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Apparent abundance of Yellowfin and Bigeye tuna in the inshore, off shore and near oceanic ranges around Ceylon

By

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INTRODUCTION

In 1952 Japan commenced longline fishery for the tunas in the eastern part of Indian Ocean and then it spread out into the central Indian Ocean, including the Bay of Bengal and the Arabian Sea. However, a rapid decline in the hooked rate of Yellowfin tuna resulted in the reduction of fishing intensity in these areas with corresponding or greater increase in the intensity of fishing for the same species in the Western part of the Ocean. Since 1964, South Korea and Taiwan have added a large fleet of tuna longliners into the Indian Ocean but details of the areas fished and catches, are not readily available. However, indirect evidence indicate that vessels from these latter nations do operate in the Oceanic range around Ceylon, particularly close to the Maldive Islands. Ceylon entered Oceanic longline fishery in 1967 and have limited the areas of operation to the central equatorial belt, thus limiting their fishery to the Yellowfin and Bigeye tunas. Ceylon while developing her coastal fishery took a leap into Oceanic longlining and in view of her programme for accelerated development of the fishing industry, has to fill the gap between the two fisheries by exploiting the intermediate range (off shore and near oceanic) which would chiefly be for tunas and sharks. The present paper has been prepared in this context, utilizing available data and information on the tuna longline fishery in the inshore (Approximately 6–15 miles), off shore (approximately 15–100 miles) and near oceanic (approximately 100–300 miles) ranges (Fig. 1).

There is an expanding surface fishery around Ceylon which is exploiting a very significant quantity of 1st year and 2nd year Yellowfin tuna (author 1971) but the Bigeye tuna does not make any noteworthy contribution to this fishery. In the oceanic ranges under consideration Japan operates tuna longliners from mother port or foreign bases and also portable boat carrying mother ships. Though Saury is their standard bait fish, recently there has been an increase in the use of squid as baitfish even in these areas. The data of their operation in the oceanic range with details of sets, hooks, catch numbers by species in $5° \times 5°$ areas and for each month, were made available by the Research Division of the Fisheries Agency of Japan (1964 to 1969). Records of each operation conducted by the two longliners in Ceylon, in the Oceanic and off shore ranges, were available from the Ceylon Fisheries Corporation. As the catch made by these vessels are taken to Penang, it was not possible to carryout a programme of length frequency sampling. Length measurements and sex ratios of tunas caught from the oceanic range were, observed during a fishing trip in June 1970. In addition, the records of approximate weight of each fish caught, were extracted from the fishing log of one tuna vessel. Sampling for longline catches made by one day trip vessel ($3\frac{1}{2}$-ton class), were carried out as detailed earlier by the author (1971). The ranges and areas covered in this study are as shown in figure 1.

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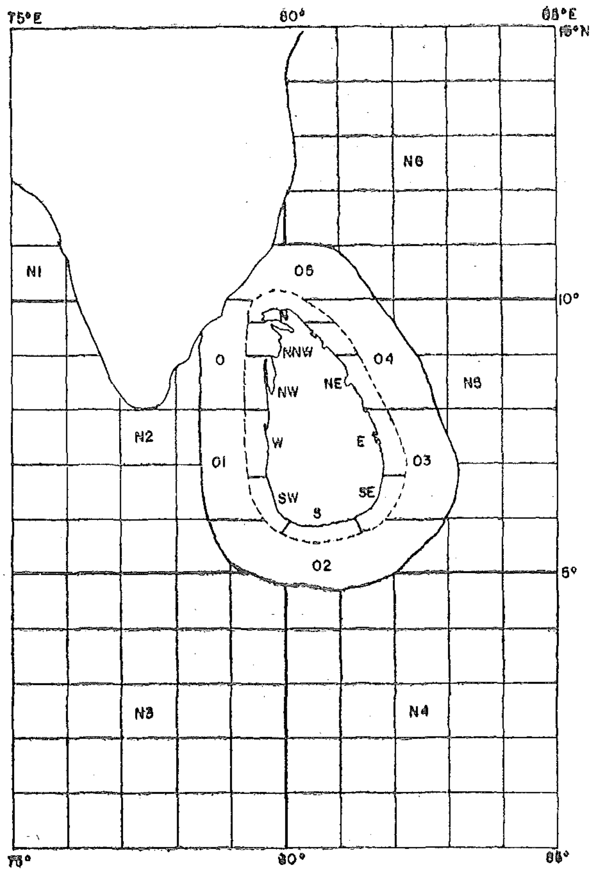

Fig. 1. Ranges and areas covered in the present Study.

Species Composition

The species of tunas, spearfish and sharks caught with the tuna longline, are the same for all three ranges except for a small quantity of albacore (T. alalunga) which appears only in the oceanic areas N3 and N4.

The percentage composition varies between areas within each range, particularly in the case of the oceanic range (Figure 2), but such differences are more marked between ranges. In the oceanic range the tunas form about 65%, spearfish 13% and sharks 20%, in the off shore range these values are approximately 60%, 10% and 25% respectively. In the inshore range the composition is approximately 20% tunas, 7% spearfish and 72% sharks. Besides the geographical factor, the 3½-ton class of vessels operate longline at night and utilise whole fish (Herring, half beak, flying fish and mackerels), cut pieces of fish (Skipjack and little tuna, etc.) or chunks of dolphin meat, as bait as against the daytime fishing in the off shore and oceanic ranges and using imported bait (Saury or mackerel) supplemented with local bait fish. In the inshore longlining, shark catches are considered desirable unlike in the cases of the other two ranges. As a result, the records of sharks caught in the off shore and oceanic range, are not maintained accurately and the percentage composition of sharks may be underestimated.

