Occasional Paper No.12

SOUTH PACIFIC COMMISSION

THE DEVELOPMENT OF TUNA FISHERIES IN THE WESTERN PACIFIC

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South Pacific Commission
Noumea, New Caledonia
January 1979

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Introduction

Tuna fisheries in the Western Pacific have been undergoing something of a revolution since 1970.

The traditional longline technique has been improved in recent years and can now exploit tuna stocks to a depth of 250 metres.

Surface techniques, both pole-and-line and seine, which were never or seldom used in the past, have developed tremendously and are steadily spreading into hitherto unexploited parts of the Pacific.

Purse-seining, widely practised in the Eastern Pacific, has only just started on an industrial scale in the west.

1. Asian longline fisheries

Longlining is practised over the whole of the Pacific Ocean, mainly by Japan, Korea, and Taiwan.

The Japanese fleet has over a thousand longline vessels, nearly as many as the Korean and Taiwanese fleets put together (568 and 680 respectively). The Taiwanese vessels are smaller than the Japanese and Korean ones (approximately 150 gross tons for the former as against approximately 250 gross tons for the latter) (Ishida, 1975).

Longline catches per unit of effort have been constantly decreasing (1.8 tonnes/fishing day in 1963, 0.8 tonnes/fishing day in 1976), which has led to a lengthening of fishing trips: an average of 106 days in 1963, 259 days in 1973. The contribution of longlining to the total catch in the Pacific dropped from 8.6 per cent to 3.1 per cent in ten years.

1.1 The Japanese longline fishery

1.1.1 Importance and trends in the Pacific

Table 1 summarises variations in longline catch rates since 1962. The number of hooks set, i.e. the fishing effort, varied very little between 1962 and 1975, but the number of fish caught dropped to less than half. Catches of large specimens became rarer and consequently the average weight declined up until 1970. After 1970, in an endeavour to reach the deeper, less exploited stocks and improve their catches, the Japanese started using longlines that went down to greater depths. Instead of being confined to depths of 50-120 m, these longlines were able to exploit tuna in depths between 50 and 250 metres (Suzuki *et al*., 1977).

This change in technique also changed the proportions of big-eye and yellowfin in the catches. The percentages for these two species almost doubled over eight years, while the percentage of albacore dropped sharply (Table 2). As the average weight of a big-eye is 60 kg and that of a yellowfin 40 kg, as against 18 kg for an albacore, the decline in weight of catches since 1970 has been less marked than the decrease in numbers.

TABLE 1 - Japanese longline tuna fishery in the Pacific

Year	Number of hooks set	Number of fish in 1000s	Weight (tonnes)	Average weight (kg)
		Tuna	Tuna	Tuna
1962	290 051	7 969	341 289	42.8
1963	337 113	8 396	364 907	43.5
1964	283 140	6 500	256 260	39.4
1965	288 771	5 880	245 940	41.8
1966	301 167	7 319	282 486	38.6
1967	305 999	5 986	208 305	34.8
1968	286 853	5 102	190 952	37.4
1969	306 024	5 154	215 000	41.7
1970	282 531	4 408	178 139	40.4
1971	273 371	3 776	162 153	42.9
1972	279 156	4 374	196 619	44.9
1973	286 918	4 230	190 212	45
1974	293 824	3 840	172 748	45
1975	263 874	3 599	169 754	47.2

TABLE 2 - Comparative percentages of different tuna species in the catches of Japanese longliners in 1967 and 1975.

Years	Albacore *Thunnus alalunga* %	Yellowfin *Thunnus albacares* %	Big-eye *Thunnus obesus* %	Other %
1967	47	23	26	4
1975	13	40	44	3

1.1.2 Activity of Japanese longliners in the South Pacific (125°E-130°W, 10°N-35°S)

About 40 per cent of Japanese longline catches come from the above defined area.

Details of the catches made in this area are set out in Table 3. This table not only gives the weight for each species of tuna but also the proportion of marlins and other billfishes, such as sailfish and broadbill swordfish. The catch weight of billfishes is about 15 per cent of the total weight of tuna catches.

The Japanese longline vessels have been divided into four classes (Table 4) according to tonnage. The small (20-50 gross tons) and medium sized vessels (50-100 gross tons) have the best catch/effort rate but their activity extends only as far as Papua New Guinea and Tokelau, beyond which vessels of 200 gross tons and more take over.

Catches of big-eye (per 5° square) do not vary much from west to east; on the other hand, yellowfin catches are always substantially higher west of 160°E (cf. annexed Map 1). There are two possible explanations for this:

- an uneven distribution of the yellowfin population, but nothing we know at present enables us to assert this;
- the presence of longliners of 50-100 gross tons which, having kept to the traditional technique, catch mainly yellowfin (Suzuki *et al*., 1977).

1.2 Activity of Taiwanese and Korean longliners in the South Pacific

From 1964 to 1974 the weight of tuna landed by Japanese longliners decreased by 33 per cent for the whole of the Pacific. This may be ascribed to Japan's declining interest in longlining, which has become only marginally profitable, and to a big increase in the fishing effort of competitor countries such as Taiwan and Korea (both of which have lower operating costs than Japan) (Otsu, 1976).

1.2.1 The Taiwanese longline fishery

Annexed Maps II and III show the geographic distribution of catches by Japanese and Taiwanese longliners in 1973. The latter operate mainly south of the equator, whereas the former take the bulk of their catch from the area between 20°N and 10°S.

The area covered by Maps II and III has been divided into 5° Lat. x 10° Long. rectangles. The second figure in each rectangle (i.e. below the number of fish) shows the catch per unit of effort or c.p.u.e.; for longliners, the c.p.u.e. is expressed as the number of fish per 100 hooks set (No./100h). The c.p.u.e. is on the whole higher for the Taiwanese longliners. In 1973 they caught 41,994 tonnes of tuna, with an average weight of 20.4 kg (as against 45 kg for the Japanese fleet).

TABLE 3 - Catches (in tonnes) of Japanese longliners in the South Pacific.

Years	S.BF	Alb.	Big.	YF	Skip.	B.B.	S.M.	Bu.M	Ba.M	SF - SS	Average weight (kg)		Catch (in tonnes)		
											Tuna	Billfishes	Tuna	Billfishes	Total
1972	17 212	3 392	29 829	34 314	360	2 475	1 584	9 960	1 625	750	45.4	82.4	85 107	16 394	101 501
1973	9 360	2 880	28 975	41 832	255	2 200	1 872	7 560	1 375	1 230	45.1	73.4	83 302	14 237	97 539
1974	9 620	2 320	34 221	30 324	304	2 585	1 392	6 000	1 250	720	47.0	74.7	76 789	11 947	88 736
1975	5 668	1 216	28 609	27 846	150	1 320	1 152	3 960	875	630	49.9	76.3	66 225	7 937	74 162

Abbreviations of tuna names	
Name	Abbreviation
Southern bluefin tuna	S.BF
Albacore	Alb.
Big-eye	Big.
Yellowfin	YF
Skipjack	Skip.

Abbreviations of billfish names	
Name	Abbreviation
Broadbill swordfish	B.B.
Striped marlin and white marlin	S.M.
Blue marlin	Bu.M
Black marlin	Ba.M
Sail fish Shortbill spearfish and longbill spearfish	S.S.

TABLE 4 - Percentage of catches (1) and catch per unit of effort (2) i.e. number of fish caught per 100 hooks by Japanese longliners of different tonnages, from 1972 to 1975.

Years \ Tonnage (GT)		20-50	50-100	100-200	200
1972	(1) % (2)	3.6 2.2	31.5 2.3	18 2.1	46.9 1.6
1973	(1) % (2)	0.5 2.4	41.8 2.6	23.4 2.6	34.2 1.5
1974	(1) % (2)	0.7 3.0	37.5 2.0	8.5 1.6	53.3 1.3
1975	(1) % (2)	0.2 2.3	49.0 1.9	9.3 1.7	41.5 1.1

1.2.2 The Korean longline fishery

Korean longliners, like the Taiwanese, mainly catch albacore (about 75 per cent of their catches), unlike the Japanese longliners in whose catches, as mentioned earlier, albacore had dropped to only 13 per cent in 1975.

This difference stems from:

(a) the fishing grounds chosen. Korea, like Taiwan (Map III) operates mainly outside and on the fringe of the inter-tropical area, where albacore is very plentiful, while the Japanese vessles do most of their fishing between 20°N and 20°S where they catch big-eye and yellowfin - these species being more tropical than albacore.

(b) the fishing technique used. As mentioned earlier, setting of hooks at a greater depth changes the catch composition considerably. Unlike the Japanese, Korean and Taiwanese fisheries do not seem to have modified their longlines.

The strong predominance of albacore in the Korean and Taiwanese catches resulted in a higher c.p.u.e. by numbers (Nb/100h.) for these two countries. On the other hand, the Japanese had the highest c.p.u.e. by weight (95 kg/100h compared to 75 for Taiwan and 68 for Korea).

1.3 Conclusion : Asian longline fisheries

Despite a marked reducation in its longline activities, Japan is still landing 200,000 tonnes of various tuna species each year. Korea and Taiwan, operating in different areas with longlines that do not go down as deep, record a lower c.p.u.e. by weight. Their total catch remains under 100,000 tonnes.

A total of 300,000 tonnes of tuna is thus taken each year from the Pacific by Asian longliners, of which nearly 35 per cent is from the Western Pacific.

2. The Japanese pole-and-line fishery

2.1 General outline

Traditionally, Japanese pole-and-line vessels used to fish just off the coast of Japan. The fleet comprised just on 4,000 units of less than 50 gross tons. Concurrently with the decline in longline catch rates (Figure 1 in the Annex), a rapid development of the pole-and-line fishery occurred in the decade between 1966 and 1976. Interest in skipjack flared up again and something like a "skipjack boom" took place in the early 1970s (Otsu, 1976). The number of large fishing vessels (over 200 gross tons) rose fairly rapidly (Table 5) and nearly 500 pole-and-line vessels of over 500 gross tons were in operation from 1973 onwards.

TABLE 5 - Size composition of Japanese pole-and-line fishing fleet (from Ishida, 1973)

Tonnage (GT) / Years	50-100	%	100-200	%	200-500	%	500	%	Total
1968	60	10	170	30	55	10	285	50	570
1969	71	13	156	28	53	9	280	50	560
1970	91	16	140	24	61	10	292	50	584
1971	133	19	129	19	83	12	345	50	690
1972	162	19	116	14	145	17	423	50	846
1973	210	21	80	9	199	20	489	50	978

Increased operating costs caused the average number of fishermen on the 100-200 gross ton vessels to be decreased from 30 in 1970 to 19 in 1976. Automatic fishing gear was installed on the more modern units and the fleet began to extend its operations southwards, since catches were no longer keeping up with the steadily growing demand for skipjack.

In the beginning, incursions into tropical waters were merely a means of continuing fishing activity after the good skipjack season was over in Japanese waters (April to September), but subsequently part of the fleet (the larger units) stayed to fish in the southern waters all the year round.

The contribution of the southern water fishery to the total Pacific catch has risen from 30 per cent in 1970 to 60 per cent in the very recent years (Ishida, 1975). Table 6 shows annual catches by Japanese pole-and-line vessels from 1978 onwards. It can be seen from these figures that:

(a) annual catches have been rising steadily (apart from a drop in 1975);

(b) skipjack is the main species landed by the Japanese pole-and-liners (approximately 75 per cent of their total catch in the Pacific - Table 6). A 67,000 tonne jump in skipjack catches occurred in 1973, as new fishing grounds were exploited. Other species caught, in variable proportions, were albacore, yellowfin, southern bluefin, big-eye and frigate tuna. South of 20°N, skipjack constitutes 95 per cent or more of the total Japanese pole-and-line catch.

TABLE 6 - Annual catches of Japanese pole-and-line vessels in the Pacific (in tonnes)

Years	Skipjack	%	Albacore	Other	Total
1968	109 018	86	12 872	5 420	127 310
1969	120 052	77	26 909	8 271	155 232
1970	139 545	84	21 119	5 946	166 660
1971	116 448	67	52 003	5 559	174 010
1972	141 112	71	48 063	10 017	199 192
1973	208 169	75	60 849	9 420	278 438
1974	209 519	74	65 586	6 367	281 472
1975	172 727	76	47 452	7 993	228 172
1976	209 281	70	76 085	13 652	299 018

The main problem for pole-and-line fisheries is availability of baitfish. It takes a Japanese pole-and-liner 8 to 10 days to reach the tropical fishing grounds. Vessels of 350 GT can carry about 1.5 t of baitfish, but very high mortality occurs (up to 60 per cent) when the ship reaches the warm tropical waters. To minimise losses, certain techniques have been developed, such as refrigerating of bait tanks, and storing of baitfish (anchovy Stolephorus) for at least one week before loading in order to increase its resistance to captivity and heat.

