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STANDARDIZED CATCH RATES OF YELLOWFIN TUNA (*Thunnus albacore*) FROM THE TAIWAN TUNA LONGLINE FISHERY IN THE CENTRAL AND WESTERN PACIFIC OCEAN*

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INTRODUCTION

Taiwan's distant-water tuna longline, or Taiwn's longline, vessels have been fishing in Pacific since 1963 and the target species is albacore (*Thunnus alalunga*)(Sun and Yeh, 1992).

Standardized abundance index has been used by scientists and fishery management organizations for monitoring the current status of fish stock for a long time (Turner, 1987).

The purpose of this paper is to develop a model, using the general linear model (GLM) procedure, to estimate the standardized catch rates of yellowfin tuna caught by Taiwanese longline fleet in the central and western Pacific. This paper provide a preliminary description of the patters or trends of abundance of the yellowfin tuna in the central and western pacific.

MATERIAL AND METHOD

The data were presented as catch, the number of fish taken and effort, the number of hooks used, in an area, $5^{o} \times 5^{o}$ square per month during the period 1967-1991. The nominal CPUE value represents catch in number of yellowfin per 1000 hooks.

The main variables chosen to implement the GLM analyses (Draper and Smith, 1986; Kimura, 1981; Robin and Punsly, 1984) were year, month, area and peak spawn season-area. The area was defined by the WPYRG convention (Fig. 1). The few observations from area WPYF-1 and WPYF-2 were excluded to insure a balanced design. The month of year was selected as fishing season and the years covered were from 1967 to 1991. Peak spawn season-area was between November-April in the western equatorial region (10^{o}N - 5^{o}S, 130^{o}-170^{o}E) and March-September in central equatorial region (10^oN-10^oS, 180^o-120^oW) described by Sakagawa (1992).

To facilitate the estimation of the parameters, the interaction terms of the main variablese were omitted and a value of 1 was added to the CPUE values to treat zero catches. The multiplicative model was reduced to:

$$LN(CPUE+1) = \mu + Y_i + M_j + A_k + P_l + \varepsilon_{ijkl}$$

where LN: Natural logarithm

CPUE: Nominal CPUE (catch in number per 1000 hooks) in year i, Month j, Area k and peak spawn season-area l

μ: overall mean

Y_i: year i

M_j: month j

A_k: WPYF area k

P_l: peak or non-peak spawn season-area

ε_{ijkl}: error term, N $(0, \sigma)$

F-tests were conducted on all main variables to determine whether or not each contributed significantly to the model. At the conclusion of each GLM run, the least significant effect was removed and the new model was tested again. This process was repeated until all remaining variable contributed significantly to the model. The frequency distribution of the standard residuals (observed - predicted)/standard error of the estimate were examined at each level of main variables and for whole model to ensure that they approximated the normal distribution. The final model was used to develop standardized catch rates for each year.

RESULT AND DISCUSSION

The total number of observations for this analysis was 6827, and the number of observations in each main variables were shown in Table 1. The frequency distribution of the standardized residual for individual variables as well as for their combined effects were shown in Fig. 2. The combined distribution of the standardized residual is very close to that of the normal distribution. In some cases the distribution of normalized residual of individual variable differs from that of the normal.

The results of using GLM analysis of variance (ANOVA) to examine logged catch rate for differences among the variable of years, months, areas and peak spawn season-area are shown in Table 2. All the main variables as well as the whole model are statistically significant. The rate of variability with a relatively moderate coefficient of multiple determination (R^2) of 0.49, only 49% of variability is explained by the model.

Estimated CPUE and nominal CPUE are shown in Figs. 3. There is a downward trend of CPUE after 1971 until 1977. An increase was noted during the 1978-79 period. The CPUE decreased to smaller than one fish per 1000 hooks after 1981, with the except in 1983, 1985 and 1988. The level of CPUE for 1989-1991 were below 0.2 fish per 1000 hooks.

Fig. 4 shows a high CPUE values by Taiwan's longline fishery during the peak spawning activity as compared data from non-peak spawning season and area. This result is similar to that of the purse seine in the same season and area noted by Sakagawa (1992).

