TABLE II

I.R. absorption bands due to $-C=N$, $N-O$, and Ring Vibrations I — IV (cm^{-1})

Compound	$-C=N$	$-N-O$	Ring I	Ring II	Ring III	Ring IV
HMPX	1515 (s)	980 (s)	1585 (s)	1564 (s)	1479 (m)	1436 (s)
$Ni(HMPX)_2Cl_2$	1632 (w, b)	1039 (s)	1612 (s)	1563 (w)	1477 (s)	1426 (m)
$Ni(HMPX)_2Br_2$	1629 (m)	1042 (s)	1595 (s)	1565 (w)	1490 (s)	1443 (m)
$Ni(HMPX)_2I_2$	1630 (sh)	1048 (s)	1598 (s)	1562 (w)	1482 (s)	1438 (w)

the out-of-plane wag of the hydrogen bonded oxime proton. Rings bands appear at 1585, 1564, 1479 and 1436 cm^{-1} in the free HMPX. However, the nickel (II) complexes exhibit the $-C=N$ band above 1600 cm^{-1} and $N-O$ band at *ca.* 1075 cm^{-1}. Similar band positions in the spectra of nickel, platinum and palladium complexes of HPOX, has previously been reported[7]. Therefore, these data indicate that oxime proton is not hydrolysed in $[Ni(HMPX)_2X_2]$ complexes and there is a contribution from the $-C=N-OH$ grouping in these complexes.

In the region 450–200 cm^{-1} HMPX exhibits absorption bands at 403s, 387m and 217m, whereas the nickel (II) complexes have absorption bands at *ca.* 425m, 417s, 344m, 321m, 278m and 230m cm^{-1} Since, there are no terminal Ni–X bands, no ν Ni–X vibrations will be expected above 200 cm^{-1} [8]. The relatively low frequencies assigned to these ν Ni–X vibrations would be consistent with a halogen bridging structure, although ν Ni–X stretching frequencies occur over a wide range and some terminal ν Ni–X frequencies have been reported. The very low-symmetry of these complexes should lead to the observations of upto four infrared active metal-nitrogen stretching vibrations. Two strong bands lie at *ca.* 350 cm^{-1} and 280 cm^{-1}, whilst a weaker band lies at *ca.* 300 cm^{-1}, these are therefore assigned as ν Ni–N vibrations.

In conclusion, reflectance and i.r. spectra indicate a *cis*-dimeric structure for $[Ni(HMPX)_2X_2]$ (X = Cl, Br or I). Dimeric structures of this type have been found to occur extensively in complexes of nickel (II) halides with ethylenediamine and related ligands.

The authors are thankful to Dr. P. C. Gupta, for providing necessary facilities in experimental work.

1. Mohan, M., Khera, H. C., Mittal, S. G. and Sirivastava, A. K., *Acta Chim.* (In Press).
2. Krause, R. A. and Busch, D. H., *J. Amer. Chem. Soc.*, 1960, **82**, 4830.
3. —, Guy, C. and Hooker, M. L., *Inorg. Chem.*, 1966, **5**, 1825.
4. Lever, A. B. P., *Ibid.*, 1965, **4**, 763.
5. Antsyshkina, A. S. and Porai-Koshita, M. A., *Doklady Akad. Nauk. S.S.S.R.*, 1962, **143**, 105.
6. Sacconi, L., *Transition. Metal Chem.*, 1968, **4**, 215.
7. Krause, R. A., Colthup, N. B. and Busch, D. H., *J. Phys. Chem.*, 1961, **65**, 2216.
8. Postmus, C., Ferraro, J. R., Quattrochi, A., Shobatake, K. and Nakamoto, K., *Inorg. Chem.*, 1969, **8**, 1851.

NANNOPLANKTON PRODUCTION IN VELLAR ESTUARY

B. R. SUBRAMANIAN, V. RAMADHAS AND V. K. VENUGOPALAN
Centre of Advanced Study in Marine Biology, Parangipettai 608 502, Tamil Nadu

ABSTRACT

Nannoplankton and netplankton primary production were estimated at 3 stations in Vellar estuary during premonsoon and monsoon months of 1974. On the average nannoplankters were responsible for 71·1% of total production in the estuary. Irrespective of surface or bottom, the nannoplankters contributed between 40 and 100% (mean 64·4%) at Station I, 50 and 100% (mean 67·7%) at Station II and 26·8 and 100% (mean 80·7%) at Station III, to the total primary production. Salinity was the chief ecological factor that influenced nannoplankton production in the Vellar estuary.

