M.L. 2017 Project Abstract
For the Period Ending June 30, 2022

PROJECT TITLE: Aquatic Invasive Species Research Center – Phase II
PROJECT MANAGER: Nicholas Phelps
AFFILIATION: Minnesota Aquatic Invasive Species Research Center, University of Minnesota
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FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a as extended by M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 18

APPROPRIATION AMOUNT: $2,700,000
AMOUNT SPENT: $2,621,072
AMOUNT REMAINING: $78,928

Sound bite of Project Outcomes and Results
This project continued MAISRC's work to develop research-based solutions that can reduce the impacts of aquatic invasive species in Minnesota. Through this appropriation, MAISRC has supported 15 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) continued to develop research-based solutions that can reduce the impacts of AIS in Minnesota and advance AIS knowledge among natural resources managers, the research community, and the public. In total, 15 subprojects were supported from this project – significantly advancing our scientific understanding and ability to manage AIS. New tools have been developed and knowledge gaps filled on many of Minnesota's most important AIS, including zebra mussels, spiny water flea, bigheaded and common carps, and starry stonewort. The results of this work have been broadly disseminated via research reports, peer-reviewed manuscripts, fact sheets, white papers, news media, newsletters, social media, and direct stakeholder engagement through presentations, workshops/trainings, and public events. Highlights of project outcomes include identifying the highest risk methods of introduction and spread of spiny water flea and baitfish viruses, advancing innovative control tools for established AIS like zebra mussels and common carp, and defining the impact of AIS on ecosystems and sportfish populations. Throughout this project, MAISRC has continued to serve as a global leader in the field of AIS research and a go-to resource for managers, researchers, and members of the public.

This project also supported MAISRC's work to ensure the effectiveness and efficiency of a center-based research model. Progress in this area included an ongoing, comprehensive process for prioritizing research needs; stronger collaboration and coordination between researchers and managers; a competitive, peer-reviewed annual proposal competition; and increased communications and outreach capacity to help managers and community members translate research findings into on-the-ground management.

MAISRC continues to advance Minnesota's resiliency and ability to address AIS issues facing our state through research, collaboration, and stakeholder engagement. This project will continue with Phase II and III appropriations awarded in 2019 and 2021.

Project Results Use and Dissemination

Website, social media, and e-newsletter

The MAISRC website has become a resource for AIS stakeholders across the state with an average of 40,000 users visiting the site each year. MAISRC and the AIS Detectors program also have active social media accounts on Twitter, Facebook, and YouTube. MAISRC and AIS Detectors' videos on YouTube, including webinars and project spotlights, have collected nearly 94,000 views, totaling an estimated 2,700 hours of watch time. MAISRC's Twitter account has grown into a popular means of connecting researchers, legislators, community organizations and nonprofits, and other AIS stakeholders. Social media posts continue to disseminate research findings, highlight behind-the-scenes project activities, promote MAISRC events and AIS Detectors workshops, and share invasive species news. In addition, the MAISRC e-newsletter delivers in-depth stories about MAISRC research and management tools to more than 5,300 people and growing.

Earned media

Over the course of the last five years, MAISRC has been in approximately 340 news stories in over 100 outlets. The most common outlets have been the Star Tribune, Minnesota Public Radio, and KSTP-TV. Other notable coverage includes The Associated Press and National Geographic.

Presentations, workshops/trainings, and events

Highlights from 2017-2022

- Held five AIS Research and Management Showcases to share MAISRC research updates, outcomes, and tools with 1,400+ unique attendees. Recordings of recent Showcase presentations can be found on the MAISRC YouTube page: https://z.umn.edu/2020ShowcasePresentations; https://z.umn.edu/2021ShowcasePresentations.
- AIS Detectors held 20 training sessions, certifying 421 AIS Detectors who contribute to AIS prevention and response efforts statewide as volunteers and professionals.
- Hosted five Starry Trek events, through which volunteers have found four new starry stonewort populations, as well as identifying new populations of zebra mussels, Eurasian watermilfoil, golden clams, and other AIS.
- AIS Detectors hosted 14 webinars on AIS and MAISRC research, reaching 2,600 live attendees and collecting nearly 5,450 views on YouTube. Webinar recordings can be viewed online: https://z.umn.edu/AISDetectorsWebinars.
- Led a series of training workshops for county and MN DNR AIS managers following the release of the AIS Explorer online dashboard. Over the course of 9 workshops, MAISRC staff taught over 50 natural resource managers how to use the AIS Explorer tool to improve their AIS prevention strategies. AIS Explorer is publicly available: https://www.aisexplorer.umn.edu/#!/.

Reports and other materials

Highlights from 2017-2022

- Created five videos, highlighting MAISRC research
  - Raising zebra mussels in the lab
  - Volunteer monitoring leads to rapid response project
  - Anti-biofouling paint inhibits spread of zebra mussels
  - Mapping zebra mussels using multibeam sonar
  - Motivations and risks of illegal baitfish release
- Produced four annual research reports, summarizing research outcomes
  - 2021 Research Report, including an online interactive report
  - 2020 Research Report

    - 2019 Research Report
    - 2018 Research Report
- Created and maintain a series of interactive maps and tracking tools
    - MAISRC Work Around the State
    - AIS Explorer
    - MAISRC Milfoil App
- Created and maintain *Stop Spiny* campaign resources to support managers and communities in preventing the spread of spiny water flea: https://maisrc.umn.edu/stopspiny

Peer-reviewed publications
Peer-reviewed publications are an essential part of MAISRC's research and dissemination activities. A full list of over 100 peer-reviewed publications can be viewed on the MAISRC website: https://www.maisrc.umn.edu/publications

Data Repository at the University of Minnesota (DRUM)
To continue providing leadership in the AIS research field and to ensure proper stewardship and accessibility of MAISRC research data, MAISRC maintains a publicly accessible data repository in collaboration with the University Digital Conservancy. Thus far, MAISRC has contributed 24 data sets to DRUM, available here: https://conservancy.umn.edu/handle/11299/197773

Note: The MAISRC DRUM portal was established to ensure that all MAISRC data is made publicly available. However, not all MAISRC projects use this platform. Some MAISRC researchers upload their data to federal databases or publish them as supplements to scientific articles to align with data-sharing standards within their fields or journal requirements.

Environment and Natural Resources Trust Fund (ENRTF)

M.L. 2017 ENRTF Work Plan Final Report (Main Document)

Today's Date: September 15, 2022

Final Report

Date of Work Plan Approval: June 7, 2017

Project Completion Date: June 30, 2022

PROJECT TITLE: Aquatic Invasive Species Research Center – Phase II

Project Manager: Nicholas Phelps

Organization: Minnesota Aquatic Invasive Species Research Center

College, Department, or Division: University of Minnesota

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Location: Statewide

Total Project Budget: $2,700,000

Amount Spent: $2,621,072

Balance: $78,928

Legal Citation: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a as extended by M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 18

Appropriation Language:

$2,700,000 in fiscal year 2017 is from the trust fund to the Board of Regents of the University of Minnesota to support the Minnesota Aquatic Invasive Species Research Center in finding solutions to Minnesota's aquatic invasive species problems through research, control, prevention, and early detection of existing and emerging aquatic invasive species threats. This appropriation is available until June 30, 2021, by which time the project must be completed and final products delivered.

M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 18. ENVIRONMENT AND NATURAL RESOURCES TRUST FUND; EXTENSIONS. [to June 30, 2022]

I. PROJECT STATEMENT:

The threats posed by aquatic invasive species (AIS) to Minnesota's lakes, rivers, and wetlands are real and growing and the science needed to address these vexing problems in Minnesota has only just begun. In order to more effectively respond to AIS, Minnesota must be equipped with better information, have more useful tools, and be able to mobilize more people who care about the quality of the state's waters. Appropriations from ENRTF (2012, 2013, 2014) provided crucial initial support for solutions-oriented research at the Minnesota Aquatic Invasive Species Research Center (MAISRC) on common and bigheaded carps, VHSV, Eurasian water milfoil, and zebra mussels. It also created the operational capacity needed to prioritize, coordinate, and spur research as well as the outreach capacity to start translating science into management action. Many of these initial projects are funded through 2019, yet other critical research needs exist. For example, more lines of research to address prevention and control of key species such as zebra mussels and curly leaf pondweed are needed, as is new research on emerging species such as starry stonewort and killer shrimp. Systems-level research is also needed on topics such as the economic impacts of AIS, rapid response techniques, and effectiveness of prevention in order to ensure our state's limited time and resources are being targeted most effectively.

With 2017 ENRTF funding and guided by MAISRC's biannual systematic Research Needs Assessments that includes input from federal, state, and local AIS managers, public stakeholders, and researchers from around the state, MAISRC will:

- Launch 5-10 scientifically rigorous research efforts to prevent, control, and manage AIS in Minnesota
- Ensure the necessary core organizational functions are in place to accomplish this work.

Funds for these research subprojects will be held in a MAISRC reserve budget until they are awarded. After the subprojects have been evaluated, peer reviewed, and have workplans approved by MAISRC, the subproject information will be submitted to LCCMR for final approval. Subproject summaries, outcomes, and brief updates will be incorporated below as part of an overall workplan on MAISRC's efforts.

MAISRC's work is conducted with assistance from a multi-organizational and cross-disciplinary Technical Committee, an internal Center Fellows Group, and a Center Advisory Board with representatives from a range of stakeholders knowledgeable about and affected by AIS. Our work is also guided by a 10-year strategic plan posted to MAISRC's website and available on request.

Note: This document is details research plans and reports significant accomplishments of subprojects funded by MAISRC through this appropriation. *Section III, Subproject 1* provides a brief narrative of relevant Center-related activities. In *Section III*, subprojects will be described and outcomes with corresponding completion dates will be outlined with enough detail to adequately convey the scope of work being conducted, why, and the projected impact. A table that summarizes the current status of each subproject will be included as an attachment to this work plan. Separate subproject work plans will not be required. A budget for each subproject will be attached to the overall work plan. MAISRC will maintain copies of research addenda for each subproject and make them available to LCCMR staff upon request. Subproject dissemination activities will be reported in *Section III*; overall MAISRC dissemination activities will be reported in *Section IV* of the work plan.

II. OVERALL PROJECT STATUS UPDATES:

First Update February 28, 2018

No report necessary per LCCMR staff on 3/1/2018.

Second Update August 31, 2018

As a result of our 2017 Research Needs Assessment process and RFP, we reviewed, evaluated, peer reviewed, and approved six new subprojects:

Subproject 20: A Novel Technology for eDNA Collection and Concentration – Dr. Abdennour Abbas
Subproject 22: Copper-based control - zebra mussel settlement and non-target impacts – James Luoma
Subproject 23: AIS Management - An Eco-economic Analysis of Ecosystem Services – Dr. Amit Pradhananga
Subproject 24: Genetic method for control of invasive fish species – Dr. Michael Smanski

One subproject was reviewed through a separate process, as guided by our Managing Director Conflict of Interest in MAISRC Proposal Funding policy. This project and work plan were approved by the MAISRC Director Project Review Committee and LCCMR.

Subproject 25: What's In Your Bucket? Quantifying AIS Introduction Risk – Dr. Nicholas Phelps

In addition to launching new projects, MAISRC also approved the extension of Subproject 15: Determining Highest Risk Vectors of Spiny Water Flea Spread. This extension applies to Activity 2 of the subproject work plan and changes the project completion date to June 30, 2020.

Amendment Request August 29, 2018
As we prepare for the second year of activities on new Subprojects 20, 23, 24, 25 and extend Subproject 15, we request a series of budget amendments to move a total of $461,236 from reserves to fund each project between July 1, 2019 and June 30, 2020.

Amendment Request 1:
Subproject 15 – move $26,581 from reserves to fund an extension of outreach activities (Activity 2) and changes the project completion date to June 30, 2020. This extension does not increase the overall budget of the project, but will incorporate funding from M.L. 2017 to cover outreach activities occurring between July 1, 2019 and June 30, 2020. Extension of Activity 2 and budget approved by MAISRC 07/17/2018 and by LCCMR on 07/31/2018.

Amendment Request 2:
Subproject 20 – move $96,264 from reserves to fund new Subproject 20 at a total amount of $96,264 for year two. Year one will be funded by M.L. 2013 funds.

Amendment Request 3:
Subproject 23 – move $110,245 from reserves to fund new Subproject 23 at a total amount of $110,245 for year two. Year one will be funded by M.L. 2013 funds.

Amendment Request 4:
Subproject 24 – move $140,004 from reserves to fund new Subproject 24 at a total amount of $140,004 for year two. Year one will be funded by M.L. 2013 funds.

Amendment Request 5:
Subproject 25 – move $88,142 from reserves to fund new Subproject 25 at a total amount of $88,142 for year two. Year one will be funded by M.L. 2013 funds.

Amendments Approved: **09/11/2018**

Third Update February 28, 2019

MAISRC released our 2018 Request for Research Proposals (RFP) in November 2018, based on the results of the Research Needs Assessment that was completed in summer 2018. To review the submitted preproposals, MAISRC assembled a review committee that included members from MAISRC's advisory board, the Minnesota DNR, and peer researchers. In total, MAISRC anticipates allocating about $1.35 million to new and continuing projects as a part of the 2018 RFP. Funding sources include the Environment and Natural Resources Trust Fund, MAISRC's 2017 legislative appropriation, and non-sponsored donations.

Amendment Request February 28, 2019
Subproject 22 – move $148,460 from reserves to fund new Subproject 22 at a total amount of $148,460 for year two. Year one will be funded by M.L. 2013 funds.

Amendment Approved: **03/11/2019**

Fourth Update August 31, 2019

As a result of our 2018 Request for Proposals (RFP), we reviewed, evaluated, peer reviewed, and approved ten new subprojects:

Subproject 4.3: Social Learning and Carp Removal – Dr. Przemek Bajer
Subproject 8.2: Impacts of invader removal on native vegetation recovery – Dr. Daniel Larkin
Subproject 12.2: Historical analyses of spiny water flea invasion patterns – Dr. Donn Branstrator
Subproject 16.2: AIS impacts on walleye populations and mercury concentrations – Dr. Gretchen Hansen
Subproject 18.2: Genetics to improve hybrid and Eurasian watermilfoil management – Dr. Raymond Newman
Subproject 21.2: Field validation of multibeam sonar zebra mussel detection – Dr. Jessica Kozarek

Two additional subprojects that were selected in the 2018 RFP will be funded through alternate funding sources (non ENRTF funds) and are not included in this report:

Subproject 7.3: Evaluation of koi herpesvirus for use as a potential biocontrol agent for common carp in Minnesota – Dr. Nicholas Phelps
Subproject 29: Will property values cool as AIS heat up? – Dr. Gretchen Hansen

Subproject 7.3 was reviewed through a separate process, as guided by our Managing Director Conflict of Interest in MAISRC Proposal Funding policy. This project and work plan were approved by the MAISRC Director Project Review Committee and LCCMR.

Amendment Request August 29, 2019
We request a series of budget amendments to move a total of $1,119,422 from reserves to fund seven new subprojects between July 1, 2019 and June 30, 2021.

Amendment 1:
Subproject 4.3 – move $188,866 from reserves (Activity 2) to fund new Subproject 4.3 at a total amount of $188,866 for two years, ending on June 30, 2021.

Amendment 2:
Subproject 8.2 – move $123,039 from reserves (Activity 2) to fund new Subproject 8.2 at a total amount of $123,039 for two years, ending on June 30, 2021.

Amendment 3:
Subproject 12.2 – move $57,363 from reserves (Activity 2) to fund new Subproject 12.2 at a total amount of $57,363 for two years, ending on June 30, 2021.

Amendment 4:
Subproject 16.2 – move $199,863 from reserves (Activity 2) to fund new Subproject 16.2 at a total amount of $199,863 for two years, ending on June 30, 2021.

Amendment 5:
Subproject 18.2 – move $236,423 from reserves (Activity 2) to fund new Subproject 18.2 at a total amount of $236,423 for two years, ending on June 30, 2021.

Amendment 6:
Subproject 21.2 – move $228,900 from reserves (Activity 2) to fund new Subproject 21.2 at a total amount of $228,900 for two years, ending on June 30, 2021.

Amendment 7:
Subproject 28 – move $84,968 from reserves (Activity 2) to fund new Subproject 28 at a total amount of $84,968 for one year, ending on June 30, 2020.

In addition, we request an amendment to MAISRC's core budget to reallocate unused funds:

Amendment 8:
Subproject 1 – we request to move $10,000 from *Capital Expenditures* to *Budget Reserves*, decreasing the *Capital Expenditures* budget to $0 and increasing the balance of the budget reserve to $50,232.

In the development of MAISRC's M.L. 2017 work plan, $10,000 was budgeted to purchase a new backpack electrofishing unit to update the electrofishing boat that was a shared resource with the Fisheries, Wildlife, and Conservation Biology (FWCB) Department at the University of Minnesota. However, updating the original boat or relying on a new backpack unit was no longer a fiscally responsible and mechanically feasible solution. With LCCMR's approval, MAISRC purchased a new electrofishing boat (in partnership with FWCB) in June 2019, using 2013 ENRTF funds. With the purchase of a new boat, the funds allocated for a new backpack unit on M.L. 2017 are no longer needed and we request that the unused capital budget be transferred to budget reserves, to be utilized in support of MAISRC subprojects.

Amendments Approved by LCCMR: **10/10/2019**

Amendment Request November 15, 2019
Amendment 1:
Subproject 1 – Combine the proposed split in funded projects in Activity 2, to launching a total of 7-10 two-year projects.

When MAISRC wrote the original proposal for M.L. 2017 funding, we intended to evaluate and launch 3-4 three-year projects, 2-3 two-year projects, and 2-3 six-month projects. However, after consulting with our Center Advisory Board, we were advised to remain consistent with project lengths and evaluate each project proposal as a part of the same RFP. We request to revise this language to launching 7-10 two-year projects, throughout the duration of M.L. 2017 funding. Evaluating and launching projects that are a consistent length of time allows MAISRC to more effectively manage each project and efficiently allocate ENRTF funds.

Language in the Subproject 1 project description and outcomes has been modified below to reflect this proposed change.

Amendment 2:
Subproject 1 – Change the titles of Activity 1 and Activity 2 in Subproject 1.

As a part of the transition to a new work plan template, we request to change the titles of Subproject 1 activities to be consistent with MAISRC's M.L. 2019 work plan and to more accurately represent changes to Activity 2 outlined in Amendment 1. The requested change would impact Subproject 1 activities as follows:

Original Titles
ACTIVITY 1: Core Center functions to support AIS research
ACTIVITY 2: Research for response to existing and new threats and rapid response to emerging high priority AIS threats

New Titles
ACTIVITY 1: Leadership to facilitate AIS research and collaboration
ACTIVITY 2: Advancing high priority and promising research to address AIS in Minnesota

Amendments Approved by LCCMR: **02/14/2020**

Fifth Update February 28, 2020

MAISRC shifted our Request for Research Proposals (RFP) and subproject timeline from the fiscal year (July 1 through June 30) to the calendar year. In alignment with the new timeline, MAISRC released our 2020 RFP on January 2, 2020. We anticipate allocating about $1.5 million to new and continuing projects as a part of the 2020 RFP. The primary funding source for the RFP is 2019 Environment and Natural Resources Trust Fund monies that have been allocated to MAISRC (M.L. 2019).

MAISRC also reviewed and approved two new subprojects:

Subproject 30: Managing Midwestern aquatic invasions in a changing climate -- a project that was reviewed and approved as a part of MAISRC's 2019 RFP, but whose start date was delayed. Subproject 30 will be supported by 2017 ENRTF funds (M.L. 2017).

Subproject 31: A statewide surveillance and early detection system for aquatic invasive species in Minnesota -- a legislative report that was requested by the 2019 MN State Legislature as a part of the 2019 state appropriation that allocated funding to MAISRC.

Following a phone conversation with LCCMR staff on 3/13/2020, the final report deadline for M.L. 2017 was adjusted to September 15, 2021 to allow time for subproject final reporting and incorporation into MAISRC's overall final report.

Amendment Request February 25, 2020

Amendment 1:
Subproject 30 – move $39,000 from MAISRC Reserves to fund new Subproject 30 at a total amount of $39,000 for 18 months, ending on June 30, 2021. This amendment will decrease the balance of MAISRC Reserves from $50,232 to $11,232.

Amendment 2:
Subproject 22 – move $3,630 from MAISRC Reserves to increase the *Professional/Technical Services and Contracts* budget from $26,670 to $30,300. This increase in funding will allow for testing additional zooplankton and macroinvertebrate samples, which will increase the project's ability to more accurately measure the effectiveness of low-dose copper treatment of zebra mussels in St. Alban's Bay. This amendment will have the following impact on the overall budget:

MAISRC Reserves – decrease from $11,232 to $7,602 (net -$3,630)

Subproject 22 – increase total budget from $148,460 to $152,090 (net +$3,630)

Amendment 3:
Subproject 4.3 – we request an amendment to the subproject work plan to shift the focus of comparing multiple lakes to focusing research efforts on a single lake.

Based on data from the 2019 field season, it appears that mostly localized carp are attracted to individual sites baited with corn, along with infrequent visitors from other areas of the lake. We hypothesize that if we provide more baited sites (10) within a single lake, rather than across two lakes (as initially proposed), we will attract the majority of carp in the single lake to the bait. This will allow us to collect behavioral data on the majority of the

population and ultimately lead to a higher yield during removal efforts. Further, in our first field season, we observed that visitation rates declined after the first removal attempt. This suggests that removal from many sites within a lake, but only once or twice per site might be more effective than repeated removal from a smaller number of sites.

For 2020 we propose focusing on a single lake (Parley Lake) and establishing 10 baited sites in it, each with 1 PIT antenna to monitor presence of carp at the bait. This should result in developing a social map for nearly the entire population in the lake and provide a wealth of individual carp detections. Analyses of detections will enable us to understand connectivity of foraging sites, recognize specific foraging groups, and begin to understand the social dynamics of local populations as well as interactions across the whole lake. We will then conduct removal of carp from all 10 sites at least twice. Ultimately, carp managers can use our new understanding of local and whole lake social dynamics to design more strategic and effective removal strategies using corn as an attractant.

This amendment will not impact the subproject budget or the completion dates of outcomes in Activity 1 and 2.

Amendment 4:
Subproject 16.2 – we request to move $6,000 to *Personnel* from *Travel* and *Equipment/Tools/Supplies*, increasing the *Personnel* budget from $127,349 to $133,349. This increase in *Personnel* funds will allow for additional support from technicians and undergraduate staff to (1) increase field efforts to maximize the probability of capturing age-0 walleye in Year 2, and (2) allow for rapid processing of samples in the lab for stable isotope and mercury analysis to ensure timely receipt of the data from the relevant labs. This amendment will have the following impact on the Subproject 16.2 budget:

Travel – decrease the budget for fieldwork travel from $25,488 to $20,988 (net -$4,500)

Equipment/Tools/Supplies – decrease from $13,663 to $12,163 (net -$1,500)

- Equipment - Lab/Field – decrease from $6,928 to $5,928 (net -$1,000)
- Supplies - Lab/Field - decrease from $6,735 to $6,235 (net -$500)

Personnel – increase from $127,349 to $133,349 (net +$6,000)

Amendment 5:
Subproject 23 – move $148 from *Personnel* to *Travel-MN* to cover slightly higher than expected travel costs for survey data collection in the field. This amendment will have the following impact on the Subproject 23 budget:

Personnel – decrease from $83,245 to $83,097 (net -$148)

Travel-MN – increase from $10,000 to $10,148 (net +$148)

Amendment Approved by LCCMR: **03/04/2020**

Amendment Request May 12, 2020

Amendment 1:
Subproject 20 – We request to remove the field testing component from the scope of Activity 2 due to delays in the project timeline.

As noted in the February 2020 update, Subproject 20 met some unexpected challenges when performing qPCR on experimental samples. We unexpectedly found that the eDNA collection technology (eDNA sorbent) causes inhibition of the qPCR reaction due to leaching of Aminoethyl[amino]propyl-trimethoxysilane (AEEAS) from the sorbents or filters. As a result, we needed to develop a redesign of both the eDNA sorbent to capture eDNA and the buffer for DNA recovery.

This redesign caused delays to the project and have resulted in our request to adjust the scope of Subproject 20 and remove the field testing component from Activity 2, due to lack of sufficient time before the project end date to accomplish field testing in Minnesota lakes. This change will allow the project team to focus personnel time and budgeted resources on completing Activities 1 and 2 for eDNA extraction kit development and prototyping, and advancing to beta-testing before the project end date on June 30, 2020.

Field testing of the nanofilter has been added to a new proposal that was submitted to MAISRC's 2020 RFP. If funded, this new project would accomplish outstanding deliverables that were slated for Subproject 20 and provide a completed test kit that could be utilized by AIS managers in the field.

Amendment 2:
Subproject 20 – We request to remove the development of a housing system for the eDNA nanofilter (Outcome 3) from the scope of Activity 1 due to delays in the project timeline.

As noted in Amendment 1, the delays that were caused by the necessary redevelopment of the eDNA sorbent and buffer for DNA recovery have resulted in our request to remove Activity 1, Outcome 3 from the scope of work for Subproject 20 – due to lack of sufficient time before the project end date to accomplish housing development. This change will allow the project team to focus personnel time and budgeted resources on completing Activities 1 and 2 for eDNA extraction kit development and prototyping, and advancing to beta-testing before the project end date on June 30, 2020.

The development of a housing system for the eDNA nanofilter has been added to a new proposal that was submitted to MAISRC's 2020 RFP. If funded, this new project would accomplish outstanding deliverables that were slated for Subproject 20 and provide a completed test kit that could be utilized by AIS managers in the field.

Amendment 3:
Subproject 15 – We request an extension to adjust the completion date of our project from June 30, 2020 to June 30, 2021.

Activity 2 of this subproject is centered around an educational outreach campaign during the spring and summer fishing season. The original plan was to launch this outreach program in late spring of 2020. However, we have been slowed in our ability to create the outreach product (a towel to wipe spiny water fleas from fishing gear) by the COVID-19 shutdown. Creating this product requires working with a printer, which has become difficult with the closing of businesses as a result of Minnesota's stay at home order. In addition, the campaign includes producing video and audio PSAs that encourage anglers to comply with gear cleaning recommendations that were developed in Activity 1. Recording audio and video for these PSAs cannot be done from home and requires working with skilled videographers and audiographers; something that cannot easily be done while maintaining safety practices to limit the spread of COVID-19.

If approved, this extension would allow us to shift the campaign timeline to launch in spring of 2021, in conjunction with the 2021 fishing opener. It would also provide our research team with a full field season over the summer of 2020 – allowing for the best possible chance to record the needed PSA audio and video, as well as additional time to work with our local printer to get the towels produced (Amendment 6) and distributed to our campaign partners before spring 2021. An extension would not increase the overall budget of the project and if approved, we anticipate being able to meet all project objectives and outcomes.

Amendment 4:
Subproject 15 – We request an amendment to revise work plan and budget language detailing the plan to purchase TV ads as a part of our educational outreach campaign, to purchasing online ads instead.

After consulting with communications professionals both externally and at the University of Minnesota, we have decided to shift our plans to run TV ads detailing the threat of spiny water flea and the importance of cleaning fishing gear, to running online ads. Moving our ads online to platforms like YouTube and Facebook, allow us to run more ads and reach our target audience more directly, at a lower cost per engagement. By refining our audience and utilizing engagement tools online we will also be able to better track how many people have not only seen our outreach messages, but engaged with them by clicking to learn more or sharing the videos with others.

This increased efficiency in reaching our target audiences allows for the reallocation of some PSA funds to the production of printed towels (Amendments 6 and 7).

Amendment 5:
Subproject 15 – Move $3,000 from *Personnel* to new budget line for *Services-Video/Audio Production*, decreasing the *Personnel* budget from $17,998 to $14,998.

Staff time that was originally allocated for the production of the video and audio PSAs is no longer available within in the University of Minnesota or MN Sea Grant. In order to produce high quality video and audio for our campaign PSAs, we request a budget amendment to hire a videographer/audiographer on contract. This additional budget line, will not increase the overall project budget.

Amendment 6:
Subproject 15 – We request an amendment to revise work plan and budget language detailing the plan to produce stickers for our educational outreach campaign, to printing towels instead.

We found that it is very difficult to find a message that can fit on a small sticker that conveys enough information to educate anglers on what to do to prevent the spread of spiny water fleas. Thus, instead of a sticker, we have decided to pursue purchase of small towels that can be used to clean spiny water flea from fishing lines and that can accommodate a printed set of instructions on how to prevent spiny water flea spread. Switching to a towel will allow us to convey more information on how to effectively clean fishing gear, while providing anglers with a tool that they can use to clean and help prevent the spread of spiny water flea. The towels will also be used in production of the video PSAs to demonstrate how to clean spiny water fleas from fishing lines.

This amendment will require reallocation of project funds to accommodate the increased cost of printing towels (Amendment 7).

Amendment 7:
Increase the *Services-Printing* budget from $2,000 to $6,000 to accommodate the increased cost of purchasing and printing on towels instead of stickers. Additional funds for the *Services-Printing* line will come from cost savings in other budget categories and will impact the project budget as follows:

- Move $2,000 from *Personnel* to *Services-Printing,* decreasing the *Personnel* budget from $14,998 to $12,998
- Move $2,000 from *Services-PSA Ads* to *Services-Printing*, decreasing the *Services-PSA Ads* budget from $6,000 to $4,000

Amendments Approved by LCCMR: **06/03/2020**

Amendment Request June 30, 2020

Amendment 1:

Subproject 23 – We request an extension to adjust the completion date of this project from June 30, 2020 to June 30, 2021.

Due to COVID-19 restrictions and the shut-down of campus and private print and mail services, we have not been able to conduct the mail survey of Minnesota residents detailed in Activity 1. The inability to complete this survey has also affected data analysis, including valuation and development of AIS framework. A 12-month extension would allow our team to administer the mail survey of residents and conduct analysis of the survey data. An extension would not increase the overall budget of the project and if approved, we anticipate being able to meet all project objectives and outcomes.

Amendment 2:
Subproject 24 – We request an extension to adjust the completion date of this project from June 30, 2020 to June 30, 2021.

Due to COVID-19 shut-down of the University of Minnesota and the research team's inability to access their lab, all genetic engineering work on this project has been suspended until the UMN reopens. We have continued to process survey results and other non-lab work associated with the project during this time, but no further progress has been made on Activity 1.3 and Activities 2.1-2.4. An extension would not increase the overall budget of the project and if approved, we anticipate being able to meet all project objectives and outcomes.

Amendment 3:
Subproject 25 – We request an extension to adjust the completion date of this project from June 30, 2020 to December 31, 2020.

Due to the COVID-19 restrictions, members of the project team have had significant impacts to their ability to complete the quantitative risk assessment and report as outlined in the work plan, including significant disruptions and decreases in working hours below what was originally planned for in the project. A 6-month extension will allow the project team to complete the quantitative risk analysis and scenario and sensitivity analyses. At this point in the project, data collection and study design are entirely complete. We have also made significant advances in literature review, data cleaning and preparation, and fitting of most distributions, but a few pieces remain and need to be sufficiently parameterized and justified for each of the scenarios we plan to model. An extension would not increase the overall budget of the project and if approved, we anticipate being able to meet all project objectives and outcomes.

Amendment 4:
Subproject 21.2 – We request an amendment to pause Subproject 21 on June 30, 2020, after completing Year 1 of the project, and begin Year 2 of the project on January 1, 2021 on M.L. 2019 funding.

Due to COVID-19 travel bans at the University of Minnesota, as well as at collaborating institutions and organizations, the research team will be unable to conduct field work in the summer of 2020. Subproject 21.2 is centered around testing the utility of a swath mapping system and multibeam sonar in the field. Without a field season, we will be unable to reach the outcomes that are detailed in the project work plan. Pausing the project and conducting Year 2 activities from January 1 – December 31, 2021, will allow the research team to utilize a full field season in 2021 and will allow MAISRC to repurpose M.L. 2017 funds that were initially allocated to Subproject 21.2, before the overall M.L. 2017 completion date on June 30, 2021.

While this pause will not affect the overall budget amount of Subproject 21.2, it will affect the allocation of funds on M.L. 2017 and M.L. 2019. These changes are detailed in Amendment 5 and in MAISRC's M.L. 2019 work plan.

Amendment 5:
Subproject 21.2 – Move $214,653 in unused M.L. 2017 funds from Subproject 21.2 into MAISRC Reserves to be utilized by other MAISRC research projects. Year 2 funding for Subproject 21.2 will be allocated from MAISRC Reserves on M.L. 2019.

Amendment 6:
Subproject 21.2 – We request to remove Northern Arizona University as a project collaborator and replace with Matthew Kaplinski.

Our collaborator at Northern Arizona University (NAU), Daniel Buscombe, has left NAU. Buscombe will remain in an advisory role to the project, however he cannot continue as a funded participant. We request that Matthew Kaplinski, a private contractor with significant expertise in multi-beam sonar surveys and experience working with our project collaborators and multi-beam sonar experts, replace Buscombe/NAU in operating the multibeam sonar in the field.

Amendment 7:
Subproject 4.3 – We request a budget amendment to move $10,000 from *Personnel* to *Equipment/Tools/Supplies* for the purchase of additional field supplies and equipment.

Based on results from the first field season and subsequent adjustment of research methods, we will need to purchase additional PIT equipment for tracking carp. We will also need to purchase additional bait for attracting carp to 10 baited sites on Parley Lake. Funds for these purchases will come from salary savings in *Personnel* due to a lower than budgeted cost for undergraduate technicians.

Amendment 8:
Subproject 16.2 – We request a change to the completion date of Activity 1, Outcome 1 from 6/30/2020 to 9/1/2020.

Due to COVID-19 disruptions in personnel time and delays in getting data from MN DNR, we have been unable to make progress on collating historical walleye recruitment data from walleye lakes into a relational database. Adjusting the completion date of Activity 1, Outcome 1 to 9/1/2020 will allow us time to complete the database as planned.

Amendment 9:
Subproject 16.2 – We request that the number of study lakes be removed from Activity 2, Outcomes 1-4

The activities outlines in Activity 2, Outcomes 1-4 were originally planned to take place on 15 study lakes. A number of COVID-19 related issues will prevent us from achieving these outcomes on 15 study lakes. First, MN DNR did not stock walleye fry in 2020, due to COVID-19. This lack of stocking will influence our capacity to collect age-0 walleye in study lakes supported primarily by stocking. Next, UMN COVID-19 restrictions on travel means that we have implemented new social distancing protocols including driving separate vehicles, avoiding overnight stays wherever possible, and staying in individual hotel rooms when overnight stays are required. This will make sampling 15 lakes more difficult within our project budget. Finally, MN DNR is currently not conducting standard gillnet surveys as scheduled, upon which we were relying for the collection of adult fish from study lakes (Activity 2, Outcome 3). This requires a substantial increase in effort (personnel) and time required for us to collect the necessary samples in the absence of DNR assistance. Our sampling is time sensitive, and the additional time required for us to complete all sampling without DNR assistance means that we will be unable to sample as many lakes as originally planned.

Due to the changes required as a result of COVID-19 impacts, we request an amendment to sample 6 lakes in 2020 instead of the scheduled 8, reducing our total number of lakes sampled from 15 to 13. Additionally, as noted in our January 2020 update, in 2019 we were unable to collect age-0 walleye from 5 of our 7 lakes, and unable to collect age-0 yellow perch in 3 of our 7 lakes, due to unexpected low densities/absence. Although we plan to employ additional gear types targeting age-0 percids in 2020, the lack of walleye stocking increases the likelihood of failing to capture age-0 fish in each of our study lakes (Activity 2, Outcome 1).

To reflect the fact that we will be unable to sample all 15 study lakes as originally proposed, and to reflect our uncertainty in the capacity to collect age-0 walleye in the absence of stocking, we request to remove the number of study lakes from the table of work plan outcomes and will report on the number of sampled lakes for each outcome as a part of our update reports.

Amendment 10:
Subproject 16.2 – We request to move $5,300 from *Travel* to *Personnel* to fund additional personnel in the field and laboratory for sample processing.

Due to the COVID-19 impacts detailed in Amendment 9, we will require more personnel to complete the additional sampling required with the loss of MN DNR support. Moving $5,300 from *Travel* to *Personnel* will impact the project budget as follows:

- Move $1,979 from *Travel/Team Meetings* to *Personnel*, decreasing the *Travel for team meetings* budget from $1,979 to $0
- Move $3,321 from *Travel/Fieldwork* to *Personnel*, decreasing the *Travel/Fieldwork* budget from $20,988 to $17,667

Amendment 11:
Subproject 15 – We request to move $3,200 from *Professional/Technical Services-Printing* to *Supplies-General Operating* for the purchase of 4,000 reusable, gear cleaning towels.

With approval of a previous amendment request (May 12, 2020) we adjusted the project budget to produce 4,000 reusable towels that would be printed with information on cleaning fishing gear, to help prevent the spread of spiny waterflea. Since making that adjustment, we have discovered that ordering the towels and printing the towels will be separate expenses. In order to purchase the towels for printing, we request to move $3,200 from *Professional/Technical Services-Printing* to *Supplies-General Operating,* reducing the *Professional/Technical Services-Printing* budget from $6,000 to $2,800. The remaining $2,800 in *Professional/Technical Services-Printing* will be used to print the towels after purchase.

Amendment Approved by LCCMR: **07/09/2020**

Amendment Request August 10, 2020

Amendment 1:
Subproject 8.2 – We request a budget amendment to move $5,500 from *Professional/Technical/Service Contracts-MAISRC Containment Lab* to *Personnel*, *Supplies-Lab and/or Field*, and *Travel* to provide for increased field expenses due to COVID-19 safety requirements. Budget savings in *Professional/Technical/Service Contracts-MAISRC Containment Lab* are the result of reduced lab needs to complete germination experiments. This amendment will impact the project budget as follows:

- Move $1,500 from *Professional/Technical/Service Contracts-MAISRC Containment Lab* to *Personnel*, increasing the *Personnel* budget from $99,492 to $100,99. These additional funds in *Personnel* will provide additional time for undergraduate research assistants working in the field.
- Move $2,000 from *Professional/Technical/Service Contracts-MAISRC Containment Lab* to *Supplies-Lab and/or Field*, increasing the *Supplies-Lab and/or Field* budget from $4,296 to $6,296. These additional funds in *Supplies-Lab and/or Field* will provide for additional costs of SCUBA supplies for field work.
- Move $2,000 from *Professional/Technical/Service Contracts-MAISRC Containment Lab* to *Travel*, increasing the *Travel* budget from $6,701 to $8,701. These additional funds in *Travel* will provide for higher than expected costs for field travel, due to vehicle occupancy restrictions imposed by COVID-19 safety requirements.

Amendment 2:

Subproject 16.2 – We request a budget amendment to move $1,000 from *Other-Travel/Domestic* to *Supplies-Lab and/or Field* to provide for increased field expenses due to COVID-19 safety requirements.

This amendment will increase the *Supplies-Lab and/or Field* budget from $6,235 to $7,235 and will provide for extra gloves, masks, hand sanitizer, wipes, and foil/bags/vials for each socially distanced team member. Budget savings in *Other-Travel/Domestic* are the result of COVID-19 travel restrictions that have reduced the research team's ability to travel to a national conference.

Amendment 3:
Subproject 18.2 – We request a budget amendment to move $3,600 from *Supplies-Lab and/or Field, Out-of-State Travel-Conference,* and *Travel-Thum* to *Field Travel* to provide for higher than expected costs for field travel, due to vehicle occupancy restrictions imposed by COVID-19 safety requirements. This amendment will impact the project budget as follows:

- Move $1,000 from *Supplies-Lab and/or Field* to *Field Travel*, decreasing the *Supplies-Lab and/or Field* budget from $4,000 to $3,000. Budget savings in *Supplies-Lab and/or Field* are the result of lower than anticipated field supply costs.
- Move $900 from *Out-of-State Travel-Conference* to *Field Travel*, decreasing the *Out-of-State Travel-Conference* budget from $1,100 to $200. Budget savings in *Out-of-State Travel-Conference* are the result of COVID-19 travel restrictions that have reduced the research team's ability to travel to a national conference. $200 will be retained in the *Out-of-State Travel-Conference* budget to provide for registration fees to participate in an online conference.
- Move $1,700 from *Travel-Thum* to *Field Travel*, decreasing the *Travel-Thum* budget from $2,000 to $300. Budget savings in *Travel-Thum* are the result of COVID-19 travel restrictions that have required that stakeholder meetings and the MAISRC Showcase be held online.

Amendment 4:
Subproject 24 – We request a budget amendment to move $27,793 from *Personnel* to *Services-Lab and/or Medical, Rental-MAISRC Containment Lab,* and *Supplies-Lab and/or Field* to provide for higher than expected costs in those categories. Budget savings in *Personnel* were the result of COVID-19 restrictions on lab use during the UMN's period of reduced operations. This amendment will impact the project budget as follows:

- Move $22,000 from *Personnel* to *Services-Lab and/or Medical*, increasing the *Services-Lab and/or Medical* budget from $4,000 to $26,000. These additional funds will provide for DNA sequencing and embryo microinjection costs for testing genetic reagents in zebrafish embryos. Our expenses in this category exceeded what was planned during the past six months due to the cost of zebrafish embryos which are used as a way to test genetic reagents.
- Move $793 from *Personnel* to *Rental-MAISRC Containment Lab*, increasing the *Rental-MAISRC Containment Lab* budget from $5,766 to $6,559. These additional funds will provide for the difference in budgeted vs. actual cost of renting space in the MCL for carp husbandry.
- Move $5,000 from *Personnel* to *Supplies-Lab and/or Field*, increasing the *Supplies-Lab and/or Field* budget from $12,000 to $17,000. These additional funds will provide for the additional expense of creating genetic constructs and purchasing carp embryo microinjection supplies

Amendments Approved by LCCMR: **08/24/2020**

Sixth Update August 31, 2020

As of June 30, three MAISRC subprojects have been completed on M.L. 2017:

Subproject 20: A Novel Technology for eDNA Collection and Concentration - Dr. Abdennour Abbas
Subproject 22: Copper-based control: zebra mussel settlement and non-target impacts - James Luoma
Subproject 28: Evaluating Innovative Coatings to Suppress Priority AIS - Dr. Mikael Elias

Final report summaries for each project are included below and abstracts will be submitted directly to LCCMR staff. One additional subproject, which was completed on June 30 and was funded through alternate funding sources (non-ENRTF funds), is not included in this report:

Subproject 31: A statewide surveillance and early detection system for aquatic invasive species in Minnesota (Legislative Report) - Dr. Amy Kinsely

Due to the challenges and delays posed by COVID-19, MAISRC approved extensions for four subprojects on M.L. 2017:

Subproject 15: Determining Highest Risk Vectors of Spiny WaterFlea Spread - Dr. Valerie Brady
1 year extension
Subproject 23: AIS Management: An Eco-economic Analysis of Ecosystem Services - Dr. Amit Pradhananga
1 year extension
Subproject 24: Genetic method for control of invasive fish species - Dr. Michael Smanski
1 year extension
Subproject 25: What's In Your Bucket? Quantifying AIS Introduction Risk - Dr. Nicholas Phelps
6 month extension

These extensions do not increase the overall budget of the projects and were reviewed and approved by LCCMR. Progress reports for each extended subproject will continue to be included as a part of reporting on M.L. 2017.

In addition, due to COVID-19 delays, MAISRC and LCCMR approved a pause to one subproject:

Subproject 21.2: Field validation of mulitbeam sonar zebra mussel detection - Dr. Jessica Kozarek

Subproject 21.2 completed its first year on M.L. 2017 and will continue its second year of activities on M.L. 2019, beginning on January 1, 2021. A summary of Year 1 activities is included below. Additional reporting on Year 2 activities will be recorded on MAISRC's M.L. 2019 work plan.

MAISRC also launched a new subproject on an alternate funding source (non ENRTF funds), which is not included in this report:

Subproject 32: Developing a genomic method to detect hybridization between native and invasive Phragmites australis (common reed) - Dr. Daniel Larkin

Amendment Request August 31, 2020

Amendment 1:
Subproject 25 - Increase the *Personnel* budget from $80,592 to $84,220 to support ongoing activities related to modeling the risk of high-priority pathogens. Additional funds for the *Personnel* line will come from cost savings in other budget categories, in part due to COVID-19 travel restrictions, and will impact the project budget as follows:

- Move $35 from *Professional/Technical Services and Contracts-@RiskSoftware*, decreasing the *@RiskSoftware* budget from $100 to $65.
- Move $593 from *Travel-MN*, decreasing the *Travel-MN* budget from $1,000 to $407
- Move $3,000 from *Travel-Domestic*, decreasing the *Travel-Domestic* budget from $3,000 to $0.

Amendment 2:

Subproject 28 - Move $3,530 from *Professional/Technical Services and Contracts* to *Supplies-Lab and/or Field* to provide for higher than anticipated supply costs to perform additional analysis on samples that included microscopy using different staining methods. This amendment will increase the *Supplies-Lab and/or Field* budget from $6,000 to $9,530 and decrease the *Professional/Technical Services and Contracts* budget from $4,500 to $970. Savings in *Professional/Technical Services and Contracts* was due to decreased diving efforts, due to COVID-19 restrictions.

Amendment 3:
Subproject 20 - Increase the *Personnel* budget from $68,264 to $71,099 to provide for higher than anticipated personnel costs. Additional funds for the *Personnel* line will come from cost savings in other budget categories and will impact the project budget as follows:

- Move $2,000 from *Travel-MN*, decreasing the *Travel-MN* budget from $2,000 to $0. Budget savings in *Travel-MN* were the results of COVID-19 travel restrictions.
- Move $835 from *Professional/Technical Services and Contracts-UMN NanoCenter*, decreasing the *UMN NanoCenter* budget from $12,350 to $11,515. Budget savings in *UMN NanoCenter* were the result of the COVID-19 closure of the lab.

