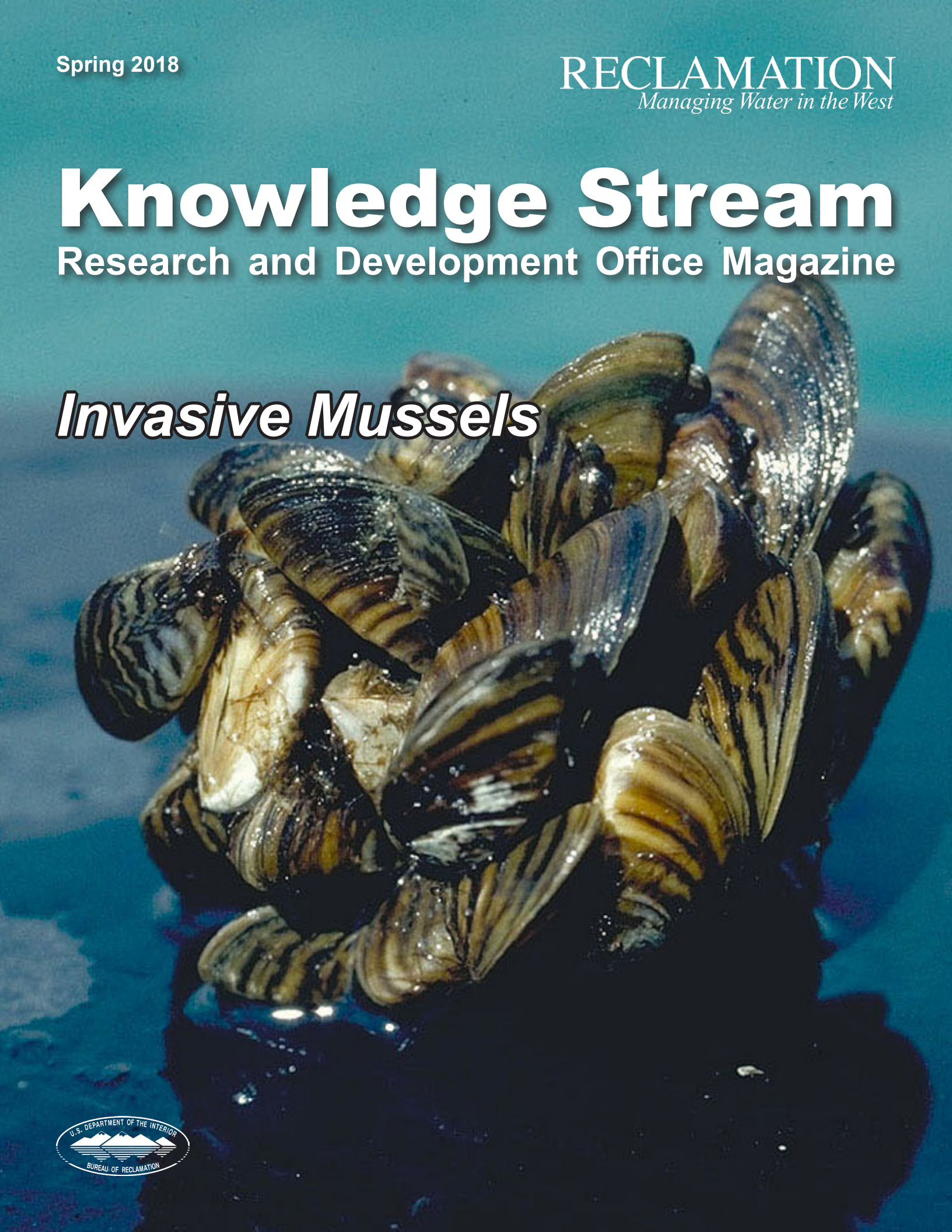
Spring 2018

RECLAMATION
Managing Water in the West

Knowledge Stream

Research and Development Office Magazine

Invasive Mussels



U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Research and Development Office Contact Information

Levi Brekke
Chief
303-445-2494
lbrekke@usbr.gov

John Whitler
Science and Technology Program Manager
303-445-2241
jwhitler@usbr.gov

Yuliana Porras-Mendoza
Advanced Water Treatment Research Coordinator and Desalination and Water Purification Research Program Manager
303-445-2265
yporrasmendoza@usbr.gov

Erin Foraker
Renewable Energy and Infrastructure Research Coordinator
303-445-3635
eforaker@usbr.gov

Ken Nowak
Water Availability Research Coordinator
303-445-2197
knowak@usbr.gov

Samantha Zhang
Technology Transfer Administrator
303-445-2126
szhang@usbr.gov

Kerry Whitford
Prize Competitions Administrator
303-445-2949
kwhitford@usbr.gov

Ronda Dorsey
Programs Information Specialist
303-445-2624
rdorsey@usbr.gov

Rosann Velnich
Budget Analyst
303-445-2231
rvelnich@usbr.gov

Patricia Loetel
Administrative Assistant
303-445-2125
ploetel@usbr.gov

Message from the Chief

Hello and welcome to the Spring 2018 edition of the *Knowledge Stream* focusing on better detection, monitoring, and control of invasive quagga and zebra mussels. This research category is one of the Science and Technology Program's priorities and supports the Department of the Interior's initiative to protect Western U.S. ecosystems and hydroelectric facilities from the effects of invasive mussels (read more about this on page 6).

Invasive mussels have the potential to adversely affect Reclamation facilities through increased operation and maintenance costs and/or interruption in water delivery and power generation functions. Depending on levels of infestation and facility operating conditions, mussel related impacts stem from "fouling" (live mussel attachment) and "clogging" (due to fouling or release of mussel shell debris) that may occur in a number of water delivery and hydropower systems. This includes intakes and penstocks, gates and valves, bypasses and air vents, cooling water systems, raw water fire protection systems, service and domestic water systems, instrumentation, and drainage and unwatering systems.

Over the last ten years since the discovery of quagga mussels in Lake Mead on the Colorado River in January 2007, Reclamation has implemented a coordinated response through a Reclamation-wide Mussels Task Force. The Research and Development Office, through its Science and Technology Program, played a key role in this response and continues to do so by supporting research efforts, including:

- protecting infrastructure with mussel resistant coatings;
- researching biocontrols and examining genetics;
- conducting DNA analyses and 3D modeling;
- discovering eradication ideas through the Water Prize Competition Center; and
- supporting the Reclamation Detection Laboratory for Exotic Species (RDLES).

Many of these technologies are highlighted in this edition. We hope you enjoy!

Levi Brekke
Chief of R&D

Subscribe to the *Knowledge Stream*:

research@usbr.gov

PO Box 25007
Denver Federal Center
Denver, Colorado 80225-0007
303-445-2125

Visit the R&D website at https://www.usbr.gov/research/

Contents

Denise Hosler, who served as Topic Editor for this issue, retired in March 2018 after 20 years of service with Reclamation.

She is best known for her central role in developing the Reclamation Detection Laboratory for Exotic Species (RDLES) and for her leadership in the agency's response to the spread of dressenid mussels in the West.

Thank you for your service, Denise!

Community Needs

Reclamation's Efforts in Invasive Mussel Management

When invasive mussels were first discovered in Lake Mead in January of 2007, it got the attention of folks in the west; most notably, the 100th Meridian stake holder group, which had been working and hoping to keep the small fresh water mussels out of the western US. The tiny zebra mussel had spread rapidly in the east, and its cousin, the quagga mussel was expected to be similarly troublesome. By October, when the bulkhead gate at Davis Dam required a crane to pull the mussel covered gate out of the water, Reclamation began a serious attempt to develop a mussel management program. The Research and Development Office (R&D) consulted with the Technical Service Center (TSC) and mussel experts from the east. The approach to the problem was to develop a threefold strategy to determine:

1. Where are Reclamation facilities vulnerable to mussels?
2. Where in the western US are they?
3. How do we control them once we find them?

With assistance of the American Recovery and Reinvestment Act (ARRA) funding from 2009-2011, R&D launched a massive invasive mussel program to try to find the answers. The initial facility vulnerability assessments were conducted under the guidance of Renata Claudi, Chief Scientist at RNT Consulting, Inc., with the understanding that these assessments were generally a one-time event. As the TSC Staff became experienced with the process, assessments were conducted by a trained group of Reclamation staff. These facility assessments were intended to help facility managers determine what changes needed to be made to keep the facilities running in the event of mussel occurrence. The idea was to give Facility Operators some time to budget and install equipment for changes to prevent unplanned operation outages. Numerous facility assessments were conducted primarily in the Great Plains and Lower Colorado Regions.

Reclamation's R&D has funded several mussel control projects over the years, including an FY 2018 prize competition.

To determine where the mussels were, a sampling program was initiated across the 17 western states. The initial methods involved substrate samples, which consisted of hard surfaced objects (such as bricks) for mussels to settle on, plankton tow net samples to capture veligers (invasive mussel larvae), and shoreline surveys. It did not take long to determine that researchers had the best chance of finding the veligers due to the massive amount of eggs that each female could produce. During this time period the Reclamation Detection Laboratory for Exotic Species (RDLES) was created and refined early detection methods for microscopy and molecular methods. The result of this effort was the improvement of mussel veliger detection and resulted in the adoption of Reclamation developed methods across the US. All

Contact

Denise Hosler
Botanist (Retired 2018)
Hydraulic Investigations and Laboratory Services
Technical Service Center

