



New Bedford, Massachusetts

Ecosystems and Invasive Species Grades 6-8

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CONTENTS

Introduction	1
Overview	
Content	
Established Goals	
Enduring Understandings	
Assessment Evidence	
Learning Experiences	
LE One: Introduction to Invasive Species	7
LE Two: High Profile Invasive Species.....	19
LE Three: Aquatic Invasive Species	24
LE Four: Broken Food Web, a Local Study	37
LE Five: Independent Invasive Species Research	42
LE Six: Population Density Lab	48
LE Seven: Public Alert Poster	56

Ecosystems and Invasive Species

Overview

What is an individual's responsibility to the local and global community and environment? How has human activity and especially global trade impacted our ecosystems? Are there invasive species here in the United States or even in my own backyard? How do we study the problem of invasive species, and what can we do about it?

This unit explores why invasive species are a problem, how they are introduced, what impact they are having on local food webs, how scientists study the problem, and finally, how we can combat the problem of invasive species.

In order for students to create a sense of urgency around the issue of invasive species, they need to be introduced to the vocabulary and review the prior knowledge necessary for the investigation. There are many layers of data and scientific research that can be accessed by students on the topic of invasive species. Selecting the appropriate path and level of study as well as reviewing or teaching necessary prerequisite knowledge is important to a successful investigation. This unit will begin with an assessment of prior knowledge and a vocabulary building exercise, which then will lead to a careful reading of an interesting article/case study.

This unit is designed for students in grades six through eight, using research and data, articles and writing as a focus for understanding how invasive species are having an impact on our environment. The ultimate goal of these learning experiences is to provide students with several means by which to access information in order to synthesize their findings, make connections in their learning, discuss solutions, and engage in further inquiry.

Content

This unit provides students with learning experiences that immerse them in the study of invasive species. Students collect and analyze their own data and then aggregate class data and draw conclusions. Students also explore methods for population sampling and estimation and research specific species impacting their local habitats.

There are seven Learning Experiences (LEs) in this module. Students are introduced to the concept of invasive species and the role that humans play in their introduction and management. Throughout the module, students are motivated to develop a deep awareness and understanding of invasive species. In the final learning experience, they create a public alert poster to help combat the problem.

This curriculum module revolves around human/environment interactions and explores the interdependence of all organisms, ecosystem equilibrium, biological invasion, and global ecology.

Important issues in the form of “Enduring Understandings” and “Essential Questions” (page 5) are addressed throughout the unit, and it is important to keep them in mind as you begin this exploration with your students. These include how the natural environment is shaped by abiotic and biotic resources, the interdependence of organisms in an ecosystem, and the impact of humans on the ecosystem. We need to think about what our responsibility is to the local and global community; what possible relationships exist between people, technology and the natural environment; and what impacts human activity, especially global trade, has on our ecosystems.

Stage 1–Desired Results

Established Goals/Standards

Teacher’s Note: Standards and goals for this module are from the *Massachusetts Curriculum Frameworks* published by the Massachusetts Department of Education. For more information, see: <http://www.doe.mass.edu/frameworks/current.html>

Science & Technology: Grades Six to Eight

- Give examples of ways in which organisms interact and have different functions within an ecosystem that enable the ecosystem to survive.
- Identify ways in which ecosystems have changed throughout geological time in response to physical conditions, interactions among organisms, and the actions of humans. Describe how changes may be catastrophes, such as volcanic eruptions or ice storms.

Math: Grade Six

- Represent real situations and mathematical relationships with concrete models, tables, graphs, and rules in words and with symbols, e.g., input-output tables.
- Produce and interpret graphs that represent the relationship between two variables in everyday situations.
- Solve problems involving proportional relationships and units of measurement, e.g., same system unit conversions, scale models, maps, and speed.
- Use tree diagrams and other models (e.g., lists and tables) to represent possible or actual outcomes of trials. Analyze the outcomes.

Math: Grades Seven and Eight

- Use ratios and proportions in the solution of problems, in particular, problems involving unit rates, scale factors, and rates of change.
- Determine when an estimate rather than an exact answer is appropriate and apply in problem situations.
- Extend, represent, analyze, and generalize a variety of patterns with tables, graphs, words, and, when possible, symbolic expressions. Include arithmetic and geometric progressions, e.g., compounding.
- Select, convert (within the same system of measurement), and use appropriate units of measurement or scale.
- Use ratio and proportion (including scale factors) in the solution of problems, including problems involving similar plane figures and indirect measurement.

- Use models, graphs, and formulas to solve simple problems involving rates, e.g., velocity and density.
- Describe the characteristics and limitations of a data sample. Identify different ways of selecting a sample, e.g., convenience sampling, responses to a survey, random sampling.
- Select, create, interpret, and utilize various tabular and graphical representations of data, e.g., circle graphs, Venn diagrams, scatterplots, stem-and-leaf plots, box-and-whisker plots, histograms, tables, and charts. Differentiate between continuous and discrete data and ways to represent them.

Social Studies: Grade Six

- Interpret geographic information from a graph or chart and construct a graph or chart that conveys geographic information (for example, information about rainfall, temperature, or population size).

Social Studies: Grade Eight

- Explain how a cause and effect relationship is different from a sequence or correlation of events.
- Distinguish between long-term and short-term cause and effect relationships.

English Language Arts: Grades Six to Eight

- Determine the meaning of unfamiliar words using context clues (definition, example).
- Identify and analyze main ideas, supporting ideas, and supporting details.
- Identify and use knowledge of common textual features (paragraphs, topic sentences, concluding sentences, glossary, index, introduction, conclusion, footnotes, bibliography).
- Identify and use knowledge of common graphic features (charts, maps, diagrams, captions, illustrations).
- Identify and use knowledge of common organizational structures such as logical order, comparison and contrast, classification schemes, cause and effect relationships.

Enduring Understandings	Essential Questions
<ol style="list-style-type: none"> 1. The natural environment is shaped by its abiotic and biotic resources. 2. The organisms in an ecosystem are interdependent. 3. Ecosystems are delicately balanced. 4. Humans are a part of the ecosystem they inhabit. 5. Human activity, especially trade and movement, can have serious impacts on ecosystems. 6. Technology increases the pace of destabilization. 7. Any particular ecosystem has a set of organisms that belong. 8. The introduction of non-native species to an ecosystem can have devastating effects. 	<ol style="list-style-type: none"> A. What is an individual's responsibility to the local and global community? B. What possible relationships exist between people, technology, and the natural environment? C. What impacts might global trade have on our ecosystems? D. How can a single invasive species impact an entire food web? E. How does geography and climate influence the health of an ecosystem? F. Why read? What can we learn from print?
<p>Students will know and understand:</p> <ol style="list-style-type: none"> a. Reading and use of data tables. b. Applications and benefits of Global Positioning Systems. c. Potential impacts of global warming. d. Ways to discover the infrastructure of their local area e. Existence of organizations that study global change and provide critical information about the impact of global change on various aspects of the environment. 	<p>Students will be able to:</p> <ol style="list-style-type: none"> a. Summarize and analyze expository text. b. Independently research an invasive species. c. Construct a food web. d. Predict the disruption of a food web caused by an invasive species. e. Collect, graph, and analyze data on invasive species. f. Synthesize information on invasive species.

Stage 2–Assessment Evidence

Performance Tasks

Students will:

1. Create a glossary of terms to be used throughout the unit.
2. Compose a short story using a word bank, in an effort to activate and assess prior knowledge.
3. Generate a “Think I Know, Need to Know, Learned, and How Can I Learn More? (T-N-L-H)” list to initiate the investigation.
4. Research several high profile invasive species and analyze their environmental and economic impacts.
5. Create a data table and a bar graph which illustrates the number of aquatic invasive species in the coastal states.
6. Diagram and construct a local food web and then illustrate the impacts of an invasive species at each energy level.
7. Use sampling techniques to estimate the number of words, characters and letters ‘e’ on a page of newsprint;
8. Identify a local invasive species, research the organism, and construct a public alert poster.

Other Evidence:

- Unit worksheets and homework assignments.
- Class discussions and responses to “Creative Hunt” Visible Thinking Routine.
- Expert group assessments and aggregate class data.

Student Self-Assessment: How will students reflect upon and assess their own learning?

- Creative writing piece with word bank and T-N-L-H chart (Learning Experience 1, Activity 2 and Handout 3).
- Rubric for public alert poster.
- Self-assessment of interest in and knowledge of invasive species.

**Stage 3–Learning Plan
(See Learning Experiences)**

This curriculum module consists of both integrated and content specific Learning Experiences.

Integrated Learning Experiences

- LE 1: Introduction to Invasive Species (Science and English Language Arts)
- LE 2: High Profile Invasive Species (Science and Social Studies)
- LE 3: Aquatic Invasive Species (Science and Math)
- LE 5: Independent Invasive Species Research (Science and English Language Arts)
- LE 6: Population Density Lab (Science and Math)
- LE 7: Public Alert Poster (Science, Social Studies and English Language Arts)

Content Specific Learning Experiences

- LE 4: Local Food Webs and Invasive Species (Science)

Learning Experience One

Introduction to Invasive Species

Overview

In this initial learning experience, students will explore their knowledge of vocabulary words found in a reading from National Geographic News entitled “Maryland Wages War on Invasive Walking Fish.” First, students will write a short story using words that are taken from the article and that may be new to them. Next, students will read the article and check their use of the words with the use of the words in the article.

