Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-025

Proposal Title: Does Micro-Pollution Impact Aquatic Food Webs And Birds?

Project Manager Information

Name: Katya Kovalenko

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Project Basic Information

Project Summary: We will assess the extent and impact of different types of micro-pollution on birds, fish, invertebrates, and food webs in Minnesota lakes

Funds Requested: $175,000

Proposed Project Completion: 2023-06-30

LCCMR Funding Category: Small Projects (H)
      Secondary Category: Water Resources (B)

Project Location

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

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

When will the work impact occur?
      In the Future

Narrative

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

Microscopic man-made materials are contaminants of emerging concern in Minnesota freshwaters. Due to the size of these micro-contaminants, they are not effectively removed by wastewater treatment plants. Microplastics have garnered considerable attention in the media, but they comprise only a fraction of the micro-pollution that can enter aquatic food webs. Other types of micro-pollution include metal flakes, paint particles, and synthetic and naturally-derived fibers. These man-made materials are often mistaken for food and eaten by a wide range of animals. Items ingested by lower trophic level organisms, such as zooplankton, could have cascading effects up the food web, potentially disrupting nutrient and energy transfer among organisms. Importantly, we have observed brightly colored synthetic microfibers ingested by macroinvertebrates and in the stomachs of dead birds in our previous studies in Minnesota, but their prevalence and effects are unknown. The vast majority of micro-pollution studies are marine, and comparatively little is known about distribution and impact of man-made materials in freshwater ecosystems.

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

To understand the impact of micro-pollution on Minnesota freshwaters, we will characterize distribution and transfer of man-made particles through the aquatic food web. Our study will focus on the St. Louis River Estuary, a fishing and birding hotspot important to Minnesota's economy, and several inland lakes. The estuary is home to a nesting colony of Common Terns (Sterna hirundo), a fish-eating colonial waterbird that is listed as threatened in Minnesota and is among the highest priority species for conservation. The estuary and the nesting colony are within 1.5 km of the Western Lake Superior Sanitary District wastewater treatment plant, a potential point source for micro-pollution. To quantify micro-pollution spanning multiple levels of the food web, we will sample the water column to determine availability of synthetic particles for ingestion and sample the stomach contents of macroinvertebrates, prey fish, and waterbirds across the gradient of micro-pollution. We will evaluate the relative abundance and size distribution of micro-pollution to determine ingestion at each trophic level and infer potential transfer and accumulation. We will also sample inland lakes with limited point-source pollution to understand background levels of micro-pollution effects on food webs.

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

The results of this project will provide novel insight into mechanisms of accumulation of emerging contaminants in a freshwater ecosystem of statewide importance, with implications for drinking water, fishing and threatened species management. Information of the pathways leading to ingestion of man-made particles will be applicable to other freshwaters across the state. Data from inland lakes will provide baseline information for broader studies on the effects of micro-pollution. Quantifying and categorizing micro-pollution will help inform consumers and regulatory agencies which materials are most prevalent in the water and which are most likely to disrupt entire food webs.

Activities and Milestones

Activity 1: Sampling and analysis of nearshore aquatic food webs for micro-pollution

Activity Budget: $80,000

Activity Description:

In Year 1, we will collect water and zooplankton (10 samples/site), macroinvertebrates (>20/site) and fish (20/site) within the estuary and nearshore Lake Superior to quantify the relative abundance and size distribution of micro-pollution in aquatic food webs. Sampling sites will be distributed based on typical avian foraging ranges and will target locations both upstream and downstream of the wastewater treatment plant. In addition to Common Terns, we will also sample the stomach contents of Ring-billed Gull (Larus delawarensis) and Herring Gull (L. argentatus) chicks, which are generalist foragers, to provide information about how foraging behaviors and diets of avian top consumers influence ingestion of micro-pollution. Carcasses of Common Tern and gull chicks (>10/species) will be collected at Interstate Island, a designated Wildlife Management Area for colonial nesting waterbirds. In Year 2, we will conduct a subset of that sampling in 5 large inland lakes away from point-source pollution (Lake of the Woods, Mille Lacs, Leech, Kabetogama, Rainy). We will determine ratios of edible material vs. micro-pollution at each trophic level by pre-processing gut samples using an established peroxide-based digestion method to dissolve organic tissues, leaving man-made materials for analyses and quantify relative volumetric contributions using microphotography.

