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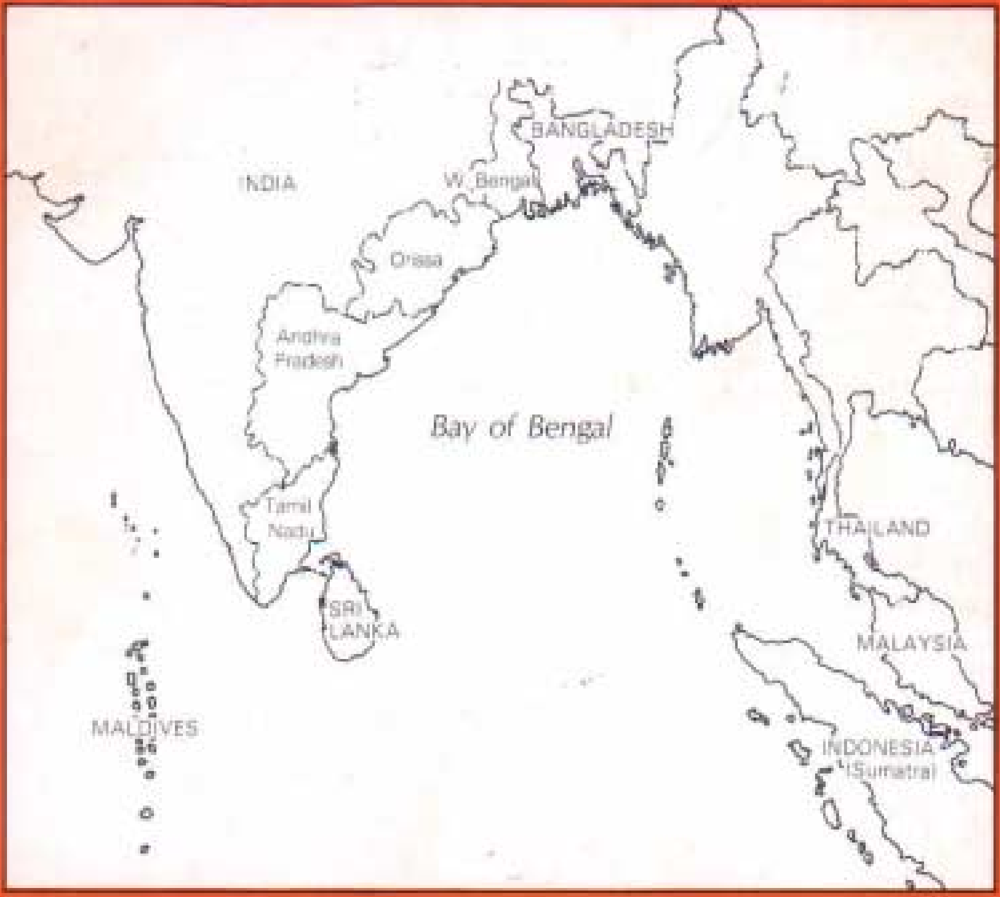
BOBP/REP/41

Marine Fishery Resources Management

RAS/81/051

Studies of the Tuna Resource in the EEZs of Maldives & Sri Lanka



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BAY OF BENGAL PROGRAMME BOBP/REP/41
Marine Fishery Resources Management (RAS/81/051)

STUDIES OF THE TUNA RESOURCE IN THE EEZs OF SRI LANKA AND MALDIVES

Executing Agency :

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Tuna are an important fishery resource in the exclusive economic zones of Maldives and Sri Lanka. In June 1984, a working group comprising representatives from the two countries met in Sri Lanka to take stock of available knowledge on tuna, identify gaps in that knowledge and evolve a workplan to fill the gaps. These were summarized in BOBP/WP/31.

The present report covers later investigations and updates knowledge on the tuna resources in the EEZs of Maldives and Sri Lanka. During this work, the working group met in Male, Maldives (October 1985) and in Colombo, Sri Lanka (September 1986). These meetings discussed the sampling programmes conducted by Maldives and Sri Lanka.

This report, as well as the meetings of the tuna working group and the sampling programme were sponsored by the "Marine Fishery Resources Management" component (RAS/81/051) of the Bay of Bengal Programme (BOBP). The project commenced January 1983 and terminated in December 1986. It was funded by the UNDP (United Nations Development Programme). Its immediate objective was to improve the practice of fishery resources assessment among participating countries (Bangladesh, Sri Lanka, Maldives, Malaysia, Thailand, Indonesia) and to stimulate and assist in joint management activities among countries sharing fish stocks.

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SUMMARY

This report summarizes available knowledge on the status of tuna stocks in the exclusive economic zones (EEZs) of Maldives and Sri Lanka.

In Sri Lanka, motorized craft account for the bulk of the tuna catch. Gillnets are the most important fishing gear, and contributions by other gears like troll line, pole and line and longline have declined considerably. The total tuna production was 25,132 t in 1985, down from 34,100 t in 1982. The decline is attributed to civil disturbances.

In Maldives, motorized pole and line craft (masdhonis) account for most of the tuna landings, which were 53,700 t in 1985, 18% more than in 1984. Skipjack tuna catches increased from 13,824 t in 1978 to 42,602 t in 1985, but yellowfin catches fluctuated between 4,000 and 7,000 t in the same period.

Skipjack catch rates in the Maldives have declined in areas of traditionally high catch rates but have increased in other areas. Catch rates of non-motorized craft have gone down considerably. while those of motorized craft have increased. In Sri Lanka, catch rates are high in the south and south-west and decline northward to the north-west coast. The catch.rates for yellowfin increase from the south-west to both the north-west and the southern coasts in Sri Lanka but there are no definite trends in annual variations. In the Maldives, the highest catch rates are found in the north-west. In general, catch rates for yellowfin are higher on the west coast than on the east coast of Maldives.

The peak catch rate season for skipjack on the east coast of Maldives is during the north-east monsoon and that on the west coast is during the south-west monsoon. In Sri Lanka, the peak season for the gillnet fishery on the south and west coasts is the south-west monsoon.

As far as yellowfin tuna is concerned, no noticeable trend was visible in those strata of Maldives where low catch rates are the norm. On the eastern side, the peak season is during the north-east monsoon and on the western side, during the south-west monsoon. On the west and south coasts of Sri Lanka, no seasonal shifts in catch rates were observed.

The catch per man-day in the pole and line fishery has been calculated on a standardized basis for both Sri Lanka and Maldives. The values for Maldives are uniformly higher than corresponding values for Sri Lanka. One reason for this could be bait limitations in Sri Lanka.

In Sri Lanka, the selectivity of the predominant gear (gillnet) influences the length frequency distributions of skipjack tuna. In the Maldives, modal progression is poor even in pole and line catches. This could be due to continuous movement of age-specific fish through the areas under study. No movement patterns for skipjack could be determined for the two countries in the absence of sufficient data. In the case of yellowfin too, insufficiency of data precludes any but tentative conclusions.

Growth constant and asymptotic length were calculated for skipjack, yellowfin, eastern little tuna and frigate tuna. For skipjack, the growth constant (K) is in the range 0.41-0.44 and the asymptotic length 76-79 cm. For yellowfin, the corresponding values are 0.36-0.40 and 173-175 cm, respectively.

Skipjack catches in the Maldives consisted predominantly of males in the size ranges 40-45 cm and 65-70 cm. Intermediate size ranges showed 48% males in the 50-55 cm range and 52% males in the 55-65 cm range. Sri Lankan trends were similar. In the surface tuna fishery of Sri Lanka, yellowfin catches showed a predominance of females in size groups less than 100 cm. No trends were available for the Maldives.

Two spawnings, one between October and March and another between May and October, are indicated for skipjack in Sri Lanka. It is difficult to define any such seasons in the Maldives due

to paucity of data. No conclusions can be drawn regarding yellowfin. Due to discrepancies in the methods of taking linear measurements, comparison of morphometric characteristics of the tuna caught off Sri Lanka and Maldives remains inconclusive.

In Sri Lanka and Maldives, two annual recruitments of skipjack tuna are postulated. In the former, these occur during January-February and June-August; in the latter, during December-January and March-April. As for yellowfin, two recruitments in Sri Lanka, during November-March and July-September, are postulated. No conclusions on yellowfin in the Maldives are possible.

Stock identities continue to be problematic. In the case of skipjack tuna, recruitments to the Sri Lankan and Maldive fisheries could be from a single stock or different stocks. No firm conclusion is possible at this stage.

It appears that skipjack tuna are being exploited at the optimum level in the Maldives and perhaps slightly in excess of this level in Sri Lanka, in areas currently exploited. There would appear to be scope for expansion of the skipjack fishery in areas of the respective EEZs that are currently not exploited. Skipjack tuna is a highly migratory species and its stock in the Indian Ocean is estimated to be considerable. Over-exploitation of this species may not therefore be imminent. But there seems to be no justification for complacency on yellowfin tuna, as this species is relatively less prevalent in the Indian Ocean. The need for an international scheme of managementfor Indian Ocean tuna, which gives due weight to the rights and requirements of traditional fishermen, cannot be over-emphasized.

1. INTRODUCTION

One of the activities identified by participating countries to assist and support the FAO/UNDP project "Marine Fishery Resources Management in the Bay of Bengal" (RAS/81/051) was a study of tuna in the adjacent EEZs of Maldives Sri Lanka and India. A working group of fishery biologists from Maldives and Sri Lanka was established in 1984. India decided not to participate. The first meeting of this group was held in June 1984 in Sri Lanka to evaluate the information available, to identify the information to **be** collected and to agree on a work plan for obtaining the required data and information. The results were published in 1985 (BOBP/WP/31).

Consequently, a sampling programme was conducted by the two countries from July 1984 until August 1986 with technical and financial support from the project. Sampling for catch and effort was done according to fishing craft and gear, length frequencies, sex ratio, gonad maturity and morphometric characteristics of the tuna species. In the case of Sri Lanka, samplings were done on a monthly basis with a systematic duration of four days per month at each sampling station. The areas covered were the entire west, south-west and south coasts of the country. In Maldives, catch and effort data, collected on a total enumeration basis, were used and sampling for biological characteristics was conducted in a few selected islands. More details are available in BOBP/WP/31.

The second and third meetings of the working group were held in October 1985 (Male, Maldives), and September 1986 (Colombo, Sri Lanka), to evaluate the progress made and to discuss the findings. The present report summarizes the findings from these two meetings. The list of participants of the two meetings is found in the Appendix, while the materials presented at the working group are incorporated in the Annexures.

2. FISHERIES-GENERAL TRENDS

In Sri Lanka, motorized craft contribute the bulk of the tuna catch : some 2,700 of the 28' (3.5 GRT) class and 77 of the 32'-34' class. In addition, there are a number of outboard engine craft and non-motorized traditional craft engaged in fishing for smaller varieties of tuna in the inshore waters. Of the four primary methods of tuna fishing, troll line, pole and line and even longline have declined steadily. Gillnet fishing has expanded and now not only compensates for the decline in production by the first three methods, but has actually pushed up production to a higher level.

Craft of 3.5 GRT are shifting from one-day fishing to trips of two to three days and the fishing is expanding offshore. Some craft now carry ice. It is observed that fishermen operating drift gillnets have started using longlines as a second gear.

Pole and line fishing operations were more more successful in 1985 than in the previous years, probably because of the availability of baitfish. There are no non-motorized craft in this fishery at present.

The range of mesh sizes in the nets and the number of panels per set have changed over the years. In 1982/83, 4-6 inch mesh sizes (stretched mesh) were popular, but during 1985-86 it appeared that 5-6 inch mesh sizes were used more frequently. This factor has to be borne in mind when comparing changes in catch rates over the years. The number of panels in each set of drift gillnets varies from 15 to 44 and the mesh sizes range between 3 and 7 inches. The popular ranges are 25-35 panels and 4.75" to 6" mesh.

Bait for longline and the pole and line fishery has become a limiting factor. In spite of the successful findings from bait surveys, no expansion of the pole and line fishery has taken place outside the traditional areas, The purse seine fishery for small pelagics catches live bait fish varieties also, but these are not being used by pole and line fishermen.

There is a slow but steady increase in the duration of fishing trips by the 11 m class of tuna fishing boats introduced recently, and the fishing grounds are extending further offshore. The 3.5 GRT boats are also gradually extending their fishing grounds further off the coast.

In the Sri Lankan tuna fishery, 87% of the production is contributed by inboard engine craft, 9% by outboard engine craft and 4% by non-motorized craft. Gillnets contributed 70%,trolling lines 20%,pole and line 6%. and longlines 4% of the total tuna landings in 1985/86.

The combination of gillnet and longline has become popular in the west coast of Sri Lanka; it is also spreading to the south.

There are differences (table below) in the production figures estimated by NARA and the Ministry of Fisheries.

		NARA	Ministry
(Figures for west 8 south coasts only. In tonnes)			
Skipjack	1983	6,115	10,01 5
	1984	6,689	7,472
	1985	9,408	not availabie
Yellowfin	1983	5,015	6,812
	1984	5,889	5,050
	1985	6,047	not available
Small tuna	1983	3,800	7,527
	1984	1,825	5,008
	1985	2,875	not available

The Ministry estimated total tuna landings at 22,400 t in 1979, at 34,100 t in 1982 and at 25,132 t in 1985. The decline in recent years is attributed mostly to the civil disturbances in the country.

Between 1983 and 1985, skipjack production increased significantly but not yellowfin production. The production of small tuna fluctuated considerably. The bulk of production came from 3.5 GRT class vessels in 1985.

In the Maldives, two types of craft primarily engage in tuna fishing. These are the pole and line craft or masdhonis (motorized and sailing) and trolling craft or vadudhonis (non-motorized). Their sizes range from 8 to 12 m in length. It was noted that the pattern of fishing by sailing masdhonis has changed since motorization. Motorized masdhonis have replaced sailing masdhonis on the pole and line fishing grounds outside the atolls. In 1985, there were 3,115 vadudhonis, 1,327 motorized masdhonis and 561 sailing masdhonis. Between 6 and 12 poles are used by the crew of the masdhonis.

Several non-motorized pole and line craft appear to have been sold to the private sector engaged in the tourist trade and in quarrying coral for construction purposes. At present the Ra and Baa atolls in the north and the atolls south of Male have most of the motorized craft. A licensing system has been introduced to permit local craft to operate within 75 miles and joint ventures outside this limit. One local company is likely to start operating longlines beyond the 75 mile limit and within 200 nautical miles. The problem in monitoring the fishery outside the 75 mile limit is a matter of concern to the Maldives government.

A slightly higher number of motorized craft was reported in the south, which is a good area for skipjack, and probably contributed to increased skipjack production. As far as the trolling craft are concerned, the number of days operated and the total catch have not changed in spite of the motorization programme.

Tuna species form 87% of the total catch in the Maldives. In 1985, the tuna catch was 53,700 t, a figure higher than the 1984 catch by 18%. Skipjack catches showed a significant annual increase from 13,824 t in 1978 to 42,602 t in 1985, but yellowfin catches have fluctuated between 4,000 and 7,000 t in the same period.

In the first half of 1986, 9,100 t of frozen tuna, 800 t of dried skipjack, 2,100 t of salted dry tuna, and 160 t canned tuna were exported, representing a total of 20,000 t fresh weight. (Conversion factors are 1, 5, 3, and 3.6 respectively.)

Improvement in data collection is being attempted with the recruitment of new field officers. Dogtooth tuna catches have been included in the catch statistics forms since 1985. The catch statistics reporting system is being reorganised so that data sheets can be obtained directly from the island chiefs, instead of through atoll chiefs.

The following ***catch composition*** is reported for Maldives and Sri Lanka (in %) :

	Gillnet	Pole and line	Trolling line
Sri Lanka			
Skipjack	86	8	6
Yellowfin	96	1	3
Small tunas	51	5	44
Maldives			
Tuna	—	95	5

In the ***Ma/dives,*** the ***species composition*** landings is (in %) :

	Skipjack	Yellowfin	Small tuna
1984	73	16	11
1985	79	12	9

In ***Sri Lanka*** some variations in the ***species composition*** of the landings have been noticed in recent years (in %).

	Skipjack	Yellowfin	Small Tuna
1983	41	34	25
1984	46	41	13
1985	51	33	16

In the absence of seasonal migration of tuna fishing craft to the east coast, the annual effort on the west coast has increased. A significant increase was noted in the cases of trolling and pole and line fisheries (60%) but not in the driftnet fishery. There is also an increase in single hook trolling for yellowfin tuna in the sub-surface layer. The composition of pole and line fishery in Sri Lanka is 80% skipjack, 1% yellowfin tuna and 9% small tunas.

Pole and line and troll catch compositions are quite similar in both countries but the gillnet fishery in Sri Lanka exhibits a different composition due to the selectivity of the gear.

North of the study area, the composition of species in the ***tuna production of India is*** significantly different (in %).

	1981/82	***1982/83***
E. affinis	62	50
Auxis spp.	8	9
T. tonggol	***0***	***0***
K. pelamis	12	10
Other spp.	14	21
Billfish	4	10

In the Minicoy-Laccadive *Islands,* where a pole and line fishery predominates, the composition is 76% skipjack and 24% of other species including yellowfin. Off the mainland of India, tuna are caught primarily by gillnets. On the east coast of India Euthynnus *affinis* and Auxis *thazard* are the predominant species in the catches, which are mainly from inshore waters. Recent experimental gillnetting in the offshore waters off Uppada (Andhra Pradesh, India) by BOBP, using beachlanding craft, indicated an abundance of skipjack and yellowfin tuna (BOBP/WP/56).

South of the equator and *around Seychelles,* yellowfin is predominant in the purse seine catches from November to July. Skipjack exceeds yellowfin catches only from August to October.

3. CATCH RATES

Skipjack

The southern waters of Maldives (Strata III +VI) (see map in Annexure 1) which usually exhibit the highest catch rates, showed a decline in 1983. In other strata, where catch rates are usually relatively poor, they showed an increase. Hence, a feature of 1983 production would be heavy contribution by the strata with lower catch rates. The phenomenon concerns small-sized skipjack, which is the major contributor to the production; but large-sized skipjack show increased catch rates in Strata III and VI.

There appears to be a significant decline in the catch rates of the non-motorized craft, between the period of purely non-motorized craft (1971) and complete motorization of craft (1985) On the other hand, it is evident from statistics available that the motorized craft catch rate has increased. However, the limited earnings from pole and line operations have encouraged shark longlining and reef fish fishery as supplementary operations.

Non-motorized			Motorized		
1971	170	kg/boat/day	1979	216	kg/boat/day
1985	35	kg/boat/day	1985	258	kg/boat/day

Around Sri Lanka, catch rates are high in the south and south-west, and decrease northwards to the north-west coast. No significant variations were evident between 1983 and 1984 but these rates are significantly less than those of 1967-1971.

An upward trend may be seen for skipjack on the west coast of Sri Lanka. The catch rate for the species was significantly higher from January to June 1986 than for the same period in 1985.

1983	33.9	kg/boat/day
1984	38.3	kg/boat/day
1985	46.4	kg/boat/day

Yellowfin

In the Maldives, the highest catch rate is in the north-west (Stratum IV) with a very significant increase from Stratum VI to Stratum IV. The catch rates are higher on the west coast than on the east coast but they increase in the same direction on both sides. Catch rates in Stratum I, which is in the north-east are less than 50% of that in Stratum IV. The annual increase in catch rate was higher in Strata IV and V during 1982/83 (see Annexure 2 for details).

The catch rate for yellowfin is relatively low off the south-west coast but is higher both off the north-west coast and also off the southern coast in Sri Lanka.

On the west coast of Sri Lanka, yellowfin catch rates do not indicate any definite trend in the annual variations. No significant difference was evident in the catch rate from January to June 1985 and 1986.

1983	24.1	kg/boat/day
1984	35.7	kg/boat/day
1985	32.5	kg/boat/day

4 . SEASONALITY

Skipjack

The peak catch rate seasons are as presented in Table 1 below:

Table 1

Peak fishing seasons of skipjack tuna in Sri Lanka and the Maldives

Sri Lanka	Year	Season	Gear
	1983	May-Aug	
	1984	Jan-March	Pole and line, gillnet
		June-Oct	Gillnet

Maldives	*1980*		**1981**	
	Small skipjack	Large skipjack	Small skipjack	Large skipjack
Stratum I	Nov-Jan	Oct-Dec	Nov-April	Oct-April
Stratum II	Nov-Feb	NC	Oct-Feb	NC
	May-Aug		**May-Sep**	
Stratum III	Nov-Mar	May	**May-Aug**	**NC**
	Jun-Aug		Sept-Dec	
	Nov-Feb	Jan-Mar	Jul-Sept	
Stratum V	May-Aug	April	**May-Sept**	**NC**
Stratum VI	Jan-April	Feb-April	June-Sept	Nov, Jan-May
	Aug-Ott	Dec		June

NC — Not well defined

The peak catch rate season in the strata on the west coast of Maldives is mainly during the south-west monsoon; on the east coast strata it is mainly during the north-east monsoon, for small skipjack. Larger-sized skipjack tend to show better catch rates more often during the north-east monsoon, in most strata, on both the east and west sides.

In Sri Lanka, the south-west monsoon is the peak season for gillnet fishery on the west and south coasts. It is primarily larger-size skipjack that tend to appear during the rest of the year.

Peak seasons in Minicoy Islands (India) have been reported to be in November and February-April, as in the case of Maldivian and Sri Lankan pole and line fisheries.

The peak season for the purse seine fishery around Seychelles has been reported to be March/April in 1981/82 and October/November in 1983/84 and 1984/85. It is noted that during March/April, yellowfin tuna dominates the purse seine catches and skipjack does so during October/November. Skipjack may have dominated the fishery in the last two years and shifted the peak seasons.

Yellowfin

In the Maldives, no noticeable change occurs in Strata III and VI which are the low catch rate areas. Seasonality is evident in the four northern strata. On the eastern side, the peak season is December-March and corresponds to the north-east monsoon. On the western side it is in July-August and corresponds to the south-west monsoon.

On the west and south coasts of Sri Lanka, no seasonal shift in catch rates with area is evident. However, the peak seasons in 1983 and 1985 were in June/July on the west coast and August-October in the south; in 1984, the peaks were in January and December. Peak seasons on the east and west coasts occur during the two monsoons, as in the case of the Maldives. April-June was a good season for the Sri Lankan gillnet fishery in 1985, for skipjack. This was not so in earlier years.

5. STANDARDIZATION OF POLE AND LINE EFFORT

Considering that the average crew has six members in Sri Lanka and 10 in the Maldives and that the techniques and duration of trips are quite similar, the catch per man-day was calculated for common fishing seasons (Table 2).

Table 2

Catch per man-day in the pole and line fishery of Sri Lanka and the Maldives

(kg/pole/day)

		Sri Lanka	Maldives
1984	January	12.76	28.6
	February	2.56	23.3
	November	6.03	33.3
	December	8.15	36.4
1985	January	38.9	35.9
	February	15.6	30.1
	March	11 .01	13.9
	April	9.1	28.4
	November	16.1	29.6
	December	23.8	42.5

Catch rates compared for the seasons of pole and line fishery in Sri Lanka showed that the Maldives catch rate is generally higher. Bait limitation in Sri Lanka might have contributed partly **to** the lower catch rates.

6. SIZE COMPOSITION, FIRST ENTRY SIZE GROUP AND SEASONAL MOVEMENTS

Skipjack tuna

During the south-west monsoon, entry of a smaller size group (<30 cm) is clear in both countries. Second entry of small fish into the fishery around March-April is indicated for Sri Lanka, both in commercial and survey catches. ELEFAN analysis indicates two recruitments annually in both countries. The minimum size observed is 19.5 cm in the central part of Maldives and around 22 cm on the western side of Sri Lanka. Mean lengths at first capture (L,) were 33.5 cm and 45 cm respectively. If only the gillnet catches are considered, L_c is about 50.5 cm in Sri Lanka because of the size selection by the large mesh sizes used.

Gillnet being the main fishing method, selectivity influences the length frequency distribution for Sri Lanka, but because of the application of a range of mesh sizes and an entangling capability in the net, reasonably wide size ranges of fish are being caught and some modal progression is also evident.

In the case of Maldives, modal progression is extremely poor in any particular area, even in the pole and line catches. It is suspected that there may be continuous movement of the age-specific fish through these areas. In the absence of length frequency distribution from different areas for the same period, it is difficult to evaluate the possibility of different size groups occurring in different areas around Maldives.

A significant increase was observed in the catches of; 60-70 cm skipjack, both around Sri Lanka and the Maldives, in 1985/86. In the previous years, the 40-60 cm group dominated the fisheries **of** both countries. Though the size composition of skipjack caught by both countries is similar, the 60-70 cm size group was dominant between January and June 1986 in the Maldives, while in Sri Lanka the 40-60 cm group was dominant during the same period.

Seasonal changes in catch rate do not indicate a sequential shift in the area of fish concentration or direction. In the absence of length frequency data from all six strata in the Maldives, it is not possible to consider any movement patterns. Neither is there evidence of localized movement close to Sri Lanka from the available information. However the seasonal pattern in the length frequency is repeated annually without significant changes in size distribution.

Negligible quantities of skipjack are caught off the Indian mainland, but in the pole and line fishery in the Minicoy-Laccadive Islands **the** size range is 30-70 cm. Small sizes (30-35 cm) are caught generally during the south-west monsoon but appear to occur in other seasons also in different years (Silas et ***a/., 1986).***

Around Seychelles the size range caught is 35-70 cm and the mean size is close to 50 cm, (Cort, 1985).

Yellowfin

One-year-old fish are predominant, and the mean size increases northward from the south-west coast of Sri Lanka, and also towards the south coast.

In 1983, small fish entered the south-west coast during the third quarter and the north-west coast during the fourth quarter. In 1984, however, entry of small fish was noticed during the third quarter on the south-west coast and in the second quarter on the north-west coast. There is a possibility of two annual recruitments along the entire west coast entering the fishery in different seasons, **but** their availability to the fishery may depend on the shoreward shifting of the thermal front.

In the Maldives, small fish may enter the fishery during the south-west monsoon on the north-west coast, and during the north-east monsoon on the north-east coast. The size range observed is 25-50 cm and the fish probably enter the areas investigated. The size frequency pattern in other areas is not known.

The general migratory pattern on the western side of Maldives and Sri Lanka, as suggested earlier, is supported by recent observations also. However, the recruitment to the fishery on the east coasts of both countries appears to occur during the north-east monsoon and hence is likely to be different from that on the west coasts. Further investigations are necessary to understand the migratory pattern from the two recruitments in the two seasons. Any catch and length frequency data available in India would be very useful for interpreting the distribution pattern.

Yellowfin tuna showed a slightly smaller mean size for the Male area (Maldives) than for the west coast of Sri Lanka.

Around Minicoy Islands the yellowfin caught are reported to be of the 30-78 cm range; smaller sizes (30-35 cm) are caught during the south-west as well as the north-east monsoon (Silas *et al., 1986).*

Around Seychelles the size range caught is very wide (30-165 cm). Smaller sizes (30-60 cm) are caught during September-November, larger sizes (120-160 cm) in July/August and medium sizes (90-120 cm) in May/June. Almost all size groups are equally well represented around March/April (Cort, 1985).

7. GROWTH PARAMETERS

The various combinations of growth parameters estimated during the investigations (see Annexures 1, 2, 5,6) were used to estimate a series of age-at-length values for the two species using the Von Bertalanffy equation (Table 3). These values were compared with the mean lengths of modal groups identified by the Bhattacharya method to trace the same cohorts in different seasons and years. Ford-Walford and Gulland-Holt plots were applied to the findings.

Table 3

Age-at-length values for skipjack and yellowfin

	Skipjack				Yellowfin		
Age	L_∞=85* K=0.44	76** 0.44	79 0.41	Age	175 K=0.40	173 0.36	174 0.36
1	29.7	27.1	26.7	1	57.6	52.3	52.6
2	49.0	44.5	44.4	2	96.0	88.7	89.3
3	61.6	55.7	56.2	3	127.3	114.2	114.9
4	69.8	62.9	64.0	4	139.7	132.0	132.8
5	75.1	67.6	69.2	5	151.3	144.4	145.2
6	78.6	70.6		6	159.0	153.6	
7	80.8	73.8		7	164.4	159.1	

L_∞ = Asymptotic length K=Growth constant

* ELEFAN method ** Bhattacharya method

On the basis of results, the working group considered the growth parameters for the two species to be in the following ranges:

Species	K	L_∞ (cm)
Skipjack	0.41-0.44	76-79
Yellowfin	0.36-0.40	173-175
Eastern little tuna[1]	0.57-0.63	60
Frigate tuna	0.51-0.54	58-59

[1]Provisional results

8. SEX RATIO

Skipjack

Catches consisted predominantly of males in the size ranges 40-45 cm and 65-70 cm. Intermediate size ranges showed 48% males in the 50-55 cm group and 52% in the 55-65 cm group in the Maldives. Sri Lankan data were similar.

Seasonally, no significant variation in the sex ratio was observed except in those months- (January and February) when very large fish were landed.

Yellowfin

In the surface tuna fishery of Sri Lanka, females were predominant in size groups less than 100 cm and males were predominant in size groups above 110 cm. Mimura (1963) described the same pattern for yellowfin tuna above 90 cm fork length, entering the sub-surface longline fishery in the same latitude (60º-80ºE, 5º-10ºN).

No information for the Maldives area is available. at present but the results are expected to be similar to those for Sri Lanka.

9. LENGTH AT FIRST MATURITY

Sri Lanka: Skipjack — 42 cm for males and 43.3 cm for females.
Yellowfin 101 cm for females.

Maldives : Skipjack — 50 cm for females (to be confirmed).
Yellowfin — undetermined.

10. GONAD MATURITY AND SPAWNING

Skipjack

In Sri Lanka, the highest percentage of ripe ovaries in skipjack was observed in October and May but the highest percentage of spent fish was seen in March and October, probably corresponding to the ripe gonads in the two respective periods. Hence, spawning may be between October and March and between May and October in Sri Lanka. Two spawnings are also clearly indicated by the separation of two modes in the ova diameter, with ripening of the ovary. Probably there is spawning off the south and south-west coasts.

Because of limited coverage in the Maldives, it is difficult to define spawning areas and seasons at this stage.

Yellowfin

As the catches of yellowfin above the mean length at first maturity are very small in the surface fisheries, and provide insufficient samples, no definite conclusions were possible.

11. MORPHOMETRIC CHARACTERS

Seven linear characteristics were compared for the yellowfin tuna from Sri Lanka and Maldives, and only two characters showed significant differences — one at 1% level and one at 5% level (see Table 4). It was noted that in the two cases of highly significant differences, the range of measurements was different and the intercepts of the regression lines were different, though the slopes were similar. It was believed that there were some discrepancies in the method of taking these linear measurements.

During one of the working group meetings a few samples of tuna were jointly examined and a common measurement system was agreed upon. The morphometric measurements will be repeated to confirm the results.

Table 5 presents the results of the analysis of covariance for heterogeneity of various morphometric measurements of skipjack around Sri Lanka and the Maldives. Significance at 5% level was obtained for almost all the characters, except for snout to second dorsal fin measurements. However, the sample numbers were small and the correlation coefficient for the characters was relatively poor in the case of Sri Lanka. Comparisons may have to be repeated with better data before any conclusions can be drawn.

12. MIGRATION

The yellowfin migration pattern appeared to be consistent with the hypothesis already proposed (BOBP/WP/31). An Indian survey report indicated northward migration of deep-swimming yellowfin, also from lower latitudes to higher latitudes in the Arabian Sea, from October to March (Sivaprakasam and Patil, 1986). No migratory pattern for skipjack tuna could be established or hypothesised.

13. RECRUITMENT

Two annual recruitments for skipjack and ye!lowfin tunas have been postulated and the seasons of entry of these recruits to the existing fisheries are as follows:

Sri Lanka	Skipjack	—	January-February,	June-August
	Yellowfin	—	November-March,	July-September
Maldives	Skipjack	—	December-January,	March-April

14. STOCK IDENTITY

Skipjack

Minimum sizes of entry into the fishery in Maldives and Sri Lanka are 19.5 and 22 cm. Recruitment into the fisheries of the two countries may be from a common stock or different stocks. Spawning areas and seasons have to be identified more clearly. The main size ranges entering the fisheries are similar in both countries and there are no indications of any age group or size group being restricted to any one of the two countries. The growth rate and length at age are similar. Natural mortality was estimated to be 0.99 and 0.98-1.01 for Maldives and Sri Lanka respectively.

Yellowfin

Similar comparisons could not be attempted in the case of yellowfin tuna because of various limitations in the data available.

15. OTHER TUNAS

Auxis thazard, Euthynnus affinis and *A. rochei* contribute 28-37% to the tuna production in Sri Lanka, mainly from the catches of inboard engine craft operating troll lines and gillnets. Nearly 80% of the catches of these species are made on the western side of the island. Growth parameters have been estimated for kawakawa and frigate tuna. In the Maldives, *A, thazard, E. affinis* and *Gymnosarda unicolor* are of commercial significance and contribute 10% 3% and less than 1%,respectively to the total tuna production. Small but unknown numbers of *T. obesus* and *T. tonggol* are also caught in both countries.

16. LONGLINE CATCH RATES IN THE SURROUNDING AREA

Yellowfin hooking rates adjacent to Maldive Islands showed that the peak season is in the last quarter of the year. West of Sri Lanka, the peak season for yellowfin tuna was in the first and last quarters, and in the area south-west of Sri Lanka, the season appears to be around the middle of the year. The hook rates are much higher in the south-west than on the western side of Sri Lanka. The hook rates for yellowfin tuna close to Maldive Islands and Sri Lanka seemed to have declined between 1974 and 1982 (see Figures l-4). The insular longline fishery around Sri Lanka has declined in most areas except at a few centres on the west coast.

Longline catch data in the study area for 1983-1984 are incomplete and do not bring out any definite trends (Figure 1). However, Indian surveys have shown a significant increase in yellowfin hook rates in 1985/86 towards the higher latitudes. It is also conjectured that there is a northward migration of yellowfin from October to March (Sivaprakasam and Patil, 1986).

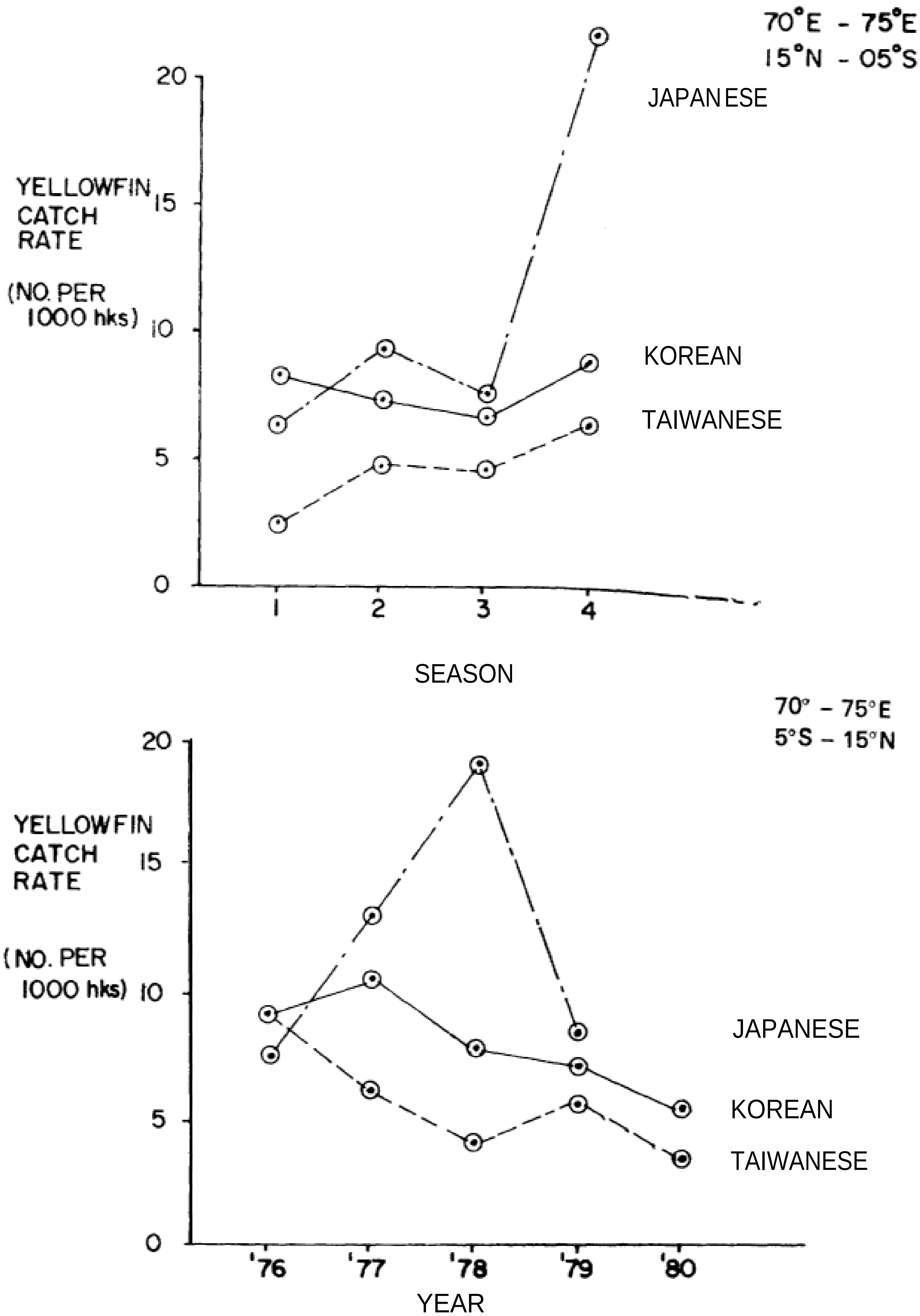

Fig. 1 Seasonal variations and annual catch rates of yellowfin tuna caught by Japanese, Korean and Taiwanese longliners in the area around Maldives (5ºS—15ºN,70º-75ºE).

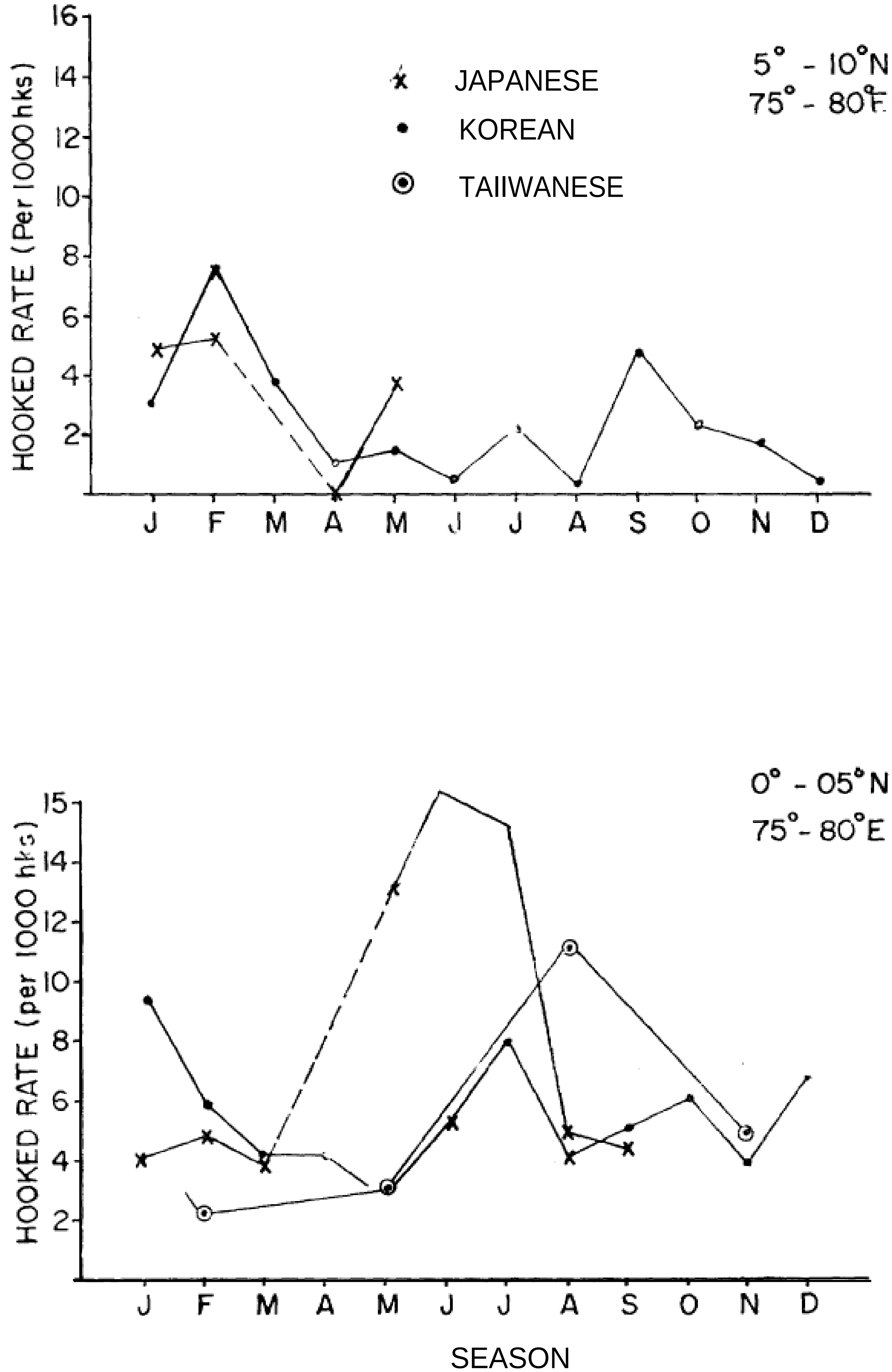

Fig. 2 Seasonal variations in the hooked rate of yellowfin tuna in the longline catches west of Sri Lanka.

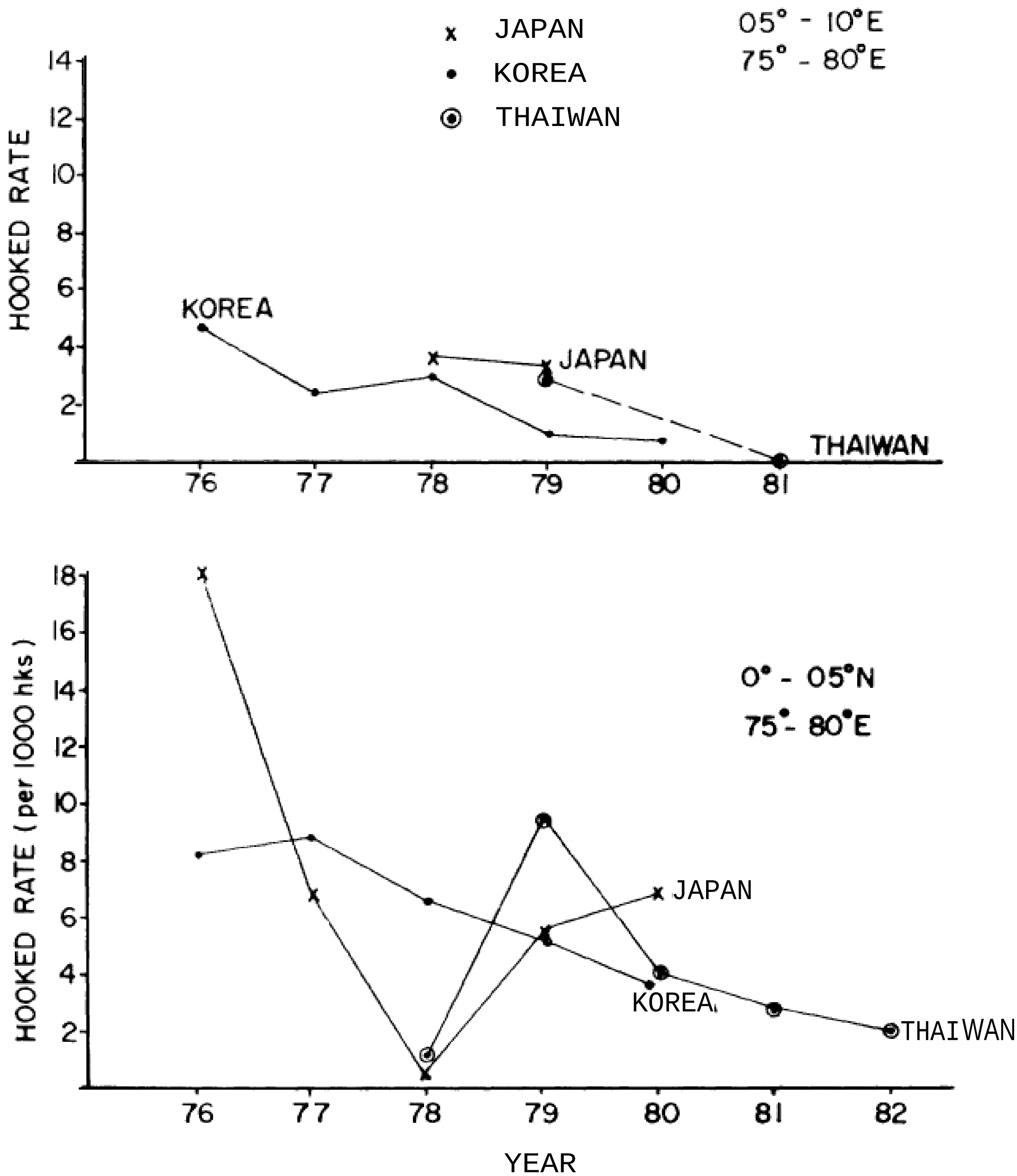

Fig. 3 Annual variations in the hooked rate of Yellowfin tuna in the longline catches west of Sri Lanka.

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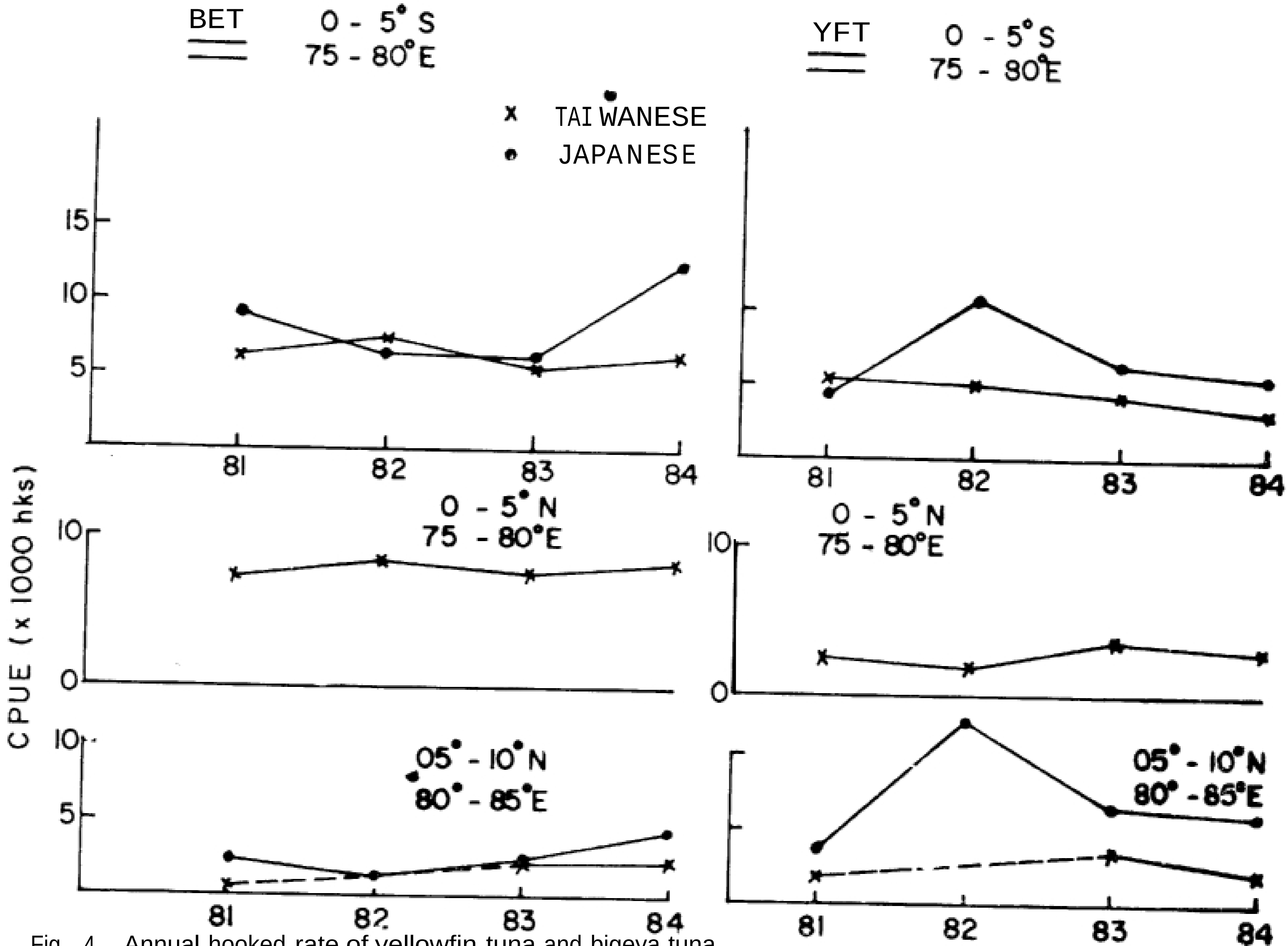

Fig. 4 Annual hooked rate of yellowfin tuna and bigeya tuna in the area within 75º-85°E,5ºS—10°N (1981—1984).

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17. PRESENT STATE OF THE TUNA RESOURCES

In view of the limited area of coverage, assessments of mortality and exploitation rates were not attempted for the stocks. However, it is noted that around Maldives, the catch rates for skipjack declined until 1983 and recovered afterwards. This is attributed to the high percentage of motorized craft in the fishery, addition to the fleet and expansion of the fishing grounds. Yellowfin tuna catch rates rose till 1982, and have been declining in recent years. Unusually large-sized fish were caught from December 1985 to February 1986.

In Sri Lanka, skipjack catch rates indicate a significant increase from 1983 to 1985. Again, the increase is due to expansion of the fishing by 3.5 GRT vessels, expansion into offshore areas, and larger trip duration. Introduction of the 34-foot class of vessels encouraged the above. Unusually large sizes of yellowfin tuna were observed in the Sri Lankan surface fishery too from troll and handline from December 1985 to March 1986.

Skipjack tuna are probably being exploited around the optimum level by Maldivian fishermen and perhaps at the optimum level or slightly in excess of that level by Sri Lankan fishermen in currently exploited areas. It is probable that expansion of fishing effort into the outer waters of the EEZs of both countries will allow increased production on a sustainable basis.

