Final Abstract

Final Report Approved on December 15, 2025

M.L. 2021 Project Abstract

For the Period Ending June 30, 2025

Project Title: Building Knowledge and Capacity for AIS Solutions

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Funding Source:

Fiscal Year:

Legal Citation: M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 06e

Appropriation Amount: $3,750,000

Amount Spent: $3,072,776

Amount Remaining: $677,224

Sound bite of Project Outcomes and Results

MAISRC continues to be a leader by advancing research-based solutions for aquatic invasive species in Minnesota. As a part of this project, MAISRC supported 12 subprojects on many of Minnesota's most important AIS, significantly advanced our scientific understanding and ability to manage AIS, and engaged thousands of stakeholders and partners.

Overall Project Outcome and Results

The Minnesota Aquatic Invasive Species Research Center (MAISRC) has advanced our collective capacity to address Minnesota's aquatic invasive species (AIS) problems through rigorous and innovative research and collaboration with researchers, managers, and volunteers across the state. Our local focus with global impact has positioned MAISRC as a leader in the field.

As a part of this project, MAISRC supported 12 subprojects, selected based on MAISRC's inclusive research needs assessment process and external peer-review. New tools were developed and key knowledge gaps were filled for many of Minnesota's most problematic AIS, including zebra mussels, bigheaded and common carps, starry stonewort, rusty crayfish, and a variety of harmful microbes. Accomplishments over the course of this project include:

-- Developing a Structured-Decision Making framework with natural resource managers to guide science-based management for zebra mussels in Minnesota lakes
-- Leveraging the latest advances in precision genome editing to advance the development of genetic biocontrol tools for common carp
-- Advancing our understanding of the ecology of starry stonewort and non-chemical control options for invasion into wild rice beds
-- Creating a guide for effectively trapping and removing rusty crayfish to protect sensitive vegetation and fish populations
-- Developing streamlined surveillance tests for high priority invasive fish pathogens and didymo across the state
-- Creating and maintaining a series of interactive AIS management tools, including AIS Explorer (https://z.umn.edu/aisexplorer), Milfoil Mapper (https://z.umn.edu/milfoilmap), Mussel Strains (https://z.umn.edu/MusselStrains), and PI Charter (https://z.umn.edu/PICharter)

The outcomes of these 12 research initiatives will have immediate and long-term impacts for how AIS is managed in Minnesota and ultimately, the wellbeing of Minnesota's lakes, rivers, and wetland, and the people who enjoy them.

Project Results Use and Dissemination

MAISRC disseminated research results by engaging end-users, developing tools and guides for AIS management, and reaching broad audiences with approachable and science-based AIS information. Over the course of the project, MAISRC events, presentations, and lab tours reached over 18,000 individuals. Our website continues to be a resource with an average of nearly 40,000 users visiting the site each year. MAISRC also produces fact sheets, research briefs, and reports that are shared both online and in print. A full list of over 150 peer-reviewed publications can be viewed on the MAISRC publication database: https://z.umn.edu/ais-publications

Environment and Natural Resources Trust Fund

M.L. 2021 Approved Final Report

General Information

Date: December 19, 2025

ID Number: 2021-188

Staff Lead: Michael Varien

Project Title: Building Knowledge and Capacity for AIS Solutions

Project Budget: $3,750,000

Project Manager Information

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Project Reporting

Final Report Approved: December 15, 2025

Reporting Status: Project Completed

Date of Last Action: December 15, 2025

Project Completion: June 30, 2025

Legal Information

Legal Citation: M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 06e

Appropriation Language: $3,750,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota for the Minnesota Aquatic Invasive Species Research Center to conduct high-priority projects aimed at solving Minnesota's aquatic invasive species problems using rigorous science and a collaborative process. Additionally, the appropriation may be spent to deliver research findings to end users through strategic communication and outreach. This appropriation is available until June 30, 2025, by which time the project must be completed and final products delivered.

Appropriation End Date: June 30, 2025

Narrative

Project Summary: MAISRC will launch 10-14 high-priority projects aimed at solving Minnesota's AIS problems using a rigorous and collaborative process. The science will be delivered to end-users through strategic communication and outreach.

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

Aquatic invasive species (AIS) are a real and growing threat to Minnesota's lakes, rivers, and wetlands. From our docks to state budgets, damaging AIS, such as zebra mussels, common carp, Eurasian watermilfoil, and many others have degraded the State's ecosystem, economy and way of life. For example, we recently found that young-of-the-year walleye are significantly smaller in our large lakes infested with zebra mussels, exacerbating already strained fisheries and local communities. In response to AIS impacts, Minnesotans invest millions of dollars each year to prevent and control infestations. These necessary investments have no doubt resulted in positive outcomes, but fall short of solving the long-term problem.

Minnesota became a national leader with the creation of the Minnesota Aquatic Invasive Species Research Center (MAISRC) in 2012. Meaningful progress is being made – already providing new tools for managers, research-based answers available for real-world decisions, and partners at all levels, locally and around the world, working in the same direction. Solutions to Minnesota's AIS problems are within reach. It is imperative that we remain committed to a long-term vision for AIS control in Minnesota, one that is informed by ground-breaking science that supports proven and efficient management action.

What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.

MAISRC was established with a game-changing investment from the ENRTF, creating a one-of-a-kind program focused on solutions-oriented research and outreach. We are driven to solve problems through innovative, rigorous and collaborative science. We have brought together 23 different project managers (UMN, UMD/NRRI, MN DNR, USGS, etc.) and their experienced teams to pursue 29 ENRTF-funded research projects (some multi-phase) on a range of high-priority species and strategies for AIS prevention, control, and management. Notable highlights are included in the infographic and much more is available here: www.maisrc.umn.edu. We are perfectly positioned to build on past success and continue to make advancements.

We propose to continue forward momentum by launching additional projects through our competitive RFP process, informed by our extensive research needs assessment and stakeholder engagement. All research will be vetted by internal and external peer-reviewers to ensure both scientific rigor and practical application. We will continue to prioritize communication and outreach to ensure results are effectively delivered to managers, practitioners, and the public to build our State's response capacity. Led by a 10-year strategic plan, we will continue to consult our external Advisory Board, Technical Advisory Board, and our Fellows Group to keep us mission-oriented.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

We will continue to advance scientific understanding and build capacity aimed at solving Minnesota's AIS problems. Through workshops and direct communication, we will translate our science and deliver tools directly to local, state and federal AIS managers. We will share research findings with diverse audiences and formats, including media interviews, local presentations, webinars, published manuscripts and much more. Through hands-on experience, this work will train the next generation of AIS professionals. Ultimately, we will be empowering more educated and active stakeholders, who are an essential part of the State's solution to improve and protect Minnesota's natural resources.

Project Location

What is the best scale for describing where your work will take place?

Statewide

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

During the Project and In the Future

Activities and Milestones

Activity 1: Leadership to facilitate AIS research, collaboration, and information sharing

Activity Budget: $1,126,647

Activity Description:
The value of a Center-based approach to AIS research reaches far beyond what a fragmented effort could accomplish. As a part of Activity 1, MAISRC will provide leadership for AIS research that establishes priorities for research funds, facilitates coordination between researchers and organizations throughout the state, and evaluates research progress in real-time. We will also provide physical infrastructure, shared equipment, and lab support to ensure resources are not duplicated across projects and are available when needed.

MAISRC serves as a go-to resource for countless individuals, groups, and advisory committees on AIS issues and information. As a part of Activity 1, MAISRC will continue our outreach and communications efforts to translate our science into public and management action. This will be accomplished by sharing research findings and making management tools and information available to the public and to state and local agencies.

In addition, to ensure that we continue to move the needle on two of Minnesota's most problematic AIS, MAISRC will support two research positions, focused on zebra mussels (1.0 FTE) and common carp (0.5 FTE). These positions are considered central to MAISRC research and are not otherwise supported by the UMN.

Activity Milestones:

Description	Approximate Completion Date
Prioritize 2024 research needs through research needs assessment process	December 31, 2023
Initial dissemination of results and next steps identified for projects completed December 31, 2023	June 30, 2024
Prioritize 2025 research needs through research needs assessment process	December 31, 2024
Initial dissemination of results and next steps identified for projects completed December 31, 2024	June 30, 2025
Continued dissemination of research results from past MAISRC subprojects to provide science-based recommendations and resources to individuals, groups, and advisory committees (as needed)	June 30, 2025

Activity 2: Solving Minnesota's AIS problems by supporting innovative, solutions-oriented research

Activity Budget: $194,141

Activity Description:
MAISRC will leverage past and future legislative appropriations to continue offering an annual, competitive RFP that is open to all Minnesota-based researchers. We will launch 10-14 subprojects (~$200,000-250,000 each, with two-year durations) addressing Minnesota's highest priority AIS research needs. New lines of research will be focused on needs identified by our comprehensive research needs assessment (Activity 1). Existing projects with high potential will be evaluated through the competitive peer-review process and continued. By providing a long-term strategy to build upon promising research, we are better positioned to realize the value of previous research investments.

As a part of the RFP, we will continue to encourage collaboration and the creation of multi-disciplinary teams. As a result, we will bring together new teams and agency partnerships from across the state and world, adding much-needed expertise and leveraging significant non-ENRTF funds. In the past, this coordinated process has also avoided duplication of research efforts and identified gaps where we have successfully recruited new research expertise to complement our current capacity.

Activity Milestones:

Description	Approximate Completion Date
Internal and external review of 2021 RFP proposals	September 30, 2021
Award subproject funding to 5-7 proposals from 2021 RFP, subprojects begin on January 1, 2022	September 30, 2021
Issue 2022 RFP on high priority research needs	March 31, 2022
Internal and external review of 2022 RFP proposals	September 30, 2022
Award subproject funding to 5-7 proposals from 2022 RFP, subprojects begin on January 1, 2023	September 30, 2022
Issue 2023 RFP on high priority research needs	March 31, 2023

Activity 3: MAISRC Subproject 4.4: Acoustic conditioning in common carp to accelerate removal and reduce cost

Activity Budget: $207,430

Activity Description:
There is a need for effective, safe, selective, and scalable technologies for removing common carp from lakes. Simple bait-and-remove strategies can remove 20-40% of carp in one season; however, the efficacy of these strategies may be significantly increased by using acoustic conditioning to ensure that carp aggregations are more synchronized and draw from larger areas. Acoustic conditioning has been shown to be effective in the lab and we will test it in the field. This research will result in an easy to implement management strategy for carp in Minnesota and elsewhere. Management methods developed through this research proposal may be most applicable in situations where winterkill/drawdown to manage carp populations is not desired or possible, in small to medium-sized basins where carp re-entry can be managed and especially in systems where carp recruitment is limited to seasonally unstable peripheral basins.

There is also a need for translating carp research into management and for making carp management an integral part of state-funded water quality management programs. To address this, we will conduct a carp summit for practitioners, policy makers, managers, and scientists. Potential users include watershed districts, watershed management organizations, and the emerging carp control industry.

Activity Milestones:

Description	Approximate Completion Date
Year 1 study lake selected, 300 carp implanted with PIT	June 30, 2022
Baiting stations with PIT loggers and acoustic equipment installed, latency and directionality tests completed	December 31, 2022
Carp Summit Phase 1 completed	December 31, 2022
Year 2 study lake selected, 300 carp implanted with PIT	June 30, 2023
Baiting stations with PIT loggers and acoustic equipment installed, acoustic conditioning experiments completed	December 31, 2023
Carp Summit Phase 2 completed	December 31, 2023
Feeding bout analyses completed	April 30, 2024

Activity 4: MAISRC Subproject 21.3: Multibeam sonar zebra mussel mapping, method development

Activity Budget: $184,167

Activity Description:
This project is a continuation of a laboratory study (Phase I) and a field study (Phase II) to test the feasibility of detecting and mapping zebra mussels and their supporting substrates using multibeam sonar. Current methods for detection of zebra mussel colonies rely on time consuming and expensive diving surveys, video imaging, or sampling of veligers. Survey design would be more efficient given spatially extensive information on the presence/absence of zebra mussel

beds. Remote sensing would also facilitate early detection through routine monitoring, or to follow changes in zebra mussel density overtime.

Phase III will apply the methods developed in Phases I and II to:
1) create maps of substrate and relative mussel densities in two different water bodies at a large scale
2) develop user-ready protocols and tools for translation of the research results to practice

As multibeam sonar systems continue to be more readily available, this will allow interested groups to utilize this technology. In lakes and rivers, this methodology will enable the scanning of large areas for:
1) the detection of zebra mussel colonies
2) the detection of areas likely to support zebra mussel colonies (through habitat mapping) that could be prioritized for other sampling methods

Activity Milestones:

Description	Approximate Completion Date
Finalize field protocols and study sites	March 31, 2022
Collect and process acoustic backscatter	September 30, 2022
Create map of substrate and relative mussel densities	December 31, 2022
Revised field data collection protocols complete	June 30, 2024
Data processing tools and documentation complete	June 30, 2024
Acoustic detection of mussels methods document complete	June 30, 2024
Prepare manuscripts for publication	June 30, 2024

Activity 5: MAISRC Subproject 24.2: Genetic method for control of invasive fish species

Activity Budget: $432,208

Activity Description:
This project is a continuation Genetic Biocontrol of Invasive Carp Phase I, in which researchers developed protocols for year-round carp spawning and carp transgenesis and created initial transgenic carp for the Engineered Genetic Incompatibility (EGI) biocontrol strategy. The success of Phase I will be leveraged to advance EGI and several alternative genetic biocontrol methods. Phase II will attempt to develop time-saving strategies to bypass the long generation time in carp to hasten multi-generational engineering/breeding efforts. These goals will be accomplished by leveraging experience in genetic design and construction of engineered systems and the team's carp transgenesis pipeline to create gene-drive, female-lethal, daughterless, and EGI carp. Lastly, the team will perform a formal Technology Readiness Assessment with stakeholders within the newly formed Genetic Control for Aquatic and Reef Pests (gCARP) international research consortium.

Developing genetic biocontrol technologies for carp and other aquatic invasive is a many-year process that will involve collaboration across many levels of government, academia, industry, and the watershed managers. No lab or field trials of biocontrol agents will occur during this phase, but we have the potential to construct viable biocontrol agents by the end of subproject.

Activity Milestones:

Description	Approximate Completion Date
Transient inactivation dnd gene in fathead minnows, goldfish, and carp complete	July 31, 2022
Technology Readiness Assessment for Female Lethality and Sterile Release	July 31, 2022
Build genetic reagents for Daughterless, Female Lethal, and Gene Drive approaches	December 31, 2022

Transplantation of carp PGCs from engineered fry to sterilized surrogate hosts	December 31, 2022
Technology Readiness Assessment for Gene Drive	July 31, 2023
Produce genetically engineered carp for each of four genetic biocontrol approaches	December 31, 2023
Measure the activity of molecular tools in fish in temperatures relevant to field release scenarios	December 31, 2023
Stable inactivation dnd gene in fathead minnows, goldfish, and carp complete	December 31, 2023
Demonstrate reproduction of viable carp fry from surrogate PGC recipients	June 30, 2024

Activity 6: MAISRC Subproject 22.3: Assessing and refining copper-based treatment to suppress zebra mussel populations

Activity Budget: $159,505

Activity Description:
Long-term assessments of AIS control actions are scarce, yet critical for determining the net benefit to a system. In 2022, a low dose of the copper-based molluscicide was applied to Maxwell Bay in Lake Minnetonka, using a modified application strategy (lower dose, shoreline application) from that used in St. Alban's Bay in 2019. This project will monitor zebra mussel veliger density and juvenile settlement, zooplankton, phytoplankton and macroinvertebrate communities, water chemistry, and chlorophyll over the reproductive season in Maxwell (treatment) and North Arm (reference) bays in 2023. One-year post-treatment data are critical for evaluating the success of the treatment strategy and determining whether the results achieved in St. Alban's Bay are repeatable on a larger scale. Data will also be used to model post-treatment shifts in native communities with zebra mussel density data and identify relationships between target and nontarget populations. Decisions on if, when, and how to respond to zebra mussel infestations are complicated and challenging, especially when stakeholder interests are diverse and management goals differ. This project will culminate in a Structured-Decision Making (SDM) workshop with area resource managers and local stakeholders to help guide future management actions for zebra mussels in Minnesota lakes.

Activity Milestones:

Description	Approximate Completion Date
One-year post-treatment assessment of zooplankton, macroinvertebrates, phytoplankton, and zebra mussel settlement is complete	April 30, 2024
Data entry, proofing, and analysis are complete. Before-and-after treatment responses are modeled	June 30, 2024
Informational materials and are prepared for SDM and stakeholder participants are identified	June 30, 2024
SDM workshop is conducted (in-person and virtual components)	September 30, 2024
Peer-reviewed manuscript is prepared	December 31, 2024
Final decision of SDM is written and reviewed by participants. Peer-reviewed manuscript is prepared	December 31, 2024

Activity 7: MAISRC Subproject 45: Carp Remediation - Climate Change, Ecological and Economic Benefits

Activity Budget: $262,907

Activity Description:
Carp are deleterious to the value and quality of lake waters although it is unknown how carp affect sediment carbon (C) accumulation and how they exacerbate green house gas emissions. The goal of this research is to provide analyses giving lake managers the applied tools they need to determine how to optimally apply carp management to Minnesota lakes. This goal will be attained by contrasting lakes with diverse amounts of carp to determine how carp impact carbon sequestration and greenhouse gas emissions and determine the climate change and economic benefits of carp removal. The study will be guided by a stakeholder focus group of those who will apply our results for management and benefit from the findings of this work. The project will analyze 18 lakes including (1) lakes with abundant carp, (2) lakes with

low- or no- carp, and (3) lakes where carp have not yet been detected, and will measure the abundance of carp and aquatic plants in these lakes and estimate sediment accumulation rates and greenhouse gas emissions (CO2, CH4, N2O). The team will then analyze the influence of carp abundance on these rates and estimate the social costs associated with carp-driven environmental change.

