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An Analysis of the Experimental Pole and Line Fishery Conducted around Sri Lanka by Nichiro Fishing Company of Japan

By

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Introduction

THE existing fishery of Sri Lanka is almost entirely a coastal one. Of the estimated annual production of approximately 100,000 tons, skipjack contributes 10 to 12%. Contribution to the tuna catch is made mainly by the drift net fishery which is relatively recent compared to the very long standing traditional pole and line fishery which has been in existance over 50 years. The trawl fishery and an insignificant oceanic tuna long line fishery contribute 3 to 4% of the annual production. As the potential for increased production is expected to be derived mainly from the surface and sub-surface tuna, marlin and shark resources in the off-shore and oceanic ranges, considerable interest and attention have recently been directed towards exploitation of such resources.

The traditional pole and line fishery is fairly successful during certain seasons, considering its level of efficiency in relation to modernized pole and line fishery elsewhere. Improvement and expansion of the pole and line fishery was therefore considered to be a rational approach to increase the skipjack production from the seas around the country, particularly in the off-shore range. On a joint agreement between the Government of Sri Lanka and the Nichiro Fishing Company of Japan, the latter undertook to conduct experimental pole and line fishery around Sri Lanka with a view to determining the feasibility of establishing a joint commercial venture. In accordance with this agreement, 3 vessels ; Seisho Maru—25, Kuroshio Maru—70, Shinshyu Maru—7, conducted live bait and pole and line fishery during the periods mentioned below.

TABLE I

Specification of the Fishing Vessels

Vessel	*Seisho Maru—25*	*Kuroshio Maru—70*	*Shinshyu Maru—7*
Shipyard	Nichiro Ship Bldg. Co.	Miho Ship Bldg. Co.	Uchida Ship Bldg. Co.
Year constructed	1967	1962	1967
Gross Tonnage	265.73 (steel)	239.77 (steel)	192.85 (steel)

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Vessel	*Seishio Maru—25*	*Kuroshio Maru—70*	*Shinshyu Maru—7*
Net Tonnage	101.54	101.93	65.14
Fish-hold cap.	187.90³	180.17³	150.10m³
Fuel cap.	85.73m³	88.79m³	81.29m-
Fresh water cap.	12.42m³	14.98m³	12.47m-
Crew accom.	23	25	25
Main Engine	Daihatsu diesel 650hp × 2	Akasaka 650 × 1	Hanshin 750 × 1
Speed	10 knots	8 knots	11 knots
Aux Engine	—	Yanmar 130hp × 2	Yanmar 100 hp × 2
Generator	Seiko 125KVA × 2	Shinko 100 KVA × 2	Taiyo 80 KVA × 2
Refrigerator	Mitsubishi MB 8CN × 2	Mitsubishi MA 4CN × 2	Sanyo 25 RT4 × 2
Radio	Transmitter 250 × 1 Receiver NRR 202 × 1	250w 100w 12 Tubes 10 Tubes	200w 75w 14 Tubes 12 Tubes
Gyro compass	Tokyo Keiki ES 11	ES 11	ES 11
Radar	Kobe Kogyo MO 811/AZ	Tokyo Keiki MR 70	Kobe Kogyo MD 808
Bait fishing boats on deck	Net Boat 8.1m 35hp × 1 (steel) Light Boat 5.3m 10 hp × 1 (steel)	Net Boat 5.5m 17 hp × 2 (FRP) Light Boat 3.5m 3hp × 1	4M wood 4 hp × 1
Fishing lamps	Underwater—220v. 250w 24v. 300w Surface—220v–1kw	same	Underwater—220v–200w Surface—220v–1kw
Bait Net and operation	Purse seine length 270m. one boat operation	Purse seine length 240m. two boat operation	Lift net 11m × 11m
Crew	Japanese—15 Sri Lanka 4—7	Japanese—16 Sri Lanka 4—7	Japanese—15 Sri Lanka 4—8

Seisho Maru	...	March, 1973 to December, 1973
Kuroshio Maru	...	June, 1973 to May, 1974
Shinshyu Maru	...	May, 1974 to Octobei, 1974

The terms and conditions of the survey required not only to investigate the economic feasibility of a joint venture in skipjack fishery utilizing fairly large-sized vessels of the type used in the experimental fishery (specification in Table I), but also to determine the feasibility of conducting a pole and line fisheiy by Sri Lanka, with vessels of approximately 30 gross ton class. Seisho Maru was originally a kind of carrier boat, which was modified into a pole and line vessel, Kuroshio Maru is a pole and line vessel constructed for operation on the west coast of Africa and Shinshyu Maru is a typical Japanese pole and line vessel. Each vessel was manned by 15 to 16 Japanese fishermen and 7 to 8 local fishermen as trainees.

Fishing Operation

All 3 vessels were based at the fishery harbour at Galle which is on the south-west corner of the island. Excellent facilities were available for beithing, fish handling and storage and this base is conveniently situated for operating on the west, south and east coasts.

Seisho Maru and Kuroshio Maru used purse seine and Shinshyu Maru used lift net, for catching live bait. Shinshyu Maru conducted drift net and long line fishing for tunas in addition to the live bait and pole and line fishery. All bait fishing operations were at night using under-water and surface fishing lamps. The specifications of the lamps used, sizes of bait fishing nets and the system of operation are summarized in table I. Scouting for surface tuna schools and pole and line fishing were conducted during the day time. Attempts were made to catch sufficient quantity of bait before proceeding to carry out uninterrupted fishing for tunas, but quite often this was not achieved as a result of which bait fishing and tuna fishing had to be conducted on the same day, on a large number of occasions.

It must be emphasized that the plan of operation was commercially oriented as will be evident from the results to follow.

TABLE II

Varieties tried out as bait fish

Scientific Name	*English Name*	*Local Name*
Sardinella jussieu Sardinella longiceps Sardinella fimbriata Sardinella ovalis	.. Sardine	.. Salaya Koromburuwa
Amblygaster sirm ..	.. Herring	.. Hurulla
Anchoviella indica Anchoviella commersonii	.. Anchovy	.. Halmessa
Thrissocles setirostris (stolephorus) Thrissocles hamiltonii Thrissocles mystax	.. Mustach Anchovy	.. Lagga
Apogonid ..	.. Cardinal fish	.. Demassa
Dipterygonotus leucogrammicus	.. Red bait	.. Hingura
Secutor ruconius Secutor insidiator	.. Silver biddies	.. Karalla
Leiognathus splendens Gazza minuta	.. Silver bellies	.. Karalla
Selar kalla ..	.. Scad	.. Parati
Decapterus russelli ..	.. Scad	.. Linna
Mene maculata ..	.. Moonfish	.. Panna
Allenetta forskali ..	.. Hardy head	.. Korala baba
Caesio chrysozonus Caesio caerulaureus	.. Fusilier	.. Ilitta

Bait Fishery

The bait tank capacity on each of these vessels should permit a carrying capacity of approximately 1.5 tons of live bait. As the suitability of various species as bait fish had not been established, all small species caught during the bait fishing operation were transferred to the bait tank and used if they remained alive. As such numerous varieties were used as live bait though only a few of them were subsequently found to be very suitable, considering their size, mortality and acceptability to the skipjack. The species commonly appearing in the bait net catches and which were tried out as live bait are listed in Table II.

Red bait (*Dipterygonotus, leucogrammiccus*) the traditionally used live bait, *Sardinella jessieu*, *Decapterus russelli*, *Caesio* species, *Allanetta* species and *Apogonid* species showed low mortality in the bait tank and have been kept alive for over two weeks. Other species of sardines, herring and scad have been used in spite of their mortality rates being over 50% in 24 hours. Anchoviella species showed above 80% mortality in 24 hours. Various other species in the list and other demersal fishes caught in the net were also occasionally tried out as live bait.

Though it was expected that the bait fishery would be carried out all round the island and outside the 10 fathom line, as laid down in the contract, it was observed that the vessels located three main grounds and the bait fishery during the entire survey period was limited to these three small grounds. 36% of the live bait catches were made close to Chilaw (7°35′N, 79°43′E), 26% of the catches were made close to Boulder point (8°57′N, 81°05′E) and another 26% of the catch was made off Trincomalee (8°31′N, 81°13′E). Only 3.5% of the bait catches were made in the coastal waters between Colombo and Galle, 2.4% between Galle and Batticaloa, 3.6% off Batticaloa, and 0.3% between Batticaloa and Trincomalee.

On the east coast where more than 50% of the bait catches were made, Sardines formed the major variety (67%) followed by red bait (6.8%), herrings (6.6%), Carangidae (6.6%) and Anchovy (3%). On the west coast too sardines were the dominent group (40.7%) followed by red bait (33.5%) and herring (23.1%) but other varieties were relatively poor in the catch. Selective fishing had been carried out and hence this composition does not project the true picture of the community in the areas. On a number of occasions the catches were not taken on board because the major variety in the catch was considered unsuitable as live bait.

The average bait catch per day for the three vessels were not very significantly different in spite of the differences in their methods of operation (Table III). A mean catch rate of 40.6 buckets per bait fishing day and 58 buckets per effective bait fishing day, were realized by the three vessels. On the assumption that one bucket of bait is equivalent to 7 kgs. of bait fish the equivalents of the catch rates would be 280 kgs. and 400 kgs. respectively.

Due to the monsoons prevailing in the region bait fishing was conducted on the west coast from November to February and on the east coast during the other months of the year. The catch rates during the first and fourth quarters of the year were relatively better than those of the second and third quarters of the year (Fig. 1, Table III). As the operations during the peak season were on the west coast, the catch rates realised on the west coast was observed to be higher than that for the east coast.

