

## Biomass & Composition of Zooplankton in Auranga, Ambika, Purna & Mindola Estuaries of South Gujarat

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Mean biomass of zooplankton in Auranga, Ambika, Purna and Mindola estuaries were 4.31, 3.46, 3.58 and 3.17 ml/100 m<sup>3</sup> respectively. Relatively higher biomass was recorded during ebb period in Auranga, Purna and st 1 of Ambika. In Mindola and st 2 of Ambika the flood period sustained higher biomass. Copepods, molluscan veligers, decapod larvae, mysids and chaetognaths were the major constituents in the collections. In general, chaetognaths, decapod larvae and fish larvae were caught in higher abundance during the flood conditions. The prevailing water quality of Ambika and Mindola indicates deteriorating conditions and consequently some reduction in biomass and population density of certain groups were observed.

Apart from a study on the plankton of the Narmada estuary<sup>1</sup> there is no other investigation on the zooplankton from any of the estuaries of Gujarat. In an estuarine habitat, tides will have profound influence on the biotic community. Influence of tides on the zooplankton populations from estuaries are limited to a few reports from Godavari estuary<sup>2</sup> and Cochin backwaters<sup>3,4</sup> in India. In this communication zooplankton biomass and composition in 4 estuaries located in South Gujarat are studied during the flood and ebb conditions.

Brackish water fauna are well adapted to tolerate wide range of environmental fluctuations, particularly that of salinity. However, in recent years, the increasing human activity is imposing stress on the ecosystem by polluting the environment. The deleterious effect caused by pollutants may not be well marked at the initial stage, but some change in the general productivity can be discernible. Among the 4 estuaries, Ambika and Mindola are found to be relatively more polluted by industrial discharge than Auranga and Purna<sup>5</sup> and hence comparison of zooplankton standing stock in the 2 types of environment also forms part of this investigation.

### Environment

The estuaries studied (Fig. 1) are of perennial rivers, being wide at the mouth region and gradually narrowing towards the upper reaches. Extensive shifting of sand banks that become exposed during low tide are found in all these estuaries. Physico-chemical characteristics of the area had been well studied<sup>5</sup>, and the following observations are based on this report: Spring-tide range at the mouth of Auranga, Ambika, Purna and Mindola are 3.4, 4.7, 4.8 and 5.9 m

respectively. Estuarine waters of Auranga and Mindola are vertically well mixed. At Ambika the mouth region is well mixed while at the upper reaches (st 2) some gradient especially during ebb tide is observed. In Purna some stratification due to the

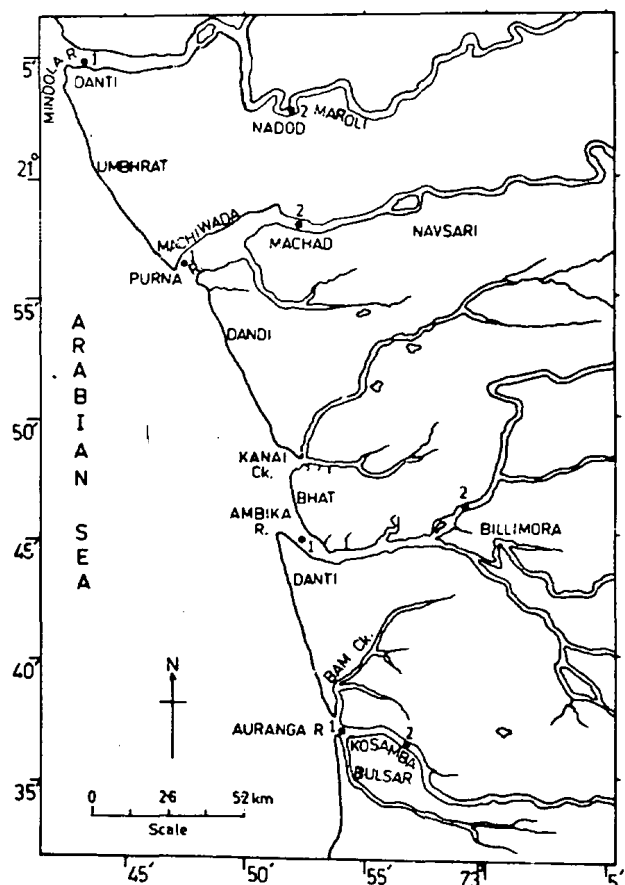


Fig. 1—Location of stations in different estuaries

incomplete mixing of river water and sea water is noticeable.

