Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2013 Minnesota Aquatic Invasive Species Research Center
Sub-Project Work Plan

Date of Report: June 6, 2017

Date of Next Status Update Report: January 31, 2018

Date of Work Plan Approval:

Sub-Project Completion Date: June 30, 2019

Project Completion Date: June 30, 2019

Does this submission include an amendment request? __No

SUB-PROJECT TITLE: MAISRC Sub-Project 14: Cost-effective monitoring of lakes newly infested with zebra mussels

Sub-Project Manager: John Fieberg

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Location: Statewide

Total ENRTF Sub-Project Budget:	**Sub-Project Budget:**	**$266,500**
	Amount Spent:	**$0**
	Balance:	**$266,500**

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

Appropriation Language:
$4,350,000 the first year and $4,350,000 the second year are from the trust fund to the Board of Regents of the University of Minnesota to develop and support an aquatic invasive species (AIS) research center at the University of Minnesota that will develop new techniques to control aquatic invasive species including Asian carp, zebra mussels, and plant species. This appropriation is available until June 30, 2019, by which time the project must be completed and final products delivered.

I. SUB-PROJECT TITLE: MAISRC Sub-Project #14: Cost-effective monitoring of lakes newly infested with zebra mussels

II. SUB-PROJECT STATEMENT:
Our objective is to develop recommendations for underwater survey methods and methods for estimating population abundance and distribution of zebra mussels, accounting for imperfect detection, which can be used to monitor newly infested lakes.

Advice regarding appropriate survey methods is desperately needed by Minnesota Department of Natural Resources' (MNDNR) staff, citizen groups, MN Counties, watershed districts, and lake managers confronted with new infestations of zebra mussels. The earliest stages of lake colonization are difficult to monitor because abundance is low, mussels are sparsely distributed, and they are hard to locate and count. Sampling designs must be feasible to implement by SCUBA divers and result in data that allow for efficient estimation of abundance and spatial distribution patterns while also accounting for imperfect detection. Methods must also be standardized to allow comparisons across lakes. We will take advantage of recent methodological advances for collecting and modeling spatial data using line-transect surveys. Line-transect sampling designs are appealing for several reasons: 1) divers can quickly survey large contiguous areas; 2) methods for estimating and correcting for imperfect detection are well developed; and 3) recent advances in spatial modeling can be used to estimate the distribution of mussels throughout the lake.

We will survey lakes in 2017 and 2018 using a variety of line-transect sampling designs. In addition, we will conduct an extensive simulation study to evaluate the efficiency of alternative survey designs and to provide recommendations regarding appropriate sampling effort. We plan to select lakes that were first listed and confirmed infested in years 2015 and 2016 from a publically available database maintained by the MN DNR Invasive Species Program (http://www.dnr.state.mn.us/invasives/ais/infested.html: updated 12/29/16). We will draw untreated reference lakes from 2015 and 2016 to bracket a range of initial densities, and will select lakes that have been treated with pesticides from MN DNR's Pilot Project Program. We will estimate abundance and distribution patterns by fitting density surface models to the resulting data. These density estimates will also allow us to develop realistic simulation scenarios for comparing alternative sampling designs and to evaluate how sampling effort affects our ability to detect changes in abundance and distribution over time and therefore the efficacy of pesticide treatments.

This work will result in the following outcomes:

1. Recommended, cost-effective monitoring programs for estimating distribution and abundance of mussels that can be implemented in recently infested lakes, allowing for targeted control efforts.
2. Estimates of population distribution and abundance patterns in 10 newly infested lakes.
3. Comparisons of mussel abundance and distribution in lakes that are and are not treated with pesticides as part of MNDNR's Pilot Project Program.

III. SUB-PROJECT STATUS UPDATES:

Sub-Project Status as of *January 31, 2018*:

Sub-Project Status as of *July 31, 2018***:**

Sub-Project Status as of *January 31, 2019***:**

Overall Sub-Project Outcomes and Results:

IV. SUB-PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Implement and evaluate feasibility of line-transect sampling designs
Description:
We plan to survey 10 lakes in both 2017 and 2018. We will survey the area surrounding the initial infestation or discovery site, nearby zones 150 m away in either direction along the shoreline, and outlying areas using transects placed perpendicular to shore. Divers will work in teams of 2, one surveying and recording finds, the other collecting mussels and photographing the lake bottom. Whenever a cluster or an isolated mussel is detected, divers will measure the distance between the mussels and the transect line. These data will be used to model the probability of detection as a function of distance off the transect line.

