Lesson: Plankton

Plankton

Most of the living organisms in the oceans we never see and rarely hear about. They are the plankton that float at or near the surface in ocean and freshwater environments. Plankton are organisms that drift passively or swim so weakly that they cannot move against even a modest current.

Although most plankton are too tiny to see, they are very abundant in the surface waters of oceans all over the globe. Plankton constitutes 95% of the oceans' biomass. They sustain the food chains of the open ocean. Because of their huge numbers, they are crucial not only to the ecology of ocean environments but also to the ecology of the whole planet. Plankton are classified in three ways:

1. the kind of organism, either as plants (phytoplankton) or animals (zoo-plankton);
2. how long they exist as plankton, either permanent (holoplankton) or temporary (meroplankton); and
3. by size, ranging from microscopic to larger than humans.

We will use each of these three categories in our investigations of plankton.

Plant-like and Animal-like Plankton

Just as we classify sea and land organisms as plants or animals, we classify plankton as plants and plantlike organisms (phytoplankton) or animals (zooplankton).

Click on these links and view the different examples of plankton.

- http://www.sahfos.ac.uk/pil/phytoplankton_images.htm
- http://www.cosee-ne.net/resources/documents/IdentificationofCommonMarinePlankton.pdf

Phytoplankton

Phytoplankton are unattached, mostly microscopic plants and plantlike organisms that float at or near the surface of the ocean and freshwater lakes, ponds, rivers, and streams. Phytoplankton live in the euphotic zone, the uppermost layer where enough sunlight penetrates so that they can photosynthesize-generally not deeper than 80 m. When they photosynthesize, they convert carbon dioxide and water into sugar and oxygen. They also absorb nutrients necessary for growing and building their bodies.

Phytoplankton play vital roles in both ocean and global ecology. All life on Earth depends on energy from the sun captured by plants in photosynthesis. Phytoplankton are the primary producers of the open ocean. Oceans cover 70% of the earth's surface, and phytoplankton are the dominant organisms. Thus phytoplankton play major roles not only in producing food but also in regulating oxygen and carbon dioxide in the oceans, and ultimately in the atmosphere as well.

Phytoplankton populations are very sensitive to changes in their physical environment, such as changes in sunlight (seasonal changes and heavy cloud cover, for example), and the amount of dissolved nutrients available to them.

Zooplankton

Zooplankton are animals, larvae, and animal-like organisms. Like all animals, they must consume food to obtain energy and materials to carry out life processes. Zooplankton also depend on phytoplankton for producing oxygen.

Zooplankton that feed on phytoplankton are herbivores. These grazing animals are sometimes described as "the cows of the sea." Zooplankton that feed on other zooplankton are carnivores; those that feed on phytoplankton and zooplankton are omnivores.

Zooplankton are used as food by many other animals, including small and large fish. Small fish like the anchovy (7 to 21 cm) feed on plankton in huge schools of thousands of individuals. The largest fish in the ocean, the whale shark, feeds on zooplankton. Huge baleen whales, the largest mammals in the ocean, also feed almost entirely on zooplankton. The world's largest animal is the 150-ton blue whale. A blue whale's stomach can hold up to 2 tons of krill. Even sessile (nonmoving) organisms, like sponges that filter-feed and corals that capture small food particles, also depend on zooplankton for food. Thus the zooplankton play important roles in ocean food chains.

Zooplankton populations quickly increase when phytoplankton are abundant. Typically, after phytoplankton populations increase, zooplankton graze on it and also reproduce rapidly into larger populations.

Permanent and Temporary Plankton

Plants and animals that live their entire lives as plankton are called permanent plankton, or holoplankton. Animals (zooplankton) that are holoplankton include jellyfish, krill, salps, and arrow worms.

Temporary plankton (meroplankton), drift only in their early stages. For example, the eggs and sperm of seaweed move by means of flagella. Sessile seaweeds release their swimming gametes into the surrounding water, where they swim about in search of a compatible gamete to fertilize. After the eggs and sperm unite, they quickly settle to the bottom to develop into attached seaweeds. Click on this link to view examples of meroplankton.

