Levi, Andrew (COMM)

From:	Esteban Chiriboga <esteban@glifwc.org>
Sent:	Monday, July 10, 2017 5:37 PM
To:	MN_COMM_Pipeline Comments
Cc:	MacAlister, Jamie (COMM); Jon Gilbert; Ann McCammon-Soltis; jcoleman@glifwc.org; 'Philomena Kebec'
Subject:	GLIFWC Comments on Line 3 DEIS
Attachments:	Line3_DEIS_Comments_Attachment1.pdf; Line3_DEIS_Comments_Attachment3.pdf; Line3_DEIS_Comments_Attachment2.pdf; Line3_DEIS_Comments_Attachment4.pdf; GLIFWC_Line3_DEIS_comments .pdf

Good afternoon,

Attached are the comments of the Great Lakes Indian Fish & Wildlife Commission on the Draft Environmental Impact statement for the Line 3 Replacement Pipeline project (docket numbers CN-14-916 and PPL-15-137). Please contact me with any questions.

Thanks,
Esteban

--
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GREAT LAKES INDIAN FISH & WILDLIFE COMMISSION
P. O. Box 9 • Odanah, WI 54861 • 715/682-6619 • FAX 715/682-9294

• MEMBER TRIBES •

MICHIGAN
Bay Mills Community
Keweenaw Bay Community
Lac Vieux Desert Band

WISCONSIN
Bad River Band
Lac Courte Oreilles Band
Lac du Flambeau Band
Red Cliff Band
St. Croix Chippewa
Sokaogon Chippewa

MINNESOTA
Fond du Lac Band
Mille Lacs Band

July 10, 2017

Jamie MacAlister
Environmental Review Manager
Minnesota Department of Commerce
85 7th Place East, Suite 280
Saint Paul, MN 55101-2198

Dear Ms. MacAlister,

Great Lakes Indian Fish and Wildlife Commission (GLIFWC) is an intertribal agency exercising delegated authority from 11 federally recognized Ojibwe (or Chippewa) tribes in Wisconsin, Michigan and Minnesota.[1] Those tribes have reserved hunting, fishing and gathering rights in territories ceded in the 1836, 1837, 1842, and 1854 treaties with the United States. GLIFWC's mission is to assist its member tribes in the implementation of their treaty-reserved harvesting rights and to protect habitats and ecosystems that support those resources subject to those rights.

GLIFWC's environmental and policy experts commented on the Draft Environmental Impact Statement (DEIS) documents for the Line 3 Replacement Project proposed by Enbridge Energy (docket numbers CN-14-916 and PPL-15-137) and I am transmitting those comments to you on behalf of those experts via this letter. These comments are submitted from an off-reservation Ceded Territory perspective and an individual GLIFWC member tribe may choose to submit comments from its own perspective. The general comments below will address the topics that were submitted to the Minnesota Department of Commerce (MNDOC) during the scoping period. Specific comments on the DEIS follow the general comments.

[1] GLIFWC member tribes are: in Wisconsin -- the Bad River Band of the Lake Superior Tribe of Chippewa Indians, Lac du Flambeau Band of Lake Superior Chippewa Indians, Lac Courte Oreilles Band of Lake Superior Chippewa Indians, St. Croix Chippewa Indians of Wisconsin, Sokaogon Chippewa Community of the Mole Lake Band, and Red Cliff Band of Lake Superior Chippewa Indians; in Minnesota -- Fond du Lac Band of Lake Superior Chippewa, and Mille Lacs Band of Chippewa Indians; and in Michigan -- Bay Mills Indian Community, Keweenaw Bay Indian Community, and Lac Vieux Desert Band of Lake Superior Chippewa Indians.

GLIFWC General Comments

Analysis of Impacts to Cultural Resources

Chapter 9 of the DEIS provides a good description of treaty rights and the tribal perspective on natural resources, the traditional lifeway, and pipeline issues. The chapter also incorporates information heard during meetings with tribes. GLIFWC's policy and environmental experts agree with the overall conclusion that the existing and proposed pipeline system will have long term detrimental effect on tribal members and tribal resources.

That being said, we notice a disconnect between the conclusions in chapter 9 and the metrics used to compare different alternatives in chapter 10.4. In this section, the comparison only develops metrics for archeological sites, historic sites and tribal land. The DEIS correctly states in chapter 9 that for tribes there is no distinction between natural resources and cultural resources. Therefore, the metrics in section 10.4 that compare route alternatives for Areas of Interest (AOIs) (e.g. musky lakes, calcareous fens, wild rice waters, etc.) should not only be evaluated from a utilitarian (e.g. number of fish harvested) perspective but also be described in the context of their cultural importance to the tribes. For example: the harvest of musky does not only provide food for the table but also provides the basis for the culturally essential activity of fishing; the harvest of wild rice provides both food and economic benefits to tribal members but is also the catalyst and focus of cultural activities across Anishinaabe territory. Loss of those resources or opportunities to access those resources has both a utilitarian and a cultural impact on the tribes. Both types of impact must be accounted for in Chapter 10. Only then can the information the MNDOC carefully collected and disclosed in Chapter 9, be properly accounted for in the identification of the least environmentally damaging alternative. 2634-1

Spatial Extent of Analysis

The DEIS uses a buffer of 2500 feet around the proposed pipeline routes to identify natural features (lakes, rivers etc.) and terrestrial habitats that could be impacted. This distance is appropriate for terrestrial environments. This distance however, is not appropriate to describe potential impacts of oil spills into waterways. Section 10.4 describes the rationale for the 2500-foot buffer along with a description of a 10-mile downstream region of interest (ROI) for rivers and streams that fall within the 2500-foot buffer. The only support for the 10-mile ROI is a report by Stantec that was commissioned by the applicant. The 10-mile ROI is not supported by river impacts observed in some recent spills. It is understandable that the applicant would wish to limit the area of the ROI, but the DEIS should seek a more comprehensive geographic scope for impact analysis. 2634-2

Experience from spills, in all size categories, at other sites indicates that oil can 2634-2 Cont'd travel large distances in a river system. The Kalamazoo River oil spill extended 32 miles downstream of the pipeline failure. Last year, the oil spill into the North Saskatchewan River in Canada extended for over 190 miles from the spill location. There are many factors that affect the distance and speed at which oil moves downgradient in a river. Factors include the specific gravity of the oil, the character of the river bed and bank, the flow of the river, etc. This complexity notwithstanding, 10 miles is not a reasonable distance to use as a ROI. The appropriate distance should vary for each stream/river crossing and should extend downgradient to the nearest major flow barrier. This barrier could be a dam or a large lake where flow energy decreases to the point of creating a depositional area for the oil. An example of this type of analysis conducted by GLIFWC is provided (Attachment 1).

History of Pipeline Safety and History of Enbridge Energy

As noted in GLIFWC's scoping letter, Enbridge Inc. has a questionable 2634-3 environmental record. The DEIS does describe the frequency of spills along pipelines in general when assessing the probability of future spills. However, a comprehensive review on the safety record of the applicant and the applicant's past performance in responding to spills and conducting cleanup and remediation activities is not found in the DEIS. Given that the DEIS does not dismiss the possibility of spills into the environment, an accounting of how Enbridge responds to these events is required, particularly when it comes to threats to treaty resources.

Surface and Groundwater Quality

In GLIFWC's scooping comments, we noted that the DEIS should put any 2634-4 reasonably foreseeable impacts of the Line 3 replacement project in the context of the Great Lakes Water Quality Agreement, which is a bi-national water quality agreement between Canada and the United States. The DEIS does not include this information.

The Lake Superior Lakewide Management Plan (LAMP) identifies pipelines as 2634-5 potential threats to the ecological integrity of Lake Superior (Attachment 2). The FEIS should describe the threats that this project poses to Lake Superior. The alternatives 2634-6 analysis should also weigh different alternatives on their relative threat to Lake Superior and the Lake Superior watershed.

Wetland Impacts and Wetland Mitigation 2634-7

There are gaps in the impact assessment that should be highlighted in the text. First, the extent of wetlands impacted by maintenance activities and routine integrity digs is unknown at this time. The DEIS characterizes these impacts as temporary or minor. GLIFWC environmental and policy experts disagree with this characterization. Maintenance activities, while minor compared to the scope of the entire project, do create hydrologic and biologic alterations that may not be temporary. For example, an integrity dig in a forested wetland would require clearing of trees that may take decades to grow again. The clearing facilitates introduction of invasive exotics species and once cleared, the forested wetland may never recover its previous function. The FEIS should clearly describe the potential for wetland impacts during these as yet undefined maintenance activities and describe a mechanism for mitigating these impacts. 2634-7 Cont'd

The DEIS does not adequately describe how long term vegetation clearing activities would be conducted within the pipeline corridor. Use of herbicides is a common method to prevent woody vegetation from becoming established near pipelines. The FEIS should describe methods that the applicant will use to keep the pipeline corridors clear of vegetation. If herbicides are to be used, the FEIS should characterize the impacts of these herbicides on biota and waterbodies. 2634-8

Chapter 10 page 33 states that wetlands are especially sensitive to spills. Because of this sensitivity, wetlands along the alternative routes should be mapped out to the 2500-foot buffer that is used for ecological impact assessment. The acreage of wetland in this buffer should be used in an analysis of potential impacts from spills. 2634-9

Financial Assurance

As discussed in GLIFWC's scoping comments, spills of oil transported through these pipelines are likely. The risk assessment in the DEIS confirms this position. Cleanup and remediation are costly and require long periods of time to complete. The Kalamazoo River oil spill has, to date, cost 1.2 billion dollars in cleanup and remediation costs. The DEIS should have described, in detail, the types of financial assurance that Enbridge will be required to provide to ensure that the public is not burdened with cleanup and remediation costs. Furthermore, financial assurance is needed to cover the costs of maintaining structural integrity of the abandoned Line 3 as well as the costs of ultimately removing pipelines from the right of way whenever that becomes feasible. 2634-10 Financial assurance information has been included in past EIS documents prepared by Minnesota state agencies (e.g. PolyMet FEIS) and should be included in the FEIS for the Line 3 replacement project.

Cumulative Impact Analysis

In GLIFWC's scoping letter we indicated that "the cumulative effects analysis must not be confined to the corridor of the pipeline projects. The analysis of cumulative effects should be broad enough to account for regional impacts such as habitat fragmentation and wetland fragmentation. Additional clarity on the spatial extent of the cumulative impact assessment is needed." Unfortunately, the DEIS does the opposite of our recommendation. It restricts the analysis to pipeline and transmission lines that cross the Line 3 route alternatives. This creates a scenario that is illogical to the extreme; the exclusion from cumulative analysis of a pipeline that runs parallel nearby, but does not 2634-11

2634-11 Cont'd

intersect the Line 3 ROW. This method of analysis is not actually cumulative because it not only ignores parallel pipelines but also ignores the existing road network and other regional activities that, in combination to the new Line 3, create regional scale impacts. For example, the existing road network is already causing habitat fragmentation and impacts to stream water quality (e.g. use of salt in winter). A question that the cumulative effects analysis should have addressed is, how do the different route alternatives expand existing habitat fragmentation? And how does the pipeline affect existing water quality impairments?

Different scales should also be used in the cumulative effect analysis to describe impacts to treaty resources. A look at industrial projects in the Ceded Territories and their existing impacts on tribal resources is needed to properly put the impacts of the proposed pipeline routes in context. A document providing information on oil transportation in the Ceded Territories is provided (Attachment 3). The document should be used to develop a cumulative effects assessment for tribal resources. 2634-12

The Environmental Protection Agency (EPA), in cooperation with Region 5 tribes, has developed a protocol for assessing cumulative effects on tribal resources. This guidance should be used in the EIS for the proposed pipeline projects. This guidance should be used to conduct an analysis that is fully cumulative in nature. An example of the types of cumulative effects analysis that the FEIS should provide is attached (Attachment 4). This cumulative effect assessment was developed by tribes and is part of the FEIS for the proposed PolyMet mine in northern Minnesota. 2634-13

Section Specific Comments

Chapter 2 – In the project description there is no discussion on the need to weigh down the pipe in wetland and stream/river areas. In previous pipeline construction projects conducted by Enbridge (i.e., Alberta Clipper and Southern Lights), the contractor conducting the project employed two different methods to add weight to the pipe. One was the use of a concrete coating on the pipe, while the other was to employ the use of gravel-filled saddle bags which hung over the pipe. The practice of adding weight to the pipe in certain areas should have been included in the project description, along with any impacts associated with adding weight to the pipeline. Given that the route alternatives are proposed in a very water rich region and that the pipeline will have hundreds of water crossings, this is an important data gap. 2634-14

2634-15

Section 2.3.2.3 – This section states that cathodic protection would be installed within a year after construction. However, the DEIS does not mention that each cathodic protection site requires electrical power and other construction activities that are needed to bring electricity to the site (access/maintenance roads, generators, electrical lines, etc.). Furthermore, any wetland impacts associated with cathodic protection site construction and operation do not appear to be included in the acreage calculations for wetland 2634-16

impacts. All impacts associated with cathodic protection requirements for the pipeline 2634-16
must be described in the FEIS. Cont'd

This section also states that coating would be added to the pipeline. The DEIS 2634-17
states in several locations that the coating is different from the one used in the existing
Line 3 which is failing. The DEIS does not provide any information on the chemical 2634-18
composition of the coating and the environmental threats that may result as the coating
ages. The FEIS should provide an accounting of the impacts that the coating on the
existing line 3 are causing to the aquatic environment as it disintegrates. The effects of
coating, both old and new, must be described in the FEIS.

Section 6.3.1 – The analysis in the section focuses on wetlands that are included in the
public waters database. The actual acreage of affected wetlands can only be defined after 2634-19
wetlands have been properly delineated and this process is likely to significantly increase
the acreage of impacted wetlands. Ideally, the delineation should have been done prior to
the development of the DEIS under the supervision of the Army Corps of Engineers. The
lack of detailed wetland information along the proposed pipeline routes is a significant
data gap and conclusions on direct and indirect wetland impacts in the DEIS are thus not
reliable.

Section 6.3.1.2.1 –This section discusses Minnesota's water quality regulations, but does 2634-20
not discuss, nor acknowledge the Fond du Lac Band's Water Quality Standards, which
include use designations different from the state and that may affect which standards
apply to a particular water. Fond du Lac's Water Quality Standards are applicable for
both RA-07 and RA-08. This section should also acknowledge the Great Lakes Water 2634-21
Quality Agreement that applies to all routes except RA-04.

Section 6.3.1.2.3 – The section is titled "Regional Analysis of the Quality of Existing 2634-22
Surface Water Conditions – Tullibee and Wild Rice" However, the section does not
include any information on stressors to wild rice or any conservation efforts related to
wild rice. The State of Minnesota wild rice water quality standard should also be
referenced.

Section 6.3.1.2.4 – This section describes potential degradation of surface water quality 2634-23
with a focus on potential spills. This section should also describe procedures that the
applicant will use to manage drilling mud and its proper disposal to prevent spills of this
material. Trout streams are particularly vulnerable to sedimentation from construction
activities or spills of drilling mud.

It is also unclear how impacts to surface water quality resulting from pipeline 2634-24
construction and operation would be measured. What surface water quality data is
available to establish baseline/existing conditions in the streams and wetlands that the
pipeline would cross? Baseline water quality data is critical to assessing future impacts of
the project and defining mitigation and restoration activities.

This section also assesses potential impacts to wild rice. The applicants proposed route crosses five wild rice waters which constitutes a very significant impact. It is stated “Although the Applicant would restore the hydrology and soils of the affected wild rice waterbodies after construction, rice yield would be reduced in the portion of the waterbody directly affected by the repair or replacement activities for the first growing season after construction.” It is not clear what background information is used to draw this conclusion. Yields in a healthy wild rice bed are highly variable from year to year whether the site is affected by a stressor or not. Sedimentation and changes in water levels can change the function of a rice bed for many years or change it permanently. In addition, seeding of wild rice would likely be needed to restore a site. How would this re-seeding be done? Finally, how would the success or failure of the hydrology and soil restoration efforts be measured? 2634-25

The significance of wild rice to the Ojibwe people cannot be understated. It provides sustenance, spiritual and cultural value, and provides tribal members with economic opportunity. The wild rice bodies identified in the applicant’s proposed route are unique and irreplaceable. While this section identifies that major impacts to wild rice bodies could occur during construction, it fails to anticipate the likelihood that a small or large spill could result in the permanent loss of wild rice in these waterbodies. The FEIS should correct this oversight. 2634-26

Section 6.3.7 – This section describes potential air emissions from the project. One significant source of emissions is diesel engines but the DEIS does not investigate alternatives to using diesel. These alternatives should be investigated and compared to diesel emissions to define the least environmentally damaging alternative. 2634-27

Section 6.3.7.3.1 – States that the Applicant would minimize dust generation from construction activities by wetting soils and limiting working hours in residential areas. Chemical additives are commonly used in dust suppression activities. The FEIS should list any chemical additives that would be added to the water and their known effects on the surrounding environment. 2634-28 In addition, the FEIS should identify what the sources would be used to provide dust suppression water, the proximity of those sources to drinking water sites, and whether other water withdrawals are occurring at each site. 2634-29

Section 8.3 – This section should clearly state that in situ abandonment of the pipeline would require inspections and maintenance in perpetuity. The FEIS should describe how this would be done, given that it is by no means obvious. 2634-30

Section 8.3.1.1 – This section discusses potential impacts of leaving old line 3 in place. However, water quality impacts of the disintegrating coating on the abandoned pipeline are not discussed. 2634-31

Section 8.3.1.2 – This section states that Enbridge would maintain cathodic protection in the abandoned pipeline. However, in earlier sections of the DEIS, it states that the coating on the existing pipeline is failing. Additional information is needed to determine if maintaining cathodic protection is enough to protect the environment in perpetuity. In addition, financial assurance is needed to maintain this cathodic protection should Enbridge become insolvent in the future. 2634-32

Section 8.3.1.3 – This section states that long-term effects from subsidence along the 2634-33
abandoned pipeline could be significant and would require site-specific mitigation
measures. The section does not contain detailed information about what steps Enbridge
would take in the event subsidence occurs on the abandoned line. Information on
inspection frequency for the abandoned line is needed as well as financial assurance to 2634-34
ensure subsidence issues can be addressed in the future. Finally, we agree that
remediation efforts will depend on site specific conditions. However, details on the types
of actions that could be taken at different sites should be provided.

Section 8.3.1.5 – This section states that "Costs for future site-specific mitigation measures…are uncertain and would depend on the nature of the mitigation measures." Because of this uncertainty, the applicant must provide adequate financial assurance to cover these costs in the event the company becomes insolvent. This is particularly important because maintenance of a pipeline that is abandoned in place must be perpetual. 2634-35

Section 9.4.4.1.1 – This section discusses traditional uses of natural resources. In this section, only Sweet Grass - Wiingash and Cedar – Giizhig(aandag) are mentioned specifically as plants having cultural significance. However, many more plants are also very significant. The text should reflect that the two plants included in this section are for illustrative purposes and acknowledge there are many more that could be included. The text should refer to "Plants Used by the Great Lakes Ojibwa" published by GLIFWC (Meeker, 1993). This book provides information on 384 species of plants that are gathered and used by the Ojibwe. 2634-36

Section 9.6.1 – This section discusses potential climate change impacts in a general sense, it should be noted here that the loss of a resource to tribes cannot be replaced in a geographically different location. For example, loss of a wild rice bed that is destroyed by an oil spill cannot be replaced by a rice bed in a lake a few miles away because of ties to tribal members that are place based. Therefore, the section should describe the ties of tribal members to the Ceded Territories and Reservations and state that they cannot move to other areas in order to preserve the traditional lifeway. 2634-37

Chapter 10 – This chapter describes the risk assessment for pipeline leaks and failures.
The section states that pipeline capacity does not change spill risk. The spill risk analysis 2634-38
is entirely dependent on the length of the pipeline. While this is true for the expected
return time of an incident, it is not true for the volume of oil that could be released if a

section of the pipeline fails. A larger diameter pipeline can contain larger volumes of oil in any single section. In fact, increasing the volume of oil transported by Line 3 is one of the objectives of this replacement project. Section 10 should describe the potential increase in the volume of oil that could be spilled by the new line as compared to the existing line 3. 2634-38 Cont'd

We look forward to working with the Minnesota Department of Commerce as the EIS process moves forward. Please contact me at 608-263-2873 with any questions.

Sincerely,

Esteban Chiriboga

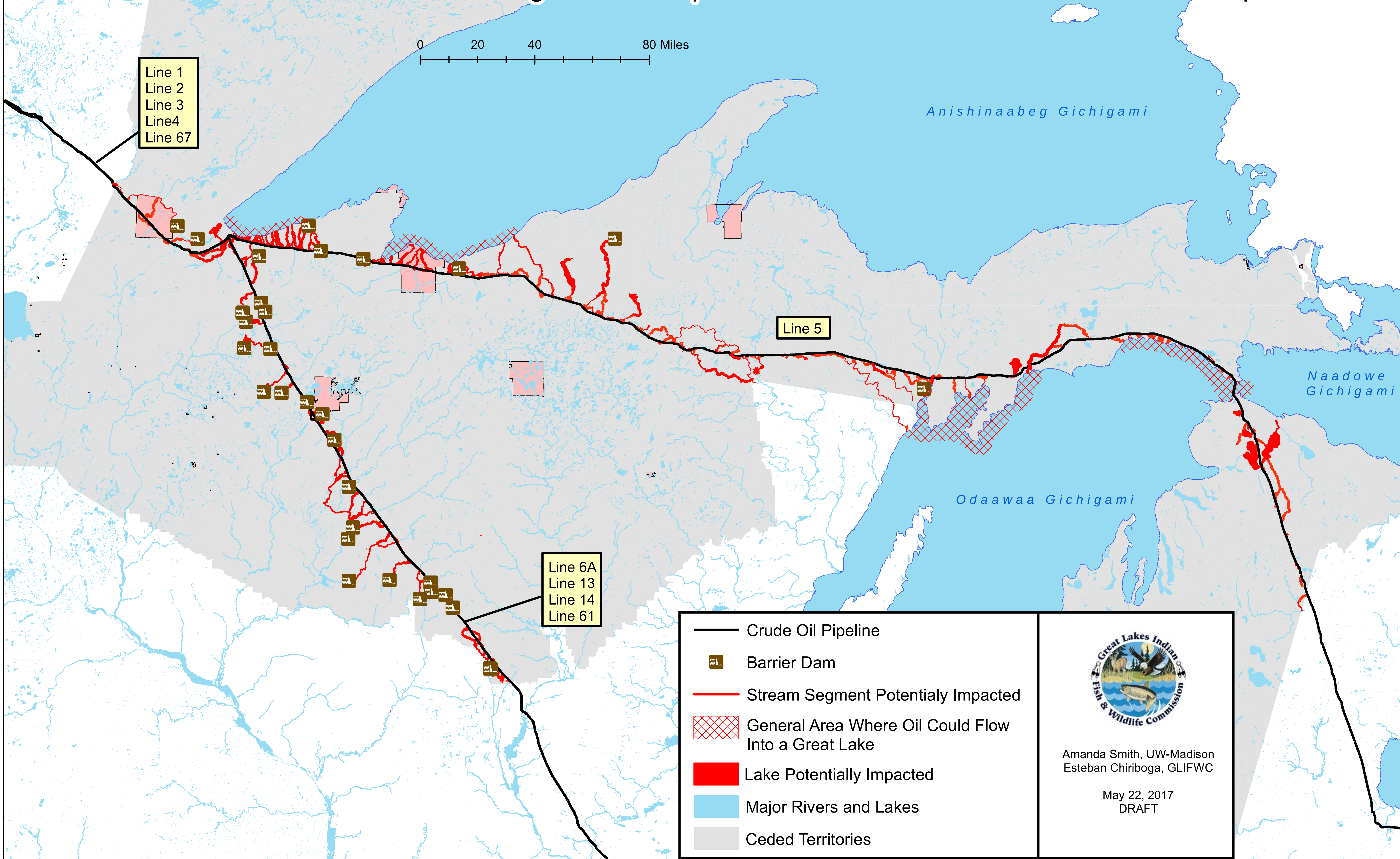
Esteban Chiriboga
GLIFWC Environmental Specialist

cc. Jonathan Gilbert Ph.D., GLIFWC Director, Biological Services
Ann McCammon Soltis, GLIFWC Director of Intergovernmental Affairs
John Coleman Ph.D., GLIFWC Environmental Section Leader
Philomena Kebec, GLIFWC Policy Analyst

Sources Cited

Meeker, James E., Elias, Joan E., and Heim, John A., “Plants Used by the Great Lakes Ojibwa”, Great Lakes Indian Fish and wildlife Commission, 1993.

