

THE INFLUENCE OF SOME HYDROGRAPHICAL FACTORS ON THE FISHERIES OF COCHIN AREA

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From the seasonal changes in the hydrographical features of Cochin area during the year 1965-66, it is possible to deduce that a shore-ward influx of upwelled water occurs from about June to October. The effect of this water is felt in very shallow areas. During this period the bottom layers become cold, markedly saline, poorly oxygenated and rich in nutrients. Minimum oxygen of less than 0.5 ml/L is recorded at 10 m in August. The fish populations are not very abundant during this season and tend to avoid the oxygen-deficient water. Both fish and prawn catches are poor from June to September. The available evidences show that the enrichment of the euphotic zone with nutrients in the post-upwelling period produces an intense phytoplankton bloom. The red-tide phenomenon which acts as a further threat to fish life is of common occurrence during this season. From November onwards there is a reappearance of fish shoals in coastal waters and a resumption of large scale fishing activity.

INTRODUCTION

Many of the accounts which have appeared in recent years on the Indian Ocean, as parts of various programmes of the I.I.O.E., clearly indicate that the Arabian Sea is characterized by a relatively lower temperature, higher salinity, higher nutrient content, greater primary productivity, richer phytoplankton and zooplankton biomass and a greater fish yield than those of the Bay of Bengal (Panikkar and Jayaraman 1966; Reddy and Sankaranarayanan 1968; Ryther and Menzel 1965; Prasad 1966; Ryther *et al.* 1966; Panikkar 1968, *See pp.* 811-832). The high level of primary productivity though restricted to certain areas, particularly to the coastal regions, has been attributed to higher nutrient contents brought to the euphotic zone by upwelling (Ryther and Menzel 1965; Ryther *et al.* 1966). The fishery resources of the west coast, rich as they are, amounting to 75% of the total marine catch of India (700-900 thousand tons annually), are subjected to wide fluctuations from year to year (Panikkar 1968).

Several earlier studies carried out on the hydrography of various parts of the Arabian Sea and the Bay of Bengal have been primarily directed to find an answer to the fluctuation of fisheries (LaFond 1954; Jayaraman and Gogate 1957; Subrahmanyam 1954; Pradhan and Reddy 1962; Prasad and Nair 1959). In most of these studies it has been pointed out that the highly complex and changing conditions of the Arabian Sea seem to be responsible for the seasonal and annual fluctuations of the fish catches. For instance, in the Bombay area, rather sudden and pronounced variations in temperature, salinity and oxygen, resulting from upwelling, influence the availability of fish (Carruther *et al.* 1959). Similarly from Cochin to Calicut, Banse (1959, 1966) by making use of the earlier informations and from his own data collected during September/October 1958, has

laid special emphasis on the phenomenon of upwelling on the west coast and its possible influence on trawl catches.

From these accounts it is clear that the phenomenon of upwelling is fairly widespread in the Arabian Sea and that it has a direct influence on the fisheries of the West Indian coast. More specific information on upwelling can be obtained from the accounts given by Ramamirtham and Jayaraman (1960), Sastry and Myrland (1959), Rao and Jayaraman (1966) and from a paper by Sharma presented at this symposium (1968). Published accounts, however, relating hydrography to parallel fish and prawn catches are very few.

METHODS

Two stations were fixed in the inshore region of Cochin during the year 1965-66. Station 1 was very close to the shore at a depth of 10 m, while the station 2 was a few miles away and had a depth of 30 m. Water samples collected at fortnightly intervals from these stations were analysed for various hydrographical features indicated in Fig. 1. For all estimations the working instructions of Strickland and Parsons (1960) were largely followed. Data on fish and prawn catches were obtained from such vessels of the Indo-Norwegian Project which continue to fish throughout the year in coastal waters.