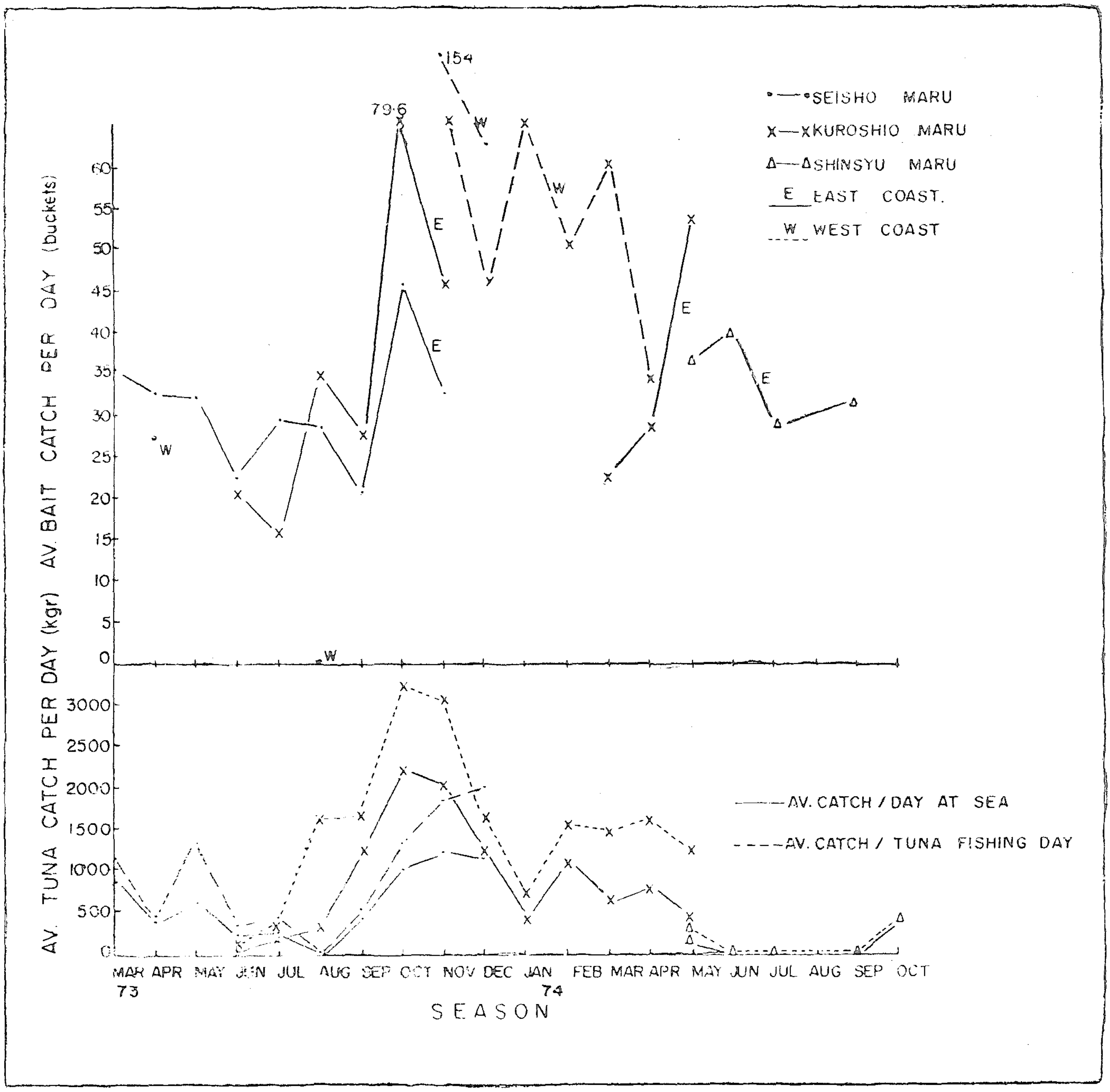

Fig. 1.—(*a*) Bait fish catch rates by vessel, area and fishing season
(*b*) Tuna catch rates by vessel and fishing season

Even though bait fishery was restricted to extremely small and specific grounds, the catch rate for any one month shows very high variability and high mean values realized during the peak months were directly influenced by the greater variability (Fig. II). Table III shows that during peak bait fishing season every day spent on the bait grounds was not an effective bait fishing day. It is observed that the vessels remained in the bait ground until sufficient live bait was collected and attempts had not been made to locate better bait concentration in the adjacent areas. The bait catch distribution pattern clearly indicates movement of fish in an out of the chosen bait grounds and experimental bait fishing conducted by the U.N.D.P. sponsored project in Sri Lanka has shown that when bait catch rate in an area becomes poor better catch rates are realizable in the adjacent areas. If bait fishing operations had been adjusted accordingly, better mean catch rates would have been realized. In view of this fact, the mean catch rates obtained may be considered as under-estimated and the catch rates derived for the effective bait fishing days may perhaps be more realistic.

Out of the total of 579 fishing days for all three vessels, bait fishery were conducted on 384 days and the effective bait fishing days were 269. Which means 66% of the total sea-days have been devoted to bait fishery, which is quite out of proportion.

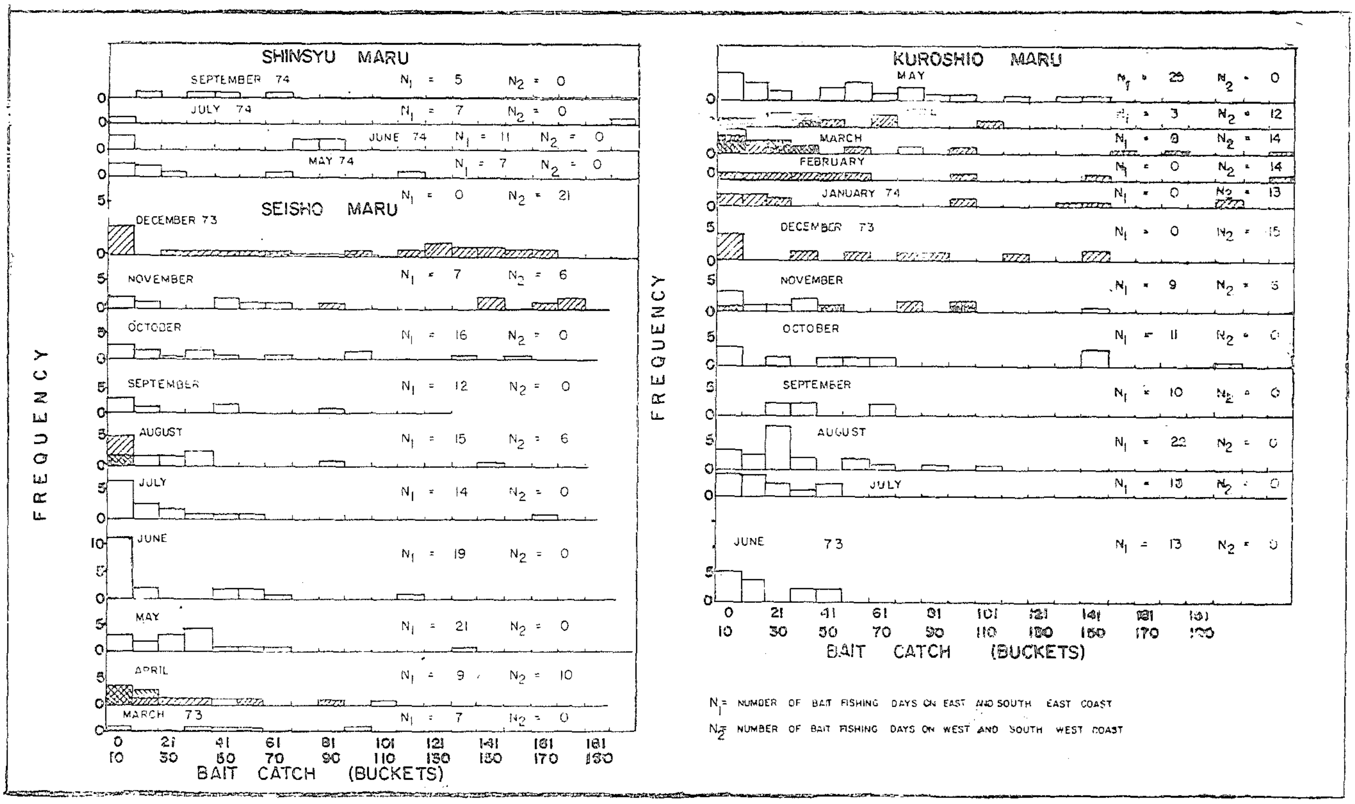

Fig. II.—Bait catch—frequency distribution, by vessel season and area.

TABLE III

Bait catch, effort and catch rates by months, area and vessel

	1973										1974										Total
	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	
I—EAST AND SOUTH-EAST Seisho Maru :																					
(C) Bait catch	248	295	679	422	412	430	246	733	228												3,693
(E_1) Total Bait fishing days ..	7	9	21	19	14	15	12	16	7												120
(E_2) Effective Bait fishing days ..	4	8	15	10	10	9	5	11	5												77
C/E_1	35·4	32·7	32·3	22·2	29·4	28·6	20·5	45·8	32·5												30.7
C/E_2	62·0	36·8	45·2	42·2	41·0	47·7	49·2	66·6	45·6												47.9
Kuroshio Maru :																					
(C) Bait catch				269	252	770	275	876	410				179	86	1345						44,62
(E_1)				13	16	22	10	11	9				8	3	25						117
E_2				12	9	21	6	11	7				5	3	20						94
C/E_1				20·6	15·7	35·0	27·5	79·6	45·5				22·3	28·6	53·8						38.1
C/E_2				22·4	28·0	36·6	45·8	79.6	58·5				35·8	28·6	67·2						47.4
Shinshyu Maru :																					
(C)															254	437	201	159			1,051
E_1															7	11	7	5			30
E_2															6	5	2	4			17
C/E_1															36·2	39·7	28.7	31.8			35.0
C/E_3															42·3	87·4	100.5	39.7			61.8
II—WEST AND SOUTH-WEST Seisho Maru :																					
(C) Bait catch		271				0			925	1,313											2,509
E_1		10				6			6	21											43
E_2		9				0			6	14											29
C/E_1		27·1				0			154·1	62·5											58.3
C/E_2		31·0				0			154·1	93·7											86.5
Kuroshio Maru :																					
(C) Bait catch									413	681	855	700	842	410							3,901
E_1									6	15	13	14	14	12							74
E_2									6	8	8	9	12	9							52
C/E_1									68·8	45·4	65·7	50·0	60·1	34·1							52.7
C/E_2									68·8	85·1	106·8	77·7	70·1	45·5							75.0

TABLE IV

Tuna catch (Kgs), number of sea-days (E_1) and catch per sea-day (C/E_1), by area and quarterly seasons

Season		*Total*	78°-80°*E* 8°–9°*N* '*NW*'	78°-80°*E* 7°–8°N 'W'	78°-80°*E* 6°–7°*N* '*SW*'	78°-83°*E* 4°–6°*N* '*S*'	81°-83°*E* 6°–7°*N* '*SE*'	81°-83°*E* 7°–8°*N* '*E*'	81°-83°*E* 8°–9°*N* '*NE*'	81°-83°*E* 9°–10°*N* '*NNE*'	80°-83°*E* 10°11°*N* '*N*'
Ist Q	C	58,974	—	2,021	8,765	34,993	3,423	9,772	0	—	—
	E_1	75	0	22	10	21	8	4	10	0	0
	C/E_1	786·32	—	91·86	876·5	1,666·3	427·87	2,443·0	0	—	—
IInd Q	C	68,476	717	15,647	2,608	2,476	1,289	8,909	23,030	13,800	—
	E_1	178	3	15	7	9	12	14	101	17	0
	C/E_1	384·69	239·0	1,043·13	372·57	275·1	107·41	636·35	228·0	811·76	—
IIIrd Q	C	59,798	—	—	4,874	0	0	16,244	1,706	36,610	364
	E_1	178	0	0	1	17	1	33	95	24	7
	C/E_1	335·94	—	—	4,874·0	0	0	492·24	17·95	1,525·4	52·0
IVth Q	C	222,458	—	53,183	61,734	11,463	0	53,568	40,859	—	1,651
	E_1	148	0	31	30	9	5	33	39	0	1
	C/E_1	1,503·1	—	1,715·58	2,057·80	1,273·66	0	1,623·27	1,047·66	—	1,651·0
Grand Total	C	409,706	717	70,851	77,981	48,932	4,712	88,493	65,595	50,410	2,015
	E_1	579	3	68	48	56	26	84	245	41	8
	C/E_1	707·6	239·0	1,041·9	1,624·6	873·7	181·2	1,053·5	267·7	1,229·51	251·8

Pole and Line Fishery

Approximately 410 tons of tuna (64.3% skipjack, 35.4% yellowfin and 0.3% mackerel tuna) were caught by the three vessels during the period of 579 sea days. The areas covered by each vessel and the number of days spent in each area during the four quarterly seasons are presented in Table IV. It is generally evident that in spite of the largeness of the size of the vessels they have not been very successful in covering the entire off-shore areas around the island and the effort on the west coast being poor during the south-west monsoon (3rd quarter) and that on the east coast was poor during the north-east monsoon (latter part of the 4th quarter and the 1st quarter). It is also evident that the number of days spent in an area was influenced by the proximity to the bait fishing ground.

