Science and management priorities for Wisconsin's Lake Superior nearshore waters

A brief for funders and regulatory agencies produced by the Nearshore Monitoring Workgroup of the Lake Superior Collaborative, December 16, 2022.

Overview

On Thursday, December 1, 2022, the Nearshore Monitoring Workgroup of the Lake Superior Collaborative met to discuss and identify current management needs and science gaps in Wisconsin's Lake Superior nearshore waters, including the Wisconsin waters of the St. Louis River estuary.

The purpose of this document is to provide policymakers, regulators, funders, researchers, managers, and others with a concise summary of the current science and management priorities for the region, as identified by this group.

Key Takeaways

Data synthesis, **data integration**, and **long-term monitoring** were identified as needs across all topic areas.

The list below shows each of the top science and management priorities in each of the topic areas discussed. The order the needs are listed does not indicate any ranking. For details on knowledge gaps associated with each science and/or management need, read the full summary beginning on page 2.

Climate Change

- Improve our understanding of how nearshore dynamics are impacted by climate change.
- Procure the necessary data to quantify climate trends, evaluate system resiliency, and plan for change.
- Understand the impacts of trends in combination with extreme events.
- Understand how winter impacts lake dynamics during other seasons.

Community Engagement and Environmental Justice

- Develop an inventory of public education programs and related training resources across Lake Superior nearshore in Wisconsin and the Twin Ports region.
- Assess environmental justice needs with an emphasis on local conditions and unique community needs.
- Improve science communication and community-led engagement in nearshore science and related local issues.

Tributaries, Estuaries, and Sediment/Nutrient Dynamics

- Improve management of sediment and nutrient loading.
- Identify sources of sediments and nutrients.
- Monitor and assess the impacts of restoration work or sediment and nutrient reduction actions in the watershed.

Emerging/Legacy Contaminants, Microplastics, and Food Web

- Improve our understanding of the food web in the St. Louis River Estuary and greater nearshore waters.
- Investigate sources, fate, and transport of legacy and emerging contaminants, including microplastics, and invasive species.
- Comprehensively analyze existing sediment contaminant data, tributary loading data, and other existing data and databases to identify patterns.

Cyanobacterial Blooms

- Improve our ability to predict when and where cyanobacterial blooms will occur.
- Develop and implement new methods to control cyanobacterial blooms.
- Improve our understanding of cyanotoxin production and health implications.
- Prioritize locations in need of bloom management.

Full Summary

Introduction

On Thursday, December 1, 2022, the Lake Superior Nearshore Monitoring Workgroup met to discuss and identify top science and management needs in Wisconsin's Lake Superior nearshore waters, including the Wisconsin waters of the St. Louis River estuary. The Workgroup is part of the Lake Superior Collaborative,[1] a watershed partnership that coordinates protection, restoration, and climate resilience efforts in the Wisconsin portion of the Lake Superior Basin.

The format of the meeting included breakout sessions on five overarching topics: 1) Climate change, 2) Community outreach and environmental justice, 3) Tributaries, estuaries, and sediment/nutrient dynamics, 4) Contaminants, microplastics, and invasive species, and 5) Cyanobacterial blooms, followed by a report out and a broader group discussion. Twenty-five attendees representing 11 organizations participated in the meeting. Represented organizations included: the Environmental Protection Agency, MarineTech, Lake Superior National Estuarine Research Reserve, National Park Service (Apostle Islands National Lakeshore), Northland College (Burke Center for Freshwater Innovation), Red Cliff Band of Lake Superior Chippewa (Treaty Natural Resources Division), University of Minnesota-Duluth (Large Lakes Observatory), University of Wisconsin-Superior (Lake Superior Research Institute), University of Wisconsin-Madison Division of Extension, Wisconsin Department of Natural Resources, Wisconsin Sea Grant, and U.S. Geological Survey. This document was also circulated to all members of the Nearshore Workgroup, a science and management community of over 90 people, who could not attend in person for additional input.

