Environment and Natural Resources Trust Fund
2019 Request for Proposals (RFP)

Project Title: **ENRTF ID: 056-B**

Satellite Tracking of Harmful Algal Blooms in Lakes

Category: B. Water Resources

Sub-Category:

Total Project Budget: $ 466,987

Proposed Project Time Period for the Funding Requested: June 30, 2022 (3 yrs)

Summary:

Harmful algal blooms (HABs) are becoming increasingly toxic and spreading north. We will use satellite imagery to create a web-based HAB tracking system to help protect Minnesotans from HAB toxins.

Name: Christopher Filstrup

Sponsoring Organization: U of MN - Duluth

Title: Research Associate

Department: Minnesota Sea Grant Program

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Web Address

Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Lakes will be sampled to create and verify Harmful Algal Bloom (HAB) algorithms from satellite imagery that will be incorporated into a user-friendly online HAB tracking system.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%
____ If under $200,000, waive presentation?			

PROJECT TITLE: Satellite Tracking of Harmful Algal Blooms in Lakes

I. PROJECT STATEMENT

Harmful Algal Blooms (HABs) commonly occur in Minnesota's southern lakes but are increasing in toxicity and spreading northward, thereby threatening vital natural resources and public health. **This proposal seeks to develop methods to accurately track HABs in near real-time using satellite images and to make maps of HAB-affected Minnesota lakes freely available online.** Our proposed cost-effective approach will regularly measure lakes statewide to identify HAB-prone lakes and provide updated information to help protect Minnesotans and their pets from exposure to HAB toxins.

Project outcomes include:

1. Addition of regularly updated HAB-prone lake maps (HAB tracking system) to the UMN Lake Browser.
2. Addition of a public-friendly user interface for the UMN Lake Browser.

This proposal leverages previous LCCMR funded-projects (Finlay et al. 2016; Peterson et al. 2018) by adding the ability to track HABs in near real-time to the UMN Lake Browser, an online resource that displays water quality measurements, such as water clarity, color, and chlorophyll, that were made from satellite imagery. The scientific and geographic breadth of our research group makes us uniquely qualified to perform this study. We draw on expertise in HABs and water chemistry from the Large Lakes Observatory (LLO) and the Natural Resources Research Institute (NRRI) at University of Minnesota Duluth (UMD), in remote sensing from the Remote Sensing and Geospatial Analysis Lab (RSL) and the Water Resources Center (WRC) at University of Minnesota (UMN), and in outreach from MN Sea Grant (MNSG) at UMD.

HAB proposals previously funded by LCCMR studied the historic spread of one tropical harmful alga and brought together professionals studying HABs to identify key issues but did little to help warn Minnesotans of HAB "hotspots" before they head to their favorite lake.

Our **overall aims** are to:

1. Measure how much and how toxic HABs are in Minnesota by sampling lakes.
2. Create and verify algorithms (computer calculations) to measure HABs from satellite imagery by comparison to water quality measurements.

To achieve these aims, we will collect 200 water samples to measure HAB abundance, toxin concentrations, and other water quality variables during years 1 and 2. We will sample near when the satellites pass overhead to develop algorithms and computer code to track HABs. Algorithms based on HAB abundance will then be tested to identify if they can also provide an estimate of toxin in the water. We will host four public focus groups throughout MN to promote and improve usability of the UMN Lake Browser HAB tracking system.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: *Lake sampling to create and verify HAB algorithms* **BUDGET: $272,272**

We will collect 200 water samples during years 1 and 2 to measure HAB abundance (by amount of phycocyanin pigment), toxic algae (by microscope counts), and toxin amounts (by LC-MS). We will measure water transparency, water color, suspended particles, dissolved organic matter, and chlorophyll. Lakes will be sampled throughout MN near when the Sentinel satellites pass overhead.

Outcome	Completion Date
1. Collect 100 samples and complete water quality analyses for Year 1	*MAR 31, 2020*

2. Collect 100 samples and complete water quality analyses for Year 2	*MAR 31, 2021*

Activity 2: *HAB tracking system that measures HABs in lakes from satellite images* **BUDGET: $154,467**

We will create and verify algorithms to track HABs from satellite images using water measurements from lake sampling (Activity 1). This process will be repeated to improve the accuracy of HAB algorithms as new lake data become available. We will create a HAB database of up-to-date maps and write code to automatically download and process new satellite images.