Activity Milestones:

Description	Approximate Completion Date
Study Lake Selection, carp and macrophyte surveys – Year 1	August 31, 2023
Monitor limnological conditions in the study lakes -- Year 1	December 31, 2023
Study Lake Selection, carp and macrophyte surveys – if needed Year 2	August 31, 2024
Installation of green house gas collection chambers and equipment and analysis of samples	September 30, 2024
Monitor limnological conditions in the study lakes -- Year 2	December 31, 2024
Collection and analysis of sediment cores for nutrients, C, and OM	May 31, 2025
Estimation of carbon lability and burial depth in sediment	May 31, 2025
Sediment dating and above results will be used to determine C burial rates	May 31, 2025
Green house gas flux will be converted to social costs using integrated economic assessment	May 31, 2025
Establish a stakeholder group for consultation throughout the project	June 30, 2025
Manuscripts for Activities 2 and 3 submitted for publication	June 30, 2025

Activity 8: MAISRC Subproject 46: Effective rusty crayfish removals to protect wild rice

Activity Budget: $155,445

Activity Description:

Wild rice is an important cultural resource vulnerable to rusty crayfish grazing. Several wild rice lakes in northeast Minnesota are invaded by rusty crayfish, and concern is mounting about their impacts on wild rice. However, the best methods to control rusty crayfish populations near wild rice is unknown. The goals of this project are to (1) find the most effective rusty crayfish trapping methods available to any Minnesotan, and (2) determine rusty crayfish movement rates near trapping areas. The research team will visit three lakes in 2023 and three different lakes in 2024. Trap and bait testing will occur over three nights in May/June and again in July/August in each lake. Crayfish will be marked during the May/June sampling and recapture marked individuals during the July/August visit. Results will provide stakeholders (lake associations, community groups, soil and water conservation districts, and Native American bands) guidance on effective rusty crayfish control using trap and bait choices that are legal in Minnesota. In addition, findings on rusty crayfish movement rates will inform stakeholders how long trapping efforts near sensitive vegetation may be protective.

Activity Milestones:

Description	Approximate Completion Date
Select 3 lakes for 2023 sampling with input from project partners	April 30, 2023
Sample 3 lakes in 2023 to test trap types and baits	September 30, 2023
Mark and recapture crayfish in 3 lakes in 2023	September 30, 2023
Replace lakes as needed for 2024 due to complications from rusty crayfish/northern clearwater hybridization	April 30, 2024
Sample 3 lakes in 2024 to test modified traps	September 30, 2024
Mark and recapture crayfish in 3 lakes in 2024	September 30, 2024
Dissemination of findings on most effective trap type and bait for rusty crayfish removal	December 31, 2024
Dissemination of findings on crayfish migration rates into depleted removal areas	December 31, 2024

Activity 9: MAISRC Subproject 47: Starry stonewort and wild rice: assessment and response

Activity Budget: $342,436

Activity Description:

There is great concern about the impacts of starry stonewort (SSW) on wild rice and effective strategies to manage SSW that has invaded wild rice beds is needed. As a sacred food and relative to Native people and prized resource for many Minnesotans, wild rice is an irreplaceable species in Minnesota. It is critical to evaluate the impacts of SSW on wild rice and implement sound response efforts to protect impacted wild rice. Supporting surveillance, outreach, and monitoring is vital for effectively responding to future spread and impacts of SSW. This project will respond to the threat of SSW spread and potential impacts to wild rice on the Leech Lake Reservation by leveraging products from previous and ongoing MAISRC research and supporting ongoing efforts of the Leech Lake Band of Ojibwe (LLBO). It will incorporate data and models on the spread of aquatic invasive plants to prioritize lakes and areas within lakes to search for SSW; monitor wild rice beds that have been invaded by SSW and evaluate the responses of wild rice and other native plants to SSW removals; provide training on SSW identification, impacts, and reporting to Leech Lake Band of Ojibwe (LLBO) community members and other stakeholders.

Activity Milestones:

Description	Approximate Completion Date
Develop a list of lakes with high risk of SSW invasion on the Leech Lake Reservation	April 30, 2023
Determine areas within Leech Lake and Lake Winnibigoshish to search for SSW	June 30, 2023
Establish all permanent monitoring transects	June 30, 2023
Search all identified high-risk areas within Leech Lake and Lake Winnibigoshish	August 31, 2023
Search all public accesses on Leech Lake, Lake Winnibigoshish, and high-risk LLBO lakes	August 31, 2024
Training workshop for SSW identification and reporting	August 31, 2024
Complete sampling of all permanent monitoring transects	September 30, 2024
Experimentally test competition between SSW and wild rice	June 30, 2025
Dissemination of information to LLBO staff and community members	June 30, 2025
Submit manuscripts for peer review	June 30, 2025

Activity 10: MAISRC Subproject 48: Beyond the sign: Influencing recreational boaters required behaviors

Activity Budget: $253,291

Activity Description:

The purpose of this project is to develop, test, and compare novel educational messaging to increase intentions to perform preventive behaviors among anglers who use boats to fish. Minnesota waterways remain at-high risk from aquatic invasive species (AIS), despite well-intended and widespread efforts to influence preventive behaviors. A priority AIS pathway is recreational boaters, particularly anglers. Existing and limited data reveal violation rates among boaters vary: they comply with some but not all required preventive behaviors. To better understand these choices, increase behavior intentions and ultimately protect waterways, the project will (1) systematically observe and compare preventative behavior at select public landings among anglers who use boats to fish, (2) conduct focus groups to understand behaviors observed, and (3) develop and test novel preventative behavioral messaging among anglers who use boats to fish; specifically we will compare typical photo/text messaging with augmented reality messaging to see if and how intentions to perform preventive messages vary. Based on the findings, the team will create a 'best practices' resource to guide educational organizations, resource managers, and scientists as well as work with existing professional and community-based (i.e. lake associations, AIS Detectors volunteers) AIS networks in Minnesota and beyond.

Activity Milestones:

Description	Approximate Completion Date
An observational form developed to identify behavioral violations related to AIS prevention	June 30, 2023
Observational data set complete	August 31, 2023
Baseline understanding of key AIS preventative behaviors performed at boat landings	August 31, 2023
Develop focus group protocol & pre test	October 31, 2023
Recruit focus group participants, conduct focus groups	November 30, 2023
Initial analysis of main themes from focus group to inform message development	November 30, 2023
Research-based informational intervention developed for augmented reality	April 30, 2024
Data collected to understand impact of novel information intervention on intention to perform preventative behaviors	September 30, 2024
Presentations and initial dissemination of informational intervention effectiveness & best practices	December 31, 2024
Publications and information sharing	December 31, 2024

Activity 11: MAISRC Subproject 49: Practical field-based tools for detecting high priority microbes

Activity Budget: $210,904

Activity Description:

Rapidly responding to the invasion of harmful microbes can be limited by insensitive and labor-intensive methods or require highly technical laboratory capacity. To address these limitations, we will develop a sensitive and field-deployable molecular tool for detecting DNA and RNA in the environment using Loop-mediated Isothermal Amplification (LAMP). In consultation with end-users, we have identified three high-priority microbes of interest for LAMP assay development: viral hemorrhagic septicemia virus (VHSV), largemouth bass virus (LMBV), and Didymosphenia geminata (Didymo). This project aims to validate and field test new assays for each microbe and build management capacity to support ongoing surveillance efforts. We will first optimize (VHSV and LMBV) and develop (Didymo) lyophilized LAMP assays for the three high-priority microbes. Each assay will be validated under laboratory conditions to determine specificity and sensitivity. Then, we will deploy the validated assays in the field by testing known-positive locations in Minnesota (LMBV and Didymo) or virus-exposed fish in the laboratory (VHSV) to evaluate detection limits compared qPCR. Field testing will done in partnership with management end users to evaluate practicality/usability of the LAMP assays and build capacity using standardized SOPs.

Activity Milestones:

Description	Approximate Completion Date
Determine analytical specificity and sensitivity of three lyophilized LAMP assays	August 31, 2023
Draft standard operating procedures (SOPs) for management partners	December 31, 2023
Determine specificity and sensitivity of lyophilized LAMP assays in field conditions and develop occupancy models	March 31, 2025
Finalize standard operating procedures (SOPs) for management partners	June 30, 2025
Fully transfer technology to management partners	June 30, 2025
Prepare open-access manuscript in peer-reviewed journal	June 30, 2025

Activity 12: MAISRC Subproject 56: Developing streamlined detection assays for invasive fish pathogens

Activity Budget: $57,200

Activity Description:

This project addresses an overdue need to develop and streamline surveillance tests for certifiable (i.e. pathogens with legally required testing), emergency and emerging pathogens relevant to fisheries managers in Minnesota. This includes four pathogens listed by MAISRC as priority species of harmful microbes: viral hemorrhagic septicemia virus, largemouth bass virus, Renibacterium salmoninarum, Myxobolus cerebralis, and Tetracapsuloides bryosalmonae. Each of these

pathogens has been known to cause disease in wild fish populations in the Great Lakes region and each is also managed with regard to fish importation/stocking by at least one state agency in the region and are classified as restricted pathogens by the Great Lakes Fish Health Committee's Model program. This panel of pathogens represents bacterial, viral and parasitic fish pathogens of non-native origins for which there is a current requirement for state agency fisheries and private aquaculture professionals to conduct diagnostic testing. This project seeks specifically to develop a simplified set of multiplexed quantitative PCR (qPCR) assays and present these assays as a surveillance tool to complement gold standard confirmatory tests such as culture, visual, and immunologic methods.

Activity Milestones:

Description	Approximate Completion Date
In-silico assays options developed for assays 1-3	January 31, 2024
Optimal assay validated for assays 1-3	June 30, 2024
Diagnostic sensitivity described for assays 1-3	November 30, 2024

Activity 13: MAISRC Subproject 58: Evaluating the source and status of invasive signal crayfish in Minnesota

Activity Budget: $37,262

Activity Description:
Multiple signal crayfish were confirmed by the Minnesota Department of Natural Resources in Lake Winona in Douglas County, MN, in October 2023. The population size, reproductive potential, extent of invasion, and source population are unknown. The threat of population expansion and profound ecological impacts make evaluation of the current population critical.

Investigating the initial discovery of invasive signal crayfish (Pacifastacus leniusculus) in Minnesota will potentially identify the first known population establishment east of the continental divide and trace the source population from the invasion. The potential for rapid expansion and detrimental ecological effects makes understanding population status imperative for the protection of Minnesota lakes. Our two main objectives are 1) use mitochondrial DNA to determine the geographic source of signal crayfish and 2) determine population status of signal crayfish in Lake Winona and surrounding lakes using traditional sampling methods and environmental DNA. Using the determined source population, we will propose likely vectors of invasion and communicate this information to prevent future establishments. We intend to assess feasibility of future control efforts based on the signal crayfish population status determined in the project. Results will inform lake managers of likely vectors to invasion and potential control measures.

Activity Milestones:

Description	Approximate Completion Date
eDNA test kit preparation and volunteer recruitment for surveillance and determination of population status	June 30, 2024
Mitochondrial analysis of captured samples to determine geographic source of signal crayfish	July 31, 2024
Three standard trapping and eDNA samplings of up to 10 lakes in Douglas County	October 31, 2024
Dissemination of findings (final report, presentation) of geographic source of signal crayfish	December 31, 2024
eDNA laboratory processing and amplification for surveillance and determination of population status	December 31, 2024
Dissemination of findings (final report, presentation) of population status	December 31, 2024

Activity 14: MAISRC Subproject 43.2: Rearing zebra mussels in the MAISRC Containment Lab - Phase II

Activity Budget: $126,457

Activity Description:

This project will continue research to establish methods that will support the successful propagation and rearing of invasive zebra mussels in a captive setting. Emerging technologies associated with implementing biogenetic control methods for zebra mussels have been restricted due to the inability to rear test subjects in a laboratory setting. The research team will continue to develop and refine methodologies to effectively spawn and rear zebra mussels in a controlled laboratory. Specifically, Phase II activities to improve efficacy will include: 1) diversifying algae species offered as food to zebra mussels; 2) completing trials for additional spawning methods such as batch spawning to include sperm as an inducer for female mussels; and 3) testing the effectiveness of static, kreisel, and fish egg hatchery tanks for larval holding. Success with this project will benefit biogenetic control research that can impact zebra mussel population management in infested lakes throughout northern latitudes worldwide.

This project will run from July 1, 2024 - June 30, 2026 with the first year of work on M.L. 2021 and leveraging funding for the second year on MAISRC's 2023 Heritage Enhancement Account Appropriation. M.L. 2021 work will occur from July 1, 2024-June 30, 2025.

Activity Milestones:

Description	Approximate Completion Date
Establishment of new algal culturing and zebra mussel propagation spaces.	July 31, 2024
Diversification of algae species available as food source.	August 31, 2024
Collection of adult zebra mussel broodstock from the wild and completion of spawning trials (2024).	October 31, 2024
Collection of broodstock, analysis, and dissemination of results (non-ENRTF funds through June 30, 2026)	June 30, 2025

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.
The translation of AIS science into public and management action is a central part of MAISRC's work and we provide a platform for information and new research findings about AIS to be widely disseminated. This is accomplished by providing rich opportunities for stakeholder engagement through the annual public Research and Management Showcase event and ongoing outreach efforts, as well as making research progress and results accessible to the public and AIS managers through reports, brochures, the MAISRC website, Facebook and Twitter, Extension programming, seminars, talks, and via peer reviewed publications and student theses. Additionally, MAISRC organizes a publicly available and indefinite data repository ("MAISRC-DRUM") in partnership with the UM Libraries for data related to ongoing and completed MAISRC projects.

The Minnesota Environment and Natural Resources Trust Fund (ENRTF) will be acknowledged through use of the trust fund logo or attribution language on project print and electronic media, publications, signage, and other communications per the ENRTF Acknowledgement Guidelines.

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this work be funded?
MAISRC has a demonstrated track record of not only conducting high-quality research, but also providing the public and managers with research tools and science-based information in understandable formats. This ENRTF funding would ensure that these activities will continue until 2025. We have, and will continue to, leverage the ENRTF investment with significant UMN support (faculty positions, foregone ICR, etc.) and external grant support from 'Partnership Projects'. However, to ensure MAISRC remains focused on Minnesota's priorities and solutions-oriented research, additional ENRTF support is crucial.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Aquatic Invasive Species Research Center - Phase II	M.L. 2017, Chp. 96, Sec. 2, Subd. 06a	$2,700,000
Building Knowledge and Capacity to Solve AIS Problems	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 06a	$4,000,000

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount	$ Amount Spent	$ Amount Remaining
Personnel										
Graduate Student		Perform research on the prevention, control and management on AIS in Minnesota. Fringe rate includes cost of tuition.			87.9%	1		$103,714	-	-
Undergraduate Students		2 Undergraduate students to support MAISRC research program, outreach to stakeholders, and dissemination of research findings.			0%	1		$15,600	-	-
Research Associate		Perform dedicated research on the control and management of zebra mussels in Minnesota.			36.5%	2		$218,400	-	-
Contract Faculty		Perform dedicated research on control and management of common carp in Minnesota.			36.5%	1		$128,251	-	-
Laboratory Manager		Maintain MAISRC Containment Lab to ensure efficiency and accessibility for MAISRC projects.			31.8%	0.1		$8,486	-	-
Communications Specialist		Maintain MAISRC communications platforms to effectively disseminate research findings and connect MAISRC research with the public.			31.8%	1.98		$188,136	-	-
Co-Project Manager		Coordinate MAISRC research program, outreach to stakeholders, and dissemination of research findings.			36.5%	1.02		$130,585	-	-
Project Manager		Lead MAISRC research activities and coordinate with local, state, and national agencies and AIS professionals.			36.5%	1		$198,842	-	-
							Sub Total	**$992,014**	**$683,562**	**$308,452**
Contracts and Services										
To be awarded to subprojects	Subaward	Budget reserve for awarding to subprojects, upon approval from LCCMR				0		$194,141	-	$194,141

Awarded to subprojects	Subaward	Cumulative budget, spent, and balance for all subprojects combined. Detailed subproject budgets are submitted in an Excel workbook via the attachments page under "Optional Attachments/Support Letter or Other" with the name as the date of submission (e.g. "YYYY-MM-DD Budget Update").				22.04		$2,429,212	$2,312,214	$116,998
Private Contractors	Professional or Technical Service Contract	General Operating Services: Mailing outreach materials, audio/visual associated with seminars and conferences, email newsletter platform, dissemination of research results through social media, etc.		X		-		$6,000	$358	$5,642
Private Contractors	Professional or Technical Service Contract	Rentals: Facilities and provisions for conferences and events (e.g. annual Showcase).				0		$10,000	$9,894	$106
UMN Strategic Partnerships & Research Collaborative	Internal services or fees (uncommon)	Strategic Partnerships & Research Collaborative (SPARC) at the University of Minnesota will provide support for MAISRC strategic planning. Work will be completed through an internal UMN contract and will support personnel time for SPARC staff to work with MAISRC.				0.33		$73,133	$49,664	$23,469
							Sub Total	**$2,712,486**	**$2,372,130**	**$340,356**
Equipment, Tools, and Supplies										
	Tools and Supplies	General Operating Supplies	Supplies for research coordination (e.g. paper, office supplies, ink/toner).	X				$7,500	$1,139	$6,361
	Equipment	Field/Lab Equipment	Equipment for research in the field and lab (e.g. storage containers,					$4,000	-	$4,000

			software, nets, and other equipment).							
	Tools and Supplies	Field/Lab Supplies	Supplies for research in the field and lab (e.g. piping, fish food, gas for boats, tanks, reagents, sampling supplies, and other consumables).					$6,000	$2,223	$3,777
							Sub Total	**$17,500**	**$3,362**	**$14,138**
Capital Expenditures										
							Sub Total	**-**	**-**	**-**
Acquisitions and Stewardship										
							Sub Total	**-**	**-**	**-**
Travel In Minnesota										
	Miles/ Meals/ Lodging	Travel for MAISRC staff.	AIS coordination meetings, support of MAISRC research, and dissemination of research results.					$10,000	$7,312	$2,688
	Conference Registration Miles/ Meals/ Lodging	Project Manager travel to two conferences.	Presentation of research findings.					$4,000	-	$4,000
							Sub Total	**$14,000**	**$7,312**	**$6,688**
Travel Outside Minnesota										
	Miles/ Meals/ Lodging	Project Manager travel to four regional AIS meetings.	Coordination of AIS research with regional managers and researchers.	X				$4,500	$1,658	$2,842
	Conference Registration Miles/	Project Manager travel to one national conference.	Presentation of research findings to strategic audiences and expanding	X				$3,500	-	$3,500

	Meals/ Lodging		AIS research for Minnesota.							
							Sub Total	**$8,000**	**$1,658**	**$6,342**
Printing and Publication										
	Printing	Annual research report, fact sheets, training materials, white papers, etc.	Dissemination of research findings and support for research activities.					$6,000	$4,752	$1,248
							Sub Total	**$6,000**	**$4,752**	**$1,248**
Other Expenses										
							Sub Total	**-**	**-**	**-**
							Grand Total	**$3,750,000**	**$3,072,776**	**$677,224**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Contracts and Services - Private Contractors	Professional or Technical Service Contract	General Operating Services: Mailing outreach materials, audio/visual associated with seminars and conferences, email newsletter platform, dissemination of research results through social media, etc.	Part of MAISRC's core work is to disseminate research results and serve has a resource for individuals, groups, and advisory committees on AIS and science-based prevention and management recommendations. This is done in large part through mailings, seminars/conferences, email, and social media to reach as many people as possible through various platforms. These expenses benefit Minnesota's environment by making MAISRC research accessible and more likely to be implemented in communities around the state.
Equipment, Tools, and Supplies		General Operating Supplies	MAISRC's core work is to prioritize and facilitate AIS research that advances AIS solutions for Minnesota. In order to do this work effectively, MAISRC staff need office supplies like paper, pens, ink/toner, file folders, etc. Office materials like these are not provided by the UMN.
Travel Outside Minnesota	Miles/Meals/Lodging	Project Manager travel to four regional AIS meetings.	Working with regional AIS managers and researchers is essential to advancing AIS solutions for Minnesota by sharing knowledge and coordinating control/management efforts that are rooted in the latest science. Participating in regional meetings allows MAISRC to engage in AIS prevention and management efforts that will have direct impacts on Minnesota waters.
Travel Outside Minnesota	Conference Registration Miles/Meals/Lodging	Project Manager travel to one national conference.	Sharing research findings at regional and national conferences allows MAISRC researchers to connect with others in the field and advance knowledge and AIS solutions. Shared research findings directly impact Minnesota by bringing new ideas and information into the state that can further AIS prevention, control, and management efforts.

