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Invaders!

What would you do if your home was taken over by invited and uninvited guests who refused to leave?

Grade Level
Upper Elementary School, Middle School, High School

Subject Areas
Life Science, Environmental Science, Ecology

Duration
Preparation time: Warm Up: 10 minutes; Part I: 10 minutes; Part II: 5 minutes; Part III: 10 minutes
Activity time: Warm Up: 10 minutes; Part I: 10 minutes; Part II: 5 minutes; Part III: 10 minutes

Setting
Outdoor and classroom

Skills
Gathering information (observing, researching); Organizing (graphing); Analyzing (identifying components and relationships among components, discussing); Interpreting (summarizing, identifying cause and effect); Applying (hypothesizing); Presenting (reporting)

Charting the Course
An adaptation of "Humpty Dumpty" is ideal for demonstrating how invasive species change ecosystems and how difficult it can be to restore native plants and animals. Invasive species could also be added to "8-4-1, One for All" as a watershed management obstacle and the basis for a discussion on how people are trying to manage invaders.

Vocabulary
Aquatic Invasive Species, lionfish, habitat, ballast, watershed, non-native, ecosystem, native, biodiversity, food chain, predator/prey relationship, riparian, bilge water

Summary
Students will learn what aquatic invasive species are and then participate in a full-body movement game that simulates competition for habitat and resources; students will also create graphs and find out about prevention and management of aquatic invasive species.

Objectives
Students will:
- define the term "aquatic invasive species."
- describe how an aquatic invasive species could be transported between water bodies.
- identify how an aquatic invasive species can impact native species and their natural habitat.
- discuss existing management strategies for controlling aquatic invasive species.
- identify at least three aquatic invasive species within their own state or region.

Materials
Warm Up
- ***Lionfish*** (one per group)

Part I
- *Carpet squares or chairs* (number of students in class minus two; you can also use chalk and draw squares on playground blacktop or in the dirt)
- *Two cards with word "Predator"* (Cards can be laminated and put on a string or attached to students' upper back with a clothespin)

Part II
- *Carpet squares or chairs* (number of students in class; you can also use chalk and draw squares on playground blacktop or in the dirt)
- *Strips of green and red paper* (at least two per student—depends on how many rounds are played)
- *Chalkboard, dry erase board or large piece of butcher paper for graphing*
- *Red and green markers*

Part III
- ***Aquatic Invasive Species Alert!*** (one per group)

Making Connections
Students may have heard the term "aquatic invasive species," but they may not know which species are causing problems, understand their impact on native species and habitat or realize how they are transported from one water body to another. Students will learn about specific kinds of aquatic invasive species, how they impact native species and habitat both generally and specifically and what they can do to prevent the spread of these invaders.

Background
Aquatic Invasive Species (AIS) are non-native organisms that require a watery habitat to live and reproduce in. They pose a serious problem in many parts of the United States.

The National Invasive Species Council defines invasive species as "…an alien (or non-native) species whose introduction does, or is likely to cause economic or environmental harm or harm to human health." Other synonyms used by scientists and federal agencies are exotic species, invasives and nonindigenous species. Invasives are typically very difficult to eradicate once they have established themselves in an ecosystem. These invaders create significant problems when they take over a habitat or ecosystem, resulting in the elimination of the native species formerly present and impacting biodiversity, food chains, predator/prey relationships and other ecosystem functions.

Aquatic invasives can be either aquatic plant or aquatic animal species. These are plants and animals that did not evolve within that watershed but have come to inhabit a niche either through accidental or purposeful introduction. Almost every watershed has troublesome non-native (introduced) species.

Invasive plant species are introduced plants that have adapted to living in, on or next to water and that can grow either submerged or partially submerged in water. Aquatic invasive animals require a watery habitat, but do not necessarily have to live entirely in water.

Some non-native species are relatively innocuous or even beneficial, providing shade, landscaping, food, shelter and other services to humans without dramatically impacting their new environments. Other non-native species, however, can have significant negative impacts on ecosystems, agriculture, recreation and other systems.

