

Hydrobiology of Surface Waters along Panaji-Bombay Coast

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Certain hydrobiological observations are made during September 1970 and May 1971 in inshore waters along Panaji-Bombay coast at 10 stations. The hydrographical features show double seasonal oscillations. Low temperature, low oxygen and high salinity of surface waters during November-December indicate the effect of possible upwelling on this coast which can be regarded as the zone of transition between the two upwelling areas of north and south. The zooplankton biomass exhibits two peaks — one immediately before and the other soon after the south-west monsoon — the later being secondary in nature. The zooplankton production seems to be associated with high temperature and oxygen and it shows a succession in space and time from southern to northern stations, which is clearly indicated by presence and movement of Cladocerans. The seasonal biomass and the list of dominant planktonic organism at different places in various months have been given. *Trichodesmium* bloom, associated with high temperature, is observed in March-April. Diatom peak is observed in April-May, but there is no definite correlation between diatoms and zooplankton.

MARINE environmental studies have been conducted in Indian waters from the beginning of the present century. Considerable work has been done particularly on the west coast of India which accounts for nearly 75% of the total marine food production of India. Detailed environmental data are available on hydrobiology for southern and northern parts of the west coast of India, but no coherent data are available for the inshore waters of the central part of the west coast (Panaji-Bombay coast) which supports a sizeable fishery. However, Rao *et al.*¹ have reported hydrological features of the Arabian Sea, off the northern and central west coast of India.

The National Institute of Oceanography, therefore, initiated a programme to study the hydrobiology of central west coast of India and this communication is the second of this programme, the first being on the distribution of chlorophyll and phytoplankton². The present paper deals with the hydrobiological aspects from September 1970 to May 1971 at 10 stations along the coast. A study of seasonal variations in phyto- and zooplankton and their possible relationship has been attempted in relation to hydrographical features.

Materials and Methods

Monthly observations were made on board Chowgule's passenger ships sailing between Panaji and Bombay. Since the ship ceased to ply during monsoon months, no data could be collected during the period of June-August. The sampling procedure and other details were the same as reported earlier².

Zooplankton samples were collected using a 1/4 m² HT net made of 300 μ (0.333 mm) nylon netting. Only vertical hauls could be taken as all the observations were made from the anchored ship. Immediately after the collection, the samples were preserved in 10% formalin neutralized with hexamine. In the laboratory, the volume of the sample was measured by the displacement method and the biomass values computed per m³.

The following 10 stations were covered between Panaji and Bombay: Vengurla, Malvan, Deogad, Vijaydurg, Musakazi, Ratnagiri, Jaigad, Harnai, Sriwardhan and Janjira (Fig. 1). At all stations

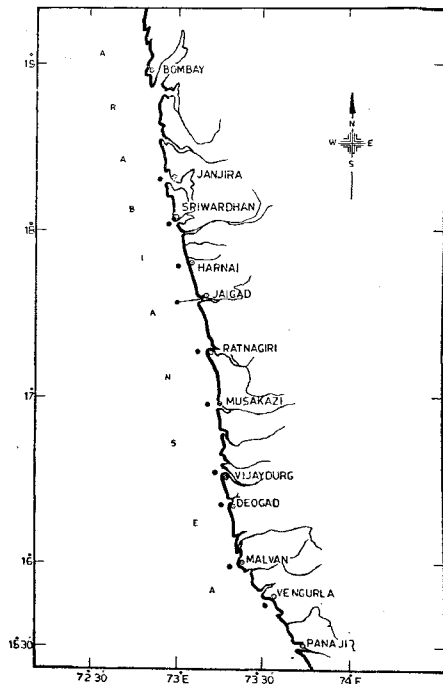


Fig. 1 — Map of the central west coast of India showing the locations of stations in closed circles

except Musakazi, Jaigad and Ratnagiri, samples were collected during daytime. Out of these 3 the first 2 were covered during late in the evening between 1800 and 1900 hr while at Ratnagiri the sampling was invariably done between 2000 and 2100 hr. The time and area of sampling remained the same throughout the period of observations. The sampling position at each station except at Jaigad was approximately 1 km away from the shore. At Jaigad the ship came alongside the jetty and, therefore, the collections were made very near the jetty. The average depth in these ports is roughly 5 m. The study was limited to surface waters only, but the zooplankton samples were collected from 3-0 m depth.