Out of the 579 days at sea, bait fishery was carried out on 384 days which allowed only 195 days purely for pole and line fishery. Effective pole and line fishing days were 148 which is satisfactory when compared to 195 days devoted entirely for pole and line fishery. However, quite often bait fishery at night had been followed by day time scouting for tuna and pole and line operations but only 18% of the effective bait fishing nights were followed by effective pole and line fishing in the day time. As mentioned earlier, quite often when bait catch rates were poor the vessels have remained in the bait ground continuously for number of days until sufficient quantity of live bait was collected. Such a situation in this combined fishery has resulted in an ill-defined effort and has therefore called for the consideration of the effort at more than one level both from the point of view of abundance estimation and economic feasibility evaluation.

At one level the effort has been taken as the actual number of days at sea and this includes bait fishing days, scouting and pole and line fishing days. This effort value has been used essentially for considering the economics of the fishing operation. At another level the effort has been considered as the number of days directed on pole and line fishery and this includes tuna scouting and pole and line days. Days on which poor bait fishery resulted in the continuation of the bait fishery in the same ground consecutively over a number of days, have been excluded. Due to the fact that only 18% of the effective bait fishing days have been effective pole and line fishery days, those days on which the vessel kept on returning to the bait grounds night after night without any success in tuna fishing have also been excluded as far as possible (Table III). For obtaining a reliable index of abundance it is necessary to utilize proper effort value. As the operation was commercially oriented there has been considerable difficulty in determining the actual number of hours spent on scouting, tuna fishing etc.

There has also been a day to day variation in the actual number of fishermen engaged directly in pole and line fishery but it has been estimated that on an average 16 men were directly engaged in the pole and line operation on each of these vessels. Under these circumstances the second level of effort has been used for considering catch rates for the availability of exploitable resource.

TABLE V

Tuna catch (C in Kgs), days at sea (E_1) days concentrated on Tuna Fishery (E_2) effective tuna fishing days (E_3) and catch rates for respective effort values, for fishing months and vessel

	1973									
	March	*April*	*May*	*June*	*July*	*August*	*September*	*October*	*November*	*December*
SEISHO MARU										
Catch Kgs C	4,503	9,886	17,618	5,245	5,744	0	112,339	27,718	26,512	26,043
Days at sea E_1	5	25	28	26	22	25	25	26	21	23
Days concentrated on Tuna operation E_2	4	24	13	16	12	24	20	20	14	13
Effective Tunafishing days E_3	2	11	10	6	4	0	3	14	8	7
C/E_1	900	395.4	629·2	201·6	261·0	0	449·5	1,066·0	1,262·4	1,132·3
C/E_2	11,25·7	411·9	1,355·2	327·8	478·6	0	561·9	1,385·9	1,893·7	2,003·3
C/E_3	22,51·5	898·7	1,761·8	874·1	1,436·0	0	3,746·3	1,979·8	3,314·0	3,720·4
KUROSHIO MARU										
C				405	6,118	10,016	32,084	58,756	49,755	32,225
E_1				17	27	27	25	26	24	25
E_2				5	18	6	19	18	14	19
E_3				3	5	3	9	16	9	9
C/E_1				23·8	226·6	370·9	1,283·3	2,259·8	2,073·1	1,289·1
C/E_2				81·0	339·8	1,669·3	1,688·6	3,264·2	3,553·9	1,696·2
C/E_3				135·0	1,223·6	3,338·6	3,564·8	3,672·2	5,528·3	3,580·5
SHINSHYU MARU										
C										
E_1										
E_2										
E_3										
C/E_1										
C/E_2										
C/E_3										

	1974											
	January	*February*	*March*	*April*	*May*	*June*	*July*	*August*	*September*	*October*	*Total*	*September*, 1973 to *March*, 1974
SEISHO MARU												
Catch Kgs C											134,508	91,512
Days at sea E1											226	95
Days concentrated on T. operation E2											160	67
Effective Tunafishing days E3											65	32
C/E1											595·1	963·3
C/E2											840·6	1,365·8
C/E3											2,069·3	2,859·7
KUROSHIO MARU												
C	7527	26,856	19,410	14,602	13,353						271,107	207,204
E1	17	24	29	18	27						286	141
E2	10	17	13	9	11						159	91
E3	5	6	5	6	4						80	55
C/E1	442·7	1119·0	669.3	811·2	494·5						947·9	1,469·7
C/E2	752·7	1579·7	1493.0	1622·4	1213·9						1,705·1	2,136·3
C/E3	1505·4	4476·0	3882.0	2433·6	3338·2						3,388·8	3,837·1
SHINSHYU MARU												
C					3140	0	0	—	0	1414	4554	
E1					16	21	16	—	11	3	67	
E2					9	11	7	—	5	3	35	
E3					1	0	0	—	0	2	3	
C/E1					196.2	0	0	—	0	481·3	67·9	
C/E2					348.8	0	0	—	0	481·3	130·1	
C/E3					3140	0	0	—	0	722	1,518·0	

Table VI

Distribution of effort (Number of Sea-days) by area, season and vessel

Area		*Vessel*	1st Q	IInd Q	IIIrd Q	IVth Q	Total	
	78°.80°E	Seisho Maru—25	0	1	0	0	1	
'North-West'	8°.9°N	Kuroshio Maru—70	0	2	0	0	2	3
		Shinshyu Maru	0	0	0	0	0	
	78°.80°E	Seisho Maru—25	1	6	0	20	27	
'West'	7°.8°N	Kuroshio Maru—70	21	7	0	11	39	68
		Shinshyu Maru	0	2	0	0	2	
	78°.80°E	Seisho Maru—25	0	5	1	12	18	
'South-West'	6°.7°N	Kuroshio Maru—70	10	2	0	18	30	48
		Shinshyu Maru	0	0	0	0	0	
	78°.83°E	Seisho Maru	0	7	10	2	19	
'South'	4°.6°N	Kuroshio Maru	21	0	6	7	34	56
		Shinshyu Maru	0	2	1	0	3	
	81°.83°E	Seisho Maru	4	6	1	4	15	
'South-East'	6°.7°N	Kuroshio Maru	4	5	0	1	10	26
		Shinshyu Maru	0	1	0	0	1	
	81°.83°E	Seisho Maru	0	9	8	15	32	
'East'	7°.8°N	Kuroshio Maru	4	2	19	17	42	84
		Shinshyu Maru	0	3	6	1	10	
	81°.83°E	Seisho Maru	0	34	40	17	91	
'North-East'	8°.9°N	Kuroshio Maru	10	41	44	20	115	245
		Shinshyu Maru	0	26	11	2	39	
	81°.83°E	Seisho Maru	0	11	6	0	17	
'North'	9°.10°N	Kuroshio Maru	0	3	10	0	13	41
'North-East'		Shinshyu Maru	0	3	8	0	11	
	80°.83°E	Seisho Maru	0	0	6	0	6	
'North'	10°.11°N	Kuroshio Maru	0	0	0	1	1	8
		Shinshyu Maru	0	0	1	0	1	
	Total	All vessels	75	178	178	148	579	

Overall catch rate realized by the three vessels were 0.7 ton per sea-day, 1.1 ton per tuna fishing day and 2.7 tons per effective tuna fishing day. However, it has been noted that there is significant difference in the catch rates between vessels (Table III), which has been attributed mainly to the differences in the fishing efficiency of the vessels and to some degree to the fact that all three vessels did not operate over the same period. The performance of Seisho Maru was about 50% of the efficiency displayed by Kuroshio Maru and that of Shinshyu Maru was too low to attempt a comparison. The total quantities of tuna caught by pole and line operation in 30′ × 30′ areas for the four quarters are illustrated in figures 3A to 3D. The catch distribution pattern clearly indicates that the fishing operation have been seriously influenced by the weather condition prevailing in the sub-region and the location of bait fishing grounds. Wide coverage was achieved during the two inter-monsoon (2nd and 4th quarters) and highest catch per unit area was obtained on the west coast and relatively high catch per unit area were also made on the east coast during the last quarter of the year. 54·3% of the total catch was made during the 4th quarter 16·7% during the 2nd quarter

14·6% in the 3rd quarter and 14.4 in the 1st quarter. By area 211.225 kgs (51·6%) of the catch was from the eastern side, 149,549 kgs. (36·5%) from the western side and 48,932 kgs. (11·9%) was from the south. The pole and line fishery was successful mainly within 60 miles from shore, except in the north-east and south-west corners of the island from where small degree of success was observed beyond this limit. Even within the 60 miles belt around the island, successful pole and line operations appeared to decline towards the outer boundary. A note-worthy point from the results is the fact that pole and line fishery was successfully conducted in the areas north of 7°N on the west coast and north of 9°N on the east coast, which are outside the traditional pole and line fishing areas

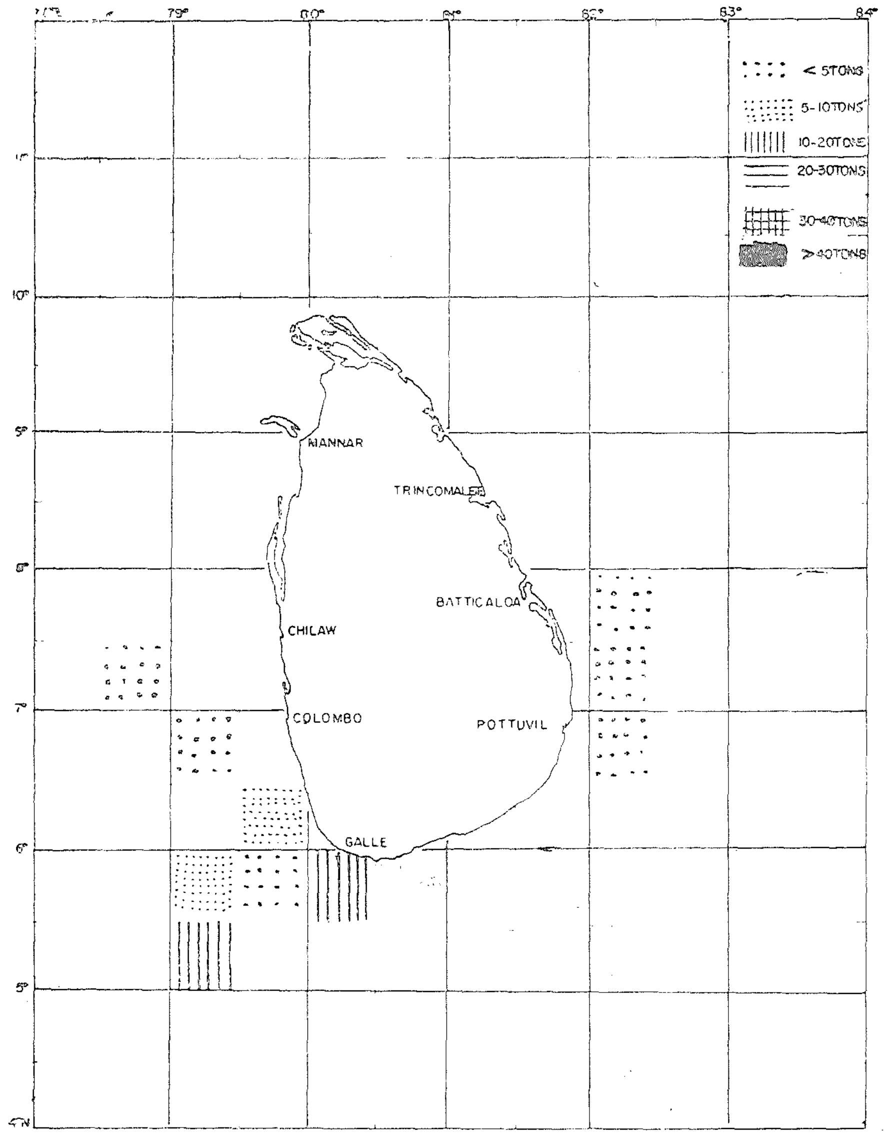

Fig 3A.—Tuna catch made in each 30′ × 30′ area, during the 1st quarter.

