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PRELIMINARY STUDIES ON CERTAIN CHANGES IN THE PLANKTON AND HYDROLOGICAL CONDITIONS ASSOCIATED WITH THE SWARMING OF *NOCTILUCA**

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AN effect of swarming of *Noctiluca* on the 'choodai' fishery was reported by one of us (Prasad, 1953) and there it was mentioned that the appearance of these swarms was accompanied by certain changes in the chemical and biological environment. There are several instances of antagonistic or lethal reactions on zooplankton caused by the presence of swarms of dinoflagellates and some of the well known examples of this phenomenon have been given by Sproston (1949). Lucas (1938) termed such interrelations the 'non-predatory' relationship and postulated the theory that these antagonistic or associative interrelations and ecological succession in plankton and elsewhere are the effects of metabolic by-products or external metabolites which he called *ectocrines*. Similarly, the sudden appearance in large numbers of any one member of the complex marine community of animals and plants may be accompanied by pronounced changes in the hydrological conditions of the environment. These changes in most cases are of a temporary nature lasting only for the period of appearance of the swarms.

Swarms of *Noctiluca* were observed in the inshore waters of the Palk Bay and the Gulf of Manaar in 1952. These swarms appeared spasmodically in varying intensities from March to November and were more often observed in the Palk Bay than in the Gulf of Manaar. During this period there were also days when these dinoflagellates were not present at all in this area.

The material consists of routine collections of plankton and surface water from inshore stations in the Palk Bay and the Gulf of Manaar made during March to November 1952. In the enumeration of diatoms, *Noctiluca* and copepods the procedure adopted by Prasad *et al.* (1952) has been followed. The methods of collection and analyses of water samples are the same as described in an earlier paper by one of us (Jayaraman, 1951).

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The present paper gives a preliminary account of the changes in the nature of plankton and attempts to correlate certain hydrological factors with the appearance of swarms of *Noctiluca* in the neighbourhood of Mandapam. Although the data collected were not concerned directly with an investigation into the causes of such a swarming, the interest stimulated by the association of the various hydrological and biological factors observed justify the purpose of this brief report.

Several instances of dinoflagellate swarms have been reported in the literature and a more or less complete review of the subject on " Blooming in the sea " has been given by Galtsoff (1948). But detailed investigations into the nature of the chemical changes associated with such phenomena are rather meagre. The only observation of importance is by Ketchum and Keen (1948) who have reported unusual phosphorus concentration in the Florida ' red tide ' sea water. During the ' red tide ', believed to have been caused by the appearance of dense populations of the dinoflagellate *Gymnodinium*, these authors have found the total phosphorus content in the surface waters to be two and a half to ten times the maximum to be expected in the sea. The occurrence of such high phosphorus concentration was considered to be the direct effect of the swarming of *Gymnodinium*.

Among the various hydrological factors examined in the present study during the swarming of *Noctiluca*, certain interesting correlations between salinity and silicates and also the occurrence of silicates in very high concentration—15 to 25 μg.—at. Si/L which is three to five times the usual concentration of silicates in local waters—were observed. Unlike Ketchum and Keen (1948) no unusual phosphorus concentrations were noticed by the present authors. Figures 1 and 2 show the distribution of salinity and silicates in the Palk Bay and the Gulf of Manaar respectively during this period, March to November 1952. It may be seen from these figures that high silica content and high salinity were occurring almost together. The months during which salinity was high coincide with the season of the south-west monsoon and from the charts for current systems in the Bay of Bengal compiled by Sewell (1929) it could be seen that in these months the local waters are influenced to a large extent by the more saline waters of the Indian Ocean and the Arabian Sea. Waters of the 'open ocean' generally contain very small quantity of silicates in solution. River and estuarine waters on the other hand are relatively richer in dissolved silicates (Harvey, 1928). Large concentration of silicates in an area is, therefore, usually associated with lowering in salinity caused by admixture with river water. The combination of high salinity and high silica content, as has been observed in the present instance is of unusual

