project FLOW

FISHERIES LEARNING ON THE WEB

FOOD WEB
Chain, Chain, Chain

WATER
Let it Flow

FISH
Today's Catch

WWW.PROJECTFLOW.US

Fisheries Learning on the Web (FLOW) PDF collection of lessons and activities about the Great Lakes ecosystem, fisheries and stewardship.

Contents

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FLOW Lesson & Activities:

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Note: Each of the 15 lessons includes the following: Objectives, Summary, Lesson Background, Activity, and Materials (e.g., games, cards, fact sheets, etc.) and Procedures for how do complete the activity. For the most current lesson content, go to the Fisheries Learning on the Web, www.projectflow.us.

Feedback: If you would like to send us your feedback about Fisheries Learning on the Web, please complete a FLOW evaluation form, see the downloads section of each unit and send it to:

Michigan Sea Grant
University of Michigan
440 Church St., Suite 4044
Ann Arbor, MI, 48109-1041

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MICHU-05-421

About Project FLOW

Fisheries Learning on the Web or FLOW, is a collection of lessons and activities about the Great Lakes ecosystem, fisheries and stewardship and was developed by Michigan Sea Grant. It is part of Michigan Sea Grant's ongoing effort to provide K-12 teachers and informal educators with high-quality curriculum materials with hands-on, "plug-n-play "educational activities. Each lesson addresses state and national educational standards and benchmarks. For the most current lesson content, go to the Fisheries Learning on the Web or FLOW web site at www.projectflow.us.

Providing Meaningful Content

According to the National Science Education Standards, "students learn more science, and learn more about the nature of science, when they actively participate in finding out answers for themselves — using the process of inquiry." Each FLOW lesson includes a classroom or field activity to facilitate problem-based learning that is meaningful for today's youth. Through this effort, Michigan Sea Grant's primary goal is to facilitate learning through knowledge of the Great Lakes ecosystem. Additional goals include:

- Providing K-12 teachers with curriculum content that addresses current state and national standards and benchmarks;
- Increasing awareness of Great Lakes ecosystem concepts among 4th - 8th grade students in Michigan;
- Facilitating easy access for K-12 teachers to high-quality, low-cost Great Lakes education resources to help improve test scores; and
- Addressing the demand for educational materials that include engaging, high quality, colorful graphics to capture the imagination of students.

Filling the Gap

Educators have limited time and resources, with federally mandated testing requirements and in many cases, increased class sizes. As reinforced in the Great Lakes Fishery Trust's 2003 meeting, "Educators need… to obtain practical, cost-effective, accessible, and easy-to-use teaching tools." Key issues outlined in the 2001 *Great Lakes Fisheries Education Assessment and Summary of Needs* report, provided the FLOW development team with a basis for structuring curriculum material.

One of the tools for Michigan educators to determine the level of student knowledge is the Michigan Educational Assessment Program (MEAP) test. Fisheries Learning on the Web (FLOW) materials are designed to help educators by:

- Ensuring that all lesson content clearly address standards and benchmarks.
- Including engaging activities designed for classroom or field experiences.
- Standardizing key elements in each lesson: background, activity, and assessment.

- Providing meaningful assessment tools that include learning objectives, student performance and recommended points.

- Partnering with state-supported educational efforts, such as the Michigan Department of Environmental Quality's Michigan Education Curriculum Support (MEECS). FLOW is linked from two areas (Ecosystems and Water Quality) of the MEECS site, see MDEQ/MEECS, www.michigan.gov/deq
- Linking to additional educational resources and supplemental materials, about the Great Lakes and oceans. Additional educational activities, supported by Michigan Sea Grant and/or NOAA-National Sea Grant, include a variety of programs and curriculum materials. For more information, see Michigan Sea Grant Education www.miseagrant.umich.edu/education.

Credits

Project Support:
The Great Lakes Fishery Trust, http://www.glft.org. The Trust provides funding to enhance, protect and rehabilitate Great Lakes fishery resources.

Michigan Sea Grant College Program, http://www.miseagrant.umich.edu. Michigan Sea Grant is a cooperative program of the University of Michigan and Michigan State University. Michigan Sea Grant is supported by NOAA-National Sea Grant.

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Feedback
Thank you to the many educators who provide ongoing feedback to help the development team keep improving the lesson content and activities. If you would like to complete a FLOW evaluation form, see the downloads section of each unit and send it to: Michigan Sea Grant, 440 Church St., Suite 4044, Ann Arbor, MI, 48109-1041.

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Assessment Overview

Assessments are provided for each lesson and include the following components:

- *Learning Objective.* Example: describe the difference between herbivores, carnivores, and producers.
- *Student Performance.* Example: Define herbivore, carnivore and producer.
- *Recommended Points.* Example: 1 point for each definition above (herbivore, carnivore and producer).

The assessment components above are based on Bloom's Taxonomy, named after Benjamin Bloom, an educational psychologist. Bloom identified the following levels of learning or cognition and provided specific verb examples that represent learning activity:

- Knowledge: arrange, define, label, memorize, order, recognize, restate, and repeat.
- Comprehension: classify, discuss, express, identify, locate, review, and translate.
- Application: choose, demonstrate, illustrate, practice, sketch, solve, and write.
- Analysis: appraise, calculate, compare, contrast, differentiate, examine, question, and test.
- Synthesis: assemble, compose, create, develop, formulate, plan, propose, and write.
- Evaluation: appraise, argue, attach, choose, defend, predict, select, support, value.

Example of Assessment Rubric: Unit 1, Lesson 1

Example Assessment: Unit 1 Lesson 5 - Ruffe Musical Chairs
16 points total (Picking a subset of questions from those given with the lesson)

1. (3 points) Identify three things that every living thing needs to live.
2. (4 points) Explain 2 things that might happen if an animal does not get its needs met.
3. (3 points) Explain why an animal may not be able to meet its needs sometimes.
4. (3 points) List three characteristics of Eurasian Ruffe, which give them an advantage in meeting their needs as compared to native species.
5. (3 points) Explain how humans can decrease Eurasian Ruffe (and other non-native species) from spreading more.

Additional Ideas About Assessment

Teachers may wish to incorporate electronic journals (e-journals) into the lesson assessment process. E-journals can be as simple as using word processing software. They allow students to communicate about their understanding of lesson content, and provide

teachers with the capability of monitoring student development during the entire learning process.

Educators have found that the following resources for assessment are helpful in creating assessment tools (rubrics):

- Rubistar, online rubric development, http://rubistar.4teachers.org
- Kathy Schrock's Guide for Educators, http://school.discovery.com/schrockguide/assess.html

Assessment References:

- Bloom's Taxonomy adapted from: Bloom, B.S. (Ed.) (1956) Taxonomy of educational objectives: The classification of educational goals: Handbook I, cognitive domain. New York; Toronto: Longmans, Green.

- Kovalchick, Ann, Milman, Natalie, Elizabeth, M., Instructional Strategies for Integrating Technology: Electronic Journals and Technology Portfolios as Facilitators for Self Efficacy and Reflection in Preservice Teachers. In: "SITE 98: Society for Information Technology & Teacher Education International Conference (9th, Washington, DC, March 10 – 14, 1998). Proceedings."

- McGrath, Diane, (2003). Rubrics, Portfolios, and Tests, Oh My!: Assessing Understanding in Project-Based Learning. Learning & Leading with Technology, Volume 30 (Number 8).

- Wall, Janet E. (2003). Harnessing the Power of Technology: Testing and Assessment Applications. In Wall, Janet E. & Walz, Garry R. (Eds.), Measuring Up: Assessment Issues for Teachers, Counselors, and Administrators. (665 – 684). Greensboro: CAPS Press.

Standards

Relevant sections from educational publications were combed for applicable science and social studies content standards, benchmarks and guidelines for each Project FLOW lesson. Specific state and national standards/benchmarks that were explicitly covered by a certain lesson were documented for two age levels: elementary (4-6 grade) and middle (6-8 grade). Publications used include the following:

- Michigan Curriculum Framework, Michigan Department of Education
- National Science Education Standards
- National Academy of Sciences, 1996, National Academy Press, Washington, DC (ISBN 0-309-05326-9).
- Benchmarks for Science Literacy, Project 2061
- American Association for the Advancement of Science, 1993, Oxford University Press, Inc., New York, New York (ISBN 0-19-508986-3).
- North American Association of Environmental Education
- Expectations of Excellence, Curriculum Standards for Social Studies National Council for the Social Studies 2004, Bulletin 89, Silver Spring, Maryland (ISBN 0-87986-065-0).

Standards Lesson Tables

See: Standards charts and detailed summaries for each lesson.

If you have specific questions regarding the standards and benchmarks, please contact the Project FLOW development team. Email: msgpubs@umich.edu

Fisheries Learning on the Web (FLOW) Feedback

Please provide us with feedback about FLOW to help us improve the lessons.

First & Last Name: Organization:
Phone: Email:
Address: City: State: Zip:

Please check your current profession and indicate grade level:
❑ Educator – grade Level: K-4 5-8 9-12 ❑ University Lecturer, Professor or Scientist
❑ Graduate Student ❑ Informal Educator (adults, children, or both adults & children):

Choose the lesson(s) that you used: ❑ Make the Connection ❑ Who's Eating Whom?
❑ Great Lakes Most Unwanted ❑ Beat the Barriers ❑ Ruffe Musical Chairs ❑ Exploring Watersheds
❑ Wetland in a Pan ❑ Water Quantity ❑ What Makes Water Healthy ❑ Hydropoly: A Decision-Making Game
❑ Fish of the Great Lakes ❑ Protecting Biodiversity ❑ Fish Habitat ❑ Great Lakes, Great Careers

Rating Scale: 1 - Very thorough, 2 - Sufficient, 3 - Somewhat lacking, 4 - Needs work

Lesson Objectives (circle one): 1 2 3 4

Lesson Background (circle one): 1 2 3 4

Materials (circle one): 1 2 3 4 Suggestions for additional items:

Procedures (circle one): 1 2 3 4 Suggestions for additional items:

Lesson Assessment (circle one): 1 2 3 4

Is the assessment useful for measuring the learning objectives of the lesson (circle one)? Yes No

Ease of organizing and assembling the materials, (circle one): 1 2 3 4

Glossary (circle one): 1 2 3 4 Are the definitions of the terms clear and useful (circle one)? Yes No
Suggestions for additional items:

Is the inclusion of the standards and benchmarks content valuable for you (circle one)? Yes No
Please rate the lesson(s) overall (circle one): 1 2 3 4

Is the material in the lesson(s) appropriate for your grade level (circle one): Yes No
If no, please specify:

Do you currently cover Great Lakes ecology in your classroom (circle one)? Yes No

Do you currently use Michigan Sea Grant activities or products (e.g., posters, fact sheets web site) in your classroom (circle one)? Yes No What product(s):

How did you find out about FLOW? (check all that apply)
❑ Michigan Sea Grant Web site ❑ Michigan Sea Grant Staff ❑ Upwellings newsletter
❑ Colleague ❑ Other, please specify:
Additional Comments or suggestions:

May we use your comments in our materials (circle one)? Yes No

Food Web Overview

This series of five lessons 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.
See: Lesson 1

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.
See: Lesson 2

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.
See: Lesson 3

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. See: Lesson 4

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.
See: Lesson 5

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

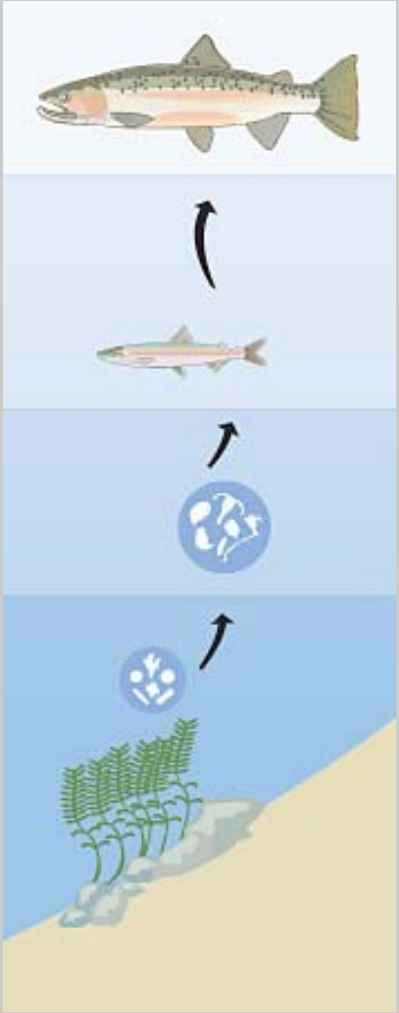
Objectives

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.



Graphics: D. Brenner

See: Additional background info on food chains and food webs.

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 (i.e, frog) or large (i.e, 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

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 State University Fisheries and Wildlife Department.

Assessment

This assessment chart was designed for teachers to create their own assessment. The recommended points show the relative difficulty of student performance. In creating assessments, the total point value will depend on the number and type of performances selected.

Learning Objective	Student Performance	Recmnd # Points
Describe the difference between herbivores, carnivores, and producers	**Define:** Herbivore, Carnivore, producer	1 each
	Order: Place herbivore, carnivore, and producer in correct order of 'who eats whom'	1 each
Answer questions about interdependence of herbivores, carnivores, producers as members of a food chain	**Categorize:** Given cards or pictures or other information about certain plants or animals, categorize each as a herbivore, carnivore or producer	2 each
Answer questions about how pollution affects food chains	**Name:** Different sources of pollution or other disturbance to aquatic food chains	1 each
	Predict: The effects of pollution or other disturbance on a particular aquatic food chain	3 each

Standards

State of Michigan

Science				Social Studies		
Elementary		Middle		Elementary	Middle	
II.1.2 II.1.4 III.5.1	III.5.2 III.5.5	I.1.6 II.1.3 III.5.1	III.5.2 III.5.6	II.2.1 II.4.5	II.2.3 II.2.4	II.2.5 II.5.3

National

NSES		AAAS			
Elementary	Middle	Elementary		Middle	
C1-1 C3-1 C3-4	C4-2 C4-3 C4-4	5A-1 5D-2 5D-4	5E-1 5E-3	5A-1 5A-5 5D-2	5E-1 5E-2

NAAEE			NCSS	
Elementary	Middle		Elementary	Middle
1-F 2.2-C 2.2-D 2.4-A	1-F 2.2-C 2.2-D	2.4-A 3-B	III.h VIII.b IX.d	III.h IX.d

Notes:
NSES = National Science Education Standards
AAAS = American Association for the Advancement of Science (Benchmarks)
NAAEE = North American Association of Environmental Education (Guidelines for Excellence)
NCSS = National Council for the Social Studies (Standards)

Lesson 2: Who's Eating Whom?

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

Graphics: D. Brenner

See: Additional background info on food chains and food webs.

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 (i.e., producers) to support fewer organisms at the top (i.e., 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) 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.

See **Downloads** page at the end of this unit for: Table 1 (food token chart), and feeding behavior cards.

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 State University Fisheries and Wildlife Department.

Downloads

See **Downloads** page at the end of this unit for: Feeding Behavior Cards

Assessment

This assessment chart was designed for teachers to create their own assessment. The recommended points show the relative difficulty of student performance. In creating assessments, the total point value will depend on the number and type of performances selected.

Learning Objective	Student Performance	Recmnd # Points
Diagram a food web	**Sketch:** The relationships between various plants and animals in an aquatic food web.	1 for each element in web
Compare a food web to a food chain and list similarities and differences	**List:** Similarities between a food web and a food chain	1 each
	List: Differences between a food web and a food chain	1 each
	Explain: The relationship between food chains and webs using the similarities and differences between them.	4 each
Discuss predator–prey and consumer–producer relationships using vocabulary words	**Explain:** Predator-prey relationships generally	2 each
	Support: The general predator-prey relationship with specific aquatic examples.	2 each
	Explain: Consumer-producer relationships generally	2 each
	Support: The general	2 each

	consumer-producer relationship with specific aquatic examples	
Make predictions about roles each link plays in the overall food web	**Identify:** A particular plant or animal as a producer, consumer, predator or prey within a food web.	1 each
Understand how lower links in a food web affect the highest links	**Predict:** What happens if there is an abundance of species lower in the food web; And what happens if there is a shortage of species lower in the food web. Trace the effects over time.	3 each

Standards

State of Michigan

Science				Social Studies		
Elementary		Middle		Elementary	Middle	
I.1.6 II.1.2 II.1.4	III.2.4 III.5.1 III.5.2	II.1.3 III.5.1 III.5.2	III.5.3 III.5.7	II.2.1 II.4.5	II.2.3 II.4.3 II.5.3	III.2.4 III.2.5

National

NSES		AAAS	
Elementary	Middle	Elementary	Middle
C1-1 C3-1 C3-3	C4-2 C4-3 C4-4	5A-1 5D-2 5D-4 5E-1 5E-3	5A-1 5A-5 5D-2 5E-1 5E-2
NAAEE		**NCSS**	
Elementary	Middle	Elementary	Middle
1-F 2.2-D 2.4-A	1-F 2.2-C 2.2-D	IX.d	IX.d

Notes:
NSES = National Science Education Standards
AAAS = American Association for the Advancement of Science (Benchmarks)
NAAEE = North American Association of Environmental Education (Guidelines for Excellence)
NCSS = National Council for the Social Studies (Standards)

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.

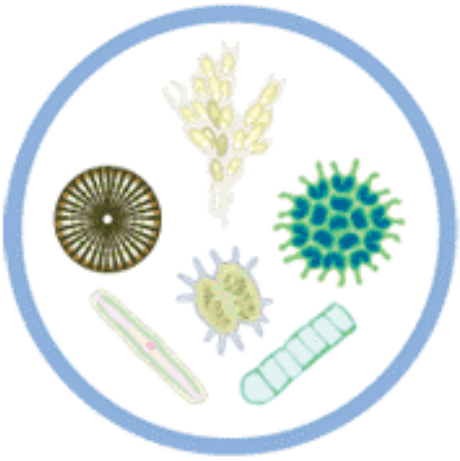
However, some changes in one part of the food web may have effects at various trophic levels, or any of the feeding levels that energy passes through as it continues through the ecosystem.