Amendment 4:
Subproject 20 - Move $208 from *Professional/Technical Services and Contracts-UMN NanoCenter* to *Laboratory Supplies* to provide for higher than anticipated supply costs. This amendment will increase the *Laboratory Supplies* budget from $11,650 to $11,858 and decrease the *Professional/Technical Services and Contracts-UMN NanoCenter* budget from $11,515 to $11,307.

Amendment 5:
Subproject 20 - Move $458 from *Professional/Technical Services and Contracts-UMN NanoCenter* to *Non-capital Equipment* to provide for the purchase of a centrifuge to complete the project. The centrifuge that was originally in use by this project was no longer accessible following the reallocation of departmental equipment to accommodate COVID-19 research. This amendment will increase the *Non-capital Equipment* budget from $0 to $458 and decrease the *Professional/Technical Services and Contracts-UMN NanoCenter* budget from $11,307 to $10,849.

Amendment 6:
Subproject 20 - Move $564 from *Professional/Technical Services and Contracts-UMN NanoCenter* to *Travel-Domestic* to provide for higher than anticipated travel costs for the PI and researcher to participate in the American Fisheries Society meeting. This amendment will increase the *Travel-Domestic* budget from $2,000 to $2,564 and decrease the *Professional/Technical Services and Contracts-UMN NanoCenter* budget from $10,849 to $10,285.

Amendments Approved by LCCMR: **12/15/2020**

Seventh Update February 28, 2021

As of December 31, 2020, one additional MAISRC subproject has been completed on M.L. 2017 – Subproject 25: What's In Your Bucket? Quantifying AIS Introduction Risk - Dr. Nicholas Phelps. The final report summary for this project is included below and an abstract will be submitted to the LCCMR.

MAISRC also launched two new, one-year rapid response and pilot projects on an alternate funding source (non ENRTF funds), which are not included in this report:

- Subproject 41: *Corbicula fluminea* surveillance on Briggs Lake, Sherburne County - Megan Weber
- Subproject 42: AIS Management Data Collection and AIS Database Exploration - Dr. Lucia Levers

Amendment Request February 28, 2021

Amendment 1:
Subproject 1 – Move the $33,734 balance from completed Subproject 28 to *MAISRC Reserves*, increasing the *MAISRC Reserves* balance from $222,256 to $255,990 (noted on the Overall Status Update).

Amendment 2:
Subproject 1 – Move the $4,048 balance from completed Subproject 25 to *MAISRC Reserves*, increasing the *MAISRC Reserves* balance from $255,990 to $260,038 (noted on the Overall Status Update).

Amendment 3:
Subproject 1 – Move $1,000 from *Equipment/Tools/Supplies-Lab and/or Field* to *Equipment/Tools/Supplies-Office and Gen Operating* to provide for higher than anticipated general operating supply costs. Budget savings in *Equipment/Tools/Supplies-Lab and/or Field* is the result of lower than expected use of MAISRC lab facilities and therefore lower supply costs. This amendment request will impact the subproject budget by decreasing the *Equipment/Tools/Supplies-Lab and/or Field* budget from $26,500 to $25,500 and increasing the *Equipment/Tools/Supplies-Office and Gen Operating* budget from $6,500 to $7,500.

Amendment 4:
Subproject 4.3 – Increase the *Travel Expenses in Minnesota-Truck Rental* budget from $7,597 to $9,947 (net +$2,350) to provide for increased truck rental costs due to COVID-19 restrictions. UMN COVID-19 safety protocols required that all research/field vehicles transport no more than one person at a time, resulting in the need to rent multiple vehicles. This amendment will impact the subproject budget as follows:

- Move $105 from *Equipment/Tools/Supplies-Gas* to *Travel Expenses in Minnesota-Truck Rental*, decreasing the *Equipment/Tools/Supplies-Gas* budget from $550 to $445. Budget savings in *Equipment/Tools/Supplies-Gas* budget is the result of lower than anticipated gas costs for the boat and generator.
- Move $500 from *Travel Expenses in Minnesota-UMISC* to *Travel Expenses in Minnesota-Truck Rental*, decreasing the *Travel Expenses in Minnesota-UMISC* budget from $500 to $0. Due to COVID-19, UMISC conference was held online and travel funds were not needed.
- Move $1,245 from *Other-NALMS* to *Travel Expenses in Minnesota-Truck Rental*, decreasing the *Other-NALMS* budget from $1,350 to $105. Due to COVID-19, NALMS conference was held online and additional travel funds were not needed.
- Move $500 from *Other-MNAFS* to *Travel Expenses in Minnesota-Truck Rental*, decreasing the *Other-MNAFS* budget from $500 to $0. Due to COVID-19, MNAFS conference was held online and travel funds were not needed.

Amendment 5:
Subproject 8.2 – Move $500 from *Travel Expenses in Minnesota* to *Personnel* to provide for additional personnel time for undergraduate research assistants. Budget savings in *Travel Expenses in Minnesota* are the result of lower than expected field travel expenses. This amendment will impact the subproject budget by decreasing the *Travel Expenses in Minnesota* budget from $8,701 to $8,201 and increasing the *Personnel* budget from $100,992 to $101,492.

Amendment 6:
Subproject 8.2 – Move $1,584 from *Professional/Technical/Service Contracts-CFANS Research Analytical Laboratory* to *Professional/Technical/Service Contracts-MAISRC Containment Lab* and *Equipment/Tools/Supplies-Office and Gen Operating*, decreasing the *Professional/Technical/Service Contracts-CFANS Research Analytical Laboratory* budget from $2,584 to $1,000. Budget savings in *Professional/Technical/Service Contracts-CFANS Research Analytical Laboratory* are due to the ability of the research team to complete needed analysis with current personnel and equipment. This amendment request will impact the subproject budget as follows:

- Move $1,084 from *Professional/Technical/Service Contracts-CFANS Research Analytical Laboratory* to *Professional/Technical/Service Contracts-MAISRC Containment Lab* to provide for additional time in the MAISRC Containment Lab, to process samples that were collected in the field.
- Move $500 from *Professional/Technical/Service Contracts-CFANS Research Analytical Laboratory* to *Equipment/Tools/Supplies-Office and Gen Operating* to provide for higher than expected expenses for SCUBA related supplies.

Amendment 7:
Subproject 15 – Increase *Professional/Technical Services and Contracts-Printing* budget from $2,800 to $3,400 (net +$600) to provide for the printing of an additional 1,500 reusable cloths (total count: 7,500) to be given out of Minnesota anglers as a part of the Stop the Spread of Spiny Water Flea campaign. This amendment will impact the project budget as follows:

- Move $600 from *Personnel* to *Professional/Technical Services and Contracts-Printing*, decreasing the *Personnel* budget from $12,998 to $12,398.

Amendment 8:
Subproject 15 – Increase the *Professional/Technical Services and Contracts-PSA Ads* budget from $4,000 to $8,000 (net +$4,000) to provide for the placement of additional online and print PSA ads sharing Stop the Spread of Spiny Water Flea messages that instruct anglers on how to effectively clean their equipment, to reduce the risk of spreading spiny water flea. Online and print PSAs will target angling audiences in the Twin Cities, Mille Lacs region, and northern Minnesota where spiny water flea are most prevalent. Additional PSA placements will allow MAISRC to reach a larger audience on a more diverse set of platforms. This amendment will impact the subproject budget as follows:

- Move $400 from *Personnel* to *Professional/Technical Services and Contracts-PSA Ads*, decreasing the *Personnel* budget from $12,398 to $11,998. Budget savings in *Personnel* is the result of lower than expected personnel costs for the project.
- Move $1,830 from *Professional/Technical Services and Contracts-Video/Audio Production* to *Professional/Technical Services and Contracts-PSA Ads*, decreasing the *Professional/Technical Services and Contracts-Video/Audio Production* budget from $3,000 to $1,170. Budget savings in *Professional/Technical Services and Contracts-Video/Audio Production* is the result of in-kind support from a University of Minnesota Duluth videographer and lower than expected production costs.
- Move $1,550 from *Equipment/Tools/Supplies-General Operating* to *Professional/Technical Services and Contracts-PSA Ads*, decreasing the *Equipment/Tools/Supplies-General Operating* budget from $3,200 to $1,650. Budget savings in *Equipment/Tools/Supplies-General Operating* is the result of the initial purchase of reusable towels/cloths on alternate funding provided by St. Louis County.
- Move $220 from *Travel-MN* to *Professional/Technical Services and Contracts-PSA Ads*, decreasing the *Travel-MN* budget from $583 to $363. Budget savings in *Travel-MN* is the result of reduced travel due to COVID-19 restrictions.

Amendment 9:
Subproject 16.2 – Move $200 from *Personnel (Faculty)* to *Equipment/Tools/Supplies-Supplies Lab and/or Field* to provide for higher than expected supply costs, due to the need for additional COVID-19 personal protective equipment in the lab and field. This amendment will impact the subproject budget by decreasing the *Personnel* budget from $138,649 to $138,449 and increasing the *Equipment/Tools/Supplies-Supplies Lab and/or Field* budget from $7,235 to $7,435.

Amendment 10:
Subproject 18.2 – Move $1,000 from *Personnel* to *Professional/Technical/Service Contracts-MAISRC/UMN Facilities* to provide for additional time in the MAISRC Containment Lab and UMN Greenhouse to run challenge tests. The need for additional lab and greenhouse time is due to a higher than anticipated need for lab space as a part of this project. This amendment will impact the subproject budget by decreasing the *Personnel* budget

from $116,248 to $115,248 and increasing the *Professional/Technical/Service Contracts-MAISRC/UMN Facilities* budget from $2,000 to $3,000. Budget savings in *Personnel* is the result of lower than expected personnel costs for the project.

Amendment 11:
Subproject 18.2 – Move $377 from *Travel Expenses in Minnesota-Field Travel* to *Professional/Technical/Service Contracts-MAISRC/UMN Facilities* to provide for additional time in the MAISRC Containment Lab and UMN Greenhouse to run challenge tests. The need for additional lab and greenhouse time is due to a higher than anticipated need for lab space as a part of this project. This amendment will impact the subproject budget by decreasing the *Travel Expenses in Minnesota-Field Travel* budget from $8,600 to $8,223 and increasing the *Professional/Technical/Service Contracts-MAISRC/UMN Facilities* budget from $3,000 to $3,377. Budget savings in *Travel Expenses in Minnesota-Field Travel* is the result of lower than expected travel costs for the project.

Amendment 12:
Subproject 18.2 – Reallocate $2,173 to *Professional/Technical/Service Contracts* for chemical analysis of herbicide challenge tests, to be completed by Wisconsin State Laboratory of Hygiene (53 samples, $41/each). These tests were not included in the original subproject budget, which was an oversight in budget planning. The Wisconsin State Laboratory of Hygiene was selected to complete the analysis because of the affordability of their processing fees and state labs in Minnesota do not routinely do the tests needed for the samples produced as a part of this project. This amendment will impact the subproject budget as follows:

- Move $150 from *Equipment/Tools/Supplies* to *Professional/Technical/Service Contracts-Chemical Analysis*, decreasing the *Equipment/Tools/Supplies* budget from $3,000 to $2,850. Budget savings in *Equipment/Tools/Supplies* is the result of lower than expected supply costs for the project.
- Move $200 from *Printing* to *Professional/Technical/Service Contracts-Chemical Analysis*, decreasing the *Printing* budget from $700 to $500. Budget savings in *Printing* is the result of lower than expected poster printing costs for the project.
- Move $623 from *Travel Expenses in Minnesota-Field Travel* to *Professional/Technical/Service Contracts-Chemical Analysis*, decreasing the budget from $8,223 to $7,600. Budget savings in *Travel Expenses in Minnesota-Field Travel* is the result of lower than expected travel costs for the project.
- Move $300 from *Travel Expenses in Minnesota-In-State UMISC* to *Professional/Technical/Service Contracts-Chemical Analysis*, decreasing the *Travel Expenses in Minnesota-In-State UMISC* budget from $300 to $0. Budget savings in *Travel Expenses in Minnesota-In-State UMISC* are the result of the UMISC conference being moved online in 2020, due to COVID-19.
- Move $200 from *Other-Out of State Travel* to *Professional/Technical/Service Contracts-Chemical Analysis*, decreasing the *Other-Out of State Travel* budget from $200 to $0. Budget savings in *Other-Out of State Travel* are due to travel restrictions posed by COVID-19.
- Move $300 from *Other-Thum Travel* to *Professional/Technical/Service Contracts-Chemical Analysis*, decreasing the *Other-Thum Travel* budget from $300 to $0. Budget savings in *Other-Thum Travel* are due to travel restrictions posed by COVID-19.
- Move $400 from *Other-Repairs* to *Professional/Technical/Service Contracts-Chemical Analysis*, decreasing the *Other-Repairs* budget from $1,575 to $1,175. Budget savings in *Other-Repairs* is the result of lower than expected repair and maintenance costs for field equipment.

Amendment 13:
Subproject 30 – Reallocate $16,238 from Subproject 30 Indiana University (IU) budget to new Subproject 30 UMN budget to provide for hiring two research field technicians in Minnesota, to complete Minnesota field work in the 2021 field season. Due to COVID-19 restrictions, the research team was unable to collect data in 2020. Hiring technicians to complete the Minnesota portion of field work will reduce overall travel costs to the subproject and provide additional personnel support to collect needed data in a condensed 2021 field season. MAISRC will serve as a partner on this project to co-supervise and administer funds for Minnesota-based staff. Muthukrishnan will remain the primary PI of Subproject 30 and will oversee all Minnesota field work.

This amendment will reduce the overall Subproject 30 IU budget from $39,000 to $22,762 and create a new Subproject 30 UMN budget with a total of $16,238. The amendment will impact the subproject budgets as follows:

- Move $5,420 from the Subproject 30 IU budget in *Travel Expenses in Minnesota-Year 1* to the Subproject 30 UMN budget in *Personnel*, decreasing the Subproject 30 IU *Travel Expenses in Minnesota-Year 1* budget from $10,145 to $4,725 and increasing the Subproject 30 UMN *Personnel* budget from $0 to $5,420. Budget savings in Subproject 30 IU *Travel Expenses in Minnesota-Year 1* are the result of a cancelled 2020 field season, due to COVID-19.
- Move $8,318 from the Subproject 30 IU budget in *Travel Expenses in Minnesota-Year 2* to the Subproject 30 UMN budget in *Personnel*, decreasing the Subproject 30 IU *Travel Expenses in Minnesota-Year 2* budget from $22,855 to $14,537 and increasing the Subproject 30 UMN *Personnel* budget from $5,420 to $13,738. Budget reductions in Subproject 30 IU *Travel Expenses in Minnesota-Year 2* will be offset by additional personnel hired for the 2021 field season.
- Move $2,500 from the Subproject 30 IU budget in *Travel Expenses in Minnesota-Year 2* to the Subproject 30 UMN budget in *Travel Expenses in Minnesota*, decreasing the Subproject 30 IU *Travel Expenses in Minnesota-Year 2* budget from $14,537 to $12,037 and increasing the Subproject 30 UMN *Travel Expenses in Minnesota* budget from $0 to $2,500. Budget reductions in Subproject 30 IU *Travel Expenses in Minnesota-Year 2* will be offset by Minnesota-based personnel that will be hired for the 2021 field season.

Amendments Approved by LCCMR: **03/26/2021**

Amendment Request April 28, 2021

Amendment 1:
Subproject 1 – Move $250 from *Supplies-Lab and/or Field* to *Services-Office and Gen Oper* to provide for U.S. Postal Service shipping costs, to ship reusable spiny water flea cleaning cloths to local stakeholders. MAISRC staff have been assisting with the rollout of the spiny water flea PR campaign in Subproject 15. Due to COVID-19 related travel restrictions, MAISRC staff are unable to deliver the reusable cloths in person and to maintain safety protocols, will ship them to campaign partners. This amendment will impact the subproject budget by decreasing the *Supplies-Lab and/or Field* budget from $25,500 to $25,250 and increasing the *Services-Office and Gen Oper* budget from $8,000 to $8,250. Budget savings in *Supplies-Lab and/or Field* is the result of lower than anticipated lab and field supply costs.

Amendment 2:
Subproject 4.3 – Increase the *Personnel* budget from $140,754 to $142,576 (net +$1,822) to provide for additional personnel time to complete project objectives. The cost of personnel time or this subproject is slightly higher than was originally projected in the subproject budget. This amendment will reallocate savings from other expense lines and will impact the subproject budget as follows:

- Move $1,283 from *Professional/Technical/Service Contracts* to *Personnel*, decreasing the *Professional/Technical/Service Contracts* budget from $8,00 to $6,717. Budget savings in *Professional/Technical/Service Contracts* is the result of lower than anticipated costs from National Socio-Environmental Synthesis Center (SESYNC) for PIT data analysis.
- Move $495 from *Equipment/Tools/Supplies-Materials* to *Personnel*, decreasing the *Equipment/Tools/Supplies-Materials* budget from $12,180 to $11,685. Budget savings in *Equipment/Tools/Supplies-Materials* is the result of lower than anticipated costs for PIT antenna materials, waders, nets, batteries, solar panels, etc.

- Move $44 from *Equipment/Tools/Supplies-Fuel* to *Personnel*, decreasing the *Equipment/Tools/Supplies-Fuel* budget from $445 to $401. Budget savings in *Equipment/Tools/Supplies-Fuel* is the result of lower than anticipated costs for fuel for the boat and generator used on this project.

Amendments Approved by LCCMR: **05/07/2021**

Amendment Request May 14, 2021

Subproject 18.2 – Move $100 from *Travel Expenses in Minnesota-Field Travel* to *Printing* to allow for higher than anticipated shipping costs for sample processing. This amendment will impact the subproject budget by decreasing the *Travel Expenses in Minnesota-Field Travel* from $7,600 to $7,500 and increasing the *Printing* budget from $500 to $600. Budget savings in *Travel Expenses in Minnesota-Field Travel* is the result of lower than anticipated travel expenses, due to COVID-19 travel restrictions.

Amendment Approved by LCCMR: **05/20/2021**

Amendment Request June 16, 2021

Amendment 1:
Subproject 1 – Move $500 from *Repairs-Lab & Field* to *Services-Office & Gen Oper* to provide for higher than anticipated service fees for MAISRC printing, email newsletters, web hosting, and transcription services for MAISRC research dissemination videos. This amendment will impact the subproject budget by decreasing the *Repairs-Lab & Field* budget from $15,500 to $15,000 and increasing the *Services-Office & Gen Oper* budget from $8,250 to $8,750. Budget savings in *Repairs-Lab & Field* is the result of lower than anticipated repairs costs for MAISRC facilities and equipment.

Amendment 2:
Subproject 16.2 – Increase the *Travel Expenses in Minnesota-Field Travel* from $17,667 to $20,125 (net +$2,458) to provide for higher than anticipated field travel costs, due to COVID-19 travel restrictions. This amendment will reallocate savings from other expense lines and will impact the subproject budget as follows:

- Move $126 from *Personnel* to *Travel Expenses in Minnesota-Field Travel*, decreasing the *Personnel* budget from $138,449 to $138,323. Personnel time on the project will be adjusted slightly to account for increased field travel expenses.
- Move $888 from *Travel Expenses in Minnesota-MN AFS* to *Travel Expenses in Minnesota-Field Travel*, decreasing the *Travel Expenses in Minnesota-MN AFS* budget from $1,664 to $776. Budget savings in *Travel Expenses in Minnesota-MN AFS* is the result of lower than anticipated travel and conference costs.
- Move $614 from *Travel Expenses in Minnesota-Lake Association Meetings* to *Travel Expenses in Minnesota-Field Travel*, decreasing the *Minnesota-Lake Association Meetings* from $614 to $0. Budget savings in *Minnesota-Lake Association Meetings* is the result of COVID-19 travel restrictions and local meetings moving online.
- Move $830 from *Other-Travel-Domestic* to *Travel Expenses in Minnesota-Field Travel*, decreasing the *Other-Travel-Domestic* budget from $830 to $0. Budget savings in *Other-Travel-Domestic* is the result of COVID-19 travel restrictions and academic conferences moving online.

Amendment 3:
Subproject 18.2 – Increase the *MAISRC/UMN Facilities* budget from $3,377 to $3,891 (net +$514) to provide for higher than anticipated facility rental costs. This amendment will reallocate savings from other expense lines and will impact the subproject budget as follows:

- Move $22 from *Personnel* to *MAISRC/UMN Facilities*, decreasing the *Personnel* budget from $115,248 to $115,226. Personnel time on the project will be adjusted slightly to account for increased facility rental expenses.
- Move $30 from *Supplies* to *MAISRC/UMN Facilities*, decreasing the *Supplies* budget from $2,850 to $2,820. Budget savings in *Supplies* is the result of lower than anticipated supply costs.
- Move $100 from *Printing/Mailing* to *MAISRC/UMN Facilities*, decreasing the *Printing/Mailing* budget from $600 to $500. Budget savings in *Printing/Mailing* is the result of lower than anticipated printing and mailing costs.
- Move $288 from *Travel Expenses in Minnesota-Field Travel* to *MAISRC/UMN Facilities*, decreasing the *Travel Expenses in Minnesota-Field Travel* budget from $7,500 to $7,212. Budget savings in *Travel Expenses in Minnesota-Field Travel* is the result of lower than anticipated field travel costs.
- Move $74 from *Other-Repairs* to *MAISRC/UMN Facilities*, decreasing the *Other-Repairs* budget from $1,175 to $1,101. Budget savings in *Other-Repairs* is the result of lower than anticipated boat and gear repair costs.

Amendment 4:
Subproject 30 – We request a budget amendment and approval for travel by UMN research technicians to assist with field work at two study sites in Wisconsin and Indiana.

Subproject 30 is a collaboration between Indiana University and the University of Minnesota (UMN) to study the effects of climate change on invasion dynamics, specifically the invasive macroalgae starry stonewort. Overall, Subproject 30 has six study sites – four in Minnesota, one in Wisconsin, and one in Indiana – to study the invasion dynamics in the upper Midwest region. This project's primary funder is Indiana University, with additional ENRTF funding through MAISRC to support staff time, supplies, and travel for Minnesota field work and UMN-based staff.

We request approval to include $2,000 in additional travel/per diem funds in the Subproject 30 UMN budget for UMN-based staff to assist with field work at the Wisconsin and Indiana field sites. While this portion of field work will be outside of Minnesota, the data collected at the WI and IN sites contributes directly to the overall findings of the research and will benefit Minnesota by informing management within the state. Allocating funds for per diem for field work at the WI and IN sites will not increase the overall Subproject 30 budget and all per diem payments to UMN staff will be in compliance with UMN travel and reimbursement policies.

We request to move $2,000 in the Subproject 30 UMN budget from *Personnel* to *Other-Travel-Domestic* for the WI and IN per diem expenses, decreasing the *Personnel* budget from $13,738 to $11,738 and increasing the *Other-Travel-Domestic* budget from $0 to $2,000. Budget savings in *Personnel* is the result of lower than anticipated personnel costs.

Amendment Approved by LCCMR: **07/14/2021**

Project extended to June 30, 2022 by LCCMR 6/30/21 as a result of M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 18, legislative extension criteria being met.

Eighth Update August 31, 2021

As of June 30, 2021, five MAISRC subprojects have been completed on M.L. 2017:

Subproject 4.3: Developing carp removal schemes using social learning behaviors - Dr. Przemek Bajer

Subproject 8.2: Impacts of invader removal on native vegetation recovery - Dr. Daniel Larkin

Subproject 12.2: Historical analyses of spiny water flea invasion patterns - Dr. Donn Branstrator

Subproject 18.2: Genetics to improve hybrid and Eurasian watermilfoil management - Dr. Ray Newman

Subproject 24: Genetic method for control of invasive fish species - Dr. Michael Smanski

Final report summaries for each project are included below and abstracts will be submitted directly to LCCMR staff. One additional subproject, which was completed on June 30, 2021 and funded through alternate funding sources (non-ENRTF funds), is not included in this report:

Subproject 7.3: Evaluation of koi herpesvirus for use as a potential biocontrol agent for common carp in Minnesota - Dr. Nicholas Phelps

Due to the challenges and delays posed by COVID-19, MAISRC approved extensions for four subprojects on M.L. 2017:

Subproject 15: Determining Highest Risk Vectors of Spiny WaterFlea Spread - Dr. Valerie Brady (6-month extension)

Subproject 16.2: AIS impacts on walleye populations and mercury concentrations - Dr. Gretchen Hansen (6-month extension)

Subproject 23: AIS Management: An Eco-economic Analysis of Ecosystem Services - Dr. Amit Pradhananga (6-month extension)

Subproject 30: Managing Midwestern aquatic invasions in a changing climate - Dr. Ranjan Muthukrishnan (1 year extension)

These extensions do not increase the overall budget of the subprojects and were included as a part of MAISRC's no-cost extension in the Environment and Natural Resources Trust Fund extensions in M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 18. Progress reports for each extended subproject will continue to be included as a part of reporting on M.L. 2017.

Amendment Request August 31, 2021

Amendment 1:
Subproject 4.3 - Move the $41 balance from completed Subproject 4.3 to MAISRC Reserves, increasing the MAISRC Reserves balance from $260,038 to $260,079.

Amendment 2:
Subproject 8.2 - Move the $4,005 balance from completed Subproject 8.2 to MAISRC Reserves, increasing the MAISRC Reserves balance from $260,079 to $264,084.

Amendment 3:
Subproject 12.2 - Move the $3,568 balance from completed Subproject 12.2 to MAISRC Reserves, increasing the MAISRC Reserves balance from $264,084 to $267,652.

Amendment 4:
Subproject 1 - Move $500 from *Professional Services & Contracts* to *Services-Office & Gen Oper* to provide for additional funds to ship Stop Spiny Water Flea cloths to distribution partners throughout the state. MAISRC outreach staff have taken on distribution activities in support of Subproject 15. This amendment will impact the Subproject 1 budget by decreasing the *Professional Services & Contracts* budget from $1,150 to $650 and increasing the *Services-Office & Gen Oper* budget from $8,750 to $9,250. Savings in the *Professional Services & Contracts* budget are due to the lack of fees/honoraria for guest speakers during the project period.

Amendment 5:
Subproject 1 - Increase the *Personnel* budget from $780,000 to $1,095,000 (net +$315,000) to provide for the extension of MAISRC Core Operations through June 30, 2022 (M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 18). This additional funding for staff time will allow MAISRC staff to continue supporting projects that

have been extended on M.L. 2017, disseminate research findings from subprojects that have been recently completed on M.L. 2017, and build research capacity on key species like common carp. This amendment will increase the overall budget of Subproject 1 and will impact the budget as follows:

- Move $21,452 from *Supplies-Lab and/or Field* to *Personnel*, decreasing the *Supplies-Lab and/or Field* budget from $25,250 to $3,798 and increasing the *Personnel* budget from $780,000 to $801,425. Budget savings in *Supplies-Lab and/or Field* are the result of lower than anticipated supply costs.
- Move $7,725 from *Equipment-Non-Capital* to *Personnel*, decreasing the *Equipment-Non Capital* budget from $8,000 to $275 and increasing the *Personnel* budget from $801,425 to $809,177. Budget savings in *Equipment-Non-Capital* are the result of lower than anticipated equipment costs.
- Move $32 from *Telecommunications* to *Personnel*, decreasing the *Telecommunications* budget from $350 to $318 and increasing the *Personnel* budget from $809,177 to $809,209. Budget savings in *Telecommunications* are the result of lower than anticipated communications costs.
- Move $650 from *Professional Services & Contracts* to *Personnel*, decreasing the *Professional Services & Contracts* budget from $650 to $0 and increasing the *Personnel* budget from $809,209 to $809,859. Budget savings in *Professional Services & Contracts* are the result of lower than anticipated service costs.
- Move $11,101 from *Repairs-Lab & Field* to *Personnel*, decreasing the *Repairs-Lab & Field* budget from $15,000 to $3,899 and increasing the *Personnel* budget from $809,859 to $820,960. Budget savings in *Repairs-Lab & Field* are the result of lower than anticipated repair costs.
- Move $3,407 from *Rentals* to *Personnel*, decreasing the *Rentals* budget from $10,000 to $6,593 and increasing the *Personnel* budget from $820,960 to $824,367. Budget savings in *Rentals* are the result of lower than anticipated facility rental costs.
- Move $2,981 from *Travel* to *Personnel*, decreasing the *Travel* budget from $16,000 to $13,019 and increasing the *Personnel* budget from $824,367 to $827,348. Budget savings in *Travel* are the result of lower than anticipated travel costs.
- Move the $267,652 balance in MAISRC Reserves to Subproject 1 *Personnel*, decreasing MAISRC Reserves from $267,652 to $0 and increasing the Subproject 1 *Personnel* budget from $827,348 to $1,095,000.

Amendment 6:
Subproject 1 - We request approval for MAISRC researcher Przemek Bajer, to spend a portion of his time paid by Subproject 1 to collaborate on a common carp removal effort on Lake Allegan in Michigan (0.25 FTE). This is the largest common carp removal project conducted to date, larger than any removal efforts in Minnesota, and involves 1,000 marked carp, 12 data monitoring stations, and 24 baited nets lifted over 200 times. A successful pilot effort in 2020 removed more than 55,000 carp. The 2021 removal effort is being conducted by private companies and the U.S. Environmental Protection Agency.

While this project is outside of Minnesota, the removal effort builds on and tests some of the removal methods that Bajer has developed with MAISRC as a part of multiple phases of Subproject 4. While the work in Lake Allegan focuses on physical carp removal, multiple analyses could be conducted to address key data gaps in carp behavior and how it could be utilized in management. Addressing these data gaps would benefit future carp removal efforts in Minnesota. Specifically, Bajer's participation in the removal project would allow MAISRC to analyze the collected data to determine:

- How carp populations respond to repeated removal events over several month period
- Net avoidance behaviors –how individual carp respond to nets being set for removal
- How quickly new groups of carp can be attracted to bait and removed following previous removal attempts

These analyses were not included in past MAISRC research because these projects included only a few removal events per trap (usually 3), while this project will involve up to 15 removal events per each trap in 24 different traps. Results from the MI project will benefit MN common carp removal by helping MAISRC and MN AIS

managers hone efficient and effective management techniques for common carp across the state. Particularly in large water systems (>1,000 acres) in southern Minnesota. Results will be published in a peer-reviewed journal and disseminated through MAISRC's communications channels and will help to inform the new *MAISRC Subproject 4.4: Acoustic conditioning in common carp to accelerate removal and reduce cost* (M.L. 2021) which will launch on January 1, 2022.

The total cost of Bajer's participation in the project will be $21,550 in salary expenses and will not impact the overall budget of Subproject 1. If approved, we will provide a summary of the MI project results and impact on common carp removal methods in our February 2022 progress report.

Amendment 7:
Subproject 15 - Extend the completion date of Subproject 15 from June 30, 2021 to December 31, 2021. Due to delays associated with COVID-19, Subproject 15 requires additional time to complete Activity 2 outreach outcomes as a part of the Stop Spiny Water Flea campaign. In addition, this year's warm fall season and warmer water temperatures have extended spiny water flea season. The invasive zooplankton is still active in many MN lakes and is predicted to be present in recreational areas into November. Extending the end date of Subproject 15 will not increase the overall budget and will impact Activity 2 outcomes as follows:

- Adjust the completion date of Activity 2, Outcome 1 from March 2021 to November 2021 to allow for continued towel distribution through the end of fishing and spiny water flea season.
- Adjust the completion date of Activity 2, Outcome 2 from March 2021 to November 2021 to allow for continued online PSA ad distribution through the end of fishing and spiny water flea season.

Amendment 8:
Subproject 15 - In the February 28, 2021 amendment for Subproject 15, we erroneously moved additional funds into *Professional/Technical/Services-PSA Ads*, instead of increasing the funds allocated to the purchase and printing of additional Stop Spiny Water Flea cloths. As a part of Subproject 15, cellulose "Swedish" dish cloths were identified as the recommended tool for cleaning spiny water flea from fishing and recreational gear. These cloths have been tremendously popular and MAISRC and the Subproject 15 team have distributed more than 10,000 of them throughout Minnesota. We request an amendment to correct the error in the rebudget from February 2021.

We request to increase the *Equipment/Tools/Supplies-General Operating* budget from $1,650 to $7,089 (net +$5,439) to provide for the purchase of additional cloths for distribution to boaters and anglers throughout the state. This amendment will impact the subproject budget as follows:

- Move $1,450 from *Professional/Technical Services and Contracts-Printing* to *Equipment/Tools/Supplies-General Operating*, decreasing the *Professional/Technical Services and Contracts-Printing* budget from $3,400 to $1,950 and increasing the *Equipment/Tools/Supplies-General Operating* budget from $1,650 to $3,100. Budget savings in *Professional/Technical Services and Contracts-Printing* is the result of ordering additional cloths from a distributor who printed the cloths with spiny water flea messaging as a part of the cloth order, rather than having them printed by a third party.
- Move $3,989 from *Professional/Technical/Services-PSA Ads* to E*quipment/Tools/Supplies-General Operating*, decreasing the *Professional/Technical/Services-PSA Ads* budget from $8,000 to $4,011 and increasing the E*quipment/Tools/Supplies-General Operating* budget from $3,100 to $7,089. Budget savings in *Professional/Technical/Services-PSA Ads* is the result of the error in our February 2021 amendment request.

Amendment 9:
Subproject 15 - Increase the *Professional/Technical/Services-PSA Ads* budget from $4,011 to $4,220 (net +$209) to provide for additional PSA ads to run through September. Additional PSA funding will allow our team to reach boaters and anglers in key areas around the north shore of Lake Superior, Mille Lacs, Lake Vermillion, and Lake

of the Woods at the end of fishing and spiny water flea season. This amendment will impact the subproject budget as follows:

- Move $143 from *Personnel* to *Professional/Technical/Services-PSA Ads*, decreasing the *Personnel* budget from $11,998 to $11,855 and increasing the *Professional/Technical/Services-PSA Ads* budget from $4,011 to $4,154. Budget savings in *Personnel* is the result of lower than anticipated personnel costs. MAISRC communications staff (Subproject 1) will be administering the PSA ads through the end of the project period.
- Move $66 from *Travel-MN: Outreach* to *Professional/Technical/Services-PSA Ads*, decreasing the *Travel-MN:Outreach* budget from $363 to $297 and increasing the *Professional/Technical/Services-PSA Ads* budget from $4,154 to $4,220. Budget savings in *Travel-MN: Outreach* is the result of lower than anticipated travel costs for outreach and dissemination of research findings.

Amendment 10:
Subproject 15 - We request approval to extend the reach of a portion our Stop Spiny Water Flea campaign PSA ads into Wisconsin, along the south shore of Lake Superior. Specifically, to spend $300 of the remaining $925 PSA budget for online ads targeted to the Superior, Ashland, and Bayfield areas of Wisconsin. This allocation would allow us to reach up to 150,000 people in the area.

This season, Subproject 15 researchers have received multiple reports of large spiny water flea populations along the south shore of Lake Superior. This is concerning for Minnesota ecosystems because of the transfer of fishing equipment across the border when anglers move from the south shore of Lake Superior in WI to the north shore in MN. Extending the reach of our PSA ads would provide critical messaging on AIS prevention to anglers along the south shore and would benefit Minnesota's natural resources by taking an ecosystem-level approach to AIS outreach along Lake Superior and preventing spread to nearby, uninfected lakes in Minnesota.

The balance of PSA funds ($625) will be used to target online ads to areas in Minnesota where fishing and recreation is still occurring in spiny water flea infested areas, including the north shore of Lake Superior, Mille Lacs, Lake Vermillion, and Lake of the Woods.

Amendment 11:
Subproject 16.2 - Extend the completion date of Subproject 16.2 from June 30, 2021 to December 31, 2021. Due to delays associated with COVID-19, Subproject 16.2 requires additional time to complete data analysis in Activity 1 and Activity 2. This extension will not increase the overall budget of Subproject 16.2 and will impact project outcomes as follows:

- Adjust the completion date of Activity 1, Outcome 2 from June 30, 2021 to December 31, 2021 to allow for analysis of the effects of zebra mussels on walleye recruitment and the evaluation of lake characteristics that increase walleye population resilience.
- Adjust the completion date of Activity 2, Outcome 8 from June 30, 2021 to December 31, 2021 to determine how much food/energy comes from nearshore versus open water habitats contributes to walleye production and how this varies with invasion status.
- Adjust the completion date of Activity 2, Outcome 9 from June 30, 2021 to December 31, 2021 to determine how mercury concentrations and pathways vary with invasion status.

Amendment 12:
Subproject 23 - Extend the completion date of Subproject 23 from June 30, 2021 to December 31, 2021. Due to delays associated with COVID-19, Subproject 23 requires additional time to complete data analysis in Activity 3. This extension will not increase the overall budget of Subproject 23 and will impact project outcomes as follows:

- Adjust the completion date of Activity 3, Outcome 4 from December 31, 2020 to December 31, 2021 to allow for a full cost-benefit analysis and dissemination of results.

Amendment 13:
Subproject 23 - Move $16 from *Equipment/Tools/Supplies-Survey Printing and Mailing* to the *Equipment/Tools/Supplies-Printing Training Materials* budget to provide for unanticipated costs of printing nametags for onsite surveyors. This amendment will impact the subproject budget by decreasing the *Equipment/Tools/Supplies-Survey Printing and Mailing* budget from $17,000 to $16,984 and increasing the *Equipment/Tools/Supplies-Printing Training Materials* from $0 to $16.

Amendment 14:
Subproject 30 - Extend the completion date of Subproject 30 from June 30, 2021 to June 30, 2022. Due to significant delays associated with COVID-19, Subproject 30 requires additional time to complete field work and data analysis in Activities 1-3. This extension will not increase the overall budget of Subproject 30 and will impact project outcomes as follows:

- Adjust the completion date of Activity 1, Outcome 2 from October 2020 to October 2021 to allow for the completion of field work.
- Adjust the completion date of Activity 1, Outcome 3 from September 2020 to June 2022 to allow for the complete evaluation of invasion dynamics.
- Adjust the completion date of Activity 1, Outcome 4 from August 2020 to June 2022 to allow for the complete evaluation of environmental determinants.
- Adjust the completion date of Activity 1, Outcome 5 from February 2021 to June 2022 to allow for data analysis and the synthesis of results.
- Adjust the completion date of Activity 2, Outcome 2 from June 2021 to June 2022 to allow for the complete analysis of stakeholder interviews.
- Adjust the completion date of Activity 3, Outcome 1 from December 2020 to June 2022 to allow for complete model development.
- Adjust the completion date of Activity 3, Outcome 2 from June 2021 to June 2022 to allow for the simulation testing of the model.

Amendment 15:
Subproject 30 - Move $952 from *Travel Expenses in Minnesota* to *Personnel* to provide for higher than anticipated personnel costs for field work in the 2021 season. This amendment will impact the subproject budget by decreasing the *Travel Expenses in Minnesota* budget from $2,500 to $1,548 and increasing the *Personnel* budget from $11,738 to $12,690. Budget savings in *Travel Expenses in Minnesota* are the result of lower than anticipated per diem costs for Minnesota-based field work.

Amendment 16:
Subproject 30 - Move $538 from *Travel Expenses in Minnesota* to *Other-Travel Domestic* to provide for higher than anticipated per diem costs for Wisconsin and Indiana field work in the 2021 season. This amendment will impact the subproject budget by decreasing the *Travel Expenses in Minnesota* budget from $1,548 to $1,010 and increasing the *Other-Travel Domestic* budget from $2,000 to $2,538. Budget savings in *Travel Expenses in Minnesota* are the result of lower than anticipated per diem costs for Minnesota-based field work.

Amendment 17:
Subproject 16.2 – Increase the *Personnel* budget from $138,323 to $142,961 (net +$4,638) to provide for higher than anticipated personnel costs to process and analyze project data. This amendment will impact the subproject budget as follows:

- Move $4,369 from *Professional/Technical/Service Contracts* to *Personnel*, decreasing the *Professional/Technical/Service Contracts* budget from $26,775 to $22,406 and increasing the *Personnel* budget from $138,323 to $142,692. Budget savings in *Professional/Technical/Service Contracts* is the result of a smaller number of samples needing to be processed by UC Davis than was originally planned.

- Move $269 from *Supplies-Lab and/or Field: Isotope Processing* to *Personnel*, decreasing the *Supplies-Lab and/or Field: Isotope Processing* budget from $7,435 to $7,166 and increasing the *Personnel* budget from $142,692 to $142,961. Budget savings in *Supplies-Lab and/or Field: Isotope Processing* is the result of a smaller number of isotope samples being collected than originally planned.

Amendments Approved by LCCMR: **11/15/2021**

Ninth Update February 28, 2022

As of December 31, 2021, three MAISRC subprojects have been completed on M.L. 2017:

- Subproject 15: Determining highest risk vectors of spiny water flea spread - Dr. Valerie Brady
- Subproject 16.2: AIS impacts on walleye populations and mercury concentrations - Dr. Gretchen Hansen
- Subproject 23: AIS Management: An Eco-economic Analysis of Ecosystem Services - Dr. Amit Pradhananga

Final report summaries for each project are included below and abstracts will be submitted directly to LCCMR staff.

With the approval of MAISRC's no-cost extension that was incorporated in the Environment and Natural Resources Trust Fund extensions in M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 18, MAISRC has continued to support ongoing subprojects and dissemination on M.L. 2017, as a part of Subproject 1: MAISRC Core Operations.

Amendment Request February 28, 2022

Amendment 1:
Subproject 16.2 - Move the $10 balance from completed Subproject 16.2 to MAISRC Reserves, increasing the MAISRC Reserves balance from $0 to $10.

Amendment 2:
Subproject 23 - Move $117 balance in *Personnel* to *Equipment/Tools/Supplies-Survey Printing and Mailing* to provide for higher than anticipated printing and mailing costs. This amendment will impact the subproject budget by decreasing the *Personnel* budget from $83,097 to $82,980 and increasing the *Equipment/Tools/Supplies-Survey Printing and Mailing* budget from $16,984 to $17,101. The overall budget amount of Subproject 23 will not be affected.

Amendment Approved by LCCMR: **03/28/2022**

Final Report between project end (June 30) and September 15, 2022
As of June 30, 2022, the final MAISRC subprojects on M.L. 2017 has been completed:

- Subproject 1: MAISRC Core Operations
- Subproject 30: Managing Midwestern aquatic invasions in a changing climate - Dr. Ranjan Muthukrishnan

Final reports for each project are included below and abstracts will be submitted directly to LCCMR staff. MAISRC continued to support Subproject 30 and research dissemination on M.L. 2017, as a part of Subproject 1: MAISRC Core Operations, through June 30, 2022.

Amendment Request September 15, 2022

Amendment 1:

Subproject 15 – Move $205 from Personnel to Professional/Technical/Services and Contracts-PSA Ads to provide for an accounting error in the Subproject 15 Final Report. This error was made due to a reporting discrepancy internally at the University of Minnesota. The amendment will decrease the Personnel budget from $11,855 to $11,650 and increase the Professional/Technical/Services and Contracts-PSA Ads budget from $4,220 to $4,425. However, the overall total expenses for Subproject 15 will remain the same with a total of $26,581 spent on the project.

Amendment 2:
Subproject 30 – Move $4,168 from Equipment/Tools/Supplies to Travel Expenses in Minnesota-Year 2 & 3 to account for higher than expected travel costs associated with the extension on Subproject 30. The one year, no-cost extension approved for Subproject 30 in November 2021 resulted in the ability to conduct a third field season in 2022. Despite planning for travel in a third year, expenses exceeded what was budgeted due to increased travel costs. This amendment will decrease the Equipment/Tools/Supplies budget from $6,000 to $1,832 and increase the Travel Expenses in Minnesota-Year 2 & 3 budget from $12,037 to $16,205. Budget savings in Equipment/Tools/Supplies is the result of the availability of supply funding through other funds contributed to the project. This amendment will not impact the overall budget amount of Subproject 30.

III. PROJECT ACTIVITIES AND OUTCOMES:

SUBPROJECT 1: MAISRC Core Operations

Project Manager: Nicholas Phelps

Organization: Minnesota Aquatic Invasive Species Research Center

Description:

Activity 1 –Leadership to facilitate AIS research and collaboration

MAISRC was formed to strengthen the state's capacity for solving AIS problems and to do so in a collaborative, coordinated, and stable environment that allowed for long term visions to be achieved. This is being achieved through the development and implementation of a strategic plan, annual Research Showcase, biennial research needs assessments, high faculty engagement, and a supportive culture for creativity and innovation. This could not be done without the core functions of the Center. The Center is an effective and efficient way to support research on AIS for many reasons. In Activity 1, MAISRC will continue to provide:

Physical infrastructure and shared equipment and lab staffing needed to enable the research – MAISRC operates a newly renovated 10,000 square foot state of the art lab facility and will provide staffing to maintain and repair the facility, assist researchers with experiment set up and organismal husbandry, and be on call to respond to emergencies that may threaten experimental organisms and research investments. Additionally, MAISRC staff will provide financial oversight and essential financial and grant reporting assistance to individual PIs. A portion of these costs will also be covered through individual research projects per the University's Internal Service Organization policy.

Leadership and direction, critical for establishing priorities and coordinating effective response – MAISRC staff oversee the organization's fulfillment of its strategic plan, including designing and implementing the biennial Research Needs Assessment and competitive grant processes; recruiting and positioning researchers for optimal response to emerging AIS threats; coordinating scientific peer review; working with the Center's Advisory Board and multi-agency technical committee; and working with the MN DNR, UMN Sea Grant and UMN Extension to coordinate outreach efforts.

Communication of research progress and implementation of science-based outreach programs to ensure results are translated into management action – MAISRC makes results of research available and translates findings in a

way that is not always possible for individual researchers to do on their own. In addition to traditional research communication (i.e. peer-reviewed manuscripts), MAISRC researchers provide opportunities to engage with stakeholders, such as at the annual MAISRC Research and Management Showcase event. MAISRC communications staff also amplify these efforts and make research progress and results accessible to the public and AIS managers through the web, newsletters, social media, seminars, webinars, brochures, and workbooks. MAISRC also supports the AIS Extension program, including development of training programs and curriculum. Through this work, as well as through our technical committees and coordination teams, we ensure translation of the latest science in ways that build statewide capacity to respond to Minnesota's AIS problems.

