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COMPARISON OF TWO ABUNDANCE INDICES BASED ON JAPANESE CATCH AND EFFORT DATA BY ONE-DEGREE AND FIVE-DEGREE SQUARES FOR THE ATLANTIC BLUEFIN TUNA IN THE GULF OF MEXICO

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SUMMARY

Two abundance indices were calculated using the Japanese catch and effort data for Atlantic bluefin tuna during 1973-1981 in the Gulf of Mexico. Comparing those indices based on one-degree and five-degree squares, no substantial differences were recognized.

RESUME

Deux indices d'abondance ont été calculés à partir des données japonaises de capture et effort portant sur le thon rouge de l'Atlantique dans le golfe du Mexique pour les années 1973-81. Une comparaison de ces indices par carrés de 1° et de 5° n'a pas révélé de différence substantielle.

RESUMEN

Se calcularon dos índices de abundancia por medio de los datos japoneses de captura y esfuerzo del atún rojo atlántico en el Golfo de México, durante el periodo 1973-1981. Comparando dichos índices en base a cuadrículas de un grado y cinco grados, no se observan notables diferencias.

Introduction

The spawning area of Atlantic bluefin tuna is located in two separated places of the Mediteranean Sea and Gulf of Mexico (Richards, 1976). In the Gulf of Mexico, Japanese tuna longliners had been mainly catching yellowfin tuna and white marlin, untilcatch of bluefin tuna exceeded 1,000 fishes in 1974 for the first time. Then the interest in this species started to increase. The reasons for a greater interest in bluefin tuna are that the bluefin tuna is fairly large (2 to 3 m) and the value of bluefin tuna as SASHIMI is high.

The number of bluefin tuna caught annually is steady in the range of 6,000 to 10,000 since 1975, but based on the agreement of ICCAT, the operation of Japanese fishing boats in this area ceased in 1982. A great interest has been occurred among the ICCAT bluefin tuna scientists as to the possibility in estimating the spawning stock abundance from the catch and effort data of Japanese longliners collected until 1981, because there is no other statistics available. Accordingly, a request was made to Japan to submit 1°-square longline CPUE data in addition to the 5°-square statistics which had been publicized (Anon., 1983).

The purpose of this report is to calculate the bluefin tuna abundance indices in the Gulf of Mexico based on the Japanese catch and effort data for 1°-squares and 5°-squares and to review whether or not there would be difference in the estimated indices for these squares.

Materials and Methods

The catch and effort data of Japanese longliners in the Gulf of Mexico for the period from 1973 to 1981 was edited for each year, month and 5° and 1° squares. The data for 5°-squares was taken from the record of Fisheries Agency (1975 - 1983). At the same time, the 1°-square data which are basis of the above data was compiled from the longliners' catch records filed by the Far Seas Fisheries Research Laboratory. In this report, the former data is called 5°-square statistics and the latter is called 1°-square statistics. The latter is only a sample, since the available data of the catch records from the fisherman were not of 100 percent coverage. The former is an estimate of the total obtained by multiplying an raising factor to the sample. The raising factor used is not the one estimated for the Gulf of Mexico only but that for the whole Atlantic ocean.

The objective research area is set to the Gulf of Mexico north of 20°N and west of 80°W. Since the area of 1°-squares varies by the latitude, it is indicated with a relative value while setting the one 1°-square area on the equator without land as the standard. The 5°-square area is the total of the 1°-squares contained in it.

$$Aj = \sum_{i=1}^{25} Aij = \sum_{i=1}^{25} Sij \cos \theta ij \quad \text{.............} \quad (1)$$

Where,

- Aj: Area of 5°-square j.
- Aij: Area of 1°-square i within 5°-square j.
- Sij: Ratio of sea surface (1.0 if there is no land) in 1°-square i within 5°-square j.
- θij: Average latitude in 1°-square i within 5°-square j.

