ANALYSIS ON THE ATLANTIC BLUEFIN TUNA STOCK CAUGHT BY LONGLINE FISHERY, BASED ON THE DATA UP TO 1978

by

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1. Change in catch by Japanese longline fleet in recent years

In the recent three or four years, Japanese longline fleet in the Atlantic Ocean has operated in four major fishing grounds for the purpose of capturing bluefin tuna. There are two major fishing grounds for the species in the northwestern Atlantic as well as in the northeastern Atlantic, i.e., in the western side an area from south of Newfoundland to off New York (W-1, W-2, W-3) and northern part of the Gulf of Mexico (W-5) and an area extending from the Strait of Gibraltar to coastal areas of Moroco (E-3) and the Mediterranean (E-4) in the eastern side (Fig. 1). In the areas W-1, W-2 and W-3, bigeye is most pursued species but bluefin, though minor in terms of number to total catches, form very important component as well.

Catches from the areas W-1 and W-2 have decreased since 1975 (Fig. 2). The decreasing trend in the area W-1 is particularly clear which reflects the change in fishing strategy of the longline boats to bigeye. As for 1977 and 1978, catches from the area W-3 are predominant, especially for 1977 catch that would be traced back to the strong 1973 year class.

Substantial longline operations for bluefin in the Gulf of Mexico has begun from 1975, followed by biggest catch of about 10,000 fish in 1976 and about 8,000 fish are estimated to have been captured in 1978 (Fig. 2).

A fairly good catch was recorded from the Bay of Biscay in 1974 but this area is no longer counted as a major bluefin fishing ground because after that year few boats have become to operate there. Except for its biggest catches in 1974 with more than 10,000 fish, the catches from the Bay of Biscay have decreased recently to a negligible level after experiencing 3,000 fish in 1975 (Fig. 3).

In the Strait of Gibraltar area, the catches were highest in 1975, about 20,000 fish and annual catch for 1976 and 1977 was about a level of 8,000 to 9,000 fish. Catch in the Mediterranean showed drastic decline after about 13,000 fish in 1974 and the estimated catch was about 3,000 fish in 1977. The observed sharp decrease of cathces in the areas E-3 and E-4 is due to effect of fishing regulation in the Mediterranean enforced by the Government of Japan for this species.

2. Change in fishing effort and CPUE in terms of fish caught per 1,000 hooks

CPUE in the area W-1 was relatively high in 1973 but after that year it has decreased gradually (Fig. 4). On the other hand, fishing effort (nominal number of hooks) in this area has increased in the recent years showing over 2 million hooks annually. This reverse trend between the two variables is due to change in target species from bluefin to bigeye as mentioned previously. In cotrast to the low CPUE in the area W-1, that in the areas W-2 and W-3 shows remarkably high values. Annual fishing effort for the area W-2 is roughly constant, about 1 million hooks while CPUE for 1974 and 1977 was very high. Fishing effort for the area W-3 is higher than that in the area W-2 and shows wider fluctuation. Yearly changes of CPUE in the areas W-2 and W-3 appear comparable and the fish caught in 1974 and 1977 would be derived from strong year classes.

Fishing effort in the Gulf of Mexico increased by 1977, recording about 4.5 million hooks in that year but decreased to about 2.9 million in 1978. Annual average CPUE in this area was highest in 1975, 3.7 but after that it decreased to 2.8 and further 2.1 in 1976 and 1977, respectively. In 1978, however, the average CPUE increased again to 2.8.

It is difficult to trace the trend of CPUE in the Bay of Biscay area (E-1) because of drastic reduction of fishing effort to this area in the recent years. Bigeye is being aimed at mainly by the Japanese longliners in the area E-2.

Peak fishing season for the Strait of Gibraltar area (E-3) is in the second quarter (April-June). Fishing effort for this area decreased sharply from 1975 to 1977 while the CPUE after 1973 during which the operations in this area for bluefin became substantial remained fairly constant. In the Mediterranean, fishing effort was relatively stable during the period 1974-1976 but it decreased in 1977. The CPUE for this area decreased from 1974 to 1976 but increased again in 1977 (Fig. 5).

The changes in the CPUE in the major bluefin fishing grounds of the two sides of the north Atlantic are rather stable and from this observation it is not considered that bluefin stock in the north Atlantic is in dangerous condition in particular.

