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STANDARDIZED CPUE TREND OF TAIWANESE LONGLINE FISHERY FOR NORTHERN ATLANTIC ALBACORE FROM 1968 to 1998

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SUMMARY

Generalized linear model (GLM) was used to standardize the CPUE for northern Atlantic albacore (Thunnus alalunga) caught by Taiwanese longline fisheries during 1968-1998. Three sub-areas, based on nominal CPUEs of the main species caught were defined. Sub-area 3, where non-albacore-directed efforts have increased recently, is not the traditional albacore fishing ground. The CPUE trends, which were derived from including or excluding the data of this sub-area, were estimated and compared. The standardized CPUE trend, estimated from the dataset including Sub-area 3, indicated that: (1) CPUE appeared to decline sharply at the beginning of the fishery (early 1968 to 1971), but it remained quite stable until the early 1990s; (2) CPUE trend appeared to decline since 1992. The CPUE series, estimated from the dataset excluding Sub-area 3, showed that: (1) although it appeared to decline from 1968 to 1970, CPUE remained stable between 1971 to 1995; (2) CPUE appeared to sharply decline at 1996, but it went up to above stable level at 1998.

RÉSUMÉ

Le modèle linéaire généralisé (GLM) a été utilisé pour standardiser la CPUE du germon (Thunnus alalunga) *nord-atlantique capturé par les palangriers du Taïpei chinois entre 1668 et 1998. Trois sous-secteurs, basés sur la CPUE nominale des principales espèces capturées, ont été définis. Le sous-secteur 3, où l'effort ne visant pas le germon s'est récemment accru, n'est pas le lieu traditionnel de pêche du germon. La tendance de la CPUE, obtenue en incluant ou en excluant les données de ce sous-secteur, a été estimée et comparée. La tendance de la CPUE standardisée estimée d'après le jeu de données qui comprend le sous-secteur 3, montre que: (1) la CPUE semble avoir décru de façon accusée lors des débuts de la pêcherie (début 1968 à 1971), mais elle est demeurée assez stable jusqu'au début des années 1990, (2) la tendance de la CPUE semble être décroissante depuis 1992. Les séries de CPUE estimées d'après les données qui ne comprennent pas le sous-secteur 3 montrent que: (1) bien qu'elle semble avoir baissé entre 1968 et 1970, la CPUE est demeurée stable de 1971 à 1995, (2) la CPUE semble avoir baissé brusquement en 1996, mais elle est revenue au niveau stable ci-dessus en 1998.*

RESUMEN

Se usó el Modelo lineal generalizado (GLM) para estandarizar la CPUE del atún blanco del Atlántico norte (Thunnus alalunga) capturado por las pesquerías palangreras de Taipei Chino entre 1968 y 1998. Se definieron tres subzonas, basándose en las CPUEs nominales de la especie principal en la captura. La subzona 3, donde el esfuerzo no dirigido al atún blanco ha experimentado un aumento reciente, no es el caladero tradicional de atún blanco. Las tendencias de la CPUE, derivadas incluyendo o excluyendo los datos de esta subzona, fueron estimadas y comparadas. La tendencia estandarizada de CPUE, estimada partiendo del conjunto de datos que incluye la subzona 3, indicaba que: (1) la CPUE pareció descender bruscamente al inicio de la pesquería (principios de 1968 a 1971) si bien permaneció

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bastante estable hasta principios de los años 90; (2) la tendencia de la CPUE pareció descender desde 1992. La serie de CPUE, estimada en base al conjunto de datos que excluye la subzona 3, indicaba que: (i) si bien pareció descender entre 1968 y 1970, la CPUE permaneció estable entre 1971 y 1995; (2) la CPUE mostró un brusco descenso en 1996, pero en 1998 volvió a subir por encima del nivel de estabilidad.

