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# ZEBRA MUSSELS



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## STOP ZEBRA MUSSELS

Curriculum Guide for Grades 5 and 6

*Note: This Curriculum Guide has been adapted from the Zebra Mussel Mania with permission from the Illinois-Indiana Sea Grant Program. The original Activities 1, 3, and 10 have been deleted because the material is not relevant to the southern region.*

*Thanks to the following for their valuable advice and assistance:*

***Baldwin County Teachers***

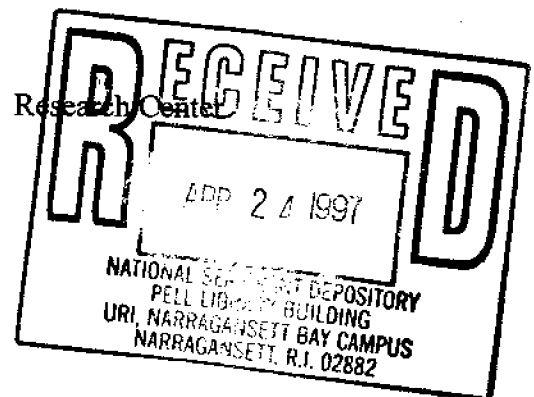
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*The Zebra Mussel Traveling Trunk was modeled after the Math and Science Hands-On (M.A.S.H. Kit) concept developed at Educational Service Center #16, Belleville, Illinois, and Southern Illinois University at Edwardsville.*

## Table of Contents

### INTRODUCTION

The Zebra Mussel Traveling Trunk at a Glance .....	1
Cooperative Learning: Classroom Management Techniques .....	3
Quick Reference Glossary .....	5
Agencies and Officials .....	9
Goals and Objectives .....	10
Setting the Stage for Learning .....	11
Student KWL Strategy .....	13
Student Attitude Survey .....	14

### MATERIALS FOR ALL ACTIVITIES

Zebra Mussel Journal .....	15
Safety Rules .....	16
Zebra Mussel Mania Post Test .....	17
Zebra Mussel Mania Post Test Key .....	20

### ACTIVITY 2: LOOKING AT THE ZEBRA MUSSEL MENACE

Activity Lesson Plan .....	23
Words of Wisdom .....	28
Sheet 2.1 .....	29
Sheet 2.2 .....	30
Key 2.1 .....	31
Key 2.2 .....	32

### ACTIVITY 4: MUSSEL TO MUSSEL

Activity Lesson Plan .....	33
Story of Shell #13 .....	39
Words of Wisdom .....	40
Record Sheet 4.3 Teacher's Key .....	41
Story 4.1 .....	42
Story 4.4 .....	44
Story 4.6 .....	45
Story 4.6 Teacher's Key .....	46

## ACTIVITY 5: HOW BIG ARE YOUR MUSSELS?

Activity Lesson Plan .....	47
Words of Wisdom .....	51
Sheet 5.1 .....	52
Sheet 5.2 .....	53
Sheet 5.3 .....	54

## ACTIVITY 6: FILTERING FOOLS

Activity Lesson Plan .....	55
Words of Wisdom .....	60
Sheet 6.1 .....	61
Sheet 6.2 .....	62
Sheet 6.2 Teacher's Key .....	63

## ACTIVITY 7: ALL CLOGGED UP

Activity Lesson Plan .....	64
Words of Wisdom .....	69
Sheet 7.1 .....	70
Sheet 7.2 .....	71
Sheet 7.2 Teacher's Key .....	72
Example Graph .....	73

## ACTIVITY 8: FAMILY REUNION

Activity Lesson Plan .....	74
Words of Wisdom .....	79
Sheet 8.1 .....	80

## ACTIVITY 9: WEB OF LIFE GAME

Activity Lesson Plan .....	81
Words of Wisdom .....	86
Food Pyramid Overhead .....	87
Sheet 9.1 .....	88

MATERIAL TO XEROX

## POCKET 1

Student KWL Strategy  
Student Attitude Survey  
ZM Journal  
Safety Rules  
ZM Mania Post Test

## POCKET 2

Sheet 2.1	Sheet 5.3
Sheet 2.2	Sheet 6.1
Sheet 4.1	Sheet 6.2
Sheet 4.4	Sheet 7.1
Sheet 4.6	Sheet 7.2
Sheet 5.1	Sheet 8.1
Sheet 5.2	

## POCKET 3

Words of Wisdom  
Activity 2 - 9

## REFERENCE MATERIAL



# **STOP ZEBRA MUSSELS EQUIPMENT BOX AT A GLANCE**

*NOTE: Alabama teachers should contact their county Extension office to check out an Equipment Box.*

## **INTRODUCTION**

The Stop Zebra Mussels Equipment Box was modeled and modified from the Illinois-Indiana Traveling Trunk. This section is written to provide you with a quick overview of the major curriculum elements around which the Illinois-Indiana Traveling Trunks were designed. In cooperation with the Illinois Rivers Project, the Minnesota Sea Grant College Program, and the University of Minnesota Bell Museum of Natural History, the Illinois-Indiana Sea Grant developed this educational resource kit. The Zebra Mussel Traveling Trunk and accompanying curriculum guide, Zebra Mussel Mania, were specifically created to provide teachers, environmental educators, natural resource agencies, and Cooperative Extension Service youth educators with a set of tools to teach 5th and 6th grade students about zebra mussels and the array of problems commonly associated with these and other exotic species. The Trunks were modeled after the Math And Science Hands-on (M.A.S.H.) kit concept developed by Educational Service Center #16 in Belleville, Illinois, and Southern Illinois University at Edwardsville.

## **SCOPE AND SEQUENCE**

Both the Alabama Cooperative Extension System's Stop Zebra Mussels Equipment Box and the Illinois-Indiana Sea Grant Program's Traveling Trunk were developed around fundamental themes in science that can be matched to concepts covered in most textbooks. Students explore these central themes as they complete seven developmentally appropriate, process-based activities.

## **BENCHMARKS**

The Alabama Cooperative Extension System's personnel were impressed with the Traveling Trunk from Illinois-Indiana Sea Grant Program and with permission developed their own using the Traveling Trunk as a template. The Stop Zebra Mussels Equipment Box contains seven activities that are slightly modified from the original ten activities in the Traveling Trunk. The Traveling Trunk was developed by Illinois, Indiana, and Minnesota educators primarily to assist classroom teachers in meeting the educational needs of their students. As a result, each investigation's instructional guide-lines focus on information in Benchmarks for Science Literacy, Project 2061 (American Association for the Advancement of Science). These guidelines include the basic concepts and fundamental skills across the curriculum: science, mathematics, social studies, language arts, fine arts, health and physical education. The trunk activities were carefully selected to prepare students to meet or exceed these benchmarks. Each of the ten activities is prefaced with specific goals and objectives to be met upon completion of the exercises that comprise the activity.

## **SCIENCE PROCESS SKILLS**

The activities in the boxes address the science process skills necessary for students to utilize when learning science: observation, measurement, classification, inference, prediction, communication, formulation of hypotheses, experimentation, and interpretation of data.

## **COOPERATIVE LEARNING**

The instructional approach utilized in this curriculum allows students to work in cooperative groups. It is recommended that the size of your cooperative groups not exceed four students. Many educational benefits occur when students work together in groups to investigate and solve problems. Cooperative learning more closely resembles the way individuals work together to solve problems in the real world. Another important reason for the use of cooperative groups is to make the acquisition, costs, and management of materials reasonable for the classroom teacher.

## **LANGUAGE ARTS**

Students read about, talk about, and write about the exciting science activities they are doing. This additional use of language along with the science investigation reinforces students' understanding of the scientific principles being explored. The trunk includes its own science-related publications and an additional list of resources.

## **MATHEMATICS**

Many of the science investigations result in an opportunity for the students to apply mathematics skills in a variety of ways. Students are encouraged to quantify their observations with metric measurements and to record and report those observations with charts, tables, and graphs. Often times students will need to apply mathematical operations to solve problems or answer questions.

## **ALTERNATIVES IN ASSESSMENT**

The activity assessment provided in this guide can be used to determine students' understanding of the major concepts dealt with in the trunk. Unit tests utilize a variety of different question formats such as fill in the blank, short answer, etc. The lesson assessment may be given in a pre-post type format in order to:

- (1) determine the increase of students' understanding as a result of this unit, and
- (2) clarify students' prior skill and knowledge of the direction instructions should take.

The trunks also include a performance-based assessment that gives the teacher the opportunity to observe what students actually can do with the science concepts and skills they have learned.



# COOPERATIVE LEARNING: CLASSROOM MANAGEMENT TECHNIQUES

- 1 In order for your students to complete the activities successfully, it is essential that they know, and follow, the ten rules for group work:
  - \* move into groups quietly, without bothering others
  - \* use quiet voices
  - \* stay with your group
  - \* everyone shares the work
  - \* no one is bossy
  - \* everyone shares materials
  - \* everyone shares ideas
  - \* take turns talking
  - \* care about other's feelings
- 2 Initially avoid competition between groups. This can be accomplished by carefully selecting groups in a variety of manners--randomly (i.e., by birthdays), by students' abilities, or by allowing students to choose the groups for themselves. It is important to note, however, that if the final technique is used to form groups, the students must be made aware that, if their group does not perform adequately or productively, alternative selection methods will be employed (i.e., TEACHER selection).
- 3 Clearly define the task to be done.
- 4 Be sure a "product" is connected with the group activity.
- 5 In setting time limits, allow TOO LITTLE TIME rather than TOO MUCH TIME for the group to finish.
- 6 Each person in the team should play an active role. Regular rotation of roles should occur to give each student the opportunity to play a different role. Roles students can have are:

**PRINCIPAL INVESTIGATOR:** This person keeps the group members on task and makes sure the activity is understood by all and is completed. Any questions will be immediately clarified with the teacher.

**MATERIALS MANAGER:** This person obtains all supplies the group needs. If the group is large enough, a second Materials Manager can be assigned to be responsible for returning materials to the supply area and having the group clean up its work area.

**RECORDER/EVALUATOR:** This person writes down responses that team members have formulated. This student notes how well group members perform their responsibilities, contributing to the overall performance and outcome of the group.

**REPORTER:** This person writes down the group's conclusions and reports to the class. The reporter may also need to record the group's data on a class graph or chart. If the group is large enough, two Reporters can be assigned--one to record conclusions and chart data, the other to present their findings to the class.

- 7 Follow the Five C's of group work in order to have a safe and FUN science activity:

**CAUTION:** Laboratory group work requires caution in every part. Safety instructions should be followed and a safety checklist should be implemented before each activity

**COOPERATE:** To ensure successful group work, each member must cooperate with the other members of the group.

**CONTRIBUTE:** Each member must make an effort to contribute to the group.

**CONTROL:** Group work requires control over our body movements, voices, and actions. To avoid chaos in the classroom, control must be practiced by each member of the group.

**CLEAN UP:** Each group member must do his or her part to clean up after the activity. Students must make sure the work area is clean and all materials are put away.

- 8 The culmination of a group activity should be a time of sharing and evaluating how well members worked together as well as examining each group's end results or products.

## QUICK REFERENCE GLOSSARY

Definitions in this Glossary are intended for teacher use and quick reference.

- \* **action project**--taking what is learned and making a plan for bringing the issue to the attention of the local community and society in general
- \* **aquatic vegetation**--the plant life that exists in a freshwater environment
- \* **area**--the measure of the surface of a solid; a part of any surface; a particular zone
- \* **ballast water**--the water carried in a boat or ship to give stability
- \* **biological diversity**--variety of life
- \* **bivalve**--any mollusks, including mussels and clams, having a shell consisting of two valves hinged together
- \* **brainstorm**--the unrestrained offering of ideas or suggestions by all members of a group seeking a solution to a problem
- \* **byssal threads**--a tuft of filaments, chemically similar to silk, secreted by various bivalves, especially mussels, used to attach the mollusk to the substratum
- \* **centimeter (cm)**--a metric unit of measure equal to 1/100 meter (about the width of your finger)
- \* **common name**--the familiar name used by everyday people to refer to any species
- \* **community**--a group or unit that lives together
- \* **congregate**--a gathering or assemblage of people or things
- \* **data**--facts, figures, or information from which conclusions can be drawn
- \* **degradation**--sedimentation in aquatic areas that affects the quality of the water; the lowering of land surfaces by erosion
- \* **dispersal**--to break up and scatter in various directions
- \* **dissolved oxygen**--the oxygen freely available in water; vital to fish and aquatic life for respiration; dissolved oxygen has been accepted as the single most important indicator of the ability of a body of water to support aquatic life

- \* **diversity**--variety
- \* **documentary**--a motion picture, television program, or other presentation that shows or analyzes news events or social conditions with little or no fictionalization
- \* **ecosystem**--the interacting system of a biological community and its non-living environmental surroundings
- \* **estimate**--to judge or determine generally, but carefully, the size, value, or cost of an item
- \* **exotic species**--the organisms that are foreign, not native, to a particular location
- \* **extrapolate**--to arrive at a conclusion or result by hypothesizing from known facts or observations
- \* **filtration**--a treatment process for removing solid matter from water by passing the water through sand or a man-made filter
- \* **flow restriction**--anything that restricts or slows water flow; for example, zebra mussels restrict flow in a water pipe, and weeds restrict flow in a canal
- \* **food chain**--a sequence of organisms, each of which uses the next lower member of the sequence as a food source
- \* **food web**--all the individual food chains in a community
- \* **glochidia**--the parasitic larval stage of freshwater mussels that infests the gills of many fish
- \* **habitat**--the place where a population lives and its surroundings, both living and non-living
- \* **indigenous species**--organisms that are native to a particular area or region
- \* **infestation**--to overrun or inhabit in large numbers, as to be parasitic in or on a host
- \* **intake**--the place fluid is taken into a pipe, e.g., intakes for water treatment plants and power industries
- \* **introduced species**--a population placed into a particular area or region the species is not native to
- \* **larval fish**--immature, free-swimming stage of a fish
- \* **life cycle**-- the series of changes in form undergone by an organism in development from its earliest stage to the recurrence of the same stage in the next generation

- \* **liter (L)**-- a metric unit of liquid measurement; it is equal to 1.06 quarts
- \* **maximum**-- the greatest number, degree, or quantity
- \* **millimeter (mm)** -- a metric unit of measure equal to one thousandth of a meter; 10 mm equals 1 cm
- \* **minimum**-- the smallest number, degree, or quantity
- \* **mollusk**-- the members of the phylum of invertebrates that include bivalves, snails, and squids
- \* **molluscicide** -- a chemical substance that poisons mollusks
- \* **mother of pearl** -- the hard, pearly internal layer of certain bivalve shells, such as abalone and the three ridge mussel
- \* **native species** -- species that naturally occur or live in a particular area or region
- \* **nonindigenous species** -- species that are not native to a particular area or region
- \* **nutrient** -- any substance assimilated by living things that promotes growth
- \* **organic detritus** -- dead animal or plant materials or debris
- \* **organic matter** -- carbon-based waste compounds produced by living plants or animals
- \* **parasitize** -- to obtain benefit from another organism at that organism's expense
- \* **percentage** -- a given part or amount in every hundred
- \* **phytoplankton** -- microscopic plants that float in the water and are eaten by aquatic animals
- \* **population** -- a group of interbreeding organisms of the same kind occupying a particular space
- \* **population density** -- the quantity or number of a species per unit, as of an area
- \* **predator** -- an animal or organism that lives by feeding on other animals
- \* **predict** -- to determine in advance what will happen
- \* **prey** -- an animal used for food by another animal
- \* **public information** -- knowledge or information that is open to and for the use and benefit of all people

- \* **public involvement** -- action taken by members of a community in response or conjunction with a particular issue or project
- \* **quantify** -- to determine or express the amount of something; to measure
- \* **questionnaire** -- a written or printed form used in gathering information about a subject; it consists of a set of questions to be answered then submitted to a group or organization
- \* **salinity** -- a condition in which salt is part of a solution; the amount of salt in water
- \* **sampling** -- the process of taking a small amount of an item or object for testing or analysis
- \* **sedentary** -- remaining or fixed in one spot
- \* **sediments** -- soil, sand, and minerals that settle at the bottom of a body of water
- \* **siphon** -- an opening through which water enters and leaves an object, such as a mussel; some species can use this activity as a means of propulsion; also a means by which a liquid is transferred from one object to another, such as to siphon water into a bottle
- \* **smallmouth bass** -- a North American fish found in cool, clear, fresh waters
- \* **submerge** -- to completely immerse in water
- \* **substrate** -- the ground or other solid material on which an animal moves or is fastened
- \* **turbidity** -- when the amount of material such as silt or organic matter in the water reduces its clarity
- \* **univalve** -- a mollusk possessing only one shell, such as a snail
- \* **veliger** -- a zebra mussel larvae
- \* **ventral line** -- a longitudinal line along the lower side of a zebra mussel
- \* **water clarity** -- a condition in which the water is unclouded
- \* **zooplankton** -- microscopic aquatic animals eaten by larger aquatic animals

## ORGANIZATIONS AND OFFICIALS

Staff members from the following organizations can be contacted to speak to your class about problems faced by the organization that relate to the activities in this guide. Representatives also may be able to discuss how they are solving problems caused by zebra mussels and other nonindigenous species. For addresses and or phone numbers, consult your local phone directory or contact your local or school library.



- \* **State Sea Grant Program**
- \* **State Natural History Survey**
- \* **State Water Survey**
- \* **State Department of Conservation/Natural Resources**
- \* **U.S. Army Corps of Engineers**
- \* **Natural Resource Conservation Service**
- \* **State Department of Transportation**
- \* **Power Company**
- \* **Municipal Water Treatment Facility**
- \* **Biology Department of a University or College**
- \* **Museum**
- \* **Extension Service**
- \* **Power Squadron**
- \* **National Estuary Program**
- \* **Estuarine Research Reserve**

## GOALS AND OBJECTIVES

### Goals

- \* To provide scientifically based education about zebra mussels for fifth and sixth grade students.
- \* To provide teachers with an interactive teaching tool and curriculum on zebra mussels.
- \* To build students' critical thinking and scientific literacy.

### Objectives

After completing *Stop Zebra Mussels*, students will be able to:

- \* Record observations of zebra mussel characteristics and be able to describe concerns about their arrival in North America.
- \* Demonstrate the ability to differentiate between freshwater mussels and zebra mussels.
- \* Measure and graph the length of the ventral side of a sample of zebra mussels.
- \* Construct a model to simulate how zebra mussels filter large quantities of water.
- \* Use a model to predict the rate of flow of water in a pipeline.
- \* Calculate the number of zebra mussels in a given area.
- \* Demonstrate critical changes in a native river ecosystem due to the introduction of zebra mussels.



## SETTING THE STAGE FOR LEARNING

- 1. Cooperative Learning Groups** -- All work in this unit is meant to be done in groups of two to four students. The importance of helping each other and sharing must be stressed. It is helpful if both individual and group goals are set by the teacher and students.
- 2. Inquiry-Discovery Method** -- Very little of this material should be TOLD to the students. They should learn by completing the activities in the unit. This provides students with valuable experiences and skills along with learning the content in the unit.
- 3. Play Time** -- Allow time for students to appreciate Zebra Mussel Mania materials in a nonstructured, informal environment before, during, and after the activity.
- 4. Material Storage** -- Allow zebra mussels and other materials to dry out before returning to packages and to the trunk. This will avoid a mold problem.
- 5. Unit Introduction** -- To find out students' prior knowledge about zebra mussels, let the children brainstorm. First, place the words zebra mussel on chart paper or butcher paper. List all the words the students give you. Remember, when brainstorming, all words are accepted. Then, form a semantic map by putting the words under different categories. Words that have nothing to do with zebra mussels will naturally be discarded. Finally have the students write their own definition of a zebra mussel.
- 6. Zebra Mussel Journal** -- Students will keep a daily journal of their research about zebra mussels. This journal can also include usage of the unit vocabulary words as well as any questions they may have. Use pocket folders or construction paper to create journals, and have students decorate the journal by drawing zebra mussels. You can reproduce pictures from the guide for a journal cover. Use the journal master page provided to make appropriate number of copies for each student.
- 7. Creative Writing** -- The zebra mussel journal sheet decorated with a zebra mussel border can be used for creative writing activities, including reports, letters, brainstorming ideas, poetry, essays, etc. Use this with any language arts activity.
- 8. Reference Materials** -- At the end of the notebook is a section containing material discussing zebra mussels.
- 9. Expanding Bulletin Board** - Use materials in the kit to prepare bulletin boards. Other material can be obtained by contacting the previously mentioned organizations.

**10. Learning Strategies** - You are encouraged to use the following strategy(s) to introduce any lesson in this unit.

\* **KWL** strategy suggests that you ask each student to identify "what you know about the topic" (**K**), "what you want to know about the topic" (**W**), and after the lesson, "what you learned" (**L**). A section on the KWL sheet can be used to indicate what the student is still confused about. Students fill out the first two columns before the activity and the last two after completing each activity. See Student KWL, page 13.

\* **Mapping** is a technique for visually organizing material. Place a concept word in the middle of the board or butcher paper and let the children give you category words and phrases that fit with your word.

**11. Attitude Survey** - The attitude survey is optional. See page 14.

**12. Safety** - Go through the safety rules found on page 16. Other safety rules may pertain if you go on a field trip.





**ZEBERA  
MUSSELS**

## **STUDENT KWL STRATEGY**

**\* Activity**

**\* Student Name**

**\* What I know**

**\* What I want to know**

**\* What I learned**

**\* What I am confused about**



**ZEBRA  
MUSSELS**

## **STUDENT ATTITUDE SURVEY**

**Name:**

**Date:**

**Directions:** Please read each of the following statements carefully. Put a check mark by each statement that you agree with.

- \_\_\_\_\_ 1. I would rather study science than any other subject.
- \_\_\_\_\_ 2. Science is of great value.
- \_\_\_\_\_ 3. I really enjoy science.
- \_\_\_\_\_ 4. Science is boring.
- \_\_\_\_\_ 5. I love to study science.
- \_\_\_\_\_ 6. Science is a waste of time.
- \_\_\_\_\_ 7. Science will benefit only the smart kids.
- \_\_\_\_\_ 8. I have no desire to learn about science
- \_\_\_\_\_ 9. Science classes are profitable to everyone who takes them.
- \_\_\_\_\_ 10. Science is practical.
- \_\_\_\_\_ 11. I like science experiments.
- \_\_\_\_\_ 12. Science experiments are dumb.
- \_\_\_\_\_ 13. Science teaches me to think.
- \_\_\_\_\_ 14. Science is of benefit to me.
- \_\_\_\_\_ 15. I hate science.

You may write any additional comments about science that you feel are important on the back.

# Zebra Mussel Journal



Name: \_\_\_\_\_

Date: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

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# **SAFETY RULES**

*These safety rules may be discussed and posted during science activities, or the teacher may have the class generate a list of safety procedures to follow.*

- 1. Listen to your teacher's instructions.**
- 2. Don't touch or pick up any materials unless your teacher tells you to.**
- 3. Follow directions.**
- 4. Ask your teacher for help if you need it.**
- 5. Cooperate with a partner or with your group.**
- 6. Never put anything in or near your eyes or mouth, and wash your hands when you have finished.**
- 7. Clean up work area and return all materials to their proper places.**
- 8. Always walk in the science area.**
- 9. Talk quietly in groups.**
- 10. Tell your teacher immediately in case of accidents.**
- 11. Be Careful !!!**



## ZEBRA MUSSEL POST-TEST

NAME: \_\_\_\_\_

### MATCHING

- |                             |  |
|-----------------------------|--|
| 1. _____ ballast water      | a. The organisms that are foreign, not native to a particular location                           |
| 2. _____ byssal threads     | b. a zebra mussel larvae   |
| 3. _____ exotic species     | c. the water carried in a boat or ship to give stability   |
| 4. _____ food chain         | d. microscopic aquatic animals eaten by larger aquatic animals                                   |
| 5. _____ indigenous species | e. a tuft of filaments used to attach the mollusk to the substratum                              |
| 6. _____ phytoplankton      | f. the organisms that are native to a particular area  |
| 7. _____ veliger            | g. the microscopic plants eaten by larger aquatic animals  |
| 8. _____ zooplankton        | h. a sequence of organisms, each of which uses the lower member of the sequence as a food source |



## ZEBRA MUSSEL POST-TEST CON'T

### TRUE OR FALSE

9. \_\_\_\_\_ Zebra mussels have only positive effects on freshwater mussels.
10. \_\_\_\_\_ Classification of shells is done using color, size, texture, and other methods involving the senses.
11. \_\_\_\_\_ There is no way to tell the difference between a shell button and a plastic button.
12. \_\_\_\_\_ The Great Lakes have been affected by zebra mussels.
13. \_\_\_\_\_ Zebra mussels traveled to North America in the ballast water of ships.
14. \_\_\_\_\_ Zebra mussels live well in water that is very salty and very cold.
15. \_\_\_\_\_ People are the main transporters of zebra mussels.
16. \_\_\_\_\_ Zebra mussels filter up to 1 liter of water a day.
17. \_\_\_\_\_ Zebra mussels help the food web of a lake.

### FILL IN THE BLANK

1. Mussels and clams which have two shells are \_\_\_\_\_ mollusks.
2. Taking a small part or quantity of something to determine population density is called \_\_\_\_\_.
3. Through \_\_\_\_\_, zebra mussels improve water clarity.
4. The variety of life in an ecosystem is called \_\_\_\_\_.





## ZEBRA MUSSEL POST-TEST CON'T

### SHORT ESSAYS

How do zebra mussels affect the food chain?

Name two negative effects of zebra mussels.

Draw a zebra mussel

Name two ways that zebra mussels spread.

What are barriers to the spread of zebra mussels?



## ZEBRA MUSSEL POST-TEST TEACHER'S KEY

NAME:

### MATCHING

1.   C   ballast water
  2.   E   byssal threads
  3.   A   exotic species
  4.   H   food chain
  5.   F   indigenous species
  6.   G   phytoplankton
  7.   B   veliger
  8.   D   zooplankton
- a. the organisms that are foreign, not native to a particular location
  - b. a zebra mussel larvae
  - c. the water carried in a boat or ship to give stability
  - d. microscopic aquatic animals eaten by larger aquatic animals
  - e. a tuft of filaments used to attach the mollusk to the substratum
  - f. the organisms that are native to a particular area
  - g. the microscopic plants eaten by larger aquatic animals
  - h. a sequence of organisms, each of which uses the lower member of the sequence as a food source



## ZEBRA MUSSELS POST-TEST TEACHER'S KEY

### TRUE OR FALSE

9.   F   Zebra mussels have only positive effects on freshwater mussels.
10.   T   Classification of shells is done using color, size, texture, and other methods involving the senses.
11.   F   There is no way to tell the difference between a shell button and a plastic button.
12.   T   The Great Lakes have been affected by zebra mussels.
13.   T   Zebra mussels traveled to North America in the ballast water of ships.
14.   F   Zebra mussels live well in water that is very salty and very cold.
15.   T   People are the main transporters of zebra mussels.
16.   T   Zebra mussels filter up to 1 liter of water a day.
17.   F   Zebra mussels help the food web of a lake.

### FILL IN THE BLANK

1. Mussels and clams which have two shells are   BIVALVE   mollusks.
2. Taking a small part or quantity of something to determine population density is called   SAMPLING  .
3. Through   FILTERING  , zebra mussels improve water clarity.
4. The variety of life in an ecosystem is called   BIODIVERSITY  .



## ZEBRA MUSSEL POST-TEST (Teacher's Key)

### SHORT ESSAY

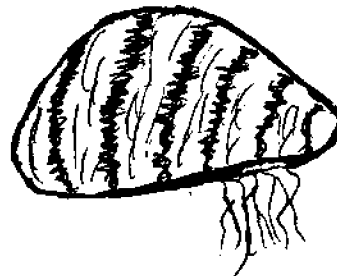
How do zebra mussels affect the food chain?

*Zebra mussels compete with other aquatic organisms for food in river, lakes, and streams. Because there are so many zebra mussels competing for food with other animals at their level in the food web, less food is available for other animals. These other animals can die for lack of food.*

Name two negative effects of zebra mussels.

*Zebra mussels clog intake pipes at water treatment and industry plants, causing great expense for removal and cleanup. They can also clog and damage the engines on boats. Zebra mussels may reduce populations or even eliminate native mussels from rivers and lakes by competing with native mussels for food, space, and oxygen.*

Draw a zebra mussel



Name two ways that zebra mussels spread.

*They attach to boats. The juvenile form is free floating and can be carried in water currents. Zebra mussels can attach to animals or birds such as diving ducks which move from one location to another.*

What are barriers to the spread of zebra mussels?

*Chlorine has been used to control zebra mussels. Boaters should clean their boats with hot water before leaving an area. This will help prevent further spread of zebra mussels.*



## ACTIVITY TWO: LOOKING AT THE ZEBRA MUSSEL MENACE

**TIME:** (2) 45-minute lessons

**SCIENCE PROCESS SKILL:** Observing, measuring, and communicating

**SCIENCE CONCEPTS:** Zebra mussels have identifiable and observable characteristics.  
Zebra mussel history and concerns can be identified from a video.

**BENCHMARKS:** Students should: Know that changes in an organism's habitat are sometimes beneficial to it and sometimes harmful.

Judge whether measurements and computations of quantities such as length, area, volume, weight, or time are reasonable in a familiar context by comparing them to typical values.

**OBJECTIVE:** Students will record observations of the zebra mussel. Students will be able to describe concerns about the zebra mussel's arrival in North America.

### WHAT YOU OUGHT TO KNOW

A zebra mussel is a bivalve mollusk. It is a fingernail-sized clam with yellowish or brownish shells marked in wavy bands. Female zebra mussels can produce 30,000 to 1,000,000 eggs per year. These eggs develop into free-swimming larvae (called veligers) that quickly begin to form shells. After approximately three weeks, zebra mussels attach to hard surfaces called substrates. These are surfaces such as rocks, gravel, metal, crayfish, native mussels and, each other. They attach to these surfaces by using their byssal threads. Byssal threads have a strong adhesive that will dry under water and even adhere to Teflon.

### ASK QUESTIONS



Zebra mussels filter plankton from the water. Adult mussels can filter up to one liter of water per day. Diving ducks and freshwater drum eat zebra mussels. However, zebra mussels reproduce at such a rapid rate they cannot be controlled by this method alone.

The activities in Day 1 allow students to observe the characteristics of the zebra mussel. Observations are made by using the five senses. Some observations are: shiny inside, two shells per mussel, and 2 cm in length. Caution students not to make inferences, such as meat is inside the shell, unless they can see it. During Day 2 students will identify some of the environmental, recreational, and industrial problems caused by zebra mussels.

### WHAT'S THE CONNECTION??



#### TO LANGUAGE:

Write letters to request information about zebra mussels from organizations listed on the Organizations and Officials sheet, page 9. Write a physical description of the zebra mussel in the journal.

#### TO MATHEMATICS:

Estimate the number of zebra mussels that will occupy a 100 ml space.

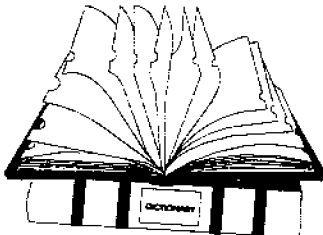
#### TO ART:

Construct a mosaic of the zebra mussel by using construction paper.

#### TO SOCIAL STUDIES:

Using a world map, trace the spread of zebra mussels over time.

### WORDS OF WISDOM



**LOOK IT UP**

Ballast, byssal threads, bivalve, ecosystem, exotic, molluscicides, salinity, substrate, veliger (see also glossary on page 5). Students should put these in their zebra mussel journal.

## RESOURCES AT THE READY

Material:	In Kit	In Notebook	Teacher Provides
	Video	ZM Journal	Newsprint Sheets
	Metric Rulers	Sheet 2.1	Group Folders
	Measuring Cups	Sheet 2.2	Scale (optional)

Video contains (combined onto one tape):

“The Invasion of the Zebra Mussel” (10:00)

“Luck Isn’t Enough” (13:30)

Note: “Luck Isn’t Enough” is not about zebra mussel, but is a good video on water quality.

For each working group:

(1) Metric ruler

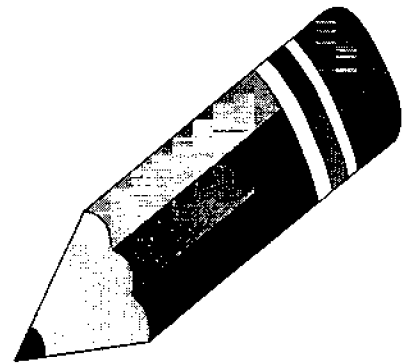
(100 ml) Zebra mussel shells

(1 or 2) Measuring cups

Zebra Mussel Observation Sheet 2.1

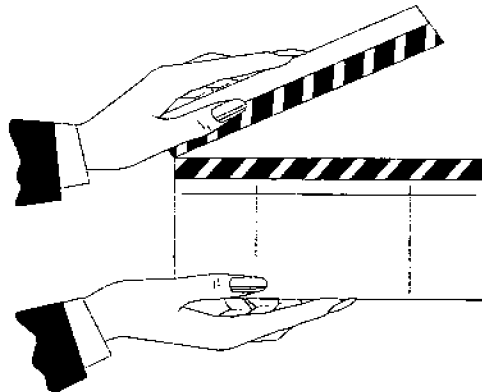
Zebra Mussel Menace Record Sheet 2.2

Group folder



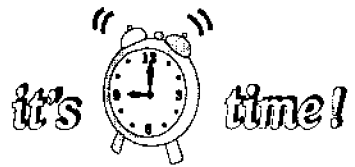
## GETTING YOUR ACT TOGETHER

Prepare the materials in a folder for each cooperative group. On newsprint, make up a summery sheet for each of the day's activities. The summary sheets should be titled "Stop Zebra Mussels." Preview the first video described in the resources section.





