OVERALL FISHING INTENSITY AND CATCH BY LENGTH CLASS OF YELLOWFIN TUNA IN JAPANESE ATLANTIC LONGLINE FISHERY, 1956-1970

by

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SUMMARY

Shiohama (1971) noted that the longline fishery catches a variety of tunas and billfishes and their species preference has considerably changed during the past ten years. He proposed a method to estimate intensity of fishing on a particular species, as free as possible from change of species preference, as well as from seasonal migration of the fishes. The present author modified Shiohama's methods and also gave procedures to calculate catch in terms of number of fish by length class. The methods were applied to the Japanese data in order to ascertain the fishing intensity on yellowfin tuna from 1956 to 1970, and catch by length class from 1965 to 1970. Fishing intensity by the whole longline fleet, including the Japanese boats, was calculated, based on the Japanese intensity and amount of yield by the whole longline fleet.

Japanese fishing intensity increased up to 1965 and then decreased rapidly. The intensity in 1970 was slightly over the 1959 level and one quarter of that in 1965. Hook rate of yellowfin tuna decreased more rapidly than expected from fluctuation in fishing intensity of the whole longline fleet, and did not recover in the following years in spite of a reduction in effort. Major portion of catch comprised large sized fish between 120 cm and 170 cm. Modal lengths in the western Atlantic have been larger than in the eastern Atlantic, although small sized fish less than 100 cm were more frequent in the former than in the latter area. In each area, modal length has decreased since the beginning of commercial exploitation, and more rapidly in the eastern Atlantic.

INTENSITE DE LA PECHE DANS SON ENSEMBLE ET CAPTURES PAR CLASSES DE TAILLES D'ALBACORE DE LA PECHERIE PALANGRIERE JAPONAISE DANS L'ATLANTIQUE, 1956-1970

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RESUME

Shiohama (1971) avait fait remarquer que la pêcherie à la palangre capturait toutes sortes de thonidés et xiphiidés, et que l'importance relative des espèces capturées avait considérablement varié au cours des dix dernières années. Il proposait une méthode pour évaluer l'intensité de la pêche d'une espèce donnée, aussi indépendante que possible des variations dans l'importance relative des espèces pêchées ou des migrations saisonnières des poissons.

L'auteur a ici repris la méthode de Shiohama en la modifiant, et a également indiqué des procédés pour calculer les captures en termes du nombre de poissons par classe de taille. Ces méthodes ont éte appliquées aux données japonaises et ont permis d'obtenir l'intensité de la pêche de l'albacore de 1956 à 1970 et les captures par classes de tailles de 1965 à 1970. L'intensité de pêche de l'ensemble de la flotte palangrière, y compris les unités japonaises, a été calculée sur la base de l'intensité de la pêche japonaise et du volume de la production palangrière totale.

L'intensité de la pêche japonaise s'est accrue jusqu'en 1965, et a ensuite rapidement diminué. En 1970, l'intensité dépassait légèrement le niveau de 1959 et n'était que le quart de celle de 1965. Le taux de prises par hameçon pour l'albacore a diminué plus rapidement que ne le laissaient prévoir les fluctuations de l'intensité de la pêche de l'ensemble de la flotte palangrière, et ne s'est pas recuperé au cours des années suivantes, en dépit de la diminution de l'effort. La plus grande partie des prises se composait de poissons de grande taille de 120 à 170 cm. Les tailles modales dans l'Atlantique Occidental dépassaient celles de l'Atlantique Oriental, bien que les poissons de moins de 100 cm aient été plus abondants dans le premier. La taille modale a diminué depuis le début de l'exploitation commerciale, de façon plus accentuée dans l'Atlantique Oriental.

INTENSIDAD PESQUERA TOTAL Y CAPTURAS POR CLASES DE TALLAS DE RABIL DE LA PESQUERIA JAPONESA CON PALANGRE EN EL ATLANTICO, 1956-1970

por

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RESUMEN

Shiohama (1971) observó que la pesquería con palangre captura una gran variedad de túnidos y marlines y que su preferencia en relación con las especies ha experimentado grandes cambios durante los últimos años. Para estimar la intensidad de la pesquería de una determinada especie, propuso un método que no tuviera en cuenta en lo posible las variaciones de esta preferencia, así como las migraciones estacionales de los peces.

El autor ha modificado en este documento los métodos de Shiohama y ha dado asimismo procedimientos para calcular las capturas en número de peces por clases de tallas. Estos métodos han sido aplicados a los datos japoneses y han permitido obtener la intensidad pesquera sobre el rabil de 1956 a 1970 y las capturas por clases de tallas de 1965 a 1970. La intensidad pesquera total de la flota palangrera incluyendo los barcos japoneses fué calculada basándose en la intensidad japonesa y en el volumen de producción de toda la flota palangrera.

La intensidad de la pesca japonesa aumentó hasta 1965 y a partir de entonces disminuyó rápidamente. En 1970, la intensidad fué ligeramente superior a la de 1959 y representó una cuarta parte de la de 1965. El índice de capturas por anzuelo de rabil disminuyó a mayor ritmo de lo previsto por la fluctuación en la intensidad pesquera del conjunto de la flota palangrera y no se recuperó en los años siguientes, a pesar de la reducción del esfuerzo. La mayor parte de la captura fué constituída por peces de gran tamaño, de 120 a 170 cm. Las modas de tallas en el Atlántico occidental han sido mayores que en el Atlántico oriental, aunque los peces pequeños, de una talla inferior a los 100 cm fueron más abundantes en la primera región que en la segunda. Desde el comienzo de la explotación comercial, la moda de talla ha disminuído más rápidamente en el Atlántico oriental.

Overall fishing intensity and catch by length class of yellowfin tuna in Japanese Atlantic longline fishery, 1956-1970.