2.2 Extension of the pole-and-line fishery

2.2.1 Traditional fishing area

North of 15°N, which is the traditional fishing area for Japanese pole-and-line vessels, activity is very intense, but c.p.u.e. is low, the maximum being 2.5 t/day (Table 7). Fishing in this area is done mainly by small units, ranging from 50 to 100 gross tons, which accounts for the small catches. On the other hand, while the number of fishing trips made by the larger pole-and-liners has been decreasing, the 50-100 GT boats made 2,000 more fishing trips in 1976 than in the previous year (Table 8).

TABLE 7 - Total catches and catches per unit of effort in the traditional Japanese pole-and-line area (southern limit 20°N and eastern limit 150°E).

Years	1972	1973	1974	1975	1976
Total Catches (t)	77 365	92 705	77 124	74 597	106 367
c.p.u.e.(t/day)	2.45	2.51	2.38	2.15	2.38

TABLE 8 -Fishing activity of the 100 GT pole-and-liners compared with activity of the total Japanese pole-and-line fleet.

		1970	1971	1972	1973	1974	1975	1976
Total Fleet	Number of fishing trips	7 207	7 725	9 088	9 325	8 496	8 694	10 376
100 gross ton units	Number of fishing trips	1 420	2 541	3 904	5 052	5 385	6 097	8 049
	Percentage	19.7	32.9	42.9	54.2	63.4	70.1	77.57
	Average number of poles	-	-	18	17.6	16.6	16.8	17.1
	Catches (t)	16 387	23 216	37 758	53 487	58 260	62 651	100 924

The 50-100 ton vessels are also the only ones to have increased their catches per fishing trip; 9.1 t in 1971, 10.3 t in 1975, while the average number of poles used on board was reduced from 18 to 16.8 over the same period (in 1976 the catch per fishing trip was 12.5 t, but the number of poles used had risen again to 17.1). Catches made by these vessels rose from 16,387 t in 1970 to 100,924 t in 1976 (which is indeed a spectacular increase).

2.2.2 East Philippines area

This area was divided into 16 rectangles (cf. Map IV) so as to make catch variations easier to follow. Pole-and-line vessels of over 250 gross tons started to operate in this area in 1968. Up to 1973 the c.p.u.e. for zones A, B and to a lesser degree C, increased steadily from year to year from west to east (Table 9). The c.p.u.e. decreased for zones I and II but not for zones III and IV (Table 10).

TABLE 9 - Variations of c.p.u.e. (t/day) from west to east (cf. annexed Map IV)

c.p.u.e.	A	B	C	D
1968	4.96	5.34	6.46	-
1969	3.69	4.73	5.28	-
1970	4.85	5.51	6.75	-
1971	5.19	5.53	6.66	7.63
1973	5.45	7.24	5.8	7.12

TABLE 10 - Variations of c.p.u.e. from north to south (cf. annexed Map IV)

c.p.u.e.	1968	1969	1970	1971	1973
I	4.90	5.88	5.77	5.74	4.96
II	6.99	5.26	7.80	4.09	5.10
III	5.88	4.64	5.95	5.64	6.02
IV	5.61	4.54	7.34	7.4	8.74

The data published by Kasahara (1978) show that the c.p.u.e. in the area considered (cf. Map V) decreased from 1973, except for zones A1 and A2 (Table 11). Total catch figures varied parallel to the c.p.u.e. values; both peaked in 1973 and then dropped off to 1976.

TABLE 11 - Variation of c.p.u.e. in the north-western tropical Pacific (cf. annexed Map IV)

	1972	1973	1974	1975	1976
A_1	3.78	4.03	4.32	3.01	3.29
A_2	3.85	2.25	6.15	3.08	1.75
A_3	4.53	5.57	5	2.4	2.7
A_4	2	8	5.3	4.5	2.8
B_1	4.09	7.65	4.2	2.7	5.6
B_2	4.30	3	2.7	3.6	2.6
B_3	3.51	5.6	4.5	2.9	3
B_4	4.48	6.41	5.6	3.3	2.4
C_1	3.99	4.3	3	4.5	4.2
C_2	2.74	4.7	2	3.1	2.1
C_3	4.64	6	5.3	3.9	3
C_4	4.87	6.5	5.1	3.7	4
D_1	3.58	5.58	2.2	4.9	3
D_2	1.46	6.1	1.6	4.2	2
D_3	6.2	6.2	4.6	4.2	4.7
D_4	5.48	8.12	5	3.3	5.46
Total catch (tonnes)	38 961	78 663	63 297	35 687	29 737

The strikingly large catch for 1973 (double that for 1972) resulted from the increased number of fishing trips made that year by vessels of over 300 gross tons (Table 12), mainly in the eastern Philippines area. Vessels of this size appear to be the most suitable for distant water fishing. After steadily rising from 1968 to 1973, catches from this area dropped in 1974 and the fishing grounds were then extended eastwards, especially towards Papua New Guinea.

TABLE 12 - Fishing activities of units over 300 GT

	1970	1971	1972	1973	1974	1975	1976
Number of fishing trips	13	18	269	542	598	719	769
Number of poles	33.3	37.5	32.4	21.9	28.6	24.8	23.6
Total catch (tonnes)	1 256	1 898	26 583	74 286	86 150	78 244	101 422
Catch per trip (tonnes)	96.6	105.4	98.8	137.0	144.1	108.8	131.9

2.2.3 North and East Papua New Guinea area

Total catches and c.p.u.e. for rectangles (5^{o} x 10^{o}) B5, C5 and C6 (cf. annexed Map VI) fluctuated in much the same way as those for the East Philippines area (Table 13). Peak figures were recorded in 1974 instead of 1973 (because intensive exploitation started later), but a similar decline followed.

The Japanese have adopted a policy of forming joint-venture companies with the countries in the southern zone (Anonymous, 1974 a). A fleet of small vessels fishes with locally caught bait and is assisted by a mother ship which carries tuna catches to Japan. In 1970 three such joint-venture companies were established in Papua New Guinea and one in Solomon Islands. This has largely solved the baitfish problem for the Japanese.

2.2.4 Western Pacific equatorial area (South of 10^{o}N, East of 150^{o}E)

The north-western zone of this area had been exploited since 1968, but fishing activity only began to expand eastwards and southwards from 1971 (Maps VII to XIII). This process of gradual extension took the Japanese fishing fleet as far east as French Polynesia and as far west as Norfolk Island by 1975. From 1968 to 1976, catches in this area rose from 2,133 t to 97,510 t, i.e. from 17 to 32.6 per cent of the total weight taken by Japanese pole-and-liners from the Pacific (Annexed Figure 2).

Through systematic analysis of the area, it is possible to calculate the average catch per 1^{o} square. Catch figures rose up to 1974, dropped in 1975, and then rose again in 1976 to the 1973-74 level. The poor 1975 catches, which were probably due to the exceptional availability of food in the natural environment, compelled the pole-and-liners to spread out very widely that year compared with 1976.

Map XIV shows how c.p.u.e. fluctuated from 1972 to 1976 inclusive. Average c.p.u.e. was around 6 t/day. Maximum c.p.u.e., localised in the north in 1972, tended to move eastwards and southwards year by year. This shift is thought to be related to the fishing effort, which was very intense for one or two years on the northern and western boundaries of the area and would tend to cause the c.p.u.e. to drop in the following years.

TABLE 13 - Variation of catches and c.p.u.e. in the Papua New Guinea coastal area. (cf. Annexed Map V)

(1) Catch (tonnes) (2) c.p.u.e. (t/day)		1972	1973	1974	1975	1976
B 5	(1)	415	2 506	13 235	866	43
	(2)	4.1	7.2	7.9	3.4	2.4
C5	(1)	3 779	8 436	14 256	8 729	1 400
	(2)	5.9	8.4	5.6	3.1	3.4
C 6	(1)	97	168	14 128	2 157	160
	(2)	3.3	4.4	9.7	4.4	4.6
Total catch (tonnes)		4 290	11 109	41 620	11 753	1 603
Average c.p.u.e.		4.4	6.7	7.7	3.6	3.4

2.3 Density index and abundance

Skipjack abundance in the various areas is more or less accurately reflected by the c.p.u.e. for each of the $5^{\circ} \times 10^{\circ}$ rectangles. However, the Tohoku Fisheries Laboratory (1978) recommends an alternative way of establishing abundance. A density index, expressed like the c.p.u.e. in t/fishing day, is calculated as follows:-

$$D = \frac{\sum_j \sum_i Aij \frac{Pij}{fij}}{\sum_j Aj}$$

Pij = Catch in the i^{th} $1^{\circ} \times 1^{\circ}$ square during the month j inside rectangle $5^{\circ} \times 10^{\circ}$.

fij = Fishing effort in this square.

Aij = Area of this square fished.

Aj = Total area fished during the month j.

This index takes into consideration how each $5^{\circ} \times 10^{\circ}$ rectangle was sampled and can therefore be regarded as expressing the skipjack density in each rectangle. Map XV shows the distribution of the index in 1976. The boundary 175°E, 10°S separates the area into a north-western zone where fishing was uniformly intensive for at least two years, and a south-eastern zone where the fishing effort was too low for the index to accurately reflect the actual abundance of skipjack.

In the north-western zone, the density index varies with the c.p.u.e.; it rises as one moves eastwards and southwards (cf. annexed Figures 3 and 4) into a zone where less fishing is done and which therefore shows a new area abundance. Some very high index values can be seen in the south-eastern zone, but one must be cautious in inferring extraordinary abundance from these, for the low fishing effort in this zone reduces the significance of the index.

2.4 Conclusion : Japanese pole-and-line fishery

Since c.p.u.e. values tend to peak and then drop, it seems likely that the pole-and-line fishery will go on expanding rapidly over the next few years southwards and eastwards (between 5°N and 20°S), in an attempt to maintain landings at a high level.

3. The purse-seine fishery

In recent years purse-seine fisheries have been developing very rapidly in the Western Pacific, and about 20,000 t of tuna were caught by this method in 1977. Purse-seining is still, however, very localised. Only two areas are at present exploited by this method: one north of Papua New Guinea by Japanese vessels, the other near the North Island of New Zealand by New Zealand and United States vessels. The waters around the Trust Territory of the Pacific Islands are also to be surveyed by American purse-seiners and by a vessel jointly owned by Nauru and Japan (Otsu, 1976).

3.1 Japan

Traditionally, the Japanese did very little purse-seining in the South Pacific. In 1974/75, the Fukuichi Maru, a 500 ton purse-seiner engaged in experimental fishing for the Japan Marine Fisheries Resource Center (J.A.M.A.R.C.) within an area situated between the Caroline Islands and Papua New Guinea, obtained yields as high as 18.8 tonnes per fishing day, and also demonstrated that purse-seining could be carried on all the year round in this area. As a result of these trials, and because of the bad fishing conditions prevailing in the traditional fishing grounds in 1976, all Japanese purse-seiners moved to the north of Papua New Guinea. In 1977, ten boats spent the whole year fishing in an area situated between 1°S and 2°N, 35°E and 155°E on the southern edge of the north equatorial counter current. The total catch of the Japanese purse-seiners operating in the South Pacific rose from 461 tonnes of tuna in 1970 to about 20,000 tonnes for the 1977/78 season (June to March) (cf. Table 14).

TABLE 14 - Catches of tuna by Japanese purse-seiners in the South Pacific from 1970 to 1977.

Year	Total tuna catch (tonnes)	Skipjack	Yellowfin	Big-eye	Others
1970	461	338	123	-	-
1971	944	706	200	35	3
1972	782	539	188	47	8
1973	1 752	1 245	412	84	10
1974	2 621	2 159	407	36	19
1975	6 975	4 991	1 726	253	-
1976	10 539	7 509	2 756	274	-
1977	20 000 *	-	-	-	-

* Estimated

The typical Japanese purse-seiner is of 500 gross tons with a carrying capacity of 350 tonnes. All the purse-seiners are at present stationed in Japan and go back there to land their catches. Fishing trips are generally between 30 and 40 days long, 12 of which are spent travelling to the fishing grounds from Japan and back again, i.e. approximately one third of the total time spent at sea. Catches were around 10 tonnes per day at sea and 15 tonnes per fishing day for the first quarter of 1977. Catch per haul averaged about 23 tonnes.

