**PROJECT TITLE: Rapid Detection of Algal Toxins in Minnesota Lakes**

1. **PROJECT STATEMENT**

**This project aims to develop a robust, cost-effective, rapid system for monitoring statewide algal toxin exposure risk in Minnesota lakes.**

In order to achieve this objective, we will:

1. **Use cutting edge genetics and toxin characterization techniques in 100 focal lakes statewide in order to identify genomic indicators of high algal toxin concentrations and produce a gene-based HAB Nowcasting model of toxin exposure risk.**
2. **Use a near real-time water quality monitoring system (WQMS) of > 10,000 lakes that is being built with a current LCCMR funded project to identify lakes with potential for HABs using a chlorophyll threshold developed in Activity 1. Develop cutting edge methods using daily Sentinel 3 satellite imagery to identify HAB pigments that indicate HABs in large lakes (>400 acres).**

Recently, harmful algae blooms (HABs) and associated threats to human and ecosystem health have increased in Minnesota. Despite the relatively low frequency of HAB occurrences in more forested areas of the state, these events are becoming more widely reported, even in “pristine” wilderness areas such as the Boundary Waters Canoe Wilderness Area. The mechanisms that regulate HAB formation and toxicity across multiple HAB species in various lakes are poorly understood, and there exists no statewide means of quantifying risk associated with HABs in order to protect lake users. As such, the proposed project will use cutting edge techniques to quantify the distribution and abundance of multiple HAB-forming species in MN inland lakes and evaluate algal toxin exposure risk at a statewide scale in order to protect public health and tourism revenues associated with Minnesota lake use.

Recent advances in environmental genomics technology, coupled with the abundance and diversity of inland lakes in Minnesota and newly available satellite imagery, provide a unique opportunity to produce a cost-effective and widely applicable long-term monitoring tool that will be effective for protecting Minnesotans from risks associated with HABs at a statewide scale. This proposal represents a collaborative effort among the Natural Resources Research Institute (UMD), Remote Sensing and Geospatial Analysis Laboratory and Water Resources Center (UMTC), and the Science Museum of Minnesota.

**II. PROJECT ACTIVITIES AND OUTCOMES**

**Activity 1: Comprehensive Genomics and Toxin Characterization.**  **ENRTF Budget: $432,098**

In order to constrain and calibrate remote-sensing based HAB predictions, as well as provide a means of differentiating between toxic and non-toxic blooms, we will characterize water quality conditions and sample water and environmental DNA three times annually in 100 Minnesota lakes. Metagenomics (based on eDNA) and toxin signatures of focal lake samples will be fully characterized using cutting-edge techniques. Gene-based risk models will be constructed and calibrated using focal lake data, and used in Act. 2 to develop remote sensing methods. The resulting early detection system will consist of identification of potentially impacted lakes using remote sensing (Act. 2), and verification of cyanotoxin production hazard using genomic markers.

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| **Outcome** | **Completion Date** |
| 1. Focal lake genetic and toxin sampling and analysis (Comprehensive analysis; Round 1-3; 100 samples/round) | Nov 30, 2020 |
| 2. Focal lake genetic and toxin sampling and analysis (Comprehensive analysis; Round 4-6; 100 samples/round, Paleolimnological analyses (10 lakes) | Nov. 30, 2021 |
| 3. Quality control of genetic, toxin, and water quality data, construction/calibration of toxin risk model for application to lakes statewide using Act 2. | Apr 30, 2023 |

**Activity 2: Remote sensing of HAB conditions in MN lakes. ENRTF Budget: $341,714**

We will create and verify algorithms to track HABs from satellite images using data from lake sampling (Act. 1). We will use the WQMS that will be operational when this project starts to develop an inventory of HAB likelihood in lakes using a chlorophyll a proxy (Sentinel 2), and explore the applicability of Sentinel 3 satellite imagery to infer phycocyanin (cyanobacterial pigment) concentrations in lakes. To further validate and refine algorithms, we will process 30 years of historical satellite imagery for 10 lakes and compare it to HAB fossils (pigments, DNA, toxins) found in sediment cores of a subset of 10 of the focal lakes. These will be lakes that are part of the MN Sentinel Lake program, allowing us to leverage existing datasets. We will add the ability to flag lakes with potential HABs in the Enhanced Lake Browser created as part of the WQMS.

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| **Outcome** | **Completion Date** |
| 1. Use cloud-based computing to measure historic water clarity in 10 lakes with sediment cores using Landsat imagery (30+ Years). | Sept. 30, 2021 |
| 2. Use sampling data (Act. 1) develop methods to predict likelihood of high cyanobacterial concentrations from Sentinel 3 satellite imagery. | Apr. 30, 2022 |
| 3. Add HAB flagging capability to Enhanced LakeBrowser | Jan. 30, 2023 |
| 4. Use paleolimnological techniques (fossil pigments and DNA) to validate remote sensing-inferred trends in cyanobacteria abundance and toxic potential. | June 30, 2023 |

**Activity 3: Development and Dissemination of HAB Nowcasting Model ENRTF Budget: $58,504**

We will work with MN Sea Grant to disseminate materials to stakeholders. Targeted avenues for outreach include a podcast episode on The Sea Grant Files; and participation in MN Sea Grant and UMN Extension outreach activities including the state fair booth, as well as specific products and outcomes described below.

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| **Outcome** | **Completion Date** |
| 1. Produce outreach materials including visual guide to potentially harmful algae, instructions for reporting suspicious blooms, initial feedback to citizen scientists and snapshot of algal toxin risk in Minnesota lakes. | Sept. 30, 2022 |
| 2. Produce statewide toxin risk map, disseminate algal toxin risk model to stakeholders, distribute results via conferences and research articles. | Apr. 30, 2023 |
| 3. Provide long-term monitoring outreach and guidance materials including user guide and training manual for sampling kit use, and recommendations for establishing a citizen science monitoring network for HAB toxins. | June 30, 2023 |

**III. PROJECT PARTNERS:** Minnesota Department of Natural Resources, Minnesota Department of Health

**IV. LONG-TERM- IMPLEMENTATION AND FUNDING:**

Potential future applications of this project include a continuously updated publicly-accessible statewide web-based toxin risk map that could be validated monthly based on citizen science sampling. This map could be accessed via a searchable, geo-linked cellular app.

**V. TIME LINE REQUIREMENTS:**

Three years, from July 2020 through June 2023.

**VI. SEE ADDITIONAL PROPOSAL COMPONENTS**