It should be noted that the yellowfin tuna is not the primary target species of Taiwanese longline fishery. It is possible for the annual trends in hook rates to be affected by trends in targeting caused by trends in alblcore fishing success.

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Turner, S.C., 1987. Catch rates of bluefin tuna in Japanese longline fishery recorded by United States observers. Int. Comm. Conserv. Atl. Tunas, Col. Vol. Sci. 26(2): 323-328.

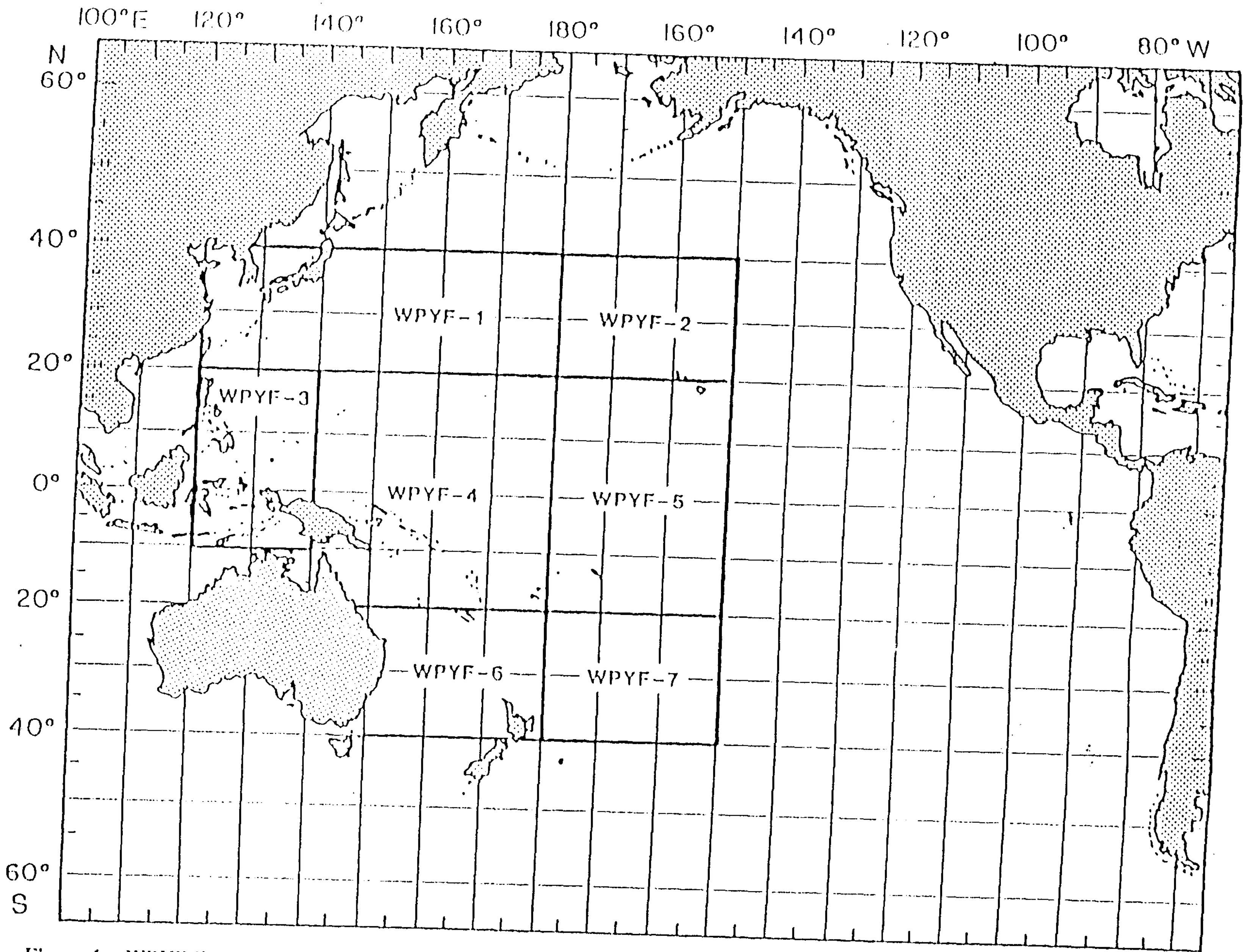


Figure 1. WPYRG statistical areas for compiling fisheries data.