3. Change in length composition of catch by area

Density index (hook rate) by length class were calculated so as to make it possible to compare directly the length composition by area across the years. The procedure is, in a given year and an area:

$$L_i = r.l_i \quad ..... (1)$$

where L_i: density index of i-th length class

r : hook rate

l_i: rate of i-th length class fish to the total

Data from the areas W-2 and W-3 were combined as the length compositions in the two areas were similar (Fig. 6). In these two areas, the fishing season extends from the end of year to January or February of the next year. Therefore, the length data were compiled over that fishing season. Although no data were available in 1974-1975 season, generally for this area, dominant modal group seems to appear at about 115 cm class which is supposed to be formed with the fish aged between three and four years old on the basis of the age-length relationship by Sakagawa and Coan (1973). Other modal groups are located at about 85 cm class and 130 cm class in the early two fishing seasons and at about 150 cm class in the later two fishing seasons.

It is suggested from the length composition in 1976-1977 fishing season that the fish aged between three and four years old, i.e., 1973 year class, would be relatively abundant. However, this abundant year class which is supposed to grow to about 130 cm by the next 1977-1978 fishing season appeared poorly in the length composition. Most possible explanation for this fact would be dispersion of this year class out of the fishing ground in the following year. Fish group with modal length at about 115 cm seems to dominate again in the 1977-1978 length composition and the apparent abundance of that group is higher than that in the 1973-1974 and 1975-1976 fishing seasons. Therefore, except for the 1976-1977 fishing season in which this group was aberrantly abundant, it is inferred that the recruitment of bluefin tuna to this longline fishing ground has been even increasing in the recent years.

Figure 7 shows length composition of bluefin tuna caught from the Gulf of Mexico (W-5) during the period 1975-1978*. Most dominant modal length seems to be located at about 240-250 cm (age 13) with minor yearly fluctuation of the modal position. Since this area is spawning ground of this species, it seems that the recruitment to the spawning stock begins when the fish reach about 190 cm and is attained completely for the fish over 240-250 cm. Considerable amount of 200-220 cm class fish (age 9-11) appears to have recruited to the spawning stock in 1975 but the abundance of this length class in other years is quite low. Run of major spawning group between 230-260 cm class (age 12-15) decreased from 1976 to 1977 but it increased again in 1978.

Data from 1975 to 1977 were available for the Strait of Gibraltar area (E-3) (Fig. 8). Size of dominant year class varied from year to year in this are, i.e., 210-250 cm class (age 10-14) in 1975, 220-260 cm class (age 11-15) in 1976 and again the 210-250 cm class in 1977. In 1977 in addition, run of 160-210 cm class (6-10) is suggested fairly significant.

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*Data for 1978 were made available from on-board measurements by the U.S. scientists.

Due to fishing regulation for the bluefin in the Mediterranean, data only out of peak fishing season are available for the area E-4 from 1975 to 1977 (Fig. 9). Range of length of fish in catch in this area is wider than that in the Strait of Gibraltar. In 1975 and 1976, 200-250 cm class formed major component of the catch while 160-230 cm class were dominant in 1977.

Including the Mediterranean area, density index by length class of bluefin tuna caught by the Japanese longliners in 1977 in the northeastern Atlantic, showing ramarkable differences from that in the previous years, indicated considerable increase of so-called "medium sized fish" ranging from 160-210 cm class.

4. Aspects of recruitment to the spawning stock of the Gulf of Mexico

As an attempt to assess the aspects of recruitment to spawning group in this area, the following calculation was made. Given density index by length class of a certain year are obtained, expected density index by length class in some later years are estimated under the condition that no successive recruitment by the following years occurred and therefore, only removal by natural and fishing mortalities from the initial population are counted in the course of the calculation. In addition, it is assumed that the growth of bluefin tuna follows to that estimated by Sakagawa and Coan (op. cit.) and the fish once recruited in the first year run and are available to the fishery successively in the later years.

Then, difference between the density index by length class expected under the aforementioned conditions in certain years later and those observed actually at that later year would reflect how the aspects of recruitment was during the period. Thus, the difference in density index by length class D is expressed:

$$D = \sum_i \left\{ ({}_{t+n}r \cdot {}_{t+n}l_{i+n}) - ({}_t r \cdot {}_t l_i) e^{-(Mn + \sum_n F_n)} \right\} \quad \ldots\ (2)$$

where ${}_t r$: CPUE (hook rate) in year t

${}_t l_i$: rate of i-th length class to the total catch in year t

M: natural mortality coefficient (0.2, constant regardless of year and length)

F: fishing mortality coefficient

n: number of year counted from the starting year (1, 2, 3, ...)

