TEN

ECOLOGY MUDBANKS — THE CURRENT SYSTEM OF ALLEPPEY MUDBANK

K. J. MATHEW, A. REGUNATHAN, C. P. GOPINATHAN, D. S. RAO and A. V. S. MURTHY

ABSTRACT

The knowledge of the water currents in the locality being essential for understanding the causes of formation, maintenance, movement and dissipation of mudbanks, the current system over two tidal cycles, one in May, before the formation, and the other in August, toward the end of the mudbank period, in 1975, at Alleppey mudbank was studied. Marked difference in the direction and velocity of the current was noticed between the two occasions. In May the effect of the tides was not noticeable on the direction of the current, which was southerly, whereas in August, though the major current continued to be southerly, the speed was considerably reduced due to tidal influence, introducing thereby a northerly component. Along with the current observations, the diurnal changes in the hydrological and biological aspects observed in the mudbank are reported.

INTRODUCTION

As the pattern of currents, with its possible influence on the physical, chemical and biological characters of the region, is bound to have a direct bearing on the formation, retention, upkeep, movement and dissipation of the mudbank, a study on the current system was made at Alleppey mudbank. Since the current velocity and other parameters would in all probability exhibit diurnal variation in relation to tide, the current system was studied at fixed intervals over two tidal cycles, one in May, prior to the formation of the mudbank, and the other in August, toward the end of its formation; after assessing the tidal influence it would then be possible to obtain the mean values of the characteristics, after eliminating the tidal influence.

MATERIALS AND METHODS

The observations were at first carried out on board the research vessel *Cadalmin-I*, anchoring in the mudbank off Purakkad at 4 m depth, about 1 km away from the coast, from 0900 hrs on 16th to 0400 hrs on 18th May 1975. For the 2nd set of observations in August, as mechanised vessels were not permitted then to operate within the mudbank area, a platform was made, tying two canoes together and anchoring it in the middle of the mudbank at 4m depth. From this platform the observations were conducted from 20.00 hrs on 16th to 19.00 hrs on 17th August 1975. On both the occasions the direction and velocity of the currents were measured by using an Ekman's Current meter, which was lowered to 2m depth, at one-hour intervals. The seawater samples for salinity, dissolved oxygen, nutrients and phytoplankton productivity were collected at 3-h intervals from surface and bottom. The quantitative and qualitative aspects of the phytoplankton were estimated by the settling method. The estimation of the chlorophyll content of the surface and bottom waters was made by filtering the samples through G. F. C. filters, dissolving in 90% acetone, centrifuging and transmission measuring using Spectronic-20. *In situ* experiments were conducted using ^{14}C for measuring the rate of primary production. Zooplankton sampling was done once in every 3 h by vertical tows from bottom to surface using a half-metre nylon net having mesh size of 0 4 mm. The volume of the plankton was determined by the displacement method. The zooplankton samples were analysed up to the group levels.

OBSERVATIONS AND RESULTS

Weather conditions

In May, at the time of starting the first set of observations, the sky was clear, the weather fair and sea calm. However, from 0200 hrs to

0900 hrs on 17th, it drizzled. The wind was calm during the midnight hours and in the early morning, but rose to a strength of 10–13 km per hour in the evening (Fig.2i). It rained heavily on the 18th morning. During the 2nd set of observations, it rained during the early hours of the night. The weather was fair during the following day. Maximum wind speed (fig.4 a) recorded was about 18 km/h, during noon on 17th August. The direction of the wind was north-easterly during night and north-westerly during the day.

Currents

The direction of the currents observed during the first observations is presented in fig-1. The figure indicates the percentage of lead balls fallen in each chamber. The distribution of total number of balls is indicated at the right extreme column of the figure. It is interesting to note that, throughout the period of observations, the directions of the current was between 150° and 180°, except at times when the flow was nearing zero and the water thrust was too feeble to keep the current meter in a fixed direction. The major direction was at 160°, indicating the coast-parallel southerly flow (longshore current), during the entire period of observations. The results obtained during the 2nd set of diurnal observations were totally differenf in that the water movement was in all the directions (Fig.3). A northerly flow was set in at about 0400 hrs, eventhough its duration was short during the tidal period. The differences in the pattern of direction of incurrents at the two phases of the mudbank is considered significant.

Fig. 2a represents hourly variations of the strength of the flow during May. The values of

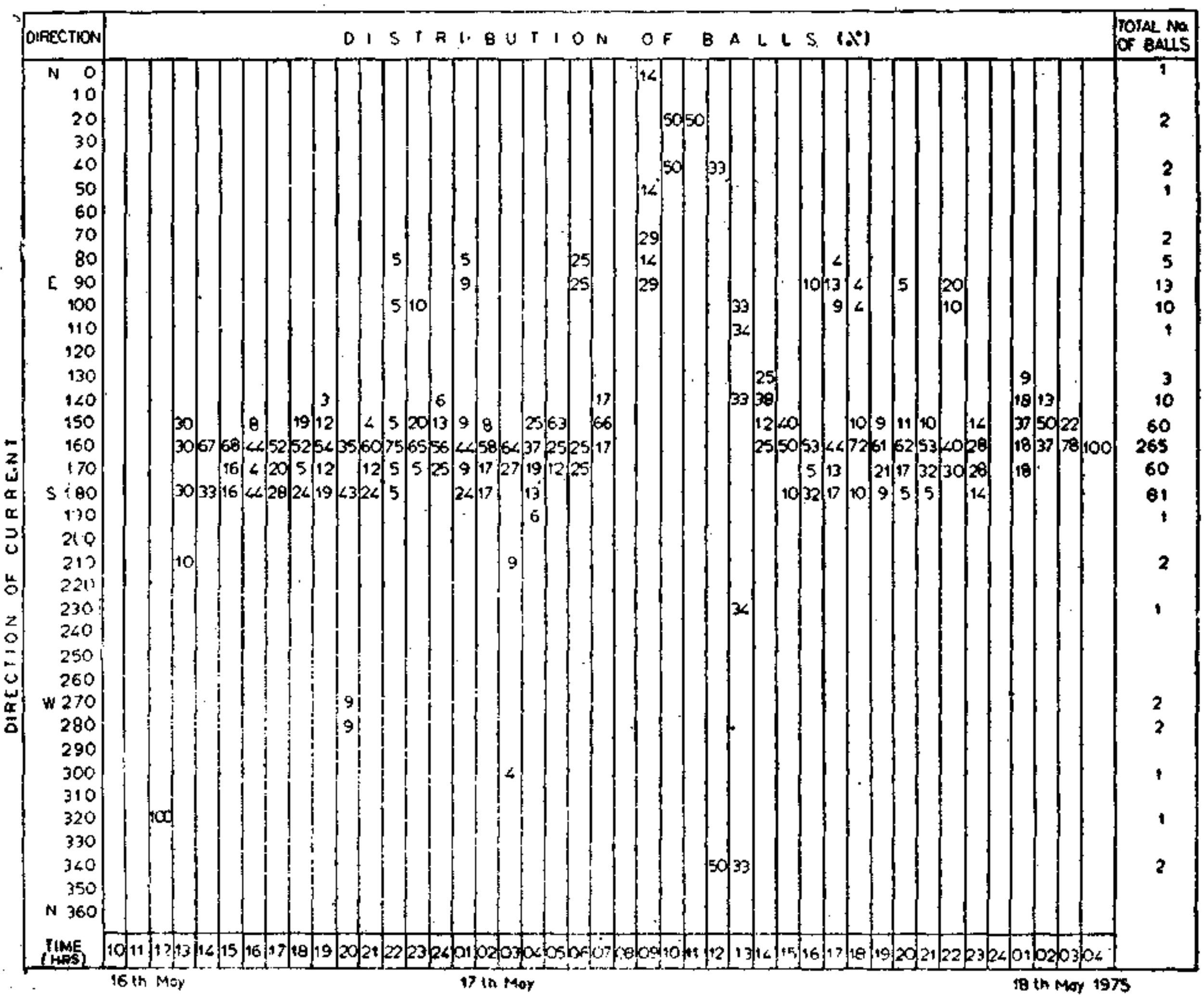

Fig. 1. The hourly distribution of balls in the current meter to show the direction of current, during 16-18 May 1975.

observed flow were smoothened out in order to eliminate the observational errors if any This smoothening effect was brought out by overlapping means, taking three consecutive values at a time. The smoothened data (Fig. 2 b) were considered for further analysis.

