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

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BAY OF BENGAL PROGRAMME
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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

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°en similar. 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

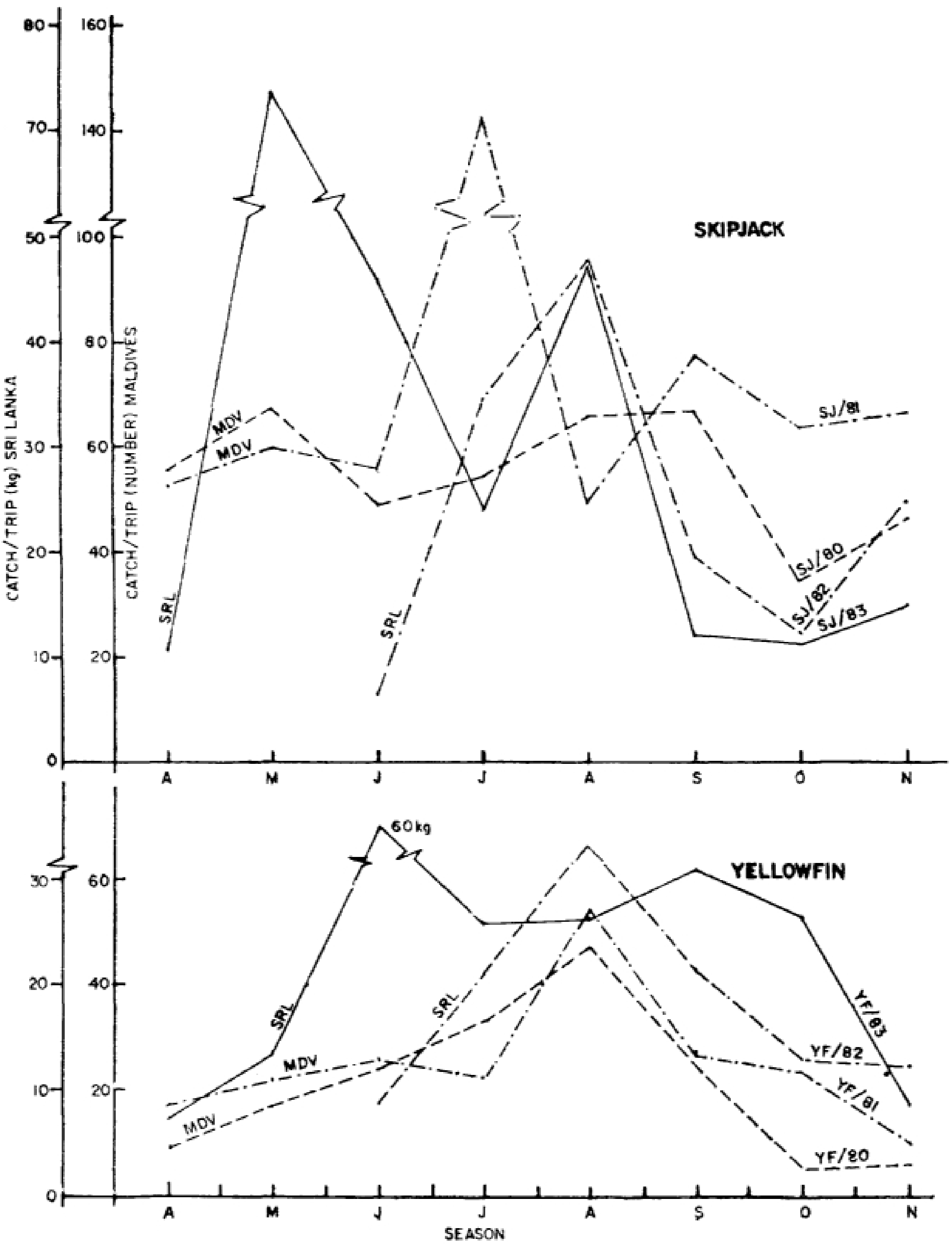

Fig. 1. Seasonal variations in the catch rates of skipjack and ye/fowl/n tunas around Ma/dives and Sri Lanka.

