



Benthic macrofauna

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8.1 INTRODUCTION

Benthic communities play a critical role in trophic relationships by providing major sources of energy to economically and ecologically important demersal fishes. Their diverse morphology and ability to adapt to various habitats make them important as food for large benthic organisms (McIntyre 1977; Gerlach 1978) and in recirculation of nutrients (Kristensen *et al.* 1985; Tamaki and Ingole 1993). The distribution of estuarine benthos varies both temporally and spatially (Rainer 1981) owing to the patchiness of their occurrence. Parulekar *et al.* (1980) and Ansari *et al.* (1986) have studied the distribution of macrobenthos in the Mandovi and Zuari estuaries; Parulekar *et al.* (1982) investigated the association of macrobenthos with the demersal fishery of the estuary. The macrofauna in these waters has been empirically defined as animals retained by 0.5 mm screens. Many organisms can thus be seen only on close inspection, while other may weigh several grams while fresh. Benthic macrofauna are good indicators of estuarine conditions because they are relatively sedentary at the sediment–water interface and within deeper sediments (Dauer and Conner 1980). The abundance of benthic animals in an area is closely related to its environment and reflects the characteristics of an ecological niche (Ansari *et al.* 2003). With this in mind, field observations on benthic macroinvertebrates in the Mandovi and Zuari estuaries were carried out during 2002–2003 as a part of a study to develop an integrated coastal zone management plan for Goa. This chapter summarizes the salient findings from these observations.

8.2 MATERIALS AND METHODS

A total of 15 stations shown in Map B were sampled from the Mandovi (nine stations) and Zuari (six stations) estuaries during 5–8 May 2002, 5–9 September 2002, and 12–14 April 2003. Sediment samples in duplicate were collected using a van Veen grab of 0.04 m² area. Macrofaunal samples were washed and sieved using a 500 µm sieve in running water and stored for sorting in a shore-based laboratory. The fauna were preserved in neutralized 5% formalin. All the animals were then identified up to the lowest possible taxa level using the keys available for the Indian coast. Macrofauna was counted and biomass was estimated by the wet weight method. Population density was converted into ind m⁻² and biomass was expressed as wet weight (g m⁻²).

8.3 RESULTS

The observed distributions are given in tables 8.1–8.6. The average density of macrofauna in the Mandovi estuary ranged from 670 to 1236 ind m⁻². The highest values were recorded during May 2002 and lowest during September 2002 (figure 8.2). Macrobenthic average density in Zuari ranged from 581–1900 ind m⁻², with the highest values during April 2003 and lowest during September 2002 (figure 8.2). The macrofaunal community at all the stations was dominated by polychaetes, which constituted more than 55% of all individuals recorded. In the

Table 8.1 Macrofaunal density (ind m⁻²) in the Mandovi estuary during May 2002.

Taxa	MZ	M ₇	M ₆	M ₅	M ₄	M ₃	M ₂	M ₁	Mean
Polychaeta	150	1425	150	80	325	175	1500	75	485
Oligochaeta	0	50	0	0	0	0	0	25	9
Bivalvia	50	50	75	180	50	25	50	0	60
Gastropoda	0	25	50	25	25	50	0	0	22
Isopoda	0	0	0	25	25	0	25	0	9
Amphipoda	100	50	0	0	3250	25	100	25	444
Tanaidacea	0	0	50	0	475	0	25	0	69
Cumacea	0	25	0	25	0	0	0	0	6
Decapoda	25	25	50	50	0	50	0	0	25
Sipunculida	0	0	25	25	0	0	0	0	6
Nemertea	25	25	50	0	0	25	0	0	16
Echiurida	0	0	25	25	0	0	0	0	6
Others	175	75	125	75	25	50	75	25	78
Total (ind m ⁻²)	525	1750	600	510	4175	400	1775	150	1236
Biomass (g m ⁻²)	14.9	15.4	11	28.2	18.4	6.6	19.8	5.3	14.95

Table 8.2 Macrofaunal density (ind m⁻²) in the Mandovi estuary during September 2002.

Taxa	M ₇	M ₆	M ₅	M ₄	M ₃	Mean
Polychaeta	225	1050	100	100	25	300
Bivalvia	300	75	1050	0	25	290
Gastropoda	25	25	0	0	0	10
Amphipoda	75	75	50	0	0	40
Cumacea	75	25	0	0	0	20
Decapoda	25	0	0	0	0	5
Nematode	0	0	25	0	0	5
Total (ind m ⁻²)	725	1250	1225	100	50	670
Biomass (gm ⁻²)	9.18	0.89	14.58	0.005	3.305	5.59

Table 8.3 Macrofaunal density (ind m⁻²) in the Mandovi estuary during April 2003.