As the observed flow was practically confined to the coastline direction with nocoast-normal component (as revealed from Fig. 1), the influence of tidal forces on the currents of the location is only oscillatory, not rotatory. In order to nullify the effect of tides on currents, mean values for 25 h were considered. Thus, there is a set of 16 moving averages obtainable from the middle portion of observations, barring the extreme 12 h on either side of the observational period from 1200 hrs on the 16th to 0300 hrs on the 18th.

It is well known that the tides and tidal currents are caused by the gravitational forces of the sun and moon exerted on the earth. The times of occurrence of high and low tides at Cochin corresponding to the period of current observations are noted from the Tide table and presented in fig. 2. The lowest low tide on 16-5-75 was 33 cm at 10.09 hrs and the highest high tide (105 cm) occured at 1722 hrs on the same day. The next day the lowest low tide of 38cm occurred at 1046 hrs, while the highest high tide of 103 cm occurred at 1759 hrs.

The tidal currents are less readily observed than the tides and even more difficult to examine theoretically (Sverdrup et al 1942). Owing to the proximity of the moon to the earth, the lunar influence are predominant on tides, and tidal currents therefore exhibit an average length of diurnal tidal period equal to a lunar day (24 h 50 min., which is approximately 25 h).

Assuming that the lunar diurnal, semi-diurnal and quarter-diurnal cyclic variations are present in the total fluctuations of currents, and considering twenty-five hourly observations from 1200 hrson16.5.75 to 1300hrs. on17.5.75, the harmonic coefficients are determined

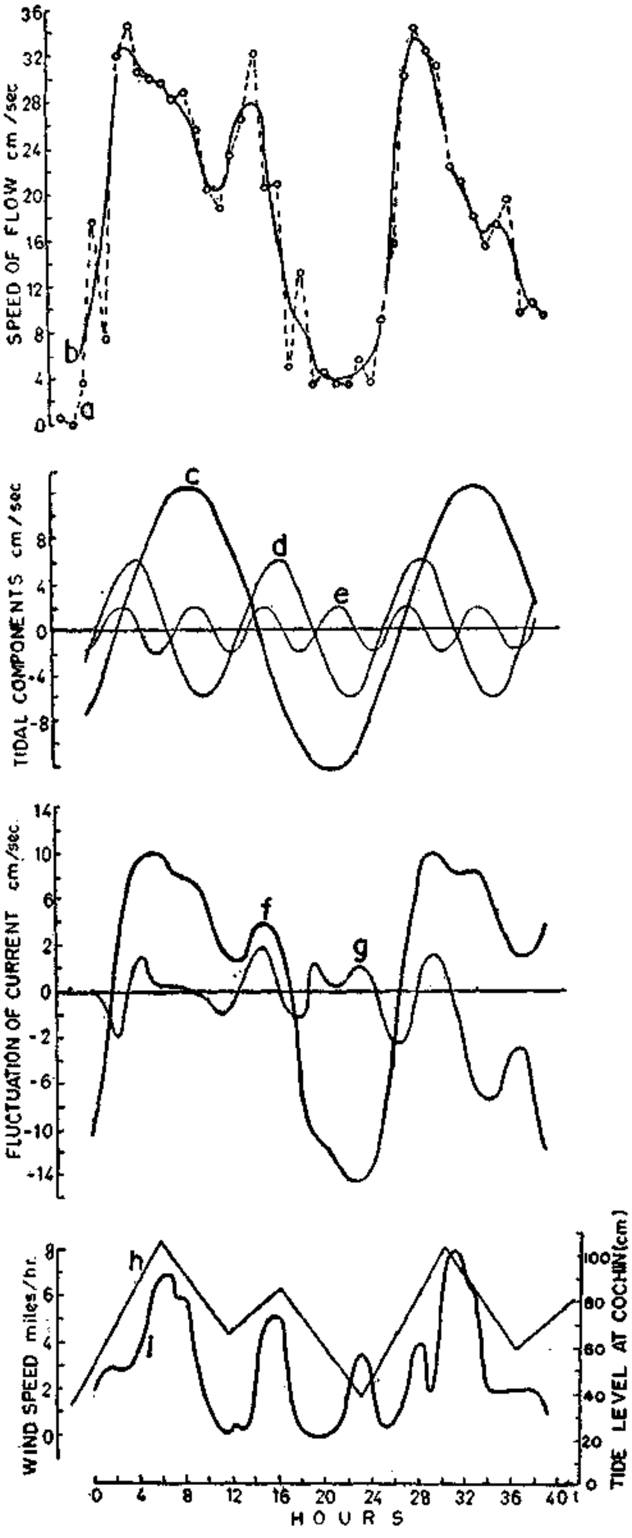

Fig. 2. Speed of current flow, tidal components, current fluctuation and wind speed during 42 hours, starting from 1200 hrs on 16th May. a: absolute values of currents observed; b: observed currents after smoothening of overlapping values; c: diurnal component of tidal flow; d: semi-diurnal component of tidal flow; e: quarter-diurnal component of tidal flow; f: effective tidal flow; g: residual flow; h: tide level at Cochin; i: wind force.

by framing linear equations (Joseph Lipka, 1918 & Selvadori, 1948). The results are:

$$V_t = 18.5 - 7.57 \text{ Cos } 2\pi \frac{t}{\tau_1} - 2.95 \text{ Cos } 2\pi \frac{t}{\tau_2} - 1.85 \text{ Cos } 2\pi \frac{t}{\tau_3} + 9.73 \text{ Sin } 2\pi \frac{t}{\tau_1} + 5.25 \text{ Sin } 2\pi \frac{t}{\tau_2} - 0.117 \text{ Sin } 2\pi \frac{t}{\tau_3}$$

where t refers to time in hours, starting from noon of 16th May 1975, τ_1 is the diurnal tidal period (24.8 h), τ_2 is the semidiurnal period (12.4 h) and τ_3 is the quarter-diurnal period (6.2 h). The mean steady current is 18.5 cm/sec. The amplitude of the three tidal components are 12.3 cm/sec., 6.0 cm/sec. and 1.9 cm/sec., respectively (Fig. 2c, d, e). The proportionality of the respective amplitudes is 6:3:1. The resultant of the three tidal components is presented in fig. 2f. From the figures it is clear that the high tides coincided with the maximum and the low tides with the minimum of the tidal component of the tidal flow. The highest high tides of both the days correspond to the peaks of southerly tidal components of the currents and the lowest low tides to the northerly components of the tidal oscillations.

The residual currents obtained on subtracting the tidal components and as expressed over the mean current (18.5 cm/sec.) is presented in fig. 2g. Therefore the zero line in figs. 2c-g refers to the steady southerly current. The positive values along the vertical axis refer to southerly fluctuations and the negative values to the northerly components of fluctuations. The estimated wind force is presented in fig. 2i for comparison of current fluctuations. Observations on wind-speed variations showed almost calm conditions during the midnight on 16/17th and also during early morning hours on 17th. The wind rose to about 10-13 km/h by the evening hours on both the days as the sea breeze gained strength. On the 17th May the wind rose to about 7 km/h between 0300 and 0400 hrs from the midnight calm conditions. Throughout the period of observations, the wind consistantly blew from northwest. There is a general agreement between the peaks of wind force and strong southerly components of the residual currents, indicating the influence of weather (wind) on such current fluctuations.

Hourly observations of currents were made over a total period of 24 h in August. Unlike the previous occasion, the water movement during the present investigation was in all the directions during the course of the tidal period (fig. 3). Nevertheless, the major currents were southerly. A northerly flow was set in, even though its duration (about 4 h) was short during the tidal period.

