

out the period of investigation. The samples collected from the foreshore zone between 2000 and 5600 m on the northern side and between 500 and 2600 m on the southern side (Fig. 1) showed the presence of tracer grains in almost all the samples. The presence of tracer grains in the samples from foreshore zone indicates shoreward movement of offshore sediments. Shoreward and seaward dispersion of tracers seem to be due to sorting effect caused by waves and tides.

In case of beach, maximum concentration of tracers is observed WSW and NW of the release points. The waves were breaking close to shore avoiding formation of surf during high tide. Therefore, the above concentration of tracers seem to be due to zigzag movement of sediments caused by waves approaching the coast from south-east. It may be inferred from the concentration pattern that beach sand moves west-south-westward during high tide in February when waves approach the coast from south or south-east. The dredged material should be disposed off quite far of from the channel on the northern side during February to avoid siltation of the same.

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Distribution of Suspended Matter in Waters of the North-Western Shelf of India

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Sixty-five water samples from surface and bottom were collected for the study of suspended matter in north-western Arabian Sea from December 1973 to May 1974. Concentration of suspended matter in surface water varied from 0.3 to 4.6 mg/litre while at the bottom it varied from 0.5 to 13.6 mg/litre. High concentration of suspended matter in its coastal water and in the vicinity of river mouth was due to inert material. In regions away from the coast higher concentrations of suspended matter were presumably due to a greater plankton production.

STUDY of particulate suspended matter in seawater is important in understanding (i) genesis of sediments in oceans, (ii) transport and dispersal

of suspended material into a basin, (iii) relative contribution of terrigenous, volcanogenous, biogenous and chemogenous material to suspended matter and variation in its concentration at different depths. Study of particulate matter is also important for forecasting the fisheries of a particular region as the particulate matter forms food for a large variety of marine life. Lisitsyn¹, Gordeev² and Serova³ have studied the distribution and composition of suspended matter in the Indian Ocean, but their studies did not cover the continental margin. The present study, though of a preliminary nature, is the first attempt in this direction.

Samples of water were collected from December to May 1974 during the INS *Darshak* Oceanographic Expedition (1973-74) in the northern Arabian Sea. Samples were collected from the surface and about 5 m above the bottom by a van Dorn sampler of 7 l capacity. Sampling was largely restricted to the shelf area, although some surface samples were collected beyond the shelf also. Each sample was filtered on board using pre-weighed membrane filters (47 mm diam. with 0.45 pores). Samples were stored in desiccators and subsequently weighed to the nearest 0.01 mg for estimating the concentration of suspended matter.

Concentrations of suspended matter in the surface water ranged from 0.3 to 4.6 mg/litre. Higher concentrations (>4 mg/litre) were found in the Gulf of Cambay and in a narrow strip bordering the coast, as far as Ratnagiri area (Fig. 1a). Moderate concentration (2 mg/litre) was found spreading to a distance of about 20 km. This represented an unusual situation as no other tropical oceanic area studied by earlier workers showed such a dispersal. North of the Gulf of Cambay, off the Kathiawar Coast, particularly off Porbander, the concentration was considerably reduced. The concentration of suspended matter again increased (>1 mg/litre) in the vicinity of the mouth of the river Indus.

The concentration of suspended matter in the bottom waters ranged from 0.5 to 13.6 mg/litre. It was particularly high in the Gulf of Cambay and in a narrow belt extending from Daman and Ratnagiri (Fig. 1b). The suspended matter both in bottom and surface waters generally decreased from the shore towards the open ocean. However, a slight increase in the concentration at the surface was often noted in the outer shelf region.

Examination of concentrations of suspended matter broadly divides the area into 3 regions: (i) region of the Gulf of Cambay and a narrow belt along the coast down to Ratnagiri, (ii) a belt along the Kutch and Kathiawar coast, and (iii) the region south of the mouth of the river Indus. Though the concentration of suspended matter was high in both surface and bottom waters, higher concentration in bottom waters persisted over a greater distance. Along the outer shelf, surface concentrations were relatively higher than those of the bottom. High suspended matter was generally restricted to the inner shelf particularly in areas with fine-grained bottom sediments. Folger *et al.*⁴ noticed a similar distribution in the waters of Somes Sound of Maine.

