

## Hudson River Temperature

**Time:** 2 class period

**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 changes in temperature affect ecosystems and be able to explain the changes taking place in the Hudson River.

### Lesson Outline:

1. Students will use historical air temperature and Hudson River temperature data to create graphs
2. Students will learn about three other animals whose populations have changed in the region
3. Students will discuss the links between these population changes and temperature change

### Materials:

Per student: Computers with Excel with pre-loaded datasets (or assign the graphing for homework) or printed handouts

Per group

Per class: Long-term data graphs (overheads or copies for students), powerpoint

**Preparation:** Students should be familiar with basic graphing skills using Excel (if you choose the first option) and the concept of global warming. Go to [www.ecostudies.org/chp.html](http://www.ecostudies.org/chp.html) for an Excel tutorial.

**Engage:** Ask: What do you know about global warming? What types of impacts have you heard about or seen? Show students photos of global change: melting glaciers, flooding, precipitation changes. Use the powerpoint titled “Climate Change” for images. If students have not had much background on the science of climate change, you can spend more time on this using the powerpoint. Ask: What types of changes might you expect in the Hudson Valley if temperatures continue to increase? Make a list on the board of student ideas. This can be done as a K-W-L chart or a conceptual circle if appropriate.

**Explore:** There are two options for this lesson, depending on whether you want your students to have more experience with graphing data. If this is not an objective for your class, use Option 2.

Option 1: Students use Excel to create graphs	Option 2: Students use pre-made graphs
1. Students graph annual air temperature data for Poughkeepsie using Excel. Graphing temperature should be done in Celsius to allow for comparisons. See “Hudson River Temperature without Graphs”.	1. Students use provided graphs to answer the same questions. See “Hudson River Temperature Worksheet with Graphs”.
2. Students read “What will climate change do to our planet?”, or go online to: <a href="http://channel.nationalgeographic.com/episode/six-degrees-could-change-the-world-3188/Overview">http://channel.nationalgeographic.com/episode/six-degrees-could-change-the-world-3188/Overview</a> and answer the question about how the planet will change with an increase in temperature of 1-2 C.	
3. After discussing the changes in air temperature, students should be encouraged to think about what this might mean for water temperature.	
4. Students graph the deviation of the average temperature for each year from the long term average which sorts the data into years with above versus below average temperatures for the Hudson River. They then answer the questions based on this graph and data about aquatic organisms that is provided on “Using Data: Hudson River Temperature Worksheet”.	4. Using the same handout (“Hudson River Temperature Worksheet with Graphs”) as Option 2 above, students use the provided data to answer questions about the changes in the Hudson River.
5. Students complete the worksheets using the graphs to look at changes in fish and frog species in the area.	

Lead a discussion with students based on the “Human Accelerated Environmental Change” diagram by Dr. Gene Likens. Ask students to talk about the ways in which human impacts can affect animal populations. Conduct research to construct a conceptual circle focusing on fish or amphibians.

**Explain:** According to data compiled and analyzed at the Cary Institute of Ecosystem Studies, the Hudson River has become warmer over the last 60 years. These were collected daily at the Poughkeepsie Water Treatment Facility, and three USGS survey sites (below Poughkeepsie [01372058], South Dock at West Point [01374019], and south of Hastings on Hudson [01376304]). These data were then averaged to create daily and monthly means.

Although no correlation studies have been done between the decrease in certain fish species and the increasing temperature of the Hudson River, it has been suggested by a number of scientists that this is a distinct possibility. In a paper by Daniels 2005, the tomcod’s temperature sensitivity is listed as a possible reason for its disappearance from the Hudson. Once found as far south as North Carolina, it is now rarely found even in the Hudson. Both Atlantic Tomcod and Rainbow smelt are at the southern portion of their range, requiring cold water for breeding. According to John Waldman, a biology professor at Queens College in New York who has long been involved in Hudson River issues, between 1996 and 2000, yearly sampling for smelt in the Hudson produced a total of 4 fish.

