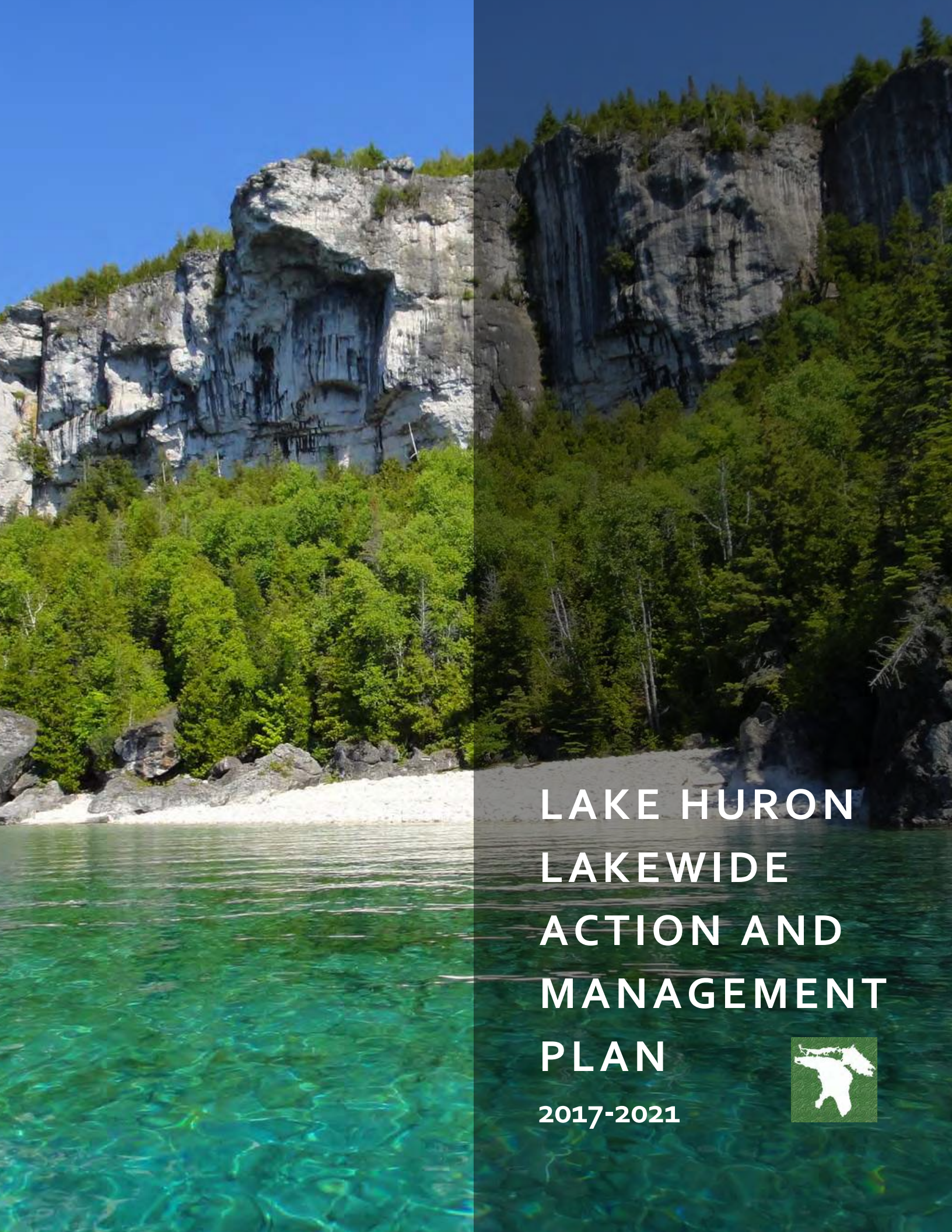


LAKE HURON LAKEWIDE ACTION AND MANAGEMENT PLAN

2017-2021

DISCLAIMER

This document is an early draft of the Lake Huron Lakewide Action and Management Plan (LAMP) that has been released for public input. Under the Great Lakes Water Quality Agreement, the Governments of Canada and the United States have committed to develop five-year management plans for each of the Great Lakes. This draft Lake Huron LAMP was developed by member agencies of the Lake Huron Partnership, a group of Federal, State, Provincial, Tribal governments and watershed management agencies with environmental protection and natural resource management responsibilities within the Lake Huron watershed.

Public input is being sought on the factual content of the report. Our goal is to produce a report that will introduce the reader to the Lake Huron watershed and the principles of water quality management, as well as describe actions that governmental agencies and the public can take to further restore and protect the water quality of Lake Huron. The Lake Huron Partnership looks forward to considering your feedback as we proceed into the final drafting stage.

Disclaimer: *Do not quote or cite the contents of this draft document. The material in this draft has not undergone full agency review, therefore the accuracy of the data and/or conclusions should not be assumed. The current contents of this document should not be considered to reflect a formal position or commitment on the part of any Lake Huron Partnership agency, including United States Environmental Protection Agency and Environment and Climate Change Canada.*

The 'Draft' 2017-2021 Lake Huron Lakewide Action and Management Plan (LAMP) was developed by member agencies of the Lake Huron Partnership and reflects the input of many resource management agencies, conservation authorities, scientists, and non-governmental organizations committed to restoring and protecting Lake Huron and its watershed. It builds on relevant information from *The Sweetwater Sea: An International Biodiversity Conservation Strategy for Lake Huron* (Franks Taylor et al., 2010), the Great Lakes Fishery Commission's Lake Huron Technical Committee technical reports, State of Lake Huron Proceedings (LimnoTech, 2015), State of the Great Lakes Indicator Reports (SOGL, 2016), and many other documents and plans.

We gratefully acknowledge Environment and Climate Change Canada's Co-Op students - David Zilkey, for his enthusiasm and hard work on initial draft sections, Michelle T. Nguyen, for her diligence and creativity in designing, reviewing and editing, and to Ellen Perschbacher, for her help in finalizing this document. The contributions of photographers are also greatly appreciated.

Lake Huron Partnership Agencies, 2017

Bay Mills Indian Community
Chippewa Ottawa Resource Authority (CORA)
Environment and Climate Change Canada (ECCC)
Fisheries and Oceans Canada (DFO)
International Joint Commission (IJC)
Little Traverse Bay Bands of Odawa Indians
Maitland Valley Conservation Authority (MVCA)
Michigan Office of the Great Lakes (MOGL)
Michigan Department of Natural Resources (MDNR)
National Oceanic and Atmospheric Administration (NOAA)
Nottawasaga Valley Conservation Authority (NVCA)
Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA)
Ontario Ministry of the Environment and Climate Change (OMOECC)
Ontario Ministry of Natural Resources and Forestry (OMNRF)
Parks Canada (PC)
Saginaw Chippewa Indian Tribe of Michigan
Sault Ste. Marie Tribe of Chippewa Indians
St. Clair Region Conservation Authority (SCRCA)
U.S. Department of Agriculture – Natural Resources Conservation Service (USDA-NRCS)
U.S. Environmental Protection Agency (USEPA)
U.S. Fish and Wildlife Service (USFWS)
U.S. Forest Service (USFS)
U.S. Geologic Survey (USGS)

Front Cover Photo Credit: Bruce Peninsula, Ontario by G. Mayne.

Back Cover Photo Credit: Port Crescent State Park, Michigan by M. Smar.

AIS – Aquatic Invasive Species
AOC – Area of Concern
AOCiR – Area of Concern in Recovery
BMP – Best Management Practice
BUI – Beneficial Use Impairment
CCME – Canadian Council of Ministers of the Environment
CMC – Chemicals of Mutual Concern
CSMI – Cooperative Science and Monitoring Initiative
Σ_2DDC-CO – Dechlorane plus expressed as the sum of *syn-* and *anti-* isomer
DDT – Dichlorodiphenyltrichloroethane
Dioxins and furans – polychlorinated dibenzo-*p*-dioxin and polychlorinated dibenzofuran; PCDD/PCDF
E. coli – Escherichia coli
EGBSC – Eastern Georgian Bay Stewardship Council
FEQG – Federal Environmental Quality Guidelines
GLEI – Great Lakes Environmental Indicator Program (1&2)
GLWQA – Great Lakes Water Quality Agreement or 'The Agreement'
GOs – General Objectives
HABs – Harmful algal blooms
HBCD – Hexabromocyclododecane
LAMP – Lakewide Action and Management Plan
LEOs – Lake Ecosystem Objectives
LC-PFCAs – Long-chain perfluorinated carboxylic acids
PBDEs – Polybrominated diphenyl ethers
PCBs – Polychlorinated biphenyls
PFOA – Perfluorooctanoic acid
PFOS – Perfluorooctane sulfonate
Phragmites – Phragmites australis subsp. australis
SAV – Submerged aquatic vegetation
SCCPs – Short-Chain Chlorinated Paraffins
TCDD – Tetrachlorodibenzo-*p*-dioxin (usually in reference to congener 2,3,7,8-)
TEQs – Toxic Equivalents
TP – Total phosphorus
Ww – wet weight

Learn about the actions government agencies are taking to address key environmental issues – and ways that YOU can help.

Learn about how researchers are supporting management actions through a better understanding of the Lake Huron ecosystem.

Learn about the role you can play in protecting, restoring, and conserving Lake Huron.

1.0 INTRODUCTION

The Lake Huron Lakewide Action and Management Plan (LAMP) is a five-year, ecosystem-based strategy for restoring and maintaining the water quality of Lake Huron and the St. Marys River.

The Lake Huron LAMP fulfills a United States (U.S.) and Canadian commitment of the Great Lakes Water Quality Agreement (the Agreement) to assess ecosystem conditions, identify environmental threats, and set priorities for research and monitoring. The Agreement recognizes that the best approach to restore the Lake Huron ecosystem and improve water quality is for the two countries to adopt common objectives, implement cooperative programs, and collaborate to address environmental threats.

The LAMP is a world-recognized model for cooperation among governmental jurisdictions and their management agencies. It represents a shared understanding of the health of Lake Huron and a means for coordinating and documenting management actions.

The LAMP was developed by member agencies of the Lake Huron Partnership, a collaborative team of natural resource managers led by the governments of the U.S. and Canada, in cooperation and consultation with State and Provincial Governments, Tribal Governments, First Nations, Métis, Municipal Governments, and watershed management agencies. The LAMP supports an adaptive management approach (Figure 1) for restoring and maintaining Lake Huron water quality and will guide activities by management agencies for the years 2017 to 2021.

1.1 THE GREAT LAKES WATER QUALITY AGREEMENT and LAKEWIDE MANAGEMENT

Since 1972, the Agreement has guided U.S. and Canadian actions that 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 (Canada and United States, 2012).

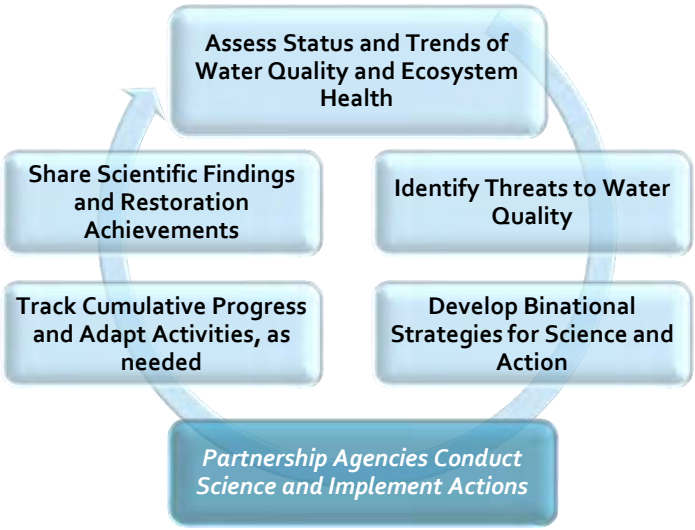


Figure 1. An adaptive lakewide management approach for Lake Huron.

Table 1. Great Lakes Water Quality Agreement Annexes.

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

The Agreement commits Canada and the United States to address 10 priority issues or 'Annexes' (Table 1). The Lake Huron LAMP is a cross-cutting approach that integrates information and management needs from each of these Annexes, with a focus on Lake Huron-specific management needs to maintain, restore and protect water quality and ecosystem health.

1.2 ALIGNMENT WITH OTHER INTERNATIONAL RESOURCE MANAGEMENT EFFORTS

The Lake Huron Partnership actively works to ensure that management actions identified in this LAMP are complementary to several other international management efforts established under various binational treaties, agreements, and programs, and also work within the Lake Huron ecosystem.

Water Levels Management: The International Joint Commission provides oversight of water levels and flows in the Great Lakes, including the control structure in the St. Marys River. http://www.ijc.org/en_/Great_Lakes_Water_Quantity

Water Withdrawals Management: The Great Lakes–Saint Lawrence River Basin Sustainable Water Resources Agreement details how eight Great Lakes states and the provinces of Ontario and Quebec manage their water supplies. The Great Lakes-St. Lawrence River Basin Water Resources Compact is a legally binding interstate compact and a means to implement the governors' commitments.
http://www.glslregionalbody.org/index.aspx
http://www.glslcompactcouncil.org/

Fishery Management: The Great Lakes Fishery Commission (GLFC) facilitates cross-border cooperation to improve and preserve the fishery. The Lake Huron Committee is comprised of senior officials from state, provincial, and U.S. intertribal fishery agencies. The Committee is charged with collecting data, producing and interpreting science, and making recommendations. The Committee also develops shared fish community objectives, establishes appropriate stocking levels and harvest targets, sets law enforcement priorities, and formulates management plans.
http://www.glfc.org/lakecom/
http://www.glfc.org/lakecom/lhc/lhchome.php

ACTIVITIES THAT EVERYONE CAN TAKE

Public awareness and appreciation of water quality issues are important aspects of this LAMP. There are many opportunities to get involved in protecting Lake Huron water quality and ecosystem health.

Look for other '*Activities that Everyone Can Take'* information in the 'Actions' section of this LAMP; also refer to the Outreach and Engagement Chapter. Local watershed organizations also work to improve water quality - contact one near you to volunteer!

During the implementation of this LAMP, member agencies of the Lake Huron Partnership will assess the effectiveness of actions and adjust future actions to achieve the objectives of this plan, as outcomes and ecosystem processes become better understood.

The LAMP is intended for anyone interested in the Lake Huron ecosystem, its water quality, and the actions that will help restore this unique Great Lake.

Picturesque islands set within crystal waters provide important habitat and recreational opportunities (E. Perschbacher).

2.0 THE INHERENT VALUE, USE, AND ENJOYMENT OF LAKE HURON

Lakewide management is guided by a shared vision of a healthy, prosperous, and sustainable Great Lakes region in which the waters of Lake Huron are used and enjoyed by present and future generations.

The Lake Huron Partnership derives its vision for lakewide management from the Great Lakes Water Quality Agreement. The Lake Huron watershed is currently home to three million people (~1.4 million Ontarians and ~1.6 million Michiganders) and has been used and enjoyed for thousands of years. We continue to recognize the inherent natural, social, spiritual, and economic value of the Great Lakes Basin ecosystem. Sound management and use will benefit present and future generations.

The following text provides a brief cultural description of the earliest inhabitants, how resource use supports the regional economy, and how tourism and recreation - a growing part of the economy - is supported by the many parks and conservation areas within the watershed.

2.1 INDIGENOUS PEOPLE AND TRADITIONAL ECOLOGICAL KNOWLEDGE

The Anishinaabeg / Anishinabek people ("the Original People") have called the Lake Huron basin home for 15,000 years as evidenced by carbon-dating on Manitoulin Island (Mindo-mnising) and elsewhere. The shores, islands, and rivers acted as gateways that carried the Anishinaabeg / Anishinabek in all directions and provided a vast trading route and opportunities to hunt, trap, fish, and harvest plant materials for food, medicines, lodges, and canoes.

Spread across Michigan and Ontario, the Anishinaabeg / Anishinabek culture, traditions, and values link communities to the land and water. The people have served as caretakers of the land, water, plants, and animals of Lake Huron (Gichi-aazhoogami-gichigami – Great Crosswater Sea) and the St. Marys River (Gichigami-ziibe – Sea River). This role maintains traditional ways of life dependent upon species such as White Cedar (*Giizhik / Giizhig*), Northern Pike (*Ginoozhe / Ngnoozhe*), Whitefish (*Adikameg / Tikmeg*), Wild Rice (*Minoomin / Manomin*), Sweetgrass (*Weengush / Wiingush*), and the earth itself in the form of clay (*waabigan / waabgan*) for use in pottery.

Figure 2: Lake Huron Basin Indigenous Communities. (Bay Mills Indian Community, Great Lakes Indian Fish and Wildlife Commission, Saginaw Chippewa Tribe, http://sidait-atris.aadnc-aandc.gc.ca/atris_online/home-accueil-eng.aspx)

Anishinaabeg / Anishinabek embrace water as a living being. It lives in all living things, water is life itself, and water is the lifeblood of Mother Earth (Shkakami-kwe). Language and the original names of the lakes, rivers, and streams give great meaning to each community's culture, identity, and heritage.

The cultures and traditions of the indigenous people are dependent upon Traditional Ecological Knowledge. The term "traditional" refers to the knowledge gathered over time and the close relationship and contact between the Anishinaabeg / Anishinabek and the environment (Shkakami-kwe - Mother Earth). It is the kind of intimacy that comes from knowing a place profoundly, not just as scenery, but also as sustenance; knowledge is passed on with a sense of trust through generations.

To continue this relationship, indigenous people integrate modern and advanced science to ensure the health of the natural world. The sacred responsibility entrusted to the Anishinaabeg / Anishinabek is to look after the four elements: earth (land), water, air, and fire. The Anishinaabeg / Anishinabek believe that everything is connected and that shared resources do not belong to any one person or nation; rather, they are viewed as part of an interconnected web of life fundamental to the traditional ways of life that must be treated with the utmost respect and care *(Content by the Union of Ontario Indians and Lake Huron Partnership members representing U.S. Tribes).*

2.2 NATURAL RESOURCES AND THE REGIONAL ECONOMY

The abundant natural resources within Lake Huron and its watershed support a strong regional economy. Extensive water-based industries, commercial and recreational fishing, commercial shipping, mining, forestry, and agricultural operations are major employers and contributors to the economy, as described below.