First, setting the length composition in 1975 as a starting year and calculating the expected length composition weighted by the CPUE in the following successive years by 1978 during which no new recruitment after 1975 was assumed, the expected and observed length compositions were compared (Fig. 10). Initial fishing mortality coefficient of 0.1 was used after Shingu and Hisada (1976) who estimated it for spawning fish. Once fishing mortality coefficient at the starting year is set, the values of F in the following years after 1975 are determined automatically. Black and hatched areas in Figure 10 denote positive and negative values of D.

Major range of length where values of D are positive covers from 230-260 cm class in the left hand side of the modal length of the expected length composition. This implies that new recruitment to the spawning stock has continued during the three years in question. Although nothing can be accurately inferred with the negative parts, they should be attributable to dispersion or removal of the fish out of the fishing season as far as the assumptions are concerned.

Description so far was the case where no new recruitment occuured during the three years. Therefore, from this calculation, the aspects of recruitment in each year are not clear because the positive parts in the last 1978 show the cumulative values of D for the three years. Next, applying the same method to two adjoining years, the result was shown in Figure 11. The range of size recruiting is roughly the same with that in the previous case whereas relative strength of recruitment varied from 1976 to 1978, largest in 1978 and smaller in 1976 and smallest in 1977.

The results of this calculation are summarized that any consistent decreasing trend was not recognized for the recruitment of spawning fish to the Gulf of Mexico area in the recent four years although relative strength of recruitment appeared to have varied from year to year.

References

Sakagawa, G. and A. Coan 1973 A review of some aspects of the bluefin tuna (Thunnus thynnus) fisheries of the Atlantic Ocean, ICCAT Coll. Vol. Sci. Papers, 2(SCRS/73/60), 259-313

Shingu, C. and K. Hisada 1976 A review of the Japanese Atlantic longline fishery for bluefin tuna and the consideration on the present status of the stock, ibid., 2(SCRS/76/43) 366-374

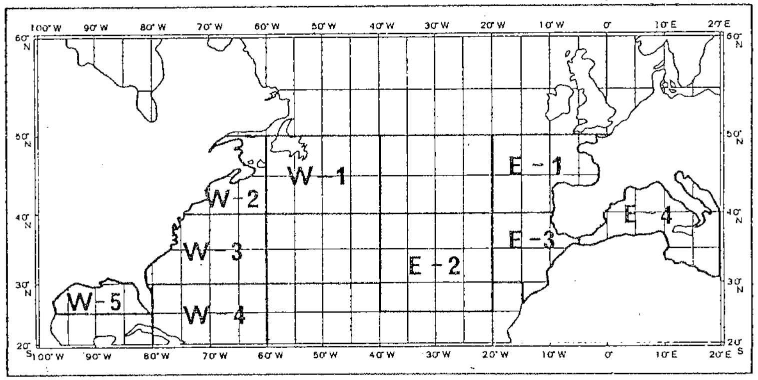

Fig. 1. Fishing areas of Japanese longliners for bluefin in the Atlantic.

