



— BUREAU OF —  
RECLAMATION

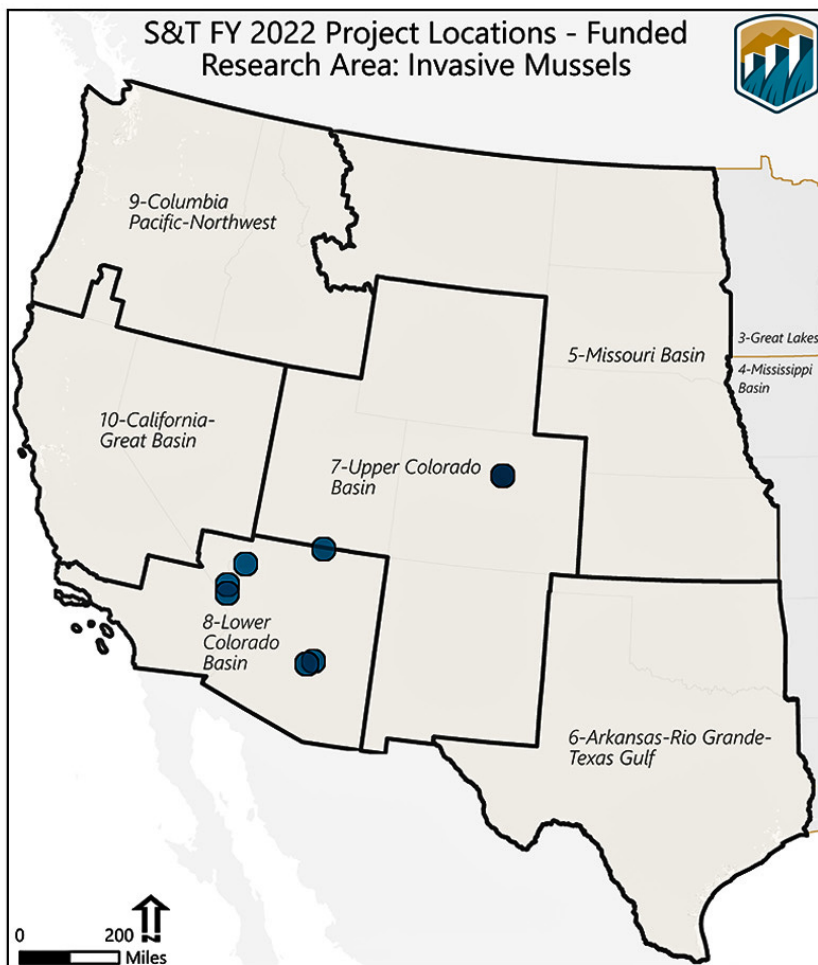
# R&D Office Research Updates

Invasive Mussels



## Executive Summary

The Invasive Mussel (ZQ) Research Category of the Science and Technology Program (S&T) includes research in the following topic areas: Prevention, Early Detection and Monitoring, Management and Control, Impact Assessments, and Increasing Fundamental Knowledge of Mussels. In FY22, S&T funded 26 ZQ projects approximately totaling \$1.6M: 6 were new totaling \$1.55M and 20 were continuing totaling \$0.05M. ZQ research is extremely valuable to Reclamation and has led to the development and implementation of new methods to control mussel fouling and reduce maintenance costs in hydropower plants. Research optimizing early detection and monitoring methods are utilized by Reclamation and partners to limit the spread of mussels in the Western United States.



Reclamation’s Research and Development Office (R&D) manages the Science and Technology Program (S&T) and is focused on providing innovative solutions for Reclamation water and power facility managers and its western customers and stakeholders, primarily through competitive funding opportunities to Reclamation employees.

The S&T Program has five research areas (listed below) directly related to Reclamation’s mission. For more information, visit: [www.usbr.gov/research/st/needs\\_priorities/index.html](http://www.usbr.gov/research/st/needs_priorities/index.html).

