An Exploration of Threats to the Great Lakes

An introduction to the science & study of the Great Lakes

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- Saga Educators, Inc. -

A Collection of Lesson Plans from

Detroit Public TV | GREAT LAKES NOW

Overview of the Collection

"Great Lakes Now: An Exploration of Threats to the Great Lakes" is an introduction to the natural threats to and human impact upon, the Great Lakes. This collection of lessons — the second volume — aims to build on prior knowledge introduced to students in the first volume pertaining to basic scientific and geographic concepts about the Great Lakes but focusing how manmade and naturally occurring conditions threaten aspects of the world's largest supply of surface freshwater.

There are 11 lessons in this collection, each aligned to the Next Generation Science Standards and either Common Core standards, Earth Science or SEP standards. The lessons feature a number of interactive and hands-on activities for students to explore topics ranging from invasive species and algae to climate change and pollution. Beyond the specific look at some of the harm to the Great Lakes environment, this lesson collection gives special attention to potential solutions to the problems threatening the Great Lakes and explores some of the restorative measures being taken on some of the issues. Through the activities and lessons, students are introduced to ways that they can adjust their own behavior, or raise the awareness of those around them in their lives, to positively impact the Great Lakes and work to mitigate the effects of some of the threats.

The 11 lessons from this collection can be taught individually or sequenced together as a larger unit on modern threats facing the Great Lakes. Embedded throughout the collection are links to videos produced by Detroit Public Television and Great Lakes Now, as well as a range of other resources from PBS that support citizen science and encourage exploration.

About Great Lakes Now

Housed at Detroit Public Television, Great Lakes Now is a unique international multimedia initiative that is building a collaborative partner network of PBS-affiliate stations and other media outlets to provide audiences news and information about the Great Lakes and water quality. Work appears on multiple platforms including TV, web, social media, in-person events and other kinds of audience engagement.

1. Dear Great Lakes

Overview and Purpose

To introduce students to the impacts of rising water levels and the particular effect they can have on coastal areas of the Great Lakes through making connections to the coastal flooding occurring on a Pacific island.

Lesson Summary

Students will be introduced to the threat of coastal flooding that faces the Great Lakes and many other coastal areas in the world due to climate change.

In order to understand some of the impact flooding has on the Great Lakes, both positive and negative, students will explore videos from Great Lakes Now about the impact of high lake levels in 2019 and 2020. They will learn more about the magnitude of long-term coastal flooding due to high water levels by exploring the stories of three children in a Frontline documentary about the Marshall Islands. Finally, they will integrate their knowledge of the situation in each of these videos by writing letters from the Marshall Islands to the Great Lakes.

By understanding the impact of long-term coastal flooding on a Pacific island and the short-term effects of high lake levels in the Great Lakes and coastal erosion, students will begin to understand the implications of increasing water levels in the Great Lakes over time.

The background context that is needed for this lesson is for students to know the basic geography of the Great Lakes and the Marshall Islands, the water cycle and how to write a standard letter.

This lesson focuses on writing, making connections between parallel situations, and productive student-to-student discourse and scaffolds students to clarify their own thinking, listen to others, deepen their understanding and think together with classmates. As they complete this lesson, they will become familiar with the reality of one of the major contemporary threats to the Great Lakes region: fluctuations in water level.

ESSENTIAL THEMES	● Lake Levels, Coastal Flooding, Water Cycle

NEXT GENERATION SCIENCE STANDARDS	➔ HS-ESS2.D.4: Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. See More HS-ESS2.D.4 Resources ➔ SEP8: Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings.
OBJECTIVES	❑ Know the significance and impact of changing lake levels on coastal areas ❑ Engage in productive academic talk with others ❑ Write a persuasive letter to communicate a claim with evidence and reasoning
ESTIMATED TIME	❖ **2-3 class periods**

Materials Needed

- Video projection monitor or screen/speakers
- Internet access
- Computers or mobile devices (e.g., tablets, cellphones)
- Notebooks and pencils
- Chart paper or a dry erase board and markers

Facilitation Steps

WARM UP: Begin by asking students to call to mind what they already know about the essential themes of the lesson and what they wonder about it. Have them turn and talk with a partner. Then, after a minute of conversation, elicit responses from a couple of volunteers and jot down 2-3 ideas on the board under the categories KNOW and WONDER. The teacher should help students clarify their ideas as they are shared by checking for understanding using a talk move such as “so you are saying…” or help students think together by asking for a show of hands of agreement from the class in response to what individual students share.

LAUNCH: Once the warm up has concluded, give a brief overview of the background context to students, making connections to their KNOW and WONDER responses as well as any other relevant prior knowledge they would have from other lessons they have learned. Describe the activities planned for this lesson to students.

ACTIVITY 1: Lakes Overflowing

First, show this interactive graphic showing the change in water level by the Big Sable Point Lighthouse to the class. A teacher or student can drag the slider from one side of the image to the other to show the difference in water levels and how they have affected the shoreline. Continue on by asking for a show of hands of how many students have personally experienced a high water level in a lake (or other body of water, e.g., river) before. Follow up the show of hands by having 1-2 students briefly share with the class what their experience was. Transition from their share out to explain to students that they will be learning about the unusually high lake levels in the Great Lakes Basin during 2019 through three video segments from Great Lakes Now.

Next, proceed to the first clip by having someone read the introductory overview about the receding shorelines of Michigan's Lower Peninsula's Northwestern Coast to the class and prepare to show the video segment. Ask students to write down one thing that they predict will be impacted by rising lake levels. Show students the video segment entitled Vanishing Shorelines. Immediately transition to read the introductory overview from the Rising Waters article to the class and prepare to show the next video segment. Ask students to write down one thing that they predict will be impacted by rising lake levels. Show students the video segment entitled Lake Levels.

Then, ask the class to raise their hands if what they predicted was confirmed by what they saw in the video. Transition to the second video by reading the introductory overview from the In the Waters article to the class and then prepare to show the video segment. Ask students to write down one thing that they predict will be impacted by rising lake levels. Show students the video segment entitled Lake Ontario Shoreline Flooding. After the video finishes, ask the class to raise their hands if what they predicted was confirmed by what they saw in the video.

Last, have students collaborate in groups of four to list as many things as they learned from the video are impacted by rising lake levels — positive or negative — and put a check mark next to anything on their list that their group members predicted before the video. Have one group share their list with the whole class, and ask for a show of hands as to which list items matched those that other groups had.

Wrap up this activity by looking at current lake levels in the Great Lakes here with the entire class and ask a few volunteers to share what about the levels seems most unexpected to them and why.

ACTIVITY 2: The Last Generation

First, explain to students that they are going to be viewing a documentary, which follows three children through the impact of rising waters on their Pacific Island, and then creating letters from the children in the Marshall Islands to one of the Great Lakes cities featured in the videos that was affected by coastal flooding. Let students know that you will be watching the introduction to the documentary as a class and then breaking off into groups to watch the segments on each child: Izerman, Julia, and Wilmer. This video will provide some basic information to them about the impacts of, and potential solutions to, coastal flooding due to rising water levels from the perspectives of children, and it may address some of their KNOWS/WONDERS from the warm up.

Introduce students to the 4 Notes Summary protocol that they will use after their group finishes the entire documentary, where they write one of each of the following:

- Oooh! (something that was interesting)
- Aaah! (something that was an ah-ha moment)
- Hmmm... (something that left them thinking afterward)
- Huh? (a question they have afterward)

Ask students to give an example of each type of note that they will be making to check for understanding.

Next, view the introduction section of the Last Generation documentary from Frontline to the whole class.

Then, after the introduction, have students independently explore the remaining three segments about each child's story in groups of four—watching the video segments and reading the pop-up information that appears in between segments. Each student should record in their notebooks a 4 Notes Summary after they complete the documentary.

Last, have groups discuss their takeaways from the video using the Conversation Roundtable protocol. In this protocol, students take turns sharing what they wrote for their individual responses to the 4 Notes Summary with their group while each student writes down what they heard the speaker say. Then, each student writes their own "sum it up" statement of their group members' responses.

ACTIVITY 3: To the Great Lakes, From the Marshall Islands

First, have a whole-class share out from the conversation roundtable. Do this by choosing a few students to share aloud with the whole class their "sum it up" statements from the conversation roundtable in their group. After each, ask all students to raise hands if what was just shared matches something that came up in their group discussion as well.

Next, tell students to recall the stories of each child they learned about in the documentary and that they will be creating a letter about one of the children's individual perspectives on flooding. To assign groups to write about each child's perspective, number off the groups from 1 to 3 (Group 1 will be writing about the perspective of Izerman, Group 2 about Julia's point of view, and Group 3 about the viewpoint of Wilmer.) Assign half of the groups to make connections between the Marshall Islands and Chicago, IL and the other groups to focus on Sodus Bay, NY. Have each group nominate a recorder (someone who will write down what everyone says) and a reporter (someone who will read the finished letter aloud) in their group.

**Optionally, if the issue of coastal flooding affects your school community directly, consider having students write their letters to local leaders in your area and actually send them in to those leaders. You might just get a response!*

Then, give students time to work with their group to write up a one-page letter about their respective child from the documentary to either the Mayor of Chicago, IL (featured in segment one video) or the Mayor of Sodus Bay, NY (featured in segment two video) addressing the high lake levels, as depicted in the Great Lakes Now video segments.

To help them begin writing their letters, give them a few starter prompts to help them begin their collaboration on writing the letters, such as:

- How would you explain who the children are and why their opinion matters to this issue?
- How would the child respond to the high lake levels situation based on what you know of him or her?
- How would his or her experience in the Marshall Islands be relatable to the situation in Chicago or Sodus Bay (or your local community)?
- What solutions might be considered or suggested in the letter?

Last, give each group the opportunity to have their designated reporter read their group's letter aloud to the class.

**Share what students create with Great Lakes Now by emailing their letters to gln@dptv.org or by posting them on Facebook or Twitter with @GreatLakesNow! And if you get a response from your letters, you can share that as well.*

SYNTHESIS: Give students individual thinking and writing time in their notebooks to synthesize their learning by jotting down their own reflections using a Word, Phrase, Sentence protocol, with:

- A **word** that they thought was most important from the lesson
- A **phrase** that they would like to remember
- A **sentence** that sums up what they learned in the lesson

After the individual synthesis is complete, students should share their synthesis with a shoulder partner.

COOL DOWN: Have students complete a 3, 2, 1 Review protocol for the lesson with a partner, recording in their notebooks or, optionally, on exit ticket slips to submit, the following:

- **3** things that they liked or learned
- **2** things that make more sense now
- **1** question that they were left with

CLOSURE: Have one student share a response from each of the categories of the 3, 2, 1 Review. Depending on the available time, the teacher can make connections between the ideas students share and the learning objectives of the lesson, and respond to the question that is shared.

EXIT TICKET: Students vote for their favorite letter and give a brief explanation of their choice.

About the Author

Gary is an educational consultant, award-winning science educator and the author of *Science With Scarlett*. He is also a double cornea transplant recipient who, since having his sight restored, was moved to use his teaching gifts to make science fun for kids. He lives with his family near Detroit and designs learning experiences to inspire children, like his own daughter, to love science. Gary is the 2014 recipient of the Michigan Teacher of the Year honor. Contact him via his consulting firm, Saga Educators, or connect with him on Twitter.

About Great Lakes Now

With a monthly magazine-style television program and daily online reports at GreatLakesNow.org, the ***Great Lakes Now*** initiative offers in-depth coverage of news, issues, events and developments affecting the lakes and the communities that depend on them, while capturing the character and culture of the region.

2. What's Greenland Got to Do With the Great Lakes?

Overview and Purpose

To understand and visualize how rising sea levels due to glacial melt from climate change could impact the Great Lakes.

Lesson Summary

Students deepen their knowledge of the impact that climate change and rising water levels can have on the Great Lakes. The focus here is to connect melting glaciers and sea level rise to the volume of water in the Great Lakes.

