Name ______________________ Date _______

Effects of Zebra Mussels on the Hudson River

How has the zebra mussel invasion changed the Hudson River ecosystem? In this activity, you will discover some of these changes using data collected by scientists.

Part 1: How did we get this data?

Read the following paragraphs, written by the researchers, about how they collected the zebra mussel data over a long period of time. Then answer the questions that follow.

These data are annual means of several important ecological variables for the growing season (May 1-September 30) for the freshwater tidal Hudson River in eastern New York State. They were collected as part of a long-term study of the Hudson River ecosystem by researchers at the Cary Institute of Ecosystem Studies, started in 1991 and continuing today. This work was supported by grants from the Hudson River Foundation, the National Science Foundation, New York Sea Grant, and the Hudson River Estuary program of the New York State Department of Environmental Conservation (we note that none of these funding agencies endorses or guarantees these data or the conclusions we reach from the data).

Zebra mussel populations are sampled using divers and grabs. Populations living on hard bottoms are sampled by a diver, who collects 10 rocks at each of 7 sampling sites in June and again in August. These rocks are put into coolers and returned to the lab, where zebra mussels are counted and the projected area of the rock estimated by tracing its outline. A subset of zebra mussels are measured for shell length (n=300/site) and to develop length-dry mass regressions (n=50/site), and samples are archived in ethyl alcohol and in the freezer. Populations living on soft bottoms are sampled in July using a standard PONAR grab (0.05 m^2) at 48 sites deployed in a stratified random design throughout the freshwater estuary. We identify, count, measure, and weigh all native unionid bivalves, continuing our long-term study of these animals and their response to the zebra mussel invasion (Strayer et al. 1994, Strayer and Smith 1994, 1996).

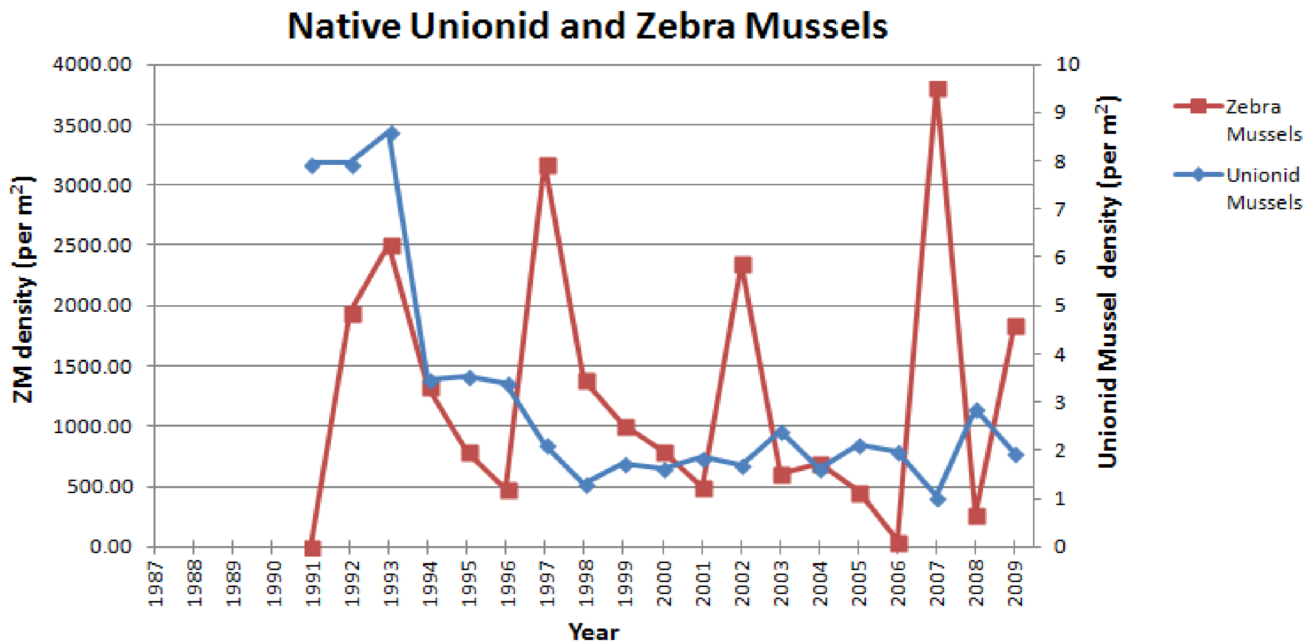
Phytoplankton are sampled weekly at our long-term station near Kingston throughout the year and in 2 sets of spatially distributed samples. We sample phytoplankton and many other variables (see below) at 6 “cardinal stations” arrayed over 120 km of the Hudson 4-6 times per year. In addition, 4-6 times a year, we sample phytoplankton and basic water chemistry and clarity every 2-4 km along the entire freshwater tidal Hudson River. Zooplankton are sampled every 2 weeks during the ice-free season at our long-term study site near Kingston. All plankton samples are taken in triplicate.