Skipjack tuna is a highly migratory species. It is felt that skipjack caught in the waters around Maldives and Sri Lanka are continuously replaced by other skipjack coming in from outside. While no reliable estimates are available, it is conjectured that the present stock of skipjack in the Indian Ocean is considerable. It is therefore likely that considerable expansion of the fishery for this species may be possible. In the case of yellowfin, however, which probably has a smaller stock size in the Indian Ocean and is already subject to a major longline fishery and a potentially significant purse seine fishery, there is less reason for complacency. Continued expansion of the tuna fisheries in other areas of the Indian Ocean would undoubtedly lead to decreased catches by the tuna fishermen of Maldives and Sri Lanka. Expansion of the surface fishery for tunas in the EEZs of Sri Lanka and Maldives beyond the present fishing ranges may also adversely affect the existing traditional fishery for tunas. This possibility must be given serious attention, in order to avoid disastrous consequences to the large community that depends on traditional methods of fishing for tunas.

The need for an international scheme of management of Indian Ocean tuna, which gives due weight to the rights and requirements of traditional fishermen, cannot be over-emphasized.

The maximum sustainable yield estimate in these cases does not represent the normal optimum level of the whole stock, which is likely to be much more abundant and more widely distributed. It represents only a benchmark for optimum exploitable levels within the exploited ranges, limited by the carrying capacity of these ranges. In the case of Sri Lanka, catch and corresponding fishing effort estimates are not available, and hence the attempt to apply the length-based approach for assessment purposes and for some guidance on the status of the tuna fishery.

18. RECOMMENDATIONS

(1) A fishery census is necessary to assess the present status of fishing craft and gear.

(2) Statistics on longline operations in the study area by distant nations are incomplete. This makes it difficult to assess the status of other tuna fisheries in the area for management purposes. Attempts should be made to obtain such information.

(3) The tuna sampling programme in Sri Lanka needs to be strengthened and intensified for catch rate and length frequency. At least the sampling at Galle and Tangalle in Sri Lanka should be intensified.

Field officers in Maldives should be encouraged to conduct sampling in all the six strata identified.

(4) Field officers in Maldives need further training to improve their ability.

(5) Considering the information on dogtooth tuna presented in Annexure 3, the study of this species in the Maldives should be continued.

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Table 4

Summary results of the analysis of morphometric data for yellowfin tuna

Measurement			Slope	Intercept	R^2	Significance
SD1	Maldives	(n= 80)	0.28	1.51	0.93	**
	Sri Lanka	(n =100)	0.26	3.10	0.97	
SD2	Maldives	(n= 80)	0.51	1.80	0.94	
	Sri Lanka	(n =100)	0.49	3.14	0.92	
HL	Maldives	(n= 80)	0.27	0.64	0.93	
	Sri Lanka	(n =100)	0.25	1.81	0.88	
SA	Maldives	(n = 80)	0.54	2.71	0.96	**
	Sri Lanka	(n=100)	0.49	3.1	0.92	
D1 D2	Maldives	(n= 80)	0.19	2.31	0.82	*
	Sri Lanka	(n=100)	0.22	0.62	0.82	
D1A	Maldives	(n= 80)	0.36	1.18	0.79	
	Sri Lanka	(n =100)	0.36	1.46	0.90	
D2A	Maldives	(n = 80)	0.22	1.17	0.89	
	Sri Lanka	(n =100)	0.24	0.84	0.77	

* Significant in 5% level

** Significant in 1% level.

Table 5

Summary results of the analysis of morphometric data for skipjack tuna

Measurement			Slope	Intercept	R^2	Significance
SD1	Maldives	(n= 80)	0.32	0.114	0.91	**
	Sri Lanka	(n ==100)	0.26	4.68	0.54	
SD2	Maldives	(n = 80)	0.65	1.49	0.85	
	Sri Lanka	(n=100)	0.52	6.26	0.73	
HL	Maldives	(n= 80)	0.27	0.64	0.80	**
	Sri Lanka	(n =100)	0.18	0.72	0.69	
SA	Maldives	(n= 80)	0.65	0.12	0.94	**
	Sri Lanka	(n=100)	0.48	12.3	0.64	
D1 D2	Maldives	(n= 80)	0.26	1.23	0.92	**
	Sri Lanka	(n =100)	0.25	2.41	0.78	
D1A	Maldives	(n= 80)	0.39	0.39	0.93	**
	Sri Lanka	(n =100)	0.37	2.84	0.69	
D2A	Maldives	(n= 80)	0.22	0.47	0.90	**
	Sri Lanka	(n =100)	0.21	2.33	0.70	

** Significant in 1% level.

Appendix 1

PARTICIPANTS IN THE SECOND AND THIRD WORKING GROUP MEETINGS

Maldives

Mr. Hassan Maniku	Senior Fisheries Development Officer Ministry of Fisheries
Mr. Ahmad Hafiz	Fisheries Research Officer Marine Research Station, Ministry of Fisheries
Dr. Charles Anderson*	Fisheries Statistician
Mr. Hasan Rasheed	Senior Statistical Officer Ministry of Fisheries
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Mr. Leslie Joseph	Scientific Officer, NARA, Mattakuliya, Colombo
Ms. C. Amarasiri	Scientific Officer, NARA, Mattakuliya, Colombo
Ms. R. Maldeniya	Scientific Officer, NARA, Mattukuliya, Colombo

RAS/81 /051

Dr. K. Sivasubramaniam	Senior Fishery Biologist, BOBP
Mr. T. Nishida	Statistician (APO), BOBP
Mr. M. Van der Knaap**	Fishery Biologist (APO), BOBP

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* Attended Second Working Group Meeting
** Attended Third Working Group Meeting

Annexure 1

SOME OBSERVATIONS ON THE TUNA FISHERIES IN THE INDIAN OCEAN, PARTICULARLY IN THE CENTRAL EQUATORIAL SUB-REGION

By **K. Sivasubramaniam**
Senior Fishery Biologist, BOBP

1. Introduction

A traditional pole and line fishery for tunas has been in existence for over 100 years in some countries of the Indian Ocean — Sri Lanka, Maldives and the Minicoy-Laccadive Islands of India. The Japanese tuna longline fishery in the Indian Ocean (for deep swimming tunas) commenced around 1953 and was followed by Taiwanese and Korean fisheries about a decade later. With the rapid mechanization of fishing crafts and the introduction of synthetic gillnets and mackerel purse seiners, tuna production improved noticeably in many countries during the 1960s and 1970s — when surface tuna resources were tapped only by the countries of the region.

Since the 1980s. Spanish and French tuna purse seiners have entered the surface tuna fisheries in the Indian Ocean. The rapid and successful development of the purse seine fishery has captured the attention of the region more than the entry of tuna longline fishery into the Indian Ocean did. This is because countries of the region are primarily engaged in surface tuna fishery, and are in the process of expanding this fishery at least up to their EEZ boundaries.

2. Surface and sub-surface fisheries

2.1 Yellowfin Tuna

There have been changes in the overall production of yellowfin tuna but the 1983 figure (59,000 t) was only a little higher than that of 1977 (50,000 t). In 1984 it jumped to 92,000 t, mainly because of the development of surface tuna fishery by distant nations.

A significant change is seen in the relative contributions of surface and sub-surface fisheries. Prior to 1983, the surface fishery contributed less than the sub-surface fisheries. In 1983 both fisheries contributed almost equally, and in 1984 the surface fishery appears to have contributed almost thrice that of the sub-surface fishery, which showed a small decline. The development of the surface fishery in the central equatorial sub-region has significantly influenced this trend. Distant nations carry out 73% of the surface production. The interaction between surface and sub-surface fisheries has therefore become an important consideration for development and management of the yellowfin tuna resources, particularly for the major tuna fishing countries in this sub-region, which have been dependent on a surface fishery of this resource (see Table 1).

2.2 Bigeye Tuna

After a high overall production of bigeye tuna in 1978 (49,000 t), the production in 1983 appears to have decreased to 37,141 t. The surface fishery for bigeye tuna was negligible (1.5%) but there has been a noticeable increase to 10% with the general increase in surface fishery for tunas. It is significant that juvenile bigeye tunas (20-79 cm) are being reported in the surface fishery off the west coast of Sumatra and around Seychelles (Table 1).

2.3 Longtail Tuna

Oceanic longline fishery contributes very little to the production of longtail tuna. Only Iran has reported production of this species by longline. However, the surface fishery is significant and it is estimated that the production by surface fishery is in the region of 20,000-25,000 t (Table I),

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if projected figures for Oman and Qatar are also included. Even the Yemen Arab Republic may be producing this species; experimental purse seine operations were conducted in that area in the 1960s. The reported production of bigeye tuna in this area possibly includes longtail tuna. On the west coast of Thailand, pole and line survey showed longtail tuna to be one of the important species within its EEZ and production of this species has been recorded.

Longtail tuna production in the Indian Ocean is primarily from areas north of the Equator — Arabian Gulf, Gulf of Oman, Gulf of Aden, east and west coasts of India, and east of the Andaman-Nicobar islands to the west coast of Thailand. More concentrated study of longtail tuna should receive special attention. However, the impression created hitherto that a major part of the coastlines of the Indian mainland has significantly large quantities of longtail tuna is not evident from recent reports (Silas et *al.,* 1986). Perhaps there is significant concentration on the north-west coast of India, but it may be negligible in other areas (0.1%), as off the coast of Sri Lanka.

The larger size longtail tuna does not appear to be fully vulnerable to existing methods of most areas in the IPFC region. Fishing trials off the south-east and north-east coasts of India have shown the occurrence of skipjack and yellowfin tuna in the offshore waters. This is so on the west coast also.

3.3 Skipjack Tuna

Skipjack production has increased significantly in recent years (approximately 104,000 t in 1984). The production by distant nations has increased from 0% in 1980 to 38% in 1984; of the 62% produced by nations of the region, three countries in the Central Equatorial sub-region (Maldives, Sri Lanka and India) account for 45% (Table 1). The possible interaction between the purse seine fishery of distant nations and the traditional pole and line fishery and gillnet fishery by local States in the Central Equatorial sub-region is a matter of urgent concern, particularly in the light of provisions of the Law of the Sea concerning highly migratory species that are exploited within the EEZs by local nations and outside the EEZs by distant nations.

4. General Observations

The Fisheries Survey of India conducted longline operations off the south-west coast of India (69º-79º E, 5º-15º N) during 1983-1986. During 1985/86, 65,450 hooks (750 hooks/set) were set and the hooked rate for tuna was found to increase from < 1% between 5” and 8” N to 2% between 8º-11º N, to 7.86% at 12” N, 9.56% at 13” N and 23.91% at 14” N. The average was 8.11% (both number and weight percentages were similar). Catch rates increased from October and reached a peak in January and the catch composition was 75% tunas, 20% sharks, 4% billfishes and 10% others. Among tunas 98.7% was yellowfin, 0.9% skipjack and 0.35% bigeye. A remarkable improvement in catch rate was seen in 1985/86.

	4/83-3/84 (Varghese *et al.,* 1984)	11/83- 10/85 (Joseph, 1986)	5/85-3/86 (Sivaprakasam & Patil, 1986)
Yellowfin . .	0.05	0.72	6.03
Bigeye . .	—	0.05	0.02
Skipjack . .	—	0.07	0.04
Billfish . .	0.08	0.13	0.31
Sharks . .	2.38	1.28	1.64
Others . .	0.03	0.18	0.07

The increase in catch rate has been attributed to improved skills. However, there are reports of significant improvements in the catch rates of yellowfin tunas in the surface and sub-surface fisheries in many areas around the world including the Indian Ocean, and scientists are investigating the possible influence of the 1982/1983 “El Nino”.

Sivaprakasam and Patil (1986) also suggest northerly migration of yellowfin tuna from lower latitudes to higher latitudes, starting from October and extending up to March. Unfortunately, length frequency data of longline catches are not available to trace the linkage between the surface and sub-surface components of the yellowfin stock in this sub-region and to confirm whether the recruitment of the two-year old fish to the longline fishery from the surface component helps increase hooked rates during the winter month or helps continue the northward migration.

In this context, it will be useful to have length frequency data by sex, to examine the interaction between surface and sub-surface fisheries, in view of the reversal of sex ratios in **the two** components.

Age-specific migration of tunas may be behind the very low growth rate pattern in a number of areas such as Maldives (report of IPFC/IOFC ad hoc working party on tuna stock assessment, (Nantes 1975). Besides this problem, irrational utilization of results from length-based methods (ELEFAN, Bhattacharya methods) may also make for too low or too high values of k and L. In this context, one notes that ***A. thazard,*** T. tonggol and ***K. pelamis*** in Indian waters have been shown to have identical k value of 0.4898 (Silas et a/., 1986). Limitations in the randomness and size of length frequency samples from catches of species with size-specific aggregation behaviour and use of highly selective gear such as gillnets are perhaps other factors. All these demand that the results from length-based methods are viewed with caution. It is also noted with interest that yellowfin tuna around Seychelles shows a very high rate of growth between one and two years of age. Emigration and immigration of different cohorts of these age groups in surface fisheries are likely to occur in certain areas where age-specific migrations are common, and they create illusionary situations particularly when data from a very short period of time (one quarter) are analysed.

Emigration of highly migratory species must be studied very carefully when determining fishing mortality and exploitation rates. In this context, one notes with interest that around the mainland of India, where no effort is specifically directed on tunas and the catches are mostly incidental to other species such as king mackerels, the exploitation rate is significantly high. The projected potential tuna yield level from that area is about 10 times the present level of exploitation.

5. Development trends

There is direct and indirect evidence of potential for the expansion of tuna fisheries in the EEZs of many countries such as Maldives, Sri Lanka, India, Thailand (West), Sumatra (North and West) and perhaps the Gulf countries (BOBP; 1985a, 1985b, Sivasubramaniam 1981, 1985). Potential for developing a tuna fishery also seems to exist in other countries such as Bangladesh, Burma and Pakistan, considering the Japanese tuna longline operations before EEZs were declared by them. Many other countries south of the Equator also have similar potential.

In most cases, expansion of the fishery would increase production of the same species; it would be caught in more areas. However, in the mainland of India, the potential in offshore ranges probably lies in the resources of skipjack and yellowfin tunas and not in the eastern little tunas and frigate tunas, which are the main contributors to tuna production at present. This is also evident from the tuna drift gillnetting trials conducted by BOBP off Kakinada in the north-east coast and the tuna gillnet fishery being carried on by a special group of fishermen in the south-east coast. In the case of Maldive Islands, the dogtooth tuna resource also may be considered underutilized, if one examines the incidental catches from the reef fish fishery and the vast extent of reef waters available for exploitation.

Presently a few areas in the Indian Ocean have fishing methods specifically directed only at tunas, which sustain large fleets of fishing crafts. These areas and **methods** are as follows:

Pole and line (live bait)	—	Sri Lanka, Maldive Islands, Minicoy-Laccadive
Drift gillnet	—	Sri Lanka
Trolling lines	—	West Sumatra

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In many other countries of the Indian Ocean, tunas are being caught in mixed-species fishery or incidentally in the fishery for other target species — gillnetting for king mackerels, purse, seining for mackerels and sardines and hook and lines for king mackerels and reef fish.

Expansion of the pole and line method is limited by availability of suitable live bait resources, specialised facilities for carrying live bait and water spraying systems, availability of tuna schools, uncertainty of the response to chumming, and availability of specially skilled fishermen. Trolling for tunas is generally an incidental method during sailing time but as the sole method of operation, it may not be economically viable, is relatively inefficient and has access to few species. In Sri Lanka, the pole and line method is fast giving way to the drift gillnet fishery because the latter has several advantages — it is effective in all seasons even if there are no tuna school formations; it requires minimum specialisation of the fishing craft; it is fuel-efficient; and it yields valuable by-catches. However, the condition of the gillnet catch tends to be poor because of the prolonged soaking time.

There is increasing interest in adopting the tuna drift gillnetting method among the countries in the region because of the ease with which it can be introduced with existing craft and crew, the possibilities for including small quantities of tuna longline baskets and the possibilities of daytime trolling (whereas driftnetting is done at night.) Adaptation of mackerel purse seiners to catch tunas is increasing in the west coast of Thailand and north coast of Sumatra. However, the size, characteristics and engine power of these crafts and the size of the net that can be handled, may permit only a moderate expansion.

It is anticipated that many nations will attempt to develop their small-scale fishery for tunas in the immediate future with the exception of a few countries (like India) that have private entrepreneurs who have already invested in the purchase of large tuna fishing vessels. Large-scale tuna fisheries in other countries are likely to develop mainly as joint ventures with distant nations.

6. Management of Tuna Resources in the Indian Ocean

Development of tuna fisheries in the Indian Ocean is different from that in the Pacific Ocean or Atlantic Ocean. The longline fishery in the Indian Ocean was established as and continues to be the activity of distant nations. A few nations in the region entered this fishery rather late and some who tried to stand on their own feet, such as Sri Lanka, failed while others such as Seychelles, who are operating with the support of a distant nation, are carrying on in a very small way.

Traditionally, there has been a modest fishery for surface tunas, which sustain large fleets of small-scale fishing craft in many countries but the surface fishery for tunas by distant nations is presently developing faster than that of the countries in the region.

The exploitation and management of the tunas in the Indian Ocean continue to be heavily dependent on nations outside the region. It has been shown that the surface fishery for yellowfin has already exceeded the production by the longline fishery and that the skipjack tuna production has been doubled overnight, with distant nations taking 55% of the total production of these species and particularly from this sub-region, which has been contributing the bulk of the production by nations in the region. Yellowfin and skipjack tuna are of primary importance to the existing tuna fisheries of the countries in the Indian Ocean and the present state of their exploitation demand prority in assessment and management of these resources.

The Indian Ocean is almost entirely surrounded by developing nations which may have serious difficulties establishing and supporting the management system required. The nations in the region must also make improvements in the areas of tuna statistics, biological research and surveys, the importance of which cannot be over-emphasized.

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Table 1

Common tuna species caught by countries in the Indian Ocean and by distant nations (1983 and 1984)

Source: IPTP (1986) Data Summary No. 5

(tonne)

Country		Yellowfin tuna 1983	Yellowfin tuna 1984	Bigeye tuna 1984	Longtail tuna 1984	Skipjack tuna 1983	Skipjack tuna 1984
Indonesia	(LL)	0	739	?		?	?
	(PS)	0	24	?	?	0	328
	(GN +Troll)	5,888	4,603	?	?	12,458	13,323
P. Malaysia	(PS)	0	0	0	?	0	0
Thailand (West)	PS)	0	0	0	5,813	0	0
	(GN)				95	0	0
India	(P+L GN)	?	?	?	220	1,801	3,485
Sri Lanka	(LL)	905	644	?	0	0	0
	(P & L)	452	258	0	0	2,095	1,510
	(GN)	7,237	5,151	?	?	11,178	8,714
	(Troll)	452	387	0		699	1,395
Maldives	(P & L)	5,984	6,893	?	?	19,491	31,714
	(Troll)	257	230	?	?	210	335
Pakistan	(GN, etc.)	?	?	7	?	733	694
Iran	(LL)	0	0	0	319	0	0
	(GN)	0	0	0	6,070	0	0
United Arab Emirates	(GN)	0	0	0	3,000	0	0
Qatar	(GN)	0	0	0	30	0	0
Oman	(GN)	?	?	?	3,000	?	?
Dem. Rep. Yemen		80	0	1,356	7	400	0

Table 1-(contd.)

Country		Yellowfin tuna		Bigeye tuna	Longtail tuna	Skipjack tuna	
		1983	1984	1984	1984	1983	1984
Seychelles	(LL)	0	198	171	0	0	0
	(Troll, etc.)	114	0	0	0	0	0
Mauritius	(PS)	I ,323 (1982)	1,274	250		2,597	2,558
	(Others)		50			0	350
S. Africa	(UNCL)	166				13	
Kenya	(LL)	322	0	0		2 $31 (others)	0 +45 (others)
Comoros	(UNCL)	100	100	?		300	300
Australia		0	0	0	0	0	0
Mozambique	(LL)	0	177	9	0		
	(P+L)	15	11	0	0	60	154
Japan	(LL)	7,039	7,467	13,516	0	3	2
	(PS)	193	0	59 (1983)		592	0
Korea	(LL)	15,337	9,895	11,481	0	8	0
Taiwan	(LL)	4,211	1,369	8,163	0	9	22
France +Ivory Coast	(PS)	10,773	39,362	1,386	0	10,075	31,598
Spain, Panama & UK	P+L)	55 (1982)	0 (?)	0	0	0	0
	(PS)	0	13,796	809	0	?	8,079
Longline catches							
Distant Nations		26,587	18,731	33,160	0	20	24
		(95.6%)	(91.4%)	(99.4%)			
Local Nations		1,227	1,758	180	319	2	0
		(4.4%)	(18.6%)	(0.6%)			
Surface Fisheries							
Distant Nations		10,066	53,158	2,195	0	10,687	39,677

Table 1 -(contd.)

Country	Yellowfin tuna 1983	Yellowfin tuna 1984	Bigeye tuna 1984	Longtail tuna 1984	Skipjack tuna 1983	Skipjack tuna 1984
	(33.8%)	(73.6%)	(57.7%)		(17.0%)	(37.9%)
Local Nations	20,745	18,981	1,606	18,228	52,053	64,905
	(66.2%)	(26.4%)	(42.3%)	(100%)	(83.0%)	(62.1%)
Total longline	27,814	20,489	33,340	319	22	24
	(46.7%)	(22.1%)	(89.8%)			
Total surface	32,450	72.139	3,801	18,228	62,740	104,582
	(53.3%)	(77.9%)	(10.2%)			
Grand Total	59,525	92,628	37,141	18,547	62,762	104,606
Total catch						
Distant Nations	37,553	71,889	35,355	**0**	10,707	39,701
	(63.1%)	(77.6%)	(95.2%)	**(0%)**	(17.1%)	(38.8%)
Local Nations	21,972	20,739	1,786	18,547	52,055	64,905
	(36.9%)	(22.4%)	(4.8%)	(100%)	(82.9%)	(62.0%)

Annexure 2

SKIPJACK FISHERY IN THE MALDIVES

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Introduction

The tuna fishery in the Maldives is a major contributor to the national economy. It provides export earnings, creates employment and is directly linked with the livelihoods of most island communities. The fisheries sector employs about one-third of the total labour force; the number of active fishermen in the Maldives, excluding Male, totalled 19,671 in 1985.

The tuna fisheries accounted for about 87% of the total fish catch of the Maldives in 1985. The catch was mainly composed of skipjack tuna ***(katsuwonus pelamis),*** yellowfin tuna (Thunnus ***albacares),*** frigate tuna ***(Auxis thazard),*** and eastern little tuna ***(Euthynnus affinis).***

Most tuna are caught by pole and line motorized masdhonis (locally built wooden craft of 8-12 m LOA). In 1985 about 94% of total tuna landed was by motorized pole and **line vessels (see** Table 5). In 1985, trolling vadu dhonis and sailing masdhonis contributed 4.7% and 0.8% of total tuna landings, respectively.

Total recorded tuna catch in 1985 was 53,700 t, which is 18.1% higher than the catch in 1984. Summaries of annual catch variation during 1970-1985 are given in Tables 1, 2, 3 and 4. Roughly half of the catch is exported.

General production trends

Variations in the annual production trends (in terms of catch numbers) were estimated for skipjack tuna, using available historical data. An uneven distribution of skipjack tuna landings in different strata was noted.

The highest production of small skipjack is in Stratum 2 (Figure 1) and that of the large skipjack is in Stratum 4. Production of small skipjack is always higher than that of large skipjack in all strata. The difference between the production of small and large skipjack is the least in Stratum 1, where a rather even mixture of both size groups is observed at a moderate level of production. The difference is the largest in Stratum 2, which showed the highest production of small skipjack.

The production of skipjack in recent years has increased tremendously — from 19,700 t in 1983 to 42,600 t in 1985, representing respectively 62.5% and 79.3% of the tuna production in the Maldives (Table 4). Changes in the proportion of non-motorized and motorized craft are evident from Tables 1, 2 and 3. More details on craft and methods are found in the Maldivian Statistical Yearbook (Anonymous, 1985).

Catch rates and seasonal variations in catch rates

According to ***one*** analysis of the 1980 and 1981 statistics (Anonymous 1985), small skipjack peak catch rates were between September and February and also between April and July, on the east coast. The peak seasons on the west coast are similar to those of the east coast, but are less distinct.

Variations in large and small skipjack catch rates in Stratum 6 show parallel trends both in 1980 and in 1981. Landings of large skipjack generally tend to decrease in the second half of the year in most of the strata, except Stratum 1, where the catch rates tend to exceed those of small

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This paper was presented at the third meeting of the working group on tunas in the EEZs of Maldives and Sri Lanka, 22-25 September 1986, Colombo, Sri Lanka.

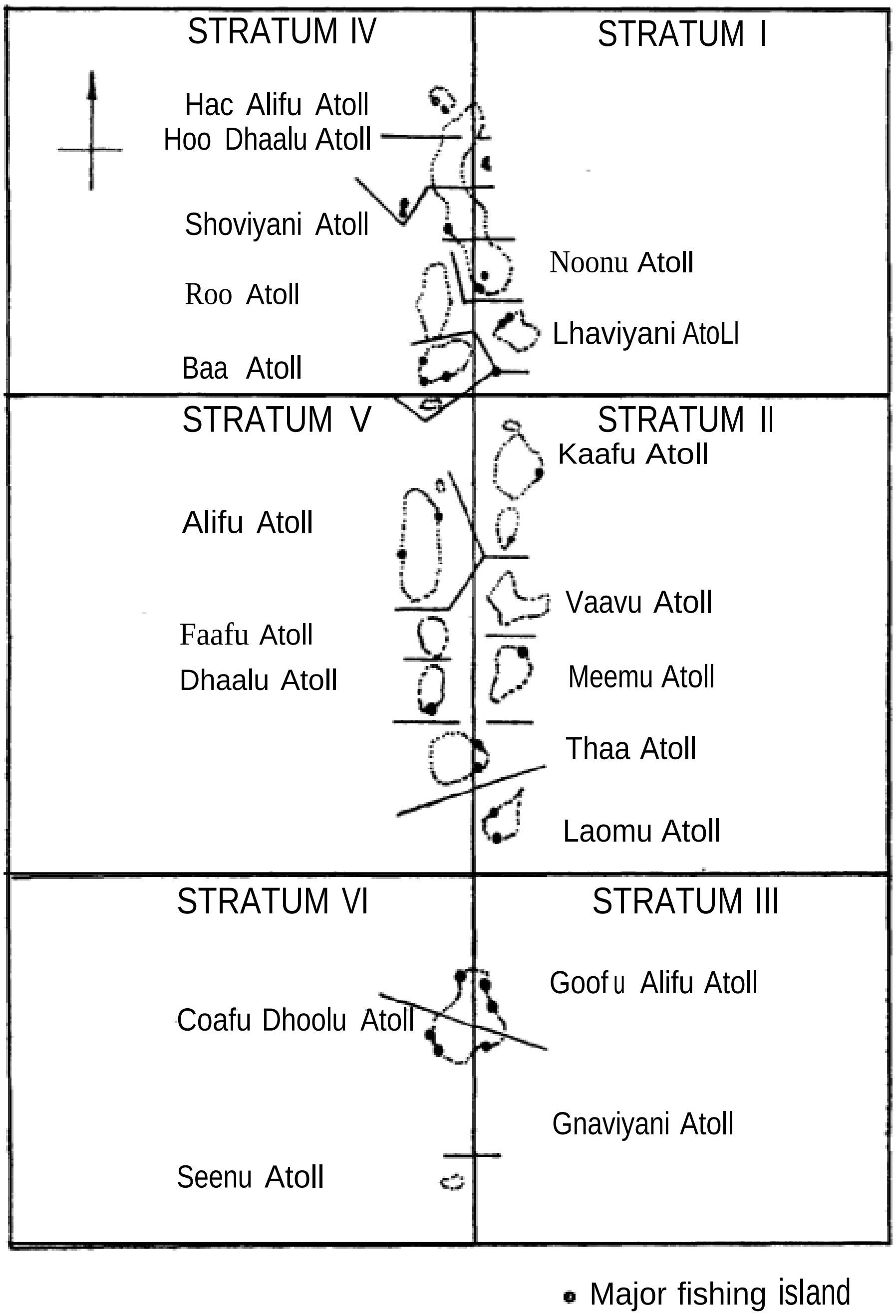

Fig. 1 Map showing the six strata of the Maldive islands.

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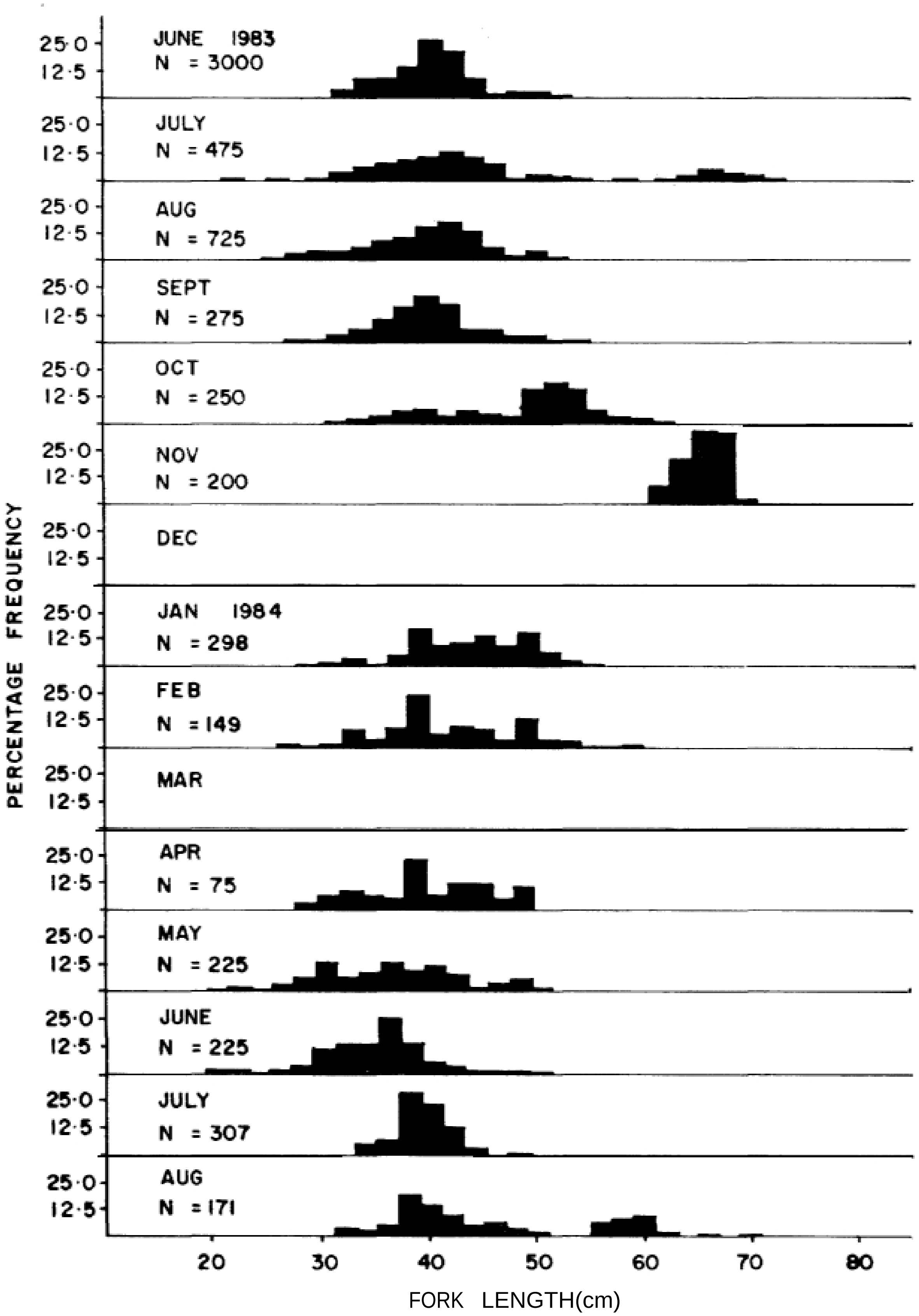

Fig. 2 Monthly length frequency distributions of skipjack tuna in the Maldives (June 1983—August 1984).

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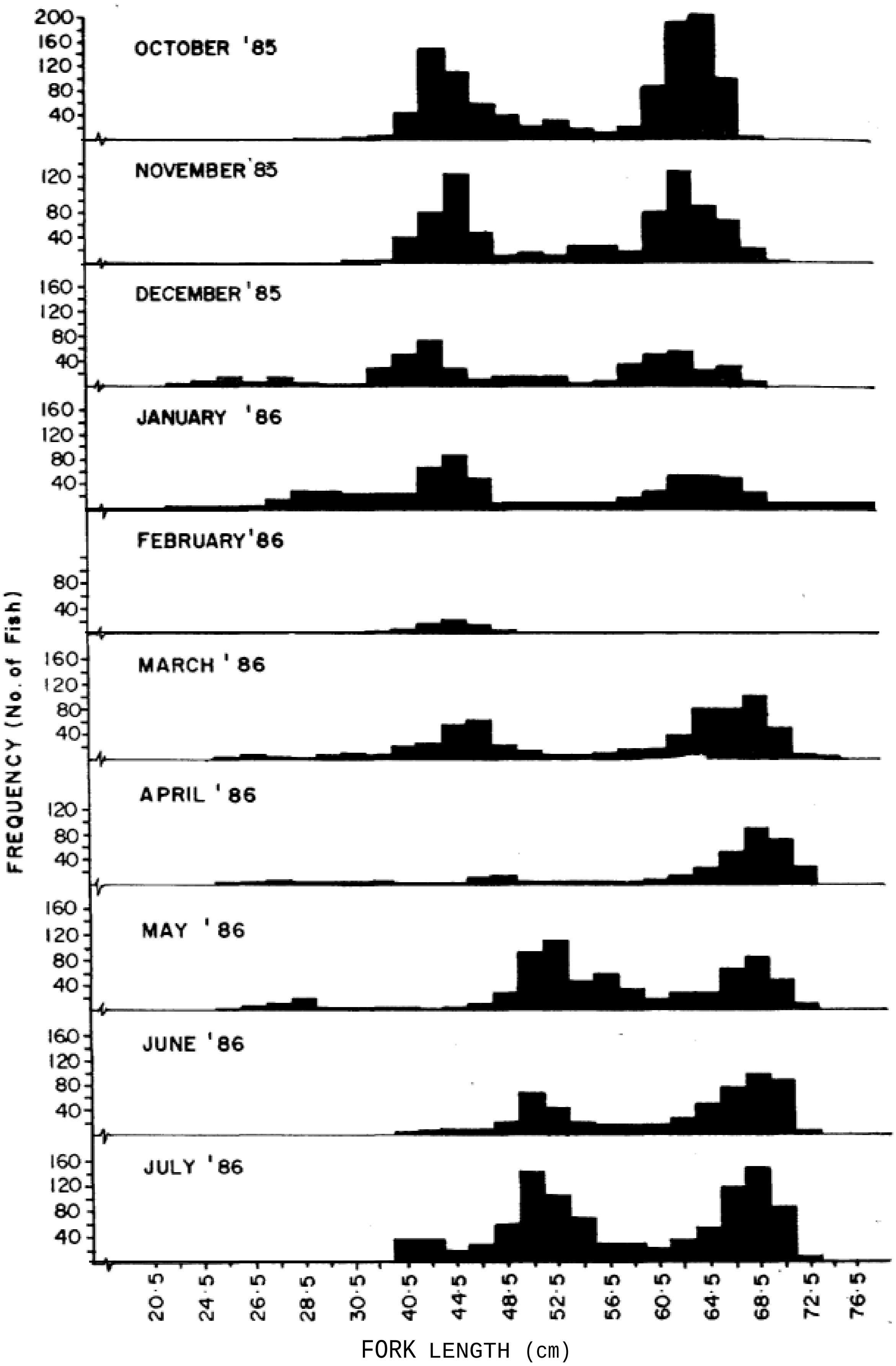

Fig. 3 Monthly length frequency distributions of skipjack tuna in the Maldives (October 1985 —July 1986).

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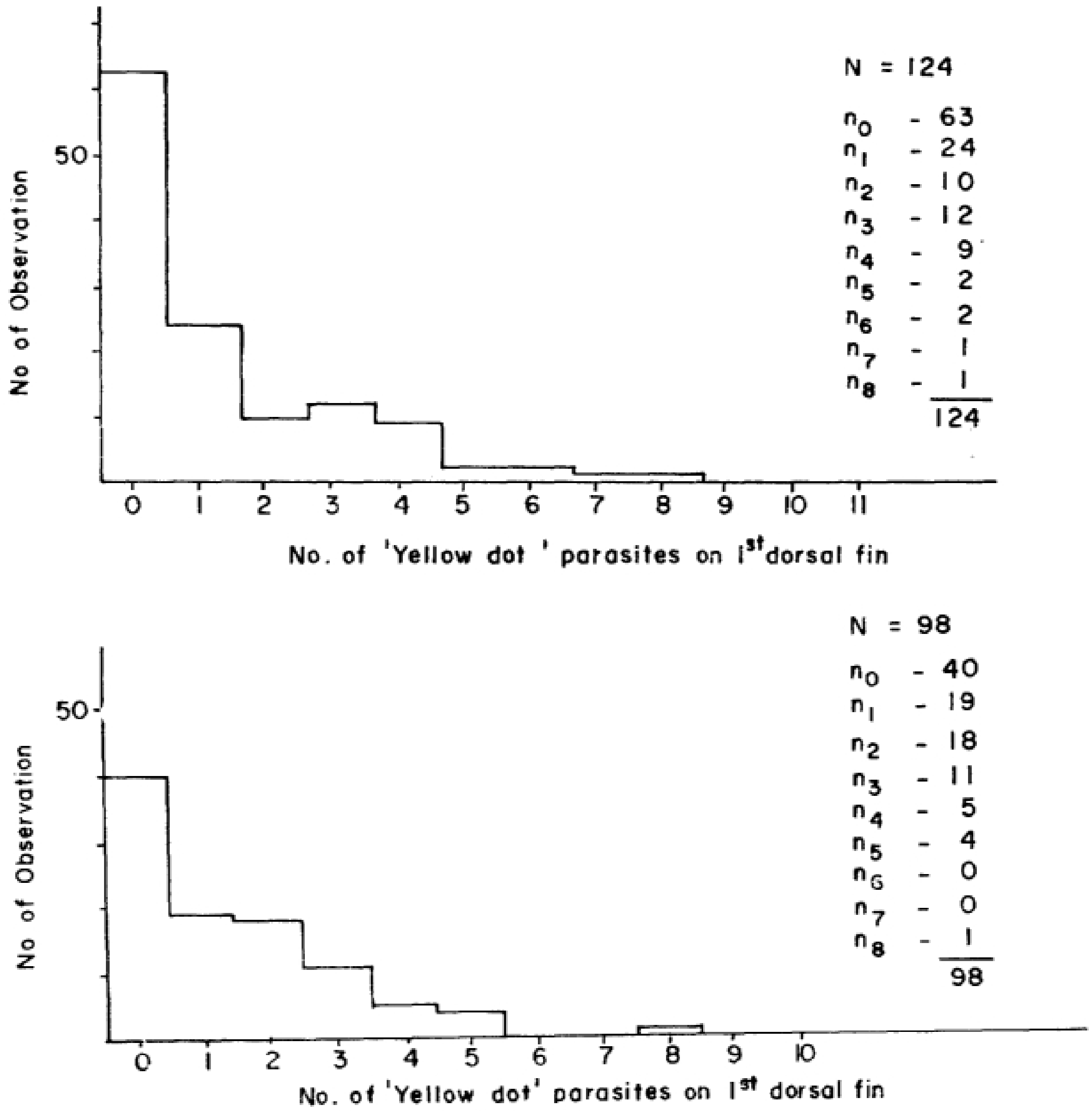

Fig. 4 Frequency distribution of dorsal fin parasites in two samples of skipjack tuna taken during August 1985.

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skipjack in certain months (July, October and November). The highest monthly catch rates were in Stratum 6 (February 1980) and Stratum 3 (July 1981), both being at the southern of the country. The high average catch rates in the south provide an incentive for the introduction end of more fishing craft into the area.

The catch rates of large skipjack in almost all strata were relatively poor in 1981 ; seasonal trends in distribution of catch rates were, therefore, not clearly evident (Anonymous, 1985).

It is assumed that the pole and line fishing method is an efficient sampling gear for the surface swimming skipjack tuna. If so, the catch rates for this method will provide indices of the relative densities and abundance of these fish within the exploited areas.

The catch rates of Strata 3 and 6 (southern end of the country) indicate relatively higher values. Strata 1, 4 and 5 reveal constantly moderate catch rates and the catch rate of Stratum 2 is in between these two levels. In all areas around the country, it is mainly small skipjack that contributes to the production, indicating a higher abundance of small skipjack tuna than any other tuna species within the exploited ranges. Stratum 1 is exceptional: there is a concentration of large skipjack very close to the concentration of small skipjack (Anonymous, 1985).

Annual variation of catch rates and fishing effort

A stratum-wise analysis of the annual variation, from 1973 to 1982, has already been presented. (Anonymous 1985). As Strata 3 and 6 exhibit higher catch rates than the others, annual variation in these areas (Strata 3+6 combined) were examined with corrected catch and effort figures for the period 1973 to 1985 (Table 6). It appears that catch rates for both small and large skipjack rose to high levels in 1979. Small skipjack catch rates reached a peak in 1981, then declined and again showed an upward trend in 1985. The catch rates of large skipjack have increased since 1982. Combined rates exhibit fluctuations between 1979 and 1985. As these values represent catch rates for motorized and non-motorized pole and line craft, the sharp rise in the catch rate level since 1979 is attributed to the influence of the significant increase in the number of motorized craft in the fleet.

Length frequency distribution

The length frequency distribution of skipjack tuna, by month, was plotted (Figures 2 and 3) with data collected from Baa Atoll Eydhafushi (Stratum 4) from June 1983 to August 1984 and from December 1985 to June 1986. The size range of skipjack tuna sampled was 20-76 cm in fork length.

There appears **to be** polymodal distribution in the length frequency distributions with some indications of modal progressions in the samples collected. The 1985/86 length frequency samples showed a greater abundance of 60-70 cm size group (Figure 3), than samples from earlier periods.

Parasites

Parasites may serve as useful stock markers in Indian Ocean skipjack.

When skipjack gonad samples were taken, numerous internal parasites were observed. However, in view of the difficulties experienced in obtaining sufficient numbers of skipjack that could be **cut** open, it may be desirable to consider ectoparasites as such potential markers.

One such parasite was observed on the first dorsal fin of skipjack unloaded at the Felivaru sampling site. This parasite appears as a yellow dot lying between the two fin membranes. Its identity has not yet been established. However, two samples were taken to quantify its occurrence and allow possible comparison with Sri Lankan samples. These data are presented in Figure 4.

Length frequency analysis by ELEFAN method

Monthly samples collected between October 1985 and July 1986 were analysed with the ELEFAN program (post Sicily version).

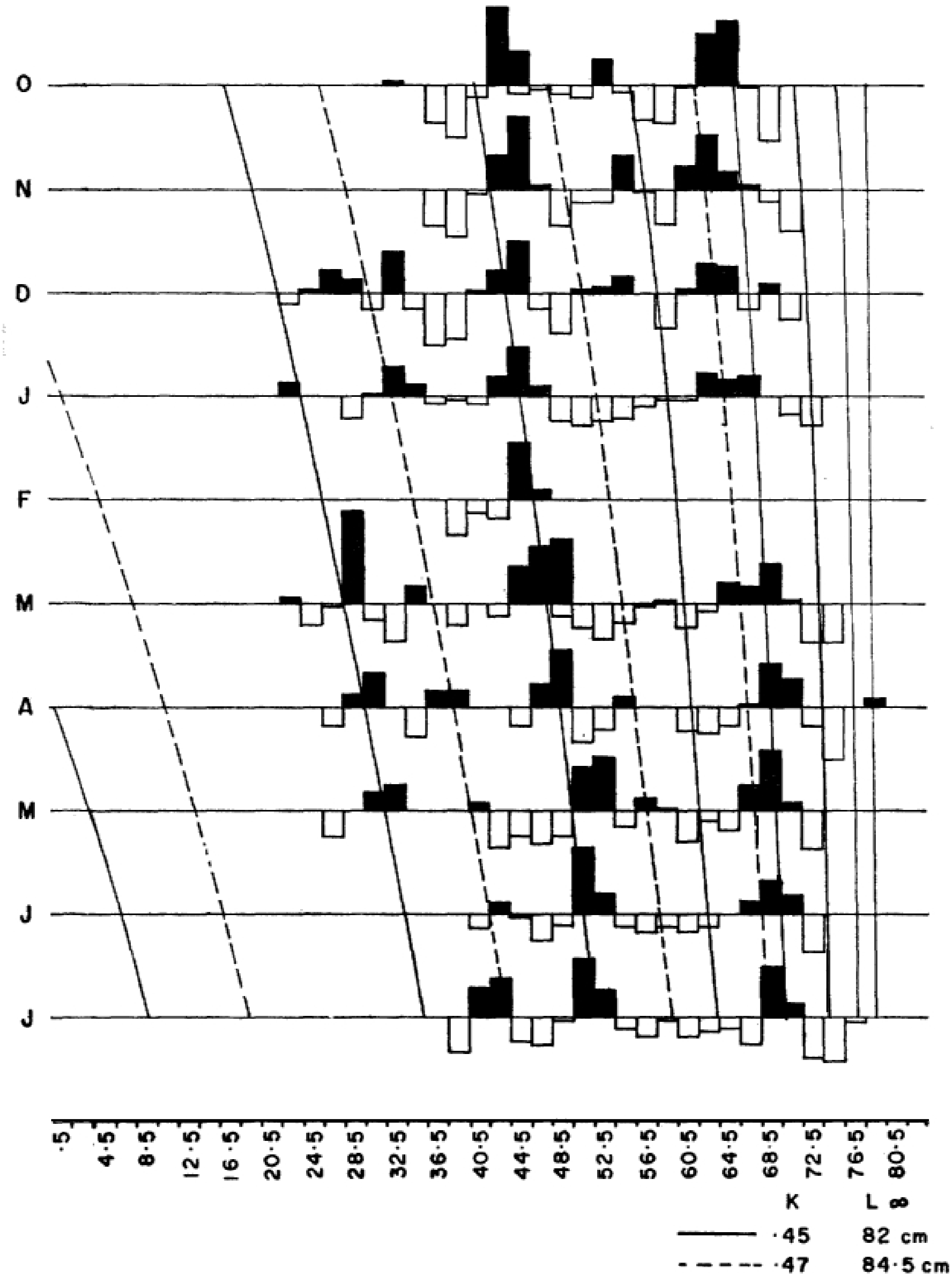

Fig. 5 Restructured monthly length frequency distribution of skipjack tuna and the growth curves.

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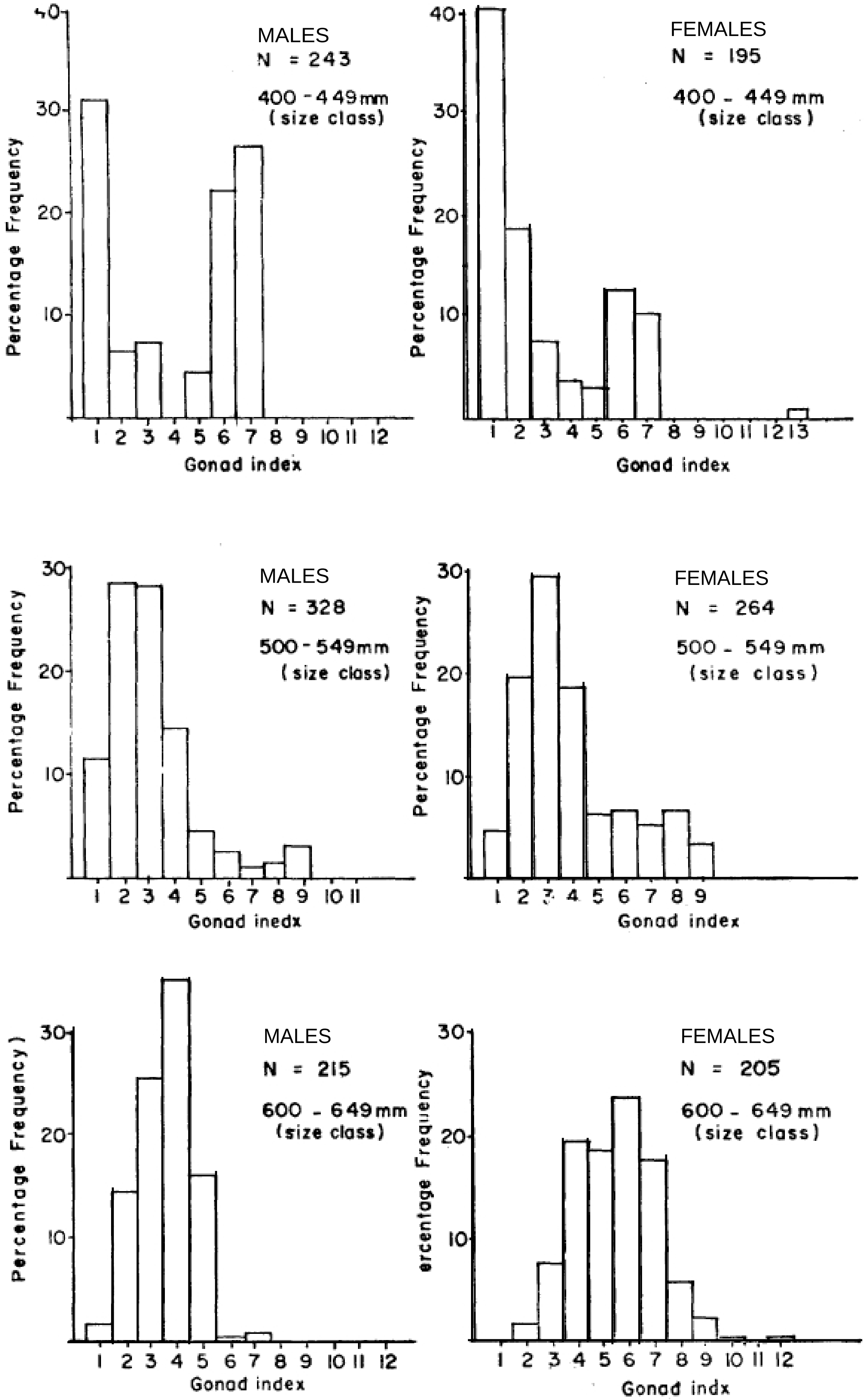

Fig. 6 Gonad indices of Maldivian skipjack tuna, June – September 1985.

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For tropical tuna species that do not exhibit marked seasonal fluctuations in growth and therefore cannot be reliably aged by conventional techniques commonly applied to the temperate species (eg. annuli on scales and otoliths), growth parameter estimation based on size frequency information is potentially a very useful technique.

From the restructured frequencies a clear modal progression was observed (Figure 5) from which two growth curves were derived, representing two broods or recruitments. The growth curves had their origins in December and March/April. The growth parameters obtained differed only slightly :

Origin	K (annual)	L_∞ (in cm)
March/April	***0.45***	***82***
December	***0.47***	***84.5***

The growth curves shown in Figure 5 imply that at least two year classes have been sampled in most months.

