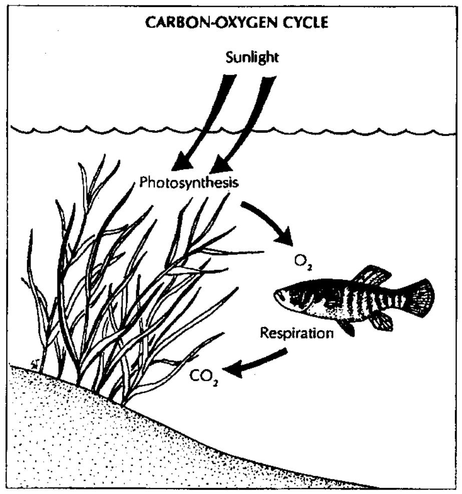
# Chapter Six
# Food Production & Consumption

The most important relationship among Bay species is their dependence upon each other as food. We are all carbon-based creatures. Carbon is the basic element of all organic compounds such as proteins, carbohydrates, lipids and nucleic acids. These compounds are the building blocks of life that make up the bodies of living organisms. Feeding is the process by which organisms cycle energy-rich carbon through the ecosystem. Each organism supplies the fuel needed to sustain other life forms.




Carbon-Oxygen Cycle

Plants and some bacteria can produce their own food through a process known as photosynthesis. Using energy from the sun, carbon dioxide and water are combined to form high-energy organic compounds. These organic compounds and other necessary chemicals form a plant's cellular structure, allowing it to grow. Because of this ability to use carbon dioxide and sunlight to produce their own food, plants are called autotrophs, or self-feeders. They are the primary food producers. All other organisms must feed, produced by plants.

Animals cannot process carbon via photosynthesis. Instead, they acquire carbon by eating the organic matter contained in plant and animal tissue or dissolved in water. The animal breaks this organic material down into components it can use for energy and growth. Animals are heterotrophs, or other-feeders.

Every biological activity, such as reproduction, growth, movement and bodily functions, requires energy. Whether organisms produce food themselves or ingest it from other sources, they all must break down organic molecules to use the carbon and energy contained within. This process is called respiration.

Aerobic respiration uses oxygen and releases carbon in the form of carbon dioxide. It complements photosynthesis, which uses carbon dioxide and produces oxygen. Together, aerobic respiration and photosynthesis compose the carbon-oxygen cycle.

All living things respire, but autotrophs carry out photosynthesis as well. Plants usually release more oxygen than they consume and animals use that excess oxygen for respiration. In turn, animals release carbon dioxide, which plants require for photosynthesis.

While carbon and oxygen are two of the most prevalent elements in our physical make-up, many others are needed. Nitrogen and phosphorus are two such elements. They are crucial to the operation of the Bay's life support system.

> BAY FACT: Each year, crabbers catch approximately 75% of the adult blue crab population in the bay.

Nitrogen is a major component of all organisms, primarily as a key ingredient in protein. When an organism dies, bacteria breaks down proteins into amino acids. Bacteria then remove the carbon, converting the acids into ammonia. Plants are able to use ammonia as a source of nitrogen. In the presence of oxygen, other bacteria convert ammonia to nitrite and nitrate, also good nitrogen sources for plants. Under low oxygen conditions, some bacteria convert nitrate to gaseous nitrogen which is unavailable to most aquatic organisms. However, in tidal freshwater, some blue-green algae are able to use gaseous nitrogen directly.

Temperature, sunlight, carbon dioxide and usable nitrogen and phosphorus control the rate of photosynthesis. Since plants are the only organisms able to produce new food from inorganic matter, the rate of photosynthesis determines the production of organic carbon compounds and, ultimately, the availability of food in the Chesapeake Bay ecosystem.

To illustrate how these factors affect the productivity of the Bay, lets look at the Chesapeake's most abundant food producer, the phytoplankton. Like all plants, phytoplankton require sunlight, nutrients and water. In the Bay, water is never a limiting factor. However, the amount of sunlight and nutrients can limit phytoplankton growth. The amount of sunlight available to an aquatic plant depends on the sun's altitude, cloud cover, water depth and turbidity (cloudiness of water). Temperature also controls the rate of photosynthesis.