Rivers and Streams Intersecting Crude Oil Pipelines and Potential Downstream Extent of a Spill



Amanda Smith, UW-Madison
Esteban Chiriboga, GLIFWC

May 22, 2017
DRAFT

Lake Superior

Lakewide Action and Management Plan

2015 - 2019

The Lake Superior Partnership

September 2016

ACKNOWLEDGEMENTS

This document was made possible by the many individuals and organizations working to restore and protect the Lake Superior ecosystem. The document builds upon many relevant local, tribal, state provincial, national and binational plans. Special thanks to all those involved in preparing *A Biodiversity Conservation Strategy for Lake Superior* (LSBP, 2015); to the Great Lakes Fishery Commission's Lake Superior Technical Committee; to the Great Lakes Water Quality Agreement Lakewide Management Annex (Annex 2) Subcommittee; to the numerous stakeholder groups that helped to refine the document through their review and comments at various stages of development; and to all the individuals of the Lake Superior Partnership who contributed to the LAMP's development and who will be collaborating during the implementation of this plan.

This document was prepared by the Lake Superior Lakewide Action and Management Plan Writing Team, co-chaired by Rob Hyde of Environment and Climate Change Canada (formerly Environment Canada) and Liz LaPlante of the U.S. Environmental Protection Agency. Writing Team members included: Jen Ballinger (GLIFWC), Marilee Chase (MNRF), Faith Fitzpatrick (USGS), John Jereczek (MNDNR), Ann McCammon-Soltis (GLIFWC), Michelle McChristie (MOECC), Henry Quinlan (USFWS), Mike Ripley (CORA), Lisa Sealock (ECCC), Stephanie Swart (MDEQ), Brent Schleck (NOAA), Amy Thomas (Battelle), Michele Wheeler (WDNR) and Laurie Wood (ECCC). The contributions of many photographers, both amateur and professional, are greatly appreciated, as is the scientific input and reviews provided by Great Lakes researchers and managers.

Lake Superior Partnership Agencies, 2015

1854 Treaty Authority	Natural Resources Conservation Service
Bad River Band of Lake Superior Chippewa	Ontario Ministry of Natural Resources and Forestry (MNRF)
Bay Mills Indian Community (BMIC)	Ontario Ministry of the Environment and Climate Change (MOECC)
Chippewa-Ottawa Resource Authority (CORA)	Parks Canada
Environment and Climate Change Canada (ECCC)	Red Cliff Band of Lake Superior Chippewa
Fisheries and Oceans Canada (DFO)	U.S. Army Corps of Engineers (USACE)
Fond du Lac Band of Lake Superior Chippewa	U.S. Environmental Protection Agency (USEPA)
Grand Portage Band of Lake Superior Chippewa	U.S. Fish and Wildlife Service (USFWS)
Great Lakes Indian Fish and Wildlife Commission (GLIFWC)	U.S. Forest Service (USFS)
Keweenaw Bay Indian Community (KBIC)	U.S. Geological Survey (USGS)
Michigan Department of Environmental Quality (MDEQ)	U.S. National Park Service (NPS)
Minnesota Department of Health (MDH)	University of Minnesota Sea Grant Program
Minnesota Department of Natural Resources (MNDNR)	University of Wisconsin Sea Grant Program
Minnesota Pollution Control Agency (MPCA)	Wisconsin Department of Natural Resources (WDNR)
National Oceanic and Atmospheric Administration (NOAA)	

Cover page photo credits

Left:
Nipigon Bay, Ontario. Credit: D. Crawford.
Oliver Bay on Bete Gris Pointe, Michigan. Credit: J. Koski, KBIC.

Right
Pebble Beach, Marathon, Ontario. Credit: K. Taillon.
Swallow tail butterfly. Credit: H. Quinlan, USFW

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1.0 EXECUTIVE SUMMARY

The Lake Superior basin is one of the most beautiful and unique ecosystems in North America. Containing ten percent of the world's surface fresh water, Lake Superior is in the best ecological condition of all of the Great Lakes.

Although the Lake Superior ecosystem is in good condition, there are serious threats including: aquatic invasive species, climate change, reduced habitat connectivity between the open lake and tributaries, chemical contaminants, substances of emerging concern, and habitat destruction.

To address these challenges, the Lake Superior Lakewide Action and Management Plan (LAMP) was developed, building upon a wide variety of local, tribal, state, provincial, national and binational plans, including "A Binational Program to Restore and Protect the Lake Superior Basin." The 2015 Lake Superior LAMP is a binational action plan for restoring and protecting the ecosystem. The LAMP documents the following:

- Current environmental conditions;
- Threats to the ecosystem;
- Lakewide objectives;
- Priorities for future scientific investigations; and
- Actions and projects to address threats and to achieve lakewide objectives.

What is the LAMP?

Under the *Great Lakes Water Quality Agreement (GLWQA)*, the governments of Canada and the United States have committed to restore and maintain the physical, biological and chemical integrity of the waters of the Great Lakes.

The Lakewide Action and Management Plan (LAMP) is a binational action plan for restoring and protecting the ecosystem. The LAMP is developed by the Lake Superior Partnership, which is led by the USEPA and Environment and Climate Change Canada, and will be implemented binationally in cooperation with all Lake Superior stakeholders.

The Lake Superior LAMP was written by members of the Lake Superior Partnership, including representatives of federal, state, provincial and tribal agencies from both the U.S. and Canada. In turn, these agencies work closely with many others to manage and protect their respective portions of the Lake Superior ecosystem.


Lake Superior has some true wilderness areas. Pukaskwa National Park alone includes 219 km (136 mi) of undeveloped coastline. Credit: Parks Canada.

The Lake Superior Partnership will use this 2015 LAMP over the course of the next five years as a guide to identify, prioritize, and implement actions to restore and protect the Lake Superior ecosystem. Protection of this resource is of the highest priority and a central tenet of ecosystem management for the Lake

Superior Partnership. A new LAMP will be developed in 2020 and every five years thereafter, with the goal of protecting this incomparable resource for generations to come.

One of the key underlying principles of the Lake Superior Partnership is the importance of involving all Lake Superior stakeholders. The ultimate success of restoring and maintaining the Lake Superior ecosystem depends on the efforts of everyone.

1.1 State of Lake Superior

The Lake Superior ecosystem continues to be in good condition, as exemplified by:

- Fisheries in good condition, supported by a robust lower food web (e.g., small, shrimp-like *Diporeia* and *Mysis*);
- Self-sustaining populations of Lake Trout and increasing abundance of Lake Sturgeon;
- Good ecological status of most major habitats on a lakewide scale, including coastal wetlands; and
- Generally decreasing or stable concentrations of legacy contaminants in the environment (e.g., PCBs).

However, the ecosystem faces a number of threats, including:

- Existing aquatic invasive species (e.g., Sea Lamprey) and the risk of new invaders;
- Effects of climate change on the ecosystem (e.g., warming surface waters are stressing some cold-water species);
- Areas of impaired habitat connectivity between the tributaries and the open lake;
- Fish consumption advisories due to legacy pollutants such as mercury and PCBs;
- Substances of emerging concern, such as microplastics; and
- Other threats (e.g., mining impacts and energy sector activities).

Pictured Rocks National Lakeshore, Michigan. Credit: S. Swart.

1.2 Lakewide Ecosystem Objectives

The Great Lakes Water Quality Agreement (GLWQA) calls for the development of lake-specific ecosystem objectives, to serve as a "benchmark against which to assess status and trends in water quality and lake ecosystem health." While GLWQA Lake Ecosystem Objectives (LEOs) have not been finalized for Lake Superior, there are nine existing lakewide objectives for water quality and habitat conditions, as found in Table 1, below.

The nine existing lakewide objectives seek to protect the physical, biological and chemical integrity of Lake Superior. Objectives for the seven major habitat types (objectives 1-7 in Table 1) were developed and assessed as part of *A Biodiversity Conservation Strategy for Lake Superior* (LSBP, 2015). These seven objectives address the physical and biological integrity of Lake Superior. The remaining two objectives (objectives 8 and 9 in Table 1) address the chemical integrity of Lake Superior. One chemical-related objective is to achieve zero release of nine specific toxic substances, which is the objective of a unique long-term pilot program in Lake Superior (see *Lake Superior Zero Discharge Demonstration Program and 1990-2010 Critical Chemical Reduction Milestones* report; LSBP, 2012). The final objective seeks to protect Lake Superior from contamination due to additional substances of concern.

Table 1. Existing Lakewide Objectives

#	Objective	Status*
1	Maintain deepwater and offshore waters in good ecological condition.	GOOD
2	Maintain nearshore zone and reefs in good ecological condition.	GOOD
3	Maintain embayments and inshore areas in good ecological condition.	GOOD
4	Maintain coastal wetlands in good ecological condition.	GOOD
5	Maintain islands in good ecological condition.	GOOD
6	Maintain coastal terrestrial habitats in good ecological condition.	GOOD
7	Maintain tributaries and watersheds in good ecological condition.	FAIR
8	Achieve zero release (from within the Lake Superior basin) of nine persistent bioaccumulative toxic substances.**	GOOD
9	Protect the Lake Superior basin from contamination resulting from additional substances of concern. ***	GOOD

* Ecological status was determined through the Conservation Action Planning (CAP) Framework, as described in *A Biodiversity Conservation Strategy for Lake Superior* (LSBP, 2015). Available Great Lakes indicators (i.e., “SOLEC indicators”) were utilized through the CAP process; details of the assessment and all indicators used are available in technical documents posted on binational.net.
Ratings for Ecological Status:
Good: In a state that is within the accepted range of variation, but some management intervention may be required for some elements.
Fair: In a state that is outside the range of acceptable variation and requires management.
Poor: Allowing the goal to remain in this condition for an extended period will result in permanent ecosystem change.
**The nine persistent bioaccumulative toxic substances include: mercury, PCBs, dioxin, hexachlorobenzene, octachlorostyrene and four pesticides (dieldrin, chlordane, DDT, and toxaphene).
*** Additional substances of concern include pharmaceuticals and personal care products, microplastics, and nutrients.

1.3 Science and Monitoring Priorities

A wide range of ongoing and special intensive science and monitoring activities are undertaken to determine ecosystem conditions and trends, assess threats, and inform actions that are necessary to achieve lakewide objectives.

The primary effort to determine lakewide science and monitoring priorities is undertaken through the Lake Superior Cooperative Science and Monitoring Initiative (CSMI), an intensive, binational scientific examination which is conducted on a five-year rotational basis. The next Lake Superior CSMI field year is 2016, with data interpretation, analysis and reporting occurring in subsequent years.

Current Lake Superior science and monitoring priorities, as developed by the Lake Superior Partnership with input from hundreds of stakeholders, include but are not limited to, the following:

- Confirm lower food-web health and stability;
- Determine progress being made on reducing the nine persistent, bioaccumulative and toxic substances;
- Determine progress being made on Lake Sturgeon rehabilitation;
- Provide information needed to support implementation of fish rehabilitation plans (e.g., Walleye, Coaster Brook Trout, and Lake Sturgeon);
- Assess baseline water quality conditions in areas of critical habitat and potential significant land-use change; and
- Identify vulnerable cold-water tributaries to Lake Superior from various stressors such as climate change.

Working Together

Lake Superior's generally good ecological condition is a result of a history of strong and ongoing actions, with an emphasis on prevention. Actions are occurring at all scales – from national, state, provincial, tribal, First Nation, Métis, and municipal programs, to lakewide initiatives, to local projects by communities, businesses, and households.

1.4 Actions to Address Threats and Achieve Lakewide Objectives

The LAMP includes a list of 74 management actions to address threats to water quality and achieve lakewide objectives. These actions can be used to help identify, support or coordinate ongoing or new projects. The actions are organized under eight categories:

- Aquatic invasive species;
- Climate change;
- Dams and barriers;
- Existing chemicals of concern;
- Additional substances of concern;
- Other threats, including resource development;
- High-quality habitats; and
- Native species management.

Actions have been identified by the Lake Superior Partnership in consultation with Lake Superior stakeholders and the public. The primary sources of the actions are: *A Biodiversity Conservation Strategy for Lake Superior* (LSBP, 2015), *Lake Superior Climate Change Impacts and Adaptation Report* (Huff and Thomas, 2014), the *Lake Superior Aquatic Invasive Species Complete Prevention Plan* (LSBP, 2014), the *Zero Discharge Demonstration Program* (ongoing) and *1990-2010 Critical Chemical Reduction Milestones* report (LSBP, 2012).

The actions are fairly broad in their scope and can be used to help identify, support or coordinate ongoing or new projects for Lake Superior. For example, the actions were used to help identify Lake Superior Partnership projects over the years 2015-2019, as described below.

1.5 Lake Superior Partnership Projects for 2015-2019

To narrow down the list of 74 management actions, the Lake Superior Partnership has identified 29 projects, as listed in Table 2, below. Projects were identified by Lake Superior management experts who comprise the Lake Superior Partnership. To be identified and confirmed as a project, several factors were considered: relevancy to the broader actions needed to address a threat (referred to above), current work underway, current state of the issue, potential for a high-degree of coordinated action, contribution to achieving lakewide objectives, and achievability over the next five years.

1.6 Implementation and Accountability

Implementation of projects will remain one of the highest priorities of the individual organizations that make up the Lake Superior Partnership. Organizations identified in Section 9.1 will take action, to the extent feasible, given budget constraints and domestic policy considerations.

Internal agency work planning and reporting will help track commitment progress and provide an accountability mechanism for the results of each individual organization. Internal Lake Superior Partnership committee workplans will help track implementation at a higher level to support coordination between organizations and in the engagement of others, as well as to support lakewide reporting on LAMP implementation (e.g., annual updates to the public on the LAMP).

Table 2. Lake Superior Partnership Projects: 2015-2019

Projects 2015-2019	Agencies Involved
Aquatic Invasive Species	
1. Add additional locations to the lakewide aquatic invasive species early detection/rapid response surveillance projects.	1854 Treaty Authority, CORA, DFO, Fond du Lac, KBIC, MDEQ, MNRF, NOAA, NPS, Parks Canada, USEPA, USFS, USFWS, WDNR
2. Undertake additional aquatic invasive species prevention outreach and education, including discussions with recreational boaters, and installation of lake access site signage.	1854 Treaty Authority, Bad River, BMIC, Fond du Lac, GLIFWC, Grand Portage, KBIC, MDEQ, Minnesota Sea Grant, MNRF, NPS, Parks Canada, Red Cliff, USFS, WDNR
3. Maintain and improve effectiveness of Sea Lamprey control, prevent introduction of new species, and limit expansion of previously-established aquatic invasive species.	1854 Treaty Authority, Bad River, BMIC, CORA, DFO, GLIFWC, NPS, Parks Canada, Red Cliff, USFWS, USGS
4. Contribute to the elimination of European Common Reed (i.e., *Phragmites australis, subsp. australis*) from the Lake Superior basin by undertaking or supporting lakewide distribution mapping, early detection efforts, and control efforts.	1854 Treaty Authority, Bad River, Fond du Lac, GLIFWC, MDEQ, MNDNR, MNRF, NPS, Parks Canada, Red Cliff, USEPA, USFS, WDNR
Climate Change	
1. Undertake or support outreach and education to stakeholders on the impacts of climate change in the Lake Superior ecosystem, including potential changes to habitat ranges, stormwater management, and nutrient/chemical cycling.	1854 Treaty Authority, Bad River, BMIC, CORA, ECCC, Fond du Lac, GLIFWC, Grand Portage, KBIC, MOECC, NOAA, NPS, Red Cliff, USEPA, USFS, USGS
2. Support local climate change initiatives to help communities and/or natural resource managers develop adaptation plans.	1854 Treaty Authority, Bad River, BMIC, CORA, Fond du Lac, GLIFWC, Grand Portage, KBIC, Minnesota Sea Grant, MNDNR, MOECC, NOAA, NPS, Red Cliff, USFS, USFWS, USGS
Dams & Barriers	
1. Improve access to high-resolution stream/river barrier data and species-specific benefit analyses in support of decision-making on Lake Superior habitat connectivity decisions.	Bad River, Fond du Lac, KBIC, MNRF, Red Cliff, USFS, USFWS, WDNR
2. Establish a collaborative Lake Superior streams improvement initiative in Canada to undertake stream monitoring, assessment, and data management activities, and to help identify stream protection and restoration priorities.	MNRF

Projects 2015-2019	Agencies Involved
Dams & Barriers (continued)	
3. Prepare an environmental studies report to explore the feasibility, costs and benefits associated with the options surrounding the proposed decommissioning of Ontario's Camp 43 dam, and the construction of a corresponding multi-purpose Sea Lamprey barrier at Eskwanonwatin Lake.	MNRF
Chemical Contaminants	
1. Continue outreach and education to the public on mercury toxicity; pathways into fish, wildlife and humans; and actions that can be taken to help remove mercury from the basin.	Bad River, CORA, Fond du Lac, GLIFWC, Grand Portage, KBIC, MDEQ, MOECC, NOAA, NPS, Red Cliff, USEPA, USFS, USFWS, USGS
2. Conduct a data synthesis of available mercury monitoring data for the Lake Superior basin to improve the inter-jurisdictional understanding and communication of mercury trends in the Lake Superior ecosystem.	Bad River, ECCC, Fond du Lac, MPCA, NOAA, NPS, USGS
3. Document which agencies and local governments collect and track the types and amounts of pesticides disposed, as feasible, so as to inform existing pesticide collection programs, such as clean sweeps. Information will be used to assess the potential for expanding collections to additional geographic areas.	ECCC, MDEQ, WDNR
4. Continue to support open burning abatement programs, such as "Bernie the Burn Barrel," to achieve reductions in the release of dioxins and furans into the Lake Superior basin from the practice of residential burning of garbage.	Bad River, CORA, Fond du Lac, KBIC, MOECC, MPCA, Red Cliff, WDNR
Additional Substances of Concern	
1. Increase efforts to educate the public on new and emerging chemicals; their potential toxicity; pathways into fish, wildlife and humans; and how the public can help remove these chemicals from the basin. Put special emphasis on the topics of microplastics and safer alternatives for personal care, household cleaning products, and pesticides/herbicides.	BMIC, ECCC, Fond du Lac, Grand Portage, KBIC, MOECC, NOAA, NPS, Red Cliff, USGS, USFWS
2. Compile information on the type and status of different pharmaceutical collection efforts in the basin and other efforts to locate and properly dispose of unwanted medication. Use this information to identify opportunities for further action.	Bad River, ECCC, KBIC, MPCA, USFWS, USGS, WDNR

Projects 2015-2019	Agencies Involved
Other Existing and Emerging Threats	
1. Provide oil spill responders with better access to existing and new spatial data (as available) on ecologically-important and sensitive habitats.	Bad River, CORA, Fond du Lac, GLIFWC, MOECC, NOAA, NPS, Parks Canada, USFWS, USGS
2. Support efforts to increase the sustainable use of Lake Superior basin resources, with specific emphasis on projects on green stormwater infrastructure, incorporating traditional ecological knowledge into projects, and/or recognizing the monetary value of ecosystem services.	1854 Treaty Authority, Bad River, BMIC, CORA, Fond du Lac, GLIFWC, KBIC, MOECC, NOAA, NPS, Parks Canada, Red Cliff, USEPA, USFWS
3. Outreach and engage with communities and others at the local scale on the value of water and best water use practices and policies.	Bad River, CORA, Fond du Lac, GLIFWC, KBIC, MDEQ, Red Cliff, USFWS, USGS, WDNR
4. Map current and proposed mining activities in the Lake Superior basin to support understanding of the potential and cumulative impacts of mining on important habitat sites. Assess impacts due to other stressors, such as climate change.	1854 Treaty Authority, CORA, Fond du Lac, GLIFWC, MPCA, NPS, USGS
High-Quality Habitats	
1. Investigate, evaluate, and if feasible, implement dredging solutions or other habitat restoration efforts at Buffalo Reef, Michigan.	GLIFWC, NOAA, USACE, USEPA
2. Improve the mapping and quantification of important spawning, nursery and foraging habitat for key fish species to support protection and restoration decision-making.	1854 Treaty Authority, CORA, Fond du Lac, GLIFWC, MNRF, NPS, Parks Canada, Red Cliff, USEPA, USFWS, USGS, WDNR
3. Promote and support local and regional implementation of *A Biodiversity Conservation Strategy for Lake Superior* (LSBP, 2015) and corresponding Regional Plans.	1854 Treaty Authority, Bad River, BMIC, CORA, ECCC, Fond du Lac, GLIFWC, Grand Portage, KBIC, MDEQ, MNDNR, MNRF, NOAA, NPS, Parks Canada, Red Cliff, USFS, USFWS, WDNR
4. Formally establish the Lake Superior National Marine Conservation Area in Canada, and Federal-Provincial harmonization committee to develop and implement management priorities for the area.	MNRF, Parks Canada
5. Integrate spatial data standards, methodologies and geomatic products to help identify and prioritize sites for habitat protection and rehabilitation.	GLIFWC, MNDNR, NOAA, NPS, USEPA, USFWS, USGS
6. Protect and enhance important coastal wetland habitats on priority state and tribal lands in western Lake Superior, including Bark Bay, Frog Bay, Bad River/Kakagon Sloughs and the St. Louis River estuary.	1854 Treaty Authority, Bad River, Fond du Lac, GLIFWC, KBIC, MNDNR, NOAA, NPS, Red Cliff, USEPA, USFS, USFWS, USGS, WDNR

Projects 2015-2019	Agencies Involved
Diverse, Healthy and Self-sustaining Native Species Populations	
1. Develop and update stock assessment models to improve management of self-sustaining commercial and sport fisheries for Lake Trout, Cisco, and Lake Whitefish.	Bad River, BMIC, CORA, GLIFWC, Grand Portage, MNRF, NPS, Red Cliff, USFWS, USGS, WDNR
2. Rehabilitate populations of indigenous aquatic species (e.g., Brook Trout, Lake Sturgeon, Muskellunge, Walleye, etc.).	Bad River, CORA, DFO, Grand Portage, KBIC, MNRF, NPS, Red Cliff, USFWS, WDNR
3. Update the Ecopath with Ecosim (EwE) ecological model (www.ecopath.org) with recently acquired data and knowledge in order to explore: a) how recent changes in fish abundance could be influencing the food web; b) how the ecosystem may respond to current and potential threats; and c) how components of the ecosystem may respond to potential management actions.	CORA, GLIFWC, Grand Portage, MNRF, USEPA, USFWS, USGS
4. Develop and implement improved monitoring approaches for inshore, embayment, and tributary fish populations.	1854 Treaty Authority, BMIC, CORA, Fond du Lac, GLIFWC, Grand Portage, NPS, Red Cliff, USFWS, USGS

Projects are not ranked in priority order. Agencies are listed in alphabetical order.