Taxa	MZ	M ₇	M ₆	M ₅	M ₄	MN	M ₃	M ₂	Mean
Obelia colony	0	0	0	0	25	0	0	0	3
Nematoda	0	0	0	0	25	0	0	0	3
Polychaeta	1575	325	825	425	900	125	575	975	716
Oligochaeta	0	0	0	175	50	25	0	25	34
Bivalvia	25	0	25	150	50	550	75	200	134
Gastropoda	0	0	0	0	0	0	25	125	19
Isopoda	0	50	0	0	50	0	75	25	25
Amphipoda	25	25	0	25	350	25	0	25	59
Harpacticoida	25	0	0	0	0	0	0	0	4
Cumacea	25	0	0	0	50	200	25	100	50
Pcynogonida	0	0	0	0	0	0	0	0	0
Decapoda	0	25	75	25	50	25	0	0	25
Cirripectida	0	0	0	0	0	0	0	0	0
Echiniodermata	50	0	0	0	0	0	0	0	6
Others	0	0	50	0	0	0	0	0	6
Total (ind m ⁻²)	1725	425	975	800	1550	950	775	1475	1084
Biomass (gm ⁻²)	5.75	0.42	0.93	25.87	3.41	98.55	0.43	3.98	17.42

Mandovi estuary, biomass values ranged from 5.59 to 17.42 gm⁻² (figure 8.1), with the highest values recorded during April 2003 and lowest during September 2002. Macrofaunal biomass in the Zuari estuary ranged from 3.38 to 10.42 gm⁻² (figures 8.2). A total of 68 taxa were identified during the study. Polychaete dominated the macrobenthic diversity. Secondary polychaetes, representing 58% of the total polychaete fauna, were the largest group.

Table 8.4 Macrofaunal density (ind m⁻²) in the Zuari estuary during May 2002.

Taxa	Z ₅	Z ₄	Z ₃	Z ₂	Z ₁	Mean
Polychaeta	2500	325	150	100	155	646
Oligochaeta	25	0	0	0	25	10
Bivalvia	25	0	125	50	0	40
Gastropoda	0	0	50	0	75	25
Amphipoda	25	25	75	50	25	40
Tanaidacea	125	25	25	50	0	45
Cumacea	0	0	0	0	0	0
Decapoda	200	25	50	0	25	60
Sipunculida	0	0	25	0	0	5
Nemertea	0	125	0	0	0	25
Echiurida	0	0	25	0	0	5
Others	200	25	0	50	0	55
Total (ind m ⁻²)	3160	550	525	300	305	968
Biomass (g m ⁻²)	24.2	2.2	12.6	5.5	7.6	10.42

Table 8.5 Macrofaunal density (ind m⁻²) in the Zuari estuary during September 2002.

Taxa	Z ₅	Z ₄	Z ₃	Z ₂	Mean
Polychaeta	825	90	900	25	460
Bivalvia	0	25	175	0	50
Gastropoda	25	25	0	0	13
Amphipoda	25	0	50	0	19
Cumacea	0	10	0	0	3
Nematode	150	0	0	0	38
Total (ind m ⁻²)	1025	150	1125	25	581
Biomass (g m ⁻²)	22.61	0.41	8.36	0.08	7.86

8.4 DISCUSSION

During the 2002–2003 observations, the macrofaunal density and biomass showed seasonal change. The lowest values of both density and biomass were recorded during September 2002 in both the estuaries (see figures 8.1 and 8.2). Given soft sediments, this is most likely a consequence of the low salinity due to the summer monsoon. Panikkar (1969) proposed partial or complete destruction of tropical estuarine fauna during the summer monsoon, followed by an annual re-population of the estuaries and backwaters after its withdrawal and the resulting salinity increase. Parulekar *et al.* (1980) undertook a large seasonal investigation of more than half of each of the two rivers (downstream parts) during 1971–1973 with the same methods as our study. They found that salinity had the largest influence on abundance in the

Table 8.6 Macrofaunal density (ind m⁻²) in the Zuari estuary during April 2003.

