TEACHING GREAT LAKES LITERACY

Buoy, is that water green!

Driving Question: How do local land use practices impact life in the Great Lakes?

TOPIC: Harmful Algal Blooms (HABs) in the Great Lakes

GRADE: 9-12

TIME: This lesson may require 5 or more class periods. There is an optional opportunity for students to collect local water quality data that may require additional planning and coordination.

DATA PROFILE:
What: Observational data from buoys
When: 2022
Source: Great Lakes Observing Systems

GREAT LAKES LITERACY PRINCIPLES
#5 The Great Lakes support a broad diversity of life and ecosystems

#6 The Great Lakes and humans in their watersheds are inextricably interconnected

#7 Much remains to learn about the Great Lakes

AUTHORS: Ogemaw Heights High School: Dominic Goulette, Chris Powley

Great Lakes Observing System: Shelby Brunner, Katie Rousseau

Michigan Sea Grant: Program Leads: Meaghan Gass, Brandon Schroeder, Angela Scapini; Editor: Angela Greene; Designer: Todd Marsee

Overview

Students will consider how human land use impacts adjacent waterways. They will consider harmful algal blooms, hypoxia and observational buoy data collection and graphing. Students will also be given the opportunity to apply what they discover to their local watershed.

Anchoring Phenomenon

Exploring the connection between local practices, harmful algal blooms, and life in Lake Huron.

Essential Questions

- What are harmful algal blooms (HABs) and what conditions can lead to their formation?
- How do HABs connect to hypoxia in the water?
- How do HABs impact life in and out of the water?
- What is observational data?
- What can observational buoy data tell us about water?
- How might our local land use practices impact our water quality and water life?

Learning Objectives

Students will be able to:

- Describe Harmful Algal Blooms (HABs) and the impacts they have on a watershed.
- Determine how human activity can contribute to HAB formation and hypoxic conditions.
- Analyze water quality data generated from buoys deployed in the Great Lakes.
- Share insights about land use with others.

3-P Learning Goals

Problem, Project, Place-Based Education

- Students will identify negative impacts on a watershed as a result of Harmful Algal Blooms.
- Students will analyze data to determine the health of local bodies of water.
- Students will collect water quality data in a local watershed.
- Students will present findings on how local land use practices impact water quality to local entities.

Standards

Math Standards

Common Core Math Standards:

- 8.SP: Investigate patterns of association in bivariate data
- 8.F 4 & 5: Use functions to model relationships between quantities

Science Standards

Michigan Science Standards Performance Expectation(s):

- **HS-LS2-2:** Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scale.
- **HS-LS2-6:** Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
- **HS-LS2-7:** Design,evaluate and refine solutions for reducing the impacts of human activities on the environment and biodiversity.

Materials Checklist

- ☐ Engagement Photo: flic.kr/p/e2CK54
- ☐ Esri Integrated Map: esriurl.com/enviroGeoinquiry7
- ☐ Student worksheet titled “Buoy, is that water green! Exploration One”
- ☐ Driving Question Board
- ☐ ArcGIS Story Map: https://myumi.ch/qZAMe
- ☐ Student page, titled: “Buoy, is that water green! Exploration Two”
- ☐ Web Resource: Great Lakes Observing System (GLOS): glos.org/observing/buoys
- ☐ Slow Reveal Slides: Slow Reveal-Explain Part 2.pdf
- ☐ Student worksheet titled: “GLOS Graphical Analysis Group Activity”
- ☐ Student worksheet titled “Michigan GLOS Data Analysis Independent Practice”
- ☐ Dissolved Oxygen and Temperature Fact Sheet from the Cooperative Lakes Monitoring Program: www.micorps.net/wp-content/uploads/2023/05/Temp_DO-factsheet-2023.pdf
- ☐ Pond and Stream Study Guide-Interpreting Physical and Chemical Factors from the Pennsylvania Fish and Boat Commission: Pond and Stream Study Guide-Interpreting Physical and Chemical Factors.pdf
- ☐ EPA’s “How’s My Waterway?”: mywaterway.epa.gov
- ☐ Saginaw Bay GIS map: arcg.is/0Gqb541
- ☐ EPA’s“Status of the Lower Food Web in the Offshore Waters of the Laurentian Great Lakes”: www.epa.gov/sites/default/files/2021-04/documents/2019_glbmp_annual_report_07-12-2019_508_compliant.pdf

Learning Plan

Lesson Introduction

Harmful algal blooms, or HABs, happen when a type of bacteria called cyanobacteria grows too quickly in lakes and rivers. Cyanobacteria are usually harmless, but when they multiply significantly they can create a bloom that can be dangerous for people and animals. In this lesson, students will determine how human activity can impact the growth and spread of HABs. The lesson will continually focus on our driving question: “How do our local land use practices impact life in the Great Lakes?” We have included a “Driving Question Board” in the teacher resource section of this lesson. This board can be used as a “whole class” debriefing tool periodically throughout the lesson, and/or as an independent reflection tool for students.

Students will analyze buoy data and describe how it helps us understand water quality and make predictions about future HAB events. Students will also explore the Rifle River watershed (connected to Saginaw Bay, Lake Huron) and explain how human activities can impact water quality in that area. Students will generate and communicate generalizations about how land use can impact bodies of water based on their learning.

Engage

Students examine a photo of water that is bright green. The photo is zoomed in on a dead fish that has washed up on the shore. The bright green color of the water is an indication that a harmful algal bloom has occurred. The photo was taken in one of the Great Lakes and the fish is a Freshwater Drum, *Aplodinotus grunniens*.

Without mentioning the phrase “harmful algal bloom”, use the photo to facilitate a “whole class” discussion with students. The following prompt and questions can help guide the discussion. Record student answers on a whiteboard, chart paper, or digitally. The discussion notes can be organized into a “Think, Notice, Wonder” chart. Save or photograph these notes to review at the completion of the learning cycle.

- Describe what you see in the photograph.
- What questions come to mind when looking at this photo?
- Why do you think the water is green?
- Why do you think the fish in the photograph appears to be dead?
- Have you seen similar water conditions near you?
- How can we learn more about what is happening in this photograph?

Explore

Explore: Part One

The "Explore" phase of the learning cycle has been written in two parts. We will be using an ESRI integrated map for part one as we conduct a "guided exploration" with students. Our goal for this activity is to provide students an opportunity to discover the relationships between land use, nutrient loading, harmful algal blooms and hypoxia.

Your role as the learning facilitator will allow students to slowly and deliberately discover these relationships in a low stakes environment. We have created a student worksheet to enable students to record their initial thoughts and rework them as they continue to learn. The worksheet can also be used for students who miss class during the guided exploration. The educator instructions below are paired with the student worksheet entitled "Buoy, is that water green! Exploration One", so the instructor can guide the exploration.

Although the map used in the exploration will ultimately have students looking along the coast of the United States, we take every opportunity to draw attention to the Great Lakes.

- Provide students with the Map URL: esriurl.com/enviroGeoinquiry7 as well as a copy of the student worksheet entitled "Buoy, is that water green! Exploration One".
  - Allow students a bit of time to become familiar with the map.
  - Begin with the following focal question: What types of land cover are distributed across our country and around our Great Lakes?
- In the upper left corner of the map, the "Details" button will show types of land cover.
  - Ask students, "What types of land cover do you notice covering the United States?" *[Answers may include: Agriculture in the plains of the Midwest, and forests in the mountains and near coasts.]*
  - "What types of land cover do you notice around the Great Lakes?" *[Answers may include Agriculture, Woody Wetlands, and Urban areas]*.
- With the Details pane visible, click the button, "Contents" to show the contents of the map. The "Contents" button is the middle icon under the "Details" button.
  - Click the checkbox to the left of the layer named "World Hydro Reference Overlay".
  - Allow students time to zoom in and out to analyze the rivers in the United States and Canada. The zoom tool is inside the map in the upper left corner.
  - Ask students to name a few of the major rivers in the United States. *[Answers may include Colorado, Mississippi, Missouri and the Ohio River.]*
  - Instruct students to use the zoom tool so they can see dotted brown lines on the map. Ask students what they think the brown dotted lines represent. *[These lines represent the major watershed boundaries in the United States]*.
  - Ask students which major river seems to have the largest amount of land in its watershed boundary? *[The Mississippi River]*
  - Ask students to trace the Mississippi River and identify the body of water it ultimately drains into. *[The Gulf of America]*

    - At this point, students need to think about the term “runoff”. Make sure students are familiar with this term as this may be the first time they’ve thought about it. Ask students to think about the runoff that occurs from the land in the watershed to the river and to a larger body of water. What types of material could be part of the runoff that ultimately ends up in a larger body of water. *[Answers may include: sediment flows, chemical runoff, and many types of pollution or marine debris.]*
    - Ask students to look back at the major rivers they identified on the map. What type of land cover do these rivers seem to flow through? If students need to look at the land covers again, they can click on the third button to access the “Legend”. *[Answer should be: Agricultural]*

- At this point, students need to recall that fertilizer application is a common practice in yards, golf courses, and large-scale agricultural farms. The excess nutrients from fertilizer application can runoff into the local watershed. Make sure students have the “Contents” pane of the map open and ask them to turn on the layer named “GLDAS Runoff”.
    - Ask students what they think the darker blue colors represent? *[The dark blue colors indicate the higher amounts of runoff. This can be verified using the “Legend”.]*
    - Ask students if they notice any patterns related to high levels of runoff? *[There are higher amounts of runoff near larger urban areas. Students may need to zoom in to test this against cities they know. Provide them time to do this.]*
    - Ask students why they think there are higher levels of runoff in urban areas. *[This is a great opportunity to introduce or review permeable and impervious surfaces. Impervious land cover increases the amount of surface runoff generated.]*

- Instruct students to turn on the layer named “Chlorophyll-a Concentration”. Make sure students are zoomed out enough to see the entire country. Chlorophyll a is a green pigment found in plants and algae that is essential for photosynthesis.
    - Ask students where they notice increased concentrations of chlorophyll? *[Near the coasts]*
    - Ask students what they think are some possible causes of elevated chlorophyll levels? *[This may be difficult for students to answer, and could be an ideal space to review photosynthesis. Answers could include: warmer water temperatures, and increased nutrient and light levels.]*

- Here is the leap we are expecting students to make: As runoff containing high levels of nutrients from fertilizer enter the rivers and dump into larger bodies of water, chlorophyll-a levels increase. This could be an indication of an algal bloom (even a harmful algal bloom). As the high number of algae begin to die, the decomposers that break them down use up the available oxygen in the water. This creates hypoxia or “dead zones” in the water.
    - This concept can be challenging for students. Give them an opportunity to create a diagram that starts with nutrient runoff from an agricultural watershed to a dead zone in a larger body of water.
    - Instruct students to turn on the layer named “Gulf of Mexico DO”.

