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PRIMARY STANDING CROP AND A FEW RELATED OCEANOGRAPHIC FEATURES IN THE LACCADIVE SEA OFF COCHIN: ONE ANNUAL CYCLE*

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Abstract

Studies made during April 1968 - April 1969, on the variations in the primary standing crop, in relation to oceanographic features such as upwelling, sinking and nutrient cycles, are presented.

Phytoplankton pigments have high values (*ca.* 150 mg/m^2) during May-October and low values (*ca.* 20 mg/m^2) during November-March. The poorest month is January, with a plant pigment content of less than 10 mg/m^2.

With the onset of the southwest monsoon in May, the new cycle of production is triggered. The relatively high standing crop of phytoplankton during May-October is sustained by the nutrients brought up by upwelling and the increased run-off from the backwaters. By November sinking starts which continues till February, followed by stable conditions in March and April. During this period the nutrients get depleted and the standing crop also becomes very low, even though there is no dearth of sunlight.

Introduction

In the sea, the primary production of organic matter is accomplished by the photo-autotrophic planktonic algae. So far as a large-scale fishery in a particular sea area is concerned, a necessary condition is that a significant part of the primary production should be within that area. Though at present primary production is measured in terms of rate of production, all of the pioneer work concerning oceanic productivity was based on standing stock. "Standing stock" or "standing crop" of phytoplankton represents the quantity of autotrophic plants at a given time and may be reported in terms of the concentration of chlorophyll. However, the relation between chlorophyll and total organic matter is variable (Steemann Nielsen, 1963). As a measure of the phytoplankton standing stock, the estimation of plant pigments, with its disadvantages, including the presence of colourless forms, the seasonal changes in pigments in individual cells (Harris and Riley, 1956), the lack of knowledge of the relation between pigments and the chemical composition of the organisms and interference by non-cellular pigments, would still give more reliable results than cell counts or volume estimations because of the ease and precision of routine estimations and greater uniformity of methods in different laboratories (Humphrey, 1960).

So far as the sea off Cochin is concerned, even though it is rich in fishery resources, data on the seasonal variation of the primary standing crop is not available. The only published works are those of Qasim and Reddy (1967) who have given an account of the plant pigments of the Cochin Backwaters during the southwest

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monsoon months and of Shah (1967, 1968, 1969) who has discussed the diel variations in certain oceanographic features including phytoplankton pigments and also compared the conditions during two seasons, in the sea off Cochin. Therefore the information summarised in this paper would form an useful adjunct to the oceanographic data already available.

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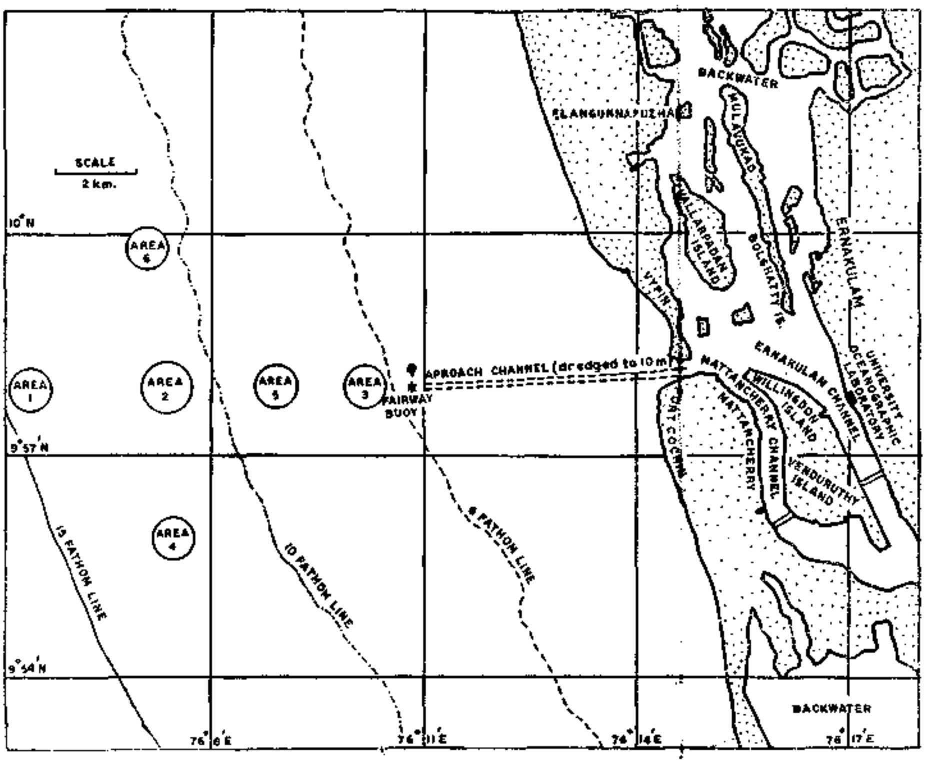

Fig. 1. Map showing areas of collection in the sea off Cochin.