### S&T Research Areas and Categories



**Water Infrastructure (WI)**  
Dams, Canals, Pipelines, and Miscellaneous Water Infrastructure



**Power and Energy (PE)**  
Hydro Powerplants, Energy Efficiency, Pumping Plants, and Non-Hydropower Renewable



**Developing Water Supplies (WS)**  
Advanced Water Treatment, Groundwater Supplies, Agricultural and Municipal Water Supplies, and System Water Losses



**Environmental Issues in Water Delivery and Management (EN)**  
Water Delivery Reliability, Invasive Species, Water Quality, Sediment Management, and River Habitat Restoration



**Water Operations (WP)**  
Water Supply and Streamflow Forecasting, Water Operations Models and Decision Support Systems, Open Data, and Climate Change and Variability

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# Invasive Mussels

## FY22 Completed Projects

### 19008: Evaluation of Preservation Methods for Veliger Detection Field Samples - Yale Passamanek

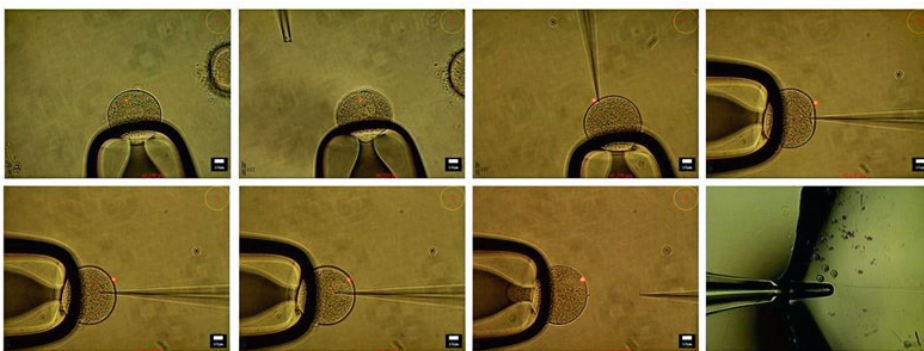
Early detection of dreissenid mussels (quagga and zebra) provides the ability to plan for and limit the impact of these invasive bivalves. Proper preservation of field samples is critical to the success of early detection efforts, as it is necessary to maintain sample integrity to ensure the reliability of sample analyses. The current study evaluated the impact of five preservatives: 20% ethanol, 70% ethanol, 70% isopropanol, Longmire's solution, and propylene glycol, on environmental DNA (eDNA) analyses for the detection of quagga mussel eDNA. All five preservatives successfully resulted in the detection of quagga mussel eDNA over 12-week time-course of the study. Results were further analyzed to calculate the starting quantity of target eDNA in the samples. 70% ethanol, 70% isopropanol, and propylene glycol all averaged similar starting quantities. Longmire's solution resulted in lower average starting quantities. Samples preserved with 20% ethanol had much higher calculated starting quantities, which was unexpected and runs counter to conventional wisdom on the necessity for high alcohol concentrations to prevent eDNA degradation. The reasons for this anomalous result are uncertain, although they may relate to the specific design of the current study.



*Sample tubes for preservation treatments, time points, and replicates.*

### 19006: Eradication of Invasive Quagga and Zebra Mussels Using Engineered Disseminated Neoplasia – Sherri Pucherelli

Biomilab LLC has been working for three years on a project aimed at developing, validating, and manufacturing an invasive mussel eradication agent that mimics a natural pathogenic mechanism found in marine bivalves called a disseminated neoplasia (DN). A DN is a form of cancer



*Progressive photographs of a cleaned zygote being microinjected.*

where the cancer cells themselves travel between organisms in a specific-species manner causing toxicity in the host. Biomilab has established invasive mussel aquaculture in their laboratory and determined methods for the prolonged survival of dissociated mussel cells in culture. They have utilized sequence data provided by Reclamation, and plasmid DNA vectors were constructed for transgene expression and tested in insect cell lines as a proxy for mussel cells. Biomilab tested more than a dozen methods of transduction on mussel cells and determined that because mitotic cells are quite rare, transduced foreign DNA cannot enter the nucleus and is not expressed. In the third year, the focus was on overcoming issues of transduction by exploring infection with recombinant viruses and by establishing methods for the controlled spawning and generation of quagga and zebra mussel embryos by in vitro fertilization.