When the hook rate of ℓ-year κ-month in the "i-th" 1°-square is expressed as $HRi\kappa\ell$, and that of the "j-th" 5°-square as $HRj\kappa\ell$, the abundance indices in the study area can be calculated from the statistics of 1°- and 5°-squares using the following formulae:

$$d\kappa\ell(I) = \sum_j \sum_i (HRi\kappa\ell \times Aij) / \sum_j \sum_i Aij \quad \cdots\cdots (2)$$

$d\kappa\ell(I)$: Abundance index of ℓ-year κ-month obtained from the 1°-square statistics.

(I): Subscript of 1°-square statistics.

$$d\kappa\ell(J) = \sum_j (HRj\kappa\ell \times Aj) / \sum_j Aj \quad \cdots\cdots (3)$$

$d\kappa\ell(J)$: Abundance index of ℓ-year κ-month obtained from the 5°-square statistics.

(J): Subscript of 5°-square statistics.

In order to study the monthly variation of the abundance through the period from 1973 to 1981, we calculated the average monthly hook rate of each 5°-square using the following formula:

$$HRj\kappa = \frac{1}{n} \sum_{\ell=1}^{n} HRj\kappa\ell \quad \cdots\cdots (4)$$

$HRj\kappa$: Average $HRj\kappa\ell$ value during 1973 - 1981.

n: Number of years in which κ-month data was available.

Results

The monthly abundance indices for the 5°-squares were calculated using Formula (4) for the period of 1973 to 1981 and the results are shown in Fig. 1. The abundance index is high in the early half of each year, especially in April and May, and it declines after that. The same comment applies to the abundance indices calculated with Formula (3) (Fig. 2). According to the figure, the number of hooks expended remains steady since 1975 at a level of three to four million each year but the peak of operation shifted to earlier months. In other words, the number of hooks expended was largest in April - August in 1973 - 1975, March - June in 1976 - 1978 and February - April in 1979 - 1981 (Fig. 2). Such annual shift of the fishing season in the Gulf is explained as follows:

1) a cut-off of July-August activity in 1976-1978 was the change in target species from yellowfin tuna and white marlin to bluefin tuna and

2) though the peak bluefin fishing season is apparently in April and May, the longliners exerted earlier season operation due to global quota set-up since 1979 according to the arrangement made between the United States and Japan.

The hook rate in 1°-squares for each year and month are shown in Fig.3. According to the figure, the sea area where the hook rate is high in April and May extends over the range of N25° - N29°, W85° - W95° off New Orleans. In the case of 1980 and 1981 in which the operation was started particularly early, the hook rate was high in the sea area of N23° - N26°, W83° - W86° off Key West in January and February, but it sharply dropped after March. Instead, the abundance became higer in the area off New Orleans, most likely reflecting the migration of the bluefin tuna.

Extremely close correlation is recognized between two abundance indices by years and by months calculated using formulae (2) and (3) (r=0.9566), and there is a linear relationship between them (Fig. 4). When the two estimates are arranged in time series, the trends in abundance indices obtained from the 1°- and 5°-square statistics are almost identical (Fig. 5).

Discussion and Conclusions

It must be noted that the main bluefin tuna distribution is in N25°-N29° in the north-south direction, as shown in Fig. 3, being represented well by the 5°-spuare strata. Furthermore, the hook rates by 1°-square within 5°-squares are inclined to be similar in the same month, suggesting that the bluefin tuna is rather uniformly distributed within a 5°-square. These may be the reasons for the small difference between the two abundance indices calculated from the 1°- and 5°-square statistics.

Based on the monthly change of 1°-square hook rate, it is observable that the bluefin tuna schools fastly migrate from the Straits of Florida to the area off New Orleans in January through March. This movement of the fish also suggests insufficiency of 1°-square as a unit area, compared to the temporal stratum of a month period. In addition, since the main line is set in a length of 50 to 60 miles on the longline tuna fishery, the area of line setting often extends to two or more 1°-squares. Accordingly, it is preferable that the stratification is made in a somewhat larger square.

