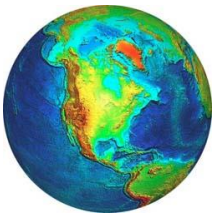


Biodiversity: Nonindigenous Species

Since the early 1800s, over 180 species of aquatic plants, algae, fish, worms, mollusks, and other organisms have invaded the Great Lakes. Likewise, some North American species such as the green sunfish (*Lepomis cyanellus Rafinesque*) have migrated eastward to become pests in Europe. Biologists worry about these intrusions because each new species in the Great Lakes alters the region's ecosystem. Any environment has a fixed amount of energy that must be divided among all the species present. When a foreign (exotic) species invades an ecosystem, it often has no enemies. This allows an invader to increase rapidly, displacing native organisms by filling their niche. This change allows the once biodiversified region to lose some of its genetic diversity. As climate changes, even more invasive species could invade the Great Lakes. This is because warming temperatures would allow species to expand their ranges into areas that were previously too cold for them to survive. In addition, native species that are pushed out by invading species could move into new areas and begin to take on invasive characteristics.

How these invaders got into the region varies, but many have been introduced accidentally. About two-thirds of invasive species introductions have occurred through the shipping industry. When ships are not loaded with cargo, they take on ballast to balance and stabilize them as they travel. The use of water as a ballast material has replaced the use of sand and stones. Ballast tanks are filled with water from the harbor where ships are loaded and then dumped, along with any aquatic organisms present, when ships reach their destination. These species can also hitchhike on recreational equipment like boats, jet skis, fishing gear, and other equipment to travel to new locations.

Invasive species may also be introduced intentionally. For example, when pet owners decide they no longer want their aquarium plants, fish, reptiles, or other animals, they often release them into the natural environment. Many of these pets are tropical or sub-tropical species that could not survive in colder water temperatures. But that could change as water temperatures warm and these species begin establishing populations in backyard lakes and ponds, and work their way through local water systems.

Activity: What do scientists know about invader species of the Great Lakes and the effects that global change will have on them?

Earth System Understanding

This activity focuses on ESU 3, 4, and 5. In addition, Extensions address ESU 1, 2, 6, and 7. Refer to the Framework for ESE for a full description of each understanding

Scenario Reference

#2, Will biological diversity in the Great Lakes region suffer?

Materials

For each group of 3-4 students:

- Copies of the included information cards. Each of the four card categories (invader picture, introduction, ecosystem impact, and climate change) should be copied onto a different color card stock paper
- Answer sheet

Invader Species in this Activity

Zebra Mussel
(Dreissena polymorpha)
Sea Lamprey
(Petromyzon marinus)
Spiny Water Flea
(Bythotrephes cedarstroemi)
Eurasian Ruffe
(Gymnocephalus cernuus)
Alewife
(Alosa pseudoharengus)
Asian Carp
(Hydrilla verticillata
Purple loosestrife
(Lythrum salicaria)
Eurasian watermilfoil
(Myriophyllum spicatum)

Objectives

At the completion of this activity the student should be able to:

- Name and visually recognize some invader (nonindigenous) species of the Great Lakes.
- Locate on a world map the origins of the Great Lakes invader species
- Explain the ways in which invader species are introduced into the Great Lakes
- Explain the impacts of invader species on the Great Lakes ecosystem
- Analyze the impacts of global change on invader species of the Great Lakes.

Procedure

1. Copy the included cards (one complete 4-color set of 32 for each group) and cut them apart.

2. Divide class into groups of three to four people each. Give each group a complete set of shuffled cards. (If there are eight groups, each group will be able to take a separate invader to report on at the conclusion of the activity).

3. Beginning with the picture of the invader, each group should match the cards to determine which introduction, ecosystem impact, and global change card goes with each invader. For each picture, there should be one matching card of each other color.

4. When group members agree that they have matched the cards to the best of their ability, they may check their answers on the answer sheets.

5. Have each group of students select an invader to present to the class; the students could construct a poster on the invader, develop a fact sheet, or create a skit to explain their invader. The impacts of the invader on human affairs should be included.

Extensions

1. Do research on controls that have been tried on various invader species and report on their successes or failures. Brainstorm a creative way to control one of the invaders.
2. Draw a humorous cartoon depicting the problem of invader species (Example: A zebra mussel looking for a place to attach on an already over-crowded lake bottom, a white perch nudging out a yellow perch, purple loosestrife chocking other plants, etc.
3. Research the temperature range of the invasive species (cold-, cool-, or warm-water) and determine if global climate would be beneficial, or harmful to that species in the Great Lakes.

