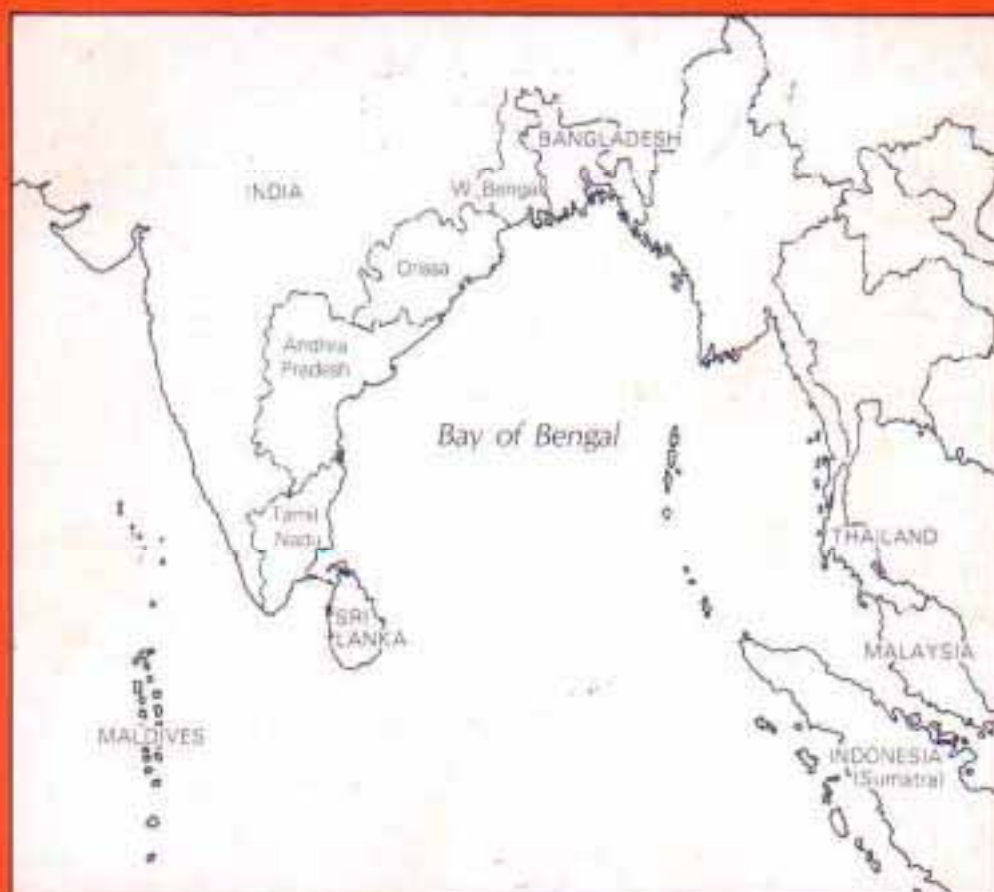


Studies of the Tuna Resource in the EEZs of Maldives & Sri Lanka



UNITED NATIONS DEVELOPMENT PROGRAMME



FOOD AND AGRICULTURE ORGANIZATION
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STUDIES OF THE TUNA RESOURCE
IN THE EEZs OF
SRI LANKA AND MALDIVES

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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.

This document is a technical report and has not been cleared by the governments concerned or the FAO.

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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 Maldivian 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 management for 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	10,015
	1984	6,689	7,472
	1985	9,408	not available
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 *Maldives*, 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
<i>E. affinis</i>	62	50
<i>Auxis</i> spp.	8	9
<i>T. tonggol</i>	0	0
<i>K. pelamis</i>	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

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

<i>Maldives</i>	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_c) 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 al., 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

Age	Skipjack			Age	Yellowfin		
	$L_{\infty}=85^*$ K=0.44	76** 0.44	79 0.41		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

¹Provisional 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 (60°-80°E, 5°-10°N).

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 yellowfin 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 Maldivian 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 Maldivian Islands and Sri Lanka seemed to have declined between 1974 and 1982 (see Figures 1-4). 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).