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Presence of various types of fisheries aiming at yellowfin tuna in the Atlantic Ocean makes it necessary to assemble catch and size composition statistics not only in the ICCAT official forms proposed in the "Field Manual for Statistics and Biological Sampling of Atlantic Tunas", but also in processed forms directly applicable to co-operative stock assessment (ICCAT 1971a, p. 10). The present report provides three of such data including (1) amount of effective fishing effort and overall fishing intensity of Japanese longline fleet for yellowfin tuna in the major distribution range, (2) Japanese longline catch in terms of number by length class in eastern and western tropical Atlantic, and (3) relations between fishing intensity and either hook rate, catch or yield of the whole Atlantic longline fishery.

1. Amount of effective fishing effort and overall fishing intensity of Japanese longline fishery, 1956-1970.

1.1. Extent of area for calculation.

Most of yellowfin tuna in the Atlantic longline fishery are caught in an area covering about 40°N and 30°S, which extends further northwards along eastern coast of North America. The fishing intensity of Japanese fleet for yellowfin tuna is estimated for such an area as represented by dots in Fig. 1, which has produced almost all of the catch in most years except 1969, when 9.1 percent came from outside (Table 1).

1.2. Data.

The present estimates of fishing efforts are based on number of hooks used, and number of yellowfin tuna caught by Japanese longliners in the Atlantic Ocean, compiled by month and by 5° square (Shiohama et al. 1965, Fisheries Agency 1965-1972, Shiohama 1971).

1.3. Methods of calculation.

(1) General. Nominal effort in number of hooks used is converted to effective effort by weighing them with relative density of the fish in the square and the month and with relative availability in the month, which are calcuated for the "average years". The average years are determined so as to represent period of years when the fishery and the stock have been fairly stable. In this report, eight years from 1963 to 1970 are taken as the "average years".

(2) Relative monthly density distribution in average years. Hook rates, d_{ijk}, in i-th square, j-th month and k-th year are averaged for the "average years". The resultant average hook rate, d_{ij}, represents relative abundance of yellowfin tuna available to longline fishery in the square.

$$d_{ij} = \frac{1}{m_{ij}} \sum_{k=1}^{m_{ij}} d_{ijk} = \frac{1}{m_{ij}} \sum_{k=1}^{m_{ij}} (C_{ijk}/g_{ijk})$$

(3) Monthly average stock number in average years. The average hook rate, d_{ij}, is multiplied by area of the square, A_{ij}, in terms of 5° square along the

Equator without lands. The stock number in the month, N_j, over the whole fishing area is sum of such products. The monthly average density index, d_j, is the mean of d_{ij}'s weighed by areas of squares.

$$N_j = \sum_{i=1}^{n_j} A_{ij} d_{ij}$$

$$d_j = N_j / A_j = \sum_{i=1}^{n_j} A_{ij} d_{ij} / \sum_{i=1}^{n_j} A_{ij}$$

(4) Effectiveness of nominal effort by month and by square. Relative effectiveness of hooks used in i-th square in j-th month, r_{ij}, is a ratio of the density index, d_{ij}, in the average years to their monthly average, d_j.

$$r_{ij} = d_{ij} / d_j$$

Monthly fluctuation in the stock number suggests that portion of yellowfin tuna stock available to longline fishery changes from month to month. Index of availability rate, a_j, is calculated as a ratio of monthly stock number indices to their yearly average.

$$a_j = N_j / \frac{1}{12} \sum_{j=1}^{12} N_j$$

The overall index of efficiency, ε_{ij}, is a product of relative effectiveness of the square and the availability in the month.

$$\varepsilon_{ij} = a_j \times r_{ij}$$

(5) Amount of effective effort and overall fishing intensity. Effective fishing effort in a month of a year is a sum of products of overall indices of efficiency and nominal hooks used in the whole 5° squares in the months.

$$X_{jk} = \sum_i \varepsilon_{ij} g_{ijk}$$

Remarkable monthly change of area of fishing ground in the average years, or distribution range of yellowfin tuna, indicates that overall fishing intensity, f_{jk}, is proportional to the fishing coefficient.

$$f_{jk} = X_{jk} / A_j$$

1.4. Results.

(1) Table 2 gives monthly extent of fishing grounds in the average years, A_j, amount of fishing effort in thousand hooks, X_{jk}, and overall fishing intensity in thousand hooks per 5° square, f_{jk}, of Japanese longline fishery, which are

calculated for the major distribution range in 15 years from 1956 to 1970.

(2) Resultant fishing intensity shows very close year-to-year fluctuation with that in fishing effort by Shiohama (1971), which was already submitted to the 1971 SCRS meeting, and the correlation coefficient between the two measures of fishing efforts is as high as 0.9988 (Fig. 2). The present estimate will be used hereafter because the area of fishing ground has shown appreciable monthly change.

(3) Japanese fishing intensity increased from 2,000 hooks per square in 1956 to 924,600 hooks per square in 1965, and then decreased rapidly. The intensity in 1970, 222,900 hooks, is lightly over the level in 1959, and one-fourth of that in 1965.

2. Catch in terms of number by length class in Japanese longline fishery, 1965-1970.

2.1. Extent of area for calculation.

Most length data, except those in 1970, were collected from the tropical waters designated as GUINEA and CARIB in Fig. 1. Catch in number therefrom comprises 84 to 97 percent of total Japanese longline catch during 1965 through 1970 (Table 1).

2.2. Data and methods of calculation.

Honma et al.'s (1971) calcuations are applied to compile sample length composition by Lat. 10° and Long. 20° quadrangle and by quarter or three-month period. The data measured in body weight were converted to length composition on the basis of length-weight relation determined for the Pacific samples by Kamimura and Honma (1959). The sample composition data for 1969 were already submitted to the 1971 SCRS meeting and those for 1970 were prepared by Shingu and Hisada (ms).

