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Phytoplankton

By R. Subrahmanyan

Central Marine Fisheries Research Institute

It is well known that all life depends primarily on the conversion of carbon and nitrogen into protoplasm. This can be accomplished only by the living plants which absorb the nutrient elements from the surroundings and with the aid of pigments in them, particularly chlorophyll, and with the energy from sunlight build up starch, proteins, fats, etc. In the terrestrial environment this is quite obvious-accomplished by plants such as grass, the crops, fruit trees and so on; in the aquatic environment, small simple plants with not much differentiation of parts, known as algae play this role.

Just as on land, animal life including that of man is not possible without the plants-plants feed the herbivores, the herbivores nourish the carnivores and man is an omnivore-so also no life can exist in the waters including that of fish without the algae. The algae contribute to the food of all organisms in the waters including that of the fishes, directly in some instances and indirectly in others through the smaller animals; and, man catches the fishes for his sustenance.

Algae are of several kinds; the greens (Chlorophyceae), browns (Phaeophyceae), reds (Rhodophyceae), yellowish-brown (Bacillariophyceae or Diatomaceae, Dinophyceae, Chrysophycese) and the blue greens (Cyanophyceae or Myxophyceae), so named because of the colouring matter in them which characterises each class; however, all of them contain the vital chlorophyll. In addition there are many minute flagellates of uncertain affinity with various hue.

The browns and reds and a good percentage of the greens are attached forms; compared with the quantity of the members of other classes mentioned above, consisting almost wholly of unicellular or simple colonial forms constituting the free floating flora, *the phytoplankton*, the bulk of the attached forms are almost insignificant from the practical and economic points of view.

In the inland waters-lakes, ponds, reservoirs and so on it is common to notice members of the Chlorophyceae, Cyanophyceae and Bacillariophyceae, chiefly in the order mentioned; in the sea, the Bacillariophyceae, commonly known as diatoms, account for the bulk of the floating vegetation.

The diatoms remained for years objects of attraction for microscopists, prized and wondered over because of the astonishing beauty of their ornamentation and sculpturing on their walls (Plate-I). Fossil deposits of these, known as kieselgur, or diatomaceous earth, were used as abrasives and bacteriological filters, and this also proved an excellent medium to hold nitroglycerine to form dynamite!

But their role, together with the other floating forms, in human economy came to be known and appreciated only recently, in the last 60 years or so, because of their value directly as food of our edible fishes. They are the most important of the prime synthesisers of all food in the vast masses of water all over. They are the *grass* of the sea. They are found in all the waters whatever be their nature and in all climes. Though individually insignificant, they surpass in their productiveness and bulk all other aquatic plants several hundred fold. Not only in the shallow waters along the coast are they available as food for fishes but they are the only prolific form of the plant life in the open sea, save the *Sargassum* (brown alga) of the Sargasso Sea off Mexico.

The study of these forms is beset with difficulties as special devices have to be employed to collect them. Usually a conical net made of the finest bolting silk (meshes of which roughly measure 50-60 microns, (one micron = 1/1000 of a millimetre) is towed through the water and the plankton collected in a small bucket attached below, or water is collected and centrifuged in a Centrifuge at high speed to concentrate the organisms in it. A high powered microscope is required to examine them. Collections have to be made at frequent intervals at different places, for which a well equipped research vessel is required It may be of interest to mention here that the Central Marine Fisheries Research Institute is engaged in this work since 20 years and recently much work is being done in the offshore waters with the help of the R. V. *VARUNA*.

Let us now examine the magnitude of the production of phytoplankton. As already mentioned, the phytoplankton constitutes the food for the smallest of animal organisms, including the young ones of fish. They are only removed one stage in the food chain of the largest mammal, the Antarctic whale, *Balaenoptera*; this whale is a feeder of the small shrimp like animal commonly known as *krill* (*Euphausia superba*); the krill is wholly dependant on the bloom of phytoplankton during the southern spring for its survival and growth. And when one considers the rate of growth of the whale, to weigh almost a 100 tons in three years, one can easily understand the importance of phytoplankton. Whales are much sought after for their meat and fats and whale fishery engages the men and hundreds of ships of several nations. The largest of the fishes, the basking shark, is also a plankton feeder, the copepod *Calanus* constituting mainly its food, the copepod itself thriving on the phytoplankton. The success of the herring fishery of the North Sea entirely depends on *Calanus*; the vicissitudes of this fishery in the past has affected the fate of several European nations. The fortunes of our oil sardine, mackerel and prawn fisheries are entirely dependant on the bloom of phytoplankton on the west coast of India. There are several other fishes; mammals of the sea and birds whose life is linked close to the phytoplankton; only the number of links in the food chain vary in each instance.

