MAHASAGAR
Vol.21, No.2 (June), 1988, pp.85-94.

PHYTOPLANKTON AND ZOOPLANKTON OF SOME PADDY-CUM-PRAWN CULTURE FIELDS IN AND AROUND COCHIN

T.C. GOPALAKRISHNAN, C.B. LALITHAMBIKA DEVI, P.N. ARAVINDAKSHAN, K.K.C. NAIR, T. BALASUBRAMANIAN AND M. KRISHNANKUTTY

National Institute of Oceanography
Regional Centre, Cochin 682018

ABSTRACT

The phytoplankton and zooplankton from the paddy-cum-prawn culture fields from 4 areas in and around the Cochin backwaters were studied. Total phytoplankton counts in the seasonal and perennial fields in all the areas showed good similarity with maximum during the monsoon period but with considerable fluctuation in abundance. Highest average count of 4617 cells/l with minimum fluctuation was observed in the seasonal fields in area 2. The high concentration of nutrients in these fields, did not appear to exert any adverse effect on phytoplankton since maximum number of genera and uniform abundance were observed here. Zooplankton counts in all the areas were generally low.

Quantitative and qualitative aspects of phytoplankton and zooplankton in the 4 areas showed that the striking regional differences in salinity and nutrient concentrations have not exerted appreciable effect on them to demarcate these regions on the basis of such differences. More frequent occurrence of unialgal blooms and total absence of zooplankton in many samples at the station close to the effluent discharge site of a fertilizer factory in area 2 however suggests adverse effect of extreme concentrations of nutrients (NO_2, 539.0; NO_3, 312.5; PO_4, 2195.0 and NH_4, 3980.0 μg at/l.), although it seems to get diluted to safer limits by the time it reaches the seasonal fields. Otherwise, the impact of the regional differences in the estuarine environment in all the areas studied appear less in the lower trophic level. The study also indicates that the cause for the variations in the tertiary production, especially of prawns in the different regions cannot be ascribed to excess nutrient concentrations either directly or by affecting primary and secondary production.

Key-words: Phytoplankton, zooplankton, prawn culture, Cochin backwater.

INTRODUCTION

Various authors (Nair and Tranter, 1971; Gopinathan, 1972; Pillai and Pillai, 1973; Devassy and Bhattathiri, 1974; Purushan, Balachandran and Sakthivel, 1974; Joseph and Kunjukrishna Pillai, 1975; Kumaran and Rao, 1975; Madhupratap and Haridas, 1975; Rao, Madhupratap and Haridas, 1975 and Haridas, 1982) have studied in detail the primary production

and zooplankton distribution of the main backwater system around Cochin, but the prawn culture fields in this area were not extensively studied until recently. In view of the growing importance of prawn culture in these fields a general ecological study was taken up. The environmental characteristics of these fields were described by Nair, Sankaranarayanan, Gopalakrishnan, Balasubramanian, Lalithambika Devi, Aravindakshan and Krishnankutty (1988). Qualitative and quantitative aspects of phytoplankton and zooplankton in the seasonal and perennial prawn fields of the Cochin backwaters in relation to the environmental parameters are described in this paper.

MATERIAL AND METHODS

Seasonal and perennial prawn culture fields north of Cochin backwaters in the Vypeen Island close to the Azhikode entrance (area 1), those south-east of Cochin backwaters in the Tripunithura region (area 2) and a reference field of perennial nature situated close to the harbour entrance (area 3) were selected for the study (Fig.1). Data were also collected from the harbour entrance (area 4). Area 2 is close to a fertilizer factory. The rivers discharge into these areas are the Periyar in the north; Muvattupuzha and Meenachil rivers in the south. Sea water influx to these fields is through the Cochin harbour and Azhikode entrance.

Sampling was done between December, 1980 and March, 1981 in the fields with seasonal prawn culture; and till November, 1981 in the perennial fields in areas 1-3 and at harbour entrance in area 4. Monthly collections were taken from 28 stations of which 9 stations were in the seasonal fields in areas 1 and 2; 3 stations in the perennial fields in areas 1, 2 and 3. The remaining 16 stations were located in canals adjacent to the fields through which the water enters the culture fields, near the effluent discharge point of the fertilizer factory in area 2 and at harbour entrance. Collections were taken on the days when the high tide fell on early morning hours. Phytoplankton was sieved from 30 litres of water using a bolting silk of 0.069 mm mesh. Zooplankton samples were collected with a HT net of 0.33 mm mesh. The standing crop of phytoplankton was estimated using a Sedgwick Rafter counting system and the number of cells per litre of water was computed. The zooplankton was sorted out into major taxa and their values were computed for 100 m^3. Phytoplankton and zooplankton groups representing more than 10% are shown separately and others are pooled together.

