



# The Zebra Mussel and Crawfish Aquaculture

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The zebra mussel, an exotic mollusc native to the temperate waters of the Black, Caspian and Aral Seas in southwestern Russia and Ukraine, has spread by natural and artificial dispersal throughout most of Europe and has now entered North America. Since first appearing in the Great Lakes in 1988, zebra mussels have spread rapidly through the Mississippi River basin to southern waters in the U.S. Their presence in the region represents a potential problem to the warm water aquaculture industry.

Their tremendous fecundity (ability to reproduce) and planktonic larval phase give them unmatched ability to disperse through natural and artificial habitats. Zebra mussels are prolific spawners, producing as many as 1 million eggs per year. Fertilized eggs hatch into semibuoyant planktonic larvae, which are easily dispersed and/or transported while in suspension. Upon metamorphosis, larvae settle out of the water column, attaching to whatever hard surfaces they encounter. Once mussels attach themselves to barges, boats or other movable objects, they can be passively transported to new areas. These factors give them an almost limitless potential for colonization of new habitats.

Because they have few natural predators, multiply rapidly, feed on phytoplankton and encrust most hard surfaces, zebra mussels may impact crawfish producers in a variety of ways, such as clogging pumps and valves, obstructing supply and drain pipes, and encrusting nets or even individual crawfish. They may also reduce natural productivity in crawfish ponds as a result of intensive filter feeding. Finally, zebra mussels frequently harbor life stages of fish-infecting trematode parasites in European waters, and could possibly do so in North America.

## **The Zebra Mussel and Crawfish Profitability**

Annual aquaculture production of crawfish in the U.S. has remained more or less unchanged in recent years, primarily because of marketing problems facing the industry. Although not as capital-intensive as some other forms of warm water aquaculture, crawfish production can be complicated by cash flow problems stemming from uncontrolled reproduction and resultant stunting, crop failures, high fuel and bait costs, and downward price pressure from imported tail meat and wild-caught product. In combination, many of these factors can be exacerbated by zebra mussel infestation. Treatment for zebra mussels is costly and disruptive to a stable aquaculture system.

### **What is the ZM/CCP Program?**

The Zebra Mussel /Critical Control Point (ZM/CCP) program is a proactive, common sense approach to address potential impacts of zebra mussels on warm water aquaculture. This goal can be achieved for specific production systems by following these guidelines:

- (1) Identify Critical Control Points (CCPs), that is, areas where zebra mussels could inadvertently enter production facilities.
- (2) Determine appropriate measures to avoid infestation and establishing monitoring procedures based on the identified problem areas.
- (3) Formulate control actions and/or remediation in the event an infestation does occur.
- (4) Establish a record keeping system to facilitate these activities.

## **Critical Control Points in Crawfish Aquaculture**

Given the zebra mussel's record for dispersal and infestation as well as its widespread presence in southern waters, it may only be a matter of time before this mollusc appears in crawfish operations. Crawfish producers should be especially aware of these CCPs:

- (1) Contaminated surface water sources. Zebra mussel populations are already well established in the Mississippi, Atchafalaya, Tennessee, and Arkansas rivers, and could potentially exist in any tributaries of these waterways. Additional introductions of zebra mussel larvae, juveniles, or adults into surface waters by recreational boaters could occur throughout the traditional range of the pond-based crawfish industry. The widespread use of surface water for pond flooding and flushing may lead to inadvertent dispersal of zebra mussels into ponds.
- (2) Equipment from zebra mussel-contaminated facilities. Water left in harvesting boats can harbor microscopic larvae and newly-settled juveniles. Motors, boat trailers, nets, baskets, boots, gloves and other equipment can harbor inconspicuous juveniles and subadults, attached directly or on bits and pieces of vegetation.

### **Determine Monitoring and Verification Procedures for CCPs**

Monitoring for zebra mussels is the most effective way to verify the presence of all the zebra mussel life stages that can potentially be introduced via each CCP. The monitoring process for each life stage is different. Adults are recognizable by their dark, zebra-like rays; very young zebra mussels, though barely visible, feel grainy to the touch, whereas the veligers (planktonic larval stage) are visible only under a microscope.

The process necessary to detect the planktonic larval (veliger) stage probably requires the most tedious procedures. Veligers must be collected using a plankton net. A dissecting microscope with a cross-polarized light system is often necessary to detect larval zebra mussels, especially in samples contaminated with other planktonic forms.

