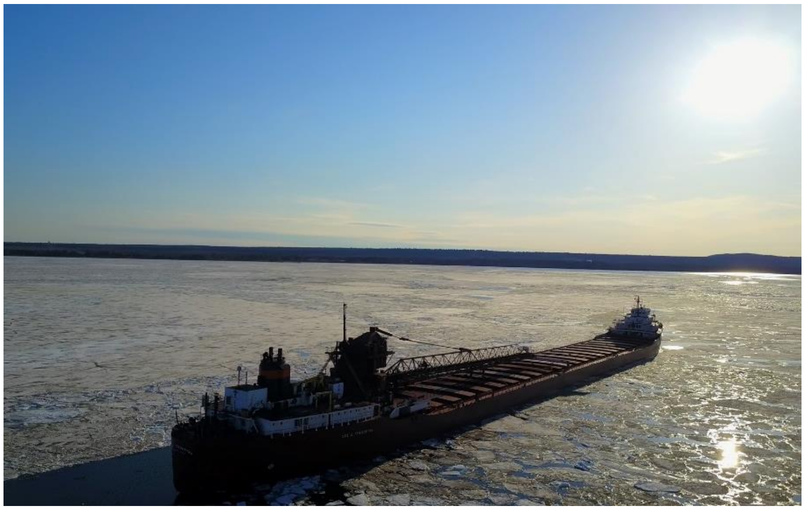
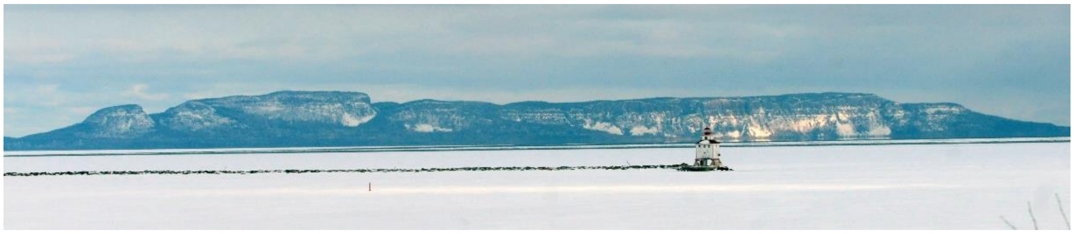


Lake Superior

2020-2024 Lakewide Action and Management Plan



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Dedication

The Lake Superior LAMP is dedicated to the memory of our beloved colleague, Michele Wheeler, who passed away on June 23, 2020, at the age of 46. Michele was a tireless advocate for Lake Superior, a dedicated and brilliant scientist, mother, partner and friend. Her passion, humor, kindness and vision continues to inspire Lake Superior Partnership members every day, as we seek to follow in her footsteps to protect, restore and maintain our water quality and ecosystem health.

Front cover photo credits, clockwise from top left: Jim Bailey, Scott Parish, David Gilroy, Esteban Chiriboga, Bay Mills Indian Community, Environment and Climate Change Canada, and Michigan Department of Natural Resources.

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The 2020-2024 *Lake Superior Lakewide Action and Management Plan* was developed by member agencies of the Lake Superior Partnership. Valuable input and advice was provided by other organizations, academics, stakeholders and interested members of the public.

Lake Superior Partnership 2020

1854 Treaty Authority (1854 TA)
Bad River Band of Lake Superior Chippewa (Bad River)
Bay Mills Indian Community (BMIC)
Chippewa-Ottawa Resource Authority (CORA)
Environment and Climate Change Canada (ECCC)
Fisheries and Oceans Canada (DFO)
Fond du Lac Band of Lake Superior Chippewa (Fond du Lac)
Grand Portage Band of Lake Superior Chippewa (Grand Portage)
Great Lakes Indian Fish and Wildlife Commission (GLIFWC)
Keweenaw Bay Indian Community (KBIC)
Lac du Flambeau Band of Lake Superior Chippewa (LDF)
Lakehead Region Conservation Authority (LRCA)
Michigan Department of Environment, Great Lakes and Energy (EGLE)
Michigan Department of Natural Resources (MDNR)
Minnesota Department of Health (MDH)
Minnesota Department of Natural Resources (MNDNR)
Minnesota Pollution Control Agency (MPCA)
National Oceanic and Atmospheric Administration (NOAA)
Ontario Ministry of Environment, Conservation and Parks (MECP)
Ontario Ministry of Natural Resources and Forestry (MNRF)
Parks Canada
Pays Plat First Nation (PPFN)
Red Cliff (Miskwabekaang) Band of Lake Superior Chippewa (Red Cliff)
Sault Ste. Marie Region Conservation Authority (SSMRCA)
St. Croix Chippewa Indians of Wisconsin (St. Croix)
University of Minnesota Sea Grant Program (MN Sea Grant)
University of Wisconsin Sea Grant Institute (WI Sea Grant)
U.S. Army Corps of Engineers (USACE)
U.S. Bureau of Indian Affairs
U.S. Environmental Protection Agency (EPA)
U.S. Fish and Wildlife Service (USFWS)
U.S. Geological Survey (USGS)
U.S. National Park Service (USNPS)
USDA Forest Service (USFS)
USDA Natural Resources Conservation Service (USDA–NRCS)
Wisconsin Department of Natural Resources (WDNR)

LIST OF ACRONYMS AND ABBREVIATIONS

Commonly Used Acronyms and Scientific Nomenclature

AIS	Aquatic Invasive Species
AOC	Area of Concern
BUI	Beneficial Use Impairment
CEC	Chemical of Emerging Concern
CMC	Chemical of Mutual Concern
CSMI	Cooperative Science and Monitoring Initiative
DNA	Deoxyribonucleic acid
E. coli	Escherichia coli
GLFC	Great Lakes Fishery Commission
GLRI	Great Lakes Restoration Initiative
GLWQA	Great Lakes Water Quality Agreement or The Agreement
HAB	Harmful Algal Blooms
IJC	International Joint Commission
LAMP	Lakewide Action and Management Plan
Phragmites	*Phragmites australis* subsp. *australis*
SOGL	State of the Great Lakes
TEK	Traditional Ecological Knowledge

Chemicals

DDT	Dichlorodiphenyltrichloroethane
Furans	Polychlorinated dibenzofurans
HBCD	Hexabromocyclododecane
LC-PFCAs	Long-chain perfluorocarboxylic acids
PAH	Polycyclic Aromatic Hydrocarbon
PBDEs	Polybrominated diphenyl ethers
PCBs	Polychlorinated biphenyls
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate
SCCPs	Short-chain chlorinated paraffins
TFM	3-trifluromethyl-4-nitrophenol

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EXECUTIVE SUMMARY

Lake Superior is one of the most unique and valuable ecosystems in the world, rich in natural and human history and especially notable for holding 12 percent of the world's surface fresh water (Langston, 2017). The first in a chain of the five Great Lakes that drain into the Atlantic Ocean through the St. Lawrence River, it is the world's largest freshwater lake by area and the deepest of the Great Lakes, with a maximum depth of 406 meters (1332 feet) (EPA, 2019). Due to its immense size, Lake Superior has a water retention time of 191 years, the longest of the Great Lakes. It is a lake of extraordinary biodiversity, supporting species and subspecies found nowhere else on the planet such as unique deep-water forms of Lake Trout (*Salvelinus namaycush*)], diverse coastal wetlands and extensive sandy beaches.

Indigenous peoples have called Lake Superior home for thousands of years. For the Ojibwe peoples, a long westerly migration ended when they found "the food that grows on the water" (Northern Wild Rice or "manoomin" [*Zizania palustris*]). From that point, Madeline Island (or *Moningwanikaaning*) became the center of the Ojibwe nation. The lake and its natural resources are also important to the local Indigenous Anishinaabe and Métis people. More than twenty First Nation and Tribal communities, as well as three Métis communities are located in the Lake Superior basin. With established and/or asserted rights, many members of these communities harvest natural resources for cultural, subsistence, spiritual, and livelihood purposes.

Today, Lake Superior is the least environmentally-impacted of all the Great Lakes, and many of its aquatic habitats, watersheds and coasts remain healthy and intact. Large areas of land are protected by the two federal governments, three states, one province, tribal governments, First Nations and Métis, and others that act as the stewards of Lake Superior.

Although the lake ecosystem is relatively healthy, Lake Superior is not pristine, nor in "good" condition in all aspects. Table 1 summarizes overall Lake Superior conditions in relation to the General Objectives of the *Great Lakes Water Quality Agreement* (Agreement or *GLWQA*).

Table 1. Status of Lake Superior in relation to the Great Lakes Water Quality Agreement General Objectives. Source: ECCC and EPA, 2021.

	GLWQA GENERAL OBJECTIVES	STATUS
1	Be a source of safe, high quality drinking water.	Good
2	Allow for unrestricted swimming and other recreational use.	Good
3	Allow for unrestricted human consumption of fish and wildlife.	Fair
4	Be free from pollutants that could harm people, wildlife or organisms.	Fair
5	Support healthy and productive habitats to sustain our native species.	Good
6	Be free from nutrients that promote unsightly algae or toxic blooms.	Good
7	Be free from aquatic and terrestrial invasive species.	Fair
8	Be free from the harmful impacts of contaminated groundwater.	Undetermined
9	Be free from other substances, materials or conditions that may negatively affect the Great Lakes.	Good

Based on the assessments of the nine State of the Great Lakes indicators, the overall status of the Lake Superior basin ecosystem is Good. The major threats to Lake Superior include chemical contaminants, invasive species and the degradation of habitat. In addition to these threats, significant climate change impacts are being observed in the Lake Superior ecosystem; Lake Superior is among the fastest warming lakes on the planet (O'Reilly et al., 2015). Projected climate change could have a range of future effects on Lake Superior ecosystems, including a decrease in the abundance of cold-water fish and changes to coastal wetlands (Huff, A. and Thomas, A., 2014). To maintain Lake Superior's overall "good" condition, restoration efforts are necessary in many degraded areas, but more importantly, protection and conservation actions are essential.

As set forth in the GLWQA, the governments of Canada and the United States of America are committed to restoring and maintaining the chemical, physical, and biological integrity of the waters of the Great Lakes. The 2020-2024 *Lake Superior Lakewide Action and Management Plan* (*LAMP*) responds to the commitments of the Agreement, as described in "Annex 2 - Lakewide Management", to assess ecosystem conditions, identify environmental threats, set priorities for research and monitoring, and identify further actions to be taken by governments and the public. These commitments also include integrating nearshore assessment information.

The *LAMP* was developed by members of the Lake Superior Partnership, a collaborative team of federal, Indigenous, state, provincial and local government agencies led by the federal Governments of Canada and the United States. The Lake Superior Partnership agencies actively engage academic institutions, non-governmental organizations, other stakeholders and the public. The restoration and protection actions identified in the *LAMP* respond to, and are categorized by, the major threats that are affecting one or more of the Agreement's General Objectives, specifically:

- chemical contaminant pollution;
- nutrient and bacterial pollution;
- invasive species;
- loss of habitat and species; and,
- other threats: plastics, risks from oil transport and mining, and cumulative impacts on the nearshore areas of the lake.

Over the next five years, members of the Lake Superior Partnership will undertake 49 actions to address priority environmental threats to water quality and the ecosystem health of Lake Superior. The actions are listed in Table 2 along with the contributing Partnership agencies. Coordination of all these efforts will be assisted by regular communication among the Partnership agencies. Tracking and reporting by the Partnership agencies will help to assess progress, determine success of implementation, support accountability, and provide feedback for future improvements.

There is a role for everyone in implementing the 2020-2024 Lake Superior *LAMP*. During *LAMP* implementation, agencies of the Partnership will regularly work with other organizations, academic institutions and communities. The public plays an important role as advocates and implementers. For each major threat, the *LAMP* includes some recommended actions that individuals can take to help protect Lake Superior. Together, collective action will reduce threats and support a prosperous and sustainable Lake Superior.

Table 2. Lake Superior LAMP 2020-2024 actions and contributing Lake Superior Partnership Agencies.

#	ACTIONS TO PREVENT AND REDUCE CHEMICAL CONTAMINANT POLLUTION	AGENCIES
1	Advance remediation of contaminated sediment in Lake Superior's Areas of Concern:	
	a. Thunder Bay Area of Concern • Support the identification of a preferred option for managing contaminated sediments in the north harbour and develop detailed project engineering design and cost estimate; and • Conduct additional monitoring to determine the extent to which the sediment left adjacent to the former Northern Wood Preservers site remediation project, completed in 2003, has naturally recovered.	ECCC, MECP
	b. Peninsula Harbour Area of Concern • Complete assessment of the *Degradation of Benthos* beneficial use impairment; and • Continue long-term monitoring and assessment of the effectiveness and ecological recovery of the thin-layer cap.	ECCC, MECP
	c. Jackfish Bay Area of Concern in Recovery • Report upon sediment conditions, benthic community health, area aesthetics, and contaminants in fish. Determine future monitoring needs.	ECCC, MECP, PPFN
	d. St. Louis River Area of Concern • Complete 31 management actions outlined in the Remedial Action Plan related to remediation of contaminated sediments that support future removal of Restrictions on Dredging beneficial use impairment; and • Complete assessment of legacy mercury and PCBs in sediment within the St. Louis River Estuary and within the designated reference area to determine their contributions to fish consumption advisories.	EPA, USACE, USGS, USFWS, MNDNR, MPCA, WDNR, 1854 TA, Fond du Lac, MN Sea Grant
	e. Torch Lake Area of Concern • Implement a Great Lakes Legacy Act cleanup of contaminated sediment in the lake.	EPA, EGLE, KBIC
2	Contribute to the implementation of the Chemicals of Mutual Concern binational strategies within the Lake Superior basin.	ECCC, EPA, NOAA, EGLE, MPCA, WDNR, Bad River, LDF, Red Cliff
3	Undertake, support and promote innovative approaches and technologies that reduce releases of harmful chemicals beyond required compliance levels.	ECCC, EGLE, MPCA, WDNR, Bad River, Fond du Lac, LDF
4	Identify and promote priority actions for reducing contaminants and pathogens from wastewater treatment plants and/or rural sources.	ECCC, MECP, MPCA, WDNR, Bad River, Fond du Lac, Grand Portage, LDF
5	Through science and monitoring, identify and track contaminants in air, water, sediment, fish and wildlife at a lakewide scale. a. Determine the spatial variation of mercury, PCB and PFAS concentrations in Lake Superior fish.	ECCC, EPA, USGS, USNPS, EGLE, MECP, MNDNR, MPCA, WDNR, 1854 TA, Bad River, BMIC, CORA, Fond du Lac, GLIFWC, Grand Portage,

	b. Determine the concentration and trends for Chemicals of Mutual Concern in Lake Superior. c. Beyond Chemicals of Mutual Concern and legacy chemicals, proactively monitor for chemicals that are found in Lake Superior water and fish, including pharmaceuticals and pesticides, such as atrazine and neonicotinoids, as a means of providing early warning for chemicals that could become Chemicals of Mutual of Concern.	LDF, Red Cliff, MN Sea Grant
6	Through science and monitoring, identify current sources and pathways of chemical contaminants with a focus on mercury and PFAS. a. Beyond Areas of Concern and sites already under purview of government regulatory programs, identify contaminated sediment sites that warrant further investigation and possible management options. b. Determine the PFAS loading from tributaries to Lake Superior. c. Identify mercury loading areas around the lake, with a priority on tributaries that may be most susceptible to greater erosion and runoff during storm events. d. Determine the source(s) of mercury being found in Lake Superior fish. e. Compile data and information on chromium and more specifically hexavalent chromium concentrations and trends in the eastern end of the Lake Superior ecosystem.	EPA, USFS, USGS, EGLE, MPCA, WDNR BMIC, Fond du Lac, LDF, MN Sea Grant
7	Assess existing monitoring programs within the St. Louis River Estuary to identify data redundancies and gaps to improve efficiencies and create a post-Area of Concern estuary monitoring framework.	EPA, NOAA, MPCA, MNDNR, WDNR, 1854 TA, FDL
8	Continue outreach and education to the public on impacts of chemical contaminants with a focus on mercury, pharmaceuticals, PFAS and dioxins; the pathways into fish, wildlife and humans; and actions that can be taken to help remove contaminants from the basin.	ECCC, Parks Canada, USNPS, EGLE, MECP, MDH, MPCA, WDNR, 1854 TA, Bad River, CORA, BMIC, Fond du Lac, GLIFWC, Grand Portage, KBIC, LDF, Red Cliff
#	ACTIONS TO PREVENT AND REDUCE NUTRIENT & BACTERIAL POLLUTION	AGENCIES
9	Undertake necessary bacterial pollution restoration or studies identified in Remedial Action Plans for Lake Superior's Areas of Concern: a. Thunder Bay Area of Concern • Complete assessment of the *Beach Closings* beneficial use impairment and complete process to change status to "Not Impaired". b. St. Louis River Areas of Concern • Complete management actions identified in the Remedial Action Plan necessary to remove the *Beach Closings* beneficial use impairment.	ECCC, MECP MPCA, WDNR

10	Encourage or support investments in green infrastructure and nature-based solutions that help to manage stormwater runoff.	EPA, NOAA, Parks Canada, USACE, USFS, EGLE, MECP, MNDNR, MPCA, WDNR, Bad River, BMIC, Fond du Lac, Grand Portage, LDF, Red Cliff, LRCA, MN Sea Grant
11	Encourage or support projects that improve soil health and forest health with a focus on increasing resilience to climate change, decreasing excessive runoff, and reducing excessive erosion and nutrient loading from Lake Superior tributaries.	USDA–NRCS, USFS, USFWS, MECP, MNDNR, WDNR, Grand Portage, Red Cliff, LRCA
12	Support local initiatives to help communities develop and/or implement watershed plans and/or climate change adaptation plans.	ECCC, NOAA, USACE, EGLE, MECP, MNDNR, WDNR, 1854 TA, Bad River, BMIC, Fond du Lac, Grand Portage, LDF, LRCA, SSMRCA, MN Sea Grant
13	Through science and monitoring, better understand modern and historical nutrient conditions in Lake Superior, and identify the conditions and locations for potential algal blooms. a. Determine if algal blooms are becoming more common compared to past decades. b. Determine how nutrient conditions, including sediment nutrients, are changing and the effects to water quality and ecosystem health. c. Identify sub-watersheds and corresponding areas of the lake that are most vulnerable to nutrient and sediment loading during flood events. d. Determine under what conditions a Lake Superior algal bloom might become toxic.	EPA, NOAA, Parks Canada, USGS, USNPS, MECP, MNDNR, MPCA, WDNR, MN Sea Grant
14	Continue outreach and education to increase the understanding of nearshore and beach health, and best management practices and policies.	ECCC, Parks Canada, USACE, USDA–NRCS, USNPS, EGLE, MECP, MDH, MNDNR, MPCA, WDNR Bad River, BMIC, Grand Portage, Red Cliff, LRCA, SSMRCA
#	**ACTIONS TO PROTECT AND RESTORE HABITAT & SPECIES**	AGENCIES
15	Undertake necessary habitat and species restoration or studies identified in Remedial Action Plans for Lake Superior's Areas of Concern:	
	a. Thunder Bay Area of Concern • Complete, share and discuss with the local community the latest studies on fish populations and habitat, and next steps for restoring wildlife habitat; and • Prepare a wildlife habitat strategy to identify and implement remaining needed habitat improvement projects.	ECCC, MNRF
	b. Jackfish Bay Area of Concern in Recovery • Evaluate the current condition of fish populations for species present in Jackfish Bay.	ECCC, MNRF, PPFN
	c. Peninsula Harbour Area of Concern • Share and discuss with local communities a proposed decision to re-designate fish and wildlife habitat and populations to not impaired.	ECCC, MNRF

	d. St. Louis River Area of Concern • Continue to implement habitat restoration projects, including wild rice restoration; • Complete management actions identified in the Remedial Action Plan necessary to remove habitat, benthos, and fish and wildlife impairments; and • To complement the RAP's management actions, identify, seek funding for, and implement additional habitat and species projects necessary to enhance habitat and populations of fish and wildlife within the AOC geographical boundaries.	EPA, USACE, USFWS, MNDNR, MPCA, WDNR, 1854 TA, Fond du Lac
	e. Torch Lake Area of Concern • Conduct a *Degradation of Benthos* beneficial use impairment pilot study to construct shoreline capping and implement habitat restoration test plots to determine if this will improve the density and diversity of the benthic community.	EPA
16	Protect Buffalo Reef (MI) and nearshore areas in Traverse Bay from further encroachment of stamp sands, and work toward long-term mitigation strategies and/or solutions.	EPA, USACE, USGS, EGLE, MDNR, GLIFWC, KBIC
17	Formally establish the Lake Superior National Marine Conservation Area in Canada and implement actions identified in the 2016 Interim Management Plan.	Parks Canada
18	Identify and restore stream and wetland connectivity and function through hydrological modifications such as dam removal, road decommissioning, construction of fish passage alternatives, stream culvert improvements, and flow modifications on regulated and unregulated tributaries to allow flows to meet early life-history requirements of species like Brook Trout. These modifications include, but are not limited to: • Removal of the Lower Dam, east branch of Ontonagon River (MI); • Stream culvert improvements on Sucker River Road (MI) and Waishka River Road (MI) Coastal HWY 61 (MN); and • Hydrological modifications identified in Lake Superior Committee (i.e., fishery management agencies) Environmental Priorities 2019.	EPA, USFS, USFWS, USNPS, EGLE, MDNR, MNDNR, MPCA, MNRF, WDNR, Bad River, BMIC, Fond du Lac, Grand Portage, KBIC, LDF, Red Cliff
19	Advance the 2015 Lake Superior Biodiversity Conservation Strategy and corresponding Regional Plans, as well as State Wildlife Action Plans and other related agency plans by taking applicable actions including, but not limited to: • Initiate or support local and community projects or citizen science to conserve biodiversity; • In Wisconsin, conduct native freshwater mussel surveys and wood turtle surveys and nest protection efforts; • In the Upper Peninsula of Michigan, and other necessary areas as identified, restore and protect pollinator habitat and species; • Protect piping plover, common tern and marsh breeding birds by identifying, assessing, conserving and restoring their habitat in St. Louis River estuary, Apostle Islands, Chequamegon Bay and other priority locations;	EPA, Parks Canada, USACE, USFS, USFWS, USGS, USNPS, EGLE, MDNR, MNRF, MNDNR, WDNR, 1854 TA, Bad River, BMIC, CORA, Fond du Lac, Grand Portage, LDF, Red Cliff

	- Continue to identify and map important habitat sites in the Lake Superior basin; and - Support protection and restoration of Lake Superior islands, particularly unique habitats and globally rare and endemic species.	
20	Rehabilitate populations of indigenous aquatic species (e.g., Brook Trout, Lake Sturgeon, Muskellunge, Walleye, etc.).	DFO, USFS, USFWS, USNPS, MDNR, MNDNR, MNRF, MPCA, WDNR, Bad River, BMIC, Fond du Lac, GLIFWC, Grand Portage, KBIC, LDF, Red Cliff, St. Croix
21	Protect and enhance through conservation easements, land acquisitions and/or other means additional coastal wetlands and important habitats including but not limited to: - Port Wing State Natural Area (WI); - Brule River State Forest (WI); and - Whittlesey Creek watershed (WI).	USFS, USFWS, Bad River, BMIC, MNDNR, MNRF, WDNR, Fond du Lac, Red Cliff
22	Restore and protect manoomin (wild rice) habitat including, but not limited to, the following areas: - St. Louis River estuary (MN and WI); - Kakagon / Bad River Sloughs in Wisconsin; - Brule River mouth in Wisconsin; and - Michigan locations including Sand River, Lake Harlow, Blind Sucker and Lake LeVasseur.	NOAA, USFS, EGLE, MDNR, MNDNR,WDNR, 1854 TA, Bad River, BMIC, Fond du Lac, GLIFWC, Grand Portage, KBIC, LDF, Red Cliff, St. Croix
23	In the St. Louis River and Bay area, restore connected coastal wetlands and floodplains, marsh breeding bird habitat and enhance spawning habitat for additional Lake Sturgeon and Walleye production.	MNDNR, WDNR, Fond du Lac
24	Support climate change impact initiatives, projects or adaptation planning that increases the resilience of Lake Superior ecosystem's habitats and species.	ECCC, EPA, NOAA, Parks Canada, USACE, USNPS, USFS, USFWS, EGLE, MDNR, MECP, MNDNR, MPCA, MNRF, WDNR, 1854 TA, Bad River, BMIC, CORA, Fond du Lac, GLIFWC, Grand Portage, KBIC, PPFN, Red Cliff, St. Croix, LDF, LRCA, MN Sea Grant
25	Plant trees best suited for a changing climate along cold-water streams, rivers and lake shorelines, with a focus on locally-prioritized sites that will enhance high quality habitat and increase cover type connectivity.	USFS, USFWS, MDNR, MNDNR, WDNR, Bad River, BMIC, Fond du Lac, Grand Portage, KBIC, Red Cliff
26	Plan, undertake and/or support low impact development, green infrastructure projects, and nature-based solutions that are suited to future extreme weather events and better protect species and habitat, including a possible pilot project to use natural alternatives to conventional pesticides.	EPA, Parks Canada, USACE, USFS, MNDNR, WDNR, BMIC, CORA, Grand Portage, Red Cliff, MN Sea Grant,
27	Through science and monitoring, update understanding of lower-food web health.	EPA, USFWS, USGS, MDNR, MNDNR, MNRF, WDNR, Fond

	a. Determine if the lower food web remains in a stable and healthy state. Explore expanding monitoring to assess the significance of picoplankton. b. Determine if the lower-trophic abundance and diversity is enough to sustain predator fish (i.e., Lake Trout) populations. Determine if Lake Trout diet preferences are changing. c. Enhance existing models to determine how the aquatic ecosystem responds to potential fishery management actions. d. Pilot efforts to assess the productivity and role of phytoplankton and zooplankton in the winter food web of the nearshore waters.	du Lac, GLIFWC, Grand Portage, LDF, Red Cliff
28	Through science and monitoring, improve understanding of the impacts of the physical changes (e.g., water levels, water temperature, etc.) and/or changing climate on water quality, habitat and species. a. Determine the vulnerabilities and potential response of coastal wetlands to future climate and water level projections. b. Determine if the hydrology and temperature of cold/cool water streams is changing. c. Use past and existing macroinvertebrate information in tributaries to help explain changes in habitat quality and water quality over time. d. Collect improved bathymetric data in selected coastal areas and wetlands.	ECCC, EPA, Parks Canada, USACE, USFWS, USGS, USNPS, MDNR, MNDNR, MNRF, WDNR, Bad River, Fond du Lac, Grand Portage, PPFN, Red Cliff
29	Through science and monitoring, update and improve information about coastal wetland conditions and trends, including use of the Great Lakes Coastal Wetland Monitoring Program data to inform planning of and/or evaluate the effectiveness of coastal wetland restoration and conservation activities. a. Determine which species of amphibians (e.g., frogs and toads) are present in coastal wetlands, noting species and locations of conservation interest. b. Gather data on coastal wetland invertebrates, fish, birds and plants. c. Support a pilot project to develop coastal wetland targets and goals in order to further prioritize protection and management actions.	EPA, Parks Canada, USGS, MNDNR, WDNR, Bad River, BMIC, Grand Portage, KBIC, Red Cliff
30	Through science and monitoring, determine if progress is being made in the rehabilitation of native fish species of conservation concern. a. Track the rehabilitation of Lake Sturgeon. b. Track the rehabilitation of Brook Trout. Determine if there are additional streams coaster brook trout are accessing to spawn. c. Track the rehabilitation of Walleye. d. Expand the understanding of travel ranges, movements, habitat preferences, and behaviors of other native fish species.	DFO, Parks Canada, USFWS, USGS, USNPS, MDNR, MNDNR, MNRF, WDNR, 1854 TA, Fond du Lac, GLIFWC, Grand Portage, KBIC, LDF, Red Cliff, St. Croix, WI Sea Grant

31	Map and/or identify remaining stamp sand piles located on the coastline. a. Determine the extent and composition of coastal stamp sand piles in, and along the shoreline of Lake Superior. b. Determine the extent of ecological implications of sand piles eroding into Lake Superior.	NOAA, USACE, USGS, GLIFWC, KBIC
32	Determine the current status of shoreline hardening and other forms of alteration. a. Identify areas of hardened shoreline. b. Improve the understanding of the risk to coastal habitats from current shoreline development.	ECCC, NOAA, USACE, USGS, MNDNR, MNRF
33	To the extent possible, quantify groundwater contribution to the water budget of Lake Superior. a. Select specific sub-basins to model an updated water budget.	USGS
34	Contribute to the development of sub-watershed assessments that identify, prioritize, and help guide implementation of on-the-ground habitat restoration and protection projects that build resilience to climate change impacts and maximizes fish production.	USFS, USFWS, USGS, MDNR, MNDNR, WDNR, CORA, Fond du Lac, LRCA
35	Improve communication, information exchange, and resource sharing across coastal and aquatic protected areas in Lake Superior to enhance conservation effectiveness of individual protected areas in support of the Great Lakes Protected Area Network and the North American Marine Protected Area Network.	Parks Canada, USNPS
36	Engage the public and landowners on the importance of Lake Superior ecosystem's habitats and species including the impacts of climate change.	Parks Canada, USFS, USFWS, USNPS, MDNR, MECP, MPCA, MNDNR, MNRF, WDNR, 1854 TA, Bad River, BMIC, Fond du Lac, GLIFWC, Grand Portage, Red Cliff, LRCA, SSMRCA, MN Sea Grant
#	**ACTIONS TO PREVENT AND CONTROL INVASIVE SPECIES**	AGENCIES
37	Maintain and improve effectiveness of the program to control Sea Lamprey.	DFO, USACE, USFWS, Bad River, CORA, KBIC
38	Contribute to the elimination of European Common Reed (i.e., *Phragmites australis*, subsp. *australis*) from the Lake Superior basin by basinwide distribution mapping, early detection efforts, control efforts and outreach to private landowners.	Parks Canada, USFS, MDNR, MNDNR, MNRF,WDNR, 1854 TA, Bad River, BMIC, EGLE, Fond du Lac, GLIFWC, Red Cliff, SSMRCA
39	Prevention, management, and mitigation/restoration for terrestrial invasive species including early detection of invasive plants, invasive plants with strong connections to water quality, invasive earthworms, and invasive insects such as the emerald ash borer, spongy moth or *Lymantria dispar dispar*, and mountain pine beetle.	Parks Canada, USDA-NRCS, USFS, USNPS, MDNR, MNDNR, MNRF, WDNR, 1854 TA, Bad River, BMIC, EGLE, Fond du Lac, Grand Portage, Red Cliff, LRCA, SSMRCA
40	Contribute to the protection of wetlands from the negative impacts of the advancing emerald ash borer populations, by planting a variety of wet tolerant trees in vulnerable or selected locations.	USFS, MDNR, WDNR, Bad River, BMIC, Fond du Lac, Red Cliff

41	Implement aquatic species plans approved by the Aquatic Nuisance Species Task Force, priorities of the Great Lakes Panel on Aquatic Nuisance Species, as well as other established federal, tribal, state, provincial and local plans or strategies.	USFWS, EGLE, MDNR, MNDNR, MNRF, WDNR, 1854 TA, Bad River, BMIC, CORA, Fond du Lac, GLIFWC, Grand Portage, KBIC, LDF, Red Cliff, MN Sea Grant
42	Conduct early detection monitoring and science of invasive species. a. Utilize the Great Lakes Aquatic Nonindigenous Species Information System to document establishment of any new non-native aquatic species. b. Monitor to determine if any new aquatic non-native species have been introduced or have become established. c. Advance understanding of the spread (or increasing population) of established invasive species, including zebra/quagga mussels, Sea Lamprey, non-native *Phragmites* and earthworms, and what impacts are they having on native species and the ecosystem.	EPA, DFO, Parks Canada, USFWS, USNPS, USFS, USGS, EGLE, MDNR, MNDNR, MNRF, WDNR, 1854 TA, Bad River, BMIC, CORA, Fond du Lac, GLIFWC, Grand Portage, KBIC, PPFN, Red Cliff
43	Undertake additional aquatic invasive species prevention outreach and education.	Parks Canada, USACE, USFS, USFWS, USNPS, EGLE, MDNR, MNRF, MNDNR, WDNR, 1854 TA, Bad River, BMIC, CORA, Fond du Lac, GLIFWC, Grand Portage, KBIC, PPFN, Red Cliff, MN Sea Grant, WI Sea Grant
#	**ACTIONS ON OTHER THREATS: Plastics, Risks from Oil Transport and Mining, and Cumulative Impacts on the Nearshore Areas of the Lake**	AGENCIES
44	Organize, participate or support capture and clean-up projects to prevent and remove plastic pollution including "nurdles" from Lake Superior waterways and land.	Parks Canada, MECP, Bad River, Grand Portage, KBIC
45	Determine the current status and sources of plastics. a. Determine the concentration of plastic in Lake Superior's water, sediment and fish. b. Identify the main sources of plastic pollution to Lake Superior.	Parks Canada, USGS, MECP, MNDNR, MPCA, BMIC, MN Sea Grant
46	Through science and monitoring, improve understanding of cumulative impacts of stressors to Lake Superior. a. Continue gathering baseline data in the Lake Superior basin to assess spatial variability in water quality in order to improve understanding of cumulative impacts of multiple stressors, including habitat disruption, change climate, mining and other stressors.	USGS, MECP, MPCA, 1854 TA, CORA, Fond du Lac, GLIFWC, Grand Portage, KBIC
47	Continue to outreach and engage the public on plastic waste pollution and ways to reduce the amount of plastic in the Lake Superior basin.	ECCC, Parks Canada, USNPS, MECP, MPCA, Bad River, BMIC, CORA, KBIC, Red Cliff
48	Make information available about the *Great Lakes Water Quality Agreement* General Objectives and related Lake Superior *LAMP* during applicable engagement processes for the planning or operations of major transportation and resource extraction projects, including environmental impacts assessments by project proponents.	ECCC, MECP, 1854 TA, CORA, Fond du Lac, Red Cliff
49	Engage the public to educate it on impacts and risks associated with transporting oils and other hazardous materials by road, rail, ship and pipeline; spill contingency plans in place; and where to report spills of oils and other hazardous materials.	Bad River, BMIC, Fond du Lac, LDF, Red Cliff, MN Sea Grant

1.0 INTRODUCTION

The 2020-2024 *Lake Superior Lakewide Action and Management Plan (LAMP)* is a binational five-year ecosystem-based strategy for restoring and protecting Lake Superior water quality. It follows the successful implementation of the 2015-2019 *LAMP*, where 27 government agencies undertook actions in cooperation with over 170 other organizations, businesses, communities and academic institutions.

The Lake Superior *LAMP* fulfills the United States of America (U.S.) and Canadian commitments under the 2012 *Great Lakes Water Quality Agreement* to assess ecosystem conditions, identify environmental threats, set priorities for research and monitoring, and to identify further actions to take by governments and the public. These commitments include integrating nearshore assessment information.

The *LAMP* is a world-recognized model for cooperation among governmental jurisdictions and their management agencies. As illustrated in Figure 1, the geographic scope of this *LAMP* includes activities in the waters of Lake Superior, and in its tributaries and watersheds so far as they impact the waters of Lake Superior. The *LAMP* is a resource for anyone interested in the Lake Superior basin ecosystem, its water quality, and the actions that will help protect this extraordinary Great Lake.

Figure 1. Map of the Lake Superior basin. Source: ECCC.

1.1 Great Lakes Water Quality Agreement

Since 1972, the Agreement has guided U.S. and Canadian actions to restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes. In 2012, the U.S. and Canada amended the Agreement, reaffirming their commitment to protect, restore and enhance water quality and to prevent further degradation of the Great Lakes basin ecosystem.

In addition to containing nine General Objectives as summarized in Table 1, the Agreement commits the U.S. and Canada to address 10 priority issues through specific Annexes as shown Table 3. The Lake Superior *LAMP* integrates information and management needs from each of these Annexes. The commitment to develop *Lakewide Action and Management Plans* is specified in the Lakewide Management Annex (Annex 2); this includes a commitment to integrate nearshore information and management actions into these Plans.

1	Areas of Concern
2	Lakewide Management
3	Chemicals of Mutual Concern
4	Nutrients
5	Discharges from Vessels
6	Aquatic Invasive Species
7	Habitat and Species
8	Groundwater
9	Climate Change Impacts
10	Science

Table 3. Annexes of the Great Lakes

In Canada, many contributions to the Agreement and the Lake Superior *LAMP* are enabled through existing government programs such as the Great Lakes Protection Initiative, as well as the Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health. Since 1971, a series of Canada-Ontario agreements have guided efforts to improve water quality and ecosystem health of the lakes and contribute to meeting Canada's obligations under the Canada-United States *Great Lakes Water Quality Agreement*.

In the U.S., many contributions to the Agreement and the Lake Superior *LAMP* are enabled through existing governmental programs and the Great Lakes Restoration Initiative (GLRI). The GLRI was launched in 2010 to accelerate efforts to protect and restore the largest system of fresh surface water in the world. Since 2010, the multi-agency GLRI has provided funding to 16 federal organizations (and indirectly, their many state, tribal, and local partners) to strategically target the biggest threats to the Great Lakes ecosystem.

1.2 Lake Superior Partnership

The *LAMP* is developed by member agencies of the Lake Superior Partnership, a collaborative team of natural resources managers led by the governments of the United States and Canada together with State and Provincial governments, Municipal governments, Tribal governments, First Nations, Métis, and watershed management agencies. Current member agencies are listed in the acknowledgements on page iii.

The Lake Superior Partnership aids in the implementation of the *LAMP* by helping member agencies to share information, collaborate on assessing the state of the lake, set priorities and coordinate their actions. The Lake Superior Partnership consists of a Management Committee of senior level representatives of government agencies with decision-making authority, and a Working Group that coordinates *LAMP* development, implementation, and reporting. The Working Group is supported by issue-specific subcommittees that bring together experts who contribute to project implementation, coordination, tracking *LAMP* progress, as well as recommending priorities for science and action.

The Lake Superior Partnership and this *LAMP* continue to carry forward the focus on chemical reduction and ecosystem protection and restoration originally initiated by the 1991 Lake Superior Binational Program's Zero Discharge Demonstration Program and the Broader Ecosystem Program.

1.3 Engagement in LAMP Development

Engagement, collaboration and active participation of stakeholders, the public and all levels of government is essential for the successful development and implementation of the *LAMP*. Local and regional organizations, academic institutions and communities are among the most effective and knowledgeable groups capable of achieving environmental objectives in their area. For these reasons, member agencies of the Partnership funded, or collaborated with, over 170 communities, organizations and institutions to implement the 2015-2019 Lake Superior *LAMP*. The results of these engagements continually inform the Lake Superior Partnership member agencies and development of the *LAMP*.

Beyond engagements conducted by individual agencies, there are coordinated lakewide public engagements. Examples of engagements that have contributed to the development of the 2020-2024 *LAMP* include:

- 2018 State of Lake Superior Conference, hosted by the International Association for Great Lakes Research and Michigan Technical University.
    - Member agencies of the Lake Superior Partnership reported out on the results of their latest science and monitoring activities, including the 2016 Lake Superior field year of the Cooperative Science and Monitoring Initiative.
    - The Conference highlighted gaps in science and monitoring that need to be addressed to better achieve ecosystem objectives.
- 2019 Great Lakes Public Forum.
    - Held every three years in alternating locations in the U.S. and Canada, this Forum provides an opportunity for the United States and Canada to discuss and receive public comments on the state of the lakes, including Lake Superior, and binational priorities for science and action.
    - A State of the Great Lakes report is presented concurrent with the Forum.
- 2019 public workshop to identify science and monitoring priorities.
    - Held in July 2019, this workshop invited the public and stakeholders to provide input on future

    - science and monitoring priorities, resulting in a report used in the development of the 2020-2024 *LAMP*.

- Lake Superior Partnership public webinars.
    - Typically held biannually, these webinars update the public on *LAMP* implementation and invite the public to share their insights and suggestions.
- 2020 draft *LAMP* public input period.
    - All public input on a draft *LAMP* is considered and incorporated where applicable, in the final *LAMP*.