Evaluation

Students compose a short story using a word bank, activate and assess prior knowledge during a T-N-L-H activity, and create a glossary of important terms. Students Jigsaw the article from National Geographic on an invasive species of fish called a Northern Snakehead and report out in small groups.

Materials

- Handout 1: “Word War”
- Handout 2: National Geographic News Article, “Maryland Wages War on Invasive Walking Fish” by Hillary Mayell
http://news.nationalgeographic.com/news/2002/07/0702_020702_snakehead.html
- Internet access
- Handout 3: T-N-L-H: Think I Know, Need to Know, Learned, and How Can I Learn More?
- Whiteboard or blackboard
- Chart paper, markers

Activity One: Word War - Creative Writing with a Word Bank

- Tell the students you will be investigating invasive species over the next few weeks, and start by familiarizing them with the vocabulary used to discuss this topic.
- Explain to students they are to write a short story about whatever they wish using at least 15 of the 30 words listed in the word bank.
- Tell students to cross a word off the list once they use it, but they can use the word more than once in the story.

- Provide each student with Handout 1: Word War – Creative Writing Assignment.
- Assure students that there is no grade for this. It is your way of finding out which words they already know.
- Process with the class. Ask students to read all or part of what they have written. Point out how students used the words from the word bank. Ask the class if they agree with how the word was used or if more clarification is needed.

Teacher Note: Students are often overly concerned about always being correct. Some students will need to be assured that there is no penalty for not using a word correctly during the creative writing exercise.

Activity Two: Think I know, Need to Know, Learned and How Can I Learn More?

- In this activity students evaluate their knowledge of invasive species and prepare to delve deeper into the topic. Students activate prior knowledge, analyze their knowledge base, and begin to plan for further research.
- Distribute copies of Handout One: Invasive Species T-N-L-H Template. Use this template to activate students' prior knowledge, determine what they already know about invasive species, surface any misconceptions, and set specific purposes for learning.
- Duplicate the template on chart paper for this activity, and hang it on the wall. As students learn about the invasive species, they can add information, assess their learning, identify additional information they need, and discuss ways to find that information.
- Explain the T-N-L-H Chart to students.
- Ask individual students to fill in as much of the template as they are able (except for the Categories or Kinds of Information box). Tell students that the purpose of the activity is to determine what they already know about invasive species.
- Remind them this may be a new topic for them and they might not be able to complete much of the "Think I Know" column.
- Encourage students to think of as many questions as they can about invasive species for the "Want to Learn" column.
- Fill in the T-N-L-H chart template as a group activity. This allows students to construct meaning together, learn from each other, be engaged, and build on each other's knowledge. As a group activity, the T-N-L-H promotes the use of oral language (critical for English Language Learners) and provides opportunities for students to learn collaboratively.
- As a follow-up, students can complete the section of the template "Categories or Kinds of Information We Expect to Use." This allows you to determine students' understanding of the T-N-L-H activity.
- Use this information to assess students' current knowledge. Compare what students already know with the knowledge and skills that are taught in this module.
 - Do students possess the vocabulary necessary for this unit?
 - Do students understand ecosystems, food webs and energy levels?
 - What other knowledge do the Learning Experiences in this module assume? What pre-teaching is necessary?

Teacher Note: This activity is adapted from the K-W-L developed by Donna Ogle (1988) and is useful for activating and assessing students' prior knowledge (T), setting the purpose(s) for learning (N), determining what has been learned (L), and identifying methods and resources for additional learning. Students use oral language, work together, and build on each other's knowledge. This promotes language and other learning.

Activity Three: Glossary Building

- Students develop a glossary of terms for use throughout the unit.
- Explain to the students that the glossary they are creating is theirs to keep.
- The words in the list are some of the more important words they will come across when researching invasive species. Tell students to add any unfamiliar words to their glossary.
 - Distribute the glossary list and assign computers or hand out dictionaries.
 - Consider dividing the students into groups of two or three to save time.
 - Ask the students to use the invasive species website first and then use the Merriam-Webster site to locate the remaining terms. If using the Internet, write the location of the following websites on the board:

www.invasivespeciesinfo.gov

1. Under **Browse by Subject**, select **Aquatic species**
2. Select **Invasive Alien Species Concepts, Terms and Context**
3. Scroll down to the alphabet and select the first letter of each word

www.merriam-webster.com (Merriam-Webster On-Line Dictionary)

- Students bring their vocabulary findings to the rest of the class to build a glossary. It is important to discuss and brainstorm ideas related to the vocabulary presented prior to reading the article to ensure that students have a grasp of the terms before they tackle the reading.

Teacher Note: The glossary can be used as a study guide for a vocabulary quiz at a later point.

Activity Four: The Article—Reading and Analyzing the Content

- Distribute Handout 3: National Geographic News Article, “Maryland Wages War on Invasive Walking Fish” by Hillary Mayell
http://news.nationalgeographic.com/news/2002/07/0702_020702_snakehead.html
- Instruct students to work individually using their glossary and copy of the article.
- The article reading can be a homework assignment or classroom activity.
- After students read the article, lead a discussion with individual students or groups reporting out and summarizing sections of the article.
- Discuss vocabulary and check for comprehension. Revisit the T-N-L-H chart and make changes or additions with the class.

Notes to Teachers

- Students can also work in groups of four to Jigsaw the article. If groups are assigned, assign one student to each section: Introduction, Battling Alien Species, Maryland's Snakehead Saga, Educating the Public. Instruct students to use summarization skills, first creating a “headline” for their portion of the article that outlines the main idea. Use the “word – sentence – phrase” Visible Thinking routine to have students come up with one word, then one sentence, then one phrase (or series of sentences) to capture the main points of their portion of the article.
- For differentiation some sections of the article are longer and more complex than others. Groups that will benefit from a longer, more challenging section should be assigned appropriately.

Handout One: Word War

Name: _____

Date: _____

Word War – Creative Writing Assignment

- **Purpose:** To generate interest in the topic, assess prior knowledge and check the understanding of words associated with invasive species.
- **Procedure:** Write a short story in the space provided using 15 of the 30 words listed below. Once a word is used, cross it off the list.

Alien	Ballast	Carapace	Carnivore	Clutch
Collapse	Consumer	Ecosystem	Eradication	Exotic
Extinct	Hitch-hiker	Indigenous	Inter-tidal	Invasion
Invasive	Larvae	Native	Nonnative	Noxious
Omnivore	Pest	Predators	Producer	Quarantine
Reproduce	Salinity	Sub-tidal	Voracious	Weevil

Handout Two: **Maryland Wages War on Invasive Walking Fish**

Hillary Mayell

National Geographic News

July 2, 2002

An angler caught an air-breathing, land-crawling, voracious predator this past weekend in a pond in Crofton, Maryland.

The good news is that the fish, a northern snakehead that has been targeted by biologists for the last several weeks, was caught. The bad news is that it was 26 inches (66 centimeters) long; the fish caught in mid-May that alerted wildlife officers to the possibility of an invasion by an alien species was only 20 inches (51 centimeters) long.



The snakehead is shown here next to a U.S. dollar bill, for scale.

Photograph courtesy of Cait Gillespie

"Either the fish grew six inches in a few weeks or we have more than one in the pond," said Bob Lunsford, a biologist with the Maryland Department of Natural Resources.

The knowledge, with the weekend catch, that there is more than one fish in the Crofton pond is what is keeping biologists awake at night.

"Our biggest fear is that there are more than one and they'll reproduce," said Lunsford.

A second fear, based on the fish's ability to breathe out of water and travel across land, is that the snakehead could leave the pond and travel the 75 feet (23 meters) or so to the Little Patuxent River, and from there invade the state's river system.

Battling Alien Species

The northern snakehead's arrival in Maryland is only the latest in a long list of invasions by alien species around the world.

Alien species—plants and animals that have become established outside of their natural range as the result of human activity—pose a huge threat to the biodiversity and health of an ecosystem. Once established, the alien species can eat the native species or compete with them for habitat, food, or both. Lacking natural predators in their new environment, the invaders can drive natives

to extinction, drastically degrade ecosystems, and cost billions of dollars a year in eradication efforts.

Businesses also suffer. The U.S. government estimates the cotton boll weevil, an exotic insect, has cost the cotton industry \$13 billion since its arrival, and that over a ten-year period, pipe-clogging masses of zebra mussels have cost the utility industry \$3 billion.

Similar ecological disasters have occurred in other parts of the world too. An invasion of the Black Sea by the comb jelly led to the collapse of the anchovy fishery, estimated to be worth \$250 million a year.

"Once an alien species establishes itself they're impossible to get rid of," said Paul Shafland, director of the Florida Fish and Wildlife Conservation's Non-Native Fish Lab.

Maryland's Snakehead Saga

An angler fishing in a pond in Crofton, Maryland, east of Washington, D.C., first caught the fish in mid-May. Unable to identify it, he took photographs before throwing it back in the water. Biologists at the state's Department of Natural Resources, working with other experts, identified the fish as a northern snakehead. They immediately began planning strategies for ridding the pond of the creature.