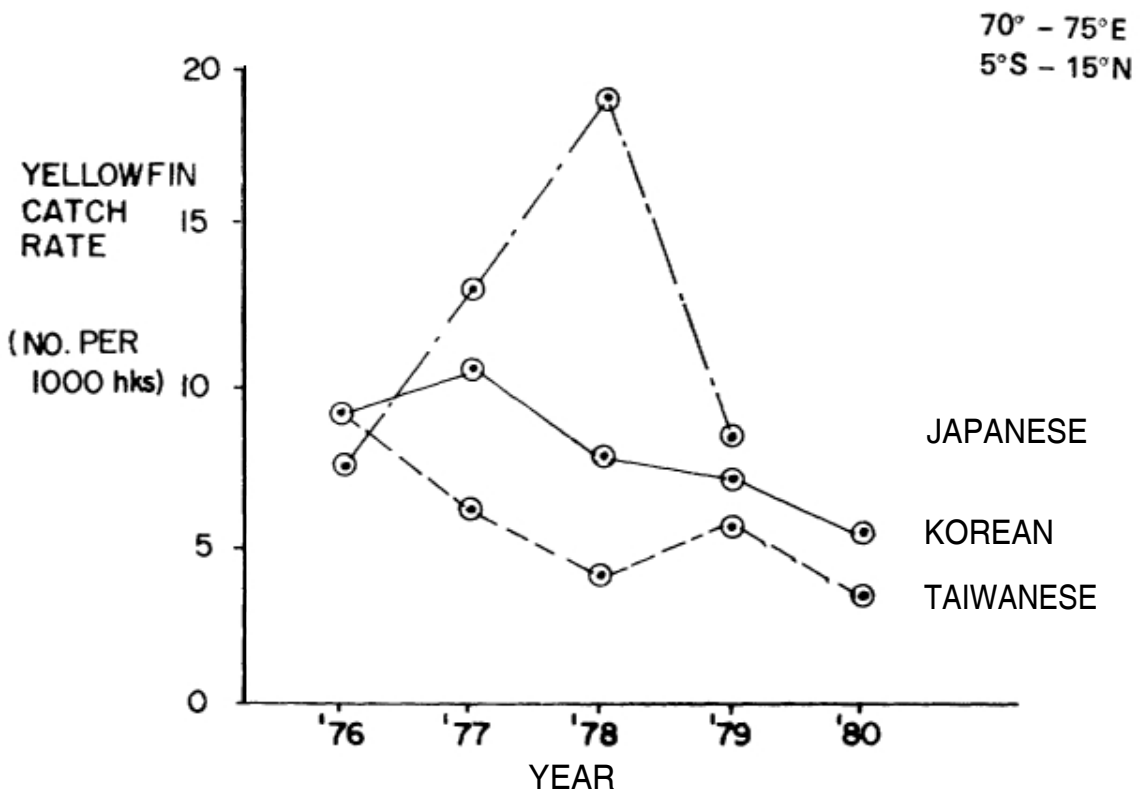
