

PASSAGE TWO

Zebra Mussels and the Hudson River

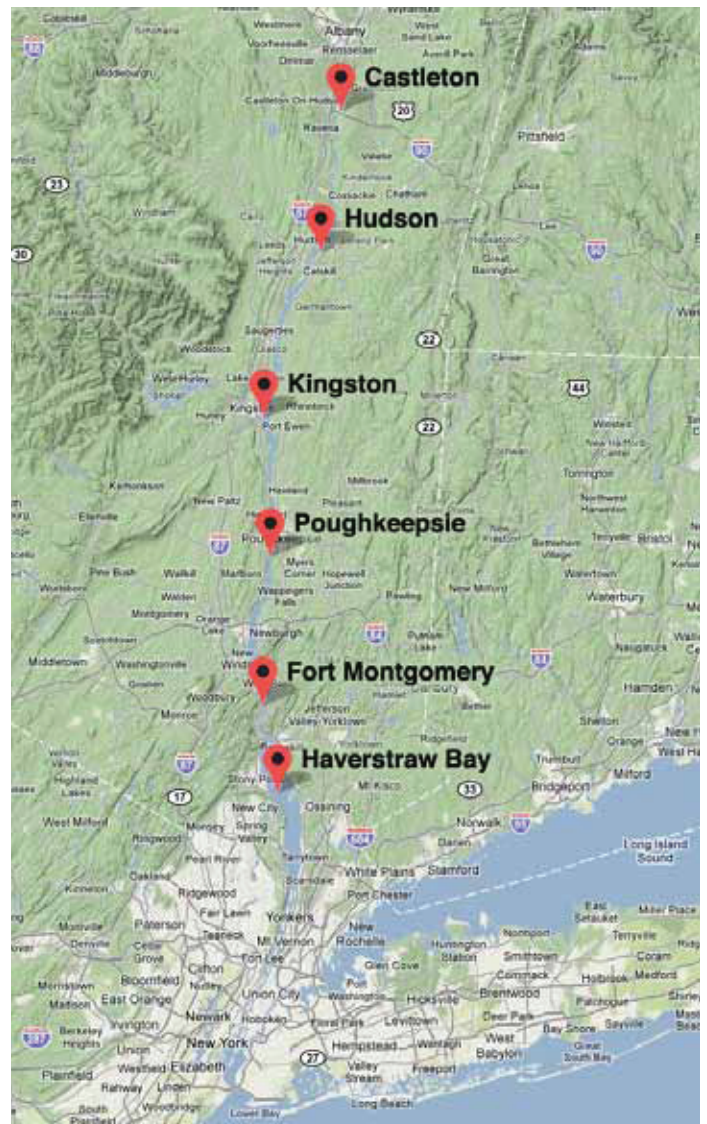
Invasion of the Zebra Mussel

A team of scientists at the Cary Institute of Ecosystem Studies has been monitoring the Hudson River ecosystem since the mid-1980's, from the way development influences the shore zone to the effect of invasive species on aquatic life. Two of these scientists are Dr. David Strayer, an ecologist who studies freshwater invertebrates, and Dr. Stuart Findlay, who's interested in the connections between terrestrial and aquatic ecosystems and microbial communities. Cary Institute research makes the Hudson River one of the most scientifically scrutinized rivers in the world. Aware that it was just a matter of time before zebra mussels showed up, Cary Institute scientists knew that a thorough understanding of baseline river conditions would help them assess the impact of the invasion. To this end, they initiated an "ecosystem approach" to studying the whole Hudson River system. Since then, for over two decades, Cary Institute scientists have maintained an ongoing database of key environmental variables, biological populations, and ecological processes. As more data are gathered, they contribute to a growing understanding of the subtle and complex interactions among both biotic (living) and abiotic (non-living) factors that characterize this unique river ecosystem.

Making Predictions

In order to predict the effect of the zebra mussels, Cary Institute scientists posed several questions. The first was: Would zebra mussels live in the river? Water chemistry information determined that the Hudson would be a suitable habitat. How many zebra mussels would live in the river, and how might they affect the food web? Based on variables known to affect zebra mussels, such as the nature of the river bottom, the scientists estimated that the river could support a population of up to 150 billion zebra mussels. Drawing on

previous studies of filtration rates, the scientists then calculated how much plankton the zebra mussels could remove from the river. The combination of water chemistry data and filtration rates of the zebra mussels suggested that the impact of zebra mussels on the Hudson River could be huge.



The six cardinal stations along the Hudson River, from which Cary Institute scientists have been collecting data since the mid-1980's.

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Monitoring the River

Cary Institute scientists combined spatial and temporal approaches to studying the Hudson River. Collecting data at many closely spaced locations (“transects”) along the river has enabled them to analyze changes across space (spatial). Sampling the same locations regularly over long periods of time has enabled them to measure changes over time (temporal).