What does the rise of sea levels have to do with the Great Lakes? If students understand the geographical features of the Great Lakes waterways and how they connect to the Atlantic Ocean, students can begin to see how a melting glacier near Greenland can have an effect on the water levels in the Great Lakes, because the Great Lakes eventually empty out into the Atlantic through the St. Lawrence Seaway.

The goal in this lesson is for students to visualize, through storyboarding, how melting ice from glaciers in the Atlantic ocean will ultimately equilibrate into connected waterways, impacting Great Lakes shorelines a great distance away.

They will learn about glacial melt, and even how unmelted icebergs affect sea level, in Greenland through a 360° Frontline documentary and then storyboard how that would ultimately impact different areas of the Great Lakes region.

The background context that is needed for this lesson is for students to know the names of the Great Lakes and have been introduced to the geography of Great Lakes waterways to know how they are connected. Students also need to know how to make a storyboard.

This lesson focuses on students comparing and connecting knowledge of two distinct topics and integrating that knowledge together with classmates to visually represent their thinking.

ESSENTIAL THEMES	● Geographic features of the Great Lakes waterways and Greenland ● Glacier composition and melt due to climate change
NEXT GENERATION SCIENCE STANDARDS	➔ MS-ESS3.A.1: Describe and graph the amounts of saltwater and fresh water in various reservoirs to provide evidence about the distribution of water on Earth. ➔ 5-ESS2-2 Describe and graph the amounts and percentages of water and fresh water in the Great Lakes to provide evidence about the distribution of water on Earth. ➔ SEP8: Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings.
OBJECTIVES	❑ Be able to explain how glaciers in far-away Greenland can affect the shorelines of the Great Lakes ❑ Create a storyboard that visually represents the impact of glacial disappearance on Great Lakes water levels
ESTIMATED TIME	❖ **1-2 class periods**

Materials Needed

- Video projection monitor or screen/speakers
- Internet access
- Computers or mobile devices (e.g., tablets, cellphones)
- Notebooks and pencils
- Chart paper or a dry erase board and markers

Facilitation Steps

WARM UP: Begin by asking students what they already know about the essential themes of the lesson and what they wonder about it. Have them turn and talk with a shoulder partner. Then, after a minute of conversation, elicit responses from a couple of volunteers and jot down 2-3 ideas on the board under the categories KNOW and WONDER. The teacher should help students clarify their ideas as they are shared by checking for understanding using a talk move such as “so you are saying…” or help students think together by asking for a show of hands of agreement from the class in response to what individual students share.

LAUNCH: Once the warm up has concluded, give a brief overview of the background context to students, making connections to their KNOW and WONDER responses as well as any other

relevant prior knowledge they would have from other lessons they have learned. Describe the activities planned for this lesson to students.

ACTIVITY 1: Greenland Is Melting

First, show the class a map of Greenland and explain to students that they are going to be viewing an interactive 360° documentary, which flies over Greenland to explore the glacial melt and iceberg movement happening in that region of the Atlantic Ocean. They will be able to use the arrows on the video to see in all directions while the video is playing. Inform them that certain locations on the video have text embedded in them for more information—this is a form of augmented reality. This video will provide some basic information to them about the disappearance of Greenland glacier ice and it may address some of their KNOWS/WONDERS from the warm up.

Introduce students to the 4 Notes Summary protocol that they will use after they finish watching the 360° video about Greenland, where they write one of each of the following:

- Oooh! (something that was interesting)
- Aaah! (something that was an ah-ha moment)
- Hmmm... (something that left them thinking afterward)
- Huh? (a question they have afterward)

Ask students to give an example of each type of note that they will be making to check for understanding.

Next, have students partner up and view the Why is Greenland Melting? 360° video from Frontline.

Then, after they finish the video, each student should record in their notebooks a 4 Notes Summary after they complete the documentary.

Last, have partners discuss their takeaways from the video, taking turns sharing what they wrote for their individual responses to the 4 Notes Summary with their partner. Ask for a few volunteers to share with the whole class what they heard their partner say in the discussion.

ACTIVITY 2: Storyboard the Impact of Melting Glaciers

First, ask students to think to themselves about how the glacial melting in Greenland might affect the Great Lakes. After giving a minute of think time, inform students that they and their partners will be cooperating to make a storyboard that will visualize what exactly the melting in Greenland has to do with the Great Lakes.

Teacher Tip: If students are unfamiliar with storyboards, you can utilize this resource on How to Create Storyboards to help introduce the method to your class.

Next, give students a chance to explore what the geography looks like for these seemingly unconnected areas of the world. Utilize this international resource about the St. Lawrence Seaway to do so and give students time to check it out.

Then, allow students time to create their storyboards to tell how the melting in Greenland would ultimately affect the shorelines of each of the five Great Lakes. You may optionally choose to set parameters on their storyboards, e.g., what needs to be included and how many steps need to be included in the visualization. The only must do aspects of storyboards are that they contain visuals and text to represent each step in the process of what's being represented.

Last, give students the opportunity to meet up with other partnerships to present their storyboards to one another and discuss similarities and differences between how they represented the connection between Greenland and the Great Lakes.

[OPTIONAL] ACTIVITY 3: An Enrichment Experience With Greenland

This activity is completely optional and can be used as an extension to enrich the learning about how climate change is affecting the Arctic and will ultimately affect connected waterways such as the Great Lakes.

Remind students about the 4 Notes Summary protocol that they used previously, and inform them that they will use that protocol again after they finish watching the expedition video about Greenland. Again, they write one of each of the following:

- Oooh! (something that was interesting)
- Aaah! (something that was an ah-ha moment)
- Hmmm... (something that left them thinking afterward)
- Huh? (a question they have afterward)

Next, show the video Greenland—Frozen Frontier from PBS to the entire class.

Then, after they finish the video, each student should record in their notebooks a 4 Notes Summary after they complete the documentary.

Last, have partners discuss their takeaways from the video, taking turns sharing what they wrote for their individual responses to the 4 Notes Summary with their partner. Ask for a few volunteers to share with the whole class what they heard their partner say in the discussion. Wrap up the activity by asking students to sum up how this Greenland expedition video relates to the Great

Lakes. Have them turn and talk with their partners before choosing a couple of volunteers to share their responses with the class.

SYNTHESIS: Give students individual thinking and writing time in their notebooks to synthesize their learning by jotting down their own reflections using a Word, Phrase, Sentence protocol, with:

- A **word** that they thought was most important from the lesson
- A **phrase** that they would like to remember
- A **sentence** that sums up what they learned in the lesson

After the individual synthesis is complete, students should share their synthesis with a shoulder partner.

COOL DOWN: Have students complete a 3, 2, 1 Review protocol for the lesson with a partner, recording in their notebooks or, optionally, on exit ticket slips to submit, the following:

- **3** things that they liked or learned
- **2** things that make more sense now
- **1** question that they were left with

CLOSURE: Have one student share a response from each of the categories of the 3, 2, 1 Review. Depending on the available time, the teacher can make connections between the ideas students share and the learning objectives of the lesson, and respond to the question that is shared.

EXIT TICKET: Students identify which of the Great Lakes they would expect to be most impacted by glacial melting in Greenland based on the storyboards and explain why.

About the Author

Gary is an educational consultant, award-winning science educator and the author of *Science With Scarlett*. He is also a double cornea transplant recipient who, since having his sight restored, was moved to use his teaching gifts to make science fun for kids. He lives with his family near Detroit and designs learning experiences to inspire children, like his own daughter, to love science. Gary is the 2014 recipient of the Michigan Teacher of the Year honor. Contact him via his consulting firm, Saga Educators, or connect with him on Twitter.

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3. Fish Population Dynamics

Overview and Purpose

To understand how the populations of a predator and prey fish species relate to one another, as well as to describe the impact that external factors may play in the population dynamics between aquatic species in the Great Lakes.

Lesson Summary

Students will model how the population of two freshwater fish species change over time and depend on one another.

The background context that is needed for this lesson is for students to know the food chains and food webs. An optional activity to first acquaint students with this concept in the context of the Great Lakes can be found here from Michigan Sea Grant. Students also need to know how to collect data in a data table and construct a line graph from a data table.

This lesson focuses on developing and using models to explain or predict phenomena that may be difficult to directly observe.

ESSENTIAL THEMES	● Predator-Prey Relationships ● Population Dynamics ● The influence of environmental changes to populations
NEXT GENERATION SCIENCE STANDARDS	➔ MS-LS2-1 Ecosystems: Interactions, Energy and Dynamics. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. ➔ MS-LS2-2 Ecosystems: Interactions, Energy and Dynamics. Construct an explanation about how the different parts of the food chain are dependent on each other. ➔ MS-LS2-3 Ecosystems: Interactions, Energy and Dynamics. Develop a model to describe the cycling of matter and flow of energy among living parts of the food chain. ➔ MS-LS2-4 Ecosystems: Interactions, Energy and Dynamics. Construct an argument, supported by evidence gathered through observation and experience, showing how changes to physical or biological components of an ecosystem affect populations. Ecosystems are dynamic in nature; their

	characteristics can vary over time. Disruptions to any physical or biological components of an ecosystem can lead to shifts in all its populations. ➔ MS-LS2-5 Ecosystems: Interactions, Energy and Dynamics. Evaluate competing design solutions for maintaining biodiversity and ecosystem services. ➔ MS-ESS3-3 Earth and Human Activity. Answer questions about how pollution affects food chains by applying scientific principles to design a monitoring plan for minimizing the human impact on the environment. ➔ SEP3: Develop and/or use a model to predict and/or describe phenomena.
OBJECTIVES	❑ Develop and use a model to analyze the relationship between populations of a predator and prey ❑ Understand the impact of external factors on the population of species in an ecosystem
ESTIMATED TIME	❖ **2 class periods**

Materials Needed

- Video projection monitor or screen/speakers
- Internet access via computers or mobile devices (e.g., tablets, cellphones)
- Notebooks and pencils
- Chart paper or a dry erase board and markers
- Flat surface, 12″ × 12″ square made from masking tape
- 300 yellow perch cards per group (tip: laminate or print on cardstock before cutting out)
- Paper cutter or scissors
- Colored tape or masking tape
- 4 walleye cards per group (represents an adult walleye)
- Population data table

Facilitation Steps

WARM UP: Begin by asking students what they already know about the essential themes of the lesson and what they wonder about it. Have them turn and talk with a shoulder partner. Then, after a minute of conversation, elicit responses from a couple of volunteers and jot down 2-3 ideas on the board under the categories KNOW and WONDER. The teacher should help students clarify their ideas as they are shared by checking for understanding using a talk move such as "so you are saying..." or help students think together by asking for a show of hands of agreement from the class in response to what individual students share.

LAUNCH: Once the warm up has concluded, give a brief overview of the background context to students, making connections to their KNOW and WONDER responses as well as any other relevant prior knowledge they would have from other lessons they have learned. Describe the activities planned for this lesson to students.

ACTIVITY 1: Introduction to Freshwater Fish Populations

First, share with students that in this lesson they will be examining the relationship between certain species in order to learn about a phenomenon that affects all species in an ecosystem: population dynamics. Take a moment to create an operational definition of the term "population dynamics" with students, and then inform them that they will be exploring population dynamics with a predator species and prey species of fish.

Next, show the class this video clip from Great Lakes Now about Native Species of Fish in the Great Lakes from 25 Days of Fishmas. Ask them to focus on how many different native species of fish are shown in the video.

Then, distribute copies of (or direct students to view online) the article from Michigan Sea Grant about the Decline in Prey Fish. Have students take turns reading each paragraph aloud.

Last, ask four student volunteers to share one response each to one of the 4 Notes Summary protocol prompts about the article they just read, where they share one of each of the following:

- Oooh! (something that was interesting)
- Aaah! (something that was an ah-ha moment)
- Hmmm... (something that left them thinking afterward)
- Huh? (a question they have afterward)

ACTIVITY 2: Walleye and Perch Population Dynamics [Simulation]

First, have students get into groups of four and distribute materials for the activity to each group:

- masking tape,
- rulers,
- activity cards for the predator and prey, and
- copies of the data table (duplicate the data table to be two-sided so students can record up to 24 generations of data total).

