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FISHERY AND BIOLOGY OF THE MACKEREL, *RASTRELLIGER KANAGURTA* (CUVIER) AT COCHIN*

A. NOBLE

Central Marine Fisheries Research Institute, Cochin, India

ABSTRACT

The fishery and biology of *Rastrelliger kanagurta*, the Indian mackerel, have been studied from May 1965 to April 1968 at Cochin. The fishery comprises of juveniles during May-August and of commercial sizes during October-April, both at the commencement of the season being about one year old. For fixing the age of the fish and to explain its rate of growth before it appears along the coast, it is suggested that these two groups correspond to two different broods. The growth determined by the length frequency studies has been found to agree fairly well with the return of some tagged fish.

INTRODUCTION

MACKEREL forms a minor fishery at Cochin. But it is important because of its high commercial value and hence worth reporting. The only available record of mackerel fishery here is about an unusual one in the Cochin Backwaters by George (1965). George and Banerji (1964) considered the length frequency data collected here for the age and growth studies on mackerel.

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MATERIAL AND METHOD

The study on the fishery and biology of the mackerel landed at Manassery (Cochin) during the period May 1965 to April 1968 constitutes this report. Regular observations were conducted thrice a week at the landing place for estimating the catch and effort, and a sample of 25 fish, subject to availability was studied in the laboratory on each day of observation for length, weight, sex, stages of sexual maturity and food and feeding. Maturity stages were determined according to the key of Pradhan (1956) and the food and feeding by gross analysis only. Forty-two fish were tagged and released in 1966-67 and 460 in 1967-68 to study their growth and migration.

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OBSERVATIONS

Fishery

The fishery in general is poor and sporadic. In 1965-66, as shown in Fig. 1, the landings in May were 3.774 tonnes and nil in June. July had 10.026 tonnes but in August, the landings came down to 5.694 tonnes. In September, they became very poor. However, October marks the peak of the year showing 33.066 tonnes of landings. The landings later dwindled and became practically nil during February-April.

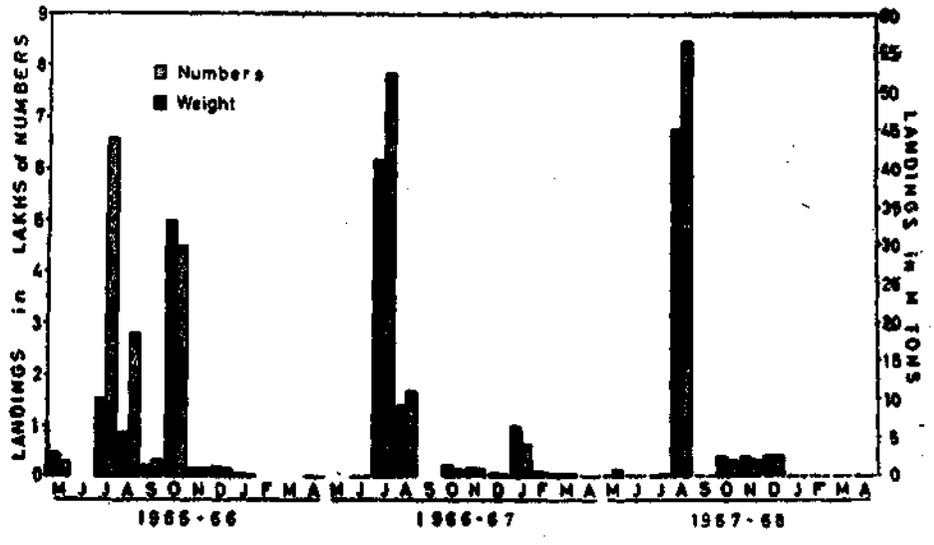

Fig. 1. Landings of mackerel at Manassery (Cochin).

In 1966-67, the scarcity or absence of the mackerel of the last quarter of the previous year continued till June. However, the landings in July were much better with 40.967 tonnes of fish and they formed the peak of the year. In August also they were comparatively good with 8.912 tonnes. In September there were no mackerel and the landings were low during October-December. In January there was a secondary peak showing 6.266 tonnes but again the landings dwindled in February and remained practically nil during March-April.

In 1967-68, unlike the previous years, mackerel were practically absent in July also. Nevertheless, they appeared in plenty in August and peaked with 45.144 tonnes of landings. As usual they were absent in September (the quantity landed being only 1.3 kg) and they occurred in small quantities during October-December. During January-April they were almost nil.

The estimated numbers of fish in the landings for each month are also given in Fig. 1.

