FLOW Unit 1: Food Web Overview

This series of five lessons from Fisheries Learning on the Web (FLOW), Unit 1, Food Web, begins by introducing the concepts of aquatic food chains and food webs. Activities demonstrate that all living organisms in an ecosystem are connected and that this structure is sensitive to change. Lessons then discuss the problem of nonindigenous species and why some of these are invasive. Invasive species disrupt Great Lakes food webs and cause long-term ecological changes.

Lesson 1: Make the Connection

Demonstrates that all organisms are linked and emphasizes the importance of these connections. Discusses herbivores, carnivores, and producers.

Lesson 2: Who's Eating Whom?

Explains that some animals eat multiple species, forming complex food webs that transfer energy. Discusses producers, consumers and top predators.

Lesson 3: Great Lakes Most Unwanted

Discusses the concept of nonindigenous species—how they're introduced into an ecosystem and why some become invasive. Presents 10 invasive species and their impacts.

Lesson 4: Beat the Barriers

Focuses on the invasive sea lamprey, its impact on the Great Lakes ecosystem, and various control methods used to manage the population.

Lesson 5: Ruffe Musical Chairs

Emphasizes the importance of meeting basic needs for food, water, and habitat. Demonstrates how invasive species can cause dramatic food web changes that impact native species.

Supplemental Materials

Note: Some lesson materials (cards, games, charts and other graphics) may be at the very end of this unit, rather than compiled with each lesson.

See the lesson section *materials and procedures* and the *Supplemental Materials* section at the end of this document.

Lesson Assessment, State of Michigan Grade Level Content Expectations (GLCE) and National Benchmarks:

See separate document: FLOW_Assessment_GLCE.pdf

Lesson 1: Make the Connection

Activity: Students work with paper cutouts to learn about the parts of a food chain, specifically herbivores, carnivores, and producers.

Grade level: 4-8
Subjects: Science, social studies
Setting: Classroom
Duration: 30-60 minutes
Key Terms: Carnivore, Food chain, Herbivore, Omnivore, Producer

Graphics: D. Brenner

Objectives

After participating in this activity, students will be able to:

- Describe the difference between herbivores, carnivores, and producers.
- Answer questions about the interdependence of herbivores, carnivores, and producers as members of a food chain.
- Answer questions about how pollution affects food chains.

Summary

All living organisms depend on one another for food. By reviewing the relationships of organisms that feed on one another, students begin to see how all organisms—including humans—are linked. If students understand the relationships in a simple food chain, they will better understand the importance and sensitivity of these connections, and why changes to one part of the food chain almost always impact another.

Background

A food chain is a simplified way to show the relationship of organisms that feed on each other. It's helpful to classify animals in a simple food chain by what they eat, or where they get their energy.

Green plants, called producers, form the basis of the aquatic food chain. They get their energy from the sun and make their own food through photosynthesis. In the Great Lakes, producers can be microscopic phytoplankton (plant plankton), algae, aquatic plants like Elodea, or plants like cattails that emerge from the water's surface.

Herbivores, such as ducks, small fish, and many species of zooplankton (animal plankton), eat plants. Carnivores (meat eaters) eat other animals and can be small (e.g., frog) or large (e.g., lake trout). Omnivores are animals (including humans) that eat both plants and animals. Each is an important part of the food chain.

In reality, food chains overlap at many points—because animals often feed on multiple species—forming complex food webs. Food web diagrams depict all feeding interactions among species in real communities. These complex diagrams often appear as intricate spider webs connecting the species. See: Unit 1, Lesson 2

This lesson demonstrates that changes in one part of a food chain or web may affect other parts, resulting in impacts on carnivores, herbivores, and eventually on producers. An example of this might be the harmful effects of pollution.

The point that should be made is that when something disrupts a food web, humans should try to understand and minimize the disturbance. Students should also come to recognize that humans, too, are part of this complex web of life.

Materials and Preparation

- Pencils
- Straightedges
- Drawing paper
- Scissors
- Glue

Note: See *FLOW Food Chains & Food Webs* fact sheet at the end of this lesson (supplemental materials).

Procedure

1. Have each student draw a large triangle, a rectangle, a circle, and a square on a sheet of drawing paper. All four shapes should fit on one sheet. Cut out each shape. Write the word “carnivore” on the square. Write the word “herbivore” on the triangle. Write the word “producer” on the circle. Write the words “large carnivore” on the rectangle.
2. Have each student place the four paper shapes on a sheet of drawing paper in an order that forms a food chain. Draw arrows to show what each of the members eats.
3. Explain what a food chain might look like in a nearby river or lake. On a chalkboard, generate lists of local animals and plants under the producer, herbivore, carnivore, and large carnivore heading. Let the students label their shapes again with the name of an animal or plant of their choice.
   Producers: Phytoplankton, algae, aquatic plants, cattails, duckweed, trees.
   Herbivores: Ducks, geese, small fish, zooplankton, tadpoles, mayfly nymphs, small crustaceans.
   Carnivores: Sculpin, alewife, small fish, turtles, frogs, toads, water snakes, dragonfly nymphs.
   Large carnivores: Lake trout, walleye, bass, herons, gulls, red tailed hawks, humans.

4. Pretend that a disease, human influence, or over-fishing has killed the carnivores in your chain. Have the students remove the square from their chain. Ask questions about interrelatedness to guide discussion and exploration.
   - If large carnivores, such as walleye in Saginaw Bay, are reduced by over-fishing, nutrient enrichment, or parasitism, what happens to small fish, zooplankton, and phytoplankton populations? (The food chain will be disrupted in a chain reaction. First, the small fish population will increase because the walleye are not eating them. Second, the zooplankton population will be greatly depleted because of small

fish eating them, and third, the phytoplankton population will increase because the zooplankton are not there to eat them.)
- If great blue herons along the Grand River are reduced, what happens to water snake and aquatic plant populations? (This food chain will also be disrupted in a chain reaction. First, the water snake population will increase, and second, the water snakes will eat and deplete herbivores. Third, since the herbivores have been depleted, aquatic plant populations will increase.)

5. Optional for grades 7-8. Pretend that chemical pollution or another human influence, such as salt pollution due to snow removal from streets, has killed the producers in your chain. Remove the circle. Ask questions about interrelatedness to guide discussion and exploration.

   If toxic chemicals reduced the growth and production of phytoplankton, what happens to the chain? (This food chain will be unable to support large numbers of animals.)
   - If city sewage gets into Lake St. Clair and provides too many nutrients for phytoplankton and aquatic plants, what happens to the food chain? (There is an over production of phytoplankton and aquatic plants. Some animals do well in these conditions, and some die, changing the food chain. Some waters will turn into a soupy green slime, and dead aquatic plants may end up on the beaches in unpleasant amounts).

Source

Adapted for the Great Lakes Education Program with permission from “Marsh Munchers,” Project WILD Aquatic. Modified by Brandon Schroeder, Michigan Sea Grant.

Assessment & Standards

See separate document: **FLOW_Assessment_GLCE.pdf**

FLOW Feedback

Please take 10 minutes to provide us with your feedback.
Go to: http://www.miseagrant.umich.edu/flow/flow-feedback.html

Supplemental Materials, Unit 1

Lesson 1 - Make the Connection - Documents:

- FLOW Food Web and Food Chains fact sheet: FLOW–Food–Chains.pdf

FLOW
FISHERIES LEARNING ON THE WEB
www.projectflow.us

Food Chains & Food Webs
Additional background information

Producers
Plants form the base of Great Lakes food chains. They're called producers, because they make their own food by converting sunlight through photosynthesis. In the process, they provide food for other organisms.

In the Great Lakes, most producers are phytoplankton, or microscopic floating plants. An example of phytoplankton is green algae. Large rooted plants, another type of producer, provide food and shelter for different organisms, fish and wildlife.

Primary Consumers
The next level in the food chain is made up of primary consumers, or organisms that eat food produced by other organisms. Examples of primary consumers include zooplankton, ducks, tadpoles, mayfly nymphs and small crustaceans.

Secondary Consumers
Secondary consumers make up the third level of the food chain. Examples of secondary consumers include bluegill, small fish, crayfish and frogs.

Top Predators
Top predators are at the top of the aquatic food chain and include fish such as lake trout, walleye and bass, birds such as herons, gulls and red tailed hawks—and humans!

Food Webs
In reality, many different food chains interact to form complex food webs. This complexity may help to ensure survival in nature. If one organism in a chain becomes scarce, another may be able to assume its role. In general, the diversity of organisms that do similar things provides redundancy, and may allow an ecological community to continue to function in a similar way, even when a formerly dominant species becomes scarce.

However, some changes in one part of the food web may have effects at various trophic levels, or any of the feeding levels that energy passes through as it continues through the ecosystem.

Plankton

Plankton are microscopic plants and animals whose movements are largely dependent upon currents. Plankton are the foundation of the aquatic food web. Plankton are vital in the food supplies of fish, aquatic birds, reptiles, amphibians and mammals. Aquatic insects, tadpoles, and small and baby fish all feed directly on plankton.

