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"PLANKTON" is the first in a series of articles we plan to publish which will give the angler a scientist's view of life in the sea.

Plankton seems a likely beginning for this series since it is one of the ocean's most minute and most vital forms of life.

Did you know, for example, that the status of our fishery stocks depends in part upon how the larval stages of sport and commercial fish fare in the plankton, or that virtually all the life in the sea is dependent upon "meadows" of microscopic phytoplankton for the basic supply of food?

The awesome world of plankton is explored here courtesy of Dr. Paul A. Sandifer and *South Carolina Wildlife*, a publication of the South Carolina Wildlife and Marine Resources Dept., Columbia, S.C., U.S.A.

PLANKTON

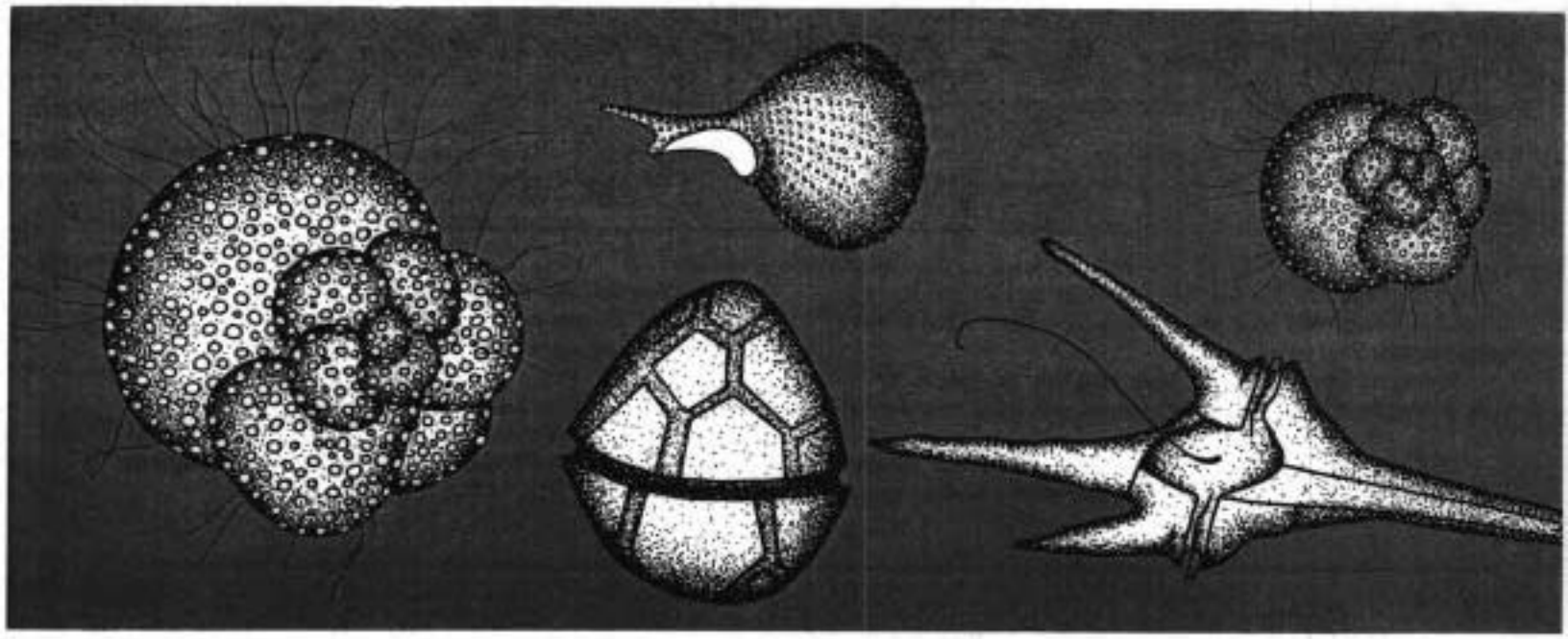
by Dr. Paul A. Sandifer

The term plankton is applied collectively to a great variety of mostly minute plants and animals which live in oceans, rivers, lakes and ponds the world over. Even the frigid Arctic and Antarctic seas and the greatest depths of the oceans are home to large populations of planktonic organisms.