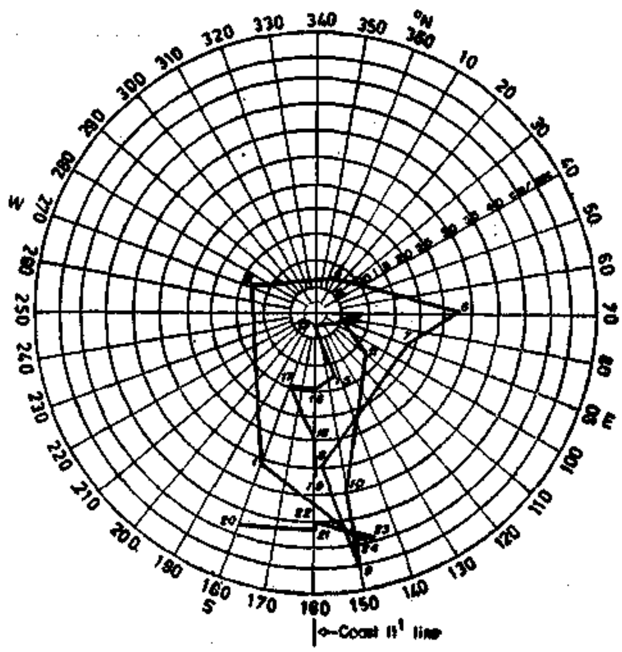

Fig. 3. Hourly observation of currents.

The mean southerly component (fig. 4 b) of the current during the tidal period was 24 cm/sec, while the mean northerly component was only 5cm/sec. The net flow (southerly) was 18 cm/sec. The coast-normal components of current are indicated in Fig. 4 c.

Hydrography

The diurnal variations in the hydrographic properties showed a high correlation with the current and tidal influence. In May the surface temperature (fig. 5 a) showed a maximum at 1500 hrs on both the days. During the second diurnal cycle (August), the temperature at both surface and bottom was more or less steady

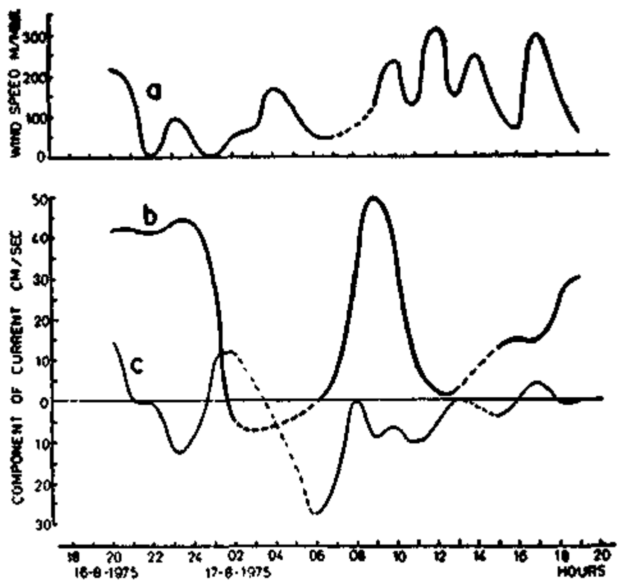

Fig. 4. Wind speed (a), coast parallel component of current (b) (positive Southerly) and coast normal component of current (c) (positive northerly).

(fig.7a). The mean of the diurnal cycle was about 26.0°C at the surface and 23.0°C at the bottom.

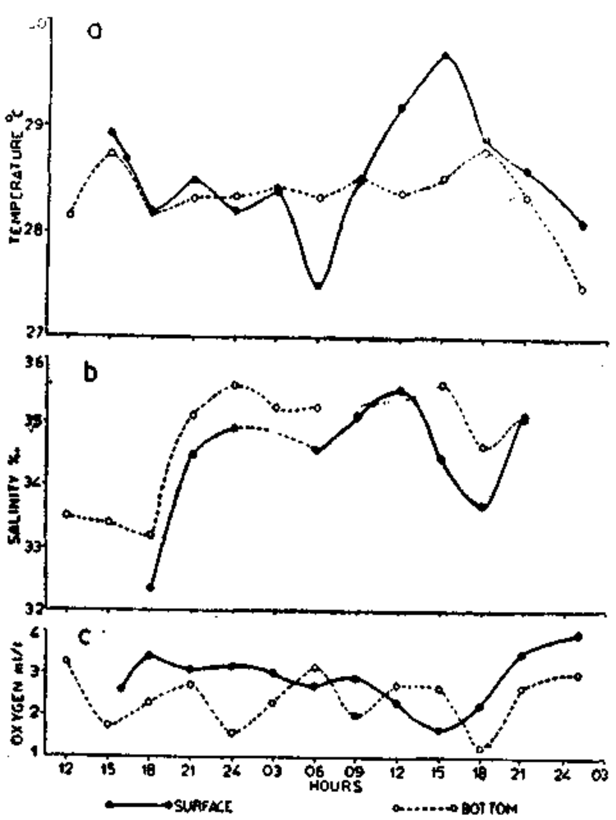

Fig. 5. Diurnal variations in the physical properties of water. a: temperature; b: salinity; c: dissolved oxygen.

Salinity

The salinity variations during the first diurnal cycle at surface and bottom are given in fig. 5 b. The surface salinity values were generally lower than the bottom. They were maximum at 1200 hrs on 17th. The bottom values showed a maximum at 2400 hrs and 1500 hrs (35.50‰). The mean values of salinity at the surface was 34.57‰, whereas at the bottom it was 34.62‰. On the other hand, the salinity values fluctuated over a wide range during August (fig. 9 a). The wide fluctuations were due to the varied degree of mixing of seawater with fresh water, which was being discharged in August from the Thottappally spillway, about 2 km south of the place of observation.

Oxygen

Fig.5 c shows the variations in the dissolved-oxygen content at surface and bottom during May. The values were more or less steady throughout the period of investigation. At the surface the values were around 3 ml/l while at bottom it was around 2.4 ml/l. During August the dissolved oxygen (fig. 7 b) of the mudbank waters fluctuated from about 0.5 ml/l to 3.0 ml/l, with a mean value of about 2 ml/l. The hour-to-hour variations were maximum, both at surface and bottom, which was indicative of the mixing process in the mudbank of waters of different qualities, which was characteristic during August.

Nutrients

The reactive-phosphate content of the water at surface and bottom in May is shown in fig. 6 a. The surface values showed that the maximum was at 2100 hrs (1.75 µg at P/l) on the 17th. Minimum was found at 1800 hrs and 2400 hrs on 16th and 1500 hrs on 17th. The bottom values showed that it was less at 1800 hrs on both the days and in the early morning hours. In August there was little difference between the surface and bottom values (fig.9 b). The values varied from 1 to 2 µg at P/l.

The Nitrite-N values of the water for May is shown in fig 6 b. NO_2-N maximum was found in the surface at midnight on 16th and at 1500 hrs and 2100 hrs on 17th. The bottom values showed peaks at 1800 hrs on 16th and

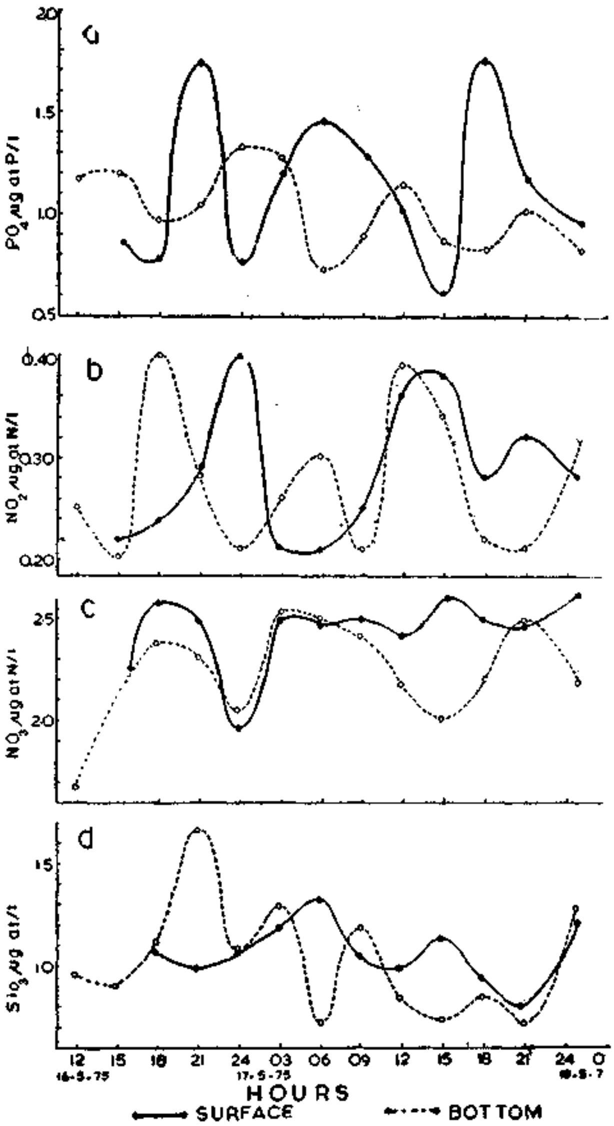

Fig. 6. Diurnal variations in the nutrient contents.. a: phosphate; b: nitrite; c: nitrate; and d: silicate.