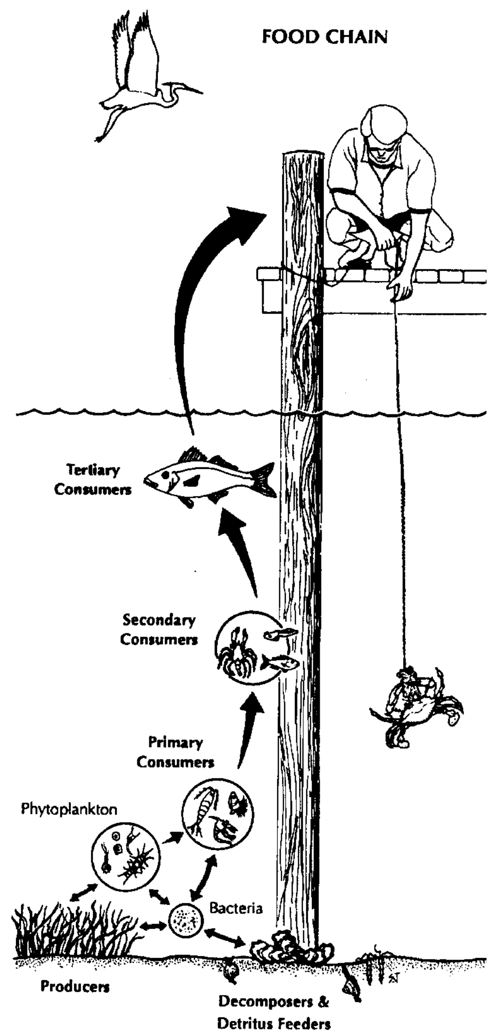
Nutrients in the form of carbon and usable nitrogen and phosphorus are rarely available in the exact proportions required by plants. Normally, one nutrient is in short supply compared to the others and is considered the limiting nutrient. If a limiting nutrient is added, a growth spurt may occur. Conversely, reducing the amount of a limiting nutrient causes plant production to decline.

Phosphorus controls the growth of some phytoplankton species in the spring, especially in the tidal freshwater and brackish areas. Nitrogen is the prime limiting factor at higher salinities, particularly during warm months.

Carbon dioxide limitations may control the rate of photosynthesis during algal blooms in tidal freshwater.

The Bay's life support system depends on maintaining the delicate balance between the living and non-living components. Although the Chesapeake's potential production capacity is massive, it is also finite. Problems affecting the simplest producers dramatically affect the survival of consumers.

### • The Food Web




As one organism eats another, a food chain is formed. Each step along a food chain is known as a trophic level and every organism can be categorized by its feeding or trophic level. The most basic trophic level is made up of producers, plants and algae which make their own food. Organisms that eat plants or other animals are consumers. Decomposers digest the bodies of dead plants and animals and the waste products of both. An example of a simple food chain starts with phytoplankton converting sunlight and nutrients into living tissue. They are, in turn, eaten by copepods, members of the zooplankton community. The copepods are then consumed by bay anchovies, which are eaten by bluefish and striped bass. These fish can be harvested and eaten by people. This illustrates how organic carbon compounds originally produced by a plant, are transferred to higher trophic levels.

Food production and consumption in the Chesapeake Bay is rarely this simple or direct. Seldom does one organism feed exclusively on another. Usually, several food chains are interwoven together to form a food web. Decomposers appear throughout the food web, breaking organic matter down into nutrients. These nutrients are again available to producers. This complex network of feeding continuously cycles organic matter back into the ecosystem.

