GREAT LAKES LEARNING

LESSONS & ACTIVITIES BASED ON THE MONTHLY GREAT LAKES NOW PROGRAM

EPISODE 2405 | SAVING WHITEFISH AND NAVIGATING NIAGARA

ALL ABOUT AQUACULTURE

OVERVIEW

This lesson will explore the phenomenon of **whitefish population decline** in the Jordan River by Green Bay, WI. Whitefish are an important source of food and commerce in the Great Lakes, but for over a century the population has been in flux due to a number of factors ranging from human impact to invasive species and climate change. As students learn about aquaculture efforts to address the fluctuations in fish populations, they will model the impact of invasive species on the food web, engage in water quality testing, and simulate species competition.

LESSON OBJECTIVES

- **Know** what aquaculture is and how it works
- **Understand** how invasive species affect the food web dynamics and can impact whitefish populations
- **Be able to** test water samples for various markers of water quality and ecosystem health

WHAT YOU'LL NEED

- Computer or mobile device with Internet access to view video and online resources
- Notebooks and pencils
- Chart paper
- Sticky notes
- Markers
- Lab supplies (see individual activities for a full list)
- Copies of the Student Handouts

GreatLakesNow
Detroit Public TV

Michigan LEARNING CHANNEL
A PUBLIC MEDIA PARTNERSHIP

INTRODUCTION

Whitefish are one of the most important freshwater species to the Great Lakes. As a source of food, the basis of a large proportion of the fishing industry, and an indicator of ecosystem health in the waters of the Great Lakes rivers and lakes, their populations are closely monitored by Departments of Natural Resources. When the whitefish numbers are in flux, how do scientists know what the cause is or how to fix the problem? The factors that affect the whitefish population are myriad, and the focus of this lesson is to investigate some of the most common influences on the populations of whitefish and efforts happening in the Great Lakes—including that of aquaculture—to bring the populations numbers in nature back up to desired levels.

This lesson includes multiple activities, including lab activities, that can span the course of several sessions or be adapted to fit the needs of your group's meeting format.

Some prior knowledge* with which students should be familiar includes:

- food chains and food webs
- predator prey relationships
- ecosystems
- properties of water
- measurement

Follow this QR Code or hyperlink to the Episode Landing Page!

*Check out our full collection of lessons for more activities related to topics like these.

**The sequence of these activities is flexible, and can be rearranged to fit your teaching needs.

NGSS CONNECTIONS

Phenomenon: Whitefish Population Decline

- LS2.A
- LS2.C
- ESS3.C

- SEP 2
- SEP 3
- SEP 4
- SEP 6

During the course of the lesson, students will progress through the following sequence** of activities:

- Class discussion to elicit and activate prior knowledge about **whitefish**
- Teacher notes on **aquaculture** in Lake Superior
- Watch a segment from *Great Lakes Now* about the warming waters of Lake Superior
- Class discussions to debrief the video
- Read about **fish farming** and **whitefish** in the Great Lakes
- Conduct an experiment to **test water quality** factors important to fish population
- Investigate how **food web dynamics** are impacted by invasive species
- Simulate **competition for food resources** between fish eggs and invasive species

The lesson progresses through three major sections: **launch, activities, and closure.** After the launch of the lesson, you are ready to begin the lesson activities. Once finished with the activities, students will synthesize their learning in the closure. You can select the activities that are best suited for your learners and teaching goals, and then sequence them in a way that makes sense within your learning progression and the scaffolds of the lesson.

If you use this lesson or any of its activities with your learners, we'd love to hear about it!

Contact us with any feedback or questions at:
GreatLakesNow@DPTV.org

TEACHER BACKGROUND INFORMATION

by Gary G. Abud, Jr., Great Lakes Now Contributor

This information can be presented by the teacher as notes to students at the teacher's discretion.

Restoring lake whitefish populations in the Great Lakes is a big job that needs an understanding of many different scientific ideas, and how they work together in nature, in order to address. Some of those topics include studying how animals interact with each other and their environment, how their populations change, and how technologies such as aquaculture can support populations of fish out in their natural habitats.

