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RECLAMATION

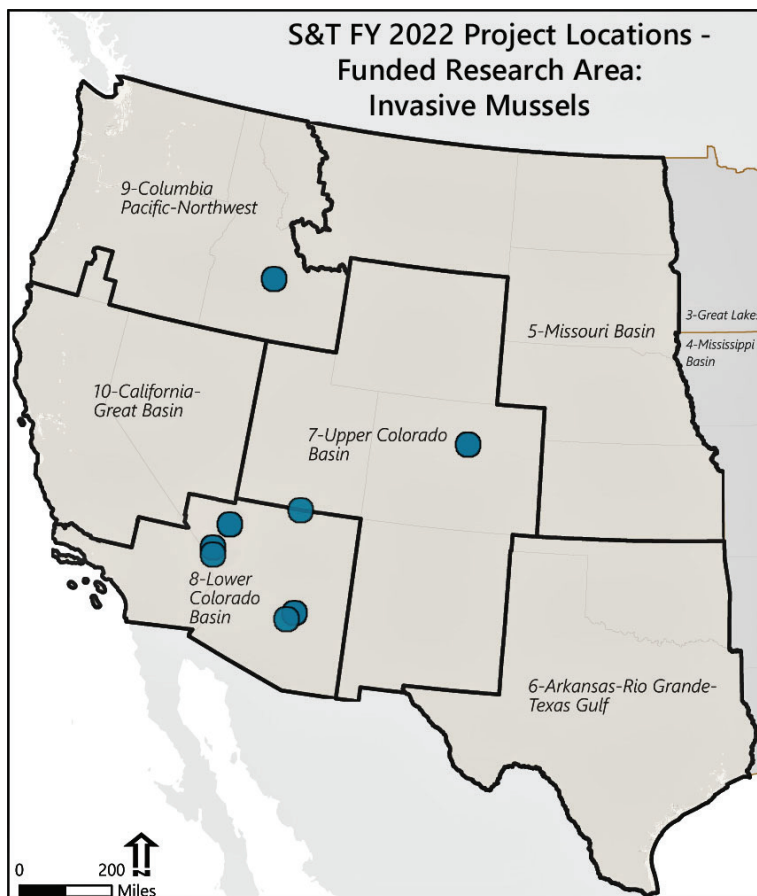
R&D Office Research Updates

Invasive Mussels



Executive Summary

The Invasive Mussel (ZQ) Research Category of the Science and Technology Program (S&T) examines 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 21 ZQ projects approximately totaling \$1.23M: 6 were new totaling \$1.02M and 15 were continuing totaling \$0.21M. To demonstrate the value of this research, a Benefit Cost Ratio calculation (BCR) is completed each year for a recently completed ZQ project. A BCR of 14.5 was calculated for the “Risk mapping for mussel infestation in the Pacific Northwest” project that was completed in early FY22. The web visualization tool will improve efficiency of mussel control resource deployment, so the same dollars spent will have a greater impact and realized value. 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.

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

Front cover: *Quagga mussels attached to a rope at Davis Dam, AZ.*
Back cover: *Quagga and zebra mussels in tanks submerged in a water bath at the Biomilab facility in MI.*

Invasive Species Coordinator:
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Invasive Mussels

FY21 Completed Projects

1852: Alternate Control Strategy for Dreissinids Using Carbon Dioxide - Kevin Kelly

Zebra and quagga mussels (*Dreissena ssp.*) 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. One potential control strategy involves the use of carbon dioxide (CO₂) to prevent the settlement of zebra and quagga mussels inside of Reclamation facilities. To determine the feasibility of using CO₂ for this purpose, this project was split into a two-prong research approach to investigate the parameters required for successful implementation. The first prong will research CO₂ treatment regimens required to prevent dreissenid settlement. A field study is being planned at Davis Dam during spring 2022. This portion of the research project will be conducted using a mobile biotesting laboratory and test on actual Lake Mohave water and quagga mussel veligers to determine effective concentrations of CO₂, minimum effective exposure period and CO₂ treatment efficacy with different water chemistry at different locations. This part of the research project is being done in partnership with the USGS, UMESC. The second prong of this research project is investigating the use of a Speece Cone as the most efficient method of carbonation of reservoir water at Reclamation dam and powerplant facilities. Since water chemistry varies with location, it is necessary to ultimately test out the Speece Cone on site where CO₂ may be used to prevent settlement of zebra and quagga mussels inside Reclamation dam and powerplant facilities. This will be done when COVID-19 travel restrictions are lifted. Since very little information exists on the operations and use of Speece Cones for carbonation, laboratory-scale studies are being performed to determine the relationships between CO₂ dosage levels with key water quality parameters such as alkalinity and pH.