Water Use and Water-based Industries: Lake Huron provides 1,461.51 million litres of freshwater per day (6,136.9 Mgal/day) to the public, agricultural, industrial, and thermoelectric power industries. Over 2.3 million people get their drinking water from Lake Huron - including communities outside of the Lake Huron watershed such as parts of Detroit, Michigan and London, Ontario. Hydroelectric generation stations on the St. Marys River generate 115 million watts of power (International Upper Great Lakes Study, 2012).

Commercial and Recreational Fishing: Lake Huron is the second major fish producing Great Lake with Whitefish, Walleye, Yellow Perch, Lake Trout, and Ciscoes comprising the foundation of the commercial fishery (Environmental Commissioner of Ontario, 2011). The 2014 harvest statistics for Ontario exceeded $4.6 million dollars (Ontario Commercial Fisheries Association, 2014). Michigan's 2015 commercial harvest exceeded $2.5 million dollars (U.S.) (T. Goniea, MDNR, pers. comm., 2016). In Canada, direct recreational fishing expenditures are highest for Lake Huron relative to other Great Lakes, totaling over $92 million (OMNRF, 2016). Saginaw Bay supports a world class recreational fishery valued in excess of $33 million (U.S.) per year (Fielder, et al. 2014).

Commercial Shipping: The St. Marys River is an industrial hub for manufacturing. The river and the Soo Locks provide U.S. and Canadian Lakers and Salties access to Great Lakes ports and eventual overseas destinations delivering approximately 79% of the iron ore mined in the United States (Kakela, 2013). Shipping ports including Goderich, Sarnia, Port Huron, Mackinaw City and Saginaw, each with a positive economic impact on Ontario and Michigan's commerce, contribute over 90,000 jobs and $13.4 billion (Can) to both economies (Chamber of Marine Commerce, 2011).

Mining: Salt, limestone and metal mines support many local economies (OMNDM, 2011; GLEAM, 2014). The world's largest limestone and salt mines are located in Rogers City, Michigan and Goderich, Ontario.

Forestry: The northern watersheds abound with forest resources that have made significant contributions to the establishment of communities and that generate economic benefits from lumber sales. One pulp and paper mill still operates at Espanola, Ontario.

Agriculture: Agriculture is an important business sector. The southern watersheds of Ontario and Michigan contain some of the most productive farmland in the basin. Approximately 800,000 hectares (1.98 million acres) of farmland are under production on 6,500 farms throughout Lambton, Huron and Bruce counties of southwestern Ontario. Annual total farm receipts amount to just over $2 billion (Can) (OMAFRA, pers. comm., 2016). In the Saginaw Bay and thumb region, there are approximately 1 million hectares (2.7 million acres) under production on 11,000 farms with the Bay, Genesee, Gratiot, Huron, Isabella, Lapeer, Saginaw, Sanilac, Shiawassee and Tuscola counties totaling roughly $76 million dollars (US) in total gross income (2012 Census of Agriculture; USDA-National Agricultural Statistics Service).

Aquaculture: Parts of Manitoulin Island, the North Channel, and Georgian Bay support a number of cage aquaculture operations growing

predominantly Rainbow Trout in Ontario waters. The 2015 production statistics indicate that approximately 4,500 tonnes of fish were produced with a farm-gate value of $23.2 million (Statistics Canada, 2016).

2.3 TOURISM AND RECREATION: PARKS, WILDLIFE REFUGES, AND CONSERVATION AREAS

Parks, wildlife refuges, and conservation areas provide opportunities for tourism and recreation, while also fostering connections with the unique places within the watershed. These areas also strengthen the resiliency of the watershed and the extraordinary diverse habitat and species found within it. Most of the nearshore waters now have established routes, known as "water trails", that provide spectacular opportunities to explore the coastline with kayaks, canoes, and other small watercraft. Despite Lake Huron's significant coastal and nearshore ecosystem, almost 82% of the shoreline is not protected. This highlights the importance of existing parks and protected areas as refuges for fish and wildlife and for the protection of biodiversity (Scott Parker, pers. comm., 2016).

The following information provides regional examples of the variety of protected areas along the shores of Lake Huron.

Southeast Shores: Few protected areas exist in the southern agricultural landscape of Ontario, making Provincial Parks like the Pinery, Point Farms, Inverhuron, and MacGregor Point important sanctuaries for rare and fragile savannahs, dunes, and vestiges of coastal wetlands. These shorelines contain some of the highest quality and longest freshwater sand beaches (e.g., Sauble Beach, Ontario) that attract residents and millions of tourists.

Sand beach and dune complex at Pinery Provincial Park, Ontario (Ausable Bayfield Conservation Authority).

Georgian Bay: On the Bruce Peninsula, 420 million year-old rock formations rise through the waters to form part of the Niagara Escarpment, one of the most prominent topographical features of southwest Georgian Bay. It is home to the Bruce Peninsula National Park and Fathom Five National Marine Park.

Crystal waters and trails provide connections to the ecology and geology of the Bruce Peninsula (G. Mayne).

Two of Canada's Biosphere Reserves are located in Georgian Bay, one on the Bruce Peninsula, and the other along the eastern Georgian Bay coast. They are recognized by the United Nations Educational Scientific and Cultural Organization as ecologically significant regions that strive to balance development and conservation.

The rugged landscape of eastern Georgian Bay and its 30,000 islands inspire tourists, artists, and nature lovers from far and near. The French River Provincial Park in north-eastern Georgian Bay protects a remarkable1,000 km (621 miles) of coastal and nearshore habitat; more than any protected area in the Great Lakes.

Scenic islands of eastern Georgian Bay (T. Morrissey).

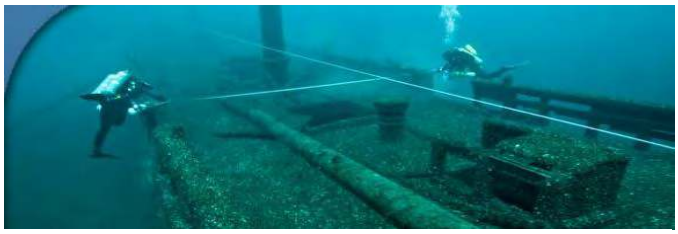
North Channel: Recognized as one of the best freshwater cruising grounds in the world, the North Channel features a vast number of uninhabited islands with sheltered anchorages, a natural fjord, and the world's largest freshwater island – Manitoulin Island.

The many islands of the North Channel provide critical habitat and recreational opportunities (OMNRF).

St. Marys River: This River is both a Great Lakes connecting channel and an international boundary water that separates Ontario and Michigan. It is a complex mix of riverine and lake-like reaches that has been modified to accommodate shipping. To the southwest, Michigan's Straits of Mackinac, Les Cheneaux island complex, and Upper Peninsula port towns and marinas provide harbours, sheltered channels and bays for excellent fishing, boating and exploring.

Aerial view showing the complexity of the St. Marys River.

Michigan's Western Shores: Michigan's coastline offers many opportunities for tourists and seasonal vacationers to explore Lake Huron. Thunder Bay National Marine Sanctuary was expanded to 4,300 square miles (11,000 km^2) in 2014 protecting one of America's best-preserved collections of 116 shipwrecks.



One of the 116 shipwrecks of the Thunder Bay National Marine Sanctuary (NOAA).

Huron National Forest: Roughly 450,336 acres (182,244 ha) of public lands extend across the northeastern part of Michigan. The Au Sable River meanders across the Forest, and crystal blue lakes dot the landscape providing recreation opportunities for visitors, habitat for fish and wildlife, and resources for local industry.

Saginaw Bay: Saginaw Bay is a shallow productive bay with 240 miles (386 km) of shoreline and abundant coastal wetlands that support a world class fishery (Fielder et. al, 2014). The Bay is designated a globally Important Bird Area for migratory waterfowl and shorebirds (MDEQ, 2012).

Saginaw Bay coastal wetlands provide critical habitat and form part of coastal trails (Saginaw Bay Water Trails).

Shiawassee Wildlife Refuge: More than 9,800 acres (4,000 ha) of marsh, bottomland hardwood forest, and grasslands are found in this Refuge. It is designated as a United States Important Bird Area for its global significance to migratory waterfowl. The Refuge's mission is to preserve and manage an undeveloped expanse of floodplain forest, marshes, rivers, and associated habitat within an agricultural and urban landscape through habitat management, encouraging public stewardship, educational programs, and private land activities.

Through sound management, Lake Huron and its watershed will continue to provide sustenance, employment, rejuvenation and inspiration to its residents and visitors.

3.0 A HEALTHY WATERSHED, A HEALTHY LAKE HURON

The Lake Huron watershed is the area of land that drains rain and snow into streams that flow into the lake. It is the largest watershed of all the Great Lakes. The water quality of Lake Huron depends on the health of its watershed.

Lake Huron's large watershed (118,000 km^2; 45,600 mi^2) and long residence time (22 years) makes it vulnerable to water quality impacts that can originate in its watershed.

This chapter begins with a brief description of the large volumes of water that move through the watershed including the St. Marys River. A "healthy watershed" is described to illustrate how water quality is maintained as water moves from the headwaters, through inland lakes and wetlands, and into the streams that flow to the lake. The chapter concludes by describing how a healthy watershed is critical to ensuring healthy coastal wetlands, nearshore, and offshore waters.

3.1 LAKE HURON WATER SOURCES AND FLOWS

Lake Huron is downstream of Lakes Superior and Michigan and upstream of Lake Erie. On average, it holds about 3540 cubic kilometers (850 cubic miles) of water, depending on the various flow into and out of the lake in a given year, as described below.

If you emptied the water in Lake Huron on to the land of its watershed, it would cover the land to a depth of over 25 meters (85 feet).

Each hour, approximately 8 billion litres of water (~ 2 billion gal) flow from Lake Superior through the St. Marys River. An additional 5.4 billion litres (~1.4 billion gal) of water flow from Lake Michigan through the Straits of Mackinac. Lakes Michigan and Huron have the same surface elevation, hydrologically making them the same body of water.

The watershed itself contributes about 10.4 billion litres of water (~2.7 billion gal) per hour to the lake. About half of the input is from water flowing over the land and into streams that empty into the lake. Rain and snow falling directly on the surface of the lake and groundwater sources contribute the other half.

Water leaves the lake through the various consumptive uses, evaporation and downstream flows. Every hour, about 4.3 billion litres (~1.1 billion gal) of water evaporate from the lake into the atmosphere. An additional 19 billion litres (~5 billion gal) of water per hour exits through the St. Clair River and eventually flows into Lake Erie (Great Lakes Atlas, 1995).

3.2 A HEALTHY WATERSHED

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

Headwaters and Uplands

Headwaters: Surface drainage features, groundwater seeps, and springs are the origin of streams and small watercourses that form the basis of ecological integrity of our watersheds.

Upland areas encompass the majority of the watershed land area and include both natural habitats and developed areas. Well-functioning uplands allow water to infiltrate into the soil, which minimizes stormwater run-off and reduces the probability of extreme flooding.

Headwaters of the Mad River in the Nottawasaga Valley, Ontario (Nottawasaga Valley Conservation Authority).

Forests: Remnants of Carolinian forest still exist in the southern-most subwatersheds and support the most diverse flora and fauna assemblage of the basin. Large tracts of Great Lakes St. Lawrence mixed-wood forest are found in parts of Michigan, and in Ontario on the Bruce Peninsula, Georgian Bay and in the northern watershed within the Canadian Shield. All Lake Huron forests and small woodlands provide habitat for wildlife, protection of source water, and important functions such as canopy shade that moderates stream temperature.

Extensive and intact mixed-wood forest of the North Channel help maintain water quality of the North Channel (G. Mayne).

Agricultural Lands: When responsibly farmed, agricultural lands use drainage systems that mimic natural conditions while still allowing for seedbed preparation and planting. The use of buffer strips, cover crops, grassed waterways, and two-stage ditches help to minimize soil erosion and flooding.

Responsibly farmed fields showing grassed waterways that slow water runoff and trap sediments and nutrients (ABCA).

Lake Plain Prairies: Much of the Great Lakes St. Lawrence mixed-wood plains have been converted to agriculture due to their rich soils. However, important vestiges of prairies are still found in the southern part of the watershed. The extensive root systems of trees, shrubs and plants of these plant communities lock soil particles together, helping to prevent soil erosion and water pollution. These sites also support a number of amphibian and reptile species as well as several species of grassland songbirds.

Coastal lake plain prairie near Alpena, Michigan (Michigan Sea Grant).

Alvars: This globally rare habitat is found in areas dominated by limestone geology, including the Bruce Peninsula, Manitoulin Island, and Drummond Island. Alvars are flat, nearly treeless areas of exposed limestone bedrock and shallow soils. In spring, alvars collect water in shallow pools and bedrock pockets, and some areas remain flooded for weeks. By summer, the soils are dry. A number of endemic species have evolved to survive only in this environment (Rescheke et al., 1999; Brownell and Riley, 2000).

One of the globally rare alvars found on the Bruce Peninsula (G. Mayne).

Urban Centers: Well-designed urban centers contain sufficient green space and green infrastructure to manage stormwater and minimize flooding. Green space refers to urban areas covered with grass or trees, such as parks, playing fields, community gardens, and cemeteries. Green infrastructure includes rain

gardens, permeable pavement, green roofs, and other stormwater management techniques that soak up, store and slow water. Projects big and small contribute to improved water quality.

Community rain garden in the village of Bayfield, Ontario as part of a green infrastructure project (ABCA).

Inland Lakes and Wetlands

Inland lakes and wetlands act as reservoirs that help to moderate the quantity of water moving through the watershed and remove excess nutrients and sediments otherwise released by severe storms.

Inland lakes: Lakes of all sizes are found throughout the watershed. The biggest inland lakes include Lake Simcoe in Ontario and Burt Lake in Michigan. Water levels in lakes rise with input from precipitation and gradually fall due to evaporation, flows to rivers and groundwater, and periods of drought.

Thousands of lakes dot the Lake Huron watershed like the sapphire waters of Killarney Provincial Park (G. Mayne).

Inland wetlands: Swamps, marshes, acidic bogs, and alkaline fens are all found within the watershed. These wetlands filter and absorb nutrients like phosphorus and nitrogen that can potentially stimulate algal blooms. Wetlands provide critical habitat, help to maintain water quality, slow water movement and minimize the impacts of flooding and pollution.

The Minesing Wetland is of international significance and is home to a diverse array of species (NVCA).

Streams

The 1,761 streams (1,334 Canada, 427 U.S.) throughout the watershed provide spawning habitat for one-third of Great Lakes fishes and allow movement between the headwaters and the lake (Liskauskas et al., 2007). In U.S. waters, over 10,000 km (6213.7 miles) of stream habitat were at one time accessible to Lake Huron fish; an even greater amount of streams habitat was available in Canada. Dams and barriers fragment and degrade river habitat and prevent fish migration; however, many northern streams continue to sustain stocks of Walleye, Pike, threatened Lake Sturgeon, and a tremendous biomass of Suckers.

The Moon River and basin of eastern Georgian Bay support critical spawning habitat (OMNRF).

Cold-water streams, such as the Au Sable River in northern Michigan and the Saugeen River in Ontario, are known world-wide as outstanding trout streams. Warm-water streams like the Ausable River in southwestern Ontario support as many as 26 species of freshwater mussels, up to 85 species of fish and several species of rare and endangered turtles (DFO, 2015).

Interconnected networks of springs, creeks, and streams contribute to biological diversity, water quantity, and quality of Lake Huron.

Coastal Shorelines

Lake Huron's coastal shorelines are renowned for their inspiring beauty. They are the place of greatest human interaction with the lake through recreational and commercial activities. Natural coastal systems are also the last line of defense for the lake, trapping pollution in water runoff before it enters the lake.

Human activities on the coastal shoreline have a direct effect on the lake.

The geology of the coast changes as you circle the lake. In the south, glacial deposits of sand, gravel and till predominate in coastal areas providing fine, white sand beaches. Limestone dominates much of the Bruce Peninsula, Manitoulin Island, the North Channel, and northern Michigan. Rocky shores associated with the Precambrian Shield extend across the eastern and northern shores of Georgian Bay and the North Channel. Natural and responsibly developed shorelines provide protection against erosion while also supporting water quality and ecosystem health.

A diverse mixture of cobble, sand, and dunes with adjacent forest cover on Christian Island, Ontario (G. Mayne).

3.3 HEALTHY WATERS OF THE ST. MARYS RIVER AND LAKE HURON

After water moves through the watershed, it flows into "the waters of Lake Huron". As described in the Agreement, the waters of Lake Huron include the St. Marys River and the interconnected zones of the lake: coastal wetlands, nearshore waters, and open waters. If pollution enters and mixes within these zones, it is nearly impossible to remove. A healthy watershed maintains the health of these waters.

The St. Marys River

The St. Marys River has a long and colourful history as an important Indigenous People gathering place, a center of French and British fur trading, and a 20th century hub for manufacturing. It is also a unique part of the aquatic ecosystem because of the large volume of water discharged (mean 2,140 m^3/s, 78,000 ft^3/s) through a relatively short river length (112 km, 80 mi).

The St. Marys River (M. Chambers).

The River includes three sections: a 22.5-km (14 mi) Lake Superior outlet section; a 1.2-km (0.75 mi) rapids section with facilities and channels for navigation, hydropower, water regulation, and an 88.3-km (55 mi) lower river section largely at Lake Huron elevation. The lower river has the morphology of a complex strait, with substantial water turnover. Narrow channels, broad and wide lakes, four large islands, and many small islands are present. The St. Marys River supports a diverse fish community and an intensive recreational, subsistence, and commercial fishery.

Coastal Wetlands

Lake Huron coastal wetlands represent 30% of those found in the Great Lakes. Wetlands link the open waters with the watershed. Georgian Bay and North Channel wetlands are rated among the most pristine of Great Lakes wetlands, and Saginaw Bay contains the largest freshwater coastal wetland system in the United States.

Coastal marshes (the predominant wetland type) provide nesting, resting, and feeding places for hundreds of thousands of migratory and nesting birdlife, including at least 30 species of shorebirds, 27 species of ducks, geese and swans, and several species of terns and gulls.