Activity Milestones:

Description	Completion Date
Collect water, fish, bird samples in 5 inland lakes with limited point-source pollution	2022-08-31
Collect water, zooplankton, invertebrates, fish and birds at eight sites spanning a point-source pollution gradient	2022-08-31
Process samples using peroxide digestion and determine dietary contribution of micro-pollution	2022-12-31

Activity 2: Quantifying abundance, size distribution, and dynamics of man-made particles in aquatic food webs

Activity Budget: $95,000

Activity Description:

We will use visual microscopic characterization and melting point forensic analysis to measure and count micro-pollution materials (> 0.2-0.5 mm minimum dimension) at each level of the food web. Pyrolysis gas chromatography mass spectrometry will be used to more precisely characterize the chemical nature of a subset of particles. Carbon and nitrogen stable isotopes collected from a subset of organisms at each trophic level will be used to confirm food web structure and micro-pollution particle size distribution will be used to infer the level at which man-made particles entered the food web.

Activity Milestones:

Description	Completion Date
Quantify distribution of micro-pollution at multiple food web levels relative to distance from wastewater plant	2023-01-31
Compare particle types and food web impact of micro-pollution in the estuary and inland lakes	2023-04-30
Evaluate food web linkages using stable isotopes and infer micro-pollution transfer and accumulation pathways	2023-04-30
Disseminate findings to local organizations and state agencies	2023-06-30

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Dr. Kathryn Schreiner	Department of Chemistry and Biochemistry, Large Lakes Observatory, University of Minnesota Duluth	Provide expertise on microplastic identification, contribute to study design, particle analysis, report and manuscript preparation	Yes
Annie Bracey	NRRI, UMD	provide bird expertise, collect bird samples, do stomach analyses and processing, contribute to analyses, reports and manuscripts	Yes
Dr. Alexis Grinde	NRRI, UMD	provide bird expertise, input on study design, analyses and report/manuscript preparation	Yes

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this be funded?

Information on types and fate of micro-pollution will help inform development of standards and new ways to address this growing concern at wastewater treatment plants or consumer sources. Sampling inland lakes with limited point-source pollution will provide essential baseline data for future studies. Additional outcomes will include outreach and education (MDNR, St. Louis River Alliance, National Estuarine Research Reserve) and peer-reviewed publications. This is a stand-alone project, but part of a larger research effort led by Dr. Kovalenko to understand freshwater food webs and ecosystem services, and identify and protect key freshwater ecosystems, while providing solutions relevant for Minnesota.

Project Manager and Organization Qualifications

Project Manager Name: Katya Kovalenko

Job Title: Research Associate and Data Scientist

Provide description of the project manager's qualifications to manage the proposed project.

Dr. Katya Kovalenko specializes in food web structure, aquatic invasive species and functional changes in response to anthropogenic stressors as well as ecological statistics. She has worked with stable isotopes in lake ecosystems (including all of the lakes in this study) and has 13 years of experience with sampling and identification of fish and macroinvertebrates and ecological data analyses. Her overall research effort focuses on freshwater food webs and ecosystem services, and seeks to identify and protect key freshwater ecosystems, while providing solutions relevant for Minnesota. She is a co-PI at the Minnesota Supercomputing Institute.

Organization: U of MN - Duluth - NRRI

Organization Description:

Natural Resources Research Institute is a part of the University of Minnesota Duluth. The Microscopy Laboratory, directed by Dr. Valerie Brady (invertebrates and fish) and Dr. Euan Reavie (algae and diatoms), is a 2,500 ft2 facility within NRRI. Laboratory staff include aquatic macroinvertebrate, algal, and diatom taxonomists and fisheries ecologists. Staff are experienced at assessing organism assemblages from a variety of aquatic habitats, evaluating aquatic habitat conditions, and establishing biological indicators for fish, amphibian, macroinvertebrate, diatom and periphytic communities. Equipment includes a variety of high quality research-grade compound and stereomicroscopes, some with

digital imaging capabilities for training, archiving images, and estimating sample biomass. NRRI field sampling equipment includes a fleet of six open water sampling vessels and two shallow water, flat bottom water craft; a variety of invertebrate, water sampling and benthic coring devices; water quality instrumentation units (e.g., Hydrolab Sondes, YSI multi-probes); shallow-water electrofishing equipment; passive fish collection equipment (fyke trap nets, purse and standard seine nets).

