

Size-Fractionated Primary Productivity of a Tropical Coastal Lagoon on the South West Coast of India

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Abstract

The size-fractionated primary productivity of Talapady lagoon, on the southwest coast of India was studied on representative days during monsoon, postmonsoon, and premonsoon seasons. The results showed significant contribution by the phytoplankters of 0.45-60 μm size fraction, to an extent of 66%. Postmonsoon season recorded the highest rates of production showing a peak between 1500 and 1800 h, while the premonsoon and the monsoon showed peaks at 0900-1200 h and 0600-0900 h respectively. The nutrients played an important role in regulating the size-fractionated productivity of this lagoon.

Introduction

Coastal lagoons are known to be among the most productive ecosystems of our planet, with an average organic production of $20 \text{ gC.m}^{-3} \text{ day}^{-1}$. These ecosystems sustain a very rich biodiversity making these environments important from environmental and commercial viewpoints. Life history stages of many fin- and shellfish feed on phytoplankton of different size ranges which are thus important in regulating the overall efficiency of the ecosystem (Takahashi and Bienfang 1983; Pena et al. 1990).

The literature available on size-fractionated primary productivity in Indian waters is rather meager. The earliest known work was on Cochin backwaters (Qasim et al. 1974). In the Vellar estuarine complex of Porto Novo, nanoplankton accounted for higher rates of primary production, assimilation rates and chlorophyll *a* concentrations (Subramanian and Venugopalan 1978).

A more recent study on the same complex revealed phytoplankton cells of the size range 5-10 μm accounting for upto 20% of the gross production (Kawabata et al. 1993). The organic production of nanoplankters in the Hooghly estuary was estimated to be between 7.5 and 30.1 $\text{mgC}\cdot\text{m}^{-3}\cdot\text{h}^{-1}$, accounting for 38% to 73.6% of the total primary production (De et al. 1991). An investigation of two estuarine-lagunar systems in Mexico showed nanoplankton production to be in the range of 32 to 71% (Espinosa and Castaneda 1992).

The present work was attempted to understand the seasonal and diel variations of size-fractionated primary productivity in relation to selected nutrients in a coastal lagoon near Mangalore on the south west coast of India.

Study area

Talapady lagoon, (12°47'N and 74°51'E), is a mangrove fringed shallow water body with an average depth of 1m and an area of 10 ha. It is a semi-enclosed water body, opening to the Arabian sea during the south west monsoon season. It receives fresh water from the Talapady river during the south west monsoon and part of the postmonsoon season.

Methods

This study was undertaken on a day during the monsoon (26 July 1996), post-monsoon (17 December 1996) and pre-monsoon (27 March 1997). The water samples for size-fractionated primary productivity were collected and incubated insitu using a floating raft, for 3 hours duration from 0600-1800 h. The surface water samples were filtered through a bolting silk of mesh size of 198 μm . These samples had phytoplankton cells of the size 0.45-198 μm , also called the total fraction. This sample was again filtered through a 60 μm bolting silk to obtain the 0.45-60 μm fraction. Both the samples were filled into 60 ml pyrex light and dark bottles, spiked with 1 ml of 5 mCi $\text{NaH}^{14}\text{CO}_3$ and incubated at 100% light intensity. The incubated samples were filtered onto 0.45 μm membrane filters on site using a field filtration unit. These filters were dried overnight and fumed over concentrated hydrochloric acid for 24 h. The filters were placed in a 1, 4-dioxan based scintillation cocktail. The activity of the filters was read using a LKB Wallace 1211 Rackbeta liquid scintillation counter. The productivity values for the size fraction of 60-198 μm was obtained by the difference of the productivity values of the total fraction 0.45-198 μm and the 0.45-60 μm size fraction.

Water samples for estimation of nutrients were collected in clean plastic cans and standard colorimetric procedures were used to estimate the nutrients. Samples for phosphate were collected in clean acid washed bottles. (Parsons et al. 1989). A Milton Roy Spectronic 21D spectrophotometer was used.

Analysis of variance (ANOVA-factorial) was applied to the data on diel and seasonal variations of size-fractionated primary productivity to find out any significant difference between seasons, size fractions and the time of the day.