MATERIALS AND METHODS

Monthly collections and observations were made from April 1968 to April 1969, at stations situated approximately 12 km off Cochin (Fig. 1), from the University research vessel CONCH. Station depths generally being 20 metres, samples were taken from surface, 5, 10 and 15m depth. Collection procedures and analytical techniques were essentially the same as described by Shah (1967, 1969), which in turn were adapted from Barnes (1959) and Strickland and Parsons (1968).

RESULTS AND DISCUSSION

The results are summarised in figures 2, 3 and 4. Fig. 2 shows the monthly variations of chlorophyll *a* along with the variations in the water temperature, salinity and dissolved oxygen at surface and 15m depth and Secchi disc depths. The dissolved oxygen content is reported in terms of percentage saturation also as it is a more valuable index of changes "in situ." Since the distribution of nutrients did not have a regular pattern with respect to depth, the amounts of phosphate, nitrite, nitrate and silicate at surface, 5, 10 and 15m depths were graphically integrated and the total in the upper 16m water column, along with the total pigments (chlorophyll *a*+, chlorophyll *c*+ and plant carotenoids) in the same water column are presented in fig. 3. Fig. 4 shows the isopleths of temperature and oxygen saturation.

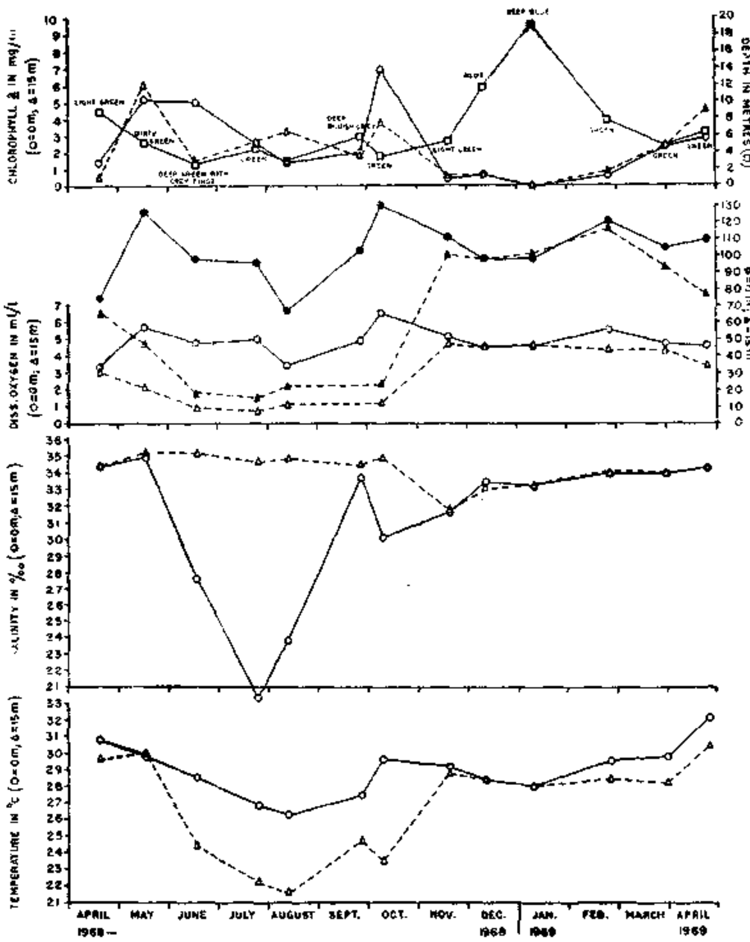

Fig. 2. Seasonal distribution of temperature, salinity, dissolved oxygen, oxygen saturation, chlorophyll *a*, Secchi disc depth and the colour of the sea.