Gear and catch per net

Thangu vala is the principal gear used for fishing both mackerel and oil sardine. It is a type of boat-seine having neither the bag nor the code end. It is just a long

net 90 m broad in the middle 24 m, and narrower at the ends 7.5 m ; made of cotton with a mesh of 20 mm size. Four long lead ropes are attached to the corners of the net. There is a head rope with floats on one of the longitudinal margins and a foot rope with weights on the other as to keep it vertical like a fence in water. The mode of operation more or less resembles that of a purse-seine. The area of operation generally varies between 4 to 10 km in the inshore waters where the depth range is between 5 to 15 m.

A large dug-out canoe 12 m long with 14 to 15 people is required to operate this net. On sighting a shoal one man jumps into the sea holding the 2 lead ropes of one end of the net. He acts in place of the small helper boat of a purse-seiner. The boat is then rowed round the shoal, paying the net and encirculing it. The man with the lead ropes of the other end of the net is picked up from the sea and the net is hauled. Now the entire crew standing on the boat work briskly. They make loud noises, shouting and banging on the sides of the canoe to drive the shoal towards the net. When the ends of the net reach the boat (after the lead ropes), the lower margin having the foot rope is hauled immediately making the encircling wall of net to cover the bottom and prevent the fish from escaping down. The wider part of the net is thus made into a shallow bag to contain the shoals. Some of the crew jump into the water making much alarm in order to prevent the shoals from escaping through below the boat just before the net is made into the bag. By slowly hauling up the head rope and the 2 ends, the shoal is brought nearer and nearer to the boat and finally the whole thing is hauled up. At this time also some of the crew jump into the water to scare off porpoises that often attack the net and steal the catch.

In Thangu vala, the mackerel mostly occur along with the catches of oil sardine, *Sardinella longiceps* Val. as a miscellaneous item. The catch of mackerel per net in numbers thus varied from nil during February-May to 477 in July.

Ayila vala, a gill-net specific for catching mackerel is used when medium sized or bigger ones occur in shoals. The catch per net in number is thus much higher than that of Thangu vala with respect to mackerel, the maximum number observed being 1969 in October 1965.

Size composition of the catches

The size range and the mode at each month are given in Fig. 2.

In 1965-66, though adults occurred in May, the landings comprised mainly of fishes ranging in size from 9.5 to 16.5 cm during July-September. As the mackerel is a commodity which fetches good price, even 17.0 cm group can be included here under commercial sizes and for convenience the size group below 17.0 cm are referred hereafter as juveniles. Towards the close of September there were some fish ranging in size from 17.0 to 19.0 cm. During October-January the size range was almost from 17.0 to 21.5 cm except a few between 14.5-16.5 cm occurring in October. In April what occurred were juveniles only.

In 1966-67, the landings in June-August constituted mainly by juveniles, though small numbers in commercial sizes were also regularly seen. But during October-April, the fishery was contributed by commercial size groups.

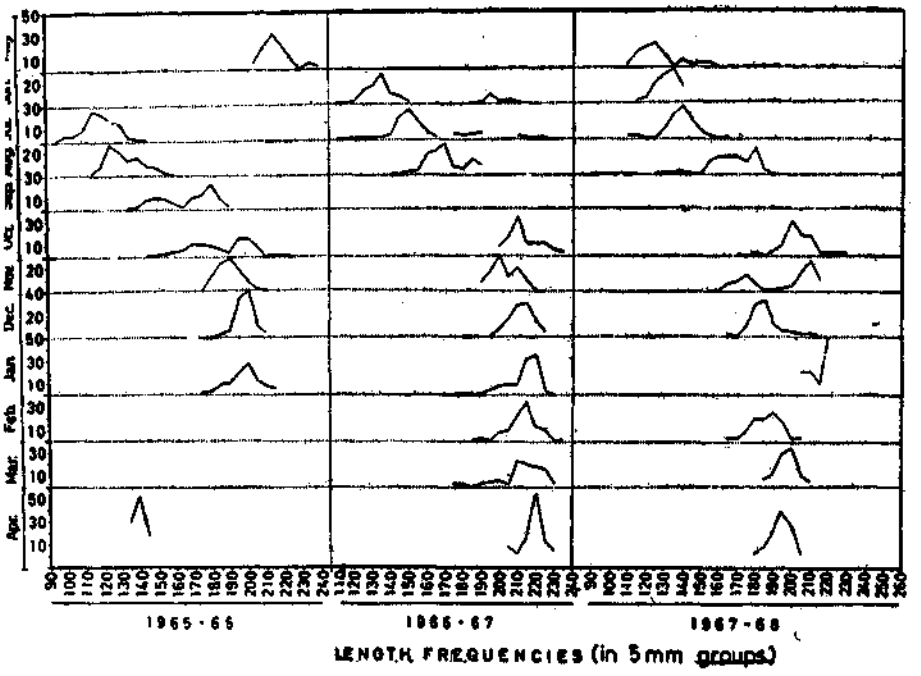

Fig. 2. Length distribution of mackerel in the landings at Manassery (Cochin).