Tamarisk (*Tamarix spp.*), an ornamental tree native to Eurasia, is one example of a widespread invasive plant species. Tamarisk can be found in lower-elevation watersheds throughout northern Mexico and the western United States. When the tamarisk was originally introduced as an erosion control measure in the 19th century, people did not foresee that it would quickly invade waterways throughout the basin, use large amounts of water, increase soil salinity, out-compete native plants and dramatically alter riparian ecosystems.

Native riparian cottonwood/willow communities, which support some of the highest numbers of breeding bird species found in any vegetative community type in the United States, have declined as tamarisk has invaded. Now tamarisk is acknowledged as a major economic and ecological problem and large amounts of money are being spent in an attempt to remove it and restore the native vegetation.

The tamarisk is certainly not the only example of an intentionally introduced nonindigenous species, however. Non-native sport fish (fish that are challenging to catch and good to eat) are sometimes stocked in lakes and ponds to create better fishing opportunities.

Nutria (*Myocastor coypus*)—large, beaver-like rodents native to South America—were brought to the United States to be farmed for fur in the 1940s, but nutria that escaped or were released into the wild from captivity went on to found populations throughout the southeastern United States.

Other aquatic invasive species introductions can be accidental, with nonnative plants and animals arriving in imported seed mixes, in the bilge water of boats, in mud on the feet of migrating birds, attached to pets and other animals, etc.

In the late 20th century, zebra mussels (*Dreissena polymorpha*) are believed to have been picked up in a freshwater European port in the ballast water of a ship and later

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Tamarisk, also called Salt Cedar, is found in many watersheds throughout northern Mexico and the western United States.

PHOTO CREDIT: © Ivana Beluzic Shejbal | Dreamstime.com

The most obvious difference between a nutria and a beaver is the animal's tail. Nutria do not have the paddle tail found on beavers.

discharged into the Canadian portion of a lake in Michigan. They then expanded their range from the Great Lakes into the Eastern Seaboard and throughout the Mississippi River Basin, traveling primarily by attaching themselves to boats. A tiny mollusk native to Eastern Europe, the zebra mussel continues to be a species of major concern as it spreads westward into lakes and reservoirs because of the damage caused when the mussels clog the workings of dams and diversions.

Zebra mussels also affect the food webs of rivers and lakes. A single zebra mussel can filter over one quart of water per day, which removes plankton from water and allows sunlight to penetrate more deeply into the water. This causes light-sensitive fish, such as walleye, to move into deeper waters. The increase in sunlight can also promote greater growth of weed beds and an increased food supply for bottom feeding fish—which can then prey on more desirable fish in a water body.

The sea lamprey (*Petromyzon marinus*) is one notorious accidentally introduced invasive that made its way into the Great Lakes in the mid-19th century through shipping canals from its native habitat in the Atlantic Ocean. Sea lamprey eventually destroyed the lake trout population of the Great Lakes and severely impacted commercial and recreational fisheries.

Aquatic invasive species also can be introduced by a combination of natural events, unfortunate accidents and human introduction. Originally from the Indo-Pacific Ocean Basin, lionfish (*Pterois volitans; P. miles*) have established a new home range in the warm Atlantic Gulf Stream waters.

In 1992, a few lionfish were most likely introduced into Biscayne Bay, Florida; when a beach side aquarium or nursery broke open during Hurricane Andrew. However, the first sighting of lionfish was actually reported in 1985, leading experts to theorize that aquarium owners were most likely releasing them—intentionally or unintentionally—into natural water bodies even before the storm.

While this fish is a valued addition to an aquarium, when out of its home range and relocated to suitable habitat in the wild such

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Zebra mussels attach to solid surfaces in water, such as branches, and can clog water pipes and affect the food web in a water body.

as the southeastern coast, it out-competes the resident predators and takes a deadly toll on native marine animals. The lionfish is now the top predator in coral reef environments along the coast of Florida, with its range stretching northward to North Carolina. Lionfish aren't picky about what they eat, preying upon more than 50 other species of fish as well as on crustaceans such as lobster, shrimp and crabs. They even eat the herbivorous fish that control seaweed growth on coral. All this negatively impacts the natural environment as well as the fishing industry.