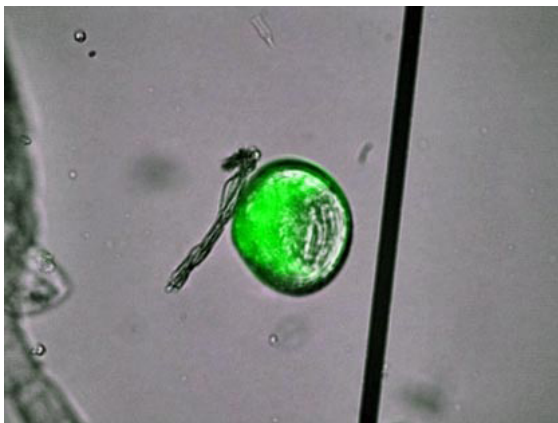
Speece Cone apparatus for the carbonation of raw water.



Quagga mussel fouling on a fixed wheel gate at Glen Canyon Dam.

1876: Case Studies: Impact and Control of Invasive Mussels at Hydropower Plants – Sherri Pucherelli

Thirteen hydropower plants with invasive quagga or zebra mussel fouling were interviewed about their experience. Information was gathered about the size and operation of the facility, the mussel infestation timeline, the systems, and structures experiencing mussel fouling, the implemented control and mitigation methods, and the expenses associated with mussel management. The severity of mussel impacts was dependent on the design of the power plant and raw water usage. The size and number of generators was not indicative of the severity of impacts. Most plants interviewed do not completely track mussel specific maintenance and costs, therefore the estimates do not provide a complete picture of the costs associated with mussel infestations at hydropower plants. These case studies provide valuable information to managers at plants preparing for the potential arrival of dreissenid mussels.



Immunofluorescence of a quagga mussel veliger tagged by a mAb that has been chemically conjugated to a fluorescent dye.

19186: Development of a Chimeric Biopesticide for the Treatment of Zebra and Quagga Mussels - Kevin Kelly

The primary objective of this Phase I research project was to develop and determine the viability of a bioengineered, chimeric protein biopesticide for the treatment of zebra and quagga mussel infestations. To achieve this goal, Environmental Quality Operations (EQO) utilized previously developed monoclonal antibodies, specific to quagga mussels, as expressed by hybridoma cell lines. Antibody expressing hybridoma cell lines were developed by Reclamation and Metropolitan Water District of Southern California in an earlier research project (Final Report ST-2014-9640-01). Hybridoma ribonucleic acid (RNA) was isolated to determine the binding regions of the expressed antibodies. Once binding regions were successfully identified, biotherapeutic agents were constructed by combining the single-chain variable fragment (scFv) binding regions with a *Pseudomonas* exotoxin-A based backbone, connected by hinge

sequences between the light and heavy chain, and between the scFv and the toxin backbone to avoid interactions between the subunits that could cause diminishment of the binding efficiency. Once chimeric biotherapeutic agents are created, a methodology for reliable transformation of a microalgae, for use as both a biotherapeutic production and delivery vectors, will be created and validated during Phase II of this research project.



Eco Lab space located at the TSC in Denver, Colorado.

