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STUDIES ON THE REVIVAL OF THE INDIAN OIL SARDINE FISHERY[1]

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STUDIES ON THE REVIVAL OF THE INDIAN OIL SARDINE FISHERY[1]

By

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The oil sardine, *Sardinella longiceps* Cuv. & Val., ranks as one of the best known commercially important fish of India, and is extensively used as food in the fresh and cured conditions. Its bye-products are of great value: the oil is widely used in the jute, leather, soap and other industries, and also for painting the canoes as it has a deterrent effect on ship-worms and other timber boring organisms ; the guano is an important fertilizer of the tobacco, coffee, tea and other crops. The annual fluctuation of the oil sardine fishery is very well known, and Day (1889) wrote about the species as follows :—" Abundant in some years, they occasionally forsake their haunts for several consecutive seasons, returning again in enormous quantities ". A pioneer attempt to determine the food, spawning habits and migration of the oil sardine was made by Hornell (1910) who also showed the necessity for a sound knowledge of the factors controlling and influencing the seasonal migrations and of those causing the extreme annual fluctuations, besides stressing the need for the proper development of the fishery. In 1923, Hornell and Nayudu published a contribution to the life-history of the oil sardine with notes on the plankton of the Malabar coast, in which they arrived at certain conclusions of which the important ones are :—

" The absence of local races among the oil sardines of the Malabar and South Kanara coasts ; the stability of the main outward characters shows this species to be little liable to individual variation. Oil sardines attain sexual maturity and almost full adult size at the age of one year, when they measure on the average 15 cm. They leave the inshore waters just prior to spawning which takes place from June to August inclusive—once only in the year. The young migrate to the shallow inshore waters in August and September, their size on their first appearance being from 4.5 to 7.5 cm to the end of scales. After spawning, mortality is high, particularly among the females. Of those that survive to spawn a second time very few indeed are met with thereafter. Growth during the second year is extremely slow and amounts to only 1 cm in length on the average. The oldest sardines examined were approximately 2½ years old, and this appears to be the ordinary limit of life in this species. The reason for the shoreward migration is to feed upon the immense quantities of unicellular plants (protophyta) and animals (protozoa) which develop and concentrate in the sheltered coastal waters towards the close of the south-west monsoon and thereafter till the end of the year. The season of chief abundance, from September to December inclusive, is one of rapid growth ; succeeding this is a long period extending till the end of April, when growth virtually ceases, due to a great decrease in the supply of food organisms in the inshore waters from January to April inclusive. During this period the fat reserve accumulated in the tissues from September to December is gradually used up in supplementing deficiency in the food supply. The period of arrested growth coincides with the appearance of what in the temperate zone would be termed a ' winter ring ' upon the scales. In the scales of very few individuals can a second of these rings be seen ; such belong entirely to the large sardines that survive in small numbers to an age of two years and upwards. The fat content of oil sardines from September to December is dependent primarily upon the abundance or scarcity of the oil-secreting organisms present in the inshore plankton during these months, whereof dinoflagellates and certain flagellate infusorians are the most important. The abundance of these minute organisms is in turn dependent on the favourable combination of several physical factors ; the more important are the presence of much nitrogenous material in solution in the inshore water, brought from the land by the monsoon floods, and an adequate amount of bright sunshine ".

In 1943, Devanesan published the results of an investigation into the causes of the fluctuation of the annual fishery of the oil sardine, the determination of its age and the discovery of its eggs and spawning grounds. His conclusions are as follows :—

" *Sardinella longiceps* depends mainly on pelagic organisms for its food and is, therefore, a surface feeder, occasionally resorting to bottom-feeding. There is no such thing as ' unrecognizable debris ' in the stomach contents. The inedible *Noctiluca* when predominant in the plankton may cause disturbance in the food-chain of the oil sardine and cause local scarcity. The free eggs of the oil sardine have been isolated from the marine plankton off Quilandy. The eggs are pelagic unlike those of the herring which are demersal. A scale of ovarian stages has been drawn up on the model of Hjort's scale for the herring. This will be useful in following the maturing stages and seizing eventually opportunities to determine the season of spawning and to conduct embryological research. The question of migration has been examined at some length and the evidence at our disposal at present does not lend support to the theory

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of migration of the oil sardine. More than two rings are found in the scale of *Sardinella longiceps*. The primordial ring and vestigial rings have been discovered for the first time in the scales of the oil sardine and an interpretation of them is beset with difficulties owing to want of collateral researches like marking experiments."

He also made certain recommendations about the future plan of work on the oil sardine.

In view of the disagreement about the span of life of the oil sardine between these authors based on their studies of the scales, Nair (1949) made a detailed study of the otoliths of the oil sardine and detected two and in exceptional cases three growth rings. He also came to the conclusion that the average span of life of the oil sardine is about three to four years. Chidambaram (1951) studied the length frequencies, size and age groups of the oil sardine and his findings lend support to Nair's conclusions. He also indicated that the availability of food and the surface temperature and salinity influence the movements of the oil sardines and also the spawning and survival of the young ones. Recently Nair and Chidambaram (1951) while reviewing the oil sardine fishery showed the irregular fluctuation encountered in the fishery at intervals ranging between two and six years and also indicated that small-sized immature oil sardines have contributed largely to the success of the fishery during the years of abundance. These authors have also pointed out the inverse relationship between the oil sardine and the mackerel fisheries supported by data relating to their landings extending over 25 years. The subject has recently been discussed by Panikkar (1952).

Even though investigations were commenced some three decades ago to study the biology and fishery of the oil sardine, precise information relating to the food and feeding habits, spawning habits and breeding grounds, development, races, migration, etc., of the oil sardine is still lacking. A knowledge of these and other kindred aspects of the biology of the fish and of its fishery is highly necessary for the proper exploitation of this valuable fishery. The results of the detailed biological investigations on the oil sardine and its fishery carried out at Kozhikode during the recent revival of the fishery after the disastrous failure of over a decade, are briefly presented in this paper.

I take this opportunity to express my grateful thanks to Dr N. Kesava Panikkar for the valuable suggestions received during the course of this investigation and to Mr. George K. Kurian, Assistant Director of Fisheries (Marine Biology), Kozhikode, for making available the data relating to the oil sardine landings presented in this paper.

MATERIAL AND METHODS

The material for this study was mainly taken from the commercial catches of oil sardines landed at Kozhikode and also from the biweekly departmental catches made from the same locality. Samples of oil sardines were also periodically examined from the other fishing zones mainly with a view to verifying the results of the investigations carried out at Kozhikode. It may be mentioned here that the oil sardines were mainly caught with two types of nets—the boat seine " Mathikolli vala " (Photograph 1) and the gill net " Mathichala vala " along the Malabar coast and the shore seine " Rampani " along the South Kanara coast.[1] Th

PHOTO 1. The oil sardines being transferred from th bag of the boat seine, "Mathikolli vala" to the 'hol of the large canoe.