In addition to these key variables, we measure water temperature, light penetration, pH, dissolved oxygen, suspended sediments, dissolved and particulate organic matter, dissolved inorganic carbon, dissolved inorganic and total nitrogen and phosphorus, and bacterioplankton abundance and productivity in our weekly samples at Kingston and at the 6 cardinal stations (Caraco et al. 1997, 2000, 2004, Raymond et al. 1997, Findlay et al. 1991, 1998, Lampman et al. 1999, Findlay 2004).

1. How did the scientists collect the zebra mussel data? For how long have they been collecting it?
2. How do the scientists collect phytoplankton and water chemistry data?
3. Why do you think long-term monitoring of ecosystems is important?
4. What are the variables in this research project?
5. In order to have an idea of how many zebra mussels live in the Hudson River, the scientists decided to collect 10 rocks at 7 sites. Why do you think this may be better than, say, collection 70 rocks at one site? What might be a problem with collecting only 2 rocks at 35 sites? Why?

Part 2: Organism Changes

Use the graphs below to answer the questions that follow. **Note that since the data have different units and are often measured at very different scales (10s versus 1000s), these graphs have **two y-axes**—one on the left and one on the right.

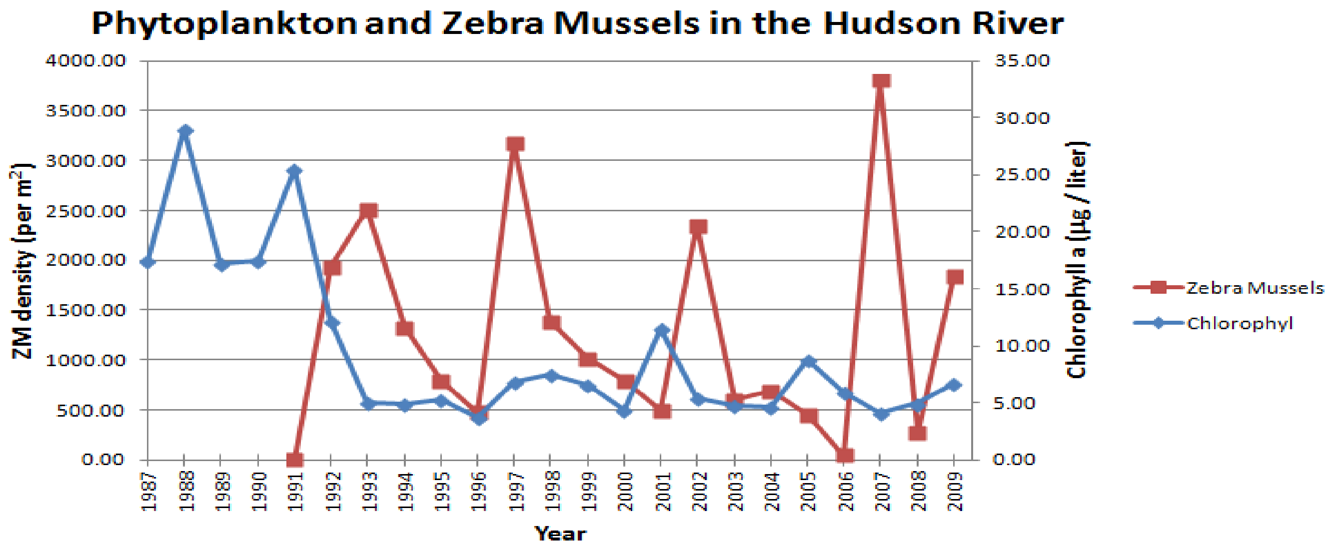


Densities of zebra mussels and unionid mussels are given in number per square meter, averaged over the freshwater, tidal portion of the Hudson (RKM 99-248. Data were collected in August for zebra mussels and July for unionids. Scientists began collecting unionid data in 1991. One meter squared equals about ten square feet.

