November 2023

Thank you to Michigan State University Extension (Tracy D'Augustino, Alcona) for working closely with us to create these lesson plans and ensure alignment with Next Generation Science Standards. These lesson plans are currently being tested in classrooms during the 2023-2024 school year. If you would like to participate in testing, we would appreciate your feedback! To supplement the lessons, we can provide additional outreach materials for your classroom. Please contact Ross Shaw at rshaw@glfc.org for more information.

Finalized lessons should be completed by fall 2024 and will include links to an updated (2024) version of the Great Lakes Fishery Commission’s Predator in Paradise video. At that time a K-3 set should also be released.

Questions and feedback regarding the lessons can be directed to Lauren Holbrook at lholbrook@glfc.org.
Great Lakes Invaders: Learning about (sea) lampreys 9-12

Introduction

Sea lampreys are prehistoric fish that feed on the blood and body fluids of other fish. They invaded the upper Great Lakes through shipping canals in the early 1920s and quickly became, and remain, one of the worst invaders to have entered the Great Lakes basin. Sea lampreys have had an enormous, negative impact on the Great Lakes fishery, inflicting considerable damage. Before the sea lamprey invasion, Canada and the United States harvested about 15 million pounds of lake trout in the upper Great Lakes each year. In the late 1940s, sea lamprey populations exploded and by the early 1960s, the amount of lake trout caught had dropped dramatically, to about 300,000 pounds, only 2% of the previous average catch. Sea Lampreys fed on lake trout, lake whitefish, and ciscoes - fish that were the mainstays of a thriving Great Lakes fishery. During the time of highest sea lamprey abundance, up to 85% of fish that were not killed by sea lampreys were marked with sea lamprey attack wounds. The once thriving fisheries were devastated, and along with them, the hundreds of thousands of jobs related to the region’s economy. This lesson will introduce students to this primitive, jawless fish and Great Lakes invader.

The lesson consists of materials that will allow students to explore the following questions:

- What is a sea lamprey?
- How did sea lampreys enter the Great Lakes?
- Why are sea lampreys a problem?
- What is the life cycle of a sea lamprey?
- What was the initial economic and biological impact of the sea lamprey?
- What is being done by the Great Lakes Fishery Commission (GLFC) and partners to protect the Great Lakes from sea lamprey?
- Why is it important to continue the sea lamprey control program?
- Why is it important that research continues to explore additional ways to control sea lamprey?

Video clips and related activities are provided to deepen student understanding of specific sea lamprey characteristics, the devastation sea lampreys brought to the Great Lakes, how the sea lamprey control program works, and how a group of researchers in the small town of Millersburg, Michigan were able to make ground-breaking strides in the battle to control sea lamprey.

Information is also provided to 1) engage students in an exploration of current control methods and 2) encourage students to design their own new and innovative control methods given specific criteria and constraints.

Learning outcomes

Following this lesson, students will:

- Explain two unique characteristics of a sea lamprey
- Describe how sea lampreys entered the Great Lakes
- Identify one initial biological and one initial economic impact of the sea lamprey invasion
- Identify why it is important to continue to control sea lamprey populations in the Great Lakes
• Describe one current method of sea lamprey control in the Great Lakes and how it impacts the sea lamprey population
• Explain why lampreys are important to the ecosystem in their native environments
• Illustrate and explain a new, potential method for controlling sea lamprey in the Great Lakes
• Evaluate new potential methods for controlling sea lamprey in the Great Lakes

Curriculum alignment (to NGSS MS Standards)
HS-LS2-1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
HS-LS2-6. 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. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in: 1) increases in the number of individuals of some species, 2) the emergence of new species over time, and 3) the extinction of other species.
HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

Classroom time required

Four time blocks of varying lengths:

Session 1: Getting to know sea lamprey (video, pheromones) – 65 minutes
Session 2: Expanding our sea lamprey knowledge (brainstorm, group research project) – 100-130 minutes
Session 3: Making Connections presentations – 60 minutes
Session 4: You be the scientist (design/refine new control methods; expansion activity) – 115-200+ minutes

Materials needed

Please note: All items labeled as printable can be found at the end of the lesson plan in the “Printable Materials” section.

