

## Aquatic Exotics

**OBJECTIVES:** Students will be able to:

- relate the differences between native, exotic, and invasive species
- provide three examples showing why invasive species are problematic
- explain why it is easier to prevent introduction of exotic species than to remove them once they are established

**METHOD:** Students will research [Invasive Aquatic Species](#) and briefly report on five different species. They will also read an article describing [Sea Lamprey Control Measures](#) and answer questions about the article.

**MATERIALS:** ● See Appendix H for a Power-Point Presentation: Invasive Species Images.

**SETTING:** Indoors or outdoors

**DURATION:** One 45-minute class period – or a possible take-home assignment.

**VOCABULARY:** Exotic species, invasive species, native species, assessment

**STANDARDS:**

**Science:** A 8.6, 12.4; C 8.4, 8.11, 12.4, 12.7; F 8.8, 8.9, 8.10, 12.7, 12.8.

**Environmental Education:** A 8.4, 8.5, 12.3; B 8.5, 8.8, 8.15, 8.18, 12.3, 12.4, 12.5, 12.8; C 12.4; D 8.1, 8.5, 12.1.

**Social Studies:** A 8.11, 12.11.

**BACKGROUND:** The vast majority of the exotic species in the Great Lakes have been unintentionally introduced. Some exotic species have swum in through connecting waterways, like the Welland Canal. The Welland is part of a network of canals extending from the Atlantic Ocean and the St. Lawrence Seaway into the Great Lakes. People dug these canals to allow for shipping between the Atlantic Ocean and the Great Lakes. At the same time, they unintentionally opened a corridor for exotic species to swim from the ocean all the way up into Lake Superior. The parasitic sea lamprey is one that took the opportunity to do so. It naturally spawns in freshwater.

Ships coming into the Great Lakes also bring surprise visitors in their ballast water. A foreign ship that is not filled to capacity with a product will fill its ballast tanks with water before it

leaves its home port. The weight of the water in the tanks gives the ship more stability when crossing the Atlantic Ocean. When the ship arrives in the Great Lakes and is filled with wheat, corn, coal, or another product, it dumps its ballast water—and any live organisms it picked up at home—into the Great Lakes. Once in one of the Great Lakes, these exotic species can swim from lake to lake or up streams to inland waters. The zebra mussel likely arrived this way.

While many exotic species have arrived unintentionally, some are brought on purpose. Since European settlement began, generations of immigrants have brought along plants and animals from their native lands for food and for familiar touches in their new homes and yards. Purple loosestrife is one example of an exotic plant that was intentionally planted as an ornamental. It was also carried along in soil that was used as ballast on ships.

All three of the species listed above have rapidly reproduced and spread to areas far removed from their original introduction. They are considered exotic invasive species. Exotic invasive species have had an enormous economic impact on the Great Lakes region. A recent study by University of Notre Dame researchers found that invasive species introduced through ocean vessels, in ballast water and attached to hulls, cost the Great Lakes region over \$200 million dollars a year. These costs are the result of lost commercial and sport fishing revenue, lost wildlife watching revenue, and increased operating costs for Great Lakes water users. Currently the United States and Canada have regulations requiring ocean ships to flush their ballast tanks with saltwater before leaving the ocean, but this regulation is not eliminating the introduction of new species. Strengthening ballast regulations is a hot topic of discussion between various states and Canada.

This lesson uses the sea lamprey as a representative invasive species because of its well-known and dramatic impact on commercial fisheries and the long term and still unsuccessful efforts to eliminate it.\* The sea lamprey is an excellent reminder of why it makes economic sense to prevent the introduction of exotic species, rather than to try to eliminate them once they are established.

\*The sea lamprey contributed to the near-annihilation of the Great Lakes commercial fishery in the 1950s.

**OPENING:** Have students read **Aquatic Exotics** up to the questions about sea lamprey. Discuss exotics as a class: How do they get here? How do exotics, natives, and invasives differ? Why are invasive species a problem? What are some of the more problematic invasive aquatic species for Wisconsin?

**MAIN ACTIVITY:** Ask students to read the article on **Sea Lamprey Control Methods** independently. They can answer the questions either in class or as a take-home assignment.

**CLOSING:** New exotic species are entering the Great Lakes every year. Have students read the **Newsflash! Asian Carp Approaching Wisconsin** paragraph. The current location of the carp is ever-changing. Students can use the internet and search for “silver carp” or “Asian carp” to see if they can discover its most recent location. In December 2008, silver carp were caught near La Crosse, marking their arrival in Wisconsin. One year later, biologists confirmed that Asian carp had entered the Chicago Sanitary and Ship Canal and the multi-state, multi-agency Asian Carp Rapid Response Workgroup was deployed to halt the Asian carp’s advance toward Lake Michigan.

