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1994

Invasion of an exotic species : stop the zebra mussel! Activities and resources for grades 8-12.

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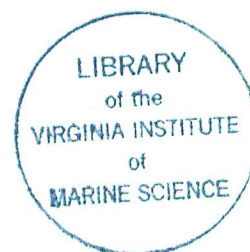
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Invasion of an Exotic Species: Stop the Zebra Mussel!



Activities and Resources For Grades 8 - 12

By
Vicki P. Clark
Thomas J. Miller



**Virginia Sea Grant Marine Advisory Program
School of Marine Science
Virginia Institute of Marine Science
The College of William and Mary
Gloucester Point, Virginia 23062**

**VIMS Educational Series No. 41
VSG 94-03**

This work is a result of research sponsored by NOAA Office of Sea Grant, U.S. Department of Commerce, under federal Grant No. NA 90AA-D-SG045 to the Virginia Graduate Marine Science Consortium and the Virginia Sea Grant College Program. The U.S. Government is authorized to produce and distribute reprints for governmental purposes notwithstanding any copyright notation that may appear hereon.

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Invasion of an Exotic Species: Stop the Zebra Mussel!



Activities and Resources For Grades 8 - 12

Thousands of exotic plants, animals, and microbes have been introduced into the United States. Some of these organisms were intentionally imported for use in agriculture, the pet industry, and fish and wildlife management. Others accidentally found their way to the United States in ships' ballast water, in packing materials, or as hitchhikers on other plants and animals. Many exotic species, such as soybeans and wheat, have been beneficial. Others, such as the Japanese beetle and kudzu, have had a negative impact. In addition, plant and animal species from the Americas have been exported to other parts of the world, with similar effects. Many exotic species displace native plants and animals, alter ecosystems, cause disease, and interfere with human activities in industry, agriculture, and recreation.

The zebra mussel is an exotic freshwater mollusk from Europe which was accidentally introduced into the United States in the Great Lakes area in 1985 or 1986. The mussel larvae were most likely transported in the ballast water of a ship and released into Lake St. Clair. The mussels reproduce rapidly in suitable habitats and have created serious environmental and economic problems in many parts of the country. Zebra mussels are spreading toward the mid-Atlantic states. Where and how will they be most likely to invade Virginia? How can the zebra mussel invasion be controlled?

The activities and resources presented in this packet will guide students in a study of the zebra mussel and the possibilities of its invasion of Virginia. Actual scientific research data are introduced as a critical part of group problem-solving activities. Students are challenged to use the scientific data and other information to design action plans to help prevent the introduction and spread of zebra mussels into the state. Additional follow-up activities extend the study of zebra mussels and encourage the investigation of the impact of other exotic plants and animals.



Acknowledgments



The information used to develop the data cards in the activity “Where Will the Zebra Mussel Invade?” was obtained from personal communications with Patrick Baker, a graduate student at the Virginia Institute of Marine Science, and from the following research reports:

Baker, Patrick, Shirley Baker, and Roger Mann. 1993. Criteria for predicting zebra mussel invasions in the mid-Atlantic region. Virginia Sea Grant College Program, Virginia Institute of Marine Science, VSG-93-03.

Baker, Patrick, Shirley Baker, and Roger Mann. 1993. Potential range of the zebra mussel, *Dreissena polymorpha*, in and near Virginia. Virginia Sea Grant College Program, Virginia Institute of Marine Science, VSG-93-04.

Supplementary materials:

North Carolina Sea Grant

Ohio Sea Grant

Virginia Sea Grant

Virginia Department of Game and Inland Fisheries

Zebra Mussel Information Clearinghouse, New York Sea Grant

Editorial Review:

Bland Crowder

Jan Hodges

Lee Larkin

Carol Rideout

Design and Layout: Susan Stein

Zebra mussel art work: Carol Allaire, Michigan Sea Grant

Printing: Sylvia Motley

Activity Instructions



Where Will the Zebra Mussel Invade?

Objective

Students will work in small groups to communicate and analyze scientific data on zebra mussels and water quality. Using this information, each group will predict the likelihood of zebra mussels becoming introduced and established in various aquatic sites in Virginia.

Student Preparation

Students should have a basic understanding of pH, temperature, and calcium content as measurable characteristics of the water in aquatic habitats. They should understand that “parts per thousand” and “parts per million” refer to the concentration of chemical substances present in a body of water.