Session 1
• Impacts of Invasive species materials (printable)
  o Question-and-Answer (Q&A) sheet with brief excerpts about Great Lakes invasive species (answer key included)
  o Graph #1: Pounds of Great Lakes fish killed annually by sea lampreys
  o Graph #2: Sea Lamprey Abundance Index by Lake
  o Graph #3: Lake Trout Recovery in Lake Superior
• Predator in Paradise video link: https://youtu.be/YIPrj8mtPXM
  o It is also included where needed below, but a free DVD can be requested from the GLFC.
• **Attractant** and **Repellant** video links (included where needed below)

### Session 2

- Sea lamprey-producing streams map (printable, or project on classroom screen)
- Computers for the team *Making Connections* research project
- List of recommended websites (see section at end of lesson plan)
- Books on Great Lakes invasive species (teacher or library provided)
- GLFC fact sheets (these will be useful for researching certain sea lamprey topics)
- Poster board for group project (if needed)
- Markers for group project (if needed)

### Session 3

- Means for showcasing presentations (computer and screen for PowerPoints and videos)

### Session 4

- Sea lamprey life cycle diagram (printable; or project on classroom screen)
- Medium for designing a sea lamprey control method (paper and markers, modeling clay, paint, computer program, etc.)
- Please note the **Additional/Expanded** project explained in Session 4 below

### Additional resources

- Sea lamprey activity booklets and tattoos (free; request from the GLFC)

### Technology resources

- Computer and screen for showing video to students, for online research, and Invasive Species presentations
- Overhead screen for projecting images as needed through lesson

### Pre-Activities:

Following the videos or at the start of each session have students review key terms like invasive, spawning, parasitic, pheromone, life cycle, and sea lamprey (definitions provided at the end of the lesson plan).

### Activities

#### Session 1

1. **20 minutes** – Impacts of an invasive species
2. **35 minutes** – Watch *Predator in Paradise* video and alarm video clip
3. **10 minutes** – Video follow-up questions
4. **10 minutes** – Pheromones: Attractants
5. **10 minutes – Pheromones: Repellants**

**Materials:**
- Question-and-Answer (Q&A) sheet (printable)
- Graph #1: Pounds of Great Lakes fish killed annually by sea lampreys (printable)
- Graph #2: Sea Lamprey Abundance Index by Lake (printable)
- Graph #3: Lake Trout Recovery in Lake Superior (printable)
- *Predator in Paradise* video [link](#)
- Attractant and Repellant videos (included where needed below as well)

1. **Impacts of an invasive species** – Provide students, or groups of students with the Q&A sheet and all three sea lamprey graphs. Have students complete the provided questions.

2. **Watch *Predator in Paradise***

   **Video Discussion questions**
   - What is a sea lamprey? *Parasitic, prehistoric fish that is native to the Atlantic Ocean, but has invaded the Great Lakes.*
   - How did sea lampreys get into the Great Lakes? *From the Atlantic Ocean, sea lampreys made their way into Lake Ontario in the mid-1800s through small shipping canals, such as the Erie Canal. Then, once the Welland Canal, which bypasses Niagara Falls, was renovated in 1919 sea lampreys were able to swim into Lake Erie and eventually, the rest of the Great Lakes by the late 1930s.*
   - Why are people concerned about sea lampreys? *While not an issue in their native range of the Atlantic Ocean where they live with - and feed on - larger marine fish, sea lampreys harm native Great Lakes fish by feeding on their blood, which typically kills them (only about 1 in 7 Great Lakes fish will survive a sea lamprey attack). Since their invasion, sea lampreys have had a dramatically negative impact on commercial and recreational fishing as well as tourism and the economy.*
   - What types of control methods are predominantly used to control sea lamprey? *Lampricides and barriers (dams) are the main two methods used. A third method of control currently in development is trapping. Traps are strategically placed near barriers to capture sea lampreys from the streams.*
   - What is the most effective method of sea lamprey control? *Lampricide, TFM.*
   - What makes TFM a good lampricide? *It is selective, that is, it harms sea lamprey, but not other aquatic organisms in the system.*

