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Environmental influence on the behaviour of Indian mackerel and their availability to fishing gear along the Malabar coast

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ABSTRACT

The upwelling phenomenon observed along the Malabar coast regularly from March to October, produces a plankton bloom. This helps in increasing the reproductive output of mackerel and effect successful spawning and recruitment. During the monsoon period the new recruits concentrate at the surface as the thermocline is very shallow. During this period they become highly vulnerable to the surface gear. With the sinking of thermocline they move to deeper waters reducing their vulnerability. Mackerel prefers a temperature around 27°C and hence stays immediately above the thermocline. Hence, there is a demersal phase in the life history of the fish during summer. The fish is a prolific breeder always ready to make use of a favourable environment for spawning.

Introduction

Pelagic fisheries of the Malabar area along the southwest coast of India underwent a series of major changes during the last decade. From the primitive small dugout canoes propelled with oars and small nets with large meshes made of cotton and hemp fibres the fishing units- changed to large plank built boats propelled by outboard engines of upto 120 hp and large ring seines with very small meshes made of nylon fibres. With the constrution of a series of fisheries harbours the fishing activity during the rough monsoon season increased considerably. With these changes one of the most important pelagic fishery of Malabar - the oil sardine *(Sardinella longiceps)* fishery - crashed in the 1990s and the most efficient pelagic fishing units of the area had to depend mainly on the stocks of Indian mackerel *(Rastrelliger kanagurta).* Mackerel were caught round the year from most of the areas of its distribution and all biological stages of the fish were available for studies. A detailed study of the mackerel fishery revealed very interesting behaviour pattern of the fish in relation to changing environment.

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Material and methods

Data on catch and effort in the fishery and biological characteristics of Indian mackerel collected from the Malabar area, especially from Calicut, during 1994-'95 formed the basis of this study. Data presented by various authors on the environment of the area were re-analysed to present the variations in environment. Regular interviews with the fishers engaged in the mackerel fishery were very useful to make important observations on the behaviour of the fish.

The environment

Rainfall : The southwest monsoon rains normally commences in the area in the first week of June every year. Peak rainfall occurs in June or July. Rainfall attains a minor peak in October with the northeast monsoon. The average monthly rainfall in Calicut during the years from 1991 to '95 is shown in Fig. 1. The date of commencement of monsoon shows year to year change from 14 May to 20 June with maximum cases between 26 May and 5 June.

Temperature: Fluctuations in the surface temperature of the coastal waters off Calicut have a definite pattern. Fig. 2 depicts the pattern observed by Hornell and Nayudu (1923) and Mukundan (1967). It had a maximum in April/May (around 30.5°C) and then reaches the lowest value in July/August (around 25.5°C). Then the temperature increases to a secondary peak by October/November. Seshappa and Jayaraman (1956) observed that the temperature at 19 m depth during the pre-mongoon months was as high as that at" the surface but minimum during August/ September. Chidambaram (1950), Pradhan and Reddy (1962), George

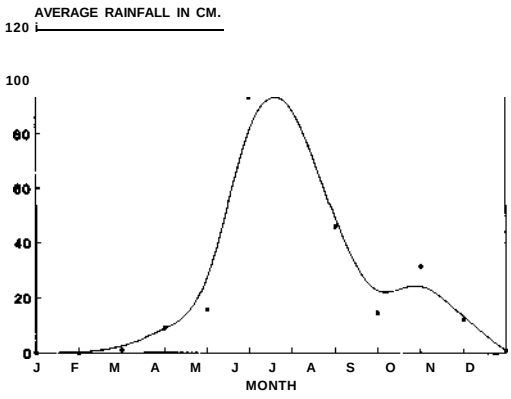

Fig. 1. Trend of monthly rainfall (in cm) in Calicut (averages of 1991-'95).

