

Aquatic Ecology And The Food Web



Some Understanding of the aquatic ecosystem is necessary before fisheries managers or pond owners can begin to understand changes in fish populations. The aquatic ecosystem is a complex of interrelated species and their reaction to each other and their habitat.

Changes in one part of the system often cause changes, large and small, throughout the system.

Eradication of aquatic plants in a pond with a healthy largemouth bass population is a good example of this concept. When all plants are eliminated from the pond in an effort to improve angling access; forage fish such as bluegill lose their protective cover and are exposed to excessive predation by largemouth bass. Bass initially respond by growing and reproducing rapidly, however, as the forage fish population declines, the once healthy bass population, limited by declining food supplies, becomes numerous, small and stunted.

The basic ecological concepts discussed in this section will provide the pond owner with the knowledge necessary to understand the reasoning behind fish and plant management techniques.

Succession

The aquatic ecosystem is a dynamic, changing environment. Daily and annual bio-geo-chemical cycles drive changes in water chemistry and the species composition of aquatic communities.

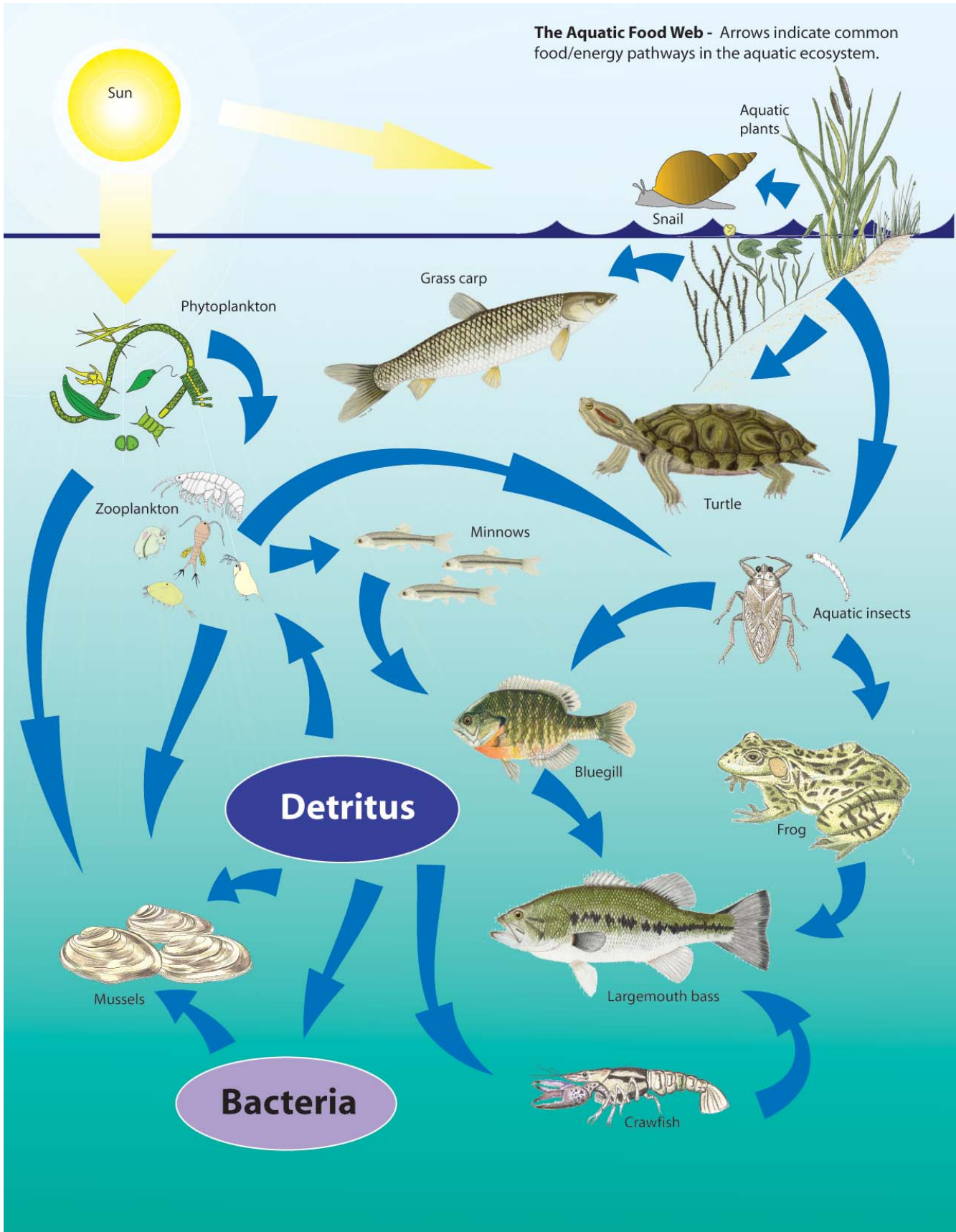
Ponds and lakes go through a cycle of changes over time, from newly created aquatic environment back to terrestrial habitat.

