# Bay of Bengal Programme

## Marine Fishery Resources Management

TUNA FISHERIES IN THE EEZs OF INDIA, MALDIVES AND SRI LANKA

BOBP/WP/31

UNITED NATIONS DEVELOPMENT PROGRAMME

FOOD AND AGRICULTURE ORGANISATION OF THE UNITED NATIONS

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(RAS/81/051)

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This paper attempts to summarize the present knowledge of those tuna resources in the EEZs of India, Maldives and Sri Lanka that are likely to be shared stocks. It contains a summary report, a survey of tuna fishery in the three EEZs and country reports from Maldives and Sri Lanka.

The material was put together following a working group meeting of scientists from Maldives and Sri Lanka, with India represented by two observers from the Indian High Commission in Sri Lanka. The meeting was held 4—8 June 1984 at the National Aquatic Resources Agency (NARA), Colombo, Sri Lanka, and was held under the auspices of the FAO/UNDP project "Marine Fishery Resources Management in the Bay of Bengal "(RAS/81/051). Dr. K. Sivasubramaniam, Senior Fishery Biologist of the project, acted as convenor. The Director General of NARA, Dr. Onil Pereira, opened the meeting.

"Marine Fishery Resources Management in the Bay of Bengal" is a component of the Bay of Bengal Programme. The project has a duration of four years; it commenced in January 1983. Its immediate objective is to improve the practice of fishery resources assessment among participating countries and to stimulate and assist in joint assessment and management activities between countries sharing fish stocks.

This document is a working paper and has not been officially cleared either by the governments concerned or by the FAO

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## CONTENTS

## 1. INTRODUCTION

With the establishment of Exclusive Economic Zones, more than 90% of the world's marine fish catch is taken within the jurisdiction of coastal states. This has increased the responsibility of the coastal states for developing, utilizing and managing fish resources in their respective EEZs. Extended jurisdiction of each coastal state, over a wider area of the sea, has also increased the need for collaboration and cooperation in controlling exploitation and management of resources shared by adjacent countries.

One of the fish resources of the latter category in the Bay of Bengal area is the tuna. Tuna fishery is becoming increasingly important because coastal nations are attempting to expand it into offshore and deep-sea ranges and also because of the growing purse seine fishery in the south-west Indian Ocean which is close to the EEZs of India, Maldives and Sri Lanka.

In pursuance of the objectives of the regional FAO/UNDP project "Marine Fishery Resources Management in the Bay of Bengal" — to stimulate and assist in joint assessment and management activities of countries sharing fish stocks—a working group meeting was convened. Held 4-8 June 1984 in Colombo, it was meant to evaluate the present state of the stock and identify areas of work to increase the knowledge of the resource. In particular, the meeting attempted

— to consider the information available on the status of the fishery, biology and resources of yellowfin *(Thunnus albacares),* big eye *(T. obesus)* and skipjack tuna *(Katsuwonus pe/amis)* in the three EEZs, which are likely to be shared stocks;

— to compare the trends in the three areas for similarities and dissimilarities;

— to identify gaps in knowledge and constraints inhibiting the proper development of tuna fishery and consider steps to overcome these;

— to consider a common approach to this study in the three countries, which would permit a collective evaluation of the information collected, and to interpret the results of the combined effort;

— to establish suitable and practical standard units of effort for tuna fishery in the three EEZs; and

— to prepare a work programme for follow-up action in accordance with the recommendations of the meeting.

A number of gaps in knowledge have to be filled, and several factors have to be taken into account, before the present status and future prospects of tuna fishery in the EEZs of India, Maldives and Sri Lanka can be properly assessed. Among them are:

— Difficulties in identifying juveniles of yellowfin, big eye and long-tail tunas and the consequences of this problem on catch composition in the area;

— Existence of morphometric and meristic differences in tuna species present in the area and the need for reconfirmation of these in respect of the three EEZs;

— Lack of assessment of the status of tuna fisheries and stocks in the region, especially after the enforcement of the new Law of the Sea;

— Recent development of the tuna purse seine fishery in the Seychelles and its expansion towards the Chagos islands directly south of the Maldives;

— Lack of information on some biological parameters such as sex ratios, gonad indices and discrepancies in the methods adopted to study, and the results obtained from, the latter;

— Surface areas of the EEZs and estimated areas of exploited ranges;

- Strong probability of more than a single annual recruitment of tunas in the area ; and
- Estimates of the production of tuna longlino fishery by distant nations, such as Japan, Korea and Taiwan, in the three EEZs.

Background material for the discussions was prepared by the convenor and the participants from Ma!dives and Sri Lanka. It appears jr this report in Appendices 1—3.

## 2. SPECIES AND STOCKS

Some mixing of species in the catch composition data is possible mainly due to difficulties encountered in the clear-cut identification of juvenile yellowfin, big eye and long-tail tunas. There is a need for a short-term, but intensive, sampling programme on the morphometric and meristic characteristics of the major tuna species in the area. This would not only contribute to better catch composition but also provide a tool for examining possible differences in the characteristics of the tunas in the three EEZs.

With respect to stock identification, besides tljO evidence available from size composition. seasonal variations in the occurrence and contiguous distribution of tuna species within the three EEZs, it would be necessary to undertake other investigations to ascertain whether more then one population or sub-population of each species contributes to the tuna fishery in the area. Besides morphometric studies, the application of electrcphoretic analysis could also be considered. Facilities for the latter are available in Sri Lanka with institutions such as the Medical Research Institute and the Ceylon Institute of Scientific and Industrial Research. Samples from the Maldives can also be analysed in Sri Lanka.

Tagging experiments on tunas are expensive and complex and any consideration of a tEgging programme might, therefore, have to be postponed until much later in the countries' tuna research programme.

## 3. PRODUCTION

Historical data on tuna production, by species, is readily available only for the Maldives. Attempts are now being made to collect catch statistics of the Bokura (row boats) handlir,e fishery which accounts for most of the dog tooth tuna *(Gymnosarda un/color)* caught there. Between January and March 1984, 1016 numbers of this species were recorded from the landings in Male alone.

In Sri Lanka, production figures for the skipjack *(K. pelamis)* and the yellowf in tuna (1. *albacares)* are available, but all other tunas and tuna-like fishes are grouped together. However, the research sampling programme provides percentage composition of the catches by various methods.

In India, estimates, by species, of the production of tunas and tuna-like fishes is available from 1981. Prior to that, these production figures were grouped together.

Nearly 70—75,000 tonnes of tunas were produced in the area in 1982, as against 136,000 torines produced from the western Indian Ocean (Area 51 only). This indicates that the three EEZs contribute significantly to the tuna fishery in western Indian Ocean. These figures also underscore the importance of tuna fishery to India, Maldives and Sri Lanka.

Tuna production trends in recent years indicate a steady increase in production in the case of Sri Lanka, fluctuation in the case of Maldives and a decline in the case of India (Appendix 1).

Production of deep-swimming tunas by distant nations (Japan, Korea and Taiwan) using the tuna longline, in 5°x5° grids falling completely or having their major portions within the EEZs of India, Maldives and Sri Lanka, is given in Table 1. The production has flLctuctcd in the last ten years. The peak production of yellowfin and big eye tunas was 773 tcnne and 792 tonne, respectively. These figures were achieved in 1979 when the effort was relatively very high.

Driftnet fishing effort by non-mechanized 6 m crafts in Tuticorin (south-east coast of India) increased from 4,000 trips per annum in 1978 to 9,400 trips/annum in 1981, while the catch rates of the main species, *Enthynnus affinis,* declined from 54 kg to 38 kg. A much greater effort has been undertaken by non-mechanized kattumarams on the south-west coast. This fluctuated between 12,000 and 25,000 trips/annum between 1970 and 1978 and the catch rates for *E. affinis* also fluctuated between 2 and 13 kg per trip without showing any definite trends. The hook and line fishery for tunas in the same area showed an even larger effort (fluctuating between 45,000 and 72,000 trips/annum in the same pericd) and the catch rate for *E. aff/nis* varied between zero and four kg per trip without any clear trends. Hardly any skipjack or yellowfin tunas were recorded in the catches off the west coast of the mainland, and effort and catch rates are not availab'e for skipjack or yellowfin caught around Laccadivc-Minicoy islands *(IPTP Data Summary, 1983,* pp. 149—1 50).

In Maldives, the effort by non-mechanized pole and line crafts before 1976 was almost twice that after 1976 (when mechanization commenced). The number of trips per annum by mechanized and non-mechanized crafts has remained fairly stable during 1980-1982 (Table 7, Appendix 1). The catch rates for skipjack increased from 91 kg in 1973 to 237 kg in 1979. These rates declined in 1981 and the decline has continued thereafter. Trends in yellowfin catch rates have also b°ensimilar. In view of the significant differences between the efficiencies of mechanized and non-mechanized pole and line crafts and the annual replacement of non-mechanized crafts by mechanized crafts (Table 8, Appendix 1), it may be concluded that the efficiency of the effort expended in Maldives would have increased even in the absence of any increase in the number of trips.

Trolling boats, which are non-mechanized crafts, also contribute significantly to fisheries in the Maldives. Their effort increased from 67,000 trips per annum in 1971 to 158,000 trips in 1978, but thereafter declined to 130,000 trips in 1981. The catch rates are relatively low and have fluctuated without exhibiting any definite trends. Further, data on trolling effort include the capture of reef fishes by this category of craft *(/PTP Data Summary, 1983,* p. 153).

In Sri Lanka, no estimates are available of effort on tunas by various categories of craft and gear. However, the annual increase in the numbers of E 26-type of mechanized boats, which are mainly involved in driftnetting for tunas, indicates that the effort on tunas might have increased steadily up to 1982. Though tuna production has shown an increase up to 1982, the catch rates estimated from the research sampling programme have indicated a decline in recent years (Appendices 1 and 3).

The data on tuna longline operations in the area are incomplete. On the basis of available data (Table 1), it can be inferred that the effort reached a peak value of 3,095,013 hocks in 1979. The highest hooked rate for yellowfin was 1.4/100 hooks in 1978 and 1.1/1 00 for big eye in 1977. A more detailed analysis of these data may not be meaningful in view of the differences in the seasons of coverage of each grid in different years, and the possibility that these data gathered from three distant nations may be incomplete. It can, however, be seen that the catch rate for yellowfin in the area exhibited a declining trend up to 1976 similar to the trend in western Indian Ocean. This decline was reversed in 1977 and 1978 but thereafter the decline resumed and has continued till 1982. These trends have to be looked at in relation to the fact that both the area covered and the effort expended have declined in recent years. The trend in big eye catch rates has been similar to that of the yellowfin.

There is some degree of similarity in the seasonal variation in the occurrence of skipjack and yellowfin tunas around Maldives, Laccadive-Minicoy islands and Sri Lanka. Shifts in the peak seasons may be expected in view of the annual variations in the environmental conditions prevailing in the respective fishing areas (Figure 1). Seasonal trends in the distribution of effort and hooked rates, derived from Korean longline fishing data for 1977 (the most recent year of good coverage), are presented in Fi ure 2. The effort south of Sri Lanka declined sharply from the early to the middle part of the year and increased again during the latter part of the

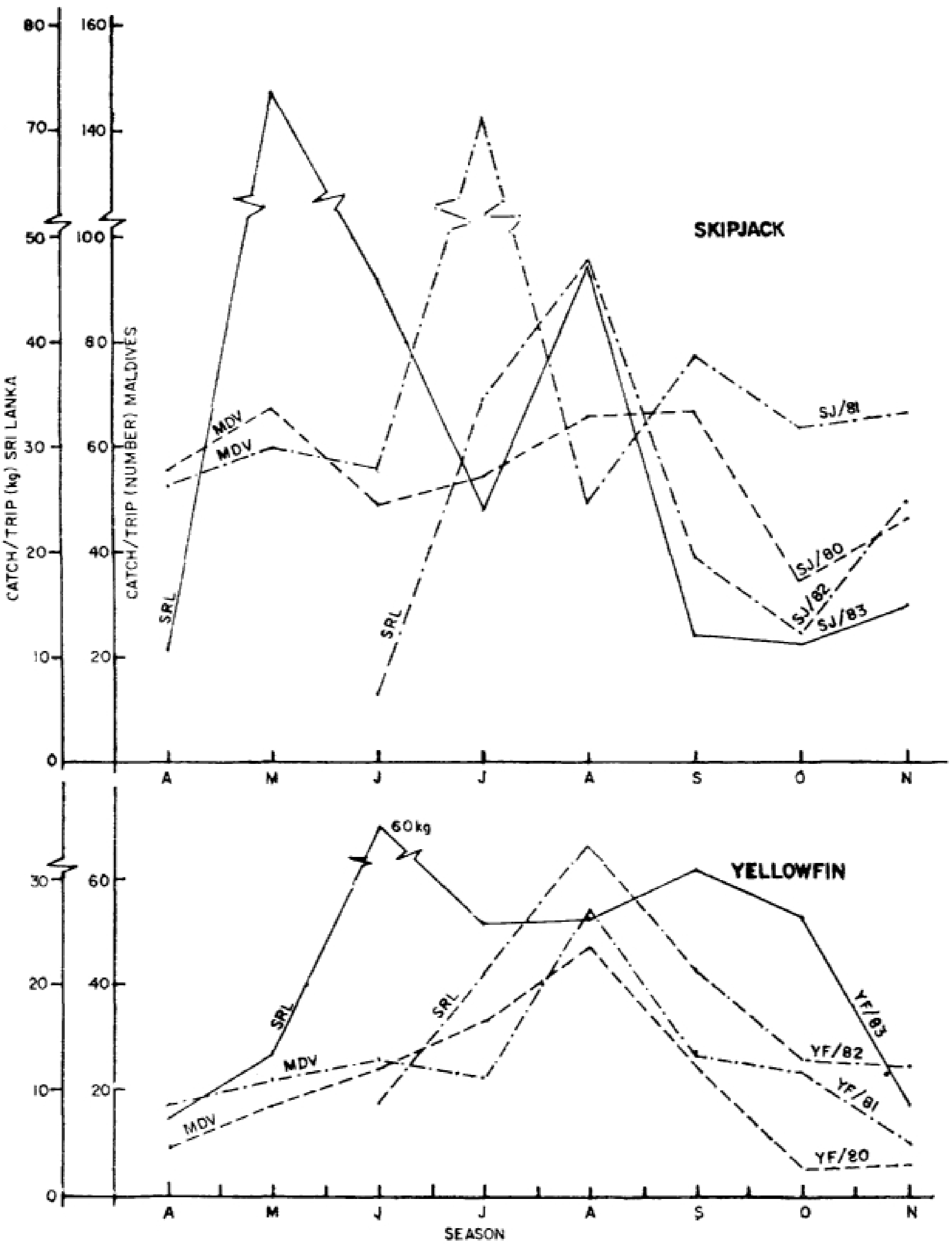


*Fig. 1. Seasonal variations in the catch rates of skipjack and ye/fowl/n tunas around Ma/dives and Sri Lanka.*



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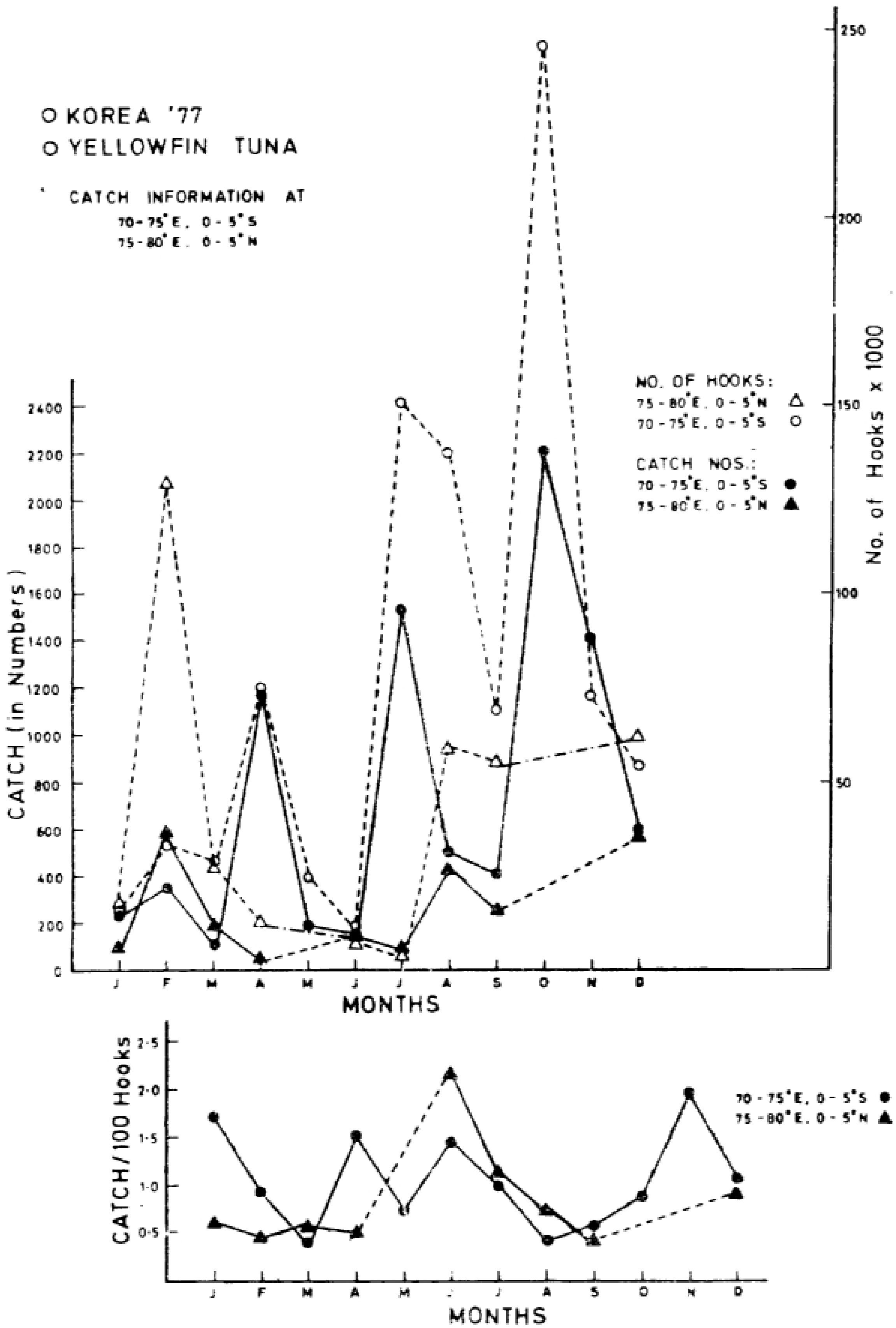


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*Fig. 2. Seasonal trends in long//ne fishery in the area.*

year. South of Maldives, the effort was very low in the first quarter and increased later to reach a very high value during the last quarter. South of Sri Lanka, the catch rate peaked in June and was fairly low in all the other months. South of Maldives, the catch rate fluctuated evenly except in August and September.

## 4. UNIT OF EFFORT

Except in the Maldives and the Laccadive-Minicoy islands of India, tuna fishery involves numerous craft-gear combinations. The influence of the characteristics of these various combinations on the catch rate,catch composition and selectivity has to bedetermined if standardized effort values for the three countries are to be arrived at. In the Maldives, attempts have already been directed at defining such a measure and no serious difficulties are anticipated. In the case of Sri Lanka, an exercise in standardization was carried out earlier, and it might be possible to re-establish the standard thus derived.

If it is considered desirable to unify the standardized tuna fishing effort of the three countries, for example, for any combined assessment, such a unification may be approached by first examining compatible classes of craft and gear in the three countries. Thus the “Mas dhoni" of the Maldives and the “Mas odi” of the Laccadive-Minicoy islands could be taken as similar in their pole and line operations and bait fishery. Similarly, the 26’-type mechanized day boats involved in large-mesh driftnetting in Sri Lanka may have equivalents within the 9.7—14 m category of mechanized boats operating large-mesh gillnets in India. With the recent removal of restrictions on the use of nets, the Maldives is also likely to commence large-mesh driftnetting and this too may lead to compatible standards. It is understood that India has commenced gillnetting operations in the Laccadive-Minicoy islands, which also could serve as a linkage among the three countries. In order to improve the unit effort value, for better estimates of catch rates, the following aspects should be taken into consideration:

(a) *Pole and//ne fishery:* The time utilized for catching bait should be taken into consideration, as this results in the loss to tuna fishing of a significant number of hours, especially during that part of the day which is best suited to fishing. Seasonal differences in the availability of bait influence the number of hours spent on tuna fishing per day in different seasons and, hence, proportionate reductions may have to be applied to the unit effort of one trip. In deriving the unit effort value, the average number of fishermen per craft should be applied in view of the fact that varying numbers of fishermen are employed on pole and line crafts of different sizes in the three countries.

(b) *Driftnet fishery:* To compare the catches made by craft in one country with those in another and to overcome the differences in the number of net pieces in a set, the number of net pieces per set should be taken into consideration to arrive at a value of catch per unit surface area of net.

(c) *Driftnet-fongline combination:* Since there is no interaction between these two gears, operation of this combination does not influence the fishing time for the two gears. Each trip with this combination may, therefore, be treated as if it were an independent trip for each element of the combination.

Separation of the catch from the combined operation may, however, create difficulties at the time of landing. When sampling such landings, net marks and hook marks on the body may turn out to be useful guides in separating the catch.

The basic issue is, however, the improvement in the accuracy of the estimated number of trips. The other factors di.scussed may be introduced step by step, once this basic accuracy is assured, to further improve the precision of the unit of effort.

In the Maldives, mechanized boats obtained through loans are free to give up fishing operations once the loan is repaid. This creates difficulties in determining whether a boat is a fishery boat



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or a passenger service boat. The new registration rules introduced in the country provide for separate registrations of the two categories, though even then passenger boats may go fishing if they so desire. The number of mechanized fishing boats in the Maldives, therefore, requires verification. In the case of trolling crafts, the effort on tunas may be over-estimated because of the large quantities of demersal fish landed by this craft through hand lining operations. The revised statistics forms now in use should take care of this problem. The effectiveness of the new forms is likely to be determined when they are received from the field.

## 5. BIOLOGY

It appears possible that there exist two annual recruitments of both yellowfin and skipjack tunas to the surface fishery around Sri Lanka. This could also be the case in the waters of the other tNo countries. For both species, these recruitmerits do not appear to be of equal strengths. Earlier studies (Appendix 1) indicate that the recruitments of skipjack tuna were mainly off the south-west coast of Sri Lanka during April/May and during July-September. In the case of yellowfin tuna, the recruitment appeared to be around March/April in the south-west and December/January in the north-west. Some deviations were observed using length frequency measurements of recent years (Appendix 3), but as the coverage is incomplete, the results derived from these studies remain inconclusive. The possibility that the two recruitments are contributed by spawners in two different areas has also to be confirmed.

It is not possible to derive similar conclusions in the case of Maldives because of the inadequacy of leiigth frequency data. A relatively higher concentation of yellowfin tuna is to be found in the north-western part of Maldives. The size range (20—55 cm) ob3erved during the five-month period between June and September 1983 in the Maldives was very much smaller than the range observed off the west coast of Sri Lanka (50—90 cm) (Appendices 2 and 3). A similar tendency obtains in respect of skipjack length frequencies as well.

In the Maldives, a programme for sampling size frequency was initiated after the FAO/TCP Training Programme (TCP/MDV/2202) in 1983. The data collected over a period of six months were, however, found to b inadequate in terms of sample size and coverage by strata and seasons. No modal progression was evident. In Sri Lanka, after some work in the early 1970s, length frequency sampling re-commenced in 1982. The results from these studies are affected by limitations in sample size and seasonal coverage. Confirmation of observations made more than a decade ago also poses problems. Length frequency data from Indian waters were not available at the meeting. It is possible that these data are available in India and Indian tuna biologists could be requested to contribute their findings. In all the three countries, there is a definite need for more intensive and regular sampling.

The mean weight of individual big eye and yellowfin tunas caught by Taiwanese longliners in the Bay of Bengal and west of Sri Lanka is presented in Figure 3. These statistics were examined for changes in the structure of exploited populations. In the case of the big eye tuna, the mean weight shows a decline till 1977 and a recovery thereafter. The yellowfin tuna, on the other hand, shows fluctuations in mean weight without any evidence of decline since 1972. The mean weight at first capture in this area has decreased and then levelled off. However, the fact that the tuna longline gear has its own pattern of selectivity, does not permit us to conclude whether the mean weight values are actually lower than what is obtained through longlining.

*Sax ratio, gdnad index and maturity:* No information is available from the area except for one paper published over 20 years ago (Raju 1963)* for the Laccadive-Minicoy islands. In order to carry out determinations of sex ratio, gonad index, etc., samples have to be obtained. In the Maldives there exist special locations for gutting the fish and also a cannery and these locations could be ideal for obtaining the required data. In Sri Lanka, there are no places where large quantities of tuna arc gutted and, therefore, obtaining the necessary data may be a problem.

* Details of references are found in Appendix 1.

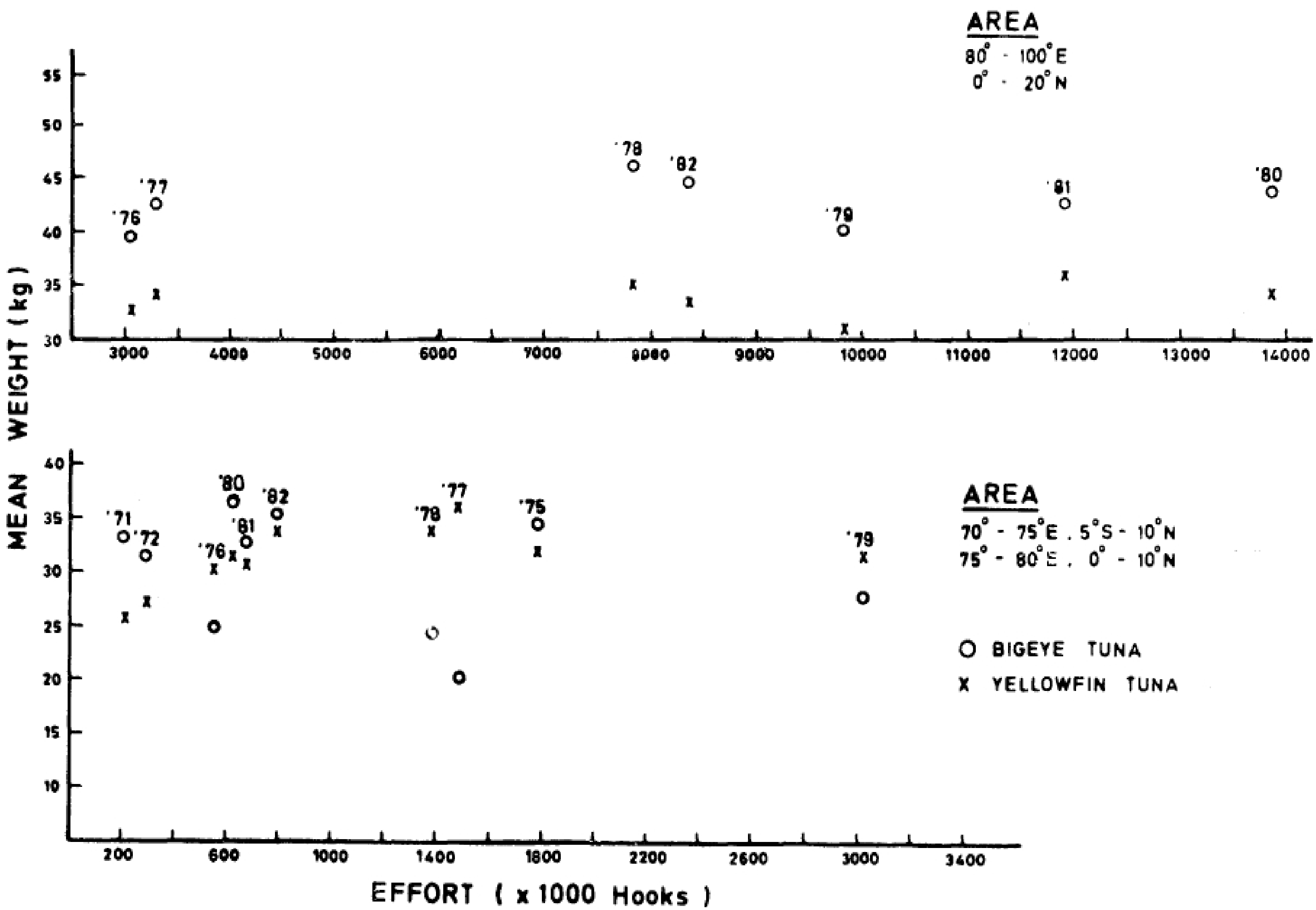


*Fig. 3. Mean weight of individual big eye and ye/towf/n tuna caught by Taiwanese long/meTs in the Bay of Bengal west of Sri Lanka.*

it might be necessary to carry out experimental fishing operations, on at least two or three days every month, for various biological determinations and also to monitor catch rates.

*Age and growth:* In view of its success in other tropical areas, the use of dorsal fin rays for age determination might be usefully applied to tunas as well. Depending upon the methodology adopted, age determination of yellowfin and skipjack tunas sometimes yields similar results, though discrepancies also occur. In the case of skipjack of 40—60 cm size range, the mean annual increment in size, as estimated by different authors, ranges from 7.0 to 13.8 cm/year. The latter figure was obtained from tagging experiments (Wild and Foreman, 1980). Chur and Zharoo (1984) estimated a high rate of increment of 29.2 cm in the first year declining to 4 cm! year by the fifth year, based on age studied with fin rays. The mean lengths of modal groups separated on probability paper, and considered as age groups for skipjack tuna around Sri Lanka, indicated a mean annual increment of about 10 cm. There was, however, no clear indication that with the increasing size range of the modal group, there was a decline in the rate of increment.

The K and $L_{\infty}$ values determined using the ELEFAN I method (Appendix 1) were well within the ranges of value obtained by various authors for skipjack tunas in various areas of the Atlantic and Pacific Oceans.

Not enough length frequency data are available from the Maldives to attempt a similar analysis. Data were not available on Indian waters and length frequency distribution of tunas have not been included in any Indian publication. The length frequency tables for male and female skipjack tuna presented by Raju (1963) in his paper on spawning studies did not exhibit seasonal modal progress and an analysis failed to produce meaningful results on growth.

Length frequency samples from gillnet fishery might be influenced by selectivity. However, each set of nets uses a wide range of mesh sizes to capture mixed species of tunas and tuna-like fishes. There is evidence of a wide range in the size of each species captured, as well as of modal progression. It could be a useful exercise to subject the data from the gillnet fishery in Sri Lanka to a detailed analysis for modal progression, etc.

## 6. ENVIRONMENTAL CONDITIONS

Though preliminary investigations have shown evidence of a correlation between surface temperature and surface tuna catches around Sri Lanka (Appendix 1), more detailed studies are required in all the three countries so as to develop a better understanding of the influence of environmental conditions on the behaviour of tunas. Tuna biologists from Sri Lanka have agreed to investigate the possibilities of undertaking such studies with the cooperation of the National Hydrographic Office established in the National Aquatic Resources Agency.

Data on temperature and other parameters from Maldivian waters have been collected by Japanese vessels for a period of about ten years. These data are available with the State Trading Organization of the Maldives. An attempt is to be made to analyse these data to detect any correlations between these parameters and tuna catches in the waters around Maldives.

## 7. POTENTIAL

Maldives and Sri Lanka exploit about 20% of their EEZs for tuna fishery. It is likely that India too exploits roughly the same proportion of its EEZ. The fishing range does not exceed a distance of 25—30 miles from the shore. Estimates of the tuna potential in the EEZ off the Indian west coast and the Laccadive-Minicoy islands amount to about 110,000 tonne/ annum (Appendix 1).

The maximum sustainable yield (MSY) for Maldives has already been estimated from the catch and effort of pole and line craft (Appendices 1 and 2). An attempt was made at the working group meeting to calculate the MSY for the total production of skipjack and yellowfin tunas by both pole and line and trolling crafts, after standardizing the effort by both types of fishing to that of pole and line craft.

| | Skipjack | | Yeliowfin | |
|---|---|---|---|---|
| Model | MSY | Opt. effort | MSY | Opt. effort |
| Schaefer | 22,460 | 126,046 | 8,963 | 102,572 |
| Fox | 19,714 | 131,136 | 5,580 | 101,186 |

Relatively better fit for the regression was obtained by the Schaefer model. Since the annual production exceeded the MSY only in 1980, it may be assumed that the present rate of exploitation is at the optimum level within the presently exploited range. Any further expansion or development of the tuna fishery should probably be based on the resources outside this range.

It i3 necessary to monitor carefully the decline in catch rates since 1980. Further improvement in the estimation of the MSY may be achieved by separating the respective catch and effort values of mechanized and non-mechanized pole and line craft and standardi?ing them. This appears possible. In Sri Lanka, the catch rates of skipjack and yellowfin tuna in 1982 and 1983 were less than the corresponding values for the early 1970s. The exploitation rate estimated by the ELEFAN II method indicates that the production of the skipjack and the yellowfin were at and above the optimum rate, respectively, in 1975. However, the production figures reveal a steady increase up to 1982. Suitable effort values are not available for the tuna fishery in Sri Lanka. Effort estimates are available for 1982 and 1983 but these cover only the west Coast.

Attempts were made to use the number of mechanized fishing boats as an index of effort but this failed to reveal any correlation between the number of boats and the catch. As in Maldives, it may not be advisable to expand the tuna fishery within the presently exploited range.