[1] *Mathikolli vala* is a boat seine made of cotton and is used exclusively for the capture of the oil sardine. The dimensions of the net are :—length 60′, breadth 18′ and mesh size 5/8″. It consists of a wide-mouthed bag, a platform and two wings and is operated by two dugout canoes. Half of the net is carried in each canoe and when the shoal is sighted the canoes separate paying out the net. The encircled shoal is driven into the net by the loud noise produced from auxiliary canoes.

former two nets constitute efficient gear for the capture of this pelagic shoaling species out in the sea, while the " Rampani " is used only when the shoals enter the shallow inshore waters. The boat seine, " Paithu vala " is also used in the oil sardine fishery along the Malabar coast, but with limited efficiency because of its structural variations. For obtaining a correct picture of the size composition of the oil sardine population in the region under investigation, the samples have been analysed irrespective of the gear employed for their capture. The toal length was measured from the tip of the snout to the end of the dorsal caudal fluke when it was held parallel to the long axis of the fish and the measurements were grouped within ten millimetre intervals (example: 10 cm size group includes oil sardines measuring from 10.0 to 10.9 cm in total length). The data relating to the estimated landings of oil sardines were compiled by the Fish Curing Yards of the South Kanara and Malabar coasts. The hydrological data presented in the paper relate to the eight fathom surface waters off West Hill, Kozhikode, and were collected at the Sub-Station. The rainfall figures have been compiled from the daily weather reports issued by the Regional Meteorological Centre, Madras.

THE FISHERY OF THE OIL SARDINE

The estimated landings of the oil sardine along the South Kanara and Malabar coasts from the 1925-26 season onwards presented in Table I show clearly the general trend of fluctuation including the recent failure extending over a number of years and the later improvement and the revival of the oil sardine fishery. The maximum catches recorded during the period was in 1933-34 with a total landing of 1.9 million maunds[1] of oil sardines. The total catch exceeded a million maunds during the 1925-26 season as well. Even though the annual catches of oil sardines varied considerably during the earlier years, the fishery proved to be a disastrous failure after the 1941-42 season and the lowest catch of 237 maunds was reached in the 1946-47 season. In the succeeding years the fishery showed steady improvement and revived considerably during the 1951-52 season. A perusal of the table of estimated landings of oil sardines shows the striking feature that the catches are, as a general rule, far greater along the Malabar coast than those of the South Kanara coast. Exceptions to this have been observed only during the 1925-26, 1929-30, 1938-39, 1944-45, 1947-48 and 1948-49 seasons.

The estimated landings of oil sardines at the different fishing villages along the South Kanara and Malabar coasts during the 1948-49 to 1951-52 seasons, have also been tabulated for the purpose of this study.

1948-49 OIL SARDINE FISHERY OF THE WEST COAST

During the 1948-49 season the catches of oil sardine along the South Kanara coast were heavy and accounted for 6,645 maunds out of the total of 7,789 maunds landed along the coast. The shoals first appeared during the season in September, 1948, at two widely separate fishing centres, namely, Polippu in South Kanara and Pudiappa in Malabar. In the next month, the oil sardine shoals occurred only at Malpe. November and December, 1948, were the best months during the season and the total landings for the two districts were 2,471 and 2,848 maunds of oil sardines valued at 0.1 and 0.2 lakhs of rupees respectively. The fishery came to a close by January, 1949, in South Kanara while small shoals continued to appear erratically along the Malabar coast until April, 1949. It is interesting to mention here that the oil sardine fishery of the 1948-49 season was more or less confined to two small zones, the first one extending from Hungarcutta to Kaup in South Kanara and the second from Quilandy to Kadalundy in Malabar. The heaviest catches of the season were recorded from the former zone which includes Malpe, the most important fishing centre of South Kanara. The landings of oil sardine at Malpe were particularly heavy during the season and accounted for approximately half the total quantity landed during the season throughout the coast.

Mathichala vala is a gill net made of cotton and is used only for catching oil sardine. The net is operated by two canoes. The dimensions of the net are :—length 36-90′, breadth 12-18′ and mesh size 3/8-5/8″. Each canoe carries 4 to 8 such pieces of net laced together and when the shoal is sighted the net is paid out quickly from both the canoes in a semicircular manner across the direction of the movement of the shoal which gets encircled by the net. The terrific noise produced by the fishermen makes the oil sardines panicky and in their attempts to escape from the net they get themselves firmly gilled.

Rampani is a very large shore seine used for catching shoals of oil sardine and mackerel. The net is made of hemp and consists of about 100 pieces linked together. The dimensions of each piece are:—length 36′, breadth 20′ and mesh size 3/4-1″. One end of the net is held by a party of 40 men in the shore and the net is carried in a large boat and is paid out in a semicircular way encircling the shoal. The other end of the net is brought ashore and is handed over to another party. The two ends of the net containing the shoal are slowly dragged by the two parties of men. Large quantities of these fishes, sometimes weighing several tons, are landed in one haul of the net.

[1] 1 Ton = 27.22 Maunds.

1949-50 OIL SARDINE FISHERY OF THE WEST COAST

The oil sardine fishery of the 1949-50 season was noticed to be better than the previous season and this was more apparent along the Malabar coast, where 74,444 maunds were landed out of the total of 90,827 maunds of oil sardines caught during the season. The oil sardine fishery commenced early along the Malabar coast and the shoals first appeared in September, 1949, at Quilandy. The fishery gradually extended to the other fishing villages and was observed to be uniformly good till the end of the season in June, 1950. The appearance of the shoals along the South Kanara coast, on the other hand, was delayed considerably and the fishery started abruptly and simultaneously in the different fishing villages in December, 1949. In the subsequent months, the landings of oil sardines decreased and the fishery of South Kanara came to a close in April, 1950. The peak of the fishery of the 1949-50 season was reached in December 1949. The landings in South Kanara and Malabar for the month were 11,676 and 23,017 maunds of oil sardines respectively valued at 3.7 lakhs of rupees. These catches constituted more than a third of the total quantity landed during the entire season. The fishery of the 1949-50 season was also confined to two zones of the West coast extending from Marwanthi to Baikampadi in South Kanara and from Madapalli to Blangad in Malabar. The catches were particularly heavy at Kozhikode and the landings at this place were nearly a third of the total quantity landed during 1949-50.

1950-51 OIL SARDINE FISHERY OF THE WEST COAST

The 1950-51 oil sardine season also maintained the steady improvement in the fishery noted during the preceding years. The fishery was very good along the Malabar coast with a landing of 139,762 maunds out of the total of 180,884 maunds of oil sardine for the entire season. The season commenced in Malabar in July, 1950 more or less in continuation of the 1949-50 season. The oil sardine shoals first appeared at Palacode and Madai and at Vadanapalli and Karimpuram situated at he northern and southern extremities respectively of the Malabar coast. The fishery extended to most of the other fishing villages of the Malabar coast during the subsequent months and terminated by April, 1951. Along the South Kanara coast the fishery commenced later, in August, 1950, and terminated also earlier, in February, 1951. The noteworthy feature of the 1950-51 season was the uniformly good condition of the fishery throughout the West coast, particularly along Malabar. The zonal occurrence of the oil sardine shoals conspicuously seen in the previous two seasons was also noted during the present season, especially along the South Kanara coast where the region of concentration of the shoals extended from Malpe to Baikampadi. The peak of the 1950-51 season was also in December, 1950, and the quantities of oil sardine landed in South Kanara and Malabar during the month were 27,219 and 74,311 maunds respectively valued at 4.14 lakhs of rupees. The landings for the month constitute more than half the total quantity landed during the entire season. Madai and Kozhikode were the two best oil sardine centres during the 1950-51 season. The oil sardine landings were heavy and exceeded 10,000 maunds at Malpe and Udayavar in South Kanara and at Cannanore and Kootayi in Malabar.

