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Edited by

K. Ravindran
Krishna Srinath
K.K. Kunjipalu
V. Sasikumar

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THE ORGANIC WEALTH AND FISH PRODUCTION IN THE SEA - Phytoplankton Production

C.P. Gopinathan
Central Marine Fisheries Research Institute
Cochin - 682 014

It is well known that all life in the sea depends primarily on the conversion of carbon and nitrogen into protoplasm. This process is mainly carried out by the microscopic plants known as phytoplankton or micro-algae. They absorb the nutrients from the surroundings and convert them into starch, fat and protein with the help of chlorophyll pigments and sunlight. Just as on land, in the sea also, animal life is not possible without plants. Plants form the food of herbivores and the herbivores nourish the carnivores. No life including fish can exist in seawater without phytoplankton. They are the primary producers and their importance lies in the fact that they are photosynthetic organisms and serve as the first link in the food chain. They are known as the grass of the sea and are the most important among the prime synthesizers of food in water.

The term productivity denotes the conversion of inorganic matter into organic form by the chlorophyllous plants. The important components of phytoplankton are the diatoms (*Bacillariophyceae*), dinoflagellates (*Dinophyceae*), blue-green algae (*Cyanophyceae*), silicoflagellates, Coccolithophores and very minute forms called the nannoplankters. Most phytoplankton organisms are unicellular; some are filamentous and colonial in habit.

Collection of phytoplankton

Special devices have to be employed to collect the standing crop or biomass of phytoplankton. Usually a conical half-a-metre phytoplankton net made of thin finest bolting silk with a mesh size 10 - 30 microns is towed through the water and the plankton is collected in a bucket which is attached below. Collection has to be made at frequent intervals at different places for which a well equipped research vessel is necessary.

A high powered microscope is required to examine them for identification. It may be of interest to mention here that CMFRI is engaged in this work since 50 years and such work was done in the inshore and offshore waters with the help of *R.V. Varuna* and FORV *Sagar Sampada*.

Link in the food chain

As already mentioned, the phytoplankton constitute the food for the smallest of animals namely the zooplankton which in turn form the food of the largest mammal. For example, the Antarctic Whale (*Balanoptera*) is a feeder of the small shrimp like zooplankton known as krill (*Euphausia*). The krill is wholly dependent on the bloom of phytoplankton for its survival and growth. The largest fish-the basking shark, is also a planktonic feeder, mainly feeding on the copepod *Calanus* which survives on the phytoplankton. The fishery for oil sardine and mackerel are entirely dependent on the bloom of phytoplankton along the west coast of India. There are several other fishes and mammals in the sea whose life is linked with phytoplankton. Only the number of links in the food chain vary in each case. Each species has its own period of growth and the growth intensity depends on many external factors such as temperature, salinity, nutrients and the physiological state. These factors are influenced by season and climate.

Peak periods of production

The peak periods of phytoplankton production in the temperate and arctic regions occur during the spring and the summer. During other seasons low temperature limits growth. In late summer the depletion of nutrients from the surface layers of water also limits the growth. In autumn, due to rough weather, the nutrients at sub-surface levels are brought to the surface by upwelling, resulting in a bloom of phytoplankton.

Along the west coast of India maximum production of phytoplankton occurs during the south west monsoon season from June to September after which there is a decline in the standing crop. Later during the northeast monsoon season another peak of production takes place during November to February, though of a much less magnitude compared with the former season. The south west monsoon can be compared to spring bloom and the north east monsoon bloom can be compared to autumn bloom of temperate waters. The magnitude of the south west monsoon bloom on the west coast is of a high order, surpassing those known from some of the most fertile regions in the world.

On the east coast generally the maximum production occurs during the south west monsoon season, followed by one or two peaks of production of a lesser magnitude during the north east monsoon season. The peaks of production are mainly due to the multiplication of diatoms, dinoflagellates and nannoplankters. The blue green algae, mostly composed of filamentous, bundle like structures called *Trichodesmium*, occur generally during the warmer months. Investigations on the factors responsible for the production of phytoplankton have shown that during the monsoon months optimum conditions such as abundance of nutrients due to upwelling and river discharge, fall in temperature and salinity are common features of the water.

The nature of phytoplankton flora changes frequently and each species appears to have its own peak periods of occurrence and associations. The species which contribute to the bulk during periods of maxima also vary from year to year.