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

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
		Frog tokens per student	5	**Macroinvertebrate** (1 of 3) tokens per student	10	**TOTAL GREEN TOKENS**	**90**
				Macroinvertebrate (2 of 3) tokens per student	10		
				Macroinvertebrate (3 of 3) tokens per student	10		

TABLE 1: FOOD TOKENS

Unit 1, Lesson 2

www.miseagrant.umich.edu/flow

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

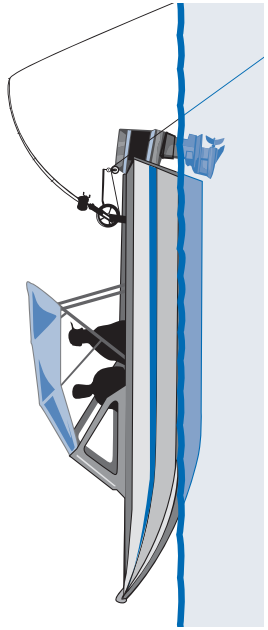
www.miseagrant.umich.edu/flow

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

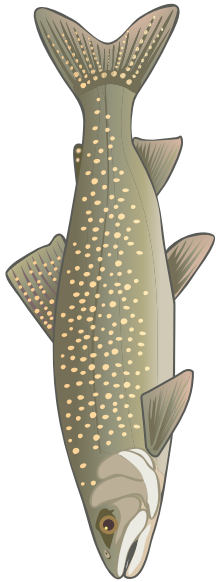
Brenner

LAKE TROUT

TOP PREDATOR

You walk around with arms held out like alligator jaws.

You eat: Macroinvertebrates, small fish and even small mammals



Brenner

FOLD

FOLD

FEEDING BEHAVIOR CARDS

Unit 1, Lesson 2

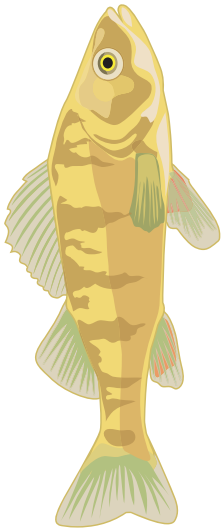
www.miseagrant.umich.edu/flow

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

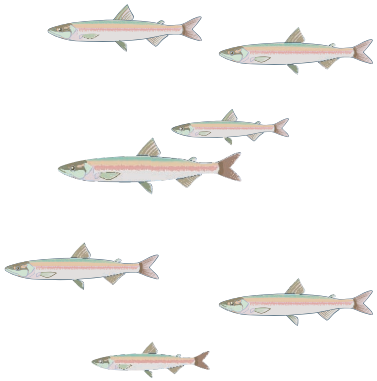
Marsee

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



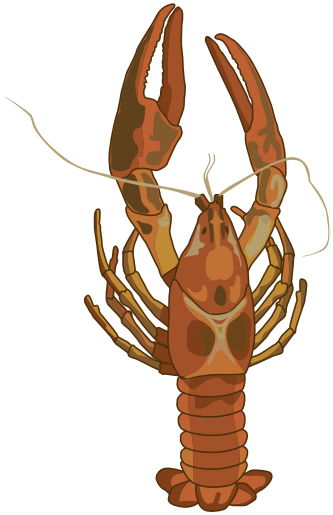
Brenner

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

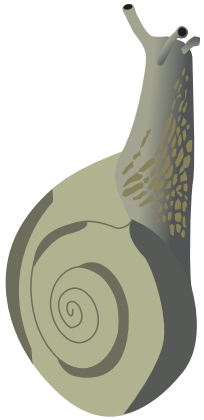
www.miseagrant.umich.edu/flow

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.

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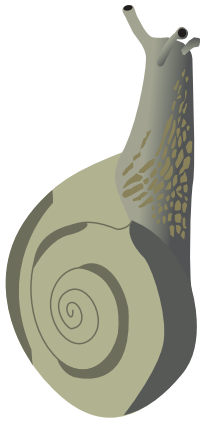


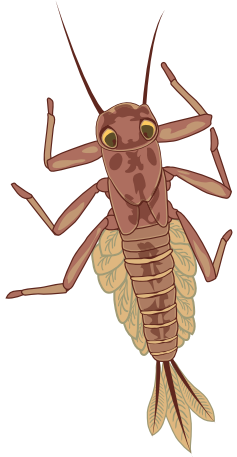
Marsee

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

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FEEDING BEHAVIOR CARDS

Unit 1, Lesson 2

www.miseagrant.umich.edu/flow

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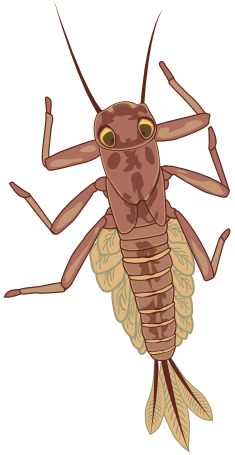


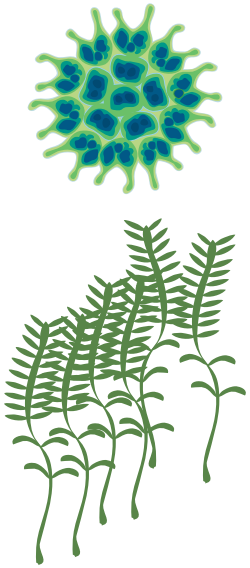
Brenner

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



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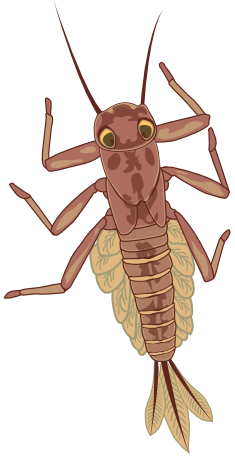

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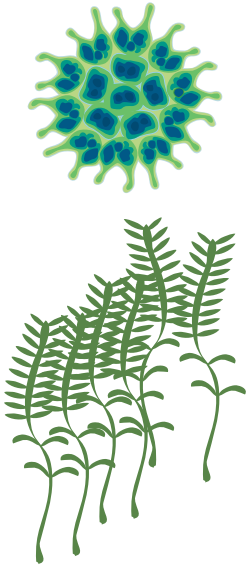

Brenner

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FEEDING BEHAVIOR CARDS

Unit 1, Lesson 2

www.miseagrant.umich.edu/flow

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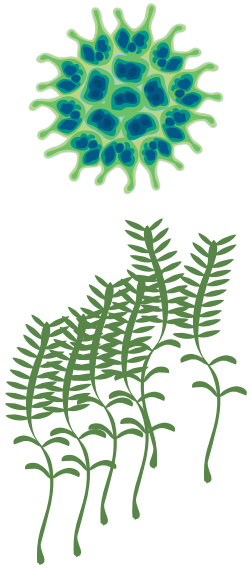

Brenner

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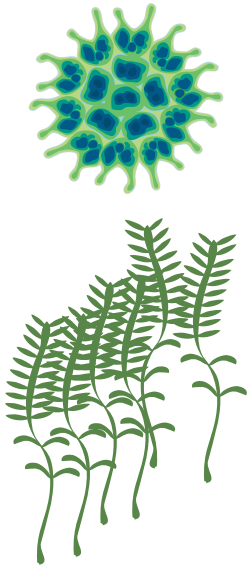

Brenner

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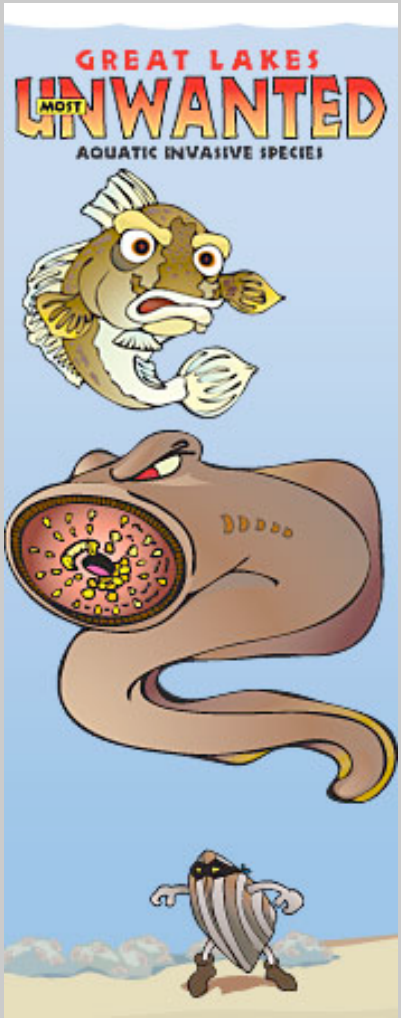
Lesson 3: Great Lakes Most Unwanted



Graphics: D. Brenner

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.

See: Additional details and photos
http://www.miseagrant.umich.edu/ais/index.html
See: Aquatic Invasive Species Poster Series
http://www.miseagrant.com/

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

Materials and Preparation

For each group of 3-4 students:

- Set of 16 invasive species 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

See **Downloads** at the end of this unit for: Set of 16 aquatic invasive species game cards.

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, Michigan State University, and Mike Klepinger.

Downloads

See **Downloads** at the end of this unit for: Aquatic invasive species game cards

Assessment

This assessment chart was designed for teachers to create their own assessment. The recommended points show the relative difficulty of student performance. In creating assessments, the total point value will depend on the number and type of performances selected.

Learning Objective	Student Performance	Recmnd # Points
Name and visually recognize the primary aquatic invasive species of the Great Lakes	**Identify:** Invasive species using pictures	1 each
Understand and analyze the negative impacts that invasive species have on the Great Lakes ecosystem	**Explain:** Negative consequences that each invasive species has on the Great Lakes	2 each
Explain the ways in which non-native species are introduced into the Great Lakes	**Name:** The method of introduction of each non-native species	1 each
Describe ways to avoid the spread of aquatic invasive species	**Explain:** Methods for controlling the spread of aquatic invasive species	3 each

Standards

State of Michigan

Science				Social Studies			
Elementary		Middle		Elementary		Middle	
I.1.2 II.1.4 III.2.4	III.5.2 III.5.5	I.1.5 II.1.3 III.5.1	III.5.2 III.5.6 III.5.7	I.2.1 II.2.4 II.4.5	IV.2.3 VI.1.3	I.2.3 II.2.4 II.2.5	II.5.3 IV.2.4 V.2.3

National

NSES					AAAS			
Elementary			Middle		Elementary		Middle	
C1-1 C1-2 C1-3 C2-1	C3-2 C3-3 C3-4 E1-2	F4-1 F4-2 F4-3 F5-1	C3-1 C3-3 C4-2 C4-4	F4-2 F4-4 F5-7	5D-1 5D-2 5D-3	5D-4 5F-1	5A-2 5A-5 5D-1	5D-2 5F-2

NAAEE				NCSS			
Elementary		Middle		Elementary		Middle	
2.2-A 2.2-C 2.3-D 2.4-A 2.4-E	3-B 3-C 3-D 3.2-B	2.2-A 2.2-C 2.3-D 2.4-A 2.4-E	3-B 3-C 3-D 3.2-B	I.b II.a II.b III.h VIII.a	VIII.b VIII.e IX.c IX.d X.c	I.b II.b III.h III.l	IX.b IX.c IX.d X.c

Notes:
NSES = National Science Education Standards
AAAS = American Association for the Advancement of Science (Benchmarks)
NAAEE = North American Association of Environmental Education (Guidelines for Excellence)
NCSS = National Council for the Social Studies (Standards)

INVASIVE SPECIES ANSWER SHEET

Unit 1, Lesson 3

www.miseagrant.umich.edu/flow

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

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.

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.

CUT

photo: Dave Jude

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.

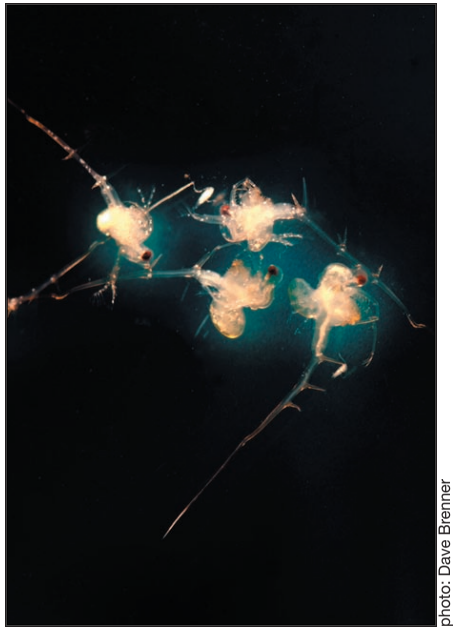


photo: Dave Brenner

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.

FOLD

CUT

FOLD

AQUATIC INVASIVE SPECIES PHOTO CARDS

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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CUT

photo: Dave Brenner

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photo: Dave Brenner

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FOLD

CUT

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.
- 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

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.

CUT

Round Goby

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.

FOLD

CUT

Spiny Water Flea

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.

FOLD

AQUATIC INVASIVE SPECIES CHARACTER CARDS

Unit 1, Lesson 3

www.miseagrant.umich.edu/flow

Sea Grant Michigan

MICHU-05-413 COPY MASTER

Zebra Mussel

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

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.

CUT

Purple Loosestrife

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.

FOLD

CUT

Eurasian Watermilfoil

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.

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

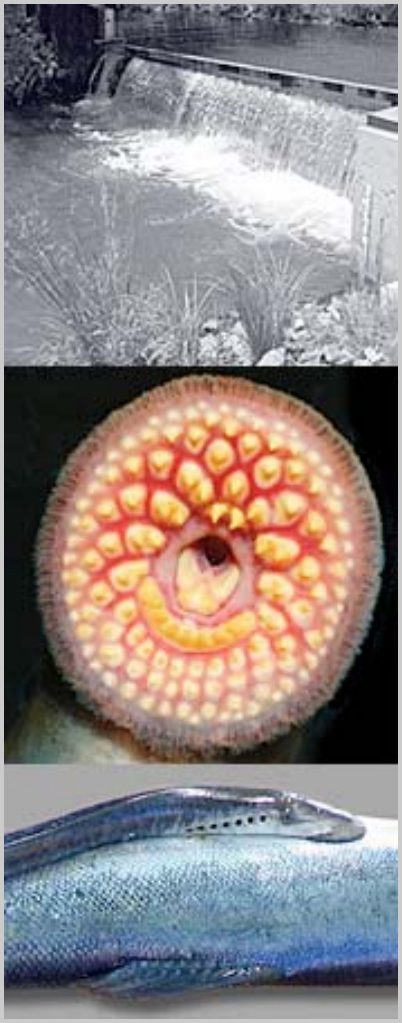
Objectives

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

See **Downloads** at the end of this unit for: Beat the Barriers game board, Barrier Cards, Lamprey Cards, and Barrier Fact Sheet.

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.

Downloads

See **Downloads** at the end of this unit for: Beat the Barriers game board, Barrier Cards, Lamprey Cards, and Barrier Fact Sheet.

Assessment

This assessment chart was designed for teachers to create their own assessment. The recommended points show the relative difficulty of student performance. In creating assessments, the total point value will depend on the number and type of performances selected.

Learning Objective	Student Performance	Recmnd # Points
Discuss the differences among the various types of technology used to control the lamprey population	**List:** Similarities between various types of lamprey control methods	1 each
	List: Differences between various types of lamprey control methods	1 each
	Explain: the 'best' lamprey control method using the similarities and differences between them all the methods.	3 each
Locate the lamprey-associated, spawning ground "hot spots" in the Great Lakes	**Name:** The spawning ground areas, using a map of the Great Lakes	1 each
Describe parasite/host relationships	**Name:** The benefits that a parasite gets from its host	1 each
	Name: The problems that a host has when it has a parasite	1 each
Identify the placement of the Great Lakes and describe how the lakes are connected	**Name:** The Great Lakes using an unlabelled map	1 each
	Name: The waterways connecting the Great Lakes using an unlabelled map	1 each

Standards

State of Michigan

Science		Social Studies	
Elementary	Middle	Elementary	Middle
II.1.2 II.1.3 II.1.4 III.4.2 III.5.5	I.1.6 II.1.3 II.1.4 III.4.1 III.5.6 V.1.1	I.4.2 II.2.4 II.4.5 II.4.6 IV.2.3 V.2.3 VI.1.3 VI.3.1	I.2.3 II.2.4 II.2.5 II.4.2 II.4.5 IV.2.4 V.2.3 VI.3.1

National

NSES		AAAS	
Elementary	Middle	Elementary	Middle
C2-1 C3-4 E1-2 E2-1 F4-2 F5-1	C3-1 E1-1 E1-4 E1-5 E1-6 F4-2 F5-7	5D-4	5D-1

NAAEE		NCSS	
Elementary	Middle	Elementary	Middle
1-F 2.2-A 2.2-C 2.4-A 2.4-B 2.4-D 2.4-E 3-B 3-C	1-F 2.2-A 2.2-C 2.3-D 2.4-A 2.4-B 2.4-E 3-A 3-B 3-C	II.f III.b III.h III.l V.f VIII.b VIII.e IX.d	II.f III.b III.h III.l V.f VI.c VIII.b VIII.e IX.d

Notes:
NSES = National Science Education Standards
AAAS = American Association for the Advancement of Science (Benchmarks)
NAAEE = North American Association of Environmental Education (Guidelines for Excellence)
NCSS = National Council for the Social Studies (Standards)

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

www.miseagrant.umich.edu/flow

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

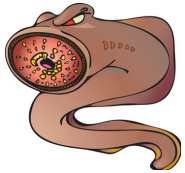
Unit 1, Lesson 4

www.miseagrant.umich.edu/flow

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.

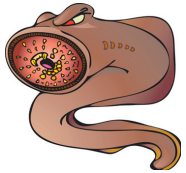
MOVE AHEAD 3 SPACES.



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!

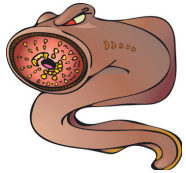
MOVE AHEAD 3 SPACES.



LAMPREY CARD

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

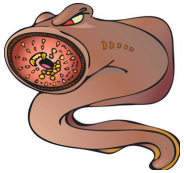
MOVE AHEAD 1 SPACE.



