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Sea Grant

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 gluelike 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.

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

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

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

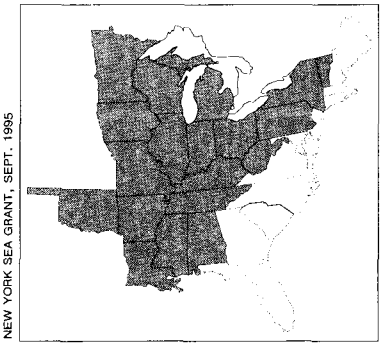
The best way to guarantee that zebra mussels won't enter your water supply is to use groundwater from a well or spring. Avoid using surface water, especially from large lakes or rivers. Once your water source is contaminated, it is difficult to keep zebra mussels out of your aquaculture facility. The 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 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.



Shaded states contain waters where zebra mussels have been detected.

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.

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