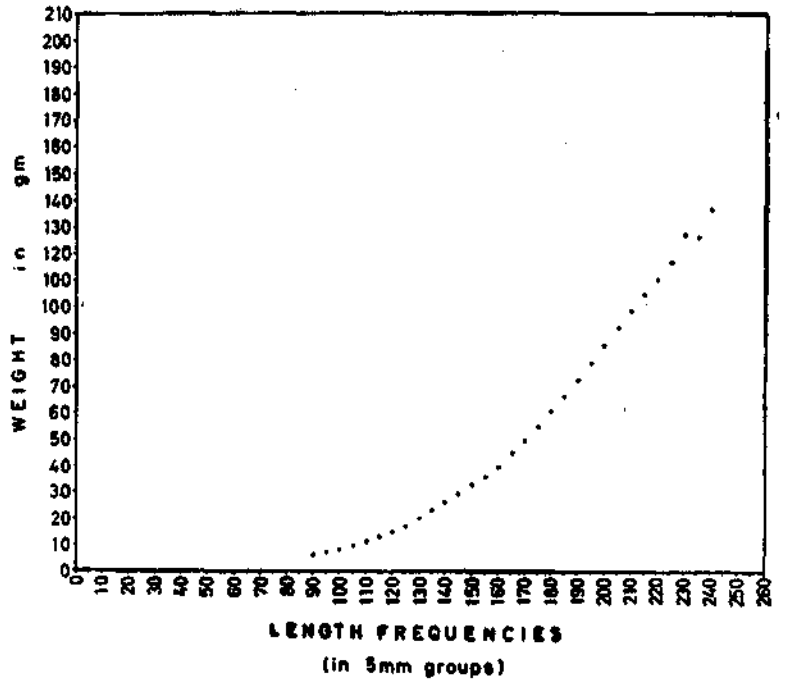

Fig. 3. Average weight of mackerel at each length group.

In 1967-68, as in the previous years the landings comprised mainly of juveniles during May-August. The smallest fish recorded was 9.0 cm long. However, there were a few commercial sizes towards the end of August. During October-April, the landings were of commercial sizes.

Weight

The average weight of mackerel at different length groups are given in Fig. 3.

Sex composition

Sexes were indeterminate in juvenile fishes especially below 12.0 cm. Among determinates, the sex ratio between male and female was almost equal.

Maturity conditions

The fish occurring through May-November are almost immature and in Stage I of sexual maturity. Though fish in Stage II start occurring then their number increases to about one-fourth only by December and later during January-March above two-thirds are observed in this stage. Maturing individuals in Stage III in turn make their appearance in January and increase to one-third by March-April. As the fish advance in maturity a rapid reduction in the number of immature fish in Stage I occurs. Hence in March only 1.4% is observed to be Stage I. But further advancement in maturity is noticed in the fish as 19.4% were in Stage IV then, and in May among adults 76% were in this stage. Fish in Stage VI are never encountered and the occurrence of Stage V is highly negligible. A few spent (Stage VII) and spent recovering fish (Stage II) have been noticed in the landings in June-July and October.

Food and feeding

Feeding appears to be moderate to good, and the food is planktonic. The food is phytoplanktonic during January-February and June-August. At other times it is zooplanktonic. Among phytoplankton, diatoms like *Nitzschia* spp., *Thallassiosira* sp., *Coscinodiscus* spp., *Thallassionema* sp., *Thallassiothrix* sp., *Chaetoceros* spp. and *Rhizosolenia* spp. form the major items. Among zooplankton, copepods are important with forms like *Oithona* spp. and *Paracalanus* sp. dominating. *Acrocalanus* sp. and *Acartia* sp. are also observed in some smaller numbers. The occurrence of dinoflagellates, tintinnids, larval forms and cladocerans was poor. Fish larvae and fish remains were not encountered in the stomachs and occurrence of fish eggs was negligible.