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Dr. Katya Kovalenko, PI		Oversee field sampling of aquatic food web, isotope and diet processing, analyze results, prepare reports			26.7%	0.2		$22,172
Dr. Kathryn Schreiner, Co-PI		Provide expertise on microplastic identification, contribute to study design, particle analysis, report and manuscript preparation			26.7%	0.08		$12,894
Dr. Alexis Grinde, Co-PI		Oversee sampling of the avian part of the food web, provide input on study design, analyses and ms preparation			26.7%	0.14		$17,246
Annie Bracey, Co-PI		Provide input on study design, collect bird samples, do stomach analyses and processing, contribute to analyses, reports and manuscripts			26.7%	0.44		$39,278
Josh Dumke		Assist with field work and provide input into fish diet analyses			26.7%	0.1		$8,932
Robert Hell		Assist with field work and lab work including sample prep for SIA and invertebrate sorting			24.1%	0.2		$14,017
Kari Hansen		Assist with lab work including sample prep for SIA			24.1%	0.18		$9,240
Holly Wellard Kelly		Macroinvertebrate Lab Technician will dissect macroinvertebrate guts and analyze particle dimensions on all samples except birds			24.1%	0.3		$18,653
Julia Agnich		Analytical Lab Technician will prepare samples for stable isotope and pyrolysis analyses			24.1%	0.2		$11,670
Field Summer Tech (undergraduate student)		Assist with field sampling			0%	0.08		$2,619
							Sub Total	**$156,721**
Contracts and Services								
Large Lakes Observatory (UMD)	Internal services or fees (uncommon)	Stable Isotope Analyses to understand food web connections: 500 samples at $11.74/sample, internal rate by LLO				0		$5,870

Large Lakes Observatory (UMD)	Internal services or fees (uncommon)	Pyrolysis GC/MS Analysis for microplastics characterization: 160 at $40 per sample, internal rate by LLO				0		$6,400
							Sub Total	**$12,270**
Equipment, Tools, and Supplies								
	Tools and Supplies	Vials for SIA analysis (500 vials $100), misc field supplies and wet ice ($100), ethanol ($200), dry ice ($200)	Sample collection and preservation					$600
	Tools and Supplies	Peroxide (6 x 1L, 30%), dissecting tools and supplies (2 sets), vials (quantity will depend on the number of particles recovered)	Microplastics digestion supplies and reagents					$1,200
							Sub Total	**$1,800**
Capital Expenditures								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
	Miles/ Meals/ Lodging	Y1 local travel (10 d, 300mi at $0.575/mi, truck, trailer rental $15/d); Y2 state 3 ppl visit 5 lakes, 2 days per visit, lodging $125/night, per diem/meals $48 partial days, 450mi, truck rental) and local travel (150 miles at $0.575/mi, 5 days of truck $15/d)	Needed to collect samples of water, zooplankton, fish, invertebrate and birds in the Minnesota portion of the St. Louis River Estuary and 5 inland lakes across MN					$4,209
							Sub Total	**$4,209**
Travel Outside Minnesota								
							Sub Total	-

Printing and Publication								
-							Sub Total	-
Other Expenses								
-							Sub Total	-
							Grand Total	$175,000

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
-			**State Sub Total**	-
Non-State				
In-Kind	UMN unrecovered indirect costs are calculated at the UMN negotiated rate for research of 55% modified total direct costs.	Indirect costs are those costs incurred for common or joint objectives that cannot be readily identified with a specific sponsored program or institutional activity. Examples include utilities, building maintenance, clerical salaries, and general supplies. (https://research.umn.edu/units/oca/fa-costs/direct-indirect-costs)	Secured	$96,250
			Non State Sub Total	**$96,250**
			Funds Total	**$96,250**

Attachments

Required Attachments
Visual Component

File: 95f7765c-eb7.pdf

Alternate Text for Visual Component

This visual shows how micro-pollution can be consumed by organisms at each level of the food web, leading to accumulation at the higher trophic levels

Optional Attachments
Support Letter or Other

Title	File
Sponsored Projects Authorization	1aa4239c-b80.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