Time Needed

1 class period (45 - 50 minutes)

Materials Needed (for each group of 4 - 6 students)

From the “Student Activities” section:

Zebra Mussel Biology

Zebra Mussel Critical Habitat Needs

Zebra Mussel Impacts

Zebra Mussel Study Site Data Cards (one set of 6 data cards per group)

Zebra Mussel Study Site Report

Optional: Virginia highway map (one per group)

Teacher Preparation

1. Read the information in the “Student Activities” section and the supplementary reference materials provided in the packet to familiarize yourself with zebra mussels and their impact.
2. Duplicate the Zebra Mussel Study Site Data Card sheets. (You will need one set of 6 cards for each student group.) Cut the data cards apart and put each set of six in a separate envelope, or paper clip them together. (If the cards become mixed up, the small number at the bottom of each card will help you put the sets back together.)

3. For each group, duplicate one copy of the other four pages (“Zebra Mussel Biology,” “Zebra Mussel Critical Habitat Needs,” “Zebra Mussel Impacts,” and “Zebra Mussel Study Site Report”). If you wish, give the “Biology” sheet to each student to read before class. You may want to make overhead transparencies of the “Critical Habitat Needs” and “Impacts” sheets and display them for reference during the activity.
4. If students are not already familiar with the concept of exotic species, decide how you will relate the zebra mussel issue to other concepts that they have studied, such as animal adaptation, species competition, impact of human activities on ecosystems, etc.

Conducting the Activity

1. Divide the class into groups of four to six students each. Assign roles within the groups as follows:

Materials Manager: Obtains activity materials from teacher, distributes them to group, and returns all materials to teacher in good order after activity is finished.

Recorder: Keeps written notes on group discussions and observations. Records group responses to questions on activity worksheets. Reads written information back to rest of group for their approval.

Reporter: Gives verbal report to the class summarizing the group’s conclusions, using the activity worksheets and other notes from the Recorder.

Research Technician(s): Provide(s) additional information to the group during the problem-solving activities by consulting supplementary handouts and reference materials.

2. Introduce students to the information from the “Zebra Mussel Impacts,” “Zebra Mussel Biology,” and “Critical Habitat Needs” sheets. You may lead a class discussion, or each small group may read and discuss the information and review it with the teacher and the rest of the class. Explain that they will be working in groups to analyze scientific information in order to predict whether or not various places in Virginia are suitable habitat for zebra mussels.
3. Give each Materials Manager a set of Zebra Mussel Study Site data cards and a copy of the Zebra Mussel Study Site Report form. The Materials Manager should distribute the data cards one at a time to all group members (some students may get more than one card if groups have fewer than six students). In turn, the students read aloud the information on their data cards to the other group members. The Recorder reads the Study Site Report form to the group.
4. Based on this information, each group develops a prediction about the likelihood that its study site will be affected by zebra mussels. The questions on the

Study Site Report form will guide their discussion. The Recorder writes the predictions and supporting information on this form.

- Once all groups have completed their report forms, each group’s Reporter shares the results with the rest of the class. To facilitate discussion as the class compares the sites, the Recorders can post on a chart or the chalkboard the predictions for their sites, along with water quality data and other important facts.
- If you plan to follow this activity with “Developing a Zebra Mussel Action Plan,” have the Recorders keep their Site Report forms to use as reference.

Summary and Evaluation

- Based on the information known about each study site, did each group make a reasonable prediction about the zebra mussel’s introduction and establishment? (See chart below for scientists’ predictions.) If students disagree, remember that all of the facts are not yet known, and that there is some room for debate.

Study Site	Chances for Introduction	Chances for Establishment
1. James River	high	high
2. Potomac River	high	high
3. Smith Mountain Lake	high	moderate
4. Rappahannock River	moderate	moderate
5. Kerr Reservoir and Lake Gaston	high	high
6. Mattaponi and Pamunkey Rivers	moderate	low
7. Lake Anna	high	low
8. Claytor Lake	high	moderate
9. South Holston Lake	high	high

- Rank the study sites from “lowest risk” to “highest risk” for the successful establishment of a zebra mussel population. Which site is closest to your school?
- Overall, what human activity might be most likely to contribute to the introduction of zebra mussels in Virginia?
- Locate the study sites on a Virginia highway map. How could the location and geography of each study site contribute to the introduction of zebra mussels? Once the zebra mussel becomes established, how far away from each study site do you think the mussel could spread?
- At which study site might zebra mussels have the most serious economic impact?

Activity Instructions



Developing a Zebra Mussel Action Plan

Objective

Students work in small groups to design and communicate action plans to help prevent the introduction and spread of zebra mussels in areas which are at risk.

Time Needed

2 class periods or more, depending on number of groups (students may need additional time outside of class to prepare group presentations)

Materials Needed

- Zebra Mussel Action Plan Outline (in “Student Activities” section)
- Zebra Mussel Study Site Reports (the same forms which were completed by the groups in the previous activity)
- Supplementary zebra mussel publications included in this packet (See “Resources” section for list of titles. You may duplicate these so that each group has a copy, or groups can share materials.)
- Posterboard, markers, and other art materials
- Optional: Additional zebra mussel articles (See “Resources” for bibliography)

Student Preparation

Students should have already completed the “Where Will the Zebra Mussel Invade?” activity and be divided into small groups.