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.

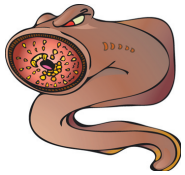
MOVE AHEAD 2 SPACES.



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.

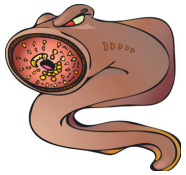
MOVE AHEAD 1 SPACE.



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.

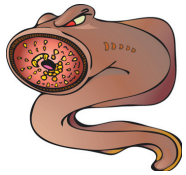
MOVE AHEAD 2 SPACES.



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.

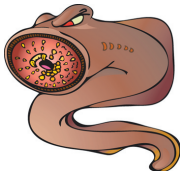
MOVE AHEAD 2 SPACES



LAMPREY CARD

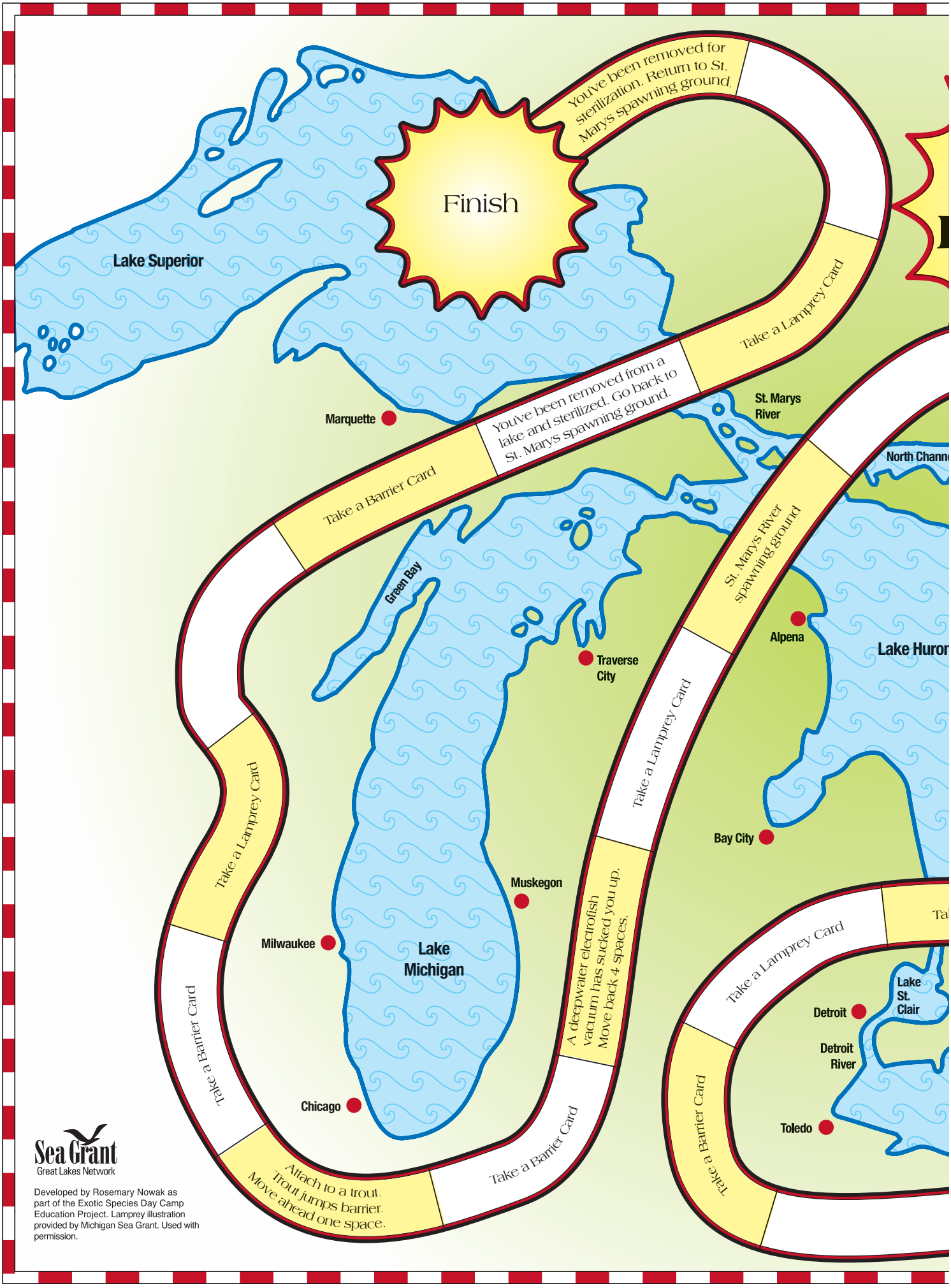
Whew! You just barely made it past the electrofish vacuum in your spawning ground.

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.

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

Take a Barrier Card

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

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

Start

North Channel

Lake Huron

St. Lawrence River

Lake Ontario

Toronto

Rochester

Niagara River

Welland Canal

Erie Canal

Buffalo

St. Clair River

Lake St. Clair

Lake Erie

Cleveland

N

W

E

S

CUT

GAME PIECES

CUT

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.

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.

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.

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 cards. Print ruffe cards on card stock, and cut out individual cards.
- “Nautical” or “fish” music.
- CD player

See **Downloads** at the end of this unit for: Ruffe Musical Chairs game cards.

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.

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

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.

Downloads

See **Downloads** at the end of this unit for: Ruffe Musical Chairs game cards.

Assessment

This assessment chart was designed for teachers to create their own assessment. The recommended points show the relative difficulty of student performance. In creating assessments, the total point value will depend on the number and type of performances selected.

Learning Objective	Student Performance	Recmnd # Points
Explain why fish populations in the Great Lakes change over time.	**Identify:** Three things that every living thing needs to live	1 each
	Explain: What happens if an animal gets its needs met	2 each
	Explain: What happens if an animal does not get its needs met	2 each
	Explain: Why an animal may/may not be able to meet its needs at different times	3 each
List three reasons why non-native ruffe have significant advantages over some native Great Lakes fishes.	**List:** Three characteristics of Ruffe that give them an advantage in meeting their needs as compared to native species	1 each
Identify two things that they can do to minimize the spread of ruffe	Explain how humans can help decrease the spread of Ruffe (and other non-native species)	3 each

Standards

State of Michigan

Science				Social Studies			
Elementary		Middle		Elementary		Middle	
II.1.4 III.4.2 III.5.2	III.5.3 III.5.5	II.1.3 III.5.1	III.5.2 III.5.6	II.2.1 II.2.4	II.4.5 IV.2.3	II.2.4 II.2.5 II.5.1	II.5.3 IV.2.4

National

NSES		AAAS	
Elementary	Middle	Elementary	Middle
C2-1 C3-2 C3-3 F4-1	C4-1	5D-1 5F-1	5A-2 5D-1 5D-2 5F-2

NAAEE				NCSS			
Elementary		Middle		Elementary		Middle	
1-F 2.2-A 2.2-C	2.3-D 2.4-A 2.4-E	1-F 2.2-A 2.2-C	2.3-D 2.4-A 2.4-E	III.h VIII.b VIIII.d	IX.c IX.d X.i	II.b III.h VIII.d	VIII.e IX.c IX.d

Notes:
NSES = National Science Education Standards
AAAS = American Association for the Advancement of Science (Benchmarks)
NAAEE = North American Association of Environmental Education (Guidelines for Excellence)
NCSS = National Council for the Social Studies (Standards)

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

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

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YOU LOST YOUR SEAT

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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.

Water Overview

This series of five lessons begins by introducing the concepts of watersheds and wetlands. The first two activities allow students to predict, observe and explain the movement of water. Lessons 3 and 4 discuss the relative availability of freshwater on earth and why water quality is so important. In the final lesson, students have an opportunity to make their own decisions concerning water quality, land use, and the environment.

Lesson 1: Exploring Watersheds

Simulates the movement and pooling of water representing rivers, lakes and ponds in a watershed.
See: Lesson 1

Lesson 2: Wetland in a Pan

Demonstrates important wetland functions including filtering, flood buffering, and fish and wildlife habitat.
See: Lesson 2

Lesson 3: Water Quantity

Reveals the relative amount of surface fresh water available for human use.
See: Lesson 3

Lesson 4: What Makes Water Healthy

Helps students think about different ways to determine water quality.
See: Lesson 4

Lesson 5: Hydropoly: A Decision-Making Game

Requires students to make land use decisions that affect the environment, especially wetlands.
See: Lesson 5

Lesson 1: Exploring Watersheds

Photo: D. Brenner

Activity: Students collaboratively build models of watersheds by placing a large piece of butcher paper over various sized objects in a large pan.

Grade level: 4-8
Subjects: Science, social studies
Setting: Classroom
Duration: Two 50-minute periods
Key terms: Elevation, Model, River system, Run-off, Slope, Watershed

Objectives

By creating a model of a watershed, students will be able to:

- Explain how water flows through a watershed
- Describe the characteristics of a watershed

Summary

Students collaboratively build models of watersheds by placing a large piece of butcher paper over various sized objects in a large pan. As students spray their model watersheds with water, they observe and mark on their map the movement and pooling representing rivers, lakes and ponds.

Background

A **watershed** is an area of land that drains into a **river** system. Any water entering a watershed, usually as precipitation, travels from higher **elevations** to lower elevations. As the water moves downward, it forms streams and rivers. The channeling and pooling of water is determined by the shape or topography of the land. Water continues to move downward, and rivers may join with lakes or other rivers as they head toward the ocean.

Materials and Preparation

- Several tall objects and short objects (2 or 3 of each per model)
- White butcher paper (3' x 4' sheets)
- Large waterproof tin trays
- Transparency film
- Small spray bottles with water
- Newspaper
- Food coloring or tempra paint
- Student worksheet. Part 1: What is a Watershed?
- Part 2: Elevation and Observation Map

See **Downloads** at the end of this unit for: Student worksheet, Parts 1 and 2.

Note: Educators should construct and test the watershed model prior to class to ensure that materials work appropriately.

Procedure

Preliminary Discussion
Ask students key questions:

- Does anyone know what causes a river to flow in a certain direction or how its shape may be altered?
- Do you think the land around our rivers affects the quality of the water?
- Introduce the term watershed. One way to introduce this term is to ask students to separate the word into "water" and "shed" (to pour or cause to pour off; to emit) and discuss what each word means. Ask students what "sheds" water? (The land around a river.)
- Inform the class that they will be learning about watersheds using a **model**, which is a simplified representation of a natural phenomenon. Models help scientists represent their current understanding of natural phenomena as well as construct new understanding.

Advance Preparation

1. Preview the materials and demonstrate how to build the watershed model. Connect the watershed model to the real world. Ask: What might be the purpose of this watershed model? Have students describe what the pieces of the model represent. (Paper = land. Spray bottle = precipitation.)

2. Have students form groups. Hand out Part 1 of the student worksheet: What is a Watershed?
3. Assign roles to group members: object placer, paper placer, taper, watershed transparency map creator, and/or sprayer. (Assigning roles is one strategy to facilitate small group interaction until students become adept at working together.)
4. Remind students that they are all responsible for creating individual watershed maps, filling out their predictions, observations, and explanations, and taking notes on the concepts they identify.
5. Distribute materials. Do not have the students get water bottles yet!

Build a Watershed Model

1. Review set-up procedure with students. (Steps 1-4 on the work sheet.)
2. Monitor students as they build their watershed models.
3. Create an elevation map. Describe the procedure for making an elevation map. (Steps 5-6 on the work sheet.) Students will mark high areas with “H” and low areas with “L” on both their model and on a separate transparency. Monitor students as they create maps.
4. Have groups raise their hands when maps are completed.
5. Predict water flow. Review steps for making predictions. (Step 7 on the work sheet.)
6. Monitor students as they make predictions and explanations on their worksheets or in journals, about how water will flow over their watershed model.
7. Have groups raise hands when predictions are completed.
8. Observe and test models. Inform the students that they are now ready to test their models and make observations. Remind them to keep detailed notes of their observations: they will use their observations to help explain their models.
9. Give each group a spray bottle. Students will use spray bottles to test their watershed model.
10. Monitor groups as students make observations. Return materials.

Source
Used with permission: Center for Highly Interactive Classrooms, Curricula and Computing in Education (Hi-ce), University of Michigan School of Education.

Discuss the Results

1. Have a few groups share their transparency elevation maps using an overhead projector. Ask:
    a. How did the water flow over the surface of the land? What patterns did you observe?
    b. How did the water accumulate? Where did the water accumulate?

   c. In what direction did the water flow? What caused the water to flow that way?
   d. The students have built a model (a representation) of a watershed. Review key concepts:
   e. What is a model? What is the purpose of a model?
   f. Have students describe what the pieces of the model represent.
2. Previously introduced watershed model parts:
3. Paper = land
4. Spray = precipitation
5. Newly introduced watershed model parts:
6. Branching pattern of the water flow (smaller rivers leading into larger rivers) = a river system
7. Wet portions of the paper = absorption of water by land
8. Flow of water over the paper = run-off
9. Change in elevations on land = slope
10. Entire model = watershed
11. Discuss how using the models can help them investigate their river.
12. Remind students that they observed the results from testing a model. To enhance understanding, students may wish to take notes, create a classroom chart, or make entries in a journal. The following key concepts should emerge:
    a. A watershed is an area of land that drains into a river system.
    b. Water moves from areas of high elevation to areas of lower elevation, following the slope in land.
    c. The flow of water occurs in a branching pattern in streams and rivers (i.e. stream system). Branches may combine to form lakes or larger rivers
    d. Effects of precipitation— i.e. rain and snow might be absorbed by the ground, or might form run-off that feeds into rivers.
13. Ask student to describe the direction of water flow within the watershed. Prompt students by asking them how elevation affects the flow of water. A common misconception is that all rivers flow south. Be sure to emphasize that rivers flow in all directions depending on the change in elevation in the watershed. (Use Michigan as an example.)
14. Ask students to draw the flow of water on their own maps.
15. Have students come to the front of the room and draw the flow of water for a specific part of the map. Students should explain why the water flows as they predict.
16. Repeat the above step until all map parts are explained.

Teaching Tips

Predict, Observe, Explain

The cycle of predicting, observing, and explaining is a strategy to support students in constructing understanding. Emphasize the reasons that predictions, observations, and

explanations are made. Encourage students to question each other, elaborate on their ideas, and share their thinking with other groups.

Time Management

The purpose of sharing ideas is to determine that students understand main ideas. Often, however, there is not enough time for all groups to present their observations. Consider having a few groups present ideas, while others participate in the discussions by stating whether or not they observed the same patterns.

Assessment

This assessment chart was designed for teachers to create their own assessment. The recommended points show the relative difficulty of student performance. In creating assessments, the total point value will depend on the number and type of performances selected.

Learning Objective	Student Performance	Recmnd # Points
Explain how water flows through a watershed	**List:** The ways that water might enter a watershed.	1 each
	Demonstrate: (Using a model) the direction water flows on an incline or slope	2 each
	Indicate: (Using a model) the final destination of water in a watershed	1 each
	Describe: How high elevation, low elevation and slope are related	1 each
	Define: Run-off	1 each
Describe the characteristics of a watershed	**Explain:** What the boundaries of a watershed are (can use a model)	2 each
	Demonstrate: (Using a model) the relationship between the land area which defines a watershed and the river system that lies within it	3 each

Standards

State of Michigan

Science		Social Studies	
Elementary	Middle	Elementary	Middle
I.1.5 II.1.2 II.1.4 V.1.1 V.2.2	II.1.3 V.1.1 V.2.2	II.2.1 II.2.3 II.4.5	II..2.2

National

NSES		AAAS	
Elementary	Middle	Elementary	Middle
n/a	D1–6	11B–1 11B–2	4B–7 11B–1
NAAEE		**NCSS**	
Elementary	Middle	Elementary	Middle
1.F 2.1-A	1-F 2.4-B	III.b III.e	III.b III.e

Notes:
NSES = National Science Education Standards
AAAS = American Association for the Advancement of Science (Benchmarks)
NAAEE = North American Association of Environmental Education (Guidelines for Excellence)
NCSS = National Council for the Social Studies (Standards)

Lesson 2: Wetland in a Pan

Photo: D. Brenner

Activity: Students observe a simple wetland model that demonstrates wetland functions including filtering, flood buffering, and nursery for aquatic organisms.

Grade level: 4-8
Subjects: Science and social studies
Setting: Classroom and/or outside
Duration: 1.5 hours
Key terms: Nursery, Wetland

Objectives

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

- Observe building a model wetland
- Understand that wetlands are defined by plants, soil and water
- Identify some wetland types and their locations
- Relate importance of wetland function to people's needs and daily lives

Summary

Wetlands provide some of the most important ecological functions of any habitat type. They provide **nursery** areas for fish, support an abundance of wildlife, help control flooding, filter nutrients and sediments and even some harmful pollutants. In the process, wetlands improve water quality and enhance our natural environment. By creating a wetland model, students observe these concepts in action and watch what can happen when a wetland disappears.

Background

Wetlands are an important feature of the Great Lake region. Marshes, a type of wetland, are found along the Great Lakes, but in some areas they've decreased by 90 percent. It is estimated that Michigan once had over 11 million acres of wetlands. Today, a little over 5.6 million acres remain.

A **wetland** is an area that periodically has waterlogged soils or is covered by shallow surface water. This surface water supports plants and animals that are adapted to living in a watery environment. Some major functions of a wetland are:

- Reduce flooding (flood buffering)
- Filter pollution
- Prevent soil erosion
- Provide habitat for aquatic and terrestrial animals and plants
- Serve as breeding, feeding, and nesting grounds

Wetlands are classified as marshes, bogs, swamps, vernal ponds, and wet meadows. These are the types found in Michigan. Some non-Michigan wetlands are salt marshes, mangrove swamps, and prairie potholes.

See: Great Lakes Coastal Wetlands
http://www.miseagrant.umich.edu/wetlands/index.html

Materials and Preparation

- Modeling clay
- Rolling paint pan (or small aluminum pan)
- Sponges
- Carpet or florist oasis foam
- Watering can or similar device
- Cup of soil
- Jar of muddy water

Procedure

Build a Model Wetland

The first part of the procedure demonstrates how wetlands prevent flooding and soil erosion.