To summarize the above, it is concluded that 5°-square statistics of the longline fishery in the past is appropriate enough to estimate the abundance of bluefin tuna in the Gulf of Mexico.

It is noted that since 1982 the longline fishery for bluefin tuna has not been conducted in the Gulf, which made it impossible to obtain abundance index of spawning stock. It is desirable that on monitoring basis longline fishery or other fishery be conducted to measure their abundance index. Most preferable time-area for monitoring should be April - May and the area of 25-30°N and 85-95°W, in which the bluefin tuna remains relatively to a sizable extent.

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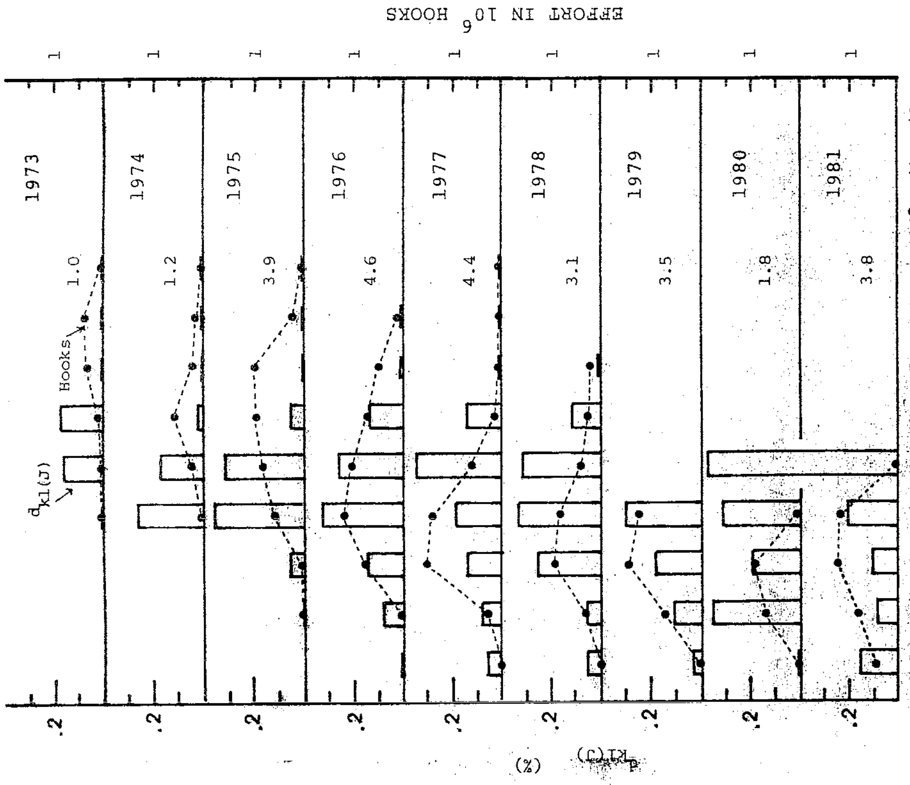


Fig. 2. Monthly change of abundance indices ($d_{k1(J)}$) and expended fishing effort. Numerals in the figure indicate total hooks in 10^6 hooks.