KEYWORDS

Taiwan, northern Atlantic albacore, catch, fishing effort, abundance, long lining

1. INTRODUCTION

Two types of fishing strategy were included in Taiwanese tuna longline fisheries. One is regular longline targeting mainly the albacore, and the other is deep longline operated mainly between 15° N and 15° S targeting bigeye tuna (Hsu, 1999). The deep longline fishery was initiated in mid-1980s, and the number of deep longline fleets increased from 37 boats in 1990 to 125 boats in 1997. This change of fishing pattern showed the lower catch rate and proportion at species composition for albacore in specific fishing ground.

Generalized linear model methods have been extensively applied to adjust the Atlantic albacore CPUE trends (Chang and Hsu, 1994, Hsu, 1996 and Lin et al., 1997). If non-species-directed efforts are not adjusted well and used in the CPUE standardization, the CPUE will be underestimated (Nakano, 1996).

The purpose of this paper is to separate the non-albacore-directed effort to obtain a more exact CPUE trend for northern albacore stock.

2. MATERIAL AND METHODS

Taiwanese longline fisheries data from 1968 to 1998 provided by the Overseas Fisheries Cooperation Council of the Republic of China was used in this study. The data were firstly identified and split into northern stock by 5 º N. The resolution of the data, which were complied from recovered logbooks of Taiwanese longline vessels, is by monthly, by 5×5 block, and by species. Some of the observations were deleted because of the fishing localities on land or without effort data. Observations with less than 3,000 hooks were also not used in this study.

The hierarchical cluster analysis (Ward method; Statistical Analysis System Inc. 1989) was used to define the Sub-area. The nominal CPUEs of albacore, bigeye tuna, yellowfin tuna, and swordfish were used in cluster analysis. The CPUE was expressed in number of fish per 1,000 hooks.

The generalized linear model (GLM) was used to adjust the CPUE trend of northern Atlantic Albacore stock. Year (YR), quarter (QT), Sub-area (AREA) were incorporated as main effects. The bycatch of bigeye tuna (BETCD), and interaction between quarter and Sub-area (QT*AREA) were also incorporated into GLM analyses. The formula of GLM is followed:

$$\text{LOG (CPUE+0.1)} = \mu + \text{YR} + \text{QT} + \text{AREA} + \text{BET} + \text{QT*AREA} + \text{E},$$

where CPUE is albacore catch in number per 1000 hooks, μ is overall mean, E is error term with N (0,S). Factors were dropped from the model, if not statistical significant at $p<0.05$ level when applying in GLM analysis. The reduced model was reexamined till all factor effects were significant.

3. RESULTS AND DISCUSSION

The dendrogram showed that the total of 102 5x5 statistic blocks was grouped into to three clusters by the cluster analysis (Fig. 1). Therefore, three Sub-areas were defined and used in GLM analysis (Fig. 2). The Sub-area 3 was general considered as the main fishing ground of deep longline fisheries since the middle of 1980s.

Two data sets were submitted to GLM analyses. The first data set includes the entire data set, but the second one excludes the data of Sub-area 3. The ANOVA results for two data sets separately revealed that all the main effects and interaction considered in this study were significant and effective (Table 1 and 2). The standardized residual patterns were shown in Figs. 3 and 4 for two data set, respectively. They show a normally distributed pattern.

The CPUE trend obtained from the first data set was shown in Fig. 5. The result indicated that: (1) although it appeared sharply CPUE decline at the beginning of the fisheries (early 1968 to 1971), CPUE remained rather stable until early 1990s; (2) the CPUE trend appeared a decline since 1992.

Fig. 6 showed the CPUE trend obtained from the second data set. The result showed that: (1) the CPUE trend remained rather stable between early 1970s and 1995; (2) although the CPUE in 1996 declined to lower level, it built up to stable level in 1998. This similar pattern was also found in the Japanese longline fisheries (Uosaki, 1999).

Annual species composition by 5x5 statistic block of Taiwanese longline fishery in northern Atlantic was shown in Fig. 7. The main caught species was albacore in Sub-area 1 and Sub-area 2, but yellowfin tuna and bigeye tuna was primary catches in Sub-area 3. We also found that the bigeye tuna occupied the highest proportion in Sub-area 3 since 1990s. The majority effort at Sub-area 3 came from deep longline fisheries since the middle of 1980s (Hsu, 1999), thus fisheries statistical data of this area may be not proper for using in the CPUE standardization of this albacore stock. The non-albacore-directed efforts used in the CPUE standardization will underestimate the CPUE (Nakano, 1996), and that may be contributed to the CPUE trend obtained from the first data set showing a continuous decline of CPUE since 1992 (Fig. 5).