Estimates of potentials in the EZZs of Maldives and Sri Lanka are not available. Using the present yield levels of skipjack and yellowfin in the two countries and the results of explorations with pole and line and resource surveys for tunas conducted by the Nichiro Fishing Company (1973—1974) and FAO/UNDP (1974—1976) up to a range of about '100 miles around Sri Lanka, an estimate of the order of magnitude of the tuna potential in EEZ areas beyond the presently exploited range can be arrived at. The catch rates for pole and line operations indicate that the rates tend to decline only beyond 60 miles from shore. The catch composition, size composition, number of schools sighted, average school size and seasonal variations in the 30—60 mile range are very similar to the presently exploited range of less than 30 miles (Appendix 1). In the estimates presented below, it was assumed, as a measure of caution, that the catch rates and density beyond 60 miles would not be less than a third of the value within 60 miles; the number of schools beyond the 60 miles range may be half the average number (1.4/day) per unit area with an average size of two tonne/school within 60 miles and that the yield per unit area within 30 miles will be obtainable up to 60 miles but beyond that it will drop to a third of this value. Based on these assumptions, the estimates arrived at are:

(values in tonne)

| Basis | Sri Lanka (EEZ) | Maldives (up to 60 miles) |
|---|---|---|
| 1. Yield per unit area | 98,874 | 39,000 |
| 2. School count and average school size | 56,600<br>(54,720) * | 40,000<br>(45,000) * |
| 3. Mean catch rate offshore | 44,188 | — |

* Biomass



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The estimates based on the number of schools and average school size were taken as biomass values while the others were considered to be potential yield levels. The yield estimates from biomass values were arrived at through Gulland's first approximation of Py==0.5 (C+MB). The value M=0.8 was based on an average of M values obtained for skipjack and yellowfin tunas by Pauly's method. The estimate for Sri Lanka, based on yield per unit area, appears to be too high, while the other values look reasonable.

Tuna longline operations by Japan, Korea and Taiwan in the area under consideration produced about 1,600 tonne of yellowfin and big eye tuna in 1979, which was the peak year. This may provide a guideline to determine the yield levels for larger yellowfin and big eye tunas from the open seas in the EEZs of India, Maldives and Sri Lanka. As these yields are likely to be components of larger stocks spread over a wider area of the Indian Ocean, the yield values have to be examined in the context of the overall status of longline fishery in the Indian Ocean.

Lee and Yang (1983) estimated the MSY for yellowfin and big eye tunas in the Indian Ocean at 39,000 tonne (168x$10^6$ hooks) and 32,300 tonne (341x $10^6$ hooks), respectively. The 1981 production levels were 34,249 tonne and 30,327 tonne respectively. There appears to have been a decline in the longlining effort in the area since 1977 which is likely to continue with the gradual withdrawal of fishing effort by distant nations within or very close to the EEZs of others.

Based on prevailing catch rates, the cost of operation of the Sri Lankan tuna long liner, "Wennapuwa Maru," and the present price of tunas, a calculation shows that the viability of tuna longlining in Maldives and Sri Lanka is problematical. Further, tuna hooked rates realised in recent experimental longline trials by India and Sri Lanka have been less than the levels required for economic viability. However, it could be worthwhile to investigate the possibility of small-scale tuna longlining up to a range of 100 miles, as, in this case, the capital and operational costs of the craft involved are sub3tantially lower than those of regular tuna longliners. Perhaps the lonçiline-cum-driftnet combination fishery that is evolving in Sri Lanka is an approach that could be followed up in bath Maldives and Sri Lanka.

## 8. WORK PROGRAMME

### A. Short-term

*1. Updating structural characteristics of craft, gear and operational system in tuna fisheries:* Numbers of each category of craft, gear, the number of units of gear per set and their specifications.

Number of fishermen per craft and gear categories.

Operational characteristics Duration of each trip, sailing time, fishing time, time spent on bait fishing, distance from shore, location of fishing ground, seasonality and gear combination used.

A short-term survey requires 56 persons for four field days (14 divisions x 4 persons x 4 days) in Sri Lanka and 200 persons for two field days (200 islandsxl personx2 days) in Maldives. These persons must be well briefed on the details to be included in the form that will be filled during the survey. The survey must be conducted simultaneously in all parts of each country.

**2.** *Identification of tuna species and morphometric studies:* It would be necessary to use FAO identification sheets for Areas 51 and 57 and FAO Species Catalogue (Vol. 2) for identification and Figure 4 for morphometric measurements of, particularly, juvenile yellowfin, big eye and long-tail tunas and also perhaps *Auxis thazard* and *A. rochei.* Short-term but intensive observations on various sizes in different locations, and at least 200 samples for morphometrics of skipjack and yellowfin tunas would be required. Morphometric measurements must be taken with calipers (Figure 5). Samples may be taken during peak and lean seasons and may be combined with other tuna sampling programmes. In Sri Lanka, particular emphasis is to be placed on the north-west, south and east coasts. In Maldives, the north, central and southern atoll groups are to be emphasized.

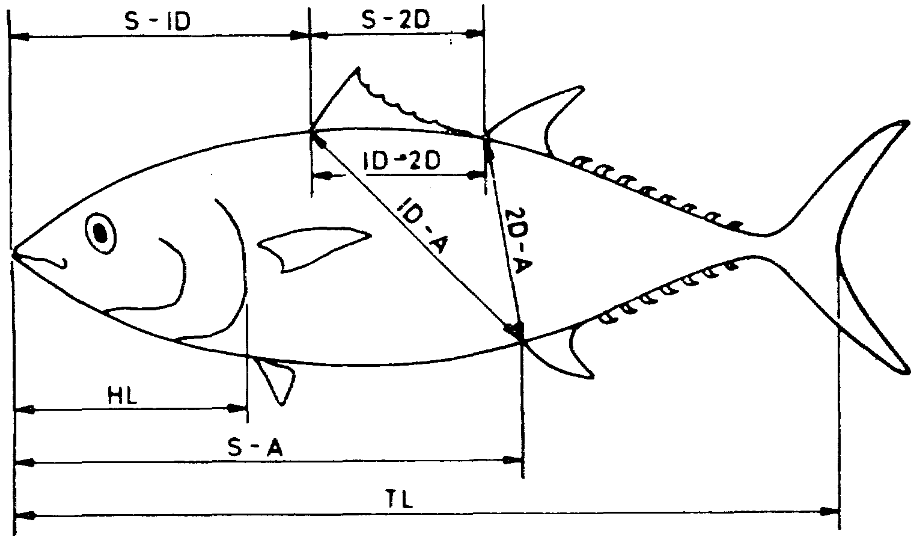


*Fig. 4. Eight morphometric measurements used to study ye/Jowfin and skipjack school characteristics*

3. *E/ectrophoretic analysis:* The possibility of the Medical Research Institute or the Ceylon Institute of Scientific and Industrial Research in Sri Lanka carrying out electrophoretic analysis of samples from Maldives and Sri Lanka is to be investigated.

B. Continuing

4. *Sampling of catch and effort at identified landing sites:* Sampling is to be done at monthly intervals with a systematic duration of four days. It could be continuous or with not more than four days' interval.

In terms of sample size, a 10% sample is to be obtained at centres with more than 100 tuna fishing craft or boats/day; 20% at centres with more than 50 craft; 40% at centres with more than 25 craft; and 100% at centres with less than 15 craft, and proportionately for numbers in between. The craft are to be selected at random, stratified by categories of craft and gear.

The data to be obtained through sampling include (a) catch composition by size and type of craft and gear – if the weight of each species cannot be obtained, eye estimates of the propor-tons may be made; (b) catch of each tuna species; if the weight of each species is not available, these could be measured using the balances carried by samplers and if this also is not possible an eye estimate of the weight should be made; (c) effort—the total number of craft of each category actually operating on sampling days at sampling centres; and (d) length frequency—the fork length from snout (upper jaw) to caudal fork may be measured using measuring boards for smaller sized tunas and calipers in the case of larger tunas. If measuring tapes have to be used, the relationship between the length measured by tape and that measured by measur-ing board or calipers, should be established through regression equations for each species.

In the case of Maldives, length-weight relationshipsfor tunas other than skipjack and yellowfin also need to be established.

All measurements are to be taken in accordance with IPTP standards, i.e., lengths from 20 to 20.9 cm recorded as 20 cm with mid length 20.5 cm.

Length frequncy measurements should be categorized by the type and specifications of the near used. A minimum number of 300 of each species every month should be measured in

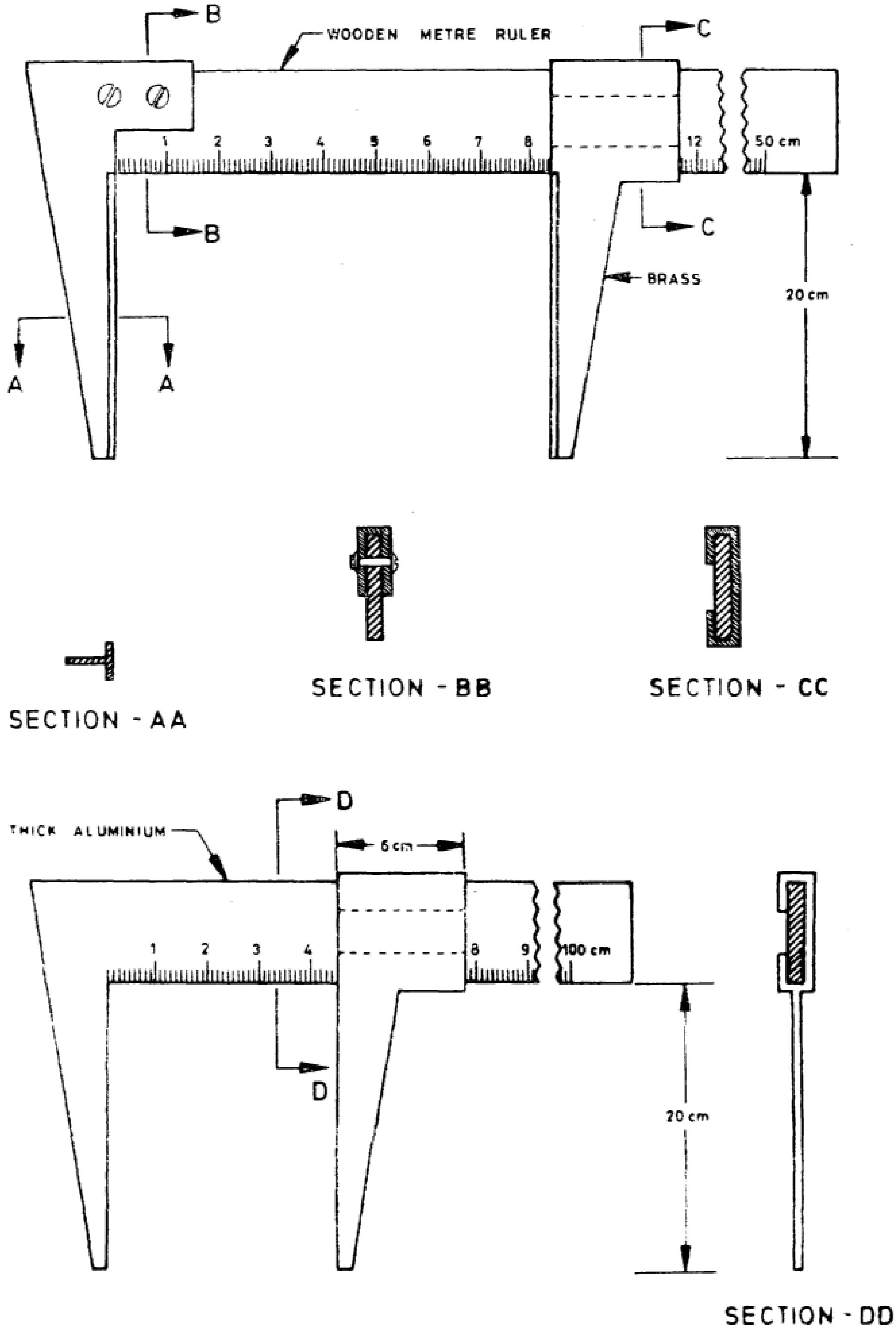


*Fig. 5. Fabrication of a caliper (0.5 m and 1.0 m).*

each stratum. This number may be reduced if the tctal landing during sampling days are poor. The use of raising factor is necessary.

At present, research sampling in Sri Lanka is restricted to the west and south coasts only. The three sampling stations on the east coast will be covered by two samplers to be recruited on a casual basis. An additional sampling station at the upper end of the north-west coast also appears essential.

In Maldives, some teachers in the northern atolls have been involved in the sampling programe. The sampling programme has been run in addition to the routine catch statistics enumerated by island chiefs. With the introduction of fisheries education in the curriculum, a scheme in which the Ministry of Fisheries is directly involved, it should be possible to implement a sampling programme with the help of teachers in various atolls. Better results may be obtained if there are incentives offered for participation in the sampling programme.

A field guide, in the Dawehi language, to explain the purposes of and procedure for sampling is to be prepared and distributed. The Ministry of Fisheries staff are to personally brief the teachers on the subject.

Sex ratio, gonad index and maturity studies will be undertaken only in locations where samples are available for such examination. In Maldives, such studies are to be carried out in the cannery in the north and the gutting centre at Male. An attempt will be made to identify a suitable location, close to the equator in the southern part of the country, for such studies. Supplementary studies will be made on catches whenever exploratory or experimental fishing operations are conducted by the Ministry of Fisheries.

In Sri Lanka, several difficulties are encountered in the collection of samples for these studies. Vessels available with the Research and Training Institute in Sri Lanka could be used to carry out two to three-day fishing operations every month to obtain samples for these studies. These operations would also make valuable contributions to other aspects of tuna fisheries.

### C. **Others**

5. *Exploratory and resources survey beyond the exploited ranges:* In the absence of data and information on surface tuna resources in the EEZs beyond the exploited range, a survey has to be undertaken to cover the unexploited area embracing the EEZs of the three countries. Four seasonal coverages are required (north-east monsoon, south-west monsoon and the two intermonsoonal periods). A minimum of four months sea time would be required and a vessel capable of operating up to 200 miles from port, with driftoets and longlines would be ideal. Purse seining and pole and line operations are to be given a lower priority. For the estimation of school count and school size (apart from visual estimation), the availability of sonar would be an advantage. Hydrographic measurements also will be made at stations on the transects extending across EEZ boundaries.

Suitable vessels for such a survey are available in India and Sri Lanka. The proposed survey will provide the information required for determining the feasibility of developing offshore tuna fisheries in the three countries. The operational cost of the survey would be around US $ 60,000 if one of the locally available vessels is used for the purpose. Alternatively, an existing large size coastal fishing vessel could be used to cover up to 60—100 miles of each EEZ, but this may not be very convenient during monsoons.

The execution of this work programme faces several constraints in terms of equipment, personnel and funds. The immediate requirements are summarized here.

| Constraint | Maldives | Sri Lanka |
|---|---|---|
| (a) Equipment | 5 good fish weighing scales | 2 triple beam balances |
| | 1 triple beam balance for the south | 4 half-metre calipers |
| | 6 measuring boards with stainless steel ruler | 12 stainless steel tapes |
| | 2 half-metre calipers | 1 micrometer |
| | 1 standard microscope | 2 bathythermographs |
| | 1 dissecting microscope | 2 Nansen bottles |
| | 4 graduated slides | 1 T—S bridge |
| | Taxonomic books for Indian Ocean | Driftnets |
| | 2 bathythermographs | |
| | 1 T—S bridge | |
| | 2 setsofgillnets (specifications required) | |
| | 2 ice boxes for samples | |
| (b) Personnel | 2 officers with scientific background for supporting and coordinating the work (Expatriates) | 3 casual samplers |
| (c) Funds | Available funds insufficient. Supplementary from RAS/81/051 if available. The project is also requested to explore possibilities of external sources of funding for EEZ surveys. The project also to provide a format to enable respective countries to take up the matter of tuna surveys in their EEZS directly with funding agencies. | |

While funds are being sought for the fifth item in the work programme, the first four components should be implemented to the extent possible. Since there was no technical-level representation from India in the meeting, the Indian component of the work programme is yet to be determined.

## 9. RECOMMENDATIONS

(1) It is recommended that the participating countries carry out research as planned. Where suitable research units do not exist, consideration could be given to the establishment of such units as this is an important initial step in the development and management of fisheries.

(2) Where there are limitations of personnel, equipment and other resources, it is recommended that the concerned authorities in the respective participating countries make the necessary arrangements to overcome these limitations as early as possible.

(3) Based on the information and data available at present, it appears that there is hardly any possibility for a significant expansion of tuna fishery within the presently exploited ranges of the EEZs of Maldives and Sri Lanka. It is necessary to consider developing tuna fishery in the EEZ areas beyond the exploited range.

(4) In view of the limited information available on resources beyond the exploited range, an exploratory and tuna resources survey should be conducted by the participating countries, either individually or collectively, in their EEZs.

(5) The RAS/81/051 project should prepare a format for a standard approach to various sampling activities, data to be compiled, standardization of effort, etc., for the participants.

(6) It is recommended that information on tunas and tuna fisheries in this area, and adjacent ones, be disseminated to participating countries through the Project. The cooperation of IPTP would be very valuable in this undertaking.

(7) Within the limited resources available to the Project, supplementary financial support should be provided to participating countries for executing the work programme, wherever necessary. IPTP may also be requested to provide assistance in improving the collection and compilation of tuna statistics from this area.

.(8) Participants should take up matters relating to these recommendations with their respective government authorities.

(9) The next meeting of the working group should be convened at the end of one year, provided sufficient progress-has been made by then.

**Table 1**
**Tuna longline catches close to India, Maldives and Sri Lanka**

| | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area 70°—75°E 0°—5°S | | | | | | | | | | | | |
| No. of hooks | 67,578 | 183,822 | 25,700 | — | 717,197 | 240,354 | 1,050,018 | 584,275 | 971,916 | 176,500 | 464,800 | 290,800 |
| Big eye | 286 | 851 | 111 | — | 5,290 | 1,450 | 10,569 | 7,158 | 6,713 | 1,181 | 1,816 | 1,461 |
| | (0.42) | (0.46) | (0.43) | — | (0.74) | (0.60) | (1.01) | (1.23) | (0.64) | (0.67) | (0.39) | (0.50) |
| Yellowfin | 1,417 | 2,449 | 306 | — | 6,168 | 2,573 | 8,316 | 8,938 | 6,249 | 695 | 2,813 | 1,188 |
| | (2.10) | (1.33) | (1.19) | — | (0.86) | (1.07) | (0.79) | (1.53) | (0.64) | (0.39) | (0.61) | (0.41) |
| Area 70°—75°E 0°—5°N | | | | | | | | | | | | |
| No. of hooks | 12,160 | 56,172 | 44,280 | — | 289,442 | 2,610 | 73,922 | 286,310 | 306,452 | 11,500 | 0 | 76,000 |
| Big eye | 29 | 312 | 220 | — | 1,979 | 15 | 977 | 4,131 | 2,555 | 69 | | 744 |
| | (0.24) | (0.56) | (0.50) | — | (0.68) | (0.57) | (1.32) | (1.44) | (0.83) | (0.60) | | (0.98) |
| Yellowfin | 188 | 590 | 297 | — | 1,660 | 21 | 832 | 2,986 | 3,007 | 33 | | 52 |
| | (1.55) | (1.05) | (0.67) | — | (0.57) | (0.80) | (1.13) | (0.04) | (0.48) | (0.29) | | (0.07) |
| Area 75°—80°E 0°—5°N | | | | | | | | | | | | |
| No. of hooks | 127,610 | 47,200 | 4,620 | 12,300 | 743,339 | 282,006 | 389,550 | 395,175 | 1,232,134 | 423,971 | 136,700 | 499,500 |
| Big eye | 653 | 318 | 38 | 10 | 5,413 | 1,947 | 3,412 | 3,462 | 11,514 | 2,692 | 1,055 | 4,375 |
| | (0.51) | (0.67) | (0.82) | (0.08) | (0.73) | (0.69) | (0.88) | (0.87) | (0.93) | (0.63) | (0.77) | (0.88) |
| Yellowfin | 913 | 400 | 31 | 55 | 2,811 | 1,922 | 2,791 | 6,599 | 7,083 | 1,742 | 386 | 946 |
| | (0.72) | (-0.85) | (0.87) | (0.45) | (0.38) | (0.68) | (0.72) | (1.66) | (0.57) | (0.42) | (0.28) | (0.19) |
| Area 75°—80°E 5°—10°N | | | | | | | | | | | | |
| No. of hooks | | | | | 66,286 | 56,760 | 22,490 | 192,996 | 584,511 | | 12,000 | |
| Big eye | | | | | 601 | 265 | 61 | 429 | 7,095 | | 12 | |
| | | | | | (0.92) | (0.47) | (0.27) | (0.22) | (1.23) | | (0.10). | |
| Yellowfin | | | | | 265 | 592 | 121 | 2,137 | 8,821 | | 0 | |
| | | | | | (0.41) | (1.04) | (0.54) | (1.11) | (1.50) | | | |

1971–1974 onlyTaiwan; 1975–1979 Japan, Korea and Taiwan; 1980 Taiwan and Japan; 1981–1982 Taiwan only.

| All4areas | | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total big eye | | 968 | 1,481 | 369 | 10 | 13,283 | 3,677 | 15,019 | 15,180 | 27,877 | 3,942 | 2,883 | 6,580 |
| | | (0.467) | (0.515) | (0.494) | (0.080) | (0.732) | (0.632) | (1.124) | (1.046) | (0.83) | (0.64) | (0.47) | (0.76) |
| Total yellowfin | | 2,518 | 3,439 | 634 | 55 | 10,904 | 5,108 | 12,060 | 20,660 | 25,160 | 2,470 | 3,199 | 2,186 |
| | | (1.214) | (1.197) | (0.849) | (0.447) | (0.600) | (0.878) | (0.902) | (1.416) | (0.81) | (0.40) | (0.53) | (0.25) |
| Total hooks | | 207,348 | 287,194 | 74,600 | 12,300 | 1,815,264 | 581,730 | 1,535,980 | 1,458,756 | 3,095,013 | 611,971 | 613,500 | 866,300 |
| Mean size (kg) | B.E. | 33.25 | 30.98 | 33.56 | 28.0 | 30.7 | 24.6 | 21.5 | 24.6 | 28.80 | 35.3 | 32.5 | 34.4 |
| | Y.F. | 24.92 | 30.62 | 29.77 | 29.1 | 29.1 | 29.4 | 32.2 | 31.12 | 31.12 | 31.0 | 31.0 | 33.6 |

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Appendix 1

## THE TUNA FISHERY IN THE EEZs OF INDIA, MALDIVES AND SRI LANKA

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*Senior Fishery Biologist*

### Introduction

The EEZs of India (western side), Maldives and Sri Lanka, have common boundaries and hence the sea area bounded by these three countries is devoid of any international waters. In the past, the small-scale fisheries of these countries exploited the tunas and bonitos in the coastal waters while the tunas in their oceanic provinces were exploited by other nations such as Japan, Korea Taiwan and also by the Soviet Union to a small degree. With the establishment of the EEZ, exploitation of tunas in this area by distant nations has been significantly reduced, perhaps to zero, because of the absence of international waters within this area and also because, at present, there are no joint tuna fishing ventures in this area.

Exploration and exploitation of the fishery resources in this area over the past three decades have shown that the tuna resources in this area consist of the yellowfin tuna *(T.a/bacares),* the big eye tuna *(T. obsesus),* the long-tail tuna *(T. tonggol),* the skipjack tuna *(K. pelamis),* the eastern little tuna *(E. affinis),* the frigate tuna *(A. thazard),* the bullet tuna *(A. rochei),* the dog-tooth tuna *(G. un/color)* and the oriental bonito *(Sarda orienta/is).* The last five species are generally considered to be insular and with localized migratory habit. The others, particularly the first two species, are known to be widely distributed not only in the area under consideration but also in other parts of the Indian ocean and the limits of distribution of the stocks of these oceanic species are not clearly understood yet.

The two oceanic species that are exploited by the three countries at present are the yellowfin (mainly immature fish) and the skipjack tunas. The distribution of skipjack and yellowfin tuna in this area extends from the oceanic to the peripheral range of the neritic provinces of the three countries and the exploitation by the three countries is primarily along the fringes of their distribution. In the case of the yellowfin tuna, the juveniles and immature fish enter the surface fishery in the insular ranges and the adults are deepswimming in the oceanic ranges where they generally contribute to the tuna longline fishery which is supposed to be non-existent in this area at present. In view of this situation, the present paper deals mainly with these two species.

As a result of the increasing trend in tuna production in the three countries, the ab3orption of the entire sea area enclosed by these countries into their respective EEZs and subsequent withdrawal from oceanic fishery by distant nations, India, Maldives and Sri Lanka alone are responsible for the rational utilization and management of the fishery resources within this area. Cooperation in the assessment of the resources and identification of any influence of the tuna fishery of one country on those of the other two may lead to the establishment of joint management of tuna resoruces within the area under consideration.

This paper is based on information available from past publications and it is anticipated that participants at the Working Group meeting will contribute supplementary information on the fishery and tuna resources obtained in recent years by the respective countries.

### Fishing methods and crafts

In all three countries, tuna fishery is on multispecies with multigears. In the Maldive islands, Minicoy islands of India and in Sri Lanka, effort is specifically directed on tuna varieties but off the mainland of India, incidental catches of tuna contribute significantly to production of these species at present.

**Table 1**
**Types of craft, fishing methods and tuna species caught**

| Country | Craft | Size & Characteristics | Operation | Gear | Tuna species caught |
|---|---|---|---|---|---|
| *MALDIVES* | Masdhoni | Mech. & Non-mech.<br>12 – 14 m LOA | 12 hr. day trip<br>Bait and tuna fishing | Liftnet for bait<br>Pole Er line for tuna | Skipjack, Yellowfin, Little tuna,<br>Frigate tuna |
| | Wadudhoni | Non-mech. – sail<br>8—10 m LOA | 12 hr. day trip<br>Tuna Er other fish | Trolling lines<br>Hand lines | Same as above |
| | Bokura | **Non-mech.** – rowing<br>2 – 5 m | 4 – 6 hrs. day trip<br>demersals & others | Handlines | Dog tooth Tuna |
| *INDIA* | Modern craft | Mach.<br>9.7 m – 14.5 m | Day boats | Gillrietting<br>Mesh 90—130mm | Little Tuna, Frigate Tuna,<br>Longtail Tuna |
| | Dugout canoes | Mech. & non-mech.<br>8.3 – 9.7 m | | | |
| | | Non-mech. 6 m | | Hand lines<br>Trolling | |
| | Purse seiners | Mech<br>14.5 m | For Mackerels, Tuna<br>incidental & sardines | Driftnet, Purse seine | Skipjack, Yellowfin, Little Tuna, |
| | 'Mas odi' | Mech. & non-mech.<br>7.9 – 12.5 m with<br>Bait tank | Day boats | Bait and pole Er line<br>Trolling | Frigate Tuna |
| | Kattumaram | Mech. – 7.9 – 9.1 m<br>10—10 hp | .. | Driftnet, Hook Er Line | Little Tuna |
| *SRI LANKA* | Modern craft | Mech.<br>28′ – 32′ LOA | Day & night op. 24 hrs. | Longline, Gillnet,<br>Pole Er Line, Trolling | Yellowfin, Big eye, Skipjack,<br>Little Tuna, Frigate Tuna |
| | Oru- Outrigger canoes | 7—12mLOA | | Pole Er Line, Trolling | |
| | Tuna longliners | 315 Gr. T * | 1-2 months duration<br>oceanic | 1. Longline | Yellowfin, Big eye Er Albacare |

* Now suspended,



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The characteristics of the crafts and methods used for catching tunas in the three countries are summarized in Table 1.

## Species composition and distribution

The tuna species contributing to the fisheries in the three countries are presented in Table 2. They do not exhibit the same order of abundance or relative levels of production because of the following reasons:

(a) differences in the selectivity of the primary tuna fishing gears used in the three countries

(b) differences in the combinations of tuna fishing methods in the respective countries, and

(c) differences in the environmental characteristics of the insular area, influencing the habitat of the different species and also the distance of the fishing grounds from the shore.

**Table** 2

**Percentage composition of the various tuna species caught by the three countries**

| Species | Maldives | India Mainland | India Laccadives | Sri Lanka |
|---|---|---|---|---|
| *T. albacares* | 16.6 | | 25.3 | 21.0 |
| *T. obsesus* | ? | ? | 1.5 | 1.0 |
| *T. tonggo/* | | 0.4 | | ± |
| *K. pelamis* | 71.5 | 11.0 | 72.5 | 37.0 |
| *E. affinis* | 4.3 | 65.4 | + | 26.0 |
| *A.thazard* | 7.5 | 6.7 | ± | 13.5 |
| *A.rochei* | | | | 1.5 |
| *Gun/color* | ++ | -F | ? | + |
| *S. oriental/s* | + | F | | + |

(?) Unknown (H-) caught but not in large quantities
(++) caught in significant quantities but no figures available

Around Maldives, skipjack and yellowfin tunas are the most abundant of the tuna species and are caught in all areas. However the production of yellowfin is more from the western side of the islands than the eastern side, while skipjack production shows the revese trend. The percentage of yellowfin is higher in the catches off the northern atolls and declines rapidly southwards but that of skipjack is higher at the southern end of the atolls and it declines less rapidly than that of yellowfin tuna towards the northern end (Table 3).

**Table 3**

**Percentage composition of tuna species in different areas around Maldives**

| Stratum | Skipjack | Yellowfin | Little tuna | Frigate tuna | Other fish |
|---|---|---|---|---|---|
| N. East – I | 63.0 | 9.0 | 1.0 | 21 | 6.0 |
| E. Central – II | 81.0 | 7.0 | 1.0 | 7.0 | 4.0 |
| S. East – III | 84.0 | 0.0 | 0.0 | 1.0 | 9.0 |
| N. West – IV | 47.0 | 28.0 | 1.0 | 1.0 | 9.0 |
| W. Central – V | 33 | 2.9 | 14.0 | 9.0 | 15.0 |
| S. West – VI | 91 | 4.0 | 0.0 | 3.0 | 2.0 |

Around Sri Lanka also, skipjack and yellowfin tunas are caught around the island except in the north. Catches around the western coastline had a higher percentage of skipjack and yellowfin than those in the south or east coasts. Again the percentage of yellowfin tuna tends to be higher in the north–west than in the south–west but the decline of the skipjack in the reverse direction is not very marked (Table 4).

**Table 4**

**Percentage composition of the tuna species caught in various areas around Sri Lanka, by two classes of driftnetters (Sivasubramaniam, 1970)**

| Coast | Yellowfin | | Skipjack | | Little tuna | | Frigate tuna | |
|---|---|---|---|---|---|---|---|---|
| | 11 G.T. Driftnet | 3.5 G.T. D.N. | 11 G.T. D.N. | 3.5G.T. D.N. | 11 G.T. D.N. | 3.5G.T. D.N. | 11 G.T. D.N. | 3.5 G.T. D.N. |
| N.N.W. | 26.3 | – | 47.2 | – | 26.2 | – | 0 | – |
| NW. | 64.0 | 56.3 | 31.4 | 62.1 | 3.3 | 0.8 | 1.1 | 0.2 |
| W | 23.6 | 19.5 | 65.9 | 62.7 | 8.2 | 15.4 | 2.1 | 2.2 |
| S.W. | 21.7 | 32.4 | 61.2 | 34.8 | 5.2 | 19.1 | 11.7 | 13.6 |
| S | 24.7 | 23.0 | 54.1 | 51.3 | 3.2 | 4.8 | 17.8 | 20.7 |
| E | 30.3 | 22.2 | 51.0 | 61.9 | 15.5 | 11.2 | 3.1 | 4.6 |
| N.E. | 32.3 | 30.1 | 34.0 | 40.9 | 13.5 | 17.0 | 19.8 | 12.4 |

The percentage of yellowfin tuna, in particular, seems to increase with increasing distance from shore. The influence of horizontal and vertical distribution of different tuna species on the catch composition is evident from Table 5.

**Table 5**

**Percentage composition of tuna species caught by various gears operated in different fishing ranges around Sri Lanka (Sivasubramaniam, 1970).**

| Gear | Fishing depth | Fishing ground | Big eye | Yellow-fin | Skipjack | Little tuna | Frigate tuna |
|---|---|---|---|---|---|---|---|
| Troll | (0—3 m) | | | | | | |
| | Surface | Inshore (<25 m) | 0 | 12.6 | 27.3 | 31.2 | 28.9 |
| Pole Er line | (0—2m) Surface | Inshore | 0 | 2.5 | 87.6 | 4.4 | 5.4 |
| | | Offshore (25—50 m) | 0 | 35.3 | 61.0 | 2.7 | 1.0 |
| Driftnet | (1.20m) | | | | | | |
| | Sub-surface | Inshore | 0 | 28.2 | 57.7 | 7.7 | 6.3 |
| Long-line | (75—125m) deep swimming | Inshore | 28.1 | 71.2 | 0.7 | 0 | 0 |
| | | Offshore | 31.0 | 68.1 | 1.0 | 0 | 0 |
| | | (750 m) | 36.7 | 62.9 | 0.4 | 0 | 0 |

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Even the total tuna components in the tuna longline catches show significant differences with increasing distance from shore.

| *Fishing area* | *Tunas* | *Bi/Ifishes* | *Sharks* |
|---|---|---|---|
| Inshore | 20% | 7% | |
| Offshore | 60% | 10% | 25% |
| Oceanic | 65% | | 20% |

The distribution of tunas in the surface waters of the oceanic ranges around Sri Lanka is not clearly established and exploratory pole and line fishery in this range, though not very encourga-ing, is not conclusive (Sivasubramaniam, 1974, 1975).

Off the mainland coast of India, the composition of tuna species caught is distinctly different from those of Maldive islands and Sri Lanka. The eastern little tuna and the long-tail tuna are the predominant species followed by the frigate tuna. Other species are comparatively negligible. According to available information (Silas *et al.* 1979, 1982), the predominance of long—tail tuna declines southwards while that of the little tuna increases, in the west coast catches. Even on the east coast, the little tuna is the predominant species in the southern part. Composition of the tuna species caught off the north-east coast is not available. Around Laccadive and Minicoy islands, the tuna catch composition is close to that of Maldive islands and the fishery is also similar. The tuna landings in the Andaman islands are negligible and consist mainly of little tuna and some yellowfin and big eye tuna.