Reproduction

Skipjack tuna gonad samples were collected from June 1985 to August 1986, at the Felivaru canning factory, on the Lhaviyani atoll. Details of sex ratio, gonad maturity and gonad indices are summarized in Tables 7 and 8 and Figure 6 respectively.

Sex ratio

Generally, males are more abundant in the samples than females. However, there was a preponderance of females in a few samples. In the combined data for five sampled months, males formed about 73% of fish in size range 400-449 mm FL, 48% in size range 450-499 mm FL, 51% in size range 500-549 mm FL, 52% in size range 550699 mm FL, 52% in size range 600-649 mm FL and 69% in size range 650-699 mm FL (Table 7).

Gonad maturity (males)

Skipjack of less than 400 mm FL were found to be immature. Maturation appears to commence in fish of about 400 mm FL. Only one immature fish of greater than 500 mm FL was found. of male skipjack of size 400-449 mm FL, 87% were at gonad maturity stage 2 (early stage of maturity). Of fish in the size range 500-549 mm FL, 54% were at a late stage of maturity (stage 3) and 67% of size 600-649 mm FL were mature (stage 4). A few ripe males of greater than 600 mm FL were found in the September sample (Table 8).

Gonad maturity (females)

Maturation appeared to commence in fish greater than 350 mm FL. No fish of greater than 450 mm FL was immature. On the basis of limited data available it seems that females start maturing at a smaller size than males.

At size 400-449 mm FL most female skipjacks are of maturity stage 2 (early stage of maturity). At size range 450-499 mm FL most were of stage 3 (late stage of maturity) and at sizes greater than 550 mm FL most were of maturing stage 4 (mature). Some of these larger individuals were classified as being ripe (stage 5) but no spent individuals were recorded.

There is insufficient information, particularly pertaining to the larger fish, to allow any generalisation to be made concerning spawning time or areas.

Gonad indices

A summary of measurements of gonad indices of skipjack tuna at Lh. Felivary Canning Factory during June-September 1985 is presented in Figure 6. For both males and females there is a general trend towards increasing gonad index with size. Not surprisingly, larger females tend to have relatively larger gonads than males. An unexpected observation, however, is that the frequency distribution of gonad indices of both males and females of size class 400-549 mm FL is bimodal. This implies that some fish start maturing at a later stage than others. The reasons for such a difference are open for discussion.

Discussion

These studies suggest that skipjack tuna in the Maldives exploited fishing area are being fished at or close to the optimum level. Thus, expansion of fishery beyond the presently exploited waters of the EEZ might enable production to be increased. However, the stock structures and migration patterns of skipjack tuna in the oceanic area around Maldives are unknown, It is likely that skipjack tuna are more mobile than frigate or eastern little tuna but there are no data on the extent of tuna migration in the Indian Ocean. Therefore it cannot be said that expansion of the Maldivian fishery into the outer waters of EEZ will definitely allow increased fish production. However, for skipjack, the highest catch rates are recorded from the southern region, where the fishing effort is the least. There may thus be room for expansion in this region. Furthermore, it is highly probable that the skipjack resources of the Indian Ocean as a whole are very large (I PTP, 1984 ; **IOFC, 1985).**

Tuna fishing effort is also increasing around Sri Lanka. India is also reported to be stepping up its tuna fishing operations. Spanish and French purse seiners are operating out of Seychelles. Far eastern longline fleets continue to operate in the region. All this fishing effort is being directed at tuna stocks in the Central Indian Ocean. To what extent these are the same stocks as those exploited by Maldivian fishermen is unknown. Thus, it is likely future over-exploitation of tunas in other parts of the region would result in declining catch rates in the Maldives. There is, therefore, a need for international management of Indian Ocean tuna stocks. To ensure the profitable continuation of its tuna fishery, the Maldives should play an active and vocal role in this process.

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Table 1

Fish catches and fishing effort by trolling vessels (vadhu dhonis) in the Republic of Maldives, 1971-1985

Year	Catch (tonne)						No. of boat-days	No. of vessels registered
	Skipjack	Yellowfin	Frigate	Little	Others	Total		
1971	509	146	166	253	643	1,717	67,378	2,898
1972	337	136	182	343	892	1,889	76,136	2,986
1973	434	241	186	514	835	2,210	90,461	3,012
1974	399	260	202	433	1,024	2,319	93,504	3,056
1975	257	262	163	268	978	1,928	90,100	3,156
1976	489	410	289	762	1,700	3,650	135,031	3,284
1977	310	350	264	767	2,183	3,876	157,949	3,385
1978	275	370	206	634	3,044	4,529	176,878	3,390
1979	338	597	272	548	1,841	3,596	132,934	3,386
1980	487	582	304	768	2,183	4,324	136,934	3,416
1981	419	544	309	871	3,130	5,273	130,362	3,364
1982	187	234	231	1,044	3,008	4,704	132,342	3,428
1983	210	257	351	1,094	3,099	5,011	118,639	3,448
1984	333	229	333	1,009	5,857	7,761	108,314	3,021
1985	398	242	637	1,218	4,326	6,821	110,061	3,115

Table 2

Fish catches and fishing effort by sailing pole and line vessels (masdhonis) in the Republic of Maldives, 1971-1985

Year	Catch (tonne)						No. of boat-days	No. of vessels registered
	Skipjack	Yellowfin	Frigate	Little	Others	Total		
1971	28,200	1,081	2,849	220	446	32,797	169,237	2,011
1972	17,634	1,940	3,004	253	403	23,234	158,544	2,089
1973	18,761	5,234	6,440	574	699	31,708	215,278	2,146
1974	21,760	3,868	5,804	397	582	32,411	203,362	2,131
1975*	13,921	3,348	3,713	140	461	21,583	171,808	2,040
1976*	14,777	3,569	1,971	157	592	21,066	153,539	1,940
1977*	6,935	2,530	1,863	112	517	11,957	104,943	1,801
1978*	3,338	1,324	720	78	1,263	6,723	53,739	1,631
1979	1,603	733	435	94	420	3,285	24,615	1,485
1980	1,349	471	207	104	349	2,480	16,877	1,255
1981	577	273	141	119	478	1,587	13,852	1,061
1982	214	167	80	172	310	943	10,036	952
1983	122	112	141	98	177	650	6,339	811
1984	131	76	66	49	233	555	6,220	651
1985	165	82	70	99	209	625	4,681	561

* Catches for these years are estimated from records of catches by the total masdhoni fleet (i.e., sailing and mechanized vessels combined).

Table 3

Fish catches and fishing effort by motorized pole and line vessels (masdhonis) in the Republic of Maldives, 1971-1985

Year	Catch (tonne)						No. of boat-days	No. of vessels registered
	Skipjack	Yellowfin	Frigate	Little	Others	Total		
1971	—	—	—	—		—	—	—
1972	—	—	—		—	—	—	—
1973	—		—	—	—	—	—	-
1974	—	—	—	—	—	—	—	1
1975*	680	164	181	7	23	1,055	4,200	42
1976*	4,826	912	448	34	126	6,346	21,800	218
1977*	7,097	1,593	953	48	203	9,894	41,300	413
1978*	10,211	1,890	735	55	772	13,663	54,800	548
1979	16,195	2,959	994	79	454	20,681	74,904	767
1980	21,725	3,176	1,084	191	919	27,095	83,134	805
1981	19,621	4,467	1,156	284	1,584	27,112	83,731	970
1982	15,480	3,603	1,750	671	2,531	24,035	97,085	1,166
1983	19,369	5,872	3,048	895	2,575	31,759	117,172	1,231
1984	31,582	6,818	2,701	646	4,688	46,435	153,460	1,296
1985	42,005	5,715	2,071	811	3,020	53,622	162,430	1,327

* Catches for these years are estimated from records of catches by the total masdhoni fleet (i.e., both sailing and mechanized vessels).

Table 4

Total fish catches in the Republic of Maldives, 1971-1985

Year	Skipjack	Yellowfin	Frigate	Little	Others	(tonne) Total
1971	28,709	1,227	3,015	473	1,489	34,914
1972	17,971	2,076	3,186	596	1,790	25,618
1973	19,195	5,475	6,626	1,088	1,789	34,173
1974	22,160	4,128	6,006	830	1,946	35,070
1975	14,858	3,774	4,057	415	1,837	24,941
1976	20,091	4,891	2,707	953	2,730	31,374
1977	14,342	4,473	3,080	927	3,493	26,317
1978	13,824	3,584	1,661	768	5,579	25,414
1979	18,136	4,289	1,701	721	3,040	27,887
1980	23,561	4,229	1,595	1,063	4,242	34,690
1981	20,617	5,284	1,606	1,274	5,540	34,321
1982	15,881	4,005	2,061	1,887	6,656	30,489
1983	19,701	6,241	3,540	2,087	6,990	38,559
1984*	32,048	7,124	3,105	1,715	11,084	55,076
1985	42,602	6,066	2,824	2,177	8,197	61,866

* Includes catches by rowing boats as well as vadhu dhonis and masdhonis.

Table 6

Catch, effort by pole and line craft and annual catch rates (kg/trip) for skipjack tuna in Strata 3 and 6 (combined)

	Small skipjack			Large skipjack		
	Catch (t)	Trips	Catch/trip (kg/trip)	Catch (t)	Trips	Catch/trip (kg/trip)
1973	1,279	15,877	81	2	15,877	—
1974	2,381	19,028	125	82	19,028	4
1975	756	12,692	60	73	12,692	6
1976	2,426	16,640	146	22	16,640	1
1977	1,717	14,297	120	94	14,297	7
1978	945	7,597	124	214	7,599	28
1979	1,603	5,706	214	519	5,706	69
1980	2,339	9,441	248	414	9,441	44
1981	2,574	8,368	308	9	8,368	1
1982	1,677	12,089	139	499	12,089	41
1983	1,438	11,192	128	928	11,192	83
1984	I.384	10,282	135	2,058	15,384	133
1985	3,717	18,376	202	1,818	18,376	99

Table 7

Sex ratio in Maldivian skipjack sample

Size Class		June 1985	July 1985	August 1985	September 1985	November 1985	December 1985	April 1986	June 1986	August 1986
300-349 mm F.L.	% Males	—	—	—	—	100				
	% Females	—	—	—	—					
	% Unknown	—	100	—	—					
	Total number	—	2	—	—	1				
350-399 mm F.L.	% Males	—	13.1	—	—					
	% Females	—	22.2	—	—					
	% Unknown	—	64.7	—	—					
	Total number	—	99	—	—					
400-449 mm F.L.	% Males	66.25	32.7	58.54	43.5		83		60	
	% Females	33.75	46.1	41.46	56.5		17		40	
	% Unknown		21.2	—	—		—		—	
	Total number	160	52	164	85		— 6		5	
450-499 mm F.L.	% Males	—	38.8	—	—		45		49	
	% Females	—	61.2	—	—		54		51	
	% Unknown	—	—	—	—		1		-	
	Total number	—	67	—	—		76		128	
500-549 mm F.L.	% Males		44.6	57.35	57.24		53		68	
	% Females	—	55.4	42.65	42.76		47		32	
	% Unknown	—	—	—			—		—	
	Total number	—	92	347	145		78		156	

Table 7-(contd.)

Size Class		June 1985	July 1985	August 1985	September 1985	November 1985	December 1985	April 1986	June 1986	August 1986
550-599 mm F.L.	% Males	—	68.75	—	—		59		52	
	% Females	—	31.25	—	—		47		48	
	% Unknown	—		—	—		—		—	
	Total number		16				46		31	
600-649 mm F.L.	% Males	—	50.0	49.0	59.6		56		52	38
	% Females	—	50.0	51.0	40.4		44		48	62
	% Unknown	—	—	—	—		—		0	—
	Total number	—	20	298	104		105		56	26
650-699 mm F.L.	% Males	—	—	55.56	—		75	66	67	57
	% Females	—	—	44.44	—		25	33	33	43
	% Unknown	—	—	—	—		—	1	—	—
	Total number	—	—	9	—		105	104	30	28

Table 8

Gonad maturity of Maldivian skipjack samples

1 immature, 2 & 3 maturing, 4 mature, 5 ripe, 6 spent

		Fork length (mm)					
		400-449	500-549	600-649	400-449	500-549	600-649
	Stage	Females			Males		
June	1	—	—	—	27.3	—	—
1985	2	63.0	—	—	67.0	—	—
	3	31.5	—	—	5.7	—	
	4	5.5	—	—	—	—	-
	5	—	—	—	—	—	—
	6	—	—	—	—	—	—
	Total number	54			106		
July	1	35.3	—	—	12.5	—	—
1985	2	64.7	7.3	—	79.2	—	—
	3	—	36.6	10.0	8.3	19.6	—
	4	—	53.7	90.0	—	60.8	—
	5	—	2.4	—	—	19.6	100.0
	6	—	—	—	—	—	—
	Total number	17	41	10	24	51	10
August	1	2.94	—	—	6.3	—	—
1985	2	97.06	8.11	0.66	90.6	10.05	0.7
	3	—	70.27	20.39	3.1	59.80	18.5
	4	—	21.62	78.95	—	30.15	80.8
	5	—	—	—	—	—	—
	6	—	—	—	—	—	—
	Total number	68	148	152	96	199	146
September	1	14.58	—	—	32.43	1.2	—
1985	2	50.0	9.7	—	51.35	38.6	9.68
	3	25.0	64.5	19.05	16.2	48.2	37.09
	4	—	9.7	35.71	—	12.0	30.65
	5	10.42	16.1	45.24	—	—	22.58
	6	—	—	—	—	—	—
	Total number				37	83	62
November	1	16.28	14.3	—	55.17	—	—
1985	2	48.84	28.57	—	27.59	87.5	19.05
	3	30.23	57.14	50	13.79	12.5	42.86
	4	4.65	—	43.75	3.45	—	33.33
	5	—	—	6.25	—	—	4.76
	6	—	—	—	—	—	—
	Total number	43	7	16	29	8	21

Table 8-(contd.)

		Fork length (mm)					
		400-449	500-549	600-649	400-449	500-549	600-649
	Stage	Females			Males		
December	1	—	—	—	—	—	—
1985	2	100	8.11	—	60	4.88	—
	3	—	37.84	4.35	40	43.90	15.25
	4	—	54.05	85.65	—	51.22	84.75
	5	—	—	—	—	—	—
	6	—	—	—	—	—	—
	Total number	1	37	46	5	41	59
June	1	—	—	—	—	—	—
1986	2	5.97	—	—	13.64	6.60	—
	3	53.73	42	3.70	63.64	60.38	6.9
	4	40.30	54	96.30	22.73	33.02	89.66
	5	—	4	—	—	—	3.45
	6	—	—	—	—	—	—
	Total number	67	50	27	66	106	29
August	1	—	—	—	—	—	—
1986	2	—	2.13	—	—	13.8	—
	3	—	57.45	—	—	67.24	60
	4	—	40.43	100	—	18.97	40
	5	—	—		—	—	—
	6	—	—	—	—	—	—
	Total number	—	47	16	—	58	10

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Annexure 3

YELLOWFIN TUNA IN THE MALDIVES

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Introduction

Yellowfin tuna *(Thunnus albacares)* is the second most important fish species caught in the Maldives. Only skipjack tuna *(Katsuwonus pelamis)* is caught in larger quantities. Betwen 1970 and 1984 the average annual yellowfin catch was about 4,200 t. This amounts to some 13% of the total annual recorded catch. Yellowfin catches have increased recently with an average of about 6,500 t caught annually between 1983 and 1985.

The bulk of the yellowfin catch comprises surface swimming juveniles taken by live bait pole and line vessels (masdhonis). Since 1974-75 the active component of this traditionally sailing fleet has been almost entirely motorized. Some yellowfin, including larger fish, are also taken by trolling and drop lining (mainly by vadhu dhonis). In addition, Far Eastern Longliners operating in the waters around the Maldives are known to take deep swimming adults.

This report summarizes biological knowledge of yellowfin caught in the Maldives.

Major trends in the Maldivian yellowfin fishery

Annual recorded catches of yellowfin by vessel type are presented in Table 1.

There is an apparent trend, albeit irregular, towards increased catch during the period 1970-1985. Recorded catches have increased from 1 ,OOO-2,000 t in 1970-l 971 to 6,000-7,000 t in 1983-l 985. However, the apparently substantial increase is probably exaggerated. Account should be taken of the probable systematic under-reporting of yellowfin catches in 1970-l 971 and over-reporting in 1984-l 985. A new catch recording scheme *was* introduced in 1970 under which yellowfin and skipjack catches were separated for the first time. It is unlikely to have been immediately effective, as part of the yellowfin catch in 1970-1971 was probably still being recorded as skipjack. Considering catch rates, more reasonable estimates of yellowfin catches in these years (and previous years as well) might be about 3,000 t in early 1984 a tax on transport vessels (i.e., all those that do not complete 180 days of fishing per year) was introduced, As a result some fishermen are known to have over-reported fishing effort and catch in 1984 and 1985. Most of the over-reporting of catch is thought to have been of skipjack, but as a rough approximation it is suggested that yellowfin catch in 1984 was over-estimated by 5%. Taking these factors into account, the true increase in yellowfin catch may have been from about 3,000 t to about 6,000 t in the 15-year period.

A most marked trend in recent years has been the almost total replacement of sailing masdhonis by motorized masdhonis in the yellowfin fishery. The first masdhoni was motorized in 1974. By 1979,80% of the recorded catch of yellowfin by masdhonis was taken by those with engines. By 1984 this figure had risen to 99%. Sailing masdhonis are no longer a force of any importance in the yellowfin fishery. Most yellowfin are caught offshore, outside the atolls. Most sailing vessels that are still fishing now confine their activities to the intra-atoll waters, where their lack of an engine is not such a disadvantage.

Vadhu dhonis (small sailing vessels) continue to make a minor but regular contribution to yellowfin production. Between 1970 and 1985 the annual recorded catch of yellowfin by vadhu dhonis was about 320 t, which is about 8% of the average annual production of this species.

This paper was presented at the third meeting of the working group on tunas in the EEZs of Maldives and Sri Lanka ; 22-25 September 1986, Colombo, Sri Lanka.

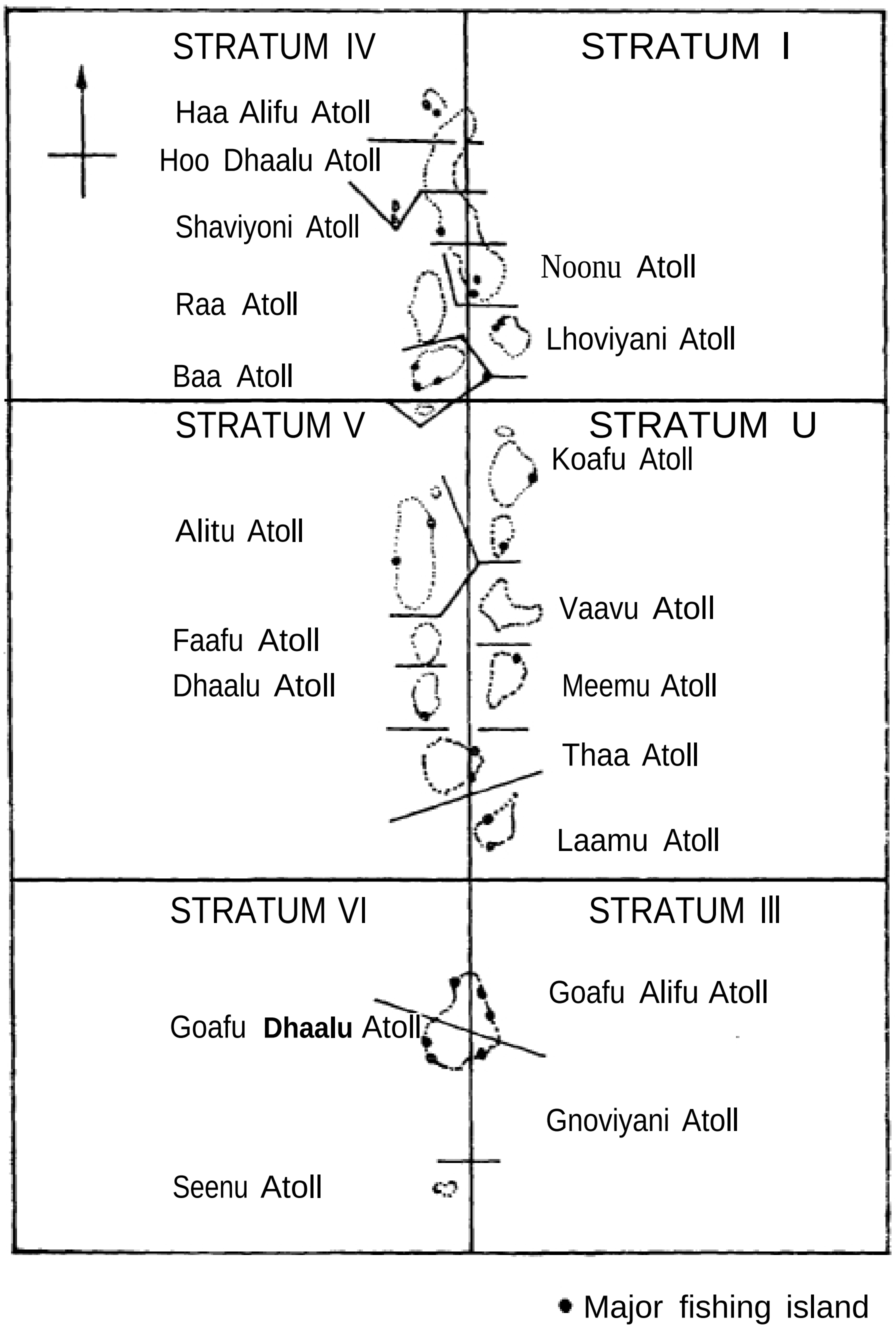

Fig. 1 Map showing the six strata of the Maldive islands.

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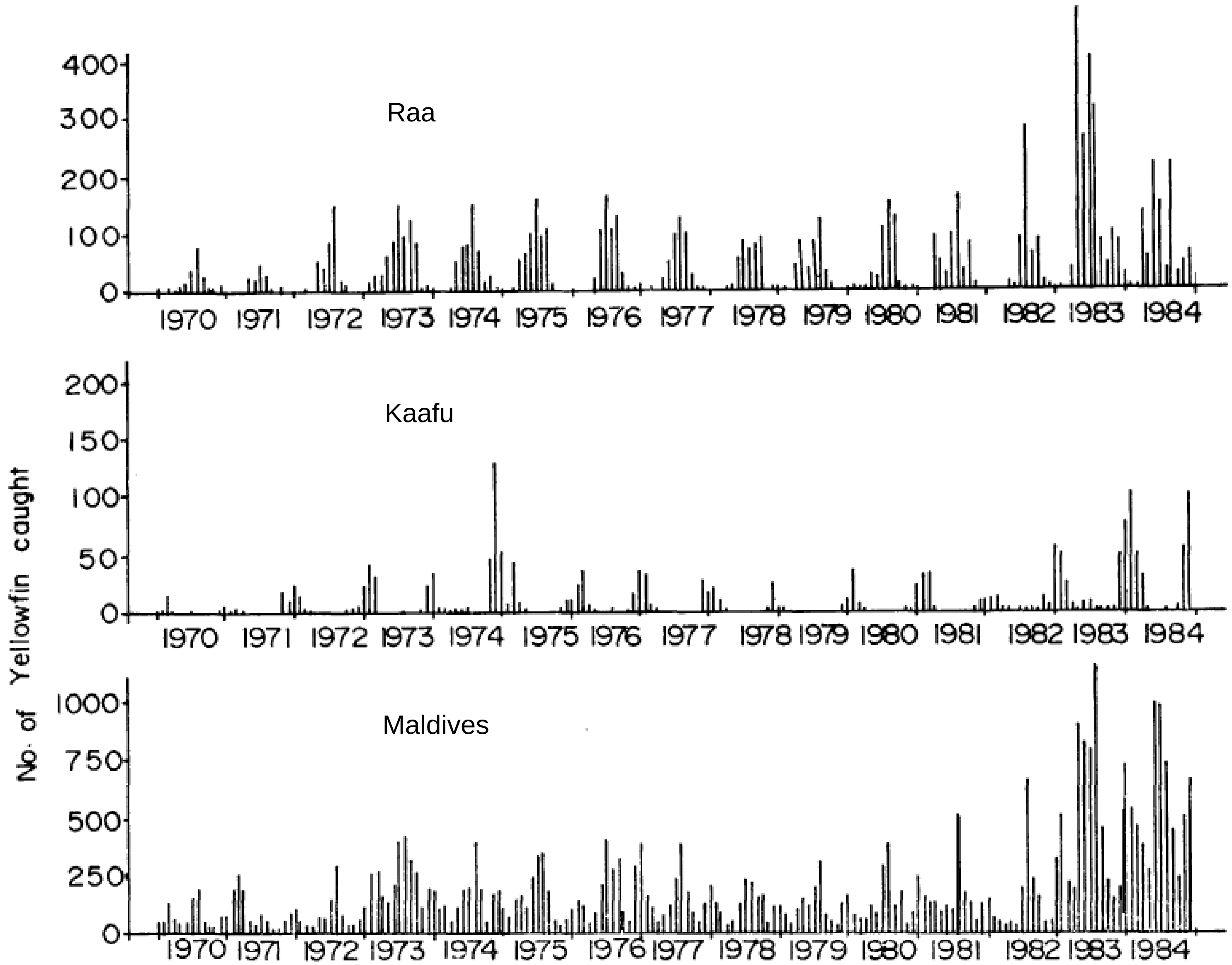

Fig. 2 Monthly catch of yellowfin tuna, 1970-1 984, in the Raa and Kaafu Atolls and in the Maldives as a whole.

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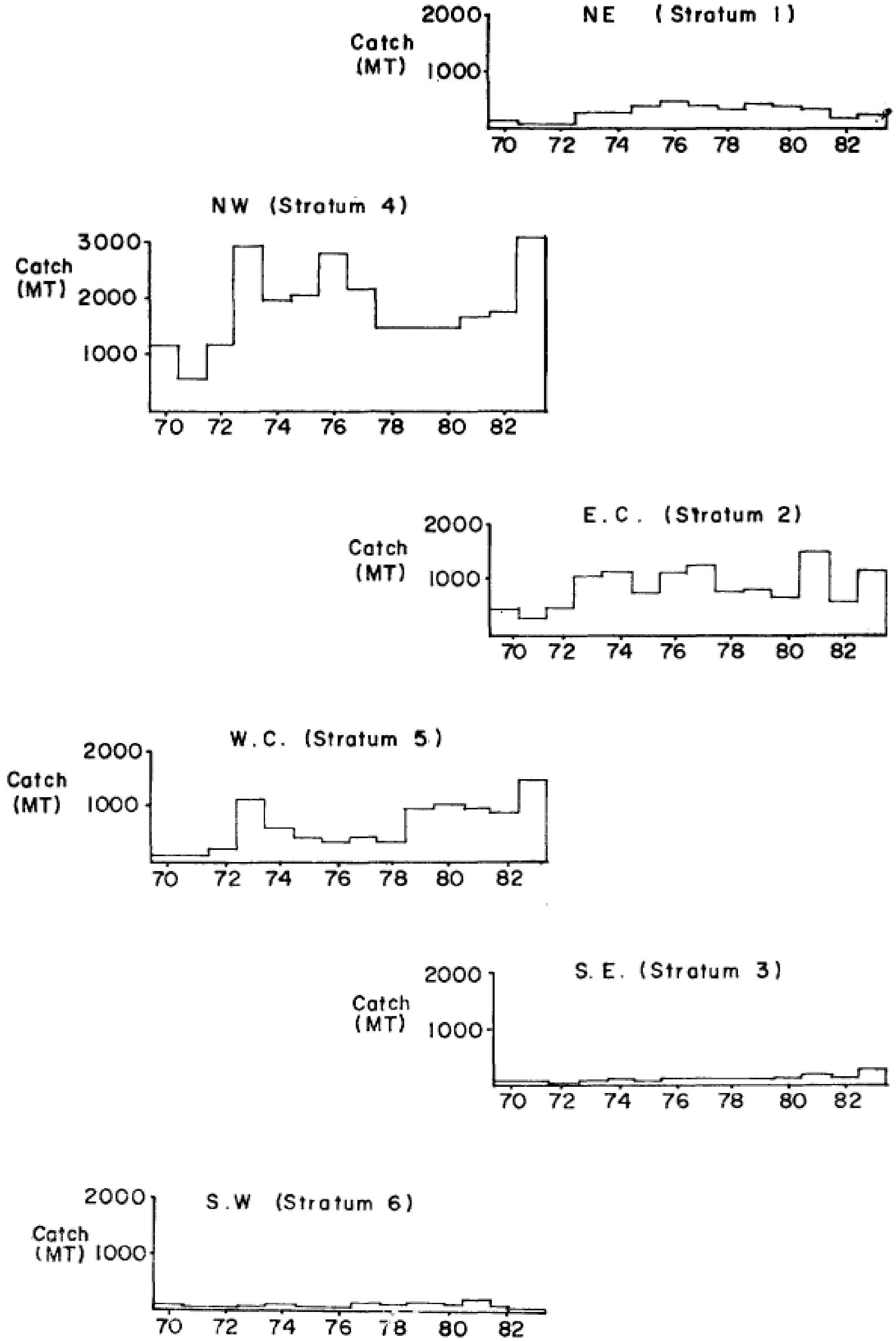

Fig. 3 Annual yellowfin catches by pole and line and trolling boats, by strata (1970-1982).

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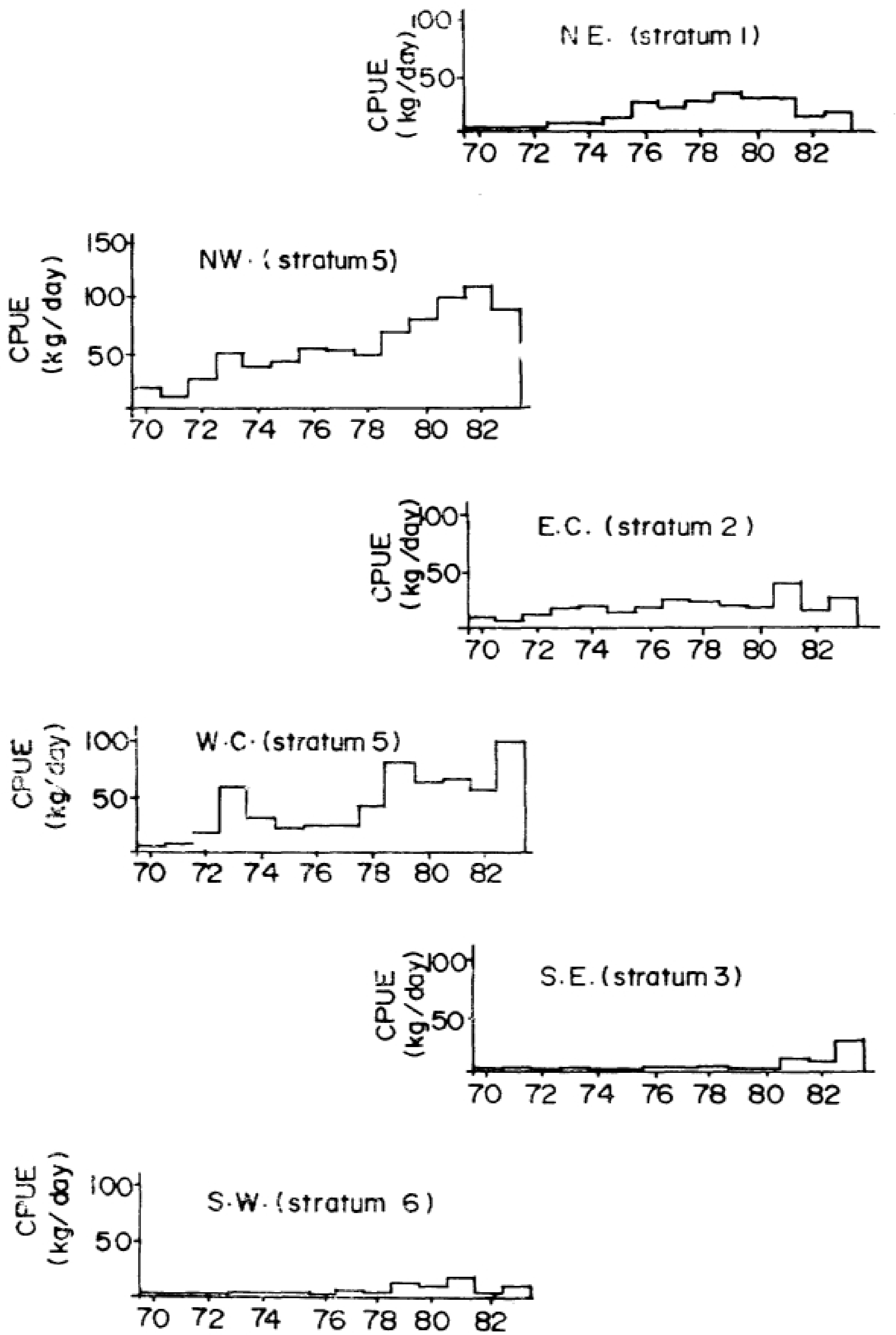

Fig. 4 Catch rate distribution of yellowfin caught by pole and line craft by strata (1970-1982).

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Yellowfin catches by vadhu dhonis increased from less than 200 t per year in 1970-l 972 to more than 500 t per year in 1979-1981. Annual catches during 1982-1985 were reduced to about 250 t. Most vadhu dhonis operate as trolling vessels within the atolls. Some, however, operate outside the atolls as trollers or dropliners. It is these that catch yellowfin.

Far Eastern Longliners have been operating in the waters around the Maldives since about 1954. Klawe (1980) estimates that during the six year period 1972-l 977 these vessels took an average of about 340 t of yellowfin each year from the waters that now form the 200 mile EEZ of **the** Maldives. The changing pattern of fishing activity of the three nations involved in this fishery in the area around the Maldives is illustrated in Figure 11.

Seasonal and regional variations in catch rate

There appear to be three major components to the Maldivian yellowfin fishery.

1. A pole and line fishery for juvenile yellowfin of size range 25-55 cm fork length (FL) off the western coast of the Maldives during the south-west monsoon season. This fishery peaks in July and August off Raa, Baa, Alifu and Dhaalu atolls, although it is discernible in atolls on the western seaboard from June to September (a map of the Maldives is provided in Figure **1).** This fishery is conducted most successfully by fishermen from just two islands, Tulaadhoo (in Baa atoll) and Kandholudhoo (Raa). During the season, fishermen from these islands leave very early each morning and travel 30-50 miles out into the ocean in search of yellowfin schools. Boats average 300 fish per day in peak months. These two islands account for nearly a third of all yellowfin tuna caught in the Maldives.

2. A pole and line fishery for juvenile yellowfin of size range 25-55 cm FL off the eastern coast of the Maldives during the north-east monsoon season. This fishery peaks from December to February and is most noticeable in Lhaviyani and Kaafu atolls. These yellowfin are often associated with oivali (pieces of driftwood and other flotsam carried by the seasonal currents from India or Sri Lanka). The highest catch rates are achieved by fishermen who locate these drifts.

3. Pole and line, trolling line, and dropline fisheries for juvenile and adult yellowfin of greater than 45 cm FL, in relatively small numbers throughout the Maldives, using pole and line. While there are undoubtedly seasonal and regional variations in catch rates, insufficient data are available at present to resolve them. However, sizeable catches of large yellowfin are reportedly taken off the southern atolls, particularly Gnaviyani, during December.

The highly seasonal nature of the two juvenile yellowfin fisheries is illustrated by Figure 2, which shows monthly catches of yellowfin in both Raa and Kaafu atolls for the 15-year period 1970-l 984. Other atolls show similar seasonal patterns, although usually not so clearly — presumably because in those cases fishing is less concentrated on one side of the atoll. There is also, in some cases (e.g., Baa, Thaa and Laamu atolls), less barrier to movement of yellowfin from one side of the Maldives to the other. For comparison, monthly catches for the whole of the Maldives are also included in Figure 2. The influx of juvenile yellowfin during the south-west monsoon season (which includes the Raa atoll catch) is clearly the largest component in the national catch. This is reflected not only by larger absolute catches, but also by higher catch rates.

Fig. 3 shows the annual catches in each of the six regional strata (refer to Figure 1 for details of these strata). The highest catches are achieved in Stratum 4 (north-west Maldives). Relatively high catches are also taken in Stratum 5 (West Central Maldives). In both cases these catches are of juvenile yellowfin during the south-west monsoon. On the eastern side of the country, the influx of juvenile yellowfin during the north-east monsoon season gives relatively high catches in Stratum 2 (East Central Malaives) and, to a lesser extent, Stratum I (north-east Maldives). Low catches of yellowfin are recorded from the south of the country (Strata 3 and 6).

These observations are mirrored in Fig. 4 which illustrates annual catch rates by masdhonis for the six strata. Since masdhonis account far some 90% of the total yellowfin catch this is not surprising. The marked increase in catch rates during this period by masdhonis operating in Strata 4 and 5 (north-west and west-central Maldives) is probably attributable to motorization which allowed masdhonis to travel greater distances offshore more easily than they used to.

Figure 5 illustrates annual yellowfin catch rates by vadhu dhonis for the years 1970-l 984. The regional pattern is different fram that for masdhonis. The lowest catch rates by vadhu dhonis are achieved in Stratum 4 (north-west Maldives), where masdhonis record their highest catch rates. This is presumably because the juvenile yellowfin found in this area during the south-west monsoon season are most abundant at some distance offshore. Catch rates by vadhu dhonis are the highest on the eastern side of the Maldives, possibly because the north-east monsoon seasonal influx of juvenile yellowfin comes much closer inshore. The smaller differences in catch rates between regions by vadhu dhonis compared to masdhonis may be attributed to their use of trolling lines and drap lines to catch large yellowfin, which are presumably more evenly distributed thruughout the Maldives or commoner in the south than are juvenile yellowfin.

Average yellowfin catch rates for different vessel types and time periods are summarized below :

Vessel type	Period	Catch rate (kg/day)
Vadhu dhoni	1970-1974	2.3
Sailing masdhoni	1970-1974	14.8
Vadhu dhoni	1979-1983	3.4
Motorized masdhoni	1979-1983	44.0
Vadhu dhoni	**1970-1983**	2.8
Total masdhoni	1970-1983	24.7

Catch rates during peak seasons can be much higher. For motorized masdhonis in Raa and Baa Atolls the average catch rate during the months of July and August (1978-1983) was 241 kg yellowfin/day. For motorized masdhonis in Lhaviyani and Kaafu Atolls, the average catch rate during the months of December and January (1979-1983) was 41 kg/day.

Catch and effort relationship

An analysis of catch and effort data with the aim of estimating maximum sustainable yields (MSY) for all four of the major tuna species was carried out by Anderson and Hafiz (1985). This section is largely based on that work.

Standardisation of fishing effort:

Fishing effort was crudely standardised to the "motarized masdhoni day". This is the best unit of effort available from Maldivian data, and it is also compatible with the aims of this workshop in that it should allow comparison of results from both countries at the level of motorized pole and line vessels.

In attempting to standardise fishing effort, the main problem has been the lack of separate catch and effort statistics for the two classes of pole and line vessels during the early period of mechanisation (1974-1978). Separate data are available from 1979 onwards only. To over-come this problem the following assumptions were made:

1. The overall catch rate of motorized masdhonis was approximately twice that of sailing masdhonis during the period of motorization (Anon, 1977; Anderson and Hafiz, 1985).

2. Prior to motorization, sailing masdhonis had the same catch composition as motorized masdhonis in 1979-l 980 (Anderson, 1984). Changes in catch composition cf sailing masdhonis that took place during 1975-1978 were assumed to be approximately linear.

3. During the period 1975-1979, motorized masdhonis completed an average of 100 fishing days per year. (Anon, 1977; Anderson and Hafiz, 1985). Increasingly uncompetitive sailing masdhonis completed increasingly fewer fishing days each year,

4. In 1970-1971, as the result of the introduction of a new catch recording scheme and the giving of prizes to top fishermen, it is assumed that yellowfin catches by masdhonis were under-estimated by 5%. As a result of the introduction of a tax on transport vessels it is assumed that yellowfin catch by motorized masdhonis in 1984 was overestimated by 5% and fishing effort by 10%.

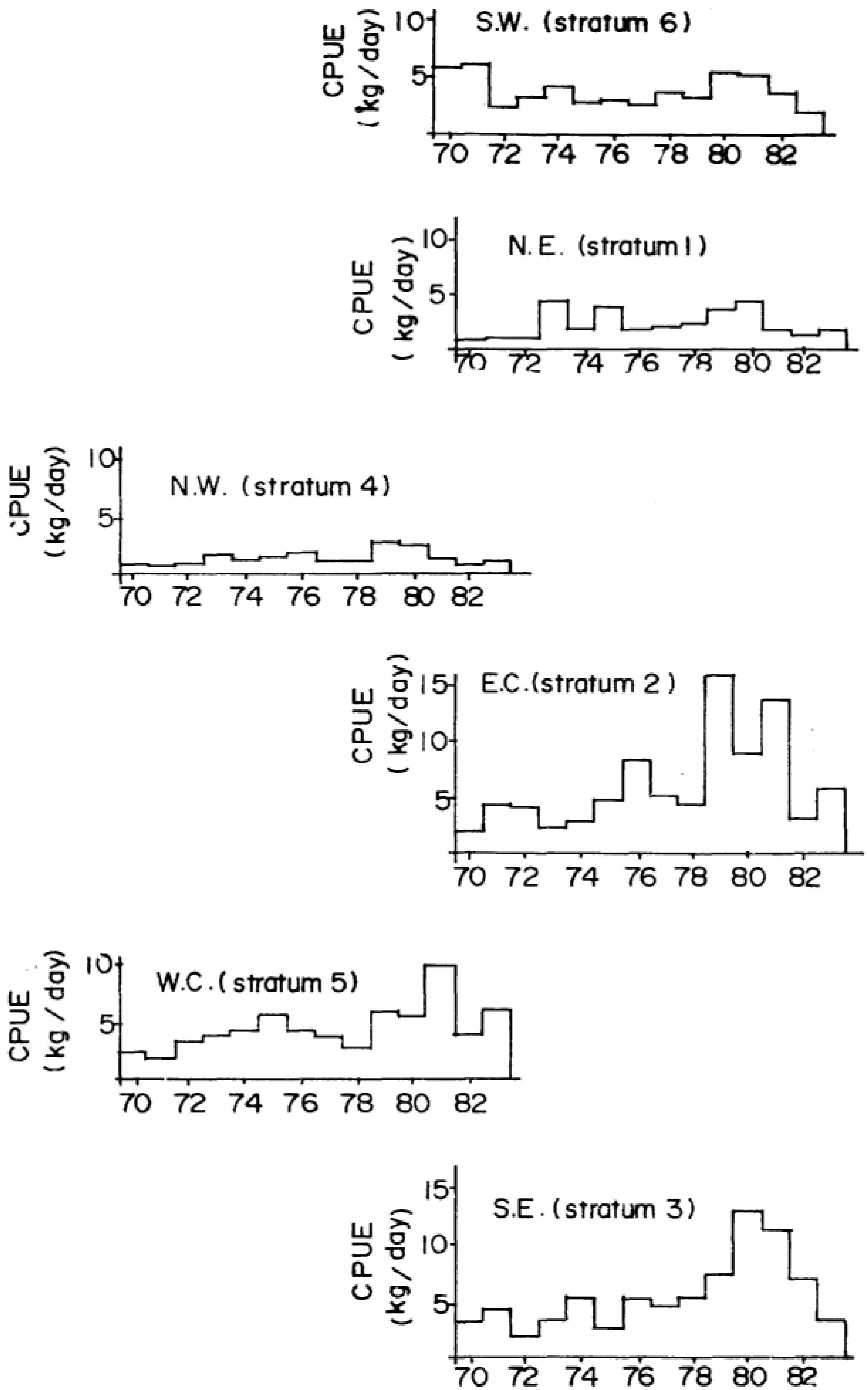

Fig. 5 Catch rate distribution of yellowfin caught by trolling craft, by strata (1970—1982).

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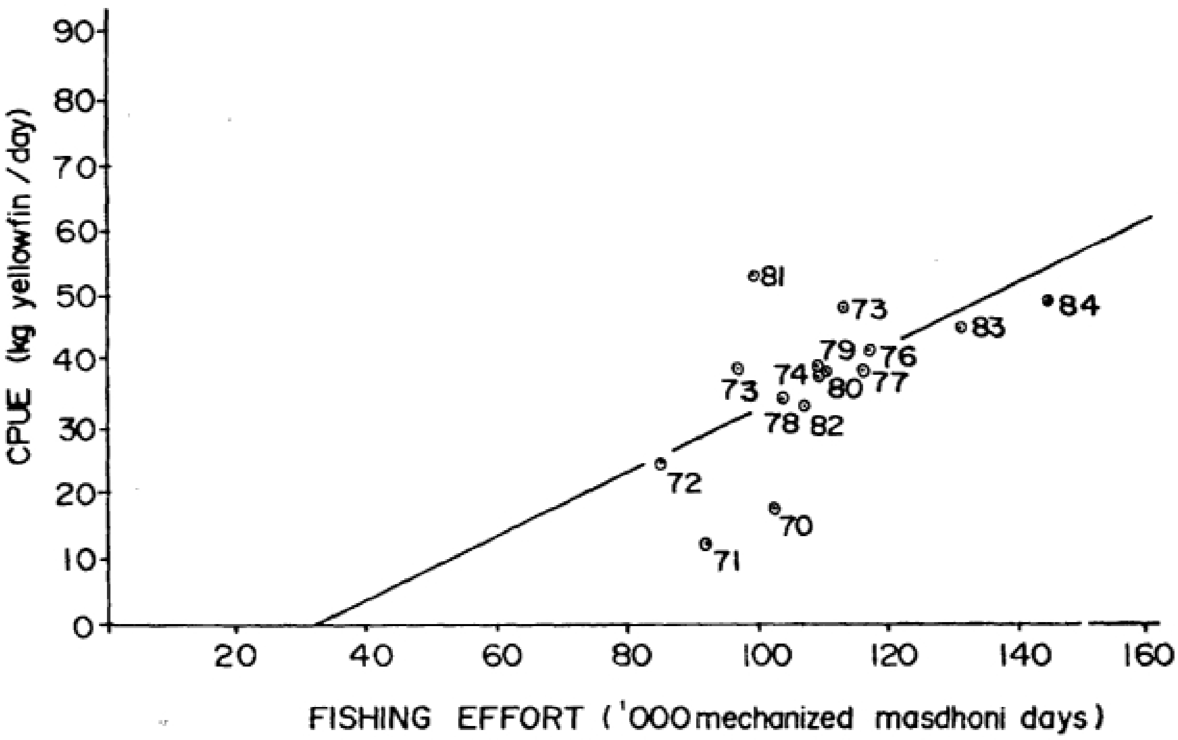

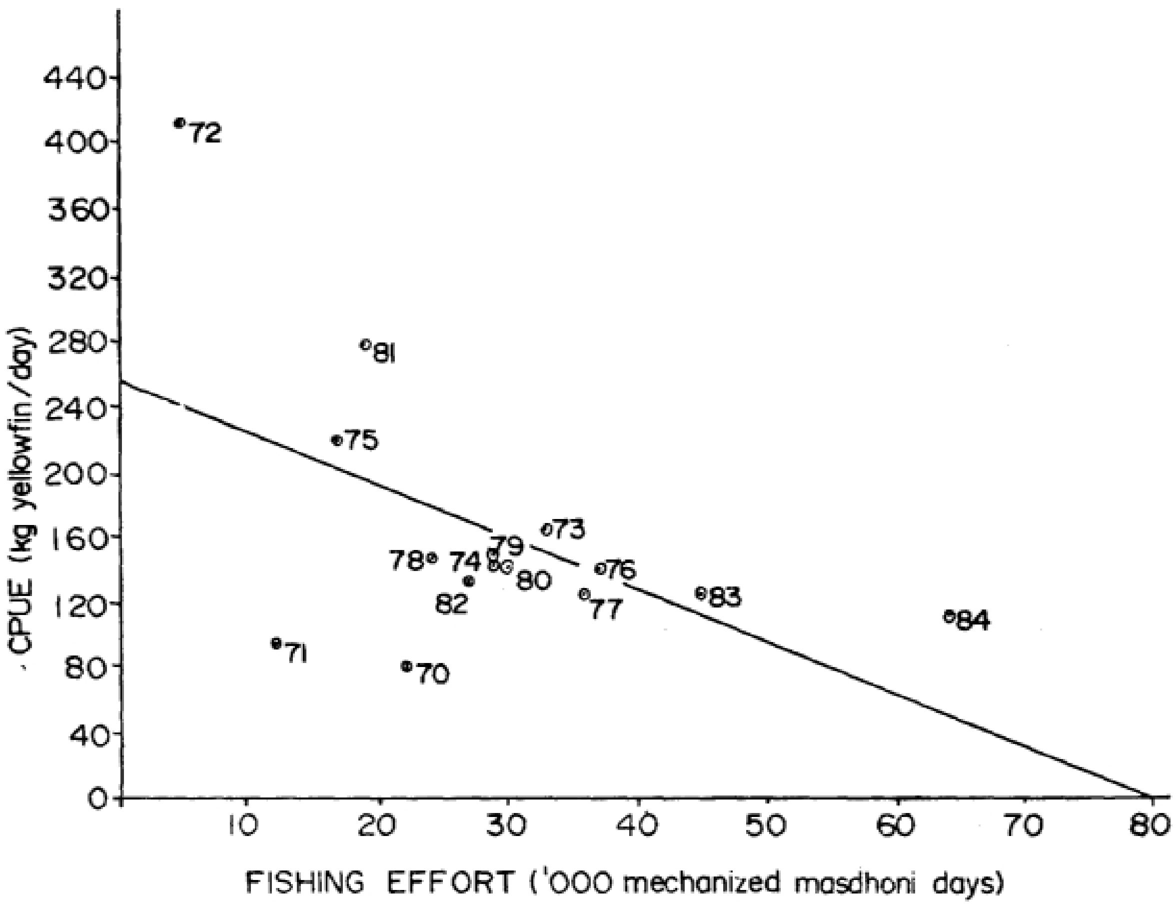

Fig. 6a and b Relationship between effort and CPUE for Maldivian yellowfin fishery.

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5. The contribution to production of the single masdhoni motorized in 1974 is assumed to be zero.

On the basis of these assumptions standardization of effort was carried out in three stages:

1. For the years 1979-l 984, given the catch and effort by motorized masdhonis and the total catch, total equivalent effort in motorized masdhoni days was calculated in proportion.

2. For the years 1975-1978, the number of days fished by both motorized and sailing masdhonis war estimated. Yellowfin catch rates by vessel type were then estimated. The total equivalent effort in motorized masdhoni days' was then calculated in proportion.

3. For the years 1970-1974, effort was standardized to motorized masdhoni days' by halving sailing masdhoni effort.

The result of these estimates is summarised in Table 2.

