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OVERALL FISHING INTENSITY AND CATCH BY LENGTH CLASS OF ALBACORE IN JAPANESE ATLANTIC LONGLINE FISHERY, 1956-1972

by

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SUMMARY

Catch, effort and sampling data in 1972 of albacore caught by Japanese longline fishery in the Atlantic were processed to supplement the previous report of this series of study. In this report, the estimation was made for the subdivision of the catch and effort statistics of whole longline fleet in four subareas. Japanese share in the longline albacore catch has been decreasing in recent years, having been reducing the accuracy in estimation of the whole longline fishing intensity.

For the South population, the fishing intensity in 1972 appears to have reached such a high level as to make further increase of effort possibly result is no substantial increase in yield. In the North population, the yield has stayed at lower level since 1970, in spite of the increase in effort. The length composition exhibit no drastic change in the immature stock of North population in N-2 subarea. On the North population, some correlations between the surface and longline fisheries were examined.

This report is the third issue of series of study on fishing intensity, length composition of catch of albacore exploited by Japanese and other longline fleets in the North and South Atlantic Ocean.

RESUME

Les données de capture, d'effort et d'échantillonnage pour 1972 concernant le germon pris par la pêcherie palangrière japonaise dans l'Atlantique ont été traitées pour compléter le rapport précédent de cette série d'études. Le présent rapport contient une estimation selon une sous-division en quatre secteurs des statistiques de capture et d'effort pour l'ensemble de la flotte palangrière. La proportion des prises japonaises palangrières de germon a décru au cours des dernières années, faisant diminuer l'exactitude de l'estimation de l'intensité de la pêche à la palangre dans son ensemble.

En ce qui concerne la population méridionale, l'intensité de pêche en 1972 semble avoir atteint un point tellement élevé qu'il se pourrait qu'une augmentation ultérieure de l'effort n'entraîne pas d'accroissement sensible de la production. Pour ce qui est de la population du nord, la production est restée à un niveau plus bas depuis 1970, en dépit de l'accroissement de l'effort. La composition par taille n'indique pas de changements graves dans le stock immature de la population du nord dans le sous-secteur N-2. Certaines corrélations entre les pêcheries de surface et à la palangre ont été étudiées en ce qui concerne la population du nord.

Ce rapport est le troisième d'une série d'études sur l'intensité de pêche et la composition par taille de la prise du germon exploité par les flottilles palangrières japonaise et autres dans l'Océan Atlantique.

RESUMEN

Los datos de capturas, esfuerzo y muestreo de albacora, correspondientes a 1972, procedente de la pesquería japonesa con palangre en el Atlántico han sido procesados, complementando así la información disponible en esta serie de estudios. En este informe, se ha hecho la estimación para subdividir las estadísticas de capturas y esfuerzo de toda la flota palangrera en cuatro subzonas. La porción de albacora capturada por la flota palangrera japonesa ha ido disminuyendo en los últimos años y ha disminuído la precisión de la estimación de toda la intensidad pesquera con palangre.

En lo que respecta a la población del sur, la intensidad pesquera en 1972 parece haber alcanzado un nivel tan elevado, que un mayor aumento del esfuerzo posiblemente no redundará en un incremento importante en la producción. La producción de la población del norte ha permanecido a su nivel más bajo desde 1970, a pesar del aumento del esfuerzo. La composición de tallas no refleja un cambio drástico en el stock inmaduro de la población del norte en la zubzona N-2. Se examinaron algunas correlaciones en la población del norte entre las pesquerías de superficie y las de palangre.

Este informe es el tercero de una serie de estudios sobre intensidad pesquera y composición de tallas de las capturas de albacora explotada por la flota japonesa y otras flotas palangreras en el norte y en el sur del Oceano Atlántico.

Appendix Table 3 reproduced in Data Record Vol. 5.

Appendice tableau 3 reproduit dans le Vol. 5 du Recueil de Données.

Apendice cuadro 3 reproducido en el Vol. 5 de la Colección de Datos Estadísticos.

1. Yield and fishing intensity

Additional data utilized in the second issue of this series (Shiohama 1974) were supplemented in this report from two statistical volumes for 1972, Fisheries Agency of Japan (1974) and ICCAT (1974). In analyzing these data, the Atlantic Ocean is divided into four subareas corresponding with major habitats of adult and immature stocks of the North and South populations seemingly delimited by the South Equatorial Current (Fig. 1). The two populations are regarded to be highly independed with each other.

1.1. Estimation of yield

The historical annual yield of albacore by country is given in Table 1. To allocate these yield for each subarea, the procedures are determined by nationals, taking into account of the difference in mode of operation and type of available data of each country.

a) Japanese yield: The procedure is the same as that explained in the previous issue. The Task 2 statistics provide catch in terms of number by subarea. A preliminaly estimate of yield in i-th subarea, Y_i', is based on catch in number in the subarea, C_i, and average body weight, $\bar{w}_i$, estimated from length composition as 22 kg in N-1 and S-1, 15 kg in N-2 and 14 kg in S-2. Actual variations in average body weight and other sources make the sum of preliminary estimates in the four subareas not to be coincident with the total Japanese yield given in the ICCAT Statistical Bulletin, Y. The final estimation of yield for i-th subarea, Y_i, is obtained based on the total yield and preliminary areal yield, $Y_i' = \bar{w}_i \times C_i$.

$$Y_i = Y \times Y_i' / \Sigma Y_i'$$

b) Korean yield: For 1964 and 1965 yields, it is assumed that Korean fisheries harvested only the adult stock in the south Atlantic, namely in subarea S-1. For the period from 1966 to 1969, the following equation was employed:

$$Y_{ki} = Y_k \times g_{ki} / \Sigma g_{ki}$$

Y: yield
g: number of operation
k: k-th year
i: i-th subarea

g_{ki} is obtained from Korean catch and effort statistics of a sampling survey (Korean Office of Fisheries 1970). Yearly total for 1970-1972 was assigned to each subarea by using the average ratio, for the years 1966-1969, of the number of operation of each subarea.

c) Taiwanese yield: In the previous report (Shiohama 1974), yields from 1962 to 1966 were regarded as being caught from south Atlantic. In this report, however, this allocation was modified to be in the subarea N-1, considering that Taiwanese fleet unloaded mainly their catch at Monrovia in 1965 and 1966 (Federation of Japan Tuna Fisheries Co-operative Associations and Japan Tuna Fisheries Federation, 1967). During the years from 1967 to 1969 and 1971, the yields by subarea were estimated by the following equation:

$$Y_{ki} = Y_k \times Y'_{ki} / \Sigma Y'_{ki}$$

where notations are the same as those of Korean estimation except that Y' is the yield obtained from the Taiwanese sample statistical reports, (Taiwan Fisheries Bureau 1968, 1969 and 1970). Yields by subarea for 1970 were estimated by using the average ratio, for 1969 and 1971, of the yield by subarea, and those for 1972 were obtained by the ratio of 1971.

d) Panamanean, Venezuelan and Cuban yields: Taking account of the not far-going operation of the fleets of these countries, their yields are assumed to be from subarea N-1.

e) Brazilian yield: The yield is assigned to subarea S-1 on the basis of the same assumption as above.

f) Argentinean yield: Japanese longliners under Argentine flag operated in subarea S-1 earlier years, so that the yield of this country is assumed to be taken from subarea S-1.

1.2. Fishing intensity and catch
Procedure of the calculation for Japanese longline fleet is referred to Honma (1973). The average year in the present calculation extends from 1966 to 1972. Catch in number and overall fishing intensity for whole longline fleet were estimated by proportionating on basis of the ratio of the overall yield against the Japaneseyield in each subarea.

1.3. Result
Hook rate (yearly catch in number / yearly sum of effective effort), catch in number, yield in weight and fishing intensity for Japanese fleet as well as for whole fleet are summarized by North and South populations and by subarea in Tables 2-7.
In Appendix Tables 1 and 2, are tabulated monthly amount of effective fishing effort and overall fishing intensity calculated by year and by month for each of the North and South populations and subarea in Japanese longline fishery.
1.3.1. North population
This population has been utilyzed by several countries. The present status of the activities of the fishery on the resources is summarized in Table 8, indicating the two major fisheries : 1) surface fishery harvesting only the immature fish in the higher latitudes and 2) longline fishery for the entire stock.
As shown in Fig. 2, annual yields were between about 50 and 60 thousand tons during the period from 1962 to 1967 and around 40 thousand tons thereafter. The proportion of the catch of the adult fish has been less than 15 % of the total albacore catch. The efficiency rate of Japanese unit fishing effort on albacore, which is the concentration index on albacore fishing ground, was calculated on annual basis as the ratio of effective effort in number of hooks against actual number of hooks used. In earlier years of Japanese longline fishery, the efficiency rate on adult stock in N-1 was on a remarkably low level as about 0.2. Since 1963 to 1970, the efficiency rate retained around 1.0, but in 1971 and 1972, dropped drastically to become around 0.2. The efficiency rate on immature stock, in N-2 subarea, had been on remarkably high level until 1970 and since 1971 decreased extremely (Fig. 3).