19214: Ecological Research Laboratory (Eco Lab) - Diane Mench

The Reclamation Ecological Research Laboratory (Eco Lab), formerly the Reclamation Detection Laboratory for Exotic Species (RDLES), received funding from the S&T Program to support research associated with the Reclamation-wide invasive mussel early detection program. The lab provides expertise in field sampling, analytical microscopic, and molecular methods for the detection and identification of threatened and invasive species. The Eco Lab provides data that is utilized for environmental compliance and to manage invasive, threatened, and endangered species that impact Reclamation. The laboratory is currently focused on invasive dreissenid mussels and has

developed expertise in multiple disciplines of this topic. The Eco Lab provides services to Reclamation regional and area offices, state aquatic invasive species (AIS) programs, water districts, and other agencies with a variety of monitoring and research projects. Over the last three years, as of August 30, 2021, the Eco Lab has received and analyzed 3,926 samples. Of these, 176 samples were positive, all from known positive reservoirs in the Salt River Project in Arizona. In addition, the Eco Lab provides monitoring of sites where mussels are established to assess population dynamics.

21035: Invasive Mussels and Harmful Algal Blooms: Interactions and Detection Methods - Jacque Keele

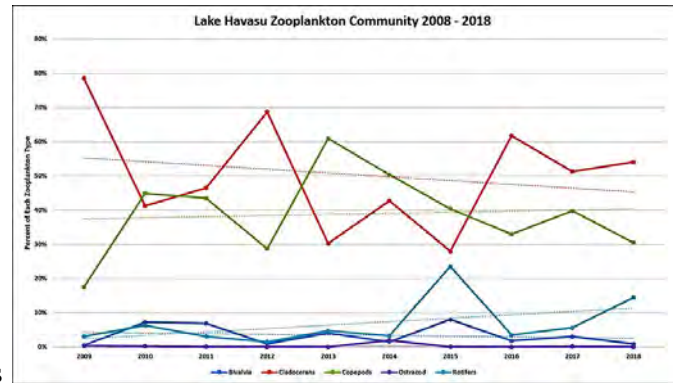
Both quagga (*Dreissena rostriformis bugensis*) and zebra (*Dreissena polymorpha*) mussels (QM/ZM) and harmful algal blooms (HABs) are topics of concern in the western United States. As QM/ZM continue to spread into new waterbodies, there is more opportunity for potential interactions between invasive mussels and algae communities. Understanding how these two separate issues impact each other is important for researchers and water managers. This scoping proposal was a literature review to assess the research that has been performed. Appendix A contains a list of State and Federal web based HAB resources. The final report contains a list of State and Federal web based HAB resources and selected abstracts that show the connections between HABs and QZ/ ZM. Some of interactions involve QM/ZM feeding on algae, water quality impacts, and algal impacts on mussel fertility. Understanding the interactions between QM/ZM and algal blooms is important as both issues continue to increase.



Algal bloom at a lake in Colorado.

21058: Invasive Quagga Mussel Impacts on the Lake Havasu Ecosystem - Aaron Murphy

Invasive quagga mussels have been present in the Lake Havasu ecosystem since at least 2007. Mussels are known to impact plankton communities, nutrient loads, macrophyte coverage, and higher organisms. This study was initiated to evaluate existing data related to ecological impacts of mussels at Lake Havasu. Data included water quality measurements and plankton survey data. No large trends were observed in the available data. Plankton communities have changed slightly, with rotifers becoming a larger percentage of the biomass. Soluble phosphorus may be shifting to deeper water, while nitrate-nitrogen and chlorophyll concentrations appear to have increased. Developing a full picture of the ecological impacts at Lake Havasu will require a standardized, long-term monitoring program that includes water quality and plankton, as well as higher organisms like fish and macroinvertebrates.



Rotifers became a larger component of the zooplankton community since 2009, while the cladoceran population has declined.

21083: Assessment of Laboratory Methods to Investigate Dreissenid Mussel Veliger Settling in Imhoff Cones Through Dense Organic Material - Rheannan Quattlebaum

The Reclamation Ecological Research Lab utilizes Imhoff cones to settle water samples specifically collected to analyze for invasive dreissenid mussel larvae. Samples are settled, and the heaviest (bottom) 15 ml are collected and analyzed under a microscope looking for the larvae. Previous research claimed that veligers present in a water sample would settle at the bottom 15 ml. This study examined whether veligers would still settle in the bottom 15 ml through water samples that contain different types of suspended solids like zooplankton and algae. This study found that suspended solids, or organic material, and the amount of that material, in water samples does interfere with settlement of veligers in the heaviest 15 ml.