### 20039: Analysis of Environmental DNA from Sediments for Detection of Invasive Dreissenid Mussels - Yale Passamanek

The present study evaluated the use of sediment DNA analysis for detection of quagga mussels from environmental samples. The study evaluated techniques for sample preservation and DNA extraction, and developed methods suited to the sample types encountered in Reclamation reservoirs. Established quantitative PCR (qPCR) assays were successfully used to detect quagga mussel DNA in sediments from reservoirs and lakes with established populations. The sediment eDNA technique was validated, but its applicability to early detection of invasive mussels may be limited.



*Quagga mussel shells on sandy sediment on the shore of Lake Mead.*



*A view of the Laboratory Trailer in Montenegro of the 72 customized testing aquaria where transinfection studies are being conducted by Molloy & Associates.*

### **19097: Use of Novel Parasites to Control Naive North American Dreissenid Populations – Jacqué Keele**

Reclamation has continued to collaborate with Molloy & Associates to search for novel hypervirulent parasites for the control of invasive dreissenid mussels in North America. The last three years has focused on expanding the field laboratory in Montenegro, identifying, and collecting isolated dreissenid ‘cousin’ species and completing a proof-of-concept trials showing the transfer of parasites between a ‘cousin’ dreissenid and zebra and quagga mussels. The final report from Molloy & Associates detailed the scope, results, and future direction of the research. A new S&T proposal will continue this research until 2024. The identification of a biological control agent for dreissenid mussels is a long-term project, and the results from the last three years have continued to move this goal forward.

### **19196: Development and Field Research on Next Generation Coatings for Mussel Mitigation on Infrastructure – Carter Gulsvig**

Testing has shown that foul release coatings (FRCs) can be used as a viable means to prevent the fouling of Reclamation structures by quagga and zebra mussels. Commercial products from Jotun, PPG, Hempel, International Paints, NuSil Technologies, Chuguko Marine Paint have shown the best performance in both flowing water and quasi-static conditions. Damage was observed on several of these products in flowing and static water conditions. This suggests that improving durability is still the concern for FRCs. In addition to the previously noted damage, blistering was observed on two of the commercially available products (Intersleek 970 and BioClean). Blistering suggests these coatings may be reaching the end of their service life. Most of the panels coated with experimental formulations provided by North Dakota State University (NDSU) had adequate durability with no erosion or abrasion damage observed. However, these formulations had blistering and disbondment of the topcoat



*Experimental test rack prior to installation for testing. Pannels are experimental formulations that have been designed to have increased durability and longer service lives.*

and need to be further developed before they can be recommended for service. Most coatings provided by NDSU also lost their foul release properties as time progressed, allowing increased mussel fouling and/or decreased cleanability. The exception was NDSU formulation C4-20% which prevented mussel fouling in both flowing and static water. The topcoat of formulation 8 was damaged meaning the durability of the coating needs to be improved before it can be recommended for service. Experimental formulations from both Adaptive Surface Technologies and Pacific Northwest National Laboratories (PNNL) prevented mussel fouling and were easily cleaned. The downside of these formulations was that all of them blistered in two years or less of testing, indicating the coating had some sort of application defect or the barrier properties of it need to be improved and is not providing corrosion protection. A minimum service life of 15 years would be desired for any foul-release coatings used on Reclamation structures. None of the experimental formulations evaluated during this research project are recommended for use on Reclamation infrastructure. Further development of the formulations is needed to improve the foul-release properties and barrier properties of the coatings before they can be approved.



