FLUCTUATIONS IN MACKEREL LANDINGS AT CALICUT IN RELATION TO HYDROGRAPHICAL FACTORS

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Introduction

Of the hydrographical factors, temperature and salinity have been found to exert a profound influence on the fish throughout its life-cycle. The tolerance range of the hydrographical factors of fishes is characteristic of the species. Even within the same species, the degree of tolerance may vary slightly, depending upon the age of fish; the degree of tolerance, however, increases with the growth of fish. Chidambaram (1950), has shown that sardine catches are maximum when the hydrographical factors are within certain limits, during the season. Pradhan (1956) remarks that the entire stock of mackerel, impounded near the mouth of Kali River is apt to die from a sudden fall in salinity, due to the influx of freshwater from the river. Similar observations were made by Hubbs (1948), Jenson (1930), Radovich (1961), Tanoue and Enami (1954), Tonoue (1958 and 1960) and Walford (1946). Hubbs (*loc. cit.*) showed that seasonal migrations of fish of the west coast of United States are controlled by temperature.

It is observed that mackerel catches show marked variations from year to year and so also the salinity and temperature of the inshore waters of this coastline. An attempt has been made to correlate the mackerel landings with these factors.

Methods

Sea-water samples were collected from stations situated two to four miles off the shore. This is the area within which the mackerel fishing is confined during the season. The temperature of water was read immediately after the sample was collected. The salinity was determined in the laboratory by titration method described by Harvey (1945). The surface data only are considered for the present purpose. The observations cover a period of three years from October 1957 to September 1960 (no data for the month of October 1958). In the following account, the three years—October 1957

to September 1958, October 1958 to September 1959 and October 1959 to September 1960—have been referred to as series 1, 2 and 3 respectively.

Temperature and Salinity Variations

Temperature.—The range of mean monthly temperature of the water during the series 1, 2 and 3 are 5·6, 4·4 and 6·0° C. respectively. Generalising the trend of variations, it may be said (Figs. 1, 2 and 3) that the temperature shows an upward trend from October to November or December and decreases in January. From February onwards, the values increase steadily up to April. Again in May, the trend is slightly downwards followed by a steep fall in June–August period. The values tend to increase once again in September. The sudden lowering of temperature in June–August coincides with the activity of the south-west monsoon. The lowest temperature is recorded during July–September months and occasionally in October and the highest values are reached in March to May period. The minimum temperatures recorded were 26·6° C. (August 1958), 25·7° C. (July 1959), and 24·7° C. (August 1960) and the maximum values were 31·2° C. (April 1958), 30·4° C. (April 1959) and 30·7° C. (April 1960). During the active period of mackerel fishing (October to March), the ranges of temperature were 1·4, 1·3 and 3·7° C., in the series 1, 2 and 3 respectively. The temperature in all the three fishing seasons varied between 26·2 and 29·9° C., the minimum being always in October and the maximum in March.

Salinity.—Salinity of the sea-water around Calicut shows wide annual fluctuations. As compared with the Bay of Bengal, the salinity is generally higher during the major part of the year in the Arabian Sea. It is interesting to note that the lowest values are also recorded on the west coast during the south-west monsoon period. The ranges of salinity during the periods of series 1, 2 and 3 are 8·39, 13·28 and 5·09‰. From Figs. 1, 2 and 3 it is seen that in general, salinity shows a fall from October to November and sometimes the downward trend extends to December and January as in 1958–59; the salinity increases gradually from December onwards reaching the maximum in March–April months. From May, the trend of salinity and temperature variations are more or less similar. The mean values are usually very low during June–September period. The sudden lowering of salinity in June and July is due to the heavy precipitation caused by south-west monsoon. The average salinity reached as low as 21·39‰ in July 1959 as compared with the highest value of 35·04‰ of March 1958. Individual values suffer much, reaching even about to 12‰ in July. The range of salinity during the active fishing season of the present series are in the order of 1·96, 1·40 and 2·71‰. The values vary between 31·53 and 35·04‰ from October

