

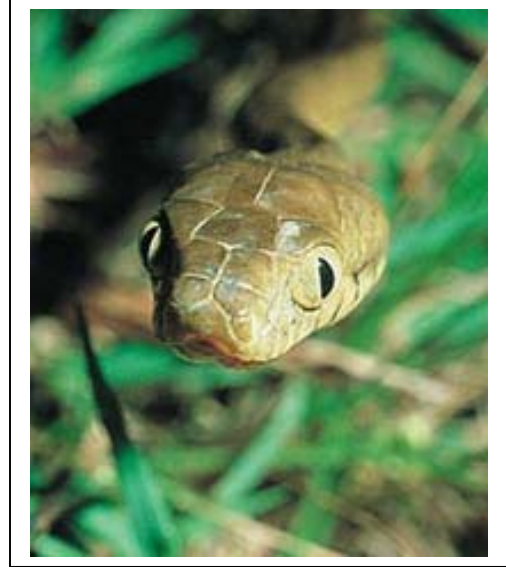
ISSUES – FIGURE SET

What Are the Impacts of Introduced Species?

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Brown tree snake, *Boiga irregularis*
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{biology.usgs.gov/s+/
imagefiles/x181w02.htm}

Figure Set 2: Zebra Mussels in the Hudson River

Purpose: To help students understand the impact of zebra mussel invasion on the ecology of the Hudson River.

Teaching Approach: "turn-to-your-neighbor"

Cognitive Skills: (see Bloom's Taxonomy) - comprehension, analysis

Student Assessment: essay quiz

BACKGROUND

The Hudson River estuary stretches about 150 miles from New York Harbor up to Troy, NY. This is about half the total length of the river. Although the water isn't salty at Troy, the Hudson here "feels the tide" and water levels rise and fall at high and low tides (see also http://www.ecostudies.org/research_hres.html and <http://www.dec.state.ny.us/website/hudson/hre.html>).

Zebra mussels were first seen in the Hudson River in 1991 (see Figure Set 1 for general information about zebra mussel introduction to the U. S.). Within little more than a year the biomass of the mussels was greater than that of all other heterotrophic animals in the Hudson. Their filtration rates are estimated at about 1-3 days for the entire freshwater estuary, and as a result, phytoplankton and small zooplankton densities have dropped to 10-20% of pre-invasion levels. The change in the Hudson as a result of zebra mussels has been large, widespread, and likely long lasting - few other human induced ecological changes to the river have been so dramatic.

What has happened in the Hudson has been seen in other places where zebra mussels have become established. Lakes and rivers colonized by the mussels often see 50-75% declines in phytoplankton and small zooplankton biomass, rise in water clarity of 50-100%, drop of more than 50% in filter-feeding zooplankton and native bivalves, and increase in macrophyte beds and animals associated with zebra mussels.

In this exercise, students describe and analyze several figures that help them understand the changes taking place in the Hudson River as a result of zebra mussel introduction.

STUDENT INSTRUCTIONS

Turn to your neighbor and first describe and then analyze Figures 2A, 2B, and 2C. Take your time with these graphs; make sure you understand the axes and what is being plotted before you attempt to analyze the data.

Figure 2A shows changes in the biomass of microscopic animals (zooplankton) in the Hudson River water and in two types of clams that grow on the river bottom.

Figure 2B shows changes in the mass of the smallest zooplankton, chlorophyll, and solids in the water.

Figure 2C shows changes in river discharge, temperature, and how quickly the water is filtered by filter feeding animals.

Discuss the following questions:

What are the major changes in the Hudson River after invasion by zebra mussel? Why did these changes occur?

- If you were to swim and snorkel in the Hudson now and in 1990, how would it look different now compared to then?
- Why did the researchers examine river discharge and temperature before and after the invasion? What question were they addressing by doing this?
- Overall in what ways has the zebra mussel altered the Hudson River? Can you list some likely negative and positive effects?

