3309 | 24478782 | 693507 |
| 1984 | 6.8108 | 5.9777 | 7.7433 | 29.4922 | 17281612 | 509673 |
| 1985 | 7.2539 | 6.472 | 8.1175 | 30.0404 | 46262198 | 1389737 |
| 1986 | 6.9815 | 6.276 | 7.7553 | 32.0134 | 66565299 | 2130983 |
| 1987 | 6.31 | 5.6578 | 7.0261 | 24.4444 | 82267921 | 2010992 |
| 1988 | 4.4494 | 3.8537 | 5.1183 | 19.8221 | 71162036 | 1410584 |
| 1989 | 3.7335 | 3.2071 | 4.3259 | 16.9833 | 65620351 | 1114448 |
| 1990 | 2.6983 | 2.3284 | 3.1095 | 17.4593 | 79805097 | 1393342 |
| 1991 | 3.872 | 3.4291 | 4.3591 | 13.1619 | 82776748 | 1089500 |
| 1992 | 4.0964 | 3.5601 | 4.6958 | 15.9358 | 81643767 | 1301061 |
| 1993 | 4.0951 | 3.644 | 4.5899 | 16.0902 | 96436018 | 1551672 |
| 1994 | 4.7827 | 4.317 | 5.2891 | 19.4513 | 95670658 | 1860917 |
| 1995 | 3.9003 | 3.5223 | 4.3099 | 12.3716 | 73527963 | 909656 |

Table 4. Adjusted CPUE (ACPUE) and its 95% lower (LCPUE) and upper bound (UCPUE), nominal CPUE (NCPUE) , total effort in hook (HOOKS), and total albacore catches (CATCH) in number for those records that albacore catch in number exceed bigeye.

| YEAR | ACPUE | LCPUE | UCPUE | NCPUE | HOOKS | CATCH |
|---|---|---|---|---|---|---|
| 1968 | 25.2745 | 22.0716 | 28.922 | 68.2547 | 10204638 | 696514 |
| 1969 | 23.7741 | 21.533 | 26.2382 | 48.0827 | 17036839 | 819178 |
| 1970 | 19.2118 | 17.3632 | 21.2466 | 39.9672 | 16574626 | 662442 |
| 1971 | 21.205 | 19.0665 | 23.5714 | 50.5023 | 24937688 | 1259411 |
| 1972 | 15.5426 | 13.9815 | 17.2664 | 37.3096 | 32254464 | 1203401 |
| 1973 | 11.6669 | 10.3651 | 13.1179 | 29.977 | 36483817 | 1093675 |
| 1974 | 12.2789 | 11.0412 | 13.6438 | 30.9197 | 31285632 | 967342 |
| 1975 | 15.2337 | 13.6412 | 16.9993 | 37.543 | 27383053 | 1028041 |
| 1976 | 14.925 | 13.4665 | 16.5306 | 29.3904 | 31566294 | 927747 |
| 1977 | 16.5099 | 14.9722 | 18.1958 | 35.1798 | 30513392 | 1073454 |
| 1978 | 15.9907 | 14.5149 | 17.6068 | 36.226 | 39447361 | 1429021 |
| 1979 | 15.4256 | 13.9357 | 17.0642 | 33.3546 | 32147900 | 1072280 |
| 1980 | 15.122 | 13.7084 | 16.6714 | 32.9567 | 33762000 | 1112683 |
| 1981 | 13.1978 | 11.9406 | 14.5772 | 29.0346 | 37555084 | 1090398 |
| 1982 | 12.566 | 11.4024 | 13.8387 | 29.7433 | 49036335 | 1458500 |
| 1983 | 12.654 | 11.3845 | 14.0537 | 28.582 | 24259246 | 693378 |
| 1984 | 15.0408 | 13.3963 | 16.8733 | 31.1622 | 16352752 | 509587 |
| 1985 | 14.2434 | 12.8668 | 15.7567 | 30.2157 | 45993242 | 1389720 |
| 1986 | 13.6277 | 12.3618 | 15.0136 | 32.1471 | 66202316 | 2128213 |
| 1987 | 11.5773 | 10.4791 | 12.7806 | 24.7029 | 80928927 | 1999178 |
| 1988 | 8.6652 | 7.7062 | 9.7297 | 19.8396 | 71077958 | 1410161 |
| 1989 | 8.0577 | 7.1335 | 9.087 | 17.3996 | 63874191 | 1111384 |
| 1990 | 8.3236 | 7.3423 | 9.4204 | 21.4871 | 63918045 | 1373416 |
| 1991 | 9.2615 | 8.2895 | 10.3351 | 17.7542 | 59332099 | 1053392 |
| 1992 | 10.5157 | 9.282 | 11.8973 | 21.9622 | 56373662 | 1238090 |
| 1993 | 10.718 | 9.6343 | 11.9121 | 21.5265 | 71642936 | 1542222 |
| 1994 | 11.9123 | 10.7873 | 13.1446 | 24.6014 | 74552746 | 1834102 |
| 1995 | 12.2374 | 11.0151 | 13.5839 | 22.9533 | 39106902 | 897634 |