1. Why was the zebra mussel population at zero for the first part of the graph? When did the zebra mussel population increase? Describe the changes within the zebra mussel population since their arrival.

2. What happened to the native mussel population after the zebra mussels arrived?

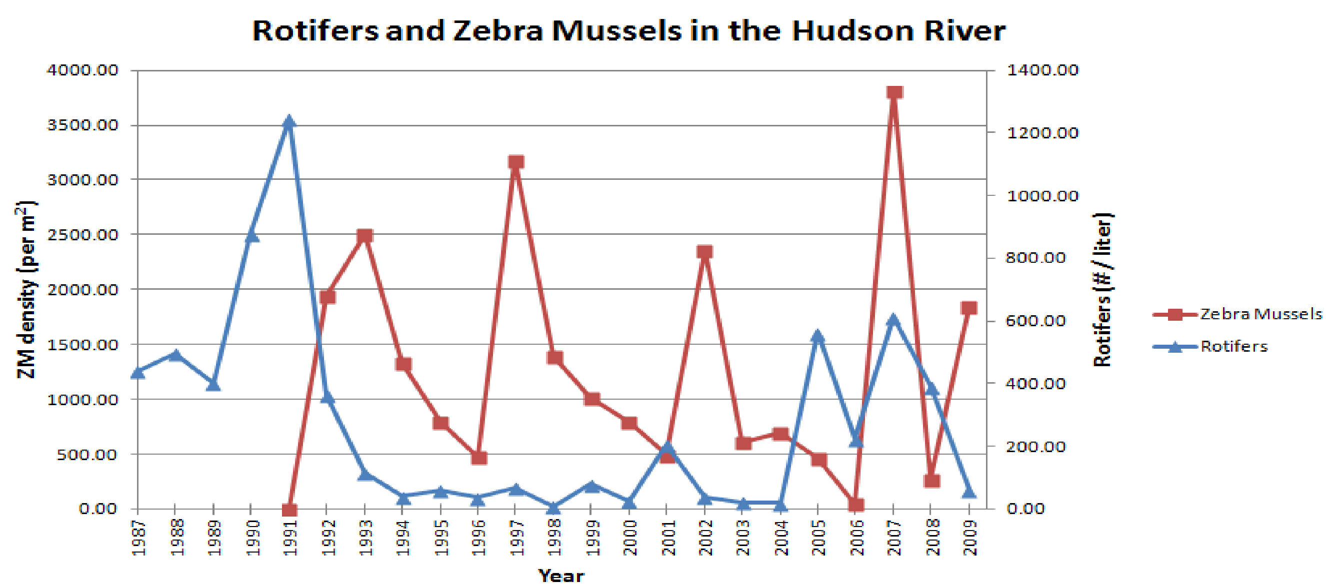
3. Why do you think the zebra mussel population numbers go up and down over time?



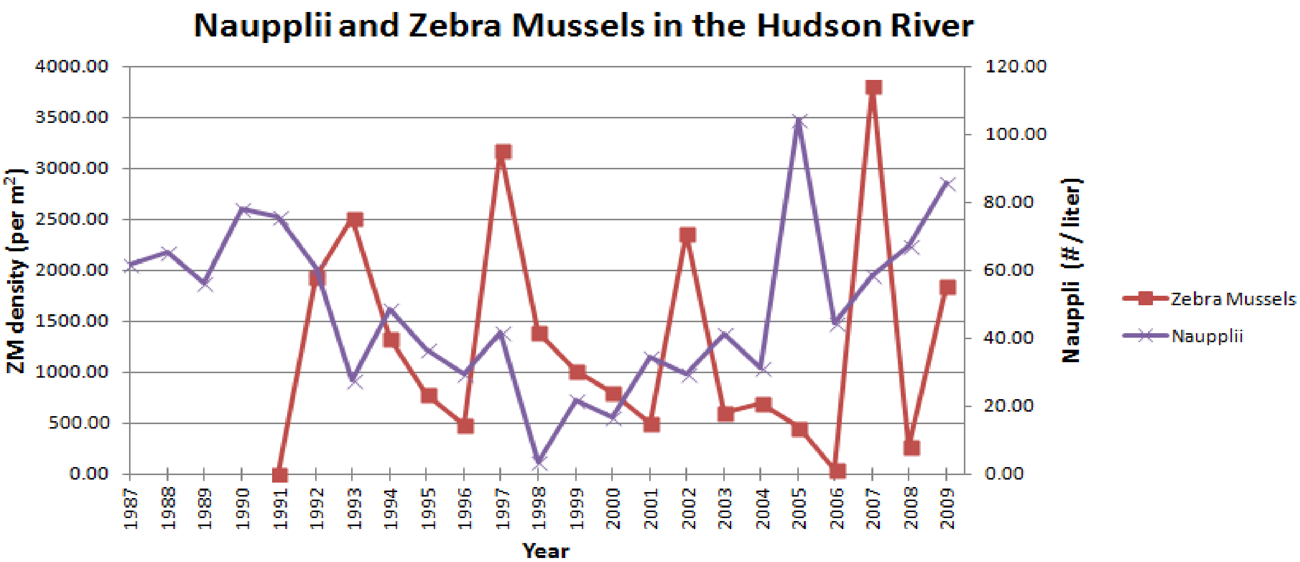
4. The amount of chlorophyll measured in the water is a good approximation of the number of phytoplankton in the water.