ACKNOWLEDGEMENT

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Table 1. Analysis of variance of standardized CPUE using GLM method of North Atlantic albacore from Taiwanese longline fisheries for including the data of Sub-area 3.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	40	413.8922	10.3473	27.69	0.0001
Error	2988	1116.3880	0.37362		
Corrected Total	3028	1530.2803			

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	30	158.8226	5.2940	14.17	0.0001
QT	3	64.57827	21.5260	57.61	0.0001
AREA	1	53.60342	53.6034	143.47	0.0001
BETCD	3	32.16660	10.7222	28.70	0.0001
QT*AREA	3	51.29064	17.0968	45.76	0.0001

Table 2. Analysis of variance of standardized CPUE using GLM method of North Atlantic albacore from Taiwanese longline fisheries for excluding the data of Sub-area 3.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	40		10.3473	27.69	0.0001
Error	2988	413.8922	0.37362		
Corrected Total	3028	1116.3880			
		1530.2803			

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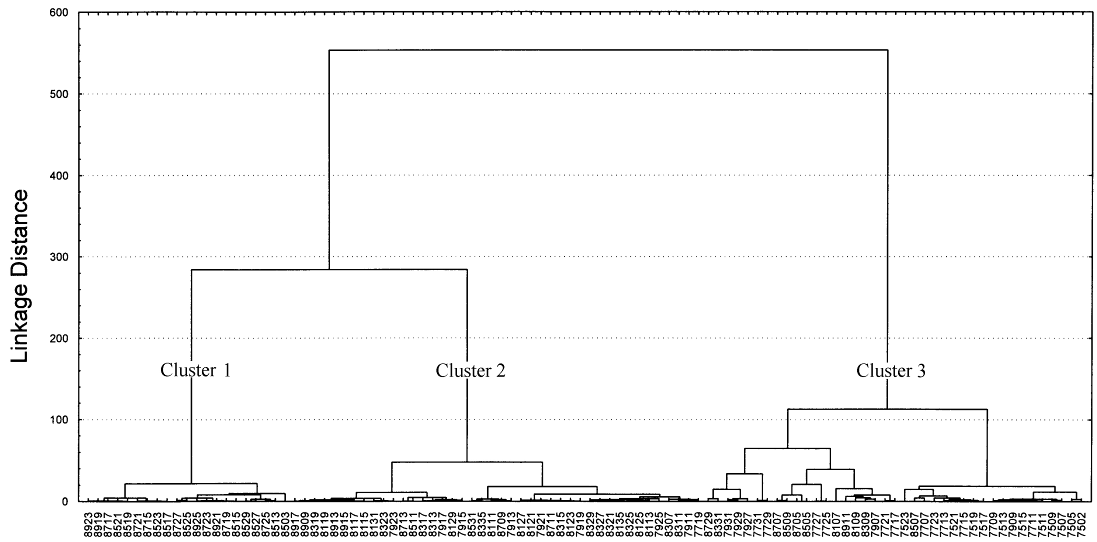


Fig. 1 Dendrogram of 105 5x5 statistical blocks.