Opportunities for statewide cross-disciplinary research collaboration on and off campus – MAISRC creates a central focus for AIS research and has become well known for its efforts in prioritization and research productivity. This has resulted in new cross-disciplinary collaborations across the University, bringing together fields such as natural resource management, veterinary medicine, molecular biosciences, social science, genetics, and public health. Likewise, new collaborations have developed across the state and country with academic (i.e. UMD), government (i.e. USGS, watershed districts, counties), and stakeholder organizations (i.e. lake associations, AIS professionals) working together to address Minnesota's AIS problems. International scholars are also seeking opportunities to collaborate with MAISRC and visitors have come from around the world to work with our researchers. Creating an environment that supports and cultivates collaboration, and in turn builds cost-effective capacity, is a major focus of MAISRC and can be continued with this project.

MAISRC core operations are supported through June of 2019 from 2013 ENRTF. No other funding exists to support the Center beyond this time. With 2017 ENRTF funding, these critical Center functions will be extended for two more years (July 2019 – June 2021) and will be leveraged by University of Minnesota contributions to base salaries for tenure track faculty, space & utilities, HR functions, payroll etc. valued at approximately $1.4m.

Activity 2 – Advancing high priority and promising research to address AIS in Minnesota

Developing solutions to Minnesota's AIS threats requires a long-term strategic vision and coordination of research efforts. It also requires being nimble enough to respond to emerging threats. In Activity 2, MAISRC will launch and support 7-10 two-year projects addressing Minnesota's highest priority research needs.
All projects will have a goal of providing solutions to high priority AIS threats or filling key knowledge gaps needed for decision-making. These needs will be identified through MAISRC's comprehensive research needs assessment process that feeds into a competitive request for proposals that is open to all Minnesota-based research organizations. We anticipate that some of these projects, however, will be launched in "rapid response" mode, depending on the nature of research need, how the threat emerges, and the range of expertise on current MAISRC teams. This could include projects related to risk assessment and communication of genetic manipulation to control animal populations or assessment of rapid response plans to improve county-based programs.

Projects selected and supported will have a strong applied focus wherever possible, with the intention of rapidly addressing existing and emerging needs. As mentioned above, the research projects launched will be informed by our inclusive and comprehensive biannual Research Needs Assessment process, including alternate year updates. The 2016 process began with the interagency MAISRC Technical Committee (MTC) meeting to review priority species and make modifications based on the present science and status of threats. The list of identified priority species (n=40) was reviewed and supported by MAISRC's Center Faculty Group and Center Advisory Board – final list available upon request.

A request for input on research ideas to address these priority species was broadly disseminated to researchers, public stakeholders, AIS managers, and others, as well as from the DNR's AIS Advisory Committee. This process yielded 383 ideas from 239 individuals and organizations. To distill and prioritize this information, additional members were selected to join with the MTC and serve on the 2016 Research Needs Assessment Team. This team of 20 people includes leading researchers, federal, state, and local AIS managers, and diverse stakeholders

from across the state. An added emphasis this time was on cross species issues, which will be informed by social scientists, a DNR conservation officer, and others.

As an example, MAISRC's 2014-2015 Research Needs Assessment identified 14 high-priority needs related to control & management of priority species (n=6), preventing establishment & spread (n=4), and risk assessment & early detection (n=4). These priorities included research needs on species not currently receiving significant attention by researchers in Minnesota, including starry stonewort, spiny water fleas, hybrid milfoil, common reed, faucet snails, and quagga mussels. In a few cases, notably zebra mussels, there was a great need to significantly expand the scope of MAISRC's research. Several needs addressed systems (vs. species), such as multi-species surveillance approaches, evaluations of pathways that are vectors for multiple species, food-web impacts, and best practices for rapid response.

The 2016-2017 Research Needs Assessment process culminated in a list of research priorities that will feed a competitive request for proposals that will be made available to all Minnesota-based researchers, in and outside of the University of Minnesota system. Minnesota-based proposers may include in their teams researchers from outside the state in order to capture capacity not otherwise available.

Selection of projects will be informed by an internal and external review process with scientists and AIS managers familiar with current science and need. Each proposal will be evaluated based on relevance to priorities, potential impact, scientific approach, researcher experience, funding and effort requested, and support from AIS stakeholders. This process insures that the projects selected are high priority topics for the state of Minnesota that are both scientifically rigorous and have a high likelihood of contributing to effective, actionable, solutions. For high quality proposals that do not get selected for funding, the MAISRC Director will discuss the feedback with the investigators with the intent of building Minnesota's capacity and the potential for future collaborations.

Subproject 1 ENRTF FINAL BUDGET: ~~$920,000~~ $1,108,868

Outcomes	Completion Date
Activity 1	
1. Biannual research needs assessments completed; RFPs issued; peer reviews conducted; research results shared; research, trainings, and outreach performed; shared equipment procured and maintained; etc.	July 1, 2021
Activity 2	
1. Launch 7-10 scientifically rigorous research efforts for response to high priority AIS research needs	RFP #1: July 1, 2018 RFP #2: July 1, 2019
2. Specific research results, solutions identified	July 1, 2020
3. Specific research results, solutions identified	July 1, 2021

First Update February 28, 2018

No report necessary per LCCMR staff on 3/1/2018.

Second Update August 31, 2018

As a result of our 2017 Research Needs Assessment process and RFP, we reviewed, evaluated, peer reviewed, and approved six new subprojects, five of which (#20, 21, 23, 24, 26) completed work plans that were subsequently approved by LCCMR. The sixth workplan (Subproject 22) is still being developed and will be submitted to LCCMR for approval before the next status update.

As a result of our 2017 RFP, we have launched six new subprojects. Four of the new projects are two-year research projects that have split funding between 2013 ENRTF (year one) and 2017 ENRTF (year two). Year two activities and spending of 2017 ENRTF funds will begin on July 1, 2019.

Subproject 20: A Novel Technology for eDNA Collection and Concentration – Dr. Abdennour Abbas
Subproject 22: Copper-based control - zebra mussel settlement and non-target impacts – James Luoma
Subproject 23: AIS Management - An Eco-economic Analysis of Ecosystem Services – Dr. Amit Pradhananga
Subproject 24: Genetic method for control of invasive fish species – Dr. Michael Smanski

In addition, one subproject was reviewed through a separate process, as guided by our Managing Director Conflict of Interest in MAISRC Proposal Funding policy. This project and work plan were approved by the MAISRC Director Project Review Committee and LCCMR. As a two-year project, funding will be split between 2013 ENRTF (year one) and 2017 ENRTF (year two). Year two activities and spending of 2017 ENRTF funds will begin on July 1, 2019.

Subproject 25: What's In Your Bucket? Quantifying AIS Introduction Risk – Dr. Nicholas Phelps

Summaries of these awards are included below. Detailed descriptions of methods and outcomes are provided in their respective work plans.

In addition to launching new projects, MAISRC also approved the extension of Subproject 15: Determining Highest Risk Vectors of Spiny Water Flea Spread. This extension applies to Activity 2 of the subproject work plan and changes the project completion date to June 30, 2020. This extension does not increase the overall budget of the project, but will incorporate funding from M.L. 2017 to cover outreach activities occurring between July 1, 2019 and June 30, 2020. All activities will be completed by the M.L. 2013 deadline of June 30, 2019.

Third Update February 28, 2019

In the summer of 2018, MAISRC worked with our Technical Committee and Research Needs Assessment (RNA) Team to review and revise our list of priority species and generate research questions to guide our work over the next two years. Based on the results of the Research Needs Assessment process, MAISRC released our 2018 Request for Research Proposals (RFP) in November 2018. In total, we received 24 preproposals requesting more than $3.7 million in funding. To review the submitted preproposals, MAISRC assembled a review committee that included members from MAISRC's advisory board, the Minnesota DNR, and peer researchers. The committee made funding recommendations to the Director, which resulted in 10 preproposals advancing to the full proposal stage of project review. Once complete, full proposals will undergo external peer review before final funding awards are granted. In total, MAISRC anticipates allocating about $1.35 million to new and continuing projects as a part of the 2018 RFP. Funding sources include the Environment and Natural Resources Trust Fund, MAISRC's 2017 legislative appropriation, and non-sponsored donations.

In addition, Subprojects 20, 22, 23, 24, and 25 that were launched in August 2018 are well underway. Specific work plan updates for the first year of activities on these projects are included in MAISRC's M.L. 2013 report, but preparations for year two spending on M.L. 2017 are underway. Updates to lab facilities, resources, and staff time to support these projects and the 2018 RFP are reflected in the budget report attached.

Fourth Update August 31, 2019

As a result of our 2018 Request for Proposals (RFP), we reviewed, evaluated, peer reviewed, and approved ten new subprojects – eight that will be funded using 2017 ENRTF funds and two which will be funded by non-ENRTF funds. Seven of the new subprojects on M.L. 2017 completed work plans that have been approved by LCCMR:

Subproject 4.3: Social Learning and Carp Removal – Dr. Przemek Bajer
Subproject 8.2: Impacts of invader removal on native vegetation recovery – Dr. Daniel Larkin

Subproject 12.2: Historical analyses of spiny water flea invasion patterns – Dr. Donn Branstrator
Subproject 16.2: AIS impacts on walleye populations and mercury concentrations – Dr. Gretchen Hansen
Subproject 18.2: Genetics to improve hybrid and Eurasian watermilfoil management – Dr. Raymond Newman
Subproject 21.2: Field validation of multibeam sonar zebra mussel detection – Dr. Jessica Kozarek

Summaries of these awards are included below. Detailed descriptions of methods and outcomes are provided in their respective work plans. An eighth workplan (Subproject 30: Managing Midwestern aquatic invasions in a changing climate – Ranjan Muthukrishnan) is still being developed and will be submitted to LCCMR for approval before the next status update. Several of the projects included significant in kind and financial contributions from outside collaborators and funding agencies, thereby leveraging our ENRTF funds to do much more research than otherwise possible.

Two additional subprojects that were selected in the 2018 RFP will be funded through alternate funding sources (non ENRTF funds) and are not included in this report:

Subproject 7.3: Evaluation of koi herpesvirus for use as a potential biocontrol agent for common carp in Minnesota – Dr. Nicholas Phelps
Subproject 29: Will property values cool as AIS heat up? – Dr. Gretchen Hansen

Subproject 7.3 was reviewed through a separate process, as guided by our Managing Director Conflict of Interest in MAISRC Proposal Funding policy. This project and work plan were approved by the MAISRC Director Project Review Committee. Information and updates about Subprojects 7.3 and 29 can be found on the MAISRC website at https://www.maisrc.umn.edu/our-research.

Fifth Update February 28, 2020

Annual Request for Proposals (RFP)
In the fall of 2019, MAISRC made the strategic decision to shift our Request for Research Proposals (RFP) and subproject timeline from the fiscal year (July 1 through June 30) to the calendar year. This decision was made in order to alleviate administrative challenges and work more efficiently, better align our RFP within the larger ecosystem of research funding opportunities, and ensure that our research teams are able to utilize two full field seasons during the course of their two-year projects and make the most of MAISRC/ENRTF funding. On this new timeline, MAISRC activities occur as follows:

- January 2 -- RFP is released
- March 1 -- Deadline for pre-proposal submission, review committee begins evaluating pre-proposals
- April 1 -- Decision deadline for pre-proposals advancing to full proposal stage, full proposal development begins
- May -- Full proposals submitted for external peer review
- June -- Feedback is shared with researchers and final revisions are made to proposals
- August 1 -- Final approval of proposals, work plan development begins
- September - December -- Prep period for allocating awarded funds, resource coordination, research teams begin recruitment and project prep
- January 1 -- New subprojects begin and run for two full years (e.g. January 1, 2020 - December 31, 2021)

It is important to note that this shift in timeline only affects the relative dates of activities. MAISRC's established, robust, and thorough review process at the pre-proposal, full proposal, and work plan stages will remain the same.

In alignment with the new timeline, MAISRC released our 2020 RFP in January of this year. RFP priorities were largely based on the results of the Research Needs Assessment that was completed in summer 2018 (a biennial process), with review from the MAISRC Technical Committee, the Center Fellows Group, and the MAISRC

Advisory Board in summer 2019. In total, MAISRC anticipates allocating about $1.5 million to new and continuing projects as a part of the 2020 RFP. The primary funding source for the RFP is 2019 Environment and Natural Resources Trust Fund monies that have been allocated to MAISRC (M.L. 2019).

MAISRC Subprojects
MAISRC is currently supporting 14 subprojects on M.L. 2017. Summaries of the progress of these subprojects are included below. In addition, MAISRC is currently supporting 5 subprojects through alternate funding sources (non-ENRTF funds).

Priority Species List
This fall, MAISRC worked with our Technical Committee (MTC) to review and revise our list of priority species. The species review process resulted in a few modifications to the high priority species list for 2019/2020:

- Vertebrates: Added Zander (*Sander lucioperca*) to the priority list and Tench (*Tinca tinca*) to the evaluation list
- Microbes: Added Chytrid fungus to the priority list and carp edema virus (CEV) to the evaluation list; moved Spring viremia of carp virus (SVCV) from the priority list to the evaluation list
- Plants: Added Parrot feather (*Myriophyllum aquaticum*) to the evaluation list; moved Water chestnut (*Trapa natans*) from the priority list to the evaluation list

This revised Priority Species List was integrated into the 2020 RFP and will be revised again in 2020 as a part of the biennial Research Needs Assessment.

AIS Detectors Program
With the completion of the founding grant for the AIS Detectors program in July 2019 (M.L. 2013), we have transitioned the program to be an ongoing, long-term partnership between MAISRC and UMN Extension that is supported by non-ENRTF funds. The programs will continue to offer the AIS Detectors course as well as a number of additional educational and training programs. In 2019 AIS Detectors launched a new series of free webinars that provide updates on AIS research and management. Thus far, the webinars have been viewed over 1,000 times either live or recorded. Recordings of the webinars are available on the AIS Detectors website: https://www.maisrc.umn.edu/ais-detectors

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. MAISRC staff work in collaboration and coordination with many state and regional organizations including local watershed districts, county agencies, Minnesota DNR, MN Sea Grant, State AIS Advisory Committee and the Great Lakes ANS Panel. We also continue to spend considerable effort on communicating the outcomes of our research, which is discussed in more detail in the Dissemination section of this report.

Sixth Update August 31, 2020

Annual Request for Proposals (RFP)
In response to MAISRC's 2020 Request for Proposals (RFP) that was released in January, we received a total of 22 research proposals, requesting more than $3.4 million. Following review of pre-proposals, we encouraged multiple teams to come together on two different projects, which resulted in improved proposals, new collaborations, and more efficient use of ENRTF funds. After thorough evaluation and external peer review, we have approved 12 new subprojects -- 11 will be funded on M.L. 2019 and one will be funded through an alternate funding source (non-ENRTF funds). Summaries of the 2020 RFP selections are detailed in MAISRC's M.L. 2019 work plan.

MAISRC Subprojects

MAISRC is currently supporting 10 subprojects on M.L. 2017. Summaries of the progress of these subprojects are included below. In addition, MAISRC is currently supporting four subprojects through alternate funding sources (non-ENRTF funds).

Three subprojects on M.L. 2017 are now complete. Summaries of the projects' results and outcomes are included below.

Priority Species List
This spring, MAISRC worked with our Technical Committee (MTC) to review our list of priority species. This review was done in preparation for MAISRC's 2020 Research Needs Assessment. No additions were made to the Priority Species List during this review but MTC did advise updating the designation of Phragmites from "species localized in MN but that have spread and caused high impacts nearby" to "species widely distributed in MN, that cause high impacts and with control potential." The full Priority Species List can be viewed on our website: https://www.maisrc.umn.edu/about-ais

Biennial Research Needs Assessment (RNA)
This summer, MAISRC began our biennial Research Needs Assessment (RNA) which aims to collaboratively and systematically identify research needs related to high-priority AIS in Minnesota. The outcomes of the RNA process are used to guide MAISRC's future research investments to ensure meaningful contributions to research-based solutions for AIS prevention, control, and management.

The RNA process begins with a public survey, in which individuals indicate their species of top concern and submit research ideas for consideration. MAISRC then coordinates a committee of 20 local and national researchers and managers who bring their unique experiences and expertise to the table, to evaluate and prioritize the submitted research ideas. The committee's work culminates in a list of 20-25 of the highest priority research needs, which are then vetted by MAISRC's Fellows Group, MN DNR, and the MAISRC Advisory Board and used to develop MAISRC's competitive Requests for Proposals (RFPs) over the next two years.

This year's RNA survey is open until September 24: https://z.umn.edu/2020RNA

AIS Detectors Program
MAISRC continues to work in partnership with UMN Extension to run the AIS Detectors program. The 2020 AIS Detectors training workshops were cancelled this spring due to COVID-19, but the Detectors team continued to host free webinars that provide updates on AIS research and management. Thus far, the webinars have been viewed over 3,400 times either live or recorded. Recordings of the webinars are available on the AIS Detectors website: https://www.maisrc.umn.edu/ais-detectors

The Detectors team also completed revisions to our popular AIS Identification Guide. The newest version of the ID guide now includes a section on emergent, invasive plant species including yellow iris, narrow-leaf and hybrid cattail, and purple loosestrife. Hard copies of the AIS Identification Guide is available for purchase and a digital version is available as a free download on the Detectors website: https://www.maisrc.umn.edu/ais-detectors/ais-idguide

Additional new Detectors programming for 2020 included the debut of the first AIS Management 101 course, a fully online course designed to provide an introduction to options and strategies for managing AIS. Designed to empower citizens and lake residents with information to better understand and contribute to lake management decisions, 71 people completed the course and it received a very positive response in post-course assessments.

New MAISRC Staff
At the beginning of 2020, MAISRC welcomed two new members to our staff:

Meg Duhr, Research Outreach Specialist

Meg joined MAISRC after spending much of her career with the U.S. Fish and Wildlife Service and most recently served as the Integrated Pest Management specialist for Mid-Columbia River National Wildlife Refuge Complex in Eastern Washington. As our Research Outreach Specialist, her primary role is to translate research into action by serving as a bridge between MAISRC research and AIS managers. She works closely with research teams to identify project outcomes that address knowledge gaps and needs that have been identified by agency staff, AIS managers, policy makers, and other stakeholders.

Kristin Loobeek, Communications Specialist
Kristin joined MAISRC after serving the State of Minnesota for five and a half years at both the Department of Transportation and the Department of Natural Resources. As our Communications Specialist, her primary role is to communicate research progress and accomplishments to MAISRC's varied audiences, continue to develop robust platforms for the dissemination of MAISRC's research findings, and coordinate events like the Research & Management Showcase.

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. MAISRC staff work in collaboration and coordination with many state and regional organizations including local watershed districts, county agencies, Minnesota DNR, MN Sea Grant, State AIS Advisory Committee and the Great Lakes ANS Panel. We also continue to spend considerable effort on communicating the outcomes of our research, which is discussed in more detail in the Dissemination section of this report.

Seventh Update February 28, 2021

Annual Request for Proposals (RFP)
MAISRC released our 2021 RFP in January of this year. RFP priorities are based on the results of the comprehensive Research Needs Assessment that was completed in October 2020 (a biennial process), with review from the Center Fellows Group, MN DNR, and the MAISRC Advisory Board. In total, MAISRC anticipates allocating about $1.3 million to new and continuing projects as a part of the 2021 RFP. The primary funding source for the RFP is M.L. 2021 Environment and Natural Resources Trust Fund monies that are currently included in the 2021 ENRTF bill (HF 151/SF 690).

The 2021 MAISRC RFP is open until March 1: https://www.maisrc.umn.edu/2021rfp

MAISRC Subprojects
MAISRC is currently supporting 9 subprojects on M.L. 2017. Summaries of the progress of these subprojects are included below. In addition, MAISRC is currently supporting 12 subprojects on M.L. 2019 and 7 subprojects through alternate funding sources (non-ENRTF funds).

Four subprojects on M.L. 2017 are now complete. Summaries of the projects' results and outcomes are included below.

AIS Detectors Program
MAISRC continues to work in partnership with UMN Extension to run the AIS Detectors program. Since the program's inception, AIS Detectors have logged over 17,900 hours of volunteer service, a value estimated at over $495,000. In response to the COVID-19 pandemic, the AIS Detectors team have developed an entirely online version of the AIS Detectors training course ("AIS Detectors Core Course") that will debut in 2021 to avoid potential cancellations of future in-person programming. The online format also creates an opportunity to reach diverse audiences that would otherwise not be able in-person.

The AIS Detectors team hosted six free webinars in 2020 that provided updates on AIS research and management. The 2020 webinars were attended by 1,176 people and recordings of the webinars have been

viewed an additional 1,250 times online. A library of recorded webinars are available on the AIS Detectors website: https://www.maisrc.umn.edu/ais-detectors/webinars

In August of 2020, the AIS Detectors team hosted the fourth annual Starry Trek - a citizen science event organized to survey the state for starry stonewort. This year's event was successfully adapted to meet COVID-19 safety protocols and hosted over 210 volunteers to search 292 public accesses on 212 water bodies across Minnesota. As a result, one new infestation of starry stonewort was found on Carnelian Lake in Stearns County. In response, Minnesota DNR is working with Stearns County and Stearns County Coalition of Lake Associations to consider management options. In addition, one infestation of freshwater golden clams was found on Briggs Lake in Sherburne County, a surprise find given the location and age classes discovered. Consequently, MAISRC launched a one year, rapid response project (non ENRTF funds) in collaboration with Sherburne County to monitor the population and assess risk.

More information about the 2020 Starry Trek event and findings can be found on the Starry Trek website: https://www.maisrc.umn.edu/ais-detectors/starrytrek

AIS Explorer Workshops
Following the release of the AIS Explorer online dashboard (Subproject 31, non ENRTF funds), MAISRC led a series of training workshops for county and MN DNR AIS managers. Over the course of 9 workshops, MAISRC staff taught over 50 working managers how to use the AIS Explorer tool to inform their AIS prevention strategies. We explored detailed, realistic scenarios with participants and helped them see how to visualize and use the available data on watercraft movement throughout the state. A post-workshop survey of county managers indicated that the majority of workshop participants planned to use the AIS Explorer dashboard to support their decision-making in watercraft inspection and AIS surveillance planning. A majority of respondents also stated that the tool was straightforward to use and would help their work in planning AIS prevention efforts.

The AIS Explorer is publicly available: https://www.aisexplorer.umn.edu/#!/

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. MAISRC staff 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. We also continue to spend considerable effort on communicating the outcomes of our research, which is discussed in more detail in the Dissemination section of this report.

Eighth Update August 31, 2021

Annual Request for Proposals (RFP)
In response to MAISRC's 2021 Request for Proposals (RFP) that was released in January, we received a total of 4 research proposals, requesting around $800,000. This response and request amount is lower than average for MAISRC. However, it is in line with many other research granting organizations that experienced a drop in proposals in 2021. After consultation with the MAISRC Fellows, we expect that the decrease in requests was due in large part to COVID-19 impacts on research teams and decreased capacity to begin new lines of research.

After thorough evaluation and external peer review, we have approved 3 new subprojects which will be funded on M.L. 2021. Summaries of the 2021 RFP selections are detailed in MAISRC's M.L. 2021 work plan.

MAISRC Subprojects

MAISRC is currently supporting 4 subprojects on M.L. 2017 that received no-cost extensions due to COVID-19 delays. Summaries of the progress of these subprojects are included below. In addition, MAISRC is currently supporting 12 subprojects on M.L. 2019 and 4 subprojects through alternate funding sources (non-ENRTF funds).

Five subprojects on M.L. 2017 are now complete. Summaries of the projects' results and outcomes are included below.

AIS Detectors Program
The AIS Detectors program delivered multiple online educational programs in the first half of 2021. In early spring, 40 participants completed the 2021 session of AIS Management 101, a fully online, self-paced course to give participants the foundational knowledge and confidence to make aquatic invasive species management decisions. Since January, the AIS Detectors team has hosted a monthly series of virtual networking events called "Detector Connectors" to educate and foster community among AIS Detectors volunteers. The AIS Detectors team also hosted two free webinars in 2021 that provided updates on AIS research and management. The 2021 webinars were attended by 442 people and recordings of the webinars have been viewed more than 200 additional times online. A library of recorded webinars is available on the AIS Detectors website: https://www.maisrc.umn.edu/ais-detectors/webinars

The AIS Detectors team launched an online-only version of the AIS Detectors Core Course including a special learning track for AIS professionals taking the course. The AIS Detectors course relaunch included an updated online course and harnessed a variety of learning technologies to engage participants in virtual workshops where they could practice species identification, talk through role-play scenarios, and prepare for their role as AIS Detectors. Over the course of three virtual workshops, 51 participants completed the AIS Detectors Core Course, including 11 professionals. MAISRC and University of Minnesota Extension will continue their partnership to deliver AIS Detectors programming in both online and in-person formats in the coming year.

MAISRC Impact Map
MAISRC staff upgraded the MAISRC Impact Map, an online interactive platform that demonstrates MAISRC's reach throughout Minnesota and the locations of MAISRC research. Geospatial information that conveys the statewide scope of MAISRC's work is important for building and maintaining awareness and support among the public and our stakeholders across Minnesota. Over the last six months, MAISRC staff worked closely with U-Spatial, the University's geospatial science and visualization group, to produce a more sophisticated, user-friendly, and visually appealing "story map" that successfully conveys MAISRC's past projects and impacts around the state and can more easily incorporate our future projects.

This story map was completed in July and allows users to view and explore different statewide maps covering each subject area of research, as well as an overall map that displays the totality of MAISRC research. Users can easily turn on layers representing different research areas, as well as view the field project areas over time, from 2014-present. The map will be included on the new MAISRC website that will launch in late summer 2021.

The MAISRC impact map is currently publicly available online: https://z.umn.edu/MAISRCImpactMap

Zebra Mussel Rearing in the MAISRC Containment Lab
MAISRC launched a collaboration with the Minnesota Zoo's native mussel research team, to develop methods for rearing zebra mussels in the MAISRC Containment Lab. Currently, research on zebra mussels in Minnesota is limited to the open-water field season and cultivating zebra mussels in the lab has proven to be unsuccessful by many groups. By combining the Minnesota Zoo's successful methods for rearing native mussels in a laboratory setting, with MAISRC's expertise in zebra mussels and state-of-the-art facility, we hope to complete the zebra mussel life cycle under controlled conditions and dramatically expand future research opportunities for zebra mussels control research.

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. MAISRC staff 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. In addition, our research teams are highly connected with a diverse network of researchers from across the state, country and world in an effort to bring together collaborative teams, advance our science in complementary ways and avoid duplication of efforts. We also continue to spend considerable effort on communicating the outcomes of our research, which is discussed in more detail in the Dissemination section of this report.

Ninth Update February 28, 2022

MAISRC Subprojects
MAISRC is currently supporting one subproject on M.L. 2017. Summaries of the progress of this subproject are included below. In addition, MAISRC is currently supporting 12 subprojects on M.L. 2019, 3 subprojects on M.L. 2021, and 2 subprojects through alternate funding sources (non-ENRTF funds).

Three more subprojects on M.L. 2017 are now complete. Summaries of the projects' results and outcomes are included below.

Common Carp Removal on Lake Allegan, MI
In 2021, LCCMR approved MAISRC researcher Przemek Bajer, to spend a portion of his time paid by MAISRC to collaborate on a common carp removal effort on Lake Allegan in Michigan that was primarily conducted by private companies and the U.S. Environmental Protection Agency. The project represented the largest common carp removal effort with baited traps to date (1,452 acres) and showed that 54% of the population was removed in one season, with almost no native fish bycatch. The team learned that carp showed no evidence of learning how to avoid being captured in baited traps, and that their feeding aggregations re-formed in just four days after a net pull, allowing for multiple harvests through the season. Overall, a new method for removing carp in large lakes has been successfully tested with promising applications to Minnesota waters.

To conduct this removal effort, 1,000 carp were tagged throughout the lake with unique electronic tags and 26 baited nets were installed, 12 of which had antennas for tracking carp activity at the bait. Six 10-day rounds of removal were completed between June and October (308 individual net-pulls) catching 61,068 carp including 543 of the tagged carp. 54% of the population was removed and carp biomass was reduced from 340 kg/ha to 155 kg/ha in one season. Native fish bycatch was < 2%. Key information about carp behavior was collected. First, carp showed high site fidelity, 60.6% were detected at only one net and 95.1% were detected at three or fewer nets. Further, it took only 3.6 days for the carp to re-form new aggregations at the bait after removal. There was no statistical difference in the number of days a tagged carp was detected at the bait between captured and uncaptured carp –while not all carp that visited the bait were captured, there was no difference how the captured and uncaptured carp used the baited sites. Overall, this effort showed that the majority of carp inhabiting large lakes can be removed in one season using a method that is selective and scalable.

Results from the MI project will benefit MN common carp removal by helping MAISRC and MN AIS managers hone efficient and effective management techniques for common carp across the state. Particularly in large water systems (>1,000 acres) in southern Minnesota. Results from the removal effort will be published in a peer-reviewed journal and disseminated through MAISRC's communications channels and will help to inform MAISRC Subproject 4.4: Acoustic conditioning in common carp to accelerate removal and reduce cost (M.L. 2021) which will launched on January 1, 2022.

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.

Final Report between project end (June 30) and September 15, 2022
The Minnesota Aquatic Invasive Species Research Center (MAISRC) continued to develop research-based solutions that can reduce the impacts of AIS in Minnesota and advance AIS knowledge among natural resources managers, the research community, and the public. In total, 15 subprojects were supported from this project – significantly advancing our scientific understanding and ability to manage AIS. New tools have been developed and knowledge gaps filled on many of Minnesota's most important AIS, including zebra mussels, spiny water flea, bigheaded and common carps, and starry stonewort. The results of this work have been broadly disseminated via research reports, peer-reviewed manuscripts, fact sheets, white papers, news media, newsletters, social media, and direct stakeholder engagement through presentations, workshops/trainings, and public events. Highlights of project outcomes include identifying the highest risk methods of introduction and spread of spiny water flea and baitfish viruses, advancing innovative control tools for established AIS like zebra mussels and common carp, and defining the impact of AIS on ecosystems and sportfish populations. Throughout this project, MAISRC has continued to serve as a global leader in the field of AIS research and a go-to resource for managers, researchers, and members of the public.

This project also supported MAISRC's work to ensure the effectiveness and efficiency of a center-based research model. Progress in this area included an ongoing, comprehensive process for prioritizing research needs; stronger collaboration and coordination between researchers and managers; a competitive, peer-reviewed annual proposal competition; and increased communications and outreach capacity to help managers and community members translate research findings into on-the-ground management.

MAISRC continues to advance Minnesota's resiliency and ability to address AIS issues facing our state through research, collaboration, and stakeholder engagement. This project will continue with Phase II and III appropriations awarded in 2019 and 2021.

SUBPROJECT 4.3: Social Learning and Carp Removal

Project Manager: Przemek Bajer

Organization: University of Minnesota

Description: Overarching goal of this project is to develop a new way to effectively and selectively remove invasive common carp from Minnesota lakes. Selective, effective and safe methods are needed to remove large numbers of carp from lakes to restore water quality and ecological services. One method shows exceptional promise: carp can be selectively attracted with food to form large foraging aggregations that can be removed with specialized nets with high precision. However, to make these nets effective, we need to understand how to maximize carp foraging aggregations using two key social learning strategies: increasing access to bait to allow both frequent visitors (often "bold") and infrequent visitors (often "shy") to participate in foraging aggregations, and releasing individuals that might bring other carp to the aggregation. We will examine these strategies in four natural lakes. This work combines basic and applied research and will result in implementation-ready management strategies.

Subproject 4.3 ENRTF FINAL BUDGET: $189,475

Outcomes	Completion Date
Activity 1	
1. Year 1 experiment on carp baiting completed in lakes 1 and 2. Preliminary results available.	January 31, 2020
2. Year 1 results analyzed. Lakes selected for year-2 experiments.	July 31, 2020

3. Year 2 experiment on carp baiting completed in lake 3. Preliminary results available.	January 31, 2021
4. Final results from Year 1 and 2 available and analyzed.	July 31, 2021
Activity 2	
1. Year 1 experiment on releasing/removing leaders on carp removal completed in lakes 1 and 2 completed. Preliminary results available.	January 31, 2020
2. Year 1 results analyzed. Lakes selected for year-2 experiments.	July 31, 2020
3. Year 2 experiment on releasing re-captured tagged carp on carp removal in lake 3completed. Preliminary results available.	January 31, 2021
4. Final results from Year 1 and 2 available and analyzed.	July 31, 2021

Fifth Update February 28, 2020

During the summer of 2019, we PIT tagged 300 carp in both Parley Lake and Halstead's Bay of Lake Minnetonka. We also installed PIT antennas and dataloggers at two sites in each lake to collect continuous data on carp foraging dynamics. The sites were baited with corn daily for 3 months and data was collected throughout. Our results for Activity 1 showed that we attracted ~10% of the carp population to each site, that more bait piles at a site doesn't result in more carp attracted, individual carp participate in feeding aggregations differently, and local baiting attracts mostly local carp. Many carp at each site returned frequently to the site. These individuals are of great interest as we continue to analyze data because they might be key to helping other carp find bait sites or to further understanding individual differences in carp behavior. As planned, we conducted six removal attempts of carp from the baited sites in Parley and three in Halstead's in Activity 2. We captured 12% and 8% of the total estimated carp population in Parley Lake and Halstead's Bay, respectively. Of the 300 carp PIT tagged in Parley Lake and Halstead's Bay, 38 and 24, respectively, were recaptured during removal but only a few were recaptured more than once. No native fish were captured, showing the high selectivity of this method.

Overall, carp are strongly attracted to corn, but only ~10% of the population is attracted to each site, and many carp do not mix between sites. For long-term management applications (and for basic data on carp behavior) we propose changing the course of the experiment in 2020. We propose focusing on one lake (most likely Parley), but increasing the number of baited sites to 10. By doing so, we expect to attract the majority of carp in the lake to the bait (> 70%, as opposed to ~ 20% currently) and learn more about social dynamics of foraging and how individuals are connected within and between local populations. We would also be able to better test the effects of removal on carp behavior because more fish will be recaptured (see amendment).

Sixth Update August 31, 2020

Using data from the 2019 season, we were able to develop the first social network analysis for common carp populations in natural lakes. This is key because it provided a new understanding of how to remove carp from baited sites. We used detection data from 305 PIT tagged common carp in Parley Lake (2019) to quantify carp networks during feeding aggregation. Of the 305 tagged carp we have identified 12 that appear to be 'superfeeders' and may in fact be serving as potential social influencers or leaders of the feeding aggregations. These superfeeders were commonly detected at the feeding sites and were socially connected with others. We also found that carp have strong preference for a particular baited site. Perhaps even more importantly, we quantified the natural patterns with which carp feeding aggregations form and dissolve on a daily basis (feeding bouts). The results indicate that carp feeding aggregations are frequent but transient. For example, large aggregations (8 tagged carp or more) form 3-5 times each day but last less than 20 minutes. This shows that to remove carp effectively, integrated monitoring systems might be needed where data from the baited sites is analyzed in real time and nets can be activated remotely.

The second field season (2020) is underway and is going well. According to plan, we are focusing on a single lake in which 8 baited sites were installed. Preliminary data shows that of the 300 tagged carp in the system, 91 visited the baited sites already, after only 5 days of baiting. For the remainder of 2020, we will continue collecting detailed data on feeding aggregations (Activity 1) and test removal schemes (Activity 2). Results from

Year 1 are currently being written up as a manuscript, which will provide the first description of wild carp feeding aggregation dynamics.

Seventh Update February 28, 2021

The second field season was conducted as planned and focused on a single lake (Parley) in which 8 sites baited with corn were installed. At each site, electronic antennas continuously scanned for tagged carp. Despite the pandemic, we were able to collect daily detection data on how carp used these sites over 12 weeks and three removal events: July 23, August 14, and September 4, 2020. Similar to past research, carp detections increased rapidly after baiting began, from 4 unique carp during pre-baiting to over 60 unique carp per day once baiting commenced. During the baiting period we collected several hundreds of thousands of individual carp detection data that is being analyzed for social feeding dynamics to determine times when carp aggregations peak, forming and dissolving carp feeding bouts, and presence of frequent and infrequent site visitors within the population. Overall, 164 tagged carp were attracted to the baited sites, a majority of the population. Over the three removal efforts, 3,602 carp were captured, including 45 of tagged carp; we captured ~ 27% of the population. Native fish bycatch was < 1%. The experiment in Lake Parley showed that simple baiting strategies can be used to remove large portions of common carp populations in short amount of time without bycatch. We are now conducting analyses of individual carp detection data to determine how the removal strategies could be further optimized by lifting the nets during peaks of carp feeding bouts.

The research team gave presentations about this project at the North American Lake Management Society meeting in November 2020 The team also presented at MAISRC's 2020 Research and Management Showcase and gave an AIS Detectors webinar.

Recording of Showcase presentations online: https://z.umn.edu/2020ShowcasePresentations
Recording of the AIS Detectors webinars online: https://z.umn.edu/AISDetectorsWebinars

Final Report August 31, 2021

Common carp is a widespread, invasive fish that negatively impacts habitat and water quality in lakes. Practical and selective removal strategies are needed for carp. Previous research showed that bait can be used to selectively attract large numbers of carp in lakes. In this experiment, we documented how the carp are attracted to the bait (Objective 1; social structure) and whether they could be removed using nets (Objective 2). In a lake with multiple baiting sites (8 sites in a 258-acre lake) and 300 carp tagged with electronic tags, 54% of carp (164 tags) were attracted to the bait over the whole summer, and ~ 20% of population were attracted daily (60 tags). Some carp ("Superfeeders") visited baited sites nearly every day, while others only every few days. The Superfeeders were significantly larger than other carp. The carp visited the bait mainly at night. Feeding aggregations were very dynamic – individual feeding bouts included 2-9 tagged carp, lasted <1 minute to over 30 min, and continuously formed and dissolved for several hours each night. We attempted three removal events at the baited sites, on 3 separate nights, collectively capturing 27% of the population (3,602 carp). Native fish bycatch was <1% (released).

Our results indicated that carp foraging is social, easily induced by species-specific bait, dominated by large-bodied individuals, and predictable (nightly). However, only a fraction of carp attracted to the bait were removed because individual feeding groups visited that bait at different times of the night. We suggest that next steps should address how to synchronize carp aggregations at the bait to increase removal efficiency (starts in January 2022 using acoustic conditioning). This line of research resulted in carp removal methods that are already being applied in Minnesota, often involving volunteers to bait the carp. Future optimizations will increase the efficacy of this new management method.

SUBPROJECT 8.2: Impacts of invader removal on native vegetation recovery

Project Manager: Daniel Larkin

Organization: University of Minnesota

Description: To evaluate the ability of invasive aquatic plant control efforts to yield recovery of native aquatic plant communities we will 1) perform in-lake invader control experiments, 2) analyze monitoring data from hundreds of lake management projects previously conducted in MN, and 3) develop a publicly available statewide plant monitoring and management database. Each year, lake managers, lake associations, municipalities, and the Minnesota Department of Natural Resources (MNDNR) manage Eurasian watermilfoil (EWM) and curly-leaf pondweed (CLP) in hundreds of Minnesota lakes, principally through herbicide applications. These control efforts are motivated in part by the expectation that reducing invader abundance will restore native macrophyte communities (Jones et al., 2012). This "spray-and-pray" approach hinges on the little-tested assumption that it is competition from invaders that has displaced native species. Because aquatic invasive plant management often yields little recovery of native vegetation, we must revisit this assumption (Jones et al., 2012; Kujawa et al., 2017). It is crucial to understand when invader reductions do foster recovery of native plants vs. when other limitations may need to be overcome to restore lost diversity.

To test the influence of suppression by invasive species on native plants and their subsequent recovery following control, we will use a small-scale in-lake experiment to evaluate how native plants respond to invader removal, seed-addition, light availability, and the combination of these factors. We have previously shown that statewide CLP control efforts are effective at reducing CLP (Verhoeven et al., In revision), and parallel work in Wisconsin has shown similar results for EWM (Kujawa et al., 2017). But, critically, the effects of statewide EWM and CLP management on native vegetation recovery have not been evaluated in Minnesota. After adding to an existing dataset, we will evaluate native macrophyte responses over nearly 20 years of EWM/CLP management. Monitoring data compiled for the project will also provide the foundation for a publicly accessible database that, to our knowledge, will be the largest public dataset for aquatic plant management, a valuable resource for state, national, and global researchers and managers.

To advance our ability to predict native responses to invader reductions, we will perform experiments and analyze statewide monitoring data to evaluate the extent to which invasive species control yields recovery of native aquatic plant communities. This research will investigate multiple mechanisms likely to influence community assembly following invasive species management. In particular, we will elucidate the contexts in which competition, light availability, and dispersal limitation drive native-invader dynamics. Our approach to this question is robust in that we have paired highly controlled, mechanistic in-situ experiments with realistic, management-scale outcomes using synthesis and analysis of long-term, statewide monitoring data. By combining experiments with observational data collected over two decades and across hundreds of lakes, this project will deliver vital information for advancing effective, science-based AIS management in Minnesota.

By combining controlled field experiments with monitoring data collected over two decades and across hundreds of lakes, this project will deliver vital information for advancing effective, science-based AIS management in Minnesota.

Subproject 8.2 ENRTF FINAL BUDGET: $119,034

Outcomes	Completion Date
Activity 1	
1. Establish all experimental plots	August 31, 2019
2. Present preliminary findings at MAISRC Showcase	September 15, 2019
2. Finish applying treatments to all experimental plots	September 31, 2020
3. Analyze results of experimental removals for 2018-2021	June 30, 2021
Activity 2	
1. Incorporation of 2000-2018 data into database	July 31, 2020

2. Analysis of plant community response to CLP and EWM removal	October 15, 2020
3. Presentation to MNDNR	March 15, 2021
Activity 3	
1. Development of public access portal for data submission	November 15, 2020
2. Web portal training workshop	February 1, 2020
3. Web portal training webinar	April 1, 2021

Fifth Update February 28, 2020

In the first six months of this project we have completed components of each activity, and have begun to disseminate the findings from our work through outreach and publications. Summer field work included setup of 32 additional experimental plots, removal of more than 2000 lbs of invader biomass from 54 plots, and our first intensive seed collection effort. Despite staffing obstacles, our progress on the experimental work has positioned our team well for the 2020 field season, when a remaining 20 experimental plots will be established and final invader removal treatments will be paired with seed addition treatments. We have also made significant strides in the collection, organization, and merging of plant survey data from across the state, resulting in a plant database with nearly 20 years of occurrence data comprising more than 3000 surveys. We diplomatically, and ultimately successfully, navigated opposition to data sharing from some plant survey contributors using a Data Practices Act request. We now have coordinated data sharing with 64 entities, and by targeting consultants and organizations that conduct those surveys, we have reduced the number of organizations from which we must gather data to 19. While the dataset is continuing to grow, we have already begun to leverage these data in a manuscript aimed at understanding *how* CLP and EWM compete with natives as well as for MAISRC Subproject 29 (Will property values cool as AIS heat up), where it serves as the ecological foundation underlying a model of economic impacts of Eurasian watermilfoil.

Sixth Update August 31, 2020

Since our last project update we have completed significant laboratory and fieldwork for this project. The research team has developed workflows and protocols in both the lab and the field to minimize risk of COVID-19 transmission while meeting the data-collection needs for the project. Weekly COVID-19 safety meetings ensure our workplace and personnel are up to date on the most recent information regarding the coronavirus pandemic.

In February, our team collected and processed lake sediment and seedbank samples for all experimental plots by sampling through the ice (Figure 1). In early spring, seed mixes collected in fall 2019 underwent identification and viability testing, and the seeding treatments were applied to our experimental plots in late June. This summer we have completed curlyleaf pondweed removals, curlyleaf pondweed surveys, and Eurasian watermilfoil removals. This work marked the completion of all treatments in the field experiments. Beginning July 9, field crews are surveying all experimental plots to quantify the effects of invasive plant removals, seed additions, and water clarity on native plant communities.

The statewide plant survey database continues to grow, with a QA/QC check of our database against contributed data resulting in 142 additional plant surveys (resulting in a new total of 3,546 surveys). These data were used to evaluate the environmental niches use by curlyleaf pondweed and Eurasian watermilfoil; results indicate that the dominance of these two species likely arises through different mechanisms.

Figure 1: Project staff use an Ekman grab sampler mounted to a telescoping pole to collect sediment samples from each experimental plot through the ice. Winter sampling on the ice provides a stable platform and allows us to collect plant seeds and turions when they are dormant.

Seventh Update February 28, 2021

We have continued to make substantial progress on the project since our last update in July 2020. Summer field and lab work were successful, and our ability to get ahead on summer 2020 fieldwork allowed us to add components to the experimental project that will significantly improve the inferences that can be made from our findings. Importantly, our team continues to work diligently to embrace—and continually improve upon—the operational changes that enabled a safe, healthy, and effective team through the COVID-19 pandemic.

By the end of summer 2020 fieldwork, we had completed treatments in experimental plots, including: 1) invasive species removals, 2) native seed additions, and 3) native vegetative propagule additions. By late July 2020 we had finished the work outlined in our summer plan, and we were able to complete whole-lake point-intercept (PI) surveys of all study lakes. In August 2020 we added native propagules to experiment plots—this allowed us to put strong native revegetation pressure on the research plots, despite the challenges we encountered in overcoming dormancy-break requirements of the seed mixes (Figure 1). Overall, a successful 2020 field season has the team looking forward to 2021 in anticipation of the final data collection work for the project.

Figure 1. Vegetative propagule used to recolonize experimental plots with native macrophytes.