Catches are made up of approximately 70 per cent skipjack, 26 per cent yellowfin, and 4 per cent big-eye. Initially, purse-seiners concentrated mainly on tuna around floating objects, but as they acquired a better understanding of the movements and behaviour of the fish, they started to fish on schools that were being circled by birds. Table 15 summarises the operations of a few Japanese purse-seiners in 1977.

TABLE 15 - Catch records of some purse-seiners operating in the tropical Pacific for the first quarter of 1977 (500 gross ton vessels).

Total catch	Number of hauls	Duration of fishing trip*	Number of fishing days (estimated)	Catch per day at sea	Catch per fishing day	Catch per haul
337.6 t	12	29 d	17	11.6 t/d	19.9 t/d	28.1 t
350.1 t	11	29 d	17	42.1 t/d	20.6 t/d	31.8 t
316.0 t	16	36 d	24	8.8 t/d	13.2 t/d	19.8 t
356.1 t	12	37 d	25	9.6 t/d	14.2 t/d	29.7 t
349.1 t	13	33 d	21	10.6 t/d	16.6 t/d	26.9 t
324.3 t	17	33 d	21	9.8 t/d	15.4 t/d	19.1 t
367.0 t	24	46 d	34	8.0 t/d	10.8 t/d	15.3 t
333.5 t	16	40 d	28	8.3 t/d	11.9 t/d	20.8 t
362.4 t	13	39 d	27	9.3 t/d	13.4 t/d	27.9 t

* Travelling time is approximately 12 days

3.2 New Zealand

Purse-seine fishing trials around New Zealand started in January 1974, after an agreement had been signed between the New Zealand Government and Star-Kist Foods Inc. of California. These trials, conducted by the vessel Paramount (450 tons, 330-350 tonnes storage capacity) up to April 1975, showed that there is a definite skipjack purse-seining season along the North Island coast from mid November to the end of March. During the 1974-1975 season, the Paramount achieved the excellent catch rate of 23.6 tonnes per fishing day. Best catches were recorded from January to March.

After these trials, the purse-seine fishery developed very rapidly and the total catch rose from 4,715 t for the 1975-76 season to 7,572 t for the 1976-77 season, although the catch per fishing day dropped from 21 to 17 t/d (Table 16).

TABLE 16 - Results of first two seasons of purse-seine fishery around New Zealand.

	75-76 Season	76-77 Season
Total catch	4 715 t	7 572 t
Number of fishing days	224 d	445.5 d
Number of hauls	304	609
Catch per fishing day	21 t/d	17 t/d
Catch per haul	15.5 t	12.4 t

Purse-seiners are currently operating in a very restricted area. Most of the fishing is done within the 12 mile zone along the north-west coast of New Zealand. The purse-seines used are reported to measure from 640 to 1,400 m with a depth of 64 to 165 m (Habib, 1977).

3.3. Conclusion: Purse-seine fishery

Recent development of the purse-seine fishery is very promising and will probably involve an expansion of fishing grounds such as has occurred in pole-and-lining.

4. Influence of hydrological conditions on fisheries

From 1972 onwards, mainly during the southern hemisphere summer (October to March), the Japanese pole-and-liners have been spreading out on either side of the equator west of 180°. The French Overseas Scientific and Technical Research Centre (ORSTOM) in Noumea, which possesses half-yearly surface salinity maps for the area lying between 150°E to 130°W and 10°N to 20°S for the years 1956 to 1973, quarterly maps for 1973 to 1975, and monthly maps from 1975 onwards, has compared these with the catch distribution maps available. The comparison covered the years 1972 to 1976 and showed a very strong correlation between catches and water salinity. This correlation is particularly marked from the year 1975, when the Japanese began to fish all the year round and remained stationed near the equator; catches appear to have been made in waters where salinity was less than 35 parts per thousand (ppt).

The high catches seem to follow the outline of the 35 ppt isohaline. Map XVI clearly illustrates this phenomenon. The quarterly fisheries maps published by Kasahara (1978) show a close correlation between the area where catches were made and the movement of the equatorial upwelling since 1972. The physical and biological aspects of this finding will be discussed in a forthcoming publication (Donguy *et al.*).

Higher catches are also recorded each year around the island groups (Carolines, Marshalls, Gilberts, Tuvalu, Bonin, Volcano) than in the oceanic zones.

It is an acknowledged fact that the vicinity of islands is generally biologically richer because of the hydrological disturbances that occur there (the wake effect of islands).

Overall conclusions

Longline fisheries, after some difficult years, appear to have settled down again and still account for a very large proportion of total tuna landings and for the entire and valuable marlin catch.

Pole-and-line fisheries will have to continue their geographical expansion, since the high c.p.u.e. values recorded in newly exploited zones invariably drop in subsequent years. It is very likely that the c.p.u.e. in new areas will become stabilized at a certain level, as has occurred in the traditional fishing grounds adjacent to Japan.

The prevailing theory in recent years was that purse-seine fisheries would be difficult if not impossible to establish in the South Pacific. This has now been thoroughly refuted. Purse-seine catch rates are at present higher here than in the Atlantic, and the future looks bright for this technique which has the great advantage of not requiring any bait.

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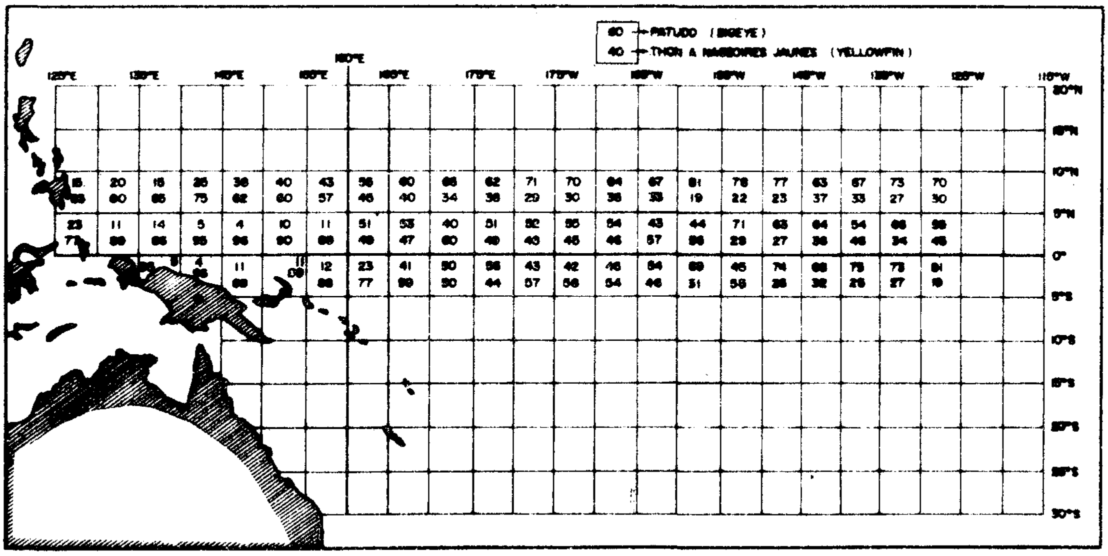
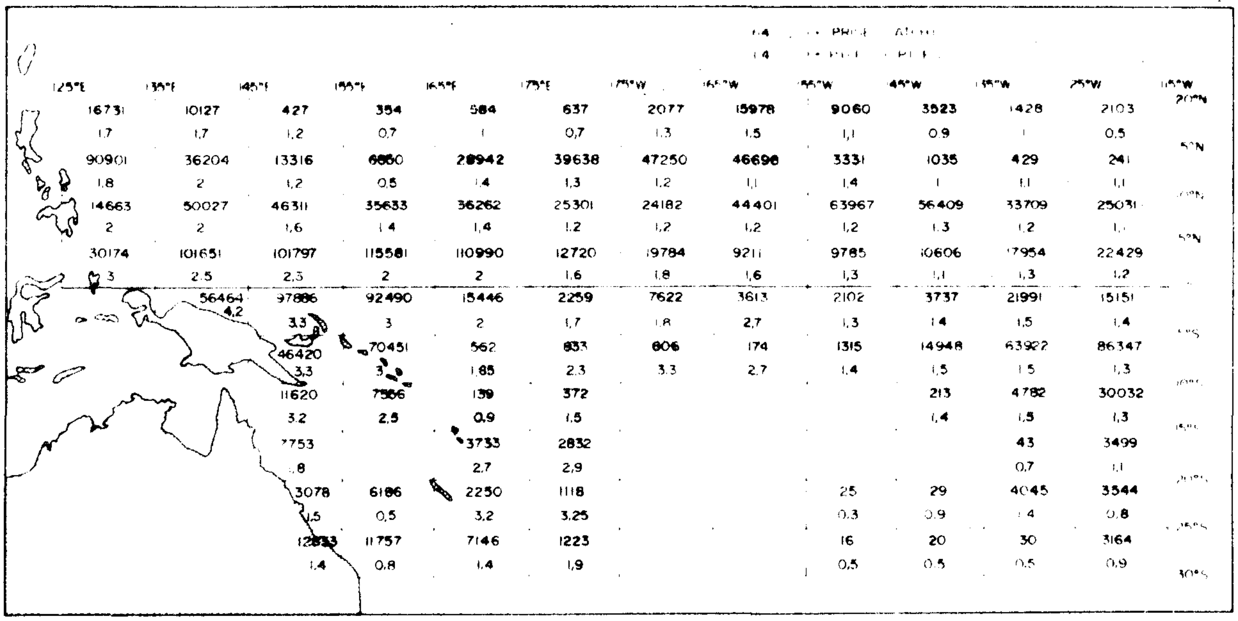
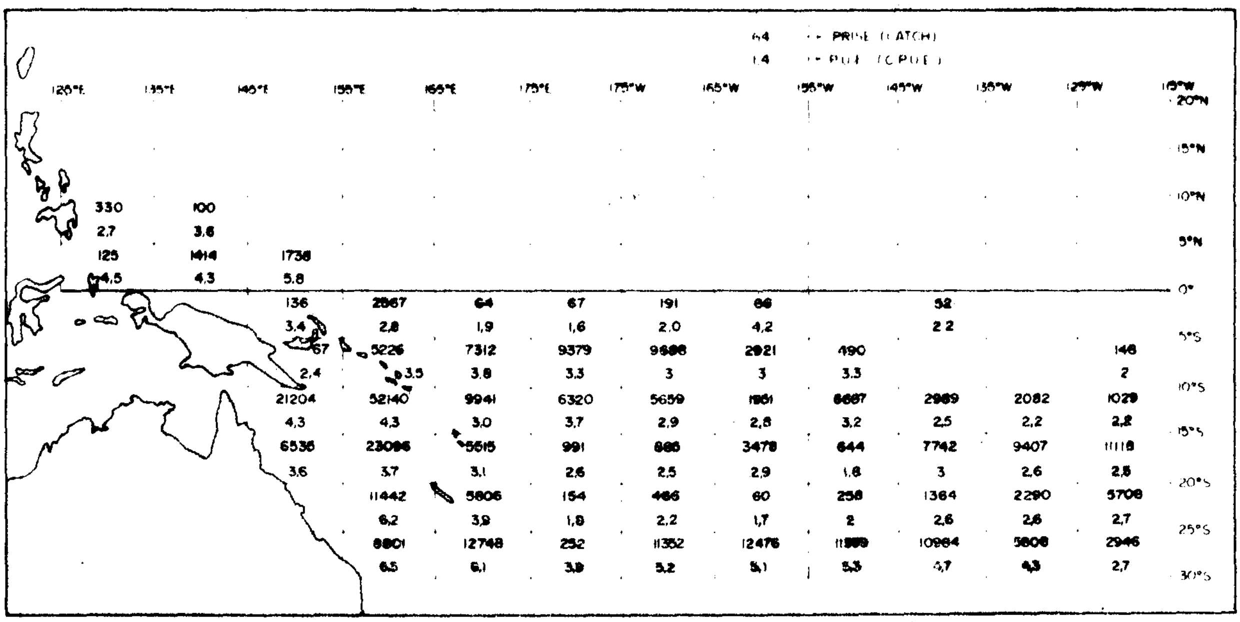