The few examples above are but a tiny sample when contrasted with the more than 6,500 invasive organisms in the United States that exact as much as $138 billion in economic, environmental and human health losses and expenditures each year.

No one method of control is sufficient to deal with AIS. Measures of eradication include chemical, biological and mechanical controls. Chemical control employs pesticides, attractants, sterilants and repellants. Biological methods rely on more natural strategies like stocking invasive-specific predators or introducing sterilized individuals. Unfortunately, these solutions are not without their own set of complications. For example, when the stocked predator is also a non-native, they may find alternative prey resulting in a compounded problem. Or the chemical control could harm native species along with the non-native invader. Mechanical controls rely on Best Management Practices such as controlling water levels, trapping invasives or extracting the species physically from the environment. Whatever the solution, each watershed requires an individual management plan that involves many both the experts and the community.

PHOTO CREDIT: © Hemera –Thinkstock Photos

Sea lamprey attach to fish and live off of the fish's bodily fluids, often killing the fish, which can have devastating effects on commercial and recreational fisheries.

PHOTO CREDIT: © Hemera–Thinkstock Photos

Lionfish have venomous tentacles, making them dangerous to humans and to potential predators.

Procedure

Warm Up

- Define for students the terms aquatic species and aquatic invasive species.
- Tell students that they will be investigating an aquatic invasive species. Provide them the **Student Copy Page—*Lionfish.***
- After they have had an opportunity to work with the **Student Copy Page,** discuss various scenarios as to how lionfish, which are native to Pacific waters, might have found their way to Atlantic waters. Discuss the threat lionfish pose for aquatic organisms as well as humans.