The CARIB and GUINEA Areas are represented by 14 and 9 quadrangles, respectively (Table 3). And, all the individuals measured in these quadrangles were simply added up to represent length composition of catch there in each quarter.

Catch by length class is calculated with procedures also given by Honma et al. (1971). Catch of quarters, in which no or only few samples were obtained, is divided by length class based on data from neighbouring quarters (Table 4).

2.3. Results.

Table 5 ☆ gives catch in number of fish for each 2-cm interval of body length compiled by area and by quarter. As aforementioned, the calculation covers more than 80 percent of catch by Japanese longline fleet in the Atlantic Ocean, 1965-1970.

Generally speaking, major portion of catch comprises large-sized fish between 120 and 170 cm in body length (Fig. 4). Small-sized fish less than 100 cm occurred frequently in the CARIB. Nevertheless, modal groups in the area have been larger than those in the GUINEA. In the CARIB, modal lengths ranged between 144-148 cm in 1965, 144-152 cm in 1966, 128-132 cm and 144-148 cm in 1967, 148-152 cm in addition to 88-92 cm in 1968, and 148-152 cm in 1969, while those in the GUINEA located between 140-148 cm in 1965, 144-148 cm in 1966, 128-132 cm and 144-148 cm in 1967, 124-128 cm and 140-144 cm in 1968, and 112-116 cm and 128-132 cm in 1969.

☆ This table has not been reproduced here but can be found in "Data Record, Vol. 1", ICCAT, Madrid 1973.

The above modal length indicate decrease of large-sized fish in both areas. Reduction of them seems to be more remarkable in the GUINEA than in the CARIB. Honma and Hisada (1971) noted that the longline catch in 1965-1967 comprised more small-sized fish than those in early years of exploitation up to 1960. Hayasi and Honma (1971) attributed such diminution of large-sized fish to increase of fishing intensity. It is very likely that reduction of large-sized fish have been due to rapid expansion of surface fisheries, especially increase of purse seiners in the eastern Atlantic (ICCAT ms), in addition to fairly high longline intensity, 1.5 to 2.5 times as much as the level in 1960 when the longline yield reached a peak, even though the intensity decreased since 1966 (see Section 3).

3. Relations between overall fishing intensity and either hook rate, catch or yield of the whole Atlantic longline fishery, 1956-1970.

It is required to calculate the indices of stock size and fishing intensity of fishery on the basis of Task 2 statistics from all the countries participating in that fishery. Because of limited information, however, the Japanese estimates are converted to those of the whole longline fleet having operated in the Atlantic Ocean during 1956 through 1970, in order to give general idea on status of yellowfin tuna stock exploited by this type of fishery.

3.1. Data and methods of calculation.

(1) Index of stock size. An yearly hook rate in the major fishing ground (Fig. 1) is obtained by dividing annual totals of Japanese catch and effective effort that are given in Tables 1 and 2. The resultant hook rates differ slightly with those based on Shiohama's (1971) estimates of effective effort calculated by methods with some difference for the whole area, mean hook rate of which must be lower than that of the major distribution range under discussion.

(2) Catch in number of fish by Japanese fleet. The Japanese statistics provide annual total of yellowfin tuna caught in the whole Atlantic Ocean (see Section 1).

(3) Yield in weight by Japanese fleet. Landings of yellowfin tuna taken by Japanese longliners in terms of weight have been compiled since 1957 (see Section 1). The data, included into the ICCAT Statistical Bulletin (1971b), are compiled by year of landing but not by year of catch.

(4) Overall fishing intensity of Japanese fleet. The estimates of Japanese fishing intensity for the major distribution range (Table 2) are converted to those for the whole Atlantic by multiplying a ratio of catch in the whole Atlantic to that in the major distribution range (Table 1).

(5) Yield in weight of fish by the whole longline fleet. Catch or landings in weight of most countries participating tuna fishery in the Atlantic Ocean are included in the ICCAT Statistical Bulletin (1971b), or reported to the ICCAT Headquarter (ICCAT ms). A minor amount of national yield is cited from Hayasi et al. (ms).

(6) Catch in number of fish by the whole longline fleet. Numbers of fish caught by Japanese longliners are converted to those by the whole Atlantic longline fleet through multiplying a ratio of total yield to the Japanese yield.

(7) Overall fishing intensity of the whole longline fleet. The best available approximate of longline fishing intensity may be that obtained by multiplying the Japanese intensity with a ratio of the whole Atlantic longline yield to the Japanese yield.

3.2. Results.

The data and obtained estimates are given in Table 6. It is clear that the hook rate decreased very rapidly from 5 percent in 1956-1959 to 0.8 percent in 1966, and then fluctuated around 0.9 up to 1970. Japanese fishing activity for yellowfin tuna, both in production and intensity, has decreased continuously since 1965. But, increase of other countries, especially Korean and Taiwanese longliners, rised the yield and fishing intensity since 1968. Because Japanese yield comprises only 30 percent in 1970, it is indispensable to assess the status of yellowfin tuna stock in longline fishery basing on data from the whole fleet.

Fig. 4 indicates year-to-year changes of hook rate, catch in number and yield in weight against fishing intensity, estimated for the whole longline fishery. As already noted (e.g. Hayasi and Honma 1971, ICCAT ms), the hook rate decreased with increase of fishing activity untill 1965, and did not recover in the following years in spite of reduction of effort. Slight decrease of catch and yield, which must not decrease with increase of fishing activity, for 1960 to 1965, may be attributed to intensified surface fishing activity (Hayasi et al. ms). Further increase of surface fisheries may have reduced the longline yield as well as hook rate since 1966.