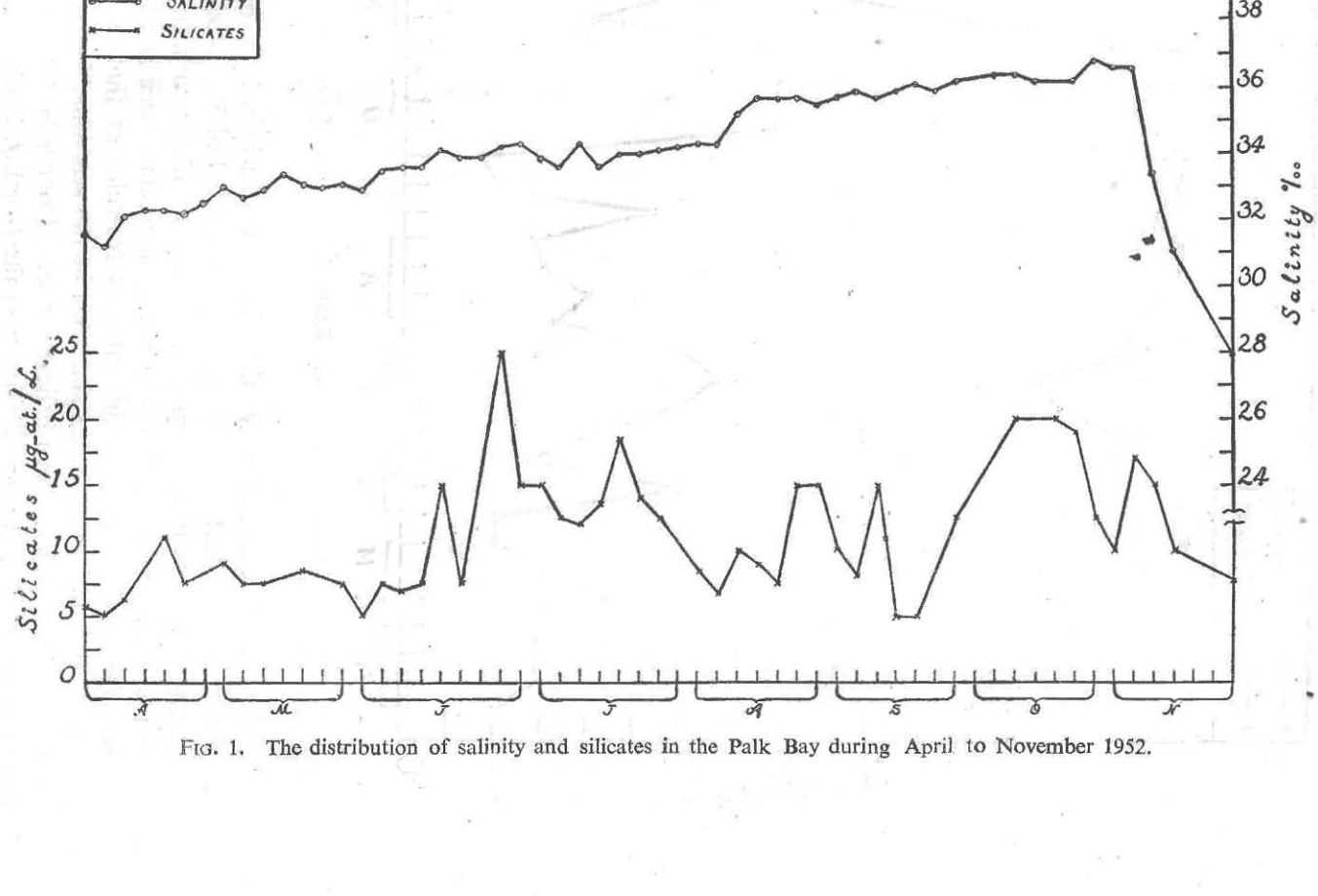

FIG. 1. The distribution of salinity and silicates in the Palk Bay during April to November 1952.

