It's a Ruffe Life
Eurasian ruffe in the St. Louis River

Summary: This lesson involves two activities. Students begin the lesson by matching images of common invasive species in Lake Superior or the St. Louis River with their characteristics and impacts. Students then engage in a musical-chairs-like activity that simulates the impacts of Eurasian ruffe on the natural ecosystem of the St. Louis River. Before adding invasive species to the activity, the concept of carrying capacity is demonstrated. The lesson concludes with a discussion about the impact that multiple stressors have on natural ecosystems and how people can help avoid creating more stress by minimizing the spread of invasive species.

Topic: invasive species, carrying capacity, human impact, ecosystem

Theme: Invasive species in Lake Superior and the St. Louis River are stressors for native fish. Eurasian ruffe is an invasive species found in the St. Louis River.

Goals: Students will learn that many invasive species in Lake Superior and the St. Louis River have negative impacts on the native ecosystem. Students will learn the negative impacts of Eurasian ruffe.

Objectives:

1. Students will name and visually recognize eight invasive species of the Great Lakes.
2. Students will identify why fish populations change naturally over time.
3. Students will participate in a demonstration of the impact of invasive species on a natural ecosystem.
4. Students will identify specific negative impacts of the invasive Eurasian ruffe on the St. Louis River ecosystem.
5. Students will identify two things they can do to minimize the spread of Eurasian ruffe.
**Lessons Adapted With Permission From:**

Illinois-Indiana Sea Grant College Program. (2001). “What do scientists know about invader species of the Great Lakes and the effects that global climate change will have on them?” *ESCAPE Compendium, Wanted: Ecosystem Invaders (17).*

Michigan Sea Grant. (October 2009). Holding Ground. *Upwellings, 32(3).*


**Suggested MN Science Standards:**

0.4.1.1.1 Life Science – Structure and Function in Living Systems
Observe and compare plants and animals.
0.4.1.1.1 Life Science – Structure and Function in Living Systems
Identify the external parts of a variety of plants and animals including humans.
0.4.2.1.1 Life Science – Interdependence Among Living Systems
Observe a natural system or its model, and identify living and nonliving components in that system.
1.1.3.1.1 The Nature and Science of Engineering – Interactions Among Science, Technology, Engineering, Mathematics, and Society
Observe that many living and nonliving things are made of parts and that if a part is missing or broken, they may not function properly.

1.4.1.1.1 Life Science – Structure and Function of Living Things
Describe and sort animals into groups in many ways, according to their physical characteristics and behaviors.
1.4.2.1.1 Life Science – Interdependence Among Living Systems
Recognize that animals need space, water, food, shelter, and air.
1.4.2.1.2 Life Science – Interdependence Among Living Systems
Describe ways in which an animal’s habitat provides for its basic needs.
3.4.1.1.1 Life Science – Structure and Function in Living Systems
Compare how the different structures of plants and animals serve various functions of growth, survival and reproduction.
3.4.1.1.2 Life Science – Structure and Function in Living Systems
Identify common groups of plants and animals using observable physical characteristics, structures and behaviors.

4.1.2.1.1 The Nature of Science and Engineering – The Practice of Engineering
Describe the positive and negative impacts that the designed world has on the natural world as more and more engineered products and services are created and used.

5.1.1.1.4 The Nature of Science and Engineering – The Practice of Science
Understand that different models can be used to represent natural phenomena and these models have limitations about what they can explain.

5.1.3.4.1 The Nature of Science and Engineering – Interactions Among Science, Technology, Engineering, Mathematics, and Society
Use appropriate tools and techniques in gathering, analyzing, and interpreting data.

5.3.4.1.3 Earth and Space Science – Human Interactions with Earth Systems
Compare the impact of individual decisions on natural systems.

5.4.1.1.1 Life Science - Structure and Function in Living Systems
Describe how plant and animal structures and their functions provide an advantage for survival in a given natural system.

5.4.2.1.1 Life Science – Interdependence Among Living Systems
Describe a natural system in Minnesota, such as a wetland, prairie or garden, in terms of the relationships among its living and nonliving parts, as well as inputs and outputs.