New ponds and lakes are usually **oligotrophic**. Oligotrophic waters have very little nutrients, a small phytoplankton population and consequently, clear water unless it is colored by dissolved or suspended minerals.

As the pond ages, leaves and other material wash into it from the watershed and plants and animals die and decay; gradually increasing the amount of nutrients available to the ecosystem. The phytoplankton community increases and the water becomes less clear and more green. Vascular aquatic plants colonize the shoreline and extend into the water as nutrients become available. Lakes with high levels of nutrients are said to be **eutrophic**. The pond has reached a mature stage of development.

Highly eutrophic or polluted lakes can result from activities in the watershed that release plant nutrients. Farm fertilizers, livestock manure, some detergents or other waste material containing nitrogen or phosphorous washing into the water produce noxious algae blooms and excessive phytoplankton production that is characteristic of this condition.

Over time, leaves, dead plants and animals and other detritus accumulates on the pond bottom. The pond becomes progressively shallower to the point that light penetrates all areas of the pond bottom and



aquatic vegetation covers the waters surface. The pond has reached the age of **senescence**. Willows, cypress, cattail and other shoreline plants advance toward the ponds center.

Eventually rooted plants cover the pond bottom and the pond becomes a bog or marsh. Dry land trees begin to invade areas that were once under water. The marsh eventually fills in and dries up. Surrounding terrestrial vegetation replaces aquatic and semi-aquatic plant species and succession is complete. This successional cycle can be disrupted at any time by natural events such as floods that can scour, deepen and rejuvenate the pond. Human activity such as draining and dredging the pond also can interrupt the successional cycle.

Energy movement in the aquatic ecosystem

An ecosystem can be thought of as a conduit of energy derived from sunlight. Energy from the sun plus inorganic materials are the basis of all life. Energy can not be recycled. It moves through the ecosystem and ultimately dissipates as heat. Energy transfer efficiencies are low, usually about 10 % between each trophic level of the ecosystem.

Trophic levels contain groups of organisms with similar methods of food (energy)consumption. Energy moves from one trophic level to the next through the **food web** fig. 1. An example of a common, linear aquatic food chain is:

Phytoplankton (microscopic plants) - Zooplankton (microscopic animals) -Insects - Blue gill - Largemouth Bass -Turtle -Bacteria

In reality, most food chains are usually complex and interconnected. They are more accurately described as **food webs**.

Producers are the first trophic level in the ecosystem and form the base of the food chain. Producers obtain nutrition from inorganic materials and sunlight energy. In aquatic

ecosystems phytoplankton are the primary producers; other aquatic plants also contribute but to a lesser extent. The total amount of energy per unit of time fixed as plant tissue is called **primary production**. Plants are able to convert only about 1-2 percent of the available sunlight energy into chemical energy usable for plant production.

Each time energy passes from one trophic level to the next, for example, a grass carp eating an aquatic plant or a largemouth bass consuming a bluegill, about 90 percent of the energy will be lost. Consequently, ecosystems require a large base of primary production to support a relatively modest level of production at higher trophic levels. The Eltonian trophic pyramid shown in fig, 2 illustrates this concept graphically.

Light is needed for all plant growth. Because clear ponds allow light penetration to greater depths than muddy ponds, more phytoplankton and other plants can grow, resulting in greater primary production in the base of the food chain.

More production in the food web base allows more production through out the aquatic ecosystem; and consequently, greater natural fish production in clear ponds than in muddy ponds.

Fish production in muddy ponds can be increased by clearing the pond or by addition of supplemental fish food to compensate for lack of primary production.