FIGURES

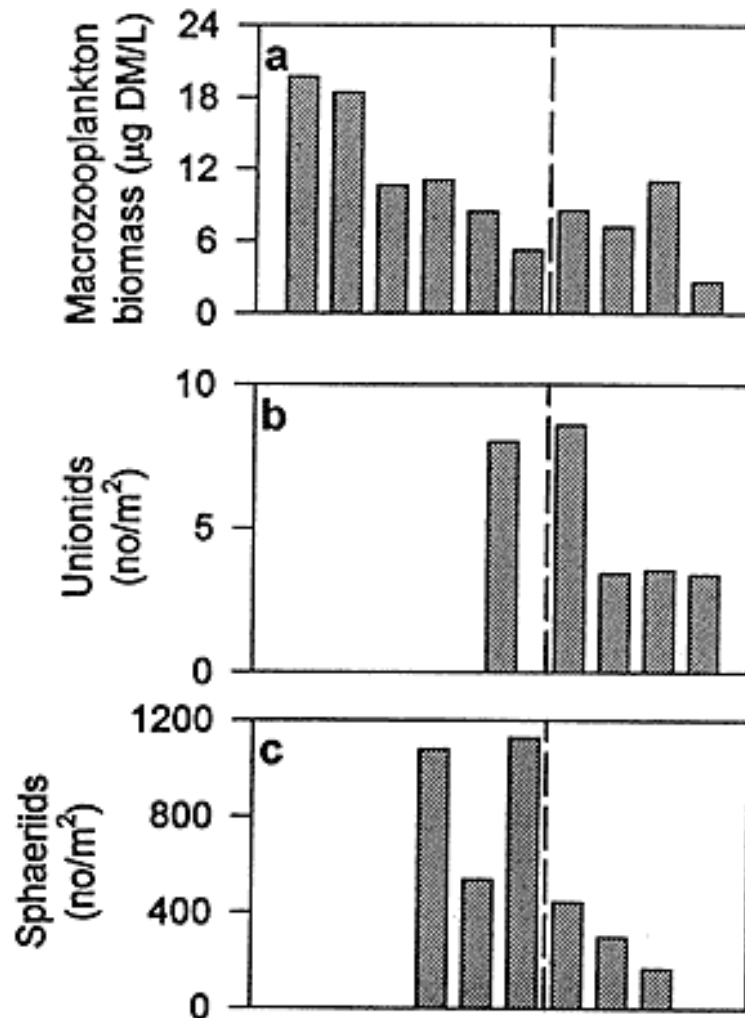


Figure 2A. Changes in populations of animals that are thought to depend on phytoplankton (microscopic floating plants) for food in response to the arrival of zebra mussels in the Hudson River. (a) Macroplankton are microscopic floating animals that are actually visible to the eye; units are micrograms of dry mass per liter (b) Unionids are clams; units are number per square meter, and (c) Sphaeriids are clams. The dashed line shows the point at which the zebra mussel became abundant. Data are yearly averages at one station during June-August; see figures b and c for dates (from Strayer, D. L., N. F. Caraco, J. J. Cole, S. Findlay, and M. L. Pace. 1999. Transformation of freshwater ecosystems by bivalves. *BioScience* 49: 19-27).