The fishing intensity on the North population turned to rapid increase from 1962 and reached its maximum, 610,000 hooks per 5° square, in 1964. From 1966 to 1969, remakable decrese in the intensity was experienced. Then, the intensity again increased to the level between 500 and 700 thousand hooks per 5° square for the years 1970-1972 (Table 2).
The yield and the catch in number of albacore taken by longline fleet attained their peak in 1964 to be 159 thousand tons and 840 thousand fish respectively. Since that year until 1969, they declined reflecting the decrease in effort. Since 1970, inspite of the increase in effort, the yields have stayed at rather lower level. Hook rate has been on the decrease and was the lowest, 0.8, in 1972, while hook rate in 1961 was 2.15, when the catch began to increase (Fig. 4).
The relations of the yield against fishing intensity in each subarea fluctuated almost linearly except the case in 1972 in N-1 (Fig. 5,6).
Since the catch and effort statistics by subarea became made available in this report, Standing on Bard's (1963) viewpoint, some kinds of correlation between both stocks of adult and immature were examined. However, significant correlations were not encountered. Some of results of calculation are shown in Table 9 and Fig.7.
1.3.2. South population
This population has been utilized exclusively by the longline fishery of Taiwanese, Korean, Japanese, Argentine and Brazilian fleets.
Japanese longline fishery was expanding until 1966, when number of hooks invested attained about 700 thousand hooks. Then the effort on albacore turned to the decreasing trend, and dropped the low level, 130 thousand hooks in 1972.
Japanese albacore yield recorded the highest amount, 28 thousand tons, in 1965, and thereafter, has decreasing to less than 3,000 tons in 1972. The Japanese share in the catch of albacore taken by whole longline fleets has been declining rapidly since 1967, and became below 10 percent in 1972 (Table 5).

The efficiency rate of the Japanese unit effort on southern population by the Japanese longline fishery indicates almost the same historical change as that on north population. The current efficiency rate was 0.17 for adult stock and 0.80 for immature stock in 1972 (Fig. 8).
The yield and the catch in number for the south population has been stable between 25 and 30 thousand tons and around 150 thousand fish respectively, since 1964. On the other hand, the fishing intensity has been increasing until 1972, so that the cpue has been on the decrease. Hook rate in 1972 was 1.3, which was 5.9 in 1957 (Fig. 9).
The relation between fishing intensity and yield for the adult indicates that the yield increased proportionally with the increase in effort until 1964. Since 1965, however, yield has leveled off around 15-20 thousand tons notwithstanding the increase in fishing intensity. The almost similar trend was observed on the immature stock (Fig. 10, 11).

2. Length composition of catch, 1972
Procedure of the calculations was already described in the first issue of this series. In 1972, 4723 albacore were measured and all samples were from the subarea N-2. For the remaining areas, data taken in preceding years were substituted (Table 10).
Appendix Table 3 gives number of albacore in 1-cm interval of length taken by Japanese longline fishery in 1972. The fish taken in N-2 subarea indicate two major modes at 77-78 cm and 85-88 cm, which correspond to age 4 and5 respectively (Fig. 12).

3. Survey activity needed
Recent concerns of the Japanese longline fleet in the Atlantic have been directed to catching bluefin group and bigeye tuna. The amount of catch of albacore by Japanese fleet has also been on the decrease and its share has been becoming lower. This species preference is reflected by the low efficiency of the effort on albacore, as already pointed out in the previous section. This suggests Japanese longline boats are operating mainly in the area of marginal portion of the albacore distribution. Under these circumstances, it is strongly desired that non-Japanese Task 2 stastics and length data should be collected sufficiently for obtaining more reliable estimates.

4 Addendum
In the previous report (Shiohama 1974), the following corrections were found:

1) In Table 1, the figures of whole fleet for 1967 should be:

Item	For	Read
Catch in 1,000 fish	643	293
Yield in 1,000 tons	12.3	5.6
Intensity in 1,000 hooks per 5° square	532.7	242.5

Accordingly, plotting for 1967 in Figs. 2 and 3 should be replaced based on the above.

2) Explanations of Fig. 2 and Fig. 3 should be exchanged each other.

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Table 1. Annual yield of albacore, by country, caught by longline fishery in the Atlantic Ocean, 1956-1972.

(unit in 1,000 tons)

Year	Argentina	China (Taiwan)	Japan	Korea	Panama	Venezuela	Brazil	Cuba	Total
1956			0.0						0.0
1957			0.9						0.9
1958			2.0						2.0
1959			3.6						3.6
1960	1.8		9.8						11.6
1961	1.5		9.3						10.8
1962	0.7	0.0	22.1						22.8
1963	1.5	0.0	29.7						31.2
1964	1.5	0.1	39.5	0.2					41.3
1965	1.1	0.1	42.6	0.5					44.3
1966	0.8	0.2	26.9	6.7					34.6
1967	0.7	1.8	12.5	10.3					25.3
1968	1.2	8.7	15.2	7.3		0.6			33.0
1969	0.4	11.5	11.0	16.0		0.8			39.7
1970	0.5	11.9	11.8	10.0		0.5			34.7
1971	0.3	19.2	10.1	11.5		0.8	0.2		42.1
1972	0.1	19.2	3.9	13.6	0.4	0.8	0.1	0.1	38.2

Source of data: 1957-1959 from ICCAT Statistical Bulletin, Vol. 1.
1960-1962 from ICCAT Statistical Bulletin, Vol. 2.
1963-1972 from ICCAT Statistical Bulletin, Vol. 4.
Japanese yield for 1956 estimated from Shiohama (1965)
Argentina and Brazil yields for 1957-1959 were excluded.

Table 2. Catch and effort statistics of Japanese longline fishery and those estimated for the whole longline fishery in the North Atlantic Ocean, 1956-1972.

Year	JAPANESE FLEET				WHOLE FLEET		
	Hook rate Catch in number per 100 hooks	Catch in number of fish in 1,000	Yield in 1,000 tons	Intensity per 5° square (1,000 hooks)	Catch in number of fish in 1,000	Yield in 1,000 tons	Intensity per 5° square (1,000 hooks)
1956	1.20	0	0.0	0	0	0.0	0
1957	6.08	5	0.1	1	5	0.1	1
1958	4.36	47	0.9	14	47	0.9	14
1959	3.18	59	0.6	25	59	0.6	25
1960	3.19	52	1.1	21	52	1.1	21
1961	2.15	18	0.4	10	18	0.4	10
1962	1.83	280	5.7	182	281	5.7	183
1963	1.83	545	14.5	345	545	14.5	345
1964	1.64	836	15.8	606	841	15.9	611
1965	1.25	555	14.3	543	559	14.4	547
1966	1.44	318	5.9	285	422	8.2	397
1967	1.53	251	4.8	217	285	5.6	252
1968	1.48	177	3.3	157	286	5.7	269
1969	1.36	146	4.7	140	232	7.5	222
1970	1.42	357	5.9	334	527	8.9	503
1971	1.07	333	6.5	418	527	10.8	695
1972	0.81	63	1.3	105	266	6.2	499

Table 3. Catch and effort statistics of Japanese longline fishery and those estimated for the whole longline fishery in the subarea N-1, 1956-1972.

Year	JAPANESE FLEET				WHOLE FLEET		
	Hook rate Catch in number per 100 hooks	Catch in number of fish in 1,000	Yield in 1,000 tons	Intensity per 5° square (1,000 hooks)	Catch in number of fish in 1,000	Yield in 1,000 tons	Intensity per 5° square (1,000 hooks)
1956	1.20	0	0.0	0	0	0.0	0
1957	6.08	5	0.1	2	5	0.1	2
1958	4.36	47	0.9	20	47	0.9	20
1959	3.18	59	0.6	36	59	0.6	36
1960	3.19	52	1.1	30	52	1.1	30
1961	2.15	18	0.4	14	18	0.4	14
1962	1.83	280	5.7	257	281	5.7	258
1963	1.84	520	14.0	456	520	14.0	456
1964	1.60	729	14.3	738	734	14.4	743
1965	1.28	359	10.4	459	363	10.5	465
1966	1.23	142	3.2	190	246	5.5	329
1967	1.45	127	2.9	149	160	3.7	189
1968	1.35	96	2.1	122	202	4.4	258
1969	1.33	99	3.6	127	155	5.6	199
1970	1.34	193	3.7	243	313	6.0	394
1971	1.07	120	2.9	192	258	6.3	413
1972	0.66	21	0.6	58	172	4.6	467

Table 4. Catch and effort statistics of Japanese longline fishery and those estimated for the whole longline fishery in the subarea N-2, 1956-1972.

Year	JAPANESE FLEET				WHOLE FLEET		
	Hook rate Catch in number per 100 hooks	Catch in number of fish in 1,000	Yield in 1,000 tons	Internsity per 5° square (1,000 hooks)	Catch in number of fish in 1,000	Yield in 1,000 tons	Intensity per 5° square (1,000 hooks)
1956	-	-	-	-	-	-	-
1957	-	-	-	-	-	-	-
1958	-	-	-	-	-	-	-
1959	-	-	-	-	-	-	-
1960	-	-	-	-	-	-	-
1961	1.27	0	0.0	0	0	0.0	0
1962	1.21	0	0.0	2	0	0.0	2
1963	1.74	25	0.5	56	25	0.5	56
1964	1.98	107	1.4	241	107	1.4	241
1965	1.21	196	3.9	796	196	3.9	796
1966	1.66	176	2.7	547	176	2.7	547
1967	1.63	124	1.9	468	124	1.9	468
1968	1.66	82	1.2	280	84	1.2	289
1969	1.44	46	1.1	194	77	1.8	320
1970	1.51	164	2.2	585	214	2.9	766
1971	1.07	213	3.5	1,101	269	4.4	1,391
1972	0.92	42	0.8	237	93	1.7	531

Table 5. Catch and effort statistics of Japanese longline fishery and those estimated for the whole longline fishery in the South Atlantic Ocean, 1956-1972.