The range of dissolved O<sub>2</sub> in Auranga (5.1-8 ml/litre) and Purna (4.7-8.7 ml/litre) indicated that the water was free from organic pollution. Variation of DO at the mouth of Ambika was conspicuous (3.6-8.2 ml/litre) while towards the upper reaches the values were very low (0-3.8 ml/litre) suggesting the deterioration of water. In Mindola the dissolved oxygen values were 2.5-8 ml/litre and the values below normal were obtained from the upstream station. Average levels of reactive phosphate and nitrate showed a variation of 34-302 and 17-243 µg/litre respectively. Nitrogen and phosphorus compounds were somewhat less in all the estuaries<sup>5</sup>.

### Materials and Methods

From all the estuaries zooplankton samples were collected from 2 stations, one located towards the mouth of the river (st 1) and another at the upper reaches of the estuary (st 2) during Oct. 1978-Oct. 1979. Surface samples were collected both during ebb and flood periods using a HT net (mouth area 0.25 m<sup>2</sup>; mesh size 0.3 mm) with a flowmeter attached. Three to four series of collections were made from each estuary and sampling was done between 0600 and 1800 hrs covering both the tides. Each sample (25%) was analysed for the representation of different taxonomic groups and density is estimated for cubic metre of water filtered.

### Results

#### Auranga River

**Biomass**—Variation in zooplankton biomass along with the prevailing salinity is given in Fig. 2A. In general, higher biomass was recorded at st 1 except in Oct. 1979. Salinity values were relatively more in January and May and zooplankton biomass was also comparable during these months. Zooplankton biomass at both the places was maximum in October. Mean biomass values for the entire period at sts 1 and 2 were 4.63 and 4 ml/100 m<sup>3</sup> respectively. Ebb period sustained higher biomass of zooplankton (Fig. 2A; Table 1). At both the stations the mean biomass during ebb was about 1.4 times higher than that obtained for flood.

**Composition**—Total population density at st 1 ranged from 20-2746/m<sup>3</sup> (av. 735/m<sup>3</sup>) while at st 2 from 11-909/m<sup>3</sup> (av. 271/m<sup>3</sup>). Copepods formed the dominant component of zooplankton throughout the period of observation except in ebb of Oct. 1979 when gastropods outnumbered copepod population (Table 2). The other common groups were gastropods, chaetognaths, decapod larvae and mysids. Lamellibranchiates, polychaetes and fish eggs and

Table 1—Biomass of Zooplankton (ml/100 m<sup>3</sup>) at Sts 1 and 2

Estuary	[Values are mean ± SD]			
	St 1		St 2	
	Flood	Et	Flood	Ebb
Auranga	3.81 ± 1.85	5.45 ± 1.21	3.33 ± 2.89	4.66 ± 2.03
Ambika	3.16 ± 3.03	7.43 ± 3.31	1.80 ± 1.06	1.49 ± 1.22
Purna	2.29 ± 0.96	3.44 ± 2.09	2.21 ± 1.11	6.29 ± 4.58
Mindola	5.47 ± 3.68	3.24 ± 1.41	1.82 ± 0.66	1.35 ± 0.37

larvae contributed not much to the total fauna. There was not much difference between sts 1 and 2 in the percentage incidence of the common groups. Decapod larvae included the economically important *Macrobrachium* spp and they were recorded only in May. Aggregations of chaetognaths were noticed in Oct. 1979 and during ebb their population density was higher than that of copepods.