Results

Values of different hydrographical parameters such as temperature, salinity and oxity in different months at these stations are shown in Fig. 2.

Temperature— All along the coast, the temperature was low in September ranging between 29° and 31°C, and decreased in the cooler months, the minimum being in December (range 24.4-26.8°C). From January there was a gradual rise in all the stations with a maximum in April, followed by a decrease in May. The temperature curve showed a double oscillation, with 2 peaks in October and April:

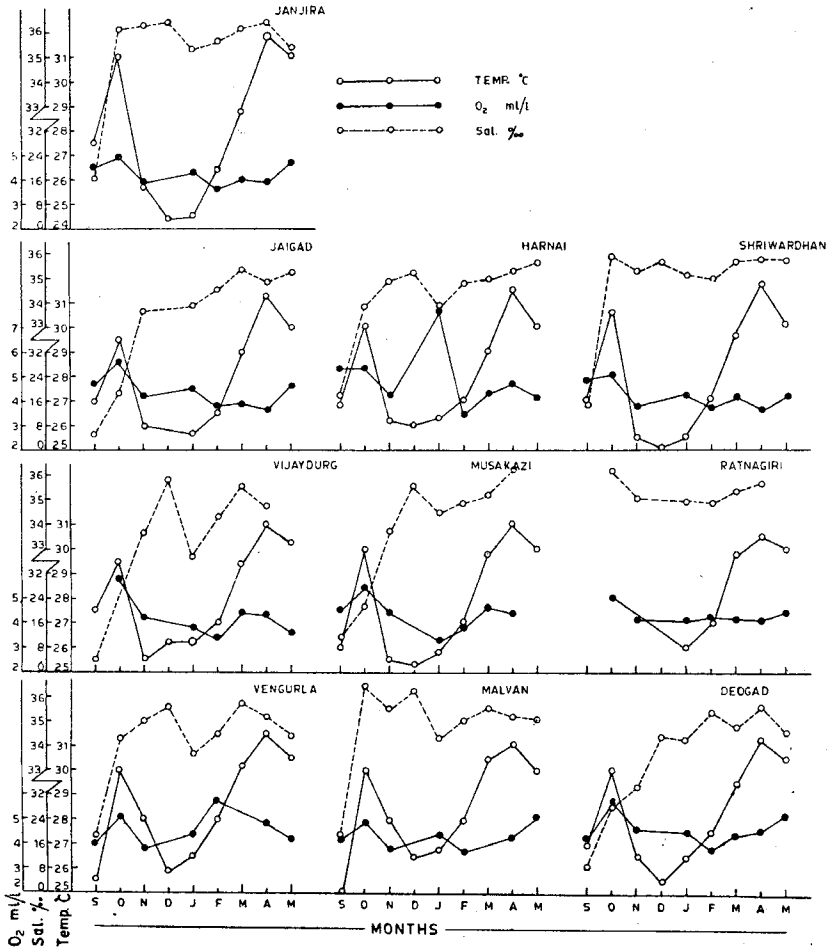


Fig. 2 — Seasonal variations in hydrographical parameters along the coast

Salinity — Salinity also showed a similar trend to that of temperature showing low values in September (4.03 to 18.60 ‰) due to the effect of monsoon with subsequent increase up to April. The peak values were seen in April (range 36.24-36.92 ‰). The salinity had 2 peaks, one in December and the other in March/April (Fig. 2).

Oxity — The dissolved oxygen content of the water was moderate at all stations during September (range 4.2-5.3 ml/litre). In October, there was an increase at all the stations showing peak oxygen values (range 4.9-5.9 ml/litre). Thereafter it decreased almost all along the coast except at Harnai during the month of January when the oxygen value was recorded 7.6 ml/litre. In February oxygen concentration was minimum on the entire coast and varied between 3.4 and 4.1 ml/litre. Again with increase in oxygen content a secondary peak of oxity occurred in April-May at most of the stations and varied between 3.7 and 5.2 ml/litre.