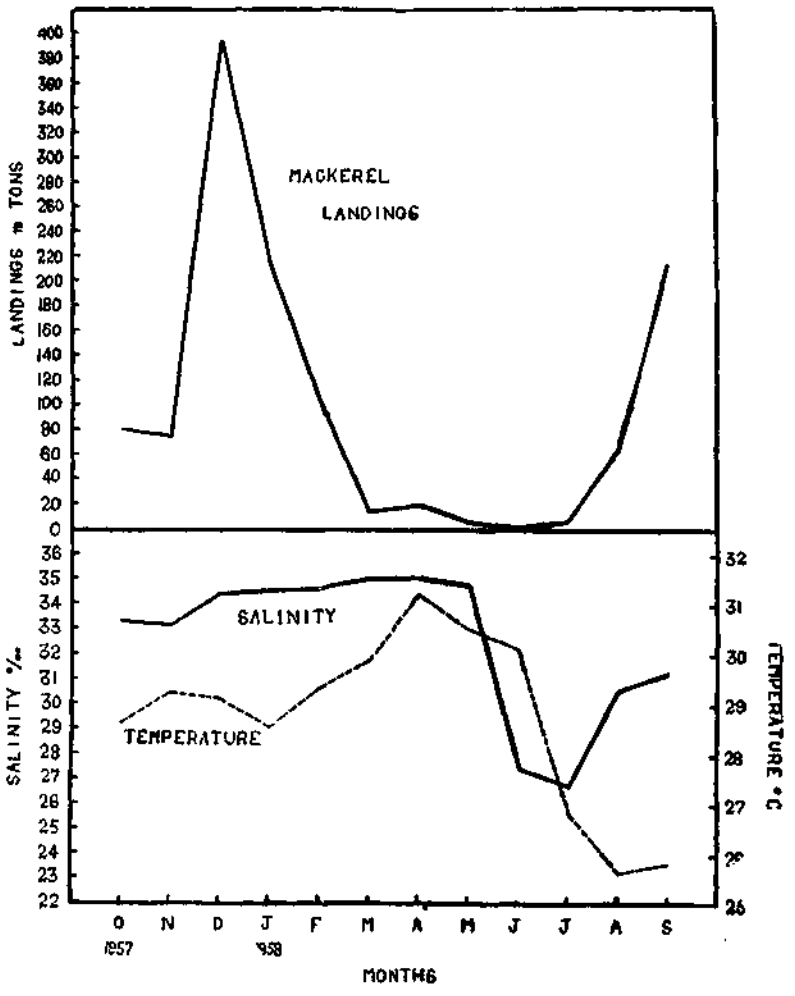

FIG. 1. Seasonal variations in the mean monthly values of temperature, salinity and mackerel landings during the period October 1957 to September 1958.

to March periods considering all the three series. It reaches maximum always in March but attains the minimum figure in November mostly, or occasionally, in December.

DISCUSSION

Fishes are known to be susceptible to the changes of temperature and salinity. Temperature is the most important factor as it controls the metabolic and spawning activities, while the salinity, besides controlling spawning, exerts profound effect on the osmotic balance of the body fluid of fishes.