Chaetognaths were represented by *Sagitta bedoti*. Sparse representation of coelenterates was observed in May and October. Other groups found in small numbers were Foraminifera, Pteropoda, Cumacea, Isopoda and Amphipoda (Table 3). Difference in numerical density of major groups of zooplankton for ebb and flood was not well marked. However, copepods, decapod larvae and fish eggs and larvae showed relatively higher abundance during flood (Table 2).

#### Ambika River

**Biomass**—Zooplankton biomass showed wide fluctuations with maximum in December (Fig. 2B). Biomass at st 1 was relatively higher than that at st 2, the mean value being 5.3 and 1.63 ml/100 m<sup>3</sup> respectively. The recorded salinity at st 2 during May was low for premonsoon (Fig. 2B). At st 1 higher biomass values obtained in December and May were associated with increase in salinity values. Mean biomass value at st 1 was 4.3 times more during ebb than that in flood (Table 1). At st 2 mean biomass value for flood was 0.3 times higher than that recorded for ebb.

**Composition**—Total zooplankton varied from 108-1670/m<sup>3</sup> (av. 620/m<sup>3</sup>) at st 1 and from 1-704/m<sup>3</sup> (av. 137/m<sup>3</sup>) at st 2. In all collections copepods were most abundant (Table 2). Gastropods, lamellibranchiates, decapod larvae and mysids were the other common groups being better represented at st 1 than at st 2. *Macrobrachium* spp, foraminiferans, hydromedusae