INTRODUCTION

STUDIES made in various biotopes[1-12], showed that nannoplankton formed the major source of primary production. Nannoplankters play a significant part in marine as well as estuarine food chain; they form the main source of food for microzooplankton[13, 14] and larvae of most of the benthic animals[15-17]. The present paper records variations in the nannoplankton primary production at 3 stations (Fig. 1) in the Vellar estuary, (mean depths 2·0, 2·5 and 2·75 m respectively) during the premonsoon (July–September) and monsoon (October–December) seasons of 1974.

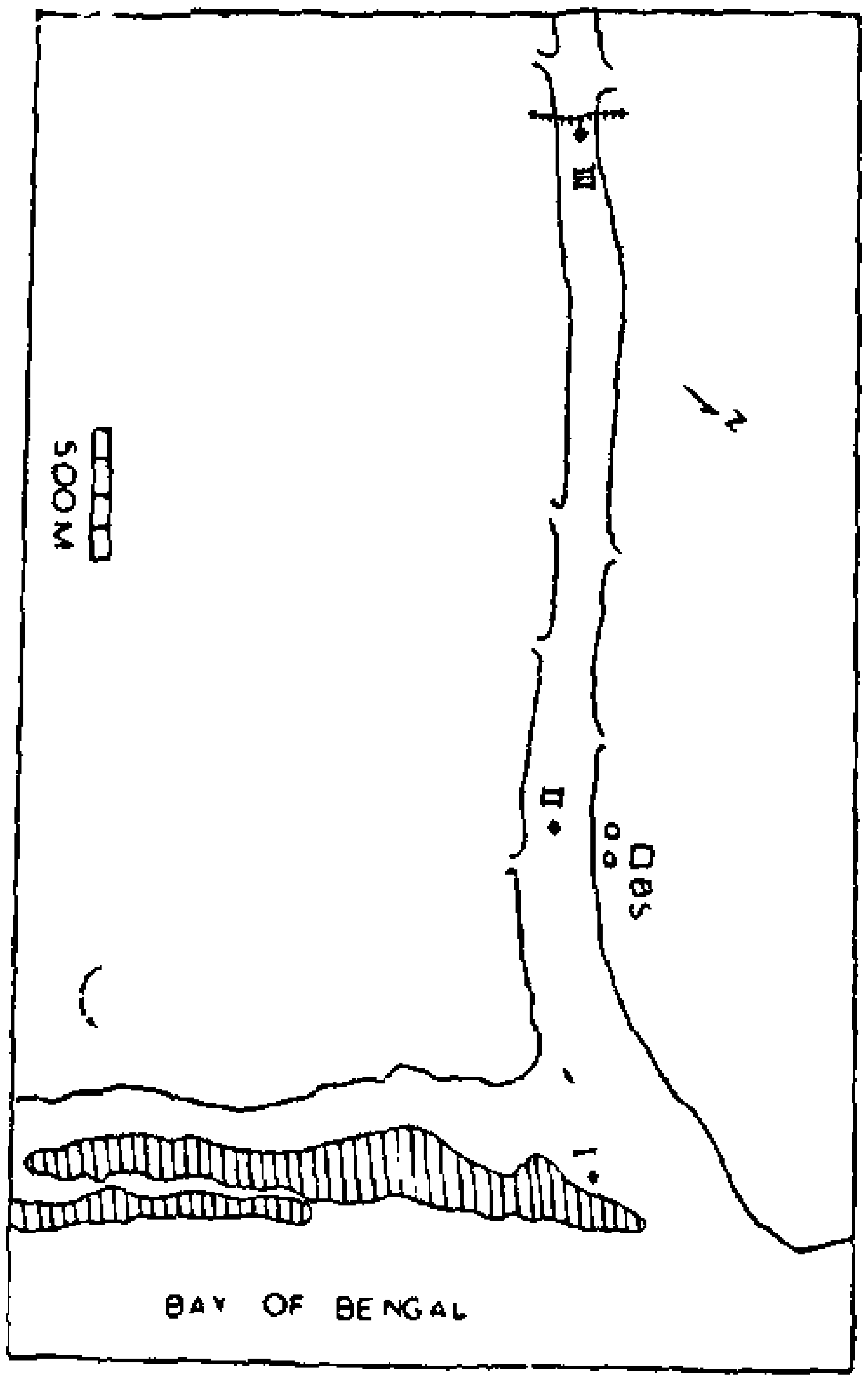

FIG. 1. Location of different stations at Vellar Estuary.