- Point out the dead zone near the coast of Louisiana. The lowest levels of dissolved oxygen are indicated in yellow. This can be verified by checking the "Legend". Ask students to measure the low DO levels near the coast of Louisiana. This can be challenging for some students. Following are tips to make using the measuring tool easier.
    - Click the measure button at the top of the map.
    - Click the button named "Distance".
    - Set the unit of measurement to square miles.
    - Position the area of interest on the map so that it is not obscured by the Measure window.
    - On the map, click once to start the measurement, click again to change direction, and double-click to stop measuring.
- Ask students what is the approximate surface area of the dead zone, indicated by the yellow color, near the coast of Louisiana? *[Approximately 7,000 square miles]*
- Ask students what relationship(s) they notice between chlorophyll concentrations and dissolved oxygen? *[Higher amounts of chlorophyll correspond with lower dissolved oxygen levels]*
- Ask students how low dissolved oxygen levels might impact local marine life? *[Fewer animals are able to live in areas of reduced dissolved oxygen.]*

- Pull the discussion together for students.
    - Ask students to define hypoxia. *[Hypoxia is low oxygen in marine environments.]*
    - Challenge students to generate a possible list of solutions to lower hypoxic conditions in marine systems. [*Possible solutions; reduce fertilizer/pesticide use and reduce runoff.]*
    - Draw students attention to our original driving question of the lesson, "How do our local land use practices impact life in the Great Lakes?"

Using the "Driving Question Board" provided in the Student Page section of this lesson will help debrief the activity.

Explore: Part Two

The “Explore” phase of the learning cycle has been written in two parts. During the second part of our exploration, students will be exploring an ArcGIS Story Map created by the Michigan Department of Environment, Great Lakes, and Energy (EGLE). Locate the story may using this URL: https://storymaps.arcgis.com/stories/5fccdbf3a18145c69c2b2eaf41d2f0c1

A student page, titled: “Buoy, is that water green! Exploration Two”, has been developed to help guide students through the exploration. Allow students to work independently or in learning pairs.

Our goal for this activity is to provide students an opportunity to develop a deeper understanding of harmful algal blooms, analyze map data showcasing HABs data, and consider mitigation strategies for HABs while localizing this phenomenon to the Great Lakes state of Michigan.

During this part of our exploration, your role as the learning facilitator should be minimal so that students have a chance to internalize concepts within their own schema. We recommend you conduct a debriefing session at the conclusion of this exploration to answer any questions and clear up misconceptions. Using the “Driving Question Board” provided in the teacher resource section of this lesson will help debrief the activity.

Explain

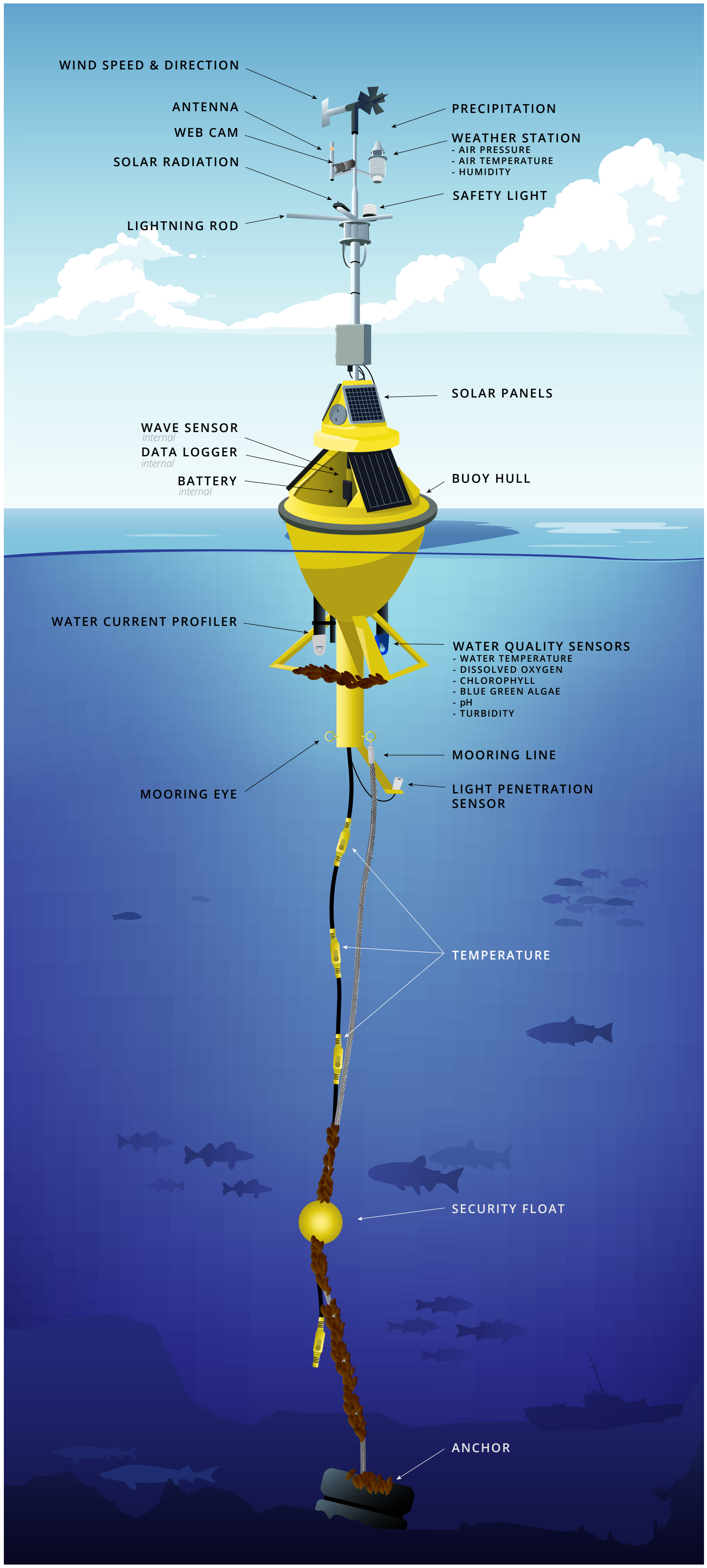
Explain: Part One

The “Explain” phase of the learning cycle has been written in three parts. In the Explain phase of our learning cycle, our goal is to support students in processing and understanding all the material they’ve explored, deepening their grasp of possible answers to our driving question and anchoring phenomenon. We will be using data from GLOS buoy data to understand what is happening in the water during summer months in locations where the land use may lead to hypoxia in local waterways. Math and science concepts we are trying to develop in this phase of the learning cycle include:

- graphs vs. tables,
- water temperature and dissolved oxygen,
- finding the mean of a data set
- finding percent change.

Keep in mind this phase provides opportunities for “explanation” to occur in multiple ways: from instructor to student, student to instructor, and among students themselves.

- We begin by challenging students to think about how water quality data is currently collected; leading us to an explanation of water buoys. Buoys are floating sensor platforms, known for their versatility and being relatively easy to deploy and maintain. Buoys can be left free-floating to drift with the lake currents or be anchored to the lakefloor to float at the surface or underwater, depending on where they need to take measurements.


WIND SPEED & DIRECTION
ANTENNA
WEB CAM
SOLAR RADIATION
LIGHTNING ROD
PRECIPITATION
WEATHER STATION
- AIR PRESSURE
- AIR TEMPERATURE
- HUMIDITY
SAFETY LIGHT
SOLAR PANELS
WAVE SENSOR
internal
DATA LOGGER
internal
BATTERY
internal
BUOY HULL
WATER CURRENT PROFILER
WATER QUALITY SENSORS
- WATER TEMPERATURE
- DISSOLVED OXYGEN
- CHLOROPHYLL
- BLUE GREEN ALGAE
- pH
- TURBIDITY
MOORING LINE
MOORING EYE
LIGHT PENETRATION SENSOR
TEMPERATURE
SECURITY FLOAT
ANCHOR

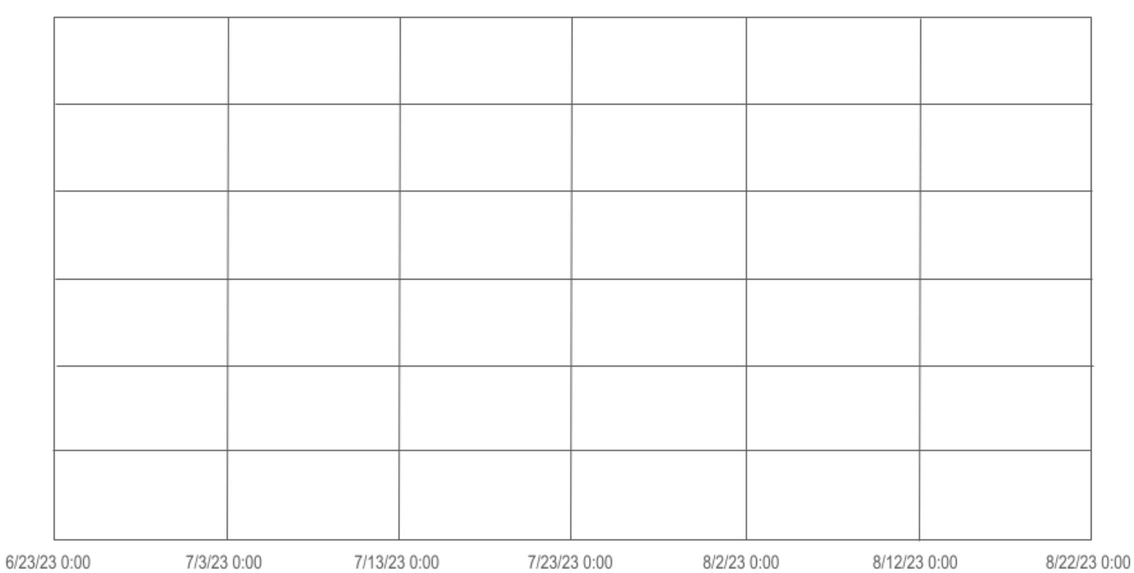
OBSERVATIONAL DATA: Data that is collected by recording events, behaviors, or phenomena as they occur naturally, without interference or manipulation.

- Connect the use of buoys to the term "observational data". In the call-out box above we defined observational data as data that is collected by recording events, behaviors, or phenomena as they occur naturally, without interference or manipulation. Using buoys as a data collection device gives scientists the ability to acquire data in this manner. Depending on how they are configured, buoys can monitor physical, chemical, and biological parameters of water and weather including wind speed, water temperature, wave height, pH, chlorophyll, and turbidity.
- Using a graphic of a buoy submerged in a lake such as the one included in this lesson on the previous page, ask students to "put on their imaginary wet suit" so they can swim from the bottom of a buoy to the surface of the water. What might they experience as they journey vertically through the water column? While under water, students may note temperature and light differences, fish or other aquatic organisms, a concrete anchor at the bottom of the buoy, a vertical mooring line, subsurface floats to keep the mooring line out the mud, and water sensors. As they emerge from the water, students may notice a large floating hull made of foam or fiberglass, weather sensors to take measurements of atmospheric conditions, solar panels to power the sensors, data loggers and communication systems to transmit data, and perhaps a safety light to alert boaters of the buoy's location. The following link provides useful information, imagery and video about the use of buoys on the Great Lakes by the Great Lakes Observing System (GLOS): glos.org/observing/buoys.
- Buoys help researchers, beachgoers, anglers, water treatment plant managers, boaters, and others make informed decisions about their interactions with water systems. In the Great Lakes region, it takes a community of dedicated professionals to monitor and care for the buoys, deploying them every spring and recovering them every fall. Allow students to watch the following video about buoy deployment on the Great Lakes (2:22) GLERL Buoy Prep
- Touch base with the "Driving Question Board" provided in the teacher resource section of this lesson debrief student understanding of water buoys.