Results

The diel and seasonal variations of size-fractionated primary productivity is presented in Figure 1. The data when subjected to factorial analysis ($p < 0.05$) (Table 1) showed significant differences between time of the day, seasons, and size fractions.

Seasonal variations in productivity were pronounced, with the highest total productivity of $13.9 \text{ mgC.m}^{-3} \text{ h}^{-1}$ recorded in the postmonsoon season, dominated by the phytoplankters of the size fraction of $0.45\text{--}60 \text{ }\mu\text{m}$ contributing upto 65% of the total productivity.

Distinct diel variations with two productivity peaks were recorded between 0600-0900 h and 1500-1800 h, during monsoon (Fig. 1a). The phytoplankton of the size range $60\text{--}198 \text{ }\mu\text{m}$ contributed upto 94% and 72% respectively to the total production. The postmonsoon season (Fig. 1b) was also characterised by two peaks, a primary peak between 1500-1800 h and a secondary peak between 0900-1200 h. The $0.45\text{--}60 \text{ }\mu\text{m}$ size fraction contributed 66% to the total productivity during the primary peak, while the $60\text{--}198 \text{ }\mu\text{m}$ size fraction accounted for 62% during the secondary peak. Premonsoon season (Fig. 1c) registered a peak at 0900-1200 h completely dominated by phytoplankton of the size $60\text{--}198 \text{ }\mu\text{m}$.

Among the different size fractions, cells in the size range of $0.45\text{--}60 \text{ }\mu\text{m}$ accounted for upto 66% of the total production in the lagoon.

Among the nutrients, nitrite-nitrogen recorded peak concentrations of $7.04 \text{ }\mu\text{g} \cdot \text{at. l}^{-1}$ at 0600 h during premonsoon (Table 2). Distinct diel variations were not observed for nitrate-nitrogen during monsoon and postmonsoon, while, a peak of $10.65 \text{ }\mu\text{g} \cdot \text{at. l}^{-1}$ was recorded at 0600 h during the premonsoon. Among the seasons, premonsoon recorded a peak in the range of $21.75\text{--}22.69 \text{ }\mu\text{g} \cdot \text{at. l}^{-1}$. During monsoon and postmonsoon, phosphate-phosphorus did not exhibit distinct variations. Premonsoon peak for this nutrient was recorded at 0600 h ($11.45 \text{ }\mu\text{g} \cdot \text{at. l}^{-1}$). Land runoff contributed to the increased concentrations of silicate - silicon during monsoon. Distinct diel variations were noted with peak concentrations of $154.95 \text{ }\mu\text{g} \cdot \text{at. l}^{-1}$ recorded at 0600 h.

Discussion

Several workers have documented the dominance of nanoplankton over netplankton production (Pant et al. 1977; Malone 1971; Garrison 1976; Kawabata et al. 1993). In the present investigation, the size fraction of $0.45\text{--}60 \text{ }\mu\text{m}$ accounted for nearly 66% of the total production. Earlier studies in Indian waters have shown that nanoplankton contributed upto 60% of the gross production (Subranarayan and Sarma 1965; Vijayaraghavan et al. 1974; Qasim et al. 1974). Globally, in marine phytoplankton production, nanoplankton have been reported to contribute upto 80% of the total production (Malone 1980).

Diel variation studies showed lower production between 0600-0900 h during premonsoon and postmonsoon. Reduced light intensities would have

resulted in lower production rates during this period. On the contrary, monsoon season was characterised by increased production values between 0600 to 0900 h and 1500 to 1800 h when the sky was clear. The phytoplankters in the size range 0.45-60 μm contributed more to the productivity between 0600 to 0900 h and 1500 to 1800 h. Nanoplankton was reported to dominate when illumination was low (Curl and Small 1965; Malone 1971; Parsons and Takahashi 1973; Vijayalakshmi 1974). Two production peaks were noticed during postmonsoon, one between 0900 to 1200 h and a second peak between 1500

Table 1. Results of Analysis of Variance for seasonal and diel variation of size-fractionated primary productivity.

