

Developed by Participants in the 2007 [Great Lakes Maritime Transportation Summer Teacher Institute](#) sponsored by the Great Lakes Maritime Research Institute (www.glmri.org)

Invasive Species Moving *Into* and *Out* of the Great Lakes

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Topic: Invasive Species (Biology)

Subject/Target Grade: Gr. 9-10 Biology

Lesson Overview:

The impact of invasive species on natural ecosystems is a typical topic to be addressed in a general biology course. Invasive species provide an example of how humans impact the environment with our movements and daily activities. The purpose of this lesson is to encourage students to explore some examples of aquatic invasive species now found in the Great Lakes Region and to be instructed on one example of an aquatic invasive species that traveled from the Great Lakes to Europe via transoceanic shipping (in ballast water). There are many excellent lesson plans available on the Internet about invasive species now found in the Great Lakes, this lesson intends to extend that concept to the idea that invasive species are a global problem and not only an issue in the Great Lakes.

Objectives:

Students will be able to:

1. Discuss how humans impact natural ecosystems in other countries as a result of invasive species introductions..
2. Investigate the different vectors for introducing invasive species into different habitats in the U.S. and globally.
3. Create and present a PowerPoint presentation that describes an invasive species.
4. Describe the effects of the invasive crayfish fungus/plague which was introduced to Europe via ballast water from a ship that traveled from the United States.

Ohio Content Standards: Science

Benchmark F: Explain the structure and function of ecosystems and relate how ecosystems change over time.

Grade 10

Diversity and Interdependence of Life

15. Explain how living things interact with biotic and abiotic components of the environment (e.g., predation, competition, natural disasters and weather).

17. Conclude that ecosystems tend to have cyclic fluctuations around a state of approximate equilibrium that can change when climate changes, when one or more new species appear as a result of immigration or when one or more species disappear.

Benchmark G: Describe how human activities can impact the status of natural systems.

Grade Ten

Diversity and Interdependence of Life

18. Describe ways that human activities can deliberately or inadvertently alter the equilibrium in ecosystems.

Materials needed:

Preserved specimen of zebra mussels, sea lamprey, Eurasian ruffe, purple loosestrife, Eurasian watermilfoil, round goby, etc. (may obtain Carolina Biological Supply, or other source, etc).

Per student:

Student Presentation on Invasive Species in the Great Lakes
Biology Quiz

PowerPoint on the Crayfish Plague of Europe (LCD and laptop)

Room Arrangement or Special Needs: Access to a computer lab with internet and PowerPoint software, capability to use PowerPoint in the classroom, including computer and projector.

New Vocabulary: (how are these words presented to students? Are they quizzed on them?)

1. invasive species- a species which is both non-native (or alien) to the ecosystem and whose introduction causes or is likely to cause economic or environmental harm or harm to human health.
2. exotic species-an introduced species that is not indigenous to the place or area where it is has been introduced accidentally or deliberately by human activity.
3. ballast water- is used in ships to provide weight to resist the lateral forces on the vessel. Insufficiently ballasted boats will tend to tip, or heel, excessively in high winds. Too much heel may result in the boat capsizing. When sailing vessels carried cargo, it was at times necessary to sail to a port with no cargo. In order to do this enough ballast of little or no value would be loaded to keep the vessel upright. This ballast would then be discarded when the cargo was loaded.
4. Eurasian ruffe (*Gymnocephalus cernuus*)- an aquatic invasive species first found in Lake Superior (Duluth Harbor) in 1986 which is a fish that has a perch-like body shape and is generally less than 6 inches long with spiny anterior dorsal fins. It was introduced via ballast water discharge into Lake Superior.
5. Eurasian Watermilfoil (*Myriophyllum spicatum*)- an aquatic invasive species which first appeared in the Great Lakes in the 1940s. It can form feathery mats of submerged vegetation that can choke out other aquatic plants in the area. It was most likely introduced by aquarium being dumped into the Great Lakes or via recreational boat transfer.
6. Spiny (*Bythotrephes longimanus*) and fishhook (*Cercopagis pengoi*) waterfleas-

small predacious crustaceans that threaten aquatic ecosystems and fishing by competing with native fish for food and fouling gear. Both arrived in ship's ballast water from Eurasia.