1.4 State of the Great Lakes Reporting

Pursuant to the *Agreement*, Canada and the United States have established a suite of nine indicators and 45 sub-indicators of ecosystem health to assess the State of the Great Lakes. Indicators are updated every three years with support from over 200 scientists and experts using data from dozens of governmental and non-governmental organizations. These experts assess the current status of each indicator using a "good", "fair" or "poor" classification and assess the directional trend for each indicator using an "improving", "unchanging" or "deteriorating" classification. The indicators presented in the Lake Superior *LAMP* are referenced as "ECCC and EPA, 2021".

2.0 INHERENT VALUE, USE, AND ENJOYMENT OF LAKE SUPERIOR

Lakewide management is guided by a shared vision of a healthy, prosperous, and sustainable Great Lakes region in which the waters of Lake Superior are used and enjoyed by present and future generations. The Lake Superior *LAMP* recognizes the inherent natural, social, spiritual, and economic value of the Lake Superior basin ecosystem. This includes the characteristics of the lake that are of global significance, the cultural significance of the area to Indigenous peoples, and the regional economic value the lake supports.

2.1 Global Significance

Lake Superior is one of the most beautiful, unique and valuable ecosystems in the world. Containing nearly 12 percent of the world's surface fresh water (Langston, 2017), Lake Superior is the world's largest lake by surface area, with a volume of 3 quadrillion gallons (11 quadrillion liters) -- enough water to cover the entire land mass of North and South America to a depth of 12 inches (30 centimeters). The lake has 2,730 miles (4,393 km) of shoreline (including islands) and the lake produces the greatest lake-effect snows on earth. The lake's natural resources support many industrial and business operations, including tourism, fishing and other outdoor recreation activities. The natural resources of the lake and the surrounding watersheds are significant to the well-being and special cultural heritage of local communities, including Indigenous peoples.

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. Lake Superior is the only Great Lake in overall "good" condition (ECCC and EPA, 2021) and is the only lake with a food web still dominated by native, self-sustaining species.

Lake Superior Physical Facts: Average depth: 147 m (483 ft) ● Maximum depth: 406 m (1,332 ft) ● Surface area: 82,103 km^2 (31,700 mi^2) ● Drainage basin: 43,153 km^2 (16,661 mi^2) ● 61% forested, 26% wetland ● 3% water, ● 3% agriculture, ● 4% developed land. Source: ECCC and EPA, 2021

2.2 Indigenous Peoples

Anishinaabeg peoples, including the Ojibwe nation, have called *Anishinaabeg Gichigami*, i.e., Lake Superior, home for thousands of years and continue to play an important role as stewards of the lake. As the place where they found *manoomin*, i.e., wild rice ("the food that grows on the water") *Mooningwanekaaning* (commonly referred to as Madeline Island in the Apostle Islands in what is now known as Wisconsin) is the center of the Ojibwe nation. The homelands of Ojibwe bands stretch from eastern Ontario to southeastern Manitoba and from southeastern Michigan to central Minnesota, with treaty-ceded territories located throughout the Lake Superior basin. The Cree nation is also present in the northern reach of the basin. Today, there are over twenty Tribal and First Nation communities located along the coast or within the Lake Superior basin. Figure 2 shows First Nations, Tribes and Treaty-defined territories within the Lake Superior basin.

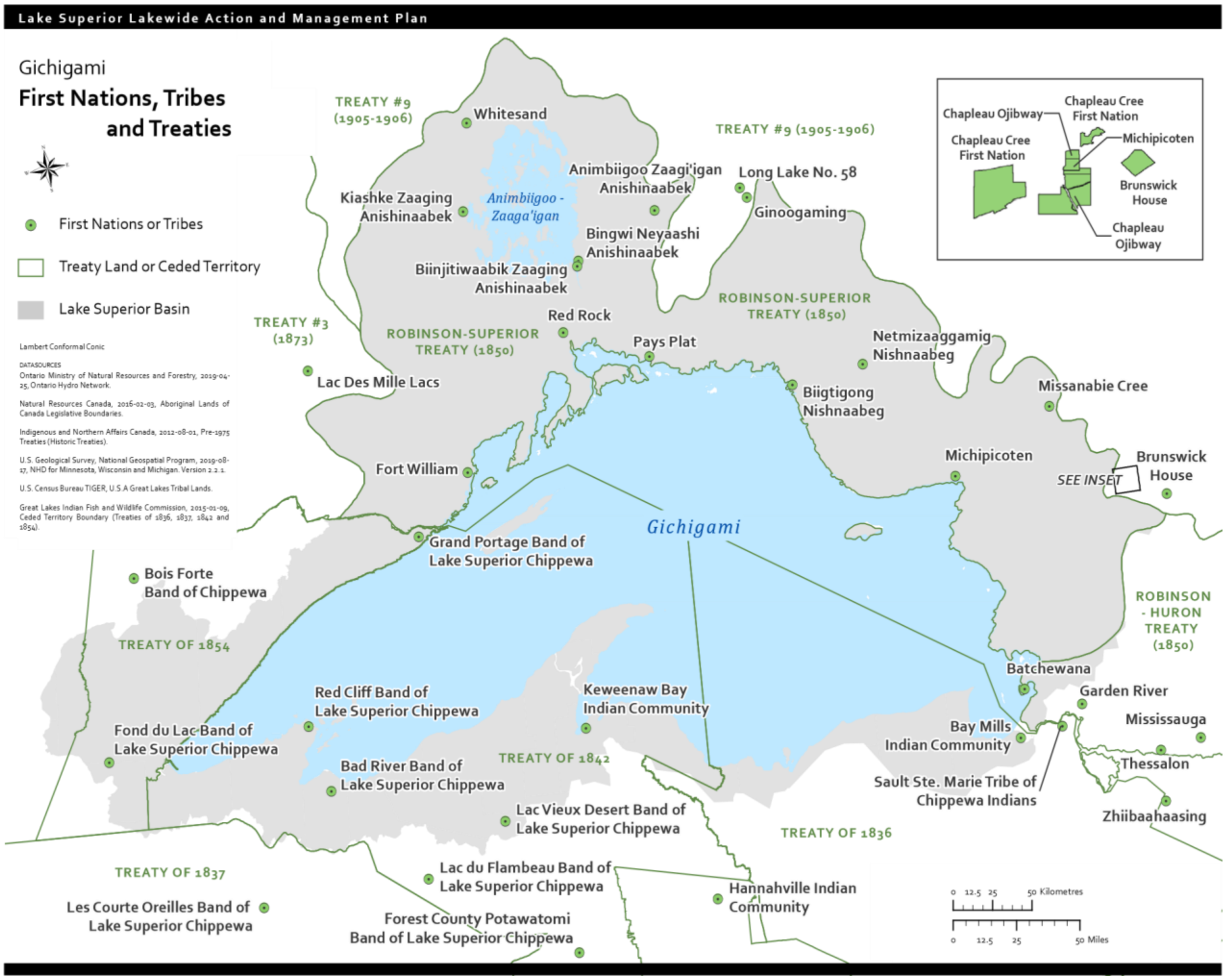

Figure 2. Lake Superior basin: First Nations, Tribes and Treaties. Source: ECCC.

The *nibi* (waters), *giigoonh* (fish), plants and wildlife in the Lake Superior basin continue to provide a sense of identity and continuity with traditional ways of life. All plant and animal life are culturally significant to Indigenous peoples. Some of the most well known examples of animal beings are migizi (bald eagle), *ma'iingan* (wolf), *na me* (Lake Sturgeon), and *ogaa* (Walleye). Well-known examples of plant beings include *manoomin* (wild rice), *mashkiigobagwaaboo* (labrador tea), *wiigwassi-mitig* (paper birch), *baapaagimaak* (black ash) and *giizhik* (cedar). Indigenous peoples continue to rely on subsistence harvesting practices throughout the basin to sustain their communities and their culture.

The historic Métis community within the Lake Superior basin developed from the inter-connected Métis populations at Michipicoten, Pic River, Fort William, Nipigon House, Long Lake, Sault Ste. Marie and its surrounding area including Batchewana, Goulais Bay, Garden River, Bruce Mines, Desbarats, Bar River, St. Joseph's Island and Sugar Island. Today, these Métis communities are represented by the Métis Nation of Ontario, Red Sky Métis Independent Nation and Jackfish Métis Association. Reliance on the waters of the Lake Superior basin for activities such as fishing, trapping, and harvesting are critical components of the history of these Métis communities. To this day, Métis continue to practice their right to harvest and rely on the waters of Lake Superior to sustain their way of life. Fishing and trapping remain vital to Métis people, not only as valuable sources of nutrition, but also as cultural traditions.

Traditional Ecological Knowledge (TEK) is a term that encompasses an ecological element of Indigenous knowledge. Indigenous knowledge encompasses environmental, socio-economic, cultural and other elements of overall knowledge held by Indigenous peoples. TEK is the knowledge system of Indigenous peoples based upon generations of direct observations of the surrounding environment. Indigenous knowledge is passed down generation to generation and is used to explain their place within the complex and interdependent relationships of all creation. According to the Ojibwe world view, *Anishinnaabeg Gitchigami* 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 the region home. One observation is that nibi (water) is life and the quality of water determines the quality of life. If water becomes sick, human beings become sick. Indigenous peoples can see their health in the health of the water. Another observation is that while non-human beings will survive, and even thrive, without the influence of humans, human beings cannot survive without the continuation of healthy and sustainable non-human beings. TEK enhances the understanding and appreciation of *Anishinaabe Gichigami* and is useful in local, regional, and lakewide management, including implementation of the *LAMP*.

2.3 Natural Resources and the Regional Economy

Lake Superior's natural resources are the backbone of the regional economy. Industries such as shipping, mining, forestry, nature-based tourism and recreation, sport and commercial fishing, and agriculture, contribute significantly to the local economies of coastal communities, as well as to the economy of the Great Lakes region as a whole. While a formal, comprehensive economic assessment has not been completed for the Lake Superior basin to date, the importance of these industries to the health and viability of coastal communities and residents cannot be overstated.

Shipping

Maritime commerce on the Great Lakes and St. Lawrence River is critical to the economies of the United States and Canada. The Duluth-Superior harbor in the U.S. is the busiest port in the Great Lakes by total cargo volume. Along with the Canadian Port of Thunder Bay and many smaller ports, Lake Superior helps connect North America to the rest of the world, through the Soo Locks located on the St. Marys River in Sault Ste. Marie, Michigan where Lake Superior empties into Lake Huron. As an example of the importance of this industry, in 2017 a total of 69.1 million metric tons of cargo (76.2 million short tons) valued at US$5.8 billion (Cdn$7.5 billion) passed through the Soo Locks and the marine cargo and vessel activity moving through the Soo Locks generated a total of US$22.6 billion (Cdn$29.3 billion) in total economic activity in the United States and Canada. In 2017, the maritime commerce transiting the Soo Locks supported 123,172 U.S. and Canadian jobs, including 39,765 direct jobs and this commercial maritime activity generated US$3.8 billion (Cdn$4.9 billion) in local, state/provincial and federal tax revenues (Martin Associates, 2018).

Minerals and Mining

The abundance of metals, minerals, sand, and gravel deposits that formed in the Great Lakes region and a consistent regional market for the material has sustained mining operations since the mid-1840s. In addition to the fourteen mines operating in the Lake Superior basin, exploration and proposed mining continues within the watershed in northern Minnesota, northern Wisconsin, the Upper Peninsula of Michigan and Ontario. These mines extract resources such as iron-ore, taconite, lead, gold, silver, copper, nickel, zinc, diamonds, and platinum group metals (platinum, palladium, rhodium, ruthenium, osmium and iridium). Iron ore is one of the most valuable nonfuel mined commodities in the Great Lakes region. In 2020, mines in Michigan and Minnesota shipped 98% of iron ore products consumed in the steel industry in the United States, having an estimated value of $4.1 billion (USGS, 2021). In 2019, gold was the highest valued commodity produced in Canada totaling $10.3 billion (NRCan, 2021). Ontario's gold production value was approximately $4.3 billion in 2019, with four of Ontario's 20 gold mines located within the Lake Superior watershed. Canadian mines shipped almost 1 million troy ounces of platinum group metals (PGMs) in 2019 with the majority of the production occurring in Ontario (75%). The United States accounted for over 76% of Canada's exports. Canada has one dedicated PGM mine located in western Ontario near Thunder Bay. However, PGMs are also recovered as co-products at many Canadian primary nickel mines. Canada is the third-largest producer of mined PGMs in the world, accounting for 7.1% of production. The Lake Superior basin is home to the Unites States' only primary nickel mine (located in Michigan), which is expected to produce 360 million pounds of nickel, 295 million pounds of copper and small amounts of other metals over its estimated mine life.

Forestry

The Lake Superior basin covers approximately 43,153 square kilometers (16,661 square miles) with forests covering approximately 26,241 square kilometers (10,131 square miles) or 61% of the basin (ECCC and EPA, 2021). Forests are not only an iconic part of the region's landscape, they are vital to its environmental and economic health. Forests provide many critical ecosystems services to coastal communities in the Great Lakes region. They help to stabilize stream banks and reduce erosion, increase infiltration, attenuate flooding, improve water quality, and provide habitat for culturally significant wildlife. In the Ontario portion of the Lake Superior basin, 75% of the land is Crown land (i.e., owned by the federal or provincial governments and providing opportunities for economic development, tourism and recreation), and forestry is administered through the Ontario Ministry of Natural Resources and Forestry. Sustainable forest licenses are used to ensure sustainable management of commercial forestry and reduce incompatible forestry practices. In the U.S. portion of the basin, 47% of forests are owned by various levels of government; public involvement in planning is more integrated at all levels. Much of the public acreage and a growing number of private lands are currently certified for sustainable forestry practices. Under these practices, timber harvesting is designed to mimic natural disturbances, retain wildlife habitat features and protect riparian areas (LSBP, 2006).

Forests also contribute economically – providing revenue and export markets through products such as pulp and paper, sawmill, engineered wood, and furniture. Forestry is one of the three principal industries of the Lake Superior basin, along with mining and tourism (LSBP 2006). With 85 billion trees on 71 million hectares (175 million acres) comprising more than 66% of Ontario's landscape, the forestry sector in Ontario generates over $18 billion Canadian annually ($14.6 billion U.S.) in revenue and supports approximately 147,000 direct and indirect jobs (MNRF, 2020). While numbers are not available specific to the Lake Superior basin, it is recognized that the basin contributes significantly to these numbers. With its 7.8 million hectares (19.3 million acres) of forests, the economic benefits of forestry to Michigan's economy are significant. Michigan's forest products industry contributes over $24.6 billion Canadian ($20 billion U.S.) annually to the State's economy and provides more than 38,000 jobs to Michigan citizens. The largest numbers of direct jobs are in wood furniture and paper and paperboard products. In the Upper Peninsula, over one-third of manufacturing jobs were in these industries and direct value of the region represents 17% of the statewide direct value added (Leefers, 2017). With its more than 17 million acres of forest, covering 41% of the state (Miles, 2017), the forestry industry plays an important role in Wisconsin's economy. In 2017, Wisconsin forest products industry directly contributed $19.9 billion Canadian ($24.4 billion U.S.) in industry output, and generated over 63,000 jobs (Dahal, 2020) to the state's economy. Forestry also continues to be a significant part of Minnesota's economy, and in 2020 forestry and related industries contributed $9.4 billion Canadian ($7.7 billion U.S.) in value added and supported 67,956 jobs across the state. Forestry is especially important in the northern part of Minnesota and the three counties bordering Lake Superior (Decision Innovation Solutions, 2020).

Nature-based Tourism and Recreation

Lake Superior is a globally significant freshwater resource that attracts visitors from around the world. The beaches, trail systems, open water, parks, and natural protected areas are key assets that support a tourism and recreation sector that provides economic sustainability and growth to coastal communities. The Canadian North Shore is anchored by two large population centres in opposite ends, with a handful of small communities in between. Thunder Bay and Sault Ste. Marie attract a large share of tourism in Ontario's North Shore, while small communities in between, like Wawa, Terrace Bay and Nipigon are increasing tourism into their areas. These areas include the longest stretches of undeveloped coastline in the Great Lakes (e.g., Pukaskwa National Park, Ontario). One-eighth of the Lake Superior's waters are within Canada's Lake Superior National Marine Conservation Area. With Duluth as its gateway, Minnesota's Lake Superior coastline is relatively well developed and a busy travel corridor during the summer months with key assets including Lake Superior, local culture and heritage, the Midwest's biggest and best ski runs, waterfalls, state parks, and trails. Wisconsin's Apostle Islands, the Ice Caves, national forests, national trails, and scenic byways draw people to outdoor recreation such as kayaking around the islands, sailing, cruising to the Apostle Islands, hiking along the 40 waterfall trails, and mountain/road biking, while in the offseason there is dogsledding and cross-country skiing.

Wisconsin is also home to the first ever U.S. Tribal National Park (i.e., Frog Bay Tribal National Park). With Marquette as the activity hub, Michigan's Upper Peninsula has been growing in popularity, especially during the summer season. Key assets include Pictured Rocks National Lakeshore, Keweenaw National Historic Park, Copper Harbour, the Soo locks, 100+ beaches, 129 lighthouses, mountain biking trails and events and campgrounds. The Upper Peninsula, which is 90% forested, retains its aura of accessible wilderness with vast wildlife and waterfowl refuges. In 2018, an analysis of tourism around the Lake Superior basin was conducted on behalf of Tourism Ontario and found that total visitor spending in the Lake Superior Watershed Region for 2016 was approximately $2.6 billion Canadian ($1.9 billions U.S.) (Deloitte, 2018).

Sport and Commercial Fishery

The Great Lakes fishery is one of the most important freshwater resources on earth. The fishery is worth more than $7 billion U.S. ($9 billion Canadian) annually (Allen et al., 2012) to the people of the region, supports more than 75,000 jobs, sustains native fishers, and is the essence of the basin's rich cultural heritage. The major threats to the Lake Superior fishery today are the same as those faced 70 years ago overexploitation of fish stocks, impacts from invasive species, and habitat degradation. Fisheries management programs, along with federal, indigenous, provincial and state pollution prevention and habitat protection initiatives, have made huge strides in protecting and restoring fish populations in Lake Superior. World-class fisheries now exist where pollution, habitat degradation, invasive species and unrestricted harvest of native species had once contributed to the collapse of fish populations and ecosystem decay. In 2020, the commercial value of the Lake Superior fishery in Ontario was $0.52 million Canadian ($0.41 million U.S.) with Lake Whitefish, Cisco (Lake Herring), Lake Trout, Walleye and Northern Pike making up the majority of the 586,532 lb total catch (Ontario Commercial Fisheries' Association, 2021). In Wisconsin the present commercial fishery operates from ports along the main shoreline, where the harvest is predominantly Lake Whitefish and Cisco. Wisconsin waters of Lake Superior are relatively shallow with a high degree of habitat complexity (e.g., Apostle Islands) in comparison to the rest of Lake Superior, which supports a highly productive ecosystem and successful commercial fishery. The Cisco (Lake Herring) and Lake Whitefish fisheries make up the majority of the catch and value of Wisconsin's Lake Superior commercial fishery and in 2020 represented 77% of the total commercial harvest of 1.24 M pounds (WDNR, 2021). In Michigan, the 2018 commercial fishery on Lake Superior consisted entirely of Lake Whitefish and the 137,208 lb total catch had a commercial value of $0.27 million U.S. ($0.34 million Canadian) ((MDNR, 2018). Commercially, fish are sold locally and to restaurants as far away as Chicago. Since 2009, an unprecedented market for Cisco roe has caused a large increase in the commercial harvest of this species. Thousands of pounds of Cisco eggs, also known as caviar and marketed as "Lake Superior gold", are annually exported as far away as Sweden. Lake Trout, Lake Whitefish, Cisco, Brook Trout, Pacific salmon, and Walleye are a few of the species that continue to draw thousands of anglers to Lake Superior every year from around the globe.

3.0 A HEALTHY WATERSHED, A HEALTHY LAKE

The Lake Superior watershed is the area of land that drains rain and snow into streams that flow into the lake. This chapter explains that the water quality of Lake Superior depends on the health of its watershed. Indigenous peoples have long understood the connectedness of all living beings as demonstrated by their aim to live harmoniously with nature. An increasing number of western scientific studies echo the long-held *Anishinaabeg* knowledge that watersheds, rivers and lakes are parts of a single web of life. Scientific studies illuminate how the watershed and the lake send and receive nutrients and energy to each other. Terrestrial vegetation develops organic soil that enters water bodies and delivers nutrients to aquatic species like Largemouth Bass, Pumpkinseed Sunfish and Fathead Minnows (Carpenter et al., 2005). Wetlands also feed nutrients into lakes, such as the Kakagon Sloughs feeding into Lake Superior (Carpenter et al., 2005). In turn, some of this terrestrial-sourced energy is returned to the land from the water through aquatic insect larvae hatches, which feed terrestrial consumers such as birds, bats and spiders (Scharnweber et al., 2014). These and other connections between land and water are outlined in Soininen et al., 2015.

3.1 Lake Superior Water Sources and Flows

Lake Superior is unique among the world's freshwater lakes. Situated at the top of the chain of the Laurentian Great Lakes system, it is the world's largest freshwater lake by surface area – 82,100 square kilometers (31,700 square miles), or roughly the size of Maine. It is also the coldest and deepest of the Great Lakes, with a maximum depth of 406 meters (1332 feet). Lake Superior's 11 quadrillion liters (3 quadrillion gallons) are enough to cover both North and South America under a foot of water (EPA, 2011).

Despite its northern location, Lake Superior rarely completely freezes over even in the coldest of winters because its extreme depth translates to tremendous heat storage capacity. It is also a lake basin with diverse coastal wetlands, extensive sandy beaches and extraordinary biodiversity, supporting fish only found in Lake Superior such as the deep-water "Siscowet" form of Lake Trout. Lake Superior's cool coastlines and islands harbor Woodland Caribou (*Rangifer tarandus*), and arctic-alpine plants.

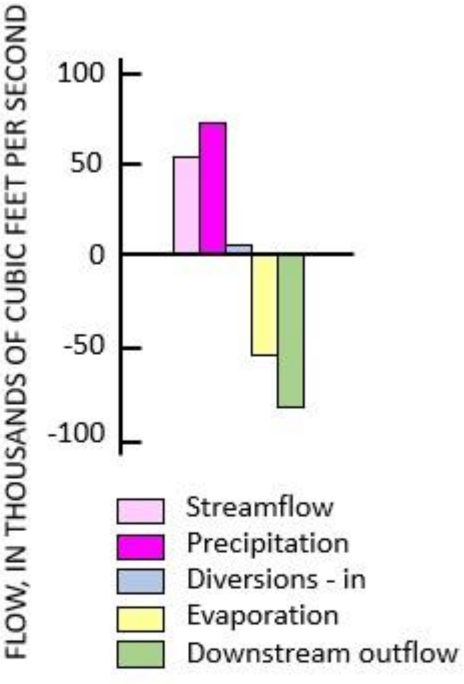

Figure 3. Lake Superior water inputs and outputs in 2003. Source: USGS

As illustrated in Figure 3, precipitation is the largest input of water to Lake Superior, followed by 848 tributaries such as the St. Louis River, Bad River, Nipigon River, and Pic River (USGS, 2003). Other sources include groundwater and water diversions, such as Ontario's Long Lac and Ogoki diversions. Lake Superior has a retention time of approximately 191 years (Neff and Nicholas, 2005), meaning that a single water molecule can stay in Lake Superior for many human lifetimes. Eventually, the majority of water flows out through the St. Marys River into Lake Huron, or leaves in the form of evaporated water.

3.2 Watershed and the Lake: An Important Connection

The Lake Superior watershed is comprised of a diverse collection of habitat types, each playing a critical role in maintaining water quality. The following section describes some of the major habitat types and how a healthy watershed functions.

Watersheds

Lake Superior's watershed covers an area of approximately 43,153 km2 (16,661 mi2) (ECCC and EPA, 2021) with the majority of that being forests and wetlands (ECCC and EPA, 2021). There are 25 tertiary (HUC-6) and 1,546 quaternary (HUC-8) watersheds in the Lake Superior basin. Watersheds are the areas of land from which water flows to Lake Superior, and include headwaters, uplands, inland lakes and wetlands.

Headwaters include surface drainage features, groundwater seeps and springs that are the sources of water for streams and small watercourses. Headwaters intrinsically link to downstream water quality through their influence on the supply, transport, and fate of water and solutes in watersheds.

Well-functioning uplands allow water to infiltrate into the soil, which minimizes stormwater runoff, reduces the potential for extreme flooding, and recharges aquifers. Today, forests cover 61% of the Lake Superior basin, while agriculture lands cover 3% and developed lands are 4% (ECCC and EPA, 2021). Other land type categories include wetlands, inland waters, grasslands and barren land.

Wetlands, and inland lakes and ponds occur throughout and cover 30% of the Lake Superior basin (ECCC and EPA, 2021). These waterbodies provide diverse habitat for aquatic and terrestrial wildlife, capture nutrients and sediments, store carbon, enable groundwater recharge and help to minimize impacts of flooding.

Tributaries

Tributaries are critical components of Lake Superior's aquatic ecosystem, providing important habitats for fish and wildlife, and transporting nutrients and sediments into embayments and nearshore waters. Approximately 2,800 rivers and streams connect Lake Superior to its surrounding watershed (Marcarelli, et al., 2018). There are 99,987 total kilometers (62,129 total miles) of tributaries in the Lake Superior basin, as calculated using stream network data from NHDPlus Version 2 and Ontario Integrated Hydrology Data's Enhanced Watercourse Dataset, compiled by Vouk et al., 2018. Runoff from the land surface contributes an average of 43% of the inputs to the Lake Superior water balance (calculated using data from Neff and Nicholas, 2005). Tributaries provide habitat for Lake Superior fish and wildlife, and act as conduits for nutrients and sediments (Cooney et al., 2018, Marcarelli, et al., 2018), cyanobacteria (Reinl et al., 2020 and Sterner et al., 2020), and contaminants (Baldwin et al., 2016, Babiarz, et al., 2012,) into Lake Superior embayments and nearshore waters. Inputs of nutrients from tributaries support nearshore ecosystems, and variation in their delivery from tributaries across a range of scales results in hotspots for biogeochemical and ecological processes (Marcarelli, et al., 2018).

The hundreds of tributaries that drain into Lake Superior vary from large rivers (including the Nipigon, St. Louis, Kaministiquia and Pic rivers) to intermittent streams (LSBP, 2006), and provide approximately 3,300 km of tributary habitat to migratory fish (Horns et al., 2003 and LSBP, 2006). Migratory fish include Lake

Superior fish that use tributaries for part of their natural life cycle, usually for spawning, but sometimes for foraging or refugia (e.g., from thermal stress, or from predation) (Brazner et al., 2005). While many migratory fishes spawn almost exclusively in rivers, some spawn in both lake and riverine habitats (including Lake Trout and Lake Whitefish on occasion). Key migratory fish that use Lake Superior and its tributaries are Lake Sturgeon, Walleye, Coho salmon, Brook Trout, suckers and many species of minnows (Horns et al., 2003).

Groundwater

Groundwater provides an important but mostly unseen link between Lake Superior and its watersheds. Groundwater serves as a subsurface reservoir that helps mediate changes in flows, water levels, and temperature in streams, lakes, and wetlands, especially during droughts. The estimated base flow component of streamflow (which is primarily derived from groundwater) on the U.S. side of the Lake Superior watershed ranges from 50 to over 80 percent, depending on the bedrock and surficial geology and the method used in the estimation (Neff et al., 2005). Streams that receive substantial amounts of groundwater discharge generally have good water quality, reliable flows and steady temperatures. The amount of direct groundwater discharge to Lake Superior is unknown, but attempts to estimate this amount based on a water balance residual model suggest it could range from 0.1 to 2.7% of the total inflows (Neff and Nicholas, 2005). Groundwater will preferentially discharge to the lake in nearshore areas through shallow, highly conductive surficial materials, where present (Granneman and Van Stempvoort, 2016).

Coastal Habitats

Coastal terrestrial habitats extend from the shoreline up to 2 kilometers inland. Lake Superior's coast is dominated by rocky shores and cliffs (50%) with cobble beaches (14%) and sand beaches (10%). Coastal terrestrial habitats also include sand dunes, raised cobble beaches and coastal forests. The vast size of Lake Superior creates a microclimate, directly influencing the habitats and species found within this coastal area (Horns et al., 2003).

Lake Superior's coast includes globally rare ecosystems along with species unique to the area, which contribute to the high regional species diversity (Kraus and White, 2009). Unique species and habitats found in the coastal terrestrial environment include arctic-alpine plants and coastal forests. Coastal forests are influenced by their proximity to the cold waters, constant winds and other micro-climate factors of the lake. Some communities include stunted "krumholtz" forests and stands with a high abundance of mosses and lichens. These coastal forests support migrating songbirds and Woodland Caribou.

Relatively large numbers of migratory birds follow the eastern and western shores during migration. Migratory raptors prefer to migrate around Lake Superior as opposed to over water, and tend to concentrate in coastal areas (LSBP, 2006). The Keweenaw Peninsula is especially favoured by migrating species. On the south shore, nine sites have been identified as potential Important Bird Areas, many for their migration staging and stopover characteristics (LSBP, 2006) but almost any coastal areas likely provide high quality stop-over habitat. It is believed that large numbers of migratory bats use the coast as a migratory route (Kruger and Peterson, 2008).

Coastal Wetlands

Coastal wetlands include all wetlands within approximately 2 kilometers (1.2 miles) of Lake Superior's coast. Coastal wetlands are a critical interface between the land and the lake, providing key ecological services such as water purification and habitat for waterfowl and fish. There are 26,626 hectares (65,794 acres) of coastal wetlands documented from Lake Superior and they occur along approximately 10% of the coast (Ingram et al., 2004). Mapping and estimates of the extent of coastal wetlands is incomplete in some areas (Rodriguez and Holmes, 2009).

The Kakagon-Bad River Sloughs located just east of Ashland, WI have been described as the "Everglades of the north". This 4,000+ ha (9880+ acre) wetland is owned by the Bad River Band of the Lake Superior Tribe of Chippewa Indians, and was designated as a Ramsar Wetland of International Significance in 2012.

Coastal wetlands in Lake Superior have been found to have relatively unique vegetation types compared to the other Great Lake wetlands due to their higher latitude and the physical features of the lake (EC and EPA, 2014). The dominant form of wetlands in Lake Superior is barrier protected (>10,000 ha / >24,700 acres). Other types of coastal wetlands in Lake Superior include drowned rivermouth wetlands, protected embayment wetlands, deltas, and open embayment wetlands (Ingram et al., 2004).

Coastal wetlands provide habitat for many fish, amphibian and reptile species at various life stages. Many bird species use coastal wetlands during breeding and migration (LSBP, 2006). Coastal wetlands also provide important ecological services for local communities. These functions include protecting shorelines from erosion, the storage and cycling of nutrients entering the lake from tributaries, groundwater recharge, and biological productivity (LSBP, 2006 and Rodriguez and Holmes, 2009).

Islands

Islands include all land masses within Lake Superior that are surrounded by water, including both natural and artificial islands. There are 2,591 documented islands in Lake Superior with a total coastline of over 2,400 kilometers (1,491 miles). Most islands are smaller than one hectare (2.5 acres). The three largest islands (Isle Royale, St. Ignace Island, and Michipicoten Island) comprise more than half of the total Lake Superior island area (LSBP 2006 and Henson et al., 2010). Lake Superior has many of the largest and most isolated islands on the Great Lakes. Several offshore islands support unique plant and animal communities. Caribou Island, located in the eastern part of Lake Superior, is the most isolated freshwater island in the world. In some early maps it is labelled "Isle of the Golden Sands". Along the northern shore of Lake Superior, the Precambrian islands are largely composed of basalt and granite, while the islands along the southern shore are Precambrian and Cambrian sandstones (Henson et al., 2010). Shifting islands of unconsolidated sediments also form in Lake Superior as the result of cobbles accumulating on reefs (Henson et al., 2010). Some Lake Superior islands provide unique opportunities to study population and predator-prey dynamics, such as the Gray Wolf (*Canis lupus*) and Moose (*Alces americanus*) study that has been ongoing on Isle Royale since 1958, and the population crashes of Woodland Caribou in concert with Gray Wolf reestablishment that have occurred on some northern islands.

The islands of Lake Superior provide habitats which are distinct from mainland sites (LSBP, 2006) and contribute to basinwide biodiversity, particularly for colonial nesting waterbirds. Many Lake Superior islands are also important sites for fish spawning and nursery areas, arctic and alpine plants, neotropical migrant songbirds and endemic plants, among other features (Cuthbert et al. 2008). Over 60 islands and island complexes have been identified as significant sites for biodiversity conservation including Pie Island, St. Ignace Island, Ile Parisienne, Patterson Island and Isle Royale (Henson et al. 2010).

Embayments

Embayments and inshore waters are defined as all Lake Superior waters with depths of 0 to 15 meters (0 to 50 feet). These waters possess distinct characteristics because they are partially protected by land from the physical dynamics of the lake. Embayments account for about 7% of the total area of Lake Superior. Some major embayments include Black Bay, Nipigon Bay, Thunder Bay, Batchawana Bay, Keweenaw Bay, and Chequamegon Bay. Embayments are warmer and have a more diverse fish species than the deeper waters. Zooplankton concentrations are highest in these waters where submerged aquatic plant communities thrive. The fish communities in Lake Superior's embayments are very diverse and include both warm and cool-water species, such as Walleye, Smallmouth Bass, Yellow Perch, Rock Bass, Northern Pike, and Lake Sturgeon (Pratt et al., 2010 and Horns et al., 2003).

Nearshore Waters

The nearshore zone of Lake Superior is defined as waters between depths of 15 and 80 meters (50 to 260 feet). The nearshore zone makes up about 16% of Lake Superior's surface area and is located primarily in the east and west ends of the lake, as well as in waters surrounding islands (LSBP, 2015). The nearshore is a highly productive zone of Lake Superior and supports a diverse range of fish species. Most fish in Lake Superior use the nearshore at some time of their life cycle, which includes spawning for Lake Trout, Cisco, and Lake Whitefish. The nearshore is home to Lake Superior's major sport and commercial fisheries.

Nearshore waters are warmer, have a greater diversity of substrate types, and contain aquatic vegetation (LSBP, 2000). Lean Lake Trout and Siscowet Lake Trout are the dominant predators in the nearshore community, as well as in shallow offshore reefs (Horns et al., 2003). Some of the fish species that are found in nearshore habitats may also spend some of their life in embayments and tributaries (e.g., Lake Sturgeon and Walleye) (Horns et al., 2003).

Offshore Waters

The offshore or deep-water zone of Lake Superior encompasses waters with a depth of over 80 meters (260 feet). Approximately 77% of the Lake Superior's surface area is contained in this zone (LSBP, 2015). The deepest areas occur in the central portion of the lake and in the western basin. Mysis, plankton and invertebrates in this zone provide a valuable mechanism for nutrient and energy exchange between the offshore and nearshore waters. This area is predominately comprised of native fish species including the Siscowet Lake Trout, Cisco, Deepwater Sculpin, Kiyi, Burbot, as well as Bloater and Shortjaw Cisco (Ives et al., 2018 and Stockwell et al., 2010).

Lake Trout are the top predator in this deep-water ecosystem, and nearly all of Lake Superior provides important habitat for this species. Lake Trout were historically adapted to a wide range of depths in Lake Superior. Siscowet Lake Trout were historically common throughout the offshore waters, while Humper Lake Trout are present on offshore shoals or banks surrounded by deep-water habitat. Research by Muir et al. (2014) has demonstrated quantitative evidence of another Lake Trout morph, the "redfin", in the waters off Isle Royale. In typical offshore fish communities, deep-water ciscoes (Kiyi, Bloater and Shortjaw Cisco) and deep-water sculpin were the main prey of these deep-water Lake Trout (Horns et al., 2003). The offshore fish community is supported by Mysis shrimp. Mysis exhibit diurnal vertical migration to find zooplankton and avoid predation. Deepwater ciscoes track the Mysis, and are in turn followed by Lake Trout. In this way, energy and nutrients are transferred vertically between the benthic and pelagic zones of this ecosystem (Gorman et al., 2012).

4.0 ROLE OF REGULATIONS AND ALIGNMENTS WITH OTHER INTERNATIONAL EFFORTS

This chapter explains how the Lake Superior Partnership agencies will implement the 2020-2024 *LAMP* within the context of existing laws and regulations. This chapter also describes how the Lake Superior Partnership agencies engage with the International Joint Commission, the Great Lakes St. Lawrence Governors and Premiers, the Great Lakes Fishery Commission, and the Great Lakes Commission.

4.1 Role of Regulations

The Lake Superior Partnership member agencies work within the context of existing laws and regulations to adopt common objectives, implement cooperative programs, and collaborate to address environmental threats to Lake Superior. Many existing federal, tribal, state, provincial and local environmental laws and regulations directly contribute to the restoration and protection of Lake Superior. These laws and regulations ban the manufacture and use of some toxic chemicals (e.g., PCBs), protect species of conservation concern (e.g., Lake Sturgeon), enforce rules to stop the introduction of invasive species (e.g., ballast water management in vessels), and provide responsible oversight to major developments (e.g., environmental impact assessments). A description of 35 pieces of existing legislation relevant to Lake Superior are listed in Appendix B, including the Canadian Environmental Protection Act (1999), and the U.S. Clean Water Act (1972).

4.2 Alignment with Other International Efforts

Actions identified in the *LAMP* are informed by, and complementary to, other applicable international management efforts established under binational treaties, agreements, and programs.

International Joint Commission

Great Lakes Oversight and Water Level Regulation

The 1909 Boundary Waters Treaty (BWT) provides principles for Canada and the United States of America to follow in using the waters they share. The International Joint Commission (IJC) is a binational organization established under the BWT that works to prevent and resolve boundary waters disputes between Canada and the United States. The IJC serves as an independent and objective advisor to the two governments and is an important mechanism for binational dialogue and planning related to implementation of the Agreement. The IJC commissioners receive advice from established boards and task forces, including the Great Lakes Water Quality Board and the Great Lakes Science Advisory Board. The International Lake Superior Board of Control is responsible for regulating the outflow of Lake Superior and managing the control works on the St. Marys River.

Great Lakes St. Lawrence Governors & Premiers

Water Withdrawals Management and Other Initiatives

Signed by the Governors of the eight U.S. States and the Premiers of Ontario and Quebec in 2005, this interstate and inter-provincial agreement contains provisions for managing and protecting the water supplies in the Great Lakes basin. The agreement spawned legally binding legislation in the states and provinces and is most well-known for a commitment to prohibit water diversion proposals which pose a risk of unsustainable water withdrawals from the basin. The *Great Lakes St. Lawrence River Water Resources Regional Body* was established through the agreement as a means for the Governors and Premiers to implement and coordinate their water resource management commitments. The Governors also created the Great Lakes Protection Fund, invest in combatting the introduction and spread of aquatic invasive species, and support international trade, maritime transportation and tourism.

Great Lakes Fishery Commission

Fishery Management and Sea Lamprey Control

The Great Lakes Fishery Commission (GLFC) is responsible for developing coordinated fisheries research programs and for implementing a Sea Lamprey control program. GLFC also facilitates cross-border cooperation of state, provincial, tribal, and federal fishery management agencies for the improvement and preservation of the fisheries (GLFC, 2007). The Lake Superior Committee of the GLFC is comprised of senior officials from tribal, state and provincial fishery management agencies. The Lake Superior Committee is tasked with sustainably and cooperatively managing Lake Superior's fisheries resources and the fish community by considering issues of common concern to the jurisdictions, developing and coordinating joint state/provincial/federal fisheries programs and research projects, and making recommendations on fisheries management issues.

Great Lakes Commission

Regional Forums

Since it was established in 1955 by the Great Lakes Basin Compact, the Great Lakes Commission has worked with its member states and provinces to address issues of common concern, develop shared solutions and collectively advance an agenda to help protect and enhance the region's economic prosperity and environmental health. One of the strengths of the Great Lakes Commission lies in its creation and facilitation of well-respected regional forums to build consensus around shared goals. These forums include the Great Lakes Panel on Aquatic Nuisance Species, the Invasive Mussel Collaborative, the Great Lakes *Phragmites* Collaborative, and the Harmful Algal Bloom Collaborative.