Chlorophyll *a* values range between almost nil and approximately 8 mg/m^3 in the surface water and between nil and 6 mg/m^3 at 15m depth (fig. 2). If total column (0-16m) pigments are considered, then the values range between approximately 10 and 210 mg/m^2 (fig. 3). It is also seen that June to October are the rich months and November to March the poor months, the average being about

150 mg/m² and 20 mg/m² respectively. In January, the poorest month, there is hardly about 10 mg/m².

The two major environmental factors controlling primary production are light and nutrients. In the sea off Cochin light will not be a factor since bright sunlight is available almost throughout the year, except for a few days during the monsoon when the sky may be overcast with clouds. Even during those days enough light may be available for production in the upper layers. A quantitative assessment of the solar radiation at Cochin has recently been reported by Qasim *et al.* (1968).

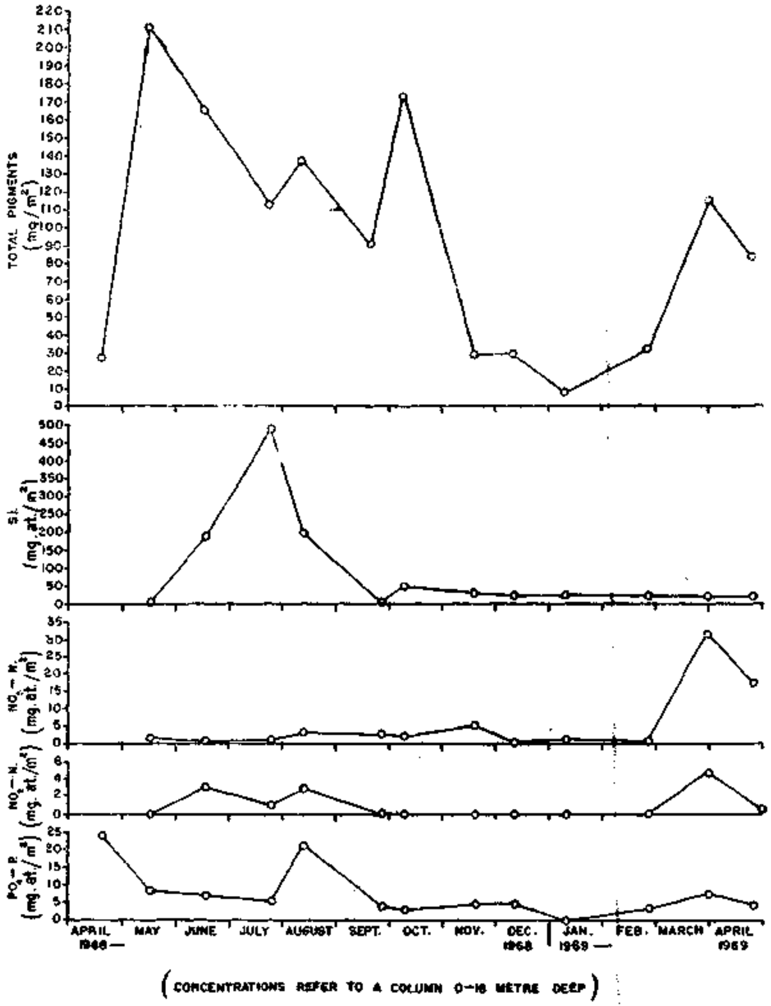

Fig. 3. Seasonal distribution of phosphate, nitrite, nitrate, silicate, and total pigments in the upper 16 metres water column.

Coming to the nutrients, two of the important elements in phytoplankton ecology are phosphorus and nitrogen. Since nitrogen can be used by the growing algae in more than one form its evaluation as a limiting factor is more complicated than that of phosphorus which is perhaps useful mainly as orthophosphate. However, for the present it may be reasonable to assume that the seasonal variation in the phytoplankton pigments is probably controlled by phosphate concentration, on the basis of the following reasoning. Inorganic phosphate content becomes almost nil during January while it is present at fairly high concentration during the southwest monsoon months and also picks up after February. The seasonal distribution curve (fig. 3) for the phytoplankton pigments seems to follow the curve for phosphate with a lag of a few weeks. Such a clear relationship is not seen in the case of other nutrients studied. It is quite possible that either ammonia or some other growth factor is, in reality, controlling the annual cycle of production in this region. This can, however, be verified only when data on the seasonal variation of all the usable forms of nitrogen as also other growth factors become available.