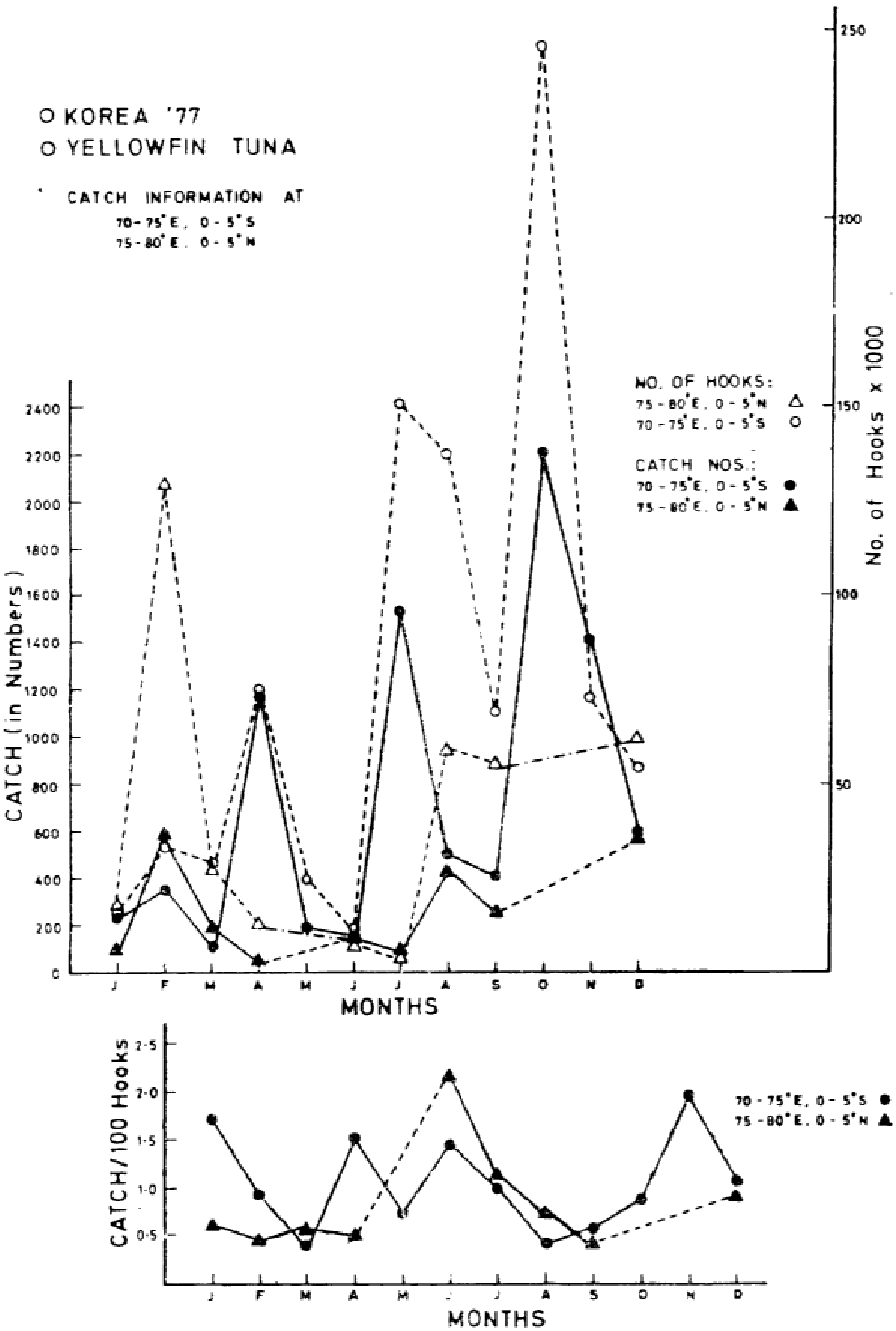

Fig. 2. Seasonal trends in long//ne fishery in the area.

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 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.