Monitoring surfaces for the settling life stages of the zebra mussel is far more practical. Although this type of monitoring is

an indicator of infestation after the fact, it is useful because zebra mussels are vulnerable to a number of control treatments at all stages of development. This type of monitoring should include deployment and regular inspection of small samples of the same hard surface materials currently being used at your facility, such as polyvinyl chloride (PVC) pipe. These samples or test plates will provide a suitable surface for attracting mussels as they settle out of the water column. Other materials can be used. Plastic mesh pot scrubbers are inexpensive alternatives that can sometimes capture all sizes of zebra mussels. These "plates" should be deployed at strategic locations (at least 6 inches under the surface where water flow is slow, oxygen and phytoplankton available, water temperature between 32-86°F or 0-30°C) throughout your facility.

Adult zebra mussels typically have small, thumb sized D-shaped shells with zebra-like bands, but some may be solid brown or black. They usually colonize in clusters. Zebra mussels are easily recognized by a simple shell test. When placed ventral side down, zebra mussel shells remain upright. Stand pipes, screens, spawning mats, boat hulls, submerged equipment such as aerators and their anchoring stakes or any other hard surfaces are good places to look for adult and subadult zebra mussels. They can also be found frequently on aquatic weeds such as naiad, coontail, milfoil, hydrilla and water hyacinth.

Zebra mussels have extremely fragile shells. Even when adult mussels are not noticeable, shells or shell fragments may be evident in various locations. Since zebra mussels will die if deprived of oxygen, they may also be detected by foul smelling odors coming from outflowing waters associated with supply lines or drains that may have been left with stagnant water for several days or weeks.

Since predicting which type of sampling will produce the first evidence of zebra mussels is impossible, a combination of plankton sampling, placement of settlement devices and regular examination of surfaces for settled adults should be used. These inspections should be made at least every two weeks, or more frequently if you suspect water or equipment from a contaminated source may have entered your facility.

Positive verification of zebra mussels should be made before any remedial action is taken. Identification assistance, including wallet-sized, free, identification cards, are available from your nearest state Sea Grant

office (Alabama 334/438-5690; Louisiana 504/388-6349; Mississippi 601/388-4710). Verification is available from most US Fish and Wildlife Service offices or Sea Grant Marine Extension Offices. Samples may also be sent directly to Dr. Bruce Thompson, Coastal Fisheries Institute, Louisiana State University, Baton Rouge, LA 70803-7507 (504/388-6337). Be sure to enclose your name, phone number and pertinent collection data (your location, water source, water temperature, pH, date of sample). Samples at all stages can be most easily verified if they are kept alive. Placed in a cooler with the water in which they are living after collection. If samples must be preserved to transport them for verification, use a 70% ethanol or isopropyl alcohol solution.

For more information on zebra mussel monitoring and identification, refer to the booklet: Standard Protocols for Monitoring and Sampling Zebra Mussels by J. Ellen Marsden, Illinois Natural History Survey, Biological Notes 138, April 1992. It is a comprehensive guide to monitoring all stages of the zebra mussel and is available from the Illinois Natural History Survey, Natural Resources Building, 607 East Peabody Dr., Champaign, IL 61820 (217/333-6880).

### **Formulate Action: Preventive Measures**

Prevention is the best approach to avoiding a zebra mussel infestation, but preventive treatments are not the same as preventing entry. Treatments when the presence of zebra mussels has not been confirmed can be expensive, expose fish to needless risks and are potentially harmful to the environment. No chemical treatment has proven 100% effective against all stages of the zebra mussel without harming other aquatic life forms, including fish. Therefore, careful surveillance and monitoring coupled with a regular procedure to prevent entry is the preferred approach.

To reduce the possibility of zebra mussels entering your facility, follow these guidelines:

- (1) When stocking ponds, inspect brood stock to be sure they are free from attached zebra mussels.
- (2) Inspect nets, boats, clothing, boots, baskets and other equipment before allowing their use in your ponds.
- (3) Steam clean or immerse in hot water (140°F or 60°C) all contaminated or possibly-contaminated equipment, or use a pressure washer if you suspect

newly-attached juveniles may be present.

- (4) Quarantine or dispose of all incoming plant material.
- (5) Use ground water wherever practical or thoroughly filter all incoming surface water.