(1953), Kasturirangan (1957) and Yohannan (1997) also gave a similar pattern. Banse (1959) opined that the sudden decrease in temperature after the fury of monsoon subsides, was caused by upwelling of the cold bottom water with low oxygen content during the whole period of southwest monsoon.

Upwelling: Sharma (1968) studied the upwelling phenomenon along the Calicut coast. Fig. 3 drawn based on the observations made by him shows that

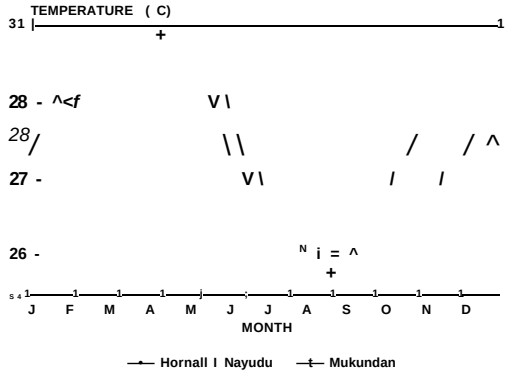

Fig. 2. Trend of. monthly variations in surface temperature (in °C) (Hornell and Nayudu, 1923; Mukundan, 1967).

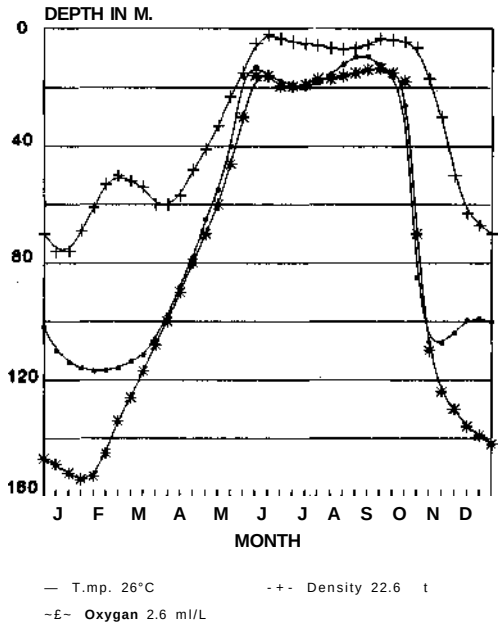

Fig. 3. Trend of monthly variations in temperature (25°C), oxygen (2.5 ml/1) and density (22.5 t) off Calicut at different depths (Sharma, 1968).

the 25°C isotherm representing the thermocline start moving up from a depth of about 115 m in February to a depth of 15 m by June and to 10 m by September. The maximum intensity of upwelling is in the Calicut-Karwar region (Ramasastry and Myrland, 1959; Rao and Ramamirtham, 1976). During July-August the surface mixed layer becomes more or less obliterated with the temperature declining to 26°C and the oxygen deficit layer migrating even to the surface.

Nutrients and primary production: Seshappa and Jayaraman (1956) observed that during monsoon there is a rapid release of phosphates from the bottom mud to the overlying column of water and the quantity of phosphate in water increases to a maximum by August/September (Fig. 4). George (1953) had observed an outburst of diatoms, dinoflagellates and other phytoplankton alongwith phosphate values during monsoon. Subrahamanyan and Sarma (1965) found peak production of phytoplankton during the southwest monsoon (Fig. 5). Yohannam (1997) observed peak values of silicates in August/September.

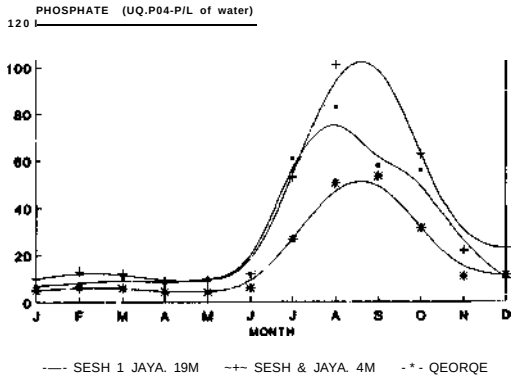

Fig. 4. Trend of monthly variations in phosphate (ug P04-P/1 of water) concentration in surface waters off Calicut (Seshappa & Jayaraman, 1956; George, 1953).