Tagging

Two per cent of the fish tagged and released in 1967-68 were recovered, the details of which are given in Table 1 and Fig. 4.

With regard to the fish recovered at Thiruvarpu market which is a suburb of Kottayam Town, an interior place 24 km away from the sea, it is reported by the informer who recovered the tag that fresh fish in this market come from the landing places at Sherthala, Alleppey and Ambalapuzha which are 42, 64 and 78 km south respectively from Malipuram where it was released on 30-11-1967. Nevertheless, in Fig. 4, the place of recovery of this fish is put as Sherthala in view of the fact that among the 3 places it is nearer to the place of release.

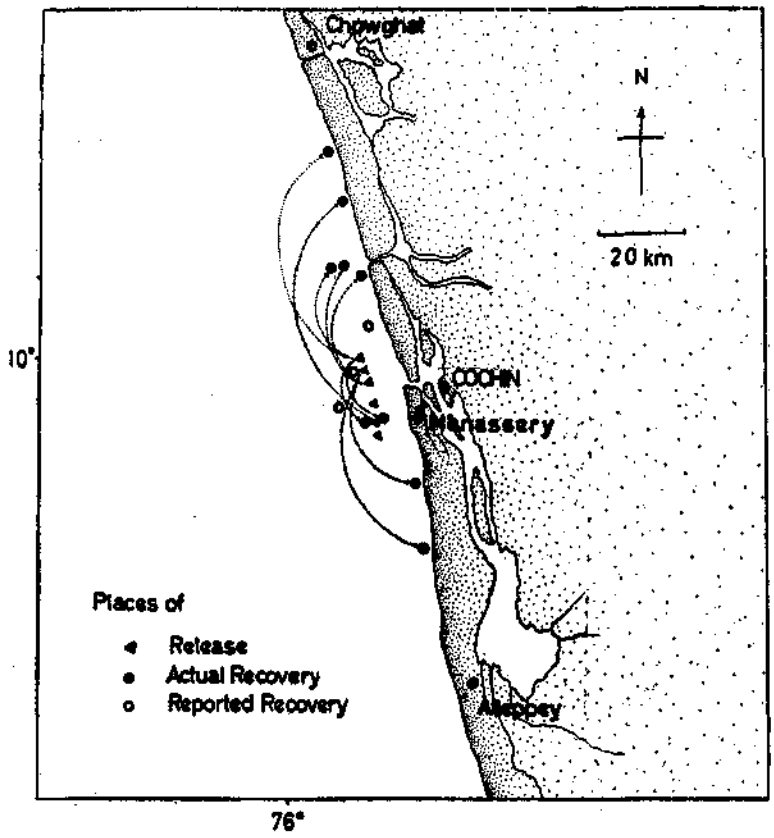

Fig. 4. Map showing the release and recovery of mackerel at Cochin.

Apart from these actual recoveries, 3 more mackerel were reported reliably to have been caught (Fig. 4) as mentioned below :

1. A mackerel with an opercular maroon tag was obtained at Malipuram on 2-12-1967 in a gill-net (Ayila vala) operated at night. The tag attached to the fish was noticed by the worker at the local fish curing yard who threw it off not knowing its importance.

2. A mackerel with a tag was recovered at Kuzhipilly which is 29 km north of Fort Cochin probably on 5-2-1968. The fish was kept there semi-dried, but was unfortunately eaten up by ants, only the skeleton remaining and the tag missing.

3. A mackerel with a tag was reported to have occurred in the catch of a trawler 'Silvi', C.P. 309 operated off Cochin some day previous to 24-3-1968 but not too long before. Ignoring the importance of the fish the crew consumed it on board throwing away the tag.

TABLE 1. *Tagging on mackerel at Cochin*

Release		Recovery		No. of days at liberty	Size at (length in cm)		Growth (in cm)
Date	Place†	Date	Place†		release	recovery	
16-11-67	Malipuram	16-12-67	Thiruvarpu market	30	*16.6	17.1	0.5
23-11-67	Malipuram	12-1-68	Pallithode	50	*17.7	18.5	0.8
30-11-67	Narakkal	2-12-67	Soudi	2	20.3	20.3	0.0
30-11-67	Narakkal	3-12-67	Azhikode	3	*19.7		
30-11-67	Narakkal	3-12-67	Natika	3	19.5	19.5	0.0
30-11-67	Narakkal	7-12-67	Manassery	7	18.9	19.1	0.2
2-12-67	Vypeen	5-12-67	Munambam	3	19.4	19.4	0.0
2-12-67	Vypeen	17-12-67	Azhikode	15	*18.5		
29- 1-68	Manassery	23- 2-68	Perinjanam	25	19.5	20.0	0.5

† See Fig. 4 for the location of the places.