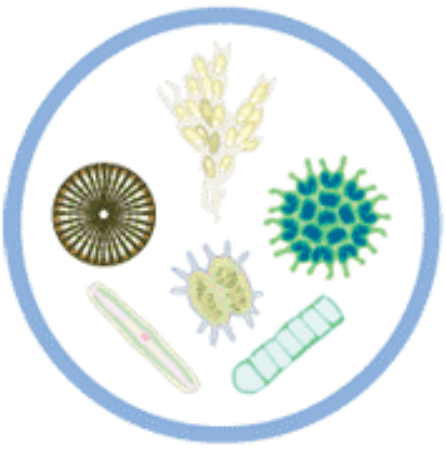
Phytoplankton

Plant plankton are called phytoplankton and may be single cells or colonies. Several environmental factors influence the growth of phytoplankton: temperature, sunlight, the availability of organic or inorganic nutrients, and predation by herbivores (plant eaters).

Zooplankton

Animal plankton are called zooplankton. Zooplankton can move on their own, but their movement is overpowered by currents.

Zooplankton may be herbivores or plant-eaters (eat phytoplankton), carnivores or meat-eaters (eat other zooplankton) or omnivores, which eat both plants and animals (eat phytoplankton and zooplankton).



Phytoplankton

Zooplankton

Lesson 2: Who's Eating Whom?

Graphics: D. Brenner

Activity: Students use body movement and pantomime to simulate the feeding motions of freshwater organisms and demonstrate the interconnectedness of a food web.

Grade level: 4-8
Subjects: Science
Setting: Outside or in a large open area
Duration: 30-60 minutes
Key Terms: Biomass, Consumer, Detritus, Food web, Macroinvertebrates, Predator, Prey, Producer, Productive

Objectives

After participating in this activity, students will be able to:

- Diagram a food web
- Compare a food web to a food chain and list similarities and differences
- Discuss predator–prey and consumer–producer relationships using vocabulary words
- Make predictions about roles each link plays in the overall food web
- Observe how lower links in a food web affect the highest links

Summary

In the Great Lakes, many different food chains interact to form complex food webs. A food web shows what fish, animals and organisms eat—sometimes multiple species—and how energy is passed from one group to another. The complexity of food webs may help to ensure survival in nature. If one organism in a chain becomes scarce, another may be able to fill its role. Students learn, however, that if too many links in the food web are lost, the changes will affect every other link including humans.

Background

Freshwater marshes and wetlands provide an ideal setting to study aquatic food webs. These nutrient-rich areas produce more organic material, or biomass, than any other ecosystem. Typical marsh conditions stimulate growth of aquatic plants, which serve as an abundant source of energy and provide food and habitat for a variety of organisms.

Food webs can have many different feeding levels. Different species make up the various levels, depending on the type of food they produce or consume. Common terms for these levels include: producers (green plants), primary consumers (organisms and small animals that feed on live plants or dead plant and animal debris), secondary consumers (i.e., small fish or frogs that may be predators (catch their food alive) or prey (animals

that are hunted or caught for food), and top level consumers or top predators (including humans) that prey upon other animals

In a simple food chain, aquatic bugs eat the plants, and small fish eat the bugs. Big fish eat the little fish, and people catch and eat the big fish. As mentioned, however, organisms often feed on more than one species. This interaction is important, because if one organism declines or disappears, the organisms that feed on it are not necessarily lost; they can find other sources of food.

No matter what the complexity of a food web, when one organism consumes another, this process transfers energy through the various levels. However, with each transfer (consumption of one organism by another), energy is lost in digestion processes. The result is that it takes larger numbers of organisms at the base of a food web (e.g., producers) to support fewer organisms at the top (e.g., top predators).

At times, organisms at the bottom or middle of the web may die before they are consumed. In this case, the biomass supports the base of the food web by providing nutrients for new plant growth.

Materials and Preparation

- Timer
- Construction paper (4 colors from *Food Token Chart*) for tokens. Red (top predators), blue (secondary consumers), brown (primary consumers), and green (producers). Cut the appropriate colored construction paper into food tokens according to Table 1.
- One envelope per student.
- *Feeding behavior cards* for organisms. Reproduce the feeding behavior cards. Put one feeding behavior card and the appropriate number and color of food tokens into each envelope.
- For additional background info on food chains and food webs, see *FLOW Food Chains & Food Webs* fact sheet.

NOTE: see *Table 1* (*Food Token Chart*), *Feeding Behavior Cards* and the *Food Chains & Food Webs fact sheet*: at the end of this lesson (supplemental materials).

Procedure

Discussion

1. Describe the Great Lakes freshwater marsh habitat in terms of plants and animals that live there. Have students discuss what they know about marshes. What lives there? Discuss the organisms. Find out how these marshes may be important to the students (e.g., for fishing, bird watching, or collecting frogs and turtles).
2. Also discuss the importance of the freshwater marshes with emphasis on their high productivity as a place for plants and animals to live. Introduce the terms “predator” and “prey” as well as “producers” and “consumers.” With the students’ help, integrate their knowledge to come up with useable and understandable definitions of these terms.
3. Explain to the students that they are going to participate in an activity in which they will become freshwater marsh plants and animals to see how food chains and food webs work. Explain that organisms (students) need to eat in order to survive and that

some of them depend on the others for that reason. Some students will be predators and others will be prey. Some students will be both: thus, they will need to eat other organisms but also avoid being eaten. Discuss this for a minute. Can there be more then one predator? Can predators eat predators? Build on previous knowledge of food chains to help learners understand these ideas.

4. For simplicity in this game, organisms are assigned specific prey that they are allowed to consume. In reality, size of an organism is a complicating factor. For example, young bass and pike (fish) may in fact be prey to an adult crayfish. Similarly, even a small raccoon that gets too close to the water could become food for a large pike. There are endless examples of how the age or size of an organism could alter the structure of a food web. However, the end result of a food web is the transfer of energy and mass from producers to the top consumers or predators.

Pre-game Preparation

1. Discuss the object of the game: By acting out the feeding motions of freshwater organisms, students will "capture" (tag) the appropriate prey and try to collect enough food tokens to survive.
2. Pass out one envelope (containing feeding behavior cards and tokens) to each student. Each envelope contains the identity of one animal that lives in a freshwater marsh. Explain that their identity is a secret—they are not to tell others. The only way others will know what they are is by the way they feed.
3. Have the students open their envelopes and see what animal they are and what feeding behavior they use. Remind them not to tell what they are. Emphasize that they are people pretending to be animals, and humans will not be able to move exactly like animals. Review the organisms and their feeding behaviors but allow students to improvise.

Explain the Rules

1. Each student represents a producer or a consumer. Consumers will play the role of predators, prey, or both.
2. Each producer has 30 green food tokens, representing 30 individual marsh plants of the same species.
3. Each primary consumer (macroinvertebrates, snails, clams) starts with 10 food tokens; secondary consumers (crayfish, frogs, small fish, bluegill) start with 5 food tokens, and top predators begin with only one red token. Each token represents an individual organism of the same species.
4. During the first cycle, or year, each consumer will need to eat enough food to survive and grow and thus to reproduce. Consumers collect tokens by identifying the feeding behaviors of their prey and then tagging them. When someone is tagged they have to give up a token. Each food token a consumer consumes will represent a new organism of the consumer species.
5. People, raccoons, blue herons, pike and bass are at the top of the food web and must consume 10 organisms to survive.
6. Bluegill, small fish, crayfish, and frogs are secondary consumers (which may be predators or prey). They will need to consume and have in possession five organisms at the end of the year in order to survive. However, they must also avoid predation. If captured, they must give up one token.
7. Clams, snails, and macro-invertebrates (primary consumers) need only to end the year with one organism to survive. However, they must also eat enough to account for predation or they will die, too.

8. Plants can die, and they are directly returned to the system as nutrients; therefore, plants need nothing to eat, but if these students are out of tokens then they must wait until another organism dies due to lack of food (i.e, a student is eliminated after losing all tokens) and returns enough nutrients to the ground to create new plant growth.
9. Any organism that does not end the year with enough tokens to survive will return what they do have to the ground for consumption by plants and other organisms that feed on decaying organisms.
10. It is important that each organism continues to act out what it is. If an organism forgets what different pantomimes represent, then it is up to them to investigate, if they want to survive. However, they will have to realize that food webs are not forgiving, and a nosey little fish that investigates a pike will become food for a pike!

Play the Game

1. Establish a play area (inside a classroom or outside) and have all producers take their envelopes with them, spread out on the playing field, and start acting out their roles.
2. Next, tell everyone else to begin to pantomime their respective behaviors, capture their prey by tagging others, and secure a food token from them, placing it in their envelope.
3. End the game after most top predators have gotten 10 food tokens.
4. Tell the students to hold onto their food envelopes so that they can participate in class discussion.

Discuss the Results

1. Did every top predator "fill up" by getting 10 food tokens during the cycle or year? If not, why not? (Some animals are more selective in feeding preferences and therefore may have a more difficult time finding food.) Talk about the different way the animals are connected to each other and the producers. Be sure that the supporting roles of decomposers do not get overlooked. Decomposers are responsible for breaking down dead organisms into nutrients usable by plants for growth.
2. Draw a food web based on what feeding interactions took place during the game. Discuss the path that some tokens took to get from the bottom of the web to the very top. Discuss how many plants and lower organisms it took to support the top of the food web.
3. Optional: Replay the simulation for a second round or year, leaving the tokens distributed as they were after the first round. Tokens left over from an organism that died during the first year will be returned to the ground for consumption by organisms such as the plants and crayfish.
4. Summarize by emphasizing the importance of freshwater marshes. These marshes provide habitat for a variety of different kinds of animals.