**ASSESSMENT QUESTIONS:** What is the difference between an exotic species, an exotic

invasive species, and a native species? Give an example of each type.

*ANSWERS: An exotic species is from another place, but is not necessarily seen as a problem (examples: coho salmon, rainbow trout). An exotic invasive species is from another place and is causing problems for native species (examples: sea lamprey, Eurasian watermilfoil, spiny waterflea). A native species is one that has existed in the local ecosystem for a very long time (many examples possible).*

**EXTENSIONS:**

**In Depth:** Have each student investigate a different invasive species and describe the best control measures based on his or her evaluation of scientific studies.

**Service Learning:** The UW Sea Grant has an “Attack Pack” designed to allow high school students to teach elementary students about aquatic nuisance species. Check the UW Sea Grant’s website for details: [seagrants.wisc.edu](http://seagrants.wisc.edu)

Contact the DNR to find out about invasive species eradication field days or projects to involve your students: [dnr.wi.gov/invasives/publications/class](http://dnr.wi.gov/invasives/publications/class)

• If you have downloaded this booklet, please see the appendix that follows for additional materials.

### Invasive species

Exotic species that often rapidly out-compete **native species**, species that live in their natural environments

PLEASE SEE APPENDIX H

PowerPoint: Aquatic Exotics

## Aquatic Exotics

When you hear of an “exotic vacation,” what do you think of? Perhaps a tropical island or maybe a trip to the Himalayas? Regardless of where you go on your imaginary exotic vacation, it will be, by definition, far away from your life here in Wisconsin. So what makes a certain plant or fish or mussel that you can find in your local stream “exotic”?

### From Another Land

**Exotic** plants and animals are species that humans have helped move from a far-away native environment, where these species would naturally live, to a new environment. This happens frequently in the Great Lakes. Since the 1800s more than 100 exotic species have been documented in the Great Lakes bordering Wisconsin. There are many potential pathways for non-native or aquatic exotic species to enter a new waterbody. Can you think of one way they could get here?



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### Competing for Space

Have you heard of people worrying about exotic species? If so, why do you think people are concerned? Why do resource managers count, discuss, and try to control exotic species? Not all exotics are of concern. In fact, some exotic species are still regularly introduced to our lakes and rivers on purpose. Chinook salmon and coho salmon are native to the Pacific Ocean, but the Wisconsin Department

of Natural Resources began stocking them in the 1960s to devour an invasive exotic, the alewife, which washed up on Lake Michigan beaches. As an added bonus, they were fun to catch and a new sport fishery was born in Wisconsin. Salmon, brown trout, and rainbow trout are reared at state fish hatcheries and stocked. They are not among the exotics that are considered invasive.

**Invasive species** are exotic species that often rapidly out-compete **native species** (species that live in their natural environments) for food, prey on native species, and/or take over a native species’ niche. These are the exotic species that resource managers and others are concerned about. Many invasive species arrive in the United States without their natural predators, so there is nothing to keep their growth in check.

The spiny water flea, for example, is a tiny crustacean with a sharp, barbed tail. It competes with young perch and other small fish for zooplankton. The spiny water flea arrived in the Great Lakes, and now many inland lakes, without predators and faces little predation from native fish because of its sharp tail. It eats without being eaten, so its population is booming, harming native species.

Resource managers are especially concerned about predator invasive species because these predators can rapidly change an ecosystem when they begin consuming native species. Because native species did not evolve with the exotic predators, they have little natural defense against them.

The sea lamprey, for example, can kill up to 40 pounds of fish in its lifetime—often focusing its efforts on the popular lake trout. The lake trout has no defense against lamprey and was nearly eliminated from the Great Lakes in the 1950s, in part because of lamprey. The diminished population of lake trout, once the Great Lakes’ top predator, has had significant effects throughout the ecosystem.

The impact of each exotic species varies, and resource managers cannot work on all of them. Instead, they focus their efforts on the most aggressive and the most controllable species in Wisconsin.



## Help is on the way: Chapter NR 40

An administrative rule, Chapter NR 40, was approved by the state legislature in 2009 to establish an invasive species control program. Check the DNR website to see the full text of this historic document.

### Take Action!

Boaters and anglers play an important role in preventing the spread of invasive species in Wisconsin waters.