Thus far, sandbags, electroshock equipment, traps, and hordes of anglers have been recruited to capture the alien fish. Wanted posters alert anglers to cut and bleed the fish if they catch it, since it can live on land for several days at least.

"We want this fish dead," said Lunsford. "No question about it."

"The folks in Maryland are not overreacting one little bit," said Walter Courtenay, professor emeritus of zoology at Florida Atlantic University.

There are 28 species of snakeheads; three are indigenous to equatorial Africa, the other 25 to Asia. The species vary in size and aggressiveness, according to Courtenay, who has been preparing a risk assessment on the snakehead for the U.S. Geological Survey since September.

One species, the bullseye snakehead, has already established itself in the waters of southern Florida, although with relatively little impact so far.

"We have not seen, and we don't anticipate, that the presence of the snakehead in Florida waters will have a catastrophic impact," said Shafland. "But it's like throwing trash out the car window; it can't be good."

Courtenay disagrees with Shafland's assessment of the Florida snakehead's potential impact, but in regard to the species found in Maryland, the question is moot. The northern snakehead is nothing like the species down in Florida, according to Courtenay.

"Ninety percent of the northern snakeheads' diet consists of other fishes," he said. "Their temperature range is between zero to 30 degrees Celsius (32 to 86 degrees Fahrenheit), and it can live under waters that have been iced over. They can grow to almost a full meter in length (more than three feet), and the females lay more eggs per year—in the neighborhood of 100,000 annually—than other species."

The snakehead in Florida is a temperate species, unable to withstand water temperatures below 50 degrees Fahrenheit (10 degrees Celsius).

Some snakehead species are imported into the United States as part of the aquarium trade, although the northern snakehead is not one of them. Snakeheads are considered a food delicacy in Asia, and live fish can frequently be found in Chinese markets. Authorities suspect that the fish in the Crofton pond was purchased in Washington, D.C.'s Chinatown district.

"A snakehead species introduced in Uzbekistan in the early 1960s spread with such rapidity and with such devastating effect on native fish populations that fishermen were able to establish a commercial fishery, turning a negative into a positive," said Courtenay.

Courtenay's report, which will be submitted to the U.S. Fish and Wildlife Service later this summer, will recommend a total ban on importation of live snakeheads.

Educating the Public

Options for catching the fish in the Crofton pond are somewhat limited. Draining the pond would flush all the fish, including the snakehead, into the Little Patuxent River. In addition, the snakehead has the ability to bury itself in the mud for several months, so it could just hide. The lower end of the pond has been sandbagged to prevent the fish from crawling into the Little Patuxent. Electroshock hasn't worked, and can't be tried again until winter when the dense vegetation in the pond has died back, allowing larger pieces of equipment to be operated.

State and local authorities have about a dozen eel pots, some baited traps, and two floating D-traps in the pond, but even if they catch more snakeheads, there is no way of knowing that all of them have been caught.

Courtenay suggests the only option might be poisoning the pond using Rotenone, a plant-derived toxin. "None of the other methods guarantee that you'll get every fish in the pond," he said.

Although possessing a live snakehead is illegal in 13 states; Virginia, Maryland, and the District of Columbia are not among them. It is however, illegal to release non-native fish into Maryland waters, said Lunsford.

"Obviously we need to do more to educate the public about the serious ecological consequences that the illegal release of exotic species represents," said Shafland. "People need to understand that once exotic species are established they're impossible to eliminate and the consequences can be catastrophic. Releasing them into the wild is not humane and it's not smart."

Handout Three: Invasive Species T-N-L-H Template

What Do We Think We Know about Invasive Species?	What Do We Need to Learn to Complete the Performances?	What Did We Learn ?	How Can We Learn More? What Resources are Available?
Categories or Kinds of Information We Expect to Use:			

The T-N-L-H teaching technique was developed in 1986 by Donna Ogle and adapted from the template in *The Strategic Teaching and Reading Project Guidebook*. (NCREL, 1995, rev. ed.).

Name: _____

Date: _____

Invasive Species Glossary Page 1

Word:	Definition:
Alien	
Ballast	
Carapace	
Carnivore	
Clutch	
Collapse	
Consumer	
Crawling	
Ecosystem	
Eradication	
Exotic	
Extinct	
Hitch-hikers	
Indigenous	
Inter-tidal	

Name: _____

Invasive Species Glossary

Page 2

Word:	Definition:
Invasion	
Invasive	
Larvae	
Native	
Nonnative	
Noxious	
Omnivore	
Pest	
Predators	
Producer	
Quarantine	
Reproduce	
Salinity	
Sub-tidal	
Voracious	
Weevil	

Learning Experience Two

High Profile Invasive Species

Overview

In this learning experience, the class will research a number of high profile invasive species that include aquatic species, plants, and animals that have invaded the United States. Students will explore invasive species through a U.S. Government website and database dedicated to invasive species (www.invasivespeciesinfo.gov). Students will explore “Species Profiles” to collect information about a species origin, means of invasion, and where it has invaded. They will show on a global map the origin of the invading species and indicate where the invasive species has invaded. After finishing the mapping, students will answer some critical thinking questions.

Evaluation

Students will collect data on an assigned (or selected) invasive species and respond appropriately to a series of questions related to this invasive species.

Materials

- Handout One: Attack of the Invasive Species
- Handout Two: Invasion Analysis
- Internet access or printouts of species profiles

Activity One: Attack of the Invasive Species

- Distribute Handout One. Tell students that they will be assigned (or can select) an invasive species to research. The directions for navigating a website to conduct their research are on the handout.
- Instruct students to collect information and map the invasion.
- Assign one species to each student or group of students (depending on the number of computers available) from the following species list:

Aquatic Plants:

1. Brazilian Waterweed (*Egeria densa*)
2. Eurasian Watermilfoil (*Myriophyllum spicatum*)
3. Giant Reed (*Arundo donax*)
4. Giant Salvinia (*Salvinia molesta*)
5. Hydrilla (*Hydrilla verticillata*)
6. Melaleuca (*Melaleuca quinquenervia*)
7. Purple Loosestrife (*Lythrum salicaria*)

8. Water Chestnut (*Trapa natans*)
9. Water Hyacinth (*Eichhornia crassipes*)

Aquatic Animals:

1. Alewife (*Alosa pseudoharengus*)
2. Chinese Mitten Crab (*Eriocheir sinensis*)
3. Eurasian Ruffe (*Gymnocephalus cernuus*)
4. European Green Crab (*Carcinus maenas*)
5. Flathead Catfish (*Pylodictus olivaris*)
6. Lionfish (*Pterois volitans*)
7. Northern Snakehead (*Channa argus*)
8. Nutria (*Myocastor coypus*)
9. Quagga Mussel (*Dreissena bugensis*)
10. Round Goby (*Neogobius melanostomus*)
11. Sea Lamprey (*Petromyzon marinus*)
12. Veined Rapa Whelk (*Rapana venosa*)
13. Zebra Mussel (*Dreissena polymorpha*)

Activity Two: Invasion Analysis

- Distribute Handout Two. Instruct students to use the information they gathered to help them answer the critical thinking questions.
- Tell students to read all the questions prior to answering them. Remind them to answer in complete sentences, and instruct them to revisit the website if needed.
- Since this activity lends itself to small group discussion, allow students with the same species to work together and discuss the questions.
- After answering all of the questions, have the groups report out. Then discuss each species with the class.

Teacher Notes:

- Explore www.invasivespeciesinfo.gov to become familiar with the website.
- If computers and internet access are not available, print out individual “Species Profiles” for each student.
- A “Species Profile” can be five pages long. Sufficient resources and time will be required to assemble the necessary materials.

Handout One: Attack of the Invasive Species

Name: _____

Date: _____

Procedure: Collect the information about your assigned species and map the invasion.

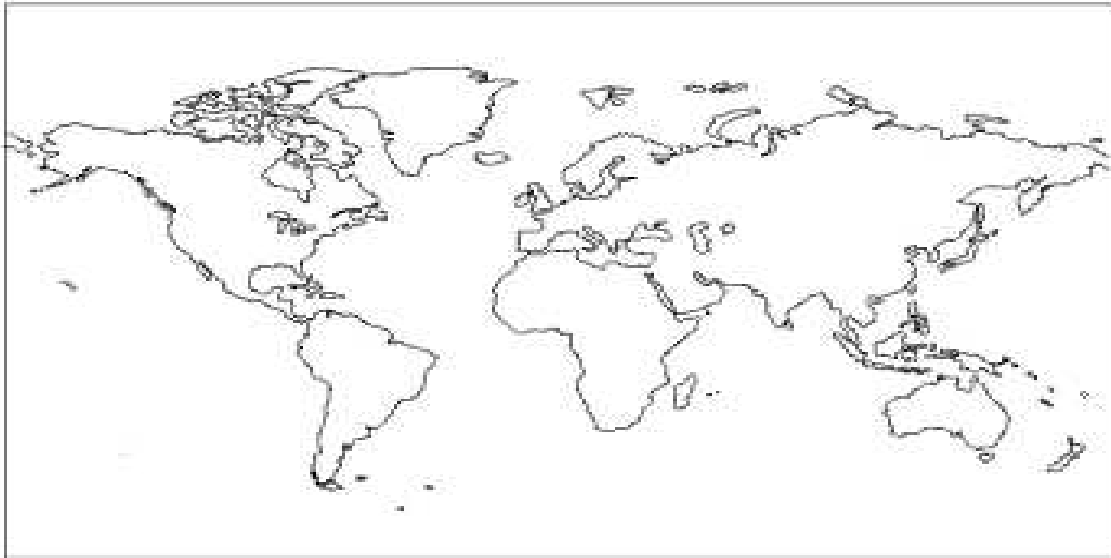
- Go to: www.invasivespeciesinfo.gov.
- Under “Browse by Subject”, select **Aquatic Species, Plants or Animals**.
- Under “Species Profile”, select the organism you have been assigned to research.