2.0 INTRODUCTION

The Lake Superior Lakewide Action and Management Plan (LAMP) is a binational action plan for restoring and protecting the Lake Superior ecosystem. The LAMP also includes information on Lake Superior conditions, stressors, threats, current strategies and science priorities.

In outlining management actions, the LAMP will guide and support the work of natural resource managers, decision-makers, Lake Superior stakeholders and the general public.


Pictured Rocks National Lakeshore, Michigan. Credit: S. Swart.

2.1 Great Lakes Water Quality Agreement (GLWQA)

The 1972 *Agreement between the United States of America and Canada on Great Lakes Water Quality* (known as the Great Lakes Water Quality Agreement or GLWQA) established formal commitments to restore and maintain the water quality of this international freshwater resource. The GLWQA was amended in 1983, 1987, and most recently in 2012. The 2012 protocol amending the GLWQA reaffirms the United States' and Canada's determination "to protect, restore, and enhance water quality of the Waters of the Great Lakes and their intention to prevent further pollution and degradation of the Great Lakes Basin Ecosystem" (Canada and United States, 2012).

The GLWQA sets forth nine General Objectives which outline desired water quality conditions. As described in more detail in Section 4.0, the General Objectives direct that Great Lakes waters should: be a source of safe, high quality drinking water; allow for swimming and other recreational uses; allow for human consumption of fish and wildlife; be free from pollutants harmful to human health, aquatic organisms, and wildlife; support healthy wetlands and other habitats sustainable to native species; be free from nutrients that may cause harmful algal blooms; be free from the spread of invasive species; and be free from other substances which may affect the chemical, physical or biological integrity of the Great Lakes.

In Annex 2 of the GLWQA, "Lakewide Management," the United States and Canada jointly commit to assessing the status of each Great Lake by addressing environmental stressors that adversely affect the waters of the Great Lakes and which are best addressed on a lakewide scale through an ecosystem approach.

2.2 Lake Superior Partnership

The LAMP was written, and will be implemented and managed, by the Lake Superior Partnership, including federal, state, provincial, and tribal governments or agencies tasked with protecting and restoring the Lake Superior ecosystem. The Partnership, led by Environment and Climate Change Canada and the United States Environmental Protection Agency, seeks to contribute to the achievement of the objectives of the GLWQA with the involvement and input of others, including the Public.

The origin of the Lake Superior Partnership goes back to 1991, in response to the International Joint Commission's (IJC) recommendation that Lake Superior be designated as a demonstration area where "no point source discharge of any persistent toxic substance will be permitted." In response to that IJC recommendation, the federal governments of Canada and the U.S., the Province of Ontario, and the States of Michigan, Minnesota, and Wisconsin announced "A Binational Program to Restore and Protect the Lake Superior Basin," known as the Lake Superior Binational Program (LSBP). In addition to public outreach and broader program activities, the LSBP included the Zero Discharge Demonstration Program (ZDDP). The ZDDP has contributed to the dramatic reduction in emissions of critical legacy pollutants, such as mercury and PCBs, within the Lake Superior basin. The Broader Ecosystem program led to the establishment of lakewide ecosystem objectives which have been used to assess progress toward restoration and protection. The agencies of the Lake Superior Partnership are discussing the future status of the LSBP and its relationship to the GLWQA.

2.3 Significance of Lake Superior

Lake Superior is one of the most beautiful, unique and valuable ecosystems in the world. Containing nearly 10% of the world's surface freshwater, Lake Superior is the world's largest lake by surface area, with a volume of 3 quadrillion gallons (11.4 quadrillion liters). The lake has 2,730 miles (4,393 km) of shoreline (including islands). The lake's natural resources support many industrial and business operations, including tourism, fishing and other outdoor recreation activities. The lake's natural resources are culturally significant to local communities, tribes, First Nations and Métis.

Lake Superior Physical Facts

- Average depth: 147 m (483 ft)
- Maximum depth: 405 m (1,330 ft)
- Drainage basin: 127,686 km^2 (49,300 mi^2)
  - 85% forested,
  - 10.4% water,
  - 1.7% agriculture
  - 1.5% developed land
  - 1.0% wetland

Source: Beall, 2011

Lake Superior has unique fauna, containing species and subspecies found nowhere else on the planet, such as Siscowet, a large deep water form of Lake Trout, and Kiyi, the primary prey of Siscowet. Parts of Lake Superior's coastline provide habitat for arctic-alpine plant species that began to recolonize in the region around 15,000 years ago as the last ice sheet retreated. The southernmost populations of Woodland Caribou still roam parts of Lake Superior's coast and islands.

Towering cliffs overlooking pebble beaches, deep, crystal-clear, frigid waters silently guarding the final resting place of more than 350 shipwrecked vessels … These are evocative images of the "greatest" of the Great Lakes – Lake Superior, or as the Ojibiwe people named it, Gichigami. Nipigon Bay, Ontario. Credit: D. Crawford.

Indigenous peoples (also known as the Anishinaabeg people, including the Ojibwe nation) of the watershed have called Lake Superior home for thousands of years, and play an important role in managing the lake. As the place where they found "the food that grows on the water" (Northern Wild Rice, *Zizania palustris*), Mooningwanekaaning (Madeline Island in Wisconsin, part of the Apostle Islands) is the center of the Ojibwe nation. In the United States, the homelands of Ojibwe tribes stretch from central Minnesota through the Upper Peninsula of Michigan, with treaty-ceded territories located throughout the Lake Superior basin. In Canada, over a dozen First Nations communities are located along the coast or within the Lake Superior basin. Figure 1 shows First Nation and tribal lands in the Lake Superior basin.

The waters, fish, plants and wildlife in the Lake Superior basin continue to provide a sense of identity and continuity with traditional ways of life. Culturally-significant wildlife include Lake Sturgeon, Bald Eagle, and Walleye, while culturally-significant plant species include Wild Rice, Labrador Tea, Paper Birch, and Cedar. Indigenous inhabitants continue to use subsistence harvesting practices throughout the basin.

Traditional Ecological Knowledge (TEK) is a term that encompasses the knowledge system of indigenous people based upon direct observations of the surrounding environment. This indigenous knowledge is passed down generation to generation and is used to explain their place in complex and interdependent relationships with all of creation. TEK enhances the understanding and appreciation of Lake Superior and is useful in local, regional, and lakewide management. TEK will be incorporated into implementation of the LAMP. According to the Ojibwe world view, Lake Superior and its connected lakes, rivers and streams are not simply the sum of their constituent parts, or the property of a state, nation, or person. Instead, they are integral parts of the web of life that supports the continuation of Anishinaabe ways of life and provides life-giving benefits to all who now call Lake Superior home.

Nipigon Bay. Credit: D. Crawford.

Tourism is one of the economic engines of the Lake Superior region. An abundance of outdoor activities, festivals, concerts, athletic events, and unique dining and shopping opportunities draw thousands of visitors each year, particularly to vibrant metropolitan areas such as Duluth, Minnesota, and Thunder Bay, Ontario. Summer brings boaters, sightseers, campers, kayakers, anglers, and swimmers to the shore, while winter attracts skiers, snowmobilers, and snowshoers from surrounding states and provinces and beyond (Minnesota Sea Grant, 2014a).

Kayaking (left), swimming (middle), and ice fishing (right) are popular recreational activities on Lake Superior. Credit: J. Bailey (left), L. LaPlante (middle), and D. Viebeck (right).

Lake Superior contains dozens of federal, provincial, tribal, and non-governmental **parks and conservation areas** which provide a wide array of recreational experiences in the Lake Superior region. Pukaskwa National Park and Lake Superior Provincial Park on the eastern coast of Lake Superior in Ontario are the book ends of the longest undeveloped coastline in the entire Great Lakes basin. In Michigan, sandstone cliffs and white sand beaches beckon visitors to Pictured Rocks National Lakeshore. In Wisconsin, lighthouses backdrop the exploration of sea caves, ice caves, and majestic islands that comprise the Apostle Islands National Lakeshore. In Minnesota, the lighthouse in Split Rock Lighthouse State Park provides a historical starting point to experiencing Lake Superior's famous cobble beaches and rocky shores. Once formally established, Canada's Lake Superior National Marine Conservation Area (NMCA) will encompass over 10,000 km^2 (3,861 mi^2) of protected aquatic and terrestrial habitat. This protected marine area will safeguard aspects of the ecosystem and provide benefits to local coastal communities that depend on marine industries, such as commercial fishing, sport fishing, recreational boating, and shipping (Parks Canada, 2015).

Resolute Forest Products, Thunder Bay, Ontario. Credit: D. McChristie.

Lake Superior's **natural resources** are the backbone of the regional economy. Industries such as shipping, forestry, mining, agriculture, charter and recreational fishing, and tourism, contribute greatly to the local economies of coastal communities, as well as to the economy of the Great Lakes region as a whole. While no formal, comprehensive economic assessment has been completed for the Lake Superior basin to date, the importance of these industries to the health and viability of coastal

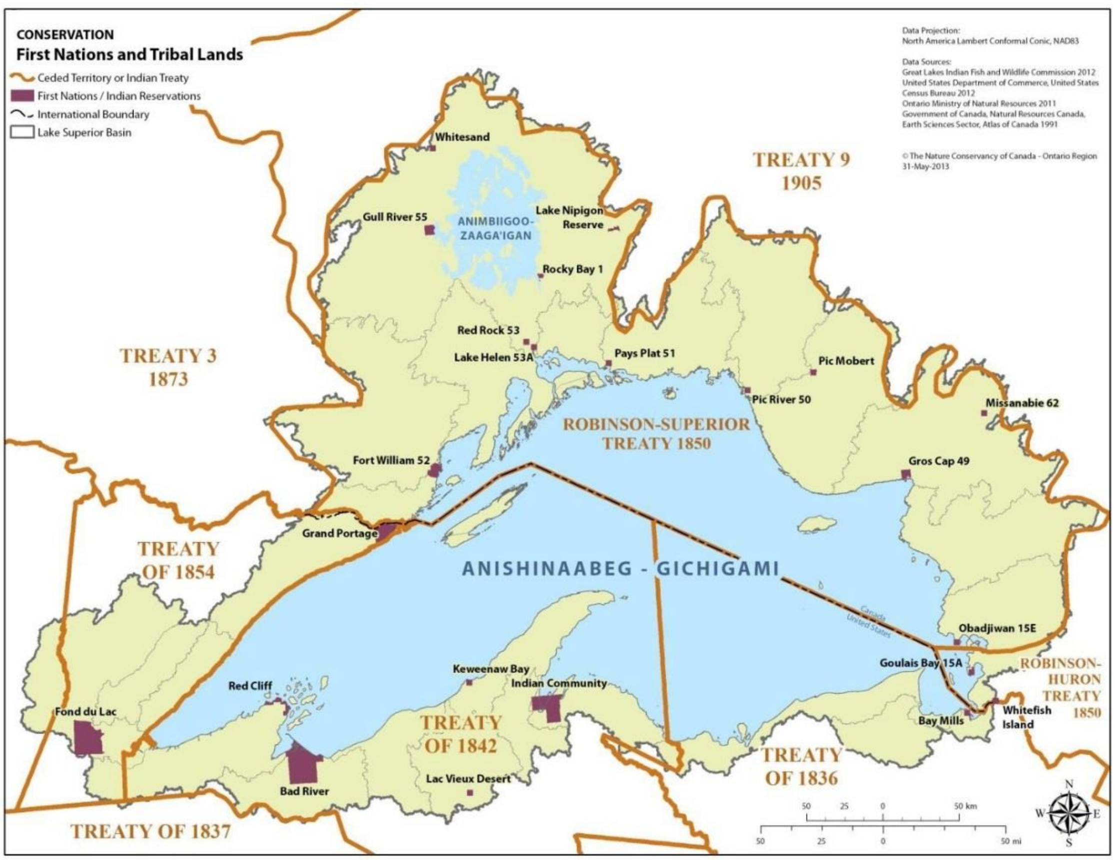


Figure 1. First Nations and tribal lands in the Lake Superior basin. Source: The Nature Conservancy of Canada.

communities and residents cannot be overstated. For example, the Great Lakes and St. Lawrence Seaway connects the Atlantic Ocean (and the world) to Lake Superior. The port of Duluth-Superior, Lake Superior's largest port (by metric tons of cargo), averages around 40 million metric tons of cargo annually, primarily consisting of iron ore, coal, and grain. The value of this cargo is estimated to be $1.9 billion (USD), while the port supports approximately 2,000 jobs (Minnesota Sea Grant, 2014b). The shipping industry contributes greatly to many other Lake Superior communities including Marquette, Michigan; Sault St. Marie, Michigan; and Thunder Bay, Ontario (Minnesota Sea Grant, 2014b).

The annual value of cargo moving through the port of Duluth-Superior is estimated to be 1.9 billion dollars (USD). Credit: S. Swart.

3.0 EXISTING LAKEWIDE OBJECTIVES

3.1 Background

Through the GLWQA, the governments of Canada and the United States have committed to establishing Lake Ecosystem Objectives (LEOs) that will specify interim or long-term ecological conditions necessary to achieve the GLWQA General Objectives. LEOs will be used as a benchmark against which to assess status and trends in water quality and lake ecosystem health. LEOs will be determined using a systematic approach that is consistent among the Lakes, but also flexible enough to accommodate the unique characteristics and challenges faced by each Lake. LEOs for Lake Superior are scheduled to be developed by the end of 2017. The current, existing lakewide objectives for Lake Superior are presented below.

3.2 Existing Lakewide Objectives

In the short term, the Lake Superior Partnership is using previously-established conservation targets for habitats and species, and previously-established chemical objectives. These existing lakewide objectives and their current status are summarized in Table 3. For details on the status assessment for these lakewide objectives, refer to *A Biodiversity Conservation Strategy for Lake Superior* (LSBP, 2015) and the Lake Superior Zero Discharge Demonstration Program and *1990-2010 Critical Chemical Reduction Milestones* report (LSBP, 2012).

Table 3. Existing Lakewide Objectives for Lake Superior

#	Lakewide Objective	Description	Status*
1	Maintain deepwater and offshore waters in good ecological condition.	Waters that are over 80 m (262 ft) in depth. The offshore waters provide habitat for a number of native fish. Example species include Siscowet, Kiyi and other Ciscoes, Burbot, and Deepwater Sculpin.	GOOD
2	Maintain nearshore zone and reefs in good ecological condition.	Waters between 15-80 m (49-262 ft) in depth, and shallow reefs. Lake Superior's major sport and commercial fisheries are located in the nearshore zone. Example species include Lake Trout and Lake Whitefish.	GOOD
3	Maintain embayments and inshore areas in good ecological condition.	Embayments and the inshore zone at depths of 0-15 m (0-49 ft). These habitats are critical for fish abundance and diversity, since these areas provide spawning and nursery habitat for many nearshore and offshore fish species, as well as waterfowl staging and feeding zones. Example species include Lake Sturgeon, Walleye, and Yellow Perch.	GOOD
4	Maintain coastal wetlands in good ecological condition.	Wetlands within 2 km (1.2 mi) of Lake Superior's coast, with an emphasis on wetlands that have historic and current hydrologic connectivity to, and are directly influenced by the lake. Example species include Northern Pike, waterfowl, and many amphibians.	GOOD

#	Lakewide Objective	Description	Status*
5	Maintain islands in good ecological condition.	All land masses that are surrounded by water, including both natural and artificial islands. Lake Superior has many of the largest and most isolated islands on the Great Lakes. Islands support colonial nesting waterbirds such as gulls, and unique ecological communities.	GOOD
6	Maintain coastal terrestrial habitats in good ecological condition.	Habitats within 2 km (1.2 mi) from the coast or to the extent of delineation. Many rare species and habitats are found in this zone including shorebirds, bald eagles, and rare plant communities.	GOOD
7	Maintain tributaries and watersheds in good ecological condition.	All rivers, streams and inland lakes that flow into Lake Superior and their associated watersheds. Lakes, rivers and streams in the basin are influenced by land use, which affects water quality in Lake Superior. Native Lake Superior fish that migrate to and depend on tributaries as part of their natural life cycle. Examples of species that depend on tributaries and watersheds include Coaster Brook Trout, Suckers, and Northern Wild Rice.	FAIR
8	Achieve zero release (from within the Lake Superior basin) of nine persistent bioaccumulative toxic substances.**	This is called the Lake Superior Zero Discharge Demonstration Program. With 1990 as the baseline year, a staged reduction plan was developed with the year 2020 as the target for the aspirational goal of virtual elimination of these substances.	GOOD
9	Protect the Lake Superior basin from contamination resulting from additional substances of concern. ***	In addition to the nine legacy chemicals, there are a large number of substances, under an umbrella term called *substances of emerging concern*. These include substances used in flame retardants, personal care products, and pharmaceuticals.	GOOD

* Ecological status was determined through the Conservation Action Planning (CAP) Framework, as described in *A Biodiversity Conservation Strategy for Lake Superior* (LSBP, 2015). Available Great Lakes indicators (i.e., "SOLEC indicators") were utilized through the CAP process; details of the assessment and all indicators used are available in technical documents posted on binational.net.

Ratings for Ecological Status:

Good: In a state that is within the accepted range of variation, but some management intervention may be required for some elements.

Fair: In a state that is outside the range of acceptable variation and requires management.

Poor: Allowing the goal to remain in this condition for an extended period will result in permanent ecosystem change.

** The nine persistent bioaccumulative toxic substances include: mercury, PCBs, dioxin, hexachlorobenzene, octachlorostyrene and four pesticides (dieldrin, chlordane, DDT, and toxaphene).

*** Additional substances of concern include pharmaceuticals and personal care products, microplastics, and nutrients.

4.0 STATE OF LAKE SUPERIOR

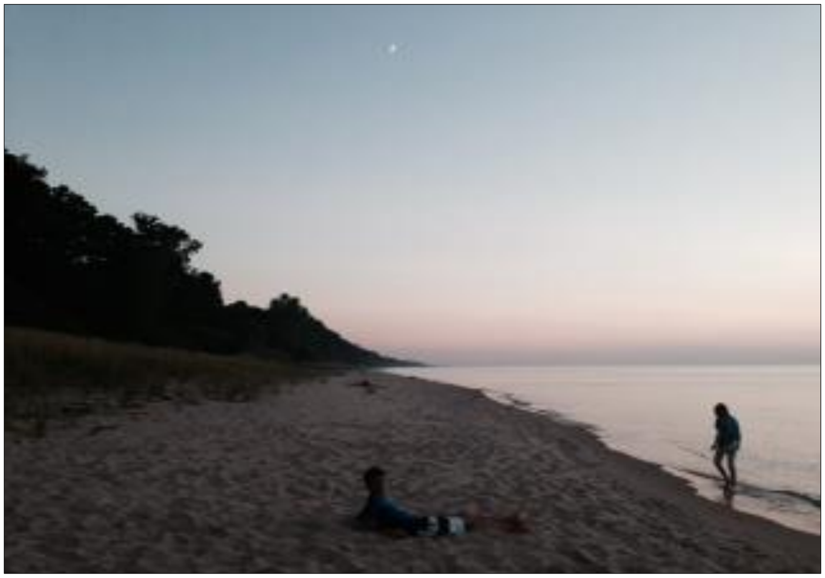
Information on the state of Lake Superior is organized under the nine General Objectives of the Great Lakes Water Quality Agreement. Information is also provided on threats to Lake Superior's habitats, species and water quality.

Unless otherwise noted, the source of the information is the *State of the Great Lakes 2011 Technical Indicator Report* by Environment Canada[1] and USEPA (2013).

In the year 2020, the next Lake Superior LAMP will use newly developed Lake Ecosystem Objectives as the benchmark with which to assess ecosystem status and trends.

The Lake Superior ecosystem is in generally good condition. Fisheries are in good to excellent condition, supported by a robust lower food web (e.g., small, shrimp-like *Diporeia* and *Mysis*); there are self-sustaining populations of Lake Trout and increasing abundance of Lake Sturgeon; most major habitats are in good condition on a lakewide scale, including coastal wetlands; and concentrations of legacy contaminants in the environment (e.g., PCBs) are generally decreasing or remaining stable.

Lake Superior faces a variety of challenges. Fish consumption advisories due to legacy pollutants such as mercury and PCBs; continued damage from aquatic invasive species (e.g., Sea Lamprey) and the risk of new invaders; effects of climate change on the ecosystem (e.g., warming surface waters stressing some cold-water species); areas of impaired habitat connectivity between the tributaries and the open lake; chemical substances of emerging concern, such as microplastics; and balancing resource development with environmental protection.



Relaxing on the beach at sunset. Credit: L. LaPlante.

