Lake Michigan Food Web and Sea Lamprey

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Lesson Overview: Students will build a food web of Lake Michigan before the construction of the Welland Canal using cards with diet information. After reviewing food web concepts of energy flow, trophic levels, and biomass, they consider the impact of the introduction of sea lamprey into their food web. Students discover that the most valuable Great Lakes fish species--Lake Trout--***were eliminated***, and tourism suffered due to many small fish species consuming all of their food resources, dying and being washed up on Great Lakes beaches. Lastly, students brainstorm ways of controlling the the lamprey.

Learning Objectives

At the end of the lesson, students should be able to:

1. Explain how energy and biomass decreases as you move up a food web.
2. Describe how invasive species can impact a food web.
3. Explain how invasive species can harm the economy, Great Lakes ecology and people's use and enjoyment of the Great Lakes.

Michigan Science Standards Addressed

Middle School Performance Expectation:

MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Science and Engineering Practices:

Developing and Using Models (Develop a model to describe phenomena)

Analyzing and Interpreting Data (Analyze and interpret data to provide evidence for phenomena)

Disciplinary Core Ideas:

Ecosystem Dynamics, Functioning, and Resilience (Ecosystems are dynamic in nature; their characteristics can change over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all of its populations.)

Crosscutting Concepts:

Stability and Change (Small changes in one part of a system might cause large changes in another part.)

High School Performance Expectation:

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.

Science and Engineering Practices:

Engaging in Argument from Evidence (Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments)

Using Mathematics and Computational Thinking (Create or revise a simulation of a phenomenon, devised device, process, or system).

Disciplinary Core Ideas:

Ecosystem Dynamics, Functioning, and Resilience (A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability).

Biodiversity and Humans (Humans depend on the living world for the resources and other benefits provided by biodiversity. Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction).

Crosscutting Concepts:

Stability and Change (Much of science deals with constructing explanations on how things change and how they remain stable).

Sources Consulted:

This activity uses pictures and information on Lake Michigan creatures taken from the NOAA website: https://www.glerl.noaa.gov/res/projects/food_web/food_web.html.

Krause, A. E., K. A. FRANK, D. M. MASON, R. E. Ulanowicz, and W. W. Taylor. Compartments revealed in food-web structure. *Nature* 426:282-285 (2003). (pdf)

Great Lakes Fishery Commission. 2017. “Sea Lamprey: A Great Lakes Invader.” http://www.glfc.org/sea-lamprey.php

Materials

Per student group:

1 set of organism cards.

Chalk (if writing on a lab table or concrete) or a large piece of paper and marker

Example of student-created food web (attached)

New Vocabulary

Producer: Organism that makes its own food.

Primary consumer: Organism that eats producers (herbivores)

Secondary and Tertiary consumers: carnivores that eat the previous trophic level.

Trophic level: energy level of a food web

Biomass: the total mass of organisms in a given area or volume

Decomposers: an organism, such as a soil bacterium, fungus, or invertebrate, that decomposes organic (plant and animal) material.

DNR: Department of Natural Resources. The state agency in charge of managing and conserving the flora, fauna, and land in Michigan.

Teacher Background

Lamprey Arrival in the Great Lakes Lampreys got here when we built a lock system around Niagara Falls. The lamprey made their way up through the locks and found a home in the Great Lakes. They spend 3-7 years as non-parasitic young, filter feeding in rivers until they leave to the Great Lakes and kill 2-3 large fish as they grow, returning to their home stream to lay eggs. They are native to the Atlantic Ocean, but since they spend the first part of their life in fresh water, they could survive in the Great Lakes.

Analyzing the food web. A student food web, when completed, will look messy. This is a good teaching point. Food webs should be messy—many creatures depending on many creatures. This allows stability for an ecosystem. In our case, the lake trout is a keystone predator of the system. Burbots are rare and prefer warmer water, so when the lake trout were removed, we saw a huge increase in the small fish (yellow layer). This, in turn, led to a decrease in zooplankton (purple layer) and an increase in phytoplankton (green layer). When the smaller fish used up all of their food resources, their population would then crash, resulting in massive amounts of dead fish on our beaches. The loss of the lake trout caused a chain effect that not only led to the loss of millions of dollars in fisheries, but also tourism dollars because our beaches were not very attractive with rotting fish. The solution was an introduction of a new predator: salmon. Chinook and Coho salmon, along with fishery-raised lake trout, now are at the top of the food chain. This has stabilized the smaller fish population as well as provided an economic boost to our fisheries.

