

## 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!**

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### 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.
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**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**

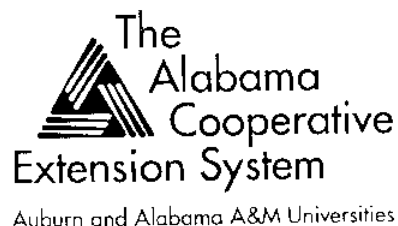
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**ALABAMA SEA GRANT EXTENSION**  
Auburn University  
Marine Extension and Research Center  
4170 Commanders Drive  
Mobile, Alabama 36615  
Phone: 334-438-5690

**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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Illustrations provided by Michigan Sea Grant Program

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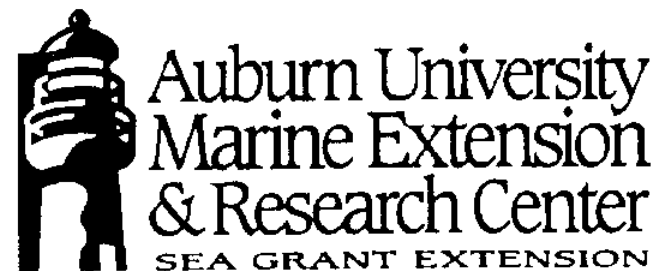
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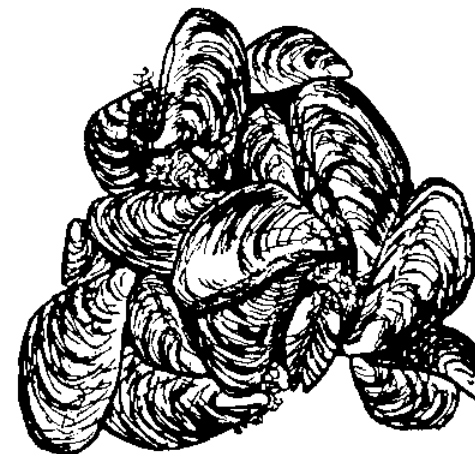


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**BOATERS:**

**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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Cooperative  
Extension Service  
AUBURN UNIVERSITY

MASGP-95-008

AUMERC-ZM-95-1

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Illustrations provided by Michigan Sea Grant Program.

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Auburn University  
Marine Extension  
& Research Center  
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.

## Ohio Sea Grant

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Sea Grant is a program within the National Oceanic and Atmospheric Administration (NOAA), Department of Commerce. Ohio Sea Grant is one of 29 state programs nationwide that work to improve the wise use and management of marine and Great Lakes resources for public benefit. Sea Grant uses university expertise in research, education and technology transfer to help solve the problems and challenges of the oceans and the Great Lakes. This publication was produced by Ohio Sea Grant (Project AZM-1, Grant NA90AA-D-SG496).

For other publications, newsletter, conference and workshop announcements, or for advice from local experts, contact the Sea Grant program or state natural resources management office nearest you. Phone numbers for the Great Lakes Sea Grant programs follow.

Illinois-Indiana 317/494-3622  
Michigan 517/353-9748  
Minnesota 218/726-8106  
New York 800/285-2285  
Ohio 614/292-8949  
Wisconsin 608/263-3259

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.

bbyssus 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.

