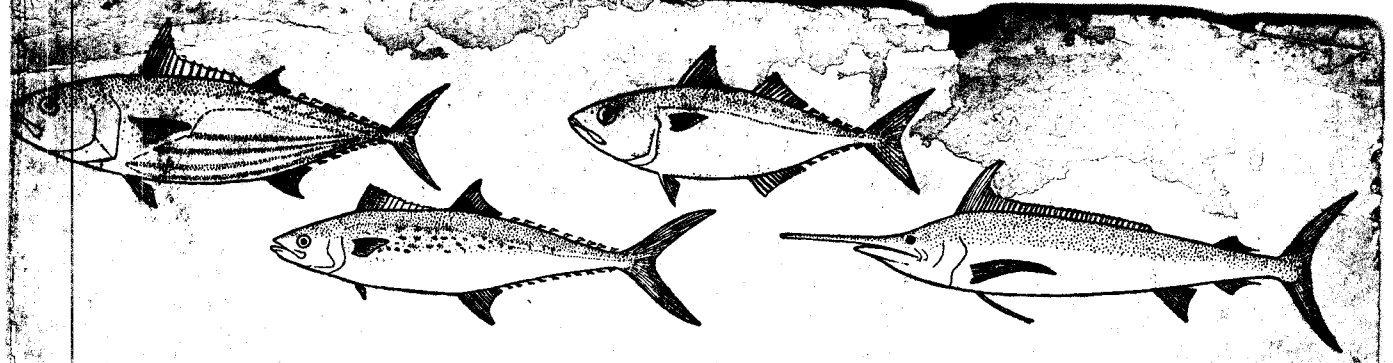
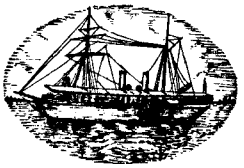
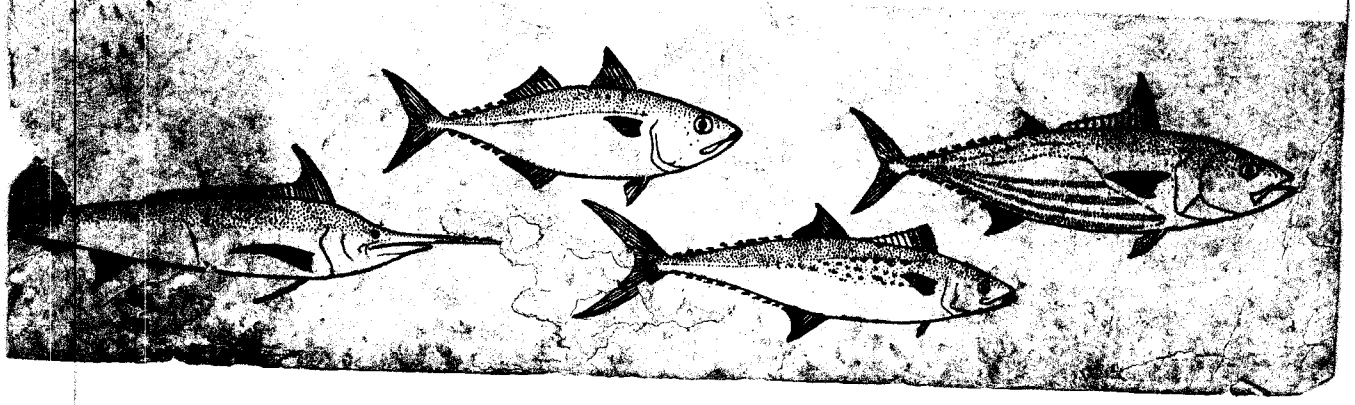


SYMPOSIUM ON SCOMBROID FISHES

PART I



MARINE BIOLOGICAL ASSOCIATION OF INDIA
MANDAPAM CAMP
S. INDIA

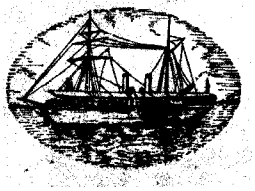


PROCEEDINGS OF THE

SYMPOSIUM
ON
SCOMBROID FISHES

HELD AT MANDAPAM CAMP FROM JAN. 12—15, 1962

PART I



SYMPOSIUM SERIES 1
MARINE BIOLOGICAL ASSOCIATION OF INDIA
MANDAPAM CAMP
S. INDIA

DISTRIBUTION OF THE YOUNG STAGES OF THE MACKEREL, *RASTRELLIGER KANAGURTA* (CUVIER) IN THE INDIAN INSHORE WATERS *

BY

K. VIRABHADRA RAO

Central Marine Fisheries Research Institute, Mandapam Camp.

The aim of this paper is to present a consolidated account of the information so far available both from the published and unpublished reports of different scientific workers on the periodical occurrence of the young stages of the mackerel, *Rastrelliger kanagurta* from the Indian inshore waters with a view to emphasising the importance of obtaining such additional information as would enable filling up certain lacunae which at present exist in our knowledge of the biology of the mackerel. If very young juveniles of the same size range occur in different seasons in different areas, as observed by several workers, it follows that the spawning activity of the adult mackerel, which has resulted in them, cannot be restricted to any one particular period all along the Indian coasts. The extent of diversity in the spawning behaviour of the mackerel from different regions is worthwhile investigating for it provides the basic information to determine the rate of recruitment of the year classes which enter the fishery. A study of the rate of growth of mackerel in the first and subsequent years of life needs immediate attention for a knowledge of this would help in fixing precisely the age of the young of any known size and tracing them back in the time scale to the spawning stocks. It is also necessary to initiate an ecological study to ascertain the relationship between the environment and the feeding habits of the mackerel in view of the very diverse opinions expressed as to whether the food of the species is determined in a general way by the availability of the edible planktonic elements or a specific selectivity is exercised by it at definite growth stages.

SIZE-FREQUENCY DISTRIBUTION OF THE MACKEREL WITH PARTICULAR REFERENCE TO THE OCCURRENCE OF JUVENILES AND THEIR FEEDING HABITS IN INSHORE WATERS

In the life-history of a fish, after the post-larva, the stage at which the young one is essentially similar to the adult is called the juvenile, which as the age advances is ascribed to the O-year class, 1-year class, 2-year class etc. When the young one attains the size of first sexual maturity it is known as the adult. The term juvenile is used here to mean a young fish. The minimum size at sexual maturity is known to be 224 mm.