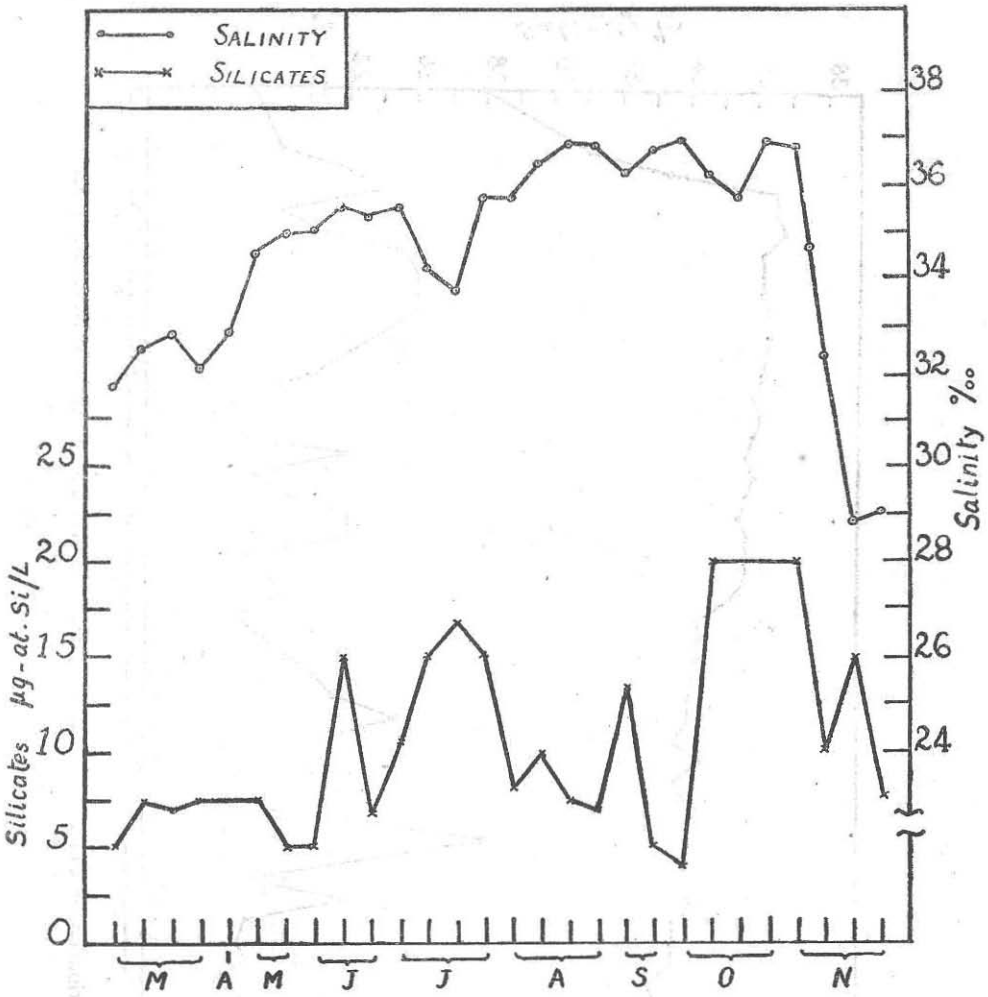

FIG. 2. The distribution of salinity and silicates in the Gulf of Manaar during March to November 1952.

occurrence in this area and may, therefore, be considered as one of the important hydrological changes during this period of *Noctiluca* swarming. The probable explanation for the occurrence of silicates in such high concentration in the surface waters is that there must have been active regeneration *in situ* of silicates from the siliceous frustules of the diatoms. The process of the solution of silica skeletons in the sea water is, however, not so simple as has hitherto been believed to be. Cooper (1952) in an interesting paper on the distribution of silicates in the North Atlantic has mentioned that the intact skeletons of diatoms are not easily acted upon by sea water.

