Indian Journal of Marine Sciences
Vol. 17, September 1988, pp. 222-227

Macrobenthos Off Versova (Bombay), West Coast of India, in Relation to Environmental Conditions

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Received 29 *June* 1987, *revised received* 2 *May* 1988

Hydrographic conditions in the nearshore areas indicated coastal pollution around Versova. Marine environment towards offshore was relatively unpolluted. Benthic macrofauna was chiefly composed of the dominant groups Foraminifera, Polychaeta and others like Crustacea and Pelecypoda. Pennatularia, Nemeritini, Sipunculoidea, fish larvae, etc. were occasional inhabitants and restricted to the offshore unpolluted zone. Biomass was poor and species composition was inhibited in polluted regions, while population density showed fluctuating trend. Similarity coefficient for polychaetes was high (0.81) towards unpolluted offshore regions. Diversity index (H) was greater for both foraminifera and polychaetes at st 1, which was under more pollution stress. The faunal diversity was more in unpolluted clean zone. High population density and biomass of macrofauna were recorded (excluding foraminifera) during postmonsoon. Foraminifera showed preference to sandy or silty substratum while polychaetes preferred muddy (clayey-silt) bottom.

Benthic organisms have an important role[1,2] in the food chain, either at secondary level as feeders of detritus and plant material or at tertiary level as food for predators like crabs and fishes. Hence, the availability of benthos at a region can be an indicator of demersal fishery potential.

Information on the subtidal macrobenthos of the Bombay coast is scanty[3,4]. The present study deals with the abundance and diversity of benthos along the coastal waters of Versova (Bombay) in relation to the prevailing environmental conditions.

Materials and Methods

Versova is a well known fish landing centre in the northwest of Bombay. It has a creek which joins with the Malad creek in the north and opens into the Arabian Sea in the south. Versova creek with an area of roughly 1.36 km^2 receives about 131 mld domestic and 6 mld of industrial wastes from the adjoining areas[5].

Monthly duplicate collections were made at 4 stations (Fig. 1) from November 1979 to December 1980, using a van Veen grab of 0.04 m^2 area. Sediments were sieved through 500 μm screen and organisms retained on the screen were preserved in 5% buffered formalin[6]. Sediment sample (50 g) was collected and preserved in ice for the analysis of sediment texture[6] and organic matter[7]. Biomass was calculated on wet weight basis. Water samples from bottom were collected using a Vandorn sampler and were analysed as per standard methods[8]. Due to rough weather and other navigational difficulties associated with the formation of sand bar at the mouth of the creek (near st 2) sampling was not possible in June 1980.

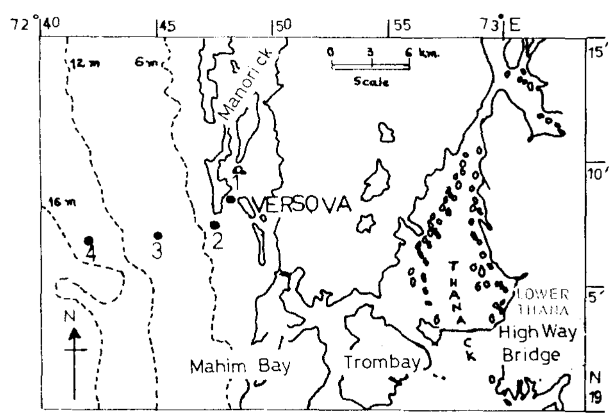

Fig. 1—Station locations

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Results

Data on environmental parameters are presented in Figs 2 and 3 and sediment characteristics in Table 1. Biological details are given in Figs 4 and 5 and Table 2.

Temperature—Variations in temperature closely followed the seasonal changes. During premonsoon the atmospheric temperature was high and consequently the sediment and water temperatures were also high. A decrease in water and sediment temperatures was noticed during December and January.

*p*H—Gradual increase in *p*H from inshore to offshore stations was observed. Generally high *p*H values were observed in March and April. During ebb, *p*H was relatively low at sts 1 and 2 than at sts 3 and 4 due to sewage influx.