Some of the biggest factors affecting whitefish populations that we can study include the competition for resources. How animals interact with each other within the **food web** is very important for identifying reasons that whitefish populations have been in flux. For example, sea lampreys, which are predators, have harmed whitefish a lot, so controlling these predators is crucial. Also, other invasive species like zebra mussels make it harder for whitefish to thrive by eating their natural food sources in the ecosystem.

Population dynamics helps us understand how the number of whitefish changes based on things like habitat quality, **water quality** conditions, and food availability. Restoring habitats means creating good places for whitefish to spawn and grow. This includes making sure there are clean, oxygen-rich rivers with the right kind of bottom for whitefish eggs to attach to, which helps them survive and grow.

It also means learning how **invasive species** like zebra mussels can outcompete the whitefish for food. Managing these invasive species is about protecting native whitefish habitats and biodiversity in the Great Lakes.

Climate change makes these problems worse by changing water temperatures, which can mess up **spawning patterns** since whitefish spawn, and their eggs hatch, at certain temperatures. Changing temperatures offset their natural cycles for reproducing.

Managing fisheries means making sure we don't overfish while allowing whitefish populations to recover. Sustainable fishing practices help balance fishing with conservation, so whitefish can grow in number and support fishing activities. But human activity, such as demand for whitefish, can complicate these efforts.

That is why **aquaculture** can be a helpful solution. It is the practice of farming or growing aquatic organisms under controlled conditions. It involves breeding, raising, and harvesting fish, shellfish, and plants in ponds, tanks, or ocean enclosures. Aquaculture and hatchery techniques help conservation efforts by improving ways to raise whitefish in controlled environments. This can provide a source of supply to meet demand without further depleting natural populations. For example, in-stream incubators simulate natural spawning conditions and help young fish survive before releasing them into the wild, which helps the population grow.

In the end, restoring lake whitefish populations in the Great Lakes needs a complete scientific approach that includes ecology, biology, climate science, and management practices. Understanding how all these parts work together is essential for creating strategies to ensure the long-term survival and health of whitefish populations in the Great Lakes.

LESSON LAUNCH

A. Warm Up

The warm up is intended to be structured as teacher-facilitated, whole-group student discussion activities. It helps students to begin thinking about the topic at the center of the lesson.

1. Ask students to list out on a piece of paper five things that come to mind when thinking of **whitefish**.
2. Have students pair up with a partner to share their five ideas with each other. If any ideas appear on both lists, have students circle those.
3. Then, engage students in a whole-group discussion to ask them to share any ideas that were circled.
4. Generate a list of the circled ideas.
5. Ask for volunteers to share any ideas that were not circled that they think are really important to include in this topic.
6. Generate a separate list of those ideas.
7. At the end of making the two lists, have students copy down one single list of all the circled ideas and important ideas in their notebooks or on their paper.
8. Ask students individually to rank the ideas in the list from most to least relevant.
9. Ask for some students to share which term should be most relevant and why they think that is. Engage the whole group in discussion to arrive at consensus about the most relevant idea related to **whitefish** that they already know about or that came to mind during this exercise.

B. Bridge to Learning

Play a quick game of musical chairs with students to simulate the impact that scarcity with resources can have on a population. Begin the game with your entire group, but instead of pulling one chair out each round, roll a die to determine how many chairs to remove. At the end, or after a few rounds, discuss with students how the competition for food resources (e.g., chairs) affects populations.

C. Close Reading a Video

Show this PBS LearningMedia video of **Aquaculture for a More Sustainable Future** and ask the students to consider how aquaculture can be beneficial. Before students respond, have them do the following with a partner:

- **Review the video** and take notes on key points, visuals, and any questions or observations that arise.
- **Summarize the main content** of the video and identify the primary themes or messages it conveys.
- **Discuss the visual elements**, e.g., angle, lighting, etc., used in the video and how they contribute to its storytelling impact.
- **Explore the concept** of skiing in the video.
- **Engage in a discussion**, sharing insights, reactions, and interpretations of the video as it relates to the question.
- **Answer the question** in a class discussion, allowing partners to talk with other students and share ideas or ask follow-up questions to one another. Facilitate the discussion to arrive at a consensus about how aquaculture can be beneficial and compare to their prior predictions.

