Environment and Natural Resources Trust Fund
2017 Request for Proposals (RFP)

Project Title: **ENRTF ID: 115-D**

Impact of Zebra Mussels on Mercury in Fish

Category: D. Aquatic and Terrestrial Invasive Species

Total Project Budget: $ 211,437

Proposed Project Time Period for the Funding Requested: 3.5 years, September 2017 - August 20

Summary:

Invasive zebra mussels have the potential to impact concentrations on toxic mercury in Minnesota's fish. We will study these effects of zebra mussels, helping understand their impact on Minnesota's resources.

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Web Address

Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

conceptual diagram of zebra mussel effects on food webs and mercury dynamics

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%

PROJECT TITLE: Impact of zebra mussels on mercury in fish

I. PROJECT STATEMENT

Fish consumption is the primary route of human exposure to mercury (Hg), a highly toxic heavy metal. High Hg levels in MN game fish result in consumption advisories that limit recreational activity on thousands of lakes. Although all lakes in Minnesota receive a similar amount of Hg (mainly from atmospheric sources), Hg content in fish differs among individual lakes and depends on (i) food web structure, (ii) fish growth rates and (iii) the rate at which Hg is converted into a biologically available form (methyl mercury) in lake sediments. A new invader to MN lakes, the zebra mussel, has a strong potential to alter food web structure, availability of food for fish and sediment chemistry in ways that could change the Hg content in valuable game fish. However, large information gaps stand in the way of predicting how zebra mussel establishment is affecting fish Hg content in MN and elsewhere. The goal of this work is to produce **a predictive understanding of how zebra mussels impact Hg concentrations in different species of game fish** in MN. This understanding will **better protect the health and recreational opportunities of anglers through appropriate fish consumption advice and more effectively guide efforts to prevent the spread of aquatic invasive species**.

Zebra mussels are bottom-dwelling filter-feeders, capable of attaining very dense populations under suitable conditions. Their activities redirect nutrients from the open water toward lake bottom (benthic) regions, negatively impacting food for fish that feed in the water column (perch, walleye) while benefiting fish that feed more on benthic resources (bass, pike). These changes can affect the position of fish in the food web and therefore the biomagnification of Hg and tissue Hg concentrations. Also, by forming a thick carpet of living mussels, discarded shells and solid wastes, zebra mussels can affect oxygen levels in the sediments, potentially increasing the rate of Hg entry into the food web. We propose to determine how zebra mussels affect Hg in game fish by testing the following hypotheses:

H1. Food web structure in invaded lakes will change, differently affecting growth rates of fish that depend on different food sources.

H2. Sediment chemistry in invaded lakes will change in ways that increase the amount of Hg that can bioaccumulate.

H3. Changes to food webs and sediments will affect Hg levels in fish. In invaded lakes, walleye and perch will have higher Hg levels than fish from uninvaded lakes; bass and pike will show the opposite pattern.

We will sample water, fish food, fish and sediments from 6 zebra mussel-invaded and 6 uninvaded MN lakes that are intensively fished to simultaneously describe food web structure, sediment chemistry and game fish tissue Hg content. We will also collaborate with the ongoing efforts of MPCA and MNDNR to obtain fish tissue Hg content from additional invaded and uninvaded lakes, thereby increasing the size of our dataset at low cost. Finally, laboratory experiments with zebra mussels and lake sediments will determine directly whether sediment Hg methylation rates are affected by mussel presence. Results of these combined efforts will provide a more nuanced understanding of the impacts of zebra mussels in MN lakes, helping safeguard the health and recreational opportunities of Minnesotans.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Sample collection and analysis, experiments **Budget: $160,487**

Collect samples for food web and Hg analyses in 6 mussel-invaded and 6 mussel-free lakes. Work with MNDNR and MPCA to obtain samples and Hg data from additional invaded and uninvaded lakes. Analyze water chemistry and biotic samples for food web information and Hg. Conduct lab experiments to determine lake sediment Hg methylation rates with and without mussels. Requested funds will support a graduate student and research technician, field sampling, analyses of collected samples and necessary supplies.