Salinity—St 1 being directly affected by sewage and industrial waste discharges, registered low salinity.

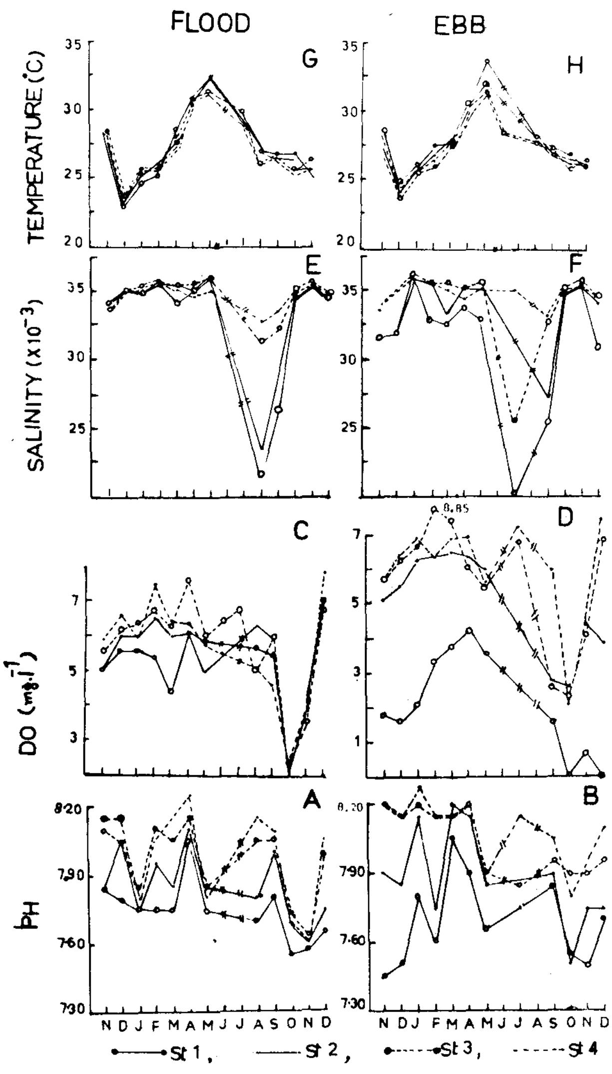

Fig. 2—Variations in *p*H (A,B), DO (C,D), salinity (E,F) and temperature (G, H)

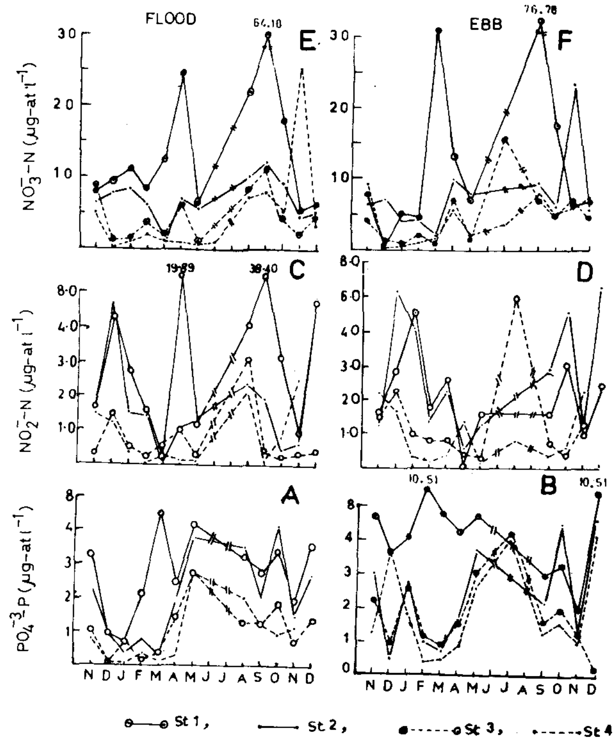

Fig. 3—Variations in phosphate (A, B) nitrite (C, D) and nitrate (E, F)

The prevailing salinity values in the remaining stations were quite comparable. As expected, low salinity was observed during ebb tide in the nearshore stations. In general, high values of salinity were observed during premonsoon period (April and May), but occasionally high values were also recorded in January and February 1980.