Phytoplankton is highly nutritious. They contain carbohydrates, proteins, fats, oils, etc. As an example, it may be mentioned that the value of cod liver and other liver oils of fish, their vitamin contents and so on, have been traced through the cod's diet ultimately to synthesis of these by the phytoplankton.

There are hundreds of species of phytoplankton in the waters, some characteristic of certain waters or regions. Thus we have freshwater and marine forms, forms of the arctics, temperate and tropical regions. Around our own shores, the writer has recorded over 500 species representing over 150 genera.

Though many species occur in the waters, only a few numbers are seen at a time and further only a few of them are found to occur in some bulk.

As each species has its period of growth and growth intensity depends on many external factors such as temperature of the water, salinity (saltiness of the water), nutrients in the water (phosphates, nitrates, silicates, trace elements and so on in solution - same as for land plants) and the physiological state of the species itself, *bulk* constituting species vary; and, external factors cited are related to water movements — horizontal (*Currents*) and vertical (*upwelling* — bottom water coming to the surface) and these in their turn are influenced by seasons and climatic factors. Thus there comes to occur a periodicity in the production of phytoplankton The peak period of production in the temperate and arctic regions occurs during the spring and summer; at other times, the temperature being very low limits growth, or, sometimes, the depletion of nutrients from the surface layers of water puts a check on growth as during late summer. In the autumn, due to rough weather, the bottom water, with nutrients is brought to the surface, upwells, when again there is a spurt of production; however, as temperature falls thereafter rapidly, production comes to an end.

Until very recently, very little was known about the conditions in our waters as most of the investigations were of a casual nature. Since the establishment of the Central Marine Fisheries Research Institute, work has been going on in our waters which has thrown considerable light about plankton life in our waters and its importance. Let us now briefly examine what obtains in the tropical waters such as ours.

In the west coast waters, maximum production of phytoplankton takes place during the south west monsoon months of May to September, after which there is a decline in the crop; later, during the north east monsoon also, another peak of production takes place– may be any time between December and February – though of a much lesser magnitude, compared with the first. The first bloom is comparable to the spring bloom and the second to the autumnal bloom occurring in the temperate regions The magnitude of the south west monsoon bloom here on the west coast waters is of a very high order surpassing those known from some of the most fertile waters of the world.

On the east coast also, though not investigated at such length, generally the maximum production occurs during the south west monsoon months followed by one or more peaks of production of a lesser magnitude during the north east monsoon months.

The diatoms form the bulk of the phytoplankton (PLATE-I); they determine the trend of fluctuation of the total phytoplankton crop; the peaks of production are mainly due to their multiplication. The Dinophyceae also show peaks of abundance, one during the south west monsoon as a result of the bloom of forms without hard cell walls (*unarmoured*) *e. g. Noctiluca*, (Plate II middle); and other blooms of armoured forms *e. g. Ceratium* (PLATE II top) during the north east monsoon months. The Cyanophyceae composed chiefly of a thread-like form, *Trichodesmium*, occurs in abundance during the warmer months of the NE monsoon.

Investigations on the factors responsible for the production of phytoplankton have shown that it is during the monsoon (active) months that conditions in the waters attain the optimum; abundance of nutrients (such as phosphates, nitrates, silicates and so on), due to upwelling and river discharges; a fall in the temperature of the water, from 31-32°C to 23-25°C; and a fall in the salinity of the water from 35‰ or more to 30-31‰, to mention the most important ones. At no time is there a complete depletion of the nutrients as in the temperate waters to act as a limiting factor. However, it is seen that the limiting factor here is the physiological state of the plankton elements themselves.

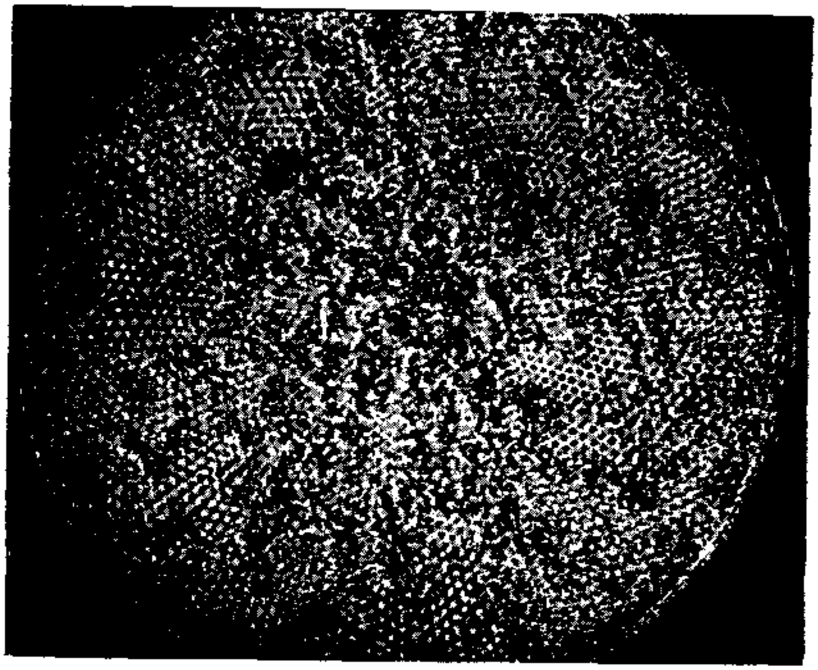
We have thus an oscillation in the production of organic matter and, as on land where crops are influenced by the monsoons, in our seas also the monsoons play an important role in the prospects of the phytoplankton crop, the basis of all food.