There should be some mechanism by which freshly fractured surface of silica are brought into contact with water before solution could take place. The commonest way of " exposing fresh silica surfaces by fracturing will occur in the guts of the herbivores which grind or triturate their food". Such a process of " comminution " will facilitate considerably the solution of silica in sea water. A change similar to this process of " comminution " of diatom skeletons might be taking place during the active feeding of diatoms by the *Noctiluca*. It is therefore, possible that when there is swarming of *Noctiluca* more and more of the covering of the diatom cells are brought into solution thereby contributing to the increase in the silica content of the surface waters.

These changes in the hydrological conditions and the presence of *Noctiluca* in very large numbers are bound to have direct effects on some of the members of the plankton community. Johnstone, Scott and Chadwick (1924) wrote: " Also we are pretty sure that the plankton communities influence each other—that there are what we may call group symbiosis on the great scale so that the kind of plankton which we may expect to be present in a certain sea-area must depend to some extent, on the kind of plankton which was previously present." In recent years a closer study of the biodynamics has brought out the great intricacy of the net-work of biological inter-relationships and more and more evidence has been accumulating regarding a type of organic relationship which may broadly be differentiated from those interrelationships which concern with feeding in the widest sense. These non-predatory relationships relate to the external metabolites which are ecologically potent and bear important significance for the organisms producing them as well as for the other members of the community. Metabolites harmful to some may be beneficial to others and the effects of these metabolites in the ecological succession cannot be over-emphasised. For a review on the subject reference may be made to Lucas (1947).

The most significant feature observed in the plankton on the days when swarms of *Noctiluca* were present was the appreciable decrease in the number of copepods in the areas where the swarms occurred. There was also a decline in the number of some of the other zooplankters although not of the same magnitude as that of copepods. This phenomenon of inverse relationship was characteristic throughout the season both in the Gulf of Manaar and the Palk Bay (Figs. 3 and 4) and is undoubtedly an example of ' animal exclusion ' due to the effect of a potent ectocrine of *Noctiluca*, the nature of which is yet unknown. Another interesting phenomenon noticed during the same period was the succession of varying intensities of diatom peaks following those of the *Noctiluca*. This is more evident in the Palk Bay