Juveniles of *R. kanagurta* of very small size are occasionally obtained along with other fishes like the white-bait, silver bellies etc., in different types of gear ordinarily employed for commercial catches. The mackerel fishery of India is supported mostly by immature ones of about 170 mm and above which move in enormous shoals and are caught almost exclusively in bag nets, gill nets, boat seines etc. The smaller ones, however, do not in general appear in appreciably large schools in the inshore waters. They have been reported from the

* Published with the permission of the Director, Central Marine Fisheries Research Institute, Mandapam Camp.

Arabian Sea off the coasts of Ratnagiri, Karwar, Mangalore, Cannanore, Calicut, Ernakulam and Vizhingam, from the Bay of Bengal off Madras and Visakhapatnam and from the Andaman Sea near Port Blair. The region-wise and length-wise distribution of the mackerel catches with notes on their biology are given below :

Ratnagiri: From Pawas a fishing village near Ratnagiri on the 24th September, 1959 young mackerel from 62 to 112 mm with two dominating groups 78 mm and 88 mm were obtained in the cast nets (George and Annigeri 1960). The feeding intensity of these was observed to be high and their stomach contents revealed diatoms, dinophysids, copepods and penaeid protozoeae. It was considered that the very young stages obtained in September were probably the result of spawning having taken place a few months earlier. From Myria Bay near Ratnagiri from 28th to 30th October, 1961, young ones from 108 mm to 151 mm with mode values at 125 to 135 mm were obtained in 'rampani nets' (Narasimham, 1962).

Karwar: Occasional stray specimens from the fishermen's catches measuring 83 mm and 95 mm on 17th April 1949, 144 mm to 154 mm on 24th April, 1953, 140 mm and 154 mm on 28th April, 1953, 172 mm to 188 mm on 7th May, 1953 and 130 mm and 170 mm on 23rd August, 1953 have been reported from Karwar (Pradhan 1956) in addition to the normally occurring individuals in different months of the year when they seem to show a definite pattern of distribution in size-groups *viz.* 120 mm to 240 mm groups averaging from 175 mm to 185 mm in October, 160 mm and still smaller groups gradually becoming less in the subsequent two months, 195 mm to 205 mm groups dominating in December-January, 195 mm to 205 mm, 215 mm to 225 mm groups dominating in succession in February and March, 200 mm to 250 mm groups with a sprinkling of 190 mm ones in April-May, 190 mm to 240 mm groups with dominating size at 225 mm in May and 200 mm to 260 mm groups in June to September. In the first half of September, mackerel from 120 mm to 160 mm have been known to be common. It may be noted that the fishery lasts from about October to March and the spawning season of the species along the coast from June to September.

From Pradhan's findings for the period 1948—1953 there is an indication that the younger groups contribute to the major portion of the catch in the mackerel fishery. Radhakrishnan (1958) has given the length frequency distribution of the catches, which show that the groups from 170 mm to 219 mm constitute over 52% of the total in 1954-55 and those between 140 mm and 219 mm to the extent of over 76% in 1955-56. The month-wise composition of the mackerel catch at Karwar for 1955-56 season given by him shows that 140 mm to 220 mm groups constitute 96.7% of the total in October, 170 mm to 200 mm groups 77% in November and 200 mm to 220 mm groups 39% in February and 49% in March.

Regarding food of mackerel from the Karwar coast in general, Pradhan (1956) states that they feed both on phytoplankton and zooplankton. Common among the phytoplanktonic elements are *Coscinodiscus, Rhizosolenia, Biddulphia* etc., and among the zooplanktonic elements are copepods, Lucifer, crustacian larvae and molluscan larvae. Occasionally some fish eggs are encountered, forms like chaetognaths, spionid larvae, stomatopods, hydromedusae, ctenophores and salpae are rarely recorded and *Noctiluca* is conspicuously absent from their stomach contents.

Malpe and nearby places, north of Mangalore between Baikampady and Tarapathy in South Kanara district, Mysore State: Sekharan's (1958) data on the age composition of the catches for 1954-55 and 1955-56 mackerel seasons for the area show that the fishery draws

its support mainly from single age-group consisting of 180 mm, 190 mm and 210 mm groups. The modal values in 1954-55 season from November to March are 185 mm, 195 mm, 215 mm, 225 mm and 225 mm for the respective months. From the analysis of the size frequency data for the South Kanara coast and from the data collected by the Madras Fisheries Department at West Hill he concludes that the mackerel attains a total length of 120 mm to 150 mm at the end of the first year and 210 mm to 230 mm at the end of second year. It may be pointed out here that Pradhan's (1956) estimation is that the species attains 100 mm at the end of the first year and 180 mm or more after completing the second year.

In the material collected in 1954-55, Sekharan found that the gonads were immature in stages I and II in November and December and in the maturing stages III and above in the following months. They were in stages III and IV in February and in a very advanced state of maturity in March, probably in stage V and some with a few transparent eggs which oozed out readily when the abdomen was slightly pressed. A study of the ova-diameter measurements for the period December to April in 1955-56 confirmed the observations he made earlier. It has therefore been concluded that the spawning commences in March or April, although the height of the breeding activity may occur later.

Ullal near Mangalore: In September 1961 mackerel obtained in the fishery ranged from 155 mm to 209 mm with one dominant mode at 185 mm - 189 mm. In the southern centres smaller ones from 65 mm to 169 mm with two modes between 80 mm-84 mm and 150 mm-154 mm comprised the catches. At Ullal in the catches by rampanis 180 mm-184 mm group dominated in October-November and 170 mm - 174 mm group in December and in those by castnets 110 mm - 114 mm group in December.

Copepods formed the main item of food. In October mackerel in stage VIa and VIb were landed in considerable numbers (*Quart. Sci. Rept., C.M.F.R.I.* Sept. and Dec. '61).