Sampling is expensive, and one challenge was deciding how many locations along the river would be sufficient. The Hudson River can be up to a mile wide and up to 90 feet deep, and its currents vary widely. Was the water homogeneously mixed, or were there significant differences between different depths and locations? How deep should they sample? Where the river is wide, would it be sufficient to sample a single point?



Small and large zooplankton are sampled by filtering river water through nets of different mesh sizes.

To reach consensus, the scientists tested a variety of sampling designs, and found that while water variables changed between stations up and down the river, as expected, there were only minimal differences among water variables when comparing one side of the river to the other, or comparing surface to depth at any one location. A single sample taken

from near the center of the channel would be adequate for most data collection. They settled on six long-term stations for detailed water analysis (located at Castleton, Hudson, Kingston, Poughkeepsie, Fort Montgomery and Haverstraw Bay) spanning 120 km (74 miles) of the river. They also settled on a transect strategy at 2-4 km (1.2-2.5 miles) intervals along the entire river (see Figure 1), to measure basic water chemistry.

As for timing and frequency, much of the changes in biotic factors take place during a “growing season” from May through October. The river is relatively dormant the rest of the year. The scientists decided to sample the 6 stations 4-6 times per year during the growing season months only, and to run their transects 4-6 times per year also during the growing season. However, they did want to have some data for the winter months and therefore chose to take samples all year long, every other week at Kingston, except when the river was iced over.

A subsequent assessment determined that the strategy was sound, and it has held up well. Launching a small motorboat from various points along the river, Cary Institute scientists have been drawing water samples for over 20 years.

BIOTIC FACTORS

Phytoplankton and Zooplankton

As in most aquatic ecosystems, a foundation of the Hudson River’s food web (see Figure 2) is phytoplankton production. Phytoplankton are tiny floating organisms (e.g., blue green algae, green algae, and some protists) that use photosynthesis to convert solar energy into sugars and plant tissues. Phytoplankton are eaten by zooplankton, tiny animals about a millimeter long that drift in open water. If the zebra mussel depleted phytoplankton, many other consumers might be affected. And if the zebra mussels ate zooplankton directly, fish populations could be affected.

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Scientists determine phytoplankton abundance by measuring concentrations of chlorophyll-a, which is a light-sensitive pigment produced by phytoplankton. (Chlorophyll gives many types of producer organisms — which include plants, algae and some types of bacteria — their green color, and is responsible for the photosynthetic process). In order to determine the amount of phytoplankton in a water sample, scientists filter out the plankton particles and extract and measure the amount of chlorophyll they contain.

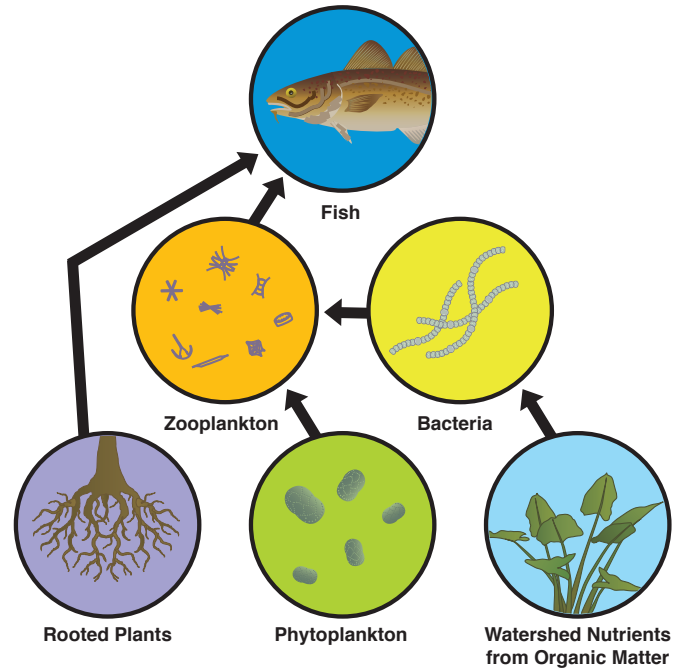
Zooplankton are sampled every 2 weeks during the ice-free season at the Kingston site. Macrozooplankton (mature copepods and cladocerans) are sampled by pumping 100 liters of water through a 70-80 micrometer mesh net. Microzooplankton (nauplii, rotifers, tintinnids) are sampled by passing two liters through a 35 micrometer mesh net.

Organic Matter from the Watershed Supporting the Food Web

Studies have shown that the major source of organic matter in the Hudson is not phytoplankton but particles from the watershed (the land around the estuary). When it rains, soil, dead leaves, and dissolved materials from tributaries upriver — a diluted “tea” steeped in the soils of the watershed — washes into the river.