Have students create a 12” by 12” square area with masking tape, on a tabletop surface or on the floor. Explain that they will be doing a predator-prey simulation of freshwater fish species using the cards in an aquatic ecosystem represented by the square area. Describe to students that walleye feed on smaller fish, such as yellow perch. While it may consume other species in nature, for the purpose of this activity we will consider only the relationship between the walleye as predator and the yellow perch as prey by assuming the yellow perch as the primary food source for walleye. In other words, if there are no yellow perch, the walleye go hungry.

Next, explain the rules of the simulation activity and demonstrate how it works with one group to the whole class:

1. Each group should begin with three yellow perch distributed throughout the square area. They will record this for the first generation on their data table.
2. Group members should take turns tossing each walleye card into the area once.
3. If the walleye card lands touching a perch card, the walleye has caught its prey, and that perch is gone from the population. If a perch is untouched by a walleye, it survives.
4. After each toss of the walleye card, remove it (and any caught perch) before the next is thrown.
5. In order to survive and have offspring, a walleye must catch three perch, or it dies.
6. Walleye offspring are added by tossing the card an additional time for each new walleye. Remember that for every three perch a walleye catches, a new walleye is added to the population. That means if a walleye catches eight perch, it survives and has two offspring that all enter the next generation.
7. In order to survive, a perch must avoid being eaten by all the walleye in a generation.
8. The surviving perch population doubles each generation (add additional perch cards before the start of the next generation to the area to show this.)
9. If no walleye survived the previous generation, another swims into the area; if no perch survive, three new perch mature and enter into the area in the next generation.

10. Be careful to track and record the number of each population over the course of the generations. Carry out the simulation to about 20 or so generations, as time allows.

Then, allow students time to conduct the simulation of the predator-prey population dynamics and record their data in the data table. Monitor the groups as the progress through the activity and ask critical thinking questions to groups based on what you observe of their progress.

Last, after groups have completed the simulation and have their data table completed, give them time to graph the predator and prey population data (in different colors on the same graph) on a large whiteboard or chart paper. Have each group include with their graph a couple of statements summarizing their data or drawing conclusions about the simulation.

Fish Population Data Table

Generation Number	Starting Number of Walleye (Total)	Starting Number of Perch (Total)	Total of Perch Eaten	Perch Survived	Walleye Starved to Death	Walleye Survived	Walleye Offspring Produced	Starting Ratio of Walleye to Perch (W/P)

Fish Population Activity Cards Template: *Before cutting out the fish, make 15 copies of this sheet for each group doing the activity, giving them 300 yellow perch and four walleye cards.

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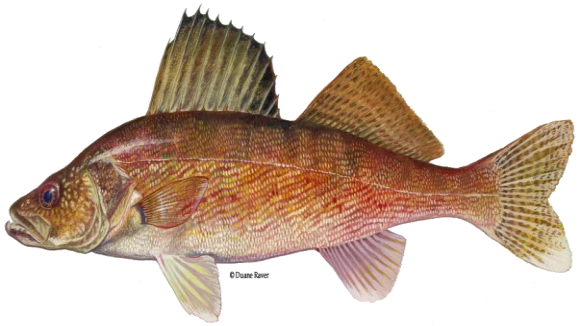
<tr><td colspan="2" rowspan="2"> 
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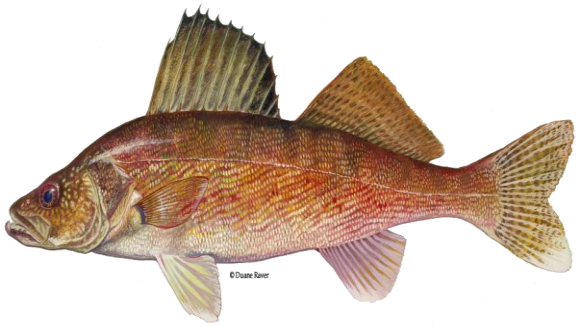
<tr><td colspan="2" rowspan="2"> 
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 **PERCH**	 **PERCH**	 **PERCH**	 **PERCH**

ACTIVITY 3: Influences on Population Dynamics

First, display all the graphs side-by-side for the entire class to see before holding the class discussion to debrief the results of the simulation activity. Ask the class to analyze (e.g., compare and connect) the results of all the groups, as well as to draw an overall conclusion (taking into account every group's data) about the relationship between the populations of each fish in the simulation. Allow students to talk directly to one another about their data, and facilitate the conversation as needed to promote understanding and answer questions.

Next, assign each group one of the following questions to go back into their groups to answer. Inform them that they will be returning to the whole-group discussion afterward to explain their response to the question. The questions are:

1. How would the population of the walleye and perch have changed over time if there were excessive **commercial fishing of walleye** throughout the first ten generations?
2. How would the population of the walleye and perch have changed over time if there were excessive **commercial fishing of perch** throughout the first ten generations?
3. How would the population of the walleye and perch have changed over time if there were **a disease that only affected perch** in the 10th generation?
4. How would the population of the walleye and perch have changed over time if there were **contaminated runoff** that entered the water of this ecosystem and killed the source of food for the yellow perch in the 10th generation?
5. How would the population of the walleye and perch have changed over time if there were **an invasive species that also ate yellow perch** as its primary source of food throughout the first ten generations?

6. What is an estimate of **the upper limit of the population of walleye** that this ecosystem can support.
7. What is an estimate of **the ideal number of walleye** that this ecosystem can support without getting too high or too low?
8. What could we conclude about the populations of walleye and perch at any given time based solely on **the ratio of walleye to perch**?

Then, allow students time to confer with their group on their question and to prepare responses to share with the class. Groups should write a response to their question by including their claim, relevant evidence from the simulation, and the reasoning that supports their claim.

Last, return to the whole-group discussion to allow each group to present their question and the response their group prepared. After each presentation, engage the class in further questions to deepen their understanding. (*An optional teacher resource for facilitating whole-group discussion questions is the Talk Science Primer from the Technical Education Research Centers).

SYNTHESIS: Give students individual thinking and writing time in their notebooks to synthesize their learning by jotting down their own reflections using a Word, Phrase, Sentence protocol, with:

- A **word** that they thought was most important from the lesson
- A **phrase** that they would like to remember
- A **sentence** that sums up what they learned in the lesson

After the individual synthesis is complete, students should share their synthesis with a shoulder partner.

COOL DOWN: Have students complete a 3, 2, 1 Review protocol for the lesson with a partner, recording in their notebooks or, optionally, on exit ticket slips to submit, the following:

- **3** things that they liked or learned
- **2** things that make more sense now
- **1** question that they were left with

CLOSURE: Have one student share a response from each of the categories of the 3, 2, 1 Review. Depending on the available time, the teacher can make connections between the ideas students share and the learning objectives of the lesson, and respond to the question that is shared.

EXIT TICKET: Students write what they think is the biggest threat to the fish populations they investigated in their simulation and provide reasoning as to why they selected that factor.

About the Author

Gary is an educational consultant, award-winning science educator and the author of *Science With Scarlett*. He is also a double cornea transplant recipient who, since having his sight restored, was moved to use his teaching gifts to make science fun for kids. He lives with his family near Detroit and designs learning experiences to inspire children, like his own daughter, to love science. Gary is the 2014 recipient of the Michigan Teacher of the Year honor. Contact him via his consulting firm, Saga Educators, or connect with him on Twitter.

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4. Does Fishing Threaten the Great Lakes?

Overview and Purpose

To relate knowledge of fish population dynamics and food chains to the commercial and recreational fishing industry in the Great Lakes.

Lesson Summary

Students will understand the link between fish population dynamics and the fishing industry. There is a mutual relationship between the two, which students should realize by the end of the lesson, because humans and fish are part of a common food chain in the Great Lakes.

Commercial fishing is a big industry in the Great Lakes, as is the pastime of recreational fishing, but fishing depends largely on fish populations. At the same time, fish populations are affected by fishing—both commercial and recreational—and so the link between the ecosystem and the environmental interactions happens in multiple ways.

The background information needed for this lesson includes a knowledge of population dynamics, the ability to graph a predator-prey population over time, as well as knowledge of food chains and food webs. Optionally, teachers can first teach the lesson titled “Fish Population Dynamics” to students prior to completing this lesson as a way to develop background knowledge.

As more fishing takes place, fish populations can decline, but as fish populations decline, fishing becomes less productive. The threat to fish populations from fishing can have an impact on the number of fish of a certain species, while the fish population will impact the fishing that is done in a certain area. The dynamics between fishing and fish populations can be further impacted when certain fish populations are affected by invasive competing species or other disruptions to the ecosystem.

This lesson focuses on the way that the fishing industry can become a threat to the native species of the Great Lakes, while at the same time the natural dynamics of fish populations can affect the freshwater fishing industry that depends on the Great Lakes. As students explore the history of commercial fishing in the Great Lakes, through articles from Great Lakes Now and the Illinois-Indiana Sea Grant, they will familiarize themselves with this interconnectedness between the ecosystem of the Great Lakes and the fishing industry.

ESSENTIAL THEMES	● Interconnectedness of the Great Lakes ecosystem to the commercial fishing industry ● The relationship between human activity and population dynamics in the Great Lakes
NEXT GENERATION SCIENCE STANDARDS	➔ MS-ESS3.A.1 Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. ➔ MS-LS2-1 Ecosystems: Interactions, Energy and Dynamics. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. ➔ MS-LS2-2 Ecosystems: Interactions, Energy and Dynamics. Construct an explanation about how the different parts of the food chain are dependent on each other. ➔ SEP2: use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.
OBJECTIVES	❑ Understand the impact of commercial/recreational fishing on the fish populations of the Great Lakes ❑ Understand the impact of declining fish populations on the commercial/recreational fishing industry in the Great Lakes ❑ Apply population dynamics principles to human activity within a food chain
ESTIMATED TIME	❖ **2 class periods**

Materials Needed

- Video projection monitor or screen/speakers
- Internet access via computers or mobile devices (e.g., tablets, cellphones)
- Notebooks and pencils
- Chart paper or a dry erase board and markers

Facilitation Steps

WARM UP: Begin by asking students what they already know about the essential themes of the lesson and what they wonder about it. Have them turn and talk with a shoulder partner. Then, after a minute of conversation, elicit responses from a couple of volunteers and jot down 2-3 ideas on the board under the categories KNOW and WONDER. The teacher should help students clarify their ideas as they are shared by checking for understanding using a talk move such as "so you are saying..." or help students think together by asking for a show of hands of agreement from the class in response to what individual students share.

LAUNCH: Once the warm up has concluded, give a brief overview of the background context to students, making connections to their KNOW and WONDER responses as well as any other relevant prior knowledge they would have from other lessons they have learned. Describe the activities planned for this lesson to students.

ACTIVITY 1: Fishing Affects Fish

First, explain to students that, as a class, they are going to read a short article on one way that fishing affects fish populations. Each student should listen while reading along and be prepared to share one thing that surprised them from the article after they finish reading it.

Next, distribute copies of the article Fishing may lead to rapid changes in Great Lakes fish from the Illinois-Indiana Sea Grant (or, alternatively, direct students to the URL to read the article online) and ask for a couple of volunteers to read the first half and second half of the article aloud to the class.

Then, proceed to have the class read the article aloud and give them time to jot down what surprised them about the article at the end.

Last, ask for a few students to share what surprised them from the article. After each share, ask for a show of hands as to whether or not students were also surprised by that same point. Conclude the reading of this article by reminding students that they are going to explore the relationship between fishing and fish populations more in depth in the upcoming activities and encourage them to look out for connections between articles.

