

## Zooplankton Standing Stock & Composition in Coastal Waters of Goa, West Coast of India

S C GOSWAMI

National Institute of Oceanography, Dona Paula, Goa 403 004

Received 25 May 1984; revised received 17 June 1985

Temporal and spatial variability in standing stock and zooplankton composition at 5 stations along the Goa coast during 1975-76 were studied. Standing stock values ranged from 22.81 to 53.65 mg C.m<sup>-3</sup>. Zooplankton community was diverse and no single group ever dominated the zooplankton. Grazers (herbivores, omnivores and detritivores) formed the main component of zooplankton population (85 to 96%). Zooplankton diversity enhanced with increase of carnivores in the ecosystem. Copepods, cladocerans, pteropods, decapod larvae and chaetognaths were the important zooplankters. Copepod species diversity values varied between 1.21 and 5.43. Diversity values were higher at stations with lesser estuarine influence.

Zooplankton by virtue of its ubiquitous distribution and abundance plays an important role in the economy of the sea. The waters along the west coast of India are rich in zooplankton production<sup>1</sup>. Nair<sup>2</sup> and Rajagopal<sup>3</sup> gave a general account of zooplankton distribution in the nearshore waters of Goa. The present paper deals with zooplankton standing stock, temporal and spatial variations in the occurrence and abundance of major groups and species of zooplankton in relation to hydrographical features in the coastal waters of Goa.

### Materials and Methods

Monthly surface zooplankton samples were collected at 5 stations along the Goa coast (Fig. 1) during Sept. 1975 to May 1976. No sampling was done during monsoon (June to Aug.). The stations were located at 10 m depth zone. The zooplankton collections were made with a modified HT net (mouth area 0.25m<sup>2</sup>, mesh size 0.33 mm) fitted with a calibrated flowmeter.

Standing stock was estimated from zooplankton biomass values<sup>4</sup>. An aliquot (5 to 10% of total sample) was examined for enumeration of major taxa and species. Number of organisms was then calculated for the whole sample. Copepod species diversity (D) values were calculated using the formula of Shannon and Weaver<sup>5</sup>. Temperature and salinity<sup>6</sup> were measured in water samples taken simultaneously along with the zooplankton collections.

### Results and Discussion

Zooplankton biomass showed 2 peaks—one in Sept. and another in April/May. Highest monthly production value (53.65 mg C.m<sup>-3</sup>) was obtained in Sept. (Table 1) at st 2 where the salinity was low (Table

2). Lower salinity coupled with enrichment due to land run off during the SW monsoon resulted in phytoplankton proliferation particularly the diatoms (*Coscinodiscus*, *Chaetoceros*, *Skeletonema*, *Nitzschia* and *Flagilaria*)<sup>7</sup>. Abundance of phytoplankton in this ecosystem leads to increased population of herbivore zooplankters. High standing stock values obtained in

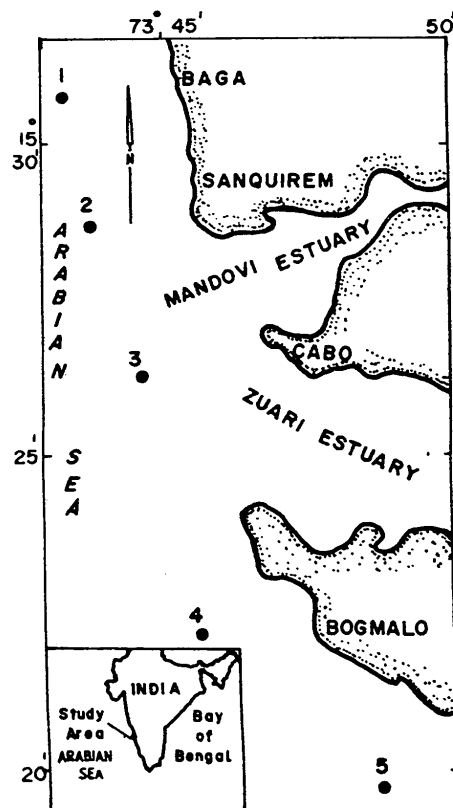


Fig. 1—Station positions

Table 1—Zooplankton Standing Stock Values (mg C.m<sup>-3</sup>) at Different Stations during Sept. 1975 to May 1976

