

## Biomass Relations Between Phytoplankton & Zooplankton in Goa Waters

A PANT, S G P MATONDKAR & S C GOSWAMI

National Institute of Oceanography, Dona Paula, Goa 403 004

Received 8 May 1983; revised received 8 June 1984

Biomass of phytoplankton and zooplankton, measured as particulate oxidizable carbon, shows that at shallowest station (5 m) there is large excess of phytoplankton organic carbon over zooplankton carbon in all the samples. There is no significant relationship between chl *a* and either glycollic acid or dissolved carbohydrates in these samples.

Earlier studies on phytoplankton and zooplankton relationships in Goa waters have been conducted either in the Mandovi-Zuari estuarine complex or in inshore waters up to 20 m contour<sup>1-3</sup>. Selvakumar *et al.*<sup>4</sup> have calculated transfer coefficients of 7% in the Mandovi-Zuari estuarine complex between phytoplankton productivity and zooplankton production. In the present study variation in phytoplankton-zooplankton biomasses on a transect up to 50 m depth contour has been estimated. Data are also collected on concentrations of glycollic acid and dissolved carbohydrates to investigate whether these parameters exhibit any association with phytoplankton concentration.

Monthly sampling was done from Sept. 1976 to May 1977 at 4 stations, situated at different depth contours on a transect from Dona Paula Bay (Fig. 1). The deepest station was approximately 25 km offshore. Parameters estimated at each station were particulate oxidizable carbon (POC), chl *a* and dissolved carbohydrate<sup>5</sup>, glycollic acid<sup>6</sup> and zooplankton biomass.

Secchi disc readings showed that at sts 1 and 2 the entire water column was within the euphotic zone and at these stations samples for chl *a*, POC and dissolved carbohydrates were taken from the surface and near the bottom. At deeper stations (sts 3 and 4) the euphotic zone was generally below 20 m and samples were taken from surface, 10 and 24 or 45 m as applicable.

Horizontal tows (2) of 5 min duration were made at each station using an HT net (330  $\mu$ m mesh, 0.25 m<sup>2</sup>). Zooplankton from the haul was used for organic carbon estimation<sup>7</sup>. All sampling was done between 0600 and 1600 hrs.

*Chl a and phytoplankton carbon*—There was no apparent stratification in temperatures during the course of these studies. Chl *a* values decreased significantly with distance from the shore but showed little variation within the column at each station (Table

1). The homogeneity of phytoplankton distributions in the water column is due to the well-mixed nature of the water at these shallow depths. Thus the arithmetic mean of chlorophyll concentrations from different depths is adequate to describe the actual chlorophyll at each station.

Decrease in chl *a* and therefore phytoplankton biomass with distance from the shore is clearly due to the effect of the Mandovi-Zuari estuary which drains the hinterland and adds nutrients to the marine environment<sup>8</sup>.

Phytoplankton carbon, calculated from chl *a* values<sup>9</sup>, forms a fairly small part of total POC. The phytoplankton-carbon/other-carbon ratio in this area is 1/30 on an average. This low ratio indicates the predominance of detritus in these samples. The high detritus content is probably due to allochthonous material discharged by the Mandovi-Zuari rivers.

