Environment and Natural Resources Trust Fund
2020 Request for Proposals (RFP)

Project Title: **ENRTF ID: 026-A**

Estimating Fish Production in Stressed Minnesota Lakes

Category: A. Foundational Natural Resource Data and Information

Sub-Category:

Total Project Budget: $ 416,500

Proposed Project Time Period for the Funding Requested: June 30, 2023 (3 yrs)

Summary:

Using Sentinel Lakes Program data, we will develop a bioenergetics-based method to predict how disruption of primary (algae) and secondary (e.g., zooplankton) production changes fish production in Minnesota Lakes.

Name: Richard Kiesling

Sponsoring Organization: U.S. Geological Survey

Job Title: Dr.

Department: Upper Midwest Water Science Center: Minnesota Office

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Location:

Region: Central, Northwest, Northeast

County Name: Clearwater, Cook, Douglas

City / Township:

Alternate Text for Visual:

Potential Sentinel Lake study locations for proposed lake bioenergetics assessments. Lake locations are presented on the underlying major biotic land types targeted by the Sentinel Lakes Program.

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

PROJECT TITLE: Estimating Fish Production in Stressed Minnesota Lakes

I. PROJECT STATEMENT

Our goal is to predict how disruption of primary (algae) and secondary (e.g., zooplankton) production changes fish production in Minnesota Lakes. Using data collected through the Sentinel Lakes Program, we will test a bioenergetics-based method for (1) estimating seasonal and annual carbon flow through the primary and secondary trophic levels of study lakes using existing lake ecosystem models; and (2) linking seasonal production estimates to annual lake cisco (*Coregonus artedi*) production in these same Sentinel Lakes.

Our project will quantify how the key drivers of water quality and hydrology contribute to fish productivity in Minnesota lakes. The outcome from the lower-trophic level bioenergetics model will be used to estimate how seasonal contributions from changing phytoplankton and zooplankton communities support fish production by the northern lake cisco (*Coregonus artedi*), an open-water, zooplanktivorous fish that plays a critical role as a forage fish in Minnesota walleye lakes. The model will be developed and validated in three Sentinel Lakes using long-term data including annual estimates of cisco abundance and biomass.

WHY: Changes at lower trophic levels caused by numerous stressors have cascading effects on algae, zooplankton and fish. Changing stressor gradients in lakes have increased the frequency and intensity of algal blooms and reduced biomass of native zooplankton by as much as 60 percent. These changes produce less food or poorer quality food for zooplankton, forage fish, and larval game fish such as walleye and largemouth bass that depend upon zooplankton production during their first year of growth. Observed reductions in the quality of phytoplankton and the quality and quantity of zooplankton food resources are predicted to reduce the net flow of energy available for fish growth, increasing overwintering mortality of young of year (YOY) fish and reducing recruitment. Fisheries managers in Minnesota need a tool that can predict how changes in the algae and zooplankton resources of the lower trophic levels of the food web drive changes in fish production.

HOW: ***Estimates of seasonal changes in primary and secondary production will allow us to use carbon-based production models to predict changes in cisco production based on changes at lower trophic levels***. Existing ENRTF-funded lake ecosystem models will be integrated into fish bioenergetics models to predict how different densities of phytoplankton and zooplankton change the carbon and energy flow available to sustain cisco growth. Integrated models will predict how changes in phytoplankton and zooplankton change cisco growth and production. Model predictions will be calibrated against independent estimates of primary and secondary production and fish biomass production data from Minnesota DNR (MNDNR) fish population surveys.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Predict carbon-based, primary and secondary production in study lakes using water chemistry and ecosystem models

Existing lake ecosystem models will be updated using a dynamic food-web sub-model and used to predict the amount of carbon-based energy available for fish production. Proposed study lakes include vulnerable Sentinel Lakes: Trout Lake, Elk Lake, Lake Carlos, and Ten Mile (figure 1). The potential study lakes are popular recreation lakes and represent a broad gradient in climate, primary productivity, and cisco population size.

Budget: $290,000

Outcome Activity 1	Completion Date
1. Calibrated lake ecosystem models for each test lake that predict how current phytoplankton and zooplankton production change food available for fish	Dec 31, 2021
2. Validation of carbon flow available for fish growth and recruitment	June 30, 2022

3. Final report to LCCMR and draft USGS Scientific Investigations Report	June 30, 2023

Activity 2: Validate the primary production rates from Activity 1 using dissolved oxygen data to estimate primary and secondary production and calculate cisco population production rates from available fish biomass survey data.