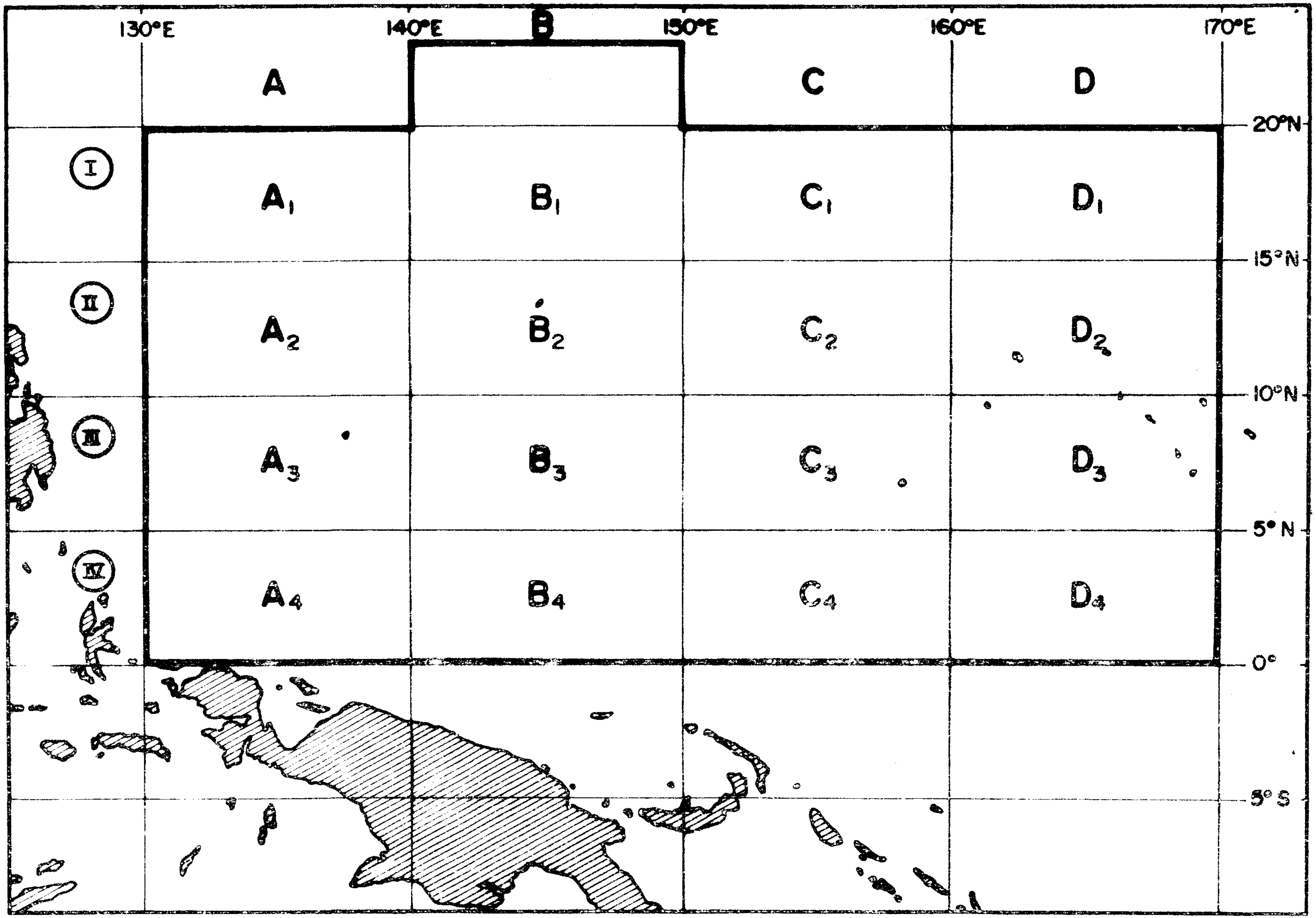
Map I - Comparative percentages of big-eye and yellowfin catches in 1975.



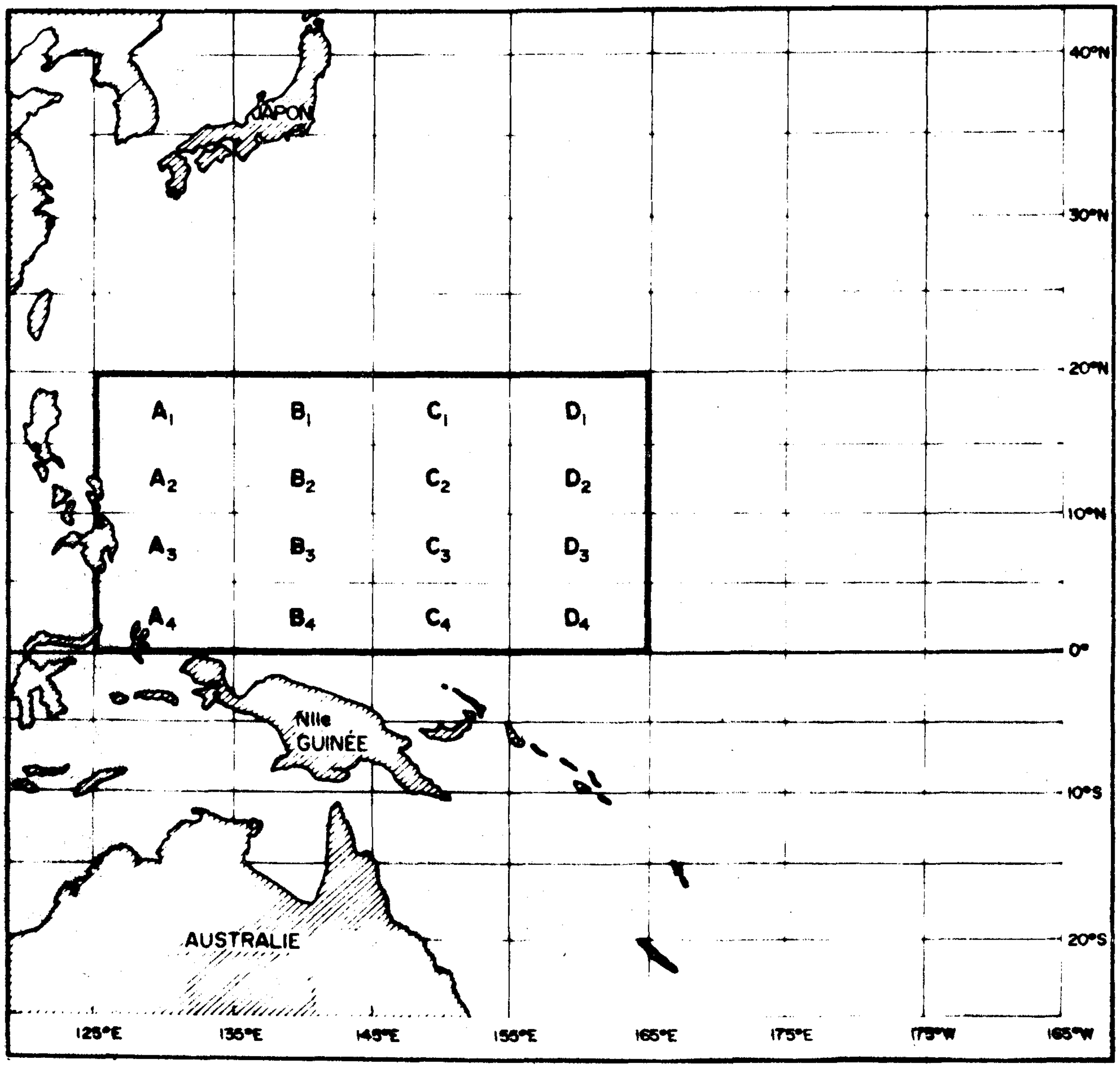
Map II - Distribution of catches and c.p.u.e. for Japanese longliners in 1973.



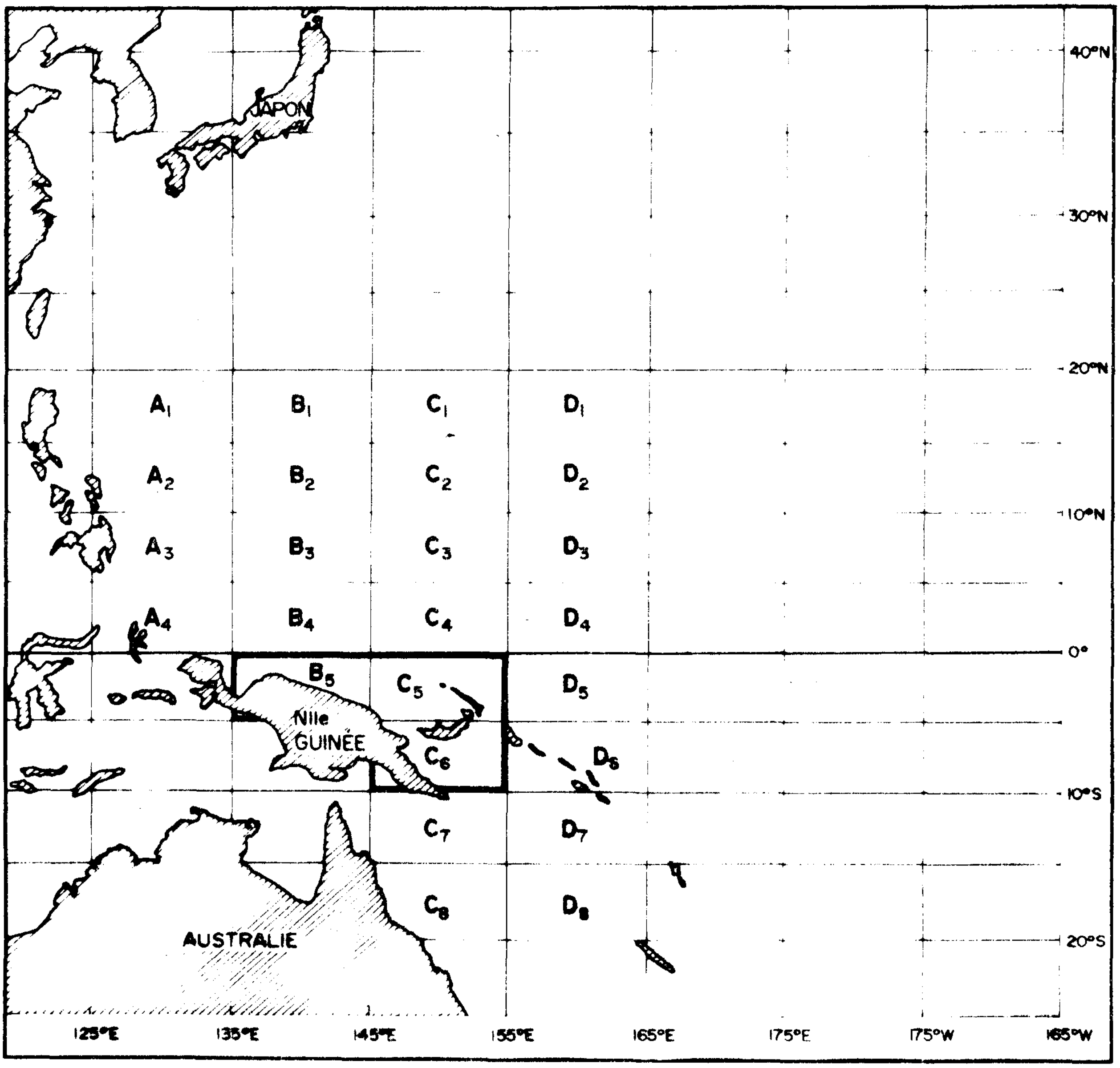
<u>Map III</u> - Distribution of catches and c.p.u.e. for Taiwanese longliners in 1973.