Non ENRTF Funds

Category	Specific Source	Use	Status	$ Amount	$ Amount Spent	$ Amount Remaining
State						
In-Kind	University of Minnesota foregone indirect costs	Administrative support of MAISRC activities including payroll and human resources, finance, facilities, and IT.	Secured	$2,750,000	$2,750,000	-
Cash	Environment and Natural Resources Appropriation M.L. 2019, Art. 1, Sec. 3, Subd. 3(j)	Appropriation language: prioritize, support, and develop research-based solutions that can reduce the effects of aquatic invasive species in Minnesota by preventing spread, controlling populations, and managing ecosystems and to advance knowledge to inspire action by others.	Secured	$1,020,000	$1,020,000	-
Cash	Environment and Natural Resources Appropriation M.L. 2021, Art. 1, Sec. 3, Subd. 3(j)	Appropriation language: prioritize, support, and develop research-based solutions that can reduce the effects of aquatic invasive species in Minnesota by preventing spread, controlling populations, and managing ecosystems and to advance knowledge to inspire action by others.	Secured	$1,820,000	$1,530,132	$289,868
			State Sub Total	**$5,590,000**	**$5,300,132**	**$289,868**
Non-State						
			Non State Sub Total	**-**	**-**	**-**
			Funds Total	**$5,590,000**	**$5,300,132**	**$289,868**

Attachments

Required Attachments

Visual Component

File: b2c15f35-48c.pdf

Alternate Text for Visual Component

Minnesota Aquatic Invasive Species Research Center: Building knowledge and capacity for AIS solutions.
A three-step process is outlined:

1. Ideas & Needs
a. Inclusive prioritization process to identify most pressing needs
b. Annual RFPs allow for agile response to emerging issues
2. Research
a. Two-year projects take testing from the lab to the lake
b. International collaboration, Minnesota-focused
3. Real World Solutions
a. Proven tactics and recommendations
b. Findings shared with decisio...

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
MAISRC Letters of Support	a29058ec-5b9.pdf
Background Check Cert.	27b1d423-54c.pdf
Budget Update 2022.11.03	7c433671-d4d.xlsx
Budget Update 2022.12.08	e1f9536c-34e.xlsx
Budget Update 2023.03.09	9284d0e1-bdc.xlsx
Budget Update 2023.05.11	780da82c-10a.xlsx
Budget Update 2023.08.30	cab84a89-0fc.xlsx
Budget Update 2023.10.10	82a1369a-612.xlsx
Budget Update 2023.10.26	d115ad19-de3.xlsx
Budget Update 2023.11.21	0a0b3ba4-9bc.xlsx
Budget Update 2023.12.18	2d54ad14-452.xlsx
Budget Update 2024.01.19	61abafb5-beb.xlsx
Budget Update 2024.02.23	28fe6717-957.xlsx
MAISRC 2024 RFP and Priority Species	b8e5d2ea-d14.pdf
Budget Amendment 2024.05.06	e97e00db-d4a.xlsx
Budget Amendment 2024.06.26	6faa6560-144.xlsx
Budget Amendment 2024.07.30	efd19dfb-44f.xlsx
Budget Update and Amendment 2024.09.13	1b4f48d8-6cb.xlsx
Subproject 4.4 Final Report Abstract	5e29f059-096.pdf
Subproject 4.4 Final Report Visual Component	310a0cee-edf.pdf
Subproject 4.4 Final Report Bullers Thesis	34ffcb20-386.pdf
Subproject 21.3 Final Report Abstract	a52f1a6d-19f.pdf
Subproject 21.3 Final Report Visual Component	13548808-f97.pdf
Subproject 24.2 Final Report Abstract	f0742a1d-652.pdf
Subproject 24.2 Final Report Visual Component	8c67107a-b25.pdf
Budget Amendment 2025.01.02	53e03061-738.xlsx
Budget Amendment 2025.01.13	a7ff0e7f-3ed.xlsx
Budget Update and Amendments 2025.02.28	b7a641ed-7c7.xlsx
MAISRC 2025 Species Priorities	c96b5029-25b.pdf

MAISRC 2025 Research Priorities	314ee906-daa.pdf
MAISRC 2024 Annual Report (PDF)	595b1b1f-34f.pdf
Subproject 22.3 Final Report Abstract	12050949-e98.docx
Subproject 22.3 Final Report Visual Component	86132b6c-c8e.pdf
Subproject 48 Final Report Abstract	e5a0d89e-b81.docx
Subproject 48 Final Report Visual Component	62634316-beb.pdf
Subproject 56 Final Report Abstract	fe903eea-e67.docx
Subproject 56 Final Report Visual Component	0785d2b4-cc5.pdf
Budget Amendment 2025.05.15	e01b4e87-8b6.xlsx
Final Budget Update and Amendments 2025.08.28	810a67a6-0c0.xlsx
MAISRC Zebra Mussel Safari Handout	6331d64d-f06.pdf
Subproject 43.2 Final Report Abstract	44d59f3c-67c.pdf
Subproject 45 Final Report Abstract	9b112fe5-7a8.pdf
Subproject 45 Final Report Map	40b104a8-d8a.jpe
Subproject 46 Final Report Abstract	2887544b-976.pdf
Subproject 46 Final Report Visual Component	0e611f69-58c.pdf
Subproject 46 Crayfish Trapping Guide	c7c9dc25-2af.pdf
Subproject 47 Final Report Abstract	e19e278b-701.pdf
Subproject 47 Final Report Map	29418625-a2f.pdf
Subproject 47 Final Report Visual Component	f404163b-777.pdf
Subproject 49 Final Report Abstract	5f125a9a-a8b.pdf
Subproject 58 Final Report Abstract	a0088913-4a6.pdf

Media Links

Title	Link
Annual Research and Management Showcase information	https://maisrc.umn.edu/showcase
List of MAISRC peer reviewed publications	https://www.maisrc.umn.edu/publications
MAISRC 2024 Annual Report	https://storymaps.arcgis.com/stories/4b555e840d8043a0857ee6df8412186e
MAISRC Data Repository at the University of Minnesota (DRUM)	https://hdl.handle.net/11299/197773
AIS Explorer Tool	https://z.umn.edu/aisexplorer
Milfoil Mapper Tool	https://z.umn.edu/milfoilmap
Mussel Strains Tool	https://z.umn.edu/MusselStrains
PI Charter Tool	https://z.umn.edu/PICharter

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

Due to the budget reduction of 25%, we have reduced the number of expected sub-projects we can support through our RFP accordingly.

Additional Acknowledgements and Conditions:

The following are acknowledgements and conditions beyond those already included in the above workplan:

Do you understand and acknowledge the ENRTF repayment requirements if the use of capital equipment changes?

N/A

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

Yes, I understand the UMN Policy on travel applies.

Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?

Yes

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

Yes

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

No

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Work Plan Amendments

Amendment ID	Request Type	Changes made on the following pages	Explanation & justification for Amendment Request (word limit 75)	Date Submitted	Approved	Date of LCCMR Action
1	Project Manager	Previous Manager: Nicholas Phelps (phelp083@umn.edu) New Manager: Cori Mattke (cmattke@umn.edu)	Nick Phelps is on sabbatical until February 14, 2023. I am filling in as a co-interim director and am handling all operations/funding/reporting until his return.	September 9, 2022	Yes	September 12, 2022
2	Amendment Request	• Project Collaborators - Project Manager Info • Attachments • Activities and Milestones • Budget - Professional / Technical Contracts • Budget - Non-ENRTF Funds Contributed	Request to (1) amend budgets for Subprojects 4.4 and 24.2, (2) allocate funds to new Subprojects 22.3, 45, 46, 47, 48, 49, and (3) record additional state funds contributed to project to primary budget.	December 8, 2022	Yes	December 8, 2022
3	Amendment Request	• Attachments	Request to (1) amend budgets for Subprojects 4.4 and 24.2, (2) allocate funds to new Subprojects 22.3, 45, 46, 47, 48, 49, and (3) record additional state funds in the primary budget that have been contributed to the project. This amendment is being resubmitted after consultation with LCCMR staff and the incorporation of requested revisions. An updated Budget Update document that reflects the requested amendments has been uploaded.	December 8, 2022	Yes	December 15, 2022
4	Amendment Request	• Attachments	Request to (1) amend budgets for Subprojects 4.4, 21.3, and 24.2, (2) approve out-of-state travel for a key project collaborator to travel to Minnesota for field work for Subproject 47. An updated Budget Update document that reflects the requested amendments has been uploaded.	May 11, 2023	Yes	May 15, 2023

5	Amendment Request	• Attachments	This amendment request is a budget amendment for Subproject 4.4 to provide for repairs to the project team's boat trailer. An updated Budget Update document that reflects the requested amendment has been uploaded.	October 10, 2023	Yes	October 24, 2023
6	Amendment Request	• Activities and Milestones • Budget - Professional / Technical Contracts • Attachments	Request to (1) extend Subproject 4.4; (2) amend budgets for Subprojects 22.3, 24.2, and 48; (3) change the subproject manager for Subproject 46; (4) allocate funds to new Subproject 56 (new Activity 12). An updated Budget Update document that reflects the requested amendments has been uploaded.	November 1, 2023	Yes	November 20, 2023
7	Amendment Request	• Activities and Milestones • Attachments	This amendment includes a request to (1) extend Subproject 21.3; (2) extend Subproject 24.2; (3) amend budget for Subprojects 24.2. An updated Budget Update document that reflects the requested amendments has been uploaded.	December 21, 2023	Yes	January 19, 2024
8	Amendment Request	• Other • Activities and Milestones • Budget - Professional / Technical Contracts • Attachments	This amendment request is an amendment to allocate funds to new Subproject 58 (new Activity 13). Funds will be allocated from MAISRC budget reserves for awarding to subprojects. An updated Budget Update document that reflects the requested amendments has been uploaded.	February 2, 2024	Yes	February 5, 2024
9	Amendment Request	• Activities and Milestones • Budget - Personnel • Budget - Professional / Technical Contracts • Attachments	This amendment request includes a request to (1) allocate additional funds to Subprojects 24.2 and 22.3; (2) amend budgets for Subprojects 45, 46, 48, 58; (3) update project outcomes for Subproject 46; (4) correct an error to the title of Activity 12; (5) allocate funds for new Subproject 43.2 (new Activity 14). An updated Budget Update document that	May 6, 2024	Yes	June 12, 2024

			reflects the requested amendments has been uploaded.			
10	Amendment Request	• Other • Activities and Milestones • Budget - Professional / Technical Contracts • Attachments	This amendment request includes a request to (1) allocate additional funds to Subprojects 22.3, 45, 46, 56, and 58; (2) extend the end date of Subproject 45. An updated Budget Update document that reflects the requested amendments has been uploaded.	June 27, 2024	Yes	July 26, 2024
11	Amendment Request	• Attachments	$3,000 from Personnel to Travel to allow one research team member to present at the North American Lake Management Society conference in Nevada. Attendees of the conference are lake management professionals - a key audience for the project. Reaching a larger audience has the potential to have a greater impact on invasive crayfish management regionally/nationally, which in turn can benefit Minnesota by reducing populations out-state that may contribute to future Minnesota introductions.	August 24, 2024	Yes	August 26, 2024
12	Amendment Request	• Budget • Budget - Professional / Technical Contracts • Budget - Capital, Equipment, Tools, and Supplies • Budget - Travel and Conferences • Budget - Printing and Publication • Budget - Non-ENRTF Funds Contributed • Attachments	This amendment request includes budget amendments for MAISRC and Subprojects 21.3, 45 and 49. Requests are detailed in the corresponding subproject updates. An updated Budget Update document that reflects the requested amendments has also been uploaded.	September 13, 2024	Yes	September 20, 2024
13	Amendment Request	• Activities and Milestones • Budget - Professional / Technical Contracts • Attachments	This amendment request includes requests to (1) amend budgets for Subprojects 46 and 48; (2) allocate additional funds to Subprojects 45 and 49; (3) extend the end dates of Subprojects 47 and 49. An updated Budget Update document that reflects the	January 3, 2025	Yes	January 8, 2025

			requested amendments has been uploaded.			
14	Amendment Request	• Attachments	This update is an amendment request to extend the end date of Subproject 58 to June 30, 2025 and reallocate funds within the subproject budget, to provide for more personnel time to conduct outreach and disseminate research results through the end of the project. An updated Budget Amendment document that reflects the requested changes has been uploaded.	January 13, 2025	Yes	January 13, 2025
15	Amendment Request	• Budget • Activities and Milestones • Budget - Professional / Technical Contracts • Budget - Capital, Equipment, Tools, and Supplies • Budget - Travel and Conferences • Budget - Printing and Publication • Attachments	This amendment request includes budget amendments for Subprojects 45, 48, and 56. As well as a request to extend the end date of Subproject 46. Amendments are detailed in the corresponding subproject updates. An updated Budget Update document that reflects the requested amendment has also been uploaded.	February 28, 2025	Yes	April 7, 2025
16	Amendment Request	• Attachments	This update is an amendment request to amend the budget for Subproject 47, to provide for additional personnel time through the end of the project. An updated Budget Amendment document that reflects the requested changes has been uploaded.	May 15, 2025	Yes	June 2, 2025
17	Amendment Request	• Budget - Professional / Technical Contracts • Budget - Non-ENRTF Funds Contributed • Attachments	This amendment request includes budget amendments for Subprojects 45, 46, 47, 58. Amendments are detailed in the corresponding subproject updates. An updated Budget Update document that reflects the requested amendment has also been uploaded.	August 29, 2025	Yes	December 1, 2025

Status Update Reporting

Final Status Update August 14, 2025

Date Submitted: August 29, 2025

Date Approved: December 1, 2025

Overall Update
As of June 30, 2025, the final MAISRC subprojects on M.L. 2021 have been completed:

Subproject 43.2: Zebra Mussel Larval Rearing (Phase II) – Seth Stapleton
Subproject 45: Carp Remediation: Climate Change, Ecological and Economic Benefits – Dr. John Downing
Subproject 46: Effective rusty crayfish removals to protect wild rice – Dr. Valerie Brady
Subproject 47: Starry stonewort and wild rice: assessment and response – Dr. Dan Larkin
Subproject 49: Practical field-based tools for detecting high priority microbes – Dr. Nick Phelps
Subproject 58: Evaluating the source and status of invasive signal crayfish in Minnesota – Dr. Gretchen Hansen

Final reports for each project are included below. Abstracts, final budget reports, and related project materials have been uploaded with this project update.

Activity 1
Presentations:
MAISRC staff and research teams gave 57 presentations to more than 6,500 people. Audiences included lake associations, youth camps, DNR-led watercraft inspector trainings, professional conferences, and community events. In addition, public tours of the MAISRC Containment Lab reached a new high this spring with 14 tours, with nearly 200 participants.