The Activity

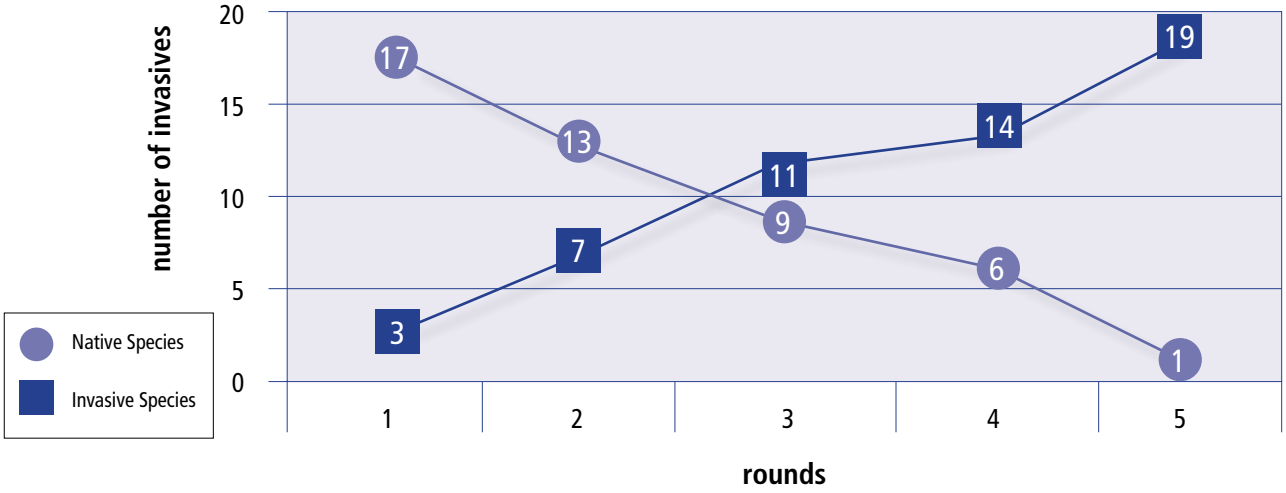
Part I

1. **Select a playing area about 40 feet on each side.** Place chairs or carpet squares within the playing area. If playing outdoors, you can also draw squares in the dirt or with chalk on pavement. Use two fewer squares than there are students.
2. **Explain to students that most of them are native animal species. The squares represent habitat which contains everything they need to survive.** Only one student (native species) can survive on each square.
3. **Assign two students to be "predators" by wearing the "predator" cards. As students seek habitat, "predators" may tag them and put them out of the game and on the sidelines. Once a student is on a habitat square they are "safe" for that round.** (For larger groups, more predators may be needed. Remove a square for each predator.)
4. **Line up students around the perimeter of the playing area. On your signal, students must find a habitat.**
5. **The game ends when most students have found a habitat (by standing on a square).**
6. **Those that do not find habitat (either because there were not enough squares or they were tagged by predators) do not survive and must go to the sidelines.**
7. **Ask students, "Was it difficult to find habitat? Did the majority of species survive? What did they observe regarding competition for habitat?"**
8. **Ask students to write a two-sentence summary of the scenario they enacted. When they are finished, have several students read their summaries. Create a class summary.** It should include the following points:
   - Native species compete for habitat and resources in the natural world.
   - Not all species survive as there may not be sufficient resources or habitat.
   - Native species are lost to predation or die from injury or age.

Part II

1. **Arrange chairs or squares (one per student) back-to-back in a curving line to represent a stream or river channel (preferred habitat for wetland plants).**
2. **Tell students they will be playing a game similar to musical chairs.** Select three students to be aquatic invasive species, and give each student a strip of red paper. Give each remaining student a green strip of paper, representing native species.
3. **For the first round, there will be enough chairs for all the students to succeed within the environment, whether they are native or an aquatic invasive species. As with musical chairs, when the music is playing, students circle the chairs clockwise. When the music stops, they must find a chair, signifying that they**

Part I: In this example of Part I of the Invaders! activity, a group of 20 students starts out as 17 native species and 3 invasive species. In just 5 rounds of play, there are 19 invasives and just 1 remaining native species.



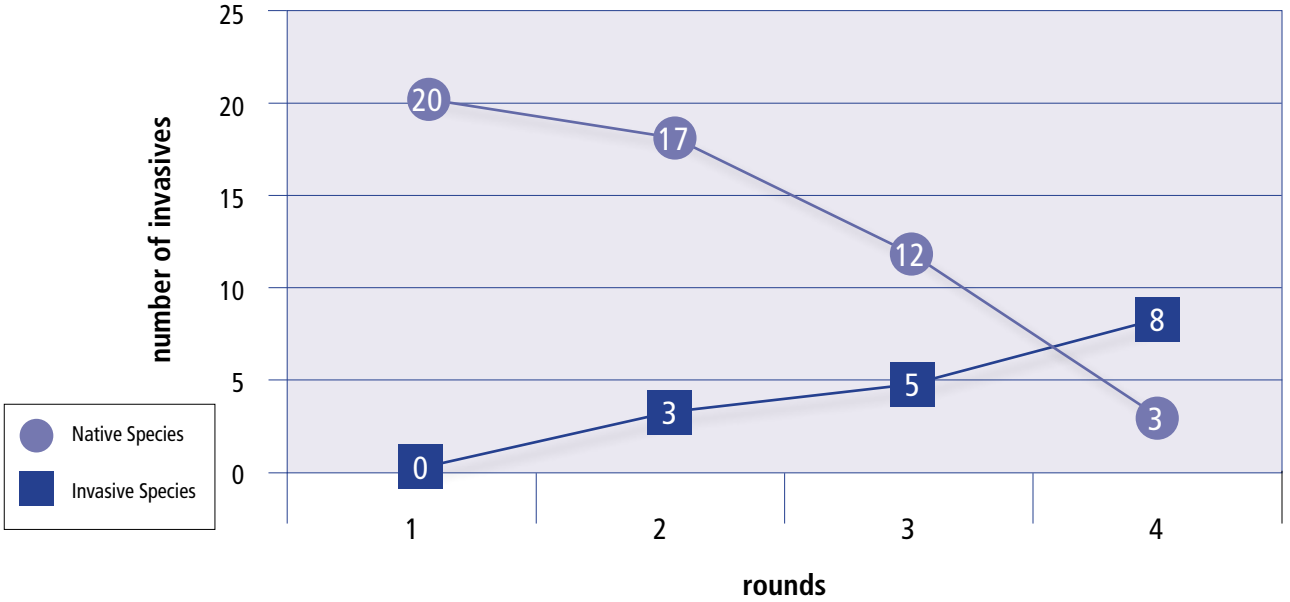
have acquired enough water and habitat resources to survive. When students leave their chairs for the next round, they should leave their strips of paper on their chairs. Tell students that invasive plant species may have a competitive advantage over native species by growing or reproducing more quickly, having fewer predators or other adaptations. Do not give new strips of paper to any students after round one.

