***Level 3: Primary Productivity in the Hudson River Estuary

Prepared by Christine Courtsunis (Newburgh HS) & Jonathan Howe (Poughkeepsie Day School)

❖ Background Information:

Productivity in the Hudson River Estuary

Tivoli Bay estuary. Picture from NYSDEC.

Primary productivity is a term used to describe the rate at which plants and other photosynthetic organisms (producers) in an ecosystem use sunlight or other energy sources to build organic compounds like sugars. This is important because producers feed the other organisms in the ecosystem, which are called consumers. Estuaries are among the most productive marine ecosystems, yet their productivity level fluctuates greatly through the seasons and in different parts of the estuary.

In the Hudson River Estuary, primary productivity is influenced by nutrient levels, flow rates, pollutant levels, availability of sunlight, residence time of water and nutrients, and ambient water temperature. The Hudson River Estuary is dynamic, with high levels of mixing between the water and sediment. It also experiences different inputs of heat, light, nutrients and sediment throughout the year, which means that productivity levels are constantly changing. The main process that contributes to primary productivity in the Hudson River is photosynthesis. In many places the Hudson River is brown with suspended particles, which limits the amount of light available to producers for photosynthesis. Photosynthesis takes in carbon dioxide and produces oxygen, so changes in carbon dioxide and oxygen levels can be used to investigate primary production levels.

Sources of Oxygen in the Hudson River Estuary

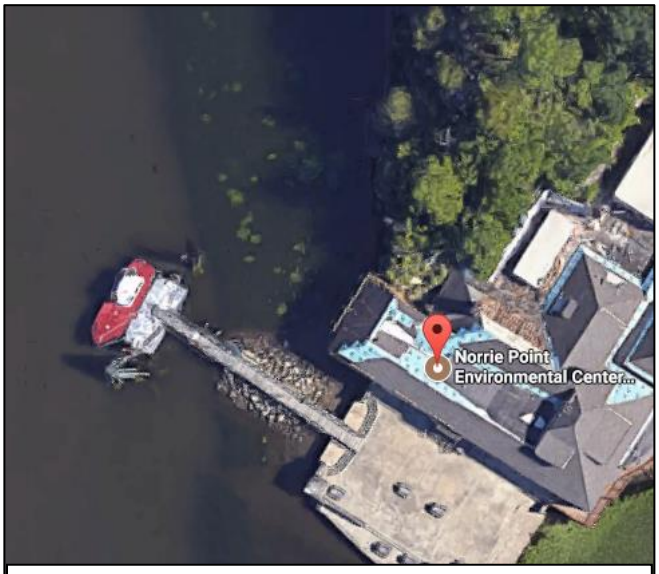
Dissolved oxygen (DO) is an important component of the Hudson River ecosystem, because aquatic animals need oxygen to survive. Oxygen can move by diffusion between the air and the water. Windy days tend to mix more oxygen into the water. Photosynthesis of aquatic plants also contributes dissolved oxygen to the water column. In the Hudson River, oxygen molecules are produced through photosynthesis by several organisms, including:

Water chestnut *(on left)* and water celery *(on right).*

Green algae (periphyton). Picture from Landcare Research

- Phytoplankton – small, often single-celled eukaryotic algae and cyanobacteria suspended in the water column.
- Periphyton – algae attached to various surfaces.
- Submergent macrophytes – plants like water celery *Vallisneria americana* that attach to the bottom and have leaves in the water column.
- Floating macrophytes – plants such as water chestnut *Trapa natans* that have their leaves above the water surface.

Most of the oxygen is added to the water column by submerged vegetation, periphyton, and phytoplankton; water chestnut and other floating plants contribute almost no oxygen to the water because the gas is released to the air. Many aquatic organisms use the oxygen produced by these sources for their respiration.



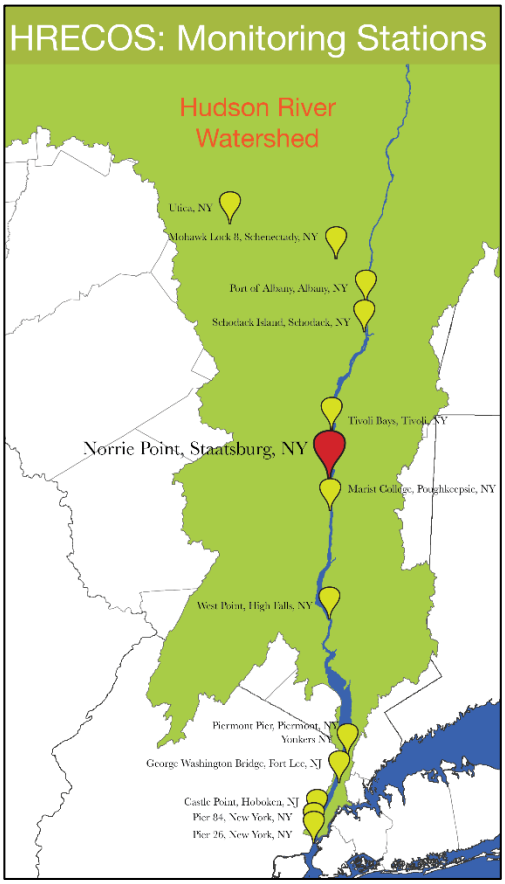
Aerial view of Norrie Point Environmental Center. Picture from Google Earth.