MAISRC research was also featured in the AIS Detectors May webinar, “Effective rusty crayfish removals to protect wild rice” (Activity 8, Subproject 46). Which is viewable online: https://z.umn.edu/RustyCrayfishWildRice

Media:
MAISRC research has been featured in two recent episodes of Pioneer PBS’ Prairie Sportsman - “Ridding the North of Rusties” (Activity 8, Subproject 46) and “Cattail Imposters” (M.L. 2019, Subproject 40). Viewable online:
Rusties - https://z.umn.edu/PSrusties
Cattails - https://z.umn.edu/PScattails

Publications:
MAISRC researchers have published five new peer-reviewed manuscripts. A full list of MAISRC publications is available online: https://www.zotero.org/maisrc_umn/library

ZM Safari:
AIS Detectors’ new Zebra Mussel Safari participatory science program, developed in collaboration with MAISRC, has deployed zebra mussel samplers on 17 lakes in Minnesota to monitor zebra mussel populations. More information is available here: https://maisrc.umn.edu/research/51
(This activity marked as complete as of this status update)

Activity 2
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 3
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 4
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 5
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 6
Final report and abstract was provided in March 2025 update.
(This activity marked as complete as of this status update)

Activity 7
Subproject 45
While invasive carp have been shown to alter nutrient levels and biodiversity in lakes, their effects on lake carbon cycling remain poorly understood. In this study, we assessed how carp invasion alters carbon cycling in Minnesota lakes. Over two years, we measured CO_2 and CH_4 emissions, water quality, sediment characteristics, and carbon burial in 10 carp-infested lakes and 8 carp-free lakes. Surprisingly, lakes with invasive carp exhibited lower CH_4 emissions despite higher levels of eutrophication, challenging the prevailing assumption that methane emissions increase with nutrient enrichment and productivity. Additionally, carp-invaded lakes had reduced sediment nutrient content and organic matter, which were associated with the lower greenhouse gas emissions. These findings show that invasive carp significantly alter lake ecosystem processes. By disturbing the sediment environment, carp reduce greenhouse gas emissions but also diminish the potential for long-term carbon storage in sediments, shifting the carbon and nutrient balance of the ecosystem.

Amendment:
Move $378 from Travel to Personnel, to provide for higher than anticipated personnel costs through the end of the project.
(This activity marked as complete as of this status update)

Activity 8
Subproject 46
Tested different trap and bait types for removing rusty crayfish near sensitive vegetation. Tracked rusty crayfish movement through a mark and recapture process to evaluate the feasibility of localized invasive crayfish reductions near sensitive vegetation. Baited wire-mesh minnow traps reported an average catch rate ca. 50-fold higher than unbaited refuge shelters. Trapping close to sensitive vegetation is more protective against rusty crayfish because their ability to travel makes localized reductions difficult. We used methods any stakeholder in the state of Minnesota can use to remove rusty crayfish. Our findings serve as a guide for those looking to reduce the impact of rusty crayfish on sensitive vegetation.

Amendment:
Adjust the budget to provide for higher than anticipated personnel and field travel costs through the end of the project.

Personnel - $118,432 to $119,006 (net +$574)
Professional/Technical/Service Contracts - $4,103 to $4,095 (net -$8)
Equipment/Tools/Supplies - $400 to $389 (net -$11)
Travel Field Work - $26,278 to $28,320 (net +$2,042)
Travel In-State Conference - $3,232 to $1,955 (net -$1,277)
Travel National Conference - $3,000 to $1,680 (net -$1,320)
(This activity marked as complete as of this status update)

Activity 9
Subproject 47
Starry stonewort (SSW) and wild rice occupy similar habitats, which creates the potential for SSW to displace and reduce the productivity of natural stands of wild rice and other native macrophytes. This project aimed to: improve SSW surveillance; assess the impacts of SSW and its management on wild rice; provide support for SSW surveillance and management. Surveys on 51 public boat accesses on the Leech Lake Reservation were conducted for SSW detection and testing of risk assessment models. We monitored wild rice beds that have been invaded by SSW and evaluated the responses of wild rice and other native plants to SSW presence. We monitored the expansion of SSW to evaluate the impact of SSW on wild rice and other native macrophytes. Preliminary results indicate that while the invasion is moving slowly it does have a measurable negative effect on native macrophytes. Project outcomes will inform the AIS management efforts of the Leech Lake Band of Ojibwe and other aquatic resource managers in Minnesota.

Amendment:
Move $4,000 from Laboratory Analysis and $66 from Supplies-GenOp to Personnel (net +$4,066) to provide for higher than anticipated personnel costs through the end of the project.
(This activity marked as complete as of this status update)

Activity 10
Final report and abstract was provided in March 2025 update.
(This activity marked as complete as of this status update)

Activity 11
Subproject 49
Molecular tools to identify environmental DNA (eDNA) in water is an emerging approach for early detection and surveillance of AIS. A key bottleneck in the approach remains the field deployability of LAMP assays. Currently, samples are collected from the field and transported to a lab for analysis. Our goal was to develop methods that put the full testing pipeline in the field. We focused on three priority harmful microbes: largemouth bass virus (LMBV), viral hemorrhagic septicemia virus (VHSV), and Didymosphenia geminata (Didymo). We were successful in collecting field samples for LMBV and Didymo, and conducting a laboratory exposure trial for VHSV. Due to persistent challenges met by the project, we were less successful validating the field deployable assays. However, we were able to test most VHSV and Didymo samples in the lab, to demonstrate the effectiveness (or not) of various sample collection methods. For static water (i.e., lake; VHSV) active filtration worked best, while passive sampling performed better for moving water (e.g., river; Didymo). We have concluded that there is significant need and promise for deploying eDNA detection methods in the field; however, the platforms and assay-specific reagents will need further optimization to reliably scale.
(This activity marked as complete as of this status update)

Activity 12
Final report and abstract was provided in March 2025 update.
(This activity marked as complete as of this status update)

Activity 13
Subproject 58

Signal crayfish were confirmed in Lake Winona in 2023 after being caught by a local bait harvester. In 2024, we carried out an extensive monitoring effort to learn more about their presence and check for possible spread to nearby lakes. We used a variety of trapping methods but did not catch any crayfish. Alongside trapping, we collected 142 total water samples from Lake Winona and nine nearby lakes, testing them using eDNA assays. eDNA testing found very small traces of signal crayfish DNA in four samples. The eDNA levels were extremely low, with only one single positive result in repeated testing for each of these samples. Trapping and eDNA results suggest a potential low-density population of signal crayfish in Lake Winona, although it is possible that eDNA was detected for other reasons. Because eDNA can detect species at very early stages of an invasion, continued monitoring will be important for understanding whether signal crayfish are becoming established or spreading in the region.

Amendment:
Move $429 from Professional/Technical/Service Contracts to Personnel to provide for higher than anticipated personnel costs through the end of the project.
(This activity marked as complete as of this status update)

Activity 14
Subproject 43.2
Over the course of the project, the research team cultured six species of live freshwater and prepared saltwater algae in the laboratory and developed protocols to provide optimal water quality and flow for captive zebra mussels.

They established an algae culture laboratory to support research evaluating various algae-based diets, offering groups of adults and larvae different feed 'treatments'. Concurrently, they improved protocols for initiating spawning, washing and determining viability of gametes, fertilizing eggs, and rearing of embryos through D-stage larvae, yielding further improvements in rates of survival, development, and longevity in 2025.

This work has advanced our understanding of zebra mussel husbandry, with initial benefits to biogenetic control research, but the team notes that veligers reared under their 'optimal' conditions survived and developed only as well as larvae that were not offered any food. As such, continued research is needed to better delineate the dietary needs of larvae. This project will continue into a second year on non-ENERTF funding and will explore additional food sources that may improve survival and development, positioning the team to further support research on zebra mussel controls.
(This activity marked as complete as of this status update)

Dissemination
A summary of communications and outreach activities in this project period are summarized in Activity 1.

Data Repository at the University of Minnesota (DRUM)
To ensure proper stewardship and accessibility of MAISRC data, MAISRC maintains a publicly accessible data repository. The DRUM now contains 45 sets of data from MAISRC subprojects and partnership projects:
https://hdl.handle.net/11299/197773

Not all projects utilize the DRUM platform - some upload their data to federal databases or in open-access publications, to align with data sharing standards within their individual fields of study or journal requirements.

Additional Status Update Reporting

Additional Status Update May 15, 2025

Date Submitted: May 15, 2025

Date Approved: June 2, 2025

Overall Update
This update is an amendment request to amend the budget for Subproject 47, to provide for additional personnel time through the end of the project. An updated Budget Amendment document that reflects the requested changes has been uploaded.

Activity 1
N/A

Activity 2
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 3
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 4
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 5
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 6
N/A

Activity 7
N/A

Activity 8
N/A

Activity 9
Subproject 47 Amendment:

Reallocate $3,000 from Supplies-Office/GenOperating, $4,000 from Professional/Technical/Service Contracts-Lab Analysis, and $5,000 from Travel to Personnel (net +$12,000) to accommodate higher than anticipated personnel costs through the end of the project. Budget savings in supplies, contracts, and travel are the result of lower than expected costs associated with each category.

Activity 10
N/A

Activity 11
N/A

Activity 12
N/A

Activity 13
N/A

Activity 14
N/A

Dissemination
N/A

Status Update Reporting

Status Update March 1, 2025

Date Submitted: February 28, 2025

Date Approved: April 7, 2025

Overall Update
Five research projects are currently underway on M.L. 2021. Summaries of the progress of these subprojects are included below. In addition, MAISRC is currently supporting 16 subprojects on M.L. 2023 and one subproject through alternate funding sources. Six of the subprojects on M.L. 2023 were selected as a part of MAISRC's 2024 Request for Proposals (RFP) and began on January 1, 2025.

Three subprojects on M.L. 2021 ended on December 31, 2024. Final report abstracts, budgets, and supplementary materials for these subprojects are included with this update. Completed subprojects include:
Subproject 22.3: Assessing and refining copper-based treatment to suppress zebra mussel populations – Dr. Diane Waller
Subproject 48: Beyond the sign: Influencing recreational boaters required behaviors – Dr. Ingrid Schneider
Subproject 56: Developing streamlined detection assays for invasive fish pathogens – Dr. Isaiah Tolo

When completing this progress report, it was discovered that the amount awarded to subprojects and the amount of budget reserve were incorrect in the overall budget (Section 6). In addition, activity level budgets in Activities 1, 2, and 49 were also incorrect. These have been updated in this report.

Activity 1
In advance of the release of MAISRC's 2025 Request for Proposals (RFP), MAISRC staff worked with the MAISRC Technical Committee, to revise MAISRC's list of priority species and 2025 research priorities. Research priorities were determined by reviewing the results of the comprehensive, biennial Research Needs Assessment that was completed in 2022 and in consultation with the Center Fellows Group, MAISRC Advisory Board, and MN DNR Invasive Species Program. The revised priority species list and 2025 RFP priorities have been uploaded with this report and can be viewed on the MAISRC website: https://maisrc.umn.edu/rfp

Three new members joined the MAISRC Advisory Board, including:
Ingrid Bey – AIS Detector, member of the Kabekona Lake Association and Hubbard County Coalition of Lake Associations
Bill Grantges – Itasca County Aquatic Invasive Species Program Manager
James Johnson – Aquatic ecologist/limnologist and owner of Freshwater Scientific Services

A full list of Advisory Board members is available on the MAISRC website: https://maisrc.umn.edu/advisory

MAISRC continues to work in collaboration and coordination with state and regional organizations including local watershed districts, county agencies, Minnesota DNR, MN Sea Grant, MN Invasive Species Advisory Council, State AIS Advisory Committee, and the Great Lakes ANS Panel.

Activity 2
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 3
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 4
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 5
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 6
Subproject 22.3
Our research investigated an alternative management approach to eradication and population suppression by targeting the sensitive larval stage of the mussel. Copper-based pesticides are the most widely used tool for open water treatments of zebra mussels. However, copper is toxic to many aquatic organisms, especially when applied at the maximum allowable concentration. We applied a low-dose copper treatment (4.7% of the maximum allowed) at peak veliger density and measured zebra mussel settlement and native community responses over the following year. The treatment reduced juvenile mussel settlement by over 90%; although native zooplankton were also reduced, their populations rebounded within 30 days. One year later, juvenile zebra mussel settlement and native community abundance were similar to pretreatment levels. The results show that control actions may have to be repeated depending on the desired level of mussel suppression.

This project culminated in a Structured-Decision Making (SDM) workshop with resource managers and local stakeholders to help guide future management actions for zebra mussels in Minnesota lakes. While initially modeled as a decision-making process for an individual lake, the lessons learned can be used to adapt and guide decisions on zebra mussel management in multiple Minnesota lakes.

Activity 7
Subproject 45
In the summer of 2024, we conducted our last field season of data collection for this project, and we are currently working to finalize all laboratory work and data analysis. In the last 6 months, we have finished processing the sediment core collected in 2023, and core dating is currently being done by the St. Croix Watershed Research Station. We are preparing to present results at the annual Association for the Sciences of Limnology and Oceanography (ASLO) meeting in March 2025 and are beginning to prepare to publish the results of the project.

Amendment:
Reallocate $2,568 from Professional/Technical/Service Contracts to Supplies Lab/Field ($1,875) and Travel in Minnesota ($693) to accommodate higher than anticipated field travel and supply costs. Savings from the Laccore coring tube were the result of a delay in approval for Laccore expenses on the project budget. By the time the budget amendment was approved, the project team was unable to shift expenses from the non-sponsored account that it was purchased on, due to UMN financial policies.

Activity 8
Subproject 46
Work on Subproject 46 concluded on December 31, 2024. The research team is currently working on summarizing findings and writing their final report.

Amendment:

Extend the end date of Subproject 46 from December 31, 2024 to March 31, 2025 to allow the research team additional time to complete their final report. In February, the subproject PI needed to take an unexpected, short-term leave of absence. While progress is being made on the final report, providing additional time will allow the team time to fully represent project results and expense reports.

Activity 9

Subproject 47

In the last six months, the research team concluded targeted surveillance efforts in collaboration with local managers, identifying three new starry stonewort (SSW) localities within the Leech Lake Band of Ojibwe Reservation boundary. Fall re-surveys of 35 permanent quadrats indicate negligible expansion of the SSW population over the past two field seasons. The team also conducted fall plant community and wild rice productivity surveys in 50 plots that suggest minimal SSW impact on native macrophytes and rice productivity. Note: results are influenced by two highly anomalous climate years and may not reflect typical conditions.

In a second array of permanent quadrats at the SSW-wild rice interface, the team continued bi-weekly plant surveys in 17 grids (6 quadrats each). Preliminary results indicate that SSW has advanced significantly in these areas.

The project's experimental remote cameras encountered challenges during the field 2024 field season. The team will made adjustments over winter with the goal of re-deploying the cameras in spring 2025.

The team presented at the 2024 MAISRC Showcase and is planning outreach at upcoming events for local ricers and participation in a webinar on non-chemical starry stonewort management methods for lake managers.

Activity 10

Subproject 48

This project tested if and how increasingly engaging message presentation impacted boating anglers' behavioral intentions to prevent AIS spread. We observed 193 fishing vessels to see what boating anglers were/were not doing at boating landings. The majority completed at least one cleaning/prevention behavior, however 21% still left the public access with visible vegetation on the boat, trailer, and/or equipment. The majority of anglers also completed at least one draining prevention behavior.

Second, we interviewed boating anglers to understand their behaviors and barriers to prevention. Based on this information and best practices, we created and tested messaging in both sign and augmented reality formats among 303 boating anglers to see if and how they impacted intentions to perform prevention behaviors. Survey respondents self-reported very high intentions to perform AIS prevention behaviors, regardless of messaging.

A follow-up experiment tested the presence of new signs and various messages to increase the time boating anglers spent conducting prevention behaviors. Neither new signage nor the messages significantly impacted time spent at the landing.

Amendment:

Reallocate $2,763 from Participant Payments to Personnel ($2,763) to accommodate higher than anticipated personnel costs through the end of the project.

Activity 11

Subproject 49

The last six months have been very productive, but progress towards our overall objectives remains a challenge. We have successfully collected all field and laboratory-exposure samples we planned for VHSV, LMBV, and Didymo. Sample collection went as expected, using a variety of sample collection strategies to optimize the detection of eDNA. We have processed all samples and begun testing used new or validated qPCR assays to confirm the presence/absence of our

target microbes. The LAMP assays, a primary goal of our project, have been difficult to optimize – our biggest obstacle has been troubleshooting primer design and sensitivity. However, we still plan to meet our goals. Another significant obstacle is the current status of the federal workforce. Thus far, we have not lost personnel working on the project, but position terminations have happened suddenly and we also are facing restrictions on purchasing even for this state-funded project. We are doing our best to find creative solutions to these challenges (but much is out of our control) and are hoping to be able to test these new primers soon, and then conduct a lyophilization test on all three assays in the next month or two.

Activity 12

Subproject 56

This project developed and streamlined surveillance tests for certifiable, emergency, and emerging pathogens. Modernizing and improving disease testing that directly applies to the diagnostic testing needs of state agency and private aquaculture producers will simplify sample collection/transport logistics, cost of testing, and improve capacity and scalability of Minnesota's fish health program – directly benefiting all stakeholders in Minnesota fisheries.

We identified available diagnostic tests for the microbes and certifiable fish pathogens and validated a practical set of multiplexed qPCR assays relevant to Minnesota's fish health program and other Great Lakes States.

Assay 1: Three bacterial pathogens screened for in coldwater (salmonid) fish inspections
Assay 2: Parasitic pathogens screened for in coldwater fish inspections
Assay 3: Two viruses and a parasite screened for in coolwater (percids and centrarchids) fish inspections

Assay 2 and 3 were determined to perform well and will be implemented in state fish health inspections available to agency and private aquaculture producers. Assay 1 was not determined to be suitable as a stand-alone test for fish health inspections and will require additional development.

Amendment:
Move $120 Supplies Lab-Field to Personnel to accommodate higher than anticipated personnel expenses through the end of the project.

Activity 13

Subproject 58

Our team completed two field visits, deploying a combination of standard funnel traps and artificial refuge traps in Lake Winona and Lake Agnes. We also worked with MN DNR to collect 71 eDNA samples from nine lakes in the Alexandria area. Additional sampling kits were distributed to Douglas County for community participation.

Despite extensive trapping efforts, no signal crayfish were captured. With approximately 80% of eDNA samples analyzed, two very weak eDNA signals for signal crayfish in Lake Winona have been detected. These findings suggest a couple of possibilities: (1) Signal crayfish may be present at very low densities, or a reproduction event in 2023 resulted in individuals too small to be captured but still releasing detectable eDNA. (2) There is a small possibility that the primers used for eDNA analysis amplified DNA from a native crayfish species (Faxonius immunis). Additional testing is underway to rule this out.

The weak eDNA detections were within Lake Winona, the initial system where the invasion was detected. The large effort of eDNA sampling across 8 other lake systems within the area gives evidence that signal crayfish are most likely contained within the initial system of invasion.