Main sources of suspended matter in the ocean are river run-off, biological productivity and eolian

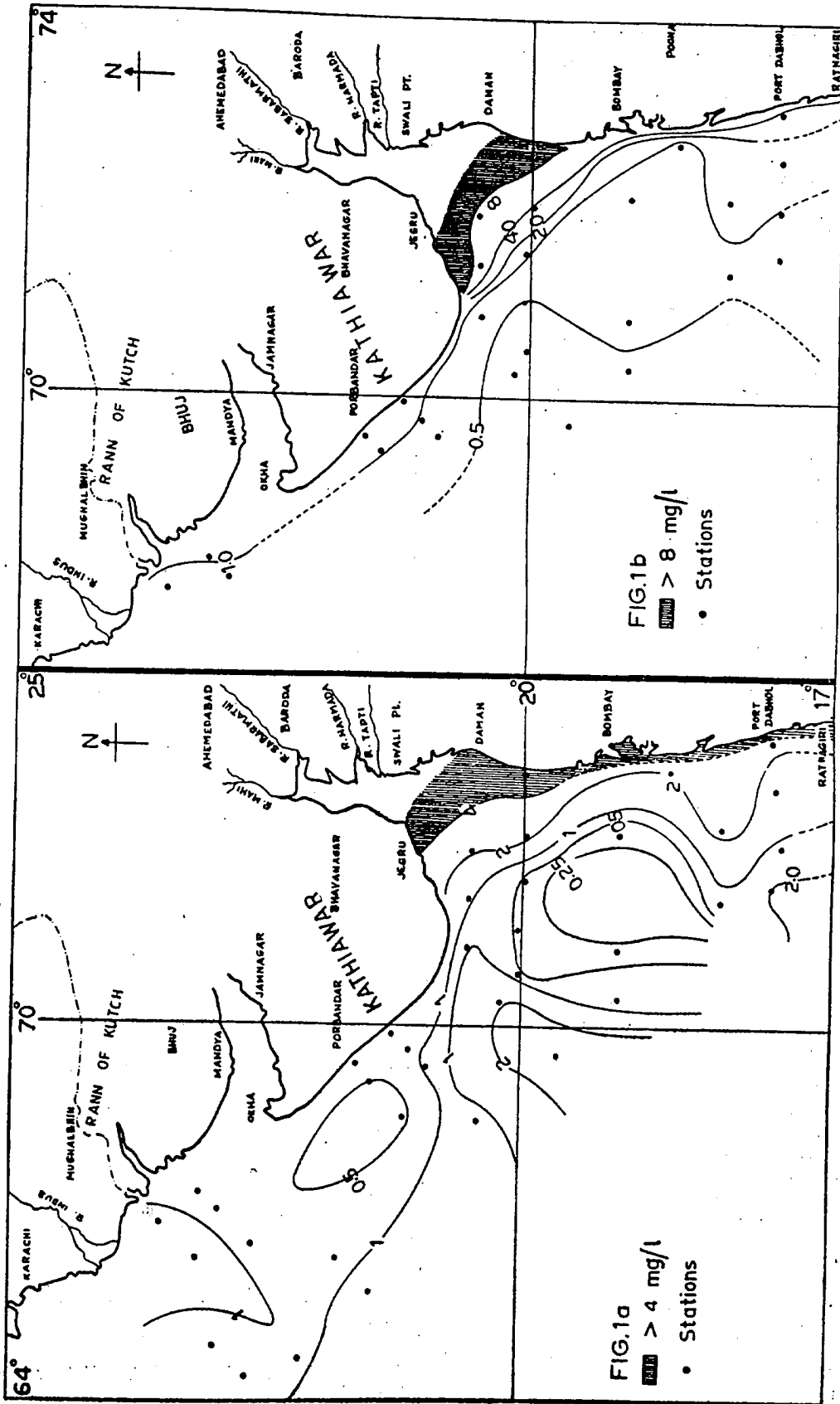


Fig. 1 — Distribution of total suspended matter in the (a) surface and (b) bottom waters of the north-western continental shelf of India