1951-52 OIL SARDINE FISHERY OF THE WEST COAST

The 1951-52 season, which was comparable to the earlier years of plenitude, marks the complete revival of the fishery after its protracted failure extending over a decade. The fishery was exceptionally good along the Malabar coast and the heavy landings amounted to 273,374 maunds during the season. In South Kanara, on the other hand, the fishery was not so good as in Malabar, and the total landings were only 19,500 maunds, less than half the quantity caught during the 1950-51 season. The 1951-52 season, like the previous one, commenced first along the Malabar coast. Shoals appeared simultaneously at its northern (Madai, Mattool and Thalayi) and southern (Nattika) extremities in July, 1951. During the next three months, the fishery spread rapidly throughout the coast. The fishery commenced in South Kanara only in August, 1951, and it was mainly confined to the southern portion. The " Malpe zone " which consistently recorded good landings of oil sardines during the last three seasons was completely forsaken by the shoals during this season. The " Hosdrug zone " which was not represented during the 1948-49 and 1949-50 seasons and indications of which were noticed during the 1950-51 season came to prominence during the 1951-52 season mainly owing to the complete absence of the oil sardine fishery at the " Malpe zone ". The peak of the fishery was reached in Malabar in October, 1951, and in South Kanara in September, 1951. The landings were 158,444 and 11,595 maunds of oil sardine valued at 9.7 and 0.7 lakhs of rupees respectively. The fishery of the oil sardine in South Kanara was also fairly good during October,

1951, with a landing of 6,475 maunds valued at 0.4 lakhs of rupees. The fishery took a sudden turn in November, 1951, when the shoals abruptly disappeared from the coastal water throughout and and in April, 1952, in Malabar. Even though a shifting of the region of maximum occurrence of the oil sardine shoals from the " Malpe zone " to the " Hosdrug zone " was seen in South Kanara

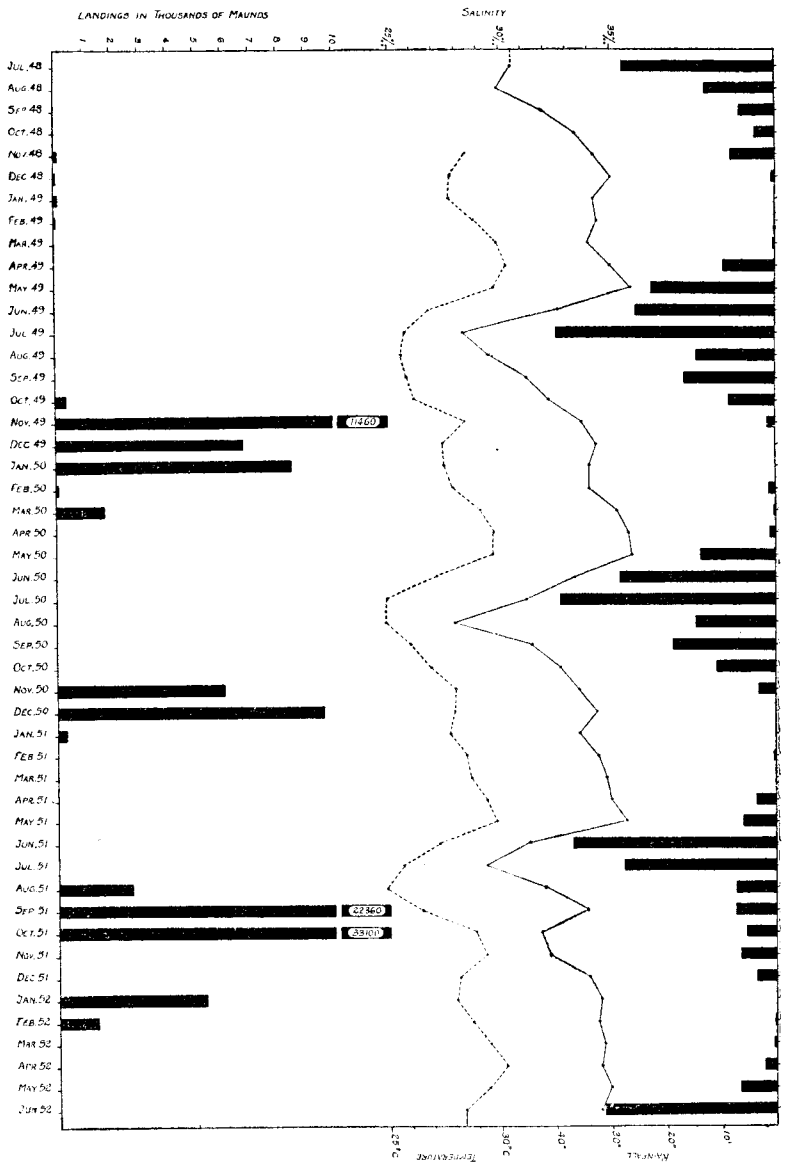

FIG. 1. Histogram showing the estimated monthly landings of oil sardine together with the total monthly rainfall and the average monthly temperature and salinity at Kozhikode from July, 1948, to June, 1952.

the catches for the month dwindled to 1,010 maunds in Malabar and to practically zero in South Kanara. The shoals reappeared in December, 1951, but in small numbers only. The fishery of the 1951-52 season terminated in January, 1952, in South Kanara during the 1951-52 season, no such change in the regional distribution was noticed along the Malabar coast, and the " Kozhikode zone " continued to yield the maximum catches. It may also be mentioned that Kozhikode landed the record

quantity of 61,800 maunds during the season. Pudiappa was the second best centre during the year with a total catch of 26,250 maunds of oil sardine. The landings at Hosdrug in South Kanara and at Quilandy, Parapanangadi, Tanur, Ponnani, Mannalamkunnu, Puthenkadapuram and Blangad in Malabar exceeded 10,000 maunds during the 1951-52 season.

THE OIL SARDINE FISHERY AT KOZHIKODE

From the general picture of the oil sardine fishery of the West coast presented above, it is apparent that there is a zonal distribution in the intensity of occurrence of the shoals and that the " Malpe zone " and the " Kozhikode zone " are the two principal regions where the shoals occur in great abundance during the season. " Kozhikode zone " in particular, appears to be the best region for the fishery. During the last four seasons, Kozhikode has landed the record average catch of 26,000 maunds of oil sardine and it is presumed that the result of this critical study of the biology of the oil sardine and of its fishery conducted at this place during these years of revival of the fishery would reflect the condition of the oil sardine fishery existing in the " Kozhikode zone " of the Malabar coast.

The estimated monthly landings of oil sardines at Kozhikode from the 1948-49 to 1951-52 seasons are given in Table II and they are shown in the form of a histogram in Figure I along with data relating to the rainfall and hydrological conditions at Kozhikode.

1948-49 OIL SARDINE FISHERY AT KOZHIKODE

The fishery, in its initial stages in July, 1948, was composed of mature oil sardines with a dominant size of 19 cm shoals of which entered the inshore fishing grounds in relatively small numbers. Later, in August, 1948, spawners belonging to the same size group contributed to the fishery in large numbers. The ovaries of these spawners were soft and translucent and completely filled with transparent eggs which were ready for extrusion. The mature ovarian eggs of the active spawners were found to have an average diameter of 1 mm with the yolk perfectly transparent and showing the vacuolated condition characteristic of clupeoid eggs. The majority of the eggs were provided with a single golden yellow oil globule measuring about 0.1 mm in diameter. These spawners in stage VI[1] and males with active motile sperms in the testes which were cream-white in colour, continued to occur in smaller numbers during September, 1948 also, but diasppeared by the end of the month from the inshore waters. Pelagic oil sardine eggs were noticed in the plankton collections made off Kozhikode during these months.[2] A sudden change in the composition of the oil sardine fishery was noticed in November, 1948, when oil sardines with a modal size of 14 cm entered the fishery in enormous numbers and formed the bulk of the catches made during the month. The oil sardines belonging to the same size group continued to occur in fairly large numbers in the commercial catches made during December, 1948, also along with those of the 15 cm size group. In the subsequent months, however, the latter size group dominated in the fishery till the end of the 1948-49 season at Kozhikode. Detailed examination showed that the oil sardines belonging to these size groups were immature and in most cases the gonads were in the course of formation. It was also observed that these juvenile oil sardines formed the mainstay of the commercial catches landed at Kozhikode.