Activity 14

Subproject 43.2

We continued our efforts to propagate and rear invasive zebra mussels in a captive setting by (1) improving nutrition

and husbandry; (2) reducing the presence of competitors; and (3) locating additional collection sites closer to the Twin Cities metro area to reduce travel time and improve efficiencies. Specifically, more frequent tank cleanings and feeding of Chlamydomonas reinhardtii algae resulted in weight gain and improved spawning among adult zebra mussels. In addition, batch spawnings in purified water and modified washing methods decreased the presence of competitive organisms and fouling materials. We successfully reared propagated larvae to D-stage veligers, a new benchmark in our captive propagation efforts. Finally, we identified a new collection site at Cedar Lake with similar conditions to the Pelican Brook site; a diversity of zebra mussel size and age classes were found in wadable water at this location, which will serve as a new collection site for 2025.

Dissemination

Annual Report:
MAISRC's 2024 Annual Report highlights research progress over the last year. A PDF of the report has been uploaded. To view online: https://z.umn.edu/AnnualReport2024

Public Presentations:
In 2024, MAISRC staff and researchers gave presentations at more than 85 events and provided 18 lab tours, reaching over 8,750 people. Events of note include the Governor's Fishing Opener, Minnesota State Fair, and the Mississippi Watershed Management Organization's Art and Science on the River.

Website/Social Media/Newsletter:
MAISRC experienced a 14% increase in website traffic throughout 2024. Social media engagement grew with a 53% increase in reach. Subscribers on YouTube also increased - up 11% over 2023 and MAISRC videos and webinars pulled in 360 total hours of viewership.

Data Repository at the University of Minnesota (DRUM):
To ensure proper stewardship and accessibility of MAISRC data, MAISRC maintains a publicly accessible data repository. The DRUM contains 44 sets of data from MAISRC subprojects and partnership projects:
https://hdl.handle.net/11299/197773

Not all projects utilize the DRUM - some upload their data to federal databases or in open-access publications, to align with data sharing standards within their individual fields of study or journal requirements.

Additional Status Update Reporting

Additional Status Update January 13, 2025

Date Submitted: January 13, 2025

Date Approved: January 13, 2025

Overall Update
This update is an amendment request to extend the end date of Subproject 58 to June 30, 2025 and reallocate funds within the subproject budget, to provide for more personnel time to conduct outreach and disseminate research results through the end of the project. An updated Budget Amendment document that reflects the requested changes has been uploaded.

Activity 1
N/A

Activity 2
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 3
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 4
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 5
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 6
N/A

Activity 7
N/A

Activity 8
N/A

Activity 9
N/A

Activity 10
N/A

Activity 11
N/A

Activity 12
N/A

Activity 13
Subproject 58 Amendment:

Extend the end date of Subproject 58 from December 31, 2024 to June 30, 2025. An incorrect end date was listed for Subproject 58 when it was originally submitted for approval from LCCMR. MAISRC and the subproject team have been operating on a February 28, 2025 completion date. In addition to correcting the error on M.L. 2021 documentation, we request an extension of the project to June 30, 2025. This additional time will allow the project team to synthesize and disseminate research results, in response to the high level of public interest in the project.

To accommodate personnel time on the project through June 30, 2025, we request increase the Personnel budget to $18,407 (net +$2,333) by reallocating budget savings in Professional Contracts ($216), General Operating Supplies ($3), Lab Supplies ($694), Travel ($1,142), Shipping ($188), and Repairs/Maintenance ($90). All subproject budget savings are the result of lower than anticipated expenses throughout the course of the project.

Activity 14
N/A

Dissemination
N/A

Additional Status Update Reporting

Additional Status Update November 12, 2024

Date Submitted: January 3, 2025

Date Approved: January 8, 2025

Overall Update
This amendment request includes requests to (1) amend budgets for Subprojects 46 and 48; (2) allocate additional funds Subprojects 45 and 49; (3) extend the end dates of Subprojects 47 and 49. An updated Budget Update document that reflects the requested amendments has been uploaded.

Activity 1
N/A

Activity 2
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 3
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 4
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 5
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 6
N/A

Activity 7
Subproject 45 Amendment:
Allocate $3,331 in additional funding from MAISRC Reserves to Subproject 45 to allow for one project team member to present research findings at the Association for the Sciences of Limnology and Oceanography (ASLO) conference in North Carolina in March 2025.

Initial results from the project have been unexpected and counter to current scientific expectation, suggesting that lakes with high carp infestation have significantly lower methane (CH4) emissions compared to lakes without carp. This contradicts the project's initial hypotheses and global patterns of higher CH4 emissions in more eutrophic lakes. These results also imply that carp deplete sediment carbon to such a substantial degree that it strangles decomposition and greenhouse gas emissions. These findings are intriguing and the team will seek input from other experts in the field at the ASLO conference to better understand their results, further analyze the data, and discuss the broader impacts of the results for science and management. Information and understanding that is gleaned from these conversations will be beneficial to carp management in Minnesota, as well as internationally.

Activity 8
Subproject 46 Amendment:

Move $3,150 from Professional/Technical/Service Contracts, $2,700 from Supplies, and $7,850 from Field Work Travel (net +$13,700) to Personnel to provide for additional personnel time as the project team finalizes data entry and quality control, statistical analyses, and drafts final reports.

Budget savings are the result of lower than anticipated supply and travel costs, as well as lower than anticipated effort on the project from Lake County Soil and Water Conservation District.

Activity 9
Subproject 47 Amendment:
Extend the end date of Subproject 47 from December 31, 2024 to June 30, 2025. The research team encountered technical difficulties in the management of starry stonewort as a part of the project. Specifically, the planned in-lake experimental removals of starry stonewort were thwarted by rapid loss of visual clarity due to highly flocculent sediments. Therefore, the team is shifting tests of competition between starry stonewort and wild rice to controlled, on-campus experiments. In addition, an extension to the end of the project will allow more time for project staff from the University of Minnesota and Leech Lake Band of Ojibwe to collaborate on outreach activities and dissemination of research results.

An adjustment to outcome completion dates is included with this request, under Activity 9.

Activity 10
Subproject 48 Amendment:
Move $3,000 from Field Travel to Participant Payments to align the budget with the UMN accounting system. Travel reimbursement for workshop participants was originally budgeted in Field Travel but is accounted for in the UMN accounting as a payment to participants. This change will more accurately reflect budgetary expenses and classification, which will aid in reporting in Subproject 48.

Activity 11
Subproject 49 Amendments:
Extend end date from 12/31/24 to 6/30/25. Due to unforeseen delays from a vendor that was contracted for the project, the team is currently behind schedule. An extension allows the team to complete analysis of assays, transfer technology to managers, and prepare a manuscript. Outcome completion dates are adjusted under Activity 11.

Allocate $23,135 from MAISRC Reserves to Subproject 49 to provide for additional staff time during the extended project period. Funds will support personnel time to complete experiments, data analysis, and reporting.

Activity 12
N/A

Activity 13
N/A

Activity 14
N/A

Dissemination
N/A

Status Update Reporting

Status Update September 1, 2024

Date Submitted: September 13, 2024

Date Approved: September 20, 2024

Overall Update
Nine research projects are currently underway on M.L. 2021. Summaries of the progress of these subprojects are included below. In addition, MAISRC is currently supporting 16 subprojects on M.L. 2023, including six new projects that were selected as a part of MAISRC's 2024 Request for Proposals (RFP). Summaries of the progress of these subprojects are included on the M.L. 2023 project update.

Three subprojects on M.L. 2021 ended on June 30, 2024. Final report abstracts, budgets, and supplementary materials are included with this project update. Completed subprojects include:

Subproject 4.4: Acoustic conditioning in common carp to accelerate removal and reduce cost – Dr. Przemek Bajer
Subproject 21.3: Multibeam sonar zebra mussel mapping - method development– Dr. Jessica Kozarek
Subproject 24.2: Genetic method for control of invasive fish species – Dr. Michael Smanski

Activity 1
The MAISRC Technical Committee will be meeting in October to determine priority species and research priorities for the 2025 MAISRC Request for Proposals (RFP) that will launch on January 2, 2025.

In addition, MAISRC staff and researchers continue to work in collaboration and coordination with many state and regional organizations including local watershed districts, county agencies, Minnesota DNR, MN Sea Grant, MN Invasive Species Advisory Council, State AIS Advisory Committee and the Great Lakes ANS Panel.

Amendment:
Add "provisions" to MAISRC budget for Rentals (Professional Services) to provide for some food/beverage costs associated with MAISRC's Research and Management Showcase. MAISRC charges a registration fee to cover the cost of food/beverage for attendees at the day-long conference. However, we have intentionally kept the cost of registration low to limit financial barriers to attending the event. This has become increasingly difficult to do with an increase in food prices over the last few years. In addition, we provide discounted rates for attendees for whom the registration price still poses a financial barrier. Adding "provisions" to our rental budget will allow MAISRC to cover any food/beverage costs over the registration revenue, allowing us to keep the Showcase accessible.

Activity 2
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 3
Subproject 4.4
The effectiveness of bait-and-removal carp management strategies is limited by the variable size and duration of carp aggregations. Acoustic conditioning, where carp are trained to associate a sound with bait delivery, could enhance this strategy by creating larger, more synchronized feeding aggregations.

To explore this, we conducted two studies on acoustic conditioning in common carp. In a laboratory setting, carp were trained to swim to a feeding ring at the sound of an acoustic cue, we found that carp remembered the conditioned

behavior longer when exposed to partial reinforcement (bait delivered after some but not all acoustic cues) than continuous reinforcement (bait delivered after every acoustic cue). In a field study in Lake Minnetonka where automated feeders and underwater speakers were deployed, we found that although the acoustic cue alone did not attract carp to baited sites, sites that used both the acoustic cue and bait attracted 11% more carp than sites where bait was used alone. Also, the carp responded quicker to the bait (by 30%) when it was accompanied by the acoustic cue. These findings suggest that acoustic conditioning can improve the efficiency of baited traps, potentially reducing removal costs.
(This activity marked as complete as of this status update)

Activity 4
Subproject 21.3
This project is the third phase of a three-phase project. Phase I - controlled feasibility experiments in a laboratory setting. Phase II - tested and refined methods in the field. Phase III - full-scale evaluation of methods. Field work was conducted in two sites. At each site, multibeam sonar data were collected with varying acoustic settings and a dive team was deployed to record relative mussel density and sediment type. This detailed dataset across a range of sediment types and mussel densities provided the basis for the evaluation of classification models to relate acoustic backscatter to substrate type and relative mussel density. Researchers mapped large areas at both sites, developed protocols and publications for dissemination, and compared multibeam sonar to other monitoring methods. As acoustic mapping methods continue to be both more accessible and more sophisticated, it is expected that this study will provide a basis for continued efforts to map invasive mussel habitat and distribution providing a valuable tool for managers and researchers to track invasion extents.

Amendment:
Move $1,000 from Professional Contracts and $970 from Supplies into Personnel (+$1,970) to provide for higher than anticipated personnel costs through the end of the project.
(This activity marked as complete as of this status update)

Activity 5
Subproject 24.2
Working toward responsibly advancing the technology development related to genetic biocontrol of common carp, we leveraged our unique capabilities to routinely spawn captive carp in the lab, to collect gametes for in vitro fertilization and transgenesis. The majority of genetic biocontrol transgenesis efforts have been geared towards making sex-ratio-biasing fish. The first G0 fish injected with sex-ratio-biasing constructs are currently sexually mature and characterization is ongoing.

To accelerate the timeframes associated with engineering biocontrol agents in non-model fish species, we made progress towards developing a surrogate host species for carp. We also developed protocols to genetically sterilize fathead minnow surrogates. While initial attempts at surrogacy were unsuccessful, we are performing one last control experiment (M.L. 2023, Subproject 24.3) before deciding on alternative approaches.

Lastly, we organized a series of stakeholder/rightsholder workshops to co-develop a shared language to describe the maturity of genetic biocontrol technologies using NASA's Technology Readiness Level framework as a guide. Workshop attendees included social scientists, state- and federal-regulators, watershed district managers, technology developers, entrepreneurs, and tribal representatives. This work resulted in a draft manuscript that is currently under revision by the co-authors prior to submission for publication.
(This activity marked as complete as of this status update)

Activity 6
Subproject 22.3
This project is evaluating the use of a copper molluscicide to reduce populations of zebra mussels in infested Minnesota

lakes by suppressing larval recruitment and targeting adult mussels during peak reproduction. One-year post-treatment samples of phytoplankton, zooplankton, and macroinvertebrate communities were processed by contract laboratories and USGS staff. These data are modeled with pretreatment data to determine post-treatment changes in non target communities. Measurements of the seasonal changes in adult zebra mussel physiological and reproductive condition were completed. These data will be modeled with toxicity and temperature data to determine optimal timing for molluscicide treatments to maximize adult and veliger zebra mussel mortality. A Structured Decision-Making process began in April with stakeholders representing the Minnesota Department of Natural Resources, lake associations, MAISRC, and USGS researchers. The proposed outcome of this SDM is a management plan to control zebra mussels in select candidate lake with the overall goal of developing a framework that can be applied to other lakes. The interest group held their first meeting to develop a problem statement, management objectives and a prototype decision framework.

Activity 7

Subproject 45

Project has made progress toward all of goals in the last 6 months. Our team is in the midst of our last season of fieldwork, and are collecting an abundance of CO2 and CH4 data from our 18 lakes to build off of last year's work. We are currently finishing processing the sediment cores we collected last fall, and all core samples will be sent for dating to the St. Croix Watershed Research Station. In addition to collecting CO2 and CH4 concentrations and emissions in each lake, we are monitoring pH overnight to gain insight into daily patterns of CO2, and have been collecting data on CH4 ebullition (bubbling) with funnel traps. We plan to wrap up all fieldwork in mid-August, and then will move onto final laboratory analyses and data processing.

Amendment:
Move $1,645 from Personnel to Professional Contracts to provide for additional laboratory testing of samples.
Move $635 from Personnel to Supplies to provide for higher than anticipated costs for supplies.
Move $1,419 from Personnel to Travel for higher than anticipated travel costs during the field season.

Activity 8

Subproject 46

An amendment to the subproject was recently approved to simplify bait choices to a single type and to reduce trap types to two instead of three; to revisit 2 lakes from 2023 instead of trapping at three new lakes; and to introduce trap modifications to improve trapping efficiency near wild rice. From the start of June through early July 2024 the NRRI field team coordinated with project partner field teams from 1854 Treaty Authority, Lake County SWCD, and Cook County SWCD to complete the 'spring' season trapping when wild rice is vulnerable to grazing but crayfish are less active due to colder water temperatures. Rusty crayfish were captured in all three lakes within proximity to wild rice beds, but in lower numbers than desired. Data from the 2024 field season is currently being compiled, and data quality control/analysis is ongoing.

Low catches of large crayfish in all lakes meant we were not able to mark and release the target number of crayfish at each lake. Lakes warmed slowly this year, and crayfish were not showing high activity despite trapping beginning later in the year than in 2023. We also encountered some hybrid crayfish in Tofte Lake.

Activity 9

Subproject 47

In the last six months, the research team has organized efforts for volunteer boat launch surveillance surveys to be conducted over the summer, began preliminary analyses on 2023 data from permanent quadrat monitoring, designed and built two experimental underwater time lapse cameras. In May, the team conducted an intensive field campaign in Steamboat Bay, Leech Lake, MN to (1) search additional sites in Leech Lake for starry stonewort; (2) install time lapse cameras paired with water temperature and dissolved oxygen data loggers to track phenology of starry stonewort and wild rice; (3) re-survey 29 permanent quadrats along both channels to monitor invasion spread; and (4) work with four

interns from the Leech Lake Tribal College, along with our Leech Lake Band of Ojibwe Dept. of Resource Management partners, to teach data processing, aquatic plant ID, and field methods. Weather during this week was particularly challenging and prevented us from searching Headquarters Bay on Leech Lake and Lake Winnibigoshish for starry stonewort.

In addition, aquatic plant surveys are being conducted throughout the growing season on 18 sites located on the interface between wild rice and starry stonewort growth.

Activity 10

Subproject 48

The primary project goal is to assess if and how more engaging messages impact boating anglers' intentions to perform behaviors that prevent the spread of aquatic invasive species. In the last six months we tested our refined messages in photo/text and augmented reality formats (AR). Specifically, we tested the messages among Midwest Sportshow attendees who were adults (18+), not trained as AIS inspectors, and had fished from a boat. Respondents were recruited at the Sportshow, incentivized with a Rapala lure for completing the questionnaire and presented with either an AIS definition in text, AIS definition in AR format, prevention messaging in photo and text or prevention messaging in AR format. We have cleaned the data, performed initial analysis, and are working through additional analysis to answer our research questions. Understanding if and how message presentation impacts behaviors can guide and enhance future informational efforts and optimize resource use to do so.

Activity 11

Subproject 49

We have successfully optimized new LAMP assays for LMBV and VHSV, improving simplicity of testing for these important viruses in the field. We experienced challenges sequencing the genome for Didymo slowing assay development; however, we are currently testing multiple approaches to overcome this obstacle. eDNA sample collection for LMBV has progressed very well – five lakes have successfully been sampled, with additional lakes scheduled to be sampled soon. Due to significant delays with the UMN IACUC review process, we were not able to begin our VHSV exposure trials in the laboratory on schedule. We are optimistic approval will come soon and we can begin in August. Didymo field sampling is scheduled to begin in October. The combination of LAMP assay validation and field testing has garnered attention from fish health experts across the region. We are excited to transfer our protocols to end-users in the coming months.

Amendment:

Move $8,830 from Personnel to Supplies to provide for higher than anticipated molecular laboratory supply costs.

Activity 12

Subproject 56

We conducted a literature review of target pathogens identifying qPCR assays suitable for multiplexing. We reviewed 32 articles including 24 published assays covering proposed assays 2 and 3 but not assay 1 for which no published qPCR assays were identified. We prioritized 13 assays for testing in proposed assays 2 and 3. We optimized nucleic acid extraction SOPs for all assays including digestion of pooled samples containing muscle and cartilage. We identified an emergent pathogen, Tetracapsuloides bryosalmonae, as a needed addition to assay 2 (salmonid parasite panel) and have optimized 3 assays for this pathogen (both nucleic acid extraction and qPCRs).