Following the summer 2020 field season, our team has begun the process of finalizing statewide data for publication as a public database. We are working now on a survey that will allow data contributors to review and verify metadata for the surveys submitted to-date and to verify personal information for inclusion as co-authors. This process has also given rise to a novel data product: a mapping tool that allows users to see which plant surveys exist for Minnesota lakes, including those that have and have not been shared with our database.

The research team gave presentations about this project to the MN DNR AIS Working Group and at MAISRC's 2020 Research and Management Showcase. A recording of the Showcase presentation is available online: https://z.umn.edu/2020ShowcasePresentations

Final Report August 31, 2021

Controlling dominant invasive aquatic plants is a common goal of many stakeholders around the state. These invader-reduction efforts are often motivated as ways to promote the health or recovery of native plant communities—but the potential for these efforts to actually meet those goals is uncertain. We hypothesized that, in addition to potential competitive effects of invasive species, insufficient water clarity and native plant recolonization can also be "rate-limiting" components of restoring lake vegetation. If so, these limitations must be addressed and invader control alone will be inadequate for restoration. We addressed this issue in two ways: (1) By evaluating responses of native plants to actual, on-the-ground management efforts in invaded lakes in MN through synthesis and analysis of monitoring data. This can tell us how management is working across the state at scales relevant to lake managers. (2) We compared those conclusions to results of field experiments designed to untangle how invaders, light limitation, and reproduction can hinder native plant recovery. Overall, our work resulted in the aggregation of more than 4,000 surveys that will be used to evaluate responses of native plants to curlyleaf pondweed, Eurasian watermilfoil, and the management of each of these AIS. The funding supported the completion of all experimental fieldwork, bringing four years of work to a conclusion. In short, our experiments and data synthesis reveal that native plant recovery following invader control is a realistic outcome—but only under certain conditions, i.e., where water clarity and propagule availability are sufficient to foster native plant recovery. In addition, our results show that Eurasian watermilfoil exerts a stronger negative effect on native plants than curlyleaf pondweed. Thus, control of Eurasian watermilfoil is more likely to foster native recovery than is control of curlyleaf pondweed. If lake management is to restore native macrophytes, it must target the factors that are limiting native species recovery, and we show that invasive species are one of multiple limiting factors in Minnesota lakes.

SUBPROJECT 12.2: Historical analyses of spiny water flea invasion patterns

Project Manager: Donn Branstrator

Organization: University of Minnesota Duluth

Description: Invasions by spiny water flea represent a potential major threat to the health of Minnesota lakes, yet we still do not understand the full extent of these threats and how many years they take to manifest. This project is a continuation of MAISRC Subproject 12 'Characterizing spiny water flea impacts using sediment records' (Phase I) that is ending June 30, 2019. The results of Phase I will advance our ability to test key cause-and-effect hypotheses about relationships between spiny water flea invasion and the response of important ecological, economic, and recreational services provided by Minnesota lakes including zooplankton abundance, fish abundance, and water clarity. The preliminary results of Phase I demonstrate that spiny water flea have been present in Lake Kabetogama and Lake Mille Lacs continuously since 1970. This timeline conflicts with currently recognized timelines of geographic invasion by spiny water flea in the region. Specifically, spiny water flea is widely thought to have first arrived in North America in the Laurentian Great Lakes during the late 1970s or early 1980s in cargo ship ballast water, and only later colonized inland Minnesota lakes by other vectors such as recreational boating.

While the validity of our preliminary results is supported by our use of widely published and vetted methods, the goal of this current subproject is to pursue three additional lines of analysis in order to help rule out artifacts associated with our methods and natural lake processes that could introduce ambiguity into the timeline of presence and abundance of spiny water flea in lake sediment cores. This will be accomplished through 1) measurements of the rates of lake sediment mixing in Lake Kabetogama and Lake Mille Lacs and 2) recovery of evidence of spiny water flea in lake sediment cores that were collected before the species was first detected in the open water plankton of three infested Minnesota lakes (Kabetogama, Rainy, and Trout) through the study of

previously collected and archived sediment core material. As a continuation of Phase I, we will also 3) estimate rates of production of spiny water flea in Lake Kabetogama and Lake Mille Lacs, and use the results to calibrate accumulation rates of spiny water flea in sediment cores. This third goal will be accomplished with in-kind support by the Minnesota Department of Natural Resources.

Subproject 12.2 ENRTF FINAL BUDGET: $53,795

Outcomes	Completion Date
Activity 1	
1. Retrieval and extrusion of cores	January 2020
2. Beryllium (^{7}Be) radioisotope dating of cores	January 2020
3. Determine an estimate for sediment mixing depths in Kabetogama and Mille Lacs lakes	January 2020
Activity 2	
1. Spiny water flea analysis of two sediment cores from Lake Kabetogama	January 2021
2. Spiny water flea analysis of one sediment core from each of Rainy Lake and Trout Lake	January 2021
3. Quantify spiny water flea presence in the sediments before it first appeared in the waters of Kabetogama, Rainy, and Trout lakes	January 2021
Activity 3	
1. Estimate historical production of spiny water flea in the waters of Kabetogama and Mille Lacs lakes	June 2021
2. Results of modeling, statistical analysis, and interpretation	June 2021
3. Oral presentation of results given at a MAISRC Showcase	June 2021
4. Oral presentation of results given at a science conference	June 2021
5. Participation on MAISRC committees	June 2021

Fifth Update February 28, 2020

We have completed all three Outcomes under Activity 1 where the goal was to estimate natural rates of sediment mixing in the surface region of the lake bottom in Lake Kabetogama and Lake Mille Lacs using ^{7}Be. The results indicate that sediments at the bottom of the lake mix down as far as 2 cm in Lake Kabetogama and as far as 3 cm in Lake Mille Lacs. Given the sediment age-at-depth calculations that we have already made for Lake Mille Lacs, the results imply that exoskeletal remains of spiny water flea there could have been mixed to depths nearly 20 years older than the remains themselves. In Lake Kabetogama where our sediment age-at-depth calculations indicate that sedimentation rates are faster, exoskeletal remains of spiny water flea could have been mixed to depths only 4 years older, at most, than the remains themselves. We have also begun work on Outcome 1 under Activity 2.

Sixth Update August 31, 2020

In the last 6 months, we completed about 50% of Activity 2 and about 75% of Outcomes 1 and 2 of Activity 3. For Activity 2, we searched most of the intervals from both archived Lake Kabetogama cores that had been collected form Lake Kabetogama in 2001 and 2005. None of the intervals produced subfossil evidence of spiny water flea. This was unanticipated and is inconsistent with our hypothesis that spiny water flea were present in the lake in the early 2000s and earlier. It suggests that either spiny water flea presence is patchy in the lake leading to no subfossils in the 2001 and 2005 cores, or that our subfossil evidence for early presence in the more recently collected cores under Phase 1 of this project is an artifact. Possible mechanisms that could cause an artifact include natural sediment mixing, sediment smearing during core collection, natural subfossil migration within the sediment, or some combination of these processes. Next we will search the intervals from the archived Rainy Lake and Trout Lake cores. For Activity 3 (Outcomes 1 and 2), we completed all of the production

modeling for spiny water flea in both lakes. Next we will compare these estimates to our estimates of spiny water flea accumulation rates in the sediments of both lakes completed under Phase 1 of this project.

Seventh Update February 28, 2021

Project Manager, Donn Branstrator, is on an emergency leave of absence from the University of Minnesota Duluth and a comprehensive project update is not available at this time. However, Subproject 12.2 continues to run on schedule and is expected to meet all outcomes by its completion date on June 30, 2021.

Final Report August 31, 2021

Spiny water fleas threaten Minnesota's lakes, including walleye health, but we do not understand how many years it takes for the threats to manifest once they invade. This project was a continuation of Subproject 12 where we sought to use evidence in lake sediments to determine the timeline of first presence and growth of spiny water fleas in Lake Kabetogama and Lake Mille Lacs. The results of Subproject 12 demonstrated that spiny water fleas have been present in both lakes continuously since the early 1900s. This timeline conflicts with data on first sightings that do not place spiny water fleas in either lake until the early 2000s. This gap of about 100 years suggests that our sediment analysis methods are biased. With Subproject 12.2, our main objective was to conduct two additional lines of inquiry to determine the suitability of our methods by 1) measuring natural rates of mixing in surface sediments of Lake Kabetogama and Lake Mille Lacs, and 2) searching sediment cores that were collected before first sightings of spiny water fleas in Lake Kabetogama. The results demonstrate that 1) natural rates of sediment mixing are not sufficient to explain the early presence of spiny water flea body remains in Lake Kabetogama or Lake Mille Lacs sediments, and 2) there is no evidence in historical core material that places spiny water fleas in Lake Kabetogama before their reported year of first detection in the water. We combined our results with results from scientists at Queen's University (Canada) who have recently used similar methods to ask similar questions, into a forthcoming publication in the Journal of Paleolimnology. In that publication we review our findings and caution the use of our methods to pinpoint early detection of spiny water fleas in lakes until further study of the methods is conducted.

SUBPROJECT 15: Determining Highest Risk Vectors of Spiny Water Flea Spread

Project Manager: Valerie Brady

Organization: Natural Resources Research Institute, University of Minnesota Duluth

Description: Spiny water flea is a predatory species of zooplankton that represents a serious threat to the ecology and recreational value of Minnesota waters. As of 2015, spiny water flea (SWF) was reported in 36 lakes in Minnesota, including some of the largest basins (Superior, Kabetogama, Lake of the Woods, Mille Lacs, Rainy, Vermilion) that now unfortunately serve as potential source populations to uninfested waters. A major potential risk for the health of Minnesota lakes is that spiny water flea is a carnivore that feeds aggressively on native herbivorous zooplankton, a food resource that is shared as prey by many species of young fish including walleye, northern pike, and yellow perch. This potential competitive interaction with young fish could slow the growth and health of many native fish species in Minnesota. A second potential risk for the health of Minnesota lakes is that herbivorous zooplankton play key roles as grazers on algae, the microscopic plants that form the base of aquatic food webs. Higher concentrations of algae are directly related to lower water clarity. Thus, through removal of herbivorous zooplankton, spiny water flea threatens to reduce the health of fish through competition and to reduce water clarity through eliminating native grazers. These impacts could bring changes to Minnesota lakes that have serious implications for recreation and wildlife. Estimates are that >40% of northern Minnesota lakes provide suitable habitat for spiny water flea, indicating that management programs that foster best practices for containment are critical.

Human recreational activity is believed to be the primary vector of spread; however, little is known about the specific pathways by which dispersal occurs. Current best management practices direct recreationalists to clean,

drain, and dry their equipment before moving it to another water body (this is the core message of the "Stop Aquatic Hitchhikers!" [SAH!] campaign). While this message should be effective if followed stringently, it is broad and fails to draw attention to what may be high risk equipment where decontamination effort could be focused or whose usage could be minimized or avoided altogether. Hence, while we have an opportunity to prevent further spread of spiny water flea in Minnesota, clear evidence-based educational messages and policies are urgently needed. A key aspect of spiny water flea behavior is that it migrates closer to a lake's surface at twilight to feed. This behavior increases its potential contact with surface-based equipment (e.g., boat live wells, bait buckets) that could boost the likelihood of a transport event. To increase the effectiveness of the SAH! Campaign against the spread of spiny water flea, we need answers to two critical questions: 1) What forms of recreational equipment pose the highest-risk pathway for spiny water flea? 2) Does usage of recreational equipment at twilight (dusk) increase the dispersal risk of spiny water flea over midday equipment usage?

Goal: The goals of this project are 1) to measure and rank recreational (mostly fishing) gear in its ability to spread the adult free-swimming spiny water flea using Lake Mille Lacs as the test lake; and 2) to widely disseminate the results, our recommendations, and gear-cleaning tips both in the Mille Lacs area and throughout the state to anglers, the tourism industry, AIS managers, agency staff and legislators, and lake associations.

How: The goal will be accomplished by deploying commonly-used forms of recreational equipment including anchor ropes, angling lines, bait buckets, downrigger cables, and live wells and then cleaning them and comparing the "load" (total number) of spiny water flea relative to the flea's natural abundances in surrounding Mille Lacs lake water. We will use NRRI's boats to test the different types of gear in Lake Mille Lacs. We will set out three different types of anchor rope and have three fishing poles each rigged with a different type of fishing line, with a hookless weight on the end. One boat will also be set up for downrigging gear to determine the numbers of spiny water flea that accumulate on the steel cable and the monofilament line. One of the boats will also have a bait bucket in the water and be running water into a live well.

At the same time as the fishing gear are in the water potentially encountering and being fouled by spiny water flea, we will determine the fleas' abundance in the water using zooplankton nets. Spiny water flea will be cleaned from all gear being tested and will be collected out of the plankton nets to determine ambient flea densities. Collected spiny water flea will be preserved and returned to the laboratory for microscopic analysis.

Field work will be done from July to September 2018 in Lake Mille Lacs. Lake Mille Lacs has supported spiny water flea since 2009 and is a major sport-fishing and recreational destination in the Midwest, elevating its potential threat as a source population for new infestations in other lakes. For statistical rigor, we plan to collect 30 samples per type of gear during daylight and again during twilight (evening). We anticipate collecting approximately 1000 samples total from the recreational gear and the sampling nets. Analyzing spiny water flea numbers on each gear type versus the spiny water flea densities in the lake at the same time will allow us to create a ranking of the threat that each type of gear poses for spiny water flea spread to other water bodies. We will use this information to create specific outreach messages for the public, including producing a supply of cleaning towels that are printed with gear cleaning tips. We will provide this information to lake associations, lake managers, anglers, and recreationalists.

Our long-term goal is to provide science-based information that will improve the effectiveness of current best management practices used in Minnesota to minimize pathways for AIS introduction. Our long-term outcome is to help slow the spread of spiny water flea to uninfested lakes.

Subproject 15 ENRTF FINAL BUDGET: $119,513

M.L. 2013, Chp. 52, Sec. 2, Subd. 06a BUDGET: $92,932
M.L. 2017, Chp. 96, Sec. 2, Subd. 06a BUDGET: $26,581

Outcomes	Completion Date
Activity 1	
1. Test anchor ropes, angling lines, bait buckets, downrigger cables, and live wells in Lake Mille Lacs for entanglement with spiny water flea on 6 different daylight and evening trips, as well as collect water column samples of spiny water flea.	Fall 2018
2. Microscopically examine samples in the lab and count the number of spiny water flea on each gear type.	December 2018
3. Determine spiny water flea transfer risk from each gear type using appropriate statistics.	April 2019
4. Write detailed report of results and conclusions; provide report to agency AIS personnel.	June 2019
5. Write peer-reviewed manuscript for submission to a scientific journal to inform other AIS researchers of findings.	June 2019
Activity 2	
1. In collaboration with MAISRC and other project partners, produce up to 8,000 reusable cleaning towels that are printed with plain language outreach messages for anglers and boaters on gear cleaning (4,000 on ENRTF funding, 4,000 on matching funds). For example: “Stop the spread of spiny water flea by wiping your fishing line and real.” Towels will be given to AIS inspectors and county AIS managers, UMN Extension and Sea Grant outreach staff, and non-profit partners to distribute throughout the 2021 fishing season.	November 2021
2. In collaboration with MAISRC, the Aquatic Nuisance Species taskforce, and Sea Grant outreach staff, we will create radio and online PSA-type ads highlighting what anglers should do; purchase spring/summer ad time for the Mille Lacs area.	November 2021
3. Presentations to AIS managers, agency staff, lake associations, tourism industry (esp. Dock Boys and Girls), policy makers, and fishing groups. Also, social media outreach messages targeted to connect with anglers and boaters.	May 2021
4. Outreach article for Minnesota Sportsman (or similar) magazine.	June 2021
5. Service for MAISRC, including participation in the 2018 and 2019 Showcase Events and participation on 1-2 committees.	June 2019

First Update February 28, 2018

Status update on subproject activities through 01/31/2018 are recorded on M.L. 2013 report.

Second Update August 31, 2018

Status update on subproject activities through 07/31/2018 are recorded on M.L. 2013 report.

Third Update February 28, 2019

Status update on subproject activities through 01/31/2019 are recorded on M.L. 2013 report.

Fourth Update August 31, 2019

Status update on subproject activities through 07/31/2019 are recorded on M.L. 2013 report. Activity 1 was funded on M.L. 2013, which ended on June 30, 2019. Activity 2, will continue on M.L. 2017 funding.

Fifth Update February 28, 2020

Our research has shown that fishing lines accumulate the most spiny water fleas and thus should be the focus of angler cleaning efforts to prevent water flea spread. Conveying this message in a way that fits well on a sticker has not proven feasible. Instead, test audiences have been more interested in a “tool” to help anglers remove spiny water fleas from their lines. Thus, we tested and are pursuing purchase and printing of small cleaning

cloths that can accommodate a printed set of instructions on how to clean angling gear to prevent spiny water flea spread. We can use this cloth in a demonstration video about removing spiny water fleas from fishing lines for the television PSA's. We anticipate that we will be able to have these towels printed and radio and TV PSA's produced for distribution in 2020 spring.

Sixth Update August 31, 2020

Our research has shown that fishing lines accumulate the most spiny water fleas and thus should be the focus of angler cleaning efforts to prevent water flea spread, along with wiping out bait buckets and livewells after draining all water. We have designed a picture and simple list of instructions on cleaning angling gear that will be printed on Swedish dish cloths. These dish cloths will be handed out to anglers at spiny water flea infested lakes in Minnesota, concentrating first on the Mille Lacs area where the research was done. We are also working on a demonstration video using the cloth to clean fishing lines for PSA's on YouTube, and a radio PSA about spiny water flea spread prevention. Both ads will play in the Mille Lacs Lake and Twin Cities markets. We had hoped to have the PSAs done this spring but COVID-19 restrictions delayed production. The SPA video is now in production.

Seventh Update February 28, 2021

Our research has shown that fishing lines accumulate the most spiny water fleas and thus should be the focus of angler cleaning efforts to prevent water flea spread, along with wiping out bait buckets and livewells after draining all water. We printed 3,000 Swedish dish cloths with a picture and simple list of instructions on cleaning angling gear and have recruited lake associations and AIS personnel around northern Minnesota who will help distribute these cleaning cloths to anglers in the spring and summer of 2021. Our focus will be on anglers who move between spiny water flea infested lakes and uninfested lakes. We also created three demonstration videos (2.5 min, 30 sec, and 15 sec) using the cloth to clean fishing lines for PSA's that will be shared via online ads and on local television as a part of the Stop the Spread of Spiny Water Flea campaign that will launch in the spring of 2021. The PSA videos will play in the Mille Lacs Lake and Twin Cities markets, targeted to anglers. We partnered with UMD's videographer, MAISRC's photographer, MAISRC outreach staff, and a free-lance video editor to create these videos, which were cost-shared with St. Louis County on a companion project. Campaign updates and resources can be found on the Stop Spiny website: www.stopspiny.org

The research team gave presentations about this project at the Minnesota Water Resources Conference in October 2020. The team also presented to the MN DNR AIS Working Group, at MAISRC's 2020 Research and Management Showcase, and gave an AIS Detectors webinar.

Recording of Showcase presentations online: https://z.umn.edu/2020ShowcasePresentations
Recording of the AIS Detectors webinars online: https://z.umn.edu/AISDetectorsWebinars

Eighth Update August 31, 2021

Our research has shown that fishing lines accumulate the most spiny water fleas and thus should be the focus of angler cleaning efforts to prevent water flea spread, along with wiping out bait buckets and livewells after draining all water. We printed an additional 5,000 Swedish dish cloths with a picture and simple list of instructions on cleaning angling gear (for a total of 8,000 cloths funded by MAISRC/ENTRF plus another 3,000 funded by St. Louis County in a companion project). The original 3,000 MAISRC and 3,000 St. Louis County dish cloths have been distributed to lake associations and AIS personnel (about 18 different partners) around northern and central Minnesota who have spent the spring and early summer distributing these cleaning cloths to anglers. We are now distributing an additional 5000 of these cloths and have facilitated other groups to order more than 9,000 cloths of their own for distribution. Our focus is on anglers who move between spiny water flea infested lakes and uninfested lakes. Our three demonstration videos (2.5 min, 30 sec, and 15 sec) using the cloth to clean fishing lines have been playing on Facebook, Twitter, websites, and TV in the Mille Lacs Lake and Twin Cities markets this summer, targeted to anglers. Additional communication efforts have included a guest

editorial in the Lake Superior Angler Magazine, an interview with Dr. Branstrator in National Geographic, and guest slot on the North Shore Community Radio. Print advertisements include the Northern Wilds Magazine, Lake Country Magazine, and Ely Summer Magazine. Since its creation, the Stop Spiny website that hosts research findings and best practices has been visited more than 2,600 times.

Final Report between project end (June 30) and September 15, 2022

Spiny water fleas are a predatory non-native zooplankton that threatens the ecology and recreational value of Minnesota lakes. Estimates are that >40% of northern Minnesota lakes are vulnerable to invasion. These invaders are primarily spread by human recreational activity, but we do not know exactly how this is happening. Our project goals were to 1) determine which types of recreational fishing gear would entangle (and thus spread) spiny water fleas, and 2) widely disseminate our results and gear-cleaning tips. We conducted 7 sampling events on Lake Mille Lacs, collecting 718 samples including zooplankton tows and spiny water flea counts on fishing gear and anchor ropes. We found that fishing lines accumulated the most spiny water fleas and thus should be the focus of angler cleaning efforts. In addition, it is critically important that all water be removed from bait buckets and livewells to prevent spread. To help recreational anglers clean their fishing gear, we printed and/or coordinated the distribution of over 20,000 cellulose dish cloths that were printed with cleaning instructions. 8,000 cloths were printed and distributed to 18 community partners (lake associations, AIS prevention staff, agency partners) as a part of this project and an additional 12,000 were printed and distributed through coordination with partner organizations and additional funders. Cloths were distributed to recreational anglers, focusing on those who move between spiny water flea infested lakes and uninfested lakes. In addition, we launched the stopspiny.org website to disseminate research findings and share prevention resources and created three PSA videos that demonstrated how to use the cloth to clean fishing lines. The videos played on YouTube, Facebook, Twitter, and TV in the Lake Superior, Lake of the Woods, Mille Lacs, Twin Cities markets. Facebook advertising was used to extend the stop spiny PSAs, reaching over 208,000 individual people and resulting in 442,000 impressions. PSA ads were also placed in local, online and print publications with an estimated reach of 103,000 readers. The research team also wrote one scientific manuscript and presented their results 19 times to about 1,500 people.

SUBPROJECT 16.2: AIS impacts on walleye populations and mercury concentrations

Project Manager: Gretchen Hansen

Organization: University of Minnesota

Description: The overall goal of this project is to assess the impacts of invasive zebra mussels on walleye in Minnesota lakes. Zebra mussels profoundly impact lake ecosystems, but their impacts on walleye are not well-known, and likely vary among lakes. We will investigate the impacts of zebra mussels on walleye and identify lakes that are most vulnerable to negative impacts by focusing on three specific objectives related to recruitment, food web dynamics, and mercury concentrations.

First, we will quantify the effects of zebra mussel (ZM) invasion on walleye recruitment using statistical analysis of data collected by MN DNR from hundreds of lakes since the 1980s. We will assess the influence of zebra mussels as well as other lake characteristics on recruitment success. Next, we will characterize the food webs of 15 study lakes using stable isotope analysis of carbon and nitrogen to determine which habitats and food resources support walleye in invaded and uninvaded lakes. Finally, we will quantify mercury concentrations in walleye tissue and characterize the mercury stable isotope composition in our 15 study lakes to identify pathways of mercury bioaccumulation and how it is influenced by zebra mussel-induced shifts in food web configuration.

Zebra mussel-induced changes in walleye recruitment, mercury concentrations, and food webs have important implications for harvest, stocking, and consumption of walleye in Minnesota lakes. The impacts of zebra mussels on walleye likely depend upon their ability to switch to alternative food sources if and when invaders cause zooplankton prey to become scarce. This ability to switch food sources likely depends on lake characteristics

including size, depth, productivity, and fish community composition. Determining how zebra mussels affect walleye, and identifying characteristics of walleye populations that can withstand these invasions with minimal effect will allow managers to set realistic goals for future walleye production and harvest. Quantifying effects on walleye recruitment will inform proactive management and allow for realistic goal setting and data-driven public communication following species invasions before a crisis hits. Understanding sources of mercury in walleye and how they are influenced by zebra mussels is critical for fish consumption advisories in Minnesota lakes.

This project builds upon work previously funded by MAISRC and ENRTF documenting the impacts of AIS on walleye in Minnesota's large lakes (Subproject 16). Phase II will be relevant to a broader group of stakeholders by expanding to additional lakes and by including analysis of mercury concentrations. As in Phase I, we continue to leverage ongoing monitoring by the Minnesota DNR valued at hundreds of thousands of dollars, which allows us to sample many lakes at low cost. Additionally, the mercury measurements for this project will be provided in-kind, which presents an unprecedented opportunity to understand how AIS affect contaminant cycling and human health. Through these partnerships, we are able to maximize the relevance of our results at relatively low cost.

Subproject 16.2 ENRTF FINAL BUDGET: $199,852

Outcomes	Completion Date
Activity 1	
1. Collate historical walleye recruitment data from walleye lakes throughout Minnesota into a relational database.	September 1, 2020
2. Estimate the effects of zebra mussels on walleye recruitment in Minnesota lakes and evaluate lake characteristics that increase walleye population resilience using statistical models.	December 31, 2021
Activity 2	
1. Collect tissue samples of invertebrates, young of year walleye and yellow perch, adult walleye, and other fishes. Sampling will be coupled with existing MN DNR sampling. Field work funded through this project will support the collection of young of year fish, littoral fish, and invertebrates for isotope and mercury analysis.	December 31, 2020
2. Collect benthic macroinvertebrates from nearshore and deepwater lake bottom areas to quantify baseline isotopic positions to determine which fish feed on these invertebrates.	December 31, 2020
3. Collect muscle tissue from fish sampled during summer and fall gillnetting. Fish targeted from this sampling include walleye, yellow perch, northern pike, cisco (where present), black basses, and other Centrarchids such as bluegill, black crappie, and rock bass (where present).	December 31, 2020
4. Collect age-0 walleye, age-0 yellow perch, and littoral prey fish in summer for isotopic analysis for food web assessment via seining, minnow traps, and/or electrofishing.	December 31, 2020
5. Process samples to prepare for stable isotope analysis. Processing includes separating major taxonomic groups, drying, grinding, and weighing samples, and sending them to an external lab for analysis.	December 31, 2020
6. Quantify stable isotope composition of Carbon and Nitrogen of each trophic group in all study lakes using an external lab. This will provide the data for the food web analysis.	March 31, 2021
7. Quantify mercury stable isotope composition and concentration in walleye and yellow perch using USGS facilities.	March 31, 2021
8. Determine how much food/energy is coming from nearshore versus open water habitats contributing to walleye production in each study lake, and how this varies with invasion status.	December 31, 2021
9. Determine how mercury concentrations and pathways vary with invasion status.	December 31, 2021

Fifth Update February 28, 2020

We successfully collected fish and invertebrates from multiple sites in our seven study lakes slated for sampling in 2019. A total of 1777 tissue samples were collected and are being processed in the lab for stable isotope and mercury analysis.

We were unable to collect age-0 walleye and yellow perch from several study lakes despite increased sampling effort and the generous help of DNR partners. We will still be able achieve our goals of quantifying the impacts of zebra mussels on food webs supporting walleye. We will simply focus more on adult walleye and food web effects. We are working to avoid this problem in 2020 by selecting lakes with the highest probability of catching age-0 walleye and yellow perch given their recruitment and stocking history and by using additional gear types.

We collated thousands of historical walleye relative abundance records for analysis of zebra mussel impacts on walleye recruitment. We are working closely with the newly formed DNR zebra mussel walleye task force to ensure we are using the best available data, that our analysis methods meet their expectations and goals, and to identify future opportunities to better understand the impacts of zebra mussels on walleye and possible management strategies.

Finally, we presented our work in progress at the MAISRC showcase. Results of Phase 1 of our project were published in a peer-reviewed journal and our project has been featured in the popular press.

Sixth Update August 31, 2020

We have made substantial progress on our project activities. We collated thousands of historical walleye relative abundance records for analysis of zebra mussel impacts on walleye recruitment. We have also collated lake data for thousands of Minnesota lakes that will be used as covariates in our analysis. With this dataset, we are prepared to begin statistical analysis of zebra mussel impacts on walleye recruitment, while accounting for differences in walleye recruitment due to other lake characteristics.
For Activity 2, we successfully processed fish and invertebrate samples from multiple sites in our seven study lakes sampled in 2019. We have also successfully begun field work on the first of our study lakes in 2020 following social distancing and safety protocols for minimizing COVID-19 risk.

We presented our work in two poster sessions at the Minnesota chapter of the American Fisheries Society meeting.

COVID-19 has been a significant obstacle in the completion of our project activities. Data collation and analysis has been delayed due to delays obtaining data from DNR staff working from home and on leave. Scientific presentations planned for the American Society of Limnology and Oceanography/Society for Freshwater Science joint meeting were cancelled due to the meeting being cancelled. Lab processing of samples collected in 2019 was delayed due to lack of person power following UMN reduced operations, and due to external labs for stable isotope (UC-Davis) and mercury (USGS) analysis shutting down for several months. However, we are optimistic that we can complete all proposed activities by the project end date as we now have all historical data in hand for our statistical analysis of walleye recruitment, students are back working in the lab and field following social distancing protocols, and external labs are now open for sample processing.

Seventh Update February 28, 2021

Working in close collaboration with MN DNR partners, the desired walleye fall electrofishing survey and stocking data have continued to be imported into the project database. With assistance from USGS staff, electrofishing data were compared with modelled temperature data to remove any surveys performed outside of the desired temperature range, in cases where temperature data was not recorded. Code for the statistical model has been started, and preliminary models will be running by the end of January 2021.

Fieldwork was carried out in seven lakes from July-Aug 2020. One lake was dropped from the original plan of eight lakes to account for the increased logistical, operational, and financial burdens due to COVID-19. In the seven lakes that were sampled, we were able to meet our sampling goals in every taxonomic group aside from some lakes with low/no catches of age-0 walleye and /or yellow perch. This was anticipated due to similar challenges in the previous field season, and in response we utilized two new sampling methods this year: small-mesh gillnets and night electrofishing. Despite this, we still had low yields. Collaborators from MN DNR provided fall-caught fish of these two groups to supplement the low summer catches, although we are still investigating the usefulness of these samples.

Lab work was also heavily impacted by COVID-19 restrictions, however we managed to process 1,696 samples in the past six months, bringing us to a total of 2,476 fish and invertebrate samples sent off for carbon and nitrogen stable isotope analysis. Several dozen samples from 2019 have also been prepped and sent off for mercury concentration and isotope analysis, with the 2020 samples scheduled to be sent off by the end of January 2021.

The research team gave a presentation about this project at MAISRC's 2020 Research and Management Showcase. A recording of the Showcase presentation is available online:
https://z.umn.edu/2020ShowcasePresentations

Eighth Update August 31, 2021

Activity 1 – historical walleye catch and effort data from MN DNR have been collated, cleaned, undergone QA/QC, and are ready to work with. A large majority of walleye stocking data are also in hand, although we are still awaiting final updated stocking data from MN DNR. The last six months, graduate student Holly Kundel has worked on gathering both stocking data and environmental data including water temperature, water clarity, and annual trends in the lakes of interest. Most of the temperature metrics that will be utilized come from a process-based lake temperature model of Minnesota lakes developed by our collaborators at the USGS. Holly, and PI Dr. Gretchen Hansen have run preliminary models with the data to better understand trends and are in discussion with collaborators over how to properly structure the final model. We plan to finalize data analysis and to begin writing a manuscript by the end of 2021.

Activity 2 – All samples have been collected from lakes and over 2,600 samples have been processed and analyzed for C13 and N15 isotope data, and preliminary data analysis has begun. However, most of the mercury data analysis from samples of walleye and yellow perch by the USGS Mercury Research Lab in Middleton, WI is behind schedule. More walleye and perch tissue samples will be prepped and sent out for analysis once the results from the previous samples are received. Data analysis will be complete by December 2021.
This project is highly collaborative, and collaborators from the MN DNR, USGS, and the U.C Davis Stable Isotope lab have offered this project incredible assistance, and information; however due to shutdowns from COVID it has been difficult to quickly relay information and samples. With labs back online, we expect to accomplish our objectives going forward with no additional delays.

Final Report between project end (June 30) and September 15, 2022

Invasive zebra mussels profoundly affect lake ecosystems, but their impacts on walleye are not well understood. We used a multi-pronged approach to understanding zebra mussel impacts on walleye in Minnesota lakes. First, we evaluated how walleye recruitment (reproduction and survival) to their first fall was affected. We used statistical models applied to data collected by the Minnesota Department of Natural Resources to quantify changes in walleye recruitment. Walleye recruitment declined by ~41% following zebra mussel invasion. Additionally, lakes with zebra mussels supported the highest walleye recruitment prior to invasion, suggesting that zebra mussels invade high quality walleye lakes. Next, we evaluated how zebra mussels influence food webs supporting walleye and yellow perch, and how food web changes influence mercury concentrations in fish tissue. Using stable isotope analysis, we found that walleye and yellow perch in zebra mussel invaded lakes use

36-50% more nearshore food resources compared to those in uninvaded lakes. Mercury concentrations in fish were also influenced by zebra mussels; mercury in fish tissue was 66% higher for adult walleye and 91% higher for adult yellow perch in lakes containing zebra mussels compared to those in uninvaded lakes. On average, mercury concentrations in 16-inch walleye from lakes containing zebra mussels were 0.28 ppm, above the 0.2 ppm threshold triggering human consumption advisories by the Minnesota Department of Health. Zebra mussel-induced changes have important implications for walleye in Minnesota lakes. Lower walleye recruitment in invaded lakes may influence abundance at later life stages, which could influence harvest and stocking plans. Walleye were able to persist on nearshore food resources following zebra mussel invasions, but mercury concentrations were higher in these fish with important implications for human consumption. Given the significance of the impacts of zebra mussels documented in our study, preventing zebra mussel invasions into additional walleye lakes is critical.

SUBPROJECT 18.2: Genetics to improve hybrid and Eurasian watermilfoil management

Project Manager: Raymond Newman

Organization: University of Minnesota

Description: Eurasian watermilfoil (*Myriophyllum spicatum*) is one of the most problematic submersed aquatic plants in North America. The invasive Eurasian hybridizes with the native northern watermilfoil (*M. sibiricum*) and the hybrid is capable of sexual reproduction with itself and northern and Eurasian watermilfoil. Hybrids are difficult to distinguish from Eurasian watermilfoil without genetic testing, and as a result, populations identified as "Eurasian watermilfoil" may be composed of "pure" Eurasian watermilfoil, hybrids, or both. Although managers and aquatic botanists increasingly recognize Eurasian and hybrid watermilfoil as distinct taxa, they are not frequently distinguished when it comes to operational management strategies and control tactics. Due to sexual reproduction, there is more genetic variability in hybrid watermilfoil. At least some hybrid genotypes are more invasive and some are more tolerant of herbicides resulting in concern for treatment effectiveness in the field.

Tolerant genotypes have been identified for an array of herbicides including auxin mimics 2, 4-d and triclopyr, fluridone and others. Although hybrid watermilfoil is broadly distributed across North America, detailed information about diversity and distribution is only now emerging (including our prior MAISRC work). In order to better manage invasive milfoil we need to know the distribution of hybrid genotypes, understand factors that promote occurrence and development of hybrids, and identify specific hybrids that may need special management attention (e.g., herbicide tolerance). Our study will use the understanding of genetic distribution within and among lakes and differences in response to management gained from the first phase to further identify problematic genotypes and develop a catalog of genotypes to improve management. The outcomes will be useful to Minnesota and provide a framework and model for other states.

The available studies comparing pure and hybrid Eurasian watermilfoil demonstrate that simply knowing if a population is pure Eurasian, hybrid, or both is not sufficient to predict growth and herbicide response. Instead, growth and herbicide response is a property of the specific genotype(s) present in a water body. For example, several studies have identified clear tolerance by some hybrid genotypes to some herbicides (e.g., fluridone), whereas studies on other genotypes have not found any evidence for tolerance. Furthermore, a recent study showed that several genotypes that were relatively tolerant to one herbicide were relatively susceptible to others, and vice versa. Therefore, the response of a population to a proposed herbicide treatment is likely to be a function of the genetic composition of the population.

Because the properties of populations likely vary as a function of their genetic composition, it is important to delineate and quantify genetic variation within and among populations, and ultimately connect that information to genotype-specific responses to management. In quantifying genetic variation, it is important to recognize that 1) different lakes can contain the same or different genotypes, and 2) the genetic composition of a focal

population can change over time. Both of these have implications for management, and for guiding and prioritizing research aimed at characterizing the responses of specific genotypes to different herbicides.

Our previous project (Subproject 18, Phase I) assessed watermilfoil distribution and occurrence across Minnesota. We surveyed 62 lakes from 24 counties across Minnesota to determine the occurrence and distribution of hybrid watermilfoil, and to delineate different genotypes of hybrid (HWM), Eurasian (EWM) and native northern (NWM) watermilfoils. Based on genetic identification, 43 lakes contained EWM, 27 lakes HWM, and 23 lakes NWM. Hybrid was most common within the Twin Cities Metro; only 5 of 20 lakes sampled outside the metro were found to have hybrid.

We identified 8 Eurasian EWM genotypes, 57 hybrid HWM genotypes, and 76 northern NWM genotypes. There was no within-lake diversity for Eurasian, and we found one genotype to be the most common and widespread (occurring in 38 lakes). Most hybrid lakes only had one genotype, but 10 lakes contained multiple hybrid genotypes. Four hybrid genotypes were found in multiple lakes; the most common one was found in 7 lakes across the northeast metro area. Taken together, these survey results indicate that there are numerous genotypes present in the state whose herbicide responses are unknown, and the next step is to begin prioritizing genotypes for herbicide study. That a few genotypes are widespread suggests that one method of prioritizing genotypes for study is based on how common and widespread they are, so that information is available for decision making on multiple lakes.

Overall, the result of our work and previous studies indicate that hybrid watermilfoil is wide-spread (but more common in the metro) and genetically diverse. We do not know if certain hybrid genotypes are more aggressively growing or herbicide tolerant, and this should be an immediate research priority. Because growth and herbicide screens are currently labor intensive, it is infeasible to exhaustively characterize them all, and methods to prioritize their characterization are therefore needed. Potentially problematic genotypes to prioritize for growth and herbicide response characterization can be identified from: 1) temporal genetic monitoring to identify any genotypes that increase in relative frequency following herbicide treatment, 2) quantitative data on herbicide efficacy for lakes with single genotypes, and 3) genotypes that occur in multiple water bodies.

These observations illustrate the need for a structured effort to identify potentially problematic genotypes of hybrid milfoil in Minnesota and begin to specifically test some of these genotypes for response to a set of herbicides. We can then assess whether the users (managers, applicators and lake associations) would support a genetic testing service and how this might be structured and implemented. Specifically, our project (Phase II) has the following four objectives:

Objective 1: Assess the response of hybrid watermilfoil to herbicidal control in a set of intensively managed lakes.
Objective 2: Assess the distribution of hybrid watermilfoil genotypes from under-sampled regions and problematic lakes.
Objective 3: Pilot herbicide challenge-screening of several hybrid genotypes identified in objectives 1 and 2 as potentially problematic.
Objective 4: Assess the need for a genetic testing service, and its potential structure.

By building a “catalog” of genotypes (distinguished by molecular markers) present, and for a subset identifying their herbicide response properties, we will begin to identify problematic genotypes requiring targeted management in Minnesota. Over the long term, this project is part of a research program aimed at identifying the genetic basis of plant traits that are important to management outcomes. The ultimate goal is to have genetic/genomic predictors of important plant traits that can be used in developing and supporting management plans.

Subproject 18.2 ENRTF FINAL BUDGET: $236,423

Outcomes	Completion Date
Activity 1	
1. Test for significant changes in genotype relative frequency of occurrence in treated versus untreated lakes.	December 2020
2. Identify 1-3 potentially problematic genotypes for laboratory characterization of growth and herbicide response (see Activity 3)	April 2020
Activity 2	
1. Select and sample lakes from under-sampled regions, and from lakes of interest to managers and DNR.	November 2019
2. Identify 1-3 potentially problematic genotypes for laboratory characterization of growth and herbicide response (see Activity 3)	April 2020
Activity 3	
1. Quantitative laboratory data on growth and herbicide response profiles for 2 to 5 potentially problematic genotypes identified in Activities 1 and 2.	January 2021
2. Share results with partners and collaborators to plan for future treatments	May 2021
Activity 4	
1. Survey stakeholders and host meetings to discuss plans and processes for integrating genetic and lab herbicide data into management decisions and permitting	May 2020
2. Group meeting at UMISC to discuss options and develop recommendations.	October 2020
3. Final recommendations for development and funding model of genetic testing service.	June 2021
Activity 5	
1. Present results at MAISRC showcase 2019, 2020, and coordinate with Larkin and communicator to address hybrids and milfoil genetics on MAISRC website.	May 2021
2. Host stakeholder meetings to discuss plans and processes for integrating genetic and lab herbicide data into management decisions and permitting. Share data on the DRUM.	June 2021
3. Submit one or more manuscripts to peer-reviewed scientific journal(s).	June 2021

Fifth Update February 28, 2020

We evaluated the response of Eurasian, northern and hybrid watermilfoil, and the associated native aquatic plant community, to intensive herbicide management in 6 lakes treated with herbicide and 6 reference lakes that are not intensively managed. Whole lake fluridone treatments were very successful in reducing watermilfoil: very few milfoil plants remained in these lakes the year after treatment. Responses in lakes with large area spot treatments of ProcellaCor or 2,4-d were more variable, but more milfoil plants remained. We do not yet have the genetic results for these samples so we do not know if hybrid watermilfoil responded differently or if various genotypes responded similarly. We also broadened our statewide survey for hybrid watermilfoil with samples from 9 additional lakes. No particularly problematic populations have yet been identified. We anticipate genetic results in late spring and will then be able to draw inferences and identify problematic genotypes for further testing. Planning has begun for spring meetings and consultation with stakeholders.

Sixth Update August 31, 2020

We evaluated the response of Eurasian, northern and hybrid watermilfoil, and the associated native aquatic plant community, to intensive herbicide management in 6 lakes treated with herbicide and 6 reference lakes that are not intensively managed. At least one reference lake will be treated in 2020, providing a good contrast for pre and post treatment. Whole lake fluridone treatments were very successful in reducing watermilfoil: very few milfoil plants remained in these lakes two years after treatment. No apparent fluridone resistant genotypes have yet emerged in MN. We are still assessing responses in lakes with large area spot treatments of ProcellaCor or 2,4-d which are more variable, and have more milfoil plants remaining. We have not completed formal

analysis to determine if hybrid watermilfoil responded differently or if various genotypes responded similarly but obvious patterns are not apparent. We obtained genetic results for hybrid watermilfoil from 10 additional lakes sampled in 2019 and found several additional, but isolated, Eurasian genotypes and several new hybrid genotypes. One hybrid genotype has now been found in 10 lakes, most in the east metro but one in Wright County, the result of clonal spread. No particularly problematic populations have yet been identified. We have identified several genotypes that should be further assessed for herbicide response with challenge testing including the common and widespread Eurasian genotype, a fairly widespread hybrid genotype, and several hybrid genotypes that may have been associated with poor response to herbicide treatments. We presented a webinar in May to introduce our results (228 viewers) and then held two zoom meetings the following week to consult with stakeholders. Approximately 25 people attended the zoom meetings including representatives of the MN and WI Departments of Natural Resources, local agency scientists and managers, and interested lake association members.

Seventh Update February 28, 2021

We evaluated the response of Eurasian, northern and hybrid watermilfoil, and the associated native aquatic plant community, to intensive herbicide management in 8 lakes that have been treated with herbicide and 5 reference lakes that are not intensively managed. One reference lake from 2019 was treated in 2020 with good control, providing a good contrast for pre- and post-treatment genotypes. Whole lake fluridone treatments were very successful in reducing watermilfoil: very few milfoil plants remained in these lakes the year after treatment, and no milfoil was found in one two years post treatment. Milfoil returned to 8% occurrence in the other lake (North Arm). No obvious fluridone resistant genotypes have yet emerged in MN although the common North Arm genotype warrants scrutiny. We are still assessing responses in lakes with large area spot treatments of ProcellaCor or 2,4-d which are more variable and have more milfoil plants remaining. We have not yet determined if hybrid watermilfoil responded differently or if various genotypes responded similarly but obvious patterns are not apparent. Our surveys now indicate 66 hybrid and 9 EWM genotypes in MN. One hybrid genotype has now been found in 10 lakes (mostly in the east metro but one in Wright County) as the result of clonal spread. No particularly problematic populations have yet been identified. We have identified several genotypes that are being assessed for 2,4-d herbicide response with challenge testing including the common and widespread Eurasian genotype, the fairly widespread hybrid genotype, the North Arm and two other hybrid genotypes.