- **INSPECT** boat, trailers and equipment and **REMOVE** plants, animals, and mud.
- **DRAIN** water from your boat, motor, bilge, live wells, and bait containers.
- **DON'T MOVE** live fish away from a waterbody. Dispatch your catch and put it on ice.
- **DISPOSE** of unwanted bait in the trash. Use leftover minnows only under certain conditions outlined on the DNR's website.
- **RINSE** boat and equipment with hot or high pressure water **OR** dry for at least five days

Wisconsin laws prohibit launching a boat or placing a trailer in the water if it has aquatic plants or mussels attached to it. Unauthorized introduction of fish, crayfish, or plants into the wild is illegal—even if you didn't mean to do it! Escaped or dumped exotic pets can also upset the balance of natural systems. Take care and don't be a part of the exotic invasion.

### Don't Dump Your Science Projects!

It's great to study living organisms in the classroom, but please do not dump any of them into Wisconsin waters, public or private. Doing so without a permit is illegal and can spread disease, invasive species, and/or undesirable genetic strains.

**INSTRUCTORS:**  
Underlined content is not provided in student manual.

## Very Horrible and Scary

Viral hemorrhagic septicemia (VHS) is an invasive disease that causes fish to bleed to death. It caused large fish kills in the lower Great Lakes in 2005-2006 and was detected in lakes Michigan and Winnebago in May, 2007. VHS spreads easily when a healthy fish eats an infected fish or when fish swim in water carrying the virus. Infected bait (often minnows) is a primary source of the disease. Anglers can make a big difference in preventing VHS from moving into new lakes. In addition to the precautions all boaters must take, anglers are also required to do the following:

- Do not move live fish or fish eggs away from any water.
- Only purchase minnows from a licensed Wisconsin bait dealer. You can use these minnows again on the same water or other waters if no lake or river water or other fish were added to the minnow container.
- You may not harvest minnows from VHS waters. However, suckers can be taken, but may not be transported away while alive. Check the DNR website for the list of VHS waters.
- Do not use dead fish for bait unless they have been preserved by methods other than refrigeration or freezing.
- Report sick fish to the DNR.

VHS does not harm humans, but it is deadly for fish. Do your part to keep the fishery healthy and check the DNR website for updates.

## News Flash! Asian Carp Approaching Wisconsin!

While resource managers are trying to control the exotic invasive species currently in Wisconsin, others are working their way into our lakes. One of the greatest threats to Wisconsin and the Great Lakes is the Asian carp.

These enormous fish, which can weigh up to 100 pounds, were brought to the United States intentionally by catfish farmers who used them to clean algae out of their ponds. In the 1990s, many rivers near the Mississippi River flooded,

connecting the catfish ponds to river systems. Asian carp made their way into the Mississippi River and from there began swimming up the Illinois River toward Chicago and Lake Michigan.

If the carp make it into the Great Lakes, they could significantly change the ecosystem. Asian carp are big eaters and rapid reproducers. They will compete with Great Lakes game fish for food and could end up a dominant species in the Lakes. Managers are trying to stop their advances. Do a quick internet search: Where is the Asian carp now?

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## Invasive Aquatic Species

List five aquatic invasive species that live in Wisconsin. What's the impact of each? How are we trying to control them?

1. Eurasian water milfoil (grows rapidly, shades natives; chemical controls attempted)

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2. Purple loosestrife (grows rapidly, outcompetes natives for space; biological and chemical controls attempted)

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3. Zebra mussel (clogs water intake pipes; chlorine, filters, and scraping used to control)

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4. Eurasian ruffe (outcompete walleye and perch; chemical controls attempted)

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5. Rusty crayfish (outcompete native crayfish; no control beyond prevention)

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## Sea Lamprey Control Methods Survey

Read the article on the next pages to answer the following questions:

- 1) How do scientists count sea lamprey in their different life stages? Of the three assessment methods described—larval, parasitic-phase, and spawning-phase—which of these do you think provides the most accurate data about the sea lamprey population? Why do you think so?

Larvae are counted after being electro-shocked. Parasitic-phase are counted by charter and commercial fishermen and reported to the government. Spawning-phase are counted by scientists using mechanical traps. Students may pick any of the three, as long as they support their choice. Most will choose the larval or spawning-phase, because individuals are concentrated in a small area. Parasitic-phase depends on what fishermen catch and what they decide to report.

- 2) Suppose you are a scientist trying to assess parasitic adult sea lamprey using the help of local commercial and sport fishermen. What kinds of information would you want the fishermen to record for you? Why would it be worth their time to help you?

