BUREAU OF RECLAMATION

Research Updates
R&D Office

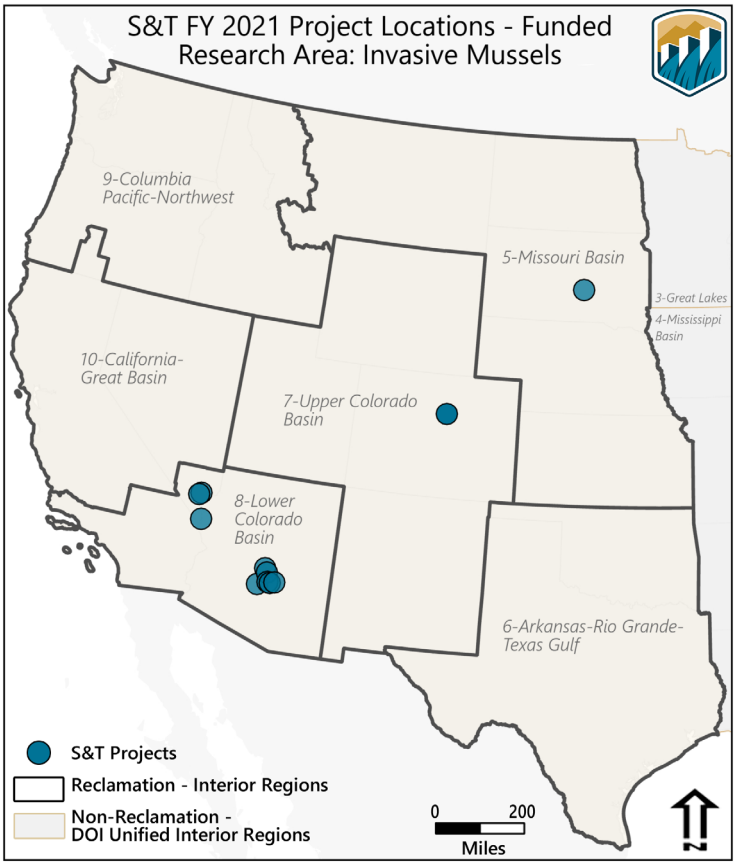
Invasive Mussels

U.S. Department of the Interior

March 2021

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 FY21, S&T funded 28 ZQ projects approximately totaling $1.78M: 9 were new totaling $0.44M and 19 were continuing totaling $1.34M. In order 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 7.7 was calculated for the "Predictive Dreissenid Mussel Modeling for the Western United States" project that was completed in FY20. The model 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: https://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

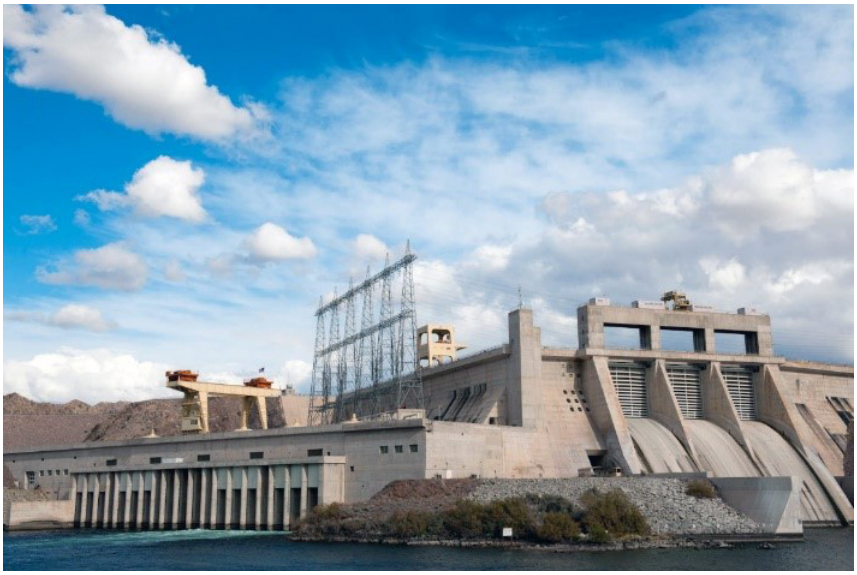
Invasive Species Coordinator:
Sherri Pucherelli spucherelli@usbr.gov