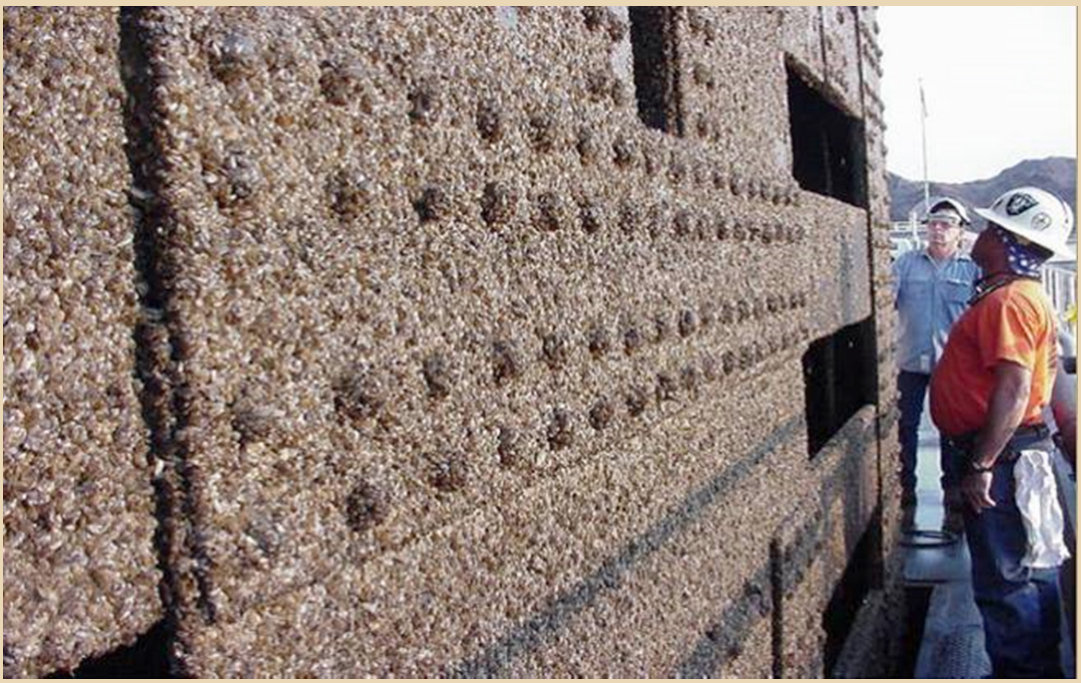
More Information

Reclamation Detection Laboratory for Exotic Species (RDLES)
https://www.usbr.gov/tsc/tscorganization/services/RDLES.html

S&T Invasive Mussel Research Projects
https://www.usbr.gov/research/invasive-mussels.html

Eradication of Invasive Mussels in Open Water Prize Competition
https://www.usbr.gov/research/challenges/mussels.html

of this was accomplished with the assistance of other partners and knowledgeable experts. RDLES was able to evaluate waters in 16 states and analyze almost 300 water bodies by 2012.



Bulkhead Gate inspection of invasive mussels at Davis Dam, Lower Colorado Region in October 2007. Invasive mussels were found in Lake Mead, also of the Lower Colorado Region, in January 2007. This gate at Davis is 67 miles downstream from Lake Mead.

Efforts to find control methods for these prolific little mussels proved to be quite a challenge. As dwellers of the open water, the use of chemicals is limited and not highly feasible. They have the ability to sense toxins and close up for days up to weeks. Most of the control research focused on how to keep the mussels from getting into or settling in Reclamation Facilities. There were several research projects looking at closed pipe treatments from filtration, to biocontrol, to turbulence, to the application of UV light. While all but turbulence have had some success, UV light treatment has proven to be the most promising for minimizing mussel impacts in Reclamation facilities. There is still no silver bullet to manage invasive mussels.

Currently, the best hope still is to prevent the spread of invasive mussels in the first place. Reclamation's previous mussel research makes it clear the first time mussel findings in a water body are most likely to occur are at a boat launch or marina, lending credence to the boat inspection effort. This year, R&D is funding an important project to evaluate efficacy and value of efforts to prevent the spread of these tiny mussels. With a veliger finding in Montana last summer, a renewed interest in invasive mussel management has sparked funding for additional mitigation efforts. This massive effort includes Federal, State, and Private Sector stakeholders to ramp up control efforts on this aquatic invasive species. R&D has funded several mussel control research projects as well as the *Eradication of Invasive Mussels in Open Water* prize competition in hopes of discovering new, innovative options for management.

While there have been a few advances in mussel management in the last ten years, the future looks promising for more successful management of mussels. With new techniques in molecular science and a better understanding of the mussel niche in the western U.S., the potential of better controls are on the horizon to support further understanding of environmental requirements and vulnerabilities to assist researchers in the quest to conquer the mussel invasion.

Key Perspectives

DOI's Invasive Mussel Initiative to Protect Western Ecosystems and Hydroelectric Facilities

In April of 2017, the Department of Interior's (DOI) acting Assistant Secretary for Water and Science Scott Cameron proposed keeping mussels out of the Columbia River Basin with the creation of a mussels initiative, in coordination with the Western Governors Association (WGA). The proposal was "…to deliver a strategic, well-integrated set of federal and state (and possibly tribal) commitments for improving the prevention, eradication, and containment of aquatic invasive species in the Pacific Northwest, with a focus on reducing the risk of zebra/quagga mussel introduction into the Columbia River Basin.."

In order to meet this goal, DOI created six subcommittees focused on the following:

- Best practices for protecting aquatic infrastructure as a prevention and/or management
- Watercraft inspection and decontamination
- Pathway monitoring
- Scientific research and technology innovation to improve prevention, eradication, and control measures
- Education, outreach, and social marketing approaches to pathway management, and
- Policy guidance and institutional coordination

Each subcommittee met weekly and included a Reclamation representative who submitted a suite of commitments and utilized a standard DOI template for submission. Once submissions of potential commitments were complete, they were reviewed by the Department for approval and summarized into a report entitled *Safeguarding the West from Invasive Species: Actions to Strengthen Federal, State, and Tribal Coordination to address Invasive Mussels*. The document was released in June 2017 at the Columbia River Basin team meeting in Helena, Montana as well as with a formal press release by Secretary Zinke, who stated, "Stopping the spread of invasive mussels and increasing our Federal-State-Tribal coordination are both critical priorities in order to ensure that we maintain hydropower as a clean, reliable, cost-effective source of energy for the West and protect our outdoor tourism economies."

Reclamation has continued to actively support the implementation of these commitments in close coordination with Departmental bureaus and the WGA while prioritizing needs identified through Reclamation Regions, Policy, and Research and Development Offices.

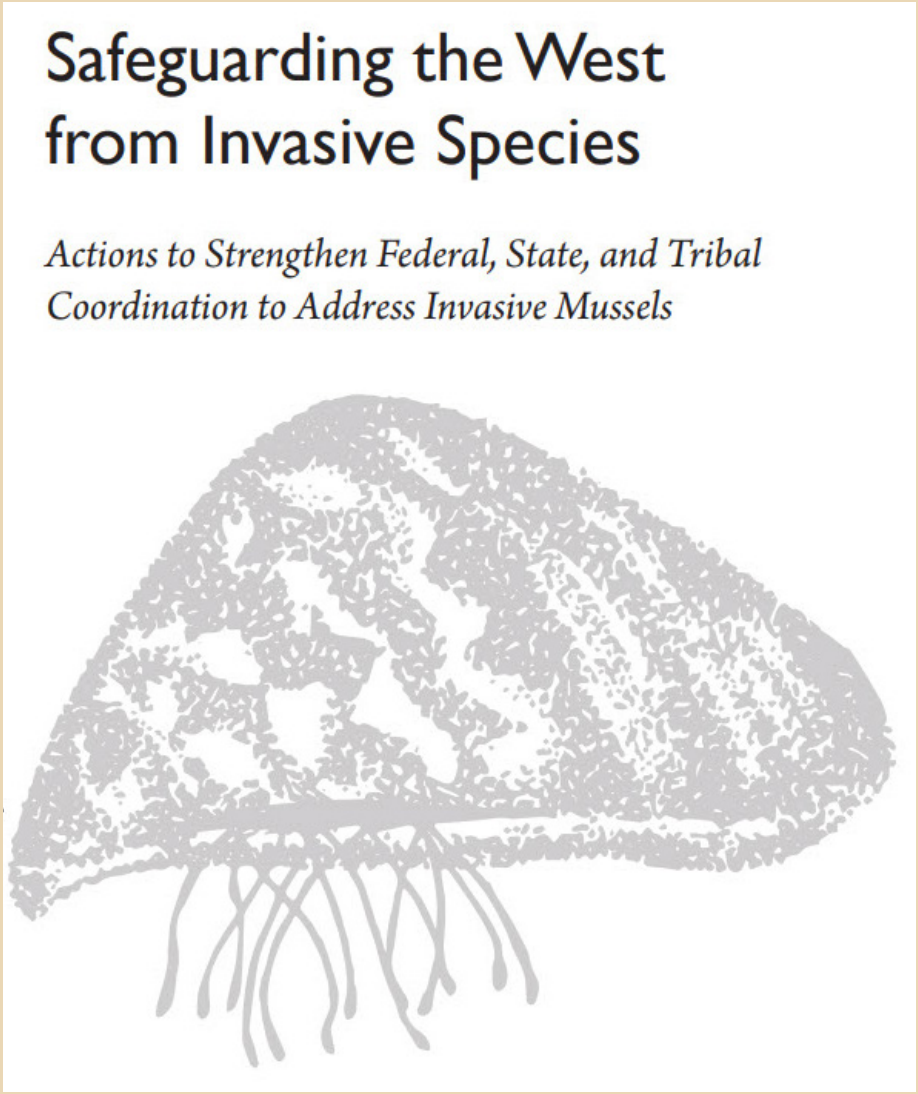
In support of this effort, for Fiscal Year 2017, DOI spent $8.6 million to prevent, contain, and control invasive mussels, including an additional $1 million for Reclamation to support implementation *Safeguarding the West from Invasive Species* (see reference on next page). In Fiscal Year 2018, the President's budget requests a total of $11.9 million for DOI for invasive mussels, including a $3.4 million increase above the 2017 enacted appropriations. These increases in capacity continue to support the wide-range of activities that Reclamation has engaged in since 2008, including: water sampling and analysis, facility vulnerability assessments, support for watercraft inspection and decontamination; outreach and education, and research and implementation of control technologies for post-infestation.

Contact

Jolene Trujillo
Natural Resources Specialist
Invasive Species Coordinator
Environmental Compliance
303-445-2903
jtrujillo@usbr.gov

More Information

DOI news release:
Secretary Zinke Announces Initiatives to Protect Western Ecosystems and Hydroelectric Facilities from Invasive Mussels
https://www.doi.gov/pressreleases/secretary-zinke-announces-initiatives-protect-western-ecosystems-and-hydroelectric



"The federal government is committed to working with the Western Governors' Association and Western States and Tribes to protect the region from invasive species.