1. Explain that wetlands, like all habitats, are very complicated natural systems. They perform some very important functions such as filtering pollutants, reducing flood damage, and preventing soil erosion. Some wetlands, at times, recharge groundwater supplies.
2. Explain that you will make a wetland model to demonstrate some of these functions in a very simplified way.

3. Put the clay along one side of the pan. Fit the piece of carpeting or sponge into the wetland area along the edge of the clay. Slowly sprinkle some rain on land (the clay) and let the students observe and describe what is happening. Ask: If I make it rain on the model, what do you think will happen to the rainwater? (Rain will flow downhill.) The wetland (carpeting) will slow the rate of flow, and the excess rain will slowly enter the body of water. Point out that the wetland absorbed some of the water—pick up the carpeting and squeeze some water out to prove it.
4. Ask: What do you think will happen if the wetland is removed? (The water will not be absorbed; it will flow more quickly into the body of water.) Remove the carpeting and water. Pour the same amount of water on the model at the same spot and rate as before. Have the students note any differences. The water should fill the body of water much more quickly and may eventually overflow and flood the land. That's because it is no longer retained by the wetland.

Discuss the Results

- Explain that most wetlands are shallow basins that collect water and slow its rate of flow and also retain water for a time. This slowing process helps reduce flooding and also helps prevent soil erosion. Ask: If a wetland is destroyed, and houses are built in its place, what might happen to the houses during a severe rainstorm? Why? (They might be flooded because the wetland will not be there to absorb and slow the rush of water from higher ground.)
- In many areas, wetlands are drained and filled, and houses and marinas are built right along the water. Without a wetland buffer, these developed areas, particularly along the coast, are often subjected to severe flooding and erosion, especially during violent storms.

Modify the Wetland Model
The second part of the procedure demonstrates how wetlands improve water quality by filtering sediments and pollutants.

1. Pour the water from the last demonstration out of the model, squeeze out the "wetland" and replace the piece of carpeting. Spread a layer of soil over the clay. Explain that this demonstration will be just like the first, except that topsoil will cover the clay. Ask: What do you think will happen to the bare soil when it rains? (The rain should pick up and carry some sediment over the land and into the body of water. Explain that this water represents polluted runoff such as silt from farmlands and construction sites or salt from snow-covered streets.)
2. Ask the students to compare the water that ends up in the body of water with the muddy water in the jar. Explain that the carpeting trapped the soil particles, making the water in the body of water much clearer. The uphill side of the wetland should be coated with trapped sediment.

3. Remove the carpeting, pour out the water, and try the experiment again. What happens without the wetland in place? Ask the students why all the soil particles end up in the body of water this time. (The thick mat of plant roots in a wetland helps trap silt and some types of pollutants, much as the carpet or foam did in the model. Without a wetland, excessive amounts of silt and pollutants can end up in lakes, rivers, and other bodies of water.)

Discuss the Results

- How might muddy water affect fish? (Makes it harder for them to see and breathe with clogged gills, and could lead to their death.) How might the muddy water affect other animals and plants? (Settling sediment smothers clams, plants do not get sunlight needed for growth, birds and other animals that eat fish or plants have less to eat if food sources die or cannot be seen in muddy water, etc.)
- How might the muddy water affect boats and ships? (The mud settles out and eventually fills channels important for navigation.) How might all of this affect you? (Decrease in natural resources and food sources; decline in quality of drinking water; impacts on recreation such as swimming and fishing; change in aesthetics; change in community economy, such as shipping problems that affect jobs and industry, etc.) How can we prevent these undesirable effects? (By protecting wetlands and helping to make their benefits known!)
- Have students describe how wetlands function to reduce flooding and retain sediments.
- Have students analyze what would happen to water, sediments, homes and wildlife if wetlands were destroyed.

Adaptations

Students, individually or as small groups, can make their own detailed wetland models using small aluminum foil pans, clay, and florist's foam, carpet, or sponges. Provide reference books with pictures of different types of wetlands. Students can use an assortment of collected material to decorate their models. Have students present their models by explaining their particular characteristics. Some ideas:

1. Use long pine needles for reeds and toothpicks to attach plants.
2. Shape wetland creatures from clay, or glue paper cutouts to toothpicks.
3. Dried flower heads make nice trees, and small pinecones painted green form evergreens.
4. For cattails, use cotton swabs. Paint sticks green and cotton parts brown, or paint toothpicks green, and attach bits of brown clay to the tops.

Source
Adapted with permission from "A Wetland in a Pan: from WOW! The Wonder of Wetlands, for the Great Lakes Education Program. Modified by Julie Champion, Metro Beach Nature Center, Michigan; Bette Nebel, Macomb Country Community College, Michigan; and Michael Schichtel, Mohawk Elementary School, Michigan.

Assessment

This assessment chart was designed for teachers to create their own assessment. The recommended points show the relative difficulty of student performance. In creating assessments, the total point value will depend on the number and type of performances selected.

Learning Objective	Student Performance	Recmnd # Points
Build a model wetland	**Identify:** The parts of the model that correspond to parts of a wetland (e.g. carpet=wetland, etc.)	1 each
	Describe: What happens to the 'rainwater' in the model with and without the 'wetland' in place	2 each
Understand that wetlands are defined by plants, soil, and water	**Name:** The three important aspects of a wetland	1 each
Identify some wetland types and their locations	**Describe:** Different types of wetlands and where they are generally found	1 or 2 each
Relate importance of wetland function to people's needs and daily lives	**Explain:** The various benefits or functions of a wetland for the whole ecosystem (including humans)	2 each
	Predict: What might happen if a lot of the wetlands disappear (e.g. by being developed, or via pollution)	3 each

Standards

State of Michigan

Science		Social Studies	
Elementary	Middle	Elementary	Middle
I.1.5 II.1.2 II.1.4 V.1.1 V.2.2	II.1.3 V.1.1 V.2.2	II.2.1 II.2.3 II.4.5	II..2.2

National

NSES		AAAS	
Elementary	Middle	Elementary	Middle
n/a	D1–6	11B–1 11B–2	4B–7 11B–1
NAAEE		**NCSS**	
Elementary	Middle	Elementary	Middle
1.F 2.1-A	1-F 2.4-B	III.b III.e	III.b III.e

Notes:
NSES = National Science Education Standards
AAAS = American Association for the Advancement of Science (Benchmarks)
NAAEE = North American Association of Environmental Education (Guidelines for Excellence)
NCSS = National Council for the Social Studies (Standards)

Lesson 3: Water Quantity

Photo: Dinny

Activity: Students remove measured amounts of water from a five-gallon bucket, simulating the amount of fresh water available on earth.

Grade level: 4-8
Subjects: Science, social studies
Setting: Classroom
Duration: 1 hour
Key terms: Freshwater, Groundwater, Salt water, Surface water

Objectives

After participating in this activity, students will:

- Experience the relative scarcity of **freshwater** on the planet
- Explain why some of the earth's water is not easily accessible

Summary

Even though the earth contains an abundance of water, only a small percentage is fresh water. An even smaller amount of this freshwater is accessible and usable by the people and animals that need it. As the human population grows, the amount of freshwater available per person shrinks. The relatively small amount of available freshwater demonstrates how critical it is for everyone to help maintain clean, healthy lakes and streams.

Background

Oceans and seas contain more than 97 percent of the water on the planet. Because it is **salt water**, it is not healthy for humans and animals to drink. The remaining supply of water on Earth is fresh water.

The amount of freshwater available for use by living beings is very small (See chart below.) The Great Lakes contain 20 percent of the world's supply of surface freshwater.

Other reservoirs of freshwater are not available for use by humans. For instance, more than 2 percent of the Earth's freshwater is "locked" in ice caps and glaciers.

The Earth's supply of water remains the same: the planet has as much water as it will ever have. Yet world population continues to grow. The relatively small amount of available freshwater supports more than 6 billion people. As this number increases, the amount of fresh water available per person decreases. Thus maintaining the quality of the Earth's available fresh water is vitally important.

Amount of water in each major reservoir on earth:

Saltwater in oceans:	97.2%
Ice caps and glaciers:	2.14%
Groundwater:	0.61%
Surface water:	0.009%
Soil moisture:	0.005%
Total:	**100%**

Materials and Preparation

- 5-gallon bucket
- 2-cup transparent measuring cup
- 1-cup transparent measuring cup
- 1 eye-dropper
- Water Body Worksheet

See **Downloads** at the end of this unit for: Water Body worksheet.

Advance Preparation

Before class starts, fill the 5-gallon bucket with water. Have the other materials nearby in a place where the whole class can observe.

Note: Be sure to wipe water off the floor if spills occur during this activity.

Procedure

1. Explain to students that the water in the 5-gallon bucket represents all the water on Earth. Ask them to name the kinds of water that exist in, on or around Earth. They should be able to name rivers, lakes, oceans, clouds or water vapor, ice caps,

groundwater, water held in soil, and water held in plants and animals. Provide hints so that all types of water are mentioned.

2. Ask two students to come up and help with the demonstration. Ask one of them to remove two cups of water from the bucket, using a measuring cup. Have the student hold that amount so everyone in the class can see it. Ask: What does the water in the cup represent? (Freshwater.) Ask: What does the water remaining in the bucket represent? (Saltwater.) Explain that the saltwater is not usable by humans because drinking it would make us very sick.
3. Move the bucket aside. Ask the first student to pour 1/2 cup of water into the one-cup measurer held by the other student. Ask: What does the 1-1/2 cups still left in the two-cup measurer represent? (Polar ice caps.) Explain that this water is unavailable for our use because it is frozen. Set this cup aside. The first student can return to his or her seat.
4. Ask the class what the 1/2 cup of water represents. (Groundwater, surface water (e.g. lakes, rivers, wetlands), and water vapor in the atmosphere.) Have the class guess how much water should be removed from the cup to represent only the surface water on Earth. After a few guesses, pull out the eye-dropper from your pocket and draw some water into it. Place one drop of water into the hand of a few students. Explain that one drop of water out of a whole 5-gallon bucket represents the water that is available to us and other animals for drinking.
5. Allow the class to think about this for a minute. Then explain to them that the total amount of water on the planet is not going to change. Even though water moves around on the planet and changes from one kind to another, we will never have any more than we have right now.

Discuss the Results

Spend some time discussing the activity with the class. The following questions are a good place to start:

- Were you surprised at how little water is available for human use?
- Would you call water a scarce or an abundant resource? Why?
- What do we need/use water for?
- Why can't we drink saltwater?
- The number of people who need to use Earth's freshwater keeps increasing. If the amount of freshwater cannot change, but there are more people who need it, what does that mean? What might happen?
- Can people and animals live without clean freshwater?
- What is the main cause of the increased demand for freshwater?

Ask students to think about the term "water quality." Find out from them what they think it means. If they get stuck, have them think about it in terms of low water quality or high water quality: would they want to drink, wash, swim, or cook with low quality water or

high quality water? Have them come up with as many descriptions as they can for what might be “low quality” and “high quality” water. See: Lesson 2.4

Source
North Carolina Museum of Natural Sciences - Adapted with permission from the Girls in Science Program. Original source content: Hands On Save Our Streams - The Save Our Streams Teacher's Manual, Chapter One, Watersheds, Water Water Everywhere and Not A Drop to Spare, Water Supply Activity, The Izaak Walton League of America.

Assessment

This assessment chart was designed for teachers to create their own assessment. The recommended points show the relative difficulty of student performance. In creating assessments, the total point value will depend on the number and type of performances selected.

Learning Objective	Student Performance	Recmnd # Points
Experience the relative scarcity of freshwater on the planet	**Compare:** The amount of available freshwater to the total amount of water on the planet	1 each
Explain why some of the earth’s water is not easily accessible	**List:** The places or types of water that are not readily useable by us	1 each
Understand that as the human population increases, the amount of freshwater per person decreases	**Explain:** That the amount of freshwater on the planet is basically constant	1 each
	Explain: That since the amount of freshwater stays the same, as the human population increases there is less freshwater per person.	3 each

Standards

State of Michigan

Science			Social Studies	
Elementary		Middle	Elementary	Middle
II.1.4 III.5.3 III.5.5 V.1.1	V.1.5 V.2.1 V.2.3 V.2.4	II.1.3 V.2.1	II.2.2	II.2.4 II.2.5

National

NSES			AAAS	
Elementary		Middle	Elementary	Middle
1-1 C1-1 C3-4 F2-1	F2-2 F3-1 F3-3 F4-2	C4-4 F1-7 F2-1	n/a	4B-8 4B-11 5D-1

NAAEE		NCSS	
Elementary	Middle	Elementary	Middle
2.3-D 2.4-A 2.4-E 3-B	2.3-D 2.4-A 2.4-E	IX.d	IX.d

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WATER BODY WORKSHEET

Unit 2, Lesson 3

In class today, you have seen how much water is on the planet and how it is distributed. One thing people don't think a lot about is that we depend on water every day. If you don't get enough (clean) water, you can get very sick. In this exercise, you will calculate how much water is in your body right now, as well as how much water you are likely to utilize in your body over your whole lifetime.

1. Figure out how many pounds of water are in your body. Approximately five sixths of your body weight is water. Use this equation:

5/6 X _____ lbs. = _____lbs.

2. Now use this answer to find out how many gallons of water are in your body. (Note: 1gallon of water weighs 8.1 lbs.)

/ 8.1 = _____ gallons

(answer from part 1)

3. Now find out how much water your body needs during your life span. Each person's body needs to replace 1.5 million gallons of water throughout their life. To get a feel for this, a back-yard swimming pool holds about 20,000 gallons of water. How many swimming pools of water will you need in your life? Use this equation:

1,500,000 gallons / 20,000 gallons = _____

(swimming pools of water used in a lifetime)

Was there anything here that was surprising to you? Explain.

_____

_____

_____

_____

_____

Lesson 4: What Makes Water Healthy?

Activity: Students make observations and measurements of several water samples. This activity helps students think about different ways to determine water quality.

Grade level: 4-8
Subjects: Science, social studies
Setting: Classroom
Duration: 50 minutes or more
Key terms: Benthic, pH, Secchi disk, Sediment, Turbidity, Water clarity, Water quality

Photo: D. Brenner

Objectives

After participating in this activity, students will:

- Develop their own criteria for the quality of water
- Understand that there is more to water quality than "meets the eye"
- Engage in a few **water quality** tests used by scientists

Summary

Water quality is one of the most important factors in a healthy ecosystem. Clean water supports a diversity of plants and wildlife. In turn, our actions on land affect the quality of our water. Pollutants, excessive nutrients from fertilizers, and **sediment** frequently get carried into local lakes and rivers via run-off from urban areas or agricultural fields. By observing and evaluating several water samples, students begin to consider the factors that influence water quality.

Background

Scientists measure a variety of properties to determine water quality. These include temperature, acidity (pH), dissolved solids (specific conductance), particulate matter (turbidity), dissolved oxygen, hardness and suspended sediment. Each reveals something different about the health of a water body.

The result of a single measurement, however, is actually less important than monitoring changes over time. For example, if you measure the pH of the creek behind your house and find that it is 5.5, you might think it is acidic. But a pH of 5.5 might be “normal” for that creek. If the pH or the turbidity of your creek begins to change, however, something may be happening (probably upstream) that is affecting water quality. Taking routine measurements at scheduled intervals allows you to monitor overall changes in water quality.

The following water properties are important in determining water quality:

- **Temperature:** Water temperature is important to fish and aquatic plants. Temperature can affect the level of oxygen, as well as the ability of organisms to resist certain pollutants.
- See: Water Temperature

- **Acidity — pH:** The measurement of pH is a measure of the amount of hydrogen ions (H+) present in a substance such as water. Knowing the amount of hydrogen in a substance allows us to judge whether it is acidic, neutral, or basic.
- See: Measuring pH

- **Dissolved Oxygen:** A small amount of oxygen, about ten molecules of oxygen per million molecules of water, is dissolved in water. Fish and microscopic organisms need dissolved oxygen to survive.
- See: Oxygen and Carbon Dioxide

- **Turbidity:** Turbidity makes the water cloudy or opaque. Turbidity is the amount of particulate matter (such as clay, silt, plankton, or microscopic organisms) suspended in water.
- See: Water Clarity

- **Specific conductance:** Specific conductance measures the capacity of water to conduct an electrical current. It depends on the amount of dissolved solids, such as salt, in the water.

- **Hardness:** The amount of dissolved calcium and magnesium in water determines its "hardness." Water hardness varies throughout the United States.

- **Suspended sediment:** Suspended sediment is the amount of soil circulating in water. The amount depends in part on the speed of the water flow. Fast-flowing water can pick up and hold, or suspend, more soil than calm water.

Materials and Preparation

- 5 clear glass jars or clear soda bottles with lids
- Instant coffee and/or cocoa, salt, hydrochloric acid, isopropyl alcohol, and food coloring (to make a purple color)
- Local river or pond water
- Water Quality Worksheet
- Water quality testing kits that can be used to measure oxygen and pH

See **Downloads** at the end of this unit for: Water Quality Worksheet.

Advance Preparation

Create water quality jars. Fill the 5 jars with water. (Jar 5 will be filled with the river water.)

- Jar 1 -Add enough coffee grounds and cocoa powder until the water has a good "dirty" look. Label the jar 1.
- Jar 2- Add food coloring so that the water appears clear purple. Label the jar 2.
- Jar 3- Add a trace of hydrochloric acid. The HCl solution should be clear and colorless. Label the jar 3.
- Jar 4- Add a few tablespoons of kosher table salt. The salt will dissolve in the water, resulting in a clear colorless solution. Label the jar 4.
- Jar 5- Fill a jar or bottle with water from your local river. Label the jar 5.

Procedure

1. In small groups, have students examine the water sample jars. You may choose to have students record their observations on the Water Quality Worksheet or in their notebooks.
2. Ask groups of students to work together to determine which of the water samples they would be willing to use for such things as fishing, swimming, boating or drinking.
3. After students have observed all the jars, have them share their consensus and rationale for their decisions regarding water use. Prompt students to provide evidence for their decisions. (You may also choose to record the class data in a chart.)
4. Using this shared experience, facilitate a discussion that leads to an agreed upon definition of “water quality.”
5. Have students brainstorm answers to the following questions: What is meant by quality? What is water quality? How can we determine water quality? Why is water quality important to us and to other animals? How did we determine water quality

for the bottles? Are these methods trustworthy? How else could we measure water quality? How might scientists measure water quality?