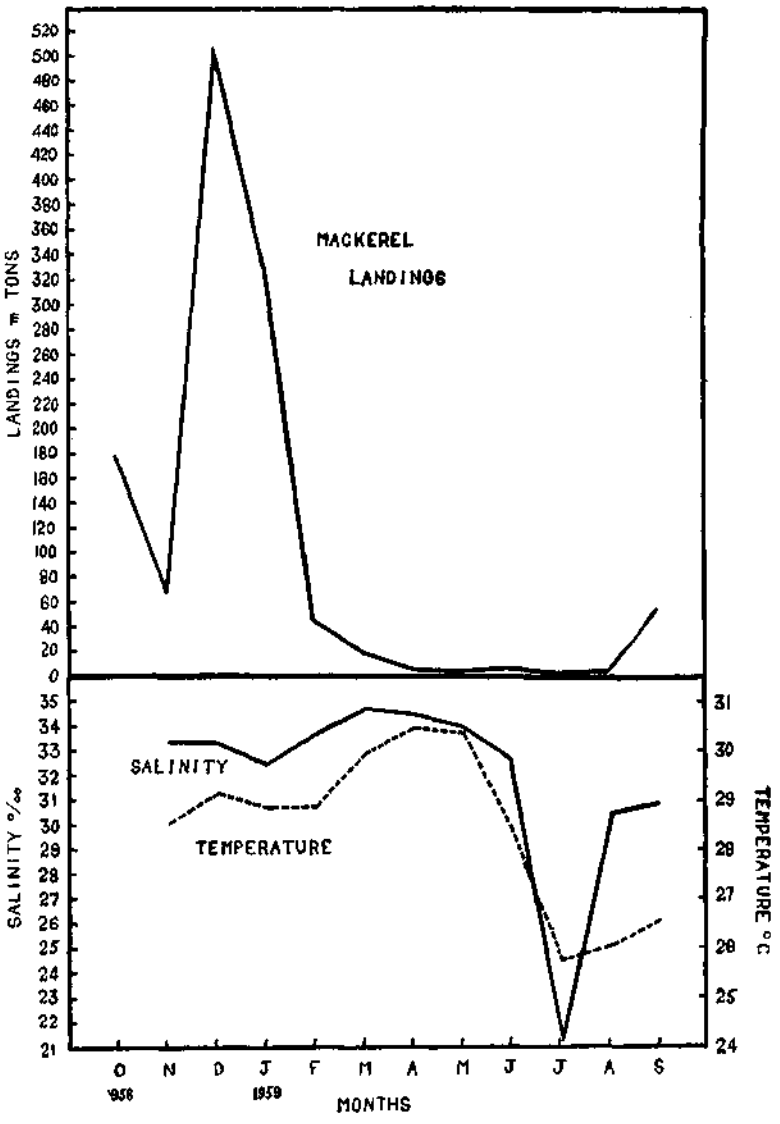

FIG. 2. Seasonal variations in the mean monthly values of temperature, salinity and mackerel landings during the period October 1958 to September 1959.

Even though fishes exhibit tolerance to these factors within certain limits, the tendency on the part of fishes appears to avoid if possible, conditions not congenial to them (*see* Tait, 1938).

The mackerel entering the fishery here are mainly immature. It may be noted that the plankton available in the months of maximum catch is

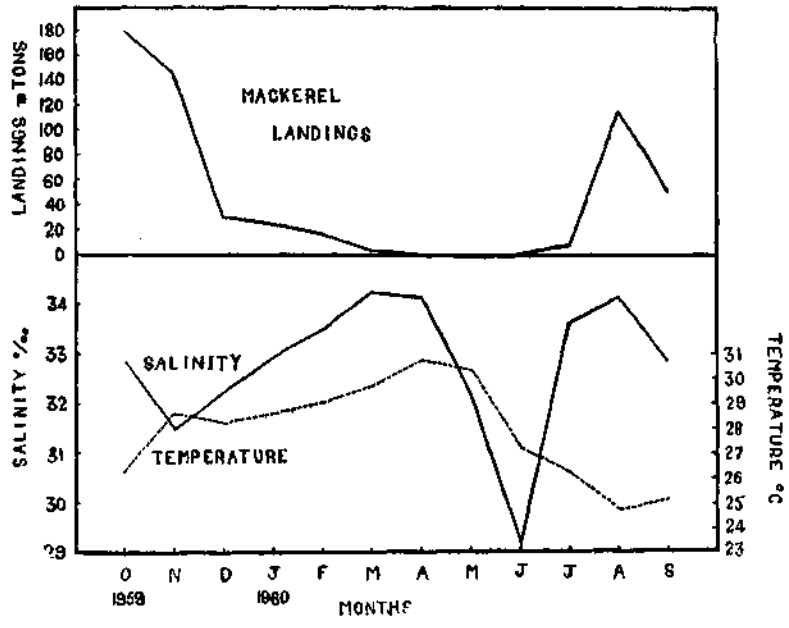

FIG. 3. Seasonal variations in the mean monthly values of temperature, salinity and mackerel landings during the period October 1959 to September 1960.