The transfer of energy from one organism to the next is, however, inefficient. Only about 10 percent of the available energy is transferred from one trophic level to the next. For example, only a portion of the total amount of phytoplankton carbon ingested by zooplankton is assimilated by the zooplankton's digestive system. Some of that is used for respiration, bodily functions and locomotion. A small fraction is used for growth and reproduction. Since these are the only functions that produce additional tissue, only this fraction of energy is available to the consumer at the next trophic level.

Economically-important foods like fish and shellfish depend upon lower trophic level organisms. For every pound of commercial fish taken from the Chesapeake, almost 8,000 pounds of plankton had to be produced. An ecosystem must be extremely productive to support large populations of organisms at the highest trophic levels. Massive quantities of plants are required to support carnivores, such as striped bass or bluefish. Because producers are the basis of all food, they influence the production of other organisms. However, an overabundance of certain producers, like algae, can also be detrimental, causing a loss of SAV and reducing the amount of dissolved oxygen available to other organisms.

Toxic substances in contaminated prey can also be passed on to the consumer. Heavy metals and organic chemicals are stored in the fatty tissues of animals and concentrate there. As a result, an animal's body may contain a much higher concentration of the contaminant than did its food. This phenomenon is known as bioaccumulation. The severe decline of the bald eagle during the 1950s and 1960s was attributed to bioaccumulation. During World War n, a chemical pesticide, DDT, was used to control insects and agricultural pests. Fish and small mammals that fed on these pests were in turn contaminated with higher concentrations. Eagles eating contaminated prey concentrated even higher levels of DDT and its by-product, DDE. The DDE caused the birds to lay eggs with extremely thin shells, so thin that most eggs broke in the nest and many eagle pairs failed to produce young. Only after banning the use of this chemical were bald eagles able to recover to the population we have today.