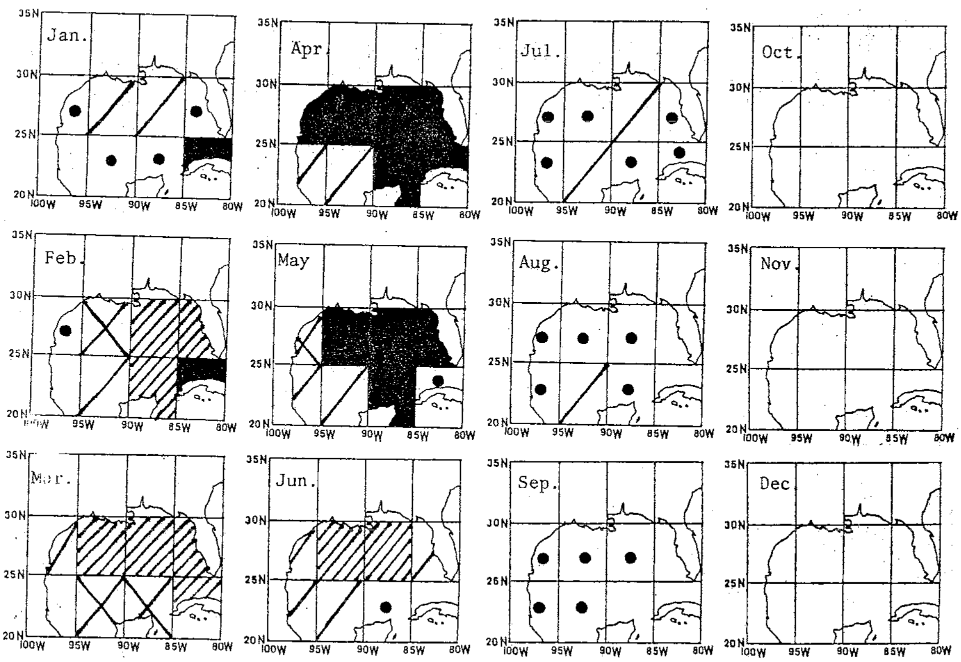


Fig. 1. Distribution of the average abundance indices (HR_{jk}) for 1973-1981.