**Table 6**

**Approximate species composition of tuna catches in India**
**(Based on Silas *et al.* 1979, 1982)**

| State | Big eye | Yellow-fin | Skip-jack | Little tuna | Long-tail | Frigate | Others |
|---|---|---|---|---|---|---|---|
| Maharashtra | — | — | — | 40 | 60 | | |
| Goa | — | — | — | ++ | ++ | | |
| Karnataka | — | — | — | 97.6 | — | — | + |
| Kerala | | + | + | 70 | + | H--F | |
| Tamil Nadu | | | | 59.7 | | 26.3 | ± |
| Av. for mainland | | | | 90 | 5% | 4 | 1 |
| Laccadives-Minicoy | 1.5 | 25.3 | 72.5 | | | | |
| Andaman islands | -F | H- | | | -F | | |

Latitudinally, the increase in the occurrence of long-tail tuna off the west coast of India and the general composition of tuna catches are similar to the observations along the Arabian coast on the western side of the Arabian sea (Sivasubramaniam, 1979). Exploratory tuna longline operations by “R. V. Varuna” also indicated the predominance of the long-tail tuna off the west coast of India.

### Catch, effort and catch rates

In the Maldive islands, catch is estimated by total enumeration of the number of each species caught. This has been practicable because the pole and line method is the primary fishing method and trolling is the secondary method in the country and their marine fishery is almost entirely concentrated on a few tuna species. The following conversion factors are applied for converting catch number to catch weight: small skipjack—2.12 kg, large skipjack—6.18 kg, yellowfin—2.12 kg, little tuna—0.95 kg, frigate tuna—0.95 kg. The effort is presented as the number of fishing trips made by both mechanized and non-mechanized pole and line craft. The relative efficiencies of the two types of crafts and the trolling crafts (non-mechanized) were observed to be as follows:

| | |
|---|---|
| mech. pole and line | 1 for skipjack and yellowfin |
| non-mech. pole and line | 0.23 for skipjack and 0.30 yellowfin (1980—82 data) |
| troll fishery pole and line | 0.01 for skipjack and 0.16 yellowfin (1980—82 data) |

Table 8 shows the annual change in the composition of various types of crafts:

**Table 8**

**Tuna fishing crafts in the Maldives (Ministry of Fisheries, Male, Maldives, 1983)**

| Year | Non-mech P Er L | Mech. P Er L | Sub-total | Troll | Total |
|---|---|---|---|---|---|
| 1970 | 1801 | | 1801 | 2710 | 4511 |
| 1971 | 2011 | | 2011 | 2893 | 4909 |
| 1972 | 2089 | | 2089 | 2936 | 5075 |
| 1973 | 2146 | | 2146 | 3012 | 5158 |
| 1974 | 2131 | 1 | 2132 | 3056 | 5188 |
| 1975 | 2074 | 42 | 2116 | 3154 | 5270 |
| 1976 | 2122 | 218 | 2340 | 3284 | 5624 |
| 1977 | 2085 | 413 | 2498 | 3383 | 5883 |
| 1978 | 1725 | 548 | 2273 | 3480 | 5753 |
| 1979 | 1574 | 767 | 2341 | 3546 | 5887 |
| 1980 | 1314 | 805 | 2119 | 3405 | 5524 |
| 1931 | 1061 | 970 | 2031 | 3364 | 5395 |
| 1982 | 952 | 1074 | 2026 | 3428 | 5454 |

The increase in the number of mechanized crafts has been compensated by the decrease in the number of non-mechanized crafts but because of the higher efficiency of mechanized crafts, the effectiveness of the effort applied has increased even though the total number of craft has not increased significantly.

The annual production of skipjack has fluctuated and a decline has been observed in recent years. Yellowfin tuna production has been fluctuating b3tween 4,000 and 5,000 tons during the last decade without clear evidence of any trend.

The production of skipjack is moderate in the north, low in the central part and high in the south of the country. Ye)lowfin shows a reverse trend. The catch rates of skipjack and yellowfin showed only slight variations but have shown a tendency to decline in recent years. The effort has been, and is continuing to be, low in areas of high catch rates and higher in the areas of moderate catch rates. Thus, the distribution of effort does not correspond to the catch rates in various strata.

**Table 7**

**Skipjack and yellowfin tuna catch, effort and catch rates**

(Source: IPTP Data Survey No. 1, 1983; Sivasubramaniam 1970, 1972; Ministry of Fisheries, Maldives)

| Country | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| India | — | | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 11648 | — | — |
| E. Little Tuna | | | | | | | | | | | | | | | | | | | | |
| *Skipjack* | | | | | | | | | | | | | | | | | | 1803 | | |
| Tunnies | | | | | | | | 6032 | 5760 | 5678 | 10839 | 11285 | 19322 | 13005 | 13893 | 26595 | 20371 | 170803 | | |
| Maldives | | | | | | | 27300 | 28900 | 16000 | 19385 | 22922 | 15103 | 19536 | 14006 | 13612 | 17670 | 23075 | 19957 | 19661 | 19491 |
| *Skipjack C* | | | | | | | | | | | | | | | | | | | | |
| Effort (P & L) | | | | | | | | | | 210278 | 203097 | 175859 | 172534 | 139944 | 108539 | 99468 | 85932 | 174526 | 106510 | 123511 |
| Mech. & non-mech. E | | | | | | | | | | | | | | | | | | | | |
| kg/boat/day C/E | | | | | | | | | | 91.2 | 109.1 | 83.8 | 111.2 | 103.3 | 137.4 | 288.3 | 236.9 | 211.3 | 151.0 | lR.8 |
| *Yellowfin* Catch | | | | | | | 2100 | 7300 | 5000 | 5569 | 3965 | 3787 | 4351 | 4123 | 3214 | 3692 | 3647 | 4740 | 3850 | 5984 |
| kg/boat/day | | | | | | | | | | 26.0 | 20.3 | 21.4 | 27.0 | 32.2 | 36.8 | 67.6 | 42.5 | 54.1 | 42.5 | 48.4 |
| Sri Lanka C | 1000 | 2500 | 3000 | 3700 | 6000 | 10000 | 11800 | 2500 | 13200 | 10400 | 12321 | 15243 | 12232 | 11339 | 10994 | 8309 | 12700 | 13758 | | |
| *Skipjack C/E* | *1000* | 11.6 | 13.3 | 16.4 | 25.0 | 45.5 | 53.4 | | | | | | | | | | | | | |
| | | 1700 | 1900 | 2400 | 4000 | 3000 | 4000 | 4700 | 6500 | 6100 | 6070 | 6611 | 6955 | 5720 | 5369 | 6166 | 6906 | 7662 | | |
| kg/boat/day | | 7.0 | 8.4 | 10.6 | 16.6 | 17.7 | 18.0 | | | | | | | | | | | | | |

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in Sri Lanka, production of both skipjack and yellowfin tunas has shown an increase but at a slow rate. The western side appears to be richer in yellowfin than the eastern side but on the western side the northern part produced higher catch rates which declined towards the south, as in the case of Maldives. Skipjack tuna catch rates were higher from the southern part of the west coast to the south coast (Table 9). The catch rates of skipjack and yellowfin tuna around Sri Lanka are much less than those of the Maldive islands, even if their pole and line fisheries alone are compared.

**Table 9**

**Mean catch rates *(lbs.)* of skipjack tuna around Sri Lanka for various classes of crafts and gear (1967—71) (Sivasubramaniam 1972)**

| Fishery | NNW | NW | W | SW | S | E | Er NE | Efficiency factor |
|---|---|---|---|---|---|---|---|---|
| 11 Gr.T. Driftnet | 6.7 | 154.8 | 311.6 | 280.9 | 254.3 | 132.7 | 30.0 | 2.36 |
| 3.5 Gr.T. Driftnet | — | 58.9 | 143.4 | 89.0 | 115.7 | 69.8 | * | 1 |
| 3.5 Gr.T. P Er L | — | — | * | 178.6 | 176.5 | 105.0 | — | 1.73 |
| 3.5 Gr.T. Troll | * | * | 17.6 | 27.3 | 22.8 | 13.9 | * | 0.20 |
| Outrigger P Er L | — | — | 92.3 | 140.4 | 127.6 | 87.7 | — | 1.14 |

(—)No fishery (*) insufficient samples

The tuna landings in India were 3015 ton in 1970, 19,332 ton in 1976, 13,005 ton in 1977, 13,745 ton in 1978 and a record 26,595 ton in 1979. Information on production by species is not available but skipjack and yellowfin are primarily caught around Laccadive-Minicoy islands where tuna production increased from 500 ton in 1970 to about 2,000 ton in 1975 and declined to 1,000 ton in 1978. A catch of 1,803 ton of skipjack has been recorded for 1979. Catch rates for skipjack and yellowfin tuna off Indian coasts are not available for comparison.

Surface fishery for tunas does not extend beyond 25—30 miles from the shore in any of the three countries. Surveys from Sri Lanka showed that the pole and line fishery can be successful mainly within 60 miles. Even within this limit, the catch rates for pole and line fishery declined towards the outer boundary. However, these results were not conclusive because of various limitations in the survey3. The catch rates realized in the offshore range were 180 kg/day at sea, 682 kg/pole and line fishing day and 1395 kg/effective pole and line fishing day. The best average catch was in the south-west for both skipjack and yeltowfin tunas, followed by areas off the west, south and east coasts of Sri Lanka (Sivasubramaniam, 1975 and 1977). Analyses of incidental catches of skipjack by tuna longline fishery showed that this species is widely distributed in the area under discussion and the relative density appears to **be** greater in the oceanic ranges west of Sri Lanka than in the eastern side (Sivasubramaniam, 1972) (Fig. 1). This trend supports the hypothesis that the skipjack tuna caught by the three nations may be from a common stock or from intermingling stocks. Though there is unofficial evidence of foreign vessels fishing for oceanic surface tunas in this area, no records of the catches are available.

It is estimated that over 2,500 ton of tunas were taken by foreign longliners operating within the area under consideration in the late 1970s. The distribution pattern of the catch rates of yellowfiri and big eye tuna within the area, based on catch rates realized by Japanese and Sri Lankan tuna longliners operating in the area between 1966 and 1970 is shown in Fig. 2. Legally the effort on the production of larger tunas in this area should be zero at present, as none of the three nations with rights to the exploitation of this area, have an offshore or oceanic longline fishery. Analyses of more recent data are not readily available for consideration. Latitudinally, hooked rates of both yellowfin and big eye tuna are equally high near the equator and that of big eye tuna tends to decline towards higher latitudes. Yellowfin tuna shows higher hooked rate in the higher latitudes on the eastern side of Sri Lanka. There is evidence of improvement in the hooked rate of yellowfin tuna in the higher latitudinal areas but not so in the areas near the equator, until 1970. Recent exploratory tuna longline operations conducted by India and Sri Lanka also tend to show good catch rates in the higher latitudinal locations within the area (Anonymous 1983).

### Seasonal variations

There is some similarity in the peak seasons for skipjack and yellowfin tuna catch rates around. Maldives, Minicoy and Sri Lanka (Table 10).

**Table 10**

**Peak seasons for skipjack and yellowfin tuna**

| Area | Gear | Peak seasons | |
|---|---|---|---|
| | | Skipjack | Yellowfin |
| Maldives | Pole Er line | May—July Er Sept.—Feb. | August—December |
| Sri Lanka | Driftnet | Jan. Er May—October | July—Aug. Er Oct.—Feb. |
| | Pole Er line | Sept.—March | February—March |
| | Troll | June to August | June to August |
| India (Minicoy) | Pole Er line | Sept.—December | |
| Calicut | Driftnet | | November |

There is some degree of annual shift in the peak seasons. Off Sri Lanka, there are some differences in the peak seasons according to the geographic location of the fishing area. In the south, skipjack tuna shows a peak for driftnet fishing in January and another in May which declines gradually until August; in the south-west coast, it is January and August. It is September on the west, October in the north and August on the eastern side. The yellowfin peak season beginning with the south-west monsoon shifts from east to south, south-west, west and then to the north-west (Sivasubramaniam, 1970, 1971 Er 1972). During the pole and line fishery survey from December 1973 to March 1975, 32.5% of the total tuna catch was made in November alone. The survey vessel averaged one tonne/day during the peak seasons and caught more than two tonne/day off the south-west and west coasts during February—March and November and April, respectively.

Longline catches of both yellowfin and big eye tunas in the inshore waters were high during the north-east monsoon and the inter-monsoon period following it. In the oceanic province too, catch rates were higher during the first quarter and the first half of the second quarter. Close to the equator, the catch rates declined rapidly during the second quarter (Sivasubramaniam, 1971).

The reasons for seasonal variations in the availability of tuna and in the schooling behaviour are not fully understood. However, environmental factors such as temperature may be contributing to this phenomenon (Fig. 3).

### Length composition

Around Sri Lanka, the size range of the exploited population of the skipjack tuna is 30—78 cm and graphical separation of polymodal length frequency distribution, using probability paper, revealed five modes—34.2, 43.0,52.4,63 and 71.5cm (Fig. 4). The first modal group occurs commonly in the south-west and east coasts; second, fourth and fifth modal groups in all areas, but predominantly in the north-west and east and the third group which is the most significant mode, was predominant in the west, south-west and south coasts. Since the introduction of driftnetting, significant quantities of the fourth and fifth modal groups enter the catches. The selectivity of driftnets, in contrast to the polo and line method, is evident from Fig. 5. In the oceanic province, the skipjack caught with tuna longline were found to be of the fourth and fifth modal groups, with very few fish of the third modal group (Fig. 6).

Length frequency distribution in the catches by various gears show that the driftnet is very selective but the popular use of multiple mesh sizes in each set of nets permits the sampling of a wide size range of the population.

In the Maldive islands, length frequency sampling was initiated with the training conducted there in 1983 and only a few months of sampling have been conducted so far. According to the available data (June—September 1983) from one area, the size of skipjack caught ranges from 25–71cm with polymodal distribution (Fig. 7). The peak modal lengths were smallerthan those from Sri Lankan waters for the corresponding months but in different years.

Length frequency distributions are not available for the Indian waters but bar charts available indicate that the size range of skipjack caught is 32—70 cm with modes between 40 and 50 cm occurring almost throughout the year and additional modes between 60 and 70 cm only from January to April (Jones and Silas, 1963). This trend, to a certain degree, resembles the pattern observed around Sri Lanka.

Yellowfin tuna caught around Sri Lanka range from 20 to 145 cm. Heavy entry of <50cm group (0 gp) is found in the south-west and east coasts. The entry in the south-west is generally high accounting for nearly 35% of the total catch from that area. The 50–100 cm group (gp I) contributes 60—95% to the total production of yellowfin by Sri Lanka (Fig. 8). The main size ranges were 50—55 cm in the south-west, 55—60 cm in the south and east, 65—70 cm in the west and 70–75 cm off the north-west coasts. The shift in size range and catch rates indicate probable entry of the 0 group into the south-west area. In the insular longline fishery, yellowfin are of 125—135cm group (gp III) and 140—1 50 cm group (gp IV) with a relatively small proportion of the 100–120 cm group (gp II). Considering that recruitment to the surface fishery is around June, the length frequency of oceanic samples for this period indicated entry of group II fish into longline catches. The occurrence of group II and III fish in the surface and longline fisheries exhibit their distribution throughout the vertical column of the mixed layer. The 0 and I groups remain in the insular surface fishery at least for one year during which period they tend to shift northwards and on becoming group II size range, they commence to spread into the deep-swimming layer. This process is accomplished by the time they reach the end of the group III size range and they are available to the longline fishery (Fig. 9).

Limited length frequency data on yellowfin tuna available from the Maldive islands fishery showed that the size range caught by pole and line method is similar to that of the skipjack tuna. Only one distinct peak was observed at 39—41 cm in June and 40—42 cm in August, but the size range was 20–55 cm during June to September (Fig. 10). Occasional landings of yellowfin over 100 cm were also observed in the first quarter of 1983. Very little information is available on the yellowfin tuna around India, based on which the size range of this species caught in the southwest coast of India is 63—78 cm (Silas *et al.*, 1979). It is noted that this size range is in keeping with the larger size entering the surface fishery on the north-west coast of Sri Lanka. An increase within the same size range was also observed from April to September.

### Length-weight relationships

Regressions available for the two species from the area under consideration are given below:

| Source | Locality | Size range | Log *a* or a | Log b or b | Weight unit | Length unit | Calculated weight at 55cm |
|---|---|---|---|---|---|---|---|
| *(a) Skipjack* | | | | | | | |
| Sivasubramaniam (1966) | (East Er West) Sri Lanka | 20–70 cm | –3.0250 | 2.8977 | oz | cm | 3.0 kg |
| Anonymous (1983) | Maldives | 30—70cm | $9.62539 \times 10^{-6}$ | 3.2050 | g | cm | 3.5kg |
| Joseph et al. (1983) | West coast of Sri Lanka | | 0.006 | 3.3 | kg | cm | 3.3 kg |
| *(b) Yellowfin* | | | | | | | |
| Sivasubramaniam (1956) | (East Er West) Sri Lanka | 25—110 cm | —3.0403 | 2.8992 | oz | cm | |
| Anonymous (1983) | Maldives | 30—70cm | 8.3249x106 | 3.2304 | g | cm | |
| Joseph *et al.* (1983) | West coast of Sri Lanka | | 0.041 | 2.8 | kg | cm | |

Calculated weight of a 55 cm skipjack varied between 3.00 and 3.50 kg for the regressions. The units used in the three cases were not identical, besides other differences. Similar calculations based on various regressions for the skipjack in the Pacific Ocean, varied between 3.33 and **3.58 kg.**

### Maturity and spawning

Raju (1963) estimated that the skipjack tuna around Minicoy reach sexual maturity around 40—45 cm and the smallest mature female recorded from this area was 39.6 cm. Around Sri Lanka, skipjack tuna of 45—50 cm are generally mature and a large quantity of this size range entering the pole and line fishery in the south coast were spent females (Sivasubramaniarn 1965 and 1972). Mimura (1962) stated that yellowfin of 0-age are immature, some individuals at 1-age show sexual maturity. Generally, yellowfin smaller than 70 cm have been considered to be in the non-spawning condition. However, studies have shown that yellowfin in coastal waters attain sexual maturity at about 50 cm whereas fish captured by longline in the oceanic province mature at about 110 cm. More recent studies by Japanese researchers indicate that spawning potential of fish smaller than 110 cm in the oceanic province may have been under-estimated (Yesaki 1983). Maturity studies of yellowfin tuna in the specific area under considera-tion are yet to be undertaken.

Off the southwest coast of Sri Lanka, spent female skipjacks were observed around January indicating that spawning may be around that period. Near Minicoy, skipjack with mature ovaries have been observed during November—July and with spent ovaries in June—August. Eggs, larvae and juveniles of skipjack have been observed in the Indian waters from January—April and possible spawning from January to April and June to September has been suggested (Raju 1963). The possibility of multiple spawning has also been indicated by the same author. This is supported by the occurrence of more than a single entry of small fish into the fishery, as evident from the length frequency distribution. This point is also supported by evidence on recruitment pattern, to be discussed later in this paper.



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However it is not clear whether the spawning of skipjack is restricted or widely spread over the area under consideration. Skipjack larvae have been collected from waters close to all these countries (Jones and Silas, 1963). Spawning of yellowfin takes place during February to April in the Laccadive sea as evidenced by the capture of larvae from the sea. Though spawning in the tropical part of Indian Ocean is supposed to occur during October to April, capture of mature fish in the northern and western parts of the Indian ocean has been used to indicate spawning during January to May (Jones and Kumaran, 1963). Yellowfin larvae have been found to be widely distributed in the equatorial belt and with concentrations in the central equatorial region. It is conjectured that spawning in this vicinity may be contributing to the recruitment to the fishery around Sri Lanka and Maldives. Juvenile yellowfin entering Sri Lankan waters each year would have been spawned during the first or second quarter of the previous year. Recruitment to Maldives fishery as in the case of Sri Lankan fishery, appears to be greater along the western side of the country.

Raju (1953) determined the regression for fecundity on length of skipjack tuna around Minicoy as Y =2.713 X-100494. No similar estimate is available for yellowlin in the Indian Ocean region but June (1953) devised the regression Y==125,000 X-2853000 (X is the weight of fish and Y the number of maturing ova) for the yellowfin in the Pacific Ocean.

**Schooling behaviour**

Though different size ranges of these two species have been found to occur in an area, each school tends to be made up of fish mainly of one size group and more than one species may occur in a schoo!. As a result, the species and the size compositions of the catch by one boat can be different from those of another boat operating from the same port and on the same day. Schooling behaviour also changes seasonally and hence the number of surface schools of tunas sighted varies significantly with seasons. During the pole and line fishery survey in 1974—75 around Sri Lanka, it was observed that the average number of schools sighted per day was 1.4 and the maximum was six schools/day. The catch/school seldom exceeded two ton and the mean value was 798 kg/school. Except for two occasions when 10 ton/day was obtained the catch/day varied under four ton and the mean value was 682 kg/fishing day. This indicated that the school sizes are generally small and remain the same throughout the year except for a slightly higher concentration during the second peak season in the south-west. The number of schools sighted per day declined to almost zero during the south-west monsoon season and increased to an average of two schools/day between February and April.

Around Maldives, the number of schools sighted per day may be slightly higher but even there sightings become extremely poor periodically. Such periods differ from area to area around the country. Around Laccadives, it has been reported that two or more schools may be sighted half a km apart but it is not clear whether this behaviour is generally prevalent throughout the year and in the entire fishing range.

During experimental pole and line fishery around Sri Lanka, 25% of the attempts resulted in no biting response to chumming. There was a mean interval of two days between fishing attempts and 3.2 days between successful attempts. These intervals were larger during June to September. During peak seasons, response to chumming is good and hence relatively less live bait is used. The average bait to tuna catch ratio was 1: 5.9 but in January to March and in November, the rates improved to 1:16. During seasons when surface school formation is reduced the fish appear to be either sparsely scattered close to the surface or concentrated in the sub-surface layer. At such times they contribute to the troll fishery or driftnet fishery. This has been shown in the section dealing with seasonal variations and has also been confirmed by aerial survey (Sivasubramaniam, 1971, 1975 Er 1977).

Fish aggregating devices have been successfully applied to aggregate skipjack and yellowfin tunas in the Pacific and were attempted in the Ma!dives and Sri Lanka. The Maldives claimed that the results were good but, due to lack of proper monitoring, it is not possible to evaluate the effectiveness of the device. In Sri Lanka, the results were not encouraging; perhaps the experimental period was too short. Even off the west coast of Thailand, experiments with FAD were not successful. Aggregating devices are presumably being used with success around Seychelles but details are not available. Behavioural characteristics of the same species appear to differ with location and environmental factors. Evidence shows that fewer schools are met with beyond 40/50 miles from Sri Lanka shores but incidental catches of skipjack by tuna longline indicates the presence of this fish even in the oceanic province.

### Age and growth parameters

Relatively less information on these parameters is available for skipjack and yellowfin tunas in the Indian Ocean than in the other two oceans. Parameters K and $L_\infty$ of the Von Bertanlaffy equation computed according to the procedure developed by Pauly and David (1980), using available length frequency data, are presented in Table 11 which also includes information from other areas in the region.

The drift gillnet is the main type of gear used in the tuna fishery in Sri Lanka and hence length compositions derived from the data obtained during the pole and line survey in 1974—75 were used to avoid influence of selectivity in the former fishing method. In the case of yellowfin tuna only the juveniles and young fish enter the surface fishery. Therefore, the best fit of the growth curve was obtained for the length frequency distribution of this fish with protracted and seeded value of $L_\infty$ based on maximum size observed (Figs. 14 and 15). The original data were not available and hence the length frequency data were read off Sivasubramaniam (1977).

Length frequency data are available from the skipjack and yellowfin tuna fishery in the Maldives for only four months, and hardly any modal progression is evident from these samples. Hence, a reasonably good growth curve could not be fitted at this stage. Even in the case of skipjack tuna caught around Minicoy islands, the percentage length frequency distribution (Tables 2 and 3 presented in Raju's paper (1963)) exhibited very poor modal progression over a one-year period. This contributed to the unimodal distribution pattern of the size range in the fishery, as described by the author. Good fit for the growth curve could not be achieved without attributing a very low value for K and a high value for $L_\infty$.

### Mortality and selection pattern

$L_\infty$, K estimates and length frequency data were used with ELEFAN II programme prepared by Pauly (1982) and Pauly *eta!* (1981), which constructs a length converted catch curve, a selection curve and the recruitment pattern and derives an estimate of the natural mortality rate (M) on the basis of Pauly's equation (1980).

$$\mathrm{Log}_{10} M = 0.0066 - 0.279 \mathrm{Log}_{10} L_\infty + 0.6543 \mathrm{Log}_{10} K + 0.4634 \mathrm{Log}_{10} T$$

(where T is the mean environmental temperature in °C).

The length converted catch curve obtained with the skipjack tuna data was reasonably straight and indicated a total mortality rate (Z) of 1.88 (Fig. 11-A). Using the estimated M value of 0.87 (T °C=28.5)the fishing mortality (F) was found to be 1.01. The exploitation rate (E=F/Z) was 0.54 which exhibits a rather optimal level of exploitation of the stock.

The selection pattern (Fig. 11-B) indicates that the mean length at first capture is 47.26 cm which corresponds to a reasonably large fraction of $L_\infty$. The recruitment pattern (Fig. 11-C) suggests that skipjack tuna in the area are recruited at least twice a year, with one recruitment being very much stronger than the other.

The same exercise with data on yellowfin tuna entering the surface fishery around Sri Lanka, gave the following values: Z==2.68, M==0.7, F=1.99, E=0.74. The rate of exploitation in this case is indicated as high and the recruitment pattern exhibits at least two recruitments with different pulses, as in the case of skipjack tuna (Fig. 12). In view of the various limitations mentioned earlier, the results are to be viewed cautiously.

The application of the ELEFAN programmes has been attempted to consider the possibility of using this methodology for fish population studies in this region where reliable data are not available for traditional methods of analyses.

### Potential yields

**The two tuna species under** consideration have a widespread distribution in the Indian Ocean and there is no knowledge available on the separation of these stocks according to geographical

**Table 11**

**Growth parameter and age in years estimated for skipjack and yellowfin tuna in the Indian Ocean**

| Source | Locality | Age in years 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | $t_0$ | K | $L_\infty$ | Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SKIPJACK | | | | | | | | | | | | | | |
| Shabotinets (1968) | Indian Ocean | | | | | 40—<br>45 | 40—<br>60 | | | | | | | First dorsal spine |
| Yesaki (1981) | West Coast Thailand | | | | | | | | | | 0 | 0.0420 | 75 | Length frequency |
| Sivasubramaniam **(1983)** | Sri Lanka | <27 | 34 | 43 | 52 | 83 | 71 | | | | 0 | 0.52 | 77 | Length frequency |
| YELLOWFIN | | | | | | | | | | | | | | |
| Shabotinets (1983) | Indian Ocean | | | | | 75—<br>**90** | 80—<br>**100** | | | | | | | |
| Yesaki (1983) | Indonesia | 48<br>46 | 82<br>79 | 107<br>104 | 122<br>123 | 138<br>136 | 148<br>146 | | 155<br>154 | 164<br>159 | 0 | 0.3—<br>0.32 | 173<br>175 | Length frequency |
| Sivasubramaniam (1983) | Sri Lanka | 50 | 90 | 110 | | | | | | | 0 | 0.50 | 174 | Length frequency |



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areas. As such, potential yields must be cautiously estimated for any small part of the whole ocean regime. Potential yields for skipjack and yellowfin tuna from the whole Indian Ocean, has been estimated to be 200,000—300,000 tonne (Kawasaki, 1972) and 39,000 tonne (Lee and Yang, 1983), respectively.

Reliable and required data are not available in the three countries concerned for a proper estimation of the potential yields. In the case of Maldive islands, some form of catch and effort (number of trips by mechanized and non-mechanized pole and line craft) data are available for a number of years. These data were analysed as part of a training course conducted in that country in 1983 (TCP/MDV/2202), to estimate the MSY. The results obtained were as follows:

| | *MSY skipjack* | *Optimum effort* (No. of trips) |
|---|---|---|
| Schaefer model | 19,261 | 113,966 |
| Fox's model | 18,035 | 114,086 |

The tuna catch rates around Maldives have shown a declining trend in recent years and considering the present level of production of the main tuna species (skipjack) *vis-a-vis* the MSY, it appears that a significant increase in the production mdy not be achieved within the presently exploited range. The fishery may have to be extended beyond the presently exploited range and the economic viability of such an expansion has to be investigated. Maldives is exploiting only that component of the stocks which lies within a very small part of its EEZ.

The present status of the tuna fishery in Sri Lanka indicates an increasing trend in production but there are indications that the catch rates may be declining. There have been changes in the combination of tuna fishery methods but changes in the overall effort on tunas are not known. The exploitation rates obtained in the previous section also tend to show that expansion of the fishery within the presently exploited range may not be rational and increase in the fishing intensity within this range, even during peak seasons, may not result in very significant improvements. Again, expansion into the offshore and oceanic ranges within the EEZ has to be considered but results of experimental fishing by FAO (1977) and Nichiro Fishing Company (1975) should be studied carefully.

Sivasubramaniam (1977) made crude estimates of the potential in the offshore and oceanic ranges of the EEZ around Sri Lanka as follows:

| | | |
|---|---|---|
| Skipjack | — | 15,000 t |
| Yellowfin | — | 3,000 t |

In view of the withdrawal of the longline fishery by distant nations, the potential for the exploitation of yellowfin may perhaps be higher than the value given. However, the economics of the fishing operation should receive primary consideration, in view of the catch rates that can be obtained.

Dwivedi and Devaraj (1983) estimated a tuna biomass of 6,000 t and an MSY of 3,000 tin the EEZ of India. This was based on the proportion of the 220,000 t tuna biomass in the Indian Ocean that is expected to be distributed within the EEZ of India (2.8%). George *et al.* (1977) have estimated the following potential exploitable yields for all tuna species within the EEZ around India:

| | |
|---|---|
| North-west coast (Gujarat and Maharashtra) | 10,000 ton |
| South-west coast (Goa, Karnataka and Kerala) | 60,000 ton |
| Lower east coast (Tamil Nadu and Andhra) | 10,000 ton |
| Upper east coast (Orissa, W. Bengal) | 10,000 ton |
| Laccadive islands | 50,000 ton |
| Andaman islands and Nicobar | 100,000 ton |
| | 240,000 ton |

(*Source:* Silas *et al*, 1982)

Unfortunately, the original source of these estimates was not accessible and hence the method of estimation is unknown to the present author. However, there is significant discrepancy in the potential estimated by the two groups mentioned above. Indirect approaches to estimation of potential yields have to be viewed very cautiously. It is understood that India conducts sampling for catch, effort and length frequency for tuna but such data have not been published. If such data are available then some direct estimation can be attempted.

### Suggestions for consideration by the Working Group

1. All available data on tuna catch, effort applied and length composition should be compiled by the respective countries.
2. Tuna biologists in the respective countries to present results of recent research/investigations conducted on tunas and their fisheries, to update the information in this Working Paper and enhance the value of the deliberations at the Working Group meeting.
3. Information on size, characteristics and operation of various crafts and gears used for tuna fishing, to be compiled and discussed at the Working Group Meeting.
4. Intensified systematic/random sampling for length compositions of tunas caught is necessary for length-based approach to fish population studies.
5. Morphometric and meristic characters may be examined for comparison between areas.
6. Sampling programmes should be standardized for compatibility of data from the three countries.
7. Selectivity of the gears used and relative efficiencies of different classes of vessels should be determined.
8. **Special** sampling programmes should be established for collecting information on spawning seasons and areas. A standardized methodology for determining maturity stages, to avoid discrepancies arising from different approaches.
9. Sampling programme for estimates of catch and effort, catch rates, independent of the routine sampling programme of the statistical division/units.
10. Exploratory fishing should be undertaken in the ranges beyond the presently exploited range. Use of gillnets, for catching tunas in the offshore and oceanic ranges, may be experimented with.

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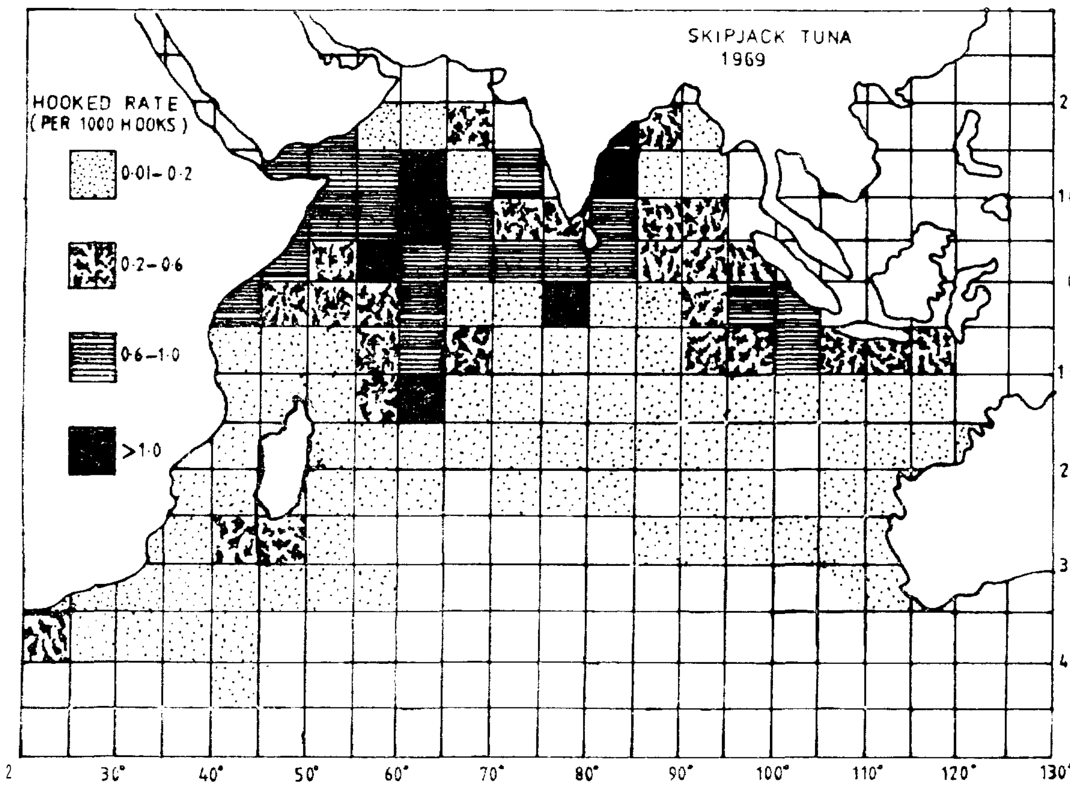


Fig. 1. Hooked rate of skipjack tuna on tuna long//ne (Sivasubramaniam 1972).

