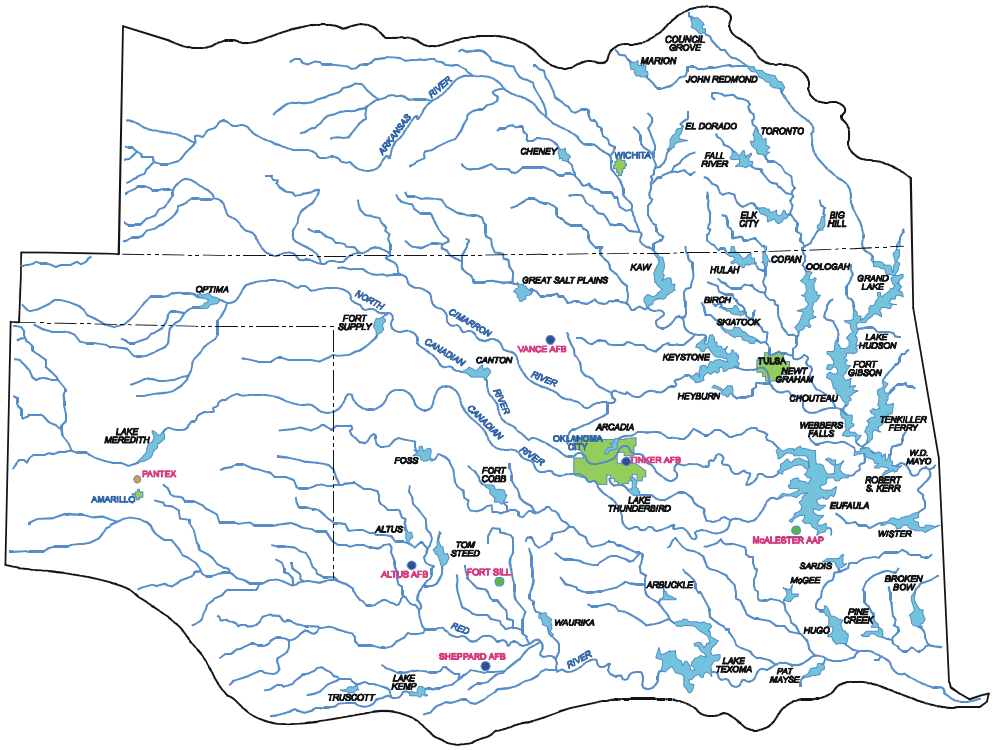
U.S. Army Corps of Engineers
Tulsa District
Zebra Mussels (Dreissena polymorpha)



by

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Introduction

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Zebra mussels, *Dreissena polymorpha*, were accidentally transported from Europe to North America in the 1980's and were first found in the United States in St. Clair Lake, Michigan in 1986. Researchers believe that the mussels were accidentally transported to North America by trans-Atlantic ships. Zebra Mussels are transported by water flow or by being carried from one waterbody to another. They can be transported overland by attaching to boats, trailers, etc. Their microscopic larvae, called veligers, can be transported in bait buckets, live wells, moisture on carpets and ropes, etc.

Zebra Mussels were first discovered in Oklahoma in January 1993 on the Arkansas River in the McClellan-Kerr Navigation System; inside Locks 14 (W.D. Mayo), 15 (R.S. Kerr), and 16 (Webbers Falls). They were found in the Verdigris River at Lock 17 (Chouteau) in June 1993 and at Lock 18 (Newt Graham) in January 1994. The first inland lake confirmation was not until May 2003 at Oologah Lake. The first inland lake in Kansas was at El Dorado Lake in August 2003. Zebra Mussel larvae were transported down the Arkansas River by high flows from El Dorado and were discovered in Kaw Lake in July 2004, but settled adults were not found until February 2005. Settlement from this continued downstream flow was found in Keystone Lake in October 2005. The infestation continued down the Arkansas River, through Tulsa County, to the already infested Navigation System. In addition, several water supply lakes that use these waters have become infested. These include Lynn Lane, A.B. Jewell, Chouteau, and Sooner Lakes.

In June of 2006 one adult was discovered at the Skiatook Dam. In August of 2007 a handful of adults were removed, but none were found anywhere else on the lake until April 2010. Divers reported thousands attached to all the substrate in deeper water.

In April of 2009 one adult was discovered on a private dock on Lake Texoma. By August they were being found at several locations on the lake. By April 2010 they were well established throughout the lake and spawning.

In Jan 2010 Zebra Mussels were found in Eufaula Lake. Monitoring is ongoing to determine the extent of the infestation and how fast they spread in the lake.

Biology and Ecology

Biological characteristics of the Zebra Mussels must be considered when developing control strategies for a facility. It is important to be able to identify the mussel and to understand basic aspects of its life history and ecological requirements. Two important aspects of the life history of Zebra Mussels are their strong byssal attachment to any firm substrate and the occurrence of Zebra Mussels as microscopic, planktonic veliger larvae in their early life history.

Spawning occurs between 12°C (54°F) and 27°C (80°F). The eggs develop in 7 days and larval life is 7 to 30 days. The eggs and larvae are easily transported by water currents; therefore, facilities upstream of known populations are at less immediate risk. Veligers may be abundant in water when temperature exceeds 12°C (54°F) and can settle at any water velocity less than 1.5 mps. They prefer flows of 1.5 to 2.0 mps. (4.8 to 6.6 fps). If high flows slow down they can attach and stay attached when velocity picks back up.