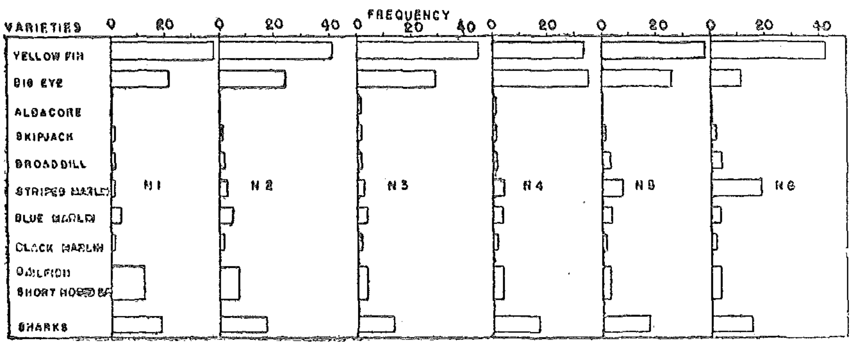

Fig. 2. The percentage species Composition in the longline catches, in the areas of the Oceanic range

Apparent Abundance

The apparent abundance of commercial varieties of fish may be best measured by the catch per unit of fishing effort applied through a commercial fishing gear. This parameter estimated is not a measure of the true abundance of a stock of fish, even in relative terms because the catch per unit of effort is influenced, by other factors like availability. However, by considering the trends of apparent abundance over space and time, variation in the availability may be to some degree averaged out, so that reasonable inferences as to real changes in the abundance of the fish, may be made. Small scale time and space variability will provide a basis for judging what large scale differences can be accepted as due to other than sampling variation (Suda and Schaefer 1965).

(*a*) Geographical variations

For the oceanic range, the geographical differences in hooked rates of yellowfin and bigeye tuna, were analysed on a 1° latitude by 5° longitude basis (Figure 3), inorder to maximise the number

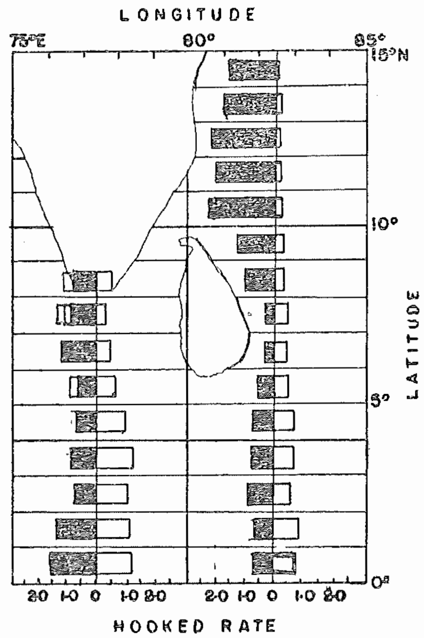

Fig. 3. Hooked rates (%) of yellowfin (shaded) and Bigeye tunas in the oceanic range

of operation involved in the estimation for each area. Latitudinally, on the western side, the hooked rate for both yellowfin and bigeye tuna are equally high near the equator (N 3) and that for bigeye tuna shows a gradual decline towards the higher latitudes. However, in the case of the yellowfin tuna there appears to be a slight decline in the value north of 2° N but improves again, in the latitudes covering Ceylon. Whereas on the eastern side, yellowfin tuna shows higher hooked rates in the higher latitudes while that for bigeye declined steeply in the same direction. The apparent abundance of yellowfin tuna appears to be very high in the area N 6 (Figure 3). Bigeye tuna showed high values closer to the equator (N 3 and N 4) than in the areas of higher latitude. Area N 6 exibits very poor abundance (Table 1).

TABLE I

Mean hooked rates for yellowfin and bigeye tunas caught by vessels from Japan and Ceylon (1969 and 1970)

Area	*N* 1	*N* 2	*N* 3	*N* 4	*N* 5	*N* 6
Yellowfin	1·0	1·2	1·1	0·83	0·76	2·1
Bigeye	0·49	0·57	1·0	0·86	0·54	0·11

The mean hooked rates estimated for the western and eastern halves, gave insignificantly different values of 1·16% and 1·23% for yellowfin tuna and 0·65% and 0·50% for bigeye tuna, respectively. It was noted that the hooked rates realised by Ceylon vessels were slightly lower for yellowfin and slightly higher for bigeye tuna, than those achieved by Japanese vessels.

In the off shore range a mean hooked rate of 1.11% of for yellowfin and 0·15% for bigeye tuna, have been realised. Unlike in the case of the yellowfin tuna, the hooked rate of bigeye is significantly lower than that for the oceanic range. Towards the north west of Ceylon (0,01) and north east (04, 05) the hooked rates for yellowfin tuna are relatively good (>1%) but south-eastern corner (03) exhibited relatively poor value (Table 2). These variation are in general agreement with the pattern observed in the case of the oceanic range, indicating that yellowfin stock in the near oceanic and off shore ranges may exhibit differences in the density of distribution, between areas of a range, but not between adjacent areas of the two ranges. In the case of bigeye tuna, comparison of the hooked rates for all the off shore areas, for a common season (February-April) shows an even density of distribution (approximately 0·25%) for all major areas excluding the north eastern areas 04 and 05 (Table 2). This corresponds with the extremely poor hooked rates for bigeye tuna in the oceanic areas of the same latitude (cf. Fig. 3). Thus, in contrast to the yellowfin, bigeye shows relatively lesser variation between areas of the off shore range but exhibits a significantly lower hooked rate in the off shore range, in comparision to that for the oceanic range.

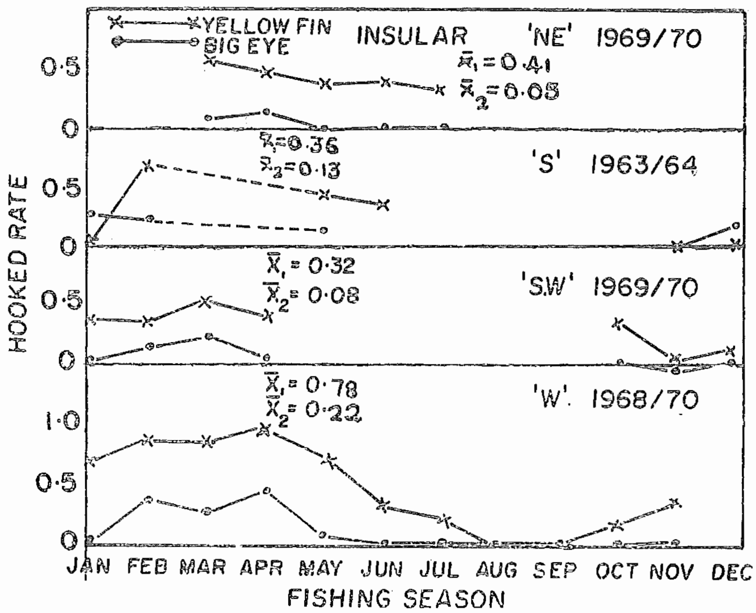

Fig. 4. Seasonal variations in the hooked rates of yellowfin and Bigeye tunas in the inshore areas