Cannanore: From July to September 1961 the mackerel fishery was supported mainly by individuals of larger sizes between 196 mm and 245 mm to the extent of about 98% the rest being composed of smaller individuals between 95 and 105 mm. The intermediate sizes commonly met with in the fisheries were absent. In October to December '61 the size range was between 102 mm and 195 mm with 175 mm - 185 mm group dominating.

The maturity stages of the adults obtained in the fishery for the six months period commencing from July were in IV to VII; in October they were in stages V to VII with VI b and VII dominating and by November all were in stage VII. The occurrence of individuals in maturity stages of V and VI b as late as in October indicates that the spawning has extended beyond the usual period from June to September. The feeding intensity was found to be high in July but low in about September, the mackerel feeding on copepods ostracods, pteropod larvae and *Bacillariophycae*. In October and November they were feeding on equal amounts of phytoplankton and zooplankton but in December, more on phytoplankton.

Calicut: Mackerel measuring 40 mm to 70 mm with a modal size at 60 mm were observed in June 1940 (Madras Fisheries Administrative Report for 1940). Bhimachar and George (1952) noticed 100 mm to 130 mm individuals in July and 56 mm to 80 mm ones in August 1949. The size frequency dtstribution of the mackerel which appear in the fishery follow more or less the same pattern as in other nearby northern centres on the west coast.

Chidambaram *et al.* (1952) have divided the mackerel season broadly into three periods *viz.*, (i) July to September when fish of all sizes appear in the inshore waters, (ii) October to

January when mostly those of intermediate sizes constitute the catches and (iii) February to the end of the season in about April when fish of larger sizes of 190 mm and above only occur. For 1949-50 season they reported the occurrence of mackerel of 135 to 152 mm in July, 60 to 245 mm (with mode values at 80, 130, 150 and 200 mm) in August, 100 to 200 mm (110, 140 and 200 mm) in September, 170 to 200 mm (180 mm) in October, 140 to 200 mm (150 and 195 mm) in November, 160 to 200 mm (180 mm) in December, 190 to 210 mm (210 mm) in January, 190 to 210 mm (200 mm) in February, 200 to 230 mm (220 mm) in March and 200 to 250 mm (215 mm) in April.

In the following account are given the size ranges of mackerel from particulars available in the quarterly Scientific Reports of the C.M.F.R.I., June-December, 1961. The size ranges in April and May 1961 were 213 mm to 230 mm and 218 mm to 231 mm respectively and these should be regarded as members comprising the fishery of the later part of 1960-61 season. In 1961-62 the mackerel fishery has been a failure all along the west coast and the season at Calicut commenced in the last week of August when a very small catch of individuals from 62 mm to 105 mm with a modal size of 85 mm were obtained in the boat-seines. In September the catch was represented by two distinct groups, one ranging from 124 mm to 154 mm with a modal size of 145 mm by gill nets (Aila chalavala) and the other ranging from 181 mm to 238 mm with a modal size of 225 mm by boat-seines (Paithuvala). The catches ranged from 157 mm to 187 mm with a modal size at 165 mm in October, 155 mm to 187 mm with a dominant size of 175 mm in November and 165 mm to 186 mm with a modal size at 175 mm in December.

Bhimachar and George (1952) have observed that the mackerel are exclusively plankton feeders, depending mainly on "copepods, cladocerans, larval and adult decapods, peridinians, diatoms and to some extent on post-larval bivalves, fish eggs and larvae, polychaete larvae, cirrepede nauplii, appendicularians and pteropods". The non-edible forms like salps, medusae, stomatopod larvae, chaetognaths and *Noctiluca* are avoided. A low feeding intensity has been observed in the pre-spawning and spawning periods and no difference between the food of the young and adults has been noticed. Feeding intensity in juveniles of 160 mm-200 mm range was found to be the highest in September to December when the inshore waters are rich in plankton.

In July to September period of 1961 in Mackerel measuring from 72 mm to 226 mm copepods formed the major portion of the stomach contents along with some decapod eggs and larvae and in a few cases with fish eggs. Phytoplankton also constituted their food, represented by *Ceratium* and *Coscinodiscus*. In October to December '61 in mackerel of 159 mm to 183 mm copepods formed the main item of the food; crustacian eggs, zoeae, bivalve larvae and *Pleurosigma* were present to some extent; fish eggs in a few (in October) and fish scales in large numbers (in December) were also noticed in the stomach contents (Quart. *Sci. Report, C.M.F.R.I.*, Sept. Dec. 1961). Chidambaram *et al.* (1952) have noticed a high fat content in two periods, October-November and March-April and this has been correlated with the greater feeding intensity in the preceeding months. In the larger size groups the higher fat content has been attributed also to the relatively greater gonadal development before the spawning season.

Regarding the breeding periodicity of mackerel along this coast, Devanesan and John (1940), Devanesan and Chidambaram (1948) and Chidambaram *et al.* (1952) have stated that spawning commences in about April, May or June and lasts till September.

Vizhingam: Balakrishnan (1957) has furnished an account of the occurrence of spawners and juveniles of mackerel along the region for the periods of March to August of 1955 and 1956. The adult mackerel of 220 mm to 240 mm groups obtained in March-April months were mostly with ripe gonads and some with spent gonads, indicating that spawning had already commenced. In the subsequent months till July the percentage of individuals with spent gonads increased in the samples examined. In plankton hauls made during the period, what could possibly be considered as mackerel eggs were observed. Very young stages of mackerel 27 mm to 50 mm were obtained in March, 1955. The size range of young ones (dominant size group within brackets) were 70 mm to 160 mm (150 mm) in March, 40 mm - 150 mm (110 mm) in April, 30 mm to 140 mm (40 mm) in May, 30 mm to 130 mm (70 mm) in June, 60 mm to 180 mm (120 mm) in July and 100 mm to 160 mm (130 mm) in August, 1956.

The size ranges of the mackerel in the fishery during 1961 are 60 mm to 270 mm with dominant size of 135 mm for the juvenile group and 225 mm for the adult group in April to June, 40 mm to 240 mm with only one mode at 130 mm in July to September, and two distinct groups one from 35 mm to 140 mm with modes at 60 mm and 120 mm and the other from 195 mm to 240 mm with a mode at 230 mm in October to December.