5.0 LAKE ACTION PLAN

The *LAMP* developed by the member agencies of the Lake Superior Partnership is an ecosystem based strategy to improve and protect the water quality of Lake Superior. The actions included in the *LAMP* respond to, and are categorized by, the major threats that are affecting one or more of the Agreement's General Objectives, specifically: chemical contaminant pollution; nutrient and bacterial pollution; invasive species; loss of habitat and species; and other potential threats including plastics, risks from oil transport and mining, and cumulative impacts on the nearshore areas of the lake. Government agencies, Indigenous peoples, stakeholders, and the public all have an important role to play in implementing the actions identified in the *LAMP*.

5.1 Chemical Contaminant Pollution

This section summarizes the scientific information about Lake Superior's water quality related to chemical concentrations, current chemical contaminant threats, and corresponding actions to be taken by Lake Superior Partnership agencies in the 2020-2024 timeframe, as well as actions that everyone can take. The scientific information is organized in response to the chemical-related General Objectives of the *Great Lakes Water Quality Agreement*, specifically: drinking water, human consumption of fish and wildlife, pollutants that could harm people and wildlife, and impacts of contaminated groundwater.

5.1.1 Objectives and Condition Overview

Four of nine General Objectives of the Agreement are addressed in this chapter, i.e., the Great Lakes should:

- Be a source of safe, high-quality drinking water;
- Allow for unrestricted human consumption of the fish and wildlife;
- Be free from pollutants that could harm people, wildlife or organisms; and
- Be free from the harmful impacts of contaminated groundwater.

The status and trend of chemical contaminant sub-indicators for Lake Superior is displayed in Table 4. Lake Superior continues to be a source of high-quality drinking water. Overall, levels of toxic chemicals monitored in Lake Superior are lower than in the other Great Lakes and long-term trends indicate that concentrations are declining. However, Lake Superior fish contain a wide range of chemicals including the Chemicals of Mutual Concern identified by the Parties to the Agreement, as well as pharmaceuticals and Contaminants of Emerging Concern. Fish consumption advisories for Lake Superior fish are necessary, largely due to mercury and polychlorinated biphenyls (PCBs), but also due to dioxins/furans and toxaphene in some areas. The large surface area, year-round cool temperatures, and long water retention time of Lake Superior also makes the lake very susceptible to the impacts of atmospheric deposition of toxic chemicals (Perlinger et al., 2004). As a result, Lake Superior's water has the highest concentrations of legacy organochlorine pesticides (e.g., a-HCH, g-chlordane, lindane and toxaphene), as well as mercury in Lake Trout when compared to the other Great Lakes (ECCC and EPA, 2021 and Dave Krabbenhoft, USGS, personal communication, 2021). The overall effect of contaminated groundwater on surface water in the Great Lakes basin is currently unknown because of gaps in scientific knowledge and insufficient information (Conant et al., 2016).

Table 4. Status and trends of chemical contaminant sub-indicators in the Lake Superior basin. Source: State of the Great Lakes report - ECCC and EPA, 2021.

Sub-Indicator	Status - Trend
Treated Drinking Water	Good - Unchanging
Contaminants in Edible Fish	Fair – Unchanging
Toxic Chemicals in Sediment	Good – Unchanging
Toxic Chemicals in Water	Fair – Improving
Toxic Chemicals in Whole Fish	Fair – Unchanging
Toxic Chemicals in Herring Gull Eggs	Good – Improving
Toxic Chemicals in the Atmosphere	Fair - Improving
Groundwater Quality	Undetermined

The management of toxic chemicals is primarily through regulatory means and occurs through a variety of domestic programs driven by legislation at the federal, tribal, provincial, state, and local levels, as listed in Appendix B. The Agreement, although voluntary, provides another tool to coordinate efforts in identifying and reducing anthropogenic inputs of chemicals. Chemicals of Mutual Concern (CMCs) are those designated by the Parties of the Agreement that may require additional measures to protect against threats to human and environmental health resulting from their presence in the waters of the Great Lakes. To date, eight chemicals (or categories of chemicals) have been designated as CMCs:

- mercury;
- polychlorinated biphenyls (PCBs);
- hexabromocyclododecane (HBCD);
- polybrominated diphenyl ethers (PBDEs);
- perfluorooctane sulfonate (PFOS);
- perfluorooctanoic acid (PFOA);
- long-chain perfluorocarboxylic acids (LC-PFCAs); and
- short-chain chlorinated paraffins (SCCPs).

5.1.2 Drinking Water

GLWQA General Objective: The Waters of the Great Lakes should be a source of safe, high quality drinking water.

How is it monitored?

In the United States, the Safe Drinking Water Act Reauthorization of 1996 requires all drinking water utilities to provide yearly water quality information to their consumers. In Ontario, municipalities and First Nation communities provide treated drinking water data to the Ministry of the Environment, Conservation and Parks' Drinking Water and Environmental Compliance Division. Monitored contaminants include inorganic (arsenic, cadmium, lead, nitrate/nitrite nitrogen), organic (benzene, perchloroethylene, nitrilotriacetic acids, certain pesticides and PCBs), microbial (bacteria), and radiological (tritium and other radiological compounds) parameters. A growing number of tests are now including polyfluoroalkyl substances (known as PFAS, such as PFOS and PFOA), which is a group of human-made chemicals used in a variety of industries around the globe that do not break down in the environment and can accumulate over time.

What is the condition?

Lake Superior continues to be a source of high-quality drinking water for treatment facilities. The status of municipal treated drinking water quality within the Great Lakes basin is classified as being in "good" condition with an "unchanging" trend for the years 2007 to 2017 (ECCC and EPA, 2021). As illustrated in Figure 4, exceedances of treated drinking water quality targets are rare. There are currently no areas within the waters of Lake Superior that have significant drinking water impairments.

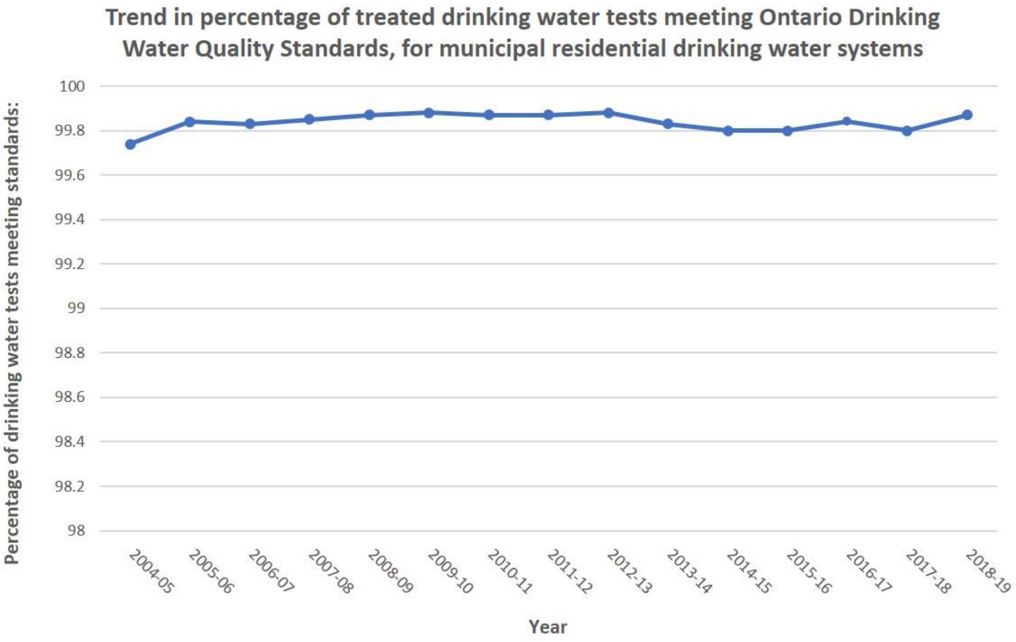

Figure 4. Percentage of Ontario drinking water tests meeting standards annually, from 2004 to 2019.
Source: Data from Chief Drinking Water Inspector Annual Reports.

What is the Threat? and other considerations for taking action

Potential threats to the sources of drinking water in the Lake Superior watershed include septic systems, fuel handling and storage, waste disposal sites, road salt applications and corresponding snow storage (MECP, 2018). Various local activities must also be considered when assessing and managing risk, including potential impacts from ship ballast water discharges, mining operations, transportation of crude oil, and the transport or application of fertilizers.

Increasing amounts of precipitation and extreme precipitation events due to climate change intensifies water runoff from the land (e.g., urban areas, agricultural lands, and watersheds) into Lake Superior, increasing the risk of introducing harmful contaminants, nitrates and/or bacteria into sources of drinking water (Wuebbles et al., 2019).

5.1.3 Fish and Wildlife Consumption

GLWQA General Objective: The Waters of the Great Lakes should allow for human consumption of fish and wildlife unrestricted by concerns due to harmful pollutants.

How is it monitored?

To determine potential risk to human health through fish consumption, Canadian and U.S. federal, tribal, state and provincial agencies monitor persistent, bioaccumulative and toxic substances such as CMCs and CECs in fish and wildlife. These monitoring programs focus on determining the safety of eating fish by monitoring chemical concentrations in the edible portions of fish (i.e., fillets). Consumption advice is issued in an effort to avoid the negative effects of harmful pollutants found in fish and wildlife. Such effects can include neurological and carcinogenic effects. For fish advisory information, visit:

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

What is the condition?

Lake Superior fish and wildlife are a nutritious food source but should be consumed in accordance with the appropriate consumption advisories. The status of contaminants in edible fish in Lake Superior is classified as being “fair” with an “unchanging” trend over the past 10 years (ECCC and EPA, 2021). Fish consumption guidelines in the open waters of Lake Superior are due to concentrations of mercury and PCBs, and in a few locations, dioxins/furans and toxaphene (ECCC and EPA, 2021). With the exception of rainbow smelt in a few location, the concentration of PFAS in most Lake Superior fish are at a low level. There were substantial improvements in PCB and mercury levels in Lake Superior fish between the 1970s and 1990s. However, since the 1990s, concentration levels have plateaued. Figure 5 shows that Lake Superior Lake Trout contain higher levels of mercury than top-predator fish in the other Great Lakes. Large predator fish, such as older Lake Trout, are more likely to have higher mercury levels than other species because they are at the top of food chain and have had more time to bioaccumulate contaminants.

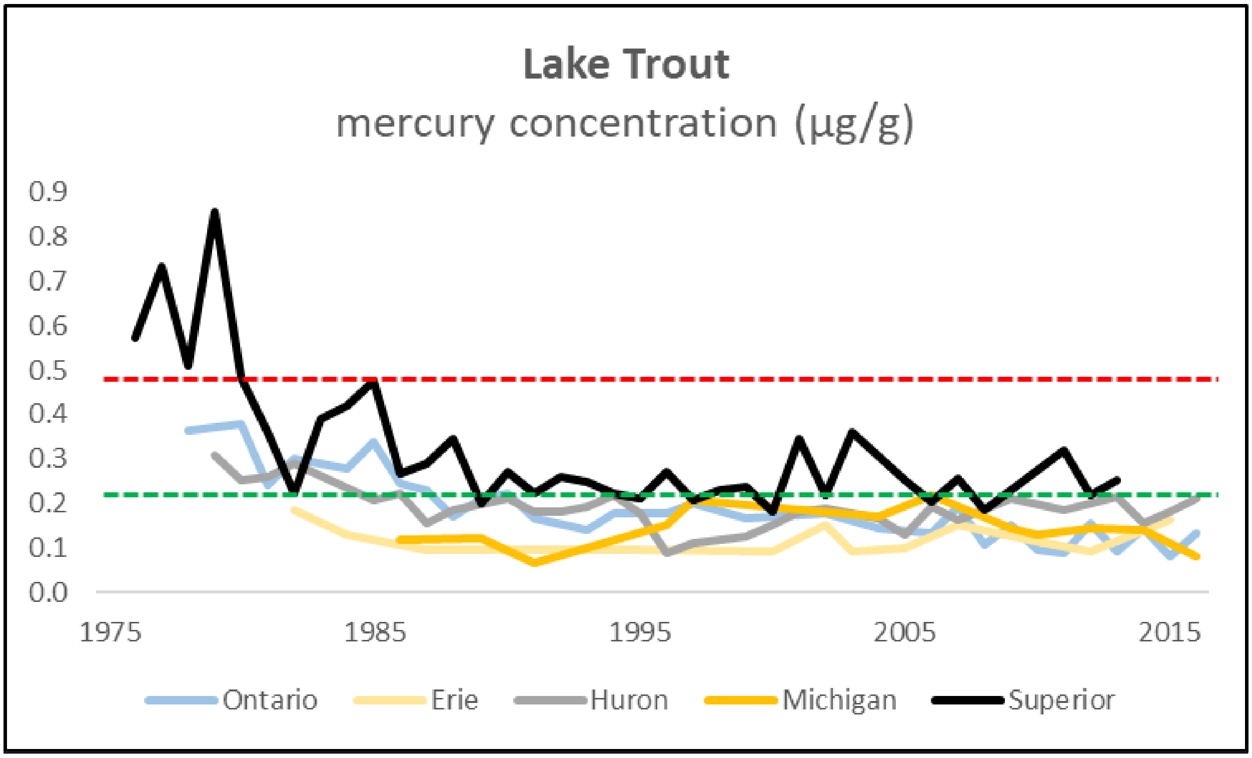

Figure 5. Total mercury concentrations in Lake Trout from the Great Lakes, observed between 1975 and 2016. Lake Michigan measurements were for skin-on fillets, while skin-removed fillets were used for the other lakes. Red and green dashed lines represent approximate health-related benchmarks for the general and sensitive populations, respectively. Source: Ontario Ministry of the Environment, Conservation and Parks and U.S. Environmental Protection Agency.

In 2011-2012, the full range of traditional food across Ontario was sampled for contaminants 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 (Chan et al., 2014). In 2013, population-based contaminant biomonitoring was conducted on individuals from the Fond du Lac Band of Lake Superior Chippewa, in Minnesota. Mercury levels found in their bodies were below levels of health concern. The results again suggest that foods, and particularly fish (which is usually the main source of mercury exposure for most people) may be safely consumed by following fish consumption guidelines (Fond du Lac and MDH, 2014).

What is the Threat? and other considerations for taking action

Contaminant levels in Lake Superior fish vary not only by type of fish and age of fish, but also by geographic location (MOECC, 2017). This is due to the large size of the lake, the variety of fish populations and feeding habitats, and by local contaminant sources.

Today, atmospheric transport and deposition of chemicals from local and distant sources is the largest contributor of contaminants (e.g., mercury) to Lake Superior. Other sources include historically contaminated sediments, and continuing local point and non-point source pollution. Local and non-point sources of chemical contaminants include agricultural and industrial runoff, mining, leaching from septic tanks and old landfills, combined sewer overflows, and effluent from sewage treatment facilities.

Some people are more vulnerable to the effects of contaminants. Developing fetuses and young children are adversely affected by lower levels of contaminants as compared to the levels necessary to adversely affect the general population. Therefore, it is especially important that women of child-bearing age and young children follow fish consumption recommendations.

As part of their traditional culture, Tribal, First Nation and Métis communities consume more local fish and wildlife, on average, compared to others living in the basin. For Indigenous peoples, there is no adequate cultural or nutritional substitute for fish. The presence of contaminants in these resources and the need for fish consumption advisories threatens not only a critical subsistence food resource, but the continuation of their way of life.

Many climate models predict that in the coming decades, climate change will increase air and water temperatures, increase the frequency of extreme weather events, and decrease the duration and extent of winter ice cover in the Great Lakes region (ECCC and EPA, 2021). Such changes could affect the exposure and susceptibility of organisms to contaminants. Increased water temperatures can also increase the rate of toxic substance uptake by aquatic organisms (Fondriest Environmental, Inc. 2014).

5.1.4 Chemical Contaminants in Ecosystem

GLWQA General Objective: The Waters of the Great Lakes should 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.

How is it monitored?

Long-term, lakewide monitoring and surveillance programs for chemical contaminants are conducted by the EPA and ECCC. Chemical contaminants are monitored in water, air, sediments, whole fish, benthic organism tissue, and Herring Gull (*Larus argentatus*) eggs. Federal monitoring programs are augmented by tribal, state, provincial, and academic contaminant science and monitoring programs. Although there are Great Lakes wildlife species that are more sensitive to contaminants than the Herring Gull (a colonial nesting waterbird), there is no other species with a longer-term dataset. The Herring Gull egg contaminants program which began in 1974, provides the longest running continuous (annual) contaminants dataset for wildlife in the world.

What is the condition?

The status of **chemicals in open (offshore) waters** is classified as being in "fair" condition and "improving" (ECCC and EPA, 2021). Chemical concentrations are not as high as they were in the 1970s but the trend has been flat in more recent years. The status of this sub-indicator in the SOGL 2017 report was classified as "good" (ECCC and EPA, 2017). The change to "fair" is not due to increases in chemical concentrations but in recognition of enhanced monitoring efforts that are able to detect CMCs in offshore waters; however, insufficient time has passed for an assessment of all CMC trends. On one hand, Lake Superior has had long-term declines in the concentrations of many legacy chemicals (e.g., mercury and PCBs), and has the lowest concentrations for a suite of new compounds, including per- and polyfluoroalkyl substances (PFAS) and brominated flame retardants (e.g., PBDEs) among the Great Lakes. On the other hand, Lake Superior has the highest concentrations of certain legacy organic contaminants such as a-HCH, g-chlordane, lindane and toxaphene. These legacy organic contaminants accumulate in the cold, deep waters, and once present are very slow to disappear due to the compounds' persistence and the long water residence time of the lake.

Atmospheric deposition of chemicals is in "fair" status and "improving" (ECCC and EPA, 2021). The atmospheric concentrations (airborne vapor, airborne particulates, and precipitation) of most monitored chemicals are generally decreasing in the Great Lakes atmosphere, especially for legacy chemicals (EPA, 2021). The halving times (the time it takes for the concentration of a chemical to decrease by a factor of two) range from 4 years for the pesticide lindane to 15 years for PCBs and pesticides like DDT to more than 25 years for some Polycyclic Aromatic Hydrocarbons (PAHs). The atmospheric concentrations of polybrominated diphenyl ethers (PBDEs) are generally starting to decline while concentrations of PBDE replacement chemicals have yet to drop.

The status of **chemicals in sediment** in the offshore waters is classified as being in "good" condition with improvements compared to 1980s, but "unchanging" in the past ten years (ECCC and EPA, 2021). Overall, contaminant concentrations in offshore deep-water sediments are very low. However, despite significant declines since the 1980s, Lake Superior still has the highest toxaphene concentrations compared to the other Great Lakes. The level of mercury contamination in surface sediments of open-lake areas varies around the lake, as displayed in Figure 6. Concentrations of copper and lead often exceed the strictest (i.e., Canadian) sediment quality guidelines due to the geochemistry of the watershed (Precambrian shield) while historical regional sources associated with mining and smelting are the likely cause of arsenic guideline exceedances (ECCC and EPA, 2021). While the concentration of some of the brominated flame retardants are the lowest out of all the Great Lakes, they are increasing in concentration (Guo, 2015), as a result of the same physical processes influencing concentrations of legacy organic contaminants.

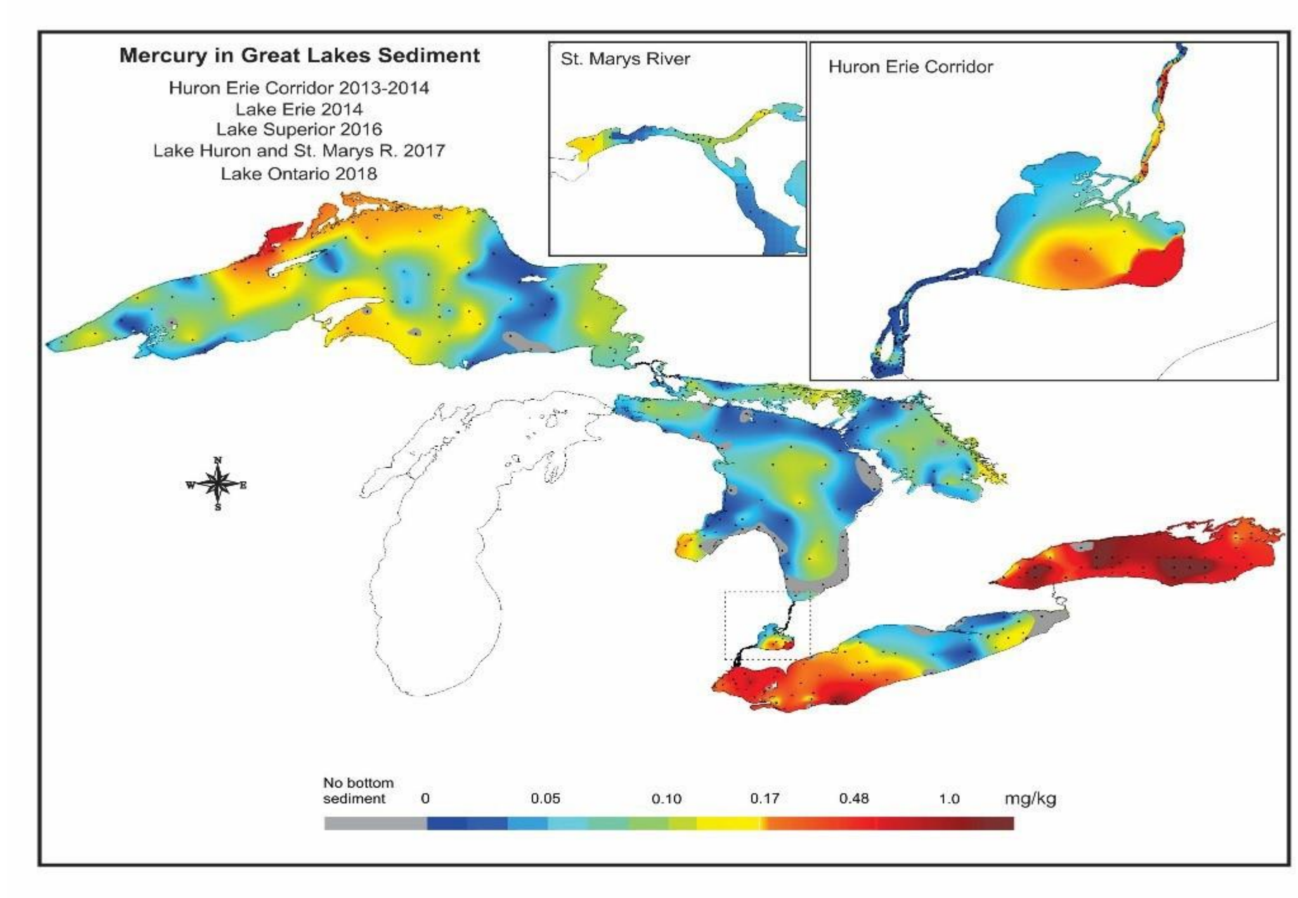

Figure 6. Spatial distribution of mercury contamination in surface sediments of open-lake areas and connecting channels of the Great Lakes. Source: Environment and Climate Change Canada.

The status of **chemicals in whole fish** as a measure of the presence of chemicals in the overall ecosystem is classified as being in "fair" condition with improvements compared to the 1970s but "unchanging" in the past ten years (ECCC and EPA, 2021). The average concentration of monitored CMCs combined together, called the mean deviation ratio, is close to meeting the desired target as represented by the green zone in Figure 7. Lake Superior is currently in the yellow zone as seen in Figure 7, illustrating that Mercury, TeBDE, HxBDE and HBCD concentrations are below Canadian Federal Environmental Quality Guidelines or other published ecotoxicological thresholds, but PCBs, PeBDE, and PFOS exceed these guidelines. Conditions have improved since monitoring began in 1977, even despite the increase in total contaminants being monitored as seen in Figure 7, which was the result of introducing PBDEs into the monitoring programs in the year 2000. Long term whole fish contaminant data show that mean total PCB and PBDE concentrations in Lake Trout have declined at the Apostle Islands collection site since 1992 and 2002, respectively (EPA, 2021). Mercury concentrations in Lake Trout have also declined at the Apostle Islands collection site since 2006 (EPA, 2021).

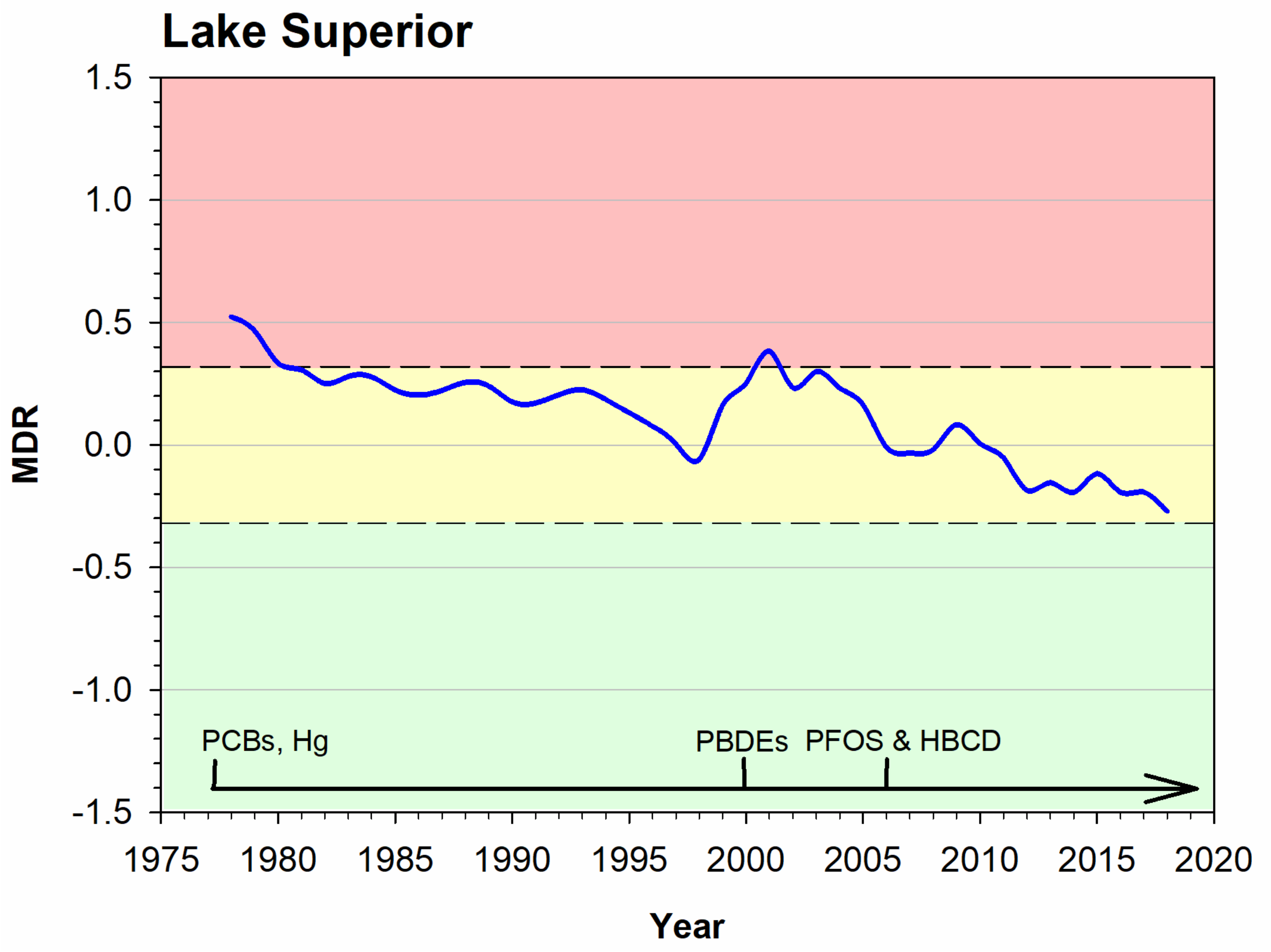

Figure 7. The total amount, as calculated as the Mean Deviation Ratio (MDR), of toxic chemicals in whole fish. Source: ECCC and U.S. EPA, 2022.

The status of **chemicals in fish eating birds** is classified as being in "good" condition and "improving" (ECCC and EPA, 2021). The Wildlife Contaminant Index for contaminants in Herring Gull eggs indicates an improvement from 2002 to 2017 for both lakewide and some individual colonies. Legacy contaminants, mercury, DDE, total PCBs and TCDD have declined significantly in the long term (1974-2017). An observed decrease of PFOS and PFOA in Herring Gull eggs between 1990 and 2010 corresponds with the manufacturers' phase out of these chemicals in North America (Gebbink et al., 2011). In the past decade however, mercury and total PBDEs have not declined significantly. Increases have been observed in dechlorane plus (DCC-CO) from 1982 to 2015, and at the Agawa Rocks colony, total PFCA (a group of PFAS chemicals) increased from 1990 to 2010.

Concentrations and trends of contaminants in bald eagle nestlings at two Lake Superior sites show similar results (Dykstra et al., 2019). DDE concentrations decreased at a rate of 5.5% per year from 1989 to 2015. Total PCBs declined from 1995 to 2011 at a rate of 3.6% per year. Mercury concentrations are at a reduced concentration compared to 1991; however, from 2006 to 2015 there has been no further significant decline.

What is the Threat? and other considerations for taking action

Atmospheric deposition is the primary means through which a number of persistent bioaccumulative toxic chemicals enter the Lake Superior basin. Atmospheric deposition of PCBs will continue for decades due to worldwide remaining residual sources. Distribution of mercury in the atmosphere from regional and global sources such as coal-fired power plants, waste incineration, and metal processing is the top source of mercury to Lake Superior (USGS, 2017). Although the deposition of mercury and dioxin has declined over the past decade, elevated environmental levels are still observed. Mining activity is the largest source of mercury from within the Lake Superior basin (LSBP, 2012).

Non-point source pollution also includes the diffuse movements of rainwater, snowmelt and groundwater across the landscape into the surface waters of Lake Superior. As water moves across the landscape, pollutants are dissolved or suspended by the water and carried into tributaries and the waters of Lake Superior. For example, the historic practice of filling or draining wetlands has created more opportunities for mercury to move from the land to the water and aquatic life (Landry and Rochefort, 2012), and runoff from rainfall and snowmelt can transport other contaminants such as pesticides and polycyclic aromatic hydrocarbons from sources to tributaries and Lake Superior (Beaton et al., 2018 and Meyer et al., 2008).

The Agreement defines an Area of Concern as a geographic area, designated by the United States and Canada, where significant impairment of beneficial uses (e.g., degradation of flora and fauna at the bottom of the lake) has occurred because of human activities at the local level, such as the impacts from mining and pulp mill operations. Environmental restoration of these areas is well underway through projects including remediation of contaminated sediment. In Peninsula Harbour, Ontario, a thin-layer cap was placed on contaminated sediment in 2012 with long-term monitoring in place to track improvements in the ecosystem. In Jackfish Bay, Ontario, conditions are being monitored to track natural recovery. A number of sediment remediation projects have also been completed in the St. Louis River, Minnesota/Wisconsin, and Thunder Bay, Ontario. As of 2020, further management of sediment contaminated by legacy pollution is needed in a number of Lake Superior Areas of Concern, specifically Thunder Bay, Ontario; St. Louis River, Minnesota/Wisconsin; and Torch Lake, Michigan.

Contaminated sediments in general represent a potential source of toxic substances through resuspension, redistribution, and biomagnification in food web pathways. The higher lake levels from increased precipitation over the past few years have increased the potential for higher rates of erosion and transport of contaminated sediment. Large deposits of contaminated sediment associated with tailings from historical mining, including copper-rich deposits along the Keweenaw Peninsula, Michigan, are a continuing source of contaminants.

Increasing precipitation, increasing temperatures, more extreme weather and water level fluctuations can increase the concentrations of chemical pollutants in Lake Superior. Shifts in weather patterns may influence the pathways in which hazardous chemicals are capable of washing into Lake Superior (Adrian et al., 2009). Extreme weather and rain events can transport pollutants from the land to the lake, and increase the risk of infrastructure failure (e.g., mining, wastewater treatment facilities, and pipelines) (Pearce et al., 2011 and Warren et al., 2014). Extreme changes in water levels can expose formerly submerged toxic chemicals and sediments, or alternatively increase coastal erosion when water levels are high. The reintroduction and redistribution of chemicals during these events can pose a threat to aquatic habitats and water quality in the lake (Dempsey et al., 2008).

PFAS are a group of compounds that are resistant to water, heat and oil, and used in adhesives, cosmetics, and cleaning products, as well as fire-fighting foams. In recent years, the presence of PFAS in the Great Lakes basin has received increasing attention because PFAS do not breakdown easily, can bioaccumulate, and when ingested at a high level, can pose a risk to human health. Compared to the other Great Lakes, Lake Superior has the lowest concentration of the suite of PFAS chemicals (Remucal, 2019). Confirmed and possible sources of PFAS in the Lake Superior basin include airports, landfills and atmospheric deposition (Scott et al., 2010 and Remucal, 2019).

Chromium is a naturally occurring metal, but can be released into the environment in the hexavalent form as a result of industrial uses, production and combustion of fossil fuels, and from smelting and refining of nonferrous base metals (Environment Canada, 1994). Hexavalent chromium is toxic (CEPA, 1999), and is the form that is most hazardous to human health. In the 1990s, elevated concentrations of total chromium were present in surface waters near Thunder Bay, and sediments near Sault Ste. Marie were severely affected due to industrial activity (Government of Canada, 1994). Data gaps exist concerning current concentrations of chromium, specifically hexavalent chromium in the Lake Superior ecosystem.

Contaminants of Emerging Concern, such as flame retardants, pharmaceuticals, personal care products and endocrine disrupting substances are frequently being detected in the Great Lakes. Between 2016 and 2018, a study of 26 undeveloped, developed, and wastewater effluent-impacted sites in the Grand Portage Indian Reservation and 1854 Treaty Ceded Territory detected 117 of the 158 compounds of interest (Deere et al., 2020). These chemicals come from a variety of sources including urban stormwater runoff, agricultural runoff, mining in tributaries, wastewater treatment plants and combined sewer overflows, often resulting in complex chemical mixtures. Multiple studies have shown that Contaminants of Emerging Concern can have negative effects on fish and wildlife; however, these studies are often limited to single-chemical exposures or exposures to a mixture of chemicals in a laboratory.

Sulfate is one of many naturally occurring forms of sulfur that exist in the environment. While sulfate is naturally occurring, it is also widely used in many manufacturing (e.g., sulfuric acid) and agriculture (e.g., ammonium sulfate) operations, which can then lead to direct or indirect releases to the environment. When sulfate concentrations in the aquatic ecosystem are higher than natural background levels, it can facilitate processes that result in eutrophication, conversion to sulfide, and mercury methylation (Caraco et al., 1993 and Mitchell, et al., 2008). These outcomes can pose a risk to human health and aquatic life including elevated mercury concentrations in fish and negative impacts to wild rice (*manoomin*), a staple of the traditional Ojibwe diet. In 2016, Fond du Lac Band of Lake Superior Chippewa and the Great Lakes Indian Fish and Wildlife Commission nominated sulfate as a Chemical of Mutual Concern under the Agreement.

A variety of chloride salts, brines and additives are commonly used in road de-icing/anti-icing and dust suppression. Road salts enter the environment through losses at salt storage and snow disposal sites and through runoff and splash from roadways. When used in large concentrations, road salts can pose a risk to plants, animals and the aquatic environment. Long-term trends indicate increasing chloride concentrations in many North America streams including the Great Lakes basin (Kaushal et al., 2018 and Corsi et al., 2016).

5.1.5 Contaminated Groundwater

GLWQA General Objective: The Waters of the Great Lakes should be free from the harmful impact of contaminated groundwater.

How is it monitored?

Existing monitoring wells are usually in locations selected to address potential local groundwater issues (quantity or quality). Federal, provincial and state agencies in coordination with Conservation Authorities (in Ontario) and municipalities conduct groundwater-quality monitoring. Under the Agreement, for each monitoring location/well, the groundwater-quality is assessed on the concentrations of chloride and nitrate.

What is the condition?

Data (from 22 wells) used in the State of the Great Lakes 2019 Groundwater Quality sub-indicator report are insufficient for assessing this component of the Lake Superior basin.

What is the Threat? and other considerations for taking action

Many of the threats to surface water quality also apply to water flowing through glacial deposits and bedrock units near the surface. Many of the streams, lakes and wetlands in the Lake Superior watershed are surface expressions of the water table and the aquifer beneath. Groundwater plays an important role as a reservoir of water that if contaminated, can become a continuous source of pollution into the Great Lakes. Groundwater can become contaminated with various substances including excessive nutrients (e.g., nitrate), salts, metals, pesticides, pharmaceuticals and other contaminants.

Nitrate and chloride are two common contaminants found in groundwater in the Great Lakes basin. Nitrate is mainly from agricultural practices and chloride is mainly an urban contaminant as a result of de-icing road salt. Elevated concentrations of nitrate in water have been shown to have detrimental effects on aquatic organisms and aquatic ecosystems (e.g., direct toxicity and increasing the risk of algal blooms and eutrophication; CCME, 2012), and human health (Health Canada, 2013). Elevated concentrations of chloride in water have been shown to have detrimental effects on aquatic organisms and aquatic ecosystems (e.g., toxicity; CCME, 2012).

A groundwater quality concern in a number of areas within the Lake Superior basin is contamination from mining operations. There have been occurrences of groundwater plumes with high levels of sulfate that can impair local water quality and species such as wild rice (Pastor et al., 2017 and Myrbo et al., 2017). Negative impacts can also occur when the mining operation pumps water to the extent that it changes the source water of downstream rivers from rainwater to groundwater (EPA, 2015). Any contaminants in that groundwater, therefore, become a new pollution source to the river.

5.1.6 Actions to Reduce Chemical Contaminant Pollution

Numerous regulatory actions and environmental programs taken by governments beginning in the 1970s, including initiatives such as the Lake Superior Zero Discharge Demonstration Program and the Great Lakes Binational Toxics Strategy, have significantly reduced the impacts of many chemical releases into the environment. While most areas of Lake Superior are not significantly impacted by chemical contaminants, environmental concentrations of some contaminants continue to be ongoing problems that may limit the full achievement of the General Objectives. Today, chemical contaminants continue to enter Lake Superior through a variety of different pathways including atmospheric deposition, point sources (e.g., municipal/industrial wastewater discharges), non-point sources (e.g., stormwater/surface runoff and mining operations), and release from existing contaminated bottom sediments. This section describes actions that will be taken to further reduce chemical contaminants in Lake Superior.

The Lake Superior Partnership agencies will implement the 2020-2024 *LAMP* within the context of existing laws and regulations which contribute to the restoration and protection of Lake Superior. Twenty-one pieces of federal, tribal, state and provincial legislation that address chemical contaminant pollution are listed in Appendix B. This legislation includes the Canadian Environmental Protection Act (1999) and the U.S. Clean Water Act (1972).

In addition, implementation of national and regional plans and initiatives contributes to reduce chemical contaminants in Lake Superior.

Across the Great Lakes, the Agreement's Chemicals of Mutual Concern (CMC) Annex calls for the Governments of Canada and the U.S. to:

- Identify CMCs and potential candidate CMCs on an ongoing basis;
- Take specific actions for identified CMCs, including development of binational strategies, which may include pollution prevention, control and reduction efforts; and
- Ensure that research, science and monitoring and surveillance programs are responsive to CMC identification and management needs.

Remedial Action Plans are designed to restore impaired "beneficial uses" in defined degraded areas known as Areas of Concern. Remedial Action Plans are being implemented in four locations in Lake Superior: Torch Lake (MI), St. Louis River (MN/WI), Thunder Bay (ON), and Peninsula Harbour (ON). Jackfish Bay (ON) is an Area of Concern in Recovery where a long-term monitoring plan is tracking environmental recovery. In Nipigon Bay (ON), all impaired beneficial uses have been restored and it will be designated as a "Restored Area of Concern" (i.e., delisted) upon final approval of a Remedial Action Plan Completion Report.

The Canada-United States Joint Inland Pollution Contingency Plan is in place, should there be a significant accidental and unauthorized release of pollutants along the Canada-U.S. border. The Joint Marine Pollution Contingency Plan is a mechanism for Canada and the U.S. to coordinate the planning and response to spills in shared waters.

