US Army Corps of Engineers
Waterways Experiment Station

Zebra Mussel Research Technical Notes

Section 2 — Control Methods

Technical Note ZMR-2-18

October 1995

Use of an Air Injection System to Control Zebra Mussels, May 1994

Background and purpose

This technical note presents data on the efficacy of an air injection system for zebra mussel removal from hard substratum.

Additional information

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Description of air injection system

A preliminary study was undertaken to demonstrate the efficacy of air injection techniques for removing zebra mussels from colonized substratum and intake orifices. Comparisons were made of an air diffuser without a facing plate and one with a facing plate to determine which design removed zebra mussels more efficiently.

The concept and principle of operation relies upon creating an energetically inhospitable environment for the zebra mussels. Air bubbles agitate the soft tissue siphon and prevent mussels from opening their valves for feeding. The two-phase alternating frictional force of water and air bubbles demands continual counteraction by the byssus-foot apparatus, resulting in an unacceptable energy demand in order for the mussel to stay in place.

Corps of Engineers personnel and industrial representatives were contacted to determine which components of locks and dams are prone to zebra mussel-related malfunctioning. Based on discussions with these individuals, it was concluded that water-level metering devices demanded immediate attention.

Tests were conducted on float devices (without instrumentation) to determine facing plate design for effective removal of zebra mussels. The most effective configuration was a cylindrical facing plate with a circular diffuser at the bottom edge. The cylinder was about 3 in. in diameter larger than the float being evacuated of zebra mussels, and the length of the facing plate cylinder was long enough to exceed the amplitude of float movement. The apparatus also had to be tested with full instrumentation to determine the effect of air bubble impact

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on measurement accuracy. Testing was conducted on both float- and transducer-type measuring devices.

The air diffuser was tested under a variety of conditions, as summarized in Table 1.

Table 1. Test Conditions for Air Diffuser Experiments

Date	PSI[1]	SCFH[2]	SCFM[3]	Treatment
Test 1 (Without Facing Plate)				
08-06-93	25	472	7.9	Install
08-11-93	25	472	7.9	Remove
Test 2 (Without Facing Plate)				
08-11-93	30	501	8.3	Install
08-16-93	30	501	8.3	Remove
Test 3 (With Facing Plate)				
09-08-93	30	501	8.3	Install
09-13-93	30	496	8.3	Remove

[1] Pounds (force) per square inch.
[2] Standard cubic feet per hour/foot.
[3] Standard cubic feet per minute/foot.

Each test of the system was preceded by a video inspection to determine the presence of zebra mussels; these inspections represented controls. Each test used a 5-ft diffuser that was placed in operation along the sea wall for a 5-day period. Tests 1 and 2 were done without the facing plate; Test 3 was done with the facing plate. The results of Tests 1 and 2 indicated no reduction of zebra mussels on the sea wall. Test 3 showed complete displacement (essentially 100 percent) along the protruding portion of the seawall. However, the recessed areas of the seawall that were not directly juxtaposed with the facing plate were not affected. For the most effective zebra mussel removal and efficiency of air usage, the air bubbles must be directed onto the colonized surface. The facing plate is a critical component in the effectiveness of the diffuser.

Tests were conducted at the seawall by the Center for Great Lake Studies (CGLS) and the Oak Creek Power Plant of the Wisconsin Electric Power Company. The first success at removing zebra mussels using air/facing plate techniques was accomplished at CGLS using a 10-SCFM diffuser. Earlier laboratory tests and these tests showed a considerable reduction of air (1.7 SCFM of diffuser) to be equally effective at removing zebra mussels. These tests demonstrated an 83-percent reduction of air usage compared with the early tests. The next goal was to demonstrate the minimum number of days necessary at 1.7 SCFM for zebra mussel removal. Both air flow and time of exposure had to be adjusted for specific conditions at the treatment site.

An additional experiment was conducted in October 1993 to determine if fewer than 5 days (the standard time used in Tests 1, 2, and 3 described above) would adequately remove mussels. This experiment was conducted at CGLS using two replicates and a 1-ft-long air diffuser fitted with a facing plate at 1.7 SCFM. Underwater photographs were taken at 24-hr intervals during the

5-day period so the sequential removal of zebra mussels could be observed.