The data from the Gibbs, 2000 study shows a change in breeding times for a variety of local amphibians, many of whom are now starting their ‘calling’ up to two weeks earlier than one hundred years ago.

**Extend:** There are two other data sets for air temperature that students can try graphing, titled: “Student Maximum Air Temp Poughkeepsie” or “Student Minimum Air Temp Poughkeepsie”. Students could also graph more than one location in New York and compare the rate of change with different elevations. See: <http://cdiac.ornl.gov/epubs/ndp/ushcn/monthly.html> . Graphing more than one location around the country over time and making comparisons would provide an additional activity extension. Students could also compare temperature graphs to CO2 level graphs ([www.esrl.noaa.gov/gmd/ccgg/iadv](http://www.esrl.noaa.gov/gmd/ccgg/iadv) , Global Monitoring Division Carbon Cycling Network) on a global basis.

**Evaluate:** Using the answers to the questions on the worksheets, students should be able to discuss the implications of climate change on some of the local organisms. Use these answers to assess student understanding. Encourage students to conduct further research into possible impacts including sea level rise, impacts on wetlands, the salt front in the river, and weather patterns that could impact drinking water.

### *Answers*

#### Part 1:

1. The air temperature has increased over the past 100 years.
2. The earth could be getting closer to the sun, the sun might be getting stronger, global warming could be occurring.
3. Heat waves will become more common, with more people dying of heat stress. Stressed plants may stop removing growing, and soil emissions of carbon dioxide will increase. Sea levels will increase between 5-6 meters, and glaciers will continue to melt at a faster rate.
4. We should be concerned because the sea level might rise, and weather may become more extreme.

#### Part 2:

1. The average river temperature has increased since 1946.
2. The highest temperatures have occurred in the last fifteen years. Based on these data, I would expect the temperature to continue to increase.
3. Any aquatic species that is sensitive to change would be affected by this change.
4. Based on this graph, I can conclude that the river is getting warmer.
5. This graph is similar to the air temperature graph, because as the air warms, so does the water. However, the air temperature is always lower than the water temperature. The water acts as sort of a buffer for the rapid changes in air temperature that happen naturally throughout a daily cycle.

#### Part 3:

1. Both the tomcod and smelt populations have declined.
2. Pollution, temperature, food sources, and predation (including fishing) could have caused these changes.
3. I would need to know whether other things have changed in the river, including the temperature changes.
4. I would say that the future of these two fish populations is not good, because very few of them survive.

5. The two fish species are very sensitive to changes in temperature. They are anadromous fish, spawning in the Hudson and moving out into the ocean later in life.
6. Based on the report, both the smelt and the tomcod are very sensitive to changes in temperature, and both are at the upper temperature tolerance in the Hudson. They have probably moved to areas further north where the water temperature is cooler.
7. I am convinced, but, I would like to know more about the fishing and pollution pressures placed on these fish species before making a definitive decision.

#### Part 4:

1. The main difference between the temperatures in 1900 and 1999 is that the temperature increased by an average of 4.1 degrees Fahrenheit. Differences in winter temperatures were much higher than that of summer temperatures.
2. Of the six anurans listed, five started calling earlier (bullfrog, gray treefrog, American toad, wood frog, and spring peeper). The gray treefrog started calling almost twenty days earlier.
3. Based on this information, amphibians are starting to mate earlier in the year. I think this is starting to happen because the winter temperatures aren't as cold anymore. I am confident in my statement, but I would like to know what other challenges the animals are facing in the region.
4. Other species that could be affected by climate change are birds that rely on insects for food. Insect populations could also be affected because they may start hatching earlier, or their populations may decline as predators arrive earlier in the year.
5. To combat the rising temperatures, we need to reduce the amount of carbon dioxide released into the atmosphere.