Co-PI Ryan Thum gave a presentation about this project at the Upper Midwest Invasive Species Conference in November 2020 and gave an AIS Detectors webinar. A recording of the AIS Detectors webinar is available online: https://z.umn.edu/AISDetectorsWebinars

Final Report August 31, 2021

Invasive Eurasian and native northern watermilfoil can hybridize and some genotypes of hybrid watermilfoil have been shown to be more invasive or resistant to herbicidal control. Our aim was to determine the occurrence and distribution of hybrid watermilfoil in Minnesota, assess the response of different genotypes to herbicidal management, identify potentially problematic genotypes and assess the response of some of these genotypes to herbicide in controlled laboratory conditions. We assessed watermilfoil genetic composition in 81 waterbodies in Minnesota; 55 lakes had pure Eurasian, mostly one widespread genotype that was found in 52 lakes. Eight other Eurasian genotypes were found. We identified hybrid watermilfoil in 39 lakes across the state, mostly, but not entirely, in the Twin Cities Metro. Hybrid watermilfoil is genetically more diverse than Eurasian watermilfoil and 82 genotypes were found. Most lakes have one unique genotype of hybrid but multiple genotypes were found in several lakes and 26 have been identified in Lake Minnetonka. One hybrid genotype has been found in 10 lakes. No clearly problematic genotypes have been identified in Minnesota but we did find changes in genotype frequency with management in an assessment of 5 managed waterbodies and 3 reference waterbodies over 3 years. Several hybrid genotypes have expanded while Eurasian decreased and two hybrids from Lake Minnetonka have persistently rebounded after control. We also identified one genotype of northern watermilfoil that may be less affected by herbicide treatment. We conducted laboratory performance and

herbicide challenge tests with the widespread Eurasian genotype and 4 hybrid genotypes. Additional experiments are needed but preliminary results suggest that two hybrid genotypes may be more tolerant of 2,4-D than the widespread Eurasian and two other hybrid genotypes. Continued identification of hybrid genotypes and response to management will improve milfoil management by allowing manager to appropriate controls for their particular populations.

SUBPROJECT 20: A Novel Technology for eDNA Collection and Concentration

Project Manager: Abdennour Abbas

Organization: University of Minnesota

Description: In a very recent informal survey of Minnesota Department of Natural Resources (DNR) managers and researchers, it became evident that a major need for aquatic surveys is not developing new detection methods but improving the sampling tools. A number of promising techniques are available today including environmental DNA (eDNA) amplification using PCR and LAMP assays or metagenomics sequencing. However, the major problem is that the results obtained from eDNA techniques do not always correlate with traditional netting data (e.g., some species are missed, or abundance relationships are weak) in part due to sample size and quality. Current attempts to use eDNA for detecting species typically require numerous samples from each site, especially when detecting rare species such as a newly invading aquatic invasive species (AIS). Improving detection probability or precision of abundance estimates by increasing the number of samples leads to high costs using current sampling methods. To convert these techniques into reliable species detection tools and enhanced quantitative tools (offering a good correlation between eDNA copies and species abundance) new efficient and cost-effective sampling methods need to be developed.

Environmental DNA (eDNA) is the genetic material (genomic DNA) obtained directly from environmental samples such as soil and water. The collection of eDNA is an emerging cost-effective alternative or complement to traditional sampling (mostly nets and electrofishing for fish, visual surveys or net tows for inverts). When combined with DNA sequencing technology or quantitative PCR (qPCR), eDNA could represent a cost-effective and reliable tool for biodiversity monitoring, including species detection and abundance. However, current eDNA sampling methods may result in significant false positives or negatives that prevent wide-spread adoption for management purposes. To avoid failure to detect a species across an entire site of interest (e.g., lakewide, stream reach), several to tens of individual water samples are typically collected. The need for a large number of samples is greatest when targeting rare species, such as a newly invading AIS where limited concentrations of DNA may be present in the water. Our improved sampler aims to reduce these per sample costs directly but could also provide savings elsewhere, including reduced staff time per site and ability to sample more locations in a single trip.

This proposal aims at developing a novel aquatic eDNA collection and concentration technology for more efficient, reliable and cost-effective screening for not only invasive aquatic organisms and pathogens but also native and endangered species. The technology would significantly enable and empower aquatic ecosystem survey and management programs in Minnesota.

Specific aim: Develop an eDNA nanofilter that specifically and rapidly captures nucleic acids (DNA, RNA) from water.

Subproject 20 ENRTF FINAL BUDGET: $190,863

M.L. 2013, Chp. 52, Sec. 2, Subd. 06a FINAL BUDGET: $94,599
M.L. 2017, Chp. 96, Sec. 2, Subd. 06a FINAL BUDGET: $96,264

Outcomes	Completion Date
Activity 1	

1. Development of eDNA nanofilter using a polymeric membrane modified with nanotechnology	March 2019
2. Evaluation of the performance of the eDNA nanofilter	November 2019
Activity 2	
1. Collection of eDNA from selected locations	April 30, 2020
2. Sample analysis: quantitative PCR of collected samples	April 30, 2020
3. Dissemination of research findings to AIS managers, policy makers, and planners, including at the annual Showcase event; coordination with MAISRC and Extension on media efforts and communications; and participation on 1-2 committees	June 30, 2020

Third Update February 28, 2019

Status update on subproject activities through 01/31/2019 are recorded on M.L. 2013 report.

Fourth Update August 31, 2019

The project is progressing as expected. We have successfully developed a new eDNA filter that captures > 90 % of DNA (our objective was 50%) within 10 seconds. The filter is a cellulose membrane functionalized with a polysiloxane polymer and put in contact with eDNA solution with concentration ranging from 10 ng/L to 1000 ng/L. The loading capacity of the new filter is up to 5 mg/g, meaning that 1 g of filter can capture up to 5 mg of DNA. This is a record-breaking capacity that enables the filtration of large volumes of water with one filter, knowing that surface water contains usually 10 ng/L of eDNA.

We are currently working on Phase 3 of Activity 1 that involves the development of a housing system for the eDNA filter to enable field use. This is expected to be completed as planned in November 2019.

Year 1 funding for this project on M.L. 2013 ended on June 30, 2019 and Year 2 activities will continue on M.L. 2017 funding.

Fifth Update February 28, 2020

The project aims to achieve two main objectives: development of a new eDNA filter (Activity 1) and the development of a housing system for rapid field sampling of large volumes of water (Activity 2). We have successfully accomplished the first objective by developing the first eDNA sorbent for eDNA capture and an extraction buffer for eDNA recovery from aquarium water with invasive carp. The sorbent and buffer form a new eDNA kit that enables the capture of 5 times more DNA (including free eDNA) is five times faster (6 min sample processing time) and is five times cheaper than commercially available filters that require Qiagen kits. We have also initiated a collaboration with industrial partners (Pisces molecular LLC, Claros Technologies Inc) and institutional partners (U.S. Fish and Wildlife Service, UMD Natural Resources Research Institute) who expressed willingness to participate in beta testing or commercialization of the new eDNA kit during summer 2020.

Final Report October 29, 2020

Background/Context: Environmental DNA (eDNA) is the genetic material (genomic DNA) obtained directly from environmental samples such water. Collection and analysis of eDNA has the potential to provide actionable information on the presence and distribution of aquatic invasive species.

Challenge: The major challenge is that the results obtained from eDNA techniques currently do not always correlate with traditional netting data due to the size and quality of sampling. Unlocking the potential of eDNA requires disruption in sampling methods and tools.

Objectives: This project aimed to develop a novel aquatic eDNA collection and concentration technology for more efficient, reliable and cost-effective screening for not only invasive aquatic organisms and pathogens but also native and endangered species. The technology would significantly enable and empower aquatic ecosystem

survey and management programs in Minnesota. Specifically, we aimed to 1) develop an eDNA nanofilter that specifically and rapidly captures nucleic acids (DNA, RNA) from water and enable the processing of large volumes of samples within a short period of time, 2) Verify increased eDNA sampling efficiency of the new nanofilter in field settings (proof-of-concept)

Results and Accomplishments: We have successfully developed a new eDNA filter that captures 50-100% of eDNA within 10 seconds. Commercial kits are incapable of capturing free eDNA. The loading capacity of the new filter is up to 5 mg/g, meaning that 1 g of filter can capture up to 5 mg of DNA. This is a record-breaking capacity that enables the filtration of large volumes of water with one filter, knowing that surface water contains usually 10 ng/L of eDNA.

Following the COVID-19 pandemic, we have adapted the nonfilter to develop an RNA extraction kit for SARS-CoV-2. The new kit was evaluated by the University of Minnesota COVID-19 Diagnostic Laboratory on 80 patient samples, and it showed that our kit has a 100% specificity and 94% sensitivity, which is respectively 12.8% and 5.4% higher than the widely used Qiagen kits

Significance and Impact to Minnesota: Ecosystem conservation managers have been relatively reluctant to use eDNA as a routine tool for ecosystems monitoring. The results obtained here can have a significant impact on the widespread adoption of eDNA technology, which will help the State enhance the accuracy and quality of the data and improve decision making for the management of invasive species. This work has also led to starting a new company, which is expected to accelerate the transfer of the technology to the market, and enhance the industry capacity to respond to the State's need for AIS management.

SUBPROJECT 21.2: Field validation of mulitbeam sonar zebra mussel detection (Year I)

Project Manager: Jessica Kozarek

Organization: St. Anthony Falls Laboratory, University of Minnesota

Description: This project is Phase II of a project to test the utility of a swath mapping system, multibeam sonar, for detecting and quantifying the presence and abundance of invasive mussels at a very large scale. Current methods for detection of zebra mussel colonies rely on time consuming and expensive diving surveys, video imaging, or sampling of veligers (larvae) in the water. Survey sampling design would be much more efficient given spatially extensive information on the presence/absence of zebra mussel beds. Such remote sensing would also facilitate early detection and warning in rivers, lakes and reservoirs through routine monitoring, or to follow changes in zebra mussel density (boom-bust cycles). Phase I of this project, laboratory experiments, revealed sufficient differences in acoustic response (echo) of mussels (native and zebra) and the supporting sediment that we are able to develop an empirical approach to zebra mussel detection. Phase II of this study will test the use of this and other acoustic signatures to detect and map zebra mussel beds in the field, incorporating a larger range of variables, such as a greater range of mussel densities and substrate mixtures, water depths and temperatures.

Year 1 activities for Subproject 21.2 are funded on M.L. 2017, which end on June 30, 2020. Year 2 activities continue on M.L. 2019 funding, beginning on January 1, 2021.

Subproject 21.2 ENRTF BUDGET: $228,930

M.L. 2017, Chp. 96, Sec. 2, Subd. BUDGET: $14,247
M.L. 2019, 1st Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 6a BUDGET: $214,653

Year 1 Outcomes	Completion Date
Activity 1	
1. Establish survey protocols and team coordination with pilot mussel study	December 2019
Activity 2	

1. Coordination with MAISRC and UMN Extension on media efforts, committees	June 2020
2. Annual MAISRC Showcase Event	September 2020

Year 2 Outcomes	**Completion Date**
Activity 1	
1. Comparison of spatial distribution as mapped by acoustic survey and diving surveys	December 2021
2. Characteristic roughness scales of mussel beds	December 2021
3. Develop methodology to incorporate acoustic surveys into zebra mussel monitoring.	December 2021
Activity 2	
1. Coordination with MAISRC and UMN Extension on media efforts, committees	December 2021
2. Acoustic detection of mussels workshop	December 2021
3. Prepare manuscripts for publication	December 2021

Fifth Update February 28, 2020

Based on results from the Phase I project; the research team's experience with multibeam sonar and mussel surveys; and recent survey work conducted by MAISRC, the research team established draft survey protocols to accurately link data collected using the multibeam sonar to data collected by the mussel survey team. This plan involves scanning areas containing mussels marked with geomarkers that are visible to both the divers and the sonar survey team. Preliminary testing was conducted using a side-scanning sonar to identify appropriate markers. To differentiate between native freshwater mussels and zebra mussels, multibeam backscatter data will be collected for substrates with both native and zebra mussels. To conduct mussel surveys in native mussel beds, permitting is required and permits for the 2020 field research have been applied for through the Minnesota DNR. Despite administrative delays in setting up subcontracts with project partners, which limited 2019 preliminary field work, the 2020 research plan has been designed to accommodate these delays and will not delay the project deliverables.

Sixth Update August 31, 2020

Following a full-team meeting in January, field protocols developed over the last year were refined and finalized and our field campaign was scheduled for June 2020. To collect appropriate data to develop and validate methodology to utilize multibeam sonar in zebra mussel monitoring, careful coordination between mussel surveys and multibeam sonar surveys is required and the final plan included survey markers, division of labor in the field, coordination between survey vessels, and contingency plans. However, COVID-19 has disrupted these plans and due to restrictions on inter-state travel, medical restrictions from members of our team, and UMN College of Science and Engineering timing on re-opening plans, June field work could not be conducted as planned. As the situation continues to evolve, the project will be paused starting July 1 and will re-start in January with the field campaign re-scheduled for Summer 2021.

Seventh Update February 28, 2021

No activity from July 1 – December 31, 2020. Status update on subproject activities beginning on January 1, 2021 are recorded on the Third Update March 1, 2021 report on M.L. 2019.

Final Report between project end (June 30) and September 15, 2022

Final report summary is recorded on M.L. 2019 report.

SUBPROJECT 22: Copper-based control – zebra mussel settlement and non-target impacts

Project Manager: James Luoma

Organization: USGS, Upper Midwest Environmental Sciences Center

Description: Development of population level management techniques that have potential to reduce the environmental and economic impacts of zebra mussels while also protecting and preserving native species and habitats are critically needed. Targeting treatments to kill zebra mussel larvae and prevent their settlement also has potential use for zebra mussel containment or eradication in small, hydrologically isolated inland water bodies. Potential users include the MN DNR, local governmental units, and water infrastructure owners/users.

This project builds upon previous work (McCartney 2016) which identified the susceptibility of larval zebra mussels to much lower doses of copper compared to adult zebra mussels. This project will involve a 10-day, low-dose (60-ppb) copper treatment of an entire enclosed bay in Lake Minnetonka. St. Albans Bay (treated bay) and Robinson's Bay (control bay) will be sampled before and after application to determine treatment-related impacts on zebra mussel veliger abundance and settlement success. Treatment-related impacts to adult zebra mussels, algal, zooplankton, benthic invertebrates, and fish communities will be assessed. The three main objectives in this project are: 1) evaluate the efficacy of low-dose copper treatments to control populations of zebra mussel veliger larvae, 2) evaluate the use of low-dose copper treatments to suppress zebra mussel larval settlement, and 3) evaluate the effects of low-dose copper treatments on native aquatic animals and algal biomass.

Subproject 22 ENRTF FINAL BUDGET: $218,956

M.L. 2013, Chp. 52, Sec. 2, Subd. 06a FINAL BUDGET: $66,866
M.L. 2017, Chp. 96, Sec. 2, Subd. 06a FINAL BUDGET: $152,090

Outcomes	Completion Date
Activity 1	
1. Refine methods to assess zebra mussel settlement	December 2018
2. Complete acquisition contract for EarthTec QZ	May 2019
3. Develop project protocol and obtain necessary permits for application and test cages	May 2019
Activity 2	
1. Conduct pretreatment collection of veliger/zooplankton tows, benthic invertebrate samples, water chemistry samples, secchi disk readings, and chlorophyll samples.	July 2019
2. Placement of buoys, nontarget fish and unionid mussels, adult zebra mussels, and zebra mussel plate samplers in control and treated bays.	July 2019
3. Entire bay applications of EarthTec QZ over 10 days, consisting of 5 independent applications.	August 2019
Activity 3	
1. Conduct post-treatment collection of veliger/zooplankton tows, benthic invertebrate samples, water chemistry samples, secchi disk readings, and chlorophyll samples.	August 2019
2. Conduct survival assessments of adult zebra mussels, unionid mussels and fish	August 2019
3. Complete assessments of settlement success on plate samplers	December 2019
4. Complete data entry, proofing, and summarization	January 2020
5. Prepare study report and peer-reviewed manuscript	June 2020

Third Update February 28, 2019

Status update on subproject activities through 01/31/2019 are recorded on M.L. 2013 report.

Fourth Update August 31, 2019

Status update on subproject activities through 07/31/2019 are recorded on M.L. 2013 report. Year 1 funding for this project on M.L. 2013 ended on June 30, 2019 and Year 2 activities will continue on M.L. 2017 funding.

Fifth Update February 28, 2020

All objectives in Activity 2 of the work plan were completed as planned and on schedule. Triplicate zebra mussel veliger/native zooplankton tows and benthic invertebrate ponar grabs were collected near each of five buoys that were placed in the treated (St. Albans) and control (Robinson) bays in Lake Minnetonka. on July 18-20, 2019. Pre-exposure water samples were also collected to determine Biotic Ligand Model (BLM) parameters, chlorophyll a, and other water chemistry parameters. Juveniles of four species of native fish and one species of native mussels as well as adult zebra mussels were placed in submerged cages near each buoy to assess treatment-related impacts on survival and accumulation of copper in tissues.

The first known large-scale (~160 surface acres) low-dose copper treatment for zebra mussel suppression was conducted in St. Albans bay using five every-other-day applications that were conducted between July 22, 2019 and July 30, 2019. Targeted delivery of 60 parts per billion (ppb) of copper to waters above the thermocline were accomplished using a custom-built, boat-mounted application system. The application system utilized a gasoline-powered water pump, a venturi chemical suction system, and a flow meter to proportion and dilute the concentrated copper solution prior to distributing into the bay using a 4.5m-wide boom fitted with dropper hoses.

Field and laboratory-based objectives for Activity 3 were completed and included post-treatment target and non-target animal density/abundance/survival assessments, plot-based surveys, veliger and zooplankton tows, benthic invertebrate samples, BLM water samples, secchi disk readings, and chlorophyll samples that were collected 48 h to 3 months after treatment. Native fish, native mussel, and zebra mussel tissue samples were analyzed for residues to assess the accumulation of copper. The suite of assessments conducted is critical to comprehensively assess treatment efficacy and non-target animal impacts. Results of sampling conducted 1 month after treatment indicate that the low-dose copper treatment substantially reduced the abundance of all lifestages of zebra mussels in St. Albans Bay. By comparison, sampling in the untreated control bay over the same time period showed an increase in zebra mussel veliger density, > 100,000 settled juvenile zebra mussels per square meter on settling plates, and > 37 resident zebra mussels per square meter in benthic quadrat samples. Nontarget animal impacts were mixed, with the most notable impacts observed in the abundance and diversity of native zooplankton and benthic invertebrates.

Table 1. Mean water column veliger density, juvenile zebra mussel density on settlement plates, and zebra mussel density in quadrat samples in the treated (St. Albans) and control (Robinson) bays of Lake Minnetonka, MN.

Bay/Treatment	Sample Time	Mean zebra mussel veliger density (#/L)	Mean juvenile zebra mussel density on settling plates (#/m^2)	Mean zebra mussel density in quadrat samples (#/m^2)
Robinson (Control)	Pre-exposure	1.17 ± 0.67	-	73.5 ± 103.7
	24-h post-exposure	7.04 ± 6.55	-	-
	1-month post-exposure	1.22 ± 0.92	135,006 ± 9,501	-
	3-month post-exposure	-	53,722 ± 17,585	37.7 ± 66.1
St. Albans (Treated)	Pre-exposure	1.85 ± 1.47	-	59.6 ± 130.7
	24-h post-exposure	0.03 ± 0.10	-	-
	1-month post-exposure	> 0.01 ± 0.03	69 ± 98	0.4 ± 1.1
	3-month post-exposure	-	25 ± 31	-

Final Report October 29, 2020

This study evaluated a low-dose copper treatment for zebra mussel (*Dreissena polymorpha* Pallas 1771) suppression by maintaining a mean copper concentration of 60 µg/L in waters above the thermocline for 10 consecutive days in St. Albans Bay (66.3-ha) of Lake Minnetonka, Minnesota. Robinson Bay (37.2-ha, Lake Minnetonka) was a control site. The volume of EarthTec QZ applied during five every-other-day applications was determined using copper concentrations measured in the field.

Treatment effects on zebra mussels lifestages were evaluated by analyzing changes in veliger abundance, juvenile settlement, benthic abundance, and adult survival. Treatment effects on nontargets were evaluated by analyzing changes in water chemistry properties, chlorophyll a, native fish (4 species) survival, native mussel (1 species) survival, native zooplankton abundance and richness, and native benthic invertebrate abundance and richness.

The copper concentration was maintained above 60 µg/L during the treatment period and returned to background levels between 60 and 90 days after treatment. The treatment adversely affected all life stages of zebra mussels throughout the study period. In the treated bay, veliger density was near zero 14 days after treatment, a strong reduction in juvenile settlement was observed, zebra mussel benthic density was sparse after treatment, and the odds of adult survival was substantially reduced. Detectable nontarget treatment-related effects included reductions in zooplankton abundance, chlorophyll a, and fathead minnow survival. Elevated copper residues in fish and mussel tissues were also observed. Decreases in benthic invertebrate abundance, secchi disk readings, and dissolved oxygen concentration were also observed after the treatment.

The data from this study can be used to assist in assessing if low-dose copper treatments are an appropriate zebra mussel management strategy for a waterbody. Any use of trade, firm, or product names in this report is for descriptive purposes only and does not imply endorsement by the U.S. Government.

SUBPROJECT 23: Public Values of Aquatic Invasive Species Management

Project Manager: Amit Pradhananga

Organization: Center for Changing Landscapes, University of Minnesota

Description: Emerging evidence shows that Aquatic Invasive Species (AIS) management can be used to restore ecosystem services. For example, management of the invasive common carp (*Cyprinus carpio*) can lead to increases in water clarity and declines in nutrient concentrations in a more cost-effective manner than other management practices (Vilizzi et al. 2015; Bartodziej et al., 2017). Yet, management of AIS is often not considered an option when planning ecosystem restoration. Even if the direct costs of AIS management are known, lack of information about the potential benefits of AIS management makes informed decision making difficult. With an accurate assessment of the costs and benefits of AIS management strategies, as well as information on public perception, resource managers will be better prepared for the efficient investment of management resources. The overall goal of this project is to quantify and analyze the ecological and economic value of AIS damages and AIS management as they relate to ecosystem services (e.g., fishing, swimming, biodiversity, navigability). The specific objectives of this project are to:

1. Assess the use and non-use values assigned to ecosystem services impacted by AIS. Use values are those values generated from using a resource, such as recreation values. Non-use values are those values generated even when a resource is not directly used-- the value a person has for a resource they never visit and never will visit. An example would be existence value—valuing a resource just for existing, or bequest value—valuing a resource for the benefit of future generations.
2. Investigate the costs and effectiveness of carp management as a strategy for water clarity restoration
3. Develop a flexible ecological and economic optimization modeling framework to inform AIS management decisions

We will employ a multi-pronged approach with five activities: estimating public benefits of AIS management (Activities 1 and 2), analyzing costs of carp management (Activity 3), and the development of a broad AIS analysis framework (Activity 4) which we will use to estimate efficient carp management (Activity 5). The main goal of Activities 1 (mail survey of residents and lakeshore owners) and 2 (onsite survey of recreationists) is to produce data which can be used to estimate the lost public value attributed to AIS. The on-site surveys will target recreationists to generate use values related to boating, fishing, swimming, and general hiking/wildlife viewing/enjoyment of nature. The third activity, a cost analysis, will focus on common carp, an established AIS with long management history. This activity will generate cost and effectiveness information for various methods of carp management, potentially including removal, prevention, and barriers. Activities 4 and 5 include the development of a programming framework both to analyze the data generated in activities one, two, and three, and to provide guidance for AIS management in other regions of the state**.**

This project will provide multiple benefits to stakeholders and natural resources throughout Minnesota, as well as other areas with AIS concerns. This project will provide both natural resource managers and water quality regulators with information that will help to prioritize AIS and water quality management projects, permitting them to make more effective use of limited conservation dollars. This project will quantify the dollar value of the public benefits of AIS management, as well as the costs of managing a specific AIS (i.e., common carp) for water quality outcomes. Expected outcomes of this project include a decision support tool that will help resource managers assess the costs and benefits of AIS management. Specific outcomes of the study include a comprehensive AIS valuation data compilation for use by other researchers, and an eco-economic programming model to predict the economic and ecological repercussions of using AIS prevention and control initiatives.

Subproject 23 ENRTF FINAL BUDGET: $242,090

M.L. 2013, Chp. 52, Sec. 2, Subd. 06a BUDGET: $131,845
M.L. 2017, Chp. 96, Sec. 2, Subd. 06a BUDGET: $110,245

Outcomes	**Completion Date**
Activity 1	
1. Develop survey questionnaire for residents and lakeshore owners	January 31, 2019
2. Administer survey to 2,000 MN residents and lakeshore owners	December 31, 2020
Activity 2	
1. Develop the survey questionnaire for recreationists (e.g. boaters, anglers), sampling plan, and sampling schedule	April 30, 2019
2. Administer onsite surveys to recreationists at boat docks	September 30, 2019
Activity 3	
1. Compile list of management cases and supporting lake and watershed data in MN	January 31, 2019
2. Conduct preliminary cost-benefit analysis and identify data gaps	July 31, 2019
3. Finalize the database by scouring out-of-state data and conducting global literature review	January 31, 2020
4. Finalize cost-benefit analysis, submit manuscript, present the results to stakeholders (e.g. Minnesota Association of Watershed Districts (MAWD))	December 31, 2021

Third Update February 28, 2019

Status update on subproject activities through 01/31/2019 are recorded on M.L. 2013 report.

Fourth Update August 31, 2019

We have made progress in Activity 1 (general resident survey), Activity 2 (onsite survey of recreationists), and Activity 3 (cost-benefit of carp management). For Activity 1, we developed a draft survey that will be administered with 2,000 residents across Minnesota. The survey is currently being reviewed by experts in survey design. For Activity 2, we developed the survey questionnaire, sampling plan, and sampling schedule. We have

also hired and trained field surveyors. The survey is being administered at 6 lakes across Minnesota. For Activity 3, we developed and administered a questionnaire with watershed districts and other carp management agencies to collect information about cost estimates (for each management action) and water quality (clarity and Phosphorus) before and after AIS management.

Year 1 funding for this project on M.L. 2013 ended on June 30, 2019 and Year 2 activities will continue on M.L. 2017 funding.

Fifth Update February 28, 2020

We have made substantial progress in Activity I (general resident survey), Activity 2 (onsite survey), and Activity 3 (cost-benefit of carp management). We developed the survey questionnaire for Activity 1, which we will be pre-testing and piloting in February 2020 and administering between February 2020 and April 2020. We also developed and administered an onsite survey of recreationists at four lakes in the summer of 2019 (between June to August 2019). We have analyzed survey data from Activity 2 and presented findings to a range of audiences including policy makers, researchers, and resource professionals. Valuation data from the onsite survey in Activity 2 was analyzed to quantify economic value associated with aquatic invasive species (AIS) management. More than half of the survey respondents were willing to pay a lake access fee, if it went towards managing AIS. We estimated mean willingness to pay to be $10.23 per day. Further, we have also conducted analysis to develop a framework of recreationists behaviors associated with AIS management. In particular, we have identified socio-economic factors (e.g., income, primary purpose of lake visit, awareness of AIS problem, perceived risk) that influence recreationists' willingness to pay for AIS management. Understanding the motivations of and barriers to recreationists' AIS prevention and management behaviors will help resource managers develop effective programs for AIS management. Survey data collected in Activities 1 and 2 will help us understand the economic damages associated with AIS, as well as the economic and social values related to AIS management. In Activity 3, we conducted 24 interviews to collect data about strategies for carp management. We have compiled a list of carp management cases and identified lakes that have implemented carp management strategies. Data collected in Activity 3 will be used to assess cost-effectiveness of various carp management strategies. We will also conduct analysis on this dataset to assess the relationship between carp management and water quality outcomes.

Sixth Update August 31, 2020

We have made substantial progress in data analysis in Activity 2 (onsite survey), and Activity 3 (cost-benefit of carp management). We have developed the survey questionnaire for Activity 1. We had to delay survey administration due to COVID restrictions. However, we plan to administer the survey between September to December, 2020. We have also analyzed survey data from Activity 2 and presented findings to a range of audiences including policy makers, researchers, and resource professionals. Valuation data from the onsite survey in Activity 2 was analyzed to quantify economic value associated with aquatic invasive species (AIS) management. More than half of the survey respondents were willing to pay a lake access fee, if it went towards managing AIS. We estimated mean willingness to pay to be $10.23 per day. Further, we have also conducted analysis to develop a framework of recreationists behaviors associated with AIS management. In particular, we have identified socio-economic factors (e.g., income, primary purpose of lake visit, awareness of AIS problem, perceived risk) that influence recreationists' willingness to pay for AIS management. We have submitted a manuscript to the *Journal of American Water Resources Association.* In Activity 3, we conducted 24 interviews to collect data about strategies for carp management. We have conducted preliminary analysis on carp management costs, management strategies, and years of implementation for those strategies. We will be analyzing this data to examine links between carp management strategies and phosphorus levels in lakes.

Seventh Update February 28, 2021

We have conducted further data analysis in Activity 2 (onsite survey), and Activity 3 (cost-benefit of carp management). We have developed and refined the survey questionnaire for Activity 1. We had to delay survey

administration due to COVID restrictions. We are currently preparing to print and mail the survey to 2000 Minnesota residents. We have also analyzed survey data from Activity 2 and presented findings to a range of audiences including policy makers, researchers, and resource professionals. We have published one peer-reviewed journal article in *PLOS ONE.* Analysis of valuation data from the onsite survey in Activity 2 suggest that more than half of the survey respondents were willing to pay a lake access fee if it went towards managing AIS. We estimated mean willingness to pay to be $10.41 per day. Further, we found that perceived risk about AIS and awareness of AIS problem were positively correlated with willingness to pay. Preliminary analysis on boater behavior data suggests that boaters who take AIS prevention actions value ecosystem services such as wildlife habitat and recreational opportunities more than boaters who do not take AIS prevention actions. Spatial analysis of recreationist visit data showed that most respondents live within 50 miles of the surveyed lakes. These findings highlight the need to emphasize both the ecosystem value of AIS management, and the risks posed by AIS to such values in AIS related communication and outreach. In Activity 3, preliminary analysis of carp removal and water quality data suggests that carp removal may be linked with reduced phosphorus levels, particularly in shallow lakes. We will be conducting further analysis of this data to assess carp management strategies and costs.

The research team gave presentations about this project at the Minnesota Water Resources Conference in October 2020. The team also presented to the MN DNR Statewide Aquatic Invasive Species Advisory Committee, at MAISRC's 2020 Research and Management Showcase, and gave an AIS Detectors webinar.

Recording of Showcase presentations online: https://z.umn.edu/2020ShowcasePresentations
Recording of the AIS Detectors webinars online: https://z.umn.edu/AISDetectorsWebinars

Eighth Update August 31, 2021

We are currently collecting survey data in Activity 1 (general resident survey) and conducing further data analysis in Activity 2 (onsite survey), and Activity 3 (cost-benefit of carp management). Preliminary analysis of general resident survey data show that most respondents are very to extremely concerned about Zebra mussels and Eurasian watermilfoil. Most respondents also believe that AIS pose risks to ecosystem services such as habitat for native fish and aquatic plants, cost of water treatment, and water quality in Minnesota's lakes, rivers, and streams. However, civic engagement (e.g., talking to others about AIS, volunteering to improve habitat affected by AIS) in AIS protection and management is generally low. Findings also suggest that respondents generally support policies to manage AIS (e.g., increased enforcement of AIS laws, increased inspections of watercraft for AIS). We have also analyzed survey data from Activity 2 and published one peer-reviewed journal article in *PLOS ONE.* Analysis of valuation data from the onsite survey in Activity 2 suggest that more than half of the survey respondents were willing to pay a lake access fee, if it went towards managing AIS. We estimated mean willingness to pay to be $10.41 per day. Further, we found that perceived risk about AIS and awareness of AIS problem were positively correlated with willingness to pay. Preliminary analysis on boater behavior data suggests that boaters who take AIS prevention actions value ecosystem services such as wildlife habitat and recreational opportunities more than boaters who do not take AIS prevention actions. Spatial analysis of recreationist visit data showed that most respondents live within 50 miles of the surveyed lakes. These findings highlight the need to emphasize both the ecosystem value of AIS management, and the risks posed by AIS to such values in AIS related communication and outreach. Findings from the survey of Minnesota residents suggest that while most residents support various management actions, their level of engagement in AIS management is low. In Activity 3, preliminary analysis of carp removal and water quality data suggests that carp removal may be linked with reduced phosphorus levels, particularly in shallow lakes. We have also documented the types of carp management strategies used by management agencies in 92 lakes across Minnesota, along with estimated cost of carp management. We will be conducting further analysis of this data to assess carp management strategies and costs.

Final Report between project end (June 30) and September 15, 2022

Minnesota hosts a number of aquatic invasive species (AIS), which have far-reaching impacts on Minnesota's waterbodies, and subsequently its population. However, little was known about how Minnesotans value AIS, as well as costs associated with AIS management. To address this, we collected data on aquatic invasive species management and costs, public perceptions, values, knowledge, and willingness to pay for aquatic invasive species management via several surveys of different types spanning 2019 to 2021. Surveys of watershed districts and soil and water conservation districts provided data from 92 lakes across 12 counties, showing that carp management is a priority in Minnesota. We also were able to collect data on costs and types of management employed. On the individual side, an onsite survey of approximately 1000 people visiting lakes in the summer showed us visitors are willing to pay for AIS management at the lakes they are visiting and hold significant value for Minnesota's water resources, though individual AIS species present are not impactful for these social values. We also collected data through a mail survey of about 300 people, which confirmed Minnesotans' intrinsic value for water resources. Many residents are willing to pay for AIS management statewide, meaning they do not have to directly visit or use a lake to find value in it. This project is important as it provides data to support the viewpoint that Minnesotans do in fact have great value for AIS management and are willing to pay to expand management across the state.

SUBPROJECT 24: Genetic method for control of invasive fish species

Project Manager: Michael Smanski

Organization: University of Minnesota

Description: Invasive fish species present an estimated $5.4 billion burden on our domestic economy, and much of that extends to the lakes and rivers of Minnesota. For example, the foraging habits of the invasive common carp, *Cyprinus carpio*, diminishes water quality, reduces vegetative cover and waterfowl numbers, and reduce the ability of lakes to absorb nutrients that enter water systems through agricultural runoff. Current control methods have not been able to stem the tide of invasive carp and other fish species, so improved strategies are needed. The overall goal of this project is to demonstrate a novel approach for controlling aquatic invasive species using invasive carp species as proof-of-concept. Success of this project would lead to its implementation in other aquatic invasive species (AIS), including Asian carp and zebra mussels.

We have three activities in this subproject. Activity 1 aims to develop state-of-the-art carp transgenesis capabilities at the MAISRC Containment Lab. Obtaining freshly laid eggs and fertilizing them with freshly collected sperm is a prerequisite for generating the young carp embryos needed for carp transgenesis. In Minnesota, wild carp only spawn during late spring/early summer, creating a very short window of opportunity for performing genetic engineering experiments. A serious effort towards developing new biocontrol methods in carp requires year-round access to young carp embryos, and we will achieve this be maintaining several independent tanks of captive carp that have been slowly 'trained' to be on different annual cycles.

Activity 2 aims to transition our new genetic biocontrol strategy into carp. We have done proof-of-concept experiments in simple laboratory organisms to demonstrate the feasibility of our approach. In this aim, we begin engineering these genetic components in carp. The complete engineering effort will require more time than is funded in this current subproject, but we have listed milestones that will demonstrate substantial progress towards our engineering goals.

Activity 3 accomplishes two tasks. First, we use computer modeling to predict the efficacy of our approach when combined with existing strategies for carp management. Second, we engage the public to develop a better understanding of their attitudes and opinions on using genetically engineered organisms as one part of an integrated pest management plan.

Subproject 24 ENRTF FINAL BUDGET: $250,116

M.L. 2013, Chp. 52, Sec. 2, Subd. 06a FINAL BUDGET: $110,112
M.L. 2017, Chp. 96, Sec. 2, Subd. 06a FINAL BUDGET: $140,004

Outcomes	Completion Date
Activity 1	
1. Begin husbandry of 4 separate carp populations synced to unique annual cycles	July 2018
2. Demonstrate the ability to harvest and fertilize carp eggs/sperm from laboratory carp during Summer, Fall, and Winter (seasons when wild carp are not actively spawning)	December 2019
3. Generate transgenic carp expressing the genes needed to engineer our biocontrol system	June 2021
Activity 2	
1. Assess genetic diversity in wild populations of common carp	June 2019
2. Generate and validate point mutations in promoters of GATA5, SSH1, and ERN, which are three genes in carp that we need to modify for our genetic biocontrol approach.	June 2021
3. Transfer sex-ratio biasing construct to the C. carpio chromosome	June 2021
4. Introduce genetic components into carp that will drive the incompatibility between wild carp and engineered fish. These components will not be toxins but will cause natural carp genes to be turned on at the wrong time during development and lead to inviable offspring.	June 2021
Activity 3	
1. Complete optimal IPM plan based on agent-based simulation models	July 2019
2. OUTREACH: Survey state-wide Watershed District Managers about GMO technologies	September 2018
3. OUTREACH: Oral presentation at MAISRC open houses	September 2018/19
4. OUTREACH: Public survey via MAISRC Detectors volunteers and 2019 MN State Fair	September 2019

Third Update February 28, 2019

Status update on subproject activities through 01/31/2019 are recorded on M.L. 2013 report.

Fourth Update August 31, 2019

Status update on subproject activities through 07/31/2019 are recorded on M.L. 2013 report. Year 1 funding for this project on M.L. 2013 ended on June 30, 2019 and Year 2 activities will continue on M.L. 2017 funding.

Fifth Update February 28, 2020

We have made substantial progress towards developing a first-of-its-kind biocontrol approach to combat invasive common carp using Sterile Male Accelerated Release Technology (SMART) carp. Since our last status update, we have successfully trouble-shot the zebrafish microinjection protocol that had slowed us down in previous reporting periods. We used our improved methods to identify suitable programmable transcription activators (PTAs) that drive lethal gene expression in fish. This data will be used to perform our first genetic engineering in carp in the coming months. We have also completed the public engagement activities (all outcomes in Activity 3) concerning genetic biocontrol of invasive carp. In total, we surveyed more than 1,300 Minnesota citizens. We learned that genetic biocontrol was seen as less acceptable than physical control methods (netting, trapping, fishing, etc.), but more acceptable than other biological or chemical methods. Of the genetic biocontrol methods, sterile release technologies were seen most favorably, followed by sex-ratio biasing and then gene-drives. This data is currently being written up for publication.

Sixth Update August 31, 2020

We have had limited progress on this project in the past six months, due to a forced lab closure due to UMN reduced operations in response to COVID-19, reduced lab activity during our Phase I reopening, and recent equipment failure in the MAISRC Containment Lab that resulted in a loss of carp associated with this project.

Since our last update, we have performed additional experiments to identify programmable activators that provide lethal gene expression in zebrafish, we have amplified genetic elements needed for carp transgenesis plasmids (ccDmrt2a::GFP and ccDmrt2a::dCas9VPR), and we have drafted a manuscript for the carp genetic biocontrol public engagement survey.

Seventh Update February 28, 2021

The most impactful accomplishment (and one that took the majority of our effort to achieve) was demonstration of our ability to create transgenic carp in off-cycle spawning. Working with carp (a very non-model organism) has been the crux of this project to date. Through multiple repeated and unsuccessful trials for induced spawning and transgenesis, we continued to refine protocols to make incremental improvements. By the end of the reporting period, we are excited to report that we have GFP-expressing carp that are alive and well. In parallel, we have finished construction of the molecular reagents that encode components of our Sterile Male Accelerated Release Technology (SMART) carp system. These are under the control of carp genetic elements that will direct their transcription and translation. With our success in demonstrating transgenesis in carp, we are currently focusing the remainder of our efforts to getting these elements introduced into carp to complete Activities 1 and 2. We are still in good position to accomplish these activities.

The research team gave presentations about this project at the Upper Midwest Invasive Species Conference in November 2020, FNIH Global GeneConvene Virtual Institute in October 2020, and at the SynBio Australasia Seminar in July 2020. The team also presented to the MN DNR AIS Working Group and at MAISRC's 2020 Research and Management Showcase. A recording of the Showcase presentation is available online: https://z.umn.edu/2020ShowcasePresentations

Final Report August 31, 2021

Invasive fish species present an estimated $5.4 billion burden on our domestic economy, and much of that extends to the lakes and rivers of Minnesota. For example, the foraging habits of the invasive common carp, *Cyprinus carpio*, diminishes water quality, reduces vegetative cover and waterfowl numbers, and reduce the ability of lakes to absorb nutrients that enter water systems through agricultural runoff. Current control methods have not been able to stem the tide of invasive carp and other fish species, so improved strategies are needed. The overall goal of this project is to demonstrate a novel approach for controlling aquatic invasive species using invasive carp species as proof-of-concept. Success of this project would lead to its implementation in other aquatic invasive species (AIS), including Asian carp and zebra mussels.

Several major obstacles had to be overcome on this project to lay the foundation for genetic biocontrol of invasive carp. These included (i) Developing husbandry for year-round carp spawning in the MAISRC Containment Lab, (ii) Demonstrating transgenesis of *C. carpio*, (iii) Testing genetic reagents in a model laboratory fish that will be needed to engineer carp, and (iv) Performing a survey to gauge public perceptions of carp genetic biocontrol. We accomplished these project goals within a one-year no-cost extension to the project funding.

The impact of our results is that we are now primed to engineer carp genetic biocontrol agents in the lab during the next phase of this award, which will begin January 2022. There is still substantial work to be done before this will directly benefit Minnesotans. Specifically, we need to demonstrate a proof-of-concept carp biocontrol system in the laboratory; perform safety/efficacy testing; obtain permits for field trials; and eventually work with key stakeholders to use this new tool in the fight against invasive carp. The overall process is expected to take 10-15 years.

SUBPROJECT 25: What's in Your Bucket? Quantifying AIS Introduction Risk

Project Manager: Nicholas Phelps

Organization: University of Minnesota

Description: The use of baitfish for recreation angling results in billions of farm-raised and wild-caught fish (and accompanying hitchhikers) being moved long distances overland and intentionally introduced into new environments. As a result, baitfish movement has been considered a high-risk activity for the spread of aquatic invasive species (AIS), with potentially major economic, ecological, and societal consequences. Consequently, state legislatures and management agencies across the country, including Minnesota, are considering dramatic overhauls of their baitfish regulations. This has put supporting a multimillion-dollar bait industry at odds with conserving a multibillion-dollar recreational fishery. The lack of a structured framework to evaluate risk in the face of differing perceptions and great uncertainty (ie. minimal data) for many aquatic hazards is limiting our collective ability to understand and mitigate the risk that baitfish movement could spread potentially devastating AIS.

While the baitfish trade has the potential to move all varieties of AIS, perhaps most vexing are invasive pathogens that can move as passengers undetected at high prevalence, have little or no management options, and can cause long lasting population-level impacts on important fish species. In Minnesota alone, numerous novel baitfish viruses have been discovered in recent years, highlighting the limited information we have regarding the health status of baitfish. There is a clear need for a rigorous risk analysis, but the lack of an informed framework to do so has limited our ability to quantify the risk and make risk-based decisions. The goal of this study is to assess the risk of introduction of important fish pathogens through the recreational use of baitfish. We will synthesize existing knowledge to identify priority hazards for the baitfish trade, develop a risk analysis framework, and characterize the volume, patterns, and complexity of baitfish use by anglers in Minnesota, to develop a tool for estimating risk of AIS introduction via the baitfish pathway. The tool will be tested with three pathogens of concern to estimate the number of likely introductions to wild fish populations - a useful metric when considering trade-offs for risk management.

This work builds upon, and will be informed by, an ongoing baitfish risk assessment led by the MN DNR, previous baitfish hazard assessments, and previous and ongoing research by members of the project team. By quantifying the actual, not just perceived risks, we will help to facilitate discussions among agency, industry, and public stakeholders, inform risk-based management decisions, and ultimately lead to better outcomes that support the state's bait and fishing industries while protecting natural resources. This project aligns with MAISRC High Priority Research Needs (Research Priority A.8), builds upon existing MAISRC research, forms a new collaborative team, and will fill critical knowledge gaps identified by managers and industry alike.

Subproject 25 ENRTF FINAL BUDGET: $195,736

M.L. 2013, Chp. 52, Sec. 2, Subd. 06a FINAL BUDGET: $111,642
M.L. 2017, Chp. 96, Sec. 2, Subd. 06a FINAL BUDGET: $84,094

Outcomes	Completion Date
Activity 1	
1. Identification of 2-4 priority pathogen hazards for further research (Activity 4) and to create an overall Hazard Report.	November 2018
2. Finalization of the hazard prioritization matrix	January 2019
Activity 2	
1. Create process model for the baitfish supply chain and points of risk that will feed in to the design of angler survey (Activity 3).	December 2018
2. Development of initial introduction risk assessment framework to assess the risk of baitfish as a pathway for pathogen entry into MN waters.	March 2019
Activity 3	
1. Finalization of survey design and initial contact for mailed survey	March 2019
2. Survey coding and data analysis of survey responses	November 2019

3. Final boat launch surveys administered and evaluated	December 2019
4. Technical report on angler bait-related behaviors and peer reviewed manuscript	September 2020
Activity 4	
1. Updated risk assessment framework to inform decision making on AIS in the baitfish trade	June 2020
2. Peer-reviewed manuscript and policy brief	September 2020

Third Update February 28, 2019

Status update on subproject activities through 01/31/2019 are recorded on M.L. 2013 report.

Fourth Update August 31, 2019

Status update on subproject activities through 07/31/2019 are recorded on M.L. 2013 report. Year 1 funding for this project on M.L. 2013 ended on June 30, 2019 and Year 2 activities will continue on M.L. 2017 funding.

Fifth Update February 28, 2020

We have made substantial progress in all the Activities in the last six months. For Activity 1, we implemented a process to elicit expert opinion and incorporated this into an improved risk ranking framework. The results were used to prioritize baitfish pathogens as high to low risk to Minnesota. The manuscript describing the hazard prioritization process will be submitted within the next few weeks. We received a total of 679 mailed surveys and 305 postcard surveys from our Activity 3 effort and the manuscript for this activity is in preparation. Interestingly, we found that approximately 20% of anglers who use live baitfish illegally release the unused bait at least some of the time. Based on the data from the survey respondents, we completed initial steps for parameterizing the risk assessment framework and have started to run preliminary simulations based on the data as described in Activities 2 and 4. These preliminary results suggest that even pathogens at low prevalence in the baitfish supply may be introduced hundreds of thousands of times into Minnesota waters. We were accepted to the Minnesota American Fisheries Society annual meeting which will take place in February and are preparing abstracts for a regional conference and a national conference in June.