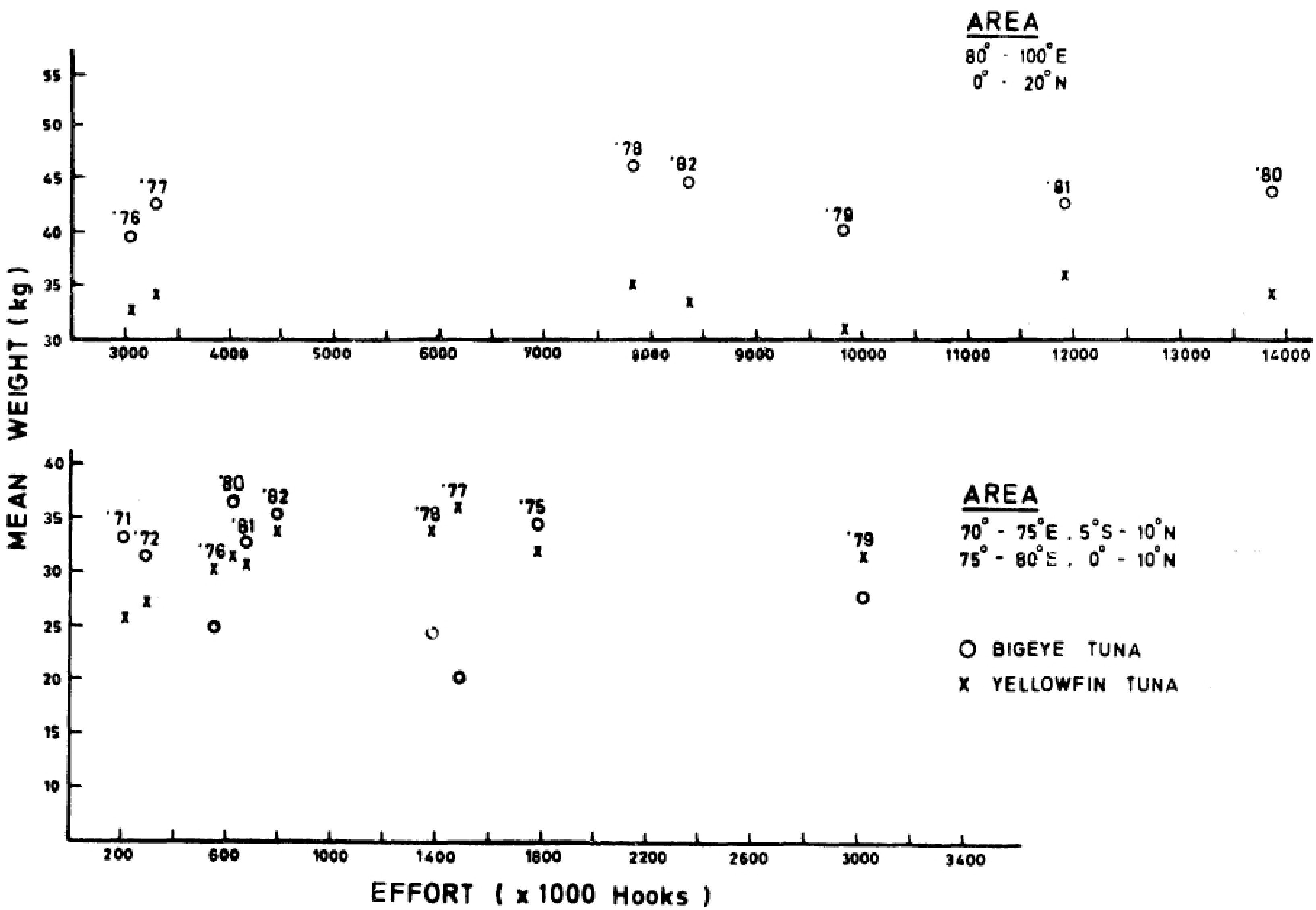

Fig. 3. Mean weight of individual big eye and ye/towf/n tuna caught by Taiwanese long/meTs in the Bay of Bengal west of Sri Lanka.

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_∞ 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 (54,720) *	40,000 (45,000) *
3. Mean catch rate offshore	44,188	—

* Biomass

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 (168x10^6 hooks) and 32,300 tonne (341x10^6 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.

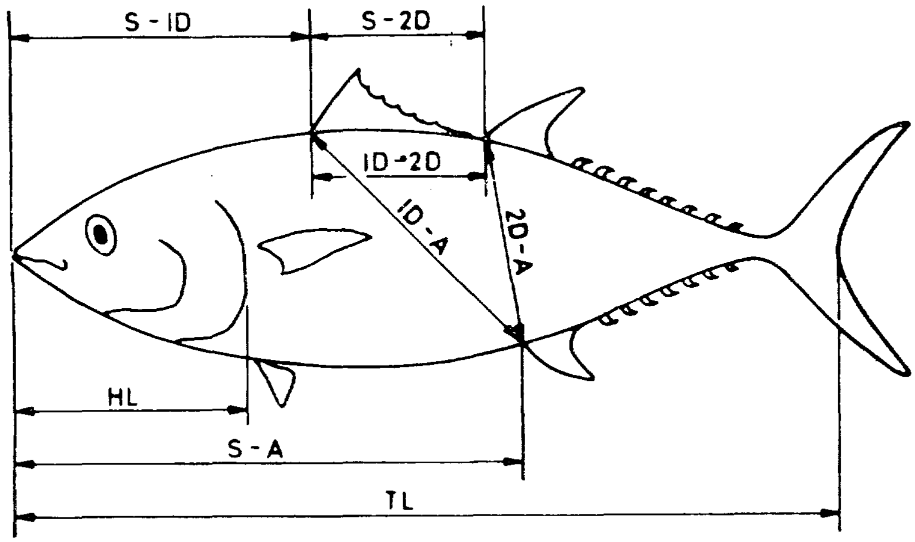

Fig. 4. Eight morphometric measurements used to study ye/Jowfin and skipjack school characteristics