Dissolved oxygen (DO)—During ebb, low values of DO were observed at st 1 and other stations showed moderate values. Seasonal variation was not pronounced but DO values were exceptionally low in October-November 1980.

Phosphate—Higher values of phosphate (PO_4-P) were obtained from st 1 throughout the study. Rest of the stations showed uniform trend with moderate values during both the tides. Values were comparatively higher during ebb tide. Seasonally the trend was uneven, although higher values were recorded from May to September.

Nitrite and Nitrate—Relatively higher values of nitrite (NO_2-N) and nitrate (NO_3-N) were recorded at sts 1 and 2 especially during ebb tide. But at sts 3 and 4 the values were comparatively low. Generally the distribution pattern of these nutrients was irregular with wide monthly variations, because of the extraneous discharges into the coastal waters.

Sediments—Sediments were blackish, may be due to the anaerobic conditions and subsequent formation of H_2S. The sediment texture was clayey silt at sts

2-4 throuhgout the year. During monsoon a sand bar was formed in between sts 1 and 2. During premonsoon sts 1 and 2 sediments were of sandy and clayey silt in nature, but during monsoon they changed to sandy silt and silty sand respectively.

Organic matter (*OM*)—A gradual increase in the mean values of OM associated with muddy (clayey silt) bottom was observed from nearshore towards offshore stations (Fig. 4A).

Table 1—Sediment Characteristics Off Versova

St No.	Temp (°C)	Percentage composition			
		Sand (63μ)	Coarse Silt (63-15μ)	Fine Silt (15-4μ)	Clay (4μ)
		Premonsoon			
1	28.50	100.00	—	—	—
2	28.50	0.59	15.93	73.60	9.88
3	27.85	0.40	15.27	76.08	8.25
4	28.00	0.09	18.45	71.80	9.66
		Monsoon			
1	27.50	30.30	0.50	51.82	17.38
2	26.75	78.00	12.00	10.00	—
3	27.33	0.07	29.18	65.40	5.35
4	27.25	0.11	15.98	74.17	9.74
		Postmonsoon			
1	25.88	8.63	8.62	75.73	7.02
2	25.63	0.77	10.05	80.10	9.08
3	25.83	0.14	9.40	76.48	13.98
4	25.79	0.10	18.00	74.77	7.13