D. Background Information Notes

Explain that you will be investigating more about **whitefish and aquaculture** before providing notes from the **Teacher Background Information**.

ACTIVITY 1: WATCH A GREAT LAKES NOW SEGMENT

This activity is a video discussion of a *Great Lakes Now* episode segment.

First, inform students that they will be watching a *Great Lakes Now* segment discussing how aquaculture is being used to help the whitefish population bounce back from decline in Great Lakes rivers. During the video they need to jot down four things they took away from the video using the **4 Notes Summary Protocol**.

Then, if students are not already familiar, introduce them to the 4 Notes Summary Protocol, which they will use after they finish watching the video, where they write down 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 wanting to know more)
- **Huh?** (a question they have afterward)

Next, have students watch the segment from episode 2405 of *Great Lakes Now* called **Can Rivers Save Whitefish?**

Last, have students complete their individual 4 Notes Summary and then discuss those in groups of 3-4 students.

> *Teaching Tip: Use the Student Handouts to help students organize their thinking in writing around each of the lesson protocols.*

Post-Video Discussion

After the groups have had time to go over their 4 Notes Summaries, invite a handful of students to share out some of their notes, eliciting at least 1-2 of each of the 4 Notes and listing those somewhere for the whole group to see.

Ask students to turn back and talk with their groups to make connections between the *Great Lakes Now* video and what they remember from the warm-up activities.

How is what we saw in the video related to what we discussed earlier during the lesson launch activities?

After giving the groups some time to talk, bring the whole group back together for a shareout and discussion of ideas.

In this culminating discussion, the goal is to help students make connections between the video segment and what they discussed during the launch activities earlier in the lesson about what they knew about **whitefish.**

Once the discussion finishes, have each student write a "**Sum It Up**" statement in their notebooks. This is a single sentence that captures the big idea of what was just learned.

Have 2-3 students share out their **Sum It Up** statements before concluding this activity.

ACTIVITY 2: READ ABOUT FISH FARMING IN THE GREAT LAKES

As natural habitats degrade, invasive species disrupt food sources, and the culinary demand for fish impacts the naturally-occurring supply, the need for the fish-equivalent of cattle ranching, known as aquaculture, continues to increase. The so-called industry of fish farming has grown in recent decades, including in the Great Lakes, and is now being studied for its impact, costs, and benefits in the region. Students will read about an ongoing study into the aquaculture of the Great Lakes.

In this activity, students will use a **Think Pair Square Protocol** for discussing what they will read about this very topic.

First, have students partner up and distribute the article **Grant Funds Study of Great Lakes Aquaculture** by Carin Tunney from *Great Lakes Echo.* Allow time for students to individually read the article, and have them jot down three things they took away from the article using the **Rose Thorn Bud Protocol**—in their notebook or using the handout.

Then, give students time after reading to discuss the article that they read with their partner. Have students share their rose, thorn, and bud with each other, including how those points connect to each other. The pair should come up with a statement to summarize all of their article takeaways.

Next, have two student pairs join up, standing near each other to form the four corners of a square, to discuss the article and what they talked about in their pairs. Encourage them to come to a consensus about which point they found most important or interesting in the article.

Last, have each group craft a summary statement of the most important point from their discussion and ask for a volunteer in each group to share that key point with the whole group. As student groups share their most important point, record their ideas on the board and have students copy the list of student ideas down into their notebooks. Once the shareout is complete, ask students to return to their groups and discuss one last question based on the article:

What might make you supportive or opposed to expanding aquaculture in the Great Lakes?

You can keep this as a class discussion based on the article itself or, after giving the groups some time to discuss this question, invite them to further research the topics, points of interest, or themes discussed in the article by generating a research question, identifying additional sources, and presenting their findings.

> *Teaching Tip:*
> *If the reading level of the article is going to be tough for some students to read individually, have partners or small groups read the article together aloud while each follows along, or the teacher might read the article to the entire class.*

ACTIVITY 3: SIMULATING SPECIES COMPETITION FOR FOOD
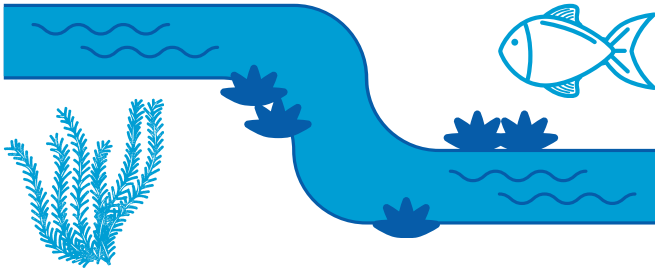
The purpose of this activity is for students to simulate and understand the competition for food resources between fish eggs and invasive species in an ecosystem.