METHODS

All the samplings were carried out during high tides and surface samples were collected with a clean plastic bucket. Bottom samples were collected by means of horizontal water scoop. Light and dark bottle technique[18] was adopted to measure primary productivity and the samples were incubated *in situ* in the natural environment for 3 hrs. By adopting fractional filtration method, using a very fine mesh net (20 μ — Nytex), nannoplankton productivity was separately determined besides total productivity.

RESULTS AND DISSCUSSION

In the present study the range of variations in temperature were between 26·5 and 31·0° C, 26·0 and 30·0° C and, 25·0 and 28·0° C at stations 1, 2 and 3 respectively. The monthly variations in salinity and light penetration are shown in Table I. The etsimated nutrient concentrations (phosphate, ammonium, nitrite, nitrate and silicate) didn't exhibit much variation in the premonsoon months, but higher concentrations were observed during the monsoon months. At Station I, in the surface waters peak nannoplankton production was observed in July. It decreased in August followed by an increase in September (Fig. 2). After that the production decreased in the following months and attained the minimum in November. However, the production due to nannoplankton increased in December. The same type of distribution

TABLE I

Monthly variations in light, salinity and premonsoon—monsoonal variations in the net: nanno ratio

Month	Depth	Ex-coefficient			Salinity %			Season	Net: Nanno ratio			For whole estuary
		Station I	Station II	Station III	Station I	Station II	Station III		Station I	Station II	Station III	
July	Surface	2·30	2·40	1·70	33·0	30·0	29·0	Pre-monsoon	0·87	0·46	0·54	0·62
	Bottom				34·0	33·5	31·0					
August	Surface	2·50	2·80	1·90	34·5	33·5	31·0					
	Bottom				35·5	34·5	33·0					
September	Surface	1·60	2·15	5·50	15·5	13·0	22·0					
	Bottom				16·5	14·0	24·5					
October	Surface	1·85	2·60	3·50	20·5	17·5	11·5	Monsoon	0·47	0·42	0·48	0·46
	Bottom				24·0	19·5	12·5					
November	Surface	2·25	2·05	2·30	25·0	14·0	9·0					
	Bottom				27·5	24·5	22·5					
December	Surface	1·85	2·05	2·20	18·5	13·5	10·0					
	Bottom				25·0	18·0	11·0					

pattern was observed in the bottom waters also (Fig. 2). But in the case of netplankton production of the surface water, the pattern was reverse in the months of July, August and September whereas in the bottom it decreased gradually from the July maximum to the December minimum (Fig. 2).

