Applied concepts in the science of estuaries:

Energy Flow in Estuary Ecosystems

Note to the teacher: This concept summary is intended for students in ***6th-8th*** *grade and is focused on science objectives related to ecosystems.*

Food chains, food webs, and energy pyramids
When one organism consumes another, molecules are metabolized and energy is transferred. As a result, energy flows through an ecosystem moving from producers to consumers. These biological interactions, or energy transformations, are traditionally represented using food chains, food webs, or energy pyramids.

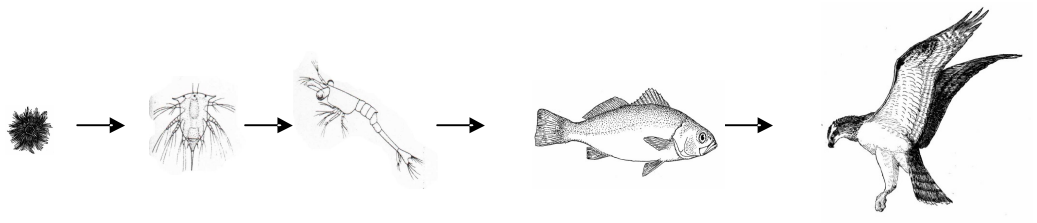

Figure 1. Representative food chain in an estuary ecosystem

The producers
At the beginning of an aquatic food chain are the primary producers, known as autotrophs. These include single celled phytoplankton, algae and seagrasses and as a whole, constitute the largest percentage of web biomass. Autotrophs convert solar energy into chemical energy and transform simple inorganic molecules to more complex organic molecules. This is accomplished by absorbing energy from the sun and releasing oxygen into the water and atmosphere. This ability to "produce" their own food by the mechanism of photosynthesis is the foundation for their collective name, the "producers."

The Primary Consumers
Unlike the producers, the consumers (heterotrophs) cannot make their own food. Instead, these organisms gain energy by consuming organic molecules created from the growth of other organisms. The primary consumers are organisms that feed on autotrophs and include macroscopic organisms such as zooplankton and filter feeders.

Daphnia *Cyclops*

Primary consumers are generally smaller in number but larger in size than the producers. Zooplankton are small, free-floating organisms that live amongst and graze upon the phytoplankton. They consist mostly of juvenile crustaceans and fish whose movements are controlled by the dynamics of the water. Also included in this trophic level are adult zooplankton, like Daphnia (a crustacean) and Cyclops (a copepod).

Among the primary consumers are filter feeders, named for their ability to feed by using their gills to strain plankton from moving water. Some filter feeders secrete slime on their cilia to hold plankton for ingestion. Filter feeders include bivalves and the juvenile stages of barnacles and some fish.

Secondary Consumers

Consumers can be characterized according to what type of food they eat. The primary consumers described above are *herbivores*, meaning they feed only on the producers. Secondary consumers include *carnivores*, which eat other consumers, and *omnivores* which eat both producers and consumers. *Detritivores* are consumers that feed on the left-overs in an ecosystem, such as the remains of animals, plants, and waste products.

Many animals, however, play more than one consumer role in a food web. The blue crab, for example, is an omnivore as well as a detritivore. The crab will eat the remains of organisms or living plants or animals if it can catch them. Animals like shrimp and crabs play important roles as they break down organic material into tiny bits of decayed organic material called *detritus*. The abundant bacteria then degrade detrital material and release nutrients back into the system. These bacteria (and fungi) belong to a group of detritivores called the *decomposers*, derived from their ability to break down complex molecules in dead tissues and wastes into simpler molecules. The role of decomposers is crucial as they set free and ultimately recycle the nutrients that form an essential part of the total food web.

Blue crab

Energy

As food is passed along each link of a food chain, significant amounts of energy are lost by one of two mechanisms (Figure 2). First, energy is lost by the organism producing heat as the animal does work, and second, by the food that is not completely digested or absorbed. This means that in order to maintain a constant supply of energy, there needs to be a much greater volume of producer biomass than subsequent consumer biomass.