TABLE 2

Results of the Longline operations by Tuna vessels "Kalmunai" and "Mirissa" in the off shore range

Area	*Season*	*Set*	*Hooks*	*Bigeye*	*Yellowfin*	*B.B.SW.F*	*St. Marlin*	*Blue M.*	*Black M.*	*Sa.F,Sh. NS.F*	*SK. J*	*Sharks*
0	May 1968	1	1,830	4(0.22)	11(0·60)	..	..	2(0·11)	1(0·05)	..	1(0·05)	12(0·65)
01	December 1968	13	26,004	14(0·05)	229(0·90)	7(0·03)	23(0·09)	..	..	7(0·03)	..	115(0·46)
	March 1969	1	1.932	6(0·31)	20(1·04)	..	..	1(0·05)	..	..	..	12(0·64)
	Sub-Total	14	27,936	20(0·07)	249(0·90)	7(0·03)	23(0·08)	1(0·003)		7(0·03)		127(0·45)
02	April 1967	1	2,076	11(0·53)	13(0·63)	3(0·14)	..	2(0·10)	1(0·05)	2(0·10)	11(0·53)	12(0·55)
	May 1968	2	3,660	12(0·33)		..	..	..	3(0·08)	..	..	6(0·16)
	March 1969	1	2,100	13(0·62)	7(0·33)	..	..	..	1(0·05)	..	..	12(·060)
	April 1969	1	1,734	3(0·17)	9(0·52)	..	6(0·35)	1(0·10)	3(0·17)	..	..	6(0·34)
	August 1969	1	2,076	11(0·53)	13(0·63)	2(0·10)	..	..	2(0·10)	2(0·10)	..	15(0·73)
	February 1970	2	3,600	13(0·36)	21(0·58)	3(0·08)	2(0·06)	..	..	1(0·03)	..	12(0·33)
	February 71	1	2,100	7(0·33)	19(0·90)	..	1(0·05)	..	1(0·05)	..	..	18(0·90)
	March 1971	8	16,775	29(0·17)	281(1·68)	12(0·07)	11(0·07	9(0·05)	7(0·04)	6(0·04)	..	48(0·29)
	Sub Total	17	34,121	99(0·29)	363(1·06)	20(0·06)	29(0·06)	12(0·04)	18(0·05)	11(0·03)	11(0·03)	129(0·38)
03	March 1968	1	2,100	2(0·10)	4(0·19)	..	3(0·14)	1(0·05)	1(0·05)	1(0·05)	2(0·10)	9(0·43)
	May 1968	1	1,800	..	6(0·33)	..	1(0·06)	1(0·06)	2(0·11)	1(0·06)	..	5(0·18)
	June 1968	1	1,800	..	10(0·55)	..	4(0·22)	..	2(0·11)	..	..	20(1·10)
	May 1969	3	6,120	3(0·05)	23(0·38)	1(0·02)	4(0·07)	4(0·07)	4(0·07)	8(0·13)	20(0·33)	20(0·35)
	March 1971	4	8,300	51(0·61)	59(0·71)	5(0·06)	1(0·01)	2(0·02)	..	1(0·01)	..	82(0·99)
	Sub Total	10	20,120	56(0·28)	102(0·51)	6(0·03)	13(0·06)	8(0·04)	9(0·04)	11(0·05)	22(0·11)	136(0·68)
04	June 1968	5	10,800	7(0·06)	229(2·12)	6(0·06)	4(0·04)	..	12(0,11)	20(0·19)	..	45(0·42)
	May 1969	7	14,460	1(0·01)	61(0·42)	9(0·06)	10(0·07)	5(0·03)	13(0·09)	13(0·09)	25(0·11)	27(0·19)
	May 1970	5	11,160	8(0·07)	74(0·66)	1(0·01)	9(0·08)	2(0·02)	6(0·05)	3(0·03)	..	40(0·36)
	March 1971	9	17,625	17(0·10)	411(2,33)	7	16	6	15	18	..	91
	Sub-Total	26	54,045	33(0·06)	775(1·43)	23(0·04)	39(0·07)	13(0·02)	46(0·09)	54(0·10)	25(0·05)	203(0·38)
05	March 71	1	2,000	..	58(0·9)	1(0·05)	2(0·10)	..	..	1(0·05)	..	4(0·20)
	Total	69	140,052	212(0·15)	1,558(1.11)	57(0·04)	97(0·07)	36(0·03)	74(0·05)	83(0·06)	59(0·04)	611(0·44)

The $3\frac{1}{2}$-ton class of vessels in Ceylon is a versatile type of boat used for drift netting, longlining, trolling, handlining and pole and line fishery. Seasonally some of these boats operate tuna longline along the west, south west, south and east coasts. The operation by this class is generally at the edge of the continental shelf or the continental slope. Because of the problems associated with manual hauling and obtaining cheap bait fish, an average of 65 hooks and a maximum of 100 hooks are used in a set. Though the hooked rates determined for such small sets tend to be somewhat like an experimental operation and cannot be compared directly with the commercial scale sets (average 2000 hooks) used in the off shore and oceanic ranges, these values can be indicative of the apparent abundance. The mean hooked rates for the different areas of this range are given in figure 4. The mean hooked rate for the entire range is 0.65% for the yellowfin tuna and 0·16% for the bigeye tuna. However, very good catches (>1%) of yellowfin and bigeye tunas are realised in the north-western region of Ceylon.

