TEACHING GREAT LAKES LITERACY

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Flexing their mussels: The population power of *Dreissenid* mussels in Lake Michigan

TOPIC: Invasive Species Impact, Population Density, Native Mussel Species, Life Cycles

GRADE: 9-12

TIME: 60 minutes

DATA PROFILE:
What: *Dreissenid* mussel population density from whole lake benthic surveys in Lake Michigan
When: 1994/1995, 2000, 2005, 2010, 2015, 2021
Source: NOAA and EPA

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

#7 Much remains to learn about the Great Lakes

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Driving Question: What are the ecological consequences when a non-native species invades a new environment?

Overview

This lesson provides students with an understanding of the life cycle of *Dreissena* mussels, their population density, and their significant impact on Lake Michigan's ecosystem.

Anchoring Phenomenon

Students simulate a PONAR grab and collect data to determine the population density of quagga mussels in a specific area of Lake Michigan.

Essential Questions

- How does the life cycle of the *Dreissenid* mussel compare to that of the native freshwater mussels?
- How does rapid reproduction contribute to the zebra and quagga mussel's invasive nature, specifically population density?
- What are the environmental, economic, and social impacts of *Dreissenid* mussels in the Great Lakes region?

Learning Objectives

Students will be able to:

- Analyze data to determine the distribution of quagga mussels in Lake Michigan.
- Describe the life cycle of zebra and quagga mussels.
- Identify the environmental, economic, and social impacts of zebra and quagga mussels in the Great Lakes region.
- Explain efforts to manage and control invasive mussel populations.

3-P Learning Goals

Problem, Project, Place-Based Education

This learning plan offers students the opportunity to explore actual data of *Dreissenid* mussels in Lake Michigan and pose questions around the impacts of this invasive species on ecosystems across the Great Lakes Basin. This lesson can be a launching point for exploring other invasive species in the watershed and how they affect communities and local ecosystems.

If you have the ability to take your students out for a field experience, invasive mussel inventories and learning how to Clean, Drain, Dry are ways to further explore this problem with a place-based lens.

- Midwest Invasive Species Information Network (MISIN) online reporting tool: Use to report this species.
- COMPASS and the Message Box Workbook: Use to make a communication action plan about *Dreissenid* mussels.

Materials Checklist

- ☐ Projector or screen to play the video of the PONAR grab being deployed.
- ☐ PONAR Grab Video for engagement
- ☐ 1 large tray per group (12 total stations)
- Beans or beads (decide on what object you want to use to represent the mussels)
  - ☐ You will need 100 beans/beads for the following depths: <30m and >90m
  - ☐ You will need 200 beans/beads for the 31-50m depth
  - ☐ You will need 250 beans/beads for the 51-90m depth
- ☐ Lamination film/clear plastic (3.5in X 3.5in) to represent the PONAR grab (1 m^2). You may use any transparent material to represent the PONAR grab (1 per group).
- Student Pages
  - ☐ Driving Question Board: Paper or digital copy, one per student
  - ☐ Population Density of Quagga Mussels in Lake Michigan: Paper or digital copy, one per student
  - ☐ Density Lab Station Cards: Paper or digital copy, one assigned per group
  - ☐ Class Data Sheet: Paper or digital copy, one per student
  - ☐ Post Activity Questions: Population Density of Quagga Mussels in Lake Michigan: Paper or digital copy, one per student
  - ☐ Lake Michigan Quagga Mussel Density Figure: Paper or digital copy, one per group
  - ☐ How do Mussels Reproduce? Life Cycle Illustration: Paper or digital copy, one per group
- Educator Resources
  - ☐ Slide Deck: Optional tool you can use throughout the lesson – especially in the Elaborate Section
  - ☐ Educator Resource Video with lesson tips from Ashley Cosme, lead lesson author
  - ☐ Setting Up Stations: Reference to help educators set up each tray for the lab
  - ☐ Post-Activity Questions: Population Density of Quagga Mussels in Lake Michigan Answer Key

Standards

Math Standards

Common Core Math Standards:

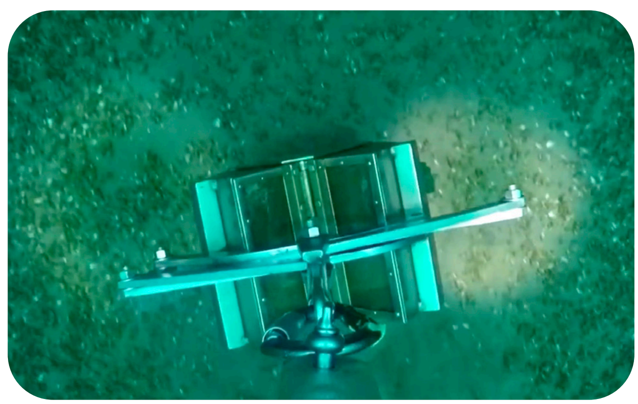
- **HSS-ID.B.6 - Interpret linear models:** Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.
- **HSF-IF.C.7 - Interpret functions that arise in applications in terms of the context:** Graph functions expressed symbolically and show key features of the graph, such as intercepts, maxima, and minima.
- **HSF-LE.A.1 - Construct and compare linear, quadratic, and exponential models and solve problems:** Distinguish between situations that can be modeled with linear functions and with exponential functions.

Science Standards

Next Generation Science Standards Performance Expectations:

- **HS-LS2-6 - Ecosystems: Interactions, Energy, and Dynamics:** Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
- **HS-LS2-7 - Ecosystems: Interactions, Energy, and Dynamics:** Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- **HS-ESS3-4 - Earth and Human Activity:** Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Learning Plan



Lesson Introduction

Quagga mussels (*Dreissena rostriformis*) and zebra mussels (*Dreissena polymorpha*) are small, freshwater mussels native to Eastern Europe. *Dreissena* mussels were first discovered in North America in the late 1980s in Lake St. Clair, near the Great Lakes, after being transported accidentally in ballast water from transoceanic ships. They quickly spread to all five Great Lakes. The high population density of quagga mussels in Lake Michigan has significant ecological effects.

Invasive quagga mussels are so influential in Lake Michigan's food web that their rising population throughout the Great Lakes is alarming. In 2015 scientists on the R/V (Research Vessel) *Lake Guardian* measured the density and biomass of quagga mussels all across the lake using a traditional sampling method called a PONAR grab. The scientists could not possibly count every single invasive quagga mussel in Lake Michigan. One way they estimated the density of a population was to collect data by taking random samples at specific locations. Three PONAR grab samples were taken at each station, and the quagga mussels were counted and recorded (number of quagga mussels/m^2).

In this lesson students will simulate a PONAR grab in the classroom and record population density data for invasive quagga mussels. There is a "Driving Question Board" in the student pages section of this lesson. This board can be used as a "whole class" debriefing tool periodically throughout the lesson, or as an independent reflection tool for students.

Engage

In the engagement portion of our learning cycle, students will view a video of a PONAR grab sampler being deployed off the side of a boat in Lake Michigan. A PONAR grab sampler is a device used to collect sediment samples at the bottom of freshwater lakes, as well as the ocean. PONAR grab samplers "grab" living organisms that are present on or in the sediment that is collected. Scientists use the PONAR grab sample to determine how many quagga mussels are in a specific area.

Use the PONAR Grab video to facilitate a full class discussion with students. The following prompt and questions can help guide the discussion. Record student answers on a whiteboard, chart paper, or digitally. The discussion notes can be organized into a "Think, Notice, Wonder" chart. Save or photograph these notes to review at the completion of the learning cycle.