# TIME TO EXPERIENCE ZEBRA MUSSEL MANIA!!!



## DAY 1

1. Show the video "The Invasion of the Zebra Mussel." The other video can be shown on this day or at a later time in the curriculum.
2. Provide the Words of Wisdom either as a handout or have the students copy them into their journal.
3. Divide students into cooperative learning groups.
4. Have each group measure 100 ml of zebra mussels. (If necessary, you could have these measured out in advance.) Before the shells are observed by the groups, have them estimate the number of mussels in the sample. Record this on the Zebra Mussel Observation Sheet 2.1.
5. Observe mussels and record observations on the Zebra Mussel Observation Sheet 2.1. You will want to support the students' observations by offering clues to the groups as needed. Some suggestions are:

What are the color variations?

Ask questions about shell symmetry and bivalve construction.

One side will feel sharp, another smooth.

How is feel related to a particular surface that is touched?

How many actual mussels were counted? (Record this on the data sheet.)

Sound is not easy to observe. In order to observe sound, something must be done to the mussels.

An obvious smell is present. Does it change when the mussels are wet?

6. Record each group's data on your newsprint sheets. Are differences apparent? Discuss the data.

## DAY 2

7. Hand out Stop Zebra Mussel Record Sheet 2.2 to each student.
8. View video again so students may complete the sheet.
9. Have the reporters summarize the data on a class chart.
10. Write group-generated answers for each question on newsprint charts.
11. Discuss and summarize the results. Each student should copy this summarized data in his/her journal.

### WHAT DID YOU LEARN???

Use the group charts to generate discussion based on observations made. The students' senses should have been used to observe zebra mussel characteristics. Taking measurements of length, width, and mass also should have helped students to identify physical aspects of zebra mussels. While watching the video, did each student make notes and contribute to the total information produced by their group? Each group member should be able to answer questions based on physical observations of zebra mussels and information gained from the video. Can they answer your questions?

### WAIT, THERE'S MORE...

Use information from the chart to have the class draw conclusions from the following questions:

1. Why are zebra mussels considered a menace?
2. How do zebra mussels affect you?
3. How did zebra mussels travel from Europe to North America?
4. How are zebra mussels transported throughout the United States?
5. What are some ways to prevent the zebra mussel spread?





## **ZEBRA MUSSELS**

### **WORDS OF WISDOM**

#### **ACTIVITY 2: LOOKING AT THE ZEBRA MUSSEL MENACE**

**BALLAST WATER:** the water carried in a boat or ship to give stability

**BYSSAL TREADS:** a tuft of filaments, chemically similar to silk, secreted by various bivalves, especially mussels, used to attach the mollusk to the substratum

**BIVALVE:** any mollusks, including mussels and clams, having a shell consisting of two valves hinged together

**ECOSYSTEM:** the interacting system of a biological community and its non-living environmental surroundings

**EXOTIC SPECIES:** the organisms that are foreign, not native, to a particular location

**MOLLUSCICIDES:** a chemical substance that poisons mollusks

**SALINITY:** a condition in which salt is part of a solution; the amount of salt in water

**SUBSTRATE:** the ground or other solid material on which an animal moves or is fastened

**VELIGER:** a zebra mussel larvae





# ZEBRA MUSSELS

## STOP ZEBRA MUSSELS OBSERVATION SHEET 2.1

Zebra Mussel Watchers' Names:

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Predict the number of zebra mussels in 100 ml \_\_\_\_\_

Count the zebra mussels in 100 ml \_\_\_\_\_

**Directions:** Record your observations of zebra mussels. Remember that you have a ruler and scale!

Sight (visual) \_\_\_\_\_

Smell (olfactory) \_\_\_\_\_

Touch (tactile) \_\_\_\_\_

Sound (auditory) \_\_\_\_\_

Size (quantitative) \_\_\_\_\_

Draw a zebra mussel



# ZEBRA MUSSELS

## STOP ZEBRA MUSSELS RECORD SHEET 2.2

Zebra Mussel Watchers' Names:

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**Directions:** Answer as many questions as you can while viewing the video.

1. Why are zebra mussels a concern? \_\_\_\_\_  
\_\_\_\_\_

2. Where did zebra mussels come from? \_\_\_\_\_  
\_\_\_\_\_

3. How did zebra mussels get to North America? \_\_\_\_\_  
\_\_\_\_\_

4. Describe the zebra mussel. \_\_\_\_\_  
\_\_\_\_\_

5. Who or what do zebra mussels affect? \_\_\_\_\_  
\_\_\_\_\_

6. List some of the rivers and lakes that have been affected by zebra mussels? \_\_\_\_\_  
\_\_\_\_\_

7. What can be done to decrease the spread of zebra mussels? \_\_\_\_\_  
\_\_\_\_\_



# ZEBRA MUSSELS

## STOP ZEBRA MUSSELS OBSERVATION SHEET 2.1

Zebra Mussel Watchers' Names:

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### TEACHER'S KEY

Predict the number of zebra mussels in 100 ml will vary

Count the zebra mussels in 100 ml will vary

Directions: Record your observations of zebra mussels. Remember that you have a ruler and scale!

Sight (visual) length, has stripes, bottom is flat, two halves, etc.

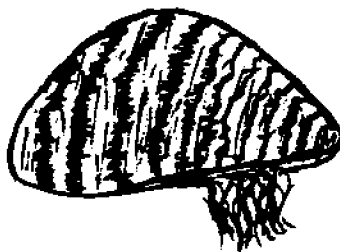
Smell (olfactory) stinks, smells bad, etc.

Touch (tactile) edge is sharp, surface is smooth, etc.

Sound (auditory) clinks together

Size (quantitative) will vary (small, tiny, big)

Draw a zebra mussel





## ZEBRA MUSSELS

### STOP ZEBRA MUSSELS RECORD SHEET 2.2

Zebra Mussel Watchers' Names:

---

---

### TEACHER'S KEY

**Directions:** Answer as many questions as you can while viewing the video.

1. Why are zebra mussels a concern? Causes some of us hard earned money, changes the way we use our lakes and rivers, undesirable environmental changes, etc.
2. Where did zebra mussels come from? Europe
3. How did zebra mussels get to North America? Surviving in the ballast water of ocean going ships, ships dumped water into Great Lakes.
4. Describe the zebra mussel. Small, bivalve mollusks, has byssal threads, prolific, has larvae called veligers.
5. Who or what do zebra mussels affect? Intake pipes, industries, boats, docks, people walking on the beach, native clams, disrupt the food chain for larger fish.
6. List some of the rivers and lakes that have been affected by zebra mussels? Mississippi, Tennessee, Tom-Bigbee.
7. What can be done to decrease the spread of zebra mussels? Drain all water and let your equipment dry, Spray boat with Hot water, Scrape off visible mussels, Don't transport bait to another body of water, Use molluscicides.





## Activity Four: MUSSEL TO MUSSEL

**TIME:** (2) 45-minute lessons

**SCIENCE PROCESS SKILL:** Classifying

**SCIENCE CONCEPT:** Native and introduced species of mussels must both be recognized.

**BENCHMARKS:** Students should: Know that a great variety of kinds of living things can be sorted into groups in many ways by using various features to decide which things belong to which group.

Understand that, for any particular environment, some kinds of plants and animals survive well, some survive less well, and some cannot survive at all.

**OBJECTIVE:** Students will demonstrate the ability to differentiate between native mussels and zebra mussels.

### WHAT YOU OUGHT TO KNOW

Almost 300 different species of native mussels have been identified from streams, rivers, lakes, and ponds of North America. They are important, both economically and ecologically. Zebra mussels compete with native mussels for food, space, oxygen, and other necessities. Some competition may not be bad if the teams are fair; but, because zebra mussels reproduce so quickly, they often will "out compete" the native mussels (and other native organisms as well). Zebra mussels may eliminate native mussels completely from many rivers and lakes. To preserve our native mussels and control or eliminate zebra mussels, we need to be able to tell the good guys (the native mussels) from the bad guys (the zebra mussels). Several characteristics and features can be used to tell the difference between each native mussels and zebra mussels.



## WHAT'S THE CONNECTION??



### TO LANGUAGE:

Write a constructed definition for each vocabulary word from given materials.

### TO MATHEMATICS:

Find the differences in length of freshwater and zebra mussels.

### TO ART:

Sketch the mussel of their choice. Construct a shell poster.

### TO SOCIAL STUDIES:

Read about the shell industry along the Mississippi River.



### WORDS OF WISDOM

LOOK IT UP

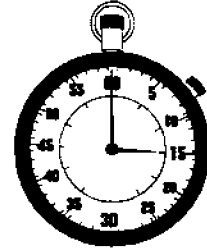
Classification, diversity, life cycle, mother of pearl, organic detritus, parasitize, sedentary, sediments, species (native, exotic, and introduced), scientific and common names, shell species (see also glossary on page 5).

### RESOURCES AT THE READY

Material:	In Kit	In Notebook	Teacher Provides
	Collection of Shells	Story 4.1	
	Shell button set	ZM Journal	
	Game 4.2 boards		
	Dry Erase Markers		
	Rulers		
	Freshwater Mussel Guides		



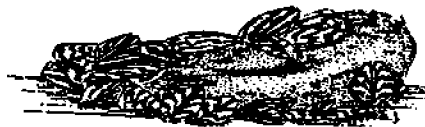
## TIME TO EXPERIENCE ZEBRA MUSSEL MANIA



### DAY 1 (USE DAY 2 TO FINISH UP IF NECESSARY)

1. Read aloud to the class Mr. Boepple's story, Story 4.1, and distribute buttons for each group of students to observe. Buttons included in the kit are made from either shells or plastic; you may want to add a few buttons of your own. Buttons on white side of strip are mussel shells; buttons on blue side are made of newer plastic materials. Have the students decide which are the shell buttons. In their journals have them write a description of the shell button and the plastic button and how they can tell the difference between the two or between others in the kit.
2. Have the students discuss the story of Mr. Boepple. What were some characteristics they saw in him that made him a good business person? What were some of his characteristics that made him a bad business person? He used mussel shells for buttons. What other uses could be made for shells? Make a list of uses for shells. What changes have been made in modern medicine that would make it almost impossible for Mr. Boepple to die today with a cut foot?
3. Explain that just as they have learned to distinguish the shell button from other buttons, shells can be classified into groups by common appearances or differences. Their next task will be to classify a group of shells by common characteristics.

### TEACHER DIVIDES THE CLASS INTO 4 GROUPS TO CLASSIFY SHELLS



## CLASSIFYING THE SHELLS

1. Each group should take a shell set and shell classification guide (Record Sheet 4.2 found in the box). Have each group sort the shells into groups that look alike. They will notice that the shells have numbers. The number will be used later in sorting the shells and to help learn their names. Have them write, in the zebra mussel journal, descriptions of each shell. Encourage them to use a ruler. Discuss how their shell groups were formed-by size, by color, by shape, by shell type, etc. Accept all answers in this discussion.
2. Explain that most shell keys are developed around a binary (two division) key. They are now going to classify the shells using Record Sheet 4.2, Mussel to Mussel Shell Classification Game.
3. The teacher should already have the questions written on the game sheet. The questions are found on the Teacher's key 4.3 found in the notebook. Please use the Dry Erase Markers provided with the box. Show students the procedure for developing the key. First have them place all the shells in one group. Place shells in the big rectangle on Record Sheet 4.2. The questions are either a yes or no that will divide the shells into groups. Physically divide the shells into those two groups. Place the shells or write the numbers of the shells whose answer is yes in that rectangle; and the number whose answer is no in that rectangle. Have the students pretend that the lines are a path on which the shells are carried to the next rectangle. Have the students keep dividing the shells by asking the questions that the teacher put on the game board. With the remaining 5 or 6 grouped shells at the end of the game board, have the students make up their own questions that would further separate the shells.
4. When finished, have each group share their classification. Discuss how the groups vary, or are the same? Why were decisions made about the grouping?
5. **MATCHING GAME**  
Hand the groups the picture guide to Freshwater Mussels of the Upper Mississippi River. Have them try to find the correct names to the numbered shells and write them down in their journal. Tell them they will be able to find the names to all of the shells except for five of them (#'s 1,2,5,7, and 11). Of these five it is their job to find the "BAD GUY". The BAD GUY (zebra mussel shell #5) will have stripes on it like a zebra..
6. Write the description of their remaining 5 shells and identify which one they think is the Bad Guy.

7. Give the students the Teacher's Key 4.4 to see if their classifications of the numbered shells was correct and make changes if necessary. If they had any wrong, have them describe why they classified as they did.
8. Tell them which one was the Bad Guy (Shell #5). Discuss why the Zebra mussel is a bad guy. Use in the discussion the "Points to Consider." Students should record these in their journal.
9. Discuss the story on shell #13. Shell 13 is unlucky because this mussel can no longer be found alive in the Illinois River. The other shells, however, can still be found at locations along the river where they once were abundant. Can the students develop some explanations for the disappearance of that species. Find out which mussels in your region are endangered. Discuss how the zebra mussel could wipe out other native mussels.
10. Go over Words of Wisdom and record in the journal.



### **POINTS TO CONSIDER WHY IS THE ZEBRA MUSSEL THE BAD GUY**

- \* Zebra mussels clog intake pipes to water treatment plants and other industries. This can be very costly and may shut water off to hundreds of people.
- \* Zebra mussels can attach to boat hulls and slow boats down. They can also clog up the boat's motor and cause it to over heat. This can ruin the motor.
- \* Zebra mussels can attach themselves to other native mussels. They prevent the native clam to open or close its shell. It also steals all of the native clam's food.
- \* A single zebra mussel can filter up to one liter of water a day. They filter out the food for other organisms. This disrupts the food chain.
- \* They filter the water so well that they can make the water clearer. Clear water isn't always healthy water.
- \* They reproduce very quickly and they reproduce massive numbers.

## WHAT DID YOU LEARN

You should be able to observe the students interact in groups as they classify the shells and compare and contrast freshwater mussels with zebra mussels. Each student should have the required information and drawing in the journal.

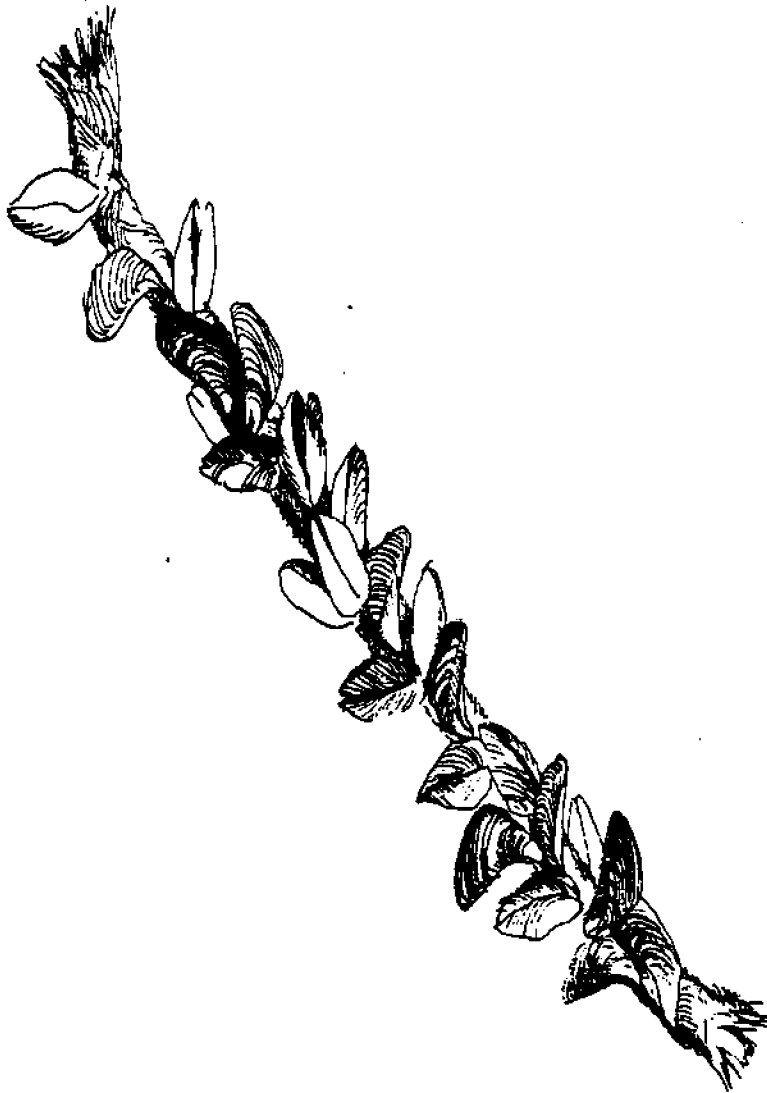
## WAIT, THERE'S MORE...

\* The students can bring in other shells or mussels (including freshwater and saltwater species) to add to your collection. Are they freshwater or marine species? Have them find the names of each from shell books.



## THE STORY OF UNLUCKY SHELL NUMBER 13

Once upon a time, the Illinois River was full of the Ebony Shell (*Fusconaia ebena*). That was not too long ago because the shells of the mussel can still be found on the river banks. But, it has not been found alive for a number of years. The species has an unusual habit of needing to host on the skipjack herring (*Alosa chrysochloris*) for a few weeks before settling on the river bottom and growing old. Because of dams on the Illinois, herrings cannot move up the river. No herring, no Ebony Shells. Old, empty shells tell the sad story of human interference. The thick shell lasts so long after the animal has died. Does your river have evidence of endangered shell species? Ask?





## **ZEBRA MUSSELS**

### **WORDS OF WISDOM ACTIVITY 4: MUSSEL TO MUSSEL**

**CLASSIFICATION:** systematic arrangement in groups or categories according to established criteria

**DIVERSITY:** variety

**LIFE CYCLE:** the series of changes in form undergone by an organism in development from its earliest stage to the recurrence of the same stage in the next generation

**MOTHER OF PEARL:** the hard, pearly internal layer of certain bivalve shells, such as abalone and the three ridge mussel

**ORGANIC DETRITUS:** dead animal or plant materials or debris

**PARASITIZE:** to obtain benefit from another organism at that organism's expense

**SEDENTARY:** remaining or fixed in one spot

**SEDIMENTS:** soil, sand, and minerals that settle at the bottom of a body of water

**NATIVE SPECIES:** species that naturally occur or live in a particular area or region

**EXOTIC SPECIES:** the organisms that are foreign, not native, to a particular location

**INTRODUCED SPECIES:** a population placed into a particular area or region that the species is not native to

**COMMON NAME:** the familiar name used by everyday people to refer to any species

**SCIENTIFIC NAME:** the Latin name used by scientists to describe species

**MOLLUSK (SHELL SPECIES):** members of the phylum of invertebrates that include bivalves, snails, and squids



# Teacher's Key

Place all shells (1-13) here. Move shells in and around the appropriate boxes as you answer questions.

Question: Is the shell a univalve snail?

YES shells 7 and 11

Question: Is the shell slender and very pointed?

NO shells 1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 13

Question: Is the shell elongated, triangular, thin?

YES shell 7

Question: \_\_\_\_\_

NO shell 11

Question: \_\_\_\_\_

YES shells 1 and 5

Question: Does the shell have a bluish tinge?

NO shells 2, 3, 4, 6, 8, 9, 10, 12, 13

Question: Does the shell have a pink luster?

Question: \_\_\_\_\_

Question: \_\_\_\_\_

Question: \_\_\_\_\_

Question: \_\_\_\_\_

Question: \_\_\_\_\_

Question: \_\_\_\_\_

Question: \_\_\_\_\_

Question: \_\_\_\_\_

NO shells 2, 3, 4, 6, 9, 10, 12, 13

Question: Is the shell longer than broad?

YES

YES

YES

YES

YES

YES

YES

YES

YES shell 9

NO

NO

NO

NO

NO

NO

NO

NO

NO shells 2, 3, 4, 6, 10, 12, 13

## **MUSSEL TO MUSSEL STORY 4.1**

### **MR. BOEPPLE'S SHELLS**

Hundreds of years ago, the American Indians and the Pilgrims lived off the land. They ate freshwater mussels. Sometimes they would find a treasure inside one of the mussels--a pearl that they could use to make jewelry. The mussels were easy to find, but they almost never had a pearl inside. Because the pearls were so rare, they became very valuable. The biggest pearls were worth the most money. People began to find pearls inside the mussels in the Mississippi River Valley during the 1850's. The pearl hunters became very rich. People began to race to find as many pearls as possible. This caused the disappearance of most of the freshwater mussels in the Mississippi River Valley.

In 1888, John Boepple came from Germany to hunt for freshwater mussel. John was not looking for pearls. Instead, he wanted to make buttons out of the shells. It would have been too expensive to bring the shells to Germany, so he decided to make the buttons in America. One day he was bathing in the Illinois River when he cut his foot on a sharp object. He had cut his foot on one of the freshwater mussel shells that he had been searching.

During the next few years he struggled to learn English; and he collected as many shells as he could. Then in 1891, using the shells he had spent years collecting, Boepple set up his first button making business in Muscatine, Iowa. Two local businessmen helped him get started. They had the money to run the business, and Boepple had the skill to make the buttons. The men soon began to argue. The investors wanted to make as many buttons as quickly and cheaply as they could. John Boepple wanted to make a quality product, but he needed the businessmen's money. Eventually, the dispute caused Boepple to look for new partners. (The first two partners tried to run their own button making business. They failed without Boepple because they knew nothing about making buttons.)

Boepple did not take long to find new partners that were very wealthy. They let him run his company as he wanted it run. The business flourished. The only problem was that Boepple had to collect the mussel shells by hand. This was a very slow process. Help was soon on the way because people began to discover pearls in the shells. Just like 40 years earlier, word began to spread about how rich a person could become by finding pearls. Soon farmers, shopkeepers, and businessmen began wading into the shallow rivers and streams hoping to get rich. Boepple was now able to buy the shells he needed to make his buttons.

In 1897, someone invented a new tool called a brail. The tool allowed mussel hunters to harvest mussels in deeper water from boats instead of wading into shallow waters. People crowded the rivers to find the mussels. Soon violence broke out. Pearl hunters robbed each other and fought over hunting space. Even though hunters rarely found pearls, they knew they could make a profit by selling the mussel shells to the button makers. As more people hunted for shells, more shells became available to make buttons.

## MR. BOEPPLE'S SHELLS (continued)

The new button makers were not as concerned about quality as John Boepple. Everyone thought there would be an endless supply of shells. Button makers became more wasteful and used the shells more foolishly. Factories were springing up everywhere. New machines made buttons faster and cheaper. Boepple became very worried about the poor quality of the buttons being made. There were many arguments, and again, the person who knew more about making buttons than anyone else in the country was forced out of business. Boepple was left with nothing.

Seventeen years had passed since John Boepple first started making buttons. Again, shell collectors and button manufacturers became concerned about the natural supply of shells. History had repeated itself. In 1908, the mussels again became very difficult to find. The few that were found were too small to be useful for button-making. Finally, in 1911 the United States government asked John Boepple to help find ways to increase the mussel population.

Boepple traveled to Indiana in search of new ways to replenish the mussel supply. He waded in Indiana's rivers looking for mussels. Just as he had done so long ago on the Mississippi River, he cut his foot on a shell on the river bottom. This time the ending was not a happy one. After several months, John Boepple died from blood poisoning from he cut. This German-American immigrant had valued the freshwater mussel more than any person in the world. Ironically, he became victim of the very thing that had given him his life's work.

Written by Cherie Van Camp \* Adapted from: The Founding and Early History of the Pearl Button Industry by Michael G. O'Hara, Muscatine Community College, Muscatine, Iowa



**ZEBRA  
MUSSELS**

**MUSSEL TO MUSSEL: SHELL IDENTIFICATION SHEET  
TEACHER'S KEY 4.4**

Zebra Mussel Watchers' Names:

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Identification for Native Mussel Shell Collection:

1. Blue Mussel
2. Asiatic Clam
3. Washboard Clam
4. Maple Leaf Clam
5. Zebra Mussel
6. Pimpleback Clam
7. Silty Hornsnail
8. Pink Heelsplitter Clam
9. Yellow Sand Shell
10. Three-horned Wartyback
11. Ponderous Campeloma
12. Three-ridge Clam
13. Ebony Shell



# ZEBRA MUSSELS

## MUSSEL TO MUSSEL: FRESHWATER AND ZEBRA MUSSEL LIFE CYCLES OBSERVATION SHEET 4.6

Zebra Mussel Watchers' Names:

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Compare zebra and freshwater mussels

Zebra mussels      Contrast      Freshwater



## ZEBRA MUSSELS

### MUSSEL TO MUSSEL: FRESHWATER AND ZEBRA MUSSEL LIFE CYCLES TEACHER'S KEY 4.6T

Zebra Mussel Watchers' Names:

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Note: Snails are closely related to mussels, but are different in that they have only one shell. Another difference is that they can be terrestrial (live on land) or aquatic (live in water).

Compare zebra and  
freshwater mussels

	Contrast	
	Zebra mussels	Freshwater mussels
Both have 2 shells	Longest is 4.5 cm	Longest may be up to 30 cm
Both live in rivers and streams	Has byssal threads	No byssal threads
Both have shells made of calcium carbonate	Distinct striped pattern and color of shell	Color of shell varies
	Thinner shell	Thicker shell
	Usually attach to hard substrate (on something solid); Shell attaches permanently after settlement	Can be found in most substrates from sand to mud to gravel and cobbles
	As adults, less than 2 inches	As adults, usually larger than 2 inches
	More offspring	Fewer offspring



## ACTIVITY FIVE: HOW BIG ARE YOUR MUSSELS?

**TIME:** (1) 45-minute lesson

**SCIENCE PROCESS SKILL:** Measuring and graphing

**SCIENCE CONCEPT:** Zebra mussels vary in length and size.

**BENCHMARKS:** Students should: Know that, when people care about what is being counted or measured, it is important for them to identify the units (three degrees Fahrenheit is different from three centimeters; three miles is different from three miles per hour).

Graphically display numbers to spot patterns that are not otherwise obvious, such as comparative size and trends.

Spread data out on a number line to see what the extremes are, where they pile up, and where the gaps are. A summary of data includes where the middle is and how much spread is around it.

Keep records of their investigations and observations and not change the records later.

**OBJECTIVE:** Students will measure and graph the length of the ventral side of a sample of zebra mussels.

### WHAT YOU OUGHT TO KNOW

Zebra mussels are found in a variety of lengths. They range in length from less than 1 mm or larger. Length measurements are made along the ventral side of the mussel, which is the straight edge. The enclosed Illinois Natural History Survey (INHS) sheet shows actual length data from three samples at one site on the Illinois River. The purpose of this activity is to determine the frequencies of shell lengths and to visually illustrate those frequencies by the use of graphs.

### ASK QUESTIONS







## WHAT'S THE CONNECTION??

### TO LANGUAGE:

Write a journal entry about the life of a zebra mussel. Have the students take the viewpoint of the zebra mussel.

### TO MATHEMATICS:

Calculate the average length of the sample of shells for each group and then for the class. Calculate the percentage of the numbers for each length. Discuss other ways to graph and have the students construct a pie graph for the group sample.

### TO ART:

Make an enlarged drawing of zebra mussel using the grid method.

### TO SOCIAL STUDIES:

Read an Illinois map to find the location of each zebra mussel sample site on the Illinois River (described in this activity). Consult monitoring agencies in your state to construct your own map of sample sites.

### WORDS OF WISDOM

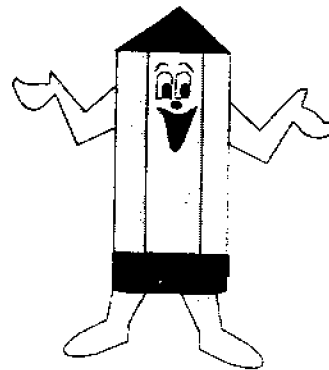
Centimeter (cm), data, maximum, millimeter (mm), minimum, percentage, ventral line (see also glossary on page 5).

### RESOURCES AT THE READY

Material:	In Kit	In Notebook	Teacher Provides
	Measuring Cups	Sheet 5.1	Graph Paper Illinois map
	ZM shells	Sheet 5.2	
	Metric Rulers	Sheet 5.3	
		ZM Journal	

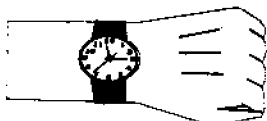
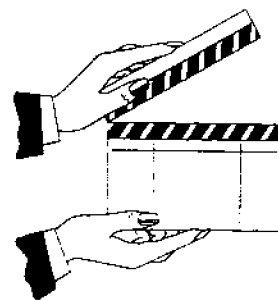
For each group

- (1) Measuring cup
- Zebra mussel shells
- (1) Metric ruler
- Graph paper
- Length Frequency Chart Data Sheet 5.1
- Length Frequency Bar Graph 5.2
- Grid Data Sheet 5.3
- Zebra mussel journal



## GETTING YOUR ACT TOGETHER

Read the Illinois Natural History Survey Zebra Mussel Length Frequency Bar Graph 5.2 to familiarize yourself with the length frequency of live zebra mussels. This information is actual data taken from three samples along the Illinois River. You should prepare a larger summation chart of the information so that students can compare data.



## TIME TO EXPERIENCE ZEBRA MUSSEL MANIA!!!

1. Go over the Words of Wisdom and have them record them in their zebra mussel journal.
2. Each group should become familiar with Data Sheet 5.1, the Zebra Mussel Length Frequency Chart. On this data table students will record zebra mussel shell length, number, total, and frequency (or percentage).
3. One student from each group should measure 100 ml of zebra mussels with the measuring cup and bring them back to the group.
4. Students will measure each shell in millimeters (mm) along the ventral line and tally the number of each one on the data table.
5. Students should total the number of shells for each length by adding up the tallies.
6. Students should total the number of all shells and then compute the percentage for each length. They then can determine the maximum and minimum lengths for each sample. (Note: Teacher should note these lengths on the board.)
7. Show the students the Illinois River Data (Bar Graph 5.2). Ask them to compare their sample to that made by scientists of the Illinois Natural History Survey. Were the percentages similar?
8. Each group should construct a graph based upon their data table illustrating the percentage of each length.

9. Each group should share measurements from their data sheet on the class summary sheet. Determine the class total percentages and maximum and minimum lengths. Is there a difference between data from the different working groups? Variation could well occur, which is the reason multiple samples are used to define a population.
10. Discuss the following questions:
  - a. What was the length of most of your zebra mussels?
  - b. What length of zebra mussels had the fewest numbers?
  - c. Give an explanation of the distribution of the lengths of the zebra mussels.

### **WHAT DID YOU LEARN???**

Can the students accurately measure a zebra mussel? When comparing the data table to the graph, are the zebra mussel groupings accurate? Can each student complete a graph and place the variables on the proper axis?

### **WAIT, THERE'S MORE...**

Study other species' populations: measure lengths of tree leaves, snail lengths, other shell lengths, seed sizes, dandelion flower or flower stalk sizes, heights or weights of students in class and school.





## ZEBRA MUSSELS

### WORDS OF WISDOM

#### ACTIVITY 5: HOW BIG ARE YOUR MUSSELS?

**CENTIMETER (cm):** a metric unit of measure equal to 1/100 meter (about the width of your finger)

**DATA:** facts, figures, or information from which conclusions can be drawn

**MAXIMUM:** the greatest number, degree, or quantity

**MILLIMETER (mm):** a metric unit of measure equal to 1/1000 of a meter; 10 mm equals 1cm

**MINIMUM:** the smallest number, degree, or quantity

**PERCENTAGE:** a given part or amount in every hundred

**VENTRAL LINE:** a longitudinal line along the lower side of a zebra mussel



HOW BIG ARE YOUR MUSSELS?  
 ZEBRA MUSSEL LENGTH-FREQUENCY CHART  
 DATA SHEET 5.1

Zebra Mussel Watchers' Names:

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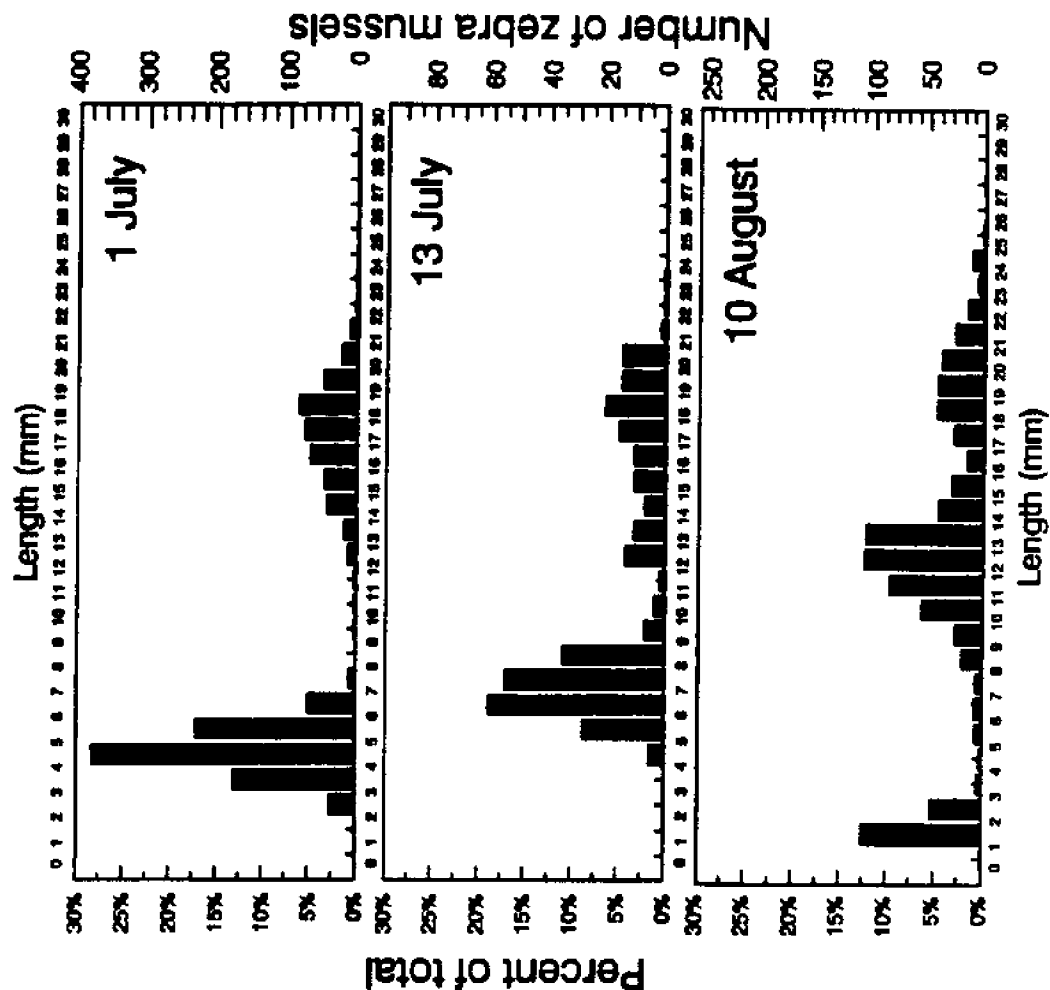
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Length	Number	Total	Percentage
1 mm			
2 mm			
3 mm			
4 mm			
5 mm			
6 mm			
7 mm			
8 mm			
9 mm			
10 mm			
11 mm			
12 mm			
13 mm			
14 mm			
15 mm			
16 mm			
17 mm			
18 mm			
19 mm			
20 mm			
21 mm			
22 mm			
23 mm			
24 mm			
25 mm			
26 mm			
27 mm			
28 mm			
29 mm			
30 mm			
maximum length _____	minimum length <sup>52</sup> _____		Total shells

HOW BIG ARE YOUR MUSSELS?  
 ZEBRA MUSSEL LENGTH FREQUENCY  
 BAR GRAPH 5.2

Researchers from the Illinois Natural History Survey made random collections of zebra mussels from the Illinois River near Peoria, IL on three dates in 1993. The samples were returned to the laboratory where the length of each shell was determined. These length data were sorted into 1-mm length intervals. Numbers of zebra mussels from each collection in each interval were tabulated, and the percentages of shells in each interval were calculated (see the table below). Percentages were then used to construct the three length frequency distribution graphs below.