An average of over one ton per sea-day was realized in almost all areas during the 4th quarter. Such catch rates were realized in the areas 'south' and 'east' during the 1st quarter, in the area 'west' during the 2nd quarter and in the area 'north-north-east' during the 3rd quarter. An annual average of over one ton per sea-day was achieved in the 'west', 'south-west', 'east' and 'north-east' areas. The highest average catch for all areas was observed during the 4th quarter followed by the 1st, 2nd and the 3rd quarters. During the 4th and 1st quarters there was significant

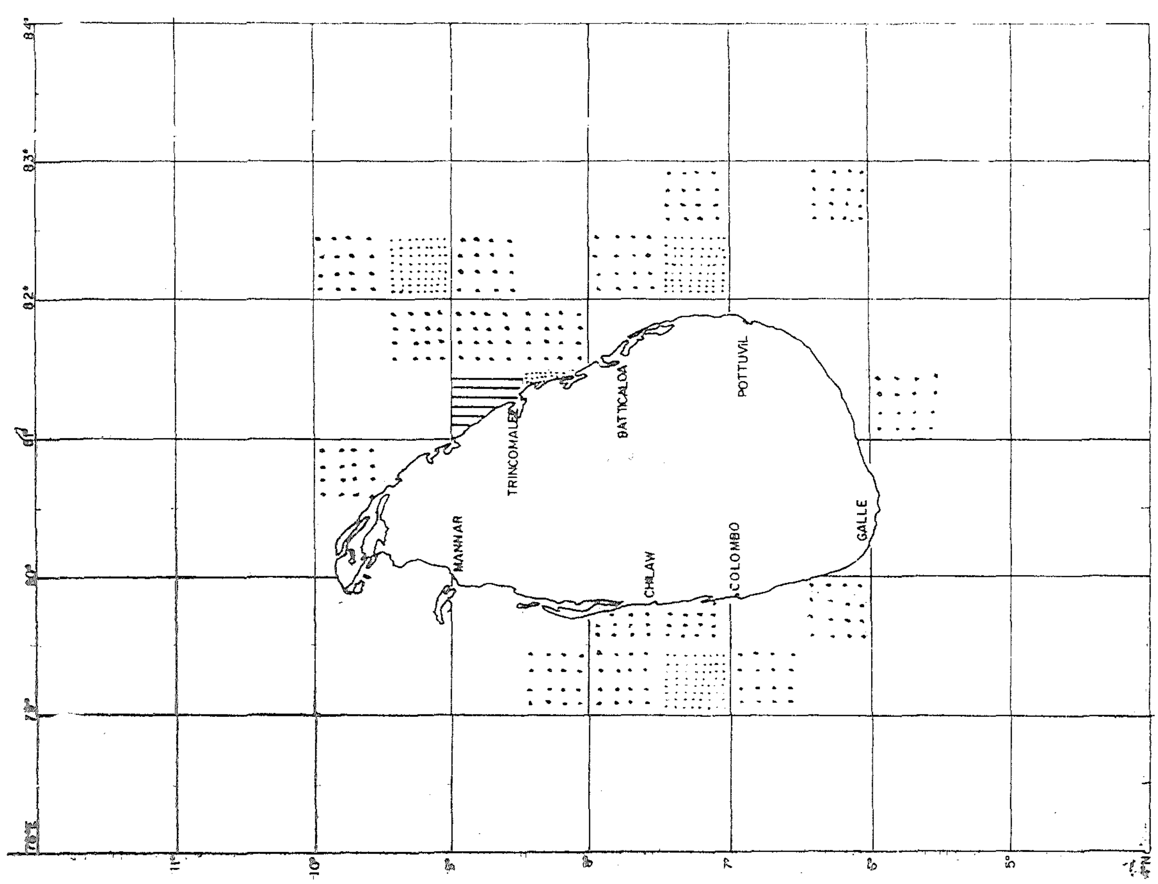

Fig. 3B.—Tuna catch made in each 30′×30 area, during the 2nd quarter.

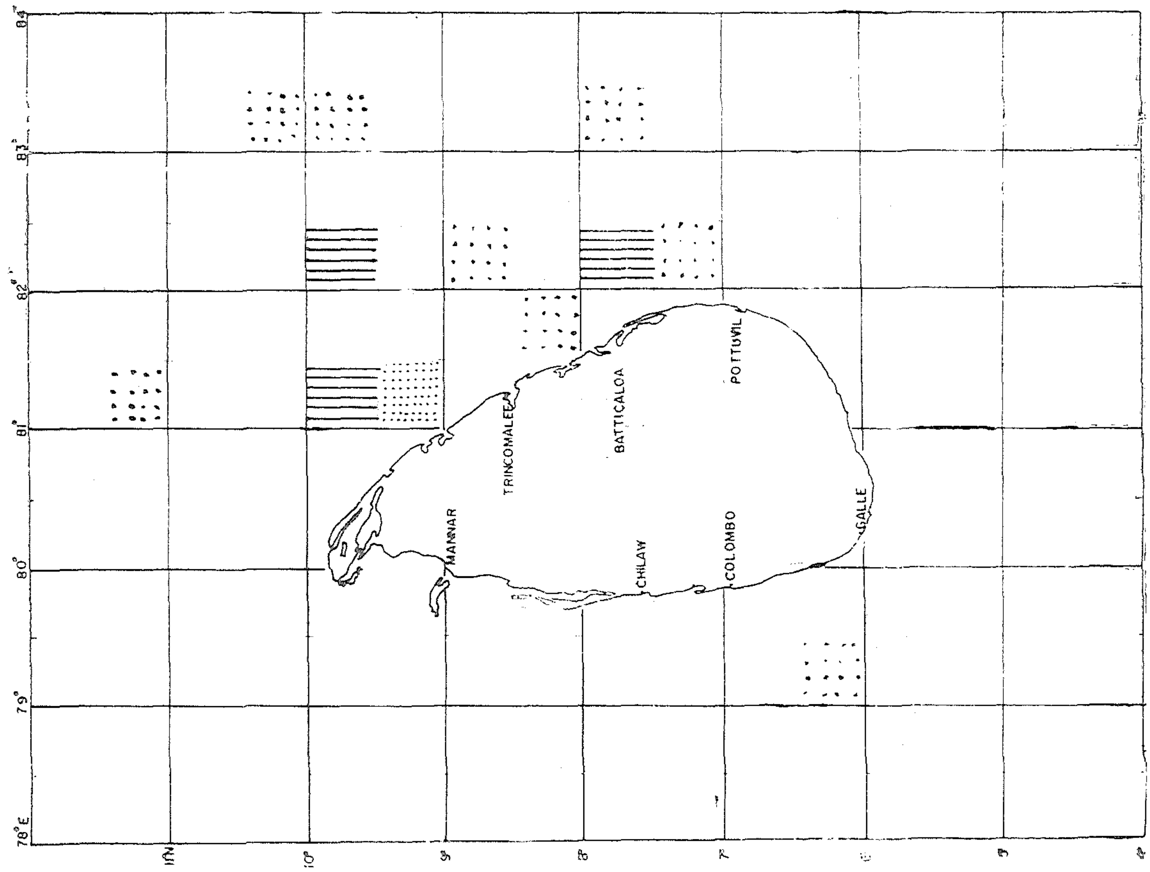

Fig. 3C.—Tuna catch made in each 30 × 30′ area, during the 3rd quarter.

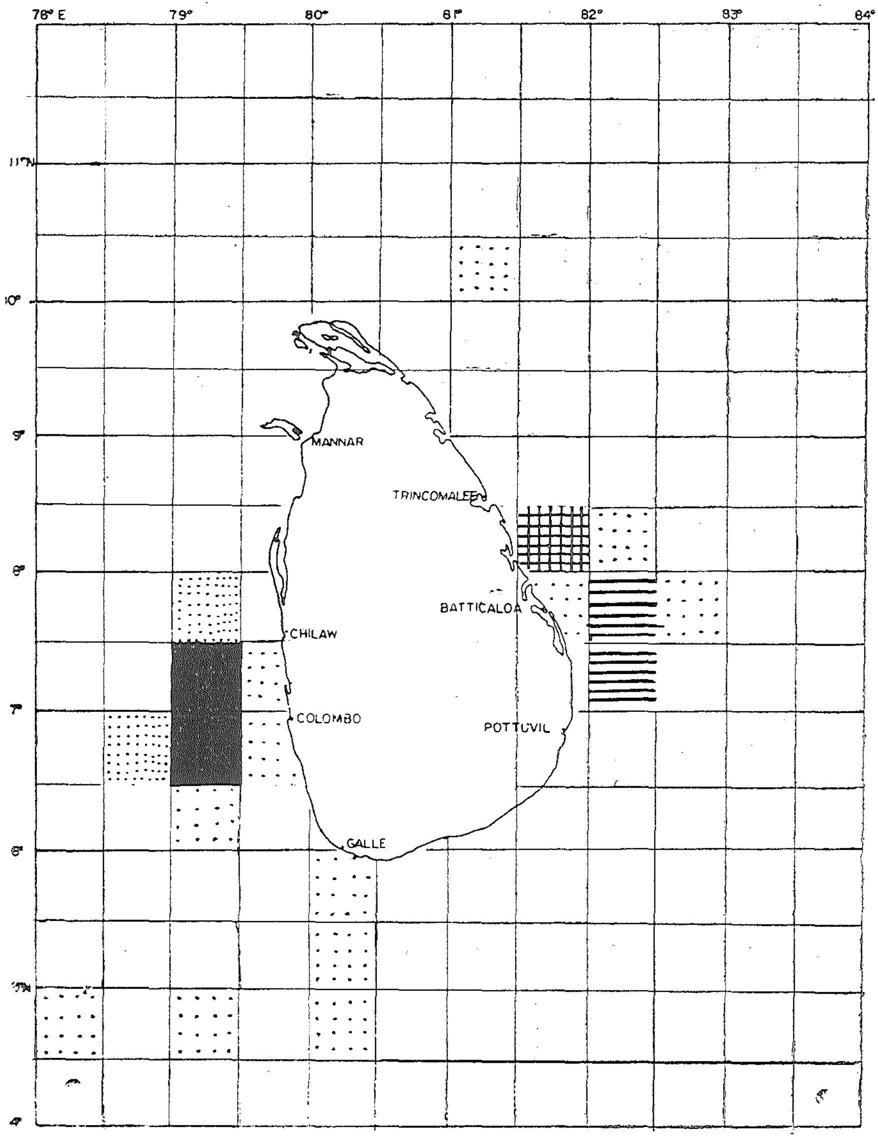

Fig. 3D.—Tuna catch per sea-day by area, during the 4th quarter.

differences in the density of distribution by areas with zero catch in the north-east areas during the 1st quarter. In the 2nd quarter the catch rates became more or less uniformly low in all areas and in the 3rd quarter the catch rates were the lowest with zero catch in the areas ' south ' and south-east '.

