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)
  - Question-and-Answer (Q&A) sheet with brief excerpts about Great Lakes invasive species (answer key included)
  - Graph #1: Pounds of Great Lakes fish killed annually by sea lampreys
  - Graph #2: Sea Lamprey Abundance Index by Lake
  - Graph #3: Lake Trout Recovery in Lake Superior
- *Predator in Paradise* video link: https://youtu.be/YIPrj8mtPXM
  - 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)
- 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)

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 repellants 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 'p*ush-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 no t 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*)
   - 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*

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.

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: Sea Lamprey *Making Connections* Research Project (Informative or Argumentative)

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

Rubric: Illustration of sea lamprey control method

Criteria	3 pts.	2 pts.	1 pt.	Total
Feasibility **Potential restrictions:** Control/reduce sea lamprey populations with little to no impact on other organisms or the environment and/or within limited budget.	The idea could potentially control/reduce sea lamprey populations with no impact on other organisms or the environment. The idea targets a particular stage, or stages, of development (e.g., a unique barrier or trap design that targets newly metamorphosed sea lamprey).	The idea could potentially control/reduce sea lamprey populations with little impact on other organisms or the environment. The idea targets a particular stage, or stages, of development (e.g., new type of lampricide that targets a different life stage than TFM).	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).	
Creativity and Originality	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).	Idea/illustration is mostly unique, indicating a moderate level of thought (see example above).	Idea/illustration is somewhat unique, indicating some level of thought, but may not be very realistic (see example above).	
Craftsmanship/Skill	Illustration indicates that the student took significant time to create it and includes detailed descriptions of its components.	Illustration indicates that the student took some time to create it and includes some descriptions of its components.	Illustration indicates that the student completed it quickly and includes little to no descriptions of the components.	

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
  - FAO's Lampreys of the World: https://www.fao.org/3/i2335e/i2335e.pdf

Comments

- Feel free to contact us with any comments – or for materials, such as sea lamprey brochures.

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- 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).

ANSWER KEY

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."

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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%)

ANSWER KEY

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?

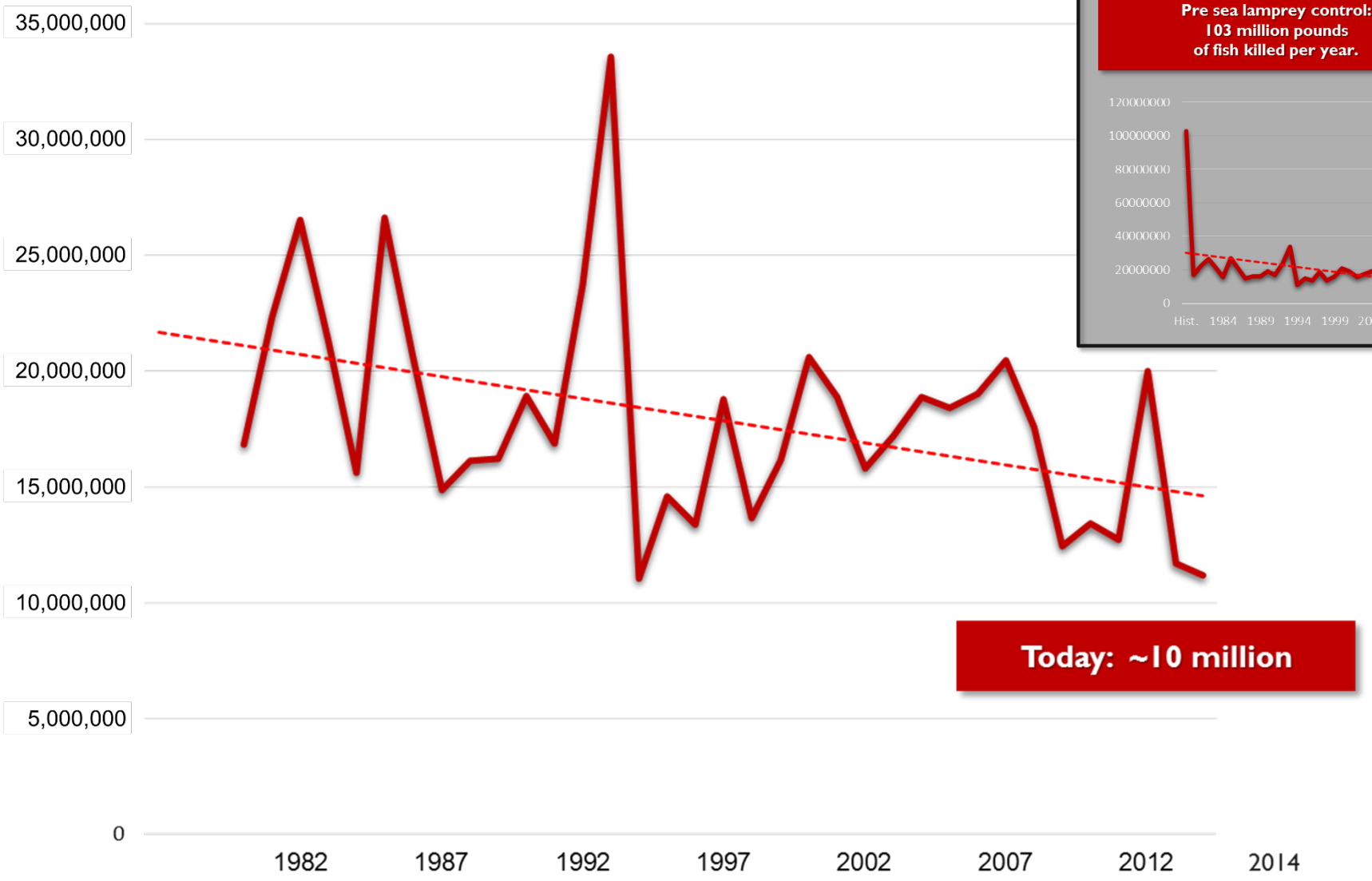
   Yes, the sea lamprey invasion had a dramatic impact on the Great Lakes economy. By killing millions of pounds of native fish, sea lamprey hurt the fishery and, in turn, the economy. Families who had been commercial fishers lost their livelihood and, therefore, income. Tourists who once visited for recreational 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.