3. **Pheromones: Attractants**
   a. What are pheromones (they were briefly covered in the *Predator in Paradise* video)? *Pheromones are “any chemical substance released by an animal that serves to influence the physiology or behavior of other members of the same species”* (dictionary.com). Some pheromones are called attractants because upon release by an individual they attract other members of the species. For sea lamprey, it is known that adult males release a scent that attracts females to the nest when it is time to spawn. Also, larval sea lampreys are known to release a scent that attracts adults to rivers for spawning.
b. View short video of a sea lamprey moving up the river to where an attractant pheromone is being released through a white tube.

Video Discussion questions

- How can pheromones help with sea lamprey control? By using the scents that attract sea lampreys as bait (think: mouse traps) we can potentially capture more sea lampreys from the Great Lakes in our traps.
- One nickname given to sea lampreys is “swimming noses,” why does this make sense given the information you just learned? Sea lampreys use their sense of smell more than any other sense to survive. Their sense of smell helps them find good spawning habitat, a mate, and likely many other things necessary for survival.

4. Pheromones: Repellants

a. Some pheromones are called repellant because upon release they cause other members of the species to be repelled. In particular, researchers have found that the scent released by dead lamprey is a repellant and leads to an alarm response from any living sea lamprey in the area.

b. View this video from Michigan State University researchers to see the response from sea lamprey exposed to the scent of dead lamprey. (WOW!)

Video Discussion questions

- How is this video evidence that the researchers found an effective repellant for sea lampreys? When the repellant was added to the sea lamprey tank the fish jumped out of the water and tried to quickly swim away from the scent of dead lampreys.
- How might researchers use a sea lamprey’s sense of smell to develop control methods? Through what is called ‘push-pull control,’ researchers hope to use the repellant scent to keep sea lampreys out of certain streams while simultaneously using attractant scents to lure sea lampreys into traps more efficiently.

Session 2

- 10 minutes – Review
- 30 minutes – Brainstorming
- 60-90 minutes (over the course of several days) – Student research time and project development (e.g., poster presentation, PowerPoint slides, or informational video)

Materials:

- Sea lamprey-producing streams map (printable, or project on classroom screen)
- Resource: Lampreys of the Great Lakes fact sheet: link here
- Computers for the team Making Connections research project
- List of recommended websites (see section at end of lesson plan)
- Books on Great Lakes invasive species (teacher or library provided)
• GLFC fact sheets (these will be useful for researching certain sea lamprey topics)
• Poster board for group project (if needed)
• Markers for group project (if needed)

Notes:
• Before students move into the development of their project, they should create an outline for the teacher to approve before proceeding
• If needed, set time limit up front for presentation (3-5 minutes) so that they can be all presented in a single class period if that is important

1. Review several video questions from Session 1

2. Brainstorming: Create a class list of ideas to be researched that will allow students to have a broader understanding of both invasive sea lampreys in the Great Lakes and the sea lamprey control program, as well as other species of lampreys around the world that are not invasive and are even considered beneficial and important to their native ecosystems.
   a. Examples:
      i. Describe the sea lamprey’s native habitat - What does spawning look like in the ocean? What is the range of sea lampreys in the Atlantic? Are they constrained by certain environmental factors, for example temperature?)
      ii. What conditions are most important for successful sea lamprey spawning? Time of year, stream bottom type, temperatures, water quality, nutrients, etc. Why might certain area of the Great Lakes be better for sea lamprey spawning and others worse? (see map of sea lamprey-producing streams)
      iii. Sea lampreys as predators AND prey: What species do sea lampreys prey on in the ocean? In the Great Lakes? While some animals occasionally eat sea lampreys in the Great Lakes, none help control the population to a useful degree. What about native sea lampreys, do they have natural predators?
      iv. Sea lampreys are often called “lamprey eels.” Are they the same type of fish? What are the differences between sea lampreys and the American eel in terms of morphology, life cycle, habitat preference, etc.? If you look for old (mid-1900s) newspaper articles on sea lampreys in the Great Lakes you will see them constantly referred to as “lamprey eels.”
      v. How do people feel about sea lampreys (and lampreys, in general) around the world? (How many species of lampreys are there? Are there some countries, or even other parts of the U.S. that use lampreys as food or that protect lampreys? (Where can you find sea lampreys - or lampreys in general - on a menu?)
      vi. In 2002, 2012, and 2015 the Great Lakes Fishery Commission (GLFC) sent frozen sea lampreys to the city of Gloucester in England. Why did we do this? What were they used for? Why couldn’t the U.K. harvest their own lamprey? (Hints: Queen’s Pie and water quality)
vii. What are the four species of native lampreys in the Great Lakes basin? How do they differ from sea lampreys? Are they a problem for the Great Lakes? (Key resource: Lampreys of the Great Lakes fact sheet)