Invasive Mussels

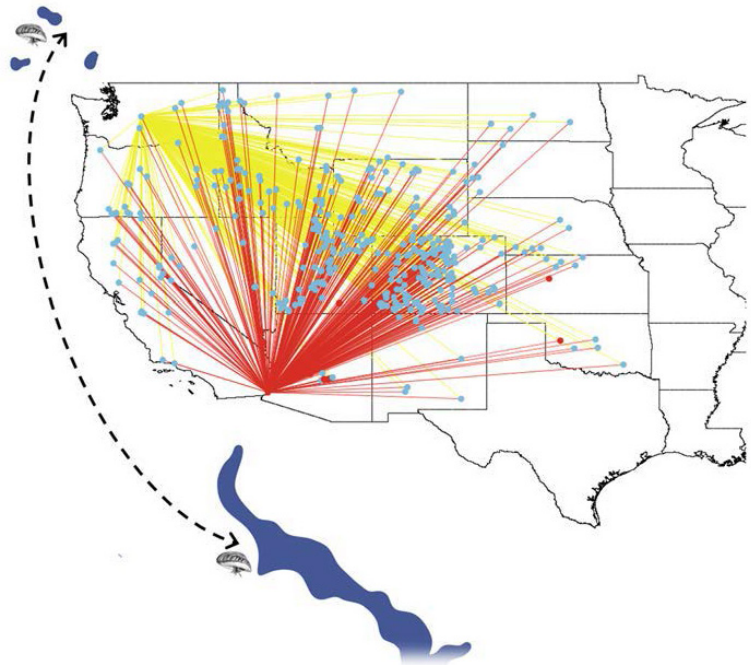
FY20 Completed Projects

7136: Compendium of Reclamation Mussel Control Research for Hydropower Facilities - Sherri Pucherelli

Over the past 10 years, Reclamation researchers and contractors have developed and tested methods for the control of invasive mussel fouling at hydropower plants. The majority of this research was conducted at Reclamation hydropower plants along the lower Colorado River, including Hoover, Davis, and Parker Dams. The focus of this research has been to reduce or eliminate mussel settlement and shell debris fouling in order to reduce mussel related O&M expenditures. The goal of this project was to summarize the control methods that Reclamation has examined or is in the process of examining. The report includes information about Reclamation studies that examine the following methods: Self-Cleaning Microfiltration, Antifouling and Foul Release Coatings, Ultraviolet Light, Zequanox, Turbulence, pH Manipulation, Endothall, Copper Ion Generator, Conductivity Manipulation, Laser-Generated Pulsed Pressure, Centrifugal Separation, Carbon Dioxide, Ultrasound, Electrical, and Self-Cleaning Strainers.



Many of the ZQ research projects summarized in this report have been conducted at Davis Dam, located on the lower Colorado River.



Map of the potential spread of invasive mussels in the western United States. The blue dots are the 402 lakes that were included in the model.

8110: Predictive Dreissenid Mussel Modeling for the Western United States - Jacque Keele

Reclamation researchers collaborated with the Integrated Ecological Modeling Team at the U.S. Army Engineer Research and Development Center to develop an integrated dreissenid mussel dispersal model that coupled boater behavior and habitat quality models to forecast the likelihood of dreissenid mussel spread across 402 lakes in the Western United States. Results from this model can be used to determine which lakes are most vulnerable to invasion, and to inform management practices to assist in decreasing the invasion probability.

