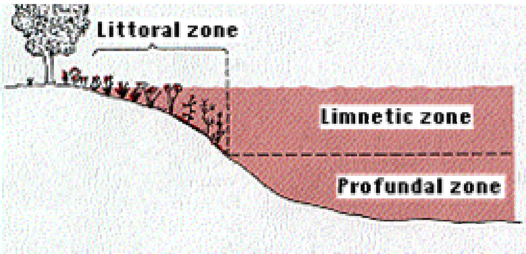

Freshwater Ecosystems

Only 3% of the world's water is fresh. And 99% of this is either frozen in glaciers and pack ice or is buried in aquifers. The remainder is found in lakes, ponds, rivers, and streams.

Lakes and Ponds

Deep lakes contain three distinct zones, each with its characteristic communities of organisms.

Littoral zone

The zone close to shore. Here light reaches all the way to the bottom. The producers are plants rooted to the bottom and algae attached to the plants and to any other solid substrate. The consumers include

- tiny crustaceans
- flatworms
- insect larvae
- snails
- frogs, fish, and turtles.

Limnetic zone

This is the layer of open water where photosynthesis can occur. As one descends deeper in the limnetic zone, the amount of light decreases until a depth is reached where the rate of photosynthesis becomes equal to the rate of respiration. At this level, net primary production no longer occurs.

The limnetic zone is shallower is turbid water than in clear and is a more prominent feature of lakes than of ponds.

Life in the limnetic zone is dominated by

- floating microorganisms - called **plankton**
- actively swimming animals - called **nekton**.

- The **producers** in this ecosystem are planktonic algae.
- The **primary consumers** include such animals as microscopic crustaceans and rotifers - the so-called **zooplankton**.
- The secondary (and higher) consumers are swimming insects and fish. These nekton usually move freely between the littoral and limnetic zones.

Profundal zone

Many lakes (but few ponds) are so deep that not enough light reaches here to support net primary productivity. Therefore, this zone depends for its calories on the drifting down of organic matter from the littoral and limnetic zones.

The profundal zone is chiefly inhabited by primary consumers that are either attached to or crawl along the sediments at the bottom of the lake.

Such bottom-dwelling animals are called the **benthos**.

The sediments underlying the profundal zone also support a large population of bacteria and fungi. The decomposers break down the organic matter reaching them, releasing inorganic nutrients for recycling.

Fall overturn

Where there is a pronounced change of seasons, the warming of the surface of the lake in the summer prevents this water from mixing with deeper water. This is because warm water is less dense than cold.

The surface water becomes enriched in oxygen

- some from the air above it
- the rest - because it is in the limnetic zone - from photosynthesis.

But the water in the profundal zone - being removed from both these sources - becomes stagnant.

In the fall, however, as the surface water cools, it becomes denser and sinks to the bottom - carrying oxygen with it.

Spring overturn

A similar phenomenon occurs when the ice melts in the spring.

Rivers and Streams

The habitats available in rivers and streams differ in several ways from those in lakes and ponds.

- Because of the current, the water is usually more oxygenated.
- Photosynthesizers play a minor role in the food chains here; a large fraction of the energy available for consumers is brought from the land; e.g., in falling leaves.

Ecosystem Ecology – Controls on System Metabolism

By now, you know that primary producers, or autotrophs, are responsible for the vast majority of all energy inputs to an ecosystem. Exceptions to this rule include ecosystems that are "powered" by organic matter flowing in from outside their boundaries as well as by carbon fixation by their own autotrophs. An example of this is a lake ecosystem, where rivers draining into the lake provide **allochthonous inputs** of organic matter while phytoplankton and fringing wetland plants produce **autochthonous inputs** of organic matter. Given the strong dependence of ecosystem energetics on primary production, it is instructive to investigate what controls rates of primary production in ecosystems. Controls internal to the ecosystem are largely biotic processes, such as limitations on the growth rates of plants or competitive interactions among plants of different energetic efficiencies. **Exogenous**, or external controls on ecosystem metabolism are often called **forcing functions**. Two very important controls on autotrophic production are **light availability** and **nutrient availability**. In today's lab, we will use light-dark bottle experiments to study how both may control primary productivity, and thus whole-system metabolism, in aquatic ecosystems.

The control light has on primary productivity should be obvious. Since photosynthesis is the biochemical process by which plants harness solar energy and us it to produce organic molecules from inorganic ones (namely CO_2 and nutrients), the amount of light available to a plant must obviously control the rate of production of organic matter. In terrestrial ecosystems, light availability is controlled by **shading**, and plants compete for light with a number of strategies. In aquatic ecosystems, shading is also a factor but the main control on light availability is the fact that water absorbs light energy. In fact, there is an exponential decline in available light as you proceed deeper in a water column—**light extinction**--such that:

$$I_Z = I_0 e^{(-kz)}$$

Where I_z is the amount of light at some depth=z, I_o is the amount of light at the surface (often expressed simply as 100%), and k is the **attenuation coefficient** (in units of 1/z, or m^{-1}). Clear water has a low attenuation coefficient, meaning that light penetrates relatively far. **Turbid** or **colored water bodies** tend to have higher attenuation coefficients. A quick and easy way to measure the attenuation coefficient of a body of water is with a **Secchi Disk** (you will learn how to do this in lab). The Secchi Disk Depth (D_s) relates to k as:

$$k = 1.7/D_s$$

In a very simple model system, you could assume that the rate of primary production is directly proportional to the amount of light at a given depth. Thus, GPP should *decline exponentially* with depth in the same way that light availability declines:

$$GPP_Z = GPP_0 e^{(-kz)}$$

Notably, this extrapolation of the first equation assumes a direct relationship between GPP and I, and thus assumes that nothing else limits primary production and whole-system metabolism.