The results of the sequential removal of zebra mussels indicated that mussel elimination was about 93 percent completed on day 4. This represents a 20-percent time reduction and operational cost savings when compared to the 5-day period that had previously been used for removal, if the 7-percent level of zebra mussels remaining can be tolerated. In other words, one fifth the total air usage was required to remove the last 7 percent of the zebra mussels.

Figure 1 illustrates the sequential reduction of mussels from the seawall at CGLS. The number of zebra mussels in replicates 1 and 2 is reported in Table 2. As illustrated in Figure 1, the number of zebra mussels was reduced from more than 5,000 individuals/m^2 to 133/m^2 in replicate 1 and 0/m^2 in replicate 2. The count for replicate 1 included a single individual (unextrapolated count) that appeared to be stuck in a crevice; however, this individual was dead, as indicated by its gaping valves. The regression analysis (Figure 2) indicates a linear reduction of zebra mussels at a rate of about 45 individuals/hr. The relationship may be slightly curvilinear. The product moment coefficient, r^2, is powerful at 0.928, indicating a very good correlation.

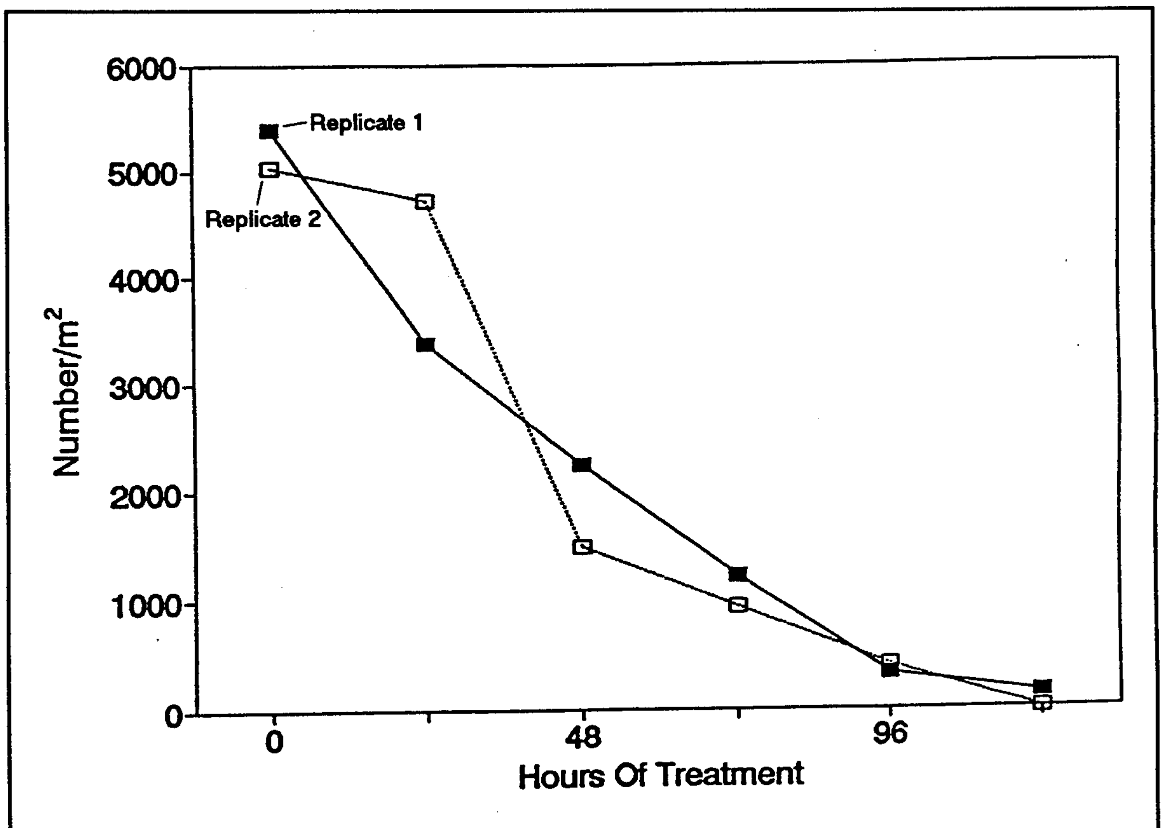

Figure 1. Sequential removal of zebra mussels (1.7 standard cubic feet per minute/foot)

Table 2. Reduction of Zebra Mussels (individuals/m^2) During 5-Day Experiment				
Hours	**Test 1**	**Test 2**	**Average**	**Percent Remaining**
0	5,400	5,040	5,220	100.0
24	3,378	4,730	4,054	77.7
48	2,252	1,486	1,869	35.8
72	1,216	935	1,075	20.6
96	315	405	360	6.9
120	133	0	66	1.3[1]

[1] A single dead individual; thus, the functional percentage is 0.