[1] References authored by Environment Canada prior to the agency's name change in 2015 continue to use the former name for consistency with the references listed in Section 10.

4.1 State of Lake Superior in Relation to GLWQA General Objectives

State of Lake Superior in relation to GLWQA General Objectives

The GLWQA contains nine General Objectives for the waters of the Great Lakes.

(i) ***Be a source of safe, high-quality drinking water***;

Lake Superior is a safe, high-quality source of water for drinking water systems. In Ontario, nearly 100% of drinking water tests meet standards. In Michigan, Minnesota and Wisconsin, health-based violations from drinking water systems are rare.

(ii) ***Allow for swimming and other recreational use, unrestricted by environmental quality concerns***;

Over 90% of the time, Lake Superior beaches are open and safe for swimming.

(iii) ***Allow for human consumption of fish and wildlife unrestricted by concerns due to harmful pollutants***;

Lake Superior fish are a healthy and nutritious food source. Consumption advisories are issued to limit exposure to harmful pollutants found in some fish in some areas.

(iv) ***Be free from pollutants in quantities or concentrations that could be harmful to human health, wildlife, or aquatic organisms, through direct exposure or indirect exposure through the food chain***;

Concentrations of most contaminants are lower in Lake Superior waters than in the other Great Lakes. However, there are exceptions, including a few chemicals found at their highest concentration in Lake Superior. In whole fish, concentrations of some contaminants are above guidelines. In waterbirds and sediments, there are locations where higher concentrations of contaminants are found, but overall concentrations are generally low compared to the other Great Lakes.

(v) ***Support healthy and productive wetlands and other habitats to sustain resilient populations of native species***;

Lake Superior's coastal wetlands are in good overall health from a lakewide perspective, as are most other major habitat types. Tributaries and watersheds are the exception, being in fair condition.

(vi) ***Be free from nutrients that directly or indirectly enter the water as a result of human activity, in amounts that promote growth of algae and cyanobacteria that interfere with aquatic ecosystem health or human use of the ecosystem***;

Offshore nutrient targets continue to be met, and conditions remain acceptable. However, localized, low toxicity harmful algal blooms have been observed in some locations.

(vii) ***Be free from the introduction and spread of aquatic invasive species and free from the introduction and spread of terrestrial invasive species that adversely impact the quality of the Waters of the Great Lakes***;

Aquatic invasive species are a high threat to the Lake Superior ecosystem, due to the persistence of established invaders, expanding ranges, and the threat of new invaders.

(viii) ***Be free from the harmful impact of contaminated groundwater***;

The full extent and impact of contaminated groundwater discharges on Lake Superior is not known.

(ix) ***Be free from other substances, materials or conditions that may negatively impact the chemical, physical or biological integrity of the Waters of the Great Lakes***;

Atmospheric deposition is the top source of many contaminants found in Lake Superior. The highest threats to Lake Superior's habitats and species are aquatic invasive species, climate change, and dams and barriers.

Be a Source of Safe, High Quality Drinking Water

Lake Superior is a safe, high-quality source of water for public drinking water systems. In Ontario, nearly 100% of drinking water tests meet standards. In Michigan, Minnesota and Wisconsin, health-based violations from drinking water systems are very rare. Health-based exceedances can be caused by microbiological or chemical contaminants. Outside of public drinking water systems, the quality of water may vary on a local basis, depending on potential sources of contamination and treatment processes.

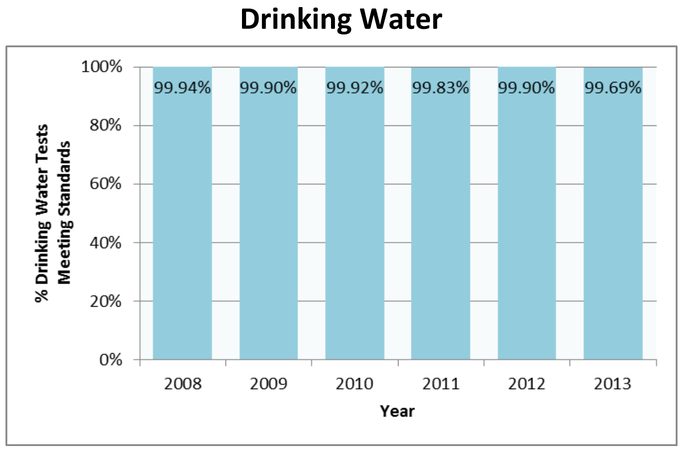


Figure 2. Percentage of Lake Superior drinking water tests meeting standards from Ontario municipal residential drinking water systems using Lake Superior water. Source: Data from Chief Drinking Water Inspector Annual Reports.

Allow for Swimming and Other Recreational Use, Unrestricted by Environmental Quality Concerns

On average, Lake Superior's beaches are open and safe for swimming and other recreational use over 95% of the time in the U.S. and over 88% of the time in Canada. Note that the U.S. and Canada use different criteria for determining when a beach is considered safe for swimming (i.e., less than 235 or 300 *E.coli* colony-forming units per 100 mL in the U.S. versus less than 100 *E.coli* colony-forming units per 100 mL in Canada). Increased beach monitoring and assessment is helping

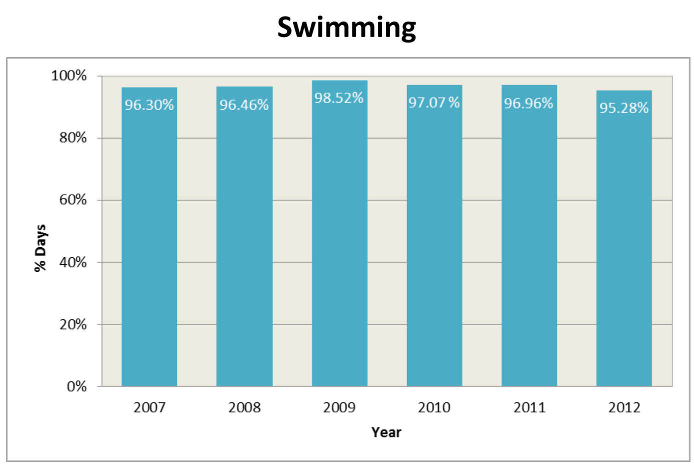


Figure 3. Percentage of days U.S. Lake Superior beaches are open and considered safe for swimming. Source: U.S. States reporting to USEPA's Beach Advisory and Closing On-Line Notification System.

to inform the public when beaches are safe for recreational use.

Major rain events and flooding can wash contaminants into the lake and overwhelm wastewater treatment plants' capability. In 2012, record flooding in the southwest part of the basin resulted in significant numbers of beach advisories. For example, beaches in Douglas County, Wisconsin, were open and safe for swimming only 70% of the time that year.

Allow for Human Consumption of Fish and Wildlife Unrestricted by Concerns Due to Harmful Pollutants

Lake Superior fish continue to be a healthy and nutritious food source. Some of the most popular species include Lake Whitefish, Lake Trout and Cisco (Lake Herring). Consumption advice is issued by states, tribes and the Province of Ontario in efforts to avoid impacts of harmful pollutants found in some fish in some areas. Developing fetuses and young children are affected by contaminants at lower levels than the general population. Therefore, it is especially important that women of child-bearing age and young children follow fish consumption recommendations (Guide to Eating Ontario Fish, 2015). Overall, there are fewer Lake Superior fish consumption advisories as compared to the other Great Lakes.

Fish consumption recommendations are provided by:

- Great Lakes Indian Fish and Wildlife Commission: glifwc.org/Mercury/mercury
- Michigan: michigan.gov/eatsafefish
- Minnesota: health.state.mn.us/fish
- Ontario: Ontario.ca/fishguide
- Wisconsin: dnr.wi.gov/topic/fishing/consumption

The two main contaminants responsible for fish advisories are polychlorinated biphenyls (PCBs) and mercury, and in a few locations, dioxins and toxaphene. Large predator fish, such as older Lake Trout, are likely to have higher contaminant levels than other species.

The eggs of Great Lakes fatty fish, especially spawning salmon species, such as Chinook and Coho Salmon, can contain elevated levels of PCBs and other organic contaminants because of their high fat content, and therefore should avoid being eaten (Ontario MOECC, 2015).

Snapping turtles may have high levels of contaminants in their fat, liver, and eggs. As a precaution, individuals are advised to trim away the fat prior to cooking turtle meat.

As part of their traditional culture, tribal, First Nation and Métis communities consume more local fish, on average, compared to others living in the basin. In 2011-2012, samples of the full range of traditional food across Ontario were collected for contaminant analyses as part of a First Nations food, nutrition and environment study. Results indicate that the ingestion of contaminants from traditional foods is not a concern, with the exception of mercury intake from fish in some locations for children and women of childbearing age (Chan et al., 2014).

These findings are consistent with Ontario Ministry of the Environment and Climate Change's *Guide to Eating Ontario Fish*, which recommends restrictions on the amount of fish consumed each month from some Lake Superior locations.

During 2013, population-based contaminant biomonitoring was conducted on individuals from the Fond du Lac Band of Lake Superior Chippewa, in Minnesota. Levels of contaminants found in their bodies were below levels of health concern. The results again suggest that fish may be safely consumed by following fish consumption guidelines (Fond du Lac and MDH, 2014).

Be Free from Pollutants in Quantities or Concentrations That Could Be Harmful To Human Health, Wildlife, or Aquatic Organisms, Through Direct Exposure or Indirect Exposure Through the Food Chain

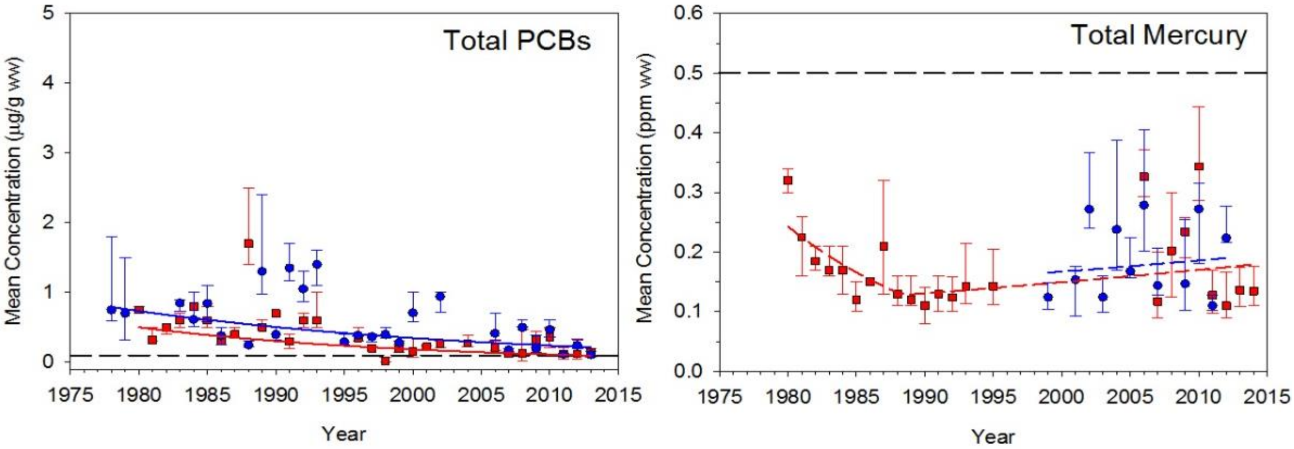
Concentrations of most contaminants are the lowest in Lake Superior water, compared to the other Great Lakes. However, there are exceptions; a few chemicals have their highest concentration in Lake Superior. In whole fish, concentrations of some contaminants are above guidelines. In waterbirds and sediments, there are locations where higher concentrations of contaminants are found, but overall concentrations are generally low compared to the other Great Lakes.


Brook trout. Credit: H. Quinlan, U.S. Fish and Wildlife Service.

Contaminants in Whole Fish

Organochlorine pesticides and total PCBs contribute equally and together make up approximately two-thirds of the chemical body burden of Lake Trout (the total amount of chemicals in the body of an organism) in Lake Superior (McGoldrick and Murphy, 2015). Total PCBs in Lake Trout are declining in Lake Superior at an annual rate between 4 and 5 percent. In 2013, the most recent year reported, 33 of 53 measurements of PCBs were above the 1987 GLWQA criteria value of 0.1 ppm. Toxaphene is the most abundant organochlorine pesticide measured in Lake Superior, unlike the other Great Lakes. Total mercury concentrations in Lake Superior Lake Trout appear to have increased slightly since 1987 but remain below the 1987 GLWQA criteria of 0.5 ppm. Some of the remaining chemicals reported in fish from Lake Superior are PBDEs, PFCs, other flame retardants, and siloxanes.

Contaminant Trends in Lake Trout



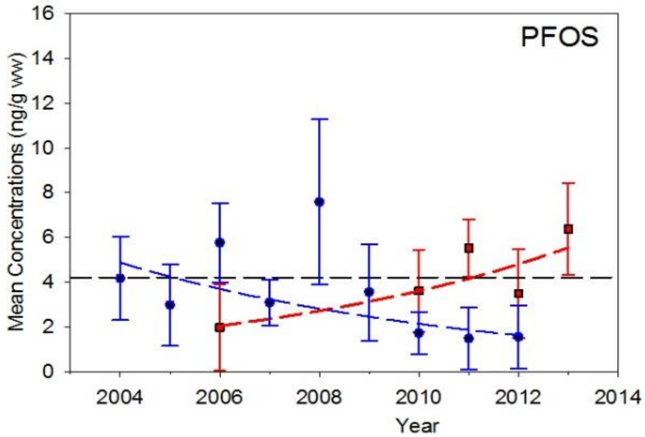


Figure 4. Temporal trends of polychlorinated biphenyls (PCBs), total mercury, and perfluorooctane sulfonate (PFOS) in Lake Trout from Lake Superior. Environment and Climate Change Canada data are shown in red and USEPA data are shown in blue. Dashed horizontal line denotes the environmental quality objective for each parameter, where available. Source: McGoldrick and Murphy, 2015.

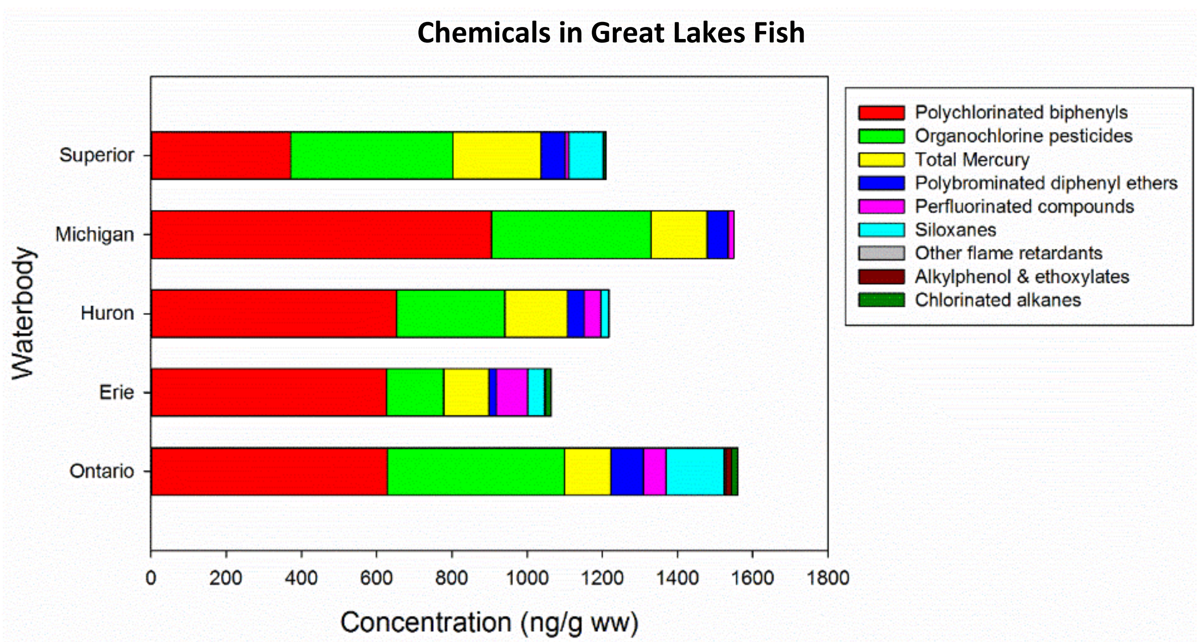


Figure 5. Contribution to Body Burden of Monitored Chemicals in Great Lakes Whole Fish (Lake Trout and Walleye in Lake Erie). Source: Environment and Climate Change Canada and USEPA.

Contaminants in Fish-Eating Birds

Contaminants, such as DDE, PCBs, and dioxins (TCDD), which interfere with the reproduction of some birds, have declined significantly in Herring Gulls and Bald Eagles compared to the 1970s and 1980s. In general, there was an exponential decline in contaminant burdens in Herring Gulls on Lake Superior from the 1970s to 2013, although concentrations appear to have stabilized in the last few years. The half-lives of contaminants in gull eggs averaged 9.9 years for pesticides, 8.2 years for dioxin, and 11.6 years for PCBs. However, DDE (associated with historical pesticide use) can still be found at levels above the threshold for healthy populations in 50% of the eagles tested.

Contaminants in Herring Gulls

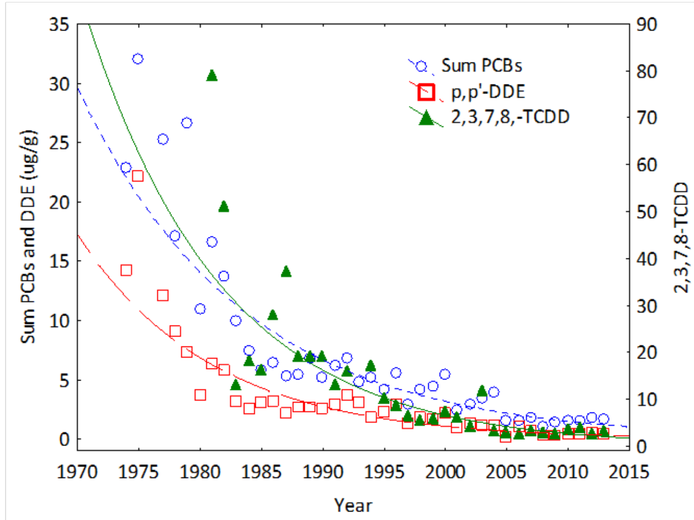


Figure 6. Changes in concentrations of sum PCBs, *p,p*'-DDE, and 2,3,7,8-TCDD (ug/g, wet weight) in Great Lakes Herring Gull eggs at Agawa Rocks, from year of first measurement to 2013. Source: deSolla et al., *in press*.

Contaminants in Offshore Waters

Contaminants are found at very low concentrations in Lake Superior's offshore waters. For example, no exceedances of Canadian federal water quality guidelines are observed for any contaminant in Lake Superior's offshore waters. Compared to the other Great Lakes, concentrations of some compounds (e.g., atrazine) are lowest in Lake Superior, but several compounds that are delivered to Lake Superior by atmospheric deposition (e.g., a-HCH and lindane) are found at higher concentrations. The lowest concentrations of mercury in the Great Lakes are observed in Lake Huron and Georgian Bay, intermediate concentrations are observed in Lake Superior and Lake Ontario, and the highest concentrations were observed in Lake Michigan and Lake Erie (EC-USEPA, 2013). Trends in Lake Superior are varied. For example, the concentration of hexachlorobenzene (HCB) is unchanging, and the concentration of dieldrin is declining.

Contaminants in Offshore Waters

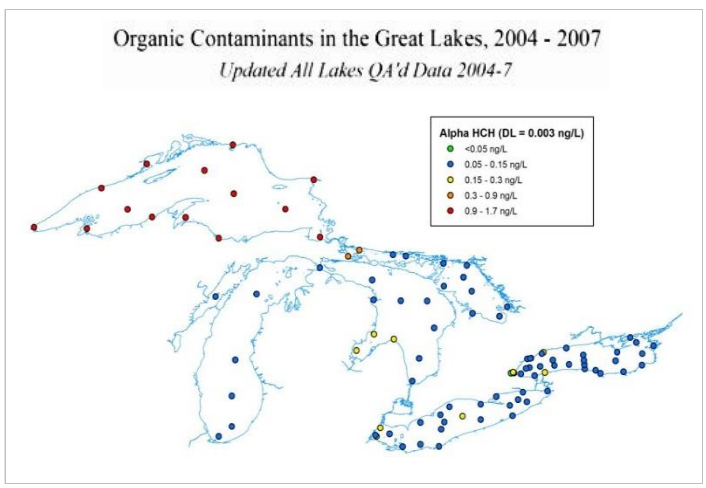


Figure 7. Spatial distribution of dissolved alpha-hexachlorocyclohexane (HCH) in Great Lakes surface waters, 2004-2007. Source: Environment and Climate Change Canada's Great Lakes Surveillance Program.

Contaminants in Air

Atmospheric PCB concentrations are decreasing relatively slowly across the Great Lakes basin. As measured by the Integrated Atmospheric Deposition Network (IADN), concentrations of PCBs are halving about every 13 years in air collected at Eagle Harbor, Michigan (Salamova et al., 2015). This declining trend is consistent with the trends seen at other IADN sites suggesting a relatively homogeneous decrease across the Great Lakes region (even with concentrations much higher at the more urbanized IADN monitoring stations).

Atmospheric concentrations of organochlorine pesticides that have been banned are also generally declining. Chlordanes and DDT-related substances have halving times of about 10 years in air collected at Eagle Harbor (Salamova et al. 2015). Concentrations of α -HCH and γ-HCH are decreasing rapidly in air, with halving times of about 4 years at all U.S. sites (Salamova et al., 2015). These are the most rapid halving times observed for any compound measured as part of IADN. The insecticides, α-endosulfan and B-endosulfan, are still on the market, but they are slated for complete elimination in 2016. Even though endosulfan is currently in use, vapor phase atmospheric concentrations around the Great Lakes are decreasing with halving times ranging from 7 to 13 years (Salamova et al., 2015).

IADN data for total polycyclic aromatic hydrocarbons (PAH) concentrations at Eagle Harbor also show some significant decreases over time, with a halving time of about 17 years. Concentrations of PAHs at Eagle Harbor are about 10 times lower than at the more urbanized IADN monitoring stations. However, the concentrations are decreasing more rapidly at urban stations (Salamova et al., 2015).

Concentrations of PBDEs were decreasing at the urban sites at Chicago and Cleveland, but were generally unchanging at the remote sites, Sleeping Bear Dunes and Eagle Harbor.