RESULTS AND DISCUSSION

The phytoplankton concentrations in the seasonal fields in area 2 on an average (seasonal) was more than twice (4617 cells/l) than in area 1 (1949 cells/l). In the perennial fields the average count for the year was 1804 cells/l in area 1 and 1786 cells/l in area 2. Maximum of 26448 cells/l was recorded at the effluent discharge site. Perennial field in area 3 also showed high phytoplankton cell counts (4690 cells/l) as in area 2. A dense *Fragilaria* bloom of 2.345×10^8 cells/l was observed in area 4

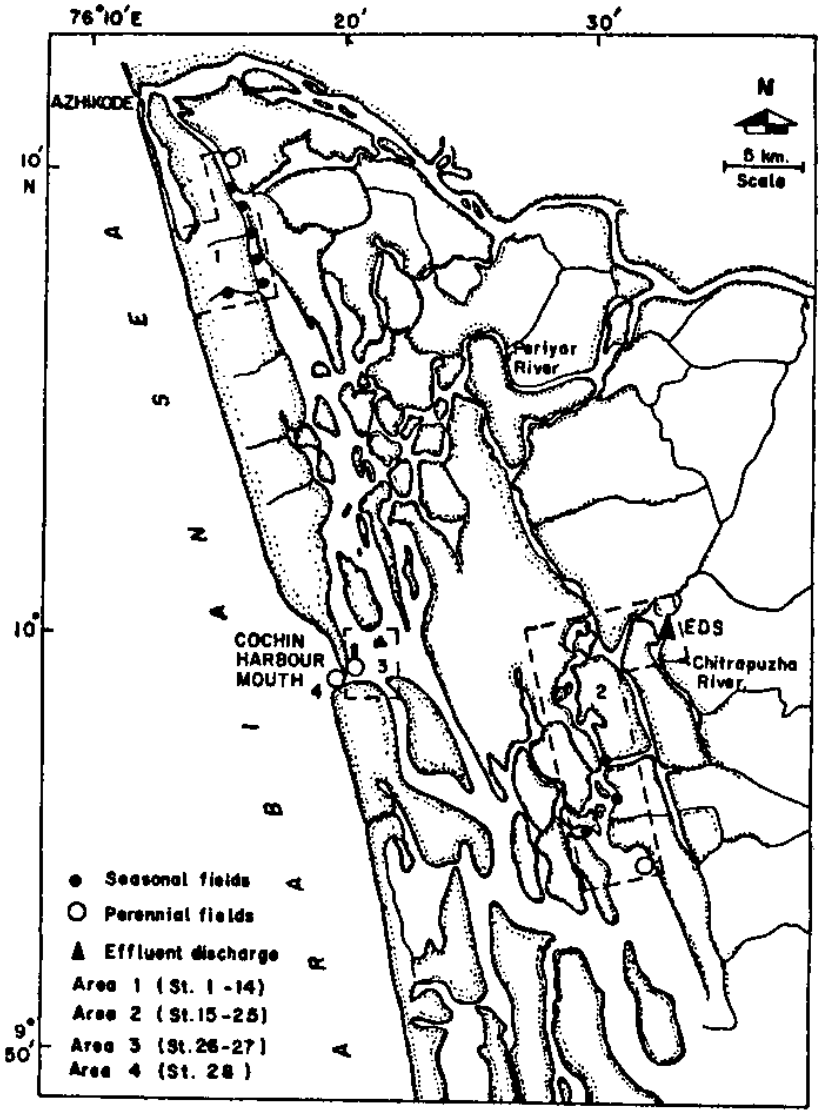

Fig.1. Station location map (EDS – Effluent discharge site)

during August. The occurrence of such postmonsoon blooms seems to be characteristic of this region (Gopinathan, Nair and Nair; 1974, and Venugopal, Haridas, Madhupratap and Rao, 1979). The overall trend in the abundance of phytoplankton was similar at all the stations. Phytoplankton counts in all the areas except in the seasonal fields of area 2 showed pulses of production followed by a decline in abundance. The cell counts were higher during the monsoon months in all the areas (Fig.2). The seasonal fields in area 2, however, maintained almost uniformly high counts which were due to the rich nutrient content from the effluents discharged from the nearby fertilizer factory.