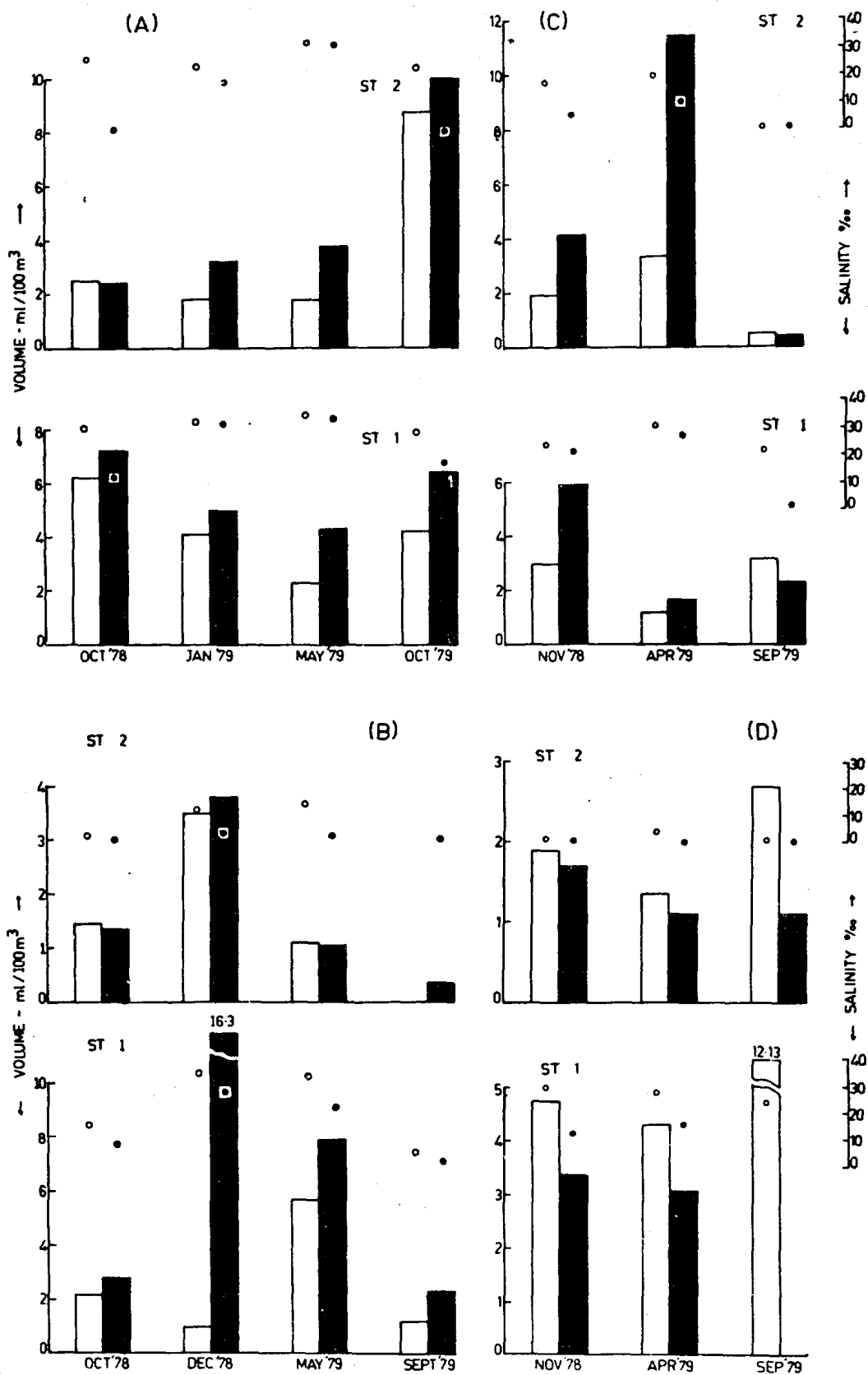


Fig. 2—Zooplankton biomass at 2 stations in Auranga (A), Ambika (B), Purna (C), and Mindola (D) estuaries. [Open area, flood; solid area, ebb. Salinity values are given for flood (O) and ebb (●)]

Table 2—Percentage Incidence of Common Groups in Auranga, Ambika, Purna and Mindola Estuaries during 1978-1979  
 [Values given in brackets under decapod larvae indicate *Macrobrachium* spp.]

Month	Polychaetes		Lamellibranchiata		Gastropods		Copepods		Mysids		Decapod larvae		Chaetognaths		Fish eggs & larvae	
	E	F	E	F	E	F	E	F	E	F	E	F	E	F	E	F
AURANGA																
St 1																
Oct '78	0.008	0.004	—	—	1.48	1.56	98.16	97.99	0.16	0.18	0.06	0.1	0.12	0.14	0.004	0.006
Jan '79	0.05	—	1.17	1.17	—	1.14	95.86	96.72	2.7	—	—	0.44	0.12	—	—	—
May '79	0.015	0.185	1.75	2.75	—	0.175	96.84	91.58	0.45	1.45	0.595	1.36	0.33	1.2	0.005	0.225
Oct '79	0.3	—	1.5	—	60.7	—	4.9	65.2	0.98	1.5	3.8	19.4	27.9	10.8	0.32	0.4
St 2																
Oct '78	—	0.01	—	—	9.9	8.4	88.3	90.6	0.05	0.07	1.7	0.07	0.1	0.12	—	0.01
Jan '79	—	0.08	7.2	9.7	8.9	—	78.5	88.9	1.2	0.9	1.1	—	3.1	0.16	—	—
May '79	0.004	0.0015	0.124	0.045	0.16	18.175	97.4	80.39	1.99	0.975	0.198	0.195	0.045	0.164	0.0405	0.0015
Oct '79	—	—	—	—	62.86	4.3	10.3	69.12	1.09	6.5	5.32	8.7	18.3	0.7	6.3	4.8
AMBIKA																
St 1																
Oct '78	—	—	1.6	3.5	5.2	1.0	93.04	95.5	0.04	—	0.01	—	0.006	—	—	—
Dec '78	0.018	0.055	5.5	2.8	0.7	—	90.99	93.94	0.75	0.055	0.93	—	0.99	0.39	0.018	—
May '79	0.465	0.042	0.11	1.15	0.412	0.569	95.76	94.03	1.23	2.25	0.21	0.084	1.75	1.6	0.03	0.143
Sept '79	—	—	—	—	0.08	0.83	99.3	98.9	0.03	0.12	0.5	0.134	—	0.005	—	0.002
St 2																
Oct '78	0.01	—	—	0.03	0.06	0.1	99.86	99.8	0.007	0.07	0.05	0.02	0.01	0.009	—	—
Dec '78	0.03	2.3	—	0.14	1.2	0.9	96.84	94.6	0.3	—	1.5	1.6	—	—	0.01	—
May '79	1.15	0.05	0.6	2.9	16.55	3.9	75.55	88.86	—	3.65	0.4	0.195	1.2	0.025	—	0.35
Oct '79*	—	—	—	—	—	—	91.84	—	—	—	—	—	—	—	—	—
PURNA																
St 1																
Nov '78	0.005	—	6.8	3.2	—	—	91.61	94.59	0.015	0.01	0.026	0.058	1.4	1.95	0.018	0.03
Apr '79	0.01	0.254	0.23	4.25	0.225	1.75	96.195	88.005	1.32	0.1	0.02	2.085	0.735	2.13	0.09	0.115
Sept '79	—	—	—	—	0.28	13.5	99.22	35.96	0.4	0.4	0.072	1.84	0.01	47.76	0.005	0.6
St 2																
Nov '78	0.005	0.5	4.25	1.4	0.02	0.015	95.1	97.15	0.025	0.017	—	0.1	0.56	0.665	0.005	0.01
Apr '79	0.01	0.05	3.7	0.7	0.9	18.54	90.14	71.75	2.45	0.9	0.104	1.1	2.56	6.65	0.14	0.203
Sept '79	—	—	2.6	—	—	1.3	95.5	96	0.6	0.8	0.75	1.5	0.3	—	0.15	0.17