The word "plankton" is derived from a Greek word which has a connotation of "wandering or drifting more or less passively." Thus, plankton is made up of mostly small organisms that have limited powers of movement and therefore are highly subject to transport by water currents. However, this does not mean that planktonic animals cannot swim. On the contrary, many of them swim quite well but, because of their extremely small size, they are able to make significant movements only in the vertical plane; that is, swimming up and down, changing their position in the water column and thus varying the conditions under which they live.

An astronomical number of different kinds of organisms may occur in the plankton, and the variety of forms is nearly infinite. Yet this vast community was unknown until 1828.

Like other communities of living things, plankton consists fundamentally of two kinds of organisms: plants (phytoplankton) and animals (zooplankton). Because of the wide diversity of plants and animals that occur in the plankton, this article is limited to only a general consideration of important forms. Also, the remarks below are directed primarily toward the plankton of the seas, but most are pertinent to freshwater plankton as well.



Phytoplankton

The fundamental importance of phytoplankters is that they are the primary producers of the sea, the base of the food chain upon which almost all marine life depends. They utilize the sun's energy, along with dissolved carbon dioxide and inorganic nutrients in the water in the presence of the pigment chlorophyll, to manufacture organic food molecules by the process of photosynthesis. Because sunlight is necessary for this process, the photosynthesizing plankton, or algae, are limited to the sunlit upper portions of the sea. The depth of this sunlit or "euphotic" zone (the zone in which sufficient light penetrates for photosynthesis) varies tremendously. In clear tropical waters sunlight may penetrate 300 feet or more, while in temperate or coastal areas light may reach only half that depth or much less, depending upon the season and the turbidity of the water.

In the marine environment small size confers distinct advantages upon plants. These advantages are the result of the simple physical fact that the smaller an organism is, the greater the ratio of its surface area to its mass (weight) and therefore the greater the frictional resistance to sinking through the water. Thus, small size is an aid to remaining in the upper sunlit areas of the sea. Many have bizarre and beautiful shapes which further increase surface area and retard sinking. Also, the greater the surface-to-volume ratio of a plant, the more readily and rapidly it can absorb nutrients and sunlight. So, unlike terrestrial vegetation, marine phytoplankton is composed almost exclusively of microscopic single-celled algae which are distributed throughout the euphotic zone. The bottom-attached seaweeds and even the floating Gulf weed, *Sargassum*, while marine plants, are not considered part of the phytoplankton. These relatively large plants are restricted to areas where the water is shallow enough for light to reach the bottom or where conditions for floating weeds are favorable.

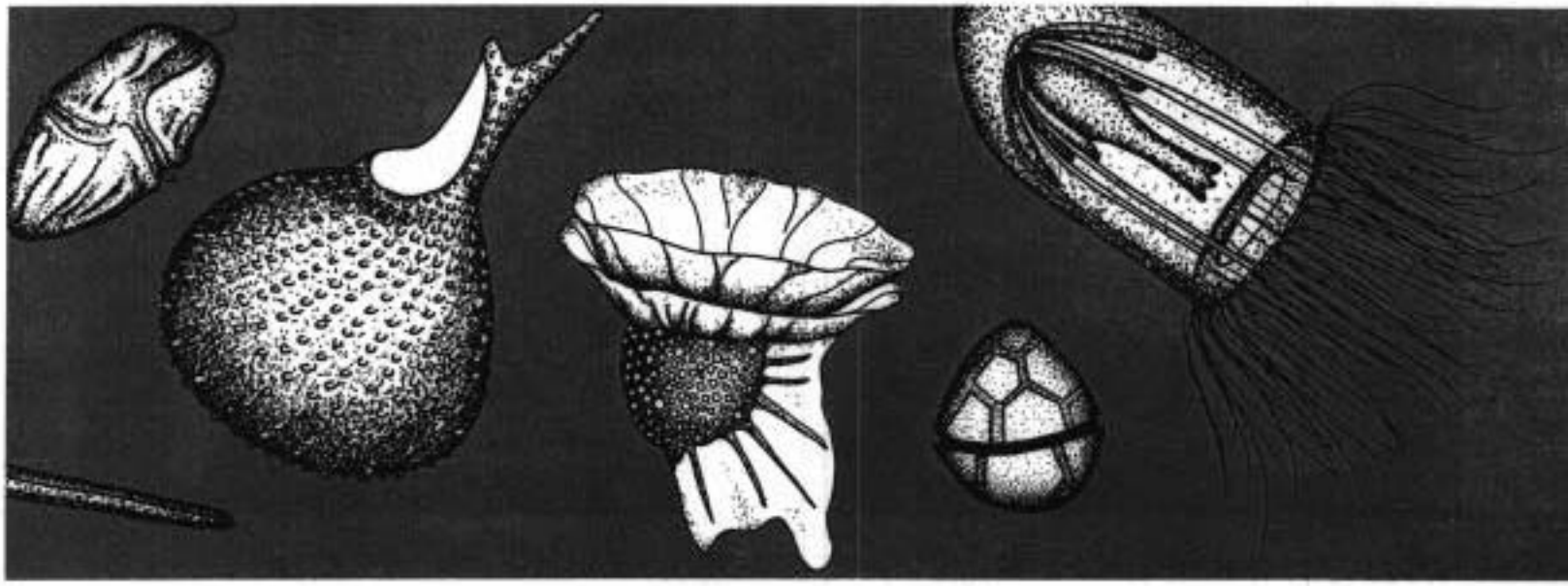
Although the variety of microscopic plants in the ocean is nearly limitless, the most important phytoplankters fall into three major groups: nanoplankton, diatoms, and dinoflagellates.