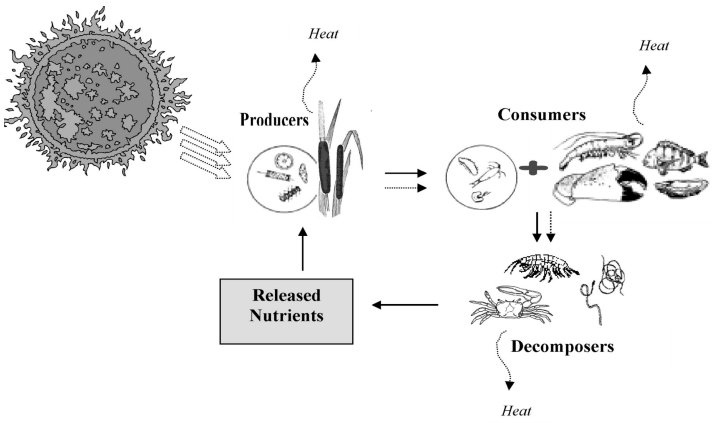

Figure 2. Heat loss and nutrient recycling in an estuary ecosystem. Energy (dotted lines) is ultimately lost to the environment while nutrients (solid lines) are recycled.

As described above, nutrients are utilized by the producers and passed to the decomposers for release back in to the system. We can then say that in an ecosystem, nutrients are recycled but energy is lost (Figure 2).

Energy Pyramids

Another way to represent energy flow in a food web is to use an energy pyramid, also known as a trophic level diagram. An organism s *trophic level* indicates the organism s position in the sequence of energy transfers.

There are two obvious trends in an energy pyramid. First, there are enormous numbers of individual animals or plants at the bottom and the numbers decrease as you reach the top. Secondly, the sizes of the individual organisms generally increase as you reach higher levels.

It should be noted that ecosystems are very complex and any food chain, food web or energy pyramid simply illustrates the general idea. It would be practically impossible to illustrate all the possible ways that animals interact and all the possible ways that energy moves throughout an ecosystem.

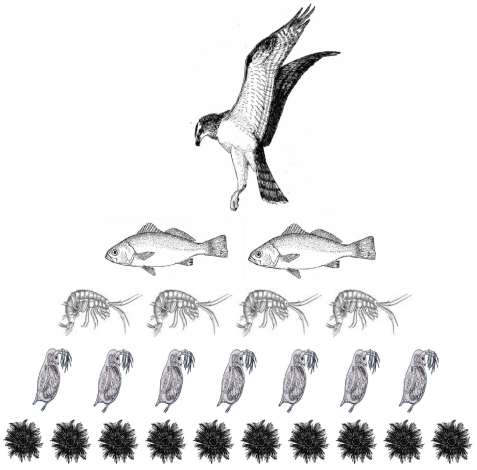

Figure 3. Representative energy pyramid for an estuary.

Questions for review: Energy flow in estuary ecosystems

1. Which of the following constitutes the largest percentage of biomass in an ecosystem?
   A. the autotrophs
   B. the primary consumers
   C. the secondary consumers
   D. the decomposers

2. What is the mechanism by which autotrophs fix energy from the sun as they transform simple inorganic molecules to more complex organic molecules?
   A. Respiration
   B. Photosynthesis
   C. Decomposition
   D. Predation

3. Which of the following is a key role of detrital consumers in an ecosystem?
   A. Make energy available for the primary consumers.
   B. Transform simple inorganic molecules into more complex organic molecules.
   C. Release nutrients.
   D. Provide protection from predators.

4. What does an organism's trophic level indicate?
   A. The organism's feeding mechanism.
   B. The organism's position in the sequence of energy transfers.
   C. The lifespan of an individual organism.
   D. The specific amount of energy used during its lifetime.

5. In this simple representation of an estuary energy pyramid, fish are represented as …
   A. producers.
   B. primary consumers.
   C. secondary consumers.
   D. autotrophs.