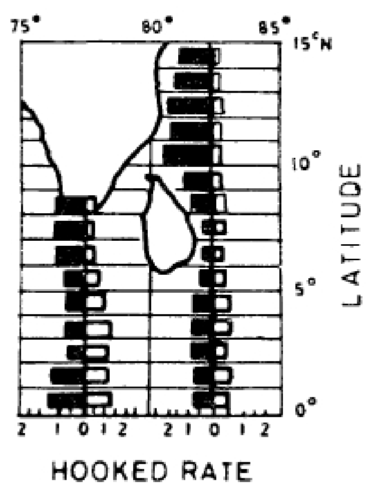


Fig. 2. Hooked rates for ye//owl/n tuna (shaded Portion) and big eye tuna in the oceanic range (Sivasubraman/am 1971).



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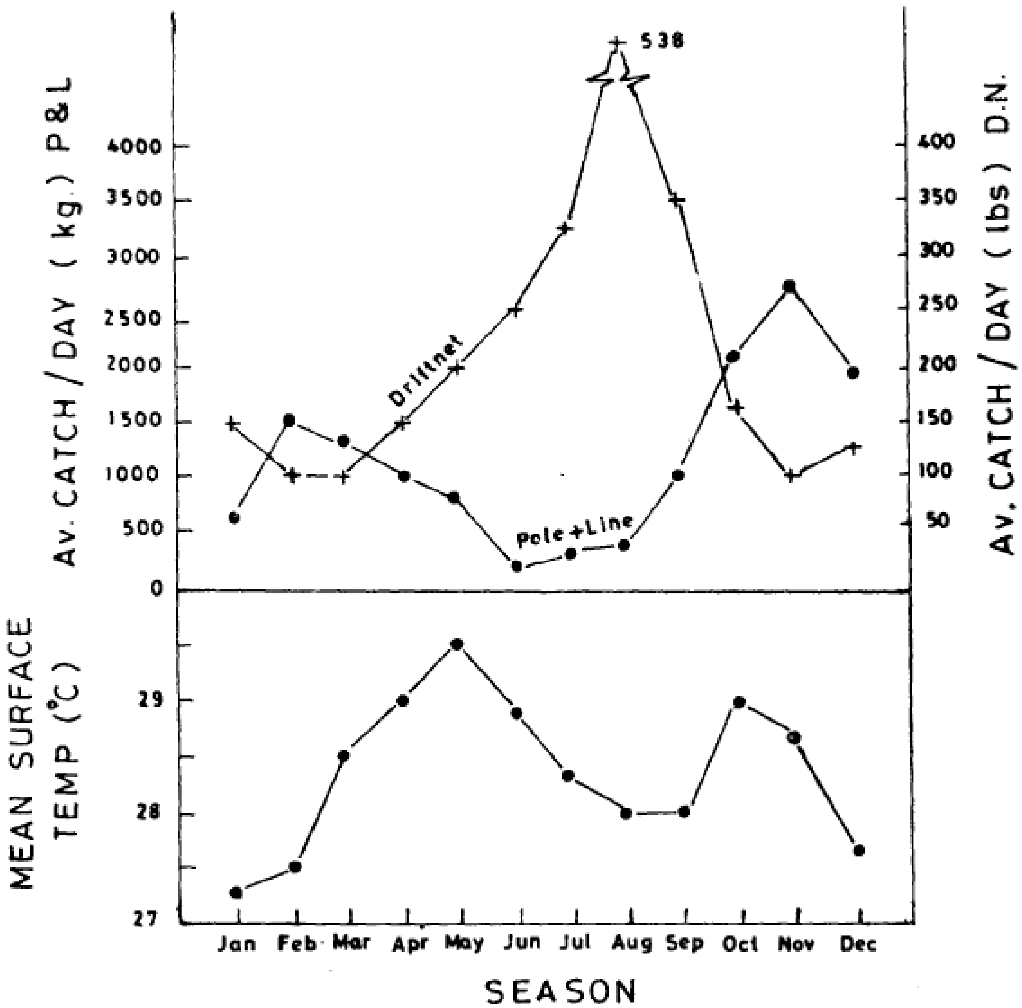


*Fig. 3. Comparisons of seasonal variation in the catch rates realised by pole and line fishery and 11-ton class driftnet fishery (Sivasubramanlam 1975).*

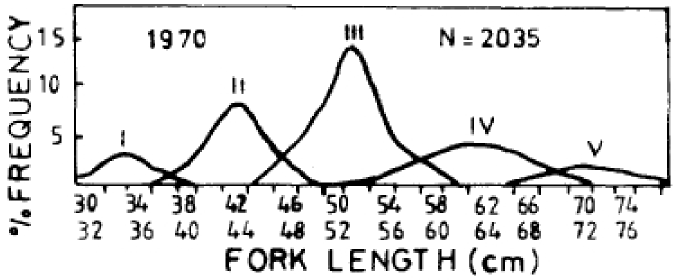


*Fig. 4. Graphical analysis of polymodal distribution of length frequency of skipjack around Sri Lanka (Sivasubramaniam 1976).*

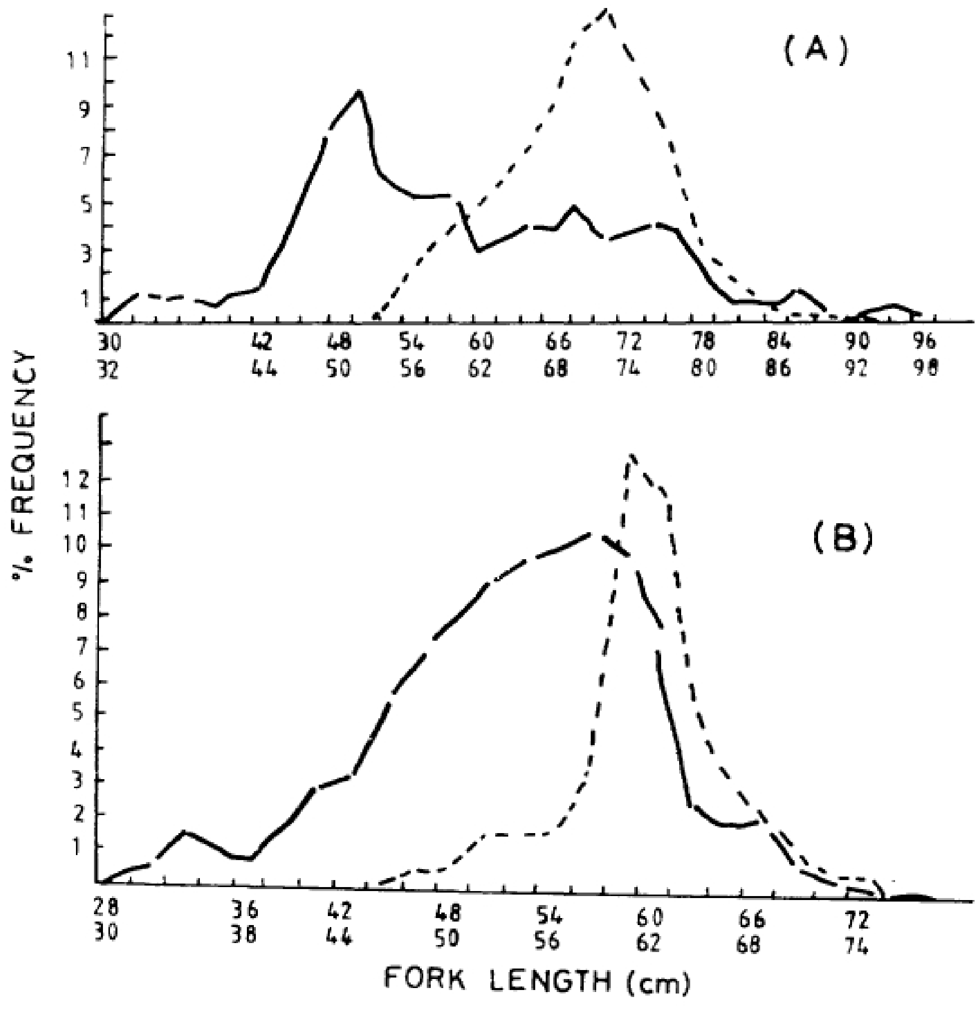


*Fig. b. Length frequency distribution of yellowfin (A) and skipjack (B) tuna caught by pole and line and 7" mesh dr/knot (Broken lines) around $ri Lanka, 1974—75 (Sivasubramanlam 1977).*

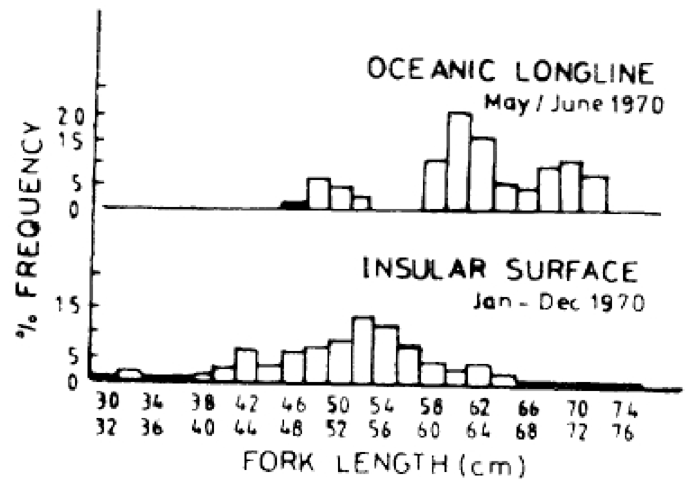


*Fig. 6. Size composition of skipjack in the insular surface and deepswimming oceanic ranges west of Sri Lanka (Sivasubramaniam 1972).*

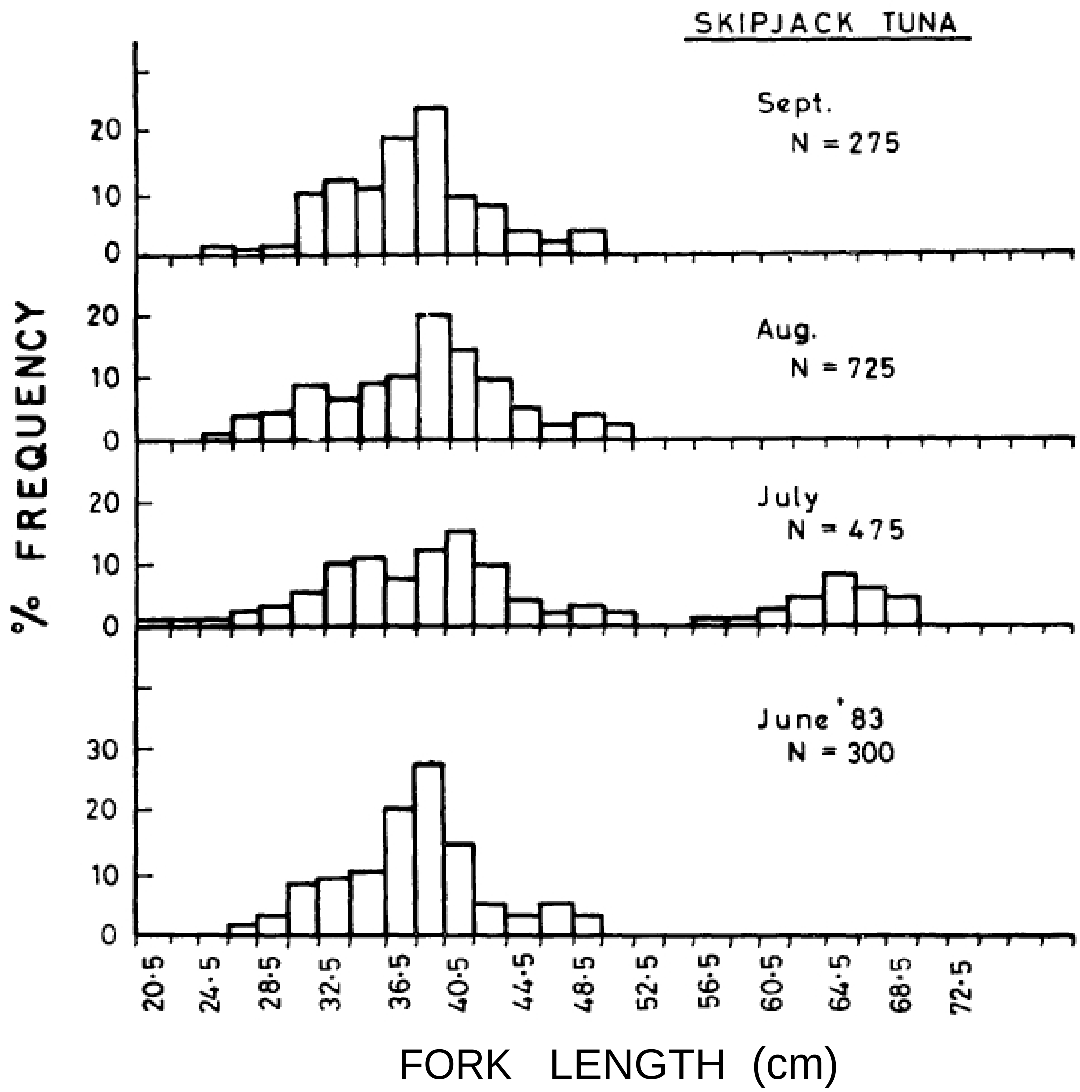


*Fig. 7. Length frequency distribution of skipjack tuna around Ma/dive islands — pole and line catch, 1983.*

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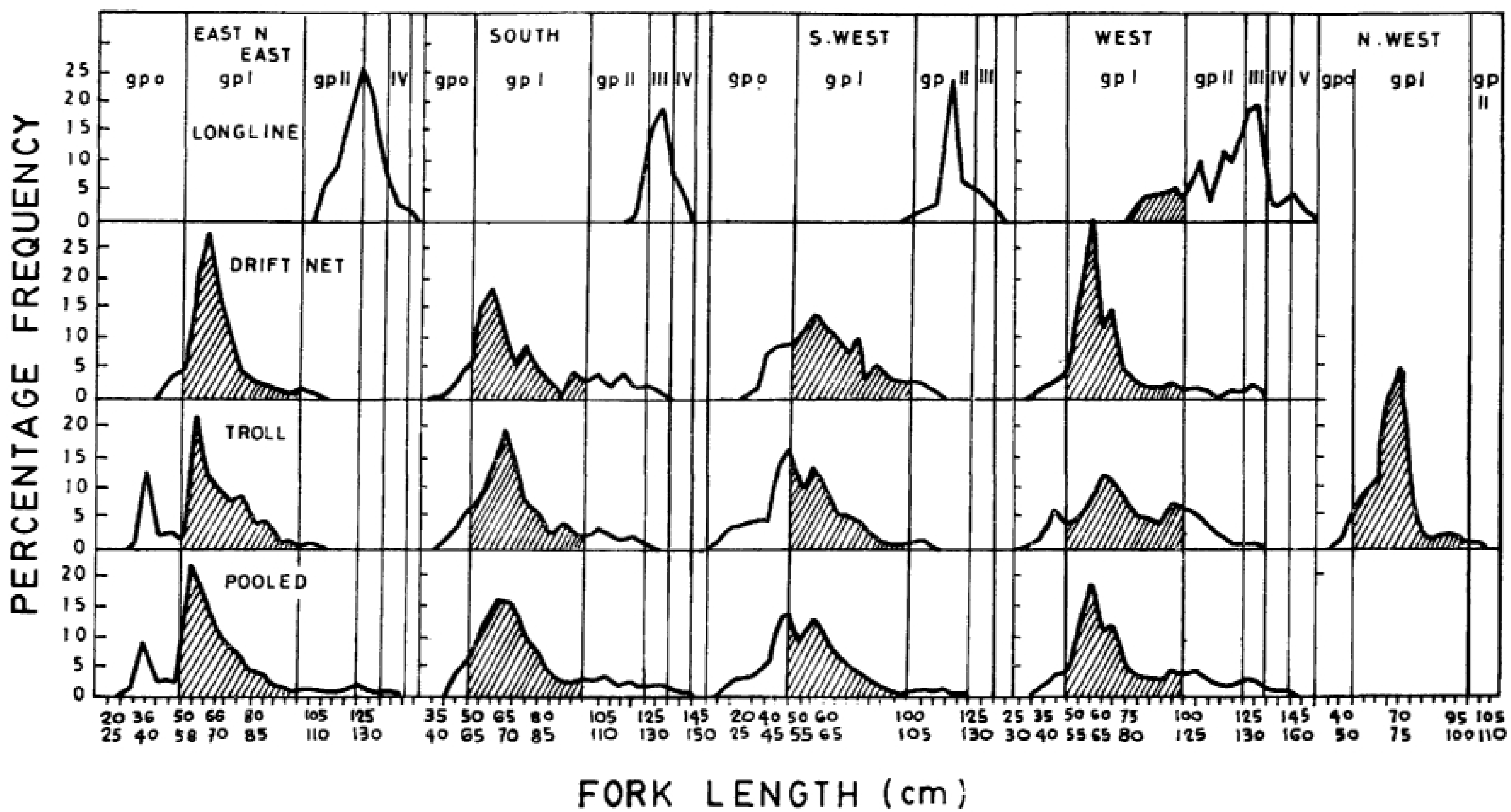


*Fig. 8. Length frequency distribution by area and gear around Sri Lanka, 1969—70 (Sivasubramaniam 1970).*



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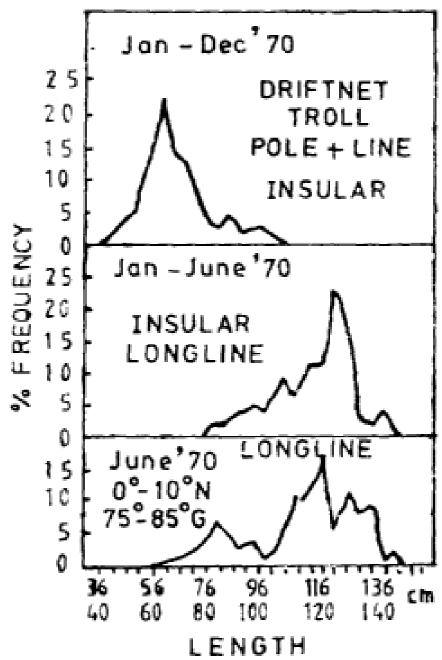


*Fig. 9. Length frequency distribution of yellowi/n tuna in the surface and deep swimming layers around Sri Lanka (Sivasubramaniam 7971).*



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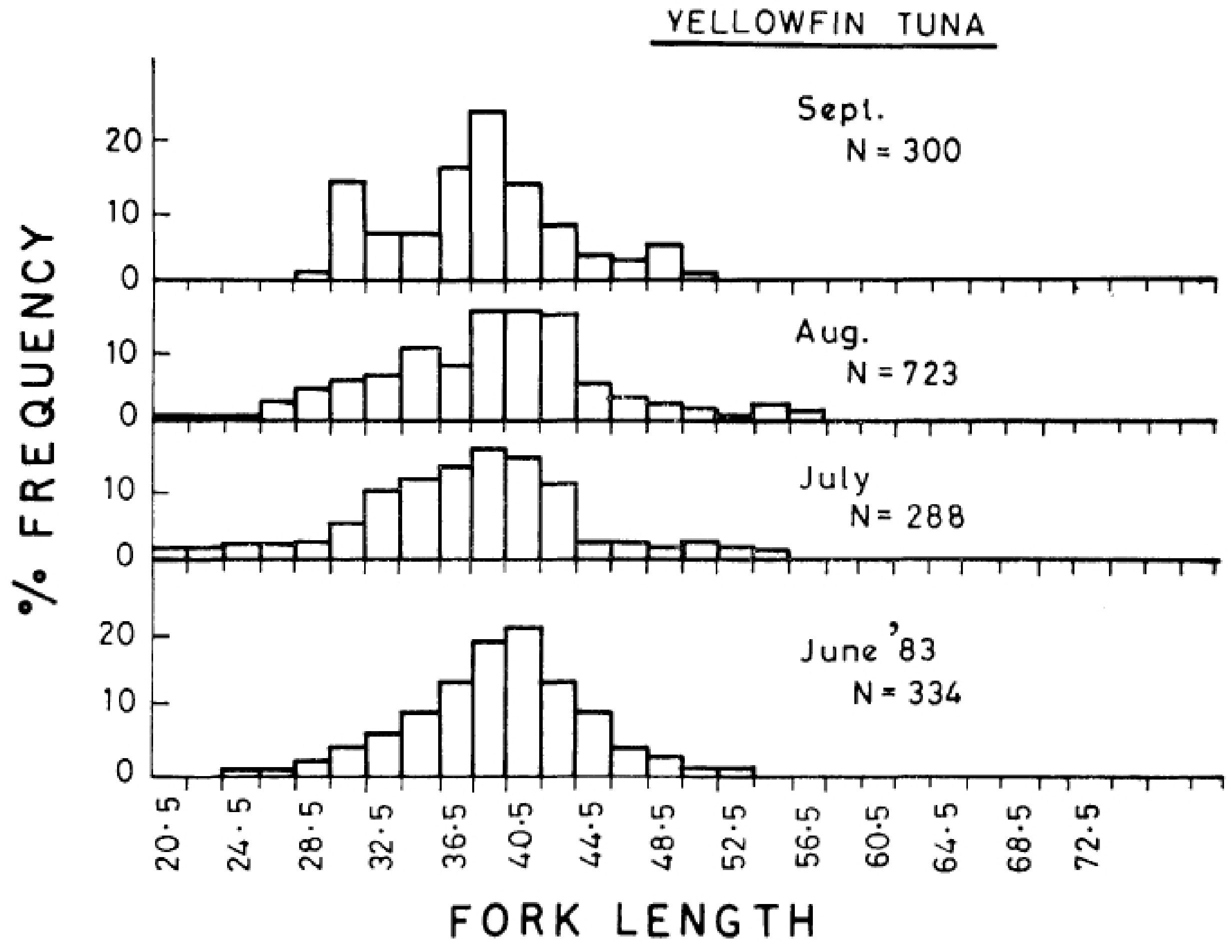


*Fig. 10. Length frequency distribution of ye//owl/n tuna around Ma/dive islands, pole and line catch, 1983.*



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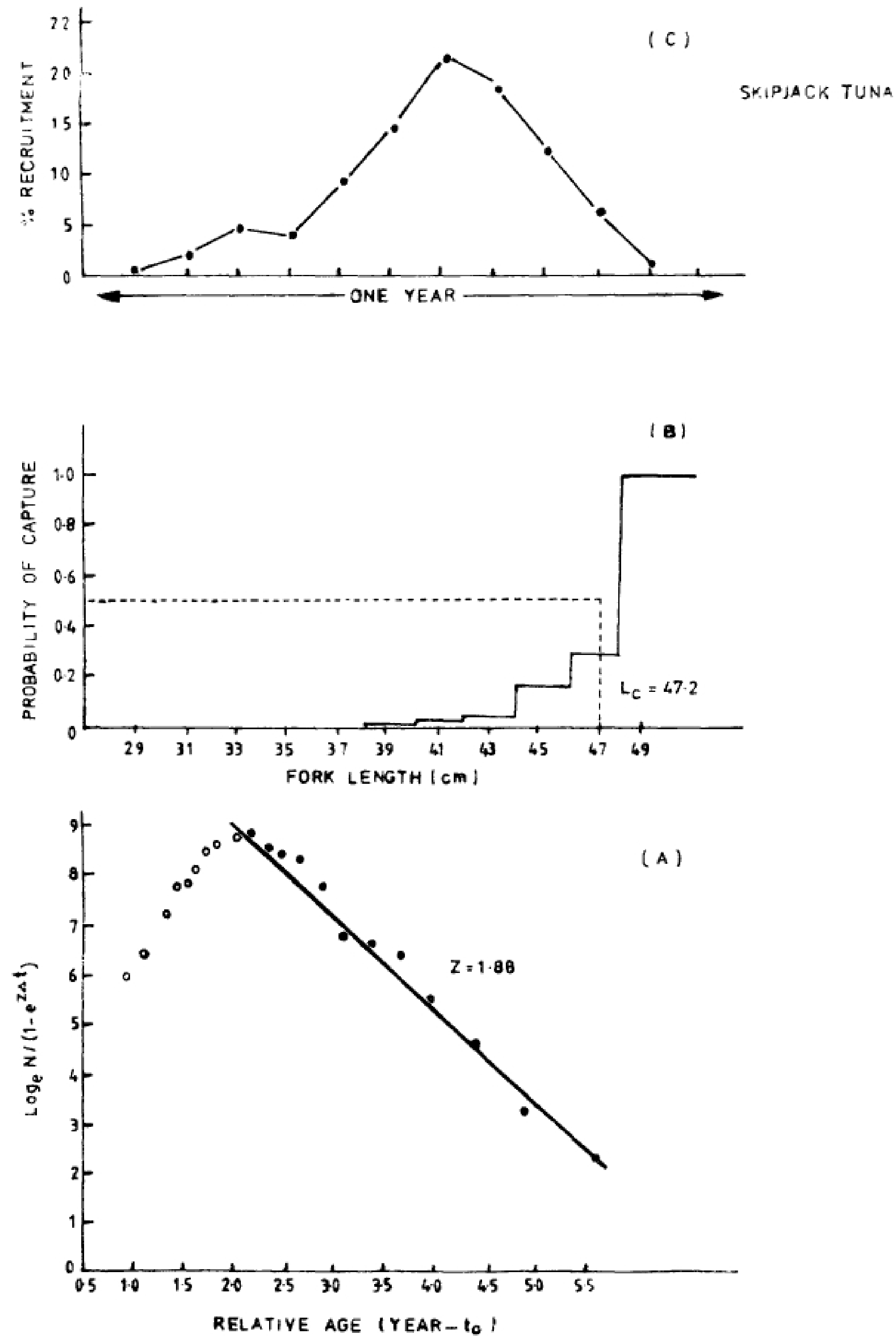


*Fig. 11. Length converted catch curve, selection pattern and recruitment pattern for* K. pelamis *caught around Sri Lanka.*



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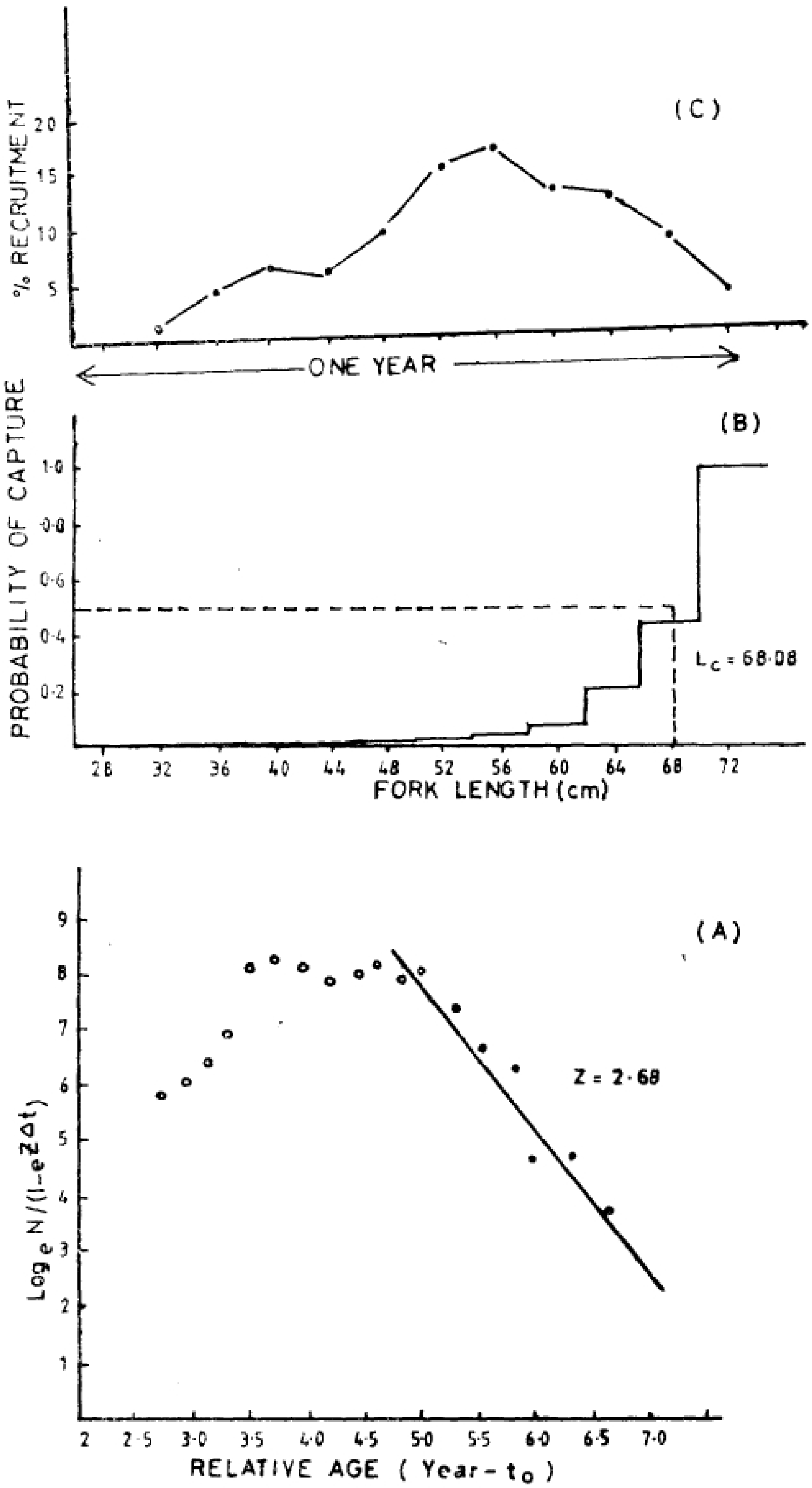


*Fig. 12.* *Length converted catch curve.* *selection pattern and recruitment pattern for* 1. albacares *around Sri Lanka.*

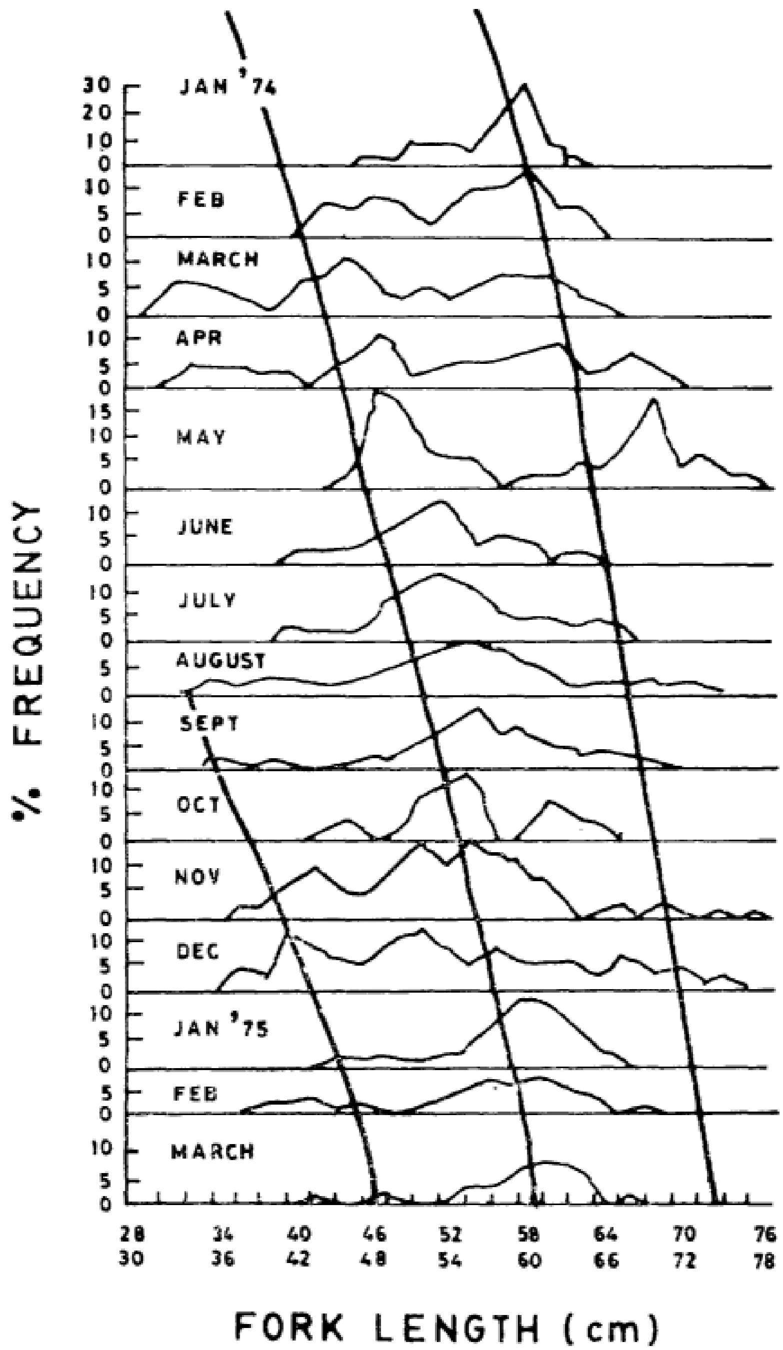


*Fig. 13. Length frequency distribution of skipjack tuna caught by pole and line method, 1974—75, and growth curve fizied by ELEFAN I.*