Year	JAPANESE FLEET				WHOLE FLEET		
	Hook rate Catch in number per 100 hooks	Catch in number of fish in 1,000	Yield in 1,000 tons	Intensity per 5° square (1,000 hooks)	Catch in number of fish in 1,000	Yield in 1,000 tons	Intensity per 5° square (1,000 hooks)
1956	2.25	1	0.0	0	1	0.0	0
1957	5.91	27	0.7	5	27	0.7	5
1958	5.01	52	1.0	12	52	1.0	12
1959	5.80	298	3.0	54	298	3.0	54
1960	5.08	400	8.7	82	483	10.5	99
1961	4.18	413	8.9	108	483	10.4	127
1962	2.81	827	16.4	308	861	17.1	322
1963	3.15	589	15.2	203	645	16.7	223
1964	2.96	1,293	23.7	469	1,383	25.4	502
1965	2.37	1,214	28.3	595	1,270	29.9	629
1966	2.16	1,268	21.0	696	1,529	26.4	876
1967	2.27	437	7.7	219	1,083	19.8	560
1968	2.35	739	11.9	380	1,596	27.3	874
1969	1.85	244	6.3	157	1,097	32.3	802
1970	1.96	454	5.9	283	1,739	25.9	1,241
1971	1.74	218	3.6	153	1,655	31.3	1,324
1972	1.34	148	2.6	134	1,540	31.9	1,667

Table 6. Catch and effort statistics of Japanese longline fishery and those estimated for the whole longline fishery in the subarea S-1, 1956-1972.

Year	JAPANESE FLEET				WHOLE FLEET		
	Hook rate Catch in number per 100 hooks	Catch in number of fish in 1,000	Yield in 1,000 tons	Intensity per 5° square (1,000 hooks)	Catch in number of fish in 1,000	Yield in 1,000 tons	Intensity per 5° square (1,000 hooks)
1956	2.25	1	0.0	1	1	0.0	1
1957	5.91	27	0.7	8	27	0.7	8
1958	5.01	52	1.0	19	52	1.0	19
1959	5.80	298	3.0	85	298	3.0	85
1960	5.08	400	8.7	128	483	10.5	155
1961	4.20	409	8.8	172	479	10.3	201
1962	2.74	774	15.7	463	808	16.4	483
1963	3.01	517	14.0	283	573	15.5	319
1964	2.70	1,032	20.3	630	1,117	22.0	681
1965	2.01	547	15.9	479	602	17.5	528
1966	1.77	368	8.2	350	580	12.9	553
1967	1.88	175	4.0	157	508	11.5	457
1968	2.05	202	4.4	174	651	14.2	560
1969	1.68	56	2.0	57	545	19.7	563
1970	1.21	46	0.9	65	640	12.4	908
1971	1.57	28	0.7	34	639	15.6	787
1972	0.77	9	0.2	21	615	16.3	1,164

Table 7. Catch and effort statistics of Japanese longline fishery and those estimated for the whole longline fishery in the subarea S-2, 1956-1972.

Year	JAPANESE FLEET				WHOLE FLEET		
	Hook rate Catch in number per 100 hooks	Catch in number of fish in 1,000	Yield in 1,000 tons	Intensity per 5° square (1,000 hooks)	Catch in number of fish in 1,000	Yield in 1,000 tons	Intensity per 5° square (1,000 hooks)
1956	-	-	-	-	-	-	-
1957	-	-	-	-	-	-	-
1958	-	-	-	-	-	-	-
1959	-	-	-	-	-	-	-
1960	-	-	-	-	-	-	-
1961	2.85	4	0.1	4	4	0.1	4
1962	4.25	53	0.7	36	53	0.7	36
1963	4.60	72	1.2	47	72	1.2	47
1964	4.79	266	3.3	167	266	3.3	167
1965	2.76	668	12.4	709	668	12.4	709
1966	2.37	900	12.8	1,114	948	13.5	1,174
1967	2.64	262	3.8	296	575	8.3	651
1968	2.48	537	7.4	636	945	13.1	1,119
1969	1.90	188	4.5	297	552	12.6	870
1970	2.10	408	5.0	587	1,099	13.5	1,579
1971	1.77	191	3.0	323	1,015	15.8	1,717
1972	1.40	139	2.3	298	925	15.5	1,988

Table 8. The present status of utilization for north Atlantic albacore.

Developmental stage	Gear	Nationality	Main fishing ground	Main fishing period	Main age group
Immature	Trolling Pole-and-line	France Spain	Bay of Biscay to Azores Plateau	June – Oct.	3 and 4 years old
	Longline	Japan Taiwan	North west Atlantic West of 30°W 28°N to 44°N	Oct. – Mar.	4 and 5 years old
Adult	Longline	Japan Taiwan Korea Venezuela Panama Cuba	Middle latitude area West of 30°W 18°N to 28°N	May – Aug.	6 and 7 years old

Table 9-1. Correlation between c.p.u.e. of class II (3 years old) of the surface fishery and either c. p. u. e. or catch in number of the adult fish of the longline fishery before three years of the c.p.u.e. of class II.

* The values of c.p.u.e. of the surface are cited from Bard(1973).

Year (X)	Surface fishery * c.p.u.e. of class II.	Longline fishery	
		c.p.u.e. (X-3)	Catch in number (X-3)
1968	39.55	1.28	362,814
1969	47.17	1.23	245,599
1970	35.45	1.45	160,336
1971	69.6	1.35	202,011
1972	66.5	1.33	154,933
Coefficient of correlation		-0.1033	-0.4065

Table 9-2. Relationships between c.p.u.e. of the surface (Bard 1973) and either c.p.u.e., catch or effort of the adult in N-1 caught by the longline.

Year (X)	C.p.u.e. of surface	C.p.u.e. of longline (N-1)			Catch of longline (N-1) (1,000 fish)			Effective effort of longline (N-1) (10,000 hooks)		
		A	B	C	A	B	C	A	B	C
1964	76.4	2.15	2.67	2.84	18	35	43	82	123	144
1965	100.1	1.83	1.99	2.39	281	149	117	1,533	807	593
1966	76.1	1.84	1.84	1.94	520	400	273	2,833	2,183	1,483
1967	85.7	1.60	1.72	1.76	734	627	512	4,599	3,716	2,988
1968	60.4	1.28	1.44	1.57	363	548	539	2,829	3,714	3,420
1969	61	1.23	1.26	1.37	246	304	448	1,998	2,414	3,142
1970	64	1.45	1.34	1.32	160	203	256	1,109	1,554	1,979
1971	91.4	1.35	1.40	1.34	202	181	203	1,496	1,302	1,534
1972	83.6	1.33	1.34	1.38	155	178	172	1,169	1,332	1,258
Coefficient of correlation		0.3626	0.3099	0.3385	0.1073	-0.2717	-0.5129	-0.0166	-0.3997	-0.5824

A; X-3 B; (X-3)+(X-4)/2 C; (X-3)+(X-4)+(X-5)/3

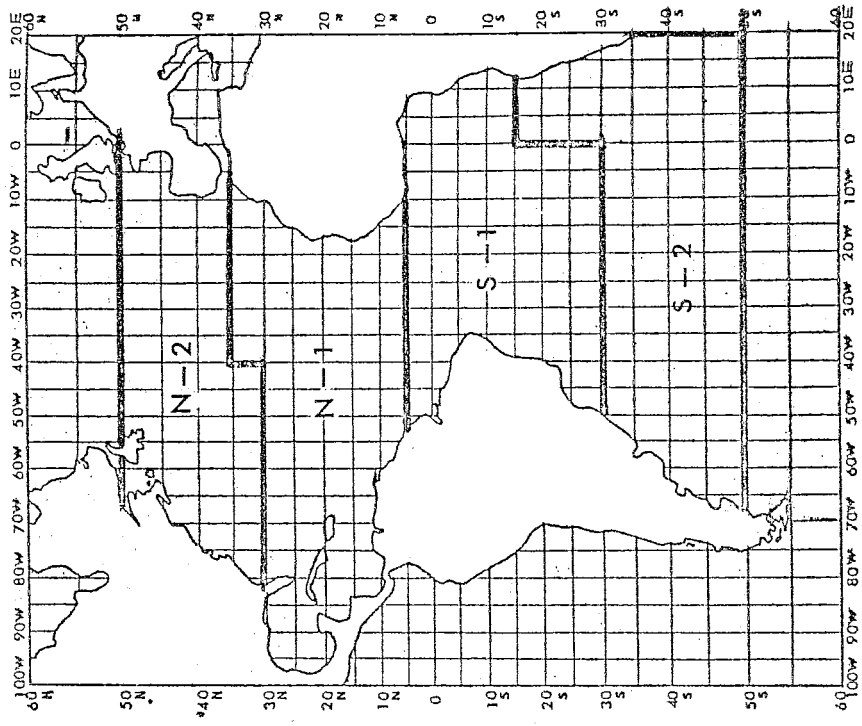

Fig. 1. Definition and division of the Atlantic Ocean for calculating amount of fishing effort and catch by length class of albacore in Japanese longline fishery, 1956–1972.

Table 10. Sample size and substituion of data for calculating catch by length class, 1972.

Numerals in parentheses denote substitutions of data.
(1) Roman numerals ; substitued data of the given quarter.
(2) Arabic numerals ; substitued data of the given year.

