SEVEN

ECOLOGY OF MUDBANKS — PHYTOPLANKTON PRODUCTIVITY IN ALLEPPEY MUDBANK

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ABSTRACT

The standing crop of phytoplankton, in terms of biomass, chlorophyll *a* and total cells, recorded high values during the rise as well as maturity of the mudbank. However, the primary production showed high values only before, and not during or after, the formation of the mudbank. Qualitatively, a total of 58 species of phytoplankters were present. A notable feature seen in association with the mudbank was the blooming of *Noctiluca miliaris*, at the time of dissipation of the mudbank during both the seasons' of 1971 and 1972. The possible relationship of phytoplankton to and the role it plays at the mudbank is briefly discussed.

INTRODUCTION

Observations hitherto made on the organic productivity of our seas and connected backwater systems (Prasad et al 1958; Nair et al 1968; Qasim et al 1969; Nair et al 1975) show that the shallow inshore regions as well as the connected backwaters are highly productive, with an average rate of production of over 1 g C/m^2/day. The season of upwelling, which coincides with the monsoon, is the most productive period, with average rates exceeding 2 g C/m^2/day. There is of course spatial and seasonal variations in the pre- and post-monsoon periods, depending on the light penetration and depth of mixing.

The mudbank, owing to its several peculiarities on account of the mud remaining in suspension, may however be considered as a special type of ecosystem. The high turbidity, owing to both man-made and natural causes, impeding the light penetration decreases thedepth of the euphotic zone. Although the euphotic zone at this time may extend down to between 15 to 50 m in the adjacent waters, in the mudbank it is generally less than 4 m. The study of the phytoplankton production at the mudbank also is confronted with certain problems. The normal *in situ* measurements, which are necessary for the evaluation of potential assimilation in *in vitro* conditions, are not possible in these waters. Therefore, the measurement of potential productivity at best can give a general idea of the productivity of the ambient waters, which nevertheless would lend a clue to the probable causes of fluctuations in the mudbank yield. The two aspects, viz., potential productivity and quantitative variation in phytoplankton, formed an important part of a comprehensive investigation on the ecology of the mudbank.

MATERIAL AND METHODS

With a view to having a general picture of the phytoplankton productivity of the Ambalapuzha coast, fortnightly collections of water samples from the surface and bottom and phytoplankton net samples (surface haul of 10 minutes duration by using a half metre bolting nylon net, No.21, mesh size 0 069 mm) were made from 4 stations (*See* Fig. 1. Chapter 4) during the year 1971-72. (These stations were fixed in June 1971 at the time of the mudbank formation, in such a way that 3 of them were within the mudbank and the 4th at a little distance outside it.) However, during the period of active mudbank, in June-August 71 and May-July 72, study on phytoplankton productivity was greatly intensified by conducting more frequent observations.

The relative abundance of dtfferent phytoplankters present in the net samples were noted. The total volume of plankton was determined from an aliquot of 1/5 of the sample, by the displacement method, after removing the zooplankters by means of an organdy cloth. Water samples were analysed both for quantitative and qualitative estimates. The samples, having brought to the laboratory, were transferred to a 50 ml settling chamber and kept for 24 h, adding a few drops of formalin. The phytoplankters present in this 50 ml of water were then identified, counted and the total cells computed per unit volume (1 litre in the present case).

For the estimation of primary production, 2 samples, one from surface and the other from bottom, were collected using a Casella bottle, transfered to 60 ml reagent bottles, and incubated with 5µ c of ^{14}C as $NaH^{14}CO_3$ under natural or artificial constant light (20 k lux) for 2-4 h. Dark uptake also was determined simultaneously. After incubation, the samples were filtered through millipore filters (25 mm; pore size 0.45µ) and the activiy of the filters were determined using a Geiger counter, the efficiency of which was 3.2%.

For the estimation of chlorophyll *a*, surface water samples, one litre each from the 4 stations, were collected and brought to the laboratory and filtered through GFC filter paper. The filtrate was then dissolved in 90% acetone, centrifuged and, using a Spectrophotometer, different wavelengths were measured and chlorophyll *a* content estimated following the equation given by Strickland and Parsons (1998).