Source

Adapted for the Great Lakes Education Program with permission from "Marsh Munchers," *Project WILD Aquatic*. Modified by Brandon Schroeder, Michigan Sea Grant and Michigan State University.

Assessment & Standards

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FLOW Feedback

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Supplemental Materials, Unit 1

Lesson 2 - Who's Eating Whom? Documents:

- Food Token Chart
- Feeding Behavior Cards
- Food Chains & Food Webs fact sheet

TABLE 1: FOOD TOKENS

Unit 1, Lesson 2

TOP PREDATORS		SECONDARY CONSUMERS may be predators or prey		PRIMARY CONSUMERS prey		PRODUCERS	
Person Fishing token per student	1	**Yellow Perch** tokens per student	5	**Clam** tokens per student	10	**Aquatic Plants** (1 of 3) tokens per student	30
Great Blue Heron token per student	1	**Small Fish** tokens per student	5	**Snail** (1 of 2) tokens per student	10	**Aquatic Plants** (2 of 3) tokens per student	30
Lake Trout token per student	1	**Crayfish** tokens per student	5	**Snail** (2 of 2) tokens per student	10	**Aquatic Plants** (3 of 3) tokens per student	30
TOTAL RED TOKENS	**3**	**Frog** tokens per student	5	**Macroinvertebrate** (1 of 3) tokens per student	10	**TOTAL GREEN TOKENS**	**90**
		TOTAL BLUE TOKENS	**20**	**Macroinvertebrate** (2 of 3) tokens per student	10		
				Macroinvertebrate (3 of 3) tokens per student	10		
				TOTAL BROWN TOKENS	**60**		

TABLE 1: FOOD TOKENS

Unit 1, Lesson 2

FOOD TOKEN	FOOD TOKEN	FOOD TOKEN	FOOD TOKEN	FOOD TOKEN	FOOD TOKEN	FOOD TOKEN	FOOD TOKEN	FOOD TOKEN	FOOD TOKEN
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FEEDING BEHAVIOR CARDS

Unit 1, Lesson 2

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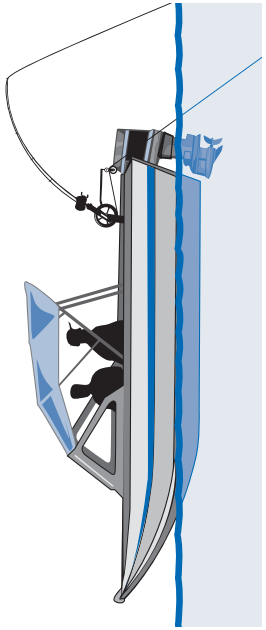
PERSON FISHING

TOP PREDATOR

You walk forward casting a fishing line and tag prey by grasping it on the shoulder.

You eat: Anything



Brenner

GREAT BLUE HERON

TOP PREDATOR

You strut with your hands on your hips, so that your elbows are like wings. When you get near prey, your arms become a beak and are used to stab at prey.

You eat: Yellow perch, small fish, crayfish, frogs, macroinvertebrates, snails, clams

Brenner

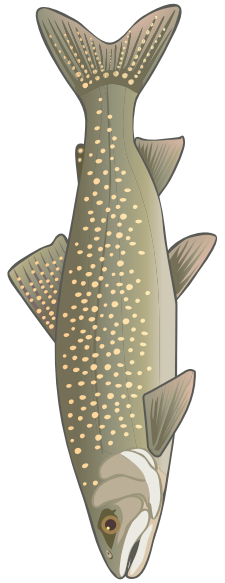
FOLD

LAKE TROUT

TOP PREDATOR

You walk around with arms held out like alligator jaws.

You eat: Macroinvertebrates, small fish and even small mammals



Brenner

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FEEDING BEHAVIOR CARDS

Unit 1, Lesson 2

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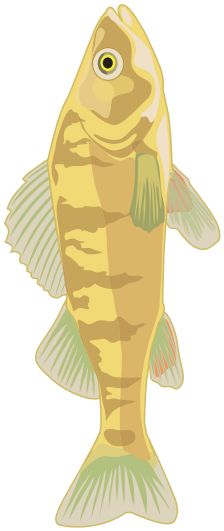
Sea Grant Michigan

YELLOW PERCH

SECONDARY CONSUMER

You walk with your hands cupped around your mouth, opening and closing to grasp prey.

You eat: Macroinvertebrates and small fish



Brenner

FROG

SECONDARY CONSUMER

You catch food with your tongue. Snap your arm back and forth like a frog's tongue.

You eat: Macroinvertebrates, snails, crayfish, small fish

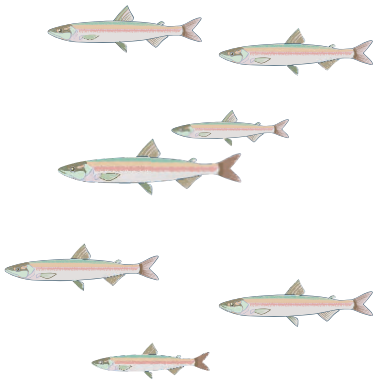
Marsee

SMALL FISH

SECONDARY CONSUMER

You feed mainly on algae, plant debris, and aquatic bugs. Pucker your lips and make sucking noises while feeding.

You eat: Macroinvertebrates, plants



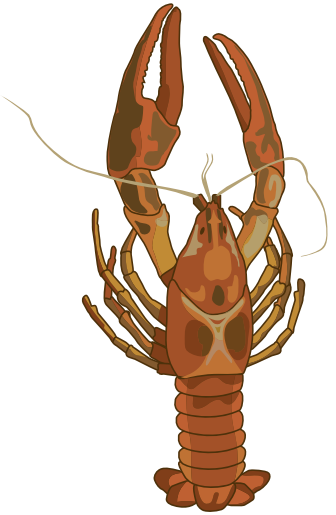
Brenner

CRAYFISH

SECONDARY CONSUMER

You capture prey and dead stuff with one or two claws. Make pinching motions using your hands like claws.

You eat: Small fish, snails, clams, macroinvertebrates, plants, animals or plants that have died



Brenner

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FEEDING BEHAVIOR CARDS

Unit 1, Lesson 2

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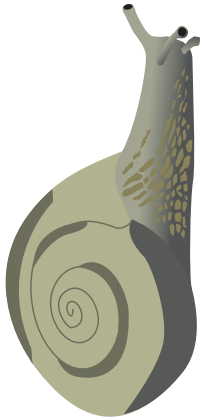
Sea Grant Michigan

SNAIL

PRIMARY CONSUMER (PREY)

You scrape plants, algae, or detritus (decaying stuff) with a special tongue. Show a licking motion using one hand as the tongue.

You eat: Live plants, animals or plants that have died



Marsee

CLAM

PRIMARY CONSUMER (PREY)

You filter tiny plants and detritus (decaying stuff) from the water. Wave your arms back and forth in the air like filters.

You eat: Live plants, animals or plants that have died

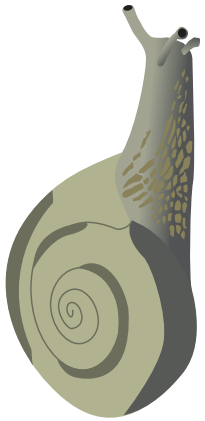
Brenner

SNAIL

PRIMARY CONSUMER (PREY)

You scrape plants, algae, or detritus (decaying stuff) with a special tongue. Show a licking motion using one hand as the tongue.

You eat: Live plants, animals or plants that have died



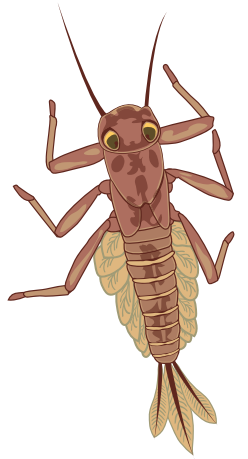
Marsee

MACROINVERTEBRATES

PRIMARY CONSUMER (PREY)

These are scavengers of plant and animal debris. Make swimming motions while you feed.

You eat: Live plants, animals or plants that have died



Brenner

FOLD

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FEEDING BEHAVIOR CARDS

Unit 1, Lesson 2

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Sea Grant Michigan

MACROINVERTEBRATES

PRIMARY CONSUMER (PREY)

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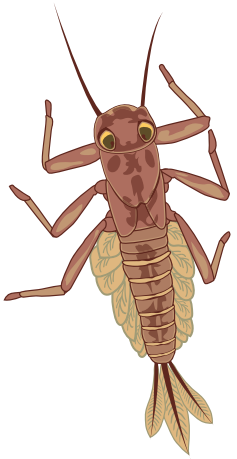
You eat: Live plants, animals or plants that have died



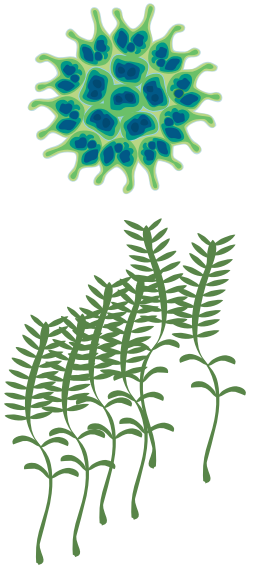
Brenner

AQUATIC PLANTS

Producer

You use sunlight and nutrients from the water to grow. Stand in one place and wiggle your hands over your head like plants moving in water.