Teacher Preparation

1. Read the “Zebra Mussel Action Plan Outline” for information on how the activity is done.
2. For each group, duplicate one copy of the “Zebra Mussel Action Plan Outline” and the supplementary publications. These publications contain background information the students will need to develop their action plans.
3. Divide students into small groups and assign roles, as in the previous activity. Groups may remain the same, or students may rotate into another group. NOTE: You may decide to have the class develop action plans only for those study sites which are at a high or moderate risk. If so, students from “low-risk” groups can be moved into “high-risk” groups.

Conducting the Activity

1. Give each Materials Manager copies of the "Zebra Mussel Action Plan Outline" sheet and the supplementary publications.
2. Briefly introduce the activity, and give students the timeline for the completion of their plans and for their class presentations (5-10 minutes each). Encourage the groups to use charts, posters, and any other creative methods to make their presentations effective.
3. On the day set aside for presentations, assign a timekeeper to help keep the activity on schedule. Each group should allow time for questions and comments from the rest of the class when its presentation is finished.

Summary and Evaluation

1. Have a small group of students serve as an evaluation team, and let them choose which plans are the most creative, comprehensive, practical, effective, etc. Alternatively, have the entire class discuss and evaluate the merits and shortcomings of each plan.
2. How do the groups' action plans compare to the efforts which Virginia and other states are making to control the zebra mussel? Students may want to contact zebra mussel specialists to get their reactions to the student plans. (See "Resources" for contact people.)



Publications Included In This Packet



- Baker, Patrick, Shirley Baker, and Roger Mann. 1993. Criteria for predicting zebra mussel invasions in the mid-Atlantic region. Virginia Sea Grant Program, Virginia Institute of Marine Science, VSG-93-03.
- Baker, Patrick, Shirley Baker, and Roger Mann. 1993. Potential range of the zebra mussel, *Dreissena polymorpha*, in and near Virginia. Virginia Sea Grant Program, Virginia Institute of Marine Science, VSG-93-04.
- Baker, Shirley, Patrick Baker, and Roger Mann. 1993. Zebra mussels in Virginia's future. Virginia Sea Grant Program, Virginia Institute of Marine Science, VSG-93-05.
- Doll, Barbara. 1993. Mid-Atlantic zebra mussel fact sheet. University of North Carolina Sea Grant, North Carolina State University.
- Heath, Robert T. 1993. Zebra mussel migration to inland lakes and reservoirs: A guide for lake managers. Ohio Sea Grant College Program, OHSU-FS-058.
- Kelch, David O. 1994. Boaters: Slow the spread of zebra mussels, and protect your boat too. Ohio Sea Grant College Program, OHSU-FS-054.
- McManus, M., N. Schneeberger, R. Reardon, and G. Mason. 1989. Gypsy moth. Forest insect and disease leaflet 162, U.S. Department of Agriculture Forest Service.
- Ohio Sea Grant College Program. A Great Lakes Sea Grant resource list on zebra mussels and other nonindigenous species. 1993. Ohio Sea Grant College Program, OHSU-FS-052.
- O'Neill, Charles R. Jr., and David B. MacNeill. 1991. The zebra mussel (*Dreissena polymorpha*): An unwelcome North American invader. New York Sea Grant.
- Snyder, Fred L., David W. Garton, and Maran Brainard. 1994. Zebra mussels in North America: The invasion and its implications. Ohio Sea Grant College Program, OHSU-FS-045.



Selected Bibliography



For more information on zebra mussels and other exotic species, check local libraries for the following publications:

- Bruenderman, Sue, and Lisie Kitchel. 1992. A hitchhiking terror: The zebra mussel. *Virginia Wildlife*, Vol. 53, No. 4, April 1992, pp. 11-13.
- Culotta, Elizabeth. 1991. Biological immigrants under fire. *Science*, Vol. 254, No. 5037, 6 December 1991, pp. 1444-1447.
- Doll, Barbara, and Jeannie Farris. 1993. Invasion of the killer mussels. *Wildlife in North Carolina*, Vol. 57, No. 3, March 1993, pp. 21-23.
- Fleming, C.B. 1991. Unwelcome immigrants: Ballast water stowaways. *Sea Frontiers*, Vol. 37, No. 3, June 1991, pp. 22-25.
- Neves, Richard. Brooding over mussels. 1994. *Virginia Wildlife*, Vol. 55, No. 1, Jan. 1994, pp. 4-9.
- Raloff, Janet. 1992. From tough ruffe to quagga. *Science News*, Vol. 142, No. 4, pp. 56-58.
- Ross, John. 1994. An aquatic invader is running amok in U.S. waterways. *Smithsonian*, Vol. 24, No. 11, Feb. 1994, pp. 40-51.
- Stolzenburg, William. 1992. The mussels' message. *Nature Conservancy*, Vol. 42, No. 6, Nov./Dec. 1992, pp. 16-23.
- Virginia Sea Grant. 1992. *Dreissena polymorpha*, the unwelcome colonizer. *Virginia Marine Resource Bulletin*, Vol. 24, Nos. 1 and 2, Spring and Summer 1992, pp. 22-23.