a. Based on the graph above, what can you say about the phytoplankton population from the data you see? Is there a trend?

b. What consequences might these changes have on other parts of the Hudson River food web?

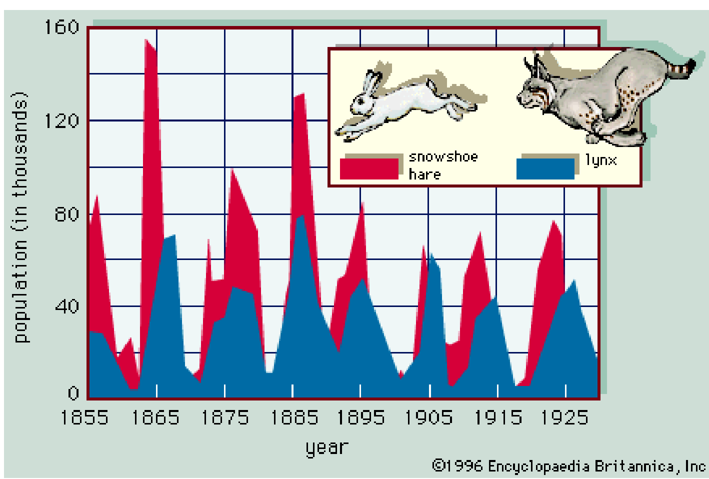


5. Based on the graph above, what can you say about the rotifer population? What consequences might these changes have on other parts of the Hudson River food web?



6. Based on the graph above, what can you say about the naupplii (young copepod) population? What consequences might these changes have on other parts of the Hudson River food web?

7. The graph below shows the population size of hare and lynx through time.

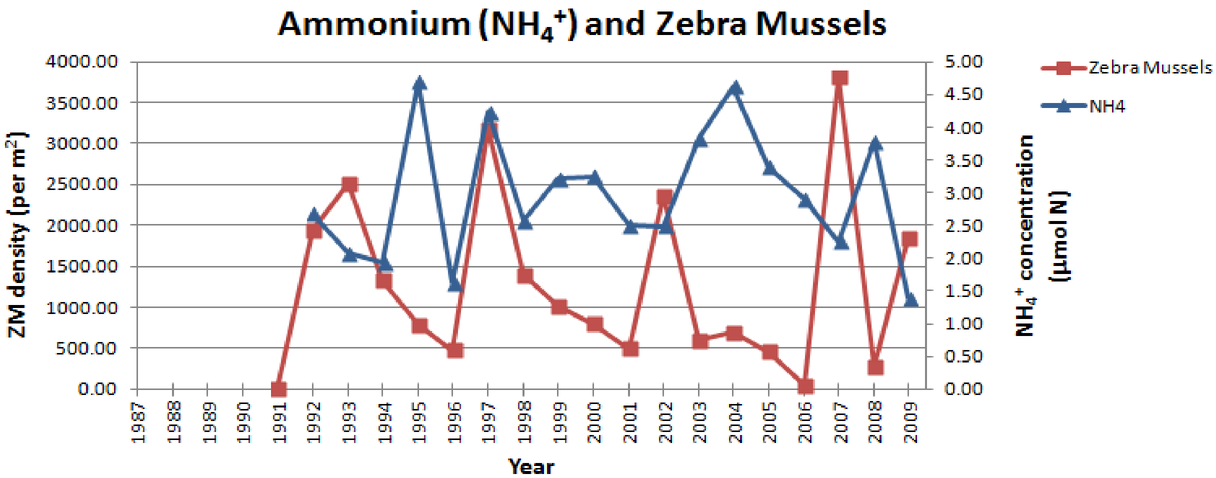


a. What basic principle of population ecology does this data demonstrate? Explain the relationship between these two animals, demonstrated by their population curves in the graph.

