Food Chains, Food Webs, and Bioaccumulation Background

Introduction

Every living organism needs energy to sustain life. Organisms within a community depend on one another for food to create energy. This feeding relationship is referred to as a food chain. A food chain is a linear arrangement of three organisms in which each uses the organism below as its food source. For example, grass→deer →humans. Within an ecosystem, there are many interactive food chains which create a food web. Both abiotic and biotic factors are involved in food webs.

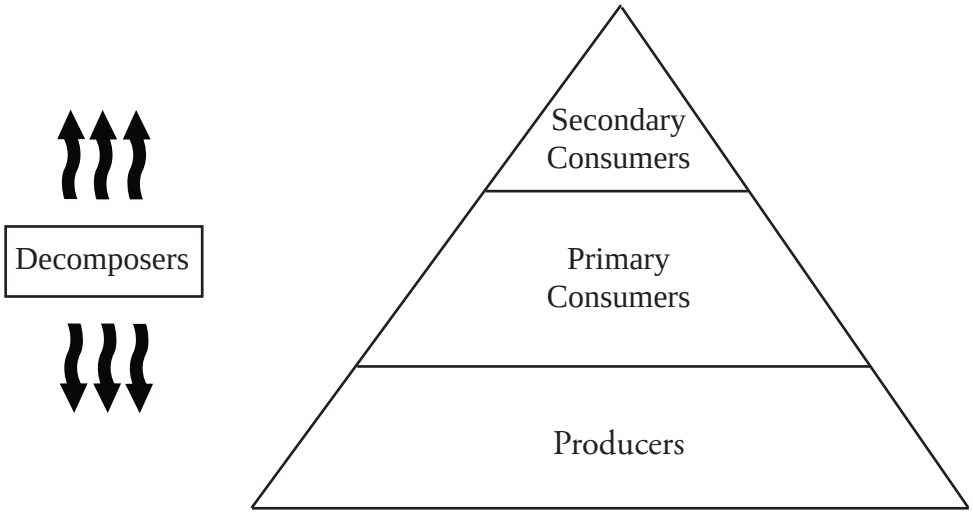
Biotic Factors

Trophic levels, or the feeding levels within a food chain, begin with producers, or autotrophs, which produce their own food through photosynthesis such as trees and shrubs. This group contains the greatest amount of energy within a food web or chain. Consumers, or heterotrophs, are those organisms that cannot make their own food, and therefore must eat producers or other consumers to gain energy (e.g. birds and rabbits). Primary consumers, or herbivores, feed solely on producers. There are three types of secondary consumers: omnivores, carnivores, and decomposers. Omnivores eat both plants and animals, carnivores eat only meat, and decomposers are those organisms that consume dead materials. Decomposers are not to be confused with scavengers, as scavengers are considered carnivores that eat parts of dead animals. Decomposers are recyclers and consume all parts of dead materials. Without them, nutrients would not cycle back into the environment, therefore making it impossible for other organisms to sustain life. Last are tertiary consumers, or top predators of an ecosystem. Examples here are grizzly bears and humans. {See Figure 1-Food Web Pyramid}

Abiotic Factors

Although, not often included in the food web, abiotic factors or the non-living aspects (water, sunlight, temperature, etc.) play an important role. Climate will decide which food resources, and how much water and sunlight, are available to organisms in any given environment. Water and sunlight are necessary for plant growth and photosynthesis, and also provide animals with the basic needs of survival.

Figure 1: Food Web Pyramid



Examples of Food Webs

In every environment there are different food webs. Although the organisms may be different, the order of producers, primary consumers, secondary consumers, and tertiary consumers, is always the same. For the purpose of this lesson, we will focus on aquatic food webs, both salt and freshwater.