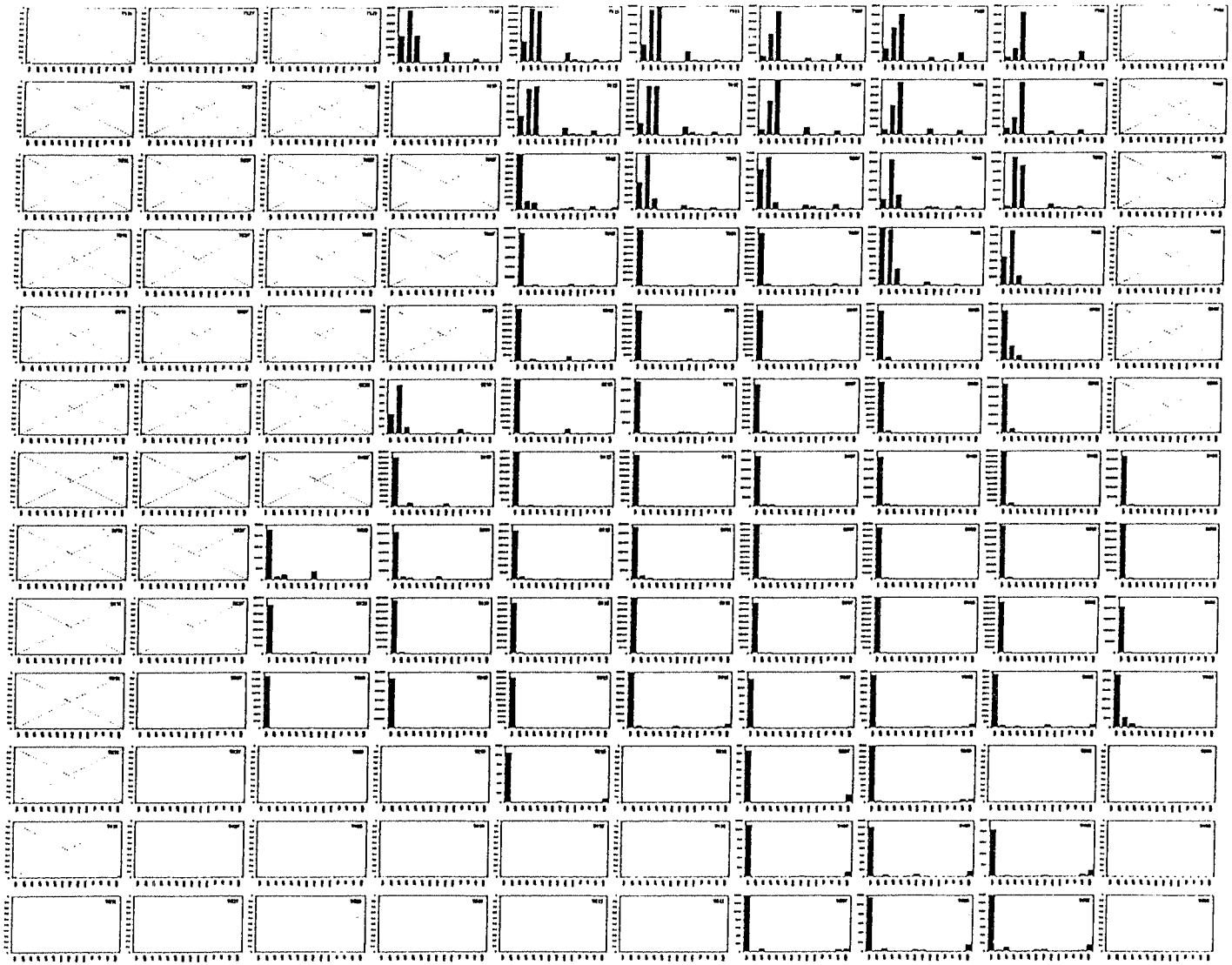

Fig. 1. Cumulative species composition by 5 x 10 block of Taiwanese longline fishery in southern Atlantic during 1968-1995.