There is a well established surface fishery for young and immature yellowfin tuna in the insular belt approximately between fifteen and thirty miles from shore (author 1971) indicating a fair abundance of the surface component of the yellowfin stock around Ceylon. Troll line catches in the off shore and oceanic ranges (Shomura 1966) and length frequency samplings of longline catches clearly indicate that young yellowfin tunas are distributed in the entire off shore and near oceanic ranges but the densities of distribution is unknown. According to the present level of exploitation, the highest catch rates for the surface as well as the deep swimming components of the yellowfin stock close to Ceylon, are being realised around the north western-region. The bigeye tuna contributes very little to the surface fishery. The abundance of surface swimming yellowfin in the inshore areas, are relatively poor but seasonal and localised migrations from the offshore into the inshore waters, results in sporadic increases in the catch rates in some areas of the inshore range. There is a very significant difference in the densities of distribution of yellowfin and other tuna and tuna like varieties in the areas of the inshore range exploited by the traditional craft (mechanised and non-mechanised) and the $3\frac{1}{2}$-ton class of mechanised vessels (author 1965). De Bruin (1970) has expressed the view that the position has changed in recent years due to the introduction of drift nets, but this appears to be based entirely on the catches made by a class of vessel larger in size (11-Ton) and fishing in the off shore range, well beyond the belt covered by the smaller craft and vessels mentioned above. Further, grouping of all varieties of tuna and tuna like fishes, with varying life histories and ecology, tends to reduce the significance of the differences in their densities of distribution and added to this, it so happens that geographical variation of these varieties in the off shore range are compensatory which almost nullifies the differences in the geographical variation of the grouped value and creates an even distribution, as realised by De Bruin (1970), among the areas ; North-west, West, South-west, and South.

The apparent abundance of deep swimming bigeye tuna declined significantly from the oceanic to the offshore and the inshore ranges. The surface component of the yellowfin tuna showed high density of distribution in the areas of the higher latitudes in the off shore range, declining towards the inshore, while the deep swimming component showed insignificant geographical variation between ranges.

(*b*) Seasonal Variation

In the inshore troll fishery, noticeable catches of surface swimming yellowfin tuna are made during the tail of the south-west monsoon and also during the north-east monsoon. The catches are predominantly first entry groups, in the south-west and east coast areas. Except for these, inshore surface catches may be considered sporadic. The drift net fishery for yellowfin in the off shore range exploited (approximately between 15 and 30 miles), indicate good catches for the east coast during the north-east monsoon and the inter-monsoon period following it; in the south, south-west, and west areas during the south-west monsoon and in the north-west during the north-east monsoon (author 1970).

When tuna longlining was commenced by Japan, in the oceanic range under consideration, operations were conducted during all months of the year but after 1966, fishery within the Bay of Bengal and the Arabia Sea have been limited to the 1st and 2nd and 4th quarters. Even the vessels from Ceylon have been limiting their operation in these seas to the same seasons. The hooked rates for yellowfin tuna in all six areas of the Oceanic range tend to be relatively high during the 1st quarter and the first half of the 2nd quarter (Figure 4). In the areas close to the equator, particularly on the eastern side (N 4), the hooked rate does not decline rapidly at the end of the 2nd quarter. Nakagome (1959) working on the hooked rates of yellowfin tuna in the Bay of Bengal and Arabia sea observed highest hooked rates between March and May and lowest values during the July to September. Though hooked rates have declined significantly since then, the trends observed for the major areas of the Bay of Bengal and the Arabian sea, at the begining of the fishery, appears to remain established even now and for the oceanic range close to Ceylon as well.

In the offshore range, only a small number of operations have been conducted and that too during few months of each year. Hence a clear picture of the seasonal variation in the hooked rate of yellowfin tuna in this range, could not be determined. However, the trends observed for the oceanic range appears to be applicable here too.

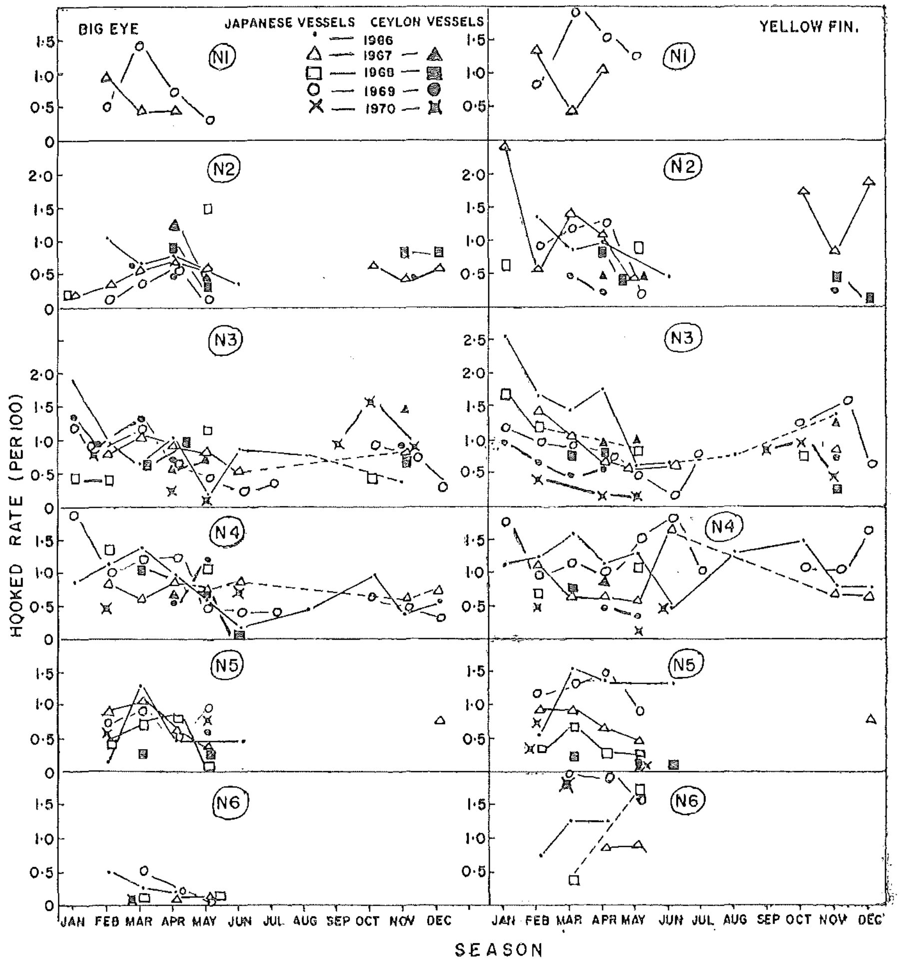

Fig. 5. Seasonal variation in the hooked rates of Bigeye and yellowfin tunas in the areas of the oceanic range

Local fishermen concentrate on tuna longlining mainly from November to May. Rest of the year, this method of fishing may be attempted only incidentally. The hooked rates of yellowfin tuna, realised from the sampling of the landings show that the seasonal variation in the hooked rates in the inshore range is similar to that of the oceanic range and that the local fishermen have made the correct choice of the season for longlining (Figure 5). Similarity in the seasonal variation in the hooked rates of yellofin tuna in oceanic and inshore ranges also adds support to the conjecture in respect of the offshore range.