Nationwide, invasive species represent one of the most significant threats to ecosystems, human and animal health, infrastructure, the economy, and cultural resources.

Invasive quagga and zebra mussels are a clear case in point. The regional cost to industry and the public is estimated at $500 million annually.

The Columbia River Basin is one of the few major U.S. watersheds uninfested by invasive mussels...

[T]he discovery in late 2016 of larval mussels in Montana near the headwaters of the Columbia River Basin highlight the ongoing and increasing risks to Western waters.

Access the June 2017 guide:
https://www.doi.gov/sites/doi.gov/files/uploads/safeguarding_the_west_from_invasive_species.pdf
Access the February 2018 progress report:
https://www.doi.gov/sites/doi.gov/files/uploads/safeguarding_the_west_progress_report_february_2018_final.pdf

Current Research and Partnerships

UV Treatment for Biofouling Control at Parker Dam

Reclamation research projects indicate ultra-violet (UV) light treatment is an effective control technique for quagga mussel settlement prevention in hydropower generator cooling systems. At Davis Dam, quagga mussel settlement was reduced by 88-99% at doses between 20 and 100 mJ/cm^2 (Pucherelli and Claudi 2017). UV treatment was selected for study in generator cooling systems because it does not impact water flow or require discharge permitting.

UV unit installed at Parker Dam (Lower Colorado River, California-Arizona).

The significant settlement reduction obtained with UV treatment prompted Reclamation's Lower Colorado Dams Office to install UV treatment at additional facilities, including Parker Dam in 2015. Parker Dam also experiences biofouling from the presence of colonial hydroid, freshwater sponge and bacterial growth. The invasive colonial hydroid *Cordylophora caspia* was identified in Lake Havasu, Mead, Mohave, and Powell in 2015 (Pucherelli et al. 2016). *C. caspia* has significant biofouling potential and has been found colonizing and clogging intake tunnels, filters, condenser tube sheets, power plant pipes, and drinking water treatment plants in Europe and the United States.

The current study was designed to determine if UV irradiation reduces overall biofouling in Parker Dam generator cooling systems. Biofouling (including mussel, hydroid, sponge, and bacteria) was monitored upstream and downstream of UV treatment in bioboxes that were plumbed into the cooling line. Settlement in each biobox was analyzed monthly and after six months by collecting organisms settled on plates and comparing biomass accumulation.

The UV dose tested at Parker Dam was approximately 100 mJ/cm^2. During the study, there were periods of time when untreated water entered the downstream bioboxes due to UV lamp malfunction and unforeseen outages. Despite test contamination, visual observations indicated a dramatic difference in the settlement between bioboxes. Monthly biomass accumulation was consistently less in the biobox receiving UV treated water. After six months the dry weight of organisms settled on plates in an untreated biobox was 494 g/m^2 while the weight of organisms settled on plates in the UV treated biobox was only 8 g/m^2.

UV treatment did not consistently reduce hydroid and sponge settlement as effectively as mussel settlement. Hydroids and sponges reproduce asexually and any fragments that survive the UV treatment or enter during a UV outage may continue to reproduce inside the system. Some effectiveness against sponge was indicated after a 3 month period without contamination, where 3 sponges were observed in the UV treated biobox and 112 sponges were observed in the untreated biobox. Additionally, a thick layer of bacterial sludge

Contact

Sherri Pucherelli
Biologist
Hydraulic Investigations and Laboratory Services
Technical Service Center
303-445-2015
spucherelli@usbr.gov

More Information

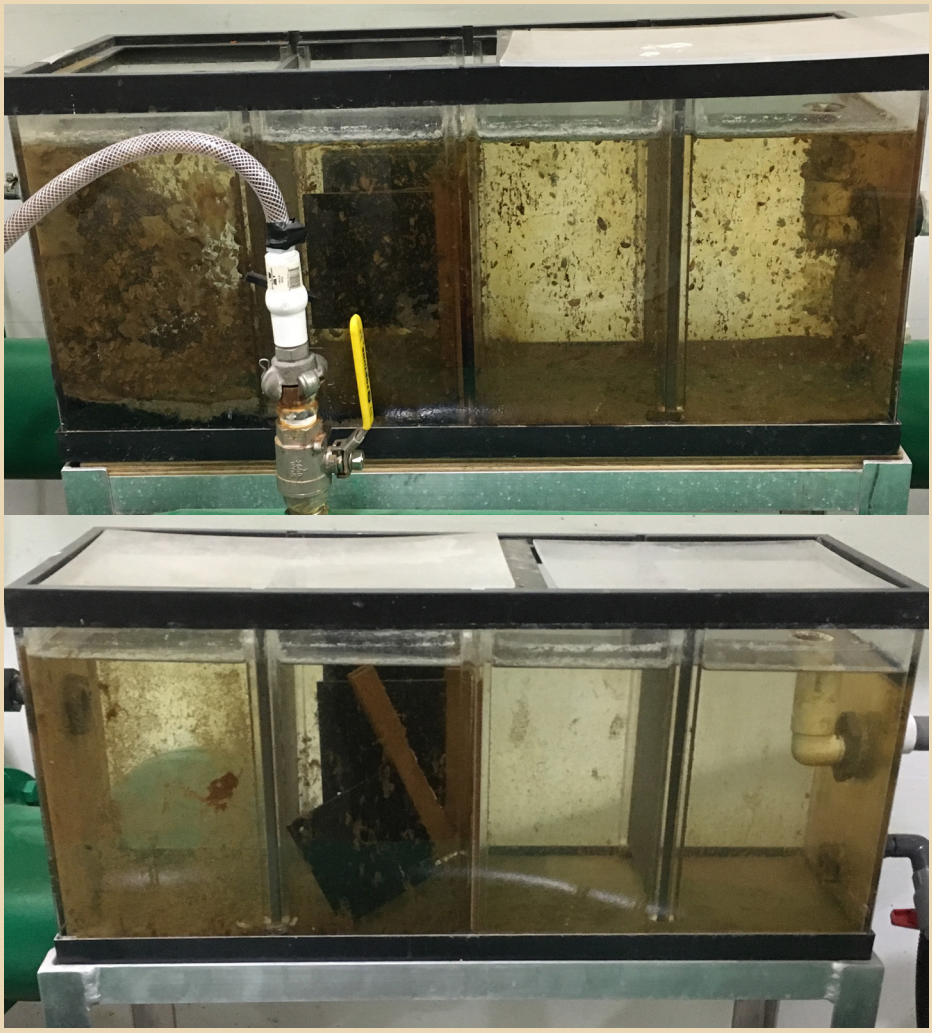
S&T Program Research Project 1712
https://www.usbr.gov/research/projects/detail.cfm?id=1712

Collaborators

Lower Colorado Dams Office
RNT Consulting, Inc.

was observed in the untreated bioboxes which was absent from the UV treated bioboxes, suggesting that UV is capable of limiting bacterial fouling.

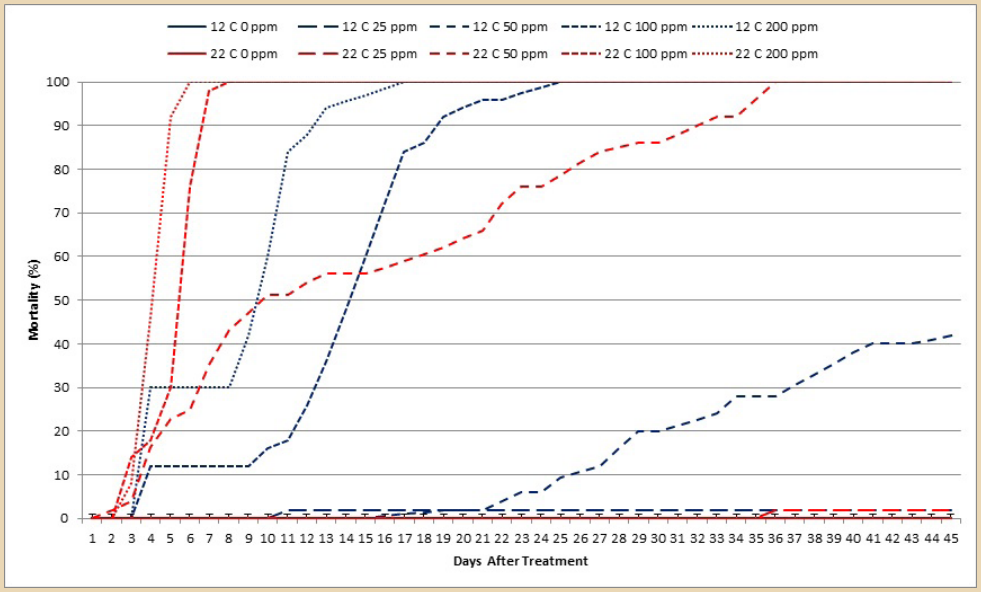
Biofouling in the generator cooler systems at Parker Dam has resulted in increased annual maintenance costs of approximately $80,000/year. Biofouling related maintenance of coolers was reduced by 75 percent after the first year of UV operation, and eliminated in the second year after implementation. The effectiveness of UV is dependent on the selected dose and site specific conditions including water clarity and temperature. Operational conditions in hydropower facilities may limit the control and effectiveness of UV treatment. Despite these limitations overall biofouling was consistently reduced.



Biofouling results after six month test in (top) untreated and (bottom) treated biobox on Parker Dam cooling system.

Use of Potash for Zebra Mussel Eradication at San Justo Reservoir

Zebra mussels were discovered in San Justo Reservoir in 2008. The reservoir is an off-stream storage facility, with distributions to agricultural and municipal users and inflows from San Luis Reservoir, which is not known to contain mussels. Because the San Justo mussel population is essentially isolated, eradication efforts have been proposed using potassium in the form of muriate of potash (potassium chloride).



Dose-exposure mortality curves for zebra mussels treated with potash at San Justo Reservoir.

Certain concentrations of potassium are known to be lethal to mussels via interference with gill membrane transport, and this method was used to successfully eradicate mussels from Millbrook Quarry, Virginia in 2006.

San Justo presents a much larger and complex situation, requiring steps to minimize risks of treatment escapes and re-infestation of the reservoir. On-site ex-situ tests were performed to address factors that could alter the lethal concentration of potassium and/or duration of exposure necessary. Primarily, competing ions can raise the effective potassium dose-exposure for complete mortality, and water temperature influences metabolic rate and potassium uptake.