You need: Dead plants or animals for nutrients



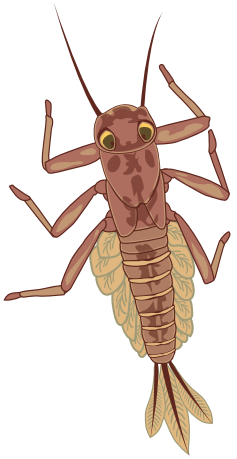
Brenner

MACROINVERTEBRATES

PRIMARY CONSUMER (PREY)

These are scavengers of plant and animal debris. Make swimming motions while you feed.

You eat: Live plants, animals or plants that have died



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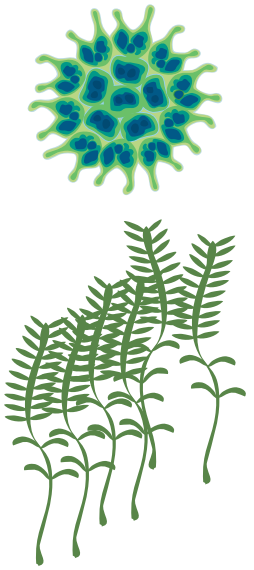

Brenner

FOLD

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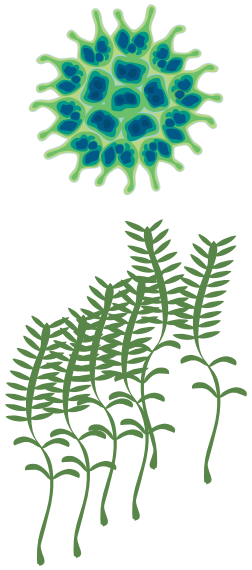

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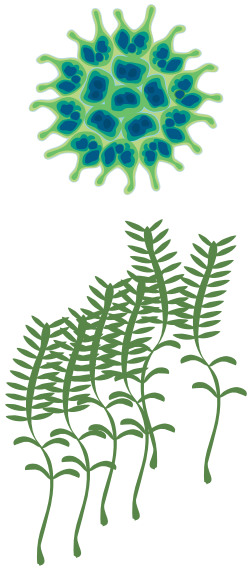

Brenner

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Lesson 3: Great Lakes Most Unwanted

Activity: Students work in small groups to organize invasive species cards, featuring facts and photos. Each group presents a different invasive species in a poster or fact sheet to the class.

Grade level: 4-8
Subjects: Science, social studies
Setting: Classroom
Duration: 2 hours
Key terms: Ballast water, Invasive, Non-native

Objectives

After participating in this activity, students will be able to:

- Name and visually recognize the primary aquatic invasive species of the Great Lakes
- Understand and analyze the negative impacts that invasive species have on the Great Lakes ecosystem
- Explain the ways in which non-native species are introduced into the Great Lakes

Summary

Many non-native species live in the Great Lakes, and some of them have become invasive. These species have established populations, multiplied rapidly, and caused profound and lasting impacts on the Great Lakes ecosystem. Others (such as Asian carp) have caused serious ecological problems in other parts of the country and threaten to enter the Great Lakes. Students will learn about some of the impacts of invasive species and how people can help prevent the spread of these unwanted species.

Background

Many non-native species have been introduced into the Great Lakes since the early 1800s, either accidentally or intentionally. Nonindigenous or non-native species are plants and animals living outside of the area where they evolved. A fraction of these species (about 10%) are considered invasive. Aquatic invasive species are non-native plants, animals and microscopic organisms that have a profound negative impact on an aquatic ecosystem or human activity.

Free from natural predators, invasive species reproduce rapidly in their new homes and compete with native species for food and habitat. They disrupt the aquatic food web by reducing food for native species or by preying directly upon native species. Invasive species are often called “biological pollutants.” They’re costly to manage and have led to a severe loss of biodiversity throughout the world.

In the Great Lakes, zebra mussels and sea lamprey are among the invasive species that have permanently altered the ecosystem, contributed to declines in native species, and impacted sport and commercial fishing. Invasive plants, such as purple loosestrife and Eurasian watermilfoil, have established themselves in many wetlands and inland lakes, respectively, resulting in a loss of native plants and the wildlife that depend upon them.

Many invasive species in the Great Lakes were transported from foreign ports in the ballast water of ocean going freighters. Ships often take on ballast water for better balance, stability, and safety. Today, the United States and Canada require that most ships entering the Great Lakes exchange their ballast water while still at sea to reduce transport and introduction of new species. Other species like sea lamprey entered the Great Lakes on their own when shipping canals were modernized. Still other introductions are the result of accidental releases.

How You Can Help

Prevent the transport of aquatic invasive species. Before leaving a body of water:

- Remove mud, plants, fish and animals from fishing gear, boats, motors, and trailers.
- Eliminate water from all equipment, including swimming floats, boat hulls, and bait buckets.
- Clean and dry anything that came in contact with the water—even boots, clothing, and pets.
- Do not release or put plants, fish or animals into a body of water unless they came out of it. Dispose of unused fishing bait in the trash.
- See: Protect Your Waters Website, www.protectyourwaters.net

Materials and Preparation

For each group of 3-4 students:

- Set of 16 *Aquatic Invasive Species Game Cards*. Each set has 8 photo cards (featuring invader photo and introduction) and 8 characteristics cards (featuring species characteristics and impacts).
- White and colored card stock
- Tape
- Copy photo cards onto white card stock. Copy characteristics cards onto colored card stock.
- Assemble all cards by cutting, folding in half, and taping to make 2-sided cards.
- Answer sheet

NOTE: Set of 16 *Aquatic Invasive Species Game Cards*, see cards at the end of this lesson (supplemental materials).

Procedure

1. Introduce the topic of invasive species to the class. Explain key points made in the background section and define difficult vocabulary words, such as non-native, invasive, ballast water, etc.

2. Have the students work in groups of three to four people, each with a complete set of 16 shuffled cards—8 photo cards and 8 characteristics cards.
3. Beginning with the photo cards, match each invader to its corresponding characteristics and impacts.
4. When group members agree that they have matched the cards to the best of their ability, they may review their answers on the answer sheets.
5. Each group selects an invader to present to the class, and constructs a poster about the invader or develops a fact sheet. Be sure to include the impact of the invader on the ecosystem. Brainstorm ways to prevent new species from entering the Great Lakes.
6. After all the groups have presented and discussed their species, review with students the importance of human behavior in preventing the introduction and spread of invasive species, which have many negative impacts on the Great Lakes ecosystem.

Adaptations

- Draw an invasive species, paying special attention to distinguishing characteristics.
- Create a humorous cartoon depicting some of the impacts of invasive species. (Example: purple loosestrife choking other plants, etc.)
- Learn about ways to prevent the introduction of new invasive species and slow the spread of existing populations using the Great Lakes Most Unwanted (poster series).

Source

Adapted for the Great Lakes Education Program with permission from “What do scientists know about invader species of the Great Lakes?” in Earth Systems—Educational Activities for Great Lakes Schools: Life in the Great Lakes. Modified by Anne Williamson and Mike Klepinger.

Assessment & Standards

See separate document: **FLOW_Assessment_GLCE.pdf**

FLOW Feedback

Please take 10 minutes to provide us with your feedback.
Go to: http://www.miseagrant.umich.edu/flow/flow-feedback.html

Supplemental Materials, Unit 1

Lesson 3 - Great Lakes Most Unwanted Documents:

- Set of 16 Aquatic Invasive Species Game Cards
- Additional details and photos about aquatic invasive species, see: www.miseagrant.umich.edu/ais
- Aquatic Invasive Species Poster Series, *Great Lakes Most Unwanted,* see: www.miseagrant.umich.edu/store

INVASIVE SPECIES ANSWER SHEET

Unit 1, Lesson 3

www.miseagrant.umich.edu/flow
Sea Grant Michigan
MICHU-05-413 COPY MASTER

SEA LAMPREY

Sea lampreys come from an ancient family of jawless fishes that look like eels. Native to the Atlantic Ocean, they entered the St. Lawrence River and eventually the Great Lakes when the Welland Canal was modernized around 1920. Today sea lampreys are found in all the Great Lakes and many tributaries, with the largest population in northern Lake Huron.

Characteristics

- Eel-like fish that attach to other fish and feed on body fluids.
- Adults grow 12 to 20 inches long.
- Round, suction disk mouth is filled with sharp teeth.

Impacts

- Can kill 40 pounds of fish during its life.
- Often kills large, predator fish, causing populations of smaller fish to grow too large.
- Has contributed to declines in native lake trout and whitefish populations in the Great Lakes.

EURASIAN RUFFE

This fish is native to Europe and Asia. It was first discovered in Minnesota's St. Louis River, the main tributary to western Lake Superior, in 1986. It arrived in the ballast water of an ocean-going vessel.