Over 40 species of rare plants and five rare reptile species are found in the coastal wetlands of Lake Huron. Fifty-nine species of fish are found in coastal wetlands. About 80% of Lake Huron fish species depend on coastal wetlands for some portion of their life cycles (Fracz and Chow-Fraser, 2013; Midwood et. al., 2015). Fish such as Northern Pike, Perch, Muskellunge, and Bowfin spawn in coastal wetlands.

Coastal wetlands are essential for supporting critical life stages of aquatic-dependent species.

Mississagi River delta illustrating riverine wetlands (OMNRF).

Nearshore Waters

The shallow nearshore waters are a highly-productive environment. Virtually all species of Great Lakes fish use nearshore waters for one or more critical life-stages or functions. As a result, the nearshore area hosts the highest diversity of fish species (Liskauskas et. al., 2007). The Agreement recognizes that nearshore waters must be restored and protected because urban and rural communities rely on this area for safe drinking water, recreational activities such as swimming, fishing and boating, and water withdrawals for industry and power generation. The nearshore is the hydrological and ecological link between watersheds and the open waters.

The quality of the shallow waters is primarily determined by land use. A sustainable and prosperous Great Lakes economy is dependent upon a healthy nearshore ecosystem.

Open Waters

When the open waters of Lake Huron are healthy, they support a robust and resilient fishery. Prior to the introduction of invasive species in the early 1900s, the deep waters of Lake Huron were dominated by Lake Trout, Lake Whitefish, and Burbot. The preyfish base was dominated by Cisco (or Lake Herring) and a number of other Deepwater Ciscos including the Bloater, with Sculpins, Lake Whitefish and Round Whitefish contributing to a lesser extent (Lake Huron Action Plan, 2008).

Deep waters of Georgian Bay framed by the Niagara Escarpment on the Bruce Peninsula (G. Mayne).

Ongoing changes to the Lake Huron food web present new challenges for resource managers. Ecological changes that formerly occurred over decades have happened in just a few years. Many questions remain unanswered, and researchers continue to monitor Lake Huron in an effort to understand this dynamic system. Because these changes are profound, developing actions are a priority for member agencies of the Lake Huron Partnership. Current management goals involve maintaining a sustainable predator-prey balance with approaches that include monitoring fish community population trends, with consideration of the effects of several non-native fish species.

4.0 STATE OF LAKE HURON

Lake Huron is in "fair" condition. Chemical contaminants, nutrient and bacterial pollution, loss of habitat and native species, and the spread of non-native invasive species limit the health, productivity, and use of Lake Huron and the St. Marys River.

The U.S. and Canada have made significant progress toward restoring and maintaining water quality of Lake Huron and the St. Marys River since first signing the Agreement in 1972. Over the past four decades, management agencies and the public have worked to reduce chemical contamination, protect habitats and native species, and rehabilitate degraded areas, resulting in a cleaner, healthier Lake Huron.

This chapter informs the public and resource managers about the current condition and ongoing threats to water quality, habitats and native species. Many sources of information were used to inform this assessment including, but not limited to, the following:

- State of Great Lakes Indicator Reports (SOGL 2016);
- Proceedings from 2015 State of Lake Huron Meeting (LimnoTech, 2015);
- Lake Huron Binational Cooperative Science and Monitoring Synthesis (LimnoTech, 2015);
- The State of Lake Huron in 2010 report by the Great Lakes Fishery Commission - Lake Huron Technical Committee;
- *The Sweetwater Sea: An International Biodiversity Conservation Strategy for Lake Huron* (Franks Taylor et al., 2010); and
- Literature reviews and information from scientists and resource managers.

Information is organized by each of the nine General Objectives of the Agreement (Table 2). Each section includes background information and methods used to determine the current status and trends. A discussion using supporting data and science-based indicators is provided along with an assessment of threats. Given that water quality is influenced by localized land use, the LAMP identifies current environmental threats by seven major regions around the Lake Huron watershed (Figure 3).

Table 2. The General Objectives of the 2012 Agreement.

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

Figure 3. Geographic regions of Lake Huron.

This is the first state of Lake Huron assessment under the 2012 Agreement. In 2017, the Lake Huron Partnership agencies will develop Lake Ecosystem Objectives (LEOs) for use as binational targets towards achieving the long-term vision of the General Objectives, and for use in assessing the condition of Lake Huron in future Lake Huron LAMPs.

4.1 BE A SOURCE OF SAFE, HIGH QUALITY DRINKING WATER

Lake Huron continues to be a safe, high-quality source of water for public drinking water systems.

4.1.1 BACKGROUND

Protecting drinking water and water resources from harmful pollutants is a priority for all levels of government and a shared responsibility involving many partners and communities.

Over 2.3 million people get their drinking water from Lake Huron.

4.1.2 HOW IS DRINKING WATER MONITORED?

The Ontario Ministry of Environment and Climate Change and the Michigan Department of Environmental Quality require municipal drinking water systems (treated water) to be regularly tested for many contaminants including inorganic (arsenic, cadmium, lead), organic (benzene, perchloroethylene, nitrilotriacetic acids, certain pesticides and PCBs) and radiological parameters (tritium and other radiological compounds).

For more information on the Ontario and Michigan drinking water programs, see:
www.ontario.ca/page/drinking-water
www.michigan.gov/drinkingwater

4.1.3 STATUS

When Lake Huron is used as a source of water, the status of municipal treated drinking water quality within the Great Lakes Basin is in 'good' condition with an 'unchanging' trend for the years 2007 to 2014 (SOGL, 2016).

4.1.4 DATA DISCUSSION

Ontario's regulated treatment systems provide high quality drinking water to its residents. Drinking water test results for selected parameters met Ontario Drinking Water Standards nearly 100% of the time in recent years. In 2014-15, 99.8% of 533,457 treated drinking water test results from municipal residential drinking water systems met Ontario's drinking water quality standards (ODWQS, 2016; OMOECC, 2015).

From 2012 – 2014, over 95% of the total population within the Great Lakes states received treated drinking water from water supply systems that were in compliance and met health-based drinking water quality standards (SOGL, 2016). Over 2.3 million Michiganders and Ontarians get their drinking water from Lake Huron - including communities as far away as Detroit and London.

4.1.5 THREATS

Lake Huron provides a safe source of treated drinking water. Potential threats include: over application of fertilizers, manure and pesticides that can enter groundwater and surface water; stormwater and wastewater sources, especially during and after extreme storm events; faulty septic systems that leach bacteria; emerging chemicals of concern, and chemical spills within the watershed and directly to Lake Huron. Continued progress toward addressing these issues will help to protect Lake Huron water quality and its use as a source of drinking water.

4.1.6 IMPACTED AREAS

There are currently no areas within the waters of Lake Huron that have significant drinking water impacts.

4.1.7 LINKS TO ACTIONS THAT SUPPORT THIS GENERAL OBJECTIVE

No specific actions other than ongoing monitoring and reporting by the state of Michigan and the province of Ontario are required to meet this General Objective. Actions that will continue to help protect Lake Huron as a source of drinking water can be found under *Chemical Contaminants* (5.1), *Nutrients and Bacterial Pollution* (5.2), and *Climate Change Impacts* (5.5).

4.2 ALLOW FOR SWIMMING AND OTHER RECREATIONAL USE, UNRESTRICTED BY ENVIRONMENTAL QUALITY CONCERNS

Most Lake Huron beaches offer safe and high-quality swimming and recreational opportunities. Some of the longest freshwater beaches are found in Lake Huron.

4.2.1 BACKGROUND

Beaches are a great place for recreation and relaxation and, if managed properly, provide many ecosystem services. They help create our sense of place, form part of our community personality, drive local economies and provide for a healthy active lifestyle. Beaches are also part of a dynamic ecosystem that can quickly change depending on localized wave energy, wind, currents, rainfall and inputs of pollutants.

4.2.2 HOW IS BEACH HEALTH MONITORED?

Water quality monitoring is conducted by county health departments (Michigan) and county health units (Ontario) at select beaches to detect bacteria that indicate the presence of disease-causing microbes (pathogens) from fecal pollution. Based on the number of *E. coli* forming units (cfu) in the water (100 cfu/100 millilitre in Canada, 300 cfu/100 millilitre of water in Michigan), and an assessment of environmental factors, health agencies may post swim advisories. Beach health for a given swimming season (Memorial/Victoria Day weekend to Labour Day) is evaluated differently in the U.S. and Canada as shown in Table 3 (SOGL, 2016).

Table 3. Canada and U.S. beach health measures based on the percentage of days within a swimming season that monitored beaches are open and safe.

TARGET	CANADA	U.S.
Good	80% or more	90%
Fair	70-79,9%	80-90%
Poor	< 70%	< 80%

4.2.3 STATUS

Lake Huron beaches are in 'good' condition and allow for safe swimming and other recreational uses unrestricted from environmental concerns for the majority of the swimming season. During 2011 through 2014, the trend was 'unchanging' in the U.S. and Canada (Huron County Health Unit, 2015; SOGL, 2016).

One of the many high quality beaches on the southeast shores (ABCA).

4.2.4 DATA DISCUSSION

During the swimming seasons from 2011 to 2014, monitored beaches were open and safe for swimming 82% of the time in Ontario and 99% of the time in Michigan (SOGL, 2016). A total of 53 Michigan beaches were monitored in 2015, 28 of which had elevated counts of *E. coli* a total of 60 times throughout the season. This resulted in 48 actions (advisories or closures) at beaches (MDEQ, 2016).

4.2.5 THREATS

Many monitored beaches of Lake Huron are safe for swimming and recreational use throughout most of the swimming season. Threats to beach health exist and water quality can change hourly or daily depending on several human and natural factors. In rural areas, field drains and rivers can transport *E. coli* to the lake from agricultural lands treated with manure. In urban settings, faulty septic systems and stormwater runoff from roads, roofs, construction sites and parking lots can carry bacterial contamination to local beaches.

Climate change brings more frequent and intense rain events that have resulted in large pulses of stormwater runoff events and inputs from combined sewer overflows and sanitary sewer overflows. Beaches found within protected embayments or adjacent to groynes (groins U.S.) and jetties (e.g., Goderich, ON) are more susceptible to bacterial pollution due to poor water circulation and exchange with the open water system (Huron County Health Unit, 2016).

Given the dynamic nature of beach environments and natural influences, it is unlikely that beaches will remain open 100% of the time. Many natural factors that influence beach water quality exist, including:

- Wave height;
- Water clarity;
- Amount of rainfall;
- Solar radiation;
- Water temperature;
- Wind speed and direction;
- Lake water level;
- Shape/contour of coastline;
- Flocks of waterfowl and gulls; and
- Environmentally adapted strains of *E. coli* in beach sand (Huron County Health Unit, 2016).

4.2.6 IMPACTED AREAS

Regions and beaches identified as vulnerable to bacterial contamination are described in Table 4.

4.2.7 LINKS TO ACTIONS THAT SUPPORT THIS GENERAL OBJECTIVE

Actions that address beach health and advance achievement of this General Objective can be found in Chapter 5.2 under *Nutrients and Bacterial Pollution*. Actions under *Loss of Habitat and Native Species* (5.3) and *Climate Change Impacts* (5.5) may also indirectly help to minimize bacterial contamination at beaches.

Table 4. Beach health related issues in the regions of Lake Huron.

LAKE HURON REGIONS	BEACH HEALTH RELATED ISSUES
Main Basin	• Covered in regional summaries below
St. Marys River	• The U.S. recently delisted the beach closings Beneficial Use Impairment (BUI) and a preliminary evaluation suggests BUI removal would be appropriate on the Canadian side • *E. coli* levels occur primarily in waters downstream of storm sewers. • Stormwater runoff entering small creeks, rivers and drains that pass through areas with higher concentrations of farming
North Channel/ Manitoulin Island	• Lack of information to determine local environmental threats to beach water quality
Georgian Bay	• Eastern Georgian Bay: Development pressure with potential septic inputs and black water discharges from power/touring boats. Periodic reports of cyanobacteria blooms • Southern Georgian Bay: Nottawasaga River plume and stormwater runoff from the agricultural-based watersheds of Nottawasaga Bay and Severn Sound • Inputs from household septics
Ontario's Southeastern Shores	• Stormwater runoff entering small creeks, rivers and drains from dense agricultural sectors (e.g., Huron County) • Inputs from household septics • Poor circulation due to shoreline shape and piers extending into the lake • Huron County: deteriorating beach water quality since 2013 for Black's Point, Goderich Main, Goderich St. Christopher's, Goderich Rotary Cove and St. Joseph's Beach (Huron County Health Report, 2015)
Saginaw Bay	• Stormwater from small creeks, rivers and drains from rural and urban areas • Inputs from household septics
Michigan's Western Shores	• Stormwater from small creeks, rivers and drains from rural and urban areas • Inputs from household septics

4.3 ALLOW FOR HUMAN CONSUMPTION OF FISH AND WILDLIFE UNRESTRICTED BY CONCERNS DUE TO HARMFUL POLLUTANTS

Lake Huron fish and wildlife are a nutritious food source, but should be consumed responsibly as chemical contaminants still trigger consumption advisories.

4.3.1 BACKGROUND

Commercial and sport fishing and hunting are popular and economically important activities. Yet, concentrations of mercury, PCBs, and dioxins/furans drive the majority of fish consumption advisories for large fish in Lake Huron (MDEQ, 2015; OMOECC 2015). Mercury is a naturally occurring metal found in the environment. It is used in numerous human applications and is released into the atmosphere when fossil fuels are burned. Polychlorinated biphenyls (PCBs) are a group of chlorinated organic compounds created in the late 1920s and banned in 1977. Dioxins and furans are unintentional by-products of several industrial processes and, in some cases, incomplete combustion. These and other toxic contaminants can persist in the environment and increase in concentration in living organisms (bioaccumulate) with each step of the foodweb (biomagnify).

4.3.2 HOW ARE FISH AND WILDLIFE CONTAMINANTS MONITORED?

Canadian and U.S. agencies monitor persistent, bioaccumulative and toxic compounds in edible portions of fish to determine potential risk to human health through fish consumption. Consumption advice is issued by the state of Michigan, tribes and the province of Ontario in efforts to avoid impacts of harmful pollutants found in some fish and wildlife in some areas. For fish and wildlife advisory information, visit:

www.michigan.gov/eatsafefish
www.ontario.ca/document/guide-eating-ontario-fish

4.3.3 STATUS

Contaminants in the edible portions of fish continue to drive fish consumption advisories. Its current status is 'fair' with an 'unchanging' trend in recent years (SOGL, 2016).

4.3.4 DATA DISCUSSION

In Ontario waters, PCB concentrations have decreased (by 44% to 81%) since the 1970s in Chinook Salmon, Lake Trout, Lake Whitefish and Walleye; however, concentrations can trigger consumption advisories. Mercury concentrations have also declined by up to 45% in some sportfish and are mostly below the "do not eat" advisory level for women of childbearing age and children (Figure 4) (OMOECC, 2015).

Fish from Michigan waters show declines of roughly 6% per year in PCB concentrations in Carp and Walleye from Saginaw Bay, as well as Walleye and Lake Trout from Thunder Bay.

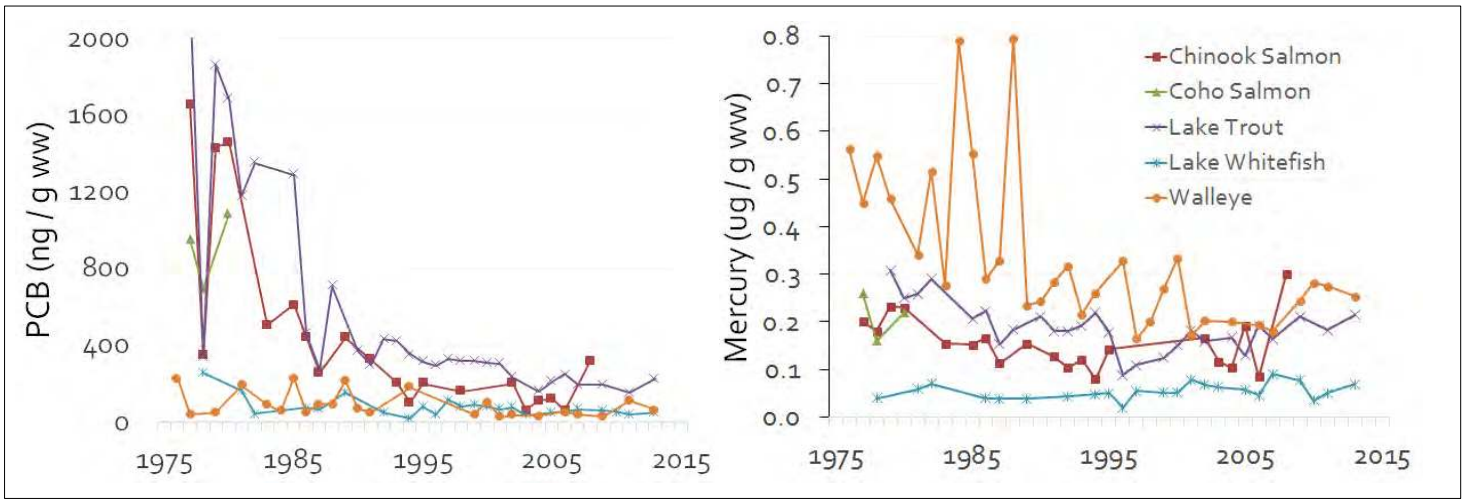


Figure 4. Concentrations of PCB and mercury for fish collected from Ontario waters of Lake Huron. Length of fish used: 55-65 cm for Chinook and Coho Salmon and Lake Trout; 45-55 cm for Lake Whitefish and Walleye (OMOECC, 2015).

Dioxins are also slowly declining in Saginaw Bay Carp (3%/year) and in Thunder Bay Lake Trout (5%/year). Mercury in U.S. fish populations is variable (MDEQ, 2015).

Dioxins, furans and dioxin-like PCBs in the floodplain of the Tittabawassee River and Saginaw River have prompted Michigan to issue wildlife (duck, deer, goose, rabbit, squirrel, and turkey) consumption guidelines.