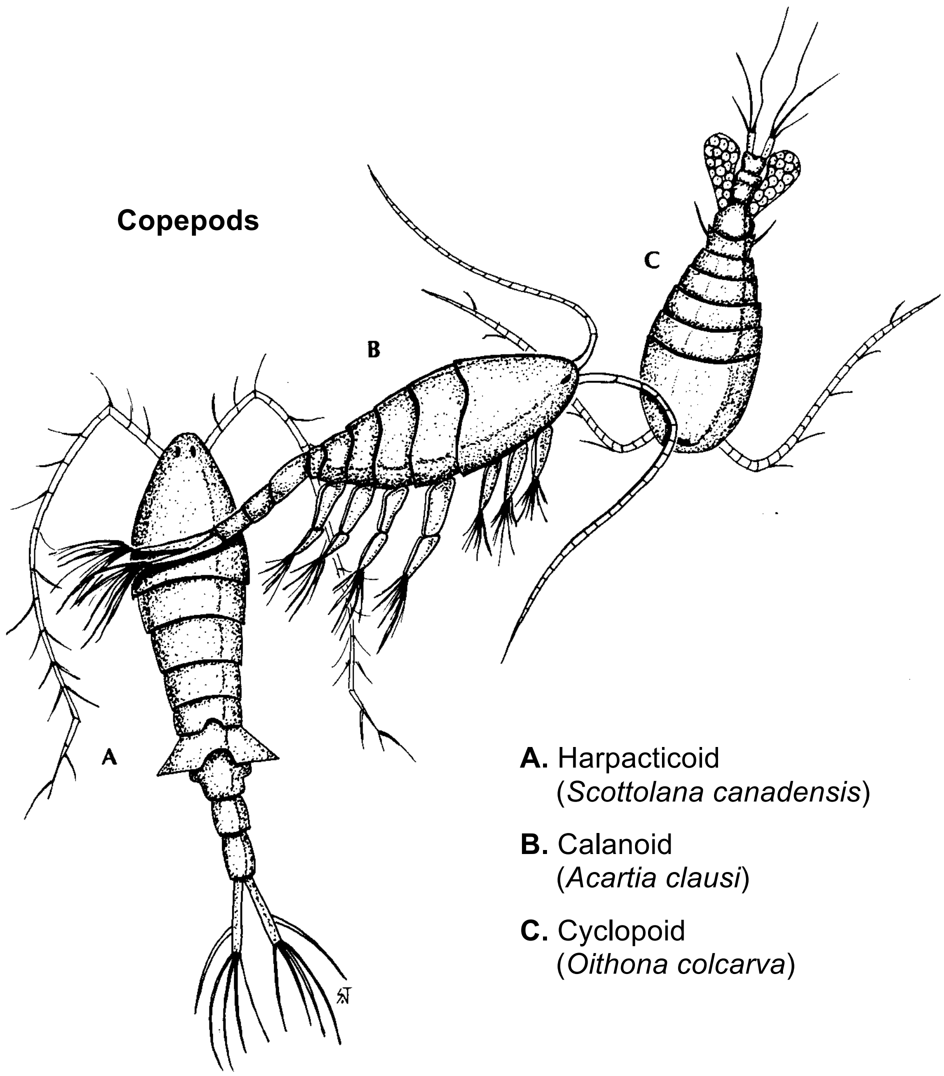
**• Direct and Detrital Pathways**

Two basic pathways dominate the estuarine food web. The direct pathway leads from plants to lower animals to higher animals. The detrital pathway leads from dead organic matter to lower animals then to animals. The detrital pathway is dominant in wetlands and submerged aquatic vegetation beds.

> BAY FACT: Most larval fish consume huge amounts of zooplankton to survive. A gallon of bay water can contain more than 500,000 zooplankton.

The direct and detrital pathways coexist and are not easily separated. Higher plants, like eelgrass, widgeon grass, saltmarsh grass and cordgrass contribute most of their carbon as detritus. However, epiphytic algae growing on these grasses is usually eaten by consumers, putting them in the direct food web.

**Copepods**




**A.** Harpacticoid
(*Scottolana canadensis*)

**B.** Calanoid
(*Acartia clausi*)

**C.** Cyclopoid
(*Oithona colcarva*)

In deeper waters, detritus from dead phytoplankton, zooplankton and larger animals, as well as detritus from upland drainage, wetlands and submerged aquatic vegetation, continually rains down on the Bay floor. Bottom-dwelling animals such as oysters, clams, crustaceans, tube worms, shrimp and blue crabs feed on it.

The direct pathway dominates the plankton community. The smallest of phytoplankton, known as nannoplankton, are fed upon by larger microzooplankton. Larger phytoplankton, like most diatoms and dinoflagellates, provide food for larger zooplankton and some fish. Bacteria, fungi, phytoplankton and possibly protozoa provide food for oysters and clams.

Copepods, a dominant form of zooplankton, play a key role in the food web between phytoplankton and animals. Copepods feed on most phytoplankton species and occasionally on the juvenile stages of smaller copepods. In marine waters, most animal protein production from plant material is carried out by copepods. Copepods and a related organism, krill, are the world's largest stock of living animal protein. Larger carnivores feed voraciously on them. Herring, for example, may consume thousands of the tiny creatures in a single day.

Most of the Bay's fish are part of the direct food web but their feeding habits are complex. Some experts contend that menhaden are the dominant fish in the Bay's intricate food web. The extremely fine gill rakers of menhaden act as a filtering net. Adult menhaden swim with their mouths open, consuming any plankton in their paths. In turn, menhaden are a major food of striped bass, bluefish and osprey. They also support a large commercial fishery that utilizes the fish for animal feed and other products containing fish meal and oil.

BAY FACT: Oysters were once so plentiful they could filter the entire volume of Bay water in a few days. The process now takes over a year.

Like menhaden, anchovies and all fish larvae are primarily zooplankton feeders. Adult striped bass, bluefish and weakfish feed mainly on other fish. Striped bass and other predators may also feed upon young of their own species. Many fish are omnivorous, eating both plants and animals. Omnivores, like eels and croakers, feed on planktonic copepods, amphipods, crabs, shrimp, small bivalves and small forage fish. Small forage fish, like killifish and silversides, often feed upon the epifauna and epiphytes along wetlands and in shallow water communities.