Watch the PONAR grab video.

Video Prompts

- What happened?
- What questions come to mind when watching?
- What do you hear?
- What do you think this device is used for?
- How can you learn more about what is happening in this video?

Explore

Your role as the learning facilitator will allow students to experience a simulated PONAR grab and collect data to determine the population density of quagga mussels in a specific area of Lake Michigan. There are 12 station cards created with real data taken from NOAA's Great Lakes Environmental Research Laboratory (GLERL) scientists. Before you assign ONE station card to each group, you have to set up the lab for your students.

Please watch the Educator Resource Video before setting up each station. Use the Setting Up Stations educator resource for guidance. You will have each tray of "mussels" and a station card that goes with that tray. Within the station cards, there are three cards for each depth. Educators can decide on the number of stations to complete with students and whether to print and cut out cards or use the digital version in the slide deck. Set everything up before students arrive.

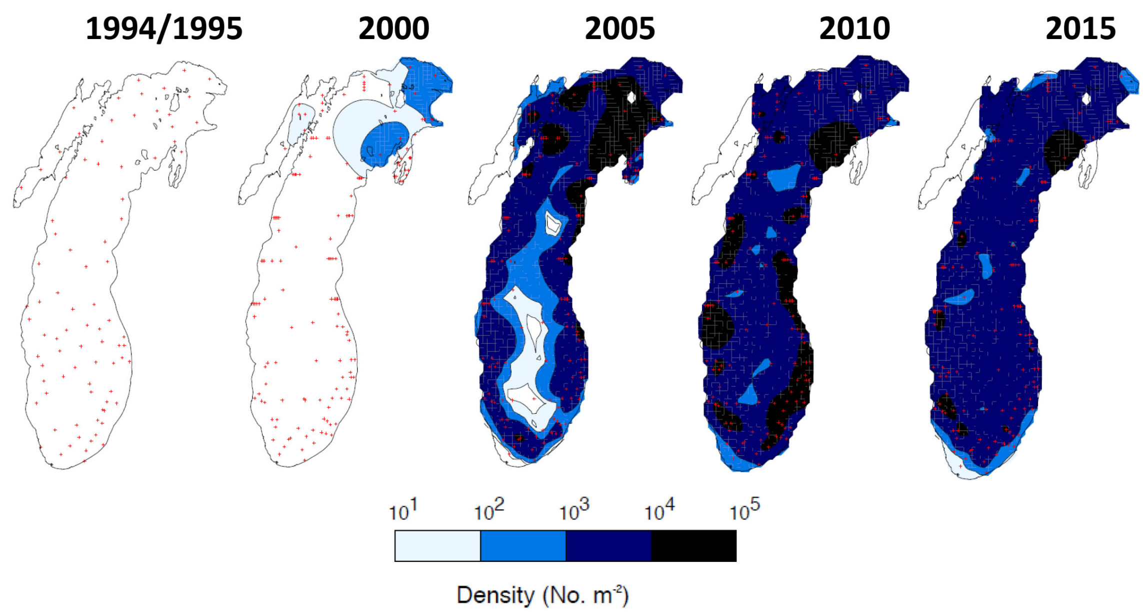
On the day of the activity, you will assign one group to each tray of beans ("mussels") with the corresponding station card. Each student will receive the student sheet, Population Density of Quagga Mussels in Lake Michigan. Students will complete the steps in the procedure and record their data. Model the procedures for your students. Please watch the Educator Resource Video again to view the procedure if needed.

Once they have completed three trials they will add their data to the Class Data Sheet.

Explain

Explain: Part One

In the Explain phase of our learning cycle, our goal is to support students in processing and understanding all the material they've explored, deepening their grasp of possible answers to our driving question and anchoring phenomenon. In this portion of the lesson, students will complete the "Post Lab Questions" sheet. In the post-lab questions students will view an image of *Dreissenid* mussel population density from whole lake benthic surveys in Lake Michigan. The Lake Michigan Quagga Mussel Density figure could be displayed on a screen in the front of the room, or printed and laminated to be shared in small groups. Before discussing the image, ask your students to look at it and try to explain what data the image is displaying.



Density (no. per m2) of *Dreissena r. bugensis* in Lake Michigan based on lake-wide surveys in 1994/1995, 2000, 2005, 2010, and 2015. Small red dots indicate location of sampling sites. Source: Figure 3 from Nalepa et al. 2020. NOAA GLERL TM-175. doi.org/10.25923/g0d3-3v41

Scientists count every single mussel that is brought up in the PONAR grab. Because the area of a PONAR grab sampler is approximately $0.05m^2$, scientists need to multiply the number of mussels retrieved in each grab by 20 ($0.05m^2$ X 20 = $1m^2$). By doing this scientists are converting the counts per grab to $\#/m^2$. Students will analyze data in the Post Activity Questions that was retrieved from Station PET-3 in the northern region of Lake Michigan. They will convert the data to $\#/m^2$. For additional guidance, please review the answer key before students complete the Post Lab Questions.

Explain: Part Two

Students will be given images of the life cycle of a native mussel. The image could be displayed on a screen in the front of the room, or printed and laminated to be shared in small groups.

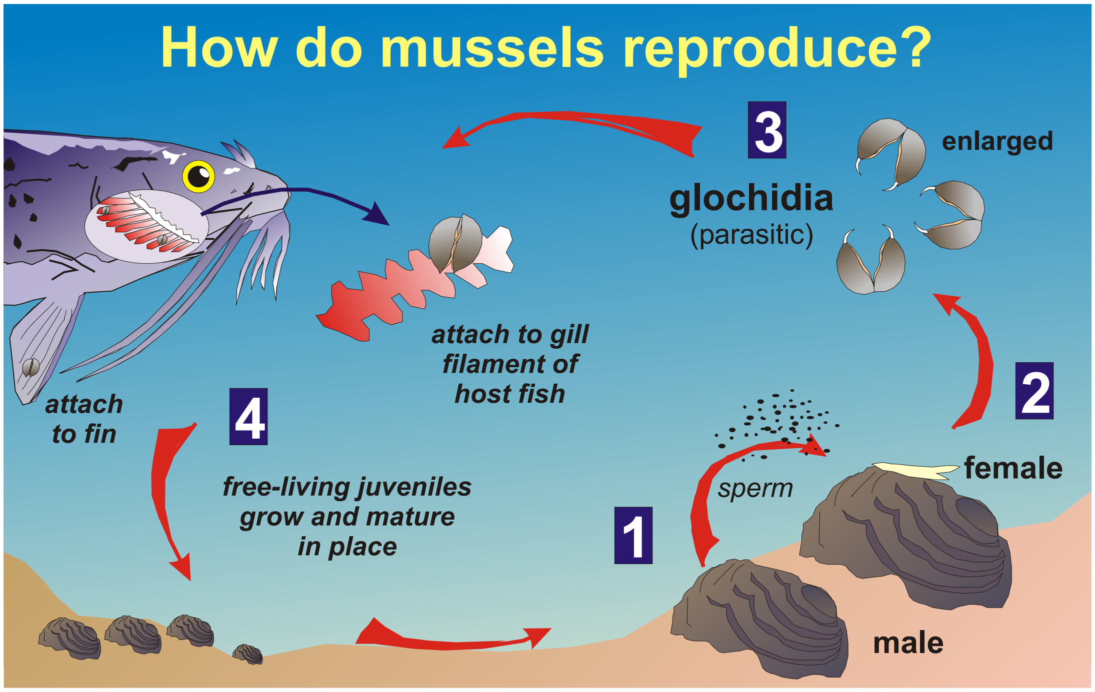


Image courtesy of Karl J. Scheidegger

Ask students to discuss how native mussels and invasive mussel life cycles differ.

