

Reclamation Tackles Quagga and Zebra Mussel Issues

A multi-pronged effort under way by the Bureau of Reclamation is focused on finding ways to combat the presence of quagga and zebra mussels in its reservoirs in the western U.S. Much of this work can be applied anywhere mussels are found.

By Peter Soeth

Quagga and zebra mussels are invasive species that arrived in North America from Europe in the 1980s. The first account of an established population occurred in 1988 in Lake Saint Clair between Lake Huron and Lake Erie, according to the U.S. Geological Survey.

By 1990, zebra mussels had been found in all five Great Lakes and over the next two years made their way into the major tributaries of the Mississippi River system. As of 2011, they had been reported within, or in waters adjacent to the borders of, 30 states. Quagga mussels were confined primarily to the Great Lakes until 2007, when a large population was discovered in Lake Mead on the Colorado River. Quagga mussels have since been reported in 15 states, USGS says.

The spread of quagga and zebra mussels has the potential to impair or interrupt water delivery and hydropower generation functions, as well as to create long-term ecological impacts. Mussels can disrupt aquatic food chains by filtering out plankton upon which fish and other organisms feed. These mussels are capable of attaching to all water-related infrastructure surfaces and thus clog pipes, pumps, trashracks, and cooling water and fire suppression systems. In addition, the mussels build up on spillway gates and other hydraulic structures, inhibiting their functions. All of these structures are critical to the reliability of Reclamation's mission of delivering water and generating hydropower.

Quagga or zebra mussels have been detected in Reclamation waters in seven states: Arizona, California, Colorado, Kansas, Nevada, New Mexico and Utah. Mussel infestations are adversely affecting several Reclamation facilities, including the 255-MW Davis, 2,078.8-MW Hoover, and 120-MW Parker projects and Imperial Dam.

Reclamation has developed and is implementing a four-part strategy to combat the presence of mussels in its waters. The components of this strategy are: outreach and education, monitoring and prevention of new infestations, control and mitigation, and research.

Outreach and education

Reclamation is concentrating on proactive measures — in coordination with other federal, state and local entities — to reduce the spread of mussels in areas where they are already established. These measures include boat inspections and educational signage at or near Reclamation reservoirs.

In addition, training and information sharing with federal, state and local partners has been important in preventing the spread of mussels. For example, Reclamation hosted two workshops about mussel issues in 2009. The first, held in Denver in January 2009 in coordination with the 100th Meridian Initiative, focused on early detection methods. This initiative is a cooperative effort between local, state, provincial, regional and federal agencies to prevent the westward spread of zebra and quagga mussels and other aquatic nuisance species in North America.

Reclamation then hosted the Western Invasive Mussel Management Workshop in Henderson, Nev., in May 2009. Participants at that workshop learned what Reclamation and its partners are doing to address the quagga and zebra mussel infestation in the western U.S. A technical tour of Hoover Dam was provided to showcase mussel mitigation methods being tested since mussels were first discovered in 2007.

In 2010, Reclamation hosted the 17th International Conference on Aquatic Invasive Species in San Diego, Calif. This conference brought experts from around the world to discuss issues regarding aquatic invasive species, including sharing information on quagga and zebra mussels.

And a protective coatings workshop was conducted in October 2011. While the primary discussion focused on minimizing and preventative coatings, a discussion on methods to control quagga and zebra mussels occurred, with emphasis on antifouling coating control methods.

In addition, Reclamation has developed a paper on management options for quagga and zebra mussels. This paper provides options for water and hydropower managers to consider implementing prior to detection of mussels and concurrent with prevention and public outreach activities. Before mussels are detected, managers should consider developing a coordinated response plan, performing infestation risk and facility vulnerability assessments, and implementing a monitoring program. If mussels are detected, managers should execute their coordinated response plan, increase monitoring of their water bodies, identify and implement appropriate facility protection measures, and identify ecological impacts.

Monitoring and prevention of new infestations

The second prong of Reclamation's efforts is monitoring and early detection of mussels in the western U.S. In 2009, Reclamation began by monitoring 150 water bodies using \$4.1 million in funding received from the American Reinvestment and Recovery Act. Beginning in 2010, Reclamation began partnering with the states and more than doubled the number of water bodies sampled to 392, including 293 Reclamation or Reclamation-connected waters.

Generally, each water body is sampled at a minimum of three locations on an average of four to five times during the season (spring through fall). The water samples are then reviewed using cross-polarized microscopy that highlights a unique feature in the shell of the quagga or zebra

mussel veliger, the larvae life stage of the mussels. If the sample is positive or suspect, it is reviewed using electron scanning microscope and/or polymerase chain reaction (PCR) testing.