Focus Question (write on board for students to see): What happens to a food web when a new species shows up?

Expected prior knowledge: Students should already have learned about energy flow, trophic levels, and biomass, food web energy transfer.

Classroom Activity – students work together in small groups to complete the following student page. They are welcome to use additional resources—textbook, internet, etc.

Student Assessment – students complete the assessment after completion of the lesson.

Lake Michigan Food Web – Student Page

Instructions to Students: You have been given a collection of cards showing creatures that lived in Lake Michigan in the early 1900s. Make a food web, showing what eats what. The outlined color of each should help you organize it into layers (trophic levels), and what each creature eats is on the back of each card. Please make arrows on your paper showing what eats what. Which way do the arrows go? After you have created your food web, answer the following questions and wait for further instructions.

1. Look at your food web. Label the layers or levels (producers, primary consumers, etc.)
    a. Of the 4 "levels", what color is the producers?
    b. What level is the color is the primary consumers?
    c. What level is the top of the food chain?

2. Energy flows through an ecosystem. Where does the original energy come from?

3. Materials "cycle" through an ecosystem. Creatures that take dead things and eat them are recyclers.
    a. What is the name of organisms that eat dead things?
    b. What types of creatures live in Lake Michigan that would eat the dead things (note: only one is in the food web—but try to name 3)?

4. Where is the most energy stored in the ecosystem (what level)?

5. Where is the most biomass (total amount of organisms) in the ecosystem?

6. As you move up the food chain, energy is lost. In other words, the producers have more energy than all the other organisms. Where does that energy go?

7. How much energy goes up each level?

8. Explain how the carbon that is in the body of the Lake Trout gets back to the producers.

Please wait for discussion before you go on.

9. In the early 1900s year, the sea lamprey began to swim around Niagara Falls after improvements to the Welland Canal established a shipping connection between Lake Ontario and rapidly spread to the other four Great Lakes. Their population exploded.
    a. What happened to your tertiary consumers?
    b. What would happen to your secondary consumers?
    c. What would happen to your primary consumers?
    d. What would happen to your producers?

10. Let's focus on the secondary and primary consumers. The secondary consumers are small fish. What do you think happened when they ran out of food?

11. Propose a solution to this problem. Understand that at this time, there are millions of sea lampreys all around the world and millions in the Great Lakes itself. Work with your group to develop a plan to solve this problem and prepare to present your plan to the rest of the class.

12. At the end of the presentations and discussion, write down what is actually being done to address this problem. What are the pros and cons of the current methods?

Lesson Extensions

a. Teach about the life cycle of sea lampreys.

b. Discuss the tradeoffs of the sea lamprey invasion through the St. Lawrence Seaway versus the construction of the Welland Canal.

c. Play a version of *Oh Deer* with fish and fishermen to show fish population changes (*Oh Deer* is described in Project Wild activity guide)

d. Show Sea Lamprey Control Video: http://www.glfc.org/eforum/article17.html produced by the Great Lakes Fishery Commission.

Lake Michigan Food Web ~ ANSWERS

1. A. B. C. Tertiary Consumers
2. Sun
3. A. decomposers B. worms (in the web), bacteria and fungus. Note: decomposers eat all dead things, so I tend to put them on the side (food web is messy enough as is)
4. Producers
5. Producers
6. Heat
7. 10%
8. Lake trout are eaten by decomposers, which burn it for energy, generating carbon dioxide (cellular respiration), and the producers use the carbon dioxide to make food.
9. A. Down (lampreys ate the lake trout--burbots were always low in number due to specific habitats. B. Up (small fish have no predators); C. Down (zooplankton eaten by increased numbers of small fish); D. Up (phytoplankton had no predators left)