- http://beyond.australianmuseum.net.au/meroplankton/meroplankton06.htm

Animal meroplankton are larvae, the stage between an embryo and an adult. As they mature, these animals either settle to the bottom, as crabs do, or become stronger swimmers, as fish do. The link above shows some examples of zooplankton that are meroplankton.

Having a larval stage gives an organism two advantages. First, it provides a way to disperse the organisms over wide areas by using the surface currents of the ocean to sweep larvae away from their place of origin. This is a useful adaptation for sessile organisms. Second, animal larvae develop rapidly into a form capable of obtaining their own food. Because of their early ability to feed, such animals need neither long-term care by adults nor a large supply of stored food (the yolk in a chicken's egg is the chick's stored food supply).

Plankton Size

Plankton vary widely in size. Phytoplankton are generally smaller than the zooplankton. The smallest are the cyanobacteria, so small that they can only been seen under powerful microscopes. Some zooplankton are exceptionally large, such as giant 10 m long salp colonies (a colonial tunicate), giant jellyfish up to 2.5 m in diameter and 40 m long, and the ocean sunfish (4 m long), which swims so poorly that it is considered plankton. Scientists who study plankton have developed a size classification system based on ranges, from very large to microscopic. This system allows them to refer to organism sizes without giving actual dimensions each time.

Because plankton are so abundant, they are one of the key agents of change in the ocean. They exchange gases and nutrients with seawater and create wastes (detritus) that alter the ocean environment.

Interactions with Seawater

Phytoplankton change the concentration of dissolved gases in the ocean. During the day, if there is enough light, they photosynthesize, removing dissolved carbon dioxide from seawater and combining it with water to release oxygen. Both day and night they respire, removing dissolved oxygen from seawater.

Phytoplankton play a critical role in determining the availability of dissolved oxygen in seawater. During the day they produce more oxygen through photosynthesis than they use in respiration. At night they continue to respire. During a phytoplankton bloom, very large numbers of plankton deplete the dissolved oxygen supply, causing organisms to die. Phytoplankton's role in gas exchange goes beyond affecting the ocean environment. Since the ocean and atmosphere interact and exchange gases, phytoplankton, also play important roles in regulating atmospheric gases.

Phytoplankton selectively absorb elements from seawater and use them to build body parts. Phytoplankton, for example, need nitrogen and phosphorus to build soft tissue, and some require calcium or silicon to build hard skeletal structures. When these materials are abundant in seawater; phytoplankton rapidly grow and multiply; when the materials are depleted, the population drops.

Biological Sediments

Zooplankton feed on phytoplankton, but they cannot digest their hard skeletons. The skeletons, made of either calcium carbonate or silicon dioxide, are also indigestible to other animals. The skeletons pass through animal digestive tracts, then are expelled as one of the substances in waste fecal pellets. Uneaten plankton that simply die without being eaten also add skeletal detritus to the ocean.

Some of the plankton skeletal materials eventually sink to the seafloor, where they accumulate as biogenic sediments. Calcium carbonate sediments, or calcareous muds, consist mainly of the skeletal remains of foraminiferans, and pteropods. Silicon dioxide sediments, or siliceous muds , consist mainly of the skeletons of diatoms and radiolarians. Organic detritus is soft, nonskeletal biological material that decomposers can digest. The soft parts of dead plankton, along with digestible material in their fecal pellets, make up much of the organic detritus in the ocean. This detritus serves as food for decomposer bacteria, which convert the detritus into simpler substances that dissolve in seawater, making them available as nutrients for phytoplankton.

Where there are enough nutrients (phosphates and nitrates) in surface layers of the water and enough sunlight to support photosynthesis, phytoplankton flourish. However, they can multiply so quickly that they deplete the surrounding water of nutrients. In the open ocean the dead phytoplankton settle to the bottom, carrying their nutrients with them. The surface water is therefore depleted of nutrients, preventing further growth of phytoplankton. In these regions, because of the lack of phytoplankton, the water is a transparent blue. Most of the open ocean is like this.

Winds, waves, and currents stirring the water distribute dissolved nutrients. Currents can move water near the seafloor back up to the surface. Water near the seafloor is especially rich in nutrients from sediments. This water may take 500 years or more to recycle to the surface unless the area has upwellings, currents flowing upward from depths of 200 m or more. Upwellings carry nutrient-rich cold water to the surface. If sunlight is sufficient, phytoplankton flourish in areas with upwellings. So do other organisms that depend on plankton for food. Most of the best fisheries are near continents where upwelling occurs.