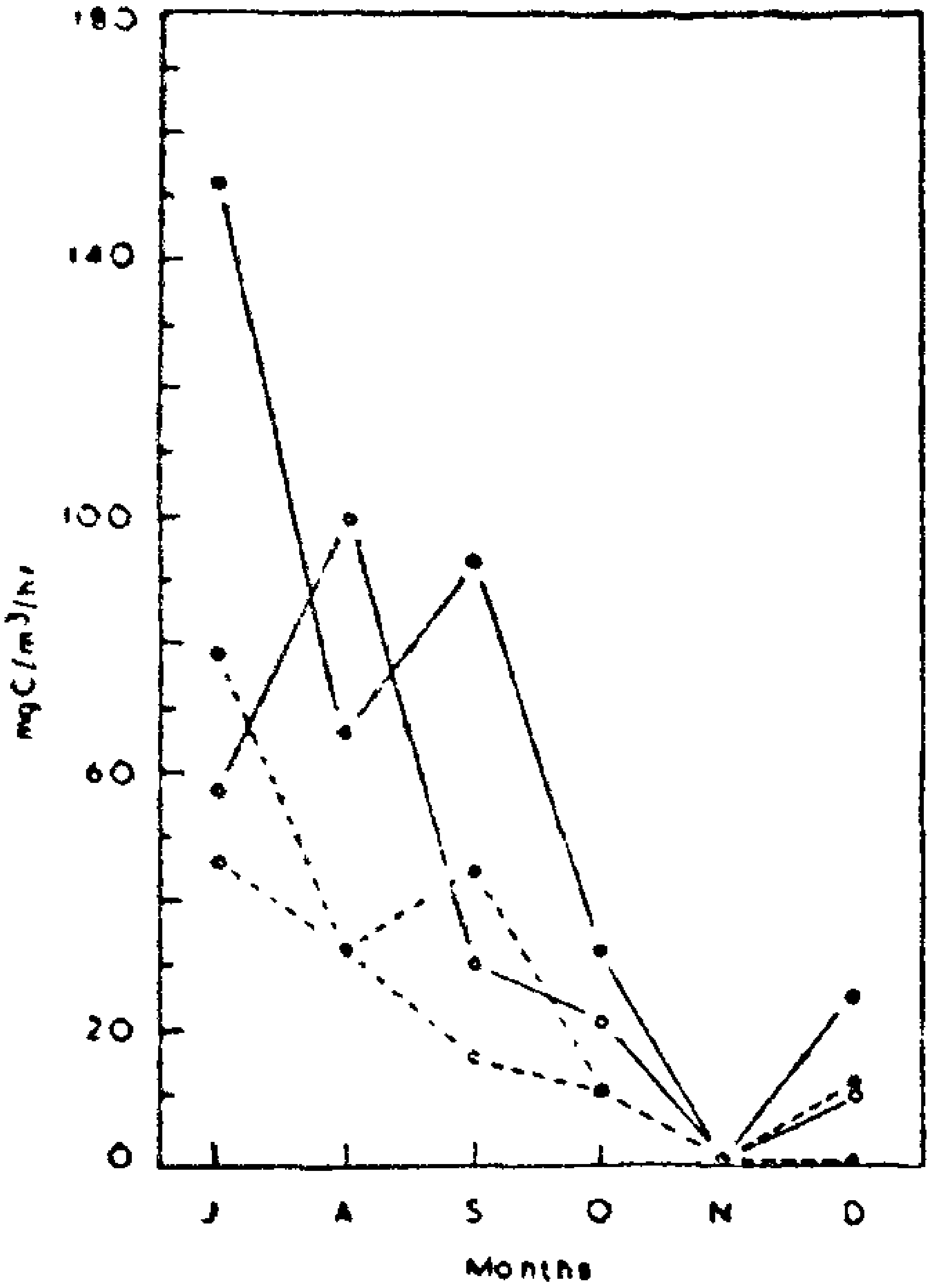

FIG. 2. Monthly variations in nanno and netplankton primary production at Station I.

At Station II, the variation in nannoplankton production of the surface water was similar to that observed at Station I, whereas in the bottom the peak production was in August unlike that of the surface waters (Fig. 3). With regard to the netplankton production in surface waters, the primary and secondary peaks were observed in the months of July and October respectively (Fig. 3). But in the bottom waters the peak value was recorded in August (Fig. 3).

At Station III, in the surface waters, the nannoplankton production increased and decreased alternately throughout the period (Fig. 4). Changes in the bottom waters were quite consistent with those of surface waters except for the decrease and increase in November and December respectively (Fig. 4). The netplankton production, in the surface decreased continually from July to November and then increased slightly in December (Fig. 4).