The tests consisted of jars containing live mussels and water from San Justo, supplied with aeration and with daily water changes to prevent die-off from lack of nutrients or oxygen. Jars were treated with potash at various concentrations, equivalent to 0 (control), 25, 50, 100, or 200 ppm potassium, each with five replicates in both low (12° C) and high temperature (22° C) water baths, corresponding to typical seasonal low and high water temperatures at San Justo. Both potassium concentration and water temperature had considerable effects on mussel mortality rates, with higher rates in 22° C water and higher concentrations of potassium. No mortality was observed in any of the control jars.

These results suggest that eradication of zebra mussels with potash at San Justo reservoir is feasible, and could eradicate mussels with a 30 day exposure even when water temperatures are low.

Effects of potash treatment on zebra mussels.

Contact

Scott O'Meara
Botanist
Hydraulic Investigations and Laboratory Services
Technical Service Center
303-445-2216
someara@usbr.gov

More Information

S&T Program Research Project 1610
https://www.usbr.gov/research/projects/detail.cfm?id=1610

Advances in Protecting Submerged Infrastructure from Invasive Mussels

The Materials and Corrosion Laboratory (MCL) at the Technical Service Center has been researching coatings and materials for zebra/quagga mussel control for the past 9 years. Since 2008, the coatings team has evaluated over 100 coatings and materials to mitigate and prevent mussel attachment.

In 2008, the coatings team observed that silicone foul release coatings (FRCs) prevented mussels from attaching to the structures. In comparison, the steel control grating was completely fouled, greatly reducing flow through the grate. This was unexpected because these coatings are designed to allow fouling on ships while docked, but the fouling organisms would wash off the coating surface as soon as ships departed. Also during this inspection, it was discovered that mussel populations accumulated to a greater degree in flowing water conditions than in static water. All previous research by others evaluated coatings in static exposure only. Another finding in this study was that antifouling paints did not work under flowing water conditions. Most of the copper alloys, including Z-Alloy examined prevented mussel attachment; the 90-10 copper-nickel is the exception.

Contact

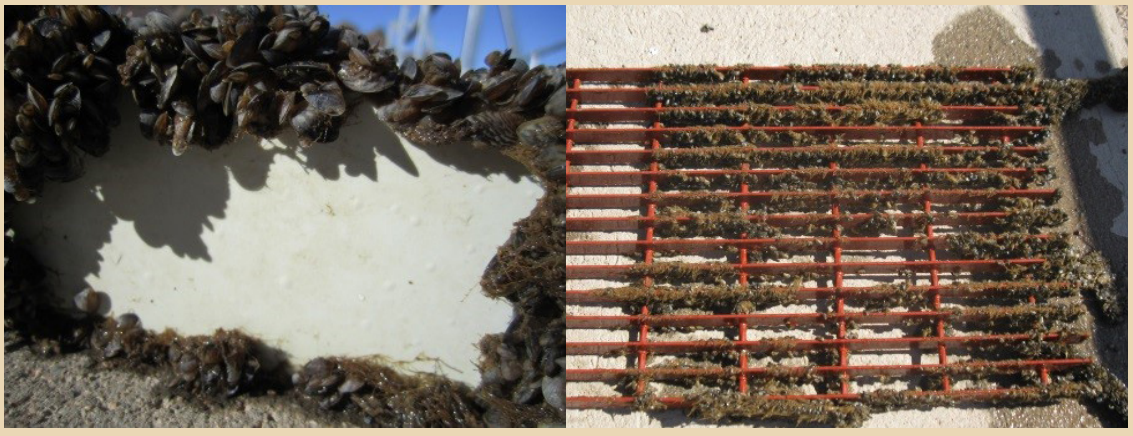
Allen Skaja
Chemist
Materials and Corrosion Laboratory
Technical Service Center
303-445-2396
askaja@usbr.gov

More Information

S&T Program Research Project 7089
https://www.usbr.gov/research/projects/detail.cfm?id=7089
Project 7095
https://www.usbr.gov/research/projects/detail.cfm?id=7095

Left to right: Silicone foul release coating, steel, Z-Alloy after 24 months of exposure.

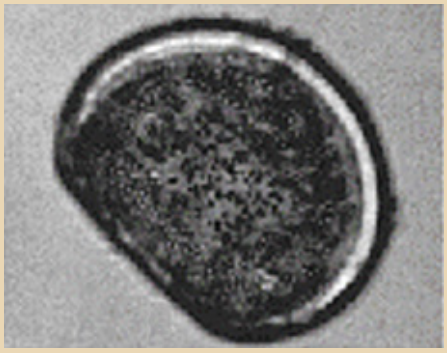
In 2013, two new products were evaluated that provide durability and mussel control. A Material Transfer Agreement (MTA) partner's experimental polyurethane/ polysiloxane FRC were observed to prevent mussel fouling. After four years of testing, these coatings are still providing easy clean surfaces. Jotun Sealion Resilient, an epoxy silicone FRC, is a hard coating that allows fouling to occur, but are still easily cleaned after four years of testing. Both durable systems were identified before the US Navy knew of the technologies.



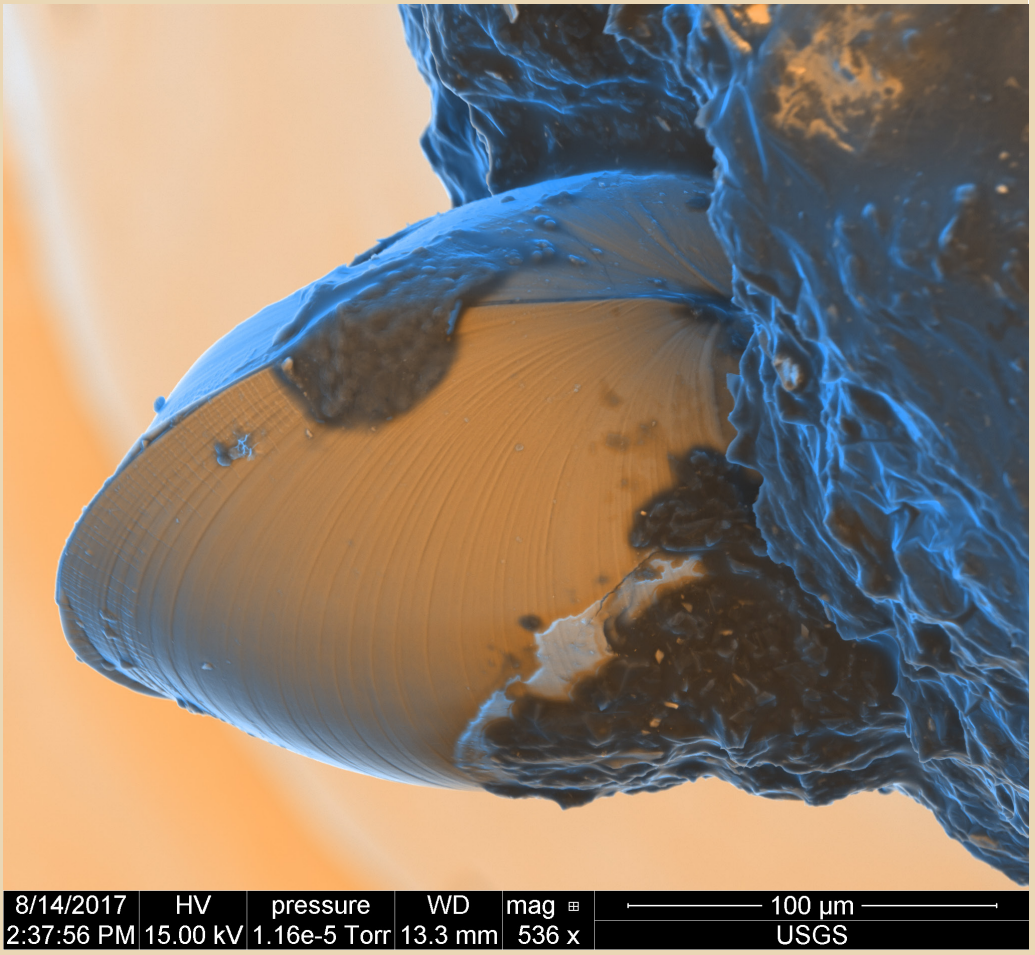
Left to right: MTA partner durable FRC, Jotun Sealion Resilient easy-clean system.

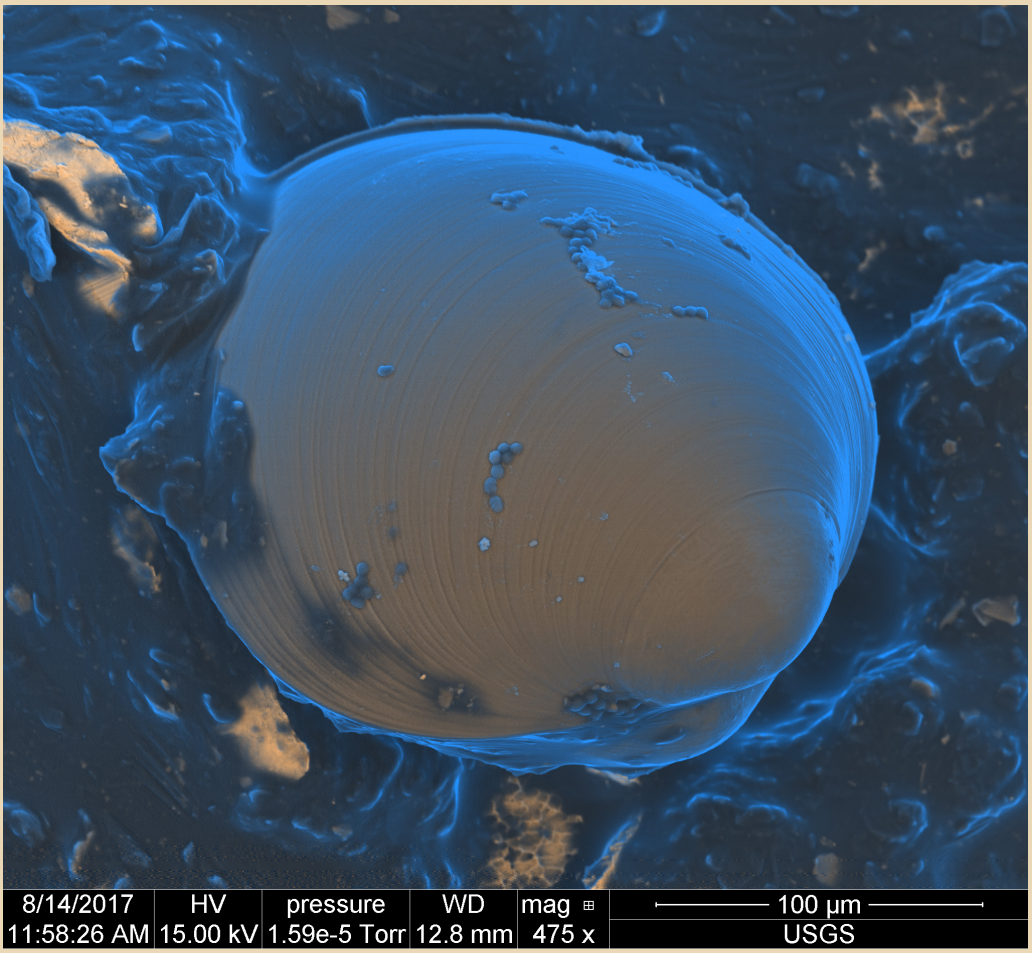
Technology Advancements with Microscopy Improve Mussel Identification Research