Since the launch of Canada's Chemical Management Plan in 2006, the Government of Canada has assessed over 3,900 substances, finding 459 to be harmful to the environment and/or human health. For these substances, over 160 risk management actions have been implemented, and additional risk management tools are in development.

Other selected regional plans and initiatives include:

- Ontario's Source Water Protection Plans;
- U.S. Great Lakes Restoration Initiative, administered by EPA; and
- Road salt guidelines and plans in Canada, Ontario, Michigan, Minnesota, Wisconsin.

LAMP Actions

Actions will be taken in the Lake Superior basin to further reduce chemical contaminants as listed in Table 5.

Table 5. Actions to prevent and reduce chemical contaminant pollution.

#	ACTIONS TO PREVENT AND REDUCE CHEMICAL CONTAMINANT POLLUTION	AGENCIES
1	Advance remediation of contaminated sediment in Lake Superior's Areas of Concern:	ECCC, MECP
	a. Thunder Bay Area of Concern • Support lead agency in their identification of a preferred option for managing contaminated sediments in the north harbour and develop detailed project engineering design and cost estimate; and • Conduct additional monitoring to determine the extent to which the sediment left adjacent to the former Northern Wood Preservers site remediation project, completed in 2003, has naturally recovered.	
	b. Peninsula Harbour Area of Concern • Complete assessment of the Degradation of Benthos beneficial use impairment; and • Continue long-term monitoring and assessment of the effectiveness and ecological recovery of the thin-layer cap.	ECCC, MECP
	c. Jackfish Bay Area of Concern in Recovery • Report upon sediment conditions, benthic community health, area aesthetics, and contaminants in fish. Determine future monitoring needs.	ECCC, MECP, PPFN
	d. St. Louis River Area of Concern • Complete 31 management actions outlined in the Remedial Action Plan related to remediation of contaminated sediments that support future removal of Restrictions on Dredging beneficial use impairment; and • Complete assessment of legacy mercury and PCBs in sediment within the St. Louis River Estuary and within the designated reference area to determine their contributions to fish consumption advisories.	EPA, USACE, USGS, USFWS, MNDNR, MPCA, WDNR, 1854 TA, Fond du Lac, MN Sea Grant
	e. Torch Lake Area of Concern • Implement a Great Lakes Legacy Act cleanup of contaminated sediment in the lake.	EPA, EGLE, KBIC

2	Contribute to the implementation of the Chemicals of Mutual Concern binational strategies within the Lake Superior basin.	ECCC, EPA, NOAA, EGLE, MPCA, WDNR, Bad River, LDF, Red Cliff
3	Undertake, support and promote innovative approaches and technologies that reduce releases of harmful chemicals beyond required compliance levels.	ECCC, EGLE, MPCA, WDNR, Bad River, Fond du Lac, LDF
4	Identify and promote priority actions for reducing contaminants and pathogens from wastewater treatment plants and/or rural sources.	ECCC, MECP, MPCA, WDNR, Bad River, Fond du Lac, Grand Portage, LDF
5	Through science and monitoring, identify and track contaminants in air, water, sediment, fish and wildlife at a lakewide scale. a. Determine the spatial variation of mercury, PCB and PFAS concentrations in Lake Superior fish. b. Determine the concentration and trends for Chemicals of Mutual Concern in Lake Superior. c. Beyond Chemicals of Mutual Concern and legacy chemicals, proactively monitor for chemicals that are found in Lake Superior water and fish, including pharmaceuticals and pesticides, such as atrazine and neonicotinoids, as a means of providing early warning for chemicals that could become Chemicals of Mutual of Concern.	ECCC, EPA, USGS, USNPS, EGLE, MECP, MNDNR, MPCA, WDNR, 1854 TA, Bad River, BMIC, CORA, Fond du Lac, GLIFWC, Grand Portage, LDF, Red Cliff, MN Sea Grant
6	Through science and monitoring, identify current sources and pathways of chemical contaminants with a focus on mercury and PFAS. a. Beyond Areas of Concern and sites already under purview of government regulatory programs, identify contaminated sediment sites that warrant further investigation and possible management options. b. Determine the PFAS loading from tributaries to Lake Superior. c. Identify mercury loading areas around the lake, with a priority on tributaries that may be most susceptible to greater erosion and runoff during storm events. d. Determine the source(s) of mercury being found in Lake Superior fish. e. Compile data and information on chromium and more specifically hexavalent chromium concentrations and trends in the eastern end of the Lake Superior ecosystem.	EPA, USFS, USGS, EGLE, MPCA, WDNR BMIC, Fond du Lac, LDF, MN Sea Grant
7	Assess existing monitoring programs within the St. Louis River Estuary to identify data redundancies and gaps to improve efficiencies and create a post-Area of Concern estuary monitoring framework.	EPA, NOAA, MPCA, MNDNR, WDNR, 1854 TA, FDL
8	Continue outreach and education to the public on impacts of chemical contaminants with a focus on mercury, pharmaceuticals, PFAS and dioxins; the pathways into fish, wildlife and humans; and actions that can be taken to help remove contaminants from the basin.	ECCC, Parks Canada, USNPS, EGLE, MECP, MDH, MPCA, WDNR, 1854 TA, Bad River, CORA, BMIC, Fond du Lac, GLIFWC, Grand Portage, KBIC, LDF, Red Cliff

Actions Everyone Can Take

- Take household hazardous materials to hazardous waste collection depots;
- Don’t burn garbage in barrels, open pits, or outdoor fireplaces to prevent the release of toxic compounds like dioxins, mercury and lead;
- Properly dispose of unwanted or expired medication through pharmaceutical take-back programs;
- Choose environmentally friendly household cleaning and personal care products;
- If you seal your driveway or parking lot, consider using driveway sealants which minimize the release of toxic substances that run off into the ecosystem during rainstorms;
- Use natural non-toxic pest-control methods;
- Use energy wisely to minimize pollution (and save money too), such as changing to energy-efficient light bulbs, washing clothes in cold water, and further winterizing your home to prevent heat loss;
- Reduce your use of fluorinated consumer products such as non-stick cookware and stain-resistant treatments;
- Try eco-friendly salt alternatives for melting ice and snow, like sugar beet juice or coffee grinds; and
- Join the Public Advisory Committee for your local Area of Concern.

5.2 Nutrient and Bacterial Pollution

This chapter summarizes the scientific information about Lake Superior's nutrient and bacterial pollution, current threats, and corresponding actions to be taken by Lake Superior Partnership agencies in the 2020-2024 timeframe, as well as actions that everyone can take. The scientific information is organized in response to the two related General Objectives of the *Great Lakes Water Quality Agreement:* that the waters are to be free from nutrients that promote unsightly algal or toxic blooms, and for the waters to allow for unrestricted swimming and other recreational use.

5.2.1 Objectives and Condition Overview

Two of nine General Objectives of the Agreement are addressed in this chapter, i.e., the Great Lakes should:

- Be free from nutrients that promote unsightly algae or toxic blooms; and
- Allow for unrestricted swimming and other recreational use.

The status and trend of nutrient and bacterial pollution sub-indicators for Lake Superior is displayed in Table 6. Beaches and the waters close to the shore continue to provide good opportunities for swimming and recreational use. Nutrient concentrations in the lake today are similar to historic values, indicating acceptable ecosystem conditions. Traditionally, harmful algal blooms and nuisance algae have not been a concern for Lake Superior with few reported observations. However, beginning in 2012 a number of short-lived non-toxic blooms of cyanobacteria have occurred, most notably in the area between Duluth Harbor and Apostle Islands. Localized, low toxicity blooms have also been sighted in the tributaries across the Keweenaw Peninsula.

Table 6. Status and trends of nutrient and bacterial pollution sub-indicators in the Lake Superior basin. Source: State of the Great Lakes report - ECCC and EPA, 2021.

Sub-Indicator	Status - Trend
Nutrients in Lakes	Good - Unchanging
Harmful Algal Blooms	Good - Undetermined
Cladophora	Good - Unchanging
Water Quality in Tributaries	Undetermined
Beach Advisories	Good - Unchanging to Deteriorating
Surface Water Temperature (1980 – 2017): Increasing	
Precipitation Amounts (1948 -2015): Increasing	

5.2.2 Nutrient Pollution

GLWQA General Objective: The Waters of the Great Lakes should 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.

How are they monitored?

The condition of the Great Lakes with respect to nutrients in the offshore waters is determined using total phosphorus data collected by ECCC and the EPA. Selected nearshore locations are monitored by a number of tribal, state, and provincial agencies, as well as academic institutions.

What is the condition?

The status of total phosphorus concentrations is classified as "good" and "unchanging" (ECCC and EPA, 2021). Objectives are consistently met, and offshore total phosphorus concentrations are similar to historic values indicating acceptable conditions as illustrated in Figure 8. Near the shore, episodic algal blooms have been occurring since 2012, particularly in parts of western Lake Superior's south shore. As of 2020, Lake Superior algal blooms have not contained harmful levels of known toxins.

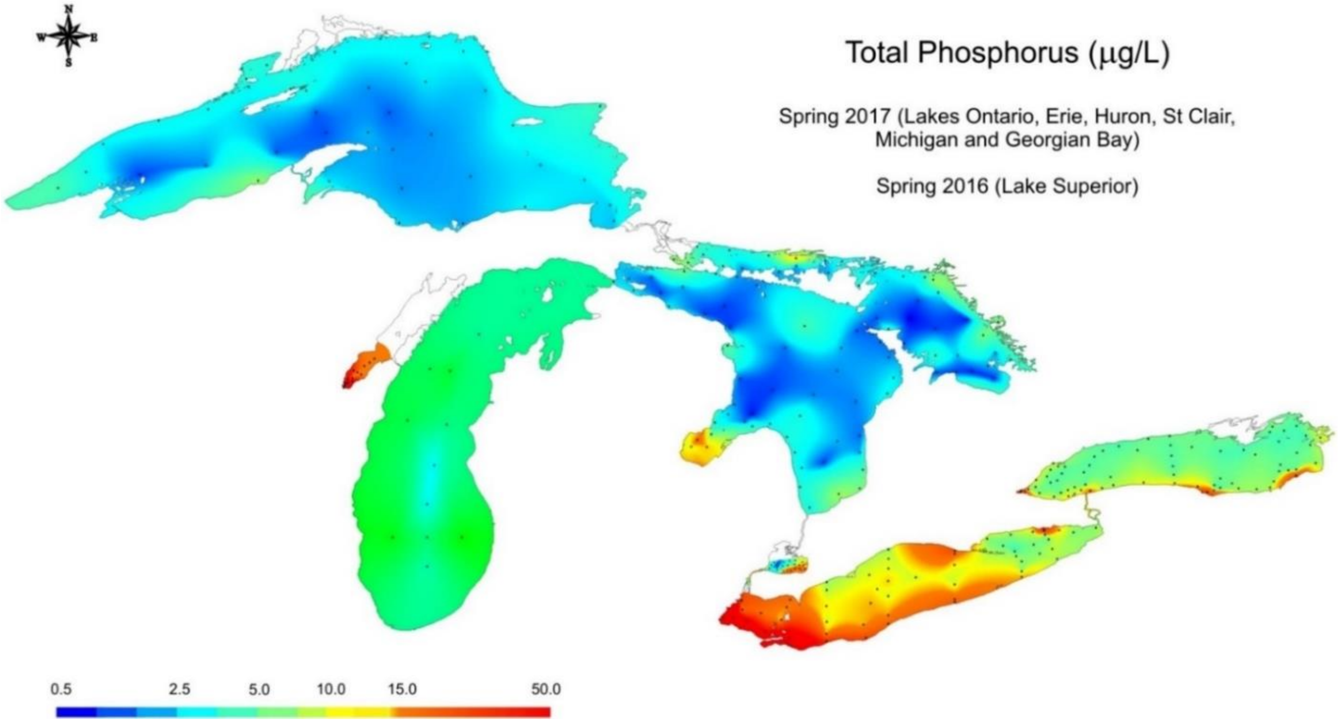

Figure 8. Spatial distribution of total phosphorus (µg/L) in the Great Lakes based on lake-wide cruises conducted during the spring 2016 and 2017. Sampling stations are shown as black dots. Data sources: ECCC, U.S. EPA and NewWater (Green Bay Metropolitan Sewerage District).

Cladophora is a filamentous green algae and the status/trend has been classified as "good" and "unchanging" (ECCC and EPA, 2021). Fouling of shorelines by *Cladophora* has not historically been an issue in Lake Superior, nor have nuisance levels of *Cladophora* been observed on the lakebed. The last comprehensive study of *Cladophora* in Lake Superior was completed between 1969 and 1971 by Parker (1979). Localized investigations in the 1960s (Herbst, 1969), 1970s (Gerloff and Fitzgerald, 1976) and 1980s (Auer and Canale, 1981; Jackson et al., 1990) identified *Cladophora* at locales adjacent to point source inputs of phosphorus and/or warm water discharges. While quantitative information is generally lacking, these studies report that the abundance of *Cladophora* was relatively low historically. Recent surveys in 2017 also failed to detect any *Cladophora* at sites in Lake Superior (Ted Ozersky, University of Minnesota-Duluth, personal communication).

Cyanobacteria are microscopic, unicellular organisms that can grow as large, visible blooms and may be a nuisance, or even toxic. There is little monitoring for toxic and nuisance harmful algal bloom (HABs) in Lake Superior. This waterbody is dominated by pico-cyanobacteria that are less likely to produce toxins compared to the larger cyanobacteria that typically dominate the harmful blooms in other Great Lakes. Algal biomass, especially for potentially toxic cyanobacterial species remains mostly at low levels, although there may be some local impairment due to local conditions.

What is the Threat? and other considerations for taking action

Lake Superior blooms differ from those in other Great Lakes because they are not associated with a single high-nutrient river, and the blooms have occurred along an exposed shoreline and not in a basin or bay (Sterner et al., 2020). Recent ephemeral algal bloom appearances are believed to be influenced by climate-related shifts in precipitation and lake temperature (Sterner et al., 2020). Figure 9 illustrates the increasing trend of total annual precipitation in the Great Lakes basin. At the same time, Lake Superior water temperatures are rising, leading to more favorable algal bloom conditions. The Lake Superior region is experiencing more frequent extreme weather events. Clay soils, particularly along the south shore, are characterized as highly erodible. Satellite imagery following large storms shows sediment plumes in Lake Superior which can contain nutrients from the watershed.

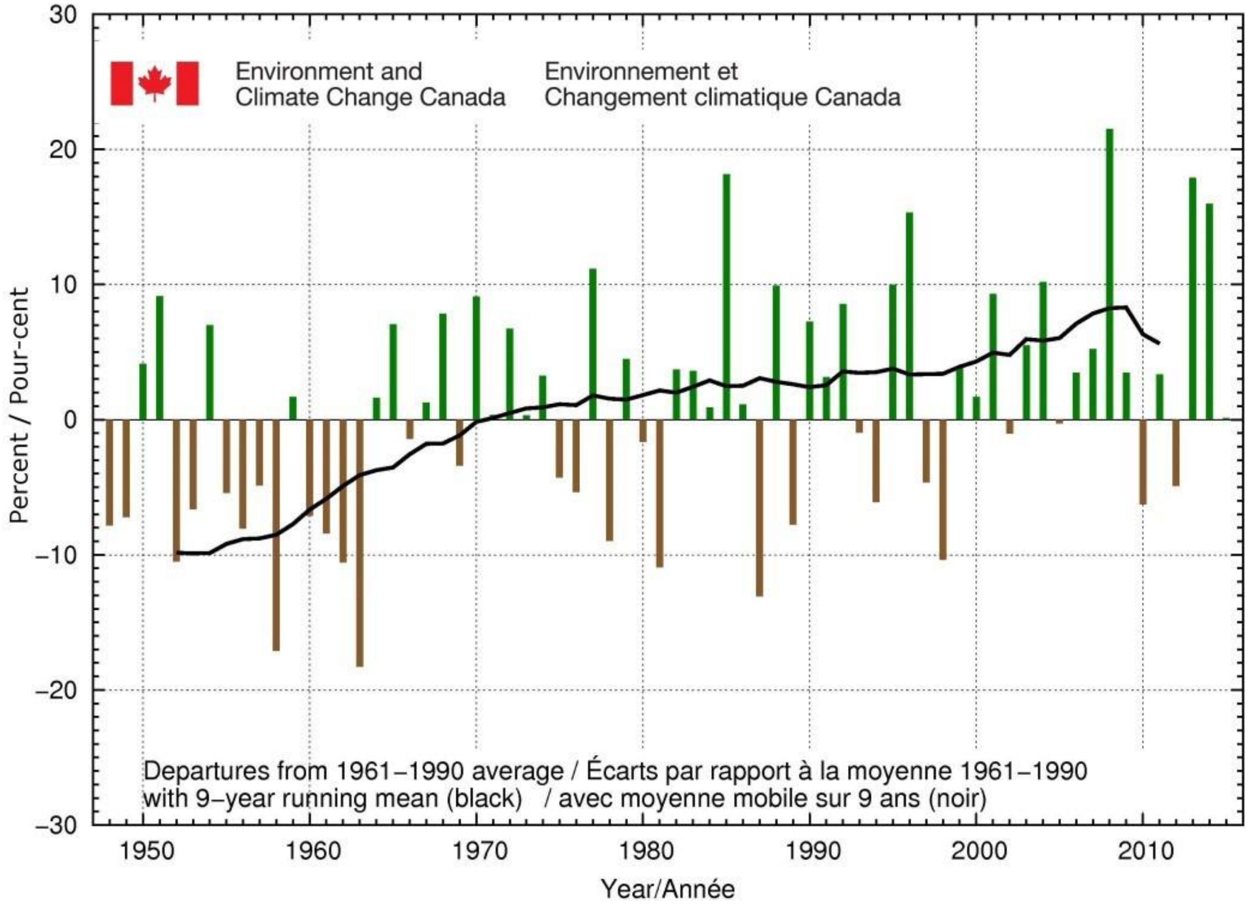

Figure 9. Annual precipitation anomaly (from the 1961–1990 mean) for the Great Lakes basin over the period 1948–2015. Note that the mean for a particular 9-year interval is centered on the middle year, meaning the first year for which the running mean can be defined is 1952 and the last is 2011.

5.2.3 Bacterial Pollution

GLWQA General Objective: The Waters of the Great Lakes should allow for swimming and other recreational use, unrestricted by environmental quality concerns.

How is it monitored?

During the recreational season, tribes, First Nation, states and local governments test beaches and, in some cases, tributaries for *E. coli*. The presence of *E. coli* is an indicator of the presence of human or animal fecal wastes in beach water. While most strains of *E. coli* are harmless, they indicate that other disease-causing (pathogenic) microbes may be present. People swimming in water contaminated with pathogens can contract diseases of the gastrointestinal tract, eyes, ears, skin, and upper respiratory tract. When monitoring results reveal elevated levels of *E. coli*, state or local government/health units issue a beach advisory or closure notice until further sampling shows that the water quality meets the applicable water quality standards. A beach advisory functions as a warning against swimming at a particular beach but is not a closure. Applicable local authorities may issue beach closures when health and safety thresholds are exceeded.

What is the condition?

The status of water quality at Lake Superior's beaches has been classified as being "good", with the 10-year trend of "unchanging" to slightly "deteriorating" (ECCC and EPA, 2021). From 2015 to 2017, monitored Canadian Lake Superior beaches were open and safe for swimming an average of 90% of the swimming season, similar to years dating back to 2011. From 2015 to 2019, U.S. Lake Superior beaches were open and safe for swimming for an average of 95% of the swimming season, slightly less than years dating back to 2007 as illustrated in Figure 10.

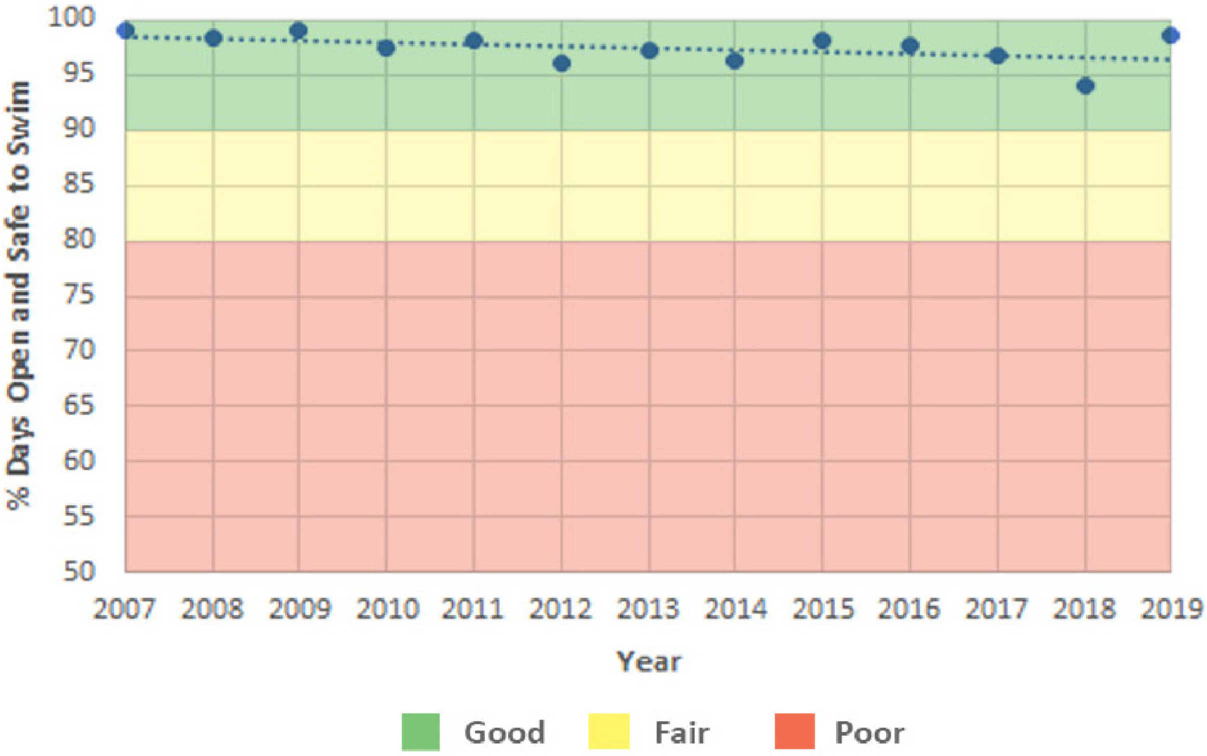

Figure 10. Percentage of days that U.S. Lake Superior beaches were open and safe for swimming from 2007 to 2019. Source: Data collected from U.S. states and reported to EPA's Beach Advisory and Closing Online Notification (BEACON) system.

What is the Threat? and other considerations for taking action

In rural areas, failing or bypassed household sewage treatment systems (e.g., leaking septic tanks) and agricultural runoff from lands treated with manure or where animals are pastured can be sources of *E. coli* contamination to the lake. In urban settings, inputs from sanitary and combined (sanitary/stormwater) sewer overflows (e.g., City of Ashland, WI), excessive pet droppings, and stormwater runoff from roads, roofs, construction sites and parking lots can carry bacterial contamination to local beaches. In both rural and urban settings, feces from geese, gulls and other shore birds congregating on or near beaches add to the bacterial contamination, particularly in areas where ready food sources exist.

Climate change impacts include more frequent and intense rain events, resulting in heavy runoff that can carry biological contaminants such as harmful bacteria from sewers and other polluted areas from the watershed to the beach (IJC, 2003). Precipitation, for example, has increased by 9.7% between 1948 and 2012 in Ontario, resulting in increased flooding and large fluctuations in water levels (Bush et al., 2018).

5.2.4 Actions to Prevent and Reduce Nutrient and Bacterial Pollution

This section describes actions that will be taken to further reduce and prevent nutrient and bacterial pollution in Lake Superior. The Lake Superior Partnership agencies will implement the 2020-2024 LAMP within the context of existing laws and regulations which contribute to the restoration and protection of Lake Superior. Eleven pieces of federal, state and provincial legislation that address nutrient and bacterial pollution are listed in Appendix B. This legislation includes the Canadian Environmental Protection Act (1999), the U.S. Clean Water Act (1972), and Ontario's Nutrient Management Act (2002).

In addition, a number of national and regional plans and initiatives, such as Ontario's 12 point plan and the U.S. Great Lakes Restoration Initiative administered by EPA, are contributing to the prevention of nutrient and bacterial pollution.

LAMP Actions

Actions will be taken in the Lake Superior basin to further prevent and reduce nutrient and bacterial pollution as listed in Table 7.

Table 7. Actions to Prevent and Reduce Nutrient & Bacterial Pollution

#	ACTIONS TO PREVENT AND REDUCE NUTRIENT & BACTERIAL POLLUTION	AGENCIES
9	Undertake necessary bacterial pollution restoration or studies identified in Remedial Action Plans for Lake Superior's Areas of Concern:	
	a. Thunder Bay Area of Concern • Complete assessment of the *Beach Closings* beneficial use impairment and complete process to change status to "Not Impaired".	ECCC, MECP
	b. St. Louis River Areas of Concern • Complete management actions identified in the Remedial Action Plan necessary to remove the *Beach Closings* beneficial use impairment.	MPCA, WDNR
10	Encourage or support investments in green infrastructure and nature-based solutions that help to manage stormwater runoff.	EPA, NOAA, Parks Canada, USACE, USFS, EGLE, MECP, MNDNR, MPCA, WDNR, Bad River, BMIC, Fond du Lac, Grand Portage, LDF, Red Cliff, LRCA, MN Sea Grant
11	Encourage or support projects that improve soil health and forest health with a focus on increasing resilience to climate change, decreasing excessive runoff, and reducing excessive erosion and nutrient loading from Lake Superior tributaries.	USDA–NRCS, USFS, USFWS, MECP, MNDNR, WDNR, Grand Portage, Red Cliff, LRCA

12	Support local initiatives to help communities develop and/or implement watershed plans and/or climate change adaptation plans.	ECCC, NOAA, USACE, EGLE, MECP, MNDNR, WDNR, 1854 TA, Bad River, BMIC, Fond du Lac, Grand Portage, LDF, LRCA, SSMRCA, MN Sea Grant
13	Through science and monitoring, better understand modern and historical nutrient conditions in Lake Superior, and identify the conditions and locations for potential algal blooms. a. Determine if algal blooms are becoming more common compared to past decades. b. Determine how nutrient conditions, including sediment nutrients, are changing and the effects to water quality and ecosystem health. c. Identify sub-watersheds and corresponding areas of the lake that are most vulnerable to nutrient and sediment loading during flood events. d. Determine under what conditions a Lake Superior algal bloom might become toxic.	EPA, NOAA, Parks Canada, USGS, USNPS, MECP, MNDNR, MPCA, WDNR, MN Sea Grant
14	Continue outreach and education to increase the understanding of nearshore and beach health, and best management practices and policies.	ECCC, Parks Canada, USACE, USDA–NRCS, USNPS, EGLE, MECP, MDH, MNDNR, MPCA, WDNR Bad River, BMIC, Grand Portage, Red Cliff, LRCA, SSMRCA

Actions Everyone Can Take

- Avoid using lawn fertilizers containing phosphorus, unless establishing a new lawn or a soil test shows that your lawn does not have enough phosphorus;
- Always pick up pet waste;
- Choose phosphate-free dishwashing detergents, soaps, and cleaners;
- Install a rain barrel to slow the fast flush of water during a storm and reuse the water for beneficial purposes, such as watering a lawn or garden.
- Plant a rain garden with native trees, shrubs, and herbaceous plants and direct rainwater to this area so that the water can soak into the ground and be used by the vegetation;
- Inspect and pump out your septic system every 3 to 5 years, or as otherwise required;
- Implement improved septic technologies, including conversion of septic systems to municipal or communal sewage systems, where available;
- In Ontario, report potential blue-green algal blooms at 1-866-MOE-TIPS (663-8477) so samples can be collected and preventative measures can be taken;
- In Wisconsin, report blue-green algae blooms or related human or animal illnesses to the Wisconsin Harmful Algal Blooms Program at 608-266-1120 or complete the online Harmful Algae Bloom Illness or Sighting Survey; and
- Participate in Bloomwatch.

5.3 Loss of Habitat and Species

Lake Superior's water quality depends on the health of the basin's ecosystem, including the interacting components of air, land, water and living organisms. This section summarizes the scientific information about Lake Superior's habitat and species, current threats, and corresponding actions to be taken by Lake Superior Partnership agencies in the 2020-2024 timeframe, as well as actions that everyone can take. The scientific information is organized in response to the habitat and species General Objective of the Great Lakes Water Quality Agreement.

5.3.1 Objective and Condition Overview

One of nine General Objectives of the Agreement is addressed in this section, i.e., the Great Lakes should:

- Support healthy and productive wetlands and other habitats to sustain native species.

Compared to the other Great Lakes, Lake Superior's habitats and species are in the best overall condition. This characterization is due, in part, to Lake Superior's sparse human population, significant amount of natural coastline and a cold ecosystem less suitable to many of the invasive species impacting the lower lakes.

Coastal wetlands conditions are good overall (LSBP, 2015). However, there is high variability in conditions at the scale of individual wetlands (ECCC and EPA, 2021; Seilheimer and Chow-Fraser, 2007). Some coastal wetlands are in excellent condition, such as several found in the Apostle Islands National Lakeshore which have among the highest floristic quality in the Great Lakes basin (Cooper et al., 2020). However, there are also areas around Lake Superior that are more degraded; these degraded coastal wetlands are located in areas of higher human development and use such as in the St. Louis River estuary and Thunder Bay.

Although in good condition, Lake Superior's habitat and species are under stress (LSBP, 2015). Lake Superior has a relatively cold climate and simple food-web, which makes the ecosystem susceptible to climate change (e.g., warming temperature) and to the impact of new invasive species and land-use changes. While restoration work is needed in degraded areas, protection and conservation actions are required to maintain Lake Superior's good condition.

5.3.2 Loss of Habitat and Species

GLWQA General Objective: The Waters of the Great Lakes should support healthy and productive wetlands and other habitats to sustain resilient populations of native species.

How are they monitored?

Long-term, basin-wide monitoring programs for habitats and species are undertaken by federal, tribal, state and provincial agencies and their partners. Coordinated lakewide monitoring efforts include surveillance and research of the lower food-web, fish species, and important habitats such as coastal wetlands. Monitoring in the watershed and tributaries is undertaken by various agencies at various scales. Through communication and data sharing, some basinwide assessments can be made for a number of indicators, including land-use trends, forest cover and aquatic habitat connectivity.

What is the condition?

The status and trend of habitat and species sub-indicators for Lake Superior is displayed in Table 8. The majority of habitat and species sub-indicators are classified as being "good", however, they range from "poor" to "good", with trends varying from "deteriorating" to "improving" (ECCC and EPA, 2021). Many habitat and species sub-indicator results are summarized below, supplemented by lake-specific studies and members of the Lake Superior Partnership and the Lake Superior Committee of the Great Lakes Fishery Commission.

Table 8. Status and trends of habitat and species sub-indicators in the Lake Superior basin. Source: State of the Great Lakes report - ECCC and EPA, 2021.

Sub-Indicator	Status – Trend
Coastal Wetland Invertebrates	Good – Deteriorating
Coastal Wetland Fish	Good – Improving
Coastal Wetland Amphibians	Good – Undetermined
Coastal Wetland Birds	Good – Undetermined
Coastal Wetland Plants	Good - Unchanging
Coastal Wetlands: Extent & Composition	Undetermined
Aquatic Habitat Connectivity	Fair – Improving
Phytoplankton	Good – Unchanging
Zooplankton	Good – Unchanging
Benthos	Good – Unchanging
Diporeia	Good – Unchanging
Lake Sturgeon	Poor – Improving
Prey Fish	Good – Unchanging
Lake Trout	Good – Improving
Walleye	Fair – Improving
Fish Eating & Colonial Nesting Waterbirds	Fair - Unchanging
Forest Cover	Good – Unchanging
Land Cover	Good – Unchanging
Hardened Shorelines	Undetermined
Watershed Stressors	Good – Unchanging
Baseflow Due to Groundwater	Undetermined
Tributary Flashiness	Unchanging
Ice Cover (1973 – 2018): Decreasing	

Water Levels (1918 – 2017): Unchanging

Watersheds and tributaries are in fair condition (LSBP, 2015). This assessment from the 2015

Lake Superior Biodiversity Conservation Strategy is based in part, on the fair status of some Lake Superior fish species that use tributary habitat, lack of habitat connectivity, and some impacts to nearshore waters, reefs, and embayments.

Aquatic habitat connectivity conditions are "fair" and "improving" over the past ten years (ECCC and EPA, 2021). Lake Superior species only have access approximately 28% of tributary habitat in the Lake Superior basin due to natural and human made barriers as illustrated in Figure 11.

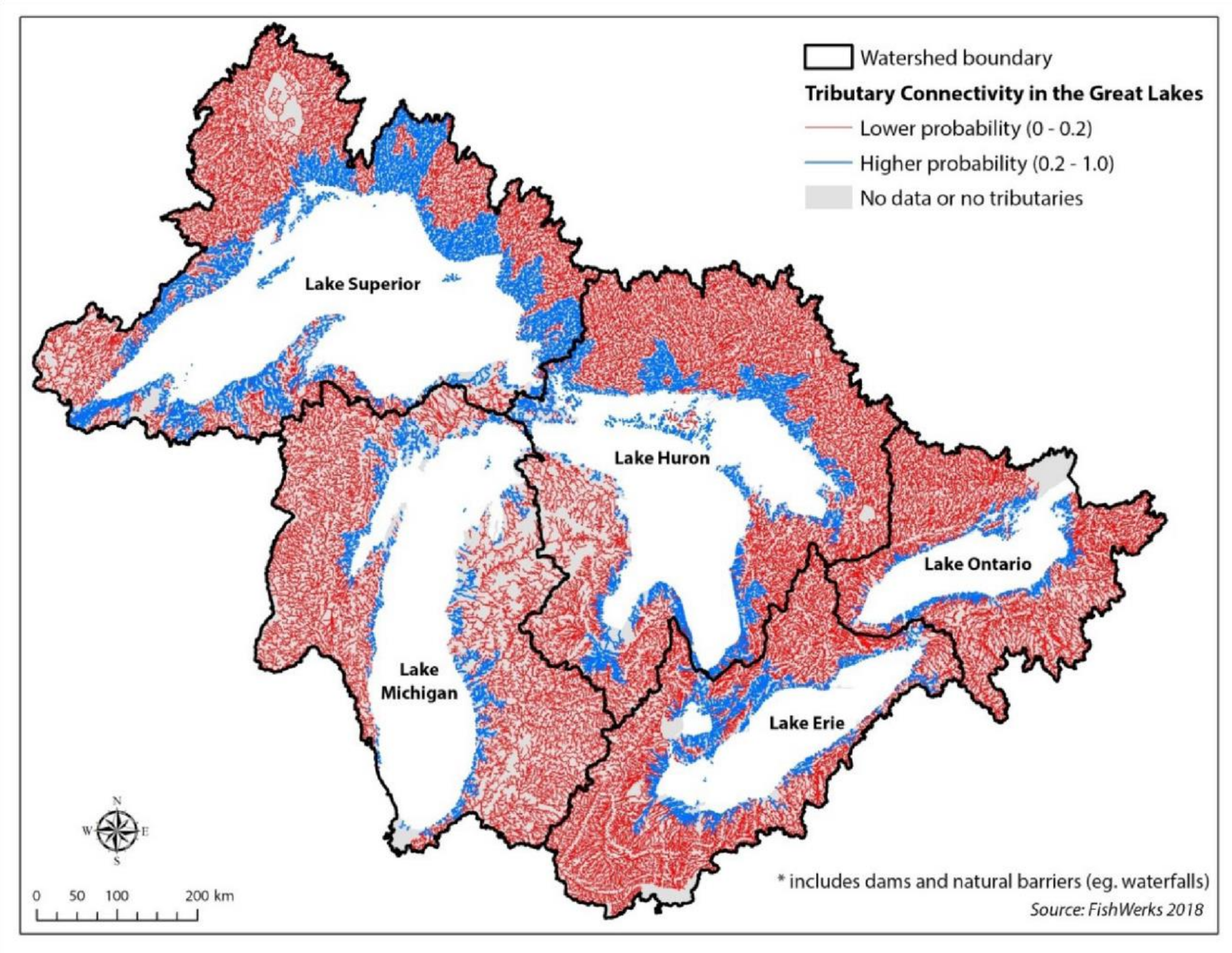

Figure 11. Tributary connectivity in the Great Lakes. Blue color represents a modelled high probability that the tributaries are connected to the lake, and the red color represents a low probability (2018). Source: Fishwerks.

Coastal habitat conditions are "good" with a high degree of regional variation around the lake (LSBP, 2015). Thirty percent of Lake Superior's coast is within parkland or conservation areas and includes many healthy ecosystems and habitat types (LSBP, 2015). The coastal areas of Isle Royale, Black Bay Peninsula, Michipicoten Island and Pukaskwa National Park are among the least disturbed coastal areas in the entire Great Lakes (LSBP, 2015).

Coastal wetland fish conditions are "good" and "improving" based on results from 2011 to 2017 (ECCC and EPA, 2021). Fifty-five percent of Lake Superior coastal wetlands have fish conditions of good quality or only mildly impacted, while the remaining are moderately impacted or moderately degraded. Conditions are classified as "improving" because the number of sites with reference quality conditions increased. Of the Laurentian Great Lakes, Lake Superior is the only one that has no coastal wetland sites with degraded or extremely degraded fish conditions.

Coastal wetland amphibian conditions in Lake Superior are "good" as illustrated in Figure 12, with most sites having high values in the Index of Ecological Condition (ECCC and EPA, 2021). Trends can not yet be determined with the available data.

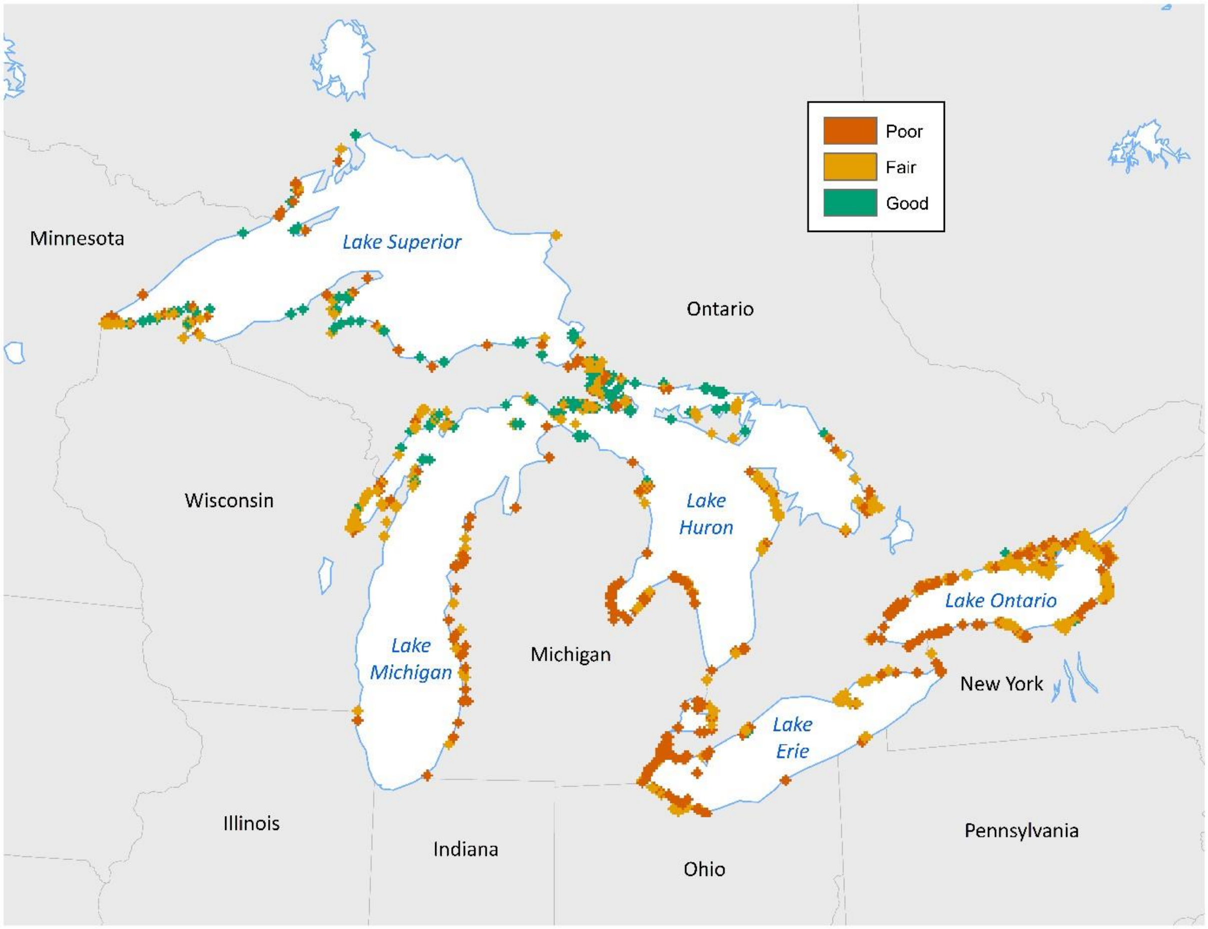

Figure 12. Coastal wetland amphibians index of ecological condition (IEC) throughout coastal wetlands of the Great Lakes (2013-2017). Source: Great Lakes Marsh Monitoring Program, Great Lakes Environmental Indicator project, Great Lakes Coastal Wetland Monitoring Program.