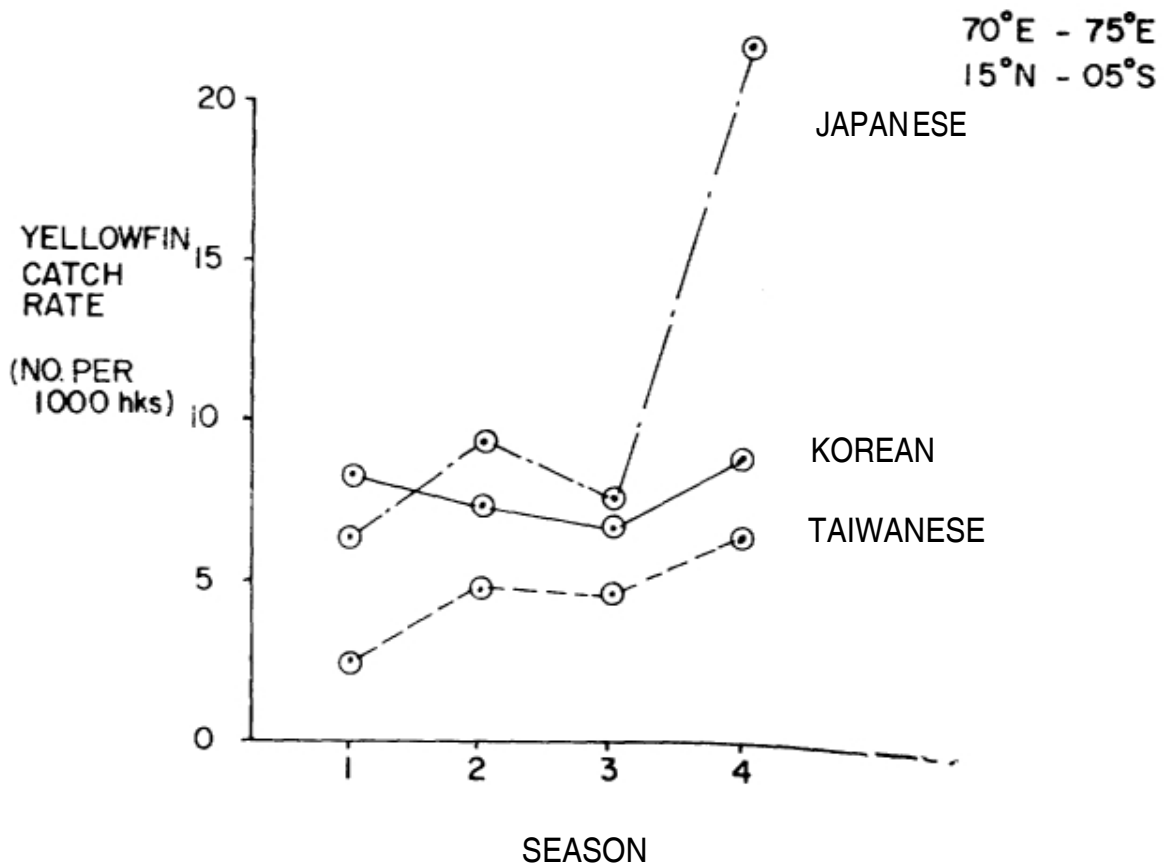