Length Interval (mm)	1 July 1993		13 July 1993		10 August 1993	
	Number	Percent	Number	Percent	Number	Percent
0 - 1	0	0.0%	0	0.0%	1	0.1%
1 - 2	1	0.1%	0	0.0%	108	12.6%
2 - 3	37	2.8%	0	0.0%	47	5.4%
3 - 4	175	13.1%	0	0.0%	4	0.5%
4 - 5	377	28.9%	5	1.8%	3	0.3%
5 - 6	229	17.2%	28	8.7%	6	0.7%
6 - 7	68	5.1%	81	18.9%	7	0.8%
7 - 8	9	0.7%	88	17.1%	5	0.6%
8 - 9	0	0.0%	36	10.8%	16	2.1%
9 - 10	2	0.2%	7	2.2%	24	2.8%
10 - 11	3	0.2%	4	1.2%	55	6.5%
11 - 12	3	0.2%	2	0.6%	84	9.7%
12 - 13	12	0.9%	14	4.3%	108	12.4%
13 - 14	17	1.3%	11	3.4%	106	12.2%
14 - 15	42	3.2%	7	2.2%	41	4.7%
15 - 16	46	3.5%	11	3.4%	28	3.2%
16 - 17	67	5.0%	11	3.4%	15	1.7%
17 - 18	75	5.6%	16	5.0%	26	3.0%
18 - 19	82	6.2%	21	6.5%	42	4.8%
19 - 20	46	3.6%	15	4.7%	42	4.8%
20 - 21	22	1.7%	15	4.7%	37	4.3%
21 - 22	11	0.8%	2	0.6%	26	3.0%
22 - 23	2	0.2%	1	0.3%	15	1.7%
23 - 24	2	0.2%	1	0.3%	6	0.7%
24 - 25	1	0.1%	0	0.0%	10	1.2%
25 - 26	1	0.1%	0	0.0%	2	0.2%
26 - 27	0	0.0%	0	0.0%	0	0.0%
27 - 28	0	0.0%	0	0.0%	1	0.1%
28 - 29	0	0.0%	0	0.0%	0	0.0%
29 - 30	0	0.0%	0	0.0%	0	0.0%
Total	1332	100%	322	100%	668	100%







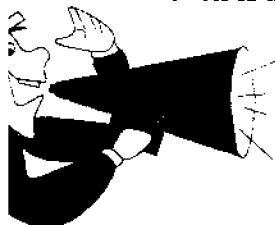


## ACTIVITY SIX: FILTERING FOOLS

- TIME:** (1) 45-minute lesson  
This activity can be done by half the class at the same time as Activity Seven is done by the other half of the class. Consider doing as outside activity.
- SCIENCE PROCESS SKILL:** Inferring and model building
- SCIENCE CONCEPT:** Zebra mussels use a biological siphon to filter large quantities of water.
- BENCHMARKS:**
- Students should:
- Know that scientific investigations may take many different forms, including observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments.
- Know that seeing how a model works after changes are made to it may suggest how the real thing would work if the same were done to it.
- Use numerical data in describing and comparing objects and events.
- OBJECTIVE:** Students will construct a model to simulate how zebra mussels remove nutrients and particles from the water.

### WHAT YOU OUGHT TO KNOW

Zebra mussels use water filtration to collect the nutrients needed to sustain life and grow. An adult zebra mussel can filter approximately one liter of water per day. A positive effect of this filtration is the increased clarity of the water filtered by the zebra mussels. However, on the negative side, the zebra mussels interrupt the food web for other forms and change the ecosystem of the aquatic habitat. Additionally, even if the water is clearer, that does not mean the water is better.



## WHAT'S THE CONNECTION??



### TO LANGUAGE:

Research and write reports on another animal using filtration.

### TO MATHEMATICS:

Calculate the amount of water a given number of zebra mussels can filter.

### TO ART:

Design a filter that would keep zebra mussels from entering industrial pipes.

### TO SOCIAL STUDIES:

List where filters are used in your home, industry, business, etc.



### WORDS OF WISDOM

Filter, filtration, liter, nutrient, siphon, submerge (see also glossary on page 5)

### RESOURCES AT THE READY

Material:	In Kit	In Notebook	Teacher Provides
	Filter models	Sheet 6.1	(8) 2-liter clear bottles
	Cotton balls	Sheet 6.2	water
	Buckets	ZM Journal	Plastic cups
	Measuring cup		
	Dirt		

For EACH group:

Two 2-liter drink bottles, clear (one for mixing dirt, one for 100 ml of water)

One filter model (made of film canister and tubing)

Several gallons of water

(13) Cottonballs

Bucket for the waste water

(4) clear plastic cups

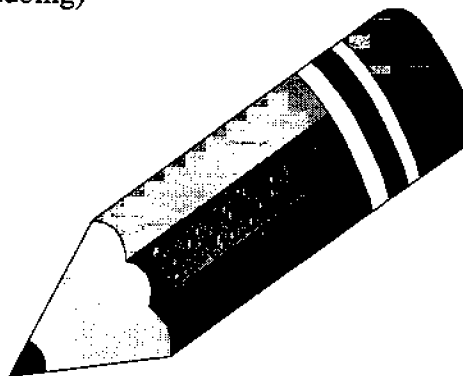
Measuring cup

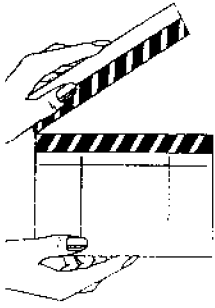
Dirt

Filtering Fools Data Sheet 6.1

Filtering Fools Observation Sheet 6.2

Zebra mussel journals





## GETTING YOUR ACT TOGETHER

This will be a wet and messy activity. You may want to consider doing this activity outside. You will probably need to have a mop on hand in case of spills. You will need to have an adequate supply of water nearby, or you will want to prepare for the lesson by having the water brought into the classroom. From the cafeteria, collect buckets, pickle jars, vegetable cans, even milk jugs to use for water, cleaning up, and collecting dirty water.

**NOTE:** You will want to consider teaching this lesson simultaneously with Activity Seven, "All Clogged Up." Copy one data sheet per group. Practice using the "zebra mussel filter model" ahead of time so you can explain and demonstrate its use to the students.

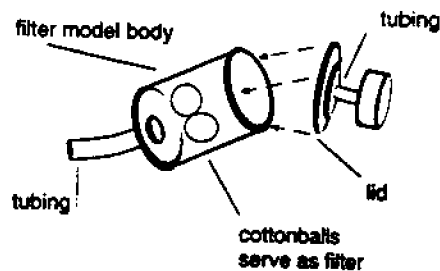
## TIME TO EXPERIENCE ZEBRA MUSSEL MANIA!!!

1. Go over Words of Wisdom and have them record in journal.
2. Have students draw and label the zebra mussel filter model in their zebra mussel journals.
3. Have each group mix exactly 15 ml (1 T) of dirt with 2 liters of water. Shake to disperse the dirt.
4. Students should observe this water and record their observation under the unfiltered water category on the Filtering Fools Data Sheet 6.1.
5. Shake the 2-liter bottle well. Then add 100 ml dirty water to a clean 2-liter bottle and screw on the zebra mussel filter model.
6. The first time don't add any cottenballs, then secure the cap and tubing and begin the filtering action. The filtered water should be collected in a clear plastic cup. Save this water for comparison. Record the results of the filtration under the zero cottonball column.



7. Now add 2 cottonballs to act as a filter. Save the cottonballs used in each filtration to compare the colors. Save these cottonballs on a paper towel.
8. Compare clean cottonballs with the two cottonballs used to filter the cup of dirty water.
9. Predict how the water will appear if it is filtered using four cottonballs.
10. Repeat the activity using four, then six cottonballs.
11. Lay the cottonballs taken after filtering in order on the paper towels. Have the Reporters for each group prepare a presentation for the other groups completing Activity 7 (if you decide to do Activity 7 simultaneously). They should demonstrate the procedure and show the results gathered.
12. Empty the water and clean the equipment, including any spilled water.
13. Discuss with the class their results comparing the number of cottonballs with the success in filtration. The millions of zebra mussels found in rivers and lakes act in the same way as the cotton filters, except the mussels eat the food trapped in their filters. Because there are so many zebra mussels, tremendous amounts of materials can be removed from the water. One zebra mussel can filter up to a liter of water each day.
14. Have each group answer questions on the Filtering Fools Observation Sheet 6.2. Discuss the answers.

### FILTER MODEL ASSEMBLY





### **WHAT DID YOU LEARN??**

Did the students complete the worksheet correctly?

Is each student able to make some comparison of the filter model to the zebra mussel?

Can each student relate the huge number of zebra mussels to the large amount of water they are capable of filtering?

### **WAIT, THERE'S MORE...**

- \* Find and display filters that are used by people.
- \* Research how other mussels and organisms collect food using the filtering process. Make a list of these filter feeders.
- \* Lake Erie and Lake Michigan have become clearer because of zebra mussels. Find out how this was done.
- \* Instead of cottonballs, try using sand, gravel, or other types of soil.



## ZEBRA MUSSELS

### WORDS OF WISDOM ACTIVITY 6: FILTERING FOOLS

**FILTRATION:** a treatment process for removing solid matter from water by passing the water through sand or man-made filter

**LITER (L):** a metric unit of liquid measurement; it is equal to 1.06 quarts

**NUTRIENT:** any substance assimilated by living things that promotes growth

**SIPHON:** an opening through which water enters and leaves an object, such as a mussel; some species can use this activity as a means of propulsion; also a means by which a liquid is transferred from one object to another, such as to siphon water into a bottle

**SUBMERGE:** to completely immerse in water



# FILTERING FOOLS DATA SHEET 6.1

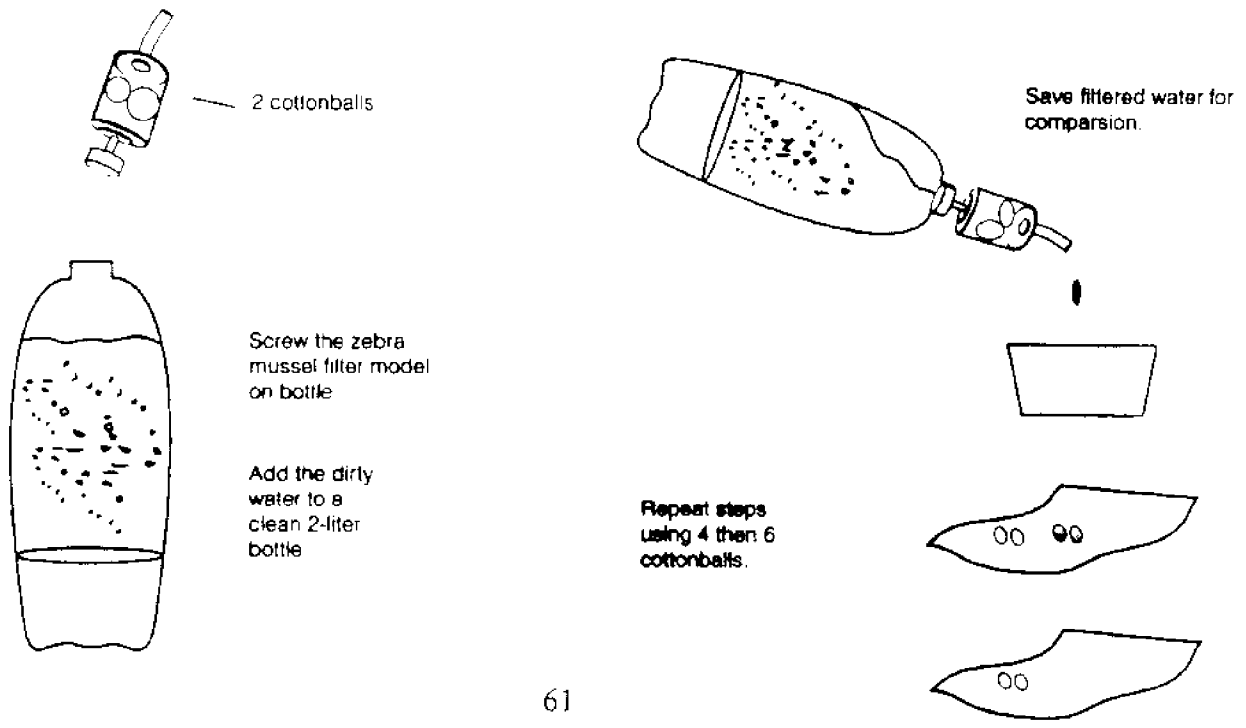
Zebra Mussel Watchers' Names:

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	Unfiltered water ● cottonball	100 ml filtered with 2 cottonballs	100 ml filtered with 4 cottonballs	100 ml filtered with 6 cottonballs
Describe the water.				
	0 zebra mussels	2 zebra mussels	4 zebra mussels	6 zebra mussels
Describe how zebra mussels affect water, based on cottonballs above.				





# ZEBRA MUSSELS

## FILTERING FOOLS OBSERVATION SHEET 6.2

Zebra Mussel Watchers' Names:

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1. Compare the cottonball filters. Did the 2, 4, or 6 filters remove more material from the water?

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2. How does this filtering demonstration relate to the zebra mussel?

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3. Write a paragraph telling why filtering of zebra mussels has such a great impact on a body of water.

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4. List at least 5 ways that filters are used by people.

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## ZEBRA MUSSELS

### FILTERING FOOLS OBSERVATION SHEET 6.2: TEACHER'S KEY

Zebra Mussel Watchers' Names:

\_\_\_\_\_

1. Compare the cottonball filters. Did the 2, 4, or 6 filters remove more material from the water?

**The six cottonballs removed more material from the water.**

2. How does this filtering demonstration relate to the zebra mussel?

**Zebra mussels filter like the cottonballs do except they eat the food they filter. The more Zebra mussels, like cottonballs, the more stuff gets filtered.**

3. Write a paragraph telling why filtering of zebra mussels has such a great impact on a body of water.

**A zebra mussel can filter a liter of water a day. When it filters, it takes food out of the water for other animals to use. The more zebra mussels there are, the less food there is for other animals. The other animals will starve. This will affect the food chain.**

4. List at least 5 ways that filters are used by people.

**Coffee filters, oil filters, air conditioners filters, water filters, gas filters, light filters on camera, etc.,**



## ACTIVITY SEVEN: ALL CLOGGED UP

**TIME:** (1) 45-minute lesson. This activity can be done by half the class at the same time Activity Six is being done by the other half of the class. You may want to consider doing this outside.

**SCIENCE PROCESS SKILL:** Predicting and model building.

**SCIENCE CONCEPT:** Zebra mussels can restrict the flow of water by congregating in water lines.

**BENCHMARKS:** Students should:  
Know that scientific investigations may take many different forms, including observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments.

Know that seeing how a model works after changes are made to it may suggest how the real thing would work if the same changes were made.

Keep records of their investigations and observations and not change the records later.

Use numerical data in describing and comparing objects and events.

**OBJECTIVE:** Students will use a model to predict the rate of flow of water in a pipeline.

### WHAT YOU OUGHT TO KNOW

Zebra mussels are gathering on water intake lines of the power companies and water treatment plants along rivers and lakes. The resulting economic impact to these companies is very serious and costs thousands of dollars for clean-up and repairs. Have students brainstorm problems that might occur if these industries and water utilities were unable to easily draw incoming water. This activity shows students how the water through a pipe can be reduced by zebra mussels. Students will be estimating the rate of water flow in a pipe when colonized by zebra mussels.

**ASK QUESTIONS**



Each tube used by the students represents one of the multiple tubes present in the cooling system of a power plant. When the pipes are clean, the water moves through quickly and in known amounts. As soon as zebra mussels come into the pipes, water flow is reduced. The more mussels in the pipes, the less water is allowed to pass through. If the cooling process is stopped, the power plant could overheat and a shutdown could occur.

### WHAT'S THE CONNECTION???



#### TO LANGUAGE:

Write a newspaper account of a nuclear power plant being shut down because of a water flow shortage.

#### TO MATHEMATICS:

Estimate the rate of flow of a 5-liter bucket draining through a 4 cm hose, 8 cm hose, etc.

#### TO ART:

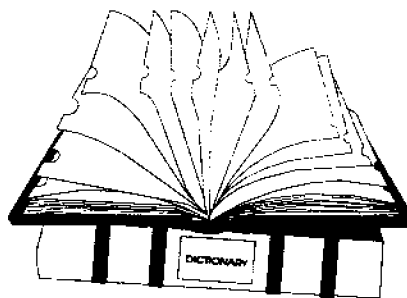
Use straws and aquarium tubing to build a water or power plant structure.

#### TO SOCIAL STUDIES:

Locate your area's water plant and power plant on a map.

### WORDS OF WISDOM

Congregate, flow restriction, intake lines, siphon (see also glossary on page 5).



**LOOK IT UP**

## RESOURCES AT THE READY

Material:	In Kit	In Notebook	Teacher Provides
	Vinyl tubing	Sheet 7.1	(8) 2-liter bottles
	Gravel	Sheet 7.2	Clean-up material
	Rulers	ZM Journal	Graph paper
	Buckets		
	Stop watch		
	funnel		

### EACH GROUP WILL NEED...

One 2.5 cm inside diameter, vinyl tubing, 1 m long with attached screen (see drawing)

(2) 2-liter bottle

Funnel

Gravel

Ruler

(2) Buckets

Clean-up equipment and water-holding materials

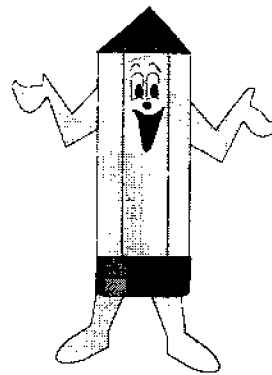
Watch or clock to record elapsed times

All Clogged Up! Data Sheet 7.1

All Clogged Up! Data Sheet 7.2

Piece of graph paper ( or use Data Sheet 5.2)

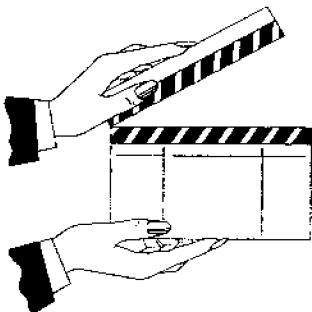
Zebra mussel journal



### GETTING YOUR ACT TOGETHER

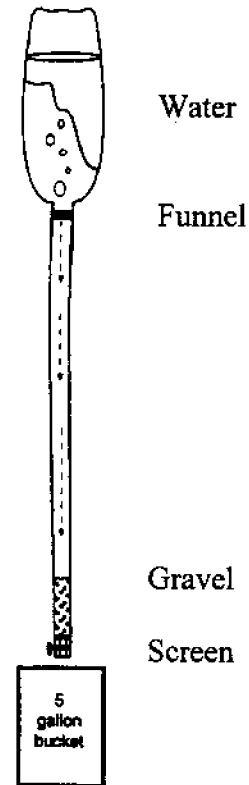
This will be a wet and messy activity. You may want to consider doing this activity outside. Have a mop on hand in case of spills. You will need to have an adequate supply of water nearby or will want to prepare for the lesson by having the water brought into the classroom. From the cafeteria, collect buckets, pickle jars, vegetable cans, even milk jugs to use for water, cleaning up and collecting dirty water.

NOTE: You may want to consider teaching this lesson simultaneously with Activity Six, "Filtering Fools."

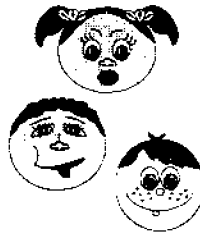


## TIME TO EXPERIENCE ZEBRA MUSSEL MANIA!!

1. Have each group fill a 2-liter bottle with water and place it on a desk or table. This bottle becomes your water intake source. NOTE: Fill the bottle ALL the way up!!
2. Use a funnel and put it into the open end of the tube. You will pour the water from the 2-liter bottle through here.
3. Watch the clock as you drain through the tube. Start timing when the bottle is inverted. Note the number of seconds that have elapsed by subtracting the times on the Data Sheet 7.1. Repeat this process at least three times. The three times should all be similar. If not, why?
4. Add 5 cm of gravel to the open end of the tube and shake the gravel down to the screen. Repeat steps 1 through 3 three times. Have students record data for each repetition.
5. Add an additional 10 cm (total of 15 cm) of gravel, repeat steps 1 through 3, and record the data.
6. Now have the students predict the rate of flow if you would add 10 cm more of gravel (25 cm total) to the hose. Make one prediction for 5 cm less of gravel (10 cm total gravel). Record these two predictions.
7. Add an additional 5 cm (total 20 cm), repeat steps 1 through 3 and record the data.
8. Check your predictions by completing steps 1 through 3 to find the actual time required. Have the students compare predictions. Which was the most accurate, the 10 cm or the 25 cm prediction?
9. Have the groups create a graph of their results without the predictions. Then have them draw a line through the observation points and develop extrapolations and interpolations for 10 cm and 25 cm of gravel. Were the graphs useful for this task?



10. Answer questions on Record Sheet 7.2. Have each group share their data with the class and compare the water output values.
11. Have the students draw the apparatus in their journals. When they have finished the drawing, have them draw a power plant with cooling tubes blocked with zebra mussels.
12. Have the Reporters for each group prepare a presentation for the group doing Activity Six. They should demonstrate the procedure and show the results.



### **WHAT DID YOU LEARN????**

Compare the students' predictions to actual observations. Can you determine if their final prediction is fairly accurate? Are the children able to demonstrate how the zebra mussels block pipes in water or power plants.



### **WAIT, THERE'S MORE....**

- \* Field trips to water utilities or power plants can provide an ideal opportunity for a first-hand look at the problems caused by zebra mussels.
- \* Invite a power plant operator or engineer to discuss zebra mussel impacts with the class.
- \* Make predictions about what would occur if the entire tube used in the lesson was clogged.



## **ZEBRA MUSSELS**

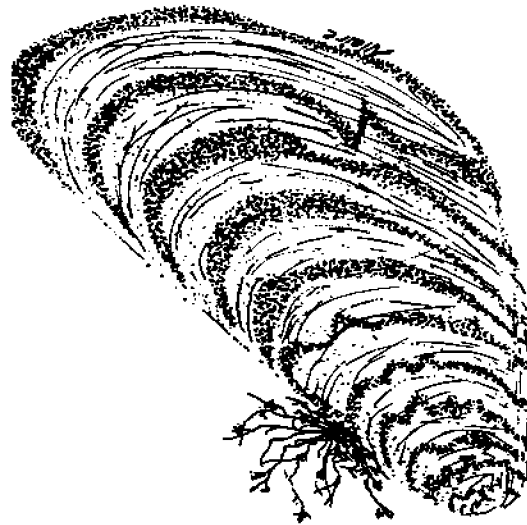
### **WORDS OF WISDOM ACTIVITY 7: ALL CLOGGED UP**

**CONGREGATE:** a gathering or assemblage of people or things

**FLOW RESTRICTION:** anything that restricts or slows water flow; for example, zebra mussels restrict flow in a water pipe, and weeds restrict flow in a canal

**INTAKE LINES:** the place fluid is taken into a pipe, e.g., intakes for water treatment plants and power industries

**SIPHON:** an opening through which water enters and leaves an object, such as a mussel; some species can use this activity as a means of propulsion; also a means by which a liquid is transferred from one object to another, such as to siphon water into a bottle





# ALL CLOGGED UP! DATA SHEET 7.1

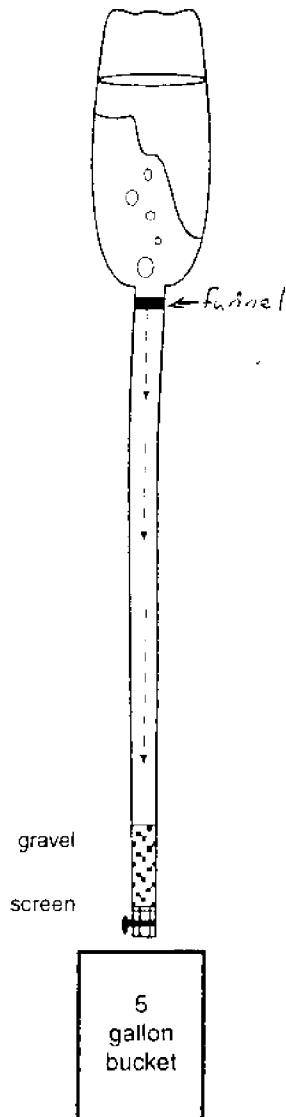
Zebra Mussel Watchers' Names:

\_\_\_\_\_

\_\_\_\_\_

## Rate of Flow Data Table

STEPS 1-5



Amount of gravel	Rate of flow in seconds			
	Trial 1	Trial 2	Trial 3	Average
no gravel				
5 cm				
15 cm				
20 cm				

Make a prediction after plotting the data on the graph paper.

Predicted rate of flow using 10 cm of gravel \_\_\_\_\_ seconds

Predicted rate of flow using 25 cm of gravel \_\_\_\_\_ seconds



## **ZEBRA MUSSELS**

### **ALL CLOGGED UP! RECORD SHEET 7.2**

**Zebra Mussel Watchers' Names:**

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Questions

1. How good was your group's prediction at the 10 cm of gravel level? Why?

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2. How good was your group's prediction at the 25 cm of gravel level? Why?

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---

3. Which prediction (10 or 25 cm of gravel) should have been more accurate? Why was one prediction more accurate than the other?

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---

4. How does this demonstration relate to zebra mussels?

---

---

5. Describe how the zebra mussel might affect pipes in water or power plant systems.

---

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## ZEBRA MUSSELS

### ALL CLOGGED UP! RECORD SHEET 7.2 TEACHER'S KEY

Zebra Mussel Watchers' Names:

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---

#### Questions

1. How good was your group's prediction at the 10 cm of gravel level? Why?  
**Will vary**
2. How good was your group's prediction at the 25 cm of gravel level? Why?  
**Will vary**
3. Which prediction (10 or 25 cm of gravel) should have been more accurate? Why was one prediction more accurate than the other?  
**10 should be more accurate because 10 cm is closer to 15 cm than 25 cm is closer.**  
**We knew the rate of flow for 15 cm and it is easier to predict what 5 cm less would be than to predict what 10 cm more would be.**
4. How does this demonstration relate to zebra mussels?  
**Zebra mussels clog intake pipes like the gravel clogged the tubing. The more zebra mussels the harder it is for water to go through.**
5. Describe how the zebra mussel might affect pipes in water or power plant systems.  
**Could completely clog it and shut it down.**

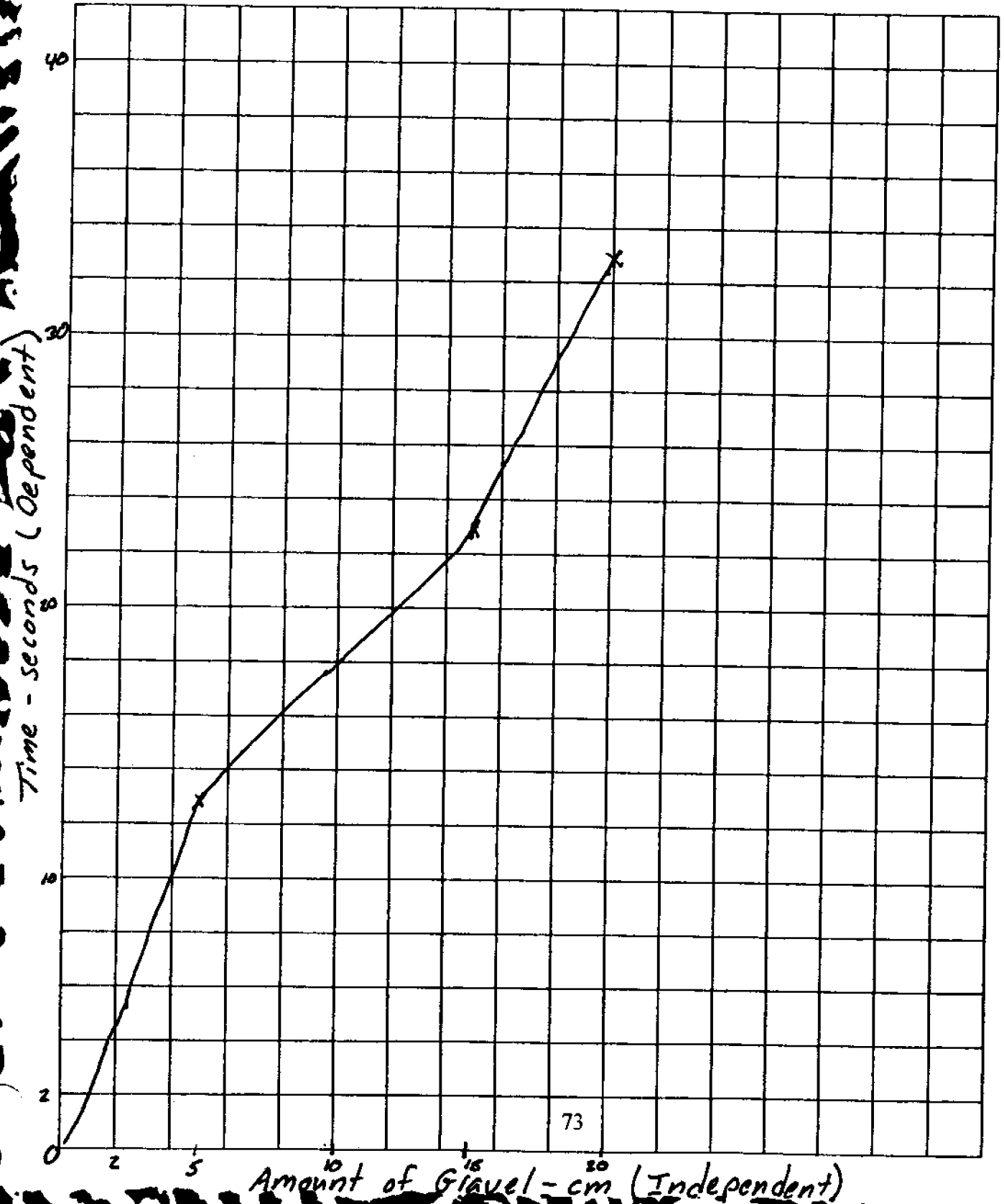
HOW BIG ARE YOUR MUSSELS?  
1 CENTIMETER GRID  
DATA SHEET 5.3

Zebra Mussel Watchers' Names:

How to Set Up Graph.

Example

Time for Water to go Through Tube





## ACTIVITY EIGHT: FAMILY REUNION

**TIME:** (1) 45-minute lesson

**SCIENCE PROCESS SKILL:** Predicting and inferring

**SCIENCE CONCEPT:** Population density can be determined by sampling.

**BENCHMARKS:** Students should:  
Know that, usually, there is no one right way to solve a mathematical problem; different methods have different advantages and disadvantages.

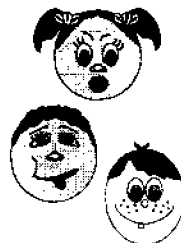
Know that results of similar scientific investigations seldom turn out exactly the same. Sometimes this is because of unexpected differences in the things being investigated, sometimes because of unrealized differences in the methods used or in the circumstances in which the investigation is carried out, and sometimes just because of uncertainties in observation. It is not always easy to determine the cause for different results.

Keep records of their investigations and observations and not change the records later.

**OBJECTIVE:** Students will calculate the number of zebra mussels in a given area.

### WHAT YOU OUGHT TO KNOW

Zebra mussels attach to hard surfaces in lakes and rivers. They attach to rocks, docks, boats, and even to each other. This activity will engage the students in a sampling technique currently being used by scientists to estimate the number of zebra mussels in rivers and lakes. The students will engage in similar sampling techniques by taking samples of gravel (zebra mussels) from a cookie sheet (lake/river bottom), and then using this information to calculate the number of pebbles in the entire pan.



When sampling zebra mussel populations in rivers such as the Illinois River, Illinois Natural History Survey divers take large metal square frames to the bottom of the river. In the dark water, they push the heavy metal square very carefully into the river bottom. Then they carefully remove everything from inside the dimensions of the metal square and place the samples in collection bags before bringing them to the surface. At the surface or in the laboratory, the scientists count the organisms. Several more samples are taken; the surface area of the entire location is measured; and the population for that large area is determined.

### **WHAT'S THE CONNECTION???**



#### **TO LANGUAGE:**

The students can write directions for using sampling to determine the number of zebra mussels in a lake or river.