- Educator Tip - The invasive mussel life cycle is different because native mussels in Lake Michigan REQUIRE a fish host to complete their life cycle, and quagga/zebra mussels do not. *Dreissenid* mussels produce free-swimming larvae that develop into the adult form WITHOUT a host.
- Due to *Dreissenid* mussels skipping the step where their larvae attach to the gill filament of a host fish, they reproduce much faster than native mussels.

Elaborate

As learners begin to elaborate on the driving question of this lesson, *What are the ecological consequences when a non-native species invades a new environment?*, try to make the connection with students between the population of quagga mussels, the ecological impacts, and the control efforts that local agencies are practicing to try to minimize the effects of quagga mussels. Here is a slide deck for use in the classroom. Feel free to make a copy and adapt!

The following documents provide background information on the history of BOTH quagga and zebra mussels, their success in the Great Lakes, and monitoring techniques. As the educator, you may be able to use information in the document to help your students elaborate on the ecological impacts and management efforts.

- Mussel Facts from the Invasive Mussel Collaborative
- Find an Expert from the Invasive Mussel Collaborative

- Monitoring Methods for Zebra and Quagga Mussels from Wisconsin Citizen Lake Monitoring Network:
    - Written Guide
    - Video Guide

Elaborate Part 1: Discuss ecological impacts

Filter Feeding: Zebra and quagga mussels are filter feeders, meaning they filter large amounts of water to consume plankton. This reduces plankton levels, impacting fish species that rely on plankton for food.

Water Clarity: Increased water clarity might seem like a positive effect, but it allows sunlight to penetrate deeper, leading to excessive growth of aquatic plants and altering habitat conditions. Increased water clarity may also make it harder for fish and other living organisms to hide from predators.

Displacement of Native Species: Zebra and quagga mussels compete with native mussels and other filter feeders, often outcompeting them due to their rapid growth rate.

Economic Impact: Zebra and quagga mussels clog water intake pipes for cities and industries, resulting in expensive maintenance and cleaning efforts.

- Show images of boats, docks, and pipes affected by zebra and quagga mussels and ask students to brainstorm why such attachment is problematic for human activities.

Elaborate Part 2: Discuss Control and Management Efforts

Public Awareness and Education: Boaters are advised to “Clean, Drain, Dry” their boats to prevent the spread of zebra and quagga mussels from one waterway to another.

- Emphasize the role that individuals can play in controlling the spread of invasive species, like zebra and quagga mussels.

Chemical Treatments: Chemical treatments like molluscicides are sometimes used, although they can affect native species.

Mechanical Removal: Power plants and water facilities use mechanical scraping and high-pressure washing to remove zebra and quagga mussels.

Biological Control: Scientists are exploring potential biological controls that would target zebra and quagga mussels without harming native species.

Encourage students to research other invasive species in the Great Lakes, comparing their effects on the ecosystem and discussing what makes zebra and quagga mussels particularly challenging to manage.

Evaluate

To evaluate whether your students understand the ecological consequences of invasive mussels in the Great Lakes, you can use a mix of **formative and summative assessment strategies** that target different levels of understanding—from basic knowledge to deeper critical thinking and application.

Students can use the Driving Question Board to build and support their argument.

- **Claims-Evidence-Reasoning (CER)**
- **Formative Assessment Options:**
  - Ask students to summarize in a few sentences why zebra and quagga mussels are so invasive and one impact they have on the Great Lakes.
  - Ask students to draw a picture to depict their understanding of the invasive zebra and quagga mussels in the Great Lakes.
  - Have students research another invasive species affecting their local environment or a different ecosystem, and compare its impacts to those of the zebra and quagga mussel.
  - Exit ticket example prompt: "Name one ecological effect of zebra mussels in the Great Lakes and explain why it matters."
- **Summative Assessment Options:**
  - Presentation or PSA Project
    - Students create a Public Service Announcement (PSA), infographic, or slideshow to educate the public.
    - Look for: clarity, scientific accuracy, ability to communicate ecological consequences.
  - Short Essay or Position Paper
    - Prompt: "Should more resources be devoted to managing invasive mussels in the Great Lakes? Support your position with ecological evidence."
    - Evaluate their grasp of impacts like: reduced phytoplankton, shifts in nutrient availability, threats to native biodiversity, economic costs (e.g. infrastructure damage).

Driving Question Board

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

Driving Question (DQ)	**How do our local land use practices impact life in the Great Lakes?**		
Activity	What did we do?	What did we learn? (words, concepts)	How can this help us answer the DQ?
PONAR Grab Simulation Lab			
Class Data - Comparing Population Density at Different Depths			
Post Lab Questions - Calculating the Number of Mussels Per PONAR Grab			
Native Mussel vs Invasive Mussel Life Cycle			
Ecological Impacts/ Control and Management Efforts Discussion			

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

____

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

____

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

____

Density Lab Station Cards

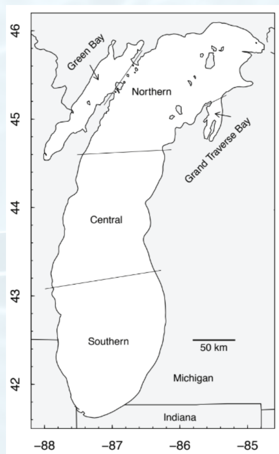
Print and cut out these cards ahead of using them with your students. For a digital version, use the [slide deck].

Station B7

- Years this site has been sampled: 1994, 2000, 2005, 2010, 2015
- Region: Southern
- Depth Zone: 31-50 m
- Actual Depth: 45 m
- Latitude: 42°22.00
- Longitude: 87°40.00

Lake Michigan quagga mussel cluster. Image courtesy of NOAA Great Lakes Environmental Research Laboratory.

Longitude



Latitude

Figure 1. Designated regions of Lake Michigan (Nalepa et al. 2014).

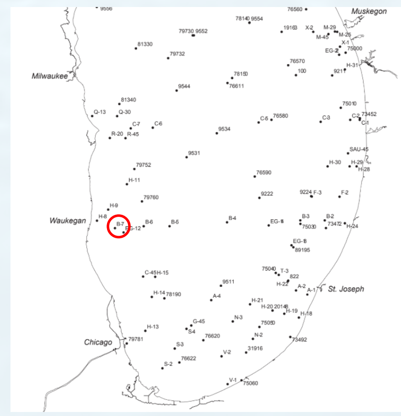


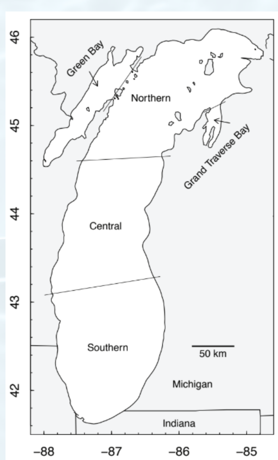
Figure 2. Station designations of sites located in the southern region of Lake Michigan (Nalepa et al. 2014).

Station Q-13

- Years this site has been sampled: 2005, 2010, 2015
- Region: Southern
- Depth Zone: <30 m
- Actual Depth: 13 m
- Latitude: 42°50.63
- Longitude: 87°47.92

Lake Michigan quagga mussel cluster. Image courtesy of NOAA Great Lakes Environmental Research Laboratory.