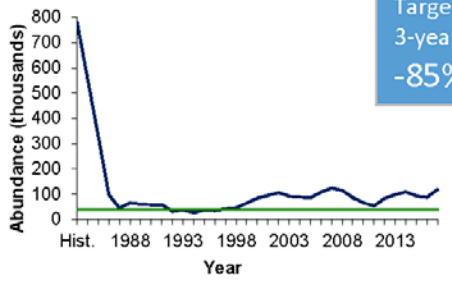
   *Native (wild) lake trout were also on the decline between the 1950s and 1970s as a result of overfishing, so it was the combination of both overfishing and the invasion of sea lampreys that nearly wiped native lake trout out of Lake Superior (and did actually wipe them from the other 4 Great Lakes). 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



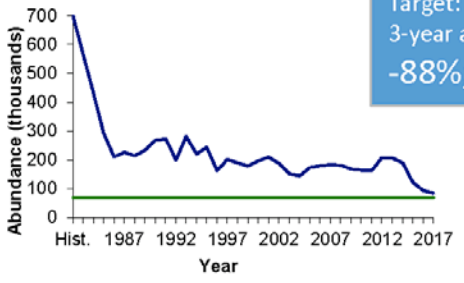
Sea Lamprey Abundance Index by Lake

Superior



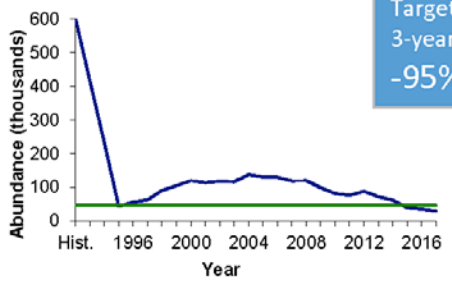
Pre-Control: 780,000
Target: 38,000
3-year average: 118,000
-85%; Above Target