ACTIVITY 2: Fishing Affects Fish Populations

First, explain to students that they are going to be reading an article from Great Lakes Now about the history of commercial fishing in the Great Lakes. This article will provide some important information to them and address some of their WONDERS from the warm up. Introduce students

to the 4 Notes Summary protocol that they will use after they finish reading the article, where they write one of each of the following notes:

- Oooh! (something that was interesting)
- Aaah! (something that was an ah-ha moment)
- Hmmm... (something that left them thinking afterward)
- Huh? (a question they have afterward)

Ask students to give an example of each type of note that they will be making to check for understanding before proceeding.

Next, distribute copies of the article Great Lakes Fishery: The start of the industry and the fall of fish populations from Great Lakes Now (or, alternatively, direct students to the URL to read the article online) and give students time to read the article individually.

Then, after the video, have students record in their notebooks a 4 Notes Summary.

Last, have students work in partners to share their 4 Notes Summary from the article with each other.

ACTIVITY 3: Fish Populations Affect Fishing Industry

First, explain to students that they are going to be reading an article from GreatLakesNow.org about the ecosystem interacts with both the recreational and commercial fishing industries in the Great Lakes. This article will provide some important information to them and address some of their WONDERS from the warm up. Remind students that they will again complete a 4 Notes Summary for this article, but this time they will do so with their partner from the end of the last activity.

Next, have students partner up (if they are not already) and distribute copies of the article Great Lakes Fishery: Commercial vs. recreational conflict from Great Lakes Now (or, alternatively, direct students to the URL to read the article online) and give students time to read the article with their partner.

Then, after the video, have students discuss with their partner and record in their notebooks a 4 Notes Summary.

Last, have partners join another set of partners to form a group of four, and have the groups share their 4 Notes Summary from the article with each other.

ACTIVITY 4: What Can Be Done?

First, explain to students that they are going to be working with their group to brainstorm possible solutions to the problems with fishing and fish populations in the Great Lakes. This solution should address one specific aspect of the problem and be backed with evidence and reasoning to support the claim students make for their solution. Inform students that they will be creating a poster to do a poster presentation to the class about the solution that they devise. Their posters should include a population dynamics graph that would show how the fish population would be affected by fishing before and after their solution.

Next, give students time to work in their groups to identify the problem and develop a solution to it, as well as create their posters. Close monitor groups as they work to ask questions to help them focus on what is important about the issue and to reference back to evidence mentioned in the articles they read. Assist groups, as needed, with constructing their graphs or developing their posters.

Then, have students present their posters with the problem and solution they addressed to the class. As students present their posters, invite students from the audience to give feedback to the group using the NOTICE and WONDER protocol (e.g., they should frame their feedback to the presenting group in the format of "I noticed…" or "I wonder…").

Last, have the class vote on which solution they think would be most workable of all the options presented to actually carry out. Ask for a couple of volunteers to share their reasons why they voted the way that they did.

SYNTHESIS: Give students individual thinking and writing time in their notebooks to synthesize their learning by jotting down their own reflections using a Word, Phrase, Sentence protocol, with:

- A **word** that they thought was most important from the lesson
- A **phrase** that they would like to remember
- A **sentence** that sums up what they learned in the lesson

After the individual synthesis is complete, students should share their synthesis with a shoulder partner.

COOL DOWN: Have students complete a 3, 2, 1 Review protocol for the lesson with a partner, recording in their notebooks or, optionally, on exit ticket slips to submit, the following:

- **3** things that they liked or learned
- **2** things that make more sense now

- **1** question that they were left with

CLOSURE: Have one student share a response from each of the categories of the 3, 2, 1 Review. Depending on the available time, the teacher can make connections between the ideas students share and the learning objectives of the lesson, and respond to the question that is shared.

EXIT TICKET: Students write one difficulty they see with the solution that was voted most workable by the class and explain why they think that it would be a difficulty.

About the Author

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5. Lake Invaders

Overview and Purpose

To understand how invasive species threaten the Great Lakes ecosystem.

Lesson Summary

Students will examine one of the most notable invasive species threatening the Great Lakes—the Asian Carp—and explore some of the solutions that are being tried to deal with the invasive species around the lakes. They will learn about the invasive species through several short videos and then integrate their knowledge by creating an infographic about the threat posed to the Great Lakes by the Asian Carp.

The background context that is needed for this lesson is for students to know predator-prey relationships, food chains and food webs, and population dynamics. Students should also be familiar with creating an infographic and using a digital tool to do so.

This lesson focuses on students collecting data and analyzing trends to make claims based on evidence and reasoning, but it also focuses on students interpreting and communicating knowledge.

ESSENTIAL THEMES	● Invasive species and their effect on ecosystems
NEXT GENERATION SCIENCE STANDARDS	➔ MS-ESS3.A.1 Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. ➔ MS-LS2-1 Ecosystems: Interactions, Energy and Dynamics. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. ➔ MS-LS2-2 Ecosystems: Interactions, Energy and Dynamics. Construct an explanation about how the different parts of the food chain are dependent on each other. ➔ SEP6: Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real world phenomena, examples, or events. ➔ SEP7: Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

OBJECTIVES	❏ Identify the types of threats posed to the Great Lakes by Asian Carp ❏ Discuss possible solutions to the problem posed by an invasive species ❏ Create a visual representation of knowledge and communicate it to others
ESTIMATED TIME	❖ **2-3 class periods**

Materials Needed

- Video projection monitor or screen/speakers
- Internet access via computers or mobile devices (e.g., tablets, cellphones)
- Notebooks and pencils
- Chart paper or a dry erase board and markers

Facilitation Steps

WARM UP: Begin by asking students what they already know about the essential themes of the lesson and what they wonder about it. Have them turn and talk with a shoulder partner. Then, after a minute of conversation, elicit responses from a couple of volunteers and jot down 2-3 ideas on the board under the categories KNOW and WONDER. The teacher should help students clarify their ideas as they are shared by checking for understanding using a talk move such as "so you are saying…" or help students think together by asking for a show of hands of agreement from the class in response to what individual students share.

LAUNCH: Once the warm up has concluded, give a brief overview of the background context to students, making connections to their KNOW and WONDER responses as well as any other relevant prior knowledge they would have from other lessons they have learned. Describe the activities planned for this lesson to students.

ACTIVITY 1: Meet the Invaders

First, explain to students that they will be learning about an invasive fish species impacting the Great Lakes—the Asian Carp—and creating an infographic to summarize the effect the Asian Carp species are having on the Great Lakes, as well as possible solutions to the problem. To help them build knowledge for making their infographics, they will be watching videos on Asian Carp from PBS NewsHour and Great Lakes Now.

Next, inform students of the essential components of the infographic so that they know what to focus on during the viewing of the video content (optionally, you may provide students with an advanced organizer that summarizes these points to use for note taking during the videos):

- Classification of each Asian Carp species (e.g., name, identifying features and locations of each)
- Why these species pose threats to the Great Lakes region
- Possible solutions to the Asian Carp threat

Then, play the following three videos for the class, take a break after each one to ask a couple of students to share takeaways from each:

1. How to identify the types of Asian Carp from Great Lakes Now for the class.
2. Episode 1003 Segment 2 (9:14 — 18:22) of Great Lakes Now
3. Midwest battles to keep invasive Asian carp out of the Great Lakes from PBS News Hour

Last, debrief the videos with the entire class using a 4 Notes Summary protocol, in which you ask for students to share aloud one of the following four notes to summarize takeaways from the video:

- Oooh! (something that was interesting)
- Aaah! (something that was an ah-ha moment)
- Hmmm... (something that left them thinking afterward)
- Huh? (a question they have afterward)

ACTIVITY 2: Great Lakes Invaders Infographics

First, explain to students that they are going to apply their learning from the videos in the previous activity by summarizing the threat that Asian Carp pose to the Great Lakes in a visual way. They will create an infographic (using an infographic tool such as Canva) about the Asian Carp threat to communicate the information about the threat this invasive species poses to the Great Lakes. Their infographics need to address the following:

- The definition of an invasive species
- List and describe each Asian Carp species (e.g., name, identifying features, current locations of each, and which part(s) of the Great Lakes they threaten)
- Explain why these species pose threats to the Great Lakes region (e.g., outcompeting native species for ecosystem resources)
- Describe possible solutions to the Asian Carp threat (e.g., electric fields, etc.)
- Highlight which solution to the problem might be the most workable to consider

- Infographics should have minimal text as well as plentiful graphics (e.g., photos, charts, graphs, icons, symbols, etc.)

Next, have students partner up to work on creating their infographics. Remind students that they should refer to their notes from the videos as they work on creating their infographics, and provide them the URLs to view the videos again, as needed, for their research on the topic. Encourage students to outline their information or sketch a draft of their infographic in their notebooks before proceeding to work with the infographic creation tool.

Then, allow students time to work on completing their infographics. Monitor students as they work on their projects to give feedback on their outlines/sketches before they proceed to creating their final infographic. At the end, they should either have them printed out or have a digital way to show their infographic to classmates.

Last, have three partnerships of students join each other to present and review their infographics together in a Cafe Meetup. In a Cafe Meetup, students sit around the same table displaying their work to one another on the table in front of them all at the same time and discuss their work by comparing and connecting the ideas of classmates to their own ideas on a given topic or task. They do this by thinking out loud about the features of their classmates' work that compare (similarities and differences) and connect (all groups included something relating to...) with their own ideas.

**Share what students create with Great Lakes Now by emailing their infographics to gln@dptv.org or by posting them on Facebook or Twitter with @GreatLakesNow!*

SYNTHESIS: Give students individual thinking and writing time in their notebooks to synthesize their learning by jotting down their own reflections using a Word, Phrase, Sentence protocol, with:

- A **word** that they thought was most important from the lesson
- A **phrase** that they would like to remember
- A **sentence** that sums up what they learned in the lesson

After the individual synthesis is complete, students should share their synthesis with a shoulder partner.

COOL DOWN: Have students complete a 3, 2, 1 Review protocol for the lesson with a partner, recording in their notebooks or, optionally, on exit ticket slips to submit, the following:

- **3** things that they liked or learned
- **2** things that make more sense now
- **1** question that they were left with

CLOSURE: Have one student share a response from each of the categories of the 3, 2, 1 Review. Depending on the available time, the teacher can make connections between the ideas students share and the learning objectives of the lesson, and respond to the question that is shared.

EXIT TICKET: Students write which of the solutions to the invasive species threat Asian Carp pose to the Great Lakes they think is most promising and explain why.

About the Author

Gary is an educational consultant, award-winning science educator and the author of *Science With Scarlett*. He is also a double cornea transplant recipient who, since having his sight restored, was moved to use his teaching gifts to make science fun for kids. He lives with his family near Detroit and designs learning experiences to inspire children, like his own daughter, to love science. Gary is the 2014 recipient of the Michigan Teacher of the Year honor. Contact him via his consulting firm, Saga Educators, or connect with him on Twitter.

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6. The Bloomin' Algae Harming Lake Erie

Overview and Purpose

To understand the relationship between nutrient cycles and Great Lakes ecosystems, with special consideration given to the algal blooms caused by runoff pollution in western Lake Erie.

Lesson Summary

Students will learn about the nitrogen and phosphorus cycles and investigate how these nutrients are cycled through the ecosystem near Toledo, OH, eventually causing significant algal blooms that threaten the water supply along the western coastline of Lake Erie.

Students will complete activities that will help them to visualize the problem behind the harmful algal blooms (HABs) in western Lake Erie as an instance of a nutrient cycle within an ecosystem. Their understanding of nutrient cycles will help them to identify potentially-effective solutions to the problem.

The background context that is needed for this lesson is for students to know that phosphorus and nitrogen are naturally-occurring elements contained within an ecosystem and necessary for plants and animals to live, which is why they are used in crop fertilizers. Students should also be familiar with food chains (e.g., how cyanobacteria play a role in the ecosystem) and the basic geography of the Lake Erie-Maumee River area near Toledo, OH.