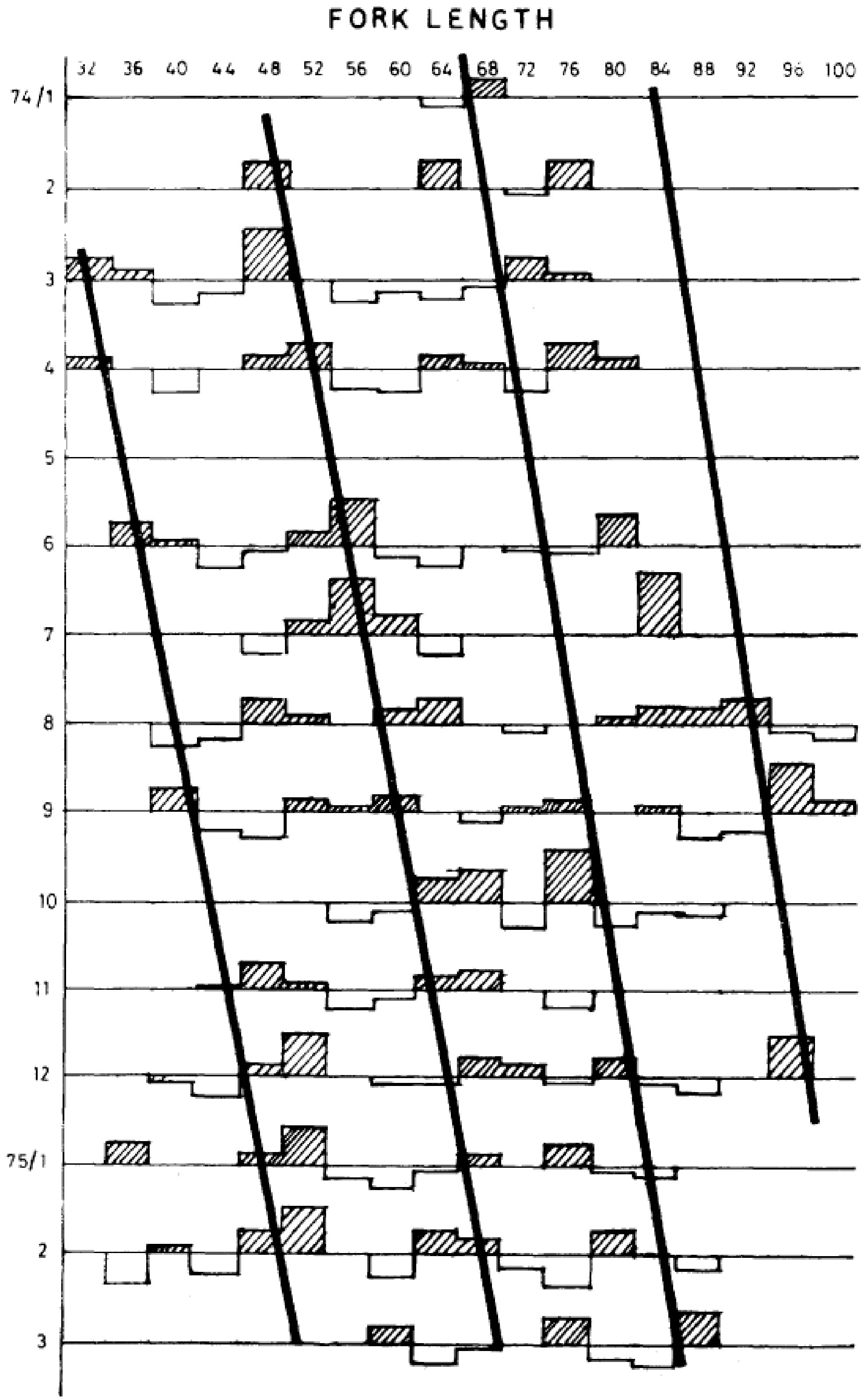


*Fig. 14. Restructured length frequency distribution of yellowfin tuna caught with pole and line method and growth curves fitted by ELEFAN I.*

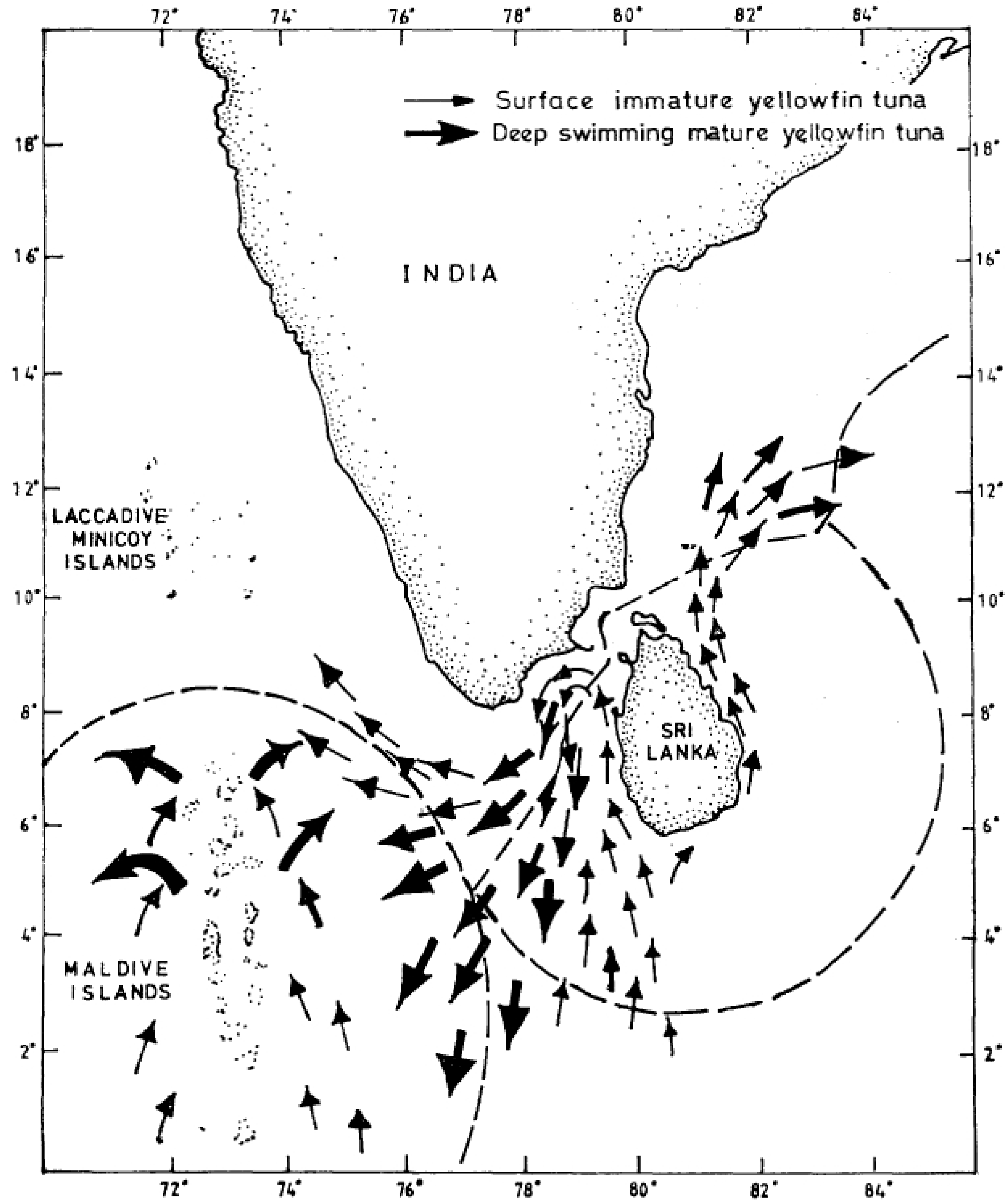


*Fig. 15. Hypothetical migratory pattern for yeio wi/n tuna near Sri Lanka.*

**Appendix 2**

## TUNAS IN THE MALDIVES

**Ministry of Fisheries**
*Male, Republlc of Ma/dives*

**Contents**

## Preamble

1. During the Technical Liaison Officers Meeting last year in Madras, geographic boundaries of the project activities were considered.

At that meeting, the area enclosing Laccadives and Maldives, although not strictly in the Bay of Bengal region, was included as part of the area under discussion. This framework needs to be redefined in order that the group may benefit fully from the study of the migratory patterns and other biological parameters of the tuna stock which would help us in advising the governments on feasible management measures.

2. At this stage it will be worthwhile to take note of some of the recommendations relevant to the work of this group. I feel we should be involved in deliberations on activities related to the recommendation nos. 3, 4, 5 and 6 of the TLO meeting in Madras.

3. I would like to mention here that Dr. Sivasubramaniam has undertaken the arduous task of putting together a concise and a very informative working paper on tunas and their fishery in the region. Thus, no attempt will be made by me here to go through the numbers, but I will try to outline here some of the constraints and a few alternatives which, I hope, will be more relevant now and can be considered fully by the group.

I feel we all should thank Dr. Sivasubramaniam for the excellent presentation that would help our discussions to be very fruitful.

4. Taking into accountthe aspects I have mentioned here, this paper will consider not only the biological aspects of the stock exploited but also the management aspects of the resources, as I strongly feel that these aspects are the priorities of the governments for immediate consideration by the Project.

5. Thus these two aspects will be dealt with separately in this paper. Biological data and related analysis are presented as annexures to the main paper, which will include most of the management constraints which I feel the group will be interested in discussing.

## 1. Introduction

The Project activities have started at a time when efforts are being mcde by the governments of the region to improve the productivity of fishing.

Even though traditional fishing techniques dominate the fishery, the introduction of mechanization has not increased the catch substantially; rather it has remained at a level which calls for the assessment of the stock exploited.

During the recent TCP extension training programme carried out in the Maldives under the umbrella of the BOBP, much progress was made in identifying some of the biological and socio-economic factors related to the overall stagnation of the fishery sector. These conclusions are highly probable, due to various reasons, which I feel will become apparent during the course of the meeting.

As this working group is interested in the tunas and their fishery, I will limit myself to the tuna fishery of the Maldives as much as possible, even though the total fishery activity needs to be known in order to fully justify the status of the tuna stock in economic terms.

it is worthwhile to note that one of the main reasons for carrying out a stock assessment programme is to advise governments on management measures. In a majority of the cases, the step from moving from scientific explanations to the more practical aspects (in terms of actual yield) in the decision-making process poses insurmountable difficulties.

I would therefore like to stress again that economic, social and cultural aspects need to be fully considered in establishing the targets, whether they be biological or economic.

It is becoming apparent that in developing countries, fishery biologists are faced with the difficult task of establishing guidelines for the management of a certain stock even after biological assessments have been conducted with the material and data available.

## II. Tuna fishing in the Maldives

Active fishery is based on tuna and tuna-like species. Of the total landings last year, 81% were of tuna-related species, with skipjack making up 51% of the total landings, and the yellowfin tunas 16%—an increase of three per cent in yellowfin catch compared to 1982.

The total yield of tuna and tuna-related species in 1983 was 38,500 tonne of which exports were 15,100 tonne and home consumption 23,400 tonne. This amounted to a decrease in exports of 6% and an increase in home consumption of 77% compared to the previous year. Such a tremendous rise in home consumption cannot be justified and the reasons for this need to be established as soon as possible. Tuna yield in 1983 was 3% higher than that in 1982.

## III. Fishing methods and crafts

In the Maldives, fishing effort is to a large extent directed to tuna varieties. Throughout the region non-mechanized and mechanized traditional crafts exist, with the bulk of the catch brought in by the mechanized crafts. A majority of the mechanized crafts carry out pole and line fishing, though troll gear is also used.

Trolling (sailing) traditional craft too contribute to the tuna catches substantially. In 1983. about 6% of the tuna landings came from the troll boats. Non-mechanized rowing boats contribute a substantial amount to catches of other marine fishes including bilifishes and dog-tooth tunas. Insufficient data exist with regard to catches by the row boats and it could be very misleading to make any attempt to analyse catch/effort, catch rates, etc.

As the characteristics of the craft, gear used and the operations involved have been mentioned in the paper presented at the TLO meeting and also in the working paper, no attempt will be made to elaborate these points here. However, much could be discussed during the course of the meeting.

One interesting aspect that needs to be considered and also taken note of is establishing the exact number of craft actively involved in tuna fishing. In the Maldives there has never been any census taken for more than a decade to establish the number of craft actually involved in fishing. Much of the information that exists regarding the number of crafts does not take into account the number of craft that have moved out of fishery, thus biasing the catch/effort values calculated.

## IV. Species composition and distribution

Tuna species contributing to the fishery of the Maldives are skipjack tuna *(K. pelamis),* yellowfin tuna *(T. albacares),* frigate tuna *(A. thazard),* and eastern little tuna *(E. affinis).* Though dog-tooth tuna (G. *un/color),* and oriental bonito *(S. orientalis)* are caught, no data are available for any scientific evaluation.

Around the Maldives, skipjack and yellowfin tunas contribute the bulk of the catch. In the past two to three years the percentage of yellowfins has increased towards the north while the skipjack has increased in the south.

Further explanation and data regarding species composition is given in Annexure 2.

## V. Catch effort and catch rates

In the Maldives, yield is estimated by total enumeration of the number of each species caught. This is practicable as pole and line and trolling are the gears mainly used. A conversion factor which was established from studies carried out in the early 60s, long before mechanization, is still in use. Thus discrepencies with the actual yield will surely exist. This can only be established by collection and analysis of length/weight information of catch for the whole region taking into account seasonal fluctuations.

In all areas of the country, small skipjack contributes to the production in the range exploited. Catch rates of juvenile yellowfin tunas are relatively better on the west coast than on the east coast. An analysis of the catch rates is given in Annexure II. Distribution of effort in the country indicates that the effort is low in areas where skipjack catches are high, while the effort has been relatively high in areas of moderate catch rates. However, the effort is on the decline when considering the efforts of 1973—78.

## VI. Length-weight relationships

As mentioned in the working paper, length frequency sampling was initiated during the training programme last year. Length frequency sampling is at present carried out in the north and at the cannery. With the available data, any monthly modal shift and age group entering the fishery can be observed. Due to the inadequacy of the sample, modes are not clearly defined for the two species, yellowfin and skipjack.

Effort is needed to establish more sampling centres in order to compare results.

## VII. Other biological parameters

I would like to mention here that little attempt has been made so far in arriving at a possible MSY using the data available. There still remains much to be done in terms of data collection, storage and upgrading some of the biological data and sampling in order to establish any figures that would be close to the Maximum Economic Yield.

Due to the lack of research facilities and capabilities in the Maldives, data collection for such activities as maturity and spawning, mortality and selection patterns, potential yields, food and feeding habits, gonad maturity, etc., remain unattended to.

Efforts are being made to establish a research unit that would be capable of handling independent research on the major species exploited.

## VIII. Discussion

In a programme for the development and management of the exploited stocks of the Bay of Bengal region, such as this, priorities should be oriented towards coordinated efforts to obtain better information on not only resource potential but also on the socio-economic aspects of the fishery sector as a whole in relation to the economy of the country.

I assume that all participating countries in this workshop attach high priority to fishery development to meet our protein requirements, to improve the socio-ecoriomic conditions of the fishing community and/or to increase foreign exchange earnings.

In the Maldives, this is reflected in our development projects and programmes, where increasing financial allocations are made for public fishery infrastructure investments and monetary incentives to private entrepreneurs for fishing craft and gear. As the country is unable to satisfy the needs, assistance is sought mainly from financial institutions such as the World Bank and development agencies. As can be seen, the assistance thus obtained goes into the development of the fishery to increase earnings rather than into the management of the stock, even though there is an urgent need to assess the resources in biological as well as economic terms in order to ensure that investment is based on a sound knowledge of the resources.

Therefore, knowledge of the resources should not be limited to analyzing the biological parameters; it is essential that the knowledge of socio-economic conditions of those directly involved in the fishing sector be taken into consideration.

In the light of these aspects, I have tried to outline here major aspects which we feel can make our discussions and deliberations fruitful.

I feel there exists the need to consider the following:

(i) Discussions related to purely biological aspects of the fish stocks under consideration, based on available information.

(ii) Discussions related to constraints and management problems

(iii) General discussions in order to arrive at conclusions and recommendations for both (i) and (ii),

Discussions pertaining to management and constraints can consider:

(a) Socio-economic aspects, ethno-technological studies related to tuna fishing.

(b) Literature review of past and traditional management techniques.

(c) Mechanics of incorporating tuna catches in the region by foreign fishing vessels.

(d) Mechanics involved in the translation of regional literature related to tuna from ihe countries concerned.

Discussions pertaining to purely biological aspects:

(a) Evaluate, compare and standardize existing data.

(b) Establish alternatives for the constraints identified.

(c) Propose a work programme to be considered nationally and regionally by the Project.

(d) Formu!ate a working programme which can be conducted with available resources with minimum input from the Project.

Group discussions can contribute to the overall project activities and recommendations.

## IX. Practical difficulties

Although quite reliable fishery-related data are available in the Maldives from 1960, the Ministry of Fisheries is experiencing certain constraints in utilizing these data fully for various reasons.

The recent TCP training programme was a success in enabling the scientific analysis of available data.

Some of the major constraints, though not an exhaustive list, follow:

(i) With regard to statistics, sampling and analysis, lack of skilled personnel has been the real inhibiting factor. This, however, has largely been overcome with the recent training programme. More field staff and training could help in completing the on-going programme by establishing a research unit so that trained staff will not be involved in other unrelated activities.

(ii) A major constraint in obtaining reliable data is the lack of transport. To carry out intermittent sampling in the fishing communities spread over 202 points over an area covering more than 500 km is no easy task. Inputs from a research organization which has suitable transport equipped with the basic research facilities to conduct tuna research can help tremendously in upgrading the existing data as well as those collected in the near future.

(iii) There is a total lack of equipment for biological sampling. During the recent training programme a few items of equipment were supplied. These, however, are not sufficient for surveys in the region.

(iv) In order to upgrade the fishery statistics there is an urgent need to carry out a fishery census. This has not so far been possible due to lack of personnel and transport. If transport can be made available this can, more or less, be achieved.

Annexure I

## TYPES OF CRAFT AND GEAR USED

| Craft | Size and character | Operation | Gear | Main species caught |
|---|---|---|---|---|
| Masdhoni | Mechanized and non-mechanized. LOA 12—14 m. | 12 hours day trip. Bait and tuna fishing. | Liftnet for bait; P/L and troll line for tuna and others. | Skipjack, yellowfin, little tuna, frigate tuna, dog-tooth tuna, rainbow runner. |
| Vadhu dhoni | Non-mechanized sailing. LOA 8-10 m. | 12 hours day trip. Tuna and others. | Trolling lines, hand lines. | Skipjack, yellowfin, little tuna, frigate tuna, dog-tooth tuna, rainbow runner. |
| Bokkura | Non-mechanized LOA 2-5 m. | 4—6 hours day and night trips. Demersals, small pelagics and others. | Hand line, hook and line. | Snappers, horse mackerel,dog-tooth tuna, grouper, marlins, sail fish, etc. |

*Note:—An* as yet undetermined number of Masdhoni and Vadhu dhoni is engaged in gillnetting for sharks and in lobster fishery.



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**Annexure II**

## ANALYSIS OF SCIENTIFIC DATA

Utilizing the historical data available the following analyses were conducted:

1. *General production trends in various strata*

Variation in the annual production trends (using catch numbers) for major tuna species were estimated.

It was found that there is an uneven distribution of skipjack and yellowfin tuna in different strata.

The highest production of small skipjack is in stratum II. The highest production of large skipjack is in stratum IV. Production of small skipjack is always higher than that of large skipjack in all strata.

The production of yellowfin tuna which has shown an increasing trend in the past few years, exceeded the production of small skipjack in stratum V from 1977.

An uneven production of skipjack and yellowfin tunas was observed in all strata.

2. *Species composition*

A good sampling gear for all species of surface tuna and tuna-like fishes should yield a species composition which reflects the composition of their population in the seas around the country. When more than one method of fishing exists in an area, there is likelihood of the catch composition showing differences between the methods, depending on the selectivity of the gear and behaviour of the fish.

There exists an uneven composition of pole and line and trolling crafts in the various strata and the differences in the species composition by strata are indicated.

The percentage species composition of catches from pole and line mechanized and sailing boats and troll boats in all strata for 1980 are given below.

**Distribution of fishing crafts (1982)**

| Strata | Mech. P/L | % | Sail P/L | % | Troll | % | Total | % |
|---|---|---|---|---|---|---|---|---|
| | 108 | 24 | 50 | 11 | 291 | 65 | 449 | 8 |
| II | 452 | 46 | 133 | 14 | 398 | 40 | 983 | 18 |
| III | 73 | 19 | 51 | 14 | 249 | 67 | 373 | 7 |
| IV | 346 | 18 | 263 | 12 | 1349 | 69 | 1958 | 35 |
| V | 92 | 12 | 226 | 28 | 419 | 60 | 797 | 14 |
| VI | 95 | 10 | 229 | 23 | 662 | 67 | 986 | 18 |
| Total | 1166 | 21 | 952 | 17 | 3428 | 62 | 5546 | 100 |



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**Percentage composition of skipjack and yellowfin tunas (1982)**

| Strata | Vessel type | Small skipjack | Large skipjack | Yellowfin |
|---|---|---|---|---|
| I | **Mechanized** | **32.0** | **31.0** | **9.0** |
| | Non-mechanized | 37.0 | 5.0 | 2.0 |
| **II** | **Mechanized** | **75.0** | **3.0** | **8.0** |
| | Non-mechanized | 38.0 | 11.0 | 25.0 |
| III | Mechanized | 92.0 | 6.0 | 0.0 |
| | Non-mechanized | 60.0 | 35.0 | 0.0 |
| IV | Mechanized | 38.0 | 9.0 | 28.0 |
| | Non-mechanized | 34.0 | 3.0 | 14.0 |
| V | Mechanized | 29.0 | 4.0 | 29.0 |
| | Non-mechanized | 11.0 | 2.0 | 23.0 |
| VI | Mechanized | 64.0 | 27.0 | 4.0 |
| | Non-mechanized | 97.0 | 0.05 | 0.42 |

In all strata, mechanized pole and line vessels had small skipjack as the largest contributor (by per cent) to the catch. Non-mechanized pole and line vessels also showed a somewhat similar trend.

Skipjack percentage increases from north to south, both on the eastern and the western side of the country, but the percentage is relatively higher on the eastern side.

Yellowfin percentage declines sharply from the north to the south and is higher on the western side of the country than on the eastern side.

**3.** *Annual variation in catch rates*

The total number of fishing crafts has been reasonably stable since 1970. The increase in mechanized P/L vessels since 1975 has been compensated to a great extent by the reduction in non-mechanized P/L vessels.

It is assumed that P/L method is an efficient gear for sampling surface tunas such as skipjack and juvenile yellowfin tunas. The catch rates for strata III and VI (southern end of the country) indicate relatively higher values. Strata I, IV aid V reveal consistently moderate catch rates. Stratum II has a rate in between these two levels.

In all cases the main contributor to production is the small skipjack, indicating a relatively higher abundance of small skipjack than of any other tuna variety within the exploited range (i.e., 25 miles along the coastline).

The smaller skipjack catch rates were rather stable until 1978, reached a peak in 1980/81 and declined in 1982 in almost all strata except stratum IV which did not show a decline.

The distribution of effort (number of trips) in the various strata indicates that the effort has been, and is continuing to be, low in areas of high skipjack catches (Str. III or VI) while the effort has been relatively very high in areas of moderate catch rates (Str. IV, V. III or I); however, the effort in the latter has been declining since 1973, except in stratum II where the decline was halted in 1978 and reversed thereafter.

The catch rates for juvenile yellowfin tunas entering the pole and line fishery are relatively better in the strata on the west coast than those on the east coast. However, they are very much lower than the skipjack catch rates and due to this, the annual variations on the east coast are not clearly identified.

4. *Catch rates*

The increase in mechanized crafts has been compensated by a decrease in non-mechanized crafts resulting in a rather stable number for pole and line fishery. The number of trolling crafts has also been steady over the years.

As a result, the number of craft has remained at relatively the same level since 1976.

The distribution of various fishing crafts in the strata was identified.

The highest percentage of all crafts is found in stratum IV and the lowest in stratum I. Mechanized and non-mechanized P/L craft are also found to be the highest in stratum IV. Mechanized and non-mechanized crafts decline south of stratum IV on the western coast, and north and south of stratum II on the eastern coast. Trolling crafts are more on the west coast than on the east coast.

Monthly catch rates (catch/trip in no. of fish) for tuna species caught by mechanized P/L vessels in six strata for two consecutive years (1980 and 1981) were determined, and the seasonal variation patterns between strata and between years were also noted.

In 1980, in strata I, II and III on the eastern side, the seasonal variation of small skipjack tuna was a lmost similar and the same is true in the case of large skipjack tuna.

In 1980, in strata I, II and III on the eastern side, the seasonal variation of small skipjack tuna was almost similar. This was true of large skipjack tuna as well.

Small skipjack peak catch rates were between September and February in the east coast. The peak seasons on the west coast tend to correspond with those of the east coast, but the peaks are less distinct.

Variation of large and small skipjack catch rates in stratum VI show a parallel trend both in 1980 and 1981. Large skipjack catch rates generally tend to decrease in the second half of the year in most strata, except perhaps in stratum I, where it tends to exceed that of the small skipjack in certain months (July, October and November).

The catch rates of large skipjack in almost all strata were relatively poor in 1981 and, therefore, seasonal trends are not clearly evident.

Monthly catch rates of yellowfin tuna are relatively low in the east coast and seasonal trends are not clearly defined. On the west coast, the peak season is distinctly around August, and September for stratum VI only.

**5.** *Size composition*

Seasonal variations in size composition of each species in different strata combined with seasonal variation in their catch rates in the respective strata could help in interpreting migratory trends, seasons and areas of recruitment to the fishery, strength of recruitment, growth rates, etc.

Length frequency sampling is at present carried out at stratum IV. With the available data any monthly modal shift and age grouping entering the fishery can be obtained. Due to insufficient samples, modes are not clearly defined for the two species under investigation (skipjack and yellowfin tunas). However, three or even four age groups are likely to be included.

The last age group appears in July and November. Peak mode in June is between 37 and 39 cm; 39 and 41 cm in July; 40 and 42 cm in August; 37 and 39 cm in September; 48 and 50 cm in October and 63 and 65 cm in November.

Yellowfin samples taken from the vessels in the same strata show considerable similarity in the size range to skipjack tuna. The size ranges indicate that they are zero age group or an age close to one year.

## 6. *MSY*

The skipjack around Maldives is assumed here to be of a unit stock. By using the catch rate and catch per unit effort, the relationship between effort and catch/unit effort was calculated and the results used to prepare production models for the skipjack tuna fishery around Maldives. A rough MSY level and optimum effort and number of crafts to sustain the fishery were determined:

| | MSY (tonne) | C/E (kg) | Opt, effort (trips) | No. of craft |
|---|---|---|---|---|
| Schaefer's model | 19,176 | 166.7 | 115,000 | 436 |
| Fox's model | 17,200 | 286.6 | 60,000 | 227 |

In addition, with the same effort figures used for skipjack a rough estimate of MSY level for yellowfin tuna around Maldives was calculated:

| | MSY (tonne) | Opt. effort (trips) |
|---|---|---|
| Shaefer's model | 4348.62 | 123,700 |
| Fox's model | 4194.26 | 133,085 |

## 7. *Units of effort and standardization of fishing effort*

Catch/effort (catch rates) for each category of craft in different strata for skipjack and yellowfin tuna were estimated from the data available for 1980, 1981 and 1982.

The calculated relative efficiencies of non-mechanized pole and line vessels and trolling vessels relative to the mechanized P/L vessels are summarized below:

| | Species | 1980 | 1981 | 1982 | Av. for 3 years |
|---|---|---|---|---|---|
| *Non-mechanized P/L* / Mechanized P/L | skipjack | 0.36 | 0.21 | 0.15 | 0.28 |
| | yellowfin | 0.72 | 0.36 | 0.66 | 0.57 |
| *Troll* / Mechanized P/L | skipjack | 0.06 | 0.02 | 0.006 | 0.01 |
| | yellowfin | 0.18 | 0.88 | 0.03 | 0.07 |

# REPUBLIC OF MALDIVES

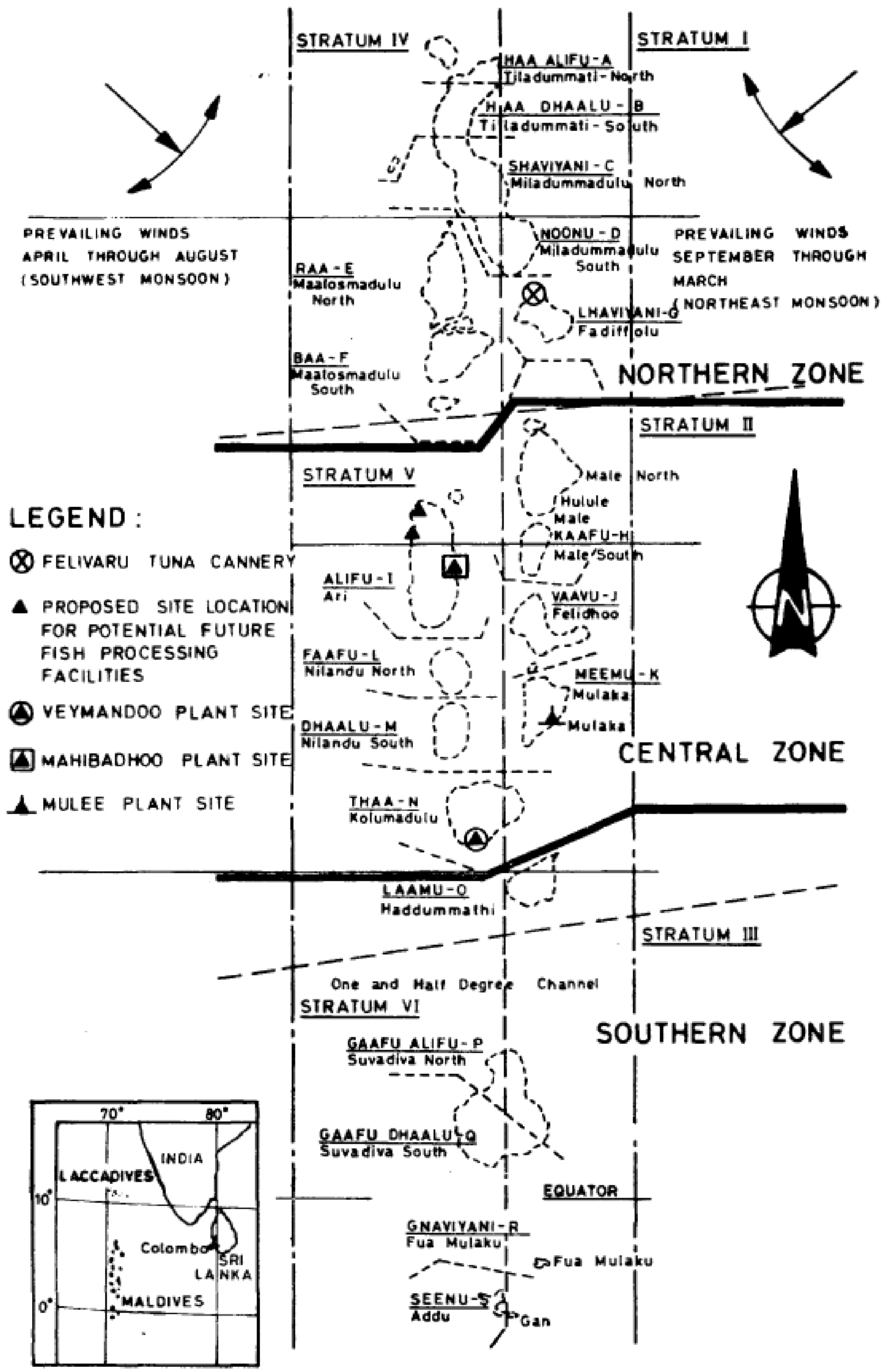


*Fig. 1. Map of Maldives.*



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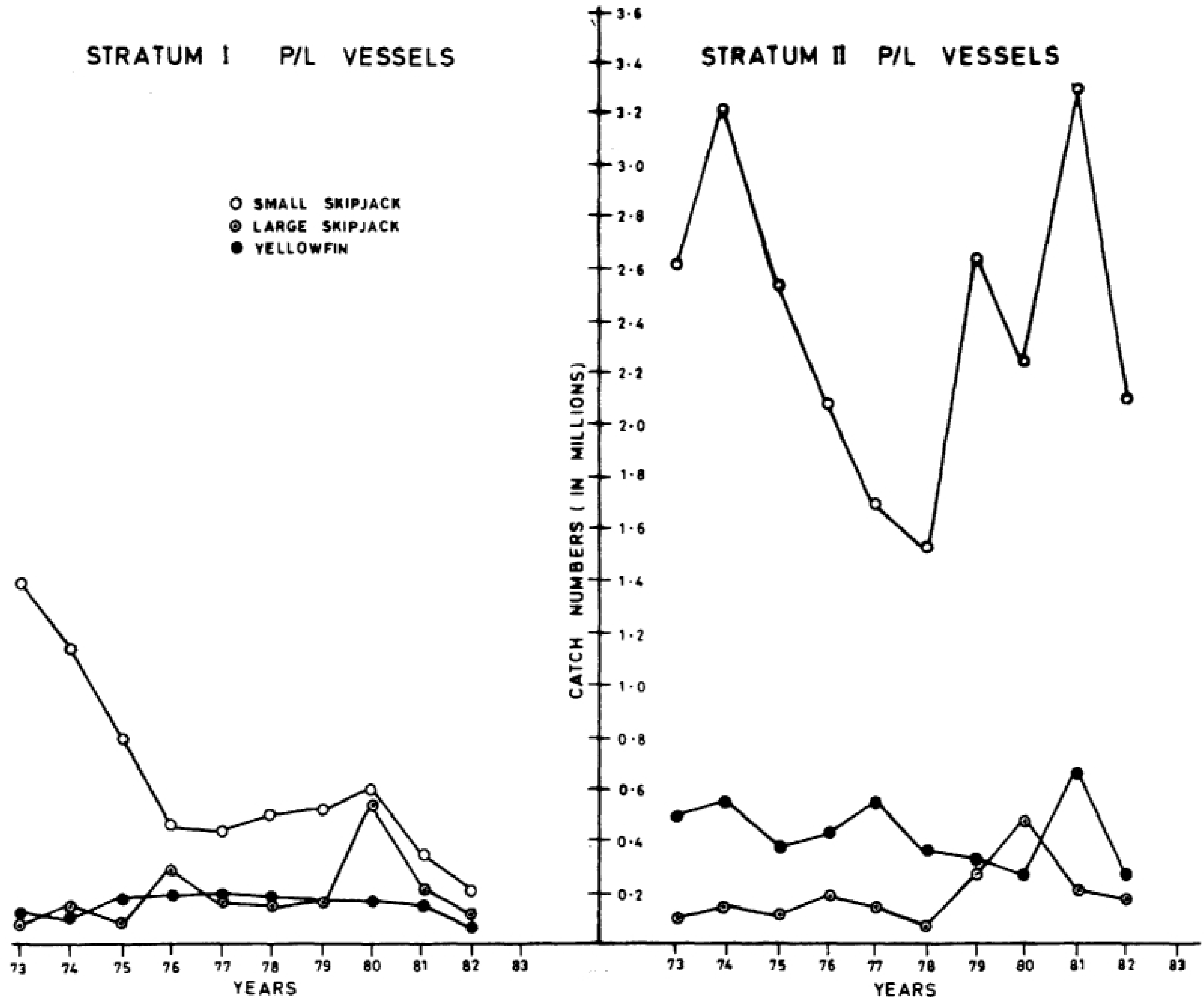