6. Introduce the concepts of dissolved oxygen and pH. Explain what numerical values for each are necessary for life. Explain that scientists use these numerical values to measure water quality.
7. Use one of the water samples from before to demonstrate how each test is conducted.
8. Allow groups of students to measure oxygen and pH for the other water samples. Summarize the results on the board. Discuss the results from a scientist's perspective. Which sample has the highest quality based on this data?
9. Discuss whether these results are consistent with the determinations made just by looking at the water.
10. Explain that water quality is a complex concept and there are many other variables that scientists use to measure it. Explain that you can't tell true water quality just by looking at it.

Adaptations

Provide students with articles from newspapers that refer to the water quality of local rivers. Choose articles that address living organisms in the water or human uses of the water. Describe how members of the community talk about their river or what actions they're taking to prevent or reduce water quality problems.

Source

Used with permission: Center for Highly Interactive Classrooms, Curricula and Computing in Education (Hi-ce), University of Michigan School of Education.

Assessment

This assessment chart was designed for teachers to create their own assessment. The recommended points show the relative difficulty of student performance. In creating assessments, the total point value will depend on the number and type of performances selected.

Learning Objective	Student Performance	Recmnd # Points
Develop their own criteria for the quality of water	**List:** Characteristics of water that they consider to be important for its health	1 each
	Defend: Their list above	2 each
Understand that there is more to water quality than 'meets the eye'	**Explain:** Why you can't tell the quality of water just by looking	2 each
Engage in some of the water quality tests used by scientists	**List:** Some of the tests that scientists do to test for water quality	1 each
	Explain: Why each test above is an important aspect of water quality	2 each
	Interpret: The results of various water quality tests – what does each one say about the quality of a water sample?	3 each

Standards

State of Michigan

Science				Social Studies	
Elementary		Middle		Elementary	Middle
I.1.1 I.1.6 II.1.4	III.5.5 V.2.4	I.1.1 II.1.2 II.1.3 III.5.6	III.5.7 IV.2.4 V.2.3	II.2.2	II.2.3 II.2.4 II.2.5 II.5.3

National

NSES		AAAS	
Elementary	Middle	Elementary	Middle
A1-1 C3-4 F1-4 F4-1	F1-7 F3-2 F4-2	11C-1	4B-8

NAAEE		NCSS			
Elementary	Middle	Elementary		Middle	
1-A 1-E 2.4-A	1-A 1-E 2.4-A	III.h III.j III.k	VIII.b IX.d	III.j III.k	VIII.b IX.d

Notes:
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AAAS = American Association for the Advancement of Science (Benchmarks)
NAAEE = North American Association of Environmental Education (Guidelines for Excellence)
NCSS = National Council for the Social Studies (Standards)

Lesson 5: Hydropoly: A Decision-Making Game

Photo: Marsee

Activity: Students play a board game to hone their decision-making skills. Through the various choices posed in the game, they are asked to consider both economic and environmental well being in making decisions.

Grade level: 4-8
Subjects: Science, social studies
Setting: Classroom
Duration: 1 hour
Key terms: Land use, Wetlands

Objectives

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

- Discuss land-use practices that affect Great Lakes wetlands
- Make decisions and recognize personal priorities with regard to wetlands
- Describe some of the economic factors that often drive **land use**

Summary

Every day we make choices. We decide simple things like what to wear, what to eat, or how much time to allow for homework. Some decisions, however, require us to think critically and consider the potential consequences of our actions. Through the various land-use choices posed in the board game Hydropoly, students must consider both the economic and environmental consequences of their decisions. This type of decision-making helps prepare young people for situations they'll encounter throughout their lives.

Background

Coastal and inland communities in the Great Lakes region face difficult land use decisions every day. Land use refers to how land within a community is used—whether for houses, businesses, agriculture or natural areas. Local leaders must decide where to build houses

and what type of industry to support. Communities must also consider another important factor—the health of the environment. A healthy environment that allows for natural areas, open green space, and clean water attracts residents and enhances quality of life.

Protecting wetlands is another way to enhance our natural environment. Wetlands provide important ecological benefits—such as water filtration, habitat and flood control—that need to be considered in land use decisions. Yet wetland benefits are frequently overlooked. Financial gain and economic concerns often override environmental issues. Despite this historic trend, some communities are recognizing that a healthy environment is closely tied to a healthy economy. We could call this principle “eco-nomics”—the healthy marriage of ecological protection and economic growth.

In essence, all land use decisions have short- and long-term consequences that affect the environment. It’s important to weigh the pros and cons of every decision and make the best choices possible.

Materials and Preparation

- Hydropoly game boards (one for each small group of students)
- One set of Decision Cards per game board
- One die (not pair) per game board
- Tape
- Scissors
- Six different-colored playing pieces per game board (construction paper squares or pieces from another game)

See **Downloads** at the end of this unit for: Hydropoly Decision Cards.

Advance Preparation

1. Read the game instructions below.
2. Copy Decision Cards (2-3 sets). Cut apart individual cards.
3. Design a game board for use in your classroom. The game board should have the following types of labeled spaces: Start, Roll Again, Lose a Turn, Decision Card, many blank spaces, The Winner.

Procedure

1. Ask students to describe decisions that they have made recently. What do they like and dislike about making decisions? What helps them make a wise choice? Have them list important considerations. Have any of them made a wrong decision recently (or ever)? How can wrong decisions be a good experience? (We can learn from our mistakes.)
2. Divide the class into small groups. Hydropoly may be played by 2-6 players, or 2-6 teams of players. Discuss “eco-nomics” before beginning to play.

Review the Rules

1. Each player (or team) selects a game piece and places it on the space marked “Start.” Each player rolls the die. The player who rolls the highest number goes first. Play proceeds in a clockwise direction.
2. The first player rolls the die and moves his or her playing piece the number of spaces indicated on the die. Move in the direction indicated by the arrows on the board. When a player lands on a blank space, his or her turn is over, and play advances to the next player. When a player lands on a space marked “Roll Again,” s/he may do so and move along the board as before. If a player lands on “Lose A Turn,” the turn is over, and s/he must skip the next turn.
3. Decision Cards: when a player lands on a “Decision Card” space, s/he must randomly select one of the cards (cards should be face-down). An opponent reads the top portion of the card aloud. (Do not read the “Consequences” out loud.) The player has a maximum of two minutes to make a decision. If playing in teams, team members may discuss the decision quietly. When a player announces his or her decision, the person holding the card reads the “Consequences,” which tell how many spaces the player has earned or lost for the decision. The player must follow the instructions given on the card and return the card to the pile. The player’s turn continues until landing on a blank space or “Lose A Turn.” Play then moves to the next player or team.
4. Players may only reach “The Winner” space by an exact roll of the die. (If a player is 4 spaces away, for example, and rolls a 5, s/he may not move and must forfeit the turn. If a player rolls a 3, s/he moves 3 spaces but must then roll a 1 to win.)

Note: The consequences specified on each Decision Card reward learners for choosing certain actions in relation to their environments. If you wish other values to be considered, have the class or team of students determine a new set of consequences and substitute them on the “Decision Cards” before the game begins.

- When students understand the rules, play the game! You may choose to have learners play “blind” first, and then discuss eco-nomics after the game. Play several games.
- After the games have ended, discuss the results—who won, and why the winner reached the end more quickly than others. What did players think about while making decisions? Students can revise or confirm the considerations they made in the opening discussion.

Discuss the Results

Discuss why it is important to consider wetlands, coastal resources, and other environmental matters in scenarios like those presented in the game. Have students research community actions regarding aquatic resource management. Do they think wise decisions were made?

Source

Adapted for the Great Lakes Education Program with permission from “Hydropoly” in WOW! The Wonders of Wetlands, pp. 260-265.

Adaptations

Have students write a series of Decision Cards that apply to the management of a wetland or other aquatic resources (such as lakes, rivers and coastlines) in their community. Include current political debates if possible.

Assessment

This assessment chart was designed for teachers to create their own assessment. The recommended points show the relative difficulty of student performance. In creating assessments, the total point value will depend on the number and type of performances selected.

Learning Objective	Student Performance	Recmnd # Points
Discuss land-use practices that affect Great Lakes wetlands	**List:** Various land-uses which occur at or near wetlands that reduces their health or existence	1 each
	List: Various land-uses which occur at a distance to the wetlands that reduces their health or existence	1 each
	Explain: How each of the above directly or indirectly affects wetlands	2 each
Make decisions and recognize personal priorities with regard to wetlands	**Argue or defend:** A personal position given a controversy over a wetland (can use news articles or create a story)	5-10 (depending on essay requirements and length, as well as grade level)
Describe some of the economic factors that often drive land use	**List:** Some ways that natural areas are altered by humans	1 each
	Explain: Each of the above in terms of the reasons people give for doing so	2 each

Standards

State of Michigan

Science				Social Studies			
Elementary		Middle		Elementary		Middle	
I.1.1 II.1.4 III.5.3	III.5.5 V.1.1	II.1.1 II.1.3 II.1.4	III.5.6 V.1.5	I.4.1 II.2.2 II.4.5	VI.1.1 VI.1.3 VI.2.1	II.2.3 II.2.4 II.2.5	II.5.3 VI.1.2 VII.1.1

National

NSES				AAAS	
Elementary		Middle		Elementary	Middle
C1-1 C3-2 C3-4 E1-2	F3-3 F4-1 F4-2 F4-3	C4-4 E1-5 F2-1	F3-2 F4-4	5D-1 5D-4 11C-2	4B-8 4C-7 5D-1 11A-2

NAAEE						NCSS					
Elementary			Middle			Elementary			Middle		
2.2-C 2.3-A 2.3-D 2.3-E	2.4-A 2.4-C 2.4-E	3-B 3.2-D 4-D	2.2-C 2.3-A 2.3-C 2.3-D	2.4-A 2.4-C 2.4-E 3-B	3-C 3.2-A 4-D	II.f III.h III.i III.k	V.g VI.c VII.j VIII.d	IX.d IX.e X.j	II.f III.g III.h III.i III.k	V.g VI.a VI.c VII.f VII.j	VIII.b VIII.e IX.d X.c

Notes:
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AAAS = American Association for the Advancement of Science (Benchmarks)
NAAEE = North American Association of Environmental Education (Guidelines for Excellence)
NCSS = National Council for the Social Studies (Standards)

HYDROPOLY DECISION CARDS

DECISIONS! DECISIONS!

You have inherited $500,000! Now you can buy land and build your dream home. You narrow your choices down to two properties. One (A) lies right along the shores of beautiful Crystal Lake; the other (B) is nestled in a quiet upland forest. Both properties cost the same. Which will you choose?

CONSEQUENCES

(A) Building that close to the water will surely harm or destroy wetlands! Move back three spaces. (B) If you cut down only enough trees to make room for the house, you will harm less natural habitat than you would in (A). Move ahead three spaces.

HYDROPOLY DECISION CARDS

DECISIONS! DECISIONS!

You live in a bustling city that lies near the Clinton River. It is election day for a new state governor. Candidate A promises increased economic growth and more jobs. He supports the construction of a huge new shopping mall near the river. Candidate B proposes to increase economic growth by promoting travel and recreation. He also wants to build a mall in an abandoned building near a major highway. Will you vote for A or B?

CONSEQUENCES

(A) Building close to the Clinton River will surely harm or destroy wetlands. The city and state do not seem to be badly in need or growth and can make money in other ways. Move back three spaces. (B) It makes sense to build in an area that is already developed, keeping wetlands intact so they can add to the economy in other ways. Move ahead three spaces.

HYDROPOLY DECISION CARDS

DECISIONS! DECISIONS!

You are a kindhearted person who donates $200 each year to a charity or good cause. You have been asked to give money to either (A) a conservation organization that helps protect wetlands worldwide, or (B) a local Boy Scout troop. If you choose A, you will be helping to preserve wetlands and protect wildlife all over the world. If you choose B, you can ask the Scouts to use the money to clean up and restore a small wetland in your community. Which will you choose?

CONSEQUENCES

Both choices have their merits and positive results. Move ahead one space.

HYDROPOLY DECISION CARDS

DECISIONS! DECISIONS!

You are a farmer who is getting older and thinking about retiring. Your land was once a Great Lakes wetland (a shallow area that stayed very wet throughout the spring). If you stop plowing the land, it will turn into a wetland again. You need to sell your land to earn retirement money. You are offered money from (A) someone who will develop the land for housing or business, and (B) a conservation organization that will keep the land as a wetland preserve, providing you with a tax break. The developer offers you twice as much money. Which will you choose?

CONSEQUENCES

(A) Move back two spaces. (B) Move ahead three spaces.

HYDROPOLY DECISION CARDS

DECISIONS! DECISIONS!

You are a town zoning officer. You decide the number and type of places that can be built in your Great Lakes area. One of only a few wetlands in the town is due for rezoning. The townspeople are encouraging you to vote in one of two ways on the zoning: (A) zone the area for preservation. Which will you choose?; (B) allow housing for the poor to be built there (this housing is badly needed)

CONSEQUENCES

(A) With so few wetlands in town, too many benefits would be lost by destroying the site in question. Move ahead two spaces. (B) The housing is needed, but it can be built in another location. The wetland is needed for good water quality. Move back two spaces.

HYDROPOLY DECISION CARDS

DECISIONS! DECISIONS!

You are a very wealthy landowner who is about to build a housing development that will make you even richer! The land contains some Lake. St. Clair and Clinton River wetlands that would be destroyed by the project. You can (A) cancel the project, or (B) go to great expense to build new wetlands nearby to replace the one that will be destroyed. Which will you choose?

CONSEQUENCES

(A) Move ahead three spaces. (B) Move ahead one space. The plan to replace the wetland is a decent choice, but the costs (money and habitat) may outweigh the benefits. Natural wetlands are likely to be healthier.

HYDROPOLY DECISION CARDS

DECISIONS! DECISIONS!

You are a farmer. You own 100 acres near the Kalamazoo River, which you plant in corn. Times are tough and you and your spouse are expecting a child. In the past, you have always left a strip of land along the waterway unplowed. The natural growth of the aquatic plants helps keep the water clean and provides habitat for many animals. But if you planted corn there instead, you would have about 15 extra acres of crops. Will you plow it this year (A) or not (B)?

CONSEQUENCES

(A) Move back three spaces.
(B) Move ahead 4 spaces. That is a tough decision!

HYDROPOLY DECISION CARDS

DECISIONS! DECISIONS!

Today is Saturday, and you have tickets to a very cool outdoor concert that you have been looking forward to for months. The tickets cost you a month's allowance, but it is worth it. Your little brother just came in and told you about the Lake Gogebic wetland clean-up day near his school. They plan to pick up trash and plant new plants all around the area. He is very excited and wants you to come and help, since they need lots of people to get the work done. If you go, you will miss the concert. Where will you go? (A) With your little brother; (B) to the concert.

CONSEQUENCES

(A) What a sacrifice! Move ahead three spaces. (B) Move back one space.

HYDROPOLY DECISION CARDS

DECISIONS! DECISIONS!

You work for the state's highway department. A new road being built will destroy six acres of Great Lakes coasts and wetlands. To get the permit to build the road, the department had to promise to replace the wetlands. You are in charge of hiring a company to do the work, and you must choose between two companies. The expensive one guarantees that the new wetlands will survive; the cheaper one does not, but thinks their wetland will be good. Will you (A) save state money and take a chance on the wetlands' survival or (B) spend more and get the guarantee?

CONSEQUENCES

(A) Move back four spaces. (B) Move ahead three spaces.

HYDROPOLY DECISION CARDS

DECISIONS! DECISIONS!

You have designed your dream house, and you are very proud of it. The plans show a beautiful front that faces a quiet street and a garage in the back with a long driveway around to it. There are Au Sable River wetlands in your back-yard that will have to be filled in for the driveway and garage. Will you (A) put the garage and a shorter driveway in front of the house? (This will be cheaper, but will wreck your design and obstruct the view of the front of your house.) or (B) build the house as planned.

CONSEQUENCES

(A) Move ahead two spaces. (B) Move back two spaces.

Water Glossary / Key Terms

Benthic: Refers to animals that live in or on the bottom of a lake, sea, or river.

Elevation: Height above sea level.

Freshwater: Not salt or ocean water.

Groundwater: Water held below the surface of the land, underground.

Land use: Refers to how land within a community is utilized. Some examples of land uses include urban, suburban, commercial (businesses/shopping districts), agricultural (farming), or natural areas.

Model: Simplified representation of natural phenomena. Models can be manipulated and used as tools to make predictions or test hypotheses.

Nursery: Breeding or nesting grounds for plants or animals.

pH: Measurement of the amount of hydrogen ions present in a substance such as water. Knowing the amount of hydrogen in a substance allows us to judge whether it is acidic, neutral, or basic.

River system: A network of small rivers leading into larger rivers.

Runoff: Excess rainfall or snowmelt that flows over land into lakes and rivers because it was not absorbed by soil or plants.

Salt water: Ocean or sea water.

Secchi disk: Instrument used by scientists to measure water clarity. The depth at which the disk's black and white marks cannot be seen is called the "secchi depth."

Sediment: Soil and other particles carried by water or settled on the bottom of a water body.

Slope: Change in elevation, such as downhill or uphill.

Surface water: Water that is above ground, e.g., in lakes and rivers.

Turbidity: Measurement of sediment and/or other particles stirred up or suspended in water.

Water clarity: Measurement of the clearness of water (e.g., low turbidity).

Water quality: Measurement of many factors that contribute to the overall health of water in an ecosystem.

Watershed: The area of land that drains into a river system.

Wetland: An area, such as a bog, swamp, or marsh that has seasonally wet soils and a distinct plant community. Wetlands provide valuable nursery areas and habitat for many plants and animals.

Fish Overview

This series of five lessons begins by introducing students to important distinguishing characteristics of Great Lakes fish. Building upon this knowledge, students use a simple key to identify several common fish families. Lessons then explore the concept of biodiversity and the importance of maintaining healthy fish habitat. The final lesson highlights a variety of people who have chosen scientific careers studying or teaching about the oceans and Great Lakes.