7. Flowering Rush (*Butomus umbellatus*)- This exotic was likely brought to North America from Europe as a garden plant. Unfortunately, it also grows well in wet places. While single flowering rush plants are not a "problem," this exotic can form dense stands which may interfere with recreational lake use. Flowering rush may also crowd out native plants and in turn harm fish and wildlife.

8. New Zealand mudsnails (*Potamopyrgus antipodarum*)- tiny invasive snails that threaten the food webs of trout streams and other waters. Native to New Zealand, they were first found in Idaho's Snake River in 1987. They were most likely introduced via ballast water discharge.

9. Purple Loosestrife (*Lythrum salicaria*)- an invasive perennial plant that is spreading rapidly in North American wetlands, shorelines, and roadside ditches. Thick stands of purple loosestrife crowd out native plants and reduce food, shelter, and nesting sites for wildlife, birds, turtles, and frogs. After multiple introductions in the 1800s for bee keeping, as an ornamental plant, and in discarded soil used as ballast on ships, this European species has invaded nearly every U.S. state and at least six Canadian provinces.

10. Round Goby (*Neogobius melanostomus*)- an invasive fish introduced to the Great Lakes via ballast water discharge. This bottom-dwelling fish can displace native fish, eat their eggs and young, take over optimal habitat, spawn multiple times a season, and survive in poor quality water — giving them a competitive advantage.

11. Rusty Crayfish (*Orconectes rusticus*)- Rusty crayfish are invasive crustaceans spreading to lakes, rivers, and streams in several areas of North America. Native to the Ohio River drainage basin, rusty crayfish have spread to several U.S. states and Ontario. They have likely spread through bait bucket release by anglers, aquarium release by hobbyists, activities of commercial harvesters, and live study specimen release by teachers and students who buy them from biological supply houses.

12. Sea Lamprey (*Petromyzon marinus*)- Sea lamprey are primitive, jawless fish native to the Atlantic Ocean. Like salmon and alewife, sea lamprey are native ocean fish that spawn in fresh water. Historically, sea lamprey have inhabited Lake Ontario and the St. Lawrence River, as they are open to the Atlantic Ocean. In 1921, lampreys appeared in Lake Erie for the first time, arriving via the Welland Canal, which was constructed for ships to avoid Niagara Falls on their way up the St. Lawrence Seaway. Shortly thereafter, sea lamprey quickly populated all of the upper Great Lakes.

13. Zebra Mussel (*Dreissena polymorpha*)- a fingernail size mussel which often times has stripes on it thus the name "zebra" mussel. It is an amazing filter feeder and is actually given credit for a majority of the cleaning of Lake Erie from eutrophication in the 1960s-70s. This aquatic invasive was introduced via ballast water discharge into the Great Lakes.

14. Crayfish Plague (*Aphanomyces astaci*) - Introduced to Italy via ballast water discharge from N. American ship in 1860. Other countries it spread to: Sweden (1907), Spain (1958), Norway (1971), United Kingdom (1981), Turkey (1984), Turkey (1987). The plague has wiped out native populations of the noble European crayfish (*Astacus astacus*) almost to the point of extinction in some locations.

15. The noble European Crayfish (*Astacus astacus*)- The “best tasting” crayfish in Europe. Considered “vulnerable” (IUCN) today because of the crayfish plague. Crayfish consumption in Europe is used in many cultural festivities/feasts.

16. Signal Crayfish (*Pacifastacus leniusculus*)- 1950s-60s the Swedish people decided to introduce the signal crayfish as a replacement for the noble crayfish. The signal crayfish are more resistant to the plague than the noble crayfish.

17. Louisiana Crayfish (*Procambarus clarkii*) -Introduction has increased the spread of the plague to even more than the signal crayfish because it is able to out-compete the native crayfish, especially in clear water. It is able to survive poor quality water and move overland to other habitats and colonize new sites.

Background Information

The following information comes from the web site:

http://other-invertebrates.suite101.com/article.cfm/european_crayfish

The European Crayfish (*Astacus astacus*), also known as the Noble Crayfish, is the best-tasting crayfish in Europe. It was common in the past, but is now an ‘endangered species’. The demise of the European Crayfish is due to many of man’s activities.

Crayfish Plague

An American parasitic fungus (*Aphanomyces astaci*) was brought to Europe in the nineteenth century, probably in the water that ships used for ballast. It has now spread throughout the whole of Europe. Crayfish Plague seems to be less of a problem for some of the American species of crayfish, and the Signal Crayfish was deliberately introduced into Sweden to take over from the disappearing European Crayfish.