RESULTS AND DISCUSSION

The immediate aim of this paper is to direct the informations on the hydrography of the inshore waters, which have been primarily collected for some other purpose, to fish catches of the Cochin area. Fig. 1 shows some of the main features at station 1. It can be seen from the figure that almost all parameters *viz.* temperature, salinity, dissolved oxygen, alkalinity, pH and nutrients are adapted to an annual rhythm and that the maximum and minimum values of these parameters alternate with each other. Temperature variations are more pronounced at the bottom than at the surface. Maximum temperature is recorded in the month of April and minimum in August and September. From December to May the temperature differences from surface to the bottom were less than 1°C, but in the monsoon months (June-October) normal variations were about 1.5-5°C. Salinity changes from surface to the bottom were also very wide. In the pre-monsoon months, January to May, when the salinity is at about its maximum, practically no change is encountered from surface to the bottom. But from June to August when there is a sharp decline in the surface salinity, the bottom salinity remains high. This indicates that wide fluctuations in the salinity due to the influx of freshwater during the monsoon months are only confined to the top-most layers and that the sharp decrease in temperature is not associated with a similar decrease in salinity at the bottom. Total alkalinity shows a direct correlation with the salinity and so has the pH. In marked contrast to the alkalinity, the oxygen values show an inverse correlation with the salinity, i.e. from May onwards when the surface oxygen is increasing, the bottom oxygen shows a sharp decline, reaching its minimum of less than 0.5 ml/L in August. During this period the phosphates show high values and same is the case with other