Saltwater

Micro-organisms known as plankton are key players in the food web of a marine environment. Occupying the photic or sun-lit portion of the water are two types of plankton, phyto and zooplankton. Phytoplankton or plant plankton account for 95% of the primary productivity in the ocean. Zooplankton or animal plankton eats phytoplankton, and thus a primary consumer. Moreover, larger zooplankton eats smaller zooplankton; small bait fish eat larger zooplankton; and large predatory fishes eat the small bait fish. This series of feeding relationships makes up the marine food chain. When you factor in other species that feed on the same organism, then the chain becomes a web. {See Figure 2: Saltwater Food Chain}

Freshwater

At the base of the freshwater food web are producers, such as phytoplankton, algae, duckweed, and lily pads. Just like on land, plants in water undergo photosynthesis and provide aquatic organisms with oxygen. Freshwater primary consumers include zooplankton and invertebrates. Smaller prey fish that consume the invertebrates are secondary consumers. Predator species at the top level include largemouth bass, smallmouth bass, walleye, chain pickerel, and perch. {See Figure 3: Freshwater Food Chains} Humans and carnivorous birds (ospreys) are also included in the freshwater food chain.[i]

Human Impacts

In many food webs, humans are usually the top predator and are responsible for the decline in population, or in some cases endangering many species. Overfishing, introduction of non-native species, eutrophication, and bioaccumulation are just a few examples of how humans impact aquatic food webs.

Eutrophication

Eutrophication is a process whereby water bodies, such as lakes, estuaries, or slow-moving streams receive excess nutrients that stimulate excessive plant growth. This is often referred to as an algal bloom. Nutrients that cause these algal blooms can come from a variety of sources: fertilizer sprayings on golf courses, parks, home lawns, etc. and sewage release from treatment plants. The influx of nutrients can have adverse effects upon an ecosystem, namely loss of water clarity, fish habitat, and open water. For example, as plant numbers increase, they cover the surface and reduce the amount of sunlight to the bottom. If plants do not receive sunlight, they cannot perform photosynthesis and eventually die. In addition, this process causes the dissolved oxygen level in the water to drop thereby influencing fish and the fish's food.

Bioaccumulation

Bioaccumulation is the accumulation or buildup of toxic substances in an organism. Mercury is a good example. In a saltwater ecosystem, phytoplankton take up mercury; zooplankton eat the phytoplankton, taking in the toxin; then a small school of baitfish, larger fish, and eventually humans. The outcome is a build up of mercury in the tissues of the different organisms. In some cases, this build up of substances is so great that it can contaminate fish for consumption.

As a result, many states issue a health advisory to inform people which fish are safe and which to avoid due to contaminate levels. Specifically in NYS, the Department of Health (DOH) states that one should eat no more than one meal (1/2 lbs.) per week of fish taken from the state's freshwaters, the Hudson River, Upper Bay of NY Harbor (north of Verrazano Narrows Bridge), Arthur Kill, Kill Van Kull, Newark Bay, Raritan Bay west of Wolfe's Pond Park, Harlem River and the East River to the Throgs Neck Bridge. DOH also lists stricter advisories for specific water bodies: http://www.health.state.ny.us/environmental/outdoors/fish/fish.htm. In addition, DOH recommends that women of childbearing age and children under the age of 15 not eat any fish from specific water bodies included in the advisory lists.[iii]

Additional Resources

Water on the Web
http://waterontheweb.org/under/lakeecology/11_foodweb.html
http://waterontheweb.org/under/lakeecology/17_eutrophication.html

New York State Department of Health-Fish Advisories
http://www.health.state.ny.us/environmental/outdoors/fish/fish.htm

Vocabulary

- Abiotic Factors: non-living aspects; i.e. water, sunlight, atmospheric gases, temperature, wind, and climate
- Biotic Factors: living aspects of the environment; i.e. plants and animals
- Carrying Capacity: population number an ecosystem can support.
- Consumers: heterotroph; those that cannot perform photosynthesis; use organic substrates to get energy; i.e. herbivores and carnivores
- Decomposers: consume dead organisms; heterotroph; i.e. bacteria, some insects, and fungi
- Ecosystem: Community of organisms and their environment; working together
- Eutrophication: process where water bodies receive extra nutrients that cause an increase in plant growth
- Food Chain: An arrangement of the organisms of an ecological community according to the order of predation in which each uses the next usually lower member as a food source
- Food Web: Interactive food chains in an ecosystem
- Producers: an autotroph; those that produce oxygen through photosynthesis;

i.e. plants

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i "The Food Web," Water on the Web. 3 March 2004. 11 December 2008 <http://waterontheweb.org/under/lakeecology/11_foodweb.html.>.

ii "Eutrophication," US Geological Survey. 13 March 2008. 16 January 2009 < http://toxics.usgs.gov/definitions/eutrophication.html>.

iii New York State Department of Health. 2008-2009 Health Advisories on Eating Sportfish: New York City area, Rockland and Westchester Counties and Long Island, Including Marine Waters of New York State.

