Historic Pollution in the Hudson

Time: 1-2 class periods
National Benchmarks: Benchmarks 5A: Diversity of Life; 5D Interdependence of Life; 5E: Flow of Matter and Energy; 9B:Symbolic Relationships; 9D:Uncertainty; 12B:Computation and Estimation; 12D:Communication Skills; 12E:Critical-Response Skills.
National Science Content Standards: *Science as Inquiry: A*; *Life Science: C*: Biological Evolution; The Interdependence of Organisms; Matter, Energy, and Organization in Living Systems; *Science and Technology: E:* Abilities of Technological Design; Understandings about Science and Technology; *Science in Personal and Social Perspectives: F:* Population Growth; Natural Resources: Environmental Quality; Natural and Human-induced Hazards; Science and Technology in Local, National, and Global Challenges
New York State Standards: 1, 2, 4, 5, 6, 7

Objective: Students will know how the pollution in the Hudson River has changed over time, and be able to explain the consequences of these changes.

Lesson Outline:

1. Students discuss impacts of excess sewage on the Hudson using historic readings from the New York Times
2. Students graph 100 years of data on nitrogen, phosphorus, total suspended solids, and biochemical oxygen demand
3. Students discuss results

Materials:

- Copies of the handout & readings. Versions of the worksheet are provided with data for those who do not have computer access, and for those who just want students to practice interpreting graphs.
- Computers with Microsoft Office Excel.
-Reference materials on the Changing Hudson website might be useful, including the Excel tutorial and the background readings on pollution indicators. Students should know about different types of pollution before beginning this lesson.

Engagement: Students should read the excerpts from the New York Times, titled "A Poor Sewerage System" and "Albany's Dangerous Basin", along with a short synopsis of water quality in New York City. Reading (or discussion) questions are provided.

Divide students into pairs and ask them to brainstorm the effects of increased nitrogen and phosphorus on an aquatic system. If they have not done any work with water quality indicators, they should be asked to write down what they would need to know in order to answer the question. Review the ideas as a group, and discuss what the impacts of sewage discharge into the Hudson might be.
Exploration: You should decide whether you want to focus on the Upper Hudson or the Lower/Mid Hudson data. You can also have students compare data for both areas, although the concentrations are very similar when adjusted for population. Upper

Hudson data includes the region from the source of the Hudson to the Federal dam at Troy. Mid Hudson starts at the Federal dam at Troy and ends at the Bronx-Westchester County boundary. Lower Hudson starts at the Bronx-Westchester County boundary and ends at the Verrazano-Narrows Bridge in the NYC harbor.

Students will open "History of Wastewater" in Excel. Students can graph all of the variables, or they can be split up into groups where each group completes one graph and then reports their results to the class. Give enough time for students to do some research on their topic(s): effluent, BOD (biochemical oxygen demand), TSS (total suspended solids), TN (total nitrogen), TP (total phosphorus). One group should be responsible for graphing the population changes. **Note: Graphing the Lower/Mid Hudson data with the Upper Hudson data eliminates much of the noticeable change in the Upper Hudson trends. Creating a secondary axis for these data is important if students want to see the changes more clearly. Remind students to label axes carefully since it can become confusing when there are different numbers of different y-axes.** You can use the Excel tutorial in the Hudson River Ecosystem module of this curriculum for help with Excel.

Explanation: Population levels have been increasing since the 1900s as people move into the area and up into the suburbs of New York City. This data shows the mid and lower Hudson Valley grouped together (the area of the Hudson River Estuary from Troy to NYC), compared with the Upper Hudson. Primary water treatment plants were constructed in 1924 at Passaic Valley, New Jersey and in Yonkers, and an additional three were added by 1938. There were seven total primary treatment plants by 1952. After the 1972 Clean Water Act, upgrades were made to the plants and additional secondary treatment procedures were added. Dramatic improvements can be seen after the early 1970s. Unfortunately, coliform bacteria was not collected in a standardized fashion before 1974.

Extend: Students can graph additional parameters.

Evaluate: Based on their graphs, students should be able to answer the following questions:

Step 2:

1. What happened to the population of the middle and lower Hudson estuary during the last 100 years?
   Population levels have increased in both parts of the estuary, with peaks occurring around 1970. The population for the lower and mid Hudson region currently stands at about 8.5 million people, while the population for the upper Hudson region is at 1.4 million.
2. What happened to the population of upper Hudson estuary during the last 100 years?
   Population levels have increased in both parts of the estuary, with peaks occurring around 1970. The population for the lower and mid Hudson region currently stands at about 8.5 million people, while the population for the upper Hudson region is at 1.4 million.
3. How do you think these changes impacted the river?
   These population levels affect the effluent rate by increasing the rate, because more people were living in the area, releasing more waste.

Step 3:

1. Describe the changes in BOD, TSS, TN, and TP over the last 100 years. Why did it change? Have things improved? Why or why not?
   BOD levels increased dramatically for both regions in the 1960s, and then declined sharply after 1970, reaching pre-1900 levels by the end of the century. While TN amounts also declined after 1970, levels are still much higher than in 1900. Total phosphorus levels have declined significantly since 1970, as has total suspended solids. In general, water quality has improved since the passage of the Clean Water Act, with nitrogen loading remaining as a significant problem.
2. Describe the variables over time.
   Students should be able to explain what has changed and how. Students should know about the Clean Water Act of 1972, after which significant improvements were made to water quality.
3. Which variable shows the most dramatic improvement since 1970? How did you determine this? What effect do you think these improvements have had on the river? Which variable showed the least improvement?
   If students find the percent of each pollutant that remains in the river, they will see that both BOD and TSS in the Lower/Mid Hudson regions have been reduced to 25% and 24%, respectively. In the Upper Hudson, BOD has been reduced to 10% of its 1970 levels, and TSS is down to 15% of its 1970 levels. These improvements have increased the amount of oxygen available in the river, as well as the water clarity. Nitrogen showed the least improvement, with 75% of total nitrogen levels remaining in both areas of the river.
4. Were you surprised by any of the results? Why or why not?

Comments:

References:

Brosnan, Stoddard and Hetling. 2006. Hudson River Sewage Inputs and Impacts" *The Hudson River Estuary,* edited by Levinton and Waldman, Cambridge Univ. Press.