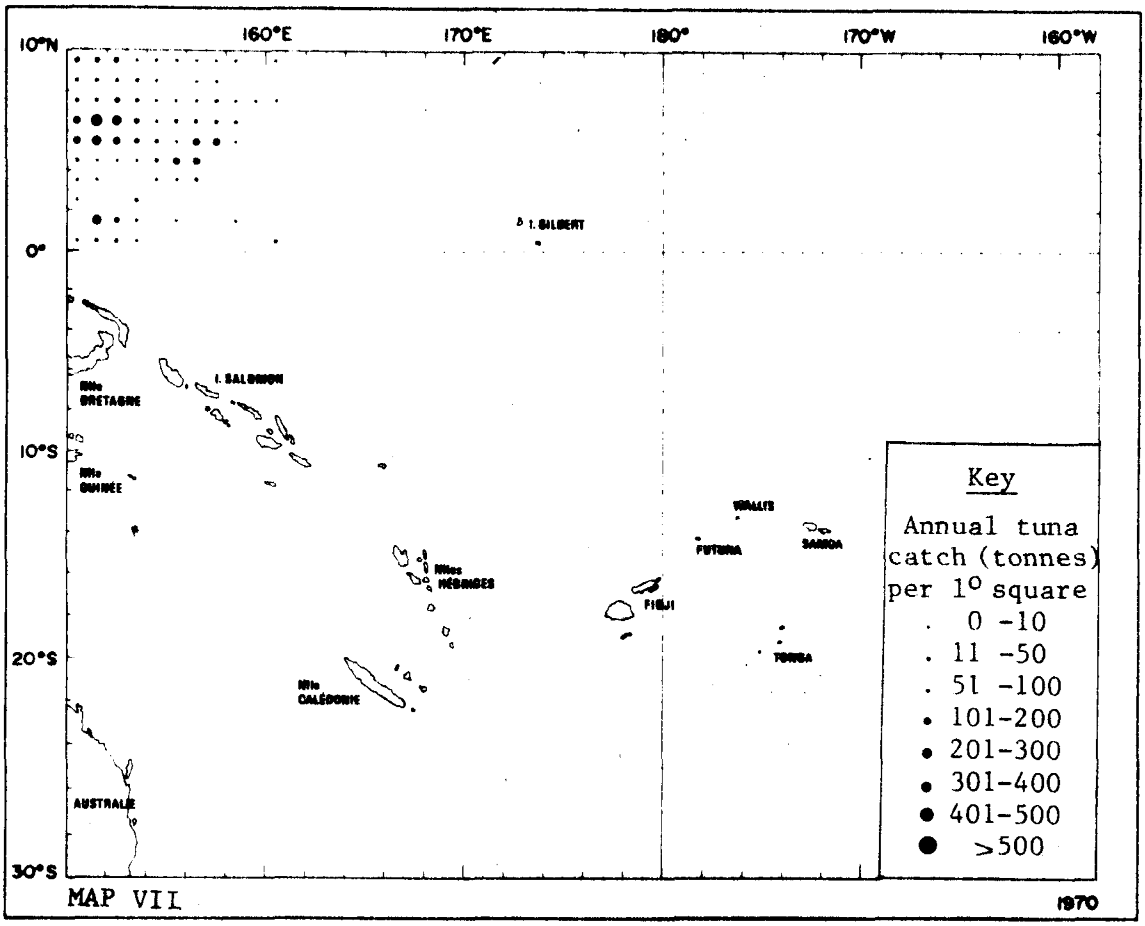
Map IV - Zones of the East Philippines area, pertaining to Tables 9 and 10.

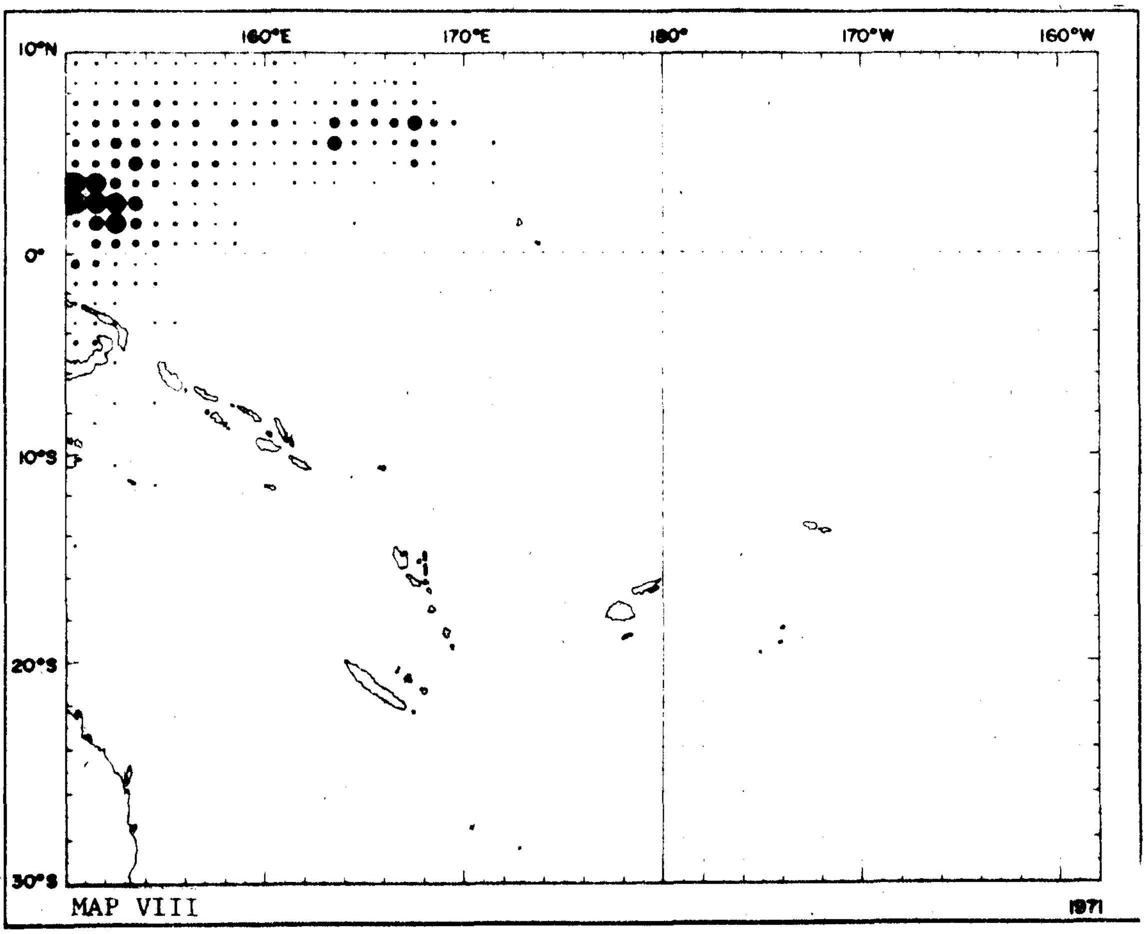


Map V - Zones of the East Philippines area, pertaining to Tables 11 and 12.

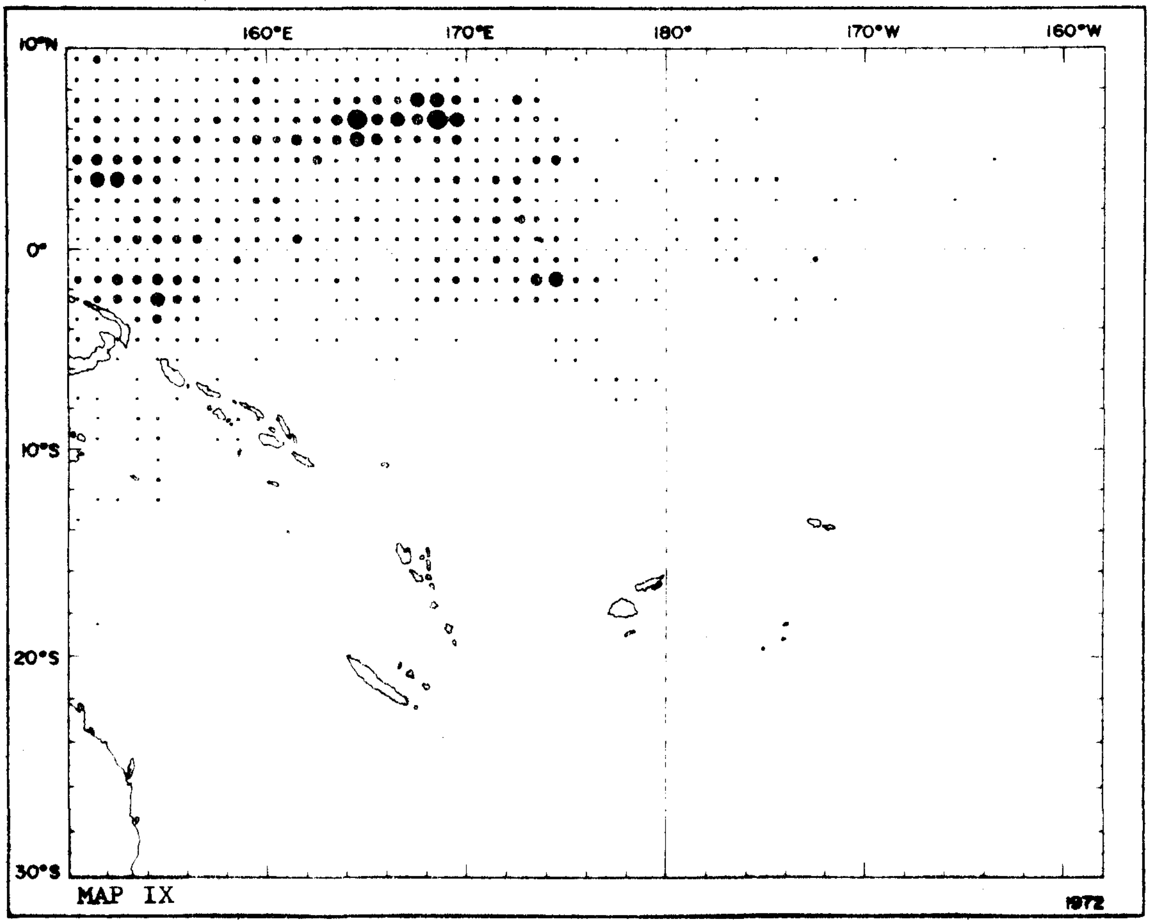


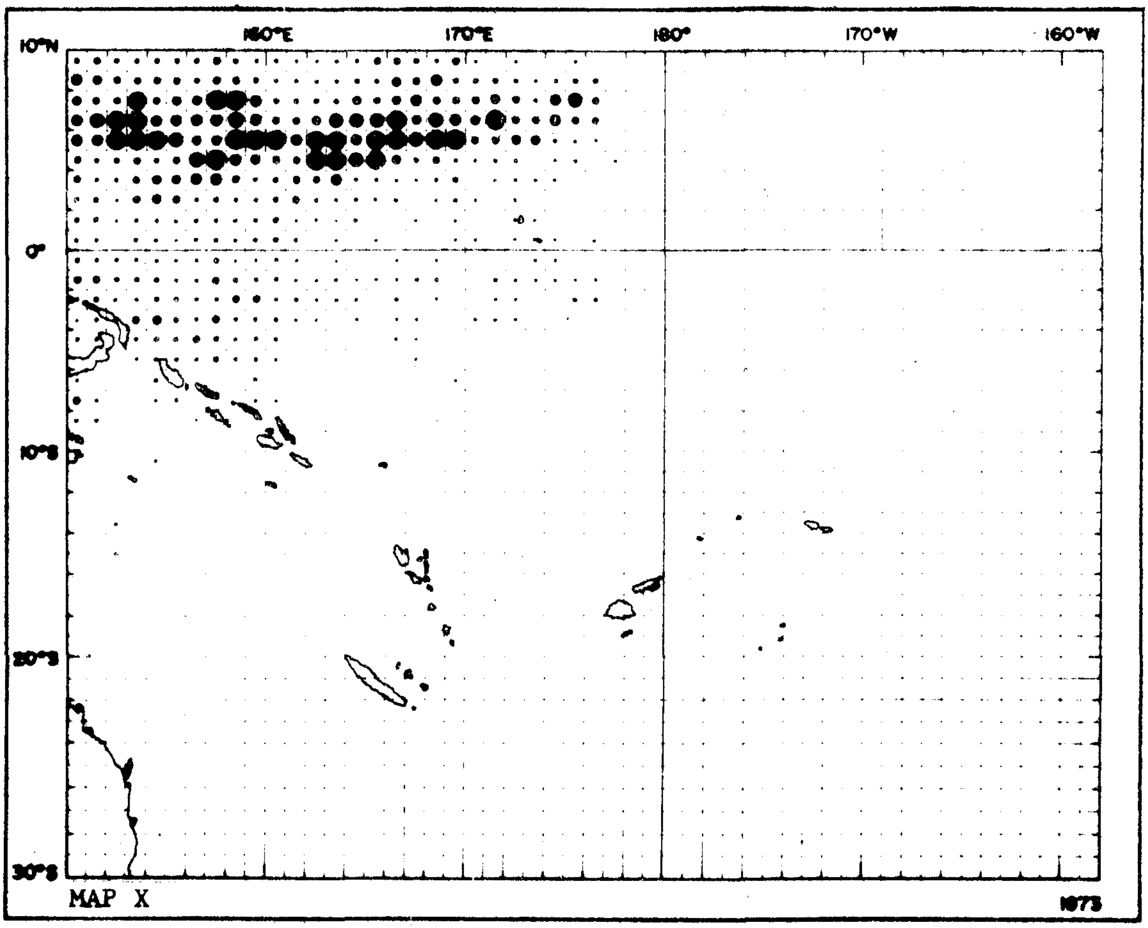
Map VI - North and East Papua New Guinea area.