Figure 2: Saltwater Food Chain

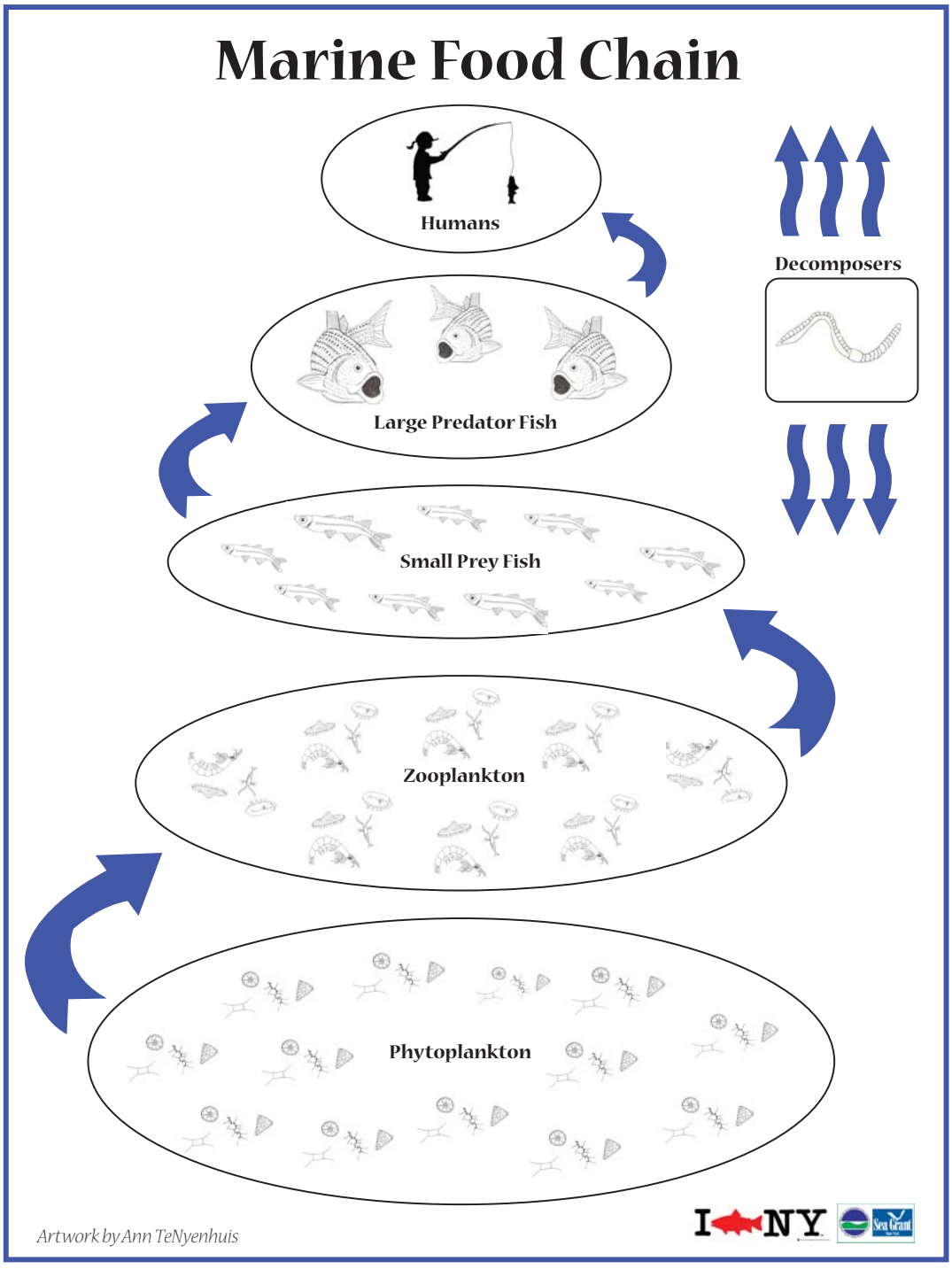

Figure 3: Freshwater Food Chain