Area	Quarter			
	I	II	III	IV
N – 2	1238	64	1727	1694
N – 1	(IV,1968)	(III,1968)	(III,1968)	(IV,1968)
S – 1	(IV,1968)	(IV,1968)	(IV,1968)	(IV.,1968)
S – 2	(I,1970)	(II,1970)	(II,1970)	(IV,1969)

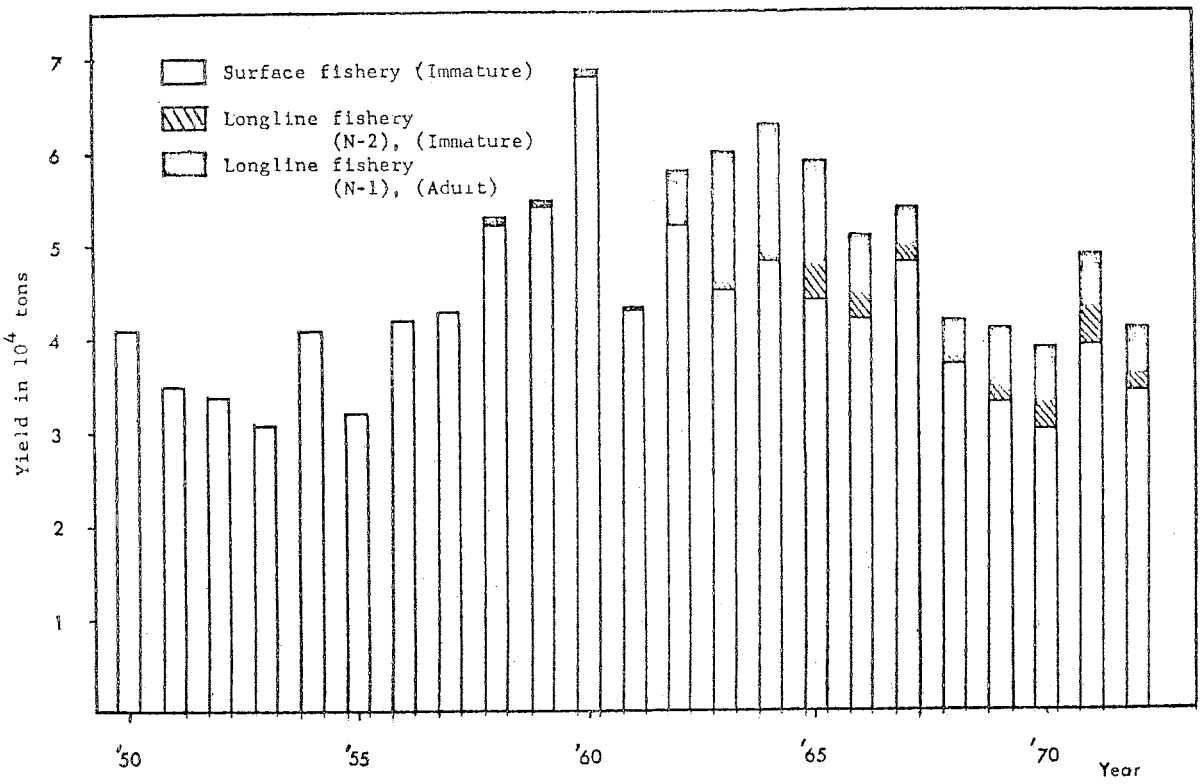

Fig. 2. Annual yield of albacore in north Atlantic Ocean by type of fishing. Surface catch is taken from the figures by Bard(1973).

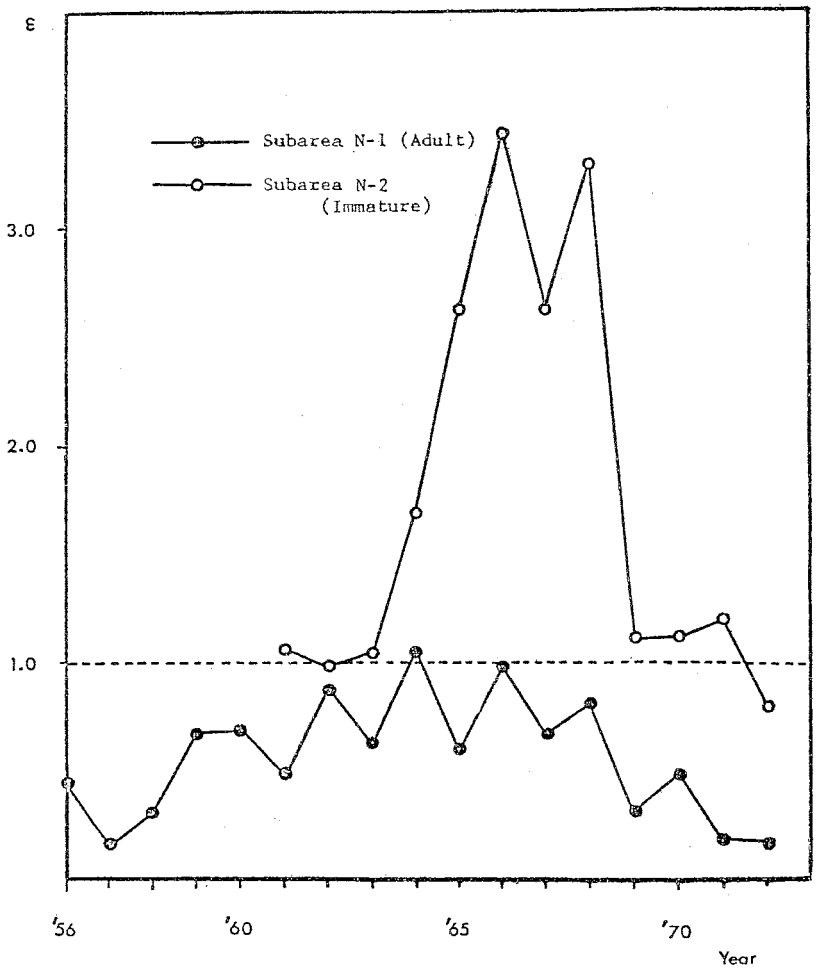

Fig. 3. The efficiency(E) of fishing effort for immature and adult albacore of the North population.

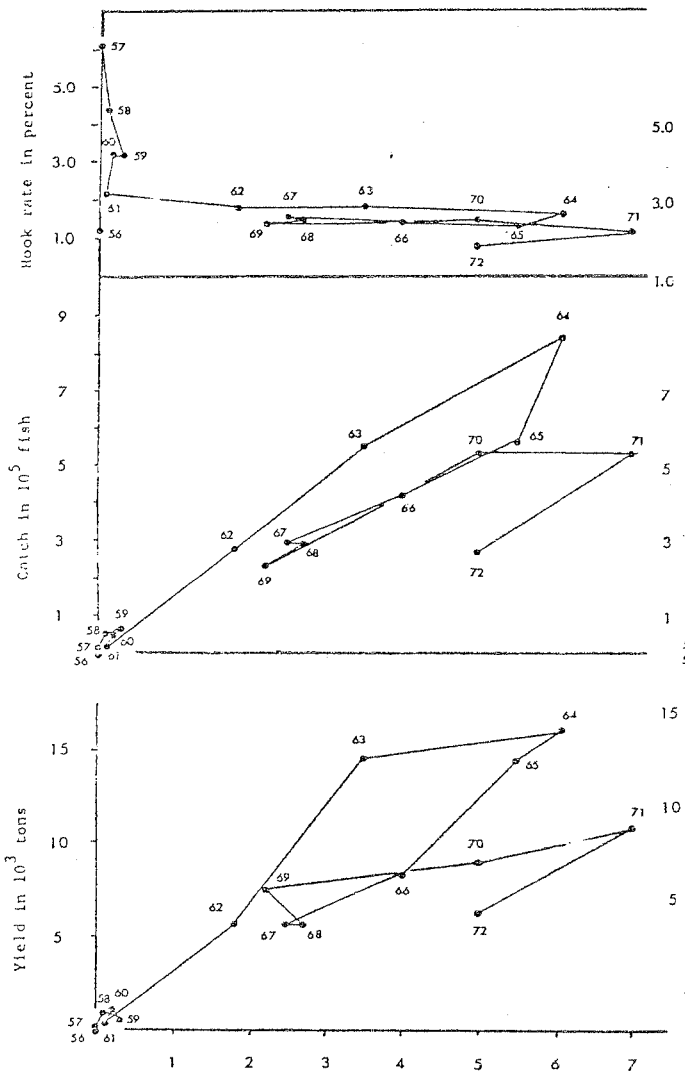

Fig. 4. Hook rate, catch and yield of albacore against overall fishing intensity in the North Atlantic longline fishery, 1956-1972.