The large number of genera and their greater abundance in the seasonal fields in area 2 (Table II, Fig.3) indicate better environmental conditions than the seasonal fields in area 1 for phytoplankton growth. The higher concentration of nutrients in the seasonal fields in area 2 (Table I) arising from their proximity to the fertilizer factory did not appear to exert

Table I — Salinity and nutrients in different areas at different months

		S	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
AREA 1	Seasonal	S‰	3.40	11.70	22.50	27.00	28.70							
		NH_4 µg at/l	5.35	5.30	3.80	1.35	3.20							
		NO_2 "	1.00	0.60	0.50	0.35	0.50							
		NO_3 "	9.50	2.00	2.80	1.35	1.45							
		PO_4 "	0.15	0.75	1.75	1.40	2.00							
	Perennial	S‰	3.40	16.60	25.00	28.00	29.90	30.80	29.60	1.70	4.70	1.60	3.10	3.40
		NH_4 µg at/l	5.35	1.45	1.50	0.50	2.50	2.25	4.75	18.20	3.50	5.50	3.70	1.80
		NO_2 "	1.00	0.15	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
		NO_3 "	9.50	1.50	4.50	4.50	3.50	3.20	1.25	19.00	7.20	6.80	8.50	5.80
		PO_4 "	2.15	1.50	1.00	1.50	3.50	3.35	3.20	1.50	2.50	4.20	1.50	2.85
AREA 2	Seasonal	S‰	0.60	5.40	11.40	15.30	17.20	15.50						
		NH_4 µg at/l	19.40	31.50	199.10	66.30	8.60	1.30						
		NO_2 "	2.80	2.55	22.50	3.40	4.65	0.50						
		NO_3 "	12.24	9.30	32.60	25.80	19.20	0.40						
		PO_4 "	8.40	10.40	37.88	17.40	25.85	6.40						
	Perennial	S‰	0.60	7.50	12.90	15.30	17.20	15.50	8.40	0.60	0.70	1.00	9.40	1.00
		NH_4 µg at/l	19.40	20.00	21.00	2.50	1.40	1.30	3.00	61.50	23.40	26.30	1.40	5.40
		NO_2 "	2.80	2.85	1.00	0.50	0.50	0.50	0.80	6.50	1.50	2.15	1.00	2.45
		NO_3 "	12.24	14.60	5.40	0.10	0.40	0.40	0.40	25.40	6.50	18.30	10.40	7.40
		PO_4 "	8.40	7.00	2.50	2.40	4.60	6.40	4.70	9.30	20.60	11.30	6.40	2.40
Effluent Discharge Site		S‰	0.50	2.00	3.50	6.50	8.30	5.50	3.90	2.30	0.80	0.90	8.50	1.00
		NH_4 µg at/l	605.00	1585.00	3550.00	3980.00	85.00	1440.00	110.00	615.00	20.00	265.00	1627.00	610.00
		NO_2 "	25.00	65.00	539.00	65.00	115.00	5.00	30.00	90.00	10.00	10.50	70.00	20.00
		NO_3 "	57.50	80.00	312.50	240.00	192.50	7.50	25.00	75.00	22.50	37.50	95.00	90.00
		PO_4 "	160.00	1865.00	934.00	1426.00	2195.00	50.00	70.00	90.00	110.00	7.50	135.00	120.00
AREA 3		S‰	5.80	13.00	26.90	27.30	27.80	15.00	19.40	0.30	3.80	4.70	14.80	7.30
		NH_4 µg at/l	23.80	15.00	11.60	3.20	6.60	2.80	4.00	24.60	6.70	13.80	8.30	16.00
		NO_2 "	5.40	1.80	1.50	1.20	0.60	1.50	1.50	3.20	1.40	0.80	1.40	11.40
		NO_3 "	25.20	35.60	10.60	6.20	4.20	7.40	7.00	10.00	16.20	13.50	15.60	11.50
		PO_4 "	1.25	4.00	3.20	3.15	3.35	3.30	1.75	4.35	2.65	5.20	3.10	3.00
AREA-4		S‰	13.60	20.20	34.99	29.20	31.62	17.30	19.90	1.40	4.00	20.40	31.44	16.30
		NH_4 µg at/l	16.60	4.60	8.00	4.60	6.00	2.30	15.50	32.13	16.50	21.10	21.30	19.00
		NO_2 "	2.30	0.40	1.90	0.90	0.70	1.70	3.30	2.80	0.80	1.20	0.70	25.30
		NO_3 "	14.50	25.60	10.60	7.40	8.50	10.50	8.70	27.40	17.30	20.50	22.80	11.00
		PO_4 "	4.05	1.45	3.05	4.15	4.15	3.45	7.80	4.80	4.80	4.80	4.35	4.10