dust. The colour of the suspended matter retained on the filter showed three distinct zones of demarcation. In the Gulf of Cambay and the adjoining belt, from Daman to Ratnagiri and south of the Indus mouth, where more terrigenous material is available, the colour included the various shades of brown (5YR and 10YR). On the Kathiawar shelf, an area of comparatively lesser terrigenous supply, the colour of the material on the filter was light greenish grey to yellowish grey (5Y). Along the outer shelf, where the bottom is covered by chemogenous and biogenous sediments, colour of the suspended matter on the filter was from light grey (N8) to yellowish grey (5Y). It is noteworthy that the colour of the suspended matter retained on the filter of the bottom samples especially on the outer shelf was almost similar to that of the sediment. This indicates that the suspended matter near the bottom was stirred up sediment. In the Gulf of Cambay and from Daman to Ratnagiri, the suspended material from the bottom samples also included the resuspended material.

Study of regional variations of the suspended matter indicates the occurrence of high concentrations near the river mouths. High concentrations in the Gulf of Cambay are due to the discharge of sediment by the rivers Mahi, Sabarmati, Narmada and Tapti. Similar distribution of concentrations of suspended matter and its relationship to river sources are reported from the Baltic Sea⁵, the Mediterranean Sea⁶, the continental margin from Cape Cod to the Florida Keys⁷, and from the south-eastern Atlantic Ocean⁸.

High concentrations along the coast, extending from Daman to Ratnagiri, may be due to the supply of suspended material by small rivers and also in some areas due to intense coastal abrasion and churning up of sedimentary material. The presence of rock outcrops at 20°00'2"N, 72°35'3"E, substantiates a greater activity of currents in this area. This strip of high suspended matter does not spread wider which may probably be due to the presence of strong long shore currents which do not permit its dispersal very far off the shore. Lower concentration of suspended matter off the Kathiawar and Kutch coasts may be due to the arid condition generally prevailing on land and because of the absence of rivers in this area.

In the Gulf of Cambay, the concentration of suspended matter decreases from the coast both in the surface and bottom waters. However, in the bottom waters, higher concentrations persist to a greater distance offshore, as was found in the Baltic Sea⁵. This may be due either to the resuspension of bottom sediments by the activity of bottom currents or settling of bulk of sediments quickly to the bottom and dispersal offshore by the bottom currents. Comparative study of the 2 mg/litre contour for both surface and bottom indicates that at the bottom the concentration increases towards south-west. This probably indicates the main direction of dispersal and the currents elevation in this area. The intermediate values in the northern portion may be attributed to the influence of the river Indus which brings a considerable amount of sediment which gets dispersed over a large area.

High surface values found offshore (off Ratnagiri, off Daman and northernmost part of the study area) may be attributed to higher plankton productivity prevailing in the off-shore region. Similar cases of high plankton production have been noticed in the Baltic Sea⁵, the Atlantic Continental Margin and the Gulf of Mexico⁹.

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Seasonal Variations in Biochemical Constituents of *Cellana radiata* (Born)

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Moisture, glycogen, protein, total lipids and ash content in the tropical intertidal limpet *C. radiata* were estimated. Two distinct periods of variations were noticeable, the 1st extending from March to October indicating high breeding activity when water content and protein values were high and the 2nd indicating the period of rest from October to March when glycogen content was high.

INTERTIDAL molluscs constitute an interesting group by virtue of their natural abundance and their adaptability to the changing environmental conditions. Considerable attention has been focused on different aspects of intertidal molluscs especially with reference to their distribution and zonation, heat resistance, feeding rates, ecology, adaptability, biochemical composition and reproduction¹. During our studies on the reproductive cycles of the intertidal molluscs of Kovalam beach on the south-west coast of India, seasonal biochemical changes in the tropical intertidal limpet *Cellana radiata* have been studied with special reference to sex.

Forty to fifty specimens of *C. radiata* were collected at fortnightly intervals during 1973-74, from