Seasonal variation in the hooked rates of bigeye tuna show high values during the 1st and 2nd quarter, in the oceanic (Figure 4*a*) and even the inshore range (Figure 5). In the inshore range the hooked rate of bigeye tuna declines so very rapidly that this fish is almost absent in the catches during the rest of the year. Nakagome (1959) and Sakamote (1967) have shown that bigeye tuna catches is the ocean range north of equator, were high between March and May and low during June to August. In the inshore range, best catches of bigeye tuna are made off the west coast during March and April. Good catches of sharks such as *S. zygaena*, *Alopias superciliosus* and *Isurus oxyrhincus* appear to coincide with the bigeye tuna season. Author's report of S. zygaena from Ceylon waters (1969) was considered a misidentification by De Bruin (1970) who appears to have based his assumption on a generalised statement by Gilbert (1965) that S. zygaena is antitropical in distribution ; rather than on field observation. The author's identification has been confirmed.

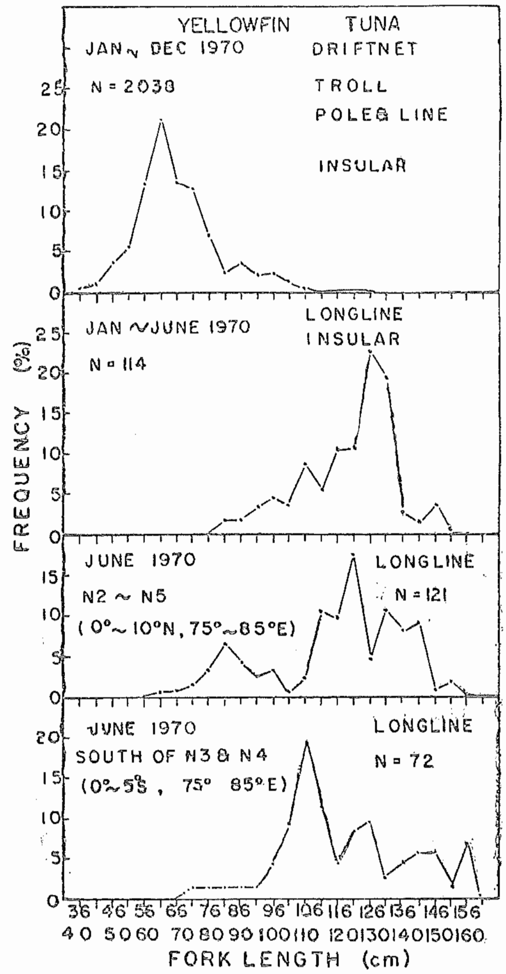

Fig. 6. Length frequency distributions of yellowfin tuna in the surface and deepswimming layers of the insular and oceanic ranges

Though there are differences in the densities of distribution between ranges, seasonal variation in these values for both Yellowfin and bigeye tunas appear to be similar.

Size Composition

The yellowfin tuna entering the surface fishery around Ceylon is mainly the second year fish with small proportions of the first year and third year fish. The modal size group is 61–65 cm. (Figure 6). The longline fishery in the inshore range, catches substantially the third and fourth year fish though smaller proportion of second year yellowfin is caught in the west and south-west areas.

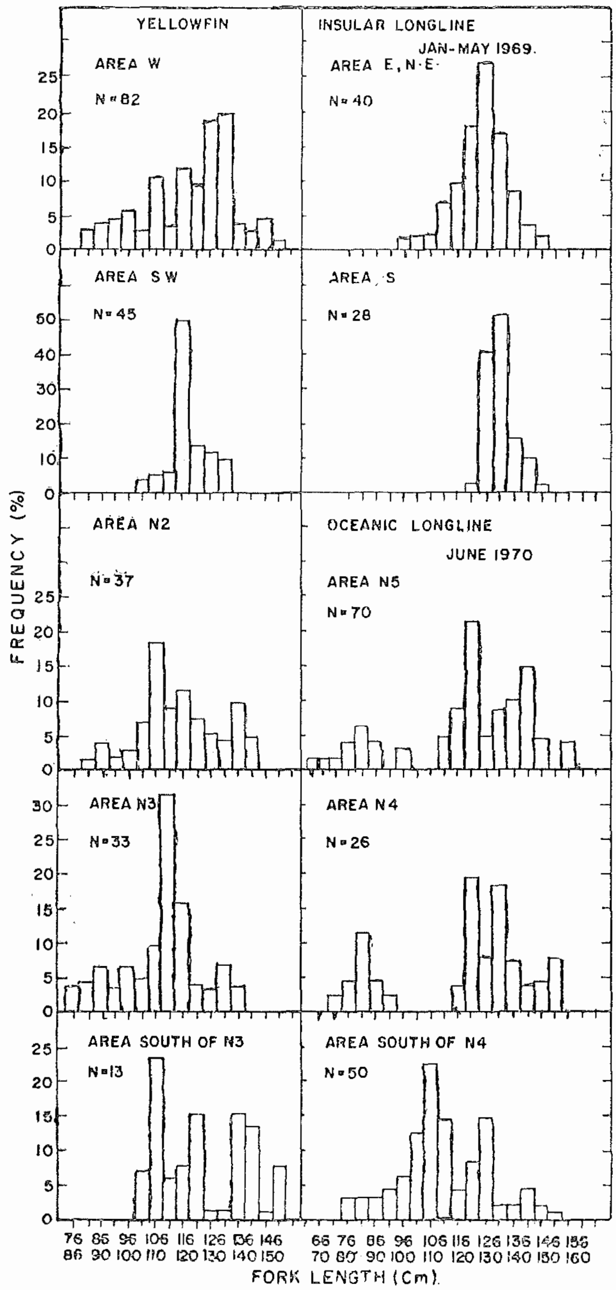

Fig. 7. Length frequency distributions for yellowfin tuna caught by longline in the different oceanic areas and insular range