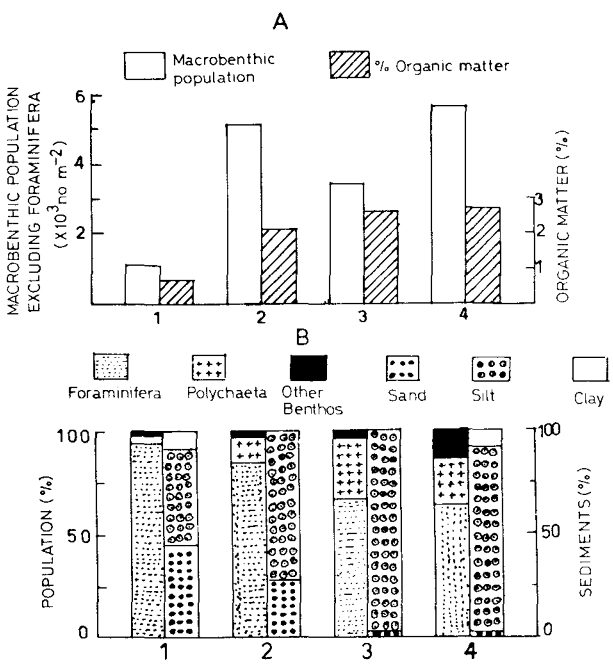

Fig. 4—Macrobenthos in relation to (A) organic matter and (B) sediment

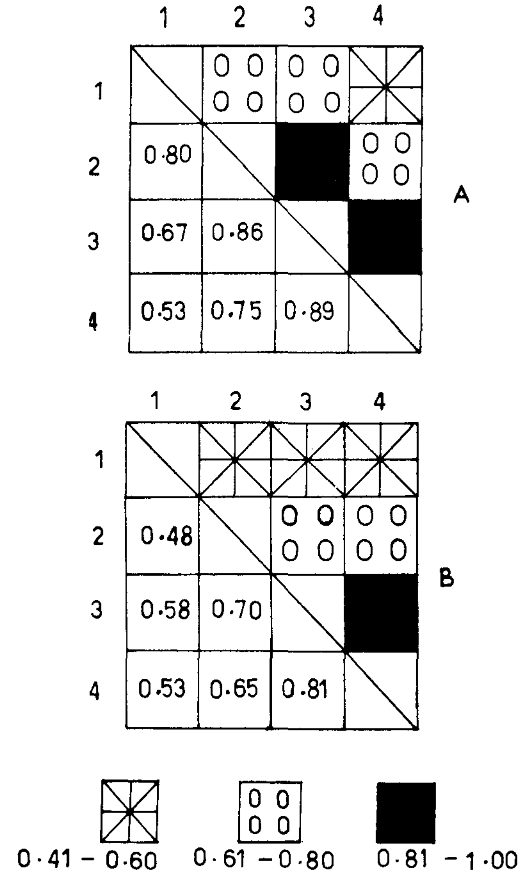

Fig. 5—Index of similarity coefficient of (A) foraminifera (B) polychaetes

Biomass—Biomass (Table 2) was mainly contributed by polychaetes. Higher biomass was observed at st 2 in December 1979, while lowest was recorded at st 4 in October 1980. The polychaetes *Prionospio pinnata* chiefly accounted for the higher biomass during post-monsoon in all stations except st 1.

Population density—Maximum population density of macrofauna was at st 2 in September 1980 (Table 2), which was chiefly contributed by foraminifera (332400 m^{-2}). The minimum population density was at st 1 in July 1980. The population density of macrofauna was high during monsoon period, mainly because of very high abundance of foraminifera. Faunal density was low during premonsoon. Excluding foraminifera, high mean population density was observed during postmonsoon period in all stations except st 4, where high density was during monsoon (7892 m^{-2}) due to the abundance of crustaceans (22025 m^{-2}) in August 1980.

Faunal composition—The macrofauna was chiefly consisted of foraminifera, Polychaeta, Crustacea (Copepoda, Amphipoda, Tanaidacea, Macrura, Brachyura and Crustacean larvae) and Pelecypoda. Pennatularia, Nemertini, Sipunculoidea, fish larvae and

Table 2—Macrobenthic Biomass ($g \cdot m^{-2}$) and Population Density ($no. m^{-2}$) of Polluted and Unpolluted Environments Off Versova

Months	Polluted stations				Unpolluted stations			
st:	1		2		3		4	
	B	PD	B	PD	B	PD	B	PD
Nov. 1979	0.63	8025	10.75	4300	18.33	21550	8.71	20275
Dec.	1.33	8975	30.12	48825	12.79	15975	27.51	35700
Jan. 1980	2.82	27200	0.32	429	16.99	50475	6.95	12075
Feb.	3.32	10300	8.57	3125	0.12	5700	5.46	9275
March	4.23	92550	2.74	6550	0.51	2575	5.55	2200
April	1.08	24875	0.50	1825	0.96	1350	11.13	6050
May	29.42	4600	0.30	600	0.87	1400	0.62	8450
June	—	—	—	—	—	—	—	—
July	0.06	50	—	—	1.46	9875	3.60	58625
Aug.	9.74	51500	0.27	6025	5.69	7225	10.53	43850
Sept.	2.55	57025	13.85	332900	0.69	2750	0.09	800
Oct.	0.97	7050	8.34	9925	1.36	8225	0.03	675
Nov.	2.68	14550	11.68	17500	11.49	8125	12.36	5500
Dec.	5.47	6875	8.39	7375	0.91	1325	2.95	2725

B = Biomass, PD = Population Density, — = No Data.

other miscellaneous groups were occasionally recorded.