Longitude



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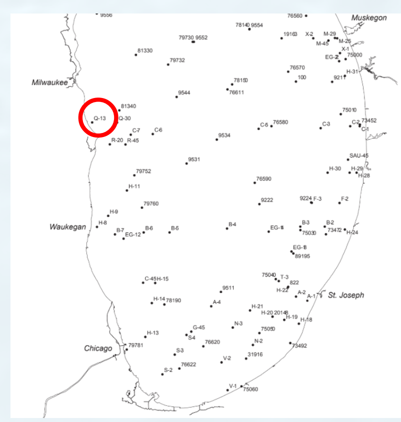


Figure 2. Station designations of sites located in the southern region of Lake Michigan (Nalepa et al. 2014).

TEACHING GREAT LAKES LITERACY

Student Page

Flexing their mussels: The population power of *Dreissenid* mussels in Lake Michigan

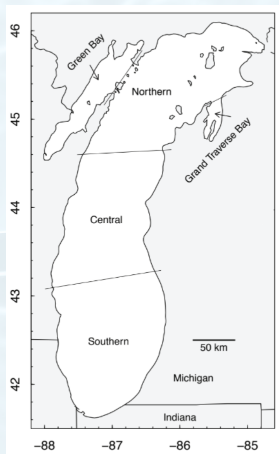
Density Lab Station Cards

Station T-3

- Years this site has been sampled: 2000, 2005, 2010, 2015
- Region: Southern
- Depth Zone: 51-90 m
- Actual Depth: 73 m
- Latitude: 42°10.00
- Longitude: 86°43.00

Lake Michigan quagga mussel cluster. Image courtesy of NOAA Great Lakes Environmental Research Laboratory.

Longitude



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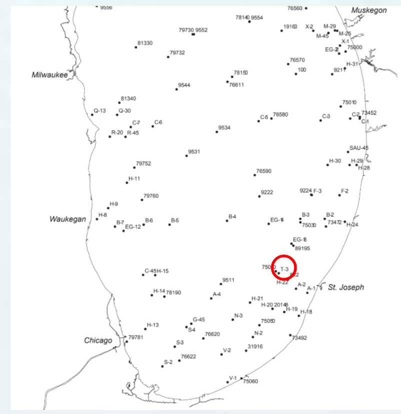


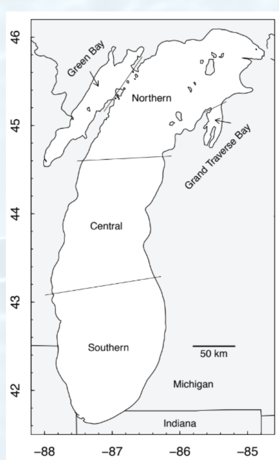
Figure 2. Station designations of sites located in the southern region of Lake Michigan (Nalepa et al. 2014).

Station V-1

- Years this site has been sampled: 2000, 2005, 2010, 2015
- Region: Southern
- Depth Zone: <30 m
- Actual Depth: 16 m
- Latitude: 41°41.80
- Longitude: 87°00.80

Lake Michigan quagga mussel cluster. Image courtesy of NOAA Great Lakes Environmental Research Laboratory.

Longitude



Latitude

Figure 1. Designated regions of Lake Michigan (Nalepa et al. 2020).

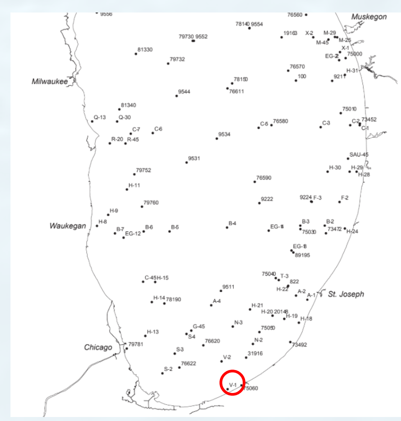


Figure 2. Station designations of sites located in the southern region of Lake Michigan (Nalepa et al. 2014).

Density Lab Station Cards

Station SY-4

- Years this site has been sampled: 2000, 2005, 2010, 2015
- Region: Central
- Depth Zone: 51-90 m
- Actual Depth: 60 m
- Latitude: 43°55.09
- Longitude: 87°30.32

Lake Michigan quagga mussel cluster. Image courtesy of NOAA Great Lakes Environmental Research Laboratory.

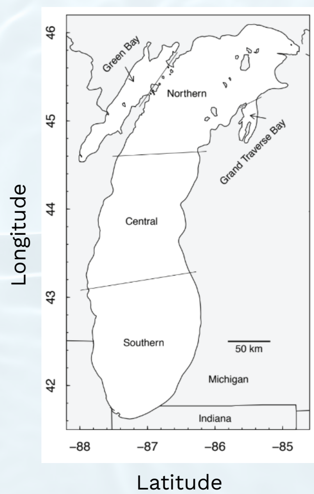


Figure 1. Designated regions of Lake Michigan (Nalepa et al. 2020).

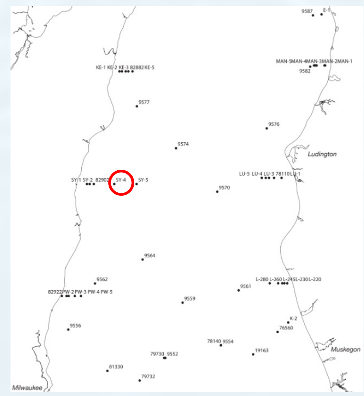


Figure 2. Station designations of sites located in the central region of Lake Michigan (Nalepa et al. 2014).

Station 82902

- Years this site has been sampled: 1994, 2000, 2005, 2010, 2015
- Region: Central
- Depth Zone: 31-50 m
- Actual Depth: 40 m
- Latitude: 43°55.09
- Longitude: 87°37.44

Lake Michigan quagga mussel cluster. Image courtesy of NOAA Great Lakes Environmental Research Laboratory.

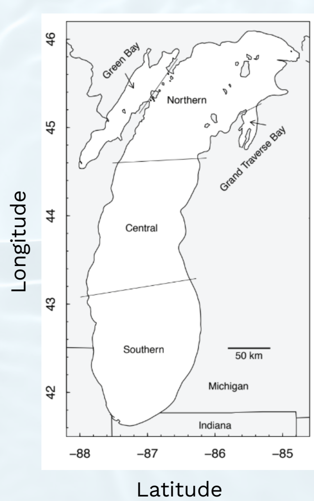


Figure 1. Designated regions of Lake Michigan (Nalepa et al. 2020).

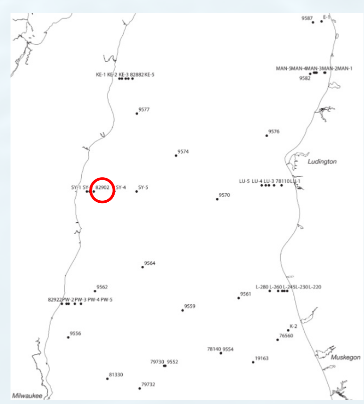


Figure 2. Station designations of sites located in the central region of Lake Michigan (Nalepa et al. 2014).

Density Lab Station Cards

Station 82882

- Years this site has been sampled: 1994, 2000, 2005, 2010, 2015
- Region: Central
- Depth Zone: 51-90 m
- Actual Depth: 60 m
- Latitude: 44°23.30
- Longitude: 87°25.40

Lake Michigan quagga mussel cluster. Image courtesy of NOAA Great Lakes Environmental Research Laboratory.