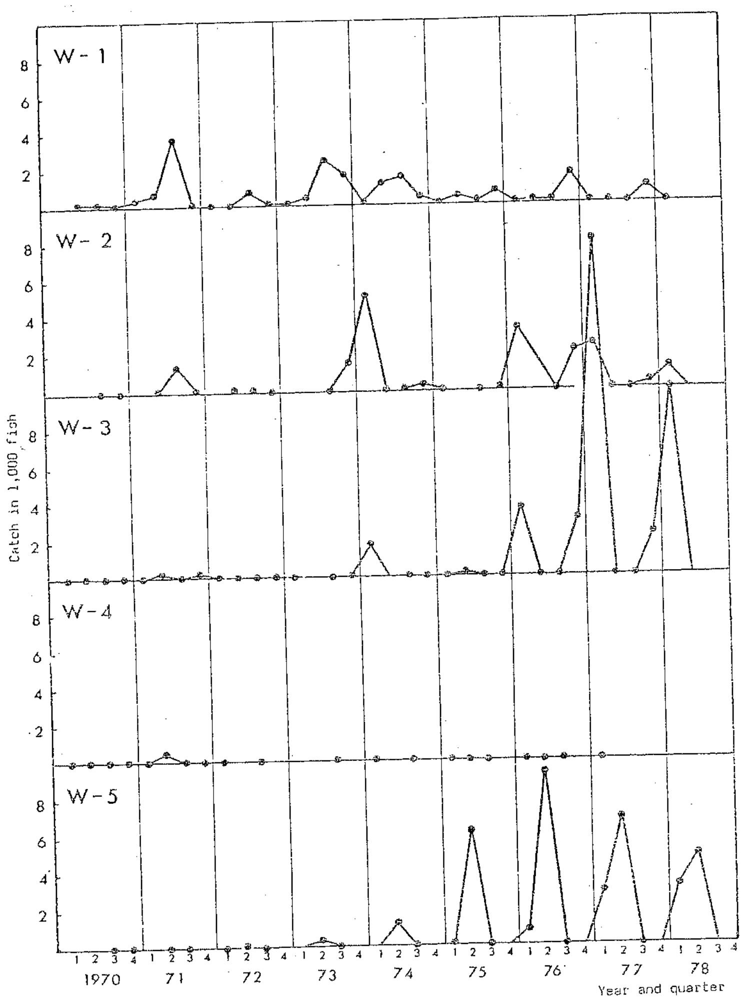

Fig. 2. Catches by area of bluefin caught by Japanese longliners in the northwestern Atlantic.

Data for 1977 and 1978 are provisional.

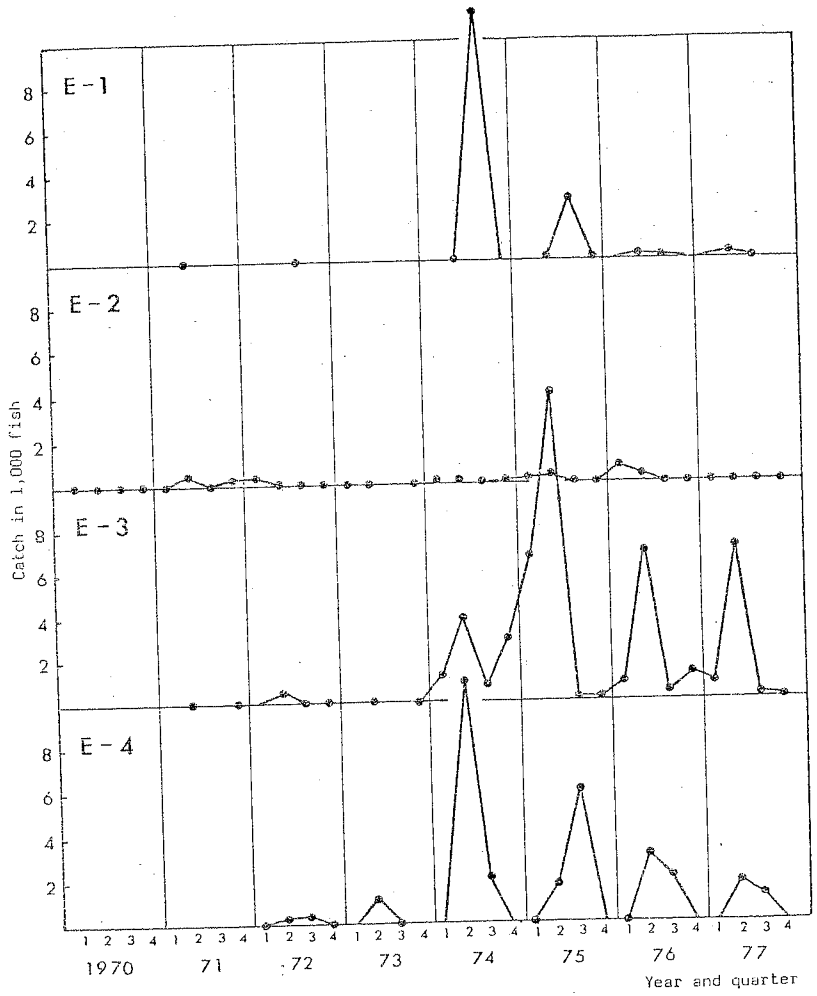

Fig. 3. Catches by area of bluefin caught by Japanese longliners in the northeastern Atlantic.

Data for 1977 are provisional.