Stations	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Average
1	47.85	39.42	22.86	28.25	36.10	40.81	39.27	52.16	49.33	39.56
2	53.65	38.97	25.09	32.44	40.16	38.72	35.11	38.92	42.65	38.11
3	39.83	36.55	22.81	31.67	28.95	37.36	33.81	41.87	40.16	34.78
4	46.89	41.11	27.63	32.34	35.19	48.63	45.22	47.83	44.60	41.04
5	48.93	39.12	21.66	39.85	41.63	38.65	35.81	37.96	32.57	37.35
Average	47.43	39.03	24.01	32.91	36.41	40.83	37.84	43.75	41.86	—

Table 2—Surface Temperature and Salinity Values

Month	Temperature (°C)						Salinity (× 10 <sup>-3</sup> )					
	St 1	St 2	St 3	St 4	St 5	Average	St 1	St 2	St 3	St 4	St 5	Average
Sept.'75	27.1	27.2	27.0	26.8	26.8	26.9	32.81	33.01	33.00	33.21	33.10	33.03
Oct.	28.9	29.0	29.0	28.8	29.1	28.9	33.13	33.42	33.72	33.52	33.16	33.39
Nov.	28.8	28.9	28.7	28.5	28.7	28.7	34.82	33.95	34.01	34.14	33.98	34.18
Dec.	26.6	26.5	26.8	26.7	27.0	26.7	34.91	34.94	35.01	35.23	34.91	35.00
Jan.'76	27.4	27.9	28.0	28.4	28.6	28.1	34.78	34.91	34.97	35.03	34.74	34.89
Feb.	28.0	28.0	28.1	28.2	28.4	28.1	35.10	34.78	35.06	35.01	34.56	34.90
March	28.6	28.5	28.8	28.9	29.2	28.8	35.31	35.56	35.71	35.82	35.44	35.57
April	28.8	28.8	29.0	29.0	29.1	28.9	35.27	35.81	35.57	34.94	35.51	35.42
May	29.2	29.4	29.5	29.2	29.8	29.4	35.86	35.90	35.92	36.01	35.87	35.91
Average	28.1	28.2	28.3	28.3	28.2	—	34.66	34.69	34.77	34.77	34.58	—

Sept. were due to abundance of cladocerans. The cladocerans are filter feeders and their association to phytoplankton especially diatoms is fairly well known<sup>8</sup>. The other peak during the late premonsoon months (April-May) was due to the gelatinous organisms such as hydromedusae, siphonophores, ctenophores and doliolids. Total zooplankton counts (no. m<sup>-3</sup>) at sts 1 to 5 varied from 181 to 4312 (av. 2396), 102 to 3115 (av. 2161), 191 to 4310 (av. 2476), 146 to 3924 (av. 2389) and 195 to 3892 (av. 2465) respectively. Counts were generally higher during Sept. to Feb. when the zooplankton community was dominated by grazers (herbivores, omnivores and detritivores). Twenty four zooplankton taxa were identified. Based on total zooplankton counts, for all the stations together, the various groups in order of abundance were copepods (56.54%), cladocerans (15.19%), pteropods (8.64%), sergestids (4.49%), other decapod larvae (3.15%), chaetognaths (2.39%), siphonophores (2.29%), hydromedusae (1.58%), polychaete larvae (1.18%), fish eggs (0.82%), oikopleurans (0.68%), ctenophores (0.41%), amphipods (0.33%), stomatopod larvae (0.32%), fish larvae (0.32%), lamellibranchiates (0.31%), ostracods (0.21%), cirriped larvae (0.21%), doliolids (0.21%), mysids (0.15%), cumaceans (0.15%), cyphonautes (0.11%), echinoderm larvae (0.04%) and others (0.24%). Zooplankton community was diverse and no single group ever dominated the zooplankton population throughout the period of observations. Numerous

cladocerans (5815 no. m<sup>-3</sup>) and pteropods (465 no. m<sup>-3</sup>) were obtained in Sept. and Oct. Swarming of pteropods (*Creseis acicula*) in the coastal waters of Goa in Oct. (1976 to 1980) was reported earlier<sup>9</sup>. Further abundance of cladocerans associated with *Trichodesmium* blooms in April was reported from the coastal waters of Goa<sup>10</sup> and during Feb. to April along the west coast of India<sup>11</sup>.