Fish production in clear ponds can be increased

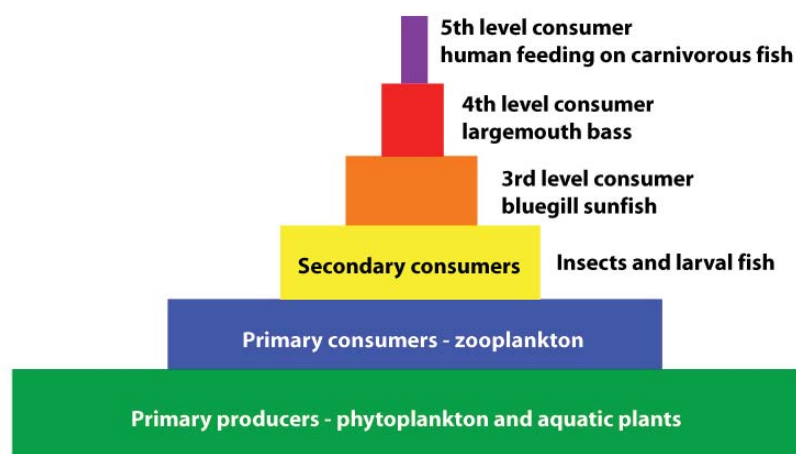


Figure 2. An Eltonian pyramid depicting relative abundance of organisms at six trophic levels.

by the addition of plant fertilizers to stimulate primary production. Fertilization only improves fish production if plant nutrients are lacking and light penetration is sufficient to allow increased plant growth. (When a specific factor is not available in sufficient quantity and restricts the growth of organisms it is called a **limiting factor**. For example, light is a limiting factor for plant growth in muddy ponds.)

In most situations, nutrients are actually over abundant, due to livestock waste or farm fertilizers. An over abundance of nutrients in clear ponds results in green, phytoplankton rich water; or excessive growth of rooted aquatic plants.

Consumers make up the next trophic level; and must eat other organisms to obtain their energy. Consumers, in turn, occupy different trophic levels. Trophic levels of common aquatic organisms are shown in table 1.

Primary consumers are herbivores, they eat plants. In our aquatic ecosystem example, zooplankton feeding on phytoplankton occupy the primary consumer trophic level. Cattle are primary consumers in terrestrial ecosystems.

Secondary consumers, represented by certain aquatic insects are carnivores and feed upon primary consumers, the zooplankton.

Our example also includes a **tertiary consumer**, the largemouth bass that feeds upon other carnivores.

The turtle, although opportunistic in its feeding

habits, is represented in the example as a **scavenger**. Organisms at this trophic level feed on large bits of dead or decaying organic matter.

Organisms of the final trophic level break down organic matter and animal waste products. These creatures are called **decomposers**, and they break down organic material back to its constituent elements. Bacteria are the most numerous and important decomposing organisms.

Ecological pyramids can be constructed using numbers of organisms, energy consumption in the

Trophic levels and feeding habits of common aquatic organisms.

Organism	Trophic level	Foods
Phytoplankton	Primary producers	Sunlight energy and dissolved nutrients
Zooplankton	Primary consumers	Phytoplankton, bacteria and detritus
Bacteria	Decomposers	Chemical molecules / detritus
Snails	Primary consumer scavenger, herbivore	Detritus / plant material
Mussels	Primary consumer filter feeders	Phytoplankton, zooplankton, detritus
Red eared slider turtle	Herbivore, scavenger	Plants, decomposing organic matter, sometimes fish
Crayfish	Scavengers, carnivore	Decomposing organic matter, fish, insects, opportunistic
Common carp	Herbivore	Plants, organic matter
Channel catfish	Scavenger, carnivore	Carrion, small fish
Largemouth bass	Carnivore	Fish, insects, frogs, crayfish
Frog	Carnivore	Insects, fish

ecosystem or total biomass to visually illustrate relationships and relative abundance of organisms among trophic levels.

The first trophic level which includes algae, phytoplankton and aquatic vascular plants, usually makes up the bulk by weight of organisms (about 85%) in natural aquatic ecosystems and forms the base of the food chain. (In some systems bacteria may actually be more abundant than plants.) Because there is up to a 90 percent loss of energy in each step of the food chain, each higher level of consumer will constitute a correspondingly lower amount of the total weight of living organisms in the pond. For example, about 100 lbs of insects, crayfish and small fish are required to produce 10 lbs of bluegill sunfish; and about 8 -10 lbs of bluegill sunfish are required to produce 1 lb of largemouth bass. This ecological fact explains why there are usually more than 10 times as many prey animals as there are predators. This is also the reason why ponds and lakes can not produce large numbers of big bass without an adequate forage base.