We will also implement a dependent double-observer approach in 1-2 lakes during the first year. This approach will require 2 dive teams, each surveying the same set of transects. The first dive team will serve as primary observers for odd-numbered transects and the secondary observers for even-numbered transects (and vice versa for the second dive team). The secondary observers will collect mussels missed by the primary observers, again recording distances from and along the transect line. Clusters missed by the primary observer but detected by the secondary observer will further inform estimates of detection probabilities.

Lastly, we will test the feasibility of implementing an adaptive line-transect design in one or more lakes. Adaptive sampling designs are intuitively appealing because they focus survey efforts on areas known to have individuals present. In addition, adaptive sampling designs often result in better precision (smaller sampling variability) than conventional (simple random or stratified random) sampling designs when species are rare and spatially clustered. With adaptive line-transect sampling, sampling effort can be increased by surveying in a zig-zag fashion whenever the number of mussels detected exceeds some pre-defined threshold. Unlike traditional adaptive designs (which are often conducted in aquatic surveys by dropping quadrats onto the lake or seabed), it is possible to control overall survey effort when using adaptive line-transect sampling. Nonetheless, divers must be willing to change their bearing on the fly, and to precisely adhere to the adaptive sampling rule set, which makes the design more challenging to implement. We will wait until the second field season to evaluate feasibility of implementing an adaptive sampling design in the field. This will allow us to use an initial estimate of mussel density to develop an appropriate adaptive rule set and to explore operating characteristics of the approach using simulated data (see activity 3).

Summary Budget Information for Activity 1:

ENRTF Budget: $112,703
Amount Spent: $ 0
Balance: $112,703

Activity Completion Date:

Outcome	Completion Date
1. *Survey 10 lakes in 2017*	November 1, 2017
2. *Re-survey the same 10 lakes in 2018, test feasibility of adaptive line-transect design*	November 1, 2018

Activity Status as of *January 31, 2018*:

Activity Status as of *July 31, 2018***:**

Activity Status as of *January 31, 2019***:**

Final Report Summary:

ACTIVITY 2: Estimate spatial-temporal distribution and abundance patterns.
Description:
For each lake, and year of survey effort, we will estimate zebra mussel distribution and abundance patterns using the *distance* and *dsm* packages of Program R, a free, open source statistical computing platform. These packages provide methods for estimating detection functions and for fitting abundance models to detection-adjusted counts associated with segments along the transects. In addition, the *dsm* library provides functions for model checking, plotting, and variance estimation, taking into account uncertainty in the detection parameters. By including spatial predictors (easting, northing) and water depth, we will be able to estimate abundance for the entire focal area. In addition to the above approach, we will also consider recently developed Bayesian approaches to fitting spatial models. The latter approach is appealing because locations of individual observations (or clusters of observations) can be modeled directly (e.g., as a function of spatial covariates) rather than relying on segment-level summaries.

Summary Budget Information for Activity 2:

ENRTF Budget: $72,399
Amount Spent: $ 0
Balance: $72,399

Activity Completion Date:

Outcome	Completion Date
1. *Report preliminary estimates of distribution and abundance patterns from lake surveys conducted in 2017*	January 31, 2018
2. *Report final estimates of distribution and abundance patterns from lake surveys conducted in 2017 and 2018*	June 20, 2019

Activity Status as of *January 31, 2018*:

Activity Status as of *July 31, 2018***:**

Activity Status as of *January 31, 2019***:**

Final Report Summary:

ACTIVITY 3: Compare alternative sampling designs using simulations. Develop recommendations for monitoring newly infested lakes.
Description:
We will use estimated density surfaces from activity 2 to inform a simulation study to compare and refine survey methods. Specifically, we will compare the precision of alternative sampling designs and evaluate sample sizes needed to detect changes in abundance between years and across treated and untreated sites. This work will initially be conducted by undergraduate mathematics and statistics students at Carleton College as part of their capstone project, and will be supervised by Dr. Katie St. Clair.