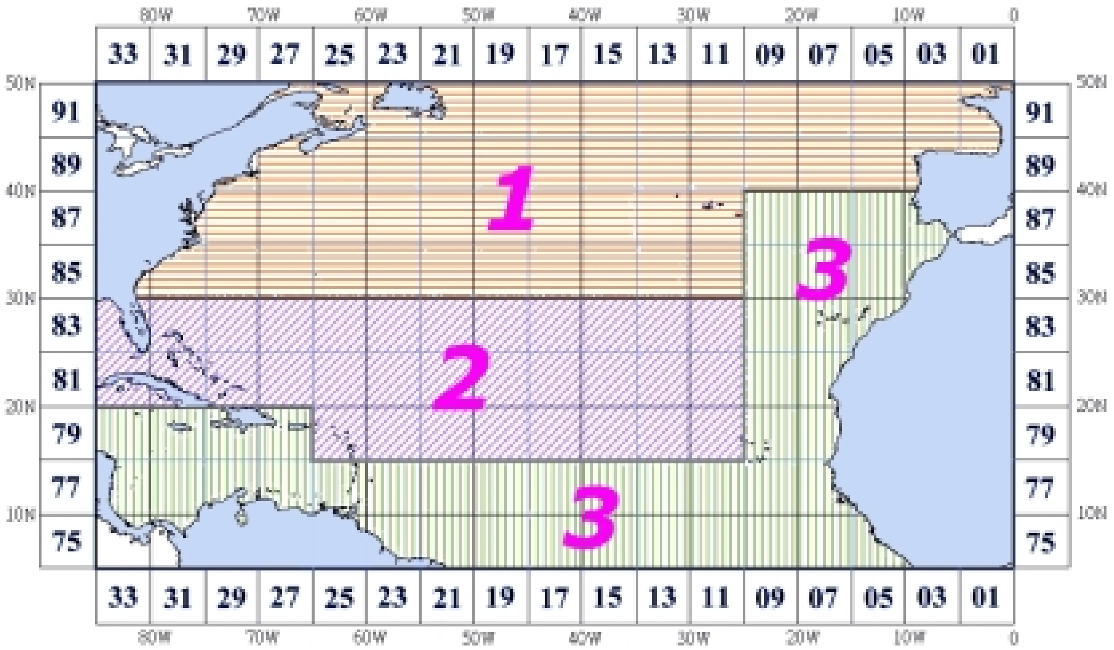


Fig. 2 Map shows the definition of subarea in the north Atlantic used in the GLM analysis.

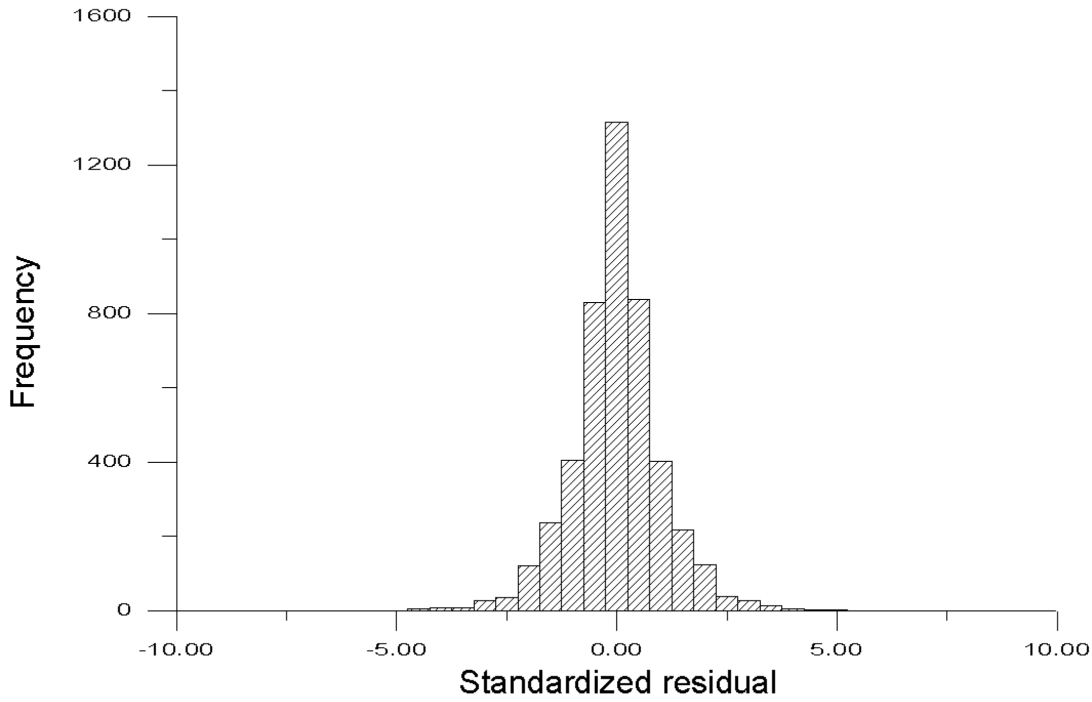


Fig. 3 Plots of standardized residuals derived from GLM model for including the data of Sub-area 3.

