**Boat Trip: Sewage Treatment Plant Study**

**Overview**

During this 2.5 hour boat trip, students will collect water samples inside and outside of the effluent plume of a wastewater treatment plant. They will use oceanographic equipment to measure water chemistry, including temperature, salinity, oxygen levels, pH, and nutrient levels (phosphorus, nitrogen, potassium, etc). Additional measurements are also possible (fecal coliform, total carbon content, etc). Discussion will focus on human impacts, nutrient cycles in ecosystems, algal blooms, and other related topics.

**Optional Pre-Trip Assignments**

**Build a Nutrient Cycle Model**

*Students will work in small groups to research and illustrate models explaining how carbon, nitrogen, phosphorus, and/or other nutrients cycle through the environment.*

**Play the Nutrient Cycle Game**

*Students take on the identity of molecules of carbon or nitrogen, and cycle through the ecosystem by rolling dice to move between nutrient reservoirs.*

**Optional Post-Trip Assignments**

**Data Analysis Activity**

*Students will enter their data into an excel spreadsheet, design graphs, and present those graphs to their peers. Discussion questions (homework, or for discussion in small groups in class) will prompt students to use the class dataset to compare water chemistry inside and outside the plume, and to discuss the environmental impact and effectiveness of the sewage treatment plant.*

**Nutrient Cycle Activity Follow-Up**

*Students will re-evaluate their nutrient cycle models based on their own nutrient data. Students will add human impacts to their models, and then explain their revised models to the class.*

**Alignment with NGSS** (assumes completion of pre- and post-trip activities)

**Performance Expectations**

**HS-LS2-2** Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

*Students will calculate means and construct graphs in order to compare water chemistry inside and outside the sewage treatment plant discharge plume. They will discuss the scale of environmental impacts from the plume.*

**HS-LS2-4** Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

*Students will build models that show how nutrients (nitrogen, phosphorus, carbon, etc) cycle through ecosystems. They will then test nutrient levels inside and outside the plume, and discuss how the sewage treatment plant impacts nutrient cycling.*

**HS-ESS2-6** Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

*Students will build models as described above for HS-LS2-4.*

**HS-ESS3-4** Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

*Students will evaluate the effectiveness of the wastewater treatment plant by comparing water chemistry, nutrient levels, and potentially fecal coliform inside and outside of the discharge plume.*

**Science and Engineering Practices**

**Developing and using models**

*Aboard the boat, students will work collaboratively to use their own data to construct a vertical profile of the water column, showing how each variable changes (or does not change) with depth. In the classroom, students will develop models (illustrations) of nutrient cycles and then use them to predict and discuss how human activity affects nutrient cycling. Students will also develop graphical models comparing nutrient levels and other aspects of water chemistry inside and outside of the discharge plume.*

**Analyze and interpret data**

*Students will organize and interpret raw data by making graphs.*

**Using math/computational thinking**

*Students will read scientific instruments and then perform calculations to characterize the physical environment. They will also use mathematical terminology and logic to compare water samples.*

**Engaging in argument from evidence**

*Aboard the boat, students will gather empirical data on the physical and chemical environment inside and outside the sewage treatment plant plume, and then use this information to make an assessment about the health of the ecosystem and the effectiveness of the sewage treatment plant, defending their assessment using the evidence they have gathered. In the classroom, they will present and defend their models, graphs, and interpretations.*

**Crosscutting Concepts**

**Patterns**

*Students will use graphs to identify patterns in their data*

**Cause and Effect: Mechanism and Explanation**

*Students will use their water quality data and their nutrient cycle models to develop hypotheses about the impact of human activity on nutrient cycling.*

**Stability and change**

*Students will analyze their data to identify the effects of human activity on the water chemistry of Long Island Sound.*

**Disciplinary Core Ideas**

**ESS3.C: Human Impacts on Earth Systems.** Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

**LS2.B: Cycles of matter and energy transfer in ecosystems.** The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways.

**Nature of Science:**

**Scientific knowledge is based on empirical evidence**

*This lesson focuses on the connection between scientific evidence (data) and explanations. As a group, the class will assemble multiple lines of evidence and then use those collectively to identify environmental impacts of the sewage treatment plant.*