Additional curriculum materials may be ordered from the following sources:

"Alien Invaders: A Case Study on Zebra Mussels"

(curriculum unit with student activities)

The Rivers Project

Southern Illinois University

Box 2222

Edwardsville, IL 62026

"Saving America's Pearly Mussels"

(video, script, and poster)

Virginia Tech Extension Distribution Center

112 Landsdowne St.

Blacksburg, VA 24061-0512



Mid-Atlantic Contacts for Zebra Mussel Information



Delaware

Tracey Bryant
Delaware Sea Grant Program
University of Delaware
Marine Communications Office
263 East Main Street
Newark, DE 19716-3530
(302) 831-8185

Jim Falk
Delaware Sea Grant Program
Marine Advisory Services
700 Pilottown Road
Lewes, DE 19958-1298
(302) 645-4997

Maryland

Dan Terlizzi
Sea Grant Extension Service
NOAA Chesapeake Bay Office
410 Severn Avenue, Suite 107A
Annapolis, MD 21403
(410) 280-1871

New Jersey

Eleanor Bochenek
New Jersey Sea Grant
Rutgers Cooperative Extension
1623 Whitesville Road
Toms River, NJ 08755
(908) 349-1152

New York

Charles O'Neill, Jr.
Zebra Mussel Information Clearinghouse
New York Sea Grant Extension
250 Hartwell Hall
SUNY College at Brockport
Brockport, NY 14420-2928
(800) 285-2285

North Carolina

Barbara Doll
North Carolina Sea Grant
Box 8208
North Carolina State University
Raleigh, NC 27695
(919) 515-7802

Virginia

William DuPaul
Vicki Clark
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P.O. Box 1346
Gloucester Point, VA 23062
(804) 642-7169

Virginia Department of Game and
Inland Fisheries
Fisheries Division
P.O. Box 11104
Richmond, VA 23230-1104
(804) 367-1000

Louis A. Helfrich
Department of Fisheries and Wildlife
Sciences
Virginia Polytechnic Institute and State
University
Blacksburg, Virginia 24060
(703) 231-5059



Other Zebra Mussel Contacts



Ohio Sea Grant College Program
The Ohio State University
1314 Kinnear Road
Columbus, OH 43212
(614) 292-8949

Michigan Sea Grant College Program
Zebra Mussel Information Office
University of Michigan
20200 Bonisteel Blvd.
Ann Arbor, MI 48109
(313) 764-1138

Minnesota Sea Grant
Zebra Mussel Information Center
208 Washburn Hall
University of Minnesota
Duluth, MN 55812
(218) 726-8712

Tennessee Valley Authority
1101 Market Street
Chattanooga, TN 37402
(800) 538-2526



Student Activities



See “Teacher’s Guide” for activity instructions.

Master copies of student activity pages included in this section are as follows:

- **Zebra Mussel Biology**
- **Zebra Mussel Critical Habitat Needs**
- **Zebra Mussel Impacts**
- **Zebra Mussel Site Report**
- **Zebra Mussel Action Plan Outline**
- **Zebra Mussel Study Site Data Cards (9 pages)**
- **Follow-Up Ideas**

NOTE TO TEACHERS AND STUDENTS:

It is against Virginia state law to import live zebra mussels or any other non-indigenous (exotic) species into the state. No activity in this curriculum involves the use of live zebra mussels. Due to the danger of accidental introduction and the strict laboratory controls required for their use, live exotic species are not recommended for student research.



Zebra Mussel Biology



The zebra mussel is a freshwater bivalve mollusk, originally found in Europe in the Caspian, Aral, and Black seas. Adult zebra mussels range from 0.5 to 3.5 cm long. The zebra mussel's scientific name is *Dreissena polymorpha*. The name *polymorpha* refers to the many individual variations in the color and pattern of the shell. Most zebra mussels have striped shells, but some are solid black or brown.

Zebra mussels feed on plankton, including algae, bacteria, larval animals, and other tiny particles of organic matter suspended in the water. The mussel pumps water into its body through a siphon tube and filters out the food. The water is pumped out through a second siphon. An adult zebra mussel filters an average of one liter of water each day.