Characteristics

- Small, aggressive fish with sharp spines on top and bottom fins.
- Grows rapidly and loves to eat.
- Can tolerate a range of water conditions.

Impacts

- Makes up an estimated 80 percent of the fish caught in the St. Louis River.
- Has spread to other areas in western Lake Superior, and Thunder Bay, Lake Huron.
- Reduces food and habitat for native fish, such as walleye and perch.

ROUND GOBY

This fish is originally from the Black and Caspian Seas. It hitched a ride to the Great Lakes in the ballast water of an ocean-going vessel. Round gobies were discovered in the St. Clair River around 1990. They've spread to all of the Great Lakes, with the greatest numbers in Lake Erie, Lake St. Clair, and southern Lake Michigan.

Characteristics

- Small, bottom-dwelling fish that resembles a large tadpole.
- Known to steal fishing bait and is often caught by anglers.
- Likes to live in rocky places and can survive in poor water quality.

Impacts

- Displaces native fish, eats their eggs and young, and takes over optimal habitat.
- Spawns multiple times per season. Population grows rapidly.
- Can become the most numerous fish in a given area.

SPINY WATER FLEA
FISHHOOK WATER FLEA

These tiny creatures are distantly related to shrimp, lobster and crayfish. To see them clearly, you need a microscope. The spiny water flea was discovered in Lake Huron in 1984. The fishhook water flea was discovered in Lake Ontario in 1998.

Characteristics

- Microscopic zooplankton that have long, barbed or hooked tails.
- Tails often catch on fishing lines and downrigger cable.
- Clumps of these zooplankton look and feel like gelatin or cotton batting.

Impacts

These zooplankton:

- Eat small plankton, reducing food for native Great Lakes zooplankton.
- Compete with small and juvenile (baby) fish for plankton such as Daphnia.
- Not a good food source for native fish. Barbed tail spines are hard to digest.
- Clog nets and fishing line, creating problems for fisherman.

ZEBRA MUSSELS

These small, striped mussels are about the size of a fingernail. Zebra mussels are native to the Caspian and Aral Seas of Eastern Europe and Western Asia. They traveled to the Great Lakes in the ballast water of ships. Zebra mussels were discovered in Lake St. Clair in 1988 and have spread to all five Great Lakes and many inland lakes.

Characteristics

- Live in colonies that attach to submerged rocks, dock pilings, boat hulls and even native clams and mussels!
- Filter thousands of gallons of freshwater every day to capture their preferred food—plankton.
- Dead ones can wash up on shore, littering beaches with their sharp shells.

Impacts

- Filter (eat) large quantities of plankton, reducing food for many native species.
- Cause water to become clearer, which promotes excessive growth of aquatic plants.
- Grow in large clusters that clog water intake pipes, boat motors, and pumps, costing millions of dollars to control each year.
- Attach to native Great Lakes mussels and clams, often smothering them.

ASIAN CARP:
BIGHEAD AND SILVER CARP

These two fish were brought to North America in the early 1970s to remove algae from aquaculture ponds (by eating lots of plankton). They escaped from farms along the Mississippi River during a flood in the early 1990s. These big fish now live in the Mississippi and Illinois rivers, and scientists fear they will enter Lake Michigan.

Characteristics

These two fish:

- Grow up to 4 feet long. Weigh over 60 pounds.
- Jump more than 15 feet out of the water. Slam into fishing boats.
- Eat more than 40 percent of their body weight each day.

Impacts

- Eat enormous amounts of plankton—including phytoplankton and zooplankton.
- Could disrupt the Lake Michigan food web and cause problems for fisheries.
- Have been spotted less than 50 miles from Lake Michigan.

PURPLE LOOSESTRIFE

Early settlers brought purple loosestrife to North America from Europe. They liked the plant's eye-catching purple flowers. From its humble beginnings as a garden plant, purple loosestrife quickly invaded wetlands in nearly every U.S. state and Canadian province.

Characteristics

- Tall, flowering plant that can grow from 3 to 7 feet high.
- Often found on the edges of wetlands, roadside ditches and other moist areas.
- Perennial plant that regenerates from its roots every spring.
- Bright purple flowers bloom during midsummer.
- Spreads quickly. A mature plant can produce more than 2.5 million seeds each year.

Impacts

- Competes with native Great Lakes wetland plants and gradually replaces them.
- Not a good food source. When this plant takes over a wetland, ducks, fish, and frogs may leave or die.
- Dense stands of this plant block access to water.

EURASIAN WATERMILFOIL

Eurasian watermilfoil was first spotted in North America in the 1940s, and some say it was brought here intentionally. Others believe the plant was transported in the ballast water of ships from Northern Europe and Asia. Today, Eurasian watermilfoil thrives in nearly every U.S. state, including Michigan, and three Canadian provinces.

Characteristics

- Submerged aquatic plant. Forms thick mats on the water's surface.
- Gets tangled in boat propellers and interferes with swimming and fishing.
- Has feathery leaves, and small red flowers that bloom above water in early summer.

Impacts

- Inhabits inland lakes including some in the Great Lakes region.
- Forms tangled mats that interfere with boating, swimming, and fishing.
- Prevents sunlight from reaching native aquatic plants.
- Reproduces from fragments. Spreads easily by clinging to boats, trailers, and fishing gear.

AQUATIC INVASIVE SPECIES PHOTO CARDS

Unit 1, Lesson 3

www.miseagrant.umich.edu/flow

Sea Grant Michigan

MICHU-05-413 COPY MASTER

photo: Dave Brenner

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CUT

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photo: Dave Jude

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FOLD

CUT

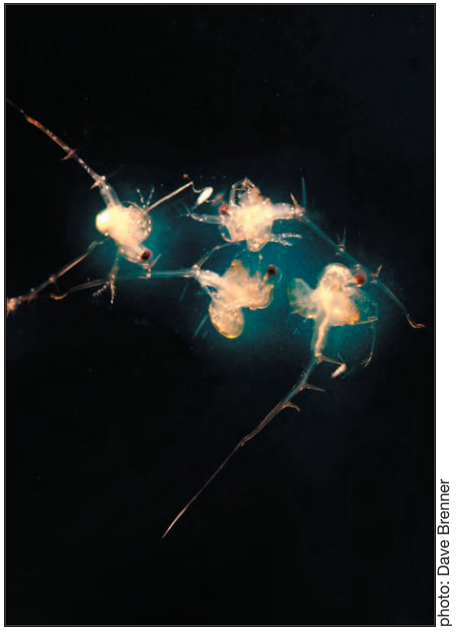

photo: Dave Brenner

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Unit 1, Lesson 3

www.miseagrant.umich.edu/flow

Sea Grant Michigan

MICHU-05-413 COPY MASTER

photo: Simon van Mechelen

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photo: David Riecks

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photo: Dave Brenner

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FOLD

AQUATIC INVASIVE SPECIES CHARACTER CARDS

Unit 1, Lesson 3

www.miseagrant.umich.edu/flow

Sea Grant Michigan

MICHU-05-413 **COPY MASTER**

Sea Lamprey

CHARACTERISTICS

- Eel-like fish that attach to other fish and feed on body fluids.
- Adults grow 12 to 20 inches long.
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IMPACTS

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CHARACTERISTICS

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IMPACTS

- Displaces native fish, eats their eggs and young, and takes over optimal habitat.
- Spawns multiple times per season. Population grows rapidly.
- Can become the most numerous fish in a given area.

Round Goby

FOLD

CUT

CHARACTERISTICS

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IMPACTS

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Spiny Water Flea

FOLD

AQUATIC INVASIVE SPECIES CHARACTER CARDS

www.miseagrant.umich.edu/flow

Sea Grant Michigan

Unit 1, Lesson 3

MICHU-05-413 COPY MASTER

Zebra Mussel

CHARACTERISTICS

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IMPACTS

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IMPACTS

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CHARACTERISTICS

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- Prevents sunlight from reaching native aquatic plants.
- Reproduces from fragments. Spreads easily by clinging to boats, trailers, and fishing gear.

Purple Loosestrife

FOLD

CUT

Eurasian Watermilfoil

FOLD

Lesson 4: Beat the Barriers

Activity: This board game teaches students about the various methods used to limit the sea lamprey population in the Great Lakes. Students assume the identity of sea lampreys and attempt to migrate from Lake Ontario to Lake Superior.

Grade level: 4-8
Subjects: Science and Social Studies
Setting: Classroom
Duration: 15-20 minutes
Key terms: Barrier, Host, Invasive species, Parasite, Spawning

Objectives

After participating in this activity, students will be able to:

- Discuss the differences among the various types of technology used to control the sea lamprey population.
- Locate the lamprey-associated, spawning ground "hot spots" in the Great Lakes.
- Describe parasite/host relationships.
- Identify the placement of the Great Lakes and describe how the lakes are connected.

Summary

Sea lampreys have been one of the most devastating invader species to enter the Great Lakes. Over time, they've contributed to the decline of native fish populations and threaten a multi-billion dollar commercial fishing industry. By learning about sea lamprey, students begin to understand how harmful exotic species can become and how expensive and complex it is to control an invasive species once it's established.

From top to bottom: Sea lamprey barrier, detail of sea lamprey mouth, and sea lamprey feeding on a fish.