Biologists typically use a polarizing light microscope to identify potential invasive mussel veligers (image below):



Species confirmation must be completed with the aid of genetic information or more detailed images from a Scanning Electron Microscope (SEM).

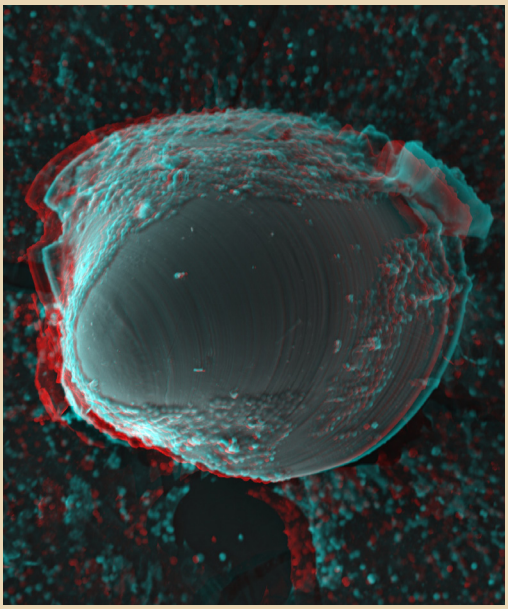


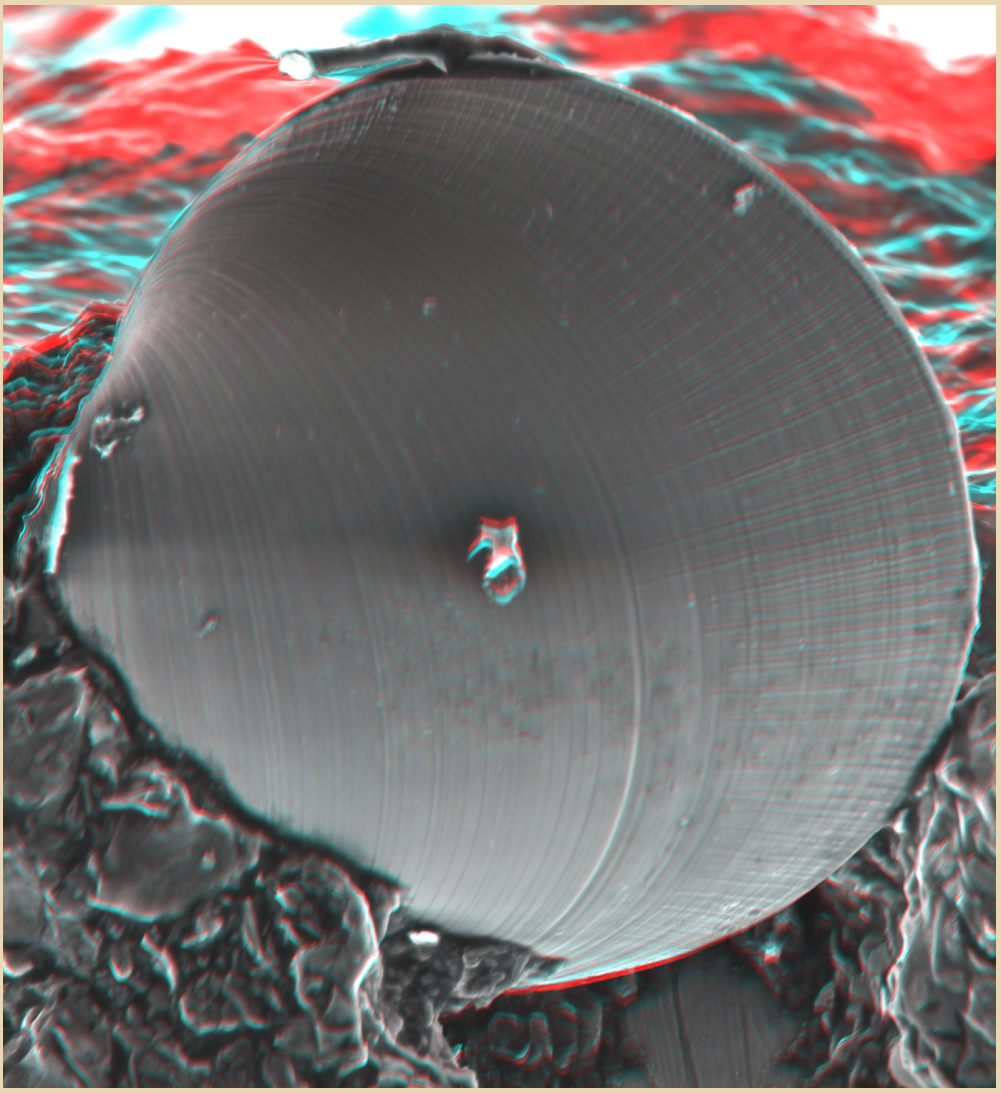


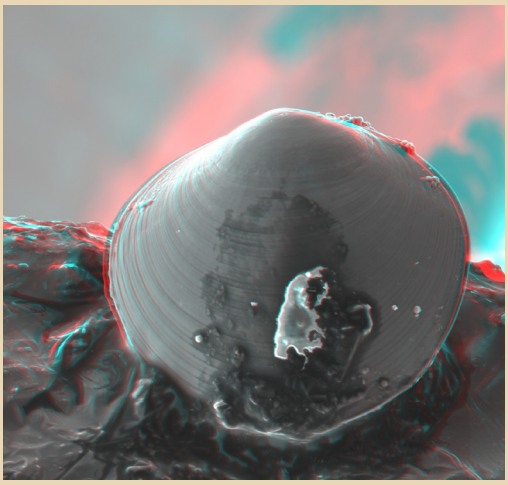
An SEM produces images of a specimen by scanning the surface with a beam of electrons that are reflected to produce signals containing information about the topography and composition of the specimen.

SEM images make it easier to identify organism traits.

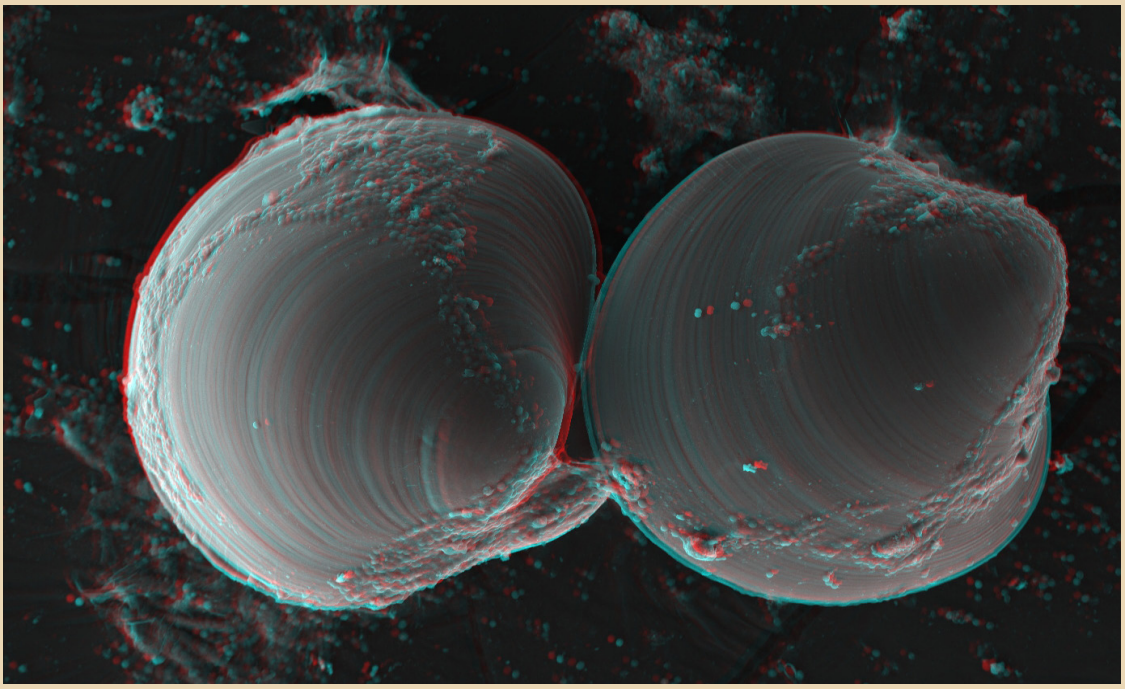
These 3D images of microscopic mussel veligers (larva) allow researchers to obtain morphological data that cannot be obtained from traditional microscopic images.







Anaglyphs (a stereoscopic picture viewed with red-cyan 3D glasses) and printed 3D models are valuable for training, education, public outreach, as well as invasive mussel control research.