0600 hrs, 1200 hrs and 2400 hrs on 17th. In August the Nitrite-N values (fig.7 c) varied between 0.15 and 0.85 µg at N/l.

The variations of NO_3-N at surface and bottom for May are shown in fig.6 c. Both surface and bottom values showed peaks at 1800 hrs on 16th and early morning hours on 17th. In general, the NO_3-N values showed the same trend at surface and bottom except at 1500 hrs and 1800 hrs on 17th. In August the nitrate values showed variations between 1.1 and 1.5 µg at N/l (fig.9 c). The values were generally more at the bottom.

The values obtained during May for the silicate content at surface and bottom are represented in fig. 6 d. In general, the silicate values were higher at the surface (10.62µg at SiO_3-S/l) than at the bottom (10.18µg at SiO_3-S/l). At the surface the peaks were at 0600 hrs and 1500 hrs on 17th and 0100 hrs on 18th, whereas at bottom the peaks were found at 2100 hrs on 16th and 0300 hrs and 0900 on 17th and 0100 hrs on 18th. During August the silicate values were comparatively more at the bottom (Fig. 9 d). An almost steady increase, both at surface and bottom, was noticed from the beginning to the end of the observation. The values ranged between 5µg at S/l to 15 µg at S/l.

Phytoplankton productivity and chlorophyll

The productivity values obtained by the ^{14}C technique indicated that on 16th May the rate of production was 35 mgC/m³/h at 0900 hrs. The production rate increased towards the noon reaching a value of 106 mgC/m³/h at 1200 hrs. Since then the rate of production showed a decline and at 1500 hrs it was only 4 mgC/m³/h. The midday maximum in the rate of production appears to be related to the sunlight conditions. In August a slight difference was noticed with regard to the time of peak production. The production rate increased from 0600 hrs and reached its maximum at 10.00

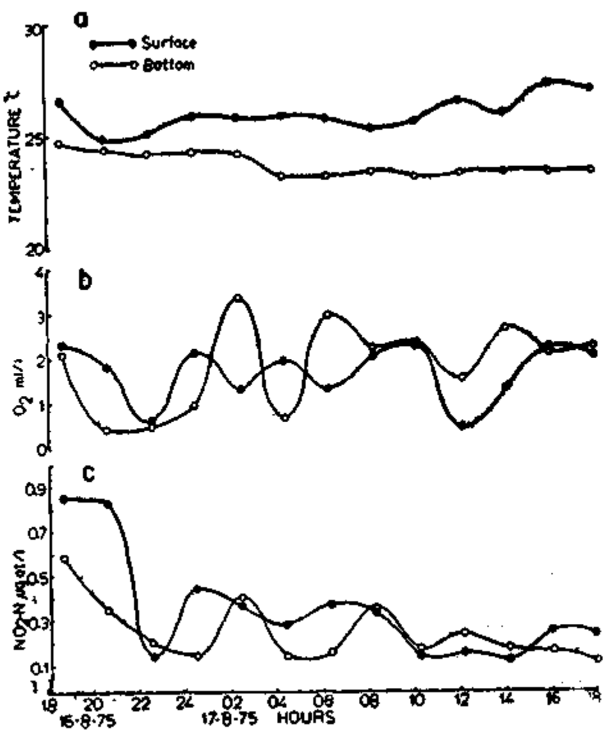

Fig. 7. Diurnal variations of temperature (a), dissolved oxygen (b) and nitrite (c).

hrs (200 mgC/m³/h) and decreased from noon to evening (Fig.9f). The low rate of production was recorded towards the evening at 1600 hrs (10.1 mgC/m³ h).

The diurnal variations of chlorophyll in May and August, for both surface and bottom, are shown in fig 8 and 9 e. In May the values showed two peaks at surface at 0900 hrs on 16th (23.5 mg/m³) and at 0300 hrs on the next day (29.37 mg/m³). The minimum value

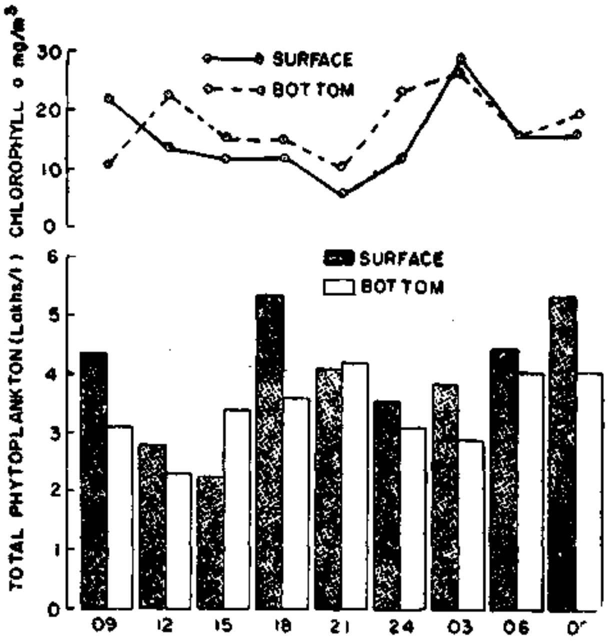

Fig. 8. Diurnal variations in the standing crop of phytoplankton in terms of total cell counts and chlorophyll *a*.

of 6.41 mg/m³ was noticed at 2100 hrs. The bottom values also showed 2 peaks; one at 1200 hrs on 16th (22.43 mg/m³) and the other at 0300 hrs on 17th (16.7mg/m³). In August the chlorophyll values showed wide fluctuations and the maximum value of 100 mg/m³ was noticed at 1000 hrs on the surface During this hour the bottom value was 80.00 mg/m³, which was the maximum for the bottom waters. The minimum values (5-6 mg/m³) were noticed during the midnight on 16th and 17th.

Qualitative studies on phytoplankton

The diurnal variations in the total cell counts of phytoplankton estimated per litre of water for both surface and bottom are given in fig.8 for May and in fig.9 f for August. In May there were two peaks at the surface, one at 0900 hrs and the other at 1800 hrs. In the case of the total cell count at the bottom, the peaks were at 0900 hrs, and at 2100 hrs. In general, the variations in the cell counts were