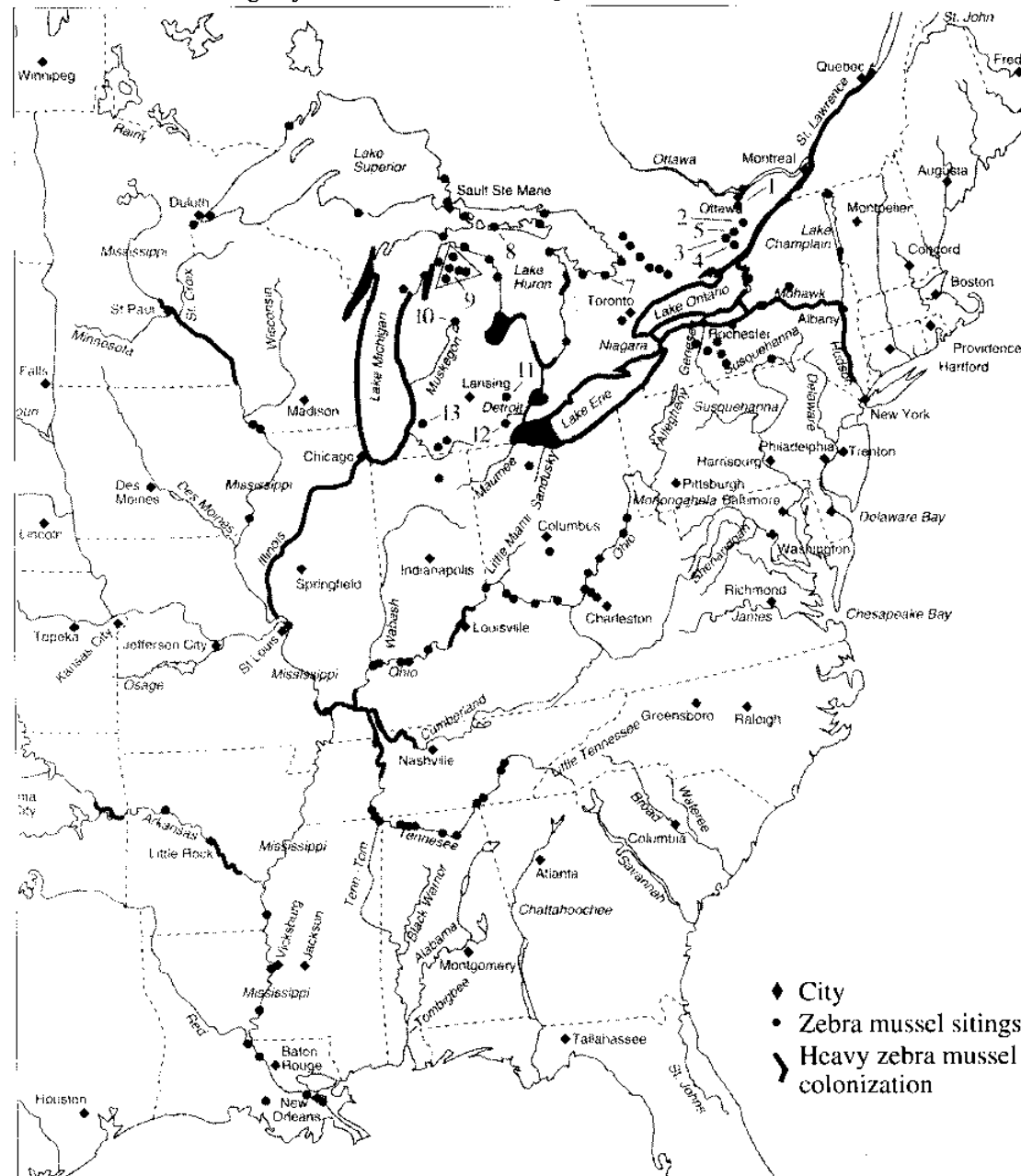
By removing significant amounts of phytoplankton from the water,

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.



- ◆ City
- Zebra mussel sightings
- ▮ Heavy zebra mussel colonization

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 110F (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.

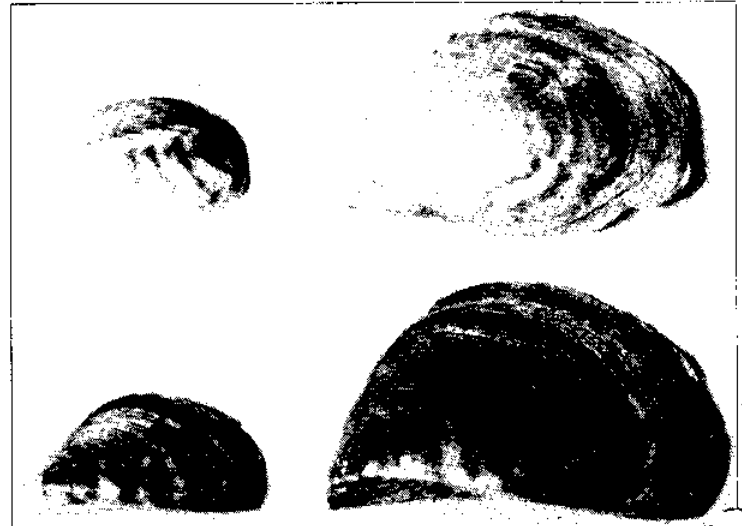
The zebra mussel is now a permanent part of the Great Lakes, many major river systems, and inland lakes; and it continues to spread rapidly

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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For other publications, newsletters, conference and workshop announcements, or for advice from local experts, contact the Sea Grant program or state natural resources management office nearest you. Phone numbers for the Great Lakes Sea Grant programs follow.