Huron



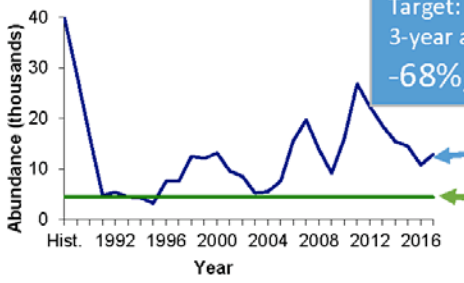
Pre-Control: 700,000
Target: 69,000
3-year average: 84,000
-88%; Above Target

Michigan



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

Erie

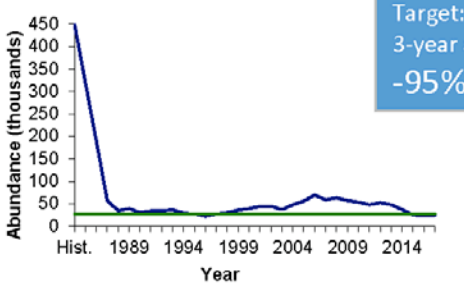


Pre-Control: 40,000
Target: 4,000
3-year average: 13,000
-68%; Above Target

Adult Sea lamprey Abundance Index

Target

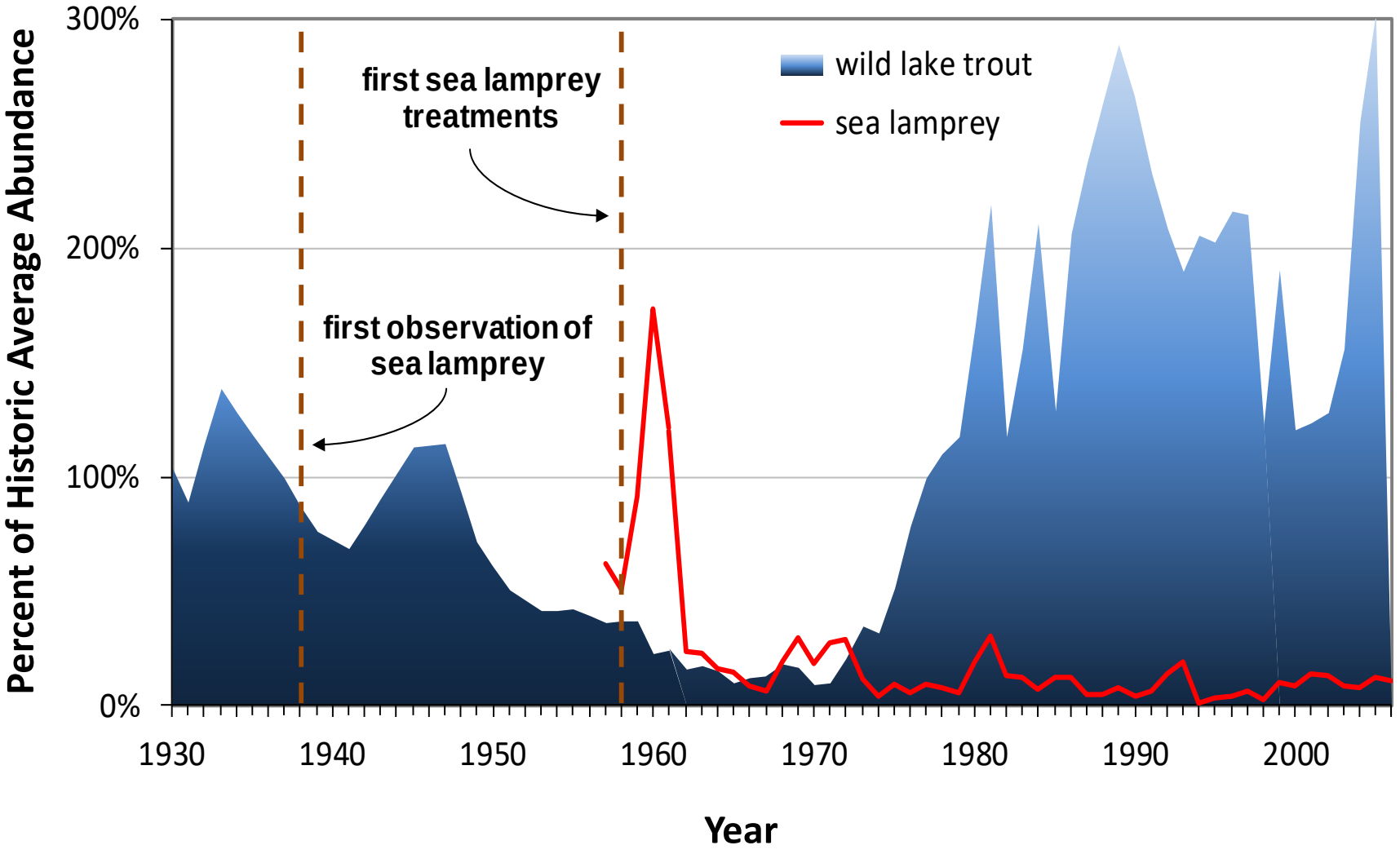
Ontario



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

- 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!



THE GREAT LAKES

Tributaries in Which Sea Lampreys Have Been Found

Lake Superior (CAN)

East Davignon Creek	1	Michipicoten River	33
West Davignon Creek	2	Dog River	34
Little Carp River	3	White River	35
Big Carp River	4	Pic River	36
Cranberry Creek	5	Little Pic River	37
Goulais River	6	Prairie River	38
Bostons Creek	7	Steel River	39
Haviland Creek	8	Pays Plat River	40
Unnamed	9	Gravel River	41
Stokely Creek	10	Little Gravel River	42
Unnamed	11	L.Cypress River	43
Tier Creek	12	Cypress River	44
Harmony River	13	Jackpine River	45
Sawmill Creek	14	Jackfish River	46
Jones Landing Creek	15	Nipigon River	47
Tiny Creek	16	Big Trout Creek	48
Chippewa River	17	Otter Cove Creek	49
Unnamed (1009)(48-1)	18	Black Sturgeon River	50
Unnamed (S-49)	19	Big Squaw Creek	51
Unger Creek	20	Wolf River	52
Unnamed	21	Coldwater Creek	53
Batchawana River	22	Pearl River	54
Unnamed (52-2)	23	D'Arcy Creek	55
Digby Creek	24	Blende Creek	56
Carp River	25	MacKenzie River	57
Pancake River	26	Current River	58
Westman Creek	27	Neebing-McIntrye Floodway	59
Agawa River	28	Kaministikwia River	60
Sand River	29	Cloud River	61
Baldhead River	30	Pine River	62
Gargantua River	31	Pigeon River	63
Old Woman River	32		