Euphotic zone and production

In the shallow coastal regions the waters are mixed up to the bottom and the phytoplankton have access to the nutrients in the water column and the bottom. But in the offshore waters the euphotic zone and the depth of the mixed layer determines the rate of phytoplankton production. The depth of the mixed layer during the pre-monsoon period is about 60 m which becomes less than 20 m during the monsoon period and during the post-monsoon period, it deepens to 40 m. In the pre-monsoon period, as there is no further addition of nutrient-rich waters, the rate of production is maintained at a lower level, till the commencement of upwelling. During the post-monsoon when the mixed layer deepens, the nutrients are not depleted and hence moderately high production is continued during this period.

Phytoplankton bloom

During certain periods, the seawater becomes discoloured owing to the intense bloom of a single species. The colour of the water changes depending on the pigmentation of the organisms concerned. Thus the dinoflagellates like *Noctiluca miliaris,* particularly during the south west monsoon, bloom so intensively that the water change into pink or red. This phenomenon is known as 'red tide'. *Hornielia marina* turns the water into green and blooming of *Trichodesmium* spp. causes brown colour on the surface waters. Toxic dinoflagellates such as *Gymnodinium, Gauniaulax* and *Peridinium* species also causes discolouration and even bad smell when they bloom.

Factors favouring production

Phytoplankton production in the Indian seas is controlled by various physico-chemical and climatic factors and vertical mixing phenomenon known as upwelling. Among the chemical factors, salinity variation affects the rate of photosynthesis and thereby the production of phytoplankton. It was observed that phytoplankton grow well in salinities of 20 to 30 ppt and diatoms do not prefer salinities higher than 35 ppt. In the inshore and marine environments, sudden fall in temperature and salinity associated with high nutrients favour the phytoplankton production.

The nutrient concentrations in the water over the shelf on the west coast of India follows a pronounced seasonal rhythm reaching the maximum during the south west monsoon months. The regional and seasonal variations in the nutrients of the upper layers follow the same trend of production of phytoplankton. During the post-monsoon period, though there is a fall in the values of nutrients, the concentrations are enough to maintain nutrients in optimum levels and moderate rates of phytoplankton production is noticed.

Among the phenomena governing the distribution of phytoplankton in the sea, the divergence and convergence play a significant role. Regions of divergence are generally rich in nutrients and have high density of phytoplankton, whereas in regions of convergence there is great accumulation of zooplankton. The phenomenon of upwelling on the west coast of India has a pronounced effect on the replenishment of nutrients and in turn phytoplankton production. It is known that in the Arabian Sea there is an oxygen minimum layer which is the result of consumption of oxygen by disintegrating organic matter in the lower layers. This layer rises during upwelling and sometimes breaks the surface resulting in the mass mortality of marine organisms.

The most significant difference between east and west coast waters is that while the biomass on the west coast is very extensive throughout the region during the south west monsoon, this is not so on the east coast where the blooms are localised apparently due to local favourable factors. The intensity of the bloom and the standing crop on the west coast is almost three times that on the east coast. Numerous species may occur, but only a few contribute to the bulk on the west coast. On the east coast, no one species is found to dominate the crop. There is a cyclical change from year to year in the species constituting the bulk, without much change in the genera.

The relationship between phytoplankton and zooplankton of the Indian seas has been described by various workers. On the west coast we have a predominantly phytoplankton period succeeded by a predominantly zooplankton period.

Phytoplankton and fisheries

One of the objectives of fishery research is to forecast and control future fish supplies. As the phytoplankters, the main synthesizers of all food in the sea, fluctuate in relation to definite environmental factors, they form an important and convenient basis for assessing the stock of fishery resources. Studies on the west coast of India indicated that there is some intimate relationship between plankton production and fish production.

The magnitude of phytoplankton production has been assessed in several parts of the world using methods such as depletion of nutrients, oxygen released during photosynthesis, biomass or standing crop estimation and in recent years by using radioisotope of carbon (C^{14}). There have been fewer attempts to relate this to actual landings of fish. Based on phytoplankton production on the west coast up to 100 m depth zone, it has been estimated that about 47 million tonnes of carbon is produced annually while in the east coast the quantity is about 17 million tonnes, with a total of 64 million tonnes of carbon produced from the Indian seas. Similarly in the EEZ of India, having an area of 2.02 million km^2, the total primary production is estimated at 283 million tonnes of carbon annually. If we use just 0.2% conversion efficiency from primary to tertiary levels, the potential estimate of harvestable resources from the EEZ will be about 5.5 million tonnes. However, present exploitation is only 2.5 million tonnes. This indicates that by strengthening our fishing activities we can exploit maximum harvestable resources from the EEZ of India.