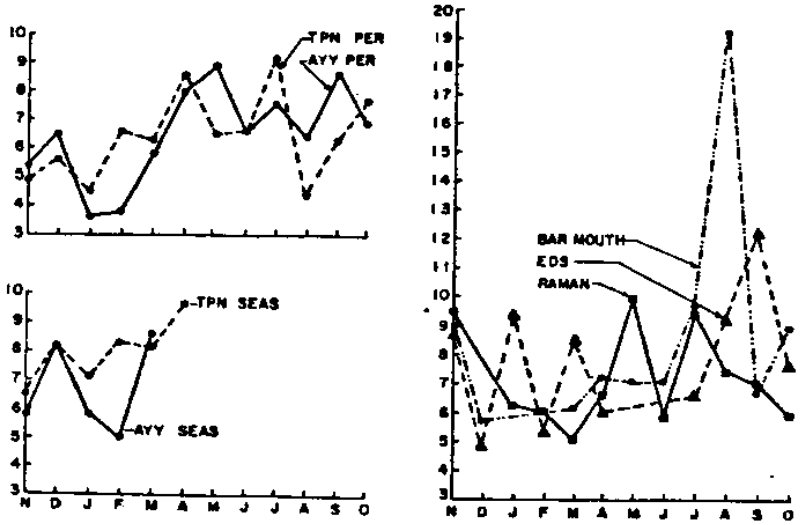

Fig.2. Phytoplankton cells — number/litre. In.
TPN PER — Tripunithura perennial, AYY PER — Ayyampilly perennial, TPN SEAS — Tripunithura seasonal, AYY SEAS — Ayyampilly seasonal, EDS — Effluent discharge site, and RAMAN — Ramanturuth.