This document represents the priorities, views, and discussion that occurred at the meeting, and does not necessarily include all possible Lake Superior nearshore priorities.

Overarching Themes

Despite the wide range of topics discussed, two overarching themes emerged from all topic areas: a need for 1) data synthesis and data integration, and 2) long-term monitoring. The group emphasized that funding for these areas is needed and should be considered a priority in the future.

Data Synthesis and Data Integration

The group discussed that a large amount of data collected in the past has yet to be analyzed due to funding being primarily directed at data collection without adequate time and resources allocated to analyzing datasets. This is especially true for large datasets such as those generated by

[1] LakeSuperiorCollaborative.org

continuous data sources including sensors. Similarly, a strong need was identified for both combining disparate data sets for analysis and finding solutions for interfacing data from different repositories. Funding to analyze and synthesize datasets, including the development of data processing tools, is needed to address these issues.

Long-term Monitoring

Long-term monitoring was also identified as critical to addressing science and management needs in nearly all topics. Long-term monitoring data provides a baseline or reference point as well as tracking change over time. The lack of funding for long-term monitoring in Lake Superior is likely in part due to its reputation as being pristine; however, the nearshore of Lake Superior is facing many threats including algal blooms, contaminants, erosion, invasive species, and more. Project-based work does not provide the foundational knowledge needed to mitigate or prevent future issues. Establishing long-term monitoring in Lake Superior's nearshore, as well as capacity for analysis and synthesis of data, is flagged as a high priority by this group.

Science and Management Priorities by Topic Area

Climate Change

Despite its enormous size, Lake Superior is not immune to the effects of climate change. Lake Superior is one of the fastest-warming lakes in the world by peak summer surface temperature[2], has experienced less ice cover, which increases summer water temperatures and winter shoreline erosion. The lake and its watershed have also experienced a higher frequency of extreme rain events that wash nutrients and pollutants into the lake, causing water quality problems, especially in the nearshore, such as increased E. coli and other beach contaminants. The increased nutrient availability coupled with warmer water temperatures and stronger thermal stratification promotes the growth of harmful algal blooms. These changes in temperature and precipitation have also led to more extreme water levels, both highs and lows, with less time between extreme conditions. The culmination of these effects and others has major implications for the future of Lake Superior.

The WICCI report states that "A healthy Great Lakes future requires understanding climate change impacts".

1. Improve our understanding of how nearshore dynamics are impacted by climate change.
    - Determine how biogeochemical processes are changing in response to climate change in coastal areas

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[2] O'Reilly, C. M., S. Sharma, D. K. Gray, and others. 2015. Rapid and highly variable warming of lake surface waters around the globe. Geophysical Research Letters 42: 10773–10781. doi:10.1002/2015GL066235

- Improve our understanding of key hydrodynamic processes influencing the nearshore
- Identify how changes in tributary flow volume and timing with lake ecosystem processes affect lake response
- Determine the effects of storm events on mediating tributaries and the receiving lake in a spatial and sub-basin context

2. Procure the necessary data to quantify trends, evaluate system resiliency, and plan for change.
    - Synthesize existing datasets for a more holistic understanding of climate change impacts, including long-term datasets for temperature, currents, and nutrients
    - Establish baseline conditions for reference in evaluating climate change impacts
    - Quantify expected phenological changes under future conditions and how will this impact the nearshore

3. Understand the impacts of climate trends in combination with extreme events.
    - Collect long-term datasets to quantify lake response to trends over time
    - Collect data surrounding extreme events to quantity impacts
    - Synthesize existing datasets to quantify the effects of climate change and extreme events

4. Understand how lake dynamics during the winter impact the other seasons.
    - Expand sampling and monitoring programs to include year-round data collection
    - Improve our understanding of winter limnology and under-ice ecology

Community Engagement and Environmental Justice

Broad public engagement in Lake Superior nearshore issues is an important piece of nearshore science and management. Coastal communities, economies, and individual residents or visitors rely on nearshore environments for recreation, aesthetics, and subsistence. Working toward a shift from an informative model of public engagement to a more community-led or community-driven model[3] will help to ensure that needs are correctly identified and addressed. We acknowledge that this will require new approaches to community engagement. In the long term, this could increase trust between community members, the public, and local, state, and federal government agencies.