From July to September, phytoplankton formed the major item of food whereas in the earlier and subsequent quarters copepods and other crustaceans dominated (*Quart. Sci. Rep. C.M.F.R.I.*, for June–Dec. 1961).

Ernakulam: As compared with other regions mentioned above, the fishery here is confined to backwaters and is of moderate magnitude. The dominant sizes or the size ranges, monthwise for the year 1960 and 1961 are given in the following table:—

Month	Dominant size or size range in 1960 (in mm.)	Dominant size or size range in 1961 (in mm.)	Month	Dominant size or size range in 1960 (in mm.)	Dominant size or size range in 1961 (in mm.)
January ...	...	210	July ...	130	...
February ...	...		August ...	160	...
March ...	...		September ...	190	110 & 180 (90-210)
April ...	210	210–230	October ...	200	180
May ...	210 & 110–150	200–220	November ...	200	(150–210)
June ...	...	200–230	December	210	150–210

Examination of the gonads of the adult mackerel had shown spent-resting condition from January to March but in one female in March spent condition with a few large residual eggs was noticed. In general feeding intensity was moderate in April to September and active from October to March; copepods, tintinnids, fish larvae, bivalvae larvae, *Fragilaria* sp, *Coscinodiscus*, dinoflagellates and diatoms formed its food. In October mackerel of 150 mm to 160 mm in length were found to feed mostly on post-larval fishes. In July to September period fish scales were often found in the stomach contents (*C M.F.R.I. Annual Report* 1960–61 and *Quart. Rep.* for April–Dec. 1961).

Madras: As compared with the mackerel catches on the west coast of India, those on the east coast are very poor comprising only about 20% of the total landings even in the best of the years when the fisheries are good (Pradhan and Rao 1959). Landings of some magnitude have been in recent years reported from Mandapam, Madras, Kakinada,

Visakhapatnam and some parts of Orissa. The appearance of the shoals is erratic and no size frequency data are available to show variation in catch composition from season to season. In the following account are dealt with the size ranges of small mackerel obtained from the fishermen's catches in certain months.

Rao and Basheeruddin (1953) reported for the first time from the east coast of India the occurrence of small juveniles of mackerel in the inshore waters of Madras, ranging from 49 mm to 103 mm with a dominant size at 89 mm. Along with these, three other groups *i.e.* 130 mm to 170 mm, 190 mm to 210 mm and 220 mm to 240 mm individuals were also obtained in the seine-net catches. It is of interest that the occurrence of juveniles of about 50 mm or slightly above in March-April months on the east coast after the north-east monsoon is similar to almost the same size groups being very commonly found along the west coast about the close or immediately after the south-west monsoon.

Basheeruddin and Nayar (1962) recorded in 1954 juveniles of 130 mm to 150 mm (135 mm) in March, 40 mm to 120 mm (70 mm) in April, 40 mm to 60 mm (50 mm) in May and in 1955, 50 mm to 110 mm (90 mm) in February, 40 mm to 100 mm (80 mm) in March, 40 mm to 120 mm (80 mm) in April, 110 mm to 140 mm (130 mm) in June and 90 mm to 170 mm (110 mm) in July. In respect of the food of the juveniles they have noted predominantly phytoplanktonic organisms with fair amounts of small zooplanktonic organisms in individuals upto 80 mm ; post larval fishes, stomatopod larvae, and other crustaceans with very little of phytoplanktonic organisms in those between 90 mm and 100 mm and crustaceans like advanced zoeae, *Acetes* and copepods along with fair amounts of phytoylanktonic organisms in those above 100 mm in total length.

Kuthalingam (1956) has given an account of the food and feeding of the mackerel at different growth stages. According to him the "post-larvae" from 5 mm to 6 mm feed on diatoms and filamentous and other types of algae, but when they grow into " juveniles ", they become omnivorous feeding on all available, edible planktonic organisms ; the " adults " are carnivorous feeding on post-larval and juvenile bony fishes. The terms " juveniles " only to those upto about 25 mm and "adults" to all from 35 mm upto 225 mm in length as applied by the author based on the material he examined are not in confirmity with the generally accepted definitions (Hubbs, 1943; Jones, 1950).

Visakhapatnam: Rao and Basheeruddin (1953) recorded juvenile mackerel from 100 to 140 mm in the month of June of both the years 1951 and 1952. Satyanarayana (1955) observed in 1954 juveniles from Lawson's Bay measuring 57 mm to 90 mm (65 mm) on 5th May, 68 mm to 121 mm (85 mm) on 24th May and 48 mm to 75 mm (55 mm) on 4th August.

Rao and Rao (1957) have studied the food habits of the mackerel from 32 mm to 243 mm in length occurring along the coast and found that in those from 32 to 90 mm, post-larval fishes formed the staple food along with some amounts of lucifers, copepods and protophyta; in those above 90 mm relatively very little of zooplankton constituted their food. They also observed that the relative growth of the alimentary canal is greater in the adults than in the juveniles and that the change in the food habits is closely associated with the relatively greater increase in the alimentary tract as the fish grows to reach the adult stage.

Port Blair (Andaman Sea): In January 1961 from the Jungleghat area near Port Blair a few small mackerel of about 50 mm in total length were obtained. Subsequently (Rao & Luther 1961) in the middle of March for a few days a large number, nearly 800 individuals,

ranging from 58 mm to 100 mm with a modal length of 74 mm were collected from the drag-nets operated in the Phoenix Bay. The stomach contents revealed copepods, polychaete remains, fish scales, diatoms as *Pleurosigma* and *Coscinodiscus*, some filamentous blue-green algae, unrecognisable green pulpy matter and fairly often detritus and sand grains. The condition of the feed was poor as the stomach contents in a majority of the individuals showed food items only in traces. The young ones in the sample after careful examination have been ascribed to *R. kanagurta*. Dr. Jones of the Central Marine Fisheries Research Institute has informed the writer that in the Andaman Sea, *R. brachysoma* also occurs and that it is worthwhile finding out differences if any in the periodical occurrence of the juveniles of the said two species.