ESSENTIAL THEMES	● Nutrient cycles (e.g., Nitrogen and Phosphorus) within an ecosystem ● The threat posed by cyanobacteria in the Great Lakes
NEXT GENERATION SCIENCE STANDARDS	➔ MS-ESS3.A.1 Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. ➔ MS-ESS3-2: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. ➔ MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

	➔ HS-LS2.B.2: Plants or algae form the lowest level of the food web. 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. ➔ SEP8: Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings.
OBJECTIVES	❑ Analyze the flow of nutrients through the water in areas of the Great Lakes, including streams, rivers, wetlands, or groundwater ❑ Understand the problem with harmful algal blooms facing the western region of Lake Erie and possible solutions to it
ESTIMATED TIME	❖ **2 class periods**

Materials Needed

- Video projection monitor or screen/speakers
- Internet access via computers or mobile devices (e.g., tablets, cellphones)
- Notebooks and pencils
- Chart paper or a dry erase board and markers

Facilitation Steps

WARM UP: Begin by asking students what they already know about the essential themes of the lesson and what they wonder about it. Have them turn and talk with a shoulder partner. Then, after a minute of conversation, elicit responses from a couple of volunteers and jot down 2-3 ideas on the board under the categories KNOW and WONDER. The teacher should help students clarify their ideas as they are shared by checking for understanding using a talk move such as “so you are saying…” or help students think together by asking for a show of hands of agreement from the class in response to what individual students share.

LAUNCH: Once the warm up has concluded, give a brief overview of the background context to students, making connections to their KNOW and WONDER responses as well as any other relevant prior knowledge they would have from other lessons they have learned. Describe the activities planned for this lesson to students.

ACTIVITY 1: How Nutrients Cycle Through an Ecosystem

First, explain to students that they are going to be viewing an informational video explaining how certain nutrients cycle through an ecosystem. This video will provide some basic information to them and address some of their WONDERS from the warm up. Introduce students to the 4 Notes Summary protocol that they will use after the video is complete, where they write one of each of the following:

- Oooh! (something that was interesting)
- Aaah! (something that was an ah-ha moment)
- Hmmm... (something that left them thinking afterward)
- Huh? (a question they have afterward)

Ask students to give an example of each type of note that they will be making to check for understanding.

Next, show the video from PBS about the Nitrogen and Phosphorus Cycles to the whole class.

Then, after the video, have students record in their notebooks a 4 Notes Summary.

Last, have a couple of students share one of the notes they wrote in their summary aloud. After students have shared takeaways from their 4 Notes Summaries, work with the whole class to try and collectively create a diagram mapping out the nutrient cycles for Phosphorus and Nitrogen based on what they learned in the video. Allow students to volunteer information while the teacher records what they say on the board, clarifying their ideas and prompting them along until a basic nutrient cycle is completed. Once the nutrient cycles are drawn on the board, have students copy them into their notebooks. (*Alternatively, depending on time, teacher can show a graphic of the Nitrogen and/or Phosphorus Cycle to students and have them sketch these into their notebooks prior to the rest of the activities in this lesson.)

ACTIVITY 2: Algae in the Black Swamp

First, have a volunteer read the overview information about the Great Black Swamp from Great Lakes Now in this article.

Next, show the video segment (starting at 17:16) from Great Lakes Now on the harmful algal blooms (HABs) in Lake Erie to the whole class.

Then, ask students to partner up and discuss how the harmful algal blooms would relate to the nutrient cycles they drew in their notebooks. Have them create a new diagram showing how the

nutrient cycles affect the cyanobacteria in Lake Erie based on the information they learned in the video.

Finally, have students volunteer to explain what they discussed and sketched with their partners. The teacher should work to sketch out on the board a representation of what the students are saying (e.g., facilitate a consensus among all the ideas) such that a diagram is created showing the nutrient cycles and how they lead to harmful algal blooms. Have partners turn and talk to summarize the class consensus with each other.

ACTIVITY 3: Why Are Microcystis a Concern?

First, show the video on Harmful Algal Blooms (HABs) from the Ohio DNR to the class.

Next either distribute copies of, or direct students to view the following documents online from Ohio DNR: HABs Fact Sheet, Recognizing HABs, and Lake Erie Harmful Algal Bloom Health Information. Have students work in groups of three to review the information provided in these two Fact Sheets about HABs and jot down 3-5 key ideas that they learned from them. They can review the information in any way they choose (e.g., jigsaw, one leader reads to the group, everyone reads all three).

Then, have students write down three questions they have about microcystis after reading these articles.

Last, have students review the Frequently Asked Questions about HABs from NOAA and try to come up with answers to the questions they had.

ACTIVITY 4: Using Data to Evaluate Solutions

First, remind students that, as they learned from earlier video activities, several factors can affect the HABs including:

- amount of fertilizer runoff into the water system
- where fertilizer runoff from farmland goes, and
- the amount of rain in the region.

Inform them that in this activity they will be analyzing historical data from the NOAA Algae Bulletins over a three-year period to see how some of the responses to HABs have made a difference. Assign them bulletins from the same week of the year from three different years (e.g., the last week in August from 2017, 2018, and 2019) in Lake Erie using the drop-down menu provided by NOAA. **Note: do not have two groups look at the same week of the year as each other.*

Next, have students summarize their findings and observations from the bulletins by describing the changes in HABs from year to year. For each year, have students claim whether the HABs increased or decreased as a threat, allow them to hypothesize what might have caused the change, and have them provide a written explanation providing evidence and reasoning from the data.

Then, have students draw a diagram to show how changing the factors, which they learned about in the videos (e.g., amount of fertilizer runoff, destination of fertilizer runoff, and amount of rain,) could affect the HABs through the nutrient cycles.

Last, have students make a claim, backed by evidence and reasoning, as to which solution they think would be most effective at controlling the HABs.

SYNTHESIS: Give students individual thinking and writing time in their notebooks to synthesize their learning by jotting down their own reflections using a Word, Phrase, Sentence protocol, with:

- A **word** that they thought was most important from the lesson
- A **phrase** that they would like to remember
- A **sentence** that sums up what they learned in the lesson

After the individual synthesis is complete, students should share their synthesis with a shoulder partner.

COOL DOWN: Have students complete a 3, 2, 1 Review protocol for the lesson with a partner, recording in their notebooks or, optionally, on exit ticket slips to submit, the following:

- **3** things that they liked or learned
- **2** things that make more sense now
- **1** question that they were left with

CLOSURE: Have one student share a response from each of the categories of the 3, 2, 1 Review. Depending on the available time, the teacher can make connections between the ideas students share and the learning objectives of the lesson, and respond to the question that is shared.

EXIT TICKET: Students explain why they think it has been so difficult to control the HABs in Lake Erie over the years.

About the Author

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7. A Freshwater Oil Spill Cleanup Simulation

Overview and Purpose

To learn about the impact oil spills have on ecosystems of the Great Lakes region and explore the nature of the work involved with cleaning up a freshwater oil spill.

Lesson Summary

Students will learn about a remote Canadian research station where scientists are working to understand the effects of oil spill pollution on freshwater and simulate an oil spill cleanup effort in the lab.

Students will first learn about the Kalamazoo River oil spill and why better cleanup efforts are needed to address oil spills in freshwater when they happen. They will do this through a video segment from Great Lakes Now. Then, they will apply their learning through a simulation in which they will create an oil spill and have to figure out a cost-effective way to clean it up.

The background context needed for this lesson is for students to know the properties of solids, liquids and gases, including density and solubility (e.g., water and oil do not mix and the less dense substance floats atop the denser substance.)

ESSENTIAL THEMES	● How oil spills affect ecosystems ● Methods of cleaning up oil spills in large bodies of water
NEXT GENERATION SCIENCE STANDARDS	➔ MS-ESS3.A.1 Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. ➔ MS-ETS2-2. Given a design task, select appropriate materials based on specific properties needed in the construction of a solution ➔ MS-LS2-5. Evaluate competing design solutions for protecting an ecosystem. Discuss benefits and limitations of each design. ➔ MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
OBJECTIVES	❑ Know the threat that oil spills pose to bodies of freshwater

	❑ Simulate how a cleanup effort for an oil spill might happen ❑ Understand the difficulties associated with cleaning up an oil spill
ESTIMATED TIME	❖ **2-3 class periods**

Materials Needed

- Video projection monitor or screen/speakers
- Internet browser
- Student computers, laptops, or tablets
- Notebooks and pencils
- Chart paper or dry-erase boards and markers
- Cotton Balls or Rounds
- Feathers
- Cotton cloth fabric squares (e.g., 12” x 12” rags)
- Q-Tips
- Cardboard Squares (1 sq-ft)
- Paper Towel Pieces (pre-cut)
- Newspaper (full sheet, folded)
- Pipe Cleaners (any size)
- Plastic Pipettes (disposable)
- 100mL Graduated Cylinders
- Liquid Dishwasher Detergent
- Aquarium skimmers (nets)
- Large plastic basins (10-20 qt)
- Motor Oil
- Blue food coloring

Facilitation Steps

WARM UP: Begin by asking students what they already know about the essential themes of the lesson and what they wonder about it. Have them turn and talk with a shoulder partner. Then, after a minute of conversation, elicit responses from a couple of volunteers and jot down 2-3 ideas on the board under the categories KNOW and WONDER. The teacher should help students clarify their ideas as they are shared by checking for understanding using a talk move such as "so you are saying..." or help students think together by asking for a show of hands of agreement from the class in response to what individual students share.

LAUNCH: Once the warm up has concluded, give a brief overview of the background context to students, making connections to their KNOW and WONDER responses as well as any other relevant prior knowledge they would have from other lessons they have learned. Describe the activities planned for this lesson to students.

ACTIVITY 1: Polluting With Purpose

First, explain to students that they are going to be viewing an informational video explaining how researchers are purposely creating oil spills on freshwater lakes to study the cleanup of oil in an ecosystem. This video will provide some basic information to them and address some of their WONDERS from the warm up. Introduce students to the 4 Notes Summary protocol that they will use after the video is complete, where they write one of each of the following:

- Oooh! (something that was interesting)
- Aaah! (something that was an ah-ha moment)
- Hmmm... (something that left them thinking afterward)
- Huh? (a question they have afterward)

Ask students to give an example of each type of note that they will be making to check for understanding.

Next, have a volunteer read the introductory overview article Polluting With Purpose from Great Lakes Now to the whole class.

Then, show the Polluting With Purpose video segment from Great Lakes Now to the whole class.

Last, after the video, have students record in their notebooks a 4 Notes Summary and have a couple of students share one of the notes they wrote in their summary aloud. Record on the board one of each type of note that students share.

ACTIVITY 2: Oil Spill Cleanup Simulation

First, explain to students that they will be learning about methods of cleaning up oil spills and then simulating an oil spill cleanup. Have volunteer students read—a couple of paragraphs at a time—the article Cleaning Up the Oil Spill about how surfactants/dispersants are used to chemically break up oil spills in New Zealand, from the Science Learning Hub at the University of Waikato. After the video get students into groups before providing the next instructions.

Next, explain to students that each group will be given a similar environment (e.g., a "lake") in which to clean up an oil spill: a large plastic basin (size can vary depending on available space) filled with roughly the same amount of blue food-colored water and the same amount of oil (e.g., 30 mL of motor oil.) They will be able to select any materials they want to clean up their oil spill, but materials will have a cost associated with them. Provide students a copy of the materials list below by displaying it on the board in the classroom, sharing it with them as a handout, or having them copy it into their notebooks. Instruct students that the challenge is to clean up as much oil as possible. The success criteria for cleanup is based on how much oil a group recovers and the amount of money they spent to clean it up.