1. Develop an inventory of public education programs and related training resources across Lake Superior nearshore in Wisconsin and the Twin Ports region.
    - Identify how people connect or engage with local government, nearshore science, or water-related organizations

[3] https://research.ku.edu/community-engagement

- Identify resources that are currently available (may include public events, equipment/lending libraries, interpretive centers, K-12 curricula, public notifications and alerts, intersections of the arts and sciences, and training opportunities for professionals)

2. Assess environmental justice needs with an emphasis on local conditions and unique community needs.
    - Identify issues related to infrastructure, flood risk, and air quality trends
    - Assess fish consumption advisories, their limitations, and their relationship to recreational or subsistence fishing in contaminated areas
    - Evaluate the accessibility of information and physical nearshore spaces (i.e., Do coastal and nearshore spaces meet accessibility under the Americans with Disabilities Act?)

3. Improve science communication and community-led engagement in nearshore science and related local issues.
    - Explore opportunities to use crowd-sourced data (i.e., community science initiatives) to help meet current data gaps
    - Establish baseline data on the use/perceptions of estuaries (e.g., the St. Louis River Estuary) in order to measure changes over time
    - Determine how harmful algal blooms (HABs) impact perceptions and recreational use of nearshore waters
    - Assess how information about nearshore health and human safety is delivered (e.g., HABs, ice safety, swimming, paddling)
    - Determine how people connect with local government and water-related organizations

Tributaries, Estuaries, and Sediment/Nutrient Dynamics

Lake Superior is often characterized using lake-wide averages, but nearshore and offshore waters are distinct from one another. The nearshore waters of Lake Superior receive significant influence from both offshore waters and inflowing tributaries that vary in size and chemical composition. The mixing of these two types of water provides a biochemical hotspot in the nearshore region, which has important management implications for the lake.

1. Improve management of sediment and nutrient loading.
    - Quantify and characterize the contribution of tributaries to sediment and nutrients in the nearshore
    - Determine if current lake nutrient and sediment standards can sustain health nearshore, St. Louis River Estuary, and other surrounding tributaries ecosystems
    - Standardize data collection across space and time in order to model robust estimates of sediment and nutrient loads
    - Improve our understanding of how hydrodynamics influence sediment and nutrient transport and retention

- Create forecasting tools to estimate future loading
- Determine how coastal wetlands and estuaries are processing, retaining, and/or cycling sediments and nutrients
- Improve our understanding of the relative importance role of tributary loading, coastal bluff erosion, and legacy resuspension of sediment and associated nutrients

2. Identify sources of sediments and nutrients.
    - Identify the major sources of nutrients and sediment from legacy inputs, bluff erosion, tributary/estuary inputs, and other sources
    - Determine the relative contribution of sediment and nutrients from these different sources
    - Utilize high-resolution mapping to quantify bluff erosion
    - Predict how climate change will alter source inputs (i.e., storm events and wind)

3. Monitor and assess the impacts of restoration work or sediment and nutrient reduction actions in the watershed.
    - Assess if we currently collect the necessary data or suitable criteria to evaluate success of restoration efforts
    - Develop customized criteria as the threshold for 'good' water quality can vary among types of systems and within a given system

Emerging/Legacy Contaminants, Microplastics, and Food Web

A range of contaminants continues to influence environmental and human health in the nearshore waters of Lake Superior, in particular within the Twin Ports region. Contaminants are often grouped into legacy (e.g., mercury, PCBs) and emerging (e.g., PFAS, microplastics, endocrine disruptors) categories for research and management purposes. Invasive species and food web dynamics were also considered as part of the contaminants group, with a focus on invasive introduction through ballast water and the influence of invasive species on food web dynamics and contaminant fate and transport.