Lake Superior (US)

Waiska River	1	Sturgeon River	47
Sec. 11SW Tributary	2	Pilgrim River	48
Pendills Creek	3	Trap Rock River	49
Grants Creek	4	McCallum Creek	50
Naomikong Creek	5	Traverse River	51
Ankodosh Creek	6	Little Gratiot River	52
Roxbury Creek	7	Eliza Creek	53
Galloway Creek	8	Gratiot River	54
Tahquamenon River	9	Smiths Creek (Bear Creek)	55
Betsy River	10	Boston-Lily Creek	56
Three Mile Creek	11	Salmon Trout River	57
Little Two Hearted River	12	Mud Lake Outlet	58
Two Hearted River	13	Graveraet River	59
Dead (Blind) Sucker River	14	Elm River	60
Sucker River	15	Misery River	61
Carpenter Creek	16	East Sleeping River	62
Sable Creek	17	West Sleeping River	63
Hurricane River	18	Firesteel River	64
Sullivans Creek	19	Ontonagon River	65
Seven Mile Creek	20	Potato River	66
Mosquito River	21	Floodwood River	67
Miners River	22	Cranberry River	68
Munising Falls Creek	23	Little Iron River	69
Anna River	24	Union River	70
Furnace Creek	25	Black River	71
Five Mile Creek	26	Montreal River	72
Au Train River	27	Washington Creek	73
Rock River	28	Bad River	74
Deer Lake Creek	29	Fish Creek (Eileen Twp.)	75
Laughing Whitefish River	30	Red Cliff Creek	76
Sand River	31	Raspberry River	77
Chocolay River	32	Sand River (Bayfield)	78
Carp River	33	Cranberry River	79
Dead River	34	Iron River	80
Harlow Creek	35	Reefer Creek	81
Little Garlic River	36	Fish Creek (Orienta Twp.)	82
Garlic River	37	Brule River	83
Iron River	38	Poplar River	84
Salmon Trout River	39	Middle River	85
Pine River	40	Amnicon River	86
Huron River	41	Nemadji River	87
Ravine River	42	St. Louis River	88
Slate River	43	Sucker River	89
Silver River	44	Gooseberry River	90
Falls River	45	Split Rock River	91
Six Mile Creek	46	Arrowhead River	92