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

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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

**Zebra & quagga mussels are not just a temporary inconvenience; they are here to stay, and we must learn to live with them. Adopt preventative measures now to slow the spread and reduce any likelihood of damage to your boat.**

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
- any water
- snorkeling and scuba gear
- fishing gear and bait buckets
- scientific equipment
- 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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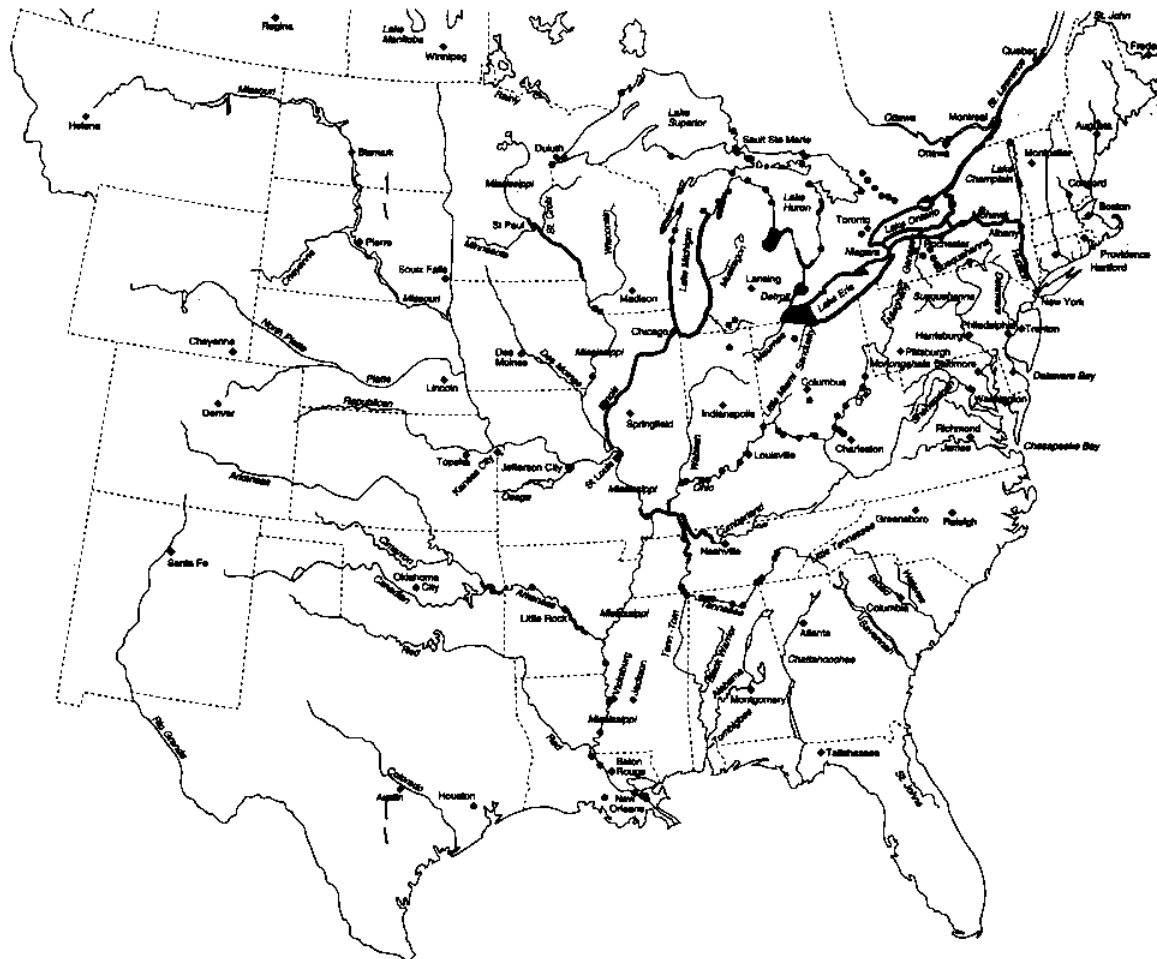
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Other U.S., state and Canadian agencies are also working on this issue. Some of the agencies working as a Great Lakes panel on nonindigenous species include:

- 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.



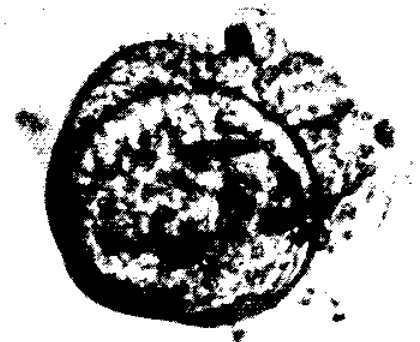
*Zebra mussels can attach to almost any hard surface, such as plastic, metal, concrete or the wooden dowel pictured above.*

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
<p><i>Note: mg/L=milligrams per liter, ppt=parts per thousand, ft/s=feet per second, m/s=meters per second.</i></p>	

## 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.

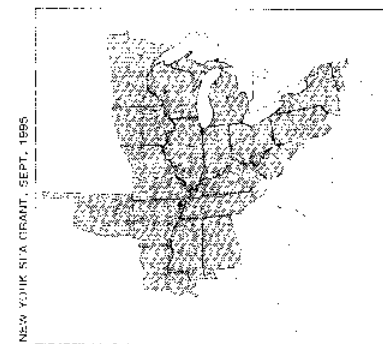
### Control

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.