4. **After the first round, demonstrate the advantages that the invasives have by allowing the students in the aquatic invasive species group to closely circle the chairs, while all the native plant students must circle at a distance of six feet.**
5. **In ensuing rounds of the game, the goal is for each native species to find a chair marked with a green strip of paper, signifying available habitat and resources not taken over by invasives.** Students already designated as invasives (red) can sit in any chair. If a native species (green) can't find a chair marked with a green strip, they must sit on a spot marked with a red strip; that student then becomes an invasive species and gains the advantage of circling the chairs closely during the next round. Once a student becomes invasive, they remain invasive throughout the duration of the game and receive a new red strip of paper at every round. If an invasive sits at a chair marked with a green strip, that chair then becomes invasive habitat and the green strip is replaced by a red strip. Continue to give only students in the invasives group red strips of paper to mark their chairs, replacing the green strips when they take over (populate) those spots (habitat).
6. **At the beginning of each round, count the number of invader students and the number of native plants students. Record these numbers so you can graph them later.** As the game progresses, more and more chairs will be taken over by the invasives, leaving less and less habitat for the native plants (as well as the animals, birds and insects that have evolved to depend on those plants). Play enough rounds so that almost all the chairs are taken by aquatic invasive species students.
7. **Make a line graph showing the number of non-native and native plants present at the beginning of each round on a dry erase board or large piece of butcher paper (see sample graph). Use a red marker to represent invaders and a green marker to represent native plants.** You'll see that the non-native line will start low and rise as the rounds progress, while the native plants will start high and decline.
8. **Explain that the data they graphed is similar to the types of data that a biologist would collect and plot. That data can be used in restoration and management efforts.** Tell students that aquatic invasive species management will be discussed in ***Part III.***

Part III

1. **Ask students if they know what is being done about invasive species.** Have they heard of any efforts to

Part II: In this example of Part II of the Invaders! activity, a group of 20 students starts out as all native species. After 4 rounds of play, just 3 native species and 8 invasives (a total of 11 species) remain.



control or manage invasive species populations?

2. **Have students visit http://nas.er.usgs.gov/queries/StateSearch.asp and using the "state search" feature find at least three aquatic invasive species in their own state or region.** If an Internet search is not possible, students can research local non-native invasive species by contacting the state agency charged with managing AIS.
3. **Hand out the Student Copy Page—*Aquatic Invasive Species* and ask students, "What would you need to know to eradicate or control an aquatic invasive species?"** Students can research answers in small groups, or the following list can be shared with them after class discussion:

   Research information may include:
   - The life history of the non-native species.
   - The life history of native species sharing the river or basin and impacted by the invader.
   - The geographic range of both native and non-native species .
   - An exploration of the control methods used by experts—chemical, biological and mechanical.
4. **Ask students why extensive research should be conducted before any method is selected.** (Chemicals [poisons] may affect native species; introduced predators may feed on native species; anything that is introduced may further disrupt the natural system.)
5. **Ask students to return to their small groups. Tell them that they are on a task force responsible for the control of an aquatic invasive species. Provide each group with the Student Copy Page—*Aquatic Invasive Species Alert!***
6. **After they have had time to work through the page, discuss group results.** Groups can appoint a "spokesperson" to explain their conclusions. Compare results. Are the groups' solutions similar or different?

Wrap Up

- Ask students if they believe it is possible for an aquatic invasive species to eliminate a native species. How do they think this would impact a natural ecosystem? (There are several examples, but one is the lionfish, which can eat the entire native fish population on coral reefs, including herbivorous fish that control seaweed growth on coral.)

Project WET Reading Corner

Aronson, Virginia and Allyn Szejko. 2010. *Iguana Invasion! Exotic Pets Gone Wild in Florida*. Sarasota, FL: Pineapple Press, Inc.