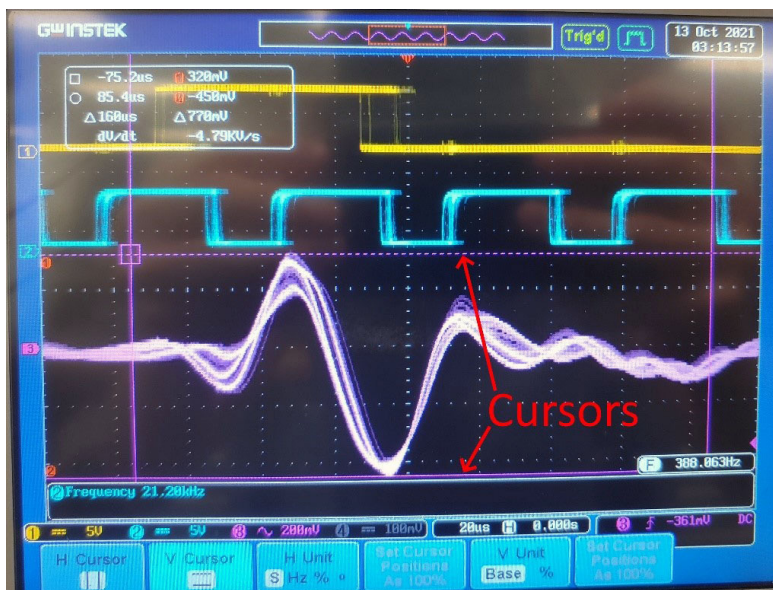
### 21031: Survey and Evaluation of Dive and Aquatic Field Gear Decontamination Protocols for Preventing the Spread of Quagga/Zebra Mussels and Other Aquatic Invasive Species – Sherri Pucherelli

This report identifies existing aquatic invasive species (AIS) decontamination protocols and studies to identify information about method effectiveness and the suitability for sensitive equipment. The two goals of this study were to compile and review existing dive and aquatic field sampling gear decontamination protocols and conduct a literature review of research focused on decontamination methods. Information was compiled from these documents to help determine most studied methods, most used methods, and information gaps or methods that have potential, but are not well studied. No single best approach for AIS decontamination emerged from this analysis but some methods do appear to be more viable than others. It was made evident that having a proactive and flexible AIS program that evaluates different scenarios and tailors techniques to specific conditions, equipment, and AIS is the best approach that should be taken.

*Reclamation dive team member inspecting a mussel infested structure.*

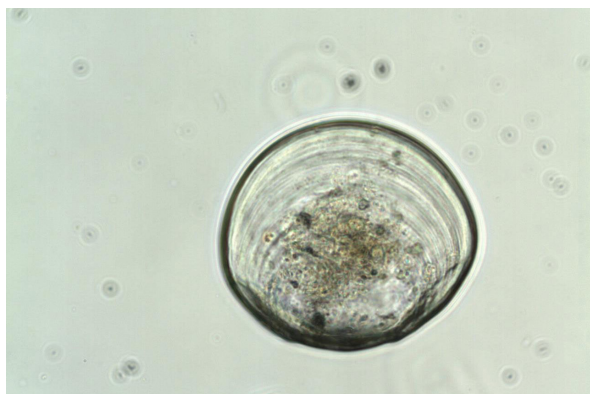
### 19174: Alternate Control Strategy for Dreissenids Using Electrical Methods – Kevin Kelly

Zebra and quagga mussels are major macrofouling species that impact the operations and maintenance of Reclamation water delivery systems. There is a need for an economical and environmentally safe control strategy for these invasive mussels within Reclamation structures. The primary objectives of this research project were to perform literature research and determine the feasibility of using electrical methods to mitigate zebra and quagga mussel infestations in Reclamation facilities. This project attempted to carry out a single established electrical testing procedure described in the literature to investigate the effectiveness of electrical control methods under field conditions similar to those found in Reclamation facilities. Multiple methods utilizing electricity have been shown to impact mussel behavior, including mortality and a reduction in the rate of byssogenesis (byssus attachment); however, a single method is chosen primarily on the basis of adaptability to small-diameter pipelines commonly found in Reclamation facilities. The method chosen for testing on this project involved high voltage pulsed electrified fields. Other methods, including direct electrical currents in the media (water), have also been identified in the literature as having the potential to prevent attachments to metallic surfaces, and these may be studied in the future after high voltage pulsed electrical fields have been assessed.