Coastal wetland bird conditions are "good" based on the Index of Ecological Condition (ECCC and EPA, 2021). Trends can not yet be determined with the available data.

Coastal wetland plant conditions are "good" and "unchanging" based on data from 2011 to 2017 (ECCC and EPA, 2021). Most wetland sites in Lake Superior have good plant conditions and recent assessments indicate that there are both sites with improving plant community conditions and sites where conditions are declining slightly.

Coastal wetland invertebrate conditions are "good" and "deteriorating" based on data from 2011 to 2017 (ECCC and EPA, 2021). Over fifty percent of sites sampled were of high quality or only mildly impacted, and no site was degraded. During the 2011-2017 timeframe there was an increase in the proportion of mildly and moderately impacted sites.

Lake Trout conditions are "good" and "improving" (ECCC and EPA, 2021). Following a population collapse in the 1950s, wild lean Lake Trout have recovered due to an aggressive rehabilitation program, ongoing suppression of the invasive Sea Lamprey, stocking of hatchery-reared fish, and fishery restrictions (Hansen et al., 1995; Bronte et al., 2003). Wild Lake Trout abundance is five times higher compared to 1975. Natural reproduction of both nearshore and offshore Lake Trout populations is widespread. Most stocking has been discontinued because rehabilitation targets have been achieved in most parts of the lake.

Lake Sturgeon conditions are "poor" and "improving" (ECCC and EPA, 2021). Historically, Lake Sturgeon populations were present in at least 21 tributaries (ECCC and EPA, 2021). The total population is a fraction of the historical estimate but increasing through natural reproduction, habitat restoration and stocking. Today, reproduction occurs in at least 11 tributaries, with self-sustaining populations in three of these tributaries (i.e., Sturgeon River (MI), Goulais River (ON), Bad River (WI)).

Walleye conditions are "fair" and "improving" (ECCC and EPA, 2021). Signs of improvement have been documented in some parts of the lake, however other local populations remain below historical levels. Many Walleye populations continue to be supported by agency stocking efforts. The Kaministiquia River in Thunder Bay, Ontario contains a small but healthy self-sustaining population with evidence of consistent recruitment. Ongoing assessment work in Black Bay is showing an increase in the relative abundance of Walleye, with information to suggest that Walleye from Black Bay exhibit a range of movement, including some individuals spending extended time outside of the bay. In Nipigon Bay and the Nipigon River, Walleye are low in abundance, but assessment work is indicating signs of increasing density (high growth rates and low mortality). The St. Louis River (Minnesota and Wisconsin) supports one of the largest self-sustaining recreational Walleye fisheries in the Lake Superior basin, with an estimated population size of 50,000 adults (Olson et al., 2016). Similar to the findings in Black Bay, Walleye associated with St. Louis River commonly migrate along the south shore eastward to Saxon Harbor and beyond.

Brook Trout are an important species in the Lake Superior watershed and their widespread presence is unique among the Great Lakes as a result of their requirement for cold, clean water, and varied stream habitats. Brook Trout were historically present throughout much of the Lake Superior basin tributaries and suitable shoreline habitat. Currently their distribution is reduced in many areas to headwater reaches and they only persist in a few shoreline areas (Newman et al., 2003; Schreiner et al., 2008). Current Brook Trout populations are increasing, especially in remote regions or in areas where protective regulations exist (Bobrowski et al., 2011; Blankenheim, 2013; Miller et al., 2016). These areas include Nipigon Bay and Lake Nipigon, Ontario, the Minnesota shoreline, Isle Royale, Michigan, and select locations in Michigan's Upper Peninsula (Quinlan et al., 2021).

Prey fish are smaller fish such as Cisco that larger fish prey upon, and their condition is "good" and "unchanging" in the past 10 years, and improved compared to the 1980s (ECCC and EPA, 2021). As shown in Figure 13, native species dominate the relatively diverse prey fish community and both metrics (i.e., diversity and percent native) classify the community as "good".

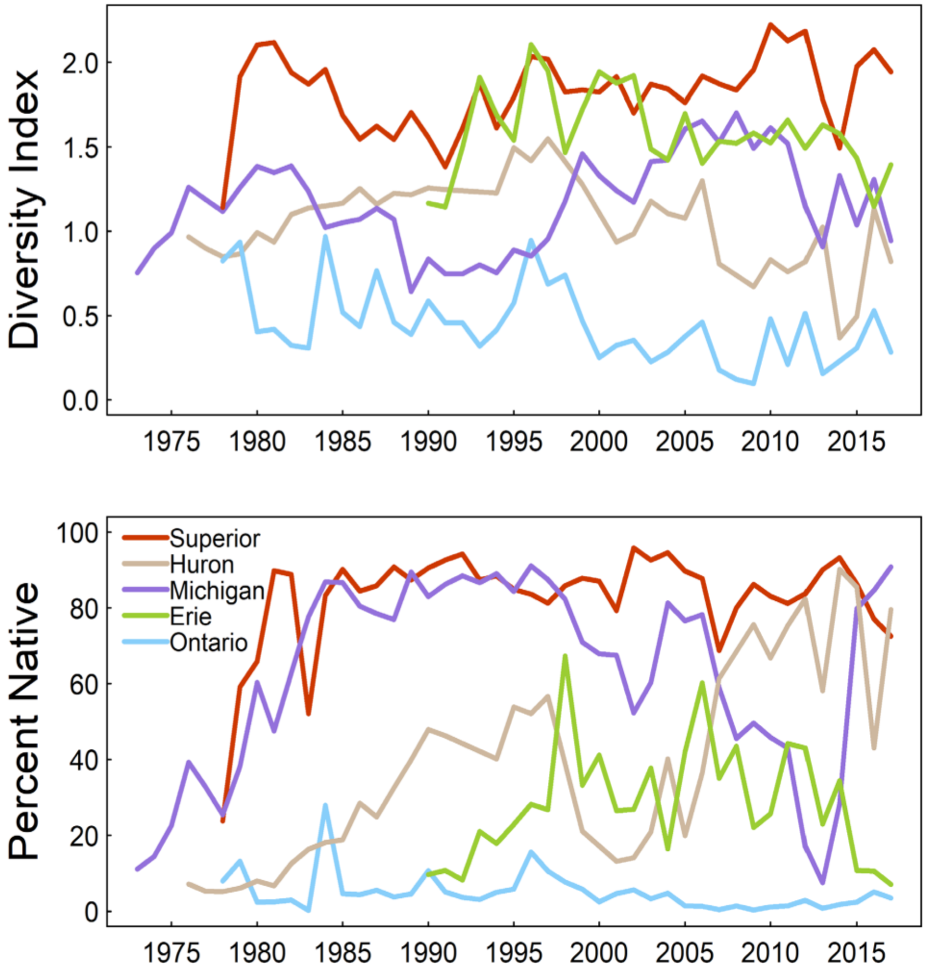

Figure 13. Diversity of prey fish species and percent native for each Great Lake. Source: ECCC and EPA, 2021.

Unlike the other Great Lakes that have a variety of non-native prey fish, Rainbow Smelt are the only non-native species that substantially contributes to the Lake Superior prey fish community; their abundance, however, has declined (Vinson et al., 2017). While the metrics suggest trends commensurate with stated objectives, Figure 14 helps illustrate concerns over population declines of important species like Cisco that serve as prey fish and also support commercial fisheries (Pratt et al., 2011). Recently, the Cisco population has experienced lower than average recruitment (Vinson et al., 2017) and elevated mortality (Pratt et al., 2011).

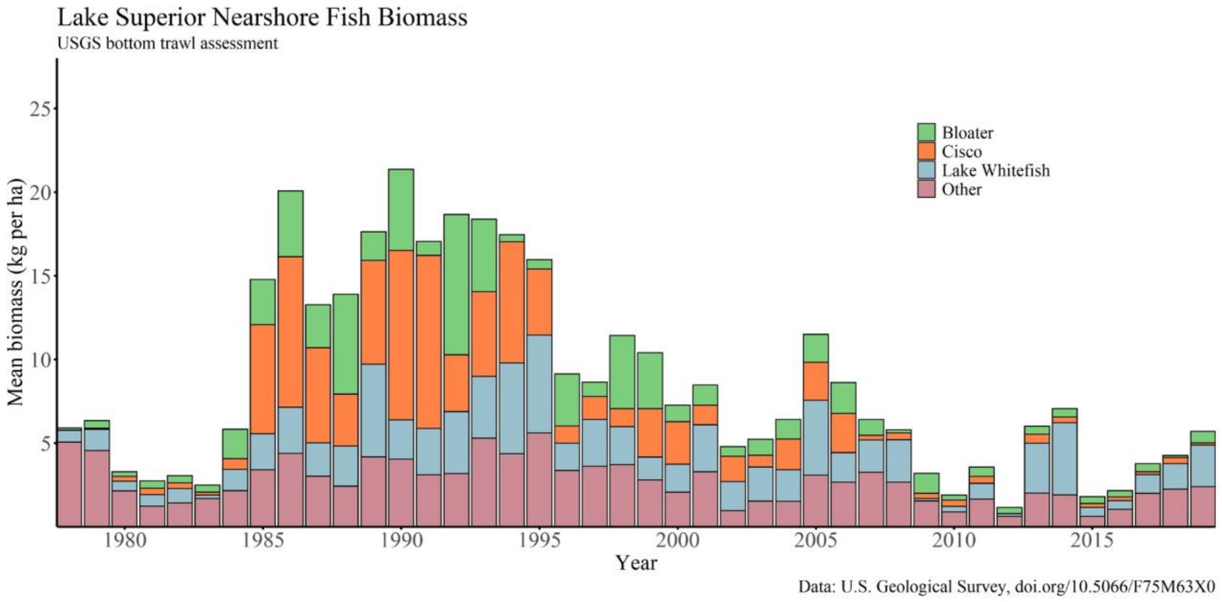

Figure 14. Lake Superior nearshore fish biomass, 1978-2019. Source: USGS bottom trawl assessments.

Diporeia is an important benthic invertebrate species consistently found throughout the lake and remains the dominant macrobenthic organism (Mehler et al., 2018). Diporeia is in “good” condition and “unchanging” (ECCC and EPA, 2021). Annual summer biology monitoring program data indicate no significant changes to benthic community structure from 1997-2018 (EPA, draft, unpublished technical report), with Diporeia typically comprising more than 50% of total density and biomass for benthic organisms. More spatially intensive surveys in 1994, 2000, 2003, and 2016 suggest that there may be a trend of decreasing density in recent decades (Figure 15), although there is also high interannual variability. Furthermore, Diporeia densities are still above the 1978 GLWQA criteria and are thus not categorized as “deteriorating” at this time.

Zooplankton are small organisms, mostly crustaceans that live in the water column and are an important part of the lower-food web; zooplankton are currently in “good” condition and “unchanging” (ECCC and EPA 2021). Annual summer biology monitoring data show that lakewide open lake (areas >100m in depth) zooplankton biomass and community structure have not changed since at least 1997, when annual monitoring began (Barbiero et al., 2021). Additional spatially extensive zooplankton sampling was conducted during 2006, 2011, and 2016 in the open lake and in shallower areas of the lake not sampled during the annual summer biology monitoring surveys. Results from these surveys were consistent with findings from the annual summer biology monitoring program and suggest that both zooplankton biomass and community composition are stable in the open lake areas, as well as shallower regions of the lake (Pawlowski and Sierszen, 2020). ***Mysis*** is a small, shrimp-like animal also eaten by many fish in Lake Superior. *Mysis* populations showed an increase of density and biomass between 2006 and 2016, but are lower than in the 1990s (Jude et al., 2018).

Phytoplankton are microscopic algae, providing food for a wide range of species. Phytoplankton conditions in Lake Superior are “good” and “unchanging” (ECCC and EPA, 2021). Long term monitoring results show that the lake has maintained a phytoplankton community characteristic of oligotrophic conditions and is not being appreciably influenced by invasive species. At the same time, some studies based on long-term phytoplankton records have shown increases in diatoms that thrive with warmer lake temperatures and longer ice-free periods, suggesting that the phytoplankton community composition is shifting in response to changing climate conditions (Reavie et al., 2017).

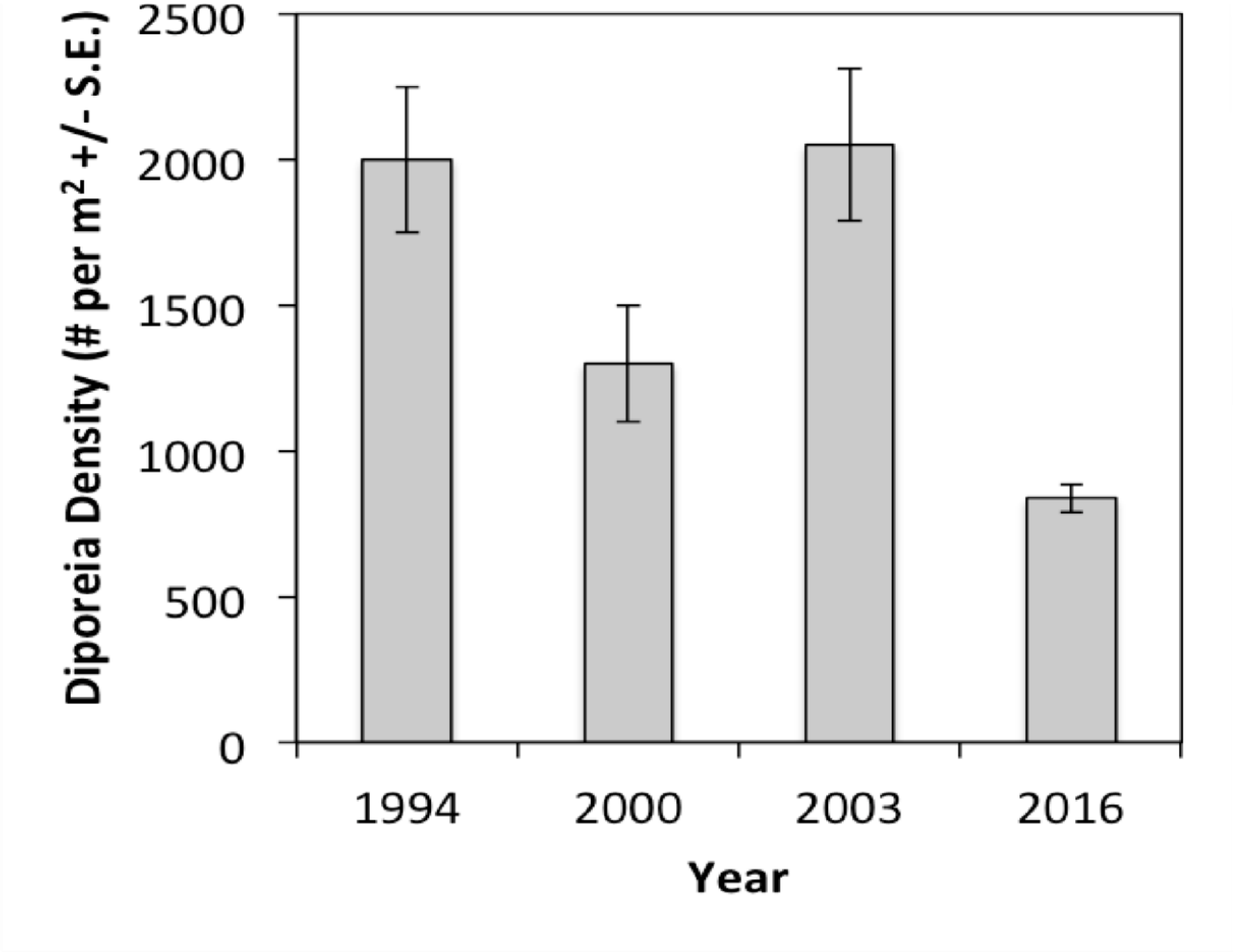

Figure 15. Mean density of the amphipod Diporeia spp. from 25 stations in the U.S. nearshore waters of southern Lake Superior in 1994, 2000, 2003, and 2016. Sources: Great Lakes Center, SUNY Buffalo; Mehler et al. 2018; Scharold et al. 2008.

What is the Threat? and other considerations for taking action

Protective actions are necessary to maintain good quality habitats in the Lake Superior ecosystem. Lake Superior is the least environmentally impacted of all the Great Lakes, and many of its aquatic habitats, watersheds and coast remain healthy and intact (LSBP, 2015). At the same time, as assessed during development of the Lake Superior Biodiversity Conservation Strategy, the overall threat rank for Lake Superior is “high” (LSBP, 2015). The implications of failing to protect the health and sustainability of Lake Superior ecosystems are substantial, as witnessed by the multi-generational efforts and investments being made to restore beneficial uses in the Great Lakes Areas of Concern and other degraded areas. One guiding principle of the Agreement says today’s approach must consider social, economic and environmental factors and incorporate a multi-generational standard of care to address current needs, while enhancing the ability of future generations to meet their needs.

Indigenous peoples continue to rely on subsistence harvesting practices throughout the basin to sustain their communities and their culture. The nibi (waters), giigoonh (fish), plants and wildlife in the Lake Superior basin continue to provide a sense of identity and continuity with traditional ways of life. All plant and animal life are culturally significant to Indigenous peoples. Some of the most well-known examples of animal beings are migizi (bald eagle), ma'iingan (wolf), na me (Lake Sturgeon), and ogaa (Walleye). Well-known examples of plant beings include manoomin (wild rice), mashkiigobagwaaboo (labrador tea), wiigwassi-mitig (paper birch), baapaagimaak (black ash) and giizhik (cedar).

Climate change impacts are expected to alter the physical, chemical, and biological integrity of Lake Superior (Huff and Thomas, 2014). Corresponding climate change impacts to the habitat and species of the Lake Superior ecosystem include:

- More frequently occurring large storm events can cause widespread tributary habitat degradation including streambed aggradation and degradation, increased bank erosion, loss of instream woody habitat, loss of riparian forest cover, and an overall loss of fish habitat.
- Increasing water temperatures favour some aquatic invasive species such as Sea Lamprey (Cline et al., 2014), White Perch, and Alewife (Bronte et al., 2003).
- A significant increase in the lake's primary productivity is attributed to increasing surface water temperatures and longer seasonal stratification related to longer ice-free periods in Lake Superior (O'Beirne et al., 2017).
- While some native species may have a more optimal growth environment due to thermal, chemical, and physical changes, many fish populations may experience lower growth rates (Collingsworth et al., 2017). Figure 16 illustrates Lake Superior's decreasing ice cover trend.

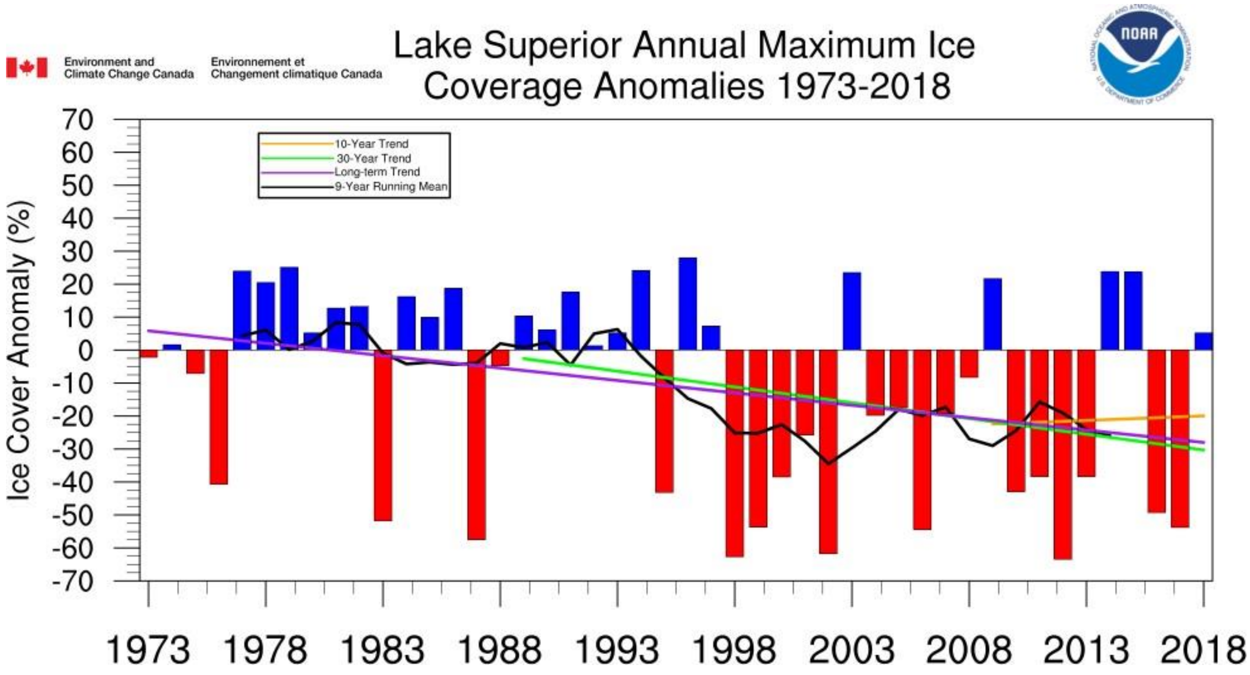

Figure 16. Lake Superior annual maximum ice coverage anomalies and trends 1973-2018. Source: NIC and CIS dataset.

- Changes in thermal habitats have increased the spatial extent and access to ideal temperatures for some fish, while others such as Siscowet Lake Trout have seen a reduced spatial extent by upwards of 13% from 2000-2006. (Cline et al. 2013).
- Disjunct and boreal species that are dependent on cooler temperatures and microclimates will face a reduction in suitable habitat due to increased air temperature (LSBP, 2015).
- Warmer air temperatures and changes in precipitation are shifting deciduous forests northward, and forest pests are able to spread more widely (LSBP, 2015).
- Water level anomalies as illustrated in Figure 17 can elevate erosion rates, physically change some coastal habitats and threaten critical infrastructure including homes, businesses and roadways.

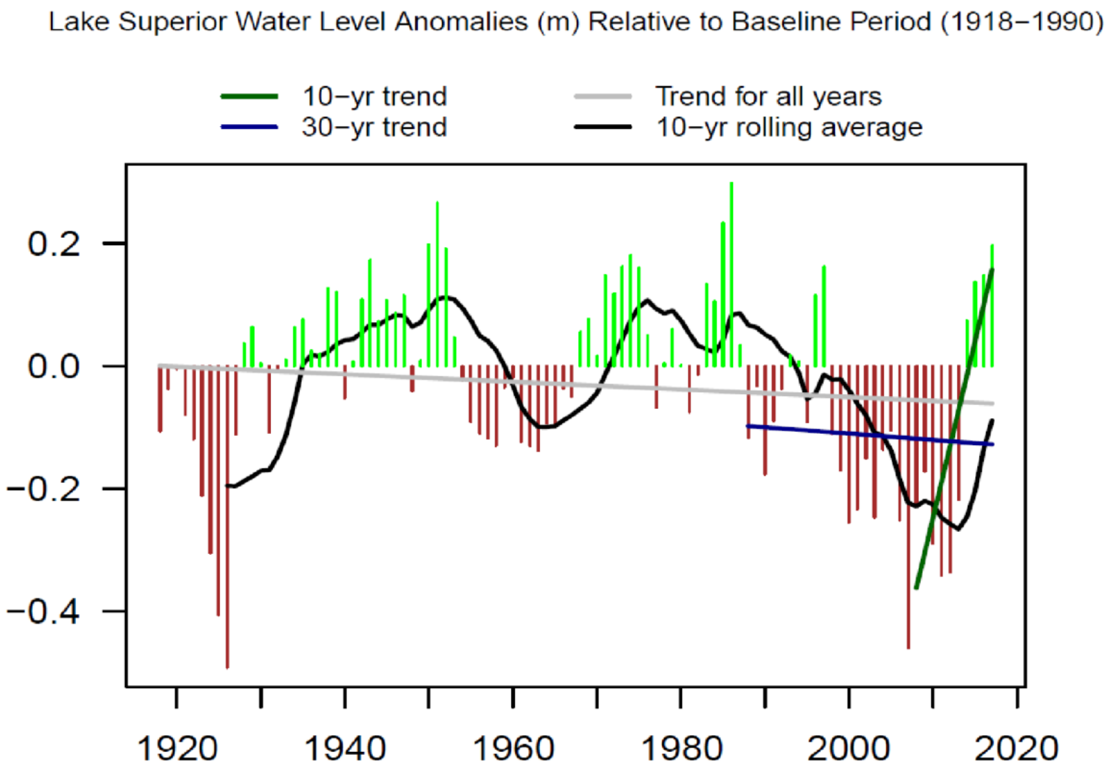

Figure 17. Water level anomalies relative to average of the baseline period 1918-1990. Data from USACE.

Beginning in the late 19th century and ending in the mid-20th century, the Lake Superior watershed experienced an intensive period of mining, deforestation and related industries (Langston, 2017). These activities resulted in loss and degradation of coastal and aquatic habitat which in turn reduced the population of many species. In 1987, seven locations were defined as Areas of Concern in Lake Superior, meaning they had significant environmental degradation due to human activity at the local level. Significant progress has been made in restoring these locations, as summarized in Appendix B. Additional restoration projects or study are needed in Thunder Bay (ON), Jackfish Bay Area of Concern in Recovery (ON), Torch Lake (MI) and St. Louis River (MN/WI).

Mining activity has the potential of impairing water quality and aquatic ecosystem health by waste products degrading fish spawning habitats, wild rice and other natural resources (Horns et al., 2003; Chiriboga and Mattes, 2008; Kerfoot et al., 2012). If not mitigated properly, after a mine closes it can remain a source of contamination for centuries. For example, copper mining was prevalent in Lake Superior's Keweenaw Peninsula between 1845 and the late 1960s. These mines produced tailings called stamp sands — coarse and fine sand produced when ore was processed in stamp mills. During the historical mining period, many millions of metric tons of stamp sands were dumped along rivers, waterways, lakes and the shores of Lake Superior. Almost 23 million metric tons of stamp sands were deposited at the Town of Gay, Michigan alone. These stamp sands are an environmental concern because they are moving into the lake, degrading important fish spawning habitat, contain levels of copper that are toxic to aquatic ecosystems, and other metals that can be harmful including silver, arsenic, cadmium, cobalt, chromium, mercury, manganese, nickel, lead, and zinc. The loss of ecosystem services in this area has been valued to be up to $1.4 million per year (Fletcher, A., Cousins, K., 2019). Recreational and commercial fishing are crucial industries in the area around the Keweenaw Peninsula and depend on the fish habitat provided by reefs that are threatened by the stamp sands.

Dams and barriers, such as perched culverts and improperly designed road crossings, are identified as a high threat to migratory fishes (LSBP, 2015) and are considered an impediment to the recovery of some fishes such as Lake Sturgeon, Brook Trout and Walleye (Horns et al., 2003). Dams and barriers disrupt connectivity for aquatic organisms and the movement of woody debris, sediment, and nutrients that are vital to the health of nearshore ecosystems. At the same time, dam and barrier removal decisions must be carefully studied because these barriers can also prevent the spread of invasive species (e.g. Sea Lamprey, Gobies, Ruffe, VHS, Rusty Crayfish, etc.) and protect native species like Brook Trout in their riverine habitat from naturalized Salmonids such as Rainbow Trout. Some dams and barriers were intentionally installed and are continually maintained for invasive species control, such as those installed to block Sea Lamprey migration in the Iron River, Bois Brule River, and Middle River, WI.

Camp 43 Dam on Black Sturgeon River, ON which was built in 1960 is located 16 kilometers (10 miles) from Black Bay. Black Bay once supported the largest population of Walleye in Lake Superior until their stocks collapsed in 1968 (Garner et al., 2013). For many years, Camp 43 Dam has been a focus for impact assessments and debates around its removal or repair. Some people fear that removing the dam opens the gates for invasive Sea Lamprey migration further upstream, while others argue that native fish populations would be given the opportunity to recover if the dam was removed and Sea Lamprey were controlled through other means. In 2020, the Ontario Ministry of the Environment, Conservation and Parks announced that they will proceed with urgent and critical repairs to the dam structure to maintain its structural integrity and protect public safety as provided for under the emergency provisions within the Class Environmental Assessment for Provincial Parks and Conservation Reserves.

In terms of shoreline development, compared to the other Great Lakes, Lake Superior has had fewer losses of natural shoreline. However, hardening the shoreline by adding piles of large rock or jetties has occurred near important, good quality habitats. Coastal development directly destroys habitats, including the loss of coastal forests, beaches and wetlands. Modifications to shorelines can alter sediment transport processes along the coast and impact beaches and wetlands. Shoreline structures and fragmented habitats can impair the natural shifting of coastal habitats and the migration of species.

The amount and timing of groundwater discharges directly to Lake Superior and indirectly to coastal wetlands, rivers, and streams has not been thoroughly investigated to date. Both direct and indirect discharges of groundwater to the lake effects habitats and species in many ways (EPA, 2018). Some Lake Superior streams and wetlands rely on a source of cold, clean groundwater to remain healthy. The role of groundwater in transporting contaminants to Lake Superior is unknown. The International Joint Commission's Great Lakes Science Advisory Board (GLSAB) identified the need for studying and modeling the water budget and groundwater contributions to Lake Superior and the other Great Lakes (GLSAB, 2018).

5.3.3 Actions to Protect and Restore Habitat and Species

This section describes actions that will be taken to further protect and restore habitat and species in Lake Superior.

The Lake Superior Partnership agencies will implement the 2020-2024 *LAMP* within the context of existing laws and regulations which contribute to the restoration and protection of Lake Superior. Eleven pieces of federal, state and provincial legislation that protect habitat and species are listed in Appendix B. This legislation includes the Canada National Marine Conservation Areas Act (2002) and the U.S. Endangered Species Act (1973).

Other contributing national and regional plans and initiatives include are described below.

The Lake Superior Biodiversity Conservation Strategy and corresponding 20 regional plans identify threats to biodiversity and act as a guide to conservation (LSBP, 2015).

The stakeholder driven collaboration, Lake Superior Binational Program, includes a Broader Ecosystem Program to restore and protect Lake Superior that places an emphasis on a basin ecosystem approach to resource protection.

A Joint Strategic Plan for Management of Great Lakes Fisheries (GLFC, 2007) provides a framework for common fishery management and mandates the development of lakewide Fish Community Objectives and related Lake Superior Committee Environmental Priorities.

Protected areas including those displayed in Figure 18 form the cornerstone of habitat and species conservation, but also conserve ecosystem services and provide “natural solutions” by:

- Sequestering and storing vast amounts of carbon in forests, wetlands and other natural ecosystems;
- Serving as a safe haven for species as climatic conditions shift. Networks of protected areas can facilitate species movement and connectivity, increasing ecosystem resilience and adaptive capacity;
- Helping to clean water, mitigate floods and prevent erosion through harbouring intact natural ecosystems, such as wetlands and forested riparian areas;
- Preventing biodiversity loss; and
- Serving as a benchmark for research and monitoring, and demonstrating evidence-based planning and management.

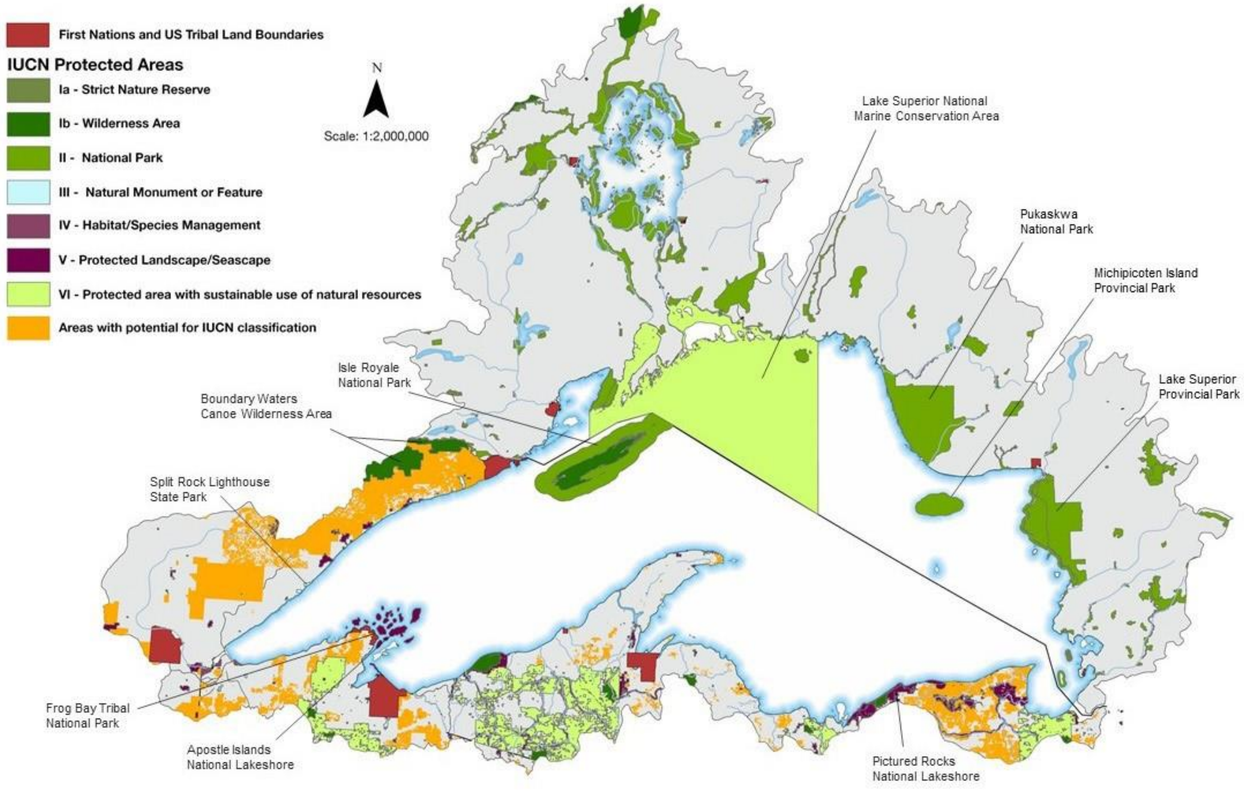

Figure 18. Selected Parks and Protected Areas in the Lake Superior basin. Source: Canadian protected and Conserved Area Database, USGS PAD-US and CEC North American Environmental Atlas, prepared by Parks Canada.

Many U.S. agencies at the federal, tribal and state level operate fish hatcheries and stock fish in Lake Superior to support conservation efforts or to increase recreational, subsistence, and charter fishing opportunities.

Remedial Action Plans are designed to restore impaired "beneficial uses" in defined degraded areas around the Great Lakes, known as Areas of Concern. Remedial Action Plans are being implemented in four locations in Lake Superior: Torch Lake (MI), St. Louis River (MN/WI), Thunder Bay (ON), and Peninsula Harbour (ON). Jackfish Bay (ON) is an Area of Concern in Recovery and a long-term monitoring plan is being implemented to confirm that the ecosystem recovers. In Peninsula Harbour (ON), community engagements are needed to discuss the recently completed scientific studies on habitat and species, now that restoration measures are complete.

Climate change adaptation strategies are active at different geographic scales and on different issues that are relevant to Lake Superior, including:

- Canada's Federal Adaptation Policy Framework for climate change;
- Climate Change Response Framework Adaptation Strategies and Approaches;
  - Dibaginjigaadeg Anishinaabe Ezhitwaad: A Tribal Climate Menu
  - Forests
  - Forested watersheds
  - Non-forested wetlands

- Federation of Canadian Municipalities (FCM)'s Municipalities for Climate Innovation Program; and
- Pan-Canadian Framework on Clean Growth and Climate Change

Additional initiatives relevant to the basin include:

  - A Made-in-Ontario Environment Plan;
  - Bad River Band of Lake Superior Chippewa Indians Ma'iingan (Wolf) Relationship Plan;
  - Bay Mills Indian Community Waishkey River Watershed Management Plan;
  - Canada's Nature Fund;
  - Canada's Climate Action and Awareness Fund;
  - Canadian Species at Risk strategies and plans;
  - Great Lakes Basin Fish Habitat Partnership Strategic Plan;
  - Keweenaw Bay Indian Community Terrestrial Invasive Species Management Plan 2018;
  - Michigan's Wildlife Action Plan;
  - Minnesota's endangered species list and guides;
  - Minnesota's Lake Superior Fisheries Management Plan 2016-2025;
  - Ontario Species at Risk recovery strategies;
  - Red Cliff Band of Lake Superior Chippewa Treaty Natural Resources Division Comprehensive Plan 2020-2030;
  - U.S. Endangered Species recovery plans;
  - U.S. Great Lakes Restoration Initiative, administered by EPA;
  - USFWS's Great Lakes Coastal Program;
  - Wisconsin's Natural Heritage Conservation Program; and
  - Wisconsin Lake Superior Fisheries Management Plan 2020-2029.

LAMP Actions

Actions will be taken in the Lake Superior basin to further protect and restore habitats and species and to track process through science and monitoring as listed in Table 9.

Table 9. LAMP actions to protect and restore habitat and species.