Materials:
- Graph paper with at least 1,000 boxes that could fit centimeter cubes in them
- Four different colors of centimeter cubes (roughly 100 of each per group)
- Scissors (if using individual sheets of graph paper)
- Dice (for species distribution)
- Notebooks and pens to record data

First, inform students that they will be simulating the competition for food resources that takes place between whitefish and zebra mussels.

Then, have students form groups of 4 and obtain the materials needed to perform the simulation.

Next, have them review* the rules of the game. Two students from each group will strategically represent the fish and the other two will strategically represent the zebra mussels. Each team is competing for the food resources needed to allow its species to survive, reproduce, and live on to see another generation.

Set up of the game:
- Each group receives a sheet of graph paper.
- Place 100 of one color of centimeter cubes in some squares on the grid within the entire area to represent food sources for the species.

Teaching Tip: two colors can be used to represent two different food sources, if desired, which might represent higher nutrients, and thus may cut in half the amount needed to eat to reproduce.

Simulation Game Rules:
1. Begin by distributing the centimeter cubes representing fish eggs and zebra mussels on the graph paper. Students can strategically select placements or randomly set them on the grid.
2. Students take turns rolling the dice to determine how many additional zebra mussel cubes they can add to cover more food source squares on the graph paper. Placement of the invasive species can be strategic (e.g., clumped distribution, uniform arrangement, or random placement).
3. After placing the invasive species for the round, roll the dice again to determine the number of cubes representing fish eggs to place. Fish eggs should be clumped together to simulate spawning in concentrated areas. _Note: If there aren't enough squares to clump all the fish eggs, only add as many as there are available squares._
4. At the end of each round, count the number of zebra mussels and fish eggs remaining on squares within the grid.
5. Determine survival and reproduction based on the number of food source squares occupied, e.g., fish eggs require 6 squares, while zebra mussels need 4 to reproduce.
6. Introduce additional fish egg and zebra mussel cubes in subsequent rounds based on surviving populations and reproduction rates, but don't remove existing cubes.
7. The game progresses through 5 rounds, or until no food sources (or cubes) remain.
8. Be sure to record the number of each species at the start and end of each round.

Post Game Discussion:
Last, after playing the game for some time, have students graph the populations of each species over time on chart paper and be prepared to present their findings. Facilitate a discussion with the whole class to compare the outcomes of each round. How did the distribution of fish eggs and invasive species impact food availability and reproduction? How does this simulation reflect competition in natural ecosystems affected by invasive species? Relate the simulation findings to whitefish ecological challenges and conservation efforts.

ACTIVITY 4: INVESTIGATING FOOD WEB DYNAMICS
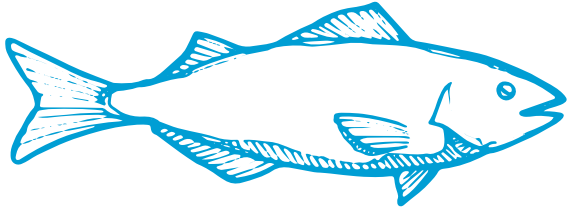
The purpose of this activity is for students to explore the impact of invasive species on the food web dynamics crucial for whitefish survival in the Great Lakes ecosystem.

First, inform students that they will be investigating how the Great Lakes food web is impacted by invasive species, specifically how zebra mussels are affecting the whitefish population. Begin with a discussion to review food webs. Discuss the importance of a food web to an ecosystem like those found in the Great Lakes. Explain how organisms in a food web are interconnected through the transfer of energy by producers and consumers, predators and prey, in various relationships to each other.

Then, have them partner up with someone for the project. Direct them to begin their research by exploring the **Great Lakes Now Guide to Zebra Mussels**, which will introduce students to the good and bad of this lake invader. In the end, they will be creating an infographic that communicates their research on the impact that the invasive species has on the food web.