Nanoplankton is composed of minute plants, mostly between 1/10,000 and 1/1000 inch in size. These plants exist in tremendous numbers in the sea, and their true importance in food production has been recognized only in recent years. In fact, many scientists now believe that the nanoplankton is the single most important group of the phytoplankton, as far as production is concerned.

Diatoms are considerably larger than most nanoplankters, but even these relatively large unicellular algae rarely surpass 1/50 inch in size. Until the discovery of the importance of the nanoplankton, diatoms were thought to be the most important primary producers of the sea and thus the basis of many food chains. The importance of the nanoplankton notwithstanding, the role of the diatoms is still tremendous.

Unlike the kinds of plants familiar to most of us, diatoms have an outer shell or skeleton of silicon. This skeleton is composed of two parts, one fitting into the other like a box and its lid. Diatom shells may be elaborately sculptured with minute spines and holes, and it is through these tiny holes that the living matter of the cell comes in contact with the sea. The diatomaceous earth that man mines and uses in polishing, insulating and filtering applications is composed of the shells of countless billions of these plants deposited through eons of time in areas that once were sea floor.

Dinoflagellates are of two main kinds. There are the naked forms which lack a shell or skeleton and the shelled forms which possess a cellulose skeleton. All dinoflagellates have one free whip-like appendage that lashes about in the water and another that is wrapped around the cell in a special groove appropriately termed the girdle. These are called flagella, from which the name of the group is derived.



Although dinoflagellates contain a good deal of chlorophyll, its green color is usually concealed by other pigments which impart a brownish color to the cells. Most of these algae are photosynthetic, but some feed on organic particles or dissolved organic matter in the water. Another interesting thing about many dinoflagellates is that they are phosphorescent, at night often imparting a soft glow to the water they inhabit.

There are many other members of the phytoplankton which do not fall into any of these groups. Some of these other plants are quite exotic, but they are beyond the scope of this article. However, we should point out that the composition and abundance of phytoplankton differs in different waters and at different times of the year. Also, in any given region of the ocean there usually are one or a few species of phytoplankton that are dominant, and this dominance may change with the seasons.

Virtually all the life in the sea is dependent upon these "meadows" of microscopic algae for the basic supply of food. The importance of this highly heterogeneous group of plants to the continued existence of life on this planet cannot be overemphasized.

Zooplankton

The zooplankton contains perhaps the most diverse assemblage of animals to be seen in any community of living things. Every major group of animals and most of the minor ones as well are represented either as adults or larval stages or both. Those that are present in the plankton throughout their lives are termed collectively holoplankters. The part-time zooplankters, such as the larval stages of fish, shrimp, crabs, oysters and numerous other animals which occur in the plankton during only a portion of their life cycles, are called meroplankters.

Even more apparent than the diversity of kinds of animals is the wealth of variation in appearances, ranging from the plain and simple to fantastic and grotesque creatures, from clear or white to brilliant hues of scarlet and blue. Paralleling the variety of kinds and appearances of zooplankters is the range of sizes in which they come. Life forms as small as protozoans may be included in the zooplankton, as also may be the large jellyfish which can measure up to several feet in diameter. The majority of zooplankters, however, falls within the midportion of this range, and generally most are much less than half an inch in length. For purposes of convenience and study, then, zooplankton is often divided into size groups, and these groups are more or less defined by the mesh sizes (that is, the size of the openings) of the nets used to collect them.

