Introduction to Plankton

Plankton is a word derived from Greek for "drifters". It refers to all the plants and animals that drift with the ocean currents as inhabitants of the open waters of the sea (and also fresh waters; but our concern here is with marine environments). Zooplankton, the planktonic animals, are all weak swimmers, whereas phytoplankton, planktonic plants, do not swim at all. Plankton have traditionally been distinguished from nekton, those animals which swim rapidly and migrate where they choose, irrespective of the directions of the currents, e.g. fish, squid, marine mammals, and sea turtles. In the open sea everything must float, swim, or sink. The only physical objects that can remain near the surface without floating are living organisms. For living plants and animals, there are only a few ways to remain near the surface in safety. This is because in open water there is no cover, no trees or rocks behind which they can hide.

Phytoplankton always live near the surface of the sea because, like all plants, they require light for photosynthesis, the transformation of water and carbon dioxide into short chain sugars. Unlike terrestrial plants that must counteract gravity to reach toward the sun, with strong trunks, branching stems and large leaves, the plants in the pelagic zone are exceptionally small, microscopic, and single-celled, buoyantly supported by the density of the surrounding water. Plants, of course, do not have muscle tissues, and so they cannot swim like oceanic animals. But without special adaptations of some type, these tiny plants would necessarily eventually either sink to the bottom and die. Plants can remain near the surface only if they are almost neutrally buoyant. Small objects weight less than large ones. Small objects have a large surface area in relation to their volume. And since phytoplankton are very small objects indeed, often only 1/1000th of a millimeter in diameter, they don't weigh very much and they have a very large surface area/volume ratio. Small objects and phytoplankton, therefore, sink slowly because they don't weigh very much and because they have a large surface area in contact with water, which is far stickier than air. Interestingly, some of the very smallest plants, the dinoflagellates, have tiny motile, tail-like appendages, called flagella, that propel the single-celled plant slowly through the water. Because the cells sink very slowly, equally slow swimming speeds can maintain these plants near the surface. Other types of cells change their buoyancy by manufacturing light-weight oils when they sink too deep. Since oil floats, the positively buoyant cell now floats slowly back toward the surface.

Phytoplankton also remain near the surface because the surface waters of the open sea and large lakes are regularly mixed each day by the wind. The sun brings light for photosynthesis to the water surface but it also brings heat, and the warm surface waters float above the denser and colder deeper water mass. The transition between these two bodies of water, where the temperature changes abruptly, is called the thermocline. When the wind blows, it mixes the surface waters but only down to the thermocline. There the density difference is sufficiently strong to resist further mixing, and so the heat accumulates mostly near the surface. The waters above the thermocline mix completely each day, from the surface to depths of 10 to 100 meters. But single celled plants sink at rates of only a few meters each day, and so even though some kinds of phytoplankton, such as diatoms, sink inexorably toward the bottom, they are mixed at greater distances and more rapid speeds throughout the upper water column by the wind each day, far faster than they can ever sink.

Miniature, almost invisible planktonic animals, the zooplankton, eat these tiny plant cells. We can not see most zooplankton without a microscope. At sea or in a large lake at the surface during the day, when we look down into the water from shore or from a small boat, we generally do not see anything at all in the clear, blue surface waters. Yet when we drag a fine plankton net through the water behind the boat and carefully examine the catch in a clear glass jar we see thousands of tiny animals darting about within the jar.

Most of these animals are less than about a millimeter long, less than 1/16 th of an inch, and most are quite transparent. They are called "net zooplankton" because we can only investigate them by the use of plankton nets. Individually these animals are difficult to see in the sea or in the lake because our eyes cannot easily resolve individual spots smaller than about one millimeter, yet when crowded together in the collecting jar of the plankton net these planktonic animals are collectively visible as a cloudy, milling mix of tiny creatures. Small size is an important survival strategy in the open sea because many pelagic predators are visual predators with eyes much like our own. If we can not see these tiny animals, then predatory fish probably can not see them either!