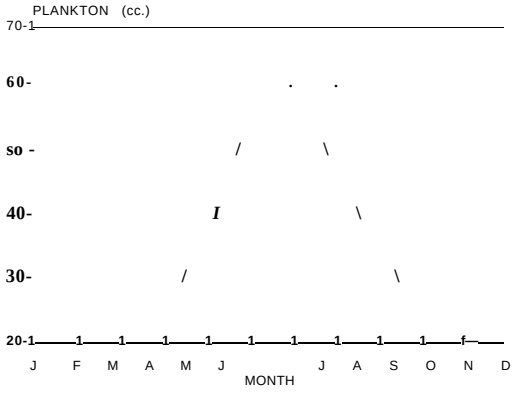

Fig. 5. Trend of monthly variations in phytoplankton (in cc) abundance off Calicut (George, 1953).

Oxygen: According to the data made available by Mr. N.P. Kunhikrishnan (personal communication) the oxygen concentration at the bottom starts falling from June and reaches a low value by August/September when the surface waters do not show appreciable decrease.

The general pattern of the changing environment is repetitive year after year but with varying intensities.

Results

The catch: The average monthly catch by different gear during 1994-'96 is shown in Fig. 7. The ring seine which is a surface gear dominated the fishery during July-October with peak catches in August-September. During this period the shoals are available at the surface and the juveniles of size below 15 cm are abundantly caught during the daytime. After September the shoals move down and the fishing is not possible in the daytime because of the difficulty in spotting them. Then the fishing will be restricted to night when they move up and will be visible by the

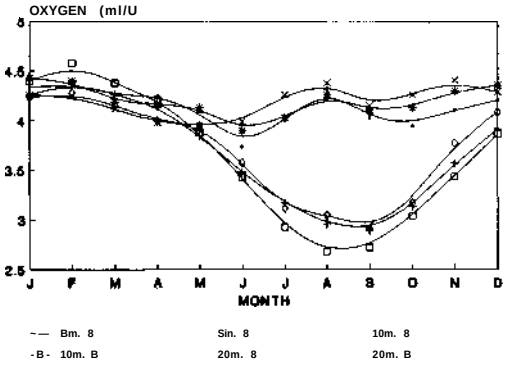

Fig. 6. Trend of monthly variations in oxygen concentration (ml/1) at surface and bottom waters off Calicut (Kunhikrishnan, personal communication).

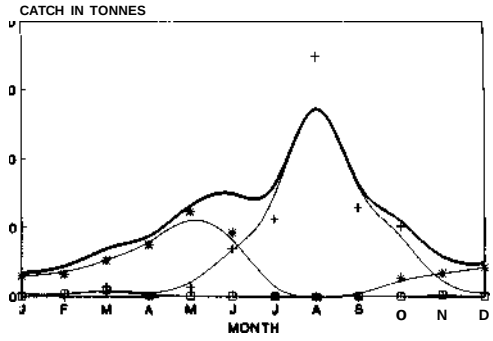

Fig. 7. Trend of gearwise monthly catch and total catch of mackerel in Calicut.

bioluminescence produced. As the season advances they move down beyond 40 m depth which is beyond the operational range of the ring seines. By then the ring seine fishing will be closed.

In February some fishers who were engaged in ring seine fishery, go for fishing with gill nets. This gear is operated as a bottom set gill net at 40 m depth by sunset. It is observed that mackerel move up from the bottom by sunset and move around. This is the time when the fish get entangled in the bottom set gill nets. Once they move upto the column they are not available to this gear. Hence, the fishing is done only for one hour. This is a kind of sustenance fishery for the ring seine fishers during the off-season eventhough the catches are poor. Two hundred number of mackerel per unit is considered a good catch.