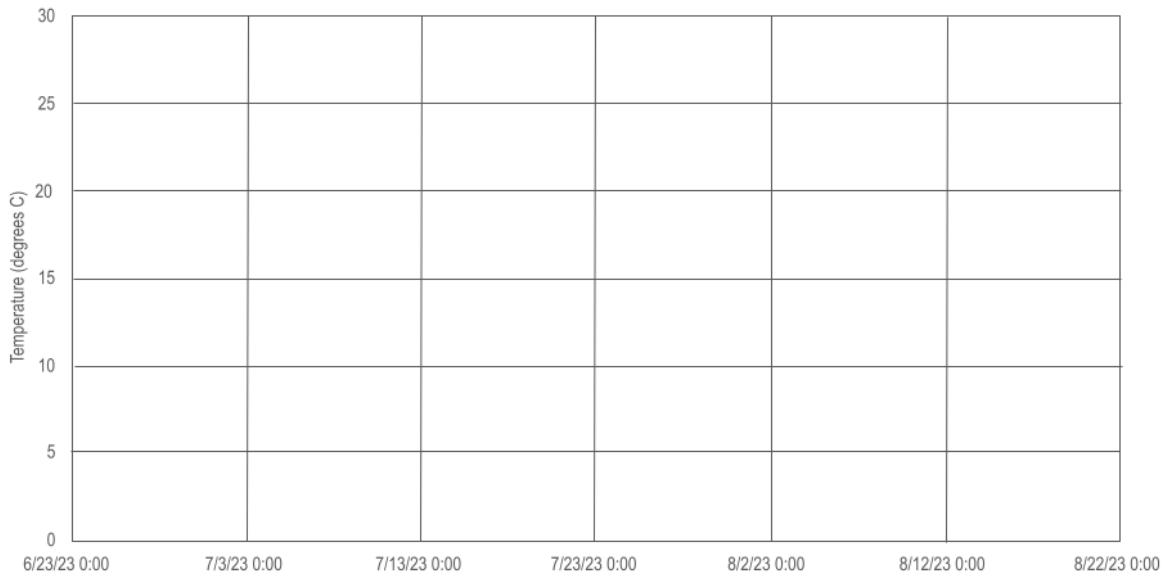
Explain: Part Two

Buoys provide us with data. Data is organized into graphs, tables and charts. During this phase of the learning cycle, we will look at our driving question and anchoring phenomenon through a mathematical lens using buoy data that has been graphed and provided to us from Great Lakes Observation Systems (GLOS).

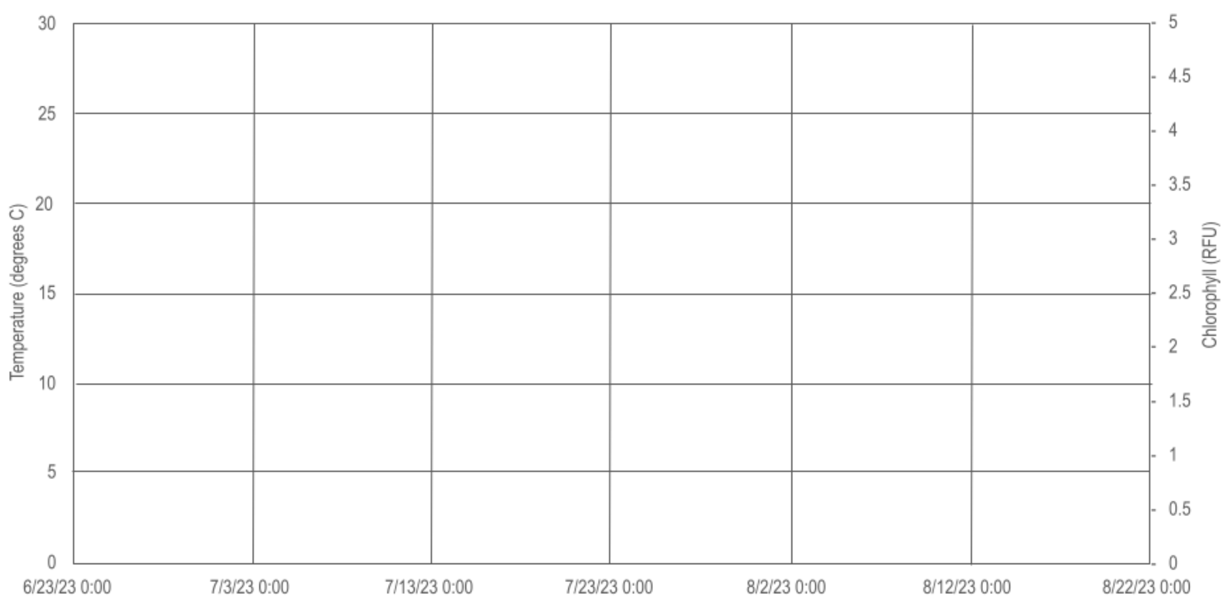
- Begin with a brief discussion about how graphs, tables, and charts help organize data, including observational data from buoys. Tailor the discussion to meet the specific needs of your students and their level of familiarity with graphing data. Perhaps your students are beginning to understand the differences between tables and graphs. (Developing Concept: Graphs vs. Tables) Discussion questions may include:
  - How are tables of data helpful to our understanding of science?
  - How are graphs of data helpful to our understanding of science?
  - What makes a table more helpful than a graph?
  - What makes a graph more helpful than a table?
- Use a "Slow Reveal" technique to introduce students to the graph entitled "Saginaw Bay Buoy Data". This graph is part of the GLOS Graphical Analysis Group Activity" student worksheet. Using a "Slow Reveal" technique allows the instructor to slowly reveal small elements of the graph paired with discussion and conjecture about the context of the graph. "Slow Reveals" help promote engagement with the data and allow students to more easily make sense of data. "Slow Reveal" slides for the following frames can be found in the "Additional Teacher Resources". More information about "Slow Reveal" graphs can be found using the following link: slowrevealgraphs.com. Here is a potential storyline and reveal pattern for this particular graph:
  - Ask students to imagine a buoy floating in a lake while collecting water data. Reveal the first frame of the graph and ask students what they notice and what is missing. *[The collection period was in late June to late August of 2023. Time is not recorded. We don't know where data was collected and we don't know what parameter was being measured.]*



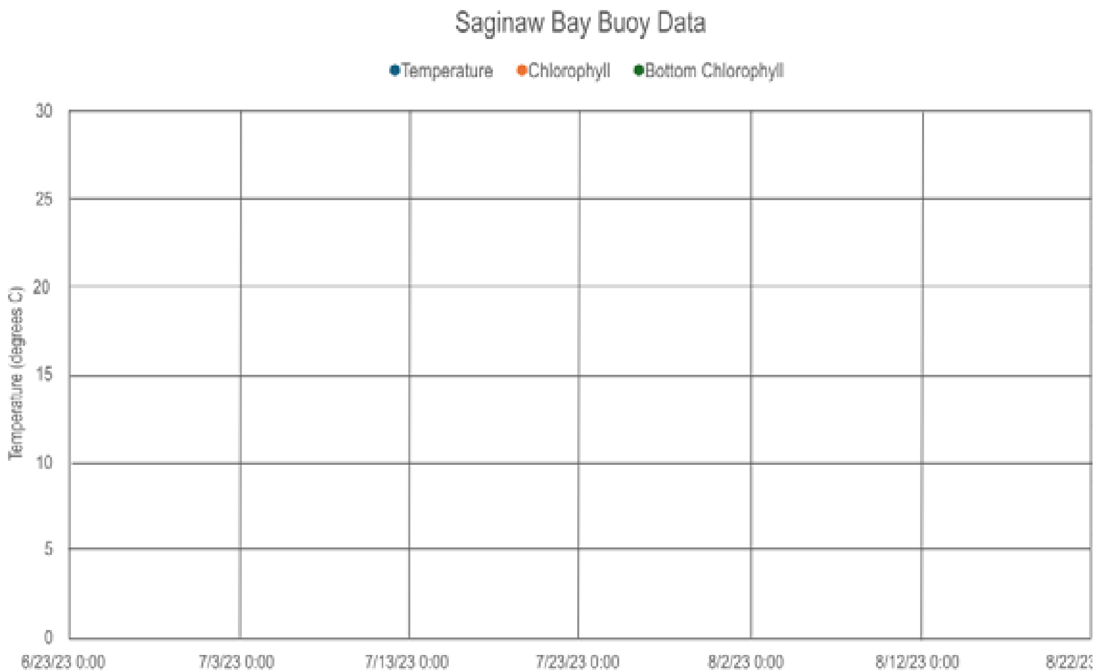
- Reveal the second frame of the graph and ask students what they notice and what is missing. *[The temperature is being measured in Celsius. We don't know if it is air temperature or water temperature. *Note: We actually will never find out if it's air or water temperature, so we must assume it's water temperature. The temperature range is from 0-30°C which we can convert to 30-86° F. We still do not know where the buoy was located during data collection.]*



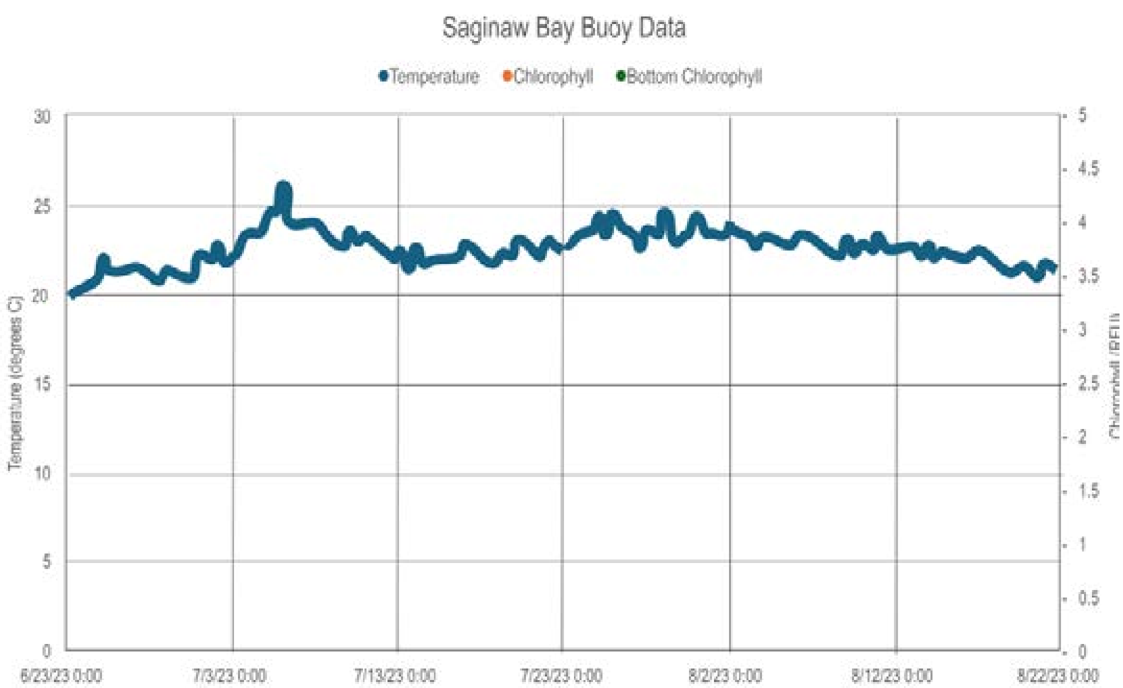
- Reveal the third frame of the graph and ask students what they notice and what is missing. *[We can now see that we are also measuring chlorophyll in RFU although we may not know what RFU stands for (relative fluorescence units) The units for chlorophyll range from zero to 5 in increments of 0.5. We still do not know where the buoy was located during data collection.]*