Copepods were abundant from Nov. onwards and 80 copepod species were identified (calanoids 56, cyclopoids 17 and harpacticoids 7). 20 species constituting about 65% of copepod population were quite common and occurred invariably in all the samples. Their occurrence at various stations and during different months are shown (Fig. 2). Spatial variability in the occurrence and abundance of copepod species was also noticed. Estuarine species viz. *Paracalanus parvus*, *P. aculeatus*, *Eucalanus subcrassus*, *Centropages dorsispinatus*, *C. tenuiremis* and *Oithona rigida* occurred more at st 3 located in the region off the mouths of the Mandovi and Zuari estuaries. Neritic forms such as *Eucalanus monachus*, *Euchaeta marina*, *Scolecithrix danae*, *Temora discaudata*, *Candacia aethiopia*, *Labidocera acuta*, *L. kroyeri*, *Calanopia elliptica*, *Pontella spinipes*, *Acartia negligens*, *Oithona plumifera*, *O. similis*, *Oncaea venusta* and *Corycaeus speciosus* were abundant in the samples taken at stations 1 and 5. Higher saline species viz. *Canthocalanus pauper*, *Centropages orsinii*, *C. furcatus*, *Candacia bradyi*, *Pontella danae*, *Acartia*

GOSWAMI: ZOOPLANKTON STANDING STOCK & COMPOSITION

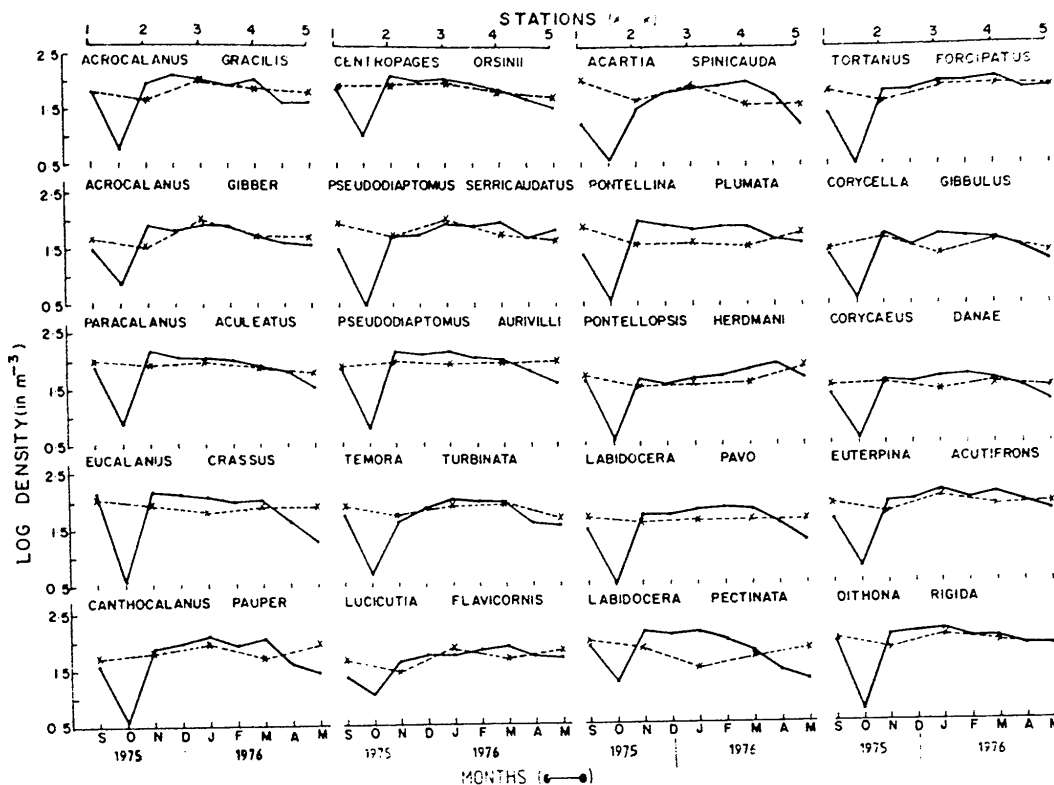


Fig. 2—Temporal and spatial variability of common copepod species

*erythraea* and *Labidocera pavo* were obtained more at sts 2 and 4. Average copepod species diversity values at sts 1 to 5 were 3.38, 3.32, 2.96, 3.77 and 3.64 respectively. Minimum copepod diversity values and total number (log values) were obtained at all stations in Oct. (Fig. 3).