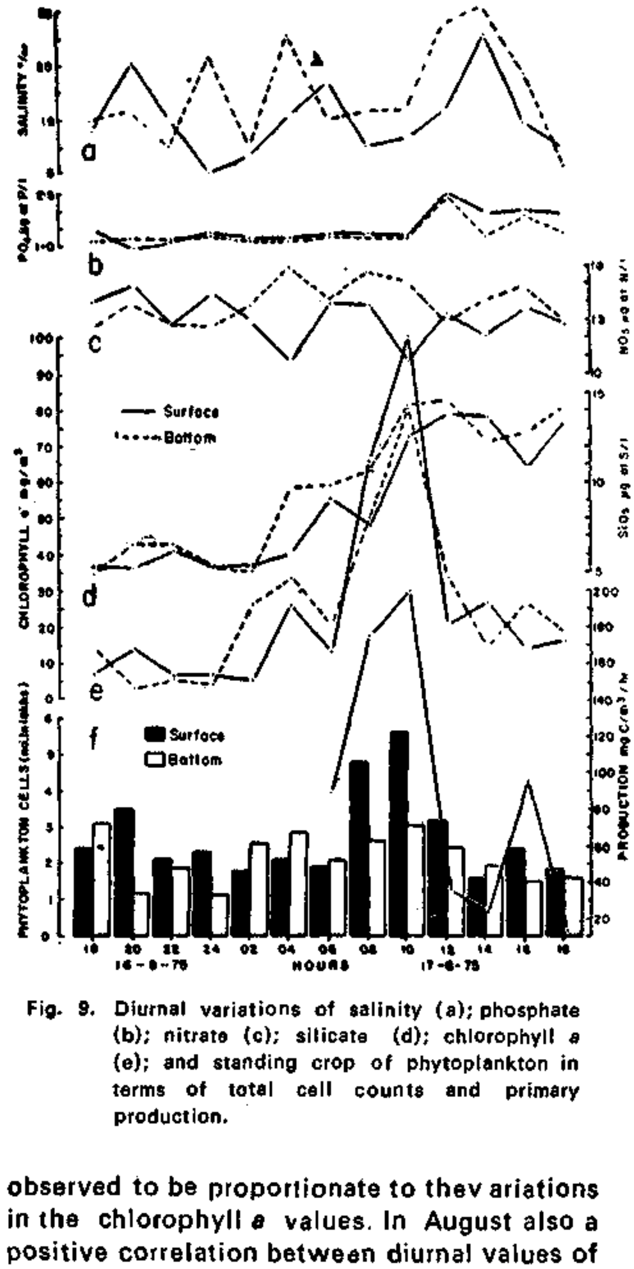

Fig. 9. Diurnal variations of salinity (a); phosphate (b); nitrate (c); silicate (d); chlorophyll *a* (e); and standing crop of phytoplankton in terms of total cell counts and primary production.

observed to be proportionate to the variations in the chlorophyll *a* values. In August also a positive correlation between diurnal values of chlorophyll *a* and total cell counts was observed. The night samples showed less number of cells and the minimum was found at 0200 hrs. The cell counts showed a gradual increase from 0600 hrs and reached the peak at 10.00 hrs whence it declined.

In May, all the samples considered together, 38 species of phyotoplankters (excluding the nannoplankton), 18 species of diatoms, 7 dinoflagellates and the other 3 species, represented by the blue-green algae, were noticed in the water. Silicoflagellates and coccolithophores were totally absent It was found that 5 species of diatoms, such as *Coscinodiscus* sp. *Biddulphia sinensis, Chaetoceros curvisetus, Thalassionema nitzschioides* and *Asterionella japonica*, were represented throughout the period of observations. In August, even though Diatomaceae were abundant in general, one member of the Cyanophyceae, *Microcystis* sp, caused a bloom, which was responsible for a high rate of production, high chlorophyll content and total cell counts. Silicoflagellates and coccolithophores were found to be totally absent in the samples. It was observed that, during this month, four species of diatoms, namely, *Coscinodiscus, Nitzschia, Navicula* and *Pleurosigma*, were represented throughout the period of investigation.

Zooplankton biomass

Owing to the comparatively large mesh size of the net (0.4 mm), relatively large zooplankters only were obtained. The zooplankton biomass was comparatively more during May.

In May the displacement volume (fig.10) varied between 0.1 ml and 2.5 ml per sample (1.27 to 3.17 ml/m³ of water). In August the displacement volume was not estimated on account of the poor quantity of zooplankton obtained. In both the months the zooplankton was more during the night. In May the biomass showed maximum at 2100 hrs and 2400 hrs on 16th and 0300 hrs and 2100 hrs on 17th. The minimum biomass was found from 0900 hrs to 1800 hrs on the first day and at 1200 hrs on the second day. On the whole, the first-night samples were richer than the second-night samples.

The relative abundance of various zooplankton groups obtained during May and August is given in Table. 1

Table 1

The relative abundance (in %) zooplankton groups

Zooplankton groups	May	August
Copepoda	87.97	10.87
Chaetognatha	7.77	—
Decapod larvae	2.20	3.09
Appendicularians	1.34	—
Pleurobrachia	0.67	—
Lucifer	0.56	—
Polychaeta	0.14	5.49
Medusa	0.13	0.10
Acetes sp.	0.13	—
Fish larvae	0.06	0.30
Amphipoda	0.02	0.83
Juveniles of *Barnea* sp.	—	72.73
Zoea larvae	—	4.30
Cladocera	—	0.41
Fish eggs	—	1.86
Cumacea	—	0.11

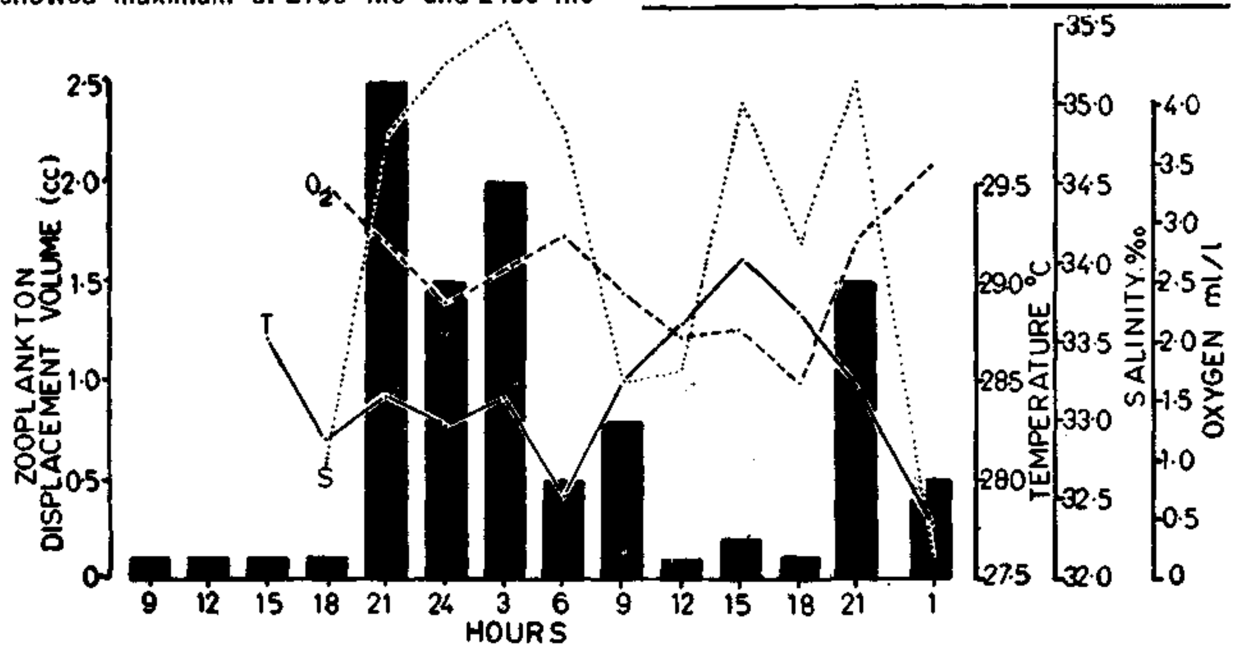

Fig: 10. Biomass of zooplankton in relation to diurnal variation in the physical properties of water.

There was a remarkable difference in the composition and relative abundance of various groups of zooplankters in the two months. While copepods formed the major group in May, the juveniles of *Barnea* sp. dominated over all the others in August. Some groups, like chaetognaths, appendicularians, lucifer, pleurobrachia, and medusa, were absent in August, which was mainly because of the low salinity of the mudbank waters during this month.