Concentrations of flame retardants (PFOS) are declining in whole fish from U.S. waters. Michigan's Department of Health and Human Services has issued 'Eat Safe Guidelines' for PFOS contaminated fish.

4.3.5 THREATS

Several decades of environmental programs have significantly reduced the threat of chemical releases into the environment. Atmospheric deposition, contaminated sediments, and localized groundwater contamination represent localized sources of contaminants to fish and wildlife. Other potential sources of chemical contaminants include industrial spills to surface waters. Agencies are also tracking new contaminants that are components of personal care products and pharmaceuticals.

4.3.6 IMPACTED AREAS

Areas of localized sediment contamination are found in the St. Marys River (Ontario), Saginaw Bay and River, and the Spanish Harbour. Groundwater contamination at Oscoda, MI represents a source of PFOS to migratory fish that enter Lake Huron.

4.3.7 LINKS TO ACTIONS THAT SUPPORT THIS GENERAL OBJECTIVE

Actions that address contaminants in fish and wildlife to achieve this General Objective are found in Chapter 5.1 under *Chemical Contaminants*.

Table 5. Fish and wildlife consumption related issues in the regions of Lake Huron.

LAKE HURON REGIONS	FISH AND WILDLIFE CONSUMPTION RELATED ISSUES
Main Basin	• Atmospheric deposition and bottom sediments continue to be a source of contaminants • Food web changes due to invasive species can alter contaminant fate, exposure, bioaccumulation rate and pathways with potential negative impacts to fish consumers
St. Marys River	• Improving conditions in the St. Marys River Area of Concern have led to U.S. and Canadian authorities reassessing the status of fish consumption advisories as a Beneficial Use Impairment in the Area of Concern • Canada: contaminated sediments remain a focus. A sediment management plan is under development
North Channel/ Manitoulin Island	• Existing sources of sediment contamination in the Spanish Harbour Area of Concern in Recovery.. Advisories are most restrictive for bottom feeding White Sucker, and less so for Walleye and Northern Pike
Georgian Bay	• No known localized sources of contaminants of human origin identified that trigger fish consumption advisories
Ontario's Southeastern Shores	• No known localized sources of contaminants of human origin identified that trigger fish consumption advisories
Saginaw Bay	• Dioxin levels (total TEQs) above fish consumption guidelines in the Area of Concern • Dioxins in the floodplain soils of the Tittabawassee River and Saginaw Rivers have prompted Michigan to issue fish and wildlife (duck, deer, goose, rabbit, squirrel, and turkey) consumption guidelines
Michigan's Western Shores	• In the Au Sable River, groundwater contaminated with perfluorinated chemicals is triggering PFOS fish consumption guidelines

4.4 BE FREE FROM POLLUTANTS IN QUANTITIES OR CONCENTRATIONS THAT COULD BE HARMFUL TO HUMAN HEALTH, WILDLIFE OR ORGANISMS THROUGH DIRECT OR INDIRECT EXPOSURE THROUGH THE FOOD CHAIN

Many legacy chemical contaminant levels have decreased. Over the last decade the rate of decline has slowed. New classes of chemicals comprise the majority of the remaining contaminant burden measured in Lake Huron organisms.

4.4.1 BACKGROUND

Some chemicals have the potential to impact the health of humans and wildlife due to their ability to persist and bioaccumulate in the environment. Government programs have significantly reduced the level of contamination in the Great Lakes, but sources of contamination remain in the Lake Huron watershed.

4.4.2 HOW ARE CHEMICAL CONTAMINANTS MONITORED?

Long-term (> 25 years), basin-wide contaminant surveillance and monitoring programs are conducted by Environment and Climate Change Canada (ECCC) and the U.S. Environmental Protection Agency (USEPA). These programs are augmented by state, provincial, tribal, and First Nations and academic contaminant science and monitoring programs. Chemical contaminants are monitored in open water, air, sediments, whole fish and Herring Gull eggs.

4.4.3 STATUS

The overall status for chemical concentrations found in the air, water, sediment, fish and wildlife of Lake Huron range from 'fair' to 'excellent' (SOGL, 2016). Chemical contaminant concentrations have generally decreased in all environmental media since the 1970s, and the trend in recent years appears to be 'improving' or 'unchanging' (Table 6; SOGL, 2016).

The tissues of some fish and wildlife can contain chemical concentrations at levels that pose a human health risk. There is no evidence that the reproductive health of the Lake Huron fishery is impacted by chemical contaminants. The "bird or animal deformities or reproduction problems" is currently a beneficial use impairment in the Saginaw Bay Area of Concern (AOC).

Table 6. Chemical contaminants status and trends.

INDICATOR	STATUS	TREND
Chemical Concentrations in Open Water	EXCELLENT	UNCHANGING
Atmospheric Deposition of Chemicals	FAIR	IMPROVING
Chemicals in Sediments	GOOD	UNCHANGING
Chemicals in Whole Fish	FAIR	UNCHANGING
Chemicals in Fish Eating Birds	GOOD	IMPROVING

4.4.4 DATA DISCUSSION

Open Water Contaminants

The current status of open water chemical contaminants is rated as 'excellent' with an 'unchanging' trend over time (SOGL, 2016). Lake Huron has one of the lowest levels of chemical contamination (open water) due to fewer industrial point sources.

Concentrations of PCBs are highest in Saginaw Bay. Concentrations in the main basin are low and decline from south to north. Mercury and several other legacy organochlorine pesticides show declining trends within the main basin (2004 to 2015). Polycyclic aromatic hydrocarbons (PAHs) are found in the St. Marys River and there is evidence of increasing levels in Georgian Bay, possibly due to boat traffic (SOGL, 2016).

Atmospheric Contaminants

The overall Great Lakes assessment of atmospheric deposition of toxic chemicals is 'fair' and 'improving' (SOGL, 2016).

Long term (1992 and 2012) air contaminant monitoring data show a slow, but decreasing trend for PCBs (half-lives of 9–39 years) suggesting a steady state with existing PCB-containing material in the Great Lakes basin. Organochlorine pesticides are declining; however, historical applications of some pesticides on surrounding agricultural cropland, including DDT, dieldrin, hexachlorocyclohexane and endosulfan (phased out in the U.S. and Canada in 2016), are ongoing sources (Shunthirasingham et al., 2016).

Sarnia, Ontario, located at the tip of Lake Huron, where approximately 40% of Canada's petrochemical industry is concentrated (Great Lakes Environmental Justice).

Sediment Contaminants

Sediment contaminant concentrations in the main basin are very low and therefore rated in 'good' condition with an 'unchanging' trend over time (SOGL, 2016). However, localized areas of sediment contamination exist, particularly in Saginaw Bay, Spanish Harbour and Canadian portions of the St. Marys River.

Contaminants in Whole Fish

The current status of contaminants in whole fish is assessed as 'fair', and this condition remains 'unchanged' over a 15 year period (1999-2013) (SOGL, 2016).

Total PCB concentrations in top predator fish such as Lake Trout have declined. Total mercury concentrations in fish declined throughout the 1970s and early 1980s but have shown large variability in recent years, likely due to the significant food web changes in Lake Huron, slower growth rates in fish, and the use of older fish in pooled samples used for contaminant analysis by the USEPA (Figure 5).

Polybrominated diphenyl ether (PBDE) concentrations in Lake Trout and Smelt increased during the early- to mid-1990s (Batterman et al., 2007), peaked in the mid-2000s, but show a slight decline in recent years (SOLEC, 2011). Perfluorooctane sulfonate (PFOS) concentrations are variable depending on sampling locations. They are generally above the Canadian Federal Environmental Quality Guidelines (FEQG) for mammalian diet of 4.6 ng/g ww in all five Great Lakes (2004-2013).

There is increasing interest in per- and polyfluoroalkyl substances (PFAS) given their wide use and persistence in the environment. PFAS has been detected in Lake Huron at levels comparable to PFOS (Figure 6) (De Silva et al., 2011).

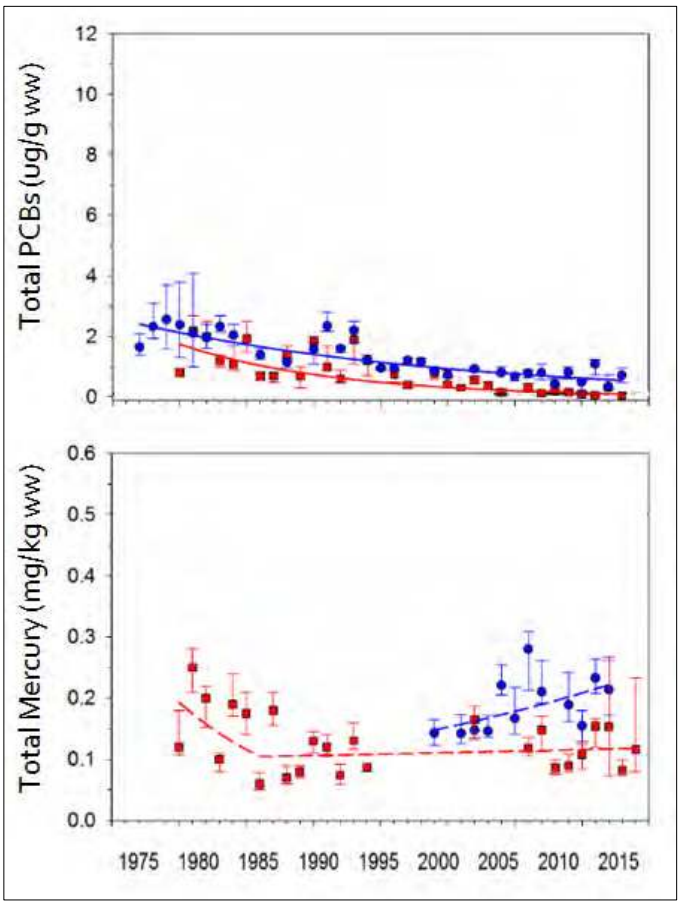


Figure 5.Total PCB and mercury concentrations in Lake Huron Lake Trout. ECCC data in red and USEPA data in blue.

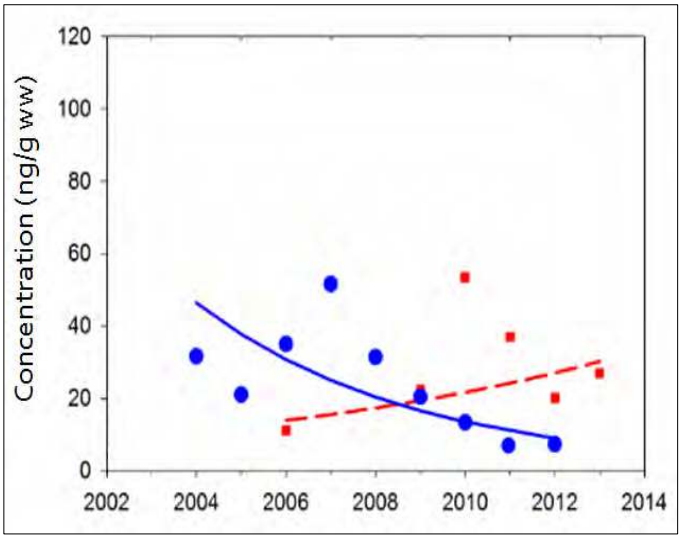


Figure 6. Mean PFOS concentrations for whole body Lake Huron Lake Trout (ECCC (red) and the USEPA (blue)).

Contaminants in Fish-Eating Birds

The current status of toxic contaminants in Herring Gull eggs is assessed as 'good' and 'improving' (1999-2013) (SOGL, 2016).

Legacy contaminant concentrations of PCBs (Figure 7), and dioxins (2,3,7,8-TCDD) (Figure 8) measured in Herring Gull eggs have decreased since the 1970s but have stabilized in recent years. Eggs collected from Double Island (North Channel) and Chantry Island (Lake Huron) show similar dioxin concentrations, and higher concentrations are found at Channel Shelter Island (Saginaw Bay) (de Solla et al., 2016).

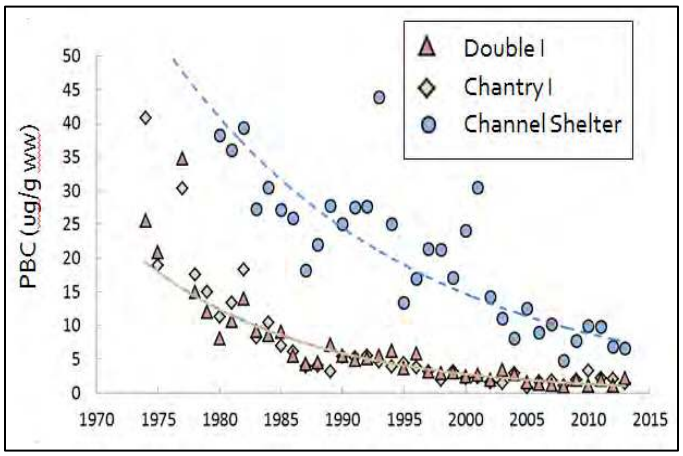


Figure 7. Trend in PCB concentrations in Lake Huron Herring Gull eggs (de Solla, 2016).

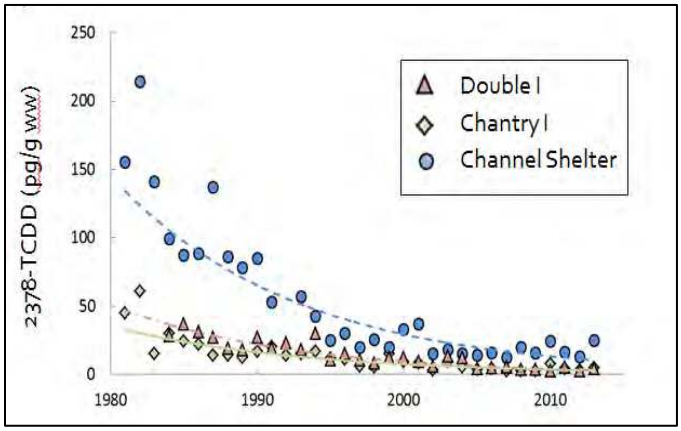


Figure 8. Trend in dioxin (2378-TCDD) concentrations in Lake Huron Herring Gull eggs (de Solla, 2016).

In contrast, egg concentrations of the flame retardant Dechlorane Plus (Σ2DDC-CO) have increased between 2008 and 2012, with the highest concentrations found in eggs from Five Mile Island located in the upper St. Marys River (data not shown, Su et al., 2015).

Dioxin, PCBs, and mercury in Herring Gull and Double-crested Cormorant eggs collected from colonies near the Spanish Harbour Area of Concern in Recovery in 2011 and 2012 were low and considered to be below levels associated with adverse effects (Hughes et al., 2014b). Reproduction and development for Herring Gulls and Common Terns breeding within the St. Marys River AOC are not associated with health impacts (data not shown, Hughes et al., 2014a).

4.4.5 THREATS

Chemical contaminant trends show a general decreasing trend, yet atmospheric deposition of chemicals like metals and PAHs is an ongoing source of chemicals. Contaminated sediments represent a pollutant sink and potential source of toxic substances through resuspension and redistribution. Legacy contaminants persist in Lake Huron, and flame retardants, current-use pesticides, and pharmaceuticals and personal care products represent future stressors.

Spills from land-based industry, shipping, and oil transportation infrastructure are a potential source of chemical contaminants. The impacts of climate change may affect the use, release, transport and fate of chemicals, potentially contributing to human and environment impacts (Chang et al., 2012).

4.4.6 IMPACTED AREAS

Localized sediment contamination are found in Canadian portions of the St. Marys River, Saginaw Bay and River, and Spanish Harbour. These areas represent sources of PCBs, mercury, dioxins and PAHs. Elevated dioxin and furan levels (byproducts from the manufacture of chlorine-based products) are found along the Tittabawassee River and downstream at sites within the Saginaw River and Bay.

4.4.7 LINKS TO ACTIONS THAT SUPPORT THIS GENERAL OBJECTIVE

Actions that address chemical contaminants and advance achievement of this General Objective can be found in Chapter 5.1 under *Chemical Contaminants*. Actions that address non-point sources of pollutants can be found in *Nutrients and Bacterial Pollution* (5.2), and *Climate Change Impacts* (5.5) may also indirectly help to minimize chemical exposure and effects to humans and wildlife.

Table 7. Chemical contaminant related issues in the regions of Lake Huron.

LAKE HURON REGIONS	CHEMICAL CONTAMINANT RELATED ISSUES
Main Basin	• Atmospheric deposition and large urban centers contribute contaminant sources • Food web changes due to invasive species can alter contaminant fate, exposure, bioaccumulation rate and pathways with potential negative impacts to aquatic organisms and fish consumers
St. Marys River	• Canada: Sediment contamination of PAHs and the health impacts on fish is a current management focus for the Area of Concern • U.S.: All actions to address known sites of contaminated sediment are complete on the U.S. side of the St. Marys River Area of Concern
North Channel/ Manitoulin Island	• Concentrations of dioxins and furans are above the Ontario provincial sediment quality guidelines in the Spanish Harbour Area of Concern in Recovery and the Whalesback Channel (SOGL, 2016). Monitoring is underway to track recovery • Elevated sediment concentrations of PBDE (Guo, 2016)
Georgian Bay	• Low but increasing PAHs in Georgian Bay (driven by naphthalene concentrations), possibly due to heavy recreational boat traffic
Ontario's Southeastern Shores	• No known localized sources of chemical contaminants of human origin that are harmful to human and wildlife health
Saginaw Bay	• Contaminants include dioxins, furans, PCBs, metals • Dioxin-contaminated sediment in the floodplain of the Tittabawassee and Saginaw Rivers • Elevated sediment concentrations for PBDE and BDE in Lake Huron (Guo, 2016) • "Bird or animal deformities or reproduction problems" and "Restrictions on fish and wildlife consumption" Beneficial Use Impairments have not been removed
Michigan's Western Shores	• Contaminated groundwater is a source of perfluorinated chemicals from use of flame retardants at the former Wurtsmith Air Force Base in Oscoda, MI

4.5 SUPPORT HEALTHY AND PRODUCTIVE WETLANDS AND OTHER HABITAT TO SUSTAIN RESILIENT POPULATIONS OF NATIVE SPECIES

Lake Huron's habitats and species are in fair condition. Continued loss and deterioration of habitats, spread of invasive species, climate change impacts and pollution are of concern.