GENERAL TREND OF THE SOUTHWEST COAST

Subrahmanyam (1959) and Nair et al (1968) studied the primary production and standing crop of the westcost of India. Radhakrishnan (1969) studied these parameters of Alleppey coast. Shah (1973) and Qasim and Reddy (1967) studied the chlorphyll *a*. Chennubhotla (1969) and Subrahmanyam et al (1975) studied the biomass and the total cells of phytoplankton. All these studies unanimously reveal that all along the west coast of India phytoplakton production is at its highest during the S.W. monsoon. A secondary peak in the primary production and chlorophyll *a* has been reported varyingly somewhere during the post-monsoon period. According to Chennubhotla (1969) and Subrahmanyam et al (1975) the plankton volume, which increases from May, after reaching a maximum in July declines sleadily up till September, the secondary peak of a lesser magnitude being visible somewhere during December-February.

According to Gopinathan et al (1974) total cells of phytoplankton standing crop in the inshore areas of Cochin are higher in the monsoon months than during the pre- and post-monsoon months.

OBSERVATIONS AT THE MUDBANK

Potential productivity : The study conducted during the two mudbank periods, one during June-August 71 and the other during May-July 72, revealed the following results. Unlike the rest of the west coast, where the maximum rate of production was during the monsoon

TABLE - 1

Potential productivity of the mudbank (surface and bottom)

Period		Production mgC/m³.h St.1	St.2	St.3	St.4
1971					
Jul	S	5.26	13.93	31.05	14.74
	B	—	—	—	—
Aug	S	71.85	28.19	7182	24.49
	B	13.98	10.0	41.40	82.6
Sep	S	1.16	1.95	1.96	0.52
	B	0.69	—	—	—
Oct	S	26.84	26.19	16.35	27.07
	B	17.40	12.61	—	26.26
Nov	S	8.76	8.98	7.68	23.36
	B	1.41	1.31	2 48	7.55
Dec	S	4 75	7.68	2.08	7.55
	B	3 40	3.12	6.85	5.03
1972					
Jan	S	59.64	40.87	29.25	36.64
	B	30.38	43.40	13.83	25.92
Feb	S	41.28	9 69	20.93	22.60
	B	11.71	5 69	14.66	14.08
Mar	S	115.88	39.21	86.52	59.81
	B	84.16	59.96	39.18	43.08
Apr	S	49.67	277.15	93.86	38.93
	B	19.77	37.79	57.50	21.89
May	S	81.53	97.01	58.68	60.20
	B	61.91	—	—	9.91
Jun	S	31.05	116.72	28.63	38.00
	B	—	—	—	—
Jul	S	21.31	5.16	2.25	4.50
	B	8.21	10.48	53.55	33.12

months, the mudbank showed low values during these periods, while during the pre-monsoon months the same area indicated high rate of production. The rate of potential assimilation was uniformly high, averaging 35 mg C/m³/h with the maximum during February-May, when there was no mudbank prevailing in this area. The monthwise production rate is shown in Table 1. High dark-assimilation rates were noted in the bottom samples and very low values were observed in the bottom at the time of munbank formation.

Chlorophyll a : The standing crop, measured in terms of chlorophll *a*, for the four stations are presented in Table 2. It is believed that the magnitude of chlorophll *a* of a water body gives a true index of the standing crop. The table 2 indicates that, during June–July of both 1971 and 72 periods, when the mudbank was active, chlorophyll *a* values were higher compared to other months. Also it revealed that chlorophyll *a* had an increasing trend during the period of mudbank as was observed at the three stations which were in the mudbank proper, while the 4th station, which was slightly deeper and far away from the mudbank, showed uniformly low values throughout the period. During the period when there was no mudbank, the chlorophyll *a* values at the surface of this area were generally less than 10 mg/m³. But during the period of the mudbank the values were double or even three fold.