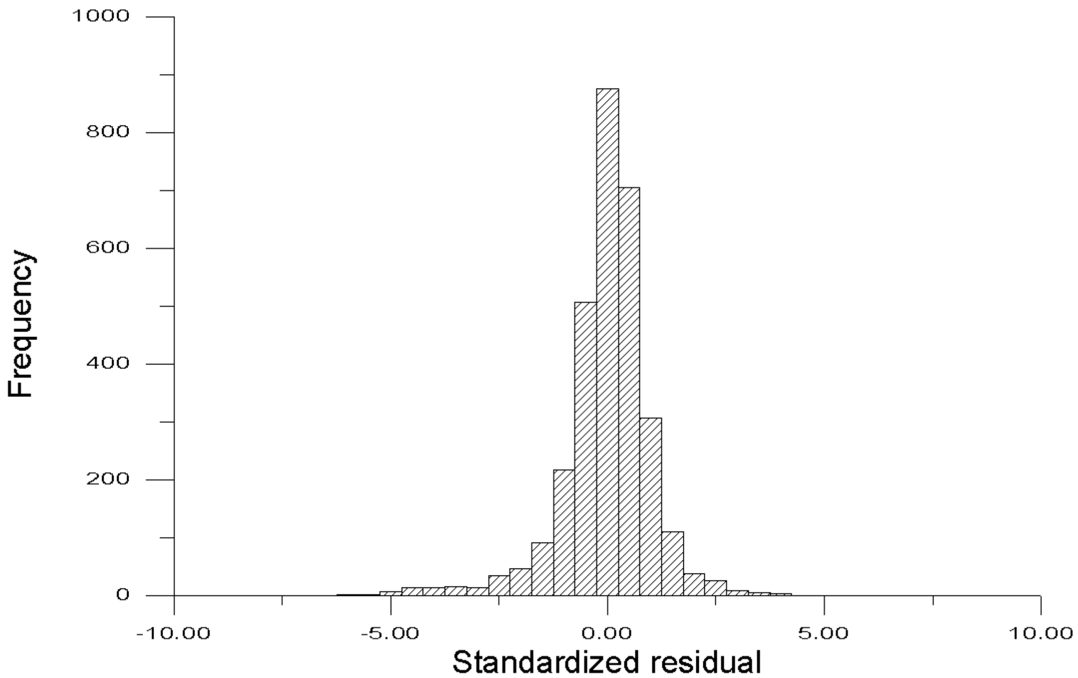


Fig. 4 Plots of standardized residuals derived from GLM model for excluding the data of Sub-area 3.