▣: no catch ▨: less than 0.05 ▩: 0.05 -0.10

▨: 0.10 -0.20 ■: greater than o.20

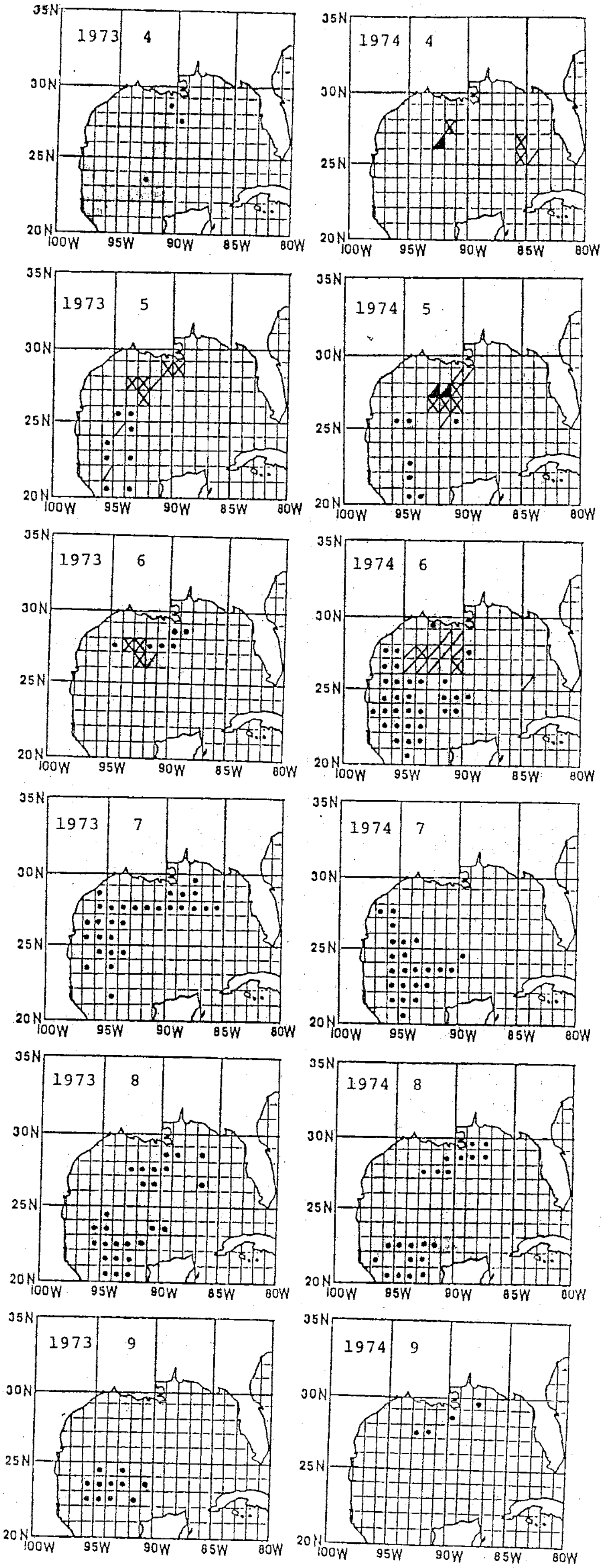


Fig. 3. Monthly distribution of hook rates by one-degree quadrangles during 1973-1981.