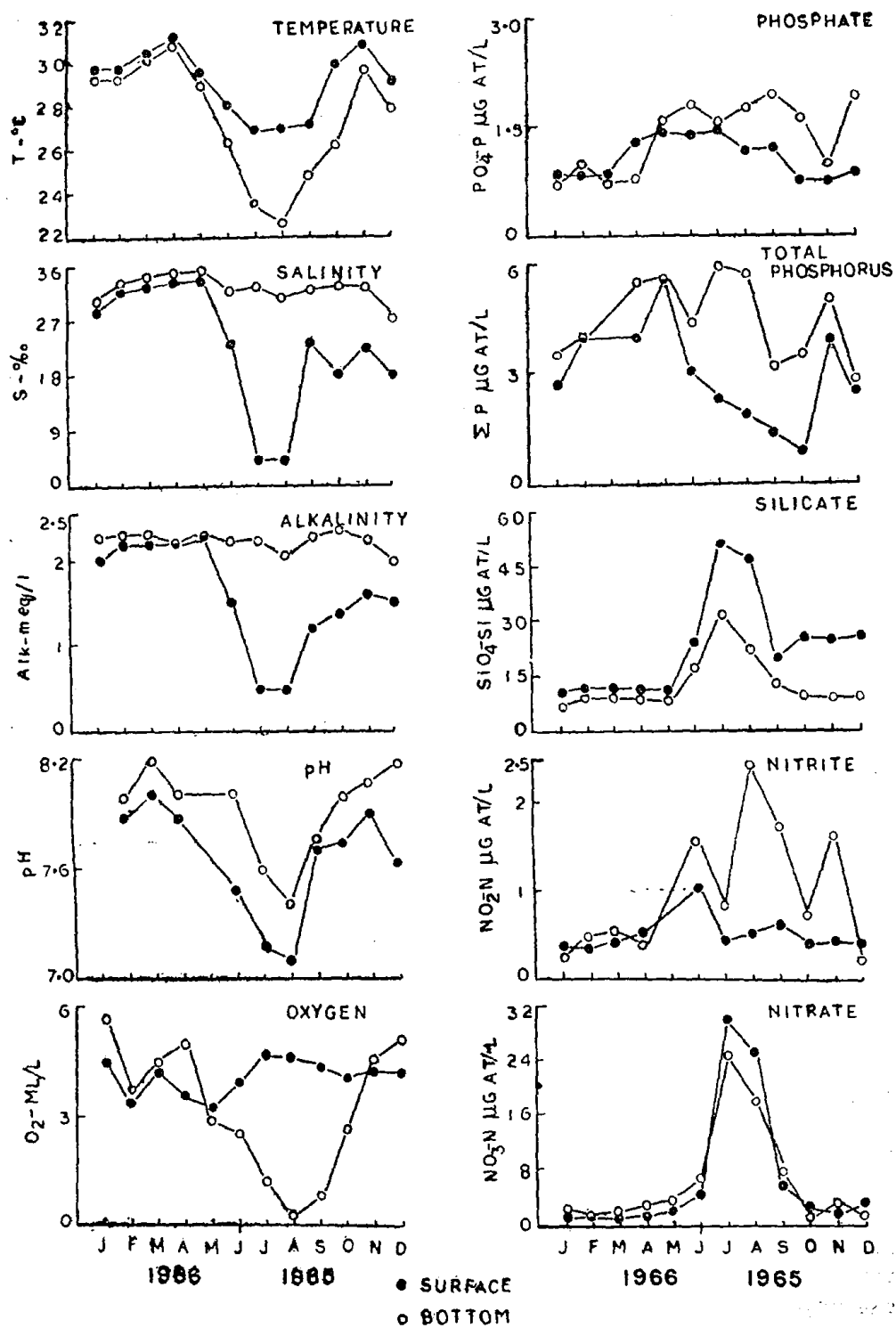


FIG. 1. Hydrographical features during the year 1965-66 at Station 1 fixed in the inshore regions of Cochin. Closed circles refer to the values at the surface and open circles to the bottom.

TABLE I

Values of temperature, salinity and oxygen at station 2 in some months of the year 1965-66

	Months						
	1966				1965		
	Febru- ary	March	April	May	October	Novem- ber	Decem- ber
<i>Temperature °C</i>							
Surface	28.80	30.00	31.00	29.50	28.10	29.00	29.00
Bottom (30 M)	28.00	29.25	29.50	29.00	24.52	28.40	28.00
<i>Salinity ‰</i>							
Surface	33.13	34.21	34.54	35.34	27.35	35.23	32.83
Bottom (30 M)	33.89	34.57	35.24	35.39	35.35	35.41	33.51
<i>Oxygen ml/L</i>							
Surface	4.34	3.68	4.92	4.77	5.43	5.16	4.78
Bottom (30 M)	3.31	4.05	4.24	3.77	0.28	4.21	3.56

nutrients (silicate, nitrite and nitrate). Almost all nutrients record peak values from June to August (Fig. 1).

Unfortunately, at station 2 similar data on all related parameters could not be obtained throughout the year. However, the values of temperature, salinity and oxygen for both surface and bottom are given in Table I for a period of seven months. It can be seen from the table that within the limits of the available data, the changes in temperature, salinity and oxygen are very similar to what has been shown at Station 1, except that the variations in salinity at the two depths (surface and bottom) are not very pronounced.

From the hydrographic conditions at the two stations presented above it is clear that if temperature, salinity, oxygen and nutrients are taken as the chief criteria, the inshore region begins to reflect the characteristics of upwelled water from June to October. Probably in June there seems an influx of cold, saline and poorly-oxygenated water, rich in nutrient, towards the shore which continues with varying degrees till about October.

Figure 2 shows the catches of fish and prawns. It can be seen from the figure that, neglecting random variations, the catches of both fish and prawns were minimum from June to September. This cannot be attributed to poor fishing effort as the data presented in Figure 2 are only related to such vessels which operate throughout the year and which allow a fair comparison of monthly hauls. Seasonal changes in temperature and oxygen when plotted along with the fish and prawn catches (Fig. 2) fell in accordance with each other i.e., minimum values of temperature and oxygen at the bottom coincided with lowest fish and prawn catches.

The main fishing season along the west coast, (leaving aside the bigger fishing boats of 50 ft and above which operate throughout the year) generally starts in October and ends in May. The termination of the fishing season is partly because the sea becomes rough and the weather due to heavy rain is unfavourable for fishing; and partly because of a general feeling amongst the fishermen that due to lack of fish, fishing in the inshore waters is not very economical.