#### **Comments:**

#### **References:**

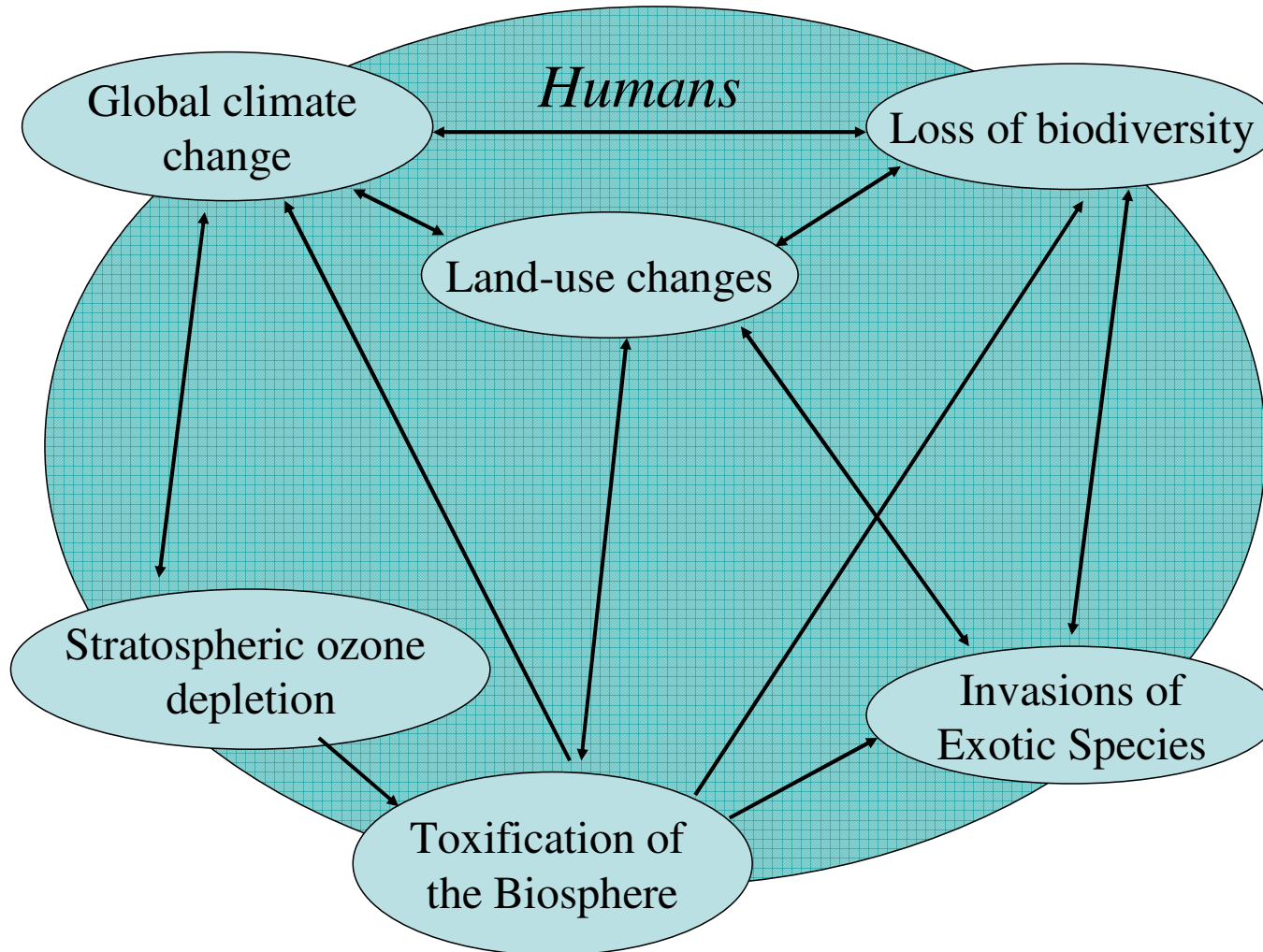
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Environmental change caused by multiple and interacting human activities.

From Likens 1998