Fig. 1 Seasonal variations and annual catch rates of yellowfin tuna caught by Japanese, Korean and Taiwanese longliners in the area around Maldives (5°S—15°N,70°-75°E).

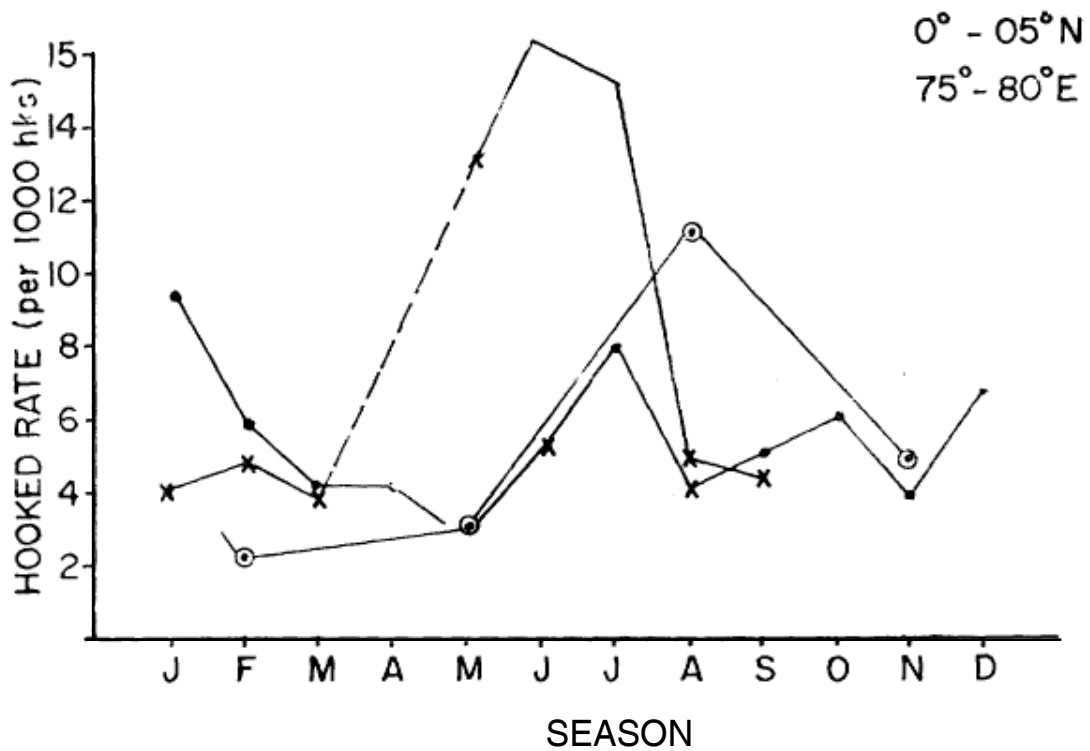
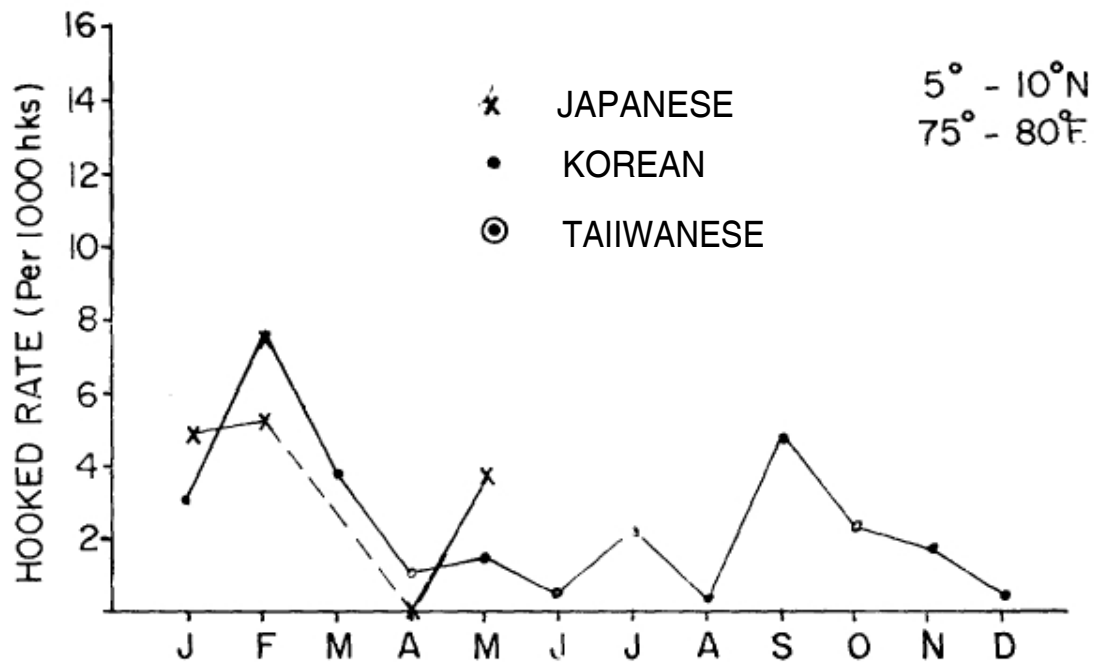


Fig. 2 Seasonal variations in the hooked rate of yellowfin tuna in the longline catches west of Sri Lanka.

