ENVIRONMENT

The area of the Indian seas where regular studies have been conducted lies between 73° and 79° 30' E longitude and upto 10°N on the south-east coast and 15°N on the south-west coast and the Laccadive Sea.

South-east coast - Gulf of Mannar and Palk Bay

This area is exposed to two prevailing monsoons but the rainfall during the south-west monsoon is very little. Extremely turbulent conditions set in during May which continue sometimes even up to August. During this period the drift is from south to north and is particularly strong through the Pamban Pass reaching occasionally a velocity of 5-6 knots. On the contrary at this time Palk Bay is calm. With the onset of the north-east trade winds, generally during September, the Gulf of Mannar becomes comparatively calm. The direction of the drift is reversed and turbulent conditions prevail in Palk Bay. The north-east monsoon then sets in bringing rains and frequent cyclones which originate in the Bay of Bengal.

Seasonal variation of the hydrographic properties:

Fluctuations in the surface temperature of the sea water of Gulf of Mannar show a double oscillation. The minimum is in January which rises steadily till April and after May decreases. There is again an increase sometime

during September-October but not to that level of April. The lowering of the surface temperature of the coastal water has been brought about by the strong winds during the south-west monsoon season. The secondary peak is brought by the dying down of the south-west monsoon winds. During the period of observation the lowest temperature recorded in January was 26.1°C and the highest in April was 32°C. The secondary peak of September-October was 30.0-30.5°C. In Palk Bay the surface temperature is of a slightly lower order.

There is a regular seasonal cycle in the salinity in both Gulf of Mannar and Palk Bay. From a low value of 26°/oo in January it gradually increases and remains high ($\geq$ 36°/oo) until the middle of November. With the onset of north-east monsoon rains the salinity falls and lowest value is reached in December.

The nutrients at both areas are distinctly lower compared to temperate regions and further they do not show such great fluctuations as are characteristic of temperate waters. The monthly average phosphate values in Gulf of Mannar varied from 0.09 to 0.30 µg.at.P/l, whereas in Palk Bay the range was 0.14 to 0.25 µg.at.P/l.

The fluctuations in the values of nitrates, on the other hand, are greater in Palk Bay, with a range from

1.5 to 5.0 µg.at.N/l. In the Gulf of Mannar monthly average values range from 1.9 to 4.7 µg.at.N/l. The silicate values show wider fluctuations 3.3 to 14.8 µg. at.Si/l in Gulf of Mannar and 5.3 to 17.9 µg.at.Si/l in Palk Bay.

The percentage saturation of dissolved oxygen in the surface waters show greater fluctuations and a wider range in Palk Bay. In the earlier investigations Prasad (1954, 1956) found that the quantities of phytoplankton and oxygen saturation did not show any relationship and an apparently overall lower oxygen saturation in Palk Bay which he believed to be due to fewer coral reefs and hence lesser quantity of "imprisoned phytoplankton" or coral zoexanthellae which produced considerable quantity of oxygen during photosynthesis.

The pH values generally vary from 8.4 to 8.7 at both the regions.

The total net plankton (Prasad loc.cit) in the Gulf of Mannar exhibit well-defined maxima and minima as well as differences from year to year. In general, the cycle is bimodal, with one peak between January and March and another during September-October. In Palk Bay also the distribution is bimodal. However, from January the total plankton steadily

increases upto May or June followed by a drop in July-August. Again there is an increase leading to a peak in September-October followed by a decline. The standing crop of plankton is often low during periods of turbulence.

The distribution pattern of total phytoplankton as observed from net collections reveal that in Gulf of Mannar there are three peaks which alternate with periods of low populations. In January the phytoplankton population is high followed by an appreciable decimation in February-March. The concentration increases during April-May and from June to August phytoplankton is low. It once again increases reaching a maximum either in October or in November. Against this abruptly fluctuating phytoplankton cycle in Gulf of Mannar, a more stable distribution is observed in Palk Bay. Starting from a rather low population in January the phytoplankton community increases steadily to a high level by May-June and remains high except for a slight decimation during July-August, upto October, after which there is an appreciable fall. Thus there is only a single prominent peak in Palk Bay in contrast to the three peaks in the Gulf of Mannar. The seasonal variation and succession pattern of the common phytoplankton are discussed separately.

Large quantities of Trichodesmium are noticed particularly in the summer months in Gulf of Mannar but are relatively scarce in the Palk Bay. In both regions Dinophyceae show two maxima with the primary peak in the summer months.

The distribution pattern of zooplankton differs widely at the two areas. When zooplankton is high in Gulf of Mannar it is relatively low in Palk Bay and vice versa. Palk Bay is characterised by a richer zooplankton.