Although they are freshwater animals, zebra mussels can survive in slightly brackish water (0.5 parts per thousand). Some adult zebra mussels have survived for several days in water with salinities as high as 12 parts per thousand under controlled laboratory conditions.

Zebra mussels grow and reproduce best in water which is 12 to 26°C with a calcium content of at least 20 parts per thousand. The calcium is important for the growth and maintenance of the shell.

Zebra mussels are either male or female. Mature females can produce 30,000 eggs each year. Some females have produced as many as one million eggs per year. Spawning occurs when water temperatures warm to 12 to 23°C. If the water temperature remains suitable, spawning may occur several times during the season.

A fertilized zebra mussel egg becomes a microscopic, planktonic larva. The larval mussel spends two to three weeks swimming about, feeding on phytoplankton. During this stage, downstream currents can easily transport the larval zebra mussel from one body of water to another.

About two to three weeks after hatching, the larva begins to settle to the bottom. To survive, it must settle on a hard surface. Almost anything will do, including rocks, pier pilings, boats, concrete, or another animal's shell. It attaches to the surface with strong fibers called byssal threads. Zebra mussels frequently grow in large colonies, with hundreds of individuals attached to an object and to each other.

Zebra mussels can crawl from place to place by secreting temporary byssal threads which the mussels attach and detach as they move along.



Zebra Mussel Critical Habitat Needs



water temperature	6 - 28°C (spawn at 12 - 23°C; die above 30°C)
pH	7.4 - 9.4
salinity	less than 5 parts per thousand (ppt)
calcium (from CaCO₃)	greater than 20 parts per million (ppm)
substrate	need firm surface for attachment

NOTE: Larval forms are more sensitive than adults, especially to cold water temperatures.



Zebra Mussel Impacts



Zebra mussels can reproduce in large numbers in suitable habitats. Although individual zebra mussels are small, they attach to each other to form large colonies which grow on almost any solid underwater material. These colonies can grow to contain as many as 100,000 mussels per square meter!

Large populations of zebra mussels in many parts of the United States can cause serious problems, such as the following:

- Clog intake pipes in water treatment plants, power generating plants, and industrial facilities, reducing water flow and causing occasional shutdowns
- Attach to pier pilings, navigational buoys and markers, and docks, interfering with navigation and increasing corrosion
- Grow on boat hulls and inside engine systems, decreasing fuel efficiency and damaging engines
- Attach to shells of native freshwater mussels, weakening or killing them by interfering with the mussels' ability to open or close their shells, as well as competing for food
- Filter large amounts of phytoplankton from the water, reducing food available for other filter-feeding organisms and many fish



Zebra Mussel Site Report



Location of zebra mussel study site:

Names of study team members:

1. The chance that zebra mussels will be introduced to this site is (circle one):

low

moderate

high

What specific facts and information about zebra mussels and about the study site led you to this conclusion?

2. If zebra mussels are introduced, the chance that they will survive and successfully reproduce in this site is (circle one):

low

moderate

high

What specific facts and information about zebra mussels and about the study site led you to this conclusion?

3. List three specific actions which your group feels people should take to prevent the introduction of zebra mussels into this site.



Zebra Mussel Action Plan Outline



Names of team members:

Location of zebra mussel study site:

Chance that zebra mussels will become introduced at this site (see your "Zebra Mussel Site Report" form):

low

moderate

high

Chance that zebra mussels will survive and successfully reproduce in this site:

low

moderate

high

Your team is responsible for developing an action plan which will help reduce the chances that zebra mussels will be introduced in your study site. As a team, discuss the following questions (be sure to have your team's recorder take notes during the discussion):

What groups of people (your "target audience") will need to know about zebra mussels?

What will each group of people need to do to help keep zebra mussels out of the area?

How will you communicate this information to each group in your target audience?

How will you pay for developing and conducting your activities?

What can you do to find out if your action plan is successful?

Use your answers to these questions to develop your action plan. Prepare a 5 - 10 minute presentation to give to the rest of the class which describes what your group wants to do. Include a written summary of the plan as well as charts, posters, or other items which will help explain your ideas.

Follow-Up Ideas

Classroom Activities



1. Work with your group to design a method to remove zebra mussels from one of the following areas:

Small lake used for swimming, fishing, and boating

Water treatment facility which provides water for an entire community, including homes, schools, businesses, hospitals, and industries

Stream which supports a population of a freshwater mussel which is important to the local economy (its shells are exported to Japan for use in the cultured pearl industry)

Consult the supplementary materials in this packet for information on zebra mussel control. As you design your control method, consider the following:

Some control methods which kill zebra mussels may also be harmful to native freshwater mussels, fish, aquatic plants, and other organisms. How will you make sure your method will not be harmful to other organisms in the area?

What will you do with the zebra mussels that you destroy?