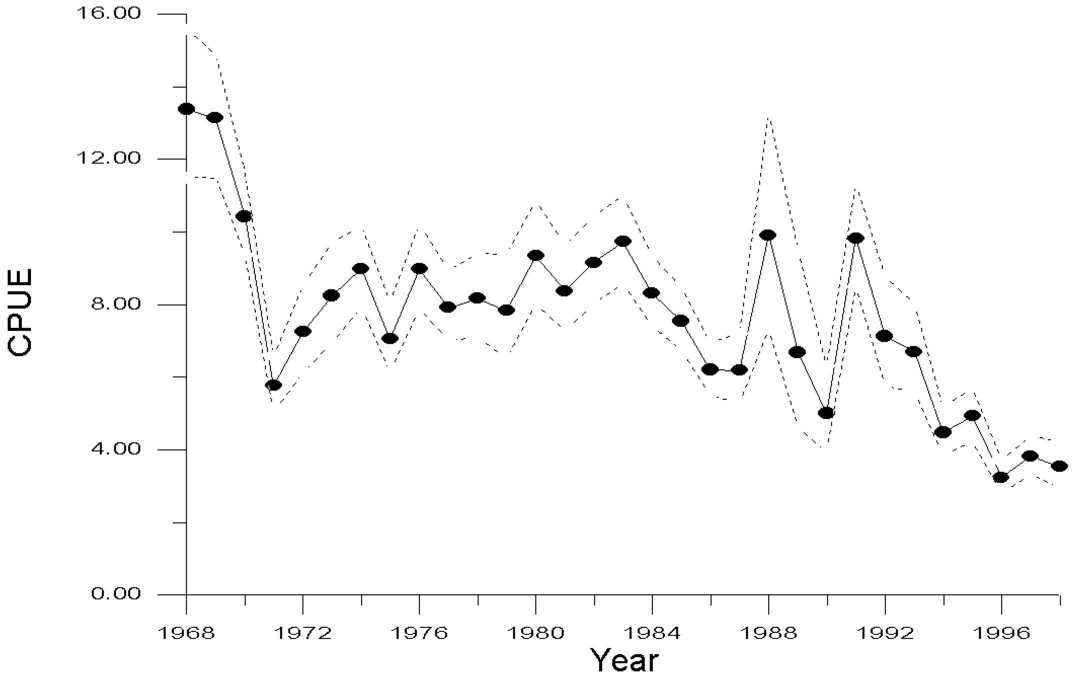


Fig. 5 Standardized CPUE of North Atlantic albacore from Taiwanese longline fisheries for including the data of Sub-area 3.