In the Hudson River ecosystem, this organic matter (derived from dead plants) is a bigger source of food than phytoplankton production (derived from living plants). This differentiates the river’s food web from those in the Great Lakes. Bacteria, which eat the lion’s share of all of this organic matter, are an important component of the river’s food web, and Cary Institute scientists measure their abundance and productivity. The organic matter also feeds many, many other organisms, from zooplankton to worm-like bottom-dwellers to crustaceans that live in the water column. These organisms, in turn, feed fish and other predators.

HUDSON RIVER ECOSYSTEM FOOD WEB



Fish

Fish occupy the top of the aquatic food web. Hudson River fish can be divided into two main groups: pelagic and littoral. Pelagic fish, which include American shad, blueback herring, alewife, white perch, and striped bass, live in open water and feed mainly on zooplankton, along with some deep-water invertebrates and smaller fish. Littoral fish, which include redbreast sunfish, smallmouth bass, pumpkinseed, tessellated darter, common carp, and spottail shiner, live in vegetated shallow waters, where they eat mainly benthic (bottom-dwelling) invertebrates and other fish.

Scientists have also found that grasslike plants called water celery grow in about 6 percent of the Hudson, where the water is shallow and clear enough for sun to penetrate to the bottom. (Most of the river is either too deep or too turbid (muddy) for light to reach the bottom, so no plants grow.) Water celery produces organic matter that also contributes to the food web.

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Zebra Mussels

In 1993 Cary Institute scientists started sampling the zebra mussel population. Twice in the summer scuba divers collect 10 rocks from the hard or rocky areas of the river bottom from each of the seven sampling sites. They put these rocks into coolers and return to the lab. There the researchers count the number of mussels attached to the rocks, and measure shell length. Samples are preserved in ethyl alcohol and stored in the freezer. In “soft-bottom” areas, scientists use a device called a benthic grab to collect material at 48 random sites. The material is sieved and transported back to the lab, where all the bivalves in the sample are counted and identified. A subset is measured for shell length. Since scientists know approximately how much of the river bottom is rocky and how much is soft, they combine these averages for an annual estimate of the total number of mussels in the freshwater portion of the river, as well as the average per unit of river bottom.

ABIOTIC FACTORS



Researchers lower probes into the river that measure temperature, dissolved oxygen, pH and conductivity.

Abiotic (physical and chemical) factors affect the kinds and abundance of organisms that can inhabit a given ecosystem. Cary Institute scientists monitor a variety of abiotic factors, including the temperature of the water, the concentration of

dissolved oxygen in the water, how acidic or basic it is (pH), how fast or slowly the current is, how much sunlight penetrates the water, how much suspended sediment the water contains, and its concentrations of nutrients (nitrogen and phosphorus). Three of these key factors are described below.



A scuba diver collects rocks from the river bottom. In the lab, zebra mussels are removed from the rocks, counted and their shells measured.

Temperature

Temperature affects the metabolic rate of organisms. Temperatures fluctuate in the short term as weather changes, over a longer term as seasons change, and over even longer periods as climate changes. Scientists have found that the life cycle stages of many organisms change with the seasons, as do air and water temperatures and the number of hours of daylight.

Dissolved Oxygen

Organisms in aquatic environments must be able to survive on lower concentrations of oxygen than organisms directly exposed to air. This is because oxygen must be dissolved in the water to reach them, and water holds nowhere near as much oxygen as does air in the atmosphere. Dissolved oxygen gas (DO) is measured in milligrams of oxygen (O₂) per liter (mg/L), which is equivalent to parts per million (ppm). If the dissolved oxygen concentration of water is below 2 mg/L (or ppm), conditions are “hypoxic” and can stress aquatic organisms. Since producers release oxygen during photosynthesis, the amount of dissolved oxygen in aquatic environments can be higher during the day than at night. Producers and consumers take up oxygen during respiration, which causes oxygen concentrations to drop. Zebra mussels, through their respiration process and by eating producers (phytoplankton) could influence DO.

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Suspended Solids

Total suspended solids (TSS) refers to solid particles that are suspended in water, which is an important indicator of water quality. Scientists measure TSS by pouring a water sample through a filter. Material too large to pass through is considered “particulate” (or a suspended solid), while the material that passes through the filter is considered “dissolved.” TSS may be composed of both biotic particles (e.g. phytoplankton) and abiotic particles (e.g. silt and clay). Scientists have found that TSS is important to aquatic producers because suspended particles scatter and absorb sunlight, which affects the amount of light available for photosynthesis. Since every particle suspended in the water ends up on the bottom of the river after being eaten by zebra mussels or wrapped in mucus and spit out, the mussels are able to clear large bodies of water. If the zebra mussels reduced TSS, it would increase the amount of sunlight in the water and in turn affect photosynthesis.

Stop and Think

1. What kinds of data are scientists collecting in the Hudson River? (How does this compare to your answer in Passage 1?)
2. What types of tools and techniques did the scientists use to gather, analyze, and interpret data?
3. How could this data help the scientists assess the impact of the zebra mussel invasion?