Air Contaminants

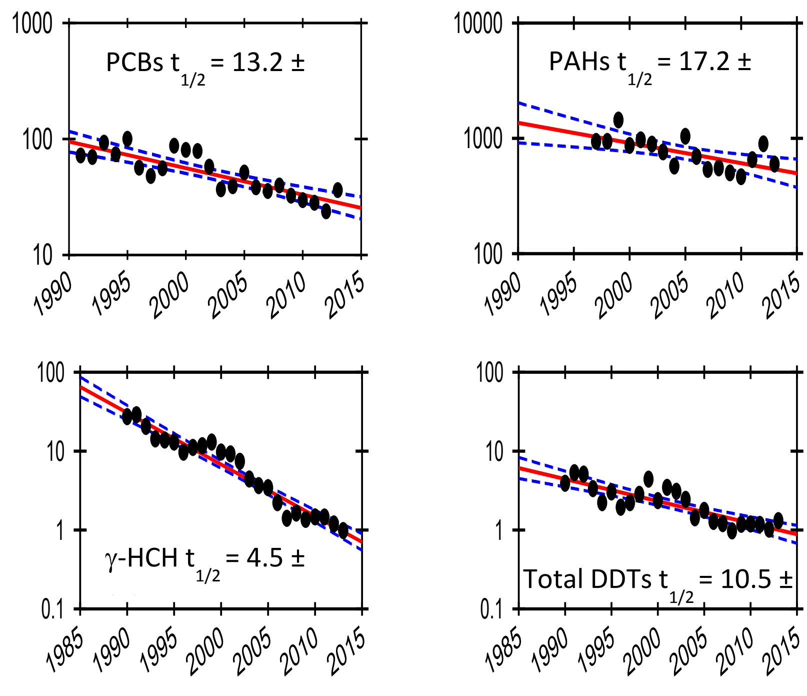


Figure 8. Concentrations of Selected Contaminants at Eagle Harbor, Michigan. Source: Integrated Atmospheric Deposition Network, at Indiana University.

Contaminants in Sediment

Sediment contaminant levels in the offshore waters consistently meet aquatic life protection guidelines. Lake Superior is the largest, coldest and deepest of the Great Lakes, resulting in slow rates of decrease in chemical concentrations in sediment. This is especially true for mercury, where no decline in concentrations is being observed, due in part to natural sources of mercury from within the watershed and mercury sources associated with past or present mining and smelting activities around Lake Superior (Environment Canada and USEPA, 2013).

Contaminants in Sediment

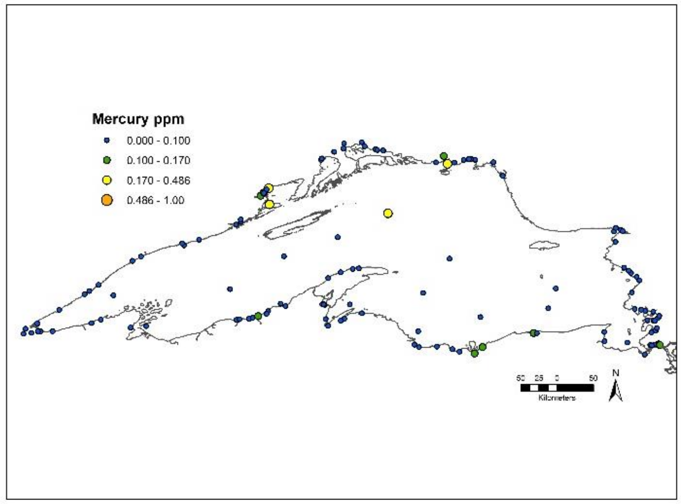
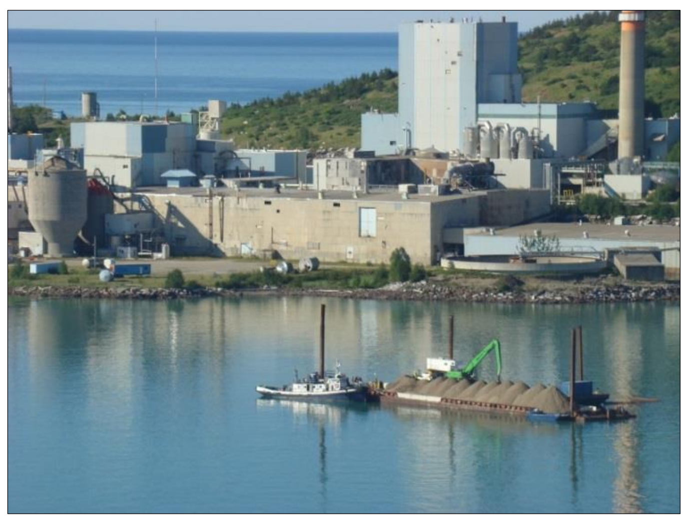


Figure 9. Spatial distribution of mercury contamination in Lake Superior's surface sediments. Sources: Environment and Climate Change Canada and USEPA.

The presence of contaminated sediment in specific nearshore locations within Lake Superior are heavily influenced by shoreline-based urban and industrial activities. For example, sediment in Peninsula Harbour, near Marathon, Ontario was contaminated with mercury and PCBs from a pulp mill that operated from 1946 to 2009. The sediment was capped with a layer of clean sand in 2012, thereby reducing the risks associated with contaminants and providing clean habitat for aquatic organisms. On the Keweenaw Peninsula, contaminated sediments or "stamp sands" are remnants of previous mining activity that continue to adversely impact the lake.



Peninsula Harbour, Ontario. Credit: Ontario MOECC.

Contaminated sediment remains in a number of locations, including: an area adjacent to a former paper mill located in the northern end of the harbor in Thunder Bay, Ontario; multiple sites in the St. Louis River, Minnesota/Wisconsin; the Ashland/Northern States Power Lakefront site in Wisconsin; and Torch Lake, Michigan. A few Areas of Concern (AOCs) are affected by contaminated sediment, as can be found in the discussion on the status of AOCs in Section 4.2.

Support Healthy and Productive Wetlands and Other Habitats to Sustain Resilient Populations of Native Species

Lake Superior's coastal wetlands are in good overall health, as are most other major habitat types. Tributaries and watersheds are the exception, being in fair condition.

Coastal Wetlands

There are 26,626 hectares (103 mi^2) of coastal wetlands documented on Lake Superior, or approximately 10% of the coast (Ingram et al., 2004). The overall condition of Lake Superior's coastal wetlands is "good," although the confidence of this ranking is low because the full suite of indicators is under development and results are not yet available. The "good" assessment is driven by the small total amounts of artificial shorelines and structures, low numbers of invasive species (including wetland species such as the common reed) and high amount of forest cover. Many coastal wetlands in Lake Superior are also subject to relatively low levels of watershed development (Trebitz et al., 2011).

Water Levels

One of the longest droughts in the Lake Superior basin started in the late 1990s and lasted into the 2000s due to a 25% drop in annual precipitation and an increase in air temperatures of about 1°C (1.8°F). The low water levels included a two-month period of record low levels in 2007. Stream flow was reduced by as much as 30% in some watersheds. These changes in water levels and stream flow affected fish migration, erosion, Wild Rice growth, and nutrient/contaminant transport and transformation. In 2014, Lake Superior water levels rose above average for the first time in 15 years. There is no evidence of a shift in water level averages over the long term, with water levels for the coming years remaining uncertain. Great Lakes water levels are primarily influenced by precipitation, evaporation, and runoff, with increased evaporation playing a larger role than changes in precipitation (Gronewold and Stow, 2014).

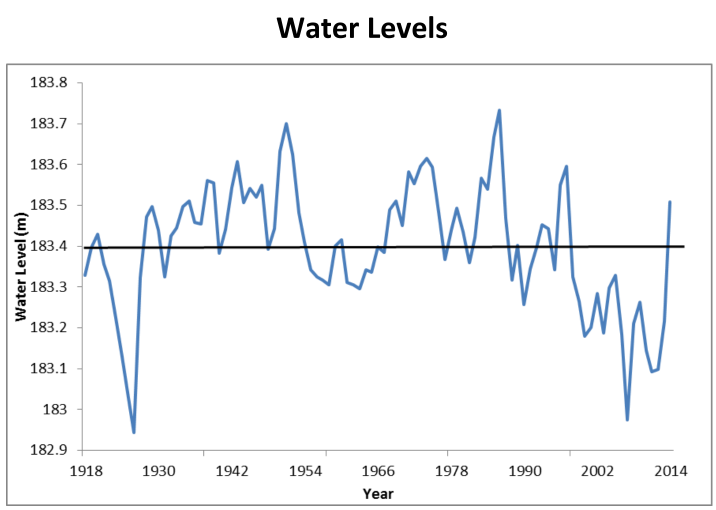


Figure 10. Annual average Lake Superior water levels 1918-2014. Long-term mean is represented by the straight black line. Source: U.S. Army Corps of Engineers, Detroit District, Great Lakes Hydraulics and Hydrology.

Land Use/Land Cover

The Lake Superior basin has high forest cover (85%) and low rates of agriculture and development (3.2%). Developed land (e.g., urban areas) and agricultural land impact coastal areas, because these land uses are concentrated near river mouths and surrounding areas. Forest cover in the Lake Superior basin continues to increase, although the composition of species is changing. Pines and maples are increasing, while species like Birch and Aspen are on the decline.

Land Use/Land Cover

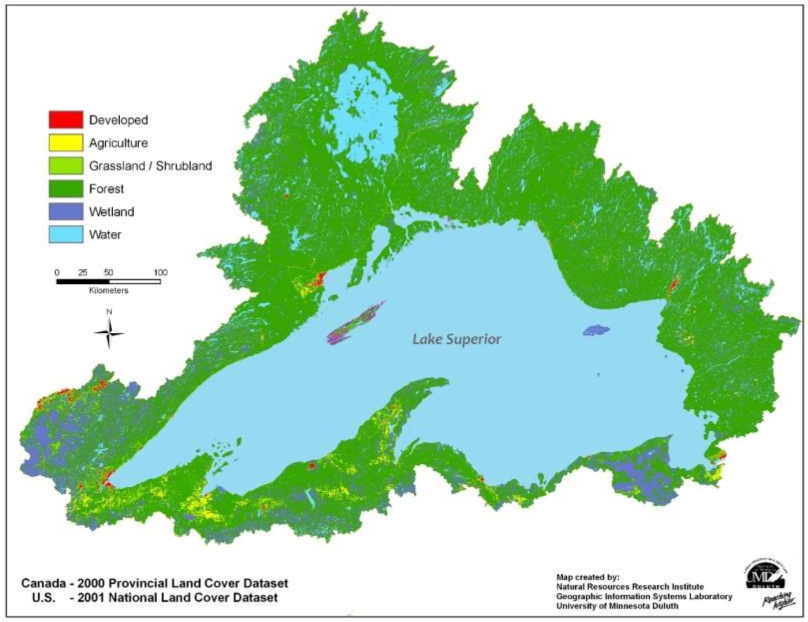


Figure 11. Distribution of land use/land cover across the Lake Superior basin in 2000 (Canada) and 2001 (U.S.) color-coded according to six land use classes. Source: Ciborowski et al., 2011.

As shown in Figure 12 below, the Chequamegon Bay area in Wisconsin provides an example of development in coastal areas that can impact wetlands and other habitats. A wide diversity of wetland and forested land cover types exists in the Chequamegon Bay area, with increasing urban development around Ashland, Wisconsin.

Land Use/Land Cover around Chequamegon Bay, Wisconsin

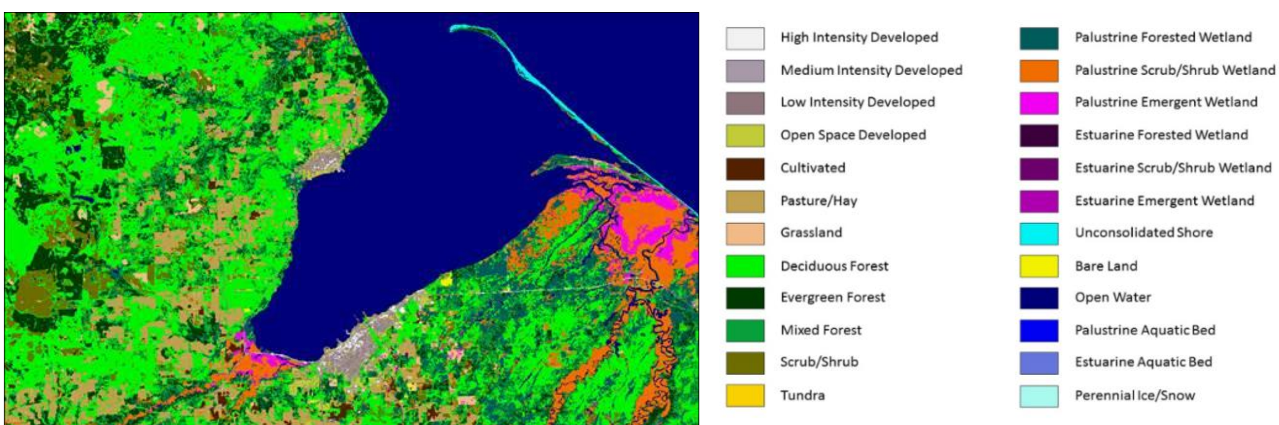


Figure 12. Chequamegon Bay, Wisconsin in 2010. Source: NOAA Office for Coastal Management Coastal Change Analysis Program. Land Cover 2010.

Species of the Lower Food Web

Mysis diluviana. Credit: USGS.

The animal portion of the lower food web is made up of numerous invertebrate species. One of the largest and most widespread species is *Mysis*, a small, shrimp-like animal that is eaten by most fish in Lake Superior. *Mysis* populations are considered to be in "good and stable" condition. Recent data suggest that populations are relatively unchanged over the past several decades. The zooplankton community, dominated by large calanoid copepods, is also considered to be in "good and stable" condition. Zooplankton are the primary prey of offshore *Coregonus* species, which include Bloater, Cisco, Kiyi, and Shortjaw Cisco. The benthic (or bottom-dwelling) invertebrate community is made up of another shrimp-like species, *Diporeia,* as well as many species of aquatic insects, worms, clams, and other species. The diversity and abundance of this community is "good and unchanging" as well. Like *Mysis*, *Diporeia* is consumed by most Lake Superior fish at some point in their lives. The lower food web components play an important role in recycling organic matter and are the energy link between primary producers, algae, and fish. As a whole, this part of the food web is considered to be in "good" condition.

Preyfish

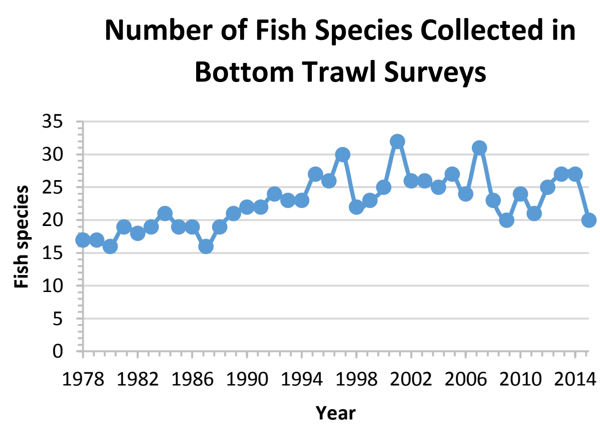


Figure 13. Number of fish species collected in annual lakewide nearshore bottom trawl surveys from 1978-2015. Source: U.S. Geological Survey - Great Lakes Science Center.

Preyfish are the intermediate player between the lower food web and predacious fish, principally Lake Trout, at the top of the food chain. The preyfish community is made up of benthic invertebrate and zooplankton-eating fish. Benthic-eating fish are dominated by native species such as Lake Whitefish. Plankton-eating fish include native *Coregonus* species such as Cisco, Kiyi, and Shortjaw Cisco. The overall biomass of Lake Superior preyfish is dominated by and reflects population trends of the many native *Coregonus* species, with Cisco being the most dominant. In recent years, recruitment of Cisco has been low, which affects the overall preyfish biomass. In general, Lake Superior's preyfish community is considered healthy due to the high number of native species, the high proportion of biomass of native versus non-native species, and the ability of the preyfish community to support a healthy sustaining predator fish population (e.g., Lake Trout).

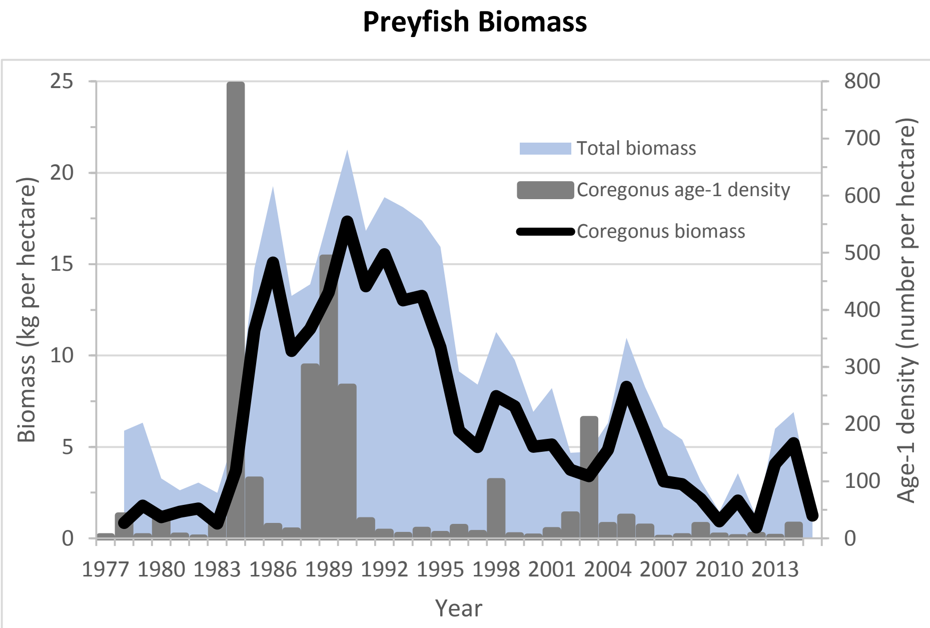


Figure 14. Mean annual total preyfish community and *Coregonus* species biomass (kg/ha) and *Coregonus* species recruitment trends (number of age-1 fish/ha) based on lakewide bottom trawl surveys from 1978-2015. *Coregonus* species include Bloater, Cisco, Kiyi, Lake Whitefish, and Shortjaw Cisco. Source: U.S. Geological Survey - Great Lakes Science Center.

Lake Trout

Lake Trout, historically the top predator fish, have self-sustaining populations throughout Lake Superior. Stocking of Lake Trout is limited to a few select management areas, such as western Wisconsin waters. Lake Trout populations are genetically diverse, with four different forms of Lake Trout (lean, siscowet, humper, and redfin).

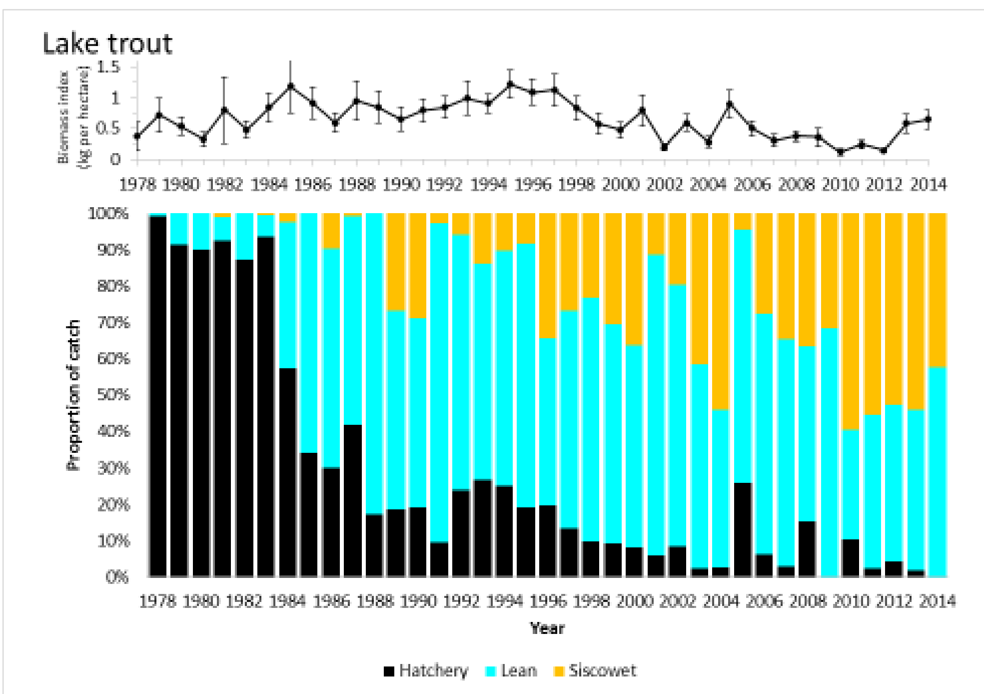


Figure 15. Lake Trout population trends, 1978-2014. Source: U.S. Geological Survey

Lake Sturgeon

Lake Sturgeon in the Great Lakes-Upper St Lawrence River and Northwestern Ontario are listed as “Threatened” by the Province of Ontario. Populations have been considered “fair” and slowly increasing over the last decade, with stocking programs and habitat restoration contributing to the increased abundance. The total population in Lake Superior is estimated to be fewer than 30,000 adults, a small fraction of the estimated historical abundance of approximately 870,000.