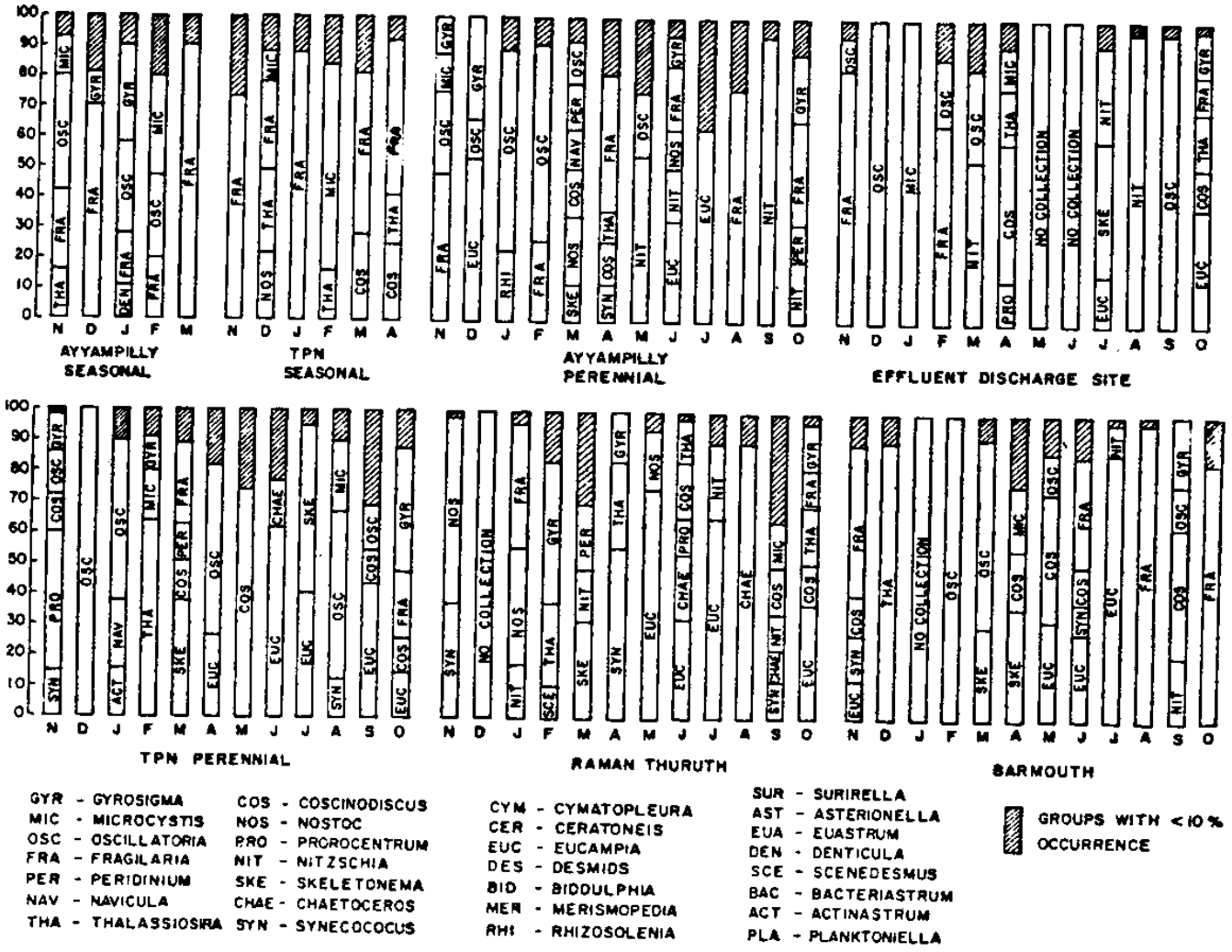

Fig.3. Percentage composition of phytoplankton genera.

Table II – Number of phytoplankton genera in different areas at different months.

Month	Area 1		Area 2		Effluent Discharge Site	Area 3	Area 4
	Seasonal	Perennial	Seasonal	Perennial			
Nov	7	4	14	7	6	9	7
Dec	14	4	6	1	1	-	3
Jan	9	4	9	7	1	4	-
Feb	12	4	11	6	6	7	1
Mar	15	9	14	8	11	11	3
Apr	-	11	15	10	5	3	8
May	-	11	-	5	-	11	6
Jun	-	7	-	10	-	6	9
Jul	-	11	-	9	6	9	6
Aug	-	6	-	6	7	5	6
Sep	-	7	-	11	6	10	4
Oct	-	6	-	6	8	6	6

any adverse effect on phytoplankton since maximum number of genera and uniform abundance were observed there. The occurrence of mass fish mortality reported by Venugopal, Remani, Saraladevi and Unnithan (1980) from area 2 is probably caused by the indiscriminate discharge of other toxic substances. The adverse effect of nitrate, phosphate and ammonia concentrations in the range of 7.5-312.5, 7.5-2195.00 and 20.00-3980.00 µg at/l respectively obtained at the station near the effluent discharge site (Nair, Sankaranarayanan, Gopalakrishnan, Balasubramanian, Lalithambika Devi, Aravindakshan and Krishnankutty, 1988) is reflected in the quantitative and qualitative nature of the phyto and zooplankton (Figs.2-4 & Table II). In contrast to the zooplankton that was either absent or poorly represented, phytoplankton abundance showed considerable increase although the average number of genera based on monthly samples was lower than in other regions. Unialgal bloom conditions are more frequent here than in other regions indicating that the conditions prevailing here allow only the growth of the more tolerant species suggesting lowering of water quality. Low diversity and unialgal blooms are possible symptoms of eutrophication which generally accompany over fertilization. But some of its well defined characteristics and the other concomitant effects such as excessive dead and decaying matter, anoxic conditions in the water and mud, etc. are not observed at the effluent discharge site. High concentration of ammonia noticed here also does not appear to be the result of degradation process accompanying eutrophication. The pH values were also only mildly acidic in most samples. It was pointed out that the effluent, probably contained high concentrations of ammonia in a relatively non toxic unionised form (Nair, Sankaranarayanan, Gopalakrishnan, Balasubramanian, Lalithambika Devi, Aravindakshan and Krishnankutty, 1988).

Fragilaria was the dominant genus in the seasonal fields of areas 1 and 2 during November-April. Postmonsoon dominance of *Fragilaria* was noticed in the perennial field of area in August. The bloom noticed at the harbour entrance (area 4) with a count of 2.345×10^8 cells