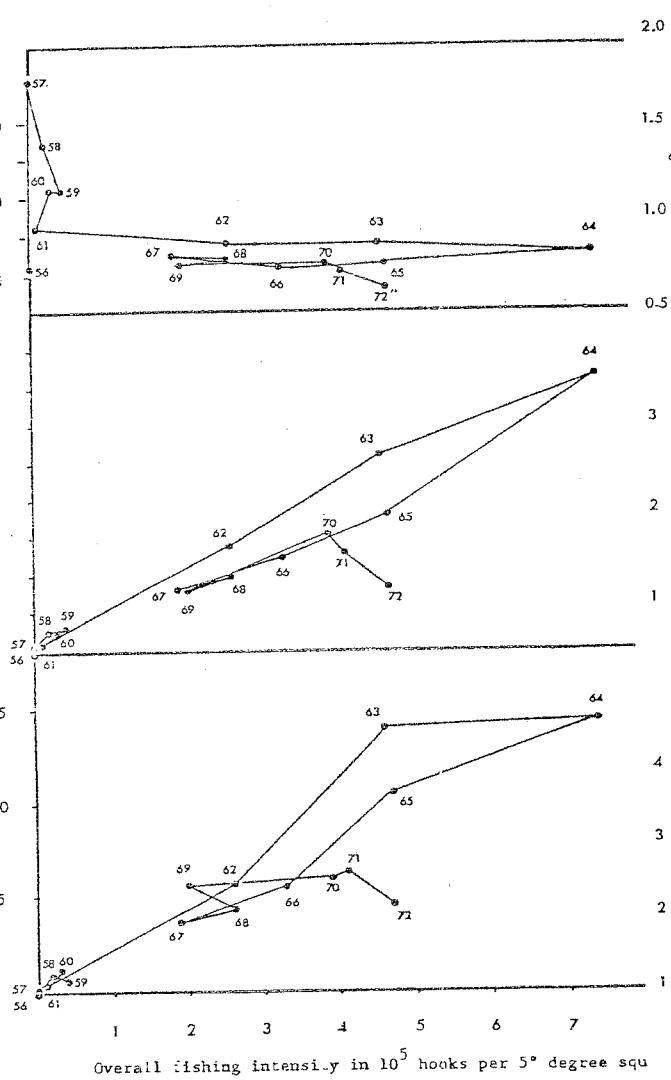

Fig. 5. Hook rate, catch and yield of albacore against overall fishing intensity in the subarea N-1, 1956-1972

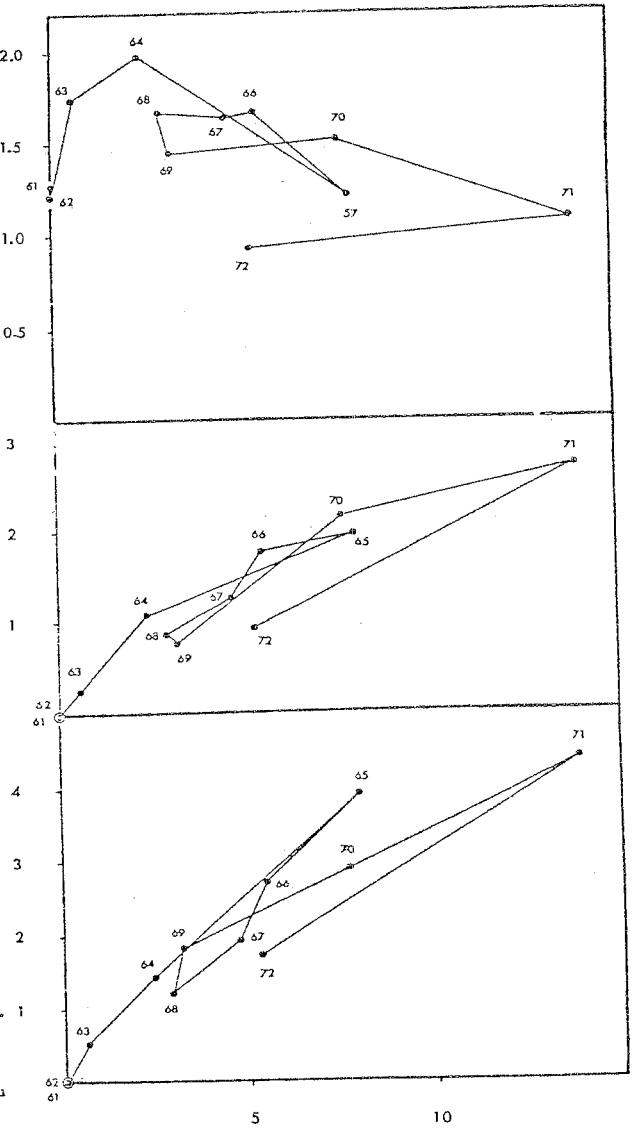

Fig. 6. Hook rate, catch and yield of albacore against overall fishing intensity in the subarea N-2, 1956-1972.

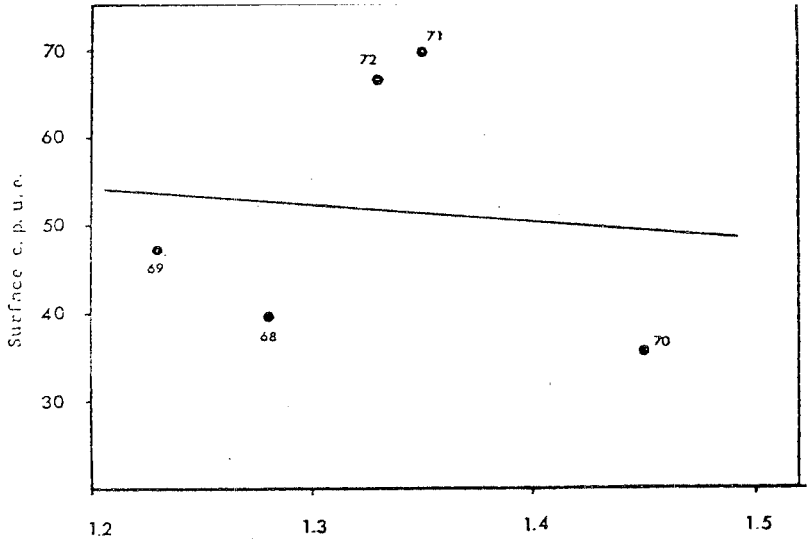

Fig. 7-1. Correlation between c.p.u.e. of class II of the surface fishery and c.p.u.e. of the longline fishery operated 3 years before in subarea N-1.

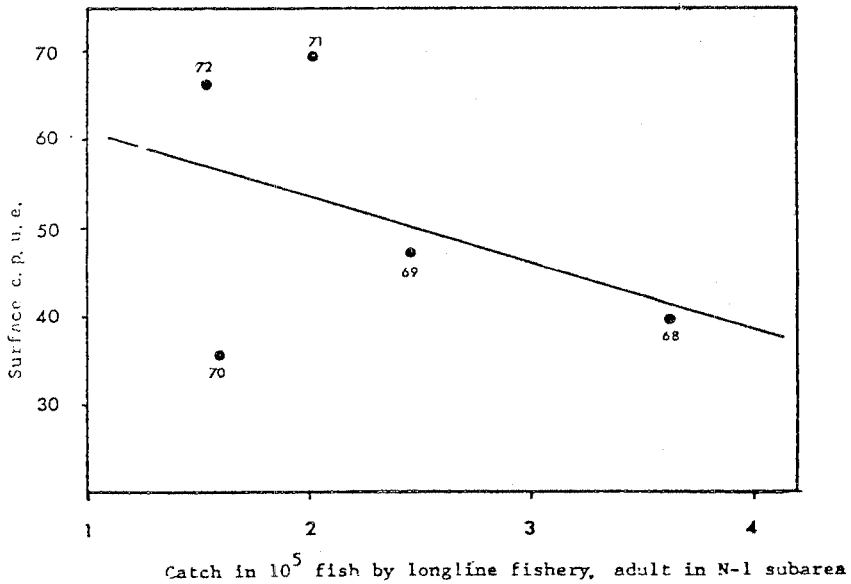

Fig. 7-2. Correlation between c.p.u.e. of class II of the surface fishery and number of fish caught by the longline fishery operated 3 years before in subarea N-1.

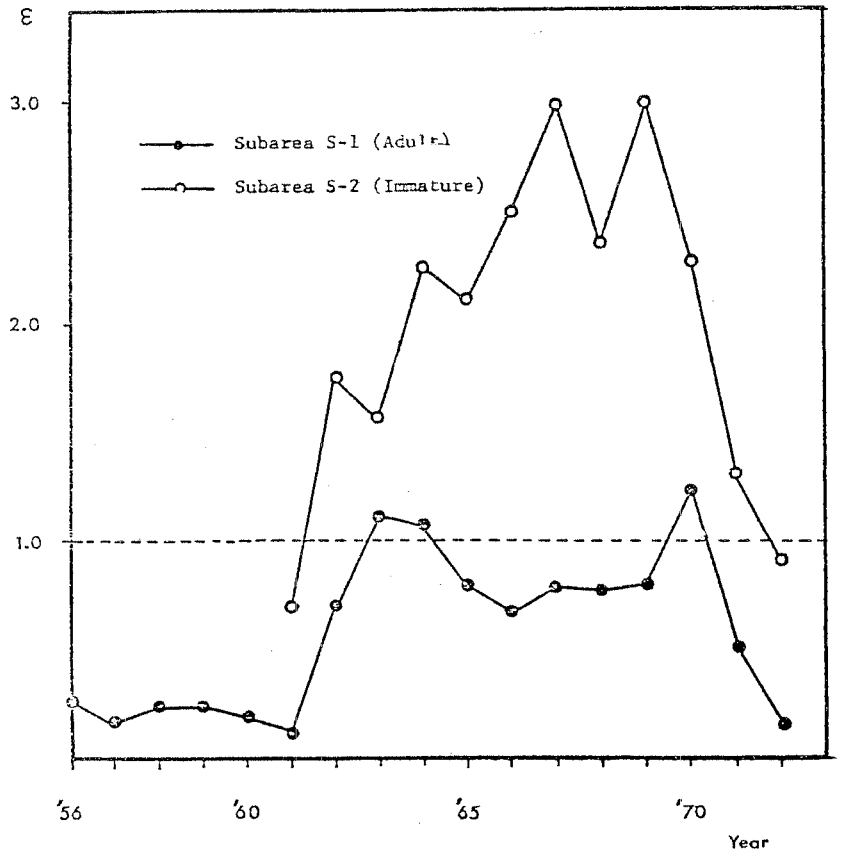

Fig. 8. Efficiency($\bar{E}$) of the fishing effort on South population by each subarea.