Most adults live two to three years. Adults are intolerant of low dissolved oxygen (less than 50% air saturation); acidic water (pH less than 7); low calcium conditions (less than 15 mg/L as divalent cation); brackish water (greater than 5 ppt); turbidity over 50 TDU; and salinity above 4.5.ppt. High water temperature (30°C)(86°F) is stressful; 32.5°C (90°F) will cause mortality in 5 hours; and 34°C (93°F) is lethal. Biochemical indicators show Zebra Mussels to be their weakest in the spring and fall.

Monitoring

Monitoring for presence/absence of Zebra Mussels is best accomplished by periodically inspecting substrate surfaces. Tests show that preference was given to upper over lower surfaces, textures over smooth surfaces, horizontal over vertical surfaces and prefer to settle near crevices and surface irregularities. Recent experiences indicate they prefer dark substrates to light substrates. They have no preference among various substrate materials such as wood, steel, aluminum, plexiglas, glass, PVC, fiberglass, concrete, and limestone. Adults can readily detach from a substrate and move 0.5 meter per hour, for over 24 hours. Light, in particular, appears to stimulate movement. Artificial monitoring stations should be set out in easily accessable areas that are not subject to vandalism.

Control Measures

Zebra Mussels are hard to control because of their high reproduction rate, rapid growth, microscopic larval stage which can be rapidly dispersed in moving water, and their ability to attach firmly to most hard substrates. Some of the more promising control measures are chlorine application, thermal treatment, surface coating, cathodic protection, mechanical filtration, and acoustics. The more popular and proven methods integrate more than one control measure.

Chlorination is popular method of control. Many factors can influence the effectiveness of chlorine, such as temperature, pH, chlorine concentration, exposure time, type and quantity of chlorine compounds formed, and the size and physiological state of the Zebra Mussels treated. For best results 0.5ppm total residual chlorine (TRC) is desired, 2.5ppm will kill adults in 10 - 15 days. Treatments can be end of season, periodic, intermittent, continuous, or semi-continuous. Managers must be aware of potential effects of chlorine to their facilities. Caution must be taken to ensure acceptable temperature and chlorine levels in wastewater and effluent. Control measures may require an EA, EIS, or NPDES. Other chemicals and biocides are being used, however, not all EPA regions have approved uses other than chlorine for Zebra Mussel control.

Thermal treatment has proven successful in many situations. Mortality can be near 100% if exposed to water temperatures of 36C (97F). Consideration should be given to the effects of thermal treatment on lubricating oil, turbine oil, hydraulic temperatures, etc. In long pipe systems the water temperature may be hard to maintain. Once the mussels have been killed most will fall off into the pipe system and must be removed. They may be found throughout the piping system, up to hydrants and nozzles. If they are clustered very thick on pipe walls the bottom layer of Zebra Mussels may not be exposed enough to kill them; therefore, another treatment may be needed. Large powerplants, with heavy infestations, recommend conducting a thermal treatment in the Fall, to kill that seasons accumulation, and another in the Spring to kill any survivors.

Where the opportunity exists, freezing Zebra Mussels has proven to work. They will die when exposed to -1.5C (23F) for long periods of time. At -3C (27F) mortality will be 100% in 12 hours. If the ZM are clustered very thick it may take 3 times as long.

Surface coatings are effective to some extent and may be the only alternative in some situations, such as on vessels or buoys. Any toxic metal-based and silicone based surface coatings will deter Zebra Mussels. The preferred coating by the U.S. Coast Guard is a

water-base inorganic Zinc paint. Zinc is toxic to Zebra Mussels. They have had no reoccurring infestation after 12 months. Cupreous oxide based marine paints have shown to be effective as well.

Cathodic protection, mechanical filtration, and acoustics have shown some promise, but not enough research has been conducted to make many recommendations yet. An alternative to direct treatments is to use toxic metals such as copper, bronze, and galvanized steel. Zebra Mussels avoid the toxic metals and the Zinc from galvanized steel will kill them. Many facilities are redesigning structures to be removable for easier cleanup.

Summary

The infestation of Zebra Mussels in the Arkansas and Verdigris Rivers appears to have been from a commercial vessel in 1992. Some U.S. waterways have reported that once the adults are introduced into an area they began to see substantial populations in about the third year. That has held true for the navigation system, Oologah Lake, and El Dorado Lake. Coincidently, during their third year, unfavorable environmental conditions also existed and the populations declined significantly. However, they have been recovering slowly each year since.

The rate of spread and the extent of Zebra Mussel impacts in the various Oklahoma waterways depend on many environmental factors. Once they are introduced into a water body, and they become established, eradication is all but impossible. We will have to learn to live with them. Often this includes implementing control measures, changing our operational procedures, and accepting the change in the ecosystem.

Preventing the introduction of Zebra Mussels, and other aquatic nuisance species, is a management and environmental priority. Education and public awareness efforts are necessary to help water users prevent their spread into non-infested waters.

For additional information the Corps of Engineers Environmental Research and Development Center maintains a Zebra Mussel Information System website at http://el.erdc.usace.army.mil/zebra/zmis.