⊡: no catch ◪: less than 0.2 ⊠: 0.2-0.5

◩: 0.5-1.0 ■: greater than 1.0

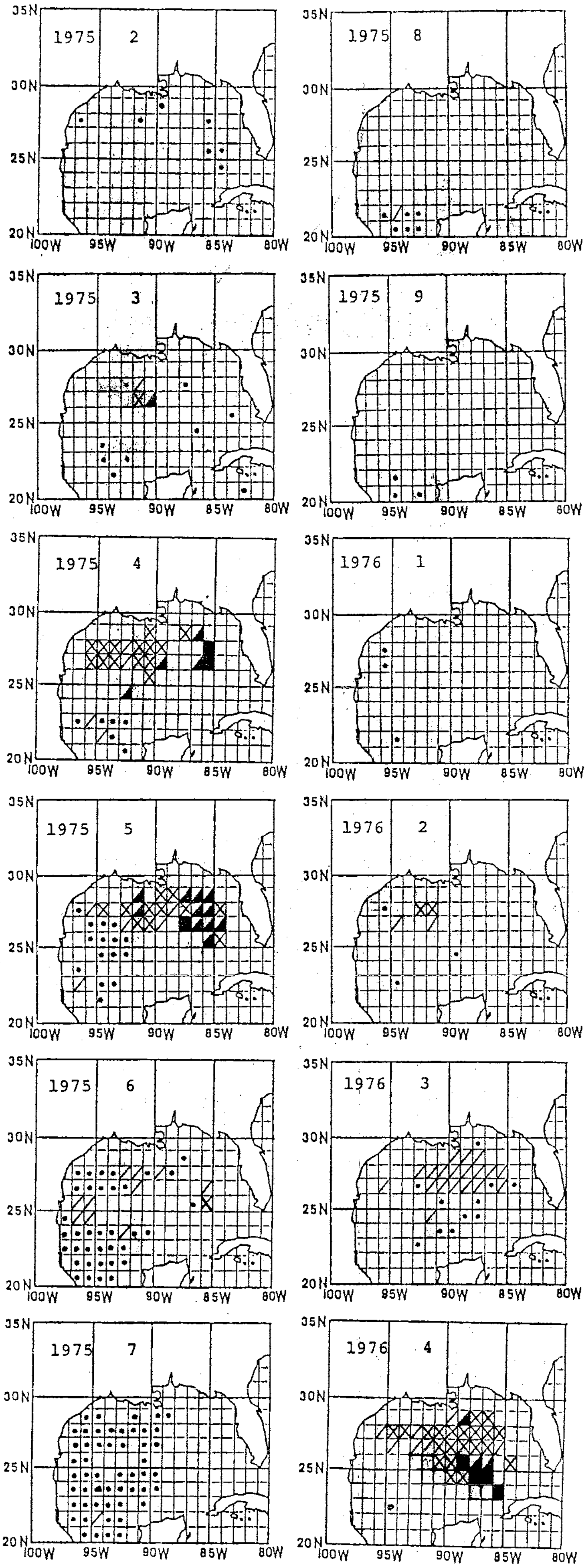
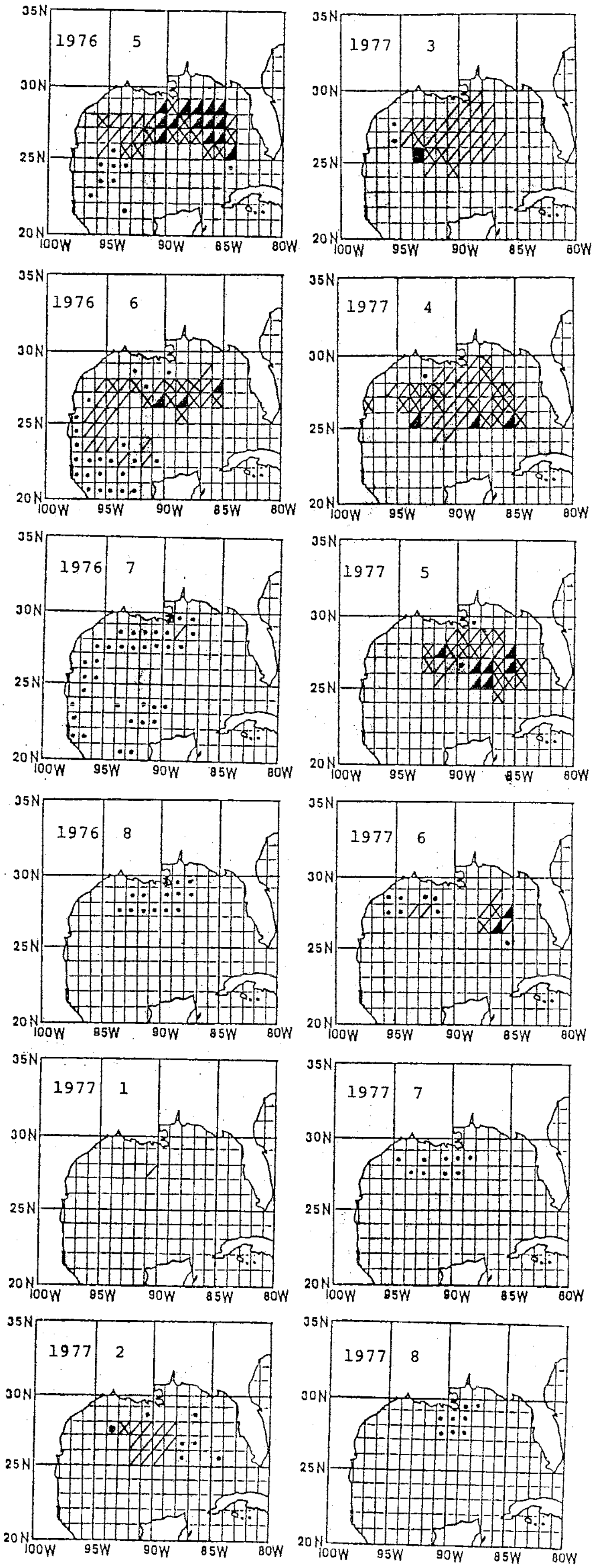