Scientific Name:
Common Names:
Native to:
Date of U.S. Introduction:
Means of introduction:
Current U.S. Distribution:

If a map is available, select the map. More information should appear.

Native Range:
Means of introduction:
Impact of introduction:

B. Draw a line from Native Origin to Invasion.



C. Indicate where the Invasive species is found.



Global Map: www.geo.arizona.edu

North America Map: <http://geog-www.sbs.ohio-state.edu/courses/G200/eboschmann/USCan.jpg>

Handout Two: Invasion Analysis

Name: _____

Date: _____

Directions: Read all the questions before answering. Be sure to answer all questions in complete sentences.

Species Name: _____

1. What route did the invasive species possibly take to get into the U.S.?

2. How is the native environment similar to the environment of the U.S.?

3. What role did technology play in establishing a nonnative species in the U.S.?

4. What damage is the invasive species doing?

5. What can be done to control the spread of the invasive species?

Learning Experience Three

Where is there a Problem with Invasive Aquatic Species?

Overview

In this learning experience students will access a national database on invasive species to examine quantitatively the problem in the United States. Students will collect data dealing with nonindigenous aquatic species. They will begin the learning experience by examining the number of nonindigenous aquatic species in Alaska, Hawaii, and Massachusetts. Next, students will determine the percentage of nonindigenous aquatic species that are considered exotic. After successfully collecting data and answering thought questions, students or student teams will evaluate the states that compose the Atlantic seaboard, Great Lakes, Gulf of Mexico, and Pacific seaboard.

Evaluation

Students will complete the data analysis sheets, which will be assessed for understanding and completion. The students will share their data with the class and graph the information using graphing software.

Materials

- Computers with internet access
- Handout One: Nonindigenous Aquatic Species Tri-State Study
- Handout Two: Analysis of Nonindigenous Aquatic Species Tri-State Study
- Handout Three: United States Nonindigenous Aquatic Species Study
- Handout Four: Analysis of United States Nonindigenous Aquatic Species Study
- Handout Five: United States Nonindigenous Aquatic Species Graphical Analysis
- Excel software or equivalent graphing software
- If computers are not available, then:
 - Graph paper
 - Body of Water and Number of Invasive Species Table (see Activity Two, Data Table 2, below)

Activity One: Nonindigenous Aquatic Species of Several U.S. States

- Distribute Handouts One and Two.
- Instruct the students, working alone or in small groups, to go to the following website, www.invasivespeciesinfo.gov and locate the information to complete Data Table 1.
- Explain the column titles in the data table and review the questions in Handout Two.

- After students have completed their research and the questions, have them report on their findings and conclusions. Make sure that all of the students have accessed the correct information. Discuss appropriate conclusions.

Activity Two: Nonindigenous Aquatic Species of Bodies of Water

- Distribute Handouts Three and Four. Explain the column titles in the data table in Handout Three, and review the questions in Handout Four.
- Ask students, working alone or in small groups, to return to the www.invasivespeciesinfo.gov website, and locate the information to complete Data Table 2 in Handout Three (completed table shown below) and answer the questions in Handout Four.
- After students have completed their research and the questions, ask them to report on their findings and conclusions. Make sure that all of the students have accessed the correct information, and discuss appropriate conclusions.

Data Table 2:

Body Of Water and Number of Invasive Species							
Atlantic Ocean		Great Lakes		Gulf of Mexico		Pacific Ocean	
State	Species	State	Species	State	Species	State	Species
ME	65	IL	84	FL	272	AK	23
NH	44	IN	66	AL	71	WA	192
MA	123	MI	86	MS	39	OR	159
RI	29	OH	90	LA	52	CA	423
CT	82	WI	87	TX	159	HI	371
NY	142						
NJ	69						
DE	36						
MD	102						
VA	134						
NC	116						
SC	60						
GA	91						
FL	272						

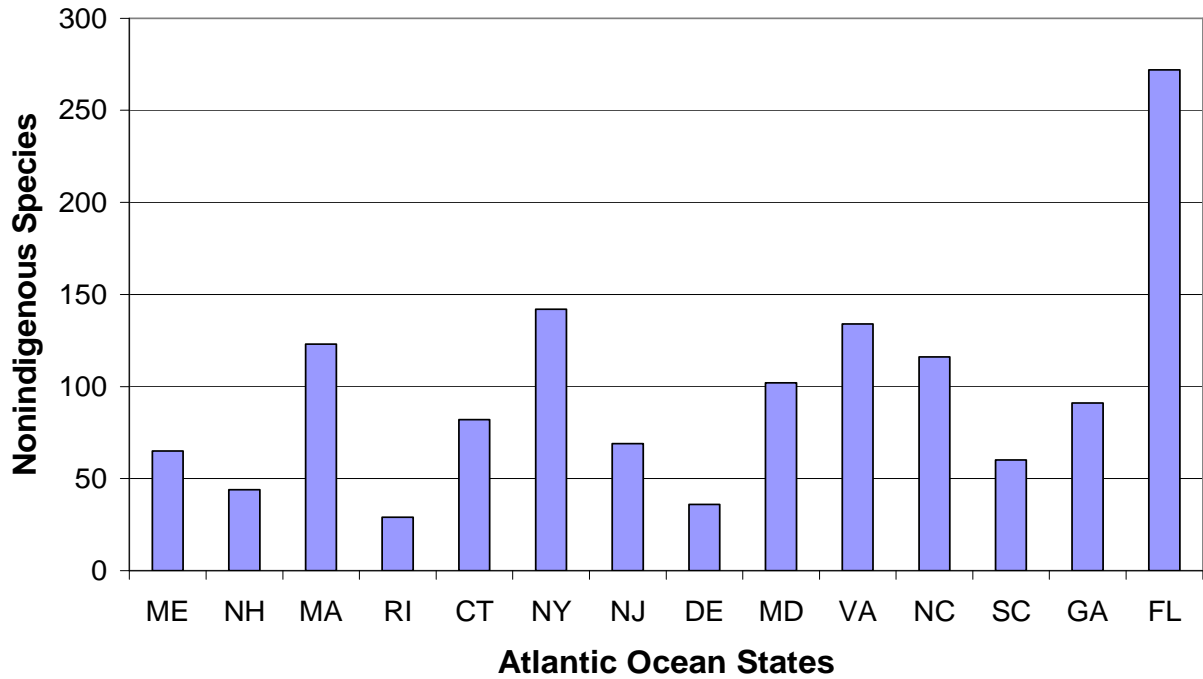
Activity Three: Graphing the Data

- Assign one of the following bodies of water to each student:
 - Atlantic Ocean
 - Great Lakes
 - Gulf of Mexico
 - Pacific Ocean.
- Distribute Handout Five, the graphing instructions, and give students time to work on computers.

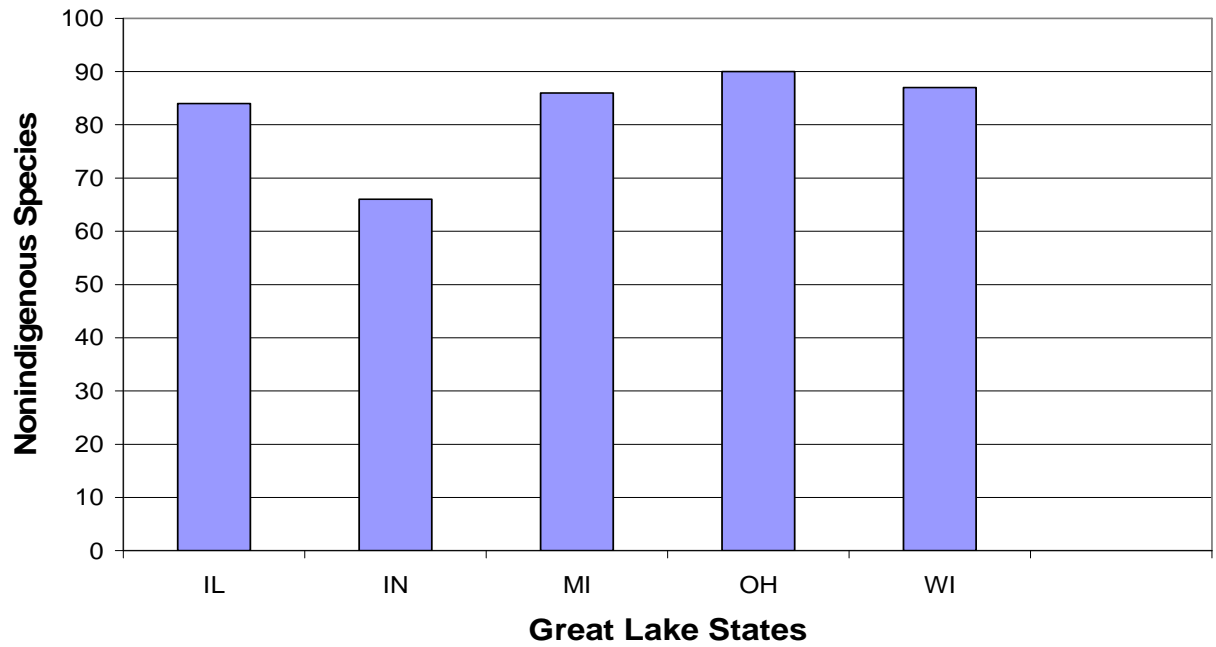
- After the students have printed their graphs, hang them on the board and discuss the results. Revisit analysis questions if appropriate.

