Lesson Plan: What can real-time-series lake data tell us about seasonal ecosystem dynamics and regional climate change?

Lesson designed for: Middle or High School students

Prerequisite Knowledge for students:

- *Knowledge of how Earth rotates on its tilted axis, how it revolves around the sun, and how those things impact daily, seasonal, and yearly dynamics.*
- *Basic Knowledge of photosynthesis($6CO_2$ + 6 H20+ light energy = $C_6H_{12}O_6$ + $6O_2$)and respiration($C_6H_{12}O_6$ + $6O_2$ = $6CO_2$ + 6H2O + energy)*

Next Generation Science Standards Addressed:

- *MS-ESS2-6: Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.*
- *MS-LS1-6: Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.*
- *HS-LS2-5: Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.*
- *HS-ESS2-4: Use a model to describe how variations in the flow of energy into and out of Earth's system result in changes in climate*
- *HS-ESS2-6: Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere and biosphere.*
- *HS-ESS3-5: Analyze geoscience data and the results from global climate change models to make an evidence-based forecast of the current rate of global or regional climate change and the associated future impacts to Earth's systems.*

Objective: The learner will use time-series data to determine how lake dymanics change daily, seasonally, and annually, in addition to being able to explain how/why lake dynamics and daily/seasonal/annual cycles are important when looking at decades and centurys of data dealing with climate change.

Engage:

Show students the Keeling curve shown below and ask them analytical questions such as:

- What is the overall trend shown in the graph?
- Why are there up and down annually recurring cyclical squiggles in the graph that look similar to the readings of a heart monitor?

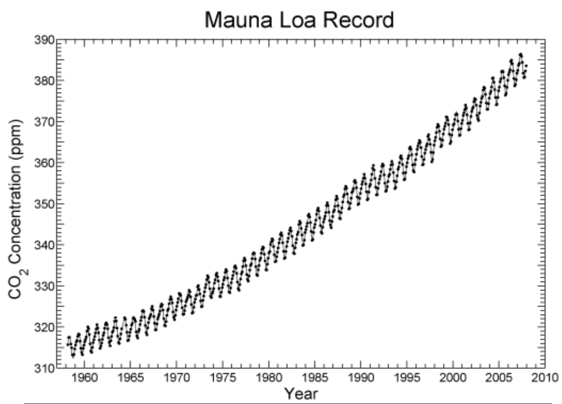
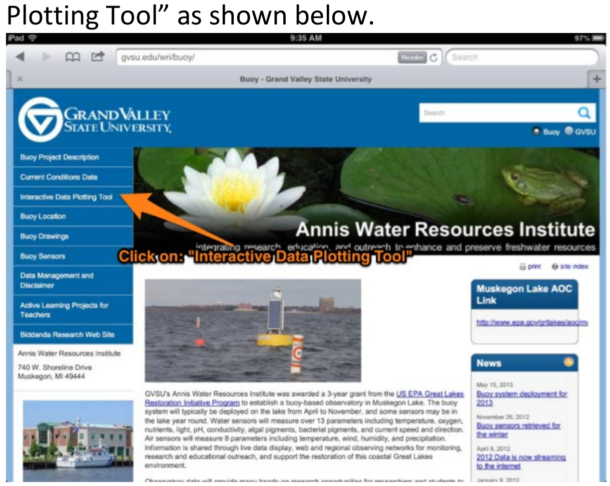


Figure: Keeling Curve (CO_2 readings from Mauna Loa): http://scrippsco2.ucsd.edu/program_history/keeling_curve_lessons.html

Explore:

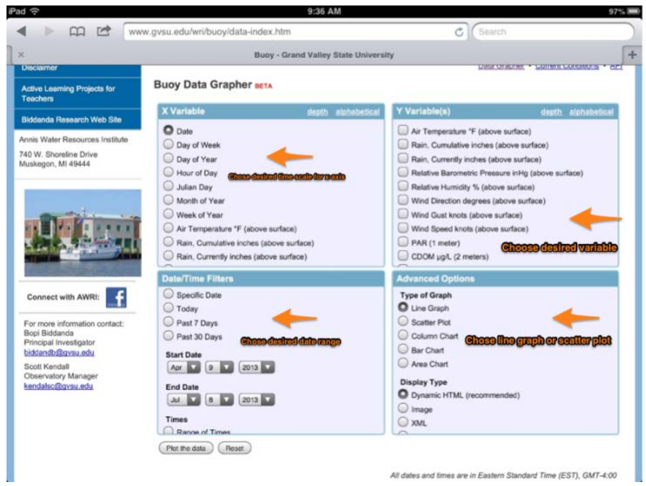
Instruct students to go to www.gvsu.edu/buoy, and click on "interactive Plotting Tool" as shown below.