* Recovered fish in these cases were not returned along with the tag. No information on the length of the fish was given in 2 such cases and in the other 2 the growth shown is based on the informations on length supplied with the tags.

DISCUSSION

Though mackerel forms only a minor fishery at Cochin it is of great significance as the occurrence of juveniles in abundant numbers during July-August marks the beginning of its season along the west coast of India. Panikkar (1952) has already stated that the mackerel appears earlier in the south and then slowly extends northwards. At Vizhinjam in the south (Balakrishnan, 1957) it appears a little earlier, and at Karwar in the north (Pradhan, 1956 ; Radhakrishnan, 1958) it is observed to commence much later in October only.

At Cochin the fishery exhibits 2 phases during a season, one of juveniles during May-August and another of commercial sizes during October-April, with either a pause or a lull in the occurrence of the mackerel in September. The occurrence of juveniles in the landings in July-September is a phenomenon usual at other places also (Pradhan, 1956 ; Sekharan, 1958), but they are not seen in such large numbers as has been observed at Cochin. This feature in the fishery poses a few questions to be answered. Why the juveniles dominate the catch prior to September and why the commercial sizes afterwards ? Why the juveniles in general appear only in smaller numbers and why the fishery is negligible or absent in September ?

First of all, as is seen from the estimated number of Thangu vala operated in August, September and October of the years under consideration (Table 2, the weakness in the fishery or its total absence cannot be due to any reduced activity in fishing in September. The effort in September though much less than that of August, especially in the last 2 years is not so poor as to affect the landings that adversely. In fact, it is more than that of October and in October mackerel appear in the landings. The south-west monsoon is most active here in June-July and it is almost during this period the small fish contribute to the fishery and thus cannot directly be the causative factor. So the dullness in the landings is due to the non-availability of them in the inshore waters in September and then what are the probable reasons for this ?

TABLE 2. *Estimated number of Thangu vala (Boat Seine) operated at Cochin*

	August	September	October
1965-66	1588	1401	1200
1966-67	1386	830	592
1967-68	1878	867	619

With regard to the change in the fishery from juveniles of July-August to that of commercial sizes in October, Pradhan (1956) from his studies at Karwar concluded that the juveniles after appearing for a short while leave the inshore waters and the commercial sizes according to him much older in age enter the fishery in October. Where do they disappear and why should they go are not made clear. In the absence of supporting data Pradhan's assumptions (1956) are hardly acceptable and what can then be the probable explanation for it ?

It is essential at this juncture to discuss about the spawning season of mackerel. Spent fish (Stage VII) though in small numbers were observed in the landings in June and October. Some spent recovering fish (Stage II) were also seen in July. There could hence be a spawning in June-July in the first instance and then in October and probably November on account of the spent recovering fish appearing in the month after the occurrence of spent one in earlier case. Actual spawners (Stage VI) and eggs and larval stages of the mackerel are not encountered in the inshore area, which incidentally indicates the location of the spawning ground somewhere outside the fishing zone. Allowing some time for the spawned fish to move to the inshore waters from the breeding ground, it will be reasonable to suppose that the actual spawning may even start in late May and late September, a little before the appearance of the spent fish in June and October respectively in the inshore catches. The ova diameter studies by Sekharan (1958) and Radhakrishnan (1962) show 2 modes in the development of the ova, which may also implies the possibility of 2 spawning seasons in the mackerel. Two distinct spawning seasons are said to occur, one during May-June and another during October-November at Mandapam, though observations and opinions differ at different places with different authors (Radhakrishnan, 1962). Report on the occurrence of mackerel larvae in the Indian Ocean (Peter, 1967) from Bay of Bengal in May and Arabian Sea in November-December fall almost in line with the 2 spawning periods at present observed, though they seem to be a little earlier in the former and a little later in the latter.

Before proceeding further it is necessary to consider the rate of growth and age of the fish. From Fig. 2, it is clear that the fish first grow faster when they are young, and the growth slows down as they advance in age. A similar rapid growth of the fish at early age and slackening afterwards was observed at Cochin by George and Banerji (1964) and along the South Kanara Coast by Sekharan (1958). But opinions vary regarding the age of the fish more than their rate of growth.

