

Productivity of Freshwater Ecosystems

All freshwater ecosystems (lakes, rivers, ponds, streams, wetlands) are home to various life forms, often collectively referred to as the food chain or food web. The numbers and variety of living organisms in a freshwater food web are dependent on the **productivity** of the ecosystem. This productivity depends on the availability of energy (usually solar) and raw materials (nutrients, minerals) within the ecosystem.

Of course, the available energy is constantly changing with daily and seasonal cycles, and the raw materials are continuously cycling (water cycle, carbon cycle, nitrogen cycle, phosphorus cycle) through and within the ecosystem. These fluctuations also help to determine the shorter-term productivity of the system.

In aquatic ecosystems, as on land, the basis of life and the resulting food web is **photosynthesis**. In simple terms, this is the conversion of solar energy and nutrients to living biomass in the form of green plants. These green plants take many forms. In aquatic systems, they are typically grouped as either macrophytes (large plants, often rooted) or algae (microscopic plants). Both types occur in shallow, nearshore areas, with the algae often attached to surfaces such as rocks, docks, and the large plants. In the deeper, open-water areas, algae are the dominant green plants. Collectively, these plants form the base of the freshwater food web. Their conversion, through photosynthesis, of inorganic nutrients and minerals to living (organic) matter is called **primary production**. Without this primary production, there would be no new biomass produced within the ecosystem to support other life forms. The greater the primary production within an ecosystem, the more living biomass that can be supported within the food web.

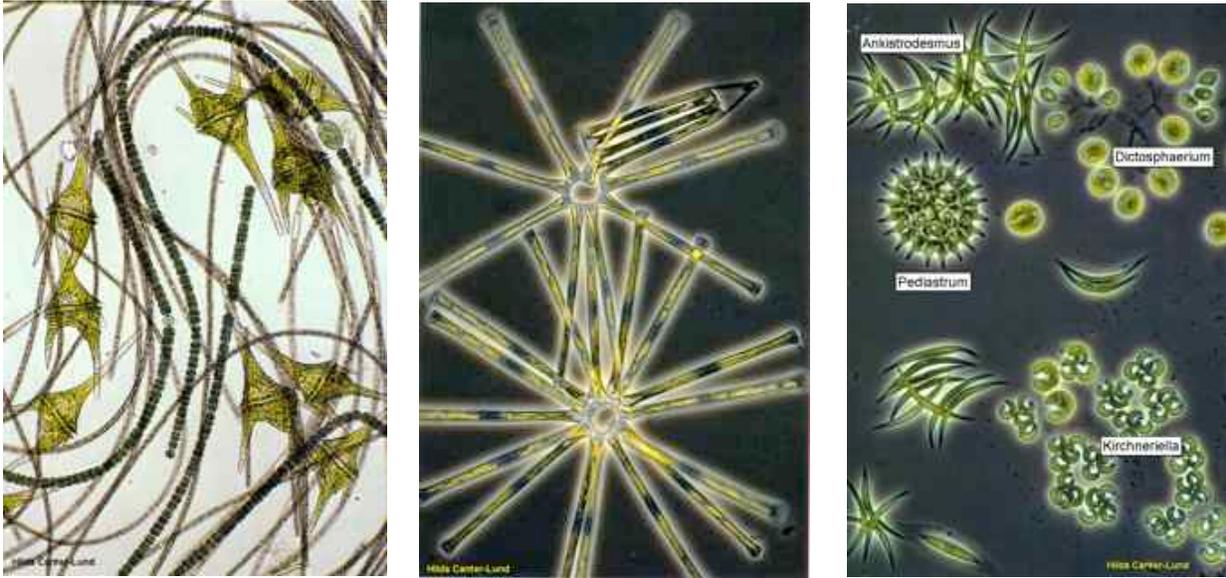
The Algae

The algae living in the open water are also referred to as **phytoplankton** (phyto = plant, plankton = wandering). Like many of the microscopic animals (zooplankton) that feed on them, these tiny “plants” float about in the open water, drifting with the slightest currents. They draw raw materials from the surrounding water and use energy from the sun to grow. When key nutrients (carbon, nitrogen, phosphorus) are available in abundance, they can grow and reproduce quickly.

Algae are extremely diverse. While they are single-celled, plant-like organisms, many algal species form complex colonies consisting of many individual cells. Among the major freshwater algal groups are chlorophytes (green algae), diatoms, euglenophytes, dinoflagellates, and chrysophytes. Cyanophytes or “blue-greens” (more properly called cyanobacteria) are grouped with the other algae, but not related. Each group consists of hundreds of species, and hundreds of different species may occur in a given lake. The three photos at the top of the page 2 show (left) a mixture of filamentous cyanobacterial colonies and dinoflagellates, (centre) some diatom colonies, and (right) a mixture of chlorophyte species. Each group and each species is adapted to certain conditions of nutrient availability, water temperature, solar energy, and other environmental factors. Thus, some species will commonly occur in certain types of lakes, or at certain times of year, or under certain special conditions. If conditions are ideal for a particular species, it will be present in high numbers and other algal species in the lake will be less abundant. If conditions change significantly, other species better

Productivity of Freshwater Ecosystems

adapted to the new conditions may outcompete the original species and begin to dominate within the phytoplankton.