*Fig. 2. Catch data for Stratum I and Stratum II pole and line vessels.*



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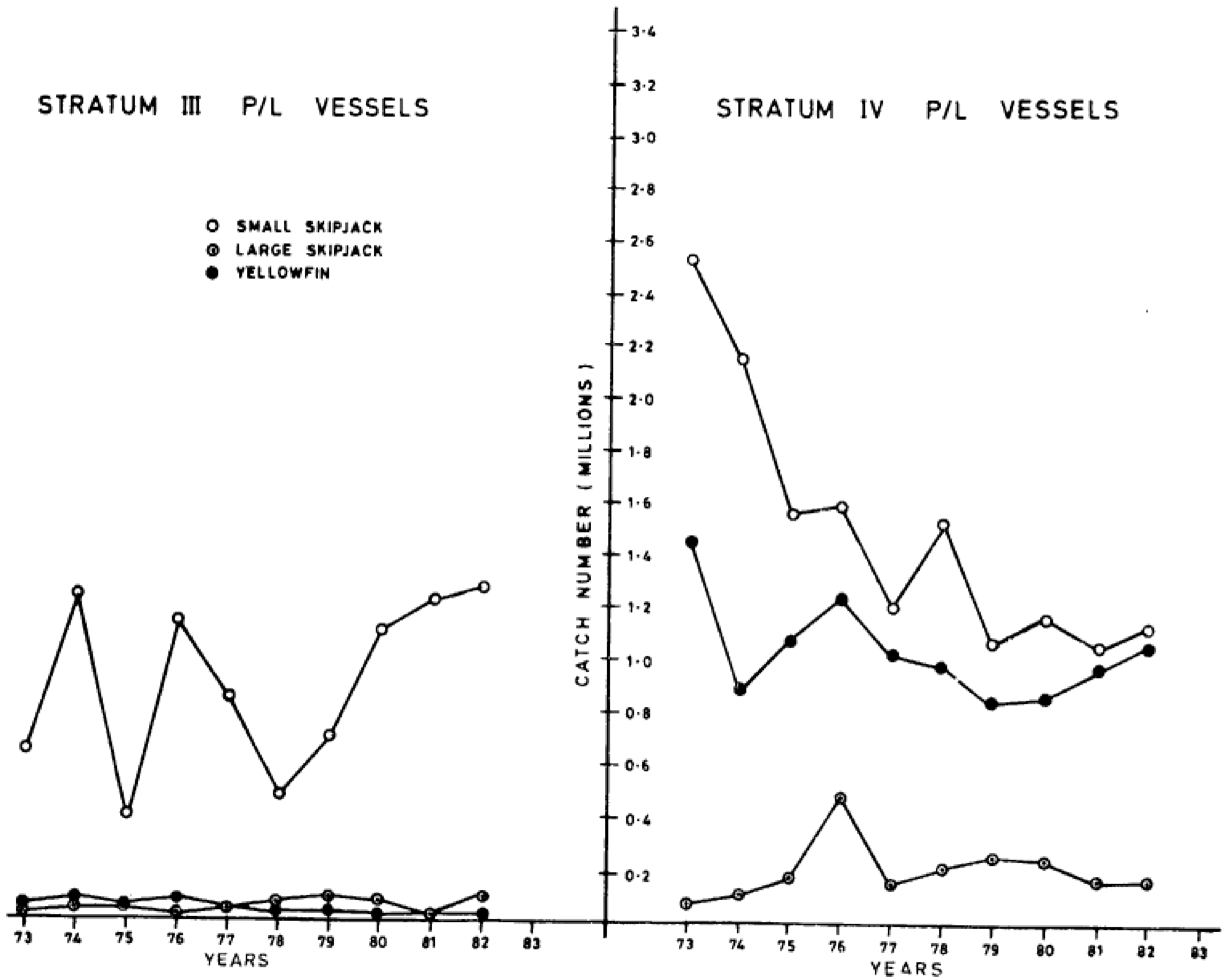


Fig. 3. Catch data for Stratum *III* and Stratum *IV* pole and line vessels.



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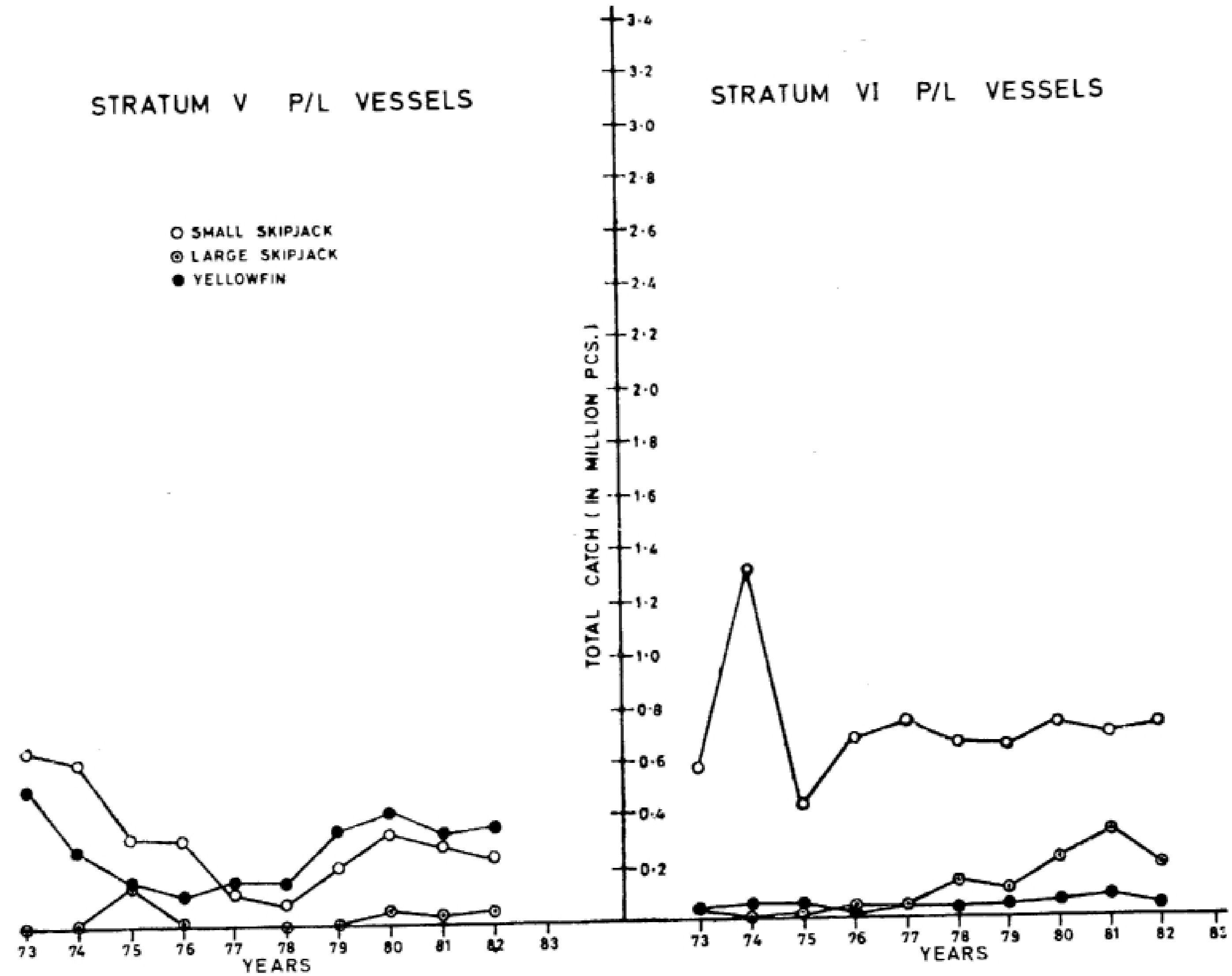


*Fig. 4. Catch data for Stratum V and Stratum VI pole and line vessels.*

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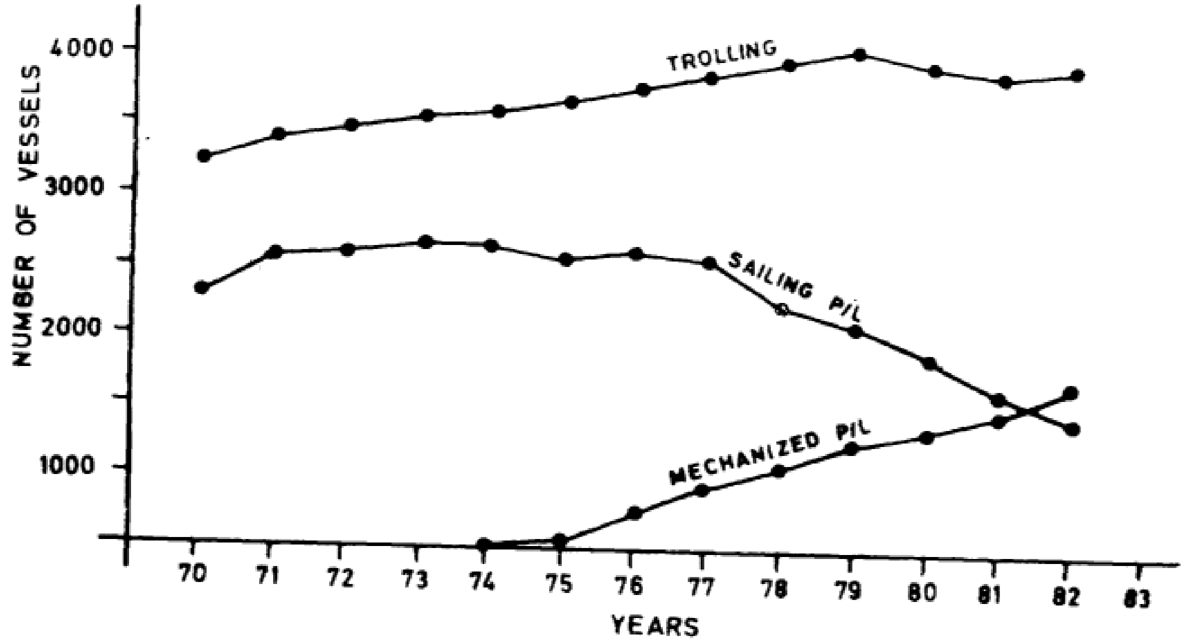


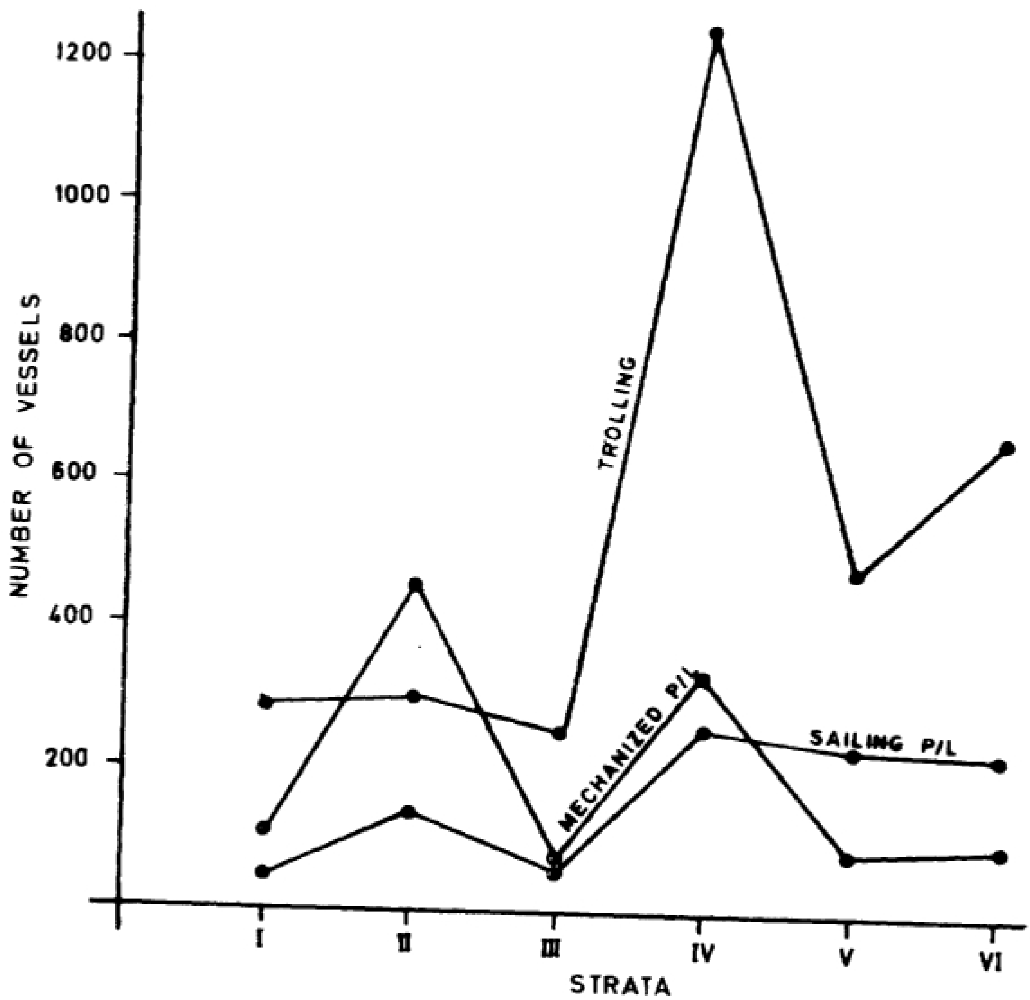


*Fig. 5. Distribution of fishing craft, 1982,*

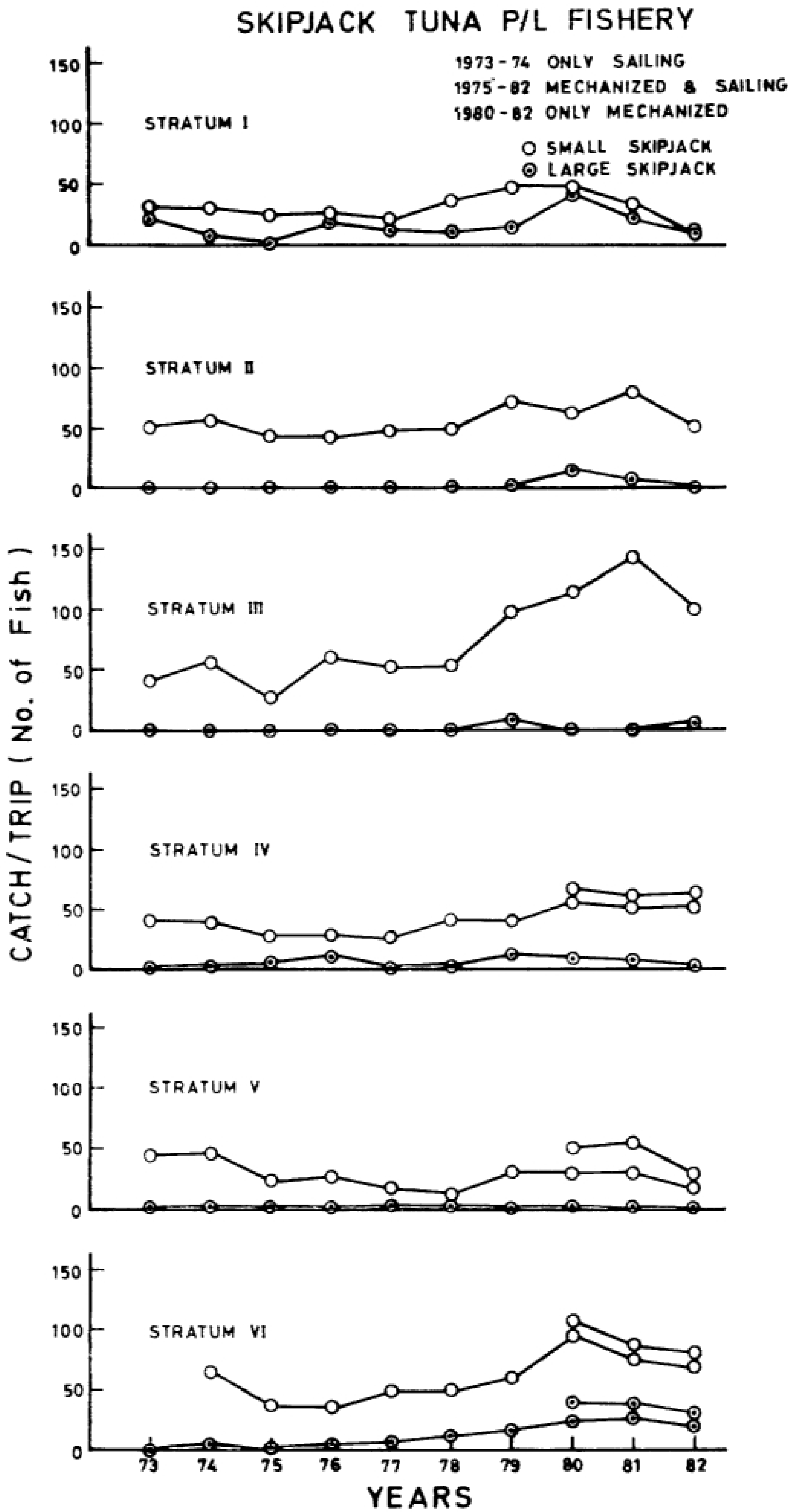


*Fig. 6. Skipjack tuna pole and line fishery, 1973–82.*

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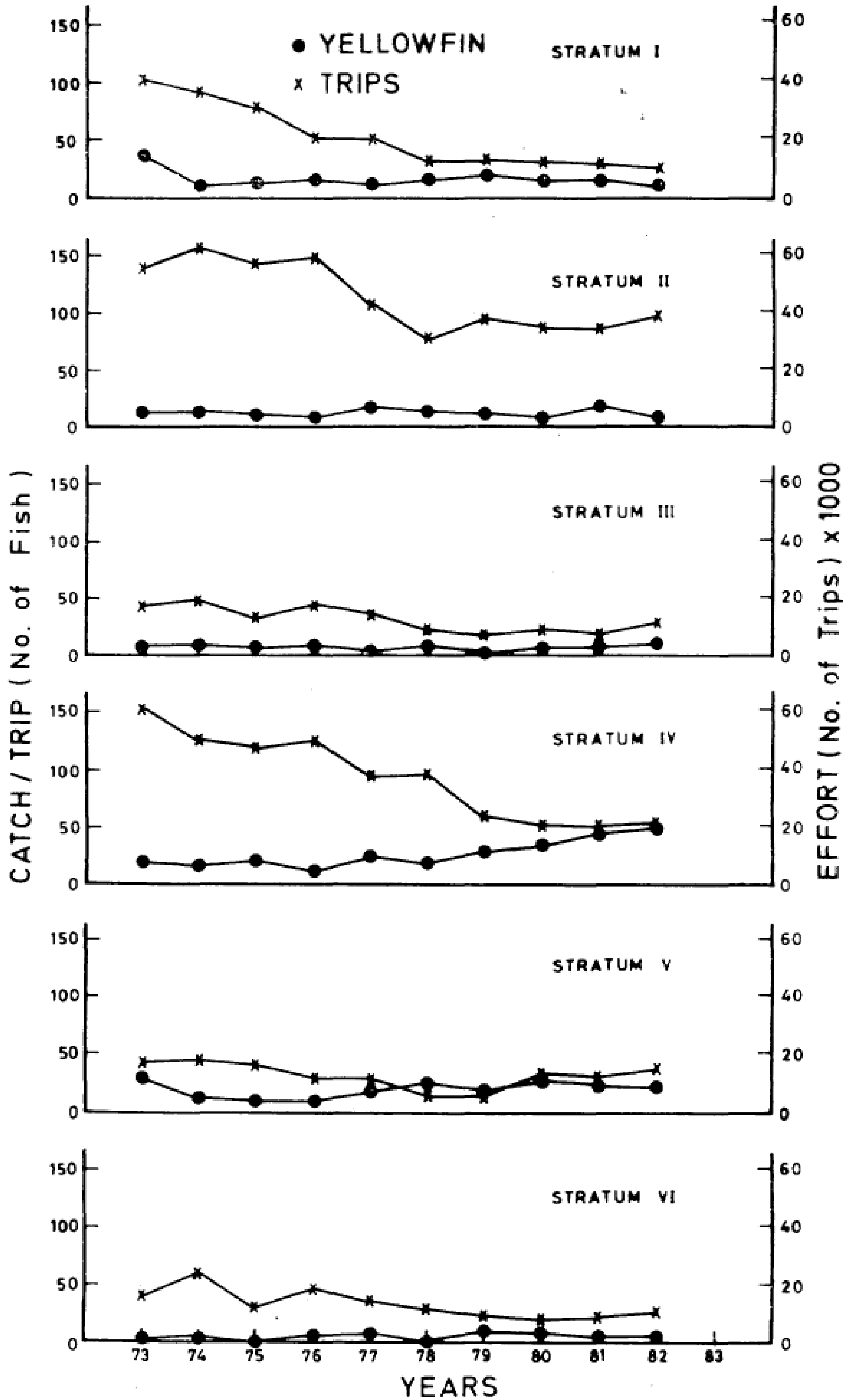


*Fig. 7, Ye/jo wfin tuna fishery, 1973—82.*



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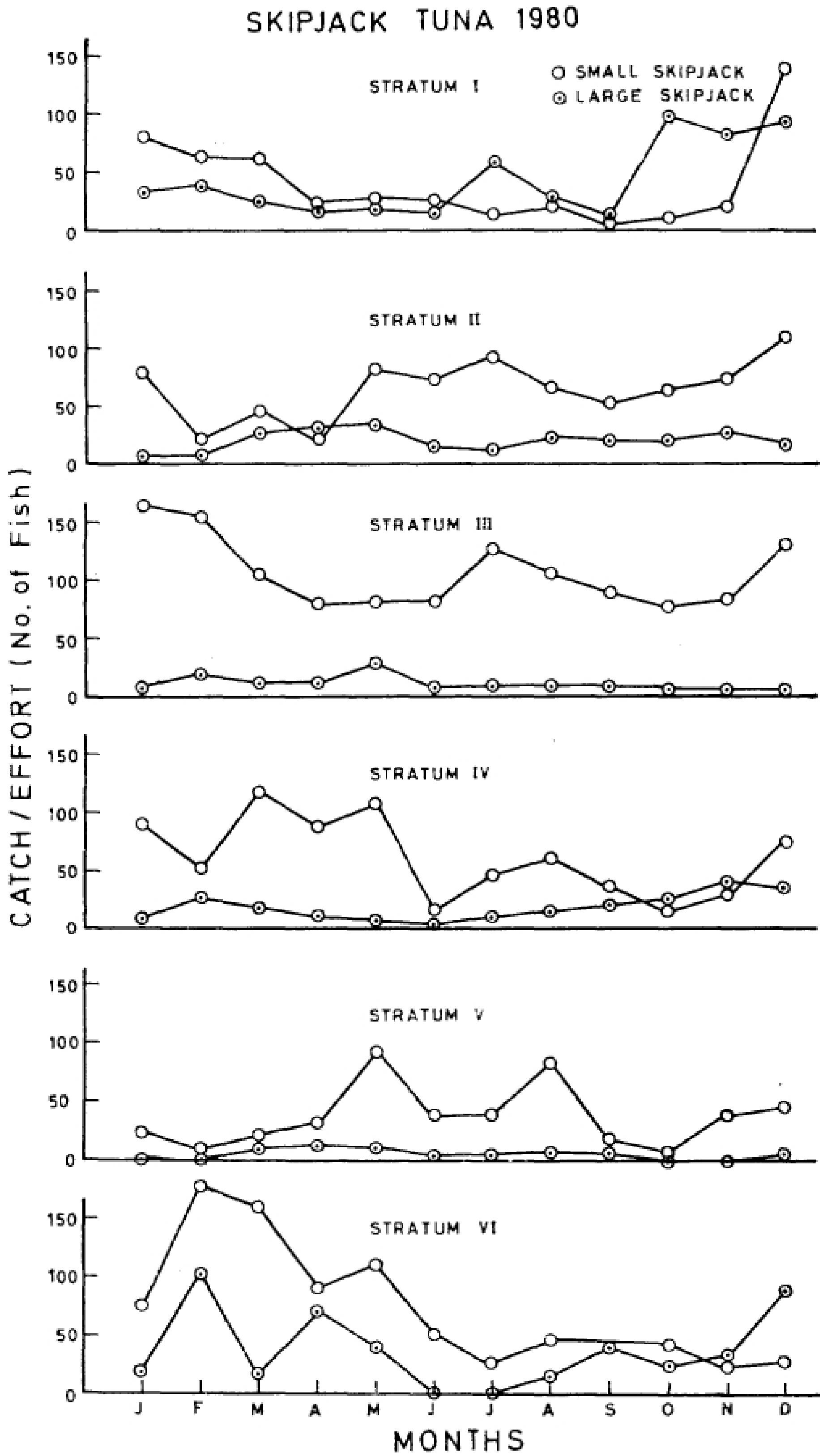


*Fig. 8. Skipjack tuna catch per Unit effort by month, 1980.*

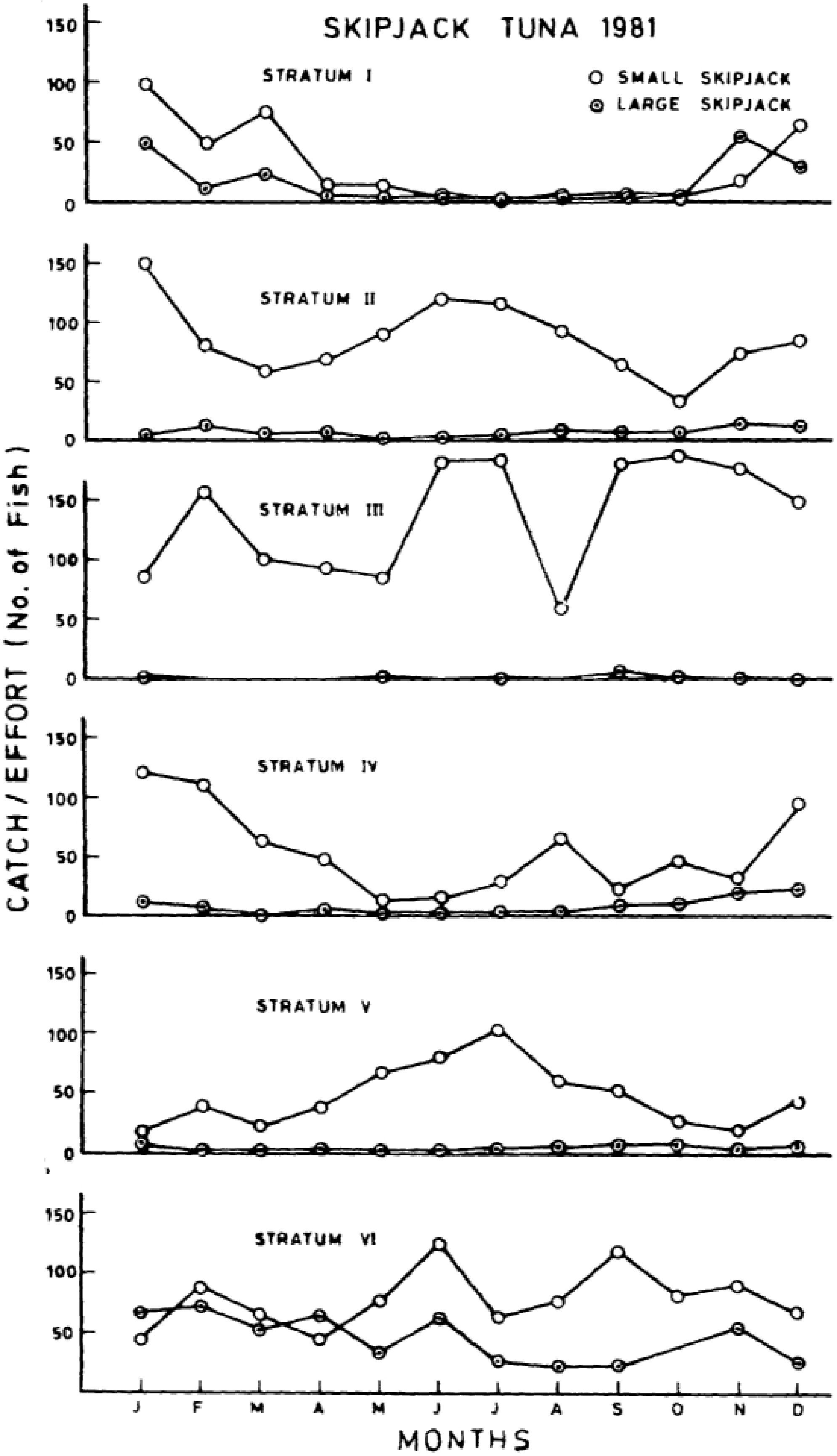


*Fig. 9. Skipjack tuna catch per unit effort by month, 1981.*



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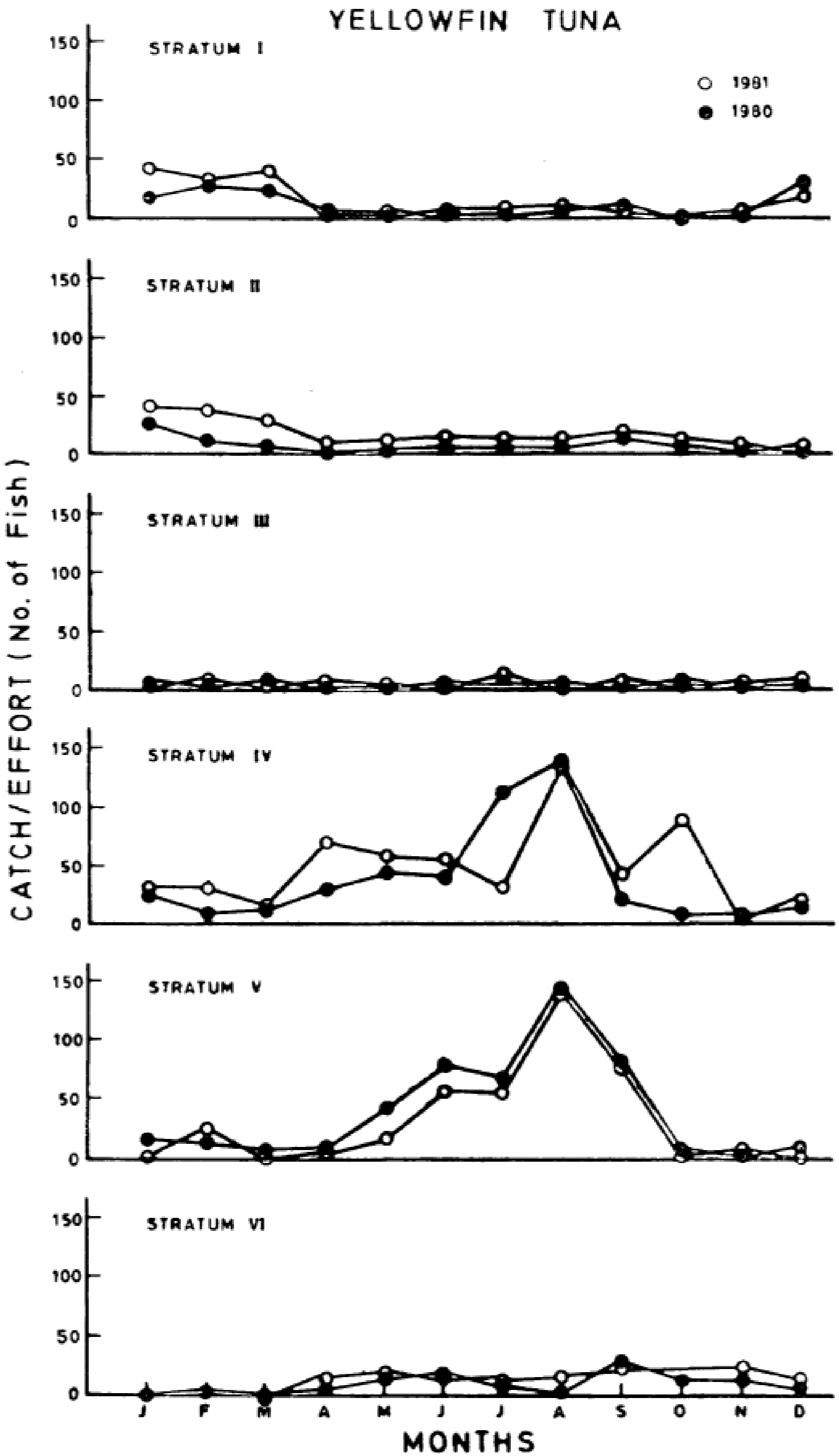