Who would have suspected that the innocent release of some unwanted pets could contribute to a real disruption in some of Florida's ecosystems?

Batten, Mary. 2003. *Aliens From Earth: When Animals and Plants Invade Other Ecosystems*. Atlanta, GA: Peachtree Publishers, Ltd.

The problems of non-native species invading ecosystems can be devastating, expensive and impossible to reverse.

NSTA Staff. 1998. *Introduced Species*. Arlington, VA: National Science Teachers Association.

If you have ever seen a field overgrown with kudzu or have seen zebra mussels in an estuary, you know the problems that these non-native species have caused.

Assessment

Have students:

- identify the term aquatic invasive species (***Warm Up).***
- describe three ways that an invasive species may be transported between water bodies (***Warm Up***).
- discuss two ways an aquatic invasive species may disrupt a natural system. (***Part I*** and ***Part II).***
- cite three management strategies to control or eradicate an aquatic invasive species (***Part III).***
- identify at least one aquatic invasive species within the student's own state or region and how it is being controlled (***Wrap Up***).

Extensions

Invite a biologist or other aquatic invasive species expert to discuss aquatic invasive species and management strategies with the class.

Teacher Resources

Books

Krasny, Marianne E. and the Environmental Inquiry Team. 2003. *Invasion Ecology* (Teacher's Guide). Arlington, VA: National Science Teachers Association.

Journals

Holiday, Susan. 2003. "A Native Species Restoration Project." *Science Scope*, 27 (2), 24-27.

Mason, Kevin, Krista James, Kitrina Carlson and Jean D'Angelo. 2010. "The Invasive Plant Species Education Guide." *The Science Teacher*, 77 (4), 32-36.

Stracey, Christine. 2008. "Science Sampler: Alien Invaders!" *Science Scope*, 31 (6), 53-57.

Websites

United States Department of Agriculture. National Invasive Species Information Center. Aquatic Species. This website discusses aquatic invasive species in the U.S. www.invasivespeciesinfo.gov/aquatics/main.shtml. Accessed May 25, 2011.

United States Department of Agriculture. Natural Resources Conservation Service. Plants Database. This site has listings for native, non-native and invasive plants found in the U.S. http://plants.usda.gov/java/. Accessed May 25, 2011.

Lionfish (*Pterois volitans; P. miles*)

Origin: Widely distributed throughout the western Pacific.

Fact: Lionfish feed on coral reef fish and essentially have no natural predators. They feed on many aquatic species such as native fish as well as on crustaceans like lobsters, shrimp and crabs. If lionfish negatively affect populations of plant eating fish (herbivorous fish) who are vital in keeping seaweed and other algae under control, their effect on coral reefs could be very serious.

Hypothesize: How could the lionfish make its way from the western Pacific (where it is native) to the Atlantic Ocean basin? Clues are found in answers to the following questions.

1. Have you ever seen a lionfish in the United States? Where? (Private or public aquarium? Pet store?) How could a fish get introduced into the Atlantic Ocean basin from a private, home aquarium?

_____

_____

_____

_____

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2. In addition to people introducing aquarium fish into an ocean habitat, what natural events could cause this introduction to occur? (Hint: What kind of natural disaster could allow captive fish from a beachside aquarium to be accidentally released into the ocean?) _____