comparatively poorer than other months (Subrahmanyan and Sarma, 1960; Sarma, personal communication). It is, however, suggested by Subrahmanyan and Sarma (*loc. cit.*), that the poor standing crop of plankton in a particular period might also be due to grazing by predators. Pradhan (1956), in his studies on the food of mackerel has observed that there is no marked variation in the food of mackerel during the mackerel season and other periods of the year. Sekharan (1958) states: "The question, whether the concentration of mackerel in the inshore waters is entirely a direct response to plankton production, still remains to be verified". From the above statements it is reasonable to assume that provided the fish is not attracted to the fishing area entirely for food in the month of maximum catches, the hydrographical conditions may be responsible for the abundance of mackerel shoals in the inshore waters and the hydrographical values will be in proximity to the optimum conditions. The overall hydrographical conditions during the fishing season should be within the tolerance range of fishes of different year classes entering the fishery during the fishing season. The variations in hydrographical factors from the optimum values may explain fluctuations in the abundance of mackerel.

From Figs. 1 and 2, it can be seen that the catches of mackerel are maximum in the month of December. In Fig. 3, the peak is conspicuously absent in December. Comparing with the other two series, December of second series claims higher catches. The hydrographical conditions during December 1958 may be considered very close to the optimum. The average temperature and salinity during that month were 29·1° C. and 33·27‰, respectively. Limiting to present data, these values may be taken as proximal optimums and any deviation from these may be correlated with the catches. In the first instance, if all the December values are considered, a striking correlation exists between the hydrographical factors and fish catches. In December of the first series, the average temperature is the same as that of the second series, but the salinity is considerably higher than the latter (Figs. 1, 2 and 3). The observed reduction in the catches might be due to the salinity deviation. In the third series, the complete failure of the expected maximum catches may be due to the deviations of both the factors from December of second series, to a great extent. It was, however, noted that pH of December 1959 (of the third series) was comparatively high, being 8·7, as against 8·0–8·3 the normally prevailing values in December. This abnormal rise in pH may be responsible for the complete failure of the mackerel fishery. Tait (*loc. cit.*) mentioned "within the limits of pH normally occurring in the open sea, fishes may not appear to react noticeably to small changes in this character. The profound effects which have been observed beyond these limits convey the impression that, were the accurate observations of pH to be included among those which are more regularly taken in hydrographical practice, valuable indications may be given of circumstances bearing directly upon the health and therefore upon the quality and perhaps also the quantity of our most prized food-fishes". As compared with series 1 and 2, the plankton was also found to be remarkably poor in December of the third series (Sarma, personal communication) which might have been the additional cause for the complete failure of the fishery.

During 1957–58 and 1958–59 seasons, a sharp rise in the catch in December, to about five-fold in the former season and eight-fold in the latter than the respective November figures was noted. This sharp rise suggests high sensitivity of fishes to the variations in the hydrographical conditions. Harvey (*loc. cit.*) pointed out "that it is of interest that the distribution of many marine animals is limited by the range of temperature and has been linked with the salinity of water and it is remarkable that some species of fish are able to perceive very small differences not only in temperature but also in salinity as little as 0·06 g. per kilo in waters containing some 35 g. per

kilo". The decreasing trend of the fishery in January seems to be considerably influenced by variations of both temperature and salinity from the proximate optimum values. From December 1957 to the following January 1958, the salinity remained more or less the same, while the temperature showed a decrease of 0·6° and from December 1958 to January 1959, the temperature deviated by 0·3° C. and also the salinity lowered from 33·27 to 32·45‰. From November 1959 to the following January 1960, the temperature and salinity were very low and added to that the pH was found to be high (8·6) and in February 1960 even though the temperature and salinity reached close to the proximate optimum values, the fishery continued to be poor which might be the possible result of the time lag for the fish to migrate once more or might be due to the prevailing higher pH conditions. In general from February onwards, the temperature as well as salinity are found to be increasing till May, and as expected the fishery during this period is generally poor (*see* Chidambaram and Menon, 1945). During the active monsoon months June and July the fishing operations are suspended for the major part due to rough sea and unsettled weather conditions. It is not known whether mackerel inhabits inshore waters in these months. It is unlikely that mackerel shoals will seek inshore waters as their habitat when the temperature and salinity of sea-water are very low and are subjected to maximum degree of variations. In regard to size of the fish and hydrographical conditions some interesting observations were made. Mackerel entering fishery in August–September months are mostly juveniles up to 16 cm. in length and the temperature and salinity values in these months are remarkably lower than those in November–January period, when larger size-groups are landed. This observation suggests that the tolerance ranges of a particular fish varies with the size or age of fish. The tendency of the larger size-groups (19–21 cm.) to frequent inshore waters from November to March when the temperature and salinity also show a gradual rise is consistent with the above observations. But during the months of highest temperature and salinity (March to May), the catches are also comparatively very poor (Figs. 1, 2 and 3). The size-groups below 19 cm. are absent in the same period. The smaller size-groups appear in large quantities from August to September–October during which period the salinity and temperature are very low.