*Example of an oscilloscope display. Vertical cursors are used to measure the peak-to-peak voltage of the output signal.*

**21094: Innovative Methods for Invasive Mussel Detection – Sherri Pucherelli**



*Microscopic view of a quagga mussel veliger.*

The goal of this scoping project was to investigate the potential of utilizing innovative methods to detect microscopic invasive dreissenid mussels in the lab and in the field. This investigation focused on scent detection by dogs and sensor technology as well as automated image analysis. The intent of this scoping project was to gather initial information about technologies that have potential, and to develop a future conducting proposal that will allow for further investigation and potentially implementation of new methods that will benefit the Reclamation invasive mussel monitoring and early detection program.

**19009: Development of Field Sampling Protocol Standards for Environmental DNA (eDNA) Monitoring of Dreissenid Mussels – Sherri Pucherelli**

There is a need to develop and evaluate eDNA dreissenid mussel field sampling protocols. We compared two common eDNA field sampling methods, sub-surface grab samples and plankton tow samples, in 12 waterbodies with known or potential dreissenid mussel infestations spanning the coterminous United States. To mimic early detection sampling scenarios, we sampled waterbodies or areas within waterbodies that had lower densities of dreissenid mussels or were suspect for dreissenid mussels. The two eDNA sampling methods resulted in similar dreissenid mussel DNA detection patterns. Both methods detected target DNA at the same 7 waterbodies and both methods failed to detect target DNA at the same 5 waterbodies. At one of the lower density sites, more mussel DNA was amplified in plankton tow samples than from grab samples.



*Invasive mussel larvae sampling using a plankton tow net.*

**FY23 Active Projects**

ID	Final Year	Title	Lead
1846	2023	Self-Cleaning Strainers and Filtration to Mitigate Mussel Impacts	Bryan Heiner
20026	2023	Investigation of Environmental RNA (eRNA) as a Detection Method for Dreissenid Mussels and Other Invasive Species	Jacque Keele
20061	2023	Ultrasonic Transducer Field Test for Quagga Mussel Settlement Control	Sherri Pucherelli
21024	2023	Analysis of the Quagga Mussel Genome for Development of Biocontrols	Yale Passamaneck
21066	2023	Alternate Control Strategy for Dreissinids Using Carbon Dioxide	Kevin Kelly
21086	2023	Factors Limiting Invasive Mussel Establishment at Salt River Project Reservoirs	Sherri Pucherelli
22005	2024	Survey of 'Cousin' Dreissenid Species in Eurasia for Potential Biocontrol Agents to Control Invasive Quagga and Zebra Mussels in North America	Jacque Keele
22038	2024	Inferring the Provenance of Invasive Dreissenid Mussel Veliger Shells through Trace Element Analysis	Yale Passamaneck
22057	2024	Development of an Engineered Disseminated Neoplasia to Control Invasive Mussels in Reservoirs	Sherri Pucherelli
22058	2024	Optimization of Sample Analysis Methods for the Early Detection of Invasive Dreissenid Mussels in Reclamation Reservoirs	Rheannan Quattlebaum
22061	2024	Development of a Production and Transport Vector for a Chimeric Biopesticide in the Treatment of Zebra and Quagga Mussels	Kevin Kelly
22063	2024	Collection and Analysis of Invasive Mussel Samples to Prevent the Spread and Impacts at Reclamation Reservoirs and Facilities	Diane Mench