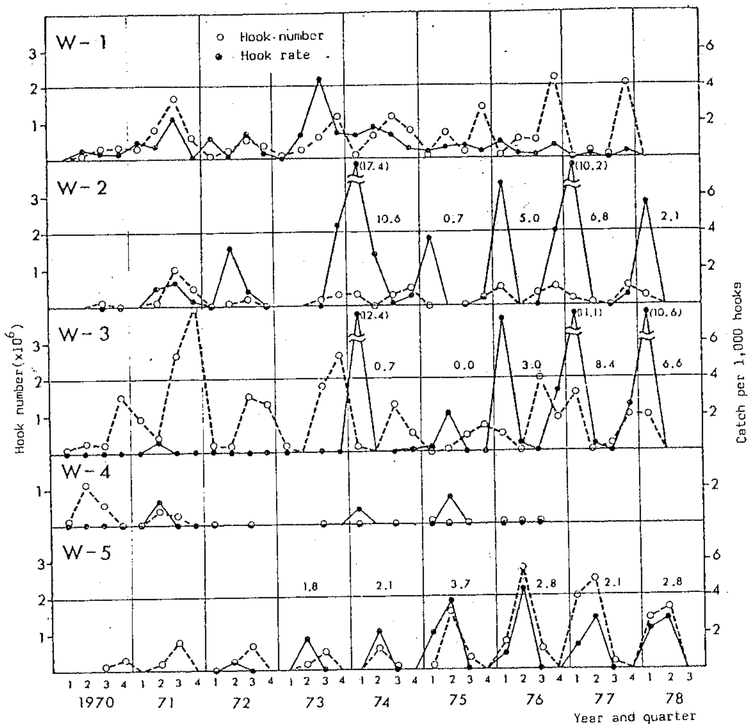

Fig. 4. Changes in fishing effort and CPUE (hook rate) on bluefin by area caught by Japanese longliners in the northwestern Atlantic.

Figures without parentheses denote annual average CPUE calculated over the period from 4th quarter to 1st quarter of the next year for the areas W-2 and W-3, from 1st to 2nd quarter for the area W-5. Data for 1977 and 1978 are provisional.

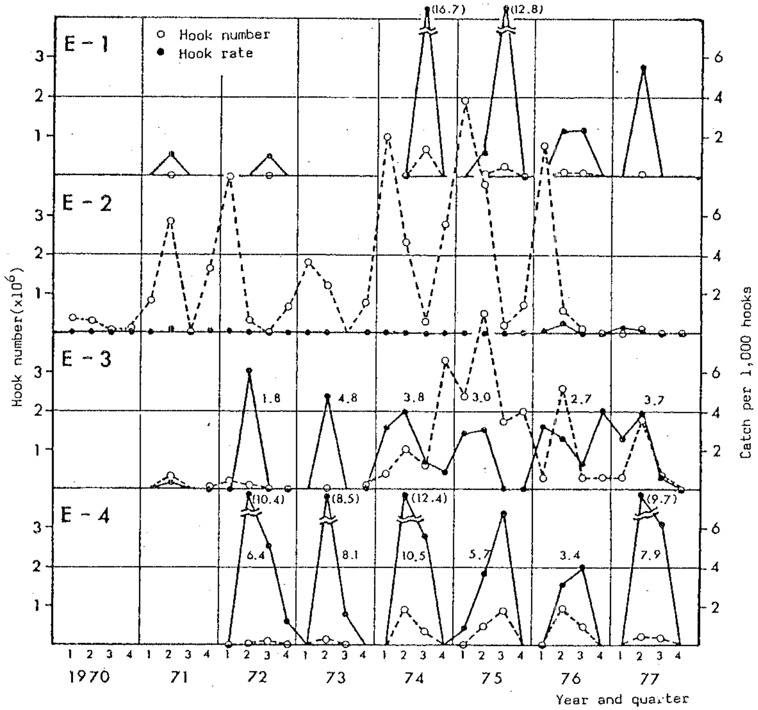

Fig. 5. Changes in fishing effort and CPUE (hook rate) on bluefin by area caught by Japanese longliners in the northeastern Atlantic.

Figures without parentheses denote annual average CPUE calculated over the period from 1st to 2nd quarter for the area E-3 and from 2nd to 3rd quarter for the area E-4. Data for 1977 are provisional.