per litre during August was mainly constituted by *Fragilaria* (98%). Other genera associated with this bloom were *Oscillatoria*, *Thalassiossira*, *Coscinodiscus*, *Skeletonema* and *Chaetoceros* together forming 2%. In October, *Fragilaria* constituted 85%, *Synecococus* 8%, *Coscinodiscus* 3%, *Oscillatoria* 2%, *Nitzschia* and *Gyrosigma* 1% each, in the same area. Similar unialgal bloom conditions of low density were observed in other areas. In the perennial field of area 1 during August, *Fragilaria* constituted 76%, *Nitzschia* 9%, *Gyrosigma* 8%, *Coscinodiscus* 4%, *Oscillatoria* 1.5% and *Thalassiossira* 1.5%. During the premonsoon period the diatom *Skeletonima costatum* is often responsible for the major bloom in the Cochin backwaters (Gopinathan, Nair and Nair, 1974). According to them the monsoon maximum was often brought about by the dinoflagellate *Prorocentrum micans* and *Ceratium furca* along with *Skeletonema costatum*. Concentrations of *Oscillatoria* were also reported during the monsoon and postmonsoon periods. The monsoon maxima noticed in July in the perennial field in area 2 was represented by *Skeletonema* (55%) and *Eucampia* (40%), whereas significant occurrence of *Oscillatoria* was noticed during August to February. Succession of blooms of *Coscinodiscus* sp. was noticed in Cochin backwaters in the salinity range of 0-25 ppt by Qasim, Bhattathiri and Devassy (1972). The only dominance of *Coscinodiscus* (75%) observed in the present study was in the perennial field of area 2 during May when the salinity was 8.4 ppt. Thus it appears that in the Cochin backwaters algal blooms are caused by different species in different years. During the period under study *Fragilaria* was the most dominant species in all the areas, followed by *Oscillatoria*. High nutrient concentrations and low salinity, appear to be favourable for the formation of *Fragilaria* blooms as it was noticed in all the areas of study. The range of variations in chlorophyll '*a*' in areas 1 and 2 was 1-25.63 mg/m^3 and in area 3 it was 1-125 mg/m^3. At the effluent discharge site it was between 6.4-224.28 mg/m^3. At the harbour entrance the range was 1-19.22 mg/m^3. The variations in chlorophyll '*a*' values in the prawn culture fields were reflected in the phytoplankton counts.

Zooplankton was very poorly represented in the samples from all the areas. Earlier observations at Ramanthuruthu (area 3) also showed the scarcity of zooplankton in the culture fields (Haridas - personal communication). Present study showed the total absence of zooplankton mostly during November & December except in area 4. Figure 4 gives the percentage composition and total abundance of zooplankton organisms in different months. Zooplankton abundance showed marked fluctuations at all stations, but their absence in the samples was more conspicuous at the station near the discharge site. Area 4 showed maximum abundance. The seasonal fields in both the areas 1 and 2 generally maintained greater abundance of zooplankton compared to the perennial fields.

Zooplankton composition in general showed dominance of amphipods in area 1 and copepods in area 2. Decapod larvae including post-larvae of penaeid prawns were present in good numbers in most of the months in areas 1 and 3. This is also a reason for the successful prawn fishery of these regions.

The average benthic biomass in the seasonal and perennial fields in area 1 was 51.2 and 51.9 g/m^2 respectively. The seasonal fields in area 2 had an average biomass of 83.2 g/m^2. The corresponding average biomass in area 3 was only 6.4 g/m^2. The low benthic biomass in areas 1 and 3 during the