(Figure 7). Considering the fact that heavy recruitment to the surface fishery around Ceylon occurs round about June, length frequency samplings of the oceanic longline catches during this period, were also examined. This indicated the entry of second year fish into the longline catches in the oceanic range (Figure 7). Poor catches of the third year yellowfins were made in the eastern ocean areas (N 4 and N 5) while this same group formed the modal size in the catches from the area south of N 4 (below the equator). Further the modal length groups in the catches from the eastern side was 121–125 cm as against 106–120 cm for the corresponding areas on the western side. Considering on the basis of the ranges, longline catches from the inshore, oceanic areas north of the equator and those south of the equator, the modal length groups observed were 126–130 cm. 121–125 cm and 106–110 cm, respectively (Figure 6). Significant quantities of second year yellowfin were also caught in the oceanic range, indicating the availability of yound and immature yellowfin in the oceanic range as well. Occurrence of the second and third year fish in the surface and longline fisheries indicate their distribution throughout the mixed layer between the surface and the thermocline.

The size range of bigeye tuna caught in the inshore longline fishery is 100–180 cm with modal length groups at 146–150 cm and 166–170 cm (Figure 8). The operation in June 1970 indicates that in

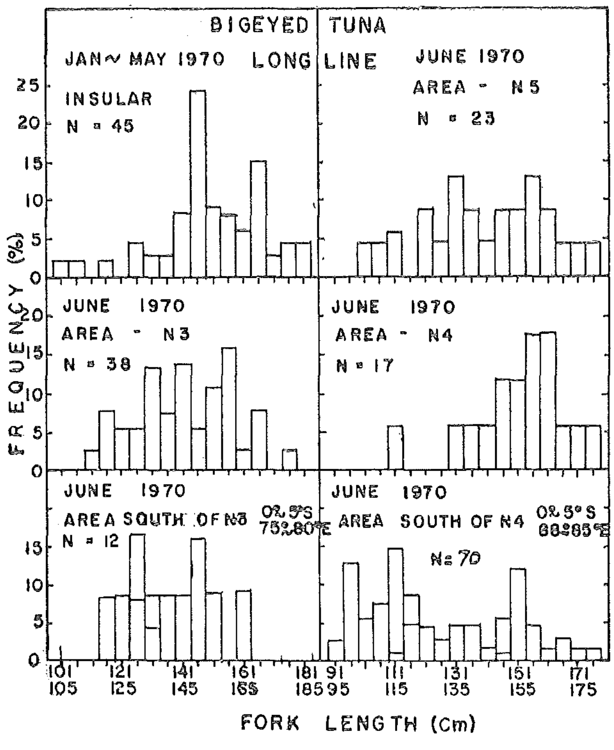

Fig. 8. Length frequency distributions for Bigeye tuna caught by longline in the insular and oceanic areas

the eastern side of the range the proportion of older fish (155–165 cm) was higher for the areas north of the equator (N 4) while a very high proportion of younger fish (90–120 cm) were caught in the areas south of the equator (South of N 4). The proportion of younger bigeye in the longline catches tends to be greater in the south-eastern part of the equatorial belt and lesser in the higher latitudes including the insular waters around Ceylon. However, deviation from these patterns of size compositions should be expected because some year classes are fully recruited at a smaller size than other year classes entering the surface and longline fisheries, in substantial abundance during the third quarter and during the first and second quarter, respectively. The longline fishery in these ranges appear to be sustained chiefly by yellowfin in their third and fourth years and bigeye tunas in their fourth and fifth years. Entry of age groups relatively younger than these has been reduced probably due to the selective power of the gear and that of relatively older fish has been reduced partly due to heavy mortality as evidenced from the beginning of longline fishery in the Indian Ocean (Mimura 1958) and partly due to differential geographical distributions of different sizes or differential catchability in the different areas under consideration.

In the oceanic and inshore ranges, little over 70% of the yellowfins and 80% of the bigeye tunas, caught by longline were males. (Mimura 1962) has shown that male yellowfin form very large proportion of the catches in the higher latitudes of the north but this declines towards the higher latitudes of south where the ratio becomes reversed.

Migration

Studies on the morphometrics of yellowfin tuna in the Indian Ocean (Hirano and Tagawa, 1956 ; Kurogane and Hiyama 1958 ; Nakagome 1958 ; Kurogane 1960) and geographical variation in the hooked rate (Mimura 1958), suggest the existence of semi-independent yellowfin tuna population with highly localised migrations. The larvae of this tuna have been found widely distributed in the equatorial belt (Uveynagi 1969). There is also a tendency for the longline catches of yellowfin in the equatorial belt, to show a decreasing proportion of smaller fish, from west to east upto about 80° E beyond which there is again a greater proportion of smaller fish (Figure 9*a*).

In the light of the findings in the equatorial Pacific (Suda and Schaefer 1956, and Suda, Kume Sheohama 1969) the above size distribution pattern may have been contributed partly by differential availability, differential catchability of different sizes in different areas in relation to the depth of the mixed layer and partly by localised migrations. The population structure of yellowfin tuna in the Indian ocean is still not clear enough to demarkate the area for any sub population. F. A. O. group of experts on tuna stock assessment have considered the catch and effort data for the region 40°–70° E, 70°–100° E and 100°—130° E, separately (1968) and as the ranges under consideration are well within the central region, it is very possible that we are dealing with a single sub population.