Review Questions

1. Why should people be concerned about nonindigenous species?
2. How can the transfer of invader species be controlled or stopped in the Great Lakes or elsewhere in the world? Draft a piece of legislation that your group thinks could be enacted to stop exotic species from invading the Great Lakes.
3. Explain what effects global warming may have on any of the invaders discussed—which species will benefit by the change and which will be negatively impacted?
4. Identify as many Great Lakes jobs as possible

Answers to Review Questions

1. Invading species threaten to change present ecosystems, often in unpredictable ways. Because invaders frequently do not have predators, they often have the ability to disrupt the existing ecological balance and dominate an area. Consider the effects of European humans after their introduction to North America. How many other species have humans displaced?
2. Ballast water is critical to the spread of invaders. Moving species via recreational activities and intentional introductions by aquarium owners are also ways species spread. Have students brainstorm different ways that invaders can be introduced and possible methods for preventing their spread.
3. Refer to Global Climate Change cards
4. Increased numbers of researchers are needed to study the potential impact and spread of the invaders. There could be new public water systems and industry jobs to keep pipes clean. Fishers will be affected because the type and quality of catch (fish size and health) will be different. Beach cleaners would be needed to get rid of dead fish, and boat cleaners will be in great demand to protect boats from invaders (potentially by developing and applying special toxic paints that will prevent zebra mussels in particular from adhering to boat hulls). Recreation facilities will most likely also experience some increased business because of the added water clarity that zebra mussels cause by filtering water, but may also lose some business because of decreased fishing opportunities. Park systems and gardeners must be concerned because invader species will compare with the native vegetation and wildlife.

Invader Cards:

Invader 1: Zebra mussel (*Dreissena polymorpha*)

Introduction: Originally from the Caspian Sea region of Poland, Bulgaria, and Russia. Canals built during the early 1800s allowed it to spread throughout Europe. By 1830 it had invaded Britain. First introduction into the Great Lakes was about 1985, when one or more transoceanic ships discharged ballast water into Lake St. Clair. Freshwater ballast from a European port likely contained larvae and possible yearlings. Being a temperate, freshwater species, it found the plankton-rich Lake St. Clair and Lake Erie to its liking.

Ecosystem Impact: It filters the plankton from the water, binding what it doesn't use into pellets that cannot be used by other plankton-feeding organisms. It accumulates on objects such as boat hulls and underwater pipes, clogging valves of both industrial and municipal water intake sources.

Effects of Global Change: It is very likely that this bivalve will be a permanent part of the Great Lakes environment. It is limited to waters with a temperature between 12°C to 27°C. As global warming increases the temperature of the Great Lakes, it will spread farther north into warmer waters. As the water level in the Great Lakes recedes, it will be able to colonize new areas that at one time were too deep for its survival.

Invader 2: Sea Lamprey (*Petromyzon marinus*)

Introduction: Originally from the Atlantic Ocean where natural populations move into Lake Ontario and the St. Lawrence and Hudson Rivers and their tributaries to spawn. It swam from Lake Ontario into Lake Erie through the Erie and Welland Canals, gaining entry into the upper Great Lakes. Prior to the opening of these canals, Niagara Falls served as a natural barrier to keep sea lampreys out of the upper Great Lakes.

Ecosystem Impact: It destroys valuable fish, especially lake trout, by attaching with its sucker-like mouth to suck out blood and body tissues. It upsets the ecological balance by removing top predators, allowing for explosion of populations of smaller fish such as alewives. It had great economic impact on the commercial fishing industry of the Great Lakes during the 1950s.

Effects of Global Climate Change: Warmer stream temperatures create a more favorable environment for this parasitic organism, enabling it to spawn successfully at more locations throughout the Great Lakes basin. This could result in an increase in population that may upset the ecological balance of the Great Lakes.

Invader 3: Spiny Water Flea (*Bythotrephes longimanus*)

Introduction: A native of northern Europe, it made its way into Lake Huron in 1984 and was present in all Great Lakes by 1987. It is believed to have been brought over in fresh water or mud in ballast water of European freighters from Eastern Baltic Ports, as studies show that the Great Lakes species closely resembles the species in ports of Finland and St. Petersburg.

Ecosystem impact: The spiny water flea is a large plankton that eats smaller plankton, thereby competing with small fish for food and affecting their survival and growth rates. Its spiny tail may prevent young fish from swallowing it, removing it from the food chain.