Contact

Audrey Rager
Geologist
Concrete, Geotechnical, and Structural Laboratory
Technical Service Center
303-445-2377
arager@usbr.gov

More Information

S&T Program Research
https://www.usbr.gov/research/projects/researcher.cfm?id=2527

Left: Scanning electron microscope (SEM) images of invasive mussel veligers from Parker Dam (Lower Colorado River, California-Arizona). These false color-composite images combine secondary electron and backscatter electron images (August 2017). Right: Anaglyphs of invasive mussel veligers also from Parker Dam (September 2017).

Hunting for Mussel Biocontrols

One of the greatest challenges with the spread of quagga mussels in western lakes and reservoirs is the lack of effective measures for controlling or eradicating populations of these invasive bivalves. Because quagga mussels lack natural predators in these new environments their populations can expand rapidly and to dramatic densities once they have been introduced and become established.

Several chemical compounds have been tested and been shown to be effective at killing quagga mussels; however, the cost of such treatments is prohibitive in all but the smallest of water bodies. In addition, some of these treatments are not species specific, and therefore cannot be used in locations where native bivalves are present.

Biological control, controlling a pest population by introducing a natural enemy, is a compelling option for dealing with invasive quagga mussels. Biological control has already been used successfully as part of a larger integrated pest management plan for invasive plants, such as salt cedar and giant salvinia, that have impacted Reclamation operations. A key to successful biological control is identification of an organism that will attack the invasive pest but not impact native species in the environment. For this reason, parasites are often selected for use as biological control agents. Parasites frequently co-evolve with a specific host species, and will not feed on organisms other than that host.

To date, over 40 different microscopic animals and single-celled organisms have been identified living on or within zebra and quagga mussel tissues. This would seem to suggest a wide range of potential biocontrol agents; however, many of these organism may be commensal, living on or in mussels but not causing them harm, versus being parasites that negatively impact the host. Another factor is that many parasites, such a trematode worms, have complex life cycles, needing to infect not only the target species, but also one ore more other species to complete their development and reproduce.

"Biological control, controlling a pest population by introducing a natural enemy, is a compelling option for dealing with invasive quagga mussels."

The Reclamation Detection Laboratory for Exotic Species (RDLES) is working with Dr. Daniel Malloy to look for biological control agents to be used against quagga mussels. Dr. Malloy is an expert on invertebrate parasites, who is responsible for the description of many of the microorganisms that have been identified from dreissenid mussels. The collaboration between Reclamation scientists and Dr. Mallow is focused on a group of single-celled microorganisms called ciliates. The available evidence suggests that ciliates in dreissenid mussels do not have to go into a host other than the mussel during their life cycle, an important characteristic for development of a biological control. In March of 2017, RDLES scientists Dr. Jacque Keele and Dr. Yale Passamaneck traveled with Dr. Malloy to the small Balkan nation of Montenegro to study these ciliates and their hosts in their native environment. The researchers identified several potential ciliate parasites from an indigenous mussel, *Dreissena carinata*. Work is currently underway to analyze the DNA from these ciliates, and this work set the stage for future efforts to test the ability of these ciliates to infect and impact quagga and zebra mussels as a tool for mitigating the impact of these species in the United States.

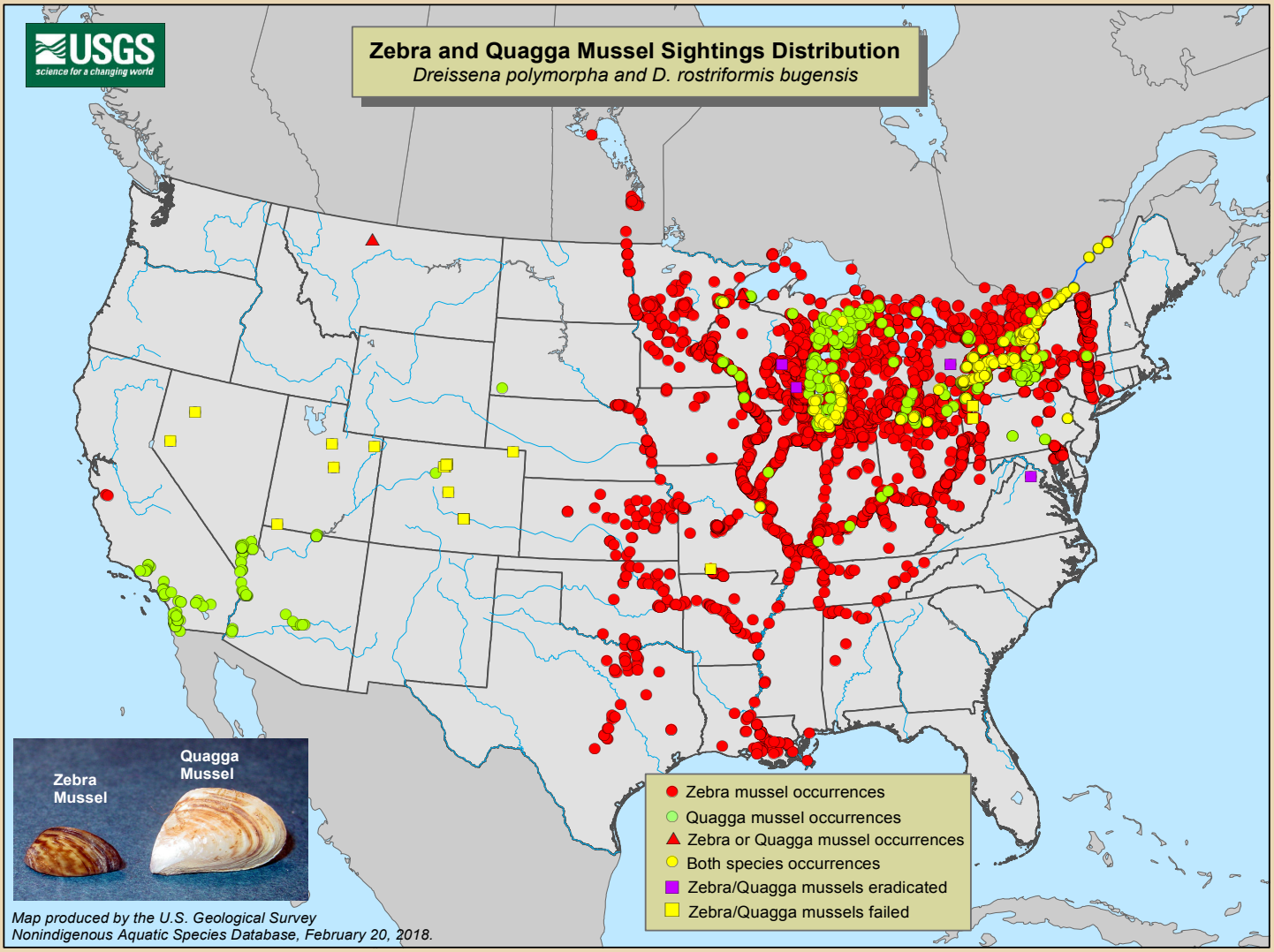
Contact

Yale Passamaneck
Ecologist
Hydraulic Investigations and Laboratory Services
Technical Service Center
303-445-2480
ypassamaneck@usbr.gov

More Information

S&T Program Research
https://www.usbr.gov/research/projects/researcher.cfm?id=2819

Reclamation Detection Laboratory for Exotic Species (RDLES)
https://www.usbr.gov/tsc/tscorganization/services/RDLES.html



View an animated version of the USGS Nonindigenous Aquatic Species at:
https://nas.er.usgs.gov/queries/SpeciesAnimatedMap.aspx?speciesID=5

Advances in DNA Analysis at RDLES

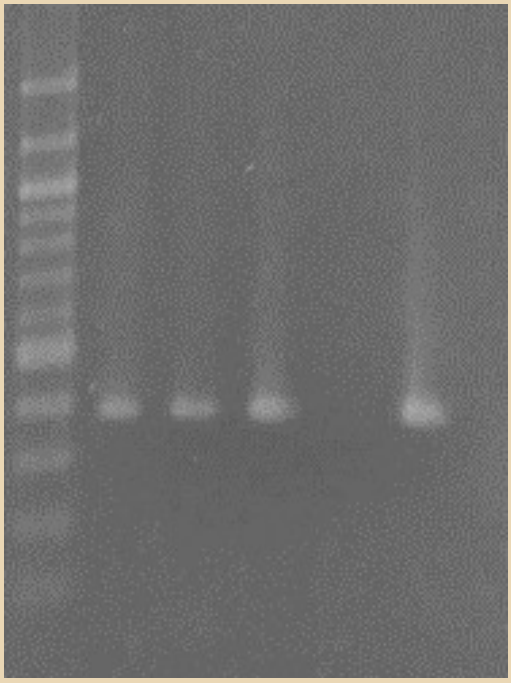
The use of molecular techniques, in particular polymerase chain reaction (PCR), has been an area of active research at Reclamations Detection Laboratory for Exotic Species (RDLES). DNA is isolated from the sample and then PCR is performed to amplify a fragment of a gene of interest. All positive PCR results are sent for DNA sequencing to confirm the finding. The analysis of environmental DNA (eDNA) to test for the presence or absence of an organism is an important technique.

Initially, PCR was first used to detect quagga and zebra mussel DNA in water samples collected from across the western United States. Optimizing and ensuring that this assay was both sensitive and specific to the invasive mussels was a major effort. In addition, research was performed to understand the impact of sample preservation on DNA analysis, how long the samples are stable, and the analysis of individual suspect veligers to determine if they are quagga or zebra mussels. The current standard operating procedure that is used by RDLES for the detection of invasive mussels by PCR analysis has been shared with researchers from around the world.

Using the knowledge gained from the work done with quagga and zebra mussels, other PCR applications have been added over the last few years:

- Adapting and modifying PCR assays for the detection of golden mussels, corbicula, and the spiny water flea in water samples.
- DNA barcoding with nonspecific PCR primers to identify samples from birds, fish, and other organisms.
- Next generation DNA sequencing to analyze whole microbiomes of organisms from a wide range of sites including Lake Mead, the Salton Sea, and wetlands.

Molecular techniques, such as PCR, will allow RDLES to continue to expand both our capabilities and knowledge. From the initial quagga and zebra mussels PCR assay, additional PCR assays have been adapted or developed for other invasive species. Finding ways to apply molecular methods to answer research questions is an ongoing goal for the biologists of the RDLES laboratory.