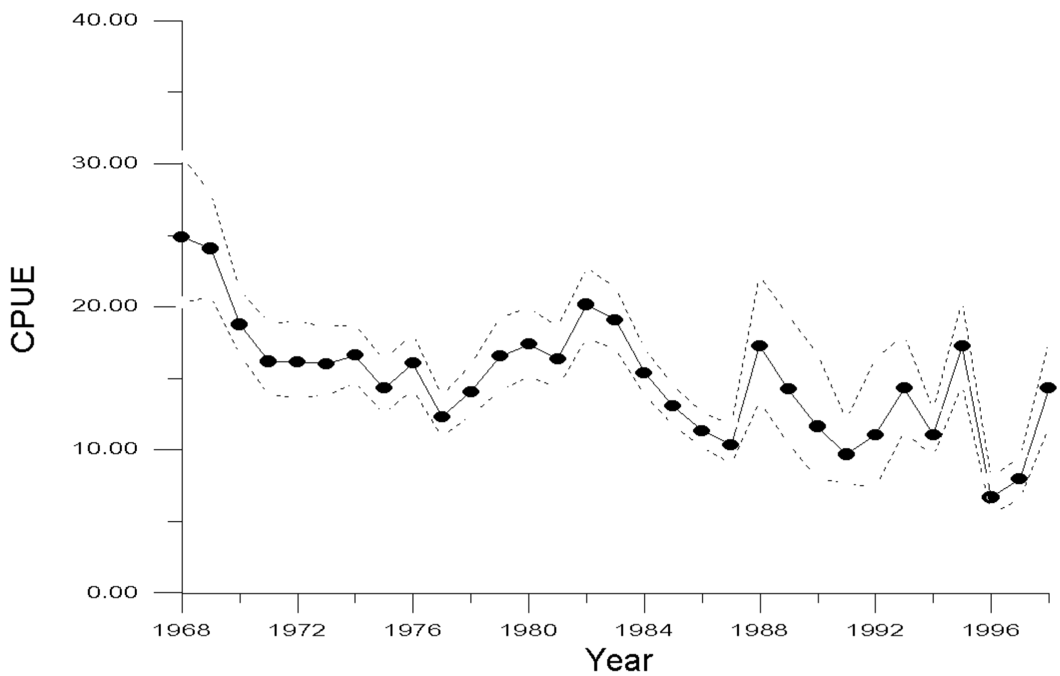
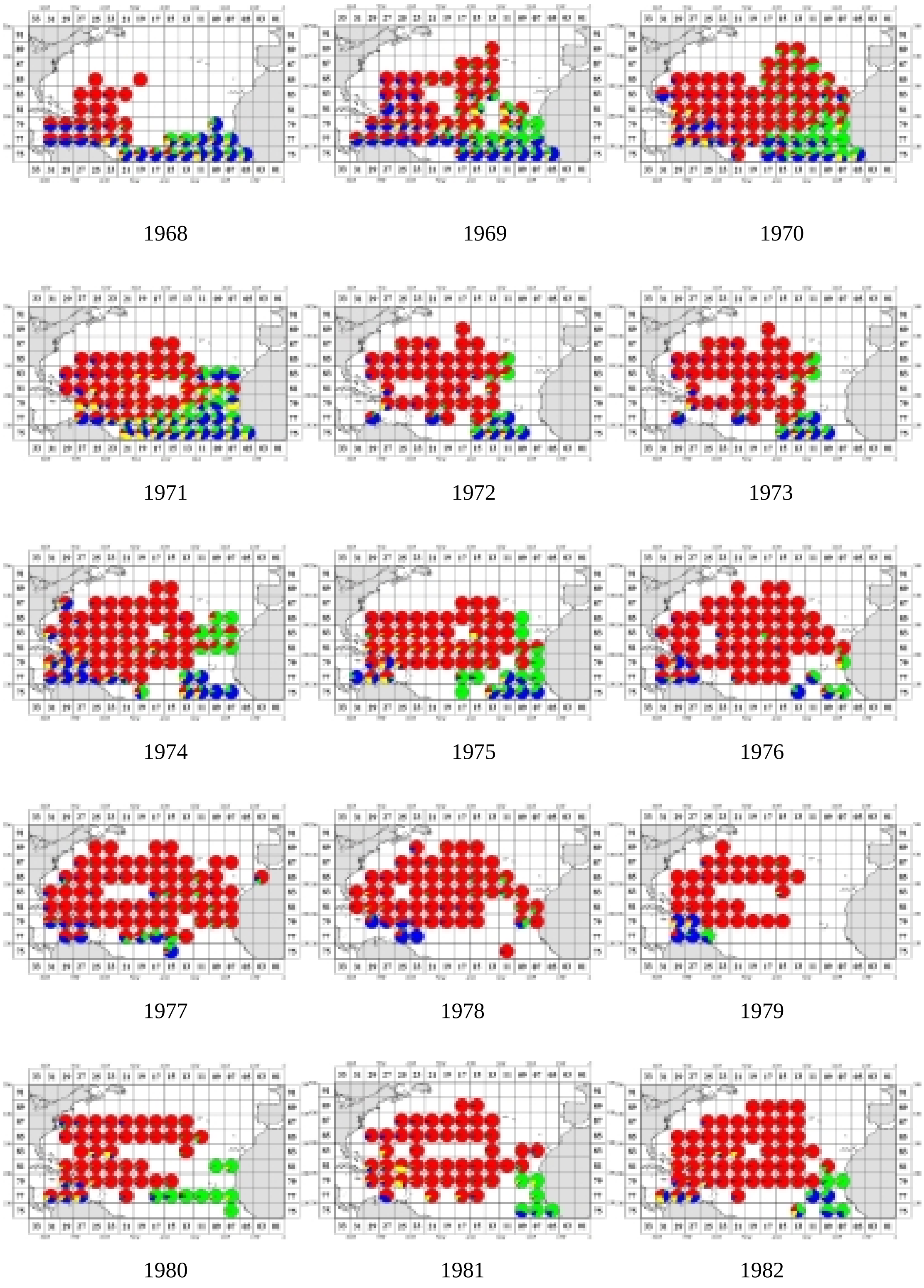


Fig. 6 Standardized CPUE of North Atlantic albacore from Taiwanese longline fisheries for excluding the data of Sub-area 3.



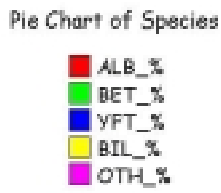


Fig. 7 Annual species composition by 5x5 block of Taiwanese longline fishery in northern Atlantic during 1968-1998.