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 frequency 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

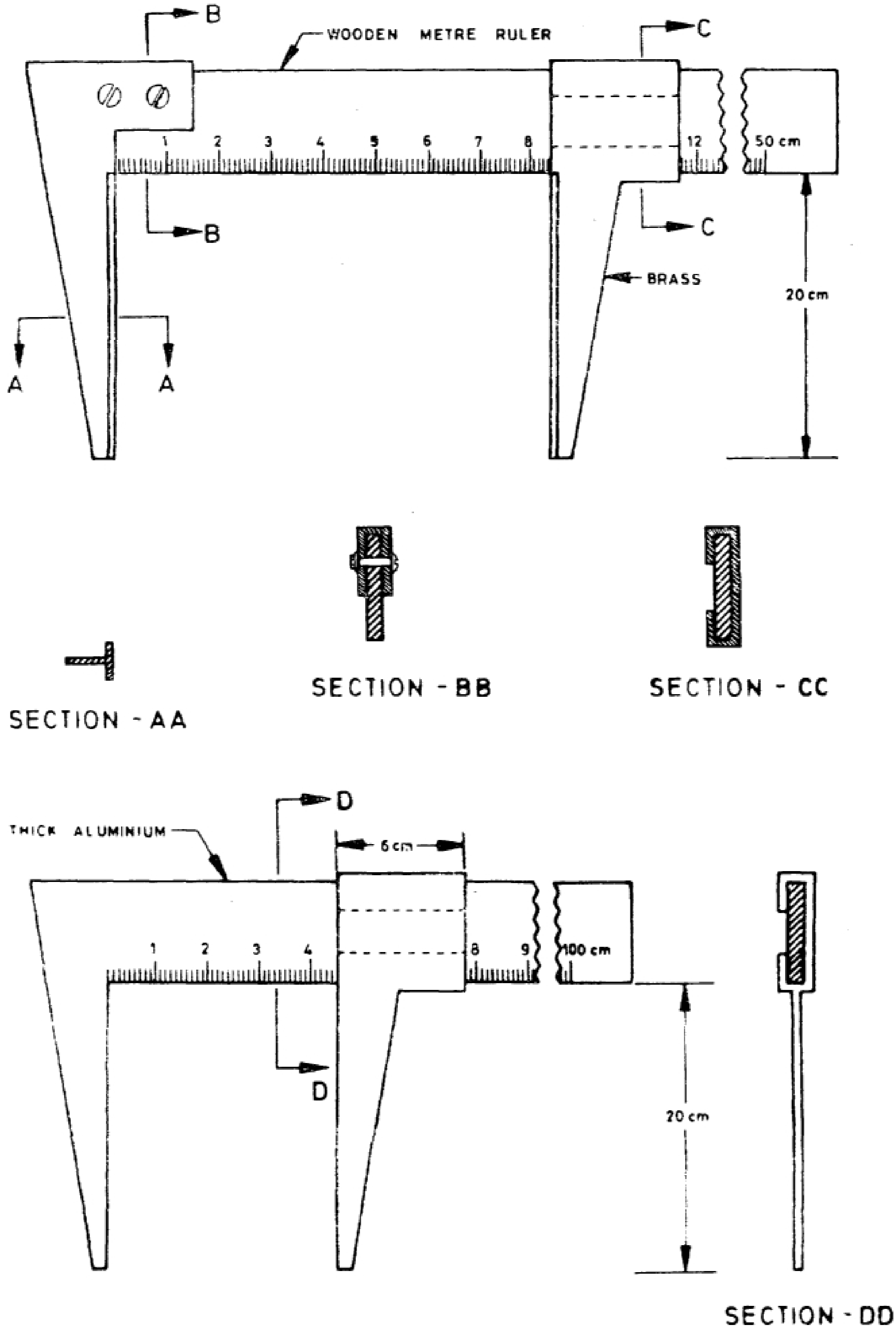

Fig. 5. Fabrication of a caliper (0.5 m and 1.0 m).

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

Area 70°–75°E 0°–5°S	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
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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