#	ACTIONS TO PROTECT AND RESTORE HABITAT & SPECIES	AGENCIES
15	Undertake necessary habitat and species restoration or studies identified in Remedial Action Plans for Lake Superior's Areas of Concern:	
	a. Thunder Bay Area of Concern • Complete, share and discuss with the local community the latest studies on fish populations and habitat, and next steps for restoring wildlife habitat; and • Prepare a wildlife habitat strategy to identify and implement remaining needed habitat improvement projects.	ECCC, MNRF

	b. Jackfish Bay Area of Concern in Recovery • Evaluate the current condition of fish populations for species present in Jackfish Bay.	ECCC, MNRF, PPFN
	c. Peninsula Harbour Area of Concern • Share and discuss with local communities a proposed decision to re-designate fish and wildlife habitat and populations to not impaired.	ECCC, MNRF
	d. St. Louis River Area of Concern • Continue to implement habitat restoration projects, including wild rice restoration; • Complete management actions identified in the Remedial Action Plan necessary to remove habitat, benthos, and fish and wildlife impairments; and • To complement the RAP's management actions, identify, seek funding for, and implement additional habitat and species projects necessary to enhance habitat and populations of fish and wildlife within the AOC geographical boundaries.	EPA, USACE, USFWS, MNDNR, MPCA, WDNR, 1854 TA, Fond du Lac
	e. Torch Lake Area of Concern • Conduct a *Degradation of Benthos* beneficial use impairment pilot study to construct shoreline capping and implement habitat restoration test plots to determine if this will improve the density and diversity of the benthic community.	EPA
16	Protect Buffalo Reef (MI) and nearshore areas in Traverse Bay from further encroachment of stamp sands, and work toward long-term mitigation strategies and/or solutions.	EPA, USACE, USGS, EGLE, MDNR, GLIFWC, KBIC
17	Formally establish the Lake Superior National Marine Conservation Area in Canada and implement actions identified in the 2016 Interim Management Plan.	Parks Canada
18	Identify and restore stream and wetland connectivity and function through hydrological modifications such as dam removal, road decommissioning, construction of fish passage alternatives, stream culvert improvements, and flow modifications on regulated and unregulated tributaries to allow flows to meet early life-history requirements of species like Brook Trout. These modifications include, but are not limited to: • Removal of the Lower Dam, east branch of Ontonagon River (MI); • Stream culvert improvements on Sucker River Road (MI) and Waishka River Road (MI) Coastal HWY 61 (MN); and • Hydrological modifications identified in Lake Superior Committee (i.e., fishery management agencies) Environmental Priorities 2019.	EPA, USFS, USFWS, USNPS, EGLE, MDNR, MNDNR, MPCA, MNRF, WDNR, Bad River, BMIC, Fond du Lac, Grand Portage, KBIC, LDF, Red Cliff
19	Advance the 2015 Lake Superior Biodiversity Conservation Strategy and corresponding Regional Plans, as well as State Wildlife Action Plans and other related agency plans by taking applicable actions including, but not limited to: • Initiate or support local and community projects or citizen	EPA, Parks Canada, USACE, USFS, USFWS, USGS, USNPS, EGLE, MDNR, MNRF, MNDNR, WDNR, 1854 TA, Bad River, BMIC, CORA, Fond du Lac, Grand Portage, LDF, Red Cliff

	science to conserve biodiversity; • In Wisconsin, conduct native freshwater mussel surveys and wood turtle surveys and nest protection efforts; • In the Upper Peninsula of Michigan, and other necessary areas as identified, restore and protect pollinator habitat and species; • Protect piping plover, common tern and marsh breeding birds by identifying, assessing, conserving and restoring their habitat in St. Louis River estuary, Apostle Islands, Chequamegon Bay and other priority locations; • Continue to identify and map important habitat sites in the Lake Superior basin; and • Support protection and restoration of Lake Superior islands, particularly unique habitats and globally rare and endemic species.	
20	Rehabilitate populations of indigenous aquatic species (e.g., Brook Trout, Lake Sturgeon, Muskellunge, Walleye, etc.).	DFO, USFS, USFWS, USNPS, MDNR, MNDNR, MNRF, MPCA, WDNR, Bad River, BMIC, Fond du Lac, GLIFWC, Grand Portage, KBIC, LDF, Red Cliff, St. Croix
21	Protect and enhance through conservation easements, land acquisitions and/or other means additional coastal wetlands and important habitats including but not limited to: • Port Wing State Natural Area (WI); • Brule River State Forest (WI); and • Whittlesey Creek watershed (WI).	USFS, USFWS, Bad River, BMIC, MNDNR, MNRF, WDNR, Fond du Lac, Red Cliff
22	Restore and protect manoomin (wild rice) habitat including, but not limited to, the following areas: • St. Louis River estuary (MN and WI); • Kakagon / Bad River Sloughs in Wisconsin; • Brule River mouth in Wisconsin; and • Michigan locations including Sand River, Lake Harlow, Blind Sucker and Lake LeVasseur.	NOAA, USFS, EGLE, MDNR, MNDNR,WDNR, 1854 TA, Bad River, BMIC, Fond du Lac, GLIFWC, Grand Portage, KBIC, LDF, Red Cliff, St. Croix
23	In the St. Louis River and Bay area, restore connected coastal wetlands and floodplains, marsh breeding bird habitat and enhance spawning habitat for additional Lake Sturgeon and Walleye production.	MNDNR, WDNR, Fond du Lac
24	Support climate change impact initiatives, projects or adaptation planning that increases the resilience of Lake Superior ecosystem's habitats and species.	ECCC, EPA, NOAA, Parks Canada, USACE, USNPS, USFS, USFWS, EGLE, MDNR, MECP, MNDNR, MPCA, MNRF, WDNR, 1854 TA, Bad River, BMIC, CORA, Fond du Lac, GLIFWC, Grand Portage, KBIC, PPFN, Red Cliff, St. Croix, LDF, LRCA, MN Sea Grant
25	Plant trees best suited for a changing climate along cold-water streams, rivers and lake shorelines, with a focus on locally-prioritized sites that will enhance high quality habitat and increase cover type connectivity.	USFS, USFWS, MDNR, MNDNR, WDNR, Bad River, BMIC, Fond du Lac, Grand Portage, KBIC, Red Cliff

26	Plan, undertake and/or support low impact development, green infrastructure projects, and nature-based solutions that are suited to future extreme weather events and better protect species and habitat, including a possible pilot project to use natural alternatives to conventional pesticides.	EPA, Parks Canada, USACE, USFS, MNDNR, WDNR, BMIC, CORA, Grand Portage, Red Cliff, MN Sea Grant,
27	Through science and monitoring, update understanding of lower-food web health. a. Determine if the lower food web remains in a stable and healthy state. Explore expanding monitoring to assess the significance of picoplankton. b. Determine if the lower-trophic abundance and diversity is enough to sustain predator fish (i.e., Lake Trout) populations. Determine if Lake Trout diet preferences are changing. c. Enhance existing models to determine how the aquatic ecosystem responds to potential fishery management actions. d. Pilot efforts to assess the productivity and role of phytoplankton and zooplankton in the winter food web of the nearshore waters.	EPA, USFWS, USGS, MDNR, MNDNR, MNRF, WDNR, Fond du Lac, GLIFWC, Grand Portage, LDF, Red Cliff
28	Through science and monitoring, improve understanding of the impacts of the physical changes (e.g., water levels, water temperature, etc.) and/or changing climate on water quality, habitat and species. a. Determine the vulnerabilities and potential response of coastal wetlands to future climate and water level projections. b. Determine if the hydrology and temperature of cold/cool water streams is changing. c. Use past and existing macroinvertebrate information in tributaries to help explain changes in habitat quality and water quality over time. d. Collect improved bathymetric data in selected coastal areas and wetlands.	ECCC, EPA, Parks Canada, USACE, USFWS, USGS, USNPS, MDNR, MNDNR, MNRF, WDNR, Bad River, Fond du Lac, Grand Portage, PPFN, Red Cliff
29	Through science and monitoring, update and improve information about coastal wetland conditions and trends, including use of the Great Lakes Coastal Wetland Monitoring Program data to inform planning of and/or evaluate the effectiveness of coastal wetland restoration and conservation activities. a. Determine which species of amphibians (e.g., frogs and toads) are present in coastal wetlands, noting species and locations of conservation interest. b. Gather data on coastal wetland invertebrates, fish, birds and plants. c. Support a pilot project to develop coastal wetland targets and goals in order to further prioritize protection and management actions.	EPA, Parks Canada, USGS, MNDNR, WDNR, Bad River, BMIC, Grand Portage, KBIC, Red Cliff
30	Through science and monitoring, determine if progress is being made in the rehabilitation of native fish species of conservation concern. a. Track the rehabilitation of Lake Sturgeon.	DFO, Parks Canada, USFWS, USGS, USNPS, MDNR, MNDNR, MNRF, WDNR, 1854 TA, Fond du Lac, GLIFWC,

	b. Track the rehabilitation of Brook Trout. Determine if there are additional streams coaster brook trout are accessing to spawn. c. Track the rehabilitation of Walleye. d. Expand the understanding of travel ranges, movements, habitat preferences, and behaviors of other native fish species.	Grand Portage, KBIC, LDF, Red Cliff, St. Croix, WI Sea Grant
31	Map and/or identify remaining stamp sand piles located on the coastline. a. Determine the extent and composition of coastal stamp sand piles in, and along the shoreline of Lake Superior. b. Determine the extent of ecological implications of sand piles eroding into Lake Superior.	NOAA, USACE, USGS, GLIFWC, KBIC
32	Determine the current status of shoreline hardening and other forms of alteration. a. Identify areas of hardened shoreline. b. Improve the understanding of the risk to coastal habitats from current shoreline development.	ECCC, NOAA, USACE, USGS, MNDNR, MNRF
33	To the extent possible, quantify groundwater contribution to the water budget of Lake Superior. a. Select specific sub-basins to model an updated water budget.	USGS
34	Contribute to the development of sub-watershed assessments that identify, prioritize, and help guide implementation of on-the-ground habitat restoration and protection projects that build resilience to climate change impacts and maximizes fish production.	USFS, USFWS, USGS, MDNR, MNDNR, WDNR, CORA, Fond du Lac, LRCA
35	Improve communication, information exchange, and resource sharing across coastal and aquatic protected areas in Lake Superior to enhance conservation effectiveness of individual protected areas in support of the Great Lakes Protected Area Network and the North American Marine Protected Area Network.	Parks Canada, USNPS
36	Engage the public and landowners on the importance of Lake Superior ecosystem's habitats and species including the impacts of climate change.	Parks Canada, USFS, USFWS, USNPS, MDNR, MECP, MPCA, MNDNR, MNRF, WDNR, 1854 TA, Bad River, BMIC, Fond du Lac, GLIFWC, Grand Portage, Red Cliff, LRCA, SSMRCA, MN Sea Grant

Actions Everyone Can Take

Here are some ways that you can do your part:

- Maintain natural vegetation along the coast, streams, and wetlands; resist the urge to "tidy up" natural vegetation and woody debris on the beach;
- Plant native trees, shrubs and flowers on your property;
- Get involved with shoreline clean up events;
- Stay on constructed beach and dune paths and avoid trampling the sparse and fragile vegetation in these areas;
- Support and/or volunteer with local conservation authorities, stewardship councils and nongovernmental environmental organizations;
- Access shoreline stewardship guides for advice, including the Michigan Natural Shoreline Partnership; and
- Share your knowledge about the rarity and ecological importance of each of the special shoreline types.

5.4 Invasive Species

This section summarizes the scientific information about Lake Superior's invasive species, current threats, and corresponding actions to be taken by Lake Superior Partnership agencies in the 2020-2024 timeframe, as well as actions that everyone can take. The scientific information is organized in response to the invasive species-related General Objective of the *Great Lakes Water Quality Agreement*.

5.4.1 Objective and Condition Overview

One of nine General Objectives of the Agreement is addressed in this section, i.e., the Great Lakes should:

- Be free from adverse impacts of aquatic and terrestrial invasive species

For the purposes of this chapter, "invasive species" refers to a subset of non-native species that are known to be causing adverse impacts to the ecosystem, recreation or economy. Information on non-native species is also presented because the possible adverse impacts of some non-native species are not known.

Please note that not everyone defines species as "native", "non-native" and "invasive". Some people, including many *Anishnaabe* recognize that living beings move and migrate, and these migrations are not inherently good or bad (Reo and Ogden, 2018). From this perspective, and recognizing that all creation has purpose, the species described in this chapter would be defined either as non-local beings or *Zhaagoojichigaadeng Meyagi-bimaadiziimagak*, translated to "being overtaken by foreign living things". Individuals with this perspective seek to learn about non-local beings, and how they could possibly co-exist to achieve a healthy and sustainable environment.

The status and trends of sub-indicators for the invasive species General Objective in relation to Lake Superior are displayed in Table 10.

Table 10. Status and trends of invasive species sub-indicators in the Lake Superior basin. Source: State of the Great Lakes report - ECCC and EPA, 2021.

Sub-Indicator	Status - Trend
Rate of Invasion of Aquatic Non-Indigenous Species	Good - Undetermined
Impacts of Aquatic Invasive Species	Poor – Deteriorating
Sea Lamprey	Fair – Unchanging
Dreissenid Mussels	Good – Unchanging
Terrestrial Invasive Species	Fair - Deteriorating

As illustrated in Figure 19, fewer new aquatic non-native species are finding their way to Lake Superior compared to decades past. However, there have been recent discoveries of new non-native zooplankton (e.g., *Hemimysis anomola* (Bloody red shrimp), *Diaphanosoma fluviatile* (a cladoceran), *Thermocyclops crassus*, *Heteropsyllus nunni*, *Schizopera borutzkyi*, and *Nitokra hiberica* (all copedpods)).

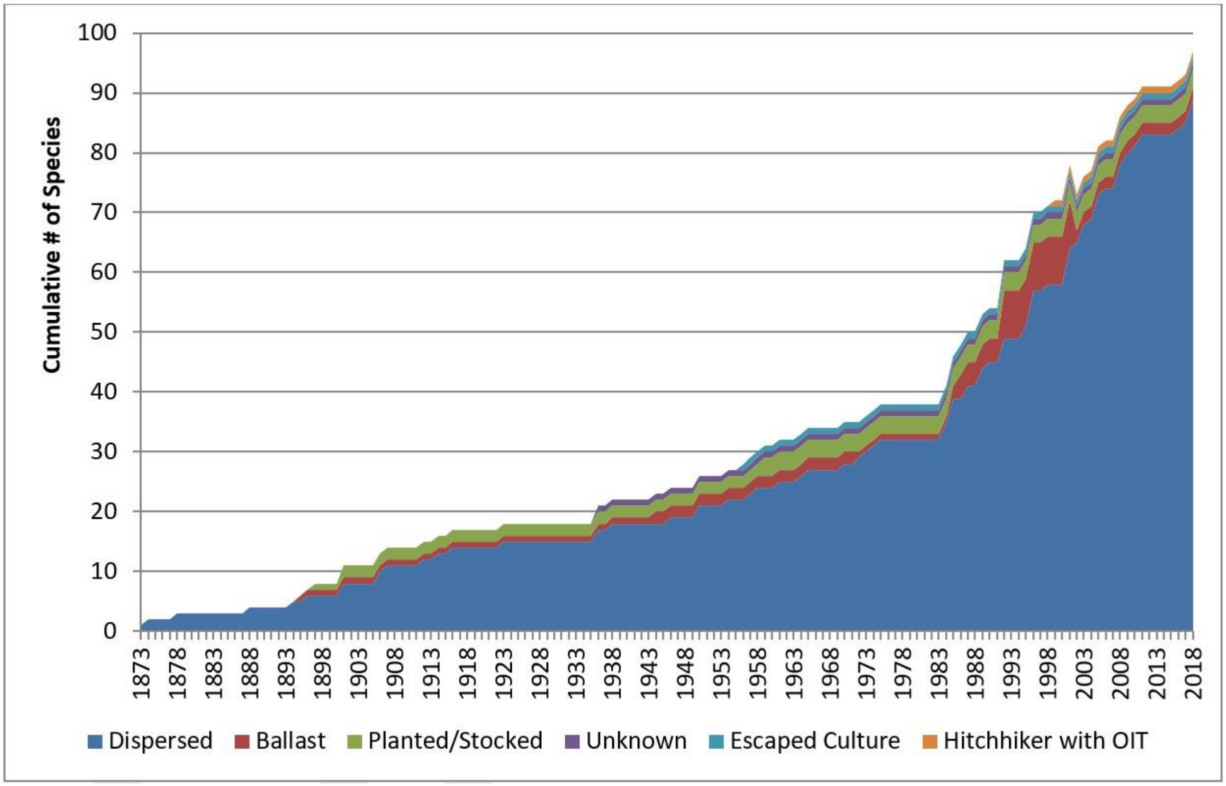

Figure 19. Cumulative establishment in Lake Superior by vector. This includes species nonnative to Lake Superior that may be native to other portions of the Great Lakes basin. 97 species have become established in Lake Superior as of 2018. OIT = Organisms in trade. Source: GLANSIS.

Invasive species have drastically altered Lake Superior's ecosystem at all trophic levels including reducing ecosystem resilience. Aquatic invasive species have entered Lake Superior through various pathways, including commercial shipping, recreational watercraft, bait and aquarium releases, and migration from other waterbodies. They have contributed to a decreased abundance of native fish, zooplankton, benthic invertebrates and plant species and the alteration of energy and nutrient pathways. Terrestrial invasive species are changing watershed processes and ecosystems (EPA, 2020); however, to what extent and what the impacts are to Lake Superior is not fully known.

5.4.2 Invasive Species

GLWQA General Objective: The *Waters of the Great Lakes* should 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.

How are they monitored?

Newly introduced, established, and potentially invasive species are monitored by a variety of organizations including local, state, provincial, and federal agencies, First Nations, Tribes, nongovernmental organizations, industries, and academic institutions. The public is also playing an increasingly important role in invasive species surveillance and community science. Monitoring and assessing the impacts of invasive species is challenging due to the size of Lake Superior and its watershed. With the exception of a few species, comprehensive lakewide assessments of invasive species do not exist.

Aquatic Invasive Species: Most of the monitoring of aquatic invasive species (AIS) occurs as a part of routine surveillance programs by federal, tribal, state and local environmental protection and natural resource management agencies. Only a few AIS have targeted monitoring programs. Sea Lamprey population trends are assessed annually by the Sea Lamprey Control Program on behalf of the Great Lakes Fishery Commission. The lakewide "Early Detection and Rapid Response Initiative" is monitoring locations in Lake Superior that are potential points of invasion by new AIS. This monitoring includes environmental DNA, which is a surveillance tool used to monitor for the genetic signature of an aquatic species in the ecosystem. New AIS reports and existing AIS distributions are tracked in several ways, including the regional GLANSIS database which is a regional node of the National USGS Nonindigenous Aquatic Species database, EDDMaps Midwest formerly the Great Lakes Early Detection Network, and the Midwest Invasive Species Information Network. Data and information are shared between these systems.

Terrestrial Invasive Species: Due to the variety of different governmental jurisdictions and the mix of public and private land ownership there is no single method for assessing the location and spread of terrestrial invasive species in the Lake Superior watershed. Some plants classified as terrestrial in this *LAMP*, such as *Phragmites* and Purple Loosestrife (*Lythrum salicaria*), also occur in wetland areas and are classified as aquatic plants in some databases.

Land managers and the public can voluntarily report sightings and share information on terrestrial invasive species distributions via the Midwest Invasive Species Network (MISIN) and the Early Detection and Distribution Mapping System (EDDMapS) hotline maintained by the Ontario Federation of Anglers and Hunters and the Ontario Ministry of Natural Resources and Forestry. Reporting can also be done online or via a phone app. MISIN and EDDMapS provide spatial data that helps track the spread of terrestrial invasive species, including Emerald Ash Borer (*Agrilus planipennis*), Asian Longhorned Beetle (*Anoplophora glabripennis*), European Buckthorn (*Rhamnus cathartica*), Garlic Mustard (*Alliaria petiolate*), *Phragmites*, invasive knotweeds and Purple Loosestrife.

Additionally, there are a number of species-specific efforts underway, including the United States Department of Agriculture Forest Service and Michigan State University's Emerald Ash Borer Information Network website, which includes monthly updates on the confirmed locations for this species in the U.S. and Canada. In Wisconsin, sightings can be checked to determine if a suspected invasive species has been previously reported through their Report Invasive Species (Wisconsin) webpage.

What is the condition?

As of 2020, Lake Superior has 97 established non-native aquatic species, of which 38 are considered invasive and the others having little impact and not considered invasive (GLANSIS database). No established non-native species has been eradicated to date. Across the entire Great Lakes system there are a total of 188 established non-native species (GLANSIS database). In Lake Superior, eleven new non-native species were found between 2009 and 2018. These species are all secondary invasions from populations established first in the lower lakes that have spread to Lake Superior. This gives a rate of 1.1 aquatic non-native species per year establishing themselves in Lake Superior, an invasion rate that has not changed significantly in the past decade. Some of the most invasive species are profiled below.

Sea Lamprey is a parasitic jawless fish that if left unmanaged will devastate the population of many fish species in the Great Lakes including Lake Trout. Sea Lamprey contributed to a collapse in Lake Superior Lake Trout populations in the mid-twentieth century. The status of Sea Lamprey in Lake Superior is "fair" and "unchanging" (ECCC and EPA, 2021). As illustrated in Figure 20, the index of abundance of adult Sea Lamprey is above target and unchanging (GLFC, 2020).

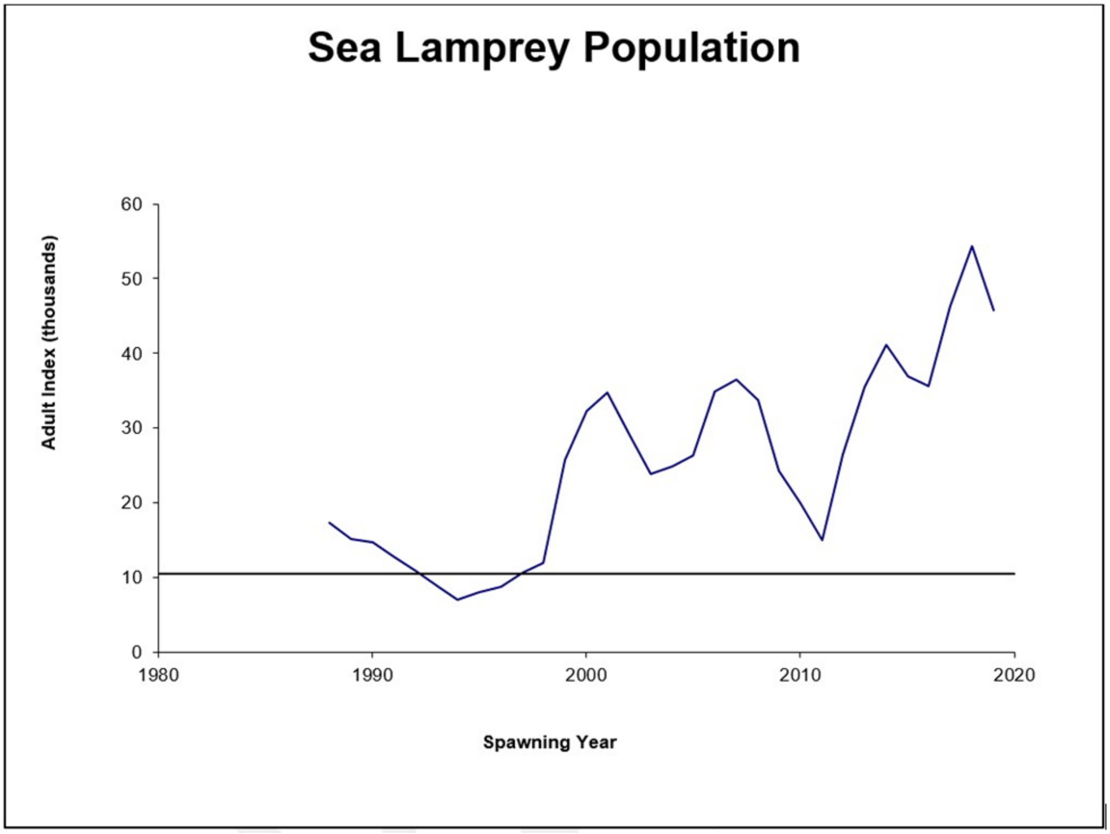

Figure 20. Index estimates of Lake Superior's adult Sea Lamprey abundance (3-year average) plotted on spawning year. Horizontal line represents target for Lake Superior. Source: Great Lakes Fishery Commission.

The target is to suppress Sea Lampreys to population levels that cause insignificant mortality on adult lake trout (i.e., 12,000 or fewer Sea Lampreys; Horns et al., 2003). Bayluscide® and 3-trifluoromethyl-4-nitrophenol (TFM) are two lampricides used to control Sea Lamprey across the Great Lakes. Granular Bayluscide® treatment is used in slower moving water, and TFM treatment requires flowing water. Local sources of concern of Sea Lamprey recruitment include river mouths of the Nipigon and Kaministiquia rivers; Mountain and Batchawana bays; and the Bad, Kaministiquia, Michipicoten, Goulais, and Sturgeon rivers.

Dreissenid mussels (e.g., Zebra and Quagga Mussels) decrease habitat quality and habitat availability for native species (Nalepa and Scholesser et al., 2013). In the lower Great Lakes, dreissenid mussels are contributing to the growth of harmful algal blooms due to selective feeding and excretion activities (Vanderploeg et al., 2017; Pillsbury et al., 2002). Low calcium and other water quality characteristics in Lake Superior pose a challenge to spawning and survival success leading to much lower densities compared to the lower Great Lakes (Trebitz et al. 2019). The status of dreissenid mussels in Lake Superior is "good" and "unchanging" (ECCC and EPA, 2021); however some natural resource management agencies are reporting the presence and spread of dreissenid mussels in a number of Lake Superior embayments (Lafrancois, T. et al. 2019). Zebra Mussels were first found in Duluth-Superior Harbor in 1989, and Quagga Mussels were subsequently found in the same area in 2005 (Grigorovich et al., 2008). Since then, the spread and population growth of both dreissenid species has occurred in a few productive areas where calcium conditions in tributary-influenced waters are sufficient to support dreissenid survival (Lafrancois B. M. et al., 2018). Discoveries include Thunder Bay, Ontario in 1990 (D. Jensen, Minnesota Sea Grant, personal communication), Chequamegon Bay, Wisconsin in 1998 (Cohen and Weinstien, 2001), Whitefish Bay, Michigan in 2002, northwestern bay of Isle Royale in 2009, Nipigon Bay, Ontario in 2012 (K. Rogers, MNRF, personal communication), and the Apostle Islands, Wisconsin in 2015 (Trebitz et al., 2019).

Phragmites (*Pharmites australis* subsp. *australis*), also known as European Common Reed, is a perennial wetland grass that outcompetes native plants and displaces wildlife. A native strain of *Phragmites* is found the Lake Superior basin, however, the non-native invasive strain is unique in its rapid and dense growth, often developing a monoculture that can greatly affect hydrology, recreational and aesthetic value, and poses risks to infrastructure. Its presence in the Lake Superior basin is very low. Infestations of the invasive *Phragmites* are limited mostly to the St. Louis River estuary. Additional infestations are found from Red Cliff to Ashland (Chequamegon Bay, Wisconsin), the Keweenaw Penninsula, Michigan, and spots along the Canadian shore from Thunder Bay to Marathon, and north of Sault Ste. Marie.

Eurasian Ruffe is a small member of the perch family that can outcompete native fish species for food and habitat. Eurasian Ruffe populations have been documented in western Lake Superior, including Duluth Harbor (1986), the Keweenaw Peninsula, as well as in Thunder Bay and the Kaministiqua River, Ontario since 1996. The spread along the south shore of Lake Superior has been relatively slow. The population size in eastern Lake Superior is currently unknown. In 2017, adult ruffe were captured for the first time in Goulais Bay and in Batchawana Bay in 2019.

Emerald ash borer (*Agrilus planipennis*) larvae feeds on all species of ash in the Great Lakes region. High tree mortality rates are typical once an infestation occurs; after 6 years of initial infestation, roughly 99% of ash trees are killed in a given woodlot (Knight et al., 2013). Emerald ash borer induced mortality can alter forest compositions in natural areas potentially leading to increased erosion, runoff, and water temperature in previously shaded streams. In urban centers, the loss of ash trees can increase the amount of stormwater runoff and exacerbate the urban heat island effect (Wisconsin DNR, n.d.). Emerald ash borer was first discovered in North America in the Detroit-Windsor area in 2002, and quickly spread throughout the Great

Lakes region. In the Lake Superior watershed, emerald ash borer has been detected in a number of locations in Michigan and Wisconsin, as well as in the city of Thunder Bay in Ontario, and southeastern St. Louis County in Minnesota (USDA, 2020).

What is the Threat? and other considerations for taking action

Invasive species have been introduced to Lake Superior through a variety of means. Historically, shipping has been a significant pathway for invasive species currently present in the Great Lakes, primarily via the discharge of ballast water (Millerd, F., 2010). Compared to the other Great Lakes, Lake Superior receives a larger proportion of ballast water discharges (O'Malia et al., 2018). River systems, canals, waterways and lakes connected to Lake Superior are also potential pathways for invasive species to spread through modes such as swimming, currents and wind seed dispersal. At the consumer level, at least 12 species were introduced into the Great Lakes through the aquarium and horticultural industry (Funnell et al., 2009). Other potential sources of introductory pathways for invasive species include recreational boating, and live fishing bait (Johnson et al., 2001), as well as construction and vehicle transportation. Once established, there is a danger the species will spread. Vulnerable areas include the port of Duluth-Superior located in the St. Louis River estuary, and the port of Thunder Bay, Ontario (Grigorovich et al., 2003).

Lake Superior's cold northern climate protects it against many invasive species compared to other Great Lakes. Changes to the climate may pose a threat to this protection and increase the lake's susceptibility to invasive species spreading from the southern areas of the Great Lakes basin (ECCC and EPA, 2021). Changes to the water temperatures and growing seasons in the Great Lakes basin are expected to pose a threat to local species and open more pathways for a variety of non-native aquatic or terrestrial plants and animals to propagate (Millerd, F., 2010). As surface temperatures increase, warm-water species gain an advantage and begin to compete with coldwater species. Increases in extreme weather events provide new routes for the introduction of invasive species, and have impacts on shoreline erosion, vegetation and habitats.

Grass Carp have not been found in Lake Superior and considered to be a low risk for arriving and establishing in Lake Superior based on thermal tolerance (i.e., cold water), food availability, predation and other factors (Cudmore et al., 2017; Currie et al., 2017; Mandrak et al., 2012).

Bighead and Silver Carp have not been found in Lake Superior. The likelihood for the establishment of Bighead and Silver Carp in the lake is moderate, and these carp are not predicted to enter within the next 20 years (Cudmore et al., 2012). At the same time, if introduced the probability of survival is high. Sixty-four percent of the Lake Superior streams examined (i.e., nine of 14 streams with sufficient data for analysis) had suitable spawning conditions. If established, Bighead and Silver Carp would aggressively compete for food resources (Irons et al., 2007) reducing food availability for native planktivorous fish (e.g., Cisco) which would subsequently lead to a decrease in Lake Trout abundance and other impacts.

5.4.3 Actions to Address Invasive Species

This section describes actions that will be taken to further prevent and control invasive species in Lake Superior.

The Lake Superior Partnership agencies will implement the 2020-2024 *LAMP* within the context of existing laws and regulations which actively contribute to the restoration and protection of Lake Superior. Seven pieces of federal, state and provincial legislation that address invasive species are listed in Appendix B. This legislation includes the U.S. National Invasive Species Act (1996) and the Canada Shipping Act (2001). Other contributing national and regional plans and initiatives are described below.

The Agreements' Invasive Species Annex is co-led by Fisheries and Oceans Canada and the United States Fish and Wildlife Service. Efforts under this annex are to identify and take actions to minimize the risk of Asian Carp and other species invading the Great Lakes using a risk assessment approach. Through efforts of federal, state, and provincial agencies, Canada and the United States have developed and implemented an Early Detection and Rapid Response Initiative with the goal of finding new invaders and preventing them from establishing self-sustaining populations.

The Great Lakes Fishery Commission in collaboration with all levels of government have been implementing a program to control Sea Lamprey since the late 1950s.

The Governors and Premiers' Aquatic Invasive Species Task Force works to stop the introduction and spread of aquatic invasive species. This includes the implementation of a Mutual Aid Agreement that empowers the States and Provinces to work together by sharing staff, expertise, and resources. The Governors and Premiers have a list of 21 "least wanted" aquatic invasive species that present serious threats to the Great Lakes - St. Lawrence Basin.

The Invasive Carp Regional Coordinating Committee is a multi-agency workgroup which provides oversight of interagency Invasive Carp Action Plan and Monitoring and Response Plan.

Other initiatives active in basin include:

- Ontario's Invasive Species Strategic Plan;
- States of Michigan, Wisconsin and Minnesota all have Aquatic Invasive Species Plans;
- Phragmites Adaptive Management Framework;
- Lake Superior Aquatic Invasive Species Complete Prevention Plan;
- U.S. Great Lakes Restoration Initiative, administered by EPA; and
- St. Louis, Lake and Cook County AIS Plans.

LAMP Actions

Actions will be taken in the Lake Superior basin to further prevent invasive species as listed in Table 11.
Table 11. LAMP actions to prevent and control invasive species.

#	ACTIONS TO PREVENT AND CONTROL INVASIVE SPECIES	AGENCIES
37	Maintain and improve effectiveness of the program to control Sea Lamprey.	DFO, USACE, USFWS, Bad River, CORA, KBIC
38	Contribute to the elimination of European Common Reed (i.e., *Phragmites australis*, subsp. *australis*) from the Lake Superior basin by basinwide distribution mapping, early detection efforts, control efforts and outreach to private landowners.	Parks Canada, USFS, MDNR, MNDNR, MNRF,WDNR, 1854 TA, Bad River, BMIC, EGLE, Fond du Lac, GLIFWC, Red Cliff, SSMRCA

39	Prevention, management, and mitigation/restoration for terrestrial invasive species including early detection of invasive plants, invasive plants with strong connections to water quality, invasive earthworms and invasive insects such as the emerald ash borer, spongy moth or *Lymantria dispar dispar*, and mountain pine beetle.	Parks Canada, USDA-NRCS, USFS, USNPS, MDNR, MNDNR, MNRF, WDNR, 1854 TA, Bad River, BMIC, EGLE, Fond du Lac, Grand Portage, Red Cliff, LRCA, SSMRCA
40	Contribute to the protection of wetlands from the negative impacts of the advancing emerald ash borer populations, by planting a variety of wet tolerant trees in vulnerable or selected locations.	USFS, MDNR, WDNR, Bad River, BMIC, Fond du Lac, Red Cliff
41	Implement aquatic species plans approved by the Aquatic Nuisance Species Task Force, priorities of the Great Lakes Panel on Aquatic Nuisance Species, as well as other established federal, tribal, state, provincial and local plans or strategies.	USFWS, EGLE, MDNR, MNDNR, MNRF, WDNR, 1854 TA, Bad River, BMIC, CORA, Fond du Lac, GLIFWC, Grand Portage, KBIC, LDF, Red Cliff, MN Sea Grant
42	Conduct early detection monitoring and science of invasive species. a. Utilize the Great Lakes Aquatic Nonindigenous Species Information System to document establishment of any new non-native aquatic species. b. Monitor to determine if any new aquatic non-native species have been introduced or have become established. c. Advance understanding of the spread (or increasing population) of established invasive species, including zebra/quagga mussels, Sea Lamprey, non-native *Phragmites* and earthworms, and what impacts are they having on native species and the ecosystem.	EPA, DFO, Parks Canada, USFWS, USNPS, USFS, USGS, EGLE, MDNR, MNDNR, MNRF, WDNR, 1854 TA, Bad River, BMIC, CORA, Fond du Lac, GLIFWC, Grand Portage, KBIC, PPFN, Red Cliff
43	Undertake additional aquatic invasive species prevention outreach and education.	Parks Canada, USACE, USFS, USFWS, USNPS, EGLE, MDNR, MNRF, MNDNR, WDNR, 1854 TA, Bad River, BMIC, CORA, Fond du Lac, GLIFWC, Grand Portage, KBIC, PPFN, Red Cliff, MN Sea Grant, WI Sea Grant

Actions Everyone Can Take

Here are some ways you can do your part:

- Learn how to identify, report and stop the spread of non-native *Phragmites* and other invasive species of concern;
- Use native plants for your yard or garden;
- Clean your boots before and after you hike in a new area to prevent the spread of weeds, seeds and pathogens;
- Clean-Drain-Dry your boat before using it on a different body of water;
- Do not move firewood that can harbor forest pests;
- Do not release aquarium fish and plants, live bait or other animals into the environment;
- Volunteer at a local park to help remove invasive species;
- Monitor your local lake, river or park for invasive species;
- Help educate others about the threat; and
- If you think you have discovered an invasive species, contact:
    - Ontario Invasive Species -1-800-563-7711 or http://www.eddmaps.org/ontario/.

- Michigan Invasive Species - https://www.michigan.gov/invasives/
- Wisconsin Invasive Species -https://dnr.wi.gov/topic/Invasives/report.html.
- Minnesota, Wisconsin and Michigan – https://www.eddmaps.org/midwest.

5.5 Other Threats: Plastics, Risks from Oil Transport and Mining, and Cumulative Impacts to Nearshore Areas

This section summarizes the scientific information about other threats specific to Lake Superior and corresponding actions to be taken by Lake Superior Partnership agencies in the 2020-2024 timeframe, as well as actions that everyone can take. This section responds to the other substances, materials or conditions-related General Objective of the *Great Lakes Water Quality Agreement*.

5.5.1 Objective and Condition Overview

One of nine General Objectives of the Agreement is addressed in this chapter, i.e., the Great Lakes should:

- Be free from other substances, materials or conditions that may negatively affect the Great Lakes.

In response to this objective, the following issues have been identified by multiple Lake Superior Partnership agencies: plastics, risks associated with oil transport and mining, and cumulative impacts to the nearshore areas.

5.5.2 Other Threats

GLWQA General Objective: The Waters of the Great Lakes should 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.

Microplastics are small particles of plastic including fibers from clothing and rope, particles from the breakdown of bags, packaging and containers, and plastic beads from personal care products. Macroplastics are particles typically more than 5 mm (0.2 inches) in size. Research has shown that plastics enter Great Lakes from a variety of pathways, including wastewater treatment plants, landfill leakage, litter, agricultural runoff, stormwater drains, and industry effluent or spills (Alimi et al., 2018; Raju et al., 2018; Ziajahromi et al., 2016). As illustrated in Figure 21, concentrations of microplastics in Lake Superior are comparable to Lake Michigan, higher than Lake Huron, and lower than Lake Erie (Hendrickson, 2017). In turn, these plastics can make their way into tap water, and other consumer products (Kosuth et al., 2018). The risks associated with plastics (micro and macro) and potential chemicals that adhere to these plastics (ex., BPA, flame retardants, metals) within freshwater communities remains largely unknown (Earn, 2019).

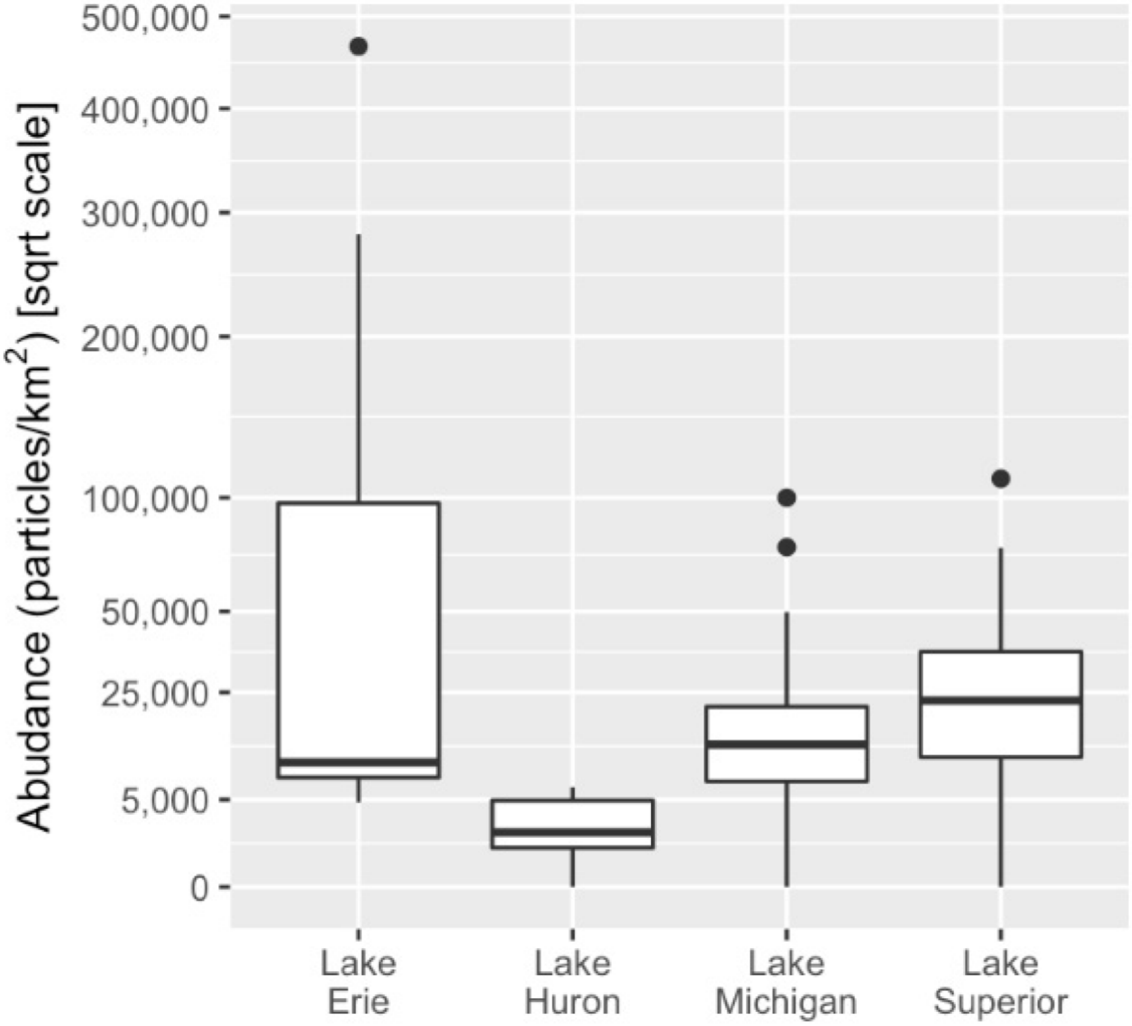

Figure 21. Reported concentrations of microplastic within the surface water of the Great Lakes. Source: Eriksen et al. (2013) and Hendrickson et al. (2018).