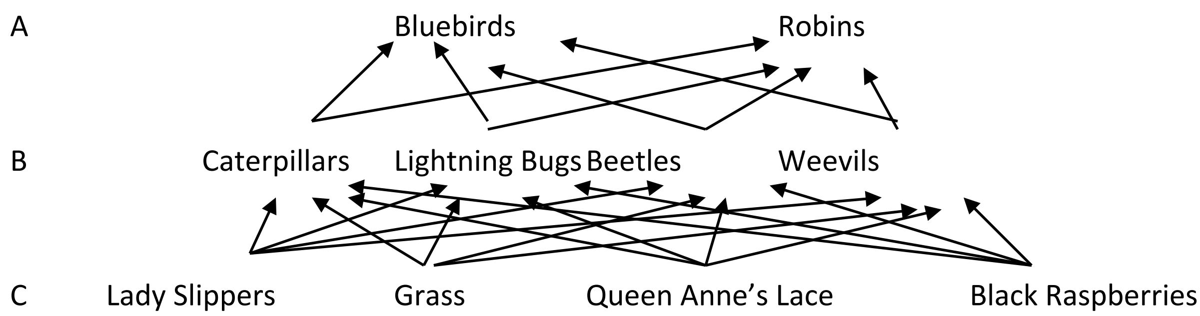
10. This is what happened. The small fish, including alewives, went way up in population until they crashed because they exhausted their resources. As a result, there were massive die-offs of small fish that literally covered the beaches of Lake Michigan, 1-2 feet thick in dead fish, and that led to a decrease in tourism.

11. Students should share their solutions (per NGSS).

12. The current and most widely used control method is to poison streams every three years with a poison that is specific to lampreys (lampricide). Since lampreys are a very different fish (Agnatha) from most of our fish (Osteichythes), the poison only works on them. We've also used low-head dams (small dams) and we've tried some other techniques, but poison is still the main method. This costs millions of dollars a year and adds chemicals into many of the pristine rivers in northern Michigan. It has been successful in keeping lamprey populations low enough so that native fish have bounced back. However, due to the slow reproductive nature of lake trout, salmon were introduced to help restore the food web.

The sea lamprey control program, administered by the Great Lakes Fishery Commission, relies on exploiting sea lamprey vulnerability when they are congregated in Great Lakes tributaries, at either the larval or adult stages of their life cycle. Lampricides—pesticides selective to lampreys and the primary sea lamprey control tactic—are deployed to kill larval sea lampreys in the tributaries, while a combination of barriers and traps are used to prevent the upstream migration and reproduction of adult sea lampreys. See Sea Lamprey Control in the Great Lakes for more information on the various sea lamprey control techniques. The Great Lakes Fishery Commission, (established in 1955 by the Canadian/U.S. Convention on Great Lakes Fisheries) coordinates Great Lakes fishery research and management, and controls sea lamprey in partnership with state, provincial, tribal and federal management agencies including the U.S. Fish and Wildlife Service, Fisheries and Oceans Canada, and the U.S. Army Corps of Engineers. The U.S. Geological Survey conducts critical sea lamprey research to aid in control. This control program has reduced sea lamprey populations by 90% in most areas of the Great Lakes, a remarkable success!

Lake Michigan Food Web - Student Assessment



1. What level (A, B, or C) is the producer level?

2. What level (A, B, or C) is the secondary consumer level?

3. What level (A, B, or C) has the most energy?

4. What level (A, B, or C) is the most biomass?

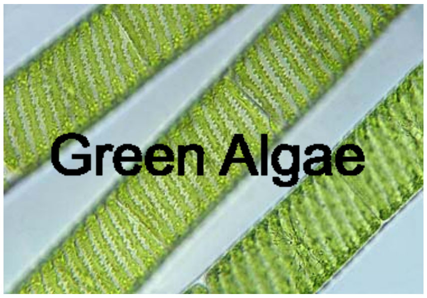
5. How much energy goes up to the next trophic level?

6. This food web is from a Michigan backyard. The bottom level are many plants that are native to Michigan, and the insects in level B are also native. There is a new plant that is showing up in shady areas called garlic mustard. It has a very strong smell and taste, so the native insects won't eat it.

   a. Explain what will happen to the other plants if nothing eats garlic mustard.

   b. Explain, in detail, why we are not seeing bluebirds in this backyard anymore.

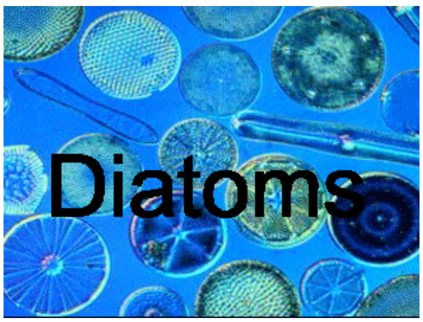
7. Propose a plan for the homeowner who owns this yard that will bring bluebirds back to this yard.