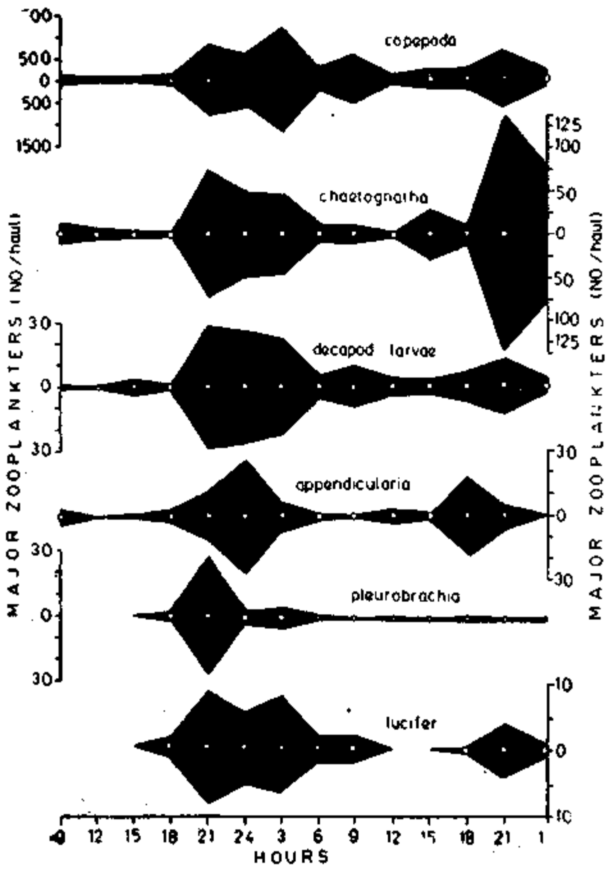

Fig: 11. Diurnal variations of the major zooplanktonic groups on 16-18 May 75.

The diurnal variations in the numerical abundance of zooplankton groups are presented in figs. 11 and 12. In May the percentage composition of copepods in the different samples in relation to other zooplankters ranged between 71.6 and 95.3 (Fig 13), while in August it varied between 0.2 and 36.7 only (Fig. 14b). Their number during the first observation showed pronounced diurnal variations, being in the range respectively of 82 to 1083 during day and 532 to 2442 during night (Fig.11) Numerically the copepods were much less during August. But as in May, they were relatively more during the night (Fig. 12). While 624 specimens were caught in 7 night collection only 94 specimen were present in the 6 day samples.

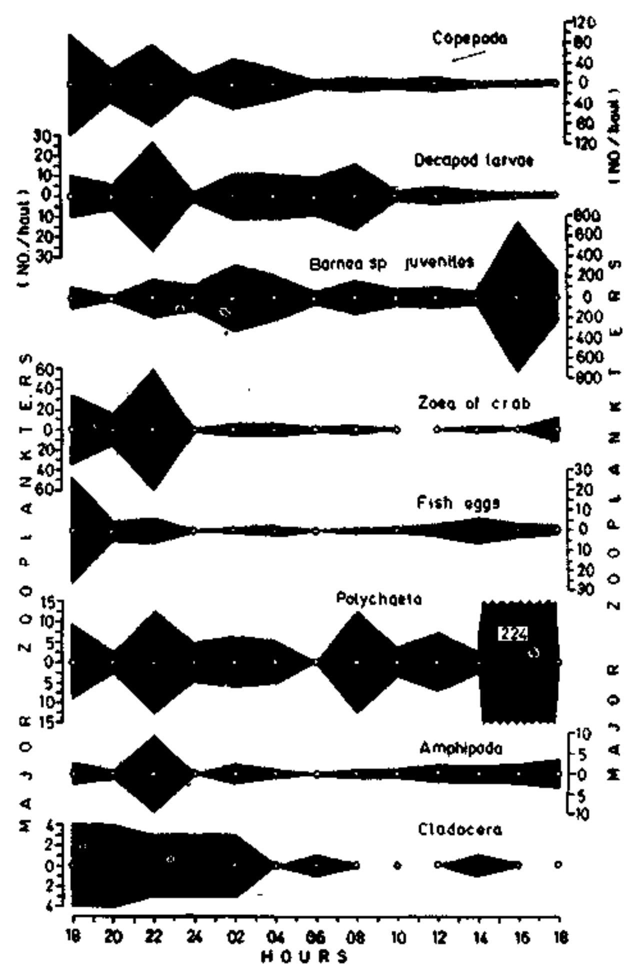

Fig: 12. Diurnal variations of the major zooplankton groups on 16-17 August 75.

The relative abundance of chaetognaths, which were present during May only, varied from 1.3 to 26 3% (Fig. 13). The maximum abundance was noticed at 2500 hrs on both the nights and minimum at 1800 hrs on 16th and 1200 hrs on 17th (Fig.11).

The decapods were mainly composed of prawn larvae. The percentage distributions in the different samples in May ranged between 1 and 7.5 (Fig. 13). The maximum number of 60 was obtained at 2100 hrs on 16th. The minimum number was found during the day hours. (Fig. 11). in August the prawn larvae occurred in all the samples, though in varying numbers. While a total of 134 specimens were present in the 7 samples collected in the night, only 70 specimens were present in the 6 days samples. Their percentage contribution in the

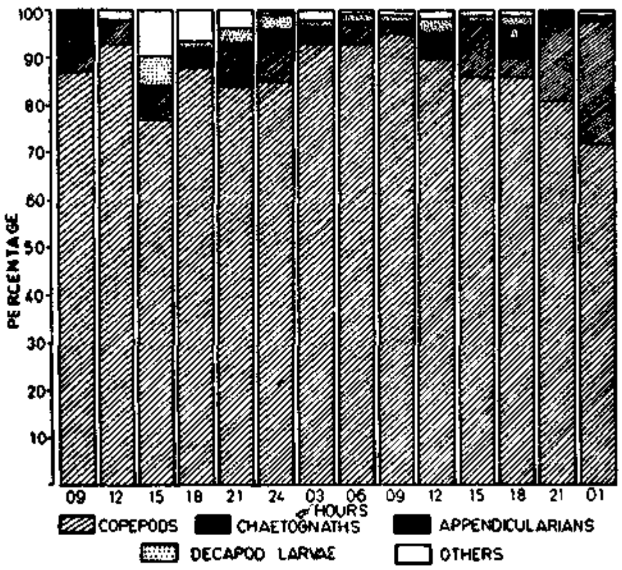

Fig: 13. Relative abundance of important zooplankton groups in the total samples.

different samples varied from 0.1 to 8.2. The maximum number of 54 was obtained around 2200 hrs (Fig. 12).

The percentage contribution of appendicularians in the different samples in May was low, ranging from 0.3 to 6.7 (Fig. 13). Their maximum abundance was noticed at 2400 hrs on the 16th and at 1800 hrs on 17 th (Fig. 11). The minimum was found during day, between 1200 and 1500 hrs on the first day and between 0600 hrs and 0900 hrs on the 2nd day. This group was absent during August.

The pleurobrachia was also present during May only. Their abundance was found only from 1800 to 0600 hrs on the first night with the peak at 2100 hrs (Fig. 11). Their percentage of abundance among other groups in the different samples ranged from 0.06 to 2.9.

Lucifer was another group which was absent in August. In May also they constituted only a small percentage in the plankton, ranging from 0.2 to 1.3. They were especially noted for their presence in the collections during the night hours (Fig.11). The maximum abundance was noticed at 2100 hrs and again at 0300 hrs on the first night. The second night collections contained less number of specimens.

Eventhough the plychaetes were present in May as well as in August, they occurred in very few numbers during the former month. Out of the 14 samples only 5 contained a single specimen each. It was interesting to note that they were present in the day samples only. However, in August, except at 0300 hrs, they were present in the samples collected in the other hours (Fig. 12). There was no indication of any difference in their diurnal abundance. In this month the percentage composition of polychaetes larvae to other zooplankton was between 1.8 and 12 9 (Fig 14 b).