Signal Crayfish

The Signal Crayfish (*Pacifastacus leniusculus*) was a great success in some ways – it provided a continued supply of crayfish to eat! Unfortunately, while not itself badly affected by the parasitic fungus, it can carry it. The subsequent introduction of Signal Crayfish into many European waters hastened the spread of crayfish plague among the remaining populations of the European Crayfish which has no resistance at all.

Louisiana Crayfish

The Louisiana Crayfish (*Procambarus clarkii*) has also been introduced into many parts of Europe, and together with the Signal Crayfish it seems to have ‘sealed the fate’ of the European Crayfish. The Louisiana Crayfish, as well as carrying the Crayfish Plague, is able to out-compete the European Crayfish in its preferred habitat (clear unpolluted water). It is

also able to live in more turbid and stagnant water, to tolerate brackish conditions and to walk across dry land to find a new home. The Louisiana Crayfish is a very competent 'invasive species' in Europe.

Bank Damage

The Louisiana Crayfish makes deep burrows in the banks of watercourses, often causing serious damage. This can allow the water to leak out of natural channels and is harmful to natural water-courses, canals and irrigation systems alike. Once established the Louisiana Crayfish is almost impossible to control and it is considered a major nuisance.

Eating Crayfish

Although the European Crayfish is supposed to have the best taste of all, the other two species are very acceptable. The problem with the loss of the European Crayfish is not so much a culinary problem as an ecological one.

Ecological Problems

The European Crayfish evolved in European waters where it had its natural predators and prey. Things were 'naturally' in balance. We do not know enough about the ecology of the European Crayfish to be able to predict what problems are likely to emerge as a result of its extinction, and it is now almost too late to carry out any research – there are very few populations left. Introduced species often present new (and unpredictable) challenges, and only time will tell how the 'replacement' species of crayfish will interact with other European organisms.

The following information comes from the website http://en.wikipedia.org/wiki/Crayfish_plague

Crayfish plague

Aphanomyces astaci, is a water mold that infects crayfish, most notably the European *Astacus* which dies within a few weeks after being infected.

History

It arrived in Italy with ballast waters from a North American ship and quickly spread through Europe. After its original introduction in Italy in 1860, it spread quickly through Europe and was discovered in Sweden in 1907, in Spain in 1958, in Norway in 1971, in the United Kingdom in 1981, in Turkey in 1984 and in Ireland in 1987.

It has wiped out large populations of *Astacus*. Unfortunately, the Swedes tried to find a replacement crayfish in the 1950s and the 1960s and settled on the signal crayfish. The signal crayfish is, although more resistant than *Astacus*, a carrier of the plague, and efforts to reintroduce the original European crayfish have been quite unsuccessful because of subsequent large implantations of signal crayfish, most of them done on private initiative.

Transmission

Implantations of the signal crayfish was the reason for the spread of the disease to United Kingdom and Ireland. Transport of signal crayfish and infected *Astacus* between waters is indeed the main cause for contamination. Transmission of the disease through items that has been in

contact with contaminated water, for example a fishing tool, a canoe or a bird, is possible but unlikely and can occur only during the relatively short survival period of the spores, which is up to one week. The spores are also sensitive to high or low temperatures. It is still advised that local rules and regulations are observed and that the amount of water moved between different waters (in for example a boat) is minimized. It is also recommended to only use fishing bait from the same lake when fishing, alternatively freeze it to at least -10 °C for one day before use, if risk for contamination exists.

Signs of the disease

If large amounts of crayfish are visible during daylight hours, it can be a sign of infection - crayfish are normally nocturnal. The crayfish can also show signs of coordination difficulties and may for example be unable to turn around if they are turned on their back. Most often, however, the disease is not noted until large numbers of dead crayfish are found.

The signal crayfish

In Sweden the signal crayfish has also started to decline in significant numbers over the last years, and researchers now suspect that the signal crayfish may be less resistant to the plague than previously believed, possibly in combination with stress or another unknown disease. Research, however, is not yet finished.

Reintroduction

The crayfish plague disappears from an infected water system (connected lakes and rivers) in a few weeks, up to a month, after the last infected crayfish is gone. Reintroduction is then possible, as long as no infected waters are in contact with the lake.