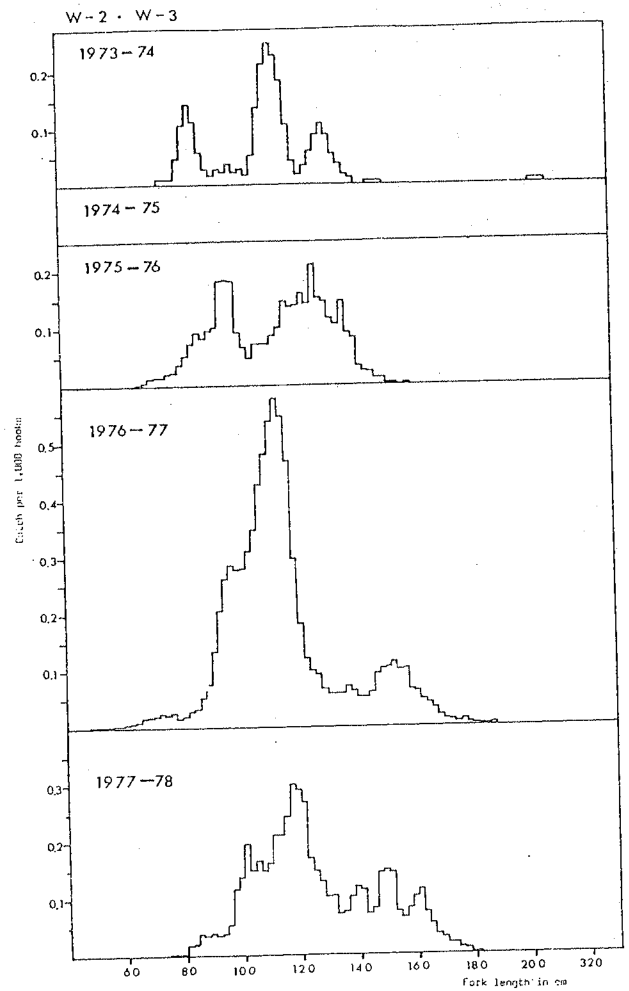

Fig. 6. Density index (hook rate) by length class of bluefin caught by Japanese longliners in the areas W-2 and W-3 in the northwestern Atlantic.

Data for the 1967-1977 and 1977-1978 seasons are provisional.

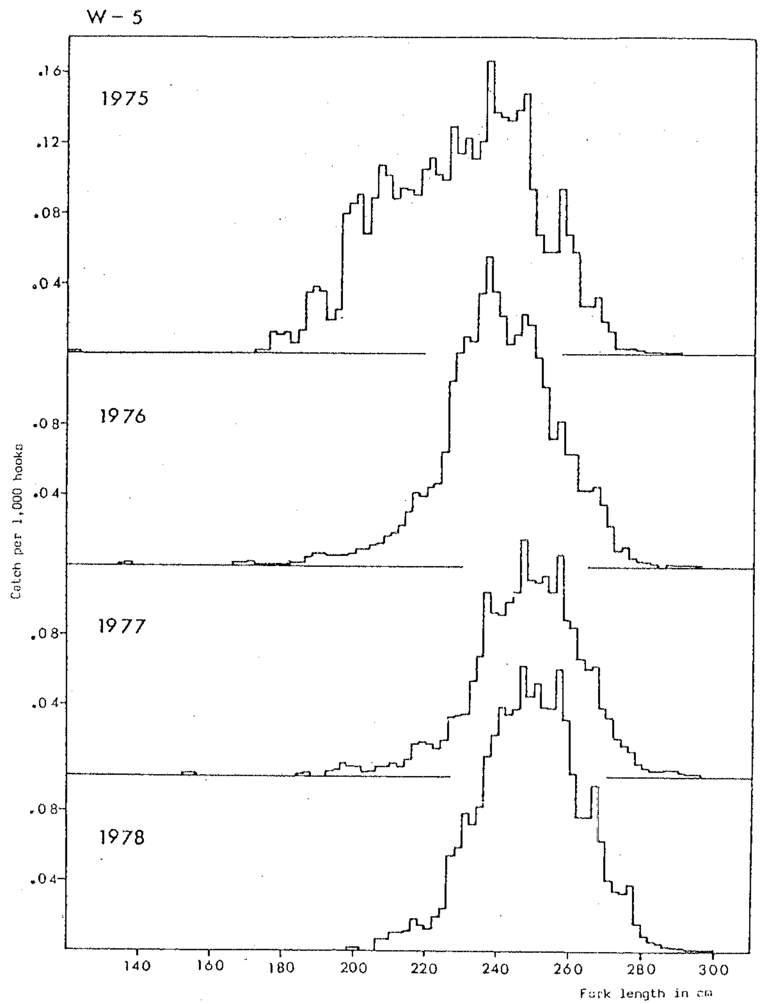

Fig. 7. Density index (hook rate) by length class of bluefin caught by Japanese longliners in the area W-5 (Gulf of Mexico)

Data for 1977 and 1978 are provisional and for the latter year, result of on-board measurements made by the U.S. scientists were used.