Sixth Update August 31, 2020

We have made substantial progress in all the Activities in the last six months. We submitted the manuscript detailing our Activity 1 Activities to *Transboundary and Emerging Diseases* and await reviewer comments. We drafted a manuscript on our results of the angler survey from Activity 3 and are in the process of preparing that for submission to the *North American Journal of Fisheries Management*. We hired a resident from the Center for Animal Health and Food Safety residency program and have made significant progress in parameterizing and running risk scenarios as described in Activity 4. We are also working with this resident to draft a manuscript explaining the methods, results, and implications of these scenarios. We presented our results at the Minnesota American Fisheries Society meeting and at via the online AFS Fish Health webinar series. We were accepted to the North American Invasive Species Management Association annual meeting which will take place in October.

Final Report March 15, 2021

In Minnesota, the illegal release of live baitfish by anglers has been identified as a weak point in our efforts to prevent the spread of aquatic invasive species and pathogenic microbes, however the magnitude of the risk and evidence-based opportunities for intervention had not been well studied. The purpose of this project was to assess the risk of fish pathogen introduction via illegal release of live baitfish by Minnesota anglers to inform strategic management strategies to reduce that risk. First, we created a semi-quantitative framework to evaluate the threat of baitfish pathogens in Minnesota and used it to rank pathogens so managers can prioritize resources. We then conducted a statewide survey of anglers to quantify risky behaviors and used those data to parameterize a risk assessment model for high-risk pathogens to estimate the number of risky trips that occur in a given year under a variety of scenarios. Our results were variable, indicating a wide range of outcomes

depending on current management strategies and pathogen prevalence. For example, with strong surveillance and controls in place for the viral hemorrhagic septicemia virus, the number of risky trips is limited in most scenarios. However, for high-risk pathogens (*Ovipleistophora ovariae*, Asian fish tapeworm) for which no controls are in place, the large number of anglers, frequency of illegal release, and the popularity of susceptible baitfish species, can result in hundreds of thousands of risky trips each year, even in low-prevalence scenarios. Ensuring a safe, pathogen-free bait supply and decreasing the percentage of anglers who release their baitfish can reduce pathogen introduction risk while preserving the important cultural and economic benefits of recreational angling. Our project provides evidence-based tools for prioritizing scarce resources and identifying weak points in our management strategies so we can improve them to protect our valuable fish and fishing resources.

The research team gave presentations about this project at the Upper Midwest Invasive Species Conference and the North American Invasive Species Management Association. The team also presented to the MN DNR AIS Working Group, at MAISRC's 2020 Research and Management Showcase, and gave an AIS Detectors webinar.

Recording of Showcase presentations online: https://z.umn.edu/2020ShowcasePresentations
Recording of the AIS Detectors webinars online: https://z.umn.edu/AISDetectorsWebinars

SUBPROJECT 28: Evaluating Innovative Coatings to Suppress Priority AIS

Project Manager: Mikael Elias

Organization: University of Minnesota

Description: This subproject will test and develop a new coating that can mitigate the spread of Zebra and Quagga mussels invasive species while minimizing non-target impacts.

The building up of algae, microorganisms, shells such as Zebra mussels onto surface, also known as biofouling, is a natural phenomenon that sticks on structures, boats, docks, anchors. It adds costs to Minnesota's industries, and is a vector for the spread of numerous invasive species in Minnesota waters. A current way of fighting biofouling involves using coatings that contain metals, which are harmful to the environment. We propose to evaluate a new generation of coatings containing a non-toxic, antifouling, biological molecule. These coatings could help mitigate the spread of sessile invasive species not only in coastal and inland waterways but also on industrial equipment surfaces, while minimizing non-target impacts.

We will take advantage of our technical (unique engineered, highly stable and active enzymes, unique formulations) and scientific (e.g. finding that lactonase induces changes in microbial communities) advances to evaluate the potential of this technology to replace toxic biocides currently used to limit biofouling. Coated samples will be submerged in the field and samples will be analyzed using microscopy, organisms will be quantified and measured, and surface microbial communities will be determined to infer the importance of signaling.

Our proposal aims at evaluating the antifouling potential of a novel, non-toxic technology using enzymes to disrupt microbial signaling. If successful, enzyme-based coatings could help mitigate the spread of sessile invasive species in Minnesota and beyond. Moreover, findings that these enzymes act on complex biological communities is an unexpected finding from our group. The comprehensive description of its effect on surface microbial communities will enlighten our understanding of the importance of signaling in complex biological processes. The potential of this technology is such that we have established contacts with the main world coating companies, as well as local stakeholders such as the painters union and the Duluth Seaway Port Authority. This proposal constitutes a key first step to decide if deeper investigations on this technology and biofouling are needed.

Subproject 28 ENRTF FINAL BUDGET: $51,234

Outcomes	Completion Date
Activity 1	
1. Coupon preparation and installation in the field	September 15, 2019
2. Sampling and analysis of the coupons.	June 30, 2021
3. Determination of the best enzymatic coating	June 30, 2021
4. Dissemination of the project's outcomes and findings	June 30, 2021

Fifth Update February 28, 2020

In the first 6 months of the project, we successfully produced the antifouling enzyme and formulated it into paint. The enzyme-embedded paint has been applied on coupon samples in different sites in Minnesota, including the Duluth-Superior Harbor, The Tonka Bay Marina at Lake Minnetonka, and the Mississippi River. The experimental coupons were monitored at multiple timepoints during the 2019 field season. Sample analysis revealed that our enzyme-embedded coating inhibits biofouling at all of the different sites, and more specifically inhibited the adhesion of zebra mussels (Figure 1). These results provide evidence that this coating technology has the potential to reduce the adhesion of sessile aquatic invasive species to surfaces.

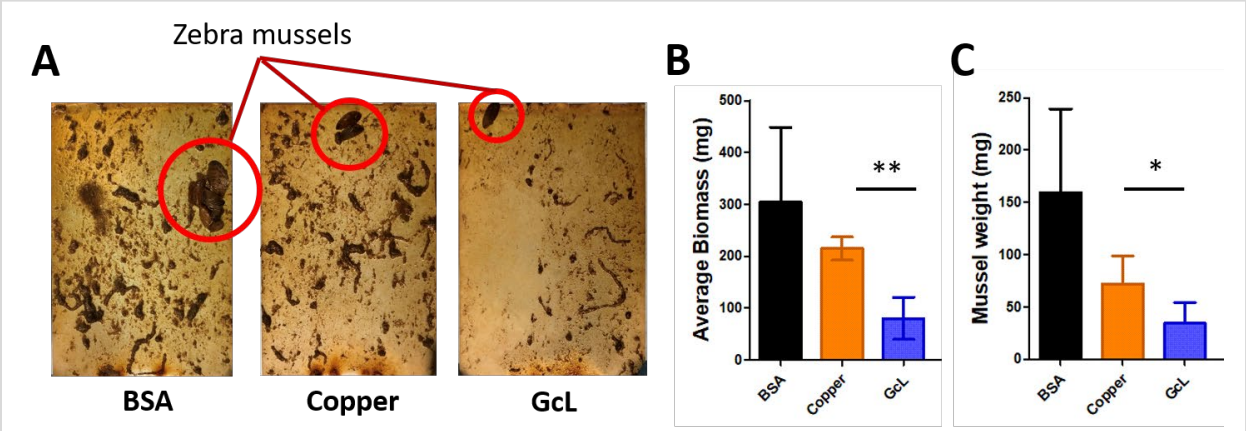

Fig. 1. Polycarbonate sample coupons coated with acrylic base, submerged at the Tonka bay marina (lake Minnetonka). (**A**) Coupons were coated with paint containing control protein (BSA; 200µg/mL), copper oxide (Copper; 200µg/mL) or our lactonase enzyme (GcL; 200µg/mL) and submerge for 45 days at the Tonka bay marine (july-august 2019). The lactonase embedded coatings shows highest performance in reducing biofouling (the dark dots attached to the coupons) and the adhesion of zebra mussels (circled in red). Replicates shows that lactonase-based coating significantly outperforms other testing coatings for biofouling (**B**) and zebra mussel adhesion (**C**).

Final Report October 29, 2020

Biofouling is a natural phenomenon that sticks on structures or boats. It is a vector for the spread of numerous invasive species in Minnesota waters. A current way of fighting biofouling involves using metals that are harmful to the environment. We successfully evaluated a new generation of coatings containing a non-toxic, antifouling, biological molecule, and demonstrate that it reduces the adhesion of invasive species. These coatings could help mitigate the spread of sessile invasive species not only in coastal and inland waterways but also on recreational and industrial equipment surfaces, while minimizing non-target impacts.

Problem: Replace current toxic antifouling coatings with coatings containing a non-toxic, antifouling, biological molecule to mitigate the spread of sessile invasive species while minimizing non-target impacts.

Methodology: We took advantage of our unique technical and scientific edges to evaluate the potential of this technology to replace toxic biocides currently used to limit biofouling. Coated samples were submerged in the field in three different sites in Minnesota, including infested sites, and samples were analyzed using microscopies, organisms were quantified and measured, and surface microbial communities determined.

Results and Significance: Biofouling is a main vector for the spread of aquatic invasive species. Current antifouling solutions are both partly effective and highly toxic to the environment. In this proof-of-concept project, we demonstrate that our non-toxic enzyme technology can prevent the adhesion of AIS on submerged surfaces. We show that in three different Minnesotan field sites that enzymatic coatings can outperform coatings containing biocides, and prevent Zebra mussels adhesion to polycarbonate surface over the course of two summer months. This enzyme-based coatings could help mitigate the spread of sessile invasive species in Minnesota and beyond. These results evidence that this novel technology has the potential to replace toxic antifouling coatings and help mitigate the spread of AIS in Minnesota and beyond.

SUBPROJECT 30: Managing Midwestern aquatic invasions in a changing climate

Project Manager: Ranjan Muthukrishnan

Organization: Indiana University

Description: The spread of invasive species is one of the most important forces impacting ecosystems today. The risks of invasive species are likely to be exacerbated under a changing climate as many of the traits that lead to their invasiveness, such as broad environmental tolerances, may also help them succeed under new climate regimes. Developing socio-ecological resilience to invasions requires an understanding of both the processes that underlie the spread and ecological effects of a particular invasive species and of the social factors that determine the potential harms and management approaches that will be acceptable to the people impacted.

Using *Nitellopsis obtusa* (starry stonewort) as a case study we will study the effects of climate change on invasion dynamics and its implications for management through an integrative approach that combines (1) empirical studies of invasion dynamics across a latitudinal gradient as a proxy for differing climate regimes, (2) interviews of stakeholders' invasive species management perceptions and preferences, (3) simulation modeling of invasions across different climate and management scenarios. Additionally, we plan to continue the project beyond this grant and hope to use the model in participatory modeling workshops that will facilitate stakeholders' usage of model products to evaluate management options.

Nitellopsis obtusa (starry stonewort) is a freshwater alga that is a key emerging invader in the upper Midwest region of the United States and has been identified as a priority species by MAISRC. *N. obtusa* can grow in incredibly dense mats, displacing native species, reducing local diversity, and creating nuisances for recreational activities. Pilot work in Minnesota has shown that population abundances and phenological patterns of *N. obtusa* can vary between years and lakes in different locations (Muthukrishnan, *unpublished data*). These patterns suggest that invasion dynamics of *N. obtusa* could be influenced by climatological factors (e.g., ice-out date, growing season length, average water temperature) and likely exacerbated by expected climate change. If this is the case, then predictions of habitat suitability or management plans based on current conditions may be unreliable. Consequently, developing effective management strategies for *N. obtusa* requires a deeper and more specific understanding of how climate change will influence invasion dynamics. Additionally, by explicitly monitoring communities across a climatic gradient we will be able to evaluate a variety of mechanisms through which climate factors influence invasion dynamics that will be relevant beyond *N. obtusa*.

Subproject 30 ENRTF FINAL BUDGET: ~~$39,000~~ $38,866

Outcomes	Completion Date
Activity 1	

1. Establishment of monitoring stations (completed on alternate funding)	August 2019
2. Measurement of phenological patterns of N. obtusa	October 2021
3. Evaluation of effects of community composition on invasion dynamics	June 2022
4. Evaluation of environmental determinants of plant populations	June 2022
5. Aggregation and synthesis of ecological field work results	June 2022
Activity 2	
1. Semi-structured interviews with stakeholders	December 2020
2. Analysis and synthesis of stakeholder interviews	June 2022
Activity 3	
1. Model development	June 2022
2. Comparison of management approaches using simulations	June 2022

Fifth Update February 28, 2020

During summer 2019 we established ecological monitoring locations at 9 lakes with established populations of *Nitellopsis obtusa* across Minnesota, Wisconsin, and Indiana. Three monitoring lakes were chosen in each state and in each lake (except for Lake Koronis) we established 4-5 30m transects that spanned a transition from a native plant dominated community to an *N. obtusa* dominated community. Plant community diversity was assessed along each transect via SCUBA survey, and biomass of all plant species was measured at each endpoint. At Lake Koronis water clarity conditions were too low to conduct SCUBA surveys and new monitoring locations were not established. However, similar monitoring transects had been established in the lake previously which we used for biomass collections.

Additionally, in summer 2019 we received IRB approval for our study and during fall 2019 and winter 2020 we began to identify lake stakeholders and managers associated with study lakes that can participate in stakeholder interviews. We have also established an interview guide to structure interviews and have begun to conduct interviews. Currently we have conducted 20 interviews, with 12 of those from Minnesota participants.

All Subproject 30 activities completed thus far have been supported by non-ENRTF funds.

Sixth Update August 31, 2020

Due to COVID-19 related restrictions we have been unable to conduct any ecological field work related to the project over the past six months. We are currently working under the expectation that we can shift all the planned effort from this summer to summer 2021 and still complete all project objectives. However, this is dependent on receiving approval for a no cost extension of funds from Indiana University. We are in the process of advocating for that, but it has not yet been confirmed. Additionally, we plan to conduct a limited field campaign this August that will allow us to minimally collect the longitudinal data for activity 1.3-Community Interactions. This is arguably the most important component of the project and we expect that minimally that objective can be achieved even, if we are unable to conduct field work next year.

Seventh Update February 28, 2021

Progress on our project in the past 6 months has been limited due to COVID-19 related restrictions. We had originally expected a major field campaign during summer 2020 to support the ecological aspect of the project, the majority of which was canceled. However, we were able to conduct a limited effort and collected our key longitudinal data. We still plan to conduct a full field season in summer 2021 which will extend our longitudinal data and provide a variety of other information. But with the data we collected this summer, we have the bare minimum necessary to evaluate invader spread rates which was our central process we were planning to measure.

In addition, the social science component of our project was able to respond to COVID-19 constraints quite effectively. We transitioned to conducting all stakeholder interviews remotely (via phone or videoconference).

While these interviews do have some limitations, relative to in-person, the lack of a need to travel for interviews allowed us to collect a large number. We have conducted 44 interviews to date (16 with Minnesota stakeholders, 9 in Wisconsin, 11 in Indiana, and 8 additional interviews with stakeholders from the broader Midwest/Great Lakes region). This is a sufficient number of interviews needed, but we continue to try recruit volunteers in a targeted manner to increase interviews from lakes or regions with less coverage. We will be beginning that process this year.

The research team gave a presentation about this project at MAISRC's 2020 Research and Management Showcase. A recording of the Showcase presentation is available online: https://z.umn.edu/2020ShowcasePresentations

Eighth Update August 31, 2021

Progress in the past 6 months has focused on preparing for and conducting fieldwork that had been postponed in 2020 due to Covid-19. Seasonal technicians were hired and the project team has been monitoring starry stonewort invasions in lakes across Indiana, Wisconsin, and Minnesota since late April. This will provide the most extensive data on the phenological patterns of starry stonewort that has yet to be published and will be critical to understanding competition with native plant species and potentially inform management practices by identifying seasonal periods where management could be most effective or have the least non-target effects. This sampling also supports our longitudinal data collection identifying yearly changes in starry stonewort abundance, the central question of the project.

Ninth Update February 28, 2022

Seasonal technicians continued to monitor starry stonewort invasions in lakes across Indiana, Wisconsin, and Minnesota through the end of the field season, collecting data on the phenological patterns of starry stonewort and supporting our longitudinal data collection identifying yearly changes in starry stonewort abundance, the central question of the project. In addition, Co-PI Sullivan hired a postdoctoral researcher who has begun to analyze social science interviews.

Final Report between project end (June 30) and September 15, 2022

Nitellopsis obtusa (starry stonewort) is a freshwater alga that is a key emerging invader in Minnesota and the upper Midwest that displaces native aquatic plant communities and restructures lake ecosystems. We conducted an interdisciplinary project to evaluate how starry stonewort will respond to climate change and to understand community decision-making about management options incorporating both ecological and social factors. We did this by utilizing a latitudinal gradient in the range of starry stonewort, from Indiana to Minnesota, as well as inter-annual variability as proxies for potential climate change. Across the region we monitored invasions to evaluate community effects of starry stonewort and conducted interviews with stakeholders to evaluate perceptions of starry stonewort impacts and management preferences. We found that starry stonewort can expand rapidly, but invasion dynamics were highly variable and influenced by climatological conditions. In some particular circumstances expansion was very limited and, in some years, native species were able to recover in areas where starry stonewort abundances decreased. From stakeholder interviews we learned that current management strategies, perceptions about the importance of addressing invasive species, and stakeholders' goals differed between states and stakeholder types. We also found that there were two distinct sets of values that motivated stakeholders, where individuals either viewed lakes as a public good or an exclusive resource.

This information can help predictions of further spread of starry stonewort and of the potential impacts of starry stonewort invasions once established. Additionally, our results can help local stakeholders understand invasion dynamics and impacts to inform their decisions about management options. At the same time our social science efforts can help inform state and regional resource managers about how they can best assist stakeholders in

their decisions and our ecological efforts can help develop standards (such as monitoring protocols) that should be included in permitting for treatments.

IV. DISSEMINATION:

Description: The Minnesota Aquatic Invasive Species Research Center provides a platform for information and new research findings about AIS to be widely disseminated. This is accomplished through the annual public Showcase event, reports, brochures, website, Facebook and Twitter, Extension programming, Advisory Board, Technical Committee, seminars, talks, and via peer reviewed publications and student theses. Additionally, as part of the MAISRC Extension partnership, Extension educators, citizen scientists, AIS practitioners and researchers will be collecting data that will be accessible to participants as part of a central data repository.

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.

First Update February 28, 2018

No report necessary per LCCMR staff on 3/1/2018.

Second Update August 31, 2018

No activity to report at this time. All MAISRC communication and dissemination activities are currently occurring under 2013 ENRTF funding, until funding completion on June 30, 2019. A summary of activities is included in the M.L. 2013 report.

Third Update February 28, 2019

No activity to report at this time. All MAISRC communication and dissemination activities are currently occurring under 2013 ENRTF funding, until funding completion on June 30, 2019. A summary of activities is included in the M.L. 2013 report.

Fourth Update August 31, 2019

All MAISRC communication and dissemination activities occurred on 2013 ENRTF funding, until funding completion on June 30, 2019. A summary of these activities is included in the M.L. 2013 report. There is no additional activity between June 30 and August 31 to report at this time.

Fifth Update February 28, 2020

2019 Research Highlights
In order to share highlights from MAISRC's work over the last year, our staff created a 2019 Research Report that includes project updates and big-wins from our research teams. Hard copies of the report were provided to key stakeholders and all LCCMR members. An online version of the report was broadly shared through MAISRC's communication channels. To view an online version of the report, visit: https://www.maisrc.umn.edu/2019-researchreport

In addition, MAISRC partnered with a local videographer to create a series of videos about our research. Video topics include:

- Common carp removal using the Whooshh system
- Genetic control of invasive carp
- Valuing aquatic invasive species management

Collectively, the videos have been viewed more than 19,500 times online. While these videos were not produced with ENRTF funds, they play an important role in keeping legislators, managers, and interested members of the public informed by explaining our research in new and different ways.

AIS Research and Management Showcase
In September, MAISRC hosted our annual AIS Research and Management Showcase and the event continues to grow – in 2019 we had about 300 attendees. As in years past, attendees of the Showcase came from a diverse set of backgrounds, including local managers, state agencies, lake shore associations, individual property owners, legislators, researchers and faculty, and students. However in 2019, approximately 40% of attendees were managers (state or county agencies, soil and water conservation districts, private companies). Presentations from the Showcase are available online, visit: https://www.maisrc.umn.edu/news/showcase-presentations-2

Newsletter and Social Media
MAISRC currently has a social media following of just under 2,500 and an e-newsletter list with just under 3,750 recipients. Social media posts about research findings, events, AIS Detector workshops, and invasive species news are posted daily. An e-newsletter goes out every other month and includes more in-depth stories about our research projects. We have continued to see growth in our online audiences year-over-year.

Earned Media
In 2019, MAISRC has been featured in 77 stories in the press. Stories have included research updates on invasive phragmites, zebra mussels, common carp, as well as the Showcase and the AIS Detectors program. We do our best to emphasize the value of ENRTF acknowledgements with the media and regret that it is not always included in their final stories.

MAISRC Website
In 2019, 51,000 unique visitors have visited our website a total of 69,000 times; viewing 122,000 pages. This is an increase of 42%, 35%, and 36%, respectively, over 2018. This consistent growth shows that MAISRC is growing in name recognition and being seen as an important resource for different stakeholders around the state.

Data Repository at the University of Minnesota (DRUM)
To continue providing leadership in the AIS research field and to ensure proper stewardship and accessibility to MAISRC research data, MAISRC has established a publicly accessible data repository in collaboration with the University Digital Conservancy. We have uploaded our first two sets of data in DRUM, available here: https://conservancy.umn.edu/handle/11299/197773

Note: The MAISRC DRUM was established to ensure that all MAISRC data is made publicly available. However, not all MAISRC projects utilize this platform. Some MAISRC researchers upload their data to federal databases or in publications in order to align with data sharing standards within their individual fields of study or journal requirements.

Peer-Reviewed Publications
Recent MAISRC publications include:

Gilmanov, A., Zielinski, D., Voller, V., & Sorensen, P. (2019). The Effect of Modifying a CFD-AB Approach on Fish Passage through a Model Hydraulic Dam. Water, 11(9), 1776.
MAISRC Subproject 26 (M.L. 2013)

Mathai, P., Magnone, P., Dunn, H., & Sadowsky, M. (2019). Water and sediment act as reservoirs for microbial taxa associated with invasive dreissenid mussels. Science of the Total Environment, 1–7.
MAISRC Subproject 2.2 (M.L. 2013)

Padhi, S., Tolo, I., McEachran, M., Primus, A., Mor, S., & Phelps, N. (2019). Koi herpesvirus and carp oedema virus: Infections and coinfections during mortality events of wild common carp in the United States. Journal of Fish Diseases, 42, 1609–1621.
MAISRC Subproject 7.2 (M.L 2013)

Hansen, G.J.A., Ahrenstorff, T.D., Bethke, B.J. et al. (2020). Walleye growth declines following zebra mussel and Bythotrephes invasion. Biological Invasions.
MAISRC Subproject 16.1 (M.L. 2013)

Verhoeven, M., Larkin, D., & Newman, R. (2020). Constraining invader dominance: Effects of repeated herbicidal management and environmental factors on curlyleaf pondweed dynamics in 50 Minnesota lakes. Freshwater Biology, 2020;00:1–14.
MAISRC Subproject 8.1 (M.L. 2013)

Glisson, W. J., C. K. Wagner, M. R. Verhoeven, R. Muthukrishnan, R. Contreras-Rangel, and D. J. Larkin. (2020). Desiccation tolerance of the invasive alga starry stonewort (Nitellopsis obtusa) as an indicator of overland spread risk. Journal of Aquatic Plant Management 58:7–18.
MAISRC Subproject 8.1 (M.L. 2013)

Glisson, W. J., M. R. Verhoeven, and D. J. Larkin. (2020). A new device for sampling submersed aquatic plants using underwater video. Journal of Aquatic Plant Management 58:76–82.
MAISRC Partnership Project

A full list of MAISRC publications can be viewed on our website: https://www.maisrc.umn.edu/publications

Sixth Update August 31, 2020

Public Presentations
Since the beginning of 2020, MAISRC staff and researchers have given 34 presentations to an estimated 2,050 state/local managers and members of the public. The majority of these talks had a Minnesota audience, but also included a few national and international audiences -- MAISRC staff presented zebra mussel research updates to a group of 40 hydropower engineers in Brazil, six online webinars with participants from across the country, and researchers have presented updates at universities in Boston, Indiana, and Buffalo, NY. MAISRC personnel also led meetings with stakeholder groups like lake associations and watershed managers, reaching another 94 people over the course of 9 meetings. These meetings allowed staff and researchers to hear directly from our stakeholders about their concerns and challenges, while giving MAISRC the opportunity to share research-informed advice and strengthen research/management partnerships. We also continue to give regular research updates to the MN DNR AIS team. While our outreach efforts have had to adapt with the impacts of COVID-19, we continue to actively disseminate research results and serve as a resource to managers and communities throughout the state.

AIS Research and Management Showcase
To ensure the safety of MAISRC staff, researchers, and the public we will be hosting our annual AIS Research and Management Showcase online from September 22-24, 2020. Details about breakout sessions and registration will be shared, as they are available, via email, social media, and on our website: https://www.maisrc.umn.edu/showcase

Newsletter and Social Media
MAISRC has an active presence on social media—including Facebook, Twitter, and YouTube—with a combined following of over 2,800 people. In 2019, MAISRC's videos on YouTube, including webinars and project spotlights, had over 8,600 views. The MAISRC e-newsletter list is currently at 3,600 recipients and growing. Social media

posts promote research findings, highlight behind-the-scenes looks at projects, advertise upcoming events and AIS Detector workshops, and share invasive species news. An e-newsletter goes out every other month and includes more in-depth stories about our research projects. We have continued to see growth and engagement with our online audiences year-over-year.

Earned Media
MAISRC researchers and grad fellows have become confident resources in Minnesota environmental and conservation news. MAISRC graduate student, Isaiah Tolo was recently featured by five individual news outlets in May of 2020 as an expert on pathogens and biocontrol of carp. As a part of all media interactions, we continue to emphasize the value of the ENRTF and its impact on AIS research in Minnesota. Links to recent MAISRC stories in the media is available on our website: https://www.maisrc.umn.edu/news

MAISRC Website
MAISRC has become a respected and trusted source for AIS information for stakeholders across the state. Organizations including the National Park Service, Minnesota DNR, Minnesota Master Naturalist, and multiple Minnesota counties link directly to MAISRC and our website for information about AIS and research progress.

Peer-Reviewed Publications
Recent MAISRC publications include:

Kanankege, K. S. T., Phelps, N. B. D., Vesterinen, H. M., Errecaborde, K. M., Alvarez, J., Bender, J. B., Wells, S., Perez, A. M. (2020). Lessons Learned From the Stakeholder Engagement in Research: Application of Spatial Analytical Tools in One Health Problems. Frontiers in Veterinary Science doi: 10.3389/fvets.2020.00254
MAISRC Subprojects 13 and 19

Feely, J. R. (2020) . The Ability of a Cyclic Sound on Its Own, and When Coupled with an Air Curtain, to Block Ten Species of Fish Including Carp in a Laboratory Flume. ProQuest Dissertations Publishing, 2020. 27998204.
MAISRC Subproject 3 (M.L. 2013)

Larkin, D., Beck, M., & Przemyslaw, B. (2020). An invasive fish promotes invasive plants in Minnesota lakes. *Freshwater Biology*.
MAISRC Subproject 8 (M.L. 2013)

Dennis, C. & Sorensen, P. (2020). High-intensity light blocks Bighead Carp in laboratory flume. *Management of Biological Invasions,* 11.
MAISRC Subproject 3 (M.L. 2013)

Verhoeven, Michael R.; Glisson, Wesley J.; Larkin, Daniel J. (2020). Niche Models Differentiate Potential Impacts of Two Aquatic Invasive Plant Species on Native Macrophytes. *Diversity 2020,* 12, 162.
MAISRC Subproject 8.2 (M.L. 2017)

Eltawely, J. A.; Newman, R.M.; Thum, R. A. (2020). Factors Influencing the Distribution of Invasive Hybrid (*Myriophyllum Spicatum x M. Sibiricum*) Watermilfoil and Parental Taxa in Minnesota. *Diversity,* 12(3), 120.
MAISRC Subproject 18 (M.L. 2013)

Muthukrishnan, R, Larkin, D.J. (2020). Invasive species and biotic homogenization in temperate aquatic plant communities. *Global Ecology and Biogeography*. 00: 1– 12.
MAISRC Subproject 8 (M.L. 2013)

A full list of MAISRC publications can be viewed on our website: https://www.maisrc.umn.edu/publications

Seventh Update February 28, 2021

2020 Research Highlights

To share highlights from MAISRC's work over the last year, our staff created a 2020 Research Report that includes project updates and big-wins from our research teams. Hard copies of the report were provided to key stakeholders and all LCCMR members. An online version of the report was broadly shared through MAISRC's communication channels. To view an online version of the report, visit: https://www.maisrc.umn.edu/2020researchreport

Public Presentations

In 2020, MAISRC staff and researchers gave 51 presentations to state/local managers and members of the public. These talks were held online and the majority were targeted to Minnesota audiences, but also included a few national and international audiences -- MAISRC presented zebra mussel research updates to a group of 40 hydropower engineers in Brazil, six online webinars with participants from across the country, and researchers have presented updates at universities in Boston, Indiana, and Buffalo, NY. MAISRC personnel also led meetings with stakeholder groups, including lake associations and watershed managers. These meetings allowed staff and researchers to hear directly from our stakeholders about their concerns and challenges, while giving MAISRC the opportunity to share research-informed advice and strengthen research/management partnerships. In 2020 we provided 9 research updates with extended dialogue to the MN DNR invasive species staff. While our outreach efforts have had to adapt with the impacts of COVID-19, we continue to actively disseminate research results and serve as a resource to managers and communities throughout the state.

AIS Research and Management Showcase

In September 2020, our annual Research and Management Showcase was held online for the first time. Despite an untraditional format, researchers and over 300 attendees were able to connect and discuss current research studies and management options. By moving the Showcase online, we were able to break down geographic and time barriers and expand the accessibility of our content. Of those who responded to the post-event survey, 95% ranked the Showcase as "very good" or "excellent" overall. Additionally for the first time this year, presentations were recorded and made available after the Showcase to attendees and the general public. To date, Showcase recordings have been viewed over 2,000 times online. To view the recorded presentations, visit: https://z.umn.edu/2020ShowcasePresentations

Newsletter and Social Media

MAISRC has an active presence on social media—including Facebook, Twitter, and YouTube—with a combined following of over 3,100 people. In 2020, MAISRC and AIS Detector's videos on YouTube, including webinars and project spotlights, had over 13,200 views. The MAISRC e-newsletter list is currently at 3,700 recipients and growing. Social media posts promote research findings, highlight behind-the-scenes looks at projects, advertise upcoming events and AIS Detector workshops, and share invasive species news. An e-newsletter goes out every other month and includes more in-depth stories about our research projects. We have continued to see growth and engagement with our online audiences year-over-year.

Earned Media

Historical events of 2020, and the media coverage of them, created a challenging earned media environment throughout the year. Overall, MAISRC experienced a slight decrease in media stories compared to previous years. However, the 58 stories that did feature MAISRC research were high-quality and syndicated through a variety of national, state, and local outlets. Notably, MAISRC researchers were interviewed by National Geographic twice in 2020 as AIS subject matter experts. Coverage in 2020 also included a feature on our research using KHV to control common carp populations, an article highlighting how MAISRC research has been successfully applied by local Minnesota resource managers, and an interview of MAISRC researchers and their study of the impacts of AIS on lakeshore property values. As a part of all media interactions, we continue to emphasize the value of the ENRTF and its impact on AIS research in Minnesota.

Spiny water flea:

https://www.nationalgeographic.com/environment/article/invasive-water-fleas-decimating-plankton-in-great-lakes

Carp control: https://www.wctrib.com/sports/outdoors/6528615-Researchers-looking-to-control-invasive-carp-spread-with-disease

Success stories: https://www.echopress.com/news/science-and-nature/6681887-Success-stories-exist-in-the-fight-against-invasive-species

Property values: https://www.grandforksherald.com/northland-outdoors/6677402-Do-invasives-harm-lake-property-values-Study-takes-a-look

MAISRC Website

In 2020, 49,000 unique visitors have visited the MAISRC website a total of 64,000 times; viewing 106,000 pages. A key factor for search engines in determining which sites to show first in search results is if the site is interconnected to other high-quality and trustworthy sites. Two of the top outside websites that directed traffic to MAISRC's website in 2020 were the National Park Service and the Minnesota Department of Natural Resources. Additional referrals included National Geographic, Minnesota Master Naturalist, Minnehaha Creek Watershed District, Michigan Department of Environment, Great Lakes, and Energy, and MPR News. MAISRC has grown, through trusted science, to be an expert reference on AIS and is trending toward midwest and national recognition online.

Data Repository at the University of Minnesota (DRUM)

To continue providing leadership in the AIS research field and to ensure proper stewardship and accessibility to MAISRC research data, MAISRC maintains a publicly accessible data repository in collaboration with the University Digital Conservancy. In 2020, we uploaded four new sets of data in DRUM, available here: https://conservancy.umn.edu/handle/11299/197773

Note: The MAISRC DRUM was established to ensure that all MAISRC data is made publicly available. However, not all MAISRC projects utilize this platform. Some MAISRC researchers upload their data to federal databases or in publications to align with data sharing standards within their individual fields of study or journal requirements.

Peer-Reviewed Publications

Recent MAISRC publications include:

Mathai, Prince P., Bertram, Jonathan H., Padhi, Soumesh K., Sing, Vikash, Tolo, Isaiah E., Primus, Alexander, Mor, Sunil K., Phelps, Nicholas B.D., Sadowsky, Michael J. (2020) Influence of Environmental Stressors on the Microbiota of Zebra Mussels (Dreissena polymorpha). Microbial Ecology, https://doi.org/10.1007/s00248-020-01642-2
MAISRC Subproject 2

Hansen, G.J.A., Ahrenstorff, T.D., Bethke, B.J. et al. (2020). Walleye growth declines following zebra mussel and Bythotrephes invasion. Biological Invasions. https://doi.org/10.1007/s10530-020-02198-5
MAISRC Subproject 16

Casas-Mollano JA, Zinselmeier MH, Erickson SE, and Smanski MJ. (2020) CRISPR-Cas Activators for Engineering Gene Expression in Higher Eukaryotes. The CRISPR Journal. Oct 2020.350-364. http://doi.org/10.1089/crispr.2020.0064
MAISRC Subproject 24

McEachran, Meg, Sampedro, F., Travis, D.A., Phelps, Nicholas (2020). An expert-based risk ranking framework for assessing potential pathogens in the live baitfish trade. Wiley Online Library https://doi.org/10.1111/tbed.13951

A full list of MAISRC publications can be viewed on our website: https://www.maisrc.umn.edu/publications

Eighth Update August 31, 2021

Public Presentations
From January to July 2021, MAISRC researchers gave 25 presentations to state and local managers, community groups, and students reaching an estimated total audience of 1,480 people. The majority of these talks were held online and targeted to Minnesota audiences, but also included a few national and international audiences. Presentations were given to local stakeholder, such as zebra mussel research virtual open houses for the Pelican Lake and Lake Minnetonka communities, academic conferences and professional meetings, speaking events to students and youth groups, and local conferences such as the St.Louis River Estuary Summit and the Great Lakes Biocontrol Workshop. MAISRC research teams also continue to regularly present updates on their work to members of the DNR Invasive Species Unit staff and the State AIS Advisory Committee. In addition, MAISRC's Research Outreach Specialist (supported by non-ENRTF funds) participated/hosted 29 engagement events with more than 600 stakeholders during the reporting period, focusing on the translation of MAISRC research into action at the local level.

AIS Research and Management Showcase
MAISRC will be hosting our annual AIS Research and Management Showcase as a hybrid, in-person/online conference on September 22, 2021. Details about breakout sessions and registration will be shared, as they are available, via email, social media, and on our website: www.maisrc.umn.edu/2021-showcase. We are monitoring the COVID-19 pandemic closely and will adjust our plans as needed, following state and University guidelines, and the best available science.

Newsletter and Social Media
MAISRC and the AIS Detectors program have active social media accounts on Facebook and YouTube. Since the beginning of 2021, MAISRC and AIS Detector's videos on YouTube, including webinars and project spotlights, had over 17,150 views, totaling over 550 hours of watch time. MAISRC's Twitter account has grown into a popular means of connecting researchers, legislators, community organizations and nonprofits, and other AIS stakeholders. Social media posts continue to disseminate research findings, highlight behind-the-scenes project activities, promote MAISRC events and AIS Detector workshops, and share invasive species news. In addition, the MAISRC e-newsletter is currently received by 4,490 individuals and continues to grow and share in-depth stories about MAISRC research.

Earned Media
MAISRC's media presence has not only rebounded back to pre-pandemic levels, but 2021 is on track to be a record year for media coverage of MAISRC research. Activities surrounding the "Stop Spiny Water Flea" campaign (Subproject 15) and the launch of AIS Explorer fueled early and frequent appearances in local newspapers and resulted in a handful of on-camera interviews, radio dialogues, and editorial columns. The AIS Detectors program—and affiliated Starry Trek event and freshwater golden clams rapid response project (non-ENRTF funding)—also gained attention throughout the spring and summer of 2021. Interviews with Extension Educator and MAISRC Researcher, Megan Weber were featured in the Voice of Alexandria, MPR, and Park Rapids Enterprise. As a part of all media interactions, we continue to emphasize the value of the ENRTF and its impact on AIS research in Minnesota. Media highlights include:

Zebra mussels: https://www.chicagotribune.com/news/environment/ct-lake-michigan-invasive-mussels-genetic-research-20210730-nx7plrceefb3tbpjwuhvm3sfe4-story.html

eDNA: http://www.timberjay.com/stories/tracking-ais-through-dna,17938

KSTP feature: https://kstp.com/news/new-tool-helps-prevent-invasive-species-from-spreading-across-minnesotas-lakes/6127056/

Launch of AIS Explorer: https://www.echopress.com/opinion/editorials/7029173-An-Echo-Press-Editorial-New-research-offers-insights-into-lake-invaders

Stop Spiny: https://www.bemidjipioneer.com/northland-outdoors/7136325-Minnesota-Aquatic-Invasive-Species-Research-Center-launches-spiny-water-flea-campaign

MAISRC Website
In 2020, 40,200 unique visitors visited the MAISRC website a total of 51,000 times; viewing 80,300 pages. A notable change this year is the web traffic coming to the Stop Spiny campaign home page. Launched in late 2020, the Stop Spiny page is now our fourth most popular page, coming in behind only the home page, 'About Common Carp' page, and news articles on zebra mussel research. The Stop Spiny page hosts information on our recent research exploring what recreational fishing gear is most likely to ensnare and therefore spread spiny water fleas from infested lakes to new waterbodies. Also of note, MAISRC will be migrating its entire website to an updated platform by the end of the calendar year. The new website will feature modern fonts and layouts, new pictures, an updated site navigation, and more.

Resources and Factsheets
In 2020, MAISRC hired its first research outreach specialist (supported by non-ENRTF funds). With the addition of this new staff member, the teamwork between our communications specialist and our research outreach specialist has resulted in numerous factsheets and handouts, both physical and electronic, for lakeshore associations, concerned citizens, and AIS managers. We also created brief handouts about projects with active fieldwork on Minnesota lakes for our researchers to provide to interested members of the public they encounter at boat launches and other public spaces. Factsheet have ranged from species and campaign-specific (such as our factsheets and briefing papers on spiny water fleas as part of the Stop Spiny campaign) to two-page handouts explaining what lakeshore associations and property owners can do once they learn their lake is infested with zebra mussels. In locations where there are particularly high levels of local interest in our work on zebra mussel control, such as at Lake Minnetonka or Pelican Lake we have created short project updates communicating preliminary results and next steps for the research. This combination of research translation, design, and direct distribution has been incredibly well received and we regularly receive requests from stakeholders for copies of these resources.

View some of the factsheets here: https://z.umn.edu/MAISRCfactsheets

Peer-Reviewed Publications
Recent MAISRC publications include:

DeWeese, N.E., Favot, E.J., Branstrator, D.K. et al. (2021). Early presence of Bythotrephes cederströmii (Cladocera: Cercopagidae) in lake sediments in North America: evidence or artifact?. Journal of Paleolimnology. https://doi.org/10.1007/s10933-021-00213-w
MAISRC Subproject 12 (M.L. 2013)

Branstrator, D.K., Dumke, J.D., Brady, V.J., Wellard Kelly, H.A. (2021). Lines snag spines! A field test of recreational angling gear ensnarement of Bythotrephes. Lake and Reservoir Management. DOI: 10.1080/10402381.2021.1941447
MAISRC Subproject 12 (M.L. 2013)

Sandlund, L.; Mor, S.K.; Singh, V.K.; Padhi, S.K.; Phelps, N.B.D.; Nylund, S.; Mikalsen, A.B. (2021). Comparative Molecular Characterization of Novel and Known Piscine Toti-Like Viruses. Viruses 2021, 13, 1063. https://doi.org/10.3390/v13061063

MAISRC Subproject 7.2 (M.L. 2013)

Kao, SY.Z., Enns, E.A., Tomamichel, M. et al. (2021). Network connectivity of Minnesota waterbodies and implications for aquatic invasive species prevention. Biological Invasions. https://doi.org/10.1007/s10530-021-02563-y
MAISRC Subproject 19 (M.L. 2013)

Levers, L.R., Pradhananga, A.K. (2021) Recreationist willingness to pay for aquatic invasive species management. PLoS ONE 16(4): e0246860. DOI:10.1371/journal.pone.0246860
MAISRC Subproject 23

Wellard Kelly, H.A., Kovalenko, K.E., Ahrenstorff, T.D. et al. (2021). Trophic complexity of small fish in nearshore food webs. Hydrobiologia 848, 2505–2521. https://doi.org/10.1007/s10750-021-04570-5
MAISRC Subproject 16 (M.L. 2013)

Glisson, W., Larkin, D.J. (2021). Hybrid watermilfoil (Myriophyllum spicatum × Myriophyllum sibiricum) exhibits traits associated with greater invasiveness than its introduced and native parental taxa. Management of Biological Invasions. https://doi.org/10.1007/s10530-021-02514-7
MAISRC Subproject 8.2

A full list of MAISRC publications can be viewed on our website: https://www.maisrc.umn.edu/publications

Ninth Update February 28, 2022

2021 Research Highlights
To share highlights from MAISRC's work over the last year, our staff created a 2021 Research Report that includes project updates and big-wins from our research teams. Hard copies of the report were provided to key stakeholders and all LCCMR members. An online version of the report was broadly shared through MAISRC's communication channels. To view an online version of the report, visit:
https://z.umn.edu/2021MAISRCstorymap

Public Presentations
In 2021, MAISRC researchers gave 32 presentations to state and local managers, community groups, and students, reaching an estimated total audience of 1,600 people. The majority of these talks were held online and targeted to Minnesota audiences, but also included a few national and international audiences. Presentations were given to local stakeholders, such as zebra mussel research virtual open houses for the Pelican Lake and Lake Minnetonka communities, academic conferences and professional meetings, speaking events to students and youth groups, and local conferences such as the St. Louis River Estuary Summit and the Great Lakes Biocontrol Workshop. 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.

In addition, MAISRC's Research Outreach Specialist (supported by non-ENRTF funds) hosted or participated in 54 engagement events with stakeholders, including local, state, and federal managers, lake associations, watershed organizations, and community groups during the reporting period, focusing on the translation of MAISRC research into action at the local level. The easing of COVID-related restrictions on local travel and in-person meetings allowed MAISRC staff, specifically our Research Outreach Specialist, to significantly increase our level of engagement and science translation work compared to 2020. Roughly half of these events were general talks to lake associations and Rotary Clubs about AIS issues and our research advances; however, each presentation was tailored to focus on the most locally relevant AIS challenges and threats. The remaining portion of the Outreach Specialist's science translation work was focused on three key initiatives: the Stop Spiny campaign and efforts to help local government AIS managers and lake associations implement MAISRC's spiny water flea

prevention and education campaign in their communities (Subproject 15); training workshops and demonstrations of the AIS Explorer online dashboard for state and local managers, as well as lake association leaders; and a presentation for lake residents with new infestations of zebra mussels that details what changes they are likely to observe and what they can and can't do about zebra mussels. She also participated in two Bell Museum of Natural History events: speaking to youth day campers about AIS and joining the Spotlight on Science series for museum visitors. In total, our Research Outreach Specialist engaged with over 1,100 stakeholders during the reporting period.

AIS Research and Management Showcase

In September 2021, our annual Research and Management Showcase was held fully online due to a surge in cases in the COVID-19 pandemic. Despite the pivot to a fully online format, researchers and over 426 attendees were able to connect and discuss current research studies and management tools. By continuing to host the Showcase online, we have been able to break down geographic and time barriers and expand the accessibility of our content to attendees throughout the state and beyond. Showcase presentations were once again recorded and broadly disseminated. To date, the 2021 Showcase recordings have been viewed over 1,375 times online. In addition, the 2020 Showcase recordings have collectively gained an additional 500 views over the last year, bringing them to 2,500 total. To view the recorded presentations, visit: z.umn.edu/2021ShowcaseVideos

Stop Spiny! Outreach Campaign

In collaboration with Subproject 15, MAISRC staff facilitated the launch and management of the Stop Spiny! Outreach Campaign in 2021. This campaign was a PR-style outreach initiative that shared research findings and recommendations from Subproject 15 about how to effectively clean recreation and fishing gear to prevent the spread of spiny water flea. The campaign included a combination of digital, print, and in-person access points for spiny water flea prevention information.