Focus Question

How are the stories of the introduction of invasive species in the Great Lakes similar to the stories of the introduction of invasive species in Europe?

Attention-Getter:

Show preserved specimen of zebra mussels, sea lamprey, Eurasian ruffe, purple loosestrife, Eurasian watermilfoil, round goby, etc. Pass these around the classroom and let students take a good look at them so when they are discussed in their classmates' PowerPoint presentations, they will have a visual. While they may look very unassuming when preserved in a jar... their impact is astounding.

Describe classroom activity:

1. Students will research an invasive species and create a powerpoint presentation to present in class.
2. Student pairs will make presentation to class. Students will take notes on each presentation.
3. After these presentations are complete, the teacher will present the entire class with the PowerPoint on the Crayfish Plague of Europe. This presentation will demonstrate that invasive

species are a global problem, and the U.S. is guilty of distributing “invasive” species into other countries, just other nations have brought invasive species to the U.S.

4. Discuss the focus question: How is the introduction of invasive species into the Great Lakes similar to the introduction of invasive species into Europe/Asian rivers and lakes?

Assessment: See Biology Quiz attached

Extensions:

Have students research and discuss other invasive species both aquatic and terrestrial. This will allow students to find that even though the details of each story of an invasive species introduction differ, there are many similarities in that all species are introduced by human activities, mostly as a result of some economic development activity.

Resources: (need complete references) I’d suggest reducing this list to the top 10 or so that you want your students to use, that represent reputable info sources like universities, govt agencies, organizations, etc.

- http://en.wikipedia.org/wiki/Crayfish_plague
- http://other-invertebrates.suite101.com/article.cfm/european_crayfish
- <http://www.mimbon.de/archiv16/01.jpg> (noble crayfish image)
- <http://www.naturephoto-cz.eu/jokirapu-pic-2514.html> (noble crayfish image)
- <http://www.biol.pmf.hr/rakovi/images/A%20astacus%20aa.jpg> (noble crayfish image)
- <http://www.iucnredlist.org/search/details.php/2191/summ>
- http://en.wikipedia.org/wiki/Astacus_astacus
- <http://www.naturephoto-cz.eu/astacus-astacus-picture-2507.html> (noble crayfish image on title page)
- <http://www.boatnerd.com/news/newpictures02/paulrtregurtha6-01-02mn-pg.jpg> (Great Lakes freighter)
- <http://www.dlc.fi/~marianna/gourmet/crayfish.htm>
- <http://images.google.com/imgres?imgurl=http://www.disease-watch.com/documents/CD/index/images/cp1.jpg&imgrefurl=http://www.disease-watch.com/documents/CD/index/html/cp001cra.htm&h=170&w=263&sz=12&hl=en&start=5&tbnid=vg-y4RVgajhwtM:&tbnh=72&tbnw=112&prev=/images%3Fq%3Dcrayfish%2Bplague%2BAphanomyces%2Bastaci%26gbv%3D2%26svnum%3D10%26hl%3D> (crayfish plague image)
- http://en.wikipedia.org/wiki/Signal_crayfish (signal crayfish image)
- http://www.waterhabitats.co.uk/Images/clip_image004_0028.jpg (signal crayfish image)
- <http://www.american.edu/ted/crayfish.htm>
- http://en.wikipedia.org/wiki/Image:Procambarus_clarkii.jpg (Louisiana crayfish image)
- http://www.panda.org/about_wwf/what_we_do/marine/problems/shipping/alien_invaders/index.cfm (image of ship releasing ballast water in port)
- http://www.imo.org/Conventions/mainframe.asp?topic_id=867
- <http://skandland.com/images/crayfish4.gif> (cartoon man eating crayfish)
- Great Ships for the Great Lakes? Commercial vessels free of invasive species in the Great Lakes- St. Lawrence Seaway System, A scoping report for the Great Ships Initiative by

Allegra Cangelosi and Nicole Mays, Northeast-Midwest Institute, May 2006,
www.nemw.org

Student Presentation on Invasive Species in the Great Lakes

Directions

1. You will be assigned a partner to work with for this project.
2. You will be given an invasive species to research from this list:
 - * Eurasian Ruffe
 - * Eurasian Watermilfoil
 - * Fishhook Waterflea
 - * Flowering Rush
 - * New Zealand Mudsnail
 - * Purple Loosestrife
 - * Round Goby
 - * Rusty Crayfish
 - * Sea Lamprey
 - * Zebra Mussel
3. You and your partner are to create a short PowerPoint Presentation (5-10 slides) to be presented to your classmates during class. It should take you 5-10 minutes to make your presentation. Include the following information in your presentation:
 - a. Description of species including photographs or line drawings.
 - b. Description of the problems that the species causes in the Great Lakes.
 - c. Explain how the species arrived in the U.S.
 - d. Describe methods or attempts used to control the species.
 - e. Describe what people can do to prevent the spread of the invasive speciesProvide a rubric – assign points for each of the above items to aid with assessment.