Michigan Science Standards Addressed:

- *S.IA.06.11/ S.IA.07.1(6th/7th grade): Analyze information from data tables and graphs to answer scientific questions*
- *E.ES.07.72(7th grade): Describe how different weather occurs due to the constant motion of the atmosphere from the energy of the sun reaching the surface of the Earth*
- *L.OL.M.6 (7th grade): Photosynthesis- Plants are producers; they use the energy from light to make sugar molecules from the atoms of carbon dioxide and water. Plants use these sugars along with minerals from the soil to form fats, proteins, and carbohydrates. These products can be used immediately, incorporated into the cells of a plant as the plant grows, or stored for later use*
- *B1.1E (HS Biology): Describe a reason for a given conclusion using evidence from an investigation*
- *B3.1C (HS Biology): Recognize the equations for photosynthesis and respiration and identify the reactants and products for both*
- *B3.1D (HS Biology): Explain how living organisms gain and use mass through the processes of photosynthesis and respiration*

As shown in the figure below, next students should choose their time scale to place on the x-axis of their graph (year? Season? Daily? change). Students should also select a lake dynamic to investigate (Photosynthetically active radiation (PAR)-light, Dissolved Oxygen (opposite of CO_2), water temperature, air temperature, or Chlorophyll). It is recommended that students use DO, water temperature and chlorophyll readings from 5m as 5m in this particular lake can give students a good reading on the "pulse" of the lake.



Once students have chosen their criteria, prior to plotting the data, they should hypothesize what they believe their particular graph will look like, and sketch the trend they expect to see. Students should be able to explain why they hypothesized the trend they sketched in terms of changing weather, day/night period, season or climate.

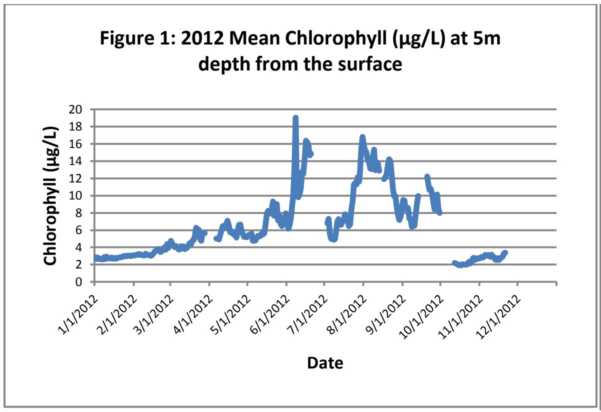
After making a hypothesis about the trend their data should show as well as giving an explanation as to why they hypothesize that way, student should plot their data, and make an accurate sketch to the trend they see.

Explain:
After students have plotted the desired data, they should analyze what the data is telling them. Students could be prompted with the following questions:

- What trend does the data show?
- Why does the data show that trend?
- Is the trend different or the same than you hypothesized? If it's the same, justify. If it's different, justify why?

Students should then have to put their findings (hypothesize/explanation, as well as data graphed/explanation) together and report to the class.

Examples of possible student graphs using Muskegon Lake 2012 observatory data and connections to the bigger picture:



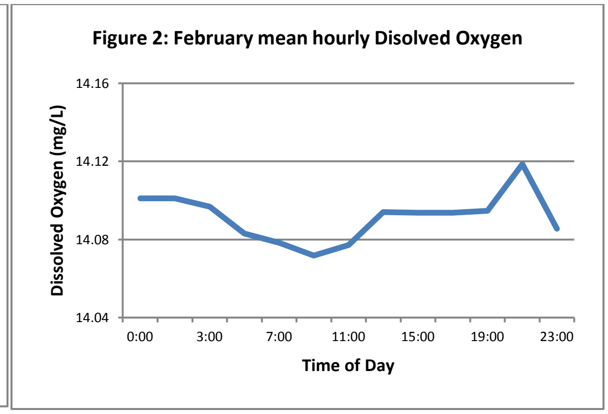


Figure 1: Yearly Chlorophyll (similar trend to what you would expect in a Northern Deciduous Temperate Forest)
Figure 2: Daily Dissolved Oxygen (Daily DO is mirroring the annual Keeling curve which shows CO2)

Elaborate: After students have presented their findings and evidence to the class, the instructor can facilitate a discussion talking about how inter-annual and daily cycles within a lake are important to the bigger picture of climate change.

- How do the daily, seasonal, and yearly trends of Muskegon Lake show in long term climate?
- How can monitoring of lake dynamics help to predict climate change or monitor environmental quality?

Evaluate:

- Students should be able to answer how inter-annual data is seen in the Keeling curve, going back to the original question: "
    - Why are there up and down squiggles in the graph that look similar to the readings of a heart monitor?"
    - What does this tell us about climate cycles?
    - How is climate different now than in the past?
    - What do you think the Keeling Curve will look like 50 years from now?
    - What will your graph or trend look like 50 years from now

References:

Next Generation Science Standards:

http://www.nextgenscience.org/next-generation-science-standards

Michican Content Expectations:

http://www.michigan.gov/mde/0,4615,7-140-28753_64839_38684_28760---,00.html

Buoy data:

Biddanda, B. and Kendall S. 2012, January 01-December 31. Muskegon Lake Observatory Data – 43.238239°N; 86.280532°W. Annis Water Resources Institute, Grand Valley State University, Muskegon, MI, USA: Environmental Protection Agency. Digital Media.