TABLE – 2

Measurement of chlorophyll a at the mudbank area

	Chlorophyll *a* mg/m³ (surface)			
	St.1	St.2	St.3	St.4
1971 Jun	26.7	18 4	25.1	—
Jul	33 2	16.1	15.5	8.0
Aug	13.7	16.1	16.6	0.7
Sep	14 3	4.9	8.6	—
Oct	14.8	8.5	0.4	9.2
Nov	5.8	2.6	3.1	12.9
Dec	—	0.6	0.9	2.5
1972 Jan	9.7	9.0	3.3	3.2
Feb	4.5	1.8	1.2	3.3
Mar	6.5	1.3	2.2	1.3
Apr	3.0	4.0	3.7	1.7
May	5.7	3.4	2.3	3.1
Jun	16.7	15.8	11.3	16.0
Jul	10.6	6.7	6.2	2 9

Biomass : The plankton volume showed a gradually increasing trend from June onwards, reaching its maximum in August primarily due to the then high abundance of the dinoflagellate, *Noctiluca miliaris*. After August there was a gradual decrease in the volume of plankton, reaching its lowest ebb in December. Again, after December, there was a rise in the volume of plankton through the succeeding months (unimodal) and reached its peak at the period of the next mudbank formation, that is in 1972 (Fig. 1). A notable feature in the biomass distribution at the mudbank was its spatial variability. The values which were highest in the first station declined gradually to the fourth station.

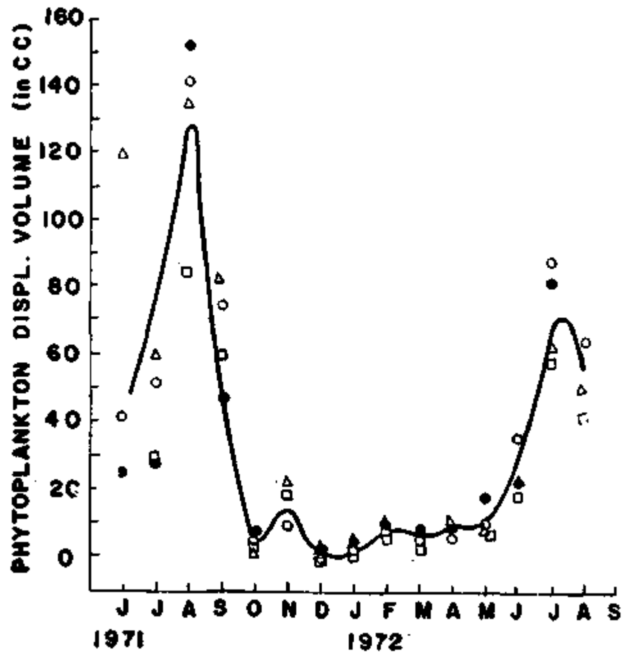

Fig. 1 Phytoplantation displacement volume

Total cells and qualitative studies of phytoplankton : The quantitative distribution of phytoplankton present in one litre of water collected both from the surface and bottom in the mudbank area during the period of investigation is presented in Table 3. The magnitude of production was different in the mudbank for the two years. Diatoms dominated during the formation of the mudbank, while dinoflagellates were most abundant during the period of its dissipation. However, nannoplankters were equally abundant all through the active period of mudbank, which was responsible for the high values of cell counts observed during this period. At the time of dissipation of the mudbank, during August of both 1971

TABLE - 3

Seasonal abundance of phytoplankton of the mudbank at Ambalapuzha. One-litre settling-chamber counts of phytoplankters (average of 4 stations).

Months		Diatoms	Dinoflagellates	Silicoflagellates	Coccoliths.	Cyanophyceae	Nanopl.	Total
1971 Jun	S	183600	650	100	—	670	213200	398280
	B	16170	240	60	—	300	111000	127770
Jul	S	181000	4400	—	—	—	211100	396500
	B	17200	320	—	—	—	112600	129800
Aug	S	35520	12630	—	—	—	116500	164650
	B	24060	17550	—	—	—	118500	160100
Sep	S	2330	16750	—	—	—	111000	130080
	B	14380	1600	—	—	—	123600	139500
Oct	S	15510	690	—	—	—	28000	224200
	B	20970	1200	—	—	—	16000	128170
Nov	S	12140	80	—	—	—	132000	144220
	B	4000	160	—	—	—	121000	125160
Dec	S	17280	1080	—	—	3800	114000	136160
	B	14400	790	—	—	3000	112000	130190
1972 Jan	S	15290	300	—	—	1800	122400	139790
	B	15140	200	—	—	1600	114000	132740
Feb	S	13630	320	—	80	600	116200	130930
	B	13000	340	—	60	250	112600	126250
Mar	S	6360	690	—	—	—	116250	123300
	B	3340	430	—	—	—	114000	117870
Apr	S	34440	970	80	—	—	118500	153990
	B	19820	450	30	—	—	113400	133900
May	S	245800	2110	400	1100	—	26400	275810
	B	44300	690	120	150	—	123600	168880
Jun	S	26280	1950	—	—	—	316800	345030
	B	22090	1050	—	—	—	246400	269540
Jul	S	353600	11050	—	—	—	211200	575850
	B	—	—	—	—	—	—	—

