Fact Sheet 045

Zebra mussels in Lake Erie: The invasion and its implications

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Zebra mussels *(Dreissena polymorpha)* were almost unheard of by Lake Erie shoreline residents until 1989. By the autumn of 1989 zebra mussels had colonized the surfaces of nearly every firm object in Lake Erie. Colonies also have been discovered throughout Lake Ontario and in Lake Michigan's Green Bay. These areas, along with Lake Huron, are likely to experience extensive colonization during 1990.

Close-up of a zebra mussel shows the tuft of byssal threads used for attachment. Particles on the ends of the threads are debris

Where did they come from? How will they impact Lake Erie's flora, fauna and human uses? Can they be controlled? Is the problem being studied? Questions about zebra mussels in Lake Erie abound, but finding answers is much more difficult. What follows are some answers to the questions posed here.

The invasion

Western and central Europe have lived with zebra mussels for nearly 200 years. Most of the available information comes from Europe, often needing translation into English. But comparing the Great Lakes situation to that of Europe won't predict the impact upon Lake Erie with accuracy. Europe's industries and commerce developed on water bodies that were already populated with zebra mussels. *Dreissena* suddenly arrived in Lake Erie to find an industrialized, plankton-filled Great Lake that is home to tens of millions of walleye and other important species.

Dreissena polymorpha originated in the Ponto Caspian region of Poland, Bulgaria and Russia. Canals built during the late 18th century allowed the mussels to begin spreading through Eastern Europe. Throughout the 1800s canals were built across the rest of Europe. The canals made bulk shipping much easier but also expanded the zebra mussel's range. By the 1830s the mussels had covered much of the continent and invaded Britain.

The first introduction of zebra mussels into the Great Lakes appears to have occurred in 1985 when one or more transoceanic ships discharged ballast water into Lake St. Clair. The freshwater ballast, picked up in a European port, likely contained zebra mussel larvae and possibly yearlings. Being a temperate, freshwater species, the zebra mussels found the plankton-rich Lakes St. Clair and Erie to their liking.

The zebra mussel's reproductive cycle is the key to its rapid spread and abundance. Egg production starts when the water temperature warms to about 54°F (12°C), usually in early May along Lake Erie. The eggs are fertilized outside the shell and within a few days hatch into free-swimming larvae. Zebra mussels continue producing eggs until the water cools below 54°, generally in October. A fully mature female mussel can produce over 30,000 eggs per season.

The free-swimming larvae are called veligers. They can keep themselves suspended in the water for at least eight days, allowing currents to scatter them far and wide. If the larvae don't settle onto firm objects in that time period they die. The majority probably suffer this fate. Those that find a hard surface quickly attach themselves to it and transform into the typical, double-shelled mussel shape.

Zebra mussels generate a tuft of fibers known as byssae, or byssal threads, from glands in their feet. The byssae protrude through the hinged area of their shells. These threads attach to hard surfaces with an adhesive secretion which anchors the mussels in place. When necessary, yearlings can break away from their attachments and generate new, buoyant threads which allow them again to drift in the currents and find a new surface.

Any firm surface that's not toxic will be colonized by zebra mussels. Rock, metal, wood, vinyl, glass, rubber, fiberglass, paper, plants, other mussels-the surface needs only to be hard. Beds of mussels in some areas of Lake Erie now contain over 30,000 and sometimes up to 70,000 animals per square meter.

Zebra mussel colonies seem to show little regard for light intensity, hydrostatic pressure (depth), or even temperature when it is within a normal environmental range. Colonies grow rapidly wherever oxygen and particulate food is available and water currents do not exceed six 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. The most extreme depth on record comes from an Italian researcher who measured colonies of 20,000 zebra mussels per square meter at a depth of 164 feet in Italy's Garda Lake.

While reported to grow nearly two inches in length, most zebra mussels are the size of a fingernail. Tiny zebra mussels readily attach to older ones, causing colonies to grow rapidly to depths of several inches.

Recent observations of new colonies suggest that zebra mussels may be able to gradually colonize soft, muddy bottoms. Hard objects deposited in or on the mud, such as pieces of native mussel shells act as nuclei for settling post-veligers. As a few mussels begin to grow, attached to their shell "nucleus," they in turn serve as hard substrate for additional colonization. In this way, extensive mats of zebra mussels can form on soft lake bottoms.