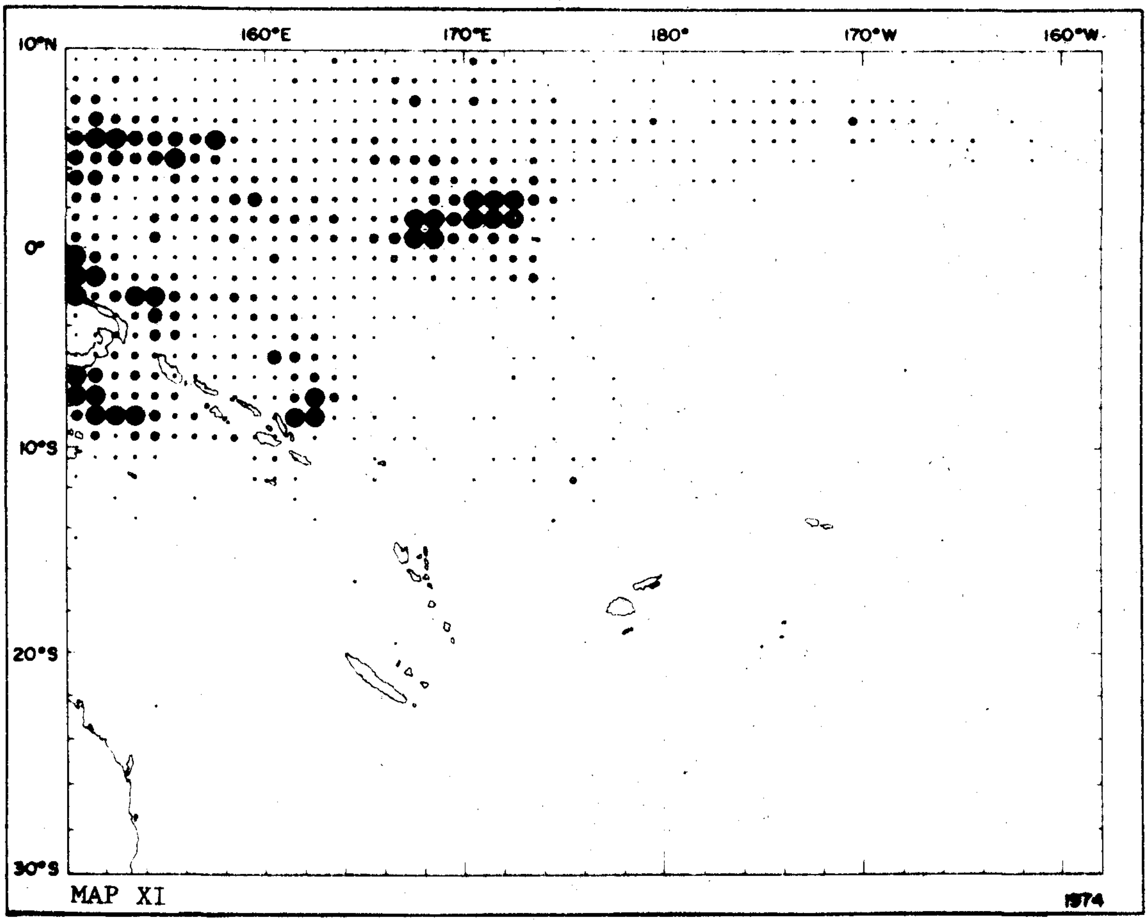


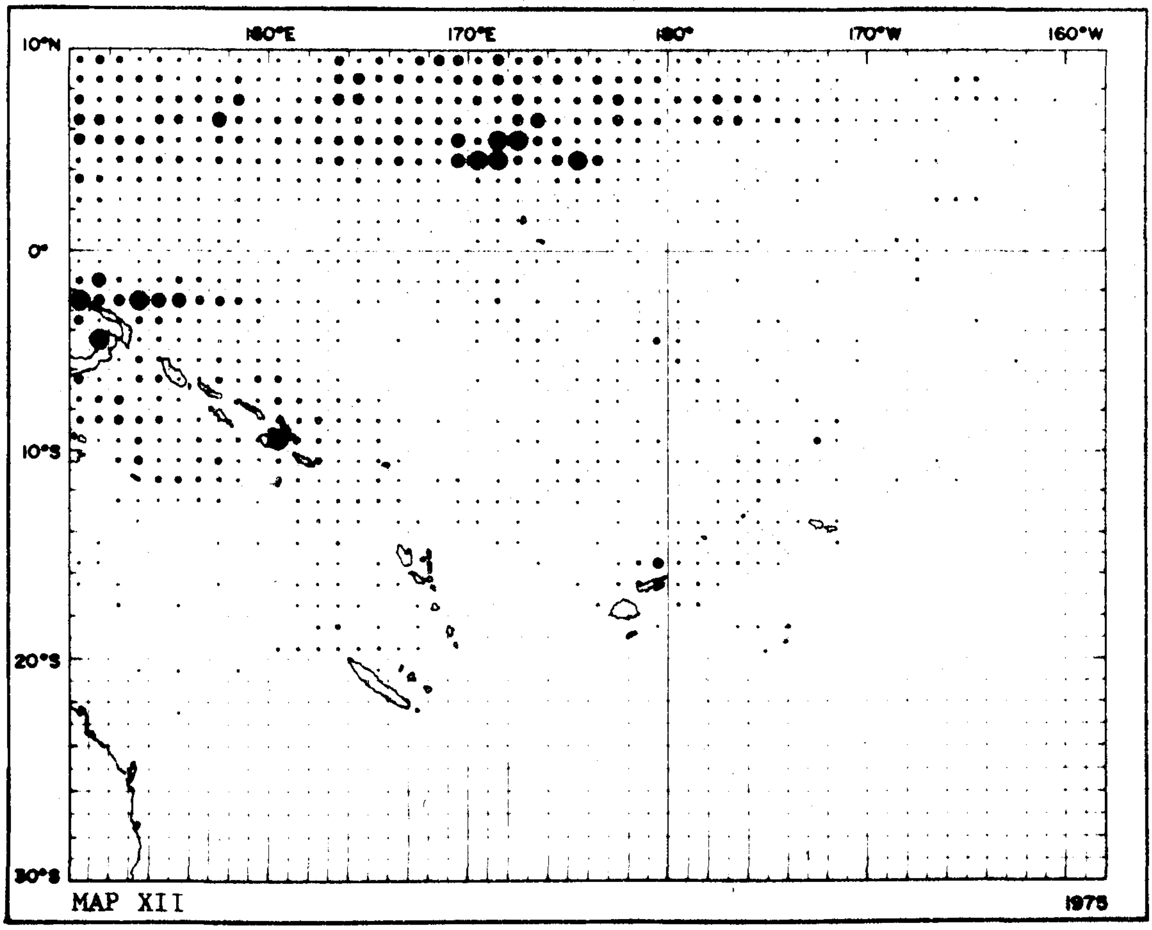


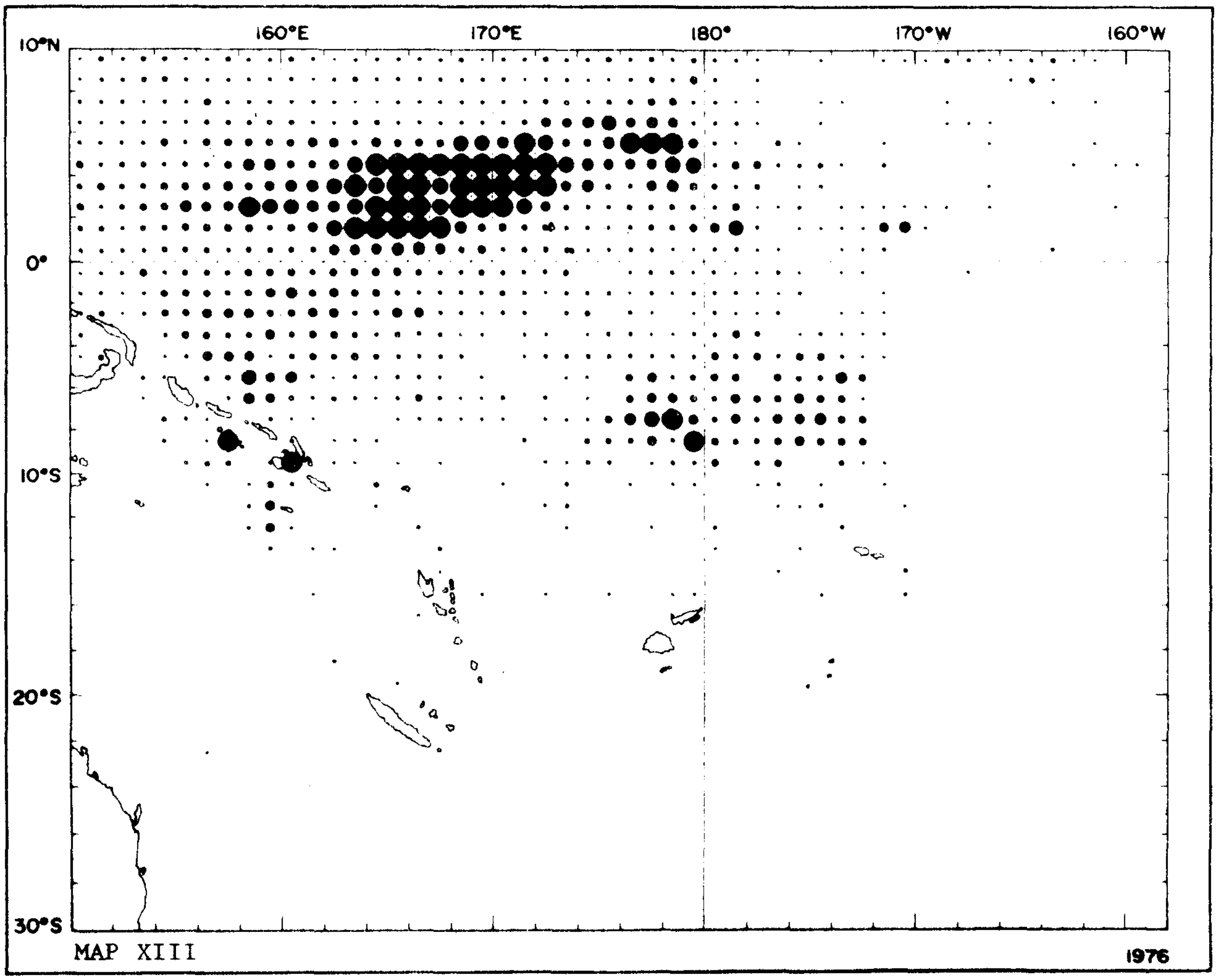
Maps VII to XIII - Extension of Japanese pole-and-line fishing grounds from 1970 to 1976