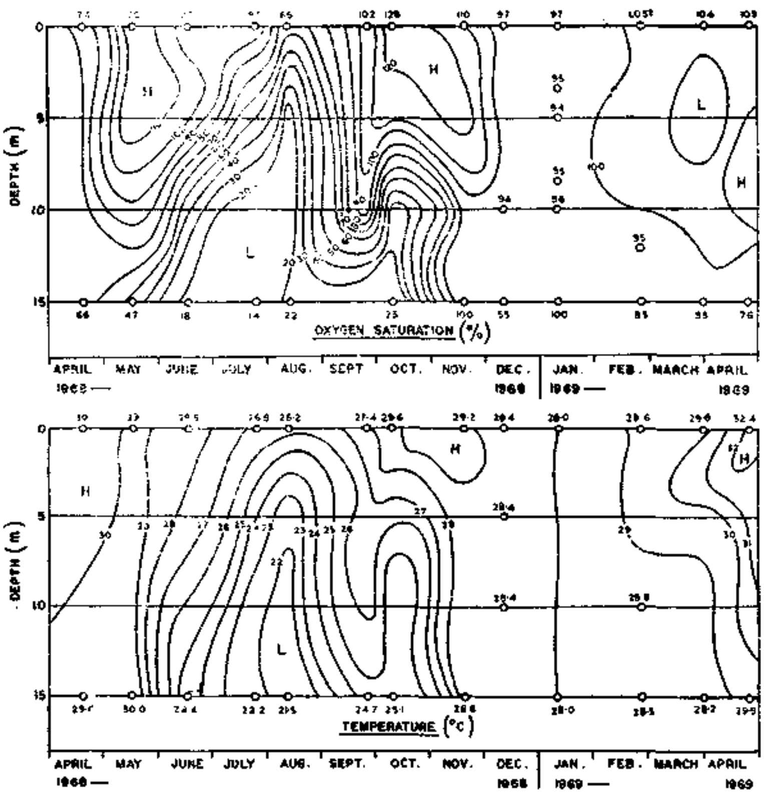

Fig. 4. Seasonal distribution of temperature and oxygen saturation.

In this context the role played by upwelling, sinking and run-off in the distribution of nutrients can be examined. In primary production, the process of upwelling is useful only if the colder subsurface water containing nutrients reach the "euphotic" surface layers. Therefore, in this study, the period of the year when these processes take place in the upper euphotic layers are considered as periods of upwelling or sinking as the case may be, and it varies slightly from the periods suggested by Banse (1959), Ramamirtham and Jayaraman (1960), and Darbyshire (1967). A study of the distribution of the isopleths of temperature, and oxygen saturation (fig. 4) indicates that, off Cochin, intense upwelling takes place during June, July and August, and the residual effects of upwelling are discernible in September and October, also sinking which starts in November seems to continue until end of February. Since the quantity of phosphate is relatively high during the upwelling months, and very low during the sinking months (fig. 3), it may be inferred that the changes in phosphate are also influenced by upwelling and sinking.

The importance of run-off in phytoplankton ecology is discussed by Strickland (1965) and Prakash and Rashid (1968) and they stated that since coastal waters receive significant quantities of humic substances and other nutrients as a result of river discharges and run-off these substances may influence the production and succession of phytoplankton species. The extent of the run-off from the Cochin Backwaters and also the period when it is comparatively very high can be judged from the distribution pattern of salinity and silicate given in figures 2 and 3 respectively. Some idea of the characteristics of the run-off water can also be had from the work of Qasim and Reddy (1967). The run-off has comparatively low salinity and can be identified as a thin surface layer during the south-west monsoon months and also brings large quantities of silicate into the area under investigation.

Two other factors affecting the standing crop are sinking and grazing by zooplankton, and a stock of planktonic algae must grow if it is not to be decimated due to sinking and grazing. Considering the fact that the present investigations pertain to an area of shallow depth (less than 20 m) it may reasonably be assumed that sinking of phytoplankton would not be a factor of any importance in controlling the standing crop. On the other hand grazing by zooplankton could be a factor of some importance, but no studies have been made to evaluate its effect on the seasonal changes of phytoplankton stock.

In conclusion it may therefore be stated that, hydrobiologically, there are two distinct periods: "May-October" and "November–April"; the former being characterised by upwelling and high standing crop and the latter by sinking followed by stable conditions and low standing crop.

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