Many people living on Lake Superior's north coast in Ontario are familiar with a train derailment in 2008 near Rossport, Ontario that resulted in pre-production plastic pellets (i.e., nurdles) being spilled into the environment and entering Lake Superior. Despite ongoing beach clean-ups, nurdles continue to be found on many beaches today. A study of 66 beaches across the all Great Lakes found the Lake Superior beach near Rossport, Ontario has the third highest amount of plastic pellets (Corcoran et al., 2020). In response to concern that fish may be swallowing plastic pellets, a study was conducted to assess plastic contents in stomachs of fish from the Nipigon Bay area, concluding that there is no evidence that a variety of fish contain nurdles (Munno et al., 2021). On the south shore in the U.S., many people were alarmed when a 2015 study of microplastics in beach sands of coastal national parks across the U.S. indicated high levels of plastic fibers at the Apostle Islands site (Whitmire et al., 2017). However, a 2018 follow-up study showed that many of these fibers were likely misidentified and that microplastics in beach sands and water were modest (Minor et al, 2020).

Most oil transported on or near water in the Great Lakes basin is moved by pipeline, followed by rail (Marty and Nicoll, 2017). No crude oil is transported on the Great Lakes by marine shipping, but the industry does utilize refined petroleum products. Figure 22 presents a map of crude oil pipelines, major rail lines, terminals and refineries. As experienced in locations where oil spills have occurred (e.g., Exxon Valdez, Deepwater Horizon and Kalamazoo River spills) there is potential for far-reaching (e.g., food web) impacts including the need for new fishing restrictions (Murray et al., 2018 and NOAA, 2019). Research has shown that when spilled on land, oil can enter the groundwater system, biological activity is adversely impacted, and the oil can remain in the aquifer for decades (Bekins et al., 2016). The impact of a spill would be greatest to the local and Indigenous peoples in the Lake Superior basin who rely on subsistence or commercial harvesting practices to sustain their communities and their culture. Figure 23 presents a map of pipelines and hazard risk zones in the Lake Superior basin.

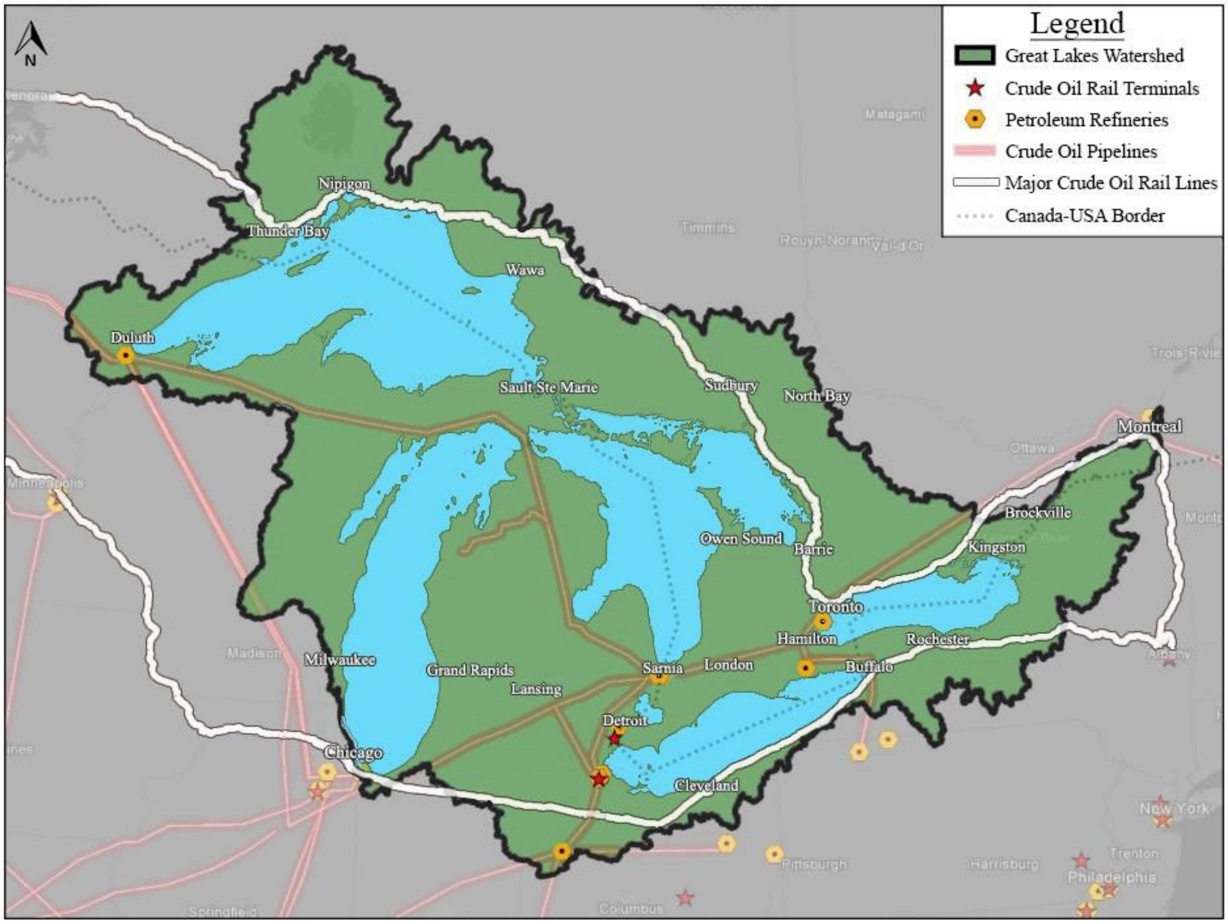

Figure 22. Crude oil pipelines, major rail lines, terminals and refineries. Source: LimnoTech under contract to the International Joint Commission. 2018. Impacts of Unrefined Liquid Hydrocarbons on Water Quality and Aquatic Ecosystems of the Great Lakes Basin.

New pipeline construction and existing pipeline repairs within the Fond du Lac Reservation have prompted that Band to develop and implement a comprehensive surface and groundwater monitoring program within the pipeline corridor, as well as to undertake extensive natural/cultural resource survey work on and beyond reservation boundaries. Due to risks of a major crude oil pipeline that runs through the Reservation of the Bad River Band of Lake Superior Chippewa (Bad River Band), they did not renew the property easement which expired in 2013, and have called for the pipeline to cease operation on the Reservation and for it to be safely removed.

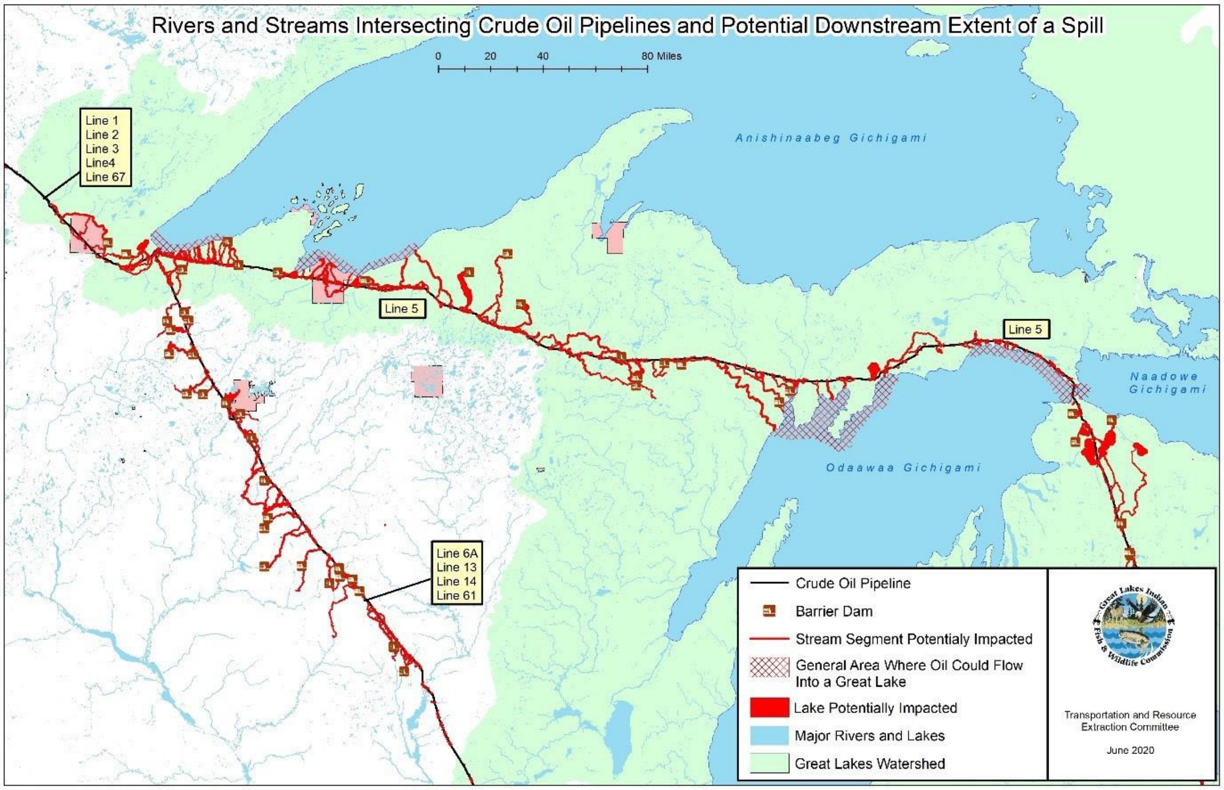

Figure 23. Rivers and streams intersecting crude oil pipelines and potential downstream extent of a spill. Source: GLIFWC.

Mining impacts cannot be easily reversed. Some impacts, if not mitigated, may cause impairment of water quality, release of mercury emissions, and degradation of habitat. For example, mining and minerals production is currently the largest source of mercury emissions from within the Lake Superior basin (LSBP, 2012), and increased sediments in the nearshore, embayments, and river mouths can cover or degrade fish spawning habitats, wild rice and other natural resources. If not mitigated properly, after a mine closes, it can be a source of contamination from chemicals and waste rock piles for decades, even centuries. Mine tailing ponds which contain stored wastes must be maintained and monitored for generations to avoid environmental impacts. Many publicly funded restoration projects to address past mining impacts have been accomplished (e.g., Deer Lake Great Lakes Area of Concern), others are underway (e.g., managing mining waste sand eroding onto Buffalo Reef, Michigan), and other sites require further investigation. The cumulative impact of mines on the ecological integrity of Lake Superior is not well understood. Figure 24 shows current mines and mineral exploration in the Lake Superior basin.

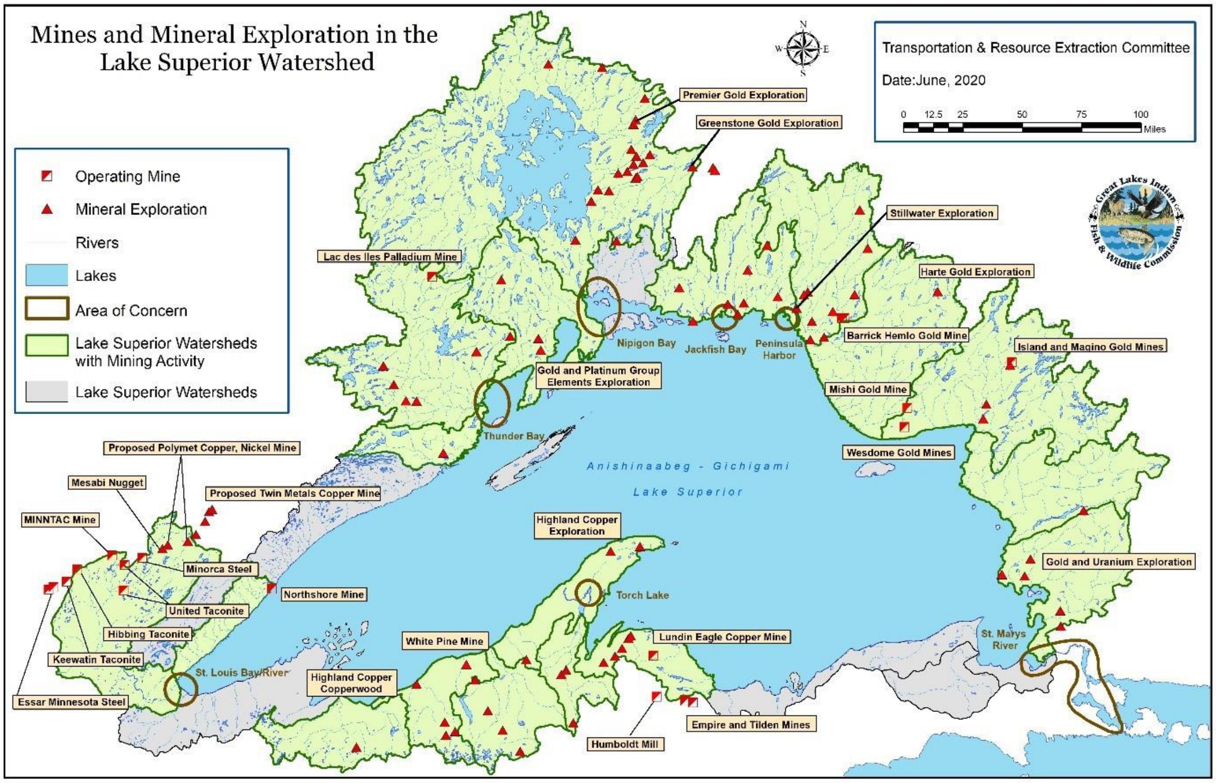

Figure 24. Mines and mineral exploration in the Lake Superior watershed. Source: GLIFWC.

5.5.3 Nearshore Framework

The Great Lakes nearshore areas are a key priority for restoration and protection because they are the source of drinking water for most communities within the basin, are the areas of the lakes where most human recreation (e.g., swimming, boating, fishing, wildlife viewing) occurs, and are the critical ecological link between watersheds and the open waters of the Great Lakes.

The Nearshore Framework is a systematic, integrated and collective approach for assessing nearshore health and identifying and communicating cumulative impacts and stresses. It was developed by Canada and the United States in 2015 under the Lakewide Management Annex of the Agreement to inform and promote action to restore and protect the ecological health of Great Lakes nearshore areas.

5.5.3.1 Canadian Nearshore Waters

Lake Superior's nearshore areas are a key priority for restoration and protection because they are a source of drinking water, are the areas where most human recreation (e.g., swimming, boating, fishing, wildlife viewing) occurs and, are the critical ecological link between watersheds and the open waters of the lake.

The Nearshore Framework is a systematic, integrated and collective approach for assessing nearshore health and identifying and communicating cumulative impacts and stresses. It was developed by Canada and the United States under the Lakewide Management Annex of the *Great Lakes Water Quality Agreement* to inform and promote action to restore and protect the ecological health of Great Lakes nearshore areas (ECCC and EPA, 2016).

HOW IS THE NEARSHORE ASSESSED?

Environment and Climate Change Canada's approach to report on differences in the state of health of nine nearshore regional units in Lake Superior, allows for the identification of both areas of high stress and areas of low stress. The Overall Assessment of Nearshore waters builds on existing monitoring data compiled by key government and non-government partner agencies and organizations, and data collected remotely through satellite imagery. Nine lines of evidence (measures) have been assessed within the following categories: Coastal Processes (shoreline hardening, tributary connectivity to the lake); Contaminants in Water and Sediment (Water quality, Sediment Quality, Benthic Community); Nuisance and Harmful Algae (Cyanobacteria); and Human Use (Treated Drinking Water, Fish Consumption Advisories, Beach Postings). The process uses a geospatial framework that allows for a scaled approach to map and communicate the assessment results. The geospatial approach provides modularity, where measures can be viewed in isolation to understand which are of low, moderate and high stress along the shores of the Lake. This allows for discrete prioritization of areas depending on the interests of the assessment user. This also allows for the discrimination of threats affecting one particular area over another, and for change detection over time. The approach has three phases:

1. Phase 1 involves delineation of the nearshore into units based on depth contours, alongshore boundaries, river mouth boundaries, consideration of gradients in wave energy density, substrate and the onshore boundary based on high water conditions. The units are then classified by ecosystem type (e.g., low, moderate and high energy nearshore, sheltered embayment, wetland, large rivermouth and connecting channel).
2. Phase 2 is the assessment of condition, using four categories of evidence: coastal processes, contaminants in water and sediment, nuisance and harmful algae and, human use. The results of these measures are compared to established thresholds or gradients of quality amongst the regional units.
3. Phase 3 is to integrate additional information and overlay with Areas of High Ecological Value to assist in establishing priorities for nearshore restoration and protection based on consideration of nearshore and whole-lake factors

NEARSHORE STATUS AND SUPPORTING DATA

The key findings from the nearshore condition assessment for the Canadian shore of Lake Superior are presented in Figure 25 and summarized below. Further details are available in the 2020 Lake Superior Canadian Nearshore Assessment report (ECCC, in preparation).

The Canadian portion of the Lake Superior nearshore was subdivided into nine regional units for the assessment. Overall, Lake Superior's nearshore areas are of low or moderate stress, and there are no areas assessed as high stress, although there are still some localized Areas of Concern within several regional units. As illustrated in Figure 25 the regional units assessed as moderate stress include: Pigeon River to Sleeping Giant (including the Thunder Bay Area of Concern), Black Bay and Chimney Point to Cap Chaillon.

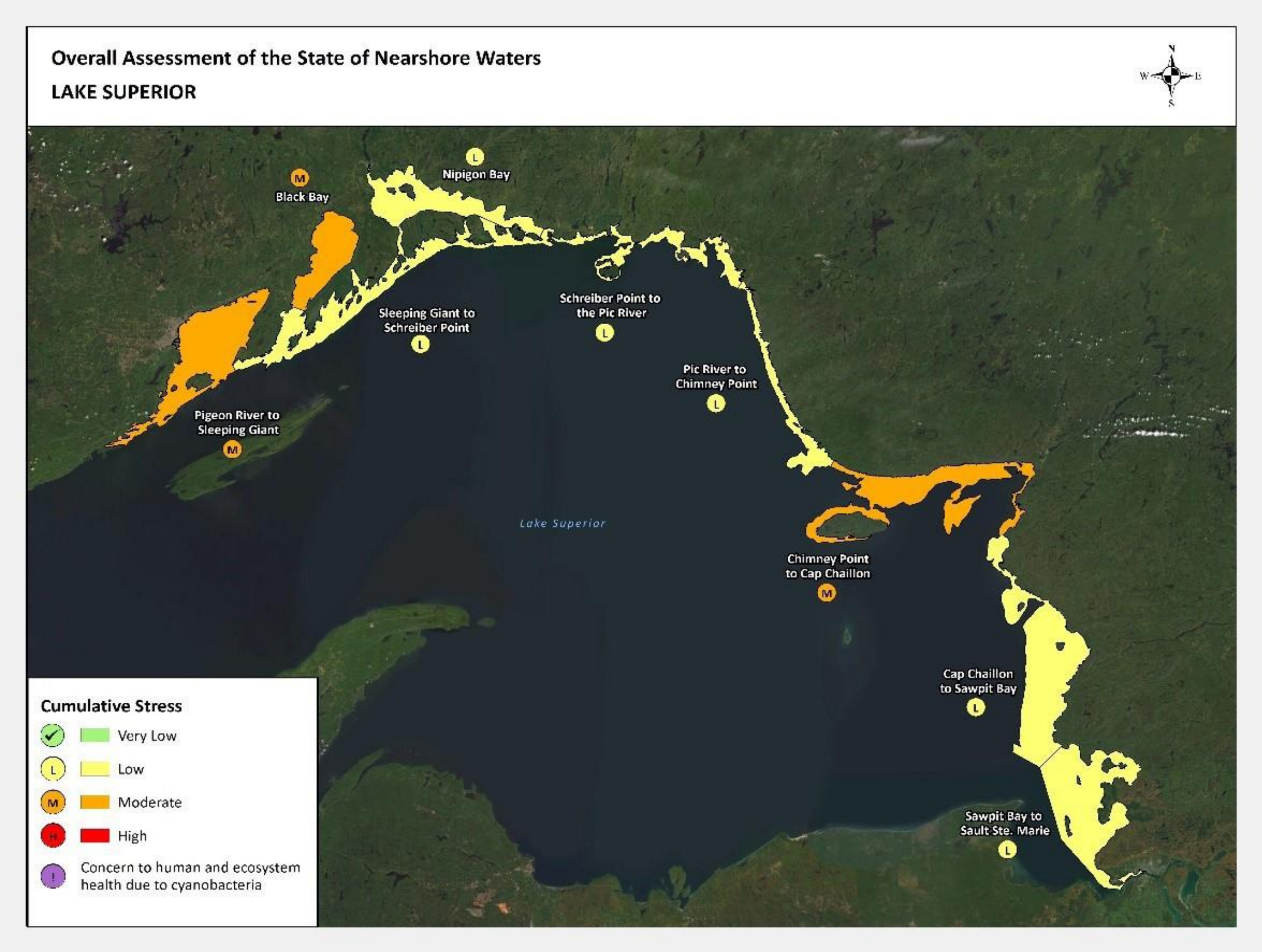

Figure 25. Results of the 2020 Lake Superior Canadian Nearshore Assessment. The Canadian assessment uses four categories of evidence; each Regional Unit is assigned a category condition score (good, fair or poor) which are rolled up into an Overall Condition score. Source: ECCC.

Issues in these areas include: advisories against consumption of some fish species; gradients at the low end of benthic invertebrate community health for Lake Superior, presence of dams which impede tributary connectivity and beach postings based on *e.coli*. contamination. Fish consumers are advised to follow the Provincial Guide to Eating Ontario Fish; however, for this assessment a range of species and advisories for the sensitive population (children under 15 and women of child-bearing age) were used. It should be noted that consumption of fish by indigenous communities and therefore, exposure, does not compare to the general public or sensitive populations and may be much higher. Fish consumption is under moderate stress for the whole lake with average consumption advisories ranging from two to seven meals per month. No nuisance or harmful algae are evident along the Canadian nearshore waters based on satellite cyanobacteria index (Wynne et al. 2010) coverage. At the time of the assessment there was no available data on *Cladophora* in Lake Superior. There is a significant lack of spatial and temporal data in Lake Superior's nearshore particularly for water quality, sediment and benthos since long-term monitoring surveys were last completed by the MECP in 2011. Many Canadian federal monitoring programs are designed to either measure open lake conditions or focus on specific Areas of Concern.

Measures of shoreline hardening and treated drinking water are all within thresholds for low stress. See below for summaries of each regional unit assessed and the scores for each evidence category according the following legend:

Very Low Stress, **all** categories met or exceeded the highest threshold of health for all assessment categories	✓
Low Stress, within threshold of good health	L
Moderate Stress, within threshold range of moderate health	M
High Stress, within the threshold range of low health	H
Concerns to Human and Ecosystem health due to Cyanobacteria blooms or Drinking Water Treatment Plant Closures	!
Insufficient Data	?

Regional Unit Summaries

M Moderate

Pigeon River to Sleeping Giant

Sheltered Embayment

L Coastal Processes

M Contaminants in Water & Sediment

M Human Use

L Nuisance and Harmful Algae

This area is primarily a sheltered embayment (Thunder Bay) and includes a large stretch of rugged rock and cliffs along the coast to the west. The Thunder Bay Area of Concern located within this regional unit has some outstanding impairments that are the subject of Remedial Action Plan activities including the sediment management project at Thunder Bay's North Harbour which is contaminated with organic wood fibre waste, oil and grease and Mercury.

Coastal Processes: 91% of the length of tributaries are connected to the lake.

Contaminants in Water and Sediment: PCBs were found in sediment above the Provincial "No Effect Level" at the Welcome Island monitoring station in 2011 (MECP) which indicates a pathway for this contaminant to enter into the food chain. Metals (Cadmium, Chromium, Copper, Iron, Manganese, Mercury, Nickel, and Zinc) were also found above the Lowest Effect Level but not at levels of concern at provincial long-term monitoring stations. Localized but large scale Mercury contamination at Thunder Bay's North Harbour is subject to an Area of Concern Sediment Management Plan and is not included in this overall assessment of the regional unit. There were no water quality results above the provincial water quality objectives in MECP long-term monitoring stations. The benthic community was fair relatively to the other regional units.

Human Use: Fish consumption advisories, averaged out across this area, recommend two meals a month based on contaminant levels in Yellow Perch (Mercury), Lake Whitefish (Dioxin-like PCBs, PCBs) and Lake Trout (Toxaphene, Dioxin-like PCBs, PCBs). The four beaches were posted an average of 5.7% of the July and August swimming season in 2015-2019 including Chippewa Main (17%) Chippewa Sandy (3%) Wild Goose (2%) and O'Connor Point (3%).

M Moderate

Black Bay
Sheltered Embayment

M Coastal Processes
? Human Use
M Contaminants in Water & Sediment
L Nuisance and Harmful Algae

The coast of this sheltered embayment is mostly natural and much of the inland area is forest. Parks and protected areas are abundant in the watershed and along the coast.

Coastal Processes: This regional unit has the only poor score in Lake Superior for tributary connectivity with only 18% of their length connected to the lake.

Contaminants in Water and Sediment: Metals (Chromium, Copper, Iron, Manganese, and Nickel) were found in sediment in 2011 at concentrations above Provincial guideline (Lowest Effect Level) but not at levels of concern. The benthic community is poor compared to other regional units in Lake Superior.

Human Use: Fish consumption advisories, averaged out across this area, recommend seven meals a month based on contaminant levels in Yellow Perch (Mercury), Lake Whitefish (Dioxin-like PCBs, Dioxin/Furans) and Lake Trout (Mercury, Dioxin-like PCBs). There are no monitored beaches in this regional unit.

L Low

Nipigon Bay
Sheltered Embayment

L Coastal Processes
L Human Use
M Contaminants in Water & Sediment
L Nuisance and Harmful Algae

This sheltered embayment is fed by the Nipigon River, which is the largest tributary on the Canadian side of Lake Superior. It is home to the largest remaining wild population of Brook Trout and is a source of their rehabilitation efforts in other areas. The Nipigon River and Nipigon Bay contain important coastal wetland, waterfowl nesting, and staging areas. The Town of Nipigon and the Red Rock Indian Band are two of many small communities throughout the region. Most of the 212 islands are undeveloped intact wilderness and the coast is primarily natural. All actions are completed in the Nipigon Area of Concern and the area is moving towards delisting.

Coastal Processes: 88% of the length of tributaries in the regional unit are connected to the lake.

Contaminants in Water and Sediment: The moderate stress rating of contaminants is due to the poor quality of benthic community compared to other regional units in Lake Superior. Metals are present (Arsenic, Chromium, Copper, Iron, Manganese and Nickel) but not at levels of concern.

Human Use: Fish consumption advisories, averaged out across this area, recommend five meals a month based on contaminants levels in Yellow Perch (Mercury), Lake Whitefish (PCBs, Dioxin/Furans) and Lake

Trout (Dioxin-like PCBs, PCBs). The low stress reflects good quality drinking water and beaches (Rossport Beach was always open for swimming during July and August in 2015-2019).

(L) Low

Sleeping Giant to Schreiber Point
Moderate to High Energy

(L) Coastal Processes
(M) Contaminants in Water & Sediment
(?) Human Use
(L) Nuisance and Harmful Algae

This regional unit is wholly within the Lake Superior National Marine Conservation Area will soon be recognized as one of the largest protected areas of fresh water in the world. Within the NMCA is the geographic feature that creates Superior Shoals, which is an undersea "mountain" where depths of less than 10 meters can suddenly drop to hundreds of meters. The cliffs at Sleeping Giant Provincial Park are some of the highest in Ontario.

Coastal Processes: 95% of the length of tributaries are connected to the lake.

Contaminants in Water and Sediment: There are no recent nearshore monitoring data available for sediment quality in this regional unit. Water quality results are in the low stress range and the benthic community are within the moderate stress range compared to the other regional units in Lake Superior.

Human Use: Fish consumption advisories, averaged out across this area, recommend no more than one meal a month based on contaminant levels in Yellow Perch, Lake Whitefish (Dioxin-like PCBs) and Lake Trout (Dioxinlike PCBs and PCBs). There are no drinking water facilities or beaches in this regional unit. Since there is only one measure in this category it is noted to have insufficient data for scoring.

(L) Low

Pic River to Chimney Point
High Energy

(M) Coastal Processes
(L) Contaminants in Water & Sediment
(?) Human Use
(L) Nuisance and Harmful Algae

This high energy coast includes a part of the largest stretch of undeveloped coastline on the Great Lakes and is protected by Pukaskwa National Park. The region contains important fish spawning habitat (e.g. Lake Sturgeon), coastal bird habitat (e.g. Peregrine Falcon), sand dunes (e.g. Pitcher's Thistle), and habitat for disjunct arctic plants. The mouth of the Pic River has been a First Nations centre for trade and settlement for thousands of years. There are very few sand beaches and dunes.

Coastal Processes: 68% of the length of tributaries are connected to the lake giving this regional unit a fair rating for coastal processes. There is a dam on the Black River, a tributary to the White River that is impeding tributary connectivity.

Contaminants in Water and Sediment: There has been no recent monitoring information for sediment (since 2011) however; water quality and benthic community quality are under low stress.

Human Use: Fish consumption advisories, averaged out across this area, recommend five meals a month based on contaminant levels in Yellow Perch, Lake Whitefish (Toxaphene, PCBs, Dioxin-like PCBs) and Lake Trout (Dioxin-like PCBs, PCBs, Toxaphene). There are no drinking water facilities or monitored beaches in this regional unit. Since there is only one measure in this category it is noted to have insufficient data for scoring.

M
Moderate

Chimney Point to Cap Chaillon
Moderate Energy

M Coastal Processes
M Contaminants in Water & Sediment
M Human Use
L Nuisance and Harmful Algae

This moderate energy regional unit's coast is natural rocky shores and cliffs. It contains numerous rivers that provide habitat for warm and cold-water fish species and the nearshore waters contain important habitat for Lake Trout and Lake Whitefish. Michipicoten Bay is regarded as important habitat for Lake Sturgeon. Lake Superior Provincial Park extends into this regional unit including Old Woman Bay.

Coastal Processes: Good quality coastal processes although tributary connectivity is only 26% due to hydrological modifications in the Michipicoten River.

Contaminants in Water and Sediment: There is no recent sediment quality monitoring data for this regional unit. While water quality is low stress, benthic community quality is poor compared to other Lake Superior regional units giving the contaminants category a moderate score.

Human Use: Fish consumption advisories, averaged out across this area, recommend four meals a month based on contaminant levels in Yellow Perch, Lake Whitefish (Dioxin-like PCBs) and Lake Trout (PCBs, Toxaphene). The three beaches are all of good quality with no postings during July and August during the years 2015 to 2019: Old Woman Bay in the Lake Superior Provincial Park, Government Dock Beach, and Sandy Beach.

L
Low

Cap Chaillon to Sawpit Bay
High Energy

L Coastal Processes
L Contaminants in Water & Sediment
M Human Use
L Nuisance and Harmful Algae

This high energy coastal area includes most of Lake Superior Provincial Park which is one of the largest provincial parks in Ontario. Much of the area is protected and under natural cover. The Agawa Rock Pictographs are within the park and accessible by foot when the lake is calm. There are several known sites from Ojibwa and pre-Ojibwa times within Lake Superior Provincial Park, on or near the shoreline.

Coastal Processes: There are many waterfalls in the tributaries draining into this regional unit so although 100% of the stream length of tributaries are unimpeded by dams, the connectivity score is based on a small extent of tributaries.

Contaminants in Water and Sediment: There is a lack of recent sediment quality monitoring data however; both water quality results and benthic community measures are low stress.

Human Use: Fish consumption advisories, averaged out across this area, recommend six meals a month based on contaminant levels in Yellow Perch (Mercury), Lake Whitefish (Dioxin/Furans) and Lake Trout

(PCBs, Toxaphene). There is no drinking water facility in the regional unit. The two beaches in Lake Superior Provincial Park at Agawa Bay and Katherine Cove were not posted at all during the July and August period of 201519.

Ⓛ Low

Sawpit Bay to Sault Ste. Marie
Sheltered Embayment

Ⓛ Coastal Processes
Ⓛ Human Use
Ⓛ Contaminants in Water & Sediment
Ⓛ Nuisance and Harmful Algae

The coastline of this regional unit is characterized by sand and cobble beaches, including some of the longest sand beaches on the Ontario side of Lake Superior. Batchawana Bay and Goulais Bay are both important areas for Lake Sturgeon. Goulais Bay is important habitat for Lake Trout and Lake Whitefish and Muskellunge have also been found. Their presence in the Ontario waters of Lake Superior is unique and exhibits the profound biodiversity in this regional unit. Almost all of the coast and watersheds are under natural cover.

Coastal Processes: 80% of the length of tributaries are connected to the lake.

Contaminants in Water and Sediment: There are no recent sediment data for this regional unit however; water quality and benthic community measures are low stress.

Human Use: Fish consumption advisories, averaged out across this area, recommend five meals a month based on contaminant levels in Yellow Perch (Mercury), Lake Whitefish (Dioxins/Furans) and Lake Trout (Toxaphene, PCBs, Dioxinlike PCBs). Six beaches in the area were posted an average of 3.5% of the July and August period during 2015-2019. Mark's Bay South (9%), Pointe des Chenes (9%), and Harmony Beaches (3%) were posted, while Havilland Beach, Batchawana Provincial Park, and Pancake Bay Provincial Park were always open.

THREATS

Threats to Lake Superior's nearshore areas include contamination of beaches in some areas due to *e.coli* levels, impediments to fish movement in tributaries, ongoing issues related to beneficial uses in AOCs and contamination of fish due to Mercury, PCBs, Dioxin-like PCBs, Dioxins/furans and Toxaphene in all nearshore areas.

5.3.3.2 U.S. Nearshore Waters

Lake Superior's nearshore areas are a key priority for restoration and protection because they are the source of drinking water for most communities within the basin, are the areas of the lakes where most human recreation (e.g., swimming, boating, fishing, wildlife viewing) occurs, and are the critical ecological link between watersheds and the open waters of the Great Lakes.

The *GLWQA* Nearshore Framework is a systematic, integrated, and collective approach for assessing nearshore health and identifying and communicating cumulative impacts and stresses.

It was developed by Canada and the United States in 2015 under the Lakewide Management Annex of the Agreement to inform and promote action to restore and protect the ecological health of Great Lakes nearshore areas.

HOW IS THE NEARSHORE ASSESSED?

The United States uses a system of long-standing collaborative programs between EPA, states, and tribes under the Clean Water Act to assess the quality of watersheds and nearshore waters in the Great Lakes. Achievement of the U.S. Clean Water Act's primary goal – to restore and maintain the integrity of the nation's waters – is dependent on having good information about watershed condition, as the health of receiving waters is heavily influenced by the condition of their surrounding watersheds.

The Impaired Waters and Total Maximum Daily Load (TMDL) Program is an important component of the Clean Water Act's framework to restore and protect U.S. waters. The program is comprised primarily of a two-part process. First, states and tribes identify waters that are impaired or in danger of becoming impaired (threatened) and second, for these waters, states and tribes determine pollutant reduction levels, called Total Maximum Daily Loads (TMDLs), or in some cases alternative restoration approaches for these waterbodies necessary to meet approved water quality standards. TMDLs establish the maximum amount of a pollutant allowed in a waterbody and serve as the starting point or planning tool for restoring water quality. Great Lakes assessment units for watersheds, coastal areas and nearshore waters for each state are shown in Figure 26.

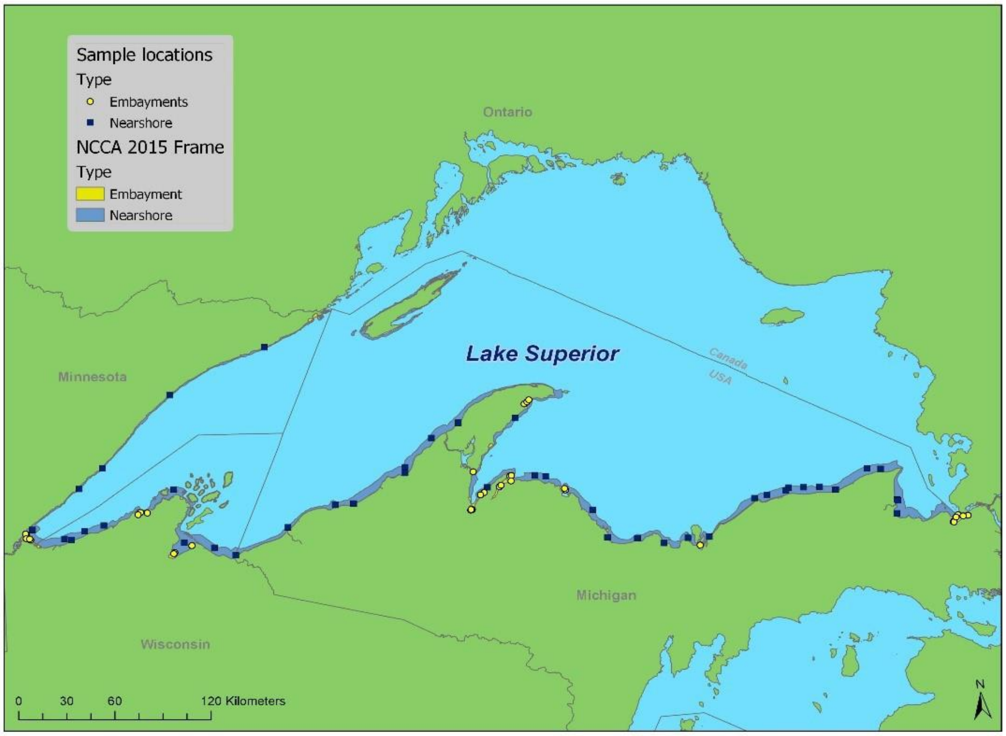

Figure 26. U.S. Great Lakes assessment units for watersheds, coastal areas and nearshore waters for each state. Source: EPA

Every two years, States are required to develop Integrated Water Quality Monitoring and Assessment Reports (also called Integrated Reports) that indicate the general condition of the State's waters and identify waters that are not meeting water quality goals. The Integrated Report satisfies the Clean Water Act requirements for both Section 305(b) for biennial reports on the condition of the State's waters and Section 303(d) for a prioritized list of impaired waters. To find impaired waters in your state using the Assessment and TMDL Tracking System (ATTAINS) visit https://ofmpub.epa.gov/waters10/attains_index.home. Because of differences in state assessment methods, the information in this site should not be used to compare water quality conditions between States or to determine water quality trends.

Under the Clean Water Act, the EPA is also required to periodically report on the condition of the nation's water resources by summarizing water quality information provided by the States. However, approaches to collecting and evaluating data vary from state to state, making it difficult to compare the information across states, on a nationwide basis, or over time. To enable this reporting, the EPA uses the National Aquatic Resource Surveys (NARS), which are statistical surveys designed to assess the status of and changes in quality of the nation's coastal waters, lakes and reservoirs, rivers and streams, and wetlands. Using sample sites selected at random, these surveys provide a snapshot of the overall condition of the nation's waters. Because the surveys use standardized field and lab methods, results from different parts of the country and between years can be compared. EPA works with State, tribal, and federal partners to design and implement the NARS program. These surveys provide critical, nationally consistent water quality information. Additionally, the national surveys are helping to build stronger water quality monitoring programs across the country by fostering collaboration on new methods, new indicators and new research.