5.4.2.1.2 Life Science – Interdependence Among Living Systems
Explain what would happen to a system such as a wetland, prairie or garden if one of its parts were changed.

5.4.4.1.1 Life Science – Human Interactions with Living Systems
Give examples of beneficial and harmful human interaction with natural systems.

6.1.3.1.1 The Nature of Science and Engineering – Interactions Among Science, Technology, Engineering, Mathematics, and Society
Describe a system in terms of its subsystems and parts, as well as its inputs, processes and outputs.

7.4.2.1.1 Life Science – Interdependence Among Living Systems
Identify a variety of populations and communities in an ecosystem and describe the relationships among the populations and communities in a stable ecosystem.
7.4.2.1.2 Life Science – Interdependence Among Living Systems
Compare and contrast the roles of organisms with the following relationships: predator/prey, parasite/host, and producer/consumer/decomposer.
7.4.2.1.3 Life Science – Interdependence Among Living Systems
Explain how the number of populations in an ecosystem can support depends on the biotic resources available as well as abiotic factors such as amount of light and water, temperature range and soil composition.

8.3.4.1.2 Earth and Space Science – Human Interactions with Earth Systems
Recognize that land and water use practices can affect natural processes and that natural processes interfere and interact with human systems.

Environmental Literacy Scope and Sequence

Benchmarks:
- Social and natural systems are made of parts. (K-2)
- Social systems and natural systems may not continue to function if some of their parts are missing. (K-2)
- In social systems that consist of many parts, the parts usually influence each one another. (3-5)
- Social and natural systems may not function as well if parts are missing, damaged, mismatched, or misconnected. (3-5)
- Social and natural systems can include processes as well as things. (6-8)
- Social and natural systems are connected to each other and to other larger and smaller systems. (6-8)
- Interaction between social and natural systems is defined by their boundaries, relation to other systems, and expected inputs and outputs. (9-adult)

Concepts addressed in this lesson: biotic factors, group, similarities and differences, cause and effect, cycles, ecosystem, patterns, predation, energy and energy flow, habitat

For the full Environmental Literacy Scope and Sequence, see: [www.seek.state.mn.us/eemn_c.cfm](http://www.seek.state.mn.us/eemn_c.cfm)

Great Lakes Literacy Principles
- The Great Lakes, bodies of fresh water with many features, are connected to each other and the world ocean.
- The Great Lakes support a diversity of life and ecosystems.
- Much remains to be learned about the Great Lakes.
- The Great Lakes are socially, economically, and environmentally significant to the region, the nation, and the planet.

For more information about and a complete listing of the Great Lakes Literacy Principles, visit: [http://greatlakesliteracy.net/](http://greatlakesliteracy.net/)
**Materials:**

*Getting to Know Invasives*
- 8 Invasive Species Match Cards from the Michigan Sea Grant’s “Great Lakes Most Unwanted” Lesson Plan
- 8 Characteristics/Impacts Cards from the Michigan Sea Grant’s “Great Lakes Most Unwanted” Lesson Plan
- Memory cards set for younger students

*Ruffe Musical Chairs*
- 10 Chairs (not provided in Great Lakes Aquarium teaching kit)
- Set of *Ruffe Musical Chairs Game Cards* from the Michigan Sea Grant’s “Ruffe Musical Chairs” Lesson Plan
  - Teacher Page from the Michigan Sea Grant’s “Ruffe Musical Chairs” Lesson Plan
- Fishy music CD or fishy music on your computer: [http://www.uwex.edu/erc/music/song_ballad_of_aquatic.html](http://www.uwex.edu/erc/music/song_ballad_of_aquatic.html)
- CD player to play fishy music (not provided in Great Lakes Aquarium teaching kit)
Background1, 2, 3, 4, 5:

**Invasive vs. Nonnative species**

Many nonnative fish have been introduced to the Great Lakes since the time Europeans first settled in the area. A **nonnative species** is simply an organism that does not naturally occur in a particular area. Not all nonnative organisms are threats to natural ecosystems; in fact, scientists estimate that only 1% of nonnative species ever become invasive (Fig 1). **Invasive species** are nonnative organisms that negatively impact an ecosystem.