Lesson 1: Fish of the Great Lakes

Introduces students to some of the distinguishing characteristics of Great Lakes fish and how these traits help fish survive in their environment.
See: Lesson 1

Lesson 2: Fins, Tails and Scales: Identifying Great Lakes Fishes

Leads students through the process of using a dichotomous key to organize and identify 8 common fish families.
See: Lesson 2

Lesson 3: Preserving Biodiversity

Discusses the ecological importance of protecting species variety.
See: Lesson 3

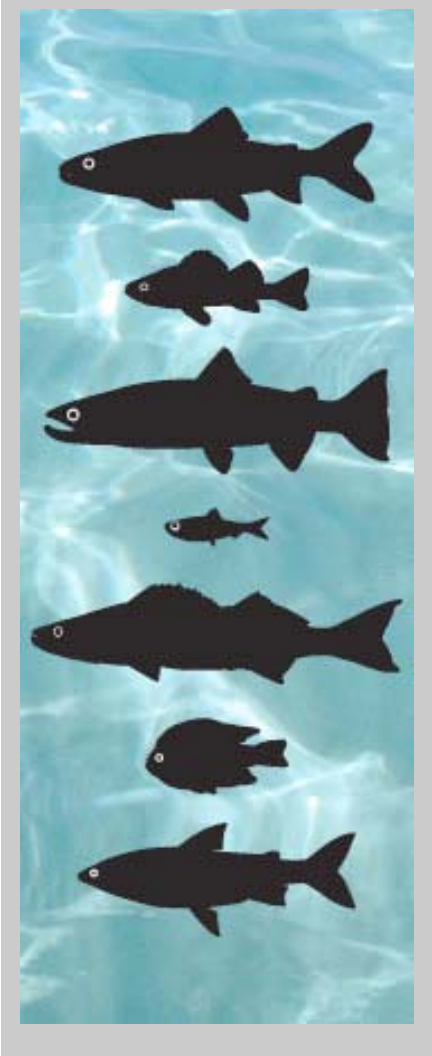
Lesson 4: Fish Habitat

Highlights the important connection between Great Lakes fish biodiversity and the need to protect and maintain healthy fish habitat.
See: Lesson 4

Lesson 5: Great Lakes. Great Careers

A lively group activity introduces students to a variety of people who have chosen scientific careers related to the oceans and Great Lakes.
See: Lesson 5

Lesson 1: Fish of the Great Lakes



Activity: Working with a set of Great Lakes fish cards, students identify distinguishing characteristics of fish and organize the collection based on similarities and differences, as well as into an interconnected food web.

Grade level: 4-8
Subjects: Science, social studies
Setting: Classroom
Duration: 30-60 minutes
Key Terms: Adipose fin, Barbels, Caudal fin, Dorsal fin, Pectoral fin, Snout

Objectives

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

- Observe important distinguishing characteristics of Great Lakes fish.
- Describe how these characteristics help fish survive in their environment.
- Organize 10 Great Lakes fish (cards) based on similarities and differences.
- Develop a hypothetical food web involving this representative subset of Great Lakes fish.

Summary

The Great Lakes and other lakes and rivers of the region are home to an impressive variety of fish. Among the species are coldwater fishes like lake trout and lake whitefish, and ancient species such as sturgeon and gar. Students may be most familiar with warm-water fishes like sunfish and bass. Each major family of fishes has traits that set it apart from others, called distinguishing characteristics. These characteristics help fish survive in their environment. By observing and comparing distinguishing characteristics, students begin to understand how fish, like other animals, can be organized and classified into meaningful groups, and how these groups are interrelated via the aquatic food web.

Background

The Great Lakes region is home to more than 160 species of fish. All have some characteristics in common, such as gills, scales, and bony skeletons. Some characteristics that differentiate fish include head shape, fin type and location, as well as average adult size. These traits also provide clues as to where certain fish typically live and what they eat. Scientists, fishery managers, and anglers use these and many other parts of a fish's anatomy to correctly identify existing fish species and classify newly discovered fish.

Some distinguishing characteristics of fish include the following:

- **Dorsal fin:** Large fin(s) on a fish's back that vary in shape and size, and may be in one or two parts. Some fish have spiny dorsal fins that help protect against predators. Others, like sunfish and bass, have two-part, connected dorsal fins that are part spiny and part soft. The dorsal fin stabilizes fish against rolling and assists with sudden turning.
- **Barbels:** These "whiskers" near the mouth are used by bottom-feeding fish to sense food.
- **Caudal fin:** The caudal fin (tail fin) is used for propulsion. It varies in shape and this affects a fish's speed and buoyancy. Fish with forked caudal fins, such as lake trout, are generally fast swimmers. Fish with rounder caudal fins, such as round goby, tend to use their tails for quick darting action to capture prey.
- **Adipose fin:** When present, the adipose fin is located between the dorsal fin and caudal fin. It's much smaller than either of these two fins, and its purpose is unclear. Note that some fish, such as lake sturgeon. have a large dorsal fin near their tail. The large size of this fin helps distinguish it from an adipose fin.
- **Snout:** Front part of a fish that includes the mouth. The size and shape of the mouth provide clues as to what a fish eats. In general, a downward oriented mouth often indicates a bottom feeder, whereas an upward oriented mouth indicates that the fish finds its food within the water column. Other fish such as invasive sea lamprey have a round, suction disk mouth for attaching to other fish and feeding on body fluids.
- **Pectoral fin:** Side fins mainly used for direction or "steering."

Note that color is not an effective distinguishing characteristic because it can change depending on physical or environmental conditions. However, color patterns, such as spots or vertical bars, may be useful.

As learned in lesson 1.2, fish occupy various niches in the aquatic food web. Chinook salmon, lake trout, and northern pike are examples of top predators that feed primarily on other fish. Medium-sized fish such as bluegill and bass eat a variety of food including small fish, crayfish, frogs, snails and macroinvertebrates. Other fish are bottom feeders, eating plankton and macroinvertebrates.

Materials and Preparation

- Download: Set of 10 fish cards for each group of students. If possible, laminate cards for multiple uses. Download also includes a generic fish graphic showing distinguishing characteristics of fish.

Downloads

See **Downloads** at the end of the unit (3.2) for: Set of 10 fish cards, and generic fish illustration.

Procedure

1. Discuss the importance of observing distinguishing characteristics of living things in order to classify and identify them.
2. Hold up several of the fish cards. Ask the students: What do you notice? Do some fish have more than one fin on their backs? Do some have “whiskers”? Are there different tail shapes? How would you describe the differences?
3. Hold up the illustration of the generic fish. Explain that this is not a real fish, but rather a composite showing a variety of traits previously discussed. Introduce students to the actual names of the fins and other distinguishing characteristics. Make sure students know where the different fins are located on the fish. Point out that some fish have a single dorsal fin on their backs, while others have a “two part” dorsal fin that may be connected or separate. Explain that the shape of caudal (tail) fin can tell us something about the swimming ability of the fish. Point out that “barbel” is the scientific term for “whiskers,” and that the purpose of the barbel is to feel along the bottom for food.
4. Following discussion, arrange the students into small groups, each with a set of fish cards and the generic fish illustration. Ask them to organize the fish based on similarities and differences, such as shape of dorsal fin(s), tail shape, presence or absence of adipose fin, barbels, etc. They may want to organize them two or three different ways. Briefly discuss the results. Which characteristics did students use to separate the fish?
5. Next, have the students arrange the fish cards into a food web, assuming that these fish were the only fish in the Great Lakes. They can use any distinguishing characteristics to justify their food webs. Have them diagram their hypothetical food webs on a separate sheet of paper. One way to do this is to have students tape the laminated fish cards to the page and draw arrows to show who eats whom.
6. After all of the groups have finished, have them present their food web diagrams to the rest of the class, explaining why they assigned certain fish to certain food web niches. Which distinguishing characteristics informed their decisions? Likely, different groups will have different webs. This is acceptable. There is no “right” answer to this

exercise. In reality, many more fish and other animals are part of the Great Lakes food web. However, this is a valuable exercise that prompts students to think about forms and functions of fish anatomy.

7. In the next lesson, students will use a simple key to identify the fish on the cards, based on distinguishing characteristics.

Source
Developed by Anna Switzer and Joyce Daniels, Michigan Sea Grant

Assessment

This assessment chart was designed for teachers to create their own assessment. The recommended points show the relative difficulty of student performance. In creating assessments, the total point value will depend on the number and type of performances selected.

Learning Objective	Student Performance	Recmnd # Points
Observe important distinguishing characteristics of Great Lakes fish	**Explain** what 'distinguishing characteristic' means	2 each
	Name possible body parts that could be distinguishing for fish	1 each
Describe how these characteristics help fish survive in their environment.	**Describe** how certain fish body parts help them survive.	2 each
Organize the collection of Great Lakes fish cards based on similarities and differences	**Differentiate** between two or more example fish based on a certain characteristic.	1 each
Develop a hypothetical food web involving these fish.	**Defend** their hypothetical food web based on what they have learned about distinguishing characteristics	3 each per logical defense

Standards

State of Michigan

Science			Social Studies	
Elementary		Middle	Elementary	Middle
I.1.6 II.1.2 II.1.4 III.2.1	III.2.2 III.4.2 III.5.1	I.1.5 I.1.6 II.1.3 III.5.1		

National

NSES		AAAS	
Elementary	Middle	Elementary	Middle
A1.2 C1.2 C1.3	C1.1 C3.4 C4.2	5A.1 5A.2	5A.2 5A.3 5A.5
NAAEE		**NCSS**	
Elementary	Middle	Elementary	Middle
1-C 1-E 2.2-A	1-C 1-E 2.2-A	n/a	n/a

Notes:
NSES = National Science Education Standards
AAAS = American Association for the Advancement of Science (Benchmarks)
NAAEE = North American Association of Environmental Education (Guidelines for Excellence)
NCSS = National Council for the Social Studies (Standards)

FISH FAMILY CARDS

Unit 3, Lesson 1

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Ichl

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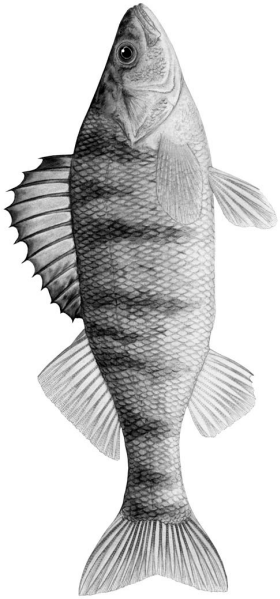

Illustration: E. Damstra

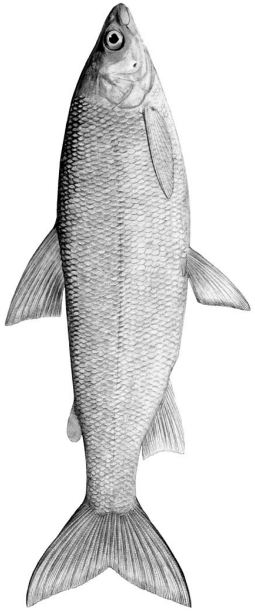

Illustration: E. Damstra

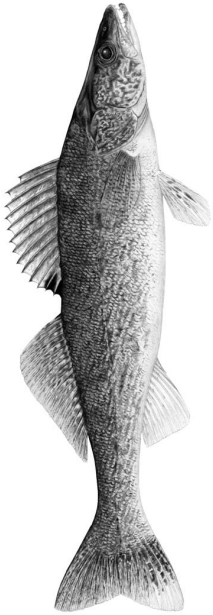

Illustration: E. Damstra

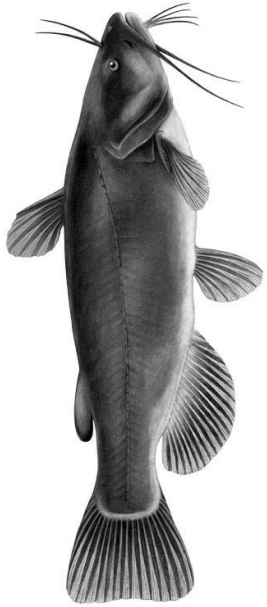

Illustration: E. Damstra

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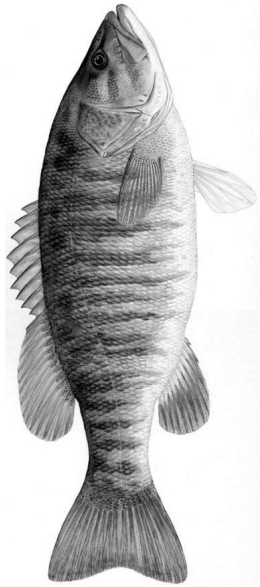

Illustration: E. Damstra

FISH FAMILY CARDS

Unit 3, Lesson 1

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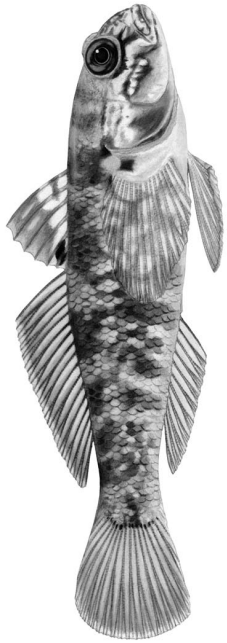

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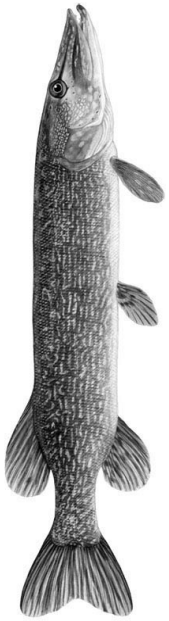


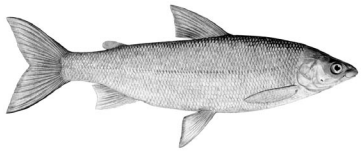
Illustration: E. Damstra

FISH FAMILY ID CARD GUIDE FOR TEACHERS

Chinook salmon

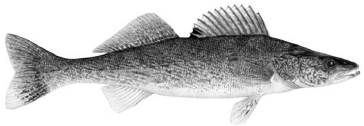
Yellow perch

Sea lamprey



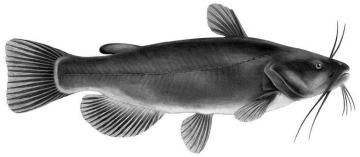
Lake whitefish

Lake sturgeon

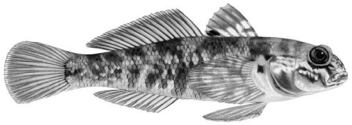


Walleye

Smallmouth bass



Black bullhead



Round goby

Northern pike

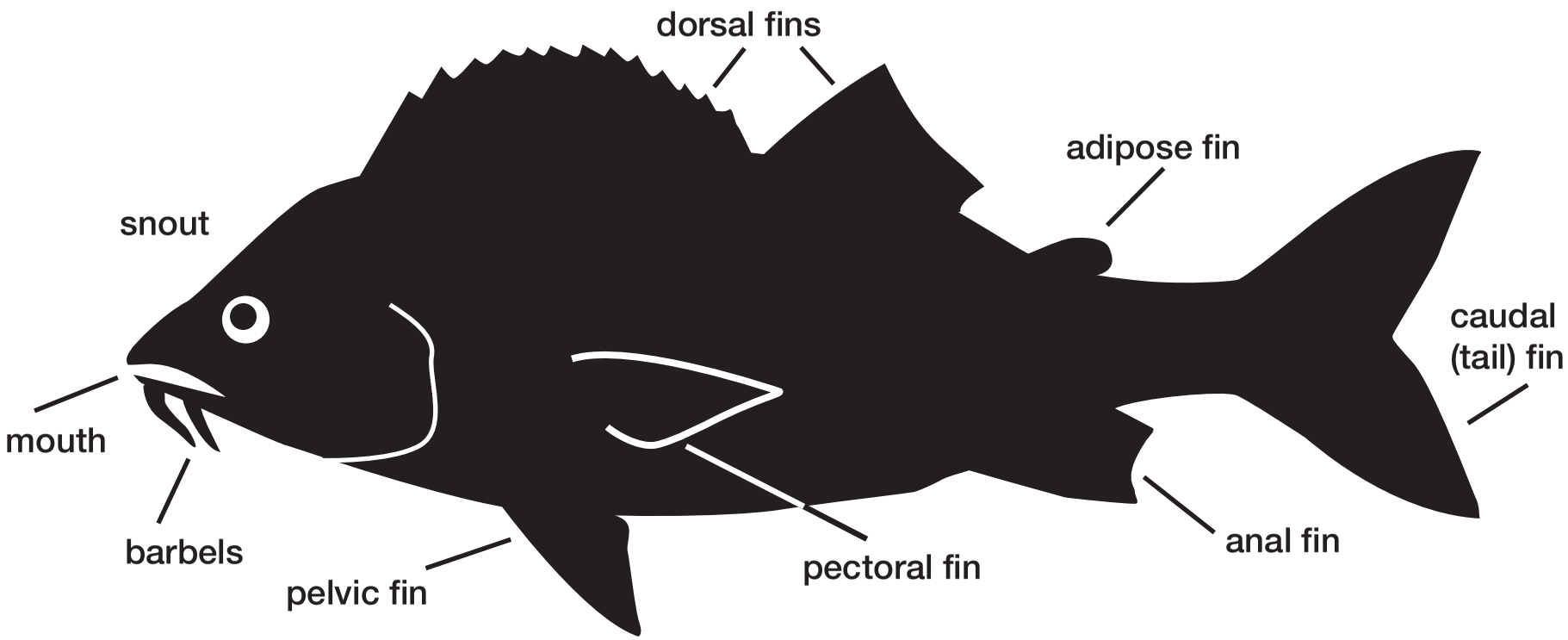
Illustrations: E. Damstra

Note: Fish size not to scale

GENERIC FISH GRAPHIC: CHARACTERISTICS OF FISH

Unit 3, Lesson 1

This generic fish illustration shows a variety of distinguishing characteristics. Scientists use these and many other traits to correctly classify and identify fish.