If drinking water supplies are affected, how will you avoid contaminating the water with chemicals and with dead zebra mussels?

Describe your control method in writing, or present a report to the class. You may want to draw diagrams and pictures or build a model to show how your control method will work.

2. Design a poster which educates recreational boaters, fishermen, and other users of lakes and streams about the zebra mussel problem. In addition, develop a bumper sticker or T-shirt design using the zebra mussel theme.
3. Produce a public service announcement for television which informs people about the zebra mussel problem. Videotape or present the announcement live to the rest of the class.
4. Write a short play or skit with a zebra mussel as the main character.
5. If you have access to a computer and a telecommunication network, contact students who live in an area where zebra mussels have become established (see range map in "The Zebra Mussel: An Unwelcome North American Invader"). Find out what people in their community are doing about the problem. If you cannot use a computer to communicate, write letters.



Field Activities



1. Visit your local water treatment facility or electric power plant to find out how the operators keep the water intake areas free of debris, animals, plants, etc. It is usually possible to schedule a tour for a group if you call in advance.
2. Take a walk around your school, a local park, or your yard. List the plants and animals which were introduced from another part of the United States or another country. A horticulture teacher, science teacher, botanist, or garden club member might be able to help you with the survey.
3. Call a local greenhouse or plant nursery and ask if your class can schedule a visit to learn about the types of plants which are grown and sold there. How many of these are native plants? What different parts of the world have provided us with some of our most common house and garden plants? What are the advantages and disadvantages of cultivating native vs. exotic plants?
4. Many exotic animals have been intentionally brought into the United States. These animals may have been imported for pets, for hunting, or for control of other species. Contact state and federal wildlife and agriculture departments for information on regulations which control the importation of exotic animals into your state. Local pet stores should also be able to explain how they are required to follow regulations concerning the sale of exotic species.
5. Many plants which originated in the Americas, including corn, tomatoes, and "Irish" potatoes, have been introduced to Europe and Africa. What impacts have these exotic species had on the economies and ecosystems of these areas?
6. Get involved in a water quality monitoring project to learn how to measure mineral content, pH, temperature, and other water conditions. Many communities have organized groups which monitor water quality in specific sites. Contact the following organizations for information on citizen water quality monitoring:

Jay West
Save Our Streams (SOS)
Izaak Walton League of America
1401 Wilson Blvd., Level B
Arlington, VA 22209
(703) 528-1818

Kathleen Ellett, Monitoring Director
Alliance for the Chesapeake Bay, Inc.
6600 York Road, Suite 100
Baltimore, MD 21212
(410) 377-6270

Global Rivers Environmental Education
Network (GREEN)
721 East Huron
Ann Arbor, MI 48104
(313) 761-8142

Zebra Mussel Study Site No. 1 James River at Richmond, VA

The land area which drains into the James River has many large lakes and reservoirs with heavy recreational use. There are over 90 public boat ramps in the area, mostly on lakes.

1

Zebra Mussel Study Site No. 1 James River at Richmond, VA

Large ships traveling from freshwater ports in Europe frequently dock at the deepwater port in Richmond. There is also heavy barge and boat traffic between the James River and other tributaries of the Chesapeake Bay.

2

Zebra Mussel Study Site No. 1 James River at Richmond, VA

Each year, professional bass fishing tournaments are held near Richmond on the tidal freshwater portions of the James. Most of these fishing boats are brought to the tournaments on trailers. The boats may have been in lakes and rivers throughout the country only a day or two earlier.

3

Zebra Mussel Study Site No. 1 James River at Richmond, VA

The water monitoring site closest to Richmond is near Cartersville. The pH of the James River at this site in August is 8.1. The calcium content of the river near Cartersville is about 22 ppm.

4

Zebra Mussel Study Site No. 1 James River at Richmond, VA

In areas where the mussels thrive, adult zebra mussels frequently attach to boats and trailers. These mussels can live out of water for two to three days under certain environmental conditions.

5

Zebra Mussel Study Site No. 1 James River at Richmond, VA

Free-swimming zebra mussel larvae can survive for several days or even weeks in the ballast water of ships. Under some conditions, they can also survive for days in water contained in bait buckets, live wells, boat trailer frames, and other enclosed areas in boats and ships.

6

Zebra Mussel Study Site No. 2 Potomac River at Alexandria, VA

Large vessels travel regularly into the Potomac River from the Great Lakes area. For example, according to officials at one dock terminal, cargo ships from Quebec City on the St. Lawrence River arrive in Alexandria six or seven times a year.

1

Zebra Mussel Study Site No. 2 Potomac River at Alexandria, VA

The pH of the Potomac River near Alexandria is 8.1 - 8.4 from May to September. Calcium content of the Potomac River near Alexandria is 32 - 40 ppm.