Lake Sturgeon

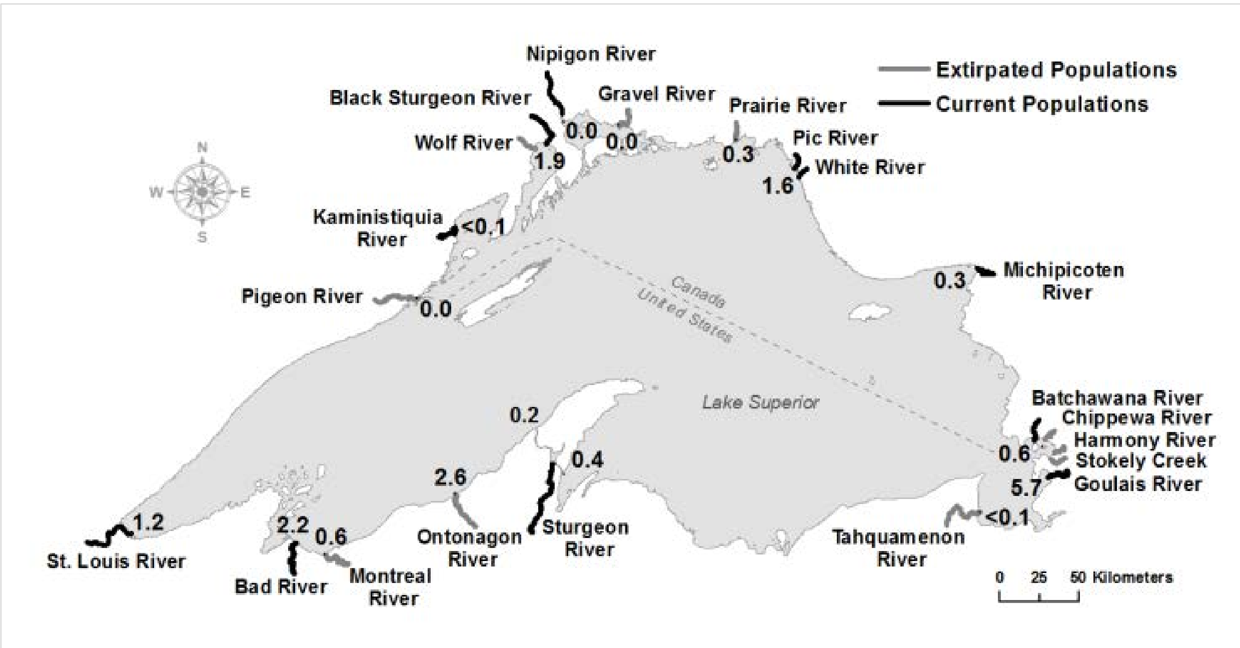


Figure 16. Catch-per-unit-effort (a relative measure of abundance) of Lake Sturgeon in inshore waters and embayments surveyed in 2011. Numbers represent the relative number of Lake Sturgeon present, meaning a river numbered 2.0 has about two times more Lake Sturgeon than a river numbered 1.0. Surveys associated with tributaries where Lake Sturgeon currently or historically spawned. Current populations indicate evidence of natural reproduction. Source: Lake Superior Lake Sturgeon Work Group, GLFC.

Walleye

Walleye populations in Lake Superior are lower than historical levels, with healthy self-sustaining populations only in the St. Louis and Kaministiquia Rivers. Many Walleye populations in Lake Superior continue to be maintained or enhanced through stocking. To date, despite stocking and fishery regulation, and presence of Walleye in locations around Lake Superior, efforts to restore the population to historic levels have had limited success. Agencies continue to address this challenge through strategies to improve and protect the quality and quantity of spawning habitat.

Fish-Eating Colonial Waterbirds

In the early 1970s, populations of many colonial waterbirds nesting in the Great Lakes suffered from high embryonic mortality, eggshell thinning and poor reproductive success, largely due to contaminants such as DDT. In Lake Superior, populations of Great Blue Herons have been stable from 1978 to 2008. Herring Gulls, however, declined from 24,900 nests in 1989 to 15,200 nests in 2008, whereas Ring-Billed Gulls declined from 18,700 nests in 1999 to 15,600 nests in 2008. Conversely, Double-Crested Cormorants increased from 35 nests in 1978 to 4,800 nests in 2008. The cause of the decline of gulls is not clear, although it may be linked to a lack of prey fish availability in the late 2000s. The increase in Cormorant nests is consistent with trends throughout the Great Lakes.

Waterbird Populations

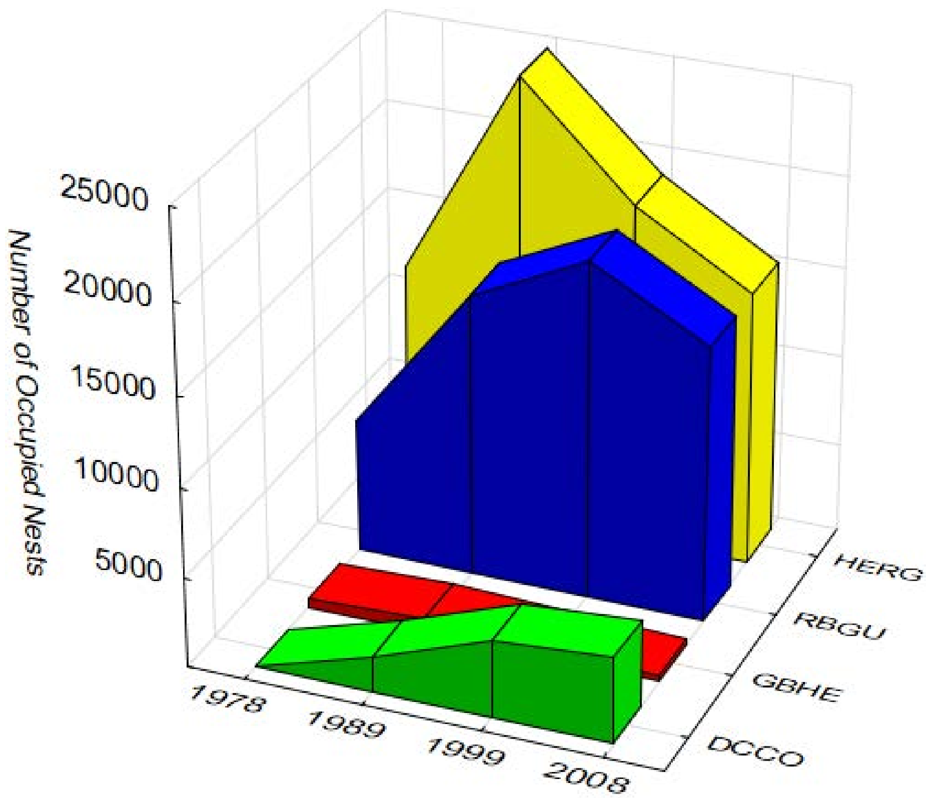


Figure 17. Number of occupied nests of four species of colonial waterbirds from Lake Superior, based upon decadal surveys from 1978 to 2008. HERG (Herring Gull); RBGU (Ring-Billed Gull); GBHE (Great Blue Heron); DCCO (Double-Crested Cormorant). Sources: Canadian Wildlife Service, Environment and Climate Change Canada, and U.S. Fish and Wildlife Service.

Be Free from Nutrients That Directly or Indirectly Enter Water as a Result of Human Activity, in Amounts That Promote Growth of Algae and Cyanobacteria That Interfere with Aquatic Ecosystem Health, or Human Use of the Ecosystem

Offshore water phosphorus targets are consistently being met in Lake Superior. Unlike the lower Great Lakes such as Lake Erie, Lake Superior did not experience significant eutrophication due to anthropogenic nutrient releases. Lake Superior has very low natural levels of phosphorus. Environment and Climate Change Canada has recently documented a statistically significant, long-term decline in total phosphorus in Lake Superior, using data from 1970 to 2013 (Dove and Chapra, 2015). The concentrations of phosphorus and its rate of the decline are lower in Lake Superior than those changes noted in the other Great Lakes. The future record will bear careful scrutiny to determine if the trend is continuing. Monitoring and research scientists are working collaboratively to investigate the causes of the declines.

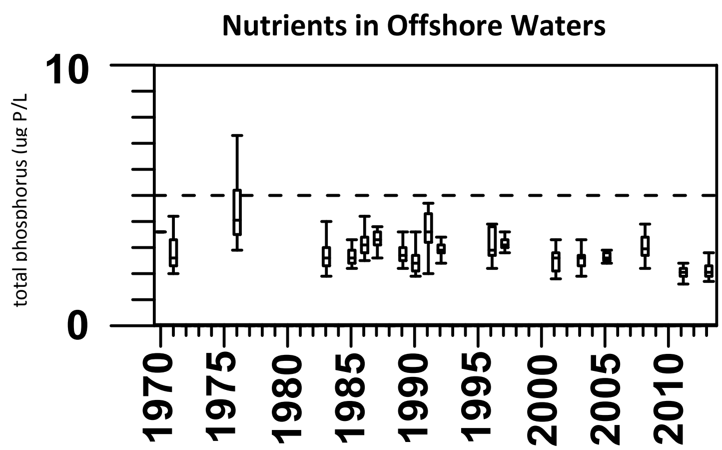


Figure 18. Long-term trend of total phosphorus (ug P/L) in Lake Superior. Dashed horizontal line denotes the environmental quality objective. Source: Dove and Chapra, 2015.

Occasional and site-specific algal blooms do occur in some locations in the nearshore zone. For example, in 2012, in conjunction with very warm water temperatures and an extreme rain event, a rare blue-green algal bloom was recorded in Lake Superior along a stretch of Wisconsin beach (Wisconsin Department of Natural Resources and Apostle Islands National Lakeshore, 2012). Other locations where elevated levels of algae have been observed include the connecting channels across the Keweenaw Peninsula (Michigan) and Lake Superior Provincial Park (Ontario).

Unlike the lower Great Lakes, shoreline fouling by mats of *Cladophora*, a green algae, has not historically been an issue in Lake Superior. There is no observational evidence that the occurrence of *Cladophora* has changed in recent years.

Be Free from the Introduction and Spread of Aquatic Invasive Species and Free from the Introduction and Spread of Terrestrial Invasive Species That Adversely Impact the Quality of the Waters of the Great Lakes

Due to the persistence of established invaders, expanding ranges, and threat of new invaders, aquatic invasive species present a significant threat to the Lake Superior ecosystem.

Lake Superior has 98 known non-native fishes, plants, invertebrates, and diseases (Minnesota Sea Grant, 2015). The newest non-native species, Banded Mystery Snail, was collected in 2014 in Waiska Bay, Michigan (United States Fish and Wildlife Service, 2015). According to the United States Geological Survey's Non-indigenous Aquatic Species web site, "At present there are no known impacts associated with this introduced species in the Great Lakes basin." On the other hand, impacts of many non-native species are often unknown until they cause very noticeable effects.

Some non-native species are known to be invasive, i.e., their introduction or spread threatens the environment, the economy, or society (including human health). By far, the most harmful aquatic invasive species currently established in Lake Superior, in terms of economic, societal and/or environmental cost, is the Sea Lamprey. This species has been the focus of control efforts for over 50 years at a cost of hundreds of millions of dollars. Aquatic invasive species with wide distribution and/or economic, societal, and/or environmental costs are listed in Table 4 on the following page.

Higgins eye mussel with zebra mussels. Credit: H. Quinlan, U.S. Fish and Wildlife Service.

Table 4. Most Harmful[1] Aquatic Invasive Species Established in Lake Superior

Species	Native Range	Pathway[2]	Economic/Societal/Environmental Impact
Sea Lamprey	North Atlantic	Canals and Diversions	Kill valuable sport and commercial fish species; destabilize food web and fish community
Rainbow Smelt	North Atlantic	Agency Activities	Prey on young fish reducing productivity of commercial fish species
Eurasian Ruffe	Europe and Asia	Maritime Commerce	Resulted in prohibition of bait harvest from Lake Superior; Nuisance for anglers; Competes for food with native fish
Common Carp	Europe	Multiple Pathways	Damage and uproot emergent aquatic vegetation such as wild rice
Viral Hemorrhagic Septicemia (VHS)	Northern Hemisphere	Multiple Pathways	Potential for large fish kills
Bacterial Kidney Disease	Northern Hemisphere	Agency Activities	Impact use of wild brood stock for rehabilitation stocking programs and hatchery production
Spiny Waterflea	Ponto-Caspian region	Maritime Commerce	Impacts recreational fishing by fouling fishing line; Causes declines in food resources for fish
Zebra Mussels	Ponto-Caspian region	Maritime Commerce	Establish on substrate, infrastructure and shipwrecks
Eurasian Watermilfoil	Europe and Asia	Multiple Pathways	Form mats that impede water recreation; Cause declines in shoreland property values.

Source: U.S. Fish and Wildlife Service and Minnesota Sea Grant, Personal communication.

[1] Harmful invasive species are considered those non-native species whose introduction or spread threatens the environment, the economy, or society (including human health).

[2] Pathways (vectors) identified in Lake Superior Aquatic Invasive Species Complete Prevention Plan (LSBP, 2014).

A total of 186 non-native species have already been established in the Great Lakes basin. An additional 53 more species have been identified as having a moderate-to-high probability of introduction AND establishment in the Great Lakes basin (GLANSIS, NOAA).

More information on Lake Superior's aquatic invasive species are described below in Section 4.2, Lakewide Threats.

Be Free from the Harmful Impact of Contaminated Groundwater

The full extent and impact of contaminated groundwater discharges on surface water bodies in the Great Lakes basin, including Lake Superior, is not known. It is known, however, that many sources of groundwater contamination including contaminated industrial sites, hazardous waste sites, spills, underground storage tanks, unlined landfills, abandoned mine sites, septic systems and sewer lines exist in the basin (Grannemann and Van Stempvoort, 2015).

Both directly and indirectly, groundwater is a major source of water to the Great Lakes and is expected to significantly affect both the quantity and quality of the water. Overall, 75% of the streamflow in Lake Superior's tributaries are fed by groundwater (Granneman et al., 2000). In the Lake Superior basin, large urban areas and areas with mining activities are the places which are likely to have the most significant disturbance of groundwater flow systems and contamination of groundwater quality. In turn, the water quality of streams, rivers and possibly nearshore lake environments would be most affected in these areas.

Some contaminants, such as perfluorooctane sulfonate (PFOS) and many personal care products, are susceptible to being transported in groundwater within the Lake Superior basin. This has implications for future monitoring programs, site investigations and restoration efforts, as well as for science activities related to water quality protection and management.

Be Free from Other Substances, Materials or Conditions that May Negatively Impact the Chemical, Physical or Biological Integrity of the Waters of the Great Lakes

The greatest threats to Lake Superior's habitats and species are aquatic invasive species, climate change, and dams and barriers. Atmospheric deposition is a source of many contaminants into Lake Superior. Information on these and other threats that may negatively affect Lake Superior are presented below, in the context of lakewide threats.

4.2 Lakewide Threats

Lake Superior faces a number of existing and emerging threats to the ecosystem. These threats have the potential to impede and/or derail progress toward achieving lakewide objectives. Understanding these threats help inform decisions on what actions can be taken. Threats are described below.

Aquatic Invasive Species

The invasive European Common Reed (a.k.a. *Phragmites*) is found in scattered occurrences in the Lake Superior watershed. It forms large, dense stands, and reduces wetland plant and animal species diversity. Credit: H. Quinlan, U.S. Fish and Wildlife Service.

Aquatic invasive species (AIS) have been designated as a "high threat" in Lake Superior because they have impacted, and have the potential to further impact, many of Lake Superior's habitats and species. For purposes of this section, the term "invasive species" refers to those non-native species that are causing harm to the ecosystem, not non-native species intentionally introduced by one or more government agencies. Once established, invasive species are extremely difficult to eradicate, and their impacts may be impossible to reverse. The introduction of a non-native species in Lake Superior may have a greater effect on the ecosystem than in other lakes, due to Lake Superior's relatively simple food web. In fact, while Lake Superior has a lower number of non-native fish species established than other Great Lakes, it has the highest ratio of non-native to native fish species. In total, Lake Superior has 98 known non-native fishes, plants, invertebrates, and diseases (Minnesota Sea Grant, 2015), many of which are deemed invasive because they threaten the environment, the economy, or society (through human health effects).

Ninety-three percent of introductions of non-native species were unintentional while 7% were intentional. Of the nine known pathways for entering Lake Superior, 48% of non-native species were introduced by ballast water discharge, 17% by diseases and parasites with introduced fish, 6% through stocked fish, 6% through canals and diversions, 5% by cultivation, 4% by aquarium releases, 4% through live bait release, 3% by recreational boaters, and 1% by packaging "hitchhikers" (Minnesota Sea Grant, 2015). As one end of the Great Lakes – St. Lawrence Seaway, the Duluth-Superior harbor is considered an invasion "hot spot" due to the potential for ships introducing invasive species through ballast water discharge.

As a testament to the tremendous effort in recent years to block the pathways that invasive species use to enter Lake Superior, the rate of introductions has slowed considerably. Since 2010, only two new invasive species have been identified in Lake Superior: the deadly infectious fish disease viral hemorrhagic septicemia (or VHS) discovered in 2010, and the Banded Mystery Snail in 2014. Constant vigilance is required to continue to block potential new arrivals, particularly in light of warming waters (i.e., more hospitable habitat conditions for some more southern invasive species) due to climate change.

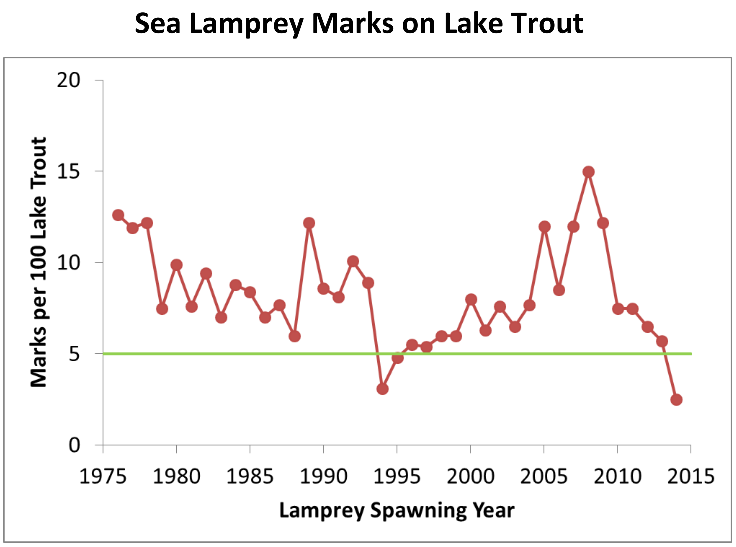


Figure 19. Yearly lakewide Sea Lamprey marking rates on Lake Trout greater than 21" (532 mm) captured in April-May assessments. The green horizontal line represents the marking rate target for Lake Superior, which is 5 marks per 100 Lake Trout. Source: Great Lakes Fishery Commission.

Sea Lamprey

The Sea Lamprey, a parasitic jawless fish that has devastated native fish populations in all the Great Lakes, contributed to the collapse of Lake Superior Lake Trout populations in the mid-twentieth century. The Sea Lamprey preys on sport and commercial fish, and is the focus of significant control efforts. The Sea Lamprey marking rate on Lake Trout in Lake Superior has been declining and is below the target for the first time since 1994. Sea Lamprey marking rates have declined in the past 10 years, while Lake Trout abundance has remained stable.

The mouth of a Sea Lamprey. Credit: Ontario Ministry of Natural Resources and Forestry.

Climate Change

Climate change is expected to alter the physical, chemical, and biological aspects of Lake Superior, as summarized in the *Lake Superior Climate Change Impacts and Adaptation* report (Huff and Thomas, 2014), include:

- Increase in air temperatures by 3 to 4.5°C (5.4 to 8.1°F) by the end of the 21st century;
- Slight increase in annual precipitation, with seasonal shifts;
- Increase in annual average water temperatures of 5 to 7°C (9 to 12.6°F) throughout the 21st century;
- Increased water temperatures of Lake Superior's streams and rivers;
- Continued decrease in the extent and duration of ice cover throughout the 21st century;

Relative Impact of Climate Change

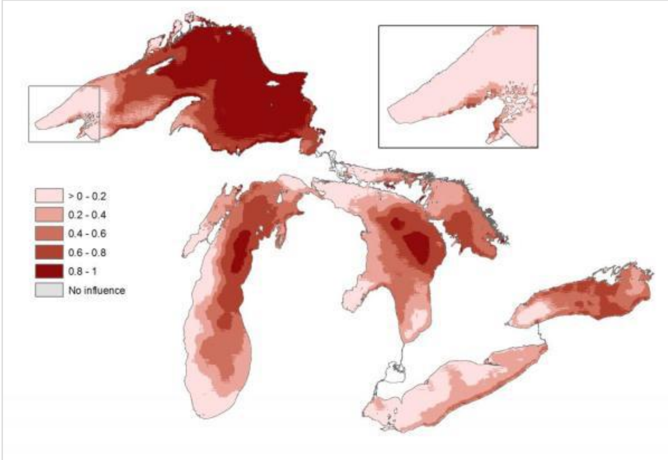


Figure 20. Weighting of the relative impact of climate change on the waters of the Great Lakes. Source: Allan et al., 2013.

- Increased wind speeds;
- Long-term decrease in water levels (although periods of higher-than-average levels are possible); and
- Earlier onset of spring and summer and an increased growing season (Huff and Thomas, 2014).

Evidence suggests that some of these changes are already underway, including increases in open-water summer temperatures, changes in lake stratification, and reductions in winter ice cover (Austin and Colman, 2008).

Changes in the Lake Superior climate could have the following effects on the Lake Superior ecosystem (Huff and Thomas, 2014):

- Higher water temperatures, favoring aquatic invasive species such as Sea Lamprey;
- Increased water temperatures, which could alter the plankton communities with potential implications for the entire food web;
- Creation of ecosystem conditions unfavorable to cold-water fish communities that require cold-water rivers and streams;
- Northward shifting of deciduous forests due to warmer air temperatures and changes in precipitation;
- Spread of forest pests, such as gypsy moth, due to higher air temperatures;

- Reduction of suitable habitat for arctic-alpine and boreal species that are dependent on cooler temperatures and microclimates, due to increased air and water temperatures;
- Increased concentrations of toxic pollutants through increased intensity of precipitation, or the exposure of previously submerged toxic sediments through lower water levels;
- Lower dissolved oxygen levels due to warmer waters, increased duration of summer stratification, and increase in algal blooms;
- Lower water levels, which would be favorable to some invasive species, such as the European Common Reed (i.e., *Phragmites*); and
- Diminishing coastal wetlands, negatively affecting fish and wildlife populations.