Marine Snow

Oceanographers coined the name marine snow for the small floating, drifting, or slowly sinking bits of detritus in the ocean. Marine snow consists of the soft organic material, fecal pellets, and skeletal remains of dead plankton plus smaller inorganic particles of mud or clay. Marine snow particles are often several millimeters across, making them easily visible to divers and submersible operators. They also show up in underwater photographs.

Click on this link to view marine snow.

- http://www.whoi.edu/oceanus/viewImage.do?id=4950&aid=2387

When marine snow particles collide, they often stick loosely together, sweeping the seawater of smaller particles as they sink. And marine snow can just as readily fall apart. About three-fourths of marine snow is either eaten or decomposed in the photic zone—the zone that light penetrates. Most falls apart or is eaten in the upper 1,000 m of the ocean. But about 0.01% sinks to the seabed, adding to the biological sediments deposited on the seafloor.

Only recently have oceanographers understood the importance of marine snow as a source of food and nutrients. Because marine snow drifts from the surface into deeper waters, it provides food for organisms at all depths. Marine snow was underestimated in earlier research on ocean food productivity, largely because its particles often break apart in sampling nets. Using sediment traps, oceanographers have found far more marine snow in the oceans than they expected—so much more that they have doubled their estimate of the biological productivity of phytoplankton.

The Greenhouse Effect and Global Warming

Scientists who study the greenhouse effect are especially interested in phytoplankton and marine snow. Greenhouse effect refers to global warming , the potential warming of the earth from the buildup of carbon dioxide and other gases in the atmosphere. An increase in CO_2 prevents heat from leaving the atmosphere and flowing into space. The CO_2 acts like the glass in a greenhouse, trapping heat in the atmosphere that could eventually cause worldwide warming. Such global warming could bring a rise in sea level, floods along coasts, and disruptive shifts in climate.

Carbon dioxide, the major gas in the greenhouse effect, dissolves in the ocean, where phytoplankton use it to build skeletal structures of calcium carbonate. Although most of the skeletal material is recycled, the amount that sinks to the seafloor can stay there for thousands of years. Some scientists have suggested that stimulating phytoplankton productivity may be one way of removing excess carbon dioxide from the atmosphere. Phytoplankton are much like the forests on land. They both use CO_2 to photosynthesize and build their plant structures, and both produce excess oxygen during daylight. Some scientists think phytoplankton are more important than land plants in controlling CO_2 levels.

Plankton Responses to Environmental Changes

Because phytoplankton are very sensitive to changes in their environment, their numbers vary throughout the year. Sudden periodic increases in phytoplankton population are called plankton blooms. Phytoplankton form the basis of the food chain, blooms are quickly followed by increases in populations of grazing zooplankton, then of predators that feed on herbivorous zooplankton. For this reason the size of the phytoplankton population tells much about the biological productivity of the ocean.

Sunlight

Increased light increases photosynthesis. Factors that decrease sunlight include nights, winters, and cloudy skies.

Nutrients

Increased supplies of nutrients (containing nitrogen in the form of nitrates, phosphorus in the form of phosphates, and potassium) speed phytoplankton growth causing population explosions or blooms.

Temperature

Warm temperatures speed the growth of many living organisms. Temperature layering occurs when the sun heats surface water, preventing it from mixing with colder, denser water. When phytoplankton deplete nutrients in upper layers, layering prevents nutrients in deeper waters from mixing into surface waters.

Grazing

Phytoplankton blooms provide abundant food for herbivorous zooplankton, stimulating the growth of their population. Because zooplankton graze on phytoplankton, the phytoplankton population falls until larger predators control the zooplankton populations.

Dissolved Oxygen

Phytoplankton and all other organisms respire continuously, taking in dissolved oxygen, during the day photosynthesis by phytoplankton produces oxygen, increasing the dissolved oxygen content of the water. At night the phytoplankton continue to respire but stop photosynthesizing, and the dissolved oxygen decreases. If the oxygen is severely depleted, large numbers of organisms can die.