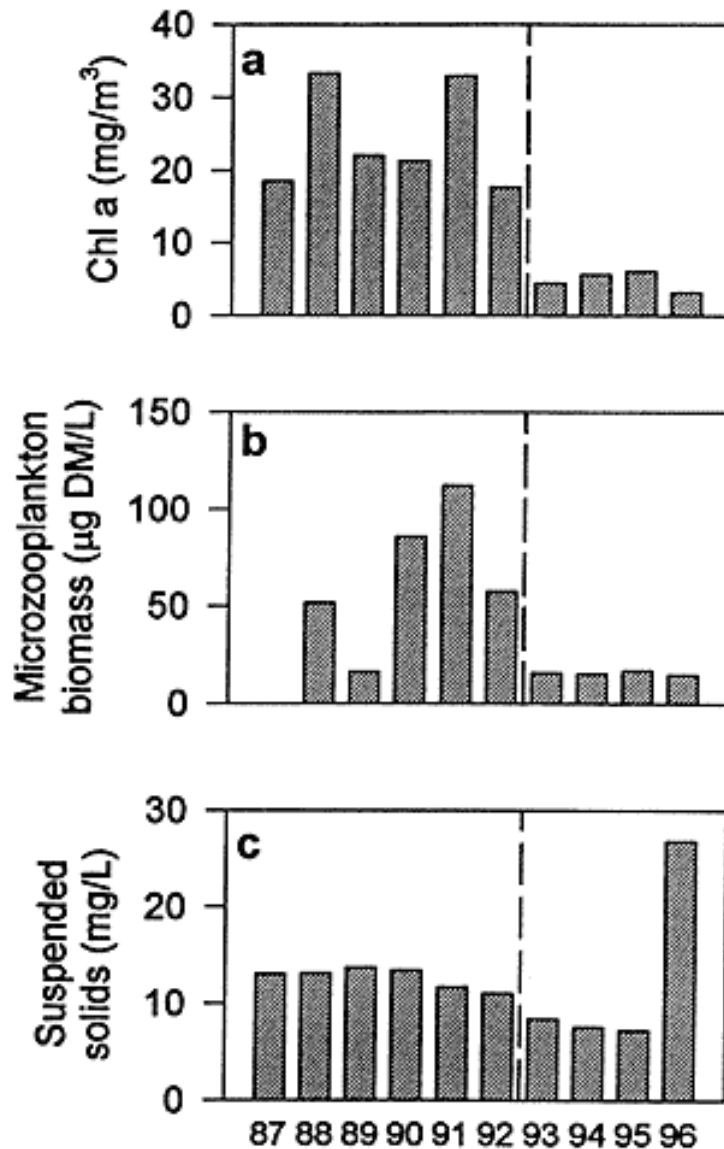


Figure 2B. Changes in concentrations of edible and inedible particles in water in response to the arrival of zebra mussels in the Hudson River. (a) phytoplankton (microscopic floating plants); measurement is concentration of the pigment chlorophyll a in milligrams per cubic meter, (b) biomass of microscopic zooplankton (tiny floating animals), units are micrograms of dry mass per liter, (c) solids suspended in the water, units are milligrams per liter. The dashed line show the point at which the zebra mussel became abundant. Data are yearly averages at one station during June-August. Unusually heavy summer rains happened in 1996 (from Strayer, D. L., N. F. Caraco, J. J. Cole, S. Findlay, and M. L. Pace. 1999. Transformation of freshwater ecosystems by bivalves. *BioScience* 49: 19-27).