viii. What types of barriers are used in the sea lamprey control program? How does each type work? Are some more effective in certain situations while others work better in different situations?

ix. What types of traps are used in the sea lamprey control program? How do they work? How effective are they? Are some more effective than others? Can they work in free-flowing streams or only when associated with barriers/dams? Do they trap other species?

x. Over 6,500 chemicals were tested in order to find two that functioned as both effective and selective lampricides; TFM being the most widely used. Why is it important that these lampricides are “selective?” What additional testing was done to determine the safety of TFM after its initial discovery?

xi. Why is it beneficial to target larval lampreys rather than other parts of the life cycle, for control with TFM? How can dams and other stream barriers aid in the effectiveness of TFM usage on larval lampreys?

xii. The sea lamprey control program is considered “integrated,” what does this mean? (This question does overlap with other questions, but is really the foundation of a successful sea lamprey control program). Hint: Multiple control methods in combination lead to greater success.

xiii. Aside from the loss of much of the commercial fishing industry and the start of sea lamprey control, what are some other events that were related to the sea lamprey invasion? Students can explore the massive alewife die-offs in Lake Michigan as well as the introduction of pacific salmon and start of the sport-fishing industry.

xiv. Newer research into sea lamprey control involves the use of pheromones, genetics, and acoustic telemetry. Describe these types of technology and how they are helping the sea lamprey control program (scientific publications as well as GLFC fact sheets can help with this). Also, why is it important to continue research even though there is already a control program in place? *This could be divided into several questions.

xv. Why should your classmates (friends, family, neighbors, etc.) care about the sea lamprey problem in the Great Lakes, especially since they are “under control”? (See this article written, in part, by the GLFC’s Marc Gaden, GLFC Communications Director & Legislative Liaison https://www.sciencedirect.com/science/article/pii/S0380133021000344)

3. Pair up students and have teams research their topic
   a. Students should:
      i. Site sources and provide a reference page
      ii. Use multiple media types
         1. Video
         2. Magazine
3. Newspapers
4. Science journals

iii. Use information from both reputable websites and scientific publications

Session 3

1. Before the presentations explain to the students that their final task in this unit is to design a new sea lamprey control method. They might want to keep this in mind during the presentations.
2. **60 minutes** – Presentations

Materials:
- Means for showcasing presentations (computer and screen for PowerPoints and videos)

1. **Student presentations**
   a. Have the class take notes as presentations are taking place

Session 4 – You be the Scientist

1. **10 minutes** – Review
2. **15 minutes** – Brainstorm
3. **90-120 minutes** – Design, Evaluate, Refine
4. **90+ minutes** – Optional additions/expansions activity (length depends on the scope of this additional project as determined by the teacher)

Materials:
- Sea lamprey life cycle diagram (printable; or project on classroom screen)
- Medium for designing a sea lamprey control method (paper and markers, modeling clay, paint, computer program, etc.)