Website – MAISRC launched the stopspiny.org website in 2021 to serve as a landing page for the campaign and to provide information and resources to the public and local AIS managers. Since its creation, the Stop Spiny campaign page has been viewed over 4,721 times. Resources included on the page include factsheets, images, videos, and fliers, and are free for use and distribution to educators, resource managers, lakeshore associations, and/or any others hoping to help prevent the spread of spiny water fleas. This resource page has acquired an additional 833 page views since its creation. To view Stop Spiny resources online, visit: https://maisrc.umn.edu/stopspiny-resources

PSA Videos – To broadly share the Stop Spiny message in a visually interesting format, MAISRC and the Subproject 15 research team collaborated to produce multiple high-quality PSA videos that detailed the impacts of spiny water flea and demonstrated how to clean fishing gear. Three different video lengths were created – 15 seconds, 30 seconds, and a full length (~2:30) – and were shared through multiple channels, including Facebook, Twitter, YouTube, and on television advertisements. On YouTube alone, the videos have accumulated over 850 views. To view the full length Stop Spiny video online, visit the Stop Spiny homepage: https://maisrc.umn.edu/stopspiny

Print Advertising – Print advertising for the Stop Spiny campaign included placements in the Lake Country Journal (based near the spiny water flea-infested Lake Mille Lacs), the Ely Summer Times (distributed along the Minnesota Iron Range, in the heart of spiny water flea-infested areas), and Northern Wilds Magazine (another Northern Minnesota distributor). The estimated reach, per outlet, are as follows; Lake Country Journal—40,000; Ely Summer Times—28,000; Northern Wilds Magazine—18,000.

Online Advertising – Northern Wilds Magazine, which also has an online edition and active online community, was contracted for Stop Spiny banner ads. The ads were placed on the Northern Wilds Magazine website for three consecutive months, from June to August 2021. Northern Wilds estimates that their web pages see roughly 17,000 page views per month.

In addition, extensive Facebook advertising was used to enhance the Stop Spiny campaign. Multiple rounds of advertisements were planned to coincide with time of year and spiny water flea population increases. Since the launch of the campaign in spring 2021, Stop Spiny advertisements on Facebook reached over 208,000 individual people and resulted in 442,000 impressions. Included in all the advertisements were hyperlinks to the Stop Spiny campaign website for additional information and resources. In total, over 1,500 people clicked from the advertisement to the Stop Spiny campaign page.

On average the amount of time an individual person will watch a video on Facebook is six seconds. Engaging users to watch more than six seconds is a huge engagement success. By the end of the Stop Spiny campaign, over 29,000 users watched the Stop Spiny video they were served to completion (15-30 seconds) and over 60,000 users watched over 50% of the video they were served (7-15 seconds).

Stop Spiny Cloths – To help recreational anglers clean their fishing gear, MAISRC and the Subproject 15 team printed a simple image of a spiny water flea, gear cleaning instructions, and funder logos on 8,000 cellulose dish cloths. These cloths look like a steam-rolled sponge and are ideal for use in cleaning gear because of how effectively they remove spiny water flea and how quickly they dry, reducing the risk of spiny water flea spread. Cloths were distributed to 18 community partners (lake associations, AIS prevention staff, agency partners, etc). In addition, MAISRC staff worked with Minnesota Lakes and Rivers Advocates to help about 25 other groups (mostly lake associations and conservation districts) order over 9,000 more spiny wipe cloths for distribution. In total, we have or are in the process of facilitating distribution of over 20,000 cloths (3,000 of these were part of our companion project funded by St. Louis County) to wipe spiny water fleas from angler fishing lines. Following the completion of the Subproject 15, MAISRC staff have been in communication with local conservation nonprofits to establish a continued source of Stop Spiny Cloths to make them easily accessible to the public into the future.

Newsletter and Social Media

MAISRC and the AIS Detectors program have active social media accounts on Facebook and YouTube. Since the beginning of 2021, MAISRC and AIS Detector's videos on YouTube, including webinars and project spotlights, had over 26,181 views, totaling over 1,000 hours of watch time. MAISRC's Twitter account has grown into a popular means of connecting researchers, legislators, community organizations and nonprofits, and other AIS stakeholders. Social media posts continue to disseminate research findings, highlight behind-the-scenes project activities, promote MAISRC events and AIS Detector workshops, and share invasive species news. In addition, the MAISRC e-newsletter is currently received by 4,452 individuals and continues to grow and share in-depth stories about MAISRC research.

MAISRC Website

In 2021, 56,900 users visited the MAISRC website, viewing 113,400 pages. A notable change this year is the web traffic coming to the Stop Spiny! Outreach Campaign home page. Launched in late 2020, the Stop Spiny page is now our third most popular page, coming in behind only the home page and a news article on zebra mussel research. The Stop Spiny page hosts information on our recent research exploring what recreational fishing gear is most likely to ensnare and therefore spread spiny water fleas from infested lakes to new waterbodies. In fall of 2021 the MAISRC website was moved to a new version of its content management system (Drupal 8). The migration allowed for an update in the site's navigation, general organization, page content, and design. The new website, while reducing some information redundancy, has also added new information on MAISRC's research needs assessment process and Priority Species List. Additionally, an added feature on many pages is an expanding accordion to improve information organization and accessibility.

Data Repository at the University of Minnesota (DRUM)

To continue providing leadership in the AIS research field and to ensure proper stewardship and accessibility to MAISRC research data, MAISRC maintains a publicly accessible data repository in collaboration with the University Digital Conservancy. In total, the DRUM currently contains 19 sets of data from 14 MAISRC

subprojects and partnership projects. In 2021, we uploaded 8 new sets of data in DRUM, available here: https://conservancy.umn.edu/handle/11299/197773

Note: The MAISRC DRUM was established to ensure that all MAISRC data is made publicly available. However, not all MAISRC projects utilize this platform. Some MAISRC researchers upload their data to public federal databases or in open-access publications to align with data sharing standards within their individual fields of study or journal requirements.

Peer-Reviewed Publications
Recent MAISRC publications include:

Glisson, W.J., Muthukrishnan, R., Wagner, C.K., Larkin, D.J. (2021). Invasive Nitellopsis obtusa (starry stonewort) has distinct late-season phenology compared to native and other invasive macrophytes in Minnesota, USA. Aquatic Botany. https://doi.org/10.1016/j.aquabot.2021.103452
MAISRC Subproject 8 (M.L. 2013)

Tolo, I.E., Bajer, P.G., Wolf, T.M., Mor, S.K., Phelps, N.B.D. (2021). Investigation of Cyprinid Herpesvirus 3 (CyHV-3) Disease Periods and Factors Influencing CyHV-3 Transmission in A Low Stocking Density Infection Trial. Animals. https://doi.org/10.3390/ani12010002
MAISRC Subproject 7.3 (non-ENRTF funding)

A full list of MAISRC publications can be viewed on our website: https://www.maisrc.umn.edu/publications

Final Report between project end (June 30) and September 15, 2022

Summary of Activity January 1 – June 30, 2022:

Public Presentations
In 2022, MAISRC researchers gave 31 presentations to state and local managers, community groups, and students, reaching an estimated total audience of 1,525 people. The majority of these talks were at events for Minnesota audiences, but also included a few national and international audiences. A few highlights of stakeholder engagement events included an information sharing and community-building meeting for all Minnesota and Wisconsin managers and consultants working on hybrid milfoil issues and two day-long AIS research conferences in outstate Minnesota that we hosted with local partners in the Whitefish Chain of Lakes area and in Detroit Lakes. MAISRC researchers continued to be strong presences in state, national, and global conferences on invasive species and aquatic sciences, as well as at university events and community gatherings like lake association meetings. 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.

In addition, MAISRC's Research Outreach Specialist (supported by non-ENRTF funds) hosted or participated in 30 engagement events with stakeholders, including local, state, and federal managers, lake associations, watershed organizations, and community groups during the reporting period, focusing on the translation of MAISRC research into action at the local level.

Newsletter and Social Media
MAISRC and the AIS Detectors program have active social media accounts on Twitter, Facebook, and YouTube. For the period of January 1 – June 30, 2022, MAISRC and AIS Detector's videos on YouTube, including webinars and project spotlights, had 38,961 views, totalling over 600 hours of watch time. MAISRC's Twitter account has grown into a popular means of connecting researchers, legislators, community organizations and nonprofits, and other AIS stakeholders. Social media posts continue to disseminate research findings, highlight behind-the-scenes project activities, promote MAISRC events and AIS Detector workshops, and share invasive species news.

In addition, the MAISRC e-newsletter is currently received by 5,336 individuals and continues to grow and share in-depth stories about MAISRC research.

Earned Media
MAISRC's current media presence is strong and steady. With an average of three media appearances a month and several high profile events coming up, we are projecting an impressive media impact by the end of this year. Through the relationship with the Legislative-Citizen Commission on Minnesota Resources (LCCMR), MAISRC will partner with a local videographer to produce several TV segments on Minnesota's aquatic invasive species. Using the latest research, these educational segments will be broadcast on local PBS channels and inform the public about the current state of AIS management happening in their backyard.

As a part of all media interactions, we continue to emphasize the value of the ENRTF and its impact on AIS research in Minnesota. Media highlights include:

Prather, S. P. (2022, April 18). Scientists design new way to remove invasive carp from Rice Creek. *Star Tribune*.

WTIP Community Radio (Podcast): Aquatic Invasive Species Update from the University of Minnesota with Dr. Nick Phelps

MAISRC Website
Almost 30,000 users visited the MAISRC website in 2022. The most visited pages concerned zebra mussel control, Eurasian watermilfoil suppression, and information on our AIS Detectors training program.

Peer-Reviewed Publications
Recent MAISRC publications include:

Kinsley, A. C., Haight, R. G., Snellgrove, N., Muellner, P., Muellner, U., Duhr, M., ; Phelps, N. B. D. (2022). AIS Explorer: Prioritization for watercraft inspections-a decision-support tool for Aquatic Invasive Species Management. *Journal of Environmental Management*, 314, 115037. https://doi.org/10.1016/j.jenvman.2022.115037
MAISRC Subroject 31 (non-ENRTF funding)

Hundt, P. J., White, L. A., Craft, M. E., & Bajer, P. G. (2022). Social associations in common carp (Cyprinus carpio): Insights from induced feeding aggregations for targeted management strategies. *Ecology and Evolution*, 12, e8666. https://doi.org/10.1002/ece3.8666
MAISRC Subproject 4.3 (M.L. 2017)

McEachran, M.C., Hofelich Mohr, A., Lindsay, T., Fulton, D.C. and Phelps, N.B.D. (2022), Patterns of Live Baitfish Use and Release among Recreational Anglers in a Regulated Landscape. *North Am J Fish Manage*, 42: 295-306. https://doi.org/10.1002/nafm.10747
MAISRC Subproject 25 (M.L. 2013, M.L. 2017)

Glisson, W., Contreras-Rangel, R., Bishop, W., & Larkin, D. (2022). Laboratory evaluation of copper-based algaecides for control of the invasive Macroalga Starry Stonewort (nitellopsis obtusa). *Management of Biological Invasions*, 13(2), 303–325. https://doi.org/10.3391/mbi.2022.13.2.04
MAISRC Subproject 8 (M.L. 2013)

Weber, M., Larkin, D., & Mulcahy, P. (2022). Creating informed consumers of aquatic invasive species management programs through online education for nonprofessionals. *Invasive Plant Science and Management*, 15(1), 41-48. doi:10.1017/inp.2022.10
MAISRC Subproject 10 (M.L. 2013)

A full list of MAISRC publications can be viewed on our website: https://www.maisrc.umn.edu/publications

Summary of Overall Dissemination Activities:

Website, social media, and e-newsletter
The MAISRC website has become a resource for AIS stakeholders across the state with an average of 40,000 users visiting the site each year. MAISRC and the AIS Detectors program also have active social media accounts on Twitter, Facebook, and YouTube. MAISRC and AIS Detectors' videos on YouTube, including webinars and project spotlights, have collected nearly 94,000 views, totaling an estimated 2,700 hours of watch time. MAISRC's Twitter account has grown into a popular means of connecting researchers, legislators, community organizations and nonprofits, and other AIS stakeholders. Social media posts continue to disseminate research findings, highlight behind-the-scenes project activities, promote MAISRC events and AIS Detectors workshops, and share invasive species news. In addition, the MAISRC e-newsletter delivers in-depth stories about MAISRC research and management tools to more than 5,300 people and growing.

Earned media
Over the course of the last five years, MAISRC has been in approximately 340 news stories in over 100 outlets. The most common outlets have been the Star Tribune, Minnesota Public Radio, and KSTP-TV. Other notable coverage includes The Associated Press and National Geographic.

Presentations, workshops/trainings, and events
Highlights from 2017-2022

- Held five AIS Research and Management Showcases to share MAISRC research updates, outcomes, and tools with 1,400+ unique attendees. Recordings of recent Showcase presentations can be found on the MAISRC YouTube page: https://z.umn.edu/2020ShowcasePresentations; https://z.umn.edu/2021ShowcasePresentations.
- AIS Detectors held 20 training sessions, certifying 421 AIS Detectors who contribute to AIS prevention and response efforts statewide as volunteers and professionals.
- Hosted five Starry Trek events, through which volunteers have found four new starry stonewort populations, as well as identifying new populations of zebra mussels, Eurasian watermilfoil, golden clams, and other AIS.
- AIS Detectors hosted 14 webinars on AIS and MAISRC research, reaching 2,600 live attendees and collecting nearly 5,450 views on YouTube. Webinar recordings can be viewed online: https://z.umn.edu/AISDetectorsWebinars.
- Led a series of training workshops for county and MN DNR AIS managers following the release of the AIS Explorer online dashboard. Over the course of 9 workshops, MAISRC staff taught over 50 natural resource managers how to use the AIS Explorer tool to improve their AIS prevention strategies. AIS Explorer is publicly available: https://www.aisexplorer.umn.edu/#!/.

Reports and other materials
Highlights from 2017-2022

- Created five videos, highlighting MAISRC research
  - Raising zebra mussels in the lab
  - Volunteer monitoring leads to rapid response project
  - Anti-biofouling paint inhibits spread of zebra mussels
  - Mapping zebra mussels using multibeam sonar
  - Motivations and risks of illegal baitfish release
- Produced four annual research reports, summarizing research outcomes

    - 2021 Research Report, including an online interactive report
    - 2020 Research Report
    - 2019 Research Report
    - 2018 Research Report
- Created and maintain a series of interactive maps and tracking tools
    - MAISRC Work Around the State
    - AIS Explorer
    - MAISRC Milfoil App
- Created and maintain *Stop Spiny* campaign resources to support managers and communities in preventing the spread of spiny water flea: https://maisrc.umn.edu/stopspiny

Peer-reviewed publications
Peer-reviewed publications are an essential part of MAISRC's research and dissemination activities. A full list of over 100 peer-reviewed publications can be viewed on the MAISRC website:
https://www.maisrc.umn.edu/publications

Data Repository at the University of Minnesota (DRUM)
To continue providing leadership in the AIS research field and to ensure proper stewardship and accessibility of MAISRC research data, MAISRC maintains a publicly accessible data repository in collaboration with the University Digital Conservancy. Thus far, MAISRC has contributed 24 data sets to DRUM, available here:
https://conservancy.umn.edu/handle/11299/197773

Note: The MAISRC DRUM portal was established to ensure that all MAISRC data is made publicly available. However, not all MAISRC projects use this platform. Some MAISRC researchers upload their data to federal databases or publish them as supplements to scientific articles to align with data-sharing standards within their fields or journal requirements.

V. ADDITIONAL BUDGET INFORMATION:

A. Personnel and Capital Expenditures

Explanation of Capital Expenditures Greater Than $5,000: N/A

Explanation of Use of Classified Staff:

Total Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation: 35.24 FTE

Total Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation: 1.60 FTE

VI. PROJECT PARTNERS:

A. Partners outside of project manager's organization receiving ENRTF funding
    - Subproject 4.3 – *National Socio-Environmental Synthesis Center* – Dr. Lauren White will be responsible for analyzing the PIT antenna data to build a statistical representation of the carp social network structure. White was selected as a partner because of her extensive experience analyzing social network data in animals using the statistical programming language R. White gained her unique skillset working at the University of Minnesota as a postdoc under Dr. Meggan Craft, who is a collaborator on this project. Both her unique quantitative skills and her

history of successful collaboration with Dr. Craft, led the project team to selecting White as a partner.

- Subproject 18.2 – *Montana State University:* Prof. Ryan Thum will conduct genetic analysis and provide expertise and input on overall analysis, interpretation, recommendations and write-up. He will help advise the University of Minnesota graduate students working on the project and participate in all aspects of the project. Thum is the foremost expert on Eurasian and hybrid watermilfoil genetics as it relates to the ecology and management of the plants with over a dozen papers on the topic. He has developed and refined methods to identify hybrid watermilfoil and milfoil genotypes, has assessed milfoil populations across the country (including Minnesota) and has already identified invasive and herbicide tolerant genotypes in Michigan. He has experience with challenge testing and will advise on procedures for that testing. He also has considerable experience with analyzing these data sets and will bring his expertise to Minnesota. Thum was a co-PI on Phase I of this project – Subproject 18 (M.L. 2013).
- Subproject 21.2 – *Macalester* College: Dr. Daniel Hornbach, Chair and Professor in Dept. of Environmental Studies; Mark Hove; Dr. Kelly Macgregor, Professor in Dept. of Geology will collaborate on this project.
- Subproject 21.2 – *Northern Arizona University, Earth Sciences and Environmental Sustainability:* Dr. Daniel Buscombe, Assistant Research Professor, is an expert with 10 years of experience in hydrographic surveying and acoustics, including 6 years of experience working with multibeam, singlebeam, sidescan, and sub-bottom profiling acoustic systems in freshwater. He has pioneered the study of acoustic substrate characterization in large regulated rivers in the U.S. He has published 6+ journal papers on substrate characterization using sonar. He has earned the runner-up prize in the 2017 R2Sonic Multispectral challenge, an international research competition on habitat mapping using new/emerging multispectral sonar acoustic technology. With this experience, Buscoumbe brings valuable expertise to the research team to be the first to study to use multispectral sonar.
- Subproject 21.2 – *U.S. Geological Survey, Southwest Biological Science Center, Grand Canyon Monitoring and Research Center (GCMRC):* Dr. Paul Grams, Research Hydrologist. Grams' research group specializes in physical and ecological studies in freshwater river systems. GCMRC has extensive experience in the use of multibeam sonar systems for mapping shallow river systems and is among the very few research facilities that are developing methods for acoustical bed substrate classification.
- Subproject 22 – *U.S. Geological Survey, Upper Midwest Environmental Sciences Center:* James Luoma, Research Fisheries Biologist, is the PI for Subproject 22.

B. Partners outside of project manager's organization NOT receiving ENRTF funding

- Subproject 1 – *MAISRC Advisory Board:* Advisory Board members are primarily external appointees who provide guidance and input to MAISRC's Director and Associate Director.
- Subproject 1 – *Minnesota Department of Natural Resources:* MAISRC scientists and leadership coordinate with DNR in multiple ways as formalized in a memorandum of understanding, signed in 2013.
- Subproject 4.3 – *Minnehaha Creek Watershed District:* will conduct electrofishing surveys to catch carp that will be tagged with PIT tags as a part of the project. They will also provide logistical support.
- Subproject 4.3 – *Carp Solutions, LLC:* will conduct carp removal for the project with a contract managed and funded by Minnehaha Creek Watershed District.
- Subproject 12.2 – *Minnesota Department of Natural Resources:* Dr. Heidi Rantala will produce spiny water flea productivity estimates for Lake Kabetogama and Lake Mille Lacs as a part of the project.

- Subproject 16.2 – *Minnesota Department of Natural Resources*: Dr. Tyler Ahrenstorff, Bethany Bethke, Jodie Hirsch, Dr. Heidi Rantala participated in study design and will assist with coordinating and carrying out fieldwork. Ahrenstorff and Bethke will assist with collating MN DNR historical recruitment data. All team members will participate in data analysis and interpretation for both activities and produce presentations and publications. Hirsch will serve as zooplankton expert and Rantala will serve as benthic invertebrate expert. MN DNR co-PI salaries are provided in-kind.
- Subproject 16.2 – *United States Geological Survey*: Dr. David Krabbenhoft will serve as the mercury concentration and stable isotope expert for this project. He participated in study design, and will analyze all mercury samples after they are collected and processed by UMN. He will participate in data analysis and interpretation and assist with presentations and publications related to mercury. His salary and all mercury analyses are provided in-kind.
- Subproject 18.2 – *Minnesota Department of Natural Resources:* AIS Management Coordinators and Regional AIS Specialists (as well as lake management companies, consultants and watershed districts) will be providing information on suitable study lakes, management history, access to sites and logistical information. They will help sample out-state lakes and will recommend and help coordinate work on intensive study lakes to be treated, as well as suggest lake with potentially problematic genotypes to assess. They will participate in our annual workshops, the UMISC testing service workshop and provide feedback on the project's approach and interpretation, particularly as it relates to management applications.
- Subproject 22 – *Tonka Bay Marina*: Owner Gabriel Jabbour, will provide logistical support and storage of equipment and supplies.
- Subproject 22 – *Chris Anderson (private consultant):* will conduct SCUBA transect dives for abundance of zebra mussels before and after treatment.
- Subproject 22 – *Iowa State University, Veterinary Diagnostic Laboratory:* will perform nontarget animal tissue analysis for copper residues. This additional analysis will be conducted using non-sponsored funds secured by MAISRC.
- Subproject 23 - *Minnesota Lakes and Rivers Advocates:* will provide input on survey design.
- Subproject 28 – *AMI Consulting Engineers:* a Minnesota company that is collaborating with the project team to place and retrieve samples in the Duluth-Superior Harbor using hard hat divers.
- Subproject 28 – *Gene&GreenTK:* a biotechnology company with expertise on enzyme engineering and enzymatic-based coatings. Their expertise will serve the improvement of the project's enzymatic coating formulations.
- Subproject 30 – Minnesota Department of Natural Resources, Wisconsin Department of Natural Resources, Indiana Department of Natural Resources, Indiana Clean Lakes Program

VII. LONG-TERM - IMPLEMENTATION AND FUNDING:

MAISRC was established to build long-term research capacity (including new faculty positions and facilities) although all initial funding sources were short-term (the main appropriation ends in 2019). We have been able to leverage the initial financial support, most notably through a university commitment, to make permanent two center positions (one faculty, one outreach staff). However, to ensure MAISRC continues to focus on the state's priorities and solutions-oriented research, additional ENRTF support is crucial.

VIII. REPORTING REQUIREMENTS:

- Project status update reports will be submitted February 28 and August 31 each year of the project
- A final report and associated products will be submitted between June 30 and September 15, 2022

IX. SEE ADDITIONAL WORK PLAN COMPONENTS:

A. **Budget Spreadsheet**
B. **Visual Component or Map**
C. **Parcel List Spreadsheet** – N/A
D. **Acquisition, Easements, and Restoration Requirements** – N/A
E. **Research Addendum**

Environment and Natural Resources Trust Fund
Minnesota Aquatic Invasive Species Research Center-- Subproject List
Legal Citation: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a
Project Manager: Nicholas Phelps
Project Title: Aquatic Invasive Species Research Center – Phase II
Organization: University of Minnesota
College/Department/Division: Minnesota Aquatic Invasive Species Research Center
Project Budget: $2,700,000
Project Length and Completion Date: 5 Years; June 30, 2022
Current Date: September 15, 2022

Subproject Number	Subproject Title	Species	Project Manager	LCCMR Approval Date	Subproject End Date	Budget	Amount Spent	Balance	Status (select from dropdown menu)
1	MAISRC Core Operations	Multiple	Nicholas Phelps	6/7/2017	6/30/2022	$ 1,187,652	$ 1,108,868	$ 78,784	Complete
4.3	Social Learning and Carp Removal	Common Carp	Przemek Bajer	8/13/2019	6/30/2021	$ 189,475	$ 189,475	$ -	Complete
8.2	Impacts of invader removal on native vegetation recovery	Curly-leaf pondweed,	Daniel Larkin	7/1/2019	6/30/2021	$ 119,034	$ 119,034	$ -	Complete
12.2	Historical analyses of spiny water flea invasion patterns	Spiny water flea	Donn Branstrator	7/1/2019	6/30/2021	$ 53,795	$ 53,795	$ -	Complete
15	Determining Highest Risk Vectors of Spiny Water Flea Spread*	Spiny water flea	Valerie Brady	6/27/2017	12/31/2021	$ 26,581	$ 26,581	$ -	Complete
16.2	AIS impacts on walleye populations and mercury concentrations	Spiny water flea, Zebra mussels	Gretchen Hansen	7/1/2019	12/31/2021	$ 199,852	$ 199,852	$ -	Complete
18.2	Genetics to improve hybrid and Eurasian watermilfoil management	Eurasian watermilfoil	Raymond Newman	7/1/2019	6/30/2021	$ 236,423	$ 236,423	$ -	Complete
20	A Novel Technology for eDNA Collection and Concentration*	Black carp, Silver carp, Bighead carp, Zebra mussels, Snakehead	Abdennour Abbas	7/31/2018	6/30/2020	$ 96,264	$ 96,264	$ -	Complete
21.2	Field validation of mulitbeam sonar zebra mussel detection (Year 1)**	Zebra mussels, Quagga mussels	Jessica Kozarek	7/1/2019	6/30/2020	$ 14,247	$ 14,247	$ -	Complete
22	Copper-based control – zebra mussel settlement and non-target impacts*	Zebra mussels	James Luoma	11/15/2018	6/30/2020	$ 152,090	$ 152,090	$ -	Complete
23	Public Values of Aquatic Invasive Species Management*	Common carp, Zebra mussels	Amit Pradhananga	7/31/2018	12/31/2021	$ 110,245	$ 110,245	$ -	Complete
24	Genetic method for control of invasive fish species*	Common carp	Michael Smanski	8/1/2018	6/30/2021	$ 140,004	$ 140,004	$ -	Complete
25	What's in Your Bucket? Quantifying AIS Introduction Risk*	Baitfish viruses, Viral Hemorrhagic Septicemia virus (VHSV)	Nicholas Phelps	8/1/2018	12/31/2020	$ 84,094	$ 84,094	$ -	Complete
28	Evaluating Innovative Coatings to Suppress Priority AIS	Zebra mussels, Quagga mussels	Mikael Elias	7/1/2019	6/30/2021	$ 51,234	$ 51,234	$ -	Complete
30	Managing Midwestern aquatic invasions in a changing climate	Starry stonewort	Ranjan Muthukrishnan	1/13/2019	6/30/2022	$ 39,000	$ 38,866	$ 134	Complete
	MAISRC Reserves		*Nicholas Phelps*	*6/7/2017*	*6/30/2022*	*$ 10*		*$ 10*	
						$ 2,700,000	**$ 2,621,072**	**$ 78,928**	

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2017 Subproject Budget - Final
Legal Citation: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a
Project Manager: Nicholas Phelps
Subproject Title: MAISRC Subproject 1: MAISRC Core Operations
Organization: Minnesota Aquatic Invasive Species Research Center
Subproject Budget: $920,000
Subproject Length and Completion Date: 5 Years; June 30, 2022
Today's Date: September 15, 2022

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	**$ 1,095,000**	**$ 1,062,952**	**$ 32,048**
1 Grad Students: $42,525 salary, $38,273 benefits (37% tuition, 9% fringe) 50% FTE x 2 years, FTE TOTAL: 1			
PI/Project Manager- Phelps: $143,775 salary, $48,452 benefits (33.7% fringe rate) 50% FTE x 2 years FTE			
PI/Project Manager- Phelps: $60,729 salary, $20,344 benefits (33.5% fringe rate) 0.47 FTE for extension to			
Co-Project Manager- Nash: $182,250 salary, $61,418 benefits (33.7% fringe rate) 100% FTE x 2 years FTE			
Co-Project Manager-Mattke: $66,111 salary, $22,147 benefits (33.5% fringe rate) 0.91 FTE for extension to			
Comm. & Admin Assistant: $ 95,175 salary 26,078 benefits (27.4% fringe rate) 100% FTE x 2 years FTE TOTAL			
Comm Specialist-Loobeek: $65,318 salary, $18,747 benefits (28.7% fringe rate) 0.99 FTE for extension to June			
2 Aquatic laboratory techs: $111,375 salary, $30,517 benefits (27.4% fringe rate) 50% FTE x 2 years, FTE			
Aquatic Lab Manager-Maher: $2,903 salary, $833 benefits (28.7% fringe rate) 0.05 FTE for extension to June			
Contract Faculty-Bajer: $43,249 salary, $14,488 benefits (33.5% fringe rate) 0.48 FTE for extension to June 30,			
Professional/Technical/Service Contracts	**$ 67,742**	**$ 27,156**	**$ 40,586**
Services - Office & Gen Oper: printing/duplication, mailing, communication/research dissemination platforms, printer repairs, audio visual associated with seminars & conferences, etc.	$ 9,250	$ 9,236	$ 14
Services - Lab & Medical: contracts for statistics, DNA analysis, supercomputing institute, data storage, sequencing, biochemistry, microscopy; well permits, discharge licences and fees, preventative maintenance and maintenance of shared lab facilities	$ 48,000	$ 7,429	$ 40,571
Professional Services & Contracts: fees or honoraria for guest lecturer and speakers, etc.	$ -	$ -	$ -
Repairs - Lab & Field: shared lab facility or other shared equipment; boats, transmitters, receivers, PCR	$ 3,899	$ 3,899	$ 0
Rentals: space and facilities for conferences and events (e.g. annual Showcase)	$ 6,593	$ 6,593	$ 0
Equipment/Tools/Supplies	**$ 11,573**	**$ 10,731**	**$ 842**
Supplies - Office and Gen Operating: paper, toner, folders, brochures, displays	$ 7,500	$ 6,659	$ 841
Supplies - Lab and/or Field: piping, glue, gas, hoses for shared washdown and laboratory facilities; anesthesia, fish, fish food, gas for boats, replacement helio & LED bulbs for experiments; tanks, reagents, sampling supplies, and other consumables	$ 3,798	$ 3,798	$ 0
Equipment - Non-Capital Lab and/or Field: replacement pumps, valves, timers if needed, for shared laboratory facilities, storage containers; surgical equipment, pipetters, incubators; computer, software; trap nets, seine nets, dip nets; pumps, timers	$ 275	$ 275	$ 0
Capital Expenditures Over $5,000	**$ -**	**$ -**	**$ -**
N/A			
Travel Expenses in Minnesota	**$ 13,019**	**$ 7,711**	**$ 5,308**
Mileage, lodging, registration and meals for investigator travel to one conference a year to present findings; research needs assessment participants; consulting researchers; meetings and field work.	$ 13,019	$ 7,711	$ 5,308
Other	**$ 318**	**$ 318**	**$ (0)**
Telecommunications: voicemail service for MAISRC researchers and staff	$ 318	$ 318	$ (0)
COLUMN TOTAL	$ 1,187,652	$ 1,108,868	$ 78,784

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State: M.L. 2017, Chp. 93, Art. 1, Sec. 3, Subd. 3 -- MAISRC Legislative Appropriation		$ 820,000	$ 820,000	$ -
In kind:		$ -	$ -	$ -

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Current appropriations: M.L. 2019, First Special Session, Art. 4, Chp. 2, Sec. 2, Subd. 06a -- Building Knowledge and Capacity to Solve AIS Problems		$ 885,000	$ 98,869	$ 786,131
Past appropriations: M.L. 2013, Chp. 52, Sec. 2, Subd. 06a -- Aquatic Invasive Species Research Center		$ 1,372,730	$ 1,351,424	$ 21,306

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2017 Subproject Budget - Final
Legal Citation: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a
Subproject Manager: Przemek Bajer
Subproject Title: MAISRC Subproject 4.3: Social learning and carp removal
Organization: University of MN, MAISRC
Subproject Budget: $189,475
Subproject Length and Completion Date: 2 Years; June 30, 2021
Today's Date: September 15, 2022

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	**$ 142,535**	**$ 142,535**	**$ -**
PostDoc (Hundt); Academic; $107,494 ($79,040 salary, $28,454, 36 %benefit rate); 50%FTE for yr 1			
Field tech, 2 people; $31,360 ($14/h,); 70 days each yr x 2 yrs			
Meggan Craft; academic, colaborator; 4% FTE for year 1 and 2; $ 8,914 salary, $ 2,986 Benefits;			
Professional/Technical/Service Contracts	**$ 6,717**	**$ 6,717**	**$ -**
Lauren White; National Socio-Environmental Synthesis Center (SESYNC); analysis of PIT detection	$ 6,717	$ 6,717	#REF!
Equipment/Tools/Supplies	**$ 30,171**	**$ 30,171**	**$ -**
Materials: PIT antenna materials, waders, nets, batteries, solar panels, etc.	$ 11,685	$ 11,685	$ -
PIT Tags: 1,200 tags $1.70 each	$ 2,040	$ 2,040	$ -
Equipment: PIT readers	$ 14,045	$ 14,045	$ -
Fuel: Gas for boat and generator	$ 401	$ 401	$ -
Bait: Corn for baiting	$ 2,000	$ 2,000	$ -
Capital Expenditures Over $5,000	**$ -**	**$ -**	**$ -**
NA			
Printing	**$ -**	**$ -**	**$ -**
NA			
Travel Expenses in Minnesota	**$ 9,947**	**$ 9,947**	**$ -**
U of M truck rental for 4 months x 2 years	$ 9,947	$ 9,947	$ -
Uppper Midwest Invasive Species Conference (UMISC) - October 12-14, 2020 in Duluth, MN Two attendees. Expenses include registration ($200/person, $400 total) and milage ($50/person,	$ -	$ -	$ -
Other	**$ 105**	**$ 105**	**$ -**
North American Lake Management Society (NALMS) conference - location TBD One attendee. Estimated expenses include registration ($400), airfare ($400), lodging ($400), and	$ 105	$ 105	$ -
American Fisheries Society, Minnesota Chapter (MNAFS) Meeting - Fargo North Dakota Two attendees. Expenses include registration ($200/person, $400 total) and milage ($50/person,	$ -	$ -	$ -
COLUMN TOTAL	$ 189,475	$ 189,475	$ -

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State: Minnehaha Creek Watershed District	Secured	$ 90,670	$ 85,168	$ 5,502
State: MAISRC (Bajer's salary and benefits; 50% YR 1, 50% YR 2)	Secured	$ 120,037	$ 116,503	$ 3,534
In kind: Carp Solutions (equipment; 12 box nets)	Secured	$ 36,000	$ 30,000	$ 6,000

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Current appropriation:				
M.L. 2013, Chp. 52, Sec. 2, Subd. 06a MAISRC Subproject 4.2 - Common carp management using biocontrol and toxins (Phase II)		$ 406,000	$ 348,913	$ 57,087
MAISRC Subproject 4.1 - Common carp management using biocontrol and toxins (Phase I)		$ 384,231	$ 384,231	$ -

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2017 Subproject Budget - Final
Legal Citation: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a
Subproject Manager: Daniel Larkin
Subproject Title: MAISRC Subproject 8.2: Impacts of invader removal on native vegetation recovery
Organization: MAISRC, University of Minnesota
Subproject Budget: $119,034
Subproject Length and Completion Date: 2 Years; June 30, 2021
Today's Date: September 15, 2022

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	**$ 101,443**	**$ 101,443**	**$ -**
Subproject Manager (Daniel Larkin); Faculty; $12,701 ($9,464 salary, $3,237 benefits at 34.2% benefit rate, 3% annual salary increase); 3.8% FTE (2 weeks) for 2 years			
Research Fellow (Wesley Glisson); Researcher 5; $66,690 ($52,000 salary, $18,051 benefits at 34.2% benefit rate); 47% FTE for 2 years (total of $49,694 salary, $16,996 benefits)			
Field Technician; $14,381 ($11,200 salary, $3,181 benefits at 28.4% benefit rate); 31% FTE (4 mo.) for			
Undergraduate research assistant; $5,720 ($11 per hour, 0% benefit rate); 12.5% FTE (260 hrs) per year for 2 years			
Professional/Technical/Service Contracts	**$ 2,509**	**$ 2,509**	**$ -**
CFANS Research Analytical Laboratory: Laboratory analyses of sediment and water chemistry	$ -	$ -	$ -
MAISRC Containment Lab: Plant Growth Chambers	$ 2,509	$ 2,509	$ -
Equipment/Tools/Supplies	**$ 6,798**	**$ 6,798**	**$ -**
Supplies - Office and Gen Operating: Supplies for data entry and storage; office and administrative tasks; management of sample and data archives	$ 39	$ 39	$ -
Supplies - Lab and/or Field: Supplies for using SCUBA; collecting, transporting, storing and analyzing samples from the field; conducting laboratory experiments; performing measurements in the field and lab	$ 6,759	$ 6,759	$ -
Equipment - Non-Capital Lab and/or Field: *NA*			
Capital Expenditures Over $5,000	**$ -**	**$ -**	**$ -**
NA			
Printing	**$ -**	**$ -**	**$ -**
Travel Expenses in Minnesota	**$ 6,884**	**$ 6,884**	**$ -**
Field travel and expenses: mileage, lodging and per-diem for in-state travel for field work.	$ 6,884	$ 6,884	$ -
Other	**$ 1,400**	**$ 1,400**	**$ -**
Annual maintenance and repair costs for field vehicle, boat, and SCUBA equipment	$ 1,400	$ 1,400	$ -
COLUMN TOTAL	$ 119,034	$ 119,034	$ -

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State: National Science Foundation GRFP (supporting Michael Verhoeven)	Secured	$ 138,000	$ 99,667	$ 38,333
Non-State: UMN Undergraduate Reseach Opportunity Program (supporting Jonah E	Secured	$ 1,740	$ 1,740	$ -
State:		$ -	$ -	$ -
In kind:		$ -	$ -	$ -

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Current appropriation:		$ -	$ -	$ -
Past appropriations: M.L. 2013, Chp. 52, Sec. 2, Subd. 06a MAISRC Subproject 8.1 - Risk assessment, control, and restoration research on aquatic invasive plant species		$ 822,000	$ 820,251	$ 1,748

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2017 Subproject Budget - Final
Legal Citation: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a
Subproject Manager: Donn Branstrator
Subproject Title: MAISRC Subproject 12.2: Historical analyses of spiny water flea invasion patterns
Organization: University of Minnesota Duluth
Subproject Budget: $53,795
Subproject Length and Completion Date: 2 Years; June 30, 2021
Today's Date: September 15, 2022

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	**$ 46,834**	**$ 46,834**	**$ -**
Associate Professor (Branstrator); Job Class (9402); $12,241 ($9,001 salary, $3,240 benefits at %36.0);			
Sr. Research Associate (Reavie); Job Class (9742R7); $6,883 ($5,061 salary, $1,822 benefits at %36.0);			
MS Graduate Student; Job Class (9521); $23,490 ($13,347 salary, $10,143 benefits at 16.1%); 58% FTE			
Principle Lab Tech (Kennedy); Job Class (4946); $2,944 ($2,274 salary, $670 benefits at 29.5%); 5% FTE			
Undergrad Research Asst (TBN); Job Class (2226); $2,230 (217 hrs x $10.26/hr - $2,230 salary, $0			
Professional/Technical/Service Contracts	**$ 6,175**	**$ 6,175**	**$ -**
St. Croix Watershed Research Station ($3,200) - Be-7 dating; $1600 per core x 2 cores	$ 3,200	$ 3,200	$ -
Sr. Scientist (Engstrom); Science Museum of Minnesota ($2,575) - Consultant on core dating and	$ 2,575	$ 2,575	$ -
St. Croix Watershed Research Station ($400) - Core archive subsampling; $100 per core x 4 core	$ 400	$ 400	$ -
Sample shipping for isotope dating and subfossil analyses ($200)	$ -	$ -	$ -
Equipment/Tools/Supplies	**$ -**	**$ -**	**$ -**
Supplies - Lab and/or Field: UMD Core collection, sectioning, and microscopic analysis	$ -	$ -	$ -
Travel Expenses in Minnesota	**$ 786**	**$ 786**	**$ -**
Field travel and expenses - Round trip vehicle travel from Duluth to field sites (Mille Lacs,	$ 786	$ 786	$ -
In-state conferences/meetings - Registration, transportation, lodging, and meals for project PI to	$ -	$ -	$ -
COLUMN TOTAL	$ 53,795	$ 53,795	$ -

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind:		$ -	$ -	$ -

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Current appropriation:				
Past appropriations:				
M.L. 2013, Chp. 52, Sec. 2, Subd. 06a MAISRC Subproject 12.1 - Characterizing spiny water flea impacts using sediment records		$ 212,266	$ 211,708	$ 558

Environment and Natural Resources Trust Fund

M.L. 2013, M.L. 2017 Subproject Budget - Final

Subproject Title: MAISRC Subproject 15: Determining Highest-Risk Vectors of Spiny Waterflea Spread

Legal Citation: M.L. 2013, Chp. 52, Sec. 2, Subd. 06a**;** M.L. 2017, Chp. 96, Sec. 2, Subd. 06a

Subproject Manager: Valerie Brady

Organization: University of Minnesota Duluth, Natural Resources Research Institute

Subproject Budget: $119,513

M.L. 2013 Subproject Length and Completion Date: 2 years, June 30, 2019

M.L. 2017 Subproject Length and Completion Date: 2.5 years, December 31, 2021

Today's Date: September 15, 2022

	M.L. 2013, Chp. 52, Sec. 2, Subd. 06a						**M.L. 2017, Chp. 96, Sec. 2, Subd. 06a**						
ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1: Determine risk of spiny water flea			Activity 2, Part I: Outreach, messaging, and			Activity 2, Part II: Outreach, messaging, and MAISRC service						
BUDGET ITEM	**M.L. 2013 Activity 1 Budget**	**M.L. 2013 Activity 1 Amount Spent**	**M.L. 2013 Activity 1 Balance**	**M.L. 2013 Activity 2 Budget**	**M.L. 2013 Activity 2 Amount Spent**	**M.L. 2013 Activity 2 Balance**	**M.L. 2017 Activity 2 Budget**	**M.L. 2017 Revised Budget 09/15/2022**	**M.L. 2017 Activity 2 Amount Spent**	**M.L. 2017 Activity 2 Balance**	**TOTAL BUDGET**	**TOTAL SPENT**	**TOTAL BALANCE**
Personnel (Wages and Benefits) - Total	**$ 79,000**	**$ 79,000**	**$ -**	**$ 4,085**	**$ 4,085**	**$ -**	~~**$ 11,855**~~	**$ 11,650**	**$ 11,650**	**$ -**	**$ 94,940**	**$ 94,735**	**$ -**
V Brady, investigator: $11,355 salary, $3,826 benefits (33.7% fringe rate); 0.14 FTE total for 2 years													
D Branstrator, co investigator: $10,527 salary, $3,547 benefits (33.7% fringe rate); .05 total FTE													
J Dumke, co investigator: $10,070 salary, $3,393 benefits (33.7% fringe rate); 0.20 total FTE													
3 ppl, field technicians: $ 20,570 salary, $5,635 benefits (27.4% fringe rate); 0.60 total FTE													
Lab technician: $12,730 salary, $3,487 benefits (27.4% fringe rate); 0.30 total FTE													
Researcher: $6,704 salary, $1,836 benefits (27.4% fringe rate); 0.16 total FTE													
3 ppl, communications: $3,965 salary, $1,085 benefits (27.4% fringe rate); 0.09 total FTE													
Professional/Technical Services and Contracts - Total	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	~~**$ 7,340**~~	**$ 7,545**	**$ 7,545**	**$ -**	**$ 7,340**	**$ 7,545**	**$ -**
Services - NRRI Machine Shop: Materials and labor for NRRI machine shop to fabricate an aluminum equipment arch to hold rods and other gear being tested.	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Services-Video/Audio Production. Contract services to produce video and audio for educational PSAs.	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,170	$ 1,170	$ 1,170	$ -	$ 1,170	$ -	$ -
Services-Printing: Print costs for 4,000 resuable towels with instructions on how to clean fishing lines and gear. Printing will be done by local print shop in Duluth.	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,950	$ 1,950	$ 1,950	$ -	$ 1,950	$ 1,950	$ -