4. Use at least three different websites to obtain all the information required. Show complete reference:

Internet Source

Author's last name, author's first name. Title of document. Name of organization that posted the document.
Retrieved on <date> from <website address>.

<http://www.seagrant.umn.edu/ais/>

Minnesota Sea Grant website

<http://www.protectyourwater.net/>

Stop Aquatic Hitchhikers Web host?

<http://www.anstaskforce.gov/>

Aquatic Nuisance Species Task Force

Web host?

<http://www.invasivespecies.gov> Federal Invasive Species Site Web host?
<http://www.nas.er.usgs.gov/> US Nonindigenous Aquatic Species U.S. Geological Survey
<http://www.protectyourwaters.net/> for boaters/anglers to stop boat/bait introductions Web host?
<http://www.habitattitude.net/> web site for pet owners and aquarium owners program to
prevent aquarium introductions Web host?
<Http://www.miseagrant.umich.edu/> Michigan Sea Grant Web host?

5. Your classmates will be taking notes on your presentation so make sure that your slides are easy to read from a distance and short enough that other students can write down the information needed easily (DO NOT CUT AND PASTE LARGE PARAGRAPHS OF INFORMATION FROM WEBSITES INTO YOUR PRESENTATION!!!)

6. This project will be worth a **test grade** and you and your partner will be graded separately for your own personal efforts on this project.

7. Good luck... it will be great to see the results of your research!



Biology Quiz

Name _____

Invasive Species *into* and *out of* the GL Period _____ Date _____

1. Describe one invasive species in the Great Lakes that was introduced as a garden plant and has escaped cultivation into the wild.

2. Describe one invasive species in the Great Lakes that was introduced via ballast water release from an overseas ship.

Match the following species with its description below:

- a. zebra mussel b. round goby c. purple loosestrife d. New Zealand mudsnail
e. spiny waterflea f. signal crayfish g. crayfish plague h. Eurasian watermilfoil
i. Eurasian ruffe j. flowering rush k. sea lamprey l. rusty crayfish
m. noble European crayfish n. Louisiana crayfish

1. _____ An invasive species in the Great Lakes(GL) that swam in through the Welland Canal and did severe damage to the fishing industry in the GL.
2. _____ An invasive species in the GL that is a small bottom-dwelling fish that does damage to the native fish by eating their eggs and taking over habitat.
3. _____ A native species in Europe's freshwater environment that is used as a food source for people and plays an important role in the ecosystem.
4. _____ An invasive species in the GL that was released as a garden plant that can form dense stands that crowds out native plants.
5. _____ An invasive aquatic submerged plant that grows in dense mats underwater and chokes out other native plants.
6. _____ A tiny snail released from ship ballast water that disrupts the food web of trout streams, first detected in Idaho' Snake River in 1987.
7. _____ Invasive species in the GL that is a small, predaceous crustacean that competes with other organisms and fouls fishermen's gear.
8. _____ An invasive species in the GL that is a tall purple-flowering plant that crowds out native plants by forming dense mats of vegetation.
9. _____ An invasive species in the GL that is a small mussel that filter-feeds an amazing amount of water and has cleaned up water quality in GL.
10. _____ The fungal plague that decimated the noble crayfish population of Europe that was introduced via ballast water from an N. Amer. ship in 1860.

Answer Key to Quiz

1. Students may discuss the purple loosestrife or flowering rush.
2. Students may discuss one of the following: Eurasian ruffe, spiny or fishhook waterfleas, New Zealand mudsnails, round goby, zebra mussel, or the crayfish plague of Europe.

Matching:

1. K
2. B
3. M
4. J
5. H
6. D
7. E
8. C
9. A
10. G
11. I
12. L
13. N
14. F

Essay: Student answers will vary but should be similar to what they presented in their PowerPoint presentation in class.