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TABLE 1 - Areal catch of yellowfin tuna in the Atlantic Ocean, 1956-1970.

Year	Catch in 1,000 fish		
	Total	Dotted area for fishing intensity	Shaded area for length composition
1956	12	12 (100.0)	12 (100.0)
1957	259	259 (100.0)	259 (100.0)
1958	746	746 (100.0)	746 (99.9)
1959	1,098	1098 (100.0)	1,090 (99.3)
1960	1,159	1,159 (100.0)	1,152 (99.4)
1961	980	980 (99.9)	967 (98.6)
1962	990	990 (100.0)	942 (95.1)
1963	886	886 (99.9)	842 (95.0)
1964	879	879 (99.9)	822 (93.5)
1965	927	926 (99.8)	899 (97.0)
1966	395	394 (99.8)	381 (96.7)
1967	366	365 (99.7)	348 (95.2)
1968	274	272 (99.2)	262 (95.6)
1969	242	220 (90.9)	204 (84.2)
1970	190	186 (98.0)	173 (91.1)

Data from Shiohama et al. (1965), Fisheries Agency (1962-1971), and Shiohama (1971).

Numerals in parentheses denote percentages to annual totals.

TABLE 2 (Caption on second page)

Month	Area	1956		1957		1958		1959		1960	
		X	f	X	f	X	f	X	f	X	f
1	118.56	-	-	-	-	1,536	13.0	1,129	9.5	1,670	14.1
2	111.44	-	-	73	0.7	978	8.8	1,070	9.6	2,987	26.8
3	96.34	-	-	64	0.7	870	9.0	1,530	15.9	2,250	23.4
4	107.55	-	-	159	1.5	644	6.0	2,212	20.6	3,659	34.0
5	118.05	-	-	543	4,6	912	7.7	2,050	17.4	2,492	21.1
6	117.31	38	0.3	189	1.6	1,677	14.3	2,393	20.4	2,782	23.7
7	120.34	18	0.2	688	5.7	1,643	13.7	2,627	21.8	4,194	34.9
8	111.29	77	0.7	600	5.4	808	7.3	2,564	23.0	3,947	35.5
9	119.92	31	0.3	570	4.8	1,668	13.9	1,751	14.6	2,382	19.9
10	132.48	33	0.2	858	6.5	2,119	16.0	3,012	22.7	2,437	18.4
11	119.56	7	0.1	781	6.5	1,197	10.0	2,076	17.4	2,014	16.8
12	114.37	26	0.2	797	7.0	832	7.3	1,372	12.0	1,668	14.6
Total	(1,387.21)	(230)	2.0	(5,322)	44.8	(14,883)	126.9	(23,788)	204.9	(32,483)	283.1

Month	1961		1962		1963		1964		1965	
	X	f	X	f	X	f	X	f	X	f
1	3,765	31.8	2,747	23.2	2,560	21.6	6,279	53.0	9,748	82.2
2	5,123	46.0	5,835	52.4	8,636	77.5	10,101	90.6	17,921	160.8
3	3,664	38.0	7,079	73.5	11,168	115.9	10,119	105.0	16,223	168.4
4	4,622	43.0	9,823	91.3	12,280	114.2	8,720	81.1	11,339	105.4
5	4,555	38.6	5,784	49.0	5,725	48.5	3,937	33.4	6,300	53.4
6	3,618	30.8	6,222	53.0	2,091	17.8	3,158	26.9	3,792	32.5
7	3,186	26.5	3,864	32.1	2,319	19.3	7,755	64.4	6,442	53.5
8	3,269	29.4	5,732	51.5	5,520	49.6	11,883	106.8	9,879	88.8
9	806	6.7	5,129	42.8	4,094	34.1	8,883	74.1	6,946	57.9
10	1,316	9.9	3,971	30.0	4,298	32.4	7,006	52.9	5,057	38.2
11	2,204	18.4	1,975	16.5	4,047	33.8	5,317	44.5	5,233	43.8
12	1,877	16.4	1,671	14.6	4,465	39.0	5,455	47.5	4,561	39.9
Total	(38,005)	355.5	(59,851)	529.9	(67,203)	603.8	(88,594)	780.2	(103,442)	924.6

TABLE 2 (cont'd)

Month	1966		1967		1968		1969		1970	
	X	f	X	f	X	f	X	f	X	f
1	3,647	30.8	1,155	9.7	4,137	34.9	1,511	12.7	1,714	14.5
2	5,964	53.5	4,215	37.8	2,852	25.6	2,732	24.5	2,366	21.2
3	9,989	103.7	5,113	53.1	4,644	48.2	3,992	41.4	2,862	29.7
4	6,627	61.6	4,696	43.7	2,005	18.6	2,626	24.4	2,024	18.8
5	2,940	24.9	2,198	18.6	1,583	13.4	2,732	23.1	1,321	11.2
6	2,218	18.9	1,291	11.0	2,650	22.6	2,726	23.2	3,913	33.3
7	4,462	37.1	2,447	20.3	2,921	24.3	2,517	20.9	4,014	33.4
8	6,027	54.2	2,352	21.1	3,157	28.4	3,111	28.0	2,545	22.9
9	4,036	33.7	2,253	18.8	1,817	15.2	1,523	12.7	1,840	15.3
10	2,379	18.0	2,509	18.9	1,465	11.1	1,144	8.6	1,413	10.7
11	624	5.2	1,880	15.7	784	6.6	1,111	9.3	988	8.3
12	403	3.5	2,800	24.5	510	4.5	951	8.3	422	3.7
Total	(49,311)	444.9	(32,910)	293.3	(28,525)	253.2	(26,677)	237.3	(25,421)	222.9

Table 2. Extent of fishing ground in 5°-square, amount of effective effort in thousand hooks, and overall fishing intensity in thousand hooks per 5°-square of Japanese longline fishery for yellowfin tuna in the major Atlantic fishing ground, 1956-1970.