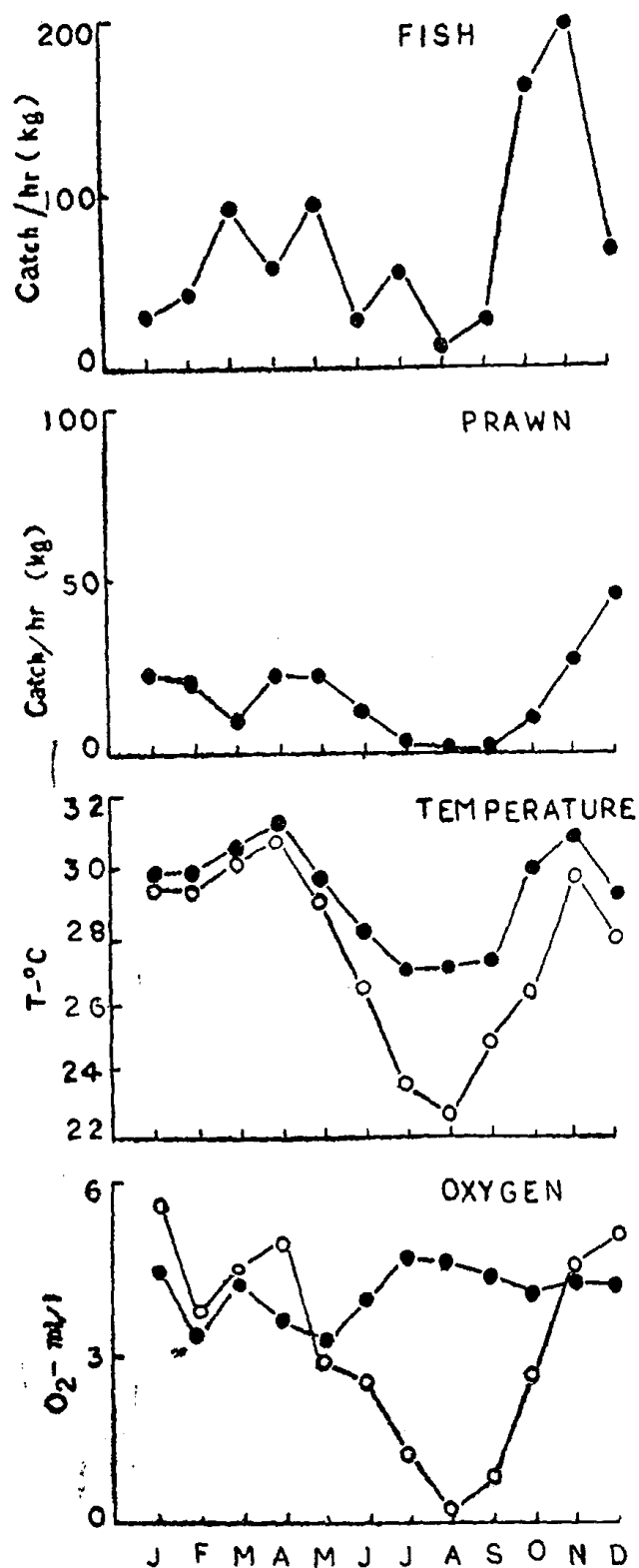


FIG. 2. Seasonal variations in fish and prawn catches of Cochin area during the year 1965-66. The seasonal changes in temperature and oxygen have also been included in the figure to show their possible influence on fish and prawn catches. For temperature and oxygen, see Fig. 1.

One of the important characteristics of the Arabian Sea is that it is greatly influenced by the monsoon cycle. The south-west Indian coast gets the full force of both S.W. and N.E. monsoons. The total annual rainfall in the Cochin area is about 3200 mm, of which nearly 75% occurs from May-September. Many complex and dynamical changes of water circulation and mixing processes have been reported in the Arabian Sea during the two monsoon periods. Although the period when widespread upwelling has been reported seems to be the two monsoons, from the available data it appears that the phenomenon is not well synchronized throughout the west coast at the same time. It seems to be delayed in latitudes further north. Thus, around Ceylon and the southern-most parts of India, from Cape Comorin to Calicut, it occurs during the S.W. monsoon, August to October (Schott 1935; Banse 1959) and more specifically in the Cochin area from late August to October (Ramamirtham and Jayaraman 1960). Around Bombay it has been shown to occur during the period of N. E. monsoon, October-December (Carruthers *et al.* 1959) and along the Bombay and Saurashtra coasts, the possibility of upwelling has been indicated during December to February (Jayaraman and Gogate 1957).