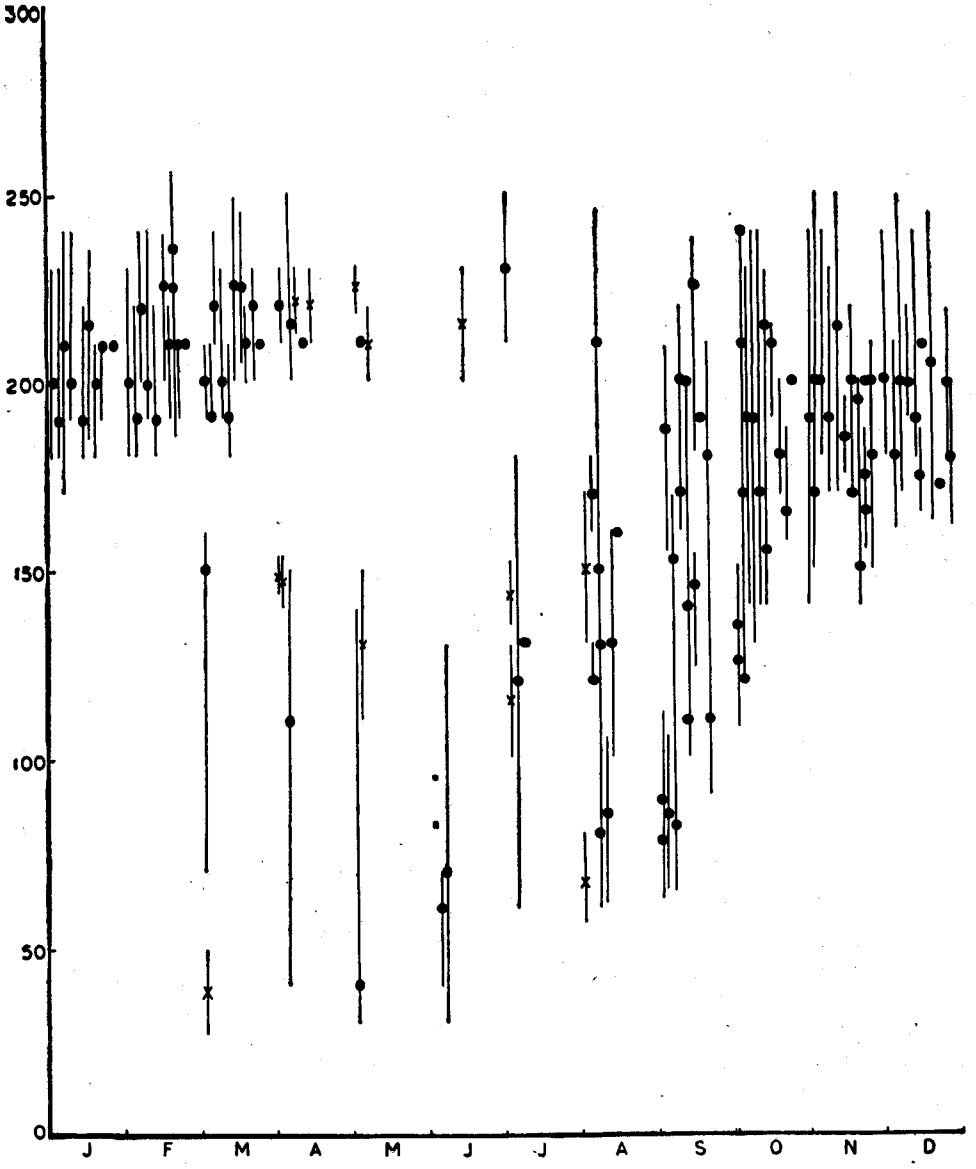
Growth of the Year Classes and Spawning Periodicity

The monthwise size frequency of the mackerel landed as gathered from the foregoing account has been shown in text figures 1 to 3, separately for the west and the east coasts of India. The data of a number of years have been treated together so as to obtain a fairly clear idea as to the probable trends in the spawning periodicity of the mackerel by tracing back the modal values of the population occurring in different months from the very older groups to the youngest ones on record.

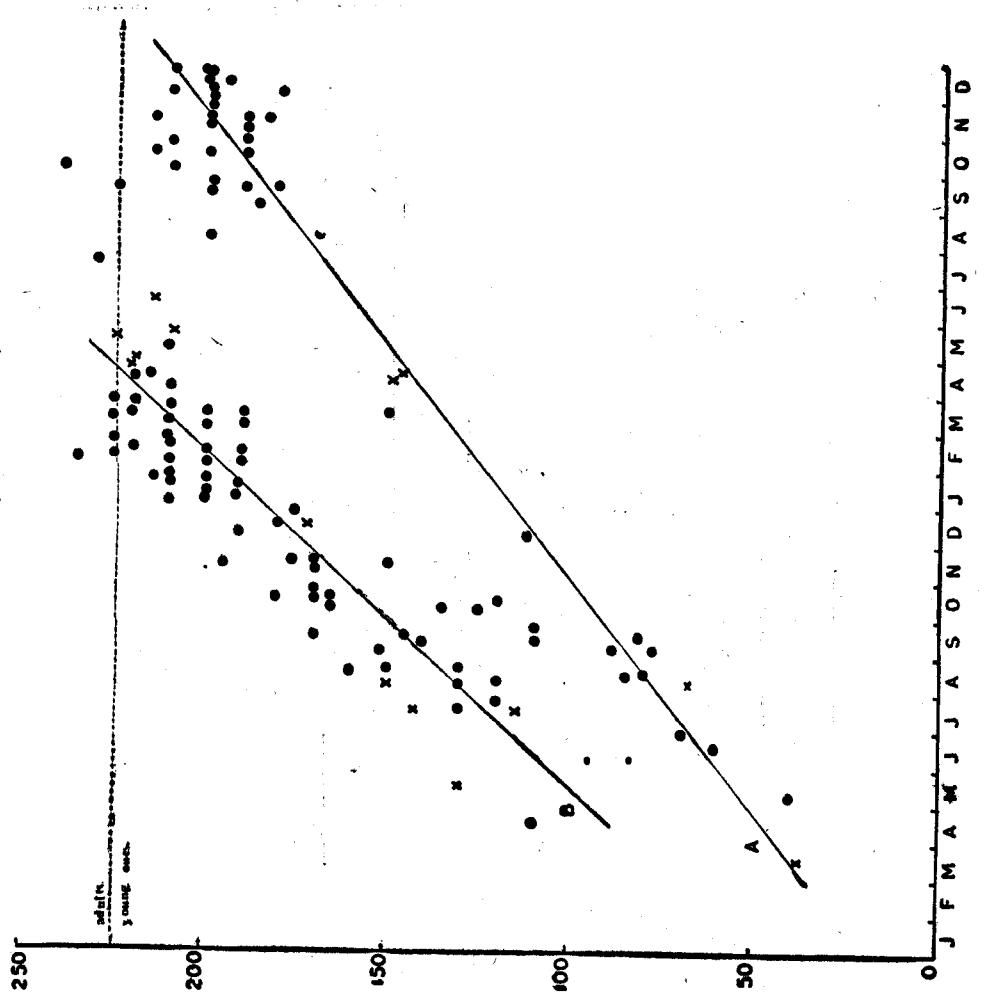
In respect of the data on the west coast in text figure 1 are shown the size ranges of different groups occurring in each month; their modal values are represented by solid circles; where the latter are not known the mid-points in the ranges are marked by crosses; and where isolated individuals only are on record they are shown by small dark solid squares. With figure 1 as the basis, figure 2 is drawn up omitting the size ranges and taking only the modal values or the mid-points of the ranges; and the higher groups, which appear along with the smaller ones in the same months, are shown separately in the corresponding months of the following year to obtain a continuity of the modal shift to trace the growth rate of the year classes. As may be seen from the figure, there appear to be two distinct groups of young ones 'A' and 'B' entering the inshore waters in different periods of a year. A freehand line passing close to the modal values or the mid-points to each one of the groups has been fitted to trace the course of the juvenile groups to the adult ones.