**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
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# 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?

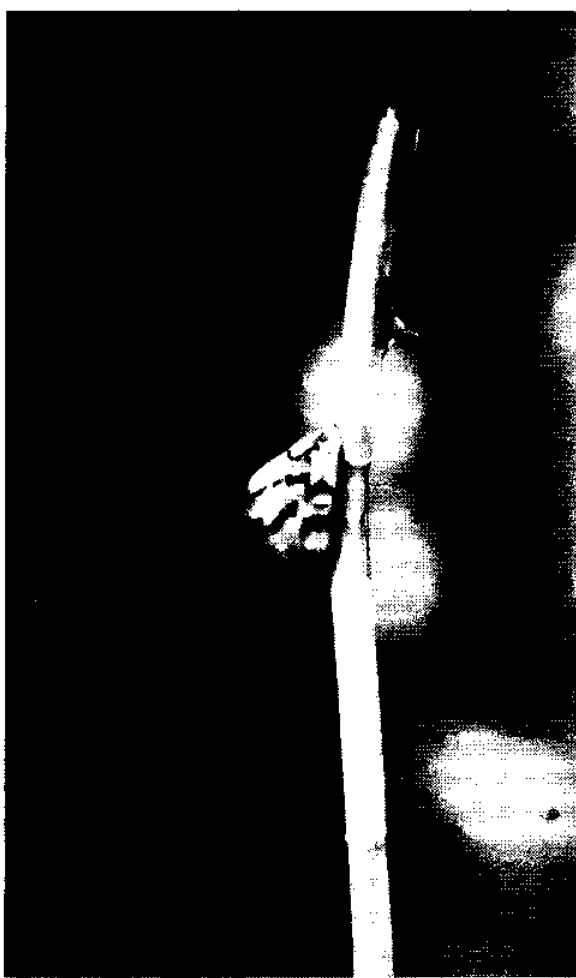
When is a body of water truly "infested?"

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.

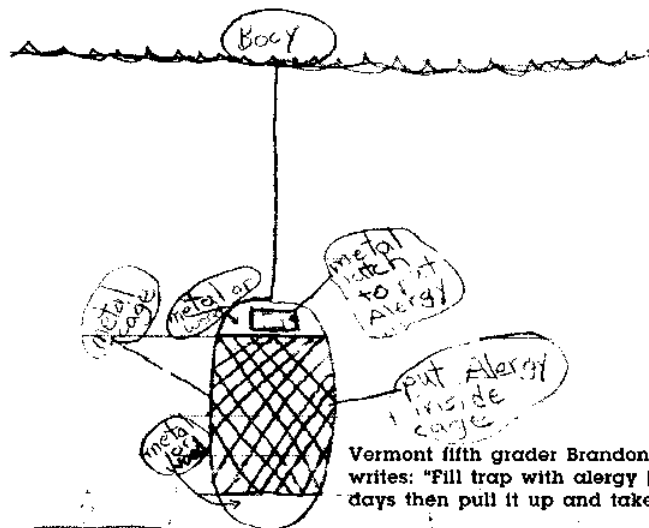
"Actions the Minnesota DNR might take depend on whether the river is officially 'infested' or not. Certain laws apply to uninfested waters, while others only apply to waters infested with exotic species. We also have specific signs for access sites on infested waters.

"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.montz@dnr.state.mn.us](mailto:gary.montz@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 algae [algae], keep in water for about a week or 10 days then pull it up and take the zebra mussels out or off."

Sand  
at bottom with  
little algae.

# 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."

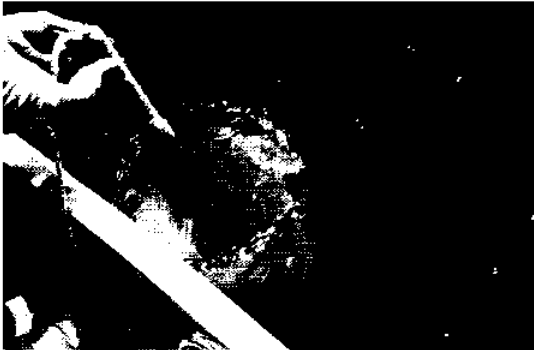
## Zebra Mussels Found in Geneva Lake

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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**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 Beeton, 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.