![Nonnative or Introduced](image)

Figure 1. Nonnative or introduced species vs. invasive species. Only about 1% of nonnative species become invasive. Image courtesy of MN DNR.

Invasive species compete with native species for habitat needs and often do not have natural predators in their new homes. This can disrupt the aquatic food web by reducing the food and space available for native species. Nonnative species that have become established in the lake cannot be eliminated without killing native species. Yet, managers do try to reduce populations of some nonnative species to restore the natural ecosystems and biodiversity of specific regions. Unfortunately, these control methods tend to be costly and inefficient. Some common invasive species in or near Lake Superior include: spiny water flea, sea lamprey, Eurasian ruffe, round goby, zebra mussels, quagga mussels, purple loosestrife, and *Phragmites* (the common reed).

**Carrying Capacity**

Aquatic habitats contain limited amounts of necessary food, water, cover, space, and other resources. The maximum number of individuals, or inhabitants, of a particular species that an environment can support is referred to as **carrying capacity**. Carrying capacity decreases if habitat is degraded. Invasive species can degrade habitat for native species by competing for the same resources, thus decreasing resource availability to natives. Because resources are limited, the population growth of a given species slows as its population approaches the habitat’s carrying capacity. If a fish population grows dramatically, becoming larger than the carrying capacity of
the lake ecosystem, the fish consume resources much faster than they can be naturally replenished. This population would exceed the carrying capacity of the environment, resulting in less reproduction and reduced growth, eventually bringing the population back down and allowing the habitat to replenish. Population numbers tend to fluctuate over time, depending on seasons and changes in weather, climate, and other environmental shifts. Other influences on native populations include excessive predation, the introduction of invasive species, disease, pollution, over-harvesting, poaching, development, agriculture, and over-fishing. Because all organisms are interconnected and depend on one another for survival, other native species can also be impacted.

**Eurasian ruffe in Lake Superior and the St. Louis River Estuary**

Eurasian ruffe were first discovered in the St. Louis River Estuary in 1986 and were likely introduced via ballast water from oceangoing ships (Figure 2).

Figure 2. Ships use ballast water to remain stable at different points throughout their journey. When ships take on ballast water, they also take up organisms that live in the water. When ballast tanks are drained, organisms are released. Image courtesy of [http://stateofthecoast.noaa.gov/invasives/ballast_water.html](http://stateofthecoast.noaa.gov/invasives/ballast_water.html) Please, visit the site for more information.
The ruffe multiplied quickly in the 1980s when it was introduced and was often the most abundant fish in the St. Louis River in the 1990s and early 2000s (Fig. 3).

![CPUE of selected St. Louis River Fish 1989-2004 and 2010-2011](image)

Figure 3. Numbers of fish caught during summer trawling surveys, 1989-2004 and 2010-2011. Tan bars indicate numbers of Eurasian ruffe caught for each year. Data prior to 2010 are courtesy of Ashland USGS office. Image courtesy of [http://1854treatyauthority.org/cms/files/REP%20Habitat%20SLR%20Trawling%202011.pdf](http://1854treatyauthority.org/cms/files/REP%20Habitat%20SLR%20Trawling%202011.pdf)

Eurasian ruffe have many adaptations that allow them to thrive in parts of Lake Superior and the St. Louis River. They have sharp spines in their dorsal and anal fins that at least initially may have deterred would-be predators. Many predators would rather eat other fish if they are available. As few species of fish initially ate ruffe (as determined by fish stomach analysis), the ruffe continued to reproduce, competing for food with many native fish. With less food and space in the ecosystem for other fish with similar diets and feeding habits, native fish like walleye, perch, and a number of small forage fish species were threatened by continued expansion of the ruffe’s range. Ruffe, as with most invasive species, reproduce rapidly and in large numbers, producing 13,000-200,000 eggs per female ruffe per season. Ruffe are tolerant of many environments with a range of temperatures, but they tend to prefer slower-moving murky water with soft bottoms. Ruffe even have special sensory adaptations to help locate food in murky waters. Populations of ruffe in the St. Louis River estuary have gone down from their initial high point, likely a result of predators learning to eat them and ruffe reaching their carrying capacity. Nevertheless, it is important to do as much as possible to prevent their invasion of new habitat.
What can we do about Eurasian ruffe?