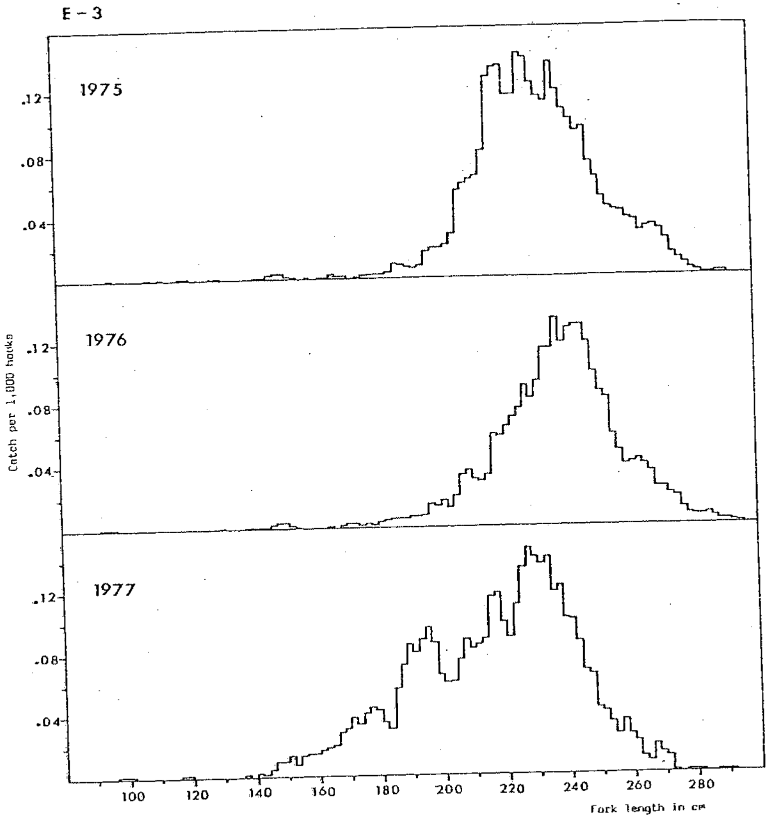

Fig. 8. Density index (hook rate) by length class of bluefin caught by Japanese longliners in the area E-3 (Strait of Gibraltar).

Data for 1977 are provisional.

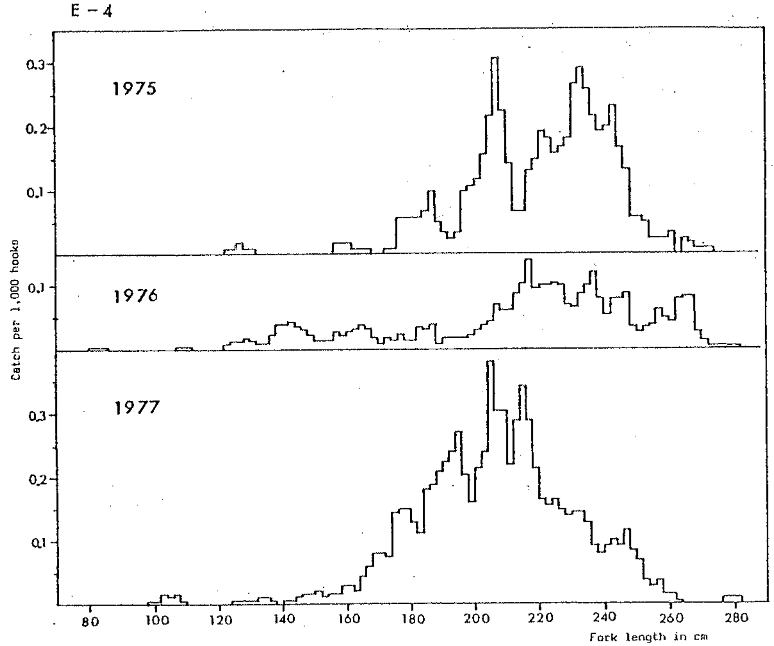

Fig. 9. Density index (hook rate) by length class of bluefin caught by Japanese longliners in the area E-4 (Mediterranean Sea)

Data for 1977 are provisional.