Foraminifera: Foraminifera was the dominant group at Versova with a mean percentage of 82.42 along the transect. The percentage composition of total foraminifera showed a gradual reduction from sts 1-4 and the values recorded were 95.50, 86.14, 67.74 and 64.50% respectively. Both maximum (332400 m^{-2}) and minimum (50 m^{-2}) population densities of foraminifera were reported from st 2 in September and December 1980 respectively. Generally high population density of foraminifera was recorded during monsoon period.

Five important species of foraminifera, viz. *Ammonia beccarii*, *Quinqueloculina seminulum*, *Discorbis nitida*, *Rotalia calcer* and *Elphidium crispum* were identified. *A. beccarii* and *Q. seminulum* showed similar pattern of distribution and were reported from all stations off Versova. *A. beccarii* was the dominant species along the transect off Versova throughout the study. Foraminifera recorded from st 1 were blackish in colour.

The range of diversity index (H) for the foraminifera was from 0.04 (st 2) to 0.61 (st 1). The diversity was more towards the offshore stations. Species *D. nitida* and *R. calcer* were recorded from sts 2 and 3 towards offshore respectively. *E. crispum* was encountered only from st 4.

Polychaeta: Polychaeta was the second dominant group reported with an occurrence of 14.28%. Maximum population density (25000 m^{-2}) was obtained in December 1979 and minimum (25 m^{-2}) in August 1980 at st 2. The mean densities of polychaetes observed were 756, 4856, 3206 and 3600 m^{-2} at sts 1-4 respectively. Seasonally high density of polychaetes was observed during postmonsoon period except at st 1. At st 1 high value was recorded during premonsoon.

Thirty four species of polychaetes belonging to 26 genera were encountered. The common species recorded along the transect were *Ancistrosyllis constricta* (Southern), *Eunice antennata* (Savigny), *Lumbriconeris latrilli* (Audouin *et* M Edwards), *Glycera alba* (Rothke), *Polydora cilliata* (Johnston), *Prionospio pinnata* (Ehlers), *Euclymene insecta* (Ehlers) and *Maldinella* sp. *P. pinnata* was the dominent. The high numerical abundance of polychaetes recorded at sts 2-4 during postmonsoon was chiefly contributed by *P. pinnata*. A gradual reduction in population of *P. pinnata* from postomonsoon and almost reaching negligible during monsoon were noted.

The abundance of *A. constricta*, *Diopatra cuprea cuprea* (Bose), *Scyphoproctus* sp. and *Protodorivellia biarticulata* was noted at st 1, while at others *Cossura coasta* (Kitamori), *P. pinnata* and *Maldinella* sp. were abundant.

Species diversity increased from inshore (st 1) towards offshore (st 4). *Phyllodce tenuissima*, *Nereis* sp., *Nephthys polybranchia* (Southern), *Glycera rouxii* (E and M Ed. W.), *Lepidonotus tenuisatosus* (Gravier) and *Polydora* sp. were reported only from sts 3 and 4. The species *Nereis capensis* (Gurbe) and *Lumbriconereis pseudobifilaris* (*Favual*) were encountered only at st 4.

Crustacea: Crustaceans were poorly represented. Their percentage occurrence for the entire period of study was 2.69. Copepoda (0.06%). Amphipoda (0.81%), Tanaidacea (1.77%) and Brachyura (0.005%) were observed. Maximum population density (22025 m^{-2}) of crustaceans was recorded in August 1980 at st 4 which was mainly contributed by Tanaidaceans (16 700 m^{-2}) and Amphipoda (5325 m^{-2}). Minimum density (25 m^{-2}) was also obtained at st 4 in November 1979. Brachyurans were encountered only from st 1. Macrurans were poorly represented. Overall pattern of incidence of crustaceans was irregular.