See Fig. 1 for fishing ground covered in the present calculation of fishing effort, or Table 1 for amount of catch.

See Fig. 1 and Table 1 for fishing ground and amount of catch covered in the present calculation of fishing effort.

Table 3. Quadrangles representing CARIB and GUINEA Areas.

Area	Quadrangles
CARIB	00N-80W, 10N-80W, 20N-80W, 30N-80W, 00N-60W, 10N-60W, 30N-60W, 40N-60W 00S-40W, 00N-40W, 10N-40W, 00S-20W, 00N-20W. 10N-20W
GUINEA	00S-20W, 00N-20W, 10N-20W, 00S-00W, 00N-00W, 10N-00W, 10S-00E, 00S-00E, 00N-00E

Numerals denote the smallest figures of latitude and longitude of each quadrangle. For instance, 00N-60W represents a quadrangle extending between Lat. 0 °N and 10 °N, and between Long. 60 °W and 80 °W.

Table 4. Sample size and substitution of data for calculating catch by length class, 1965-1970.

Area	Year	Quarter			
		I	II	III	IV
CARIB	1965	2,777	564	934	4 (III)
	1966	230	744	911	787
	1967	122	8 (I)	336	(III)
	1968	52	91	709	950
	1969	(II)	211	(1968)	23 (1968)
	1970	1 (II, 1969)	(1969)	(IV)	342
GUINEA	1965	4,020	465	705	270
	1966	1,843	470	26 (II)	100
	1967	472	(I)	135	853
	1968	3,337	527	753	91
	1969	(II)	211	9 (1968)	(1968)
	1970	(II, 1969)	(1969)	(1968)	19(1968)

Arabic numerals without parentheses denote number of individuals determined by either body length or body weight.

Numerals in parentheses denote substitutions of data:
(1) Roman numerals; substituted data of the given quarter of the same year.
(2) Arabic numerals; substituted data of the same quarter of the given year.
(3) Roman and Arabic numerals; substituted data of the given quarter and year.

Table 6. Hook rate, catch in number of fish, yield in weight, and effective overall fishing intensity of yellowfin tuna in Japanese longline fishery, and catch, yield and effective overall fishing intensity in the whole longline fishery operated in the Atlantic Ocean, 1956-1970.

Year	Hook rate in percent	Japanese fleet			Whole fleet		
		Catch in number of fish	Yield in tons	Intensity in 1,000 hooks per-5° square	Catch in 1,000 fish	Yield in 1,000 tons	Intensity in 1,000 hooks per 5°-square
1956	5.24	12,028	..	2.0	..	..	42.0
1957	4.86	258,544	13,198	44.8	270,334	13.8	146.8
1958	5.02	746,490	27,159	126.9	772,319	28.1	131.3
1959	4.61	1,097,535	44,071	204.9	1,138,034	45.7	212.5
1960	3.57	1,158,534	50,822	283.1	1,205,802	52.9	294.7
1961	2.58	980,339	42,609	335.5	1,026,121	44.6	351.2
1962	1.66	990,472	41,973	529.9	1,080,704	45.8	578.2
1963	1.32	885,796	37,717	603.8	1,009,807	43.0	688.3
1964	0.99	879,188	35,106	780.4	959,106	38.3	851.3
1965	0.90	927,267	36,619	926.0	997,647	39.4	996.3
1966	0.80	394,538	22,123	445.7	461,886	25.9	521.8
1967	1.11	366,046	12,809	294.0	580,110	20.3	466.0
1968	0.95	274,181	13,857	255.3	514,446	26.0	479.1
1969	0.82	241,832	9,823	261.1	627,772	25.5	677.9
1970	0.73	189,569	6,674	227.4	622,033	21.9	746.1