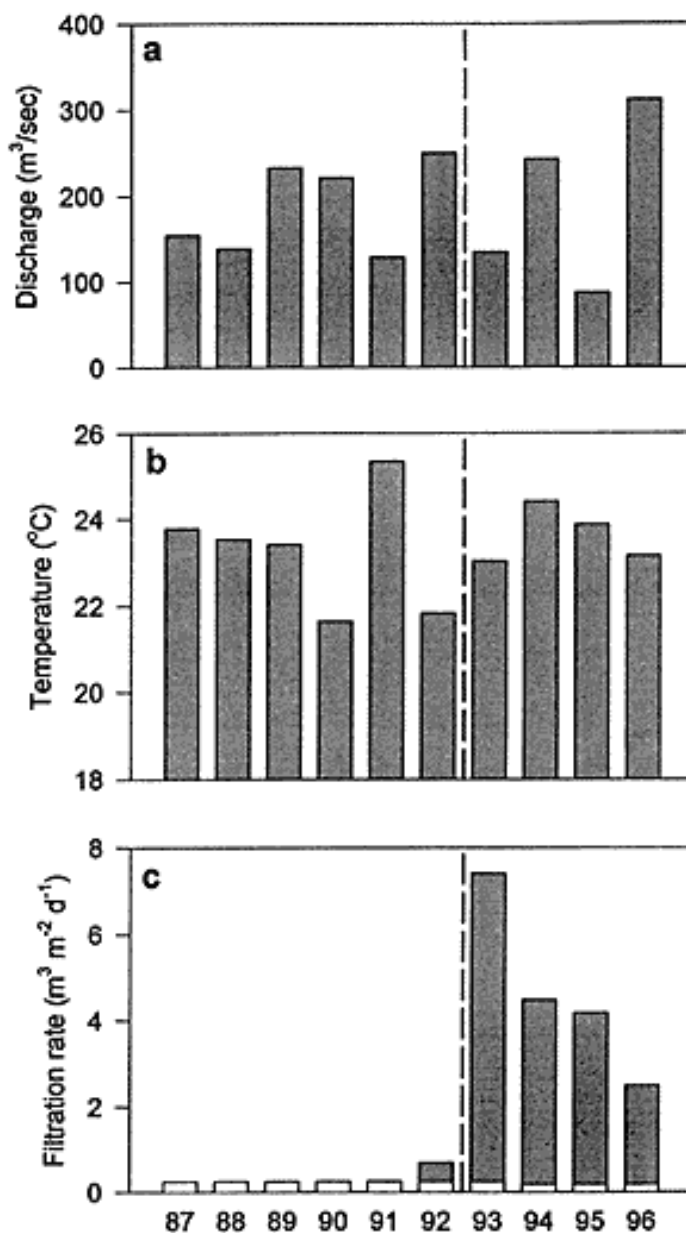


Figure 2C. Key variables in the Hudson River ecosystem. (a) freshwater discharge; units are cubic meters per second. (b) water temperature, and (c) estimated filtration rate of zebra mussels (grey bars) and all other filter feeding animals (white bars) averaged for the river. The dashed line shows the point at which the zebra mussel became abundant. Data are yearly averages at one station during June-August. (from Strayer, D. L., N. F. Caraco, J. J. Cole, S. Findlay, and M. L. Pace. 1999. Transformation of freshwater ecosystems by bivalves. *BioScience* 49: 19-27).

FACULTY NOTES

In "Student Instructions" students are asked to look at 3 different figures from a paper by Strayer et al. (1999). This will take a fair amount of time. An alternative is to show (project) or hand out one or more of the figures and lead a discussion. If you decide to do this, give students time to make sense of the figures on their own first — or with another student (as in "turn-to-your-neighbor").

The first 2 figures are fairly straightforward. There are dramatic decreases in macro zooplankton and clams after zebra mussel introduction. Chlorophylla values (measurement of phytoplankton biomass) and micro zooplankton also sharply decrease. These data also clearly show the value of long-term data sets; 6 years of measurements prior to introduction gave the researchers much more confidence in their conclusions about zebra mussels.

The increase in 1996 in suspended solids (Figure 2b) shows that other factors besides zebra mussels can be important in this river and that researchers must attempt to tease these out. This is most clearly seen in Figure 2c; temperature and discharge rate can also influence water clarity and chlorophyll concentrations but the data show no consistent pre and post difference in either temperature or discharge.

Zebra mussels are not all "bad"; this is an important point for students to understand. Zebra mussels can have a positive effect in very eutrophic water bodies because their filtration rates are so high; mussels remove phytoplankton from the water column, which is much clearer as a result (see <http://www.sgnis.org/publicat/cjfas617.htm>). They have also been used as indicators of low oxygen and pH.

Student Assessment: Essay Quiz

- What is the main question the researchers were asking in this study?
- Why did they get data on suspended solids, river discharge (rate of river flow) and temperature in addition to zebra mussel densities?

Evaluating an Issue: How do you know whether it is working?

On-going (also called formative) evaluation of the approaches you are using is critical to the success of student-active teaching. Why try out new ideas if you don't know whether or not they are working? This is a brief overview of formative evaluation. For more information, go to the Formative Evaluation essay in the Teaching Section.

Course Goals:

Formative evaluation only works if you have clearly described your course goals - because the purpose of the evaluation is to assess whether a particular technique is helping students reach these goals. For instance, most of us have "learn important ecological concepts and information" as a course goal. If I reviewed the nitrogen cycle in a class, for evaluation I might ask students to sketch out a nitrogen cycle for a particular habitat or system. Each student could work alone in class. Alternatively, I might ask students to work in groups of 3 and give each group a different situation (e.g. a pond receiving nitrate from septic systems, an organic agricultural field, an agricultural field receiving synthetic fertilizer). The students could draw their flows on a large sheet of paper (or an overhead transparency) and present this to the rest of the class.

The Minute Paper:

Minute papers are very useful evaluative tools. If done well they give you good feedback quickly. Minute papers are done at the end of a class. The students are asked to respond anonymously to a short question that you ask. They take a minute or so to write their response in a 3x5 card or a piece of paper. You collect these and learn from common themes. In the next class it is important that you refer to one or two of these points so that students recognize that their input matters to you. The [UW - FLAG site \(www.wcer.wisc.edu/nise/cl1/flag/\)](http://www.wcer.wisc.edu/nise/cl1/flag/) gives a good deal of information about using minute papers including their limitations, how to phrase your question, step-by-step instructions, modifications, and the theory and research behind their use.