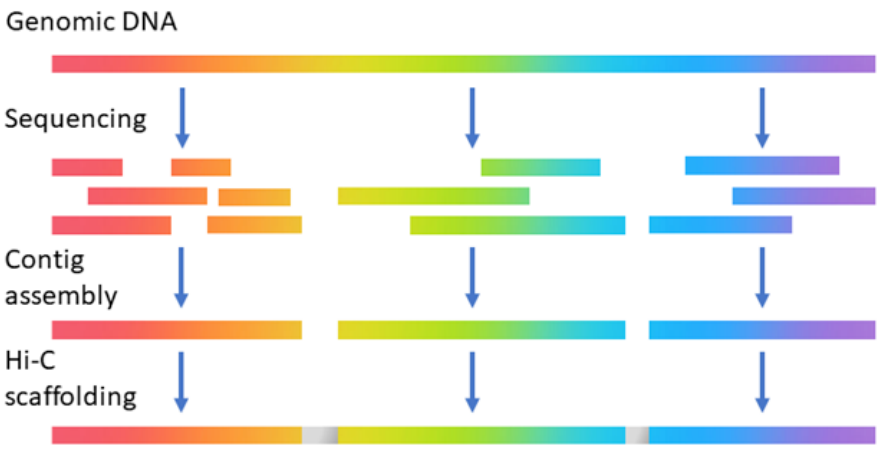
1831: Investigation of DNA metabarcoding for macroinvertebrate surveys and invasive species detection - Yale Passamaneck

DNA metabarcoding is an approach to surveying the whole community of organisms from an individual environment by using modern DNA sequencing technologies to capture thousands of sequences in parallel. Resultant sequences, and the taxa they are derived from, can then be identified through comparison to validated sequences in reference databases. DNA barcoding has the potential to be faster and less expensive than traditional surveys, and to cause less impacts to the sampled environment. In this study metabarcoding was evaluated with samples collected near Folsom Dam, CA, where long-term monitoring of macroinvertebrate populations has been conducted. Sequence data were obtained and analyzed, and sequences were identified as having come from a range of macroinvertebrate taxa. DNA metabarcoding has significant potential for adoption for future projects. It is expected that as the technique gains more widespread usage, the challenges and limitations identified in this study will be overcome through standardization of practices.

Photomicrographic images of macroinvertebrates collected from sampling sites near Folsom Dam.

1866: Sequencing of the quagga mussel genome as a tool for biocontrol - Yale Passamaneck

This project conducted DNA sequencing and assembly of the quagga mussel genome using a variety of technologies and analytical approaches. The quagga mussel genome presented considerable challenges due to its large size and high degree of heterozygosity. A high-quality assembly was developed for the quagga mussel with chromosome-scale scaffolding. The final assembly is composed of 16 scaffolds with a total length of 1,613 megabases, matching the number of chromosomes and genome size of the source organism. The assembly has excellent completeness, with a more than 96% of conserved genes identified based on analysis with Benchmarking Universal Single-Copy Orthologs (BUSCO) software. The resultant reference sequence is one of the most complete and contiguous genome assemblies developed to date for any bivalve mollusk. This will provide a valuable resource for the development of genetic biocontrols and investigations of quagga mussel biology.



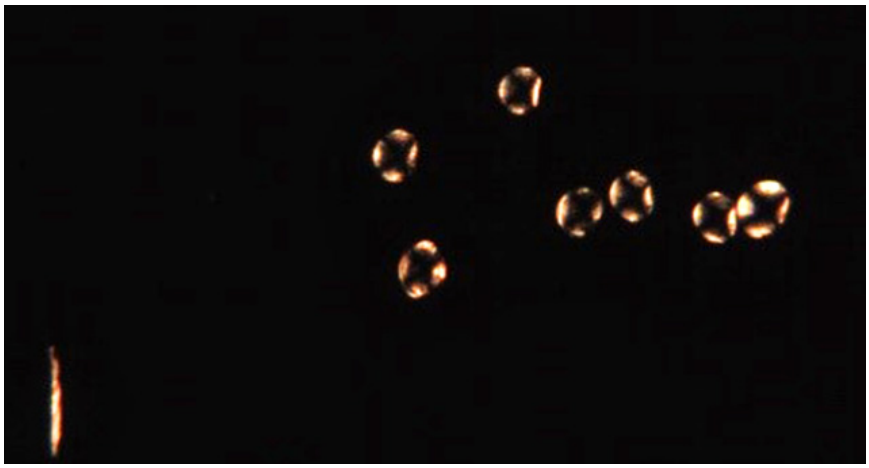
Strategy for quagga mussel genome sequencing, assembly, and scaffolding.