Monthly average catch per day for all areas combined (Fig. 1B and Table V) show the peak months to be September to December. Between February and May the catch rates were around 50% of the peak season and the period June to beginning of September proved to be extremely poor pole and line season with the vessel Seisho Maru showing a nil catch return for the whole month of August. As in the case of the bait fishery, the tuna catch-frequency distribution (Fig. 5) also exhibited high variability and nil catch days were high for all months. It is clearly evident that catches have been sporadic.

Results of the experimental fishery did not bring out any clear migratory pattern. However, there is low density of distribution at the surface (less than 1,000 kgs.) in all areas within the 2nd quarter but during the 3rd quarter there is some evidence of increase in surface concentrations in the south. During the 4th quarter surface concentration increased with a southerly shift and in the 1st quarter the concentration begins to dwindle in the same direction (Fig. 4A-D).

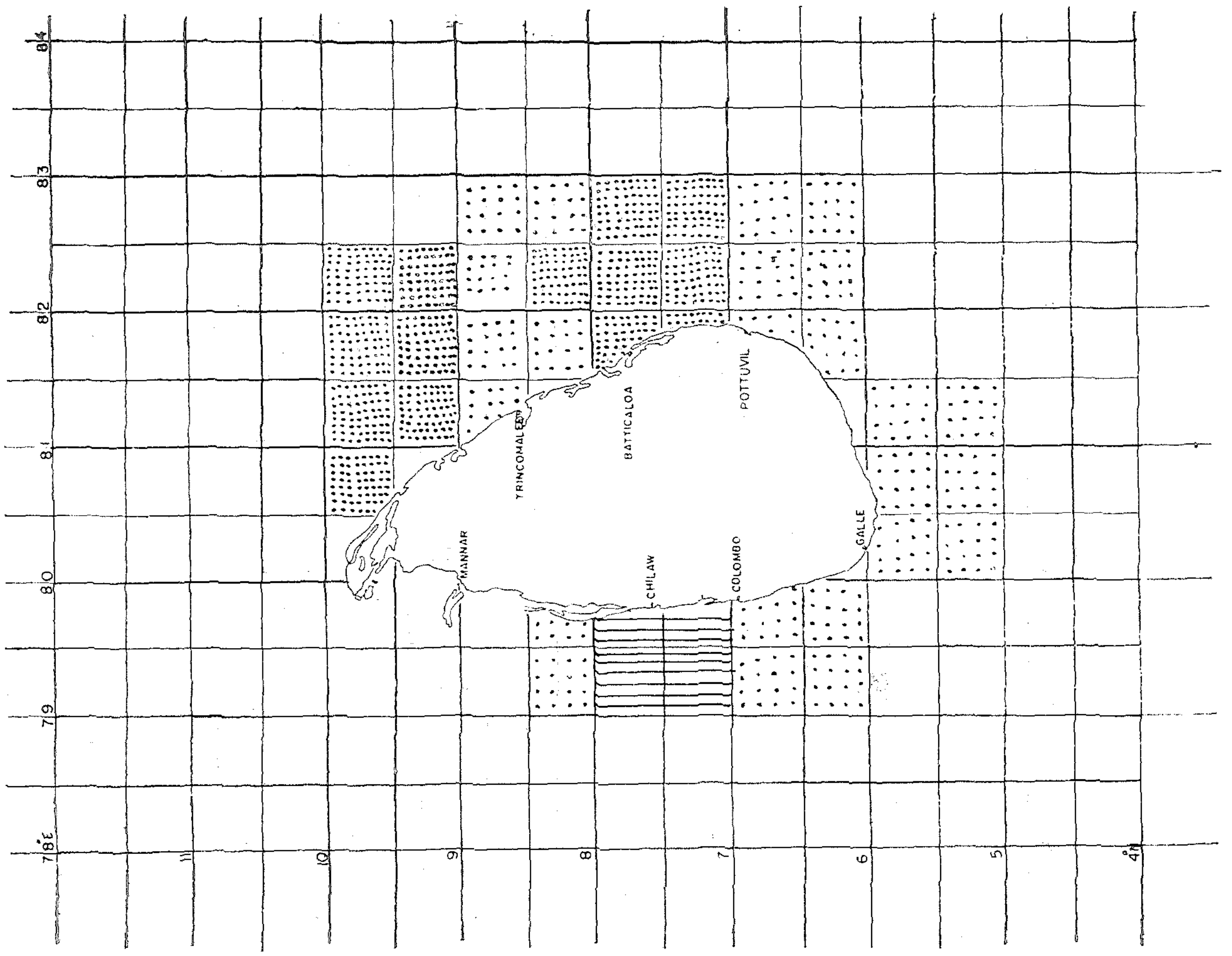

Fig. 4B.—Tuna catch per sea-day by area, during the 2nd quarter

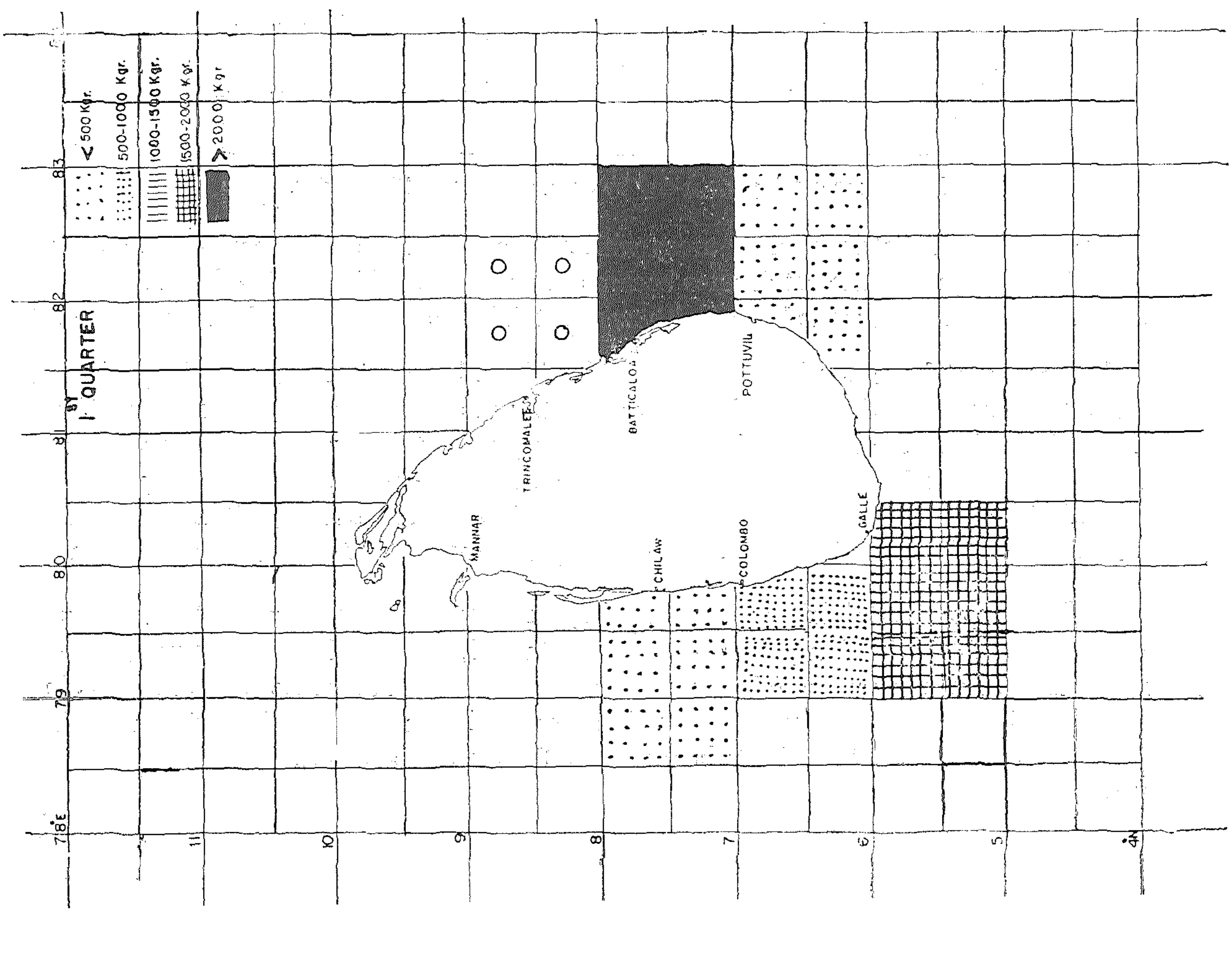

Fig. 4A.—Tuna catch per sea-day by area, during the 1st quarter.