According to Pradhan (1956), the mackerel of an average size of 10.0 cm occurring in July-September, presumably the offspring of fish spawned in the breeding season of the previous June-September may be one year old. Disappearing from the inshore waters they grow to 18.0 cm or more in the next year and enter the commercial catches when they have completed 2 years of life. The normal modal size of one year-old mackerel according to Sekharan (1958) appears to be 12.0-15.0 cm, and at the end of the second year of life they probably measure 21.0-23.0 cm. His statement is based on an assumption that when a 6.0 cm mode is 0-year-class, 12.0-15.0 cm should be one year. From the observations on the progression of mode at successive months, George and Banerji (1964) assume that the fish at one month average 6.0 cm in length. Using Von Bertalanffy's equation they calculated that the fish grows to 13.5, 16.1, 17.9, 19.2 and 20.2 cm at 3, 4, 5, 6, and 7 months respectively. Based on their computations, if a fish at 13.5 cm length has to appear in the catch in July, it should be born in April completing 1 month in May, 2 in June and 3 in July. A fish at 18.0 cm entering the fishery in October should likewise be born in May completing 5 months in October. If that is so, the 18.0 cm long fish caught in September 1965-66 at Cochin during the present study should have been born in April and those which appeared in the catches in August 1967-68 should have been born in March. There are 18.0 cm fish occurring here in July also (Fig. 2) in which case the time of their birth might be even earlier. The spawning of the mackerel during the years under discussion on the lines of the calculations of George and Banerji (1964) must be during March-May or even earlier, whereas from the occurrence of the spent and spent recovering fish it is inferred to be during June-July and October-November. According to Sekharan (1958) also, the height of spawning might be some time after April only. Then what is the age of the fish when they initially appear along the coast in the fishery.

From the data gathered at Cochin and discussed in this paper, the age of the fish at its entry can tentatively be fixed as 12 months. The juveniles that occur in July-August are thus the offsprings of fish spawned in June-July of the previous year. The commercial recruits of October are also one year old and they come from the previous October-November season. So the fish of June-July brood grow to a size round about 14.0 cm, whereas the fish of October-November brood grow to 18.0 cm or so in one year. This differential growth between the 2 groups is likely to be due to the effect of monsoon on them. In the absence of any knowledge on the location of the spawning ground it is essential to assume that it is subjected to the destructive dynamics of the monsoon to the fish population, especially of their early larval stages and the fishes of June-July season sustain heavy damages in growth and in their very existence. The natural mortality being very high probably limits their occurrence in the catches along the west-coast in general in number and period. The fishes of October-November season, however, have to encounter this unfavourable situation when they are 8 to 9 months old and can probably withstand it to a great extent suffering only a little retardation in growth and reduction in numbers. Having born in favourable circumstances with abundant supply of food and calm weather they grow more quickly than the June-July groups of fish and contribute largely and steadily to the fishery which occurs from October onwards. Such

differential growth in case of 2 broods separated by a small interval is observed in other marine fish elsewhere.

The herring at the Grande-Riviere (Jean, 1956), for instance, spawn once in the spring during May and June and again the fall during the second fortnight of August and September, the 2 seasons being separated by an interval of only 6 weeks. The spring larvae exposed to higher temperatures and abundant food supply during the first month of their lives grow at a faster rate than the fall larvae. On the other hand, water temperatures are decreasing at the time fall larvae hatched. Food in the fall is becoming less abundant and winter sets in before the larvae have time to grow appreciably. Environmental conditions are thus less favourable to survival and growth in the fall than in the spring. Shelbourne (1965) commenting on rearing marine fish for commercial purposes says that, ' Our common food fishes take four to five years to reach marketable size in the sea. Winter growth is restricted by low water temperatures and perhaps seasonal food scarcity. In good condition for continuous rapid growth, we might be able to reduce the time taken for a plaice, sole or turbot to reach marketable size, from 5 years to 18 months.' In the same manner, on an uninterrupted favourable environment with abundant supply of food the mackerel is bound to grow faster continuously than the ones which suffer retardation under the stress and strain of unfavourable climatic conditions and consequent paucity of food, for a good part of their early life during which time they are supposed to attain considerable length. The initial differences thus developed are not likely to be made up in short time in the succeeding months. The studies on herring (Jean, 1956), for example, further shows that the difference in length gained by faster growth during the first year of life of the 2 sets of fish born under 2 different environmental conditions, is maintained through adult, mature and spawning fish. The difference is, however, less in older fish than in the younger ones, and the advance in growth between one from the other is acquired during the first years of life.