and 1972, blooming of the harmful dinoflagellate, *Noctiluca miliaris,* was a highly noticeable feature· Silicoflagellates and Coccolithophores were found to be very rare and the blue-green alga *(Trichodesmium* spp.) was found to be abundant during June.

From one litre of water sample examined, 58 common species of phytoplankters were identified, among which diatoms constituted 38 species; dinoflagellates 14; Silicoflagellates 2; Coccolithophore 1 and blue-green algae 2. The species-wise distribution of the above mentioned phytoplankters is given in Table 4.

Other observations : In August and in early September of both 1971 and 72, when the mudbank was in the dissipating stage, bright red patches were observed in the surface waters all along the mudbank region. This discolouration was due to extremely high concentration of the dinoflagellate, *Noctiluca miliaris.* A green discolouration was also noticed on 27th August 1971, which was caused by the 'green' *Noctiluca. (Noctiluca* with a green euglenoid symbiont, *Protoeuglena noctilucae).* In September 1971 also, a green discoluration of the water was noticed which was however due to high incidence of the diatom, *Fragilaria oceanica.*

DISCUSSION

Although the regional and seasonal variability and magnitude of primary production in the inshore environments of the west coast of India is known and has been correlated with the potential fishery resources (Prasad et al 1970),

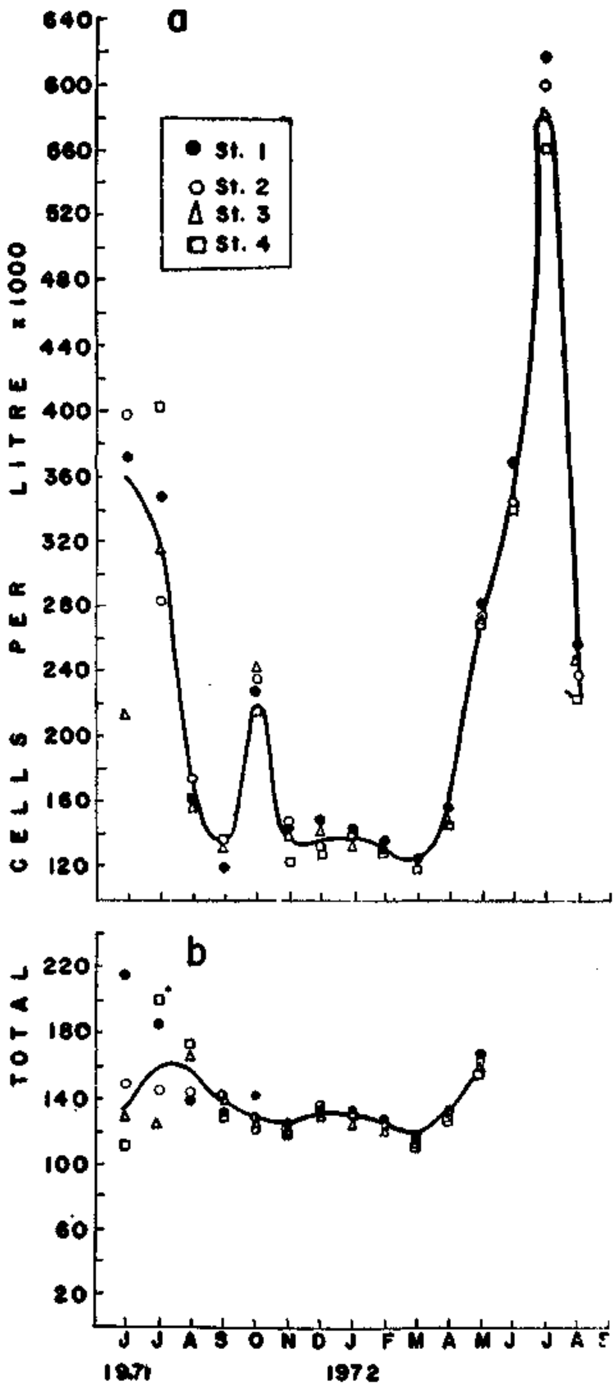

Fig. 2 a-b, Standing crop of phytoplankton in terms of total cell counts (surface and bottom)