The following pages show the graphs the students will be creating:

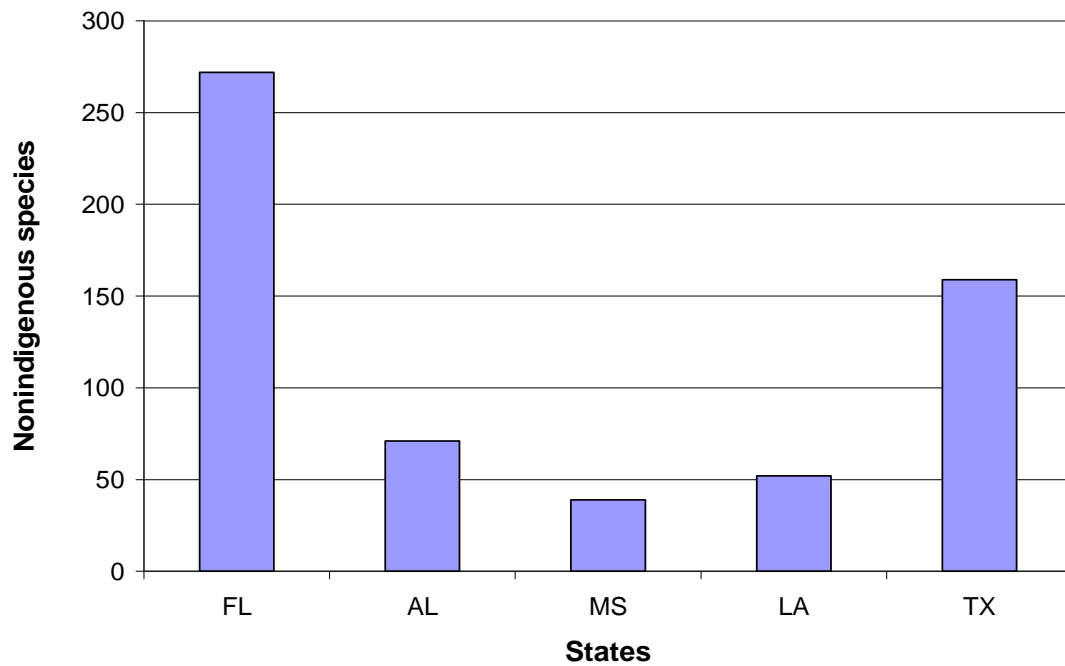
Nonindigenous Species of the Atlantic Ocean States



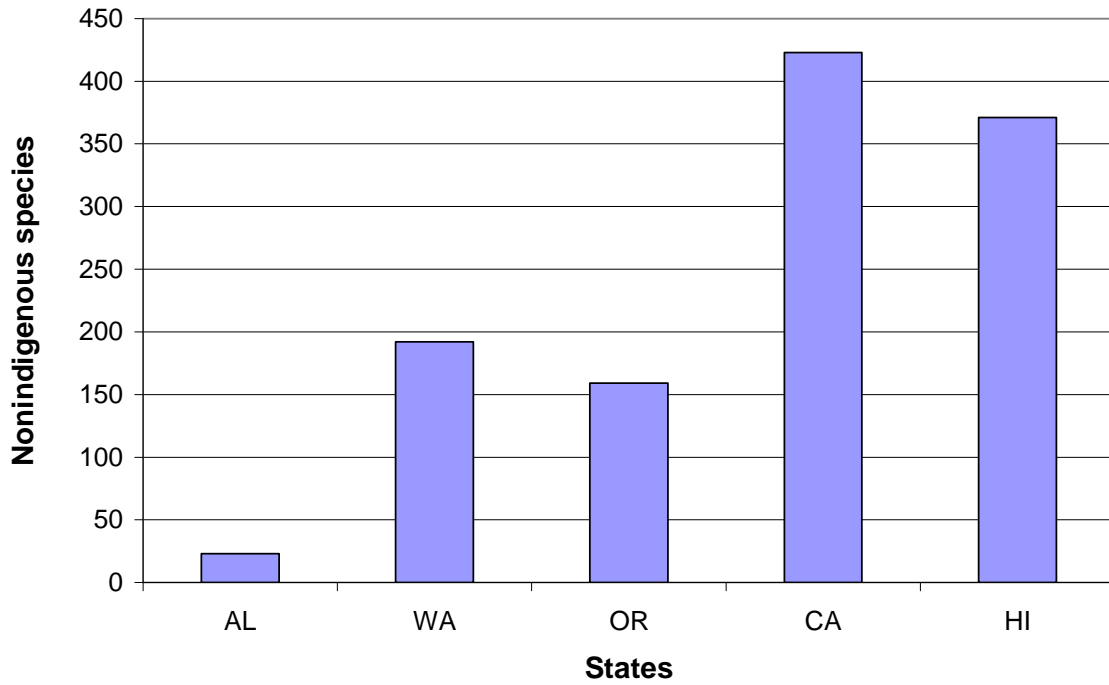
Nonindigenous Species of the Great Lake States



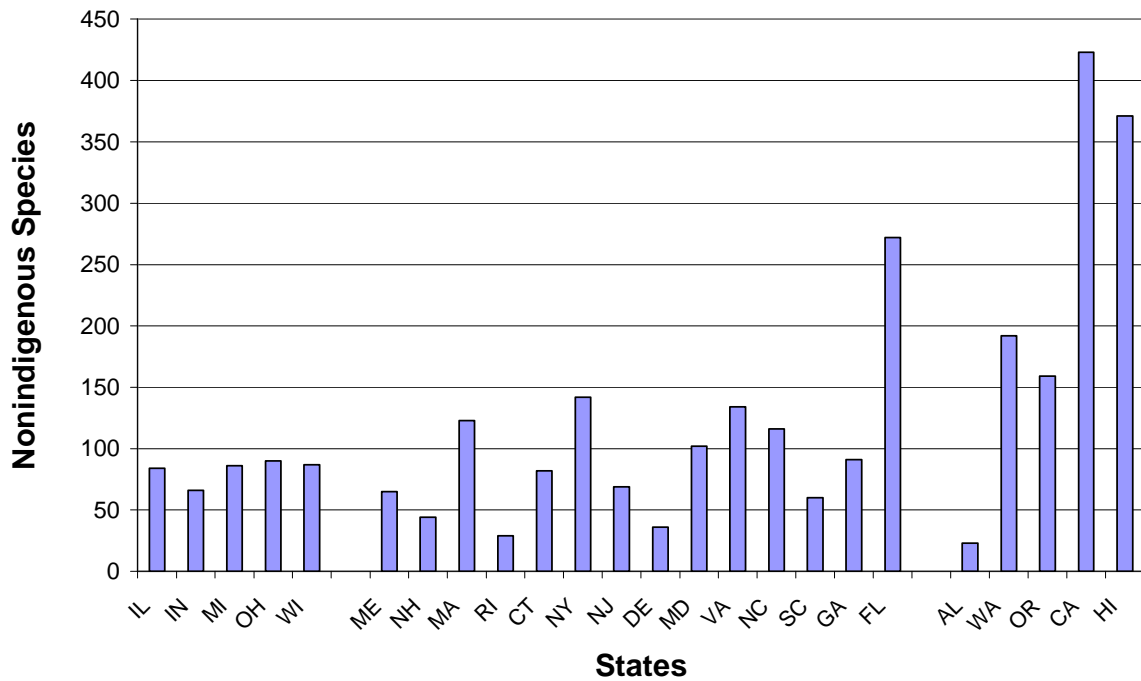
Nonindigenous Species of the Gulf of Mexico



Nonindigenous Species of the Pacific Ocean States



Nonindigenous Species of Water States



Teacher Notes

- If students have limited experience creating data tables, it may be helpful to collect the first set of data as a whole class and then allow students to work on their own or in groups.
- If students are unfamiliar with Excel and/or have not had experience with the graphing wizard function, it may be necessary to insert a mini-lesson at this point to teach the necessary skills.