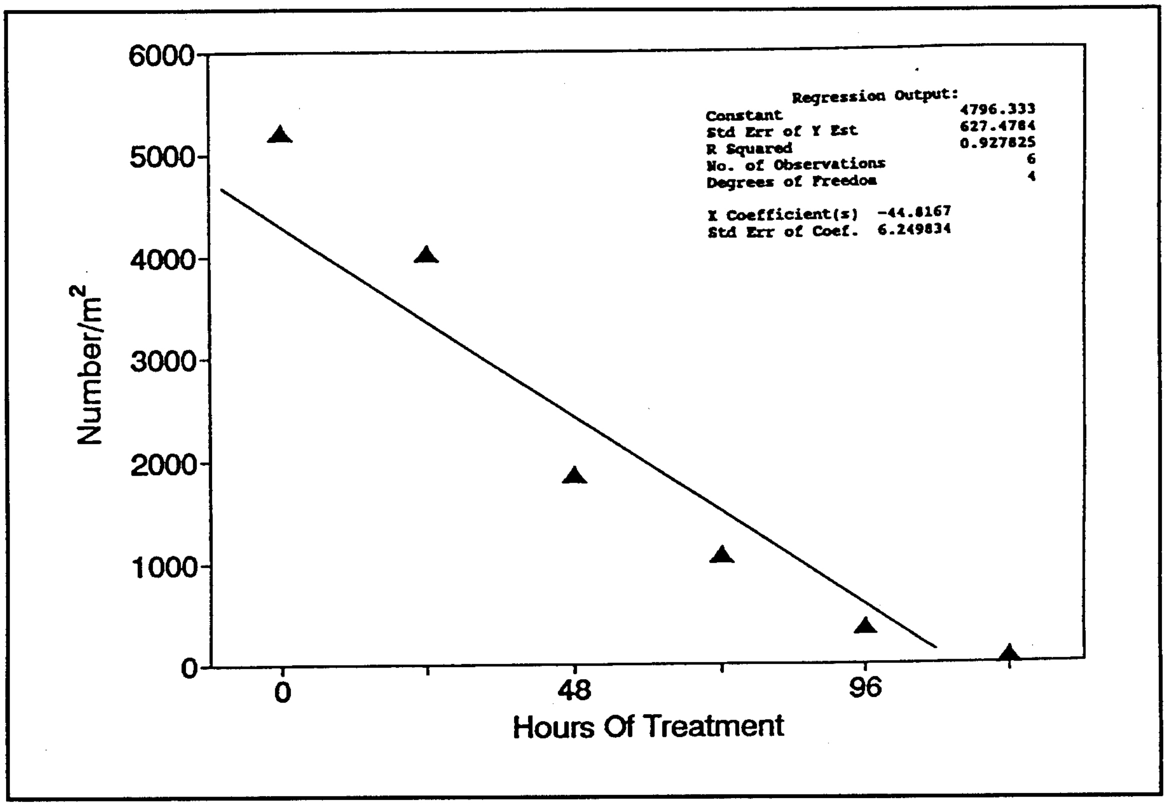

Figure 2. Regression of zebra mussel removal (1.7 standard cubic feet per minute/foot)

Summary Air injection is practical for both short-term abatement and as a long-term, cost-effective method for routine elimination of zebra mussels and other encrustations. Air injectors/diffusers can be implemented on a continuous or an intermittent basis to preclude colonization or to evacuate previously colonized zebra mussels from critical components of locks, dams, or other structures.

The air injection technique using the facing plate proved to be very efficient. This contrasts with the same technique used without the facing plate, which proved to be totally ineffective at removing adult zebra mussels. The time required to remove 100 percent of the mussels was between 96 and 120 hr.