FY21 New Projects

21086: Factors Limiting Invasive Mussel Establishment at Salt River Project Reservoirs – Sherri Pucherelli

The goal of this study is to identify habitat aspects that may be limiting mussel establishment at Bartlett and Roosevelt Reservoirs or influencing sudden population declines at other Salt River Project Reservoirs with established mussel populations. Water chemistry, hydrology, geology, phytoplankton, and zooplankton data will be collected alongside mussel monitoring at Bartlett, Roosevelt, Apache, Canyon, and Saguaro Reservoirs, and Granite Reef Dam Forebay. This research project will provide information that can be included in invasive mussel risk assessments that will be utilized by federal and state resource managers to determine which water bodies are prioritized for monitoring and boat inspections.

Water quality data will be collected alongside mussel monitoring at Salt River Project Reservoirs, similar to other sampling efforts on the Lower Colorado River.



Invasive quagga mussel veligers as seen under cross-polarized light microscopy. Microscopy is the traditional method used to detect mussel veligers and this research will investigate new methods that have the potential to be faster while still providing the same level of accuracy.

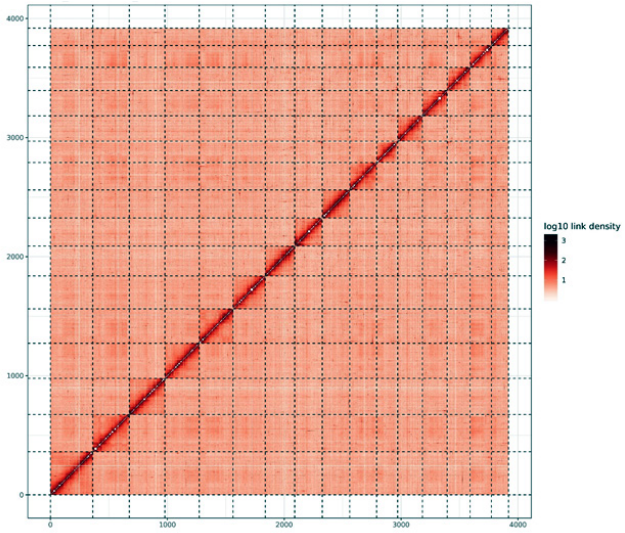
21094: Innovative Methods for Invasive Mussel Detection - Sherri Pucherelli

This scoping study will identify innovative methods for the detection of invasive mussel larvae (veligers) to strengthen the ability to detect mussels in a variety of situations and to potentially reduce the costs associated with traditional microscopy analysis. Automated analysis of samples and detection of veligers and eDNA using trained dogs are two methods that will be pursued.

21101: Use of Copper Ion Generators for Mussel Control at USACE and Reclamation Hydropower Plants - Sherri Pucherelli

Monitor the effectiveness of a copper ion generator that will be installed at the USACE Big Bend hydropower plant for zebra mussel settlement prevention. The project will provide direct evidence of the effectiveness and ease of use of copper treatment for mussel settlement prevention in generator cooling systems. Study results will provide a reference for Reclamation hydropower facilities that must consider mussel mitigation strategies.

The effectiveness of copper treatments at preventing invasive mussel settlement in pipes will be analyzed using bio-boxes similar to those installed at Davis Dam.