According to Sekharan (1958) as cited earlier the mackerel attains a size of 120 to 150 mm after completing one year and 210 to 230 mm after the second year. On this assumption the individuals of the lot 'B' in the months of July-August showing mode values of 120 to 160 mm are just one year old and are therefore the result of spawning that should have taken place in about the same months of the previous year. There is a gradual shifting of the mode values in this group in the subsequent months *viz.*, to 140 to 170 mm in September, 165 to 180 mm in October, 150 to 195 mm in November, 170 to 190 mm in February, 190 to 225 mm in March and 210 to 220 mm in April. The modal size remains more or less the same in May and it is difficult to follow this group thereafter as the catches seldom show adults of 230 mm and above. As indicated by the extension of the line representing this group the members are expected to attain a modal size of about 240 mm by July-August when they complete the second year of their life.

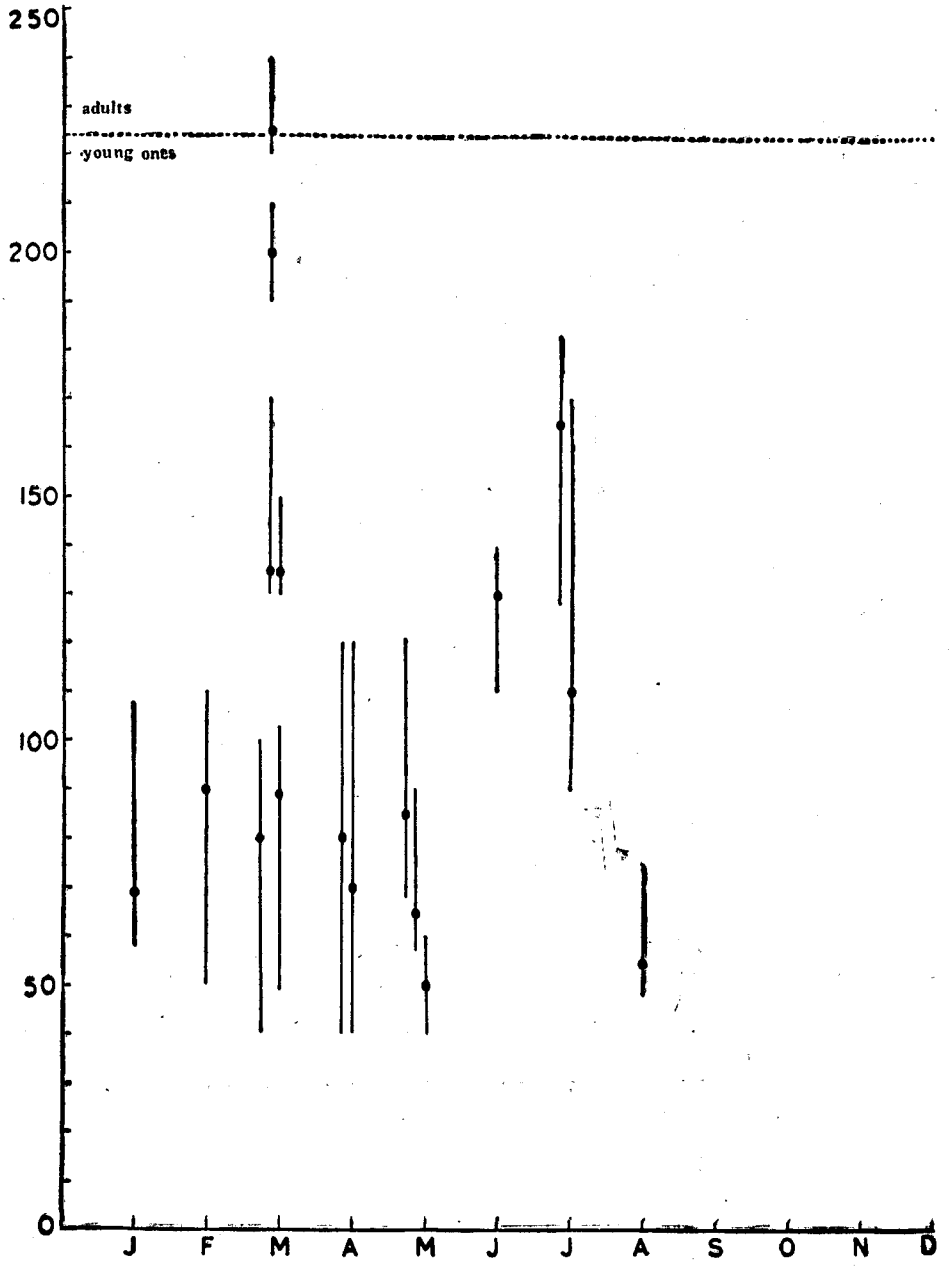
That in the months of July-August spawning takes place in mackerel is supported by the findings of several workers as already stated. Hornell (1910) observed "On the West Coast mackerel are found with fully developed roe in June-July and August; the bulk of spawning occurs at the end of July and beginning of August". However, that there is also



Text Fig. 1. Size-Frequency Distribution of the Mackerel, *Rastrelliger kanagurta* along the West Coast.