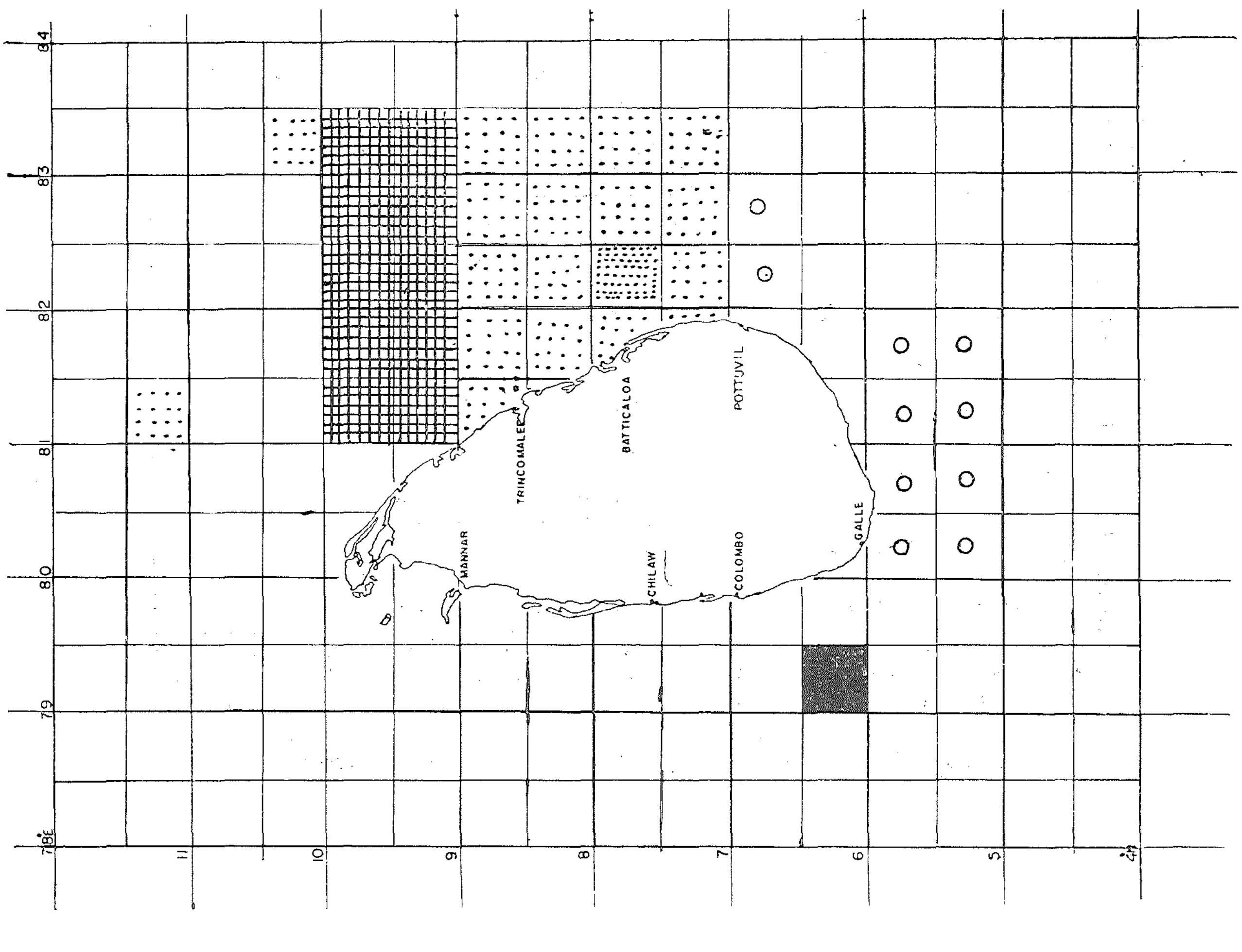

Fig 4c.—Tuna catch per sea-day by area, during the 3rd quarter.

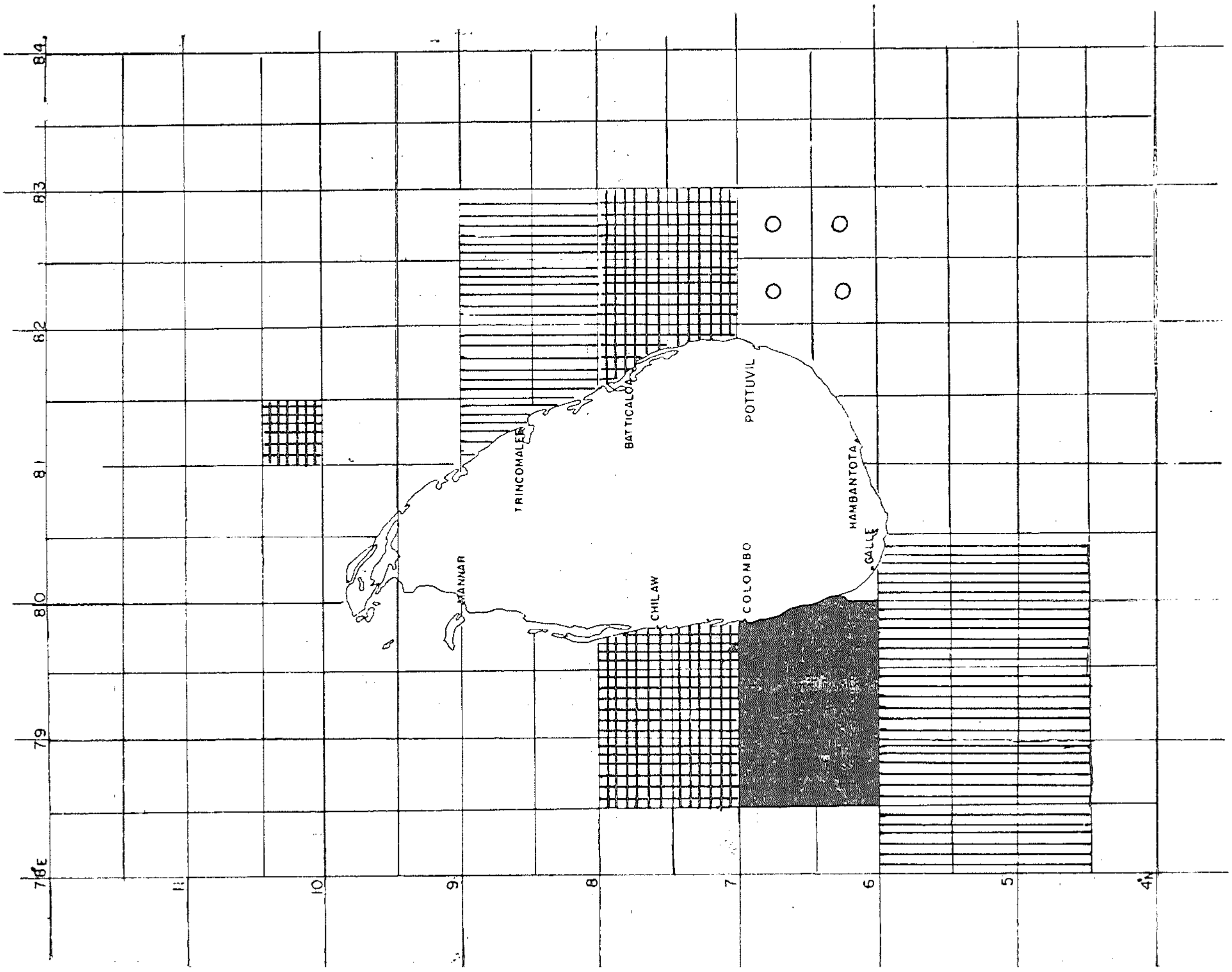

Fig 4D.—Tuna catch per Sea-day by area, during the 4th quarter.

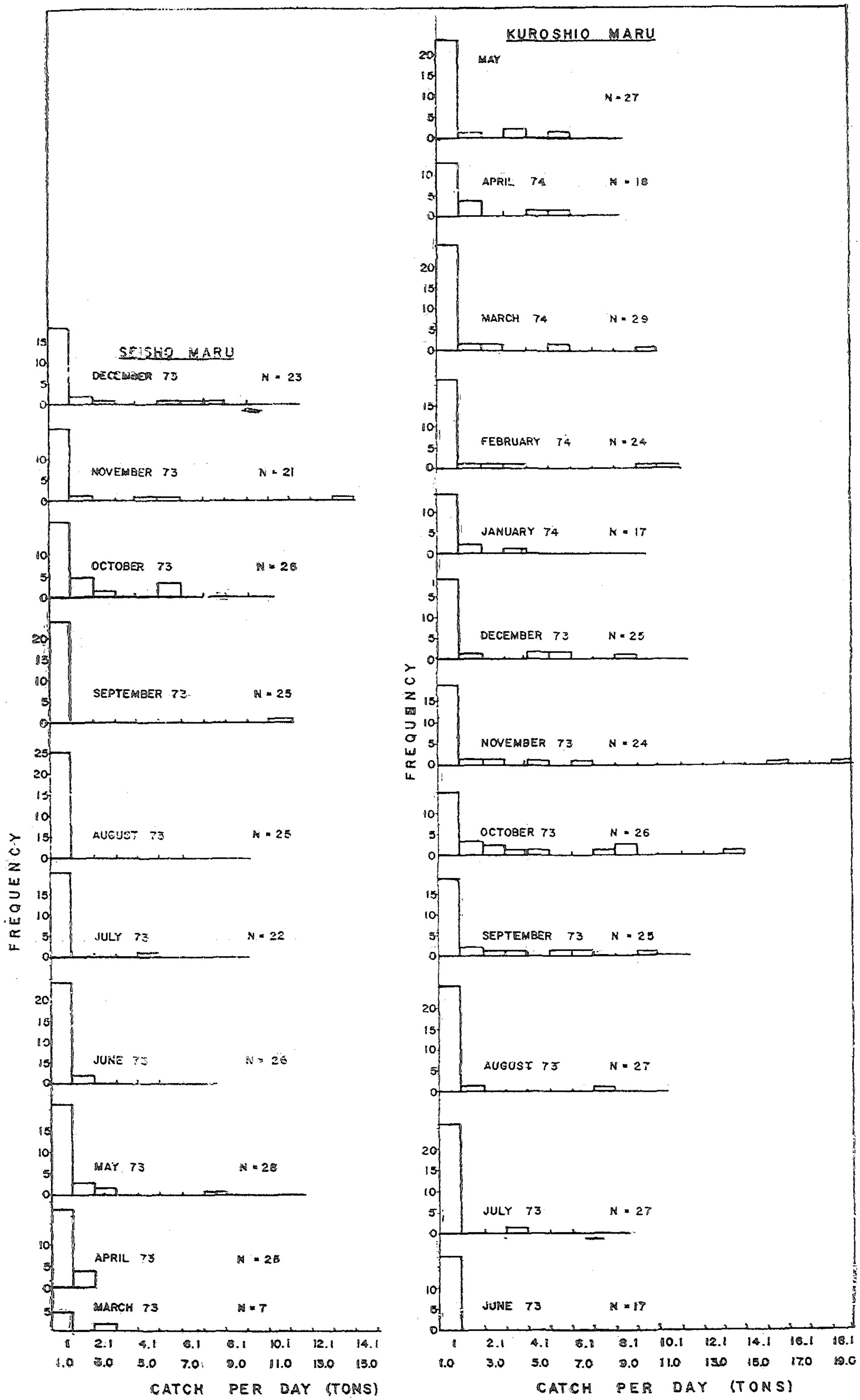

Fig. 5.—Tuna catch—frequency distribution by vessel and season.

Considering the entire catch, the mean weight of the fish caught were calculated as 2·5 kgs. for skipjack, 3.0 kgs. for yellowfin and 0·8 kgs. for MT. The seasonal variation in the size composition of the skipjack and yellowfin tuna was observed to be the same as those already reported (Sivasubramaniam 1970, 1972). Though the size range of tuna exploited by pole and line is very wide (Fig. 6) small-sized skipjack (less than 3 kgs.) formed almost the entire catch at the beginning of the 3rd and 1st quarters (Fig. 7). Even during the rest of the year the skipjack caught show fairly high percentage of fish under 3 kgs. mean weight. Yellowfin tuna forms very small percentage of the catch during the first half of the year. But it is noted that during the peak pole and line season the percentage of yellowfin in the catch composition tends to be equal to or slightly higher than that of skipjack (Fig. 7). Separation of the tuna catch by species indicates that the seasonal variation in the skipjack tuna catch per tuna fishing day averaged a little over 1,000 kgs. during both January to April and October to December seasons and the average for the period in between was 300 kgs. per tuna fishing day. Hence, the catch rates of over 2 tons of tuna per tuna fishing day realized during certain months was due to equally high contribution by both yellowfin and skipjack tuna. In fact the highest tuna catch per tuna fishing day was realized in November and in this month the contribution by yellowfin was greater than that by skipjack, by weight. The very poor tuna catch rates obtained during June to August, may have been the cumulative effect of relatively poor contribution by yellowfin (Fig. 7), the shifting of the skipjack tuna concentration to subsurface layers and the few surface skipjack schools available to the pole and line fishery being made up almost entirely of small sized fish (<3 kgs.) Recruitment of skipjack tuna to the exploitable stock in the Sri Lanka waters has been observed to be in this period. However, skipjack has made better year round contribution than yellowfin tuna, to this surface fishery. Another note-worthy point is that frigate mackerel (*Auxis* species) and mackerel tuna (*Euthynnus affinis*) were very insignificant in the catches during the experimental fishery. This may have been due to the fact that these species are poorly distributed in the deep waters, beyond the continental shelf, where the fishery was concentrated and also due to the possibility that these species respond less to chumming in pole and line fishery.