With the help of global positioning and mapping technology, larval "hot spots," such as the St. Mary's River, are recorded and targeted for control.

Background

Sea lampreys are eel-like fish that are native to the Atlantic Ocean. Since the 1830s, they have been migrating into the Great Lakes via Lake Ontario and the Erie Canal. Niagara Falls acted as a natural barrier for sea lampreys until the Welland Canal was improved in 1919. Once sea lampreys entered Lake Erie, they quickly spread to Lake Huron and Lake Michigan. In 1938, sea lampreys entered Lake Superior by attaching to ships passing through the Soo Locks on the St. Marys River. Because sea lampreys attach to and feed on native freshwater fish, they have posed a serious threat to whitefish, lake trout, and salmon during the past 50 years.

A single lamprey is capable of consuming 40 pounds of host fish in its lifetime. During an adult lamprey's 18-month life span, it will attach to a host fish with its suction-like toothed mouth, then suck nutrition out of the host fish, often killing it. The rapid decline in the number of native freshwater fish affects a Great Lakes sport and commercial fishing industry valued at almost $4.5 billion annually.

Biologists use a combination of methods to control the sea lamprey population in the Great Lakes. Several types of mechanical and electrical barriers have been constructed in strategic locations on Great Lakes tributaries. The barriers allow native freshwater fish to migrate upstream but block sea lampreys from reaching spawning habitat. Sterilization programs for male sea lampreys have also reduced the sea lamprey population. Finally, a special chemical that kills sea lamprey larvae, and an underwater high-power vacuum have both been used in the St. Marys River lamprey spawning grounds to eliminate thousands of lamprey larvae.

Materials and Preparation

- Dice
- Beat the Barriers game board
- Barrier Fact Sheet
- Barrier Cards
- Lamprey Cards

NOTE: *Beat the Barriers Game Board*, *Barrier Cards, Lamprey Cards*, and *Barrier Fact Sheet*, see the end of this lesson (supplemental materials).

Advance Preparation

1. Copy and assemble the game boards. Tape together two sections to make each game board. Copy enough game boards so that four students can play each game.
2. Copy game cards and fact sheet. Copy one or two sets of barrier cards and lamprey cards for each game. (Two sets for each game are advised since students go through one set quite rapidly.) Copy one barrier fact sheet for each game. Students will cut out the sea lamprey picture on the side of game board to use as moveable game pieces.

Procedure

1. Show pictures of sea lampreys attached to lake trout on the Barrier Fact Sheet. Explain a little bit about sea lampreys, parasite/host relationships, and the value of host fish.
2. Describe methods to control sea lamprey populations, including various barriers used in the game.
3. Explain that fisheries managers use barriers to prevent sea lampreys from migrating through all of the Great Lakes. If lampreys did not reach the spawning grounds, managers could discontinue the chemical control methods currently used to eliminate larvae.
4. Divide students into cooperative learning groups of up to four students. Distribute the barrier fact sheet to each group, and have students cut out and color the game pieces.
5. Four students can play the game at a time. Each player assumes the identity of a sea lamprey and attempts to move from the "Start" position, which is Lake Ontario, up through the Great Lakes to the "Finish" position, which is Lake Superior.

6. Players should read each space carefully as they proceed through the game. Players must do what is written on the game space or card. A player's turn continues until there are no more instructions to move the game piece.
7. When landing on a space marked "Take a Barrier Card" or "Take a Lamprey Card," a player must draw a card from the appropriate pile, read it aloud to the other players, and move his or her game piece as instructed. After a card has been read, it should be returned to the bottom of the pile of cards.
8. The winner is the first lamprey to migrate all the way from Lake Ontario to Lake Superior. Players must roll the exact amount to reach the "Finish" position.
9. After playing the game, have students list or discuss the types of methods being used to slow the increase of the lamprey population.
10. Have each student write a paragraph about the two methods that he or she believes to be the most effective, explaining why they have been chosen. Have them refer to the barrier fact sheet.

Source

Prepared by Rosemary Nowak, Eden Elementary School, Eden, New York, for the *ESCAPE Compendium*, developed by the Great Lakes Sea Grant Network.

Assessment & Standards

See separate document: **FLOW_Assessment_GLCE.pdf**

FLOW Feedback

Please take 10 minutes to provide us with your feedback.
Go to: http://www.miseagrant.umich.edu/flow/flow-feedback.html

Supplemental Materials, Unit 1

Lesson 4 - Beat the Barriers Documents:

- Beat the Barriers game board
- Barrier Fact Sheet
- Barrier Cards
- Lamprey Cards
- Additional details and photos about aquatic invasive species, see: www.miseagrant.umich.edu/ais
- Aquatic Invasive Species Poster Series, *Great Lakes Most Unwanted,* see: www.miseagrant.umich.edu/store

BARRIER FACT SHEET

These are the current types of barriers that are being used in the Great Lakes. They attempt to keep sea lampreys from migrating upstream to their spawning grounds.

FOR MORE INFORMATION ABOUT SEA LAMPREY CONTROL, SEE THE GREAT LAKES FISHERY COMMISSION WEB SITE: WWW.GLFC.ORG/SLFT.HTM

LOW HEAD BARRIER

Two to four feet high, this barrier is placed in a river and prevents lampreys from moving further upstream. A lip is used to keep lampreys from using their suction-cup mouths to climb over the barrier. A jumping pool near the barrier allows other fish to easily jump over the barrier.

ADJUSTABLE-CREST BARRIER

These barriers have adjustable, inflatable crests that are raised only during sea lamprey spawning season. The barrier is computer controlled and adjusts to the water level of the stream. It remains lowered on the river bottom except during lamprey spawning season. As a result, most fish can easily swim over the barrier.

VELOCITY BARRIER

Sea lampreys are poor swimmers that tire easily and need to attach to solid surfaces to rest. Velocity barriers create areas of rapidly moving water. Lampreys are not able to attach to surfaces next to these barriers. Fish can swim through these barriers.

ELECTRICAL BARRIER

DC current is run through these barriers at places where lampreys attempt to pass. The current stops the lamprey.

For more info see: www.glfc.org

BARRIER CARDS

Unit 1, Lesson 4

Sea Grant Michigan

BARRIER CARD

A lip on the **low-head barrier** is used to keep lampreys from using their suction-cup mouths to climb over the barrier.

LOSE A TURN.

BARRIER CARD

The **adjustable-crest barriers** have adjustable, inflatable crests that are raised only during sea lamprey season. You just made it.

MOVE AHEAD 1 SPACE.

BARRIER CARD

The **adjustable-crest barriers** remain lowered on the river bottom except during lamprey spawning season, and as a result most fish can easily swim over the barrier.

MOVE BACK 1 SPACE.

BARRIER CARD

Electrical barriers have DC current running through them at places where lampreys attempt to pass. The current stops the lamprey.

GO BACK TO "START."

BARRIER CARD

A jumping pool near the **low-head barrier** allows other fish to easily jump over the barrier.

MOVE BACK 3 SPACES.

BARRIER CARD

Velocity barriers create areas of rapidly moving water, with surfaces that make it impossible for lampreys to attach.

GO BACK TO "START."

BARRIER CARD

Velocity barriers don't prevent fish from swimming through them. Sea lampreys are poor swimmers that tire easily and cannot go through this barrier.

MOVE BACK 2 SPACES.

BARRIER CARD

The **adjustable-crest barriers** are computer controlled and adjust to the water level of the stream.

STAY WHERE YOU ARE.

FOLD

FOLD

LAMPREY CARDS

Unit 1, Lesson 4

www.miseagrant.umich.edu/flow

Sea Grant Michigan

LAMPREY CARD

You reached the Great Lakes, which contain few natural predators for sea lampreys. Because there is limited danger of another species killing you, you are free to attach to as many fish as you like.

MOVE AHEAD 3 SPACES.

LAMPREY CARD

You found your way to Lake Huron where the sea lamprey population is estimated to be equal to that of the four other Great Lakes combined!

MOVE AHEAD 3 SPACES.

LAMPREY CARD

You successfully spawned with a female and beat out a sterilized male sea lamprey.

MOVE AHEAD 1 SPACE.

LAMPREY CARD

You have reached a barrier in a river that has not been well maintained due to high costs. You find a way through the barrier.

MOVE AHEAD 2 SPACES.

LAMPREY CARD

Scientists began treating Lake Erie with a chemical that kills sea lamprey larvae. However, you found the mouth of a small stream where these chemical methods cannot be used.

MOVE AHEAD 1 SPACE.

LAMPREY CARD

Because sea lampreys did not evolve with the native fish of the Great Lakes, your aggressive behavior gives you a strong advantage over your native fish prey.

MOVE AHEAD 2 SPACES.

LAMPREY CARD

Local scientists have improved the water quality in a nearby lake. This has created a nice home for you and your sea lamprey family.