We examine our catch of net plankton carefully under the lens of a microscope or magnifying glass, and we see now that not only are there thousands of tiny animals but also there are many different types of animals, with strange shapes and appendages. Some of the most common are clearly tiny crustaceans, darting copepods with long antennae but with shrimp-like legs. Other recognizable animals are tiny jellyfish, rapidly beating their transparent bells. Tiny clams lie quietly on the bottom of the dish but then they suddenly open their valves and dart off into the water. Other animals are unlike anything that we have ever seen before, strange creatures that live only in the plankton, like arrow worms and radiolarians, and we are amazed and yet perplexed by the diversity of so many different types of such tiny animals all living in such clear water, apparently devoid of living things.

Other kinds of zooplankton also occur at the surface of the sea during the day…the gelatinous zooplankton. This is an assemblage of much larger animals than we captured in our nets, consisting of large jellyfish, planktonic, transparent snails, comb jellies, large arrow worms, and pelagic tunicates, like salps and appendicularians. All of these animals are transparent, soft bodied, and delicate, with the consistency of jello. Many scientists refer to this group of animals as "jello-plankton". Gelatinous zooplankton are fairly large animals, from centimeters to even meters in diameter (1/2 inch to 6 feet) for the largest jellyfish. They do not swim rapidly but remain buoyant despite large size because the mixture of salts in their gelatinous tissue is lighter than the weight of the salt in the seawater within which they swim. Gelatinous zooplankton almost never occur in freshwater habitats because in the absence of salts they cannot regulate their buoyancy to remain up in the water column. At sea gelatinous zooplankton are both important predators (jellyfish and comb jellies) and filter-feeding herbivores (pelagic tunicates), and they can have an enormous impact on the food webs of the sea. Historically these animals were difficult to study because their delicate tissues were invariably damaged by nets. During the past 20 years, however, gelatinous zooplankton have been investigated extensively by scuba divers who hand-collect animal at sea, capturing perfect, undamaged specimens one at a time in individual jars that are then transported back to the laboratory aquarium for study. Gelatinous zooplankton are also difficult to study because they are hard to see within the sunlit waters of the open sea because of their transparency, which provides important protection from visual predators in the open sea.

At night larger herbivores and carnivores migrate up to the surface to feed. In the dark they cannot be seen by their even much larger predators, so they can feed in relative safety near the surface at night. Ultimately all of the food in the sea comes from the surface waters where the planktonic plants live, and it makes sense to come to the surface because that is where the food is located. But at dawn, light once again penetrates the surface, the migratory animals become visible, so they migrate swiftly down into the permanent dark of the deep during daylight hours for protection. This periodic vertical swimming behavior therefore occurs twice a day. The behavior pattern is called *vertical diurnal migration*, and it one of the most pervasive behavior patterns on earth. In the exceptionally clear waters of the open sea, sunlight can penetrate to depths of several thousand feet during the day, so vertical migrators often have to swim several thousands of feet twice a day. This can be accomplished only by relatively large animals with good swimming ability.

Consequently most of the vertical migrators are 1 to 10 centimeters long (1/2 to 4 inches), much larger than net zooplankton. Shrimp-like krill, small squids and many species of small fishes make up the vertical diurnal assemblage. At night, when one fishes the surface waters with a plankton net, the catch is much different than it was during the day because at night the net captures tiny net zooplankton, larger vertical diurnal migrators, and, of course, gelatinous animals, which are usually damaged and squished by the net.

There are interesting and predictable seasonal changes in plankton communities. There is little phytoplankton growth during the winter, but winter storms mix the open waters of the sea to great depths, bringing nutrients to the surface. In spring, the days begin to lengthen, the surface of the sea begins to warm, and a shallow, seasonal thermocline is formed anew. Now is the optimal time for phytoplankton growth, and these rapidly growing tiny plants experience population explosions, “blooms”, and “red tides”, utilizing the nutrients upwelled in winter. Later in the spring, zooplankton populations begin to rapidly expand, grazing upon the phytoplankton, and then top carnivores, the pelagic fish, spawn, producing vast shoals of larval fish, that feed in turn on zooplankton. In summer, marine mammals calve and produce pups, just as the larval fish have turned into bite sized juveniles. And then summer passes, predators migrate toward the tropics, the winds of fall and winter begin to blow and the annual cycle repeats.

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