The catch per day has been mostly from a single school and occasionally from two schools of tuna. Off the continental shelf the chances of sighting more than one school per day were rare during the 2nd and 3rd quarters and the chances of sighting more than two schools increases during the 4th quarter and the 1st quarter. In fact in the traditional pole and line fishery up to five schools have been sighted in a day during peak pole and line seasons (Sivasubramaniam, 1965). However, the size of the school seems to vary very widely and small-sized schools are more frequently met with than large size ones. The catch-frequency distribution and the catch rates per effective fishing day give an idea of the sizes of schools fished. Very seldom pure schools of skipjack have been fished and the species composition of the schools varies according to the mean size of the fish in the school. But, generally, the schools are mainly composed of skipjack and yellowfin with the skipjack being the dominant species. It is also known that the smaller tuna like the frigate mackerel and mackerel tuna respond less to this method of fishing in these waters. It has also been known that sometimes schools of skipjack do not respond to chumming and during this experimental fishing such cases have been noticed particularly during the 2nd and 3rd quarters. Bait preference also cannot be ruled out as evidenced on number of occasions when response to chumming was poor with certain bait fishes like sardines and scad while it was better when species such as red bait was used.

In pole and line fishery it is common practise to determine the ratio of tuna catch to the quantity of bait used. In this experimental fishery the bait to tuna ratios realized were 1: 3, 1 : 4.6 and 1:0.6 for the vessels Seisho Maru, Kurosho Maru, and Shinshyu Maru, respectively. These values cannot be considered as the true ratio as they have been based on the bait catches made and not on the

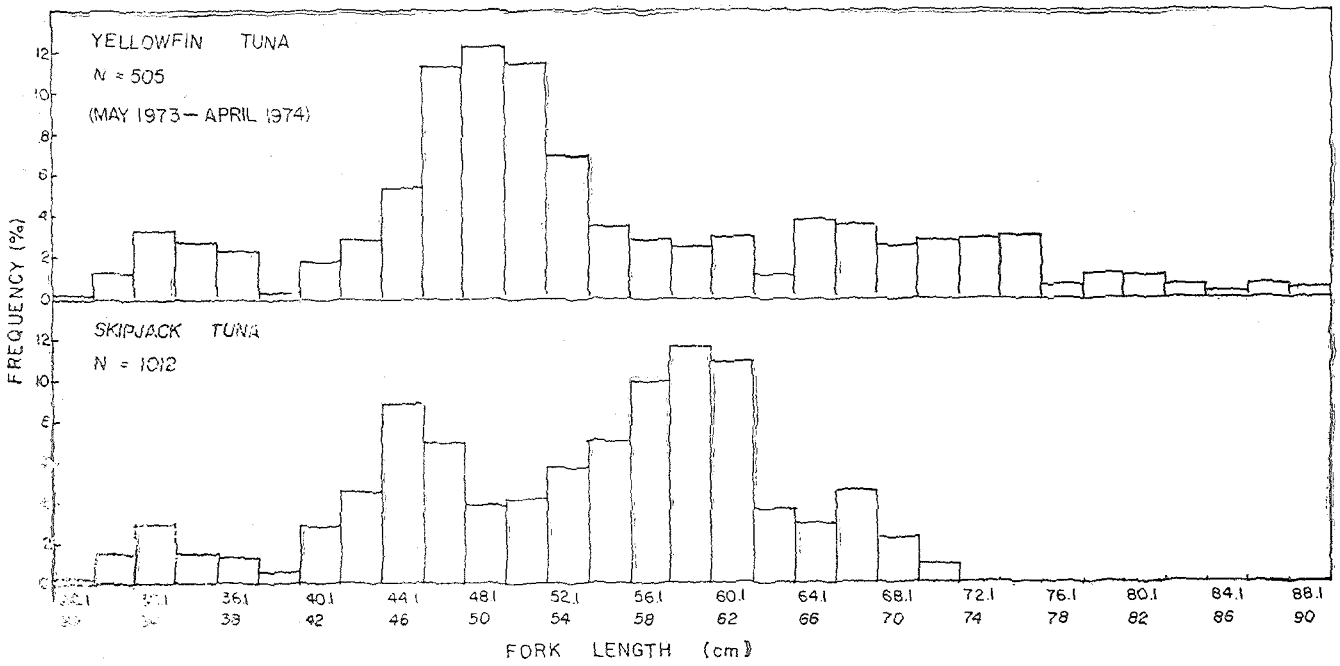

Fig. 6.—Length-frequency distribution for yellowfin and skipjack tuna caught during the experimental pole and line fishery.

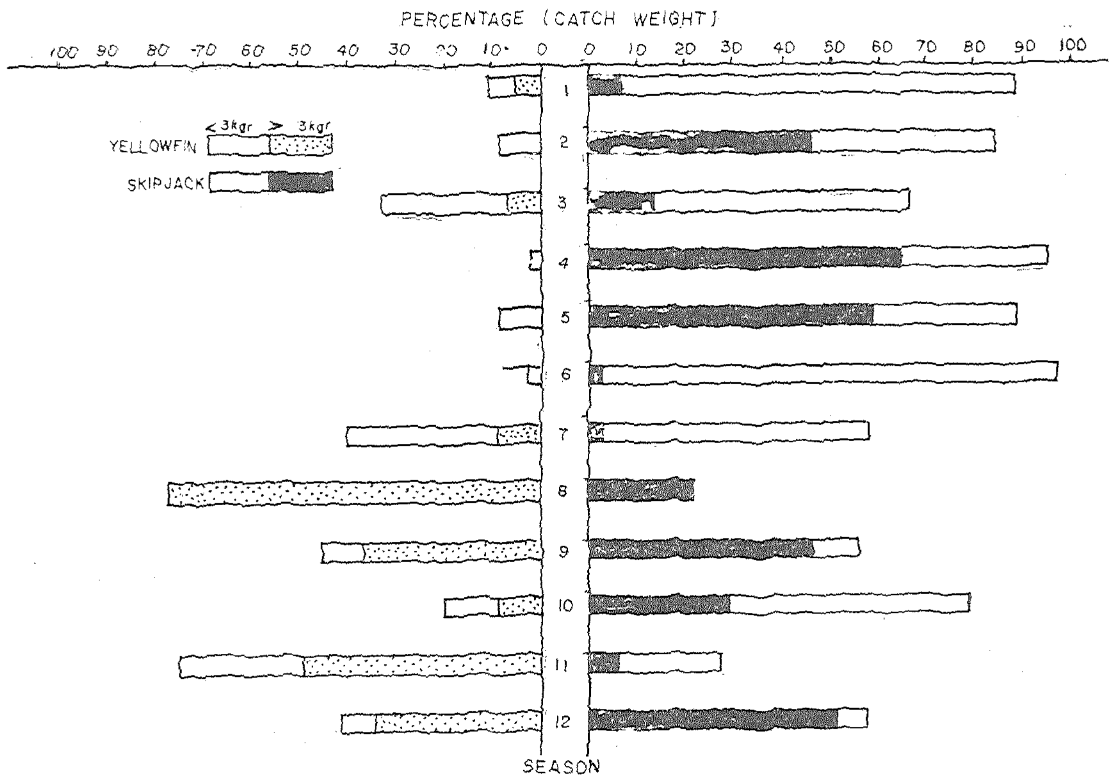

Fig. 7.—Monthly variation in the percentage composition of yellowfin and skipjack tuna caught during the experimental pole and line fishery.

quantity of bait used. Further, it has also been observed that the ratios change very significantly with seasons and the degree of response to chumming. There have been occasions when approximately 10 tons of tuna had been caught with approximately 150 kgs. of bait fish.

DISCUSSION

Considering the magnitude of the existing fishery for tunas particularly skipjack tuna (10 to 12 thousand tons per annum) the results of the three vessels were much below expectation. In addition, the significant difference in performance between vessels manned by skilled Japanese crew, has also been a matter for serious consideration.

Comparison of Tables II Iand VI and Figure 1 clearly show that there was partically no bait catches made on the west coast between May and November and therefore, the attempt at tuna fishing on the west coast during this period would have been limited by this factor. A total of 404 days were spent on the east coast as against 175 days on the west and south coasts.

Though, about 109,312 kgs. were caught during the bait fishery, the actual quantity utilized may not have been more than 50 to 60%, due to the high mortality in the cases of many species, suitability of bait size, etc. Figure 1 shows that peak tuna catch period roughly coincides with the peak bait catch season. Short life in the bait tank for many of the species would have limited the effectiveness of the survey for tuna particularly in the distant waters. This may have been the reason for the relatively poor survey in the south coast.

In order to determine the influence of bait fishery on the tuna fishery, the weekly bait catch was plotted against the corresponding weekly tuna catches, for the peak months on the east coast (Fig. 8) and a correlation is evident indicating that poor tuna catches made during the peak season may have been due to poor bait catches. This is also supported by the inverse relationship between average tuna catch per day for each month of the peak season and the number of days spent in the bait grounds during the corresponding months (Fig. 9).

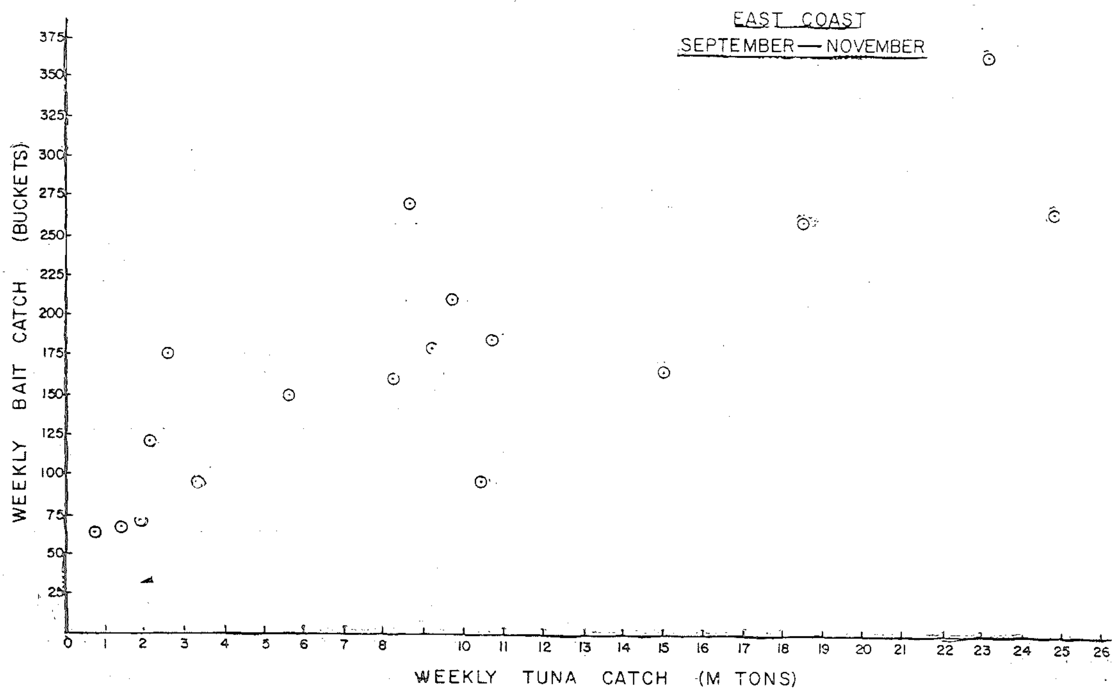

Fig. 8.—Correlation between weekly bait catch and tuna catch made during the peak pole and line season, on the east coast.