The first step in helping stop the spread of Eurasian ruffe is being able to identify the fish. It is part of the perch family. The ruffe has a small, down-turned mouth, glassy eyes, a gill cover with many sharp spines, and is usually less than six inches long.

If you catch a ruffe outside Lake Superior or the St. Louis River Estuary contact your area DNR invasive species specialist or call the University of Minnesota Sea Grant Program in Duluth at (218) 726-8712 to report your sighting. Minnesota prohibits transportation of live ruffe. For more information, visit http://www.dnr.state.mn.us/invasives
To be sure you don’t transport or introduce Eurasian ruffe or any other aquatic invasive species, you can do the following:

1. **Clean** visible aquatic plants, zebra mussels and other prohibited species from watercraft, trailers, and equipment before transporting from any water access.
2. **Drain** water from bilge, livewell, motor, ballast tanks, and portable bait containers before leaving water accesses or shoreline property. **Keep** drain plug out and water-draining devices open while transporting watercraft.
3. **Dump** unwanted bait in the trash.

**You May Not.**
- **Transport** aquatic plants, water, or prohibited invasive species such as zebra mussels or Eurasian watermilfoil.
- **Dump** live bait into state waters, on shore, or on the ground.
- **Launch**, or attempt to place, watercraft, trailers, or equipment with aquatic plants, zebra mussels, or prohibited invasive species into any state waters.

**Additional Recommended Precautions**
1. To remove or kill hard-to-see aquatic invasive species before moving to other water bodies the following is advised:
   - **Spray** with high-pressure water and rinse with very hot water and/or
   - **Dry** boats and water-related equipment for at least five days
2. **Report** new sightings of aquatic invasive species. If you suspect a new infestation of an invasive plant or animal, save a specimen and report it to a local natural resources office.

For more on Minnesota invasive species laws, please visit: [http://www.dnr.state.mn.us/invasives/laws.html](http://www.dnr.state.mn.us/invasives/laws.html)
Vocabulary⁵⁻⁶:

**Adaptation** – physical, biological, or behavioral characteristics that help a plant or animal adjust to a particular environment

**Ballast water** – water carried in a boat or ship to give it stability

**Carrying capacity** – the maximum number of individuals or inhabitants that an environment can support without detrimental effects on the habitat or to the organisms over time

**Ecosystem** – the set of elements, living and nonliving, that interact, over time, within a defined locale

**Introduced species** – synonymous with nonnative species

**Invasive species** – plant or animal species that are foreign, not native, to a particular location and negatively affect the natural ecosystem

**Native species** – plant or animal species that naturally occur or live in a particular area or region

**Nonnative species** – plant or animal species that do not naturally occur or live in a particular area or region

**Predator** – an animal that hunts, captures, and consumes other animals

**Prey** – an animal that is consumed by a predator
Procedure:

*Getting to Know Invasives*<sup>3, 7</sup>

Adapted with permission from Project FLOW (Fisheries Learning on the Web), developed by Michigan Sea Grant College Program, see: www.miseagrant.umich.edu.