Budget: $126,500

Continuous dissolved oxygen data collected through the Sentinel Lakes Program will be used to validate the energy flow in lakes between major trophic levels: from algae to zooplankton and from zooplankton to fish. Algal (primary) and zooplankton (secondary) production will be quantified using observed changes in oxygen concentrations and zooplankton populations through time. Pelagic cisco fish biomass data from annual fish population surveys (vertical gillnets and hydroacoustic surveys) will be used to validate the model results under Activity 1.

Outcome Activity 2	Completion Date
1. Collect and quantify size-class specific phytoplankton and zooplankton carbon from three Sentinel Lakes; quantify nutrient-dependent phytoplankton growth	Dec 31, 2021
2. Quantify algal, zooplankton, and fish production from existing and new data	June 30, 2022

III. PROJECT PARTNERS AND COLLABORATORS:

The Principal Investigators for this project are Richard Kiesling and Erik Smith, USGS Upper Midwest Water Science Center (UMidWSC). Dr. Smith is an expert in lake ecosystem model development and validation having published models for five Sentinel Lakes and Lake St. Croix in the past five years. He will direct Activity 1 and manage data collation and ecosystem model updates with assistance from Jeff Ziegeweid, USGS UMidWSC biologist with expertise is fish growth rates and production estimates. Dr. Kiesling is an expert in lake water quality and lake metabolism and will serve as Project Manager while directing Activity 2 and supervising a graduate student research assistant for the project. Dr. Casey Schoenebeck, Sentinel Lakes Program Coordinator, Division of Fish and Wildlife, MNDNR, will oversee project coordination and provide access to Sentinel Lakes Program data through Program staff as necessary.

IV. LONG-TERM IMPLEMENTATION AND FUNDING:

The proposed research ties directly to the Minnesota DNR strategic plan by forecasting the impacts of large-scale stressors on multiple trophic levels in Minnesota lakes. Secondly, the proposed research fits with several Section of Fisheries Information Need Priorities including those related to what drives the pelagic fish community, zooplankton and secondary production, and identifying the impacts of climate change and other stressors on lake trophic levels. Outcomes from the study will provide information necessary to manage Minnesota lake fish communities in ways that mitigate impacts of stressors on primary and secondary production. Finally, the proposed research will further the key mission of the Sentinel Lakes Program, a Section of Fisheries priority, which is to nurture monitoring and research efforts across multiple agencies and partners to better understand the drivers of ecological change in aquatic resources.

Timeline Requirements

Three years of funding are being requested for this study beginning July 1, 2020 and ending June 30, 2023

V. SEE ADDITIONAL PROPOSAL COMPONENTS: A, B, F and G

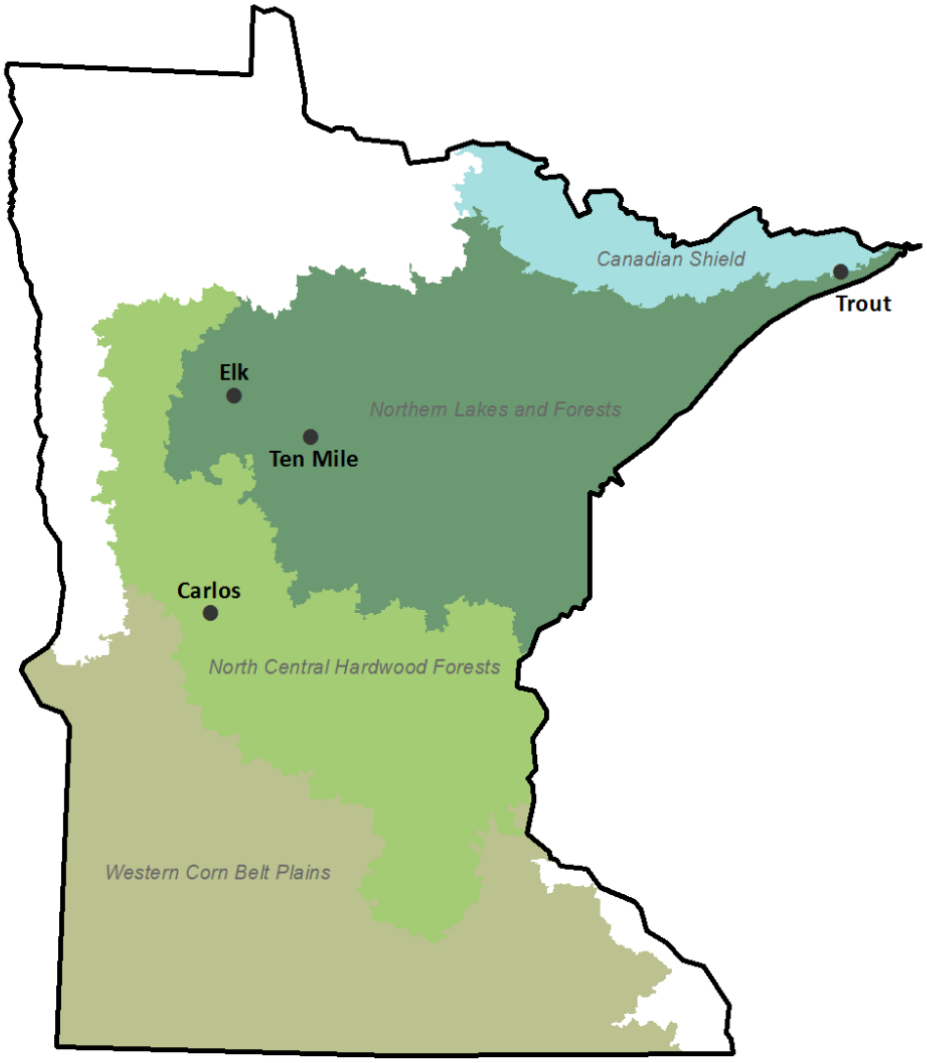
Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: R. Kiesling
Project Title: Estimating Fish Production in Stressed Minnesota Lakes
Organization: US Geological Survey
Project Budget: $416,500
Project Length and Completion Date: 3 years; June 30, 2023
Today's Date: April 12, 2019