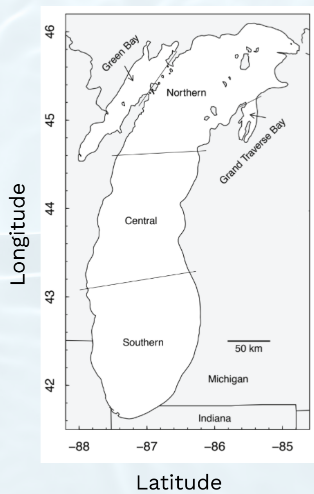


Figure 1. Designated regions of Lake Michigan (Nalepa et al. 2020).

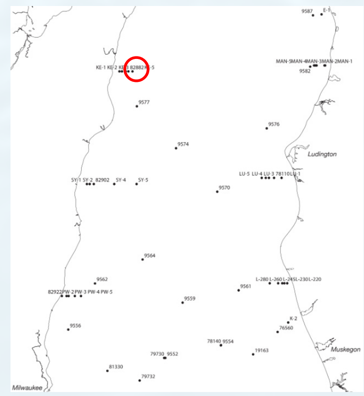
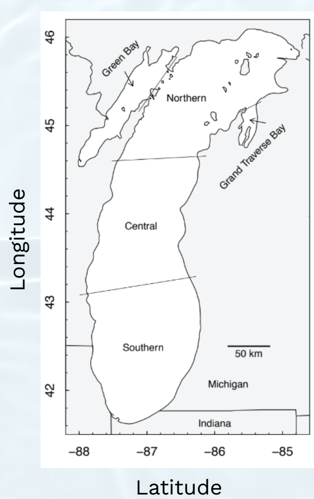


Figure 2. Station designations of sites located in the central region of Lake Michigan (Nalepa et al. 2014).

Station 9570

- Years this site has been sampled: 1995, 2010, 2015
- Region: Central
- Depth Zone: >90 m
- Actual Depth: 174 m
- Latitude: 43°53.16
- Longitude: 86°54.48

Lake Michigan quagga mussel cluster. Image courtesy of NOAA Great Lakes Environmental Research Laboratory.



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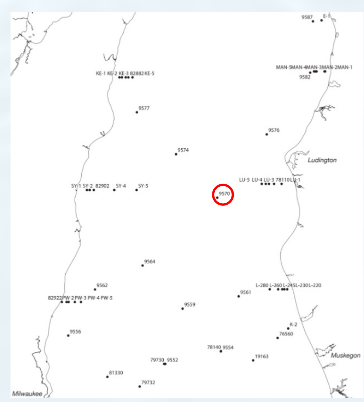


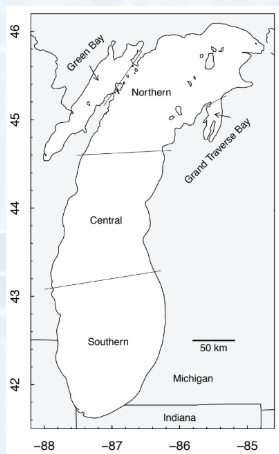
Figure 2. Station designations of sites located in the central region of Lake Michigan (Nalepa et al. 2014).

Density Lab Station Cards

Station WI-1

- Years this site has been sampled: 2000, 2005, 2010, 2015
- Region: Northern
- Depth Zone: <30 m
- Actual Depth: 20 m
- Latitude: 45°14.85
- Longitude: 86°54.30

Lake Michigan quagga mussel cluster. Image courtesy of NOAA Great Lakes Environmental Research Laboratory.



Longitude

Latitude

Figure 1. Designated regions of Lake Michigan (Nalepa et al. 2020).

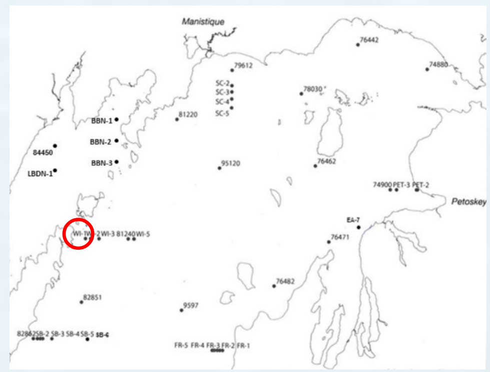
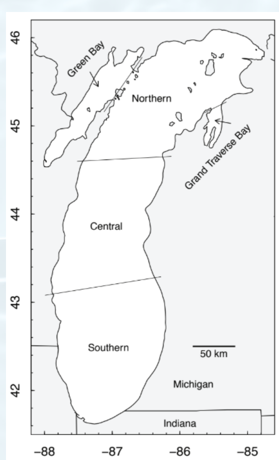


Figure 2. Station designations of sites located in the northern region of Lake Michigan (Nalepa et al. 2014).

Station 95120

- Years this site has been sampled: 1995, 2010, 2015
- Region: Northern
- Depth Zone: >90 m
- Actual Depth: 140 m
- Latitude: 45°31.44
- Longitude: 86°10.14

Lake Michigan quagga mussel cluster. Image courtesy of NOAA Great Lakes Environmental Research Laboratory.



Longitude

Latitude

Figure 1. Designated regions of Lake Michigan (Nalepa et al. 2020).

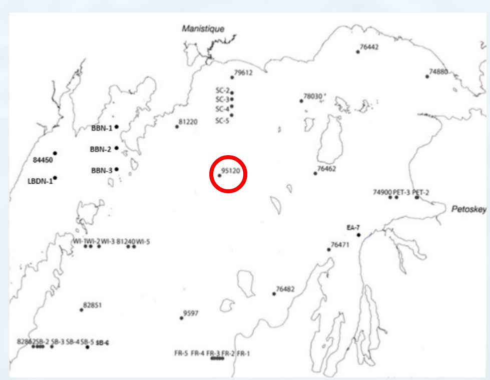


Figure 2. Station designations of sites located in the northern region of Lake Michigan (Nalepa et al. 2014).

Density Lab Station Cards

Station 76471

- Years this site has been sampled: 1994, 2000, 2005, 2010, 2015
- Region: Northern
- Depth Zone: 31-50 m
- Actual Depth: 32 m
- Latitude: 45°14.52
- Longitude: 85°33.36

Lake Michigan quagga mussel cluster. Image courtesy of NOAA Great Lakes Environmental Research Laboratory.

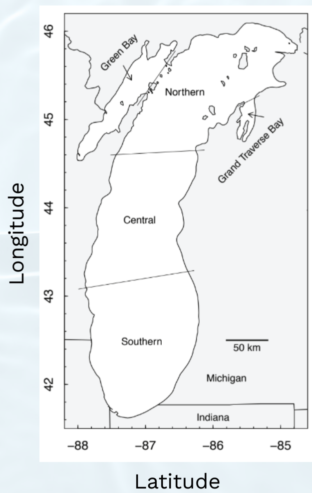


Figure 1. Designated regions of Lake Michigan (Nalepa et al. 2020).

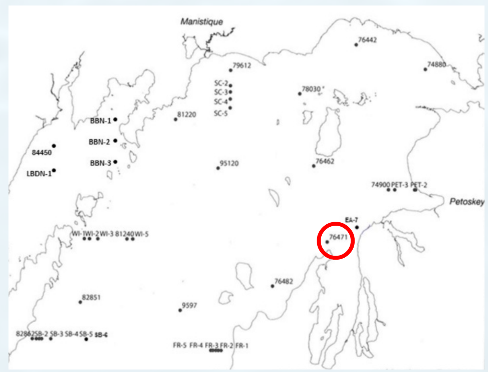


Figure 2. Station designations of sites located in the northern region of Lake Michigan (Nalepa et al. 2014).