Pelecypoda: These were poorly represented (0.07%) in the macrobenthic fauna of Versova. Maximum population density (175 m^{-2}) was obtained at st 1. Three species of pelecypods *Meretrix meretrix* L, *Tellina* sp. and *Donax* sp. were chiefly identified. Pelecypods were abundant in the sandy bottom.

Others: The remaining macrobenthic fauna along the Versova transect was contributed by Pennatularia (0.22%), Nemertini (0.03%), Sipunculoidea (0.09%), fish larvae (0.01%) and miscellaneous group (0.16%). The last group included *Squilla* sp., Isopoda, Cirripedea and a few unidentified forms. These organisms were occassional inhabitants and rarely present in the samples. Pennatularia was absent at st 1 and 2 and rarely at st 3. Nemertini was absent at st 1. Fish larvae were confined only to st 3 and 4.

The index of similarity coefficient for foraminifera and polychaeta is presented in Fig. 5.

Discussion

The hydrographic conditions are quite variable in the coastal regions of Versova because of various interactions, especially those caused by sewage and industrial waste discharges. Low salinity, DO, *p*H and high nutrients (PO_4-P, NO_2-N, NO_3-N) encountered at inshore st 1 (Figs 2 and 3) clearly show the extent of pollution stress. High BOD (100 $mg.l^{-1}$) and nil DO level in the inshore coastal regions of Bombay (Mahim creek) have been reported[9]. St 2 shows somewhat moderate conditions of water quality. On the otherhand sts 3 and 4 with comparatively normal salinity, *p*H, DO, and low nutrients coupled with few fluctuations of these parameters indicate relatively healthy and insignificant pollution stress as reported for the waters of Mahim creek[9].

Numerically (no.m^{-2}) mean population densities of macrobenthos are high in stressed inshore sts 1 (24121) and 2(36615) as compared to unpolluted offshore sts 3 (10504) and 4(15862). This is because of abundance and survival of foraminifera in the stressed inshore condition as reported earlier[10,11]. On the contrary mean biomass (g m^{-2}) is poor in st 1 (4.94) than the relatively normal sts 2 (7.99), 3 (6.25) and 4 (7.34).

A.beccarii is the dominant species of foraminifera encountered in this area and *P. pinnata* dominant among polychaetes. It is evident that foraminifera and polychaetes contributed to the major part of the macrofauna especially in the region where pollution stress was more.

The distribution of the minor macrofaunal groups was poor, uneven and mostly restricted to the offshore areas. Their presence was very much important in view of their role in the food chain. Their absence may bring about a break in the food cycle and ecological imbalance.

Agglutinating foraminifera shows preference to sandy or silty sand bottom of polluted regions (sts 1 and 2) whereas polychaetes prefer muddy bottom (sts 3 and 4) (Fig. 4B) as reported earlier[12-14].

No consistant relationship between OM and macrobenthic population is observed. Concentration up to 3% of OM in sediment is favourable for high density of infaunal bivalves[12], beyond this level bacterial decomposition and decline in available oxygen takes place, which in turn may result in the decline of population.

Diversity index *H* (Shannon Wiener function) is high at st 1 for both foraminifera and polychaetes which agrees with the definition i.e., the greater the diversity index greater the uncertainty. Overall, diversity of foraminifera, polychaetes and other minor groups is more towards the unpolluted offshore stations. For marine benthic organisms of South California[11] it has already been reported that diversity tends to decrease in the areas of acute pollution stress, where total productivity increases.

In the present study fluctuations in the population density and species composition of macrofauna seem to be inhibited at the stations which are under severe pollution stress. Perhaps this can be attributed to the definite signs of ecological imbalance of the ecosystem[15].

Acknowledgement

The authors are thankful to Dr S Z Qasim, Secretary and to Dr S N Dwivedi, Additional Secretary, DOD, New Delhi for their interest and suggestions.

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