The same principle explains why muddy ponds, containing little phytoplankton can not produce as many pounds of fish per acre as a clear pond filled with phytoplankton, algae and vascular plants. The base of the food chain in a muddy pond is not large enough to support large populations of fish.

Many aquatic organisms occupy more than one trophic level and also feed on a variety of foods items from different trophic levels. Thus the concept of the ecological pyramid though useful, does not fully explain the complexities and interrelationships that exist among organisms in the pond.

Individual organisms and their roll in the aquatic community

An organism's **niche** includes all of the characteristics of its way of life. It includes the animal's habitat, physical and chemical tolerance limits, food, behavior and habits. Niche can be thought of as having multiple dimensions that define the organism's place in the environment. Aspects of a species ecological niche can be plotted on a graph to

visually show how the animal fits into its community. Plots can include temperature tolerance, oxygen requirements, food requirements, habitat preferences or any other aspect of interest concerning a particular species (fig. 3) .

Niches of different species may overlap to varying degrees. Overlapping niches usually result in competition among species. Two species with the same niche requirements for food will compete for this resource. Closely related species may have very similar niches, however, it is rarely possible for two different species to have identical niches. One species will eventually out compete the other. This theory is known as the **competitive exclusion principle**.

It has not been proven to be universally true although documented incidences of competitive exclusion have been observed. Two species with identical niche requirements could coexist in a habitat that contained essentially unlimited resources necessary for survival and reproduction.

Niches also can overlap only during certain life stages. For example, young bluegill and young green sunfish may compete for similar sized food items.

Species with overlapping niches may reduce competitive pressures by diversifying or partitioning the niche. Niche partitioning or diversification is accomplished in many ways. A common food resource may be used during the day by one species and at night by another; for example, hawks may feed on mice during the day while owls feed on them at night.

The aquatic habitat

Changes in light penetration and plant growth dictate much of the habitat variety found in the aquatic ecosystem.

The **benthic** or bottom dwelling aquatic communities begin at the shore line and extend to the deepest parts of the pond. Many bacteria, phytoplankton and protozoa live between the damp particles of sand and soil. Sedge species, bullrush and cattail also colonize the area and often extend out into the pond to depths of 4 feet or more.

The **littoral zone** extends into the body of water from the shore to the deepest area of rooted plant growth. The extent of the littoral zone depends on water clarity, light penetration and wave action. The littoral zone must have adequate light for photosynthesis.

The depth of this zone in your pond can be roughly calculated by lowering a white coffee cup on a string into the water and measuring the depth at which it just disappears. Multiply this depth by 2.75 to estimate the depth of the deepest rooted plants in the pond.

The littoral zone contains a large and diverse community of aquatic organisms. Vascular aquatic plants in this region support a variety of insects, snails, crawfish, mussels, frogs, turtles, larval fish and their predators. Many of the mobile organisms

such as turtles and fish occupy more than one habitat zone.

Below the littoral zone is the **sub-littoral** region. This habitat is characterized by accumulations of