MOVE AHEAD 2 SPACES

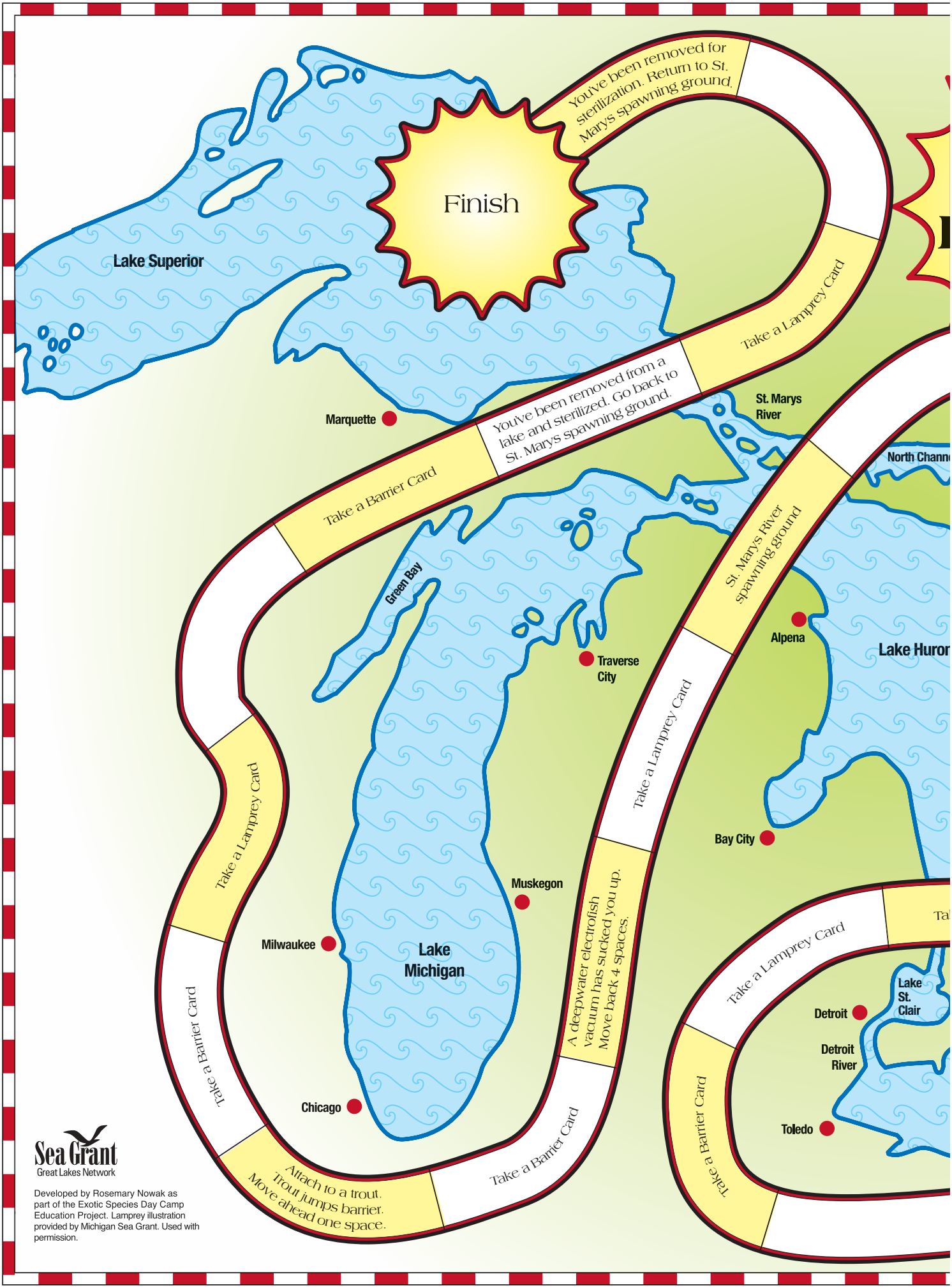
LAMPREY CARD

Whew! You just barely made it past the electrofish vacuum in your spawning ground.

MOVE AHEAD 1 SPACE.

FOLD

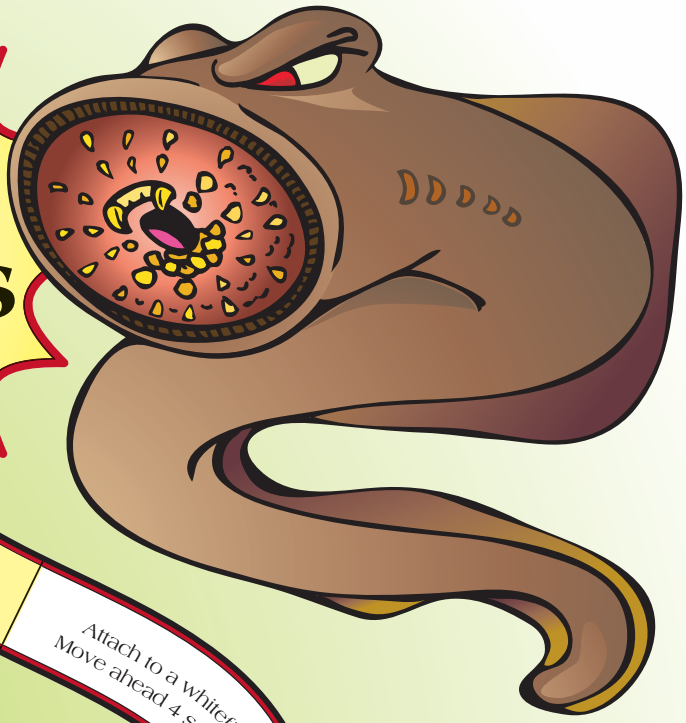
FOLD



Sea Grant
Great Lakes Network

Developed by Rosemary Nowak as part of the Exotic Species Day Camp Education Project. Lamprey illustration provided by Michigan Sea Grant. Used with permission.

Beat the BARRIERS



Take a Lamprey Card

Attach to a whitefish. Move ahead 4 squares.

North Channel

Lake Huron

St. Lawrence River

Grab a ride on a trout. Move ahead 3 spaces.

Lake Ontario

Toronto

Rochester

Niagara River

Welland Canal

Erie Canal

Buffalo

Take a Barrier Card

St. Clair River

Lake St. Clair

Lake Erie

Start

Grab a ride on a trout. Move ahead 3 spaces.

Cleveland

Pulled out of Lake Erie while attached to a whitefish. Go back to start.

N

W E

S

CUT

CUT

GAME PIECES

CUT

FOLD

CUT

FOLD

CUT

FOLD

CUT

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FOLD

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Lesson 5: Ruffe Musical Chairs

Activity: Students use role-play to mimic the behavior of an invasive, non-native fish called Eurasian ruffe (pronounced rough) to experience firsthand how and why the species has multiplied so rapidly in some Great Lakes harbors.

Grade level: 4-8
Subjects: Science, social studies
Setting: Classroom
Duration: 1 hour
Key Terms: Invasive, Nonindigenous, Predator

Objectives

After participating in this activity, students will be able to:

- Explain why fish populations in the Great Lakes change over time.
- List three reasons why non-native ruffe have significant advantages over some native Great Lakes fishes.
- Identify two things that they can do to minimize the spread of ruffe.

Summary

All animals must meet basic needs for food, water, and habitat in order to survive. There are times, however, when some animals can't meet their needs. One reason may be due to competition for food and habitat caused by an invasive species. By learning about the aggressive ruffe, students begin to see how a single species can cause other fish species to decline, and create a dramatic change in the Great Lakes food web in a relatively short time.

Background

Eurasian ruffe, small members of the perch family, are aggressive fish native to Europe and Asia. They were first discovered in the St. Louis River, the main tributary to western Lake Superior, in 1986. They arrived in the ballast water of an ocean-going vessel. In the absence of natural predators, ruffe populations multiplied rapidly.

Ruffe illustration by D. Brenner, graphic by T. Marsee

Once established, the ruffe population grows rapidly and takes over habitat. Ruffe reduce food for some native fish including walleye, yellow perch, and several small fish. Some species of native fish have declined in areas where ruffe have become numerous.

Today, ruffe make up an estimated 80 percent of the fish caught in the St. Louis River. Since their arrival, ruffe have spread to other rivers and bays along the south shore of western Lake Superior and northward to Thunder Bay, Ontario. Ruffe also thrive in the waters near Alpena, Michigan on northern Lake Huron. Rapid growth of ruffe populations has reduced food and habitat for native fish with similar diets and feeding habits, including walleye, perch, and a number of small fish.

Several factors allow ruffe to displace native species in newly invaded areas. First, ruffe grow rapidly and produce many offspring. Ruffe can reproduce in their first year, and an average female can produce 13,000 to 200,000 eggs per season. Second, ruffe can tolerate a range of environmental conditions, including murky water. Ruffe are primarily bottom feeders, and they prefer dark environments where they can hide from predators. Finally, even though ruffe are small (usually less than 5 inches), ruffe have few predators due to the spines on their fins.

Materials and Preparation

- 10 chairs. Place chairs in two rows of five, back to back.
- Set of *Ruffe Musical Chairs Game Cards*. Print ruffe cards on card stock, and cut out individual cards.
- "Nautical" or "fish" music.
- CD player

NOTE: *Ruffe Musical Chairs Game Cards*, see cards at the end of this lesson (supplemental materials).