Outcome	Completion Date
1. Create and verify HAB algorithms using field data (Activity 1) and develop computer code	*JUN 30, 2021*
2. Implement code using supercomputers to create HAB database	*DEC 31, 2021*
3. Create database with approximately biweekly HAB data for more than 10,000 lakes	*JUN 30, 2022*

Activity 3: *Create HAB tracking system to help protect people from toxins* **BUDGET: $40,248**

Add HAB tracking system to freely available UMN Lake Browser (www.lakes.rs.umn.edu). Host four statewide focus groups to improve public awareness of, encourage use of, and identify ways to make the tracking system more user-friendly.

Outcome	Completion Date
1. Near real-time HAB tracking capabilities added to UMN Lake Browser	*DEC 31, 2021*
2. Improved user interface added to UMN Lake Browser based on public focus groups	*APR 30, 2022*

III. PROJECT PARTNERS:

A. Partners receiving ENRTF funding: None

B. Partners NOT receiving ENRTF funding

Name	Title	Affiliation	Role
P. Anderson	Supervisor WQ Monitoring Unit	MN Pollution Control Agency	Share data/feedback on database and HAB tracking system
P. Jacobson, G. Hansen	Fisheries Supervisor, Research Scientist	MN Dept. Natural Resources	Share data/feedback on database and HAB tracking system
T. Robinson	Supervisor Waterborne Diseases Unit	MN Dept. of Health	Share data/feedback on database and HAB tracking system
J. Sventek	Water Resources Assess. Manager	Metropolitan Council	Use/provide feedback on database and HAB tracking system

IV. LONG-TERM- IMPLEMENTATION AND FUNDING:

Our project creates a cost-effective HAB tracking system that can be used now and in the future by state agencies to help develop strategies to mitigate HABs and by the public to help avoid exposure to toxins. At minimal cost to WRC, semi-automated computer code can be written to acquire satellite imagery and measure HABs. The UMN Lake Browser is a popular resource offered by RSL and WRC that will be maintained into the future. Additionally, MNSG will develop web content to increase public awareness of HABs and the HAB tracking system, and will incorporate related content into existing and future outreach efforts.