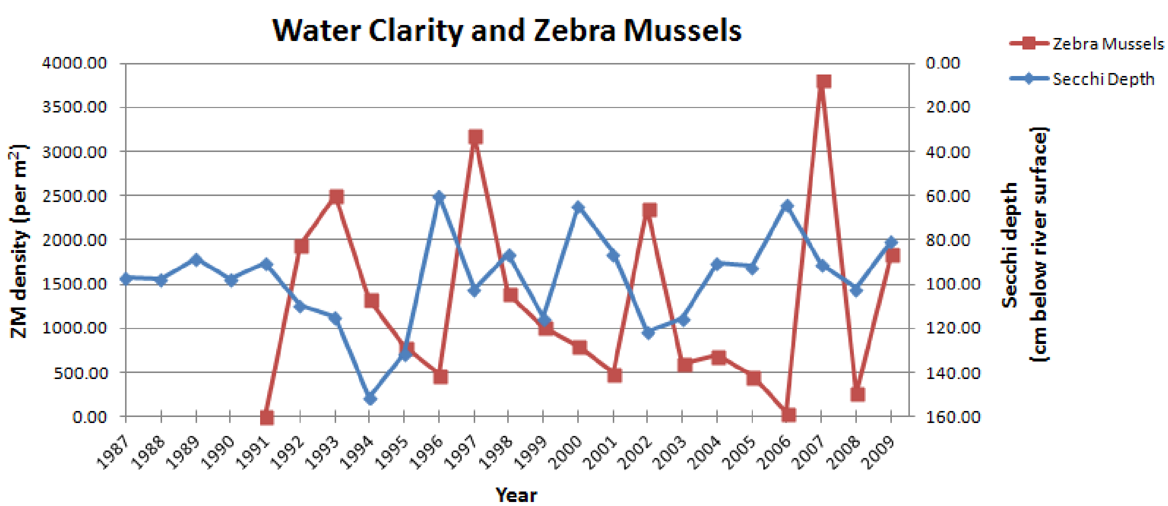
b. Do the zebra mussels have the same effect on the plankton populations? Why or why not?

Part 3: Chemistry Changes

Now that you've learned about changes in zooplankton and phytoplankton after the arrival of the zebra mussels, you're going to learn about some chemical changes in the river. Use the graphs to answer the questions below.



1. What relationship, if any, do you see between changes in the amount of nitrogen in the form of ammonium (NH_4^+) and the zebra mussels? List several factors that you think may affect the amount of NH_4^+ in the water.



2. In the graph above, 'Secchi depth' is a measure of how deep one can see an object in the water (specifically, a Secchi disk). **Note that since the depth was measured as cm <u>down from the river surface</u>, the values are plotted <u>from the top</u> of the graph. This means that that higher values are at the bottom of the graph (i.e. you can see the object when it's farther down).

a. In which year was the water at its clearest?
b. In which year was it least clear?
c. What relationship do you see, if any, between water clarity and the zebra mussel population?

3. a. What factors regulate water clarity?

b. Which factors do the zebra mussels control?

c. What else would you need to know before deciding if the zebra mussel invasion affected the clarity of the water?

4. If water clarity changes, how might this affect the other organisms in the Hudson River?

Part 4: Synthesis

1. Do you think all of these changes are a direct result of the invasion of the zebra mussel? Is there anything else that could have caused some of these changes? If so, what?

2. There are statistical techniques that allow researchers to quantify the effects of different factors on the plankton communities. Because these are complex computations, we will not replicate them in the classroom, but scientists employed these techniques and found that the changes are indeed primarily caused by the zebra mussels.

Summarize the changes that have taken place in the Hudson since the arrival of the zebra mussel, referring specifically to graphs that you created to support your claims. Hypothesize how these observed changes might affect other parts of the food web.