

### The Hudson and Eutrophication

**Time:** 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, 3, 4, 5, 6, 7

**Objective:** Students will know the history of nutrient loading in the Hudson River, the consequences, and be able to recommend ways to reduce the levels of nitrogen and phosphorous in the future.

**Lesson Outline:**

1. Students will discuss the implications of nutrient pollution on aquatic ecosystems.
2. Students will read and answer questions.

**Materials:** Copies of the reading.

**Engage:** Ask: What are the implications of high levels of nutrients in an aquatic system? Based on their experience with previous lessons, they should be able to answer this question. Ask: Do you think the Hudson is eutrophic? How could you find out?

**Explore:** Students will use the accompanying reading and graphs to answer a variety of questions about the nutrient levels in the Hudson River.

**Explain:** The Hudson River has always had problems with pollution, but the focus has shifted in the last twenty years from toxic substances to the control of nutrient pollution and consequent eutrophication. More than sixty percent of coastal waters in the U.S. are moderately to severely degraded by nutrient pollution, most of which originates in the interior of the U.S.

Eutrophication from excess nutrients leads to decreasing biodiversity, increasing frequency of algal blooms, and degradation of water quality due to reduced dissolved oxygen levels. In the Hudson River, primary productivity has increased dramatically since the 1970s, and is considered eutrophic.

Step 1: Answers

1. It went above very eutrophic line eight times.
2. The Hudson was more likely to be very eutrophic during low tidal ranges.
3. During times of low tidal range, the phytoplankton had more time to reproduce, adding to the gross primary productivity of the river. These data are for the lower Hudson, where the tidal mixing is much stronger, and thus stratification breaks down more easily.
4. The lower, saline Hudson is 'flushed' every day.

5. The Hudson is less sensitive to nutrient pollution than other estuaries because of the rapid flushing rate.
6. The Hudson would quickly show visible signs of eutrophication.
7. The two things that affect the amount of phytoplankton production are the range of the tides and the amount of water discharged into the river.

**Step 2: Answers**

1. The total nitrogen amounts changed from  $49 \times 10^3$  tons per year to  $43 \times 10^3$  tons per year. The phosphorus changed from  $9.6 \times 10^3$  tons per year to  $4.8 \times 10^3$  tons per year. This probably happened due to improvements in wastewater treatment plants, as well as a ban on phosphates in detergent.
2. The majority of the 1990s nutrient input comes from wastewater treatment plant effluent.
3. Upriver tributaries contribute nutrients in the form of runoff from agricultural lands.
4. Farmers could reduce the amounts of fertilizers they use, and properly dispose of their animals' waste.

**Step 3: Answers**

1. BOD: 32% removed after primary, 92% after secondary, and 93% after nutrient removal
2. Nitrogen: 23% removed after primary, 37% removed after secondary, and 77% after nutrient removal
3. Phosphorus: 33% removed after primary, 50% after secondary, and 75% after nutrient removal
4. A  $1,500 \text{ m}^3$  treatment plant using secondary treatment would cost \$420/day or \$153,300/year. A nutrient removal treatment plant would cost \$555/day or \$202,575/year.
5. Nitrogen benefits the most from the nutrient removal process. Depending on the student, they may or may not believe that the cost is justified.

**Extend:** Students could research connections with human health.

**Evaluate:** Collect student answers to the reading.

**Comments:****References:**

Howarth, R.W., Swaney, D., Butler, T.J., and Marino, R. 2000. Climatic control on eutrophication of the Hudson River estuary. *Ecosystems*. 3:210-215.

Howarth, R., Anderson, D., Cloern, J., Elfring, C., Hopkinson, C., Lapointe, B., Malone, T., Marcus, N., McGlathery, K., Sharpley, A., and D. Walker. 2000. Nutrient Pollution of Coastal Rivers, Bays, and Seas. *Issues in Ecology*. No. 7.

Howarth, R.W., Marino R., Swaney D., and E. W. Boyer. 2006. Wastewater and Watershed Influences on Primary Productivity and Oxygen Dynamics in the Lower Hudson River Estuary, in *The Hudson River Estuary*, Levinton & Waldman, editors. Cambridge Press.