Effects of Global Climate Change: This invertebrate is sensitive to warmer temperatures of about 25°C, as noted in the Western Basin of Lake Erie. As water

temperatures increase, they will move into colder, deeper parts of the Great Lakes, where temperature conditions are more hospitable.

Invader 4: Eurasian Ruffe (*Gymnocephalus cernuus*)
Introduction: Arriving from the freshwater and brackish water regions of northern Europe, this invader was discovered in Lake Superior in 1986. It is assumed that it "hitchhiked" in ballast water from Europe and Asia. In just five years after its introduction, its population reached 1.8 million adults, making it the most abundant fish in the Duluth harbor. This bottom feeder can reproduce in its first year, and females can lay between 13,000 to 200,000 eggs per season.
Ecosystem Impact: Only about 8 inches long, this perch-like fish has little value as a sport or food fish. It is less temperature-dependent than perch and tolerates more polluted areas. It can also find hidden prey in soft sediments more efficiently than its competitors. This fish is not preferred by predators because of its spiny fins. It displaces sport and food fish, especially perch and walleye, yet it is not readily consumed in the food web. This invader made up 90 percent of the fish population in the Scottish lake, Loch Lomond, only 9 years after it was introduced.
Effects of Global Climate Change: This species is currently found in Lake Superior, Lake Huron and Lake Michigan. As a perch-like fish, Eurasian ruffe prefers warmer temperatures than those found in the upper lakes, where they were first introduced. Warmer temperatures in those lakes caused by predicted climate change may provide more favorable conditions for European ruffe, which could help them expand their range.

Invader 5: Alewife (*Alosa pseudoharengus*)
Introduction: Coming from the salty Atlantic Coast, this invader migrated through water routes, including canals in New York State and the St. Lawrence River. It swam into the upper Great Lakes through the Welland and/or Erie barge canal before 1931.
Ecosystem impact: Large numbers of die-offs clog municipal and industrial intake pipes and foul beaches. In 1967 bulldozers had to remove 50,000 tons of rotting fish. The sea lamprey enabled this invader to thrive in Lake Erie by killing predators like the lake trout and other fish at the top of the aquatic food chain. After the sea lamprey arrived, this invader proliferated. Between 1960 and 1966, for example, they went from representing eight percent to 80 percent of Lake Michigan's fish by weight. Presently, this invader is forage for larger game fish.
Effects of Global Climate Change: These herring-like fish need deep water with moderate temperature to overwinter. A rise in water temperature would probably result in fewer die-offs and would enable the fish to be more abundant in Lake Superior where they are currently scarce. While this would alter local fisheries, but the specific impacts are not yet clear.

Invader 6: Bighead and Silver Carp (Asian Carp) (*Hypophthalmichthys nobilis* and *H. molitrix*)
Introduction: Bighead and silver carp are members of the Asian carp complex, along with grass and black carp. They were both intentionally introduced into the United States to control algae growth in aquaculture ponds. During flooding in the early 1980s, they