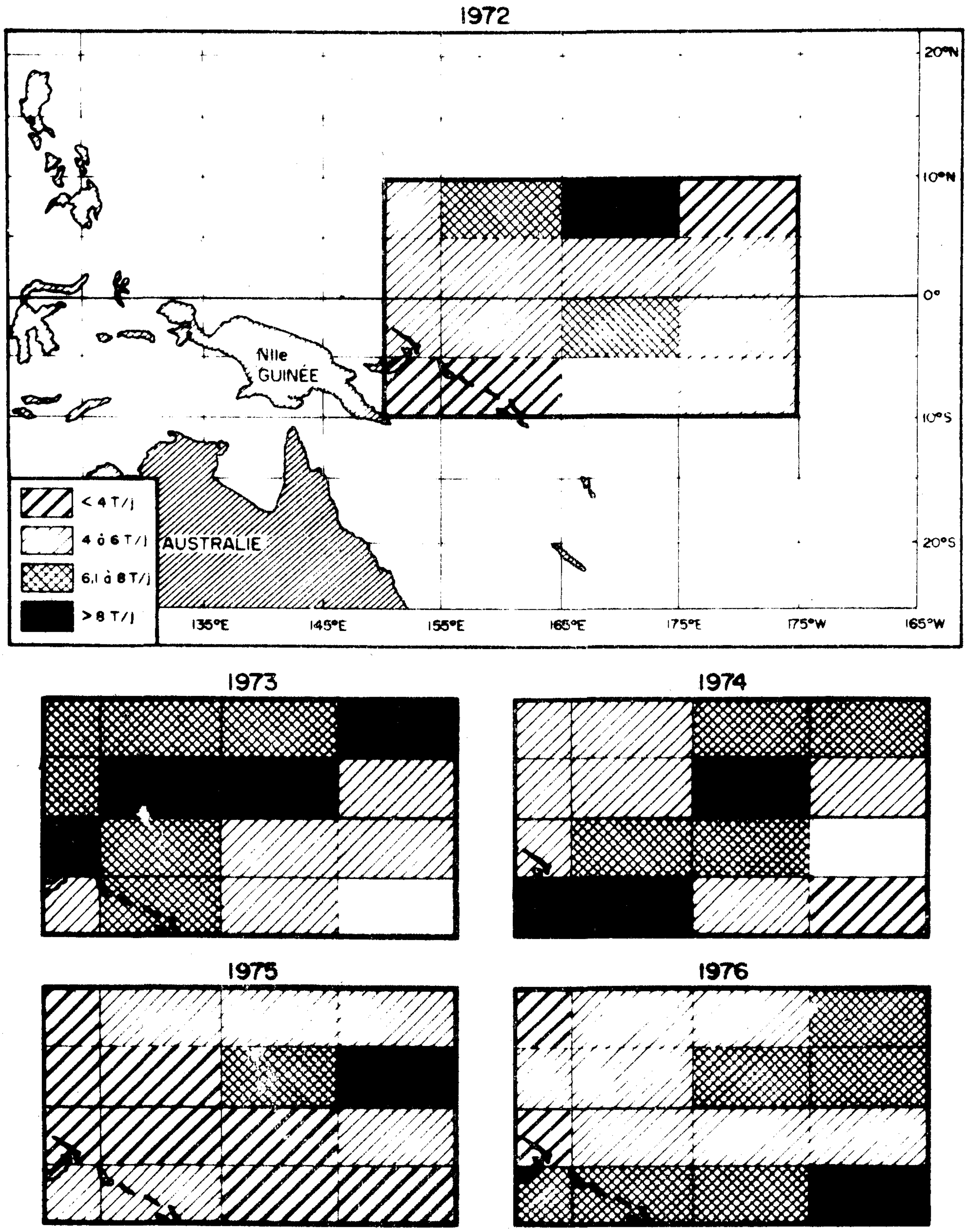

160°E
170°E
180°
170°W
160°W
10°N
0°
10°S
20°S
30°S
MAP IX
1972


160°E
170°E
180°
170°W
160°W
10°N
0°
10°S
20°S
30°S
MAP X
1973

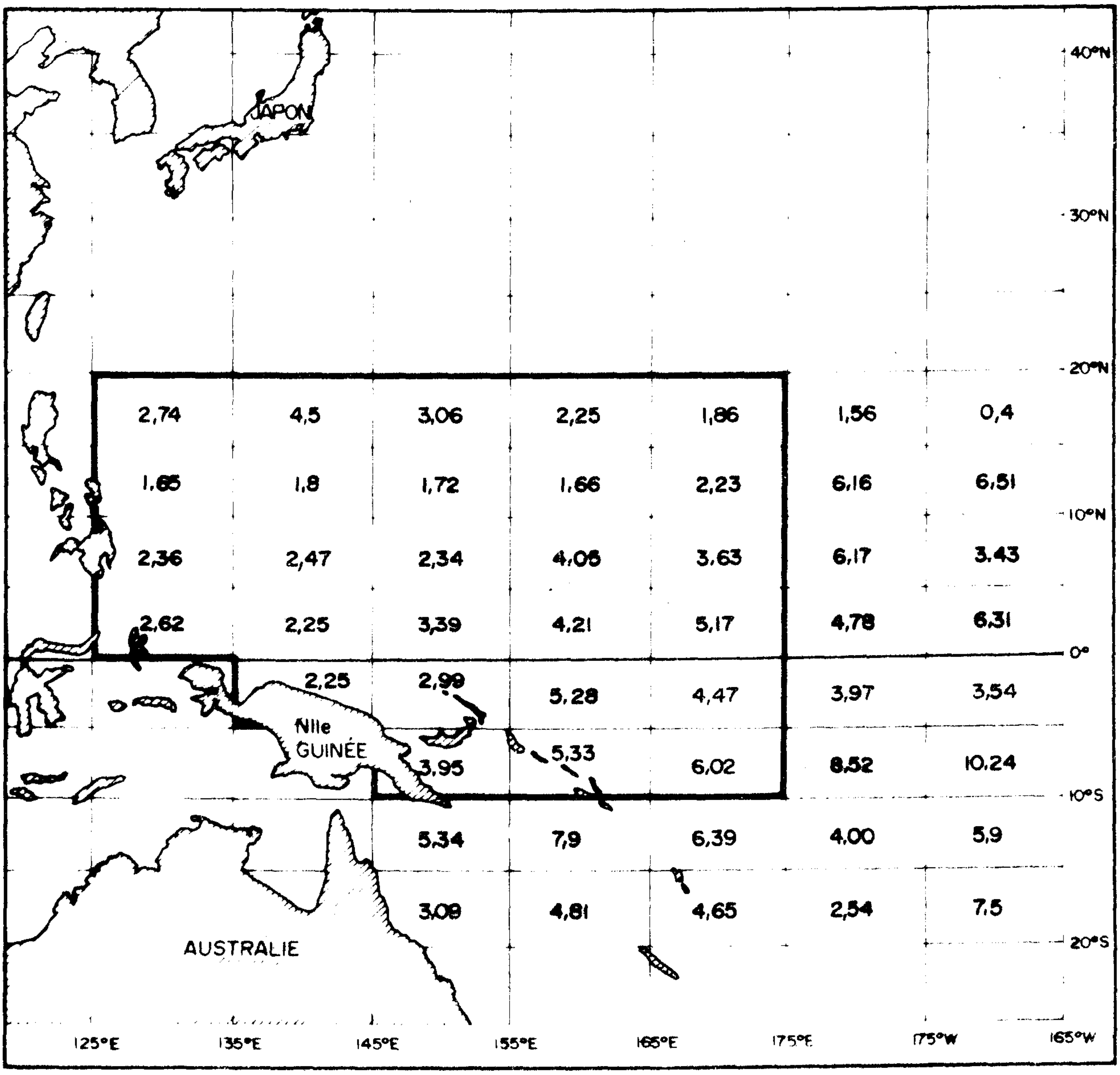

10°N
160°E
170°E
180°
170°W
160°W
0°
10°S
20°S
30°S
MAP XI
1974


10°N
160°E
170°E
180°
170°W
160°W
0°
10°S
20°S
30°S
MAP XII
1975

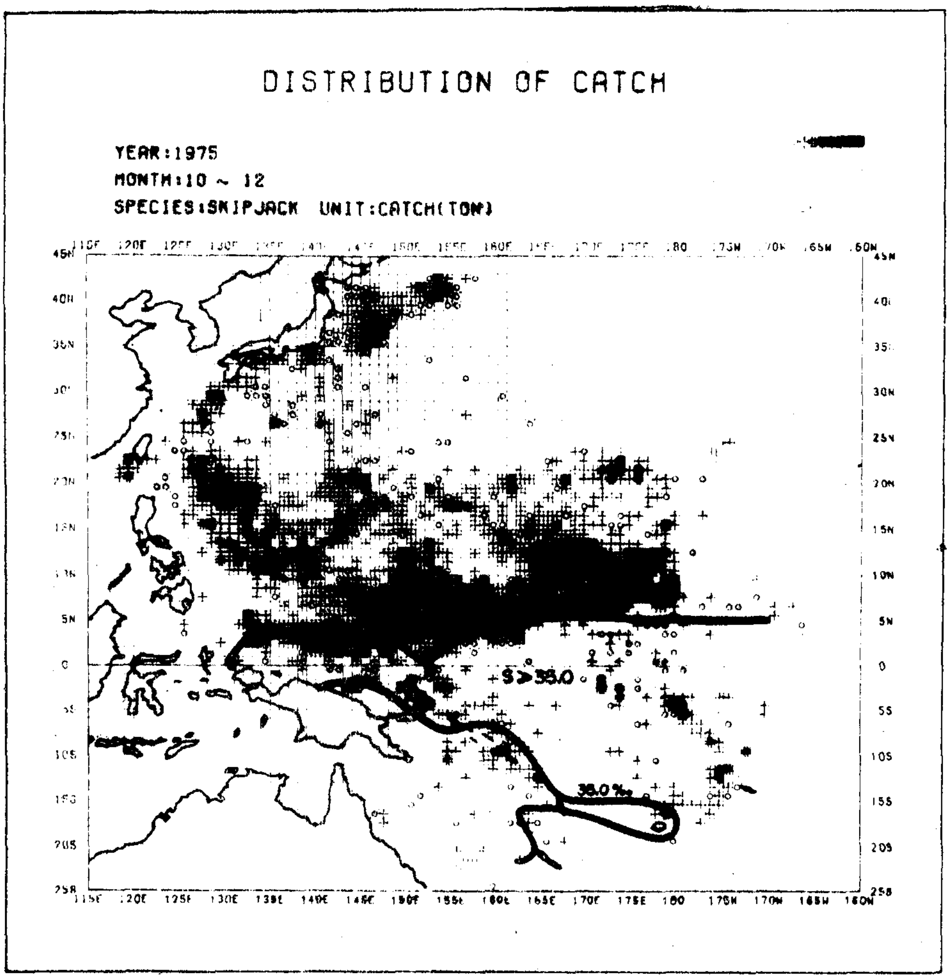

10°N
160°E
170°E
180°
170°W
160°W
0°
10°S
20°S
30°S
MAP XIII
1976



<u>Map XIV</u> - Variation of c.p.u.e. per statistical square in Western Pacific equatorial area, from 1972 to 1976.



Map XV - Distribution of density index in the Western tropical Pacific in 1976.



Map XVI - Illustration of relationship between the equatorial upwelling and Japanese pole-and-line catches (last quarter 1975).