Lake Michigan

Brevort River	1	Bear Creek	63
Paquin Creek	2	Door County #23 Tributary	64
Davenport Creek	3	Ahnapee River	65
Hog Island Creek	4	Three Mile Creek	66
Sucker Creek	5	Kewaunee River	67
Black River	6	East Twin River	68
Mile Creek	7	Fischer Creek	69
Millecoquins River	8	Burns Ditch	70
Rock River	9	Donns Creek	71
Crow River	10	Trail Creek	72
Cataract River	11	State Creek	73
Point Patterson Creek	12	Galien River	74
Hudson Creek	13	St Joseph River	75
Swan Creek	14	Rogers Creek	76
Seiners Creek	15	Brandywine Creek	77
Milakokia River	16	Black River	78
Bulldog Creek	17	Allegan 5 Creek	79
Gulliver Lake Outlet	18	Allegan 4 Creek	80
Marblehead Creek	19	Allegan 3 Creek	81
Manistique River	20	Kalamazoo River	82
Southtown Creek	21	Gibson Creek	83
Thompson Creek	22	Pine Creek	84
Johnson Creek	23	Pigeon River	85
Deadhorse Creek	24	Grand River	86
Gierke Creek	25	Black Creek	87
Bursaw Creek	26	Muskegon River	88
Parent Creek	27	Duck Creek	89
Poodle Pete Creek	28	White River	90
Valentine Creek	29	Flower Creek	91
Little Fishdam River	30	Stony Creek	92
Big Fishdam River	31	Pentwater River	93
Sturgeon River	32	Bass Lake Outlet	94
Ogontz River	33	Pere Marquette River	95
Squaw Creek	34	Lincoln River	96
Hock Creek	35	Cooper Creek	97
Whitefish River	36	Gurney Creek	98
Rapid River	37	Manistee River	99
Tacoosh River	38	Bowen Creek	100
Days River	39	Betsie River	101
Escanaba River	40	Platte River	102
Portage Creek	41	Crystal River	103
Ford River	42	Good Harbor Creek	104
Sunny Brook	43	Leland River	105
Bark River	44	Leo Creek	106
Cedar River	45	Boardman River	107
Sugar Creek (Ruleau Creek)	46	Mitchell Creek	108
Arthur Bay Creek	47	Acme Creek	109
Rochereau Creek	48	Yuba Creek	110
Johnson Creek	49	Elk Lake Outlet	111
Bailey Creek	50	McGeach Creek	112
Beattie Creek	51	Loeb Creek	113
Springer Creek	52	Monroe Creek	114
Menominee River	53	Jordan River	115
Little River	54	Porter Creek	116
Peshtigo River	55	Boyne River	117
Oconto River	56	Horton Creek	118
Pensaukee River	57	Bear River	119
Suamico River	58	Wycamp Creek	120
Ephraim Creek	59	Big Sucker Creek	121
Hibbards Creek	60	Big Stone Creek	122
Whitefish Bay Creek	61	Carp Lake River	123
Lily Bay Creek	62		

Lake Huron (CAN)

St. Marys River	1	Timber Bay Creek	32
Root River	2	Manitou River	33
Garden River	3	Blue Jay Creek	34
Echo River	4	Kaboni Creek	35
Bar River	5	Chikanishing River	36
Desbarats River	6	French River	37
Stoby Creek	7	Key River	38
Sucker Creek	8	Still River	39
Unnamed	9	Magnetawan River	40
Twotree River	10	Naiscoot River	41
Richardson Creek	11	Shebeshekong River	42
Watson Creek	12	Boyne River	43
Gordon Creek	13	Squirrel Creek	44
Browns Creek	14	Musquash River	45
Koshkawong River	15	Simcoe/Severn System	46
Unnamed	16	Coldwater Creek	47
Unnamed	17	Sturgeon River	48
McBeth Creek	18	Hog Creek	49
Thessalon River	19	Lafontaine Creek	50
Livingstone Creek	20	Nottawasaga River	51
Mississagi River	21	Pretty River	52
Blind River	22	Silver Creek	53
Lauzon River	23	Beaver River	54
Spragge Creek	24	Bighead River	55
Unnamed	25	Bothwell's Creek	56
Serpent River	26	Sydenham River	57
Spanish River	27	Sauble River	58
Kagawong River	28	Saugeen River	59
Silver Creek	29	Nine Mile River	60
Sand Creek	30	Maitland River	61
Mindemoya River	31	Bayfield River	62