Fishermen could be convinced to help, because reducing lamprey populations is in their best interest. They should be asked to record the number of lamprey they catch, the number of lamprey scars on fish, and the times and locations where the lamprey were caught.

- 3) How effective has TFM been at controlling lamprey without hurting other species? Why? State at least three reasons.

TFM is remarkably effective because it is selective for sea lamprey, is applied at their most vulnerable stage (larval), does not bioaccumulate in the environment, and breaks down in a matter of days. Invertebrates that are affected by TFM are able to recover in the long interval between TFM applications.

- 4) Describe at least three advantages or benefits of using sea lamprey barriers when compared to the use of TFM.

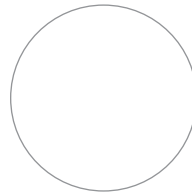
Benefits are reduced lampricide costs, reduced application costs, more efficient sea lamprey control, increased opportunities for population assessment and male-sterilization collection, and longer duration (one barrier works for years).

- 5) According to the fact sheet, about 25,000 male sea lamprey are caught each year in traps. If you had the choice between destroying these lamprey or sterilizing and then releasing them, which would you choose? State a reason to support your answer.

Students should demonstrate their understanding that sterilized males are in their spawning phase and no longer harming fish. By releasing them, scientists are assuring that at least some of the eggs produced that year will not be fertilized.

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6) If you were managing the Great Lakes fishery, which method of sea lamprey control would you devote the most time and money to—lampricides, sterile males, or barriers? Why? Make a pie graph showing how you would divide your funds.



Students may choose any answer, as long as they support it. Students may choose lampricide because it is so successful, barriers because they involve one investment as opposed to many, or male sterilization because of its potential to rapidly reduce larval lamprey. Students should give some thought to a combination. The actual breakdown of the money given to control measures in 2008 was 80% to TFM (\$10.9 million), 12% to barriers

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7) Do you think it will ever be possible to eliminate all the sea lamprey in the Great Lakes? Why or why not?

Theoretically, with enough money and manpower, it seems possible. However, it is unlikely as there will always be some small number that escape barriers, spawn in unusual areas, or show resistance to lampricides. Our track record for wiping out invasives is not good.

8) In 2008 the Great Lakes Fishery Commission spent over \$18 million dollars on sea lamprey management. Do you think this is a worthwhile investment? Why or why not?

Let students know: Sport fishing brings over \$7 billion dollars to the Great Lakes region, and commercial fishing is worth millions more.

9) Why is it important for scientists to study other invasive species? Why is it important for us to try to prevent the introduction and spread of new invasive species?

We need to study invasive species to determine the extent of their effect on the natural ecosystem and to learn their life histories well enough to develop effective control measures. Students may come up with other answers as well.

Help students to recognize and explain that it is much easier to prevent than to eliminate.

10) Could any of the methods used for sea lamprey control be used on other invasive species? Why or why not?

Highlight the fact that decades of research have gone into creating controls that are specific to lamprey and will not affect other species. The lampricide and specific barriers and sterilization chemicals used on lamprey would likely not be effective on other species. However, the ideas behind each of the controls—a special chemical, a physical barrier, a sterilization process—could give inspiration to other projects, like the carp barrier on the Illinois River.



## Sea Lamprey Control Methods

### A Summary of Great Lakes Fishery Commission Reports

Sea lamprey are eel-like jawless fish native to the Atlantic Ocean. They entered the Great Lakes system in the 1800s through a series of manmade locks and shipping canals. Sea lamprey were first observed in Lake Ontario in the 1830s. They were discovered in Lake Michigan in 1936 and in Lake Superior in 1938. By the late 1940s, sea lamprey populations had exploded in all of the Great Lakes, causing severe damage to lake trout, salmon, rainbow trout, whitefish, chub, burbot, walleye, and catfish populations. Because Great Lakes fish did not evolve with sea lamprey, the fish do not have defense mechanisms against the aggressive predacious behavior of lamprey. Sea lamprey have no native predators in the Great Lakes.

### Lamprey Life Cycle

Sea lamprey begin their lives in tributary streams of the Great Lakes, where they hatch from eggs laid in gravel nests. Once hatched, wormlike larvae are swept downstream until they burrow into sand and silt substrates. The larvae feed on algae and bottom debris for four to six years, until they are six inches long. Once large enough, the larvae transform into their parasitic phase and migrate downstream to the open waters of the Great Lakes. There they attach to large fish with their sucking mouths, rasp through skin and scales, and feed on a fish's bodily fluids. This action often kills the fish. A lamprey can kill 40 or more pounds of fish in its lifetime. After 12 to 20 months of feeding on fish, the lamprey enter their spawning phase and migrate upstream to lay eggs and die.