This enormous production of phytoplankton goes to cater to the requirements of hundreds of species of animals in all stages of development and size, the zooplankters, the fishes and so on. In fact, there is generally an increase in the population of these predators (*e. g* Plate-II, bottom, a Copepod) side by side with the increase of phytoplankton; and, often the plants are eaten up and one comes across only an animal population in the water some time. The latter aspect occurs during the north east monsoon season, when phytoplankton production is not as intense as during the earlier monsoon.

The links in the chain would have become evident from the above – the more plankton is produced, more food for the animal life, which in their turn constitute the food of many predators including young ones of valuable fish; more food for the latter means better survival rate and better harvest of fish for us at a later date.

Before concluding this review, it may be worthwhile to examine the magnitude of production of phytoplankton and its relationship to commercial fish landings. This would throw some light on the intensity of exploitation going on at present and also show whether there is scope for increased exploitation or whether we are already depleting the stock.

The phytoplankton production calculated for the west coast for an area of 155,400 sq. kilometres of 100 metres depth, a potential fishing area, works out to 1,813 million metric tonnes. The quantity of commercial fish landed on the west coast, on an average (upto 1965) is about 519,00 tonnes – represents about 76% of the total marine fish landed in India. The ratio of phytoplankton production to fish landed works out to only 0.029 %; this is only *about half* of the corresponding figure of 0.06% for the North Sea, an intensively fished area, probably the maximum return one can expect. The rate of turnover being



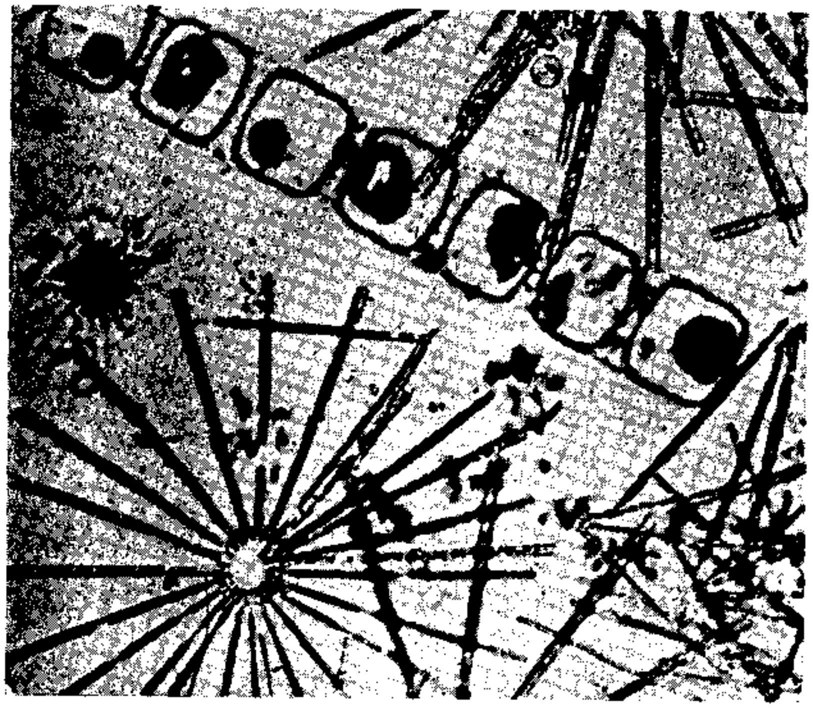


PLATE I. Upper: Photomicrograph of a diatom cell (portion) showing sculpturing on its wall.

Lower: Photomicrograph of some species of phytoplankton (diatoms).

— Photos by courtesy of Mr. P. R. S. Tampi.