Handout One: Nonindigenous Aquatic Species Tri-State Study

Name: _____

Date: _____

Directions:

- Go to www.invasivespeciesinfo.gov
- Under “Browse by Geography”, select **United States**.
- Select **Nonindigenous Aquatic Species by State**.
- Under “Species List by State”, select **Alaska**.
- When the report appears, record in Data Table 1 the **Number of Records** listed at the top under **Nonindigenous Species**.
- Count how many of the listed species are **Exotic** (red letters on blue background). Record the information in Data Table 1.
- Divide **Counted Exotics** by **Nonindigenous Species**, and multiply by 100 to get **Percent Exotics**,
- After completing the data table, answer the questions on the following pages.

Data Table 1:

State	Nonindigenous Species	Counted Exotics	Percent Exotics
Alaska			
Hawaii			
Massachusetts			

Handout Two: Analysis of Nonindigenous Aquatic Species Tri-State Study

Name: _____

Date: _____

Directions: Answer the following questions in complete sentences and have your teacher sign off on your completed work.

1. How is the geography of Alaska, Hawaii and Massachusetts similar? _____

2. How is the geography of Alaska, Hawaii and Massachusetts different? _____

3. What is the relationship between climate and number of nonindigenous species for the above states? _____

4. What is the relationship between climate and number of counted exotics for the above states? _____

5. Predict the trend that will be found along the Atlantic seaboard from Maine to Florida. _____

Name: _____

6. Predict the trend that will be found for the Great Lakes._____

7. Predict the trend that will be found along the Pacific seaboard from Alaska to Hawaii._____

Teacher approval to continue: _____

Handout Four: Analysis of United States Nonindigenous Aquatic Species Study

Name: _____

Date: _____

Directions: Answer the following questions in complete sentences and have your teacher sign off on your completed work.

1. What is the general trend in the data for the Atlantic Ocean? Great Lakes? Gulf of Mexico? Pacific Ocean? _____

2. Is the data consistent? Explain. _____

3. How do the bodies of water differ? _____

Name: _____

4. How do the differences between the bodies of water account for the results?

5. How do the states differ geographically? _____

Teacher approval to continue: _____

Handout Five: United States Nonindigenous Aquatic Species Graphical Analysis

Body of Water: _____

Name: _____

Date: _____

Instructions:

- Go to the desktop on your computer.
- Select **Start** at the bottom of the page.
- Select **All Programs**.
- Open **Excel**. A spreadsheet will appear.
- The **Excel** spreadsheet is divided into columns (letters) and rows (numbers). The first box is **A1** (column A, row 1).
- Type **State** in box **A1**. Type **Species** in box **B1**.
- In column **A**, starting with **A2**, type in the two letter code for each state along the body of water you have been assigned. Continue down the column. Organize the data north to south.
- In column **B**, enter the corresponding number of nonindigenous species.
- After inputting the data, click and drag to highlight the data.
- Select **ChartWizard** at the top of Excel. The icon is under help and has blue, red and yellow columns. (If you cannot locate the **ChartWizard** icon, click **Insert** on the tool bar, and then click on **Chart**. The **ChartWizard** will appear.)
 - Step 1 of 4: Chart Type: Select the first vertical column graph. Click on **Next** at the bottom of the box.
 - Step 2 of 4: Chart Source Data: The data should appear as columns. Click on **Next** at the bottom of the box.
 - Step 3 of 4: Chart Options: Fill in the text boxes by typing in the title (i.e. **Nonindigenous Species of the _____** (body of water). Type **State** under x-axis. Type **# of Nonindigenous species** under y-axis. Click on **Next** at the bottom of the box.
 - Step 4 of 4: Chart Location – VERY IMPORTANT: Select **As new Sheet**. Click on **Finish** at the bottom of the box.
 - An entire graph should appear. Students can change the color, font, or axis by double clicking on the graph.

Teacher approval to continue: _____

- **Print Graph after obtaining the teacher's approval.**

Learning Experience Four

Broken Food Web: A Local Study **What happens when a food web is stressed?**

Overview

In this learning experience, students will construct a food web with a minimum of eight organisms from their local environment demonstrating the principles of energy flow from sun to producer to herbivore to carnivore. Students will then introduce an invasive species at different energy levels and predict the consequence for the food web.

Evaluation

Students will construct a two-dimensional model of a local food web including eight organisms with a minimum of four energy levels. Students will then introduce at each energy level an invasive species that disrupts the food web. Students will document and diagram their predictions.

Materials (determine numbers according to the number of groups)

- Handout One: Local Food Web Diagram
- Handout Two: Broken Food Web
- Red pencils or pens
- Note cards
- White string or yarn
- Red and black markers for string
- Paperclips
- Scissors

Activity One: Brainstorm Local Organisms

- Prepare for the session by making three columns on the board titled “Producer”, “Herbivore”, and “Carnivore”.
- Review the meaning of the terms before beginning the brainstorming session.
- Brainstorm a large list of local organisms, asking students to help you assign each organism to the appropriate column as they develop the list.

Teacher Note: Leave the list on the board for the next activity.

Activity Two: Create a Local Food Web

- Review the structure of a food web by creating an exotic example. Discuss the energy levels and flow.
- Ask the students to predict the effects of a drought or disease, and diagram the results on the board as an example.
- Review the list of local organisms and their energy levels.
- Discuss each organism's source of food and potential predators.
- Distribute Handout One.
- Demonstrate what the model is to look like by creating the exotic example illustrated on the board.
- Place students in small groups.
- Ask each group to select eight to ten organisms and create a food web. Students first list the organisms on Handout One and then draw their food web diagram on the first page of the Handout.
- Distribute note cards, white string or yarn, red and black markers, and paperclips.
- Ask students to prepare the notes cards and string or yarn as instructed on page two of Handout One.
- Have each group arrange on a desk or table the organisms of the food web at the proper nutritional level.
- Allow students to view each other's models.

Teacher Note: If class ends prior to Activity Three, store the student work so it can be used during the next session.

Activity Three: Introduce an Invasive Species

- Distribute Handout Two. Ask student to introduce an invasive species at each energy level and make predictions of the consequence for the food web. Have students write their prediction on the left side of Handout Two and diagram the corresponding food web on the right.

Teacher Notes:

- Students will need to have a basic knowledge of an ecosystem that includes trophic energy levels and modes of obtaining energy: producer, herbivore, carnivore, and omnivore.
- Students will need to know that most food webs are dependent on the sun and photosynthetic producers to transform light energy to chemical potential energy.

Handout 1: Local Food Web Diagram

Name: _____

Date: _____

Organism	Role in Food Web	Organism	Role in Food Web
1		6	
2		7	
3		8	
4		9	
5		10	

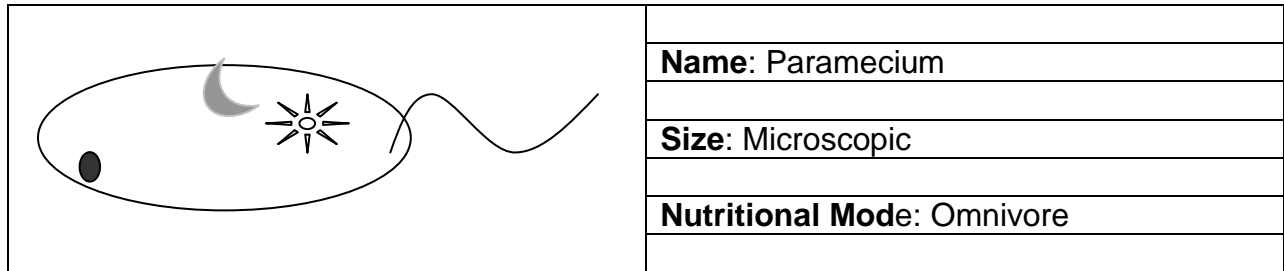
Draw a diagram of a food web using arrows to show the flow of energy.



Show the location of invasive species that would disrupt the food chain using a red pencil or pen.

Creating Your Local Food Web Organisms on Index Cards

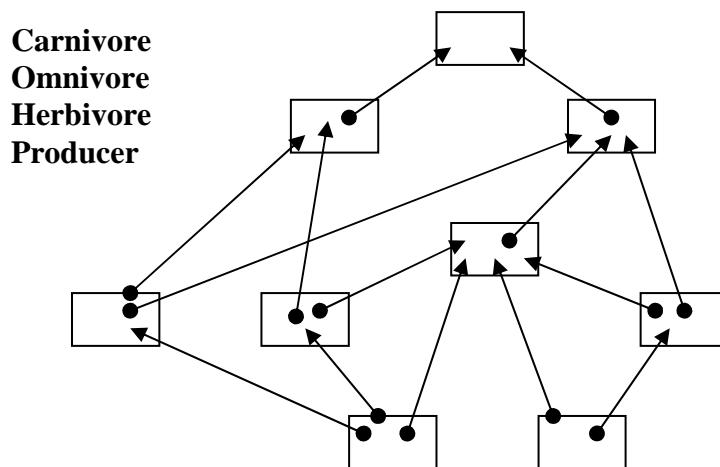
Obtain ten 5x3 index cards (one for each species of the food web). On one side of the index card put an image of each species that makes up the local food web. Images can either be drawn, cut out photos from magazines, or images found on the internet. If the images are not drawn, then attach the images to the front of the index card. On the back of the index card write the name of the organism, indicate the size, and mode of nutrition: producer, herbivore, omnivore, or carnivore. See example below.