Station 9597

- Years this site has been sampled: 1995, 2000, 2005, 2010, 2015
- Region: Northern
- Depth Zone: >90 m
- Actual Depth: 164 m
- Latitude: 45°58.32
- Longitude: 86°22.20

Lake Michigan quagga mussel cluster. Image courtesy of NOAA Great Lakes Environmental Research Laboratory.

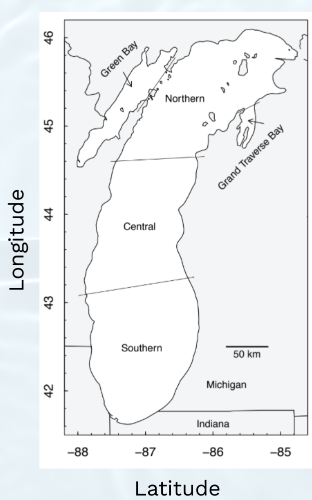


Figure 1. Designated regions of Lake Michigan (Nalepa et al. 2020).

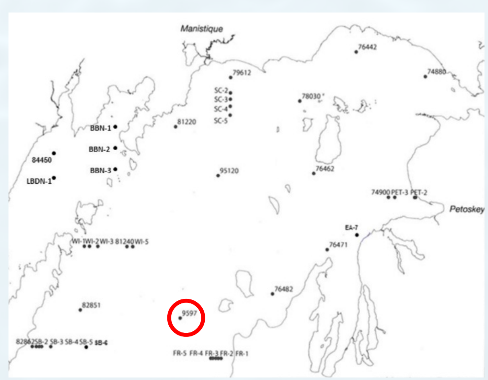


Figure 2. Station designations of sites located in the northern region of Lake Michigan (Nalepa et al. 2014).

Team member names: ____

Post Activity Questions: Population Density of Quagga Mussels in Lake Michigan

Background

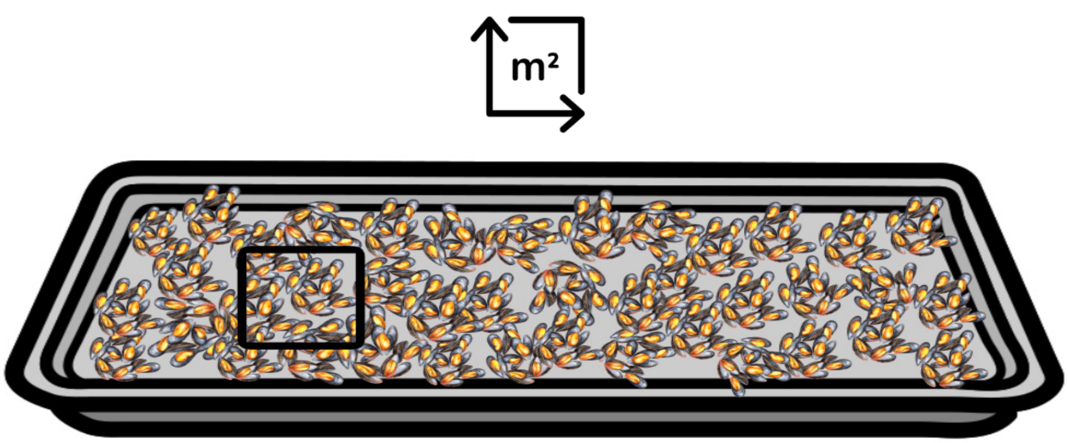
Invasive quagga mussels are so influential in Lake Michigan's food web that their rising population throughout the Great Lakes is alarming. In 2015 scientists on the R/V *Lake Guardian* measured the density and biomass of quaggas all across the lake using a traditional sampling method called a PONAR grab. The scientists could not possibly count every single invasive quagga mussel in Lake Michigan. One way they estimated the density of a population was to collect data by taking random samples at specific locations. Three PONAR grab samples were taken at each station, and the quagga mussels were counted and recorded (#/m^2).

Objective

In this lab activity you will demonstrate how scientists determine the density of quagga mussels at different depths.

Procedure

- Your lab group will be assigned a Station Card and a simulated model that demonstrates a specific station that scientists have explored for the presence of quagga mussels in Lake Michigan.
- Review your Station Card so you can gain a better understanding of the environment where one can possibly find quagga mussels.
- Your teacher may use beans or another small object to represent the quagga mussels that are present at your station. Randomly drop your clear square into your tray. Don't move a mussel! Be sure to keep all beans/beads in their original location. Your group is only counting them through the clear square.



Student Page

Flexing their mussels! Population Density of Quagga Mussels in Lake Michigan, page 2

Team member names: ____

- Count every single mussel that the square covers and touches. If there are mussels on the edge of the square, include them in your final count. Add your data to Table 1.
- You will repeat steps 3 and 4 two more times and add your data to Table 1.
- Average the total number of mussels caught from the three trials and add your average to Table 1.

Table 1. Number of mussels counted per m^2.

Trial #	Station Card Number	# of Mussels Counted/m^2
1		
2		
3		
Average		

Look at your Station Card again and record the depth at which your data was collected:

____

____

____

Please enter your data into the *Class Data Sheet*.

Class Data Sheet

Class Data - Only fill out data that you collected from your assigned station.

Station	Depth of Station	Average Mussel Density (m^2)
WI-1	<30 m	
Q-13	<30 m	
V-1	<30 m	
		Average:

Station	Depth of Station	Average Mussel Density (m^2)
76471	31-50 m	
82902	31-50 m	
B7	31-50 m	
		Average:

Station	Depth of Station	Average Mussel Density (m^2)
82882	51-90 m	
SY-4	51-90 m	
T-3	51-90 m	
		Average:

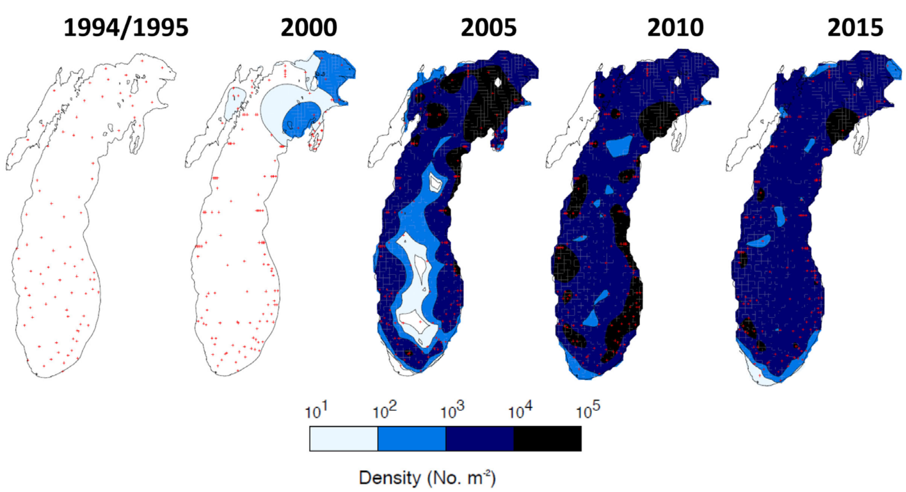
Station	Depth of Station	Average Mussel Density (m^2)
9597	>90 m	
95120	>90 m	
9570	>90 m	
		Average:

Post Activity Questions: Population Density of Quagga Mussels in Lake Michigan

Describe population density.____

When analyzing the *Class Data Sheet*, which depths have the highest and lowest densities of quagga mussels? Why do you think this is? ______________________________

Review the figure below. What can be inferred from the data that is represented in years 2005 and 2010 for quagga mussel density in Lake Michigan? ____________________



Density (no. per m2) of *Dreissena r. bugensis* in Lake Michigan based on lake-wide surveys in 1994/1995, 2000, 2005, 2010, and 2015. Small red dots indicate location of sampling sites. Source: Figure 3 from Nalepa et al. 2020. NOAA GLERL TM-175. doi.org/10.25923/g0d3-3v41

Hypothesize why zebra mussel populations are more coastal, rather than in deep water like the quagga mussel. ______________________________________

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Student Page

Flexing their mussels! Post-Activity Questions, page 2

The area of a PONAR grab is about 0.05m2, therefore scientists need to multiply the number of mussels retrieved in each grab by 20 ($0.05m^2$ X 20 = $1m^2$). By doing this scientists are converting the counts per grab to #/m^2.____

____

____

____

Analyze the data below that was retrieved from Station PET-3 in the northern region. Convert the data to #/m^2.