The fishery at Cochin (Fig. 1) is good in July-August comprising mainly of juveniles (Fig. 2) probably consequent on the shifting of the fishery to the north when it is time for the commencement of the commercial season. The annual variations in the landings are thus dependent upon the influence of rainy season on October-November group if the entire west coast is taken into consideration. It is worthy to mention here that an inverse correlation between the catch of a year and the preceding monsoon, the catch decreasing with increasing rains and vice versa, has been observed on the mackerel at Karwar (Noble, 1972). The lean fishery in September or its absence altogether, can be a reflection of the break observed between the 2 spawning seasons.

The growth rate observed from the shifting of modal sizes in successive months (Fig. 2) is mostly 1.0 to 1.5 cm per month. Mackerel at earlier stages, as mentioned earlier, is believed to have growth faster than the one given above. But in view of the fact that they suffer much retardation in growth at some time during this period, in average the rate of growth may work out to be 1.0 to 1.5 cm only suggesting that the fish by one year may attain a length between 12.0 to 18.0 cm depending on the time of birth already discussed. Afterwards during the period of commercial fishery the growth rate decreases and they attain a length of 22.0 cm at the end of April showing an increase of 4.0 cm in 6 months time. The growth determined by the length frequency studies has been found to agree fairly well with the return of some tagged fish (Table 1). A tagged fish recovered after 7 days has grown from 18.9 to 19.1 cm and another after 25 days from 19.5 to 20.0 cm. George and Banerji (1964) also

gives identical growth pattern at these lengths, a fish growing from 19.0 cm to 19.7 cm in one month and from 19.7 cm to 20.1 cm in the subsequent month. Assuming the fish to grow very fast in the early stages they consider the 6.0 cm to be one month old. But Rao (1962) in the east coast of India, observing the growth of the fish ranging in size from 3.2 to 24.3 cm concluded that the fish of lengths 5-6 and 15-16 cm represent 2 months and 7-8 months' growth respectively. Balakrishnan (George and Banerji, 1964) reports from Vizhinjam that the rate of growth of the Indian mackerel is slightly more than one cm a month during the first year. It is likely that the fish may grow to 18.0 cm or so in one year under favourable circumstances, as already discussed earlier. At the closure of the season a fish might attain 18 months of age. Later the growth reduces much or even probably stops. The fishery is thus on one-year-old and it is in agreement with the observations of Panikkar (1952), Sekharan (1958) and Rao, Sekharan and Pradhan (1962). By the time they attain 18 months of age they advance in maturity and the mackerel first spawn in June-July when they are 20 to 21 months old and again once more in October-November at the age of 24 to 25 months. Total life span of the fish is a controversial subject and how long they can live is still unknown.

At Vizhinjam, the spawners are reported to be represented by the size groups measuring 23.0 cm and above (George and Banerji, 1964). Seshappa (1958) observed no rings on the scales of the Indian mackerel below 22.0 cm, while all individuals above 23.0 cm showed clear rings and he suggested them to be the spawning marks. It is seen in the above paragraph that the fish grows to 22.0 cm in 18 months and when they spawn first they are at the age of 20 to 21 months. Attainment of a length of 23.0 cm showing 1.0 cm increase in 2 to 3 months time at this stage seems quite normal.

The suggestion by Seshappa (1958) that the rings he observed in the scales are not annual growth checks sounds correct as the conditions prevalent in the tropical climate cannot cause any set back in the biological activity of a pelagic fish which migrate to favourable environments, resulting in the formation of rings in the scales. Our monsoon is not comparable to the winter conditions of temperate zone causing growth checks every year, and during monsoon mackerel continues to be vigorous in their activities having a hard way in the struggle for existence. There appears no abstinence from feeding during and due to monsoon and hence no rings are formed each year to mark their age.

However, studies on the food and feeding of mackerel at Calicut (Bhimachar and George, 1952) and Karwar (Noble, 1962) point out the possibilities of actual spawners to abstain from feeding. This starvation together with the utilization of spent up energy for purposes of spawning could only cause the formation of a ring in the scales. The 2 spawning seasons are so close to each other, and occurring so close the resulting growth checks appear only as a single ring in the scales. This happens when the fish is round about 2 years old and 23.0 cm in size and that is why Seshappa (1958) could find the rings only in fishes of that size and above. Sekharan (1958) also observed the fish to spawn first when they are 2 years old.

