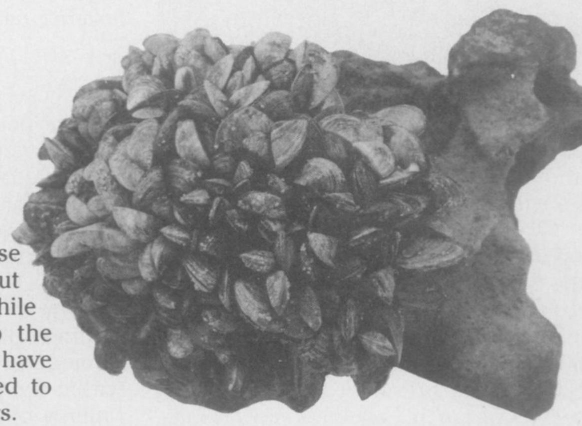
Dreissena Disaster

Scientists battle an invasion of zebra mussels

By TIM WALKER


NASA

Dreissena polymorpha must seem downright unneighborly to the residents of Monroe, Mich. In December 1989, for instance, thousands of these little mollusks, commonly known as zebra mussels, clogged the sole intake pipe of the town's water treatment plant, forcing a two-day shutdown of Monroe's schools, industries and businesses.

In this and other cities on Lake Erie, water intake pipes provide ideal feeding grounds for the stripe-shelled bivalves, which sift microscopic nutrients from passing water. While the mussels may relish their easy access to this aquatic buffet, they are viewed as unwelcome trespassers by Great Lakes utilities and industries, which expect to spend up to $4 billion this decade to unclog mussel-infested intake pipes.

Zebra mussels also pose a threat to the food web of the Great Lakes and surrounding waters. Because zebra mussels reproduce rapidly – an adult female produces up to 50,000 eggs a year – and eat massive amounts of phytoplankton, they have the potential to overwhelm and starve out native species, such as clams, which dine off the lower end of the food chain.

Scientists believe *D. polymorpha*, native to the Caspian Sea, arrived as a stowaway in the ballast water of a transatlantic freighter in 1985 or 1986. Flushed into Lake St. Clair, which lies sandwiched between Lakes Erie and Huron, the immigrant mollusk has since spread into all five Great Lakes and other inland waters, including the Erie Canal and the New York State Barge Canal. And because they face few, if any, natural predators, the North American communities of these mussels have experienced explosive growth.

Tiny zebra mussel larvae can ride water currents for hundreds of miles. Adults, however, attach themselves with a powerful glue to any hard surface, including buoys, pipes and piers (SN: 1/5/91, p.8). Because the bi-valves can survive out of water for several days while attached barnacle-style to the hulls of boats, they already have been inadvertently portaged to many inland lakes and rivers.

These mussels also colonize the rocky bottoms where walleye and lake trout spawn in shallow near-shore waters. If allowed to take over and despoil these species' spawning grounds, the mollusks could jeopardize the walleye fishing industry (valued at $900 million a year in Lake Erie alone) and thwart efforts to reintroduce lake trout to the Great Lakes, just as the trout have begun to recover from massive predation by another Great Lakes invader, the sea lamprey.

Simple filters cannot stop the near-microscopic zebra mussel larvae from entering water intake pipes, where they eventually anchor along interior surfaces. As a result, these homesteaders are infiltrating and fouling everything from the cooling systems of nuclear power plants to the engines of powerboats. Environmental engineers have begun fighting back with a range of toxic agents, including chlorine. But because chlorine combines with organic matter to form carcinogenic hydrocarbons, it can be safely used only in tightly contained spaces such as the interior pipes of power plants. Paying an underwater diver to scrape away the mussels – a costly, time-consuming and dangerous task – constitutes the best available alternative.

However, killing or scraping off resident bivalves provides only a temporary solution; incoming water soon brings more larvae, and the control efforts must begin again. Moreover, toxic molluskicides cannot be dispersed in open waters to keep *D. polymorpha* from overwhelming habitats of other aquatic species. So scientists are investigating safer control measures.

Fearing the mussels will spread throughout most of the United States and southern Canada, researchers have mobilized to control this small but destructive bivalve. Since biologists didn't discover *D. polymorpha* in the Great Lakes until the summer of 1988, they are only beginning to plan their strategy to combat it. If the battle with the sea lamprey proves any guide, zebra-mussel researchers can expect full-time employment for many years to come. The eel-like, ocean-dwelling lamprey – which became a Great Lakes scourge after the 1959 opening of the St. Lawrence Seaway provided it entry – went uncontrolled until the 1970s.

"There won't be one answer to the zebra mussel problem," says Daniel P. Molloy of the New York State Museum Biological Survey Field Research Laboratory in Cambridge. "We are going to need a bag of tricks."