It is apparent from Table I, that for a good mackerel season the degree of variations in temperature and salinity during the active mackerel season should be least within the tolerance range.

The present data indicate higher susceptibility of mackerel towards temperature variations than to those of salinity and the added effect of these

TABLE I

Mackerel season	Average temperature variation ° C.	Average salinity variation ‰	Total seasonal catch in metric tons
October 1957–March 1958 ..	1·4	1·96	887·63
October 1958–March 1959 ..	1·3	1·40	1145·42
October 1959–March 1960 ..	3·7	2·71	401·45

two factors may be considerably high. Increase in temperature and salinity adversely affects mackerel catches, whereas their low values have less pronounced effect. Other important environmental factors like oxygen, pH and plankton constituting the food of mackerel may also influence the movement of mackerel to some extent. In the present investigation the effect of oxygen was found to be negligible. since the surface values were quite normal, between 3·0 and 5·0 c.c. per litre. The effect of pH has already been stated. Food of fish is undoubtedly an important factor but even when the food available in a particular region is below the normal requirements, mackerel may prefer the medium with favourable conditions to areas of rich food with unfavourable hydrographical conditions not congenial to them.

In addition, the effect of certain meteorological factors like rainfall and windforce were considered. It was noted that complete failure of mackerel fishery in 1959–60 season coincided with unusual heavy rainfall in 1959 (428 cm.). The landings in that season touched the lowest figure of 401·45 m. tons, of the three series under discussion. In contrast to this, the highest landings (1145·42 m. tons) were recorded when the rainfall was the lowest (270 cm.). In 1957–58 season, the fishery was moderate, the rainfall for 1957 being 328 cm. The effect of rainfall is always reflected in the temperature and especially in the surface salinity of waters and thus affecting the fishery indirectly. The wind force cannot be considered as a decisive factor, but it does indicate, in a general way, the trend of the fishery in correspondence with the wind force. During the peak period of mackerel season —November and December—it was higher in 1958 (5·5 and 5·6 m.p.h. respectively) than 1957 (5·3 and 5·3 m.p.h.) or 1959 (5·2 and 5·3 m.p.h.). The most successful fishery coincided with the same period (November and December 1958) when the wind force was nearest to the mean values (5·6

and 5·7 m.p.h. respectively) given in the calendar of environmental factors by Subrahmanyan and Sarma (1960).

Summary

An attempt has been made to correlate mackerel landings at Calicut with hydrographical conditions during the period of three years, from October 1957 to September 1960. Considering all the three seasons—1957–60, the hydrographical conditions in the season of maximum catches (October 1958 to March 1959), showed marked differences as compared with those of the other two seasons. Increase in temperature and salinity has been found to affect adversely mackerel catches, whereas, their low values exerted less pronounced effect.

Observations show the higher susceptibility of mackerel towards temperature variations compared to salinity and their combined effect appears to be considerably high; the tolerance ranges of hydrographical factors may be different depending upon the size of mackerel. High tolerance towards the increase in temperature and salinity was found in bigger size-groups (19–21 cm.). The smaller size-groups usually occur in large numbers during the period (June–September) of low levels of temperature and salinity. One of the criteria of good mackerel season appears to be that the degree of variations of temperature and salinity should be least within the tolerance ranges of these two hydrographical factors. The complete failure of the 1959–60 season coincided with high pH and very low values of temperature and salinity suggesting that higher pH may have an added adverse effect on the fishery. Probable effects of certain meteorological factors like rainfall and wind force are also briefly discussed.

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