Lake Huron (US)

Mission Creek	1	Elliot Creek	32
Frechette Creek	2	Greene Creek	33
Ermatinger Creek	3	Grass Creek	34
Charlotte River	4	Grace Creek	35
Little Munuscong River	5	Black Mallard Creek	36
Big Munuscong River	6	Mulligan Creek	37
Carlton Creek	7	Seventeen Creek	38
Canoe Lake Outlet	8	Ocquesc River	39
Bear Lake Outlet	9	HBBS Creek	40
Carr Creek	10	Johnny Creek	41
Joe Straw Creek	11	Schmidt Creek	42
Saddle Creek	12	Nagels Creek	43
Huron Point Creek	13	Trout River	44
Albany Creek	14	Swan River	45
Trout Creek	15	Grand Lake Outlet	46
Beavertail Creek	16	Middle Lake Outlet	47
Prentiss Creek	17	Long Lake Creek	48
McKay Creek	18	Squaw Creek	49
Flowers Creek	19	Devils River	50
Ceville Creek (Pearson Creek)	20	Black River	51
Hessel Creek (Mackinac Creek)	21	Mill Creek	52
Steeles Creek	22	AuSable River	53
Nunns Creek	23	Tawas Lake Outlet	54
Pine River	24	East AuGres River	55
McCloud Creek	25	AuGres River	56
Carp River	26	Rifle River	57
Martineau Creek	27	Saginaw River	58
266-20 Creek	28	Rock Falls Creek	59
Beaugrand Creek	29	Elm Creek	60
Little Black River	30	Mill Creek	61
Cheboygan River	31	Cherry Creek	62

Lake Erie (CAN)

St. Clair River	1		
Thames River	2		
East Creek	3		
Catfish Creek	4		
Silver Creek	5		
Big Otter Creek	6		
South Otter Creek	7		
Clear Creek	8		
Big Creek	9		
Forestville Creek	10		
Normandale Creek	11		
Fishers Creek	12		
Youngs Creek	13		

Lake Erie (US)

Black River	1		
Pine River	2		
Belle River	3		
Clinton River	4		
Chagrin River	5		
Grand River	6		
Wheeler Creek	7		
Ashtabula River	8		
Conneaut Creek	9		
Raccoon Creek	10		
Crooked Creek	11		
Canadaway Creek	12		
Halfway Brook	13		
Cattaraugus Creek	14		
Delaware Creek	15		
Buffalo River	16		

Lake Ontario (CAN)

Niagara River	1		
Ancaster Creek	2		
Grindstone Creek	3		
Bronte Creek	4		
Fourteen Mile Creek	5		
Sixteen Mile Creek	6		
Credit River	7		
Humber River	8		
Rouge River	9		
Petticoat Creek	10		
Duffins Creek	11		
Carruthers Creek	12		
Lynde Creek	13		
Oshawa Creek	14		
Farewell Creek	15		
Bowmanville Creek	16		
Wilmot Creek	17		
Graham Creek	18		
Wesleyville Creek	19		
Port Britain Creek	20		
Gage Creek	21		
Cobourg Brook	22		
Covert Creek	23		
Grafton Creek	24		
Shelter Valley Creek	25		
Colborne Creek	26		
Salem Creek	27		
Proctor Creek	28		
Smithfield Creek	29		
Trent River(Canal System)	30		
Moira River	31		
Salmon River	32		
Napanee River	33		

Lake Ontario (US)