2

Zebra Mussel Study Site No. 2 Potomac River at Alexandria, VA

Many zebra mussels live in the St. Lawrence River near Quebec City in Canada.

3

Zebra Mussel Study Site No. 2 Potomac River at Alexandria, VA

Free-swimming zebra mussel larvae can survive for several days or even weeks in the ballast water of ships. Under some conditions, they can also survive for days in water contained in bait buckets, live wells, boat trailer frames, and other enclosed areas in boats and ships.

4

Zebra Mussel Study Site No. 2 Potomac River at Alexandria, VA

Alexandria is the largest port in the freshwater portion of the Potomac River. No one knows the volume of ballast water dumped by ships in the port at Alexandria. Commercial and recreational traffic into the Potomac estuary from neighboring estuaries is very high.

5

Zebra Mussel Study Site No. 2 Potomac River at Alexandria, VA

The Potomac is the Virginia estuary which is closest to the Susquehanna River. Zebra mussels are living in the Susquehanna River in the vicinity of Johnson City, NY.

6

Zebra Mussel Study Site No. 3 Smith Mountain Lake

Smith Mountain Lake is a large reservoir on the headwaters of the Roanoke River near the city of Roanoke.

1

Zebra Mussel Study Site No. 3 Smith Mountain Lake

The pH of Smith Mountain Lake in the summer ranges from 7.6 to 9.1.

2

Zebra Mussel Study Site No. 3 Smith Mountain Lake

Smith Mountain Lake is heavily used for recreational boating and fishing. There are 17 public boat ramps and a very popular state park located on the lake.

3

Zebra Mussel Study Site No. 3 Smith Mountain Lake

The calcium level of Smith Mountain Lake is about 15 - 17 ppm.

4

Zebra Mussel Study Site No. 3 Smith Mountain Lake

A large professional bass tournament is held annually on Smith Mountain Lake. Participants travel from all over the country to compete, and bring their own boats on trailers.

5

Zebra Mussel Study Site No. 3 Smith Mountain Lake

In areas where the mussels thrive, adult zebra mussels frequently attach to boats and trailers. These mussels can live out of the water for two to three days under certain environmental conditions.

6

Zebra Mussel Study Site No. 4 Rappahannock River

Along the Rappahannock there are several reservoirs which are used for recreational boating and fishing. There are 11 public boat ramps in the freshwater portion of the river.

1

Zebra Mussel Study Site No. 4 Rappahannock River

Near Fredericksburg, the Rappahannock River has a pH of 7.8 (measured in August).

2

Zebra Mussel Study Site No. 4 Rappahannock River

Boat traffic into the Rappahannock from other estuaries is low to moderate. Residential development surrounds several large, private reservoirs in the Rappahannock drainage area.

3

Zebra Mussel Study Site No. 4 Rappahannock River

Calcium levels of the Rappahannock in August have been measured at 5.2 ppm.

4

Zebra Mussel Study Site No. 4 Rappahannock River

Free-swimming zebra mussel larvae can survive for several days or even weeks in the ballast water of ships. Under certain conditions, they can also survive for days in water contained in bait buckets, live wells, boat trailer frames, and other enclosed areas in boats and ships.

5

Zebra Mussel Study Site No. 4 Rappahannock River

Currents moving downstream from one body of water to another can easily transport larval zebra mussels.

6

Zebra Mussel Study Site No. 5 Kerr Reservoir and Lake Gaston

Kerr Reservoir and Lake Gaston are on the Roanoke River. Both lakes are heavily used for recreational boating and fishing.

1

Zebra Mussel Study Site No. 5 Kerr Reservoir and Lake Gaston

Water chemistry varies from place to place in both Lake Gaston and Kerr Reservoir. Scientists have recorded pH readings of 6.9 - 9.3 in parts of both lakes.

2

Zebra Mussel Study Site No. 5 Kerr Reservoir and Lake Gaston

Currents moving downstream from one body of water to another can easily transport larval zebra mussels.

3

Zebra Mussel Study Site No. 5 Kerr Reservoir and Lake Gaston

Scientists have measured calcium levels in Lake Gaston at 24 - 44 ppm. Data on calcium levels in Kerr Reservoir are not yet available.

4

Zebra Mussel Study Site No. 5 Kerr Reservoir and Lake Gaston

Several public-access reservoirs with a total of 80 public boat ramps are located upstream from both lakes.

5

Zebra Mussel Study Site No. 5 Kerr Reservoir and Lake Gaston

In areas where the mussels thrive, adult zebra mussels frequently attach to boats and trailers. These mussels can live out of the water for two to three days under certain environmental conditions.

6

Zebra Mussel Study Site No. 6 Mattaponi and Pamunkey Rivers

The Mattaponi and Pamunkey rivers flow together at West Point to form the York River. The York River has a salinity of about 5 ppt at West Point.