1. Improve our understanding of the food web in the St. Louis River Estuary and greater nearshore waters.
    - Establish a baseline understanding of the food web, including the role of invasive species, in order to inform ballast water treatment efforts and aid in detecting new invasive species
    - Examine the contaminant profiles of nearshore food webs
    - Use a combination of molecular and traditional approaches to understand current food-web dynamics and detect future changes

2. Investigate sources, fate, and transport of legacy and emerging contaminants, including microplastics, and invasive species.
    - Compare the roles of legacy and emerging contaminants
    - Identify and quantify legacy and emerging contaminants loadings from stormwater and tributaries
    - Study the role of regional nearshore connectivity in the transport of contaminants,

plastics, and invasives between the Twin Ports and Apostle Islands (and beyond)
- Explore the role of sediment size in contaminant fate and transport
- Quantify the extent of marine debris and microplastic pollution in the region
- Determine whether green infrastructure is an effective tool for removing legacy and emerging contaminants from stormwater

3. Comprehensively analyze existing sediment contaminant data, tributary loading data, and other existing data and databases to identify patterns.
    - Evaluate the St. Louis River Area of Concern clean-up efforts
    - Complete a comprehensive analysis of sediment contaminant data and loading from tributaries and stormwater
    - Determine the effects of sediment size distribution data on contaminant fate and transport (e.g., how do contaminants like microplastics or invasive species like zebra mussels move in nearshore waters of Lake Superior?)

Cyanobacterial Blooms

Cyanobacterial blooms have recently been observed in the nearshore waters of Lake Superior and St. Louis River Estuary, beginning in 2012. Cyanobacteria are a type of photosynthesizing bacteria that are often grouped with algae that have the ability to produce toxins. These blooms (also known as Harmful Algal Blooms (HABs) have become a major ecological and public health issue worldwide. Cyanobacterial blooms are typically associated with warmer, eutrophic waters, but they have also been observed in cold, oligotrophic systems such as Lake Superior. Until 2022, bloom samples tested for toxins in Lake Superior did not show any toxicity; however, in 2022 Microcystin was observed in the Nearshore of Lake Superior near Wisconsin Point Beach. Similarly, toxic blooms have been observed in the mouth of the St. Louis River Estuary (SLRE), which exchanges water with Lake Superior multiple times per day.

1. Improve our ability to predict when and where cyanobacterial blooms will occur.
    - Describe the phytoplankton community structure in nearshore waters, tributaries, and estuaries
    - Study the effects of climate change on driving blooms including long-term changes and extreme events
    - Identify the role of hydrodynamics in supporting cyanobacterial blooms
    - Identify the role of macronutrients (i.e., nitrogen and phosphorus) and micronutrients (i.e., iron) and stoichiometric balances in favoring cyanobacteria
    - Understand ecophysiological adaptations of cyanobacteria (i.e., heterocysts, akinetes, and gene expression)
    - Use remote sensing and paleolimnology techniques to investigate historical occurrences of blooms
    - Develop predictive models for near and long-term bloom forecasts

2. Develop and implement new methods to control cyanobacterial blooms.
    - Increase our understanding of biological control measures
    - Increase our understanding of the efficacy of different treatment options, including the applicability of treatments for closed systems (i.e., inland lakes) to open systems (i.e., Lake Superior nearshore)

- Develop options for nutrient control measures including internal and external loading

3. Improve our understanding of cyanotoxin production and health implications.
    - Identify the conditions that cause toxin production and toxin release
    - Understand how food web dynamics and community structures impact toxin production
    - Determine which cyanobacterial species are producing toxins in Lake Superior nearshore blooms
    - Identify the linkages between blooms and toxins (e.g., Do they occur separately or together?)

4. Prioritize locations for management of blooms.
    - Determine where cyanobacterial blooms are most severe (i.e., magnitude and/or toxicity)
    - Quantify the spatial and temporal distribution of blooms
    - Identify the source of blooms versus where blooms are observed
    - Address observation bias in bloom detection
    - Identify bloom areas that experience the most human interaction