Gonadal conditions: The catch of these gill nets are landed in the night and the mackerel are found invariably spawners. The gonads are not very heavy but the ovaries contain transparent mature ova ready to spawn. As the season advances the ovaries reduce in size gradually. But still the transparent

ova are seen. A study of the diameter of the ova revealed the presence of at least 6 batches of ova. A typical distribution is given in Fig. 8. Another interesting observation made on the night landings of gill nets was that though in the beginning of this fishery the sex-ratio was almost 1:1, the number of females decreased gradually and by the end of the season the M:F ratio was found to be 1:0.1.

In contrast, the mackerel catch made from the same area during daytime by bottom trawls showed a different situation. The ovaries never contained transparent ova. The ova diameter distribution of a typical ovary is given in Fig. 9. The sex ratio was maintained almost at 1:1. The catch of mackerel by bottom trawls start from October and the catches gradually increase and reach a peak in May and ends by June.

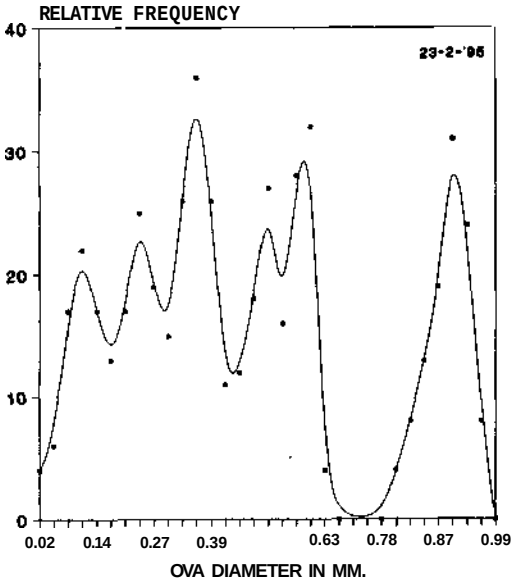

Fig. 8. Ova diameter frequency distribution in mature ovaries with transparent ova.

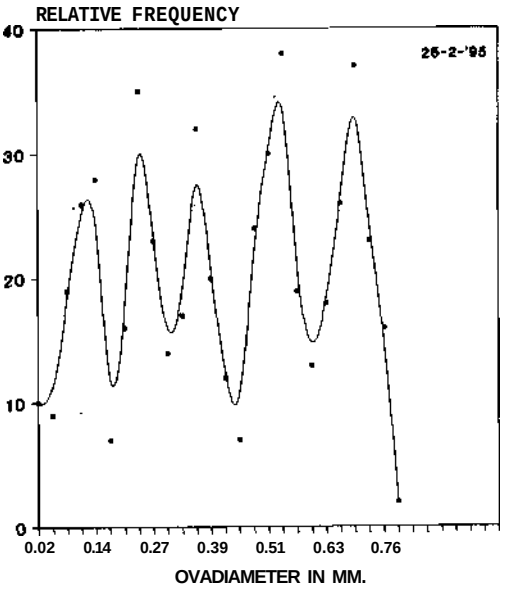

Fig. 9. Ova diameter frequency distribution in mature ovaries without transparent ova.

The important size groups that support the fishery in different months are given in Fig. 10. Peak fishery by ring seines is in monsoon (July-September) and the catch is mainly juveniles. Maturing takes place by October and

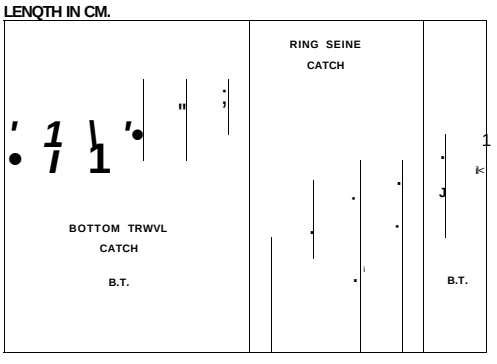

Fig. 10. Length-frequency distribution and important modal values of major broods of mackerel supporting the fishery of Malabar.