Qualitative and quantitative studies on the stomach contents of the oil sardine samples examined during the season showed that the active spawners invariably had empty stomachs indicating the cessation of feeding activity at the time of spawning. The mature adults, on the other hand, showed frequent changes in the composition of the stomach contents and the main constituents noted in large numbers were *Coscinodiscus concinnus*, *Dinophysis caudata*, *Ornithocercus magnificus*, *Peridinium depressum*, *Biddulphia mobiliensis*, *Evadne tergestina*, copepods, etc. The analysis of the stomach contents of the immature juvenile oil sardines showed remarkable similarity in the composition of the food taken by them during the few months they dominated in the fishery. *Fragilaria oceanica* was observed to constitute the important food of these sardines. *Asterionella japonica* was another diatom noticed to contribute to the food of the juveniles in large numbers. *Prorocentrum micans*, *Biddulphia mobiliensis*, *Pleurosigma angulatum* var. *strigosa*, *Nitzschia sigma* var. *indica*, *Planktoniella sol*, *Coscinodiscus* spp. and a few other forms occasionally dominated in the food of the juvenile sardines.

[1] The stages mentioned in this paper are after the maturity scales adopted by the International Council for the Exploration of the sea.

[2] The embryonic and larval development of the oil sardine have been worked out in detail and an account of its life-history is being published elsewhere.

1949-50 OIL SARDINE FISHERY AT KOZHIKODE

During the earlier part of the 1949-50 season, the oil sardine fishery was very irregular partly on account of the intensity of the South West monsoon and the periodic appearance of swarms of *Noctiluca miliaris* constituting the red water phenomenon characteristic of the West coast. However, on days when conditions were favourable for fishing operations, particularly by the middle of August, 1949, large shoals of very small sardines with a modal size of 7 cm were encountered in the 10-15 fathom waters off Kozhikode and they were extensively caught by the commercial fishermen with large boat seines along with large numbers of *Rastrelliger kanagurta*, *Decapterus russelli* and *Anchoviella commersonii*. These small-sized juveniles disappeared altogether after a few days. Unlike the immature adults and spawners which feed mostly on phytoplankton, the food of these very young sardines was found to be composed mainly of copepods like *Euterpina acutifrons*, *Oithona brevicornis*, *Acartia erythraea*, *Paracalanus parvus*, copepodites and the cladoceran *Evadne tergestina* in large numbers. Mature sardines with a modal size of 18 cm entered the fishery by September, 1949, and the ovaries of almost all the females were well developed reaching stage V. The composition of the stomach contents of these sardines frequently showed sharp changes which were mainly caused by the fluctuations in the abundance of planktonic diatoms and other forms during the monsoon months. The oil sardines examined on the 31st August, 1949, were observed to have fed on large swarms of *Chaetoceros lorenzianus* while those caught the next day showed swarms of *Fragilaria oceanica*. *Coscinodiscus concinnus*, *Thallassiothrix frauenfeldii*, *Biddulphia mobiliensis*, *Pleurosigma* spp., *Nitzschia seriata*, *N. sigma* var. *indica*, *Ceratium massiliense*, *C. fusus*, *Peridinium depressum* and *Dinophysis caudata* were the other organisms found in large numbers in the stomach contents of these adult oil sardines.

In the subsequent months the oil sardine fishery showed remarkably steady improvement and the peak of the fishery was reached at Kozhikode in November, 1949, when the sardines practically dominated the commercial catches. The landings at Kozhikode for the month were 11,460 maunds. These were mainly caught with the boat seine, "Mathikolli vala" from waters at a distance of 8-10 miles from the shore. Gill nets were also used during this month, but only when the shoals entered the shallower inshore waters. The boat seine catches were observed to be composed exclusively of oil sardines while *Rastrelliger kanagurta* and *Sardinella fimbriata* were also caught along with the oil sardines in the gill net. Frequent changes in the population of the oil sardine in the fishing grounds were also observed with the improvement of the fishery in October, 1949. The spawners observed in the fishery during September, 1949, disappeared from the foreshore waters and the month of October, 1949, saw the entry of a different size group having a modal size of 13 cm in the commercial catches. Adult oil sardines with a modal size of 17 cm again appeared in the fishery in November, 1949, but these completely disappeared by the middle of December, 1949, when small-sized immature juveniles with the majority sizes ranging from 10-12 cm appeared in enormous numbers along the entire coast and dominated the fishery till the end of February, 1950. It is apparent that this year class of immature oil sardines which contributed in no small measure to the improvement of the fishery of the 1949-50 season, is a new stock probably the result of the successful spawning observed during the last season. The fishery rapidly declined during the succeeding months and this tendency was seen early in March, 1950, when the shoals occurred rather erratically in the inshore waters. These shoals were also observed to be composed of spent oil sardines.

The food of the spawners during the first week of September, 1949, consisted mainly of huge swarms of *Fragilaria oceanica* and this was replaced by *Nitzschia seriata* by the end of the month. During October and November, 1949, though the volume of food in the gut was relatively low, less than 1 cc in most cases, *Coscinodiscus concinnus* formed the major food. *Fragilaria oceanica*, *Pleurosigma* spp., and *Dinophysis caudata* also contributed to the food of the mature oil sardines. Active spawners in stage VI were again noticed to have empty stomachs confirming the observation made earlier that there is very little feeding activity at the time of spawning. The stomachs of these spawners were always observed to be very much distended probably owing to intense pre-spawning feeding activity.

The juvenile oil sardines were observed to have fed on *Evadne tergestina* and *Penilia avirostris* by the middle of October, 1949, but a week later their food was mainly composed of *Peridinium depressum* swarms. The cladocerans again formed the important food of the young sardines in November, 1949. *Prorocentrum micans*, *Dinophysis miles* and *Coscinodiscus* spp. were also present in large numbers and formed a major portion of the food of the juvenile sardines. Early in December, 1949, the food of the young oil sardines was found to be composed mainly of *Trichodesmium erythraeum* along with *Coscinodiscus* spp. and *Evadne tergestina* in small

numbers. A change in the composition of the food was noticed by the middle of the month when *Fragilaria oceanica* dominated among the constituents of the stomach contents. During this period *Trichodesmium erythraeum*, *Coscinodiscus* spp. and *Pleurosigma* spp. also formed major elements of the food of the oil sardine. By the middle of January, 1950, another change was noticed when the tintinnids formed the important food along with *Biddulphia mobiliensis*, *Fragilaria oceanica*, *Ceratium massiliense*, *Trichodesmium erythraeum*, etc., in fair numbers. In March, 1950, the food was mainly composed of *Nitzschia seriata*. *Trichodesmium erythraeum* was again noticed to contribute to the food of the oil sardine in large numbers during April, 1950. It is interesting to mention here that the polychaete, *Prionospio pinnata*, was noticed for the first time in large numbers in the stomach contents of the juvenile oil sardines caught on the 16th February, 1950, which was a new moon day. The volume of food in the gut of these sardines rose to the high figure of 3.5 cc mainly owing to the presence of large numbers of this polychaete worm.