Estimation of MSY

Analysis of these data was carried out using the FAO fisheries statistics package for Apple Ile microcomputers made available through BOBP. MSY analysis by both Schaeffer's and Fox's method was attempted. Meaningful results were not obtained. A positive correlation of catch rate (CPUE) with effort was found (Fig. 6a). This implies that increasing fishing effort will always be rewarded by ever-increasing catches, an obviously impossible situation.

Apart from minor errors in the data and inadequacies in the standardisation of fishing effort, there are two major explanations for this result. First, the fishery for yellowfin is to a large extent seasonal and directed. Use of total Maldivian fishing effort in these models will therefore grossly overestimate the actual effort directed against yellowfin. By assuming that various proportions or absolute amounts of annual effort were not directed against yellowfin, new correlations of CPUE on E were calculated (one such is illustrated in Figure 6b). Iterative optimization leads to the estimation of an MSY of about 5,000 t of yellowfin per year. However, a second major problem remains. This simple MSY approach may not be appropriate, not only because there are distinct and possibly separate components to the Maldivian yellowfin fishery, but also because the yellowfin fished in the Maldives may suffer fishing mortality in other areas by fleets of other countries. Wider problems of tuna stock assessment are discussed by Gulland (1984) and Sharp (1983).

Morphometrics

Eight morphometric measurements (as recommended in BOBP, 1985) were taken from samples of yellowfin for comparison with Sri Lankan data. In all, 274 yellowfin ranging in size from 366 to 1 ,151 mm FL were measured. A summary of samples is given below:

Month	Atoll	Size range (mm FL)	Number
June 1985	Baa	398- 476	85
	Raa	366- 500	85
July 1985	Lh	432- 620	27
	Raa	370- 653	31
August 1985	Lh	440- 527	19
	Raa	375- 477	40
September 1985	Lh	585-1.151	37

One yellowfin from each of the two June samples was measured ten separate times in order to check on the accuracy of measurements. Both fish were of about 41 cm FL. In both cases the range of recorded values for each morphometric measurement was about 5-6 mm (maximum 8 mm). These variations are felt to be due largely to human error, but also to systematic changes in fish shape. This phenomenon was observed more obviously in some skipjack 'control' specimens that clearly changed shape during the time that measurements were being taken (i.e.

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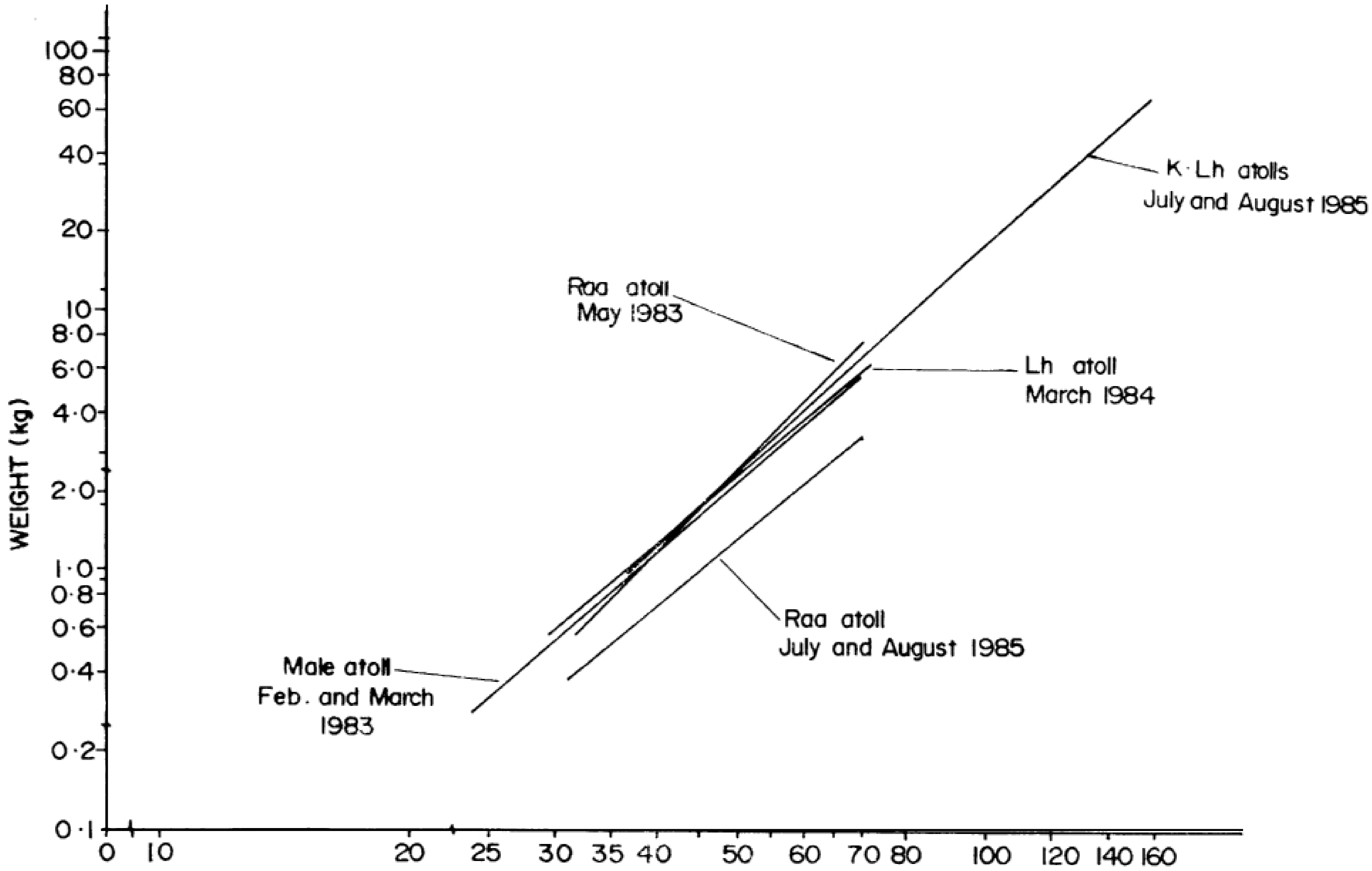

Fig. 7 Length-weight relationships for five samples of yellowfin tuna from the Maldives (log scale).

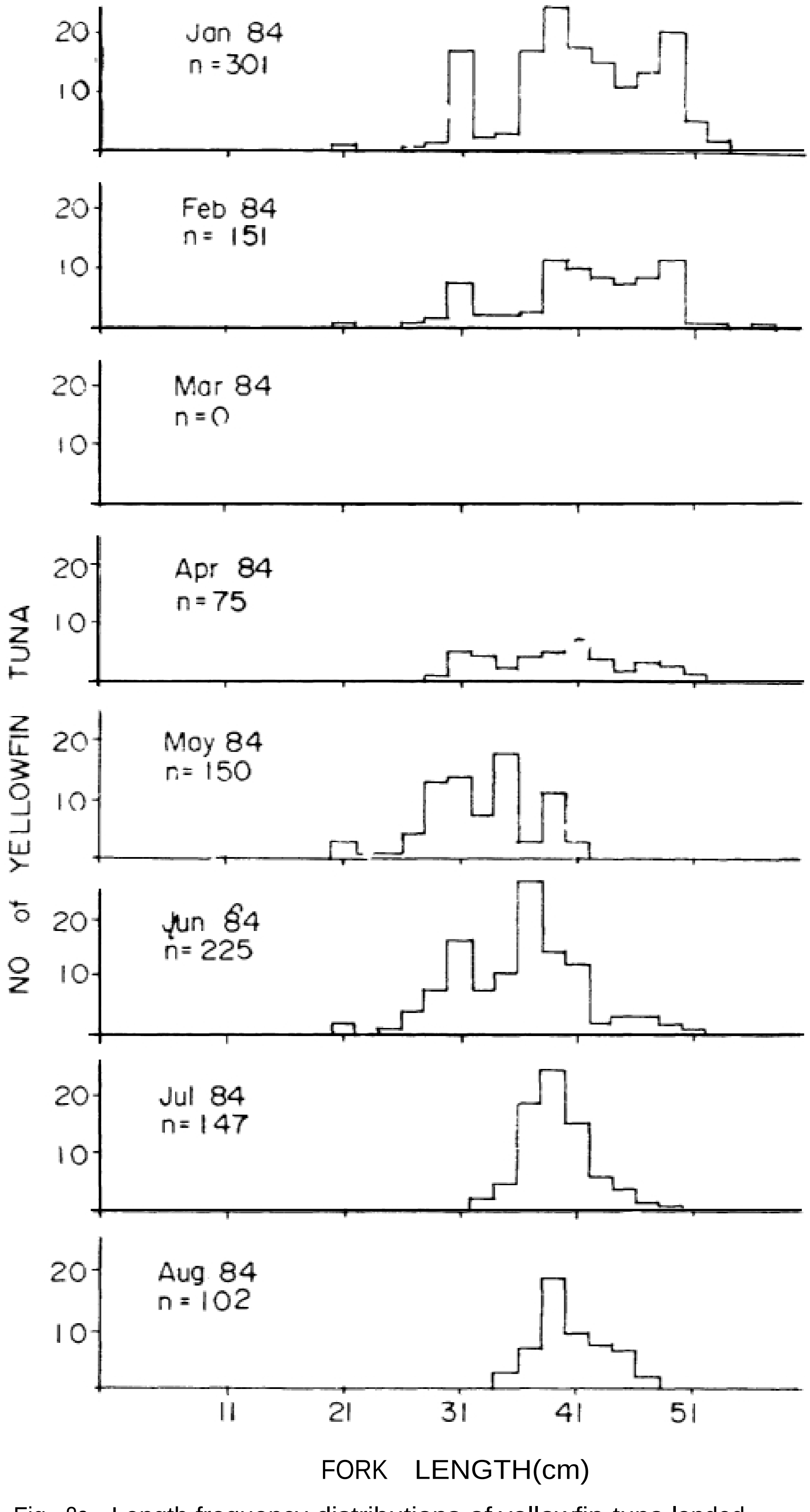

Fig. 8a Length frequency distributions of yellowfin tuna landed at Eydafushi (Baa Atoll) by pole and line craft (1984).

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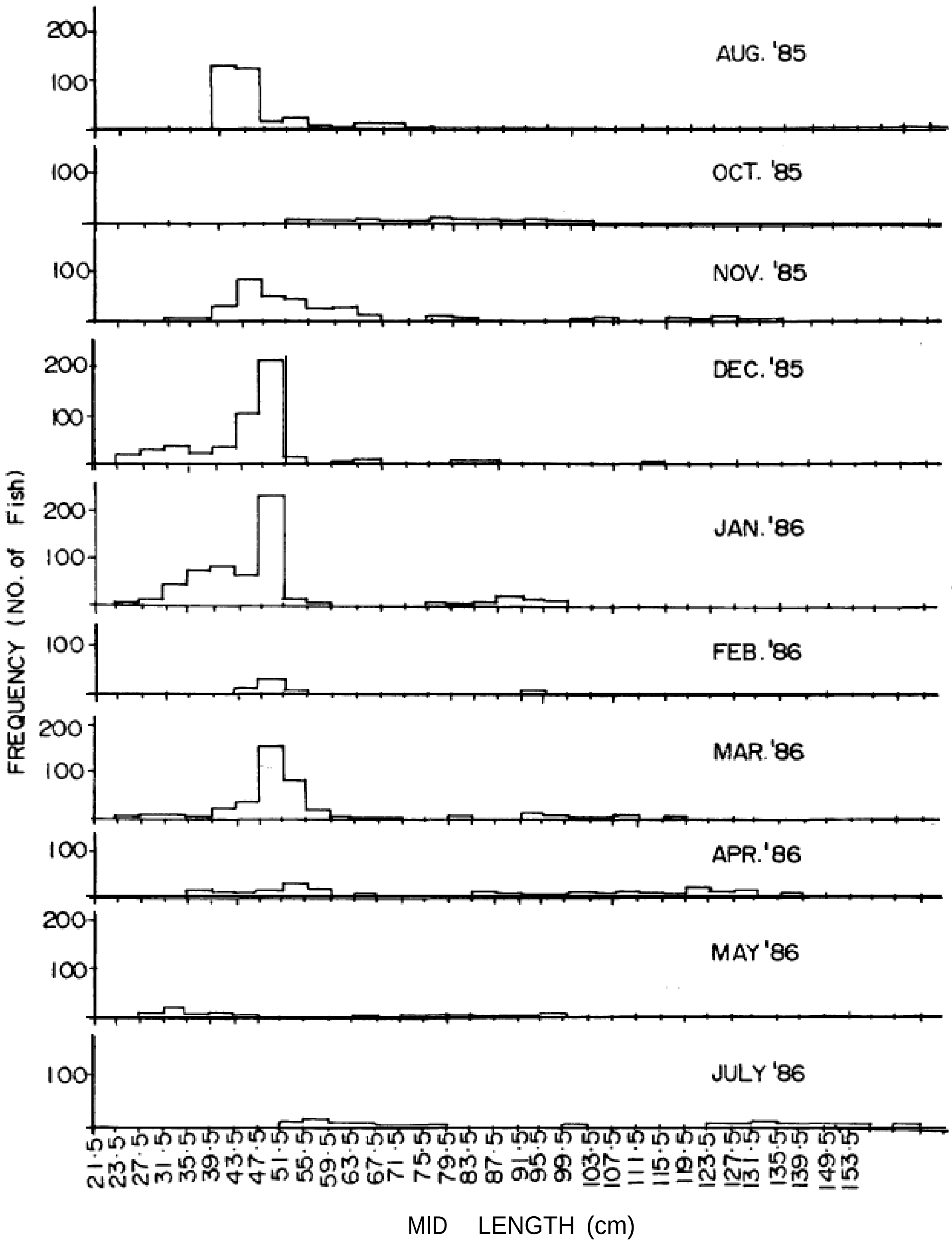

Fig. 8b Length frequency distribution of yellowfin catches landed at Eydafushi by pole and line craft (1985/86).

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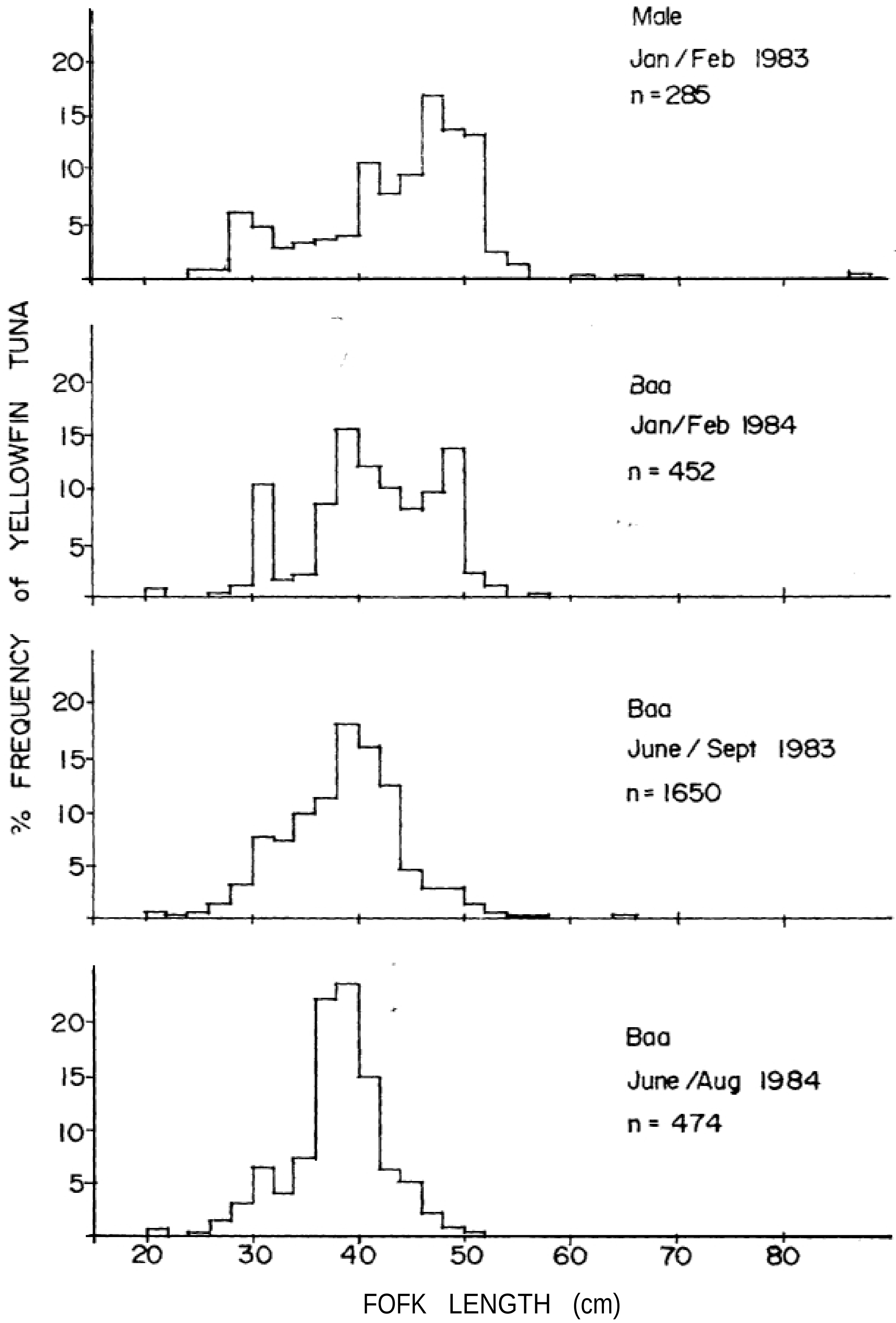

Fig. 9 Yellowfin length frequency distributions from Male and Baa Atolls.

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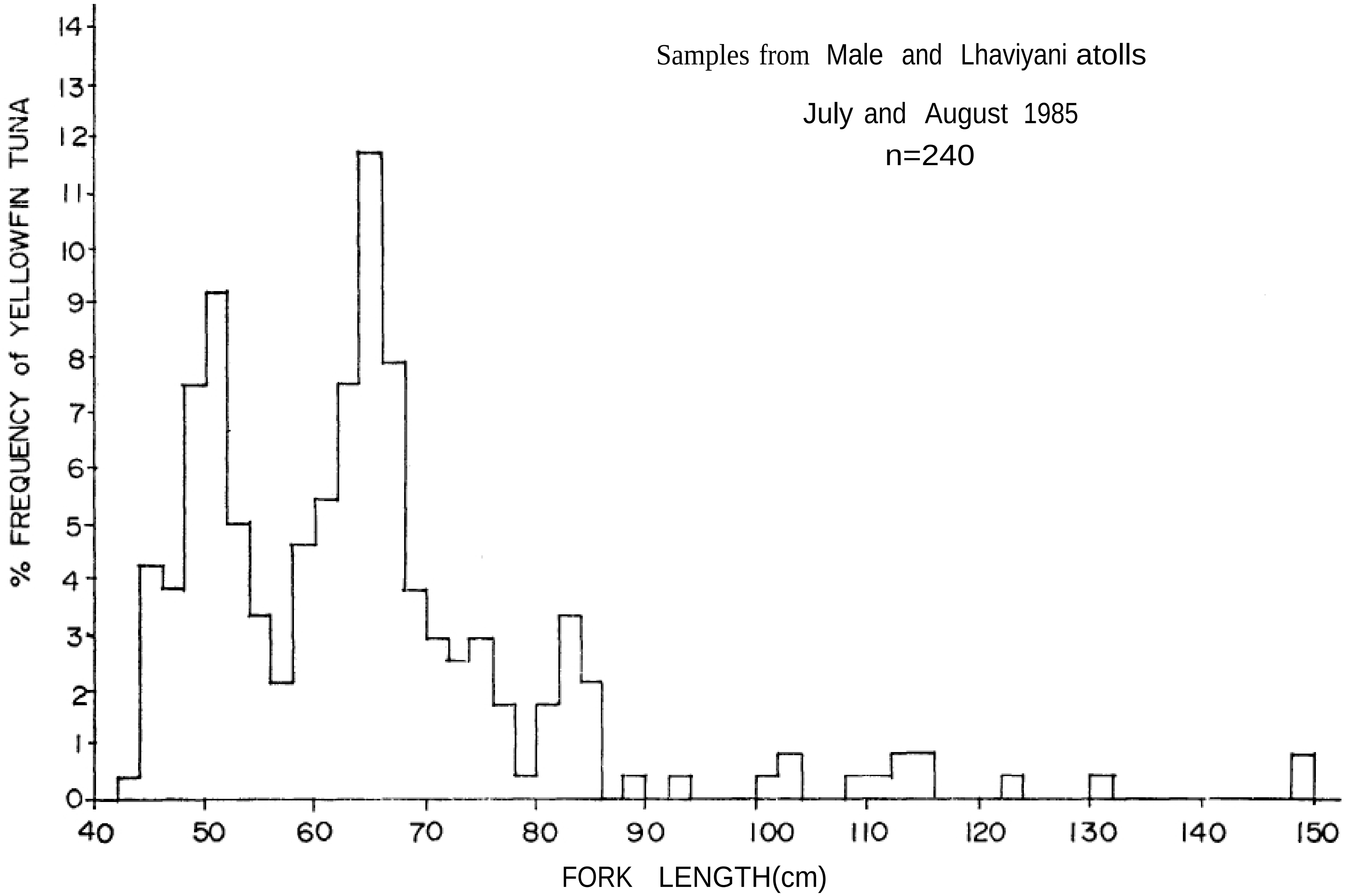

Fig. 10 Length frequency distributions of yellowfin from Male and Lhaviyani Atolls.

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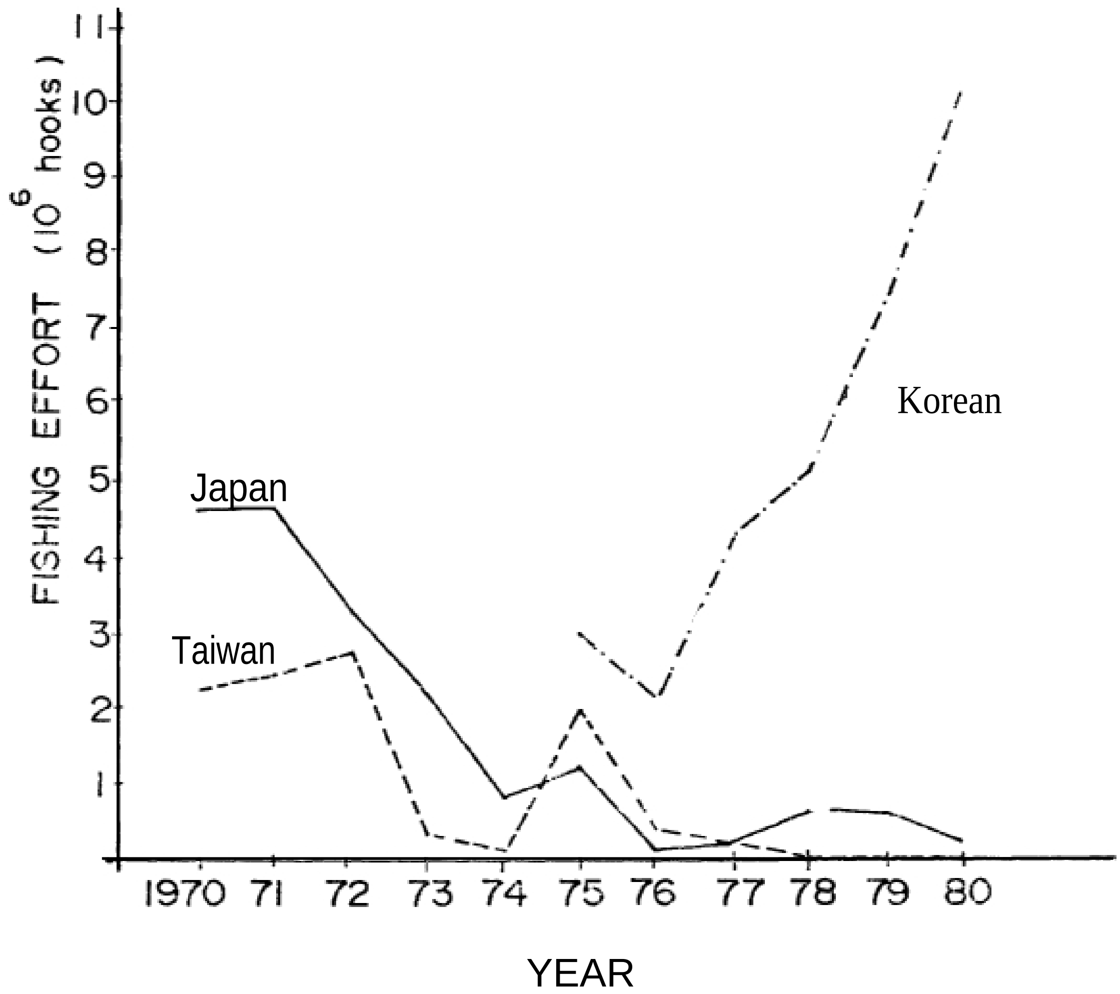

Fig. 11 Fishing effort by far eastern tuna longliners in the waters around the Maldives (10°N– 5°S.65°E—80°E).

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during a period of up to l-l .5 hours exposure). Morphometric measurements might be affected by time elapsed between capture and measurement, and also by handling. According to Sharp (1981), freezing and thawing undoubtedly affect morphometric measurements. Account should be taken of the size of these observed inconsistencies in the data when comparing samples.

Length-weight relationships

Weight-at-length data are available from five yellowfin samples. Fork lengths were measured to the nearest whole centimetre. Weights were measured in kilograms to the nearest tenth. Length-weight relationships of the form

$$\text{Weight} = A \times \text{Length}^{B}$$

were computed for each sample and are presented in Table 3. For ease of comparison these results are also presented graphically in Fig. 7. Note that for four of the samples there is considerable similarity in weight-at-length, particularly in length range 35-55 cm, where there is maximum data overlap. One sample, however, is noticeably different from the rest. This is the sample of fish from Kandholudhoo in Raa Atoll measured during July and August 1985 (i.e., the only sample from the substantial incursion of juvenile yellowfin off the west coast of the Maldives during the south-west monsoon season). To further illustrate the differences between these samples, estimated average weights at three lengths are tabulated below:

Sample		Estimated average weight (kg) at length		
Atoll	Date	35 cm	45 cm	55 cm
K	2+3/83	0.83	1.67	2.92
R	5/83	0.80	1.82	3.54
Lh	3/84	0.91	1.79	3.08
K +Lh	7 +8/85	(0.86)	1.84	3.25
Unweighted average of above		0.85	1.78	3.22
R	7+8/85	0.52	1.03	1.79

Possible explanations for these not insubstantial differences include :

1. Fundamental stock differences
2. Environmental differences acting on components of a single stock
3. Experimental errors.

At present it is not possible to distinguish between these possibilities. It will be necessary to take further samples from Raa Kandholudhco or Baa Tuladhoo in July and August 1986 to confirm these results. Meanwhile, comparison of morphometric data collected from Raa Atoll during July and August 1985 with that available from elsewhere may provide further insights into the extent of, if not the reasons for, these differences.

Length frequency distributions

Length frequency sampling of yellowfin catches was carried out at Eydhafushi, Baa Atoll, from June 1983 to August 1984. The 1983 data were presented at the 1984 workshop (Anon., 1985). Data from 1984 and 1985/86 are presented in Figures 8a and 8b. Other length frequency data are available from Male from January and February 1983, and Male and Lhaviyani from July and August 1985. These data are presented in Figs. 9 and 10.

As already noted, there are two major components to the surface fishery for juvenile yellowfin in the Maldives: one that peaks during December-February off the east coast, and one that peaks in July-August off the west coast. The length frequency data available from these two components are summarized in Fig. 10. Two years' data are available for each seasonal component. Note that while both fisheries are based on yellowfin of size range 25-55 cm FL, there are marked differences in their length frequency distributions, The south-west monsoon seasonal component (i.e., that which peaks in July-August) has a length frequency distribution with a single major peak at about 39 cm FL. In addition, there is a suggestion of a minor peak at 31 cm. The north-east monsoon component (i.e., that which peaks in January) has a distinctly poly-modal distribution. There are peaks at about 30 cm, 40 cm and 48 cm FL. On the whole, both fisheries had similar length frequency distributions in 1983 and 1984, although there are differ-ences of detail between years.

In addition to these two highly seasonal and somewhat localized incursions of yellowfin juveniles, larger sub-adult and adult yellowfin are taken in much smaller numbers year round throughout the Maldives. While there are undoubtedly seasonal variations in the availability of these fish (for example they are apparently particularly abundant off the southern atolls during December), there are at present insufficient data to fully resolve them. One length frequency sample is available, taken during July and August 1985 from Lhaviyani and Kaafu Atolls (Figure 10). There are peaks in the length frequency distribution of this sample at about 51 cm, 65 cm and 83 cm FL. The largest fish measured was 149 cm FL. It is not known to what extent this sample is representative of the 'large yellowfin' fishery as a whole.

Analysis of the yellowfin length frequency sample time series available from Baa Atoll (June 1983-August 1984) by the ELEFAN method (e.g. Pauly, 1982) was not attempted. This time series contains samples from two separate seasonal incursions of juvenile yellowfin and thus does not provide a suitable data base for analysis. It would be necessary to obtain monthly length frequency samples from the 'large yellowfin' fishery for such analysis. Even then the data may not be suitable. Estimation of growth rates is likely to be seriously affected by spurious modal progressions caused by yellowfin migrations, as has been noted elsewhere (Sharp, 1983). Mortality rates are likely to be overestimated by the use of data obtained from a surface-oriented fishery that almost certainly under-samples the largest fish.

Reproduction

Only one yellowfin sample was obtained for gonad analysis. This was from the Felivaru canning factory (Lhaviyani Atoll) during August 1985. Two hundred and forty one fish of between 40 and 70 cm FL were sampled. Observations are summarized in Table 4.

The majority of yellowfin sampled were immature (maturity stage 1). All the rest, which com-prised most of the larger fish, had early maturing gonads (maturity stage 2). No well developed gonads were observed in this sample of relatively small yellowfin. The largest gonads observed were testes of weight 15 g (taken from males of 760 mm and 681 mm FL) and ovaries of weight 35 m (from a female of 630 mm FL). The presence of large numbers of individuals of indeter-minate sex below 70 cm FL makes accurate determination of sex ratios impossible. However, from the limited data available it does appear that females start maturing at a smaller size than males.

No data were obtained on gonad maturity of larger fish, or on spawning areas and seasons. However, the occurrence of two separate seasonal incursions of juvenile yellowfin into Maldivian waters does suggest two seasonal periods of spawning activity in the central Indian Ocean area. A simple explanation of the observed occurrence of juvenile yellowfin is that juveniles appearing off the west coast of the Maldives during the south-west monsoon season were spawned during the previous south-west season, while those appearing off the east coast during the north-east monsoon season were spawned during the previous north-east season.

Growth

If the above hypothesis concerning yellowfin spawning and recruitment around the Maldives is correct, then certain assumptions about yellowfin growth rates can be made. Both seasonal incursions of juvenile yellowfin comprise fish of about 25-55 cm FL. On the above hypothesis it might be supposed that fish of 25-30 cm FL were about six months old, while fish of 50-55 cm FL were about one year old. However, there is no clear modal progression within the seasonal components, so this interpretation of spawning and recruitment patterns may be of more value for its simplicity than its realism. The age of the juvenile yellowfins might be checked by studies of daily growth rings in otoliths.

First dorsal spines were taken from nine larger yellowfin at Felivaru during August and September 1985. These fish ranged in size from 50 to 115 cm FL. Simple cross-sectioninq failed to reveal any clear annuli, although there was some suggestion of rings in the largest specimen. Thin sectioning might reveal further details.

Migration

According to most Maldivian fishermen juvenile yellowfin usually swim with the current. Certainly, yellowfin caught during the north-east monsoon off the east coast of the Maldives are often aggregated under pieces of driftwood. These fish might therefore be assumed to have entered Maldivian waters from the east. The juvenile yellowfin caught off the west coast cf the Maldives during the south-west monsoon are presumably coming from the west. Maldivian fishermen believe that these fish actually come from the south because this seasonal fishery sometimes starts slightly earlier in Tuladhoo (Baa Atoll) than in Kandholudhoo (Raa). Interestingly, there is, according to Sharp (1979), a major incursion, from the south and west of water suitable for yellowfin off the west coast of the Maldives during August. This is exactly the time that this fishery peaks. Knowing details of surface currents, back calculation might lead to identification of possible areas of origin, i.e. spawning grounds.

It may be that the small yellowfin (22-44 cm FL) caught off the south-west coast of Sri Lanka during the south-west monsoon season (Joseph et a/., 1985), have origins similar to those arriving off the west coast of the Maldives at the same time. It is also possible that the next largest size group observed in south-west Sri Lanka catches then (i.e., mode 49 cm FL in July, 1983 to mode 65 cm FL in December 1983) may, in part at least, be derived from fish that appear off the east coast of the Maldives during the previous season. Detailed consideration of yellowfin catches by length and season in the Maldives, Sri Lanka and India, could lead to a productive (and testable) updating of Dr. K. Sivasubramaniam's useful hypothesis of yellowfin migration in this region (BOBP, 1985, p. 47).

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Table 1

Yellowfin tuna catch in the Maldives by vessel type, 1970-1984

Year	Sailing masdhoni	Motorized masdhoni	Total masdhoni	Vadhu dhoni	(Tonne) Total catch
1970	1,799	—	1,799	190	1,989
1971	1,081	—	1,081	146	1,227
1972	1,940	—	1,940	136	2,076
1973	5,234	—	5,234	241	5,475
1974	3,868	—	3,868	260	4,128
1975	3,348*	164*	3,512	262	3,774
1976	3,569*	912*	4,481	410	4,891
1977	2,530*	1,593*	4,123	350	4,473
1978	1,324*	1,890*	3,214	370	3,584
1979	733	2,959	3,692	597	4,289
1980	471	3,176	3,647	582	4,229
1981	273	4,467	4,740	544	5,284
1982	167	3,603	3,771	234	4,005
1983	112	5,872	5,984	257	6,241
1984	76	6,818	6,894	230	7,124
1985	82	5,715	5,797	269	6,066

* Estimated from total masdhoni catch and numbers of each vessel type, taking into account assumed catch rates and number of days fished by each vessel type.

Table 2

Standardized catch figures for yellowfin in the Maldives

	Corrected total yellowfin catch (t)	Total equivalent fishing effort (motorized masdhoni)	Standardized catch rate (kg yellowfin per motorized masdhoni day)
1970	2,439	98,607	24.7
1971	1,497	89,075	16.8
1972	2,076	84,829	24.5
1973	5,475	112,595	48.6
1974	4,128	108,516	38.0
1975	3,774	96,651	39.0
1976	4,891	116,912	41.8
1977	4,473	115,967	38.6
1978	3,584	103,917	34.5
1979	4,289	108,572	39.5
1980	4,229	109,907	38.5
1981	5,284	99,045	53.3
1982	4,005	107,917	37.1
1983	6,241	124,535	50.1
1984 .. .	6,783	144,639	46.9

Table 3

Summary of length-weight relationships for five samples of yellowfin tuna from the Maldives

Atoll	Location Island	Date Month	Year	Size range (cm FL)	n	A	B	r
K	Male	2,3	83	25.65	255	4.2095×10^{-5}	2.7817	0.94
R	Kandholudhoo	5	83	35.64	99	6.5198×10^{-6}	3.2952	0.99
Lh	Naifaru	3	84	35.58	117	6.3641×10^{-5}	2.6918	0.97
R	Kandholudhoo	7,8	85	36.65	92	2.9307×10^{-5}	2.7496	0.97
K/Lh		7.8	85	43.148	108	2.0186×10^{-6}	2.9995	0.99

Table 4

Summary of observations of yellowfin gonads at Felivary Cannery (Lhaviyani Atoll) during August 1985

Size range (mm FL)	Atoll	Number of fish sampled	% of sample immature and of indeterminate sex	% of females among fish of determinate sex
400-449	R	105	100	—
500-599	Lh	41	98	100
600-699	Lh	93	22	66
700-799	Lh	2	0	0

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Annexure 4

A SUMMARY OF INFORMATION ON THE FISHERIES FOR BILLFISHES, SEERFISHES AND TUNAS OTHER THAN SKIPJACK AND YELLOWFIN, IN THE MALDIVES

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Introduction

Tunas and tuna-like species dominate the Maldivian fish catch. Skipjack and yellowfin tuna are the most important species, but several others make valuable contributions to the catch. These include frigate tuna *(Auxis thazard),* eastern little tuna *(Euthynnus affinis),* dogtooth tuna, *(Gyrnnosarda unicolor),* seerfishes (mainly wahoo, *Acanthocybium solandri),* and billfishes (mainly the sailfish, *lstiophorus platypterus).* A list of local names of these species is appended.

Frigate tuna

Frigate tuna is the third-most important species in the Maldivian catch, after skipjack and yellow-fin. Between 1970 and 1984 frigate tuna accounted for an average of nearly 10% by weight of the recorded catch. This amounts to an annual average of some 3130 MT.

Production trends

Although the average catch of frigate tuna has been about 3130 MT per year it has fluctuated widely about this level (Table 1). During 1970-72 the annual catch was about 3070 MT. In 1973 ii climbed to 6600 MT and in 1974 it was 6000 MT. After these two peak years it declined rapidly to an average of 1640 MT during 1978-81. Since then, catches have climbed back to something over 3000 MT per year. This pattern suggests either gross stock fluctuations through natural causes, or overfishing during 1973-74 leading to a decline in stock size in the late 1970s. This second interpretation is supported by the findings of Anderson and Hafiz (1985), who suggested that frigate tuna in the Maldives has an average maximum sustainable yield (MSY) of about 3700 MT. However, it is difficult to explain why overfishing should have occurred in 1973-74 at what was no more than an average level of fishing effort. In 1973 there were 'peak' catches of yellowfin and little tuna as well as frigate tuna, although not of skipjack, so perhaps unusual oceanographic conditions in that year affected their catchability.

Catch rates

Most frigate tuna (over 90%) are taken by pole and line vessels, but trolling vadhu dhonis do make a small regular contribution to production. As with other tuna species, catches by sailing masdhonis have been almost entirely replaced by those of motorized masdhonis since 1974-75 (Table 1). Stratum-wise catch rates by motorized masdhoni is and vadhu dhonis for the years '1980-83 are presented in Table 2 (see Fig.1 for details of strata).

During 1980-83 the average catch rate of frigate tuna by motorized masdhonis was about 17-18 kg/day, while that by vadhu dhcnis was 2.0-2.5 kg/day. For both vessel types the highest catch rates were recorded in the north of the Maldives, the lowest in the south. There

'Paper presented at the third meeting of the working group on tunas in the EEZs of Maldives and Sri Lanka; 22-25 September 1986, Colombo, Sri Lanka.

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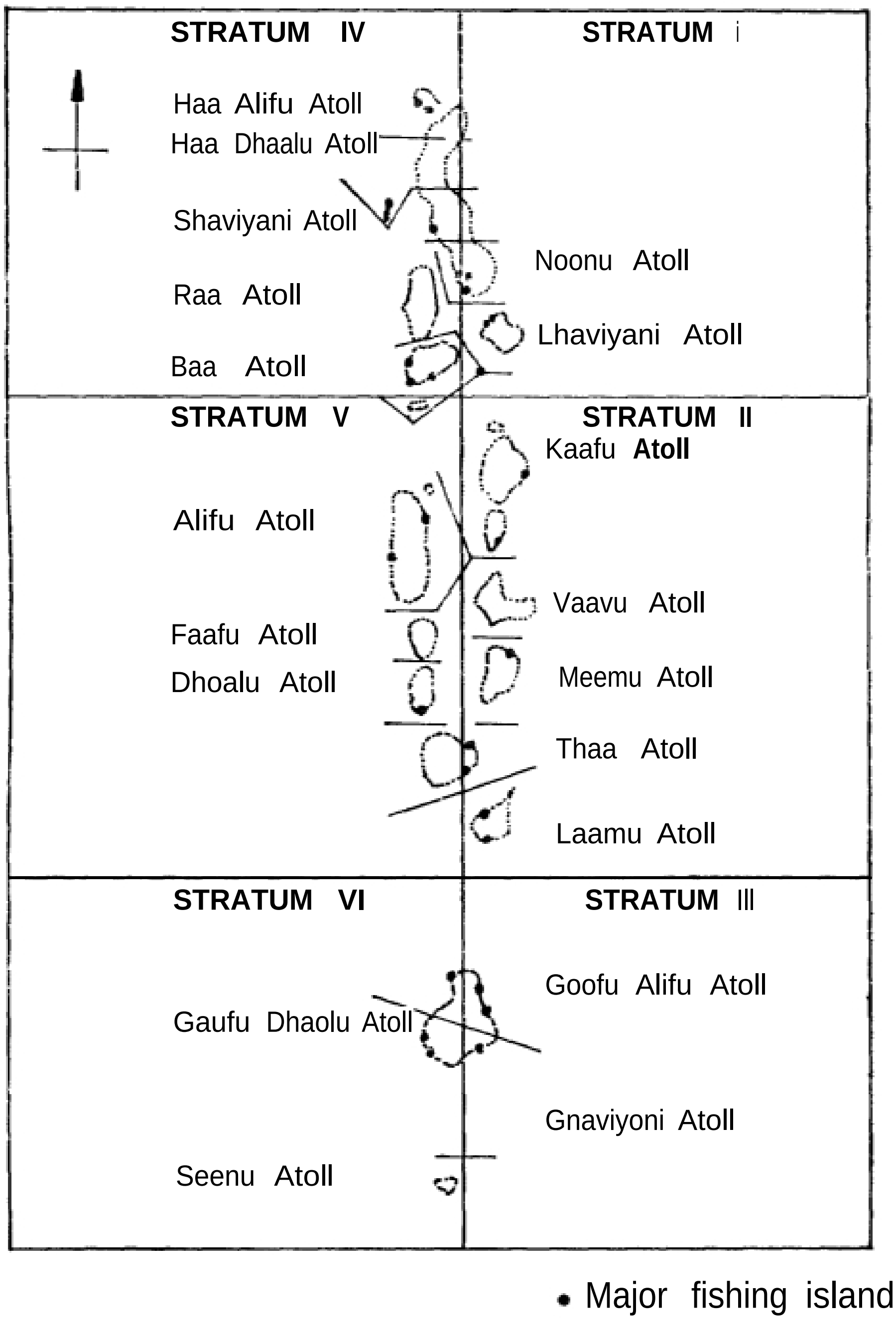

Fig. 1 Map showing the six strata of the Maldive Islands.

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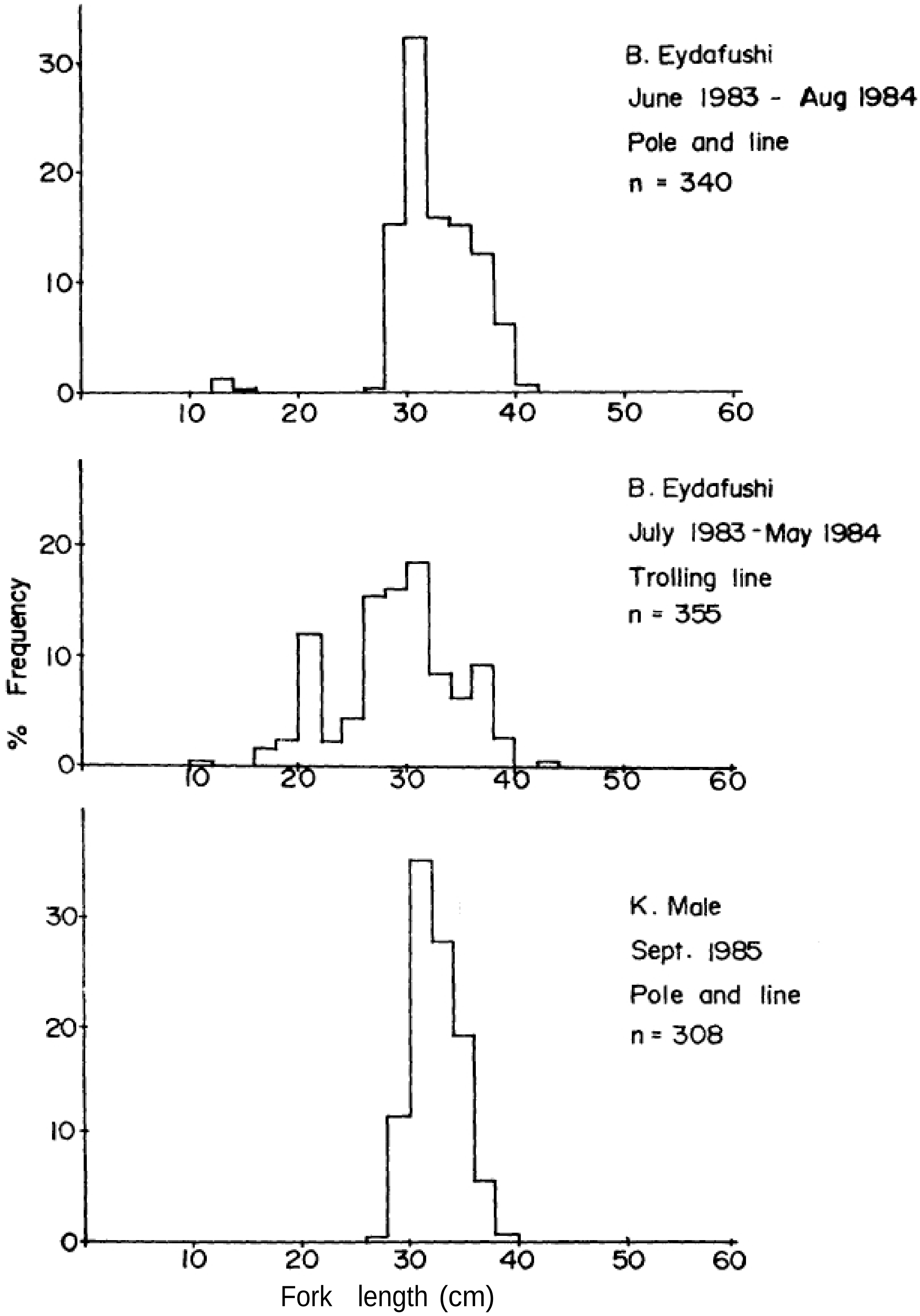

Fig. 2 Length frequency distributions of frigate tuna in the Maldives.

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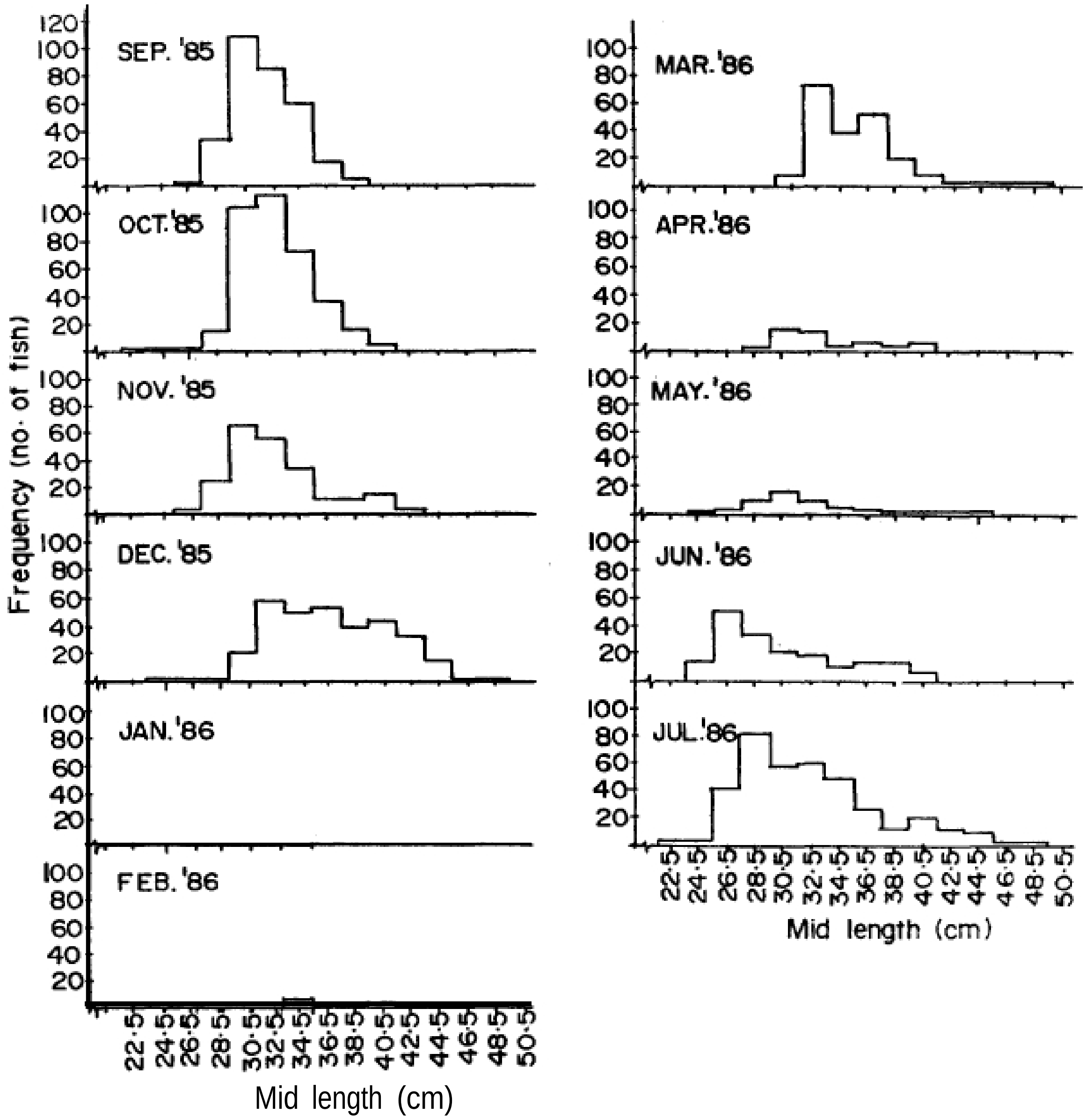

Fig. 3 **Seasonal changes in the length frequency distributions of frigate tuna in the Maldives.**

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is no clear seasonal pattern in catches, although atolls on the west coast of the Maldives appear to achieve their largest catches during the north-east monsoon season (December to May) while those on the east seem to make their best catches during the south-west monsoon season (July to November).

Length frequency distributions

Systematic and stratum-wise length frequency sampling of frigate tuna has not been carried out. Length frequency distributions of three samples that are available are summarized in Fig. 2. The two samples from pole and line vessel catches are very similar, both having single peaks at about 31 cm FL (fork length). The sample from trolling vessel catches shows a much wider range of lengths and includes a greater **proportion** of small fish. Whether this is a real difference reflecting size segregation of frigate tuna or just a sampling artefact is unknown. Length frequency distribution observed during the sampling from September 1985 to July 1986 is shown in Fig. 3.

Little tuna

The eastern little tuna, or kawa kawa, is the fourth most important tuna species taken in the Maldives. Between 1970 and 1984, little tuna accounted for an average of 3% by weight of the national catches.