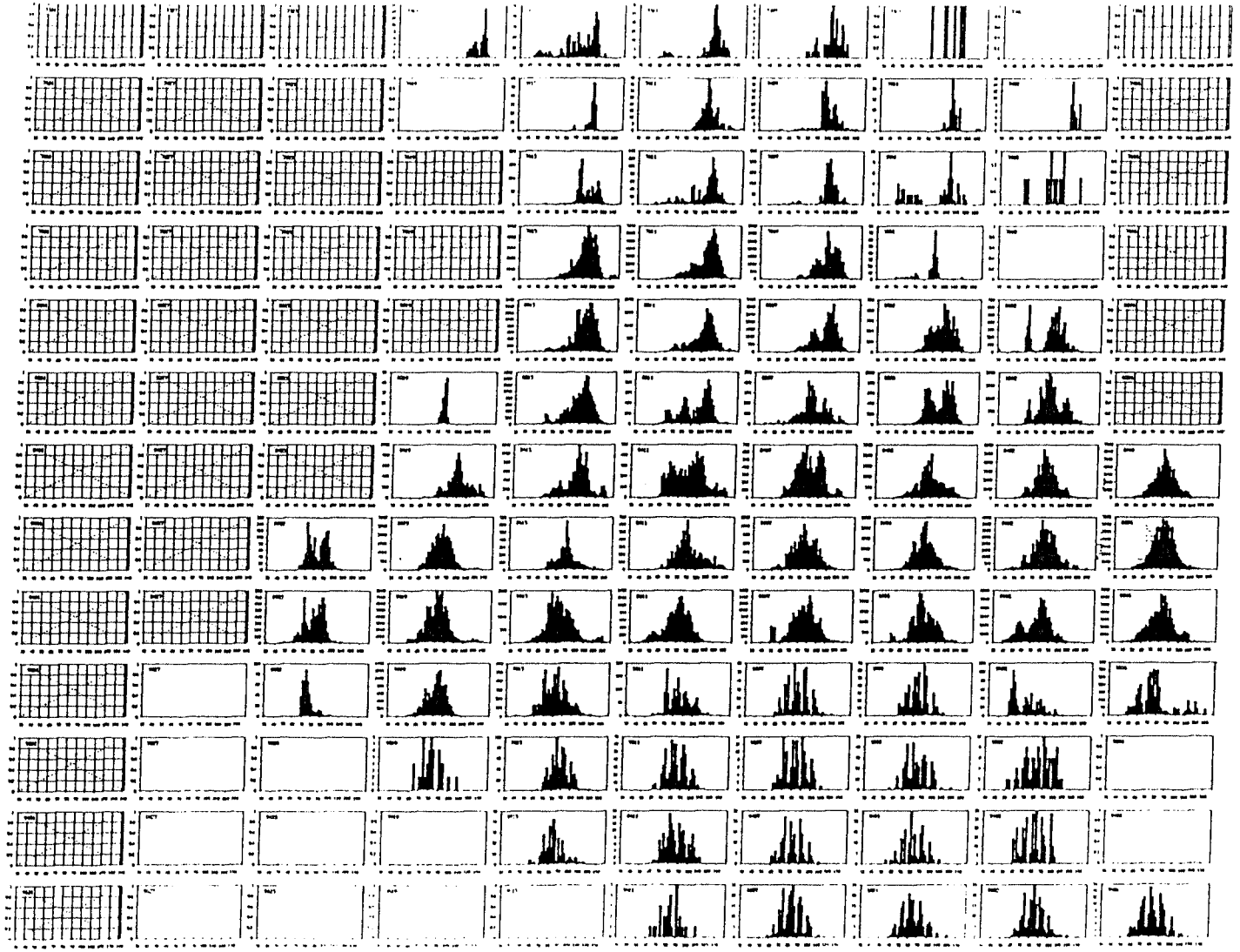

Fig. 2. Cumulative fork length distributions by 5 x 10 block of Taiwanese longline fishery in southern Atlantic during 1981-1995.

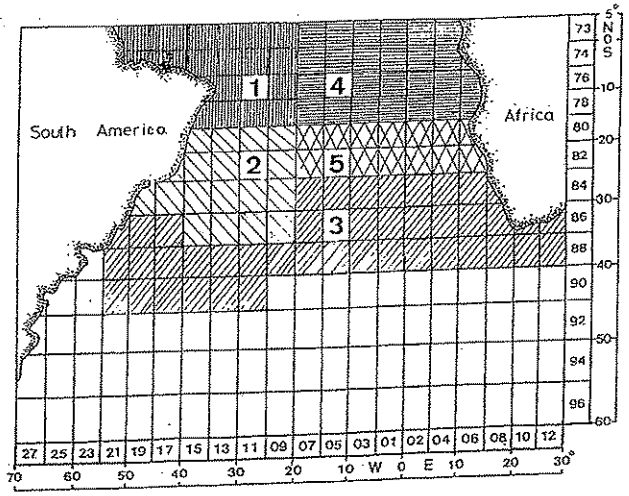


Fig. 3. Demarcation of subdivisions of southern Atlantic used in the GLM analysis in this analysis.