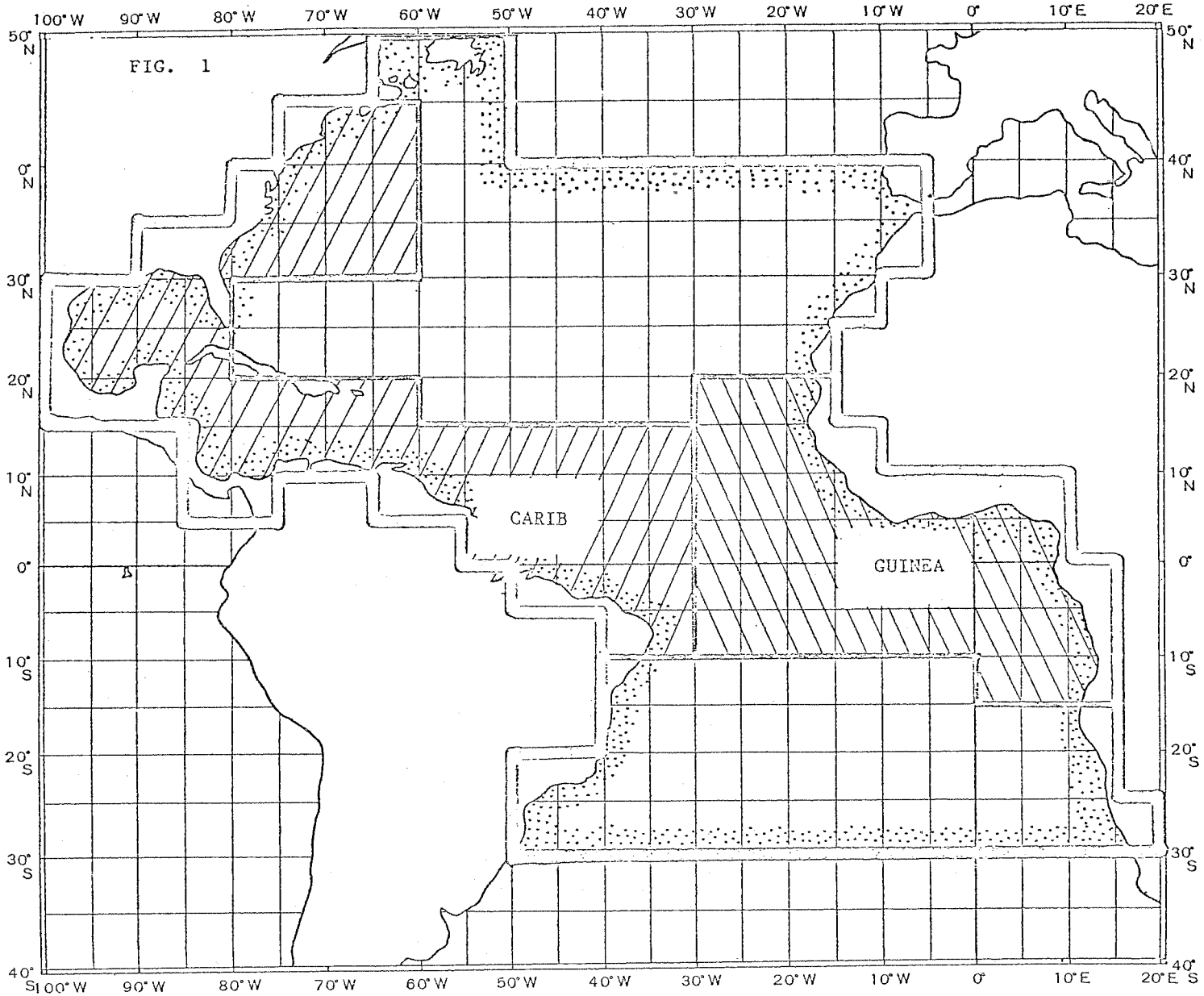

Fig. 1. Divisions of the Atlantic Ocean for calculating either amount of fishing effort and overall fishing intensity, dotted area, or catch by length class, shaded areas, of yellowfin tuna in Japanese longline fishery, 1956-1970.

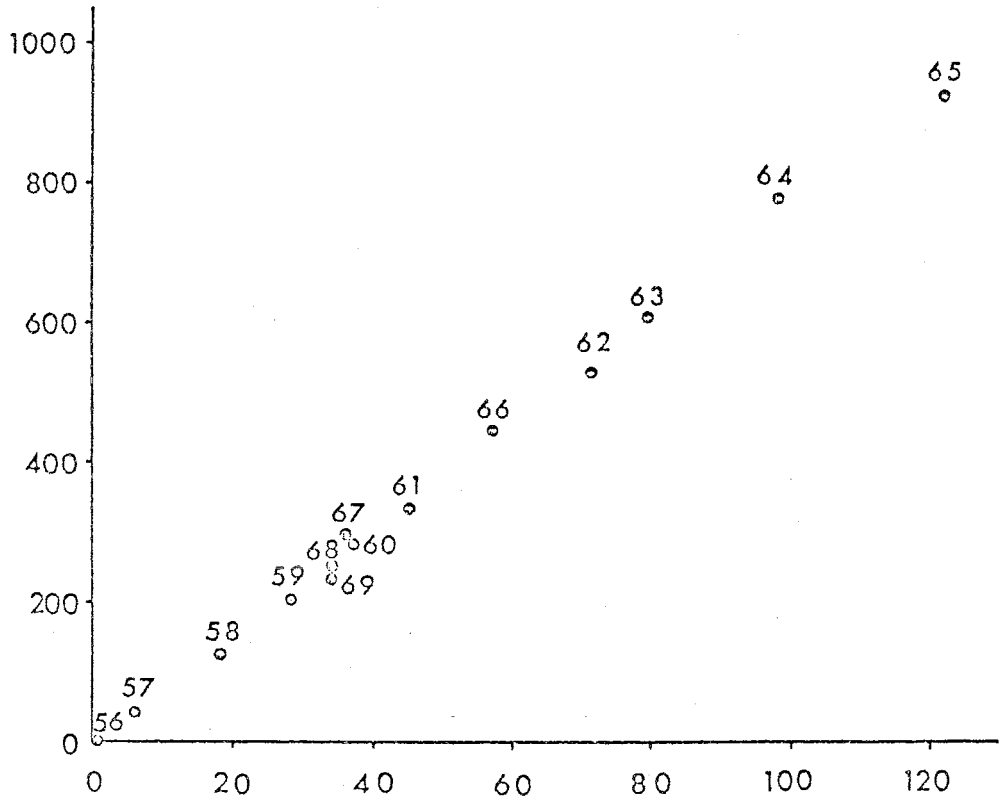

Fig. 2. Relation between amount of fishing effort in million hooks by Shiohama (1971) on ordinate and present estimates of over-all fishing intensity in thousand hooks per 5-degree square on abscissa, of Japanese longline fishery for yellowfin tuna in the Atlantic Ocean, 1956-1969.