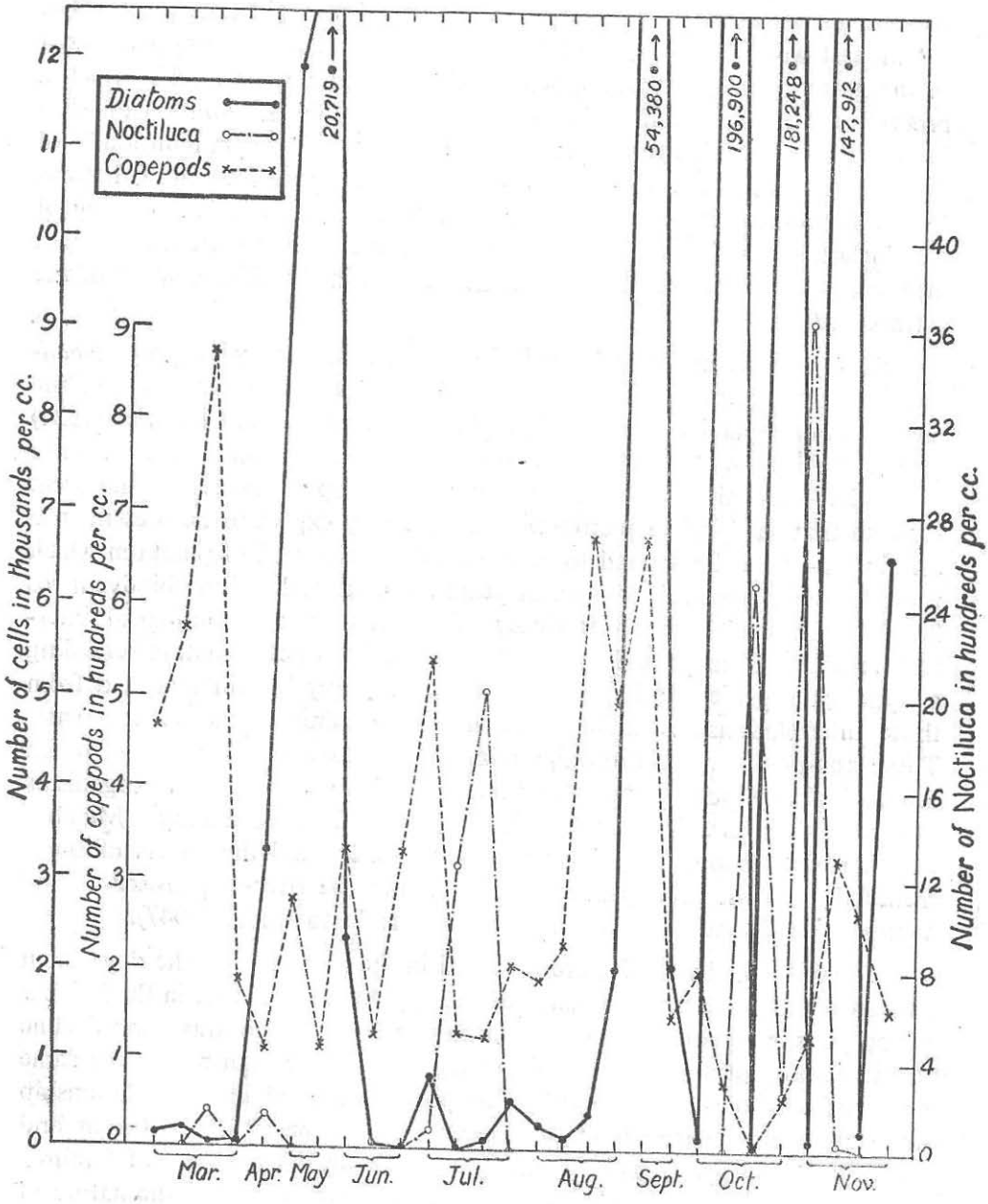

FIG. 3. Showing the distribution of *Noctiluca* copepods and diatoms in the Gulf of Manaar during March to November 1952.