Outcome	Completion Date

1. Synthesis of existing data for assessing effects of mussel invasion	Jan. 2017
2. Detailed dataset of existing and new food web and Hg data in water, sediment and biota in invaded and uninvaded Minnesota lakes	Aug. 2018
3. Sediment chemistry and Hg methylation results from sediment experiments with and without zebra mussels	Nov. 2018

Activity 2: Data analysis, food web and mercury modelling **Budget: $44,260**

Use models to assess food web structure in study lakes. Infer Hg bioaccumulation and growth dilution rates from food web and fish growth indices. Differences among lakes in food web structure and Hg concentrations will be correlated with physical and chemical lake characteristics. Formulate predicative relationships between zebra mussel presence, lake characteristics and Hg levels in game fish including walleye, pike, bass, perch. Requested funds will support a graduate student and travel to support research.

Outcome	Completion Date
1. Create quantitative food web models for focal lakes, detailing sources and pathways of energy flow in invaded and uninvaded lakes	Dec. 2018
2. Derive Hg bioaccumulation factors for biota in invaded and uninvaded lakes	Dec. 2018
3. Produce predictive statistical relationships between lake characteristics, invasion status, food web structure and Hg dynamics	Jan. 2019

Activity 3: Outreach and communication of results **Budget: $6,690**

State and federal resource management agency staff with a role in AIS management will be the primary target of outreach to stakeholders. Communicate results through peer-reviewed publications, a student presentation at the Minnesota Water Resources conference and an international scientific conference. A short summary report/pamphlet for dissemination to managers and policy makers will be developed. Requested funds will support travel to conferences and publication costs.

Outcome	Completion Date
1. Presentation of results at conferences	Oct. 2019
2. Produce information pamphlet for managers, policymakers, public	Feb. 2019
3. Publication of peer-reviewed manuscripts	Before June 2019

III. PROJECT STRATEGY

A. Project Team/Partners

Ted Ozersky (UMD-Biology/LLO) and Nathan Johnson (UMD-CivEng) will co-lead the project. Dr. Ozersky will lead the food web portion of the work and Dr. Johnson will lead the Hg bioaccumulation portion. The project PIs will co-supervise a PhD student and will build on existing relationships with MNDNR and MPCA staff to choose sites in the context of routine biomonitoring and obtain additional samples for Hg analysis. Both PIs will receive and share funds from the LCCMR request and will equally contribute to the in-kind/cost share funds.

B. Project Impact and Long-Term Strategy

The long term goal of this research is to build a predictive understanding of dreissenid mussel impacts on trophic structure and Hg bioaccumulation in MN lakes. The more nuanced understanding that our results will provide will help make consumption advisories more effective: by avoiding over-protective advice (that unnecessarily limit recreation) and under-protective advice (that presents risk to anglers). Additionally, the results of this work will enable resource managers to assess which lakes are most susceptible to negative impacts of dreissenid mussels, focusing their invasion prevention efforts accordingly.

C. Timeline Requirements

This is a three-year project (2017-2019). Field work and sample analyses will occur in years 1 and 2. Years 2 and 3 will be dedicated to data analysis and communication of results to the public and scientific community.