Contd

Table 2—Percentage Incidence of Common Groups in Auranga, Ambika, Purna and Mindola Estuaries during 1978-1979—Contd

[Values given in brackets under decapod larvae indicate *Macrobrachium* spp.]

Month	Polychaetes		Lamellibranchiates		Gastropods		Copepods		Mysids		Decapod larvae		Chaetognaths		Fish eggs & larvae	
	E	F	E	F	E	F	E	F	E	F	E	F	E	F	E	F
MINDOLA																
St 1																
Nov '78	0.008	—	1.8	1.85	0.06	0.045	96.16	96.15	0.115	0.15	0.41 (0.01)	0.675 (0.03)	0.975	1.1	0.0075	0.008
Apr '79	—	0.06	0.8	15.45	5.05	0.35	93.3	59.05	0.15	7.4	0.35	0.265 2.3	0.155	16.85	0.02	0.175
Sept '79 <sup>f</sup>	0.1	—	1.4	—	10.2	—	78.9	—	—	—	—	—	6.96	—	—	—
St 2																
Nov '78	0.02	0.01	9.6	—	0.2	0.2	89.8	99.5	—	—	0.21 (0.01)	0.25 (0.05)	—	0.006	—	0.01
Apr '79	0.21	—	—	—	8.1	30.7	85.91	68.6	0.05	0.03	1.3	0.5	0.01	0.06	—	0.03
Sept '79	—	—	3.9	—	—	1.6	36.6	88.2	—	—	58.5	9.7 (0.3)	—	—	—	0.5

Data for flood\* and ebb<sup>f</sup> period not available

and cumaceans were recorded only at st 1 while isopods and insect larvae were confined to st 2. The ebb and flood showed difference in the numerical representation of a few groups. There was better representation of lamellibranchiates during flood while decapod larvae and chaetognaths showed higher abundance during ebb.

**Purna River**

**Biomass**—Zooplankton biomass showed considerable fluctuations with maximum values in November at st 1 and in April at st 2 (Fig. 2C). Mean zooplankton biomass at sts 1 and 2 was 2.87 and 4.25 ml/100 m<sup>3</sup> respectively. Associated with the relatively higher salinity in April an increase in zooplankton biomass was observed at st 2 but at st 1 such an increase was not discernible. Zooplankton biomass during ebb was usually higher than in flood. Mean zooplankton biomass at sts 1 and 2 was more during ebb than in flood and the recorded values were 1.2 and 4.1 times higher respectively.