Filtration is probably the most efficient and economical avoidance method for operations that use surface waters. Backwashable sand filters and submerged infiltration beds are presently available that will eliminate veligers and juvenile mussels from intake waters.

Since crawfish in European and North American waters have occasionally been documented to feed on zebra mussels, they may also feed directly on newly-settled zebra mussels in ponds. This could prevent infestations from developing in ponds over a period of time. However, this factor does not guarantee a zebra mussel-free system because no data is available to confirm that crawfish will feed on zebra mussels in a volume that controls their population.

#### **Formulate Action: Control Measures**

Besides monitoring CCPs, crawfish producers should regularly check pipes, pumps, screens and aerators in the aquaculture system for adult zebra mussel colonies and shell fragments. Zebra mussels are known to foul and clog pipes, significant to the pumping and drainage systems on crawfish ponds. If zebra mussels are found through monitoring or periodic equipment checks, several courses of action to eliminate them are available:

##### Treatment with hot water/steam:

Contaminated equipment like hauling tanks or vats should be steam cleaned or immersed in hot water (140°F or 60°C) for 23 minutes.

Desiccation. Pumps, boats, nets, trailers, floats, and other contaminated equipment should be allowed to air dry at least one week in humid climates. Infested ponds should be drained and allowed to dry thoroughly for at least two weeks, preferably during very cold or hot weather. The annual management drawdown cycle for crawfish production should eliminate pond infestations if they occur, but separate treatment may be required for pumping/drainage systems suspected of having zebra mussel settlement.

Salt. A 1% treatment of sodium chloride (24 hours) will kill all larval stages of the

zebra mussel and most newly-settled juveniles. However, indefinite exposure to such high concentrations may corrode equipment and would be detrimental to crawfish.

Disinfection. Traditional aquaculture disinfectants, calcium hypochlorite and iodine, do not appear to effectively eliminate zebra mussels from tanks and equipment. Benzalkonium chloride is effective against all stages of the zebra mussel at 100 mg/L for three hours and at 250 mg/L for 15 minutes. It can be used to disinfect hauling-tanks, stainless steel troughs, vats, nets and other equipment suspected of harboring zebra mussels. This compound is commercially available as ROCCAL™. Note that benzalkonium chloride is highly toxic to most fish species and should be used with extreme care. Thorough rinsing and proper disposal of runoff is essential to avoid impacts to fish stocks within and outside the facility.

Treatment with traditional fisheries chemicals. Rotenone™ (15 mg/L for 24 hours) or chelated copper (2 mg/L for 48 hours) have been shown to kill zebra mussels when applied for other control purposes in infested ponds. These compounds are not, however, labeled specifically for zebra mussel control in aquaculture settings. Note that Rotenone is classified as a restricted use pesticide, and can be purchased and applied only by a certified pesticide applicator.

One fishery chemical with some promise for zebra mussel control is potassium chloride. Research suggests that exposure to KCl concentrations as low as 100-200 mg/L for 24 hours should kill roughly 50% of all zebra mussel life stages. Although the FDA has issued LRP (Low Regulatory Priority) guidelines for up to 2000 mg/L of potassium chloride to provide for stress reduction and osmoregulatory enhancement, these levels may not eliminate all veligers/juveniles even over a 24-hour period, and could result in extreme stress or mortality for any crawfish present.

Hydrated lime (CaOH). Addition of calcium hydroxide (hydrated lime) to newly drained ponds at 1000-2000 lb/acre will kill all stages of the zebra mussel as well as other unwanted organisms.

Molluscicides/toxic compounds. No compounds have been approved specifically for zebra mussel control in aquaculture facilities. Draining a crawfish pond and forgoing additional harvest for the remainder

of the season will usually be a less costly alternative than utilizing chemical treatments to control zebra mussels. Although a number of molluscicides have been investigated or permitted for use in eradicating zebra mussel infestations at public and private utilities and industries throughout the Great Lakes and Mississippi valley, regulatory agencies are understandably concerned with potential environmental impacts to adjacent aquatic habitats whenever these types of compounds are applied. The use of any of these chemicals requires specific permission from state and federal agencies. Be sure to contact your state environmental agency as well as your local EPA and/or FDA office to determine the latest regulations and options pertaining to toxic chemical or molluscicide treatments.

Natural Predators. The natural feeding habits of crawfish will probably result in control of pond infestations before they occur, but this will not be sufficient to prevent infestation of water supply systems.