Taxa	Z ₅	Z ₄	Z ₃	Z _n	Z ₂	Mean
Obelia colony	0	475	0	50	0	105
Nematoda	0	50	0	25	0	15
Polychaeta	1600	775	100	2675	250	1080
Oligochaeta	0	0	0	25	0	5
Bivalvia	0	275	0	100	50	85
Isopoda	75	0	0	475	150	140
Amphipoda	75	550	0	300	0	185
Harpacticoida	0	25	0	0	0	5
Cumacea	0	0	0	425	25	90
Pcynogonida	0	25	0	0	0	5
Decapoda	0	0	0	50	0	10
Echinodermata	0	850	0	0	0	170
Others	0	0	0	25	0	5
Total (ind m ⁻²)	1750	3025	100	4150	475	1900
Biomass (g m ⁻²)	0.97	8.73	0.06	6.58	0.59	3.38

Mandovi, while in the Zuari it was a combination of environmental factors. The r^2 values of their multiple correlations were rarely > 0.25 (see also Alongi (1990), for observations made elsewhere in the tropics).

Macrofaunal density during April and May 2002 was higher in the Zuari estuary than in the Mandovi, but biomass was higher in the Mandovi than in the Zuari (compare figures 8.1 and 8.2). The higher biomass in the Mandovi estuary was due to the presence of bivalves (see tables 8.1–8.3). Molluscs are known to be dominant in regions with a sandy bottom, whereas polychaetes prefer muddy substratum. The highest bivalve density in the present study was observed in the Mandovi at station M₅ (tables 8.1–8.3), where the sediment was sandy. The stations in Zuari, which had silty clay, were dominated by polychaetes. These results agree with those of Parulekar and Dwivedi (1973), who observed higher benthic biomass in the Mandovi estuary and attributed this to the more favourable substratum.

A comparison of the present data with those reported earlier (where the same sampling gear was used in all these studies) indicates that the abundance and distribution of fauna has changed. Polychaetes and bivalves accounted for more than 70% of the fauna during 1972–1973. During 1982–1983 and 1992–1993, the polychaetes continued to be the dominant fauna, but crustaceans replaced bivalves. The same is the case observed during the 2002–2003 observations. The reasons behind these changes are not known. Nevertheless, one cannot avoid noting that two activities that can have an impact on benthic populations have been on the rise during the last few decades. The first of these is mining of iron and manganese. Initiated in 1950, the last couple of decades have seen a consistent increase in this activity. Mining rejects often end up in the estuary and are therefore expected to contribute