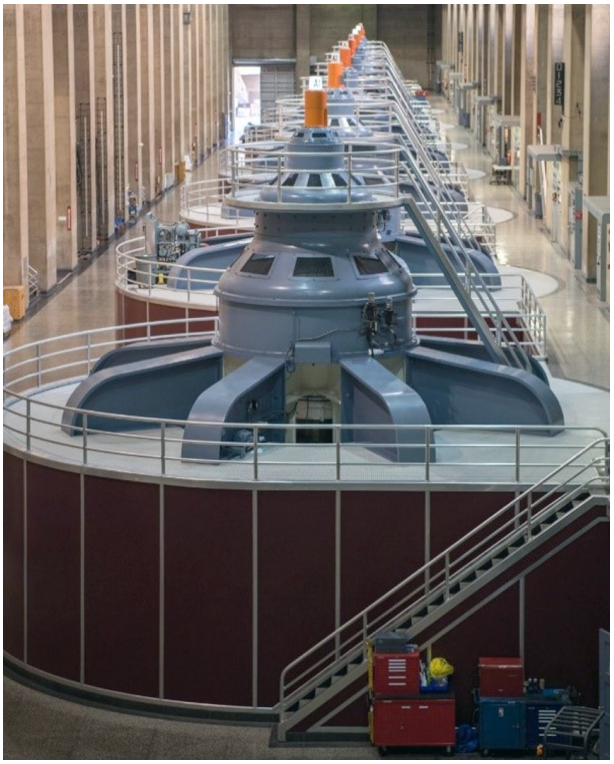
Heatmap of linkages in the scaffolded quagga mussel genome assembly.

21024: Analysis of the Quagga Mussel Genome for Development of Biocontrols – Yale Passamaneck

Recent sequencing and assembly of the quagga mussel genome provides the opportunity for the development of genetic controls and more detailed studies of the invasion biology if this species. This project will conduct annotation of the genome to identify protein coding genes and other features. Functional genomic approaches will be used to identify genes involved in gonad development and maturation, and to look for vulnerabilities that could be targeted for genetic biocontrol. Development of tools for transgenesis, required for the development of genetic biocontrols, will also be pursued.

21066: Alternate Control Strategy for Dreissinids Using Carbon Dioxide – Kevin Kelly

Investigate the effectiveness and target levels of carbon dioxide for quagga mussel settlement prevention in site-specific conditions found in Reclamation facilities. Develop and test an efficient process for the carbonation of water in pressurized pipes that will prevent veliger settlement and colonization within Reclamation structures.



Generators at Hoover Dam. The goal of this study is to determine if carbon dioxide can be used to prevent invasive mussel settlement in critical hydropower structures such as generator cooling systems.

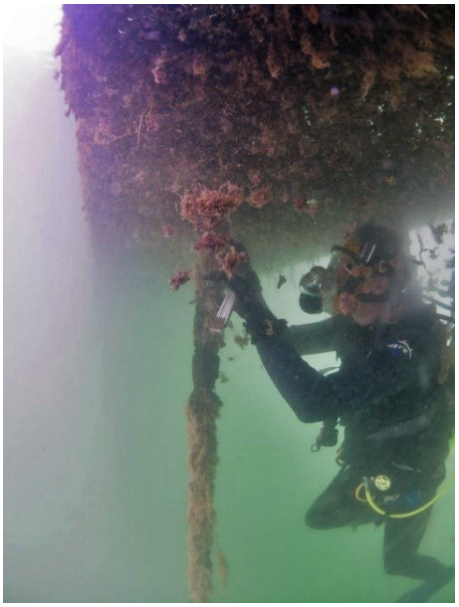
Imhoff settling cones containing invasive mussel early detection samples at the Reclamation Ecological Research Lab.

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

The goal of this research is to evaluate the effectiveness of using Imhoff settling cones for invasive mussel early detection samples that contain dense algae, sediment, and zooplankton. The ability to recover a known number of mussels after these samples are settled will be evaluated.

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 - Jeff McPherson

This scoping project will collect and evaluate existing studies and protocols used by dive and aquatic field sampling organizations to identify existing protocols, assess studies conducted on decontamination protocols that validate their efficacy, and synthesize data to provide recommendations to enhance dive and aquatic gear decontamination protocols.



Reclamation dive team member diving in a reservoir with invasive mussels. Reclamation's dive teams work at many different reservoirs and must effectively decontaminate their gear after leaving sites with known invasive species populations.

Fish in Lake Havasu, AZ. It is unclear how or if fish populations in Lake Havasu have been impacted by quagga mussel populations.

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

The goal of this project is to improve the understanding of how invasive quagga mussels have impacted the ecosystem of Lake Havasu and the rest of the Lower Colorado River system since their discovery in 2007. Long-term changes to the environment of infested reservoirs poses a threat to recreational sport fisheries, as well as other native fish and wildlife.