these studies are not comparable with those of the mudbank, which, as an ecosystem, is a unique one by itself. Light is never a limiting factor in the tropical waters. But in the mudbank area light penetration is highly restricted due to the suspension of fine particles of mud confining the phytoplankton production to the top few centimetres. The live phytoplankton seen throughout the mixed layer, which in the mudank reaches to the very bottom, may be due to the high rate of primary production observed before the formation of the mudbank.

For the entire west coast and connected backwaters, the monsoon period is the most productive time, with high values exceeding 2 g C/m²/day, followed by fairly high production rates during the post-monsoon period, because of the proportionate availability and replenishment of nutrients (Subrahmanyan 1969; Nair et al 1968; Nair et al 1975; Gopinathan et al 1974; Radhakrishna 1969; and Joseph and Pillai 1975). At Ambalapuzha area, where the mudbank is usually formed, on the other hand, the productivity values are high just before the formation of the mudbank and afterward decrease through the period of mudbank. The reason for the high values of production before the formation of the mudbank may be because there was an abundant population of diatoms during this period (Table 3).

The chlorophyll *a* values in the mudbank are also very high when compared with the values reported from the inshore areas of Cochin by Shah (1973) and Gopinathan et al, (1974). Qasim and Reddy (1967) observed that the values in the Cochin backwater were all less than 10 mg/m³ during the monsoon months. But in the mudbank the chlorophyll *a* values are observed ranging from 10 to 33 mg/m³ during this period.

It is thus seen from the present investigations that the mudbank, in spite of its limited primary production potential due to the shallow euphotic zone, is nevertheless characterised by a high standing crop, as represented by biomass, chlorophyll *a* and total cell counts, especially at its formation as well as its maturity period, presumably favoured by abundant rainfall and enrichment of nutrients from the bottom. Another reason for the high standing crop of phytoplankton at the period of mudbank may be that the nannoplankters contribute to about 70% of the total cells, which is also responsible for the high values of chlorophyll *a* during this period.

TABLE 4

Seasonal variations of different phytoplankters present in one litre of water surface
(average of two years)