Oil sardine eggs were noticed in small numbers in some of the townet collections made from the sea off West Hill during the latter half of November, 1949.

1950-51 OIL SARDINE FISHERY AT KOZHIKODE

The noteworthy feature of the oil sardine fishery of the 1950-51 season was the early appearance of the active spawners in July, 1950, and the commencement of the spawning season much earlier than in the previous two seasons. It was also observed that the spawning period was somewhat protracted during the year judging from the gonadial condition of the spawners which appeared erratically along the coast. The first shoal of active spawners appeared on the 8th July, 1950, off Kozhikode even though the sea at that time was very rough owing to the intensification of the South West monsoon along the coast which resulted in the formation of mud banks in the foreshore regions extending to about the four fathom limit. The shoals of oil sardines composed exclusively of spawners appeared irregularly on the subsequent days also and they were mostly captured from the eight fathom regions where the water was very clear. The spawners had the characteristic bulging belly caused by the fully-developed and enlarged ovaries in stage VI containing transparent eggs which were ready for extrusion. The mature eggs oozed out in most of the specimens at the slightest pressure and milt was also observed to come out when the belly of the males was gently pressed. The spawners continued to occur till the end of November, 1950. During the next month exceptionally large shoals of immature oil sardines with a modal size of 9 cm and spent oil sardines dominated in the fishery. The immature oil sardines were particularly abundant during this month which constituted the peak period of the oil sardine fishery of the 1950-51 season and large shoals frequently entered the very shallow inshore waters where heavy catches were made with the boat seine and the cast net. The immature oil sardines continued to appear irregularly and in smaller numbers in January, 1951, and the fishery came to a close by the end of the month.

The stomach content examination of the different samples from the catches made during the year showed again that there is active pre-spawning feeding activity as shown by the large volume of food present in the stomachs of females in stage V. The stomachs of the spawners were also observed to be greatly distended. On the contrary, the stomachs of the active spawners were always found to be empty indicating the cessation of feeding activity at the time of spawning. Active feeding was again noticed in the spent individuals. *Thallassiothrix frauenfeldii* in huge swarms formed the important food of the adult oil sardines in June, 1950. *Fragilaria oceanica* in swarm condition dominated in the constituents of the stomach contents in July, 1950, and the first half of August, 1950. The cladoceran, *Evadne tergestina*, in exceptional numbers, was seen dominating in the stomach contents of the mature oil sardines caught during the latter half of August, 1950. *Fragilaria oceanica* again formed the chief food of the mature ones in September, 1950. Other planktonic forms like *Nitzschia seriata*, *Coscinodiscus lineatus*, *Asterionella japonica*, *Bacteriastrum varians*, *Rhizosolenia robusta*, *Biddulphia seriata*, *Peridinium depressum* and *Dinophysis caudata* also formed the important food of the grown-up oil sardines during the season. The spent oil sardines have been observed to have fed on swarms of *Peridinium conicum*, *Nitzschia sigma* var. *indica*, *Dinophysis caudata*, etc. in November, 1950. *Prorocentrum micans* and *Nitzschia seriata* formed the chief food of the juveniles during October and November, 1950. *Fragilaria oceanica*, *Coscinodiscus* spp., *Thallassiothrix frauenfeldii*, *Nitzschia seriata* also contributed to the food of the juveniles during the season.

Detailed examination of the plankton collections made from the commercial fishing grounds where the active spawners of the oil sardines occurred in large shoals, revealed the presence of oil sardine eggs in large numbers in August, 1950, and in relatively smaller numbers in September, 1950, and the average number of eggs present in a haul of 15

minutes duration was about 50 in the former month. The unusually abundant occurrence of the oil sardine eggs in the plankton off Kozhikode showed the success of spawning during the 1950-51 season and based on this and other factors a tentative forecast of the improvement of the oil sardine fishery of the 1951-52 season was made possible by the end of December, 1950.

1951-52 OIL SARDINE FISHERY AT KOZHIKODE

The 1951-52 oil sardine fishery at Kozhikode commenced early in August, 1951, immediately after the cessation of the South West monsoon. As usual the oil sardine fishery commenced with the appearance of spawners which had a modal size of 18 cm during the first half of August, 1951. The second half of the month witnessed a sudden change in the composition of the oil sardine population of the fishing region. The indeterminate juveniles with a dominant size of 12 cm entered the fishery during the latter half of the month in enormous shoals and exceptionally heavy catches were made reminiscent of the former years of abundance. During the next two months the oil sardine fishery showed remarkable improvement with a record catch of 22,360 and 33,100 maunds during September and October, 1950, respectively. The catches of oil sardine during this glut period was also used for the manufacture of oil and guano in newly erected oil and guano factories. It may be mentioned that the success of the fishery during this period was mainly due to immature oil sardines with a dominant size of 15 cm. The shoals abruptly disappeared from the inshore waters during the next two months and no catches were made by the commercial fishermen. The juveniles, the disappearance of which was responsible for the temporary setback in the fishery seen during this period, reappeared in large shoals from the second week of January, 1952. They continued to occur in February, 1952, also along with spent oil sardines with a modal size of 19 cm. The oil sardine fishery of the 1951-52 season came to a close by the end of February, 1952, at Kozhikode. It is interesting to mention here that in spite of the remarkable improvement of the fishery of the 1951-52 season, active spawners in stage VI and planktonic oil sardine eggs were not encountered during the year and it is likely that their absence may adversely affect the oil sardine fishery of the 1952-53 season.

The detailed qualitative and quantitative study of the food of the oil sardine conducted during the season has shown that *Fragilaria oceanica* which occurred in enormous swarms in the coastal waters during the post-monsoon months formed the chief food of the juvenile oil sardines. The juveniles which reappeared in the fishery in January, 1952, after the temporary setback in the fishery showed again large quantities of *Fragilaria oceanica* though the species was not present in such abundance in the coastal plankton. It is possible that *Fragilaria oceanica* occurred in patches in the offshore waters and that the oil sardines had fed on these patches. However, the study of the food and feeding habits clearly show that the availability of *Fragilaria oceanica*, the favourite food of the oil sardine, partly controls the movements of the oil sardine shoals, especially of the juveniles which form the mainstay of the oil sardine fishery during the years of abundance. *Thallassiothrix longissima*, *Peridinium conicum*, *P. depressum* and *Pyrophacus horologicum* formed the main food of the mature adults observed in the fishery in August, 1951, while swarms of *Ornithocercus magnificus*, *Dinophysis caudata* and *Prorocentrum micans* constituted the chief food of the spent oil sardines noted in the fishery at the end of the 1951-52 season.

STUDIES ON THE LENGTH FREQUENCY

During the four years of study, 7,316 oil sardines were measured for total length and the size group analyses for the different seasons were made, the number of individuals in each size group being expressed as percentage of the total number examined during the different months and years with a view to facilitate comparison. The length frequency histograms from the seasons 1948-49 to 1951-52 and the average length frequency histogram for the entire period of investigation are given in Figure 2. A study of the length frequency tables, histograms and polygons made shows clearly the presence of distinct size groups denoting age classes comprising the fishery every season and also their passage through the fishery in the succeeding months.

In the fishery of the 1948-49 season two distinct modes were observed to be present represented by group A at 19 cm and group B at 15 cm (Fig. 2). The latter group was constituted by immature juveniles which entered the fishery in November, 1948, and formed the mainstay of the fishery of the season. This group predominated in the commercial catches and formed more than 43% of the landings. Group A was composed mainly of adult oil sardines including the active spawners which contributed to the fishery from July to September, 1948 (Fig. 5).