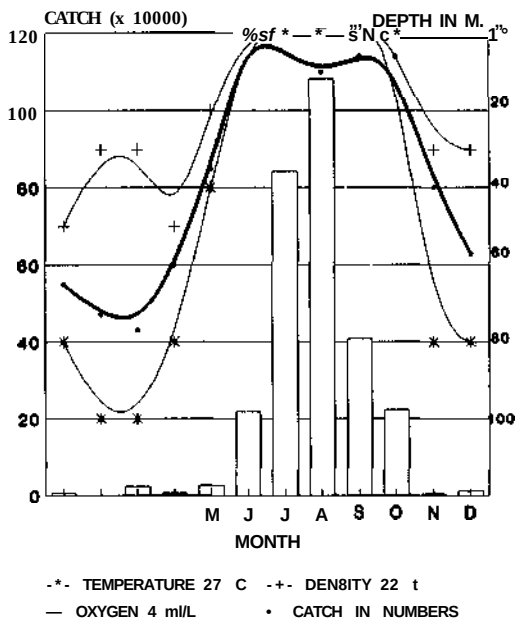

Fig. 11. Trend of monthly variations in temperature (27°C), oxygen (4 ml/1) and density (22 t) off Calicut at different depths (Sharma, 1968) and the catch in numbers of mackerel caught by ring seines.

spawning starts in February, but the ovaries are comparatively lighter. By May the ovaries start becoming heavier and spent by September. A minor brood (not shown in the figure) often observed in the fishery gets maturing by September and spawn by November.

The general pattern of the fishery and the biological conditions of the fish were similar during the years of study with minor variations in the intensity of exploitation.

Discussion

The monsoon and upwelling cause dynamic changes in the coastal environment. The nutrients in the upwelled water enrich the coastal surface waters. The deficiency in oxygen is made up by wind and turbulence characteristic of monsoon and plankton bloom occurs with the help of nutrients and sunlight. This causes rapid increase in the reproductive output of mackerl resulting in intensive spawning and recruitment. Growth is fast and the juveniles are intensively exploited at an age of 2 months and onwards. Mackerel cannot go below the thermocline but stays immediately above it. The juveniles are forced to remain at the surface during the monsoon because the thermocline is only 10-15 m below. In the much reduced mixed layer the juveniles become highly vulnerable to the surface gear like ring seines. After September, as the sinking of the thermocline starts, mackerel can move down reducing their vulnerability to the surface gear. As the temperature increases they stay at the bottom to come up only after sunset. By November they are available only to trawl in daytime. The surface gear take them only at night. By February they go farther 40 m area and stay deep beyond the operational range of the ring seine. The bottom set gill nets perhaps operate only at the boundaries of their distribution. The boats trawling beyond 40 m depth regularly bring mackerel till the next upwelling period.

When mackerel are recruited to the fishery during monsoon they are caught alongwith other species of same size like anchovies, *Decapterus* spp. etc, until they reach a size of around 10 cm. By the beginning of July when they grow above this size they form pure shoals of same species. Density of shoals is maximum in July-September and are visible at the surface in daytime as dark grey patches. After September when they move to deeper waters they will be visible only in the night due to bioluminescence produced by the plankters

caused by the movement of shoals. On newmoon nights this will be visible even upto a depth of 40 m.

The shoals were found to become more compact when they are disturbed by sound. A boat slowly moved above the shoals producing sound by beating on the sides if the boat resulted in the aggregatron of mackerals. According to fishermen the oil sardine shoals disperse when such sound is made.