For instance, chrysophytes, such as *Dinobryon* sp. (below, left) typically are found in Boreal Shield lakes, where nutrient concentrations are low. With limited availability of key nutrients, particularly phosphorus, these species can thrive in the cold, clear water of these lakes, but the overall biomass of the community will be low.



On the other hand, cyanophytes, such as *Anabaena* sp. (above, right) are generally adapted to warmer, nutrient-rich water, such as is found in many prairie lakes. If phosphorus is available in abundance, either naturally or through human activities, many cyanophyte species can grow and multiply at a rapid pace, quickly dominating the

Productivity of Freshwater Ecosystems

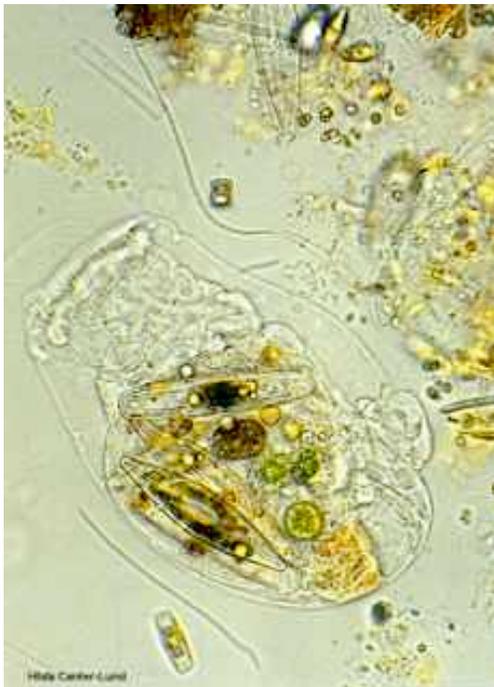
phytoplankton community. Some of these blue-green species can form chains of specialized cells, some of which contain gas vacuoles that serve as flotation chambers to keep the chain floating at the surface where the other cells in the chain can utilize the abundant solar energy while taking the raw materials for rapid growth from the water. Some, similar to legumes on land, can fix nitrogen from the air and use it for rapid growth provided there is plenty of phosphorus also available. This can result in the formation of massive surface “blooms” that can block sunlight from reaching other species deeper in the water. When the cells forming the bloom die off, they leave large quantities of decomposing biomass. Bacteria carrying out this decomposition may remove much of the dissolved oxygen from the water, sometimes killing fish and other species of animals requiring considerable oxygen.

For more detailed information about algae, check web sites such as

http://silicasecchidisk.conncoll.edu/LucidKeys/Carolina_Key/html/Group_List.html
or www.lennotech.com/eutrophication-water-bodies/algae.htm

The Invertebrates

In general, where there is more algal growth (greater primary productivity), there will be more food for things that eat algae. Most of these algae eaters are invertebrates such as microcrustaceans, insect larvae, and mollusks. Many small fish, including minnows and the young of larger species, also feed directly on algae and other plants. However, not all algae are equally edible for these “critters”. Some algal species have spines and other structures that make their cells more difficult for small animals to consume. Some of the blue-greens and dinoflagellates can produce toxins that can be fatal. Below, left, is a transparent, sac-like animal called a rotifer, its gut filled with diatom cells. To the right is a tiny crustacean, *Bosmina sp.*, its long gut filled with cells of the algae it has been eating. These small animals are food for larger animals, including fish.



Productivity of Freshwater Ecosystems

Lakes that produce more algae will normally produce more invertebrates and small fish. More invertebrates and small fish will normally mean more food to support large fish. Therefore, we would expect more fish biomass in a lake where primary productivity is high. However, high productivity lakes will not support all kinds of fish. Each species is best adapted to certain conditions, and will not do well where these conditions do not exist.

The Fishes

Normally, when primary productivity in a lake is low, the lake will support only fish species that are adapted to this oligotrophic (low nutrition) system. Lake trout (below) are one such species. Because they are adapted to cold, well-oxygenated, clearwater lakes, with relatively little algal productivity, their food resources are limited. They tend to grow slowly, become sexually mature at a later age, and reproduce slowly. Therefore, lake trout populations are very susceptible to over-fishing.



On the other hand, species, such as bass or walleye (below), that are adapted to life in warmer, shallower, more productive lakes, will have more food available. Thus, these fish can grow faster and reproduce more rapidly than lake trout. As a result, these fish populations are themselves more productive and can withstand heavier fishing pressures without suffering significant population losses.



However, all fish populations, and particularly those that are piscivorous (eat other fish) and occupy a niche near the top of the lake food web, can be harmed by overfishing. Greatly increased fishing pressures result from continued construction of new roads and trails, easier access through use of all terrain and other off-road vehicles, and major advancements in fish finding technologies and techniques. In our modern world, wild fish populations have few places to hide.