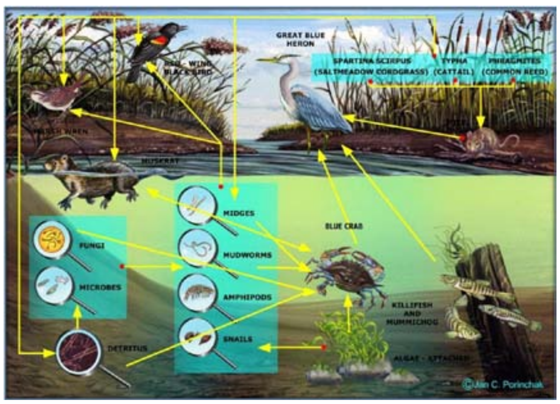
Biomagnification: Cadmium in the Food Web

Why do some organisms have so much cadmium in them?

To understand why cadmium is a problem for the environment, people, and other organisms, we need to learn about cadmium **pathways**. The previous lesson focused on abiotic factors that moved cadmium around. This lesson will investigate biotic pathways, also known as food webs. The first section of the reading describes the Foundry Cove food web. The second section explains the process of biomagnification, which can lead to high levels of toxins or other harmful compounds in animals at the top of the food chain.



The Aquatic Food Web

The Hudson is a constantly changing river, and along its length you will find a number of different food webs, depending on such factors such as salinity, depth, and temperature. Major Hudson River food webs are Freshwater Shallows, Brackish Channel, Freshwater Channel, and Marsh. Foundry Cove is part of the Hudson River, and both marsh and freshwater shallows environments are found within the cove.

Foundry Cove is tidal and is part of the estuarine portion of the Hudson River. Usually, Foundry Cove is a freshwater environment. However, in dry times, it can become slightly brackish or salty. The information below should help you think about the basics of a complex food web that connects the marsh and freshwater cove with the main stem of the Hudson River. We can visualize the cove as a system of feeding links or a food web.

Unlike most land-based food webs, much of the plant material in Foundry Cove is not consumed by herbivores. Instead, cattails and other large plants (macrophytes) break down into small pieces of detritus and even smaller pieces of particulate organic matter. These small organic bits form the basis for food webs in Foundry Cove and in the Hudson River. Some mud-dwelling invertebrates such as worms ingest sediment and digest some of the detritus and smaller pieces of organic matter along with fungi and bacteria that live on it. In this way, the worms and other invertebrates help to speed up decay or decomposition of dead plant matter.

Carnivores such as the grass shrimp, fish, spiders, birds and raccoons consume small herbivores. Large carnivores such as fishes consume the smaller ones. Some larger carnivores are migratory. For example, striped bass and blue crabs come into the river only during the warmer months to feast on their prey.

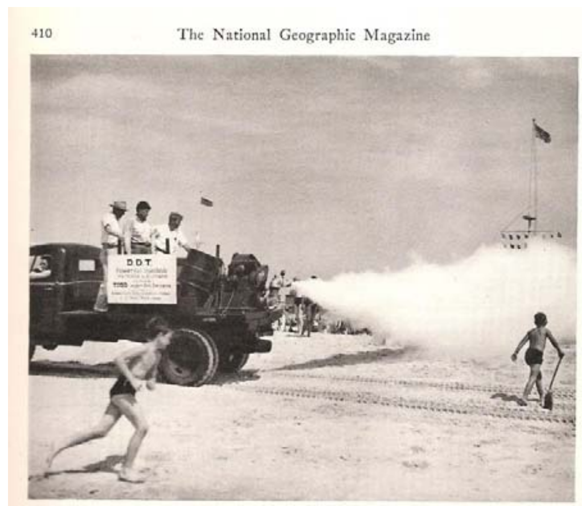
Worms, fly larvae, and other organisms that feed on sediments are most likely to be affected by cadmium, which accumulates in the sediments. However, other animals can be affected by cadmium, too. Muskrats eat cattails and use them to build their lodges, and have high levels of cadmium in their bodies due to the biomagnification of this metal.

Effects of cadmium and other kinds of pollution are difficult to predict for single organisms and for whole food webs. Food webs in marshes and coves are complex and there is still much to learn. A basic understanding, though, will give you the background to follow some of the cadmium pathways in Foundry Cove.

Biomagnification

The increase in concentration of a particular toxin, such as cadmium, PCB, or DDT, in animals high up the food chain is called **biomagnification**. Top predators such as bald eagles have much higher levels of some toxins than the fish they eat. Detritus, along with small amounts of algae and aquatic plants, forms the base of the Hudson River food web and is eaten by small zooplankton, which is eaten by larger zooplankton, and so forth. If a toxin accumulates in the tissues of organisms, that toxin will move up the food web.

Two similar words, bioaccumulation and bioconcentration, are often used interchangeably with biomagnification though they refer to different but related processes. **Bioaccumulation** is a natural process in all organisms, including us. When we eat, we accumulate vital nutrients such as vitamins and protein that we need in order to survive. **Bioconcentration** is used to describe the bioaccumulation of toxins or other harmful chemicals. Any compound, either natural or manmade, will be stored (or accumulate) in an organism if it is taken up faster than it is broken down (metabolized) or excreted.



A pesticide called DDT is perhaps the most well-known cases of biomagnification. DDT was used in the United States as an agricultural pesticide from the late 1940s through the early 1970s (it was banned in 1972). It was such an effective insecticide that communities would drive trucks down the road, spraying DDT in a huge white cloud to kill mosquitos and other pests while neighborhood kids played in the plume (see photo at right).

However, DDT caused top bird predators such as eagles, osprey, and pelicans to lay eggs with very thin eggshells that broken when the birds sat on their nests. The numbers of these birds dropped so dramatically, that once the Endangered Species Act was passed, bald eagles, osprey, and pelicans had nearly become extinct and were designated Endangered by the federal Environmental Protection Agency. Both bald eagles and osprey have slowly increased their numbers in the Hudson River Valley over the past few decades.

One study of DDT levels showed that where soil levels were 10 parts per million (ppm), DDT reached a concentration of 141 ppm in earthworms and 444 ppm in robins. Though the concentration of a chemical may be low in the air, water, or soil, biomagnification can lead to death or adverse effects on behavior, reproduction, or disease resistance in top predators.