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

This project seeks to better understand how dreissenid mussels and algae that cause harmful algal blooms interact and what methods can be used in the lab and field to detect harmful algal blooms. The goal of this one-year project is to produce a literature review that will increase our understanding of the connections between invasive mussels and harmful algal blooms.

Algae covering the surface of a lake and decreasing sunlight penetration.

FY21 Active Projects: Invasive Mussels

ID	Final Year	Title	Lead	FY21 Funding Amount*
1846	2021	Self-Cleaning Strainers and Filtration to Mitigate Mussel Impacts	Bryan Heiner	$76,398
1852	2021	Alternate Control Strategy for Dreissinids Using Carbon Dioxide	Kevin Kelly	$12,559
1876	2021	Best Practices for Mussel Control and Mitigation at Hydropower and Water Delivery Facilities	Sherri Pucherelli	$41,426
8142	2021	Economic evaluation of activities associated with invasive mussel management	Jolene Trujillo	$50,573
19006	2022	Eradication of invasive quagga and zebra mussels using engineered disseminated neoplasia	Sherri Pucherelli	$300,000
19007	2021	Risk mapping for mussel infestation in the Pacific Northwest	Anthony Prisciandaro	$5,744
19008	2021	Evaluation of preservation methods for veliger detection field samples	Yale Passamaneck	$36,401
19009	2022	Development of field sampling protocol standards for environmental DNA (eDNA) monitoring of dreissenid mussels	Sherri Pucherelli	$30,000
19011	2021	Evaluation of veliger survival on boats	Sherri Pucherelli	$22,686
19097	2021	Use of Novel Parasites to Control Naive North American Dreissenid Populations	Jacque Keele	$50,000
19134	2021	Refining Quagga Habitat Suitability Models	Yale Passamaneck	$40,000
19138	2021	Invasive Mussel Literature Resource	Yale Passamaneck	$16,000
19174	2021	Alternate Control Strategy for Dreissinids Using Electrical Methods	Kevin Kelly	$80,759
19186	2021	Development of a Chimeric Biopesticide for the Treatment of Zebra and Quagga Mussels	Kevin Kelly	$51,644
19196	2021	Development and Field Research on Next Generation Coatings for Mussel Mitigation on Infrastructure.	Carter Gulsvig	$63,576
19214	2021	Reclamation Detection Laboratory for Exotic Species (RDLES)	Diane Mench	$300,000
20026	2022	Investigation of environmental RNA (eRNA) as a detection method for dreissenid mussels and other invasive species	Jacque Keele	$60,000
20039	2022	Analysis of environmental DNA from sediments for detection of invasive dreissenid mussels	Yale Passamaneck	$50,000
20061	2022	Ultrasonic Transducer Field Test for Quagga Mussel Settlement Control	Shane Mower	$53,980
21058	2021	Invasive Quagga Mussel Impacts on the Lake Havasu Ecosystem	Aaron Murphy	$30,000
21035	2021	Invasive Mussels and Harmful Algal Blooms: Interactions and Detection Methods	Jacque Keele	$30,000
21031	2021	Survey and evaluation of dive and aquatic field gear decontamination protocols for preventing the spread of quagga/zebra mussels and other aquatic invasive species.	Jeff McPherson	$25,000
21066	2023	Alternate Control Strategy for Dreissinids Using Carbon Dioxide	Kevin Kelly	$66,100
21083	2021	Assessment of Laboratory Methods to Investigate Dreissenid Mussel Veliger Settling in Imhoff Cones Through Dense Organic Material	Rheannan Quattlebaum	$60,000
21086	2023	Factors Limiting Invasive Mussel Establishment at Salt River Project Reservoirs	Sherri Pucherelli	$93,969
21094	2021	Innovative Methods for Invasive Mussel Detection	Sherri Pucherelli	$30,000
21101	2023	Use of Copper Ion Generators for Mussel Control at USACE and Reclamation Hydropower Plants	Sherri Pucherelli	$66,700
21024	2023	Analysis of the quagga mussel genome for development of biocontrols	Yale Passamaneck	$40,000

* For projects with no funding, these projects are nearly complete and received funding in past years for this work.