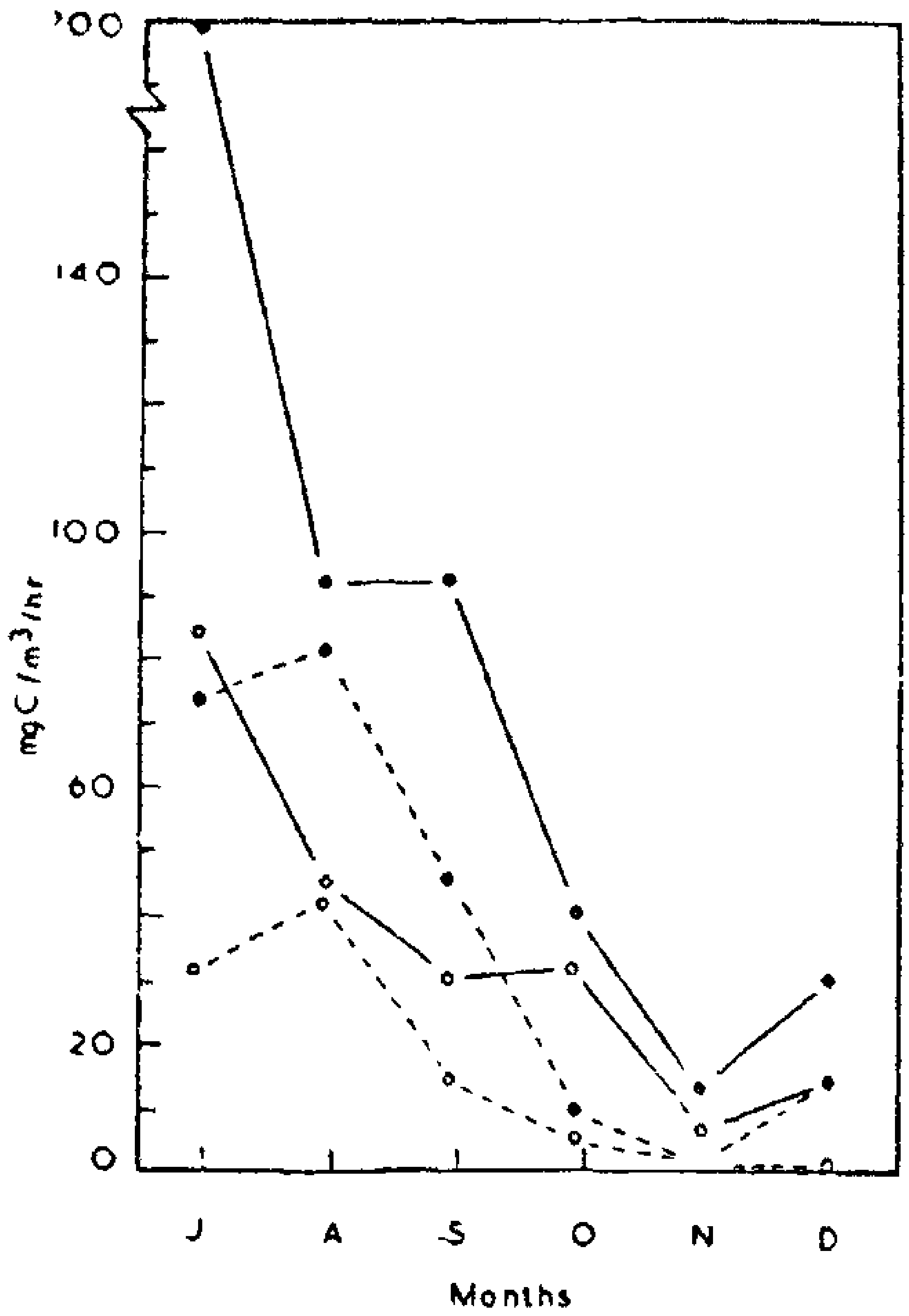

FIG. 3. Monthly variations in nanno and netplankton primary production at Station II.