Procedure

Preliminary Discussion

- Introduce or revisit the basic needs of animals. Students need to understand that all animals must meet needs for food, water, and habitat in order to survive.
- Ask volunteers to describe times when they looked for something they wanted or needed and it wasn't there, or when they went to do something but there wasn't room for them to participate. After hearing a few of these stories, ask the students what it felt like. Ask them to imagine what it would be like to not meet a basic need like food, water or shelter.
- Ask students if they think that there are instances in nature when animals can't meet their basic needs. When might this happen? Explain that students will experience this during the game they are about to play.

Play the Game

The first half of the game demonstrates the competition for food and habitat.

1. Start with two rows of five chairs, placed back to back in an area clear of other furniture. Explain that the chairs represent the basic needs of native fish in the Great Lakes—meaning they represent food, water and shelter. Choose five students to represent native Great Lakes fish and play the game just like "Musical Chairs." Because there are five students and ten chairs they will easily find seats.
2. Explain that since they were so easily able to meet their needs, they were also able to produce offspring. Add five more students and play again. All seats will now be full.
3. Add five more students (15 total), due to reproduction, and play again. This time, when the music stops, there will be plenty of competition to observe. Those students who can't find seats get eliminated. Ask or explain what this represents. (When too many creatures are produced, those who can't find food or meet other needs must leave the area to look elsewhere or die.)
4. Play a few more rounds with 15 students until all students have had a chance to play.

5. Place Ruffe cards face down on three of the seats. Play the round with 15 students again, and have those who land on cards read and interpret them. Explain that ruffe are a new kind of fish accidentally introduced into the area by ocean-going ships. Ruffe are competing for the same needs as the local or native fish. If students have a card with "Sorry, you lost your seat," they are eliminated for that round as well as the students who couldn't find a seat.
6. Pick up the ruffe cards, shuffle them with the others and put six down on different chairs. Play the round with 12 students instead of 15 (because with less food, water and habitat, there will be less reproduction and survival of young). Again, those cards with "Sorry, you lost your seat" are eliminated along with those who don't find chairs.
7. Pick up the cards, shuffle, and put down eight cards. Play the round with eight students.
8. Cover all the chairs with a card, shuffling between rounds, and play until no student (representing Great Lakes fish) survives the round.
9. Also see the sidebar (below) to modify the game.

Discuss the Results

- Ask students what it feels like to have the ruffe taking over their lake. Ask if they know of other species (plants or animals) that try to come in and take over where they don't belong. (Dandelions and other weeds are good examples.)
- Explain, or have the students explain, that non-native species like this can create real problems for the native species living in an area because they compete for basic needs.

Modify the Game

The second half of the game demonstrates what happens when predators are also considered.

1. Play the game again with 9 native fish, 2 predators (representing walleye and northern pike), and 2 ruffe.
2. If the "predators" don't find seats when the music stops, they're allowed to eliminate other "fish," or take over chairs. (Predators prey upon smaller fish.)
3. Play the game until the ruffe finds a seat. For every successful ruffe, add 2 more ruffe, and continue playing the game. (The ruffe population has established itself and is growing rapidly.) The predators are not allowed to eliminate ruffe, or take over their chairs, because they prefer feeding on native species. (Ruffe have spiny fins that are hard to digest.)
4. Keep playing until the ruffe have taken over most or all of the seats.

Discuss the Results

- Ask the students why ruffe were so successful in taking over the chairs. Explain that all these things are true for ruffe in the Great Lakes and they are expanding at a fast rate and into new areas.
- Ask the students if they know of any ways to prevent the spread of ruffe. Indicate the things mentioned in the background material if the students don't think of them. See: How You Can Help in Lesson 1.3 (in the right sidebar, under the graphic).

Source

Adapted from Musical Mussels. From Fish Ways Project, MNR, Ontario, Canada.

Assessment & Standards

See separate document: **FLOW_Assessment_GLCE.pdf**

FLOW Feedback

Please take 10 minutes to provide us with your feedback.
Go to: http://www.miseagrant.umich.edu/flow/flow-feedback.html

Supplemental Materials, Unit 1

Lesson 5 - Ruffe Musical Chairs Documents:

- Ruffe Musical Chairs Game Cards
- Additional details and photos about aquatic invasive species, see: www.miseagrant.umich.edu/ais
- Aquatic Invasive Species Poster Series, *Great Lakes Most Unwanted,* see: www.miseagrant.umich.edu/store

RUFFE MUSICAL CHAIRS

The following statements relate to the Ruffe Cards used in this activity.

TEACHERS: READ THE FULL STATEMENTS TO STUDENTS BEFORE PLAYING RUFFE MUSICAL CHAIRS.

- **Ruffe are eating your food. You have to look somewhere else. Ruffe eat small aquatic insects and other organisms that live on the bottom.** Because there are so many ruffe, other fish with similar feeding habits (such as walleye and yellow perch) don't get enough food.
- **Ruffe are eating your offspring's food. Many of your young are starving.** Ruffe eat such a wide variety of foods and exist in such large numbers that they can create a "bottle-neck" for the young of native species by reducing food for that life stage, which resuls in fewer adults.
- **You can't eat ruffe because of their spiny fins. Go search for other prey.** Ruffe have spines on their dorsal fins as well as on their gill covering, making them hard for would-be predators to digest.
- **Ruffe produce so many offspring that they're taking over.** Ruffe grow very fast and reach reproductive age more quickly than native species. They also produce large amounts of eggs each time they spawn.
- **Ruffe can survive in murky water. But, you leave to search for better habitat.** Ruffe can thrive in a wide range of temperatures and habitat. Unlike some perch species, ruffe are more tolerant of murky conditions.
- **Ruffe haven't moved into your area yet. You are meeting your needs.** So far, ruffe appear to be concentrated in certain harbors and rivers. Resource managers want to prevent ruffe from spreading.
- **Ruffe haven't eaten all of your food. You are meeting your needs.** In some places, ruffe populations have not yet taken over. Native fish can still find food.

RUFFE MUSICAL CHAIRS GAME CARDS

Unit 1, Lesson 5

www.miseagrant.umich.edu/flow

Sea Grant Michigan

SORRY
YOU LOST YOUR SEAT

Ruffe are eating your food. You have to look somewhere else.

SORRY
YOU LOST YOUR SEAT

Ruffe are eating your offspring's food. Many of your young are starving.

SORRY
YOU LOST YOUR SEAT

You can't eat ruffe because of their spiny fins. Go search for other prey.

SORRY
YOU LOST YOUR SEAT

Ruffe produce so many offspring that they're taking over.

SORRY
YOU LOST YOUR SEAT

Ruffe can survive in murky water. But you leave to search for better habitat.

GREAT NEWS
YOU MAY TAKE A SEAT

Ruffe haven't spread to your area yet. You are meeting your needs.

GREAT NEWS
YOU MAY TAKE A SEAT

Ruffe haven't eaten all of your food. You are meeting your needs.

GREAT NEWS
YOU MAY TAKE A SEAT

RUFFE MUSICAL CHAIRS GAME CARDS

Unit 1, Lesson 5

www.miseagrant.umich.edu/flow

Sea Grant Michigan

SORRY
YOU LOST YOUR SEAT

Ruffe are eating your food. You have to look somewhere else.

SORRY
YOU LOST YOUR SEAT

Ruffe are eating your offspring's food. Many of your young are starving.

SORRY
YOU LOST YOUR SEAT

You can't eat ruffe because of their spiny fins. Go search for other prey.

SORRY
YOU LOST YOUR SEAT

Ruffe produce so many offspring that they're taking over.

SORRY
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Ruffe can survive in murky water. But you leave to search for better habitat.

GREAT NEWS
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Ruffe haven't spread to your area yet. You are meeting your needs.

GREAT NEWS
YOU MAY TAKE A SEAT

Ruffe haven't eaten all of your food. You are meeting your needs.

GREAT NEWS
YOU MAY TAKE A SEAT

Food Web Glossary / Key Terms

Ballast water: Water carried by ships for balance and stability.

Barrier: A natural feature, human-built structure or technology that prevents passage.

Biomass: The total mass of all living things in a given area.

Carnivore: A meat eater.

Consumer: An organism that eats food produced by another organism.

Decomposer: An organism that feeds on dead plant and animal matter, breaking it down for reuse by plants.

Detritus: Organic material that is either waste material from an organism or decomposing plants and animals.

Exotic species: Plant or animal that does not naturally occur in a specific location or ecosystem.

Food chain: Simplified representation of the relationship of organisms that feed on each other.

Food web: Shows what a group of fish, animals and organisms eats—often multiple species—and how energy is passed from one group to another.

Herbivore: A plant eater.

Host: An organism that harbors and provides nourishment for a parasite.

Invasive species: An animal or plant that has a profound and negative impact on an ecosystem.

Macroinvertebrates: Small animals, able to be seen with the naked eye, that do not have a backbone.

Nonindigenous species: Species that are living outside of the area where they evolved.

Omnivore: An animal that eats both plants and animals.

Parasite: An organism that lives in or on another living organism and receives nourishment from it but gives nothing in return.

Photosynthesis: The process by which a green plant makes sugar, part of the food it needs to grow, and produces oxygen.

Predator: A meat eater that catches its food (prey) alive.

Prey: An animal that is hunted or caught for food.

Producer: An organism that produces its own food (for example, a green plant).

Productive: Biologically active, supporting a diversity of aquatic life.

Spawn: To breed and deposit eggs.