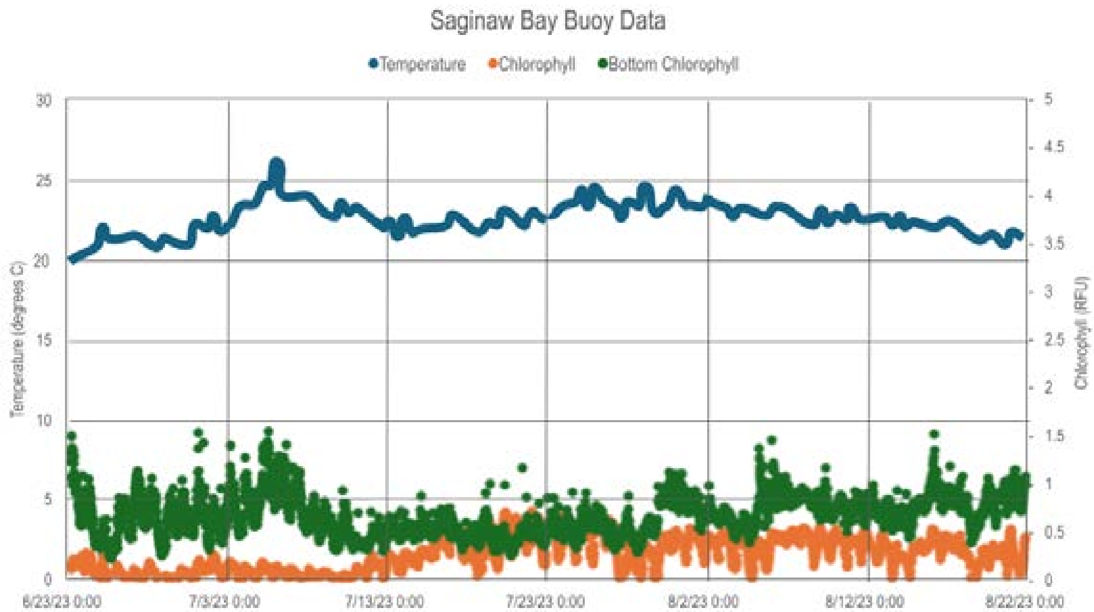
- Reveal the fourth frame of the graph and ask students what they notice and what is missing. *[We know the data was collected in the Saginaw Bay. Provide students with access to a map to locate this body of water and note that it is part of Lake Huron. We also know that in addition to temperature and chlorophyll, the buoy also collected bottom chlorophyll.]*



- Reveal the fifth frame of the graph and ask students what they notice and what is missing. *[The temperature data has been added to the graph as a line graph.The temperature stays consistently between 20 and 25°C with a slight increase in early July. The warmest consistent temperatures occurred in late July and early August. We do not see data for chlorophyll or bottom chlorophyll.]*



- Reveal the sixth frame of the graph and ask students what they notice and what is missing. *[We can see the data for chlorophyll and bottom chlorophyll.]*



After engaging with the data through the slow reveal process, students can try to derive meaning from the graph. Provide each student with a copy of the "GLOS Graphical Analysis Group Activity" student pages. Organize students into small groups to complete questions. Opportunities to share findings using an "ambassador speaker" with the whole class have been built into the activity. An answer key has been provided in the Additional Teacher Resources section of the lesson.

Explain

Explain: Part Three

We conclude our analysis of GLOS buoy data with an opportunity for students to work independently, in pairs or small groups with two additional graphs. It is at the discretion of the teacher to determine if students need a "Slow Reveal" process before engaging with the graphs. We are also including two additional resources to help students (and educators) better understand the content surrounding hypoxia. The first resource explains the relationship between dissolved oxygen and temperature. The second is a pond and stream study guide that will help students interpret physical and chemical factors. Provide each student with a copy of each of the following documents:

- Student page titled "Michigan GLOS Data Analysis Independent Practice"
- Dissolved Oxygen and Temperature Fact Sheet from the Cooperative Lakes Monitoring Program: www.micorps.net/wp-content/uploads/2023/05/Temp_DO-factsheet-2023.pdf
- Pond and Stream Study Guide - Interpreting Physical and Chemical Factors from the Pennsylvania Fish and Boat Commission

Engage with students as a whole class by debriefing this activity together. Help students refine their thinking by revisiting your driving question board as you try to make connections between how land use impacts water quality.

Elaborate

As we begin to elaborate on the driving question of this lesson, How do our local land use practices impact life in the Great Lakes?, we try to make the connection with students between what is happening in the surrounding watershed to algal blooms and hypoxia in the water. Understanding and even making predictions about these connections is difficult. Our strategy was to localize the issue by studying the Rifle River, a specific area in our own watershed where land is being used primarily for agriculture while hypoxic events were occurring in the Saginaw Bay. We encourage educators to localize the remainder of this lesson. The following activities outline how we proceeded to learn about land use and its impact on water near the Rifle River where it drains into the Saginaw Bay.

- Allow students to study their watershed using “How’s My Waterway?”, an online and interactive tool provided by the Environmental Protection Agency (EPA).
  - Information about the tool: www.epa.gov/waterdata/hows-my-waterway
  - The tool is located here: mywaterway.epa.gov
- After students familiarize themselves with their watershed and the parameters provided by the “How’s My Waterway?” tool, we use a GIS map showing watershed basins of Michigan. This will enable students to look more closely at our local watershed around the Rifle River.
  - Our GIS map is located here: arcg.is/0Gqb541
  - Use the search bar by entering “Rifle River”. This will lead students to the mouth of the Rifle River where it meets Lake Huron in Saginaw Bay. Place a “Map Note” here by clicking on the map note tool.
  - Use the search bar again by entering “Rifle River Recreation Area”. Place another “Map Note” here as this is a testing site for water quality at the headwaters.
  - Use the search bar again by entering “Irons Park West Branch” Place another “Map Note” here as this is a second water quality testing site.
  - Measure the distance from the headwaters of the Rifle River to the mouth. Also measure the distance from the headwaters of the west branch of the Rifle River to where it meets the main branch of the Rifle River. These measurements will be an approximation in miles as it is difficult to measure with the measuring tool. First click on the measuring tool then choose linear miles. Then go to the map and click on the head waters and trace the river leaving points as it meanders through the watershed. Allow students to agree up and record measurements on a white board.
    - Approximate miles of the West Branch of the Rifle River________________________
    - Approximate miles of the Rifle River____
    - Approximate miles total____

- Ask students to analyze the land around the Rifle River to determine how it is used. *[primarily agriculture]*.
- Ask students to analyze the area of water where the Rifle River drains into Saginaw Bay.
- Allow students to change the basemaps to see how the map changes.
  - Are there different basemaps that would make measuring easier?
  - Is there a particular base map that students find more useful?
- Now change the basemap to “NAIP Imagery Hybrid”.
- Look for the headwaters of the Rifle River, the headwaters of the west branch of the Rifle River, and the mouth of the Rifle River as it enters Saginaw Bay in Lake Huron.
- Discuss land use and the appearance of the water in the Saginaw Bay.
- At this point in the lesson, authors felt it necessary to share the following document with students to add to their thinking. “Status of the Lower Food Web in the Offshore Waters of the Laurentian Great Lakes”, a document provided by the EPA: www.epa.gov/sites/default/files/2021-04/documents/2019_glbmp_annual_report_07-12-2019_508_compliant.pdf
- After exploring the watershed digitally, students visit the two locations to complete water quality testing. Students will spend a day collecting water quality data, mirroring the parameters collected by the buoys.
  - Our preferred water quality protocol, “H2O Q in the Classroom: www.cmich.edu/academics/colleges/college-science-engineering/centers/institute-for-great-lakes-research/GL-collaborative-research-workshop
  - Other testing kits include those produced by companies such as LaMotte or Hach.
  - Our testing parameters and analysis can be found in the following student data sheet. drive.google.com/file/d/1TdkwG5BVozeW2iUj-HH4LjgXmp8lu-1L/view?usp=sharingTGLL-GLOS-Stream Data Gathering Group Activity.pdf
  - For benthic macroinvertebrate monitoring, Stroud Water Research Center has many resources including the following.
    - “Macroinvertebrate Identification Key”: stroudcenter.org/macros/key/
    - “Michigan Environmental Education Curriculum Support: MEECS Water Quality”: thinktv.pbslearningmedia.org/collection/meecs/t/meecs-water-quality

Evaluate

Complete the learning cycle with a final look at the Driving Question Board. If you chose to collect water quality data in your watershed with students this is a good opportunity to compare findings to buoy data. Students can also review the data they collected using their new understanding of stream quality to draw conclusions about the health of the tested streams. They can analyze how local land use affects water quality.

Bring students attention back to the photo and notes taken during the Engage portion of this learning cycle. Examine the photo of water that is bright green. The photo is zoomed in on a dead fish that has washed up on the shore. The bright green color of the water is an indication that a harmful algal bloom has occurred. The photo was taken in one of the Great Lakes and the fish is a Freshwater Drum, *Aplodinotus grunniens*. Review the original notes taken when students first viewed the photo. Allow students to discuss how their thinking has changed as a result of this lesson.

Students can share their learning by developing presentations to share with local audiences highlighting ways to positively impact their local watershed. These presentations might include Story Maps, slide shows, poster boards, and more.

The following list includes additional resources we wanted to share to help educators and students deepen their understanding of our driving question, "How do our local land use practices impact life in the Great Lakes?" as well as effective ways to communicate scientific ideas to others.

- C-CAP Land Cover Atlas: Find information about local land use in this NOAA Digital Coast tool: coast.noaa.gov/digitalcoast/tools/lca.html
- Model My Watershed: Model different land use (not specific to any area): runoff.modelmywatershed.org
- COMPASS Message Box Workbook: Tool for developing effective science communication: www.compassscicomm.org/wp-content/uploads/2020/05/The-Message-Box-Workbook.pdf
- Cyanobacteria Algal Bloom from Satellite in Saginaw Bay, MI - NCCOS Coastal Science Website: coastalscience.noaa.gov/science-areas/habs/hab-monitoring-system/cyanobacteria-algal-bloom-from-satellite-in-saginaw-bay-mi
- GLOS YouTube Channel: www.youtube.com/@RealGLOS
- Video: 2024 University of Minnesota-Duluth: Meteorological Buoy Deployment (4:53): www.youtube.com/watch?v=lNNoOXztZfE

Driving Question Board

Driving Question (DQ)	How do our local land use practices impact life in the Great Lakes?		
Activity	What did we do?	What did we learn? (words, concepts)	How can this help us answer the DQ?
ESRI Map Exploration			
ArcGIS Harmful Algal Bloom Story Map			
Understanding How Water Quality Data is Collected			
Analysis of Buoy Data			
Analysis of Local Data Collected in the Field by Students			

Use this to organize and keep track of how what you learn from activities helps you answer the driving question.