#### **Some Vendors for Zebra Mussel Monitoring, Prevention and Control**

Because research on zebra mussels control measures continues, no list of vendors, including this one, can be complete. New vendors are entering the marketplace every day. The following list includes vendors who have notified Sea Grant that they have provided consultation, products, or other services relative to zebra mussel monitoring and control in various parts of the U.S. This list does not represent an endorsement or any type of judgment by the authors or their programs of any individual, corporation, or product associated with these vendors, nor does it guarantee the accuracy of these business addresses or telephone numbers after date of publication.

Acres International  
140 John James Audubon Parkway  
Amherst, NY 142281180  
716/689-3737  
Products: Monitoring programs for zebra mussel identification

Aim Trading Company  
21 Bishops Road  
St. Catharines, Ontario,  
Canada L2M1T8  
416/934-0830  
Products: Self cleaning filter systems

Alex Milne Associates Ltd  
3700 Weston Road  
New York, Ontario, Canada M9L 2Z4  
416/742-4911  
Products: Sand filters and backflush  
systems

Aquacenter  
166 Seven Oaks Road  
Leland, MS 38756  
800/748-8921  
Products: Rotenone™, chelated copper and  
other chemicals

Argent Chemical Laboratories  
8702 152nd Ave NE  
Redmond, WA 98052  
800/426-6258  
Products: Benzalkonium chloride, chelated  
copper, Rotenone™ and other chemicals

Filtomat  
40 N. Van Brunt Street  
Englewood, NJ 07631  
201/568-3311  
Products: Automatic self cleaning water  
filter systems

Fuji America, Inc.  
Dept. T  
4044 Yancey Road  
Charlotte, NC 28217  
704/527-3854  
Products: Automatic backflushing systems

Lakos Plum Creek  
1911 North Helm Avenue  
Fresno, CA 93727  
209/255-1601  
Products: Self cleaning pump intake screens

Ronningen Petter  
9151 Shaver Road  
P.O. 188  
Portage, MI 49081  
616/3231313  
Products: Automatic backflushing systems

S.P. Kinney Engineers, Inc.  
P.O. Box 445  
Carnegie, PA 15106  
412/276-4600  
Products: Automatic self cleaning strainers

University of Wisconsin  
Sea Grant Advisory Service  
Philip Keillor, Coastal Engineer  
1800 University Ave.  
Madison, WI 53705  
608/263-5133  
Products: Sand filters and buried  
infiltration systems

### Sample Record Keeping for ZMCCP

An example of suggested information that should be included on a ZMCCP Report:

#### ZMCCP REPORT

Discovery Date \_\_\_\_\_  
Name of Operation \_\_\_\_\_ Owners  
Name \_\_\_\_\_  
County \_\_\_\_\_ Town/City \_\_\_\_\_ State \_\_\_\_\_  
Phone Number ( ) \_\_\_\_\_

#### COLLECTION SITE LOCATION

Water Source \_\_\_\_\_  
Where Found: (Circle)  
Standpipe Screen Aerator Float Floating plants Filter Equipment  
Boat/Trailer Ponds Vats Tanks Other \_\_\_\_\_  
Type Substrate: (Circle)  
Concrete Metal PVC Plant Wood Plastic  
Possible source of introduction (For previous 6 to 12 months): \_\_\_\_\_

Possible introductions to other ponds/facilities:  
\_\_\_\_\_  
\_\_\_\_\_

Collected By \_\_\_\_\_  
Identified By \_\_\_\_\_

Comments, Notes or Map:

#### FOR MORE INFORMATION

Mississippi State University  
Coastal Research and Extension Center  
2710 Beach Blvd., Suite 1E  
Biloxi, MS 39531  
601/388-4710  
Publications: What Every Fish Farmer  
Should Know about the Zebra Mussel;  
The Zebra Mussel and Aquaculture

Auburn University  
Marine Extension and Research Center  
4170 Commanders Drive  
Mobile, AL  
334/438-5670  
Publications: Boaters: Beware of Zebra  
Mussels

Louisiana State University  
Cooperative Extension Service  
P.O. Box 25100  
Baton Rouge, LA 70894  
504/388-2152  
and  
Louisiana Sea Grant College Program  
Louisiana State University  
Baton Rouge, LA 70803-7507  
504/388-6349  
Publications: Invasion of the Zebra  
Mussels; Lower Mississippi River Valley  
Zebra Mussel Newsletter