According to the seasonal variation of the hooked rates for yellowfin and bigeye tuna in the main areas of the Bay of Bengal and Arabian Sea (Nakagome 1959, Sakamote 1966, 1967) and the same fort he ranges close to Ceylon, there is a very strong possibility of a latitudinal migratory movement. As the larval stages appearing widely in the equatorial belt have heavier concentration south-west of Ceylon and the percentage of small and medium sized yellowfin are relatively greater on the same side (Figure 9*a*), recruitment to the stock in the ranges under consideration may also be from this region. The young yellowfin entering the insular waters of Ceylon each year would have been spawned during the 1st or 2nd quarter of the preceeding year and size composition of the yellowfin caught in the surface fishery (author 1971) indicate that these young fish remain in the insular surface habitat for at least one year during which period they may shift northwards but within the insular range. In their third year they may spread out into the deep swimming layer and become available to the longline catches in these ranges. The size composition of the catches from the surface and longline fisheries indicate that both methods are not operating on completely different size components of these stock. However, larger yellowfin will be more prevalent in the deepswimming layers.

In the case of the bigeye tuna, young fish appears to be greater in the longline catches from the south-eastern region (Figure 9*b*). Suda and others (1969) have attributed size and catch distribution pattern in the Indian ocean, partly, to the geographical variation in the depth of the permanent thermocline. Younger or immature bigeye tuna is seldom caught in the surface fishery but occasionally, large bigeye tunas (> 160 cm) have been found in the drift net catches during

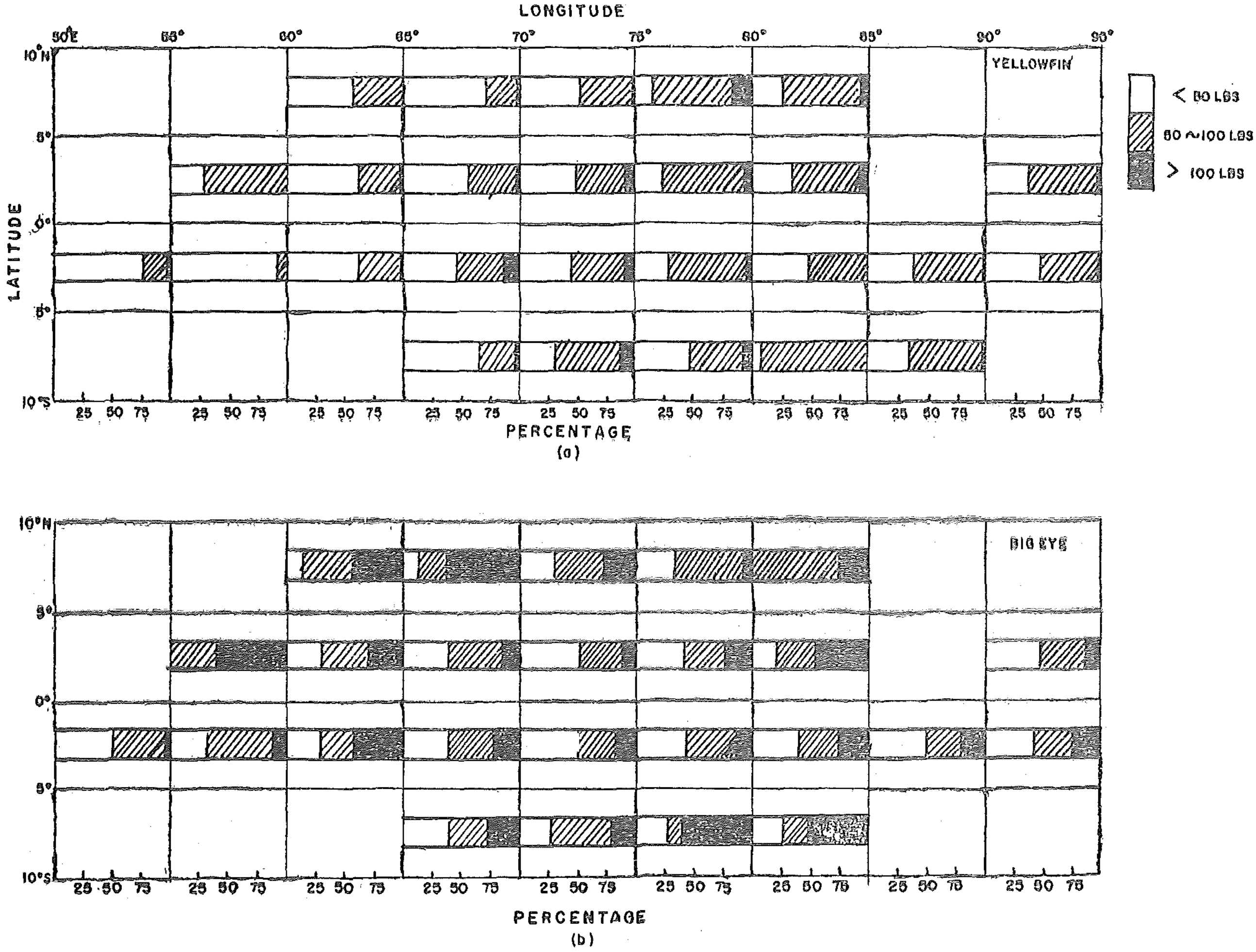

Fig. 9. Percentage composition by weight of Yellowfin and Bigeye tunas caught in different areas of the Indian Ocean.

April–May. Sakamoto (1957) reports that this species is mainly located in the eastern half of the Indian ocean during the fourth quarter, shifting into the western half by the middle of the following year and scatter over a wide area during the third quarter. On the basis of this finding and the size distribution given above, its appears that the good fishery in the ranges around Ceylon coincides with the movement from the east to the west.

Trends in relation to fishing effort

Until 1967 the surface component of the yellowfin tuna in the inshore waters had been contributing under two thousand tons per annum chiefly trolling, and to a lesser extend by Pole and line and Drift net methods. Since 1967, introduction of 11-ton class vessels for operating drift nets in the off shore range, has indirectly encouraged the $3\frac{1}{2}$-ton class of vessel also to operate drift net for tunas in the fringes of the offshore range, thus resulting in the substantial increase in the production of yellowfin tuna to the level of four thousand tons per annum and without significant increase in the strength of the fleet. The annual variation in the catch per unit of effort has not indicated definite tendencies to decline and further increase in production of this surface yellowfin resources may be expected if the entire off shore range is exploited.