While not finding suitable published qPCR assays for bacterial pathogens in assay 1 was a setback, we identified target sequences used as multiplexed targets in other molecular diagnostic assays and are in the process of designing a custom multiplex assay. Addition of T. bryosalmonae also represents extra effort but has been valuable to this work as this important invasive microbe has been identified in the Great Lakes for the first time and addition to assay 2 development allows us to determine its range in Minnesota.

Activity 13

Subproject 58

Significant progress has been made in the genetic and field sampling aimed at assessing the distribution of signal crayfish in Alexandria, Minnesota. We successfully mtDNA sequenced signal crayfish specimens captured from Lake Winona. Sequencing results identify a common, invasive linearage of signal crayfish known from other non-native populations and the Winona population was likely sourced from the coastal Pacific Northwest.

Our team conducted two sampling events using physical trapping methods for both adult and juvenile crayfish as well as eDNA sampling to assess the prevalence of signal crayfish. No signal crayfish were captured during the field sampling in April nor in June, suggesting they are living in low density or may not be present. Approximately 40 environmental DNA samples were collected and are currently undergoing DNA extraction to provide additional information if signal crayfish are present at Lake Winona and nearby systems.

Throughout the project, we have collaborated with Douglas County Land and Resource Management and the Minnesota Department of Natural Resources. We distributed 13 community eDNA kits to interested community members. Community members were able to target surrounding lakes in the Alexandria area not sampled by our team and are currently undergoing DNA extraction.

Activity 14

Subproject 43.2

Project began in May 2024. Project manager and research team are currently planning and beginning work on subproject activities.

Dissemination

Public Presentations

To date, MAISRC staff and researchers have given 59 presentations, reaching more than 3,500 people. This year, MAISRC spent two days at the MN State Fair, where staff provided AIS education and updates on MAISRC research. In addition, we launched a new monthly tour of the MAISRC Containment Lab that is open to the public. Since opening the lab for general tours, MAISRC staff have provided 17 tours, hosting nearly 200 AIS and natural resource professionals, student groups, and members of the public.

Research & Management Showcase

MAISRC's annual Showcase is our keystone event to share research updates, recommendations/tools, and provide a venue for AIS researchers, managers, and the public to connect and learn from each other.

This year, MAISRC will be hosting our first in-person Showcase since 2019. The event will feature 22 presentations from MAISRC researchers, four lab tours, and a reception featuring interactive research demonstrations with an additional six research teams. For more information, visit: https://maisrc.umn.edu/showcase

Peer Reviewed Publications

MAISRC researchers have published eight new peer-reviewed manuscripts in 2024, thus far. A full list of MAISRC publications is available online: https://www.maisrc.umn.edu/publications

Additional Status Update Reporting

Additional Status Update June 27, 2024

Date Submitted: June 27, 2024

Date Approved: July 26, 2024

Overall Update
This amendment request includes:

1. Allocation of additional funds to Subprojects 22.3, 45, 46, 56, and 58
2. Six month extension for Subproject 45

An updated Budget Update document that reflects the requested amendments has been uploaded.

Activity 1
N/A

Activity 2
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 3
N/A

Activity 4
N/A

Activity 5
N/A

Activity 6
Subproject 22.3 Amendment:
Move $18,000 from MAISRC budget reserves to Subproject 22.3 to provide for additional personnel time to organize and assist with facilitation of the project's Structured Decision Making (SDM) workshop. Personnel time will also be used to prepare handouts, summarize products from the SDM, and to prepare the final analysis and written product of the workshop - a peer-reviewed manuscript. The SDM workshop has required more personnel time that was originally budgeted for the subproject.

Activity 7
Subproject 45 Amendments:
Extend the end date of Subproject 45 from December 31, 2024 to June 30, 2025. Large winter kills in the winter of 2022-2023, combined with low water in the summer of 2023, required the research team to find many new study lakes, as many of the planned study lakes were inaccessible or no longer had carp. The delay and increased logistics of identifying new study lakes has put the project behind on their completion timeline. While the team is making good progress in the field, extending the end date of the project will allow them to complete data analysis and document results.

Move $29,905 from MAISRC budget reserve to Subproject 45 to provide for additional personnel time in the extended project period, to complete data analysis and reporting.

Activity 8
Subproject 46 Amendment:
Move $11,351 from MAISRC budget reserve to Subproject 46 to allow the research team to sample one of the study lakes an additional time, due to poor crayfish catch during their first visit. Additional funds will provide for personnel time ($7,659), field supplies ($100), and in-state travel and boat rental ($3,592) to allow for an additional week of sampling in the 2024 field season.

Activity 9
N/A

Activity 10
N/A

Activity 11
N/A

Activity 12
Subproject 56 Amendment:
Move $4,200 from MAISRC budget reserves to Subproject 56 to add an additional pathogen, Tetracapsuloides bryosalmonae, to the list of harmful microbes that the project is developing screening tests for. Tetracapsuloides bryosalmonae is on the MAISRC priority species list and is a non-native parasite of salmonid fish. It is a newly detected invasive species in Michigan in multiple locations including two of the Great Lakes and creating a screening tool will make surveillance in Minnesota (and other states) possible. Additional funds will provide for the lab supplies needed to develop PCR assays specific to Tetracapsuloides bryosalmonae.

Activity 13
Subproject 58 Amendment:
Move $7,526 from MAISRC budget reserves to Subproject 58 to streamline eDNA sample collection and expand eDNA sample coverage. Specifically, to purchase two battery-operated eDNA samplers to increase sample capacity by decreasing collection time and minimizing contamination risk; acquire additional filtering kits to test more water bodies for signal crayfish and engage more community members in the process; and provide community members with opportunities to frequently test surrounding area lakes throughout the summer of 2024. Funding for equipment/supplies will be provided on non-ENRTF funds. Additional ENRTF funds for Subproject 58 will provide for personnel time ($2,803) and sample analysis ($4,723).

Activity 14
N/A

Dissemination
N/A

Additional Status Update Reporting

Additional Status Update May 6, 2024

Date Submitted: May 6, 2024

Date Approved: June 12, 2024

Overall Update
This amendment request includes:

1. Allocation of additional funds to Subprojects 24.2 and 22.3
2. Budget amendments for MAISRC and Subprojects 45, 46, 48, 58
3. Changes to project outcomes for Subproject 46
4. Error correction to the title of Activity 12
5. Allocation of funds for new Subproject 43.2 (new Activity 14)

An updated Budget Update document that reflects the requested amendments has been uploaded.

Activity 1
Amendment: Move $73,133 from MAISRC Personnel to Professional/Technical Contracts to provide funding for MAISRC to work with the Strategic Partnerships and Research Collaborative (SPARC) at the UMN to update MAISRC's strategic plan. Budget savings in Personnel are the result of lower than anticipated personnel costs for core MAISRC work, as a result of MAISRC being able to secure non-ENRTF funding for some of our dissemination and research coordination activities.

MAISRC's current strategic plan, that has guided our work over the last 10 years, is set to expire in 2025. We rely heavily on our strategic plan to shape and focus our efforts to facilitate AIS research and collaboration, disseminate research findings, and engage with stakeholders throughout the state. When the original MAISRC strategic plan was written in 2015, the AIS landscape was very different than it is today. Revising the strategic plan presents a tremendous opportunity to incorporate new perspectives, AIS threats, and research/management realities, to ensure MAISRC continues to drive towards solving the AIS issues facing our state. It will also give us an updated framework for using state appropriated funds in the most strategic way possible, maximizing the impact of state funding on addressing AIS.

Activity 2
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 3
N/A

Activity 4
N/A

Activity 5
Subproject 24.2 Amendment: Move $1,236 from MAISRC budget reserve to Subproject 24.2 to provide for higher than anticipated space rental costs in the MAISRC Containment Lab.

Activity 6
Subproject 22.3 Amendments:
Move $18,106 from MAISRC budget reserve to Subproject 22.3 to provide for additional staff time to organize and

support Structured Decision Making (SDM) process that is outlined in subproject activities. The SDM process will be led by Michael Colvin, a researcher at USGS Columbia Environmental Research Center and well-established as an SDM facilitator. The objectives of this work is to (1) compile and summarize results of open water treatments to control dreissenid mussels using copper products and other pesticides, (2) facilitate a SDM with stakeholders, and (3) produce a final decision on a dreissenid control strategy in Minnesota lakes to stakeholder groups.

Move $1,790 from MAISRC budget reserve to Subproject 22.3 to provide for processing additional samples to monitor zooplankton and zebra mussel recovery in study lakes that were treated with low-dose copper. Additional samples will allow for a clearer understanding of the effectiveness of copper treatment and resilience of non-target species after treatment.

Activity 7

Subproject 45 Amendments:

Move $7,930 from Supplies-Lab/Field and $146 from Personnel into Field Travel (net +$8,076) to provide for higher than anticipated field costs in the first year of the project. The 2023 field season was impact by a combination of high winter kill of fish and very low water levels, which required more field travel than was predicted at the start of the project to complete field season objectives.

Move $2,568 from Personnel into Professional/Technical/Service Contracts to create a new budget line for Laccore. Due to the unavailability of an in-house coring tube, the research team will need to rent a coring tube to take sediment samples for the project.

Salary savings in Personnel will be accomplished by reducing budgeted salary for select project staff and is not expected to impact the overall outcomes of the project.

Activity 8

Subproject 46 Amendments:

Move $3,000 from Personnel and create a new budget line for Supplies-Lab/Field ($3,000) to allow for the modification of crayfish traps in advance of the 2024 field season. In the 2023 field season, the research team faced challenges with maintaining functional traps in the loose/mucky substrate of the project's sample sites. In preparation for the 2024 field season, the team has designed modifications to the traps to help them function more effectively. Budget savings in Personnel are the result of staffing changes within the project that have resulted in surplus personnel funds.

Adjust milestones three and four in response to challenges faced in the 2023 field season. In 2024, the research team will return to two lakes where they had success and replace a study lake full of hybrid crayfish for a new study lake with rusty crayfish and no/few hybridization opportunities to ensure that they are testing how to capture rusty crayfish, not hybrids. The team will also be modifying their traps to prevent them from sinking in the lake substrate.

Activity 9

N/A

Activity 10

Subproject 48 Amendments:

Move $3,000 from Field Travel to Participation Payments to ensure participation/completion of the project questionnaires. Increased participation in message and platform evaluation will strengthen the overall outcomes of the project and efficacy of message delivery for use in the future. Budget savings in Field Travel is the result of the research team not using travel funds that were budgeted for focus groups, as anticipated.

Move $400 from Supplies-Lab/Field to Printing to produce signage and materials for a boat show that the research team

will be attending in March to conduct message delivery. Budget savings in Field Supplies is due to the use of existing protective equipment at the UMN, which meant that the team did not need to purchase new equipment.

Activity 11
N/A

Activity 12
Update title of Activity 12 to "MAISRC Subproject 56: Developing streamlined detection assays for invasive fish pathogens" to correct the subproject number in the LCCMR grant management system. The correct subproject number is 56, not 53.

Activity 13
Subproject 58 Amendments:
Move $39 in approved boat gas budget from Field Travel to Supplies-Lab/Field to align with the University of Minnesota accounting system, which considers boat gas a consumable supply.

Move $200 in approved boat maintenance budget from Field Travel to Other-Repair/Maintenance to align with the University of Minnesota accounting system, which has a separate budget category for repairs and maintenance.

These changes will allow the project team to more accurately track and report project expenses.

Dissemination
N/A

Additional Status Update Reporting

Additional Status Update February 15, 2024

Date Submitted: February 23, 2024

Date Approved: May 3, 2024

Overall Update
As a result of our 2023 Request for Proposal (RFP), MAISRC has reviewed, evaluated, peer reviewed, and approved one new subproject on M.L. 2021 – Subproject 56: Developing streamlined detection assays for invasive fish pathogens.

In addition, MAISRC approved a one-year, rapid response project to determine the geographic source of signal crayfish that were recently detected for the first time in Minnesota and determine the population status of the species in Lake Winona where it was found and the surrounding area. The project is titled – Subproject 58: Evaluating the source and status of invasive signal crayfish in Minnesota.

Both projects began on January 1, 2023 and the project managers are currently building their teams and are beginning work on subproject activities.

Overall, MAISRC is currently supporting 11 subprojects on M.L. 2021. Summaries of the progress of these subprojects are included below. In addition, MAISRC is currently supporting 10 subprojects on M.L. 2023, and three subprojects through alternate funding sources (non-ENRTF funds).

Activity 1
In advance of the release of MAISRC's 2024 Request for Proposals (RFP), MAISRC staff worked with the MAISRC Technical Committee, to revise MAISRC's list of priority species and 2024 research priorities. Research priorities were determined by reviewing the results of the comprehensive, biennial Research Needs Assessment that was completed in 2022 and in consultation with the MAISRC Technical Committee, Center Advisory Board, Fellows Group, and Grad Fellows Group. The revised priority species list and 2024 RFP priorities have been uploaded with this report.

All M.L. 2021 subprojects that were initially scheduled to end on December 31, 2023 have been extended to June 30, 2024. Therefore, no dissemination or outreach has been done with the research results at this time. However, MAISRC continues to disseminate research results on past projects. An update on this work is included below in the Dissemination section.

MAISRC staff also continue to work in collaboration and coordination with many state and regional organizations including local watershed districts, county agencies, Minnesota DNR, MN Sea Grant, MN Invasive Species Advisory Council, State AIS Advisory Committee and the Great Lakes ANS Panel.

Activity 2
All Activity 2 activities are complete and there are no additional updates for this reporting cycle. Overall, progress on the 2024 RFP is noted on MAISRC's M.L. 2023 progress report.
(This activity marked as complete as of this status update)

Activity 3
Since the last reporting period, the research team has completed both the lab and field experiments to test if common carp can associate an acoustic cue with bait. The lab experiment revealed that carp subjected to partial reinforcement displayed the conditioned behavior (swimming to the feeding ring on the onset of acoustic cue) for a longer duration after the food reward was terminated compared to continuous reinforcement. Additionally, carp under partial

reinforcement regained the conditioned behavior faster upon reward reintroduction than carp subjected to continuous reinforcement. This has management significance because intermittent baiting may elicit the same, if not higher response rates if used in the field, potentially saving money on both bait and labor.

The field experiment at Harrisons' Bay, Lake Minnetonka concluded on September 24, 2023. Preliminary data analysis showed that the acoustic cue alone did not deter carp and combining it with bait led to more synchronized aggregations of carp. Furthermore, the average amount of time it took to attract 80% of the carp detected throughout the whole night was shorter when sound was accompanied with bait than bait alone. Data analysis for the field component of the project is still ongoing.

Activity 4

Building on the laboratory and field experiments conducted in Phases I and II of this project, Phase III focuses on translating research on the use of multibeam sonar to detect zebra mussels into practice by 1) conducting a full-scale proof of concept by mapping areas of different sediments with invasive zebra mussels and native mussels, 2) defining method limitations and challenges and developing best practices and guidance for mapping mussel containing sediments, and 3) developing a cost-benefit analysis of multibeam sonar mapping versus other zebra mussel monitoring methods. Sediment type and relative mussel density ground truth data were collected in two waterbodies: White Bear Lake and the St. Croix River near Lakeland, MN in June 2022. The post-processed bathymetry and acoustic backscatter (4 frequencies) information from these surveys has been combined with the ground truth data to classify and map sediment type and relative mussel density using data driven models revised from Phases I and II. The models have been compiled, tested and debugged and are currently being edited for distribution. Data and associated metadata are being prepped for distribution.

Activity 5

The overall goal of this project is to responsibly advance the technology development related to genetic biocontrol of AIS, specifically common carp. In the past six months, the team has made substantial progress on many fronts. They have continued to leverage carp spawning, in vitro fertilization, and microinjection procedures to create new G0 transgenic fish. They have tested the percentage of germline transgenesis in previously injected fish and they range from 10% to 100% transgenic F1 offspring. They have tested genetic reagents which show promise in discriminating between male and female fish based on a genetic test (so fish can be determined as males or females in their fry stage). They have tested the complete primordial germ cell transplantation process from common carp to fathead minnows. They have promising results when starting with spermatogonia but need to refine protocols for starting with primordial germ cells. Lastly, the team has continued to write the Technology Readiness Level manuscript that came from engagement with diverse stakeholders.

An amendment will be submitted following the acceptance of this progress report, to correct negative budget balance in Lab/Medical Services.

Activity 6

A low-dose treatment of a copper molluscicide (EarthTec QZ™) was applied in Maxwell Bay, Lake Minnetonka, in 2022. In the continuation project the research team is assessing the effects of the treatment 1 year later on zebra mussel recruitment and native communities. In the last 6 months, the team completed 1-year post-treatment sampling in the treatment and reference bays to assess zebra mussel veliger density and juvenile settlement, zooplankton, phytoplankton, and benthic invertebrate community composition and copper concentration in water and sediment. They completed enumeration of zebra mussel settlement on substrate samplers in 2023. Benthic invertebrate samples from study sites were identified and enumerated. These data are important for before-after comparison, within and between bays, of prolonged effects of copper treatment on zebra mussel density and native community composition. The team also identified a list of stakeholders and a facilitator for a Structured-Decision Making workshop focused on management approaches for dreissenid mussels in Minnesota. The workshop will begin in spring 2024. With supplemental funding, the team completed seven copper toxicity trials to compare adult mussel sensitivity to copper

over the reproductive season. These data provide resource managers information on optimal timing for copper applications.

Activity 7

In the last six months, the research team has continued an abundance of field and lab work, as well as started data analysis and formed a focus group to disseminate results. At the end of the summer, the team completed establishing a network of 18 lakes with diverse carp infestation levels, where carp abundance was estimated, plant abundance, and water chemistry. This fall, the team continued field sampling and completed collecting cores from all 18 lakes. Core samples will be used to estimate the impact of carp nutrient and carbon mobility in the sediment, and will continue to process and analyze samples in the laboratory over the winter.

In addition, the research team has begun to form a stakeholder focus group where they will aim to translate research findings to management actions. The goal is to form a 20 person focus group with representatives from the MN-DNR, the MPCA, the MN-DHS, Soil and Water Conservation Districts, and tribal governments. The intent is to have this group fully formed by this spring to begin communicating results as data is analyzed.