1. **Review Questions**
   - *What is an invasive species?* **Invasive species** - As per **Executive Order 13112** an "invasive species" is defined as a species that is: 1) non-native (or alien) to the ecosystem under consideration and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health. Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions. ([https://www.invasivespeciesinfo.gov/whatis.shtml](https://www.invasivespeciesinfo.gov/whatis.shtml))
   - Describe the life cycle of a sea lamprey (printable; or project on classroom screen)
   - What is the most effective method of sea lamprey control? **Lampricide, TFM.**
   - What makes TFM a good lampricide? *It is selective,* that is, it harms sea lamprey, but not other aquatic organisms in the system.
   - What are pheromones (they were briefly covered in the *Predator in Paradise* video)? **Pheromones are “any chemical substance released by an animal that serves to influence the**
Some pheromones are called attractants because upon release by an individual they attract other members of the species. For sea lamprey, it is known that adult males release a scent that attracts females to the nest when it is time to spawn. Also, larval sea lampreys are known to release a scent that attracts adults to rivers for spawning.

2. You be the Scientist
   a. Have students silently brainstorm other methods that might help us control the sea lamprey population. It can be a variant of something already done (like a new type of barrier or more effective trap), or completely unique. Discuss aloud if desired.
      i. Optional: Give students criteria/constraints for their project, such as:
         1. Control method can have little to no impact on other organisms or the environment.
         2. Control method must be reasonably feasible from a financial perspective.
   b. Provide each team or individual with a copy of the rubric or other scoring criteria. Then allow students time to sketch and/or create one of their ideas.
      i. Students should identify key parts and explain how it works as well as state how the shape (or purpose, if it is something like a chemical) of the object they created helps it function as needed to solve a given problem.
      ii. Have students present their models/drawings with the class and after all have shared, brainstorm/evaluate* how well each is likely to meet the criteria and constraints of the problem, keeping in mind the desire to maintain both biodiversity and ecosystem services. (Teachers, please feel free to scan these in and send them back to us in case we want to use some of the ideas!) 😊
      iii. *Evaluations can be done individually, with teacher-created evaluation sheets, or as a class in a group discussion.

Optional additions/expansions: This project can be greatly expanded and become a significant engineering project where designs are tested, evaluated and revised to improve the capabilities.

Unit wrap-up discussion or writing activity (choose any or all questions)

Have students answer questions about the sea lamprey

- Explain two unique characteristics of a sea lamprey
- Describe how sea lampreys entered the Great Lakes
- Identify one initial biological and one initial economic impact of the sea lamprey invasion
- Identify why it is important to continue to control sea lamprey populations in the Great Lakes
- Describe one current method of sea lamprey control in the Great Lakes and how it impacts the sea lamprey population
- Give one reason why lampreys are important to their native ecosystems
Assessment

1. Rubric for Making Connections research Project (HS-LS2-6.)
2. Rubric for illustration and evaluation of sea lamprey control method (HS-LS2-7.)
3. Additional/expanded activity to test illustration of sea lamprey control method (HS-LS4-6.)
4. Student answers to the unit wrap-up discussion or writing assignment serve as a summative assessment for this unit.

### Rubric: Seawater Making Connections Research Project (Informative or Argumentative)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>3 pts</th>
<th>2 pts</th>
<th>1 pts</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topic identified (introduction)</td>
<td>Clearly states the specific information or argument to be presented</td>
<td>Provides information and argues a topic but topic not clearly identified</td>
<td>Lacks an introduction</td>
<td></td>
</tr>
<tr>
<td>Information development</td>
<td>Arguments or information are well developed and clearly site multiple sources</td>
<td>Arguments and information somewhat developed but does not include sources</td>
<td>Information is poorly developed and difficult to follow</td>
<td></td>
</tr>
<tr>
<td>Transitions</td>
<td>Sections are smoothly linked and have varied transitions</td>
<td>Limited transition and sections not always linked</td>
<td>Poorly linked and lacking transitions</td>
<td></td>
</tr>
<tr>
<td>Language use</td>
<td>Language use is appropriate for the audience and includes key words specific to the topic</td>
<td>Language used varies and is not always appropriate for the audience and includes several key words specific to the topic</td>
<td>Language used was mildly appropriate for the audience and few key words specific to the topic were used</td>
<td></td>
</tr>
<tr>
<td>Conclusion</td>
<td>Clearly states the specific information or argument that was presented</td>
<td>Provides information and argues a topic but topic not clearly identified</td>
<td>Lacking a clear conclusion</td>
<td></td>
</tr>
</tbody>
</table>