Water samples spiked with mussel veligers and settled in Imhoff cones to observe settlement efficiency.

FY22 New Projects

22005: Survey of 'Cousin' Dreissenid Species in Eurasia for Potential Biocontrol Agents to Control Invasive Quagga and Zebra Mussels in North America - Jacque Keele

This project is designed to identify potential biological control agents for quagga and zebra mussels. Populations of closely related mussel species in Eurasia will be analyzed for parasites. Quagga and zebra mussels will be exposed to the parasites to seek evidence of lethality.

22038: Inferring the Provenance of Invasive Dreissenid Mussel Veliger Shells Through Trace Element Analysis - Yale Passamaneck

The goal of this project is to identify chemical "fingerprints" for the shells of invasive quagga and zebra mussels. This project will build confidence among natural resource managers that newly detected veligers are derived from a breeding population at the site of discovery, rather than having been transported from another location.

22057: Development of an Engineered Disseminated Neoplasia to Control Invasive Mussels in Reservoirs - Sherri Pucherelli

The goal of this project is to utilize genetic engineering tools to create disseminated neoplasia cells that can be used to transmit and foster a lethal, self-spreading cancer into invasive zebra and quagga mussel populations in reservoirs to achieve population control.

FY22 New Projects *-continued*

22058: Optimization of Sample Analysis Methods for the Early Detection of Invasive Dreissenid Mussels in Reclamation Reservoirs - Rheannan Quattlebaum

The objective of this project is to optimize analysis of early detection and population monitoring samples to increase sensitivity of current methods and investigate new methods that can overcome challenges associated with samples that contain high total suspended solids or samples with large numbers of veligers.

22061: Development of a Production and Transport Vector for a Chimeric Biopesticide in the Treatment of Zebra and Quagga Mussels -Kevin Kelly

Based on previous success with immunotoxins, it is expected that the biopesticide produced by the approach proposed here will exhibit direct cell kill efficiency values (EC50) in the low pM concentration range.

22063: Collection and Analysis of Invasive Mussel Samples to Prevent the Spread and Impacts at Reclamation Reservoirs and Facilities - Diane Mench

The objective of this project is to collect and analyze invasive quagga and zebra mussel early detection samples from reservoirs across Reclamation. Samples will be collected from approximately 280 Reclamation reservoirs that have been determined to be most at risk for mussel infestation based on habitat suitability and recreational boating use.

FY22 Active Projects

ID	Final Year	Title	Lead
1846	2022	Self-Cleaning Strainers and Filtration to Mitigate Mussel Impacts	Bryan Heiner
19008	2022	Evaluation of Preservation Methods for Veliger Detection Field Samples	Yale Passamaneck
19009	2022	Development of Field Sampling Protocol Standards for Environmental DNA (eDNA) Monitoring of Dreissenid Mussels	Sherri Pucherelli
19134	2022	Refining Quagga Habitat Suitability Models	Yale Passamaneck
19174	2022	Alternate Control Strategy for Dreissinids Using Electrical Methods	Kevin Kelly
19196	2022	Development and Field Research on Next Generation Coatings for Mussel Mitigation on Infrastructure.	Carter Gulsvig
20026	2022	Investigation of Environmental RNA (eRNA) as a Detection Method for Dreissenid Mussels and other Invasive Species	Jacque Keele
20039	2022	Analysis of Environmental DNA from Sediments for Detection of Invasive Dreissenid Mussels	Yale Passamaneck
20061	2022	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
21031	2022	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
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
21094	2022	Innovative Methods for Invasive Mussel Detection	Sherri Pucherelli
21101	2023	Use of Copper Ion Generators for Mussel Control at USACE and Reclamation Hydropower Plants	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