Cladocerans were represented by *Eradne tergestina* and *Penilia avirostris* (Table 3). Based on total number at all stations, the former was abundant (79.04%) than the latter (20.96%). *E. tergestina* was more during postmonsoon season (65.5%) while *P. avirostris* during premonsoon season (66.58%). *E. tergestina* was reported to occur discontinuously throughout the year in the coastal waters of the Arabian Sea<sup>12</sup>, while swarm of *P. avirostris* associated with *Trichodesmium* bloom and pteropod abundance (*Creseis acicula*) was reported off Cochin in March<sup>11</sup>. *C. acicula* was the main pteropod species during the present study. *Lucifer hanseni* was the common sergestid and occurred in large numbers along with pteropods in October. Brachyuran and anomuran larvae constituted the major portion of non-penaeid population of the decapod larvae. Brachyuran zoea were numerous (26.2 no. m<sup>-3</sup>) at st 3 in May when temperature and salinity values were higher (Table 2). An account of distribution of penaeid prawn larvae constituting other decapods in the area studied was given earlier<sup>13</sup>.

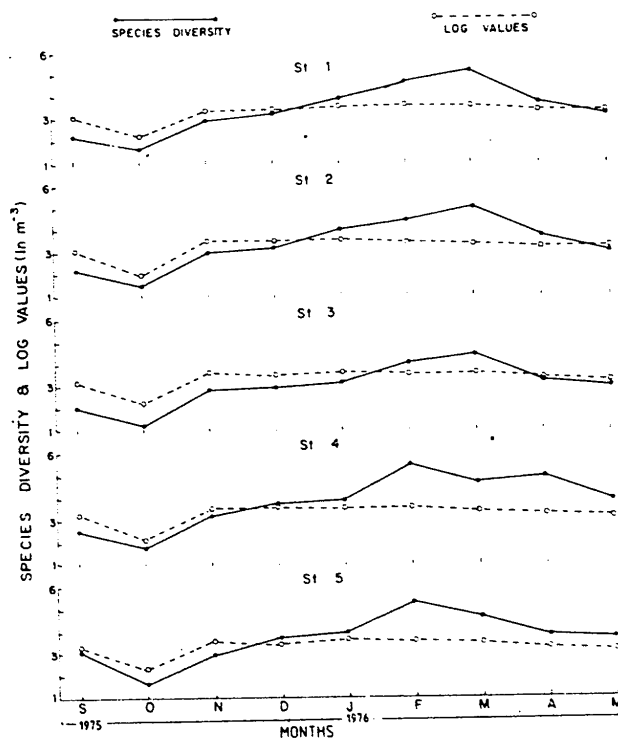


Fig. 3—Copepod species diversity and log values at various stations during different months

Table 3--Percentage Occurrence of Cladoceran and Chaetognaths Species

St	Species	Sept.'75	Oct.	Nov.	Dec.	Jan.'76	Feb.	March	April	May
Cladocerans										
1	<i>Eradne tergestina</i> Claus	81.30	86.49	75.0	58.4	25.64	58.46	33.34	37.17	30.70
	<i>Penilia acirostris</i> Dana	18.70	13.51	25.0	41.6	74.36	41.54	66.66	62.83	69.30
2	<i>E. tergestina</i>	94.63	78.65	56.0	62.5	43.64	35.48	61.80	40.96	41.44
	<i>P. acirostris</i>	5.37	21.34	44.0	37.5	56.36	64.52	38.20	59.04	58.56
3	<i>E. tergestina</i>	79.33	50.55	65.90	30.95	48.25	43.45	27.41	29.25	21.14
	<i>P. acirostris</i>	20.67	49.45	34.10	69.05	51.75	56.55	72.59	70.75	78.86
4	<i>E. tergestina</i>	80.43	69.45	67.76	40.74	39.13	40.39	31.04	38.85	32.38
	<i>P. acirostris</i>	19.57	30.55	32.24	59.26	60.87	59.61	68.96	61.15	67.62
5	<i>E. tergestina</i>	94.52	77.69	61.65	58.43	34.29	34.29	43.94	43.41	40.0
	<i>P. acirostris</i>	5.48	22.31	38.35	41.57	52.17	65.71	56.06	56.59	60.0
Chaetognaths										
1	<i>Sagitta enflata</i> Grassi	40.42	37.14	39.02	55.06	60.56	47.42	48.36	50.42	56.20
	<i>S. bedoti</i> Berneck	53.19	42.86	24.39	28.09	22.54	30.17	18.03	9.24	—
	<i>Sagitta</i> spp.	6.39	20.00	36.59	16.85	16.90	22.41	33.61	40.34	43.80
2	<i>S. enflata</i>	49.37	48.19	34.54	35.95	52.25	49.56	46.51	44.44	63.92
	<i>S. bedoti</i>	50.63	39.76	29.10	55.06	21.62	26.96	19.38	22.22	9.02
	<i>Sagitta</i> spp.	—	12.05	36.36	8.99	26.13	23.48	34.11	33.34	27.06
3	<i>S. enflata</i>	42.86	53.57	40.98	43.04	45.22	42.55	50.00	65.15	62.79
	<i>S. bedoti</i>	57.14	32.14	34.43	24.05	31.30	38.30	15.45	4.55	—
	<i>Sagitta</i> spp.	—	14.29	24.59	32.91	23.48	19.15	34.55	30.30	37.21
4	<i>S. enflata</i>	47.67	41.33	37.08	48.05	53.72	38.54	45.04	61.64	51.97
	<i>S. bedoti</i>	45.35	34.67	43.82	23.38	23.97	31.25	19.85	2.74	—
	<i>Sagitta</i> spp.	6.98	24.00	19.10	28.57	22.31	30.21	35.11	35.62	48.03
5	<i>S. enflata</i>	52.32	47.42	43.96	43.82	53.85	49.29	42.63	57.65	49.62
	<i>S. bedoti</i>	41.86	29.90	23.27	34.83	23.93	40.85	17.06	5.55	8.40
	<i>Sagitta</i> sp.	5.82	22.68	32.77	21.35	22.22	9.86	40.31	36.80	41.98