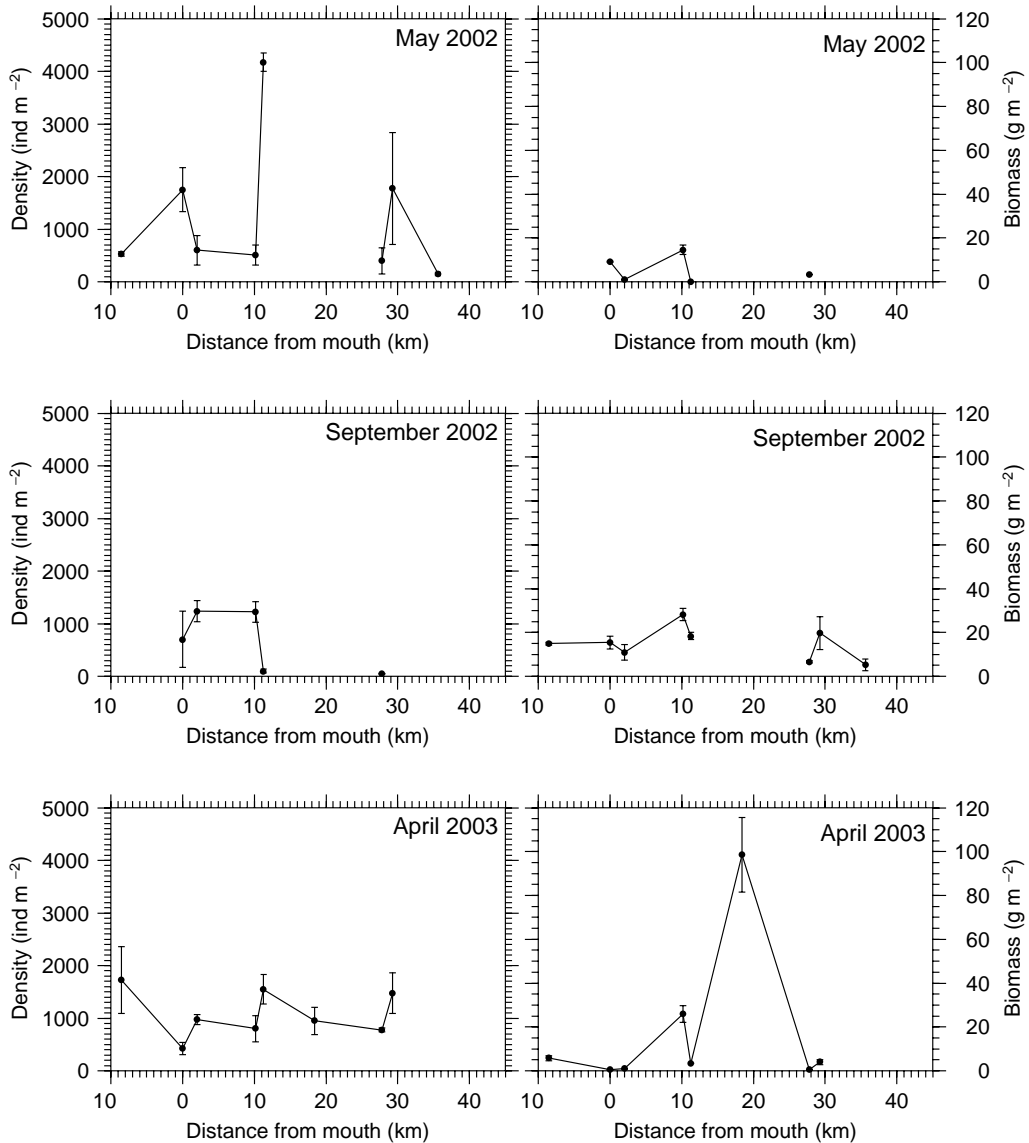


Figure 8.1 Macrofaunal density (left panels; ind m⁻²) and biomass (right panels; g m⁻²) in the Mandovi estuary during May 2002 (top), September 2002 (middle), and April 2003 (bottom). The horizontal axis gives distance from the mouth (km). In May 2002 and April 2003, one station on the shelf (hence, negative distance on the axis) was also sampled. The vertical bars indicate range of observed values at the respective stations.

to a change in the substratum. The precise implications of such a change are not known. The second activity that disturbs the substratum is mining of sand from the bed of the estuaries. With the increase in building construction in Goa, mining of sand is also on the rise, and we do not know the impact it has had on benthic life.