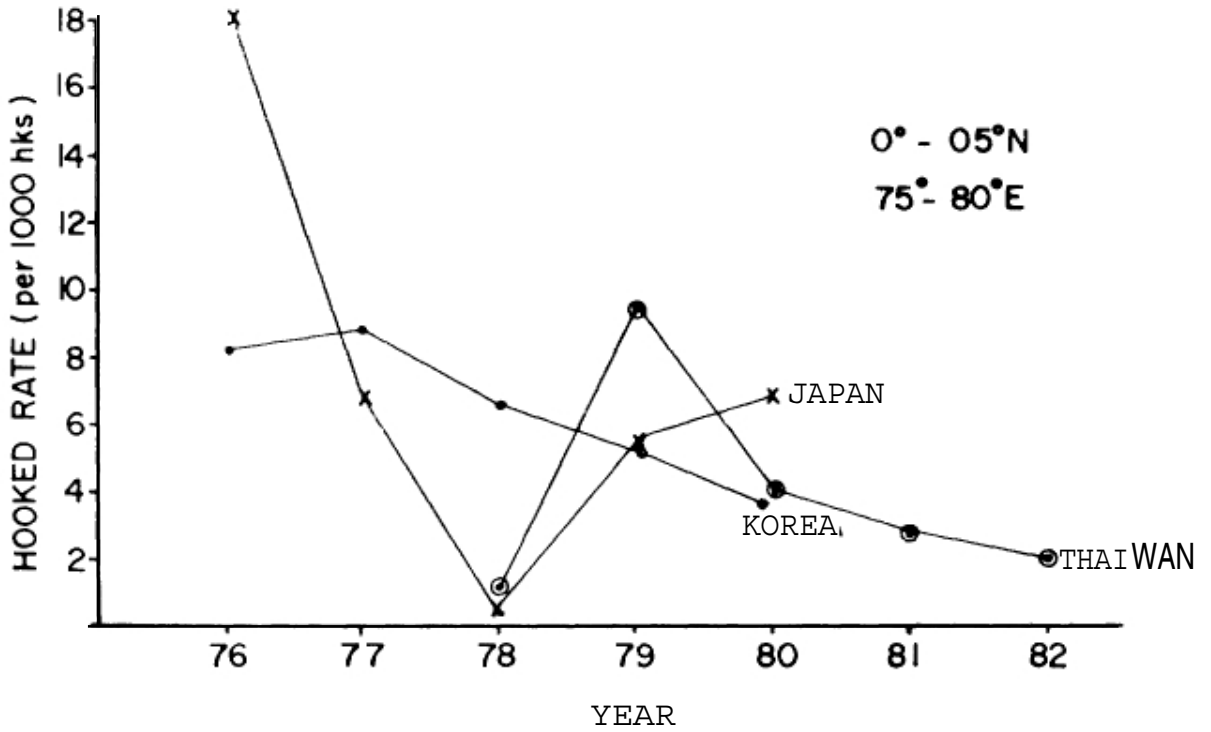
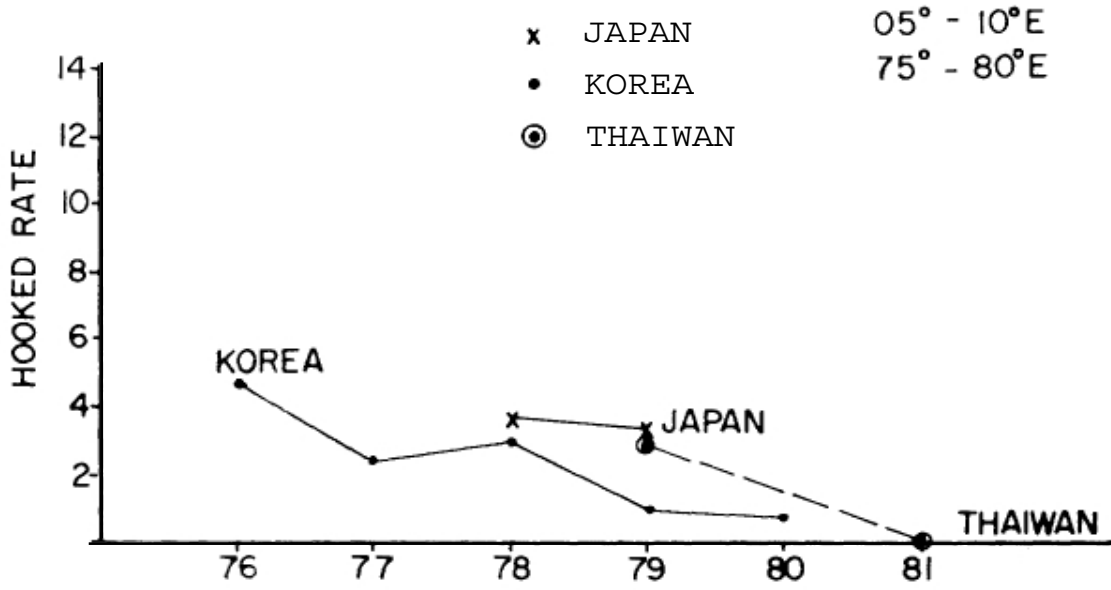


Fig. 3 Annual variations in the hooked rate of Yellowfin tuna in the longline catches west of Sri Lanka.