The seasonal upwelling and the associated upward movement of oxygen-deficient water seem to regulate the local fisheries. The termination of the fishing season towards the end of May, therefore, seems to coincide with a decrease in fish abundance from the inshore regions. In the Bombay region the fish, in order to avoid low oxygen concentration, has been reported to migrate towards the shallow regions, near the coast (Carruthers *et al.* 1959). This is because the influx of poorly-oxygenated water does not reach very close to the shore. But in the Cochin area the upwelled water not only reaches the near-shore waters (10 m depth), but its effect is even felt in the lower reaches of the backwaters (Ramamirtham and Jayaraman 1963). This may probably be due to the shelf region being narrow in the Cochin area and very wide along the Bombay region, and presumably for this reason the fish migration does not occur towards the inshore waters of the Cochin area. There is, however, an interesting instance on record by the present authors (during one of the cruises of 'R. V. Varuna' in early October), when the poorly-oxygenated water was still prevalent at the bottom (Table I), repeated trawling near Cochin resulted in very poor catches. But during the same cruise, about 50 miles down south, near Quilon, trawling was most encouraging. An examination of water taken from 30 m and below showed the oxygen content to be appreciably higher than at Cochin. This confirms that the disappearance of fish shoals from one locality is to avoid the poorly-oxygenated water and that their migration seems to be either directed towards other coastal regions or towards deeper water, probably in such areas where dissolved oxygen is not very low. It may even be directed towards the surface, in which case, the operation of non-mechanised country-crafts, which involves the use of various indigenous gears whose working range is limited to a few metres near the surface, would be more useful than trawling, particularly for prawns and soles which have a limited migratory power.

To sum up it seems that the seasonal fluctuations of the fisheries of the west Indian coast are governed, to some extent, by the intensity of upwelling, and since

its time and duration vary from one region to the other and these may not be repeated with utmost accuracy and intensity year after year, it may eventually prove to be one of the main factors controlling the seasonal abundance of fish in a particular region. In other words, while the phenomenon of upwelling is very important in replenishing the nutrients of the impoverished euphotic zone and increasing the phytoplankton productivity and finally the fish catches, its influence during the season initially becomes a deterrent to fish life in many ways. Firstly, it very often leads to mass fish mortality by sudden changes in temperature, salinity or due to the influx of oxygen-deficient water which is well-known in the Arabian Sea (Brongersma-Sanders 1957; Foxton 1965). Secondly, the enrichment of water with nutrients produces an intense outburst of phytoplankton bloom whose rapid growth in the absence of secondary consumers such as zooplankton and fish, leads to anaerobiosis which becomes a further threat to animal life (Ryther and Menzel 1965). Finally, it gives rise to an accelerated growth of a few organisms or the red-tide — a phenomenon of common occurrence along the south-west coast (Bhimachar and George 1950; Subrahmanyam 1954; Prakash and Sarma 1964). It is interesting to note that the period when the red-tides have generally been reported, September to November, coincides with the end of the upwelling season, when the weather is warmer with far greater sunshine hours than during the monsoon months. Very often, mass mortalities of fish and invertebrates have been found associated with the blooms during this season.

From November onwards the changes reported in the sea have been termed as "sinking" which are followed by stable conditions till April (Ramamirtham and Jayaraman 1960). It may be recalled that fishing season starts from October when both fish and prawns begin to reappear in large numbers in coastal waters. It is gradually intensified and the peak season approaches during a period when stable conditions begin to prevail in the sea.

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