*Fig. 10. Ye/lowfin tuna catch per unit effort by month, 1980 and 1987.*



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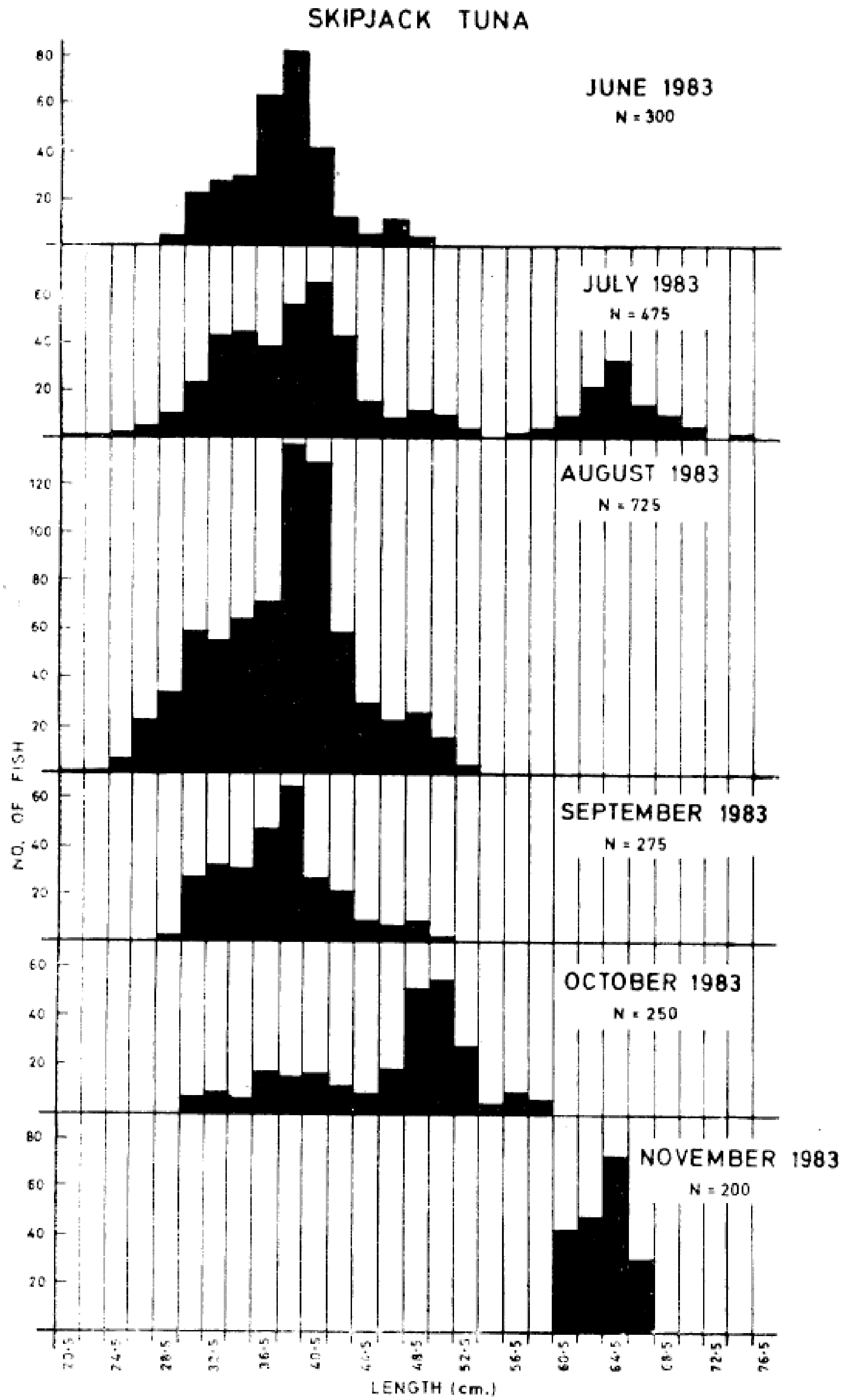


*Fig. 17. Length frequency distribution of skipjack tuna.*

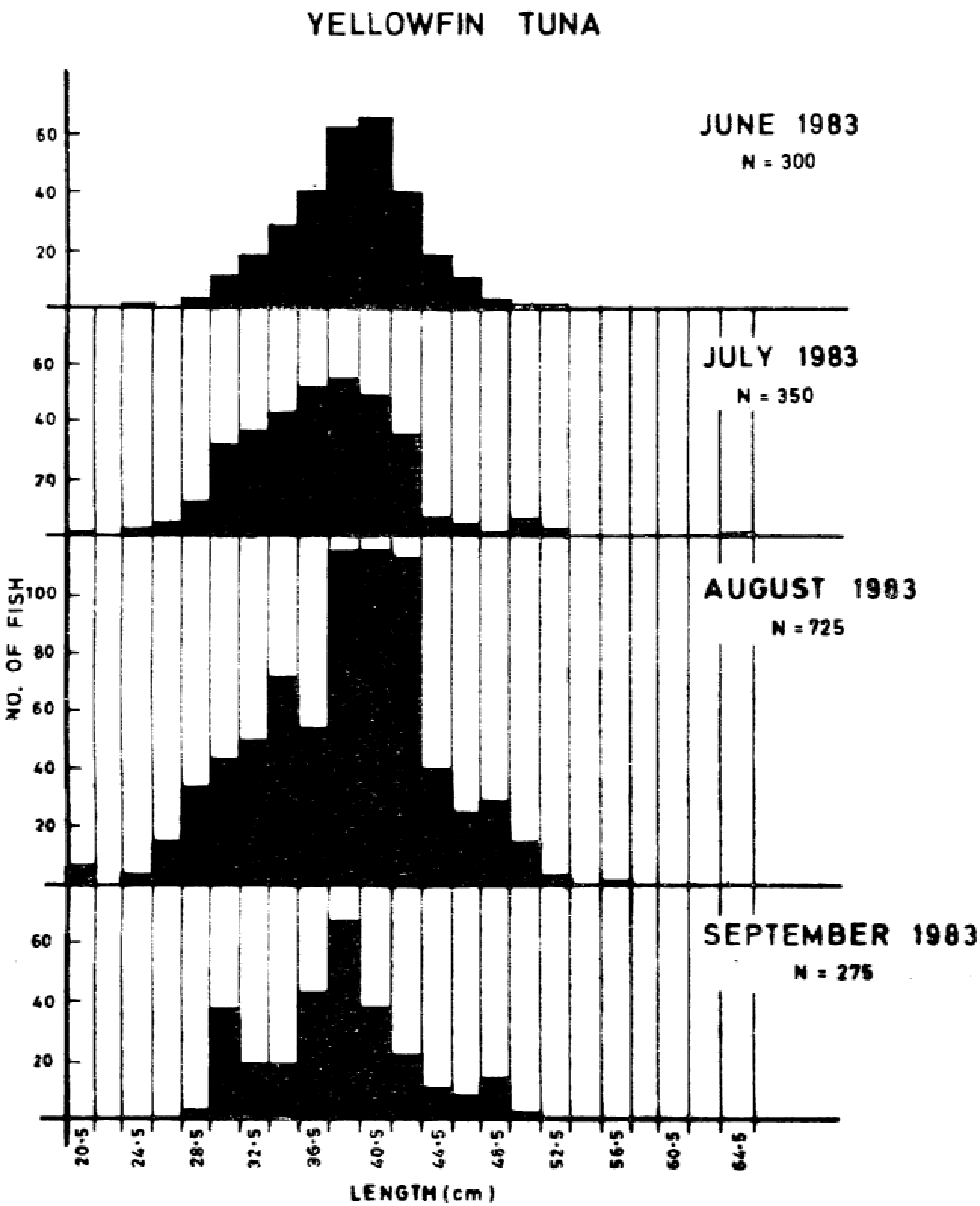


*Fig. 12. Length frequency distribution of yel/owfin tuna.*

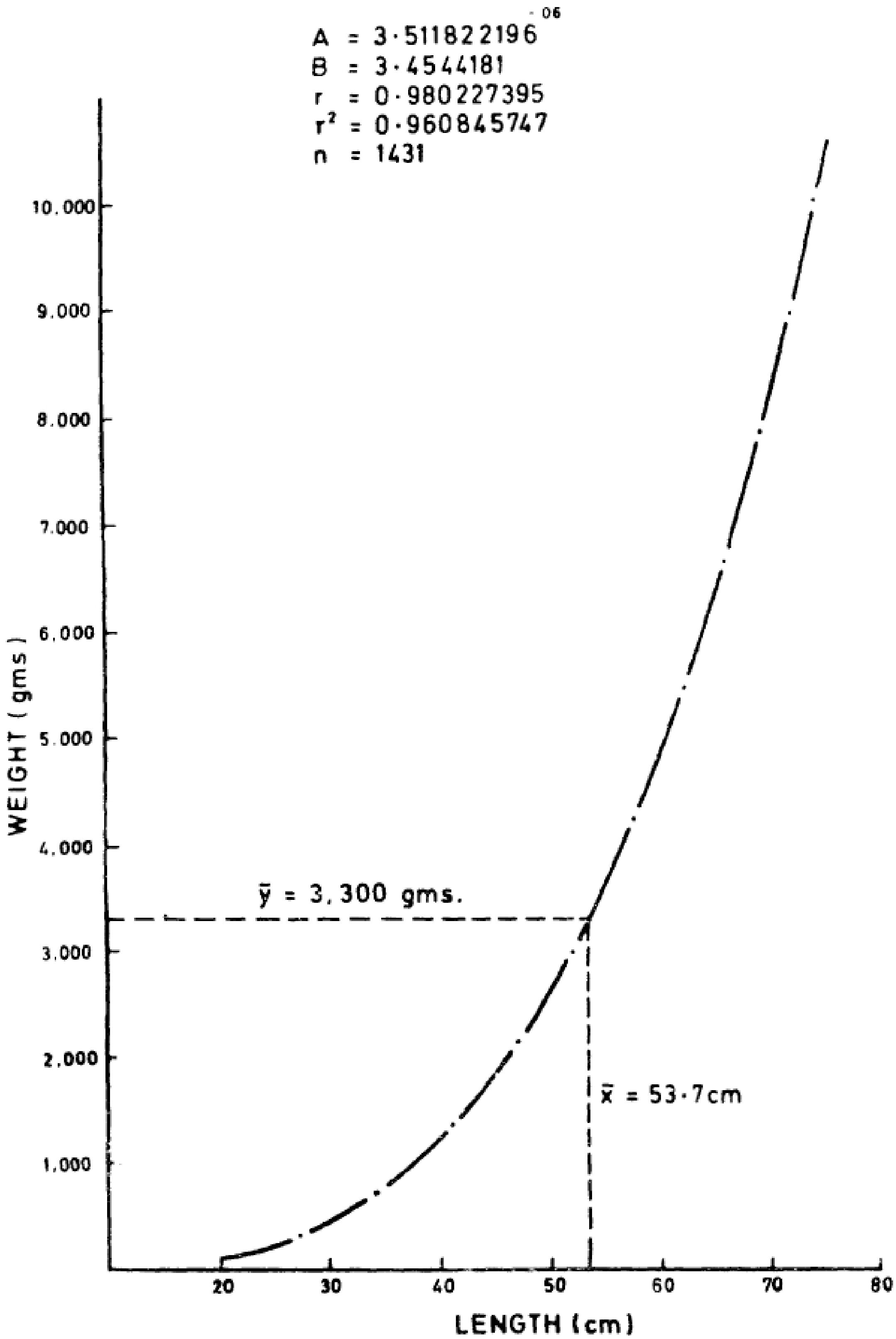


*Fig. 13, Length-weight relationship for skipjack tuna.*

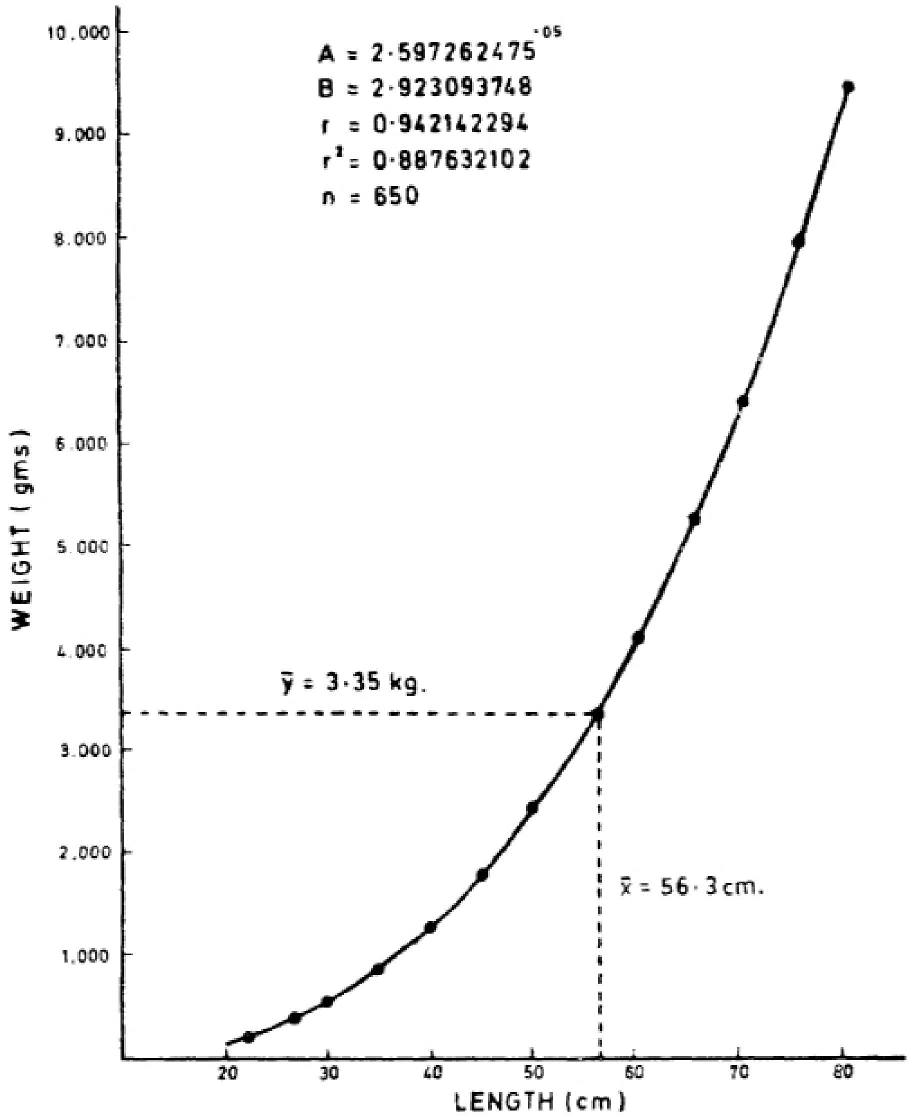


*Fig. 14. Length-weight relationship for ye/fowl/n tuna.*



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Appendix 3

# DRIFTNET FISHERY FOR TUNA IN THE WESTERN COASTAL WATERS OF SRI LANKA

L. Joseph, C. Amarasiri and R. Maldeniya

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## Introduction

**The** estimated annual production of 30000 tonne cl tuna frcm the coastal waters of Sri Lanka in recent years makes up 15 to 20 per cent of all fish landed in the country. Driftnet is the dominant gear in this multispecies, multigear fishery. Except for the north, Gulf of Mannar and Palk Bay areas, the 3.5 G.T., 8.4 metre boats in other areas constitute the main fishing fleet exploiting tuna and tuna-like fish from the coastal waters of Sri Lanka. There were over 3,000 of these boats in operation during '1982 and 1983. In addition, some of the FRP crafts with outboard engines also exploit tunas during the season. While the 3.5 G.T. class of boats are day beats covering a range of 20 to 25 miles, the 10.2 metre class of boats introduced under the North-west Coast Fishery Development Project which at present number 30. are expected to carry out driftnetting and loriglining in an extended range, staying out two to three days per fishing trip.

The peak fishing season for driftnet fishing on the western coast is during the south-west monsoon period of May to October. This paper analyses the performance of the 3.5 CT. class of vessels in the tuna fishery during south-west monsoon periods of 1982 and 1983. While the coverage for 1982 is limited from JLIly to November, the 1983 season has been covered from April to November, The period of study is extended to include April and November months so as to cover the fishery prior to and after the south-west monsoon season.

## Study area and sampling strategy

The study area extends from Kandakuliya on the north-west coast to Kirinda on the scuth (Fig. *7).* This area falls within eight DFEO (District Fisheries Extention 01 'ice) areas set up for fisheries administration purposes. The distribution of 3.5 G.T. class of boats in these areas during 1982 and 1983 is given in Table 1. The study area has been sub-divided into sub-areas, north-west, west, south-west and south, with the different DFEO divisions falling into different sub-areas given in Table 1.

A total of 15 main fish landing centres in the study area were selected far sampling the fishery. These are shown in Fig. 7 While some centres were covered every month, others were covered during alternate months. This was done in the south where there were relatively more sampling centres compared to other areas.

The sub-area north-west includes DEFO areas Chilaw and Puttalarn Over 60 per cent of the fishing fleet is concentrated at Kandakuliya during the peak fishing season. Chilaw, the other landing centre selected for sampling the fishery in this area, has nearly 10 per cent of the 3.5 G.T. class fishing fleet in the area. In the west, which includes the DFEO areas Negomba and Colcmbo, the larger concentration of 3.5 G.T. boats is located at Negombo. This area is also different from other areas in having a significant tuna longline fishery. While a few beats from each of the other areas may carry out tuna longline fishing, a considerable number of boats in this area is engaged in tuna longline fishing in combination with di'iftnet fishing. While the number of pieces and mesh sizes used in the drifteets are the sanie as observed in the driftnct fishery conducted by the rest of the fleet, the longline gear consists of 20 to 30 baskets (total of 100 to 150 hooks), with cut pieces of tuna, marlins and, sometimes, dolphins being used as bait.

The largest concentration; of 3.5 G.T. driftnetters in south-west are located at the Beruwala and Galle fisheries hrirbours. It is customary for the boats in the area to use the harbour facilities at these two places, particularly during the south-west monsoon period. The largest concentration of 3.5 G.T. boats engaged in tuna fishery is located in the south, which includes DFEO areas Matara and Tangalle. The fishing fleet is scattered around eight major fish landing centres in this area.

Eight to nine days sampling per month has been attempted in the study area. In addition, information on the fishery during the rest of the periods was available from boat owners at some of the centres. Information collected during the sampling visits included those on catch and effort (total catch, species), composition, number of boats operated and fishing gear and biological parameters (length frequencies, length and weight, arid maturity).

## Fishing effort and catch per unit effort

The driftnets used in the fishery vary both in number of pieces used arid in mesh size A sample survey covering all areas gave the following information

*(P) Distribution of nets*

| No. of pieces | No. of boats | Percentage |
|---|---|---|
| 20—24 | 20 | 40 |
| **25—29** | **12** | **24** |
| 30–34 | 24 | 28 |
| 35—40 | 4 | 8 |
| | 60 | |

***(b) Mesh size distribution***

| Mesh size | Percentage |
|---|---|
| 4", 4Y' | **9.5** |
| **5",** 5½", 5¾" | 47.6 |
| 6", 6½", 6¾" | **39.6** |
| 7" | **3.3** |

The information given above revealed that the boats mostly carry 20 to 34 pieces of nets per boat with most of the nets being 5" to 6¾" mesh size.

in this study the fishing effort is considered in terms of boat days. The driftnetters leave port around noon and return from fishing early next morning. In some areas, particularly in the west, a considerable number of driftnetters carries out driftnetting and longlining simultaneously. These boats leave port in the morning and return the following afternoon, coverirg an extended range. Each day on which a boat leaves port for fishing, is considered a fishing day. It is assumed that each boat averages twenty days of fishing per month during the season. The total fishing effort available from the whole fleet in each area in terms of boat days is also given in Table 1. Fishing effort in the driftnet fishery in different areas and its proportion in the total available effort (in per cent) is given in Table 2.

The monthly variation in fishing effort in different sub-areas is shown in Figures 2 and 3 for 1982 and 1983, respectively. A decline in effort towards the end of monsoon is seen in both years in the north-west, with the decline being more marked during 1982. A sineilar decline in effort on driftnet fishing towards the end of monsoon is observed in other areas too. However, in the west, it is still higher than that observed in other areas, possibly due to interest in longline fishing which is usually carried out in combination with driftnet fishing. In the south-west and the south, effort on dirftnet fishing is high from June to September. While a consistently high effort has been maintained Irons April to September during 983 in the south-west, there is an increase in effort in November in the north-west, the west and the south-west during 1982 and also in the west during 1983. According to Sivasubrarnaniam (1972) the pole and line fishery on the western coast exploits pure schools of skipjack tuna moving into the western coastal waters from November to March. These schools of skipjack tuna are also exploited by driftnets, resulting in an increase in effort, particularly in November.

Variation in catch per unit effort (boat day) of all fish caught in the driftnet fisheiy on a monthly basis is given in Table 3 and also shown in Figs. 2 and 3. Considering these on an area-wise basis, it is seen that while July and November recorded high catch rates durir.g 1982 for the north-west, June, September and October were the peak months during 1983. The catch rates thus show fluctuations with no definite trend being established. The highest catch rates in the west have been during the months of May, June in 1983 and July, August in 1982.

The mean monthly catch rates obtained in the south-west for most months in 1 982 and 1983 are high compared to those obtained in other areas. While high catch rates have been recorded in June, August, September and November during 7982, catch rates have been high from April to September during 1983. The period June to September has yielded high catch rates in the south for both years. An examination of mecn catch rates obtained in different monlhs in different areas during 7982 and 1983 reveal the four-month period of June to September to be the peak season for the driftnet fishery in the area.

**Species composition in driftnet fishery**

The species composition (percentage by weight) in the tuna driftnet fishery during the period June to November 1982 and April to November 1983 are given in Tables 4 and 5, respectively.

The tuna species dominant in the driftnet fishery are the yellowfin *(Thunnus albacares),* skipjack *(Katsuwonus po/amis),* eastern little tuna or kawakawa *(Enthynnus affinis),* frigate tuna *(Auxis thazard)* and bullet tuna *(Auxisrochei).* Other tuna species caught in driftnets in small numbers include the long-tail tLina *(Thunnustonggo/),* oriental bonito *(Sarda orienta/is)* and the dog-tooth tuna *(Gymnosarda un/color).*

Tunas make up 50 to 70 per cent by weight of the fish caught in the drifteet fisheiy. The balance is made up of sharks, billfishes and various species of pelagic, and sometimes demersal, fish, depending on the area of operation, particularly in relation to distance from the shore. No attempt has been made to identify the various species of sharks caught in the driftnet fishery during this study. However, available information from Sivasubramaniam (1969), de Bruin (1970) and Goonewardene (1971) suggest that the species of sharks most commonly caught in driftnets around the coastal waters of Sri Lanka include the silky shark *(Carcharhinus falci-formis),* white-tipped shark ***(C.*** */ongimanus),* black-tipped shark *(C. malanopterus),* grey shark ***(C.*** */imbatus),* cub shark ***(C. brachyurus), C.*** *a/bimarginatus, C. dussumferi, C. rnenisorrah, C. gengiricus* and the hammerhead sharks *Sphyrna blochii, S. lewini* and ***S. zygaena.***

The billfishes common in driftnet catches include the striped marlin *(Tetrapturus andax),* blue marlin *(Makaira migricans),* black marlin *(M. inc-/ica),* the sail fish, *Istiophorus orientalis* and the swordfish *Xiphius fladius.* The scombridae comprising *Scon'beromorus comnserson, S. guttatus, S. lencolatus, S. semifasciatus* and *Aconthocyhiurri so/andrialso* form a very important group in the driftnet catches. Other common species of pelagic fish identified in the driftnet fishery include the dolphin fish, *Coryphaena hippurus,* the rainbow runner, *Elagatis bipinnulatus* and the devil ray, *Mobula diabofus.*

The percentage contribution of tuna to driftnet catches in different areas during the south-west monsoon of 1983 was higher than duriry the south-west monsoon of 1982, except in the west. An examination of percentage contributions by the two dominant tuna species – skipjack and yellowfrn - show that in the north-west, the increase during 1983 was due to increased contribution from yellowfin, while the skipjack contribution dropped during 1 983. On the other hand, the contribution of yellowfin dropped and that of skipjack increased during 1983 in the west, compared to 7982. However, the overall contribution of tuna to driftnet catches in this area during the two years remains more or less the same.

In the south-west and the south, the increase in percentage contribution of tLina in the driftnet fishery in 1983 has been due to the increased contribution from skipjack while the percentage contribution of yellowfin remained the same for bath areas during the two seasons.

In the west, a considerable amount of driftnetting is carried out in combination with longlining. These combination driftnets/longliners are presumed to cover an extended range compared to the other driftnetters. Twenty-five to 35 per cent of the driftnet fishing effort in different months during 1982 and 15 to 38 per cent of the driftnet fishing effoit in different months during 1983, was in combination with tuna longlining. The mean catch per boat day, for different months for driftnets iii the combination driftnet/longline fishery, showed fluctuations compared to those obtained in the regular driftnet fishery in 1982. However, in 1983, the mean catch per boat day values in the regular driftnet fishery for all months were higher than those estimated for driftnets in the combination fishery.

The species composition in the drittnet fishery from the combination boats is given in Table 6 for the two seasons. A comparison of percentage values obtained for yollowfin and skipjack tuna with those obtained in the regular driftnet fishery in west, given in Tables 4 and 5, show skipjack to be dominant in the driftnet catches made by combination boats while yellowfin is dominant in the regular driftnet fishery.

Monthly variation in the percentage contribution of skipjack, yellowfin, eastern little tuna and *Auxis* spp. in different areas is shown in Figs. 4 and 5 for 1982 and 7983, respectively. A high value in the percentage species composition sometimes is not reflected in the actual contribution by weight due to a low catch rate. Figs. 4 and 5 should, therefore, be considered together with Table 7 which gives the contribution by weight of the two main tuna species, skipjack and yellowfin, to the estimated mean catch per day for different months. For example, the high percentage contribution made by skipjack in the north-west during September 1982 is not reflected in the actual weight of skipjack in the mean catch per day, whereas, it is higher in July, even though it exhibits a low percentage value compared to September.

It is seen from Table 7 that the availability of skipjack and yellowfin to the drftnet fishery show monthly fluctuations. The fluctuations are more marked in the north-west and the west than in other areas. The catch rates of skipjack for most months during 1982 were higher in the combination driftnet/longline fishery. Since the cornbnation fishery is presumed to take place in more offshore waters (25 miles and more) compared to the regular driftnet fishery (15—20 miles), the relative abundance of skipjack may be high in the more offshore waters in this area. The opposite trend is observed for yellowfin, though only for a lesser numbar of months. These trends were not observed during 1983.

The mean catch per day values estimated for skipjack and yellowfin tuna in the driftnet fishery during the south-west monsoon periods of 1982 and 1983 are given in Table 8. The catch rates of skipjack are compared with those estimated for the same species (Sivasubramaniam, 1972) from the driftnet fishery by the 3.5 CT. class of vessels during early 1970s. The catch rates show a drop for most areas.

**Length distribution**

Percentage length frequency distributions for skipjack yallowfin tuna are shown in Fgs. 6 and 7, respectively.

The size range of skipjack tuna sampled was 24 to 78 cm. Length frequency distribution from June to December 1982 showed the presence of three distinct modes even though these have been sampled during different months. The smallest mode, with a modal length of 34 cm was observed in the September/October period and had been sampled predominantly from the north-west and the south. The second mode, with a length of 44 cm was observed in June while a third mode at 54 cm was ob.;erved from August onwards.

Progression of some of these modes could be followed in the length frequency distribution obtained for April to December 1983. Appearance of small fish of 26—34 cm size range in the driftnet fishery is indicated during April and October/November periods. While these small fish have been sampled mostly from the soLith during April, they have been sampled from the north-west and the south during October/November, as observed during 1982. Two annual recruitments are thus indicated, one around April and a second, more prominent one, around the September—November period.

The mode at 54cm observed in August 1982 can be followed clearly *up* to 64cm in July **1983. For most months of 7983, the length frequencies obtained show the presence of two recruilments** per year.

A comparison of these modes at their lowest points with previous data from Sivasubramaniam (1972) is given below. The mode at 64—66 cm observed during July 1983 is also considered as a new mode since other modes too were observed during the months of June, August and September.

| | | 1972 | 7982/1983 |
|---|---|---|---|
| 1st Mode | .. | 34.5cm | 34cm |
| 2nd Mode | .. | 43.0 cm | 44 cm |
| 3rd Mode | .. | **52.4 cm** | **54** cm |
| 4th Mode | .. | 63.0 cm | 64–66 cm |

Even though the modes obtained by graphic separation of length frequency distribution using probab;hity paper in 1972 were for skipjack caught by all gears, the result bears a close resens-blance to modes observed in the present study where only driftnet catches have been sampled. The length distribution also shows that despite the fact that driftnets are a very selective gear, the range of mash razes used ire the fishery allows exploitation of a wide size range of the population.

Yellowfire tuna sampled ranged from 28 cm to 180 cm fork length. Two distinct modes are observed in the length frequency distribution of June to December 1982. The first mode can be followed from June to December with a modal length at 70 cm in August. A second mode, with a modal length at 48 to 50 cm is observed from September onwards. Small fish of 36 to 40 cm fork length have b3en sampled during September and October from the north-west and south-west areas.

The modal group first observed at 48 to 50 cm length during September 1982 could be 'lohiowed clearly up to June '1983 where it is at 60 to 62 cm length. A new mode appeared during July 1983 with the modal lengths at 48 ens. This could be followed clearly until October 1983 and is identical to the mode at 48 cm observed during August 1982. Small yehowfin of 28 cm to 40cm fork length were sampled in August and November 1983, particularly from the north-west and south-west areas. Considering both years, the peak season of recruitment of yellowfin to driftnet fishery appears to be frons August to November.

Even though there is no indication of two ann Lial recruitments to the extent observed in skipjack tuna, the spread of length distribution and peaks point to this possibility.