Summary Budget Information for Activity 3:

ENRTF Budget: $81,399
Amount Spent: $ 0
Balance: $81,399

Activity Completion Date:

Outcome	Completion Date
1. *Senior capstone project, simulation study to compare alternative sampling designs*	*June 1, 2018*
2. *Develop recommendations for monitoring newly infested lakes*	*June 30, 2019*

Activity Status as of *January 31, 2018*:

Activity Status as of *July 31, 2018***:**

Activity Status as of *January 31, 2019***:**

Final Report Summary:

V. DISSEMINATION:

Description:
We will communicate results of this study via MAISRC's AIS Spotlight e-newsletter, www.maisrc.umn.edu, and Facebook and Twitter accounts, and we will present our findings at the annual MAISRC Showcase event. We will share results with members of MNDNR's Pilot Project Program and to the Invasive Species Program through Dr. Kelly Pennington, MN DNR Invasive Species Prevention Coordinator, who has led efforts at drafting of monitoring protocols for zebra mussels in the Pilot Project Program. Population abundance and distribution estimates will also be shared with Megan Weber and entered into web forms for integration with the AIS Trackers program (citizen monitoring of changes in AIS population sizes) on an annual basis. Research to optimize survey design will be communicated to Pilot Project participants and to MNDNR biologists who conduct zebra mussel surveys by SCUBA to inform pre- and post-treatment monitoring in ongoing and new pesticide treatment projects. DNR biologists Tom Jones and Rich Rezanka have led these teams for > 10 years and will assist us with developing field survey logistics. Results of this study will be disseminated to other stakeholders in the state, including Steve McComas, a member of the MAISRC Advisory Board, and a veteran diver who has conducted zebra mussel surveys for lake associations for years, as part of his lake management consulting company Blue Water Science. Results will also be communicated to federal and bi-national agencies (Great Lakes Commission, USFWS, USGS, NOAA) in the Invasive Mussel Collaborative (interests in surveying mussel biomass to assess ecological impact) and be published in peer-reviewed literature. All data and computer code for analyzing the data will be archived with the Data Repository for the University of Minnesota (https://www.lib.umn.edu/datamanagement/drum).

Status as of *January 31, 2018*:

Status as of *July 31, 2018***:**

Status as of *January 31, 2019***:**

Final Report Summary:

VI. SUB-PROJECT BUDGET SUMMARY:

A. Preliminary ENRTF Budget Overview:
*This section represents an overview of the preliminary budget at the start of the project. It will be reconciled with actual expenditures at the time of the final report. See the Sub-Project Budget document for an up-to-date project budget, including any changes resulting from amendments.

Budget Category	$ Amount	Explanation
Personnel:	$226,384	1 Professor at 3.8%FTE in year 1, 7.7% in years 2 and 3 ($34,326), 1 professor at 8.3%FTE in years 1-3 ($30,272), Postdoctoral researcher at 92% FTE in year 1 and 100% FTE in year 2 and 3

		($114,302), SCUBA technician and lead diver at 25% FTE in years 1 and 2 ($22,806), SCUBA technician assistant at 25% FTE in years 1 and 2 ($20,311), Field assistant and boat tender at 23% FTE in years 1 and 2 ($9,374), SCUBA assistant/temp casual 3.8% FTE in years 1 and 2 ($1377)
Professional/Technical Services and Contracts:	$15,910	Mailing and publication costs ($800), Subcontract to Dr. Katie St. Clair for statistical consulting relative to simulation study ($9000), SCUBA tank air fills ($3,510), repairs to SCUBA gear, boat ($1000)
Equipment/Tools/Supplies:	$7,500	Office supplies (paper, folders, scientific graphic software, annual license fee for SAS statistical software, annual license fee for endnote bibliography software; $500), SCUBA gear, field sampling gear ($7000)
Capital Expenditures over $5,000:	$	
Travel:	$16,706	MN Truck rental, MAISRC truck mileage, fuel, lodging, per diem ($13,706), Travel domestic conferences in lower Great Lakes ($3000)
Other:	$	
TOTAL ENRTF BUDGET:	**$266,500**	