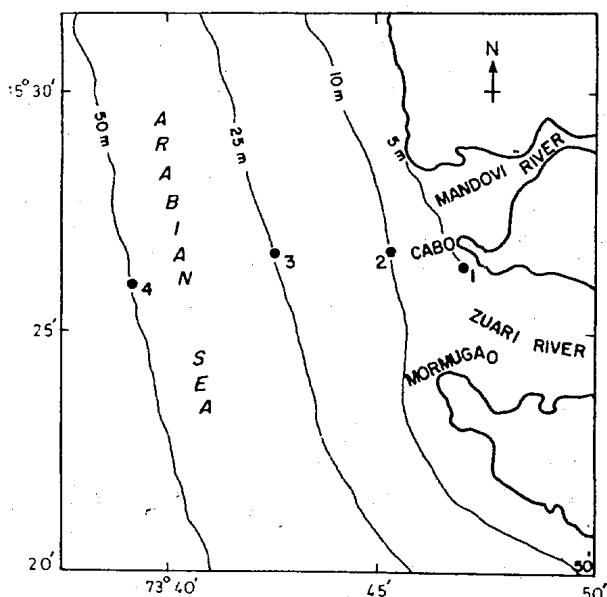


Fig. 1—Location of sampling stations

**Phytoplankton-zooplankton inter-relationships**— Standing stocks of phytoplankton and zooplankton carbon vary from station to station (Table 1). Thus, the 8 month average ratios are 20.39/0.36, 13.22/1.7, 10.26/1.35 and 2.14/1.55 at sts 1 to 4 respectively indicating large excess of phytoplankton carbon over zooplankton carbon at st. 1. As far as the estuary itself is concerned (st 1), the present results are comparable to those of Bhattathiri *et al.*<sup>1</sup> who have stated that phytoplankton production in the estuary can adequately support zooplankton food requirements in the area. All zooplankton samples in these 2 studies were collected during the day. It has been shown, however, that the night values of zooplankton biomasses are significantly higher than the day values both within the estuary and in inshore waters<sup>2</sup>. In view of this, whether phytoplankton carbon alone can meet the food demand of zooplankton even within the estuary remains an open question. Biomass ratios at the deeper stations on the transect suggest that zooplankton food requirements must be met by components other than phytoplankton, possibly detritus.

There is, in fact, no unequivocal evidence that herbivorous copepods in the environment differentiate between phytoplankton and detritus of equal sizes as food. Mullin<sup>10</sup> has suggested the term particle grazers for some calanoid copepods that depend on particle size rather than taxonomy for selection of food. Harding<sup>11</sup> has examined the gut contents of 163 deep sea copepods and found that heterotrophic microorganisms, probably associated with detritus make up the bulk of the ingested material. Thus, neither the available experimental evidence nor the measured biomass carbon values presented here justify a causal hypothesis between phytoplankton and zooplankton in this environment. Further, it would seem that any estimate of fish production based on phytoplankton alone<sup>1,4</sup> is likely to underestimate the actual potentials<sup>12</sup>. In an area as rich in detritus as this, non-phytoplanktonic carbon would appear to be more important, certainly in the suspended load and possibly as food material for the next trophic level.

**Detritus, dissolved carbohydrate and glycollic acid**— Detritus values show an interesting relationship with distance from the shore. The highest average value for

Table 1—Chlorophyll, Phytoplankton Carbon, Zooplankton Carbon and Detritus at Different Stations  
(Values expressed as  $\mu\text{g. l}^{-1}$ )

	St 1 (5 m)				St 2 (10 m)				St 3 (25 m)				St 4 (50 m)			
	Chl a	Phy-carb	Zoopl. carb	Detritus	Chl a	Phy-carb	Zoopl. carb	Detritus	Chl a	Phy-carb	Zoopl. carb	Detritus	Chl a	Phy-carb	Zoopl. carb	Detritus
Sept. 1976	0.46	23.0	—	0.36	0.18	9.25	2.09	0.12	0.15	7.5	4.43	0.076	0.013	0.65	0.45	0.18
Nov.	0.94	47.0	—	0.14	0.37	18.75	7.68	0.12	0.28	13.8	1.04	0.17	0.03	1.72	4.06	0.12
Dec.	0.48	24.0	0.24	0.26	0.18	9.25	1.09	0.08	0.18	8.9	1.54	0.11	0.03	1.75	0.71	0.03
Jan. 1977	0.7	35.0	0.65	0.42	0.23	11.5	0.18	0.4	0.11	5.34	0.37	0.25	0.06	2.9	—	0.03
Feb.	0.28	14.0	0.28	0.38	0.35	17.5	0.44	0.75	0.15	7.54	0.47	0.11	—	—	2.3	—
March	0.52	26.0	0.21	0.28	0.26	13.0	1.14	0.71	0.15	7.34	1.1	0.27	0.09	4.8	1.96	0.11
April	0.34	17.0	0.25	0.38	0.34	17.0	0.21	2.52	0.48	20.4	1.32	0.4	0.04	1.8	0.96	0.19
May	0.38	19.0	0.56	0.34	0.19	9.5	0.57	0.58	0.23	11.3	0.5	0.36	0.03	1.35	0.4	0.03