Production trends

During the period 1970-71 the average annual catch of little tuna was 740 MT. It has increased since then with an annual average catch of about 1600 MT in the period 1980-84 (Table 3). The bulk of the little tuna catch (67% of the total during 1970-84) is taken by trolling vadhu dhonis operating mainly inside the atolls. The rest of the catch is taken by the pole and line fleet, in which motorized vessels have almost entirely replaced sailing vessels in the last few years. The production in 1985 was 2177 t.

Catch rate

Catch rates by vessel type and by stratum for the years 1980-83 are given in Table 4, Overall catch rates by vadhu dhonis are somewhat higher than those by masdhonis. This is the opposite of what happens with the major tuna species and implies that the little tuna leads a largely atoll-associated life. Only in Stratum 5 (which includes Ari Atoll, where much reef fishing is carried out and many masdhonis fish inside the atoll) do masdhonis achieve a higher catch rate than vadhu dhonis. For both vessel types, little tuna catch rates are highest in the north and centre of the Maldives and lowest in the south. Highest catches are taken in May and June, although there is a smaller peak in December and January.

Catch and effort relationship

Anderson and Hafiz (1985) carried out surplus production model analysis on available catch and effort data. Effort was standardized to the level of ‘trolling vessel day’ (Table 3). Meaningful results were not obtained. A positive correlation of CPUE on E was found, implying that increasing effort will bring ever increasing catches, an impossible situation. The most obvious explanation for this result is that the effort data used do not distinguish between fishing effort directed against reef fishes and that directed against tuna. It is therefore possible that little tuna catch rates are indeed decreasing with increasing effort. However, recorded reef fish catches by vadhu dhonis have in fact increased substantially over the last few years (average 1970-71, 1000 MT; average 1982-83, 3000 MT), while fishing effort has not increased by anything like as much (average 1970-71, 86,000 days; average 1982-83 ; 125,000 days). This, togethet with the overall increase in catch rates of little tuna by both vadhu dhonis and masdhonis, mighr indicate an increase in stock abundance. Possible explanations include reduced competition from decreased stocks of frigate tuna (see above), or reduced predation from decreased stocks of such intra-atoll predators as sailfish and wahoo. These latter may have declined as a result of increased fishing to supply the tourist market.

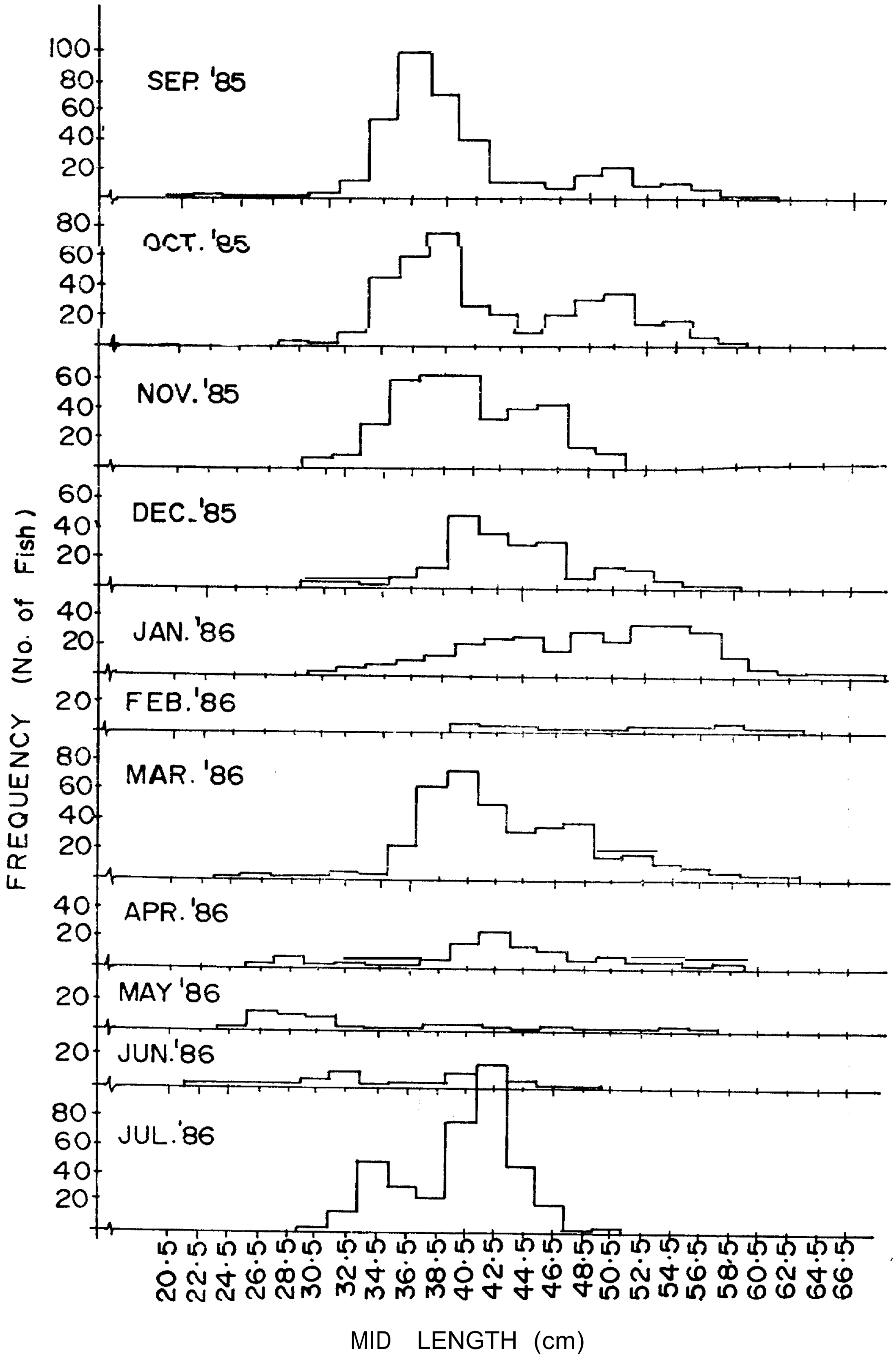

Fig. 4 Seasonal changes in the length frequency distributions of kawakawa in the Maldives.

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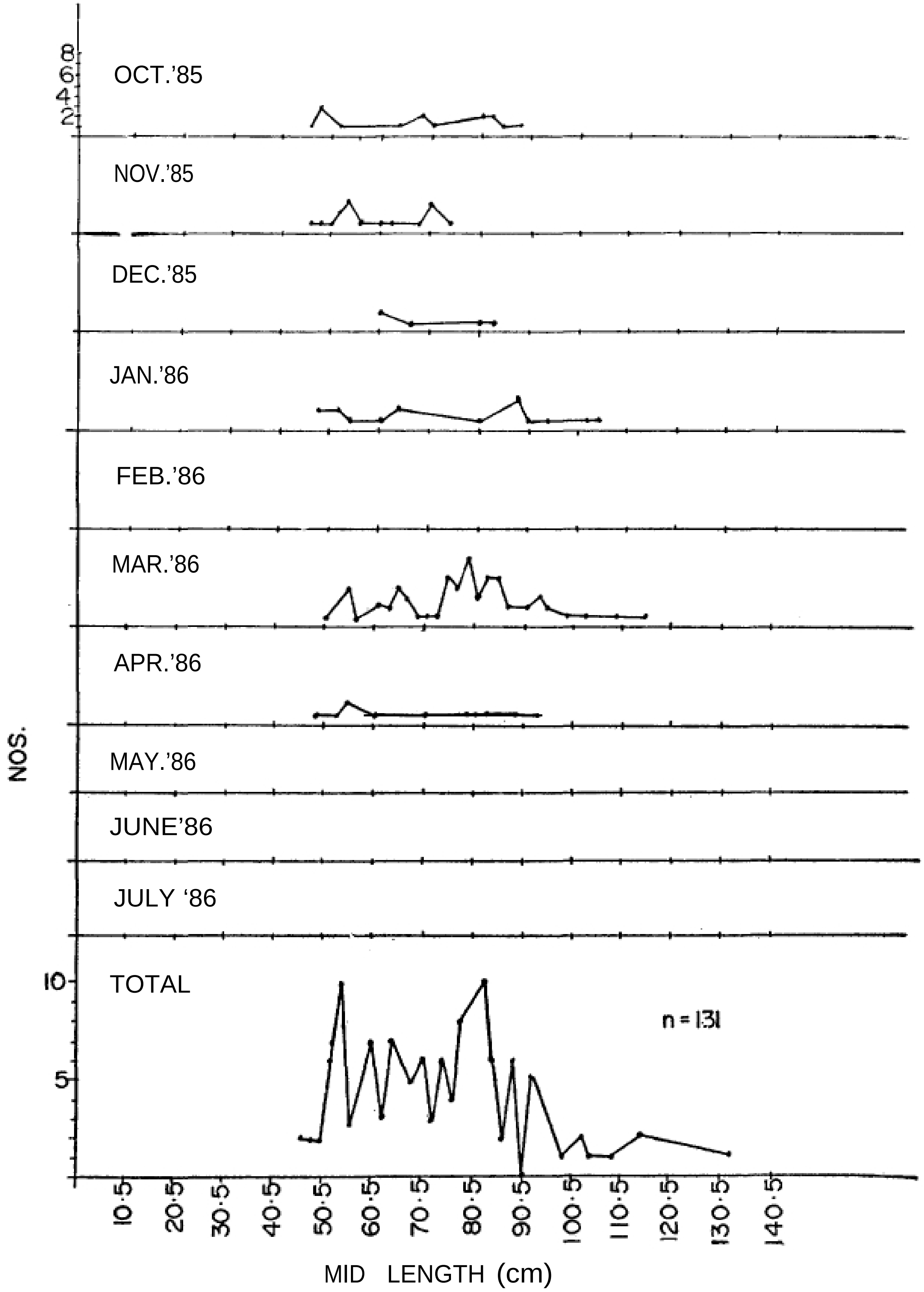

Fig. 5 Monthly length frequency distributions for dogtooth tuna landed at Male.

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Length frequency distributions

Systematic and stratum-wise length frequency sampling of little tuna has not been carried out. Length frequency distributions from the sampling from September 1985 to July 1986 are summarised in Fig. 4. There appear to be two or three size classes in each sample. The smallest individual measured was 11 cm FL, the largest 60 cm FL. Samples from catches of masdhonis and vadhu dhonis at Eydafushi (Baa Atoll) showed similar length frequency distributions. This suggests that little tuna in this area show little size segregation. However, these samples were not taken over the same time period, so this interpretation may not be valid.

Bullet tuna

Observations in Male fish market carried out approximately once every two weeks from January 1984 to February 1985 revealed only one specimen of the bullet tuna, *Auxis rochei.* This species may therefore be considered to be very rare in the central region of the Maldives, although it is possible that it is more common in the northern region.

Dogtooth tuna

Dogtooth tuna is caught in relatively small numbers throughout the Maldives. Separate statistics for dogtooth tuna catches have been kept only since the beginning of 1984. Recorded catches by vessel type during 1984 and 1985 are given below:

	1984	1985
Motorized masdhoni	92 MT	32 MT
Sailing masdhoni	3	4
Vadhu dhoni	25	23
Rowing boat	1	?
Total	121	59

Dogtooth tuna are reef-associated fishes. Most are caught by vessels operating within, or just outside, the atolls using trolling or droplines. Occasionally live frigate or little tuna may be used as bait to catch large individuals. There is no obvious regional pattern to fish catches, althovgh it may be that dogtooth is less common in the south than elsewhere in the Maldives. The highest catches are achieved in atolls that concentrate on reef fishing (notably Ari Atoll), and the lowest catches in those atolls where there is little reef fishing (e.g. Lhaviyani Atoll).

Length frequency sampling conducted in Male between October 1985 and July 1986 was incomplete and insufficient. The results presented in Fig. 5 suggest that most dogtooth tuna landed are in the range 40-130 cm FL. There are occasional reports of catches of larger individuals, over 1.5 m in length.

Underwater observations by the authors reveal that dogtooth tuna are most often seen in small groups of two to six individuals, although single fish and larger groups are also seen. This is compatible with other observations on dogtooth tuna summarised by Silas (1963).

Bigeye tuna, albacore and longtail tuna

Bigeye tuna *(Thunnus obesus),* albacore *(Thunnus alalunga)* and longtail tuna *(Thunnus tonggol),* are probably all taken in small quantities in Maldivian waters. No separate statistics for these species are maintained. Maldivian fishermen recognise these species as varieties of yellowfin tuna *(Thunnus albacares)* and any catches are probably recorded as such.

Juvenile bigeye tuna are apparently present among the large catches of juvenile yellowfin taken off the north-west coast of the Maldives during July and August. Larger bigeye tuna constitute nearly a half of all tuna longline catches in the area around the Maldives (Klawe, 1980). There are rare reports of longtail tuna caught in the northern atolls, and some albacore are taken by longline, especially in the south.

Seerfishes

Observations of landings at Male fish market suggest that catches of seerfish are composed almost entirely of the wahoo. Occasional specimens of the narrow-barred Spanish mackerel, *Scomberomorus commerson,* are also landed. Landings of wahoo are not separately recorded, so it is **not** possible to give accurate catch statistics. As a very crude first estimate it is suggested that something of the order of 400 MT (± 100 MT) are landed annually. Catches might have increased over recent years to meet the growing demand **for** tourist resorts and the expatriate population in Male.

Wahoo are usually caught within or immediately outside the atolls by trolling line from masdhonis or vadhu dhonis, or from bokkura (rowing boats), Fishermen in these skate a wooden model of a flying fish held at the end of a pole and line across the sea surface to lure the wahoo within reach of their harpoons.

Billfishes

The following species of billfish are caught in the Maldives : sailfish, swordfish *(Xiphias gladius)* blue marlin *(Makaira maazara),* black marlin *(Makaira indica),* and striped marlin *(Tetrapterus audax).* By far the greatest billfish catch is that of sailfish. These are usually taken within the, atolls by vadhu dhonis trolling with lures, or by rowing boats using droplines with live tuna bait. Swordfish and marlin are occasionally caught outside the atolls by masdhonis using trolling lines. They are also taken by longliners operating in the waters around the Maldives. Klawe (1980) estimates that Far Eastern longliners operating in what is now the Maldives EEZ during 1972-77 took an annual average of 106 MT of billfish. Of this 37% was blue marlin, 19% swordfish, 19% sailfish, 18% striped marlin, and 7% black marlin. There are no records of Maldivian catches of billfishes. However, in recent years commercial tuna purchasing companies have bought about 15-20 MT of billfish annually for export. As a crude first estimate it is suggested that something of the order of 80-100 MT of billfish are caught each year.

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Table 1

Frigate tuna catches in the Maldives by vessel type, 1970-84

	Catch (MT)					Standardized catch rate (kg/motorized masdhoni day)
	Vadhu dhoni	Sailing masdhoni	Motorized masdhoni	Total masdhoni	Total	
1970	248	2,775	-	2,775	3,203	27.5
1971	166	2,849	-	2,849	3,015	31.9
1972	182	3,004	-	3,004	3,186	37.9
1973	186	6,440	-	6,440	6,626	59.8
1974	202	5,804	-	5,804	6,006	57.1
1975	163	3,713*	181*	3,894	4,057	43.1
1976	289	1,971*	448*	2,419	2,707	20.6
1977	264	1,863*	953*	2,816	3,080	23.1
1978	206	720*	735*	1,455	1,661	13.4
1979	272	435	994	1,429	1,701	13.3
1980	304	207	1,084	1,291	1,595	13.0
1981	309	141	1,156	1,297	1,606	13.8
1982	231	80	1,750	1,830	2,061	18.0
1983	351	141	3,048	3,189	3,540	26.0
1984	338	66	2,701	2,767	3,105	22.5

* Estimated

Table 2

Average catch rates of frigate tuna by motorized masdhonis and vadhu dhonis in the six regional strata of the Maldives, 1980-83

(kg/day)

Vessel type	Area	1980	1981	1982	1983
Motorized masdhoni	1	30.3	30.4	33.1	61.8
(Pole Et line)	2	7.1	11.9	17.3	22.9
	3	1.7	2.2	2.9	2.1
	4	21.5	21.8	34.3	36.1
	5	12.8	3.9	5.4	6.9
	6	5.0	2.6	6.1	4.7
	Overall	13.0	13.8	18.0	26.0
Vadhu dhoni (Trolling)	1	3.0	5.3	2.2	2.5
	2	0.2	0.3	0.4	0.2
	3	0.1	0.0	0.0	0.2
	4	3.1	3.0	2.3	4.1
	5	1.4	1.2	0.9	0.9
	6	0.1	0.2	0.2	0.1
	Overall	2.2	2.4	1.7	3.0

Table 3

Little tuna catches in the Maldives by vessel type, 1970-84

Year	Catch (MT)					Standardized catch rate (kg/vadhu dhoni day)
	Vadhu dhoni	Sailing masd honi	Motorized masdhoni	Total masdhoni	Total	
1970	402	242	—	242	644	3.9
1971	253	220	—	220	473	3.8
1972	343	253	—	253	596	4.5
1973	514	574	—	574	1,088	5.7
1974	433	397	—	397	830	4.6
1975	268	140*	7*	147	415	3.0
1976	762	157*	34*	191	953	5.6
1977	767	112*	48*	160	927	4.9
1978	634	78*	55*	133	768	3.6
1979	548	94	79	173	721	4.1
1980	768	104	191	295	1,063	5.6
1981	871	119	284	403	1,274	6.7
1982	1,044	172	671	843	1,887	7.9
1983	1,094	98	895	993	2,087	9.2
1984	1,019	49	646	695	1,714	9.3

* Estimated.

Table 5

Local names of tunas and tuna-like fishes caught in the Maldives

Latin name	English name	Dhivehi name
Katsuwonus pelamis	Skipjack	Kalubilamas Godhaa (Large)
Thunnus albacares	Yellowfin	Kanneli
Thunnus obesus	Bigeye tuna	Loabodu kanneli
Thunnus alalunga	Albacore	Kanfaiydhigu kanneli
Euth ynnus a ffinis	Little tuna	Latti
Auxis thazard	Frigate tuna	Raagodi
Acanthocybium solandri	Wahoo	Kurumas
Istiophorus platypterus	Sailfish	Fangaduhibaru
Xiphias gladius	Swordfish	Thungaduhibaru
Mackaira and *Tetrapturus*	Marlin	Mashibaru

Annexure 5

TUNA FISHERIES — AN UPDATE FOR SRI LANKA

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Introduction

Besides sustaining the motorized fishing fleet operating beyond the inshore waters of Sri Lanka, tunas have contributed 15% to 20% of all fish landed in Sri Lanka in recent years. The fishery has undergone changes in craft and gear over the last two to three decades. These and other research and development activities in tuna fisheries have been well documented. While most of the available literature is based on tuna fisheries in the past, a revival of research on tuna since 1982 has resulted in more information being available in recent years on the biology and fishery of tunas around Sri Lanka. These include reviews on tuna and their fisheries (Joseph, 1984 and Sivasubramaniam, 1985) covering the period 1950 to 1980, analysis of fishery and biological studies on major species (Joseph *et* al., 1985; Amarasiri and Joseph, 1985; and Joseph and Amarasiri, 1985).

The present paper examines recent trends in the tuna fisheries in Sri Lanka, covering the seven year period 1979-1985. Trends in catch and effort and other development activities in tuna fisheries are analysed and compared with past data.

For ease of analysis, the 14 fisheries administrative areas around the coastal belt (District, Fisheries Extension Office or DFEO areas) are grouped into 8 sub-areas. Tuna production, distribution of craft and distribution of resources are analysed on this basis. Since the mid- 1970s, tuna production has been estimated separately for skipjack and yellowfin, while production of other varieties is given under 'other blood fish'. Smaller tuna varieties provide the bulk of the catches in this group. Hence, the category "other blood fish' is represented by 'smaller tuna' in this paper.

Fishing craft and gear

Tuna production in 1983 by different categories of craft showed that 87% of production came from craft with in-board engines, 9% from craft with out-board engines and 4% from non-motorized traditional craft. Overall, 96% of the tuna is landed by motorized craft. The percentages of species-wise production with respect to craft categories are as follows:

	Craft with in-board engines	Craft with out-board engines	Non-motorized traditional craft
Skipjack . .,	46.1	17.4	41.9
Yellowfin	30.6	8.2	12.1
Smaller tuna	22.3	74.3	49.9

Craft with in-board engines, the 3.5 GT class of boats (9 metre) and the 11 metre class of boats, with gillnet as the dominant gear, record larger percentages of skipjack and yellowfin in the

This paper was presented to the third working group meeting on the tunas around the Republics of Maldives and Sri Lanka, 22-25 September, 1986, Colombo, Sri Lanka.

catches. The smaller FRP boats and mechanised traditional crafts with out-board engines, using gillnets and troll lines, generally fish further inshore than the larger boats and land higher catches of smaller tuna varieties. This category of craft is more active in the tuna fisheries off the north-west, southwest, southeast and east coasts.

The bulk of the tuna production comes from the fleet of 3.5 GT class motorized craft with in-board engines. The distribution of these craft on a regional basis during 1978, 1980/81 and 1984/85 is given below :

Sub-area	DFEO area	1978	1980181	1984/85
North	Mullaitivu Jaffna Mannar	656	1176	971
Northwest	Puttalam Chilaw	304	282	101
West	Negombo Colombo	318	383	208
Southwest	Kalutara Galle	216	370	334
South	Matara Tangalle	487	595	564
Southeast	Kalmunai	31	53	180
East	Batticaloa	82	55	88
Northeast	Trincomalee	77	253	271
		2171	3112	2717

These boats have been issued at subsidised cost (35% subsidy on hull, engine and gear). As the subsidy scheme was temporarily suspended in 1982, there were no new additions to this fleet, except as replacement craft.

The fleet of 11 metre boats, introduced during 1982 through the foreign funded Northwest Coast Fishery Development Project, numbered 24 by the end of 1983, 44 by the end of 1984 and 77 by the end of 1985. These operated without fixed bases, either independently or in groups, from Colombo (west), Beruwala and Galle (southwest), Mirissa and Tangalle (south), Trincomalee, Poduwakkatuwa (northeast) and Kalpitiya (northwest), migrating from place to place depending on fishing season and catch potential.

A large number of 3.5 GT boats also migrate, sometimes along the same coast from one DFEO area to another, or from one coast to another (west and south coasts to east coast), with the change in fishing conditions and availability of tuna.

Fishing gear used in tuna fisheries in Sri Lanka include the gillnet (drift gillnet), troll line, pole and line and the longline. The relative importance of these gears in the tuna fishery in recent years differs markedly from the relative importance observed in the past. Statistics collected by fisheries inspectors during sampling visits to landing sites cannot be used to compute fishing effort in relation to different gears. Catch and effort data on tuna fishery, collected through ongoing research programmes, is also limited to the northwest, west, southwest, south and northeast coasts. However, the percentage distribution of effort by different gears, obtained through research, is compared below with similar estimates made by Sivasubramaniam (1966 and 1970a) for the tuna fishery during the period 1960-1970.

Sub-area	Fishing gear			
	Troll	Gillnet	Pole & line	Longline
1960-1967				
North	4	92	0	3
Northwest	—	—	—	—
West	64	11	0	24
Southwest	70	2	23	5
South	62	0	28	6
Northeast	40	45	5	10
1968-1970				
Northwest	15.6	82.4	0	2.0
West	16.2	75.6	0	8.2
Southwest	35.0	45.9	9.1	10.0
South	24.4	60.6	11.5	1 .o
1983-1985				
Northwest	6.0	87.6	0	6.4
West	7.8	70.7	0	20.7
Southwest	22.8	69.9	4.9	2.4
South	33.4	57.8	6.7	2.1

The impact of motorization of the island's fishing craft and the introduction of synthetic nets during the early 1960s is reflected in the changes in relative importance of fishing gears during the periods 1960-1967 and 1969-1970. Troll lines were the dominant gear in tuna fisheries before the developments mentioned above. Pole and line fishing in the south and southwest also contributed significantly to the total tuna production in the country and was conducted using large outrigger canoes. The level of effort and production of tuna in the north and north-west was low compared to other areas and was mainly directed through gillnets. Longlining for tuna was also introduced along with the introduction of the 3.5 GT, 9 metre boats to the fishing industry. This method became very popular off the west coast.

Motorization of craft and introduction of synthetic nets resulted in the gillnet replacing troll as the dominant gear in tuna fisheries. The pole and line fishery also declined in the south and southwest, partly because of the increasing popularity of gillnets and partly because of problems associated with the supply of live bait. The popularity of longlines also declined because of the inadequate supply of good quality bait. These trends, visible in 1968-l 970, have been accurated in the next decade and a half.

Research data on fishing effort by 3.5 GT class of boats available for the northwest, west, south-west and south coasts from 1983 to 1985 indicate that except for the gillnet, other methods seem to be dominant only in areas where these were traditionally popular: e.g., trolling and pole and line in south/southwest and longlines in west. Overall, the percentage breakdown of effort in tuna fisheries in western and southern areas of Sri Lanka is 70.4, 19.7, 3.7 and 6.1 for gillnet. trolling, pole and line and longline respectively. In the case of the larger 11 metre boats, the effort is directed through gillnets and longlines. The smaller 5-6 metre FRP boats predominantly use gillnets in tuna fisheries.

The number of pieces and the mesh sizes of gillnets used in tuna fisheries vary between boats. In the case of 3.5 GT craft, the following information is available :

No. of pieces	Percentage	
	West and south coasts (Joseph *et al.,* 1985)	South coast (Joseph and Amarasiri, 1985)
15-19	—	4.4
20-24	40	27.6
25-29	24	25.0
30-34	28	25.0
35-39	8	8.9
40-44	—	8.9
Mesh sizes		
3"-3 3/4"	—	3.3
4"-4 1/2"	9.5	17.2
4 3/4"-5 3/4"	47.6	68.6
6"-6 3/4"	39.6	10.4
7"	3.3	0.3
No. of boats sampled	60	40

Each piece of net is 500 meshes long and 110 meshes deep. The majority of the 3.5 GT gillnetters carry 20 to 35 pieces of net with 4½ to 6" range of mesh sizes being the most popular with the fishermen. The complement of nets and the range of mesh sizes used do not seem to have changed over the years. Although detailed information is lacking, 30 to 40 pieces of net of over 4" mesh size had been carried on board this type of craft (Sivasubramaniam, 1970). While the 11 metre class of boats are initially issued with 60 pieces of gillnets of 5", 5½" and 6" mesh size in equal proportion and 100 baskets of drift longline, the smaller FRP craft carry a smaller number of gillnet units with smaller mesh sizes compared to a 3.5 GT craft.

The troll gear popular in the south and southwest areas consists of two main lines, each with branch lines ending in jigs. While over 70% of the troll boats carry a total of 200 to 220 jigs, most of the boats also carry 10-12 independent lines, ending in large hooks and directed on larger tuna and other Scombrids (Joseph and Amarasiri, 1985).

Unlike in the past, even in areas where it is traditionally established, longlining is always carried out in combination with gillnet fishing. The gear consists of 20 baskets, and cut pieces of tuna, dolphin, mackerel etc. are used as bait. It is customary even for the other gillnetters to carry a few baskets of longline gear.

Production trends

Estimates of tuna production available at the Ministry of Fisheries for the seven-year period 1979-1985, given in Table 1, indicate that the total annual production of tuna increased from 21,990 t in 1979 to a peak of 34,115 t in 1982. Thereafter, production has declined with the disruption of the fishery, caused by the civil disturbances in the country, since mid-1983. Production of skipjack shcwed a 70% increase, from 8,179 t in 1979 to 13,972 t in 1983, while during the same period, production of yellowfin showed nearly a 50% increase, from 6,070 t in 1979 to 9,046 t in 1983. Production of smaller tuna varieties recorded a peak of 12,515 t in 1982, an increase of over 50% over the production of 8,141 t in 1979.

Production of skipjack, yellowfin and smaller tuna on a regional basis is shown in Fig. 1, 2 and 3 respectively. There are annual fluctuations in the tuna production in the north with a decline in skipjack and smaller tuna and an increase in yellowfin tuna landings. This trend is reversed in 1984. A significant increase in tuna production is shown in the northwest from 2,663 t in 1979 to 5,942 t in 1984, an increase of over 100%. In contrast to the north, skipjack and smaller tuna were largely responsible for this increase, while catches of yellowfin have shown only marginal

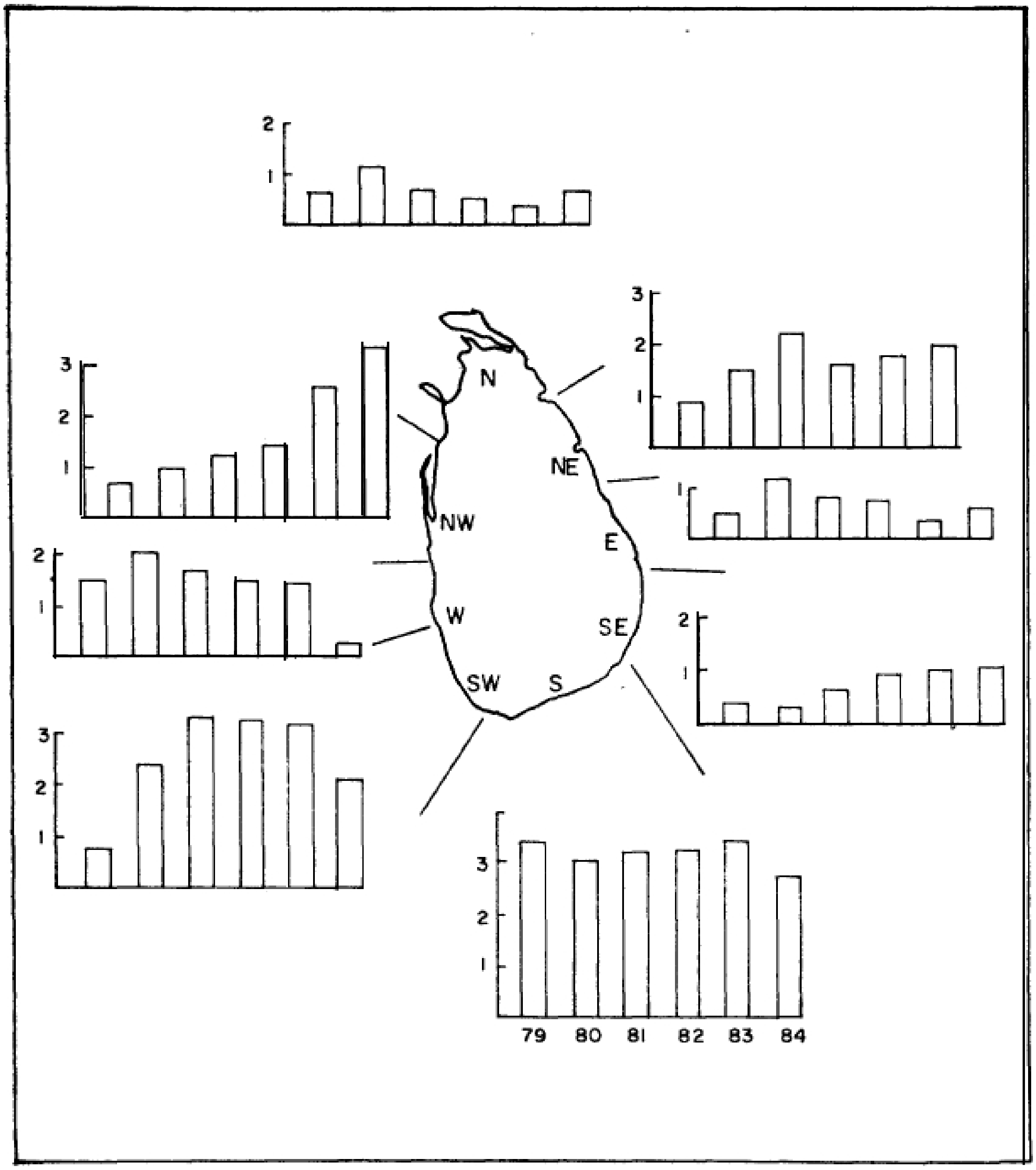

Fig. 1 Production of skipjack tuna in Sri Lanka. 1979—1984 (x 1000 MT)

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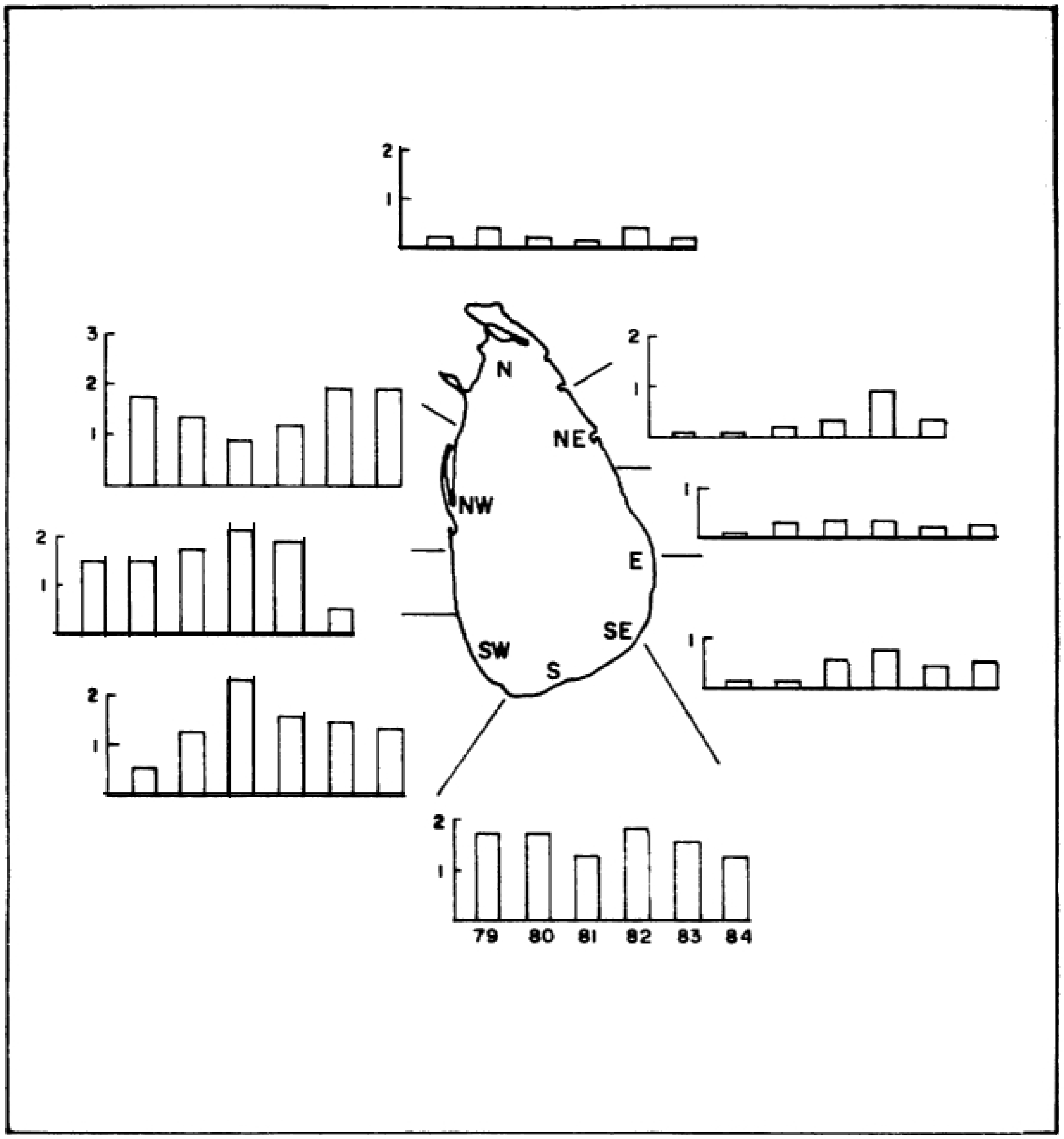

Fig. 2 Production of yellowfin tuna in Sri Lanka, 1979—1983 (x 1000 MT).

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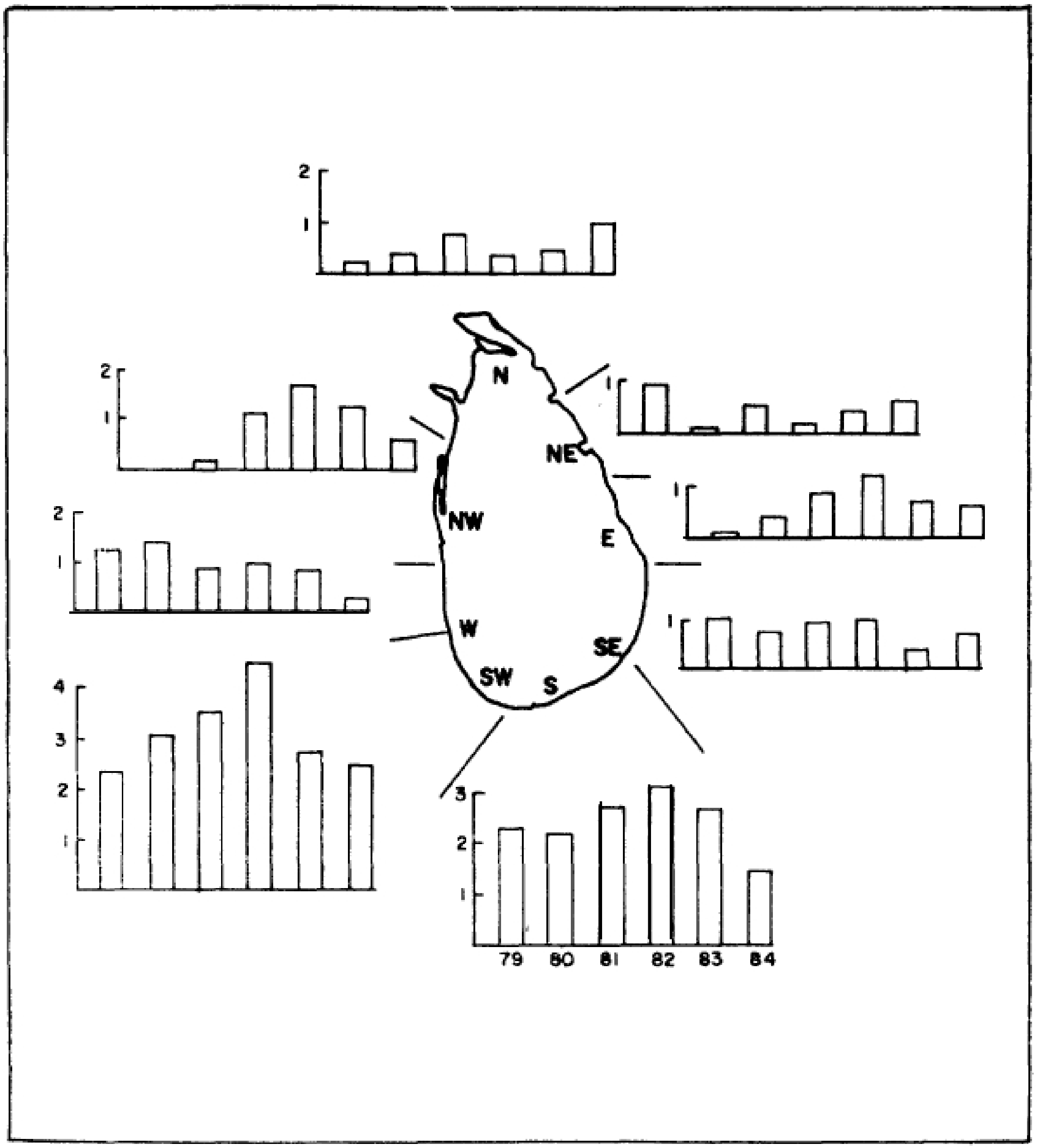

Fig. 3 Production of small tuna in Sri Lanka, 1979—1983 (x 1000 MT)

increases. Off the west coast, total tuna landings have tended to remain more or less steady, with an average annual production of 4,450 t during the years 1979 to 1983. Production dropped to 1 ,156 t in 1984, a reduction of nearly 75% from the previous production levels, while landings of skipjack and smaller tuna declined after a peak in 1980, landings of yellowfin show a decline from 1982 onwards. Another significant increase in tuna landings is seen in the southwest, where production rose from 3,650 t in 1979 to a peak of 9,239 t in 1982 before declining to 4,789 t in 1984. A four-fold increase in skipjack and a two fold increase in yellowfin landings have been the contributing factors. Catches of smaller tuna were higher than those of skipjack and yellowfin, except in 1983. The reduction in catches since 1982 is more dramatic for skipjack and smaller tuna.

As in the southwest, a steady annual growth in production has been recorded for the south, with a peak of 8255 t in 1982 and a decline thereafter. The decline is more marked in the case of smaller tuna than in skipjack and yellowfin. Off the southeast coast, production has fluctuated annually, with the 1984 production of 2,317 t second only to the peak annual production of 2,628 t recorded for 1982, during this period. Species-wise, there is a steady rise in the production of skipjack while the production of yellowfin and smaller tuna was higher in 1984 than in 1983. Total landings of tuna on the east coast show a decline in 1983, after increases in previous years. This decline is reflected in landings of skipjack and smaller tuna while landings of yellowfin are low and steady during this period. Total production in 1984, however, is about 15% more than the recorded figure for 1983. Tuna production on the northeast also increased by over 50% during this period, with the highest annual production recorded in 1983 (3,088 t) and 1984 (2,890 t), The fishery in this area attracts migrant fishermen from the western and southern coasts. A tendency in recent years of a considerable number of these fishermen to remain permanently in the area probably helped to increase production. While skipjack and yellowfin tuna have recorded increases, landings of smaller tuna have shown annual fluctuations.

The largest contribution to the tuna production in the country comes from the southwest and south, where tuna fisheries have traditionally played an important role in the marine fisheries of these areas. The west and northwest are the next important tuna fishing areas in the island. On the eastern side, tuna fisheries grew with migration of fishermen from western and southern coasts, but the level of production is not as high as on the western and southern coasts. Migrant fishermen who have gradually begun to settle down more or less permanently on the eastern coast, for instance in northeast, have pushed the production up in recent years.

The percentage contribution of different species to the total tuna production is shown below:

	1979	1980	1981	1982	1983	1984
Skipjack	35.3	44.9	42.3	38.8	43.1	44.7
Yellowfin	27.6	24.4	23.3	24.4	27.9	24.8
Smaller tuna	37.0	30.6	34.4	36.2	28.9	30.5

Skipjack tuna, the dominant species among tunas caught in Sri Lanka, constitute 35% to 45% of tuna landed in recent years. Yellowfin tuna is the second-most dominant, with a percentage contribution ranging from 23% to 28% .Eastern little tuna (Euthynnus affinis) and *Auxis* species (*Auxis* thazard and *Auxis* rochei) together contribute to the bulk of the smaller tuna landed. While oriental Bonito (Sarda orientals) and big-eye tuna (Thunnus *obesus)* are landed in very small quantities, specimens of longtail tuna (Thunnus tonggol) and dogtooth tuna (Gymnosarda unicolor) are also occasionally encountered.

In the case of 3.5 GT boats and smaller craft, catch data are collected by fisheries inspectors through a two-stage stratified sampling scheme. In the case of the 11 -metre boats, the skippers are expected to send in returns on catch, fishing effort and other information related to fishing operations.

The percentage species composition in the gillnet fishery conducted by the 3.5 GT class of boats in the northwest, west, southwest and south coasts is given in Table 2. A list of species including non-tuna varieties caught in the gillnet fishery is given in Joseph *et al.* (1985). Fifty to 83.7% of the catch in gillnet fishery consists of tuna, with skipjack and yellowfin being the dominant species. While the percentage contribution of skipjack decrease from south to northwest, those of yellowfin increase northwards.

The production of skipjack, yellowfin and smaller tuna estimated through research sampling of the fisheries conducted by 3.5 GT boats in these areas is compared with the production estimates made by the Statistics Division of the Ministry of Fisheries, which include production by all types of craft and all gear, in Table 3. Area-wise production data for 1985 is not available in the case of the Ministry of Fisheries statistics, while research sampling did not cover all of 1982. From the estimates of skipjack and yellowfin production made for all fisheries conducted by the 3.5 GT class of craft in the study area, it is seen that 86.5% and 96.8% of skipjack and yellowfin produced in the area during the period 1983-1985 come from the gillnet fishery.

In troll and pole and line fisheries, which are traditionally strong in the south and southwest, tunas make up 80-97% of the catch in troll fishery and 99% of the catch in pole and line fishery. The percentage species composition in these fisheries is shown in Table 4. The troll fishery is mainly directed at smaller tuna varieties, which form over 50% of the catch. While the yellowfin catches in the troll fishery show a steady increase, the total catch of tuna shows a decline. This reflects the increasing use of large hooks directed at yellowfin tuna and billfishes. The pole and line fishery is specifically directed at skipjack, which forms 80% of its catch. In the longline fishery, which is more popular off the west coast, nearly all the catch is shark and billfish. The following percentage composition was obtained for the tuna produced by the 3.5 GT class of boats in the western and southern coasts from 1983 to 1985.

	Skipjack	Yellowfin	Smaller tuna
1983	40.9	33.6	25.5
1984	46.3	40.9	12.7
1985	51.3	33.0	15.7

In the gillnet fishery, the catch rate (catch per boat per day) for skipjack showed an increase from 33.9 kg in 1983 to 38.3 kg in 1984 and 46.4 kg in 1985, while for yellowfin, the catch rates were 24.1, 35.7 and 32.5 kg respectively for the years 1983, 1984 and 1985.

Performance of the 11 -metre boats

Introduction of the 11 -metre class of gillnetters to the offshore tuna fishery, through the Northwest Coast Fishery Development Project, commenced during the second half of 1982. The total of 10 boats at the begining of 1983 increased to 24 by the end of 1984, and 77 by end of 1985. Provided with radio communication and ice, these boats are expected to stay out for more than a day during each fishing trip. Although the proportion of day trips was initially high, there is a shift towards an increasing number of trips lasting more than a day. This is seen in the percentage breakdown of trips given below on the basis of number of days taken per fishing trip.

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Fishing trips	1983	1984
1 day trips	37.8%	27.7%
2 day trips	38.7	31.2
3 day trips	19.6	30.1
4 day trips	4.2	7.7
5 day trips	—	2.8
6 day trips	—	0.2
Total no. of trips	560	1074

The mean number of fishing days per boat per month is plotted in Fig. 4(a) for 1983 and 1984. The mean during 1983 ranged from 4.7 to 11.8 days per month, while some boats achieved 17 to 18 fishing days during certain months. The mean values obtained during 1984 are higher than those obtained during 1983, with a range of 9 to 14 days per month. Some boats have been able to achieve 21 to 22 days of fishing during certain months in 1984. However, for the two year period, the mean number of fishing days per boat per month has not exceeded 15. The mean values also give a total of 92.2 days fishing per boat during 1983 and 123 days fishing per boat during 1984.

The mean catch per boat per fishing day on a monthly basis is plotted on Fig. 4(b) for 1983 and 1984. The values ranged from 104.0 kg to 480.5 kg in 1983 and from 138.5 kg to 327.0 kg in 1984. Highest catch rates were obtained between May and October in both years. The estimated mean number of fishing days per boat per month and the mean catch rates give an annual production of 22.5 t and 28.8 t per boat, during 1983 and 1984 respectively.

Although the skippers of these boats are expected to provide information on fishing operations in their returns, such information is almost always incomplete. For instance, the number of operations during each fishing trip is not separately reported. The catch is also not reported in terms of the gear used. The percentage species composition given in Table 4 therefore represents the catch composition of the combined gillnet/longline fisheries. It is given on a regional basis as the boats operated from various ports during the year, as already reported.

Fishing operations conducted during 1983 by these boats, covered 11 months off the south coast, 7 months off the west and northwest coast, 5 months off the northeast coast and 2 months off the southwest coast. During 1984, the coverage was 12 months off the south coast, 10 months off the west coast, 9 months off the northwest coast, 7 months off the northwest coast and 6 months off the northeast coast.

It is evident from Table 5 that skipjack tuna, yellowfin tuna, shark and billfish dominated the combined gillnet/longline fishery. During both years, the contribution of skipjack tuna to the catches decreased from south to north on the western side of the island. A reverse trend of increased contribution from south to north is observed in the case of yellowfin tuna. In the northeast, skipjack tuna contributes over 50% to the production by these boats. On the western side, the relative contribution of shark to the catches in different areas is similar to that of skipjack tuna.

Discussion

Tuna fisheries in Sri Lanka have been generally confined to the coastal zone, an area extending upto 40 kilometres and to the fringes of the off-shore. The few attempts in the past to develop fisheries in the off-shore range, 40 to 160 km off-shore, have had limited success. For economic viability, it is essential that boats introduced into this range stay out at sea for more than a day during each fishing trip. However, because of technological problems associated with the boats and because the fishermen were not used to staying longer stretches of time at sea, most of the boats introduced for off-shore fishery ended up as day boats like the 3.5 GT boats.

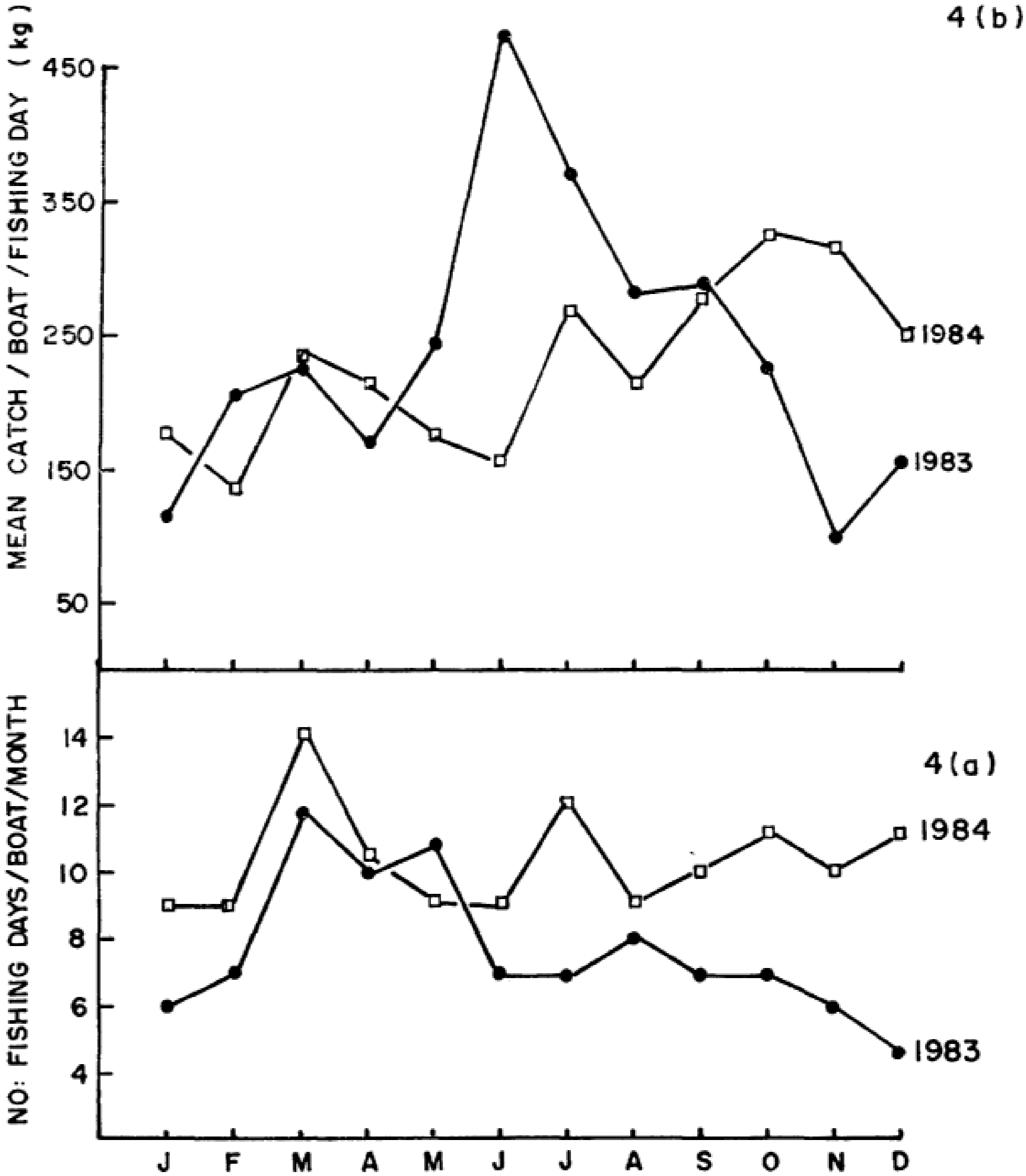

Fig. 4 (a, b) Monthly variation in fishing effort and catch per unit effort in the gilinet/longline fishery conducted by the 11 metre boat.