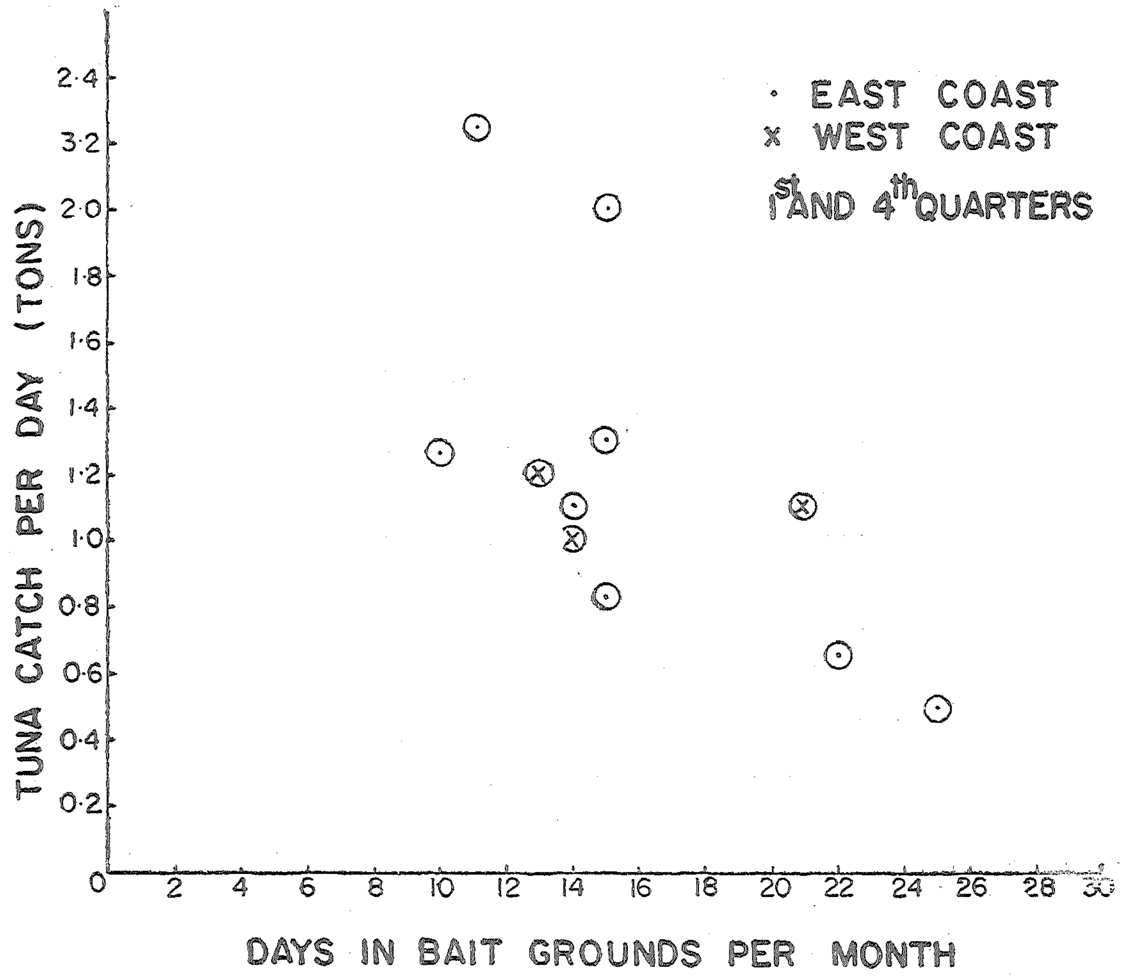

Fig. 9.—Relationship between tuna catch per sea-day for each month within the peak season and the number of days spent in the bait grounds during the corresponding month.

It is well known that unfavourable weather and sea conditions prevail in this sub-region during the south-west and north-east monsoons. The experimental fishing vessels have reported wind force of over 3 beaufort in most of the off-shore areas around the island during about 6 months of the year. Nichiro Fishing Company has reported this as a very serious limiting factor in their operation. Significance of this fact is very great considering the fact that fishery has been possible mainly within 60 miles from shore and vessels to be introduced in future to cover such a small range is very likely to be much smaller than the experimental fishing vessels used. However, it has to be borne in mind that Kuroshio Maru and Seisho Maru were constructed and modified for operation in the calm waters of West Africa and may not have been quite suited for the conditions prevailing around Sri Lanka.

Traditionally the pole and line fishing season in Sri Lanka are August, September on the east coast and October to February on the south-west coast. The results of the present experimental fishing has confirmed this. During the other months of the year surface schools are seldom observed and during the south-west monsoon drift net fishing for skipjack has been established as a very effective method indicating presence of skipjack below the surface (Fig. 10). This has been confirmed by aerial survey during the peak drift net fishing season (Sivasubramaniam, 1971). This change in the behavioural pattern of the skipjack tuna suggests seasonal alternation of the two types of fishery in order to achieve any degree of success for a year round fishery for skipjack tuna. Though the reasons for this behaviour is not clearly known, envoirnmental factors such as temperature may be contributing to this phenomenon (Fig. 10). Further, the tuna schools did not show clear evidence of associating with driftwood, bait fish, etc. There is also no clear evidence, of any definite areas around the island, where surface schools of tuna tend to concentrate. In view of the significant seasonal changes in the availability of tuna to the pole and line and drift net fisheries, the results of the pole and line fishery alone may not be sufficient to obtain a reasonably good index of the abundance. It was concluded that aerial survey would not be a satisfactoiy method for εvaluating skipjack resource around Sri Lanka because surface schools did not project the true abundance of the exploitable skipjack resource in the seas around Sri Lanka (Sivasubramaniam, 1971). Therefore the results of pole and line fishery cannot be expected to give a proper index of abundance for the skipjack and young yellowfin tuna. However, there were certain months of the year during which catch rates of 3 tons per tuna fishing day have been realized and considerable weightage has to be placed on this value in any consideration

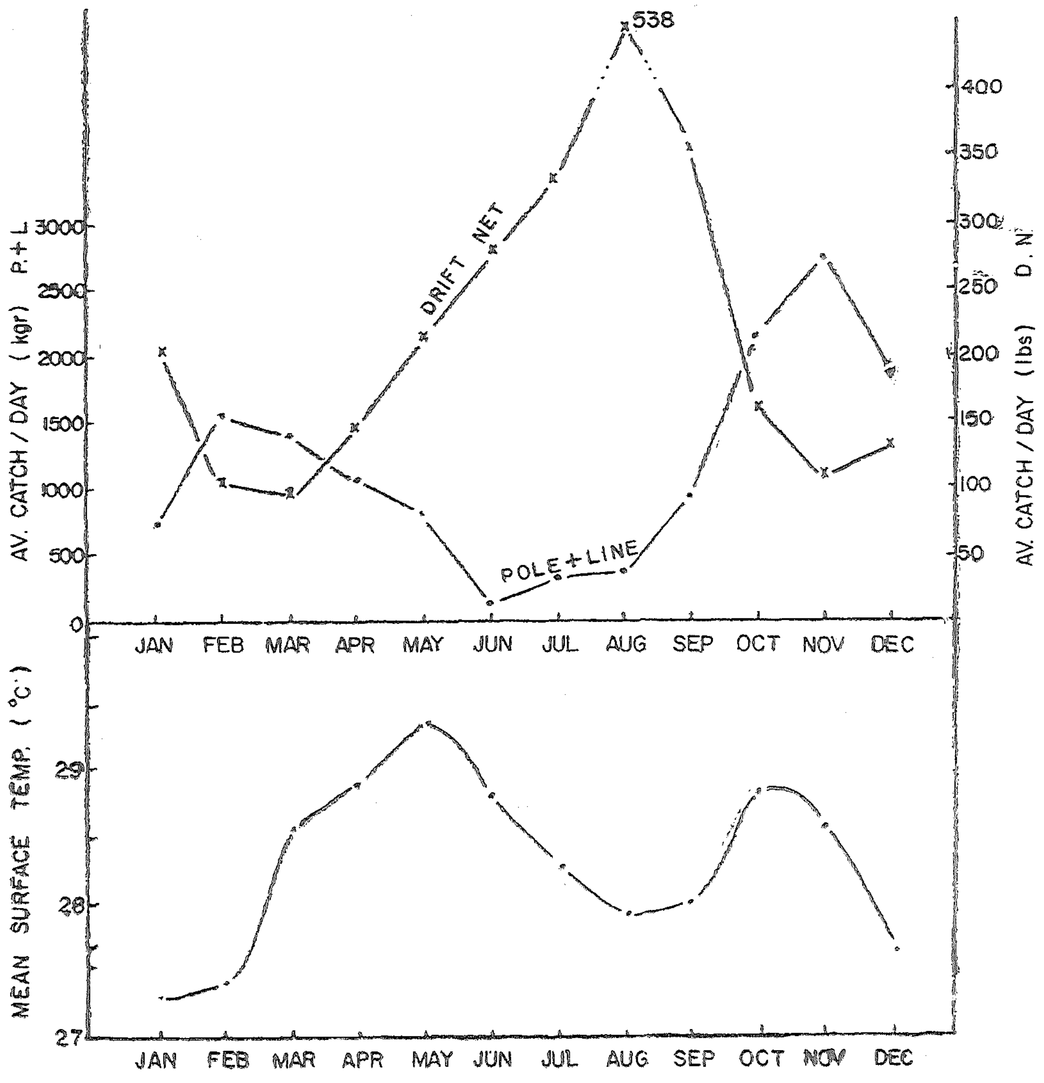

Fig. 10—Comparison of the seasonal variation in the catch rates realized by the experimental pole and line fishery (yellowfin and skipjack) and the 11-ton class drift net fishery (skipjack only). Seasonal variation in the mean surface water temperature around the island, observed during the experimental pole and line fishery is also presented.

of the abundance of the tuna resource around the island. It may be stated that the catch rates realized does not give any encouragement for a joint venture with larger vessels of the class that was used but the pole and line catch rates realized for the season September to March (Table V) and the drift net catch rates made by small mechanized boats from May to September (Fig. 10) indicate that smaller class (45/50 ft.) of combination type of vessel, operating pole and line and drift net alternately, from a number of bases around the island, may be a feasible proposition.

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