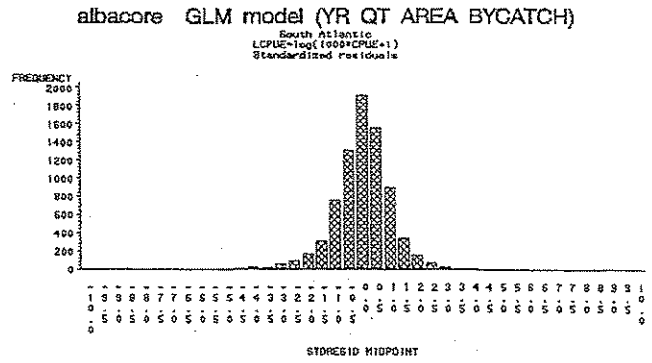


Fig 4. Plots of residuals of the formulated GLM analysis for all Taiwanese task II data file.

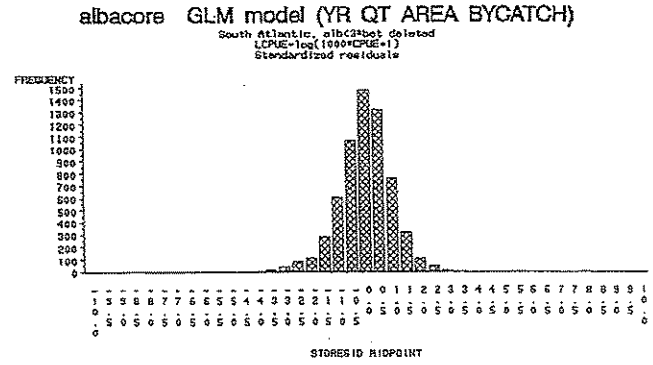


Fig 5. Plots of residuals of the formulated GLM analysis for those records that albacore catch in number exceed bigeye.

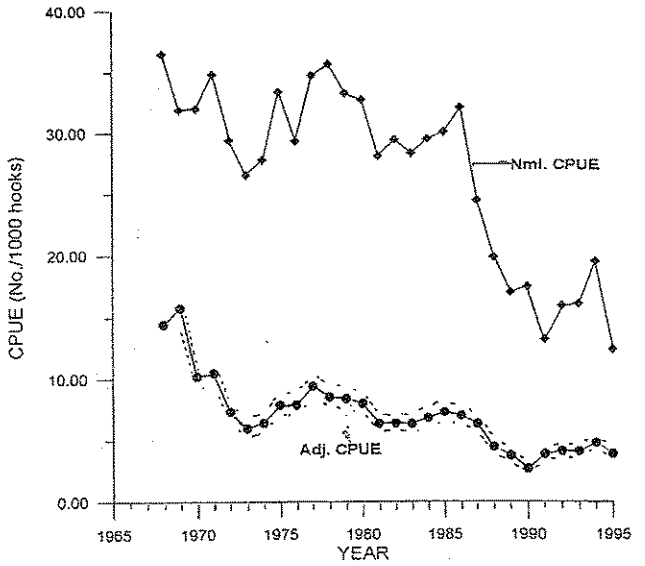


Fig. 6. GLM adjusted Southern Atlantic albacore CPUE trend based on all Taiwanese Task II data file.

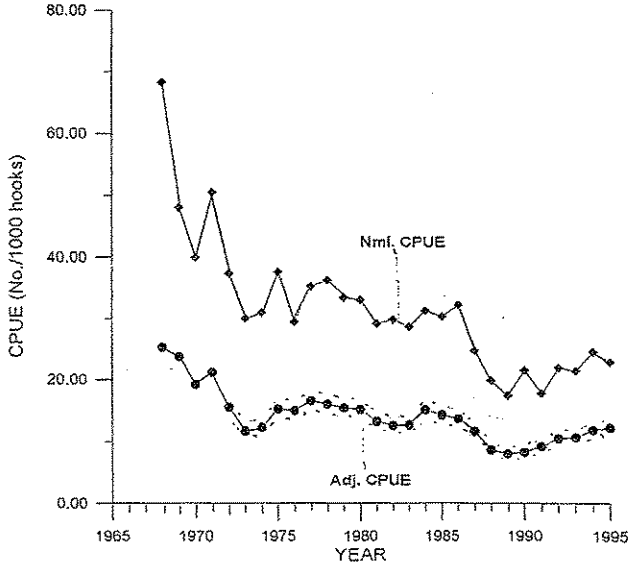


Fig. 7. GLM adjusted southern Atlantic albacore CPUE trend base on those records that albacore catch in number exceed bigeye.