Text Fig. 2. Size-Frequency Distribution of the Mackerel *Rastrelligen kanagurta* along the West Coast.



Text Fig. 3. Size-Frequency Distribution of the Mackerel, *Rastrelliger kanagurta* along the East Coast.

a supplementary or late spawning period in mackerel in about November-December is evident from the following account:—

The second lot of individuals under 'A' shows a mid-value of the range at 38 mm in March and a mode value of 40 mm in May. The corresponding values in the subsequent months are 62 mm to 70 mm in June, 78 to 88 mm in September and about 112 mm in December of the same year. In the following year the respective values are 150 mm in March, 170 to 200 mm in August, 180 to 225 mm in September, 190 to 215 mm in October, 185 to 215 mm in November and 180 to 210 mm in December. As two-year old mackerel are between 210 mm and 230 mm according to Sekharan, the occurrence of about this size range of individuals in November-December, traceable through younger individuals in earlier months is suggestive of their being the result of spawning two years earlier. Sekharan's data reveal an average growth of 10 to 12 mm per month when the mackerel are in their first year and on this assumption too the recorded occurrence of mackerel between 27 and 50 mm with a mid-value range at 38 mm in March (Balakrishnan's data 1957) is traceable to spawning at about the end of December. It may be mentioned in this connection that George *et al* (1959) had observed adult mackerel from the Netravati estuary showing partially spent gonodal condition during the period of the fishery commencing from January 1958 indicating presumably spawning having taken place about January. The occurrence of maturity stages of V and VI b in mackerel examined from Cannanore area in October 1951 (*Quart. Sci. Rept. CMFRI* for Dec. 1961) is also indicative of either a supplementary or very late spawning in November-December period.

Although the main spawning is about July-August followed by a supplementary spawning as explained above, yet from the wide scattering of the mode values in between 'A' and 'B' there appears to be some intermittent spawning. As stated by Pradhan (1956) the Indian mackerel like the European species *Scomber scombrus* seems to spawn in succession over a prolonged period liberating each time a small number of eggs. The range of the spawning period in *Rastrelliger kanagurta* is not yet fully understood. It is stated to extend from June to September (Devanesan and John 1940) or from May to September (Chidambaram and Venkataraman, 1946) or from March to September (Sekharan, 1958). In the light of a few findings in recent years, the period of spawning seems to be yet more prolonged, probably extending upto December.

The size frequency data of the mackerel on the east coast of India are too meagre to draw any definite conclusions ; yet it may be seen that juvenile mackerel falling within the range of 40 to 100 mm from Madras and Visakhapatnam occur from February and occasionally upto July. Mackerel coming within the range appeared in Port Blair region in the months of January to March. On the west coast of India, the mackerel of this range occur mostly from July to September in all the observation centres except in Vizhingam where the dominant sizes observed were 40 and 70 mm in the months of May and June respectively (Balakrishnan, 1957). Thus the distribution of juveniles in time and space seems to indicate that the period of spawning of the mackerel differs in different regions in the inshore waters.

Assuming a rate of growth of 10 to 12 mm a month, the occurrence of mackerel of modal size of 89 mm in March-April is traceable to spawning in about October; similarly those of modal size of 70 mm in April to spawning in November and those of modal value of 50 mm in May to spawning in December (Data from Rao and Basheeruddin, 1953 and Nayar, 1962). Possibly therefore the intensive spawning season is about October to December

on the east coast. Satyanarayana's data (1954) show mackerel of modal size of 55 mm in August and these, on the basis of the same rate of growth, should have resulted from spawning in April. Unless we have more data on the size frequency measurements and sexual maturity stages of mackerel from this coast for a continuous period of a few years, it is difficult to say with certainty whether there is a single period of spawning from October to April or more than one spawning period.

In Ceylon small juveniles of *Rastrelliger* are encountered annually in about April onwards on the southern coast and occasionally again in about September (de Zylva, 1956 *). It is possible that as in Ceylon on the east coast of India there are two distinct broods of juveniles entering the inshore waters during the same year.

One point of interest to note is in regard to the location of the spawning grounds. From the occurrence of the spawners in the usual fishing grounds, the eggs and early stages of development in the plankton hauls from Vizhingam to Cape Comorin, Balakrishnan (1957) observes that the spawning grounds are about this region on the west coast of India. Observations on the east coast of India (Kuthalingam, 1956) point out to the presence of similar spawning grounds in the Madras inshore area.

SUMMARY

1. Small juveniles of *Rastrelliger kanagurta* have been known to occur periodically in the inshore waters and are reported from several places off the coasts of the Arabian Sea, the Bay of Bengal and the Andaman Sea.
2. The region-wise and lengthwise distribution of the catches obtained in the mackerel fisheries at various centres with notes on the biology of the species is given.
3. A careful study of the length-frequency distribution of the mackerel on the west coast of India revealed that two distinct groups of young ones enter the inshore waters in different periods of a year.
4. On the west coast intensive spawning appears to take place in about July-August followed by a supplementary spawning in November-December. However, there seems to be also intermittent spawning in between the two periods. The exact period of spawning is not definitely understood, but from the available data it appears to commence from the end of March and extend upto December.
5. On the east coast of India spawning appears to commence by about October. A second spawning period is also likely to occur in about April.
6. There appear to be good spawning grounds in the inshore waters off Vizhingam on the west coast and off Madras on the east coast. There may be similar spawning grounds of mackerel in yet other places but we have as yet no knowledge of them.
7. An analysis of the stomach contents of the juvenile mackerel from different coastal regions shows that there is no uniformity in their feeding habits. In general the juveniles are plankton feeders like the adults, but the proportion of the phytoplanktonic to zooplanktonic elements has been reported by some workers

* de Zylva, E.R.A. 1956, *Rastrelliger* (MS) as referred to by Rosa, Jr. H. 1956.

to vary at different stages of growth. The juveniles occasionally feeding on post-larval fishes exhibit a carnivorous tendency.