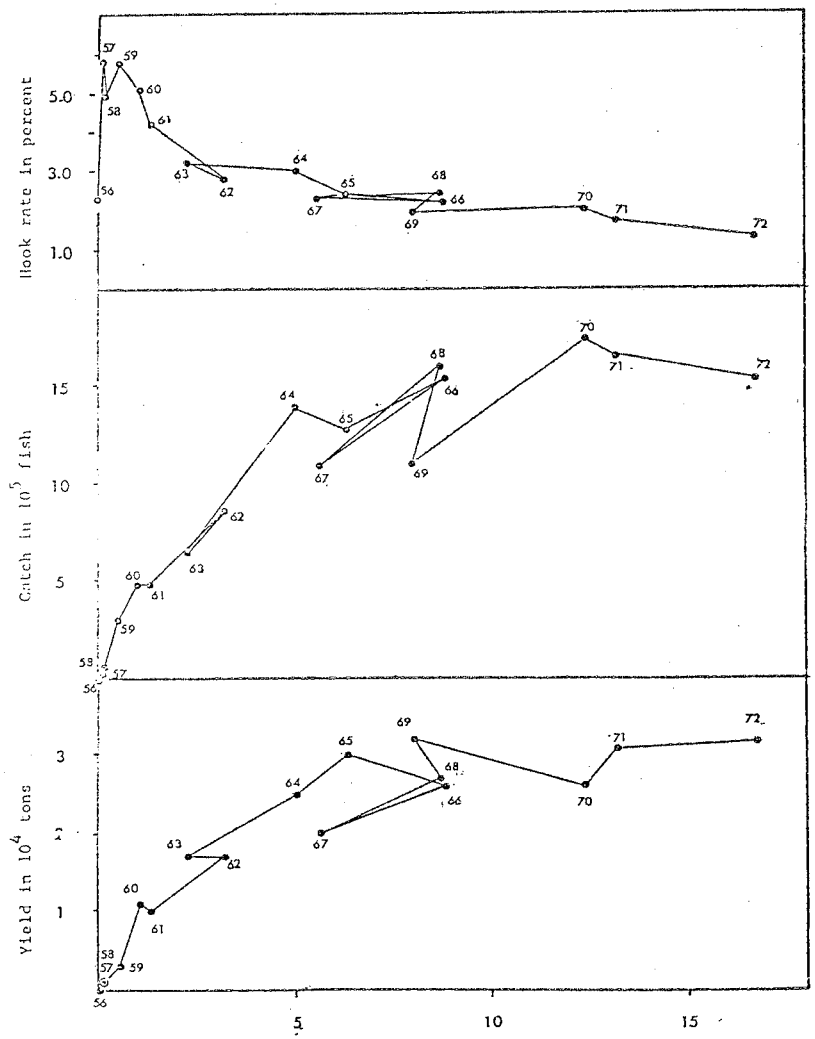

Fig. 9. Hook rate, catch and yield of albacore against overall fishing intensity in the South Atlantic longline fishery, 1956-1972.

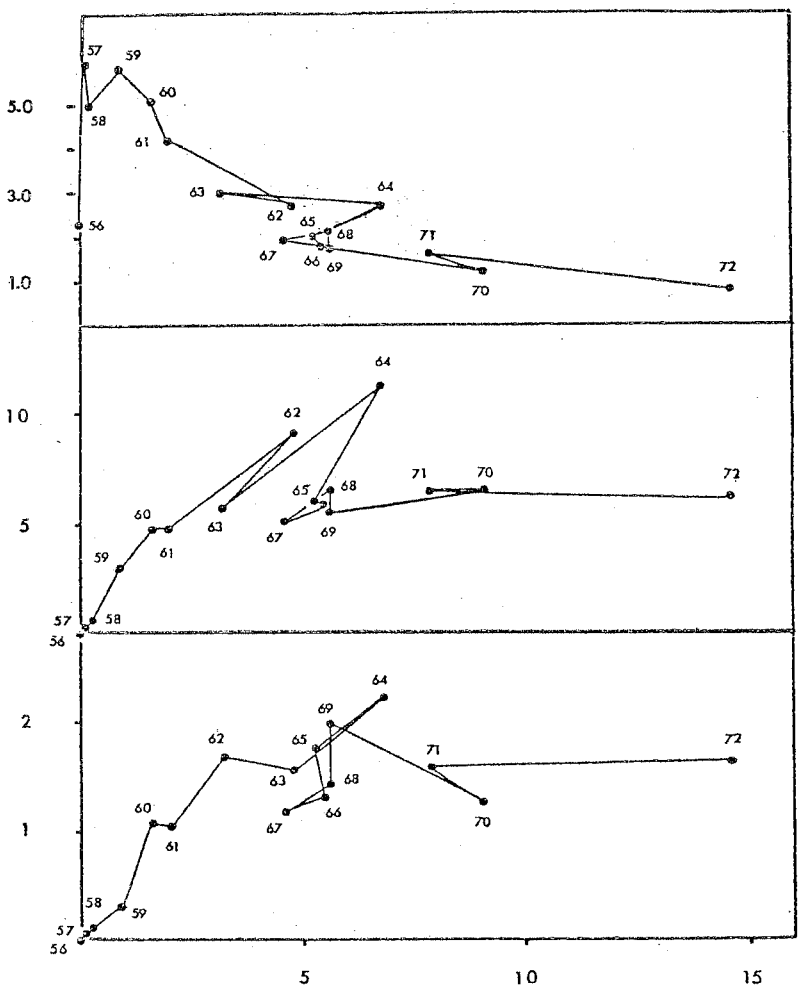

Fig. 10. Hook rate, catch and yield of albacore against overall fishing intensity in the subarea S-1, 1956-1972.

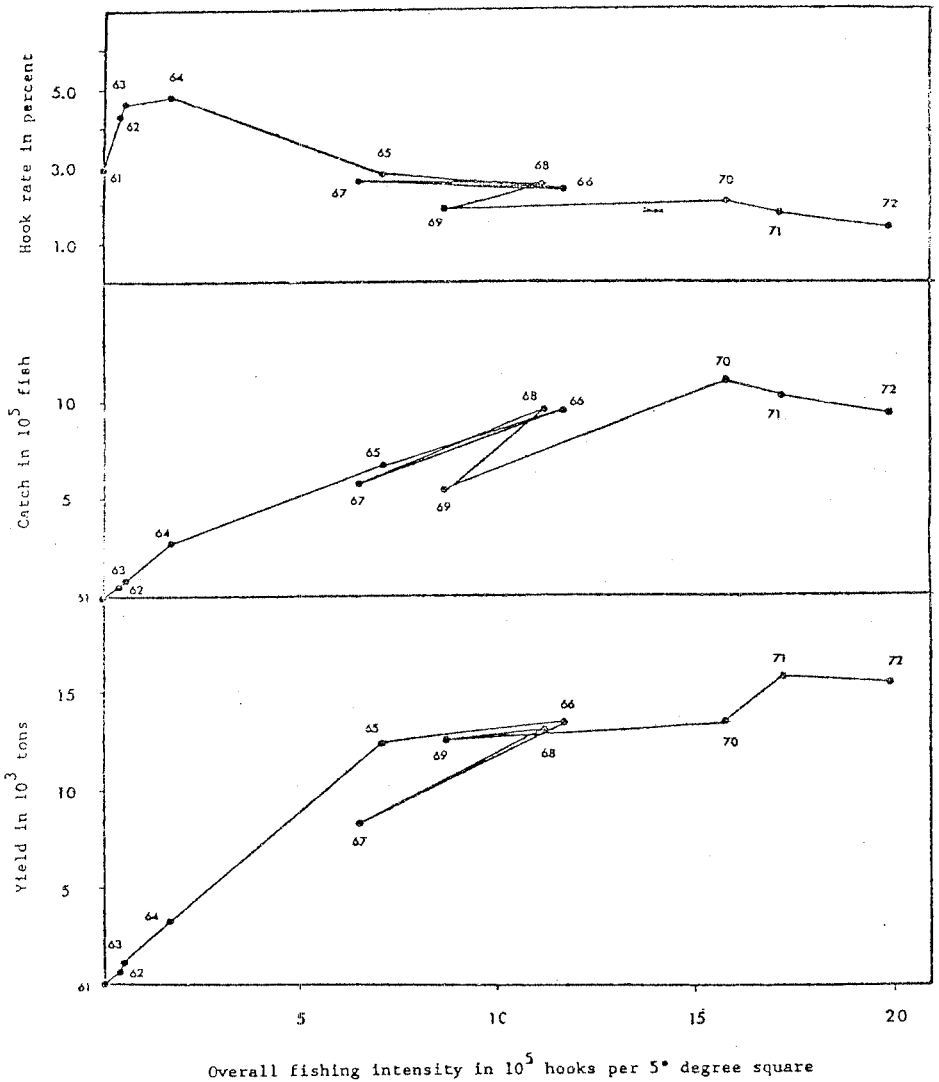

Fig. 11. Hook rate, catch and yield of albacore against overall fishing intensity in the subarea S-2, 1956-1972.