#### **TO MATHEMATICS:**

The students can determine the number of zebra mussels it would take to cover the gym floor, cafeteria wall, classroom floor, or playground area.

#### **TO ART:**

Students can construct a zebra mussel colony using macaroni shells (2 sizes) to represent their sample.

#### **TO SOCIAL STUDIES:**

The students will brainstorm ways in which sampling can be used by business, industry, and the government to control the zebra mussel population.



## WORDS OF WISDOM

Area, estimate, extrapolate, population, population density, predict, quantify, sampling (see also the glossary)

## RESOURCES AT THE READY

Material:	In Kit	In Notebook	Teacher Provides
	Cookie pans	Sheet 8.1	(4) cardboard milk cartons (pt. or qt)
	Gravel	ZM Journal	Balance
	Spoons		

Set up four lab stations. Each group of students will rotate from station to station

Each group will need:

Cookie pan

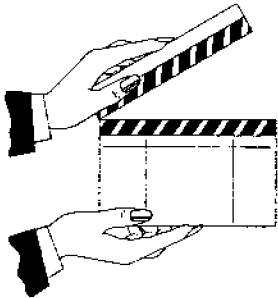
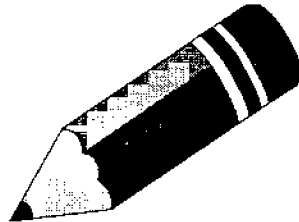
Lightweight gravel

Spoons for moving and counting the gravel

Cardboard milk cartons

Family Reunion Data Sheet 8.1

Zebra mussel journals



## GETTING YOUR ACT TOGETHER

Collect, rinse, and clean milk cartons, one for each lab station. Cut out the carton's top and bottom so you have an open-ended square box. The carton box should be at least 5 cm deep. You may want to reinforce the edges of the carton with masking tape. Fill four pans with 2 cm of gravel and move some of the gravel to make the surface uneven, thus more natural. Tell the class that the pans represent four sites on the river bottom. Assign groups to survey each site, just as they would if four boats were needed. The sites represent typical populations of zebra mussels for an area.



## TIME TO EXPERIENCE ZEBRA MUSSEL MANIA!!!



1. Go over Words of Wisdom and have them record them in their zebra mussel journal.
2. Discuss the problem of counting an entire population of anything. This is what zebra mussel experts come across when they deal with an entire river or lake to determine a population. Pretend that the gravel covering the pans are zebra mussels. Ask the students if they could quickly count all the pebbles (zebra mussels) in the pan. The correct response is, "Not easily." But students can learn to take samples and use those samples to extrapolate or predict a larger population.
3. Use the Data Sheet 8.1 to record the area of the pan and area of the carton.
4. Have the students estimate the number of cartons needed to cover the pan. They should record their predictions.
5. The students should then calculate the actual number of cartons needed to cover the pan and record this information. Determine the number of cartons needed by dividing the area of the pan by the area of the carton.
6. Take an actual sample from the pan by using the carton. Students should push the carton down, open ended, through the gravel until the carton rests on the bottom of the pan.
7. The students will remove their sample from the inside of the carton by using a spoon. Quantify the sample by counting. Record the sample counts in the journals and on Data Sheet 8.1.
8. After each group has completed the four sampling, have them share their results with the entire class. Place the numbers on the class chart. Show the class how to do an average. Have the students write the procedure for collecting samples in their zebra mussel journals.
9. Explain to the students that, by taking the average number of pebbles and multiplying that by the number of cartons needed to cover the pan, they will arrive at the population density of zebra mussels in the entire pan.

**WHAT DID YOU LEARN???**

Can the students tell you the procedure for collecting a sample and determining the density of a population? You can determine the validity of the mathematical calculations by checking the students' data sheets. Do their sampling procedures reflect concern for developing accurate data?

**WAIT, THERE'S MORE...**

You also can quantify the sample by another sampling technique. To do this, use a balance to find the mass of a know sample, say 100 pebbles chosen randomly. If 100 has a mass of X grams, any future mass can be used to determine the number of pebbles.



## **ZEBRA MUSSELS**

### **WORDS OF WISDOM ACTIVITY 8: FAMILY REUNION**

**AREA:** the measure of the surface of a solid; a part of any surface; a particular zone

**ESTIMATE:** to judge or determine generally, but carefully, the size, value, or cost of an item

**EXTRAPOLATE:** to arrive at a conclusion or result by hypothesizing from known facts or observations

**POPULATION:** a group of interbreeding organisms of the same kind occupying a particular space

**POPULATION DENSITY:** the quantity or number of a species per unit, as of an area

**PREDICT:** to determine in advance what will happen

**QUANTIFY:** to determine or express the amount of something; to measure

**SAMPLING:** the process of taking a small amount of an item or object for testing or analysis



# FAMILY REUNION! DATA SHEET 8.1

Zebra Mussel Watchers' Names:

\_\_\_\_\_

\_\_\_\_\_

1. Area of pan \_\_\_\_\_ cm<sup>2</sup>      Area of carton \_\_\_\_\_ cm<sup>2</sup> (length x width = \_\_\_\_\_)
2. Estimate cartons per pan \_\_\_\_\_
3. Actual cartons per pan \_\_\_\_\_ (determined by area of pan x area of carton)

Average number of pieces of gravel per carton \_\_\_\_\_

Number of cartons sampled \_\_\_\_\_

## Number of Pebbles Collected

River site	Student sampling group				Average
	A	B	C	D	
1					
2					
3					
4					

Total population density of: site 1 \_\_\_\_\_ site 2 \_\_\_\_\_ site 3 \_\_\_\_\_ site 4 \_\_\_\_\_  
(determined by taking the sample average x actual number of cartons that fit into pan)

Total population density of all sites \_\_\_\_\_ 80  
(add population densities of all sites and divide by 4)



## ACTIVITY NINE: WEB OF LIFE GAME

**TIME:** (1) 45-minute lesson

**SCIENCE PROCESS SKILL:** Inferring, predicting, and drawing conclusions

**SCIENCE CONCEPT:** Nonindigenous species will severely impact a native food web.

### BENCHMARKS:

Students should:

Know that, for any particular environment, some kinds of plants and animals survive well, some survive less well, and some cannot survive at all.

Know that organisms interact with one another in various ways in addition to providing food.

Know that, in all environments--freshwater, marine, forest, desert, grassland, mountain, and others--organisms with similar needs may compete with one another for resources, including food, space, water, air, and shelter. In any particular environment, the growth and survival of organisms depend on the physical conditions.

Know that models are often used to think about processes that happen too slowly, too quickly, or on too small a scale to observe directly; that are too vast to be changed deliberately; or that are potentially dangerous.

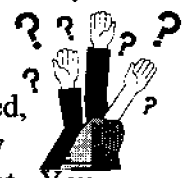
Know that people can keep track of some things--see where they come from and where they go.

**OBJECTIVE:** Students will demonstrate the critical changes in a native river ecosystem due to the introduction of zebra mussels.

### WHAT YOU OUGHT TO KNOW

A native river habitat is a fluid yet fragile community. Introduced species have altered, permanently in some cases, the natural food chain. The "Web of Life Game" actively demonstrates to students the impact zebra mussels have in a native river environment. You should discuss at length the food pyramid overhead provided. Students will understand the impact zebra mussels better by playing the "Web of Life Game." Dissolved oxygen, the available oxygen needed for species to live underwater, is a critical ingredient in a river habitat. All plants use carbon dioxide and water to produce oxygen during photosynthesis. In a river ecosystem, plants in the water produce oxygen; and underwater animals, including zebra mussels, use this dissolved oxygen. When zebra mussel numbers increase rapidly, they use tremendous amounts of dissolved oxygen, which cause native fish to die.

ASK QUESTIONS



## WHAT'S THE CONNECTION???



### TO LANGUAGE:

Students will record in their journal each of the three phases of the game.

### TO ART:

Students will draw a river habitat before the game and before looking at the river poster included. After the game, when they are more familiar with the food chain, students will redraw or add to their pregame picture, using the rivers and wetland poster included.

### TO SOCIAL STUDIES:

Interview Department of Natural Resources staff specialists about other ecosystems or habitats in trouble. Students will report their findings to the class.

### WORDS OF WISDOM

Biological diversity, dissolved oxygen, ecosystem, food chain, food web, habitat, larval fish, native species, organic matter, zooplankton, veligers (see also the glossary)

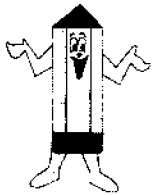


## RESOURCES AT THE READY

Material:	In Kit	In Notebook	Teacher Provides
	Name tags	Sheet 9.1	Pad of paper
	150 blue pieces	Food pyramid overhead	
	150 red pieces		
	Poster		

Character name tags (double sided) with zebra mussels on the back of all 30 tags

Names: larval fish (10)  
native mussels (10)  
larger fish (10)



3 diving ducks (name tags without zebra mussels on the back)

150 blue game pieces-indicates dissolved oxygen

150 red game pieces-indicates zooplankton

Chalkboard, pad of paper, or pencil to record students' observations after the game has concluded



### TIME TO EXPERIENCE ZEBRA MUSSEL MANIA!!!

Before beginning the game, go over the Words of Wisdom so the children can become familiar with them. Have them put the words into their zebra mussel journal. The following game is played in three rounds. As each round is completed, the teacher and students should discuss the changes that have occurred in this simulated ecosystem.



## WEB OF LIFE GAME

### SETTING UP THE GAME:

The following game instructions are based on using 30 students; the game may need to be adjusted for a different number of students. If possible, the game should be played in the gym or cafeteria, on the playground, or any other area with enough room to allow the students plenty of movement. Begin the game with 10 larval fish, 10 native mussels, and 10 larger fish.

### OBJECT OF THE GAME:

To survive as long as possible.

### DIRECTIONS FOR STUDENTS

#### ROUND ONE

1. Students put on the name tags, and the teacher scatters the game pieces in a large playing area so all students have easy access to the game pieces.
2. At a signal from the teacher, all students scramble to collect as many game pieces as possible.
3. Each species needs a certain amount of dissolved oxygen and zooplankton to survive. Students and teacher determine which species have survived based on the species needs in the following chart:

	DISSOLVED OXYGEN (blue game pieces)	ZOOPLANKTON (red game pieces)
larval fish	6	6
native mussels	6	6
larger fish	10	10
zebra mussels*	2	2
diving ducks*	14	14

\*These two species will participate later in the game

4. Species must have at least the required number of the specific game pieces to survive; survivors remain the same species for the next round. Species that do not have the required number of game pieces die and become zebra mussels in the next round (by turning their tag over).

### **ROUND TWO**

5. Collect and rescatter the game pieces. Have the students again collect as many game pieces as possible.
6. Repeat step 3 to determine who survived. If many animals other than zebra mussels survive, repeat round two.
7. At the end of round two, each animal keeps the game pieces he/she collected in preparation for round three.

### **ROUND THREE**

8. Select three students at random to become diving ducks. The diving ducks may "eat" any surviving animals by tagging them.
9. The diving ducks take all the game pieces from each animal as it is tagged. The tagged animal now has been "eaten" and is out of the game. The round concludes when all game pieces have been collected.
10. Students and teacher discuss who has survived and why (see chart in step 3).
11. Students and teacher discuss the game to illustrate the impact of zebra mussels on the native species, and the impact of diving ducks on zebra mussels and larval fish. Students should understand the effects of zebra mussels and how they can destroy an ecosystem and its biodiversity.
12. The results may be different each time the game is played. If you choose, play the game again.

### **WHAT DID YOU LEARN???**

Chart the results from the first and second games. Compare the results to see how in nature the food web interactions are constantly changing. More zebra mussels will reduce the numbers of large fish because the zebra mussels are depleting necessary nutrients and life support.

#### **WAIT, THERE'S MORE...**

Play the game using different numbers of animals per species for different results.



## **ZEBRA MUSSELS**

### **WORDS OF WISDOM ACTIVITY 9: WEB OF LIFE GAME**

**BIOLOGICAL DIVERSITY:** variety of life

**DISSOLVED OXYGEN:** the oxygen freely available in water; vital to fish and aquatic life for respiration; dissolved oxygen has been accepted as the single most important indicator of the ability of a body of water to support aquatic life

**ECOSYSTEM:** the interacting system of a biological community and its non-living environmental surroundings

**FOOD CHAIN:** a sequence of organisms, each of which uses the next lower member of the sequence as a food source

**FOOD WEB:** all the individual food chains in a community

**HABITAT:** the place where a population lives and its surroundings, both living and non-living

**LARVAL FISH:** an immature, free-swimming stage of a fish

**NATIVE SPECIES:** species that naturally occur or live in a particular area or region

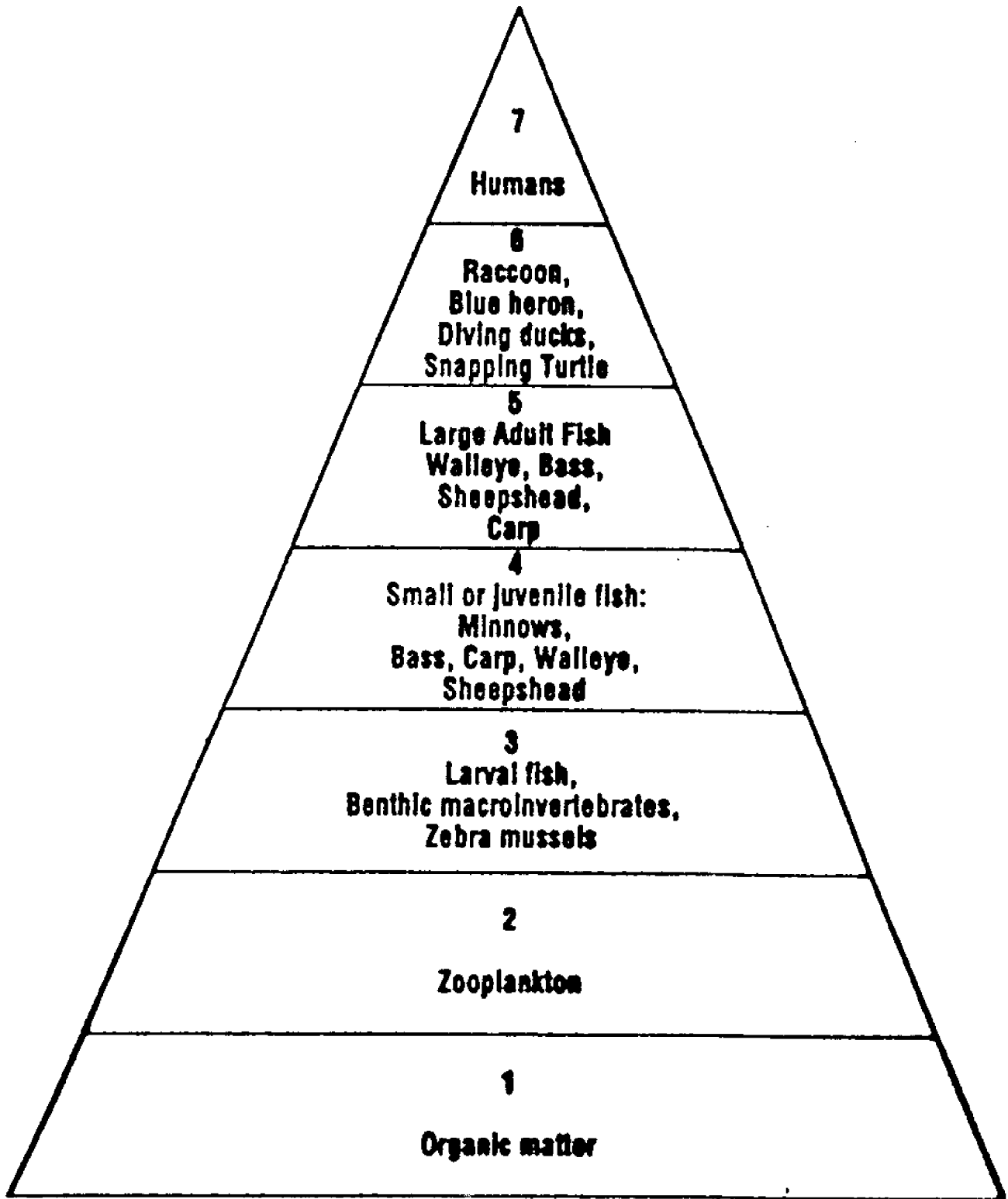
**ORGANIC MATTER:** carbon-based waste compounds produced by living plants or animals

**ZOOPLANKTON:** microscopic aquatic animals eaten by larger aquatic animals

**VELIGER:** a zebra mussel larvae



# The Food Pyramid



**WEB OF LIFE GAME FOOD PYRAMID OVERHEAD  
TEACHER'S KEY 9.1**

**FOOD PYRAMID**

The food pyramid describes the energy flow between producers and consumers. Producers are plant forms on the lower levels of the food pyramid. They consist of plants and organic matter. These plants and organic matter produce the energy that begins its journey through the food pyramid. The plants grow, store energy, and are consumed by organisms called consumers. The consumers that eat only plants are called herbivores. Carnivores are meat eaters, and omnivores are consumers that eat both plants and animals. As you progress up the food pyramid, the foods that are eaten by consumers become more varied. The variety helps many organisms to survive when one type of food becomes extinct.



MATERIAL TO XEROX



**ZEBERA  
MUSSELS**

## **STUDENT KWL STRATEGY**

**\* Activity**

**\* Student Name**

**\* What I know**

**\* What I want to know**

**\* What I learned**

**\* What I am confused about**





## ZEBRA MUSSELS

### STUDENT ATTITUDE SURVEY

**Name:**

**Date:**

**Directions:** Please read each of the following statements carefully. Put a check mark by each statement that you agree with.

- \_\_\_\_\_ 1. I would rather study science than any other subject.
- \_\_\_\_\_ 2. Science is of great value.
- \_\_\_\_\_ 3. I really enjoy science.
- \_\_\_\_\_ 4. Science is boring.
- \_\_\_\_\_ 5. I love to study science.
- \_\_\_\_\_ 6. Science is a waste of time.
- \_\_\_\_\_ 7. Science will benefit only the smart kids.
- \_\_\_\_\_ 8. I have no desire to learn about science
- \_\_\_\_\_ 9. Science classes are profitable to everyone who takes them.
- \_\_\_\_\_ 10. Science is practical.
- \_\_\_\_\_ 11. I like science experiments.
- \_\_\_\_\_ 12. Science experiments are dumb.
- \_\_\_\_\_ 13. Science teaches me to think.
- \_\_\_\_\_ 14. Science is of benefit to me.
- \_\_\_\_\_ 15. I hate science.

You may write any additional comments about science that you feel are important on the back.



# **SAFETY RULES**

*These safety rules may be discussed and posted during science activities, or the teacher may have the class generate a list of safety procedures to follow.*

- 1. Listen to your teacher's instructions.**
- 2. Don't touch or pick up any materials unless your teacher tells you to.**
- 3. Follow directions.**
- 4. Ask your teacher for help if you need it.**
- 5. Cooperate with a partner or with your group.**
- 6. Never put anything in or near your eyes or mouth, and wash your hands when you have finished.**
- 7. Clean up work area and return all materials to their proper places.**
- 8. Always walk in the science area.**
- 9. Talk quietly in groups.**
- 10. Tell your teacher immediately in case of accidents.**
- 11. Be Careful !!!**



## ZEBRA MUSSEL POST-TEST

NAME: \_\_\_\_\_

### MATCHING

- |                             |  |
|-----------------------------|--|
| 1. _____ ballast water      | a. The organisms that are foreign, not native to a particular location                           |
| 2. _____ byssal threads     | b. a zebra mussel larvae   |
| 3. _____ exotic species     | c. the water carried in a boat or ship to give stability   |
| 4. _____ food chain         | d. microscopic aquatic animals eaten by larger aquatic animals                                   |
| 5. _____ indigenous species | e. a tuft of filaments used to attach the mollusk to the substratum                              |
| 6. _____ phytoplankton      | f. the organisms that are native to a particular area  |
| 7. _____ veliger            | g. the microscopic plants eaten by larger aquatic animals  |
| 8. _____ zooplankton        | h. a sequence of organisms, each of which uses the lower member of the sequence as a food source |



## ZEBRA MUSSEL POST-TEST CON'T

### TRUE OR FALSE

9. \_\_\_\_\_ Zebra mussels have only positive effects on freshwater mussels.
10. \_\_\_\_\_ Classification of shells is done using color, size, texture, and other methods involving the senses.
11. \_\_\_\_\_ There is no way to tell the difference between a shell button and a plastic button.
12. \_\_\_\_\_ The Great Lakes have been affected by zebra mussels.
13. \_\_\_\_\_ Zebra mussels traveled to North America in the ballast water of ships.
14. \_\_\_\_\_ Zebra mussels live well in water that is very salty and very cold.
15. \_\_\_\_\_ People are the main transporters of zebra mussels.
16. \_\_\_\_\_ Zebra mussels filter up to 1 liter of water a day.
17. \_\_\_\_\_ Zebra mussels help the food web of a lake.

### FILL IN THE BLANK

1. Mussels and clams which have two shells are \_\_\_\_\_ mollusks.
2. Taking a small part or quantity of something to determine population density is called \_\_\_\_\_.
3. Through \_\_\_\_\_, zebra mussels improve water clarity.
4. The variety of life in an ecosystem is called \_\_\_\_\_.



## ZEBRA MUSSEL POST-TEST CON'T

### SHORT ESSAYS

How do zebra mussels affect the food chain?

Name two negative effects of zebra mussels.

Draw a zebra mussel

Name two ways that zebra mussels spread.

What are barriers to the spread of zebra mussels?



# ZEBRA MUSSELS

## STOP ZEBRA MUSSELS OBSERVATION SHEET 2.1

Zebra Mussel Watchers' Names:

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Predict the number of zebra mussels in 100 ml \_\_\_\_\_

Count the zebra mussels in 100 ml \_\_\_\_\_

**Directions:** Record your observations of zebra mussels. Remember that you have a ruler and scale!

Sight (visual) \_\_\_\_\_

Smell (olfactory) \_\_\_\_\_

Touch (tactile) \_\_\_\_\_

Sound (auditory) \_\_\_\_\_

Size (quantitative) \_\_\_\_\_

Draw a zebra mussel



# ZEBRA MUSSELS

## STOP ZEBRA MUSSELS RECORD SHEET 2.2

Zebra Mussel Watchers' Names:

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**Directions:** Answer as many questions as you can while viewing the video.

1. Why are zebra mussels a concern? \_\_\_\_\_

---

2. Where did zebra mussels come from? \_\_\_\_\_

---

3. How did zebra mussels get to North America? \_\_\_\_\_

---

4. Describe the zebra mussel. \_\_\_\_\_

---

5. Who or what do zebra mussels affect? \_\_\_\_\_

---

6. List some of the rivers and lakes that have been affected by zebra mussels? \_\_\_\_\_

---

7. What can be done to decrease the spread of zebra mussels? \_\_\_\_\_

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## **MUSSEL TO MUSSEL STORY 4.1**

### **MR. BOEPPLE'S SHELLS**

Hundreds of years ago, the American Indians and the Pilgrims lived off the land. They ate freshwater mussels. Sometimes they would find a treasure inside one of the mussels--a pearl that they could use to make jewelry. The mussels were easy to find, but they almost never had a pearl inside. Because the pearls were so rare, they became very valuable. The biggest pearls were worth the most money. People began to find pearls inside the mussels in the Mississippi River Valley during the 1850's. The pearl hunters became very rich. People began to race to find as many pearls as possible. This caused the disappearance of most of the freshwater mussels in the Mississippi River Valley.

In 1888, John Boepple came from Germany to hunt for freshwater mussel. John was not looking for pearls. Instead, he wanted to make buttons out of the shells. It would have been too expensive to bring the shells to Germany, so he decided to make the buttons in America. One day he was bathing in the Illinois River when he cut his foot on a sharp object. He had cut his foot on one of the freshwater mussel shells that he had been searching.

During the next few years he struggled to learn English; and he collected as many shells as he could. Then in 1891, using the shells he had spent years collecting, Boepple set up his first button making business in Muscatine, Iowa. Two local businessmen helped him get started. They had the money to run the business, and Boepple had the skill to make the buttons. The men soon began to argue. The investors wanted to make as many buttons as quickly and cheaply as they could. John Boepple wanted to make a quality product, but he needed the businessmen's money. Eventually, the dispute caused Boepple to look for new partners. (The first two partners tried to run their own button making business. They failed without Boepple because they knew nothing about making buttons.)

Boepple did not take long to find new partners that were very wealthy. They let him run his company as he wanted it run. The business flourished. The only problem was that Boepple had to collect the mussel shells by hand. This was a very slow process. Help was soon on the way because people began to discover pearls in the shells. Just like 40 years earlier, word began to spread about how rich a person could become by finding pearls. Soon farmers, shopkeepers, and businessmen began wading into the shallow rivers and streams hoping to get rich. Boepple was now able to buy the shells he needed to make his buttons.

In 1897, someone invented a new tool called a brail. The tool allowed mussel hunters to harvest mussels in deeper water from boats instead of wading into shallow waters. People crowded the rivers to find the mussels. Soon violence broke out. Pearl hunters robbed each other and fought over hunting space. Even though hunters rarely found pearls, they knew they could make a profit by selling the mussel shells to the button makers. As more people hunted for shells, more shells became available to make buttons.

## MR. BOEPPLE'S SHELLS (continued)

The new button makers were not as concerned about quality as John Boepple. Everyone thought there would be an endless supply of shells. Button makers became more wasteful and used the shells more foolishly. Factories were springing up everywhere. New machines made buttons faster and cheaper. Boepple became very worried about the poor quality of the buttons being made. There were many arguments, and again, the person who knew more about making buttons than anyone else in the country was forced out of business. Boepple was left with nothing.

Seventeen years had passed since John Boepple first started making buttons. Again, shell collectors and button manufacturers became concerned about the natural supply of shells. History had repeated itself. In 1908, the mussels again became very difficult to find. The few that were found were too small to be useful for button-making. Finally, in 1911 the United States government asked John Boepple to help find ways to increase the mussel population.

Boepple traveled to Indiana in search of new ways to replenish the mussel supply. He waded in Indiana's rivers looking for mussels. Just as he had done so long ago on the Mississippi River, he cut his foot on a shell on the river bottom. This time the ending was not a happy one. After several months, John Boepple died from blood poisoning from he cut. This German-American immigrant had valued the freshwater mussel more than any person in the world. Ironically, he became victim of the very thing that had given him his life's work.

Written by Cherie Van Camp \* Adapted from: The Founding and Early History of the Pearl Button Industry by Michael G. O'Hara, Muscatine Community College, Muscatine, Iowa



## **ZEBRA MUSSELS**

### **MUSSEL TO MUSSEL: SHELL IDENTIFICATION SHEET TEACHER'S KEY 4.4**

Zebra Mussel Watchers' Names:

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Identification for Native Mussel Shell Collection:

1. Blue Mussel
2. Asiatic Clam
3. Washboard Clam
4. Maple Leaf Clam
5. Zebra Mussel
6. Pimpleback Clam
7. Silty Hornsnail
8. Pink Heelsplitter Clam
9. Yellow Sand Shell
10. Three-horned Wartyback
11. Ponderous Campeloma
12. Three-ridge Clam
13. Ebony Shell



# **ZEBRA MUSSELS**

## **MUSSEL TO MUSSEL: FRESHWATER AND ZEBRA MUSSEL LIFE CYCLES OBSERVATION SHEET 4.6**

Zebra Mussel Watchers' Names:

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**Compare zebra and freshwater mussels**

**Contrast**  
**Zebra mussels**

**Freshwater**

HOW BIG ARE YOUR MUSSELS?  
 ZEBRA MUSSEL LENGTH-FREQUENCY CHART  
 DATA SHEET 5.1

Zebra Mussel Watchers' Names:

\_\_\_\_\_

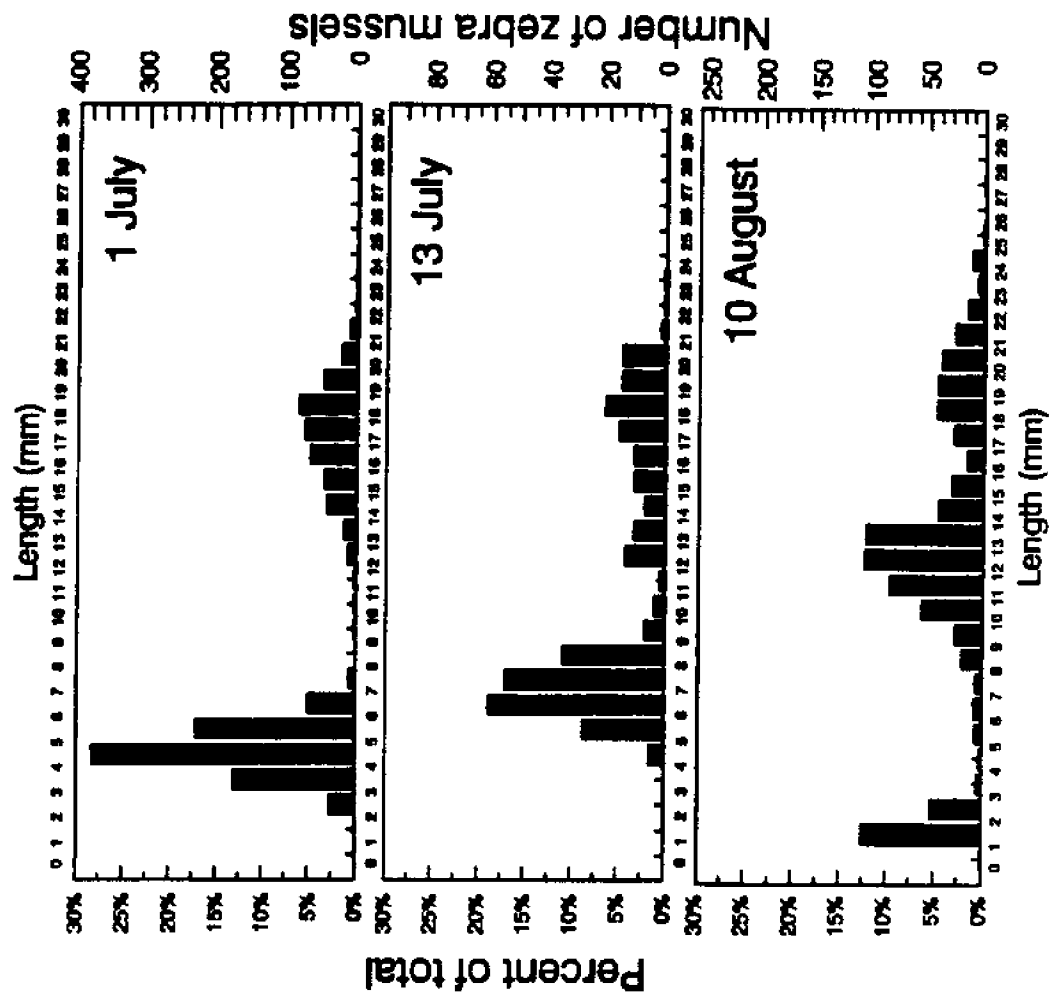
\_\_\_\_\_

Length	Number	Total	Percentage
1 mm			
2 mm			
3 mm			
4 mm			
5 mm			
6 mm			
7 mm			
8 mm			
9 mm			
10 mm			
11 mm			
12 mm			
13 mm			
14 mm			
15 mm			
16 mm			
17 mm			
18 mm			
19 mm			
20 mm			
21 mm			
22 mm			
23 mm			
24 mm			
25 mm			
26 mm			
27 mm			
28 mm			
29 mm			
30 mm			
maximum length _____	minimum length <sup>52</sup> _____		Total shells

HOW BIG ARE YOUR MUSSELS?  
 ZEBRA MUSSEL LENGTH FREQUENCY  
 BAR GRAPH 5.2

Researchers from the Illinois Natural History Survey made random collections of zebra mussels from the Illinois River near Peoria, IL on three dates in 1993. The samples were returned to the laboratory where the length of each shell was determined. These length data were sorted into 1-mm length intervals. Numbers of zebra mussels from each collection in each interval were tabulated, and the percentages of shells in each interval were calculated (see the table below). Percentages were then used to construct the three length frequency distribution graphs below.