How Climatic Factors Might Influence Dataset Variables

Rainfall will dilute the salinity and can either warm or cool the temperature of the river. Colder water can hold more oxygen than warm water. A violent storm tends to increase turbidity by stirring up sediments and washing sediment in from tributaries. Cloud cover will reduce sunlight available to the water surface. Acidity will vary with rainfall, ambient air pollution, cell respiration and photosynthetic processes.

❖ **Dataset Timeframe:**

The dataset includes data recorded every hour for the first five days of February, April, June, and August, in 2017 at Norrie Point Environmental Education Center, Staatsburg NY. Each week of data is highlighted in a different color.



❖ **Information About Site:**

The data was collected at Norrie Point Environmental Education Center, Staatsburg, NY (41°49'54.75264"N 73°56'29.7812"W). This site is a bedrock outcropping into the main stem of the Hudson River adjacent to a cove. During the growing season (June – September), the cove is dominated by the invasive floating macrophyte *T. natans* (water chestnut).

Norrie Point has a tidal range of 1.19 meters and has a soft silty bottom. The depth at the sampling location ranges from approximately 1.0 to 3.0 meters and contains sensors for temperature, conductivity, pH, dissolved oxygen, turbidity, and chlorophyll *a*. The site also collects meteorological data with an array of sensors located on a pier in the river.

❖ **Data Collection Methods**:

HRECOS sensors collect data every 15 minutes from multiple locations along the Hudson River. This dataset uses the hourly readings from the Norrie Point Environmental Center HRECOS station.

❖ **Dataset Variables:**

- **Date/Time:** The date and time given in 24-hour time. Measurements were taken hourly for the first 5 days of February, April, June, and August in 2017.
- **Week Hour:** Hours of the five-day period numbered sequentially (1-120).
- **Wind Gusts (knots)**: The maximum wind speed during the 15-minute sampling period. Wind can mix surface water, increasing the dissolved oxygen in the sample area.
- **Radiation PAR (mmol/m^2)**: Photosynthetically Active Radiation: The amount of available sunlight in the range of wavelengths useful to producers for photosynthesis.
- **Rainfall daily accumulation (in)**: The cumulative amount of rain that fell since midnight of the respective day. Data points reflect the daily total up to that hour of the day.
- **Chlorophyll (g/L**): Measure of the amount of chlorophyll *a* pigments per liter of water. This can be used as a proxy measure of the amount of photosynthetic phytoplankton present.
- **Depth (ft):** A measure of water depth above sensor, which relates to tide and rainfall.
- **Dissolved Oxygen (percent):** The amount of oxygen dissolved in the water compared to the amount it could hold when it is at equilibrium with the atmosphere. This is dependent on temperature. Warmer waters can hold less oxygen.
- **pH:** A measure of the acidity of the water. The pH in the water can be affected by atmospheric conditions and also by photosynthesis, which takes CO_2 out of the water and

increases pH. Conversely, cell respiration *increases* CO_2 concentration, which can in turn decrease pH.

- **Turbidity (NTU)**: The amount of suspended solids in water solution. It is measured in Nephelometric Turbidity Units (NTU), which measures how light is scattered when passing through the water.
- **Water Temperature (ºF)**: The temperature at the sensor. Water temperature can affect water's ability to hold dissolved oxygen.

❖ **Source of Dataset:** Hudson River Environmental Conditions Observing System (HRECOS) http://hudson.dl.stevens-tech.edu/hrecos/d/index.shtml

❖ **Inquiry Idea Starters:**

Here are some sample questions you could ask using these datasets. These are just suggestions, and we hope you'll come up with many interesting questions on your own!

- Is there a relationship between dissolved oxygen and chlorophyll concentration? Does this vary over time?
- What other factors seem to correlate with dissolved oxygen? Why might these be related?
- Do measures of primary productivity, such as chlorophyll concentration, vary between months? What about over the course of a day?

References/Additional Resources:

The Hudson River is Buffered against Acid Rain (Web log post). Last Updated Monday, 05 October 2009. Retrieved January 12, 2018 from: http://www.hrecos.org/index.php?option=com_content&view=article&id=91:acidity-drops-after-a-heavy-rain&catid=42:hrecos-stories&Itemid=60

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