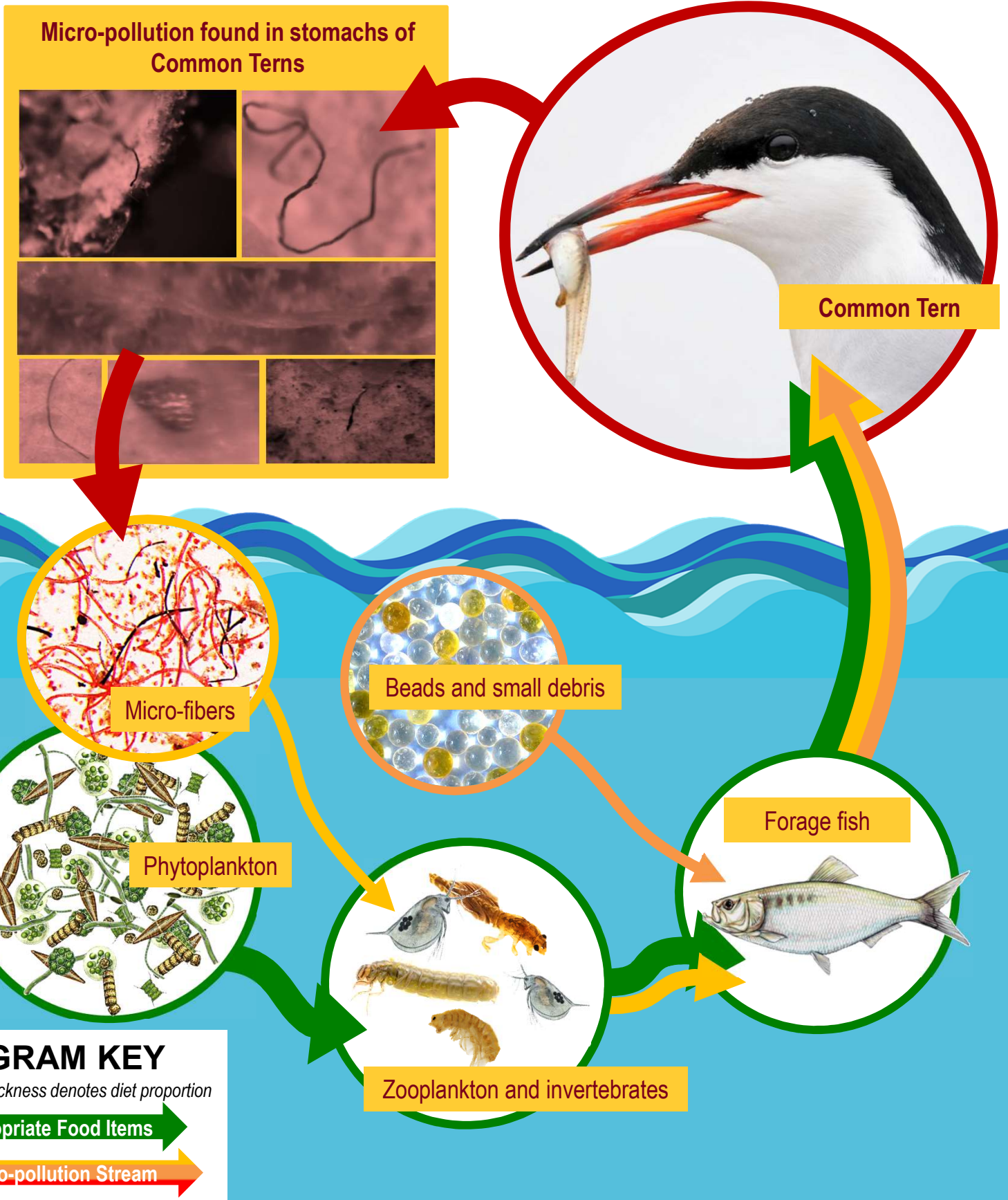**Does your project have patent, royalties, or revenue potential?**

No

Does your project include research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Natural Resources Research Institute
UNIVERSITY OF MINNESOTA DULUTH
Driven to Discover

PROJECT TITLE:
Does micro-pollution impact aquatic food webs and birds?

Micro-pollution found in stomachs of Common Terns

Common Tern

Micro-fibers

Beads and small debris

Forage fish

Phytoplankton

Zooplankton and invertebrates

DIAGRAM KEY
Arrow thickness denotes diet proportion

Appropriate Food Items

Micro-pollution Stream

We will assess the extent and impact of different types of micro-pollution on birds, fish, invertebrates, and food webs in Minnesota lakes.