Creating Your Local Food Web Model

Constructing a Food Web:

- Put a paperclip on each index card.
- Arrange on a desk or table the organisms of the food web at the proper nutritional level.
- Using markers, color one end of each string or yarn red and the other end black.
- To show what organism eats what other organism, tie the black end to the prey and the red end to the predator.



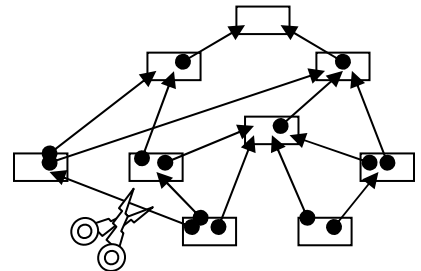
Handout 2: Broken Food Web

Name: _____

Date: _____

Directions:

- Once the food web is completely constructed, cut the string where an invasive species has removed a species from the food web.
- In the table below, write a prediction of what would happen if an invasive species removed a member of the food chain at each level.
- Diagram the new food web.



Invasive Species

A. Prediction if invasive species removed a producer	
Prediction:	Diagram:
B. Prediction if invasive species removed a herbivore	
Prediction:	Diagram:
C. Prediction if invasive species removed a carnivore	
Prediction:	Diagram:

Learning Experience Five

Independent Species Research

Overview

In this learning experience, students will read a public bulletin about the invasive species *Hemigrapsus sanguineus*. They will be assigned an invasive species to investigate, and they will examine how the species became invasive and explore the role of humans and technology played in this biological invasion. Students will list and categorize their data to look for trends and commonalities.

Evaluation

Students will complete the student data sheets, which will be assessed for thoroughness and completion. The students will share their data with the class, for everyone to record. Students will then divide into groups to look for trends and commonalities.

Materials

- Handout One: *Hemigrapsus sanguineus* Bulletin
- Internet access
- Handout Two: Independent Species Investigation
- Handout Three: Aggregated Class Data and Identifying Data Trends
- Handout Four: Class Summary of Trends
- Overhead or white board

Teacher Note: This is a time consuming learning experience. When dividing the activities, try to plan for Activities Three, Four and Five to take place during the same class period.

Activity One: Read *Hemigrapsus* Bulletin

- Distribute Handout One and instruct the students to read it on their own in class or as homework. Ask the students to reflect on the information in the bulletin and prepare for a group discussion.
- Instruct students to think about what information is in the bulletin, what the bulletin is trying to do, and with whom the bulletin is attempting to communicate.

Teacher Note: The “Creative Hunt” Visible Thinking routine can be used to help students look at the parts, purposes and audience for the bulletin and understand the key components of the posters they create in Learning Experience Seven. The

“Creative Hunt” thinking prompts that should be asked about the bulletin are: What is the main purpose here? What are the parts of the bulletin and their purposes? Which parts are especially smart or creative? (Asterisk or mark them.) Who is the audience for this bulletin?

Activity Two: How Did This Happen?

- Distribute Handout Two. Assign a species to each student or student group, or allow them to select one from the following online lists:
 - http://en.wikipedia.org/wiki/List_of_invasive_species#North_America (wiki list)
 - <http://www.cyberonic.com/~gwlt/invasive.html> (MA plants)
 - <http://tncweeds.ucdavis.edu/index.html> (The Global Invasive Species Initiative)
- After students/student groups select a species, instruct them to fill in all the data in the table. Tell them to return to www.invasivespeciesinfo.gov as needed. After exhausting the database, students should try other search engines to find the remaining information.
- Students identify place of origin, method of species introduction, and the role humans and technology have played.

Activity Three: Group Trend Part A

- Bring the class back together after the individual research is completed.
- Distribute Handout Three, Aggregated Class Data.
- Recreate the aggregated class data table on the board.
- As a class, fill in the first entry to show the students how to complete the table.
- Instruct students or student groups to go to the board and fill in the information they found.

Teacher Note: Make sure the rest of the class fills in the entire data table because it is needed for Activity Four.

Activity Four: Group Trend Part B

- After the aggregate data is compiled, divide the students into seven groups and assign one of the column headings to each group. (If the groups are too large, multiple groups can work on the same column heading).
- Each group examines the class data for the column heading they have been assigned in order to identify trends in the information.
- The groups document their findings on Handout Three and select one team member to report out the information to the class.
- Distribute Handout Four. Instruct students to complete the entire data table as the groups report out.
- Make sure that students save their research, because it is needed for Learning Experience Seven.

Handout One:

NONINDIGENOUS SPECIES INFORMATION BULLETIN

Asian shore crab, Japanese shore crab, Pacific crab, *Hemigrapsus sanguineus* (De Haan) (Arthropoda: Grapsidae)

IDENTIFICATION: The Asian shore crab has a square-shaped shell with 3 spines on each side of the carapace. The carapace color ranges from green to purple to orange-brown to red. It has light and dark bands along its legs and red spots on its claws. Male crabs have a distinctive fleshy, bulb-like structure at the base of the moveable finger on the claws. This species is small with adults ranging from 35 mm (1.5 in) to 42 mm (1.65 in) in carapace width.

NATIVE RANGE: *Hemigrapsus sanguineus* is indigenous to the western Pacific Ocean from Russia, along the Korean and Chinese coasts to Hong Kong, and the Japanese archipelago.

LIFE HISTORY: This species is an opportunistic omnivore, feeding on macroalgae, salt marsh grass, larval and juvenile fish, and small invertebrates such as amphipods, gastropods, bivalves, barnacles, and polychaetes. The Asian shore crab is highly reproductive with a breeding season from May to September, twice the length of native crabs. The females are capable of producing 50,000 eggs per clutch with 3-4 clutches per breeding season. The larvae are suspended in the water for approximately one month before developing into juvenile crabs. Because of this, the larvae have the ability to be transported over great distances, a possible means of new introductions.

HABITAT: This versatile crab inhabits any shallow hard-bottom intertidal or sometimes subtidal habitat. They can live on artificial structures and on mussel beds and oyster reefs. They also tend to aggregate at high densities under rocks where they overlap habitats with native crab species. *Hemigrapsus* can tolerate wide ranges of salinity and temperature as well as damp conditions in the upper intertidal regions.

NONINDIGENOUS OCCURRENCES: *Hemigrapsus* was first recorded in the United States at Townsend Inlet, Cape May County, New Jersey in 1988. This species is now well established and exceptionally abundant along the Atlantic intertidal coastline of the United States from Maine to North Carolina. It is actively breeding and expanding its population within its nonnative range. Because the species is tolerant of a wide range of environmental conditions, it is likely that the invasion will continue along the US coastline.

MEANS OF INTRODUCTION: It is not known how this species was introduced to the United States Atlantic coast, but many speculate that adults or larvae were brought by incoming ships of global trade via ballast water discharge.

IMPACTS: Because this species has a very broad diet, it has the potential to affect populations of native species such as crabs, fish, and shellfish by disrupting the food web. It also occupies habitats very similar to our native mud crabs, possibly overwhelming and dominating their habitat. This potential impact on native species populations may be a result of direct predation or competition for a food source. *Hemigrapsus* may compete with larger species, like the blue crab, rock crab, lobster, and the nonnative green crab. Recent trends show numbers of shore crabs are steadily increasing while native crab populations are declining. These opportunistic omnivores may also pose threats to coastline ecosystems and aquaculture operations. There are still many questions to be answered by scientists about impacts this species may pose to biodiversity in those ecosystems affected.

CONTROL AND MANAGEMENT: Preliminary evidence shows that rockfish and seagulls may prey upon *Hemigrapsus*. Parasites, which help control populations of *Hemigrapsus* in its native range, are not present along the US Atlantic coast. The shore crab may continue to expand its range along the US Atlantic coastline until it reaches its salinity and temperature tolerance levels. Scientists are monitoring changes in native species, tracking the shore crab's spread along the coastline, and conducting experiments to increase their knowledge of basic biology and ecology of this species. Ballast water management is also being researched to reduce or eradicate new introductions from occurring.



http://cars.er.usgs.gov/Nonindigenous_Species/Asian_shore_crab/asian_shore_crab.html

Handout 2: Independent Species Investigation Worksheet

Student Name: _____

Date: _____

(Return to www.invasivespeciesinfo.gov as needed)

Species Name:	
Place of Origin	
Climate/Habitat	
Transportation	
Motivation to Introduce	
Damage to the Environment	
Methods to Eradicate	
Solutions to Invasion	

Handout 4: Class Summary of Trends

Student Name: _____

Date: _____

Record trends found by the expert groups in the table below.

Species	Trend
Place of Origin	
Climate/Habitat	
Transportation	
Motivation to Introduce	
Damage to the environment	
Methods to Eradicate	
Solutions to Invasion	

Learning Experience Six (Optional)

Attack of Invasive Species - Population Study How Many of Them Are There?

This learning experience is optional. It depends on the grade level and mathematics capability of the students.