4.5.1 BACKGROUND

Lake Huron's geological past provides a setting for a high level of diversity in its natural environment, including: the southern glacial till (deposits of clay, sand and gravel); the Niagara Escarpment, or 'Great Arc' of limestone extending through the Bruce Peninsula, Manitoulin Island and Michigan's Upper Peninsula; and the northern Precambrian Shield. The open lake ecosystem, coastal wetlands, islands, rocky shorelines, sand and cobble beaches, dunes, alvars, and the hundreds of interconnected streams and their headwaters provide the essentials of life for a multitude of species.

4.5.2 HOW IS HABITAT AND NATIVE SPECIES HEALTH MEASURED?

The Lake Huron Biodiversity Conservation Strategy provided a health assessment of seven conservation features that represent the lake's biological health (Franks Taylor et al., 2010). Updated and revised *State of the Great Lakes Ecosystem* indicator reports provide recent information on status and trends (SOGL, 2016). A coastal wetland science synthesis amalgamates several information sources to provide a comprehensive assessment for Lake Huron (Ciborowski et al., 2015). Several indicator assessment reports from the '2016 State of the Great Lakes' series are used in this assessment, as are submissions from various scientists and members of the Lake Huron Technical Committee.

BIOLOGICAL DIVERSITY

Biodiversity refers to the variety of life, as expressed through genes, species and ecosystems, and is shaped by ecological and evolutionary processes.

4.5.3 STATUS

As summarized in Table 8, the overall condition of Lake Huron's habitats and species (its ***biological diversity***) is 'fair', and the trend has remained constant since the 2010 evaluation (Franks Taylor et al., 2010; SOGL, 2016).

Table 8. A summary of the Lake Huron status and trends for habitat and species by State of Great Lake indicator and other data (SOGL, 2016).

FEATURE	INDICATOR	STATUS	TREND
Coastal Wetlands	Plants	FAIR-GOOD	DETERIORATING
	Fish	FAIR	IMPROVING
	Birds	GOOD	UNCHANGING
Native Migratory Fish	Lake Sturgeon	POOR	IMPROVING
Native Migratory Fish Open Water	Walleye	FAIR-GOOD	UNCHANGING
	Aquatic Habitat Connectivity	POOR	IMPROVING
	Open Water (Total Phosphorus)	FAIR	NEEDS FURTHER ASSESSMENT
Open Water Aerial Migrants	Phyto-plankton	FAIR	DETERIORATING
	Zooplankton	FAIR	UNCHANGING
	Diporeia	POOR	DETERIORATING
	Preyfish	FAIR	UNDETERMINED
	Lake Trout	GOOD	IMPROVING
	Lake Whitefish	POOR	NEEDS FURTHER ASSESSMENT
	Ciscoes	UNDETERMINED	UNDETERMINED
	Colonial Nesting Waterbirds	FAIR	UNCHANGING
OVERALL ASSESSMENT		FAIR	MIXED

4.5.4 DATA DISCUSSION

This section reports on the status and trends of several habitat types and the native species that depend upon them. It begins with an assessment of coastal wetlands given the essential role they play in maintaining the health of the aquatic ecosystem. Nearshore areas are discussed given the current management focus for restoration and protection and the ecological connection between the watershed and the open waters. The open water ecosystem is explained using a bottom-up approach (open water nutrients, plankton to top predators) to illustrate the interconnection within the aquatic food web. We also include colonial fish-eating waterbirds in this assessment as they serve as sentinels of aquatic ecosystem health.

Coastal Wetlands

Lake Huron coastal wetlands account for roughly 64,641 ha (159,663 acres), almost 30% of the total wetland area for all five Great Lakes (Chow-Fraser, 2008). More than 3700 coastal wetlands (17,350 hectares; 42,873 acres) are found along the eastern Georgian Bay coast (Fracz and Chow-Fraser, 2013), and the St. Marys River contains approximately 10,790 ha (26,663 acres).

A synthesis of 157 wetlands sampled in 30 quaternary watersheds using several U.S. and Canadian datasets provides a comprehensive analysis of wetland condition. Index scores for water-quality data and the presence of wetland vegetation and fishes are presented (Figure 9). All three indices indicate a 'very good' to 'excellent' condition for coastal wetlands along the Canadian shoreline, especially those in eastern and northern Georgian Bay. However, wetlands assessed as 'fair' or 'good' condition are found near towns and marinas of southern Georgian Bay. Some coastal wetlands of the Bruce Peninsula were rated as 'fair' or 'poor' condition. Results are more variable for Michigan wetlands with most being in 'poor' or 'fair' condition. These patterns are consistent with the increased level of anthropogenic stressors on U.S. coastal wetlands and the largely undisturbed watersheds in eastern and northern Georgian Bay (Ciborowski and Chow-Fraser, 2015).

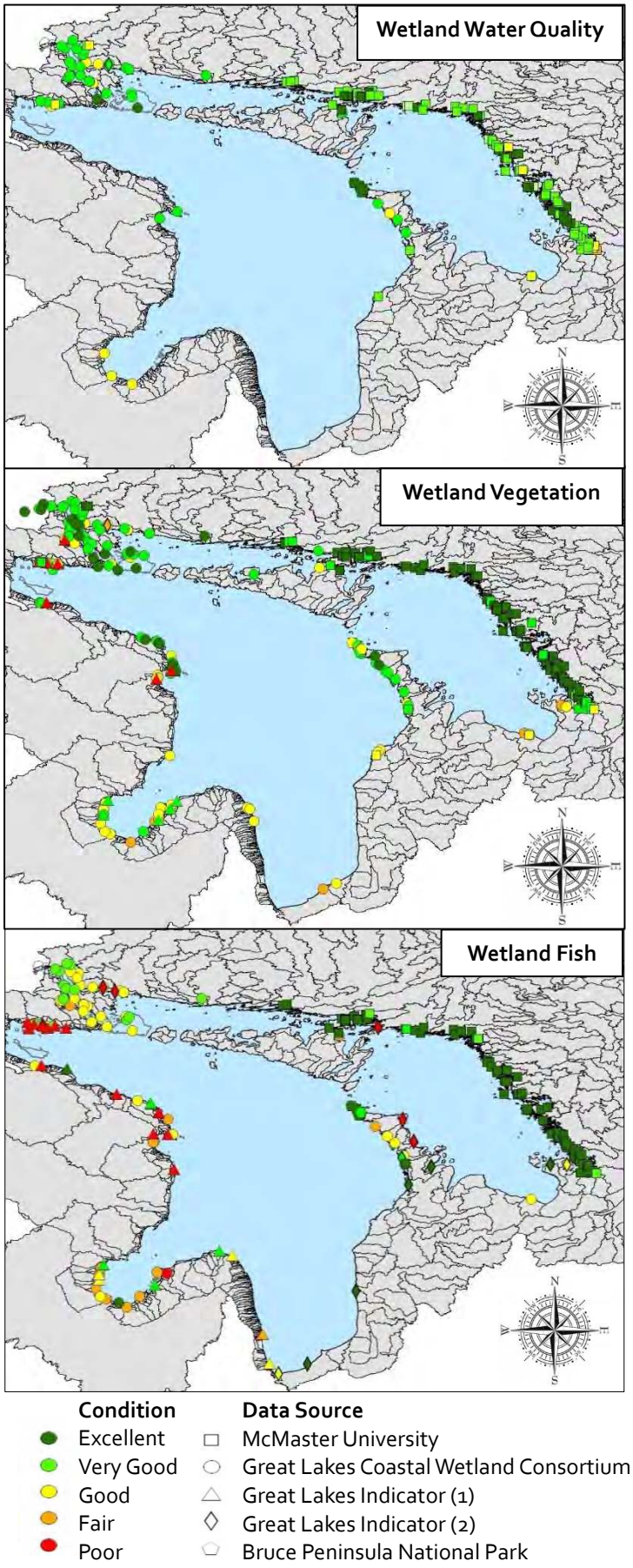


Figure 9. Coastal wetland health as represented by indices of water quality, wetland vegetation and wetland fish.

Nearshore Ecosystem

In shallow nearshore waters of Ontario, there is a high level of diversity of small fishes (>60 species), the majority of which are native to Lake Huron (Mohr et al. 2013). In Michigan waters, the diversity of the nearshore fish community has decreased following the spread of invasive non-native species (Loughner, unpublished data). Saginaw Bay shows an increase in Walleye abundance (Fielder et al. 2010), and eastern Georgian Bay shows an increase in Smallmouth Bass (Fielder et al., 2013).

Native Migratory Fish

Lake Sturgeon population structure is rated as 'poor' (five of the 33 historical spawning populations are self-sustaining) except where consistent spawning occurs in three streams of the North Channel, the Nottawasaga River, and the mouth of the St. Clair River (Franks Taylor et al., 2010; Chiotti et al., 2013). The trend may be improving, as spawning activity is observed in new locations including the Moon and Musquash Rivers in eastern Georgian Bay and the Manitou River on Manitoulin Island. Lake Sturgeon no longer spawn in the Saginaw River watershed although spawning habitat exists below the Dow Dam on the Tittabawassee River and below Hamilton Dam on the Flint River (Boase, 2007). Stream-side hatcheries and stocking have been initiated to help restore Sturgeon populations in the U.S.

Spawning Lake Sturgeon near the Bluewater Bridge, Sarnia, Ontario (A. Lintz).

The health of native ***Walleye*** populations range from 'fair' (Franks Taylor et al., 2010) to 'good' (SOGL, 2016). Saginaw Bay contains the largest Walleye stock in Lake Huron (Figure 10) and its recovery was aided by stocking and ecosystem changes that led to the decline of non-native prey fish such as Alewife. In Ontario, the majority of Walleye stocks are far below historic levels and reflect a legacy of habitat alteration and exploitation. Remaining stocks are associated with tributaries draining the North Channel and Georgian Bay (Fielder et al., 2010).

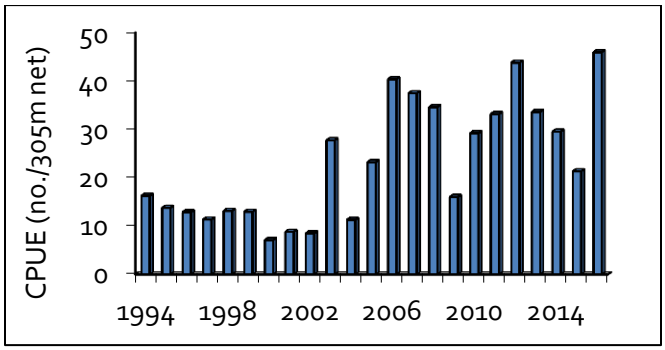


Figure 10. Saginaw Bay Walleye abundance as determined by CPUE (catch per unit effort) (Fielder, pers. comm., 2016).

Open Water Ecosystem

In general, the open water ecosystem is in 'fair' condition. The trend is variable, and there is uncertainty around lake productivity and changes in the composition and abundance of phytoplankton, zooplankton and some species of the lower and upper food web. Future trends may be dependent upon *Dreissenid* mussel density and nutrients.

The status of ***open water nutrients*** for Lake Huron is "fair" and generally consistent with an oligotrophic (low nutrient) status. Data, however, show decreasing phosphorus concentrations (mid-2000s), but this trend may be reversing (Figure 11). Additional research is needed to better understand the spatial and temporal trends and the related impacts on productivity.

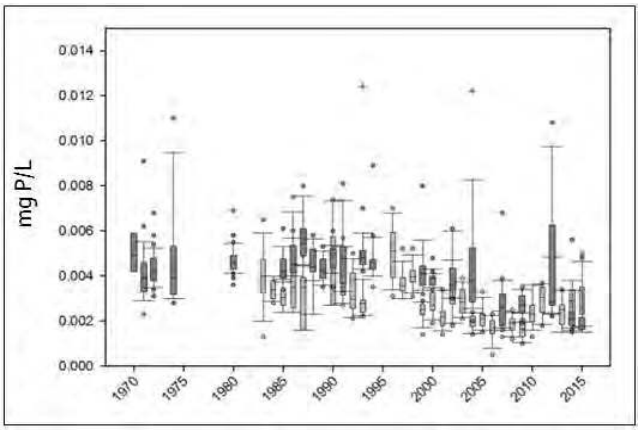


Figure 11. Main basin long-term phosphorus concentrations in the open waters (USEPA (grey) and ECCC (black)).

Phytoplankton abundance and community composition in the open water reflect a system in 'fair' condition with a 'deteriorating' trend. The significant decline in spring diatom bloom that occurred around 2003 continues to this day (SOGL, 2016). The mean phytoplankton abundance declined 88% between 1971 and 2013 (Figure 12) (Reavie et al., 2014).

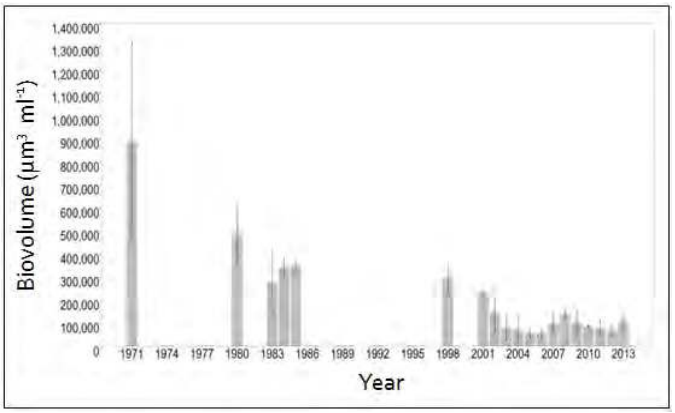


Figure 12. Lake Huron biovolume (± SE) of phytoplankton displayed as the mean of April and August estimates (multiple data sets combined by Reavie et al., 2014).

Diporeia (a freshwater shrimp-like crustacean) is one of the most important organisms in the Great Lakes food web. It supported most species of Lake Huron fish, including Whitefish and many smaller fish eaten by Lake Trout and Walleye. The abundance of *Diporeia* has drastically declined (Nalepa et al., 2007; Barbiero et al., 2011) (Figure 13). The status is 'poor' with a 'deteriorating' trend (SOGL, 2016).

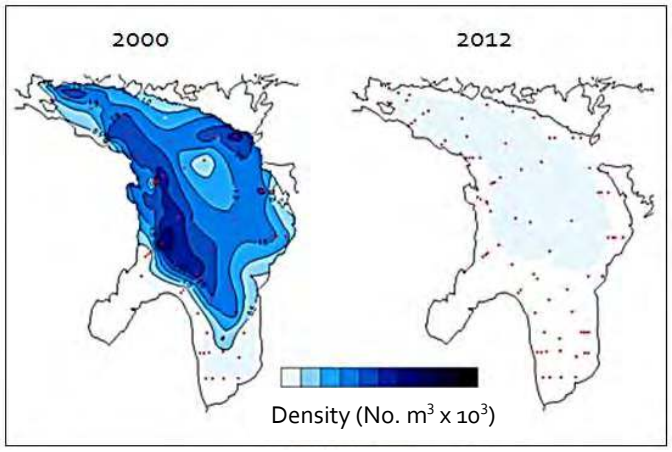


Figure 13. Trends in *Diporeia* showing the decline in density and distribution (Nalepa et al., in prep).

The status of ***zooplankton*** is in 'poor' with an 'unchanging' condition. Zooplankton declined significantly between 1998 and 2006 (Barbiero et al., 2009, 2012) driven by a 95% decline in the abundance of herbivorous crustaceans like cladocerans (Bunnell et al., 2012). Other forms of crustaceans (calanoid copepods) now dominate (Pothoven et al., 2013) Lake Huron and Saginaw Bay. Declines are attributed to changes in the fish community, the non-native, predatory Spiny Water Flea (*Bythotrephes)* and nutrient availability.

Preyfish historically consisted of a mixture of native species but became dominated by non-native Alewife and Rainbow Smelt from the 1970's to the early 2000s. Over the last two decades, Alewife populations declined significantly (Riley et al., 2009; Roseman and Riley, 2009), Rainbow Smelt and native Sculpin species reached record low abundance (O'Brien et al., 2009; O'Brien et al., 2014; Roseman et al., 2015), and there is uncertainty as to the abundance and spread of Round Gobies. The result is a preyfish community that is lower in abundance and diversity. Its status is 'fair' with an undetermined trend (Figure 14).

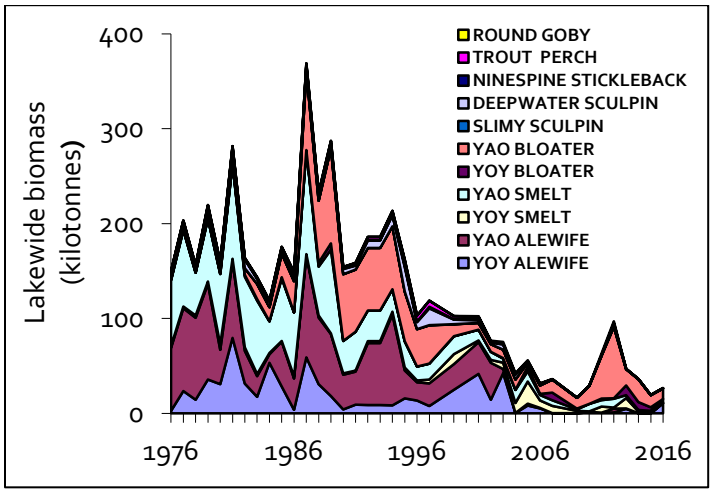


Figure 14. Lake Huron biomass of major pelagic fish species (1976-2014) (USGS, 2016).

Cisco is a general term to describe a flock of seven coregonid species that occurred in Lake Huron during the early 20th century and in the same genus as the commercially important Lake Whitefish. Only two species still remain, and taxonomic uncertainty remains an ongoing research question for *Coregonus artedi* ("Cisco", previously known as "Lake Herring") and *C. hoyi* ("Bloater"). *C. artedi* mainly occur in the North Channel and in the very northern part of the main basin, but are much less abundant than in the early 20th century. *C. hoyi* occur

throughout the basin, and their abundance has approached near record-high levels over the past five years. The commercial harvest of these two coregonid species, however, remains a fraction of historic levels (B. Bunnell, pers. comm., 2016).