Mackerel is a partial and protracted spawner. The fecundity estimates made by Devanesan and John (1940), Rao (1967) and Gopakumar *et al.* (1991) have to be considered as underestimates since they had considered only the ova present in the ovary and not those already spawned and the would be eggs. Ova diameter studies indicated the presence of at least six batches of ova at a time in the ovary while the oogenesis continue. The most advanced batch of ova ripens quickly for spawning leaving a gap in the diameter frequency distribution between this batch of ova and the next batch, the most advanced batch of opaque ova, in the ripe ovaries (Fig. 8). The presence of transparent ova in the ripe ovaries in the fish caught by gill nets after sunset and their absence in the fish caught in the daytime by trawls indicates that the final ripening takes place at sunset and the spawning occurs at night. The reduction in the ratio of females in the gill net catches indicates that only the fishes ready to spawn move up from the bottom and as the spawning progresses the number of females ready to spawn decrease. The weight of mature gonads was found to decrease from February to March. This is the period of low abundance of plankton along the southwest coast of India which may be causing this reduction. By May as the plankton availability increased the gonads were found to increase in weight.

The observations indicate that there is a definite demersal phase in the life history of the fish. This happens when the thermocline starts sinking and receding from the continental shelf. The surface temperature starts increasing above 28°C. When summer advances, as believed by the fishermen, the fish lie close to the bottom mud and move up a little at sunset. The rate of mackerel catch from this area by bottomset gill nets and trawls are very poor. A catch of 20 kg per boat is considered a good catch. But due to the sheer intensity of effort the catch by trawl adds up to a very substantial quantity. They move to deeper areas of the bottom as the thermocline recedes further.

What controls this movement? Sette (1950) has given a detailed account of the habits of the Atlantic mackerel *(Scomber scombrus)* which broadly agrees with that of Indian mackerel observed here. Yohannan (1997) has estimated the optimum temperature of the fish as 27°C. Fig. 11 drawn from the data presented by Sharma (1968) shows the vertical time section of temperature (27°C), oxygen concentration (4 ml/1) and density (22 t) off Calicut. The monthly average number of mackerel caught by ring seine during the study period also is shown in the figure. It can be assumed that the fish prefers temperatures lower than 28°C provided the oxygen concentration is around 4 ml/1. This keeps the fish always above the thermocline. Thermocline may be considered as the lower limit of the distribution of mackerel. It is the rising of the thermocline which controls the pelagic phase of the fish. They form large shoals

during the upwelling period because they are abundance immediately after recruitment and perhaps it is an adaptation to make use of the plankton abundant during this period. With sinking of the thermocline their area of distribution increase reducing the compactness of shoals. By February as the plankton abundance is low they lie diffused at the bottom. The benefit of forming compact shoals to feed on plankton has been explained by Sette (1950). This behaviour of the fish can cause bias if the catch or catch rates are taken as the indicators of abundance of the stock and mortality estimates are made on such data.

The intensity of upwelling and plankton bloom plays a major role in the recruitment of mackerel to the fishery of the Malabar area with corresponding intensity of spawning and survival of the larvae. The duration of upwelling controls the duration of the availability of dense shoals to the surface gear. Until the last decade the monsoon fishery was not at all active due to the inability of the primitive fishing units to defy the rough weather and lack of landing facilities. This helps the new recruits to tide over the period of vulnerability to surface gear. The recent increase in the monsoon fishery with faster boats, larger surface gear with smaller meshes and harbour facilities resulted in the intensive exploitation of new recruits. Spreading to deeper areas with downwelling reduce the vulnerabi-lity of shoals to exploitation. With the recent popularisation of bottom trawling to deeper areas the vulnerability in this area also has increased. Thus, all the natural refuges offish is being violated.

Mackerel is a prolific breeder starting spawning at the age of 8 months and continuing it for at least 6 months. The growth is very fast in the period of plankton abundance. It helps the fish to take advantage of any favourable situation for spawning and recruitment. With the refuges of the fish violated this perhaps is the only guarantee for the sustainability of stocks. If the fishery is allowed an unmanaged development this guarantee also can soon become obsolete.

Acknowledgement

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