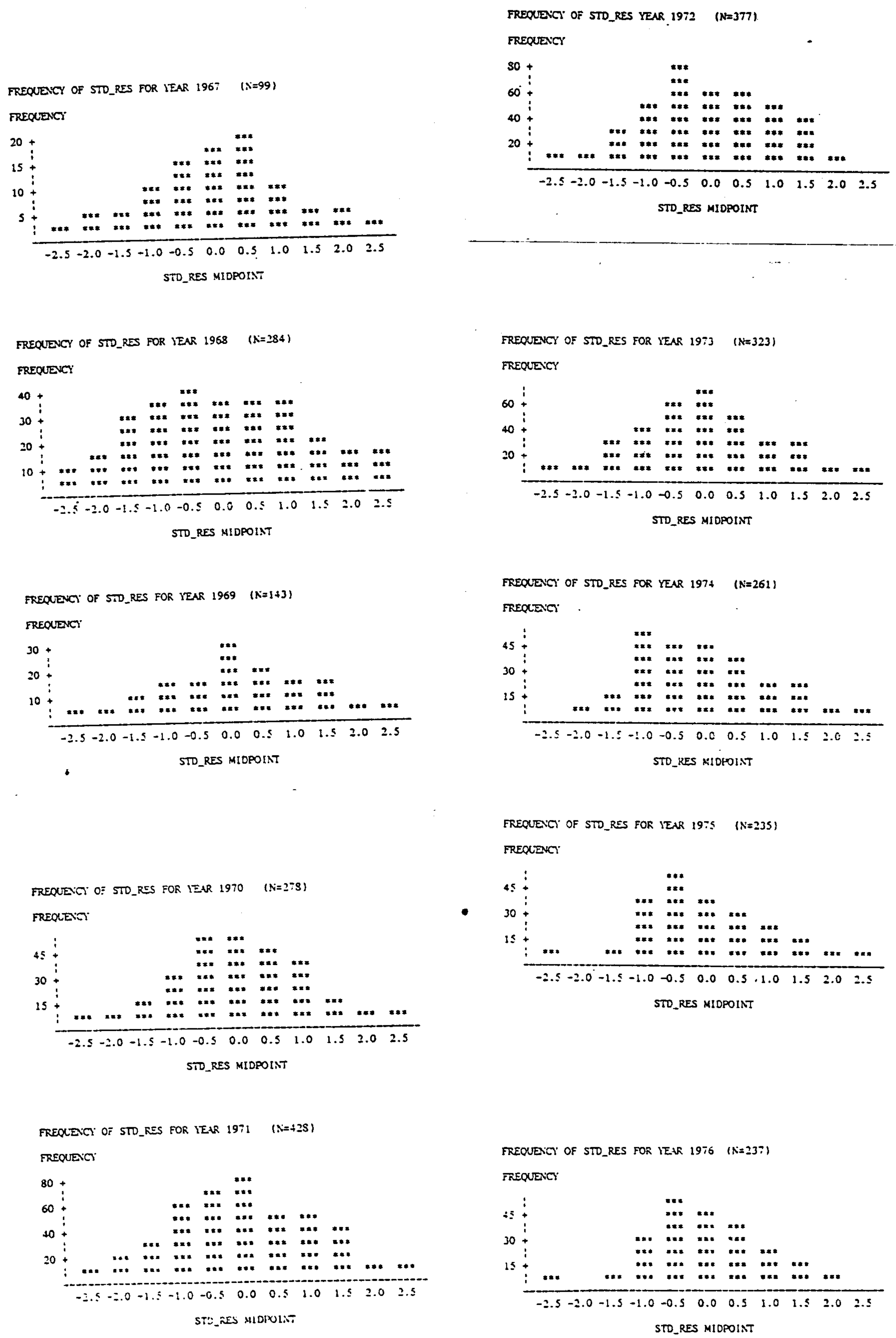


Fig. 2-1. Distributions of standardized residuals at each level of year tested in the GLM procedure.