### Control Measures

The Great Lakes Fishery Commission and its agents gather information to assess the population dynamics of sea lamprey. The purpose for collecting and analyzing data is to develop the most efficient and effective sea lamprey control program at the lowest cost and with the least possible negative effects on the environment.

### Gathering Information

Larval sea lamprey live in tributary streams and in some offshore areas of the Great Lakes. To estimate the number of larvae that will migrate into the Great Lakes, biologists use a backpack electro-shocker in shallow waters and a deep-water electro-fisher in harder-to-reach waters. The electro-fisher equipment delivers electricity to the water and stimulates (shocks) the larvae out of their burrows to the surface, where they can be counted.

Through a cooperative program, charter boats and commercial fishermen provide government agencies with data on their sightings of parasitic-phase sea lamprey in the open waters of the Great Lakes. To monitor lamprey in their spawning phase, mechanical traps are set in streams to catch the sea lamprey on their spawning migrations. The sex, weight, and length of the trapped sea lamprey are recorded to understand population characteristics. The data collected from all three life phases help scientists determine where and when to apply control measures.

### TFM

During the 1950s, scientists tested almost 6,000 compounds to identify one to which sea lamprey were especially sensitive but other aquatic species were not. Through this research, scientists discovered in 1958 that TFM (3-trifluoromethyl-4-nitrophenol) was remarkably effective at controlling lamprey. Sea lamprey are most



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vulnerable to TFM during their larval phase. For this reason, TFM is applied in streams, not to the open waters of the Great Lakes. A typical treatment takes between 48 and 72 hours to complete, but can take as long as a week. At the levels used, TFM is non-toxic to fish other than lamprey, but it does harm short-lived invertebrates. However, because TFM is applied to a stream in three- to ten-year intervals, populations of these invertebrates can recover between treatments.

TFM does not bioaccumulate in the aquatic environment, and it breaks down in a matter of days. In the Great Lakes, long-term studies have shown no traces of TFM in fish, even in multiply-treated streams in which the fish were caught. Through careful TFM use, the Great Lakes Fishery Commission and its agents have successfully reduced sea lamprey populations in the Great Lakes by 90%.

### Sea Lamprey Barriers

Sea lamprey barriers are non-chemical weapons used to control lamprey as they attempt to migrate up streams to spawn. Barriers are constructed across streams in strategic locations throughout the Great Lakes Basin to prevent sea lamprey from getting to their spawning locations, thus reducing the number of streams that produce lamprey. When properly constructed, barriers prevent lamprey passage while still allowing desirable fish species to pass. In some cases, lamprey may spawn below the barriers, but these short stretches of streams are usually much easier and less expensive to treat with TFM than an entire river system. The benefits of barriers include savings in lampricide chemical and application costs and more efficient sea lamprey control. Types of barriers include:

- low-head barriers that create walls across the stream which trout and salmon can jump, but lamprey cannot;
- adjustable-crest barriers, which pop up only during lamprey migration;
- velocity barriers, which make the stream move too swiftly for a lamprey to swim; and
- electrical barriers, which send a current across the stream and are only used during lamprey migration to deter the fish's passage.

### Sterile-Male Release Technique

A sterile-male release technique has been used successfully around the world to reduce populations of insect pests. In 1991, scientists began a similar program to control sea lamprey populations in the Great Lakes, starting with Lake Superior. Lamprey are trapped in strategic locations, often at sea lamprey barriers, on Great Lakes tributaries and the males are taken to a sterilization facility where they are injected with a chemical that makes them sterile. These males are in their spawning phase and are no longer feeding on fish.

Once the males are fully sterilized, they are released back into Lake Superior tributaries. Why not just destroy these males? Scientists believe that releasing the sterilized males will actually reduce the number of sea lamprey produced in tributaries, because the sterilized males will compete with normal males to mate with females. None of the eggs produced by the mating of a sterile male and normal female will hatch. Without sterilized males competing during the spawning run, all spawning would be done by normal males and all eggs would be fertilized. The goal of the sterile male release technique is to increase the ratio of sterile to normal males. Early results show success so far.

Source: Great Lakes Fishery Commission Sea Lamprey Control website: [glfc.org/lampcon.php.php](http://glfc.org/lampcon.php.php)