Explanation of Use of Classified Staff:

Explanation of Capital Expenditures Greater Than $5,000: NA

Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation: 3.61FTE

Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation: 0.083FTE

B. Other Funds:

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
Non-state			
	$	$	
State			
(In-kind support): cost of lake pesticide treatment attempts, per treatment is $100,000 ($50,000 in materials + $50,000 personnel costs) + 2 years of post-treatment monitoring at $10,000 per year. These costs are shared by Pilot Project permittees, and by MnDNR—the share is project-specific. The estimate is based on costs	$600,000	$ Three current projects = $360,000; $240,000 estimated for 2 future projects	This is not intended to be a match requirement for ENRTF funding.

for the Christmas Lake treatment attempt, and a projection that data from 5 treated lakes total will be available for this 2-year study.			
TOTAL OTHER FUNDS:	**$600,000**	**$360,000**	

VII. SUB-PROJECT STRATEGY:

A. Sub-Project Team/Partners:

Project Partners Receiving Funds:

- Dr. John Fieberg—Assistant Professor, FWCB ($34,326). Fieberg will consult on survey designs and oversee a post-doc responsible for fitting spatial-temporal abundance models.
- Dr. Michael A. McCartney—Research Assistant Professor, MAISRC ($30,272). McCartney will direct the field program, and help perform SCUBA surveys of untreated lakes, and work with the MN DNR Pilot Project Program to coordinate data collection from treated lakes.
- Katie St. Clair – Associate Professor, Carleton College ($9,000). St. Clair will supervise a senior capstone project at Carleton College in which students will compare alternative sampling designs using simulated data. St. Clair will also serve as a consultant on other aspects of the study, including choice of methods for fitting spatial density models.

Project Partners Not Receiving Funds:

- Tom Jones, MN DNR, Aitkin Fisheries Office, and Rich Rezanka, Invasive Species Specialist, MN DNR, Grand Rapids will serve as advisors/consultants. Jones and Rezanka set up the 1st long-term monitoring program for zebra mussels in MN and established methods for SCUBA surveys—on Mille Lacs Lake and other infested lakes.

B. Sub-Project Impact and Long-term Strategy:

This project will lead to recommendations for underwater survey methods and methods for estimating population abundance and distribution of zebra mussels, accounting for imperfect detection, which can be used to monitor newly infested lakes. Implementation of these recommendations will result in standardized data that can be used by Minnesota Department of Natural Resources' (MNDNR) staff, citizen groups, MN Counties, watershed districts, and lake managers to monitor spatial-temporal trends in abundance and distribution patterns, and to evaluate effectiveness of treatments, following new infestations of zebra mussels. The monitoring recommendations, and comparisons of treated vs. untreated lakes will inform management of zebra mussels in across the nation.

We expect to be able to meet project objectives during the proposed project period (July 2017- June 2019) with the requested funds. In future research, we hope to adapt methods to plot-based surveys required for later-stage infestations. We will seek external funding to support those efforts as needed and appropriate.

C. Spending History:

Funding Source	**M.L. 2008 or FY09**	**M.L. 2009 or FY10**	**M.L. 2010 or FY11**	**M.L. 2012 or FY13**	**M.L. 2013 or FY14**
Clean Water Funds to McCartney—salary to support development of zebra				$11,092	

mussel pesticide treatment monitoring protocols, and to support development of this proposal.					

VIII. ACQUISITION/RESTORATION LIST: N/A

IX. VISUAL ELEMENT or MAP(S): N/A

X. ACQUISITION/RESTORATION REQUIREMENTS WORKSHEET: N/A

XI. RESEARCH PROPOSAL: See attached Research Proposal

XII. REPORTING REQUIREMENTS:
Periodic work plan status update reports will be submitted no later than January 31, 2018, July 31, 2018, and January 31, 2019. A final report and associated products will be submitted within two months of the anticipated sub-project completion of June 30, 2019.