Project Title: Impact of zebra mussels on mercury in fish

IV. TOTAL ENRTF REQUEST BUDGET 3 years

BUDGET ITEM	AMOUNT
Personnel: Graduate Research Assistant (55% salary+45% fringe; 50% FTE- 12 mo/year, September 1, 2017-August 31, 2019)	$ 85,951
Personnel: Field/labortatory technician (72.6% salary+27.4% fringe; 100% FTE- 4 mo; May 1, 2018-August 31, 2018)	$ 13,650
Non capital equipment/Tools/Supplies: Field sampling equipment (nets, minnow traps, water sampler) for a total of $1,460; Lab supplies and equipment (microscope $2,500, and filters, sample containers $2,250). Supplies for Hg methylation experiment ($2,500)	$ 8,710
Capital equipment: Methyl Mercury (meHg) analysis module for Mercury Analyzer. We are requesting $15,000 towards the total cost of the unit ($21,717) and will seek $6,717 matching funds from the Swenson College of Science and Engineering (UMD). Purhasing MeHg module is cost effective: Hg+MeHg analyses at extrernal labs will cost $200/sample. Analysis cost at UMD would be ~$50/sample + MeHg module. Since we intened to run more than 100 samples (closer to 500), purchasing the MeHg module will save costs, while adding important analytical ability at UMD.	$ 15,000
Travel: Travel to field sites for sampling and to pick up samples collected for us by citizen scientists and state agencies. We estimate 5000 miles of travel at $0.575/Mile for a total of $2,875. Gasoline for motor boat to be used for sampling ($250). Travel to in-state and international conferernce for graduate student and PIs to present results of work ($4,000)	$ 7,030
Additional Budget Items: Analysis of water samples at the Large Lakes Observatory (chlorophyll, phosphorus, nitrogen, dissolved carbon) for a total cost of $2,343. Analysis of carbon and nitrogen stable isotope samples at the Large Lakes Observatory (15.26-16.90/sample, depending on sample type) for a total cost of $12,593. Analysis of deuterium stable isotopes at the UC Davis stable isotope lab, at $40/sample for a total cost of $30,000. Analysis of total and methyl mercury in samples at UMD civil engineering at $50/sample for a total cost of $25,500. Open source publication charges for peer-review publication of results in open-source format at $3,000	$ 81,096
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 211,437

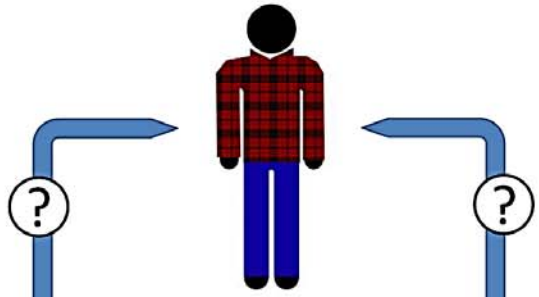
V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period:	$ -	N/A
Other State $ To Be Applied To Project During Project Period: Matching funds from SCSE for purchase of Methyl Mercury analysis module. Applied for.	$ 6,717	*Secured*
In-kind Services To Be Applied To Project During Project Period: Indirect costs	$ 78,833	*Pending*
Funding History:	$ -	N/A
Remaining $ From Current ENRTF Appropriation: *S*	$ -	*N/A*

Impact of zebra mussels on mercury in fish

Ted Ozersky, Nathan Johnson (University of Minnesota Duluth)

Mercury to game fish consumers



Hypotheses

- H1: zebra mussels will modify food web structure, affecting fish food resource availability and growth of game fish species
- H2: sediment chemistry in invaded lakes will change in way that will increase Hg methylation in sediments and Hg bioavailbility
- H3: changes to food web and sediment properties will affect Hg concentrations in game fish. Hg levels in invaded lakes will increase in walleye and perch, potentially decrease in bass and pike.

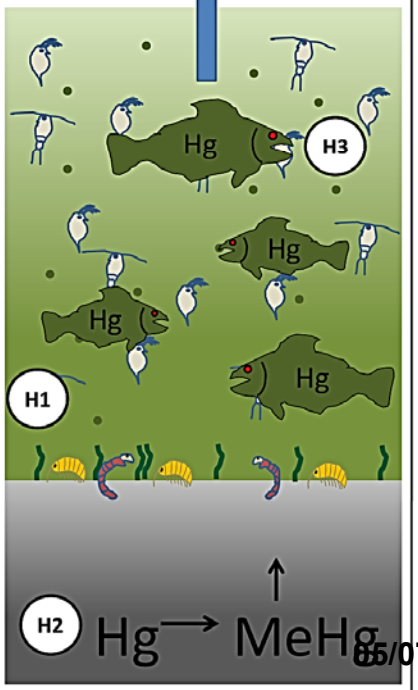
No zebra mussels

water column

- High phytoplankton and zooplankton biomass
- Low bottom-dwelling animal biomass
- Food web fuelled by water column resources
- Higher abundance and growth rates of walleye, perch

sediment

- Deep oxygen penetration into sediment
- Low mercury methylation rate
- Lower inputs of MeHg into food web