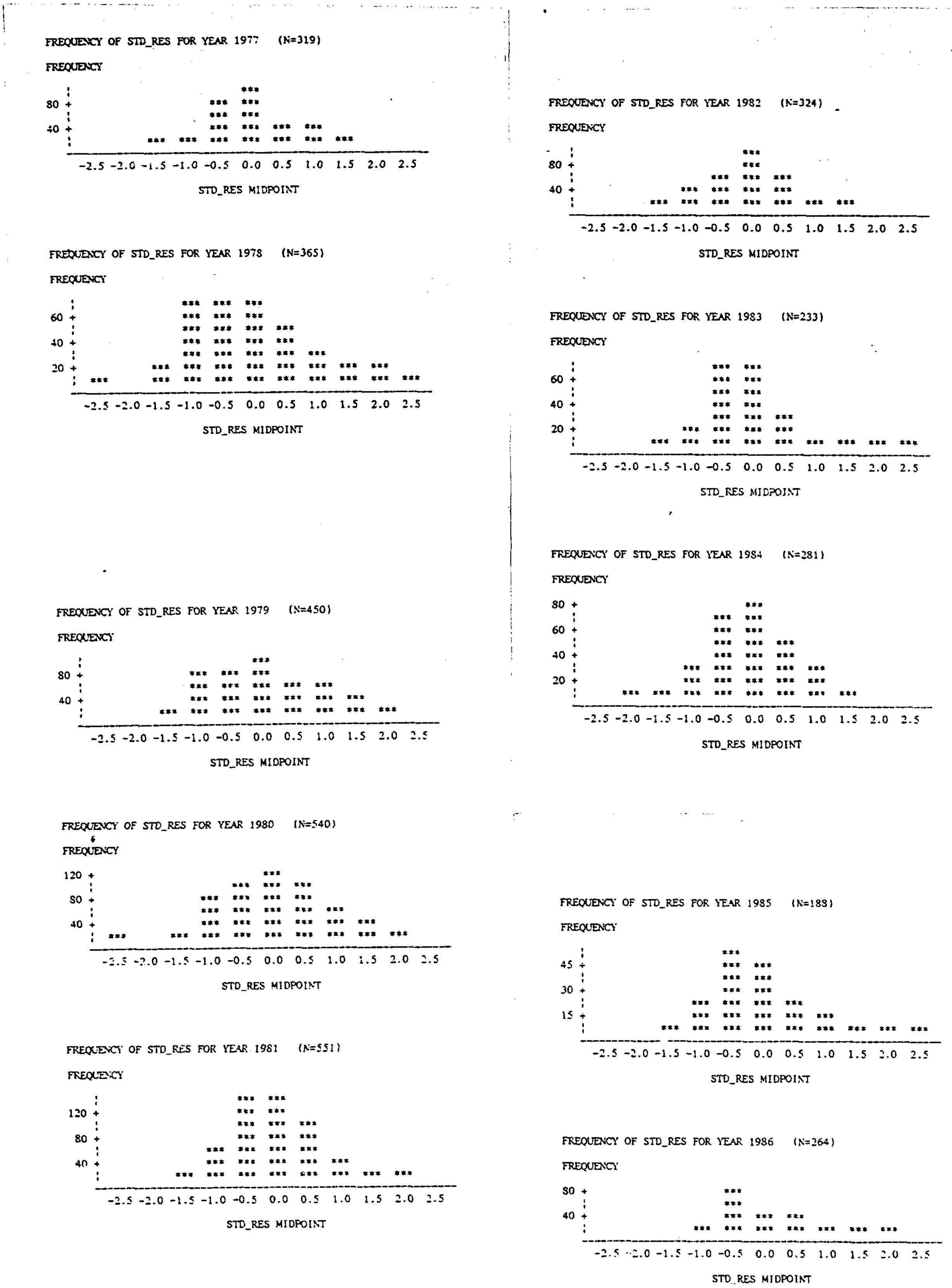
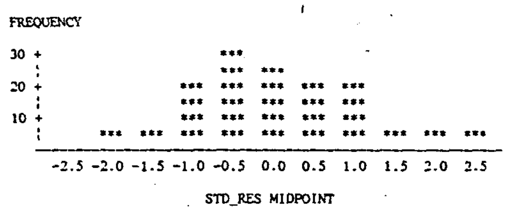
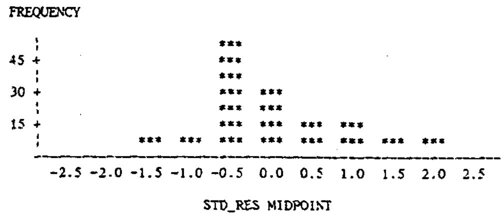