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 220,000	$ -	$ 220,000
Hydrologist - Project Manager: 10% FTE, 75% salary, 25% benefits, 1 person			
Hydrologist - Lake modeler: 35% FTE total, 70% salary, 30% benefits, 2 people			
Hydrologist - Program Manger: 5% FTE total, 75% salary, 25% benefits, 2 people			
Budget Analyst: 3% FTE, 68% salary, 32% benefits, 1 person			
Professional/Technical/Service Contracts			
USGS National Water Quality Laboratory: analysis of monthly inflow or outflow water quality samples for six months for total particulate organic and inorganic carbon and nitrogen (TPCN); total organic carbon (TOC); dissolved organic carbon (DOC); major ions; total and dissolved nutrients (inorganic and organic) - 30 samples total for 6 months at two calibrations lakes for $1100 per sample = $33,000. Analysis of bi-monthly lake water quality samples to augment Sentinel Lakes sampling for the same constituent list as above plus zooplankton size fraction particulate carbon and nitrogen - samples at two depths for tree lakes for three months at $1500 per sample = $27,000. Blank water and field equipment blank water quality assurances samples - 4 samples at $1250 per samples = $5000	$ 65,000	$ -	$ 65,000
USGS Cooperative Research Unit graduate student annual seasonal intern - 3 years for 8 months a year for a total of 24 monthly samples	$ 45,000		$ 45,000
USGS Reston Stable Isotope Laboratory: carbon and nitrogen isotope analysis for algae and zooplankton from three lakes for three years for a total of 40 samples at $875	$ 35,000		$ 35,000
Equipment/Tools/Supplies			
Equipment rental: 8 pressure transducers with temperature loggers for 20 months at $79 per month for inflow and outflow gages	$ 12,640	$ -	$ 12,640
Water quality sampling supplies: organic and particulate carbon sampling bottles; major ions and nutrient sampling supplies including bottles, capsule filters; algal biomass sampling and analysis supplies including filters, buffers, pigment extraction solvents and standards; field sampling conductivity and pH standards;	$ 3,360	$ -	$ 3,360
Printing			
Open access fee ($3200) and figure production costs ($800) for peer-reviewed scientific journal report using most recent journal article in *Science of the Total Environment* as an example	$ 4,000	$ -	$ 4,000
Travel expenses in Minnesota			
Local travel to sites for sample collection and servicing and downloading transducer data for an estimated 10 trips per site and 200 miles.	$ 7,500	$ -	$ 7,500
Other			
Over-night shipping for 280 samples to two contract labs ($5600); data transmission costs for temperature sensors at transducer locations (cell modems and cloud storage, $4000); water quality field meter maintenance for six YSI 6920 series or similar ($1200 per year per sonde for 2 years).	$ 24,000	$ -	$ 24,000
COLUMN TOTAL	$ 416,500	$ -	$ 416,500

SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State: USGS Cooperative Water Funds	pending	$ 68,400	$ -	$ 68,400
State:		$ -	$ -	$ -
In kind: MN DNR Sentinel Lakes Coordinator (120 hours)	pending	$ 5,200	$ -	$ 5,200

Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	Budget	Spent	Balance
USGS received ENRTF support for Sentinel Lakes Phase 2 Bio-physical modeling through sub-contract with the MN DNR	Complete 6/30/2016	$ 197,000	$ 197,000	$ -
USGS received ENRTF support for Sentinel Lakes Phase 3 Internal Loading dynamics for HAB development through sub-contract with the St. Croix Research Station, Sci. Museum of MN	Complete 6/30/2019	$ 50,000	$ 50,000	$ -

Figure 1. Potential Sentinel Lake study locations for proposed lake bioenergetics assessments. Lake locations are presented as solid black circles with names in block letters. The sites are presented on the underlying major biotic land types targeted by the Sentinel Lakes Program: Canadian shield, Glacial drift Northern Forest, North Central Hardwood Forest, and Western Corn Belt Plains. Details available at https://www.pca.state.mn.us/water/sentinel-lakes



LCCMR Project Manager Qualification: Richard L Kiesling, Ph. D.

U.S. Geological Survey, 2280 Woodale Drive, Mounds View MN 55112
VOICE 763-783-3131; FAX 763-783-3103; CELL 612-817-2826

Project Manager Qualifications:

Dr. Kiesling is a hydrologist and limnologist with the U.S. Geological Survey. He holds a B.S. in Biology from the University of Minnesota (1980) and a Ph.D. in Ecology from the University of Michigan (1990) with specialization in limnology and community ecology. He is currently the Lake and Water Quality Specialist with the USGS Minnesota Water Science Center.

Dr. Kiesling will function as the project manager for the proposed study. He will coordinate the work of USGS with the in-kind contributions from the Sentinel Lakes program of the Minnesota Department of Natural Resources. Dr. Kiesling has over twenty years of research and applied research project management experience in lake and reservoir studies, including three Sentinel Lake modeling studies in Minnesota.

USGS Organization Description:

As the Nation's largest water, earth, and biological science and civilian mapping agency, the USGS provides scientific understanding about natural resource conditions, issues, and problems through joint studies with local, state, tribal and federal partners. The diversity of our scientific expertise enables us to carry out large-scale, multi-disciplinary investigations and provide impartial scientific information to resource managers, planners, and other customers.

Additional Project Manager Information:

Dr. Kiesling Appointments:

US Geologic Survey - Limnologist and Hydrologist 8/01 to present
St. Cloud State University - Adjunct Professor. Dept. of Biology, 9/2013 to 12/2019
University of Texas - Research Fellow, Environmental Science Institute, 1/02 to 8/2008
Tarleton State University: Adjunct Professor1/99 to 8/06; Research Scientist, 1/98 to 8/01

Relevant Selected Publications:

Smith, E.A., Kiesling, R.L., and Ziegeweid, J.R., 2017, Water-quality models to assess algal community dynamics, water quality, and fish habitat suitability for two agricultural land-use dominated lakes in Minnesota, 2014: U.S. Geological Survey Scientific Investigations Report 2017–5056, 65 p., https://doi.org/10.3133/sir20175056.

Smith, E.A., Kiesling, R.L., Galloway, J.M., and Ziegeweid, J.R., 2014, Water quality and algal community dynamics of three deepwater lakes in Minnesota utilizing CE-QUAL-W2 models: U.S. Geological Survey Scientific Investigations Report 2014–5066, 73 p., http://dx.doi.org/10.3133/sir20145066.

Christensen, V.G., Maki, R.P., and Kiesling, R.L., 2013, Evaluation of internal loading and water level changes: implications for phosphorus, algal production, and nuisance blooms in Kabetogama Lake, Voyageurs National Park, Northern Minnesota: Journal of Lake and Reservoir Management 209: 202-215. doi:10.1080/10402381.2013.831148

Christensen, V.G., Maki, R.P., and Kiesling, R.L., 2011, Relation of nutrient concentrations, nutrient loading, and algal production to changes in water levels in Kabetogama Lake, Voyageurs National Park, northern Minnesota, 2008–09: U.S. Geological Survey Scientific Investigations Report 2011–5096, 50 p.