Several scientists are focusing on manipulating the sex life of the marauding mussels.

For instance, Jeffrey L. Ram of Wayne State University in Detroit and David W. Garton, a zoologist at Ohio State University in Columbus, hope to capitalize on the fact that these bivalves spawn when they detect an explosive growth, or "bloom," of phytoplankton. This timing ordinarily ensures sufficient food for the larvae that hatch several hours later.

But Ram and Garton want to trick the mussels into spawning at less opportune times, since the larvae are very vulnerable to starvation.

"Once you get the males to spawn, the presence of sperm in the water rapidly triggers the females [to release eggs]," Garton points out. There are at least two ways to exploit this, notes Ram. If he and his colleagues can discover an agent that triggers premature release of sperm – and out-of-season spawning – they may be able to starve the larvae. Toward this end, Garton and Ram will test extracts of zebra mussel sperm in Lake Erie this summer.

Alternatively, if Ram can identify what constituents in the sperm initiate female egg release, he and his co-workers might develop a water treatment program that essentially puts the male and female spawning cycles out of sync with one another.

"At this point," Garton says, "we really want to find something that's very effective [at manipulating] the males [to spawn]."

In experiments last year, Ram and Susan J. Nichols of the U.S. Fish and Wildlife Service in Ann Arbor, Mich., discovered one such chemical – serotonin. Male *D. polymorpha* released their sperm when injected with this natural neurotransmitter, present in everything from snails to humans. Though the discovery ensures researchers a good supply of mussel sperm for their laboratories, Ram and Nichols caution that this potent nervous-system messenger affects too many other animals to safely release it in the wild as a weapon against zebra mussels. The researchers are now planning to investigate whether chemicals extracted from sperm might provide more environmentally benign and species-specific agents for controlling mussel spawning.

Garton has identified another potential vulnerability in the zebra mussel's sex life: hunger.

To get the energy they need to produce sperm or eggs, mollusks feed voraciously just before spawning. By forcing zebra mussels to close their shells at the right time, Garton hopes to shut down the important feeding frenzy that fuels successful spawning. Right now, he is looking at the effects of spreading an irritant over a colony of zebra mussels. The challenge, he says, is finding a selective irritant that causes *D. polymorpha* to clam up but does not shut down its more benign bivalve neighbors.

Such sex-cycle manipulation might prove sufficient for controlling zebra mussels if the aquatic pests spawned just once a year, during a relatively brief period. However, Nichols says, with year-round access to ample food supplies, many of these mollusks don't appear to wait for the typical midsummer phytoplankton bloom before they spawn, but instead may release small amounts of sperm and eggs throughout the summer.

Moreover, she notes, because the characteristics of zebra mussel colonies even a mile apart can differ greatly, researchers cannot automatically assume that any one control method will work equally well for all colonies. "They don't call these things *polymorpha* for nothing," she says.

Nichols is particularly concerned about a zebra mussel colony she's studying near Monroe in the Raisin River. These waters receive plentiful supplies of organic nutrients from the rainwater running off nearby farmlands. The fact that the Monroe mussels "get 750 million gallons of food-filled water an hour being shoved right by them" helps explain why they can carry ripe sperm and eggs all year and produce larvae anytime between May and October, she says. Indeed, she suggests, biologists may have no "window of vulnerability" to exploit for controlling zebra mussel colonies in this kind of environment.

A molluskan propensity for changing sex may also complicate the biologists' task.

Whenever the environment strongly favors one sex over another, many mussels of the unfavored sex begin changing their gender, Nichols notes. Though she has never observed this phenomenon in zebra mussels, she suspects they possess such capabilities. Colonies dominated by females can be very fertile, Ram says, because a few males can produce enough sperm to fertilize most of the females' eggs. And in the Monroe colony, females currently outnumber males five to one.

Nichols says biologists could doom such a colony to extinction if they could inhibit the community's relatively small number of males from releasing their sperm. Ram hopes to explore whether inhibiting the serotonin-controlled male sexual response might accomplish this.

Though perhaps less intricate than interrupting the animals' sex life, a strategy suggested by Susan W. Fisher may lead more quickly to mussel control.

Fisher, a toxicologist at Ohio State, is very good at killing zebra mussels. In her studies, she subjects them to all manner of poisons under a wide variety of conditions to determine, among other things, the minimum lethal dose of each toxicant.