Lake Whitefish harvests have declined from peak levels of the early 2000s (Figure 15). This is largely due to fewer adult fish and low recruitment of young fish to the adult stock, particularly in the north. Researchers speculate that this may be due to limited nearshore plankton food, loss of *Diporeia*, a shift to less nutrient-rich food (e.g., *Dreissenids*) and the rising predation on small fishes as predators shift from Alewives to juvenile life stages (S. Lennart, pers. comm., 2016).

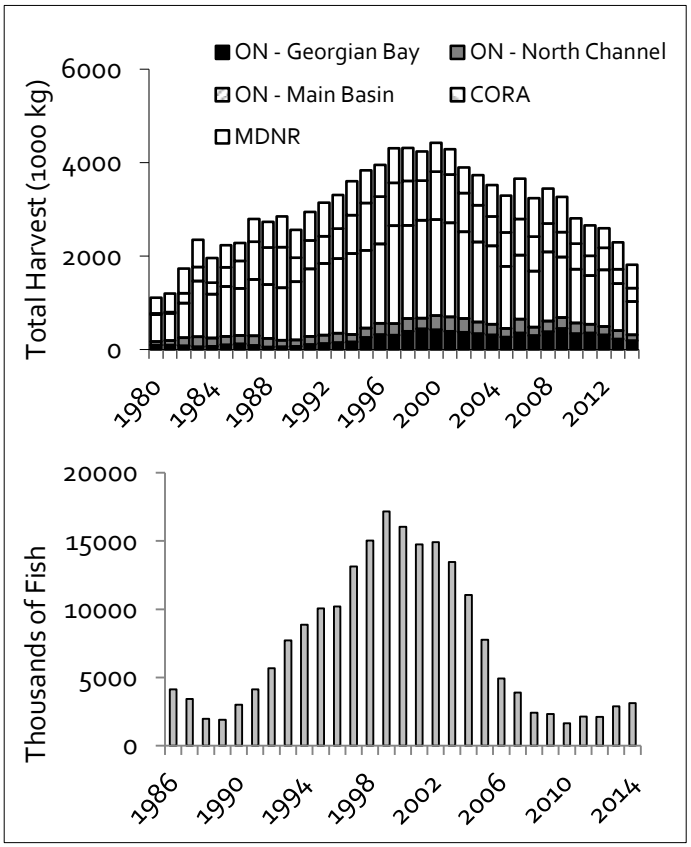


Figure 15. Trends in commercial yield of Lake Whitefish by (top) jurisdiction and basin, and (bottom) estimates of recruitment at age 4 in the 1836 Treaty waters of Lake Huron (U.S. waters north of Alpena) (Mohr et al., 2015; 2000 Consent Decree Modeling Subcommittee (MSC)).

The status for ***Lake Trout*** is 'good' and the trend is 'improving (SOGL, 2016) as progress towards Lake Trout rehabilitation is evident in the Main Basin and North Channel (Figure 16). Wild fish now compose nearly half of the adult population, and wild juvenile abundance reached a new high since 2010. Less progress toward rehabilitation has been observed in Georgian Bay, and populations there remain largely dependent on stocking to maintain current levels (GLFC, 2013; SORR, 2010).

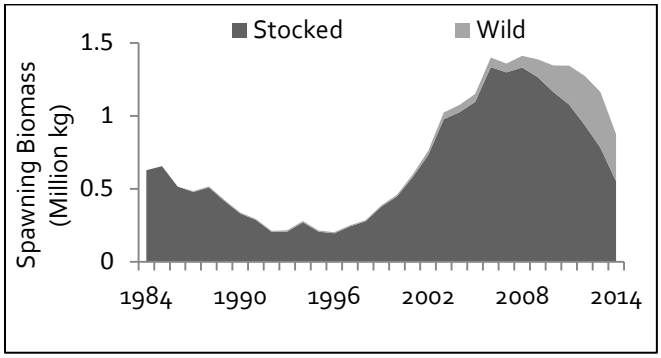


Figure 16. Trends in Main Basin spawning biomass (millions kg) of stocked and wild Lake Trout (He et al., 2012).

Aerial Migrants

The status for ***colonial nesting water birds*** is 'fair' based on a low degree of disturbance and high availability of nesting habitat on islands, as well as the population size and structure, which tend to range from 'good' to 'very good' in the northern basin and 'fair' to 'good' in the south (Franks Taylor et al., 2010; SOGL, 2016). Populations of Double-crested Cormorants, Great Egrets and Black-crowned Night Herons have increased since 1976 (Figure 17).

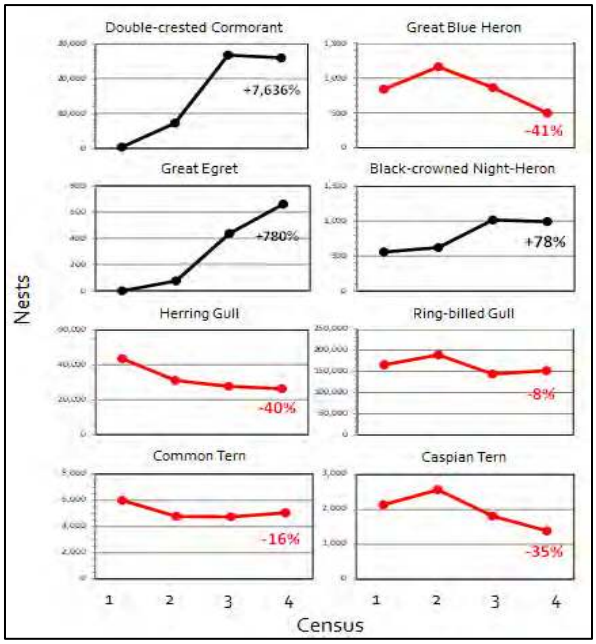


Figure 17. Changes in nest numbers for eight waterbird species during four census periods (1 = 1976-80; 2 = 1989-91; 3 = 1997-2000; 4 = 2007-09) (D. Moore, pers. comm., 2015).

Over the same time period, populations of Great Blue Herons, Herring Gulls, Ring-Billed Gulls, Common Terns and Caspian Terns declined, consistent with Great Lake wide trends. The observed declines in Caspian Terns on Lake Huron are in contrast to increases on the other Great Lakes. Herring Gull egg size and development, and possibly population-level effects, have been linked to the decline of prey fish abundance (Hebert et al., 2008, 2009; Hebert et al., 2000).

4.5.5 THREATS

The Great Lakes Fishery Commission's Environmental Objectives for Lake Huron (Liskauskas et al. 2007) and the Lake Huron Biodiversity Conservation Strategy (Franks Taylor et al., 2010) identified chemical contaminants, excess nutrients, loss and degradation of habitat and native species, non-native invasive species, and climate change as critical threats to biological diversity. These threats impede the full achievement of the General Objective to "support healthy and productive wetlands and other habitat to sustain resilient populations of native species". Three of these threats are covered in other "state of" chapters and include *Chemical Contaminants* (4.4), *Nutrients and Algae* (4.6), and *Invasive Species* (4.7).

Shoreline development and dams and barriers are two additional management challenges. Shoreline development, hardening, and the construction of groynes, dredging and infilling are widespread and have destroyed or degraded coastal wetlands and other nearshore habitat negatively impacting native fish species (Dodd and Smith, 2003; Frank Taylor et al., 2010; Leblanc et. al., 2014). Dams and hydropower facilities and other barriers have reduced stream habitat connectivity and altered in-stream flow, temperature, and stream habitat (Gebhardt et al., 2005; Franks Taylor et al., 2010).

4.5.6 IMPACTED AREAS

Degradation and loss of habitat in streams, nearshore areas and coastal wetlands are major stressors throughout Lake Huron and its watershed; however, parts of the basin still exhibit a high level of biological and geophysical diversity that supports productive aquatic habitat and native species.

While a small fraction of pre-settlement wetlands remain (Krieger et al., 1992), no comprehensive estimate of wetland loss is available. Large scale loss has not occurred in the North Channel and Georgian Bay to the extent of southern regions, mostly due to sparse population and the irregular and, in some cases, remote shoreline of the northern coast. Wetland loss and degradation continue to occur in developed areas, adjacent to high road density and near cottage development.

Non-native invasive species such as Quagga Mussels, Sea Lamprey, and Round Goby are found throughout the basin. The Common Reed known as *Phragmites* is most dense along the southern coastlines but continues its northward spread throughout the watershed via roads, ditches and shorelines.

Developed shorelines and areas with high wave-energy are most prone to alteration by landowners. Shallow-sloping shorelines are vulnerable to sustained low water levels, and landowners have extensively dredged to gain water access. Dams and other barriers to fish movement are found throughout the basin. In some areas, dams and low-head barriers are a major Sea Lamprey control mechanism. Therefore, decisions on dam removal must balance competing environmental interests and goals.

4.5.7 LINKS TO ACTIONS THAT SUPPORT THIS GENERAL OBJECTIVE

Actions that address loss of habitat and native species and advance achievement of this General Objective can be found in Chapter 5.3 – *Loss of Habitats and Species*.

Actions that address other threats such as *Chemical Contaminants* (5.1), *Nutrients and Bacterial Pollution* (5.2), *Invasive Species* (5.4), and *Climate Change Impacts* (5.5), will also help to minimize the loss of habitat and the native species that they support.

Table 9. Habitat and species related issues in the regions of Lake Huron.

LAKE HURON REGIONS	HABITAT AND SPECIES RELATED ISSUES
Main Basin	• Non-native invasive *Dreissenid* mussels in the nearshore and offshore are taking nutrients from the water column and moving them to the benthic zone of the lake • The abundance of *Diporeia* has drastically declined in offshore waters. The cause is unknown
St. Marys River	• Shoreline development and alteration • Altered flow regime of the St. Marys River and watershed streams due to agriculture, deforestation, urban development, drainage, channelization, dams and barriers • Historic loss of rapids habitat due to navigational structures requires remedial action in Canada • Historic wetland loss
North Channel / Manitoulin Island	• *Phragmites* continues to spread northward to the North Channel and Manitoulin Island • Non-point sources of sediment and excess nutrients cause algal blooms degrading habitat • Stream habitat fragmentation and altered hydrological flow due to dams and barriers
Georgian Bay	• Stream habitat fragmentation and altered hydrological flow due to dams and barriers • Parry Sound, Severn Sound, Nottawasaga Bay experience population growth, shoreline development pressure, intense recreational use, historic and present industrial activities with wetland and island habitat impacts • Eastern and southern Georgian Bay vulnerable to shoreline alteration under sustained low water levels; ranging from rock blasting to extensive nearshore dredging (> 30 cuts/km) • Southern Georgian Bay: non-point sources of pollution mostly in the agricultural south • *Phragmites* spread to coastal wetlands and river mouths of southern and eastern Georgian Bay
Ontario's Southeastern Shores	• Stream and nearshore water quality impacts on aquatic habitat due to non-point source pollution from dense agricultural sector • Stream habitat fragmentation due to dams and barriers • Continued loss and degradation of coastal wetlands • Dense stands of *Phragmites* continue to spread northward
Saginaw Bay	• Stormwater runoff from urban areas and dense agricultural activity with impacts to stream and nearshore habitats • Wetland loss and degradation; areas of native wetland have been replaced by *Phragmites* • Stream habitat fragmentation due to dams and barriers • Loss of offshore reef spawning habitat
Michigan's Western Shores	• Wetland loss and degradation • Non-point sources of pollution • Stream habitat fragmentation due to dams and barriers • Loss of offshore reef spawning habitat

4.6 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

Elevated nutrients in some areas of the nearshore contribute to excessive amounts of nuisance algae and cause episodic outbreaks of cyanobacteria blooms.

4.6.1 BACKGROUND

Nutrient pollution is one of the most challenging environmental problems and is caused by excess nitrogen and phosphorus in the water. As a natural and essential part of aquatic ecosystems, nutrients play an important role in supporting the production of aquatic plants and algae which provide food and habitat for small organisms and fish. When too much nitrogen and phosphorus enter the environment, the water can become polluted and lead to excessive amounts of benthic macro-algae (e.g., *Cladophora, Chara* and periphyton) and harmful algal blooms (*Cyanobacteria*).

POTENTIAL FACTORS THAT CONTRIBUTE TO ALGAE BLOOMS

1) Excess nutrients (nitrogen and phosphorus)
2) Warm water temperatures and sunlight
3) Increased light penetration
4) Calm and slow-moving water

CLADOPHORA

CYANOBACTERIA

4.6.2 HOW IS NUTRIENT POLLUTION MONITORED?

In Canada, the Ministry of the Environment and Climate Change oversees long term water monitoring and science programs that provide information on nearshore water quality condition and identification of threats.
In the U.S., EPA's Office of Water in partnership with States and Tribes conducts the National Coastal Condition Assessment. This assessment is designed to yield unbiased estimates of the condition of the nearshore waters based on a random stratified survey and to assess changes over time.

4.6.3 STATUS

Management actions have reduced the amount of phosphorus discharged from sewage treatment plants, and concentrations in the Great Lakes nearshore zone declined significantly between the 1970s and 1990s. The overall status of nearshore health (<30m) of Lake Huron as determined by the presence of nuisance and harmful algae is currently 'fair' with an 'undetermined' trend (Table 10; SOGL, 2016).

Table 10. Current status and trends of nutrient concentrations and occurrence of algal blooms.

NUTRIENTS AND ALGAE	INDICATOR	STATUS	TREND
Nuisance Algae	*Cladophora*	FAIR	UNDETERMINED
Harmful Algal Blooms	*Cyano-bacteria*	FAIR	DETERIORATING

4.6.4 DATA DISCUSSION

Nutrient levels are highest in nearshore waters near stream mouths that drain urbanized or agricultural areas (Figure 18). In some nearshore areas, elevated nutrient levels and environmental conditions result in episodic nuisance algae growth and harmful algal blooms.

In Ontario, elevated phosphorus and nitrate concentrations occur along the southeast shores (Dove, pers. comm., 2016). Four of the top ten Canadian subwatersheds with the highest intensities of nitrogen and phosphorus production from livestock manure are located along the southeast shores of Lake Huron (Statistics Canada, 2013).

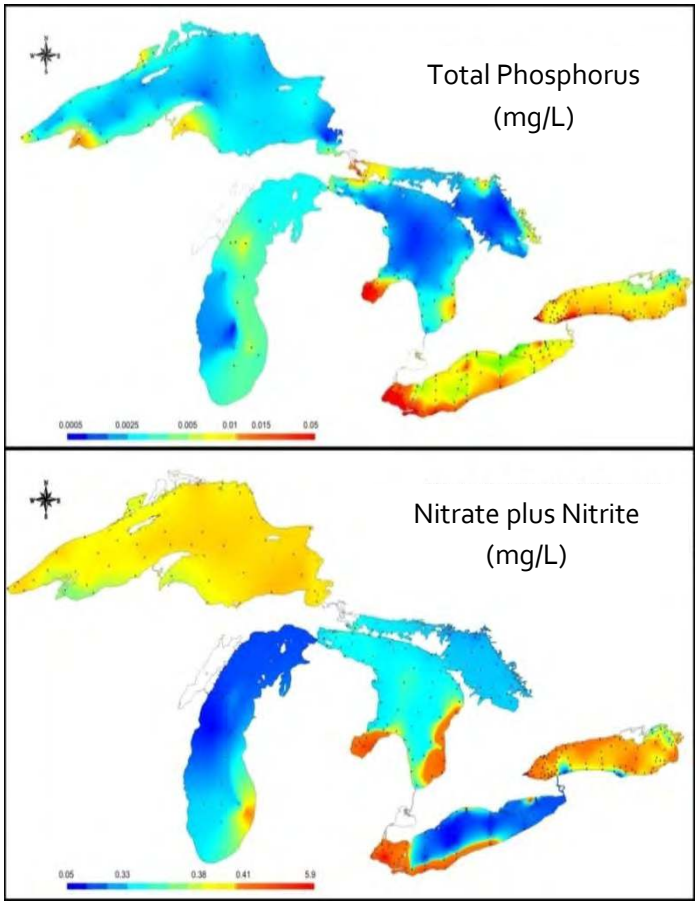


Figure 18. Spring surface total phosphorus (mg/L) and nitrate plus nitrite (mg/L) concentrations in the Great Lakes (2013-2014) (ECCC and the USEPA, 2014).

Signs of nutrient enrichment in this area occur from the outlet of Saugeen River south to Kettle Point near Sarnia, where the density of bottom-dwelling worms (indicators of organic pollution) increased 20-fold since the early 2000s (Figure 19) (Nalepa et al., in prep).

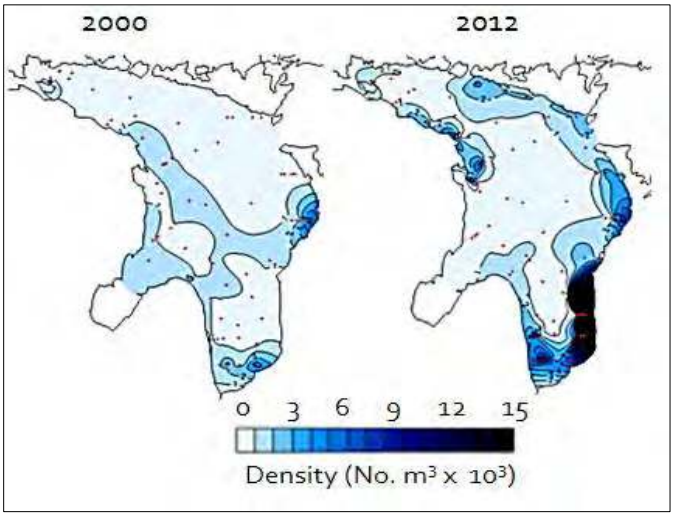


Figure 19. Oligochaete (blood worm) density change between 2000 and 2012 (Nalepa et al., in prep.)