Zooplankton — A study has been made of seasonal variations of biomass of zooplankton expressed in ml/m³. Biomass values (Table 1) varied from 0.66 to 32 ml/m³. The primary peak in southern part (Vengurla-Deogad) was observed after south-west monsoon from September to November with a second maximum in April-May (4.0-0.66 ml/m³) while in the northern stations (Jaigad-Janjira) the position was reversed, the primary peak being in pre-monsoon months of April-May (20.0-0.66 ml/m³) and the secondary peak during post-monsoon months of September-November (18.64-0.66 ml/m³). The biomass was higher in northern and southern parts and moderate in the central part (Vijaydurg-Ratnagiri). Highest concentration of plankton (32 ml/m³) was, however, recorded at Vengurla in the month of September. It is interesting to note that the biomass value progresses by about a month from southern to northern region (Table 1). The area of high production was Janjira, followed by Vengurla and Shriwardhan. Apart from Vengurla in the south all other stations to the north of Ratnagiri were productive in general. The dominant planktonic organisms in space and time along the coast are given in Table 2. This table does not include copepods which are generally dominant in all the samples except at the following places where

the other groups are dominant: Vengurla, Deogad and Jaigad (September); Vengurla, Malvan and Harnai (October); Malvan (November); Vijaydurg and Musakazi (December); Harnai (January); and Musakazi and Ratnagiri (March).

TABLE 2 — DOMINANT PLANKTONIC ORGANISMS IN DIFFERENT MONTHS ALONG PANAJI-BOMBAY COAST

Group	Month	Area of dominance
DIATOMS		
<i>Rhizosolenia</i> sp.	December	Vijaydurg and Musakazi
<i>Coscinodiscus</i> sp.	January	Harnai
BLUE-GREEN ALGAE		
<i>Trichodesmium</i> sp.	March April	Harnai and Shriwardhan Musakazi and Vijaydurg
DINOFLLAGELLATES		
<i>Noctiluca</i> sp.	December	Janjira
ZOOPLANKTON (EX. COPEPODS)		
Medusae	November	Shriwardhan
Polychaete larvae	September	Vengurla
Decapod larvae	do	Malvan, Deogad and Vijaydurg
<i>Lucifer</i> sp.	October	Malvan
Cladocerans	November September October	Shriwardhan Vengurla
	October	Vengurla, Deogad, Ratnagiri, Jaigad and Harnai
	November	Vengurla, Malvan, Musakazi, Ratnagiri and Harnai
	December January	Harnai Musakazi, Jaigad and Harnai
Molluscan larvae (both young ones of bivalves and gastropods)	October	Vengurla and Malvan
Pteropods	do	Vijaydurg and Musakazi
Chaetognaths	do	Vijaydurg, Ratnagiri and Janjira
Appendicularians	May September October	Harnai Musakazi and Jaigad Shriwardhan
Fish eggs	March September	Musakazi and Ratnagiri Vengurla

TABLE 1 — DISPLACEMENT VOLUME (BIOMASS) OF ZOOPLANKTON (ml/m³)

Station	1970				1971					Total	Mean for 1970-71
	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May		
Vengurla	32.00	18.64	4.00	11.32	0.33	0.66	1.33	0.33	4.00	72.61	8.09
Malvan	1.33	13.33	4.00	4.00	0.33	0.66	0.66	1.33	1.33	26.97	3.00
Deogad	0.66	15.33	1.20	3.33	0.66	4.00	0.66	0.66	1.33	27.83	3.09
Vijaydurg	7.44	5.60	10.00	8.00	1.00	1.33	2.00	4.00	—	39.37	4.92
Musakazi	0.66	5.30	3.66	5.60	0.66	1.00	2.66	0.66	—	20.20	2.52
Ratnagiri	—	5.30	8.00	—	0.66	1.33	2.00	11.33	—	28.62	4.77
Jaigad	1.33	2.66	3.33	—	1.33	5.33	1.33	0.66	2.66	18.63	2.33
Harnai	0.66	4.00	10.00	1.33	8.00	1.33	5.33	1.33	4.33	36.31	4.03
Shriwardhan	0.66	14.00	12.00	1.33	1.00	6.00	18.64	0.66	2.00	56.29	6.25
Janjira	18.64	14.66	5.33	2.33	3.33	9.33	13.33	20.00	2.66	89.61	9.96
Total	68.38	98.82	61.52	37.24	17.30	30.97	47.94	40.96	18.31	416.44	48.96
Monthly mean for region	7.04	9.88	6.15	4.66	1.73	3.10	4.79	4.10	2.62	44.07	4.90