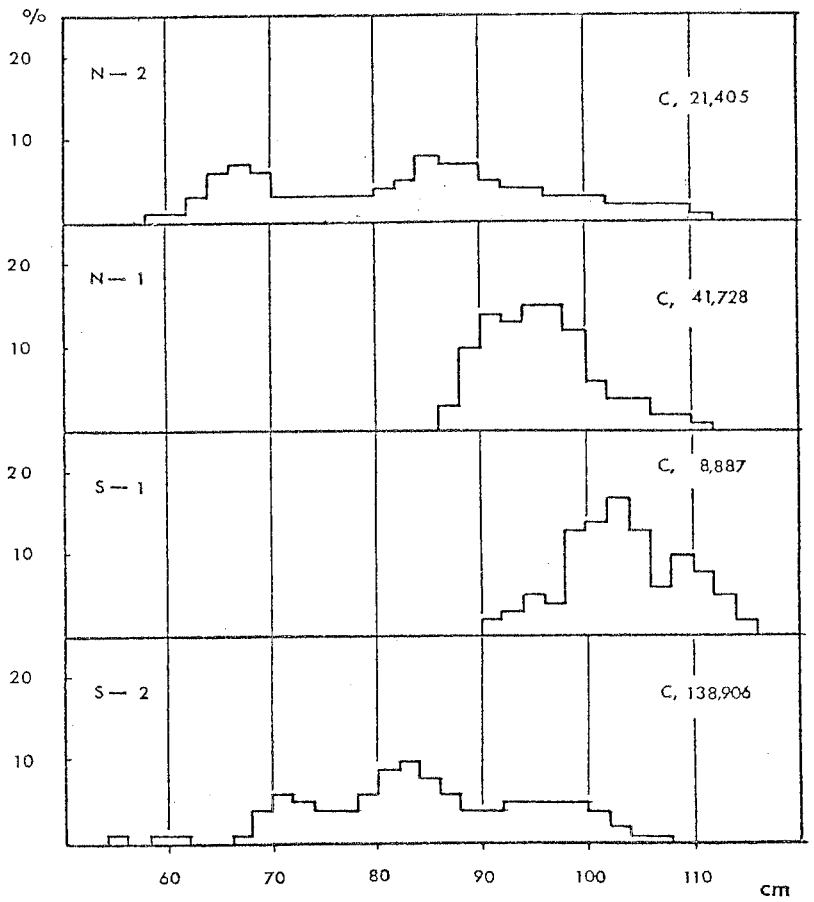

Fig. 12. Percentage length composition of albacore caught by Japanese longline fishery in the Atlantic Ocean, 1972. See fig.1 for division of area.

Appendix table 1. Extent of distribution range of the North population of albacore in 5°-degree square in the average years, and amount of effective effort in thousand hooks and overall fishing intensity in thousand hooks per 5°-degree square of Japanese longline fishery, 1956-1972.

A. N-1 subarea for adult stock.

Month	Area	1956		1957		1958		1959		1960	
		x	f	x	f	x	f	x	f	x	f
Total	658.16	9	0.1	82	1.5	1,085	19.9	1,858	35.7	1,634	29.9
1	56.89	—	—	—	—	7	0.1	119	2.1	66	1.2
2	55.04	—	—	—	—	—	—	58	1.1	15	0.3
3	48.00	—	—	—	—	—	—	19	0.4	2	0.0
4	57.01	—	—	—	—	—	—	68	1.2	20	0.3
5	67.17	—	—	—	—	131	2.0	84	1.3	40	0.6
6	65.59	3	0.1	8	0.1	209	3.2	331	5.1	119	1.8
7	58.73	—	—	8	0.1	151	2.6	160	2.7	173	2.9
8	59.50	2	0.0	12	0.2	57	1.0	54	0.9	422	7.1
9	52.04	1	0.0	8	0.2	137	2.6	79	1.5	292	5.6
10	51.86	3	0.1	38	0.7	194	3 7	206	4.0	367	7.1
11	39.76	—	—	6	0.2	138	3.5	253	6.4	107	2.7
12	46.57	—	—	1	0.0	62	1.3	426	9.2	9	0.2

Month	1961		1962		1963		1964		1965		1966	
	x	f	x	f	x	f	x	f	x	f	x	f
Total	820	14.3	15.283	257.1	28,300	455.7	45,671	737.6	27,987	450.5	11.578	190.4
1	38	0.7	5	0.1	10	0.2	117	2.0	1.061	18 6	639	11.2
2	—	—	—	—	29	0.5	298	5.4	890	16.2	214	3.9
3	2	0.0	—	—	28	0.6	498	10.4	550	11.5	171	3.6
4	4	0.1	73	1.3	198	3.5	1,438	25.2	1,003	17.6	645	11.3
5	49	0.7	427	6.4	4,278	63.7	14,348	213.6	6,351	94.5	2,720	40.5
6	107	1.6	2,627	40.1	13,103	199.8	13,841	211.0	8,961	136.6	3,208	48.9
7	250	4.3	6,641	113.1	7,133	121.5	8,027	136.7	4,641	79.0	1,782	30.3
8	133	2.2	4,222	71.0	1,723	29.0	3,562	59.9	2,070	34.8	1,007	16.9
9	106	2.0	704	13.5	467	9.0	1,679	32.3	689	13.2	613	11.8
10	111	2.1	493	9.5	757	14.6	387	7.5	588	11.3	306	5.9
11	13	0.3	91	2.3	330	8.3	535	13.5	176	4.4	48	1.2
12	7	0.1	—	—	243	5.2	940	20.2	1,008	21.7	226	4.9

Month	1967		1968		1969		1970		1971		1972	
	x	f	x	f	x	f	x	f	x	f	x	f
Total	8,760	149.2	7,091	122.3	7,484	127.4	14,379	242.8	11,276	192.4	3,246	57.9
1	618	10.9	515	9.1	360	6.3	189	3.3	780	13.7	1,187	20.9
2	462	8.4	219	4.0	663	12.1	640	11.6	585	10.6	484	8.8
3	239	5.0	560	11.7	789	16.4	831	17.3	484	10.1	482	10.0
4	585	10.3	334	5.9	458	8.0	578	10.1	902	15.8	270	4.7
5	774	11.5	659	9.8	1,274	19.0	1,538	22.9	1,490	22.2	169	2.5
6	1,804	27.5	1,757	26.8	1,412	21.5	3,578	54.5	2,580	39.3	315	4.8
7	1,889	32.0	1,639	27.9	1,526	26.0	3,490	59.4	2,031	34.6	120	2.0
8	1,540	25.9	516	8.7	676	11.4	2,128	35.8	842	14.1	85	1.4
9	218	4.2	394	7.6	66	1.3	851	16.3	677	13.0	77	1.5
10	301	5.8	200	3.9	139	2.7	397	7.7	367	7.1	—	—
11	132	3.3	190	4.8	55	1.4	90	2.3	71	1.8	5	0.1
12	208	4.4	107	2.3	67	1.4	68	1.5	468	10.1	51	1.1

Appendix table 1. (Continued).

B. N-2 subarea for immature stock.

Month	Area	1956		1957		1958		1959		1960	
		x	f	x	f	x	f	x	f	x	f
Toatl	236.69	—	—	—	—	—	—	—	—	—	—
1	16.63	—	—	—	—	—	—	—	—	—	—
2	14.69	—	—	—	—	—	—	—	—	—	—
3	9.80	—	—	—	—	—	—	—	—	—	—
4	15.10	—	—	—	—	—	—	—	—	—	—
5	21.45	—	—	—	—	—	—	—	—	—	—
6	24.74	—	—	—	—	—	—	—	—	—	—
7	26.03	—	—	—	—	—	—	—	—	—	—
8	23.67	—	—	—	—	—	—	—	—	—	—
9	23.18	—	—	—	—	—	—	—	—	—	—
10	21.49	—	—	—	—	—	—	—	—	—	—
11	17 98	—	—	—	—	—	—	—	—	—	—
12	21.93	—	—	—	—	—	—	—	—	—	—

Month	1961		1962		1963		1964		1965		1966	
	x	f	x	f	x	f	x	f	x	f	x	f
Toatl	1	0.0	38	1.8	1,442	55.7	5,410	240.7	16,229	795.5	10,567	546.7
1	—	—	—	—	—	—	—	—	2,133	128.3	208	12.5
2	—	—	—	—	—	—	—	—	94	6.4	—	—
3	—	—	—	—	—	—	—	—	—	—	128	13.0
4	—	—	—	—	—	—	384	25.4	1,334	88.4	1,938	128,4
5	—	—	—	—	—	—	173	8.1	4,821	224.8	2,006	93.5
6	—	—	—	—	9	0.4	2,172	87.8	2,599	105.0	849	34.3
7	—	—	—	—	1,373	52.7	505	19.4	973	37.4	255	9.8
8	—	—	—	—	60	2.5	240	10.1	527	22.3	189	8.0
9	1	0.0	—	—	—	—	111	4.8	209	9.0	419	18.1
10	—	—	38	1.8	—	—	—	—	679	31.6	1.311	61.0
11	—	—	—	—	—	—	185	10.3	1,205	67.0	1,923	107.0
12	—	—	—	—	—	—	1.640	74.8	1,654	75.4	1,341	61.2

Month	1967		1968		1969		1970		1971		1972	
	x	f	x	f	x	f	x	f	x	f	x	f
Total	7,626	467.8	4,922	279.9	3,224	193.8	10,832	585.5	19,955	1100.7	4,541	237.1
1	420	25.3	454	27.3	343	20.6	1,082	65.1	3,223	193.8	1,238	74.4
2	1,025	69.8	221	15.1	362	24.6	419	28.5	1,848	125.8	552	37.6
3	921	93.9	369	37.7	295	30.1	386	39.4	1,834	187.2	6	0.6
4	1,526	101.1	1,161	76.9	977	64.7	1,159	76.8	694	46.0	199	13.2
5	1,232	57.4	548	25.5	46	2.2	836	39.0	304	14.2	162	7.6
6	182	7.3	156	6.3	—	—	109	4.4	1,291	52.2	182	7.3
7	—	—	385	14.8	243	9.3	280	10.8	3,880	149.1	588	22.6
8	79	3.3	476	20.1	193	8.2	240	10.2	1,054	44.5	641	27.1
9	410	17.7	118	5.1	364	15.7	429	18.5	533	23.0	216	9.3
10	638	29.7	560	26.0	169	7.8	1,705	79.3	1,529	71.1	302	14.1
11	786	43.7	349	19.4	—	—	2,267	126.1	2,214	123.2	259	14.4
12	408	18.6	127	5.8	234	10.7	1,920	87.5	1,549	70.6	198	9.0

Appendix table 2. Extent of distribution range of the South population of albacore in 5°-degree square in the average years, and amount of effective effort in thousand hooks and overall fishing intensity in thousand hooks per 5°-degree square of Japanese longline fishery, 1956-1972.