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The most recent attempt at extending tuna fisheries to the offshore range, through the foreign funded Northwest Coast Fishery Development Project, seems to have overcome some of the problems faced during similar attempts made in the past. There is an increasing trend toward fishing trips lasting more than a single day. During 1983 and 1984 respectively, 62.5% and 72.3% of all trips exceeded a day. However, there are still problems in key areas as the mean number of fishing days recorded by a boat per month is considered too low. With more and more of this class of boats entering the off-shore fishery since 1983, there is a growing tendency among the 3.5 GT day boats to shift theirfishing range further off-shore, carrying ice and making fishing trips lasting two to three days. This may partly explain the increased production of tuna, particularly the production of skipjack and the increase in the proportion of large skipjack of 60-70 cm range in the catches made off the western and southern coasts during 1985 compared to the preceding two years. It is of interest to note here that a similar catalytic role was played by the 11 ton class of gillnetters in late 1960's. popularising gillnet fishery for tuna in the off-shore among the smaller 3.5 GT class of boats (Sivasubramaniam, 1970b).

The percentage species composition in the gillnet fishery conducted by the 9 metre, 3.5 GT class of boats closely resembles that of the 11 metre class of boats. In both, the distribution of yellowfin and skipjack along the coast shows an increase northwards for yellowfin and a decrease northwards for skipjack. This is also supported by the catch rates (catch per boat-day) shown in Maldeniya and Joseph (1986) and Amarasiri and Joseph (1986) for yellowfin and skipjack respectively.

Production estimates made by the Statistics Division, Ministry of Fisheries, do not, however, conform to the above distribution pattern of yellowfin and skipjack tuna. In the case of yellowfin, the most effective gear is the gillnet for immature, surface swimming fish and the longline for deep-swimming older fish. With very little longlining being conducted in the south and southwest, the bulk of the production in these areas come from the gillnet fishery. The troll fishery and pole and line fishery, with levels of effort and catch rates for yellowfin well below that of gillnet fishery, cannot be expected to contribute significantly to the yellowfin production in these areas.

In the case of skipjack tuna, estimates made by the Ministry of Fisheries for the west and northwest coasts are very much higher than those made from research studies. In the absence of pole and line fisheries in these areas and with the low level of effort in troll fisheries, the major contribution to production of skipjack is from the gillnet fishery. The wide disparity in the two estimates particularly off the northwest coast could be because of mis-identification of species on the part of the fisheries inspectors. In the south and southwest, pole and line and troll fisheries also contribute to production of 600 to 700 t of skipjack tuna per year, by the 3.5 GT class of boats. The production of skipjack by this class of boats in the southwest and south compare well with the estimates made by the Statistics Division, Ministry of Fisheries.

The more or less similar percentage species compositions in the gillnet fisheries conducted by the 9 metre and 11 metre class of boats point to an extension of the resource in the offshore range similar to what is observed within the coastal zone. While a 9 metre boat is estimated to land an annual catch of 22 to 26 t, a doubling up of the number of fishing days recorded by a 11 metre boat could help it to land a potential catch of 50 to 60 t per annum.

Tuna resources are considered to be heavily fished in the coastal range presently exploited by the 9 metre boats and other smaller craft. In the period 1983-1985, tuna production in the western and south coasts by the 3.5 G.T. class of boats showed an increase from 14,929 t in 1983 to 18,330 t in 1985, with the major component for this increase coming from skipjack tuna. In recent years, the gillnet has firmly established itself as the dominant gear in the tuna fishery, while the other gear types have become seasonally important in certain areas. In spite of exploratory fishing surveys for both live bait and tuna, that indicated possibilities of expanding pole and line fishing into other areas, pole and line fishing is still restricted to the south, southwest and east coasts. Furthermore, while considerable amounts of live bait preferred by local pole and line fishermen are landed by in-shore purse seiners off the west coast, the pole and line fishery in the south and southwest is hampered by limited supply of live bait. A more vigorous and effective link between research and extension could contribute more toward increased production of tuna from the existing fishery.

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Table 1

Tuna production in Sri Lanka 1979-1985

(metric tonnes)

Sub-area	DFEO area	1979	1980	1981	1982	1983	1984	1985
North	Mullaitivu Jaffna Mannar	850	3,483	1,635	991	1,436	1,829	
Northwest	Puttalam Chilaw	2,663	2,620	3,203	4.090	5,795	5,942	
West	Negombo Colom bo	4,178	4,962	4,336	4,598	4,198	1,156	
Southwest	Kalutara Galle	3,650	6,694	9,077	9,239	7,206	4,789	
South	Matara Tangalle	6,910	7,050	7,261	8,255	7,633	5,643	
Southeast	Kalmunai	1,558	1,287	2,194	2,668	1,812	2,317	
East	Batticaloa	717	1,802	2,017	2,219	1,208	1,414	
Northeast	Trincomalee	1,864	1,491	2,823	2,053	3,088	2,890	
Total		22,390	27,830	32,546	34,115	32,376	25,980	25,132

Source: Ministry of Fisheries
No provincial data available for 1985.

Table 2

Percentage species composition in the gillnet fishery conducted by 3.5 GT (9 metre) craft in Sri Lanka

	Northwest	West	Southwest	South
1983				
Skipjack	13.2	32.1	31.2	35.9
Yellowfin	47.5	32.2	13.5	26.1
Eastern little tuna	0.6	1.8	18.2	5.2
Auxis spp.	1.1	0.6	3.0	4.4
	62.4	66.7	65.9	71.6
1984				
Skipjack	11.7	22.3	42.9	52.8
Yellowfin	61.7	53.6	16.1	20.3
Eastern little tuna	0.9	0.9	3.7	2.5
Frigate tuna	1 .0	0.9	1.1	4.8
Bullet tuna	0.1	1.5	1.1	0.8
	75.4	77.2	65.0	81.3
1985				
Skipjack	27.3	31 .1	32.7	50.2
Yellowfin	52.4	22.7	20.2	22.2
Eastern little tuna	0.7	1.8	5.7	2.7
Frigate tuna	0.8	0.2	2.8	4.6
Bullet tuna	0.3	0.3	1.0	0.4
	83.3	56.1	62.4	80.3

Table 3

Tuna production-A comparison of estimates

(tonne)

	1982		1983		1984		1985	
	A	B	A	B	A	B	A	B
Skipjack tuna	—	9,444	6,115	0,515	6,670	7,472	9,408	—
Yellowfin tuna	—	6,726	5,015	6,814	5,889	5,050	6,047	—
Smaller tuna	—	10,31 5	3,807	7,527	1,825	5,008	2,875	—

A: Estimate for the 3.5 GT class of boats

B : Estimate from Ministry of Fisheries for all class of boats

Table 4

Percentage species composition in troll and pole and line fisheries in South-Southwest areas

	Troll			Pole and line		
	1983	1984	1985	1983	1984	1985
Skipjack tuna	17.5	35.3	9.6	—	79.8	80.7
Yellowfin tuna	1.4	9.9	12.3	—	1.3	1.1
Eastern little tuna	26.1	22.3	29.1	—	16.6	2.2
Auxis spp.	52.2	24.6	28.2	—	1.4	15.5
	97.2	92.1	79.2	—	99.1	99.5

Table 5

Percentage species composition in the combined gillnet and longline fishery conducted by the 11-metre boats

	Northwest	West	Southwest	South	Northeast
1983					
Skipjack	13.7	37.7	51.8	32.5	55.2
Yellowfin	74.4	19.9	28.1	14.1	6.6
Eastern little tuna	2.2	—	—	—	—
Shark	2.6	23.9	16.5	41.6	19.1
Bill fish	3.7	15.4	2.3	8.9	14.8
Others	3.1	2.7	1.1	2.7	4.1
1984					
Skipjack	10.6	36.2	48.9	40.3	51 .1
Yellowfin	45.1	37.2	12.9	12.0	11.7
Eastern little tuna	11.7	—	—	—	—
Shark	10.6	13.8	20.7	34.1	15.6
Bill fish	3.1	5.9	8.4	7.5	13.7
Others	17.8	6.7	8.9	5.7	7.2

Annexure 6

SKIPJACK TUNA *(K. PELAMIS)* — ASPECTS OF THE BIOLOGY AND FISHERY FROM THE WESTERN AND SOUTHERN COASTAL WATERS OF SRI LANKA*

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Introduction

Skipjack tuna, Katsuwonus *pelamis,* is the single most dominant species in the tuna fisheries in Sri Lanka. The production in recent years has increased from 7,779 t in 1979 to 13,972 t in 1983, making up 32% to 43% of the tuna production in Sri Lanka (Table 1). Except in the pole and line fishery, skipjack is exploited by other gear in multispecies fisheries.

Due to the importance of skipjack in Sri Lanka's tuna fisheries and the potential role it can play in future development and expansion of tuna fisheries in the region, a number of exploratory and experimental fishery surveys and development projects have been conducted in the past, with foreign assistance and/or collaboration. These and the fishery on skipjack tuna in Sri Lanka are well documented.

Very little information is available, however, on the dynamics of the exploited population of skipjack around Sri Lanka and its biology. Sivasubramaniam (1972) separated the polymodal length frequency distribution using the probability paper method described in Harding (1949) and Cassie (1954). More recently, age and growth of skipjack tuna has been studied using ELEFAN computer programs by Sivasubramaniam (1985), Amarasiri and Joseph (1985) and Joseph and Amarasiri (1985).

The present study attempts to determine the seasonal and spatial distribution of skipjack tuna on the western and southern coastal waters of Sri Lanka and its population biology, on the basis of samples from commercial fisheries, during the period 1982-1986. Reproductive biology of the species was also studied for a period of two years and the major findings, as reported by Amarasiri *et al., (1986),* are also summarised here.

Study area and sampling strategy

The study area extends from the northwest to south coast of Sri Lanka. This area covers fisheries administrative areas (District Fisheries Extension Office areas or EFEO) Puttalam, Chilaw, Negombo, Colombo, Kalutara, Galle, Matara and Tangalle. Three-fourth of the skipjack landed in the country come from this area, On the basis of statistics available from the Ministry of Fisheries, the production of skipjack in 1983 from this area, in terms of different categories of crafts is given below. The study area was divided into 4 sub-areas : northwest, west, southwest and south.

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*This paper was presented to the third working group meeting on the tunas around the Republics of Maldives and Sri Lanka, 22-25 September 1986, Colombo, Sri Lanka.

Sub-area	DFEO area	Production of skipjack tuna (MT)			
		Craft with in-board engines	Craft with out-board engines	Non-motorized craft	Total
Northwest	Puttalam Chilaw	2,582	5	3	2,590
West	Negombo Colombo	1,284	—	151	1,435
Southwest	Kalutara Galle	3,077	2	5	3,084
South	Matara Tangalle	3,296	110	0	3,406
		10,239	117	159	10,515

Except for a very small quantity, nearly all the skipjack landed from these areas come from craft with in-board engines. These are mostly the 3.5 GT, 9 metre class of boats, the distribution of which is shown below for 1980/81 and 1983/85.

Sub-area	Number of units	
	1980/81	1983/85
Northwest	282	101
West .. .	383	208
Southwest	370	334
South . ..	595	564

This study is based on the fishery conducted with the 9 metre class of boats. The fishery has been studied through a two-stage stratified sampling programme, similar to the one conducted by fisheries inspectors of the Ministry of Fisheries, from which production is estimated. Sampling visits made to selected major landing sites averaged two days' coverage per fortnight. Information obtained on number of boats operated, geer used and catch and effort of different fisheries were used to estimate monthly catch, total effort and catch per unit effort for each sub-area.

Length measurements (fork length) were taken from randomly selected samples of skipjack tuna at the landing sites. Length data were grouped into 2 cm intervals and then pooled on a monthly basis. Growth and population parameters were derived from length data using ELEFAN computer programs, on an Apple IIe microcomputer. The program is described in Pauly and David (1981), Pauly et al., (1981). David et al. (1982) and Brey and Pauly (1986). Growth and population parameters were also derived by separating the length frequency distributions, using Bhattacharya method (Bhattacharya, 1967) modified by Pauly and Caddy (1985) and applying Ford-Walford plot. The program for Bhattacharya method used was translated for use on Apple IIe microcomputer by Goonetilleke and Sivasubramaniam (1986), and it also included other length-based methods for assessment of growth and population parameters such as the Ford-Walford plot, Gulland and Holt plot, von Bertalanffy plot (for growth parameters), Jones and van Zalinge method, Sparre's method and Wetherall et al., method (for total mortality estimation).

Maturity studies were carried out at marketplaces where fish is cut up for sale and at sites where fish is cut up for the preparation of Maldive fish, at times of glut. Maturity stages were assigned on visual examination of the gonads, based on size of gonad in relation to body cavity and colour and nature of its contents. A six point maturity scale (Immature-I, maturing (early stage)

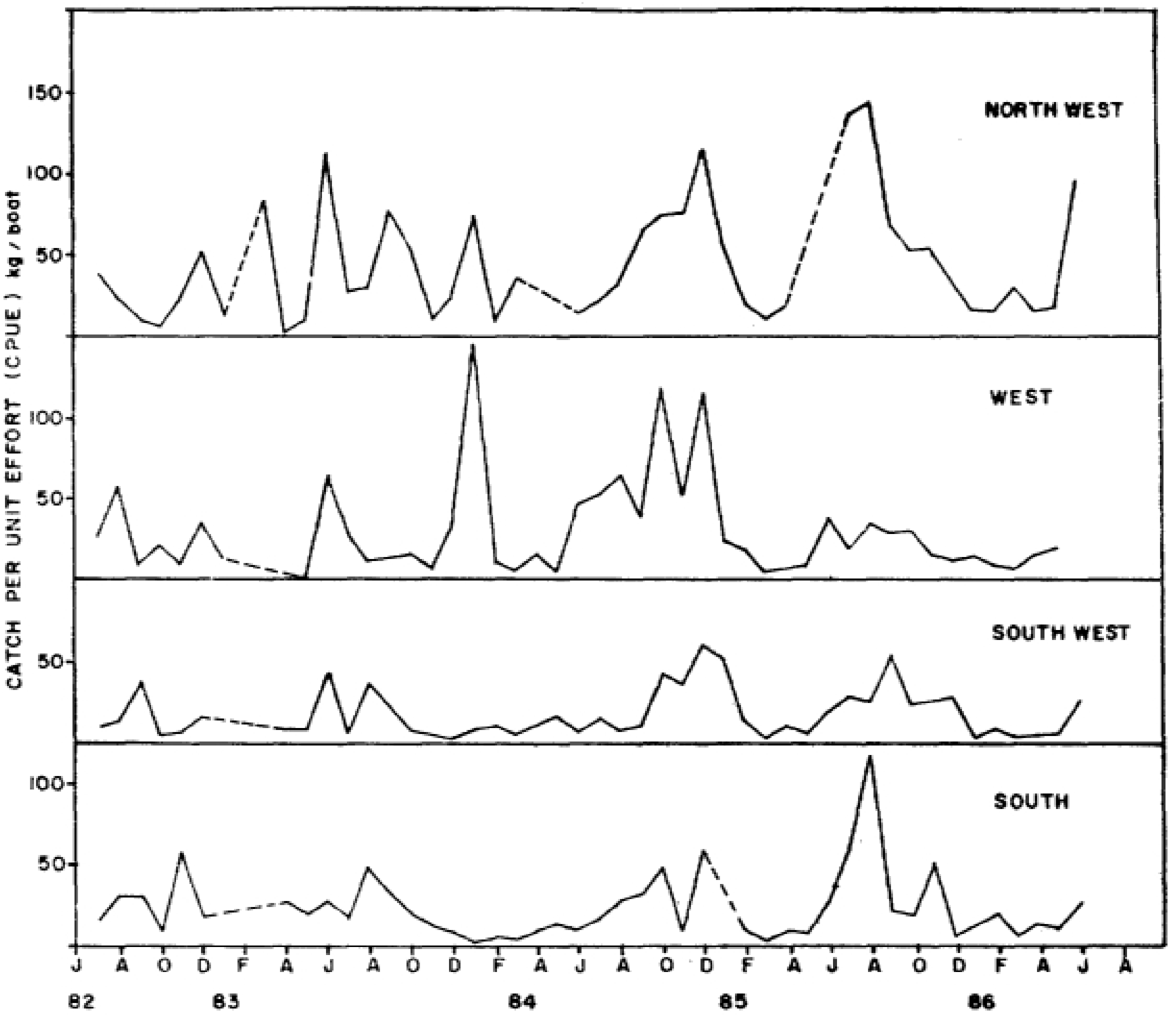

Fig. 1 Month'y variation in catch per unit effort of yellowfin tuna in the gilinet fishery.

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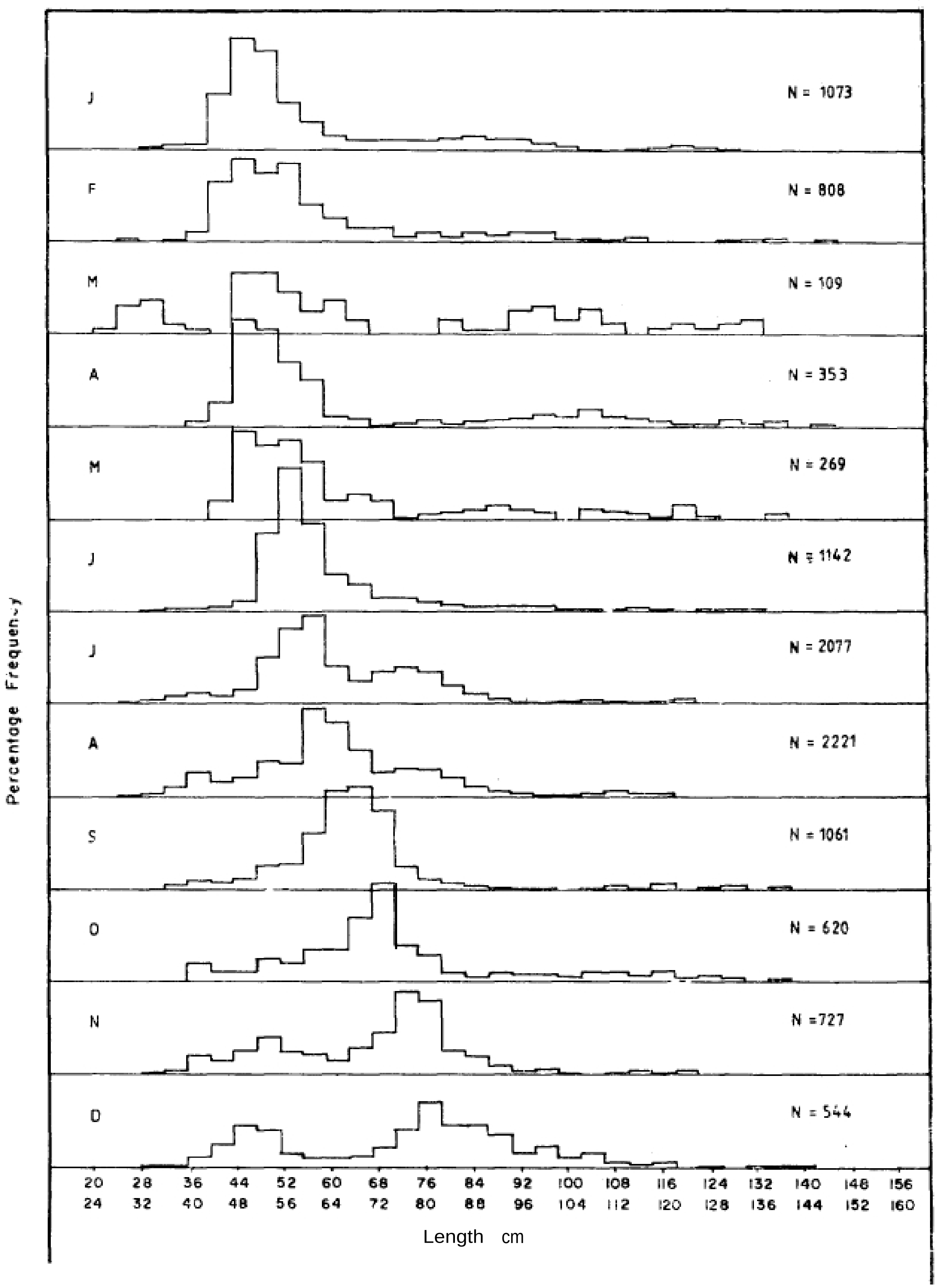

Fig. 2 Monthly length frequency distribution of yellowfin
na from the gilinet fishery in 1985.

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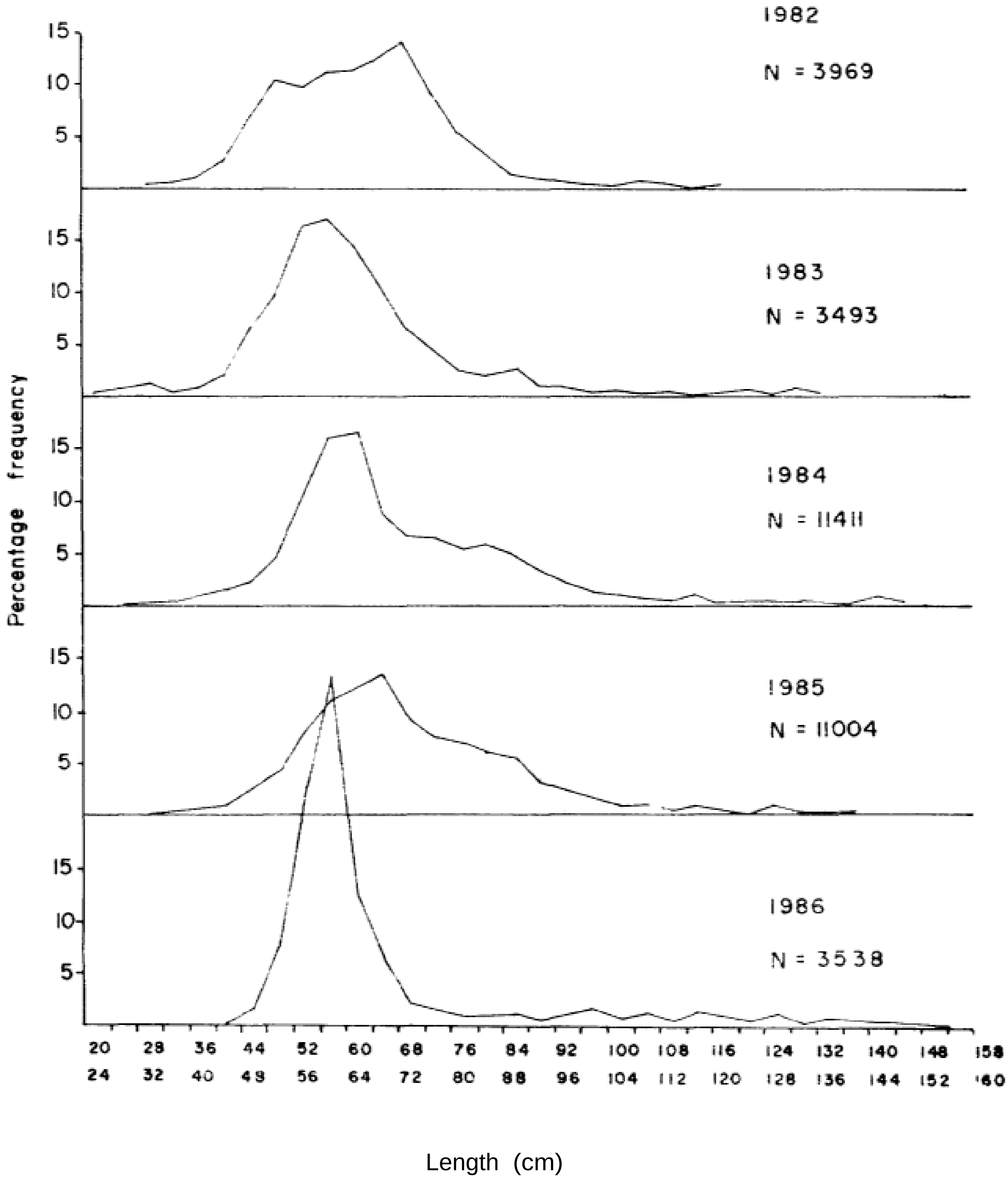

Fig. 3 Annual length frequency distribution of yellowfin tuna from the gillnet fishery, July 1982 —June 1986.

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-II, maturing-(late stage)-III, ripe-IV. oozing-V and spent-VI) was used for this purpose. Ovaries from mature fish were selected for fecundity estimates using gravimetric sub-sampling (Amarasiri et al., 1986).

Results and analysis

(a) *Fishing gear and effort*

The relative importance of different gear in the tuna fisheries in the study area, on the basis of fishing effort, is given in Joseph and Moyiadeen (1986), for the period 1982-1985. Of the three methods for exploiting skipjack tuna, the gillnet is the dominant gear in all sub-areas. The other two methods, trolling and pole and line, are important only in the southwest and south. While the majority of gillnetters carry 25 to 35 pieces of net (range — 20 to 45 pieces) with 4½" to 6" mesh sizes being more popular (range — 3¾" to 7"), the trolling boats carry two main lines with 200 to 220 jigs and 10 to 12 independent lines with hooks for larger tuna and other scombroids (Joseph and Amarasiri 1985).

The gillnet fishery is conducted year round, with effort being considerably more during the southwest monsoon period of May to October. On the other hand, troll lines and pole and lines, popular in the southwest and south, are mostly operated during the rest of the year. The pole and line fishery extends from November to March while the troll fishery, although a year round fishery, also peaks during non-monsoon months. Total monthly effort from the south and southwest during 1984 and 1985 has been pooled together and shown in Fig. 1 to illustrate the annual and seasonal varia ion in fishing effort by different gear exploiting skipjack tuna in these areas.

(b) *Catch and catch per unit effort*

The effort in tuna fisheries conducted through varied gear such as gillnet, troll, pole and line and longline is considered in terms of boat days. Irrespective of which of the above gear is used, each fishing trip lasts less than 24 hours.

The monthly variation in the mean CPUE in the gillnet fishery for the years 1983, 1984 and 1985 is shown in Figure 2, together with the estimated total monthly effort for 1984 and 1985. In southwest and south, the total effort is high during the southwest monsoon period of May to October and then declines towards the end of the year. No such trend is observed in the west and northwest where the effort towards tne end of the year is at the same level or even higher than that observed during the southwest monsoon.

It is also seen that the monthly variation in catch per unit effort has not been influenced by the total monthly effort. This allows the use of catch rates as indices of abundance. A decline in the catch rates from south to northwest may therefore indicate a gradual reduction in the distribution and availability of this species from south to northwards on the western side of the island. Except during August 1985, the mean monthly CPUE of skipjack tuna obtained foi northwest is generally low. A comparison of annual mean catch rates of skipjack tuna in different areas in different years is aiven in Table 2, together with a mean calculated for the southwest monsoon period of May to October, in each area.

Northwest recorded lowest CPUE values except during 1985 when a high catch rate obtained in August has given a high mean CPUE for the whole year as well as for the southwest monsoon period. Off the west coast, high mean CPUE values are recorded during the southwest monsoon period of 1984 and 1985, whereas in the southwest, it is high for the same period in 1983 and 1984. The biggest annual increase in mean CPUE of skipjack in the gillnet fishery during the southwest monsoon period is seen in the south where it has increased from 38.8 kg in 1983 to 62.9 kg in 1984 and to 101 .1 kg in 1985.

The contribution of skipjack tuna to the gillnet fishery during 1983, 1984 and 1985, is given below as percentages of the total catch and tuna catch.

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Area	Percentage of total catch			Percentage of tuna catch		
	1983	1984	1985	1983	1984	1985
Northwest	13.2	11.7	27.3	21.2	15.6	32.7
West	32.1	22.3	31 .1	48.1	28.1	55.5
Southwest	34.6	42.9	32.7	54.9	65.9	52.4
South	35.9	52.8	50.2	50.2	64.9	62.5

The decline of skipjack towards the north and the increased contribution of skipjack in the gillnet fishery in the south and southwest compared to other areas are also evident from the above. Further, while the importance of skipjack tuna in the gillnet fishery in the west and northwest may vary annually, depending on its general availability in the whole study area, it is the dominant species in the gillnet fishery in the southwest and south, judginq from the CPUE values and percentage contribution to the catches.

In the troll fishery, skipjack tuna are landed generally in small numbers. The catch rates in the troll fishery are also not as high as in the gillnet fishery. In the south and southwest, CPUE for skipjack tuna in the troll fishery were low during the southwest monsoon months and tended to increase during the other months. The gear is mainly directed toward catching smaller tuna varieties (eastern little tuna and frigate tuna) and the percentage contribution of skipjack tuna in the troll catches is not very high : 14.7, 8.0 and 9.3 in the southwest and 16.8, 18.3 and 9.7 in the south, during 1983, 1984 and 1985 respectively.

The level of effort in the pole and line fishery, conducted only in the south and southwest coasts, is heavily dependent on the live bait supply. While there was practically no pole and line fishing during 1983, the catch rates estimated in the fishery during 1984 and 1985 showed wide variation, from 24.4 kg to 261 .O kg. Mean monthly CPUE values obtained in this fishery indicated a more successful fishery in 1985 compared to previous years, with a species composition in the catches of 80.6% skipjack, 16.0% frigate tuna, 2.0% eastern little tuna and 1.2% yellowfin tuna.

The total production of skipjack tuna from all fisheries conducted by the 3.5 GT class of boats in the study area is given in Table 3. A comparison with total skipjack production in the area by all gears and craft signify the importance of the 3.5 GT class of boats in the tuna fishery. While the bulk of the production is from the southwest and south, a significant increase in production is recorded for the whole study area during 1985 compared to 1984 and 1983. Gear-wise separation of total production shows that the gillnet catches contributed 84.4% and 82.8% of the production in 1984 and 1985 respectively. While the contribution from troll fishery dropped from 10.4% in 1984 to 2.3% in 1985, that from the pole and line fishery increased (5.1% in 1984 to 14.8% in 1985).

(c) Age and growth

Age and growth of skipjack tuna was studied using length frequency distributions obtained from the gillnet fishery in 1984 and 1985. Though considered to be size selective, the wide range of mesh sizes used in the gillnet fishery and the entangling nature of the gear have allowed sampling of a wide size range of the population (24 to 80 cm), with evidence of modal progression. This was considered adequate to yield meaningful results from the analysis with ELEFAN program.

With the length data for 1985, the program yielded values of 0.44 and 85.0 cm for K and L_∞ of the von Bertalanffy growth equation, the ESP/ASP ratio being 0.239 for a single cohort. The Bhattacharya method was used to separate the normal distributions in the length frequency distributions given on a quarterly basis and also from the annual total length frequency distribution. The mean lengths of the groups separated by this method, from the length data of 1984 and 1985, are as follows.

Year			Quarter			Total
		I	II	III	IV	
1984	. . . .	68.0	43.7	30.7	43.9	30.7
			48.4	40.7	57.0	42.5
			53.7	57.9		48.9
1985	. . . .	57.0	33.1	49.8	46.0	48.7
		63.1	49.4	58.0	57.0	58.2
			59.8	65.7	67.3	

It was assumed that the modes in a quarterly or annual distribution represent different year classes and/or cohorts. Pairs of modes were picked out for a Ford-Walford plot and the results of two such exercises are shown below:

L_{t+1}	L_t	L_{t+1}	L_t
33.1	49.4	33.1	49.4
46.0	57.0	43.7	53.7
49.4	59.8	46.0	57.9
57.8	63.1	49.8	58.0
57.9	67.3	57.8	63.1
58.0	65.7	58.0	65.7
		63.1	68.0

K	=0.408	0.441
L_∞	79.77 cm	75.986 cm
r	0.970047	0.982581

Since the ELEFAN program is known to overestimate L_∞, the acceptable values for K and L_∞ are 0.44 and 76.0 cm respectively. If the above growth parameters are used with the von Bertalanffy growth equation (keeping t_o =0), the length at age values are as follows:

Age (yrs)	1	2	3	4	5	6	7	8	9
Length (cm)	27.1	44.5	55.7	62.9	67.6	70.6	72.5	73.8	74.6

(d) Size *composition of skipjack tuna*

Monthly length frequency distribution of skipjack tuna sampled from the gillnet fishery during 1984 and 1985 are shown in Figures 3 and 4 respectively. It is seen that the bulk of the landings are of the 40 to 65 cm length range. Small skipjack of length less than 35 cm have been sampled in the gillnet fishery mainly during July/August 1984 and June/July 1985. Although not as distinct, there have also been small skipjack sampled in February 1985. Area-wise length data available for 1984 and 1985 show that small fish have been sampled mostly off the southwest and south coasts during both years, with a small contribution coming from the west coast, particularly during January/February 1985.

The annual length frequency distribution obtained for skipjack tuna from the gillnet fishery in western and southern areas is given in Figure 5 for the years 1982 to 1986. While the length frequency distribution given for 1982 covers only the second half of the year (July to December), that given for 1986 covers only the first half of the year (January to June). A comparison between years shows that there has been a substantial contribution of large skipjack (above 60 cm fork length) to the catches in 1983 and 1986. In the other years, the 40 to 60 cm length group has been dominant in the catches.

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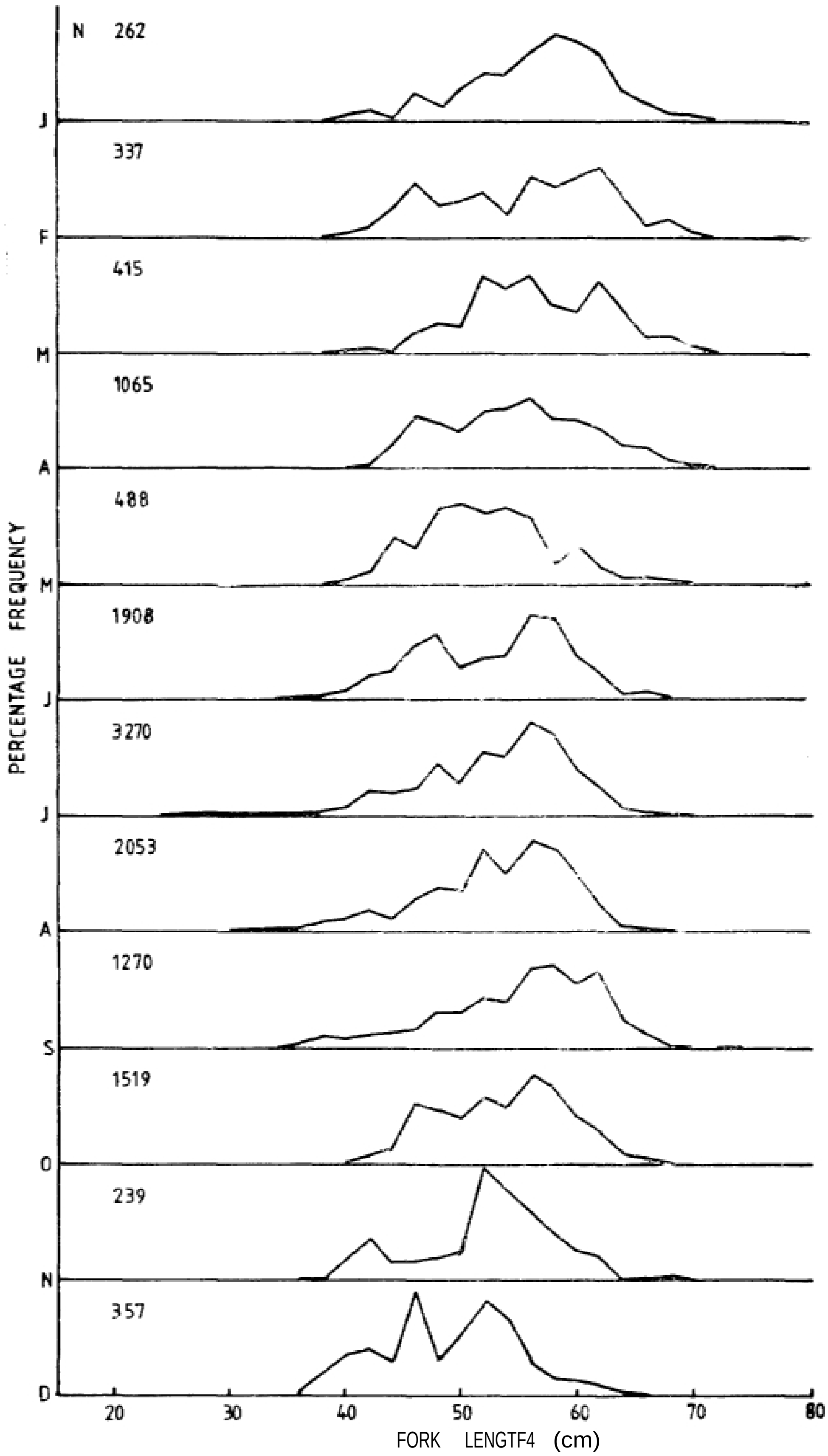

Fig. 3 Monthly length frequency distribution of skipjack tuna from the gillnet fishery, 1984.

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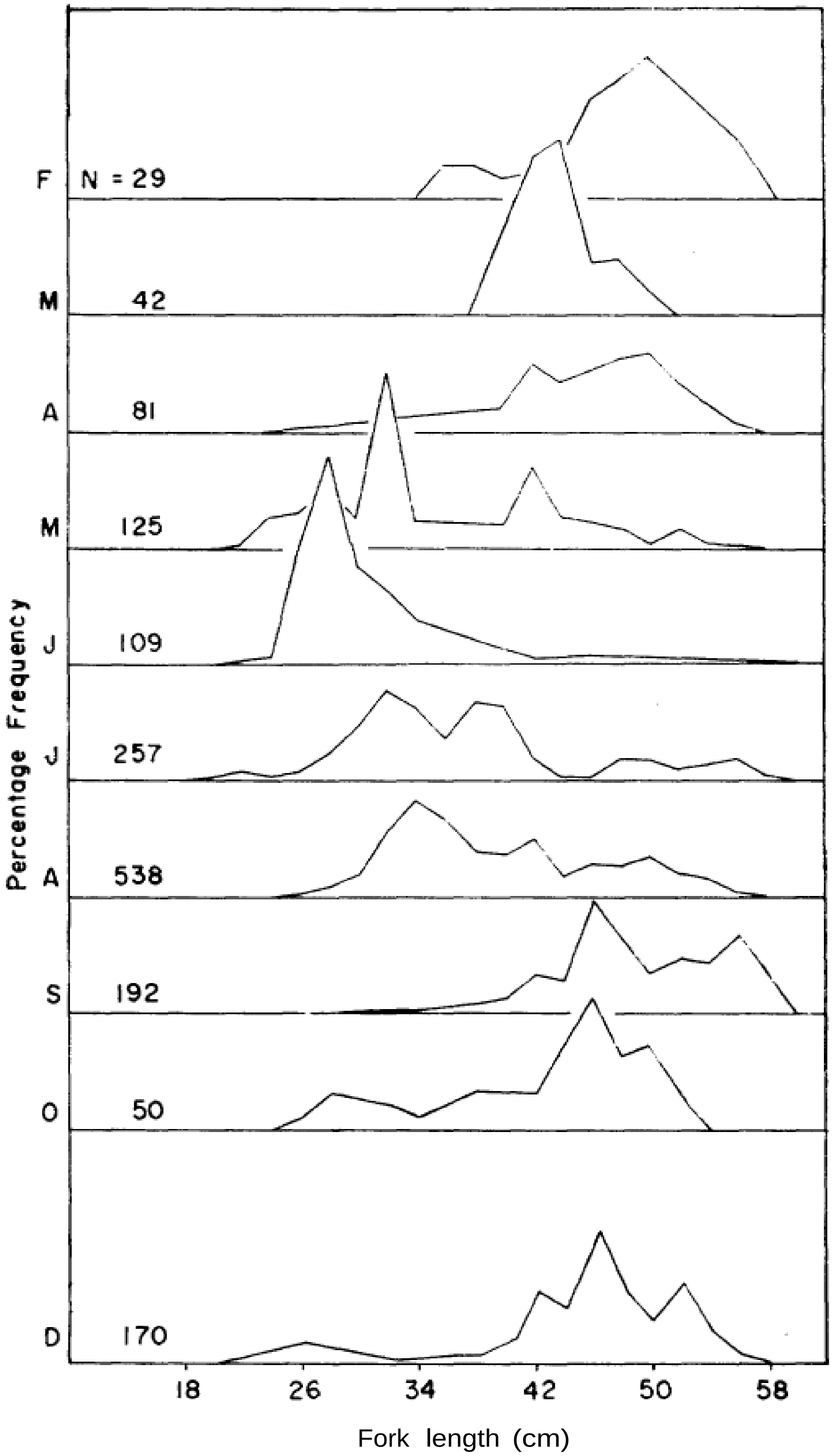

Fig. 4 Monthly length frequency distribution of skipjack tuna from the gilinet fishery, 1985.

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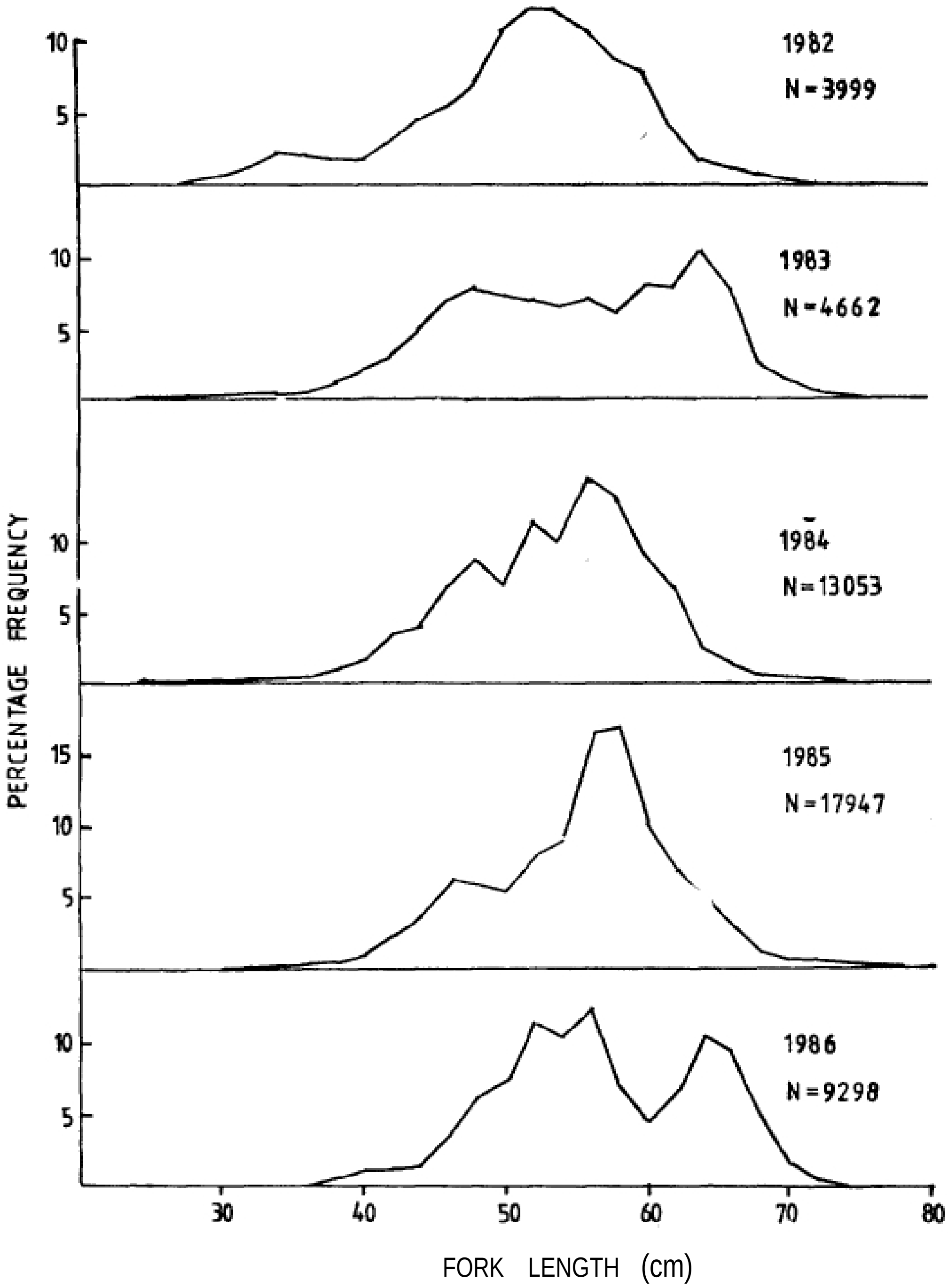

Fig. 5 Length frequency distribution of skipjack tuna from the gilinet fishery. 1982 —1986.

From the length at age data obtained in this study, it appears that the fishery is primarily based on fish between one and six years of age. While fish of ages two and three years were dominant in the catches during 1982, 1984 and 1985, four- and five-year-old fish have also contributed significantly to the catches during 1983 and 1986.

(e) Maturity and spawning

Amarasiri ***et a/. (1986)*** report on a study of the reproductive biology of skipjack tuna from the south and southwest, conducted over a period of two years, August 1984 to July 1986. While the overall ratio of male to female fish was 1 :0.85 (889:763), there was a preponderance of males among the large skipjack, of >62 cm. Monthly variation in the sex ratio showed a gradual increase of male fish from October, reaching a peak in January/February and then moving towards a 1 :1 ratio.

Although ripe and oozing ovaries were observed in all months of the year except in November and December, spawning activity seemed to be more concentrated between February and October. A high percentage of ripe and oozing ovaries were observed in March-May, 1985 and June-July 1986.

In both sexes, all fishes larger than 50 cm in fork length were mature. The length at first maturity has been estimated from a plot of percentage of mature fish in the sample against length and the length at 50% level of maturity was observed as 42.0 cm and 43.3 ***cm*** for male and female skipjack respectively. The size distribution of eggs was polymodal in maturing and oozing fish. Three size groups of ova were recognised in ovaries of mature fish, one more than in maturing and immature fish. Distribution of ova diameter showed modes at 0.38 mm and 0.75 mm for the two large size groups which together made up 62% to 66% of the ova in mature ovaries. Fecundity ranged from 211,410 to 2,952,253 in fish ranging from 44.0 to 68.0 cm fork length.

Discussion

In the study area, skipjack tuna is the most important species in the giilnet fisheries of the southwest and south, its importance as well as relative abundance, as evident from the catch rates, decreasing northwards. Sivasubramaniam (1972) also observed the lowest catch rates for skipjack in the northwest, compared to the west, southwest and south, in the gillner fisheries conducted by the 9 metre and 11 metre class of boats during the period 1967 to 1971. Catch rates and production estimates made for the years 1983, 1984 and 1985 reveal increased availability of the species to the Local fisheries in recent years. Although the study has been restricted to the western and southern coasts, these trends could probably be the same in other areas too.

Length frequency distribution shown for 1985 and 1986 indicates a heavy recruitment to the exploited stock during the southwest monsoon period (June/July) and possibly another recruitment at the beginning of the year, which is not as well defined as that during the southwest monsoon period. According to Sivasubramaniam (1972), recruitment of skipjack to the local fishery may be occurring irregularly throughout the year with a peak around the third quarter of the year (July/August). Length frequency distribution of skipjack tuna available from pole and line and gillnet fisheries conducted by 'Kosei-Maru' (Sivasubramaniam, 1977) showed recruitment during March/April and August/September periods. There **is** therefore evidence from length data obtained in different periods of time that show two major recruitments per year.

Maturity studies conducted by Amarasiri ***et*** al., (1986) have shown a high proportion of mature and spawning fish during March/May and June/July periods. The appearance of two large size groups of ova with the onset of maturity also provide evidence in support of two spawning pulses or peaks per year resulting in two recruitments.

Length at age and growth parameters, L_{∞} and K, estimated for skipjack tuna in various studies, mostly from the Pacific Ocean, are reported in Matsumoto et al. (1984) and Pauly (1978). Values obtained for L_{∞} ranged from 62.3 to 141.8 cm, with the majority falling between 80 and 88 cm. Similarly, values for K varied between 0.19 and 1.16 with the 0.40 to 0.50 range being more predominant. In previous studies on age and growth of skipjack tuna from Sri Lanka, Sivasubramaniam (1985) obtained values of 0.52 and 77.0 cm for K and L_{∞} using ELEFAN programs on length data from pole and line fishery. Amarasiri and Joseph (1985) and Joseph and Amarasiri (1985) obtained values of 0.62 and 85.0 cm for K and L,, using ELEFAN programs on length data from gillnet fishery. The ELEFAN program is generally considered to yield a high value for L_∞ . The program used in the present exercise was different from the one used in **the** studies previously conducted in that the Post-Sicily version (Brey and Pauly, 1986) reduces the impact of isolated large fish on the estimates of growth parameters. For skipjack tuna from Minicoy waters, Mohan and Kuhnikoya (1985) obtained values of 0.4898 and 90.0 cm for K and L_∞ respectively. Considering the range of values obtained, it is apparent that age and growth of skipjack tuna needs further investigations.