During the 1949-50 season, three distinct modes were represented in the fishery, viz., group B at 17 cm, group C at 13 cm and group D at 10 cm

(Fig. 2).The group D composed of juveniles with

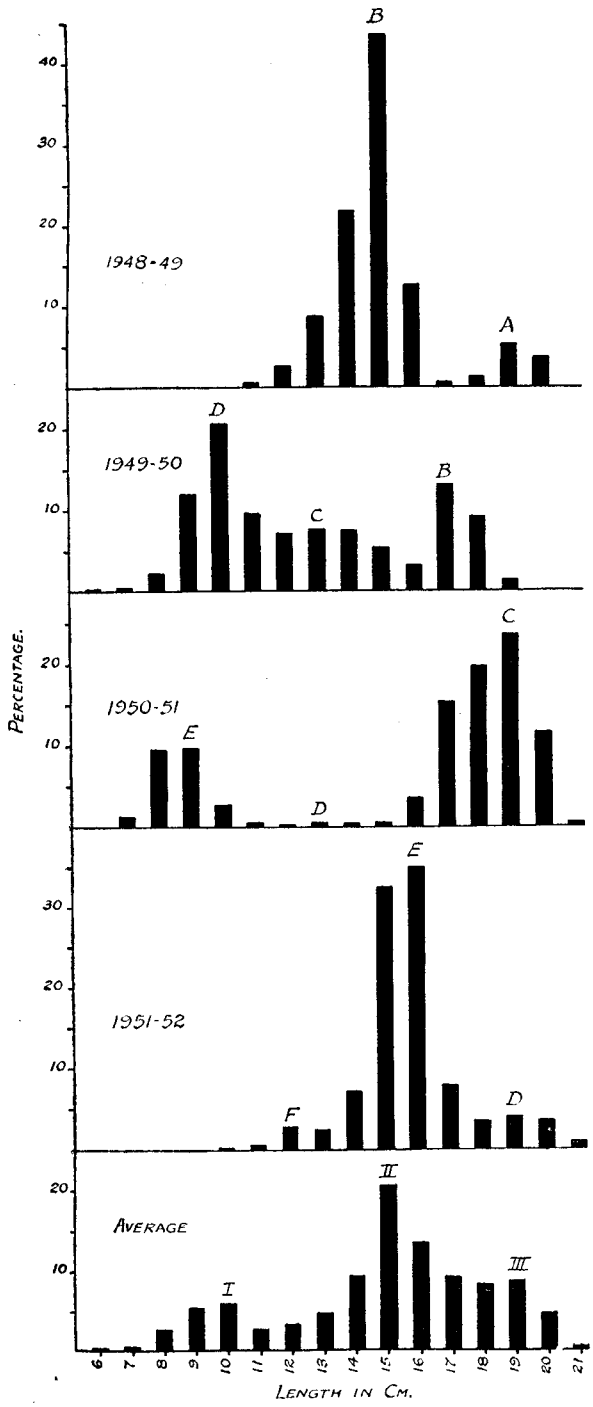

FIG. 2. Length frequency histograms of the oil sardine for the seasons 1948–49 to 1951 -52 and the average length frequency histogram for the entire period of investigation.

undeveloped gonads dominated in the fishery during December, 1949, and represented more than 25% of the catch. This group belonged to a new stock recruited during the previous season. Group C which was insignificant in comparison with the other two groups of the season, was also composed of immature oil sardines with the gonads in the earlier stages of development. On the other hand group B, which was also present in the previous season and had increased in length by 2 cm was found to be composed of mature adults including the active spawners. This group appeared in the fishery during November and December, 1949. Group A of the previous season was not represented in the fishery of the 1949-50 season.

In the 1950-51 oil sardine fishery, three modes dominated and these were group C at 19 cm, group D at 13 cm and group E at 9 cm (Fig. 2). Group E was a new stock composed of indeterminate juveniles, the result of the spawning of the 1949-50 season. Group D which had registered an increase of 3 cm in total length was poorly represented in the fishery and was composed mostly of oil sardines with gonads in the course of development. Group C was composed of adult oil sardines and active spawners. It may be recalled that the spawning season of the 1950-51 oil sardine season was unusually longer than that of the previous season and the adult and the spawning oil sardines formed the bulk of the catches from July to December, 1950. This group was present in the fishery of the previous season and showed a growth of 6 cm. Group B of the 1949-50 season had disappeared from the fishery of the 1950-51 season.

Three distinct modes represented by groups D, E and F at 19, 16 and 12 cm respectively were noticed in the fishery of the 1951-52 season (Fig. 2). It is clear that group F composed of indeterminates encountered in the fishery in August, 1951, was the product of the intensive spawning observed during the previous season. Group E which entered the fishery during the last season practically dominated in the fishery during January, 1952. Group D which was observed first in the 1949-50 fishery constituted the mature adults of the 1951-52 season.

The different age groups of the oil sardines seen in the fishery of the four seasons showed variations in their rate of growth. Groups D, E and F recorded a growth of 10, 9 and 12 cm respectively at the end of the first year. Similarly, groups B, C, D and E also showed different growth increments at the end of the second year when they measured 15, 13, 13, and 16 cm respectively. There is some uniformity in the size reached at the end of the third year as shown by groups A, B, C and D which measured 19, 17, 19 and 19 cm respect-

ively. Accurate determination of the growth rate of the oil sardine based on modal progression during the successive months is rendered difficult owing to the tendency of uniformly sized oil sardines to form the shoals which move in and out of the zone of study. Apart from the sampling error likely to be caused by the shoaling and migratory habits of the oil sardine, it is probable that such variations in the growth rate of the different year classes are caused by the slight shifting of the time of recruitment during the spawning season and also by the fluctuations in the availability of the favourite food of the larval and juvenile oil sardines.

The length frequency histogram based on the averages of percentages for the four seasons under investigation shows the presence of three distinct modes represented by the 10, 15 and 19 cm groups in the population of the oil sardine at Kozhikode (Fig. 2). It is obvious that these three groups represent year classes and that the life span of the oil sardine is three to four years. The new stock recruited during the short spawning season extending from August to November grows to a size of 10 cm and enters the fishery of the succeeding year in a very immature condition. At the end of the second year, when the gonads are in the early stages of development, the oil sardines measure 15 cm and again contribute the bulk of the fishery. They attain the adult spawning size of 19 cm at the end of the third year. A small percentage of the oil sardine population alone reaches the maximum size of 21 cm and even though this group was not represented as a distinct mode in any of the seasons under investigation, it is possible that this size is reached during the fourth year of existence.