Chaetognaths, hydromedusae, siphonophores and ctenophores were the main carnivores in the zooplankton samples taken at all stations during March to May. Species of *Sagitta* constituted the chaetognath population. *S. enflata* was the most common species followed by *S. bedoti* (Table 3). *Sagitta* spp occurred more at sts 1 and 5. *S. ferox*, *S. robusta* and *S. neglecta* were reported to occur occasionally in the nearshore waters of Goa<sup>2</sup>. *Eirene ceylonensis*, *Eirene* spp; *Eutima commensis* and *Obelia* spp were the common hydromedusae. Species of the genera *Diphyes* and *Lensia* represented the siphonophores. They were abundant in samples at st 4 in April. *Pleurobrachia globosa* and *Beroe* sp were the common ctenophores. Coincident occurrences of swarms of the carnivores *S. enflata* and *P. globosa* in the coastal waters of Goa was described by Goswami<sup>14</sup>.

Nutrient enrichment caused by upwelling<sup>15</sup> and land run off along with lowering of temperature and salinity during the southwest monsoon leads to proliferation of phytoplankton<sup>7</sup> and swarming of filter feeders in the coastal waters of Goa. The carnivores succeeding the filter feeders and omnivores contribute to trophic and species diversity in this ecosystem.

#### Acknowledgement

The author is grateful to Dr V V R Varadachari,

former Director for help and facilities. Sincere thanks are due to Dr T S S Rao, for valuable comments.

#### References

- 1 Menon M D & George K C, *Proc Symp Warm Water Zoopl* (NIO/UNESCO) 1977, 205.
- 2 Nair V R, *Indian J Mar Sci*, **9** (1980) 116.
- 3 Rajagopal M D, *Indian J Mar Sci*, **10** (1981) 112.
- 4 Cushing D H, *FAO Fish Tech Pap*, **84** (1969) 40.
- 5 Shannon C E & Weaver W, *The mathematical theory of communication* (University of Illinois Press, Urbana) 1963, 177 pp.
- 6 Strickland J D H & Parsons T R, *A practical handbook of seawater analysis* (Bull Fish Res Bd Can, Ottawa, No 167) 1968, 11.
- 7 Devassy V P, *Mahasagar - Bull Natn Inst Oceanogr*, **16** (1983) 221.
- 8 Madhupratap M, *Mahasagar - Bull Natn Inst Oceanogr*, **14** (1981) 215.
- 9 Goswami S C, *Mahasagar - Bull Natn Inst Oceanogr*, **16** (1983) 459.
- 10 Devassy V P, Bhattathiri P M A & Qasim S Z, *Indian J Mar Sci*, **8** (1979) 89.
- 11 Sakhivel M & Haridas P, *Mahasagar - Bull Natn Inst Oceanogr*, **7** (1974) 61.
- 12 Della Croce N & Venugopal P, *Mar Biol*, **15** (1972) 132.
- 13 George M J & Goswami S C, *Proc symp Warm Water Zoopl* (NIO/UNESCO) 1977, 146.
- 14 Goswami S C, *Mahasagar - Bull Natn Inst Oceanogr*, **15** (1982) 163.
- 15 Sankaranarayanan V N, Rao D P & Antony M K, *Mahasagar - Bull Natn Inst Oceanogr*, **11** (1978) 125.