Name: Green algae

Kingdom: Protista

Food: Autotroph



Name: Diatoms

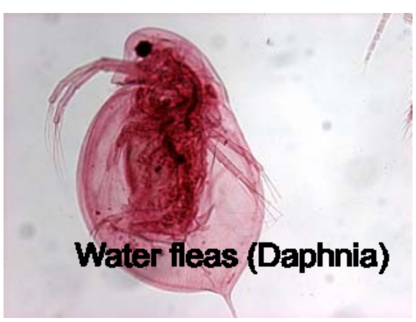
Kingdom: Protista

Food: Autotroph

Name: Rotifer

Kingdom: Animal

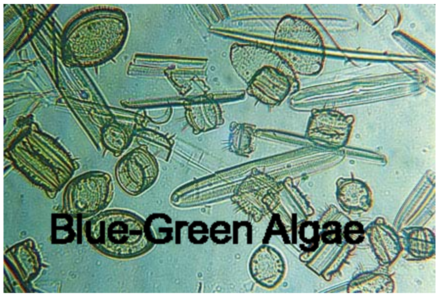
Food: Diatoms, Green algae, flagellates



Name: Daphnia

Kingdom: Animal

Food: Diatoms, Green algae, flagellates, blue-green



Name: Blue-Green Algae

Kingdom: Monera

Food: Autotroph

Name: Flagellates

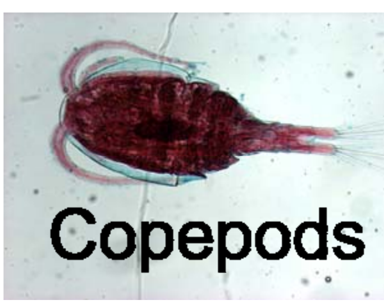
Kingdom: Protista

Food: Autotroph

Name: Amphipods

Kingdom: Animal

Food: Diatoms, Green algae, flagellates



Name: Copepods

Kingdom: Animal

Food: Diatoms, Green algae, flagellates, blue-green

Name: Rainbow smelt

Kingdom: Animal

Food: Daphnia, Copepods, Oppossum Shrimp, Amphi-

Name: Lake Whitefish

Kingdom: Animal

Food: Daphnia, Copepods, Oppossum Shrimp, Amphipods, Mollusks, Aquatic Worms, Rainbow smelt

Name: Mollusks

Kingdom: Animal

Food: Diatoms, Green algae, Flagellates

Opossum Shrimp

Name: Oppossum Shrimp

Kingdom: Animal

Food: Diatoms, Green algae, Flagellates, Copepods,

Name: Lake Perch

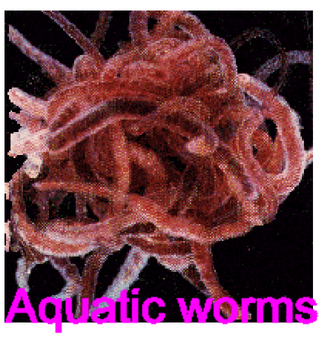
Kingdom: Animal

Food: Daphnia, Copepods, Oppossum Shrimp, Amphipods, Aquatic Worms

Name: Bloater

Kingdom: Animal

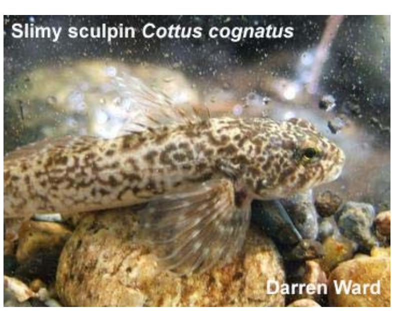
Food: Daphnia, Copepods, Oppossum Shrimp, Amphipods, Aquatic Worms