An amendment will be submitted following the acceptance of this progress report, to correct negative budget balance in Field Travel.

Activity 8

From the end of July through August 2023 the NRRI field team coordinated with project partner field teams from 1854 Treaty Authority, Lake County SWCD, and Cook County SWCD to successfully complete the 'summer' season trapping when wild rice is less susceptible to grazing but crayfish are more active due to warmer water temperatures. Rusty crayfish were captured in Garden, Caribou, and Dumbbell lakes in proximity to wild rice beds, and more rusty crayfish were caught than in the 'spring' season in May-June. Data from the 2023 field season has been compiled and data QC/analysis is ongoing.

Low catches of crayfish in Garden and Dumbbell lakes during the spring sampling event meant that the research team was not able to mark and release the target number of crayfish. This led to very few recaptures of marked crayfish during the 'summer' trapping visits, and it will be difficult to generate data on crayfish movement from these data. In the 2024 season, the team will start trapping in June instead of May in hopes that higher water temperatures will increase crayfish activity before beginning to trap and mark crayfish.

Activity 9

In the second six months of the project the research team conducted a second intensive field campaign in Leech Lake, MN, in September with all members of the project team. The team (1) collected data from 63 wild rice monitoring plots and concurrent spun rake surveys, for comparison of wild rice biomass and productivity, starry stonewort (SSW) biomass, and associated aquatic macrophyte community composition across and beyond the invasion front; (2) established 20 high-resolution plots along the interface of wild rice bed and SSW, monitored for insights into competition; (3) established pre/post DASH monitoring plots in Steamboat Bay, although the team was met with difficulty in DASH implementation again due to the very flocculent sediment at this site. In addition, the team has established a prioritization and framework for volunteers to assist with boat landing surveys; this effort was limited in 2023 due to staffing changes which has now been resolved. The team also developed a prototype underwater time-lapse camera system for deployment in 2024 to investigate SSW phenology and its relation to water quality parameters.

Activity 10

To better understand anglers' aquatic invasive species prevention behaviors the research team completed unobtrusive observations of them at four boat landings and conducted interviews with them online. The observations provided objective information on actual behaviors to a) document current baseline actions of anglers who fish from a boat and b) inform the next research phases to better understand and influence behaviors of this important AIS pathway. The

interviews allowed the team to follow up on observations and provided angler insights on how to best influence their peers. Based on this information, a literature review, and the advice from the project advisory committee, the team has developed messaging to increase anglers' intentions to perform AIS prevention behaviors. Visualization of these messages are in process, using the photos and videos captured earlier in 2023.

Activity 11
The research team designed new isothermal assays for both LMBV and VHSV, which became necessary when it was determined that existing assays were not suitable for strains relevant to Minnesota. Both these assays worked successfully on viral extracts. The team collected Didymosphenia geminata (Didymo) samples from the North Shore, however no reference sequence data are available so the team are coordinating with an ongoing project at the Science Museum of Minnesota to obtain tissues. These samples will be sequenced and used for the Didymo assay design. The inability to use existing assays has delayed the timeline for Activity 1, but the team was successful in designing the new assays means that the project should still be completed on time. In particular, the team still expects to have field-ready assays in the next 6 months. Field and laboratory experiments (Activity 2) are being developed now and will begin as planned in 2024.

Activity 12
Project began on January 1, 2024. Project manager and research team are currently planning and beginning work on subproject activities.

An amendment will be submitted following the acceptance of this progress report, to correct the subproject number in the title of Activity 12. The project is Subproject 56, not 53.

Activity 13
Project began on February 12, 2024. Project manager and research team are currently planning and beginning work on subproject activities.

Dissemination
Public Presentations
In 2023, MAISRC staff and researchers gave more than 60 presentations and lab tours to state and local managers, community groups, and students, reaching an estimated total audience of more than 2,000 people. MAISRC research teams also continue to regularly present updates on their work to members of the DNR Invasive Species Unit staff, the State AIS Advisory Committee, and DNR Fisheries Program staff.

Research & Management Showcase
In September 2023, MAISRC hosted our annual Research and Management Showcase as an online conference. As a part of the event, researchers and over 170 attendees were able to connect and discuss current research studies and management tools. Showcase presentations were once again recorded and broadly disseminated. To view the recorded presentations, visit: https://z.umn.edu/2023ShowcaseVideos

Website/Social Media/Newsletter
MAISRC had nearly 38,000 users to its website in 2023, reading over 51,000 pages of content. In 2023, MAISRC added Instagram and Threads to our suite of social media platforms and both outlets continue to grow along with our Facebook and X (Formerly Twitter) following. In addition, MAISRC currently has 4,600 email subscribers tuning in to the latest research news.

Status Update Reporting

Status Update March 1, 2024

Date Submitted: February 2, 2024

Date Approved: February 5, 2024

Overall Update
This amendment request is for the allocation of funds to new Subproject 58 (new Activity 13). An updated Budget Update document that reflects the requested amendment has been uploaded.

Activity 1
N/A

Activity 2
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 3
N/A

Activity 4
N/A

Activity 5
N/A

Activity 6
N/A

Activity 7
N/A

Activity 8
N/A

Activity 9
N/A

Activity 10
N/A

Activity 11
N/A

Activity 12
N/A

Dissemination
N/A

Additional Status Update Reporting

Additional Status Update December 20, 2023

Date Submitted: December 20, 2023

Date Approved: January 19, 2024

Overall Update
This amendment request includes:

1. Six month, no-cost extension for Subproject 21.3
2. Six month, no-cost extension for Subproject 24.2
3. Budget amendment for Subprojects 24.2

An updated Budget Update document that reflects the requested amendments has been uploaded.

Activity 1
N/A

Activity 2
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 3
N/A

Activity 4
Subproject 21.3 Amendment: Extend the end date of Subproject 21.3 from December 31, 2023 to June 30, 2024 to allow for additional time for data analysis, documentation of methodology, and outreach/dissemination. Analysis and documentation have taken longer than expected due to the temporary family leave of one of the primary researchers. Extending the end date of the project will allow the research team to fully process data and disseminate research results. This extension will have no impact on the overall subproject budget.

Activity 5
Subproject 24.2 Amendment: Extend the end date of Subproject 24.2 from December 31, 2023 to June 30, 2024. While the research team has made substantial progress towards accelerating carp engineering by shortening the effective life-cycle, additional time is needed to demonstrate reproduction of viable carp fry from surrogate PGC recipients (milestone 7). Extending the end date of the project will allow the research team to demonstrate the surrogate host technology - showing viable engraftment of carp primordial germ cells in sterilized fathead minnows.

To provide for additional staff time to complete this milestone, we request to move $11,295 to Personnel from Professional/Technical/Service Contracts - Workshops ($1,628), Travel Expenses in Minnesota ($4,441), and Travel Expenses Outside of Minnesota ($5,226). Budget savings in these areas are the result of lower than anticipated workshop costs and the decision to move some workshop content online.

Activity 6
N/A

Activity 7
N/A

Activity 8
N/A

Activity 9
N/A

Activity 10
N/A

Activity 11
N/A

Activity 12
N/A

Dissemination
N/A

Additional Status Update Reporting

Additional Status Update November 21, 2023

Date Submitted: November 21, 2023

Date Approved: December 20, 2023

Overall Update
Uploaded an updated Budget Update that includes personnel detail for MAISRC subprojects on M.L. 2021.

Activity 1
N/A

Activity 2
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 3
N/A

Activity 4
N/A

Activity 5
N/A

Activity 6
N/A

Activity 7
N/A

Activity 8
N/A

Activity 9
N/A

Activity 10
N/A

Activity 11
N/A

Activity 12
N/A

Dissemination
N/A

Additional Status Update Reporting

Additional Status Update October 25, 2023

Date Submitted: November 1, 2023

Date Approved: November 20, 2023

Overall Update
This amendment request includes:

1. Six month, no-cost extension for Subproject 4.4
2. Budget amendments for Subprojects 22.3, 24.2 and 48
3. Change of project manager for Subproject 46
4. Allocation of funds to new Subproject 56 (new Activity 12)

An updated Budget Update document that reflects the requested amendments has been uploaded.

Activity 1
N/A

Activity 2
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 3
Subproject 4.4 Amendment: Extend the end date of Subproject 4.4 from December 30, 2023 to June 30, 2024 to allow for additional time for data analysis. Both the field and lab portions of Subproject 4.4 took longer than anticipated to complete. Extending the end date of the project will allow the research team to fully process data and disseminate research results. This extension will have no impact on the overall subproject budget.

Activity 4
N/A

Activity 5
Subproject 24.2 Amendment: Move $32,245 from Personnel to Lab/Medical Services ($7,245) and Supplies-Lab/Field ($25,000) to allow the research team to complete additional DNA sequencing, development, and testing in the lab, to increase opportunities for success of the genetic biocontrol strategies that are being developed. Budget savings in Personnel are the result of lower than anticipated personnel costs.

Activity 6
Subproject 22.3 Amendment: Move $440 within Professional/Technical/Service Contracts, from RMB Laboratories to MN Divers LLC to provide for higher than anticipated scuba diving costs during the 2023 field season. Budget savings in RMB Laboratories are the result of lower than anticipated costs associated with sample processing.

Activity 7
N/A

Activity 8
Subproject 46 Amendment: Change the subproject manager from Josh Dumke to Dr. Valerie Brady for the duration of Subproject 46. Josh Dumke has accepted a new position outside of the Natural Resources Research Institute (NRRI) and University of Minnesota and will no longer be able to serve as the manager of Subproject 46. This change will have no

anticipated impact on the project's scope or outcomes.

Josh Dumke
Senior Research Scientist
Natural Resources Research Institute
University of Minnesota Duluth

Valerie Brady
Research Associate, Aquatic Ecosystem Ecologist, Interim Water Group Leader
Natural Resources Research Institute
University of Minnesota Duluth

Activity 9
N/A

Activity 10
Subproject 48 Amendment: Move $4,661 from MAISRC budget reserve to Subproject 48 to provide for additional contract work with Wild Carrot Production. Specifically, the acquisition of underwater multi-media assets (photos, videos and audio) to enhance visualization and understanding of under-water environments and the impacts of AIS. As well as, jump-start the project's baseline message development in text and augmented reality formats.

Activity 11
N/A

Dissemination
N/A

Additional Status Update Reporting

Additional Status Update October 6, 2023

Date Submitted: October 10, 2023

Date Approved: October 24, 2023

Overall Update
N/A

Activity 1
N/A

Activity 2
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 3
Subproject 4.4 Amendment: Move $1,500 from Non-Capital Equipment to Other-Repairs to allow for the repair of the project team's boat trailer that broke while in the field conducting activities for Subproject 4.4. Repair is essential for transporting the boat to and from field sites and the trailer is used solely on Subproject 4.4. Therefore, the full repair cost will be paid off of the subproject budget. Budget savings in Non-Capital Equipment are the result of lower than anticipated equipment costs throughout the course of the project.

Activity 4
N/A

Activity 5
N/A

Activity 6
N/A

Activity 7
N/A

Activity 8
N/A

Activity 9
N/A

Activity 10
N/A

Activity 11
N/A

Dissemination
N/A

Status Update Reporting

Status Update September 1, 2023

Date Submitted: September 1, 2023

Date Approved: October 4, 2023

Overall Update
Nine research projects are currently underway on M.L. 2021. Summaries of the progress of these subprojects are included below. In addition, MAISRC is currently supporting five subprojects through alternate funding sources (non-ENRTF funds).

Activity 1
Outreach and dissemination activities through June 30, 2023 are noted on MAISRC's M.L. 2019 final report, in support of the subprojects that were wrapping-up on M.L. 2019. Work on M.L. 2021 began on July 1, 2023 and will be reported in the next reporting cycle.

MAISRC continues to work closely with our Center Advisory Board, Fellows Group, and Technical Committee to ensure high quality and high priority research and outreach is being conducted through MAISRC projects and programs. We also continue to meet monthly with the MN DNR Invasive Species Unit to share information, updates, and explore opportunities for coordination.

Activity 2
All Activity 2 activities are complete and there are no additional updates for this reporting cycle. Overall, progress on the 2023 RFP is noted on MAISRC's M.L. 2023 progress report. However, as a result of our 2023 Request for Proposal (RFP), MAISRC has reviewed, evaluated, peer reviewed, and approved one new subproject on M.L. 2021:

Subproject 56: Developing streamlined detection assays for invasive fish pathogens – Dr. Isaiah Tolo

This subproject is currently in the work plan development phase and will be submitted for LCCMR review and funding allocation in September/October. The project will begin on January 1, 2024 and will be previewed at our annual Research & Management Showcase on September 20, 2023: https://z.umn.edu/AIS2023
(This activity marked as complete as of this status update)

Activity 3
From January - June 2023 the research team conducted lab and field experiments to test if common carp can associate an acoustic cue with bait. In the lab, carp learned to associate acoustic cues with bait after only one week of training. Carp subjected to the intermittent reward (every third acoustic cue followed by food reward) remembered the acoustic cue equally long as those subject to continuous reward. This suggests that in future management efforts, baiting carp every other or third day while playing acoustic cue daily may be sufficient to elicit the same response as baiting daily, saving resources and labor. Preliminary results from the field show that combining acoustic cues with bait leads to synchronized aggregations of carp. It is yet unknown if those aggregations are more synchronized than those caused by bait alone. Finally, a carp management workshop to facilitate collaboration among stakeholders and accelerate the transfer of knowledge to practitioners. It was attended by over 100 participants from state agencies (MN DNR, MN PCA, BWSR), watershed managers, watershed and soil and water conservation districts, as well as members of consulting and commercial fishing groups.

Activity 4
The research team completed data collection to map sediment type and relative mussel density in two waterbodies in

MN: White Bear Lake and the St. Croix River near Lakeland, MN in June 2022. Each site was surveyed at four frequencies utilizing a research-grade multibeam sonar. The post-processed bathymetry and acoustic backscatter information from these surveys has been combined with ground truth data to classify and map sediment type and relative mussel density using data driven models revised from Phases I and II. The models have been compiled, tested and debugged and are currently being edited for distribution. To evaluate various methods of collecting zebra mussel distribution data, the research team also utilized an underwater remotely operated vehicle (ROV) to gather video of each ground truth location and surveyed each area with an off-the-shelf side scan sonar. As a supplementary project, an undergraduate student analyzed the 2022 ROV video to quantify substrate and relative zebra mussel density after training with the Phase II 2021 ROV video. She is comparing these video-based ground truth data to the data collected by the SCUBA divers.

Activity 5

In the past six months, we have made substantial progress on many fronts. We have continued to improve our carp spawning, in vitro fertilization, and transgenesis procedures. We have created several different transgenic carp, the first of which have reached sexual maturity and have been outcrossed to wildtype carp to test their efficacy. We have made progress on surrogate host technologies, which promise to accelerate research and developement efforts in common carp and other AIS. Towards that end, we have improved fathead minnow (the surrogate host) husbandry, spawning, and transgenesis protocols. We have also demonstrated transgenic labeling of common carp primordial germ cells. We are currently at a place where we have begun testing the complete primordial germ cell transplantation process from common carp to fathead minnows.

Lastly, we have continued the social outreach objective of our project by hosting a second AIS Genetic Biocontrol Technology Readiness Level (TRL) workshop. While there is still some ambiguity amongst stakeholders and rightsholders around the timing and type of social engagement/outreach in the TRL classification system, we are preparing a manuscript to communicate the results of the 2022 and 2023 workshops.

Activity 6

The project team developed a study plan and obtained required permits for conducting sampling at designated locations within the two study bays (Maxwell, North Arm). Sampling devices for zebra mussels and native macroinvertebrates were placed at 10 sites across the two study bays. Three of seven sampling events were completed in May and June to assess copper concentration in the water and sediment, zooplankton and phytoplankton community composition, and veliger density. These data are important for before-after comparison, within and between bays, of prolonged effects of the copper treatment on zebra mussel density and native community composition. We continued to summarize and analyze data from a 3-year project in St. Albans Bay, Lake Minnetonka, and from the 2022 Maxwell Bay treatment in preparation for a Structured-Decision Making workshop with stakeholders. With supplemental funding, we are evaluating seasonal changes in the sensitivity of zebra mussels to copper treatment. We conducted three of six copper toxicity trials to model copper concentration and mussel mortality. As part of each trial, we are comparing mussel condition, reproductive status, copper tissue concentration, and activity of several enzymes related to metal toxicity. These results are providing information on the optimal timing of a mussel control application.

Activity 7

The team has successfully established a network of 18 lakes with diverse carp infestations, estimated the relative carp abundance in each, estimated the macrophyte abundance in each, and estimated the limnological characteristics of all these lakes. The team is ahead of schedule on estimating greenhouse gas emissions in each of the lakes. Sediment sampling will be done and analyzed this autumn and winter and the team will establish a stakeholder group and hold a workshop/conference on the preliminary results of the work. Although the work has advanced successfully, the very long ice-cover this winter caused a lot of under-ice fish kills and drought conditions made some of the lakes inaccessible to boats. Therefore, the team expended substantial field time and mileage on finding accesses and seeking new lakes to sample. Travel costs for sampling were much higher than expected due to the need to modify selected lakes. More than half of the originally planned lakes were inaccessible, had major fish kills, or had water too low to float our boats.

However, we are ahead of schedule on some parts of this work which will permit much more robust results to help guide management decisions.

Activity 8

The project team met virtually and discussed potential lakes for this research. Lake selection was supported by data project partners had from recent wild rice and crayfish trapping surveys. Our project team selected three lakes for 2023 sampling (Garden, Dumbbell, and Caribou) and the NRRI field team coordinated with project partner field teams from 1854 Treaty Authority, Lake County SWCD, and Cook County SWCD to successfully conduct our 'spring' season trapping when wild rice is most vulnerable to grazing by underwater foragers, such as rusty crayfish. Rusty crayfish were captured among all lakes in proximity to wild rice beds, though our catches of rusty crayfish during the 'spring' season seem to be correlated to water temperature (catches were lowest in the first lake sampled and highest in the third lake sampled).