V. TIMELINE REQUIREMENTS: Three years, from July 2019 through June 2022.

2019 Proposal Budget Spreadsheet

Project Title: Satellite Tracking of Harmful Algal Blooms in Lakes

IV. TOTAL ENRTF REQUEST BUDGET *3* **years**

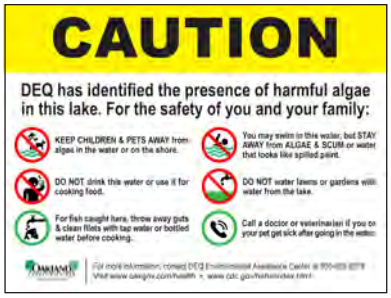
BUDGET ITEM (See "Guidance on Allowable Expenses")	**AMOUNT**
Personnel:	$ 344,477
Christopher Filstrup, PI (75% salary, 25% benefits); 25% in Years 1-3: $55,723	
Leif Olmanson, Co-PI (75% salary, 25% benefits); 15% in Year 1 and 25% in Years 2-3: $60,190	
Andrew Bramburger, Co-I (75% salary, 25% benefits); 15% in Years 1-3: $47,613	
Kathryn Schreiner, Co-I (75% salary, 25% benefits); 50% in 2 summer months in Years 1-3: $33,933	
Marte Kitson, Outreach Coordinator (75% salary, 25% benefits); 10% in Years 1-3: $17,161	
Benjamin Page, Research Assoc. in remote sensing (75% salary, 25% benefits); 40% in Years 1-3: $91,052	
Julia Halbur, Lab Tech for toxin analysis (79% salary, 21% benefits); 17% in Years 1-3: $20,892	
Graduate student (87% salary, 13% fringe); 100% for 3 summer months in Years 1-3: $17,121	
Undergraduate student (100% salary, 0% benefits); 36 hours in Years 1-2 @ $11 per hour: $792	
Professional/Technical/Service Contracts:	$ -
Equipment/Tools/Supplies:	$ 50,680
Equipment	
Spectroradiometer for characterizing lake water color. Custom build. Cost estimates from previous construction. Item purchased in Year 1. $12,000	
Equipment sub-total: $12,000	
Supplies	
Toxin supplies: $16,862.40 each year for Years 1 and 2 for consumables (supplies, standards, columns, etc.) and machine time (3% inflation in Year 2). $34,230	
General lab supplies: $1500 each year for Years 1 and 2 for lab consumables (gloves, storage containers, foil, pipet tips, etc.). $3,000	
General field supplies: $400 each year for Years 1 and 2 for field consumables (gloves, sample bottles, coolers, batteries, ice, etc.). $800	
Data duplication and storage: $150 each year for 3 years for remote and external data storage. $450	
Outreach supplies: $200 in Year 3 for focus group supplies (paper, pens, flip charts, name badges, etc.). $200	
Supplies sub-total: $38,680	
Acquisition (Fee Title or Permanent Easements):	
Travel:	$ 15,280
Field travel: 3 trips (3 days each) for 2 field teams (Duluth, TC based) to sample 100 lakes in each of Years 1 and 2 (3 trips x 2 nights @ $120 + per diem for 4 travelers @ $51 (full rate; $38.25 for 75% rate) + mileage + 18 crew-days truck and boat use) = $5636 per year (3% inflation in Year 2)). $11,441	
Outreach meetings: 4 meetings throughout MN (Rochester/Twin Cities, St. Cloud/Brainerd, Bemidji, Grand Marais) in Year 3 (4 trips x 1 night @ $120 + per diem for 2 travelers @ $38.25 (75% rate) + mileage). $2,587	
Sample transport: 6 trips in each of Years 1, 2 (UMD rental rate + mileage = $617 per year (3% inflation in Year 2)). $1,252	
All travel amounts follow University of Minnnesota travel reimbursement policy guidelines.	
Additional Budget Items:	$ 56,550
Algae community characterization: 100 samples each in Years 1 and 2 @ $200.00 each (includes tech time, microscope time, supplies; 3% inflation in Year 2). $40,600	
Optical water characterization: 100 samples (+ 10% replication) each in Years 1 and 2 for chlorophyll a ($3.50), phycocyanin ($4.50), CDOM ($7.00), and TSS/ISS/VSS ($21.50) (includes tech time, machine time, supplies; 3% inflation in Year 2). $8,150	
Outreach participant costs: 4 meetings x 16 participants @ $50 stipend each + catered lunch ($400 each meeting). $4,800	
Remote Sensing and Geospatial Analysis Laboratory Fee: $1000 each year for 3 years. $3,000	
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 466,987

V. OTHER FUNDS *(This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)*

SOURCE OF FUNDS	**AMOUNT**	**Status**
Other Non-State $ To Be Applied To Project During Project Period:		
John Downing, Co-I (75% salary, 25% benefits); 2% in Years 1-3	$ 18,332	*Secured*
Other State $ To Be Applied To Project During Project Period: *N/A*	$ -	*N/A*
In-kind Services To Be Applied To Project During Project Period:		
Unrecovered indirect: 54% MTDC, $454,987 base (Direct cost less equipment costs)	$ 245,693	*Secured*
MN DNR will provide project support @ 100 hours for 1 year	$ 5,250	*Secured*
Past and Current ENRTF Appropriation:		
ENRTF 2018: *Providing Critical Water Quality Information for Lake Management* . PI Peterson, co-PI Olmanson.	$ 250,000	*Secured*
Other Funding History:	$ -	*N/A*

Satellite Tracking of Harmful Algal Blooms in Lakes

1. HABs can sicken people, pets, and animals



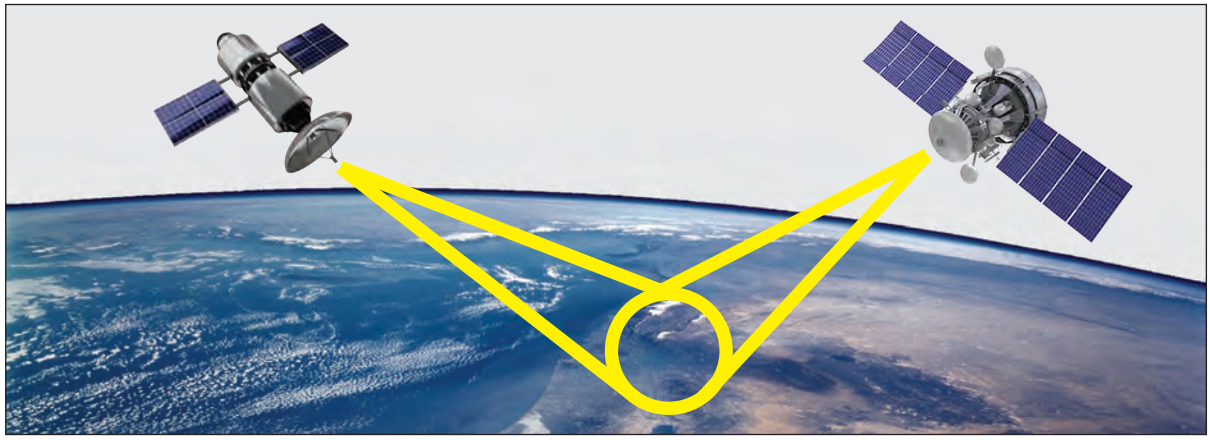
2. Sample lakes when satellites pass to provide HAB data