	J	F	M	A	M	J	J	A	S	O	N	D
Bacillariophyceae (Diatoms)												
1. *Melosira sulcata*	—	—	—	—	R	R	—	—	—	—	—	—
2. *Hyalodiscus subtilis*	—	—	—	R	R	—	—	—	—	—	—	—
3. *Stephanopyxis palmariana*	R	—	—	R	—	R	R	—	C	—	—	—
4. *Skeletonema costatum*	A	A	A	B	A	A	A	C	R	B	—	R
5. *Thalassiosira decipiens*	—	R	—	R	—	R	R	F	—	C	—	F
6 *T. subtilis*	C	—	F	R	F	C	—	—	—	A	—	R
7. *Coscinodiscus spp.*	C	C	C	A	A	A	F	A	C	A	F	F
8. *Planktoniella sol*	—	—	—	R	A	—	R	R	—	R	—	R
9. *Lauderia annulata*	—	—	—	R	—	F	R	—	—	—	R	—
10. *Schoederella delicatula*	—	R	—	F	A	R	—	—	R	—	—	R
11. *Guinardia flaccida*	—	F	—	F	A	F	R	F	—	—	C	—
12. *Rhizosolenia spp.*	F	—	F	R	F	C	R	A	—	F	R	—
13. *Bacteriastrum varians*	—	—	—	R	—	—	R	—	—	—	—	—
14. *Chaetoceros lorenzianus*	R	R	—	C	R	C	C	—	R	—	A	R
15. *C. decipiens*	—	—	—	R	F	F	—	—	R	—	A	R
16. *C. curvisetus*	—	F	—	R	—	R	R	—	—	—	R	—
17. *C. affinis*	—	—	R	R	R	—	—	—	R	—	—	—
18. *Eucampia zoodiacus*	—	—	—	R	—	R	R	—	—	—	—	—
19. *Climacodium frauenfeldianum*	—	R	—	—	—	—	R	A	—	—	R	—
20. *Streptotheca themesis*	—	—	F	—	—	R	A	—	—	R	—	—
21. *Bellerychea malleus*	—	—	—	—	—	—	—	—	—	R	F	—
22. *Ditylum brightwelli*	R	R	C	F	A	F	R	—	—	—	F	—
23. *Triceratium favus*	F	—	—	F	R	—	R	—	R	—	—	—
24. *Biddulphia sinensis*	—	R	F	F	C	A	R	—	—	R	—	—
25. *Biddulphia mobiliensis*	—	R	C	C	C	—	R	A	R	A	R	C
26. *Cerataulina bergonii*	R	R	R	—	—	—	—	—	—	—	R	—
27. *Hemiaulus sinensis*	—	—	—	—	—	R	C	—	—	R	F	—
28. *Hemidiscus hardmannianus*	R	R	R	—	—	—	—	—	—	—	—	—
29. *Fragilaria oceanica*	A	—	—	A	A	—	A	B	—	—	—	—
30. *Thalassionema nitzschioides*	R	R	—	A	A	F	R	A	—	C	—	—
31. *Thalassiothrix frauenfeldii*	R	—	—	A	—	—	A	F	—	—	F	F
32. *Asterionella japonica*	R	F	C	C	A	R	R	F	—	—	—	C
33. *Pleurosigma elongatum*	—	—	R	—	F	—	—	—	R	—	R	—
34. *P. normanni*	—	R	—	—	F	—	—	F	—	—	—	R
35. *P. directum*	—	—	—	R	F	—	—	F	—	—	—	—
36. *Navicula sp.*	—	—	C	—	—	—	—	F	—	—	—	—
37. *Nitzschia longissima*	C	—	R	A	—	—	—	A	C	R	—	—
38. *N. seriata*	R	R	—	C	—	—	R	—	—	C	R	—

Table 4 (contd.)

	J	F	M	A	M	J	J	A	S	O	N	D
Dinophyceae												
39. *Prorocentrum micans*	—	—	—	—	A	C	—	—	—	C	R	R
40. *Dinophysia caudata*	—	—	—	—	R	—	—	—	—	—	—	R
41. *D. miles*	—	—	—	—	—	—	—	—	—	—	R	R
42. *Ornithocercus magnificus*	—	—	—	—	R	—	—	—	—	—	R	R
43 *Noctiluca miliaris*	—	—	—	—	—	F	A	B	B	F	R	P
44. *Pyrophacus horologicum*	—	—	R	R	—	—	—	—	—	—	—	—
45. *Peridinium depressum*	R	—	R	R	R	—	R	R	—	—	-	R
46. *P. oceanicum*	—	—	—	—	—	—	—	—	—	—	—	R
47. *P. claudicans*	—	—	R	—	R	—	—	—	—	—	—	—
48. *P. pentagonum*	—	—	—	—	R	—	—	—	—	—	—	—
49. *Diplopsalis lenticula*	—	R	—	—	R	—	—	—	—	—	—	—
50. *Goniaulax polyhedra*	—	—	R	—	—	—	—	—	—	—	—	—
51. *Ceratium furca*	—	R	R	R	R	—	F	—	—	—	—	F
52. *C. fusus*	—	R	R	—	—	—	R	—	—	—	—	R
53. *C. breve*	—	R	R	—	—	—	—	—	—	—	R	R
Silicoflagellates												
54. *Dictyota fibula*	—	—	—	R	R	—	—	—	—	—	—	—
55. *Distephanus speculum*	—	—	—	R	R	—	—	—	—	—	—	—
Coccolithophore												
56. *Coccolithus* sp.	—	—	R	R	F	—	—	—	—	—	—	—
Cyanophyceae												
57. *Oscillatoria* sp.	—	—	—	—	—	C	—	—	—	—	—	R
58. *Thricodesmium theibautii*	R	C	—	—	—	—	—	—	—	—	—	C

B=bloom (10,000 cells and above); A=abundant (1000-10000 cells); C=common (500 to 1000 cells); F=few (250 to 500 cells); R=rare (below 250 cells); dash denotes absent.