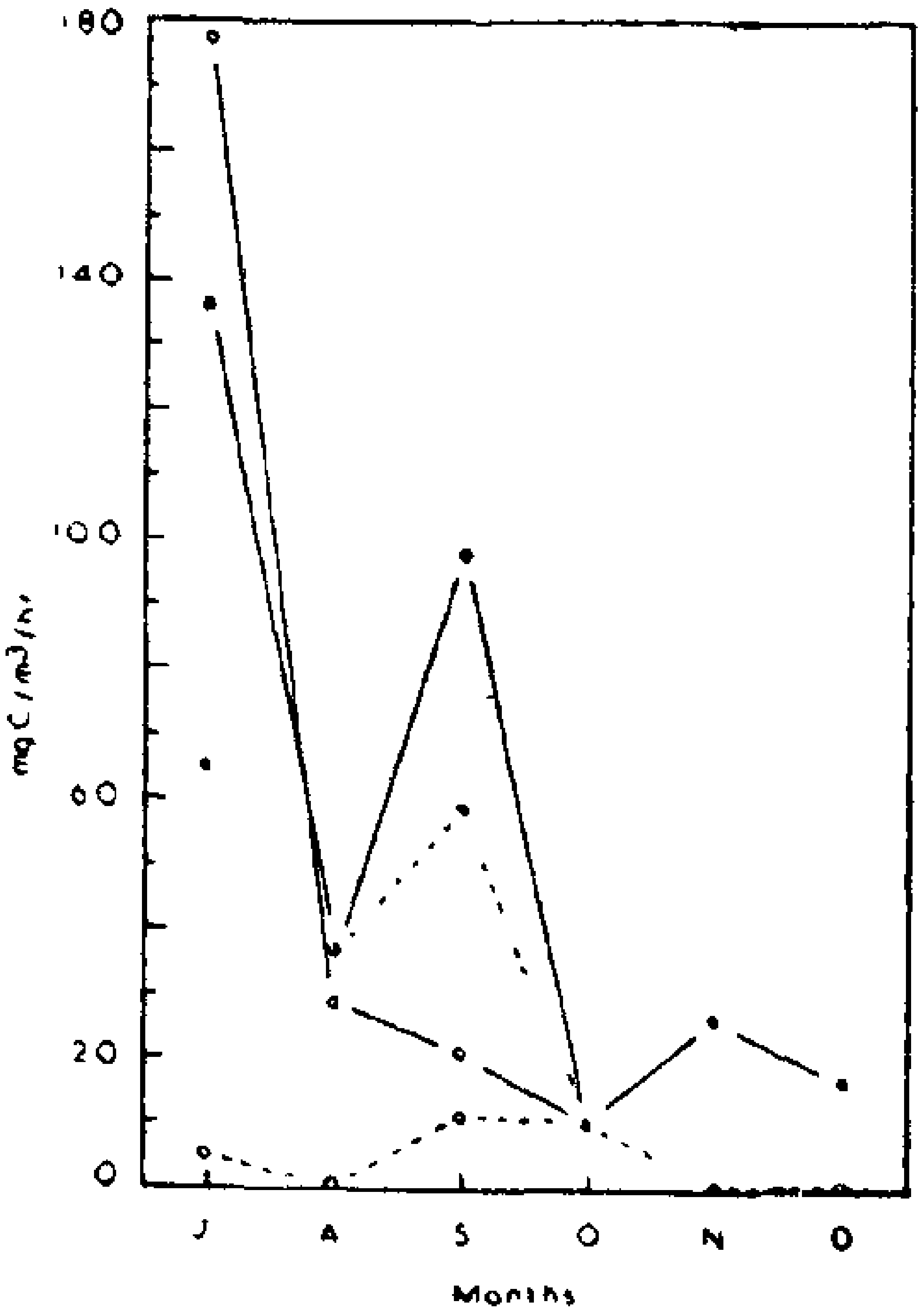

FIG. 4. Monthly variations in nanno and netplankton primary production at Station III.

●——● Nanno production in surface.
●- - - -● Nanno production in bottom.
○——○ Netplankton production in surface.
○- - - -○ Netplankton production in bottom.

Studies made so far in various neretic and oceanic waters, on nannoplankton primary production, indicated that nannoplankters contributed between 80 and 100% to total production[1,2,6-8]. In Brazilian mangroves, the range of nannoplankton production observed was from 64·3 to 95·8%[19] while in some eutrophic temperate lakes it was 90% and 50%[20,3]. In the mangrove and backwaters of Porto Novo, nannoplankton production was 80·5% and 62·1% respectively[21].

With regard to other estuaries, in the Chesapeake Bay estuaries, nannoplankters contributed between 89·6 and 93·4%[11] to the total plant production. In Cochin backwater's nannoplankton production was 74·47%[12]. The extent of nannoplankton production observed in the present study was more or less similar to that of the above observations. Among the three stations chosen in the Vellar estuary, Station II (Tidal zone, situated in the middle region of the estuary) showed higher rates of production due to nanno- as well as netplankton, during most of the months. Qasim *et al.*[22] pointed out that moderately low salinity would facilitate maximum production of most of the tropical phytoplankters. During the present study the salinity values observed in the tidal zone were consonant enough to promote larger plant production. Further as pointed out by Nash[23], the continually changing tidal direction in the estuary would have facilitated the phytoplankton forms to exist indefinitely within the middle region of the estuary thus contributing much to the greater productivity of that region. Although all the stations were shallow (Depth range 2·0 to 2·75 m) a definite decreasing gradient was obvious in nannoplankton productivity between surface and bottom waters (Figs. 2, 3 and 4). This might partly be due to the restricted sinking of the smaller cells having a high area/volume ratio as shown by Eppley *et al.*[24], and partly due to the aggregation of nannoflagellates towards the light saturated surface waters[25,26].