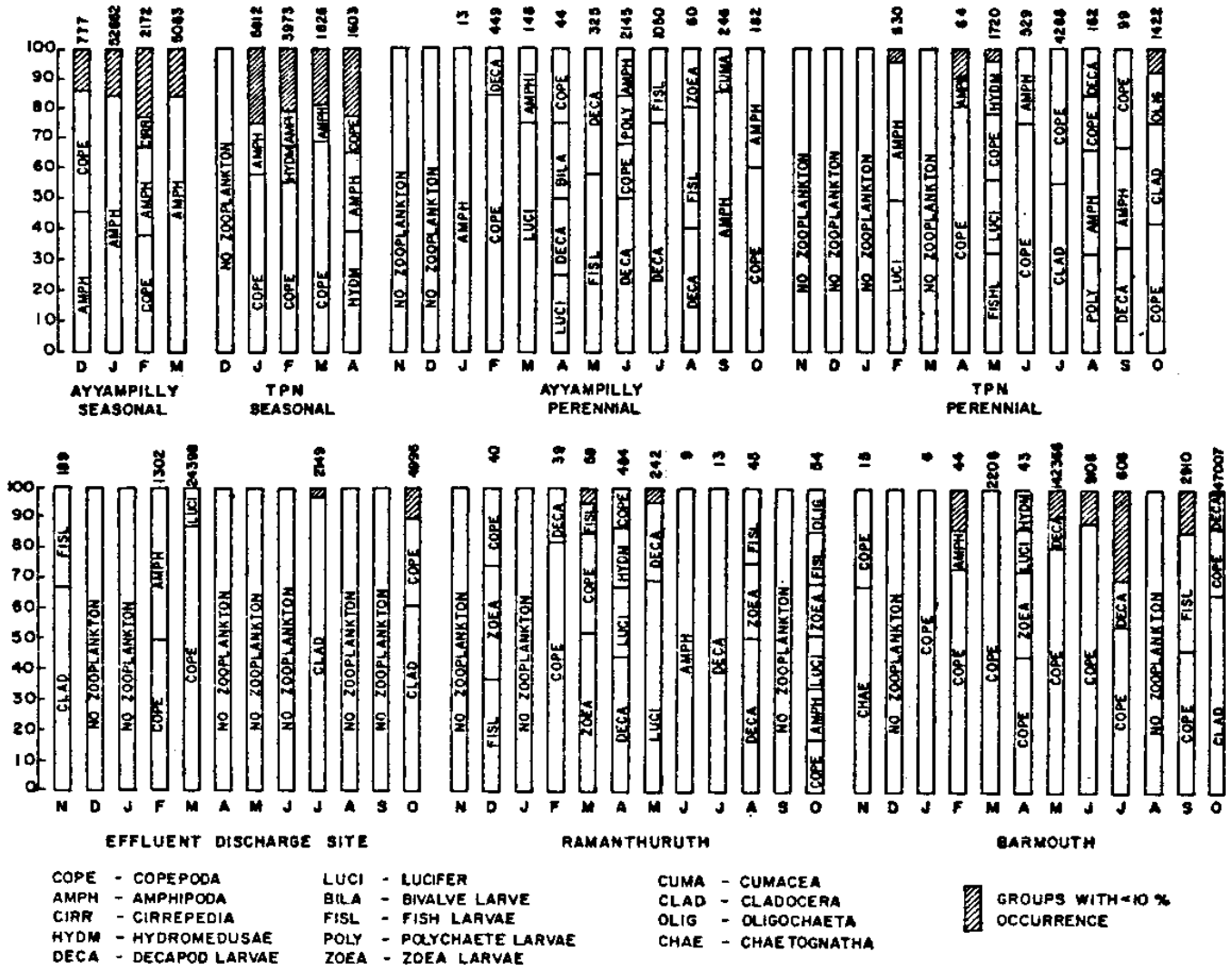

Fig.4. Zooplankton/100 m^3. Percentage composition and total number.

growing season of prawns is due to predation. The lower abundance of prawns in area 2 supports this view. Among the seasonal fields area 1 showed highest prawn production (772.2 kg/hec.) and the lowest was in area 2 (100.6 kg/hec.). Area 3 had 820.6 kg/hec.

Qasim, Wellershaus, Bhattathiri and Abidi (1969) have estimated net primary production in the lower reaches of the Backwater. Haridas (1982), Nair and Tranter (1971), Madhupratap and Haridas (1975), Madhupratap, Rao and Haridas (1977) have studied the zooplankton of the area. They have, in general, reported high zooplankton production during the pre-monsoon period and very low production in the low saline periods. The ratio of secondary production to primary production at the lower reaches of the estuary was reported to be 12.5% by Madhupratap, Rao and Haridas (1977). Thus an excess of basic food is available for alternate utilization in the estuary which is contributed to the detritus. The higher percentage of prawns (60 to 70%) from the total annual fish landings of the Kerala Backwaters (George and Sebastin, 1970) shows the importance of organic detritus in the food chain. Even though Qasim and Sankaranarayanan (1972) reported that significant amount of detritus entered the backwaters from

other sources, contributions from the primary and secondary producers also formed rich sources of food for prawns and other benthic feeders.

Variations in the prawn production in different areas investigated during the present study do not thus appear to be due to variations in production in the lower trophic levels or due to scarcity of food. As pointed out by Sankaranarayanan, Kumaran, Balasubramanian, Rosamma Stephen and Panampunnayil (1982); Nair, Sankaranarayanan, Gopalakrishnan, Balasubramanian, Lalithambika Devi, Aravindakshan and Krishnankutty (1988) and Krishnankutty (1986), salinity may be a deciding factor in prawn production in the Cochin backwaters since other major ecological factors in all the areas studied appear to be favourable for prawn production. But neither the phytoplankton abundance nor the species diversity seem to have been effected by the lower saline conditions. Studies by Qasim (1973) and Qasim, Wellershaus, Bhattathiri and Abidi (1969) showed that phytoplankton production increased during monsoon. The effect of salinity appears to be more pronounced only from secondary trophic level onwards.

ACKNOWLEDGEMENTS

The authors are grateful to the Director, NIO, for encouragement. Thanks are also due to Mr. K.J. Joseph, School of Marine Sciences, Cochin University of Science and Technology for the help in identifying phytoplankton.

REFERENCES

Devassy, V.P. and P.M.A. Bhattathiri, 1974. Phytoplankton ecology of the Cochin Backwaters. *Indian Journal of Marine Sciences*, **3**: 46-50.