The medusae were poorly represented in May and were found in only 5 samples, mostly collected during the night. In August 6 specimens were present in a single night collection. *Acetes* sp. was also rare occurring only in 4 samples collected in the night in May. A total of 7 fish larvae were found in 3 samples collected in May. In August they occurred in 4 samples of which 3 were collected

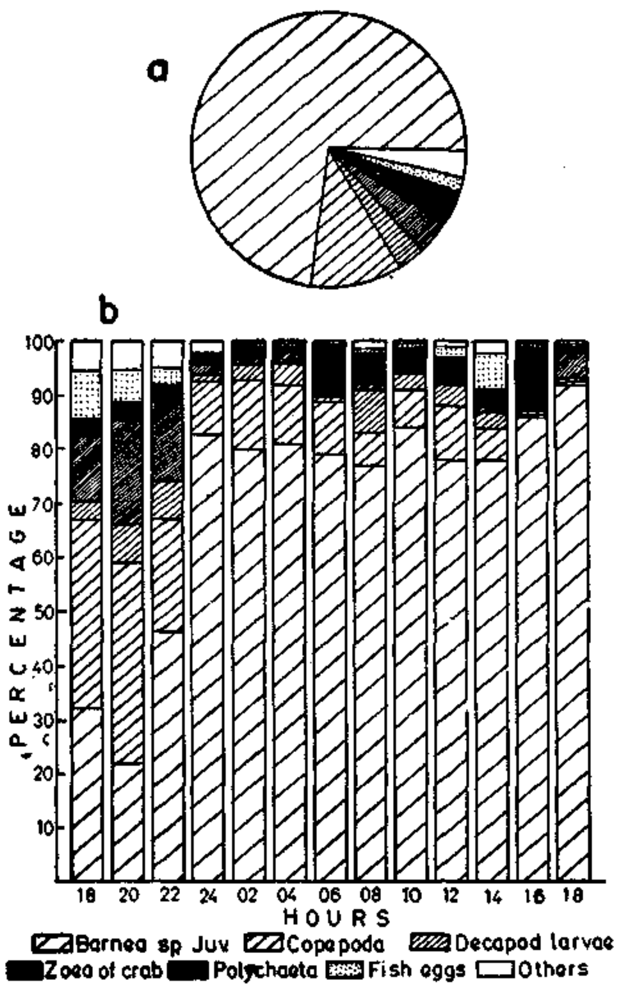

Fig: 14. Percentage composition of important zooplankton groups in the total samples (a); and their percent composition in various samples (b).

during the night. One specimen of amphipoda was present in each of the 2 samples in May.

The percentage abundance of juveniles of *Barnea* sp.,a bivalve present in the zooplankton, varied between 22.2 and 91.6. They were present in August and was them the most abundant form. The number in the different samples ranged from 40 to 1500. However, diurnal variation was not noticed. The zoea larvae, which constituted 4.3% in the total plankton, was the 3rd abundant group in August. They showed marked diurnal variations The cladocerans, though were present in a limited number of samples (only in August), were remarkable for their diurnal variations. Among the night samples they were present in all but one. One specimen each was present in 2 of the day samples also.

The fish eggs were present in all but 2 samples in August and their percentage in the different samples ranged between 0.2 and 2.4. A good number of them were present in the beginning of the observations and at 1800 hrs, 53 numbers of eggs were present, Eventhough the fish eggs were more in 3 of the night samples, a diurnal difference in their presence was not noticed. Six number of benthic cumaceans were also present in 4 of the night samples of August.

DISCUSSION

The investigation shows that, during May, the seasonal currents in the mudbank was southerly. The peaks correspond to the high tides and the troughs to the low tides. Therefore the high tide corresponds to the southerly component of the tidal current. The lowest low tide (1100 hrs), which reversed the tidal current to the northerly direction (14 cm/sec.) was sufficient to nullify the steady southerly flow (18.1 cm/sec.) completely. Thus the current direction was always maintained at 160° (southerly). In August change in the direction of current was observed. The weaker coast-normal currents indicated the transitions of the change over from the southerly currents during monsoon to the northerly current system during the winter. It may be noticed that, in August, the offshore components, though feeble, was present almost throughout the day. Such a development in the current systems towards the end of the mudbank sea-

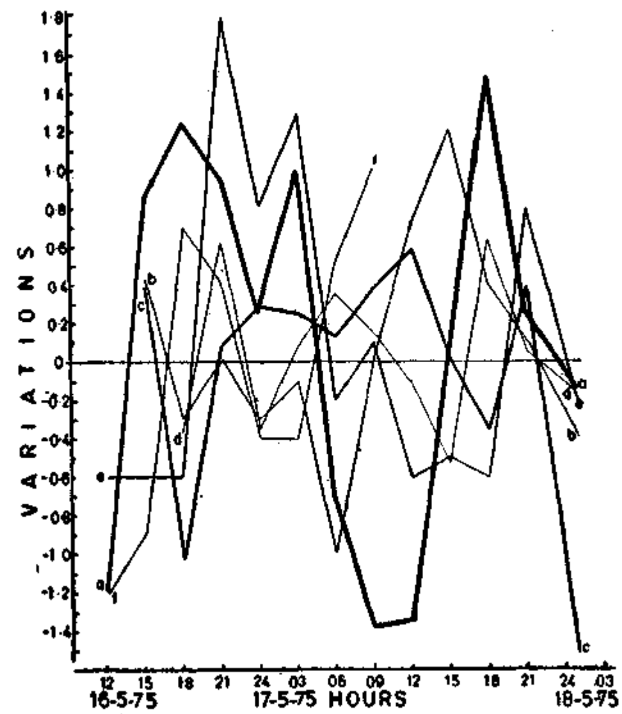

Fig. 15. Anomaly of various parameters studied: a-current (from 18 cm/sec: Scale X10 = velocity in cm/sec); b. surface temperature (from 28.5° C); c. surface salinity (from 34.35 ‰); d. surface phosphate from 1.13/g at P 1); e. mean values of zooplankton displacement volume (from 0.1 cc); f. mean cell counts of phytoplankton (in lakhs).

son has a definite bearing upon the dissipation of the mudbank. The stronger the development of the offshore currents, the quicker the dissipation by mixing with the offshore waters.

When the anomaly of various parameters, such as temperature, salinity, reactive phosphate, phytoplankton cell counts and zooplankton biomass, was compared with the changes in the pattern of the currents in May, a high degree of correlation was noticed and the same is presented in fig. 15. However, in August, the centre of observation being closer to Thottappally spillway, through which there was a constant outflow of fresh water, and being further influenced by the tides, and currents, the hydrographic properties, such as temperature, salinity and dissolved oxygen, showed great fluctuations from hour to hour. The complexity of variations was such that a definite correlation of any of the hydrographic parameters with the pattern of the currents was not possible. With regard to the phytoplankton productivity, no significant changes