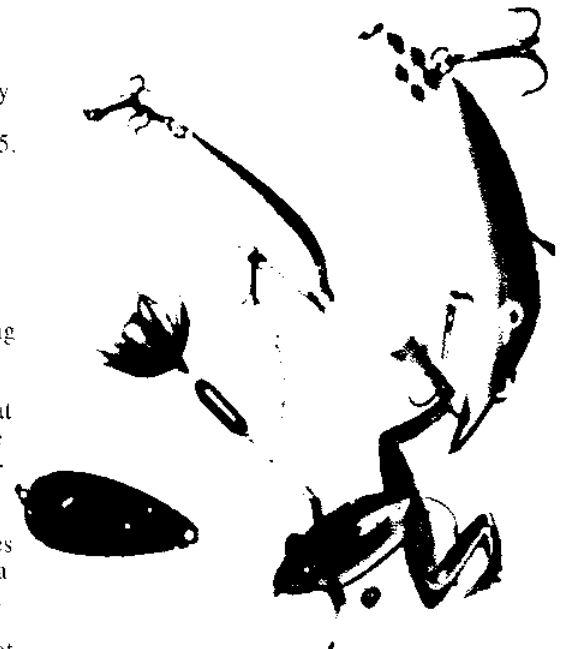
Using video equipment developed by J. Rudi Strickler of the Center for Great Lakes Studies at UW-Milwaukee, Vanderploeg made monthly observations of zebra mussel behavior during the algal blooms. Although the mussels remained open and siphoning, they exhibited a definite distaste for *Microcystis*, spitting 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

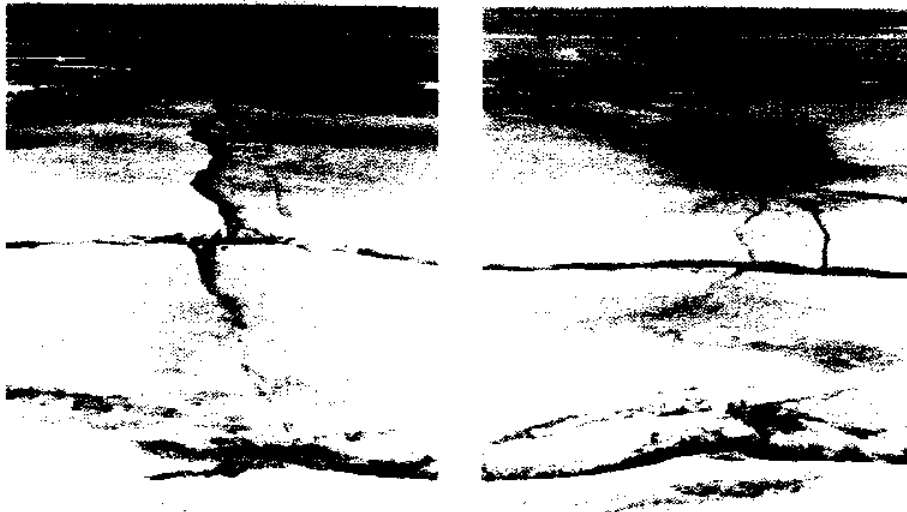
The Champlain Water District will test the use of plasma sparker technology this spring to keep zebra mussels from clogging a 2,500-foot-long water intake line at the district's treatment plant in South Burlington, Vt.

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.

Sarker 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 americana*, 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.

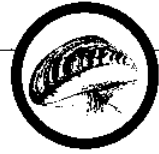
Lake Erie's clearing has not been good for all aquatic plants. Five species of low-light plants, such as Sago pondweed, a submersed species, aren't as abundant as they were a few years ago.

"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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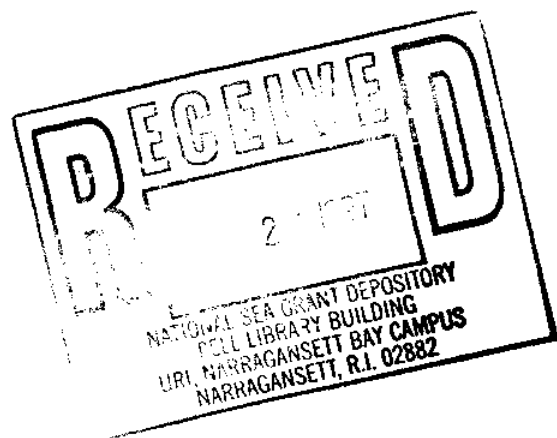
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