The longline catches of yellowfin tuna in the inshore, offshore and near oceanic ranges have declined significantly from a mean hooked rate of about 5% to the present level of a little over 1%.

The effort (by Japan and Ceylon only) and the catch per unit of effort in the oceanic range over the last seven years (1964–1970) are shown in figure 10. The effort applied in each area of the oceanic range shows wide annual fluctuation and this is greater in the areas of the higher latitudes The hooked rates of yellowfin tunas also has been fluctuating with definite declining trends only in the areas closer to the equator. In the higher latitudinal areas (N 1 and N 6) there is evidence of improvement in the hooked rates, particularly in area N 6 in the Bay of Bengal. The yellowfin hooked rates in the mid-latitudinal areas (N 2 and N 5) exhibit rather an intermediate condition. With the decline in the abundance of the older fish and the dependance of the longline fishery on the third year fish as its significant first entry group, a very large annual variation in the abundance of this relatively young age group, which may not always be at a depth vulnerable to the longline fishery, should be expected.

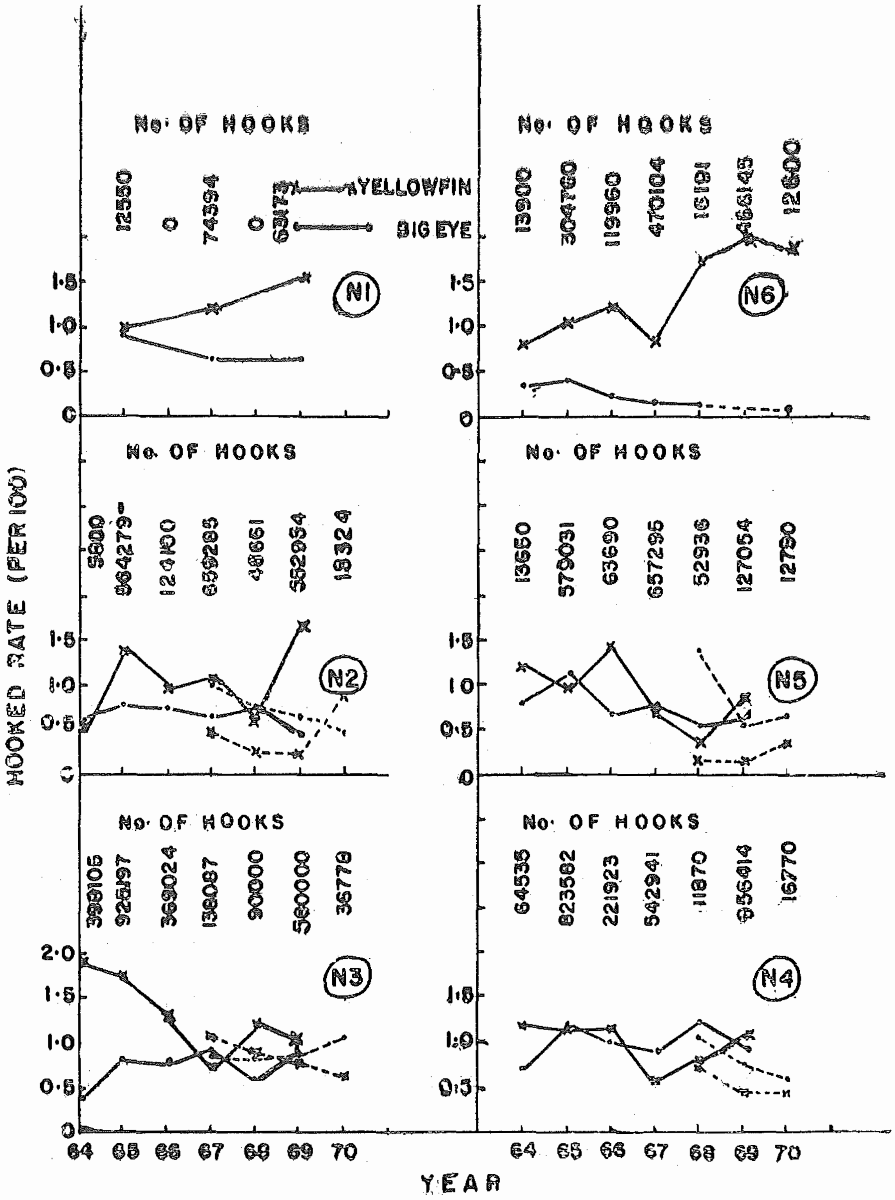

Fig. 10. Annual variations in the effort and hooked rates for Yellowfin and Bigeye tunas in the oceanic areas. (Complete line for Japan and incomplete lines for Ceylon).

The deep swimming component of the yellowfin tuna in the inshore and off shore areas presently exploited by surface fisheries, is not intensively fished by Ceylon and the size composition of the catches indicate the presence of relatively large proportions of the 4th year group. However, it is suspected that other nations may be operating in the offshore range at least during the good season. Suda (1970) estimated that a surface catch of 10,000 tons of yellowfin tuna in the Atlantic, diminishes about 14% of the recruitment to the longline fishery. The longline catches of older fish (3–5 years) in the insular waters, by Ceylon, is very small (about 200 tons) compared to the production of younger yellowfins (1–3 years) from the surface (about 4,000 tons) that in terms of number of fish caught, the former component becomes relatively negligible. As such it is rather difficult at present to evaluate the impact of the steadily growing surface yellowfin fishery, on the recruitment to the longline fishery in these ranges.

The hooked rates of bigeye tuna in these ranges, show relatively lesser variations and appears to remain in a steady state, in the relatively abundant areas (N 2 to N 5). According to figures 4 and 10, Ceylon vessels show a relatively higher hooked rate for bigeye tuna and relatively lower value for yellowfin tuna in some areas of these ranges, when compared with those values for the Japanese vessels. This has been attributed to the fishing gear used by Ceylon vessels. Until recently, these vessels have been operating six hooks-baskets with corresponding increase in the length of the mainline. This results in the increase of fishing depth without altering the denseness of hooks and this contributes to an increase in hooks rate for bigeye tuna and not for yellowfin (author 1963, Suda 1969).

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