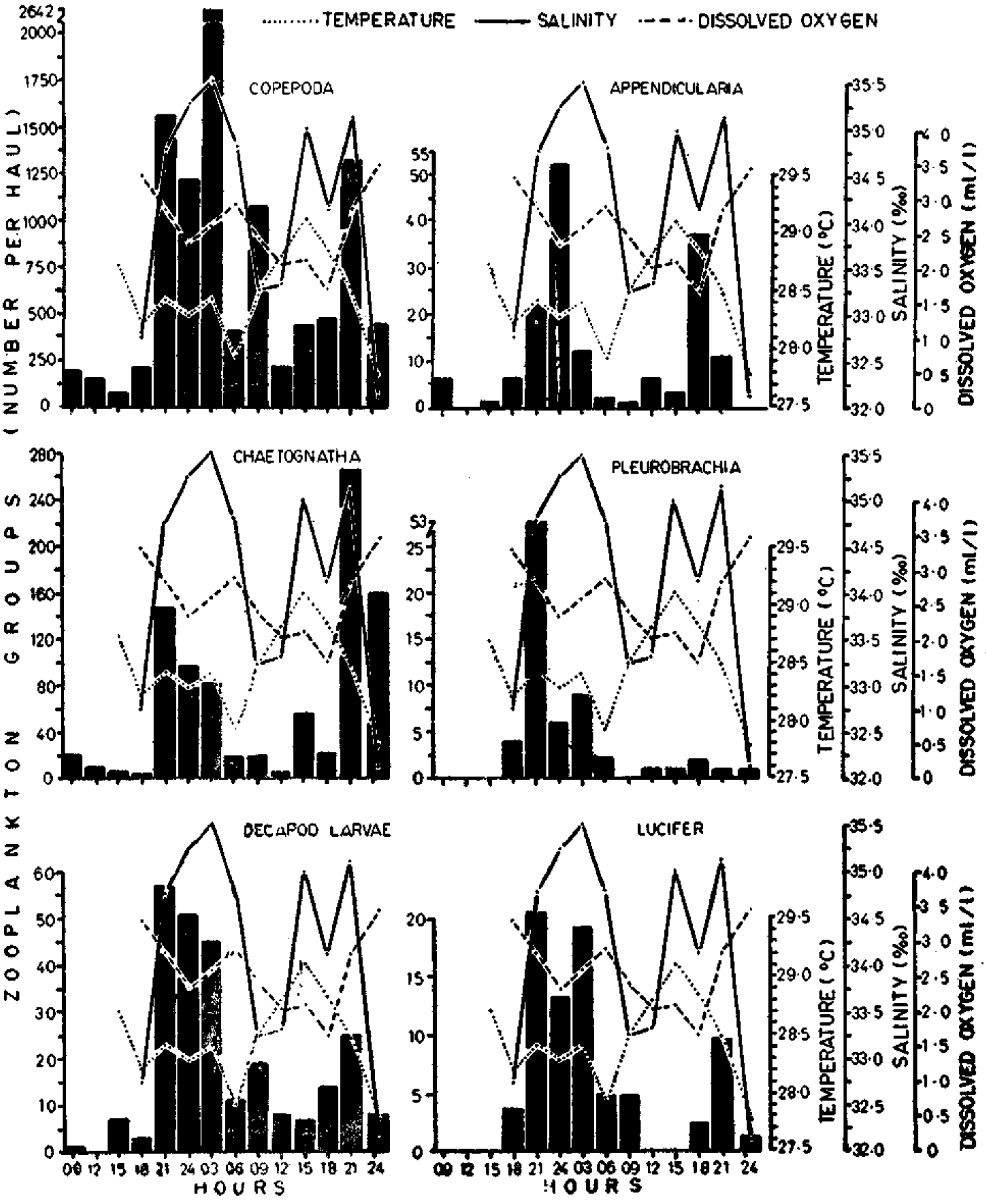

Fig. 16. Diurnal abundance of the important zooplankton groups in relation to environmental parameters on 16-18 May 1976.

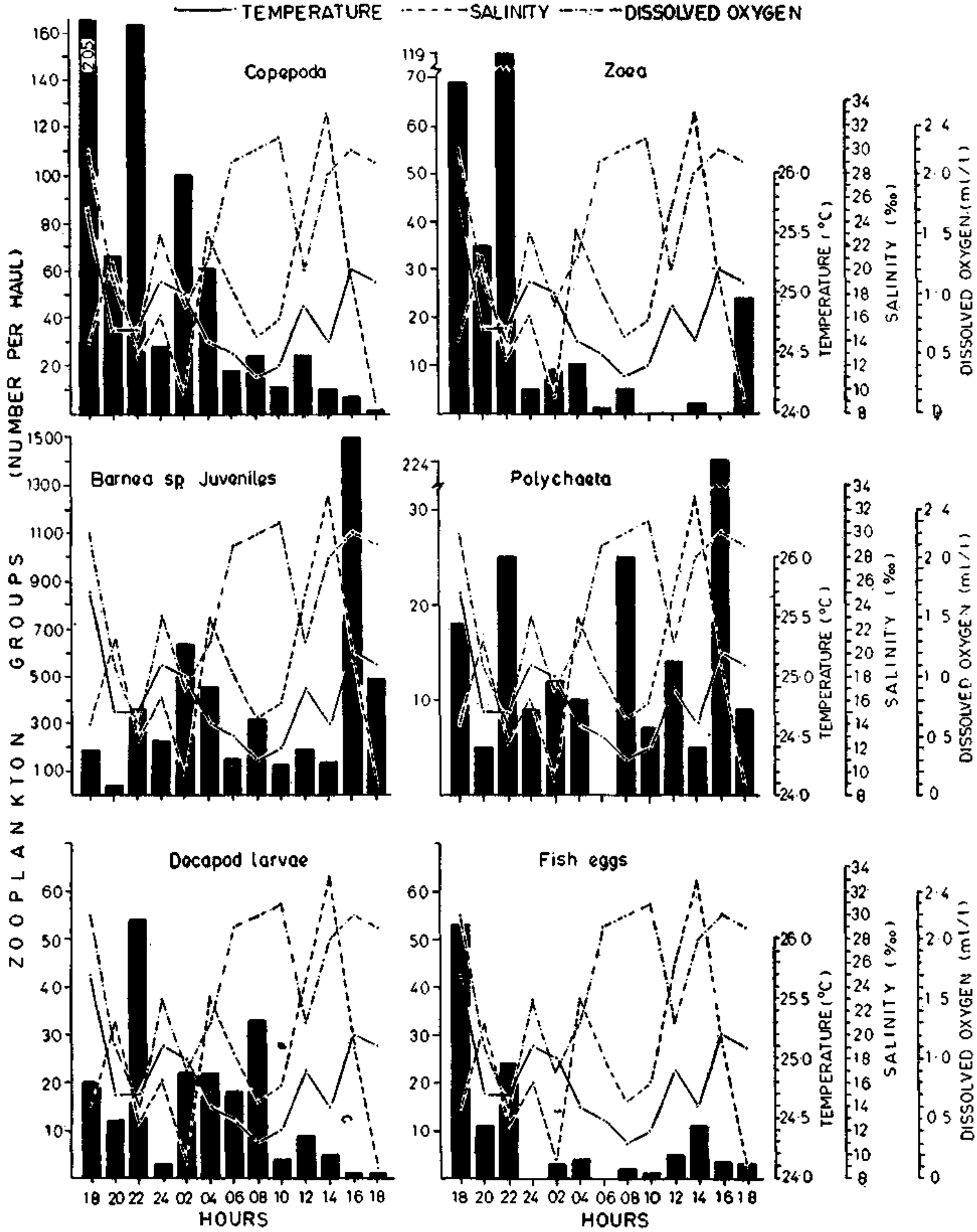

Fig. 17. Diurnal abundace of the important zooplankton groups in relation to environmental parameters on 16-17 August 1975

were noticed during the diurnal observations in May other than what usually happens in the inshore areas.

The production at the primary level during the 24-h period in August was generally high. However, this high rate of production was mainly due to the presence of *Microcystis* sp., a freshwater alga which was brought down through the spillway. Its population was especially more between 0800 hrs and 1200 hrs. during which period the marine diatoms and dinoflagellates, such as *Nitzschia, Pleurosigma. Ceratium* and *Peridinium,* were totally absent,

During both these periods of diurnal observations the zooplankton was more during the night. This cannot be attributed to the vertical migration. as the plankton samples were collected from the bottom to the surface straining the complete water column. The avoidance reaction of zooplankton to the sampling net could be one reason for their reduced frequency in the day samples. However, light being the most important factor in the vertical distribution of the zooplankton, their day time aggregation in the deeper strata may reflect in a low catch by the net. During the night the diffused condition of the zooplankton distribution in the complete water column enhances the chances of capturing the zooplankters. In spite of the rather turbid nature of the subsurface water at the mudbank, this general principle of the zooplankton distribution was found operating in the mudbank.

Eventhough light plays an important role in the diurnal variations of the plankton in general, the effect of temperature and salinity are also significant. In May the plankton showed maximum abundance when these two environmental parameters were almost steady (fig:16). For example the salinity was at its maximum during the whole period of the first night and the temperature was moderate. This was followed by the maximum abundance of plankton in general and different groups in particular. But during the second night the salinity showed greater fluctuations and declined to the minimum at 0100 hrs. The temperature also showed a steady decrease during the period and dropped to the minimum by 0100 hrs and the plankton was less in quantity. During August also the hydrological parameters influenced the occurrence and abundance of the zooplankton. The relationship of the major zooplankters with the hydrographic properties is given in fig. 16–17. A significant result of the extreme dilution of the mudbank waters during August was the absence of chaetognaths and appendicularians, which frequent the coastal waters in all the seasons. Similarly the copepods, which usually form the most dominant groups, were present in less numbers.