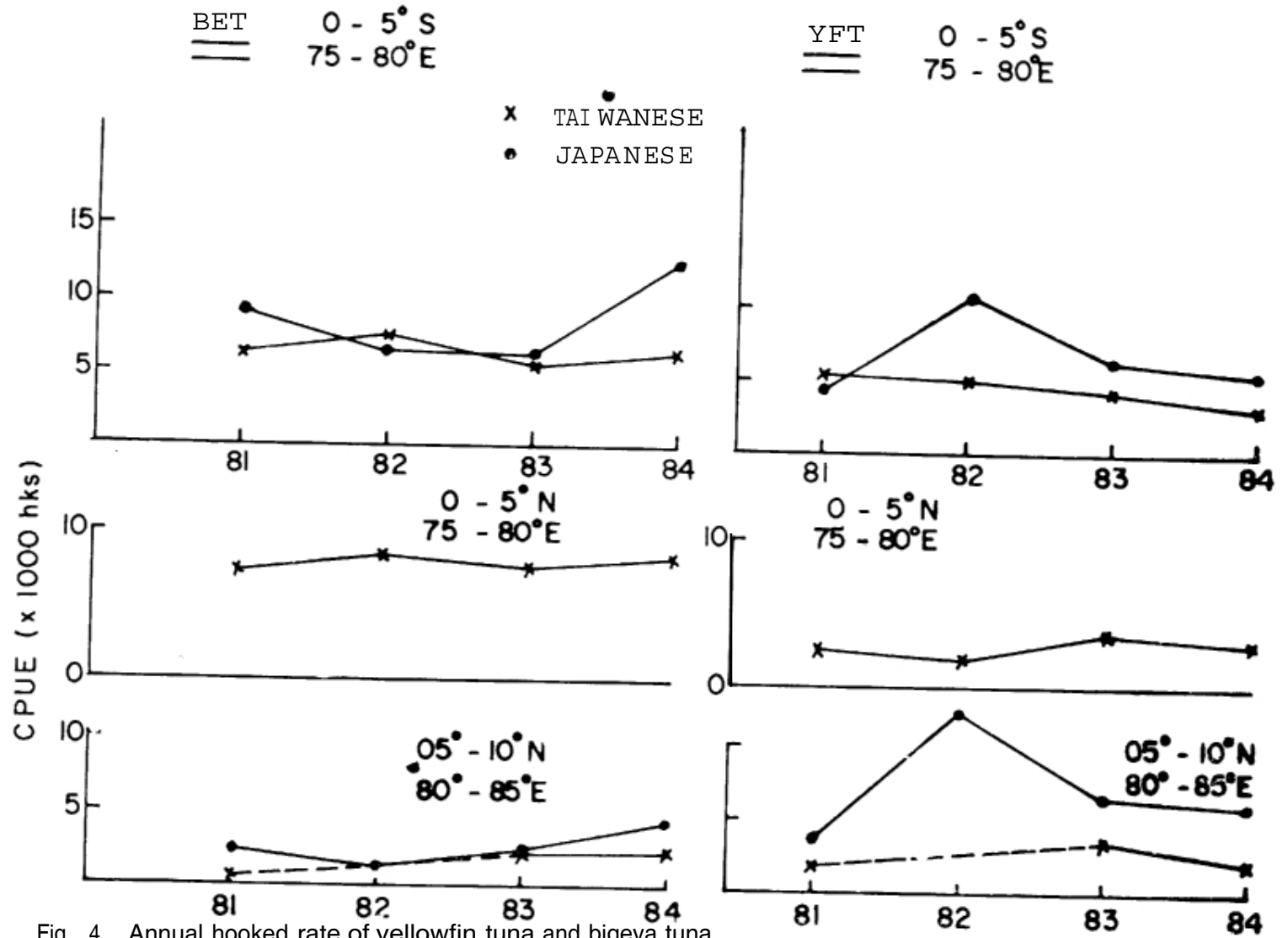


Fig. 4 Annual hooked rate of yellowfin tuna and bigeye tuna in the area within 75°-85°E, 5°S—10°N (1981—1984).

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.