### Rubric: Illustration of sea lamprey control method

<table>
<thead>
<tr>
<th>Criteria</th>
<th>3 pts.</th>
<th>2 pts.</th>
<th>1 pt.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feasibility</td>
<td>The idea could potentially control/reduce sea lamprey populations with no impact on other organisms or the environment.</td>
<td>The idea could potentially control/reduce sea lamprey populations with little impact on other organisms or the environment.</td>
<td>The idea looks like it might control/reduce sea lamprey populations but will have a negative impact on other organisms or the environment (e.g., TNT).</td>
<td></td>
</tr>
<tr>
<td>Potential restrictions: Control/reduce sea lamprey populations with little to no impact on other organisms or the environment and/or within limited budget.</td>
<td>The idea targets a particular stage, or stages, of development (e.g., a unique barrier or trap design that targets newly metamorphosed sea lamprey).</td>
<td>The idea targets a particular stage, or stages, of development (e.g., new type of lampricide that targets a different life stage than TFM).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creativity and Originality</td>
<td>Idea/illustration is unique and indicates a high level of thought (e.g., idea is plausible and shows that the student is thinking deeper, not just going off of ideas they already heard; see example above).</td>
<td>Idea/illustration is mostly unique, indicating a moderate level of thought (see example above).</td>
<td>Idea/illustration is somewhat unique, indicating some level of thought, but may not be very realistic (see example above).</td>
<td></td>
</tr>
<tr>
<td>Craftsmanship/Skill</td>
<td>Illustration indicates that the student took significant time to create it and includes detailed descriptions of its components.</td>
<td>Illustration indicates that the student took some time to create it and includes some descriptions of its components.</td>
<td>Illustration indicates that the student completed it quickly and includes little to no descriptions of the components.</td>
<td></td>
</tr>
</tbody>
</table>
Critical vocabulary (All definitions taken from dictionary.com, unless otherwise noted)

- **Invasive species** - As per Executive Order 13112 an "invasive species" is defined as a species that is: 1) non-native (or alien) to the ecosystem under consideration and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health. Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions. (https://www.invasivespeciesinfo.gov/whatis.shtml)

- **Metamorphosis** – a profound change in form from one stage to the next in the life history of an organism, as from the caterpillar to the pupa and from the pupa to the adult butterfly.

- **Parasite** – an organism that lives on or in an organism of another species, known as the host, and from which it obtains nutrients.

- **Pheromone** – any chemical substance released by an animal that serves to influence the physiology or behavior of other members of the same species.

- **Larvae** – the young of any invertebrate animal.

- **Spawning** – the mass of eggs deposited by fishes, amphibians, mollusks, crustaceans, etc.

- **Filter feeding** – A method of feeding occurring in some aquatic animals, such as planktonic invertebrates and whalebone whales, in which minute particles are filtered from the surrounding water.

- **Biodiversity** - The number, variety, and genetic variation of different organisms found within a specified geographic region.

- **Ecosystem Services** - the important benefits for human beings that arise from healthily functioning ecosystems, notably production of oxygen, soil genesis, and water detoxification.

Websites

- **General:**
  - Great Lakes Fishery Commission: glfc.org
  - Hammond Bay Biological Station: usgs.gov/hbbs
  - NEMIGLSI: http://www.nemiglsi.org/
  - Sea Lamprey - From Crisis to Control GLFC outreach video: https://www.youtube.com/watch?v=JVlHApc3h1c

- **Making Connections** research project
  - NOAA
  - Michigan Sea Grant
  - Minnesota Sea Grant
  - Wisconsin Sea Grant
  - Ohio Sea Grant
  - Illinois-Indiana Sea Grant
  - New York Sea Grant
  - GLFC Annual Reports: http://www.glfc.org/annual-reports.php
Comments