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Table 1

Skipjack tuna production in Sri Lanka, 1979-1984 (MT)

Sub-area	DFEO area	1979	1980	1981	1982	1983	1984
North	Mullaitivu Jaffna Mannar	627	1,118	692	530	348	604
Northwest	Puttalam Chilaw	775	1,059	1,260	1,449	2,590	3,365
West	Negombo Colombo	1,432	2,040	1,699	1,526	1,435	259
Southwest	Kalutara Galle	736	2,397	3,263	3,220	3,084	1,028
South	Matara	2,819	3,064	3,221	3,249	3,406	2,820
Southeast	Tangalle Kalmunai	390	277	644	918	973	1,020
East	Batticaloa	114	1,072	795	708	348	553
Northeast	Trincomalee	886	1,475	2,218	1,650	1,788	1,970
		7,779	12,502	13,792	13,250	13,972	11,619

Source : Ministry of Fisheries

Table 2

Mean catch per unit effort of skipjack tuna in the gillnet fishery, 1983-1985

(kg)

Sub-area	All year January-December			Southwest monsoon period May-October		
	1983	1984	1985	1983	1984	1985
Northwest	10.4	9.8	28.4	14.4	7.4	52.6
West	15.0	26.7	27.0	20.5	39.5	37.2
Southwest	41 .1	35.3	35.8	52.7	59.2	46.2
South	27.8	41.2	65.5	38.8	62.9	101.1

Table 3

Estimated production of skipjack tuna by 3.5 GT class of boats in the study area (1983-1985)

(MT)

Area	1983	1984	1985
Northwest	427.7	353.0	1,138.1
West	1,048.4	903.4	958.4
Southwest	2,512.8	2,308.4	1,950.9
South	2,126.5	3,105.0	5,360.9
Total	6,115.4	6,669.8	9,408.3

Annexure 7

ON THE DISTRIBUTION AND BIOLOGY OF YELLOWFIN TUNA *(T. ALBACARES)* FROM THE WESTERN AND SOUTHERN COASTAL WATERS OF SRI LANKA

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Introduction

Yellowfin tuna *(T. albacares)* contributes 23 to 28% of all tuna landed from the coastal waters of Sri Lanka, in recent years. The production ranged from 6070 t in 1979 to 9046 t in 1983 (Table I), making it the second most dominant species in Sri Lanka's tuna fisheries, next to skipjack tuna.

Tuna fisheries in Sri Lanka have been well documented. Those dealing specifically on yellowfin include studies on fisheries and abundance of yellowfin around Sri Lanka (Sivasubramaniam, 1970 and 1971). There are, however, no studies on age and growth and biology of the species from Sri Lanka.

This paper reports on the distribution and biology of yellowfin tuna from the western and southern coastal waters of Sri Lanka. The areas covered in this study contribute to nearly 75% of the yellowfin tuna landed in the whole country. While the distribution is studied using catch and effort data from the gillnet fishery and also length frequency distributions, studies on reproductive biology are based on samples collected from the west, southwest and south coasts.

Material and Methods

The study area includes the northwest, west, southwest and south coasts. Separation of the yellowfin catch during 1983 around the whole island, including the study area, by craft categories shows that 95% of the island's catch and practically the total catch of yellowfin in the study area is landed by craft with in-board engines, mainly the 9 metre 3.5 GT craft. There were 101, 208, 334 and 564 of these craft in the northwest, west, southwest and south respectively during 1984/85. These craft, particularly those on the west and northwest coasts, tend to migrate along the coast depending on seasonal availability of fish. it is also customary for some of these boats in all the sub-areas to migrate to the eastern coast during the off-season on the western and southern coasts.

The present paper is based on the tuna fisheries conducted by the 9 metre, 3.5 GT class of boats in the study area. A total of 13 major fish landing centres were covered during this study. Fortnightly sampling of the fishery was conducted with three days coverage per fortnight in each sub-area. Information collected at each landing centre included number of boats operated and fishing gear used. Random sampling was conducted for catch, effort and length frequency data. Catch and effort data obtained through a two-stage stratified random sampling were used to estimate total catch, total effort and catch per unit effort (CPUE) for different sub-areas, on a monthly basis.

Due to high costs involved, adequate samples were not available for other biological studies, particularly on maturity. These were carried out at places where fish were cut up for sale, at market places or at landing sites when fish were cut up for sun-drying, particularly at times of

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glut when the prices paid were low. Due to this limitation, the numbers of fish examined were low during most months.

In the field, gonad maturity stages were assigned visually on the basis of a six-stage maturity cycle (immature I, early developing II, late developing III, mature IV, gravid V and spent VI), which takes into account the size, colour and nature of contents of the gonad. When ever possible, gonads were brought to the laboratory on ice, weighed and stored in Gilson's fluid for subsequent analysis.

Age and growth of yellowfin were determined from length data using ELEFAN and Bhattacharya methods. These programs, described in David et *al.* (1982), Pauly and David (1981), Pauly and Caddy (1985) and Goonetilleke and Sivasubramaniam (1986). were run on an Apple IIe microcomputer.

Analysis and Results

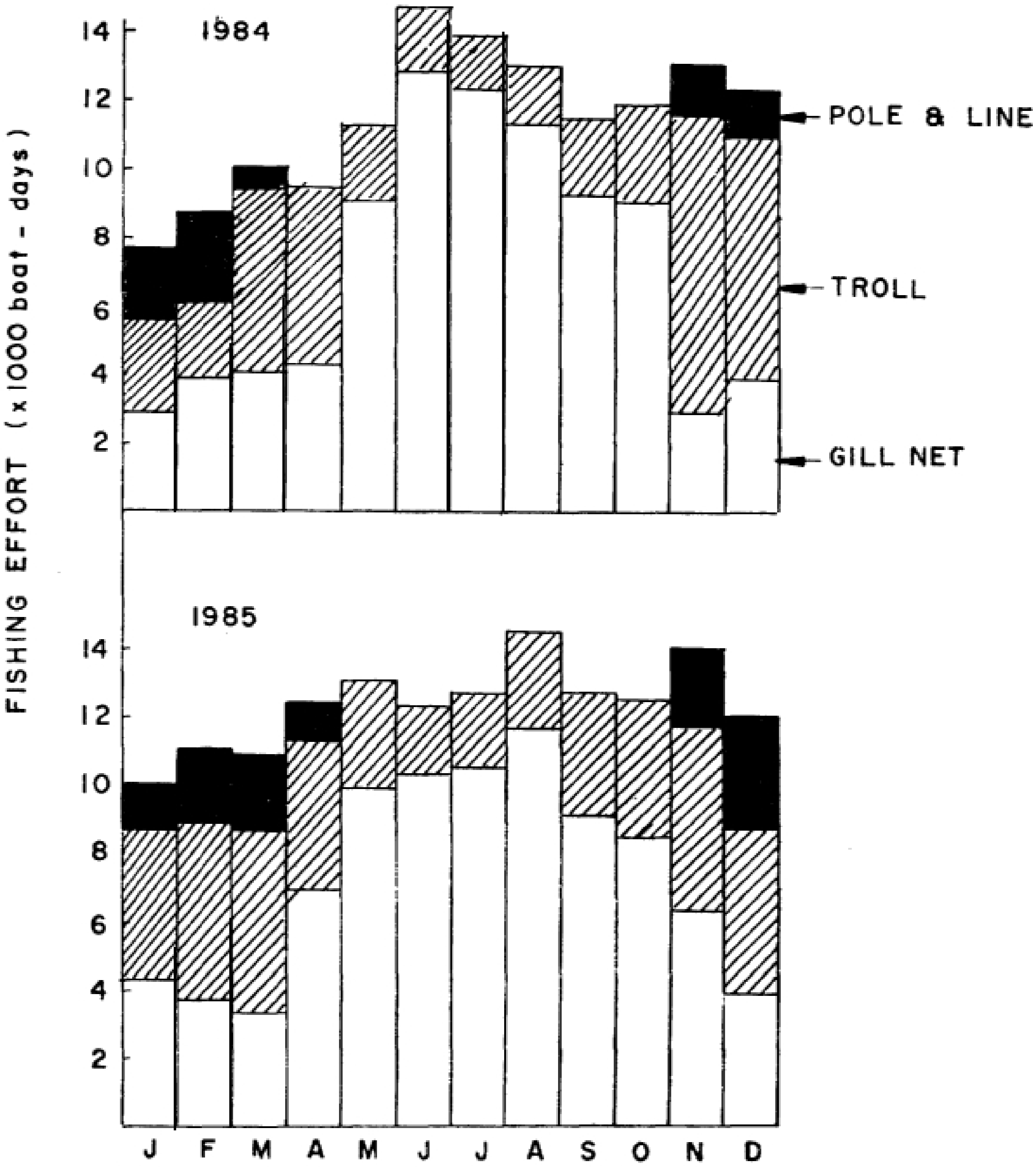
(a) *Catch, effort and catch per unit effort*

Yellowfin tuna and other tuna varieties in Sri Lanka are exploited by four main gear types: the gillnet (drift-gillnet), troll line, longline, and pole and line. It is difficult to standardise the effort by surface and subsurface fishing methods. The 9 metre craft using these gear are all day boats with fishing operations conducted within 24 hours; hence the catch per trip has been used as the catch rate. The percentage breakdown of total effort on tuna fisheries, in terms of different gear in the study area for the period 1983 to 1985, is given in Joseph and Moyiadeen (1986). In the whole study area, 70.4, 19.7, 3.7 and 6.1 per cent of the effort on tuna fisheries is applied through gillnet, troll, pole and line and longline respectively. On a sub-area basis, longlining is important on the west coast while trolling and pole and line are more popular in the southwest and south coasts. Gillnetting is carried out year round and is the dominant tuna fishing method in all sub-areas.

The longline fishery, which mostly uses cut pieces of tuna, dolphin and other varieties as bait, is known to land sharks and billfishes, which make up over 90% to 95% of the catch. Very little tuna (yellowfins and bigeye tuna, *T.* obesus) is landed in this fishery which now is basically directed towards sharks. Joseph and Moyiadeen (1986) give the percentage species composition in troll and pole and lint fisheries in the south and southwest areas. The yellowfin tuna contribution by weight to the total production from pole and line fishery is very low, 1.3 and 1 .1 per cent during 1984 and 1985 respectively. In the troll fishery, yellowfin tuna contributed 1.4, 9.9 and 12.3 per cent to the total catch in 1983, 1984 and 1985 respectively. The bulk of the yellowfin produced in the area therefore comes from the gillnet fishery. In addition to tuna, the gillnet fishery land sharks, billfishes, scombroids and other varieties, a list of which is given in Joseph et *al.* (1984). Contribution of yellowfin in the gillnet catches, as a percentage of the total catch and as a percentage of all tuna landed in the fishery, is given below on an area-wise basis, for 1983, 1984 and 1985.

Area	Percentage of total catch			Percentage of tuna catch		
	1983	1984	1985	1983	1984	1985
Northwest	*47.5*	*65.7*	*54.2*	*76.0*	*81.8*	*65.0*
West	*32.2*	*53.6*	*22.7*	*48.2*	*67.6*	*40.4*
Southwest	*13.5*	*16.1*	*20.2*	*20.5*	*24.8*	*32.4*
South	*26.1*	*20.3*	*22.2*	*36.4*	*25.0*	*27.7*

The contribution of yellowfin tuna in the gillnet fishery increases northwards and in the northwest, it is the dominant species in the gillnet fishery. Its presence in the gillnet catches in the south coast is slightly higher than that in the southwest coast.



SEASON

Fig. 1 Seasonal variation in fishing effort by gear, south/southwest,1984-1985.

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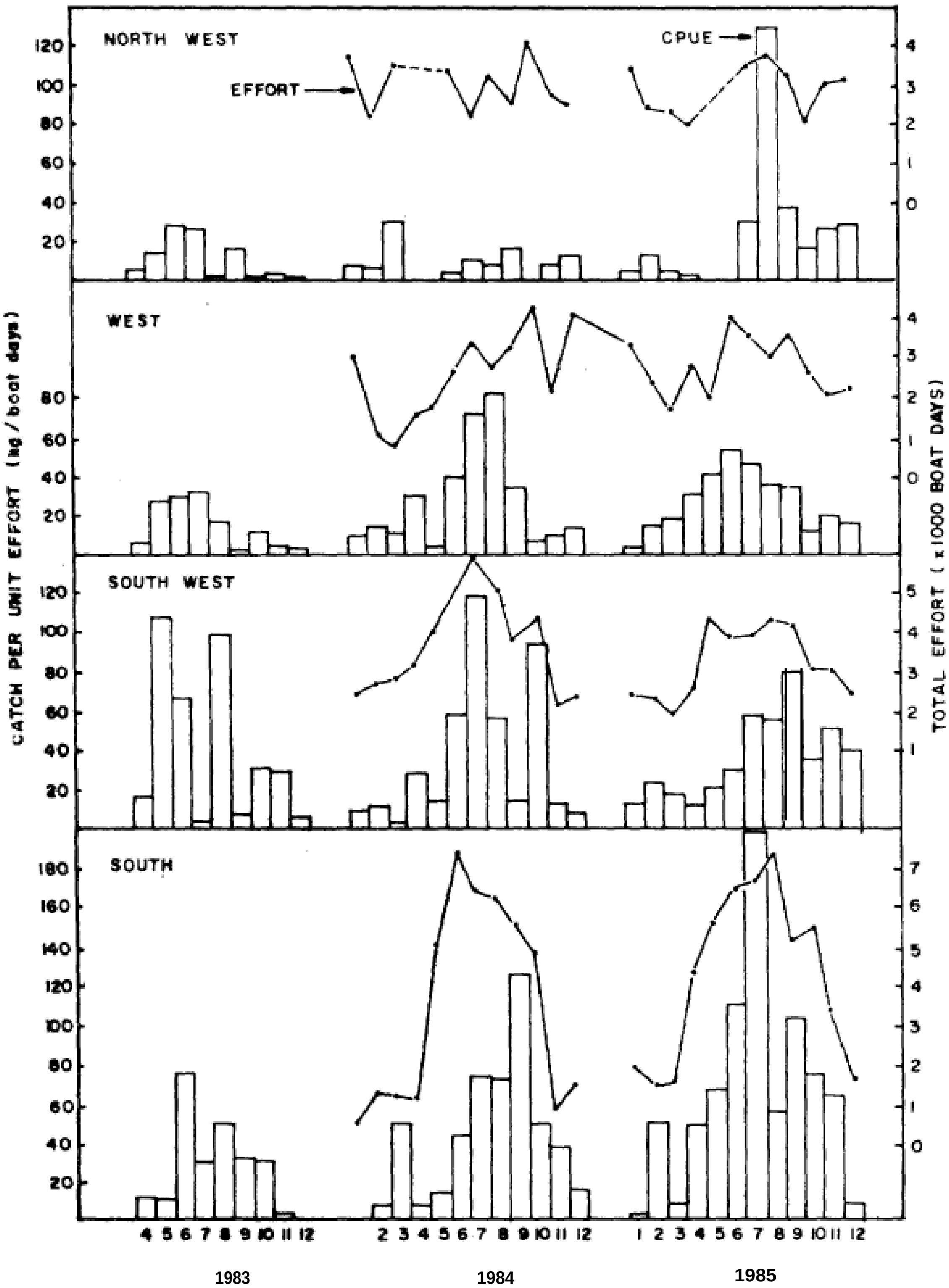

Fig. 2 Seasonal variation in total effort and catch per unit effort of skipjack tuna in the gilinet fishery.

The monthly mean CPUE of yellowfin tuna in the gillnet fishery in different sub-areas is shown in Figure 1, for the period July 1982 to June 1986. CPUE values are low in the south and southwest compared to the other areas and are the highest in the northwest. In 1983, the catch rates in the south and southwest reached a peak in the June to September period and then declined. In the west and northwest, catch rates showed wider monthly fluctuations and were also high in January 1984. Except during January 1984, the catch rates in all sub-areas exhibit the same monthly variation, although the actual values showed differences between areas as already stated. The peak season during 1984 was from August to December, extending to January 1985. The peak season during 1985 was around the middle of the year, the catch rates declining from September onwards. The catch rates at the beginning of 1986 were not high in all sub-areas, in contrast to high catch rates observed in January 1984 and 1985.

Mean CPUE values estimated on an annual basis for different sub-areas as well as for the whole study area are given below:

	1982	1983	1984	1985	1986
Northwest	24.2	39.7	50.4	58.6	31.2
west	24.6	18.0	54.5	19.0	14.3
Southwest	12.7	14.8	18.7	23.4	7.3
South	23.2	23.9	19.0	29.1	13.1
Study area	21.2	24.1	35.7	32.5	16.5

Values estimated for 1982 cover the second half of the year while those for 1986 cover only the first half of the year. Annual CPUE values estimated for the other years do not exhibit any definite trend except the increasing trends in the northwest and southwest coasts.

The estimated total production of yellowfin tuna by the 3.5 GT class of boats in the study area was 5015.4, 5889.6 and 6047.4 t for the years 1983, 1984 and 1985 respectively. Whiie the production during 1984 was 17% more than that of 1983, production during 1985 was only marginally higher than that of 1984. During the three year period 1983 to 1985, area-wise separation of yellowfin production indicate that 33.3, 23.1, 17.0 and 26.6 per cent of the total production have come from the northwest, west, southwest and south respectively. Gear-wise separation of the yellowfin production during this period shows that 96.8, 3.0 and 0.1 per cent of the total production has been realized through gillnet, troll and pole and line respectively.

(b) Age and growth

Although gillnet samples contained a wide size range of 21 to 162 cm, the bulk of the catches was composed of fish between 40 to 100 cm in fork length. The monthly length frequency distribution of yellowfin tuna sampled from the gillnet fishery during 1985 is shown in figure 2. These length frequency data were used with ELEFANI to obtain growth parameters K and L_{∞} of the von Bertalanffy growth equation. The program yielded values of 0.4 and 176 cm (ESP/ASP ratio 0.21462) and 0.4 and 174 cm (ESP/ASP ratio 0.20125) for K and L_{∞} of two cohorts.

The Bhattacharya method did not provide a satisfactory separation of modes from monthly length frequency distributions. Such an exercise was attempted on annual length frequencies available for 1983 to 1985 (Figure 3) and the modes identified are as follows:

1983	38.0	49.2	83.0	103.0	109.0	139.0	145.0
1984	36.0	47.3	85.6	113.5	127.0	140.0	151.0
1985	—	48.0	82.7	113.7	125.0	146.4	158.0

The following modal values were selected from the above and used in a Ford-Walford plot.

L_t	49.2	85.6	83.0	113.5	139.0	127.0	151.0
L_{t+1}	85.6	113.7	113.5	127.0	151.0	140.0	158.0

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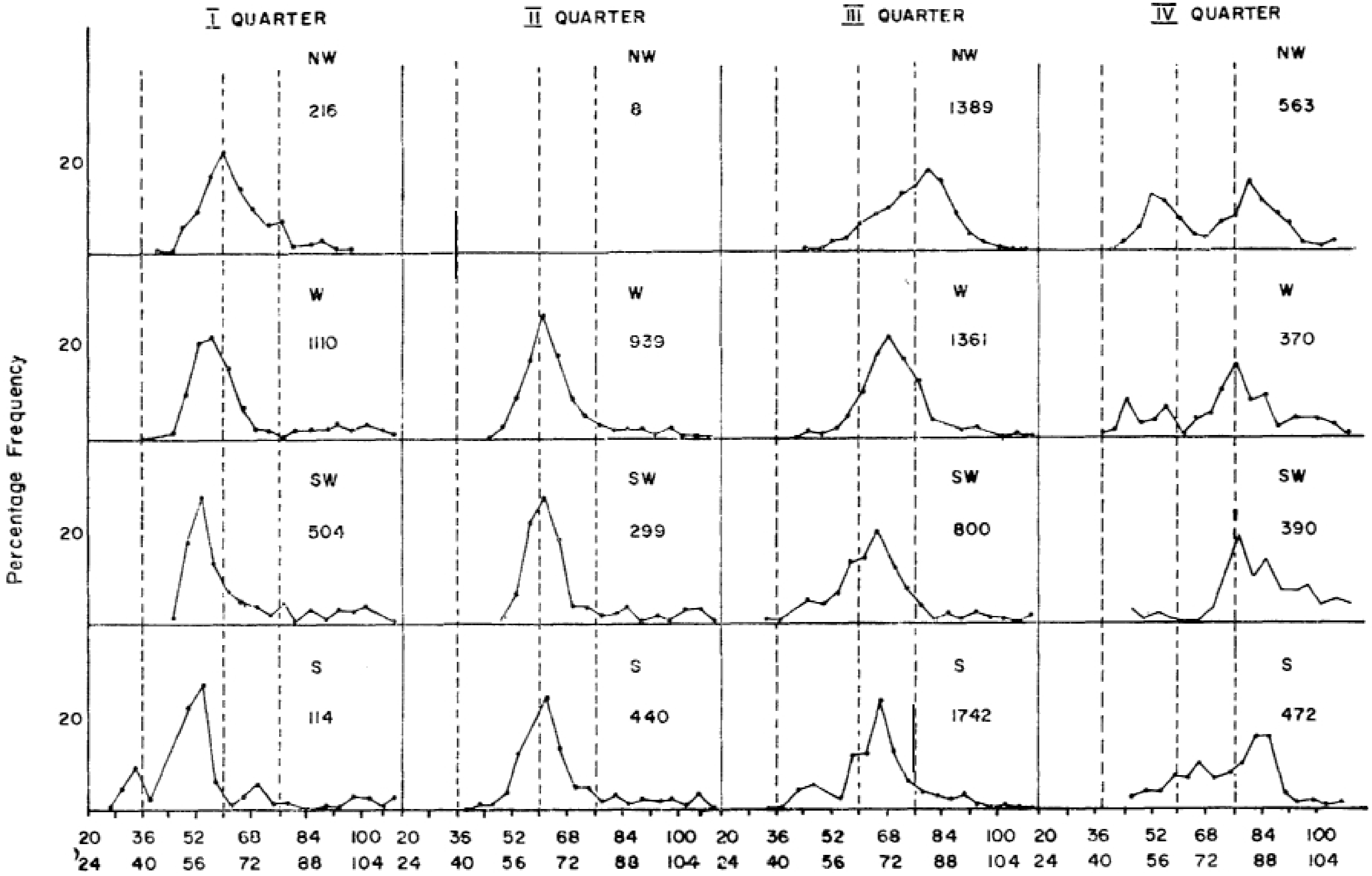

Fig. 4 Quarterly length frequency distribution of yellowfin tuna from gilinet fishery in different areas in 1985.

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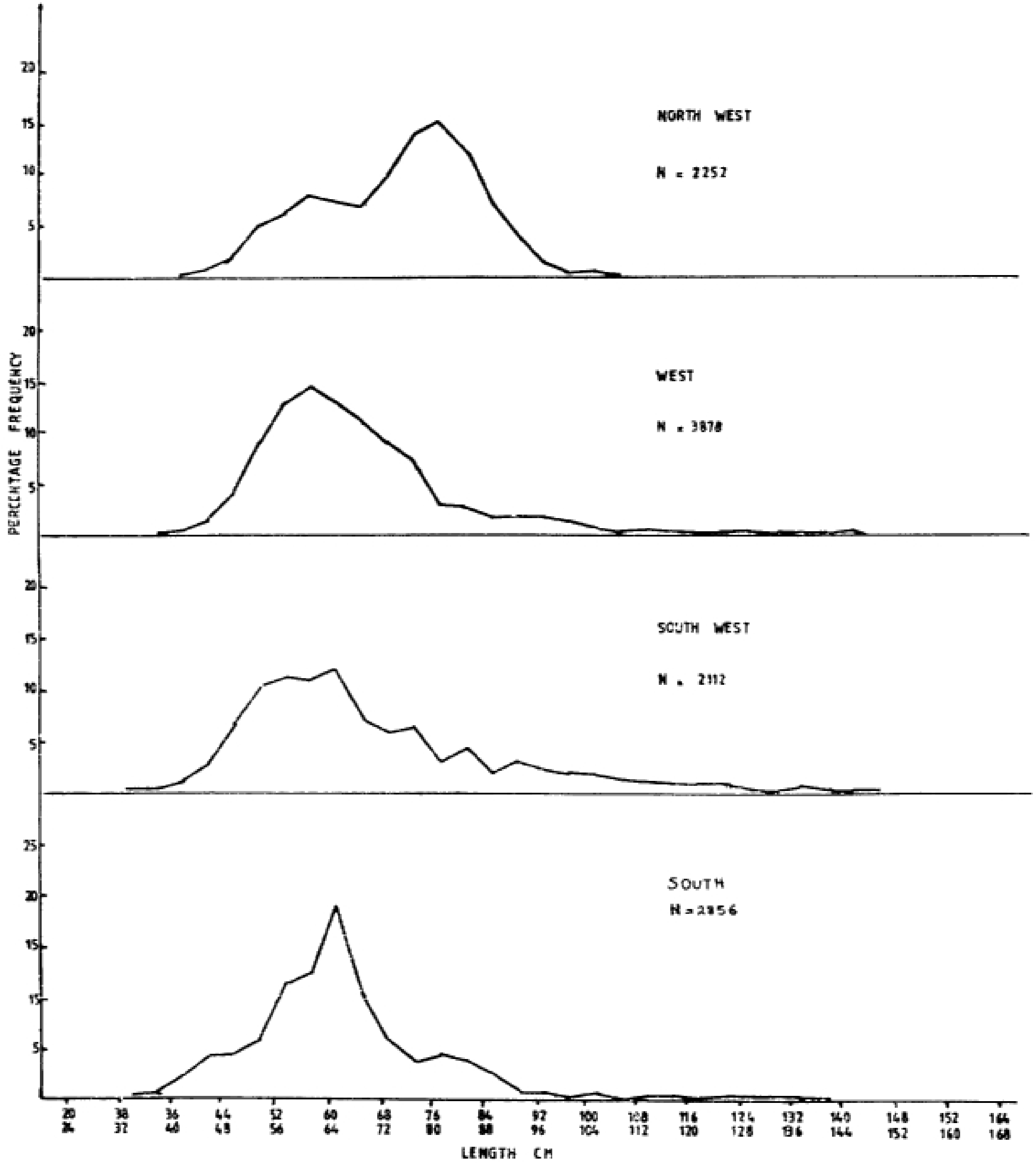

Fig. 5 Annual length frequency distribution of yellowfin tuna from the gilinet fishery in 1985.

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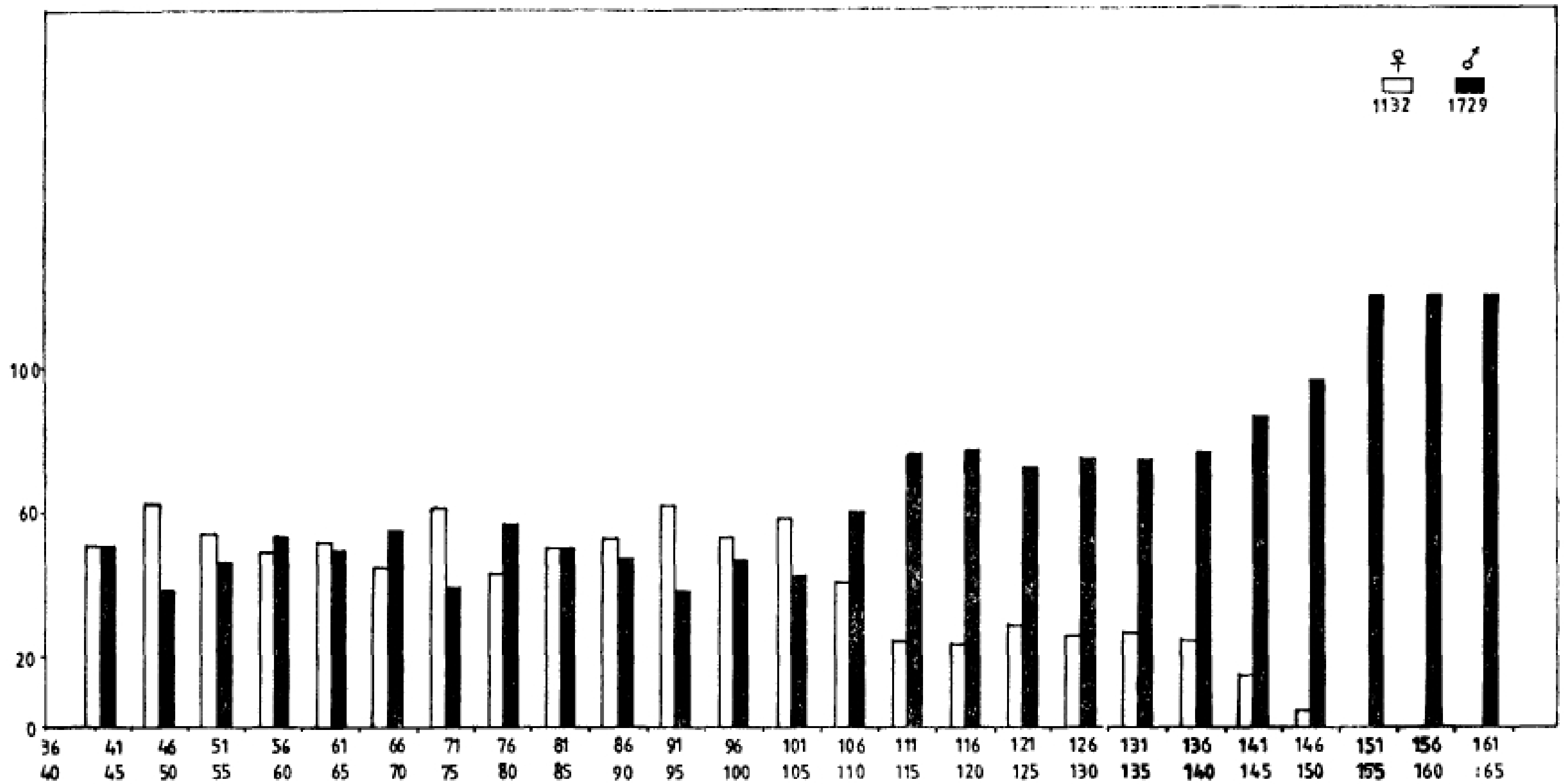

Fig. 6 Percentages of maleiand females in various size groups of yellowfin tuna, in the fishery off Sri Lanka.

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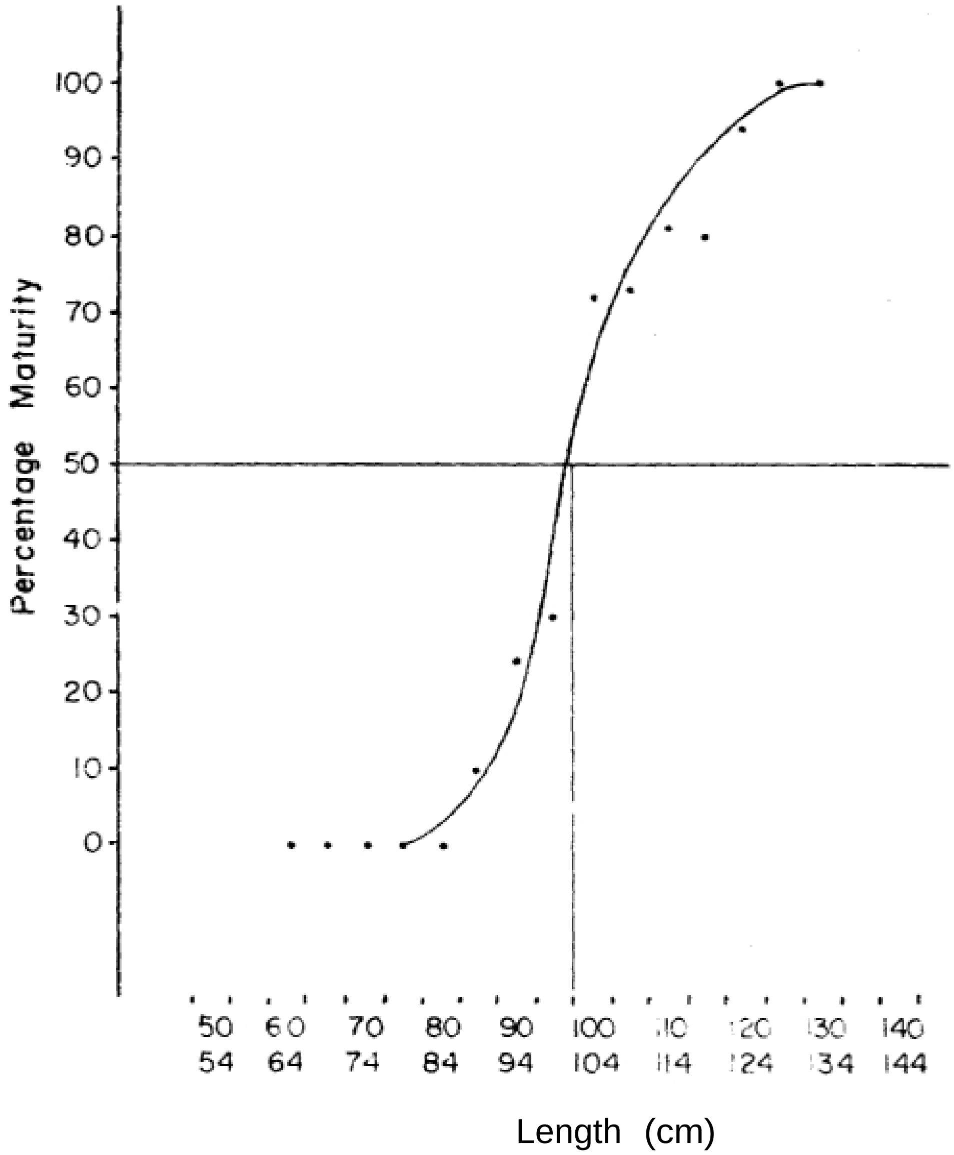

Fig. 7 Mean ength at first maturity of yellowfin tuna.

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The Ford-Walford plot yielded values of 0.36 and 173.0 cm for K and L_{∞} respectively. If these values were used in the von Bertalanffy growth equation, assuming t_o =0, the approximate length at age values would be 52.2,88.7, 114.4, 131.9, 144.5,153.1, 159.2, 163.3 and 166.3 cm for fish of ages one to nine years respectively. Correlation of these approximate length at age values with length frequency distributions given in Figures 2 and 3 reveal that the fishery is primarily based on one and two-year-old fish.

Figure 3 also shows the annual variations in length frequency distribution of yellowfin tuna sampled from the gillnet fishery in the study area. More large-sized yellowfin have been sampled during the second half of 1982 than in the first half of 1986, probably illustrating the differences in the size groups of the population exploited between the two halves of the year. Length frequency available for whole of 1983, 1984 and 1985 are more or less the same, with a slight shift of the dominant mode from 1983 to 1985 and more large yellowfin being sampled during 1984 and 1985, than in 1983.

(c) Recruitment and migration

Length frequency distributions obtained in different areas were examined to determine seasons and areas of recruitment to commercial fishery as well as possible trends of migration along the coast. Since length frequency data obtained in some months were inadequate, these have been pooled on a quarterly basis for these purposes.

Quarterly length frequency distributions obtained in different areas during 1985 are shown in Figure 4. During each quarter, there was a shift of the main mode from southwest to northwest. While this was clearly evident during first, third and fourth quarters, there were no length data in the northwest during the second quarter to identify such a shift. Furthermore, in each sub-area, there was a shift towards large fish being sampled in successive quarters.

Similar quarterly length data available for 1983 and 1984 also point to a gradual shift of the main mode northwards, indicating a possible movement of the fish northwards. The annual length frequency distributions obtained for yellowfin tuna in the four sub-areas during 1985 is shown in Figure 5. The proportion of large yellowfin sampled in the northwest is higher than those for the other areas. The reverse trend is observed with regard to the proportion of small fish sampled, between the northwest and other sub-areas.

Small fish of less than 36 to 40 cm were sampled in the south during the first quarter and to a lesser extent in south and southwest during the third and fourth quarters. Similarly, small fish have been sampled in the south and southwest during the third quarter of 1983 and during the third and fourth quarters of 1984 in the same sub-areas. Major recruitment to the fisheries in the study area seems to occur predominantly off the southwest coast and extend over a large period of time, probably as a result of an extended spawning season. Possible annual variations or shifting of the peak spawning period may result in recruitment occurring in different quarters, as observed in the present study.

(d) *Maturity and spawning*

A total of 3409 individuals of yellowfin were examined during maturity studies covering a two-year period, from July 1984 to June 1986. Sex could not be determined by visual examination of the gonads in 248 fish within the 26 to 45 cm length range. The rest consisted of 1729 males and 1432 females, a ratio of 1: 0.8. The percentages of male and female yellowfin tuna according to size of fish is given in Figure 6. A significant reduction of female yellowfin beyond 110 cm fork length was indicated, with only 29% of yellowfin examined beyond this length being females. The degree of sexual maturity that was visually determined, gonad index, and measurement of ova diameter helped in assigning maturity stages in doubtful cases. Gonad index was calculated using the following relationship :

$$G.I.=W/L_3 \times 10, \text{ where}$$

W=weight of the gonad in g

L_3=fork length of fish in mm.

Length of fish is used in the above relationship instead of weight of fish as it is easier to measure the length than weight under field conditions. It is also assumed that weight is proportional to the cube of length.

Mature, gravid and spent fish were present during most months (Table 2). Considering the numbers observed in each month, a high percentage of mature, gravid and spent fish were present from March to May 1985 and again in April/May 1986. There were also indications of spawning activity toward the end of the year, between October to December, although not as pronounced as that between March to May.

The range of gonad index values obtained per gonad maturity stage is given below:

Stage of maturity	Gonad index	No. of ovaries
I — Immature	0.1-0.4	96
II — Early developing	0.5-1.3	105
III — Late developing	1.4-2.2	62
IV — Mature	2.3-3.4	15
V- Gravid	3.5 and up	9
VI — Spent	0.4-I .5	2

While it was not possible to measure ova diameter in immature and early developing stages, size distribution of ova in mature (Stage IV) ovaries showed two modes, at 0.42 mm and 0.75 mm. There is a shift in these modes in gravid (Stage V) ovaries, to 0.58 mm and 0.80 mm. The size range of ova in relation to maturity stage is as follows:

Stage of maturity	Ova diameter (mm)	No. of ovaries
I — Immature		
II — Early developing		
III — Late developing	0.35-0.45	18
IV — Mature	0.34-0.46/0.6-0.8	9
V — Gravid	0.38-0.60/0.68-0.82	5
VI — Spent	0.84	2

The smallest fish that had a gravid ovary measured 94 cm. In determining length at maturity, all fish assigned maturity stages I to III were considered immature, other than the larger fish which probably have spawned previously. All the others placed under maturity stages IV to VI were treated as mature fish. The mean length at first maturity for female yellowfin tuna was at 101 cm fork length (Figure 7).

Discussion

The bulk of the yellowfin tuna produced in the study area come from the gillnet fishery, with over 50% of the gillnet catches consisting of yellowfin in the northwest. The catch rates indicate an increase in the relative abundance of the species towards the north. The monthly variation in catch rates in the different areas does not indicate any migratory trend of the species along the western coast of the island. However, there is a definite shift of increasingly large fish being caught off the northwest coast, as seen from the length frequency distributions obtained in different areas. This supports the northward migration of this species proposed by Sivasubramaniam (1970).

Maturity studies, even though hampered by small numbers of mature fish sampled, indicated high percentages of mature, gravid and spent fish during March to May and October to December. There is therefore a possibility of two spawnings per year, most probably two spawning peaks or pulses within an extended spawning season. A high percentage of first entry group in the catches off the southwest coast led Sivasubramaniam (1970) to conclude that recruitment to Sri Lanka fishery mainly occurs in this area. The two cohorts obtained from the ELEFAN I program have their origins in May and December, coinciding with the peak spawning activity observed from maturity studies. The shift in the peak fishing season observed between years could be due to differences in the relative strengths of the two spawning pulses.

The gillnet fishery has sampled fish up to 162 cm, while the L_{∞} was calculated at 173 cm. However, the length frequency distributions indicate that fish above 100 cm length were significantly low in the catches, The fishery is therefore based on fish less than two years of age. The length at first maturity studies also indicate that nearly all the fish at two years of age are sexually immature.

The sex ratio shows a preponderance of males beyond 100 cm length. There is no evidence of different growth rates for male and female yellowfin. Growth parameters derived from computer analysis of length frequency distributions of male and female yellowfin catches in the Philippines were essentially the same. Yesaki (1983) and Davidoff (1963) showed that the growth rates of male and female yellowfin were the same at least up to 130 cm. No differences in growth rates between sexes were found from readings of daily rings of otoliths from Eastern Pacific yellowfin (Anonymous, 1981). Suda and Schaefer (1965) concluded that male and female yellowfin in the Eastern Pacific grew equally to about 140 cm, but were uncertain about larger fish. It is possible that the large females stay either in deeper water or further away in surface waters, out of the normal fishing range of the gillnetters. It is of interest to note here that there are more males than females beyond a length of 110 cm in the longline catches made in the Indian Ocean (Mimura, 1963).

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Table 1

Production of yellowfin tuna, 1979-l 984

Sub-area	DFEO area	**1979**	1980	1981	1982	1983	1984
North	Mullaitivu Jaffna Mannar	29	441	209	158	638	185
Northwest	Puttalam Chilaw	1,883	1,394	915	1,217	1,945	1,903
West	Negombo Colom bo	1,515	1,504	1,742	2,140	1,912	581
Southwest	Kalutara Galle	579	1,244	2,239	1,560	1,446	1,334
South	Matara Tangalle	1,756	1,734	1,275	1,809	1,511	1,232
Southeast	Kalmunai	155	133	590	769	454	553
East	Batticaloa	102	337	389	385	224	295
Northeast	Trincomalee	51	11	197	312	916	356
		6,070	6,798	7,556	8,350	9,046	6,439

D.F.E.O. area : District Fisheries Extension Office area

Source : Ministry of Fisheries

T a b l e 2

Maturity of yellowfin tuna

Month	Maturity stage						
	I	II	III	IV	V	VI	No. fish
1984 July	62.7	32.2	5.1				59
August	55.0	30.0	15.0				20
September	36.8	26.3	36.8				38
October	—	58.1	29.0	12.9			31
November	—	25.6	38.5	23.0			39
December	56.3	31.3	12.5		12.8		32
1985 January	52.9	32.3	14.7				34
February	50.0	15.0	20.0	—	15.0		20
March	52.6	—	10.5	21 .1	15.8		19
April	—		50.0	16.7	33.3		06
May	10.5	10.5	42.1	26.3	10.5		38
June	29.4	34.4	21 .o	9.0	5.0	2.0	163
July	16.0	65.3	9.3	4.0	2.6	2.6	150
August	16.3	47.0	32.7	3.1	0	0	196
September	3.1	50.0	31.3	7.8	4.7	3.1	128
October	3.8	53.8	26.9	3.8	11.5	0	52
November	13.6	59.0	27.3	0	0	0	44
December	8.7	26.1	26.1	8.7	15.2	0	46
1986 January	38.2	29.4	20.6	2.9	4.4	0	68
February	25.7	34.3	20.0	5.7	14.2	0	70
March	36.4	22.7	40.4	0	0	0	88
April	5.0	0	35.1	47.0	11.9	0	134
May	18.8	0	31.2	35.9	9.4	4.7	64
June	19.6	65.2	66.5	0	0	8.7	92

Annexure 8

FISHERY OF KAWAKAWA AND FRIGATE TUNA, THEIR AGE AND GROWTH

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Introduction

Nine species of tuna are reported to occur in the catches of Sri Lanka's local commercial fisheries that extend to about 30 to 40 miles from the shore, with surface fishing gears such as gillnet, pole and line and troll lines being dominant (Sivasubramaniam, 1965; Joseph, 1984). Except for skipjack and yellowfin, annual production statistics of all species are lumped together and given as 'other blood fish' by the Ministry of Fisheries. Annual landings of this group have been in the region of 8,000 to 12,500 t in recent years, constituting 30 to 35% of all tuna landed in the country.

Of the seven species making up the group "other blood fish", the oriental bonito *(Sarda orientalk)* and the bigeye tuna *(Thunnus* obesus) are frequent in catches in small quantities while specimens of dogtooth tuna *(Gymnosarda unicolor)* and longtail tuna (T. *tonggol)* are occasionally encountered in commercial catches. The bulk of the catches in this group is, therefore, made up by the eastern little tuna or kawakawa *(Euthynnus affinis)* and *Auxis* spp. *(A. thazard* and *A. rochei).* The only published work on these species in Sri Lanka include a study on the co-occurrence and relative abundance of *Auxis* spp. around Ceylon by Sivasubramaniam (1973) and a study on the biology of kawakawa off the southwest region of Ceylon, also by Sivasubramaniam (1970).

This paper reports on the fishery for kawakawa and *Auxis* spp. conducted along the western and southern coastal waters of Sri Lanka and aspects of population biology (age and growth) of kawakawa and frigate tuna *(A. thazard).*

Material and Methods

Statistics on tuna production for 1983 (source: Ministry of Fisheries) show that nearly 70% of the tuna classified under 'other blood fish' were landed by craft with in-board engines, i.e., the 3.5 GT, 9 metre class of boats and the 11 metre combination boats (gillnetter/longliner). The balance of production came from craft with out-board engines, the 5-6 metre FRP boats and motorized traditional craft (25% of the total production) and the non-motorized traditional craft (5% of the total production). Among the craft with in-board engines, the smaller 3.5 GT, 9 metre craft were by far the main fleet in local tuna fisheries, with a total fleet strength of nearly 2,700 compared to the 80 boats of 11 metre class. This study is based on fishing conducted by the 9 metre class of boats.

Statistics on tuna production available for recent years also indicate that 60 to 80% of the catches in the 'other blood fish' group have come from the western and southern coastal waters encompassing the DFEO (District Fisheries Extension Office) areas of Puttalam, Chilaw, Negombo, Colambo, Kalutara, Galle, Matara and Tangalle. The fishery has been studied at selected main landing sites along this coastal belt through a two-stage stratified sampling scheme described by Amarasiri and Joseph (1986).

Paper presented to the third working group meeting on the tunas between the Republics of Maldives and Sri Lanka, 22-25 September 1986, Colombo, Sri Lanka.

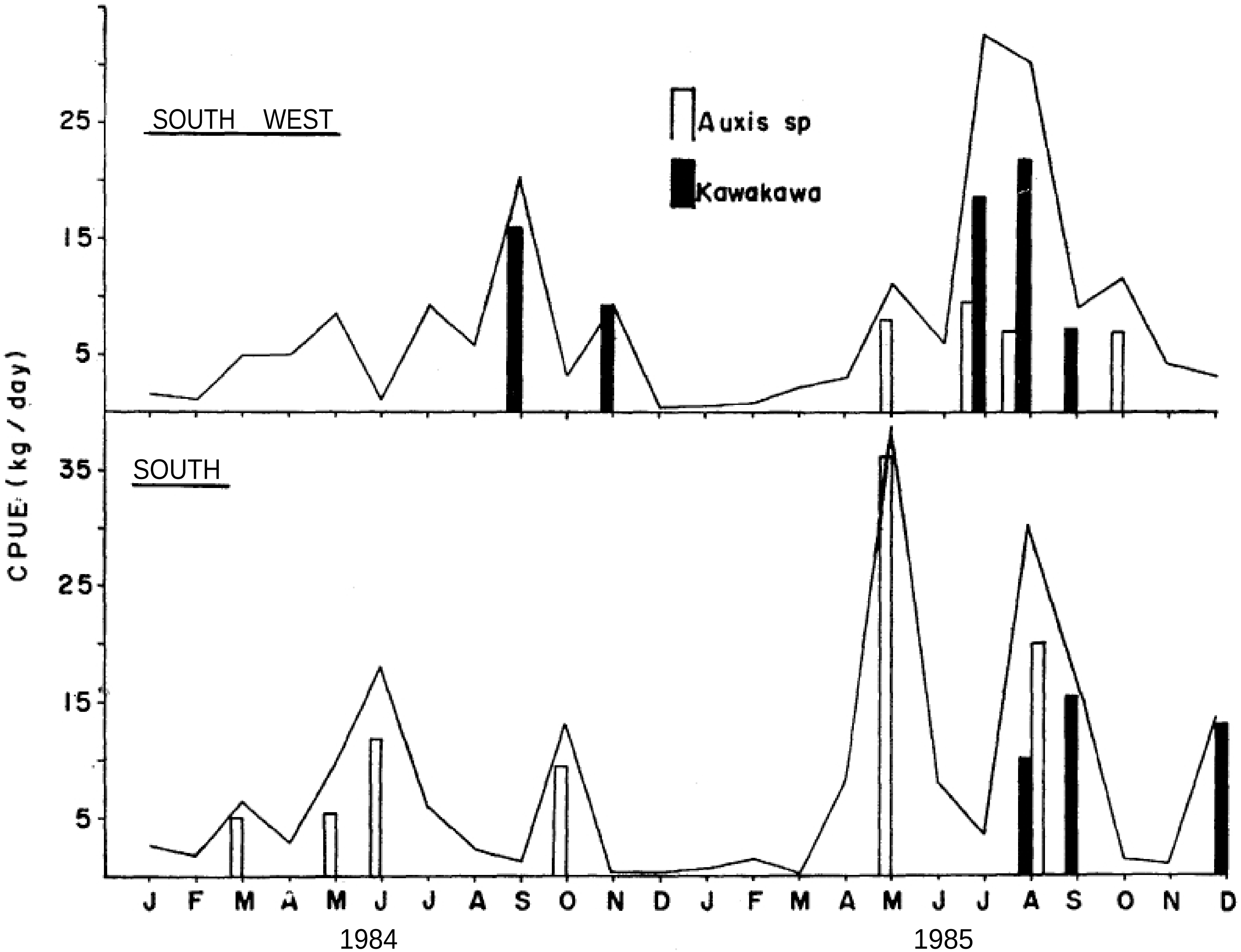

Fig. 1Seasonal variations in catch per unit effort of kawakawa and *Auxis* sp. in gilinet fishery – South/Southwest, 1985.

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Age and growth of kawakawa and frigate tuna were studied using length data collected randomly, mainly from the sub-areas southwest (Kalutara, Galle) and south (Matara, Tangalle). Length data were grouped into 2 cm intervals and pooled on a monthly basis. ELEFAN computer program (as described by Brey and Pauly, 1986) and Bhattacharya method (as described by Goonetilleke and Sivasubramaniam, 1986) were used to extract growth parameters from length data, using an Apple IIe microcomputer.

Analysis and Results

(a) *Effort and catch per unit effort*

Joseph and Moyiadeen (1986) have estimated fishing effort in terms of number of boat days for the 3.5 GT class of boats fishing for tuna using gillnet, troll, pole and line and longline gear. The relative importance of these methods in the tuna fisheries conducted in the whole study area, in terms of percentage of total annual effort for the period 1983 to 1985 was 70.4%. 19.7%. 3.7% and 6.1% through gillnet, troll line, pole and line and longline respectively.

Longlines are generally set to catch large yellowfin and bigeye tuna inhabiting sub-surface waters and, in Sri Lanka, particularly for the sharks. Of the three methods contributing to catches of kawakawa, frigate and bullet tuna (A. *rochei),* the gillnet is dominant in all sub-areas while troll and pole and line methods are more popular in the southwest and south DFEO areas (Joseph and Moyiadeen, 1986).