The free-swimming veligers usually reach their greatest abundance at depths of 10 to 23 feet, and in many cases have been observed to resist going below the thermocline. The larval mussels are more sensitive to low temperatures than are the adults. Both life stages are sensitive to low levels of dissolved oxygen, particularly as temperatures increase. Young adult zebra mussels typically migrate from the shallow habitats they occupy in late summer to deeper areas, increasing the densities of zebra mussels found on deep structures during the winter.

Biological and ecological concerns
The feeding method of zebra mussels points to one of the growing concerns in regard to Lake Erie's food chain. Each adult mussel is capable of filtering about one liter of water per day. Nearly all particulate matter, including the plankton, is strained from the water. The zebra mussels eat mostly algae, but select primarily the 15-40 micrometer size range for consumption. Instead of passing the uneaten plankton back into the water, the mussels bind it with mucous into a pellet called a pseudofece. These pseudofeces are ejected from the mussels' siphons and accumulate among the shells in the colonies. Thus, a considerable quantity of plankton is removed from the water, unavailable to microscopic crustaceans which feed larval and juvenile fishes and unavailable to the plankton-feeding forage fish which support Lake Erie's sport and commercial fisheries.

Canadian researchers have calculated that if zebra mussels achieved a uniform density of 7,000 animals per square meter allover western Lake Erie; they would be able to filter the entire Western Basin once a day. But much of the Western Basin is mud flats that aren't significantly colonized. Therefore, it would take the mussels several days to filter all the water. That's little consolation in a lake in which the food web is largely dependent upon plankton.

Other concerns are arising regarding the reefs and other rocky habitat. Most rocky areas appear to be almost completely covered with mussels already. The zebra mussels attach to each other, sometimes forming layers that are several inches thick. The accumulation of pseudofeces in these beds creates a foul environment. As the waste particles decompose, oxygen is used up and the pH becomes very acidic. Research is needed to determine if these anaerobic, acidic conditions will be detrimental to the hatching success of reef-spawning fish species such as walleye, white bass and small mouth bass.

Zebra mussels are known to be intermediate hosts for a number of parasites which can also infect certain fishes and birds. While the European experience with *Dreissena* has not indicated a major problem with disease or parasites, it merits further observations in North America.

Industrial and commercial concerns
The zebra mussel's proclivity for hard surfaces located at moderate water depths has made water intake structures, such as those used for thermal power plants or municipal water treatment plants, susceptible to clogging during even the earliest stages of the Great Lakes invasion. During 1989, plants located on the Michigan and Ontario shorelines of Lake Erie reported significant reductions in pumping capabilities due to zebra mussel encrustment, a trend that surely will continue.

Several approaches to zebra mussel control on intake structures have been examined, including pre-chlorination, preheating, electrical shock and sonic vibrations. Control methods that currently appear most feasible include pre-chlorination, ozone injection and sand bed filtration. Pre-chlorination has been the most common treatment used to date; but it also raises concerns about the toxicity of chlorinated compounds to other aquatic organisms.

Zebra mussels are very sensitive to high temperatures. Researchers have obtained 100 percent mortality after five hours at 90° or 91° F, but after only 15 minutes at 104° F. Other reports show minor variation around these figures, but they clearly indicate that heat can be an effective control for zebra mussel infestations. Methods for applying heat to very large underwater structures, however, are very difficult.

Recreational industries along Lake Erie already have been impacted by zebra mussels as unprotected docks, breakwalls, boat bottoms and engine out drives were rapidly colonized during 1989. *Approved antifouling paints containing copper have been effective in resisting infestations on boats.* Aluminum boats and out drives can be protected by applying approved paints containing slow-release polymers of tributyltin (TBT). (After March 1, 1990 it will not be legal to sell restricted TBT paints to persons who do not hold a pesticide applicators certificate or for unlicensed persons to apply restricted paints. TBT-containing paints sold in 16 ounce spray cans and used for outboard engines and lower units may still be purchased and used by uncertified persons. Consult with your marine maintenance person.) Still, reports are numerous of boat engines overheating due to cooling water inlets being clogged by colonies of zebra mussels. Boaters probably will need to make frequent inspections of these areas in the future.

Lake Erie's beaches are also likely to be impacted by zebra mussels. By autumn of 1989, extensive deposits of zebra mussel shells could be seen on many beaches. The extent of these deposits seemed to vary with successive periods of high wave activity. As sharp-edged shells accumulate along swimming beaches, the soft, warm sands which attract recreationalists may no longer be so appealing.