In the U.S, Saginaw Bay was highly eutrophic in the late 1990s, improved to mesotrophic in 2002, but is again trending toward eutrophic (SOGL, 2016). Saginaw Bay continues to exceed the interim total phosphorus loading target for a mesotrophic aquatic ecosystem due to its dense agricultural and urban development (Robertson and Saad, 2011; Stow et al., 2014). It is important to note that the validity of this nutrient target, which was established in the 1980's prior to the Zebra Mussel invasion, is uncertain. (This is discussed further in Stow et al., 2014.) Under current ecological conditions, nutrient levels in Saginaw Bay support a productive fishery (Sesterhenn et al., 2014) and are a significant source of nutrients (~28% of total loads) to the open waters of Lake Huron.

In general, the U.S. nearshore water quality is in good condition based on the results of an extensive Coastal Condition Assessment conducted in 2010 (Figure 20; Nord et al., 2015).

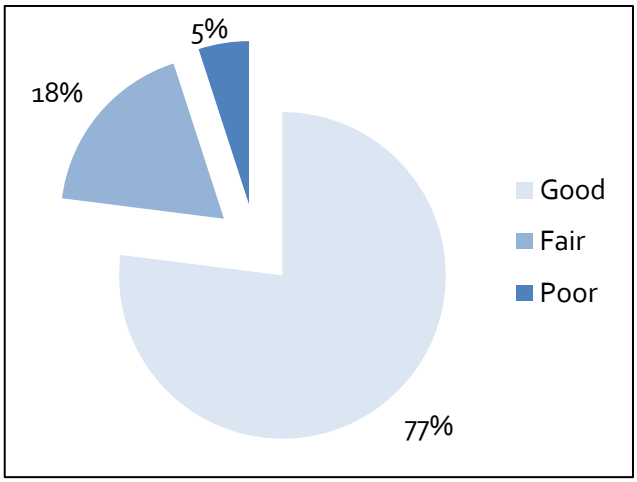


Figure 20. Water quality index results showing overall good nearshore and embayment water quality condition with some areas exhibiting fair (18%) and poor (5%) condition (Nord et al., 2015).

Nuisance Algae

The current status of the *Cladophora* indicator for Lake Huron is 'fair' with an 'undetermined' trend (SOGL, 2016).

Approximately 15% of the Lake Huron shoreline is impacted by submerged macro-algae, predominately *Cladophora, Chara* and periphyton, found mostly near the mouths of drains and streams (Barton et al., 2013; Grimm et al., 2013). *Cladophora* occurs at some

shoreline locations associated with areas of local nutrient inputs; *Chara* fouling occurs at depths of 2-3 m, but the causes are unknown. Deepwater periphyton has been observed by divers and with video reconnaissance at depths of up to 20 m (Barton et al., 2013).

Cladophora can reach nuisance levels in some reaches of the southeast shores. Little growth of *Cladophora* is detected on the nearshore lakebed of eastern Georgian Bay (Howell, 2015, unpublished data). *Cladophora* is part of an assemblage of benthic macro-algae in Saginaw Bay linked to episodic fouling due to decaying organic matter (beach muck) (SOGL, 2016). Lake Huron commercial fisherman occasionally report collecting algae in their deep water nets, suggesting that some nearshore algae is sloughed off and carried to the open waters.

Cladophora muck along the shoreline in Saginaw Bay near Bay City (NOAA).

Harmful Algal Blooms (HABs)

The current status of harmful algal blooms is 'fair' with an 'undetermined' trend offshore, and a 'deteriorating' trend nearshore (SOGL, 2016).

Other than episodic summer blooms that occur in Saginaw Bay, Sturgeon Bay and Deep Bay (Georgian Bay), and parts of the North Channel where farming occurs, Lake Huron waters are safe and substantially free from toxic and/or high abundances of harmful algae (SOGL, 2016).

4.6.5 THREATS

A variety of human activities can increase nutrient pollution and promote nuisance and harmful algae growth. Sources of excess nutrients from urban areas include runoff and sewer overflows. In rural areas, the mishandling of animal waste or fertilizers can contribute to excess nutrients. Cage aquaculture operations must be properly sited and managed to minimize enrichment of nearby waters. Faulty septic systems can leak nutrients (and bacterial pollution) into nearshore waters. The impacts of climate change are causing increased nutrient pollution due to severe rain events and warmer conditions that promote nuisance and harmful algae growth.

Stormwater runoff from farmland (ABCA).

4.6.6 IMPACTED AREAS

Regions with intensive agricultural activity are most at risk. Embayments with limited circulation and mixing with the open waters are more vulnerable to landscape-derived stressors than high energy nearshore areas. These areas may serve as water quality sentinels (Table 11).

4.6.7 LINKS TO ACTIONS THAT SUPPORT THIS GENERAL OBJECTIVE

Actions and control measures that address excessive nutrient inputs and nuisance and harmful algal blooms are presented in Chapter 5.2 – *Nutrients and Bacterial Pollution*. Actions that address the *Loss of Habitat and Native Species* (Chapter 5.3) and *Climate Change Impacts* (Chapter 5.5) will indirectly help to address excess nutrients and algal blooms.

Table 11. Nutrient related issues in the regions of Lake Huron.

LAKE HURON REGIONS	NUTRIENT RELATED ISSUES
Main Basin	• No nuisance algae growth or harmful algal blooms • Anecdotal reports from commercial fisherman suggest that nearshore *Cladophora* growth is sloughed off and transported to the main basin, as evidenced by undecomposed filamentous algae caught in fishing nets
St. Marys River	• Urban development a source of stormwater runoff and nutrients • Surrounding agricultural areas include a number of streams that drain to the St. Marys River through tile drainage and lake plain farmland with flashy discharges to streams • Inputs from household septics
North Channel/Manitoulin Island	• Occasional *Cyanobacteria* blooms at Desbarats Lake watershed
Georgian Bay	• Enclosed embayments of most concern due to relatively high phosphorus concentrations; episodic *Cyanobacteria* blooms at Sturgeon Bay and Deep Cove in eastern Georgian Bay • Phosphorus concentrations at the mouth of the French River are relatively high, and cyanobacteria blooms are reported upstream • Go-Home Bay, Twelve Mile Bay, Cognashene Lake, Honey Harbour, North Bay, South Bay, Church Bay, the Severn River and Port Severn experience one or more of the following conditions: high phosphorus concentrations; increased filamentous algae and aquatic plant growth; low dissolved oxygen concentrations impacting fish habitat; declines in water clarity, and shifts in aquatic invertebrate and phytoplankton community structure • The Lower and Middle Nottawasaga River reaches and the Innisfil Creek have the lowest stream health ranks with high phosphorus concentrations and turbidity due to agriculture and wastewater inputs from high density residential development • Inputs from household septics
Ontario's Southeastern Shores	• High density agriculture and intensive livestock operations contribute phosphorous and nitrate concentrations to the nearshore • Extensively farmed region with tile drained land resulting in flashy discharges to area streams and nearshore • Signs of excessive nutrients; nuisance *Cladophora, Chara* and periphyton (beach muck) • Inputs from household septics
Saginaw Bay	• "Eutrophication or undesirable algae" is a Beneficial Use Impairment in the Area of Concern • High density agriculture contributes elevated phosphorous and nitrate concentrations • Episodic summer outbreaks of *Cyanobacteria* blooms • Episodic algal fouling with *Cladophora, Chara* and periphyton (beach muck) • Inputs from household septics
Michigan's Western Shores	• Stormwater runoff from urban, rural and agricultural areas • Inputs from household septics

4.7 BE FREE FROM THE INTRODUCTION AND SPREAD OF AQUATIC INVASIVE SPECIES AND FREE FROM THE INTRODUCTION AND SPREAD OF TERRESTRIAL INVASIVE SPECIES THAT IMPACT THE QUALITY OF WATERS OF LAKE HURON

Aquatic invasive species, such as Zebra and Quagga Mussels, and terrestrial invasive species, such as Emerald Ash Borer and Garlic Mustard, continue to impact water quality and limit the productivity of Lake Huron.

4.7.1 BACKGROUND

Aquatic and terrestrial invasive species impact Lake Huron water quality by disrupting chemical, physical, and biological processes in the ecosystem. They also directly compete with native species for food and habitat.

There are now over 75 aquatic invasive species that have been detected within Lake Huron (Bunnell et al., 2014; Nelapa, 2015, unpublished; SOGL, 2016). Several of these are causing both direct and indirect impacts to water quality. Limited information is available on the impact of terrestrial invasive species, but land managers are concerned by the presence of species in the watershed that are known to cause water quality impacts.

4.7.2 HOW ARE INVASIVE SPECIES MONITORED?

Monitoring and assessing the impacts of invasive species is a significant challenge for management agencies. The sheer size of Lake Huron and its watershed makes a comprehensive assessment nearly impossible. As a result, estimates of the status and trends of aquatic and terrestrial invasive species are based on limited information, as described below.

Aquatic Invasive Species: Most of the monitoring of aquatic invasive species occurs as a part of routine surveillance programs by environmental protection and natural resource management agencies. Only a few aquatic invasive species have targeted monitoring programs. Adult Sea Lamprey status is measured annually by the Sea Lamprey Program of the Great Lakes Fishery Commission. The population size of invasive Zebra and Quagga Mussels is estimated on a five-year cycle through a multi-agency sampling effort.

The binational "Early Detection and Rapid Response Initiative", recently established by experts working under Annex 6 of the Agreement, is now monitoring additional locations in Lake Huron that are potential points of invasion by new aquatic invasive species.

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 that assesses the location and spread of terrestrial invasive species in the Lake Huron watershed.

New internet-based technologies, including the Early Detection and Distribution Mapping System (EDDMapS) (http://www.eddmaps.org/), allow land managers and private citizens to voluntarily share information. EDDMapS provides some limited spatial data that helps track the spread of terrestrial invasive species, including Emerald Ash Borer, European Buckthorn, Garlic Mustard, *Phragmites* and Purple Loosestrife.

The USDA Forest Service and Michigan State University maintain the Emerald Ash Borer Information Network website, which includes monthly updates on the confirmed locations for this species in the U.S. and Canada: http://www.emeraldashborer.info/about-eab.php

4.7.3 STATUS

Lake Huron water quality is significantly impacted by invasive species. The overall status of this general objective is 'poor', and most of the indicators report a deteriorating trend (Table 12). There is, however, some good news. Sea Lamprey control has successfully suppressed Sea Lamprey populations in the St. Marys River to all-time lows, and the adult Sea Lamprey populations in Lake Huron are now at target levels.

Table 12. Current status and trends of invasive species in Lake Huron.

INDICATOR	STATUS	TREND
Aquatic Invasive Species	POOR	DETERIORATING
Sea Lamprey	GOOD	IMPROVING
Dreissenids mussels	POOR	DETERIORATING
Terrestrial Invasive Species	POOR	DETERIORATING

4.7.4 DATA DISCUSSION

Environmental policies have reduced the rate that new invasive species are introduced into the Great Lakes; however, species which have already been established are becoming more widespread within the Lake Huron watershed and have caused significant ecological change and impacts to water quality (Bunnell et al., 2014; Nelapa, 2015, unpublished; SOGL, 2016).

Presence, Number and Distribution of Aquatic Invasive Species

The Great Lakes Aquatic Non-Indigenous Species Information System (GLANSIS) and the State of the Great Lakes report 75 to 77 known non-native aquatic species including fishes, plants, invertebrates, and diseases (Table 13) (NOAA, 2012; USGS, 2012; SOGL, 2016).

Table 13. A selection of aquatic invasive species established in Lake Huron (USGS, 2012).

SPECIES	ABUNDANCE	VECTOR
Sea Lamprey	Abundant	Canals
Zebra Mussel	Abundant[1]	Ballast water
Quagga Mussel	Abundant[1]	Ballast water
Round Goby	Abundant[1]	Ballast water
Alewife	Rare[2]	Canals
Rainbow Smelt	Abundant[2]	Stocked
Spiny Waterflea	Abundant[1]	Ballast water
Fishhook Waterflea	Rare[1]	Ballast water
Rusty Crayfish	Common	Bait release[3]
European Frog-bit	Unknown	Introduced
Eurasian Watermilfoil	Abundant	Introduced

[1]Bunnell et al., 2014; [2]Roseman et al. 2015; [3]DiDonato and Lodge, 1993)

The GLANSIS records show three new species established in 2016: New Zealand Mudsnail, European Frogbit, and Yellow Iris.

There are currently limited management tools to significantly limit the spread of aquatic invasive species once they have become established in the waters of Lake Huron. Records indicate range expansion for 54 species within the Lake Huron basin; many are high impact species (SOGL, 2016).

Sea Lamprey: Unlike most other aquatic invasive species, there are management tools available for controlling Sea Lamprey. Using barriers, chemical lampricides, and other techniques, Sea Lamprey populations have been reduced to about 10% of their historic levels. Sea Lamprey abundance has decreased, due to effective control, and is in 'good' condition and 'improving' (SOGL, 2016).

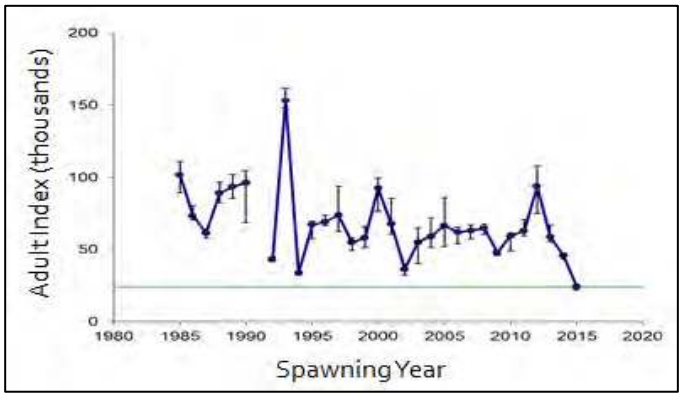


Figure 21. Adult Sea Lamprey index estimate showing achievement of target in 2015 (Sullivan and Adair, 2015).

In 2015, the Lake Huron population control target was achieved for the first time in 30 years (Figure 21). However, marking rates on Lake Trout still exceed the lakewide target of 5 per 100 fish greater than 533mm in length (Sullivan and Adair, 2015).

Most of the adult Sea Lamprey population comes from spawning in just ten Lake Huron streams; however, there are many other streams with suitable spawning habitat that are currently inaccessible due to dams at the river mouths. As discussed in section 5.4, the removal of any dams to improve habitat connectivity must consider the potential for Sea Lamprey to access additional spawning habitat and the resulting increases in parasitism of Lake Huron fish.

Dreissenids: The overall status of *Dreissenids* is 'poor' and 'deteriorating' (SOGL, 2016). Invasive mussel populations continue to expand in Lake Huron. These filter-feeding organisms remove algae and small zooplankton from the water, reducing the food available for young fish and other native species.

This filter-feeding activity has resulted in greater water transparency, while "pseudo-feces" excreted by the mussels create a localized source of fertilizer. Increased light availability and more nutrients have contributed to excess algal growth – even in areas which do not have significant land-based sources of nutrient pollution.

Quagga Mussels appear to have replaced Zebra Mussels, except in shallow, nearshore zones. The population density appears to have stabilized at 31-91m, but is increasing at depths greater than 90 m. Densities in Georgian Bay (at 31-90m) decreased two-fold between 2007-2012, and no Quagga Mussels were observed at sampling sites in the North Channel (Figure 22). Few Zebra Mussels were found at sampling sites throughout the Lake Huron basin in 2012 (Nalepa et al., 2007; Bunnell et al., 2014; Nalepa, 2015, unpublished). The filter-feeding activity of Quagga Mussels in the constantly-cold, offshore environment is believed to remove nutrients and plankton that historically drove the springtime diatom bloom.

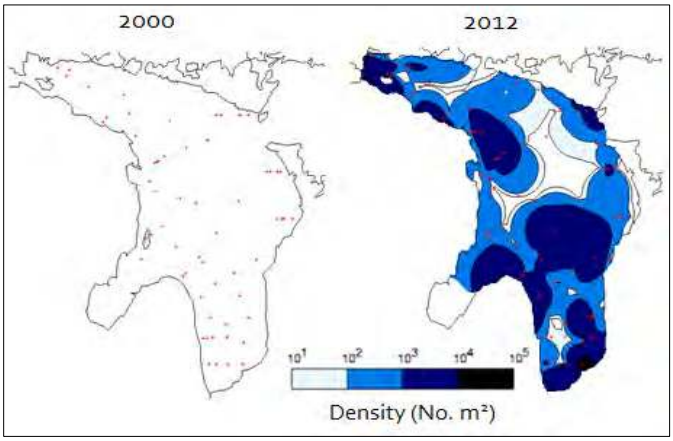


Figure 22. Comparison of densities (m^2) of Quagga Mussels in the main basin of Lake Huron, 2000-2012 (Nalepa, 2015).

Dreissenids are also linked to recent outbreaks of botulism. Botulism is a food-borne, paralytic illness produced by the bacteria *Clostridium botulinum* and caused by the toxin botulinum. The bacterium is widely distributed in the Great Lakes. The strain of toxin (Type-4) it produces (under anaerobic conditions) is the most toxic substance known to man. Outbreaks of Type E botulinum have been a recurrent event in Ontario waters since the late 1990s on beaches between Sarnia and Tobermory and especially in southern Georgian Bay, killing hundreds of Lake Sturgeon and thousands of shorebirds, gulls, terns, diving ducks, mergansers, grebes and loons.

A bird's carcass following a botulism outbreak on the shores of Lake Huron (OMNRF).

Researchers suspect that mussels facilitate toxin production by 1) allowing light to penetrate deeper due to filtering the water, 2) providing a hard substrate for *Cladophora* colonization, and 3) providing soluble phosphorus to *Cladophora*. High levels of *Cladophora* growth result in large amounts of algae being sloughed during storms and deposited on the lake bottom, which rot and provide the anaerobic environment required by the bacteria. It is not certain what invertebrates ingest and move the toxin up the food web, but it is unlikely that mussels are the vector. Round Gobies have been implicated as a vector to birds because they are often found in the guts of infected birds.

Terrestrial Invasive Species

The status of invasive species in the terrestrial and coastal ecosystem is rated as 'poor' condition with a 'deteriorating' trend (SOGL, 2016). Despite ongoing management efforts, terrestrial invasive species that are associated with water quality impacts continue to spread within the Lake Huron watershed.