Next, further focus their research by assigning students to investigate:
- Key species in the food web (e.g., whitefish, zebra mussels, plankton, other predators).
- Interactions between these species (e.g., predator-prey relationships, competition for resources).
- The role of zebra mussels as invasive species and their impact on native species, especially whitefish.

Allow students time to conduct their research and gather information. Encourage students to use credible sources such as scientific journals, government publications, and reputable websites. They should collect data on population trends, ecological impacts, and any research findings related to zebra mussels and whitefish interactions.

Last, instruct students to create an infographic based on their research that visually represents the following:
- Structure of the Great Lakes food web, including different trophic levels (producers, consumers, decomposers).
- Specific interactions between zebra mussels and whitefish, with emphasis on how zebra mussels affect:
  - Food availability and competition.
  - Habitat alteration (e.g., filter feeding impacting plankton populations).
  - Potential indirect effects (e.g., changes in water clarity affecting fish spawning grounds).

The infographic should include:
- Visuals like icons, charts, or diagrams to illustrate relationships and data.
- Captions or annotations explaining each component of the food web and the impact of zebra mussels.
- Key statistics or findings from their research presented in a clear and organized manner.

Allow students to present their infographics to each other, comparing and connecting their research on the significance of food web dynamics in Great Lakes ecosystems.

*Teaching Tip: If having students create a digital infographic, consider curating a set of templates for them to choose from ahead of time and make those available.

ACTIVITY 5: TESTING FACTORS THAT AFFECT WATER QUALITY

The purpose of this activity is for students to assess water quality parameters that affect whitefish spawning and growth in different aquatic environments.

Materials:
- Water samples from various sources (rivers, lakes)
- Water testing kits or probes/sensors (for temperature, pH, dissolved oxygen, turbidity, and other relevant parameters)
- Notebooks and pencils to record data

Note: if obtaining actual lake/river water samples is not possible, students can obtain water samples from any available source to test the various parameters and then look up water quality information from a monitoring organization online to learn about the water quality measures in the Great Lakes.

First, inform students that they'll be studying water quality and its affect on fish populations like whitefish. To first understand the water quality markers that are important to the Great Lakes ecosystems, have them review and research the Environmental Protection Agency's **Great Lakes Water Quality Monitoring Program**. Based on your available water testing tools, select several parameters from the EPA's list to test. Next, have them research the water quality standards needed for whitefish to spawn and thrive.

Next, have students partner up and obtain the supplies needed to perform the water quality testing experiment. Give each pair several water samples to test and have them take measurements of the various water quality parameters that you have selected as important for Great Lakes water health.

Then, allow students time to capture their quantitative measurements and record some qualitative observations about the water (e.g., smell, look, etc.) and record them in their log.

Last, have a way to compile class data from each of the lab groups that took measurements. This will help account for any variance in measurements taken among similar samples. Make the class data available for the entire group to analyze. Give groups time to identify which samples meet the optimal conditions for supporting healthy whitefish spawning and growth.

Facilitate a class discussion on the significance of each water quality parameter in relation to whitefish biology and ecology, e.g. temperature ranges to support spawning, pH levels that are harmful to fish eggs and larvae, available oxygen needed for fish, and turbidity levels that could reduce visibility to fish.

*Teaching Tip: You can obtain real-time data in lieu of doing water testing, or to compare the findings from their experiment, using the Great Lakes Environmental Research Laboratory's database at: glerl.noaa.gov/data

ACTIVITY 6: READ ABOUT WHITEFISH IN THE DETROIT RIVER

Historically, the Detroit River was renowned for its abundant fisheries, including lake whitefish in the late 1800s. However, over-harvesting and habitat degradation, exacerbated by the construction of shipping channels like the Livingstone Channel, led to severe declines in the fish populations by the early 1900s. Students will read about the significance of lake whitefish in the Great Lakes region, particularly focusing on population changes in Lake Erie and the Detroit River.

In this activity, students will use a **Think Pair Square Protocol** for discussing what they will read about this very topic.