George, A.I. and M.J. Sebastin, 1970. Review of the backwater fisheries and brackish water fish culture in Kerala state. Symposium on Coastal Aquaculture. *Proceedings of the Indo Pacific Fisheries Council*, IPFC/C 70/SYM, 19 (Mimeo).

Gopinathan, C.P., 1972. Seasonal abundance of phytoplankton in the Cochin backwaters. *Journal of the Marine Biological Association of India*, **14**: 568-577.

Gopinathan, C.P., P.V. Ramachandran Nair and A.K. Kesavan Nair, 1974. Studies on the phytoplankton of the Cochin backwaters, a tropical estuary. *Indian Journal of Fisheries*, **21**: 501-513.

Haridas, P., 1982. Zooplankton studies in the Cochin environs. *Ph.D. Thesis, University of Cochin*, 203 pp.

Joseph, K.J. and V. Kunjukrishna Pillai, 1975. Seasonal and spatial distribution of phytoplankton in Cochin backwaters, *Bulletin of the Department of Marine Sciences, University of Cochin*, **7**: 171-180.

Krishnankutty, M., 1986. Oceanology Cochin — Past, present and future from a limited perspective (In press).

Kumaran, S. and T.S.S. Rao, 1975. Phytoplankton distribution and abundance in the Cochin backwaters during 1971-72. *Bulletin of the Department of Marine Sciences, University of Cochin*, **7**: 791-799.

Madhupratap, M. and P. Haridas, 1975. Composition and variations in the abundance of zooplankton of backwaters from Cochin to Alleppey. *Indian Journal of Marine Sciences*, **4**: 77-85.

Madhupratap, M., T.S.S. Rao and P. Haridas, 1977. Secondary production in the Cochin backwaters, a tropical monsoonal estuary. *Proceedings of the Symposium on Warm Water Zooplankton, Special Publication, UNESCO/ NIO*: 515-519.

Nair, K.K.C. and D.J. Tranter, 1971. Zooplankton distribution along salinity gradient in the Cochin backwaters before and after the monsoon. *Journal of the Marine Biological Association of India*, **13**: 203-210.

Nair, K.K.C., V.N. Sankaranarayanan, T.C. Gopalakrishnan, T. Balasubramanian, C.B. Lalithambika Devi, P.N. Aravindakshan and M. Krishnankutty, 1988. Environmental conditions of some paddy-cum-prawn culture fields around Cochin (In press).

Purushan, K.S., T. Balachandran and M. Sakthivel, 1974. Zooplankton abundance off the Kerala coast during February and April, 1970. *Mahasagar – Bulletin of the National Institute of Oceanography*, **7**: 165-175.

Pillai, P.P. and M.A. Pillai, 1973. Tidal influence on the diel variations of zooplankton with special reference to copepods in the Cochin backwaters. *Journal of the Marine Biological Association of India*, **15**: 411-417.

Qasim, S.Z., 1973. Productivity of backwaters and estuaries. *The biology of the Indian Ocean*, edited by Zietzschel (Springer Verlag). *Ecological Studies*, **3** : 143-154.

Qasim, S.Z., S. Wellershaus, P.M.A. Bhattathiri and S.A.H. Abidi, 1969. Organic production in a tropical estuary. *Proceedings of the Indian Academy of Sciences*, **69(B)**: 51-94.

Qasim, S.Z., P.M.A. Bhattathiri and V.P. Devassy, 1972. The influence of salinity on the rate of photosynthesis and abundance of some tropical phytoplankton. *Marine Biology*, **12**: 200-206.

Qasim, S.Z. and V.N. Sankaranarayanan, 1972. Organic detritus of a tropical estuary. *Marine Biology*, **15**: 193-199.

Rao, T.S.S., M. Madhupratap and P. Haridas, 1975. Distribution of zooplankton in space and time in a tropical estuary. *Bulletin of the Department of Marine Sciences, University of Cochin*, **7**: 695-704.

Sankaranarayanan, V.N., S. Kumaran, T. Balasubramanian, Rosamma Stephen and S.U. Panampunnayil, 1982. Carbohydrates in the waters of ponds of Ramanthuruthu Island, Cochin. *Indian Journal of Marine Sciences*, **11**: 253-255.

Venugopal, P., P. Haridas, M. Madhupratap and T.S.S. Rao, 1979. Incidence of Red Water along south Kerala coast. *Indian Journal of Marine Sciences*, **8**: 94-97.

Venugopal, P., K.N. Remani, K. Sarala Devi and R.V. Unnithan, 1980. Fish kill in Chitrapuzha. *Seafood Export Journal*, **12**: 1-4.