Fig. 2-1. Distributions of standardized residuals at each level of year tested in the GLM procedure. (contd.)

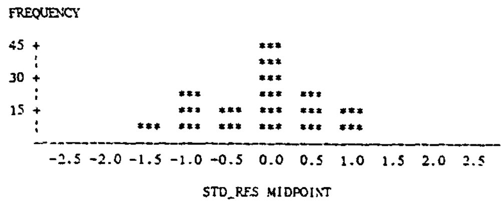
FREQUENCY OF STD_RES FOR YEAR 1987 (N=134)



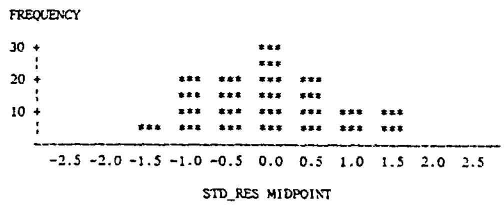
FREQUENCY OF STD_RES FOR YEAR 1988 (N=138)



FREQUENCY OF STD_RES FOR YEAR 1989 (N=133)



FREQUENCY OF STD_RES FOR YEAR 1990 (N=112)



FREQUENCY OF STD_RES FOR YEAR 1991 (N=130)

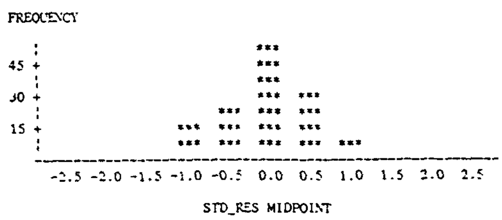


Fig. 2-1. Distributions of standardized residuals at each level of year tested in the GLM procedure. (contd.)