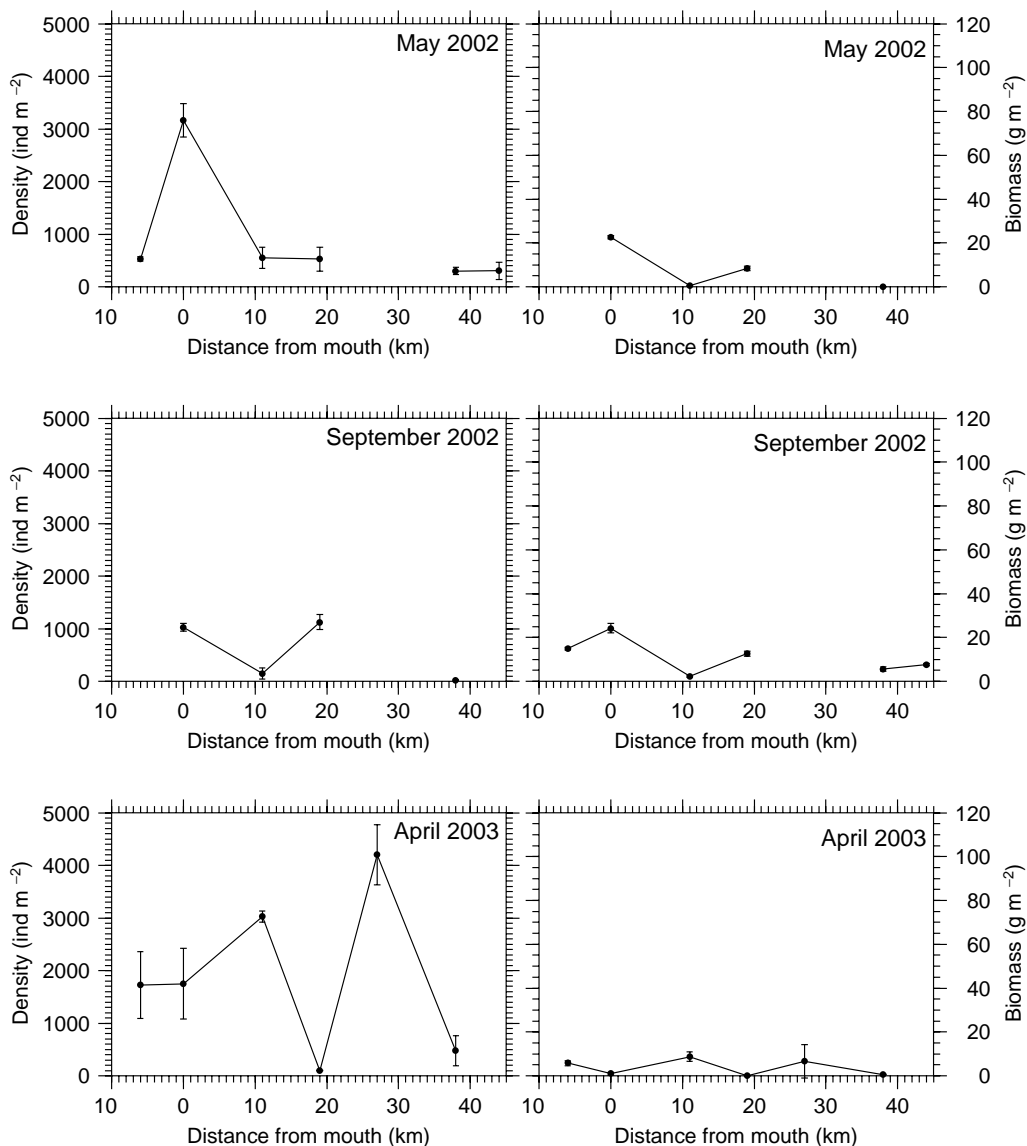


Figure 8.2 Macrofaunal density (left panels; ind m⁻²) and biomass (right panels g m⁻²) in the Zuari estuary during May 2002 (top), September 2002 (middle), and April 2003 (bottom). The horizontal axis gives distance from the mouth (km). In May 2002 and April 2003, one station on the shelf (hence, negative distance on the axis) was also sampled. The vertical bars indicate range of observed values at the respective stations.

Nonetheless, studies that have earlier noted a change in both abundance and diversity of benthic populations are worth noting here. Parulekar *et al.* (1980) reported the presence of 111 species (0.5 mm mesh size) of macrobenthos during 1972–1973. The data from 1982–1983 on abundance and species occurrence reported by

Ansari *et al.* (1986) showed a decline in the number of species with only 67 recorded. Polychaeta were the dominant fauna during 1972–1973 and were followed by Bivalvia. During 1982–1983, however, crustaceans replaced bivalves as the second dominant group. Observations carried out in 1992–1993 showed a further decline in the number of species, the new number being 48. The total number of benthic organisms also declined. The observations carried out during 2002–2003 showed that there was an increase in the number of species from 1992–1993. A total of 67 species were recorded and bivalves again constituted the second dominant group after polychaetes. The dominant polychaete species during the present study were *Mediomastus* sp., and *Cossura* sp. During the earlier studies, *Diopatra neapolitana*, *G. alba*, and *P. pinnata* were dominant. Three species, namely *M. casta*, *C. fluviatilis*, and *A. chilensis*, endemic to the two estuaries earlier, were either absent or recorded in low numbers at various stations during 2002–2003. The number of crustaceans has oscillated: the average density during 1972–1973 was 1604 ind m^{-2} , it decreased to 573 ind m^{-2} in 1992, but rose to 1073 ind m^{-2} in 2002–2003.

In essence, while the present data are too meagre to arrive at a statistically significant conclusion regarding all aspects of abundance and diversity of benthic populations in the Mandovi and Zuari estuaries, there is empirical evidence to support two conclusions. The first is that benthic macrofauna in the two estuaries go through an annual cycle of destruction and rejuvenation. Indications are that the destruction occurs when the salinity drops owing to runoff during the summer monsoon, as also shown by earlier works cited above. Rejuvenation follows withdrawal of the fresh water. The second conclusion is that rejuvenation differs from year to year. While it has been reported that there have been long-term changes in benthic populations in the Mandovi and Zuari estuaries, and that these changes can be associated with environmental changes due to mining of ore on land and of sand from the estuarine channels, firm evidence is lacking.

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