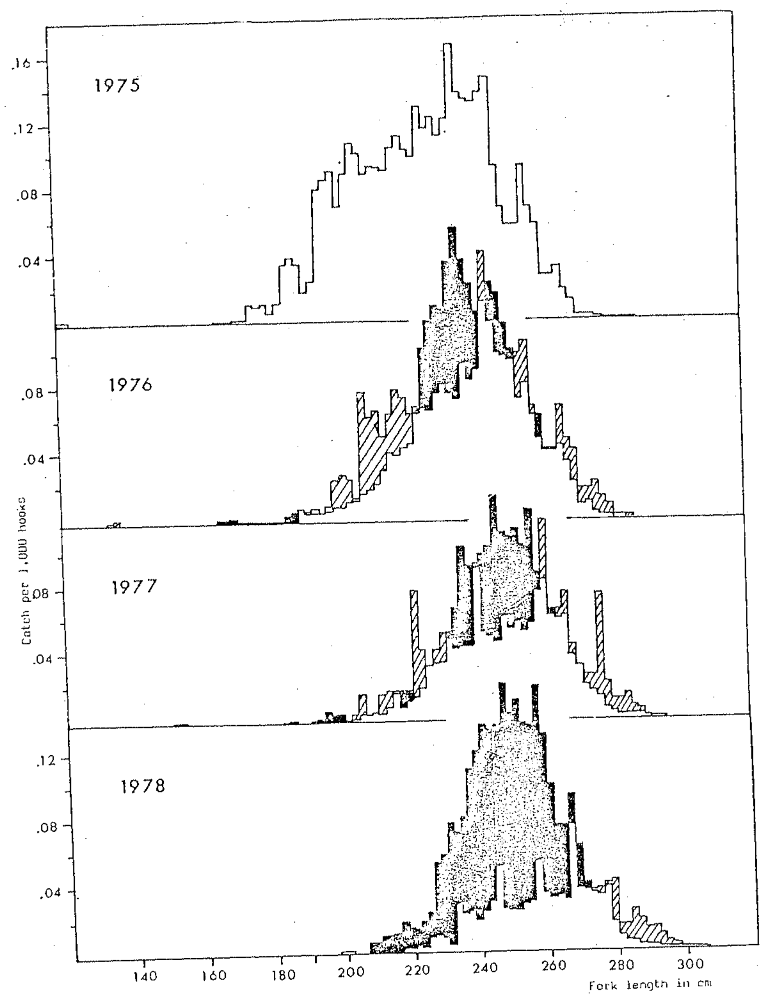

Fig. 10. Comparison of theoretical density index by length class calculated assuming no recruitment after 1975 (blank plus hatched areas) and observed density index by length class (blank plus black areas) for the bluefin caught by Japanese longliners in the Gulf of Mexico.

See text for explanation.

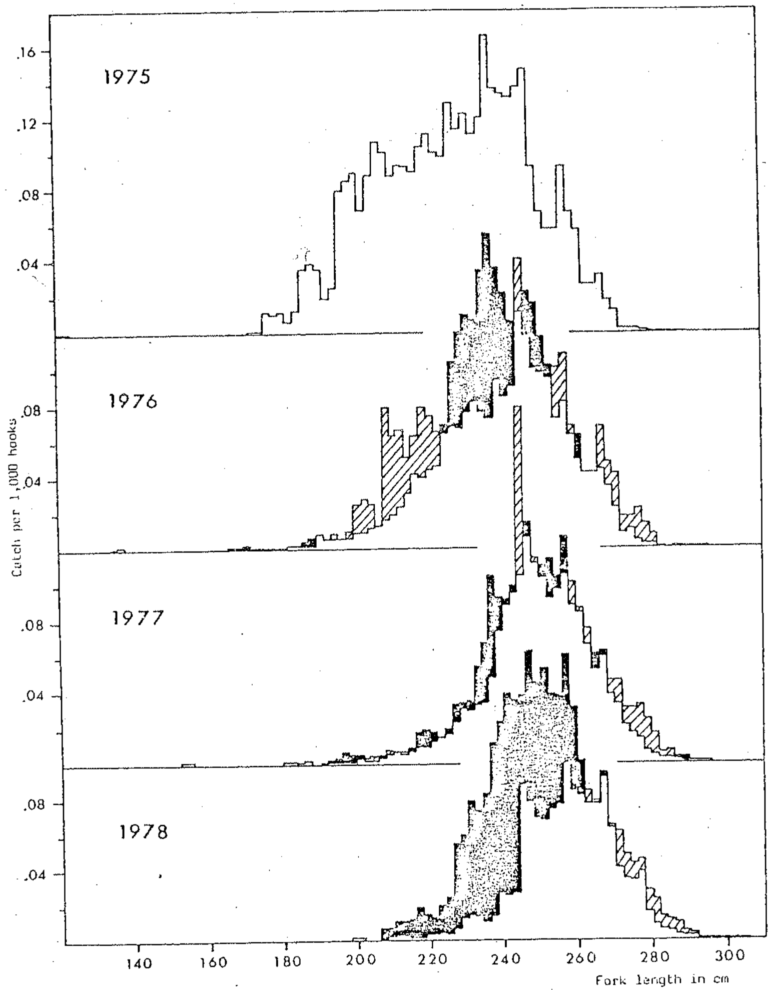

Fig. 11. Comparision of theoretical density index by length class calculated assuming no recruitment during two adjoining years (blank plus hatched areas) and observed density index by length class (blank plus black areas) for the bluefin caught by Japanese longliners in the Gulf of Mexico.

See text for explanation.