What KEY WORDS could be used when answering the driving question? ____________________

____

What EXAMPLES could be used when answering the driving question? ____________________

____

What EVIDENCE or DATA could be included when answering the driving question? __________

____

Buoy is that water green! Exploration One

Name ______________________________

Class Period ______________________________

1. Open the map using this URL: esriurl.com/enviroGeoinquiry7
   - Spend a few minutes exploring the map and become familiar with its functions.
   - Let's think about this question as we explore this map together: What types of land cover are distributed across our country and around our Great Lakes?
2. In the upper left corner of the map, the "Details" button will show types of land cover.
   - What types of land cover do you notice covering the United States? ______________________________
   - What types of land cover do you notice around the Great Lakes? ______________________________
3. With the Details pane visible, click the button, "Contents" to show the contents of the map. The "Contents" button is the middle icon under the "Details" button.
   - Click the checkbox to the left of the layer named "World Hydro Reference Overlay".
   - Zoom in and out to analyze the rivers in the United States and Canada. The zoom tool is inside the map in the upper left corner.
   - What are the names of a few of the major rivers in the United States? ______________________________
   - Zoom in on the United States just enough so you can see dotted brown lines on the map. What do you think the brown dotted lines represent? ______________________________
   - Which major river in the United States seems to have the largest amount of land in its watershed boundary? ______________________________
   - Trace the Mississippi River and identify the body of water it ultimately drains into. What is the name of this body of water? ______________________________
   - Think about the term "runoff"and the runoff that occurs from the land in the watershed to the river and to a larger body of water. What types of material could be part of the runoff that ultimately ends up in a larger body of water? ______________________________

- Look back at the major rivers you identified on the map. What type of land cover do these rivers seem to flow through? If you need to look at the land covers again, click on the third button to access the "Legend". ______________________________________

4. You may already know that fertilizer application is a common practice in yards, golf courses, and large-scale agricultural farms. The excess nutrients from fertilizer application can runoff into the local watershed. Make sure you have the "Contents" pane of the map open and turn on the layer named "GLDAS Runoff".

- What do you think the darker blue colors represent? If you are unsure, take a look at the "Legend" of the map again. ______________________________________

- Do you notice any patterns related to high levels of runoff? You may need to use a very close zoom to notice something significant. ______________________________________

- Why do you think there are higher levels of runoff in urban areas? ____________________

5. Turn on the layer named "Chlorophyll-a Concentration". Make sure you are zoomed out enough to see the entire country. Chlorophyll a is a green pigment found in plants and algae that is essential for photosynthesis.

- Where do you notice increased concentrations of chlorophyll-a? ____________________

- What do you think are some possible causes of elevated chlorophyll levels? ____________

6. As runoff containing high levels of nutrients from fertilizer enter the rivers and dump into larger bodies of water, chlorophyll-a levels increase. This could be an indication of an algal bloom (even a harmful algal bloom). As the high number of algae begin to die, the decomposers that break them down use up the available oxygen in the water. This creates hypoxia or "dead zones" in the water.

   - Create a diagram below that starts with nutrient runoff from an agricultural watershed that ultimately creates a dead zone in a larger body of water.

   - Turn on the layer named "Gulf of Mexico DO".

   - Notice the dead zone near the coast of Louisiana. The lowest levels of dissolved oxygen are indicated in yellow. This can be verified by checking the "Legend". Measure the low DO levels near the coast of Louisiana. Here are a few tips to make using the measuring tool easier.

     - Click the measure button at the top of the map.
     - Click the button named "Distance".
     - Set the unit of measurement to square miles.
     - Position the area of interest on the map so that it is not obscured by the Measure window.
     - On the map, click once to start the measurement, click again to change direction, and double-click to stop measuring.
     - What is the approximate surface area of the dead zone, indicated by the yellow color, near the coast of Louisiana? ______________________________
     - What relationship(s) do you notice between chlorophyll concentrations and dissolved oxygen? ______________________________

       ____

- How do you think low dissolved oxygen levels might impact local marine life? ____

7. Let's pull everything we have discovered together.

- Define hypoxia.____
- Generate a possible list of solutions to lower hypoxic conditions in marine systems.
- Recall our original driving question of the lesson, "How do our local land use practices impact life in the Great Lakes?" If you were tasked with explaining this phenomenon to a group of citizens in your community what would you say to them?____

Buoy is that water green! Exploration Two

Name ______________________________

Class Period ______________________________

1. Open the story map using this URL: https://storymaps.arcgis.com/stories/5fccdbf3a18145c69c2b2eaf41d2f0c1
   - Spend a few minutes exploring the story map and become familiar with the content and beautiful photo and video assets.
   - Keep the driving question of our lesson in mind as you explore the story map. How do our local land use practices impact life in the Great Lakes?
2. What is another name for blue-green algae? ______________________________
3. If blue-green algae are a natural component of our lakes, rivers and ponds why are they so harmful? ______________________________
4. What are HABs? ______________________________
5. Watch the video featuring Aaron Parker, Michigan Department of Environment, Great Lakes and Energy (EGLE)'s senior aquatic biologist. The video helps us with the identification of HABs.
   - View the images associated with the video.
   - Describe the "stick test" and how it is used. ______________________________
6. Create a list of conditions that would enable a HAB to occur in a body of water. ______________________________
7. How might nutrient levels in water increase? ______________________________
8. How do invasive species make conditions more favorable for cyanobacteria? ______________________________

9. Using the mapping tool developed by the Michigan Department of Health and Human Services (MDHHS), select three different sites on the map, each of a different color.

- Record the location of each site with latitude and longitude.
- Record the color displayed for each site.
- Provide a description of what the site color indicates for each location.
- Organize your response in a data table. Be sure to include headers for each column of your data table.
- Provide your data table a title that includes the year 2023.

Site Number	Location	Color	Description

10. Using the same mapping tool you used for the prompt above, toggle the button to show map data for 2022. Create a second data table with three sites. Try to select sites that are the same or close to the same as the sites you selected for 2023.

- Record the location of each site with latitude and longitude.
- Record the color displayed for each site.
- Provide a description of what the site color indicates for each location.
- Organize your response in a data table. Be sure to include headers for each column of your data table.
- Provide your data table a title that includes the year 2022

Site Number	Location	Color	Description

11. Analyze your data tables.

- Were any of your sites coded as RED in both years? ______________________
- If you answered yes to the above question, where is this location? ______________________
- Does this make you wonder how the land is being used in this location? ______________________
- Poke around on the 2023 and 2022 map to see if you can find RED locations for both years.

12. What symptoms might a human exhibit if they have been exposed to HAB toxins?______________________

13. What effects do exposure to HAB toxins have on our pets and livestock?______________________

14. How do HABs impact aquatic ecosystems? ______________________

15. According to the story map, how can humans reduce nutrient levels in a water system?

16. In the navigation pane at the top of the story map, locate the tab named “ Prevention”. In this section of the story map, scroll down to “Miscellaneous Prevention Steps”. Four strategies for preventing the occurrence of harmful algal blooms are provided.

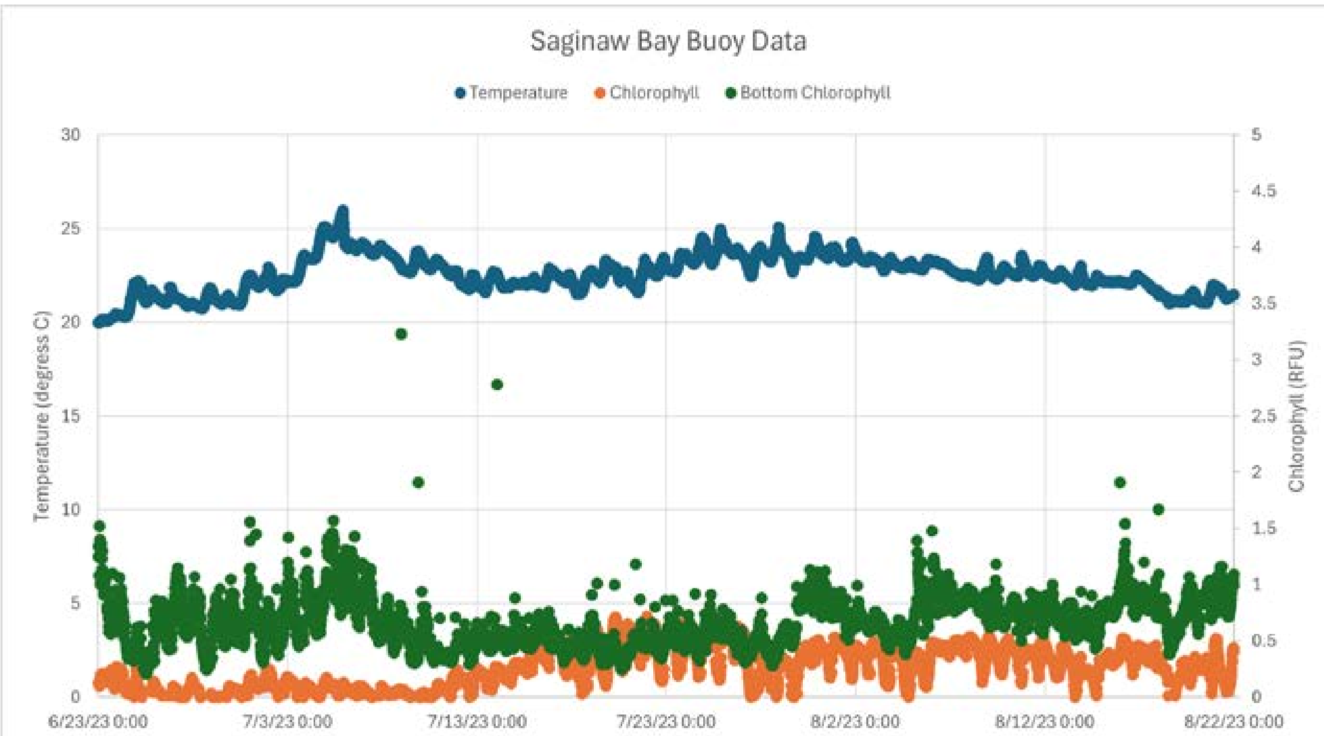
- Rewrite these strategies here, but write them in the order that you are most likely or most able to do.
- Provide one specific detail on how you might accomplish your first and second ranked strategy.
  - ______________________. Detail ______________________
  - ______________________. Detail ______________________
  - ______________________.
  - ______________________.

17. Take a look at the section of the story map that tells us what the state of Michigan is doing about HABs. Also look at the recommendations provided to YOU if you suspect a HAB has occurred in a local body of water. After thinking about these strategies and recommendations, design a public sign (much like the signs we see on our roads as we drive in traffic.) that provides a warning about a potential HAB in a local swimming or fishing lake.
18. Once again, bring to mind our driving question: "How do our local land use practices impact life in the Great Lakes?" If you were, again, tasked with explaining this phenomenon to a group of citizens in your community would there be anything else you might include in your talk?