Overview

By calculating the area of a location to be sampled and counting the number of organisms within a known percentage of the location, a reasonable estimate of the population size of the organism being counted can be made for that location. The following pre-lab and lab will go through the basic math involved in such sampling techniques.

Evaluation

Pre-Lab and Lab worksheets will be collected and assessed for understanding and completion. The students will share their results with the class and discuss the relevance of the activity.

Materials

- Dense newsprint (same copy for each student or team)
- Handout One: Attack of Invasive Species – Population Study – Pre-Lab
- Handout Two: Attack of Invasive Species – Population Study – Lab
- Metric rulers (up to 20 mm)
- Scissors
- Index cards
- Pencils
- Calculators (optional)

Activity One: Attack of Invasive Species - Population Study Pre-Lab

- Place students in small groups.
- Distribute Handout One and ask groups to complete the activity.
- As a class, review groups' results.

Teacher Note: Walking through this worksheet as a class may be helpful. It is critical that the students understand the concepts and have mastery of all the area and density calculations used in the exercise.

Activity Two: Attack of Invasive Species - Population Study Lab

- Distribute Handout Two to all students.
- Students may work alone or in groups.
- Demonstrate the procedure once in front of the class, and check for clarity.
- Instruct the students or student groups to complete the lab, and then discuss the results.
- Discuss the relevance and limitation of this sampling technique with the class before moving on.

Teacher Notes:

- These activities can be altered or simplified, based on the results of your ongoing assessment.
- Be sure to give each student or group the exact same news print and count the actual number of words, characters and letters 'e' prior to beginning the lesson.

Handout 1: Attack of Invasive Species - Population Study – Pre-Lab

Name: _____

Date: _____

How Many of Them Are There?

Background: By knowing the area of a location to be sampled, and counting the number of organisms within a known percentage of the location, a reasonable estimate of the population size of the organism being counted can be made. The following pre-lab will go through the basic math involved.

1. What is the area of a rock covered beach with a width of 100 m and a length of 12 m? **Location Area = length x width**

This data was collected from random sampling of Green, Japanese, and Mud crabs along a rocky shoreline. Each sampling was of an area 1m^2 .

Sample #	Sample Area	Green	Mud	Japanese
1	1 m^2	0	0	3
2	1 m^2	1	1	0
3	1 m^2	0	0	4
4	1 m^2	2	1	0
5	1 m^2	0	1	1
6	1 m^2	0	1	2
7	1 m^2	0	0	5
8	1 m^2	1	0	1
9	1 m^2	0	1	1
10	1 m^2	1	2	0
10	10 m^2	5		

2. Complete the table above by determining the total number of Mud and Japanese crabs.

3. Determine the **Population Density** (organisms per area) by dividing the total number of each species by the sampled area. For example:

Green Crabs: $5 \text{ Green Crabs} / 10 \text{ m}^2 = 0.5 \text{ Green crabs/m}^2$

Mud Crabs:

Japanese Crabs:

4. Determine the **Population Size** of each species by multiplying the **Population Density** by **Location Area**. For example:

Population Size = Population Density x Location Area.

Green Crab Population Size = $0.5 \text{ Green crabs/m}^2 \times 1200 \text{ m}^2 = 600 \text{ green crabs}$

Mud Crab Population Size =

Japanese Crab Population Size =

Handout 2: Attack of Invasive Species - Population Study – Lab

Name: _____

Date: _____

How Many of Them Are There?

Purpose: To model determining the density and total number of an organism within a known area. In this study the density and total number of characters, letters 'e', and words on a page will be determined.

Procedure

1. Measure in millimeters the length and width of the printed page provided by the teacher. Record (**Not edge to edge just the area with text**).
2. From the index card, cut out a 10 mm x 10 mm square.
3. Lay the printed page flat out the desk and toss or drop the square onto the page. With a pencil, trace around the square and label #1.
4. Count the following things if inside the sketched box:
 - a. Words: only if more than $\frac{1}{2}$ the letters are in the box.
 - b. Characters: letters and punctuation marks that are more than $\frac{1}{2}$ in the box.
 - c. Letter 'e': capital or lower case.
5. Record in the data table.
6. Repeat 15 times.

A. Determining Area

- Width of page [mm]: _____
- Length of page [mm]: _____
- Area of page:
($L \times W = \text{Area mm}^2$): _____

B. Density Measurements

Sample #	Sample Area	Words	Characters	"e"
1	100mm ²			
2	100mm ²			
3	100mm ²			
4	100mm ²			
5	100mm ²			
6	100mm ²			
7	100mm ²			
8	100mm ²			
9	100mm ²			
10	100mm ²			
11	100mm ²			
12	100mm ²			
13	100mm ²			
14	100mm ²			
15	100mm ²			
Total: 15				

C. Analysis

1. Determine the total area sampled: (15 samples 100mm² each).
2. Determine the number of words, characters, and letters 'e' counted by adding up each column.
3. Determine the density of words, characters, and letters 'e' on the page.
 - Divide the number of words, characters, and letters 'e' on the page by the area counted.
 - Answer should have units. For example, 222 words/mm².
4. Determine the total number of words, characters, and letters 'e' on the page.
 - Multiply the total area of the printed page by density.
 - Units of area should cancel out.
5. Determine the percent error: $(\text{Experimental} - \text{Actual})/\text{Actual} \times 100$

- Actual number of words: _____
- Actual number of characters: _____
- Actual number of letters 'e': _____

Learning Experience Seven

Invasive Species Public Alert Poster

Overview

Students will use the research they collected during Learning Experience Five to prepare an invasive species public alert poster. Students will provide information for identification, mode of introduction, likely habitat, damage caused, and control methods.

Evaluation

The poster will be evaluated based on the rubric provided, and students will conclude the unit with a post assessment of interest and importance.

Materials

- Computers with networked printers
- Internet access
- Poster board (approximately 24" x 36")
- Construction paper
- Scissors
- Glue
- Colored markers
- Grading Rubric

Activity One: Create an Invasive Species Public Alert Poster

- Instruct the students to take out their research from Learning Experience Five. Tell them that they are going to make a public alert poster much like the Hemigrapsus bulletin they read. The object of the poster is to make the public aware of the dangers of invasive species (in particular, the one they were assigned), including how to identify the organism and what to do if they see one.
- Write the following criteria on the board, and distribute the grading rubric. Discuss the multiplier and its meaning. Discuss how some content is more important and challenging than others and is therefore allotted more points.

Every poster must include the following:

- Common and Scientific Names of Invasive Species
- An Image of the Invasive Species
- Key Physical Traits for Identification
- Likely Mode of Introduction

- Habitat of the Invasive Species
- Damage Caused by the Invasive Species
- Potential Economic Costs of the Invasive Species
- Methods to Control the Invasive Species
- Whom to Contact if the Invasive Species is Found
- The poster will also be graded on:
 - Visual Appeal
 - Neatness and Organization
 - Spelling and Grammar
 - Overall Quality
- Allow for classroom time to work on the poster or assign it for homework.
- Display the completed posters in a highly visible location.

Teacher Note: A public forum, such as the library or town hall, to display the posters will help raise awareness within the community and reinforce the importance of the students' work and knowledge.

Activity Two: Take the Post Assessment

- Distribute the post assessment and tell the students to answer the questions openly and honestly. Stress that the answers are anonymous, will not be graded, and will be used to improve the unit in the future.

Teacher Notes:

- If the students are up to the challenge, the entire poster can be made as a PowerPoint slide. In the PowerPoint software, select File and Page Setup, and change the width to 36 inches and height to 24 inches.
- Students can then work on one slide to create a poster.
- Before attempting the PowerPoint poster, make sure there is a way to print the poster.

Student Name: _____

Date: _____

Rubric: Invasive Species Public Alert Poster

Grading Criteria:

Surpasses Standard **Meets Standard** **Standard Deficient** **Standard Absent**
 5 4 3 2 1 0

Content Criteria	# Grade (5- 0)	Multiplier	Total
Common and Scientific Names		X 1	
Image of Invasive Species		X 1	
Key Physical Traits for ID		X 1	
Mode of Introduction		X 2	
Habitat		X 2	
Damage Caused		X 2	
Economic Costs		X 2	
Methods of Control		X 2	
Whom to Contact		X 1	
Accuracy of Information		X 2	
Construction Criteria	# Grade (5- 0)	Multiplier	Total
Visual Appeal		X 1	
Neatness / Organization		X 1	
Spelling / Grammar		X 1	
Overall Quality		X 1	
		Percent Score:	

Self-Assessment of Interest in Invasive Species

Circle the value that best represents what you think/feel.

(1 is the lowest and 5 is the highest)

A. The issue of invasive species is important to me.

1 2 3 4 5

B. The issue of invasive species is important to my community.

1 2 3 4 5

C. The issue of invasive species is important to my country.

1 2 3 4 5

D. The issue of invasive species is important to the planet.

1 2 3 4 5

E. Humans play a major role in non-native species becoming invasive.

1 2 3 4 5

F. Technology speeds up the process of non-native species invasion.

1 2 3 4 5

G. Invasive species has been one of the better topics I have studied.

1 2 3 4 5

H. I like reading about invasive species.

1 2 3 4 5

I. I like researching information on invasive species.

1 2 3 4 5