THE OIL SARDINE FISHERY IN RELATION TO HYDROLOGICAL CONDITIONS AND THE PHYTOPLANKTON

The South West monsoon with its heavy downpour during June and July is an important factor regulating the annual biological cycle of the West coast. The heavy rains prevailing at the height of the monsoon affect both the fauna and flora of the coastal waters. The influx of rain water brought down by the rivers Beypore, Kallayi and Korapuzha alters considerably the hydrological conditions of the sea off Kozhikode and the lowest temperature and salinity are reached during these months as evident from Table III and Figure 1 which show the monthly average surface temperature and salinity of Kozhikode waters and the total monthly rainfall at Kozhikode. The change in the hydrological conditions brings about marked alterations in the composition of the plankton of the coastal waters as well. The sudden outburst of phytoplankton bloom is the characteristic feature of the monsoon months and the diatom dominance in the plankton extends usually from July to September. It is during this period that the oil sardine fishery usually commences along the West coast. The active spawners appear in the fishery first and the detailed studies have shown that they do not show any feeding activity. It can, therefore, be reasonably assumed that the spawners enter the coastal waters only for spawning and the stimulus for breeding activity is given by the outbreak of the monsoon which alters the hydrological conditions considerably. Panikkar and Aiyar (1939) and Nair (1952) have arrived at the same conclusion in regard to the breeding of marine fishes of the East coast. With the return of higher values of temperature and salinity during the post-monsoon months, the spawners forsake the coastal waters and the composition of the fishery also changes during this time. The immature and juvenile oil sardines gradually enter the fishery when the temperature and salinity are on the increase and they practically dominate the fishery from November to January which represent the peak period of the fishery at Kozhikode. The salinity at this time is usually high and varies from 34 to 35‰. The temperature, on the other hand, after showing a progressive increase to 28-29°C in November declines again and this fall is partly caused by the occasional rains of the North East monsoon. The temperature generally varies from 27-28°C during the peak period of the fishery. The second minor peak in the production of phytoplankton extending usually from December to January coincides with the peak period of the oil sardine fishery. The immature and juvenile oil sardines apparently enter the inshore waters during this period when the temperature and salinity are higher than those of the monsoon months, mainly to feed on the phytoplankton at its secondary maximum period. The juvenile oil sardines disappear from the coastal waters by February or March when stray shoals of spent oil sardines alone appear in the fishery. The oil sardine fishery generally terminates by March or April which are poor months for the occurrence of phytoplankton.

The food and feeding habits of the oil sardines as observed during the last four seasons have also shown that phytoplankton forms the chief food of the juvenile and adult oil sardines, and among the different diatoms, *Fragilaria oceanica* is the most important constituent of the food of the fish. A significant correlation has been found to exist between the occurrence of this diatom and the oil sardine in the waters off Kozhikode. The major peak in the occurrence of the diatom is during June and July, representing the monsoon months. A

minor peak is reached during September-October, more or less coinciding with the peak period of the oil sardine fishery. The relationship which became apparent during the earlier seasons was seen markedly during the 1951-52 season which was a very good year both for the diatom and the oil sardine. During this season, the maximum occurrence of *Fragilaria oceanica* was observed during the monsoon months June and July, 1951. In the next month, however, a sudden decline in their production was seen and it registered a low position in the phytoplankton composition of the month. A steady increase in their numerical abundance was observed in the two subsequent months and the secondary maximum in its occurrence was reached in October, 1951. The diatom was practically absent during November and December, 1951, in the inshore waters. It again reappeared in the plankton in January, 1952, though in smaller numbers.[1] The data relating to the commercial catches of oil sardines at Kozhikode show a direct correlation with the fluctuation in the abundance of *Fragilaria oceanica* in the coastal waters. Large-scale commercial exploitation of the oil sardine fishery commenced only in August, 1951. The fishery also showed steady improvement in the subsequent months and the peak of the fishery was also reached in October, 1951. The fishery suffered a setback during the next two months caused mainly by the disappearance of *Fragilaria oceanica*, the favourite food of the juvenile oil sardines from the inshore waters. The fishery recovered in January, 1952, with the reappearance of the diatom in the sea off Kozhikode. The availability of *Fragilaria oceanica* is probably one of the main factors responsible for the seasonal fluctuations of the oil sardine fishery.

OIL SARDINE FISHERY IN RELATION TO OTHER FISHERIES

The oil sardine and the mackerel are the two principal fishes which contribute to the marine fish production of the West coast. The fluctuation characteristic of the fishery of the oil sardine does not normally affect that of the mackerel. An inverse relationship in the annual yields of these two fisheries has been indicated in an earlier paper (Nair and Chidambaram, 1951). The fluctuations in the oil sardine fishery seen within the season do not in any way influence the course of the mackerel fishery. The estimated monthly landings of the oil sardine and the mackerel at Kozhikode for the 1951-52 season are given in Table III. It is seen that the landings of these fishes have been uniformly good during the different months. The oil sardine fishery was poor during November and December, 1951, and a similar decline in the landings of mackerel was also observed during these months.

On the other hand the success or failure of the oil sardine fishery has been observed to exert a profound influence on the other sardine fisheries of the West coast, namely, of *Sardinella fimbriata*, *Sardinella brachysoma*, and *Kowala coval*. The oil sardine being a more highly priced and esteemed fish than even the mackerel, its fishery is intensively exploited neglecting the other fisheries of the West coast. This relationship existing between these fisheries is clearly seen from the monthly landings presented in Table II. It may be mentioned that the 1951-52 season also showed prospects of a very good fishery of the other sardines and enormous shoals of these fishes frequently entered the very shallow inshore waters, but their fisheries were neglected by the commercial fishermen owing to the unusual improvement of the more lucrative oil sardine and mackerel fisheries at that time. Commercial exploitation of these fisheries was observed only on those days when the oil sardine and mackerel were scarce in the fishing grounds.

DISCUSSION

This study brings out clearly the regular cyclical changes in the composition of the oil sardine stocks encountered in the fishery during the 1948-49 to 1951-52 seasons. The oil sardine fishery always commences during the South West monsoon with the appearance of the spawners along the coast. The post-monsoon months show the disappearance of the spawners and the entry of the juvenile oil sardines which practically form the bulk of the commercial catches during the peak period of the fishery. The spent oil sardines generally appear in the closing stages of the fishery.

Detailed biological investigations conducted during the four seasons of progressive improvement of the fishery, have shown that the oil sardines reach the average size of 10, 15 and 19 cm at the end of the first, second and third year respectively and that the one-year old oil sardines are indeterminates, the two-year old oil sardines are immature with developing gonads and the three-year old oil sardines are mature adults and active spawners. This is in agreement with the earlier findings based on the studies on the otoliths of the oil sardine (Nair, 1949). The presence of the first growth ring followed by a narrow growth zone in the indeterminate oil

[1] I am thankful to Dr R. Subrahmanyam for the information relating to the occurrence of *Fragilaria oceanica* during the 1951-52 season.

sardines of the 12 cm size group, one growth ring and a wide growth zone in the immature oil sardines of the 15 cm size group and two growth rings followed by a wide growth zone in mature sardines belonging to the 19 cm size group was shown in this paper. Judging from the size of the fish, the number of rings and the width of the last growth zone, it can be assumed that these size groups represent one-, two- and three-year old oil sardines. In the majority of the preparations two rings alone were detected and in exceptional cases indications of the third ring were also seen.

The present study has established that the oil sardines show a definite preference for phytoplankton food. Phytoplankton production commences along the coast with the onset of the South West monsoon and paucity of phytoplankton is generally observed during the summer months extending from March to May. It is probable that the growth checks detected on the otoliths of the oil sardine, especially the first two ones, are formed during the summer months when there is scarcity of phytoplanktonic food. The third ring encountered in some oil sardines is either caused by the same factor or by the cessation of feeding at the time of spawning.

Chidambaram (1950) has also arrived at the same conclusion in regard to the span of life and rate of growth of the oil sardine. Based on length frequency studies he has shown very similar growth rate, namely 10.0, 14.5, 18.3 and 20.5 cm during the first, second, third and fourth year of life of the oil sardine. It may be mentioned that the growth rate of the oil sardine arrived at by these studies on the otoliths and length frequencies is in general agreement with that of the sardines of other countries, particularly the Australian pilchard, *Sardinops neopilchardus* (Blackburn, 1949).