Length Interval (mm)	1 July 1993		13 July 1993		10 August 1993	
	Number	Percent	Number	Percent	Number	Percent
0 - 1	0	0.0%	0	0.0%	1	0.1%
1 - 2	1	0.1%	0	0.0%	108	12.6%
2 - 3	37	2.8%	0	0.0%	47	5.4%
3 - 4	175	13.1%	0	0.0%	4	0.5%
4 - 5	377	28.9%	5	1.8%	3	0.3%
5 - 6	229	17.2%	28	8.7%	6	0.7%
6 - 7	68	5.1%	81	18.9%	7	0.8%
7 - 8	9	0.7%	88	17.1%	5	0.6%
8 - 9	0	0.0%	36	10.8%	16	2.1%
9 - 10	2	0.2%	7	2.2%	24	2.8%
10 - 11	3	0.2%	4	1.2%	56	6.5%
11 - 12	3	0.2%	2	0.6%	84	9.7%
12 - 13	12	0.9%	14	4.3%	108	12.4%
13 - 14	17	1.3%	11	3.4%	106	12.2%
14 - 15	42	3.2%	7	2.2%	41	4.7%
15 - 16	46	3.5%	11	3.4%	28	3.2%
16 - 17	67	5.0%	11	3.4%	15	1.7%
17 - 18	75	5.6%	16	5.0%	26	3.0%
18 - 19	82	6.2%	21	6.5%	42	4.8%
19 - 20	46	3.6%	15	4.7%	42	4.8%
20 - 21	22	1.7%	15	4.7%	37	4.3%
21 - 22	11	0.8%	2	0.6%	26	3.0%
22 - 23	2	0.2%	1	0.3%	15	1.7%
23 - 24	2	0.2%	1	0.3%	6	0.7%
24 - 25	1	0.1%	0	0.0%	10	1.2%
25 - 26	1	0.1%	0	0.0%	2	0.2%
26 - 27	0	0.0%	0	0.0%	0	0.0%
27 - 28	0	0.0%	0	0.0%	1	0.1%
28 - 29	0	0.0%	0	0.0%	0	0.0%
29 - 30	0	0.0%	0	0.0%	0	0.0%
Total	1332	100%	322	100%	668	100%





# FILTERING FOOLS DATA SHEET 6.1

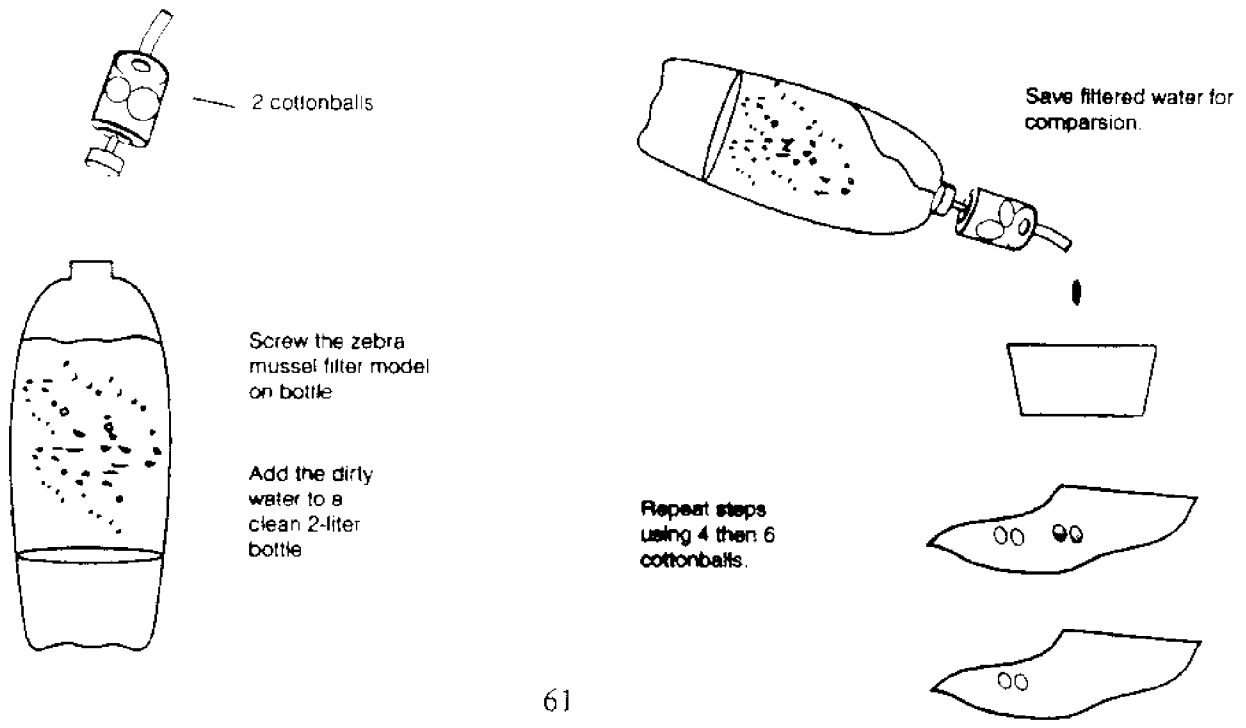
Zebra Mussel Watchers' Names:

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	Unfiltered water ● cottonball	100 ml filtered with 2 cottonballs	100 ml filtered with 4 cottonballs	100 ml filtered with 6 cottonballs
Describe the water.				
	0 zebra mussels	2 zebra mussels	4 zebra mussels	6 zebra mussels
Describe how zebra mussels affect water, based on cottonballs above.				





# ALL CLOGGED UP! DATA SHEET 7.1

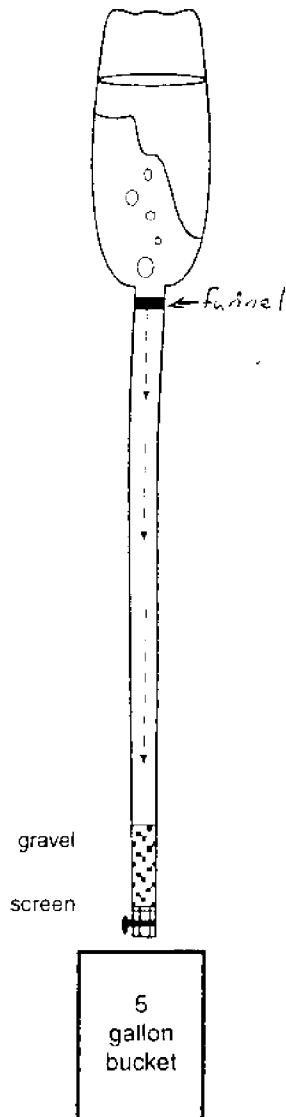
Zebra Mussel Watchers' Names:

\_\_\_\_\_

\_\_\_\_\_

## Rate of Flow Data Table

STEPS 1-5



Amount of gravel	Rate of flow in seconds			
	Trial 1	Trial 2	Trial 3	Average
no gravel				
5 cm				
15 cm				
20 cm				

Make a prediction after plotting the data on the graph paper.

Predicted rate of flow using 10 cm of gravel \_\_\_\_\_ seconds

Predicted rate of flow using 25 cm of gravel \_\_\_\_\_ seconds



# ZEBRA MUSSELS

## FILTERING FOOLS OBSERVATION SHEET 6.2

Zebra Mussel Watchers' Names:

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1. Compare the cottonball filters. Did the 2, 4, or 6 filters remove more material from the water?

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2. How does this filtering demonstration relate to the zebra mussel?

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3. Write a paragraph telling why filtering of zebra mussels has such a great impact on a body of water.

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4. List at least 5 ways that filters are used by people.

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## ZEBRA MUSSELS

### ALL CLOGGED UP! RECORD SHEET 7.2

Zebra Mussel Watchers' Names:

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Questions

1. How good was your group's prediction at the 10 cm of gravel level? Why?

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2. How good was your group's prediction at the 25 cm of gravel level? Why?

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3. Which prediction (10 or 25 cm of gravel) should have been more accurate? Why was one prediction more accurate than the other?

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4. How does this demonstration relate to zebra mussels?

---

---

5. Describe how the zebra mussel might affect pipes in water or power plant systems.

---

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# FAMILY REUNION! DATA SHEET 8.1

Zebra Mussel Watchers' Names:

\_\_\_\_\_

\_\_\_\_\_

1. Area of pan \_\_\_\_\_ cm<sup>2</sup>      Area of carton \_\_\_\_\_ cm<sup>2</sup> (length x width = \_\_\_\_\_)
2. Estimate cartons per pan \_\_\_\_\_
3. Actual cartons per pan \_\_\_\_\_ (determined by area of pan x area of carton)

Average number of pieces of gravel per carton \_\_\_\_\_

Number of cartons sampled \_\_\_\_\_

## Number of Pebbles Collected

River site	Student sampling group				Average
	A	B	C	D	
1					
2					
3					
4					

Total population density of: site 1 \_\_\_\_\_ site 2 \_\_\_\_\_ site 3 \_\_\_\_\_ site 4 \_\_\_\_\_  
(determined by taking the sample average x actual number of cartons that fit into pan)

Total population density of all sites \_\_\_\_\_  
(add population densities of all sites and divide by 4)



## **ZEBRA MUSSELS**

### **WORDS OF WISDOM**

#### **ACTIVITY 2: LOOKING AT THE ZEBRA MUSSEL MENACE**

**BALLAST WATER:** the water carried in a boat or ship to give stability

**BYSSAL TREADS:** a tuft of filaments, chemically similar to silk, secreted by various bivalves, especially mussels, used to attach the mollusk to the substratum

**BIVALVE:** any mollusks, including mussels and clams, having a shell consisting of two valves hinged together

**ECOSYSTEM:** the interacting system of a biological community and its non-living environmental surroundings

**EXOTIC SPECIES:** the organisms that are foreign, not native, to a particular location

**MOLLUSCICIDES:** a chemical substance that poisons mollusks

**SALINITY:** a condition in which salt is part of a solution; the amount of salt in water

**SUBSTRATE:** the ground or other solid material on which an animal moves or is fastened

**VELIGER:** a zebra mussel larvae





## **ZEBRA MUSSELS**

### **WORDS OF WISDOM ACTIVITY 4: MUSSEL TO MUSSEL**

**CLASSIFICATION:** systematic arrangement in groups or categories according to established criteria

**DIVERSITY:** variety

**LIFE CYCLE:** the series of changes in form undergone by an organism in development from its earliest stage to the recurrence of the same stage in the next generation

**MOTHER OF PEARL:** the hard, pearly internal layer of certain bivalve shells, such as abalone and the three ridge mussel

**ORGANIC DETRITUS:** dead animal or plant materials or debris

**PARASITIZE:** to obtain benefit from another organism at that organism's expense

**SEDENTARY:** remaining or fixed in one spot

**SEDIMENTS:** soil, sand, and minerals that settle at the bottom of a body of water

**NATIVE SPECIES:** species that naturally occur or live in a particular area or region

**EXOTIC SPECIES:** the organisms that are foreign, not native, to a particular location

**INTRODUCED SPECIES:** a population placed into a particular area or region that the species is not native to

**COMMON NAME:** the familiar name used by everyday people to refer to any species

**SCIENTIFIC NAME:** the Latin name used by scientists to describe species

**MOLLUSK (SHELL SPECIES):** members of the phylum of invertebrates that include bivalves, snails, and squids



## ZEBRA MUSSELS

### WORDS OF WISDOM

#### ACTIVITY 5: HOW BIG ARE YOUR MUSSELS?

**CENTIMETER (cm):** a metric unit of measure equal to 1/100 meter (about the width of your finger)

**DATA:** facts, figures, or information from which conclusions can be drawn

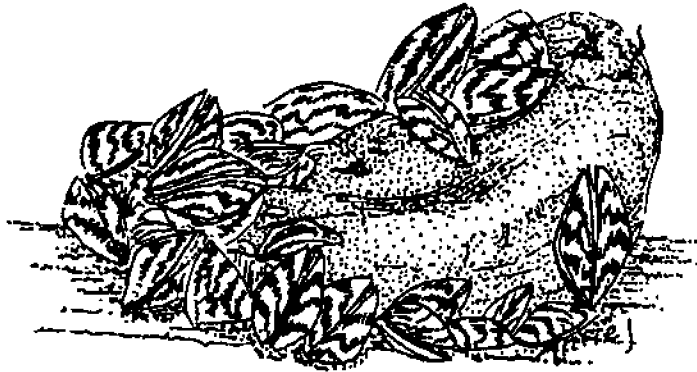
**MAXIMUM:** the greatest number, degree, or quantity

**MILLIMETER (mm):** a metric unit of measure equal to 1/1000 of a meter; 10 mm equals 1cm

**MINIMUM:** the smallest number, degree, or quantity

**PERCENTAGE:** a given part or amount in every hundred

**VENTRAL LINE:** a longitudinal line along the lower side of a zebra mussel





## ZEBRA MUSSELS

### WORDS OF WISDOM ACTIVITY 6: FILTERING FOOLS

**FILTRATION:** a treatment process for removing solid matter from water by passing the water through sand or man-made filter

**LITER (L):** a metric unit of liquid measurement; it is equal to 1.06 quarts

**NUTRIENT:** any substance assimilated by living things that promotes growth

**SIPHON:** an opening through which water enters and leaves an object, such as a mussel; some species can use this activity as a means of propulsion; also a means by which a liquid is transferred from one object to another, such as to siphon water into a bottle

**SUBMERGE:** to completely immerse in water







## ZEBRA MUSSELS

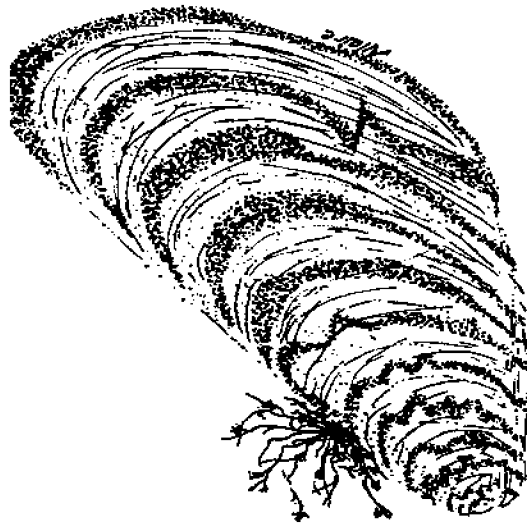
### WORDS OF WISDOM ACTIVITY 7: ALL CLOGGED UP

**CONGREGATE:** a gathering or assemblage of people or things

**FLOW RESTRICTION:** anything that restricts or slows water flow; for example, zebra mussels restrict flow in a water pipe, and weeds restrict flow in a canal

**INTAKE LINES:** the place fluid is taken into a pipe, e.g., intakes for water treatment plants and power industries

**SIPHON:** an opening through which water enters and leaves an object, such as a mussel; some species can use this activity as a means of propulsion; also a means by which a liquid is transferred from one object to another, such as to siphon water into a bottle





## **ZEBRA MUSSELS**

### **WORDS OF WISDOM ACTIVITY 8: FAMILY REUNION**

**AREA:** the measure of the surface of a solid; a part of any surface; a particular zone

**ESTIMATE:** to judge or determine generally, but carefully, the size, value, or cost of an item

**EXTRAPOLATE:** to arrive at a conclusion or result by hypothesizing from known facts or observations

**POPULATION:** a group of interbreeding organisms of the same kind occupying a particular space

**POPULATION DENSITY:** the quantity or number of a species per unit, as of an area

**PREDICT:** to determine in advance what will happen

**QUANTIFY:** to determine or express the amount of something; to measure

**SAMPLING:** the process of taking a small amount of an item or object for testing or analysis





## **ZEBRA MUSSELS**

### **WORDS OF WISDOM ACTIVITY 9: WEB OF LIFE GAME**

**BIOLOGICAL DIVERSITY:** variety of life

**DISSOLVED OXYGEN:** the oxygen freely available in water; vital to fish and aquatic life for respiration; dissolved oxygen has been accepted as the single most important indicator of the ability of a body of water to support aquatic life

**ECOSYSTEM:** the interacting system of a biological community and its non-living environmental surroundings

**FOOD CHAIN:** a sequence of organisms, each of which uses the next lower member of the sequence as a food source

**FOOD WEB:** all the individual food chains in a community

**HABITAT:** the place where a population lives and its surroundings, both living and non-living

**LARVAL FISH:** an immature, free-swimming stage of a fish

**NATIVE SPECIES:** species that naturally occur or live in a particular area or region

**ORGANIC MATTER:** carbon-based waste compounds produced by living plants or animals

**ZOOPLANKTON:** microscopic aquatic animals eaten by larger aquatic animals

**VELIGER:** a zebra mussel larvae





## REFERENCE MATERIAL



## Zebra Mussel **ALERT**

The barnacle-like zebra mussel poses a multibillion-dollar threat to North America's industrial, agricultural and municipal water supplies, and it could become a costly nuisance for freshwater shipping, boating, fishing and clamming as well. First found in 1988 in the Great Lakes, this invader could become more widespread than the German carp and cause far more economic damage than the Mediterranean fruit fly.

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**PUBLIC ASSISTANCE IN REPORTING ZEBRA MUSSEL SIGHTINGS AT NEW LOCATIONS IS ESSENTIAL TO HELP PREVENT ITS SPREAD TO OTHER LAKES AND RIVERS!**

---

### How to Identify It

- ▼ Zebra mussels look like small clams with a yellowish or brownish "D"-shaped shell, usually with dark- and light-colored stripes (hence the name "zebra").
- ▼ They can be up to two inches long, but most are under an inch. Zebra mussels usually grow in clusters containing numerous individuals (see photo) and are generally found in shallow (6-30 feet), algae-rich water.
- ▼ Zebra mussels are the **ONLY** freshwater mollusc that can firmly attach itself to solid objects — submerged rocks, dock pilings, boat hulls, water intake pipes, etc.

### What to Do

- ▼ Note the date and precise locations where the mussel or its shell(s) were found;
  - ▼ Take the mussel with you (several, if possible) and store in rubbing alcohol (in any case, **DON'T** throw it back in the water); and
  - ▼ **IMMEDIATELY** call the Alabama Sea Grant Extension office at (334)438-5690, (email: [zebra@acenet.auburn.edu](mailto:zebra@acenet.auburn.edu)), or the Mississippi Sea Grant Advisory office at (601)388-4710.
-





**ZEBRA MUSSELS  
CAN CAUSE THESE PROBLEMS  
FOR YOU AND YOUR BOAT**

- Increased water resistance which decreases speed and efficiency;
- Damage to painted surfaces that are not protected by antifoulant paints;
- Increased maintenance and repair;
- Engine failure from damage to moving parts or from overheating;
- Unexpected expense because most insurance will **not** pay for zebra mussel induced damage since it is listed as a preventable problem.

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**To Report Zebra Mussel Sitings or  
For More Information:  
Contact the Southern States Zebra Mussel  
Program in Your Area**

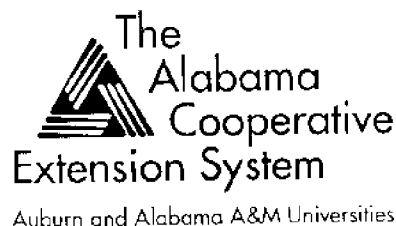
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**ALABAMA SEA GRANT EXTENSION**  
Auburn University  
Marine Extension and Research Center  
4170 Commanders Drive  
Mobile, Alabama 36615  
Phone: 334-438-5690

**LOUISIANA SEA GRANT COLLEGE PROGRAM**  
Louisiana State University  
107 Wetland Resources Building  
Baton Rouge, Louisiana 70803  
Phone: 504-388-6710

**MISSISSIPPI SEA GRANT ADVISORY SERVICE**  
Coastal Research and Extension Center  
2710 Beach Boulevard, Suite 1-E  
Biloxi, Mississippi 39531  
Phone: 601-388-4710

or, the **TENNESSEE VALLEY AUTHORITY**  
**ZEBRA MUSSEL HOTLINE**  
**1-800-538-2526**



MASGP-95-014

AUMERC-ZM-96-1

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J.J. BACHANT, Zebra Mussel Outreach  
RICHARD K. WALLACE, Extension Marine Specialist  
BILL HOSKING, Extension Marine Economist and  
Marine Programs Coordinator

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Illustrations provided by Michigan Sea Grant Program

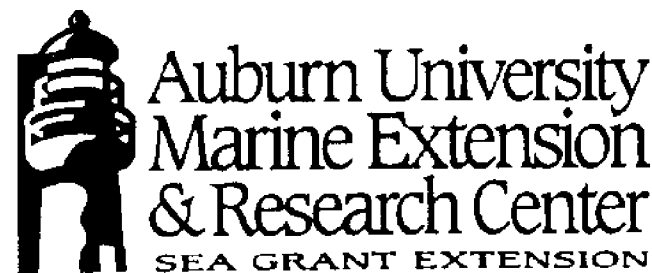
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Partly sponsored by the Southern States Zebra Mussel Program, a cooperative effort including: the Mississippi-Alabama Sea Grant Consortium, the Louisiana Sea Grant College Program, and NOAA, Office of Sea Grant, Department of Commerce, under Grant No. NA56RG0129.

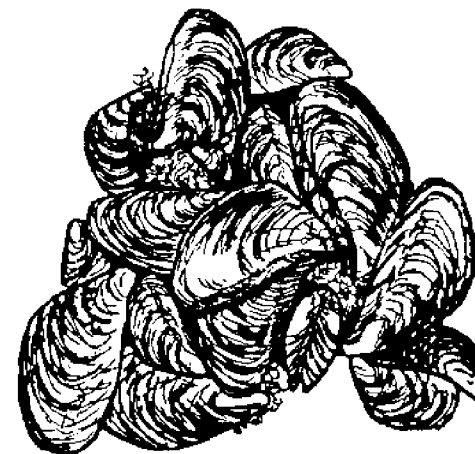
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**BOATERS:**

**BEWARE OF  
ZEBRA MUSSELS**



**MASGP-95-014**

# ZEBRA MUSSELS

Zebra mussels are native to the streams and rivers of the colder portions of Europe. They were first found in the U.S. in the Great Lakes region during the mid-1980s. They have readily adapted to our warmer, southern waters and can even tolerate brackish waters. Zebra mussels have no known natural predators, multiply rapidly, feed on phytoplankton (microscopic aquatic plants), and settle on any hard surface - even on top of each other - forming dense colonies. They filter feed very effectively and hoard the food they cannot immediately consume by binding it with a mucus that makes it unavailable to other animals.



## WHAT DOES THIS MEAN TO YOU AS A BOATER?

Zebra mussels can settle on any hard surface and rapidly reduce the inside diameter of an intake pipe or fill in the spaces in an outboard motor, blocking the flow of air or water. This can ultimately cause the motor to overheat. When attached to a boat hull, they cause the boat's engine to work harder thus lowering fuel efficiency. Their feeding is so efficient they can disrupt freshwater food chains and may cause major changes in some fish populations.

## HOW ARE YOU INVOLVED?

Boaters are one of the major contributors to the spread of zebra mussels from infested waters to uninfested waters. Zebra mussels attach themselves to any solid surface not protected by antifoulant paints. This includes any surface that may get wet, such as boat hulls, motors, swim platforms, trim tab plates, and electronic transducers. A boat moving from one lake or river to another, even over land, can accidentally carry zebra mussel larvae (veligers), which are microscopic in size. They can survive and be transported in standing water found in the live well, bilge, boat decking, trailer frame, or marine toilet. Veligers can also be found in the water of motor cooling systems and can even be transported in bait buckets.

## WHAT CAN YOU DO?

If you use the water as a boater, angler, water-skier, scuba-diver, or canoeist, there are some important things you can do to help prevent the transport of zebra mussels to your favorite waterbody.

**Know your enemy.** Adult zebra mussels are small mollusks (clam-like animals) about the size of your fingernail, but can grow up to 2 inches long. They have a zebra-striped pattern on the shell. Veligers cannot be seen with the naked eye. Veligers attached to a boat hull will feel rough like grit or sand.



## Follow this CHECKLIST everytime:

- **Inspect** your boat, trailer, and all boating equipment that gets wet and remove any plants and animals that are visible **before** leaving any waterbody.
- **Drain** water from the motor, live well, bilge, and transom wells **while** on land **before** leaving any waterbody.
- **Empty** your bait bucket on land **before** leaving the waterbody. Never release live bait into a waterbody, or release aquatic animals from one waterbody into another.
- **Wash/Dry** your boat, trailer, tackle, and other boating equipment to kill veligers that were not visible at the boat launch. This can be done on your way home or once you have returned home. Adult zebra mussels can survive 10 to 14 days out of water, so it is important to either:
  - **Rinse** your boat and equipment that normally gets wet with hot tap water: or use a concentration of 1/2 cup salt to 1 gallon of hot water. Salt will kill the mussels. However, you must thoroughly rinse with fresh water to prevent corrosion from the salt; **or**,
  - **Spray** your boat and trailer with high-pressure water; **or**,
  - **Dry** your boat and equipment for at least 5 days before launching somewhere else.
- **Report** any sightings to the appropriate agency in your state.



## HOW YOU CAN HELP

- Become more aware and knowledgeable about how to slow the spread of zebra mussels in Alabama by participating in Sea Grant Extension and ACES educational programs.
- If you are a recreational boater or fisherman, request additional zebra mussel related boating information from the Auburn Marine Center or your County Agent.
- If you work in an industry that has a freshwater intake, please give this brochure to someone in the engineering department and ask them to contact the Auburn Marine Center.
- If you are involved in aquaculture, request additional zebra mussel related information from the Auburn Fisheries Department or your County Agent.
- It will take all of us working together to slow the spread of zebra mussels in Alabama. Thanks in advance for your help!

## SOURCES OF ADDITIONAL ZEBRA MUSSEL INFORMATION

AUBURN UNIVERSITY  
Marine Extension and Research Center  
4170 Commanders Drive  
Mobile, Alabama 36615  
Phone: 334/438-5690  
E-Mail: zebra@acenet.auburn.edu

AUBURN UNIVERSITY  
Department of Fisheries and Allied Aquacultures  
203 B Swingle Hall  
Auburn University, Alabama 36849  
Phone: 334/844-9211

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SEA GRANT EXTENSION

# The Zebra Mussel Invasion IN ALABAMA



MASGP-95-008

# ZEBRA MUSSELS:

## *Invading Alabama's Waters*

Zebra mussels are an extremely adaptable exotic species that have become well-established in the Great Lakes and are now settling in southern fresh waters. They have no known natural predators, multiply rapidly, feed on phytoplankton (microscopic aquatic plants) and settle on **any** hard surface, even on top of each other.

As a result, they may rapidly reduce the inside diameter of an intake pipe or fill in the spaces in an outboard boat motor, blocking the flow of air or water. In Monroe, Michigan a power plant was actually shut down by zebra mussels. They can disrupt any industrial facility with a raw water intake from a fresh waterbody, including irrigation and aquaculture intakes.

They feed voraciously and hoard the food they cannot immediately consume by binding it with a mucus that makes it unavailable to other animals. Their feeding is so efficient that they could disrupt freshwater food chains and cause major decreases in our fish populations.

Zebra mussels have been confirmed in the Mississippi, Atchafalaya, Tennessee, Red, White, and Arkansas Rivers in the southern region. Two major waterways, the Mississippi and the Tenn-Tom, are both heavily used by barge traffic and contain colonies of these animals.

If zebra mussels aren't in your county yet, they will be soon unless Alabamians act now to slow the spread of this alien invader. These animals are often transported by barge traffic or recreational boaters as they move from zebra mussel-infested rivers and lakes to our uninfested waters.

It was originally thought that these animals were not a real threat to the southern United States because they were a cold-water species. However, recent research at Louisiana State University and the University of Texas suggests that zebra mussels are adapting to both higher temperatures and low salinity water as they migrate southward.

Research is also being conducted by the Corps of Engineers and Tennessee Valley Authority on zebra mussels. The U.S. Fish and Wildlife Service monitors zebra mussels in southern waters and the National Biological Service compiles a map of zebra mussel sightings bimonthly.

The Auburn University Department of Fisheries and Allied Aquacultures has several zebra mussel research projects underway in Alabama. Public awareness and education programs on the zebra mussel invasion are being conducted by Alabama Sea Grant Extension and the Alabama Cooperative Extension Service for both youth and general audiences.

### **COMMONLY ASKED QUESTIONS ABOUT ZEBRA MUSSELS**

#### ■ WHAT DO THEY LOOK LIKE?

Zebra mussels are tiny mollusks (clam-like animals) about the size of an adult fingernail with a zebra-striped pattern on the shell.



#### ■ WHERE DID THEY COME FROM?

These animals were first discovered in the Caspian Sea - Ural Mountain area of the former Soviet Union about 200 years ago. They entered the U.S. about 1986 in the ballast of an ocean-going vessel trading in the Great Lakes and began to colonize Lake St. Clair adjacent to the Great Lakes in 1988. Large numbers of zebra mussels now exist in most of the Great Lakes with only Lake Superior avoiding heavy colonization.

#### ■ HOW SERIOUS IS THIS THREAT?

Industries in numerous states including Louisiana, Mississippi and Alabama have begun to request information about zebra mussels. Many have begun monitoring for the mussels; some are now treating with molluscicides. Others are using anoxia or lack of oxygen and thermal measures to control the mussels. There is no *perfect* control method.

California and Florida have enacted regulations making it illegal to knowingly bring zebra mussels into the state. These animals can live for several days after they are taken out of the water. Live mussels have been found on some incoming trailered vessels during inspections made at the California state line.

Some recreational lakes in the Great Lakes region have been closed to visitors and tourists and only landholders can use them. Some reservoirs, previously open to public recreation are now restricted. The reason is to exclude the possibilities of zebra mussel infestation from transient vessels.

Arkansas aquaculture businesses were refused entry into other states to deliver fingerlings after zebra mussels were confirmed in the Arkansas and White Rivers. The state had to devise a method of certifying that the aquaculture sources for the fingerlings were free of zebra mussels before business could continue.





# Zebra mussels in North America: *The invasion and its implications*

## OHSU-FS-045

by Fred L. Snyder, Maran  
Brainard Hilgendorf and  
David W. Garton. 1990.  
Revised 1991, 1992 & 1994.

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Other Sea Grant programs and other agencies also have information available on this issue.

Zebra mussels (*Dreissena polymorpha*) were first discovered in Lake St. Clair in 1988. Within one year, they had colonized the surfaces of nearly every firm object in western Lake Erie. As of December 1993, zebra mussels have been found in all of the Great Lakes and in waterways in 18 states and two provinces. Major river systems that now have zebra mussels include the St. Lawrence Seaway and the Hudson, Illinois, Mississippi, Ohio, Arkansas, and Tennessee Rivers.

Zebra mussels also have been reported in several inland lakes, including Lake Wawasee in Indiana; Hargus Lake and White Star Quarry in Ohio; Kentucky Lake and Dale Hollow Reservoir in Kentucky; at least 10 lakes in Michigan; and Balsam, Rice, and Big Bald Lakes in Ontario.

In 1991, a second species of *Dreissena* was discovered in North America but was only recently identified. Quagga mussels (*Dreissena bugensis*) have been found in the St. Lawrence Seaway, Lake Ontario, Lake Erie, and Saginaw Bay in Lake Huron.

It is not clear when, how far and into which waterways the zebra and quagga mussels will spread. The zebra mussel has spread faster and farther than expected. Its southward spread will likely be limited because of average summer water temperatures above 81 F (27 C). The northward spread might be limited by soils deficient in calcium or by summer water temperatures below 54 F (12 C).<sup>1</sup>

Questions about zebra and quagga mussels abound, but finding answers is a difficult task. The following information answers some of the more commonly asked questions about zebra and quagga mussels.



Lloyd Lemmerman

## The invasion

*Dreissena polymorpha* and *Dreissena bugensis* are native to an area in Russia near the Caspian Sea. Canals built during the late 1700s allowed the mussels to spread throughout eastern Europe. During the early 1800s, canals were built across the rest of Europe, which made bulk shipping much easier but also allowed rapid expansion

of the zebra mussel's range. By the 1830s, the mussels had covered much of the continent and had invaded Britain.

The introduction of zebra mussels into the Great Lakes appears to have occurred in 1985 or 1986, when one or more transoceanic ships discharged ballast water into Lake St. Clair. The freshwater ballast, picked up in a European port, may have contained zebra mussel larvae and possibly juveniles; or, adult mussels may have been carried in a sheltered, moist environment, such as a sediment-encrusted anchor or chain. The faster speed of today's ships provides exotic species a better chance of surviving the trip across the Atlantic. Being a temperate, freshwater species, the zebra mussels found the plankton-rich Lakes St. Clair and Erie to their liking.

## Zebra and quagga mussels

The rapid spread and abundance of both mussels can be partly attributed to their reproductive cycles. A fully mature female mussel may produce up to one million eggs per season. Egg release starts when the water temperature warms to about 54 F (12 C) and continues until the water cools below 54 F. In Lake Erie, spawning may begin as early as May and end as late as October, but it peaks during July and August at water temperatures above 68 F (20 C).

Eggs are fertilized outside the mussel's body and within a few days develop into free-swimming larvae called veligers. Veligers swim by using their hair-like cilia for 3 to 4 weeks, drifting with the currents. If they don't settle onto firm objects in that time, they die; and the vast majority actually suffer this fate. It is estimated that only 1 to 3 percent survive to adulthood. Those that find a hard surface quickly attach and transform into the typical, double-shelled mussel shape; they are then considered to be juveniles.

Mussels become adults when they reach sexual maturity, usually within a year. They grow rapidly, nearly an inch in their first year, adding another 1/2 to 1 inch their second year.

European studies report mussels may live 4 to 6 years. Three years seems to be the maximum life span in Lake Erie, but there is insufficient data to know what to expect in other North American bodies of water.

Zebra mussels generate a tuft of fibers known as a byssus, or byssal threads, from a gland in the foot. The

*Dreissena* arrived in North America and rapidly colonized industrialized, plankton-filled Great Lakes, which support multi-million-dollar sport and commercial fisheries.

byssus protrudes through the two halves of the shell. These threads attach to hard surfaces with an adhesive secretion that anchors the mussels in place. Small juveniles can actually break away from their attachments and generate new, buoyant threads that allow them to drift again in the currents and find a new surface. Zebra mussels can colonize any firm surface that is not toxic: rock, metal, wood, vinyl, glass, rubber, fiberglass, paper, plants, other mussels—the surface need only be firm. Beds of mussels in some areas of Lake Erie now contain more than 30,000—and sometimes up to 70,000—mussels per square meter.

Zebra mussel colonies show little regard for light intensity; hydrostatic pressure (depth); or even temperature, when it is within a normal environmental range. The life stage most sensitive to low temperature

Because of its shallow, warm, nutrient-enriched environment, Lake Erie will always support significant populations of zebra and quagga mussels.

is the veliger stage, and juveniles are more sensitive than adults. All life stages are sensitive to low levels of dissolved oxygen, particularly as temperature increases. Colonies grow rapidly wherever oxygen and particulate food are available and water currents are not too swift (generally less than 6 feet per

second). Thus, colonies are rare in wave-washed zones, except for sheltered nooks and crevices. In most European lakes, the greatest densities of adult mussels occur at depths ranging from 6 to 45 feet.

Zebra mussels can also colonize soft, muddy bottoms when hard objects deposited in or on the mud—such as pieces of native mussel shells—serve as a substrate (base) for settling veligers. As a few mussels begin to grow, they in turn serve as substrate for additional colonization, forming what is known as a *druse*. Quagga mussels can live directly on a muddy or sandy bottom and appear more tolerant of low temperatures and extreme depths than zebra mussels.

### Biological and ecological concerns

Zebra mussels disrupt the aquatic food chain. Literature reviews suggest that they eat mostly algae in the 15-40 micrometer size range. Each adult mussel, however, is capable of filtering 1 or more liters of water each day. They remove nearly all particulate matter, including phytoplankton and some small forms of zooplankton, including their own veligers. Instead of passing any undesired particulate matter back into the water, mussels bind it with mucous into loose pellets called pseudofeces that are ejected and accumulate among the shells in the colony.