Since the inception of this monitoring effort, Reclamation has tested more than 3,000 samples using microscopy, with 428 positive samples further confirmed using the scanning electron microscope or PCR testing. Using this process, new detections of mussels have been made in Arizona, California, Colorado, Kansas, Nevada, New Mexico, Oklahoma, Texas and Utah.

In conjunction with the mussel sampling work, Reclamation analyzed the water quality of the bodies of water tested, including dissolved oxygen, temperature, pH and total dissolved ions. This information is providing a benchmark to help Reclamation and its managing partners (a water district or other agency that operates a Reclamation-owned reservoir) predict the compatibility of water bodies to host mussels. If mussels are eventually detected, this data also will allow the water quality to be compared over time to show the ecological impact of the mussels.

To assist in preventing the spread of quagga and zebra mussels, Reclamation developed an equipment inspection and cleaning manual in 2009 that was updated in 2010. It provides guidance for inspecting and cleaning vehicles and equipment. Preventing the spread of invasive species is a cost-effective approach because, once mussels are established, controlling them may require significant and sustained budget expenditures.



Quagga and zebra mussels completely clog a steel grate in just seven months.

Control and mitigation

Reclamation is actively working to ensure that mussels do not impact the operation of its water and power facilities. To date, there have been no reductions to water and power generation at Reclamation facilities.

A facility vulnerability assessment template was developed in 2009 for Reclamation and other entities to download from Reclamation's mussel website. This assessment helps facility managers understand the vulnerability of their facilities to invasive mussel impacts. Combining this assessment with active monitoring for early detection is expected to assist with planning and budgeting that enables facilities to take action before impacts to infrastructure and water resources are realized. Currently, more than 50 facilities have been assessed using this template, and it has provided Reclamation managers the information they need to reduce impacts of invasive mussels to the facilities for which they have responsibility.

Research

Research activities into quagga and zebra mussels are one of the top priorities for Reclamation. Ongoing and new research activities will continue to be directed toward improving early detection methods; identifying developing, demonstrating and implementing facility protection technologies and strategies; and assessing ecological impacts.

Reclamation has a cooperative research and development agreement with Marrone Bio Innovations to study using Zequanox™ (*Pseudomonas fluorescens*) to control quagga and zebra mussels in dams. *Pseudomonas fluorescens* is a dead bacteria, commonly found in soils throughout the world, that has been determined to be lethal to quagga and zebra mussels in certain situations. Various tests are being conducted to study the effectiveness of this product. Results of this research are promising but are still being evaluated.

Reclamation has been conducting on-going field tests of various commercially available coatings at Parker Dam since 2007. Results to date have identified certain coatings systems that inhibit mussel fouling. However, durability in those cases remains low and may shorten service life of the coatings to five to 10 years. While considering the physiochemical characteristics of mussel adhesion, Reclamation researchers are working to further identify and evaluate durable coatings solutions with the desired anti-fouling or foul release performance features.

Another research project is focused on preventing quagga and zebra mussels from settling in water lines, particularly generator cooling systems. The larval stages of quagga and zebra mussels enter hydropower facilities through water intake structures, where they settle and become aggressive biofoulers. They easily attach and grow to maturity, which can lead to restriction or blockage of water flow and result in overheating or damage to the hydropower generation system components.

Mussels treated with UV light were found to be less active than untreated mussels. Smaller, less-developed mussels were more affected immediately after the UV treatment than larger, more-

developed mussels. Quagga mussels treated with UV light experienced significantly greater mortality 168 hours after treatment than untreated mussels. Mussel settlement and growth were observed in two flow-through bio-boxes. Over a six week period, mussels settled and grew with and without treatment, but a higher percentage of untreated mussels appeared to survive and grow over time in comparison with mussels that were exposed to UV light.

Overall, it appears that the UV light dose tested will not completely prevent the settlement and growth of quagga mussels in cooling pipes. However, it did have a considerable effect on the mussels, so it would be beneficial to continue researching the effects of higher UV light doses. Further research will be conducted to test the effects of the increased dose.

Reclamation and Fluid Imaging Technologies Inc. have signed a cooperative research and development agreement to improve the capacity and speed of Fluid Imaging Technologies' FlowCAM® instrument for detecting and documenting quagga and zebra mussel larvae in water samples. Comparing this device to the traditional cross-polarized microscopy, it has the potential to provide automated sample processing and photography of individual particles if additional analysis is necessary.