The writer expresses his gratitude to Dr. S. Jones, Director of the Central Marine Fisheries Research Institute for according permission to make use of the data available in the departmental reports and for offering his encouragement in the presentation of this paper. The writer is also thankful to his co-workers in the Institute who made available unpublished information based on their own observations.

REFERENCES

BASHEERUDDIN, S. AND NAYAR, K. N., 1962. A preliminary sludy of the juvenile fishes of the coastal waters of Madras City—*Indian J. Fish.* 8,169–188.

BALAKRISHNAN, V., 1957 : Occurrence of larvae and young mackerel (*Rastrelliger canagurta* Cuvier) off Vizhingam, near Trivandrum—*Curr. Sci.*, **26**, 57–58.

BHIMACHAR, B. S. AND GEORGE, P. C., 1952. Observations on the food and feeding of the Indian mackerel—*Rastrelliger canagurta* (Cuvier)—*Proc. Indian Acad. Sci.*, **36 b**, 105–18.

CHIDAMBARAM, K. 1944,. Food of the Indian mackerel (*Rastrelliger kanagurta* Russell) of the West Coast of Madras Presidency—*Curr. Sci.*, **13**, 214–15.

————AND VENKATARAMAN, R. S., 1946 : *Tabular Statements on the Natural History of Certain Marine Food Fishes of the Madras Presidency West Coast*—Government Press, Madras, 1–26.

———— KRISHNAMURTHY, C. G., VENKATARAMAN, R. AND CHARI, S. T., 1952. Studies on mackerel fat variations and certain biological aspects—*Proc. Indian Acad. Sci.*, **35**, 43–68.

DEVANESAN, D. W. AND CHIDAMBARAM, K., 1948. *The common food fishes of the Madras Presidency*, Dept. of Industries & Commerce, Government Press, Madras, 1–79.

————AND JOHN, V., 1940. On the natural history of *Rastrelliger kanagurta* (Russell) with special reference to its spawning season and eggs.—*Curr. Sci.*, **9**, 462–64.

GEORGE, P. C., DHULKHED, M. H. AND RAO, V. R., 1959. Observations on the mackerel fishery of the Netravati Estuary, West Coast, South India—*J. Bomb, Nat. Hist. Soc.*, **56**, 32–38.

————AND ANNIGERI, G. G., 1960. On the occurrence of small size mackerel [*Rastrelliger canagurta* (Cuvier)] off Ratnagiri coast—*Curr. Sci.*, **29**, 319–320.

HORNELL, J., 1910. Report on the results of a fishery cruise along the Malabar Coast and to the Laccadives Islands in 1908 ; Mackerel (*Scomber microlepidotus*, Rupp.) and present position of the Mackerel Industry—*Madras Fish. Inv.*, **4**, 105–108.

HUBBS, C. L., 1943. Terminology of early stages of fishes—*Copeia*, **4**. 260.

JONES, S., 1950. A note on the terminology of the early developmental stages of fishes—*J. Zool. Soc. India*, **2**, 39–41.

KUTHALINGAM, M. D., 1956. Observations on the food and feeding habits of the Indian Mackerel, *Rastrelliger kanagurta* (Russell)—*J. Zool. Soc. India*, **8**, 99–106.

NARASIMHAM, K. A., 1962. Occurrence of juvenile mackerel along the Ratnagiri coast—unpublished—personal communication.

PANIKKAR, N. K., 1952. Fisheries Research in India, Part I.—*J. Bombay Nat. Hist. Soc.*, **50**, 741–65.

PRADHAN, L. B., 1956. Mackerel Fishery of Karwar—*Indian J. Fish.*, **3**, 141–185.

PRADHAN, L. B. AND RAO, K. V., 1959. The Mackerel—*Fisheries of the West Coast of India*, 38–44.

RADHAKRISHNAN, N., 1958. Observations on Mackerel Fishery at Karwar for the seasons 1954–55 and 1955–56 —*Indian J. Fish*, **5**, 258–269.

RAO, K. V. AND BASHEERUDDIN, S., 1953. Occurrence of young mackerel, *Rastrelliger canagurta* (Cuvier) off Madras coast—*Curr. Sci.*, **22**, 182–83.

————AND LUTHER, G., 1961. Young mackerel from Andaman Sea—unpublished personal observation.

RAO, K. V. N. AND RAO, K. P., 1957. Differences in the food of the young and adult mackerel, *Rastrelliger kanagurta* (CUV.) *Nature* **180**, 711–712.

ROSA, JR. H., 1956. Synopsis of Data on the species of the genus *Rastrelliger* Jordan and Starks 1908—I.P.F.C. *Meeting of the Sub-Com. on Rastrelliger*, Malaya, App. 7 (iv), 1–16.

SATYANARAYANA, A. V. V., 1955. Juvenile mackerel from the Lawson's Bay—unpublished—personal communication.

SEKHARAN, K. V., 1958. On the South Kanara Coastal Fishery for mackerel, *Rastrelliger canagurta* (Cuvier) together with notes on the biology of the fish—*Indian J. Fish.*, **5**, 1–31.

Government Departmental Publications :

Madras Fisheries Department Administration Report, 1940.

Annual Report of the Director, Central Marine Fisheries Research Institute for the year ending 31st March, 1961.

Quarterly Scientific Report, Central Marine Fisheries Research Institute for the period ending 30th June, 1961.

Quarterly Scientific Report, Central Marine Fisheries Research Institute for the period ending 31st September, 1961.

Quarterly Scientific Report, Central Marine Fisheries Research Institute for the period ending 31st December, 1961.