Contradicting views were, however, expressed by earlier workers about the life span of the oil sardine. Hornell and Nayudu have suggested on the basis of their studies on the scales, that the oil sardine attains sexual maturity and almost full adult size at the age of one year when it reaches 15 cm. According to them growth during the second year is very slow and amounts to only 1 cm. Their estimation of the span of life of the oil sardine is about two and a half years only. Devanesan, from his studies on the scales of the oil sardine, suggested that the oil sardine of 6.5 cm belonged to the second year class, 8.7 cm to the sixth year class, etc., and 21 cm to the fourteenth year class. It is clear from the photographs illustrating his paper that he had counted the false rings also along with the true ones for determining the age of the oil sardine.

Another point which has emerged as a result of this investigation is about the size and age of the oil sardine at the time of the first maturation and spawning. Hornell and Nayudu state that the oil sardine attains sexual maturity when it reaches 15 cm even though none was ever found by them in the actual spawning or oozing condition. Devanesan collected spawners of oil sardines from Quilandy in the oozing condition. He does not record the measurements of these active spawners but indicates only the size range of the random sample which contained the spawners. The earlier authors appear to have made no distinction between the conditions found in the gonads reaching maturation and those ready for spawning for they appear to have assumed that spawning takes place immediately after the gonads attain the normal size, which according to these authors takes place when the fish reaches a size of 15 cm in length. The present study has shown that the one-year old oil sardines are always indeterminate with undeveloped gonads while the two-year old oil sardines are immature with the gonads usually in the earlier stages of development. Active spawners and spent oil sardines in stages V to VII have always been encountered in the three-year old sardines only. This investigation also shows the possibility that the oil sardines spawn only once in their lifetime as shown by the simultaneous maturation and extrusion of almost all the ovarian eggs and the absence of recovering specimens among the spent oil sardines.

Based on Walford's (1946) positive correlation of the summer salinity with the fluctuations in the abundance of the year classes of the Pacific sardine, *Sardinops caerulea*, Chidambaram has also attempted to explain the migrations of the oil sardine in relation to temperature and specific gravity. He suggests that the oil sardine shoals appear in inshore waters when the temperature is low and disappear from these waters because of higher temperature. It is true, no doubt, that the spawners enter the inshore waters when the temperature and salinity are at their lowest during the monsoon, but for the appearance of the juveniles which form the mainstay of the oil sardine fishery every year, higher temperature and salinity, especially the latter, appear to be necessary. Immense shoals of juveniles have been encountered in the fishery during the peak period from November to December alone when the temperature and salinity vary from 27 to 28°C and 34 to 35‰ respectively. Perhaps, these are the optimal hydrological conditions for the appearance of the juveniles in the coastal waters. The abundance of phytoplankton, particularly of *Fragilaria oceanica*, appears to be another causative factor which influences the movements of the juvenile shoals, on the availability of which depends

the success and failure of the oil sardine fishery every year.

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EXPLANATION OF FIGURES AND PHOTOGRAPH

Fig. 1.—Histogram showing the estimated monthly landings of oil sardine together with the total monthly rainfall and the average monthly temperature and salinity at Kozhikode from July, 1948, to June, 1952.

Fig. 2.—Length frequency histograms of the oil sardine for the seasons 1948-49 to 1951-52 and the average length frequency histogram for the entire period of investigation.

Photo 1.—The oil sardines being transferred from the bag of the boat seine, " Mathikolli vala " to the ' hold ' of the large canoe.

TABLES

Table I.—Estimated landings of oil sardine in South Kanara and Malabar from the 1925-26 to 1951-52 seasons.

Table II.—Estimated landings of oil sardine and other sardines at Kozhikode from July, 1948, to June, 1952.

Table III.—Estimated monthly landings of oil sardine and mackerel at Kozhikode during the 1951-52 season.

TABLE I

Estimated Landings of Oil Sardine in South Kanara and Malabar

Seasons	Landings of oil sardine in maunds		
	South Kanara	Malabar	Total
1925-26 ..	650,707	541,742	1,192,449
1926-27 ..	74,021	322,626	396,647
1927-28 ..	63,673	129,339	193,012
1928-29 ..	8,465	39,968	48,433
1929-30 ..	42,122	31,656	73,778
1930-31 ..	4,824	111,048	115,872
1931-32 ..	17,175	41,378	58,553
1932-33 ..	212	29,901	30,113
1933-34 ..	796,805	1,126,788	1,923,593
1934-35 ..	10,796	547,414	558,210
1935-36 ..	961	39,188	40,149
1936-37 ..	122,365	605,361	727,726
1937-38 ..	76,445	379,592	456,037
1938-39 ..	66,873	24,576	91,449
1939-40 ..	78,240	111,724	189,964
1940-41 ..	290,603	386,406	677,009
1941-42 ..	13,442	105,789	119,231
1942-43 ..	690	23,948	24,638
1943-44 ..	5,867	5,991	11,858
1944-45 ..	17,472	123	17,595
1945-46 ..	195	281	476
1946-47 ..	30	207	237
1947-48 ..	25,494	6,419	31,913
1948-49 ..	6,645	1,144	7,789
1949-50 ..	16,083	74,744	90,827
1950-51 ..	41,122	139,762	180,884
1951-52 ..	19,500	273,374	292,874

TABLE II

Estimated Landings of Oil Sardine and Other Sardines at Kozhikode from July, 1948, to June, 1952

Months	Oil Sardine	Other Sardines
Jul., 1948	..	..
Aug., 1948	..	..
Sep., 1948	..	..
Oct., 1948	..	535
Nov., 1948	..	1,810
Dec., 1948	42	2,895
Jan., 1949	23	7,250
Feb., 1949	44	3,070
Mar., 1949	23	..
Apr., 1949	..	..
May, 1949	..	..
Jun., 1949	..	..
Jul., 1949	..	..
Aug., 1949	..	..
Sep., 1949	..	1,050
Oct., 1949	..	..
Nov., 1949	405	..
Dec., 1949	11,460	..
Jan., 1950	6,775	..
Feb., 1950	8,500	..
Mar., 1950	30	..
Apr., 1950	1,730	..
May, 1950	..	..
Jun., 1950	..	..
Jul., 1950	..	..
Aug., 1950	..	..
Sep., 1950	..	..
Oct., 1950	..	6,050
Nov., 1950	..	5,850
Dec., 1950	6,025	70
Jan., 1951	9,645	..
Feb., 1951	308	..
Mar,. 1951	..	3,570
Apr., 1951	..	175
May, 1951	..	20
Jun., 1951	..	..
Jul., 1951	..	..
Aug., 1951	..	..
Sep., 1951	2,640	..
Oct., 1951	22,360	7,540
Nov., 1951	33,100	820
Dec., 1951	..	..
Jan., 1952	..	150
Feb., 1952	5,300	250
Mar., 1952	1,400	..
Apr., 1952	..	..
May, 1952	..	..
Jun., 1952	..	..

TABLE III

Estimated Monthly Landings of Oil Sardine and Mackerel at Kozhikode during the 1951-52 Season

Months	Oil Sardine	Mackerel
Jul., 1951	..	..
Aug., 1951	2,640	5,070
Sep., 1951	22,360	41,100
Oct., 1951	33,100	34,640
Nov., 1951	..	17,100
Dec., 1951	..	31,400
Jan., 1952	5,300	23,050
Feb., 1952	1,400	10,050
Mar., 1952	..	7,250
Apr., 1952	..	..
May, 1952	..	910
Jun., 1952	..	..