First, have students partner up and distribute the article **Detroit River's Important Role in Lake Whitefish** by John Hartig from *Great Lakes Now.* Allow time for students to individually read the article, and have them jot down three things they took away from the article using the **Rose Thorn Bud Protocol**—in their notebook or using the handout.

Then, give students time after reading to discuss the article that they read with their partner. Have students share their rose, thorn, and bud with each other, including how those points connect to each other. The pair should come up with a statement to summarize all of their article takeaways.

Next, have two student pairs join up, standing near each other to form the four corners of a square, to discuss the article and what they talked about in their pairs. Encourage them to come to a consensus about which point they found most important or interesting in the article.

Last, have each group craft a summary statement of the most important point from their discussion and ask for a volunteer in each group to share that key point with the whole group. As student groups share their most important point, record their ideas on the board and have students copy the list of student ideas down into their notebooks. Once the shareout is complete, ask students to return to their groups and discuss one last question based on the article:

What makes whitefish so important to the Great Lakes region?

You can keep this as a class discussion based on the article itself or, after giving the groups some time to discuss this question, invite them to further research the topics, points of interest, or themes discussed in the article by generating a research question, identifying additional sources, and presenting their findings.

Teaching Tip:
If the reading level of the article is going to be tough for some students to read individually, have partners or small groups read the article together aloud while each follows along, or the teacher might read the article to the entire class.

LESSON CLOSURE

After the conclusion of all the activities, help students to make connections* between everything they did in the lesson and what they learned overall.

A. Free Recall

Group students in pairs or triads (e.g., in groups of 2-3 partners) and distribute the **Free Recall Protocol handout**, Alternatively, you can have students do this in their notebooks. Set a 3-min timer and have students generate a list of everything they can remember learning about in this lesson related to the central topic of the lesson. This doesn't have to be in depth, just whatever each group can call to mind. Have them draw lines between any terms that relate to one another. After the timer finishes, give groups a chance to volunteer to share aloud 2-3 things from their free recall lists and any of the connections that they made with those. Jot down any ideas that come up multiple times during the shareout for the whole group to see.

B. Lesson Synthesis

Give students individual thinking and writing time in their notebooks to synthesize their learning, by jotting down their own reflections using the **Word, Phrase, Sentence Protocol.**

In the Word-Phrase-Sentence Protocol, students write:

- 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

C. Cool Down

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

After sharing their syntheses, have students complete a **3, 2, 1 Review** for the lesson with their partner, recording in their notebooks or, optionally, on exit ticket slips to submit, each of the following:

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

Invite several students to share aloud what they wrote in either the synthesis or 3, 2, 1 Review.

Lastly, ask one student volunteer to summarize what has been heard from the students as a final summary of student learning.

Optionally here, the teacher can revisit the learning objectives and make connections more explicit for students.

> *__Teaching Tip:__ Use the Student Handouts to help students organize their thinking in writing around each of the lesson protocols.*

NAME: _____

A Word, Phrase, Sentence Protocol

What is a **word** that you thought was most important from this lesson?

What is a **phrase** that you would like to remember from this lesson?

What is a **sentence** that sums up what you learned in this lesson?

3, 2, 1 Review Protocol

What are **3 things that you liked or learned** from this lesson's activities?

-
-
-

What are **2 ideas that make more sense** now to you?

-
-

What is **1 question that you were left with** after this lesson?

-

NAME: _____

Free Recall Protocol

With 1-2 partners, generate a list of everything you can remember learning about in this lesson related to the central topic of the lesson. Draw lines between any terms that relate to one another.

NAME: _____

4 Notes Summary Protocol

OOOH!

Something that was interesting to you

AAAH!

Something that became clearer; an "ah-ha" moment

HMMM...

Something that left you wanting to learn more

HUH?

Something you questioned or wondered

Sum It Up Statement:

Summarize your group discussion about your 4 Notes Summaries below:

NAME: _____

Think Pair Square Protocol

THINK
Write down your own individual ideas

PAIR
Summarize what you and your partner discussed

SQUARE
Summarize what your group discussed

NAME: _____

Rose, Thorn, Bud Protocol

ROSE

Something that "blossomed" for you in your learning

THORN

Something that challenged your thinking or was difficult to understand

BUD

Something that's new and growing in your mind — a "budding" idea