Year	#/$0.05m^2$	#/m^2
2000	1.785/$0.05m^2$	
2005	1,702.176/$0.05m^2$	
2010	591.192/$0.05m^2$	
2015	266.0455/$0.05m^2$	
2021	419.684/$0.05m^2$	

From 2000 to 2021, what is the general trend that was observed with the mussel population density? ____

____

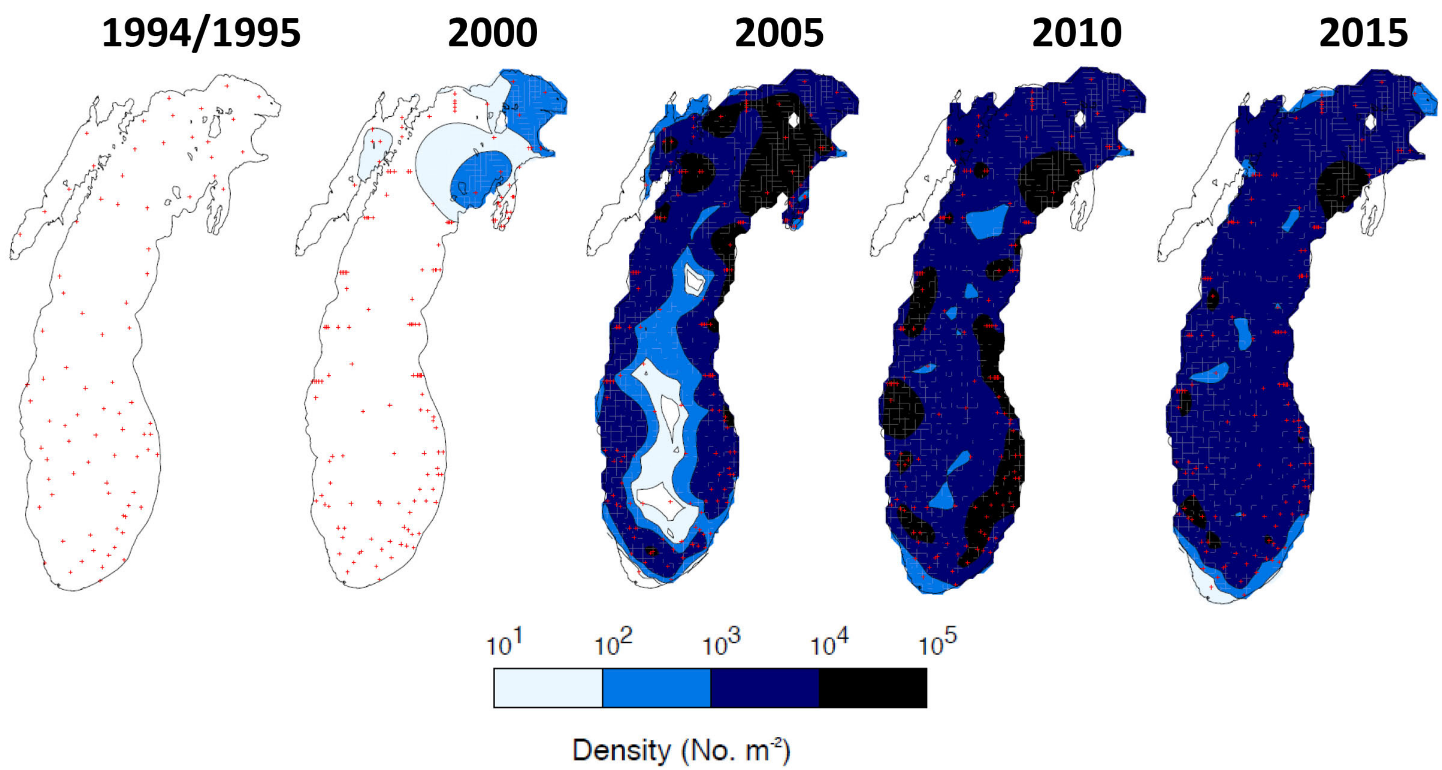
____

What are the environmental, economic, and social impacts of *Dreissenid* mussels in the Great Lakes region?____

____

____

Lake Michigan Quagga Mussel Density Figure



Density (no. per m2) of *Dreissena r. bugensis* in Lake Michigan based on lake-wide surveys in 1994/1995, 2000, 2005, 2010, and 2015. Small red dots indicate location of sampling sites. Source: Figure 3 from Nalepa et al. 2020. NOAA GLERL TM-175. doi.org/10.25923/g0d3-3v41