Lake Superior Water Temperatures

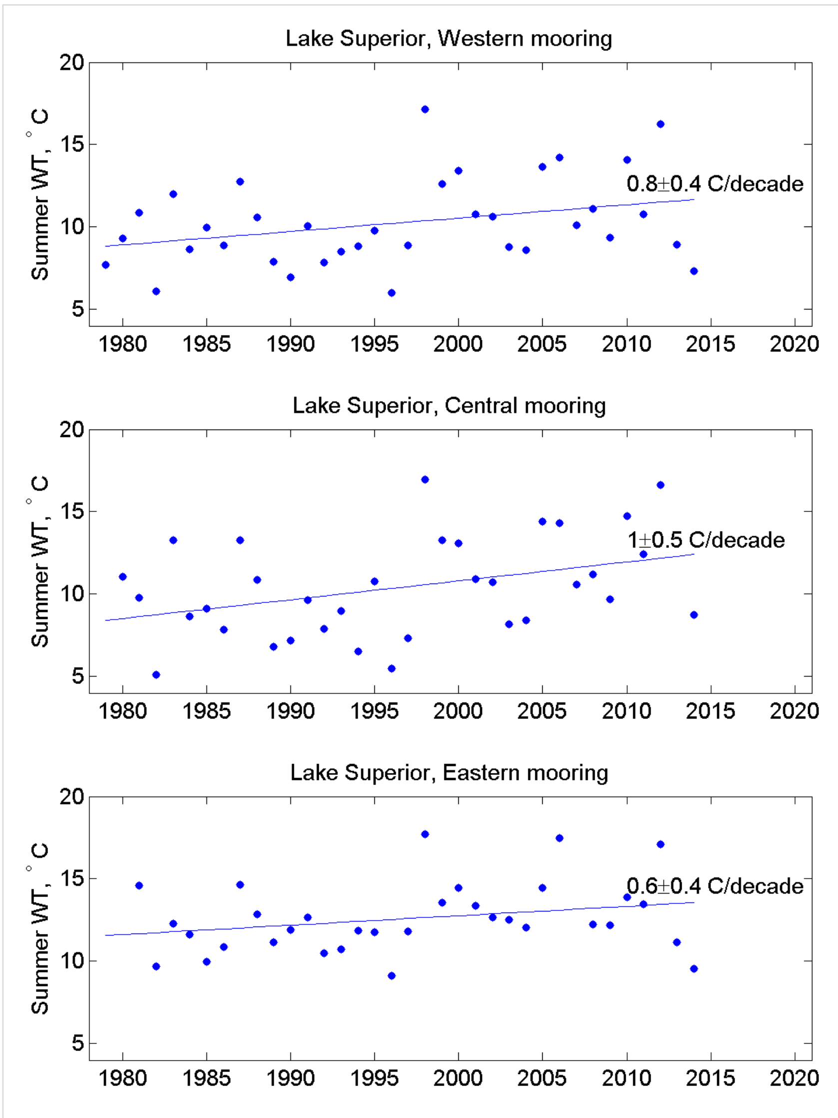


Figure 21. Lake Superior summer water temperatures, 1978-2014, collected from NOAA buoys in the western, central, and eastern basins. Source: J. Austin, UMN.

Dams and Barriers

Over 23,600 dams and other potential barriers, such as weirs and poorly installed road-stream crossings, have been documented within the Lake Superior watershed. Dams and other barriers disrupt habitat connectivity for aquatic organisms and can degrade water quality through the disruption of the natural movement of woody debris, sediment and nutrients. Dams are a major factor in the low population of some Lake Superior fish stocks compared to historical observations, since the fish cannot access spawning areas above the dam. Many dams in the basin are now more than 50 years old and deteriorating. The removal of dams and other barriers can be a difficult issue: While these barriers prevent native fishes from accessing their tributary habitats, they also limit the spread of invasive species and prevent the invasive Sea Lamprey from accessing additional spawning areas.

A culvert barrier. Credit: M. Fedora, U.S. Forest Service.

Older dams have a greater impact because newer dams were constructed with newer regulations and stronger environmental assessments. Protecting and restoring connectivity, where appropriate, requires removing dams, upgrading stream/road crossing infrastructure, or implementing other solutions, and prioritizing barrier removal considering the benefits and costs of various options.

Dams and Barriers

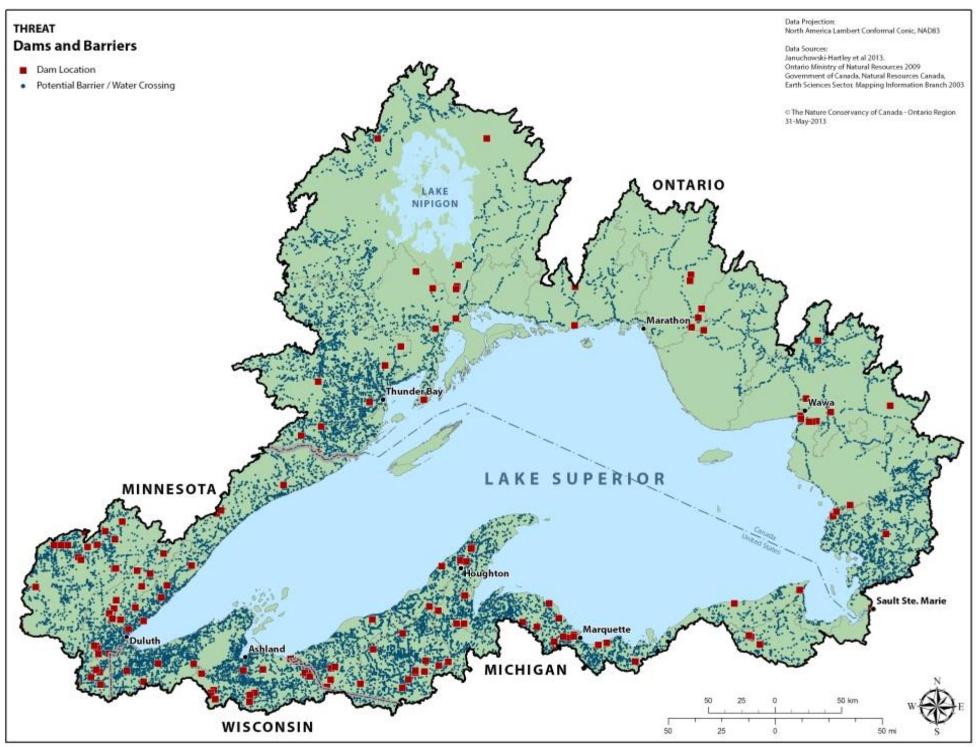


Figure 22. Dams and road stream crossings in the Lake Superior basin. Source: The Nature Conservancy of Canada.

Chemical Contaminants

Special efforts have been made to eliminate Lake Superior basin sources of many legacy chemicals through the Lake Superior Zero Discharge Demonstration Program. Local, regional and national actions targeting the nine critical pollutants have resulted in the achievement of chemical reduction targets to date. It is becoming increasingly challenging to make further reductions from the remaining sources (LSBP, 2012).

Lake Superior Zero Discharge Demonstration Program

In 1991, the Zero Discharge Demonstration Program was established in Lake Superior as a demonstration project to achieve zero discharge and zero emission of nine toxic, persistent, and bioaccumulative chemicals: mercury, total polychlorinated biphenyls (PCBs), dieldrin/aldrin, chlordane, DDT, toxaphene, 2,3,7,8-TCDD (dioxin), hexachlorobenzene (HCB), and octachlorostyrene (OCS). The target date for zero discharge is 2020, with interim reduction targets in 2000, 2005, 2010 and 2015.

In-Basin Sources of Legacy Chemicals

Compared to the baseline year of 1990, notable achievements have been made in reducing the emissions and discharges of legacy chemicals from within the Lake Superior basin:

- 80% reduction in mercury;
- 85% reduction in dioxin, HCB, and octachlorostyene;
- Significant reduction of materials containing PCBs; and
- Ongoing collection and safe disposal of the waste pesticides aldrin/dieldrin, chlordane, DDT/DDE, and toxaphene.

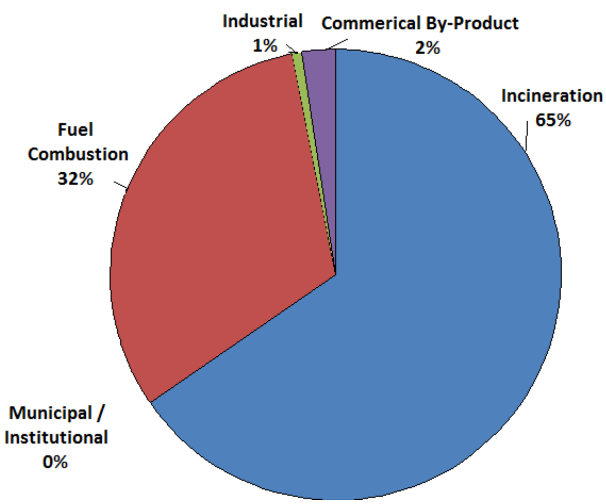


Figure 23. Percentage of dioxin releases from different sectors in the Lake Superior Basin, 2010. Source: LSBP, 2012.

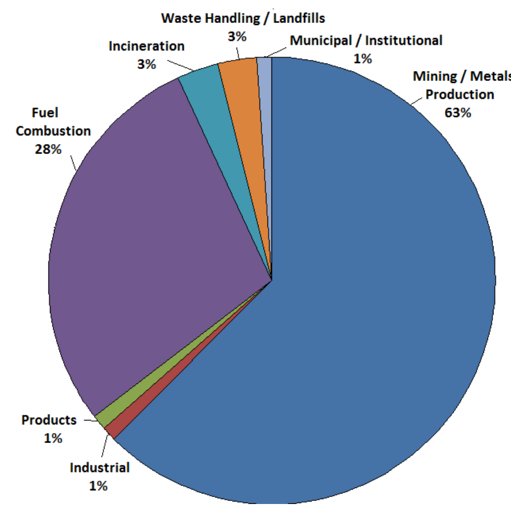


Figure 24. Percentage of mercury releases from different sectors in the Lake Superior Basin, 2010. Source: LSBP, 2012.

Chemicals of Mutual Concern

Under the 2012 GLWQA, Canada and the United States committed to designate certain chemicals found in the Great Lakes as *chemicals of mutual concern* that are potentially harmful to human health or the environment. To date, eight chemicals (or categories of chemicals) have been recommended for designation as Chemicals of Mutual Concern.

- Mercury;
- PCBs;
- Brominated flame retardants: hexabromocyclododecane (HBCD) and polybrominated diphenyl ethers (PBDEs);
- Perfluorinated chemicals: perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and long-chain perfluorinated carboxylic acids (PFCAs); and
- Short-chain chlorinated paraffins.

Mercury

Mercury is a heavy metal that can enter the environment as a result of natural processes (e.g., forest fire, volcanic activity) or as a result of anthropogenic activities (e.g., combustion of coal and refined petroleum products, extraction of metals from ore, the use and disposal of mercury-containing consumer products, and use in some manufacturing processes). A recent study found that atmospherically derived mercury is the dominant contributor of mercury to Lake Superior sediment, though watershed sources are significant near river mouths, such as the St. Louis River and Thunder Bay (Lepak et al., 2015).

Atmospheric Deposition

Lake Superior's large surface area and small human population relative to the other lakes contribute to the significance of atmospheric deposition as a source of chemical contamination relative to the other Great Lakes. Sources of air contamination come from local activities, such as cars, trucks and industry, and from activities far away such as pesticide applications in other parts of North America, and from power plants in China. Chemicals from atmospheric deposition affect the lake by contaminating offshore waters, sediments, fish and waterbirds.

Total atmospheric mercury emissions from anthropogenic sources from within the entire Great Lakes basin declined by approximately 50% between 1990 and 2005 (Evers et al., 2011). Since 2005, atmospheric mercury concentrations have decreased about 2% per year as measured in Canada's Experimental Lakes Area (west of Lake Superior). Wet deposition measurements from the North American Mercury Deposition Network follow these trends, with deposition decreasing about 1.6% per year since 1996 (Zhang et al., 2016).

PCBs

PCBs are a mixture of synthetic chemicals that do not occur naturally in the environment. They were used up through the 1970s primarily as coolants and lubricants in a wide variety of applications such as electric transformers, capacitors and switches, electrical components in fluorescent lighting fixtures and appliances, and hydraulic and heat transfer systems. PCBs were banned in 1977 but are still being found in the environment.

PCBs are declining in the atmosphere over the Great Lakes, but at a slow rate, due to residual sources found in transformers, capacitors, and other equipment. This rate of decline is expected to continue into the future. In a 2011-2012 lake-by-lake water quality study by Venier et al. (2014), the highest concentrations of total PCBs were measured in Lake Ontario (623 ± 113 pg/L) and the lowest were measured in Lake Superior (average 117 ± 18 pg/L). For individual samples, the highest concentration measured in Lake Superior was at a station in Whitefish Bay (165 pg/L).

Brominated Flame Retardants

Flame retardants, such as polybrominated diphenyl ethers (PBDEs), are compounds added to manufactured materials and surface finishes to inhibit, suppress or delay the production of flames and to help prevent the spread of fire. In general, penta-BDE concentrations in a range of environmental media (air, sediment, landfill effluent, aquatic biota and birds) increased until approximately 2000, when levelling off or decreasing trends were observed (Backus et al., 2010). Concentrations seem to have stabilized in Lake Superior, but have not begun to decline significantly. A study by Venier et al. (2014) in which water samples were collected in the spring of 2011 and 2012 at 18 stations throughout the Great Lakes, found that total PBDE concentrations were lowest in Lake Superior, with an average of 34 ± 11 pg/L.

A passive air and water sampling study in Lake Superior in 2011 showed that atmospheric (gaseous) and dissolved PBDEs, in particular BDE-47, were greatest near urban and populated sites (Ruge et al., 2015). Net gaseous deposition of BDE-47 was observed at coastal sites, while the central open lake and at Lake Superior's IADN station of Eagle Harbor generally displayed volatilization of PBDEs into the atmosphere, mainly of BDE-47.

IADN measurements show that Great Lakes concentrations of an alternative flame retardant, pentabromoethyl benzene, or PBEB, are highest at Eagle Harbor (Liu et al., 2016). While trends of PBEB in the air are decreasing at most other IADN sites, they are not at Eagle Harbor. It is unknown why Great Lakes concentrations of PBEB are highest at Eagle Harbor.

2-ethylhexyl-2,3,4,5-tetrabromobenzoate (TBB) and bis(2-ethylhexyl)-tetrabromophthalate (TBPH) are the two main components of FireMaster 550, which is a replacement for the penta-BDE commercial mixture. The atmospheric concentrations of TBB+TBPH are significantly and rapidly increasing at all IADN sites including Eagle Harbor, with doubling times of 2–5 years.

HBCD is another category of brominated flame retardants, and in the study by Venier et al., HBCD was detected in all five Great Lakes at concentrations ranging from 0.2 to 4.36 pg/L. Of the five Lake Superior stations sampled, HBCD was detected at the Thunder Bay station and the station outside Duluth at concentrations of 1.6 pg/L and 0.8 pg/L, respectively.

Perfluorinated Chemicals PFOS, PFOA and long-chain PFCAs

Perfluorinated chemicals (PFCs), which include perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and long-chain perfluorocarboxylic acids (PFCAs) have been used for a wide number of applications which take advantage of their surfactant-like properties including aqueous film forming foams, lubricants, polishes, cosmetics and paints. PFOS concentrations in some Great Lakes fish and herring gull eggs exceed relevant guidelines derived for the protection of avian and mammalian predators and consumers of fish and wildlife. PFOS concentrations in Herring Gull eggs in the Great Lakes show that colonies in urban environments have not been consistently declining in concentrations, while in remotely-located colonies, such as Lake Superior, a decline is evident (Environment Canada, 2013). PFCs can accumulate in different ways, and trends vary in wildlife. Fish and birds, for example, represent two very different trophic levels with different food sources and ecosystems that influence their PFOS levels. Increasing concentrations of PFOS and PFOA, and to a lesser extent long-chain PFCAs, have been observed in sediment.

Short-Chain Chlorinated Paraffins

Chlorinated paraffins (CPs) are divided into groups according to their carbon chain length, namely short chain (SCCP), medium chain (MCCP) and long chain (LCCP) chlorinated paraffins. They have been used as flame retardants and plasticizers and as additives in metal working fluids, in sealants, paints and coatings. CPs can be released into the environment during production, storage, transportation, industrial and consumer usage of CP-containing products, disposal and burning of waste, and land filling of products. Short-chain chlorinated paraffins (SCCPs) are bioaccumulative in wildlife and humans, are persistent and transported globally in the environment, and are toxic to aquatic organisms at low concentrations. CPs occur in complex mixtures that are very difficult to analyze in environmental matrices, and data for Lake Superior is very limited.

Additional Substances of Concern

Commercial and consumer-use chemicals, and other substances (such as microplastics), can be detected in Lake Superior at very low levels. While the science continues to advance with respect to detecting these chemicals of concern, there is still much to be studied with respect to the potential adverse effects associated with acute and chronic exposure.

Pharmaceuticals and personal care products (PPCPs) are a diverse group of chemicals that enter waterways through wastewater treatment plant discharges after human use, and from agricultural run-off due to spreading of biosolids or use in livestock. There are concerns about the presence of pharmaceutical and personal care products chemicals in water as many are bioactive, some have the potential to bioaccumulate, some are persistent, and as the sources are often continuous (wastewater), there are constant exposures in waters where discharges occur. Pharmaceuticals include therapeutic substances for pain and inflammation (e.g., ibuprofen, naproxen), epilepsy/mood (e.g., carbamazepine), anti-biotics (e.g., sulfamethoxazole), blood pressure (valsartan), and hypertension (atenolol), to name a few. They also include recreational compounds such as caffeine, narcotics, and cotinine from cigarettes. Personal care products (PCPs) are a diverse group of compounds used in personal hygiene (e.g., shampoos, conditioners, lotions, soaps, toothpaste, deodorant) and for beautification (e.g., cosmetics, hair dye, perfumes). The primary classes of PCPs include disinfectants (e.g., triclosan), fragrances (e.g., musks), insect repellents (e.g., DEET), preservatives (e.g., parabens) and UV filters (e.g., methylenzylidene camphor).

Two recent studies have been conducted in the Lake Superior region to screen for chemicals of emerging concern in the nearshore waters impacted by urban run-off, municipal wastewater treatment plant effluent and industrial effluent discharges (Christensen et al., 2012; Ontario MOECC, unpublished). In the vicinity of the St. Louis River, St. Louis Bay, and Superior Bay, 33 of 89 (37%) chemicals were detected in the water samples (Christensen et al., 2012). Using passive samplers in water near Thunder Bay and Sault Ste. Marie, Ontario, 40 compounds were detected out of the 135 (30%) that were being screened (Ontario MOECC, unpublished). In both studies, DEET was the most commonly detected chemical of emerging concern. While estimated concentrations were very low in the Canadian samples, some of the chemicals detected most frequently included codeine, atenolol, valsartan, DEET, sulfamtheoxazole, carbamazepine, and naproxen (Ontario MOECC, unpublished). In the U.S. samples, frequently detected compounds included caffeine, benzophenone, carbamazepine, esterone, cotinine, and a fragrance hexahydrohexa-methyl cyclopentabensopyran (Christensen et al., 2012).

Microplastics are plastic particles that are generally less than 5 millimeters in size and made of non-biodegradable organic polymers such as polyethylene, polypropylene, and polystyrene. Microplastics include fibers, such as those from clothing and rope, plastic particles from the breakdown of bags, packaging and containers, and plastic beads. They are also used in a variety of products, including personal care products, certain over-the-counter drugs and sand-blasting. An open water survey investigated plastic pollution within Lakes Superior, Huron and Erie in 2012 (Eriksen et al., 2013). Results showed that the concentration of plastic particles increased as they moved from Lake Superior through to the lower Great Lakes, consistent with greater populations in the Lake Erie region and given the water flows from one lake to the next. Abundance counts at the five sites sampled in Lake Superior ranged from 1,277 to 12,645 particles per square kilometer, based on the presence of 3 to 16 plastic particles collected in 2-4 km long trawls (Eriksen et al., 2013). In comparison, the highest abundance found in Lake Erie was over 450,000 particles per square kilometer.

Microplastics Distribution

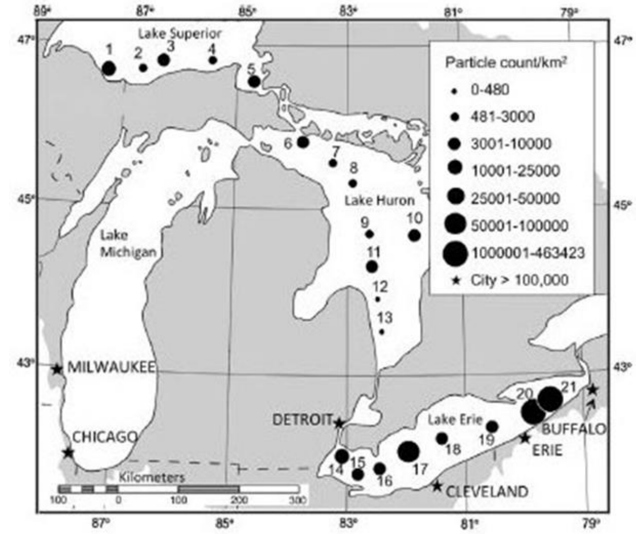


Figure 25. Distribution of plastic particles by count for 21 samples collected in three of the Great Lakes, 2012. Source: Eriksen et al., 2013.

Excessive nutrients (e.g., phosphorus) are a threat in the lower Great Lakes, but not in Lake Superior. The SPARROW model (Robertson and Saad, 2011), applied to the U.S. side of the Lake, predicted the largest source of phosphorus was from forests and wetlands, followed by point sources (e.g., regulated wastewater treatment plant discharges). Most eutrophic occurrences are generally limited to the nearshore areas with greater municipal or industrial activity. In particular, shallow bays that do not mix as readily with offshore waters are more vulnerable to the effects of increased nutrients. The SPARROW model does not attribute agricultural land uses as a major input to Lake Superior; however, in some regions around the lake agricultural land is more concentrated (primarily the southwest shore in the U.S.), and provides a greater relative contribution

Nutrient Loadings

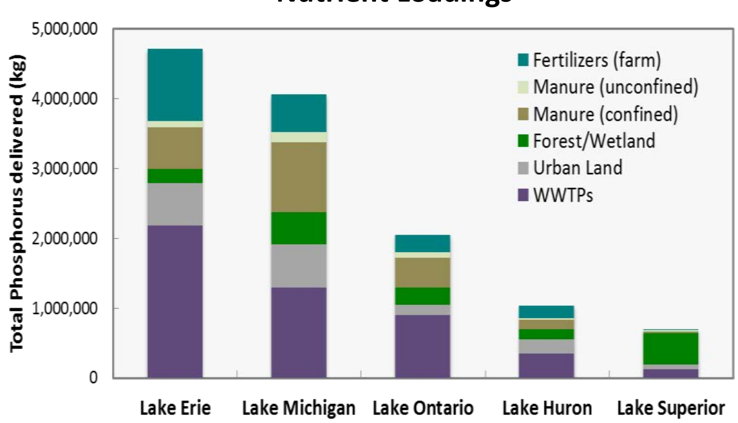


Figure 26. SPARROW model of total phosphorus delivered (kg) in the U.S. to each Great Lakes. Source: Robertson and Saad, 2011.

of nutrients in those areas. In the future, climate change is expected to increase water temperature and the frequency of extreme precipitation events (Huff and Thomas, 2014). These changes, combined with additional developments, could potentially increase the likelihood of nutrient enrichment to some specific locations in Lake Superior (LaBeau et al., 2014). Ongoing efforts are being made to better understand nutrient dynamics in Lake Superior and identify the most vulnerable locations for eutrophication.