In the Vellar estuary, among the ecological factors considered, salinity appeared to be the most important factor in controlling the productivity of both nanno- and netplankton. Loftus *et al.*[26] pointed out that locally restricted heavy rainfall generally increased the rate of nannoplankton production in Chesapeake Bay estuarine waters. In the present study also a sudden decline in salinity due to local rainfall lead to an increase in nannoplankton production in all the 3 stations in the month of September (Figs. 2, 3 and 4). This may be attributed to dilution of estuarine water to a moderate salinity level which might have favoured the primary producers[22]. However, prolonged decrease in salinity during monsoon months lead to very low rates of production in all the 3 stations (Figs. 2, 3 and 4). This may be attributed to the washing away of the primary producers to the heretic region by the monsoonal flood. Though the rate of production decreased, the percentage contribution by nannoplankton increased and this was evident from the lower values of net : nannoplankton production ratio (Table I) observed for the whole estuary.

ACKNOWLEDGEMENT

The authors wish to thank Dr. R. Natarajan, Professor and Director, Centre of Advanced Study in Marine Biology, for his interest and encouragement. One of us (V. Ramadhas) gratefully acknowledges a Junior Research Fellowship by the U.G.C., Dehli.

---

1. Yentsch, C. S. and Ryther, J. H., *J. Cons. perm. Int. Explor. Mer.*, 1959, 24, 231.
2. Anderson, G. C., *Limnol. Oceanogr.*, 1964, 9, 284.
3. Kalff, J., *Ibid.*, 1972, 17 (5), 712.
4. Mommaerts, J. P., *Br. Phycol. J.*, 1973, 8, 13.
5. Czeczuga, B., Gradeki, F. and Petrusewicz, K., *Bull. Acad. Pol. Sci. Ser. Sci. Biol.*, 1974, 22 (6), 399.
6. Teixeira, C., *Bolm. Inst. Oceanogr.*, 1963, 13, 53.
7. Malone, T. C., *Limnol. Oceanogr.*, 1971 *a*, 16, 633.
8. —, *Fish, Bull.*, 1971 *c*, 69, 799.
9. Tundisi, J. G., In: *Fertility of the Sea*, Ed. by J. D. Costlow, 1971, 2, 603.
10. —, *Contracoes Inst. Oceanogr. Univ. S. Paulo. ser. Ocean. Biol.*, 1970, 19, 1.
11. McCarthy, J. J., Taylor, W. R. and Loftus, M. E., *Mar. Biol.*, 1974, 24 (1), 7.
12. Qasim, S. Z., Sumitra, V., Joseph, K. V. and Balachandran, V. K., *Ind. J. mar. Sci.*, 1974, 3 (2), 146.
13. Parsons, T. R. and LeBrasseur, R. J., In: *Marine Food Chains*, Ed. by J. H. Steele, 1970, p. 325.
14. Kristianzen, J., *Mitt. Int. Ver. Theor. Angrew. Limnol.*, 1971, 19, 253.
15. Bruce, J. R., Knight, M. and Park, M. W., *J. mar. biol. Asso. U.K.*, 1940, 40, 337.
16. Stickney, A. P., *Ecology*, 1946, 45 (2), 283.
17. Tanaka, Y., Seijin, I. and Kiyoshi, K., *Bull. Tokai. reg. Fish. Res. Lab.*, 1970, 63, 79.
18. Strickland, J. D. H. and Parsons, T. R., "A practical hand book of sea water analysis," *Fish. Res. Board Can., Ottawa Bull.*, 1968, 167, 311.
19. Teixeira, C., Tundisi, J. and Santoro, J., *Bolm. Inst. Oceanogr., S. Paulo*, 1967, 16 (1), 39.
20. Gelin, C., *Oikos*, 1971, 22 (2), 230.
21. Ramadhas, V., Subramanian, B. R. and Venugopalan, V. K., *Mahasagar*, 1975 (In press).
22. Qasim S. Z., Bhattathiri, P. M. and Devassy, V. P., *Mar. Biol.*, 1971, 12, 200.
23. Nash C. B., *J. mar. Res.*, 1947, 6, 147.
24. Eppley, R. W., Holmes, R. W. and Strickland, J. D. H., *J. exp. mar. biol. ecol.*, 1967, 1 (2), 191.
25. —, Holm-Hansen, O. and Strickland, J. D. H., *J. Phycol.*, 1968, 4 (4), 349
26. Loftus, M. E., Subbarao, D. V. and Seliger, H. H., *Ches. Sci.*, 13 (4), 289.