1. Introduce the idea of invasive species to your class. Explain that nonnative species are different from invasive species. We’re worried about invasive species because they can outcompete native species.
2. Explain that today students will learn the names of lots of invasive species, what they look like, and how they impact the ecosystem of Lake Superior.
3. Divide the class into groups of 3-4 students.
4. Give each group a complete set of shuffled Invasive Species Match cards – both the photo cards and the characteristics/impacts cards.
5. Groups should then try to match the photo card of each invader to the correct characteristics card for that particular invader.
6. When group members have matched the cards to the best of their ability, they may check with the teacher to see if they have completed the matching correctly.
   a. Use the chart included in this lesson plan to check if students have matched the cards appropriately. Share more information about the introduction of the species and the effects climate change may have on each species.
7. Ask each group to present a specific invader to the class and read the characteristics card aloud.
8. As students read the cards, bring attention to the impacts of each invasive species. If applicable, connect the impacts to previous lessons in which students have participated regarding the Lake Superior food web.
9. Explain that there are many things we can do to help stop the spread of invasive species. One of these is to get familiar with the invasive species, so we can identify them, talk about their impacts, report sightings to authorities before the invasives get established, and prevent their spread. In the next activity, students will get to know the Eurasian ruffe!
<table>
<thead>
<tr>
<th>Invasive Species</th>
<th>Introduction</th>
<th>Characteristics</th>
<th>Impacts</th>
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</thead>
<tbody>
<tr>
<td><strong>Sea Lamprey</strong></td>
<td>This eel-like, jawless fish originally comes from the Atlantic Ocean. The Welland Canal allowed lamprey to migrate from Lake Ontario to the upper Great Lakes.</td>
<td>Eel-like fish that attaches to other fish and feeds on their body fluids. Adults grow 12 to 20 inches long. Round, suction disk mouth is filled with sharp teeth.</td>
<td>Can kill 40 pounds of fish during its life. Often kills large, predator fish. Has contributed to declines in native lake trout populations</td>
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<tr>
<td><strong>Eurasian Ruffe</strong></td>
<td>First discovered in Lake Superior in 1986, it is believed the fish hitchhiked in ballast waters from Europe and Asia.</td>
<td>Small, aggressive fish with sharp spines on top and bottom fins. Grows rapidly and loves to eat. Can tolerate a range of water conditions.</td>
<td>At least initially, made up an estimated 80% of the fish caught in St. Louis River. Has spread to areas in western Lake Superior, Thunder Bay, and Lake Huron. Reduces food and habitat for native fish, such as walleye and perch.</td>
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<tr>
<td><strong>Round Goby</strong></td>
<td>Gobies hitchhiked in the ballast water of ocean-going vessels. They are originally from the Black and Caspian Seas.</td>
<td>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.</td>
<td>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.</td>
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<td><strong>Spiny Water Flea</strong></td>
<td>This invasive is native to northern Europe and arrived in the Great Lakes in the early 1980s. It is believed to have been transferred via ballast water of European freighters.</td>
<td>Microscopic zooplankton that have a long, barbed tail spine. Tail spines often catch on fishing lines and downrigger cable. Clumps of these zooplankton look and feel like gelatin or cotton batting.</td>
<td>Eat small plankton, reducing food for native Great Lakes zooplankton. Compete with small and juvenile fish for plankton such as <em>daphnia</em>. Not a good food source for small or young fish – barbed tail spines are hard to digest. Clog fishing nets and line.</td>
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<tr>
<td><strong>Zebra Mussels</strong></td>
<td>This species is native to the Caspian and Aral Seas of Eastern Europe and Western Asia. Ballast water likely contained larvae and possibly yearlings. They are now found in all five Great Lakes, although they have not become well-established in Lake Superior, probably because of its cold water.</td>
<td>Live in colonies that attach to submerged rocks, dock pilings, boat hulls, and even native clams and mussels. One adult zebra mussel can filter up to a liter of water a day and capture their preferred food – plankton. Dead ones can wash up on shore, littering beaches with their sharp shells.</td>
<td>Consume large quantities of plankton, reducing food for many native species. Cause water to become clearer, but this also means there is less food in the water for native fish. Grow in large clusters that clog water intake pipes, boat motors, and pumps, coating millions of dollars of control each year. Attach to native Great Lakes mussels and clams, often smothering them.</td>
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<tr>
<td><strong>Purple Loosestrife</strong></td>
<td>This flowering plant was imported from northern Europe over 100 years ago, because it was a popular garden plant with beautiful flowers. It spread quickly and invaded wetlands throughout North America.</td>
<td>Tall, flowering plant that can grow from 3-7 feet high. Often found on the edges of wetlands, roadside ditches and other moist areas. A perennial, it 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.</td>
<td>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.</td>
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<td><strong>Eurasian water milfoil</strong></td>
<td>It is unclear whether this plant was introduced as an aquarium plant or was transported in ballast water. Native to Europe, Asia, and North Africa, it appeared in North American in the 1940s.</td>
<td>Submerged aquatic plant. Forms thick mats on the water’s surface. Has feathery leaves and small red flowers that bloom above water in early summer. Can easily be confused with beneficial native watermofils.</td>
<td>Inhabits inland lakes and is present in the St. Louis River estuary. Tangled mats at the water’s surface 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.</td>
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<tr>
<td><strong>Asian Carp</strong> (not currently in Lake Superior, but a concern for other Great Lakes)</td>
<td>Introduced to North American ponds in the 1970s to remove algae by eating plankton. They soon found their way to the Mississippi River in the 1990s and are now working their way to the Great Lakes.</td>
<td>Group up to be 4 feet long and weigh over 60 pounds. Jump more than 15 feet out of the water and slam into fishing boats. Eat more than 40% of their body weight each day.</td>
<td>Eat enormous amounts of plankton – including phytoplankton and zooplankton. Could disrupt food webs.</td>
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</table>
**Adaptations for Younger Students:**