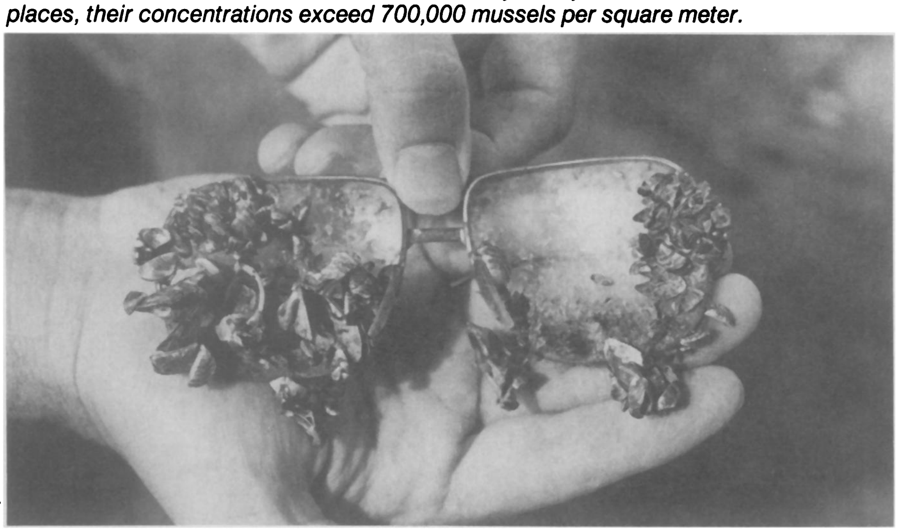
To Fisher's surprise, zebra mussels died when she put them in distilled water made to match the recipe of EPA standards for "pure" water. She ultimately determined that potassium compounds in this "safe" solution killed the mussels by destroying their gill tissue. Since the toxic substance came from water that EPA considers innocuous, Fisher immediately concluded that she had found the perfect molluskicide.

Further testing tempered her enthusiasm. She found she needed fairly high concentrations of potassium to kill large numbers of adult zebra mussels – and at such doses, the metal also began killing bivalve mollusks closely related to *D. polymorpha*.

However, potassium may still have a role, Fisher says, because it is a lot less harmful to species unrelated to mollusks than currently available mussel poisons. Her data also indicate potassium may prevent zebra mussels from attaching themselves to surfaces, thereby keeping the mollusks from clogging pipes and engines. The concentration needed to do so might be "substantially lower than the dose that kills them outright," says Fisher, who plans to test that hypothesis this summer in Lake Erie. If her hunch is confirmed, low levels of potassium might be continuously released around pipes to prevent zebra mussels from colonizing them, she says.

A paint company has also expressed interest in adding potassium phosphate into its marine paint to discourage the mussels from adhering to the hulls of boats, Fisher adds. If effective, this coating might prove a safer alternative to

Adult zebra mussels can attach themselves firmly to any hard surface. In some places, their concentrations exceed 700,000 mussels per square meter.



Lloyd Lemmermann/OSU

today's copper- and tributyltin-based "anti-biofouling" paints, which poison other species.

At the New York State Museum, Molloy is searching for a natural microbe to control *D. polymorpha.* The best way to find zebra mussels infested with a naturally occurring parasite, Molloy says, is "to go where the zebra mussels have spent centuries, if not millennia. That would be the Caspian Sea." However, since he doesn't expect that costly proposal to win funding, he is screening soil and water microorganisms native to North America, hoping to find one that produces a substance toxic to this pest.

Although the odds of discovering such a microorganism may seem daunting, Molloy points out that an earlier systematic screening of soil bacteria identified a microbe that kills black-fly larvae. The bacterium was a variety of *Bacillus thuringiensis* found in Israel.

Microbial toxins have two main advantages over currently used chemical molluskicides such as tributyltin and chlorine, according to Molloy. First, microbial secretions often prove toxic only to a few species, he says, so one that kills zebra mussels might largely ignore the mussels' aquatic neighbors. The species-specificity of the bacterium active against black-fly larvae, for instance, "is extremely unusual for an insecticide," Molloy notes.

Second, a naturally occurring North American microorganism might present less risk of environmental harm – an important concern in getting regulatory agencies to approve commercial use of such control methods.

Molloy recently began screening spore-forming bacteria, which generally produce toxins, hoping to find one toxic to zebra mussels. Both zebra mussels and black-fly larvae are aquatic filter-feeders, Molloy says, which makes him optimistic that if enough scientists join the search, they will eventually find a microbial toxin for *D. polymorpha.* "It's a question of screening enough of them," he asserts.

Though the zebra mussel's invasion of the Great Lakes threatens the region's environment and economy, it has brought one unexpected benefit. Because each of these voracious feeders can filter microscopic algae from up to 1 liter of lake water per day, the bivalves have dramatically cleared Lake Erie's water.

"It's hard to dismiss the fact that when you go up to Lake Erie now, you can see to the bottom," says Fisher. "And that's only come about in the last three or four years – which is precisely the time at which the mussels invaded." □