GLOS Graphical Analysis Group Activity

Name ______________________________

Class Period ______________________________



1. Talk with your group and record 2 or 3 patterns or trends you are seeing in the graph above.
2. Select an ambassador within your group and prepare to share-out one pattern or trend with the class.
3. After each group has shared their pattern or trend, let's examine our graphical data to determine if those patterns or trends stay true throughout the given season. If not, where do we notice any exceptions? ______________________________

____

____

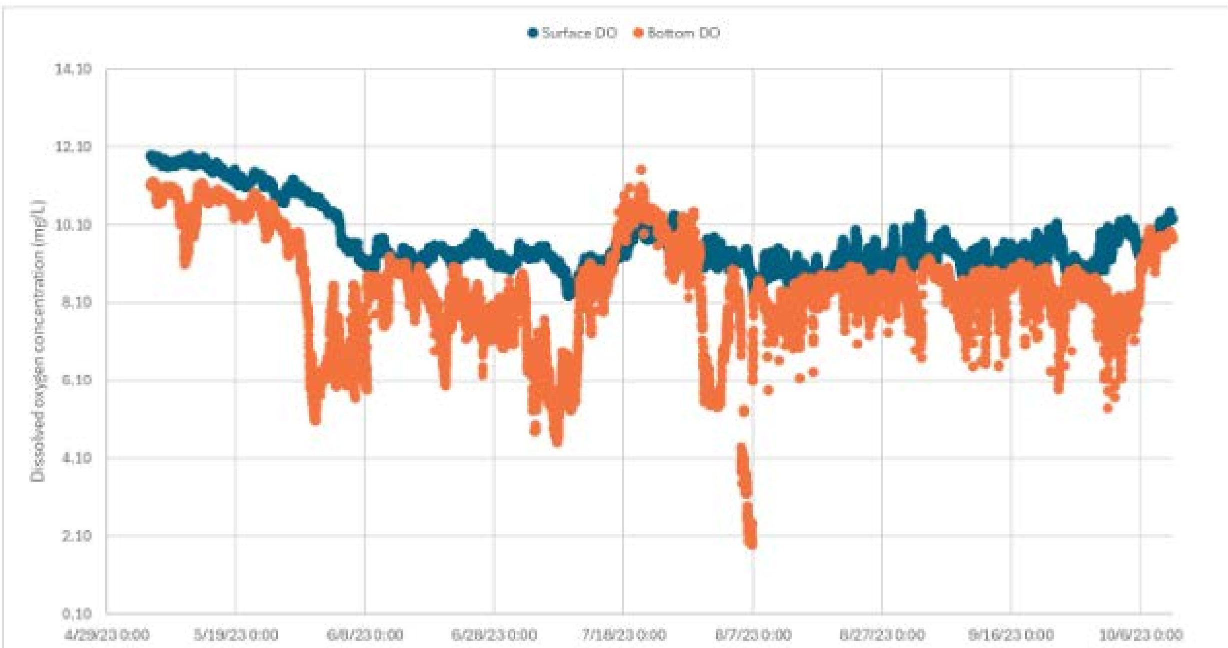
____

TEACHING GREAT LAKES LITERACY

Student Page

GLOS Graphical Analysis Group Activity, page 2

2023 Saginaw Bay Buoy Data of Dissolved Oxygen



4. With your group, take a few minutes to study the parts of the graph above. Record 2 or 3 patterns or trends you are seeing in the graph.
5. Prepare your group's ambassador to share-out one pattern or trend with the class.
6. After each group has shared their pattern or trend, let's examine our graphical data to determine if those patterns or trends stay true throughout the given season. If not, where do we notice any exceptions? ____

____

____

7. Examine the graphical data for the second half of July. With your group, make a scientific claim describing the change in surface and bottom dissolved oxygen.
8. Using both graphs to guide your thinking, work with your group to determine why this change is happening. Guesses are encouraged.
9. Next, examine the first ten days of August. What do you notice is happening? ____________

____

____

10. How might the organisms living deeper in the Saginaw Bay be impacted by the phenomenon occurring in the first ten days of August? ______________________

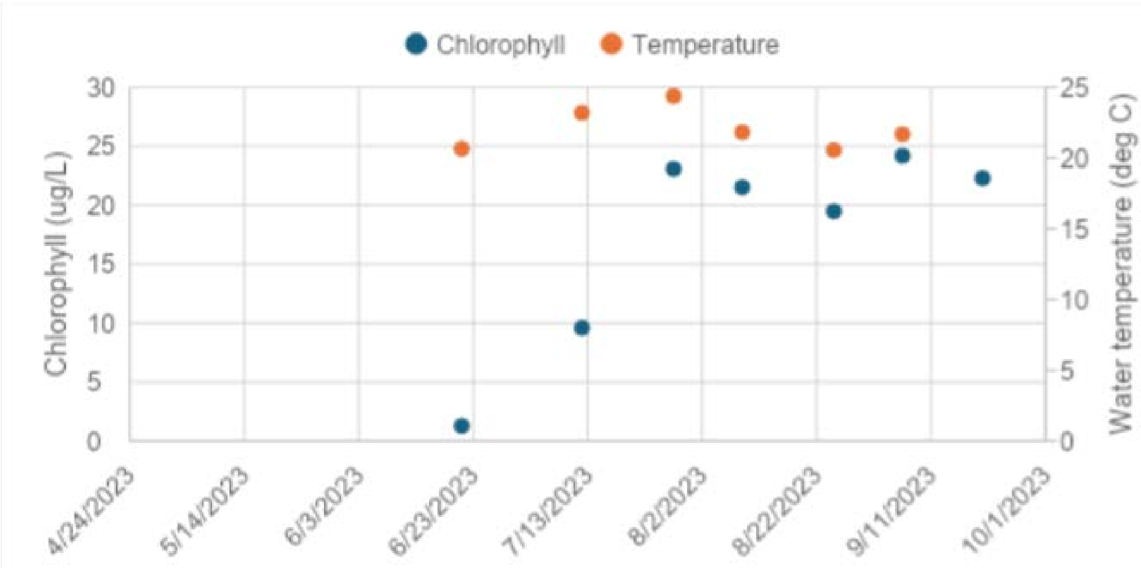
____

____

Michigan GLOS Data Analysis Independent Practice

Name ______________________________

Class Period ______________________________



1. Analyze the graph above and make 3 general statements regarding patterns, relationships or general trends. ______________________________

2. Use the graph above to make predictions about what the data might look like for the next two months. Give rough estimations of temperatures and chlorophyll levels and explain why you are predicting that. ______________________________

3. With your knowledge of Michigan's climate (seasons), how might your predictions be different from other people's that might not be familiar with the seasonal weather changes? ______________________________

4. Use your background knowledge to make a few predictions explaining why the initial sample (on 6/23) of chlorophyll concentration was so low. ______________________________

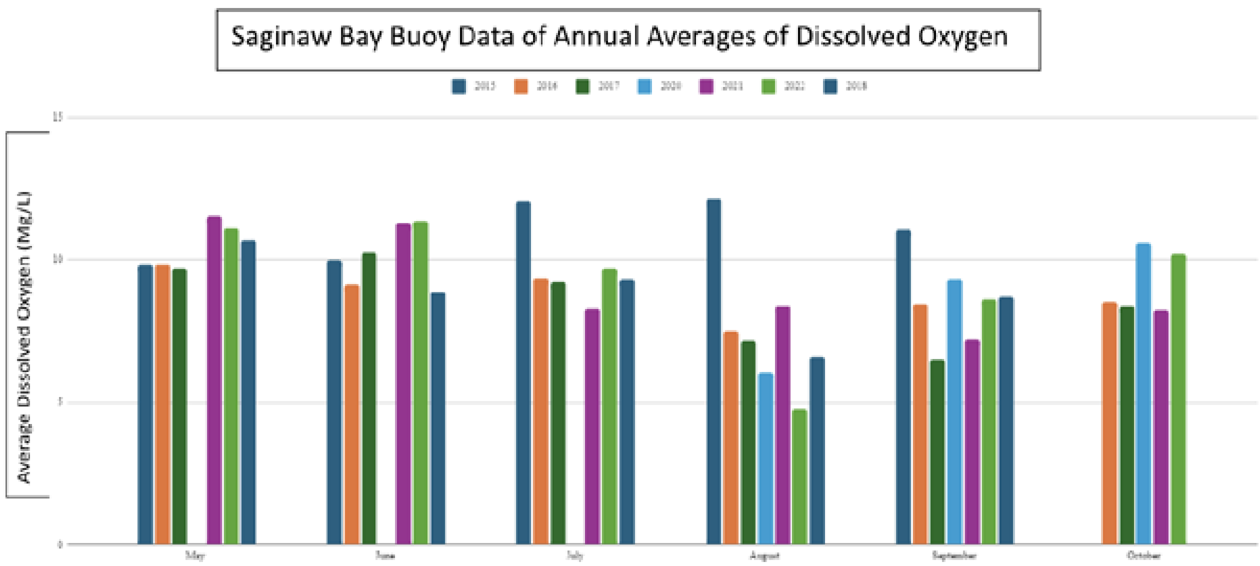
TEACHING GREAT LAKES LITERACY

Student Page

Michigan GLOS Data Analysis Independent Practice, page 2

5. Analyze the graph below and make 3 general statements regarding patterns, relationships or general trends. ____

____



6. Use the graph above to make predictions about what the data might look like for the next two months. Give rough estimations of temperatures and dissolved oxygen levels for each year and explain why you are predicting that.
7. Use the graph to find the annual mean of dissolved oxygen levels of two different years.
8. Pick a year and calculate the % change for each of the following months: June, July, August, September, October.

Month/Year	2015	2016	2017	2018	2020	2021	2022
June							
July							
August							
September							
October							

9. When answering questions 7 and 8, what challenges did you face? Why might a data table be more appropriate for calculating these figures? ____

____

____

____

Buoy is that water green! Exploration Two

1. Open the story map using this URL: https://storymaps.arcgis.com/stories/5fccdbf3a18145c69c2b2eaf41d2f0c1
   - Spend a few minutes exploring the story map and become familiar with the content and beautiful photo and video assets.
   - Keep the driving question of our lesson in mind as you explore the story map. How do our local land use practices impact life in the Great Lakes?
2. What is another name for blue-green algae? *[Cyanobacteria]*
3. If blue-green algae are a natural component of our lakes, rivers and ponds why are they so harmful? *[Some cyanobacteria can produce toxins, called cyanotoxins (cy·a·no·tox·ins), that can make people and animals sick.]*
4. What are HABs? *[When conditions are right, cyanobacteria organisms can rapidly increase to form cyanobacterial blooms—or Harmful Algal Blooms (HABs). These blooms can last a few days, weeks, or longer, and are considered harmful because they may contain cyanotoxins. A bloom can start out small, become very large in size, and may give off a bad odor.]*
5. Watch the video featuring Aaron Parker, Michigan Department of Environment, Great Lakes and Energy (EGLE)'s senior aquatic biologist. The video helps us with the identification of HABs.
   - View the images associated with the video.
   - Describe the "stick test" and how it is used. *[Wondering if it's a harmful algal bloom? Use the 'Stick Test'! Try to pick it up with a stick or a paddle: If you can pick it up then it's filamentous green algae and not capable of producing toxins.]*
6. Create a list of conditions that would enable a HAB to occur in a body of water. *[A bloom can form when the water temperature is warm, water is calm, and there is a high level of nutrients, like phosphorus or nitrogen. Invasive zebra and quagga mussels can also help make water conditions right for harmful algal blooms. They eat other algae suspended in the water, but release cyanobacteria back into the water.]*
7. How might nutrient levels in water increase? *[lawn and farm fertilizers, malfunctioning septic systems, animal manure, storm water runoff, sewage treatment plant discharges]*
8. How do invasive species make conditions more favorable for cyanobacteria? *[Invasive zebra and quagga mussels can also help make water conditions right for harmful algal blooms. They eat other algae suspended in the water, but release cyanobacteria back into the water.]*

9. Using the mapping tool developed by the Michigan Department of Health and Human Services (MDHHS), select three different sites on the map, each of a different color.