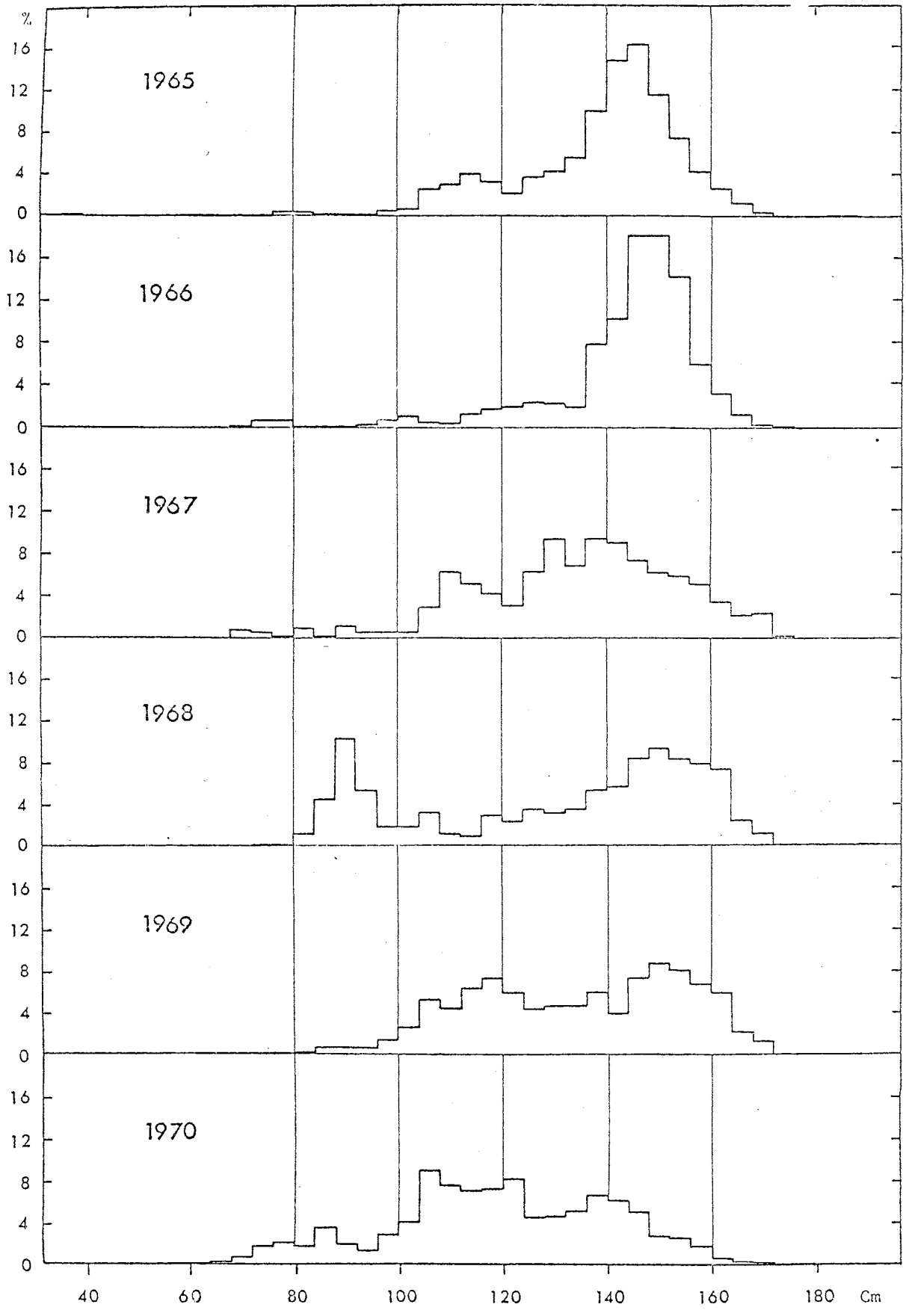

Figure 3 - Length composition of yellowfin tuna caught by Japanese longline fishery in either CARIB Area or GUINEA Area, 1965-1970. See Figure 1 for extents of the areas.