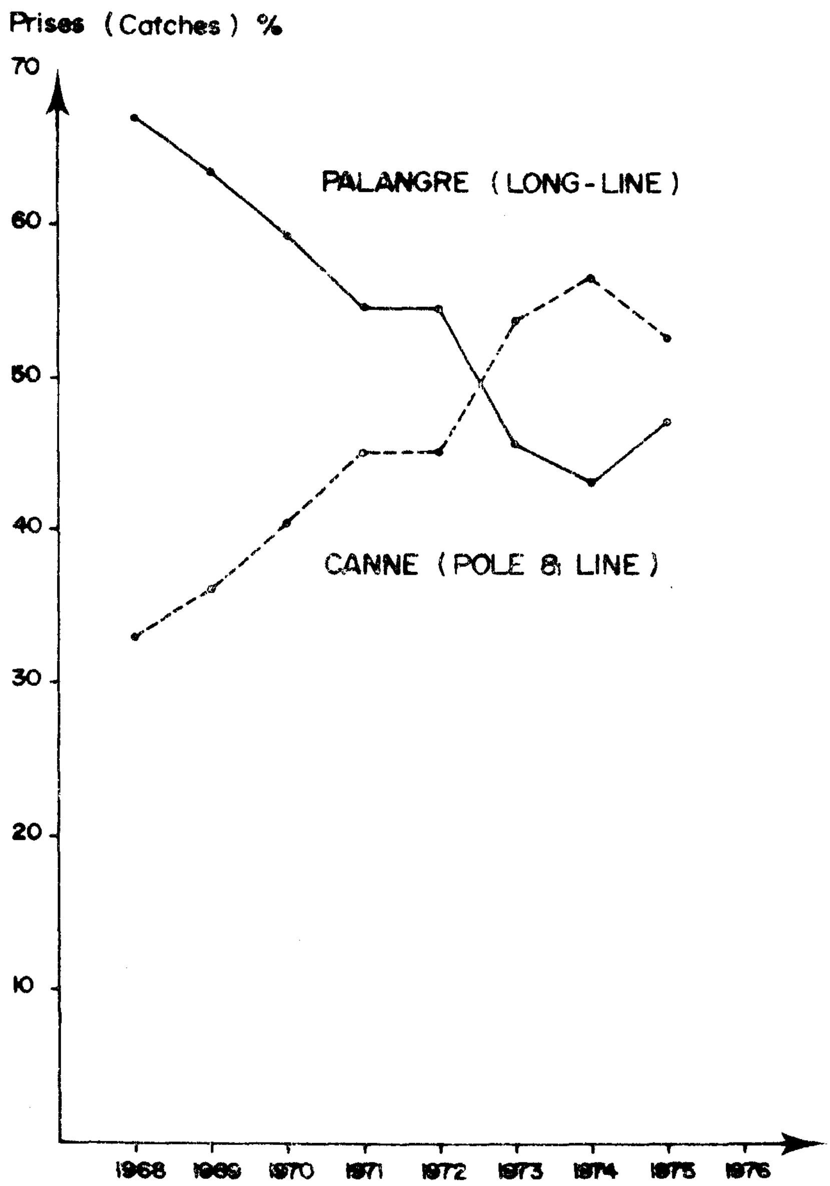


Figure 1 - Comparative percentages of catches by Japanese longline and pole-and-line vessels in the Pacific.

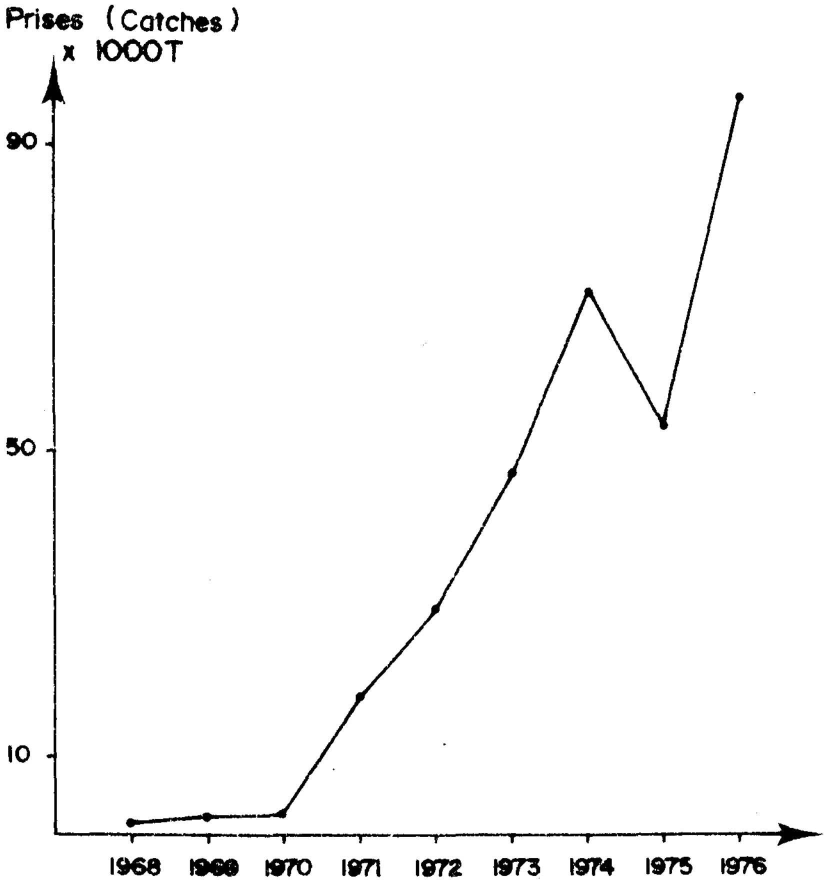


Figure 2 - Annual catches by Japanese pole-and-liners in the Western Pacific equatorial area.

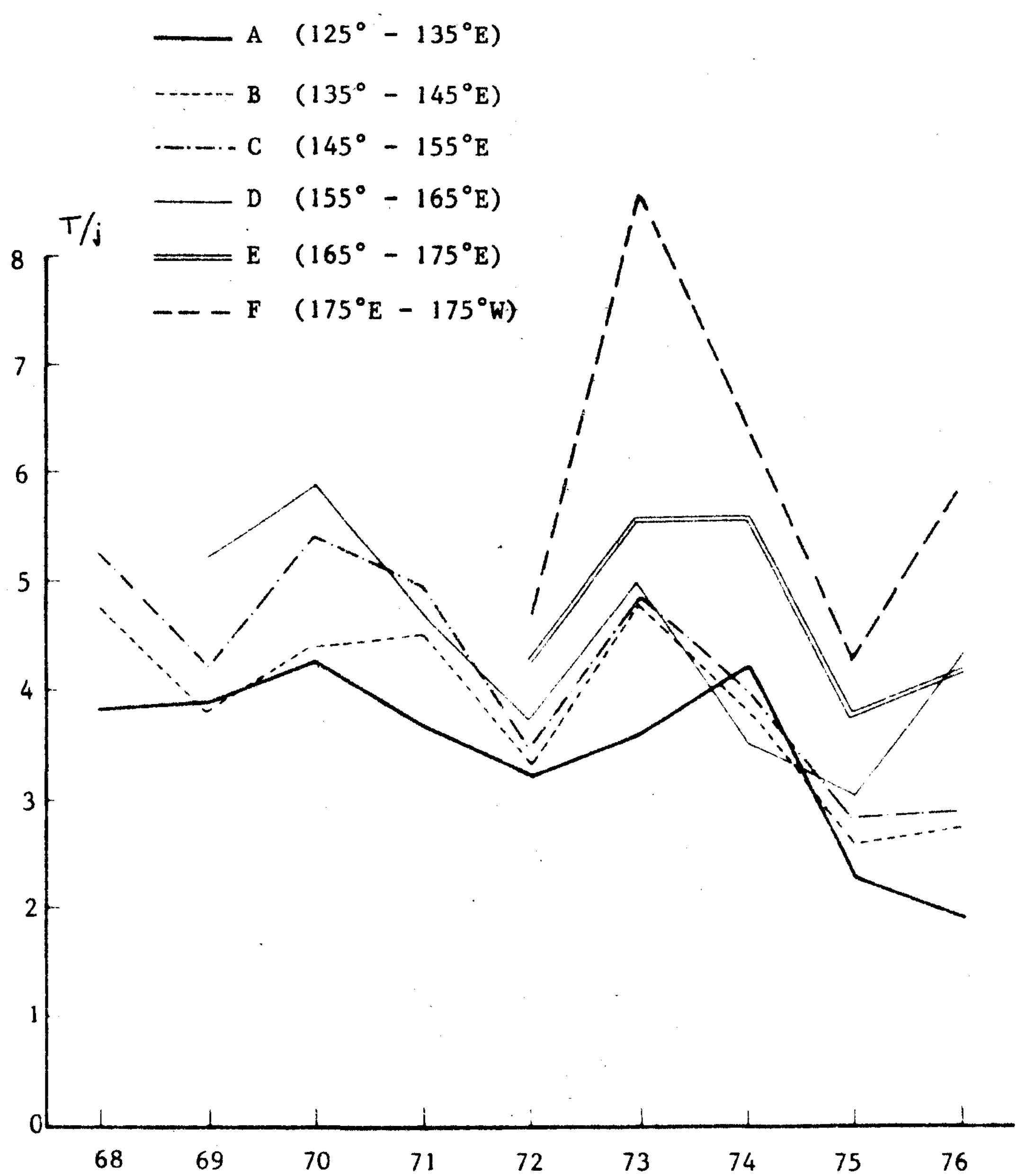


Figure 3 - Variation of density index by 10° longitude sections.

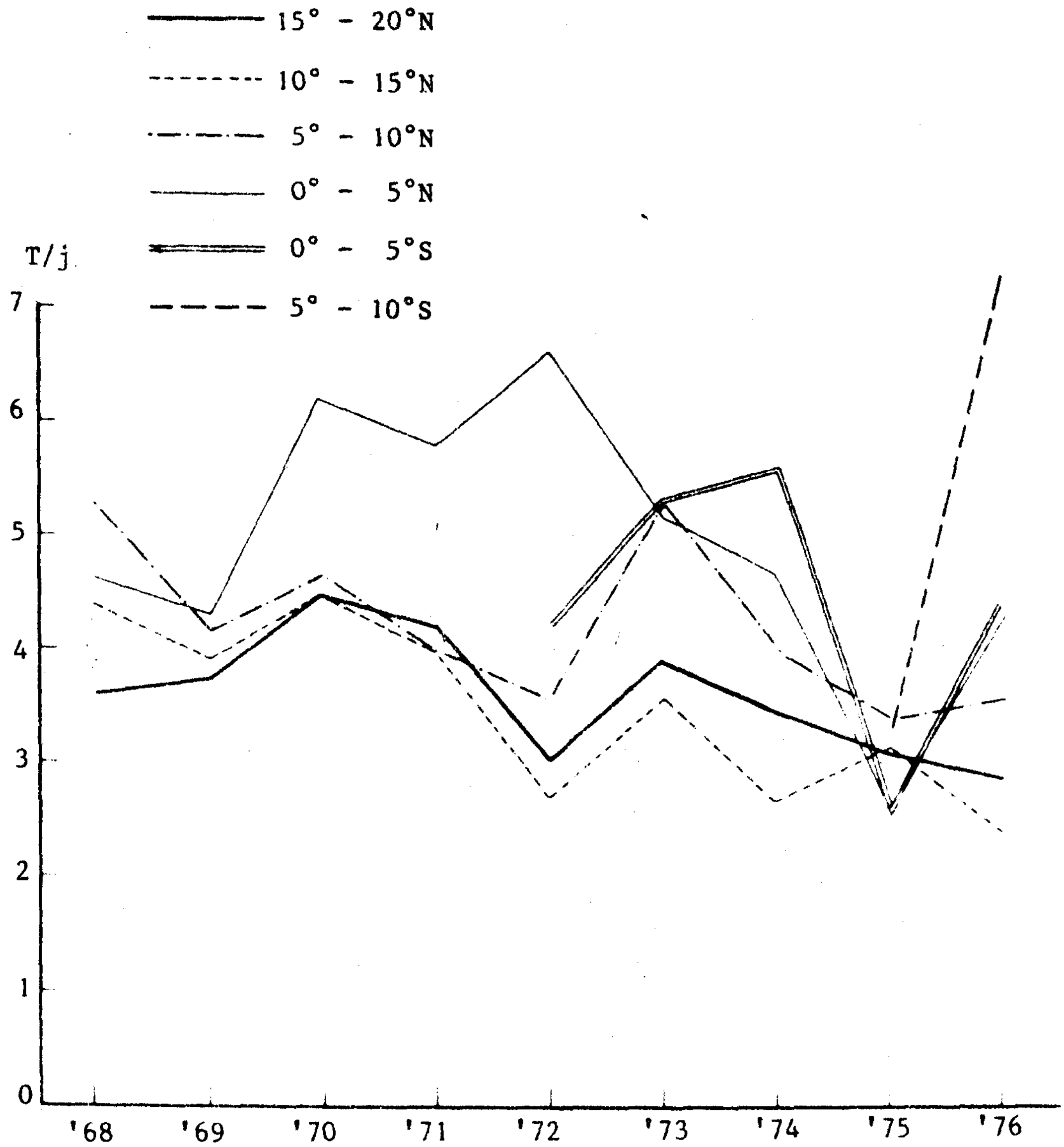


Figure 4 - Variation of density index by 5° latitude sections.