- Record the location of each site with latitude and longitude.
- Record the color displayed for each site.
- Provide a description of what the site color indicates for each location.
- Organize your response in a data table. Be sure to include headers for each column of your data table.
- Provide your data table a title that includes the year 2023

Harmful Algal Bloom Reports from 2023

Site Number	Location	Color	Description
Answers will vary.	Answers will vary.	Answers will vary.	Answers will vary.
Answers will vary.	Answers will vary.	Answers will vary.	Answers will vary.
Answers will vary.	Answers will vary.	Answers will vary.	Answers will vary.

10. Using the same mapping tool you used for the prompt above, toggle the button to show map data for 2022. Create a second data table with three sites. Try to select sites that are the same or close to the same as the sites you selected for 2023.

- Record the location of each site with latitude and longitude.
- Record the color displayed for each site.
- Provide a description of what the site color indicates for each location.
- Organize your response in a data table. Be sure to include headers for each column of your data table.
- Provide your data table a title that includes the year 2022

Harmful Algal Bloom Reports from 2022

Site Number	Location	Color	Description
Answers will vary.	Answers will vary.	Answers will vary.	Answers will vary.
Answers will vary.	Answers will vary.	Answers will vary.	Answers will vary.
Answers will vary.	Answers will vary.	Answers will vary.	Answers will vary.

Answer Key

Buoy is that water green! Exploration Two, page 3

11. Analyze your data tables.

- Were any of your sites coded as RED in both years? *[Answers will vary.]*
- If you answered yes to the above question, where is this location? *[Answers will vary.]*
- Does this make you wonder how the land is being used in this location? *[Answers will vary.]*
- Poke around on the 2023 and 2022 map to see if you can find RED locations for both years.

12. What symptoms might a human exhibit if they have been exposed to HAB toxins? *[Breathing in or swallowing water with harmful algal blooms and their toxins may cause runny eyes or nose, asthma-like symptoms, difficulty breathing, vomiting, diarrhea, weakness, numbness, headaches, or dizziness. Frequently swallowing or swallowing large amounts of cyanotoxins can harm the liver and kidneys. Skin contact may cause rashes, blisters, or hives.]*
13. What effects do exposure to HAB toxins have on our pets and livestock? *[Symptoms in animals can include: vomiting, diarrhea, fatigue, staggering, excessive drooling, and convulsions. Deaths can occur.]*
14. How do HABs impact aquatic ecosystems? *[Blooms can become so dense that they block sunlight from reaching other plants and animals in the lake. This can impact their survival. When a large bloom dies and begins to decay, oxygen can be heavily consumed by this process potentially suffocating fish and animals.]*
15. According to the story map, how can humans reduce nutrient levels in a water system? *[High levels of nutrients may come from agricultural fertilizer, lawn fertilizer, detergents, sewers, and malfunctioning septic systems. You can reduce nutrients by: using phosphate-free detergents, removing pet waste from lawns, applying fertilizers only when necessary, at the recommended amount, and leaving a buffer between lawns and the water's edge.]*
16. In the navigation pane at the top of the story map, locate the tab named " Prevention". In this section of the story map, scroll down to "Miscellaneous Prevention Steps". Four strategies for preventing the occurrence of harmful algal blooms are provided.

- Rewrite these strategies here, but write them in the order that you are most likely or most able to do.
- Provide one specific detail on how you might accomplish your first and second ranked strategy.
  - [Answers will vary.]. Detail [Answers will vary.]
  - [Answers will vary.]. Detail [Answers will vary.]
  - [Answers will vary.].
  - [Answers will vary.].

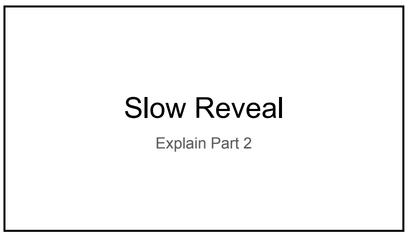
17. Take a look at the section of the story map that tells us what the state of Michigan is doing about HABs. Also look at the recommendations provided to YOU if you suspect a HAB has occurred in a local body of water. After thinking about these strategies and recommendations, design a public sign (much like the signs we see on our roads as we drive in traffic.) that provides a warning about a potential HAB in a local swimming or fishing lake. *[Answers will vary.]*

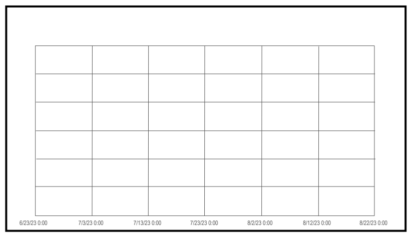
18. Once again, bring to mind our driving question: “How do our local land use practices impact life in the Great Lakes?” If you were, again, tasked with explaining this phenomenon to a group of citizens in your community would there be anything else you might include in your talk? *[Answers will vary.]*

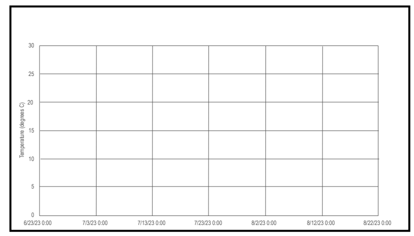
Slow Reveal Slides for Explain Part 2

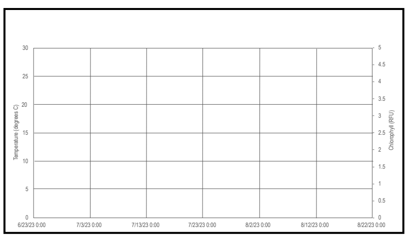
Download slide deck:

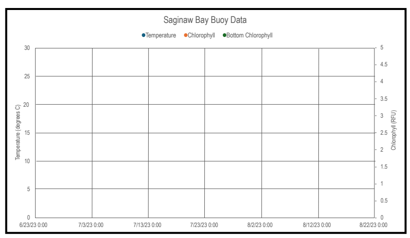
cgll.org/wp-content/uploads/2025/03/Slow-Reveal-Explain-Part-2.pdf

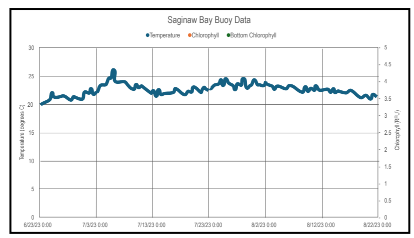


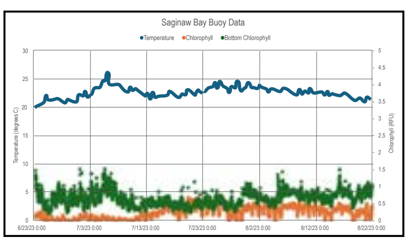






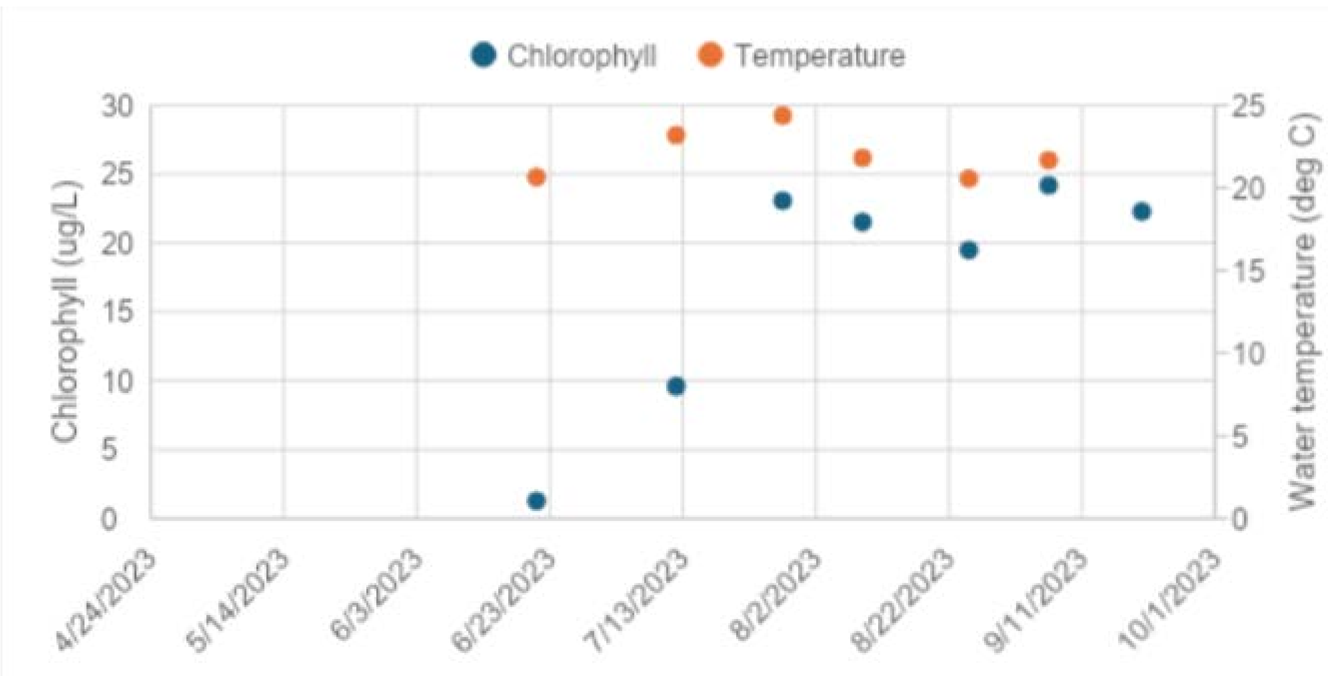






GLOS Graphical Analysis Group Activity

1. Talk with your group and record 2 or 3 patterns or trends you are seeing in the graph above. *[Answers may vary. Potential answers may include the following. As temperature increases in June and begins to stabilize, stable temperatures lead to chlorophyll spikes. Bottom chlorophyll is generally higher than surface chlorophyll.]*
2. Select an ambassador within your group and prepare to share-out one pattern or trend with the class.
3. After each group has shared their pattern or trend, let us examine our graphical data to determine if those patterns or trends stay true throughout the given season. If not, where do we notice any exceptions? *[Answers may vary. Potential answers may include the following. Temperature increases early, but then declines and stabilizes. A few dates in late July and early August show surface chlorophyll higher than bottom chlorophyll.]*