**Note: plastic garbage bags or painter's sheet plastic should be used to cover table tops under the "lake" and students should wear latex-free gloves when conducting this lab activity.*

Material	Category of Material	Cost
Cotton Balls or Rounds	Absorber	10 for $1
Feathers	Absorber or skimmer	5 for $1
Cotton cloth fabric squares (e.g., 12” x 12” rags)	Absorber or skimmer	$5 each
Q-Tips	Absorber	25 for $1
Cardboard Squares (1 sq-ft)	Boom	$10 each
Paper Towel Pieces (pre-cut)	Absorber or skimmer	$1 each
Newspaper (full sheet, folded)	Absorber, skimmer, or boom	$1 each
Pipe Cleaners (any size)	Skimmer	$1 for 10
Plastic Pipettes (disposable)	Skimmer	$10 each
100mL Graduated Cylinders	Skimmer	$25 each
Liquid Dishwasher Detergent	Dispersant	$1 per mL
Aquarium skimmers (nets)	Skimmer	$20 each

Then, provide groups time to research the materials and plan for their oil spill cleanup, before distributing the “polluted lakes.” Once they have their lakes setup, allow them to purchase materials from the supply station—have the group show you on paper how much of each supply they are taking and the total cost so that you can sign off before they begin the cleanup process.

Last, give groups time to clean up as much of the oil as they can with their supplies. Remind them to record observations and findings as they work (e.g., someone can be the designated recorder of data for the group.) At the end of the time allowed, have students measure and record the volume of oil they recovered from the oil spill and return any unused supplies they purchased. Finally, have them calculate their final cleanup budget after returning unused materials. Once the lab is completed, have students fully clean up their workstations and return all supplies before you debrief the lab activity the next day.

**Share what students create with Great Lakes Now by emailing experimental results and photos from students’ oil spill cleanup efforts to gln@dptv.org or by posting them on Facebook or Twitter with @GreatLakesNow!*

ACTIVITY 3: Oil Spill Cleanup Debrief

First, have students display, on chart paper or dry-erase boards, a summary of their oil spill cleanup effort (e.g., what materials they purchased, their procedure, amount of oil recovered, notable observations, and the total final cost of cleanup.)

Next, arrange the class in a circle so that all students are facing one another and can all see each other's lab posters. If students have their posters, instruct them to hold those in front of themselves so they face the class. Alternatively, if students used wall space to display their posters, arrange the class in a semi-circle so that they can see all the results next to one another.

Then, have students review the class solutions to the oil spill problem and debrief their solutions with each other. Have the class respond to any of the following prompts on what happened with the oil spill in order to facilitate the discussion and reach consensus about what methods were most effective:

- What happened to the oil after it was added to the water—how do you know?
- What made it most difficult to clean up the water?
- Which materials were most effective and which were least effective at cleaning the oil?
- Did any solution completely recover all of the oil?
- Would you change any of your cleanup decisions if you had this to do over again?
- How would cleanup have been different had there been a limit to how much money you spent?

Last, ask students to turn and talk with their groups about how this oil spill simulation connects to the efforts to clean up oil in the Great Lakes water system—for example, what extra considerations might complicate a real-life oil spill more than the conditions in our simulation? After giving groups some time to discuss the connections and compare the simulation to an oil spill in the Great Lakes, a couple of volunteers should share their ideas.

ACTIVITY 4: Lake Pollution Cleanup Revisited

First, explain to students that after exploring ways to clean an oil spill, they are going to now be viewing a video that explores the cleanup from other pollutants in the Great Lakes. This video will look at the pollution cleanup that arose as a consequence from copper mining near Lake Superior. Instruct students that they will again be using the 4 Notes Summary protocol to debrief what they learned after the video is complete.

Next, have a volunteer read the introductory overview article Buffalo Reef Restoration from Great Lakes Now to the whole class.

Then, show the Waters Restored video segment from Great Lakes Now to the whole class.

Last, after the video, have students record in their notebooks a 4 Notes Summary and have a couple of students share one of the notes they wrote in their summary aloud. Ask students to reflect on how much more the oil spill cleanup lab gives them an appreciation of pollution cleanup efforts in the Great Lakes.

SYNTHESIS: Give students individual thinking and writing time in their notebooks to synthesize their learning by jotting down their own reflections using a Word, Phrase, Sentence protocol, with:

- A **word** that they thought was most important from the lesson
- A **phrase** that they would like to remember
- A **sentence** that sums up what they learned in the lesson

After the individual synthesis is complete, students should share their synthesis with a shoulder partner.

COOL DOWN: Have students complete a 3, 2, 1 Review protocol for the lesson with a partner, recording in their notebooks or, optionally, on exit ticket slips to submit, the following:

- **3** things that they liked or learned
- **2** things that make more sense now
- **1** question that they were left with

CLOSURE: Have one student share a response from each of the categories of the 3, 2, 1 Review. Depending on the available time, the teacher can make connections between the ideas students share and the learning objectives of the lesson, and respond to the question that is shared.

EXIT TICKET: Students describe which method of cleanup (e.g., absorbers, booms, skimmers, or dispersants) was most effective and why.

About the Author

Gary is an educational consultant, award-winning science educator and the author of *Science With Scarlett*. He is also a double cornea transplant recipient who, since having his sight restored, was moved to use his teaching gifts to make science fun for kids. He lives with his family near Detroit and designs learning experiences to inspire children, like his own daughter, to love science. Gary is the 2014 recipient of the Michigan Teacher of the Year honor. Contact him via his consulting firm, Saga Educators, or connect with him on Twitter.

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8. Restoring Rivers of the Great Lakes

Overview and Purpose

To introduce students to some of the ways that rivers are being restored from the consequences of industrialization and urbanization in the Great Lakes region.

Lesson Summary

Students will become familiar with two major river projects, one in the Chicago River and the other on the Cuyahoga River, and the restoration efforts involved with each.

They will learn about what happened to each river to cause damage to the river's ecosystem and what is being done to repair the harm. Students will analyze and evaluate the restoration efforts of each river and make comparisons and connections to understand how river restoration is important to protecting the Great Lakes.

The background context that is needed for this lesson is for students to know the basic geography of the Cuyahoga River and Chicago River with respect to the Great Lakes region. It is also helpful if students understand the concept of an ecosystem and can describe how that might apply to a river.

ESSENTIAL THEMES	● River ecosystems, water restoration efforts, the Cuyahoga River and the Chicago River
NEXT GENERATION SCIENCE STANDARDS	➔ SEP8: Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings. ➔ MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. ➔ SEP2: use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales. ➔ MS-LS2-5. Evaluate competing design solutions for protecting an ecosystem. Discuss benefits and limitations of each design.

OBJECTIVES	❑ Know some of the ways that rivers are threatened and being restored from those threats ❑ Understand the ways in which Great Lakes waterways involve rivers ❑ Make comparisons and connections between solutions to environmental challenges
ESTIMATED TIME	❖ **1 class period**

Materials Needed

- Video projection monitor or screen/speakers
- Internet browser
- Student computers, laptops, or tablets
- Notebooks and pencils
- Chart paper or dry erase boards and markers

Facilitation Steps

WARM UP: Begin by asking students what they already know about the essential themes of the lesson and what they wonder about it. Have them turn and talk with a shoulder partner. Then, after a minute of conversation, elicit responses from a couple of volunteers and jot down 2-3 ideas on the board under the categories KNOW and WONDER. The teacher should help students clarify their ideas as they are shared by checking for understanding using a talk move such as "so you are saying..." or help students think together by asking for a show of hands of agreement from the class in response to what individual students share.

LAUNCH: Once the warm up has concluded, give a brief overview of the background context to students, making connections to their KNOW and WONDER responses as well as any other relevant prior knowledge they would have from other lessons they have learned. Describe the activities planned for this lesson to students.

ACTIVITY 1: Floating River Habitats

First, direct students' attention to the impact that urbanization would have on the natural ecosystems and habitats in the Great Lakes region, such as in an area by a big city like Chicago and the Chicago River. Call their attention specifically to the way that a lack of native plants might affect the aquatic species in the water by a big city. Ask them to consider what the impact of declining native species might have on the fish and elicit 1-2 student responses.

Next, introduce students to the 4 Notes Summary protocol that they will use after they water the upcoming video on floating habitats, where they write one of each of the following:

- Oooh! (something that was interesting)
- Aaah! (something that was an ah-ha moment)
- Hmmm... (something that left them thinking afterward)
- Huh? (a question they have afterward)

Ask students to give an example of each type of note that they will be making to check for understanding.

Then, have a volunteer read the introductory overview article on Floating Habitats before showing the video segment about the Floating Habitats from Great Lakes Now.

Last, have students create a 4 Notes Summary on the article and elicit a few responses from students to the whole class about what they took away from the video.

ACTIVITY 2: River On Fire

First, pair students up with a partner and have them share their responses to the 4 Notes Summary from the Floating Habitats video activity with each other.

Next, direct students to view online, the article and video River on Fire from Great Lakes Now. Have them read the article and watch the first segment from the River on Fire video on their own.

Then, have partners create a Comparison and Connection T-chart summarizing how the first video about the Chicago River compares and connects with the second video about the Cuyahoga River. In this chart, the comparisons should include ways in which the two river situations are similar and how they are different; the connections should include ways that the two situations connect to each other (either directly or indirectly) based on the students' discussion.

Last, have pairs share with the class some of their connections and comparisons between the situations of restoration with both rivers while the teacher generates a class Comparison and Connection T-chart on the board. End the activity by asking the students to turn and talk with their partner about what factors they think would be most preventable in issues like the ones described between both rivers and how they would suggest preventing them. Ask for a couple of volunteers to share their ideas.

SYNTHESIS: Give students individual thinking and writing time in their notebooks to synthesize their learning by jotting down their own reflections using a Word, Phrase, Sentence protocol, with:

- A **word** that they thought was most important from the lesson
- A **phrase** that they would like to remember
- A **sentence** that sums up what they learned in the lesson

After the individual synthesis is complete, students should share their synthesis with a shoulder partner.

COOL DOWN: Have students complete a 3, 2, 1 Review protocol for the lesson with a partner, recording in their notebooks or, optionally, on exit ticket slips to submit, the following:

- **3** things that they liked or learned
- **2** things that make more sense now
- **1** question that they were left with

CLOSURE: Have one student share a response from each of the categories of the 3, 2, 1 Review. Depending on the available time, the teacher can make connections between the ideas students share and the learning objectives of the lesson, and respond to the question that is shared.

EXIT TICKET: Students describe what they think would be the biggest obstacle to restoration efforts on rivers and explain why.

About the Author

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9. Responding to the PFAS Crisis

Overview and Purpose

To develop student understanding of an important chemical threat to the Great Lakes—per- and poly-fluoroalkyl substances (PFAS)—and to apply learning by generating questions and answers about PFAS problems and potential solutions.

Lesson Summary

Students will learn about per- and poly-fluoroalkyl substances (PFAS) and synthesize their learning into curious questions, as well as evidence-based responses, about the chemical that is threatening the Great Lakes.

This lesson can build on prior knowledge, if you have already completed the lesson Contemporary Issues Facing the Great Lakes, or can be an introduction to PFAS for students.

The required background context for students to have prior is of the interconnectedness of the Great Lakes. This lesson has students utilize a claim-evidence-reasoning framework for their position when they respond to questions or even generate questions.

ESSENTIAL THEMES	● per- and poly-fluoroalkyl substances (PFAS) ● Chemical threats to freshwater of the Great Lakes
NEXT GENERATION SCIENCE STANDARDS	➔ SEP7: Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints. ➔ MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
OBJECTIVES	❑ Understand the environmental threat posed by chemicals such as PFAS ❑ Generate scientific questions and answers based on evidence and reasoning
ESTIMATED TIME	❖ **2 class periods**

Materials Needed

- Video projection monitor or screen/speakers
- Internet browser
- Student computers, laptops, or tablets
- Notebooks and pencils
- Chart paper or dry erase boards and markers

Facilitation Steps

WARM UP: Begin by asking students what they already know about the essential themes of the lesson and what they wonder about it. Have them turn and talk with a shoulder partner. Then, after a minute of conversation, elicit responses from a couple of volunteers and jot down 2-3 ideas on the board under the categories KNOW and WONDER. The teacher should help students clarify their ideas as they are shared by checking for understanding using a talk move such as “so you are saying…” or help students think together by asking for a show of hands of agreement from the class in response to what individual students share.