A. S-1 subarea for adult stock.

Month	Area	1956		1957		1958		1959		1960	
		x	f	x	f	x	f	x	f	x	f
Toatl	642.84	43	0.8	451	8.4	1,043	18.8	5,131	85.1	7,881	128.3
1	61.48	—	—	—	—	65	1.1	461	7.5	1,016	16.5
2	59.55	—	—	6	0.1	258	4.3	484	8.1	433	7.4
3	47.52	—	—	4	0.1	83	1.8	140	2.9	104	2.2
4	46.21	—	—	12	0.3	72	1.6	105	2.3	158	3.4
5	42.39	—	—	76	1.8	35	0.8	166	3.9	123	2.9
6	45.10	3	0.1	38	0.8	135	3.0	84	1.9	85	1.9
7	41.67	7	0.2	8	0.2	6	0.1	18	0.4	24	0.6
8	46.73	12	0.3	28	0.6	20	0.4	—	—	7	0.2
9	58.21	7	0.1	103	1.8	31	0.5	12	0.2	46	0.8
10	66.19	6	0.1	51	0.8	240	3.6	338	5.1	546	8.3
11	65.95	1	0.0	49	0.7	37	0.6	1,019	15.5	2,009	30.5
12	61.84	7	0.1	75	1.2	61	1.0	2,303	37.2	3,321	53.7

Month	1961		1962		1963		1964		1965		1966	
	x	f	x	f	x	f	x	f	x	f	x	f
Total	9,742	172.1	28,216	463.0	17,169	288.0	38,265	629.8	27,158	479.4	20,738	350.2
1	1,447	23.5	5,731	93.2	8,415	136.9	7,404	120.4	6,050	98.4	8,218	133.7
2	735	12.4	1,865	31.3	2,243	37.7	3,031	50.9	2,548	42.8	3,453	58.0
3	361	7.6	410	8.6	682	14.3	792	16.7	744	15.7	296	6.2
4	573	12.4	656	14.2	836	18.1	668	14.5	796	17.2	243	5.3
5	356	8.4	176	4.2	101	2.4	85	2.0	90	2.1	40	0.9
6	529	11.7	185	4.1	2	0.0	144	3.2	277	6.2	9	0.2
7	490	11.8	91	2.2	43	1.0	453	10.9	930	22.3	216	5.2
8	202	4.3	619	13.3	205	4.4	1,197	25.6	4,541	97.2	1,662	35.6
9	56	1.0	505	8.7	322	5.5	3,627	62.3	2,524	43.4	1,126	19.3
10	530	8.0	1,145	17.3	617	9.3	6,504	98.3	2,823	42.7	691	10.4
11	1,116	16.9	6,167	93.5	1,522	23.1	7,090	107.5	2,751	41.7	1,940	29.4
12	3,347	54.1	10,666	172.5	2,183	35.3	7,270	117.6	3,083	49.9	2,845	46.0

Month	1967		1968		1969		1970		1971		1972	
	x	f	x	f	x	f	x	f	x	f	x	f
Total	9,292	157.1	9,856	174.2	3,300	57.4	3,766	64.7	1,765	34.1	1,161	21.2
1	2,736	44.5	1,760	28.6	674	11.0	1,870	30.4	88	1.4	131	2.1
2	353	5.9	495	8.3	147	2.5	937	15.7	75	1.3	155	2.6
3	158	3.3	74	1.5	158	3.3	90	1.9	135	2.8	26	0.6
4	129	2.8	39	0.9	113	2.4	58	1.3	292	6.3	20	0.4
5	42	1.0	25	0.6	91	2.1	33	0.8	205	4.8	5	0.1
6	13	0.3	295	6.5	129	2.9	83	1.8	74	1.6	8	0.2
7	1	0.0	639	15.3	103	2.5	76	1.8	89	2.1	87	2.1
8	899	19.2	1,498	32.1	181	3.9	200	4.3	155	3.3	295	6.3
9	1,602	27.5	1,230	21.1	134	2.3	103	1.8	219	3.8	38	0.6
10	959	14.5	1,273	19.2	267	4.0	63	0.9	326	4.9	87	1.3
11	738	11.2	957	14.5	586	8.9	76	1.2	106	1.6	216	3.3
12	1,662	26.9	1,570	25.4	715	11.6	177	2.9	2	0.0	92	1.5

Appendix table 2. (Continued).

B. S-2 subarea for immature stock.

Month	Area	1956		1957		1958		1959		1960	
		x	f	x	f	x	f	x	f	x	f
Toatl	405.51	—	—	—	—	—	—	—	—	—	—
1	33.50	—	—	—	—	—	—	—	—	—	—
2	33.73	—	—	—	—	—	—	—	—	—	—
3	28.30	—	—	—	—	—	—	—	—	—	—
4	34.25	—	—	—	—	—	—	—	—	—	—
5	33.67	—	—	—	—	—	—	—	—	—	—
6	36.60	—	—	—	—	—	—	—	—	—	—
7	31.89	—	—	—	—	—	—	—	—	—	—
8	33.98	—	—	—	—	—	—	—	—	—	—
9	33.88	—	—	—	—	—	—	—	—	—	—
10	34.68	—	—	—	—	—	—	—	—	—	—
11	36.56	—	—	—	—	—	—	—	—	—	—
12	34.47	—	—	—	—	—	—	—	—	—	—

Month	1961		1962		1963		1964		1965		1966	
	x	f	x	f	x	f	x	f	x	f	x	f
Total	130	3.8	1,255	36.2	1,559	47.1	5,548	166.6	24,150	709,1	37,995	1114.3
1	—	—	7	0.2	28	0.8	—	—	67	2.0	195	5.8
2	—	—	—	—	4	0.1	—	—	61	1.8	316	9.4
3	—	—	—	—	1	0.0	40	1.4	224	7.9	909	32.1
4	—	—	—	—	—	—	—	—	547	16.0	5,329	155.6
5	—	—	—	—	—	—	—	—	2,849	84.6	8,657	257.1
6	11	0.3	—	—	—	—	139	3.8	5,945	162.4	8,752	239.1
7	45	1.4	72	2.3	616	19.3	1,928	60.4	7,495	235.0	5,528	173.3
8	0	0.0	9	0.3	393	11.6	1,519	44.7	1,273	37.5	3,986	117.3
9	—	—	512	15.1	429	12.7	1,425	42.1	1,222	36.1	1,448	42.7
10	0	0.0	295	8.5	81	2.3	358	10.3	2,423	69.9	1,374	39.6
11	57	1.6	339	9.3	3	0.1	130	3.6	2,006	54.9	826	22.6
12	16	0.5	21	0.6	4	0.1	9	0.3	36	1.1	677	19.6

Month	1967		1968		1969		1970		1971		1972	
	x	f	x	f	x	f	x	f	x	f	x	f
Total	9,919	296.2	21,633	635.9	9,897	296.9	19,411	586.9	10,788	322.6	9,901	298.4
1	318	9.5	68	2.0	270	8.1	298	8.9	155	4.6	125	3.7
2	349	10.4	—	—	915	27.1	1,800	53.4	749	22.2	750	22.2
3	1,044	36.9	657	23.2	1,198	42.3	3,368	119.0	1,012	35.7	1,788	63.2
4	976	28.5	3,539	103.3	1,096	32.0	4,727	138.0	2,222	64.9	2,504	73.1
5	1,420	42.2	5,539	164.5	1,568	46.6	4,188	124.4	2,013	59.8	1,625	48.3
6	1,279	34.9	5,041	137.7	1,598	43.6	2,701	73.8	1,334	36.5	1,412	38.6
7	1,138	35.7	3,221	101.0	1,284	40.3	988	31.0	1,139	35.7	239	7.5
8	898	26.4	1,459	43.0	556	16.4	420	12.4	693	20.4	244	7.2
9	509	15.0	945	27.9	319	9.4	66	2.0	842	24.9	171	5.1
10	1,459	42.1	824	23.8	332	9.6	181	5.2	143	4.1	465	13.4
11	411	11.2	217	5.9	327	8.9	376	10.3	192	5.3	346	9.5
12	119	3.5	123	3.6	432	12.5	297	8.6	294	8.5	231	6.7