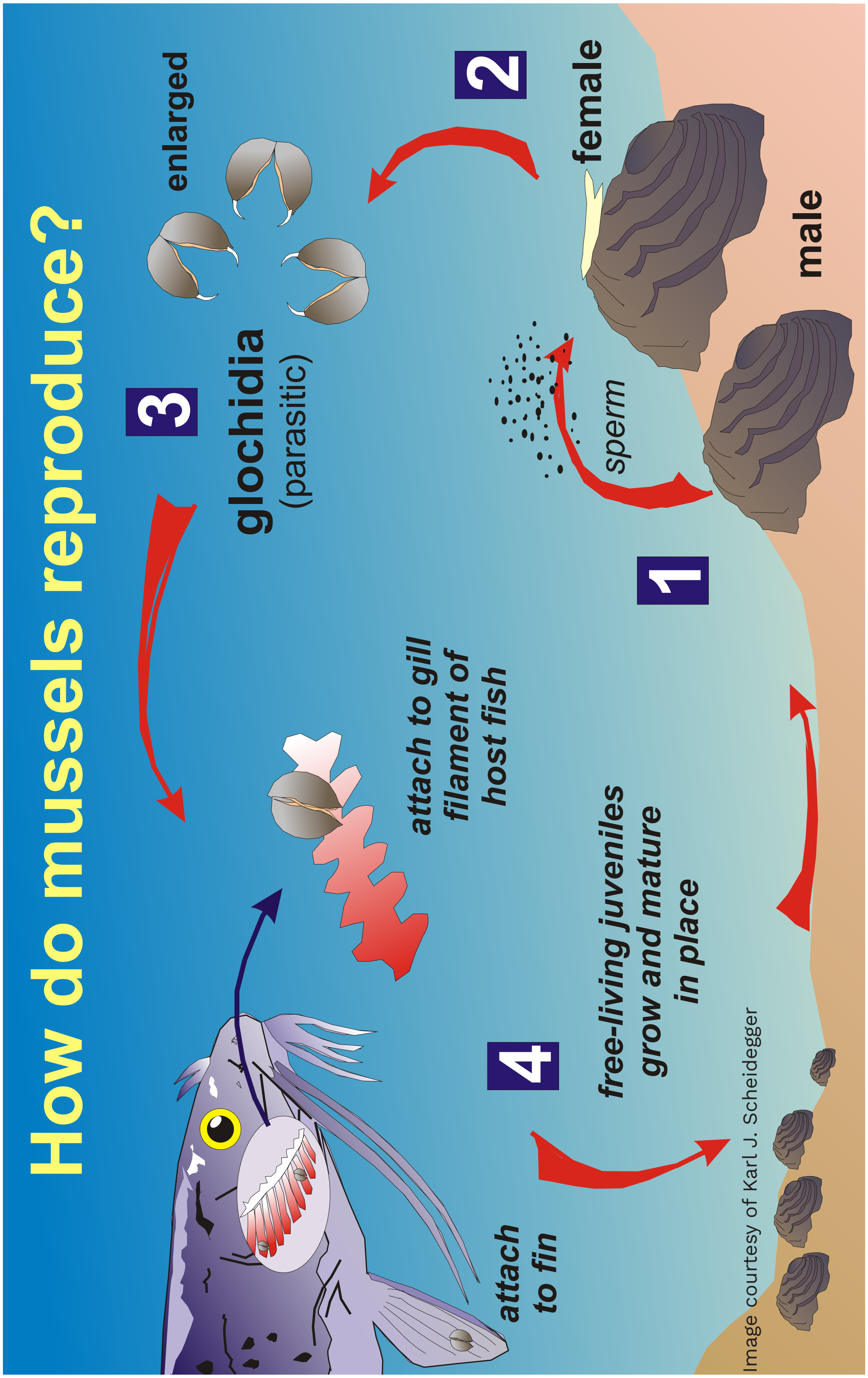
Lake Michigan Quagga Mussel Density Figure Source: Nalepa, T. F., Fanslow, D. L., Lang, G. A., Mabrey, K., & Rowe, M. (2014). Lake-wide benthic surveys in Lake Michigan in 1994–95, 2000, 2005, and 2010: Abundances of the amphipod Diporeia spp. and abundances and biomass of the mussels Dreissena polymorpha and Dreissena rostriformis bugensis (NOAA Technical Memorandum GLERL 164). Great Lakes Environmental Research Laboratory. https://repository.library.noaa.gov/view/noaa/11167 Educator Resources

TEACHING GREAT LAKES LITERACY

Student Page

Flexing their mussels: The population power of *Dreissenid* mussels in Lake Michigan

How do Mussels Reproduce? Life Cycle Illustration



Setting Up Stations

This is a reference to help educators set up each station and distribute the beans in each tray to simulate the abundance of mussels at each depth.

If you teach multiple courses and need to move trays between classes, glueing the beans onto the tray may be helpful to keep their distribution.

Depths <30 m | 100 beans total

- Stations that are at a depth of <30 m generally have a lower density of quagga mussels than the deeper stations. **When creating the trays for these stations, place the beans in clumps with large open spaces between them.** Quagga mussels in shallow waters are generally found with large open areas between the clumps of the mussels.
  - Station Q-13
  - Station V-1
  - Station WI-1

Depths 31-50 m | 200 beans total

- Stations that are at depths of 31-50 m have demonstrated a much higher density of quagga mussels than in shallow waters. **When creating the trays for these stations, place the beans in smaller clumps than the <30 m trays and have less open areas than the stations that are representing depths of <30 m.** Quagga mussels have the ability to thrive on silt and sand giving them the ability to be successful in deeper waters. They also can thrive in colder waters, creating an increase in density moving away from shallower areas.
  - Station B7
  - Station 82902
  - Station 76471

Depths 51-90 m | 250 beans total

- Stations that are at depths of 51-90 m have demonstrated a much higher density of quagga mussels than in shallow waters. **When creating the trays for these stations use MORE beans than you did for the 31-50 m trays and place them more evenly dispersed through the tray.** Quagga mussels have the ability to thrive on silt and sand giving them the ability to be successful in deeper waters. They also can thrive in colder waters, creating an increase in density moving away from shallower areas.
  - Station T-3
  - Station SY-4
  - Station 82882

Depths >90 m | 100 beans total

- Stations that are at depths of >90 m have demonstrated a lower density of quagga mussels than in the 31-50 m and 51-90 m depths. **When creating the trays for these stations use FEWER beans than you did for the 51-90 m trays and place them evenly dispersed through the tray.**
    - Station 9570
    - Station 95120
    - Station 9597

Conversion Notes

- 1 meter = 3.28 feet
- 30 meters = 98.43 feet
- 50 meters = 164.04 feet
- 90 meters = 295.28 feet

Post-Activity Questions: Population Density of Quagga Mussels in Lake Michigan, Answer Key

Describe population density.

Average number of quagga mussels in a given area of Lake Michigan.

When analyzing the *Class Data Sheet*, which depths have the highest and lowest densities of quagga mussels? Why do you think this is?

Answers may vary based on class data. In Lake Michigan, the highest population density of quagga mussels is found at depths between 31-90 meters, while the lowest density is typically near the shoreline due to wave action and shallower depths; meaning the greatest concentration of quagga mussels is found in the mid-depth range of the lake. Furthermore, quagga mussels can attach to both hard and soft substrates, including sand and silt, allowing them to inhabit deeper water areas with less rocky terrain.

Review the figure below. What can be inferred from the data that is represented in years 2005 and 2010 for quagga mussel density in Lake Michigan?

Quagga mussels rapidly increased in abundance during 2000–2010.

Hypothesize why zebra mussel populations are more coastal, rather than in deep water like the quagga mussel.

Zebra mussels prefer hard surfaces like rocks, wood, and concrete for attachment, which are more readily available in shallow, coastal regions. Conversely, quagga mussels can attach to both hard and soft substrates, including sand and silt, allowing them to inhabit deeper water areas with less rocky terrain.

The area of a PONAR grab is about $0.05m^2$, therefore scientists need to multiply the number of mussels retrieved in each grab by 20 ($0.05m2 \times 20 = 1m^2$). By doing this scientists are converting the counts per grab to $\#/m^2$.

Analyze the data below that was retrieved from Station PET-3 in the northern region. Convert the data to $\#/m^2$.

Year	$\#/0.05m^2$	$\#/m^2$
2000	$1.785/0.05m^2$	*$35.7/m^2$*
2005	$1{,}702.176/0.05m^2$	*$34{,}043.52/m^2$*
2010	$591.192/0.05m^2$	*$11{,}823.84/m^2$*
2015	$266.0455/0.05m^2$	*$5{,}320.91/m^2$*
2021	$419.684/0.05m^2$	*$8{,}393.68/m^2$*

From 2000 to 2021, what is the general trend that was observed with the mussel population density?

Trend: Population density started low, increased sharply, then decreased and stabilized.

What are the environmental, economic, and social impacts of *Dreissenid* mussels in the Great Lakes region?

Answers will vary, but potential impacts include (not limited to) food web changes to fundamental species like Diporeia; establishment of other invasive species; more water clarity leading to growth of Cladophora, which can contribute to beach muck; mussels on beaches impacting tourism and recreation; clogging of water intake pipes of water treatment and power plants, which can change pumping capacity and cost money to remove.

Photo: Dave Jude

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Lesson Disclaimer

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

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