TABLE 3 — DIATOM COUNTS PER LITRE AT SELECTED STATIONS ALONG PANAJI-BOMBAY COAST

Station	(Values are expressed in hundreds/litre)								
	1970					1971			
	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May
Vengurla	37	28	13	14	17	2	34	147	55
Malvan	45	25	25	30	24	9	61	—	64
Deogad	21	58	73	14	52	12	17	82	6
Vijaydurg	—	—	27	120	68	6	24	145	—
Harnai	250	88	39	34	45	5	15	131	5 (muddy)
Shriwardhan	315	11	4	10	4	5	5	135	5
Janjira	40	—	12	21	7	7	10	—	1.1

Discussion

The main hydrographical features of the surface waters show seasonal oscillations with 2 peaks. In the present investigation, low temperature supported by low oxygen values during November-December and simultaneous rise in salinity indicate the effect of possible upwelling in this area. Since the upwelling in northern and southern parts has already been reported by several workers^{1,2,7}, this middle zone seems to connect the two upwelling regions of the west coast. Similar conclusions are drawn on the basis of chlorophyll distribution². Sankaranarayanan and Jayaraman⁸ have reported the intrusion of upwelled water into Mandovi and Zuari estuaries while incursion of such water in Cochin backwaters has also been reported^{9,10}. Therefore, the spreading of upwelled water from nearby deeper regions and its subsequent effect on nearshore water of this area is surmised.

Zooplankton biomass exhibits 2 peak periods one immediately after and the other immediately before the south-west monsoon. The peak of zooplankton biomass (Table 1) is observed in September-October at Vengurla, Malvan and Deogad in southern part while at Shriwardhan and Janjira in northern part of the coast the peak is seen in March/April. The stations Vijaydurg, Musakazi, Ratnagiri, Jaigad and Harnai show moderate values of biomass during the period of observations. The maxima of zooplankton biomass coincide with peaks of temperature and oxygen in October and in April-May. The biomass table shows a succession of zooplankton production in space and time from southern to northern stations. These observations compare favourably well with those of Dehadrai and Bhargava² who found similar succession in case of phytoplankton and plant pigments.

The secondary peak of zooplankton in April-May especially towards northern stations appear to be associated with high diatom count during these months as noted by Dehadrai and Bhargava² who also attributed the high oxygen value to the high photosynthetic activity of the phytoplankton. This trend is repeated after the monsoon particularly at Shriwardhan, Janjira and Harnai where high zooplankton biomass is preceded by abundant phytoplankton. Otherwise as seen from the diatom and zooplankton tables (Tables 1 and 3) no definite correlation can be established between them. As seen from Table 2 *Rhizosolenia* spp. and *Coscin-*

discus spp. are present in abundance in December and January respectively, the former at Vijaydurg, Musakazi and the latter at Harnai. This is associated with high concentrations of chlorophyll *a* at these places. *Trichodesmium* bloom is observed at Harnai and Shriwardhan in March and at Musakazi and Vijaydurg in April. This is associated with high temperature and salinity (Ramamurthy *et al.*¹¹ for Goa waters). On the other hand, *Noctiluca* sp. is associated with low temperature and high salinity as at Janjira in December.

Among zooplankton, decapod larvae were found in abundance in September at Malvan, Deogad and Vijaydurg where there is fresh water influx lowering the salinity. Cladocerans are another important group of zooplankton which are useful as indicator species. These are seen at Vengurla during September, but in October they are observed up to Harnai. This supports the view expressed by Selvakumar¹² about the movement of cladocerans followed by mackerel shoals during late monsoon from south to north. The cladocerans are abundant at Harnai till December and show a secondary peak and later moving southwards. This supports the view that the mackerel fishery is late and short at northern point and is presumed that migration of shoal starts southwards some time in January.

The moderate high values of biomass as found in the present study may be explained due to the high organic production in the coastal waters of west coast of India as reported by Prasad¹³. Since the fishery potential can be expressed by zooplankton biomass, there is, therefore, need to study in detail the hydrobiology of these areas so as to characterize the waters through biological production processes.

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