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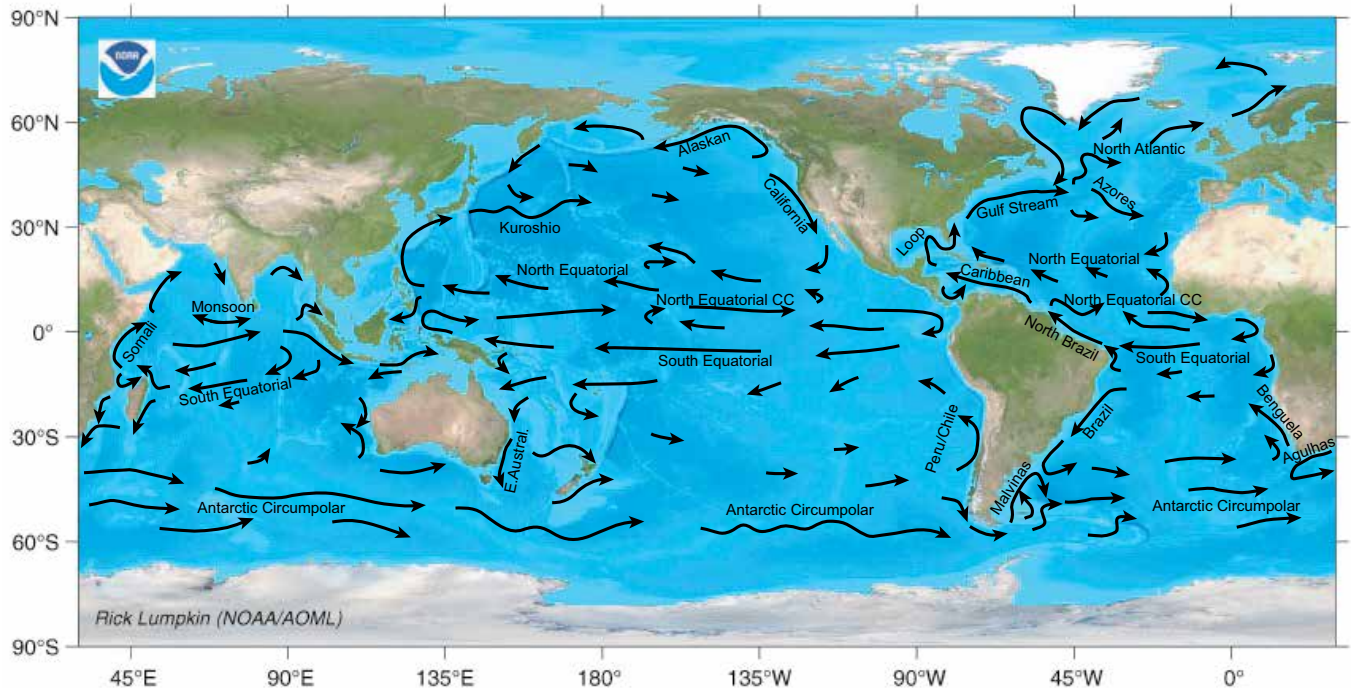
Lionfish have venomous tentacles, making them dangerous to humans and to potential predators.

Map courtesy of U.S. Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA) and Reef Environmental Education Foundation (REEF).

Current distribution of non-native lionfish in the Caribbean Sea and eastern U.S. (2011).



Map courtesy of Rick Lumpkin of the National Oceanic and Atmospheric Administration (NOAA) and the Atlantic Oceanographic and Meteorological Laboratory (AOML).

A map of ocean currents around the world.

3. Lionfish require warmer waters. What allows lionfish to survive in the Atlantic waters? (Hint: think of ocean currents) _____

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_____

4. What advice would you have for aquarium owners related to lionfish and other non-native animals and plants? _____

_____

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Imagine that you are on a task force to manage an aquatic invasive species in your region. Once you have selected the AIS to be managed by the task force, fill in the blank chart using the answers to the following questions. Use the provided Zebra Mussel chart as an example.

Aquatic invasive species (AIS) name: _____

1. Where did this species originate? _____

_____

2. How and when was it transported to this region? _____

_____

3. What native species have been displaced or are being displaced by the AIS? _____

_____

4. Are there other negative impacts associated with this AIS? _____

_____

5. What attempts have been made to manage this AIS? _____

_____

Keeping in mind the answers to these questions, what would your task force recommend for dealing with this local invader?

Name	Located	Origin	How Transported	Species Displaced	Other Negative Impacts	Management

Example

Name	Located	Origin	How Transported	Species Displaced	Other Negative Impacts	Management
Zebra Mussel (Dreissena polymorpha)	Great Lakes and much of the U.S.	Eurasia	Cargo ship ballast water, boats, fishing equipment	Competes with native species	Efficient filter feeders; Lessens plankton in water for native filter feeders; Clogs intake pipes	Monitoring: Boat owner education; Eradication through chemicals, dredging and hand harvesting