Lesson 2: Fins, Tails and Scales: Identifying Great Lakes Fish

Photos: D. Brenner

Activity: Students use a simple classification system (dichotomous key) to identify 8 common Great Lakes fish families based on distinguishing characteristics.

Grade level: 4-8
Subjects: Science, social studies
Setting: Classroom
Duration: 30-60 minutes
Key Terms: Dichotomous key, Family, Ichthyologist, Species

Objectives

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

- Use a **dichotomous key** to identify 10 Great Lakes fish representing 8 common families.
- List distinguishing characteristics of some of the families.
- Name several common Great Lakes fish.

Summary

Scientists use classification systems to organize living organisms into groups based on similarities, distinguishing characteristics and other attributes or behaviors. Incorporating the traits described in Lesson 3.1, this lesson introduces students to a simple dichotomous key that can be used to identify some common families of Great Lakes fish.

Background

Many **species** of Great Lakes fish look similar in size, shape and color. It can sometimes be difficult to tell them apart. However, each species belongs to a larger **family** that shares similar characteristics. There are 28 fish families in the Great Lakes. To organize and identify the main families, **ichthyologists** (fish scientists) use a dichotomous key

based on distinguishing characteristics. A dichotomous key is a classification "tool" used to sort, organize and identify a collection of objects or living organisms.

A dichotomous key is made up of a series of questions with two choices. Each choice leads to another question. The key can appear in narrative form (as numbered questions), graphically (resembling a flow chart), or a combination of graphics and narrative. By starting at one common point and progressing through the key, making choices based on distinguishing characteristics, the user is led through a path that ends with a correct identification of the object or organism.

A dichotomous key can be complex (incorporating all families and species of a particular animal) or simple. In this lesson, a simplified key has been created that distinguishes 8 Great Lakes fish families. By using their knowledge of distinguishing characteristics, students use illustrations of fish to work through the key and make identifications.

Materials and Preparation

- Download: Set of 10 Great Lakes Fish cards
- Download: Dichotomous key to 8 common Great Lakes fish families. Note: This key will print out as 2 pages that will need to be taped together.
- Download: Generic fish illustration
- Post-it notes

See **Downloads** at the end of this unit for: Set of 10 Great Lakes fish cards, generic fish illustration, and dichotomous key.

Procedure

1. Divide the class into small groups. Explain the need to use classification systems to organize living organisms. Describe a dichotomous key, emphasizing that this type of key uses a series of questions based on distinguishing characteristics. For example, a key to identify fish might ask: Does the fish have barbels (whiskers)? or Is the dorsal fin spiny?
2. Explain that each group will use a dichotomous key to identify 8-10 of the fish pictured on the Great Lakes fish cards. The cards represent 8 common families: Trout and Salmon, Pike, Sturgeon, Lamprey, Sunfish and Bass, Perch, Goby (invasive), and Catfish. Note that there are 10 fish cards. Yellow perch and walleye both belong to the Perch family. Chinook salmon (an introduced species) and lake whitefish both belong to the Trout and Salmon family.
3. Pass out the generic fish diagram and remind students of some of the distinguishing characteristics of fish covered in the previous lesson (Lesson 3.1).

4. Using the set of 10 Great Lakes fish cards, have students begin by selecting one fish and "keying it out" by answering the questions and following the arrows as indicated on the key. For each fish, they should identify the correct fish family. As they identify each illustration, have them write the name of the family on a post-it note and label each card. Note that there are Bonus Questions on the key that ask students to identify 4 fish at the species level.
5. Discuss the results. Did everyone correctly identify all fish? Was it difficult to distinguish some of the characteristics, such as a rounded or forked tail? How else might some of the characteristics be described? One limitation of a dichotomous key is that all fish of a given family or species do not look exactly alike (as with humans). There will always be individual differences. Still, the process of using a dichotomous key is valuable in many disciplines. Also, by learning to observe important fish characteristics, students will be more competent in identifying common Great Lakes fish families—a useful skill whether they enjoy fishing or simply want to know what lives in their local lake or river.

Adaptations

1. Have students create their own dichotomous keys using a group of commonly found objects, such as pasta, buttons, dried beans, or fruit.
2. Explain that the goal is to sort a large set of items into smaller sets based on distinguishing characteristics, until the items can no longer be sorted.
3. Divide the participants into smaller groups of four to five people, and provide each group with a collection of items to sort. Have them develop a key by forming questions about the objects. An example might be: Is the object textured or smooth? Is the shape curved or straight? Let students work for a few minutes and then stop them to make sure they are using terms everyone will understand.
4. Once the groups have finished sorting the items, ask them to switch their items and keys with another group. Other groups should be able to use the key to sort the items in the same way. Once all the groups have completed this, ask one group to share and demonstrate their key.

Source
Developed by Anna Switzer and Joyce Daniels, Michigan Sea Grant.

Assessment

This assessment chart was designed for teachers to create their own assessment. The recommended points show the relative difficulty of student performance. In creating assessments, the total point value will depend on the number and type of performances selected.

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Observe important distinguishing characteristics of Great Lakes fish	Explain what 'distinguishing characteristic' means	2 each
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Describe how these characteristics help fish survive in their environment.	Describe how certain fish body parts help them survive.	2 each
Organize the collection of Great Lakes fish cards based on similarities and differences	Differentiate between two or more example fish based on a certain characteristic.	1 each
Develop a hypothetical food web involving these fish.	Defend their hypothetical food web based on what they have learned about distinguishing characteristics	3 each per logical defense

Standards

State of Michigan

Science				Social Studies	
Elementary		Middle		Elementary	Middle
I.1.1 I.1.2 I.1.5 I.1.6 II.1.2	II.1.4 III.2.1 III.2.2 IV.1.1	I.1.1 I.1.2 I.1.5	I.1.6 II.1.3 III.2.1	n/a	n/a

National

NSES		AAAS	
Elementary	Middle	Elementary	Middle
A1.2 B1.1	A1.1 C5.1	5A.1 5F.1 12D.1	5A.2 12D.1 12D.2

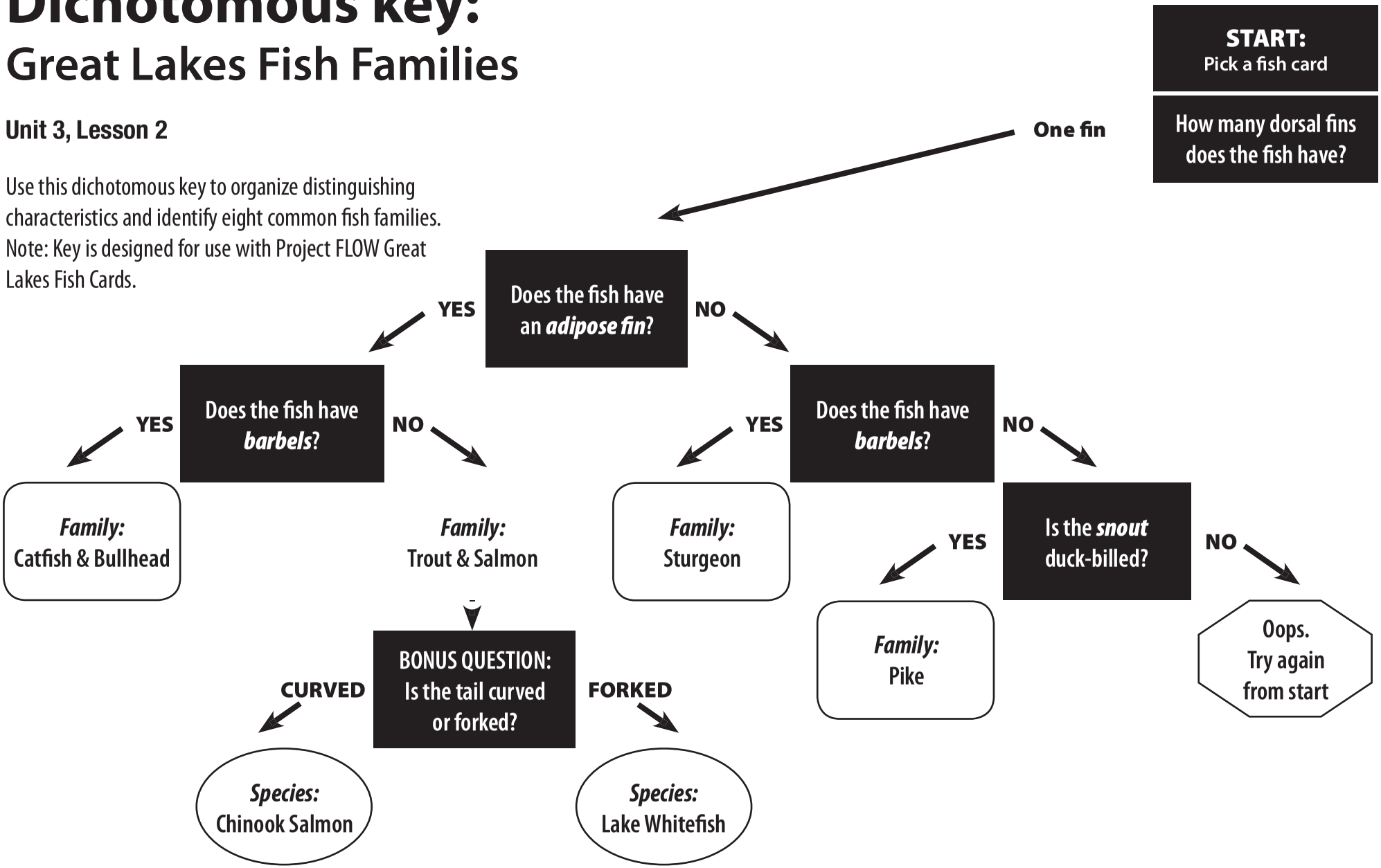
NAAEE				NCSS	
Elementary		Middle		Elementary	Middle
1-A 1-C 1-E	1-F 2.2-A	1-A 1-C 1-E	1-F 2.2-A	n/a	n/a

Notes:
NSES = National Science Education Standards
AAAS = American Association for the Advancement of Science (Benchmarks)
NAAEE = North American Association of Environmental Education (Guidelines for Excellence)
NCSS = National Council for the Social Studies (Standards)

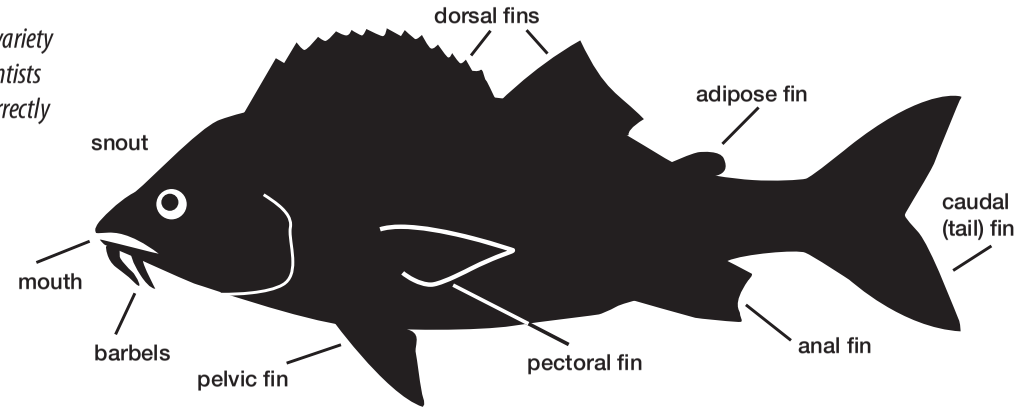
Dichotomous key:
Great Lakes Fish Families

Unit 3, Lesson 2

Use this dichotomous key to organize distinguishing characteristics and identify eight common fish families. Note: Key is designed for use with Project FLOW Great Lakes Fish Cards.



This generic fish illustration shows a variety of distinguishing characteristics. Scientists use these and many other traits to correctly classify and identify fish.



Two fins

Is one *dorsal fin* spiny and one smooth?

- **YES** → **Are the two fins well connected?**
  - **YES** → ***Family:*** Sunfish & Bass
  - **NO** → **Is the *caudal (tail) fin* rounded or forked?**
    - **FORKED** → ***Family:*** Perch → **BONUS QUESTION: Does the fish have vertical stripes?**
      - **YES** → ***Species:*** Yellow Perch
      - **NO** → ***Species:*** Walleye
    - **ROUNDED** → ***Family:*** Goby
- **NO** → **Does the fish have a round *mouth***
  - **YES** → ***Family:*** Lamprey
  - **NO** → Oops. Try again from start

www.miseagrant.umich.edu/flow

Sea Grant Michigan

MICHU-05-10 **COPY MASTER**

Lesson 3: Preserving Biodiversity

Activity: Following class discussion, students create an educational poster or booklet highlighting the importance of biodiversity.

Grade level: 4-8
Subjects: Science, social studies
Setting: Classroom
Duration: 1 hour
Key terms: Biodiversity

Photos 1-3: D. Brenner, Photo 4: T. Marsee

Objectives

Following this lesson, students will be able to:

- Explain what is meant by **biodiversity** and why it's important.
- Describe some of the benefits of having a diverse population of plants and animals.
- Describe some of the major threats to Great Lakes biodiversity.

Background

Life on earth depends on the interaction of many different plants and animals. Each has unique abilities, some of which include absorbing carbon dioxide and producing oxygen, filtering water, and producing food and medicines. This variety also enriches our own lives with natural beauty and mystery. In biodiversity, bio means life, and diversity means variety. In essence, biodiversity means "variety of life," or the number and variety of all living things on earth. We can think about biodiversity in several ways:

- Variety of genes
- Variety of species (and populations)
- Variety of ecosystems

Unfortunately, this variety is rapidly declining. According to the Biodiversity Project, as many as 500 plant and animal species have disappeared forever since people first arrived in North America. Some loss has always occurred over time, but species loss has

accelerated with increasing human influence and activity. Some of the major threats to biodiversity are habitat loss, introduced species, pollution, population growth, and over-consumption.

These same threats have affected biodiversity in the Great Lakes. In the mid 1800s as the region's human population grew rapidly, a number of factors combined to impact some native fish species beyond recovery. Blue pike is one example of a fish that succumbed to a combination of factors including over-fishing, pollution and habitat loss. Today, populations of lake sturgeon and lake trout are examples of fish that have declined to such an extent that restoration projects have been launched to enhance habitat and aid recovery.

For some species, however, recovery strategies have not been identified. One example is *Diporeia*, a shrimp-like organism that lives in bottom sediments and provides food for many species of Great Lakes fish. In recent years, it has declined in all the lakes except Lake Superior. While the causes are complex, scientists believe invasive zebra mussels are a contributing factor. They filter massive amounts of plankton from the water column, reducing food for native species.

This type of disruption of the aquatic food web has potentially long term impacts. As biodiversity declines, the aquatic ecosystem becomes increasingly vulnerable to disturbances. Some strategies to address the loss of biodiversity are to prevent the introduction and spread of invasive species, reduce pollution, and protect habitat. (See lessons 2.5 and 3.4)

Also see:
American Museum of Natural History
http://www.amnh.org

Biodiversity Project
http://www.biodiversityproject.org

Michigan Natural Features Inventory
http://web4.msue.msu.edu/mnfi

Number of Fish Species Found in the Great Lakes Basin*

Basin (Lake/River)	*No. of Species*
Erie:	129
Ontario:	119
Huron:	117
Michigan:	136
Superior:	83
Lake Nipigon:	39
St. Lawrence River:	105
Total 5 lakes and tributaries:	172
Total basin:	179

Source: Coon 1999 in Taylor and Ferreri 1999
**Includes tributaries*

Materials and Preparation

- Construction paper
- Markers
- Poster board
- Magazines
- Internet or reference materials for additional research (optional)

Procedure

1. Discuss the concept of biodiversity and what it means. Ask students why it might be important to have a diversity of living plants and animals. Answers might include: natural beauty, food, medicine, oxygen, clean water, etc.
2. Explain to the students that they'll be creating an educational poster or booklet—incorporating pictures from magazines, original artwork, or narrative—describing what biodiversity means to them. Some examples might include:
   - Bugs and Bogs: Show the variety of life—cattails, frogs, turtles, insects and fish—in a nearby pond or river, or use species from around the world.
   - Time for Lunch: Highlight the variety of food people enjoy, including vegetables, grains, fish, spices, etc. Prompt students to consider where it all comes from (different plants and animals around the world).
   - In the Garden: Cultivating a diversity of native plants also supports biodiversity by providing food and habitat for native species. Along lakes and rivers, plants help maintain water quality by filtering nutrients and sediments.
   - Get Involved: Describe a stewardship activity to clean up parks, collect recyclables, or use environmentally friendly household products. Each of these

activities contributes to a high quality natural environment that supports biodiversity.

3. After students have completed their posters and booklets, ask for volunteers to present them to the class, explaining what illustrations and/or photos they used and why they chose them.

Adaptations

- A Fishy Tale: Have students conduct supplemental research and tell the story of a native Great Lakes fish species that has been significantly affected over time. When did the species live? Is it still living? What factors have affected the population? Use words and pictures to tell the story. Examples include: lake trout, lake sturgeon, walleye, yellow perch, grayling, and blue pike.
- For older students: Construct a poster or short narrative that focuses on some of the threats to biodiversity. Examples of threats include invasive species, pollution, and loss of habitat (often due to unplanned urban development). Students might focus their project on preventing the spread of invasive species, or protecting water quality by reducing pollution, especially runoff from things like lawn fertilizers and household chemicals.

Source
Developed by Elizabeth LaPorte, Anna Switzer and Joyce Daniels, Michigan Sea Grant.

Assessment

This assessment chart was designed for teachers to create their own assessment. The recommended points show the relative difficulty of student performance. In creating assessments, the total point value will depend on the number and type of performances selected.

Learning Objective	Student Performance	Recmnd # Points
Explain what is meant by biodiversity and why it's important	**Express** biodiversity as a two-part word and define each part	3 total
	Name the three levels of biodiversity that are important	1 each
	Explain why having a biologically diverse planet is important	3 pts.
Describe some of the benefits of having a diverse population of plants and animals	**Give reasons** to support the idea that within one ecosystem, having many plants and animals is beneficial to that ecosystem	3 pts. per valid reason
Describe some of the major threats to Great Lakes biodiversity	**List** the three main threats to GL biodiversity.	1 each
	List the three main threats to GL biodiversity.	1 each
	Choose one of the threats to biodiversity and explain how that threat could be reduced.	3 pts.