**Composition**—Total zooplankton varied from 26-1310/m<sup>3</sup> (av. 472/m<sup>3</sup>) at st 1 and 13-1315/m<sup>3</sup> (av. 523/m<sup>3</sup>) at st 2. Copepods formed the major part of the zooplankton in all collections except in Sept. 1979 at st 1 for flood (Table 2). Chaetognaths, mysids, lamellibranchiates and decapod larvae were the other common species. Molluscan larvae and mysids had better representation at st 2 than at st 1. Chaetognaths were very abundant in this river and in September during ebb they outnumbered the copepod population. *S. bedoti* was the only chaetognath species found in the collections. *Macrobrachium* spp were found at both the stations. Coelenterates were sparsely represented in the collections. Ostracods, isopods and stomatopods were recorded from the river mouth while Foraminifera were confined to the upstream station. Decapod larvae, chaetognaths and fish eggs and larvae were invariably represented in higher numbers during flood. Relative abundance of gastropods was more during flood period while lamellibranchiates, copepods and mysids showed higher density during ebb.

**Mindola River**

**Biomass**—Zooplankton biomass indicated only limited fluctuations (Fig. 2D). Maximum biomass was recorded at the river mouth in Sept. 1979. Biomass at st 1 was always more than that at st 2. Mean biomass at sts 1 and 2 was 4.81 and 1.52 ml/100 m<sup>3</sup> respectively. Compared to st 1 salinity at st 2 was very low throughout. Higher biomass was always associated with flood. Mean biomass at st 1 during flood was 2.2 times more than the ebb. At st 2 mean biomass for flood was 0.5 times higher than that for ebb.

Table 3—Rare Groups of Zooplankton Found in Samples

Auranga	Ambika	Purna	Mindola
		<i>Foraminifera</i>	
May (sts 1&2)	May (st 1)	April (st 2)	April (st 2)
		<i>Hydromedusae</i>	
May (st 1) Oct (st 1)	May (st 1)	April (sts 1&2) Sept (st 1)	April (st 1)
		<i>Siphonophora</i>	
May (sts 1&2) Oct (sts 1&2)	Oct (sts 1&2) Dec (st 1)	April (st 1) Nov (sts 1&2)	Nov (st 1)
		<i>Pteropoda</i>	
Jan (st 1)	—	—	—
		<i>Ostracoda</i>	
—	—	April (st 1) Nov (st 1)	—
		<i>Cumacea</i>	
Jan (sts 1&2) May (st 1)	Oct (st 1)	—	Nov (st 2)
		<i>Isopoda</i>	
Oct (st 2)	Oct (st 2)	April (st 1) Sept (st 1) Nov (st 1)	
		<i>Amphipoda</i>	
Jan (st 2) May (sts 1&2) Oct (sts 1&2)	May (st 1) Sept (st 1) Dec (st 2)	April (sts 1&2) Sept (st 2)	Sept (st 1)
		<i>Insect larvae</i>	
—	May (st 2)	—	April (st 1)
		<i>Stomatopoda</i>	
—	—	April (st 1)	—

**Composition**—Total number of zooplankton at st 1 ranged from 27-1297/m<sup>3</sup> (av. 602/m<sup>3</sup>) and at st 2 from 7-720/m<sup>3</sup> (av. 237/m<sup>3</sup>). Copepods dominated in all samples except at st 2 in September during ebb (Table 2). Decapod larvae, gastropods and chaetognaths were the other common groups. St 1 sustained higher abundance of lamellibranchiates, mysids, chaetognaths and fish eggs and larvae. Gastropod and decapod larvae had relatively higher abundance at st 2. Chaetognaths represented by *S. bedoti* were very sparse at st 2. Decapod larvae showed unusual abundance during September at st 2. *Macrobrachium* spp were recorded at both the stations. Compared to other estuaries rare organisms were very poorly represented in Mindola (Table 3). Coelenterates, amphipods and insect larvae were recorded only at st 1. Foraminiferans and cumaceans were recorded at st 2 alone. Distribution of different groups did not show much variation during the ebb and flood period. However, chaetognath and fish eggs and larvae showed better representation during the flood period.