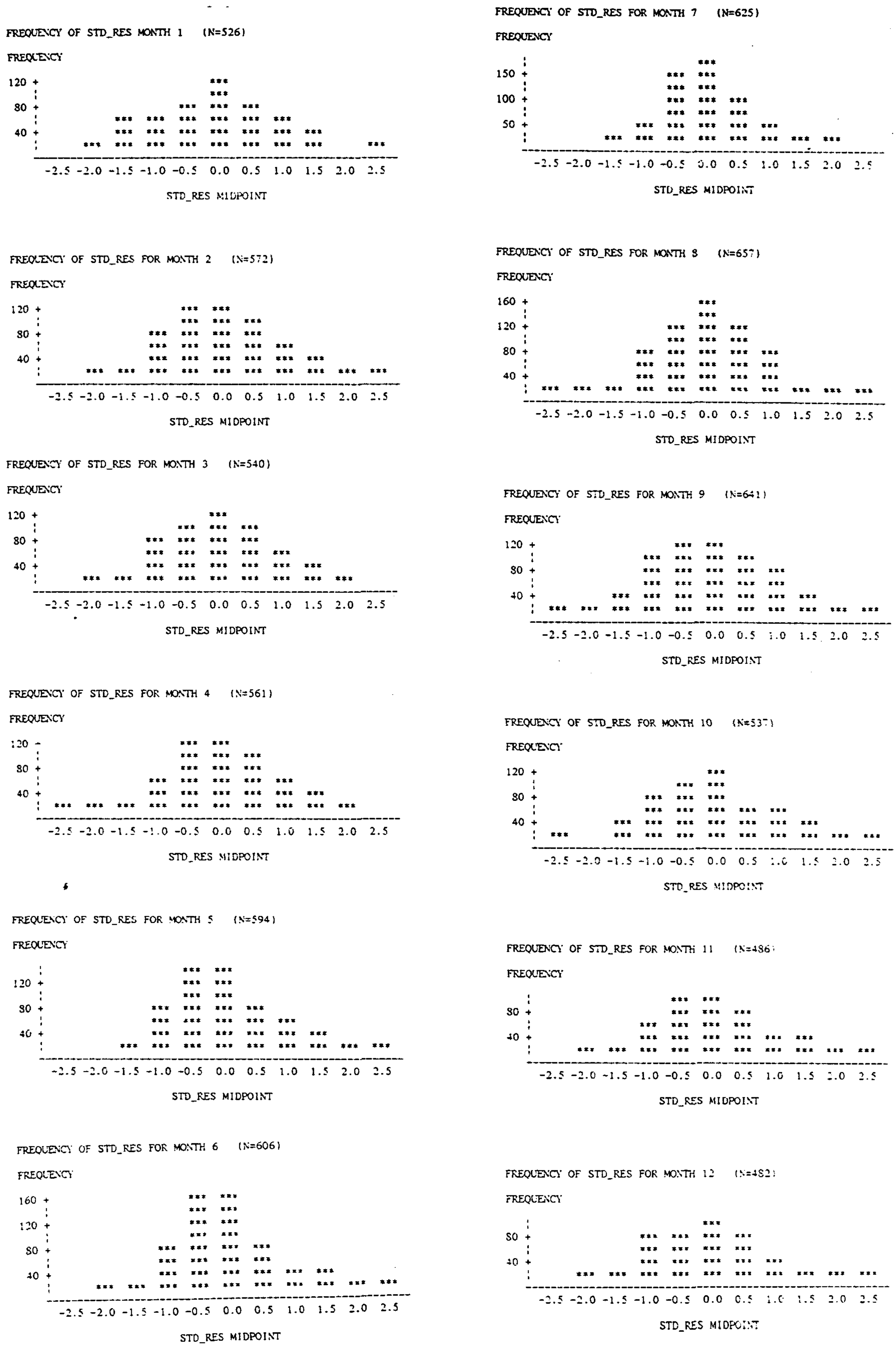


Fig. 2-2. Distributions of standardized residuals at each level of month tested in the GLM procedure.

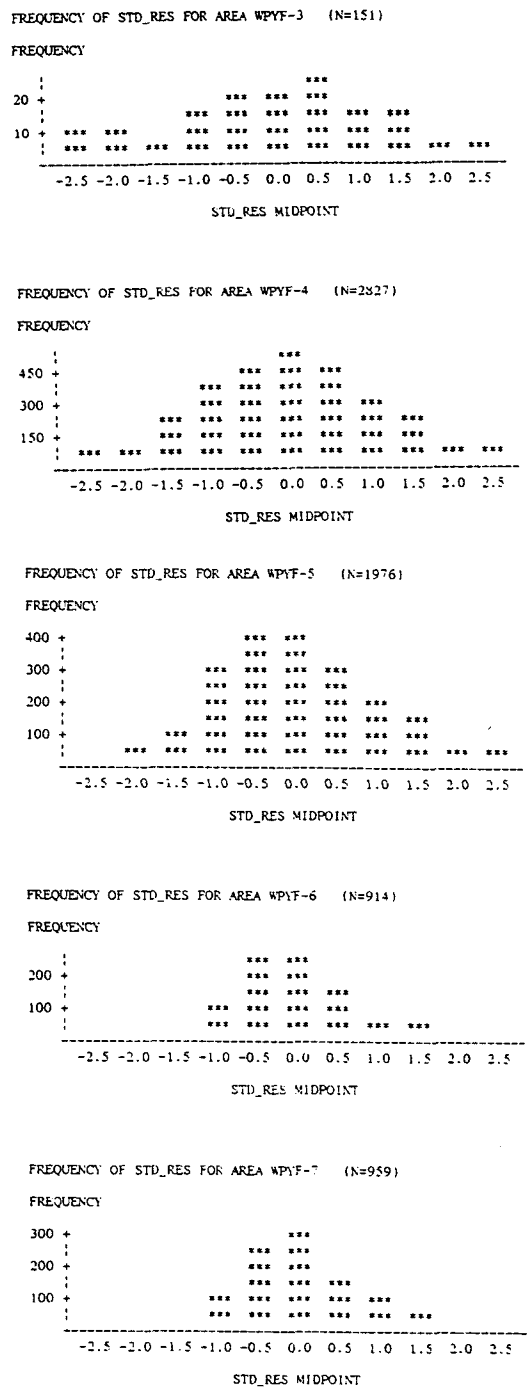


Fig. 2-3. Distributions of standardized residuals at each level of area tested in the GLM procedure.