Standards

State of Michigan

Science			Social Studies	
Elementary		Middle	Elementary	Middle
I.1.2 I.1.5 II.1.2	II.1.4 III.5.2 III.5.5	I.1.5 II.1.3 III.5.1	II.2.1 II.4.5 IV.1.3	II.2.4 II.5.3 V.1.2 V.1.3

National

NSES		AAAS	
Elementary	Middle	Elementary	Middle
C3.2	C4.1 C4-4	n/a	n/a

NAAEE		NCSS	
Elementary	Middle	Elementary	Middle
1.A 1.C 2.4.E 3.A 3.2.B	1.A 2.4.E 3.A 3.2.B	III.k IX.d	III.k IX.d

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Lesson 4: Fish Habitat

Photo 1: D. Brenner, Photo 2: E. LaPorte

Activity: Students listen to an online interview with a fisheries researcher who studies Great Lakes fish and their habitats. Students will use a KWL chart to review what they know, what they want to know, and what they've learned.

Grade level: 4-8
Subjects: Science, social studies
Setting: Classroom
Duration:
Key terms: Habitat, Restoration

Objectives

Following this lesson, students will be able to:

- Identify some of the features that contribute to healthy fish **habitat**.
- List several fish species and the types of habitat they require.
- Describe some of the factors that impact fish habitat and affect fish populations.

Summary

A healthy environment supports a variety of native species. This is especially true for Great Lakes fish. Different species of fish require specific habitats, and loss or alteration of fish habitat can lead to population declines. This lesson explains some of the characteristics of fish habitat and some of the changes that have taken place over time, including pollution, invasive species, and urban development.

Background

Like people, fish must meet certain basic needs for survival, as described in lesson 1.4. Food, water and shelter are among the most important requirements:

- **Food:** Fish must be able to find enough to eat at various life stages, whether they feed on microorganisms, small fish or larger prey.

- **Water:** Water composition can vary greatly from one location to another. Variables include water temperature, depth, speed of water flow, amount of oxygen, and degree of clarity.
- **Shelter:** At various stages in their lives, fish need a place to hide from predators and to reproduce. Some fish can be found on rocky lake or river bottoms, while others prefer weedy shorelines. Many fish need special habitat conditions to spawn such as coastal wetlands, sheltered bays, or rivers and streams.

Many factors have impacted or altered fish habitat and affected native fish populations. Some examples include:

- **Invasive Species:** Invasive species compete with native fish for food and habitat. Round goby and Eurasian ruffe are examples of fish that have displaced native species in some locations. Invasive species can also change habitat. By filtering microorganisms, zebra mussels reduce food for native species and increase water clarity, which stimulates growth of aquatic plants.
- **Coastal Development:** Increasing development in coastal areas threatens fish habitat, especially for species that depend on coastal wetlands for critical life stages. Dams and other obstacles can prevent some fish from migrating upstream to reach spawning habitat.
- **Pollution:** Industrial pollutants, urban and agricultural runoff and sewage overflows are some of the sources of pollutants that continue to impair Great Lakes water quality and impact fish habitat.
- **Habitat Restoration:** People around the Great Lakes region are working to restore fish habitat for a number of native fish populations. Some examples include:
    a. **Lake Trout:** Management agencies maintain a lake trout stocking program and work to control the invasive sea lamprey, which preys heavily on lake trout and other native fish.
    b. **Lake Sturgeon:** Several groups teamed up to construct new spawning reefs for lake sturgeon in the Detroit River to increase population of this primitive species.
    c. **Walleye:** The Fisheries Division of the Michigan Department of Natural Resources has developed a walleye recovery for Saginaw Bay to increase population to historic levels.
    d. **Coaster Brook Trout:** Researchers in the Upper Peninsula and Canada are tagging and monitoring this fish to learn more about its unique habitat requirements.

Materials and Preparation

- Classroom computer with Internet access.
- K-W-L chart (one per student). Download or have students create their own.

See **Downloads** at the end of this unit for: K-W-L chart and transcript of audio interview.

Procedure

1. Begin with a group discussion on fish habitat. Ask students: What do fish need in order to survive? (Basic needs include food, water and shelter.) How might these characteristics vary? (Water can be clear, turbid, cold, warm, fast moving, etc.) What types of activities harm fish habitat? (Pollution, invasive species, destruction of wetlands, urban development, etc.)
2. Ask the students about their own fishing experiences. Have they or their parents ever caught a fish? What was the habitat like? (Answers might include: sunfish caught in a pond or inland lake; brook trout caught in clear, fast-moving river; salmon caught on open waters of the Great Lakes; yellow perch caught in a coastal wetland; largemouth bass caught in a weedy area of an inland lake.)
3. Download or have students create simple KWL charts. In the first chart column, instruct students to write 5 facts about fish habitat that they **Know** already.
4. In the second chart column, instruct students to write 5 questions about fish habitat that they **Want** to know.
5. Tell the students they're now going to hear a Great Lakes fisheries scientist talk about his research related to fish and their habitats. While listening to the audio clip (or reading the printed transcript), instruct students to write 5 facts that they've **Learned** about fish habitat, in the third chart column. To play the audio clip, access the Project FLOW Web site on the classroom computer. Note: Windows Media Player must be installed. The software is free.
6. Discuss the results. What new information did students learn about fish habitat? How many different responses were there? What was the most interesting aspect of the scientist's work related to fish and their habitats?

Source
Developed by Anna Switzer and Joyce Daniels, Michigan Sea Grant.

K-W-L Teaching Technique

K = KNOW already
W = WANT to know
L = LEARNED

This is a technique used to draw students into the learning cycle. First, it gives students a forum to express what they already know on a topic as well as what they would like to know before that topic is addressed in class. After the topic has been explored, it gives students a chance to express what they've learned. Using the K-W-L technique has the potential to show students as well as teachers what has been accomplished in class. It can be used on smaller scales (like here, at the topic level), or larger scales (with an entire curriculum or subject of study).

Assessment

This assessment chart was designed for teachers to create their own assessment. The recommended points show the relative difficulty of student performance. In creating assessments, the total point value will depend on the number and type of performances selected.

Learning Objective	Student Performance	Recmnd # Points
Identify some of the variables that comprise Great Lakes fish habitats	**Name** some of the general characteristics that might influence the suitability of a habitat (e.g. temperature, food source, etc.)	1 each
	For each general characteristic **explain** its significance to providing good habitat	2 each
List several fish species and the types of habitat they require	**Name** some of the fish species that were discussed in the interviews	1 each
	Explain for each fish, the specific characteristics it requires in its habitat (e.g. cold water, plant growth, etc.)	2 each
	Compare and **contrast** the habitat requirements for the different fish discussed in the interviews	3 pts.
Describe some of the factors that have changed fish habitat	**Describe** how some fish habitat characteristics have been altered over time	2 each
	Explain the positive and negative aspects of these changes	3 pts.

Standards

State of Michigan

Science			Social Studies	
Elementary		Middle	Elementary	Middle
II.1.4 II.1.5 III.2.4	III.4.2 III.5.3 III.5.5	II.1.3 II.1.5 II.5.6	II.2.1 II.2.3 II.4.5	II.2.4

National

NSES				AAAS	
Elementary		Middle		Elementary	Middle
C1.1 C3.2 C3.4 E1.4	F4.1 F4.2 G1.3 G1.4	A1.4 C4.1 C4.4 E1.2	E1.3 F5.5 G1.1 G2.1	1B.1 1C.3 5D.1 5D.4	1B.1 1C.1 1C.4 3A.2 5D.1

NAAEE		NCSS	
Elementary	Middle	Elementary	Middle
2.2-A 2.2-C	2.2-A	III.h III.i VIII.b IX.d	III.i IX.d

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K-W-L (KNOW, WANT TO KNOW, LEARNED SHEET)

Unit 3, Lesson 4

www.miseagrant.umich.edu/flow

K KNOW ALREADY	W WANT TO KNOW	L LEARNED
		Researcher: Fish studied: Cool fact: Habtitat: Threats to habitat: What's Being Done (ie, restoration):

WRITTEN TRANSCRIPT OF ED RUTHERFORD AUDIO INTERVIEW

Fish (Unit 3, Lesson 4)

Name and title:

My name's Ed Rutherford. I'm a research scientist at the University of Michigan. I work with the Michigan Department of Natural Resources, Fisheries Division here at the Institute for Fisheries Research.

What fish do you study?

I study a lot of fishes that use the rivers entering the Great Lakes for spawning and growing up and then migrate out to the Great Lakes to spend their adult lives.

The fish I work on is Chinook salmon, and this fish is not native to the Great Lakes. It was introduced to the Great Lakes in the 1960s, and it's important for a number of reasons. One is that it's the basis for the sport fishery in the Great Lakes. So it grows to a big size, people love to catch it, and in the process they spend lots of money trying to catch it, so it supports Michigan's economy.

The other reason it's really important is an ecological reason. The Chinook salmon was introduced to eat and control another non-native species, the alewife, which got into the Great Lakes in the 1940s and out-competed the native fishes for food. The Michigan Department of Natural Resources in the 1960s brought the salmon in to try and eat and knock down the alewife to low levels, so that the other fishes would be able to survive. And that actually worked. It was a real-life experiment that worked.

Chinook salmon now are at the top of the food chain in the open waters of the Great Lakes, so they serve both an important ecological role and also an important economic role.

What kind of habitat do Chinook salmon need?

They need good quality habitat in both the rivers and Great Lakes themselves. In the rivers, they need cold, clean water with lots of oxygen in it that is flowing pretty fast. They like to spawn in shallow areas that have gravel and cobble on the bottom. They also need sides of rivers. After they first hatch out of their nest, they migrate to the side of the river to feed, so they need wood in the stream to use as shelter—so big logs or brush that has fallen down is really important to help young fish survive.

And then, later as they grow up and start to move out toward the Great Lakes, they need cold, clean water in the Great Lakes and plenty of food to be able to grow.

What are some of the threats to Chinook habitat?

There are a couple of things that are really serious threats. One is construction of dams or dam operations. That's a threat because dams can constrict the amount of habitat that they [Chinook] have available to them. And then dams tend to heat up water, which makes it too hot for salmon to live in when they're young. Because the water heats up, the oxygen content drops. And then some operators hold the water back and release it a couple of times during the day to make it more efficient to run their turbines. But that has the effect of eroding the substrate and the sediment that's in the river, which then gets the silt and sand off the river banks and ends up covering salmon nests and suffocating them and ruining their habitat.

Another big problem or threat to their habitat is invasive species that come in and out-compete some of the native species and change the food web. So an example would be zebra mussels, which have gotten into the rivers where salmon first hatch out and grow up. And zebra mussels have changed the source of food for the salmon, and we found that some of their growth and survival has gone down since zebra mussels have entered the rivers.

How does your research address these problems?

What I'm doing is trying to figure out, first of all, how the fish use their habitat. What are their critical habitat needs? Where in these rivers do they first spawn, hatch out and grow up?

And then I work with hydrologists and land planners to understand how development affects the amount of sand and silt that goes into the rivers, and also affects the water quality. I'm working with modelers to try and make plans for a whole watershed in terms of what's the best… If you wanted to protect the habitat for fish like salmon or sturgeon, what's the best option for developing the watershed, or for building homes or having farms?

Similarly, I'm studying the food webs out in the Great Lakes to see how invasive species have changed the food webs and how that might have affected survival and growth of salmon.

COPY MASTER

Lesson 5: Great Lakes, Great Careers

Activity: Students review a selection of career profiles and play a lively classroom game to find out more about marine and aquatic science professionals.

Grade level: 4-8
Subjects: Science, social studies
Setting: Classroom
Duration: 1 hour
Key terms: Career, Profile

Photo 2: D. Jude, Photos 3, 4: D. Brenner

Objectives

Following this lesson, students will be able to:

- Name at least 5 careers in marine and aquatic science, including both the oceans and Great Lakes.
- Identify several recent contributions people have made in marine and aquatic science fields.
- Describe a marine or Great Lakes science career that interests them.

Summary

A variety of people make their living studying the oceans and Great Lakes or educating others about these valuable natural resources. Yet for many students in the U.S., these careers may seem relatively remote or unattainable—until they learn about the actual people who do them. This activity will help students become familiar with possible and exciting careers.

Background

"As a child, I became fascinated with the ocean while visiting the New Jersey shore with my family," says marine ecologist Deborah McArdle. For some young people, that's all it takes—an early fascination that leads to a lifelong passion. Others, however, may not realize that related careers even exist, much less that they would enjoy the work!

McArdle is one of more than 50 people profiled on web pages created by WHOI and NH Sea Grant programs (see: www.marinecareers.net) The pages provide an excellent introduction to a wide range of marine career fields and to people working in those fields. The featured men and women tell how they got started in their careers, what they like and dislike, and give advice for young people. Fields covered include marine biology, oceanography, ocean engineering, and related fields such as marine law, education, and economics.

Materials and Preparation

- Select approximately 15 career profiles, available online: www.marinecareers.net. It is best to select a wide range of careers and a diversity of men and women.
- Make multiple copies, so that each student has a stapled packet of all 15 profiles.
- Create stickers or labels with the name of each person profiled.

Note: Many Great Lakes career profiles are currently available online in a variety of formats.

1. Extension Educator
   http://www.miseagrant.umich.edu/about/staff/stewart.html
2. Aquatic Ecologist and Artist
   http://www.miseagrant.umich.edu/pubs/up/oct04/art1.html
3. Business Owner
   http://www.msfishcompany.com/our_story.shtml
4. Marine Policy 1
   http://www.miseagrant.umich.edu/pubs/up/win02/cimo.html
5. Marine Policy 2
   http://www.miseagrant.umich.edu/pubs/up/spring99/knauss.html

Procedure

1. Begin by introducing the topic of marine and aquatic science careers. Point out that for each of the prior lessons in Project FLOW, people are employed in related fields—as ecologists, wetland biologists, water quality experts, fisheries researchers, natural resource educators, science writers and a host of others. Ask students if they know of family members or friends who make a living by studying or educating others about the oceans and Great Lakes.
2. Distribute the packet of career profiles to each student. Explain that each of the profiles describes a real person whose career involves the oceans or Great Lakes. Explain that they'll be playing a game using these profiles.

3. Next, place a sticker on the back of each student, identifying a person in one of the profiles. Students are not allowed to see their own stickers. The goal of the game is for each student to figure out whose name is on his or her own back, by asking other students questions.
4. Start the game. Allow the students to mingle, while carrying the profiles. When two students meet, they should first look at the name on the other person's back and consult the appropriate profile for information. They then ask each other a yes-no question about their own identity. (For example: Am I a fisheries biologist? Am I female?) They are only allowed to ask one question per pairing and then must move on to mingle with others.
5. Once they have gathered enough answers to guess their own identify (the name on their back), they can remove the sticker, sit down, and read about that professional. They then become the "expert" on this person. After everyone is sitting and has had a chance to read about their person, ask each student to "introduce" the person to the class. They can talk about what the profiled professional does in relation to the oceans or Great Lakes, what he or she enjoys most, and what skills or education are needed to do this kind of job, etc.

Source
Developed by Anna Switzer and Joyce Daniels, Michigan Sea Grant

Extension

If students have Internet access, have them spend 15 minutes reviewing a variety of the profiles on www.marinecareers.net Ask students if they had to choose a career involving the oceans or Great Lakes, which one most interests them? Students will write a short essay explaining why they like this career, why they would be good at it, what kind of education they would need, and where—if they could choose anywhere in the world—they would like to work.

Additional Career Information
Sea Grant Network
See: www.marinecareers.net

Assessment

This assessment chart was designed for teachers to create their own assessment. The recommended points show the relative difficulty of student performance. In creating assessments, the total point value will depend on the number and type of performances selected. See: Example

Learning Objective	Student Performance	Recmnd # Points
Name at least five careers in marine and aquatic science, including both the oceans and the Great Lakes	Name two or three careers which are specific to the oceans	1 each
	Name two or three careers which are specific to the Great Lakes region	1 each
Identify several contributions people have made in marine and aquatic science fields	Describe the position of one or more marine/aquatic scientists and explain the benefits to the world (physical, animal, or human) of that position	3 each
Describe a marine or Great Lakes science career that interests them	Describe the career that most interests you of the ones that were explored in class or on the web.	2 each
	Explain what aspects of that career seem interesting.	2 pts.
	Explain how science (which aspect/ discipline) plays a role in that career.	2 pts.

Standards

State of Michigan

Science		Social Studies	
Elementary	Middle	Elementary	Middle
II.1.3 II.1.5	II.1.3 II.1.5	n/a	n/a

National

NSES				AAAS	
Elementary		Middle		Elementary	Middle
E1.3 E1.4 E1.5	F5.1 G1.2 G1.4	E1.2 E1.3 F5.2 F5.4	F5.5 G1.1 G1.2 G3.1	1C.1 1C.3	1C.1 1C.3

NAAEE		NCSS	
Elementary	Middle	Elementary	Middle
n/a	n/a	VIII.b	n/a

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Fish Glossary / Key Terms

Adipose fin: When present, the adipose fin is located between a fish's dorsal fin and caudal fin.

Barbels: These "whiskers" are used by bottom-feeding fish to sense food.

Biodiversity: The number and variety of all living things.

Career: A chosen profession or occupation.

Caudal fin: Tail fin.

Dichotomous: Divided or dividing into two parts.

Dorsal fin: Large fin or fins on a fish's back that vary in shape and size and may be connected or separate.

Family: (Biol) A taxonomic category ranking below an order and above a genus.

Habitat: An area that provides life requirements such as appropriate food, water, shelter and space for a particular organism.

Ichthyologist: Scientist who studies fish.

Key: (Biol) A systematic classification of the significant characteristics of the members of a group of organisms to facilitate identification and comparison.

Profile: A biographical essay presenting the subject's most noteworthy characteristics and achievements.

Restoration: To return to nearly a former condition or status.

Snout: Front part of a fish that includes the mouth.

Species: A fundamental category of taxonomic classification ranking after a genus and consisting of organisms capable of interbreeding.