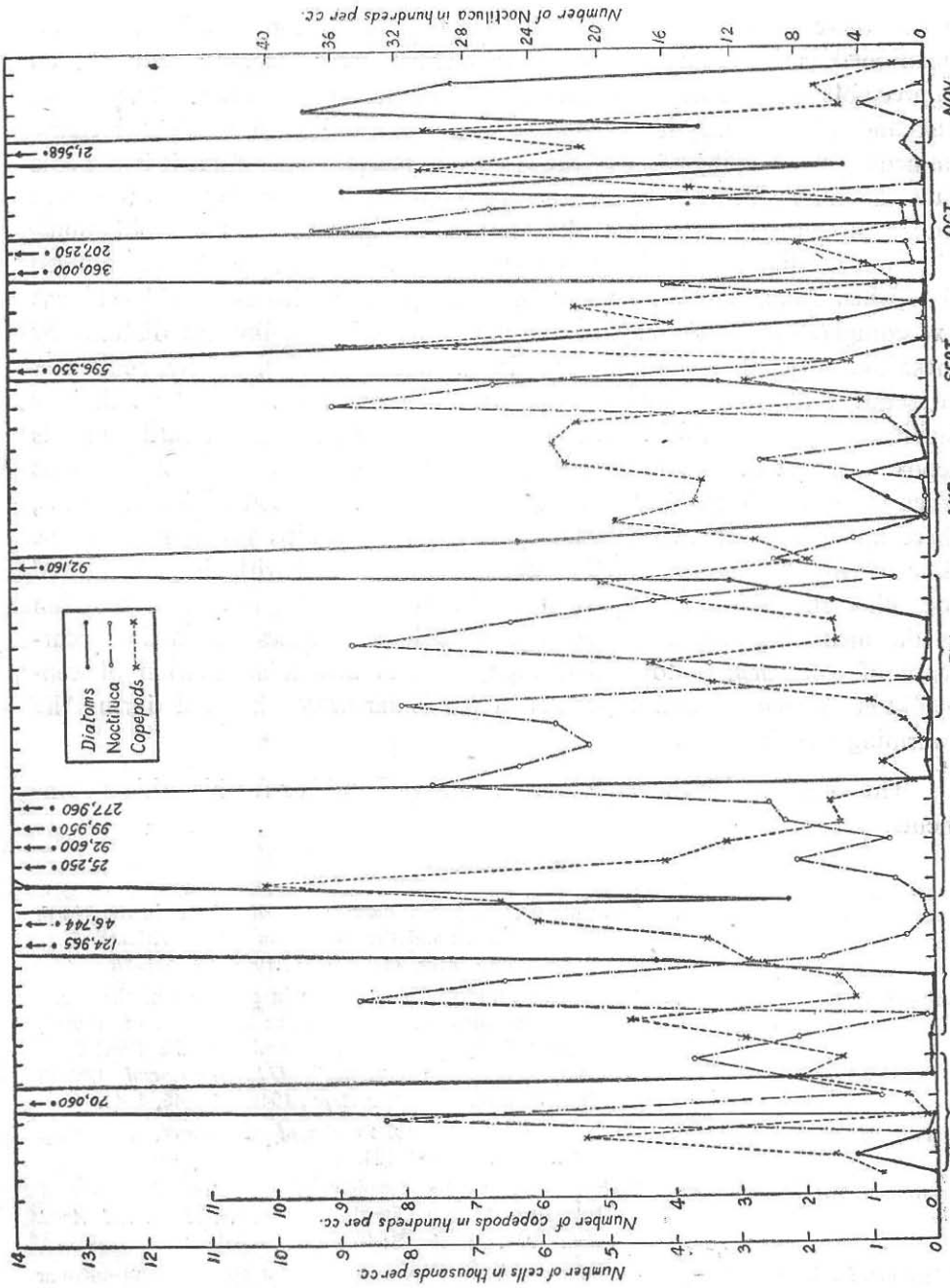

FIG. 4. The distribution of *Noctiluca* copepods and diatoms in the Palk Bay during April to November 1952.

where there were greater concentrations of *Noctiluca* populations. It was mentioned earlier that the *Noctiluca* swarms were accompanied by an appreciable increase in the silicate content of the surface water. There were also indications that the phosphate and nitrate showed a slight increase immediately following most of the *Noctiluca* peaks. Therefore, it is possible that the high silicate content together with an increase in the other two important nutrient salts created conditions favourable for the rapid multiplication of diatoms resulting in distinct peaks. It will be further noticed that when *Noctiluca* was present in great numbers the diatom level was exceedingly low which may be the effect of active feeding on diatoms by these dinoflagellates. The increase in the silicate content of the sea water consequent on the feeding by the *Noctiluca* on the diatoms and thereby facilitating quicker solution of silicates, as already pointed out earlier in this report, support the assumption that the significant reduction in the diatoms when there were large *Noctiluca* populations was due to consumption. Thus, there appears to be two distinct types of relationships functioning at the time of *Noctiluca* swarms in this area—one concerned with the feeding and the other the non-predatory relationship in which the *ectocrines* function as the mediating substance. A regular ecological succession in the occurrence of *Noctiluca*, diatoms and copepods and also a decimation of zooplankton in general and copepods in particular were observed during the swarming of *Noctiluca*.

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ADDENDUM

Since this paper was sent to the press, Subrahmanyan (*Proc. Ind. Acad. Sci.*, 1953, **39**, Section B, 118–127) also has recorded high silicate values during the occurrence of *Noctiluca* peaks.