Low catches of rusty crayfish in our first lake sampled in 2023 will make generation of usable data for Activity 2 difficult. We suspect the low catch during our sampling visit was due to cold water temperatures in mid-May and pre-molt crayfish being relatively inactive. We will change the start of our field season in 2024 to increase our chances of high catches during the 'spring' visit.

Activity 9

In the first six months of the project, we have planned and initiated research activities. Through the winter and spring, we refined research plans through regular meetings with the project team, which comprises researchers and managers from MAISRC, the Leech Lake Band of Ojibwe Division of Resource Management (DRM), and Boston University. We began field research in June, including establishing and monitoring 34 1-m2 plots to track the spread of starry stonewort (SSW) into wild rice beds and providing training to partners and their interns on underwater survey methods and aquatic plant identification. Planning for two late-summer activities (SSW surveillance and monitoring of diver-assisted suction harvesting [DASH] treatments) is underway. We have been engaged in outreach to LLBO leaders and community members about the threat of SSW in general and our research objectives and approaches.

Activity 10

We designed, tested, and implemented a protocol for unobtrusive observations at four boat landings to better understand behaviors anglers who fish from a boat may or may not take to prevent the spread of AIS. We worked with partners to select comparable boat landings between the metropolitan area and greater Minnesota. As of the end of June, we had observed 77 anglers exiting boat ramps at four lakes: two in greater Minnesota (Reno and Ida, Douglas County) and two in the metropolitan area (Peltier and Centerville, Anoka County). These observations provide objective information on actual behaviors to a) shed light on the status of current baselines actions of anglers who fish from a boat and b) inform our next phases of research to better understand and influence behaviors of this important group.

In addition, we inventoried existing AIS messaging and social science literature to develop foundational ideas for our baseline message. Informed by this knowledge, we created a baseline message and then acquired underwater photo, video and audio assets to support it as well as enhance our messaging capabilities for the test messages.

Activity 11

The first year of this project focuses on the laboratory validation of new diagnostic assays for high priority microbes. Led by the USGS team at the Upper Midwest Environmental Science Center, we are in the process of designing and testing each of the assays for the three targets: VHSV, LMBV, and Didymo. As planned in the proposal, we are moving forward with testing the previously published VHSV LAMP assay. We had originally planned to use a previously published LMBV assay and design additional loop primers, but the existing assay was not suitable for loop primer design which helps speed up the reaction. Therefore, we designed candidate assays for LMBV that we will test soon. We are currently designing the assay for Didymo. We had scheduled the assay validation to be complete by August 2023; we are behind that timeline, but this activity will still be completed in the fall and this will not affect the overall progress of the project.

Dissemination

No activity to report at this time. All MAISRC communication and dissemination activities during the current reporting period occurred on M.L. 2019 funding. A summary of activities is included in the M.L. 2019 final report.

Additional Status Update Reporting

Additional Status Update May 11, 2023

Date Submitted: May 11, 2023

Date Approved: May 15, 2023

Overall Update
This amendment request includes:

1. Budget amendments for Subprojects 4.4, 21.3, and 24.2
2. Approval for out-of-state travel for a key project collaborator to travel to Minnesota for field work for Subproject 47

An updated Budget Update document that reflects the requested amendments has been uploaded.

Activity 1
N/A

Activity 2
N/A

Activity 3
Subproject 4.4 Amendment: Move $1,000 from Supplies-Lab/Field to Shipping to cover the cost of shipping carp to the MAISRC lab for lab trials. Shipping was originally budgeted in Supplies-Lab/Field but was invoiced separately by the supplier, thus the need to shift funding to the Shipping line.

Activity 4
Subproject 21.3 Amendment: Move $608 from Supplies-Lab/Field to Namtek ($508) and In-State Travel ($100) to provide for higher than anticipated field expenses. Budget savings in Supplies-Lab/Field are the result of lower than anticipated supply costs for planned activities.

Activity 5
Subproject 24.2

Amendment 1: Move $4,000 from Contracts-University of Exeter and $2,000 from Services-Workshops to Supplies-Lab/Field (net +$6,000) to provide for additional chemical, enzymes, and other consumables associated with transgenesis experiments, to account for an increased rate of processing. Budget savings in Services-Workshops is the result of lower than anticipated hosting costs. Funds for the University of Exeter are no longer needed due to the collaborator (Kokotovich) accepting a new position and being unable to work on the project. Planned contributions to the project by Kokotovich will be provided by other collaborators already working on Subproject 24.2.

Amendment 2: Move $7,000 from Travel-Minnesota to Lab/Medical Services to provide for higher than anticipated lab costs for developing zebrafish lines bearing unique genetic constructs that are needed to guide the work in carp. Budget savings in Travel-Minnesota are the result of a high number of workshop attendees from Minnesota that did not require travel/accommodations.

Activity 6
N/A

Activity 7
N/A

Activity 8
N/A

Activity 9
Subproject 47 Amendment: We request approval to allocate $640 in the Subproject 46 contract with Boston University to provide funds for Ranjan Muthukrishnan to travel to Minnesota to participate in field work and stakeholder engagement at their Leech Lake study site. Muthukrishnan is an important collaborator on this project because of his specific experience and expertise with starry stonewort and early investigations into its impact on wild rice. Travel from Boston, Massachusetts to Minnesota is out-of-state travel and is considered a generally-ineligible expense, but we are requesting approval for Muthukrishnan's travel expenses to Minnesota because of his key role in the project and the inability to perform field work and on-site engagement with stakeholders and collaborators during the field sessions remotely. All other travel that is budgeted for the subproject will occur within Minnesota.

Activity 10
N/A

Activity 11
N/A

Dissemination
N/A

Status Update Reporting

Status Update March 1, 2023

Date Submitted: March 9, 2023

Date Approved: May 4, 2023

Overall Update
As a result of our 2022 Request for Proposal (RFP), MAISRC has reviewed, evaluated, peer reviewed, and approved 6 new subprojects on M.L. 2021:

Subproject 22.3: Assessing and refining copper-based treatment to suppress zebra mussel populations – Diane Waller
Subproject 45: Assessing and refining copper-based treatment to suppress zebra mussel populations – John Downing
Subproject 46: Effective rusty crayfish removals to protect wild rice – Josh Dumke
Subproject 47: Starry stonewort and wild rice - assessment and response – Daniel Larkin
Subproject 48: Beyond the sign: Influencing recreational boaters required behaviors - Ingrid Schneider
Subproject 49: Practical field-based tools for detecting high priority microbes – Nicholas Phelps

All six projects began on January 1, 2023 and project managers are currently building their teams and are beginning work on subproject activities.

Overall, MAISRC is currently supporting 9 subprojects on M.L. 2021. Summaries of the progress of these subprojects are included below. In addition, MAISRC is currently supporting 8 subprojects on M.L. 2019, and 4 subprojects through alternate funding sources (non-ENRTF funds).

Activity 1
MAISRC continues to work closely with our Center Advisory Board, Fellows Group, and Technical Committee to ensure high quality and high priority research and outreach is being conducted through MAISRC projects and programs. We also continue to meet monthly with the MN DNR Invasive Species Unit to share information, updates, and explore opportunities for coordination.

Activity 2
MAISRC released our 2023 RFP in January of this year. RFP priorities are based on the results of the Research Needs Assessment that was completed in October 2022 (a biennial process), with review from the Center Fellows Group, the MAISRC Advisory Board and the MN DNR invasive species leadership team. In total, MAISRC intends to allocate about $2 million to new or continuing projects as a part of the 2023 RFP. The primary funding source for the RFP is M.L. 2023 Environment and Natural Resources Trust Fund monies that are currently included in the 2023 ENRTF bill (HF 172/SF 442). The full 2023 RFP can viewed on the MAISRC website: https://maisrc.umn.edu/rfp

Activity 3
The first field season was largely completed as planned. However, while the carp in the study lake were attracted to the bait, they did not associate sound with food and acoustic conditioning was not successful. This was despite extending the conditioning period, trying a more enticing/complex bait, and monitoring carp at the bait in real time to ensure that acoustic cue was played when carp were near the site. It is possible that the selected study lake had too few carp to be strongly attracted to the bait and associate bait with sound.

Currently, laboratory experiments are being set up in the MAISRC containment lab to further explore acoustic conditioning in common carp. First, carp's ability to associate an acoustic cue with food reward will be replicated. Then,

we will test the effect of continuous vs. random (all or nothing) reward on acoustic conditioning. The information gathered through these laboratory experiments should help improve the protocol for the upcoming field season.

Activity 4
The research team completed data collection to map sediment type and relative mussel density in two waterbodies in MN: White Bear Lake and the St. Croix River near Lakeland, MN in June 2022. Each site was surveyed at four frequencies utilizing a research-grade multibeam sonar. The bathymetry and acoustic backscatter information from these surveys has been post-processed and is being combined with ground truth data to classify and map sediment type and relative mussel density. Other information collected by divers such as vegetation presence and relative coverage will be used in evaluation of methodology and recommendations. To evaluate various methods of collecting zebra mussel distribution data, the research team also utilized an underwater remotely operated vehicle (ROV) to gather video of each ground truth location and surveyed each area with an off-the-shelf side scan sonar. The research team has finished post-processing the collected data to utilize the scripts modified in Phase II to classify and map mussel containing substrates.

Following the approval of this status update, we will be submitting an amendment request to adjust the budget and cover overspending.

Activity 5
In the past six months we have confirmed our ability to modify the germline of carp. A transgenic carp engineered to express a reporter gene encoding Green Fluorescent Protein reached sexual maturity and was crossed to wild type females. We could observe GFP-positive offspring, indicating that the germline received the transgene. This bodes well for our fish injected with biocontrol constructs, as they have the possibility to be passed on in the germ line. We have also made substantial progress in developing and demonstrating protocols for transgenesis of fathead minnows. We are currently testing the ability of injected mopholinos to sterilize fathead minnows. We have not yet attempted transplantation of carp primordial germ cells into sterile fathead minnows but anticipate this work will be done in the next six months.

A manuscript based on our first Stakeholder Workshop in June 2022 has been drafted and a date is set for a second workshop (May 2023) that will reconvene the stakeholders to revise/refine the draft manuscript and extend the focus of the working group to self-spreading genetic biocontrol technologies.

Activity 6
Project began on January 1, 2023. Project manager and research team are currently planning and beginning work on subproject activities.

Activity 7
Project began on January 1, 2023. Project manager and research team are currently planning and beginning work on subproject activities.

Activity 8
Project began on January 1, 2023. Project manager and research team are currently planning and beginning work on subproject activities.

Activity 9
Project began on January 1, 2023. Project manager and research team are currently planning and beginning work on subproject activities.

Activity 10
Project began on January 1, 2023. Project manager and research team are currently planning and beginning work on subproject activities.

Activity 11

Project began on January 1, 2023. Project manager and research team are currently planning and beginning work on subproject activities.

Dissemination

Project began on January 1, 2023. Project manager and research team are currently planning and beginning work on subproject activities.

Additional Status Update Reporting

Additional Status Update December 8, 2022

Date Submitted: December 8, 2022

Date Approved: December 15, 2022

Overall Update
This amendment request includes:

1. Budget amendments for Subprojects 4.4 and 24.2
2. Allocation of funds to new Subprojects 22.3, 45, 46, 47, 48, 49 (new Activities 6-11)
3. Record additional state funds in the primary budget that have been contributed to the project

This amendment is being resubmitted after consultation with LCCMR staff and the incorporation of requested revisions. An updated Budget Update document that reflects the requested amendments has been uploaded.

Activity 1
N/A

Activity 2
N/A

Activity 3
Subproject 4.4 Amendments:

Reallocate budget savings in Supplies-Lab/Field ($4,615) to Other-Shipping ($300) to provide for shipping costs associated with the construction of remote controlled feeders, Printing and Publication ($315) to provide for poster printing for a conference presentation, and Services-MAISRC Containment Lab ($4,000). The research team will move into the lab this fall as a result of expected results in the 2022 field season, to test acoustics in a controlled setting prior to next field season. Researchers will expand on existing studies that show that carp can be acoustically conditioned and focus on social dynamics among schools of carp as well as retention of the acoustic cue. Strategies developed in the lab will inform protocols for the 2023 field season. Budget savings in Supplies-Lab/Field are the result of efficiencies in building remote controlled feeders.

Reallocate budget savings in Non-Capital Equipment-Lab/Field to Services-Biomark ($2,228) to provide online access to the Biomark monitoring system. Funding for the Biomark expense was originally budgeted in Non-Capital Equipment-Lab/Field but will be billed as a service, thus the need to shift funding to a new lab services line.

Activity 4
N/A

Activity 5
Subproject 24.2 Amendment:

Reallocate funds from Supplies-Lab/Field to Lab/Medical Services to provide for higher than anticipated lab costs for maintaining transgenic lines of zebrafish. Maintaining these populations of fish will allow the research team to test genetic reagents in zebrafish, prior to using them in carp or fathead minnows, thereby increasing the efficiency of the team's work. Budget savings in Supplies-Lab/Field are the result of lower than anticipated supply costs for planned activities.

Activity 6

Activity 7

Activity 8

Activity 9

Activity 10

Activity 11

Dissemination
N/A

Status Update Reporting

Status Update September 1, 2022

Date Submitted: December 8, 2022

Date Approved: December 8, 2022

Overall Update
As a result of our 2021 Request for Proposal (RFP), MAISRC has reviewed, evaluated, peer reviewed, and approved 3 new subprojects on M.L. 2021:

Subproject 4.4: Acoustic conditioning in common carp to accelerate removal and reduce cost - Dr. Przemek Bajer
Subproject 21.3: Multibeam sonar zebra mussel mapping: Method development - Dr. Jessica Kozarek
Subproject 24.2: Genetic method for control of invasive fish species: Phase II - Dr. Michael Smanski

All three projects began on January 1, 2022 and project managers are currently building their teams and are beginning work on subproject objectives.

Overall, MAISRC is currently supporting 3 subprojects on M.L. 2021. Summaries of the progress of this subproject are included below. In addition, MAISRC is currently supporting 11 subprojects on M.L. 2019, and 3 subprojects through alternate funding sources (non-ENRTF funds).

Activity 1
Research Coordination:
MAISRC continues to work closely with our Center Advisory Board, Fellows Group, and Technical Committee to ensure high quality and high priority research and outreach is being conducted through MAISRC projects and programs. We also continue to meet monthly with the MN DNR Invasive Species Unit to share information, updates, and explore opportunities for coordination.

Activity 2
Annual Request for Proposals (RFP):
MAISRC released our 2022 RFP in January of this year. RFP priorities were based on the results of the Research Needs Assessment that was completed in summer 2020 (a biennial process), with a recent review from the MAISRC Technical Committee, the Center Fellows Group, the MAISRC Advisory Board and the MN DNR invasive species leadership team in fall 2021. In total, MAISRC intends to allocate about $2 million to ten new or continuing projects as a part of the 2022 RFP. The primary funding source for the RFP is M.L. 2021 Environment and Natural Resources Trust Fund monies that have been allocated to MAISRC. The full 2022 RFP can viewed on the MAISRC website: https://maisrc.umn.edu/rfp

2022 Proposals that were selected for funding are now in the work plan development phase and will be submitted for funding and LCCMR review this fall.

Activity 3
In summer 2022, 140 common carp were PIT tagged through electrofishing and box netting. Four bait sites have been established – the first two sites will be used in a latency test, which will provide evidence of acoustic conditioning and the second two sites will be used in a directionality test, which will show if carp can localize sound in a natural lake. Each of the four sites have been sound mapped by using a hydrophone to measure the distance the sound will travel from each speaker. After sound mapping, automatic feeders were installed at the two sites for the first experiment. The control site has an automatic feeder whereas the test site has both an automatic feeder and an underwater speaker. Both sites have a PIT detection antenna that records when fish are present at the site. The study is currently in the

conditioning phase prior to the start of the first experiment. Each site is baited every night and the acoustic cue is played at the test site only. The team has completed the original 10-day conditioning period, and the carp are not yet conditioned to the acoustic cue.

Activity 4

Building on the laboratory and field experiments conducted in Phases I and II of this project, Phase III focuses on translating research on the use of multibeam sonar to detect zebra mussels into practice. The research team has completed data collection to map sediment type and relative mussel density in two waterbodies in MN: White Bear Lake and the St. Croix River near Lakeland, MN. Each site was surveyed in June 2022 at four frequencies utilizing a research-grade multibeam sonar. These surveys provided bathymetry and acoustic backscatter information that will be combined with ground truth data to classify sediment type and relative mussel density. Divers collected semi-quantitative ground truth data in one m2 quadrats to define sediment type and relative mussel density. In addition, divers also recorded vegetation presence and relative coverage. To evaluate various methods of collecting zebra mussel distribution data, the research team also utilized an underwater remotely operated vehicle (ROV) to gather video of each ground truth location and surveyed each area with an off-the-shelf side scan sonar. The research team is currently post-processing the collected data to utilize the scripts modified in Phase II to classify and map mussel containing substrates.

Activity 5

In the past six months, we have designed, built genetic reagents, and introduced those genetic reagents to carp via microinjection, for genetic biocontrol via sex-ratio-biasing. We have several dozen putative mosaic (not 100% of their cells carry the foreign DNA in this generation) being reared in the MCL. One obstacle that we are currently overcoming in this activity is that the fluorescent reporter genes we used in these constructs did not work effectively, meaning we will have to screen for transgenesis by molecular biology methods. We are changing the reporter gene component of future genetic constructs.

We have made substantial logistical progress in this activity by (i) establishing a broodstock of fathead minnows in the MCL, and (ii) confirming that our primordial germ cell-labeling genetic constructs work in zebrafish. One obstacle that we are currently overcoming is that the primordial germ-cell-labeling constructs are not specific to PGCs in carp, but instead result in fluorescence in the entire body. We are currently troubleshooting by altering the genetic design of these constructs.

In addition, we held an in-person workshop with 16 diverse stakeholders in June 2022 and are currently drafting a manuscript based on that activity.

Dissemination

No activity to report at this time. All MAISRC communication and dissemination activities have occurred on 2017 and 2019 ENRTF funding thus far. A summary of activities is included in the M.L. 2017 and M.L. 2019 reports.