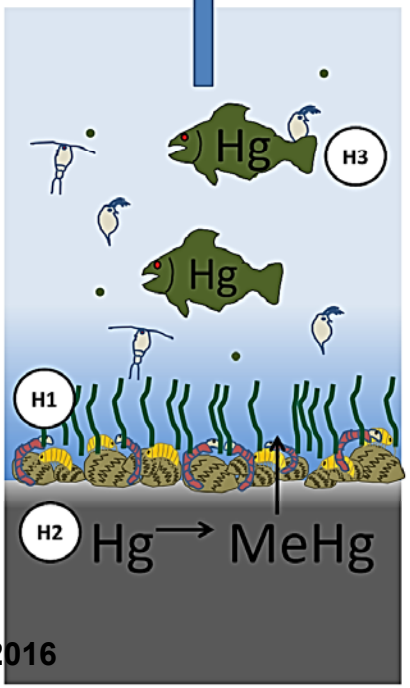
With zebra mussels

water column

- Low phytoplankton and zooplankton biomass
- High bottom-dwelling animal biomass
- Food web fuelled by benthic resources
- Lower abundance and growth rates of walleye, perch

sediment

- Shallow oxygen penetration into sediment
- High mercury methylation rate
- Higher inputs of MeHg into food web



Project Manager Qualifications & Organization Description

The proposed project will be led by **Dr. Ted Ozersky**, an assistant professor of Biological Limnology at the **Biology Department, University of Minnesota Duluth** and the Large Lakes Observatory, University of Minnesota Duluth. Dr. Ozersky has extensive experience working with invasive dreissenid mussels, authoring or co-authoring 11 peer-reviewed publications on a range of subjects concerning dreissenids, including their roles in food web and contaminant dynamics. Dr. Ozersky has worked in diverse aquatic systems, from small steams to the world's largest lakes, and has experience performing the majority of sample/data collection and analyses proposed for this project. Dr. Ozersky has experience in the supervision of graduate students and environmental technicians and has coordinated a number of complex environmental research projects, including international work in remote locations.

Education

PhD, University of Waterloo, Canada. 2010. Thesis title: *Dreissenid mussels and large lakes: effects on littoral ecology.*
BSc, University of Waterloo, Canada. 2005.

Employment

Assistant Professor. University of Minnesota Duluth. 2014-present.
Postdoctoral scholar. Wellesley College. 2012-2014.
Research biologist. Ontario Ministry of Natural Resources. 2011-2012.

Most relevant publications

- **Ozersky T**, Ginn B, Evans DO. 2015. Dreissenid impacts on nutrient and carbon cycling and storage in a large, shallow lake. *Freshwater Biology* 60: 827-843.
- **Ozersky T**, Barton DR, Hecky RE, Guildford SJ. 2013. Dreissenid mussels enhance benthic surface area, nutrient efflux and primary production in shallow littoral region of a large lake. *Biological Invasions* 15: 2799-2810.
- Poste AE, **Ozersky T**. 2013. Dreissenid mussels and round gobies: A novel benthic pathway for the trophic transfer of microcystin. *Environmental Toxicology and Chemistry* 32: 2159-2164.
- **Ozersky T**, Barton DR, Evans DO. 2012. Invasive mussels alter the littoral food web of a large lake: stable isotopes reveal drastic shifts in sources and flow of energy. *PLOS ONE* 7(12): e51249.
- **Ozersky T**, Barton DR, Evans DO. 2011. Fourteen years of dreissenid presence in the rocky littoral zone of a large lake: effects on macroinvertebrate abundance and diversity. *Journal of the North American Benthological Society* 30: 913–922.

The project co-PI is **Dr. Nathan Johnson**, an associate professor of **Civil Engineering** at the **University of Minnesota Duluth**. Dr. Johnson is an expert in mercury geochemistry and has extensive experience analyzing and interpreting mercury concentrations in diverse environmental samples.

Both PIs will receive and share funds from the LCCMR request and will equally contribute to the in-kind/cost share funds.

Organization description

The **Large Lakes Observatory** (LLO) is a research center focused on study of the biology, physics, chemistry and geology of lakes. The LLO has the facilities and equipment needed to perform the proposed field work and the majority of the analyses described in the project pre-proposal. UMD **Civil Engineering** has purchased a state-of-the-art mercury analyzer, which will allow performing all mercury analyses "in house". A methyl mercury analysis module—which is part of the funding request for this pre-proposal—will substantially improve our ability to use the results of mercury analyses to understand bioaccumulation pathways in the study lakes.