Analysis of polymerase chain reaction (PCR) products on gel. PCR is a precise laboratory technique used to amplify fragments of DNA.

Contact

Jacque Keele
Biologist
Hydraulic Investigations and Laboratory Services
Technical Service Center
303-445-2187
jkeele@usbr.gov

More Information

S&T Program Research
https://www.usbr.gov/research/projects/researcher.cfm?id=2509
S&T Program Research
https://www.usbr.gov/research/projects/detail.cfm?id=1866
Project 1831
https://www.usbr.gov/research/projects/detail.cfm?id=1831

Reclamation Detection Laboratory for Exotic Species (RDLES)
https://www.usbr.gov/tsc/tscorganization/services/RDLES.html

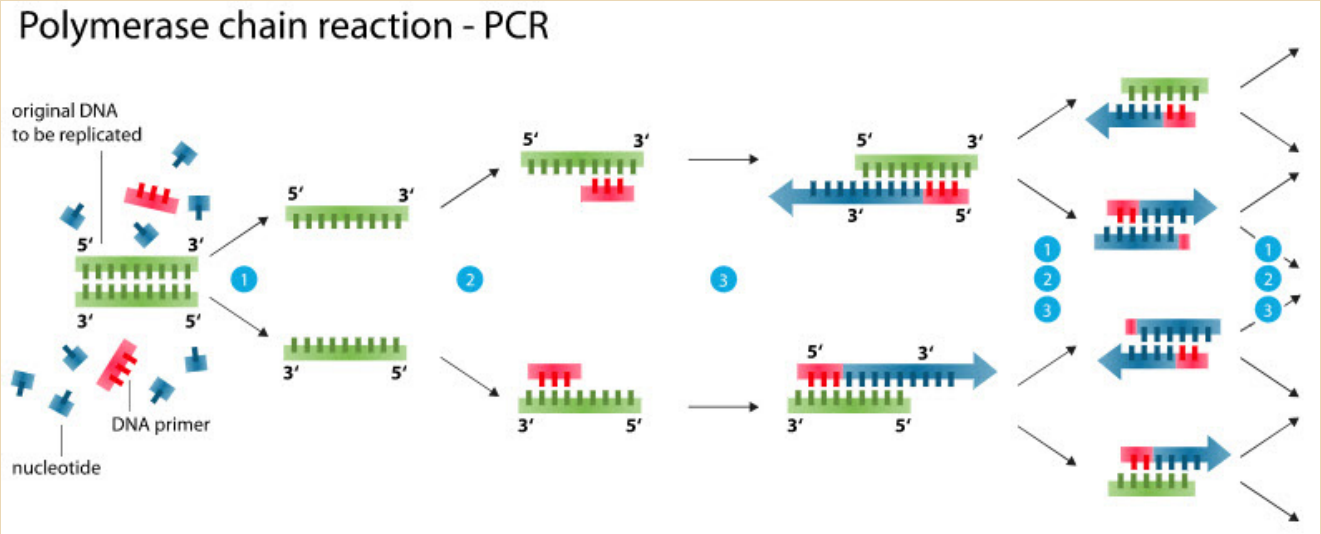
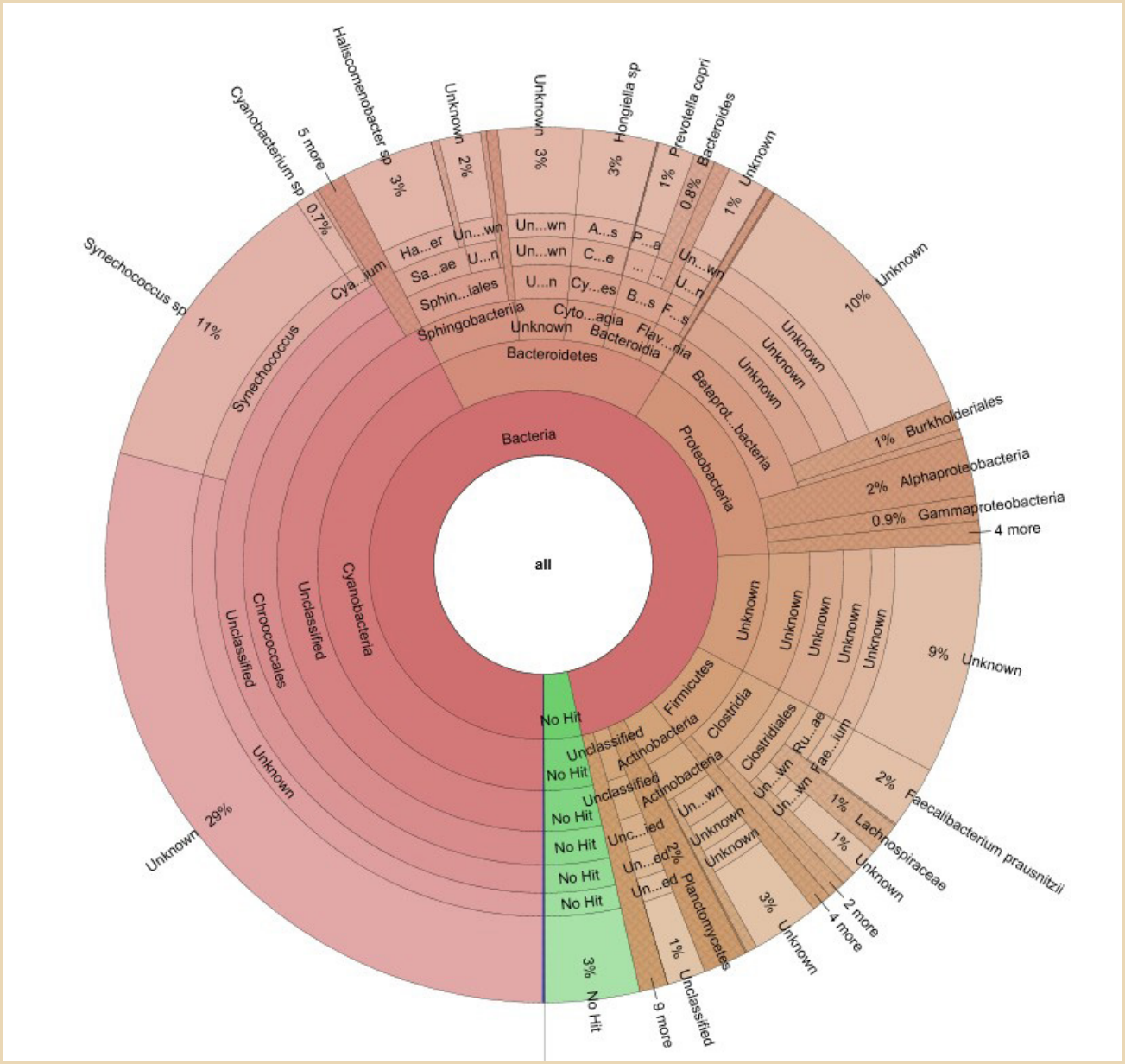


Image created by Enzoklop and shared under a Creative Commons CC BY-SA 3.0 from Wikimedia Commons.



Example of next generation DNA sequencing data.

Effective and Safe Decontamination for Divers

Reclamation has maintained underwater inspection teams since the 1960s to carry out mission critical and routine facility reviews of submerged structures. Reclamation underwater inspection activities may serve as a transport vector for quagga and zebra mussels, especially for the microscopic larva life stage called veligers.

The primary goal of this research is to test the effectiveness and health safety of various decontamination protocols for underwater diving equipment routinely used by Reclamation, such as scuba dive gear, remotely-operated vehicles, and surface-supplied air equipment. Members from both Reclamation underwater inspection teams from the Lower Colorado and Pacific Northwest Regions are performing this research.

Dive team members perform underwater inspections of normally-inaccessible features in support of facility reviews, reviews of operations and maintenance, oversight of contracted construction activities, and special investigations, including underwater surveys for quagga and zebra mussels. Dive teams often carried out back-to-back inspections of multiple facilities in different reservoirs on the same trip.

While "Clean, Drain, and Dry" may work well for diving activities completed at a single location, the potential for transporting veligers on wet diving equipment from one reservoir to another on the same trip necessitates a more proactive approach of decontamination. To address this issue, dive team members initially drafted protocols utilizing a saltwater solution soak (Reclamation Technical Memorandum No. 86-68220-07-05). However, the preparation and disposal of large quantity of saltwater solution is complicated by the length of time to adequately prepare a large enough quantity of saltwater solution to soak all dive equipment, finding a water source free of veligers in remote locations, and the variable disposal requirements among local regulations.

Download the manual at:
https://www.usbr.gov/mussels/prevention/docs/EquipmentInspectionandCleaningManual2012.pdf

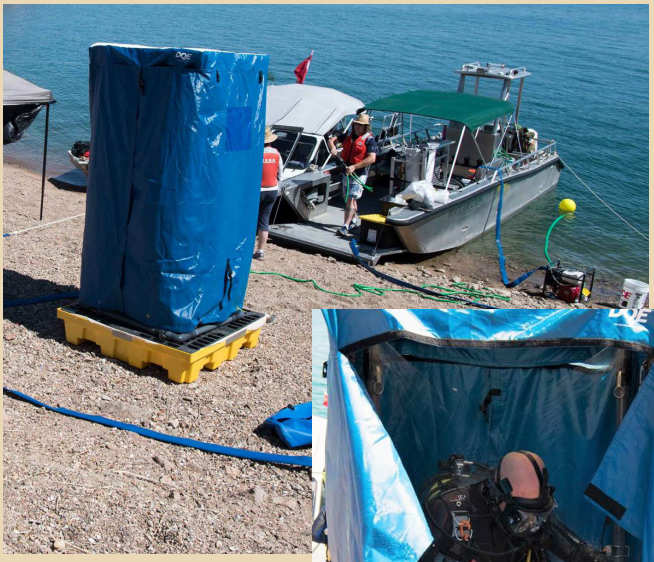
Another challenge of diving equipment decontamination is to avoid causing damage to diving equipment or harm to the diver's health. Popular decontamination procedures such as chlorination and hot water rinse are not suitable for maintaining the material integrity of dive equipment and minimizing the potential for harm to the diver's health.