South-west coast of India

The west coast of peninsular India forms a narrow belt of low land lying between the sea and the Western Ghats which extend throughout the whole length of the peninsula varying in width from 30 to 150 km inland and running in a direction north-northwest and south-southeast. There are a number of short rivers, many of which drain into the back waters of varying breadth occurring parallel to the coast.

The outstanding feature of the wind system in the Indian seas is a seasonal reversal of the direction associated with the two monsoons. During December to February, the northeast winds of the land origin prevail. The transition begins by about March and lasts through April. By the

middle of May the south-west monsoon winds of the oceanic origin are established, which continue to increase gradually until June when there is sudden strengthening. During July and August, the winds blew at their greatest strength and in September, the wind force decreases in preparation for the transition which lasts through October and November. Of the two monsoons, the south-west monsoon endures over a longer period in the Arabian Sea and is stronger and steadier than the north-east one. The onset of south-west monsoon is associated with overcast skies, showers and strong winds, as a result of which the solar insolation is cut off to a large extent. The incident radiation varies from 750 ly on a bright day to 150 ly on a cloudy day in July (Qasim et.al.,1968). Despite the humid conditions evaporation in the Arabian Sea is maximum during the south-west monsoon unlike the usual intense evaporation in winter. (Venketeswaran, 1956; Jagannathan and Ramasastry, 1964).

From the vertical density structure Sharma (MS) has inferred that the process of upwelling of the west coast of India in the deeper layers of about 90 m sets in by March and the upwelled water reaches the surface by May. The cessation of upwelling takes place in August and the reverse process of sinking begins by September. In a period of two months, the vertical movement is 80 m, giving rise

to an average intensity of upwelling of 40 m per month - i.e., 1.5 x 10^{-3} cm sec^{-1}(Sharma, MS). The earlier authors (Banse, 1959; Rama Sastry and Myrland, 1959; Ramamirtham and Jayaraman, 1960) had inferred that upwelling off the south-west coast of India starts with the onset of the south-west monsoon. Regular upwelling is absent north of 15°N.

From July onwards cool water is present below 50 m, some times even at shallower depths which has a low oxygen content 50% or less of saturation appear to be the rule at the inshore regions throughout the entire upwelling season (Banse, 1968).

Seasonal variation of the hydrographic properties of the shelf waters off the west coast of India:

Time-series observations, during research cruises conducted by the Central Marine Fisheries Research Institute since 1957 off the west coast of India on board the Indo Norwegian Project vessels R.V. KALAVA and R.V. VARUNA, have provided data on the hydrology of the west coast. (Banse, 1959; Rama Sastry, 1959; Rama Sastry and Myrland, 1960; Ramamirtham and Jayaraman, 1960; Patil and Ramamirtham, 1965; Ramamirtham and Patil, 1965; Sharma, 1968; Banse, 1968).

The surface temperature all along the coast exhibits a double oscillation during the year with the primary maximum in April and the secondary in November. The corresponding

minima take place in July/August and December/January. The low temperatures are spread over a longer period in the north than in the south. The low temperature in the monsoon period is due to reduction in the insolation due to the cloudy conditions and the monsoon rains and run off waters.

Generally, the coastal surface currents off the west coast of India set towards the south from February until late October or November and are reversed during the rest of the year.

There is no prominent seasonal variation in the dissolved oxygen content of the surface waters all along the coast but it does vary considerably in the subsurface layers. However, higher oxygen values of oxygen in the surface waters, in general, are noticed in June and September and lower values in January and July. The stratification of coastal waters during July and August in the depth range of 10 to 30 m results in the depletion of oxygen below the depth of stratification.

The depth of the mixed layer changes from a depth of more than 60 m in January-February to a depth less than 60 m by March-April. By May-June the mixed layer still moves to upper layers and the least depth of less than 20 m is observed in July-August. From then, it starts deepening to a depth of about 40 m by September-October.(Sharma, personal communication).

Studies conducted for prolonged periods at different centres had indicated that phosphate, nitrate and silicate show a seasonal fluctuation, the peaks in their concentration being attained during the south-west monsoon months. It is also found that when there is an abundant supply of these nutrients in the water the ratio of N:P is 15:1, the same as has been found in the temperate regions (Subrahmanyan, 1959).

Banse (1968) after reviewing the hydrography of the Arabian Sea shelf of India had inferred that the seasonal cycle of primary production is apt to be quite similar all along the west coast and that high photosynthetic rates can be expected during the south-west monsoon and later until the cool, deoxygenated subsurface water withdraws from the shelf. During the remainder of the year the density stratification in the surface layer will keep the photosynthetic rates low, near oceanic levels.