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
13	**ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET**	Activity 1: Determine risk of spiny water flea			Activity 2, Part I: Outreach, messaging, and			Activity 2, Part II: Outreach, messaging, and MAISRC service						
14	**BUDGET ITEM**	**M.L. 2013 Activity 1 Budget**	**M.L. 2013 Activity 1 Amount Spent**	**M.L. 2013 Activity 1 Balance**	**M.L. 2013 Activity 2 Budget**	**M.L. 2013 Activity 2 Amount Spent**	**M.L. 2013 Activity 2 Balance**	**M.L. 2017 Activity 2 Budget**	**M.L. 2017 Revised Budget 09/15/2022**	**M.L. 2017 Activity 2 Amount Spent**	**M.L. 2017 Activity 2 Balance**	**TOTAL BUDGET**	**TOTAL SPENT**	**TOTAL BALANCE**
27	Services-PSA Ads: $4,000 for online and print ads, focused on angling audiences.	$ -	$ -	$ -	$ -	$ -	$ -	~~$ 4,220~~	$ 4,425	$ 4,425	$ -	$ 4,220	$ 4,425	$ -
28	**Equipment/Tools/Supplies - Total**	**$ 1,577**	**$ 1,401**	**$ 176**	**$ -**	**$ -**	**$ -**	**$ 7,089**	**$ 7,089**	**$ 7,089**	**$ -**	**$ 8,666**	**$ 8,490**	**$ 176**
29	Lab supplies: Vials $0.2 x900 = $180; Foreceps $20 x4 = $80; Nitrile gloves (1 box each L&M) = $25	$ 537	$ 510	$ 27	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 537	$ 510	$ 27
30	Supplies - General Operating: Purchase of reusable towels that will be printed with instructions on how to clean fishing lines and gear.	$ -		$ -	$ -	$ -	$ -	$ 7,089	$ 7,089	$ 7,089	$ -	$ 7,089	$ 7,089	
31	Field supplies: Field Support- Ethanol preservative 120 ga @ $7.5/gal = $900; Tupperware containers for anchor rope 30 x $10 ea = $300; Eye bolts ($3 ea x30) and cement ($15) for rope anchors $105; Scrub brushes for anchor rope cleaning $8 x4 = $32; Write in rain paper, special markers and labels $120; Livewell hose $0.79/ft at 20' = $16; Battery and box to power light bar $150; Wire, electrical connectors, fuses, switch $35; Zooplankton net (spare) $400; Boat fuel and wheel bearing grease $100; Boat decontamination (fuel for hot-water pressure washer) $40. Safety and crew supplies- Headlamps $20 x4 = $100; Batteries (gps, headlamps, line counters) = $50; Emergency GPS subscription (3 mo @ $36/mo) = $108; Safety glasses (2 pair each 4 ppl) $10 x2 x4 = $80; Sunscreen, bugscreen, headnets, hand sanitizer = $100	$ 1,000	$ 851	$ 149	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,000	$ 851	$ 149
32	Field gear for testing: Bait bucket: Frabill Flow Troller $15 * 2 (1 deployed, 1 spare) = $30, Anchor rope: 500' ea polypropylene, braided nylon, twist nylon = $275 per "set" to complete 5 point deployments; * 2 of "sets" = $550; Fishing line: 10# monofilament $20 (*2 rods) = $40, 10# flourocarbon = $20, 10# braid = $20. Total is $80 * 2 (mid-season re-spooling) = $160; Downriggers: Canon Easi-Troll ST (depth counter + 200' cable) = $200, Downrigger ball,caddy, release: $85; Fishing rod/reel: $100 per combo * 4 = $400, External fishing line counter: $20 * 4 = $80; Terminal tackle: lead weights, swivels, quick snaps = $30	$ 40	$ 40	$ 0	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 40	$ 40	$ 0
33	**Capital Expenditures Over $5,000 - Total**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
34														
35	**Travel - Total**	**$ 7,800**	**$ 7,800**	**$ -**	**$ 470**	**$ 470**	**$ -**	**$ 297**	**$ 297**	**$ 297**	**$ (0)**	**$ 8,567**	**$ 8,567**	**$ (0)**
36	Travel - MN: Fieldwork - mileage costs: 10 trips by 2 NRRI vehicles, ea avg 250 mi RT (total 5000 mi) * $0.535/mile = $2675. NRRI truck and trailer fee at $15/day * 10 days * 2 trucks and trailers = $300. Total = $2975. Meals for personnel for traveling employees: 6 people per trip * 10 trips * $38 = $2280. Meal expense is no greater than the amount provided for in the University of Minnesoty travel policy. Lodging: 2 rooms at $175/night * 10 nights = $3500.	$ 7,800	$ 7,800	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 7,800	$ 7,800	$ -
37	Travel - out of state: outreach/research presentation to the International Association for Great Lakes Research (IAGLR) in Brockport, NY, June 10-14, 2019\	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
38	Travel - MN: Outreach presentations to managers, lake associations, tourism industry, and fishing groups, Mille Lacs area: est total mileage at 1250 mi * $0.535/mile = $669. Hand deliver outreach stickers to bait shops, gas stations near boat launches, and fishing license sales locations, St. Louis county: est total mileage at 400 miles * $0.535/mile = $214. Total $883.	$ -	$ -	$ -	$ 470	$ 470	$ -	$ 297	$ 297	$ 297	$ (0)	$ 767	$ 767	$ (0)
39	**Other - Total**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
40														
41	**COLUMN TOTAL**	**$ 88,377**	**$ 88,201**	**$ 176**	**$ 4,555**	**$ 4,555**	**$ -**	**$ 26,581**	**$ 26,581**	**$ 26,581**	**$ (0)**	**$ 119,513**	**$ 119,337**	**$ 176**

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2017 Subproject Budget - Final
Legal Citation: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a
Subproject Manager: Gretchen Hansen
Subproject Title: MAISRC Subproject 16.2: AIS impacts on walleye populations and mercury concentrations
Organization: University of Minnesota
Subproject Budget: $199,852
Subproject Length and Completion Date: 2.5 years, December 31, 2021
Today's Date: September 15, 2022

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	**$ 142,961**	**$ 142,961**	**$ -**
UMN graduate assistant in Conservation Sciences; $88,433 ($47,967 salary, $32,456 tuition, and $8010 benefits at 16.6%); 50% RA for two years			
G. Hansen, project manager and lead PI, Assistant professor; $19,956 ($14,870 salary, $5,086 fringe at 34.2%); 3.8%FTE for year 1, 7.6%FTE for year 2			
UMN undergraduate student workers; $18,960 (0% fringe); 2 students at 11.5% FTE for year 1 and 19.2% for year 2. One student at 7.2%FTE for years 1 and 2.			
Professional/Technical/Service Contracts	**$ 22,406**	**$ 22,406**	**$ -**
Contract with UC-Davis for C and N stable isotope analysis ($26,775; 210 samples/ lake, 15 lakes, $8.5/sample). The stable isotope analysis lab at UC-Davis is the most commonly used lab for processing stable isotope samples for ecology in the quantities and timeline required for this project. Other labs such as that at the University of Minnesota do not have the capacity to analyze thousands of samples within 3 months as will be required to complete the activities of this project in the timeline required.	$ 22,406	$ 22,406	$ -
Equipment/Tools/Supplies	**$ 13,094**	**$ 13,094**	**$ -**
Equipment- Lab and/or Field: PPE [$400], ponar grab and wash bucket [$1338], Coolers [$200], kick nets [4@$170], buckets [10@$20], Beach seine [$750], minnow traps [20@$18], decontamination gear [$500], sample grinder [$1500]; magnifying lamps [$150]; lighting for invertebrate processing [$100]; travel dissecting microscope [$500]; misc. field proceesing gear [trays, forceps, squirt bottles, etc $250];	$ 5,928	$ 5,928	$ -
Supplies - Lab and/or Field: supplies for stable isotope processing. Some supplies are needed for each lake; per lake costs estimated as vials [$75], vial boxes [$78]; bags [$45], dry ice [$120], regular ice [$40], tin capsules for isotopes [$22], isotope sample trays [$13], petri dishes [$6]; multiplied by 15 lakes. Other supplies include ethanol [$500], and lab processing supplies [dissecting kits, drying trays; $250]	$ 7,166	$ 7,166	$ -
Travel Expenses in Minnesota	**$ 20,891**	**$ 20,891**	**$ -**
Fieldwork to sample fish and invertebrates from each of 15 lakes. For collecting invertebrates and littoral fishes, 5 days per visit * 3 ppl* 6 weeks (assuming 2-3 lakes sampled per week); Total based off 800 miles@$0.7/mi + 4 lodging nights@$350/night (for shared cabin rental) + 5 days of meals @$36/day for 3 people (meal estimate based on state per diem rate; actual costs will be reimbursed) + $200 for boat gas + $200 incidentals per week of sampling = [$17,400]. Adult fish sampling will be in collaboration with DNR and costs were estimated assuming 12 visits for one person; total based off 600 miles @$0.54/mile + 2 lodging nights @ $130/night + 2.5 days of meals @$36/day (meal estimate based on state per diem rate; actual costs will be reimbursed) for 12 visits [$8088].	$ 20,116	$ 20,116	$ -
Travel for UMN personnel to 1 project team meeting in Duluth in years 1 & 2 [$1,819]. Cost estimated as mileage (310 miles RT @ $0.56/mile), 2 nights lodging for two people @$150/night, and meals (2 people for 3 days @ $36/day) in years 1 and 2. Actual costs will be reimbursed	$ -	$ -	$ -
Travel for two project team members to present results at an in-state professional conference (e.g., Minnesota AFS, Midwest Invasive Species Conference) . Cost estimated as registration ($200), mileage (400 miles RT @ $0.56/mile), 2 nights lodging (2 nights @$150/night), and meals (3 days @ $36/day). Actual costs will be reimbursed.	$ 775	$ 775	$ -

Travel to lake association meetings (2). Cost estimated as two trips consisting of mileage (350 miles RT @ $0.56/mile), 1 nights lodging (@$150/night), and meals (2 days @ $36/day). Actual costs will be reimbursed.	$ -	$ -	$ -
Other	**$ 500**	**$ 500**	**$ -**
Shipping: sending samples to UC-Davis and USGS for stable isotope analysis	$ 500	$ 500	$ -
Travel - domestic: travel for one team member to present results at a national conference (e.g., the American Fisheries Society meeting in Columbus, OH in 2020). Costs calculated as $400 airfare, $450 conference registration, 4 nights lodging @$200/night, and 5 days of meals at $36/day (costs are estimated, actual expenses will be reimbursed).	$ -	$ -	$ -
COLUMN TOTAL	$ 199,852	$ 199,852	$ -

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	**Status (secured**	**Budget**	**Spent**	**Balance**
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: Minnesota DNR co-investigator salary + fringe [$31,021]; UGSS co-investigator salary + fringe [$9,500]; cost of mercury stable isotope analysis [$90,000]	Secured	$ 130,521	$ 130,521	$ -

PAST AND CURRENT ENRTF APPROPRIATIONS	**Amount legally obligated but not yet spent**	**Budget**	**Spent**	**Balance**
Current appropriation:				
Past appropriations: M.L. 2013, Chp. 52, Sec. 2, Subd. 06a MAISRC Subproject 16.1 - Sustaining walleye populations: assessing impacts of AIS		$ 198,700	$ 197,569	$ 1,131

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2017 Subproject Budget - Final
Legal Citation: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a
Subproject Manager: Raymond M Newman
Subproject Title: MAISRC Subproject XX: Genetics to improve hybrid and Eurasian watermilfoil management
Organization: University of Minnesota FWCB
Subproject Budget: $236,423
Subproject Length and Completion Date: 2 Years; June 30, 2021
Today's Date: September 15, 2022

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	**$ 115,226**	**$ 115,226**	**$ -**
Ray Newman Professor: $11,728 salary, $4,011 benefits (34.2% fringe rate); 0.09 FTE total			
Name - Research Technician (Civil Service): $39,375 salary, $11,183 benefits (28.4% fringe rate); 0.875 total FTE			
Name - Graduate Student: $24,338 salary, $20,532 (67.66% tuition, 16.7% fringe rate); 0.5 total FTE			
Name - Undergraduate Student: $11.50/hr salary, 220 hrs per year for 2 years, $0 benefits (0% fringe rate); 0.106 total FTE			
Professional/Technical/Service Contracts	**$ 109,564**	**$ 109,564**	**$ -**
Montana State University - expenses in contract include: Ryan Thum, co-PI, will leading the genetic analysis. Thum will oversee data analysis, help advise the graduate student and assist with writing reports and manuscripts. Expenses include 1 month salary each year, for two years, fringe benefits 37% (Total: $21,000). Master's level technician (0.5 FTE) to assist with molecular work at $16/hour and 44% fringe for two years (Total: $47,500). Automated genotyping of microsatellites and AFLPs (Total: $5,000). Supplies to process plants from up to 25 lakes. Supplies required for molecular genotyping work include: DNA extraction kits, pipette tips, tubes, 96-well reaction plates, Taq DNA Polymerase, unlabeled and fluorescently-labeled PCR primers, dNTPs, buffers, and molecular grade water, gel electrophoresis reagents (e.g., agarose, buffers, DNA stains such as "gel-Red"), gloves, and cleaning supplies (Total: $27,500). This work is being conducted by Thum at MSU because they are the preeminent lab doing such reseach and analyses for hybrid watermilfoil and have procedures and identifications in place for Minnesota watermilfoils based on two years of prior collaboration and interactions with the DNR and local constituents.	$ 101,000	$ 101,000	$ -
Software and BioBase mapping subscription ($1,250 per year)	$ 2,500	$ 2,500	$ -
MAISRC and UMN faciltities usage fee for environmental chambers for challenge tests	$ 3,891	$ 3,891	$ -
Chemical analysis of herbicide challenge tests, completed by WI State Laboratory of Hygiene (53 samples, $41/each)	$ 2,173	$ 2,173	$ -
Equipment/Tools/Supplies	**$ 2,820**	**$ 2,820**	**$ -**
Supplies - Lab and/or Field: coolers for shipping samples, boat gas, sample bags, write in rain paper, microcentrifuge tubes, sample disruption beads and sample boxes, silica gel, dry ice, liquid nitrogen, and other expendable supplies	$ 2,820	$ 2,820	$ -
Capital Expenditures Over $5,000	**$ -**	**$ -**	**$ -**
NA			
Printing	**$ 500**	**$ 500**	**$ -**
Poster printing and sample fedex overnight mailing to Thum	$ 500	$ 500	$ -
Travel Expenses in Minnesota	**$ 7,212**	**$ 7,212**	**$ -**
Field travel and expenses: Vehicle rental and mileage for travel to field sites, local meetings and suppliers.	$ 7,212	$ 7,212	$ -
In-state UMISC conference to present results and to meet with stakeholder regarding genetic testing service. Travel costs ($100) and lodging for grad student and PI ($200).	$ -	$ -	$ -
Other	**$ 1,101**	**$ 1,101**	**$ -**
Out of state travel to one conference (e.g., APMS) by one team member (PI or grad student) to present results of project. Estimated airfare ($500), lodging ($400), conference registration ($200). Addional meeting costs will be covered from other sources (e.g., graduate program funds if needed).	$ -	**$ -**	$ -
Thum travel to MN for MAISRC Showcase and local stakeholder meetings in Minnesota ($2000). Estimated airfare $400/trip, lodging $200/trip and per diem ($66/trip). It is essential that Thum meet with constituents and stakeholders to get input and provide feedback on genetic results and the potential to develop a genetic testing service (Activity 4).	$ -	**$ -**	$ -
Repairs - Lab and/or Field: boat, trailer and gear repair, calibration and maintenance; $750 year 1, $725 year 2	$ 1,101	$ 1,101	$ -
COLUMN TOTAL	$ 236,423	$ 236,423	$ -

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind:		$ -	$ -	$ -

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Current appropriation:				
Past appropriations: M.L. 2013, Chp. 52, Sec. 2, Subd. 06a MAISRC Subproject 18.1 - Eurasian and hybrid watermilfoil genotype distribution in Minnesota		$ 221,375	$ 220,412	$ 963

Environment and Natural Resources Trust Fund
M.L. 2013, M.L. 2017 Subproject Budget - Final
Project Title: MAISRC Subproject 20: A Novel Technology for eDNA Collection and Concentration
Legal Citation: M.L. 2013, Chp. 52, Sec. 2, Subd. 06a; M.L. 2017, Chp. 96, Sec. 2, Subd. 06a
Project Manager: Abdennour Abbas
Organization: University fo Minnesota
Subproject Budget: $190,862
Subproject Length and Completion Date: 2 Years; June 30, 2020
Project Length and Completion Date: 4 Years; June 30, 2021
Today's Date: September 15, 2022

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Year One: M.L. 2013, Chp. 52, Sec. 2, Subd. 06a			Year Two: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a					
BUDGET ITEM	**Year 1 Budget**	**Amount Spent**	**Year 1 Balance**	**Year 2 Budget**	**Amount Spent**	**Year 2 Balance**	**TOTAL BUDGET**	**TOTAL SPENT**	**TOTAL BALANCE**
Personnel (Wages and Benefits) - Total	**$66,599**	**$66,599**	**$0**	**$71,099**	**$71,099**	**$0**	**$137,698**	**$137,698**	**$0**
Researcher 4 100% time (27.2% fringe rate). Year 1 $37,367 salary, $13,961 fringe; Year 2 $38,301 salary; $14,310 fringe. Researcher will work on developing the eDNA collection and concentration system under Professor Abbas.									
Faculty summer salary: Year 1 $11,454 salary; $3,817 fringe. Year 2 $11,740 salary; $3,913 fringe. Prof. Abbas will design the experiment and direct the research and prepare the publicaitons and possible intellectual property. The costs are adjusted to the rate of 4% inflation for the following years.									
Professional/Technical Services and Contracts - Total	**$6,805**	**$6,805**	**$0**	**$10,285**	**$10,285**	**$0**	**$17,090**	**$17,090**	**$0**
Quantitative PCR at the University of Minnesota Genomc Center (This service was cancelled due to time constraint. We have decided to purchase the equipment and perform qPCR in hourse instead of spending the same amount of money on services.)	$0	$0	$0	$0	$0	$0	$0	$0	$0
SEM and TEM microscopy of the eDNA nanofilters at the University NanoCenter and Characterization Center ($40/sample) and Water analytical lab (user fees: $40/sample). We expect to analyse around 50 samples/year	$6,805	$6,805	$0	$10,285	$10,285	$0	$17,090	$17,090	$0
Equipment/Tools/Supplies - Total	**$21,195**	**$16,859**	**$4,336**	**$12,316**	**$12,316**	**$0**	**$33,511**	**$29,175**	**$4,336**
Laboratory Supplies: Chemicals, reagents, media and consumables for eDNA quantification and qPCR; supplies for device development and testing of the eDNA collection system and field sampling; metal salts, pipes and 3D printing supplies for the fabrication of a housing system for the eDNA filters.	$10,451	$9,305	$1,146	$11,858	$11,858	$0	$22,309	$21,163	$1,146
Non-capital equipment: Flow meter ($4,409), laptop for field use ($1,150) and Origin Pro data analysis software ($2,185), high flow water pump ($3,000).	$10,744	$7,554	$3,190	$458	$458	$0	$11,202	$8,012	$3,190
Capital Expenditures Over $5,000 - Total	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
	$0	$0	$0	$0	$0	$0	$0	$0	$0
Travel - Total	**$0**	**$0**	**$0**	**$2,564**	**$2,564**	**$0**	**$2,564**	**$2,564**	**$0**
Travel - MN: Travel for project meetings, meeting with academic, public, or industrial partners.	$0	$0	$0	$0	$0	$0	$0	$0	$0
Travel - Domestic: The PI and his researcher will participate at 149th Annual Meeting of the American Fisheries Society in Reno (Nevada) (Accepted abstract)-Cost breakdown provided in the workplan	$0	$0	$0	$2,564	$2,564	$0	$2,564	$2,564	$0
	$0	$0	$0	$0	$0	$0	$0	$0	$0
Other - Total	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
									$0

	A	B	C	D	E	F	G	H	I	J
12	**ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET**	**Year One: M.L. 2013, Chp. 52, Sec. 2, Subd. 06a**			**Year Two: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a**					
13	**BUDGET ITEM**	**Year 1 Budget**	**Amount Spent**	**Year 1 Balance**	**Year 2 Budget**	**Amount Spent**	**Year 2 Balance**	**TOTAL BUDGET**	**TOTAL SPENT**	**TOTAL BALANCE**
38	**COLUMN TOTAL**	**$94,599**	**$90,263**	**$4,336**	**$96,264**	**$96,264**	**$0**	**$190,863**	**$186,527**	**$4,336**

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2013, M.L. 2017 Subproject Budget - Final
Legal Citation: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a; M.L. 2019, 1st Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 6(a)
Subproject Manager: Jessica Kozarek
Subproject Title: MAISRC Subproject 21.2: Field validation of mulitbeam sonar zebra mussel detection
Organization: St. Anthony Falls Laboratory, University of Minnesota
M.L. 2017 Subproject Budget: $14,247
M.L. 2019 Subproject Budget: $214,653
M.L. 2017 Subproject Length and Completion Date: 1 Year; June 30, 2020
M.L. 2019 Subproject Length and Completion Date: 1 Year; December 31, 2021
Today's Date: September 15, 2022

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	**Year 1:** M.L. 2017, Chp. 96, Sec. 2, Subd. 06a Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	**$ 12,283**	**$ 12,283**	**$ -**
Subproject Manager (Jessica Kozarek); Researcher 6; $40,327($29,652 salary, $10,675 benefits at 36% benefit rate); 20%FTE for 2 years			
Associate Engineer (Chris Milliren); Camp Plan/Eng/Safe Prof 2; $27,184 ($21,223 salary, $6,261 benefits at 29.5% benefit rate); 20%FTE for 2 years			
Field Assistant (TBD); Temp/Casual; $12,612 ($11,656 salary, $956 benefits at 8.2% benefit rate);			
Instrumentation Specialist (Erik Steen); Job Class; $8,572 ($6,619 salary, $1,953 benefits at			
Student Researcher (TBD); Undergraduate; $5,181 ($5,181, $0 at 0%benefit rate); 10%FTE for 2			
Professional/Technical/Service Contracts	**$ 1,898**	**$ 1,898**	**$ -**
Matthew Kaplinski, private contractor ($59,562) - Lead acoustic remote sensing	$ -	$ -	$ -
USGS/Paul Grams ($10,000) - Provide acoustic equipment and advise field work	$ -	$ -	$ -
Macalester College/Daniel Hornbach, Kelly MacGregor, Mark Hove ($53,359) - Mussel and sediment surveys. Provide research vessel and SCUBA equipment.	$ 1,898	$ 1,898	$ -
Equipment/Tools/Supplies	**$ 66**	**$ 66**	**$ -**
Supplies - Lab and/or Field: Instrumentation mount, sediment lab supplies, power (batteries),	$ 66	$ 66	$ -
Equipment - Non-Capital Lab and/or Field: *NA*			
Capital Expenditures Over $5,000	**$ -**	**$ -**	**$ -**
ROV (Remotely Opertated Vehicle) Deep Trekker			
Printing	**$ -**	**$ -**	**$ -**
Printing workshop materials	$ -	$ -	$ -
Travel Expenses in Minnesota	**$ -**	**$ -**	**$ -**
Field travel and expenses	$ -	$ -	$ -
Travel for one team member to present research findings and connect with practitioners at the Upper Midwest Stream Restoration Symposium in Feb 2020. Estimated cost includes $350 for conference registration and $200 for lodging.	$ -	$ -	$ -
Travel for one team member to present overall research findings at the Minnesota Water Resource Conference in Oct 2020. Estimated cost includes $250 for conference registration.	$ -	$ -	$ -
Other	**$ -**	**$ -**	**$ -**
Supplies - Office and Gen Operating: Instrumentation shipping	$ -	$ -	$ -
COLUMN TOTAL	$ 14,247	$ 14,247	$ -

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind:		$ -	$ -	$ -

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Current appropriation:				
Past appropriations: M.L. 2013, Chp. 52, Sec. 2, Subd. 06a MAISRC Subproject 21.1 - Early detection of zebra mussels using multibeam sonar		$ 96,549	$ 96,175	$ 374

Environment and Natural Resources Trust Fund

M.L. 2013, M.L. 2017 Subproject Budget - Final

Subproject Title: MAISRC Subproject 22: Copper-based control - zebra mussel settlement and non-target impacts

Legal Citation: M.L. 2013, Chp. 52, Sec. 2, Subd. 06a**;** M.L. 2017, Chp. 96, Sec. 2, Subd. 06a

Subproject Manager: Nicholas Phelps

Organization: Minnesota Aquatic Invasive Species Research Center (MAISRC), University of Minnesoa

Subproject Budget: $218,956 ($134,218 USGS; $84,738 MAISRC)

Subproject Length and Completion Date: 2 Years; June 30, 2020

Today's Date: September 15, 2022

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Year One: M.L. 2013, Chp. 52, Sec. 2, Subd. 06a			Year Two: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a					
BUDGET ITEM	**Year 1 Budget**	**Amount Spent**	**Year 1 Balance**	**Year 2 Budget**	**Amount Spent**	**Year 2 Balance**	**TOTAL BUDGET**	**TOTAL SPENT**	**TOTAL BALANCE**
Personnel (Wages and Benefits) - Total	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Professional/Technical Services and Contracts - Total	$ -	$ -	$ -	$ 30,300	$ 30,300	$ -	$ 30,300	$ 30,300	$ -
RMB Laboratories - processing of plankton tows for veligers and native species (qty = 90), processing and identification of sorted benthic invertebrate samples (qty = 60), analyses of water samples for dissolved organic carbon (DOC), sulfate (SO4), chloride (Cl), and chlorophyll A (CHLA) (qty = 50, 50, 50, and 90, respectively)	$ -	$ -	$ -	$ 30,300	$ 30,300	$ -	$ 30,300	$ 30,300	$ -
Equipment/Tools/Supplies - Total	$ 54,438	$ 50,008	$ 4,430	$ -	$ -	$ -	$ 54,438	$ 50,008	$ 4,430
Earth Sciences Laboratories - EarthTec QZ 13 totest @ 275 gallons each and shipping to St. Albans Bay Marina, Excelsior, MN	$ 54,438	$ 50,008	$ 4,430	$ -	$ -	$ -	$ 54,438	$ 50,008	$ 4,430
Capital Expenditures Over $5,000 - Total	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Travel - Total	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Other - Total	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
COLUMN TOTAL	$ 54,438	$ 50,008	$ 4,430	$ 30,300	$ 30,300	$ -	$ 84,738	$ 80,308	$ 4,430

Subproject Title: MAISRC Subproject 22: Copper-based control - zebra mussel settlement and non-target impacts

Legal Citation: M.L. 2013, Chp. 52, Sec. 2, Subd. 06a**;** M.L. 2017, Chp. 96, Sec. 2, Subd. 06a

Project Manager: James Luoma

Organization: Upper Midwest Environmental Science Center, USGS

Subproject Budget: $218,956 ($134,218 USGS; $84,738 MAISRC)

Subproject Length and Completion Date: 2 Years; June 30, 2020

Today's Date: September 15, 2022

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Year One: M.L. 2013, Chp. 52, Sec. 2, Subd. 06a			Year Two: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a					
BUDGET ITEM	**Year 1 Budget**	**Amount Spent**	**Year 1 Balance**	**Year 2 Budget**	**Amount Spent**	**Year 2 Balance**	**TOTAL BUDGET**	**TOTAL SPENT**	**TOTAL BALANCE**
Personnel (Wages and Benefits) - Total	$ 12,428	$ 12,428	$ -	$ 121,790	$ 121,790	$ -	$ 134,218	$ 134,218	$ -
Professional/Technical Services and Contracts - Total	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Equipment/Tools/Supplies - Total	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Capital Expenditures Over $5,000 - Total	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Travel - Total	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
								$ -	$ -
Other - Total	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
									$ -
COLUMN TOTAL	$ 12,428	$ 12,428	$ -	$ 121,790	$ 121,790	$ -	$ 134,218	$ 134,218	$ -

Environment and Natural Resources Trust Fund

M.L. 2013, M.L. 2017 Subproject Budget - Final

Subproject Title: MAISRC Subproject 23: Public Values of Aquatic Invasive Species Management

Legal Citation: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a

Subproject Manager: Amit Pradhananga

Organization: Center for Changing Landscapes, University of Minnesota

Subproject Budget: $242,090

Subproject Length and Completion Date: 3.5 years, December 31, 2021

Project Length and Completion Date: 4 Years; June 30, 2021

Today's Date: September 15, 2022

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Year One: M.L. 2013, Chp. 52, Sec. 2, Subd. 06a			Year Two: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a					
BUDGET ITEM	**Year 1 Budget**	**Amount Spent**	**Year 1 Balance**	**Year 2 Budget**	**Amount Spent**	**Year 2 Balance**	**TOTAL BUDGET**	**TOTAL SPENT**	**TOTAL BALANCE**
Personnel (Wages and Benefits) - Total	**$ 122,603**	**$ 121,908**	**$ 695**	**$ 82,980**	**$ 82,980**	**$ -**	**$ 205,583**	**$ 204,888**	**$ 695**
Research Assistant Professor (Bajer); $22,238 (74% salary, 26% benefits); 10% FTE for 2 years									
Researcher 6 (Pradhananga); $35,014 (74% salary, 26% benefits at 34.5% fringe rate); 20% FTE for 2 years									
Researcher 5 (Dalzell): $22,058 (74% salary, 26% benefits at 34.5% fringe rate); 15% FTE for 2 years									
Researcher 5 (Levers); $32,280 (74% salary, 26% benefits at 34.5% fringe rate); 20% FTE for 2 years									
Graduate Assistant (1): $84,700 (54% salary, 46% benefits); Salary and fringe for one University of Minnesota graduate student (MS) at 50% FTE per year for 2 academic years and 1 summer. Graduate fringe is budgeted at 83% of salary and includes tuition for the academic year, health care for the fiscal year and social security and Medicare for 6.5 pay periods (including summer)									
Undergraduate Research Assistants (4): $13,200 (100% salary); Salary for 4 undergraduate research assistants 0.25 FTE per year for 2 years ($12/hr; No fringe)									
Professional/Technical Services and Contracts - Total	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
N/A							$ -	$ -	$ -
							$ -	$ -	$ -
Equipment/Tools/Supplies - Total	**$ 4,742**	**$ 4,741**	**$ 1**	**$ 17,117**	**$ 17,117**	**$ -**	**$ 21,859**	**$ 21,858**	**$ 1**
Survey printing and mailing	$ -	$ -	$ -	$ 17,101	$ 17,101	$ -	$ 17,101	$ 17,101	$ -
Ipads (4) for onsite survey administration ($400 ea.) The use of iPads improves the efficiency and accuracy of data collection. Data are saved in “real-time”, which eliminates the need to hire and train data entry staff. The use of iPads also reduces the potential for human errors in data coding and data entry.	$ 1,916	$ 1,916	$ -	$ -	$ -	$ -	$ 1,916	$ 1,916	$ -
Onsite survey materials (paper copies of survey, survey log sheets)	$ 1,680	$ 1,680	$ 0	$ -	$ -	$ -	$ 1,680	$ 1,680	$ 0
Printing training materials (onsite survey training manual, sample surveys)	$ -	$ -	$ -	$ 16	$ 16	$ -	$ 16	$ 16	$ -
Camping equipment (for onsite surveyors)	$ 1,146	$ 1,146	$ 0	$ -	$ -	$ -	$ 1,146	$ 1,146	$ 0
Capital Expenditures Over $5,000 - Total	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
N/A			$ -				$ -	$ -	$ -
			$ -				$ -	$ -	$ -
Travel - Total	**$ 4,500**	**$ 4,500**	**$ 0**	**$ 10,148**	**$ 10,148**	**$ -**	**$ 14,648**	**$ 14,648**	**$ 0**
Travel - MN: Travel to and from survey locations for survey data collection (Mileage, lodging, and meals) *Surveying 3 lakes - 4-6 one week trips, 2 personnel on each trip*	$ 4,500	$ 4,500	$ 0	$ 10,148	$ 10,148	$ -	$ 14,648	$ 14,648	$ 0

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Year One: M.L. 2013, Chp. 52, Sec. 2, Subd. 06a			Year Two: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a					
BUDGET ITEM	Year 1 Budget	Amount Spent	Year 1 Balance	Year 2 Budget	Amount Spent	Year 2 Balance	TOTAL BUDGET	TOTAL SPENT	TOTAL BALANCE
N/A							$ -	$ -	$ -
							$ -	$ -	$ -
COLUMN TOTAL	**$ 131,845**	**$ 131,149**	**$ 696**	**$ 110,245**	**$ 110,245**	**$ -**	**$ 242,090**	**$ 241,394**	**$ 696**

Subproject Title: MAISRC Subproject 24: Genetic method for control of invasive fish species

Legal Citation: M.L. 2013, Chp. 52, Sec. 2, Subd. 06a**;** M.L. 2017, Chp. 96, Sec. 2, Subd. 06a

Subproject Manager: Michael Smanski

Organization: University of Minnesota

Subproject Budget: $250,116

Subproject Length and Completion Date: 3 Years; June 30, 2021

Today's Date: September 15, 2022

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Year One: M.L. 2013, Chp. 52, Sec. 2, Subd. 06a			Year Two: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a						
BUDGET ITEM	**Year 1 Budget**	**Amount Spent**	**Year 1 Balance**	**Year 2 Budget**	**Amount Spent**	**Year 2 Balance**	**TOTAL BUDGET**	**TOTAL REVISED BUDGET**	**TOTAL SPENT**	**TOTAL BALANCE**
Personnel (Wages and Benefits) - Total	**$ 90,588**	**$ 90,588**	**$ -**	**$ 88,711**	**$ 88,711**	**$ -**	**$ 179,299**	**$ 179,299**	**$ 179,299**	**$ -**
Professor/PI (Smanski); $0 salary, $0 benefits at 33.7% fringe rate; 0% FTE (one month effort/year)										
Research Assistant Professor/PI (Bajer); $34,616 ($25,891 salary, $8,725 benefits at 33.7% fringe rate); 15% FTE for 2 years										
Post Doctoral Fellow (Das); $81,480 ($67,478 salary, $14,002 benefits at 20.75% fringe rate); 67% FTE for 2 years										
Graduate Student (Erickson); $84,320 ($46,376 salary, $37,944 at 80% tuition, 20% fringe rate); 100% FTE for 2 years										
Undergrad hourly										
Professional/Technical Services and Contracts - Total	**$ 6,538**	**$ 6,538**	**$ -**	**$ 32,559**	**$ 32,559**	**$ -**	**$ 39,097**	**$ 39,097**	**$ 39,097**	**$ -**
Services - Office and General Operations: None	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Services - Lab and/or Medical: *DNA sequencing*	$ 893	$ 893	$ -	$ 26,000	$ 6,266	$ 19,734	$ 26,893	$ 26,893	$ 7,159	$ 19,734
Professional Services and Contracts: *None*	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Repairs - Lab and/or Field: *None*	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Rental: S*pace in MAISRC research and holding facility*	$ 5,645	$ 5,645	$ -	$ 6,559	$ 26,293	$ (19,734)	$ 12,204	$ 12,204	$ 31,938	$ (19,734)
Equipment/Tools/Supplies - Total	**$ 11,020**	**$ 10,608**	**$ 412**	**$ 17,000**	**$ 17,000**	**$ -**	**$ 28,020**	**$ 28,020**	**$ 27,608**	**$ 412**
Supplies - Office & Gen Operations: *None*	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Supplies - Lab and/or Field: Molecular Biology Reagents ($6000 per year; $12,000 total) [Enzymes, chemicals, synthetic DNA, etc.]; Lab consumables ($6000 per year; $12,000 total)	$ 11,000	$ 10,588	$ 412	$ 17,000	$ 17,000	$ -	$ 28,000	$ 28,000	$ 27,588	$ 412
Equipment - Non-Capital Lab and/or Field: None	$ 20	$ 20	$ 0	$ -	$ -	$ -	$ 20	$ 20	$ 20	$ 0
Capital Expenditures Over $5,000 - Total	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
N/A						$ -	$ -	$ -	$ -	$ -
Travel - Total	**$ 1,000**	**$ 306**	**$ 694**	**$ -**	**$ -**	**$ -**	**$ 1,000**	**$ 1,000**	**$ 306**	**$ 694**
Travel - MN: Field site travel for and from 5 local lakes: All lakes within 60 miles of St Paul; number of trips required will vary by fishing success	$ 1,000	$ 306	$ 694	$ -	$ -	$ -	$ 1,000	$ 1,000	$ 306	$ 694
Other - Total	**$ 966**	**$ 960**	**$ 6**	**$ 1,734**	**$ 1,734**	**$ -**	**$ 2,700**	**$ 2,700**	**$ 2,694**	**$ 6**
Incentives for Survey Participation: Drawstring backpacks will be designed and purchased to distribute as incentives to complete the survey at the 2019 State Fair.	$ 966	$ 960	$ 6	$ -	$ -	$ -	$ 966	$ 966	$ 960	$ 6
Research - Specific Utilities: Space and tablet computer rental at MN State Fair	$ -	$ -	$ -	$ 1,734	$ 1,734	$ -	$ 1,734	$ 1,734	$ 1,734	$ -
COLUMN TOTAL	**$ 110,112**	**$ 109,000**	**$ 1,112**	**$ 140,004**	**$ 140,004**	**$ -**	**$ 250,116**	**$ 250,116**	**$ 249,004**	**$ 1,112**

Project Title: MAISRC Sub-Project 25; What's in your bucket? Quantifying AIS introduction risk.

Legal Citation: M.L. 2013, Chp. 52, Sec. 2, Subd. 06a; M.L. 2017, Chp. 96, Sec. 2, Subd. 06a

Project Manager: Nick Phelps

Organization: University of Minnesota/MAISRC

SubProject Budget: $195,736

SubProject Length and Completion Date: 2.5 Years; December 31, 2020

Today's Date: September 15, 2022

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Year One: M.L. 2013, Chp. 52, Sec. 2, Subd. 06a			Year Two: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a					
BUDGET ITEM	**Year 1 Budget**	**Amount Spent**	**Year 1 Balance**	**Year 2 Budget**	**Amount Spent**	**Year 2 Balance**	**TOTAL BUDGET**	**TOTAL SPENT**	**TOTAL BALANCE**
Personnel (Wages and Benefits) - Total	**$ 80,642**	**$ 78,592**	**$ 2,050**	**$ 80,592**	**$ 80,592**	**$ -**	**$ 161,234**	**$ 159,184**	**$ 2,050**
Dr. Fernando Sampedro Parra - Assistant Professor: $21,997 salary, $7,369 benefits (33.5% fringe rate); 0.2 total FTE									
Dr. Dominic Travis - Associate Professor: $24,430 salary, $8,184 benefits (33.5% fringe rate); 0.14 total FTE									
Margaret McEachran - Graduate Student: $47,030 salary, $37,474; 1.0 total FTE									
TBD - Undergraduate Student: $10,800; 900 hours, $12/hour									
Thomas Lindsay - Assist Director: $1,490 salary, $510 benefits									
Alicia Hofelich Mohr - Resarch Support Coord: $2,235 salary, $765 benefits									
Professional/Technical Services and Contracts - Total	**$ 11,000**	**$ 9,616**	**$ 1,384**	**$ 3,115**	**$ 3,115**	**$ -**	**$ 14,115**	**$ 12,731**	**$ 1,384**
Professional Services and Contracts: Publication of three peer-reviewed manuscripts	$ 1,000	$ -	$ 1,000	$ 2,000	$ 2,000	$ -	$ 3,000	$ 2,000	$ 1,000
Professional Services and Contracts: Purchase @Risk Software (Palisade, Inc.)	$ -	$ -	$ -	$ 65	$ 65	$ -	$ 65	$ 65	$ -
Services - Office and General Operations: Postage for postcard logs and survey materials	$ 10,000	$ 9,616	$ 384	$ 1,050	$ 1,050	$ -	$ 11,050	$ 10,666	$ 384
Equipment/Tools/Supplies - Total	**$ 19,000**	**$ 12,971**	**$ 6,029**	**$ -**	**$ -**	**$ -**	**$ 19,000**	**$ 12,971**	**$ 6,029**
Supplies - Office & Gen Operations: Postcard logs, survey invitations, survey reminders, and survey.	$ 11,500	$ 6,584	$ 4,916	$ -	$ -	$ -	$ 11,500	$ 6,584	$ 4,916
Supplies - Lab and/or Field: Survey incentives ($4,000), supplies and food for workshop ($1,500), misc project supplies ($900)	$ 6,000	$ 4,898	$ 1,102	$ -	$ -	$ -	$ 6,000	$ 4,898	$ 1,102
Equipment - Non-Capital Lab and/or Field: One MacBook Pro and accessories ($1,500)	$ 1,500	$ 1,489	$ 11	$ -	$ -	$ -	$ 1,500	$ 1,489	$ 11
Capital Expenditures Over $5,000 - Total	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
n/a									
Travel - Total	**$ 1,000**	**$ 361**	**$ 639**	**$ 387**	**$ 387**	**$ -**	**$ 1,387**	**$ 748**	**$ 639**
Travel - MN: Travel for workshop attendees and present at the MN Chapter of the American Fisheies Society Annual Meeting.	$ 1,000	$ 361	$ 639	$ 387	$ 387	$ -	$ 1,387	$ 748	$ 639
Travel - Domestic: Attend and present at the national American Fisheries Society annual meeting.	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Other - Total	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
n/a									
COLUMN TOTAL	**$ 111,642**	**$ 101,540**	**$ 10,102**	**$ 84,094**	**$ 84,094**	**$ -**	**$ 195,736**	**$ 185,634**	**$ 10,102**

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2017 Subproject Budget - Final
Legal Citation: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a
Subproject Manager: Mikael Elias
Subproject Title: MAISRC Subproject 28: Evaluating Innovative Coatings to Suppress Priority AIS
Organization: University of Minnesota
Subproject Budget: $51,234
Subproject Length and Completion Date: 1 Year; June 30, 2020
Today's Date: September 15, 2022

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	**$ 39,704**	**$ 39,704**	**$ -**
Dr. Simon Huang; researcher; $54,000 salary, $18,468 fringe at %33.4); 1.0 FTE for 1 year			
Professional/Technical/Service Contracts	**$ -**	**$ -**	**$ -**
AMI Engineer ($4,500) - Professional divers to install and sample coupons in the DSH	$ -	$ -	**$** -
Equipment/Tools/Supplies	**$ 11,530**	**$ 11,530**	**$ -**
Supplies - Lab and/or Field: plastic ware, growth media, chromatography columns, chemicals,	$ 9,530	$ 9,530	**$** -
Supplies - Lab and/or Field: material for coupons, coatings	$ 2,000	$ 2,000	**$** -
Capital Expenditures Over $5,000	**$ -**	**$ -**	**$ -**
Printing	**$ -**	**$ -**	**$ -**
Travel Expenses in Minnesota	**$ -**	**$ -**	**$ -**
Other	**$ -**	**$ -**	**$ -**
COLUMN TOTAL	$ 51,234	$ 51,234	$ -

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: Faculty salary time paid by the University of Minnesota, indirect cost matching (54% mtdc)	secured	$ 48,882	$ 48,882	$ -

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Current appropriation:		$ -	$ -	$ -
Past appropriations:		$ -	$ -	$ -

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2017 Subproject Budget - Final
Legal Citation: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a
Subproject Manager: Ranjan Muthukrishnan
Subproject Title: MAISRC Subproject 30: Managing Midwestern aquatic invasions in a changing climate
Organization: Indiana University
Subproject Budget: $39,000 ($22,762 IU; $16,238 MAISRC)
Subproject Length and Completion Date: 3 years, June 30, 2022
Today's Date: September 15, 2022

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Revised Budget 09/15/2022	Amount Spent	Balance
BUDGET ITEM				
Personnel (Wages and Benefits)	**$ -**	**$ -**	**$ -**	**$ -**
Professional/Technical/Service Contracts	**$ -**	**$ -**	**$ -**	**$ -**
Equipment/Tools/Supplies	**~~$ 6,000~~**	**$ 1,832**	**$ 1,700**	**$ 132**
Supplies - Lab and/or Field: *transect tapes, sampling frames, SCUBA supplies and maintenance,*	~~$ 6,000~~	$ 1,832	$ 1,700	$ 132
Capital Expenditures Over $5,000	**$ -**	**$ -**	**$ -**	**$ -**
Printing	**$ -**	**$ -**	**$ -**	**$ -**
Travel Expenses in Minnesota	**~~$ 16,762~~**	**$ 20,930**	**$ 20,930**	**$ -**
Year 1 Ecological Fieldwork (3-5 people, 15 days) - lodging ($4,125), per diem ($1,950), vehicle rental ($900) Social Science Fieldwork (1-2 people, 12 days) - lodging ($1,800), per diem ($650), vehicle rental ($720)	$ 4,725	$ 4,725	$ 4,725	$ -
Year 2 <u>& 3</u> Ecological Fieldwork (3-5 people, ~~35~~ <u>68</u> days) - lodging (~~$9,625~~), per diem (~~$4,525~~), vehicle rental (~~$2,100~~)	~~$ 12,037~~	$ 16,205	$ 16,205	$ -
Other	**$ -**	**$ -**	**$ -**	**$ -**
COLUMN TOTAL	$ 22,762	$ 22,762	$ 22,630	$ 132

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget		Spent	Balance
Non-State: Environmental Change Grand Challenge initiative administered by the Environmental Resilience Institute at Indiana University	Secured	$ 113,601		$ 100,000	$ 13,601
Muthukrishnan startup funds	Secured	$ 70,000		$ 70,000	$ -
State:		$ -		$ -	$ -
In kind:		$ -		$ -	$ -

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget		Spent	Balance
Current appropriation:		$ -		$ -	$ -
Past appropriations:		$ -		$ -	$ -

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2017 Subproject Budget - Final
Legal Citation: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a
Subproject Manager: Nicholas Phelps
Subproject Title: MAISRC Subproject 30: Managing Midwestern aquatic invasions in a changing climate
Organization: Minnesota Aquatic Invasive Species Research Center (MAISRC), University of Minnesoa
Subproject Budget: $39,000 ($22,762 IU; $16,238 MAISRC)
Subproject Length and Completion Date: 3 years, June 30, 2022
Today's Date: September 15, 2022

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	**$ 12,690**	**$ 12,688**	**$ 2**
Research/Field Technician; Temp/Casual; $6,869 ($6.360, $509 at 8% benefit rate); 0.2 FTE for 1 year			
Research/Field Technician; Temp/Casual; $6,221 ($5,760, $461 at 8% benefit rate); 0.18 FTE for 1			
Professional/Technical/Service Contracts	**$ -**	**$ -**	**$ -**
Equipment/Tools/Supplies	**$ -**	**$ -**	**$ -**
Capital Expenditures Over $5,000	**$ -**	**$ -**	**$ -**
Printing	**$ -**	**$ -**	**$ -**
Travel Expenses in Minnesota	**$ 1,010**	**$ 1,010**	**$ -**
Year 2 - Two field technicians, estimated 45 days, per diem for meals and incidentals for field work at Minnesota field sites	$ 1,010	$ 1,010	$ -
Other	**$ 2,538**	**$ 2,538**	**$ -**
Travel-Domestic: *Year 2* - Two field technicians, estimated 45 days, per diem for meals and incidentals for field work at Indiana and Wisconsin field sites	$ 2,538	$ 2,538	$ -
COLUMN TOTAL	$ 16,238	$ 16,236	$ 2

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind:		$ -	$ -	$ -

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Current appropriation:		$ -	$ -	$ -
Past appropriations:		$ -	$ -	$ -