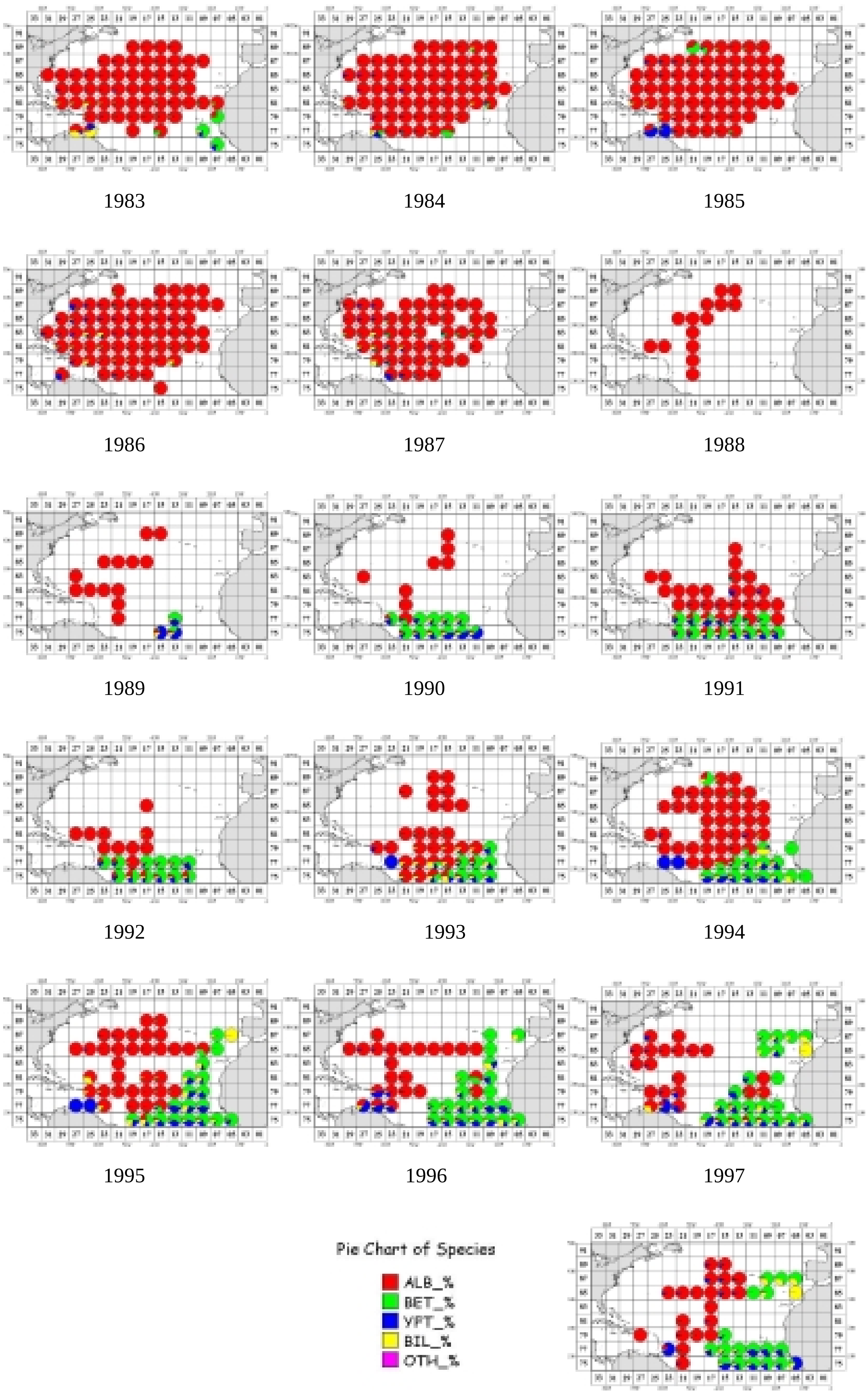


Fig. 7 (continued)

1998