Other Threats

Threats to the Lake Superior ecosystem are not limited to the issues identified above. At regional and local scales, the risk of a wide range of particular threats varies greatly. Other threats described below include the impacts of coastal development, oil transport, mining, and Areas of Concern. In some locations, other issues that can impact the achievement of lakewide objectives include discharges from vessels, unsustainable forestry practices, energy transport and development, and point source pollution. Through research, monitoring and other science, current and future threats are assessed regularly.

Mining Impacts

The Lake Superior basin has a long history of mining operations and related impacts. While mining operations can offer economic benefits, they also present threats to the environment. For example, two Great Lakes Areas of Concern, Deer Lake and Torch Lake, were so designated in the Lake Superior basin due to impacts from past mining operations. Fourteen mines

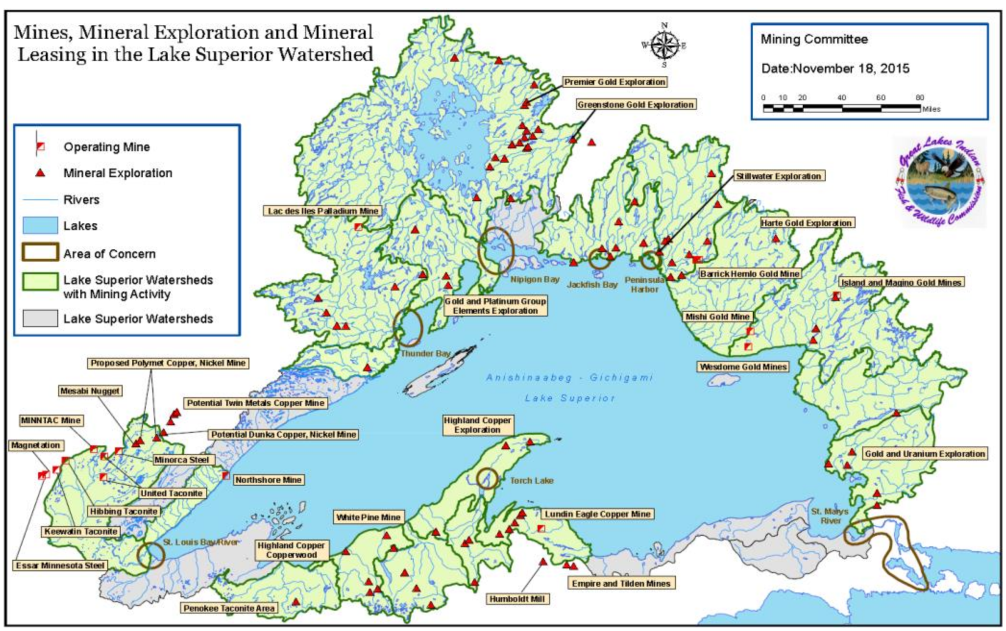


Figure 27. Mines, mineral exploration and mineral leasing in the Lake Superior watershed. Source: Great Lakes Indian Fish and Wildlife Commission, 2015.

currently operate in the Lake Superior basin, with many explorations and expansions underway. Current and/or past mines in the basin have extracted gold, silver, copper, platinum, palladium, nickel, zinc, diamond, lead, iron-ore and taconite, as well as quarried brownstone. Mining impacts cannot be easily reversed – some can cause far reaching and lasting environmental damage. Mining activity has the potential to impair water quality (e.g., mining is currently the largest source of mercury emissions from within the Lake Superior basin) and degrade habitat (e.g., through increased sediments). Mining sediments in the nearshore, embayments, and river mouths may cover or degrade fish spawning habitats, Wild Rice and other natural resources. After a mine closes, it can remain a source of contamination from chemicals and waste rock piles; tailing ponds must be monitored and maintained for centuries to avoid environmental impacts.

Coastal Development

Structures that protect shoreline properties can also alter sediment transport process along the coast and, in turn, impact the quality of beaches and wetlands. Artificial shorelines replace natural habitat, and these developments are often found in the important habitat areas of river estuaries and embayments. Overall, the Lake Superior shoreline remains in a largely natural state compared to the other Great Lakes – less than 5% of the shoreline has been developed and converted into an artificial or hardened shoreline. In some communities, former industrial lands are being reclaimed for public waterfront access, or to create green space along the shore. At the same time, however, some stretches of shoreline are becoming increasingly developed for roads and residential, commercial or industrial land uses.

Oil Transportation

The transport of crude oil from Bakken shale oil and Alberta bitumen sources presents risks to Lake Superior due to proposed increases in the amount of oil being refined and transported. In the U.S., 9,500 carloads of crude oil were carried by train in 2008, with 650,000 carloads forecasted by the end of 2014, a more than 68-fold increase (GLC, 2015). In Canada, 500 carloads were carried in 2009 with 140,000 carloads estimated to be carried by the end of 2014, a 28-fold increase. Existing pipelines are being upgraded to carry oil from west to east, and new pipelines are proposed or underway. Shipping depots and oil storage and transfer facilities are proposed in the Lake Superior basin. Transfer of oil by shipping vessels across Lake Superior to refineries located on the shores of the lower Great Lakes has been proposed in the past.

Unknown threats

New, previously unidentified threats will be addressed as they are identified, using an adaptive management approach, and appropriate actions will be initiated as needed.

Areas of Concern

The 1987 GLWQA defined Areas of Concern (AOCs) as “geographic areas that fail to meet the general or specific objectives of the GLWQA where such failure has caused or is likely to cause impairment of beneficial use of the area's ability to support aquatic life.” In short, an AOC is a location that has experienced environmental degradation as a result of human activities at the local level. The status of the seven AOCs located in the Lake Superior basin is presented below.

Delisted AOCs

- In October 2014, Deer Lake AOC, located in Michigan on the southern shore of Lake Superior, was delisted from the binational list of toxic hotspots in the Great Lakes.

AOCs in Recovery

- Canada and Ontario formally recognized Jackfish Bay as an “AOC in Recovery” in 2011. Fish health and sediment quality in the area will continue to be monitored to assess progress toward environmental recovery.

Listed AOCs

- At the Torch Lake AOC, the State of Michigan is leading a multi-year project to identify the source(s) of PCBs that are causing levels in fish and sediments to remain high.
- Feasibility studies, design work, and permitting are underway for large-scale restoration and remediation projects on the Wisconsin and Minnesota sides of the St. Louis River AOC. Construction began in 2015. Eight BUIs remain.
- Most remedial actions for the Thunder Bay AOC are complete, with positive effects on the environment. Work is underway to develop the best solution for managing 22 hectares of contaminated sediment in the north harbor. The sediment cleanup is the largest and most significant project needed to address remaining environmental issues in the area.

Beneficial Use Impairments (BUIs)

Impairment of a beneficial use is a reduction in the chemical, physical, or biological integrity of the waters of the Great Lakes sufficient to cause any of 14 specific problems

1. restrictions on fish and wildlife consumption;
2. tainting of fish and wildlife flavor;
3. degradation of fish and wildlife populations;
4. fish tumors or other deformities;
5. bird or animal deformities or reproduction problems;
6. degradation of benthos;
7. restrictions on dredging activities;
8. eutrophication or undesirable algae;
9. restrictions on drinking water consumption, or taste and odor problems;
10. beach closings;
11. degradation of aesthetics;
12. added costs to agriculture or industry;
13. degradation of phytoplankton and zooplankton populations; and
14. loss of fish and wildlife habitat.

http://binational.net/annexes/a1/

- Thanks to the collaborative efforts of governments, industry, and community partners over more than two decades, the environmental goals set for the Nipigon Bay AOC have been met. The governments of Ontario and Canada are recommending the removal of Nipigon Bay from the list of Great Lakes AOCs.
- In 2012, Canada and Ontario completed sediment remediation via thin-layer capping, which was the last major action needed to address environmental problems in the Peninsula Harbour AOC. Long-term monitoring is underway to make sure the environment is recovering. To date, results show that cap materials have remained in place and some aquatic vegetation is growing in the capped area.

Vistas of Nipignon Bay (foreground) and Red Rock (background). Credit: D. Crawford.

5.0 SURVEYS, INVENTORIES AND OUTREACH

5.1 Cooperative Science and Monitoring Initiative (CSMI)

As part of a five-year cycle to assess and monitor the chemical, physical, and biological integrity of Lake Superior, the Lake Superior Partnership implements a Cooperative Science and Monitoring Initiative (CSMI). CSMI results are used to assess the state of the lake (reported in Section 4). The binational research and monitoring program involves an intensive, management-related scientific examination of each Great Lake, on a staggered five-year rotational basis. The current five-year cycle for Lake Superior CSMI consists of the following steps:

- Identify science needs (completed in 2014);
- Develop priorities (completed in 2015);
- Conduct field work (planned for 2016);
- Perform laboratory analysis and compile results (planned for 2017); and
- Report results (planned for 2018).

Monitoring on the USEPA research vessel, *Lake Guardian*. Credit: S. Swart.

Science and monitoring priorities are identified through the lakewide management process, with open discussion and input opportunities available to all stakeholders and the interested public. For Lake Superior, the last year of intensive field work and monitoring took place in 2011. A number of resulting studies were completed by various agencies and together they present a comprehensive assessment of the state of the Lake Superior ecosystem. Priority research topics ranged from emerging and legacy contaminant trends in water, fish, wildlife, and humans to ecosystem-wide assessments of fish, coastal wetlands, invasive species, and lakewide trends in tributary flows.

As part of the reporting phase of the last CSMI cycle, Environment and Climate Change Canada and the USEPA hosted a monitoring workshop on September 24-25, 2013, in Duluth, Minnesota. The workshop had a dual purpose: first, to allow researchers to present their recent Lake Superior science and monitoring results (with a focus on activities undertaken as part of the 2011 monitoring year); and second, to begin discussions of ongoing and new information needs, potential partners and potential funding mechanisms for conducting new field studies in 2016. See Section 8 for a list of Lake Superior CSMI priorities for 2016.

5.2 Ongoing Science and Research

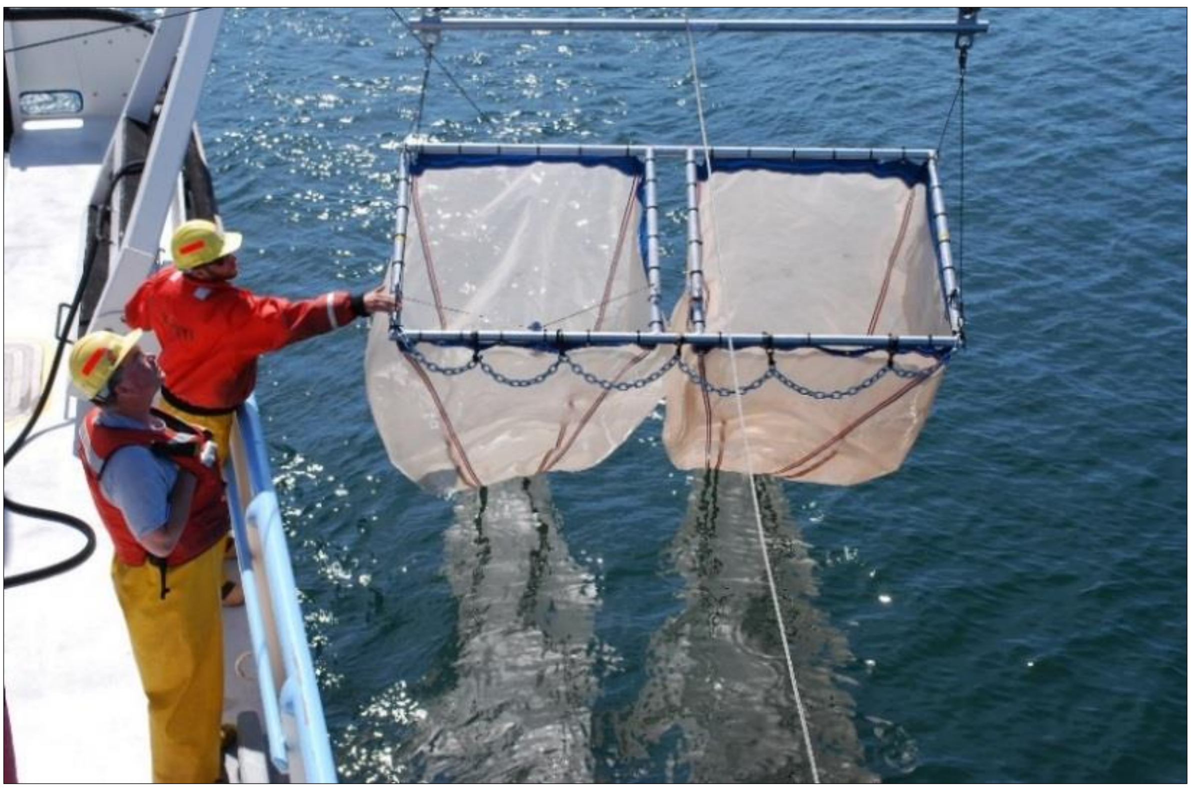
In addition to CSMI, the agencies of the Lake Superior Partnership conduct a wide range of ongoing science and monitoring activities. This work provides a foundational understanding of

Lake Superior's conditions and threats, as well as guidance to various restoration and protection programs and initiatives. The results of the science and monitoring efforts are shared, and where applicable, coordinated among various natural resource agencies.

For example, every state and province monitors contaminant levels in fish on an ongoing basis in order to provide public advice on safe fish consumption, such as the *Guide to Eating Ontario Fish*. Similarly, the Great Lakes Indian Fish and Wildlife Commission has undertaken monitoring of and communication regarding mercury levels in fish in targeted areas of importance to tribal communities who depend on these fish for food and their traditional ways of life. Similar programs exist in each of the Lake Superior states.

Coordination of fisheries activities across Lake Superior is undertaken by the Lake Superior Technical Committee, under the auspices of the Great Lakes Fishery Commission. Fishery agencies have developed protocols to standardize collection of biological data.

These are two of many examples of the ongoing science and monitoring activities undertaken by agencies that make up the Lake Superior Partnership.



Monitoring from the U.S. Geological Survey research vessel, *Kiyi*. Credit: J. Bailey.

5.3 Outreach and Engagement

The Lake Superior Partnership has a long history – over 25 years – of extensive public engagement in the lakewide management program. Historically, outreach and engagement activities were undertaken by two entities:

1. The Lake Superior Partnership Communications Committee; and
2. The Lake Superior Binational Forum.

The Lake Superior Binational Forum, a binational group of stakeholders from a wide array of sectors, helped establish an effective multi-sector stakeholder process through public meetings, webinars, workshops, radio shows, publications, newspaper inserts, social media and websites. In particular, through social media and their website, the Forum shared important information on the Lake Superior ecosystem and helped foster an appreciation and awareness of the lake through Lake Superior Day and annual stewardship awards. Past Lake Superior Binational Forum activities included:

- Annual Lake Superior Day celebrations;
- Annual Lake Superior stewardship awards;
- Hazardous, e-waste and pesticides disposal days;
- Outreach on reduction of backyard trash burning, the largest source of dioxins to Lake Superior;
- Public meetings and webinars around the basin on mining, AIS, and other issues; and
- Contributions to establishment of chemical reduction targets and timeframes.

Purpose of Outreach and Engagement

- Provide information on GLWQA, particularly Annex 2
- Provide opportunity for stakeholder input on GLWQA Annex 2 products
- Tech transfer of information on the Lake Superior ecosystem
- Create a direct link between Lake Superior stakeholders and the Partnership
- Disseminate information on LAMP implementation, and how to be involved
- Identify opportunities for projects related to LAMP goals and priorities
- Promote LAMP to the public— help people take ownership of issues within their watershed
- Help identify emerging issues of concern about Lake Superior.

Although the Lake Superior Binational Forum is no longer operational, the Lake Superior Partnership is committed to formulating a robust, meaningful, and substantive outreach and engagement program and process. Under the 2012 GLWQA, the Lake Superior Partnership is specifically responsible for conducting outreach activities, identifying the need for further engagement by governments and the public, and providing annual updates to the public under each LAMP. The Lake Superior Partnership is committed to these activities, in accordance with the requirements of GLWQA Annex 2.

A Lake Superior Partnership Outreach and Engagement Committee will continue these types of activities and further strengthen outreach and awareness to ensure that the needs and concerns of the diverse population in the Lake Superior basin are being met.

The Lake Superior Partnership's Outreach and Engagement Committee helps plan, deliver and support communication and outreach activities and products. Examples of outreach activities which are proposed to continue into the future are presented below.

Outreach on AIS

A significant project related to public outreach is the lakewide effort to raise awareness about aquatic invasive species. In Ontario, this effort has been led by the Ontario Federation of Anglers and Hunters with funding from the Ontario Ministry of Natural Resources and Forestry (MNRF). Other organizations, including state governments, tribal organizations and non-government organizations such as Minnesota Sea Grant, are also leading AIS outreach and education programs. In 2014, the Ontario Federation of Anglers and Hunters published *The Lake Superior Aquatic Invasive Species Guide* as an informational resource for recreational lake users to be aware of potential invaders and how to report a sighting.

Burn Barrel Outreach

Open burning of household wastes continues to be a basinwide problem that contributes to air quality and human health issues by releasing particulates, specifically dioxin, and other contaminants. The "Bernie the Burn Barrel" program is based on a cartoon character who teaches children about the problems associated with open burning. Bernie has been used throughout the Lake Superior basin over the last 15 years to instill in school children the idea of reducing trash burning.

Emerging Contaminants

Outreach activities will continue on educating basin stakeholders about the environmental health issues associated with personal care products. Although the Lake Superior Partnership has focused past efforts on legacy pollutants through the Zero Discharge Demonstration Program, the Lake Superior Partnership also conducts research and outreach on emerging chemicals such as those found in cleaning products, personal care products and pharmaceuticals. Outreach efforts have ranged from establishing pharmaceutical "take back" programs and promoting medicine cabinet clean-ups to supporting hands-on workshops where participants learn how to make household cleansers or bath products. These workshops help teach stakeholders that simple, natural products are effective and safer for humans and the environment.

The beauty of Lake Superior elicits a jubilant reaction from toddler. Credit: M. Collingsworth.

Potential Public Outreach and Engagement Activities

Going forward, proposed outreach and engagement activities for the public conducted by the Lake Superior Partnership include the following:

- Publish Lake Superior annual updates;
- Develop Lake Superior ecosystem objectives;
- Develop a nearshore framework;
- Prepare Lake Superior LAMP 2020;
- Assess science priorities, i.e., workshops, publications;
- Develop binational strategies;
- Conduct Outreach and Engagement Committee activities;
- Host Lake Superior State of the Lake Conferences; and
- Organize subject matter webinars.

The lake on Manitou Island. Credit: P. Nankervis.

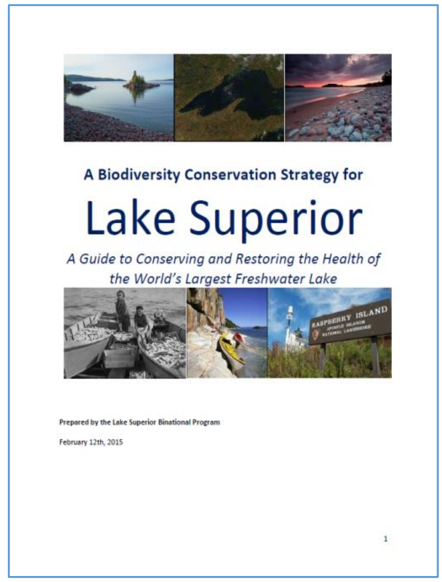
6.0 BINATIONAL STRATEGIES

Under the 2012 GLWQA, the Lake Superior Partnership is directed to develop and implement lake-specific binational strategies to address current and future potential threats to water quality. The first binational strategy developed under the 2012 GLWQA was *A Biodiversity Conservation Strategy for Lake Superior*, *2015* (LSBP, 2015).

A Biodiversity Conservation Strategy for Lake Superior, 2015

This Strategy provides a summary of the health of and threats to the biodiversity of Lake Superior, and presents a guide to implementing effective lakewide and regional conservation strategies. This Strategy contributes to the 2012 GLWQA commitment of developing lakewide habitat and species protection and restoration conservation strategies.

Government agencies, local stakeholders, organizations, and groups were all instrumental in developing *A Biodiversity Conservation Strategy for Lake Superior*. The information in the Strategy is intended to help all stakeholders to identify and implement necessary actions pertaining to Lake Superior`s watersheds, coasts, and waters. The Strategy has been highly influential in the development of the Lake Superior LAMP.


A Biodiversity Conservation Strategy for

Lake Superior

A Guide to Conserving and Restoring the Health of the World's Largest Freshwater Lake

Prepared by the Lake Superior Binational Program

February 12th, 2015

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A Biodiversity Conservation Strategy for Lake Superior, 2015 is available at binational.net.

In conjunction and coordination with the Strategy, 20 corresponding regional plans identifying local and regional conservation opportunities were developed. The conservation actions identified in the regional plans were developed with extensive input from local stakeholders. Together, the Strategy and the Regional Plans will support and encourage actions around Lake Superior that meet the overarching goal of protecting and restoring Lake Superior's habitat and species.

Map of Regional Planning Areas, for *A Biodiversity Conservation Strategy for Lake Superior*

Figure 28. Corresponding regional plans highlight special features, issues and local conservation opportunities. Source: LSBP, 2016.

Past Lake Superior Partnership Binational Strategies

Other binational strategies developed under previous versions of the GLWQA continue to inform, or are being incorporated into efforts of, the Lake Superior Partnership. Table 5 lists these strategies.

Table 5. Past Lake Superior Partnership Strategy Documents

Title	Date	Summary
Initiated under the 1987 GLWQA		
Climate Change Impacts and Adaptation	2014	Synthesizes the current science on climate change impacts to the Lake Superior ecosystem, lists current adaptation actions undertaken by Lake Superior partners, and outlines possible actions and strategies that can be implemented in the future.
Aquatic Invasive Species Complete Prevention Plan	2014	Documents the current status of AIS in the Lake Superior basin, the vector pathways of entry, current actions and projects undertaken by LAMP partners; and outlines strategies and actions to prevent future AIS from entering the basin.
1990-2010 Critical Chemical Reduction Milestones	2012	Describes and analyzes the sources and emissions of the nine ZDDP critical pollutants and sets strategies for achieving future milestone reductions; includes actions presently being undertaken by Lake Superior partners.
1990-2005 Critical Chemical Reduction Milestones	2006	Describes and analyzes the sources and emissions of the nine ZDDP critical pollutants and lays out strategies for achieving future milestone reductions; includes actions presently being undertaken by Lake Superior partners.
Zero Discharge Demonstration Program	1991	Created as part of the Lake Superior Binational Program, the ZDDP targets nine critical legacy pollutants for zero discharge in the Lake Superior basin by 2020. So far, the reduction targets have been reached for each chemical through 2015.