Contact

Kevin Kelly
Research Chemist
Materials and Corrosion Laboratory
Technical Service Center
720-663-7944
kkelly@usbr.gov

More Information

S&T Program Research Project 1755
https://www.usbr.gov/research/projects/detail.cfm?id=1755



Above: A diver decontamination shower system site set up and demonstrated (right) at Lake Mead in the Lower Colorado Region.

State and federal regulations prohibit the transport of potentially live quagga or zebra mussels (including microscopic mussel larvae, known as veligers) away from an infested dive site.

Therefore, all exposed underwater dive gear must be treated on site after completion of dive activities.

Below left: Reclamation's Chris Waechter, Environmental Engineer, wears his design of a backpack filtration system. This system is a portable alternative to the shower system (left). The advantage of the unit is the potential for use by Reclamation dive teams at remote locations.

Below center: A Lower Colorado Regional Diver is rinsed with filtered Lake Mohave water from the backpack filtration system.

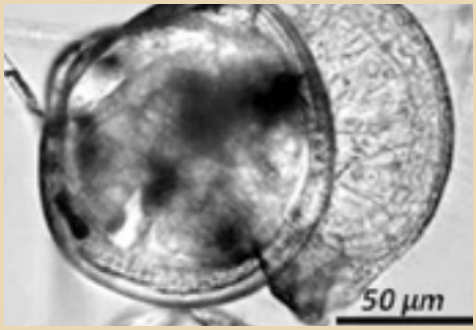
Below right: Ground view of the backpack filtration system.

Collaborators on this project included: Lower Colorado Regional Dive Team Lead Caireen Ulepic, Pacific Northwest Regional Dive Team Lead Ryan Hedrick, TSC Advanced Water Treatment Group's Christopher Waechter, TSC Hydraulic Investigations and Laboratory Services Group's Sherri Pucherelli, Rochester Institute of Technology's Asher Kirschbaum.

Research Updates

Reclamation's Science and Technology Research

These invasive mussel projects showcase ongoing and/or completed research within Reclamation's Science and Technology Program. Contact the principal investigators for more information.



Project ID 6712

Examining Genetic Structure of Quagga Mussel Populations in the Lower Colorado River

Microsatellite analysis of quagga mussels

"In comparison to populations in their native range, and in the Great Lakes and Mississippi River Basins, quagga mussel populations in the Western United States are likely adapting to the unique habitat characteristics of highly managed waters."

Sherri Pucherelli | spucherelli@usbr.gov

https://www.usbr.gov/research/projects/researcher.cfm?id=2511

Project ID 5270

Foul-Release Scaleup: A Real World Trial of Mussel Resistant Coatings

Foul-release coatings applied on a new 10'x10' trashrack panel were put to the ultimate test at Parker Dam

"Silicone foul-release coatings appear to be a promising solution for controlling mussels on Reclamation's infrastructure."

David Tordonato | dtordonato@usbr.gov

https://www.usbr.gov/research/projects/researcher.cfm?id=1957

Project ID 1608

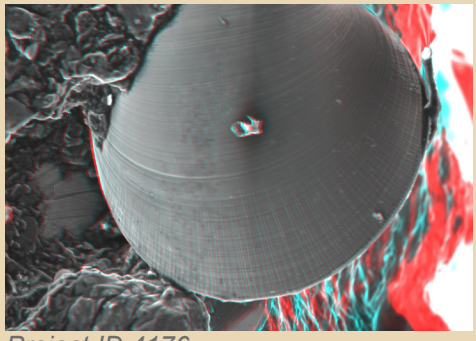
Mussel-Related Impacts and Costs at Hoover, Davis, and Parker Dams

Determining the historical costs attributable to the infestation of mussels may help establish a process for future tracking of impacts and costs

"Each site should fully assess their facility and make pro-active changes to minimize the impacts of quagga mussels."

Joe Kubitschek | jkubitschek@usbr.gov

https://www.usbr.gov/research/projects/researcher.cfm?id=115



Project ID 4176

3D Models of Invasive Mussel Veligers

Creating detailed 3D models using stereopairs of SEM images

"By acquiring SEM images at various angles, we can create 3D models from which we can produce anaglyphs and enlarged printed 3D models. This allows researchers to study veliger morphology in more detail to improve training, education, and outreach, as well as support invasive mussel control research."

Audrey Rager | arager@usbr.gov

https://www.usbr.gov/research/projects/researcher.cfm?id=2527

Featured Faces

Highlighting Researcher Excellence

The following Reclamation researchers are critical to the success of the agency's work in Invasive Species management. Look for their contributions within this issue of the *Knowledge Stream*.

Jacque Keele

Jacque is a Biologist in the Reclamation Hydraulic Investigations and Lab Services group with the Technical Service Center. Her past work has focused on optimization of extracting DNA from water samples, QM/ZM PCR assays, and DNA barcoding. She has recently started to use next generation DNA sequencing in the analysis of microbiomes of different sites.

jkeele@usbr.gov | 303.445.2187

Scott O'Meara

Scott is a Botanist in the Reclamation Detection Laboratory for Exotic Species (RDLES), part of the Hydraulic Investigations and Laboratory Services group in the Technical Service Center. His work with invasive mussel projects have included cooperative work with industry in development of monitoring and detection technology and preliminary molluscicide testing, as well as mussel treatment planning, habitat suitability research, and impact assessments.

someara@usbr.gov | 303.445.2216

Sherri Pucherelli

Sherri is a Biologist in the Reclamation Detection Laboratory for Exotic Species (RDLES) at the Technical Service Center. Recently her research has focused on testing quagga mussel settlement control technologies for hydropower facilities. Sherri is also involved in conducting aquatic and terrestrial invertebrate monitoring and research.

spucherelli@usbr.gov | 303.445.2015

Chris Waechter

Chris is an Environmental Engineer in the Advanced Water Treatment Group of the Technical Service Center. His work has included research projects involving biological treatment and advanced reverse osmosis membrane materials, as well as design work including filtration systems for decontaminating divers after work in mussel infested waters.

cwaechter@usbr.gov | 303.445.3893

Technology Prize Competitions

Reclamation's Water Prize Competition Center Update

Since the America COMPETES Reauthorization Act of 2010 (15 U.S.C. § 3719), Reclamation's Water Prize Competition Center has the authority to use prize competitions as a tool to seek solutions to challenging problems from beyond the usual sources of potential solvers and experts.

Reclamation's Water Prize Competition Center has launched the following reduction-to-practice prize competitions seeking citizen solvers who can find innovative solutions for some of the most critical water and water-related resource problems facing the Nation.

Infrastructure Sustainability Theme Area

Detecting Leaks and Flaws in Water Pipelines - Stage 1

Closes May 7, 2018

Reclamation's water conveyance system includes over 20,000 miles of buried pipelines made of various materials including metal, plastic, concrete, and composite. Detecting water loss from pipelines will trigger appropriate maintenance, allowing conservation of scarce water resources and more reliable service to clients. This competition is seeking methods and technologies that can reliably and easily detect leaks and flaws in operating, pressurized water pipeline infrastructure regardless of size, depth of burial, pipe material or interior lining. The primary focus is finding condition assessment solutions for 48-inch or greater pipe diameters and for steel and prestressed concrete cylinder pipe types, although solutions for all pipe types and diameters greater than 24 inches will be considered.

Prize Competition Team Lead: Jessica Torrey | jtorrey@usbr.gov
Learn more at: *https://www.usbr.gov/research/challenges/leakypipes.html*

Water Availability Theme Area

Sub-Seasonal Forecast Rodeo

Closes May 3, 2018

Improving sub-seasonal forecasts of temperature and precipitation (lead-times ranging from 15 to 45 days and beyond) would allow water managers to better prepare for shifts in hydrologic regimes, such as the onset of drought or occurrence of wet weather extremes. This competition involves solvers submitting forecasts of temperature and precipitation for 1 year, competing in real-time against other teams as well as official forecasts from the National Oceanic and Atmospheric Administration (NOAA). Recognizing NOAA's leadership and role in forecasting, Reclamation has partnered with NOAA on this prize competition. To be eligible for prizes, solvers with skillful performance during the competition will be required to submit documentation of their forecast technique.

Prize Competition Team Lead: Kenneth Nowak | knowak@usbr.gov
Learn more at: *https://www.usbr.gov/research/challenges/forecastrodeo.html*

Contact

Kerry Whitford
Prize Competition Coordinator
303-445-2949
kwhitford@usbr.gov

More Information

Water Prize Competition Center
https://www.usbr.gov/research/challenges/index.html

About the *Knowledge Stream*

The *Knowledge Stream,* published by the Bureau of Reclamation's Research and Development Office, is a seasonal magazine bringing mission-critical news about the agency's research and science, as well as the many challenges associated with managing water and generating power in the West, including: projects, tools, methods, practices, results, innovation, prize competitions, publications, and more.

Regional Science and Technology Coordinators Contact Information

Whether you are a regional researcher, Reclamation partner or customer, or just have an idea for a project that can help your region, the Regional Science and Technology Coordinators can help you with your research ideas, proposals, and projects.

Region	Coordinators	Email	Telephone
Pacific Northwest	Jennifer M. Johnson Jennifer Cuhaciyan	jmjohnson@usbr.gov jcuhaciyan@usbr.gov	208-378-5225 208-378-5271
Mid-Pacific	Jobaid Kabir Rod Wittler*	jkabir@usbr.gov rjwittler@usbr.gov	916-978-5091 530-262-3670
Lower Colorado	Nathaniel Gee KayLee Nelson	ngee@usbr.gov kdnelson@usbr.gov	702-293-8029 702-293-8073
Upper Colorado	Mark McKinstry John Rice	mmckinstry@usbr.gov jrice@usbr.gov	801-524-3835 801-524-3685
Great Plains	Collins Balcombe Jennifer Beardsley	cbalcombe@usbr.gov jbeardsley@usbr.gov	512-599-4162 406-247-7722

**Rod Wittler is also the Mid-Pacific Region Science Liaison.*

On the Covers—

Front Cover: Photo of zebra mussel cluster by D. Jude. Shared with a Creative Commons CC BY-SA 2.0 license.

Back Cover: Zebra mussel shell debris along the shoreline of San Justo Reservoir, California. Reclamation photo.