#### Discussion

Overall picture on zooplankton distribution in the 4 estuaries indicates that they are fairly productive systems, productivity being higher at the mouth than at upper reaches. Mean biomass values of zooplankton in Auranga, Ambika, Purna and Mindola were 4.31, 3.46, 3.58 and 3.17 ml/100 m<sup>3</sup> respectively. Considering the conversion factors suggested for estuarine waters<sup>6</sup> if these values are converted in terms of carbon the zooplankton production rate will be 81.1, 65.1, 67.37 and 59.65 mg C/100 m<sup>3</sup>/day respectively. The reported value of zooplankton production rate for Narmada estuary is only 24.47 mg C/100 m<sup>3</sup>/day<sup>1</sup>. Concomitant with the higher biomass total population density of zooplankton was relatively higher at Auranga (503/m<sup>3</sup>) and Purna (498/m<sup>3</sup>). Lower values were recorded at Ambika (379/m<sup>3</sup>) and Mindola (419/m<sup>3</sup>).

Dominant component of zooplankton varies in different estuaries. Cirripede nauplii dominate the Southampton waters and York river<sup>8</sup>. Polychaete

larvae form the major component in Raritan Bay and both polychaete and lamellibranchiate larvae in Narrangasett Bay<sup>8</sup>. In all the 4 estuaries copepod dominated the total zooplankton population similar to the earlier records from estuaries of India<sup>9-12</sup>.

In an estuarine habitat tides have profound influence on the plankton community. There are a few conflicting reports on the effect of tides on zooplankton from tropical estuaries. In Cochin backwaters Madhupratap and Rao<sup>4</sup> found no significant effect of tides on zooplankton biomass while Pillai and Pillai<sup>3</sup> observed zooplankton having partial relationship with the tide, higher values were recorded during ebb as well as flood. Periodic fluctuation in zooplankton biomass and copepod species correlated with tide was reported from St. Margarets' Bay<sup>13</sup>. In the present study relatively higher biomass was observed during ebb in Auranga, Purna and st 1 of Ambika estuary. In Mindola and st 2 of Ambika flood sustained higher biomass of zooplankton. Distribution of different groups of zooplankton was not uniform for the 2 periods and it also varied from estuary to estuary. In general, chaetognaths, decapod larvae and fish larvae were caught in higher abundance during flood.

Chemical characteristics indicate deteriorating conditions in Ambika and Mindola rivers<sup>5</sup>. Completely deoxygenated water was often observed around st 2 of Ambika and DO level was below normal at st 2 of Mindola. During ebb conditions are worse and may even impair normal distribution of zooplankton. This is quite evident by the relatively lower biomass recorded during ebb from st 2 of Ambika and Mindola. Again, mean zooplankton standing stock was relatively low in Ambika and Mindola than the other 2 estuaries. Chaetognaths which are sensitive to environmental changes were very sparsely represented at st 2 of Mindola and Ambika (Table 2). Larval forms are more sensitive to the change

in environmental conditions and consequently a reduction in the numerical abundance of fish larvae and lamellibranchiate larvae were observed in polluted areas. In Raritan Bay, a polluted estuary in New Jersey, lamellibranch veligers were found to be adversely affected by high concentrations of organic debris in the water column<sup>8</sup>.

In polluted estuary the cumulative effect of various factors is responsible for an eventual stress on aquatic life. Abundance and scarcity of more sensitive groups and species can be considered as biological indices to forecast polluted and unpolluted waters of similar habitats. If this assumption is acceptable, biological studies in the 4 estuaries indicate some inimical conditions in Ambika and Mindola rivers.

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