LAUNCH: Once the warm up has concluded, give a brief overview of the background context to students, making connections to their KNOW and WONDER responses as well as any other relevant prior knowledge they would have from other lessons they have learned. Describe the activities planned for this lesson to students.

ACTIVITY 1: What Are PFAS Anyway?

First, inform students that they are going to be viewing a video documentary about per- and poly-fluoroalkyl substances (PFAS). Explain to them that PFAS is an acronym for a class of industrial chemicals, which have been linked to certain cancers, thyroid and liver disorders, birth defects and high cholesterol.

These chemicals are contaminating drinking water and showing up in people's blood. That’s because they are in most homes and are now being detected in an increasing number of people’s water systems in Michigan and other states and provinces.

Let them know that this video will provide some basic information to them about the chemicals and address some of their WONDERS from the warm up. Introduce students to the 4 Notes Summary protocol that they will use after the video is complete, where they write one of each of the following:

- Oooh! (something that was interesting)
- Aaah! (something that was an ah-ha moment)

- Hmmm... (something that left them thinking afterward)
- Huh? (a question they have afterward)

Ask students to give an example of each type of note that they will be making to check for understanding.

Next, show the class the video "The Forever Chemicals" a 30-minute documentary from Great Lakes Now.

Then, after the video, have students record in their notebooks a 4 Notes Summary.

Last, have students form a group of four to discuss their takeaways from the video using the Conversation Roundtable protocol. In this protocol, students take turns sharing what they wrote for their individual responses to the 4 Notes Summary with their group while each student writes down what they heard the speaker say. Then, each student writes their own "sum it up" statement of their group members' responses. After the Conversation Roundtable, have a whole-class share out. Choose a few students to each share their summaries from their group discussion aloud with the whole class. After each, ask students to raise hands if what was just shared matches something that came up in their group discussion as well.

**Note: if you have already completed the previous Great Lakes Now lesson on the Forever Chemicals, entitled Contemporary Issues Facing the Great Lakes, you can show the class the Forever Chemicals trailer and the 1-minute explainer on PFAS (bottom of page) to remind them of the documentary they watched and then give them access to the documentary to view parts of it on their own, as needed for the second activity.*

ACTIVITY 2: PFAS in Ann Arbor

First, inform students that they are going to be viewing a video showing how PFAS is affecting one particular city—Ann Arbor. Explain to them that Ann Arbor is one of many places reporting an issue with PFAS. Show the map of PFAS reports in the U.S. to the class and ask them which area of the country currently seems most affected.

Next, have a volunteer read the introductory paragraphs about when industrial chemicals get in a city's water supply from Great Lakes Now.

Then, show the video segment from Great Lakes Now on PFAS in Ann Arbor drinking water.

Last, ask students to turn and talk with a classmate about one thing they learned from the video. Have a few student volunteers share their responses aloud with the whole class.

ACTIVITY 3: PFAS AMA (Ask Me Anything)

First, inform students that they will be doing an Ask Me Anything (AMA) about the PFAS chemicals that they learned about in the Forever Chemicals documentary. They will be working with their group from the conversation roundtable to create their questions, and then the class will share questions with each other in an effort to get responses to them. Each group should work to generate 8-10 questions. Explain to students that they should be able to support the questions that they create using a claim-evidence-reasoning framework to explain why they asked their question, and later in how they respond to questions to provide answers.

Next, give students a chance to generate the questions that they have about PFAS. They can research online or reference the Forever Chemicals documentary, as needed, to help them formulate their questions. Once they have 8-10 questions, they should make a poster of their questions, either using chart paper or dry erase boards, so that everyone in the class can see each other's questions. Encourage them to be specific and clear with their wording when they generate their questions. Give students some examples of what they can focus their questions about PFAS on such as, but not limited to, the following:

- health risks
- safety concerns
- effects on the water supply
- ways people can protect themselves and their families
- the cost of PFAS contamination

Then, have students do a gallery walk to give groups a chance to read the other question posters and discuss as a group which questions they would like answered off of other groups' posters. They should choose 2 questions from each poster (including their own) and should put a checkmark next to their chosen questions on each poster. At the end of the gallery walk, students return to their seats and the teacher compiles a single list of the most upvoted questions from each poster for the whole class to see. Remember to list any similar questions only once, so as to avoid duplicates.

Last, go through the combined questions list and have the class vote on the top 3 questions, which they all would like to get an answer on, and send those questions to Great Lakes Now. To help them deliberate, you may ask them to consider which questions on the list could students in the class answer. After the class has selected the questions to send in and you have submitted them to Great Lakes Now, go through the remaining questions on the list and ask for responses to them from students in the class. Use this as an opportunity to facilitate class discussion and link back to their original KNOW and WONDER responses when possible.

**Note: You should check out a few of the questions that have already been submitted to Great Lakes Now and answered in short explainer videos here and compare those questions to the*

ones that students wanted to know. This could be done before you submit questions to Great Lakes Now or at the end of the activity.

SYNTHESIS: Give students individual thinking and writing time in their notebooks to synthesize their learning by jotting down their own reflections using a Word, Phrase, Sentence protocol, with:

- A **word** that they thought was most important from the lesson
- A **phrase** that they would like to remember
- A **sentence** that sums up what they learned in the lesson

After the individual synthesis is complete, students should share their synthesis with a shoulder partner.

COOL DOWN: Have students complete a 3, 2, 1 Review protocol for the lesson with a partner, recording in their notebooks or, optionally, on exit ticket slips to submit, the following:

- **3** things that they liked or learned
- **2** things that make more sense now
- **1** question that they were left with

CLOSURE: Have one student share a response from each of the categories of the 3, 2, 1 Review. Depending on the available time, the teacher can make connections between the ideas students share and the learning objectives of the lesson, and respond to the question that is shared.

EXIT TICKET: Students describe which question surprised them most of all the questions that they saw on all the posters, and explain why it surprised them.

About the Author

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10. The Supply and Demand of Groundwater

Overview and Purpose

To introduce students to the impact that land development, e.g., residential and commercial, can have on the naturally available groundwater in an area.

Lesson Summary

Students will investigate solutions to groundwater shortage and be introduced to the story of Ottawa County, MI where a water shortage caused such water scarcity that taps ran dry for residents.

The purpose of introducing this context is for students to understand how supply and demand for groundwater affects a community and can impact other above-the-surface bodies of water in an area such as the Great Lakes region. They will get a sense of how important groundwater is to residents and business owners, as well as how much we depend on groundwater in various areas.

Students will engage in a series of activities, from Great Lakes Now and the US Geological Survey to understand the importance and vulnerabilities of groundwater. They will watch the story of Ottawa County, MI and their groundwater crisis. They will take a groundwater trivia quiz, experience a groundwater simulation, and analyze statistics from the Michigan Department of Environmental Quality on groundwater availability. They will finish the lesson by researching, evaluating, and discussing potential solutions to the groundwater shortage problem depicted in the video.

The background context that students should have is a basic understanding of the layers of earth directly below the surface as they relate to groundwater, as well as a knowledge of the principle of supply and demand.

ESSENTIAL THEMES	● Groundwater ● The impact of community development on groundwater ● Supply and demand

NEXT GENERATION SCIENCE STANDARDS	➔ MS-ESS3-2: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. ➔ HS-ESS3.1: Construct an explanation based on evidence for how availability of natural resources, occurrence of natural hazards and changes in climate have influenced human activity. ➔ MS-ESS3-1 Construct a scientific explanation based on evidence for how the uneven distribution of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. ➔ SEP4: Analyze and interpret data to provide evidence for phenomena. ➔ MS-ESS2-2: Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. ➔ HS-ESS2.A.4: The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. ➔ SEP8: Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings. ➔ SEP3: Develop and/or use a model to predict and/or describe phenomena.
OBJECTIVES	❑ Know the impact that humans can have on naturally occurring resources, such as ground water ❑ Understand how groundwater accumulates ❑ Create a written argument, in claim-evidence-reasoning format, to support the selection of potential solutions to an environmental problem
ESTIMATED TIME	❖ **3 class periods**

Materials Needed

- Video projection monitor or screen/speakers
- Internet access
- Notebooks and pencils
- Sponges
- Plastic wrap
- Dissection trays
- 100mL graduated cylinders

Facilitation Steps

WARM UP: Begin by asking students what they already know about the essential themes of the lesson and what they wonder about it. Have them turn and talk with a shoulder partner. Then, after a minute of conversation, elicit responses from a couple of volunteers and jot down 2-3 ideas on the board under the categories KNOW and WONDER. The teacher should help students clarify their ideas as they are shared by checking for understanding using a talk move such as "so you are saying..." or help students think together by asking for a show of hands of agreement from the class in response to what individual students share.

LAUNCH: Once the warm up has concluded, give a brief overview of the background context to students, making connections to their KNOW and WONDER responses as well as any other relevant prior knowledge they would have from other lessons they have learned. Describe the activities planned for this lesson to students.

ACTIVITY 1: Groundwater Basics

First, have students take the groundwater true/false quiz from USGS to assess their prior knowledge. You can have students take the quiz individually, with a partner to discuss, or you can go through the questions one-by-one with the whole class and have them respond by a vote of hands for each question. The answers at the end provide short explanations that can be helpful talking points to give students more background context.

Next, show the groundwater diagram from the USGS and have a volunteer read the paragraph description, which explains groundwater, to the class.

Then, do this sponge demonstration from the USGS for your class, or have students do the demonstration in a group of four students to model what happens in the earth to accumulate groundwater:

1. Get two sponges and lay one on top of the other in a dissection tray.
2. Pour water (precipitation) on top from the graduated cylinder and let it seep through the top sponge downward into the bottom sponge. If you stopped adding water, the top sponge would dry up and, as the water dripped out of the bottom sponge, it would dry up too.
3. Now, put a piece of plastic wrap between the sponges, creating your "confining layer" (making the bottom sponge an impermeable rock layer that is too dense to allow water to flow through it).
4. Now when you pour water on the top sponge, the water will seep downward until it hits the plastic wrap. The top sponge will become saturated, and when the water hits the plastic wrap it won't be able to seep into the second sponge. Instead, it will start flowing sideways and come out at the edges of the sponge (horizontal flow of groundwater). This happens inside the earth all the time -- and it is an important part of the water cycle.

Last, show the animation of groundwater video from PBS LearningMedia to the class. After the animation is complete. Do the quiz How Much Do You Know About Groundwater from PBS LearningMedia with the entire class, having groups nominate a reporter to raise their hand to volunteer answers to each question, after they confer with their group, as you go through them with the whole class.

ACTIVITY 2: The Day When the Drinking Water Ran Out

First, explain to students that they are going to be viewing an introductory video about a community that faces water shortage near the southeastern region of Lake Michigan. This video will provide some basic information to them and address some of their WONDERS from the warm up. Introduce students to the 4 Notes Summary protocol that they will use after the video is complete, where they write one of each of the following:

- Oooh! (something that was interesting)
- Aaah! (something that was an ah-ha moment)
- Hmmm... (something that left them thinking afterward)
- Huh? (a question they have afterward)

Ask students to give an example of each type of note that they will be making to check for understanding.

Next, have a volunteer read the introductory overview from the Out of Water article about the water shortage in Ottawa County, MI to the class before you show the video Out of Water from Great Lakes Now to the whole class. Follow up after the video by having students record in their notebooks a 4 Notes Summary.

Then, distribute copies of, or direct students to view online, the article from the Michigan Department of Environmental Quality about groundwater statistics in the state. Have students read over the statistics and do a turn-and-talk with a classmate to discuss how they relate to what they saw in the video.