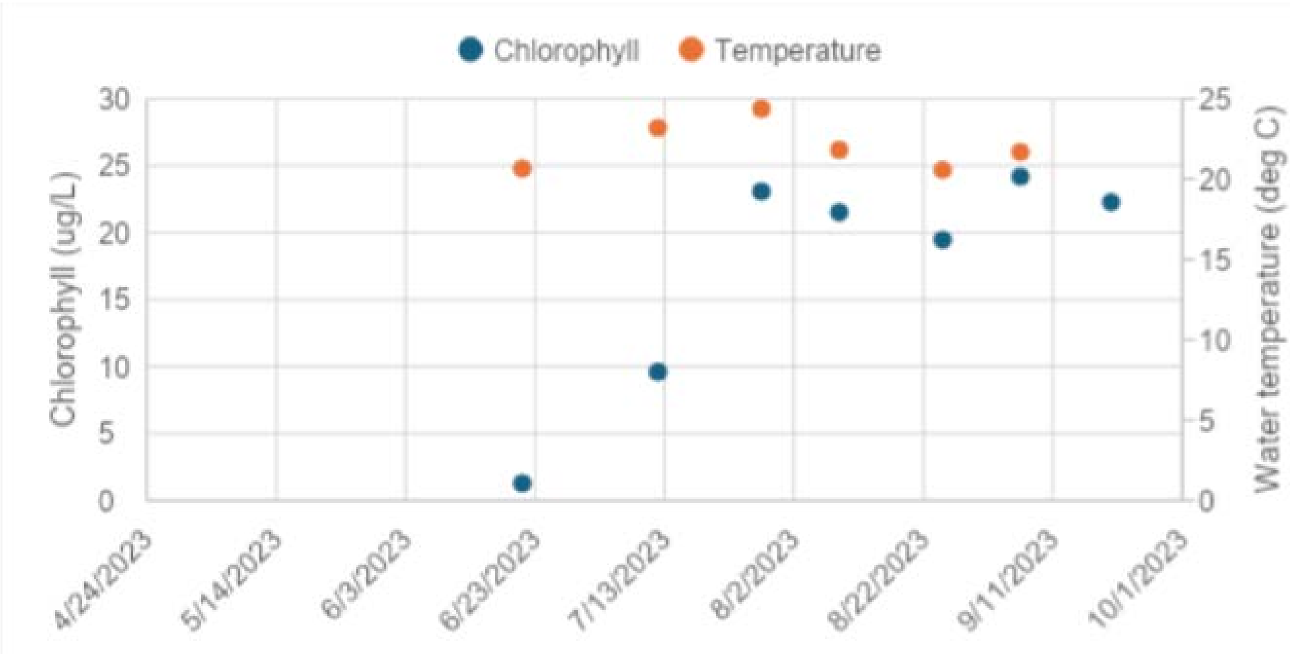
4. With your group, take a few minutes to study the parts of the graph above. Record 2 or 3 patterns or trends you are seeing in the graph. *[Provide students with time and assistance to understand this new graph. Answers may vary. Potential answers may include the following. Generally the surface dissolved oxygen is higher than the bottom dissolved oxygen. The surface dissolved oxygen is much more stable than the bottom dissolved oxygen which has a lot of variability. Around mid-July, the bottom dissolved oxygen is at a high point. During the first week of August, the bottom dissolved oxygen drops significantly. This may signal a hypoxic event. (hypoxia)]*

Answer Key

GLOS Graphical Analysis Group Activity, page 2

5. Prepare your group's ambassador to share-out one pattern or trend with the class.
6. After each group has shared their pattern or trend, let's examine our graphical data to determine if those patterns or trends stay true throughout the given season. If not, where do we notice any exceptions? *[Answers may vary. Potential answers may include the following. Surface dissolved oxygen is higher than bottom dissolved oxygen except in mid-July. Surface dissolved oxygen is relatively stable, but shows more variation in late July and August.]*
7. Examine the graphical data for the second half of July. With your group, make a scientific claim describing the change in surface and bottom dissolved oxygen. *[Students should describe the fact that surface dissolved oxygen stabilizes with only minor fluctuations. Students could also point out that the bottom dissolved oxygen shows large fluctuations indicating a hypoxic event is occurring when the dissolved oxygen reaches less than 2-3 mg/L.]*
8. Using both graphs to guide your thinking, work with your group to determine why this change is happening. Guesses are encouraged. *[If students focus on surface dissolved oxygen, they may discuss the stability in temperature at the surface and/or the photosynthetic activity creating the stable levels. If students focus on bottom dissolved oxygen, they may discuss stratification and / or microbial decomposition consuming oxygen in the deeper waters.]*
9. Next, examine the first ten days of August. What do you notice is happening? *[The major event happening here is the sharp decline in bottom dissolved oxygen. This appears to indicate a hypoxic event occurring.]*
10. How might the organisms living deeper in the Saginaw Bay be impacted by the phenomenon occurring in the first ten days of August? *[Answers may vary. Potential answers may include the following. Stress and reduced metabolic function which reduces growth and reproduction. Avoidance and displacement as mobile organisms leave. Mass mortality and possible food web disruptions.]*

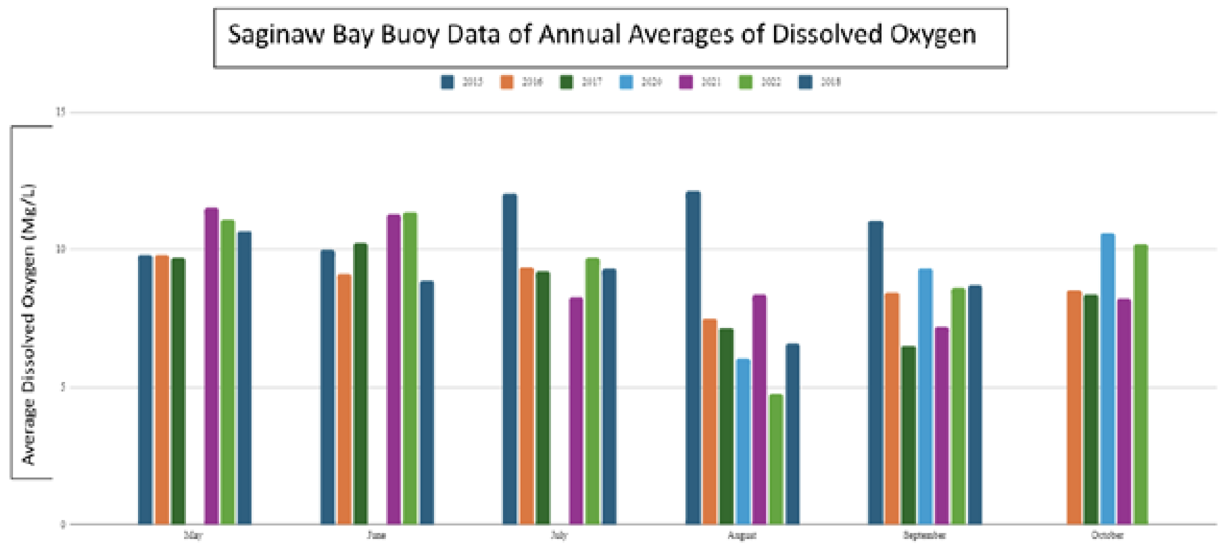
Michigan GLOS Data Analysis Independent Practice



1. Analyze the graph above and make 3 general statements regarding patterns, relationships or general trends. *[Answers may vary. Potential answers may include the following. The lowest temperature and chlorophyll occur in the first data point near the end of June. Chlorophyll levels mirror temperature changes. Temperatures peak near the end of July.]*
2. Use the graph above to make predictions about what the data might look like for the next two months. Give rough estimations of temperatures and chlorophyll levels and explain why you are predicting that. *[Answers may vary. Potential answers may include the following. A steady decline in temperatures and chlorophyll levels. Some students may note a daylight decrease as time goes on impacting chlorophyll levels as well.]*
3. With your knowledge of Michigan's climate (seasons), how might your predictions be different from other people's that might not be familiar with the seasonal weather changes? *[Students unfamiliar with Michigan's climate may have to research average temperatures in the fall months. Also the change in daylight exposure in the upper northern hemisphere may not be familiar to someone living closer to the equator.]*
4. Use your background knowledge to make a few predictions explaining why the initial sample (on 6/23) of chlorophyll concentration was so low. *[Answers may vary. Potential answers may include the following. A lack of nutrient availability in the early spring months as well as lower water temperatures. Students with more indepth background and knowledge may discuss stratification of the water with colder water near the bottom and warmer water near the surface. Also some students may respond with information about zooplankton consuming the phytoplankton (algae). As the zooplankton numbers increase it will cause the algae population to decrease.]*

Answer Key

Michigan GLOS Data Analysis Independent Practice, page 2



5. Analyze the graph above and make 3 general statements regarding patterns, relationships or general trends. *[Answers may vary. Potential answers may include the following. Students may discuss the general decline in oxygen levels as each year progresses, usually seeing decreases in August and September. Students may discuss that generally May-July show the highest oxygen levels. Students may indicate the distinct differences from one year to the next. They may notice that in the month of October levels usually level out.]*
6. Use the graph above to make predictions about what the data might look like for the next two months. Give rough estimations of temperatures and dissolved oxygen levels for each year and explain why you are predicting that. *[Answers may vary. Potential answers may include the following. Since we see a leveling out (recovery) of oxygen levels in October, we could predict November and December would yield similar results. Since colder water is able to hold more oxygen, the colder months may allow the oxygen levels to increase.]*
7. Use the graph to find the annual mean of dissolved oxygen levels of two different years. *[Because exact values are not given, the following answers are estimations. It is advised to give your students a range of acceptable answers or agree on exact values for each value displayed for each bar on the graph.]*

- 2015: ~ 10.8 mg/L
- 2016: ~9.5 mg/L
- 2017: ~9.8 mg/L
- 2018: ~10.2 mg/L
- 2020: ~8.6 mg/L
- 2021: ~9.0 mg/L
- 2022: ~8.3 mg/L

Answer Key

Michigan GLOS Data Analysis Independent Practice, page 3

8. Pick a year and calculate the % change for each of the following months: June, July, August, September, October. *[These values would also be based on visual estimations, so an acceptable range should be used.]*

Month/Year	2015	2016	2017	2018	2020	2021	2022
June	*5%*	*-10%*	*5%*	*2%*	*-12%*	*8%*	*3%*
July	*10%*	*-5%*	*-8%*	*8%*	*15%*	*-10%*	*-5%*
August	*-25%*	*-15%*	*-20%*	*-30%*	*-40%*	*-12%*	*-35%*
September	*-10%*	*10%*	*-10%*	*5%*	*15%*	*-5%*	*20%*
October	*12%*	*5%*	*8%*	*10%*	*10%*	*7%*	*5%*

(New Value-Old Value / Old Value x 100)

9. When answering questions 7 and 8, what challenges did you face? Why might a data table be more appropriate for calculating these figures? *[Answers may vary. Potential answers may include the following. Students may discuss issues with exact vs. estimated values. Consistency and precision may become concerns without exact values.]*

cgll.org

Lesson Disclaimer

This lesson has been reviewed for content and accessibility by the Center for Great Lakes Literacy.

Teaching Great Lakes Literacy is a Center for Great Lakes Literacy capstone project supported by Michigan Sea Grant, Michigan State University Extension, Great Lakes Fishery Trust, MiSTEM Network, and the Great Lakes Restoration Initiative.

Michigan Sea Grant helps to foster economic growth and protect Michigan's coastal, Great Lakes resources through education, research and outreach. A collaborative effort of the University of Michigan and Michigan State University and its MSU Extension, Michigan Sea Grant is part of the NOAA-National Sea Grant network of 34 university-based programs.

This article was prepared by Michigan Sea Grant under award NA22OAR4170084 from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce through the Regents of the University of Michigan. The statement, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of the National Oceanic and Atmospheric Administration, the Department of Commerce, or the Regents of the University of Michigan.

MICHU-25-801