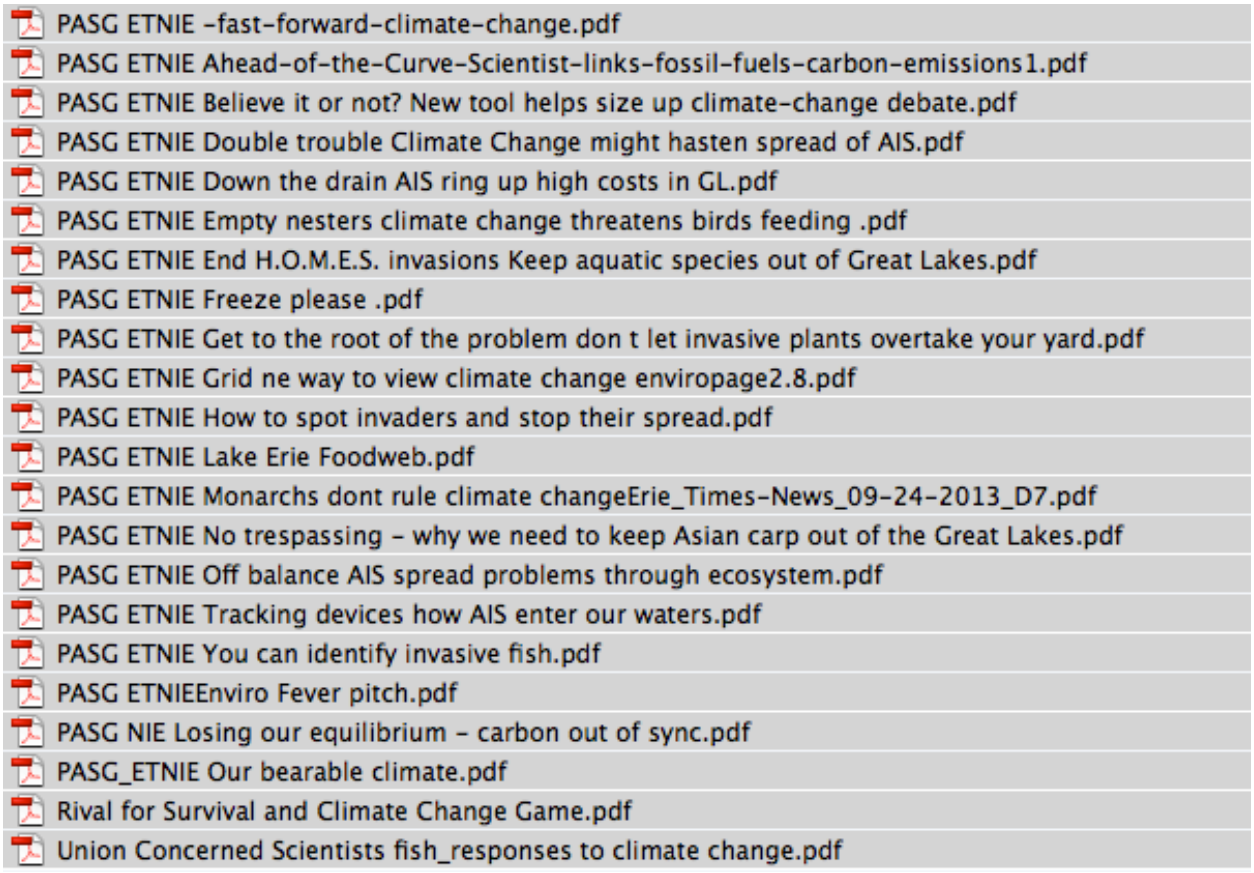
escaped into the Mississippi River and have since moved upstream towards the Great Lakes.
Ecosystem impact: Asian carp consume vast amounts of plankton and detritus each day, competing with native filter feeders and juvenile fish for food. This impact on the food web and trophic structure of the ecosystem could result in large population declines, impacting biodiversity as well as commercial and recreational fishing. In addition, when startled by boat motors or other equipment, the silver carp can leap up to 10 feet out of the water, endangering boaters and water sport enthusiasts.
Effects of Global Climate Change: There are several factors that could limit the Asian carp's distribution in the Great Lakes, including temperature, and the availability of food sources and spawning habitat. As temperatures warm, productivity and food availability could increase in the open waters of the Great Lakes, increasing the amount of suitable habitat available for this species. In addition, the amount of time spent in the eggs stage is temperature dependent for Asian carp; therefore, warming temperatures could reduce the gestation time of the egg, and reduce the amount of stream habitat needed for spawning.

Invader 7: Purple loosestrife (*Lythrum salicaria*)
Introduction: This species was intentionally imported from Northern Europe over 100 years ago because its hardiness and beautiful flowers were popular with landscapers, florists, and gardeners.
Ecosystem Impact: It is called "the beautiful killer," because its dense roots choke waterways as it competes with other vegetation. It spreads quickly, crowding out valuable plants that provide food for migrating waterfowl, and destroys habitat for almost all other forms of wetland life.
Effects of Global Climate Change: As water levels decrease, this invader will find new wetlands in which to spread, choking out more and more vegetation as it follows the receding waterline.

Invader 8: Eurasian watermilfoil (*Myriophyllum spicatum*)
Introduction: It came from Europe, Asia, and North Africa and was introduced into North America as an aquarium plant. It has since spread to 37 states and three Canadian provinces.
Ecosystem Impact: Forms thick mats that choke out native aquatic vegetation. It disrupts all forms of water recreation—boating, swimming, and fishing.
Effect of Global Climate Change: This plant thrives as waters warm each summer, increasing in volume in relation to the increased water temperature. As waters in the Great Lakes region warm, this invader could thrive in the new climate, spreading rapidly to become an even bigger problem

Resources:

- Union of Concern Scientists - http://www.ucsusa.org/global_warming/
- http://www.paseagrant.org/fact_sheet_group/invasive-species/
- PA Sea Grant/Erie Times-News in Education pages Climate change/AIS pages listed below can be found in the resource folder.



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Sea Grant Great Lakes

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