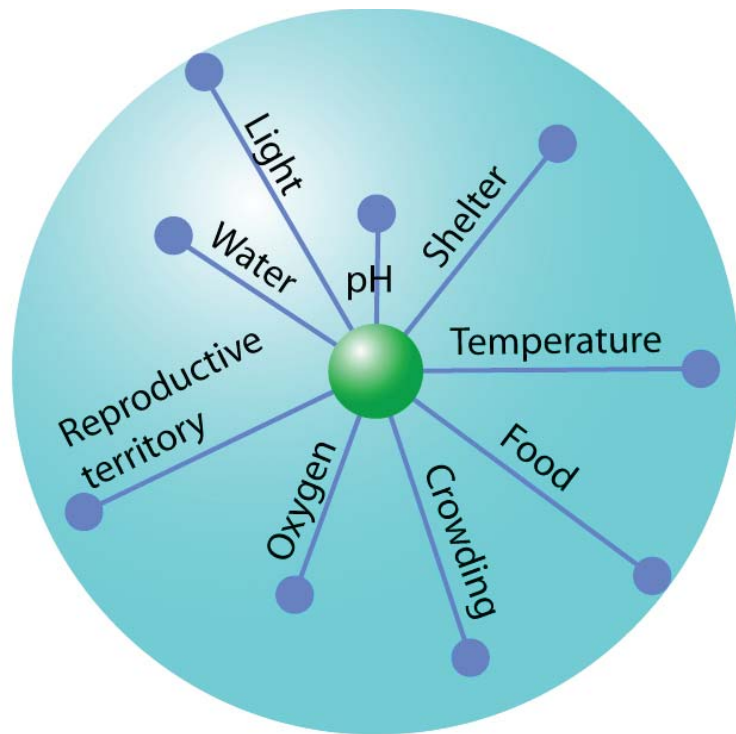


Fig. 3 Multi-dimensional niche space.

crustacean, mussel shells, and some dead plant material. This region is well oxygenated but poorly lighted. Fewer species are found here than in the littoral zone.

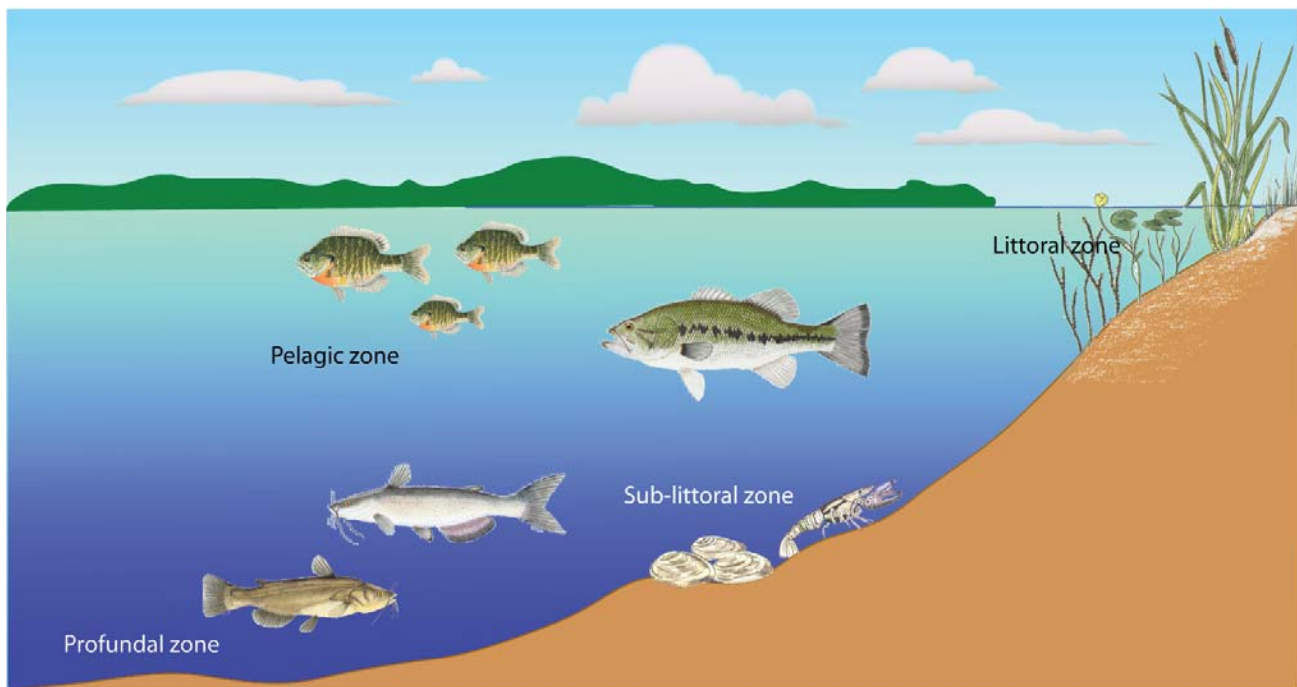


Fig. 4 Aquatic habitat zones in freshwater lakes and ponds.

In ponds large enough to thermally stratify, a profundal zone exists. The **profundal zone** is usually a stable environment except during periods of pond turn over. Oxygen levels are low or absent and there is little light penetration and no plant growth. Water temperature is usually cool and fluctuates little. The profundal zone is composed of detritus, and the bacteria and other organisms that feed on and decompose this material.

The open water is known as the **pelagic zone**. Plankton and other free swimming or drifting plants and animals inhabit this region as well as fish and other large, mobile organisms.