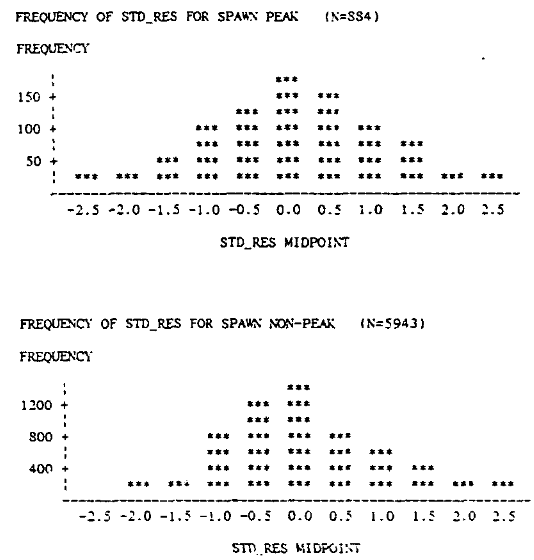


Fig. 2-4. Distributions of standardized residuals at the level of peak and nonpeak spawn season-area tested in the GLM procedure.

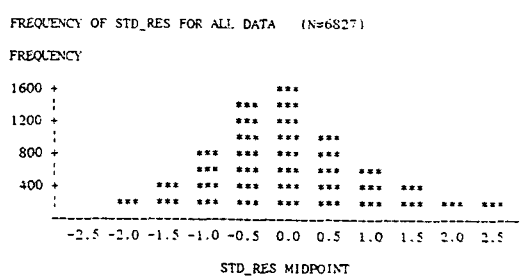


Fig. 2-5. Distributions of standardized residuals of the final model determined using the GLM procedure.