Algae counts

Phycocyanin

Toxins

3. Create algorithms to track HABs using satellite images



4. Develop and improve online HAB tracking system

Project Manager Qualifications and Organization Description

Christopher T. Filstrup, Lead PI: Dr. Filstrup will coordinate overall project activities, lead lake sampling based out of Duluth, co-advise MS student, and help with outreach. Dr. Filstrup is a Research Associate at the Large Lakes Observatory (LLO) and Minnesota Sea Grant (SG) at the University of Minnesota Duluth (UMD) specializing in phytoplankton ecology and Harmful Algal Blooms (HABs). He has been studying water quality issues related to HABs for almost 20 years. He previously was a primary point-of-contact for water quality issues for Iowa while directing the Iowa Lake Monitoring Program, as well as serving as Co-PI on numerous state-sponsored projects ($1.76 million over six years). He has published 25 peer-reviewed articles on HABs and large-scale water quality issues, frequently presents research at international conferences, and assists with education and outreach efforts within Minnesota. He leads a strong research team at UMD specializing in HABs and water chemistry, with **Dr. Bramburger (Co-I)** leading algae analyses and assisting with field sampling and outreach, **Dr. Schreiner (Co-I)** leading toxin analyses and advising MS student, and **Dr. Downing (Co-I)** assisting with data interpretation and outreach. **Marte Kitson (Co-I)** will lead outreach efforts and public focus groups.

Leif Olmanson, Co-PI: Dr. Olmanson will lead remote sensing activities and HAB algorithm development, supervise the remote sensing Research Fellow, and lead lake sampling based out of the Twin Cities. Dr. Olmanson is a Research Associate at the University of Minnesota Twin Cities (UMN) Remote Sensing and Geospatial Analysis Laboratory and Water Resources Center specializing in remote sensing applications for measurement of water quality in Minnesota's inland lakes, as well as co-developing the Lake Browser online tool (www.lakes.rs.umn.edu). He is Co-PI/Technical-PI on the LCCMR Peterson et al. 2018 project that is building the near real-time water quality monitoring system for Minnesota's 10,000 lakes with the Minnesota Supercomputing Institute (MSI). Also, he will help coordinate activities of the project team with the MSI group and project partners to ensure long-term implementation and use of resulting data products and tools.

University of Minnesota Duluth is perfectly equipped to perform the proposed water chemistry and phytoplankton analyses, with laboratories housed within LLO and the Natural Resources Research Institute (NRRI). The Biological Limnology Laboratory at LLO will perform water chemistry analyses and is equipped with fluorometers for chlorophyll *a* and phycocyanin analyses, a UV-Vis spectrophotometer for CDOM, as well as general laboratory equipment for sample preparation and storage. The Organic Geochemistry Laboratory at LLO will perform toxin analyses and is equipped with an Agilent LC triple quadrupole MS along with peripherals and related equipment for toxin extraction and general laboratory equipment. The Phycology Laboratory at NRRI will perform phytoplankton and suspended solids analyses and is equipped with numerous compound and inverted microscopes and peripherals, general equipment for slide preparation, and ovens and furnaces. LLO and NRRI are also equipped with vehicles, boats, and sampling equipment for sample collection related to this project.

The Remote Sensing and Geospatial Analysis Laboratory (RSL) at University of Minnesota Twin Cities is perfectly equipped to perform the proposed remote sensing algorithm development. RSL has state-of-the-art computing and software resources, as well as a wide array of ancillary and supporting equipment. Computers have all required data analysis, image processing, and GIS software installed. RSL also has free access to data processing at the Minnesota Supercomputer Institute, which maintains compute, storage, and application systems to support advanced research. Co-PI Olmanson also has access to a vehicle, boat, and sampling equipment, including one spectroradiometer, for sample collection and *in situ* measurements.