A seasonal variation in the relative importance of gillnet, troll and pole and line gear is observed in the southwest and south. The monthly variations in fishing effort by these gears in the southwest and south for 1984 and 1985, given in Amarasiri and Joseph (1986), show year-round gillnet and troll activity, with the gillnet being dominant during the southwest monsoon period of May from October and comparatively more trolling being conducted during non-monsoon months. Pole and line fishery is highly seasonal, the season falling within the non-monsoon months from November to March/April.

The percentage breakdown of total effort by gear type during the two main seasons (monsoon and non-monsoon) shown below for the years 1984 and 1985 depict the change in importance of various gear with season.

		Gillnet	Troll	Pole/line
1984				
Southwest monsoon period	Southwest	83.4	16.6	—
	South	84.2	15.8	—
Non-monsoon period	Southwest	54.7	34.4	10.8
	South	20.6	65.3	14.0
1985				
Southwest monsoon period	Southwest	75.5	24.5	—
	South	77.9	22.1	—
Non-monsoon period	Southwest	51 .o	38.1	10.8
	South	37.7	50.9	11.3

The mean monthly catch per unit effort values (catch/boat/day) estimated for kawakawa and *Auxis* spp. in the gillnet fishery during 1984 and 1985 are shown in Figure 1 for southwest and south. The gillnets, with mesh sizes ranging from 4" to 6½" (Joseph and Moyiadeen, 1986) are mainly directed at skipjack and yellowfin tuna and the CPUE values estimated for the three species under consideration are generally low for most months. In the southwest coast, highest

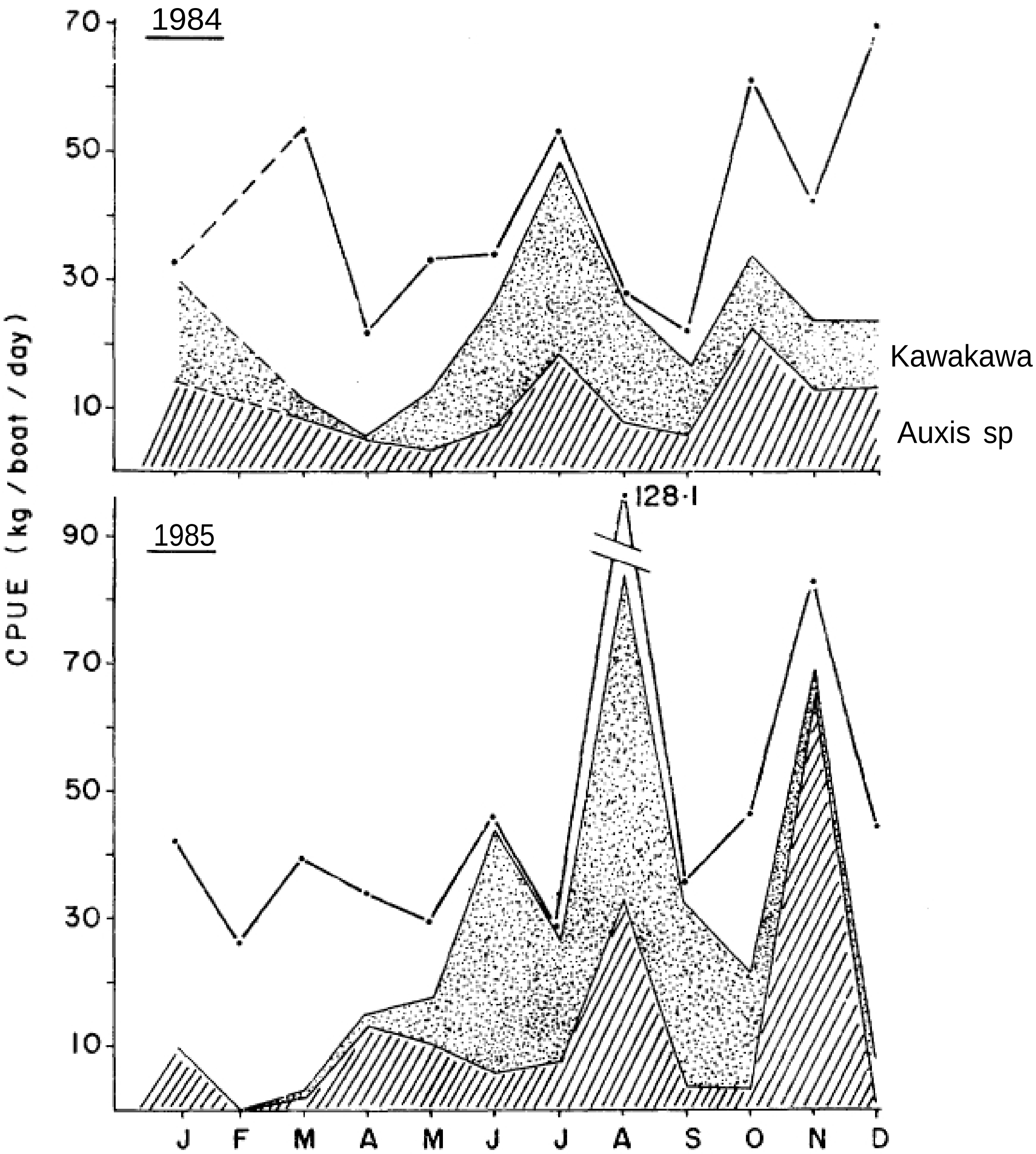

Fig. 2 Seasonal variation in catch per unit effort of kawakawa and *Auxis* spp. in troll fishery – South/Southwest, 1985.

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CPUE values have been estimated for kawakawa during September and November 1984 and July end August 1985. For *Auxis* species, highest values have been recorded in May, July and August 1985. The CPUE values of these three species together made up over 10% of the estimated CPUE of all fish in the gillnet fishery only during the months of September and November 1985, and May, July and August 1985.

Similarly, high CPUE values in the south for kawakawa have been recorded in August, September and December 1985 and for *Auxis* species in June and October 1984 and May and August 1985. The CPUE of these three species together made up more than 10% of the total CPUE during the months May and June 1984 and May, August, September, October and December 1985.

The mean monthly CPUE values obtained for kawakawa, frigate end bullet tuna in the troll fishery in the south and southwest during 1984 and 1985 are shown in Figure 2, together with the mean monthly CPUE estimated for the whole fishery. It is seen that during most months, the three species have contributed to the bulk of the catches in the troll fishery from June to September 1984 and from June to October 1985, while *Auxis* species have been dominant from October to December 1984 and in August and November 1985. In the pole and line fishery, kawakawa and *Auxis* spp. were present generally in small quantities, except for high catches of kawakawa in January and February 1984 and *Auxis* spp. in January and November 1985.

(b) *Production*

The percentage contribution by weight of kawakawa and frigate tuna in the catches made by the different gear during 1984 and 1985 are given in Table 1. Catches of bullet tuna have been virtually nil in the pole and line fishery and very low in gillnet (0.4% and 0.8% in the south and 1 .I% and 1 .O% in the southwest during 1984 and 1985 respectively) and troll fisheries (4.2% in 1984 and 2.0% in 1985). It is seen from Table 1 that 40% to 55% of the troll catch is made up of kawakawa and frigate tuna.

The estimated production (t) of these varieties by the 3.5 GT class of boats in the study area during the period 1983-l 985 is given below :

	Kawakawa	Frigate tuna	Bullet tuna	Tota l
1983	2267.4	1539.1	—	3806.5
1984	849.8	728.4	244.3	1822.5
1985	1288.9	1420.6	165.7	2875.2

Production of *Auxis* spp. in 1983 has not been estimated separately for frigate and bullet tuna and is given under frigate tuna. Except for 1983, the production of the two *Auxis* species together exceeded that of kawakawa. Among the *Auxis* species frigate tuna made up 25.1% and 10.4% of the catch during 19845 and 198 respectively. For the two years, the overall ratio of frigate tuna to bullet tuna in the catches is approximately 5 :1.

Gear-wise separation of total production of kawakawa and *Auxis* spp. during 1984 and 1985 in the whole study area shows that 42.9, 52.0 and 5.1 per cent of the production of kawakawa was realired by the gillnet, troll and pole and line respectively. The corresponding figures for *Auxis* spp. are 44.7, 44.6 and 10.7 per cent. On a sub-area basis, there are variations in the relative contributions by various gear due to the differences in the level of application of these gear in different areas.

(c) Age and growth

Monthly length frequency distributions of kawakawa obtained from troll and gillnet fisheries in the south and southwest are shown in Figures 3 and 4. In the troll fishery, the fish sampled fall within a range of 18 to 53 cm while in the gillnet fishery, the range is from 20 to 63 cm, with only two specimens measured being over 60 cm fork length. In the pole and line fishery, where length data for kawakawa are available for only three months (January, March and December 1985) the range of fish sampled is from 26 and 50 cm. Figure 5 shows the annual

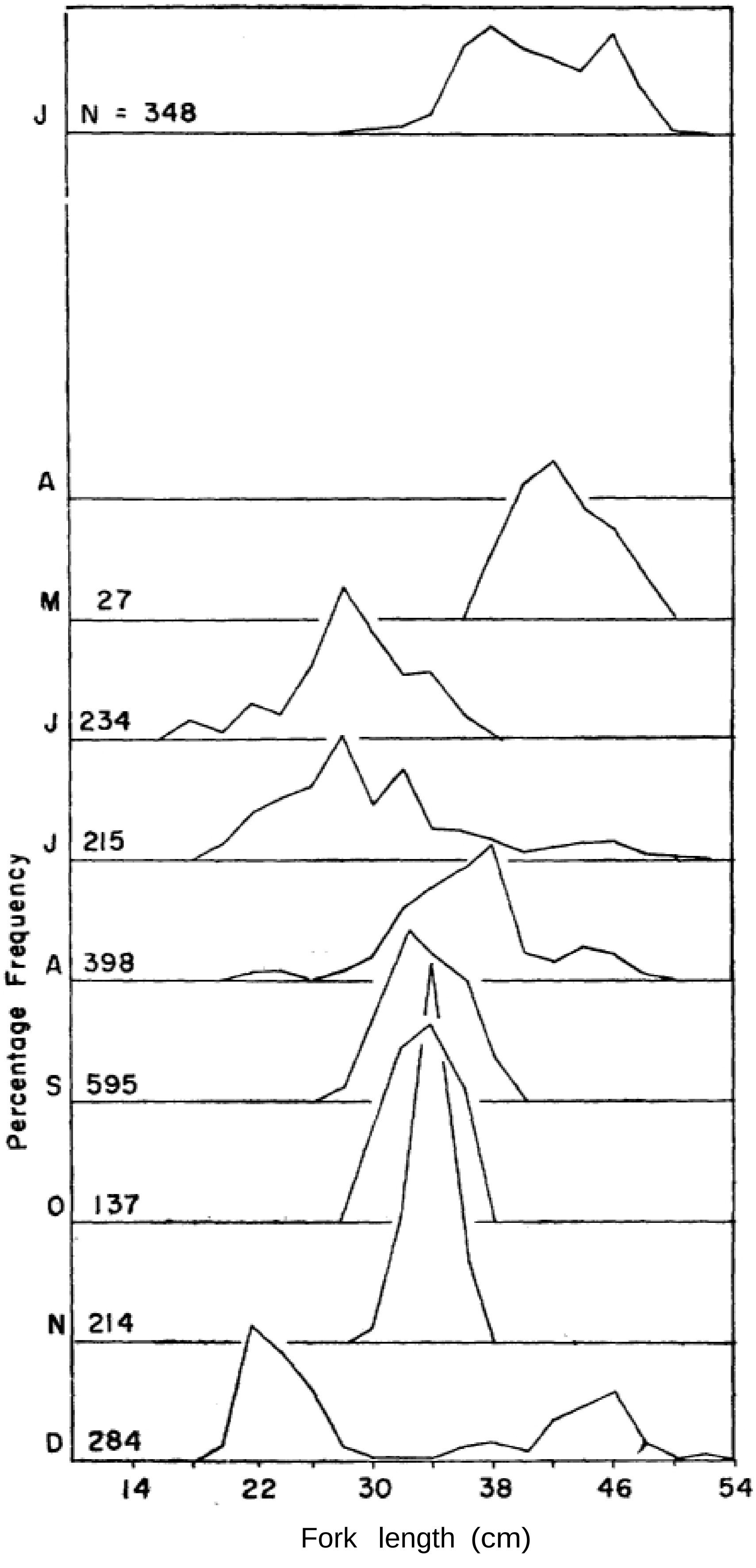

Fig. 3 Monthly length frequency distribution of kawakawa from the troll fishery _ South/Southwest. 1985.

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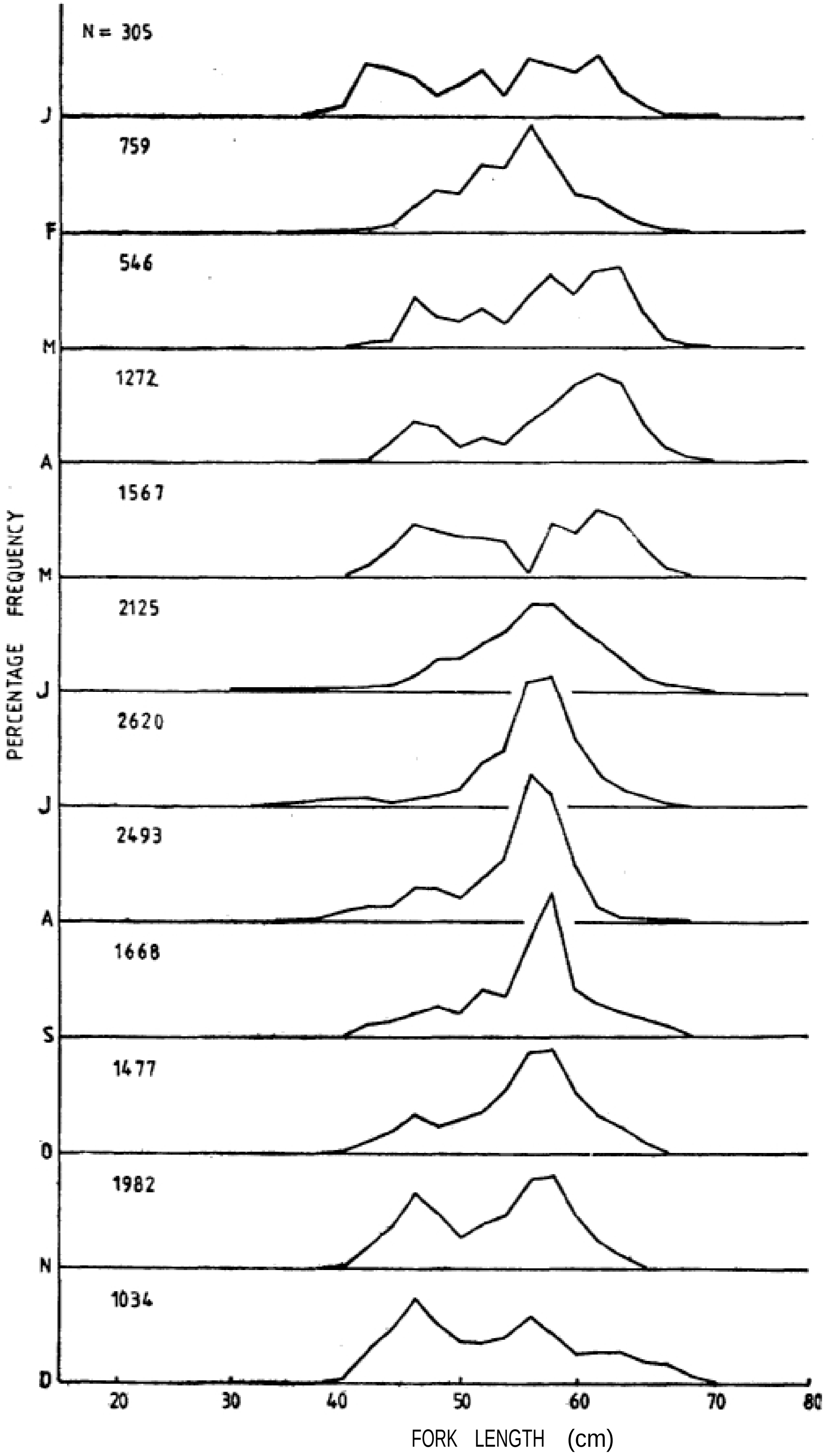

Fig. 4 Monthly length frequency distribution of kawakawa from gilinet fishery - South/Southwest, 1985.

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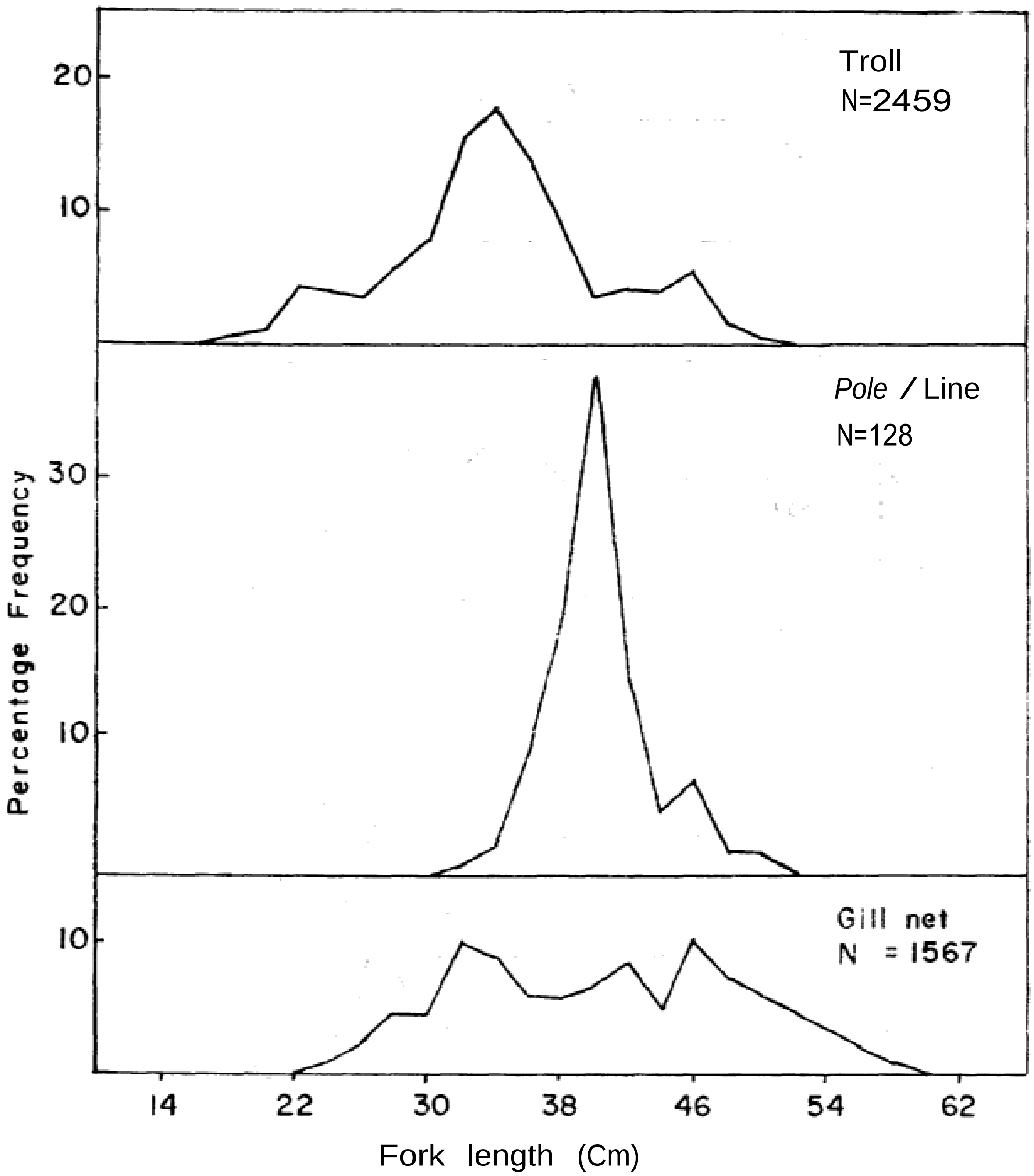

Fig. 5 Length frequency distribution of kawakawa from gilinet, troll and pole and line fishery-—South/Southwest, 1985.

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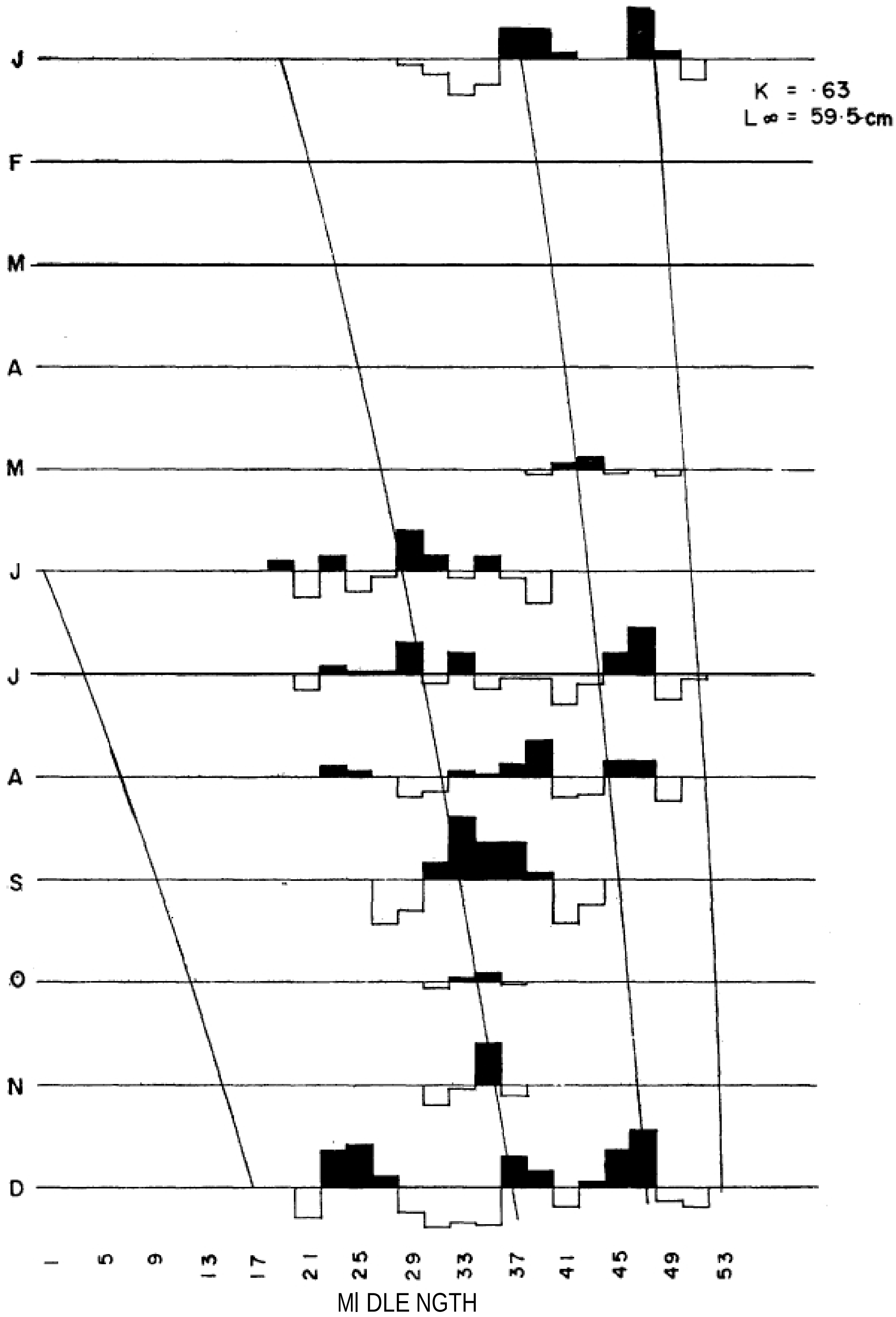

Fig. 6 Restructured length frequencies and growth curve of kawakawa from ELEFAN I (data obtained from the troll fishery, 1985).

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length frequency distributions of kawakawa obtained in the different fisheries. The dominant size group in the troll catches is between 26 and 40 cm, while in the pole and line fishery it is slightly higher, between 30 and 44 cm. Two dominant size groups can be recognized in the. length frequency distribution obtained from gillnet fishery, between 22 to 58 cm fork length. While more of the smaller fish have been sampled in the troll fishery, the gillnet catches have brought in more large size fish. The size range of fish caught in the pole and line fishery is between those from troll and gillnet fisheries.

In the monthly length frequency distributions shown for kawakawa in Figures 3 and 4, adequate length data were not available from the troll fishery during February, March and April and from the gillnet fishery during January and February. Small fish have been sampled from the troll fishery during July and August and again in December. In the gillnet fishery, small fish are present in the catches from May to July and in November.

The ELEFAN I program was applied to the length data from the troll fishery in order to extract growth parameters L_{∞} and K of the von Bertalanffy growth equation. Four different combinations of K and L_{∞} were obtained from the length frequencies from the troll fishery but with the same ESP/ASP ratio (0.601), and one combination was obtained from the length frequency from the gillnet fishery. The combinations are presented in Table 2. The growth curves for kawakawa are presented in Figures 6 and 7.

The following modes were identified for monthly and annual length frequency data using the Bhattacharya analysis.

	Troll fishery			Gillnet fishery				
January	39.1	46.7		—				
February	—			38.5	50.1			
March	—			38.3				
April	—			50.1				
May	42.5			45.9				
June	30.1	34.1		28.9	32.4			
July	26.0	35.9	50.7	34.9	39.4	50.6	53.5	
August	32.0	37.1	45.0	35.2	54.0			
September	33.6			34.0	41.3	46.6		
October	34.5			25.2	47.8	54.2		
November	34.6			—				
December	24.3	39.0	46.1	—				
Annual	25.1	34.8	46.4	29.8	34.4	48.2	53.5	56.4

The modes obtained for the combined annual length frequency data from troll and gillnet fisheries were at 25.6, 34.7, 47.1, 53.3 and 56.4 cm respectively. The last four modes were used in the Ford-Walford analysis, yielding a correlation coefficient of 1.0 and values of 59.5 cm and 0.69 for L_{∞} and K respectively (Table 2).

The approximate length at age values computed (assuming t=0) using the values obtained for K and L_{∞} from ELEFAN and Bhattacharya methods are given below:

	K	L_{∞}	1	2	3	4	5	6	7 yrs.
A1	0.63	59.5	28.2	42.8	50.6	54.8	57.0	58.2	58.8
A2	0.61	63	38.8	44.4	52.9	57.5	60.0	61.4	62.1
B	0.69	59.5	29.8	44.6	52.0	55.9	57.7	58.3	58.9

A1= ELEFAN method, troll fishery

A2= ELEFAN method, gillnet fishery

B= Bhattacharya method

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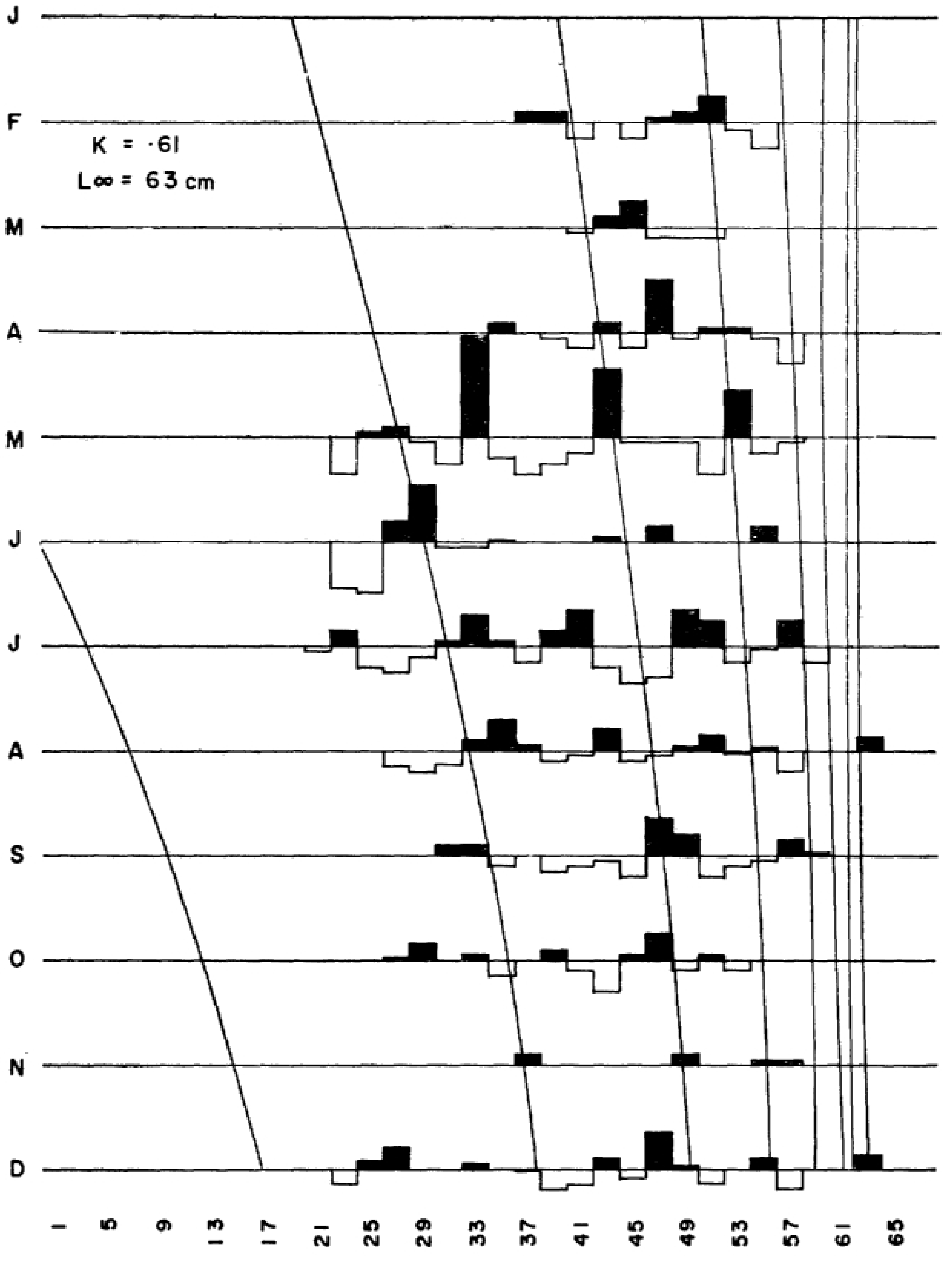

Fig. 7 Restructured length frequencies and growth curve of kawakawa from ELEFAN I data obtained from the gilinet fishery, 1985.

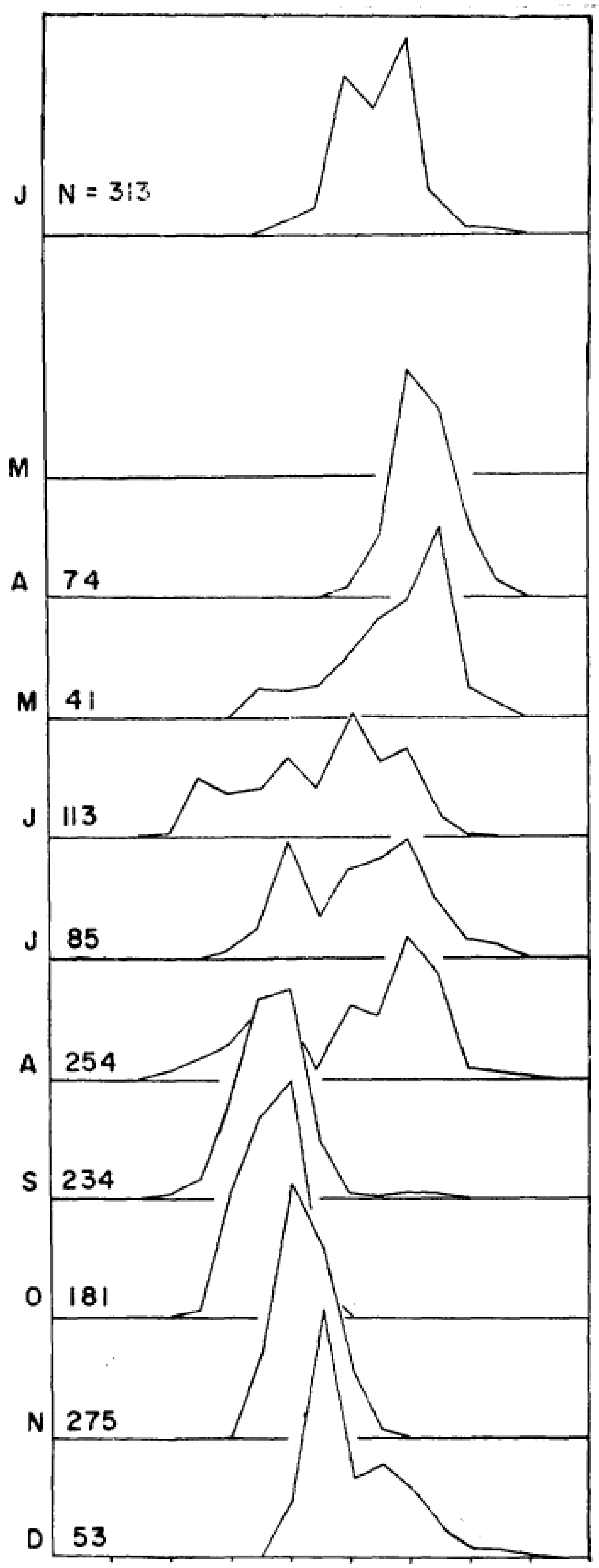

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Fig. 8 Monthly length frequency distribution of frigate tuna from the troll fishery – South/Southwest, 1985.

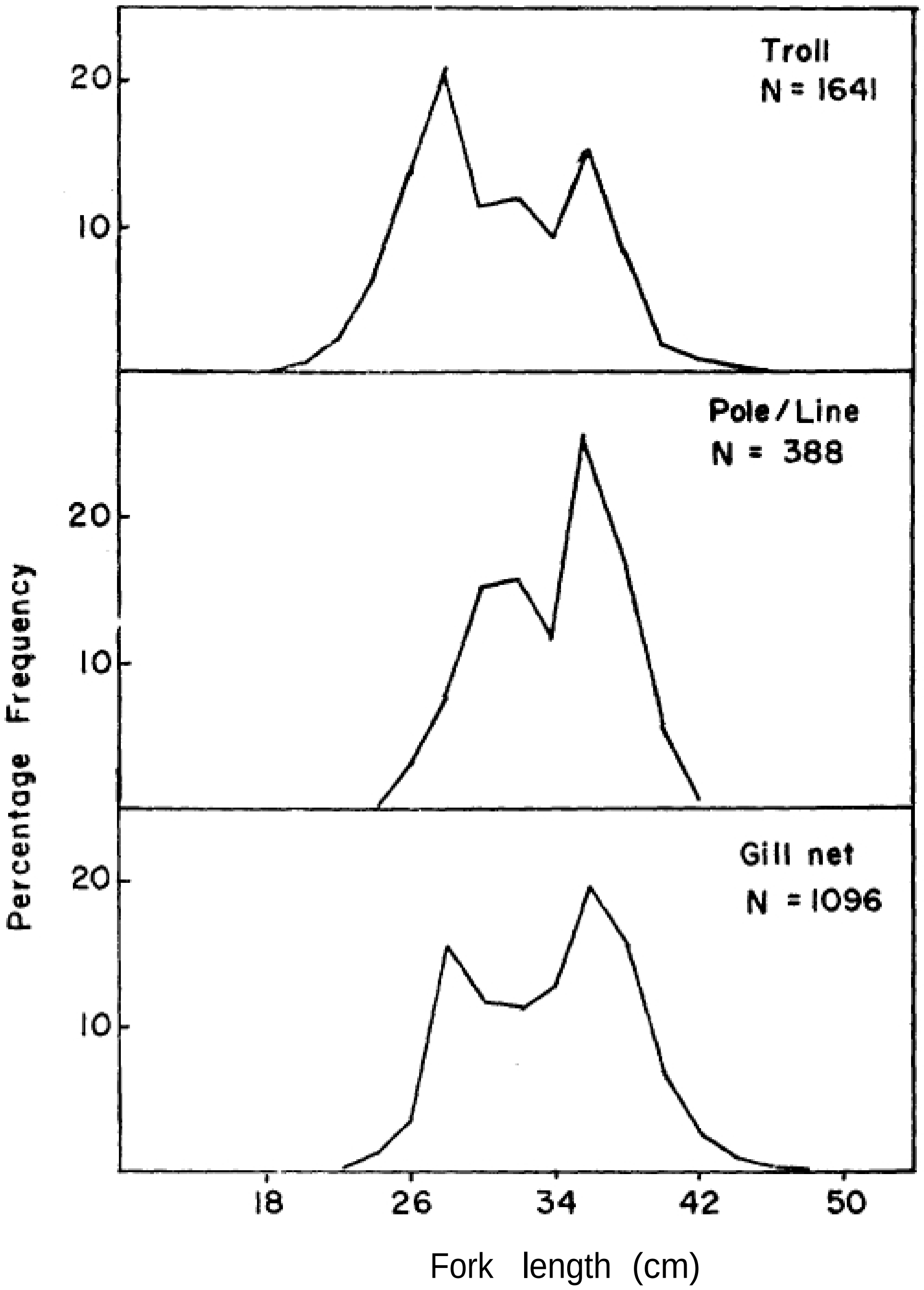

Fig. 9 Length frequency distribution of frigate tuna from gilinet, troll and pole and line fisheries, South/Southwest, 1985.

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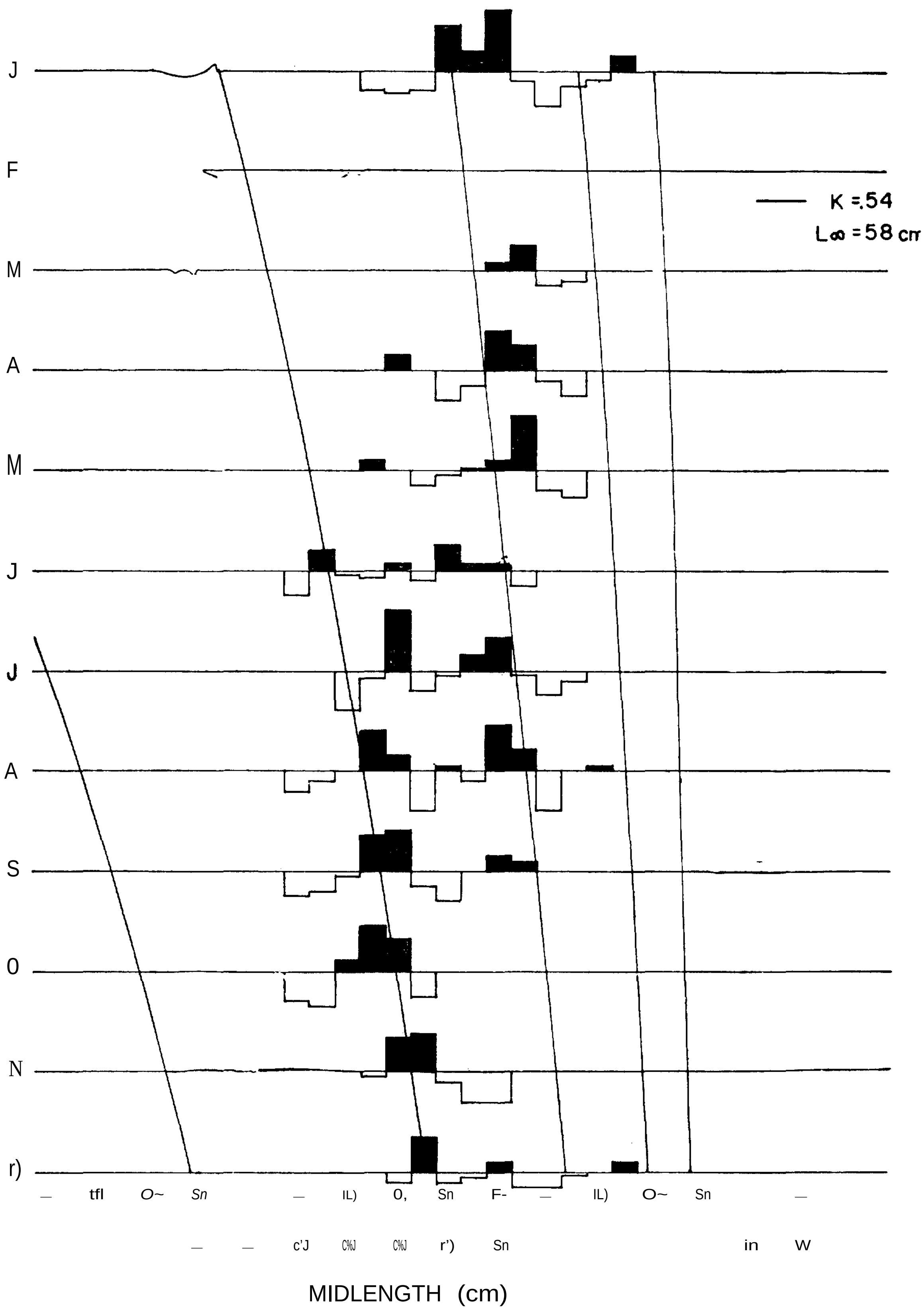

Fig. 10 Restructured length frequencies and growth curve of frigate tuna from ELEFAN I (data obtained from the troll fishery, 1985)

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Monthly length data obtained for frigate tuna in the troll fishery from the south and southwest are shown in Figure 8. The size range of fish caught is from 20 to 46 cm, with the smaller fish appearing in the catches in June, August, September and October. Length frequency distributions of frigate tuna obtained from the south and southwest during 1985 from the three fisheries-troll, pole and line and gillnet — are compared in Figure 9. In the gillnet fishery, the length range of fish caught is from 22 to 49 cm whereas in the pole and line fishery, it is from 26 to 42 cm. In both gillnet and pole and line fisheries, the large-size groups were dominant in the catches while in the troll fishery, small size groups were dominant.

Analysis with ELEFAN I program resulted in two sets of values of L_∞ and K, 59 cm and 0.51, and 58 cm and 0.54, both with an ESP/ASP ratio of 0.413. The growth curve for frigate tuna is presented in Figure 10. The Bhattacharya method identified only one mode per month for most months, except for three months during which two modes per month were obtained. The combined length data for the whole year also yielded two modes at 30.2 cm and 36.9 cm. Because of a paucity of modes representing annual modes or year classes, a Ford-Walford plot was not attempted for frigate tuna.

The length at age values, using the values of 0.54 and 58.0 cm for K and L_∞ obtained from ELEFANI (assuming $t=0$) would be 24.9, 38.7, 46.8, 51.4, 54.2, 55.8 and 56.7 for ages 1 to 7 years respectively.

Discussion

The catch rates realized in the gillnet fishery for kawakawa and *Auxis* spp. are very low in the whole study area compared to those realized in the troll fishery predominant in the southwest and south. Despite the very low catch rates, the effort applied through gillnet in the study area is so high (70.4%) as to ensure a total production of these varieties in the same magnitude as realized from the troll fishery. For kawakawa, Sivasubramaniam (1970) has observed two peak seasons in the troll fishery off the southwest coast, January to March and July to September, coinciding with the entry of new recruits. In the gillnet fishery, the peak season has been between May and July, High catch rates for kawakawa in the troll fishery have been realized in the present study from June to October during both years. The peak season observed at the beginning of the year by Sivasubramaniam (1970) is not so well defined, a high catch rate being observed only during January 1984. In the gillnet fishery, the catch rates of kawakawa are so low for most months, making it an incidental catch, that no attempt was made to identify seasons and compare with previous information. However, high catch rates have been generally recorded during the second half of the year.

For Auxis spp. high catch rates in the gillnet fishery have been recorded within the southwest monsoon period, from May to October. Sivasubramaniam (1973) has stated that the catch rates of Auxis spp. reach a peak during and at the tail end of the southwest monsoon, due to the heavy recruitment season and vulnerability of new recruits to fishing gear like the troll line. High catch rates for *Auxis* spp. in the troll fishery, from October to December 1984, and August to November 1985, and in the pole and line fishery during January and November 1985, seem to suggest that the peak season during the present study is more towards the tail end of the southwest monsoon period.

Sivasubramaniam (1973) estimated that *Auxis* spp. contributed 15% by weight to the total annual tuna landings in the country prior to 1970, with frigate tuna and bullet tuna contributing 92% and 8% respectively. In the present study, the overall ratio of frigate tuna and bullet tuna in the catches has been approximately 5 :1. With the introduction of 11 ton class of gillnetters to tuna fisheries and large scale shifting from longline, pole and line and trolling to gillnetting among the 3.5 GT class of boats, particularly from 1970 onwards, there has been an increased exploitation of larger frigate tunas, raising the estimated contribution of Auxis spp. to the total tuna catches to 20% (Sivasubramaniam, 1973).

Commercially exploited size range of kawakawa from the western and southern coasts is 18 to 63 cm. Although fish below and above this range (15 to 20 cm and 65 to 68 cm) were occasionally encountered in the fisheries during the period 1967-1970, Sivasubramaniam (1970) also

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stated that the fisheries exploited mainly fish within a range of 20 to 65 cm. The troll fishery seems to exploit a size range as wide as in the gillnet fishery. However, the troll gear has taken a larger component of the small fish with modes at 22 and 34 cm, whereas the gillnet has taken more of large fish, with modes at 32-34 cm and 46 cm. Sivasubramaniam (I 970) also observed that the troll gear sampled the widest size range of kawakawa population in the southwest region, but the numbers of fish in the catches beyond 36 cm were rather low, the dominant modes being 16-20 and 28-32 cm. Considering the length at age values obtained for kawakawa in this study, it seems that the troll gear has a very high selective power for young kawakawa of under two years of age. The size range (22 to 62 cm) and the length frequency distribution of kawakawa obtained from the gillnet fishery during the present study as well as by Sivasubramaniam (1970) indicate that the gillnets predominantly capture two and three-year old fish, with smaller amounts of four, five and six-year old fish. The size range sampled in the pole and line fishery is relatively more restricted (30 to 52 cm) and more or less similar to the size range of skipjack tuna caught in the pole and line fishery.

The size range of frigate tuna exploited by gillnet, pole and line and troll line in the south and southwest during 1985 has been ubserved to be between 20 and 49 cm. A comparison with length at age values obtained indicate that the fisheries are primarily based on one to three-year old fish, with the troll fishery taking more of one year old fish whereas the gillnet and pole and line fisheries take a high proportion of two-year old fish. Sivasubramaniam (1973) observed a size range of 20 to 58 cm for this species, with the range 22 to 40 cm being the main component exploited in local fisheries. In the troll fishery off the southwest coast, the dominant mode during 1964 has been observed at 31 to 35 cm with an overall size range of 21 to 55 cm. Length frequencies shown for friqate tuna in Sivasubramaniam (1973) indicate modes at 28-32, 32-36 and 36-40 cm in troll, pole and line and gillnet fisheries off the south coast during 1968. A more or less similar trend is observed in the present study, with the dominant mode in troll fishery, 26-30 cm, shifting to 34-42 cm in gillnet and pole and line fisheries.

According to Sivasubramaniam (1970). the major recruitment of kawakawa to the exploited stock in the southwest is during the months of June and July and to a smaller degree during the period November to February. In the case of frigate tuna, the major recruitment in the south and southwest coasts occurs between March and August (Sivasubramaniam, 1973). In the present study, small kawakawa have been sampled in both gillnet and troll fisheries from May to August and in November/December. Length data over a period of years may be necessary before the seasons of recruitment of both species can be established with certainty. There could also be annual variations or shifts in the seasons of recruitment, giving rise to high annual variations in production and catch rates over space and time. In fact, Sivasubramaniam (1973) attributed the high annual variation in catch rates and production of *Auxis* spp. observed during the period 1963 to 1968 to the changes in the season of major recruitment.

The available information on age and growth of kawakawa and frigate tuna is sketchy and fragmentary. The maximum size and longevity of kawakawa are not well defined and Yoshida (1979) refers to instances where specimens of over 100 cm length have been reported from Japanese waters and a specimen of 87 cm caught off Mauritius/Seychelles area. Yoshida (I 979) has reviewed available information on age and growth of kawakawa, mainly from Seychelles, Aden and Red Sea areas. The length at age values are 25-34.5,45,50-65,55-65 and 65-80 for one, two, three, four and five-year-old fish. In India, where this species formed over 50% of the tuna and billfish catches during 1982/1983, Silas et *al.* (1985) obtained values of 0.37 and 81 .O cm for K and L_{∞} of the von Bertalanffy growth equation. Compared to the range exploited in Sri Lanka, the size range of kawakawa exploited in commercial fisheries in India is wide, generally between 20 to 74 cm. In the case of frigate tuna, Silas et al (I 985) obtained values of 0.49 and 63.0 cm for K and L_{∞} respectively. Information on age and growth of kawakawa and frigate tuna presented here should only be considered as preliminary. Further studies need to be conducted to confirm or modify these preliminary estimates.

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Table 1

Percentage contribution of kawakawa and frigate tuna in the gillnet, troll and pole and line fishery on the south and southwest coasts

Gear		1984 Kawakawa	1984 Frigate tuna	1985 Kawakawa	1985 Frigate tuna
Gillnet	— South	2.5	4.8	2.7	4.6
	Southwest	3.7	2.8	5.7	1.1
Troll	— South	20.8	19.7	31.8	25.4
	Southwest				
Pole and line	— South	17.0	1.4	2.1	16.3
	Southwest				

Table 2

Growth parameters of kawakawa obtained from several sources and methods (K annual, L_{∞} in cm)

Method	Source of data	K	L_{∞}
ELEFAN	Troll fishery	0.57	61
	" "	0.59	60.5
	" "	0.61	60
	" "	0.63	59.5
ELEFAN	Gillnet fishery	0.61	63
Bhattacharya	Troll and gillnet	0.69	59.5

Publications of the Buy of Bengal Programme (BOBP)

The BOBP brings out six types of publications.

Reports (BOBP/REP/ . . . .) describe and analyze completed activities such as seminars, annual meetings of BOBP's Advisory Committee, and projects in member-countries for which BOBP inputs have ended.

Working Papers (BOBP/WP/. . .) are progress reports that discuss the findings of ongoing BOBP work.

Manuals and Guides (BOBP/MAG/. . .) are instructional documents for specific audiences.

Miscelloneous Papers (BOBP/MIS/.) concern work not originated by BOBP — but which is relevant to the Programme's objectives.

Information Documents (BOBP/INF.. .) are bibliographies and descriptive documents on the fisheries of member-countries in the region.

Newsletters (Bay *of Bengal* News), issued quarterly, contain illustrated articles and features in non-technical style on BOBP work and related subjects.

A list of publications follows.

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