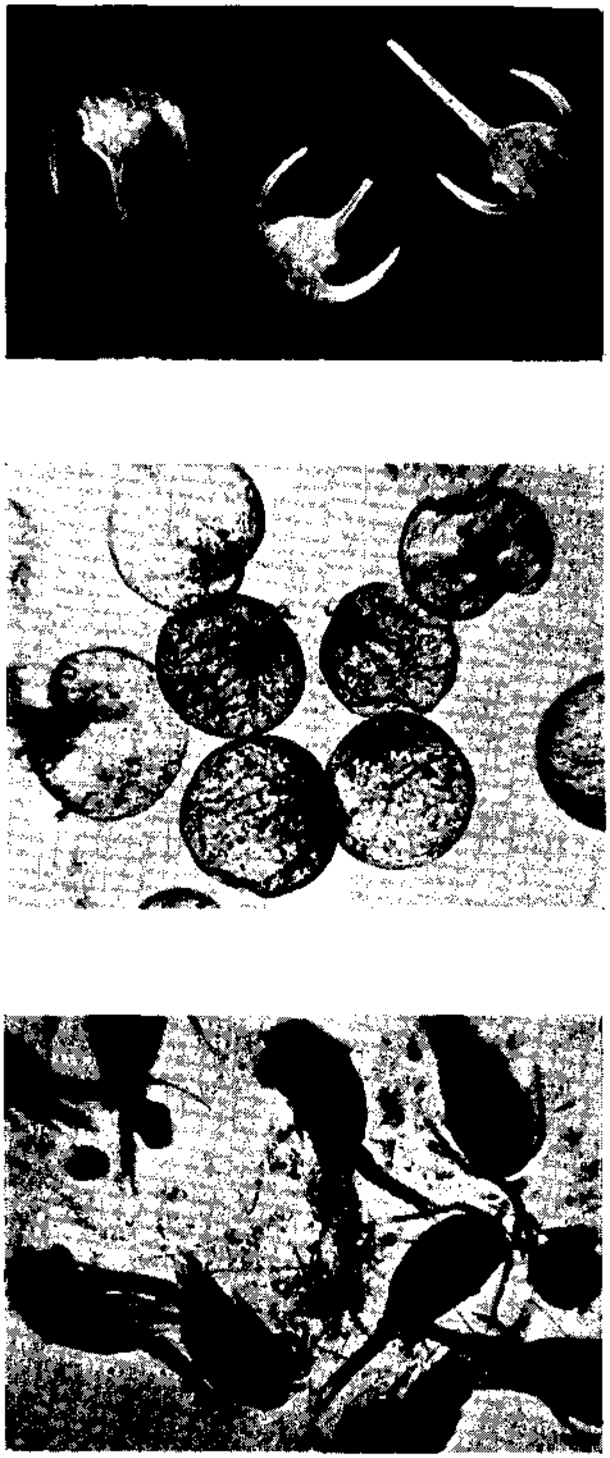


PLATE II. Upper: Photomicrograph of a Dinophyceae.
Middle: Photomicrograph of another Dinophyceae which at times discolours the water.
Lower: Photomicrograph of some copepods, small animals which feed on the phytoplankton.

—Photos by courtesy of Mr. P. R. S. Tampi.

more in our tropical environment one could expect the same return if not more; therefore, our fish landings could be increased atleast two times or more with increased effort. Similar estimates for the south east coast of India indicates prospects of a five fold increase. These hypotheses have been substantiated by the increased landings since 1955 on the west coast with more fishing vessels operating and on the SE coast by the exploratory fishing of the Indo-Norwegian Project vessels. On the west coast, in 1955, the exploitation was 0.025%; which is about $\frac{1}{3}$ of the North Sea figure; in 1965, the ratio has increased to $\frac{1}{2}$ of the North Sea figure showing therby that there is still scope for exploitation.

Another interesting observation was that while a few species in great bulk constitute the landing on the west coast, on the east coast, the landings comprise of several species. A similar feature is noted in the constitution of the phytoplankton also; a few species account for bulk on the west coast while no one of the species can be said to occur in *bulk* on the east cost. Further, the magnitude of production on the west coast is many times that of the east coast waters; this is reflected in the fish landings also, 76% of the marine landings being on the west coast. Again, it was found that the plankton of the west coast contained more fat in them when compared with those of the east coast. This is of significance, for, this might explain the high fat content of the oil sardine and the mackerel caught on the west coast and their nutritive value as also the oil deposits off the west coast; for, it is due to the activity of these microorganisms at an earlier geological epoch that such deposits are caused.

The question may occur that as plankton is produced in such abundance and is very nutritive, why not catch plankton itself for food. Unfortunately, the quantity of water that has to be filtered to obtain, say 1 kg of plankton, will be so enormous that the attempt will have to be given up as it will be economically not feasible. Fishes are still the best and economical mode of utilizing this vast production of matter.

It may be mentioned in passing that an intense bloom of certain species which at times discolours the water red, yellow, green, brown and so on according to the pigments present in them, acts as a set back to the fisheries or even brings about mortality of marine organisms including fish. However, this is not of such frequent occurrence in our waters to cause any anxiety.

The phytoplankton, the pastures of the sea, thus play an important role of significance to our food resnurces from the sea and thereby in our economic life.