There are many important constituents of the zooplankton, but on a worldwide basis the arthropods perhaps contribute most. The Arthropoda is an extremely large group of invertebrate animals that characteristically possess a hard external skeleton and jointed limbs. This vast group of animals includes all the insects, shrimps and crabs plus a host of lesser-known forms. The group of arthropods that is most important with regard to zooplankton is the Crustacea, and this group is probably the single most important assemblage of animals represented in plankton. The Crustacea include the extremely abundant and ubiquitous copepods which are sometimes termed the "insects of the sea" because they are so numerous, plus all the shrimps and crabs of which larval and sometimes adult stages occur in the plankton, as well as several other planktonic groups.

Another important zooplanktonic group is the fishes. Most of the game and commercial fishes in our waters spend their early lives in the plankton, first as eggs and then as larval stages. The young of our commercial shrimp, blue crabs, and oysters also must survive a planktonic period before becoming adults. The status of our fishery stocks depends in part upon how these larval stages fare in the plankton, and their period of planktonic existence is by no means an easy one. Early stages of fishes, shrimp, crabs and oysters are preyed upon

heavily by fellow zooplankters and other animals. Also, upon entering the plankton the larvae must find enough food of the right kinds and suitable conditions of temperature and salinity in order to survive and develop. Finally, eggs and larvae are more or less at the mercy of water currents and thus may be carried into areas where conditions are unsuitable for their survival or further development. Only a small percentage of fish, shrimp, crab and oyster larvae survive the planktonic period.

Food Chain Considerations

In an eternal cycle of eat and be eaten, every kind of organism in the oceans becomes the food source for some other organism. The primary producers, the phytoplankters, are the food of herbivorous zooplankters which in turn are preyed upon by carnivorous zooplankters, and these are eaten by other carnivorous zooplankters or larger animals and so on. Of course, not every plant or animal is eaten by the next level of organisms in the food chain. Many die naturally of old age or disease or because of unfavorable conditions of temperature, salinity or other environmental factors. The carcasses of these organisms may then be attacked by bacteria which break them down into their basic inorganic ingredients, or along with other material they may form the food of detritus-eating zooplankters. The waste materials excreted by zooplankters also are attacked by bacteria and reduced to inorganic nutrients. Thus, material not transferred upward in the food chain becomes recycled as inorganic nutrients which then are utilized by the phytoplankters at the base of the chain in the manufacture of organic food molecules. Nothing is useless and nothing is lost, with the exception of what man and a few other creatures remove from the sea. However, these losses are more than balanced by the influx of sewage, detritus, and farm fertilizers from the land.

While there are no real losses from the sea, the inorganic nutrients necessary for phytoplankton growth are continuously being depleted from the euphotic zone as dead and dying plants and animals sink out of the sunlit layers. These nutrients only return to the surface waters under special conditions that produce upward movements of water from the depths. In areas where this "upwelling" of rich, nutrient-laden water occurs (for example, along some coasts and around islands), fantastic "blooms" of algae occur followed by burgeoning populations of small herbivores which in turn attract great numbers of fish and other animals. However, the relatively low concentrations of the vital inorganic nutrients in most surface waters restrict the net productivity of wide areas of the sea to relatively low levels compared with the land.

It has been suggested that plankton have a potential as food for man. This is the so-called theory of "working back down the food chain." The basic premise of this theory is that for every amount of fish, shrimps, crabs or shellfish we catch, we might instead harvest ten times as much plankton. However, proponents of this theory often overlook a fundamental reality. In most areas plankton is a hodge-podge of myriad kinds of organisms and is not in a form in which it can be used readily as a food source by man. Further, plankton is rarely concentrated enough to allow efficient harvesting. Because plankton is so dispersed, effort expended in harvesting it might more than offset any gains attained by consuming at a lower level on the food chain.

In one case at least, however, plankton appears to hold some promise of a food harvest for man or his domestic animals. In Antarctic waters occur vast concentrations of "krill" (small shrimp-like crustaceans called euphausiids) which form a major portion of the diet of certain whales. These concentrations of krill are now being investigated by the Russians and others to determine the feasibility of harvesting them and to develop methods of preparing acceptable food products from them.