The mackerel fishery is important at Manassery in July-August though in 1965-66, according to the landings in weight (Fig. 1) October appears to be the peak month. But considering the estimated number of fish in the catch, the fishery is important in July having 656,332 fish against 445,787 in October. In July the fish were very small ranging in size between 9.5 to 14.5 cm with the mode at 11.5 cm (Fig. 2). The average weight of these fish (Fig. 3) ranges between 7.0 and 29.5 gm

and at 11.5 cm it weighs only 13.4 gm. The fish of longer sizes weigh much more than the juveniles. In October, more than 86% of the fish were in size range 17.0-22.5 cm weighing in total 30.711 tonnes (93% of the months' landings), the rest being smaller fish weighing only 2.355 tonnes (7%). The difference in the landings in number and weight is thus due to different size groups entering the fishery. Pradhan (1956) observed at Karwar that a successful fishery of a season depends upon the dominant size class, the catch becoming comparatively poor when they are small and good when they are large and in a season of fast growth say George and Banerji (1964) that a relatively higher modal size will be seen. As a result, though there is not much increase in the number of fish in July-August of the remaining years the catches appeared almost 4 times more in weight (Fig. 1). When the catches of July and August had only juveniles in 1965-66, in these years a certain percentage (Fig. 2) of the fish were big weighing more. In addition to this from the modal sizes it could be seen that the juveniles of July-August, 1965-66 were too small, whereas at other times they were bigger.

The mackerel are more at Cochin at a time when they are small (Figs. 1 and 2) and their fishing uneconomical as they fetch no price worthy of them. The Table 3 gives the number of juveniles landed in each year with their quantity in weight, and also shows how much an equal number of commercial sizes ranging from 17.0 to 22.0 cm with an average weight of 85.550 gm each can amount to. Besides being financially unprofitable the fishery is thus a loss which is almost 5-fold in 1965-66 and 2 times in the succeeding years under consideration to the resource. Indiscriminate exploitation of the non-commercial sizes is to be avoided to make the maximum use of our fishery potential.

TABLE 3. *Number and weight of the juvenile mackerel landed in each year and the estimated weight of an equivalent number of commercial sizes*

	Number	Observed weight (Juveniles)	Calculated weight (commercial sizes)
1965-66 ..	1,006,166	18.298 tonnes	86.078 tonnes
1966-67 ..	681,173	30.808 ,,	58.270 ,,
1967-68 ..	403,467	18.088 ,,	34.517 ,,

The rational exploitation of the resources urges the study of the migration of the mackerel with prime importance. It is not appropriate, on the light of the discussions made in the paper to take into cognisance Pradhan's (1956) views that the juveniles after the short sojourn along the coast line during the pre-fishery period return to the offshore grounds. Accepting the popular notion that they come to the inshore waters to feed (Bhimachar and George, 1952), one will be prone to doubt like Sekharan (1958), why the juveniles alone go back from the inshore feeding grounds where the commercial sizes linger on. As discussed earlier, it may be possible that these juveniles originating from the June-July brood being limited in number cannot sustain continuous recruitment like the commercial sizes which emerge abundantly from the October-November brood.

Besides the shoreward migration the mackerel is believed to move along the coastline also parallel to it. The commencement of the season first in the south and subsequently spreading to the north, itself indicates the shifting of the shoals to a northerly direction (Panikkar, 1952). The recoveries of tagged mackerel at Cochin, actual as well as the reported ones (Fig. 4), also indicate the trend of movement of the mackerel to be to the north than south. In the absence of information on the exact location of recapture of the tagged fish recovered at Thiruvarpu market, the recaptures were within an area of 55 km from the places of release. The number of days each fish took to cover the distance along the coast is no index to the speed of migration as the actual course taken during the days at liberty is not traceable. However, the fish took longer time to wander south (Table 1), whereas their migration to the north was faster. When the fish recovered at Pallithode 28 km south of Malipuram where it was released took 50 days, the fish at Natika 47 km north of Narakkal where it was released took only 3 days to cover the distance. The fish got from Thiruvarpu market also took a period longer than the fish which were caught in the north. This shows that there is an urge in the mackerel to move north than south and the latter ones are to be considered as stragglers only. But from the distance covered it should be presumed that their movement having once entered the coastal belt is much restricted. Tagged mackerel in Thailand (Bandhukul, 1961 ; Chirastit, 1962) are also observed to have very restricted movement only. Movement of the tagged fish off-shore is not known for want of any commercial exploitation outside the conventional narrow coastal fishing grounds and due to the absence of contemporary exploratory work to trace their trail off-shore. The successful management of any fishery depends mainly, if not solely, on the total awareness of the life-history of the concerned fish and it is a must in the case of the mackerel also.

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