- Feel free to contact us with any comments – or for materials, such as sea lamprey brochures.
  Lauren Holbrook
  Communications Associate, Great Lakes Fishery Commission
  lholbrook@glfc.org

- This lesson plan was developed through the Great Lakes Fishery Commission, with assistance from Tracy D’Augustino through Michigan State University Extension.
Printable Materials
Impacts of Invasive Species

“The Great Lakes ecosystem has been severely damaged by more than 180 invasive and non-native species. Species such as the zebra mussel, quagga mussel, round goby, sea lamprey, and alewife reproduce and spread, ultimately degrading habitat, out-competing native species, and short-circuiting food webs. Non-native plants such as purple loosestrife and Eurasian watermilfoil have also harmed the Great Lakes ecosystem. Unfortunately, the damage caused by invasive species often goes beyond the ecological. They can threaten human health and hurt the Great Lakes economy by damaging critical industries such as fisheries, agriculture, and tourism. It is extremely difficult to control the spread of an invasive species once it is established, which makes prevention the most cost-effective approach to dealing with organisms that have not yet entered or become established in the Great Lakes.”

Excerpt taken from NOAA: Great Lakes Region Invasive Species

“An invasive species is a plant or animal that is foreign to an ecosystem. During the past two centuries, invasive species have significantly changed the Great Lakes ecosystem. These changes have greatly affected the economy, health, and well being of the people that rely on the system for food, water, and recreation. Once established, it is extremely difficult to control their spread. At least 25 invasive species of fish have entered the Great Lakes since the 1800s.”

Excerpt taken from EPA: Invasive Species in the Great Lakes

1) The Great Lakes are home to more than ______ invasive and non-native species, and of these, at least ______ are fish.

2) List 3 problems created by invasive species:
   a. 
   b. 
   c. 

3) From Graph #1 titled, “Pounds of Great Lakes fish killed annually by sea lampreys” would you say that sea lampreys impacted the biology of the Great Lakes? How can you tell this from the graph?
4) By what percent did the “pounds of Great Lakes fish killed annually by sea lampreys” decrease between historical values and the present?

5) From Graph #2 titled, “Sea Lamprey Abundance Index by Lake,” which lake has the largest sea lamprey population at present? Smallest?

6) What does the sharp decline represent on each graph?

7) Based on what you read and the graphs you examined, do you think sea lampreys had an impact on the economy of the Great Lakes? Why or why not?

8) Explain, in 1-2 paragraphs, the story of sea lampreys and lake trout in Lake Superior (using Graph #3 as reference).
Impacts of Invasive Species

“The Great Lakes ecosystem has been severely damaged by more than 180 invasive and non-native species. Species such as the zebra mussel, quagga mussel, round goby, sea lamprey, and alewife reproduce and spread, ultimately degrading habitat, out-competing native species, and short-circuiting food webs. Non-native plants such as purple loosestrife and Eurasian watermilfoil have also harmed the Great Lakes ecosystem. Unfortunately, the damage caused by invasive species often goes beyond the ecological. They can threaten human health and hurt the Great Lakes economy by damaging critical industries such as fisheries, agriculture, and tourism. It is extremely difficult to control the spread of an invasive species once it is established, which makes prevention the most cost-effective approach to dealing with organisms that have not yet entered or become established in the Great Lakes.”

Excerpt taken from NOAA: Great Lakes Region Invasive Species

“An invasive species is a plant or animal that is foreign to an ecosystem. During the past two centuries, invasive species have significantly changed the Great Lakes ecosystem. These changes have greatly affected the economy, health, and well being of the people that rely on the system for food, water, and recreation. Once established, it is extremely difficult to control their spread. At least 25 invasive species of fish have entered the Great Lakes since the 1800s.”

Excerpt taken from EPA: Invasive Species in the Great Lakes

1) The Great Lakes are home to more than _180_ invasive and non-native species, and of these, at least _25_ are fish.