Use the “Invasive Species Match” cards to play a memory game. Break students into groups of 3-4; give each group a set of 16 matching cards. Have students lay the cards out in a 4 x 4 square and take turns trying to create a match. Encourage the students to say the name of each creature as they flip the card.

**Ruffe Musical Chairs**

Adapted with permission from Project FLOW (Fisheries Learning on the Web), developed by Michigan Sea Grant College Program, see: [www.miseagrant.umich.edu](http://www.miseagrant.umich.edu).

1. Ask students to summarize the impacts of invasive species. If possible, make a list on the board.
2. Acknowledge that a big part of the impact is that invasive species take away things that native species depend upon. Ask students to describe a time when they needed something or were looking for something and it just wasn’t there.
   a. Ask students to imagine what it would be like to not meet a basic need like food, water, or shelter. Having all important elements of a good habitat is important for survival.
3. The game we are going to play will simulate an environment with native species and what happens when animals can’t meet their basic needs.
4. Draw a chart on the board to record the population of native fish (Figure 3 provides an example of what your graph might look like towards the end of the game).

![Chart](chart.png)

**Figure 3.** The above figure represents the population of walleye and ruffe throughout the rounds of the game.
5. **The first half of the game demonstrates the idea of carrying capacity.**

6. 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 Lake Superior.
   a. Have students identify what those basic needs (elements of the habitat) are: food, water, shelter, space, oxygen.

7. Choose 5 students to represent walleye, a fish native to Lake Superior and St. Louis River estuary (Idea: have students who can name a native Lake Superior fish be your first 5 volunteers).

8. Play musical chairs with these 5 volunteers. Because there are 5 students and 10 chairs, each “walleye” will easily find a seat.
   a. Put a point on your graph to indicate that there were 5 walleye in Round 1.

9. Since they so easily met their survival needs, the 5 walleye were able to reproduce successfully! Add in 5 more walleye and play again. All seats will now be full.
   a. Put a point on your graph to indicate that there were 10 walleye in Round 2.

10. Introduce the rules of successful reproduction (for the purposes of the game):
    a. If all chairs are filled with no extra fish, the habitat has supported those fish well enough for half of the fish to reproduce successfully (for the purposes of the game). As such, add half the number of existing walleye to the game.
    b. If there are too many fish for the chairs, the habitat is stressed and the fish are not able to reproduce successfully (for the purposes of the game). As such, do not add more walleye to the game.

11. In Round 2, all walleye found a chair in the habitat but all the chairs are filled; add 5 (see number 10 for explanation) more walleye to total 15. Play again.
    a. Put a point on your graph to indicate that there were 15 walleye in Round 3.
    b. Now there will be ample competition for resources.
    c. Those who cannot find a seat are eliminated.
       i. Ask students to explain why this happened.
ii. Put a point on your graph to indicate that there were 10 walleye in Round 4.

12. Explain that half of the walleye who did find a seat were able to reproduce successfully. Add 5 more students into the mix, to total 15 again, and play again.
   a. Put a point on your graph to indicate that there were 15 walleye in Round 5.
   b. The same competition will happen.

13. Repeat Steps 11-12 until all students have had an opportunity to play. Continue putting points on the graph for each round indicating the number of fish in play. After a few rounds, you should see a pretty consistent carrying capacity line that goes up and down predictably (see Chart on page 14).

14. Introduce the term carrying capacity. Explain that the environment can only provide enough resource for a finite number of creatures. When too many creatures exist within an environment, those who can’t find needed habitat elements must move out or die.