Table 2—Dissolved Carbohydrate and Glycollic Acid Surface Values  
[All values in  $\mu\text{g.l}^{-1}$ ]

Month	St 1		St 2		St 3		St 4	
	DCHO	GLY	DCHO	GLY	DCHO	GLY	DCHO	GLY
Sept. 1976	1.07	0.36	0.56	0.51	0.53	0.39	0.39	0.34
Nov.	0.35	0.46	0.4	0.25	0.46	0.3	0.18	0.2
Dec.	4.0	0.49	3.2	0.4	0.6	0.3	2.9	0.37
Jan. 1977	6.9	0.51	4.7	—	3.0	—	1.4	0.54
Feb.	6.3	0.55	3.2	0.4	0.6	—	1.9	—
March	4.6	0.64	3.3	0.5	3.8	0.32	2.4	—
April	4.6	0.73	4.0	0.49	2.7	0.33	3.2	—
May	3.8	0.63	3.6	0.58	1.6	—	4.5	—

this component, calculated as the difference between POC and phytoplankton carbon is at st 2 (Table 1). This is the region of maximum barge activity. Thus, high average detritus values at this station are probably an effect of both river runoff and turbulence due to barge movement. Apart from this exception detritus decreases with distance offshore.

Dissolved carbohydrate and glycollic acid concentrations (Table 2) decrease significantly with distance from the shore. The correlations between chl *a*/glycollic acid and chl *a*/dissolved carbohydrate are not significant. In the Menai Straits Al-Hassan *et al.*<sup>13</sup>, found an inverse relationship between phytoplankton biomass and amount of glycollic acid and this is not apparent in the present data. On the other hand, these data show that glycollic acid in these nearshore waters is 5 to 6 times higher than in the temperate Menai Straits and almost 10 times higher than in the Arabian Sea proper<sup>14</sup>. The high concentration of glycollic acid in Goa waters may be due to breakdown of humic acids from the mangrove environments along the Mandovi and Zuari rivers or degradation of organic matter by bacteria rather than as a consequence of phytoplankton excretion alone.

The authors are grateful to Head, Biological

Oceanography Division and Director for their encouragement and facilities.

#### References

- 1 Bhattathiri P M A, Devassy V P & Bhargava R M S, *Indian J Mar Sci*, 5 (1976) 83.
- 2 Pant A, Bhargava R M S & Goswami S C, *Indian J Mar Sci*, 5 (1976) 103.
- 3 Qasim S Z, in *Proc Symp Warm Water Zoopl* (Sp Publ; UNESCO/NIO) 1977, 700.
- 4 Selvakumar R A, Nair V R & Madhupratap M, *Indian J Mar Sci*, 9 (1980) 7.
- 5 Strickland J D H & Parsons T R, *A practical handbook of seawater analysis* (Bull Fish Res Bd Can No 168) 1968.
- 6 Shah N M & Wright R T, *Mar Biol*, 24 (1974) 121.
- 7 El-Wakeel S & Riley J P, *J du Cons Int L + Expl Mer*, 22 (1957) 180.
- 8 De Souza S N, Sen Gupta R & Rajagopal M D, *Indian J Mar Sci*, (1984) (in press).
- 9 Strickland J D H, *Measuring the production of marine phytoplankton* (Bull Fish Res Bd Can No 122), 1960, 172.
- 10 Mullin M M, *Some contemporary studies in marine sciences*, edited by H Barnes (George Allen & Unwin, London), 1966.
- 11 Harding G C H, *J Mar Biol Assoc, UK*, 54 (1974) 141.
- 12 Qasim S Z, Wafar M V M, Vijayaraghavan S, Royan J P & Krishnakumari L, *Indian J Mar Sci*, 7 (1978) 84.
- 13 Al-Hassan R S, Conghlan J, Pant A & Fogg G E, *J Mar Biol Assoc, UK*, 55 (1975) 557.
- 14 Pant A, *Indian J Mar Sci*, 8 (1979) 238.