The National Coastal Condition Assessment (NCCA) is a national coastal monitoring program with rigorous quality assurance protocols and standardized sampling procedures designed and used by NARS to produce unbiased national and regional estimates of coastal condition and to assess change over time. The sample design is based on a random, stratified survey, where each site sampled represents a known amount of area of the nearshore system. NCCA surveys are conducted every 5 years and the data collected are used to evaluate four primary indices of condition: water quality (which is a composite of chlorophyll a, water clarity, dissolved oxygen, and total phosphorus conditions), sediment quality (which is a composite of sediment toxicity and sediment contaminant conditions), benthic community condition, and fish tissue contaminants – to evaluate the ecological condition and recreational potential of nearshore areas of the Great Lakes.

During the summer of 2015, 78 NCCA sampling stations were visited in Lake Superior for a lakewide assessment of conditions. In addition to the four primary NCCA indices of condition, additional parameters collected in Lake Superior included phytoplankton, algal toxins, enterococci fecal indicator bacteria, underwater video footage of benthic habitat and invasive species, and mercury from fish tissue. Results for each index of condition are categorized as good, fair, and poor based on set thresholds (Gregor and Rast, 1979; PMSTF, 1980). Details about the methods used for data collection and indicators are available here. Results from the 2015 NCCA surveys are considered provisional at this time. The EPA and state partners conducted surveys of all of the Great Lakes under NCCA during the summer and fall of 2020.

Critical coastal monitoring also occurs via implementation of the U.S. Coastal Zone Management Program. The program is a voluntary partnership between the federal government and U.S. coastal and Great Lakes states and territories, authorized by the Coastal Zone Management Act (CZMA) of 1972 to address national coastal issues. The program is administered by NOAA. The Coastal Zone Enhancement Program was established in 1990 under Section 309 of the Coastal Zone Management Act to encourage improvements to state and territory coastal management programs. The focus is on nine enhancement areas: wetlands, coastal hazards, public access, marine debris, cumulative and secondary impacts, special area management plans, ocean and Great Lakes resources, energy and government facility siting, and aquaculture.

Recent coastal monitoring initiatives by Great Lakes States' Coastal Zone Management Programs include:

Michigan:

The Michigan Coastal Management Program (MCMP) provides technical assistance and grant funding to coastal communities to assist in their efforts to mitigate coastal hazards, create healthy habitats, support coastal eco-tourism opportunities, and support resilient and sustainable coastal economies. The program boasts more than 40 years of existence and accomplishments. In Lake Superior, the program has provided technical and financial support to projects that mitigate erosion issues in such locations as McLain State Park near Marquette, MI. The program also administers the Coastal and Estuarine Land Conservation Program, which facilitated land acquisition and public access to nearly 10,000 ft of Lake Superior shoreline in the past five years.

The MCMP is overseen by the Michigan Department of Environment, Great Lakes, and Energy (EGLE) Office of the Great Lakes. EGLE is involved in a variety of other Great Lakes monitoring and protection efforts. For example, EGLE provides funds and resources to local managers to monitor beach safety and contamination on public beaches of the Great Lakes and compiles these data to report on water quality. EGLE is also a partner in AOC monitoring and clean-up efforts on Lake Superior and provides funding and support for shoreline protection projects.

Minnesota:

Minnesota's Lake Superior Coastal Program provides technical and financial resources for Minnesota's Lake Superior communities, by bringing federal dollars into Minnesota for the Lake Superior coastal area. The Coastal Program's goal is to preserve, protect, develop, and where possible, restore or enhance coastal resources along Minnesota's North Shore of Lake Superior. Between 2015 and 2018, the program provided funds for 65 coastal management projects to preserve, protect, develop, restore, or enhance coastal resources. This included projects related to monitoring common tern populations and habitat and updating North Shore stream inventories so that local resource managers would have contemporary information about streams in the region.

Wisconsin:

Wisconsin Coastal Management Program (WCMP) is dedicated to preserving and improving access to the natural and historic resources of Wisconsin's Great Lakes coasts. Since 1978, the program has worked cooperatively with state, local, and tribal government agencies and nonprofit organizations to manage the ecological, economic, and aesthetic assets of the Great Lakes coastal areas. In recent years, the program has provided funds and technical guidance for ensuring accessibility and erosion prevention in several locations, including the Apostle Islands of Lake Superior. This work is part of ongoing efforts to assist Lake Superior coastal community tourism opportunities and to protect the environment from stressors related to tourism.

NEARSHORE STATUS AND SUPPORTING DATA

Lake Superior NCCA results (2015)

During 2015, 78 sites were sampled to assess 3,202 km2 of Lake Superior's nearshore area (Figure 26). Most of the nearshore area of Lake Superior was in good condition based on the four primary indicators (Figure 27). Based on the water quality index, 62±10% of Lake Superior combined nearshore area was classified as being in good condition, 30±11% was in fair condition, 8±5% was in poor condition, and less than one percent was unassessed. Of the water quality index components, chlorophyll a and dissolved oxygen conditions were good in 86±7% and 100% of the nearshore area, respectively. Total phosphorus and clarity conditions were good in 18±9% and 54±11% of Lake Superior nearshore area, respectively.

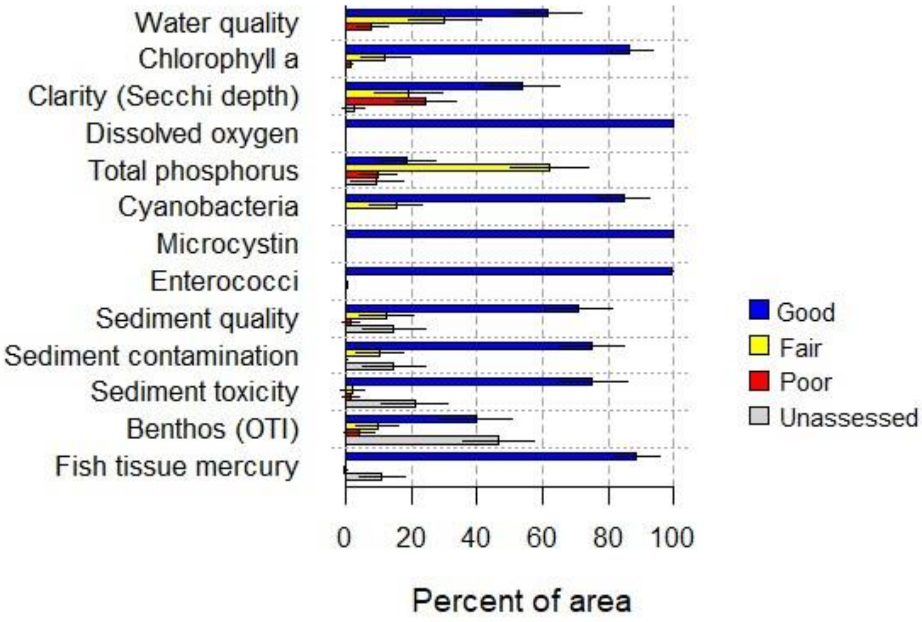

Figure 27. Ecological conditions in the U.S. nearshore waters (<30 m depth and <5km from shore) of Lake Superior based on the 2015 NCCA survey. The water quality indicator is a composite of Chlorophyll a, clarity, dissolved oxygen, and total phosphorus. The sediment quality indicator is a composite of the sediment contamination and toxicity indicators. Source: EPA.

Conditions based on cyanobacteria cell counts were good in 85±8% of the Lake Superior nearshore area, and were fair in the remaining nearshore area of the lake (Figure 27). Microcystin concentrations at all sites in Lake Superior were below the threshold of 8 µg/L for low risk to recreational users so 100% of the nearshore area assessed in Lake Superior had good conditions based on this indicator. Microcystin was detected at only 7 of the 78 sites in Lake Superior and each had a concentration of 0.1 µg/L, which was the detection limit for the microcystin assay. Three sites exceeded the EPA recreational threshold of 1,280 calibrator cell equivalents (CCE)/100 mL for enterococci in Lake Superior in 2015, but enterococci conditions were good in 99% of the nearshore area.

Sediment quality conditions in Lake Superior were good in more than 70% of the area in the nearshore because sediment contaminant and sediment toxicity conditions were also generally good (Figure 27).

Benthos conditions could not be assessed in 46% of the Lake Superior nearshore area. Of the unassessed area, 21% was due to PONARs not being collected and 25% was due to PONAR samples not containing the tolerance-classified oligochaetes necessary to calculate the OTI. Benthos conditions in the assessed area of the nearshore were 40±11% good, 10±6% fair, and 4±4% poor. Efforts are being made to utilize more of the benthic organisms, not just oligochaetes, for benthic assessments. This will eventually increase the amount of area that can be assessed.

Fish tissue mercury conditions in Lake Superior were good in about 89±7% of the nearshore area (Figure 27). Less than one percent of the area of the nearshore was found to have poor fish tissue mercury conditions and the remaining 10% went unassessed due to lack of sufficient amounts of fish caught.

Based on underwater video, round gobies were suspected for an estimated 4% of the nearshore area in Lake Superior, with no positive goby observations. However, 34% of the area went unassessed due to poor video quality (Figure 28). Dreissenid mussels were estimated to be present across 3% of Lake Superior's nearshore area, represented by a single site with mussels in the nearshore near Port Wing, Wisconsin. Dreissenids are uncommon in the open waters of Lake Superior. However, the observation of adult dreissenids in this survey and dreissenid veligers other recent surveys (Trebitz et al., 2019) in Lake Superior suggest that Lake Superior may be becoming more suitable habitat for dreissenids. Video and PONAR data from future NCCA surveys will help to determine whether dreissenids are becoming more widespread in Lake Superior's nearshore.

Planned Lake Superior NCCA work in 2020-2021

The NCCA base surveys of the Great Lakes have been augmented, or enhanced, by USEPA Great Lake National Program Office (GLNPO) and Office of Research and Development (ORD) since 2010. Enhancements, where either more indicators or sites (or both) are sampled than in a base survey, respond to management or science needs. Past NCCA enhancements have included sampling in Great Lakes embayments in 2010 and 2015 to compare their conditions with general nearshore conditions as well as enhanced sampling in Lake Erie in 2015 and 2020 to allow for separate assessments of its 3 basins in addition to whole-lake condition estimates. The monitoring and assessment objectives vary by enhancement but often are used to estimate conditions in a specific area or region within the nearshore waters (i.e., the target population). These estimates may then be compared to management objectives, previous estimates (possibly revealing trends), watershed conditions or land-use policies, or condition in nearby or whole-lake conditions as determined by the base survey.

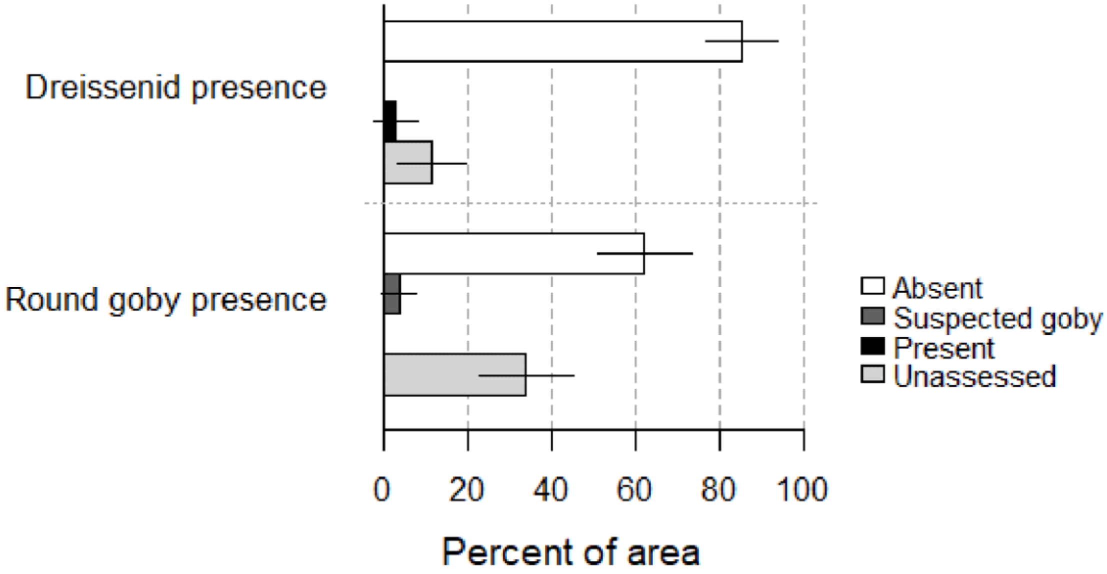

Figure 28. Invasive species detection results for round goby using drop down camera and for dreissenids using both drop down camera and PONAR in Lake Superior from the 2015 NCCA.

As part of the 2020-2021 NCCA survey, GLNPO, ORD, and USEPA Region 5 worked with the State of Wisconsin to design an enhancement of Lake Superior's Chequamegon Bay. This survey was designed to yield the first statistically based estimates of bay conditions using NCCA indicators and protocol. While the entire area of Chequamegon Bay fits the NCCA's definition of nearshore, enhancements are opportunities to redefine the target population to fit specific assessment and monitoring objectives, such as *LAMP* science priorities. Data from the Chequamegon Bay enhancement will provide whole-bay context for conditions in the bay compared to the rest of the nearshore waters and can provide important information for future surveys, research, or management actions. In addition, this enhancement could provide a framework for additional enhancements elsewhere in the lake to address science and monitoring needs.

THREATS

Threats to Lake Superior's nearshore areas include impacts to habitats and/or water quality due to shoreline hardening; loss of tributary connectivity and coastal wetlands; invasive species; nuisance algae; harmful algal blooms; and contaminants and bacteria.

IMPACTED NEARSHORE AREAS

Michigan:

For its state integrated reporting, Michigan monitors beach conditions on the shores of Lake Superior, and also assists other agencies with coastal wetlands monitoring and the EPA with the NCCA program. The 2018 integrated report provides links to the beach monitoring efforts of the Michigan Department of Environmental Quality. Beaches along Lake Superior tend to have low incidence of high bacteria levels compared to the other Great Lakes. In the draft 2020 integrated report, it is noted that Lake Superior has been listed as impaired by PFOS and Toxaphene for fish consumption. This report also notes that new efforts have been undertaken to monitor sediment chemistry and sediment toxicity in the waters off of Gay, Michigan to estimate the amount of area where stamp sand deposition could be affecting aquatic life.

Minnesota:

The Minnesota Pollution Control Agency (MPCA) monitors water quality and bacterial conditions along beaches of Lake Superior for its state integrated reporting. Of the 6.73 miles of Lake Superior Beaches monitored for the 2018 integrated report, 5.6 miles were supporting water quality standards for recreational use while 1.05 miles of shoreline exceeded concentrations of *E. coli* and did not support recreational contact.

Wisconsin:

The 2018 Wisconsin Integrated report outlines the state's efforts in meeting the *LAMP* priorities for Lake Superior as well as describes accomplishments in monitoring and protection activities for Lake Superior ecosystems. Some of these accomplishments include supporting monitoring efforts in Lake Superior coastal wetlands, tributaries, and embayments.

The state also monitors public beach conditions and found that some Lake Superior beaches were not supporting recreational use according to the state's *E. coli* criteria for beaches. Additional impairments noted in the report include fish tissue contaminant impairments for mercury and PAHs.

5.5.4 Actions to Address Other Threats

The Lake Superior Partnership agencies will implement the 2020-2024 *LAMP* within the context of existing laws and regulations which actively contribute to the restoration and protection of Lake Superior. A number of pieces of federal, state and provincial legislation that address invasive species are listed in Appendix B. These include Canada's Impact Assessment Act (2019) and the United States' Protecting our Infrastructure of Pipelines and Enhancing Safety Act (2016).

Spill prevention and contingency plans are in place for Ontario, Minnesota, Wisconsin, Michigan.

In addition, the Canada-United States Joint Inland Pollution Contingency Plan is in place, should there be a significant accidental and unauthorized release of pollutants along the Canada-U.S. border. The Joint Marine Pollution Contingency Plan is a mechanism for Canada and the U.S. to coordinate planning and response to spills in shared waters. This plan covers all potential sources of marine pollution in contiguous waters (i.e., ships, offshore platforms, mystery spills).

Other contributing national and regional plans and initiatives include, but are not limited to:

- Great Lakes Marine Debris Action Plan 2020-2025;
- New measures in 2020 to enhance Canadian railway safety and the safe transportation of dangerous goods;
- Canadian 2018 ban of the manufacture and import of all toiletries that contain plastic microbeads;
- U.S. 2017-2019 ban on the manufacturing, packaging, and distribution of rinse-off cosmetics containing plastic microbeads; and,
- U.S. Great Lakes Restoration Initiative, administered by EPA.

LAMP Actions

Actions will be taken in the Lake Superior basin to further address plastics, risks from oil transport and mining, address cumulative stress as listed in Table 12.

Table 12. Action to address other threats

#	**ACTIONS ON OTHER THREATS: Plastics, Risks from Oil Transport and Mining, and Cumulative Impacts on the Nearshore Areas of the Lake**	AGENCIES
44	Organize, participate or support capture and clean-up projects to prevent and remove plastic pollution including "nurdles" from Lake Superior waterways and land.	Parks Canada, MECP, Bad River, Grand Portage, KBIC
45	Determine the current status and sources of plastics. a. Determine the concentration of plastic in Lake Superior's water, sediment and fish. b. Identify the main sources of plastic pollution to Lake Superior.	Parks Canada, USGS, MECP, MNDNR, MPCA, BMIC, MN Sea Grant
46	Through science and monitoring, improve understanding of cumulative impacts of stressors to Lake Superior. a. Continue gathering baseline data in the Lake Superior basin to assess spatial variability in water quality in order to improve understanding of cumulative impacts of multiple stressors, including habitat disruption, change climate, mining and other stressors.	USGS, MECP, MPCA, 1854 TA, CORA, Fond du Lac, GLIFWC, Grand Portage, KBIC
47	Continue to outreach and engage the public on plastic waste pollution and ways to reduce the amount of plastic in the Lake Superior basin.	ECCC, Parks Canada, USNPS, MECP, MPCA, Bad River, BMIC, CORA, KBIC, Red Cliff
48	Make information available about the *Great Lakes Water Quality Agreement* General Objectives and related Lake Superior *LAMP* during applicable engagement processes for the planning or operations of major transportation and resource extraction projects, including environmental impacts assessments by project proponents.	ECCC, MECP, 1854 TA, CORA, Fond du Lac, Red Cliff
49	Engage the public to educate it on impacts and risks associated with transporting oils and other hazardous materials by road, rail, ship and pipeline; spill contingency plans in place; and where to report spills of oils and other hazardous materials.	Bad River, BMIC, Fond du Lac, LDF, Red Cliff, MN Sea Grant

Actions Everyone Can Take

- Report an oil or hazardous materials spill;
- Ontario's pollution reporting hotline at 1-866-MOE-TIPS (663-8477);
- Wisconsin's active spill or release to waters hotline at 1-800-943-0003;
- Minnesota's Duty Officer for petroleum or hazardous materials spills at 1-800-422-0798;
- Michigan's pollution emergency alerting system at 1-800-292-4706;
- Participate in public input opportunities for major development proposals;
- Purchase and launder clothing made of natural materials like cotton or wool, and/or install a synthetic fibers capture trap on your washer to reduce the release of plastic fibers from materials like polyester, nylon and acrylic;
- Use reusable products, and limit use of single use plastic products;
- Recycle plastic products; and
- Pick up litter on the beach, or organize a group shoreline clean-up.

6.0 LAKEWIDE MANAGEMENT

Achieving the General Objectives of the Agreement is a challenging task and one that requires collective action by many partners throughout the Lake Superior basin. The 2020-2024 Lake Superior *LAMP* presents current ecosystem conditions and threats, sets priorities for research and monitoring, and identifies actions to take by governments and the public. The *LAMP* is a resource for anyone interested in the Lake Superior basin ecosystem, its water quality, and the actions necessary to help protect this Great Lake.

6.1 Implementation, Engagement and Reporting

Lake Superior Partnership agencies commit to incorporate *LAMP* actions in their decisions on programs, funding and staffing to the extent feasible. Each Lake Superior Partnership member agency will contribute to the implementation of one or more of the *LAMP*'s 49 actions.

Implementation of the *LAMP* is guided by a governance system overseen by the Great Lakes Executive Committee and illustrated in Figure 29.

Great Lakes Executive Committee	Led by senior federal government agency representatives from Canada and the United States to delivery major programs under the Great Lakes Water Quality Agreement (GLWQA).
Lake Superior Partnership Management Committee	Senior level representatives from federal, state and provincial governments, tribal governments, First Nations, Métis, municipal government and watershed management agencies with decision-making authority on direction, development, and implementation efforts in the Lake Superior basin ecosystem.
Lake Superior Partnership Working Group	Government agency representatives who contribute to and coordinate *LAMP* development, implementation and reporting.
Lake Superior Partnership Subcommittees	Led by one or more Lake Superior Partnership Working Group member to engage experts and facilitate issue specific collaboration and development of recommended priorities for science and action.

Figure 29. Lake Superior lakewide management under the Agreement.

Lake Superior Partnership agencies are guided by a set of principles and approaches found in the Agreement, including those presented in Table 13. An update to the public on *LAMP* implementation accomplishments and challenges will be released annually.

Table 13. Selected principles and approaches found in the Agreement.

Principles & Approaches	Implementation Description
Accountability	Tracking and evaluating agency actions. Regular reporting, including public annual updates.
Coordination	Undertaking opportunities to coordinate on protection and restoration projects, science and monitoring, communications and engagements.
Ecosystem Approach	Taking actions that integrate the interacting components of air, land, water, living organisms including humans.
Public Engagement	Incorporating public opinion and advice gathered through agency engagements, as well as Lake Superior Partnership public webinars, presentations, and updates.
Science Based Management	Using current and best available science and traditional knowledge in management decisions.

The Cooperative Science and Monitoring Initiative (CSMI) is a joint United States and Canadian effort implemented under the Science Annex of the Agreement. CSMI provides managers with the science and monitoring information necessary to make management decisions on each Great Lake. CSMI follows a five-year rotating cycle in which one lake undergoes intensive investigation each year. The emphasis on a single lake per year allows for coordination of science and monitoring activities focusing on the information needs of lakewide management for the particular lake. The current 5-year CSMI cycle for Lake Superior is depicted in Figure 30. Previous Lake Superior intensive field years took place in 2016, 2011 and 2006.

Figure 30. Lake Superior CSMI 2021-2025 timeline.

Another effective *LAMP* implementation strategy is to further enable the large number of regional and local businesses, academic institutions and community groups who are also working to protect the Lake Superior ecosystem.

Everyone has a role to play in protecting, restoring, and conserving Lake Superior. Engagement, collaboration, and active participation of all levels of government, watershed management agencies, and the public are the cornerstone of current and future actions. Collective action is essential for the successful implementation of this *LAMP* and for the achievement of the General Objectives of the *GLWQA*. The challenges and threats to Lake Superior need to be more widely recognized, as do opportunities for everyone to play a role in finding solutions that ensure a healthy watershed and lake ecosystem now and into the future.

Engagement, education, and involvement will support and move the public from the role of observer to active participant. Local communities, groups, and individuals are among the most effective champions to achieve environmental sustainability in their own backyards and communities. Member agencies of the Partnership will pursue binational and domestic outreach and engagement activities to consult on challenges, priorities, and strategies and to encourage and support active community-based environmental action.

Individuals can get more involved by:

- Reviewing and providing input on the development of Lakewide Action and Management Plans;
- Keeping informed, through access to *LAMP* annual updates at www.binational.net;
- Attending public meetings or summits hosted by government agencies of the Lake Superior Partnership;
- Participating in Great Lakes events, many of which are captured on www.glc.org/greatlakescalendar/;
- Contributing to projects run by local organizations to improve water quality and ecosystem health; and
- Attending the triennial Canada-U.S. Great Lakes Public Forum, scheduled next for 2022.

6.2 Collective Action for a Healthy Lake Superior

The 2020-2024 *LAMP* identifies actions needed to address priority threats in Lake Superior. The public plays a key role as partners, advocates, and implementers for lakewide protection and management. Together, with federal, state and provincial governments, tribal governments, First Nations, Métis, municipal governments, watershed management agencies, and other local public agencies we can collectively:

- **Prevent and reduce chemical contaminant pollution** by controlling and reducing Chemicals of Mutual Concern and Chemicals of Emerging Concern through existing programs, undertaking site-specific remedial action where appropriate, and studying and characterizing pollutants. Everyone can help prevent the release of harmful chemicals into the environment through activities such as taking household hazardous materials to hazardous waste collection depots and refraining from burning garbage in barrels, open pits, or outdoor fireplaces.
- **Prevent and reduce nutrient and bacterial pollution** by investing in climate resiliency through green-infrastructure and forest health in order to prevent excessive run-off and erosion from the land to the lake, and by increasing our scientific understanding of Lake Superior algal blooms. Everyone can help to prevent nutrient and bacterial pollution through actions such as picking up pet waste, and avoiding the use of lawn fertilizers containing phosphorus when possible.
- **Protect and restore habitats and species** by remediating and protecting habitats, rehabilitating native species, increasing habitat resiliency to climate change impacts, and by increasing scientific understanding of the aquatic food web, fish dynamics and coastal wetlands. Everyone can help protect habitats and species through activities such as taking care of local natural spaces.
- **Prevent and control invasive species** by preventing their introduction, limiting their spread or eradicating where possible, by early detection and response, and by improving our understanding of

their impacts. Everyone can help control invasive species through activities such as learning how to spot, report and control the most harmful invasive species in your local natural spaces.

Together, our collective action will help advance the achievement of the nine *Great Lakes Water Quality Agreement's* General Objectives by reducing chemical contamination, preventing nutrient and bacteria pollution, protecting habitats and species, preventing and controlling invasive species, and helping to address other threats such as plastics, risks from mining and oil transport, and cumulative impacts on the nearshore areas of the lake.

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Appendix A: Areas of Concern

The Agreement defines an Area of Concern (AOC) as a geographic area designated by Canada and the United States of America where significant impairment of beneficial uses has occurred as a result of human activities at the local level. Below is a summary of the status of Lake Superior Areas of Concern in January 2020.

THUNDER BAY AREA OF CONCERN

It was designed an AOC due to historical ecosystem impairments as a result of urbanization, industrial and municipal wastewater discharge, and hydroelectric development along local tributaries. Significant efforts have been made over the years to remediate historical impacts within the AOC, which have led to the re-designation to Not Impaired status of 6 out of 11 original beneficial use impairments (BUI) as of October 2020. Additional assessments are underway for other re-designations.

NIPIGON BAY AREA OF CONCERN

By 2014, environmental monitoring confirmed that all beneficial uses have been restored in the AOC in accordance with the criteria established in the Remedial Action Plan (RAP). This prompted drafting of a RAP Completion Report detailing AOC accomplishments, science to support BUI re-designations and AOC delisting, and a summary on other initiatives that will continue after delisting. Community consultations on the RAP Completion Report and delisting Nipigon Bay continue to be underway. Bolstering the case to delist, the construction of a new secondary wastewater treatment plant in the Township of Red Rock started in May 2019, with completion currently scheduled for early 2021. The project cost is funded by Ontario and Infrastructure Canada.

JACKFISH BAY AREA OF CONCERN in RECOVERY

In 2010, Jackfish Bay was recognized as an Area of Concern in Recovery (AOCiR) due to significant ecological improvements. Yet additional time was required for sufficient ecosystem recovery. In order to monitor ecosystem health, a focused monitoring program has been implemented since 2011, and continues to collect information about Jackfish Bay to conclusively track ecosystem recovery towards the long-term goal of addressing the remaining impairments and delisting the AOC.

PENINSULA HARBOUR AREA OF CONCERN

Historical environmental issues included high levels of contaminants in fish and sediment, loss of fish habitat, and degraded fish and benthic communities, caused primarily by discharges from the pulp mill (decommissioned in 2009) and associated chlor-alkali plant (decommissioned in 1977), log booming debris, and discharges of municipal wastewater. Significant efforts have been made to remediate these historical impacts within the AOC. In 2012, a thin-layer cap consisting of medium and course sand was placed on top of contaminated sediment in Jellicoe Cove – an area with the highest sediment contamination within the AOC.

Covering approximately one-quarter of Jellicoe Cove (or 2.5% of the AOC), this sediment management project was the last management action remaining for the Peninsula Harbour AOC. It was designed to reduce the risk from, and spread of, contaminated sediment, expedite natural recovery, and facilitate ecosystem recovery of the AOC. A Long Term Management Plan is in place to monitor and evaluate the effectiveness of the cap every five years over a period of 20 years. Results from the first round of sampling, in 2017, show the cap is stable and effective in reducing the contaminant concentrations. Assessment supporting the re-designation of 3 BUIs have been completed and public engagement on the assessments is currently underway.

TORCH LAKE AREA OF CONCERN

The Torch Lake Area of Concern (AOC) was so designated because of contaminant loadings from the mining and production of copper. Waste products from industrial milling, smelting and leaching operations of the mined ore are the main source of pollution in Torch Lake. In addition to copper, other contaminants of concern in the AOC are heavy metals, PCBs and polycyclic aromatic hydrocarbons. The three original Beneficial Use Impairments (BUIs) were *Restrictions on Fish and Wildlife Consumption, Degradation of Benthos and Fish Tumors or Other Deformities*. The Fish Tumor BUI was removed in 2007.

The Torch Lake *Degradation of Benthos* BUI project is a benthos pilot study funded by the Great Lakes Restoration Initiative. The developing plan includes construction of a series of pilot-scale shoreline capping and habitat restoration test plots. The pilot study will determine the potential to improve the density and diversity of the Torch Lake benthic community. Construction of the pilot study test plots was recently completed; monitoring will take place in subsequent years.

EPA recently signed a Great Lakes Legacy Act Project Agreement with Honeywell International, Inc. to perform a focused feasibility study at the Torch Lake AOC. The study will focus on developing remedial alternatives for addressing PCBs, lead and arsenic contaminated sediment, as well as for drums abandoned in the lakebed in the Hubbell Processing Area. Addressing contaminated sediment in these two areas will contribute to removing the *Restrictions on Fish and Wildlife Consumption* BUI.

ST. LOUIS RIVER AREA OF CONCERN

The St. Louis River AOC was designated due to habitat degradation and sediment contamination as well as water quality issues related to excess sediment and nutrient inputs. All of the management actions identified in the RAP are underway or complete. Decades of work by many partners to restore the AOC have resulted in the removal of three of the nine identified beneficial use impairments: *Degradation of Aesthetics* (removed in 2014), *Fish Tumors or Other Deformities* (removed in 2019), and *Excessive Loading of Sediment and Nutrients* (the SLR name for the GLWQA Eutrophication or Undesirable Algae BUI; removed 2020). For the remaining six beneficial use impairments, management action implementation is in progress. As of 2021, 47 of 80 management actions have been completed or need no further action (59%). Completed actions include contaminated sediment remediation at four Minnesota sites [MN Slip, Slip 3 and Slip C Azon/DSPA Garfield Slip]; construction of the piping plover nesting habitat project at the WI Point Bird Sanctuary;avian habitat restoration at Interstate Island; sheltered bay habitat restoration at the Kingsbury Bay and Grassy Point sites in MN; and Barkers Island (WI) beach restoration.

Delisting the AOC will happen after all beneficial use impairments have been removed.

DEER LAKE – delisted.

Table 14. Beneficial Use Impairment status for Lake Superior Areas of Concern as of January 2020.

AOC	BENEFICIAL USE IMPAIRMENT (BUI) STATUS													
🟩 BUI RESTORED 🟨 BUI IMPAIRED ⬜ NOT APPLICABLE	Restrictions on fish and wildlife consumption	Tainting of fish and wildlife flavor	Degradation of fish and wildlife populations	Fish tumors and other deformities	Bird or animal deformities or reproductive problems	Degradation of benthos	Restriction on dredging activities	Eutrophication or undesirable algae	Restrictions on drinking water consumption or taste/odor	Beach closings	Degradation of aesthetics	Added costs to agriculture or industry	Degradation of phytoplankton/zooplankto	Loss of fish and wildlife habitat
Jackfish Bay (CA)	⬜	⬜	🟨	🟩	⬜	🟨	🟩	⬜	⬜	⬜	⬜	⬜	⬜	🟨
Nipigon Bay (CA)	⬜	🟩	🟩	⬜	⬜	🟩	🟩	🟩	⬜	⬜	🟩	⬜	⬜	🟩
Peninsula Harbour (CA)	🟨	⬜	⬜	⬜	⬜	🟨	🟩	⬜	⬜	⬜	⬜	⬜	⬜	⬜
St. Louis River & Bay (US)	🟨	⬜	🟨	🟩	⬜	🟨	🟨	🟩	⬜	🟨	🟩	⬜	⬜	🟨
Thunder Bay (CA)	⬜	⬜	🟨	⬜	⬜	🟨	🟩	⬜	⬜	🟨	🟩	🟩	⬜	🟨
Torch Lake (US)	🟨	⬜	⬜	🟩	⬜	🟨	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜

Appendix B: Selected Legislation that Contributes to the Protection and Restoration of Lake Superior

The Lake Superior Partnership member agencies work within the context of laws and regulations to adopt common objectives, implement cooperative programs, and collaborate to address environmental threats to Lake Superior. Selected legislation is presented in Table A-2.

Table 15. Selected Legislation that Contributes to the Protection and Restoration of Lake Superior.

LEGISLATION	LAKE SUPERIOR ISSUE(S)	DESCRIPTION
Canada		
Canadian Environmental Protection Act, 1999	• chemical contaminants • nutrients & bacterial pollution	Pollution prevention and the protection of the environment and human health in order to contribute to sustainable development.
Fisheries Act, 2016	• chemical contaminants • habitat & species • nutrients & bacterial pollution • invasive species	Conservation and protection of fish and fish habitat, including by preventing pollution.
Canada Shipping Act, 2001	• chemical contaminants • invasive species	Protect the marine environment from damage due to navigation and shipping activities, including ballast water control and management regulations.
Impact Assessment Act, 2019	• chemical contaminants • habitat & species	Outlines approach for determining and undertaking a federal environmental assessment for proposed projects.
Canada National Marine Conservation Areas Act, 2002	• habitat & species	Protect and conserve marine areas for the benefit, education and enjoyment of the people. Prohibits mining and oil/gas exploration.
Canada National Parks Act, 2000	• habitat & species	Protects the ecological integrity of national park managed lands and waters.

Species at Risk Act, 2002	• habitat & species	Protect endangered or threatened organisms and their habitats.

United States		
Clean Water Act, 1972	• chemical contaminants • nutrients & bacterial pollution	Regulates discharges of pollutants into the waters of the U.S. and establishes water quality standards for surface waters. Implementation and enforcement may be delegated to the Tribes and States.
Safe Drinking Water Act, 1974	• chemical contaminants • nutrients & bacterial pollution	Protects public water supplies from harmful contaminants by establishing standards and treatment requirements for public water supplies, control underground injection of wastes, finance infrastructure projects, and protect sources of drinking sources.
Clean Air Act, 1990	• chemical contaminants	Regulates air emissions from stationary and mobile sources and establishes National Ambient Air Quality Standards to protect public health. Implementation and enforcement may be delegated to States or Tribes.
Pollution Prevention Act, 1990	• chemical contaminants	Directs EPA to undertake a series of activities aimed at preventing the generation of pollutants, rather than controlling pollutants after they are created.
Protecting our Infrastructure of Pipelines and Enhancing Safety (PIPES) Act, 2016	• chemical contaminants • other	Requires annual federal reviews of all pipelines' age and integrity.

U.S. Toxic Substances Control Act, 1976	• chemical contaminants	Addresses human health and environmental impacts of chemicals in industrial use through a combination of voluntary and regulatory risk management activities.
Solid Waste Disposal Act and Resource Conservation and Recovery Act	• chemical contaminants	Regulates solid and hazardous wastes, and mandates corrective action to address improper waste management practices.
Comprehensive Environmental Response, Compensation (Superfund), 1980	• chemical contaminants	Cleans up abandoned chemical contamination sties, which threaten human health. Toxics Release Inventory (TRI), developed under the Emergency Planning and Community Right-to-Know Act.
U.S. Great Lakes Legacy Act, 2002	• chemical contaminants	Provides federal funding to accelerate contaminated sediment remediation.
Agricultural Act of 2014 (U.S. Farm Bill)	• nutrient & bacterial pollution	Provides authorization for services and programs by the U.S. Department of Agriculture, which include several agricultural environmental conservation programs that benefit water quality.
Coastal Zone Management Act, 1972	• nutrient & bacterial pollution	Provides for the management of the nation's coastal resources, including the Great Lakes. The Act outlines three national programs, the National Coastal Zone Management Program, the National Estuarine Research Reserve System, and the Coastal and Estuarine Land Conservation Program.
Endangered Species Act, 1973	• habitat & species	Protect and recover imperiled species and the ecosystems upon which they depend.

National Invasive Species Act, 1996	• invasive species	U.S. Federal law intended to prevent invasive species from entering inland waters through ballast water carried by ships.
Lacey Act, 1900	• invasive species	U.S. Federal act that prevents transport of species designated as “Injurious to Wildlife”.

Tribes		
Water laws	• chemical contaminants	A number of tribes are authorized to develop and administer water quality standards under the U.S. Clean Water Act, including: Bad River Band of Lake Superior Chippewa; Fond du Lac Band of Lake Superior Chippewa; Grand Portage Band of Lake Superior Chippewa; Lac du Flambeau Band of Lake Superior Chippewa; and the Keweenaw Bay Indian Community.
Ontario		
Nutrient Management Act, 2002	• nutrient & bacterial pollution	A nutrient management framework for Ontario’s agricultural industry, municipalities, and other generators of materials containing nutrients; includes environmental protection guidelines.
Ontario Water Resources Act, 1990 and Environmental Protection Act, 1990	• chemical contaminants • nutrients & bacterial pollution	Regulation of private and industrial discharges of contaminants from prescribed industrial sectors into surface waters, prohibiting the discharge of contaminants/ polluting materials without the required permissions.
Ontario Invasive Species Act, 2015	• invasive species	Rules to prevent and control the spread of invasive species in Ontario.

Fish and Wildlife Conservation Act, 1997	• habitat & species	Provides the protections and regulations for fishing and hunting activities in Ontario.
Great Lakes Protection Act, 2015	• chemical contaminants • nutrients & bacterial pollution • habitat & species	Requires the development of science-based targets and action plans to address threats such as nutrients. Ensures that programs or other actions will be used to monitor and report on array of ecological conditions.
Environmental Assessment Act, 1990	• chemical contaminants • nutrients & bacterial pollution	Requires potential environmental effects to be considered before an infrastructure project begins.
Conservation Authorities Act, 1990	• habitat & species	Provides for the organization and delivery of programs and services that further the conservation, restoration, development and management of natural resources in watersheds.
Safe Drinking Water Act, 2002	• chemical contaminants • nutrient & bacterial pollution	Provides the control and regulation of drinking-water systems and drinking-water testing.
Michigan		
Natural Resources and Environmental Protection Act, 1994	• chemical contaminants • invasive species	Establishes regulatory and permitting and programs for water quality. Defines prohibited and restricted species in Michigan and limits the possession, import or sale of such species.
Wisconsin		

Natural Resources and Environmental Protection Laws for water, waste, air, invasive species and threatened & endangered species laws	• chemical contaminants • nutrients & bacterial pollution • habitat & species • invasive species	Establishes regulatory and permitting and programs for waterway and wetland protection and threatened and endangered species protection laws. Includes water quality standards for the Clean Water Act, regulates pint and non-point discharges of chemicals, nutrients and bacteria. Statues regulate surface water and groundwater use and land use adjacent to public waters. Administrative Code NR40 defines prohibited and restricted species and limit possession, import or sale of these species.

Minnesota		
Clean Water Legacy Act, 2006	• chemical contaminants	Provides authority and resources to achieve the water quality standards of the federal Clean Water Act, and statues for water use and land use adjacent to public waters.
Clean Water, Land and Legacy Amendment (Legacy Act), 2008	• habitat & species	Increases the state sales tax by three-eighths of one percent beginning on July 1, 2009 and continuing until 2034. The additional sales tax revenue is distributed into four funds including the clean water fund and the outdoor heritage fund.