1

Zebra Mussel Study Site No. 6 Mattaponi and Pamunkey Rivers

Free-swimming zebra mussel larvae can survive for several days or even weeks in the ballast water of ships. Under some conditions, they can also survive for days in water contained in bait buckets, live wells, boat trailer frames, and other enclosed areas in boats and ships.

2

Zebra Mussel Study Site No. 6 Mattaponi and Pamunkey Rivers

Large barges and ships travel up and down the York River to and from a large paper mill in West Point. The barges travel between West Point and the Eastern Shore of Virginia. The ships travel from a number of ports in northern Europe, Canada, and South America.

3

Zebra Mussel Study Site No. 6 Mattaponi and Pamunkey Rivers

At the Beulahville monitoring site northeast of Mangohick, scientists measured the pH of the Mattaponi in July at 6.9. Calcium content was 3.7 ppm.

4

Zebra Mussel Study Site No. 6 Mattaponi and Pamunkey Rivers

The Mattaponi River has several freshwater reservoirs upstream from West Point. These reservoirs are used for boating and fishing. Lake Anna, a large freshwater reservoir in the Pamunkey River drainage, is also a popular boating and fishing site.

5

Zebra Mussel Study Site No. 6 Mattaponi and Pamunkey Rivers

In June at the Hanover monitoring site, scientists recorded pH readings for the Pamunkey at 6.9. Calcium content was 9 ppm.

6

Zebra Mussel Study Site No. 7 Lake Anna

Lake Anna, the largest reservoir in the Pamunkey River drainage, is a very popular site for recreational fishing and boating. There are nine public access boat ramps on the lake.

1

Zebra Mussel Study Site No. 7 Lake Anna

Larval zebra mussels can easily be transported by currents moving downstream from one body of water to another.

2

Zebra Mussel Study Site No. 7 Lake Anna

The pH of Lake Anna measures 7.9 in some branches of the lake during the summer, but most of the lake has a pH of slightly less than 7.0.

3

Zebra Mussel Study Site No. 7 Lake Anna

There is a nuclear power plant located on Lake Anna which requires large amounts of water for its operation.

4

Zebra Mussel Study Site No. 7 Lake Anna

The greatest calcium content measured in Lake Anna waters is 6.0 ppm.

5

Zebra Mussel Study Site No. 7 Lake Anna

In areas where the mussels thrive, adult zebra mussels frequently attach to boats and trailers. These mussels can live out of the water for two to three days under certain environmental conditions.

6

Zebra Mussel Study Site No. 8 Claytor Lake

Claytor Lake has heavy recreational use. There are eight public boat ramps on the lake, and eight more are located on the New River upstream.

1

Zebra Mussel Study Site No. 8 Claytor Lake

The calcium level in Claytor Lake is usually low, around 9.0 to 10.0 ppm. However, in some years, the calcium has been measured at 30.0 ppm.

2

Zebra Mussel Study Site No. 8 Claytor Lake

Claytor Lake hosts numerous fishing tournaments. Participants travel with their boats to Claytor Lake from many areas outside of Virginia.

3

Zebra Mussel Study Site No. 8 Claytor Lake

Claytor Lake was built as a reservoir to provide water for a hydroelectric power plant.

4

Zebra Mussel Study Site No. 8 Claytor Lake

The pH of surface waters in Claytor Lake in June ranges from 7.3 to 9.3.

5

Zebra Mussel Study Site No. 8 Claytor Lake

In areas where the mussels thrive, adult zebra mussels frequently attach to boats and trailers. These mussels can live out of the water for two to three days under certain environmental conditions.

6

Zebra Mussel Study Site No. 9 South Holston Lake

South Holston Lake is located near Abingdon on the South Fork of the Holston River. The Holston is a tributary of the Tennessee River.

1

Zebra Mussel Study Site No. 9 South Holston Lake

The pH of South Holston Lake has been measured at 6.9 to 8.6 in June and July.

2

Zebra Mussel Study Site No. 9 South Holston Lake

South Holston Lake is only a few hundred miles from other lakes in the Tennessee River system. Zebra mussels are living and successfully reproducing in the Tennessee River.

3

Zebra Mussel Study Site No. 9 South Holston Lake

Calcium levels in South Holston Lake range from 18 to 30 ppm.

4

Zebra Mussel Study Site No. 9 South Holston Lake

There are 16 public boat ramps on South Holston Lake and two more upstream on Hungry Mother Lake.

5

Zebra Mussel Study Site No. 9 South Holston Lake

In areas where mussels thrive, adult zebra mussels frequently attach to boats and trailers. These mussels can live out of the water for two to three days under certain environmental conditions.

6