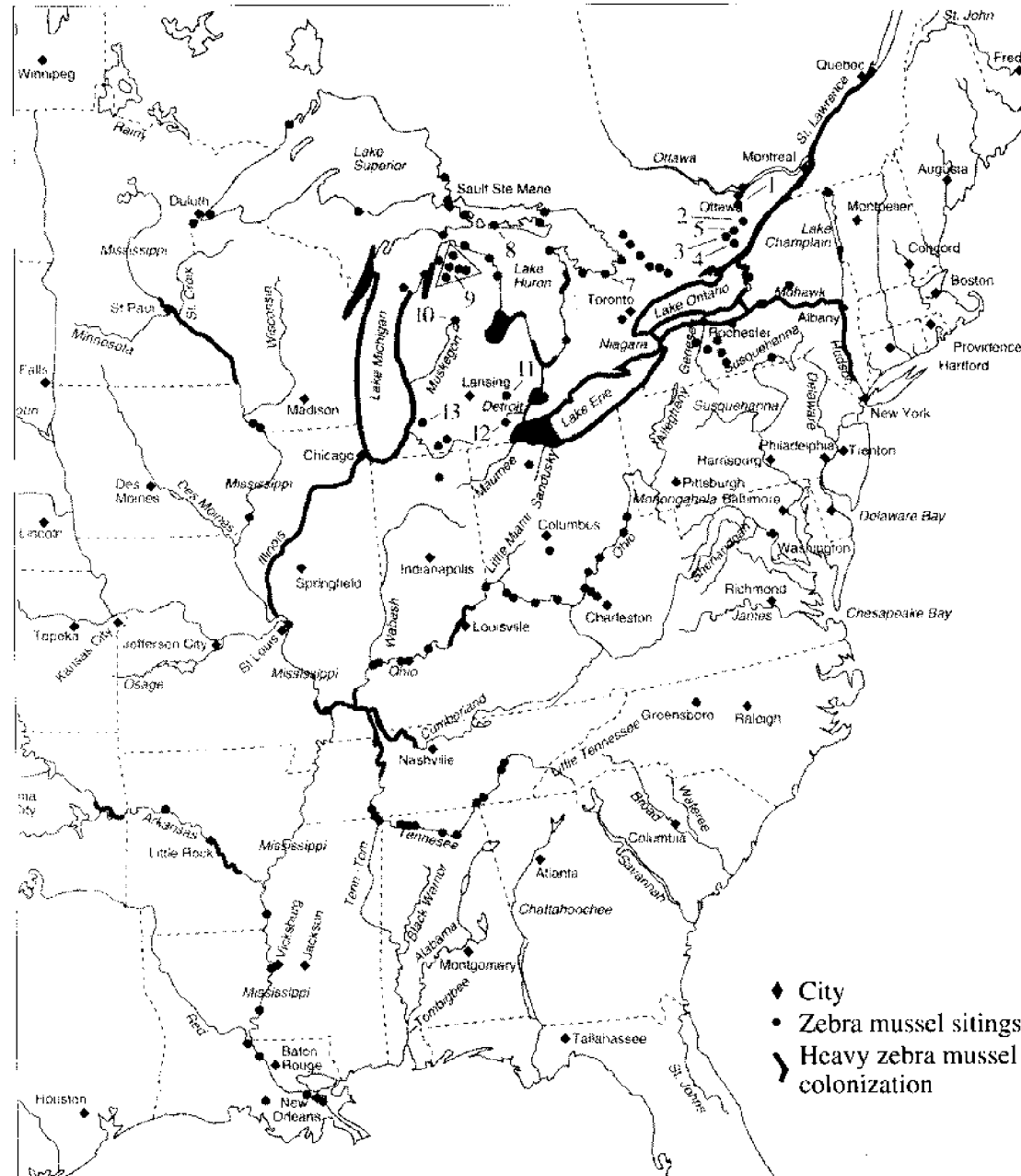
By removing significant amounts of phytoplankton from the water,

zebra mussels remove the food source for microscopic zooplankton, which in turn are food for larval and juvenile fishes and other plankton-feeding forage fish. These forage fish support sport and commercial fisheries. This competition for phytoplankton, the base of the food chain, could have a long-term negative impact on Great Lakes fisheries. Observations of the effects of zebra mussel filtration up the food base for fish communities are still inconclusive.

Most rocky areas in Lake Erie are almost completely covered with mussels several inches deep. In laboratory observation, the accumulation of pseudofeces in these beds creates a foul environment. As waste particles decompose, oxygen is used up, and the pH becomes very acidic. Biologists were initially concerned that such poor environmental conditions could potentially hinder normal egg development of reef-spawning fish (walleye, white bass, and smallmouth bass). However, large hatches of walleye documented in Lake Erie in 1990, 1991, and 1993 suggest that flushing water currents are sufficient to prevent environmental deterioration.

Zebra mussels readily encrust native North American mussels (family

North American range of the zebra mussel as of 15 December 1993.



Exotic species are nothing new in the Great Lakes. Scientists believe the sea lamprey led the way back in the 1830s. Since then, scientists have identified 136 plant, fish, and mollusk species that have been introduced.



*Uniodidae*). In Lakes St. Clair and Erie, heavy fouling by zebra mussels has severely reduced populations of native mussels. Some native mussel species are more tolerant to fouling than others, but even for these resistant species, zebra mussel encrustation leads to reduced energy reserves and vulnerability to other environmental stressors, such as extreme water temperatures, lack of food, or parasites and disease. As zebra mussels spread, biologists are concerned that populations of native mussels will decline, and perhaps some of the rarer species may be completely eliminated.

Zebra mussels apparently have contributed to the improvement of Lake Erie's water clarity, which began with the initiation of the phosphorus abatement programs of the 1970s. Shallow embayments are being recolonized by rooted, aquatic plants, since turbidity no longer shades them out. According to Dr. Ruth Holland Beeton, who conducted research near Stone Laboratory on Lake Erie in the 1970s, before phosphorus abatement programs, water clarity was approximately 3 feet, improved to 6 to 10 feet in the 1980s after a decade of reduced phosphorus inputs, and improved again to 10 to 17 feet in the early 1990s, after zebra mussels colonized the area.

The prodigious filtering of water by zebra mussels may increase

Clear waters do not necessarily mean safe, clean waters. Zebra mussel's activities may make toxic substances available to new organisms in the food chain. Because zebra mussel feces and pseudofeces stay at the bottom of the lake, zebra mussels transfer plankton to the benthos, where they create a potentially tainted food supply for benthic organisms, such as gammarid amphipods.

human and wildlife exposure to organic pollutants (PCBs and PAHs). Early studies have shown that zebra mussels can rapidly accumulate organic pollutants within their tissues to levels more than 300,000 times greater than concentrations in the environment. They also deposit these pollutants in their pseudofeces. These persistent contaminants can be

### Industrial, commercial, and recreational concerns

The zebra mussel's proclivity for hard surfaces located at moderate depths has made water intake structures, such as those used for power and municipal water treatment plants, susceptible to colonization. Since 1989, some plants located in areas of extensive zebra mussel colonization have reported significant reductions in pumping capabilities and occasional shutdowns.

Investigations of zebra mussel control on intake structures have included prechlorination, preheating, electrical shock, and sonic vibrations. Current control methods include prechlorination, ozone, potassium permanganate injection, and sand bed filtration. Prechlorination has been the most common treatment used to date, because it is already approved for use by the Environmental Protection Agency; it also raises concerns about the toxicity of chlorinated compounds to other aquatic organisms.

Zebra mussels are very sensitive to high temperatures. Some thermal electric plants currently are experimenting with the diversion of waste heat into intake structures to kill zebra mussels or prevent settlement.

Recreation-based industries along Lake Erie have been impacted by zebra mussels. Unprotected docks, breakwalls, boat bottoms, and engine outdrives were rapidly colonized beginning in 1989. Consequently, there were numerous reports of boat engines overheating due to colonies of zebra mussels clogging cooling water inlets and mussels colonizing boat hulls.<sup>2</sup>

Beaches are also affected by zebra mussels. The sharp-edged mussel shells along swimming beaches can be a hazard to unprotected feet. By autumn of 1989, extensive deposits of zebra mussel shells were on many Lake Erie beaches. The extent of these deposits varied with successive periods of high wave activity.

### Zebra mussel control

Lake-wide control of zebra mussels is not feasible. The European community, after two centuries of infestation, and the Great Lakes community, after years of infestation, haven't been able to develop a chemical toxicant for lake-wide control that isn't deadly to other aquatic life forms.

In some parts of Europe, large populations of diving ducks have actually changed their migration patterns in order to forage on beds of zebra mussels. The most extreme case occurred on Germany's Rhine River. Overwintering diving ducks and coots consumed up to 97 percent of the standing crop of mussels each year. High mussel reproduction rates, however, replenished the population each summer.

In North America, the species most likely to prey on relatively deep beds of zebra mussels are scaup, canvasbacks, and old squaws. But populations of these species are quite low; in fact, canvasbacks are so rare that they are protected. In the Great Lakes, diving ducks are migrating visitors, pausing only to feed during north- and southward migrations. However, Canadian researchers have documented increasing numbers of migrating ducks around Pt. Pelee in western Lake Erie, and these ducks were observed to be feeding heartily on zebra mussels. In southern Lake Michigan, zebra mussels encrusting an underwater power plant intake attracted flocks of lesser scaup. Unfortunately, some were pulled into the intake pipe and drowned. The stomachs of these dead scaup were full of zebra mussels. Mallard ducks also are frequently observed foraging on zebra mussels on shoreline rocks and shallow structures. In addition, freshwater drum, or sheepshead, are known to feed substantially on zebra mussels; and yellow perch have been observed feeding on juveniles, particularly when they are detached and drifting.

One novel approach to controlling zebra mussel populations is by disrupting the reproductive process. Zebra mussel eggs are fertilized externally; therefore, males and females must release their gametes (sperm and eggs) simultaneously. After release, zebra mussel sperm remain viable for only a short time—perhaps only a few minutes. Disrupting the synchronization of spawning by males and females may effectively reduce the numbers of fertilized eggs. Researchers are currently studying the environmental cues and physiological pathways that coordinate zebra mussel spawning activity.

### Spread to inland waters

Zebra mussels can spread to other inland waters either as veligers transported in water or as adults attached to boat hulls, engines, aquatic weeds, or other surfaces. Veligers are small—about the size of the period at the end of this sentence—and may be able to survive in any residual water source.

Adult mussels are very hardy and can survive out of water for extended periods depending upon temperature, humidity, wind, and sunlight. Maximum out-of-water survival time in ideal conditions is about 10 days for adults and 3 days for newly-settled juveniles.

Based on a survey of boat users in Michigan, Dr. Ladd Johnson recommends the following to prevent further spread of zebra mussels:

- Remove any visible vegetation from items that were in the water, including the boat, trailer, and all equipment.
- Flush engine cooling system, live wells, and bilge with tap water. If possible, use hot water.
- Do not re-use bait if exposed to infested waters.
- Dry boat and other equipment for at least 48 hours before using in uninfested waters.
- Examine boat exterior for mussels if it has been docked in infested waters; if mussels are found or exterior is heavily fouled by algae, either clean fouled surfaces or leave boat out of the water for at least 5 days before entering uninfested waters.

Be advised that these recommendations are still being studied by researchers and resource managers.

Tests show that mussels will die if they are exposed to water hotter than 110 F (40 C) for more than 15 minutes or to freezing temperatures (0 F or -18 C) for more than 24 hours.

In earlier versions of this publication, chlorine disinfection was suggested but is no longer recommended since chlorine is toxic to other organisms and may also damage boat equipment. Salt water mixtures are also not recommended.

Veligers may be transported easily in water used in live bait containers. Minnows or crayfish used in lakes containing zebra mussels should be transferred to well water or aged chlorinated tap water before carrying them to other bodies of water.

Waterfowl and other wildlife may transport zebra mussels, carrying veligers and/or adults in wet fur or feathers.

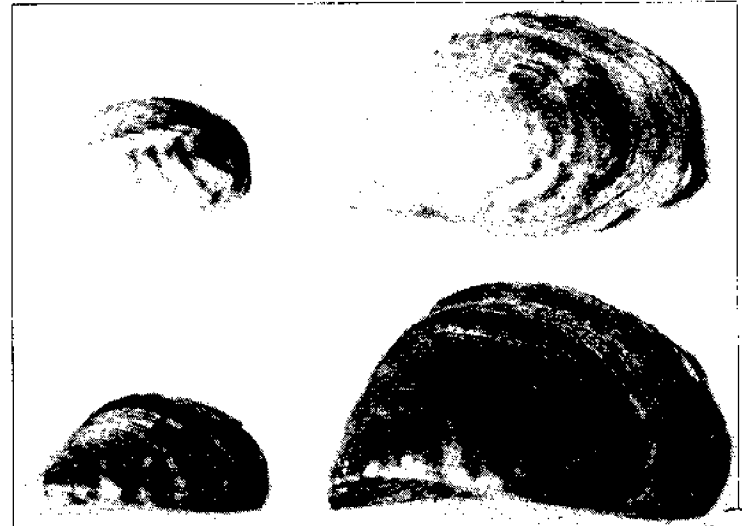
The zebra mussel is now a permanent part of the Great Lakes, many major river systems, and inland lakes; and it continues to spread rapidly

throughout major river basins. Increased support for research is needed to gain understanding of its natural predators, spawning activity, and pollutant uptake, as well as its effects upon ecosystems, industries, and local economies.

Theoretically, zebra mussel populations should peak a few years after initial infestation and then decline, depending upon predation and upon each water body's carrying capacity. There is little doubt that the zebra mussel's impact will be felt by everyone who uses our nation's inland waters.

<sup>1</sup> For more information on this issue, request a copy of Ohio Sea Grant's fact sheet titled *Zebra mussel migration to inland lakes and reservoirs: A guide for lake managers* (OHSU-FS-058).

<sup>2</sup> For more information on this issue, request a copy of Ohio Sea Grant's fact sheet titled *Slow the spread of zebra mussels and protect your boat and other equipment, too* (OHSU-FS-054).



The quagga mussel (*Dreissena* sp.) above, and zebra mussel (*Dreissena polymorpha*) below

## Zebra mussels and Quagga mussels

Zebra mussels (*Dreissena polymorpha*) were accidentally introduced into the Great Lakes in the mid-1980s. Quagga mussels (*Dreissena bugensis*), an East European relative of the zebra, was found in the colder depths of Lake Ontario in 1991, across the bottom of Lake Erie in 1992, and in Saginaw Bay in Lake Huron. This table contrasts the characteristics of the two species.

	ZEBRA MUSSELS	QUAGGA MUSSELS
<b>Shell</b>	Triangular shape Obvious ridge between side and bottom Sides merge with bottom Byssal (ventral) side flat	Rounder sides Ridge lacking  Byssal side rounded
<b>Color</b>	Variable colors and patterns Usually dark	Pale near hinge Dark concentric rings on the shell
<b>Byssal</b>	Large groove in middle of flat side; allows tight hold on rocks	Small byssal groove near the hinge
<b>Depth in Lake</b>	3 to 98 feet (1-30 m) Maximum 33 feet (10 m); rare below 50 feet (15 m.)	3 to 351 feet (1-107 m)  Commonly found down to 98 feet (30 m.)
<b>Temperature</b>	32 to 86 F (0 to 30 C)	32 to 86 F (0 to 30 C)
<b>Tolerance</b>	54 to 68 F (12 to 20 C) preferred	39 to 68 F (4 to 20 C) preferred
<b>Reproductive Temperature</b>	Young present at 57 to 68 F (14 to 20 C)	Young present as low as 46 F (8 C)
<b>Growth</b>	Up to 1 inch (25 mm)/year	Up to 0.8 inch (20 mm)/year

Provided by Ontario Ministry of Natural Resources, with an update by Dr. Robert Heath of Kent State University.



# FS-054 | Slow the spread of zebra mussels and protect your boat and motor, too

## OHSU-FS-054

by David O. Kelch, Ohio Sea Grant Extension specialist, and Maran Brainard Hilgendorf, Ohio Sea Grant Communications director. 1992. Revised 1994.

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Zebra mussels (*Dreissena polymorpha*) have spread throughout the Great Lakes and in waterways in 18 states and two provinces since they were accidentally introduced into Lakes Erie and St. Clair in the 1980s. In 1991, a second species, quagga mussels (*Dreissena bugensis*), was discovered. Quagga mussels are similar to zebra mussels, but they survive in deeper, colder waters. They have been found in the St. Lawrence Seaway, Lake Ontario, Lake Erie and Saginaw Bay in Lake Huron.

The zebra mussels' range will continue to expand naturally as flowing water carries their young—veligers—downstream. Commercial and recreational vessels and equipment also can spread zebra mussels when they move from infested waters to uninfested waters. Adult mussels may attach to hard surfaces, and veligers

may be transported in water. Veligers are small—about the size of the period at the end of this sentence—and may be able to survive in any residual water. Zebra mussels spawn when the water temperature is between 57 and 68 F (14 to 20 C). Young quagga mussels have been observed in water as cool as 46 F (8 C).<sup>1</sup>

Some inland lakes have already been colonized by zebra mussels because of man's activities. For example, White Star Quarry, a 15-acre, 90-foot-deep Ohio lake, is not connected to any other waterway and is not used by boaters. It is, however, used by divers and anglers; and now it, too, is colonized by zebra mussels.<sup>2</sup>

Nearly anything that has been in zebra and quagga mussel infested waters may have the mussels on them. This list of potential carriers includes:

- plants and animals
- fishing gear and bait buckets
- any water
- scientific equipment
- snorkeling and scuba gear
- boats, trailers and related equipment.

Placing these items in uninfested waters without following precautions may lead to an *accidental* introduction of these pesky mussels. The guidance provided in this publication is not guaranteed to remove or kill all the mussels; but it should vastly reduce the number being transported away from infested sites, and thus greatly reduce the probability of accidental further spread.

There are currently several states with laws that prohibit *intentional* introduction of non-native species such as the zebra mussel. Other states prohibit the possession of some plants and animals, and still other states have laws pending. Researchers must follow protocols approved by an interagency committee to impede the spread of mussels to uninfested waters.

## How to slow the spread

The first step in prevention of spread is to develop an attitude of concern. Second, accept the fact that your activities are a potential means of transportation, and third, adhere to the recommendations in this publication and to those of your state natural resources agency.

An interagency Great Lakes task force recommends the actions (listed below) be taken after using a boat or other equipment in zebra mussel-infested waters. Be advised that these recommendations are still being studied by researchers and resource managers; therefore, the recommendations may change.

### Actions

➤ **Remove any visible vegetation** from items that were in the water, including boat, propeller, trailer and all equipment. (Zebra mussels readily attach to aquatic vegetation.)

➤ **Flush engine cooling system, live wells and bilge with hot water.** If hot water is not available, use tap water.

*Rinse* any other areas that get wet, such as water collected in trailer frames, safety light compartments, boat's decking and the lower portion of motor cooling systems.

(Water hotter than 110 F will kill veligers, and 140 F will kill adults. If hot water is not available, it is still important to rinse your boat and equipment. Do not use salt and chlorine water mixtures as both mixtures are very toxic to other organisms and may also damage boat equipment. Therefore, neither is recommended now for use outdoors.)

➤ **Always air dry boat and other equipment for five days before using in uninfested waters.** If boat and equipment are completely dry for two days, it may be safe to use in uninfested waters.

➤ **Examine boat exterior for mussels** if it has been docked in infested waters; if mussels are found or exterior is heavily fouled by algae, either clean fouled surfaces or leave boat out of the water for at least five days before entering uninfested waters.

If your gear feels gritty, then young microscopic mussels may be attached. Any mussels scraped off should be bagged and discarded in the trash.

➤ **Do not re-use bait** if exposed to infested waters.

## How to protect your boat and motor

The longer a boat remains in zebra mussel-infested waters, the more apt it is to be fouled by zebra mussels. Therefore, boats that are docked or moored are more likely to be fouled by mussels than boats that are launched and retrieved in a single day.

### Usage

The most expensive type of destruction to your boat is probably motor damage. Veligers can cause this harm when they are taken into the cooling system, where they can attach, grow and block intake screens, internal passages, hoses, seacocks and strainers.

The best prevention against such damage is to use your boat. Try to run your boat twice a week at high speed for 10 to 15 minutes. The mussels can't attach when the water velocity exceeds 1.5 meters a second (about 3.5 mph or about 3 knots) and may be washed off at speeds exceeding two meters a second (about 4.5 mph or 4 knots). The high-speed running will also help flush any attached young mussels from inside the motor systems, and the heat generated past the water pump will kill any veligers that may have been drawn into the system.

For outdrives and inboard units, run the engine at operation temperature for one-half hour each week. Watch temperature gauges and record readings for each use; any increase in readings over the previous use warrants disassembly and inspection of the cooling system. Consider installing a high temperature alarm.

After returning to the dock, flush any veligers out of the lower unit's intake by running tap water through the system. (Never use a chlorine mixture in the engine cooling system.) Do this by having a hose fitting installed on the intake system or investigate current commercial "engine boot" systems that contain lower unit water and that recirculate the heated water through the engine. This flushing practice, however, won't prevent veligers from entering the intake screens while your boat is at the dock.

Mussels can also accumulate around propeller shafts and can cause increased wear and possible damage to drive shafts or shaft seals. Reduce the amount of time in the water by tipping the drive units *up* and *out* of water when at dock.

During pre-season maintenance, and frequently thereafter, inspect cooling systems, intake screens, lower unit steering and hydraulic controls, propellers and propeller shaft seals. Frequently inspect the rubber boot that surrounds the I/O unit at the hull, because mussel shells can tear the boot, resulting in water entering the hull. Check water pump impeller for damage from shell fragments if adults are found near the intake systems. At the end of the season, follow the pre-season guidelines and disassemble everything, including the parts between the seacock and the engine.

### Antifoulant products

Maintain a good quality antifoulant paint on the hull and other accessories because such paint releases toxins. Most marine algae, slime growths and mussels—including zebra and quagga mussels—are sensitive to these chemicals and will not attach to them. Several types of antifoulant paints exist, including copper-based, tributyltin (TBT)-based, copolymer, vinyl/epoxy binder, resin binder and hard- and soft-film types.

*Copper-based paints* are used on fiberglass and wooden hulled boats and accessories (trim tabs, etc.). They are usually viable for one or two seasons. A primer may be necessary on some surfaces, and the old coating must be removed first. A

primer coat is absolutely necessary before applying to aluminum, because the aluminum and copper react with each other (electrolytic action) and cause corrosion. (Most lower motor units are aluminum.)

*Tributyltin (TBT)-based antifoulants* are restricted by law because they are extremely toxic. Early forms of TBT antifoulant paints leached biocides into the water and contaminated and killed nontarget organisms. In 1988, a federal law restricted the use of TBT as an antifoulant.

Some states have approved use of newer "slow-release" TBT paints (bulk brush-on) for application only on the hulls of aluminum boats and vessels exceeding 82 feet in length. This treatment can last two to three seasons when properly applied. The person applying the paint is required to obtain a pesticide applicator's license, generally available through your state's agriculture agency, to purchase and apply this antifoulant. Some states and provinces, including Michigan and Ontario, have banned the use of TBT paints altogether. Check applicability and legality of use of these paints with the product's manufacturer, boat dealer or regulatory agency. Where legal, a TBT-based spray for use on outboards, I/O sterndrives, propellers and internal passages is available for over the counter purchase.<sup>3</sup>

*Copolymer coatings* are best for high-speed boats because they are thinner and smoother than the others. They are also recommended for trailered or rack storage boats because they only react when immersed in water. Other coatings oxidize when exposed to air for as little as one week and become useless.

*Vinyls, epoxies and resin coatings* allow biocides to leach to the surface.

*Soft-film types* result in a soft residue remaining after the biocide is leached out and are well suited for boats that remain in the water.

*Hard-film types* can be sanded to restore effectiveness.

Consult your manufacturer or boat dealer to determine the type best suited for your hull and accessories. Applying paints to some accessories may cause a loss in performance. Apply spray inside passages as far as possible. Some units require an annual breakdown for lubrication of the drive shaft; this is an excellent opportunity to spray deep inside otherwise hidden water passages.

Never apply a new antifoulant over an existing coating of another type. Remove old paint and read container labels for compatibility.

***Remember, it may take only a few viable adult zebra mussels or a minnow bucket containing microscopic veligers to start a new colony. Do your part to prevent the spread while protecting your boat and equipment, too!***

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<sup>1</sup>For more information about zebra and quagga mussels, request Ohio Sea Grant's fact sheet *Zebra mussels in North America: The invasion and its implications* (OHSU-FS-045).

<sup>2</sup>For more information on this subject, request Ohio Sea Grant's fact sheets *Zebra mussel migration to inland lakes and reservoirs: A guide for lake managers* (OHSU-FS-058) or *Safe use of zebra mussels in classroom and laboratories* (OHSU-FS-059).

<sup>3</sup>A 1990 Ohio Sea Grant study revealed a loss of effectiveness of TBT-based spray coatings used on accessories after 9 to 12 weeks in the water.



# Zebra mussel migration to inland lakes and reservoirs: A guide for lake managers



OHSU-FS-058

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The Great Lakes Sea Grant Network is a cooperative program of the Illinois-Indiana, Michigan, Minnesota, New York, Ohio, and Wisconsin Sea Grant programs. Sea Grant is a university-based program designed to support greater knowledge and wise use of the Great Lakes and ocean resources.

Through its network of advisory agents, researchers, educators and communicators, the Great Lakes Sea Grant Network supplies the region with usable solutions to pressing problems and provides basic information needed to better manage the Great Lakes for both present and future generations.

Sea Grant is a program in the National Oceanic and Atmospheric Administration (NOAA), Department of Commerce.

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Since the introduction of zebra mussels (*Dreissena polymorpha*) from Europe into Lake St. Clair in 1986, they have spread to all the other Great Lakes and the inland navigation system of major rivers, notably the Cumberland, Mississippi, Ohio, Susquehanna, Hudson and Tennessee rivers. They have recently been sighted in some small inland lakes and reservoirs, and it is generally believed that they will soon spread to many others. Which environmental factors are most important in determining whether a lake can support large populations of zebra mussels? What will be the ecological and economic impacts of zebra mussels in inland lakes and reservoirs? What can be done to prevent and mitigate the spread of zebra mussels? The purpose of this publication is to summarize current views on these topics to aid resource managers in planning.

## Lake conditions most likely to support zebra mussels

Moderately hard-water lakes with calcium ( $\text{Ca}^{2+}$ ) concentrations above 12 mg/L, alkalinity above 50 mg  $\text{CaCO}_3/\text{L}$  and pH above 7.2 provide the necessary chemical environment for adult zebra mussels. Zebra mussels will tolerate oxygen concentrations as low as 25 percent saturation (about 2 mg/L at 25°C), but they die in anoxic water. Lakes with prolonged periods above 54° F (12°C) and with maximum temperatures of 64-74°F (18-23°C) provide optimum conditions for growth and reproduction. Development of large populations of zebra mussels also depends on sufficient hard substrate onto which the adults can attach, as well as an abundant edible phytoplankton community. For example, the western basin of Lake Erie, with  $\text{Ca}^{2+}$  concentrations above 30 mg/L, alkalinity of 86 mg  $\text{CaCO}_3/\text{L}$ , pH of 8.4, mean temperatures around 68°F and a rocky bottom, is able to support massive populations of zebra mussels; more than 100,000 adults/m<sup>2</sup> have been reported in some places.

Although these are the optimum conditions for production of large populations, managers need to recognize that zebra mussels readily adapt to a wide range of conditions. In Europe, their range extends from the southern parts of Sweden to the Mediterranean shores. Recent physiological studies indicate that zebra mussels are more tolerant of mild salinity and wide swings of temperature than many indigenous bivalve mollusks, indicating that they may

successfully invade some regions that offer only marginal environments to other mollusks. Zebra mussels are genetically diverse and readily produce genetic variants, a characteristic that permits them to invade a wide variety of habitats and that may permit them to expand their limits of tolerance.

Recent field and laboratory studies report that calcium and alkalinity are the major factors that determine growth and reproductive success of zebra mussels. Zebra mussels require  $\text{Ca}^{2+}$  concentrations greater than 12 mg/L to establish significant populations, which is considerably higher than required by other bivalve mollusks (typically 3-4 mg/L). Adult mussels are unable to survive in aquaria below 3.6 mg  $\text{Ca}^{2+}/\text{L}$  and an alkalinity of 4.7 mg  $\text{CaCO}_3/\text{L}$ . Larval veligers are more sensitive to low calcium and alkalinity than adults.

Mussels are sensitive to acidic waters, too. Below pH 6.8, adult zebra mussels have a net loss of calcium, sodium and potassium to the surrounding water; however, they are able to adapt to mildly acidic conditions. After several days at pH 5.5-6.0, adults adapt to these conditions and their net rate of ion loss decreases. Zebra mussels are unable to withstand prolonged periods below pH 5.2 and eventually die because of ionic imbalance. Veligers are more sensitive to low pH than adults.

Temperature is another factor that can limit the extent of zebra mussel colonization. Each mature female produces several hundred thousand eggs during the breeding season, which occurs when the water temperature is above 54°F (12°C). The longer this period the more successful colonization is likely to be. Adults are unable to survive prolonged exposure to temperatures above 90°F (32°C). They can tolerate temperatures as low as 32°(0°C), provided they do not freeze.

## Ecological effects of zebra mussels in inland lakes

Zebra mussels graze on several species of algae at different rates and can remove large portions of the phytoplankton community from the water column, greatly increasing water clarity. Zebra mussels graze on particles greater than 0.00004 in. (1µm) in size. Free-living bacteria are smaller than this and apparently are not grazed by zebra mussels. These mussels graze on algae, protozoans and rotifers, but not indiscriminately. Recent investigations in Saginaw Bay indicate that zebra mussels establish abundant populations most readily in regions with large populations of diatoms and small edible green algae. Zebra mus-

sels appear to graze on large filamentous blue-green algae and colonial algal forms less readily, and they greatly decrease their filtering rate in the presence of toxins released from certain blue-green algae (even if those algae aren't present).

The particles zebra mussels filter and eat are digested and released through the exhalant siphon as fecal material, which rapidly decomposes. The particles zebra mussels filter and reject are coated with mucous and expelled through the inhalant siphon as pseudofeces, which sink and decompose slowly at the sediment surface. The net effect of zebra mussels on the benthic (bottom-dwelling) community is unclear; some organisms benefit from their presence, others are harmed. Gammarid amphipods feed on feces and pseudofeces and seem to benefit from the increased food supply on the bottom of the lake. On the other hand, zebra mussels compete with other organisms (e.g. mysid decapods) for the same plankton resources. Populations of burrowing unionid clams have been nearly eliminated from Lake St. Clair because of zebra mussels that attach to the exposed portion of their shells.

Recent studies indicate that zebra mussels may mobilize toxic materials from the sediments into the food chain in two ways. When zebra mussels filter algae to which toxic materials are sorbed, they either ingest these toxic algae or release them in pseudofeces. Zebra mussels are capable of accumulating toxic compounds (PAHs and PCBs) in their fatty tissues, reaching concentrations 50,000 times greater in concentration than the surrounding water and about 10 times greater than other invertebrates. If edible fish begin to eat zebra mussels in large quantities, biomagnification of these accumulated toxic organic materials could increase the toxic load to humans. Also, zebra mussels provide a new mechanism of introducing toxins to the food chain, as amphipods that graze on pseudofeces containing toxin-sorbed algae are then eaten by fish.

Removal of significant proportions of plankton at the base of the food chain will diminish the energy available for fish production. Inland lakes that support large populations of zebra mussels may experience a diminished fish yield, especially of fish feeding in the open water. On the other hand, stimulation of the benthic community may increase the productivity of bottom-dwelling fish. Open-water piscivorous fish may change their feeding habits to prey more on benthivorous fish or may decrease in production. As water clarity increases, changes in fish populations may occur as conditions become more favorable for "clear-water" fish (e.g. pike) and less favorable for "turbid-water" fish (e.g. walleye). Increased water clarity will increase the light penetration into the water, increasing growth of aquatic weeds, providing increased habitat for fish that prefer to spawn and hide in weed beds (e.g. sunfish).

Increased water clarity can also cause community and ecosystem changes. Abundant growth of these aquatic weeds will oxygenate the bottom waters, further supporting benthic community life. Recent studies indicate that zebra mussels increase the remineralization and recycling rate of nitrogen and phosphorus, providing an increased availability of nutrients such as nitrate and phosphate, essential for growth of benthic organisms.

### **Economic impact of zebra mussels on inland lakes**

Hydroelectric power plants, municipal drinking water facilities

and other water-using industries are likely to be most heavily impacted by zebra mussel populations. Mussels colonize the surfaces of pipes, diminishing the flow rate through water intake pipes. Unless preventive measures are taken, larval zebra mussels colonize the interior parts of turbines and other equipment, leading to costly repairs. Preventive measures such as retrofitting backwash filters or pre-chlorination devices for water intake pipes are also costly. Great Lakes industries have spent millions of dollars combating and preventing zebra mussel damage.

Zebra mussels can also attach to water intake pipes of boats, preventing sufficient flow of coolant water, leading to engine failure. Mussel attachment to boat hulls increases drag and decreases fuel efficiency. Removal of mussels from boat hulls can be time-consuming and costly. Anti-fouling paints are expensive; some are highly toxic, heavily regulated and need to be applied by a licensed specialist.

The full economic impact of zebra mussels is still under investigation. Recent studies report that zebra mussels hasten the corrosion rate of iron and steel structures at the point of attachment. Enhanced growth of aquatic weeds resulting from increased water clarity has led to taste and odor problems in drinking water supplies, necessitating more expensive and aggressive water treatment procedures.

### **Prevention and remediation of the zebra mussel invasion**

Boat and barge traffic is the major vector spreading zebra mussels inland from the Great Lakes through the inland waterways. From these inland waterways, it is expected that zebra mussels will be carried unwittingly to inland lakes and reservoirs on the hulls of boats. They also may be carried in live wells and bait buckets, on fish nets and possibly by waterfowl and other wildlife moving from infested waters.