2) List 3 problems created by invasive species:
   a. Degrade habitat
   b. Out compete native species
   c. Reproduce and spread quickly
   (extra: short-circuit/destroy food web)

3) From Graph #1 titled, “Pounds of Great Lakes fish killed annually by sea lampreys” would you say that sea lampreys impacted the biology of the Great Lakes? How can you tell this from the graph?
   Yes, sea lampreys impacted the biology of the Great Lakes. They killed millions of pounds of native fish, as seen on the graph. This would cause a disruption in the food web and ecosystem.

4) By what percent did the “pounds of Great Lakes fish killed annually by sea lampreys” decrease between historical values and the present?
   Answer: 90.3% (10,000,000 present #/103,000,000 historical # = 9.7%; 100% - 9.7% = 90.3%)
5) From Graph #2 titled, “Sea Lamprey Abundance Index by Lake,” which lake has the largest sea lamprey population at present? Smallest?
Answer: Largest: Lake Superior; Smallest: Lake Erie

6) What does the sharp decline represent on each graph?
Answer: The start of sea lamprey control and the decline of sea lampreys.

7) Based on what you read and the graphs you examined, do you think sea lampreys had an impact on the economy of the Great Lakes? Why or why not?
Yes, the sea lamprey invasion had a dramatic impact on the Great Lakes economy. By killing millions of pounds of native fish, sea lamprey hurt the fishery and, in turn, the economy. Families who had been commercial fishers lost their livelihood and, therefore, income. Tourists who once visited for recreational fishing were no longer interested, hurting coastal town business owners.

8) Explain, in 1-2 paragraphs, the story of sea lampreys and lake trout in Lake Superior (using Graph #3 as reference).
In the 1930s lake trout numbers were fairly strong in Lake Superior. But, by the end of the 1930s sea lampreys had invaded the lake and lake trout populations began to decline through 1970*. Sea lamprey control treatments began in the late 1950s and eventually, as the treatment brought down the number of sea lampreys, native (wild) lake trout abundance in Lake Superior began to increase again, leading to a major success for the sea lamprey control program.

*Native (wild) lake trout were also on the decline between the 1950s and 1970s as a result of overfishing, so it was the combination of both overfishing and the invasion of sea lampreys that nearly wiped native lake trout out of Lake Superior (and did actually wipe them from the other 4 Great Lakes). Lake Superior was the last lake to be invaded by sea lampreys and the first to experience sea lamprey control treatments, thus allowing for the survival and comeback of native lake trout populations in that lake.
Pounds of Great Lakes fish killed annually by sea lampreys

Pre sea lamprey control: 103 million pounds of fish killed per year.

Today: ~10 million

Hammond Bay Biological Station
Sea Lamprey Abundance Index by Lake

- **Superior**
  - Pre-Control: 780,000
  - Target: 38,000
  - 3-year average: 118,000
  - -85%; Above Target

- **Huron**
  - Pre-Control: 700,000
  - Target: 69,000
  - 3-year average: 84,000
  - -88%; Above Target

- **Erie**
  - Pre-Control: 40,000
  - Target: 4,000
  - 3-year average: 13,000
  - -68%; Above Target

- **Michigan**
  - Pre-Control: 600,000
  - Target: 47,000
  - 3-year average: 29,000
  - -95%; Meeting Target

- **Ontario**
  - Pre-Control: 450,000
  - Target: 27,000
  - 3-year average: 24,000
  - -95%; Meeting Target

- **Summary**
  - Sea lampreys are resilient
  - Control must be ongoing or sea lampreys will bounce back
Lake Trout Recovery in Lake Superior: A Victory for Sea Lamprey Control!

Year

Percent of Historic Average Abundance

- first observation of sea lamprey
- first sea lamprey treatments

Wild lake trout
Sea lamprey

SEA LAMPREY LIFE CYCLE

12-18 MONTHS
One summer, fall, and winter feeding on blood of host fish

Migration of adults into streams

Migration of adults after spawning

3-10+ YEARS

JUNE-MARCH
Emergence from stream bed

3
Parasitic juvenile

4
Metamorphosis

1
Spawning adult

2
Larva

Downstream migration to lakes