Fig. 3. (Continued)



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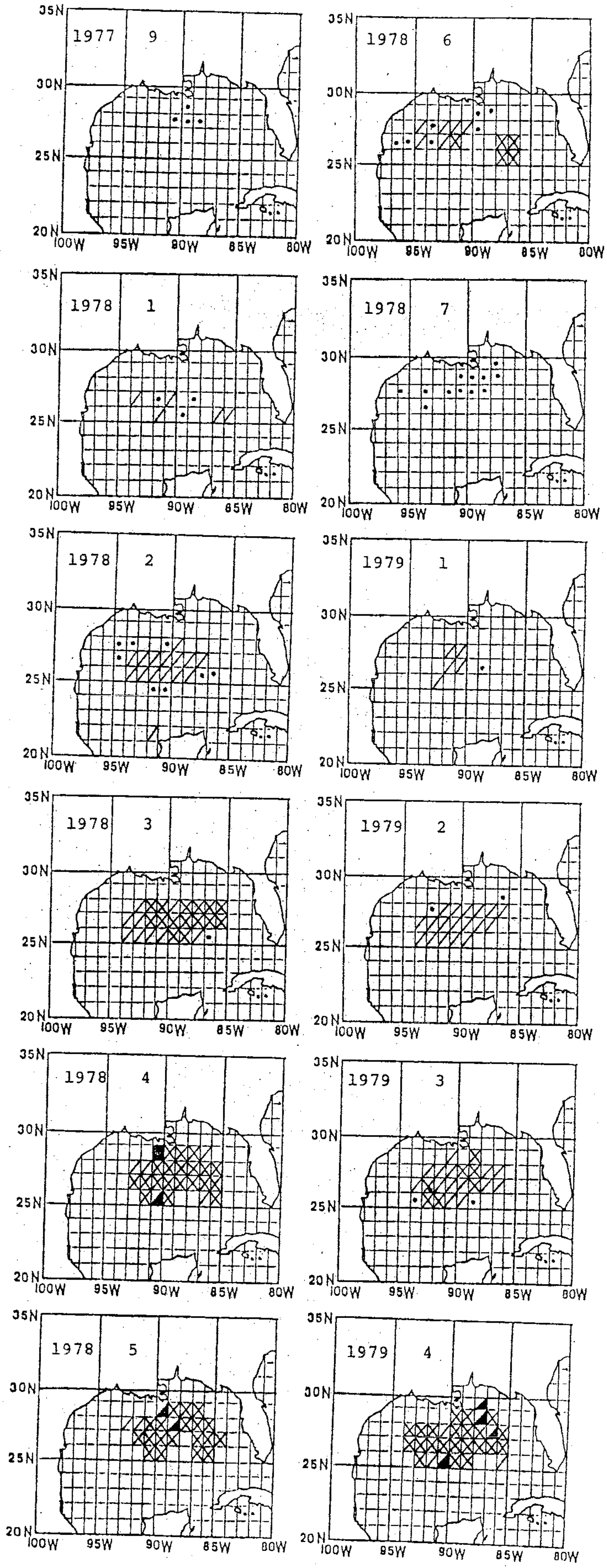

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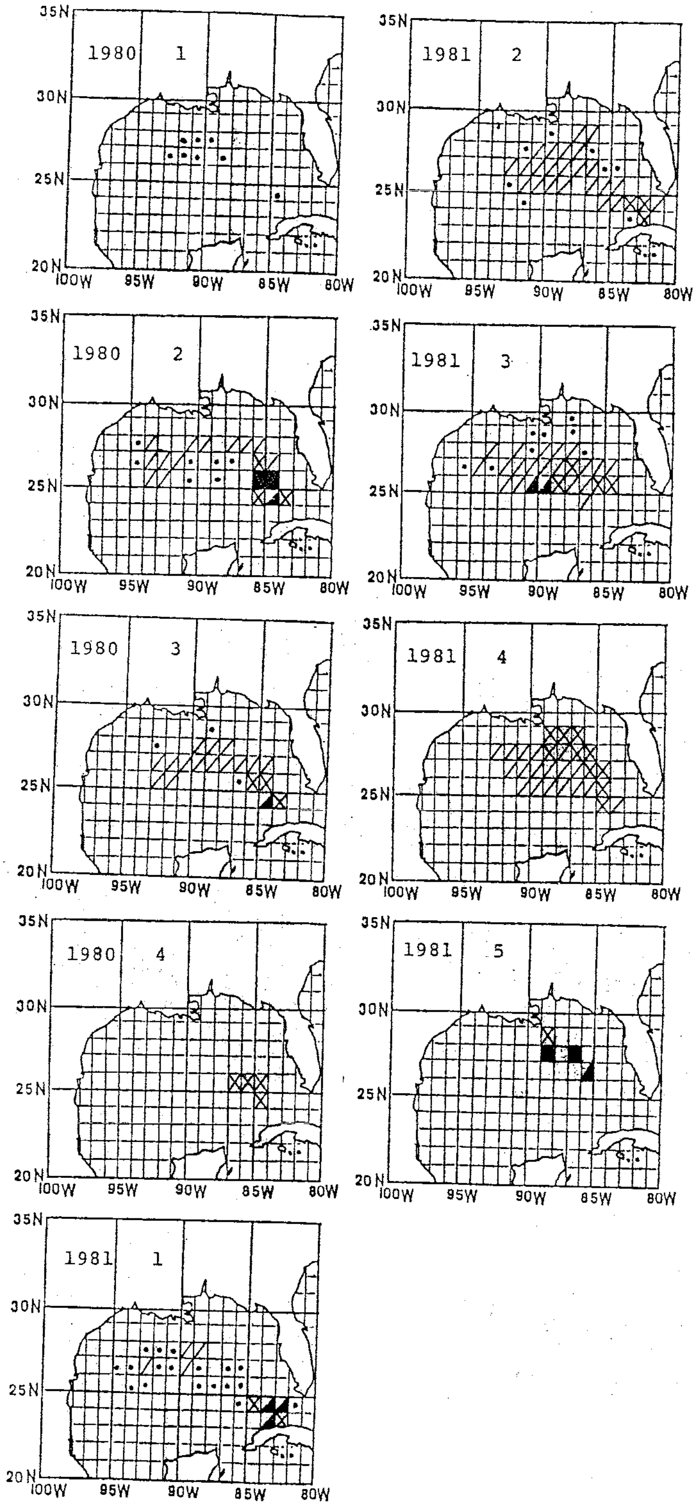