Controlling the movement of contaminated boats appears to be the only significant means of preventing, or at least slowing, the spread of zebra mussels from infested waters. The most effective and least environmentally damaging method of control is to drain the boat thoroughly and let it dry for several days before transferring it to other waters. Although the veligers are sensitive to drying, individual adult mussels are very hardy and can survive at least several days out of water, especially in moist environments. Washing the boat with hot water (at least 110°F; 42°C) using a high pressure hose is also effective in removing zebra mussels attached to boat surfaces. Inspection of boat hulls and scrubbing have a limited effectiveness because very young mussels are difficult to detect, often being smaller and more transparent than a sesame seed.

Zebra mussels are sensitive to potassium and to modest amounts of chlorine bleach (one part bleach to ten parts water). Chlorine bleach is useful for disinfection of live wells and bilges. Although dipping boats into holding ponds of potassium chloride or chlorine bleach for several hours has been contemplated as a means of decontaminating boat hulls, this is generally not considered feasible because both the economic and environmental costs may outweigh the benefits. Chemical treatments are expensive in the large quantities required and can damage some boat equipment. Disposal of large quantities of chemicals is problematic because of toxicity to aquatic life. For more infor-



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**Michigan Sea Grant College Program**

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**Minnesota Sea Grant**

1518 Cleveland Avenue North, Suite 302, St. Paul, MN 55108,  
512/625-6781

**New York Sea Grant Institute**

Hartwell Hall, SUNY College at Brockport, Brockport, NY 14420-  
2928, 716/395-2638 or 800/285-2285

**Ohio Sea Grant College Program**

The Ohio State University, 1314 Kinnear Road, Columbus, OH  
43212-1194, 614/292-8949

**Wisconsin Sea Grant Institute**

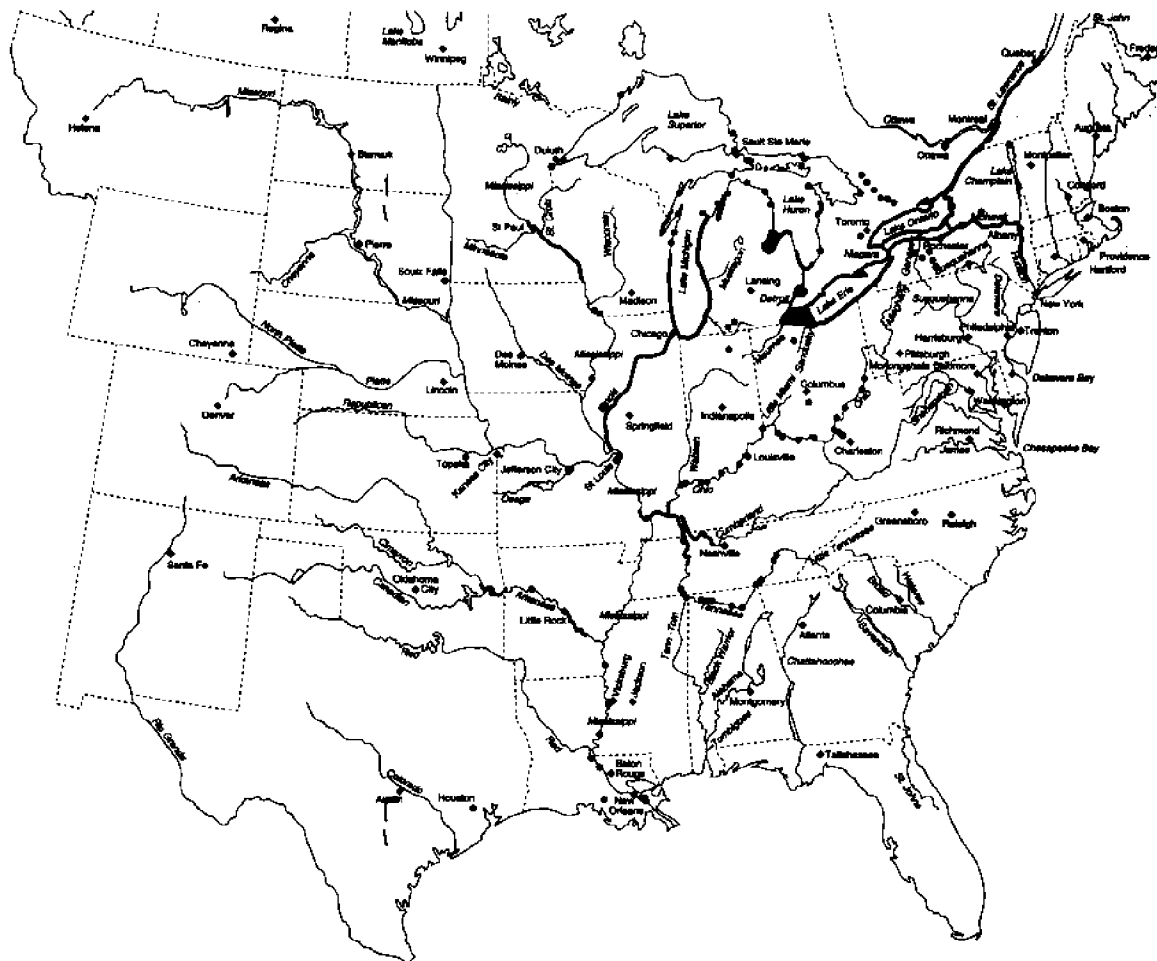
ES 105, UW-Green Bay, Green Bay, WI 54311-7001, 414/465-2795

Other U.S., state and Canadian agencies are also working on this issue. Some of the agencies working as a Great Lakes panel on nonindigenous species include:

- U.S. Fish & Wildlife—monitor and research
- Coast Guard—regulatory activities
- Great Lakes Environmental Research Lab, NOAA—research
- Great Lakes Fishery Commission—research
- Great Lakes Commission—policy development and coordination
- Sea Grant—university-based research, education and technology transfer

**Range of the zebra mussel in North America  
as of August/September 1993**  
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Compiled by New York Sea Grant with information from: Empire State Electric Energy Research Corp., Fisheries and Oceans Canada, Great Lakes Sea Grant Network, Illinois Natural History Survey, Ontario Hydro, Ontario Ministry of Natural Resources, Tennessee Valley Authority, US Army Corps of Engineers, US Fish & Wildlife Service, and utilities and others throughout North America.





# ZEBRA MUSSELS AND AQUACULTURE: WHAT YOU SHOULD KNOW

## *A blueprint for success*

Zebra mussels are small, clamlike, freshwater mollusks native to Eastern Europe and Central Asia. First found in the United States in the Great Lakes, these foreign invaders probably made their way to North America in the ballast water of ships sailing from European ports. Since their discovery in 1988, zebra mussels have spread rapidly throughout the Great Lakes region, colonizing the Mississippi and other major river systems as well as many inland lakes. Now present in at least 19 states, they are likely to spread to more inland and tidal waters in the United States.

Zebra mussels pose a serious threat to aquaculture. Using their glue-like byssal threads, the mussels attach to almost any hard surface and can form thick mats of several hundred thousand individuals per square meter. Mussel colonies can clog pipes and valves, damage pumps, generators and motors and cause other costly problems for fish farmers.



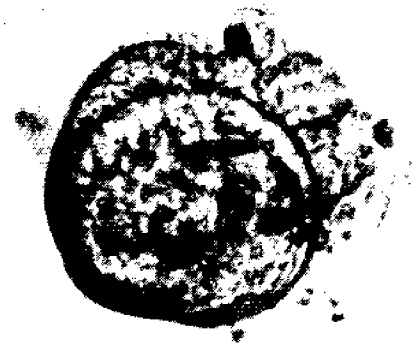
*Zebra mussels can attach to almost any hard surface, such as plastic, metal, concrete or the wooden dowel pictured above.*

Yet few aquaculturists are aware of these risks. A recent 31-state survey revealed that most aquaculturists are unfamiliar with zebra mussels and the problems they can cause, even in areas where the mussels are already present. Knowing the facts about zebra mussels and knowing how to exclude them can help you protect your aquaculture facility and reduce the spread of this pest.

### Life Cycle

Zebra mussels can grow to 2 inches in length (5 centimeters), but most are less than 1 inch (2.5 centimeters) long. These rapidly growing mollusks mature in one

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*The zebra mussel's microscopic, free-swimming larvae are called veligers. This veliger is shown magnified to 200 microns.*

to two years and can spawn throughout the year in warm, fertile waters (about 54 F to 82 F or 12 C to 28 C). A single large female can produce up to 1 million eggs per year. Within a few days, the eggs hatch into microscopic, free-swimming larvae called veligers. Around two to three weeks after hatching, the larvae settle and attach to a hard surface.

Zebra mussels feed by filtering phytoplankton, bacteria and detritus (dead organic matter) from water. Adults can filter more than 1 quart (1 liter) of water per day, and many live up to three years or more.

### Environmental Requirements

Current information suggests that zebra mussels are able to thrive under a wide range of conditions (See Table 1). In many cases, the temperatures, water chemistry and water quality maintained in aquaculture facilities are ideal for zebra mussel growth and reproduction. These facilities are highly vulnerable to invasion by zebra mussels and have the potential to spread them further. But by learning zebra mussel preferences and evaluating their facilities, aquaculture operators can take steps to protect their businesses.

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**Table 1. Environmental Tolerances of Zebra Mussels**

Temperature	32-91 F (0-33 C) adequate for survival 55-77 F (13-25 C) preferred range
Calcium	5-6 mg/L necessary for survival 10-12 mg/L required for reproduction 35 mg/L best for growth
Alkalinity	15 mg/L necessary for survival 35 mg/L best for growth, reproduction
Hardness	22 mg/L necessary for survival 42 mg/L best for growth, reproduction
pH	6.9 necessary for survival 7.5 best for growth, reproduction
Dissolved Oxygen	2 mg/L necessary for survival 90 percent saturation best for growth
Salinity	up to 12 ppt for short-term tolerance 1 ppt best for growth
Desiccation	3-10 days, depending on air temperature and humidity
Current Speed	5-6 ft/s or 1.5-2 m/s for settlement 0.5-1.6 ft/s or 1.5-0.5 m/s best for growth
<i>Note: mg/L=milligrams per liter, ppt=parts per thousand, ft/s=feet per second, m/s=meters per second.</i>	

## Problems for Aquaculturists

Zebra mussel infestations can be time-consuming and expensive. Mussels can clog intake and drain pipes, encrust boats and equipment, damage pumps and block outboard motor cooling systems. Heavy mussel buildup may sink floating aerators, cages or net pens. Mussel colonization can reduce water flow and oxygen levels inside aquaculture cages. Mussel shells may make seining difficult by interfering with harvest and damaging seines. Other zebra mussel characteristics can also cause problems for fish culturists. Because of the mollusk's high filtering capacity, even a modest density of zebra mussels can reduce the food available for newly hatched fry or other fish reared on microscopic plankton. As plankton disappears, the resulting increase in water clarity could encourage the growth of aquatic weeds and may increase the efficiency of fish-eating birds. Zebra mussels may also increase parasite problems. In Europe, zebra mussels are often intermediate hosts for trematode worms that infect fish, although no such cases have been observed yet in North America.

## Prevention

As with many nuisances, prevention is the best (and most cost-effective) medicine. So how can you keep zebra mussels from invading your aquaculture facility? Zebra mussels are most likely to enter an aquaculture facility attached to equipment used in an infested water body or carried as microscopic larvae in infested surface water or hauling tank water. Aquaculturists can protect themselves from zebra mussels and help prevent their spread by following a few basic safety precautions:

### ✓ Inspect

Always carefully inspect any equipment used in waters known to or suspected to contain zebra mussels. Seines, buckets, boats, motors, trailers, pumps and hauling tanks can all carry hitchhiking mussels. Because of their small size (0.008 to 0.012 inches or 0.2 to 0.3 millimeters), newly settled mussels are difficult to see, but they give normally smooth surfaces a grainy texture.

### ✓ Drain

Drain and flush all tanks, live wells, buckets and other containers that might carry water contaminated with zebra mussel larvae. Do not let water drain into a pond, creek, lake or other water body.

### ✓ Clean and Disinfect

Thoroughly wash all hauling tanks and equipment using a hard spray from a garden hose. If your equipment was in infested waters for several days, or you found any attached mussels, use hot water (140 F or 40 C) or a high pressure washer (250 pounds per square inch). Scrape off any zebra mussels you see and throw them in the trash. Remove all aquatic weeds — they can carry zebra mussels.

Recent research shows that disinfection of nets and equipment with benzalkonium chloride at typical treatment rates (10 milligrams per liter for 24 hours, 100 milligrams per liter for 3 hours, or 250 milligrams per liter for 15 minutes) will also effectively eliminate all zebra mussel life stages. However, two other commonly used disinfectants, calcium hypochlorite and iodine, are ineffective against zebra mussels.

### ✓ Dry

Adult zebra mussels can live more than a week out of water in moist, shaded areas. Dry tanks, boats, nets and other equipment used in infested waters in the sun for two to four days after cleaning or at least one week if not thoroughly cleaned. If adult mussels are present, dry equipment for two weeks.

## ✓ Check Your Hauling Water

One of the greatest avenues for the introduction and spread of zebra mussels to aquaculture is through contaminated hauling water, which may contain zebra mussel larvae. In many areas of the United States, surface water is used extensively for shipping fish and fingerlings. Fortunately, the salt treatments used to reduce fish stress during transport and hauling will kill zebra mussel larvae. Exposure to 1 percent Sodium Chloride (NaCl) for 24 hours will eliminate all veligers and 98 percent of newly settled mussels.

But as zebra mussels continue to expand their range, chances will increase that your next delivery may contain unwelcome stowaways. To reduce your risk, talk to your suppliers and make certain any hauling water entering your facility comes from a mussel-free source, preferably a well.

There is a particular danger for the bait fish industry. Anglers may inadvertently spread zebra mussels when they dispose of contaminated bait bucket water. Several states have initiated voluntary or mandatory programs for live-bait growers, dealers and retailers to certify their products as zebra mussel-free. If you ship live fish of any kind, always use well water if possible and consider providing your buyers with documentation that your shipments don't contain zebra mussels. As concern about zebra mussels grows, this will be a good marketing tool and may eventually be required.

## ✓ Protect Your Water Supply

The best way to guarantee that zebra mussels won't enter your water supply is to use groundwater from a well or spring. Avoid using surface water, especially from large lakes or rivers. Once your water source is contaminated, it is difficult to keep zebra mussels out of your aquaculture facility. The fine filter size (60 to 70 microns) required to remove zebra mussel veligers makes it impractical to filter large volumes of water. In some situations a buried intake or sand filter may filter mussel veligers and still allow adequate water flow.

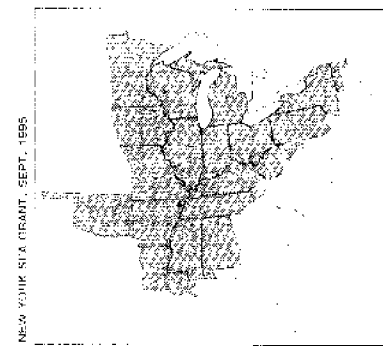
## Control

Once established in a system, zebra mussels are difficult to eliminate. Most control methods used in industrial and municipal water systems, such as hot water exposure or chemical treatments, are not acceptable for fish-rearing facilities. To date, a treatment that eliminates all zebra mussel life stages without harming fish or other aquatic organisms has not been discovered.

Some common aquaculture practices can help control zebra mussels, such as the salt treatments used in shipping and handling fish or disinfecting nets with benzalkonium chloride. Zebra mussels can be eliminated from a pond by

draining and drying it for an extended period, preferably during the winter when the remaining mussels might freeze. Rotenone treatment to kill unwanted fish species will also kill 100 percent of all zebra mussel life stages.

Although the application of some therapeutic treatments, pond treatments or disinfectants for their labelled uses may also kill zebra mussels, currently no aquaculture



*Shaded states contain waters where zebra mussels have been detected.*

chemicals are labeled specifically for zebra mussel control. Before using any chemical treatment for zebra mussels, contact your local Cooperative Extension agent or Sea Grant office to determine the latest regulations concerning its use. Because chemical toxicity can vary with fish species, water

chemistry and environmental conditions, always conduct a preliminary test to make sure your fish will be safe.

Controlling zebra mussels with mussel-eating fish is not effective. Several native species, such as sheepshead, blue catfish and common carp, eat zebra mussels but don't significantly affect mussel populations. Some aquaculturists have considered importing exotic fish, such as the Chinese black carp, to eat zebra mussels. These exotics are unlikely to provide mussel control. Europeans tried to control mussels in culture ponds with black carp in the 1960s, but they were unsuccessful.

Typically, exotic species cause more problems than they solve, and stocking them is illegal in many states. Consult your state fisheries agency before considering introduction of any exotic species.

## Monitoring for Zebra Mussels

If zebra mussels invade your facility or water source, early detection can minimize their impacts. To monitor for zebra mussels, hang a small PVC plate or concrete block at midwater depth, and check it regularly for attached mussels. For earlier detection, plankton samples must be examined for mussel larvae. If you think you have found a zebra mussel, save it in alcohol and contact your local extension agent or Sea Grant office. These agencies can accurately verify your sample and provide you with the latest information on zebra mussel control and prevention methods.

**James Rice, North Carolina State University  
Extension Fisheries Specialist**

## **For More Information about Zebra Mussels:**

### **Alabama**

- William Hosking, Alabama Cooperative Extension Service, Auburn University, Marine Extension and Research Center, 334/438-5690
- Auburn University, Department of Fisheries and Allied Aquacultures, 334/844-4786.

### **Connecticut**

- Connecticut Sea Grant Marine Advisory Program, 860/445-8664.

### **Delaware**

- John Ewart, aquaculture specialist, Delaware Sea Grant Advisory Service, 302/645-4060.

### **Florida**

- Marion Clarke, Florida Sea Grant Extension Program, 904/392-1837.

### **Illinois-Indiana**

- LaDon Swann, aquaculture extension specialist, Illinois-Indiana Sea Grant Program, 317/494-6264.

### **Louisiana**

- Marilyn Barrett, Louisiana Sea Grant Program, 504/388-6349.
- C. Gregory Lutz, Louisiana Cooperative Extension Service, 504/388-2152.

### **Maryland**

- Donald Webster, Maryland Sea Grant extension agent, 410/827-8056.

### **Minnesota**

- Doug Jensen, Exotic Species Center coordinator, Minnesota Sea Grant Extension Program, 218/726-8712.

### **Mississippi**

- David Veal, Mississippi Sea Grant Advisory Service, Coastal Research Extension Service, 601/388-4710.

### **North Carolina**

- James Rice, North Carolina State University extension fisheries specialist, 919/515-4592.
- North Carolina Sea Grant Program, 919/515-2454.
- For North Carolina Cooperative Extension county office numbers, call the main office at 919/515-2811.

### **South Carolina**

- West McAdams, water quality specialist, South Carolina Marine Extension Program, 803/722-5940.
- Danny Johnson, co-chair, South Carolina Zebra Mussel Task Force, South Carolina Department of Natural Resources.

### **For General Information**

- The New York Zebra Mussel Information Clearinghouse, 1-800/285-2285.

**North Carolina Sea Grant  
Box 8605  
North Carolina State University  
Raleigh, NC 27695-8605**

**Notice:**

Due to a production error, Table 1 of the Zebra Mussels and Aquaculture Blueprint was printed with the "≤" or "≥" signs missing from several rows. This is the table in its correct form.

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Hardness	≥ 22 mg/L necessary for survival ≥ 42 mg/L best for growth, reproduction
pH	≥ 6.9 necessary for survival ≥ 7.5 best for growth, reproduction
Dissolved Oxygen	≥ 2 mg/L necessary for survival 90 percent saturation best for growth
Salinity	up to 12 ppt for short-term tolerance ≤ 1 ppt best for growth
Desiccation	3-10 days, depending on air temperature and humidity
Current Speed	≤ 5-6 ft/s or 1.5-2 m/s for settlement 0.5-1.6 ft/s or 1.5-0.5 m/s best for growth
Note: mg/L=milligrams per liter, ppt=parts per thousand, ft/s=feet per second, m/s=meters per second.	

**Notice:**

Due to a production error, Table 1 of the Zebra Mussels and Aquaculture Blueprint was printed with the "≤" or "≥" signs missing from several rows. This is the table in its correct form.

**Table 1. Environmental Tolerances of Zebra Mussels**

Temperature	32-91 F (0-33 C) adequate for survival 55-77 F (13-25 C) preferred range
Calcium	5-6 mg/L necessary for survival 10-12 mg/L required for reproduction ≥ 35 mg/L best for growth
Alkalinity	≥ 15 mg/L necessary for survival ≥ 35 mg/L best for growth, reproduction
Hardness	≥ 22 mg/L necessary for survival ≥ 42 mg/L best for growth, reproduction
pH	≥ 6.9 necessary for survival ≥ 7.5 best for growth, reproduction
Dissolved Oxygen	≥ 2 mg/L necessary for survival 90 percent saturation best for growth
Salinity	up to 12 ppt for short-term tolerance ≤ 1 ppt best for growth
Desiccation	3-10 days, depending on air temperature and humidity
Current Speed	≤ 5-6 ft/s or 1.5-2 m/s for settlement 0.5-1.6 ft/s or 1.5-0.5 m/s best for growth
Note: mg/L=milligrams per liter, ppt=parts per thousand, ft/s=feet per second, m/s=meters per second.	





# Zebra Mussel

Update no. 26



• No. 26 • January 1996. A national publication of the Great Lakes Sea Grant Network

## Inland Lake Sightings: A Tale of Two States

Michigan inland lakes are becoming more rapidly colonized than Wisconsin lakes, according to the results of a cooperative project supervised by Ladd Johnson (Université Laval) and Clifford Kraft (University of Wisconsin-Madison), with assistance from many cooperating individuals and agencies. The comparison showed a different pattern developing in each state.

By the end of 1995, adult or larval zebra mussels had been confirmed in 33 inland Michigan lakes, five more than at the end of the previous year. Adult zebra mussels had been confirmed in 21 Michigan lakes; veligers had been detected in other 12 lakes. Unconfirmed adult sightings had also been reported from an additional five inland lakes.

Wisconsin sightings have been scarcer than in Michigan.

Adult or larval zebra mussels had been detected in seven inland Wisconsin lakes by the end of 1995, three of which were new sightings. In total, four Wisconsin lakes had confirmed adult populations; the other three lakes had veligers.

No unconfirmed adult sightings have been reported from Wisconsin lakes.

It is unlikely that the observed differences in inland lake sightings are due to sampling differences because the sampling efforts were similar in both states. Rather, Johnson and Kraft speculate that the abundance of submerged macrophytes in source waters may be responsible for the different pattern in each state.

In earlier work, Johnson noted that submerged macrophytes with attached zebra mussels were often found hanging on boats and trailers being removed from zebra mussel-infested Lake St. Clair. The abundant macrophyte growth in Lake St. Clair could have contributed to the rapid spread of mussels to inland Michigan lakes. To date, Lake Michigan, which is relatively free of macrophytes, has been Wisconsin's primary zebra mussel source.

Unfortunately, this could change now that several macrophyte-rich inland Wisconsin lakes are infested and have become potential sources for further inland lake colonizations.

## St. Croix River Infested?

When is a body of water truly "infested?"

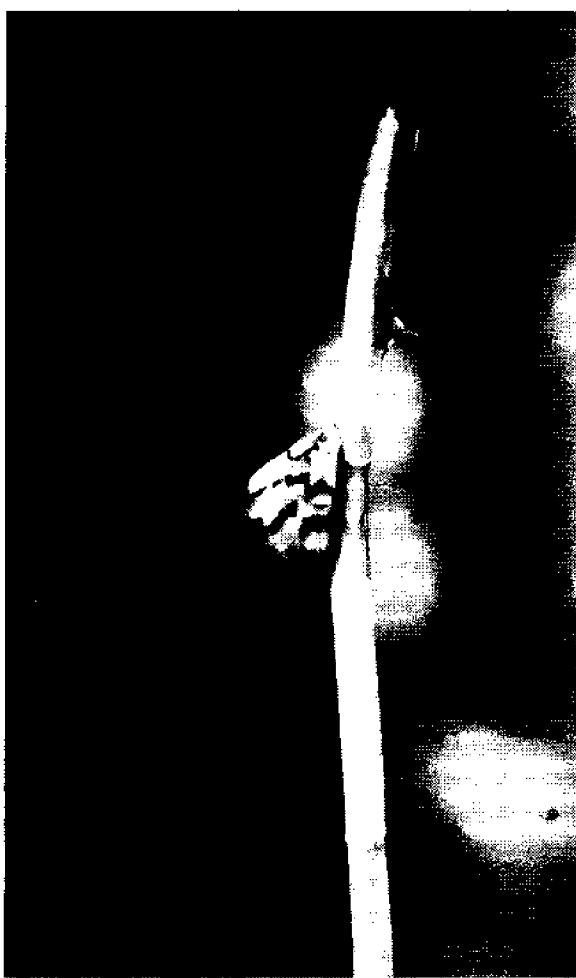
Minnesota DNR Ecological Service Section's Gary Montz recently wrote ZMU requesting help from the zebra mussel community to define the term.

Montz wrote:

"A number of agencies in Minnesota and Wisconsin are trying to keep the zebra mussel from spreading into the St. Croix National Scenic Riverway, which is home at last count to over 40 species of unionids, including the Winged Mapleleaf. The St. Croix is a tributary to the Mississippi River below the Twin Cities, and supports a tremendous amount of recreational boating traffic in the lower 26 miles. Above that area, the river becomes much shallower and boating traffic decreases. ▶



The abundance of submerged vegetation in source waters may be responsible for different colonization patterns developing. (Photo courtesy of University of Wisconsin Sea Grant Institute / Clifford Kraft)



(Photo courtesy of University of Wisconsin Sea Grant Institute / Clifford Kraft)

"The problem in trying to stop the zebra mussel arises from the boat travel between the Mississippi and St. Croix rivers. Additionally, this lower part of the St. Croix includes border waters managed by both Minnesota and Wisconsin, with federal agencies such as the USFWS, National Park Service and Coast Guard having additional responsibilities.

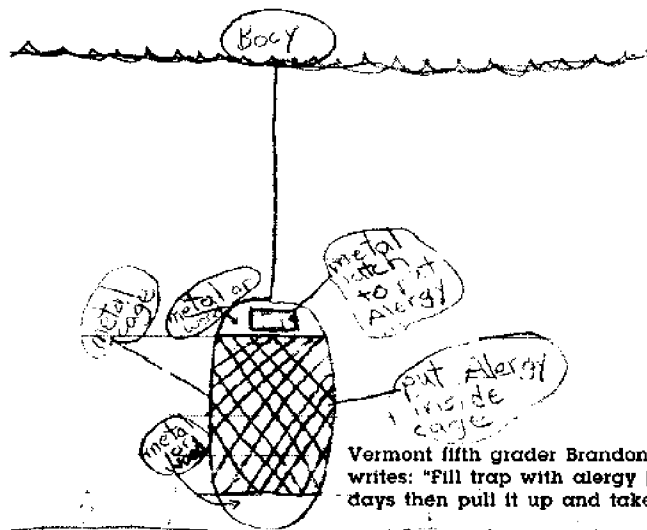
"Actions the Minnesota DNR might take depend on whether the river is officially 'infested' or not. Certain laws apply to uninfested waters, while others only apply to waters infested with exotic species. We also have specific signs for access sites on infested waters.

"Together with the other agencies working on the zebra mussel issue, we need to determine if the St. Croix River should be declared 'infested.' However, there are widely differing opinions on what determines infestation.

"I would appreciate input from on some of the following issues:

1. How would you determine when a river (or lake) is 'infested' with zebra mussels? Do specific densities need to be reached? Do you need evidence of reproduction? Or is the presence of zebra mussels on multiple fixed substrates (bridge piers, rip-rap, etc.) sufficient to assu me infestation? What about multiple size classes attached to river substrate?
2. If evidence of reproduction is necessary, what level of sampling is necessary in a large river system to document this event? Should plankton samples or mesh samplers be used, or settling plates? Is any sampling likely to catch reproduction in the early stages?
3. Should we be looking at intermediate stages before calling something infested? For example, should we be telling people that we have found attached zebra mussels, but no evidence of reproduction, and that we are waiting for this to declare infestation?
4. What about remediation to prevent or slow the infestation of zebra mussels? Is having divers physically remove mussels from river substrates a viable option? Or is this a gesture as futile as trying to bail out the ocean with a bucket? Is there a density at which this might make sense? Has this been tried in any form elsewhere and, if so, what happened?

"Please send comments to me via email: [gary.moniz@dnr.state.mn.us](mailto:gary.moniz@dnr.state.mn.us). You can also fax me at (612) 296-1811, or call (612) 297-4888. I'd also like to try and organize an informal session at the 6th Zebra Mussel Conference to discuss these topics."



Vermont fifth grader Brandon Cobb designed this mussel trap. Cobb writes: "Fill trap with alergy [algae], keep in water for about a week or 2 days then pull it up and take the zebra mussels out or off."

# Carp Feast on Zebra Mussel in Mississippi

There was widespread media attention this fall about common carp feeding on zebra mussels. (See Cliff's Notes for more on the subject.) The stories were inspired by the findings of John Tucker, a biologist with the Upper Mississippi River Long-Term Resource Monitoring Program in Alton, Ill. Given all the hoopla, we contacted Tucker and he sent this intriguing response:

"I was fishing with my daughter near Brussels Ferry, Ill., this summer when we caught a common carp 290 mm long. To satisfy my daughter's curiosity, we took it home to dissect. When we examined it, we found that the fish's gut was completely packed with fragments of zebra mussels.

"Because the common carp had not been reported to feed extensively on zebra mussels in the United States, I asked station biologists to collect carp from the Mississippi River, just below the confluence with the Illinois near Grafton, Ill. This collection site has been monitored for zebra mussels since 1992 and is known to be heavily colonized by them.

"Of the 31 common carp examined (ranging in size from 243-559 mm), 26 contained the remains of one or more zebra mussels. With few exceptions, the zebra mussel shells were crushed and well fragmented by the carp. Staff members determined the number of zebra mussels present in each gut by halving the number of internal septa found. The number of zebra mussels consumed ranged from 0 to 204. Measurements are incomplete at this time, but the largest carp contained specimens of zebra mussels estimated to have been 15-18 mm in shell length, based on septa lengths. Smaller fish contained zebra mussels estimated to be less than 12 mm in shell length."

Tucker said he publicized his initial findings because some aquaculturists have suggested releasing other exotic carp species to control zebra mussels. Substantial common carp predation further diminishes the rationale for introducing another exotic carp to prey on zebra mussels, he said. Moreover, predation evidence can be collected without killing the fish by expressing feces from the vent of the carp. The feces can then be examined for zebra mussel shell fragments.

Further investigation into the phenomenon appears warranted, agreed Steve Gutreuter, director of monitoring and research at the National Biological Service Environmental Management Technical Center in Onalaska, Wis.

"It is far too soon to tell whether carp might help control zebra mussel populations," he cautioned. "The fact that zebra mussels and carp are both abundant in some areas of the upper Mississippi River suggests that carp are unlikely to be controlling the densities of zebra mussels. However, in areas where zebra mussels may already be limited by lack of suitable conditions, the additional mortality from carp predation might be important."

## DNA Probe to Detect Veligers Developed

A new technique to detect larval zebra mussels is close to being developed by a research team at Rensselaer Polytechnic Institute (RPI).

Sandra Nierzwicki-Bauer, chairwoman of biology at RPI and director of RPI's Darrin Fresh Water Institute, and postdoctoral research associate Marc Frischer are investigating the use of DNA genetic probes to test for the presence of zebra mussel veligers. The project was initiated in September 1994, with a \$112,000 grant from New York Sea Grant.

The most common technique for identifying zebra mussel veligers requires examining water samples under a stereo microscope equipped with cross-polarized light. By using the new DNA genetic probe, which still requires a microscope, the identification process will be much quicker and allow more water samples to be tested, Frischer believes. Using the new technique will not require the expertise of a highly trained scientist, he said.

The researchers have already completed the first step of the project, which involved identifying a portion of the mussel's genetic makeup and a sequence of 1,800 segments. A probe is now being created that will link to only the RNA of the zebra mussel. The probe is a combination of a piece of DNA synthesized to match the sequence of the zebra mussel and a "reporter" molecule. Veligers will appear colored when the probe attaches to them.

"This will allow us to get very sensitive detections, higher than what can be done right now microscopically, and has the potential of being automated," Frischer said. "The genetic approach is also providing information about the zebra mussel's evolutionary history which improves our basic understanding of this animal. We see our next steps as using the probe to study more of the ecology, the larval ecology, what happens to the veligers — how they move, mortality factors — and things we don't really have the answers to," Frischer said.

— Judith N. Hogan, New York Sea Grant

left. Zebra mussels take hold of the *Aloha*, a schooner-berge built in 1888 which sank in a gale in 1917 near Kingston, Ontario. Mussels are attached to a dislocated piece of ferrous rigging (center) and to hull timbers. The photograph was taken August 1994 in 55 feet of water. Today all surfaces of the wreck are completely covered by mussels.

right. Zebra mussels begin to cover a pulley block resting on the *Aloha*. The planking on which the block lies is almost completely covered by mussels.

(Photos courtesy of Preserve Our Wrecks (Kingston) / Gary Thibault)



## The Great Cover-up

A marine heritage preservation group in Kingston, Ontario, is currently undertaking a project to photographically record a number of local historic shipwrecks being colonized by zebra mussels.

Jonathan Moore, a marine archaeologist and member of the group "Preserve Our Wrecks (Kingston)," is concerned not only with the masking of submerged archaeological resources by zebra mussels, but also that stripping zebra mussels from the surfaces of these resources will result in damage and the loss of important information.

"Byssal threads of the mussel invariably pull off fragments of the material to which they are attached," Moore said. "Repeated cycles of mussel attachment and removal might result in serious damage to the surface of the site."