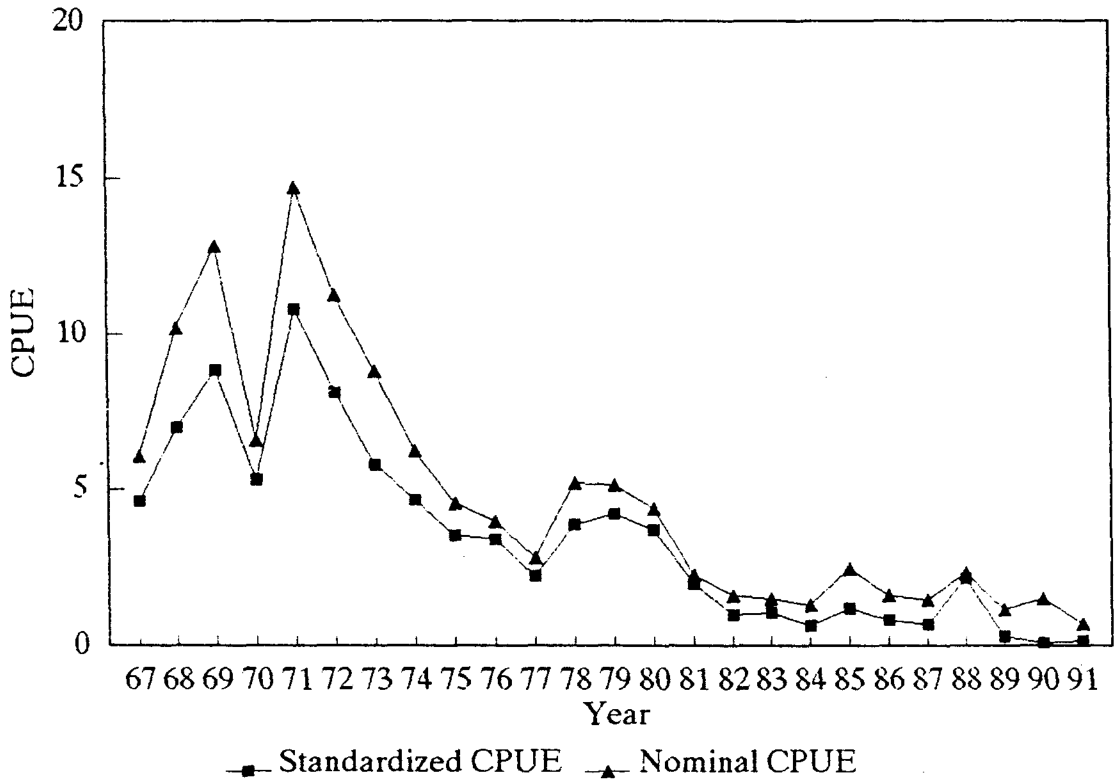


Fig. 3. Standardized and nominal CPUE (number of fish per 1000 hooks) of yellowfin tuna for Taiwan longline fishery in the central and western Pacific. 1967-1991.

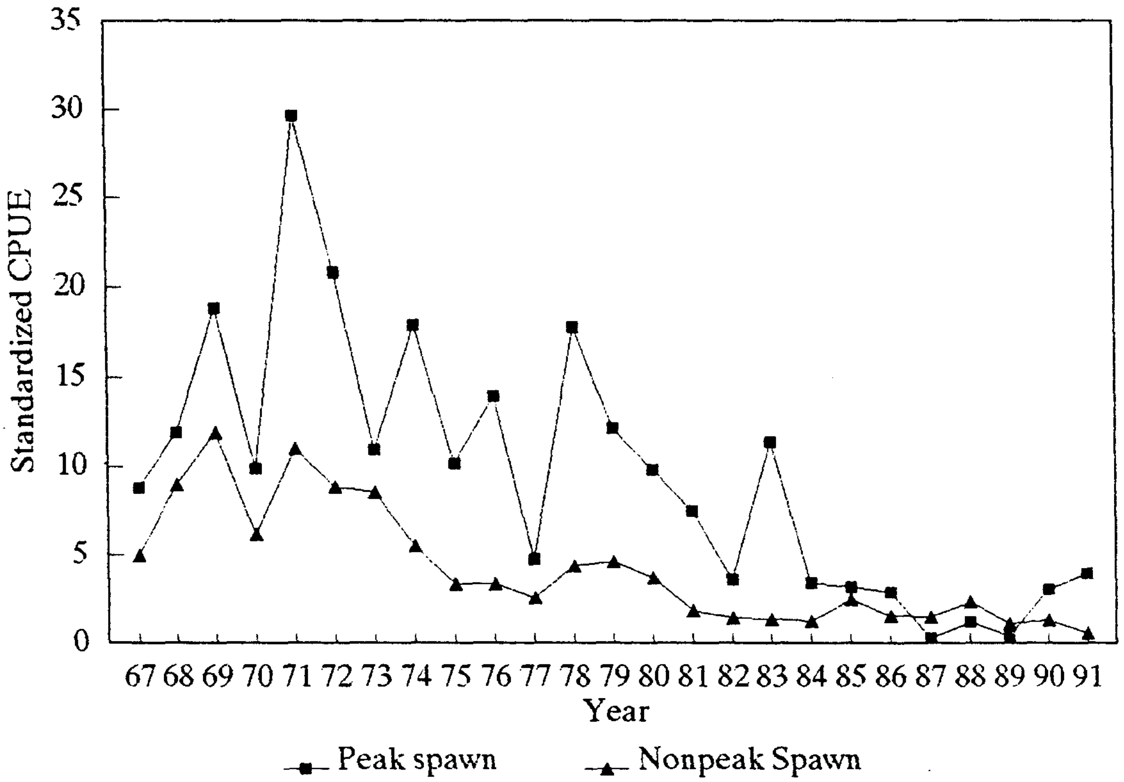


Fig. 4. Standardized and nominal CPUE (number of fish per 1000 hooks) of yellowfin tuna by peak and nonpeak spawn season-area for Taiwan longline fishery in the central and western Pacific, 1967-1991.