15. Add the Eurasian ruffe. Begin the introduction of an invasive species on a round where you have 15 walleye.
   a. Explain that Eurasian ruffe have been introduced into the ecosystem. They are nonnative and invasive.
   b. Ask students what they remember about Eurasian ruffe from the warm-up activity. Have students predict ways that the ruffe might disrupt the walleye population.
   c. Explain that on three seats, you will place a “ruffe card.” These cards represent ruffe taking over habitat that was occupied by walleye. The game will be played exactly as before, but afterward walleye that landed on a card will read that card aloud. Some walleye may not survive.
   d. Make a note on your graph to indicate this is the round in which you added an invasive species.
   e. For every card that kills a native fish, count that as one ruffe on the graph. Count the ruffe even if no walleye sat on the card.

<table>
<thead>
<tr>
<th>Carrying Capacity</th>
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<td>The maximum number of individuals or inhabitants that an environment can support without detrimental effects on the habitat or to the organisms over time.</td>
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16. Play a round.
17. Have students who sat on cards read them aloud. If a student has a card that says “Sorry, a Eurasian ruffe took your place” that walleye is eliminated for that round as well as any walleye that didn’t find a seat.
   a. Read the extra information about the “ruffe cards” from the Teacher Page.
   b. Explain as before, that if everyone found a seat successfully, half of the surviving walleye may reproduce successfully (that is, you may add more walleye); if there were more fish than the habitat (chairs) would allow, no successful reproduction happens. Add in the appropriate number of walleye and put a point on the graph indicating the number of walleye in the next round.
18. Pick up the “ruffe cards.” Shuffle them with the others and put 6 down on different chairs.
19. Play again. That fewer walleye have food, shelter, and spawning habitat available (because of competition from ruffe), resulting in less reproduction and survival of young.
20. Have walleye who landed on a card read aloud. If the card says “Sorry, you lost your seat,” that “fish” is eliminated as are the “fish” who couldn’t find a seat.
   a. Explain that as before, if everyone found a seat and there were no extra fish without seats, half of the surviving walleye may reproduce; if there were more fish than the habitat (chairs) would allow, no successful reproduction happens. Add in the appropriate number of walleye and put a point on the graph.
21. Pick up the “ruffe cards” and shuffle again with all the cards.
22. Continue to play as in steps 18-20 above.
23. Repeat steps 18-20 until you have an appropriate number of points on your graph for your purposes.
24. Cover all chairs with a card, being sure to shuffle between rounds.
25. Play until very few native fish survive the round.
26. Ask students to interpret what is going on in the game. Challenge them to use the graph to explain their ideas.
27. Explain to students that this game is not a perfect representation of what actually happens in the lake and that the concepts of competition and carrying
capacity are much more complex in the real world. Ask if the students can identify parts of the demonstration that are different from how things might work in the lake.

Optional:
1. *Add in predators.* Play the game again with 9 native fish and 2 “ruffe cards” distributed on the chairs. Add 2 extra native fish or anglers as predators – these fish can eliminate (take the seat of) the other native fish at the end of the round.
   a. The predators are not allowed to take over ruffe chairs because they prefer to feed on native species (ruffe have spiny fins that are hard to digest).
2. For every chair that is left open because of a “ruffe card,” add 2 more “ruffe cards” to other chairs and continue play.
3. Keep playing until “ruffe cards” represent most or all of the seats available.

Discussion

1. Ask the students why ruffe were so successful in taking over the chairs. Explain that all these things were true when ruffe invaded the St. Louis River.
2. Ask students how they would know if an invasive species was in a particular body of water.
   a. How do students think they could watch for invasive species like the ruffe?
3. Ask students to make a list of things that stress the native fish of an ecosystem. Native fish have to deal with a lot of “stressors.”
   a. Students could list all the invasive species that they have learned about as well as environmental and human impacts such as polluted stormwater, floods, temperature changes, overfishing, etc.
   b. Each stressor in a particular environment makes it harder for native fish to survive.
4. Remind students that we can do a lot to help reduce stress on native fish by learning to identify invasive species, watching for them, reporting them to proper authorities, and working to prevent their spread. Review the ways we can prevent the spread of invasive species from the Background section.
References:


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