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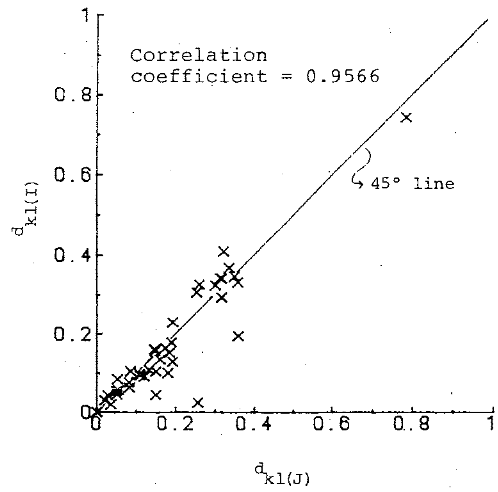

Fig. 4. Relationship between two abundance indices.

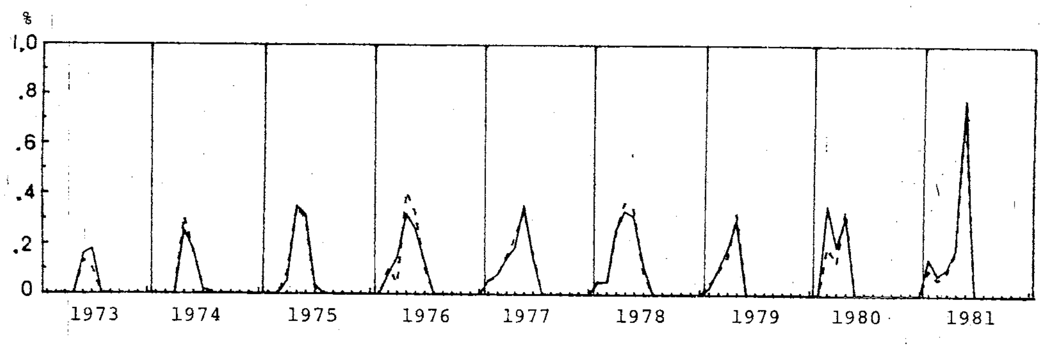

Fig. 5. Monthly change of abundance indices in the Gulf of Mexico during 1973-1981. The broken line and the solid line represent $d_{kl(I)}$ and $d_{kl(J)}$, respectively.