Johnson Creek	1	Oswego River	18
Oak Orchard Creek	2	Catfish Creek	19
Salmon Creek	3	Butterfly Creek	20
Northrup Creek	4	Little Salmon River	21
Larkin Creek	5	Sage Creek	22
Irondequoit Creek	6	Snake Creek	23
Forest Lawn Creek	7	Grindstone Creek	24
First Creek	8	Salmon River	25
Third Creek	9	Deer Creek	26
Sodus Creek	10	Little Sandy Creek	27
Wolcott Creek	11	Blind Creek	28
Red Creek	12	Lindsey Creek	29
Blind Sodus Creek	13	Skinner Creek	30
Sterling Creek	14	South Sandy Creek	31
Nine Mile Creek	15	Sandy Creek	32
Eight Mile Creek	16	Stony Creek	33
Rice Creek	17	Black River	34

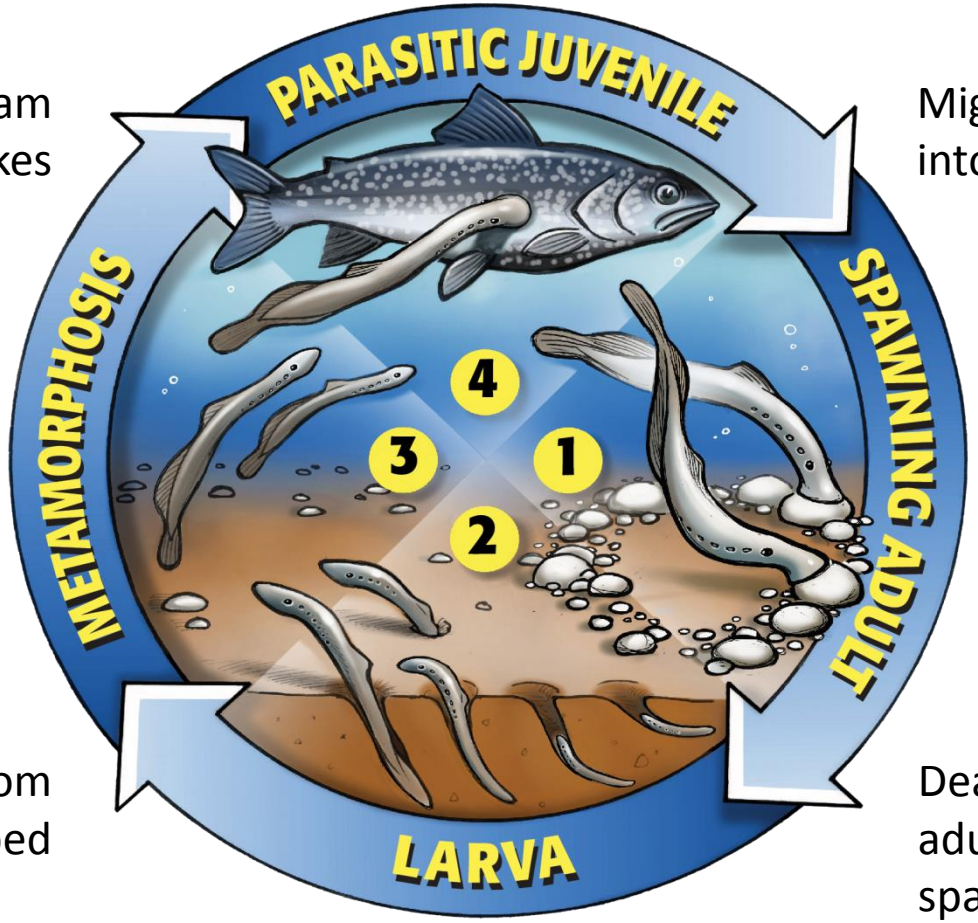
SEA LAMPREY CONTROL CENTRE
SAULT STE. MARIE, ONTARIO

created by: Kevin Tallon

data supplied by:
Sea Lamprey Control Centre
Marquette Biological Station
Ludington Biological Station

SEA LAMPREY LIFE CYCLE

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



Migration of adults into streams

MARCH-JULY

Death of adults after spawning

3-10+ YEARS

Emergence from stream bed

JUNE-MARCH

Downstream migration to lakes

SEA LAMPREY LIFE CYCLE