"The lakes, rivers and minor water bodies of North America contain rich archaeological resources from historic shipwrecks to prehistoric habitation sites. These benign freshwater environments can preserve archaeological resources for centuries. The introduction of the zebra mussel to these environments is a challenge to archaeologists and preservationists as zebra mussels attach themselves to historic structures and artifacts."

The initial impact of zebra mussel attachment is the loss of "archaeological visibility" — the surfaces of a historic shipwreck can literally disappear under layers of mussels.

"Like an historic building covered in ivy, we can recognize its shape, but details of its surface and construction are obscured," Moore said. "If we cannot see, recognize, accurately measure and examine diagnostic features of a shipwreck (i.e., steering mechanisms, machinery, hull construction or fastenings) free of mussels, our ability to study the site is dramatically impacted. The dilemma we face is that the removal of mussels to expose the sources of the site is potentially destructive."

Moore would like to hear from others with similar concerns. He can be contacted at Marine Museum of the Great Lakes at Kingston, 55 Ontario St., Kingston, Ontario, Canada K7L 2Y2, or reached via email: [jmoore@limestone.kosone.com](mailto:jmoore@limestone.kosone.com).

## Zebra Mussels in the Illinois River: Here Today, Gone Tomorrow?

A mysterious new chapter was written in 1995 in the ongoing Illinois River zebra mussel saga. Almost no mussels were found this fall in the lower 120 miles of the river.

In October, Illinois Natural History Survey (INHS) biologist Scott Whitney sampled sites in the area and found less than one gallon bucket of live zebra mussels. Whitney had found abundant mussels at these sites earlier this summer.

"In 1993, our divers were collecting five gallons in five minutes at these same sites," INHS biologist Doug Blodgett said. "We were afraid we'd find something similar this fall." Instead, Whitney found piles of zebra mussel shells, almost all of which were empty — evidence of another significant die-off.

INHS biologists observed a zebra mussel population boom during surveys conducted in 1993. These populations radically declined in late 1993 and 1994 along the lower 120 miles of the river, the area regularly surveyed by INHS biologists.

"High mortality with densities at one site dropped from over 60,000 per square meter in summer 1993 to less than 600 per square meter by fall 1994," Blodgett said.

Another expanding population had been expected earlier this year.

"It's obvious zebra mussels were doing well somewhere upriver earlier this year because we calculated over 60 million veligers per second drifting by our station on a couple occasions," Blodgett said. 1995 continued to look like a big mussel year when divers found small, newly settled zebra mussels in densities of 1-5,000 per square meter in July. But between July and October something happened.

Sporadic episodes of poor water quality — low dissolved oxygen, heavy silt loads and high water temperatures — could be responsible, Blodgett speculated. As long as reproducing zebra mussels persist upriver, the lower Illinois River will be vulnerable to continuing boom and bust cycles, he believes.

— Robin Goettel, Illinois-Indiana Sea Grant

## Building New Barriers?

A small group of state and federal agencies and Great Lakes organizations recently explored alternatives to prevent the transfer of exotic species from the Great Lakes to inland water systems. The Nov. 20 meeting, "Introduction Pathway of Exotics to Inland Waters of the U. S. Chicago Sanitary and Ship Canal," was sponsored by the U.S. Fish and Wildlife Service and the U.S. Army Corps of Engineers-Chicago District.

Zebra mussels originally gained access to many U.S. inland waterways through the Chicago Sanitary and Ship Canal connection between Lake Michigan and the Mississippi basin.

Major conference concerns included identifying a barrier that would stop nuisance species such as ruffe, round goby and zebra mussels from reaching inland waters, and controlling the spread to the Illinois River. Eurasian ruffe is expected to make its way inland unless barriers are erected to block its movement.

Discussions included adding exotic species control devices to the Chicago Sanitary and Ship Canal system.

Attendees also noted that the Chicago Sanitary and Ship Canal poses a hazard by allowing non-native species (such as nonindigenous zooplankton) to enter the Great Lakes.

For further information contact Jay Troxel, Aquatic Nuisance Species Coordinator for the U.S. Fish and Wildlife Service, phone, (703) 358-1718.

— Robin Goettel, Illinois-Indiana Sea Grant

### New Publications:

## Zebra Mussels and Aquaculture

"Zebra Mussels: A Crisis in Aquaculture" is a new four-page pamphlet discussing potential problems zebra mussels can cause for aquaculturists. Written by North Carolina State University Extension Fisheries Specialist Jim Rice, the pamphlet provides suggestions for protecting aquaculture water supplies and discusses ways to prevent the contamination of water used for hauling fish and fingerlings. Other topics include the use of disinfectants, control measures for infested facilities, and the implementation of inspection and monitoring programs to detect the presence of zebra mussels.

The publication is available from North Carolina Sea Grant, P.O. Box 8605, North Carolina State University, Raleigh, NC 27695-8605, phone (919) 515-2454, email: [harriss@unity.ncsu.edu](mailto:harriss@unity.ncsu.edu).

## Zebra Mussels Make Top Ten List of Worldwide Trends

A Worldwatch Institute mail solicitation recently identified "Ten Key Findings" from the State of the World 1996, including the following:

"Economic costs of the introduction of exotic species such as the Zebra mussel [sic] in the U.S. Great Lakes are adding up to billions of dollars each year, and will likely increase, creating a drag on the region's economy."

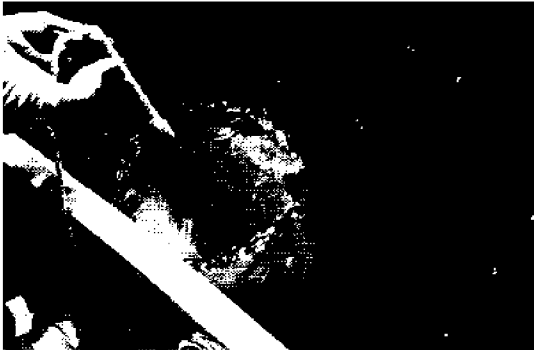
## Zebra Mussels Found in Geneva Lake

Adult zebra mussels were found on three different occasions this fall in Walworth County's Geneva Lake, according to officials at the Geneva Lake Environmental Agency.

The first sighting occurred in October. About a dozen adult zebra mussels were found attached to a dry-docked boat at Gage Marine. The boat had been moored near the city of Lake Geneva boat launch site, which is near the Geneva Lake outlet to the White and Fox rivers.

Following confirmation of the initial sighting by Wisconsin Department of Natural Resources (DNR) and UW Sea Grant staff, a lone zebra mussel was recovered from the lake during a scuba survey. Later in the fall several other mussels were reportedly found during removal of piers along the shoreline, according to Geneva Lake Environmental Agency's George Johnson.

Geneva Lake is a large (5,400 acre), heavily used recreational lake close to metropolitan Chicago and Milwaukee. The lake generally does not contain a lot of macrophytes due to its deep configuration. Once known as "The Newport of the West," and now promoted with the slogan "Enjoyed for 100 Years by the Rich and Famous," Geneva Lake had 4,500 resident boats in 1995, 60 percent of which were over 21 feet long, according to Johnson. In 1994 almost 20,000 boat launches occurred at lake ramps, suggesting great potential for spreading mussels to other inland lakes.



Zebra mussel sampling with a plankton net.  
(Photo courtesy of University of Wisconsin Sea Grant Institute / Clifford Kraft)

## Zebra Mussels in Lake Winnebago?

Lake Winnebago may be infested.

A boat moved to Oshkosh in August transported zebra mussels from Green Bay to the upper Fox River a few miles from where the river enters Lake Winnebago, Wisconsin DNR officials reported in October.

Two adult zebra mussels and a dozen smaller zebra mussels were found in part of the inboard/outboard drive system of a boat taken out of the Fox River, according to DNR fisheries biologist Lee Myers.

Because Green Bay is infested with zebra mussels, it's likely the mussels were picked up there, Myers said. This is the first detection of zebra mussels in the Lake Winnebago system.

"The adult mussels appeared to be alive, and the boat was in the Fox for about two months," Myers said. "But we had no way of knowing if the adults reproduced during that time."

Lake Winnebago is home to an estimated 25 million freshwater drum and 40,000 lake sturgeon larger than 45 inches, both of which consume native fingernail clams, according to DNR fisheries biologist Ron Bruch.

"Winnebago will be a good test case of whether fish predation can limit zebra mussel populations," Bruch said.

## Filtering the Flow As You Go

Although many companies have created products for preventing zebra mussel infestations, one boat manufacturer has devised a product designed to help prevent recreational boaters from spreading them to new locations.

MirroCraft Boats is marketing an environmentally friendly recreational boat that comes with a filtration system designed to remove zebra mussel veligers from "live well" intake water. Wisconsin boater advisory guidelines recommend that water in the live wells of recreational boats be drained when moving from one lake to another to avoid transporting veligers.

Company vice president Dan Boettcher said the live well pump intake system includes a filter that should remove particulate material less than 30 microns in size. Wisconsin Sea Grant staff plans to test the effectiveness of this system next summer.

## Mussels in the Mighty Miss'

Since zebra mussels were first found in the Mississippi River near La Crosse, Wis., in 1991, the population has grown much denser and become more widely distributed. Densities in the Minnesota stretch of the Mississippi River are highest at the southern end of Lake Pepin, near Red Wing, Minn., according to Minnesota Department of Natural Resources fisheries biologist Mike Davis. The highest densities approach 5,400 per meter square, averaging well over 1,700 per square meter at some locations.

Zebra mussels are found everywhere downstream from there, according to Davis.

"I've found specimens up to 50 mm long, with many about 20 mm long," he said. "In many areas, the average size of last year's cohort is about 10 mm."

Zebra mussels are also found at every lock and dam north of Lake Pepin. Infestations are not as dense because veligers drifted farther downstream before settling, Davis speculated.

What impacts are zebra mussels having in the river?

First, the infestation is causing industries using Mississippi River water to implement on-line control strategies. In addition, a team of natural resource agencies, led by the U.S. Fish and Wildlife Service, has moved hundreds of unionid mussels from the river to save them from becoming encrusted with zebra mussels. The unionids will be temporarily held in experimental ponds at the Genoa Fish Hatchery south of La Crosse. If unionids can be successfully maintained in hatchery ponds, more river specimens will be moved; if an effective control can be developed or if the infestation eventually subsides, the native unionids will be returned to their native habitat.

At least five recreational boats suffered problems during the 1995 boating season because zebra mussels clogged their engine cooling systems, according to John LaRocque of Northport Marina in Alma, Wis.

"Two engines were wrecked completely," LaRocque said. "Three others experienced overheating, but suffered no damage. Another boat that came up river from Iowa had so many zebra mussels on the outdrive it couldn't be turned to the right."

Mussel-caused nuisances weren't exclusive to boaters, either. Anglers reported that their lines had been cut by the mussels' sharp shells, the Minnesota DNR's Davis said.

— Doug Jensen, Minnesota Sea Grant



## Cliff's Notes

I knew something was up when he called across the locker room, "Hey, I heard on the radio that carp are going to get rid of your mussels."

Moose is always ahead of the curve. A former professional baseball player, Moose and I talk about two things — zebra mussels and sports — and this conversation wasn't going to be about my pitching arm. Moose always alerts me when the public is getting a new zebra mussel-related pitch.

Two years ago it was sponges. Before that it was red pepper in paint. Now it was carp. And once again, Moose was right. Within a week the story was in the local paper. Within a month it was in *Newsweek* accorded the same importance as Yeltsin's health and Bosnian peace talks.

It's amazing how quickly public attention is drawn to stories of salvation and harmony in nature. Zebra mussels being eaten by carp: nasty new immigrants getting beat up by the fish Americans love to hate. While the subject has merit (see related item in this newsletter) and deserves further exploration, the media should have taken a seventh inning stretch until more research is done.

Madison's *Wisconsin State Journal* was so taken by the topic that a Sunday editorial concluded that "next time you catch a carp, don't kill it — toss it back. You just might be firing an important shot in the war against zebra mussels."

In the spirit of Charley Brown, my only response is "Auggghhhhh!!!!" I'm going to stick with the sports pages — until I can figure out how to fire an important shot in the war against stupid zebra mussel stories.



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If you have zebra mussel information, contact ZMU editor Clifford Kraft at (414) 465-2795, FAX (414) 465-2376, email: [kraftc@uwgb.edu](mailto:kraftc@uwgb.edu)

World Wide Web location: <http://www.seagrants.wisc.edu/Communications/Publications/ZMU/ZMU.html>

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**Zebra Mussel Update**







# zebra mussel

Update no. 27

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## The Blue-Green Blues

Offensive summer blooms of the potentially toxic blue-green algae, *Microcystis*, have returned to some Great Lakes waters, particularly Lake Huron's Saginaw Bay and Lake Erie.

Saginaw Bay experienced blooms in both 1994 and 1995. In September 1995, Lake Erie's entire western basin was covered with what looked like "a thick slick of grass-green paint," according to the Ohio State University Stone Laboratory's John Hageman. Nuisance *Microcystis* blooms haven't occurred since the 1970s and early 1980s, before the United States and Canada lowered phosphorus inputs to the Great Lakes.

The correspondence of the 1990s algal blooms with the arrival of the zebra mussel would seem entirely coincidental, given the mussel's reputation for filtering large quantities of plankton from the water column daily.

"Since the zebra mussel's arrival, we hadn't seen, nor did we expect to see, any bloom of any kind of algae," said Alfred Becton, director of the NOAA Great Lakes Environmental Research Laboratory (GLERL) in Ann Arbor, Mich. So the algal blooms are puzzling, given the zebra mussel's acknowledged role in producing the clearest water in decades in Lake Erie and Saginaw Bay.

However, Henry Vanderploeg, also of GLERL, may have found a positive link between the zebra mussels and summer blooms of *Microcystis*. In his studies of the ecological effects of zebra mussels on Saginaw Bay, he has observed zebra mussels selectively filtering and rejecting phytoplankton in a way that could both promote and maintain *Microcystis* blooms.

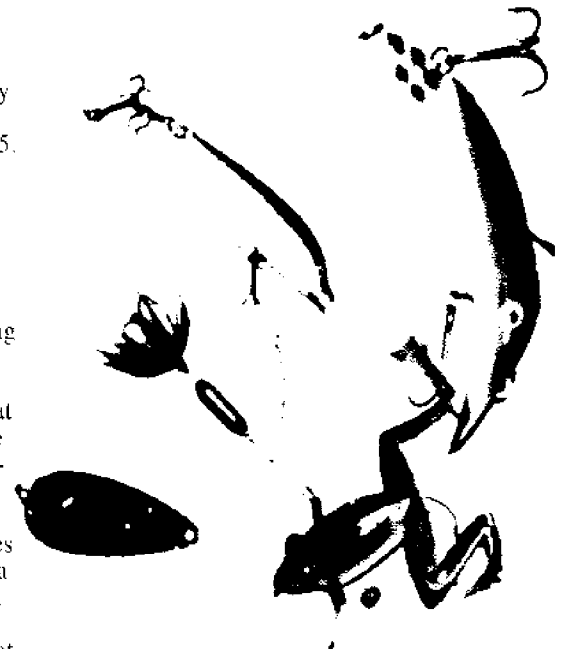
Using video equipment developed by J. Rudi Strickler of the Center for Great Lakes Studies at UW-Milwaukee, Vanderploeg made monthly observations of zebra mussel behavior during the algal blooms. Although the mussels remained open and siphoning, they exhibited a definite distaste for *Microcystis*, spitting BB-sized blobs of these algae back out into the water column, where they became resuspended. Vanderploeg speculates that these algal cells were uninjured and could continue to grow.

While the mussels seldom slowed their pumping rates, their actual feeding rate declined due to the amount of *Microcystis* they spewed back into the water. In laboratory experiments using *Microcystis* from the Lake Erie 1995 bloom and a species of small laboratory-cultured algae (*Rhodomonas*), Vanderploeg confirmed that the mussels could continue to select smaller algae for normal digestion while expelling *Microcystis*.

Because *Microcystis* may have a competitive advantage over other algae in conditions of high ammonium, the form of nitrogen excreted by the zebra mussels, it would be expected that fertilization of Saginaw Bay by zebra mussels would encourage *Microcystis*. But despite the high density of zebra mussels, Vanderploeg found nitrate concentrations (a form of nitrogen used by most algae) were 10-20 times higher than ammonium concentrations in the bay. Phosphorus, another element that might preferentially stimulate *Microcystis*, was excreted by the mussels at very low levels. Therefore, it appears that nutrient excretion by the mussels was not a major factor in promoting the *Microcystis* bloom.

In addition to the aesthetic drawbacks of blue-green algal blooms and potential food chain disruptions, biologists are concerned about the potential toxicity of *Microcystis*. The algae is known to be responsible for some bird and fish kills and to cause gastrointestinal distress to humans.

"In fact," Vanderploeg said, "the algal toxins may be what is causing the zebra mussels to reject *Microcystis*." ▶



Zebra mussel-influenced improvements in water clarity have prompted some anglers to change the colors of their lures. See story on page 2.

(Photo courtesy of New York Sea Grant Institute)



Zebra mussel expelling *Microcystis* as loosely consolidated pseudofeces.

LEFT: Mussel is filtering with siphons in normal position. "E" shows excurrent siphon. "I" shows incurrent siphon.

Continued from page 1 ▶

MIDDLE: Excurrent siphon retracted and incurrent siphon starting to expell the *Microcystis* as pseudofeces.

RIGHT: Pseudofeces ejected. (Spot in front of incurrent siphon is a lens flare).

(Photo courtesy of Michigan Sea Grant College Program / Hank Vanderploeg)

Vanderploeg is continuing to examine this issue. In the meantime, scientists caution that the presence of toxins in the algae does not automatically make *Microcystis* harmful to fish and humans. According to Wayne Carmichael, an expert in algal toxins at Wright State University in Dayton, Ohio, a certain toxin level must be reached, which depends on the algae's growth conditions and on how fish or humans are exposed.

Martha Walter, Michigan Sea Grant

## Alluring Colors

Zebra mussel-influenced improvements in water clarity have prompted some anglers to change the colors of their lures.

Before zebra mussels arrived, Lake Ontario's color was blue-green. The lake's current deep-blue color is more typical of lakes that contain fewer suspended particles, such as Crater Lake and Lake Superior.

"Years ago, the brighter lure colors seemed to work well, because the water had a murkiness to it," said Lake Ontario charter boat captain Tim Walsh, who noted that even with the change in water clarity, orange and chartreuse lures still work well. With 10 fishing poles on his boat, *Reel Time*, Walsh tests the effectiveness of multiple lure colors until he finds the combination that works best.

New York Sea Grant Extension Specialist David MacNeill recommends anglers use fluorescent orange lures in turbid waters close to shore, and fluorescent green and orange lures for clearer offshore waters. For clear, open waters, fluorescent greens and whites are best, he said.

Julie Zeidner, New York Sea Grant

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## Southern Accents

As zebra mussels spread across the country, the body of zebra mussel literature keeps growing. For the southern region of the United States, Louisiana Sea Grant's *Southern Region Zebra Mussel Newsletter* offers information about new settlement sites and control experiences.

The spring 1996 issue covers adult mussel and veliger densities at power plants and industrial facilities along the southern reaches of the Mississippi River. Along with reports on recent research, new products and regulations relative to zebra mussel dispersal, the newsletter offers such tidbits as the fact that no municipal water intakes in the New Orleans area, except Jefferson Parish Waterworks, have yet been treated for zebra mussels.

To receive copies of the newsletter, which is free, contact Marilyn Barrett-O'Leary, Louisiana Sea Grant, Louisiana State University, Baton Rouge, LA 70803-7507, phone (504) 388-6451, email [moleary@lsuvm.sncc.lsu.edu](mailto:moleary@lsuvm.sncc.lsu.edu).

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## Crayfish Population Boom

Crayfish numbers have dramatically increased at a natural, rocky (cobble) reef in southwestern Lake Michigan as a result of the zebra mussel invasion, according to Nancy Tuchman, an Illinois-Indiana Sea Grant-funded researcher.

Prior to the 1992 invasion, crayfish (mostly *Orconectes propinquus* and *O. virilis*) were sparse (about 0.5/m<sup>2</sup>) in southwestern Lake Michigan, the Loyola University professor said. In 1993, however, crayfish numbers doubled. By 1995, the population had increased twelvefold to six per square meter, about one crayfish every few feet.

By filtering the water, zebra mussels have increased the water clarity in Lake Michigan, which has affected the amount of light reaching the reef, Tuchman said. Because the reef received more light, there was an increase in algae and in organisms that eat algae, such as insects. This has led to increases in the number of crayfish, which consume both algae and insects.

Tuchman noted she frequently finds crayfish hiding in algae rather than in rock crevices, which is their preferred habitat, because zebra mussels now cover the crevices.

Pat Charlebois, Illinois/Indiana Sea Grant



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(Photo courtesy of Minnesota Sea Grant / Jeff Gunderson)

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## New Publications

Three new free publications on nuisance exotic aquatic species have been printed during the past year courtesy of Brunswick Marine:

• **A Spiny Water Flea, *Bythotrephes cederstroemi*: A New Unwelcome Invader to the Great Lakes** (FS-049)

• **Ruffe *Gymnocephalus cernuus*** (FS-064)

• **Round Gobies Invade North America** (FS-065)

If you would like copies of these publications, please contact the Ohio Sea Grant College Program, phone (614) 292-8949. Large orders may require reimbursement for shipping costs.

# Zebra Mussels Costing \$120 Million in Five Years

Great Lakes facilities using surface water incurred total costs of \$120.4 million for zebra mussel monitoring and control between 1989-1994, according to the results of a 1995 survey by Ohio Sea Grant researcher Leroy Hushak.

Hushak's findings were summarized in the *Aquatic Nuisance Species Update (ANSU)*, a quarterly publication of the Great Lakes Commission.

According to *ANSU*, the survey was sent to 1,400 Great Lakes facilities. In total, 585 facilities responded, 165 of which said they used well water or purchased water rather than surface water. Of the 420 surface water facilities, 160 said they had zebra mussels at their facilities. One hundred forty reported zebra mussel monitoring and control expenses of \$60.2 million.

Facilities reporting monitoring and control costs spent an average of \$430,000 during 1989-1994, according to the survey.

Great Lakes facilities reported average cumulative expenditures of \$538,000, compared to nearly \$200,000 spent by facilities located on tributaries or waterways not connected to one of the Great Lakes.

Survey results provide a benchmark on which to assess zebra mussel costs in the Great Lakes Basin. They also can be used to project costs in other parts of the country where the zebra mussel is spreading, such as the lower Mississippi River Basin and many inland lakes and rivers.

For further information, contact Leroy Hushak, phone (614) 292-3548 or email [hushak.l@osu.edu](mailto:hushak.l@osu.edu), or *ANSU* editor Kathe Glassner-Shwayder at (313) 665-9135 or email [shwayder@glc.org](mailto:shwayder@glc.org).

## Shocking Mussels

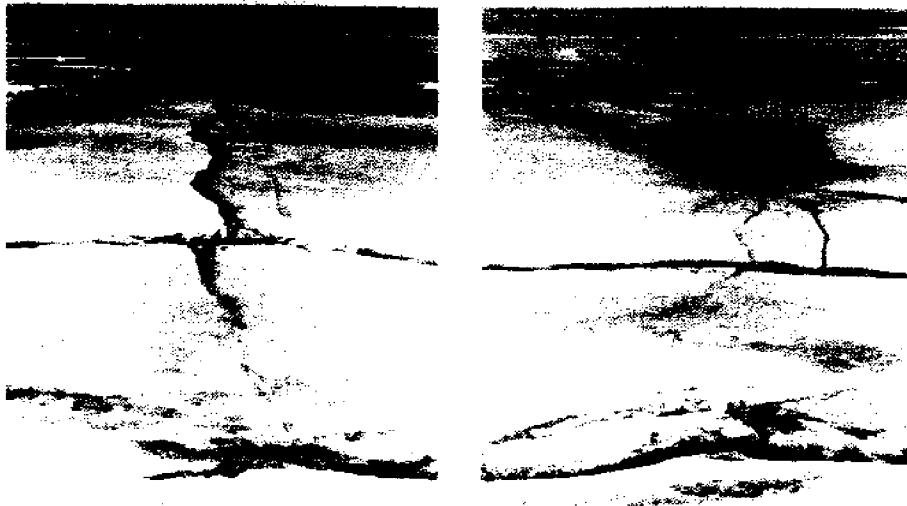
The Champlain Water District will test the use of plasma sparker technology this spring to keep zebra mussels from clogging a 2,500-foot-long water intake line at the district's treatment plant in South Burlington, Vt.

The sparker works on the same principle as a spark plug. It creates a high-energy arc -- basically a miniature lightning bolt -- between two submerged electrodes. The shock wave from this arc will point down the water-intake line, preventing zebra mussels from attaching to the inside surface of the pipe.

The water district currently is using chlorination to control zebra mussels. According to materials provided by the water district, the \$91,500 project is being funded with grants from the Green Mountain Power Corporation, the Electric Power Research Institute, the New England Water Works Association, Champlain Water District and "in-kind" services from the water district and Clancy Environmental Consultants, Inc.

Sparke units have previously been installed to protect the Vergennes/Panton and St. Alban's, Vt., water systems.

For further information, contact James Fay of the Champlain Water District, phone (802) 864-7454.



After winter ice disappears from lakes in the Upper Midwest, few live zebra mussels are found along the shoreline. This mid-March photo of the Green Bay ice cover was taken at Bayshore Park, near Dykesville, Wis.

(Photo courtesy of University of Wisconsin Sea Grant Institute / Clifford Kraft)

## Collected Papers on Zebra Mussels in Saginaw Bay

A special section of the *Journal of Great Lakes Research (JGLR)* includes results of coordinated studies conducted during the early years of the zebra mussel invasion of Lake Huron's Saginaw Bay. The studies were largely conducted by scientists at the Great Lakes Environmental Research Laboratory (GLERL) at Ann Arbor in collaboration with scientists funded by several other agencies.

The results, which can be found in volume 21, No. 4, of the *JGLR*, provide a uniquely comprehensive look at the early ecosystem effects of zebra mussels. Papers document broad temporal and spatial changes in water quality parameters, primary production, nutrients, and submersed aquatic plants and benthic algae. Other studies report impacts on planktonic bacteria, protozoa and nutrient dynamics.

In a preface to the articles, GLERL scientists Tom Nalepa and Gary Fahnenstiel note that the studies "illustrate the dramatic and immediate impact *Dreissena* can have on a given ecosystem." Water quality measurements in Saginaw Bay over the past 20 years show three distinct phases: pre-phosphorus control, post-phosphorus control and post-zebra mussel.

The preface continues: "Given findings in Saginaw Bay, the establishment of *Dreissena* has long-term implications when defining ecosystem response to management actions. For one, eutrophication models that link nutrient loadings and pelagic measures of water quality are no longer valid in areas with large populations of *Dreissena*."

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## Upcoming Conference

The Illinois-Indiana Sea Grant Program is hosting a zebra mussel conference focusing on control and prevention for inland water users June 12-13 in St. Louis, Mo.

The conference will include case studies of successful control systems developed by Great Lakes utilities, discussions of regulatory issues and information about the biological and ecological impacts of zebra mussels. Commercial vendor exhibits will be on display. For further information, contact the Illinois-Indiana program at (217) 333-9448.

## Return of the Natives

Water plants that had not been seen in more than 30 years may be staging a comeback in Lake Erie due to improved water clarity resulting from the presence of zebra mussels, Ohio State University researchers have reported.

Researchers located nine plant species that have either returned to the lake or appeared for the first time, said Ronald L. Stuckey, professor emeritus of plant biology at Ohio State. Stuckey and David Moore, a former Ohio State graduate student, reported their findings in the June issue of the *Ohio Journal of Science*. The inventories were conducted at Put-in-Bay Harbor, part of an island group in western Lake Erie.

Fourteen plant species have survived since zebra mussels were first detected in the lake in 1988, the researchers noted. One plant, *Vallisneria spiralis*, or tape grass, has grown in such abundance that it covers most of the bottom of Put-in-Bay Harbor, Stuckey said.

One cause for the resurgence of these plants, scientists believe, may be improved water clarity caused by zebra mussels, which consume algae and other organisms on rocks and on the bottom of the lake. Clearer water allows for more photosynthesis and increased growth of certain plant species, Stuckey said.

"Before the presence of the mussels, the water was very turbid," he said. "Many of the plants received little or no sunlight. Now it's clearer, and the lake flora seems to have returned to a condition similar to what it was like 100 years ago."

Stuckey's plant research in Put-in-Bay Harbor began in the summer of 1967. Since that time, he has noted declines in certain plant species and increases in others.

Following the 1988 zebra mussel invasion, Stuckey noticed a significant rise in the abundance of many of the plant species. He also noted the return of some species that had not been reported in decades. One of those, *Potamogeton pusillus*, or small pondweed, had not been seen in more than 30 years.

"It's apparent that the seeds for this plant and other annuals have been able to survive on the lake bottom for 30 or 40 years," he said.

Species new to Lake Erie have also been identified. Specimens of *Najas minor*, commonly called minor naiad, were obtained in 1994 near the docks at Gibraltar Island.

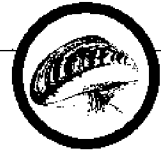
Lake Erie's clearing has not been good for all aquatic plants. Five species of low-light plants, such as Sago pondweed, a submersed species, aren't as abundant as they were a few years ago.

"Plants have a tolerance to certain conditions," Stuckey said. "Some plants are quite tolerant to turbid water conditions, and some flourish under those conditions. Others are intolerant to turbid conditions. These are the ones that are returning."

Although the studies were done in Put-in-Bay Harbor, Stuckey said conditions should be similar in other western Lake Erie harbors.

"Aquatic plant growth of this type can be beneficial to certain aquatic animals," he said. "These plants can serve as a food source, and they also can increase the level of oxygen in the water. Plant growth may also cause an increase in the zebra mussel population. It's really too soon to tell."

Kelli Whitlock, Ohio State University Communications



## Task Force Fact Sheet

A well-run zebra mussel preparedness program can save time and money, particularly in areas where zebra mussels have yet to be detected. That's one of the conclusions of "Organizing A Zebra Mussel Task Force," a new fact sheet produced by North Carolina Sea Grant.

Written by Sea Grant Water Quality Specialist Barbara Doll, the fact sheet discusses the benefits of forming a zebra mussel task force, describes various roles they have taken, gives tips on organization, and supplies the phone numbers and addresses of task forces in the United States. For more information, contact Rachel Wharton at 919/515-2454, or email: [r\\_wharton@ncsu.edu](mailto:r_wharton@ncsu.edu).

## Zebras and Quaggas in the St. Lawrence

The proportion of quagga mussels in the St. Lawrence River has been steadily increasing over the past four years, according to Environment Canada scientists.

The proportion of quagga mussels in the overall population of mussels has increased at a rate of two percent per year, and last summer represented six percent of the total number of mussels attached to navigation buoys, according to Yves de Lafontaine, chief of the Aquatic Contaminants Section at the St. Lawrence Centre of Environment Canada. The increase was more pronounced in Lake St. Francis, where quagga mussels now represent a fourth of all mussels sampled in 1995.

The St. Lawrence Centre of Environment Canada is operating a program to monitor the distribution and abundance of zebra mussels from Cornwall to Quebec City. Every fall, mussel densities are recorded from more than 250 navigation buoys retrieved from the St. Lawrence River.

"Considering that quagga mussels presumably prefer deeper waters," de Lafontaine said, "the measured relative proportion of quagga mussels attached to buoys occupying the first 1.5 meters of surface water may represent a minimal estimate of the relative abundance of quagga mussels for the St. Lawrence River. It is, however, relatively clear that quagga mussels have gradually increased in numbers over the last four years."

I confess that I'm not fond of surveys. Or, more accurately, I don't like being surveyed because I don't like being asked weird questions. I always want to answer the question with a question: why are they asking that? One memorable question from the last survey I answered was, "When you think of the Pillsbury Doughboy, what image comes to mind?" Why did they want to know?

But, unexpectedly, my work as a zebra mussel researcher brought me a survey I liked. In fact, it was the final frontier of survey subjects: invasion by aliens from outer space. I was going through my mail at the office when I came across the "Planetary Protection Survey," which was apparently being conducted by NASA. Here's a sample:

"As a zebra mussel researcher you are no stranger to the dangers posed by nonindigenous or exotic species... But have you considered the dangers that life forms from other planets may pose to Earth... Your opinions may be important in determining what some of NASA's policies will be."

Wow. This was heaven for someone raised in the era of "The Twilight Zone," "Star Trek" and "E.T." Of course, I have considered the dangers that life forms from other planets may pose to Earth. People my age have probably spent more time discussing alien invasions than important issues like U.S. foreign policy or the Pillsbury Doughboy. This is one subject on which I've had an unwavering opinion since I was a child, and my education and life experiences haven't changed my attitude one bit.

My answer? Let them come. I mean, how much worse could they be than human invasions? And if they're so smart, why would they want to come here anyway? We're too bony to eat, and not very smart or friendly.

Happily, I filled out the survey.

So once again, zebra mussels added a new dimension to my life. I am now officially on record as having helped establish U.S. policy towards invaders from outer space.

A childhood fantasy has come true!





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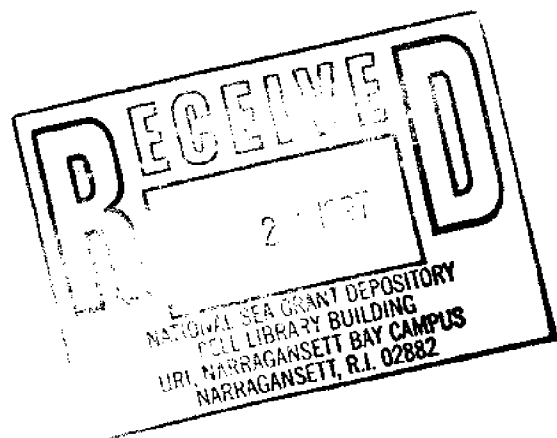
If you have zebra mussel information, contact ZMU editor Clifford Kraft, phone: (414) 465-2795, FAX: (414) 465-2376, email: [kraftc@uwgb.edu](mailto:kraftc@uwgb.edu)

World Wide Web location: <http://www.seagrants.wisc.edu/Communications/Publications/ZMU/ZMU.html>

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