A. CARIB Area.

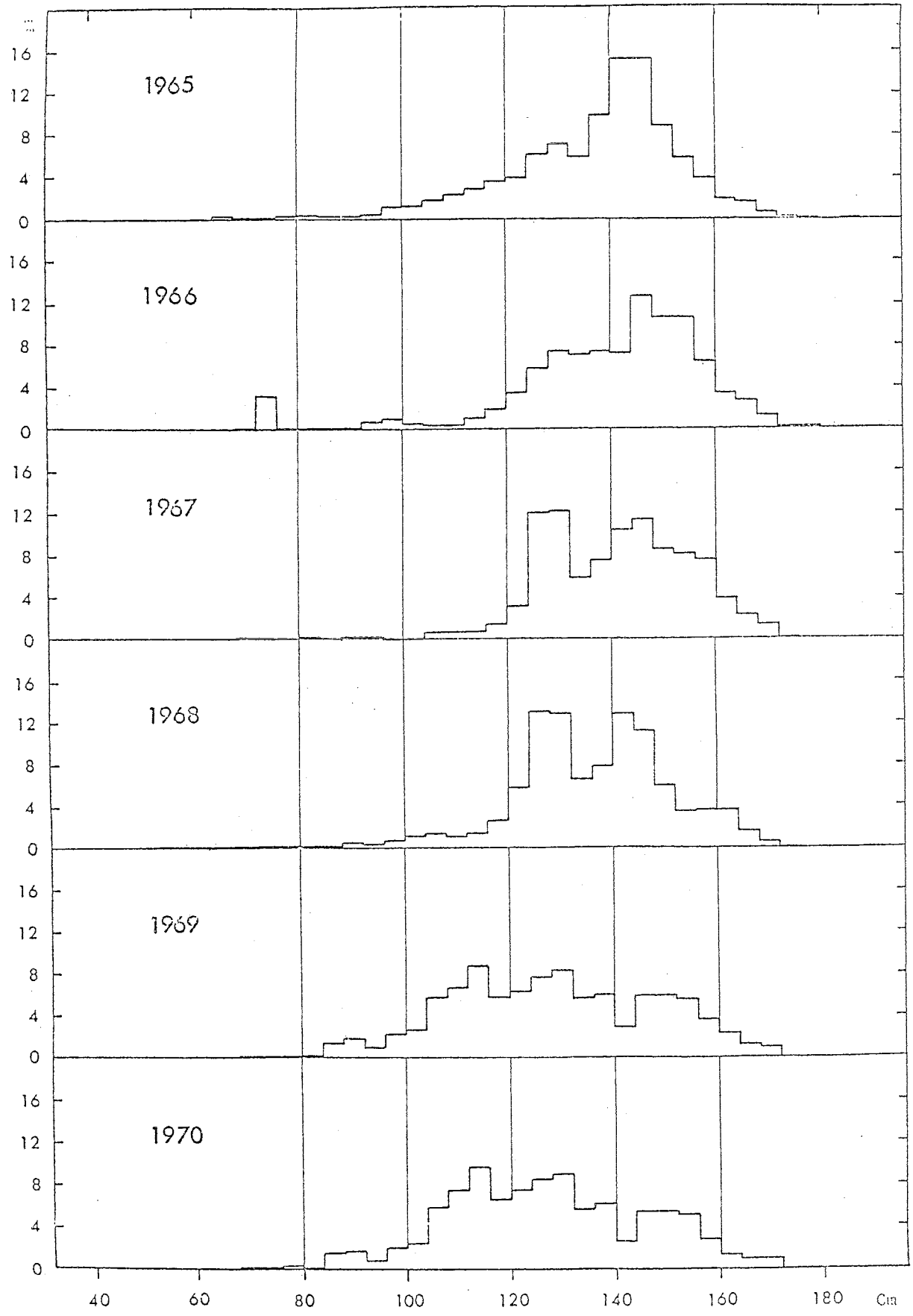

Figure 3 - Continued.

B. GUINEA Area.

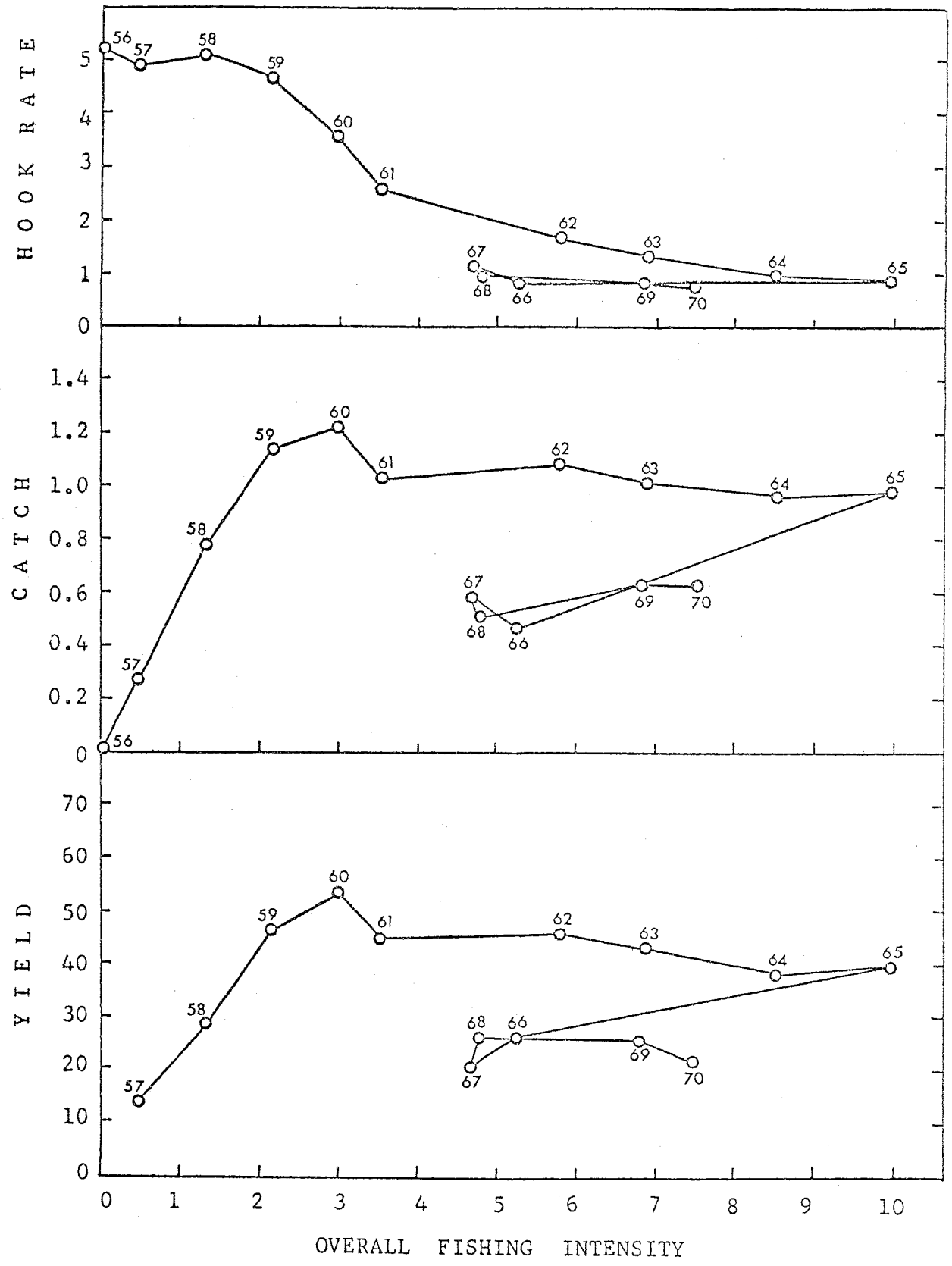

Fig. 4. Hook rate in percent (upper panel) catch in million fish (central panel), and yield in thousand tons (lower panel) of yellowfin tuna against overall fishing intensity in hundred thousand hooks per 5° square in the Atlantic longline fishery, 1956-1970. See footnote of Table 3 for source of data.