Last, have students form a group of four to discuss their takeaways from the video using the Conversation Roundtable protocol. In this protocol, students take turns sharing what they wrote for their individual responses to the 4 Notes Summary with their group while each student writes down what they heard the speaker say. Then, each student writes their own "sum it up" statement of their group members' responses. After the Conversation Roundtable, have a whole-class share out. Choose a few students to each share their summaries from their group discussion aloud with the whole class. After each, ask students to raise hands if what was just shared matches something that came up in their group discussion as well.

ACTIVITY 3: Workable Water Conservation Solutions

First, students should stay with their Conversation Roundtable groups from the previous activity to work on this activity. Explain to them that they will be researching potential solutions to the groundwater shortage depicted in the video. Their task will be to identify what they think are the top three most workable solutions to the problem of the groundwater shortage that Ottawa County faces due to rapid development. Have students volunteer to share ideas for a solution with the whole class, as the teacher writes down their ideas in a list on the board. Take ideas until about five different suggestions have been given. Afterward, depending on student responses, ask them "what about…?" for any unmentioned ideas from the following list of possibilities and add them to the list for them to consider with their group. The class list should include at least:

- Zeroscapes (e.g., rock gardens instead of grass like they have in the southwestern U.S.)
- Water Restrictions/Allotments/Rations (e.g., property owners are allowed so much water)
- Building Regulations (e.g., limits to how much and what kind of building can take place)
- Reclaiming used water for certain non-drinking purposes (e.g., watering landscaping)
- Man-made lakes/ponds (e.g., to serve as additional reservoirs)
- Categorization and separation of water by type designation (e.g., drinking and non-drinking)
- Water diversion plans (e.g., divert water from outside sources into the area)

Next, instruct students that they will be researching some of the possible solutions and organizing their findings into a claim-evidence-reasoning poster for their top three choices on a chart paper poster or dry erase board. These tables should include the claim they make for each

potential solution, evidence that they found to support their claim, and the reasoning behind their claim. **Teacher tip: alternatively, you could assign groups three possible solutions to research.*

Then, allow students time to research the possible solutions online, discuss their findings and create their posters.

Last, give students the opportunity to present and share their posters with each other in a large circle discussion. In this presentation format, all students should sit in a circle with their posters visible to everyone (e.g., students hold them in front of them in the circle or they all are hung on the wall.) The teacher should facilitate productive academic talk in the discussion so that students identify similarities and differences between their posters, ask for and provide further clarification on their posters, and reach a consensus about what might be the most workable solution.

SYNTHESIS: Give students individual thinking and writing time in their notebooks to synthesize their learning by jotting down their own reflections using a Word, Phrase, Sentence protocol, with:

- A **word** that they thought was most important from the lesson
- A **phrase** that they would like to remember
- A **sentence** that sums up what they learned in the lesson

After the individual synthesis is complete, students should share their synthesis with a shoulder partner.

COOL DOWN: Have students complete a 3, 2, 1 Review protocol for the lesson with a partner, recording in their notebooks or, optionally, on exit ticket slips to submit, the following:

- **3** things that they liked or learned
- **2** things that make more sense now
- **1** question that they were left with

CLOSURE: Have one student share a response from each of the categories of the 3, 2, 1 Review. Depending on the available time, the teacher can make connections between the ideas students share and the learning objectives of the lesson, and respond to the question that is shared.

EXIT TICKET: Students write what solution to the groundwater shortage they think is least workable and explain why.

About the Author

Gary is an educational consultant, award-winning science educator and the author of *Science With Scarlett*. He is also a double cornea transplant recipient who, since having his sight restored, was moved to use his teaching gifts to make science fun for kids. He lives with his family near

Detroit and designs learning experiences to inspire children, like his own daughter, to love science. Gary is the 2014 recipient of the Michigan Teacher of the Year honor. Contact him via his consulting firm, Saga Educators, or connect with him on Twitter.

About Great Lakes Now

With a monthly magazine-style television program and daily online reports at GreatLakesNow.org, the ***Great Lakes Now*** initiative offers in-depth coverage of news, issues, events and developments affecting the lakes and the communities that depend on them, while capturing the character and culture of the region.

11. Fatberg, Right Ahead!

Overview and Purpose

To introduce students to the growing environmental problem of fatbergs, how they are caused, and what can be done about them.

Lesson Summary

Students will become familiar with fatbergs, how they form, move, and affect the sewer systems of municipalities.

Students will learn about fatbergs through a video from Great Lakes Now, conduct an experiment to see how exactly different materials breakdown over time, and then use the results from their experiment and knowledge of fatbergs to create a public service announcement informing their school of the fatberg problem.

The experiment in this lesson requires students to collect observations and data over the course of several days, up to a week, and then compare the results. The lesson itself will take more time at the beginning and end of the multi-day learning progression, but requires only that students take data on the days in between. Thus, this lesson can be taught concurrently with other lessons happening during the days where students only need to collect observations from their lab.

The background context needed for this lesson is to be able to create a public service announcement (e.g., infographic poster, video, etc.) and conduct an experiment that is carried out over multiple days.

ESSENTIAL THEMES	● Fatbergs ● How our household habits affect our sewer systems ● Public Service Announcements
NEXT GENERATION SCIENCE STANDARDS	➔ SEP2: Develop and/or use a model to predict and/or describe phenomena. ➔ SEP8: Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings.

	➔ MS-ESS3-2: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. ➔ HS-ESS3.1: Construct an explanation based on evidence for how availability of natural resources, occurrence of natural hazards and changes in climate have influenced human activity.
OBJECTIVES	❑ Know what fatbergs are ❑ Understand how fatbergs are formed, affect sewer systems, and can be remedied ❑ Create a public service announcement to educate the school community about fatbergs and how they can help be part of the solution to them
ESTIMATED TIME	❖ **10 class periods**

Materials Needed

- Video projection monitor or screen/speakers
- Internet access
- Notebooks and pencils
- Beakers
- Masking tape and markers
- Scissors
- 2L plastic soda bottles, labels removed
- Toilet Paper
- Facial Tissue
- Paper Towel
- Flushable Wipes
- Cotton (swabs or balls)

Facilitation Steps

WARM UP: Begin by asking students what they already know about the essential themes of the lesson and what they wonder about it. Have them turn and talk with a shoulder partner. Then, after a minute of conversation, elicit responses from a couple of volunteers and jot down 2-3 ideas on the board under the categories KNOW and WONDER. The teacher should help students clarify their ideas as they are shared by checking for understanding using a talk move such as "so you are saying..." or help students think together by asking for a show of hands of agreement from the class in response to what individual students share.

LAUNCH: Once the warm up has concluded, give a brief overview of the background context to students, making connections to their KNOW and WONDER responses as well as any other relevant prior knowledge they would have from other lessons they have learned. Describe the activities planned for this lesson to students.

ACTIVITY 1: What Is a Fatberg, Exactly?

First, explain to students that they are going to be viewing an introductory video about fatbergs—a problem facing communities worldwide—from Great Lakes Now. Inform them that after the video, they will be using their new knowledge to create an informative public service announcement (PSA) about fatbergs. This video will provide some basic information to them that will help in the creation of their PSAs, and address some of their WONDERS from the warm up. Introduce students to the 4 Notes Summary protocol that they will use after the video is complete, where they write one of each of the following:

- Oooh! (something that was interesting)
- Aaah! (something that was an ah-ha moment)
- Hmmm... (something that left them thinking afterward)
- Huh? (a question they have afterward)

Ask students to give an example of each type of note that they will be making to check for understanding.

Next, have a volunteer read the introductory overview from the article on Fatbergs from Great Lakes Now.

Then, show the video segment on Fatbergs from Great Lakes Now to the whole class and, afterward, have students record in their notebooks a 4 Notes Summary about it.

Last, have students form a group of four to discuss their takeaways from the video using the Conversation Roundtable protocol. In this protocol, students take turns sharing what they wrote

for their individual responses to the 4 Notes Summary with their group while each student writes down what they heard the speaker say. Then, each student writes their own “sum it up” statement of their group members’ responses. After the Conversation Roundtable, have a whole-class share out. Choose a few students to each share their summaries from their group discussion aloud with the whole class. After each, ask students to raise hands if what was just shared matches something that came up in their group discussion as well.

ACTIVITY 2: Should It Flush?

First, inform students that they are going to work with their groups from the Conversation Roundtable in the last activity to conduct an experiment with was referenced in the video. Ask for a show of hands about how many students noticed the containers with flushable wipes—including one that was sitting there for a year—in the video. After the show of hands, explain that they will be doing a variation of that experiment to let different types of materials sit in water over time and compare the results to see for themselves what should or should not be flushed down the toilet.

Next, ask for suggestions of common materials that get flushed down the toilet and write them on the board as students give them. Discuss with students the relevance to fatbergs of each one on the list, and try to parse the large list down to a list that focuses on the following materials to investigate:

- Toilet Paper
- Facial Tissue
- Paper Towel
- Flushable Wipes
- Cotton (swabs or balls)

Inform them that they will put these materials in containers (2L plastic bottles) filled with the same amount of water and take observations of each over time. The times at which groups should take observations of each material sitting in water, in order to to include in their data table, should be:

1. 5min
2. 1 day
3. 2 days
4. 3 days
5. 1 week

Then, have each group set up an experimental bottle with the same amount of water (they can determine how much) and place a similar-sized sample (they can determine how big) of each

material in each corresponding bottle and label the bottle with what is in it. The bottles should get capped to model the relatively closed system of underground sewer pipes.

Last, have students collect data and observations for each bottle at the designated time intervals and keep all data organized in their notebooks. After the final data is collected in the bottles, have students pour out the water from each bottle and get the material out (e.g., cut open the bottles) to examine them by touch, and take observations about how much each has broken down. Once all observations are complete, have students summarize their findings in a data table and make some analysis about what happened with each material. Remind students that they should conclude how flushable each material is and which material would be safest to flush.

ACTIVITY 3: Fatberg Public Service Announcement

First, explain to students that they are going to apply their learning from the fatberg video and lab in the previous activities to create a public service announcement informing people about fatbergs and explaining which materials should or should not be flushed down the toilet. They can create a video, image (e.g., meme or GIF), radio announcement, or an infographic (using an infographic tool such as Canva) about fatbergs.

Ask them what they think should be included in the PSAs and discuss with them what additional features you think should be included in a good PSA. At the least, each PSA should include a:

- Description of what a fatberg is and why they are a problem
- Explanation of how fatbergs are formed
- Summary of the findings from their fatberg experiments
- Call to action for what the public should do, or not do, as a result of this knowledge

Next, give students time to work with their group on creating their PSAs.

Then, after the PSAs are finished, allow students to present them to the class and get feedback from one classmate and the teacher.

Last, have the class vote on which PSA they think would be most impactful to their school. Give students a chance to discuss how they think that PSA should be distributed to the school community (e.g., read on the daily announcements, posted online, etc.) and work with them to get that to happen in a manner consistent with the requirements and practices of the school.

**Share what students create with Great Lakes Now by emailing students' experimental results (from Activity 2) or their PSAs (from Activity 3) to gln@dptv.org or by posting photos of them on Facebook or Twitter with @GreatLakesNow!*

SYNTHESIS: Give students individual thinking and writing time in their notebooks to synthesize their learning by jotting down their own reflections using a Word, Phrase, Sentence protocol, with:

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CLOSURE: Have one student share a response from each of the categories of the 3, 2, 1 Review. Depending on the available time, the teacher can make connections between the ideas students share and the learning objectives of the lesson, and respond to the question that is shared.

EXIT TICKET: Students write an "I used to think… Now I think…" statement about what they flush down the toilet.

About the Author

Gary is an educational consultant, award-winning science educator and the author of *Science With Scarlett*. He is also a double cornea transplant recipient who, since having his sight restored, was moved to use his teaching gifts to make science fun for kids. He lives with his family near Detroit and designs learning experiences to inspire children, like his own daughter, to love science. Gary is the 2014 recipient of the Michigan Teacher of the Year honor. Contact him via his consulting firm, Saga Educators, or connect with him on Twitter.

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