Zebra mussel control?
Lake Erie-wide control of zebra mussels currently appears to be out of the question. After 200 years of infestation,' the European community hasn't been able to develop a chemical toxicant for lake-wide control that isn't deadly to other important 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 occurs in Germany's Rhine River which hosts the highest densities of zebra mussels ever found in central and Western Europe. Over wintering diving ducks and coots were seen to consume up to 97 percent of the standing crop of mussels each year, although the mussel population was replenished each summer by mass migrations of yearlings.

Diving ducks appear to hold less promise for Lake Erie. The most likely species to prey on zebra mussels are scaup, canvasbacks and old squaws. But scaup populations are depressed to the point that the special late hunting season for them was curtailed in 1989, and canvasbacks are so rare that they are totally protected. Old squaws rank in the rare visitor category.

Certain Lake Erie fish species are likely to use zebra mussels in their diets, but research is needed to determine which ones will act as predators and just how much effect their grazing will have. Freshwater drum, or sheepshead, have been seen to feed substantially on zebra mussels at least on occasion, and yellow perch have been reported to sometimes contain a small zebra mussel or two. Much needs to be learned about natural predators.

Potential for spread in inland waters
Zebra mussels can potentially spread from the Great Lakes to inland waters either as veligers transported in water or as newly transformed young adults attached to boat hulls, engines fish cages or on a number of other items. Waterfowl and other wildlife may also aid in the dispersal of zebra mussels carrying veligers in wet fur or feathers.

Out of the water, adult zebra mussels appear very hardy. With their shells closed, they can survive drying for several days. In moist environments, they can survive out of the water even longer.

Wildlife agencies have urged boaters to clean boat hulls, trim tabs, outdrives and outboard lower units, and to disinfect live wells with bleach before transfer- ring a boat from Lake Erie to inland waters.

Even more significant pathways for the spread of zebra mussels to inland waters are the existing diversions of Great Lakes water to other watersheds. The Chicago Sanitary Canal carries water each day from Lake Michigan to the Mississippi River. Likewise the Mohawk River connects Lake Ontario with the Hudson River.

Most authorities consider the spread of zebra mussels across North America to be almost a certainty. The southward spread probably will be limited by average summer water temperatures above 81°F. The northward spread might be limited by Canadian soils deficient in calcium or by summer water temperatures below 54°F. But the broad region having favorable environmental conditions for zebra mussels could extend from the East Coast to the West Coast and from Canada to our southernmost states.

The zebra mussel very likely will be a permanent part of the Great Lakes environment. Increased support for research is needed to gain understanding of its effects upon the lake's ecosystem, industries and the economic implication. Theoretically, zebra mussel populations should peak a few years after the initial infestation and then decline to a somewhat lower level, depending upon predation and the lake's carrying capacity. But there's little doubt that the zebra mussel’s impact will be felt by great numbers of people who use Lake Erie.

Zebra mussel research & **Ohio Sea Grant's role**
The Lake Erie Programs at The Ohio State University, which includes Ohio Sea Grant, has become the unofficial center of "Ohio's Zebra Mussel Research Program."

Ohio Sea Grant and the Division of Wildlife have identified the following ten research needs.

1) Zebra mussels' biology and life history
2) Zebra mussels' impact on Lake Erie plankton
3) Zebra mussels' impact on walleye spawning
4) Freshwater drum feeding on zebra mussels
5) Perch and walleye feeding on zebra mussels
6) Fish impact on eating zebra mussels
7) Benthic impacts of zebra mussels
8) Control of zebra mussels
9) Transportation to central Ohio and beyond
10) Education and communication programs

Ohio Sea Grant is a university-based program working toward the wise use and development of the nation's ocean, Great Lakes and coastal resources. Sea Grant brings university expertise in research, education and technology transfer to bear on the problems and challenges of the Great Lakes and marine resources.

The Ohio Sea Grant College Program is part of the National Sea Grant College with Sea Grant programs across the nation in 29 states and Puerto Rico. Ohio Sea Grant is a state-wide program based at The Ohio State University; however, it is a cooperative effort with other universities and colleges participating. Ohio Sea Grant works with individuals; communities; marine industries; local, state and federal agencies, and private organizations to help identify and solve Great Lakes and marine-related problems.

Ohio Sea Grant began in 1977. The program includes an education program which has 'made significant contributions of curricula and marine related education research. Research funded includes studies in aquaculture, fisheries/ aquatic biology, wetlands research, biotechnology/molecular biology, social sciences, ocean and coastal engineering, material flux and marine pollution. Three full-time Ohio Co-operative Extension district specialists transfer the knowledge from the researchers and educators to the people who can directly use the information.

The three specialists are conducting seminars on the topic of zebra mussels. For more information on zebra mussels, contact one of the following.

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