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F- ratio
Due to times of the day	3	108.5732	36.1911	7.57*
Due to seasons	2	566.3757	283.1879	59.21*
Due to size fractions	2	178.9994	89.4997	18.71*
Interaction of times and size fractions	6	50.7344	8.4557	1.71
Interaction of size fractions and seasons	4	91.6800	22.92	4.79*
Interaction of times and seasons	6	243.8144	40.6357	8.49*
Error	12	57.3908	4.7826	
Total	35	1297.5679		

* $p < 0.05$

Table 2. Distribution of nutrients in Talapady lagoon, Mangalore, India.

Parameter	Seasons	0600 h	0900 h	1200 h	1500 h
Nitrite-Nitrogen ($\mu\text{g-at.l}^{-1}$)	Monsoon	1.40	1.46	1.33	1.35
	Postmonsoon	1.11	1.13	1.31	1.17
	Premonsoon	7.04	1.54	1.48	2.57
Nitrite-Nitrogen ($\mu\text{g-at.l}^{-1}$)	Monsoon	21.75	21.85	22.69	22.64
	Postmonsoon	3.63	3.03	2.29	2.46
	Premonsoon	10.65	9.23	6.52	7.24
Phosphate-Phosphorus ($\mu\text{g-at.l}^{-1}$)	Monsoon	3.65	3.78	3.83	3.74
	Postmonsoon	4.10	3.96	4.41	4.19
	Premonsoon	11.45	5.79	5.88	4.73
Silicate-Silicon ($\mu\text{g-at.l}^{-1}$)	Monsoon	154.95	145.27	48.54	130.13
	Postmonsoon	115.49	108.22	109.92	109.92
	Premonsoon	32.44	33.17	33.04	32.20

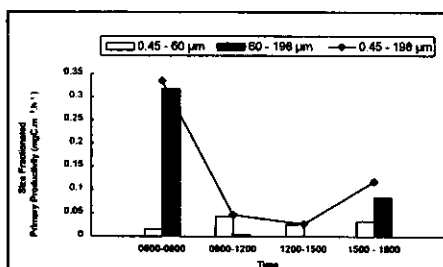


Fig. 1a. Diel variation in size fractionated primary productivity during monsoon in Talapady lagoon, Mangalore, India.

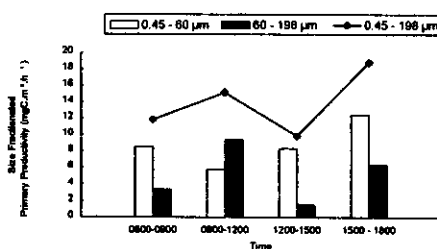


Fig. 1b. Diel variation in size fractionated primary productivity during postmonsoon in Talapady lagoon, Mangalore, India.

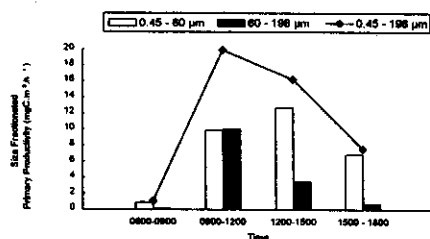


Fig. 1c. Diel variation in size fractionated primary productivity during premonsoon in Talapady lagoon, Mangalore, India.

to 1800 h. The premonsoon peak was observed between 0900 to 1200 h. The study revealed increased rates of production during postmonsoon and premonsoon seasons dominated by the 0.45 - 60 μm size fraction. The lagoon becomes stagnant and is completely enclosed during these two seasons, providing conducive conditions for phytoplankton production. We also observed utilization of nitrite-nitrogen by the phytoplankton cells resulting in its depletion at 0900 and 1200 h during premonsoon, coinciding with the productivity peak. Nitrate-nitrogen, too is utilized by the phytoplankton, as seen by its reduction during postmonsoon and premonsoon, when the cells of the smaller size fraction contributed more to the production. Lower nitrate-nitrogen values have been associated with the presence of small celled organisms, chiefly nanoplankton (Eppey et al. 1969; Pant et al. 1977). Silicate-silicon and phosphate-phosphorus were also utilized.

From this study we could assume that light and levels of nutrients influence the size-fractionated primary productivity of this lagoon. Similar observations have been reported in similar biotopes elsewhere (Lorenzen 1963; Curl and Small 1965; Newhouse, et al. 1967; Pant et al. 1977; Malone 1980 and De et al. 1991).

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