Name: Aquatic Worms

Kingdom: Animal

Food: Dead stuff



Name: Slimy Sculpin

Kingdom: Animal

Food: Aquatic worms, amphipods, oppossum shrimp

Name: Burbot

Kingdom: Animal

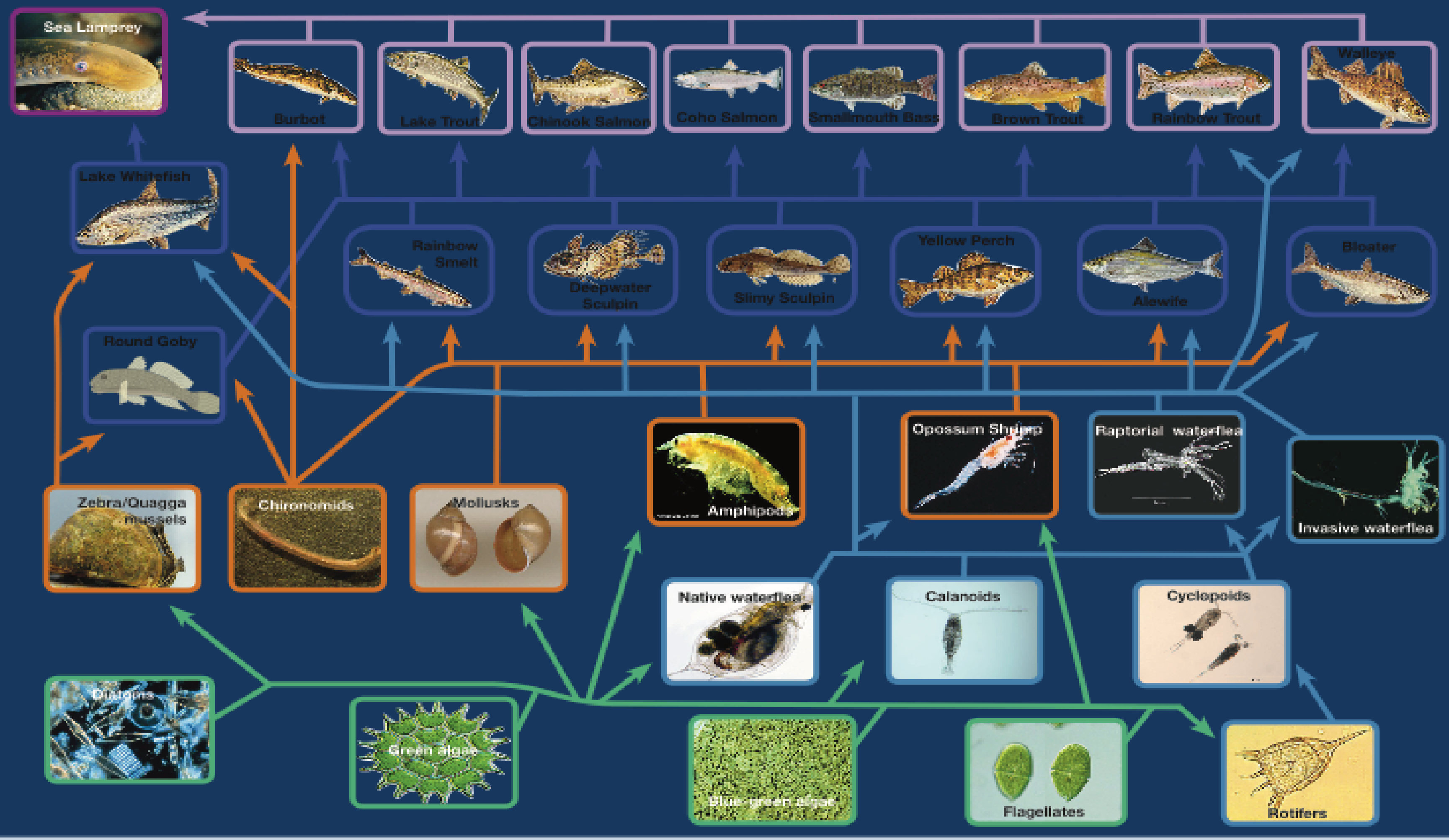
Food: Oppossum Shrimp, Amphipods, Slimy Sculpin, Rainbow smelt, Bloater

Name: Lake Trout

Kingdom: Animal

Food: Slimy Sculpin, Rainbow smelt, Bloater

Lake Michigan Food Web



Foodweb based on "Impact of exotic invertebrate invaders on food web structure and function in the Great Lakes: A network analysis approach" by Mason, Krause, and Ulanowicz, 2002 - Modifications for Lake Michigan, 2009.

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734-741-2235 - www.glerl.noaa.gov

Sample Student-Generated Food Web