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Table 1

Distribution of 3.5 G.T. boats in the study area and estimated fishing effort (boat days)

| Sub-arcs | DFEO area | Total no. of 3.5 G.T. boats | Maximum fishing effort/month (b3at days) |
|---|---|---|---|
| North-west | Puttalam | 209 | 4180 |
| | Chilaw | 20 | 400 |
| | | 229 | 4580 |
| West | Negomba | 392 | 7840 |
| | Colombo | 76 | 1520 |
| | | 468 | 9360 |
| South-west | Kalutara | 196 | 3920 |
| | Galle | 174 | 3480 |
| | | 370 | 7400 |
| South | Matara | 403 | 806(1 |
| | Tangallo | 173 | 3460 |
| | | 576 | 11520 |

Table 2

Fishing effort on tuna driftnet fishery and percentage of maximum available effort in different areas— June to November, 1982 and April to November 1983

| | North-west | | West | | South-west | | South | |
|---|---|---|---|---|---|---|---|---|
| Month | Boat days | Percentage of total effort | Boat days | Percentage of total effort | Boat days | Percentage of total effort | Boat days | Purcontage of total effort |
| *7982* | | | | | | | | |
| June | | --- | | — | 3960 | 53.5 | 7160 | 62.2 |
| July | 4080 | 75.3 | 7300 | 78.0 | 4680 | 63.2 | 7760 | 67.4 |
| August | 1920 | 35.4 | 7480 | 79.9 | 5460 | 73.8 | 6660 | 57.8 |
| September | 1720 | 31.7 | 4180 | 44.7 | 4460 | 60.3 | 6320 | 54.9 |
| October | 1900 | 35.1 | 4760 | 50.9 | 3400 | 45.9 | 5420 | 47.0 |
| Novembar | 3280 | 60.5 | 5680 | 60.7 | 3680 | 49.7 | 3500 | 30.4 |
| *7983* | | | | | | | | |
| April | 2140 | 39.5 | 5880 | 62.8 | 4560 | 61.6 | 3900 | 33.9 |
| May | 2700 | 49.8 | 8040 | 85.9 | 4600 | 62.2 | 5700 | 49.5 |
| June | 4040 | 74.5 | 6740 | 72.0 | 4740 | 64.1 | 7480 | 649 |
| July | — | — | — | — | 4440 | 60.0 | 7140 | 62.0 |
| August | 3230 | 59.6 | 6980 | 74.6 | 5280 | 71.4 | 7140 | 62.0 |
| September | 2400 | 44.3 | 6860 | 73.3 | 3600 | 62.2 | 4440 | 38.5 |
| October | 2700 | 49.8 | 4460 | 47.6 | 3180 | 42.9 | 4880 | 42.4 |
| Novembar | 940 | 17.3 | 5660 | 60.4 | 2800 | 37.8 | 2740 | 23.8 |

Table 3

Catch per unit effort in tuna driftnet fishery

*kg per boat day*

| Month | Area: North-west | West | South-west | South |
|---|---|---|---|---|
| *1982* | | | | |
| June | — | — | 96.9 | 52.0 |
| July | 184.3 | 106.2 | 81.2 | 77.2 |
| August | 83.6 | 96.6 | 131.7 | 141.0 |
| September | 41.9 | 56.4 | 142.4 | 109.6 |
| October | 80.1 | 49.3 | 96.6 | 52.3 |
| November | 96.9 | 88.6 | 78.3 | 93.1 |
| *1983* | | | | |
| April | 64.9 | 29.9 | 106.6 | 86.3 |
| May | 57.1 | 96.7 | 381.5 | 62.2 |
| June | 168.4 | 163.4 | 226.6 | 168.1 |
| July | 80.3 | | 125.6 | 190.3 |
| August | 71.5 | 80.6 | 161.5 | 139.1 |
| September | 112.2 | 41.3 | 104.3 | 111.2 |
| October | 100.8 | 61.6 | 82.5 | 71.5 |
| November | 31.2 | 32.0 | 98.8 | 32.2 |

Table 4

Percentage species composition in tuna driftnet fishery
June to November, 1982

| | | North-west | West | South-east | South |
|---|---|---|---|---|---|
| Tuna | Skipjack .. .. | 23.5 | 6.1 | 24.6 | 25.3 |
| | Yellowfin .. .. | 19.9 | 41.2 | 13.1 | 26.2 |
| | East. little tuna .. | 3.1 | 3.9 | 5.7 | 3.1 |
| | *Auxis* sp. .. .. | 4.4 | 2.7 | 10.0 | 7.4 |
| | | 50.9 | 53.9 | 53.4 | 62.0 |
| Billfish | Marlin .. .. | 7.2 | *11.7* | 20.1 | 12.6 |
| | Sail fish .. .. | 3.9 | 7.1 | 3.2 | 4.2 |
| | Sword fish .. | 0.5 | 1.1 | 1.0 | 1.0 |
| | | 17.6 | 19.9 | 24.3 | 17.8 |
| Shark | .. .. | 22.7 | 8.1 | 18.1 | 12.3 |
| Scomberomoridae | .. | 3.4 | 9.6 | 1.0 | 4.3 |
| Skate/rays | .. | 4.0 | *1.1* | 1.0 | 1.0 |
| Carangidae | .. | 4.2 | 2.9 | 1.0 | 1.6 |
| Demersal sp. | .. | 1.7 | 1.6 | 1.0 | 1.0 |
| Dolphin fish | | 1.0 | 1.2 | 1.0 | 1.0 |

Table 5

Percentage species composition in tuna driftnet fishery
April to November, 1983

| | | North-west | West | South-west | South |
|---|---|---|---|---|---|
| Tuna | Skipjack .. .. | 13.1 | 19.1 | 37.9 | 35.5 |
| | Yellowfin .. .. | 51.8 | 31.9 | 13.8 | 27.7 |
| | East. little tuna .. | 0.6 | 2.2 | 10.4 | 3.8 |
| | *Auxis* sp. .. .. | 1.2 | 0.8 | 3.3 | 6.0 |
| | | 66.7 | 54.0 | 65.4 | 73.0 |
| Billfish | Marlin .. .. | 2.9 | 70.0 | 18.8 | 3.5 |
| | Sail fish .. .. | 2.3 | 13.0 | 3.0 | 2.3 |
| | Sword fish .. | 0.2 | 0.8 | 0.6 | 0.2 |
| | | 5.4 | 23.8 | 22.4 | 6.0 |
| Shark .. .. | | 5.8 | 6.3 | 9.3 | 10.1 |
| Scomberomoridae .. .. | | 1.9 | 6.1 | 1.0 | 3.9 |
| Skate/rays .. .. | | 4.2 | 3.1 | 1.0 | 1.7 |
| Carangidae .. .. | | 10.3 | 3.2 | 1.0 | 4.2 |
| Demersal sp. .. .. | | 3.1 | 1.3 | 1.0 | 1.0 |
| Dolphin fish .. .. | | 1.0 | 1.0 | 1.0 | 1.0 |

Table 6

Percentage species composition in driftnet catches in combination
drift net/longline fishery — West

| | | 1982 June—November | 1983 April November |
|---|---|---|---|
| Tuna | Skipjack .. | 49.9 | 37.7 |
| | Yellowfin .. | 16.4 | 28.9 |
| | Mackerel tuna | 0.3 | 2.2 |
| | Frigate mackerel | 2.7 | 0.4 |
| | | 69.3 | 69.2 |
| Shark | | 22.7 | 10.8 |
| Billfish | Marlin .. | 1.8 | 8.7 |
| | Sail fish .. | 2.6 | 3.7 |
| | Sword fish.. | 0.7 | — |
| Scomberomoridae | | 1.0 | 2.9 |
| Skate/rays | | 1.0 | 3.0 |
| Carangidae | | 1.0 | 1.2 |

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Table 7

Contribution of skipjack and yollowfin tuna by weight to the mean catch per day estimated for different months.

| Area | 1982 (kg) | | | | | | 1983 (kg) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | J | A | S | 0 | N | A | M | J | J | A | S | O | N |
| *Skipjack* | | | | | | | | | | | | | | |
| NW | – | 67.0 | 4.1 | 17.4 | 1.2 | 4.5 | 5.6 | 14.0 | 27.7 | 27.1 | – | 16.4 | 1.3 | 2.5 |
| W | – | ¶1.5 | 1.0 | 3.0 | 2.1 | 14.3 | 3.2 | – | 40.3 | – | 27.6 | 1.7 | 13.6 | 9.9 |
| | | (55.0) | (144.2) | (13.5) | (43.4) | (5.7) | (9.6) | (28.6) | (9.6) | – | (12.7) | (3.1) | (4.9) | (2.2) |
| SW | 8.1 | 23.8 | 59.9 | 31.0 | 4.1 | 41.5 | 16.9 | 253.3 | 66.3 | 3.6 | 98.8 | 7.1 | 6.7 | 55.4 |
| S | 4.7 | 15.3 | 30.1 | 31.4 | 8.6 | 54.0 | 20.2 | 8.9 | 87.5 | 41.6 | 51.1 | 31.9 | 28.8 | 3.6 |
| *Ye/towfin* | | | | | | | | | | | | | | |
| NW | – | 37.5 | 21.3 | 10.1 | 4.7 | 21.1 | – | 8.7 | 112.4 | 27.5 | 28.1 | 76.1 | 52.7 | 11.1 |
| W | – | 46.4 | 70.8 | 2.3 | 6.7 | 12.2 | 4.6 | – | 73.7 | – | 6.1 | 11.2 | 20.8 | 2.0 |
| | | (4.1) | (11.6) | (18.6) | (36,1) | – | (2.4) | (1.0) | (36.8) | – | (11.6) | (13.8) | (3.2) | (59) |
| SW | 5.1 | 9.4 | 12.3 | 37.5 | 2.9 | 4.3 | 8.3 | 19.0 | 41.6 | 4.8 | 35.5 | 20.6 | 31.1 | 8.7 |
| S | 12.6 | 10.4 | 51.4 | 36.6 | 11.6 | 9.7 | 13.7 | 224.7 | 30.7 | 43.5 | 48.4 | 33.3 | 22.7 | 12.4 |

(Figures in parantheses are for driftnet fishery in the combination driftnet/longline fishery)



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Table 8

Catch rates of skipjack and yellowfin tuna in driftnet fishery

| Area | Yellowfin (kg) | | Skipjack (kg) | | Siva sub ramania m |
|---|---|---|---|---|---|
| | 1982 | 1983 | 1982 | 1983 | (1972) |
| NW | 18.9 | 39.6 | 22.2 | 13.5 | 26.8 |
| W(a) | 27.7 | 19.7 | 6.4 | 16.1 | 65 2 |
| (b) | 14.1 | 10.7 | 52.4 | 10.1 | — |
| SW | 11.9 | 21.2 | 28.1 | 82.5 | 40 5 |
| W | 22.0 | 28.6 | 24 0 | 34.2 | 52.6 |

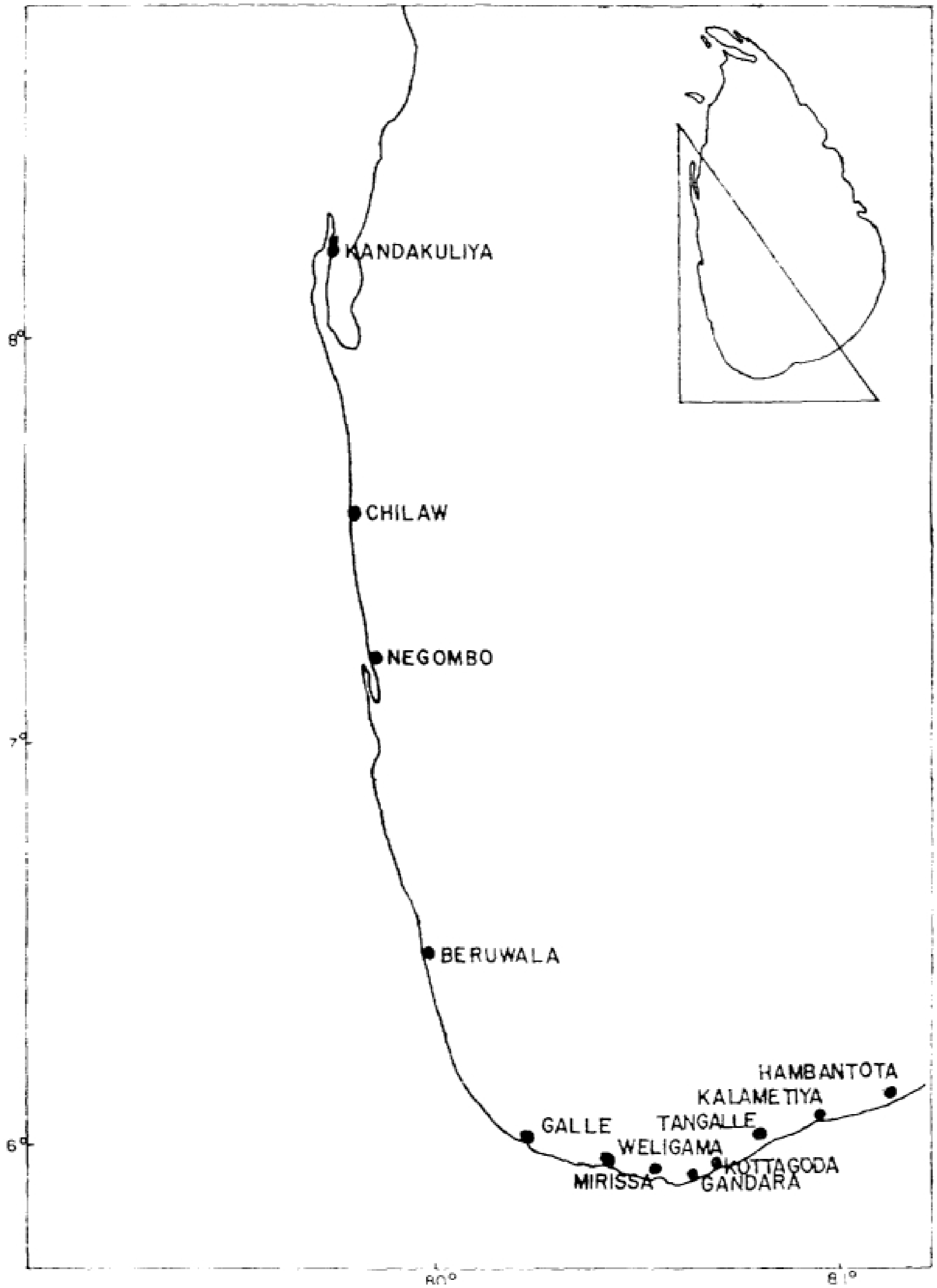


*Fig. 1. Study area.*

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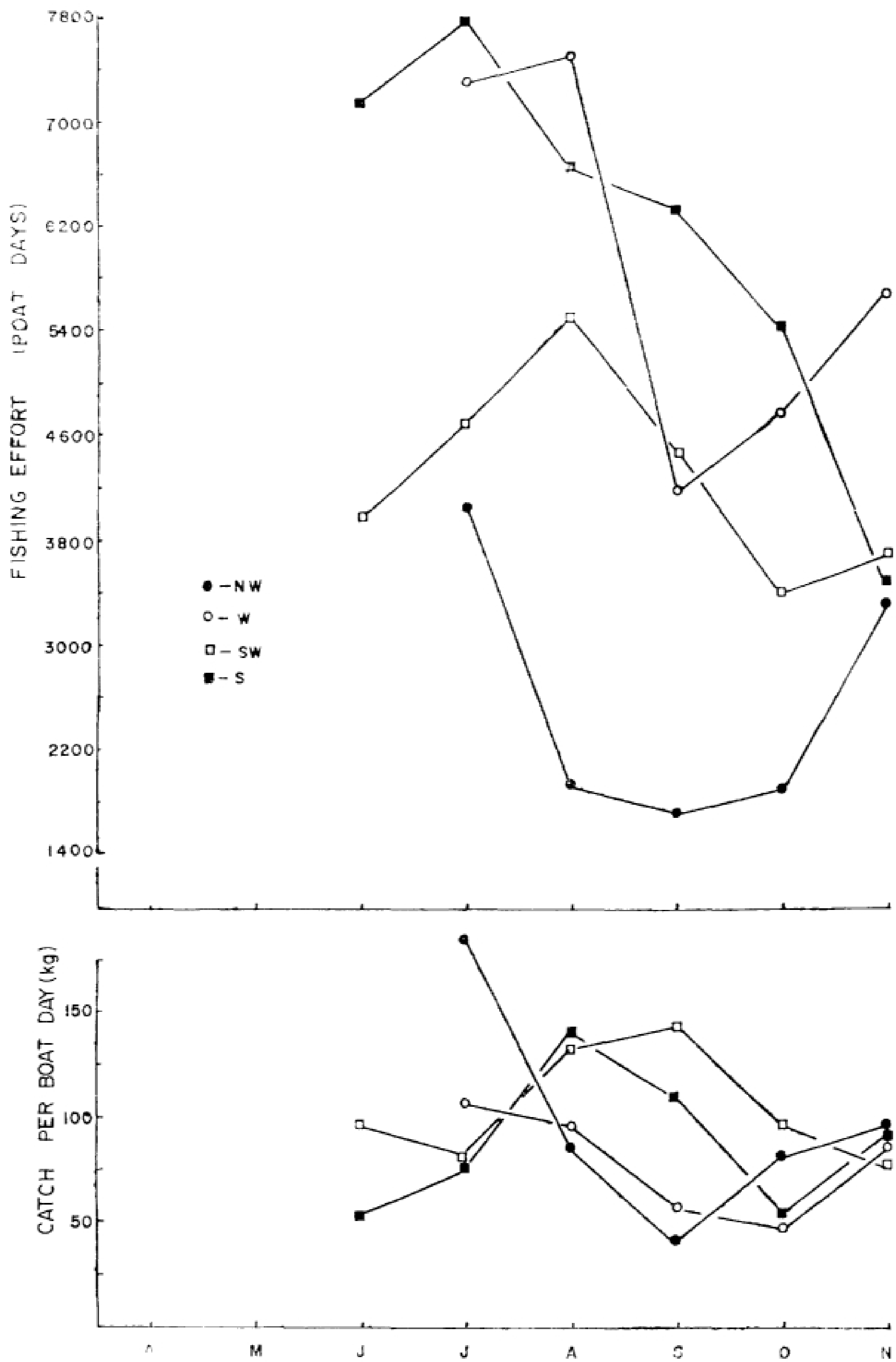


*Fig. 2. Monthly variation in total fishing effort and catch per unit effort, June to November.*



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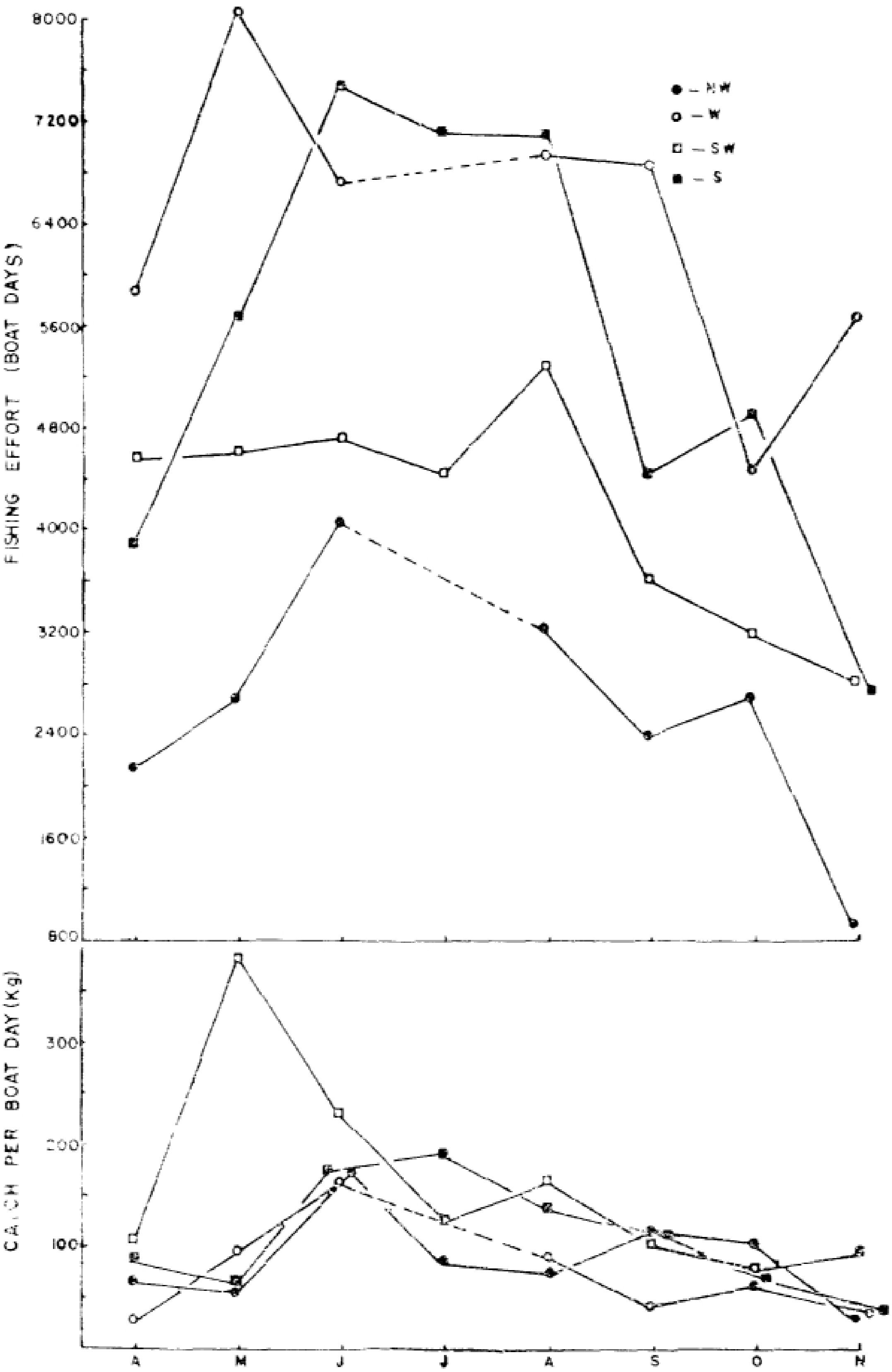


*Fig. 3. Monthly variation in total fishing effort and catch per unit effort, April to November 1983.*

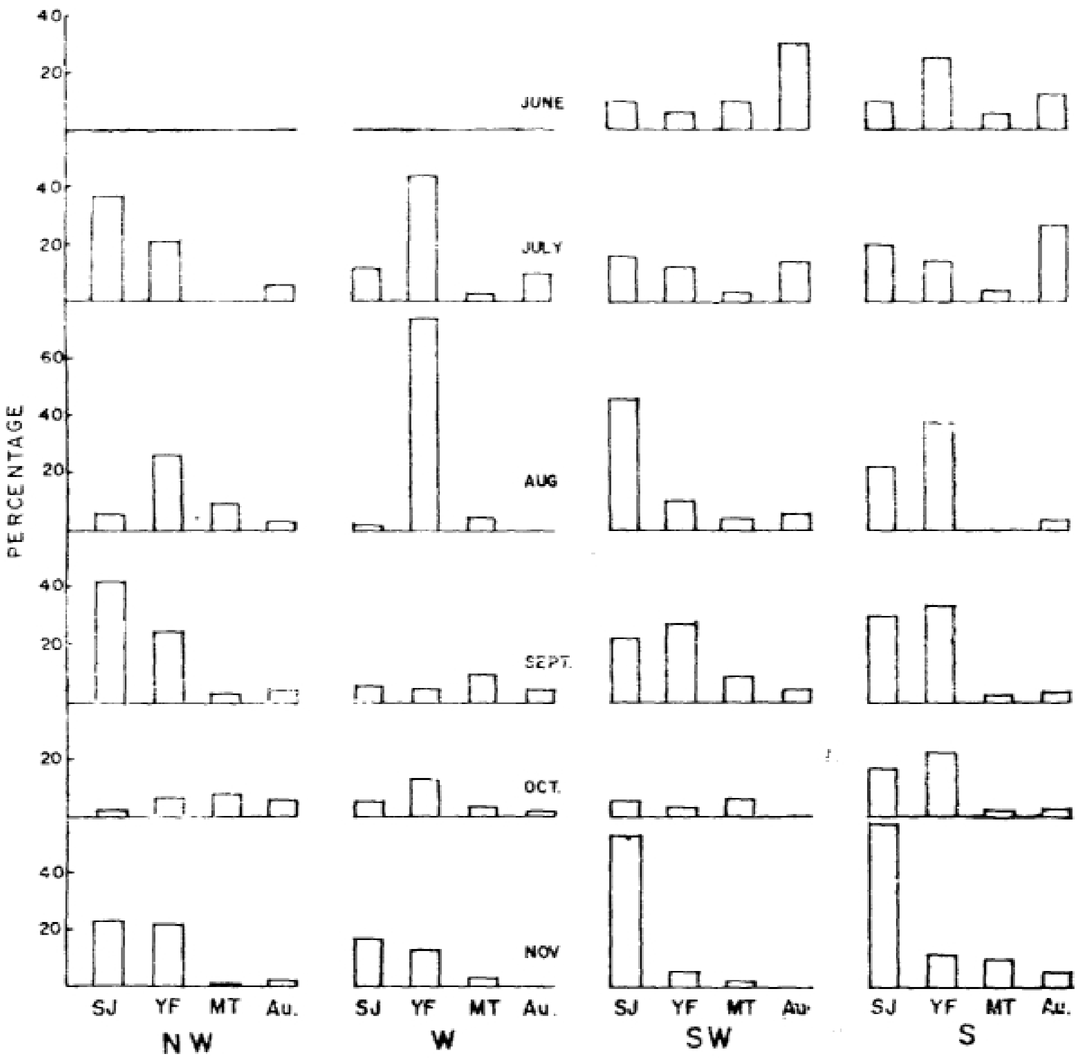


*Fig. 4. Percentage contribution of tuna to the driftnet fishery, June to November 1982.*

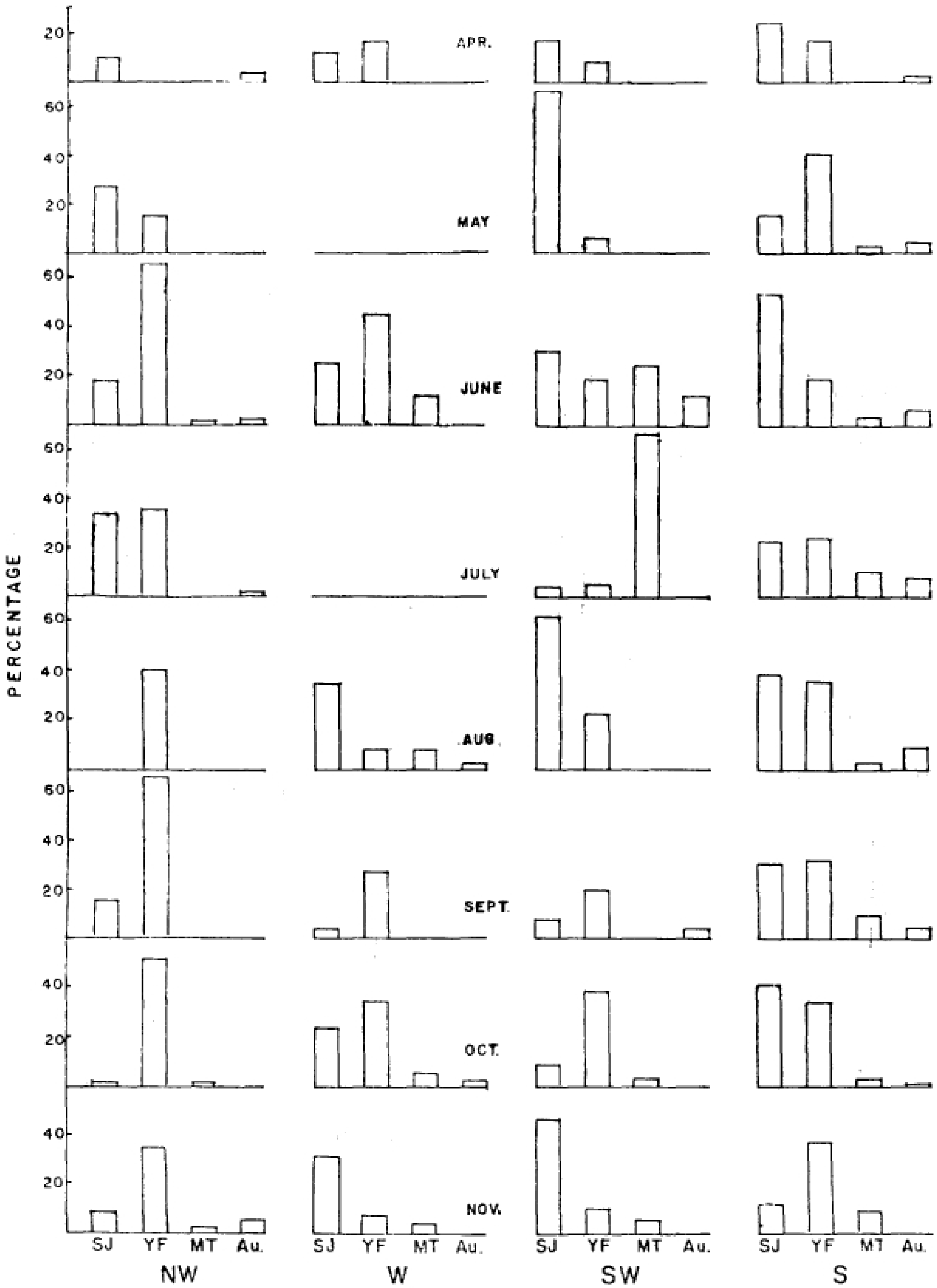


*Fig. 5. Percentage contribution of tuna to the driftnet fishery, April to November 1983.*

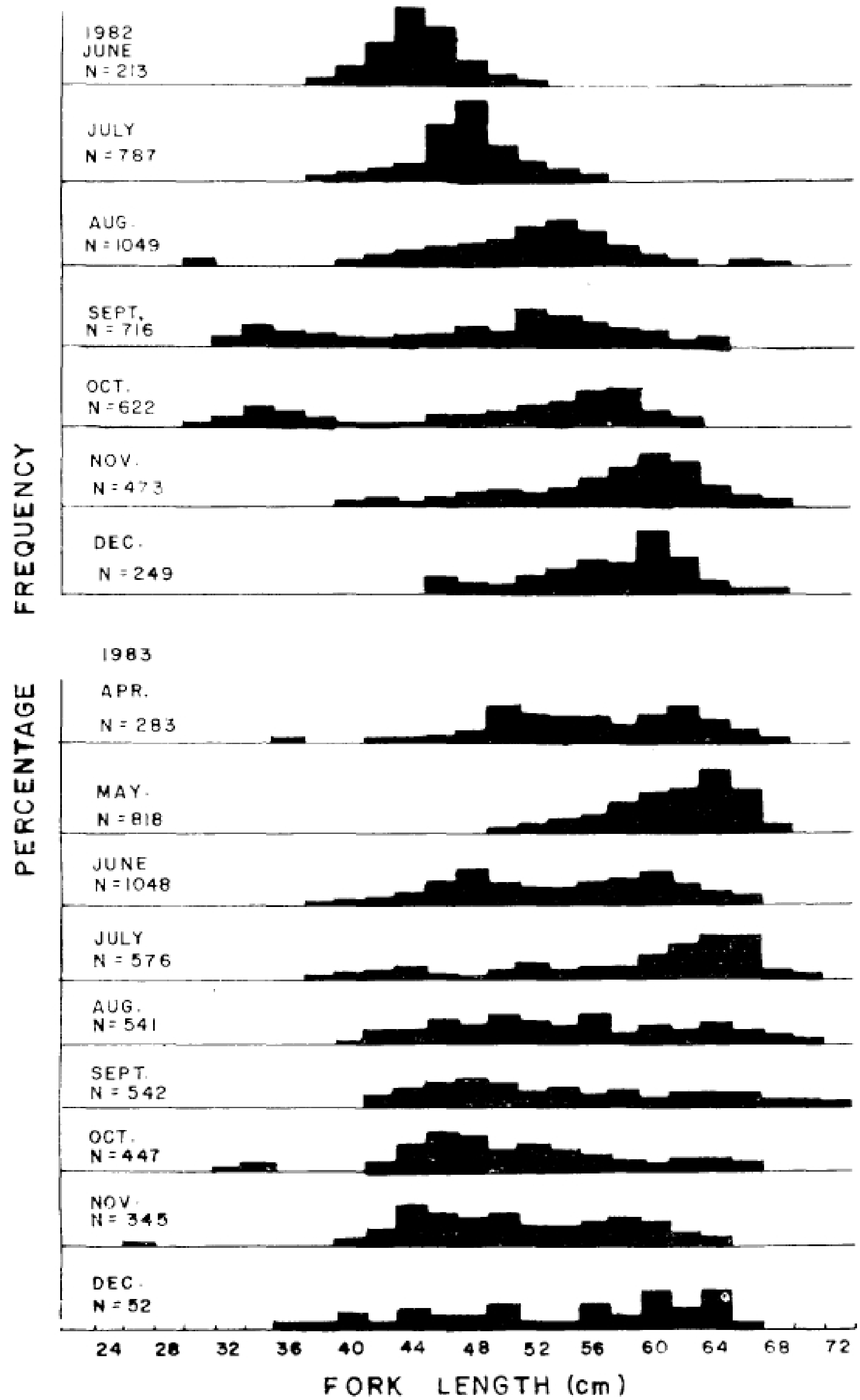


Fig. 6. Length frequency distribution of skipjack tuna in the driftnet fishery.



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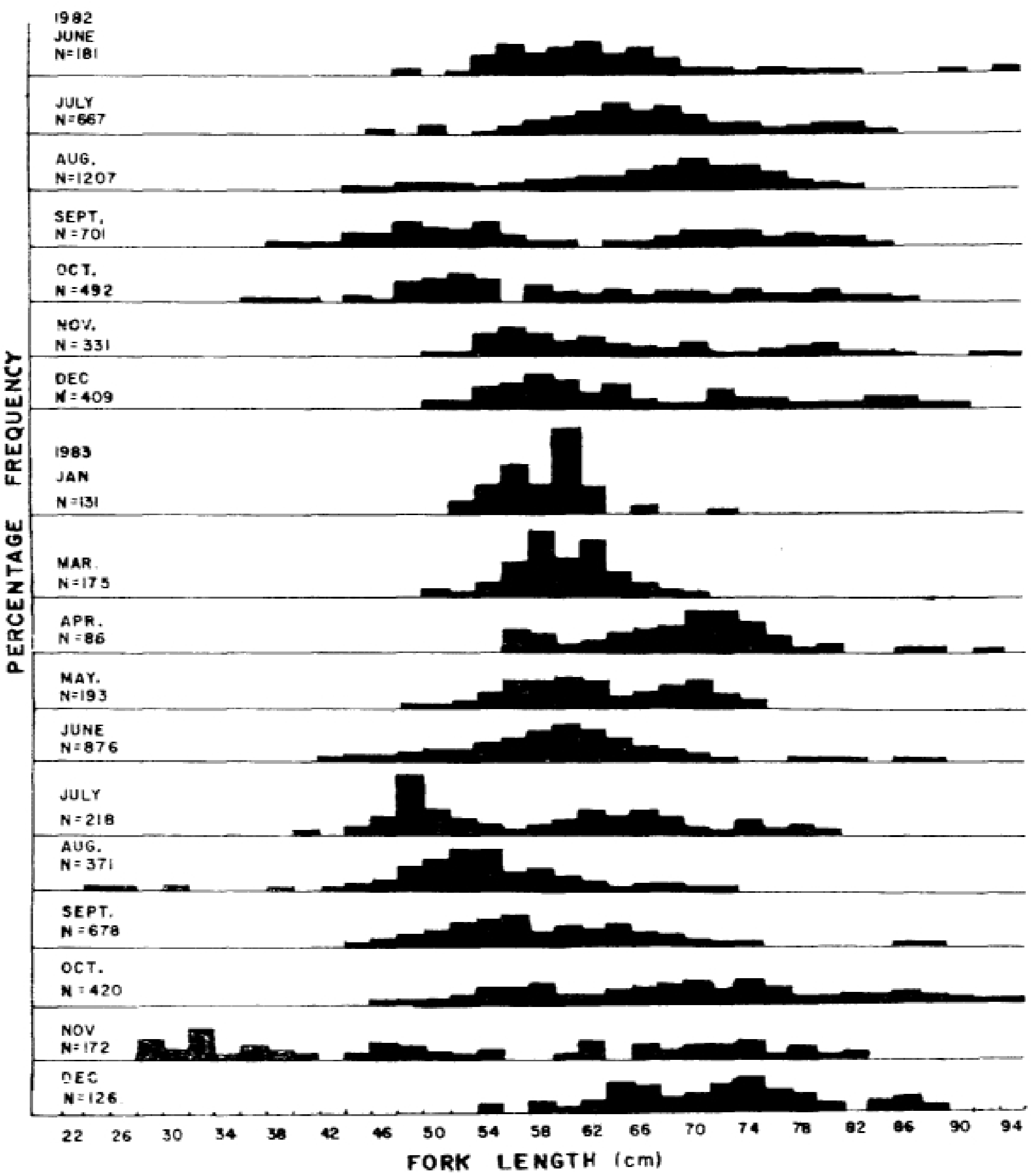


*Fig. 7. Length frequency distribution of ye/Iowfin tuna in the driftnet fishery.*

Appendix 4

## LIST OF PARTICIPANTS AND OBSERVERS

### Participants

*Maid/yes*

| | |
|---|---|
| Mr. Hassan Maniku | Senior Fishery Development Officer<br>Ministry of Fisheries<br>Male |
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*Sri Lanka*

| | |
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| Mr. Leslie Joseph | Research Officer<br>National Aquatic Resources Agency<br>Colombo |
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| Dr. M. Siddeek | Technical Liaison Officer<br>National Aquatic Resources Agency<br>Colombo |

*FAO/BOBP*

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| Mr. 1. Sakurai | Senior Fishery Statistician<br>IPTP, Colombo, Sri Lanka |
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| Mr. J. Hertel-Wulif | Fishery Biologist<br>BOBP, Colombo, Sri Lanka |

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|---|---|
| Mr. M. J. Abraham | High Commission of India<br>Colombo, Sri Lanka |
| Mr. B. A. Ravi | High Commission of India<br>Colombo, India |

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