The **Emerald Ash Borer** (*Agrilus planipennis*) was first discovered in North America in the Detroit-Windsor area in the early 2000s and has quickly spread throughout Michigan and into southern Ontario. This insect feeds on green, red, white, black and blue ash. High mortality rates are typical once an infestation occurs; after 6 years of initial infestation, roughly 99% of ash trees are killed in the woodlot (NRCAN, 2016). Deforestation in natural areas can increase 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 Department of Natural Resources, n.d.).

European Buckthorn (*Rhamnus cathartica*) and Garlic Mustard (*Alliaria petiolata*) impair watersheds by altering forest composition and understory growth. Buckthorn takes over forest understories, choking out native plants and preventing native hardwood saplings from becoming established. Rain quickly washes exposed soil under the Buckthorn into nearby water bodies, causing erosion and water pollution. Garlic Mustard can control the nutrient supply in soil, making it difficult for tree seedlings to germinate (Rodgers, Stinson & Finzi, 2008). It is also toxic to the larvae of some butterflies, which results in a reduction of plant pollination (Lake Huron Centre for Coastal Conservation, n.d.).

Purple Loosestrife (*Lythrum salicaria*) and invasive *Phragmites* (Common Reed *Phragmites australis* subsp. *australis*) directly degrade inland and coastal wetlands by reducing plant species richness and diversity. Purple Loosestrife weaves thick mats of roots that cover vast areas, impacting the quality of habitat for birds, insects and other plants (Government of Ontario, 2012). Furthermore, Purple Loosestrife threatens wetland ecosystems by altering water levels and reducing food sources for both aquatic and terrestrial native species (Thompson, Stuckey & Thompson, 1987).

Phragmites is considered to be the most aggressive, invasive species of marsh ecosystems in North America (Bains et al. 2009), and Canada's worst invasive plant (Catling & Mitrow, 2005). This aggressive spreading invasive plant out-competes all native vegetation and expands into massive mono-culture stands. The loss of native plant diversity and habitat complexity directly impacts wildlife by reducing suitable habitat. There are also negative impacts on tourism, society and local economies due to loss of shoreline views, reduced recreational use and access, fire risks, declining property values, and plugged roadside and agricultural drainage ditches (Gilbert, pers. comm., 2016; Kowalski et al., 2015). No natural controls exist to regulate *Phragmites* populations, underscoring the need for human intervention. It is now found extensively throughout the Lake Huron basin. In Michigan, over 10,000 hectares (24,711 acres) of dense *Phragmites* stands were detected by radar imagery in 2010 (SOGL, 2016).

4.7.5 THREATS

The spread of aquatic and terrestrial invasive species occurs as an unintended consequence of global trade, movement of people, and recreational activities like boating and fishing.

Potential pathways for the introduction of invasive species include canals and waterways, boating and shipping, illegal trade, and the release of aquarium species and live bait. Plant species purchased through nurseries, internet sales and water garden trade can also be vectors of spread. Private sector activities related to aquaria, garden ponds, baitfish and live food fish markets continue to be of concern.

Silver and Bighead Carp escapees from southern U.S. fish farms have developed into large populations in the Mississippi River, threatening the Great Lakes. While no Asian Carp have been observed in Lake Huron or its tributaries, the hydrological connection with the Mississippi River via the Chicago Sanitary and Ship Canal represents a potential pathway for invasive species to the Great Lakes.

Changes in water quantity and quality, climate change impacts, land use changes, and alterations to the nearshore and shoreline may make Lake Huron more hospitable for new invasive species and the spread of existing invasive species.

4.7.6 IMPACTED AREAS

Non-native invasive species have impacted Lake Huron water quality and ecosystem health and integrity, as explained in Table 14.

4.7.7 LINKS TO ACTIONS THAT SUPPORT THIS GENERAL OBJECTIVE

Actions that address invasive species and advance the achievement of this General Objective can be found in Chapter 5.4 – *Invasive Species*. Actions under *Loss of Habitat and Native Species* (5.3) will also help to minimize the impact of invasive species.

Table 14. Invasive species related issues in the regions of Lake Huron.

LAKE HURON REGIONS	INVASIVE SPECIES RELATED ISSUES
Main Basin	• Potential vectors for the spread of invasive species* • Quagga Mussels have altered the food web, energy cycle and lake productivity by removing large energy resources from the water column and concentrating it in their tissue, bottom sediments and algae; degrading native fish spawning and nursery habitat on reefs • Round Goby have been implicated as a vector of botulism poisoning to waterfowl
St. Marys River	• Potential vectors for the spread of invasive species* • The St. Marys River continues to be an important Sea Lamprey producer, requiring significant control effort on an annual basis • Potential for spread of terrestrial invasive species, including Purple Loosestrife, European Buckthorn, Emerald Ash Borer and *Phragmites*
North Channel/ Manitoulin Island	• Potential vectors for the spread of invasive species* • Several important tributaries for Sea Lamprey production, including the Garden, Thessalon and Mississagi Rivers • Spread of terrestrial invasive species, including *Phragmites*
Georgian Bay	• Potential vectors for the spread of invasive species* • Spread of *Phragmites*
Ontario's Southeastern Shores	• Potential vectors for the spread of invasive species* • Quagga Mussels have changed the nearshore system by increasing water clarity, altering nutrient pathways, and causing increased density of macro-algae such as *Cladophora* • Spread of *Phragmites*
Saginaw Bay	• Potential vectors for the spread of invasive species* • Quagga Mussels have changed the nearshore system by increasing water clarity, altering nutrient pathways, and causing increased density of macro-algae such as *Cladophora* • Important Sea Lamprey producing streams include tributaries to the Saginaw River and the Rifle River • Spread of terrestrial invasive species, including Purple Loosestrife, European Buckthorn, Emerald Ash Borer and *Phragmites*
Michigan's Western Shores	• Potential vectors for the spread of invasive species* • Spread of terrestrial invasive species, including Purple Loosestrife, European Buckthorn, Emerald Ash Borer and *Phragmites*

*Includes, but is limited to, recreational boating and fishing, illegal trade and transport of banned species, and deliberate and accidental release of aquarium pets and water garden plants.

4.8 BE FREE FROM THE HARMFUL IMPACT OF CONTAMINATED GROUNDWATER

There is no evidence of significant impacts of contaminated groundwater to Lake Huron. Known contaminated groundwater sites are actively managed and monitored through environmental programs.

4.8.1 BACKGROUND

Shallow groundwater is linked with surface water and other parts of the water cycle. Groundwater influences water quality and the availability, amount, and function of habitats for aquatic life within streams, inland lakes, coastal wetlands, and nearshore waters (Grannemann et al., 2000). Lake Huron cannot be protected without protecting the groundwater resources in the Great Lakes Basin (IJC, 2010).

4.8.2 HOW IS GROUNDWATER MONITORED?

Groundwater quality is monitored and reported by Ontario Conservation Authorities, partnered with the Ontario Ministry of the Environment and Climate Change (OMOECC) as part of a provincial groundwater monitoring network. Nitrate and chloride are used as anthropogenic impact indicators in groundwater quality as both come from multiple contaminant sources in rural and urban areas. Elevated concentrations of these compounds have detrimental effects on aquatic ecosystems and human health.

In the U.S., contaminated groundwater is monitored on a site-by-site basis. Several sites within the Lake Huron watershed are managing contaminated groundwater plumes. Contaminated site information is available at the Cleanups in My Community (CIMC) website: www.epa.gov/cleanups/cleanups-my-community.

4.8.3 STATUS

The full extent of groundwater contamination and the overall status of this General Objective are not fully understood for Lake Huron. Limited information suggests that Lake Huron has not been adversely impaired by groundwater with excessive levels of nutrients, chloride or other contaminants in the relatively pristine northern region of Lake Huron, and the undeveloped, mostly forested areas in the northern Lower Peninsula of Michigan (Grannemann and Van Stempvoort, 2016). The overall quality of groundwater in the southern watershed, for which data exist, appears to be in 'good' condition with an 'undetermined' long-term trend (SOGL, 2016).

4.8.4 DATA DISCUSSION

Ontario's groundwater monitoring network rarely found levels of contaminants above Ontario drinking water quality standards. In the south and particularly in the agricultural areas of Ontario, of the 77 wells that were assessed, groundwater quality was 'poor' in 14 (18%), 'fair' in 16 (21%), and 'good' in 47 (61%). Groundwater quality is generally in good condition throughout the agricultural watersheds of southern Ontario (ABCA, 2013). The Maitland and Saugeen Valley Conservation Authorities report excellent groundwater quality based on indicators of nitrites, nitrates, and chlorides (MVCA, 2013; SVCA, 2013). Annual monitoring by the Nottawasaga Valley Conservation Authority indicates that all monitoring wells (19) meet Ontario Drinking Water Quality Standards. Chlorides are slightly elevated, suggesting that road salts may be infiltrating into these aquifers (NVCA, 2014). Less information is available for the northern region of the Lake Huron basin.

A few industrial sites within the Saginaw Bay region are currently undergoing groundwater remediation. These sites are well-mapped and managed.

The use of flame retardants at the former Wurtsmith Air Force Base in Oscoda, MI has resulted in groundwater contamination of perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS), and other perfluorinated chemicals (PFCs). The full extent of this groundwater contamination is currently under investigation by the Michigan Department of Environmental Quality and Michigan Department of Health and Human Services (MDHHS). Additional information and updates on this contaminated site are available at: www.michigan.gov/mdhhs/0,5885,7-339-71551_2945_5105-285528--,00.html www.dhd2.org/index.php/wurtsmith-activities.

4.8.5 THREATS

Many potential sources of groundwater contamination exist (Grannemann and Van Stempvoort, 2016). Spills and legacy contamination at industrial sites are potential sources. Improper use or management of fertilizers, manure, or pesticides in agricultural operations can find their way into groundwater. Faulty septic systems and underground storage tanks that contain home heating oil, diesel or gasoline are also potential sources.

In the southern watershed, glacial deposits (clay, silt, sand, gravel, rock) are associated with shorter transport pathways and residence times in the aquifer, leaving the aquifer vulnerable to contamination from human activities. Here, shallow groundwater is more likely to be impacted by nutrients and pesticides from agricultural activity. The Karst topography of the Bruce Peninsula is also vulnerable to human activity leading to groundwater contamination. Development in urban areas depletes direct recharge to groundwater, and there is considerable evidence indicating that urbanization radically alters the entire urban water cycle (Custodio, 1997; Lerner, 2002). Chloride contamination from salts is likely to occur wherever road density is greatest. It is estimated that 20% of septic systems cause excessive nutrient leaching into groundwater due to poor design, poor maintenance and inappropriate site conditions (CCA, 2009; IJC, 2011).

4.8.6 IMPACTED AREAS

The use of flame retardants at the former Wurtsmith Air Force Base in Oscoda, MI has resulted in groundwater contamination of perfluorinated chemicals (PFCs). Other areas where groundwater is most adversely impacted are described in Table 15.

4.8.7 LINKS TO ACTIONS THAT SUPPORT THIS GENERAL OBJECTIVE

Many of the actions identified in Chapter 5 advance the achievement of this General Objective, particularly Chapter 5.1 – *Chemical Contaminants* and Chapter 5.2 – *Nutrient and Bacterial Pollution*.

Table 15. Groundwater related issues in the regions of Lake Huron.

LAKE HURON REGIONS	GROUNDWATER RELATED ISSUES
Main Basin	• Not applicable
St. Marys River	• No information available
North Channel/ Manitoulin Island	• Agricultural pesticides, fertilizers, and livestock waste (e.g., manure) are potential sources of groundwater contamination if not properly used
Georgian Bay	• In southern Georgian Bay, agricultural pesticides, fertilizers, and livestock waste (e.g., manure) are potential sources of groundwater contamination if not properly used • Inputs from household septics
Ontario's Southeastern Shores	• Agricultural pesticides, fertilizers, and livestock waste (e.g., manure) are potential sources of groundwater contamination if not properly used
Saginaw Bay	• Agricultural pesticides, fertilizers, and livestock waste (e.g., manure) are potential sources of groundwater contamination if not properly used • Several industrial sites have active groundwater mitigation programs • Inputs from household septics
Michigan's Western Shores	• Groundwater contamination of perfluorinated chemicals from use of flame retardants at the former Wurtsmith Air Force Base in Oscoda, MI • Inputs from household septics

4.9 BE FREE FROM OTHER SUBSTANCES, MATERIALS OR CONDITIONS THAT MAY NEGATIVELY AFFECT THE GREAT LAKES

Most threats to Lake Huron are being addressed through ongoing environmental programs. Microplastics are a recent concern in freshwater environments, yet sources, transport, and fate remain unclear.

4.9.1 CURRENT CONCERNS

Other issues of public concern may impact ecosystem health and impede progress to achieve this General Objective. Understanding these threats will help inform the public and guide management decisions and priority actions.

Microplastics

Defined as plastic particles generally less than 5 millimeters (0.2 inches) in size, microplastics are non-biodegradable organic polymers such as polyethylene, polypropylene, and polystyrene. Fibers from clothing and rope, plastic particles from the breakdown of bags, packaging and containers, and plastic beads (from personal care products) are part of the mix.

Studies on the effects on freshwater fish are still in their early stages, but experts agree microplastics (and microfibers in particular) may be a growing threat to water quality and wildlife. U.S. researchers recently examined plastic pollution in 29 streams of the Great Lakes and found that 98% of plastics collected were microplastics; 71% of these were microfibers (Knezevic, 2016). An open water survey of plastic pollution within Lakes Superior, Huron and Erie showed that concentrations of plastic particles increased from Lake Superior to Lake Erie, consistent with populations (Figure 23) (Eriksen et al., 2013).

The U.S. government signed into law H.R. 1321, the Microbead-Free Waters Act of 2015 on Dec. 28, 2015. The bipartisan legislation will begin the phase out of plastic microbeads from personal care products on July 1, 2017. The Canadian government released proposed regulations on Nov. 4, 2016, to ban the sale of microbeads in toiletries by July 2018. By July 2019, natural health products and non-prescription drugs containing microbeads will be banned.

The ban on the use of microbeads in personal care products was an important first step in reducing the flow of microplastics into the Great Lakes, but numerous other, potentially more important sources of microplastics remain. These sources include: urban runoff (Styrofoam, plastic bags, bottles, wrappers, cigarette butts, and tire particles), fishing gear and discarded debris from boats, plastic shavings and dust from factory floors, wastewater treatment facility effluent (synthetic fibers from clothing and textiles, fragments of larger debris), combined sewer overflows, and atmospherically-deposited synthetic fibers.

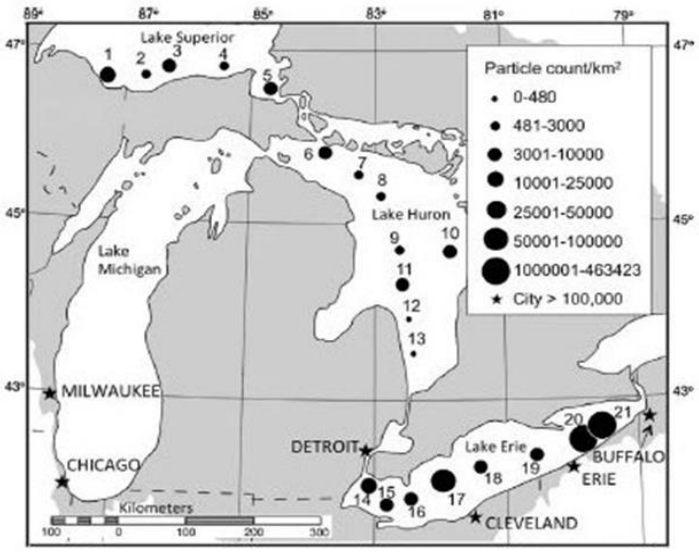


Figure 23. Distribution of plastic particles by count for three of the Great Lakes (Eriksen et al., 2013).

5.0 ACTIONS THAT ADVANCE ACHIEVEMENT OF THE GENERAL OBJECTIVES

Member agencies of the Lake Huron Partnership have developed an ecosystem-based strategy to improve the water quality of Lake Huron. Government agencies, stakeholders, and the public all have an important role in implementing priority actions over the next five years.

As reported in Chapter 4, several of the Agreements' General Objectives are not being fully achieved (Table 16). Fish consumption advisories are in place due to legacy contaminants and other chemicals of concern. The majority of nearshore waters are of high quality; however, areas of the southeast shores, Saginaw Bay, and parts of eastern Georgian Bay experience episodic algal blooms. Aquatic habitat and native species face multiple threats and *Diporeia*, an important native species and food source for prey fish has declined, significantly impacting native fish production. Quagga Mussels are expanding in the deep waters of Lake Huron and are associated with nuisance algal growth and food web changes. These threats interact with a changing climate to produce complex management challenges.

Table 16. The status of Lake Huron by General Objective.

GENERAL OBJECTIVE		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 the fish and wildlife.	FAIR
4.	Be free from pollutants that could harm people, wildlife or organisms.	GOOD/FAIR
5.	Support healthy and productive habitats to sustain our native species.	FAIR
6.	Be free from nutrients that promote unsightly algae or toxic blooms.	FAIR
7.	Be free from aquatic and terrestrial invasive species.	POOR
8.	Be free from the harmful impacts of contaminated groundwater.	GOOD
9.	Be free from other substances, materials or conditions that may negatively affect the Great Lakes.	FAIR

This chapter describes five binational strategies and identifies actions that address key environmental threats discussed in Chapter 4. The strategies are based on an assessment of the scope and severity of impacts to water quality. Each strategy has links with various General Objectives as illustrated in Table 17.

Table 17. Crosswalk between LAMP binational strategies and each of the Agreement's General Objectives.

Binational Strategy	General Objective Not Achieved
Chemical Contaminants	3, 8*
Nutrients and Bacterial Contamination	5, 6,
Loss of Habitat and Native Species	5, 6, 7
Invasive Species	5, 7
Climate Change Impacts	5, 6, 7

Actions in binational strategies will also help to maintain General Objectives (1, 2, 4, 8, and 9) in "Good" condition.
*Due to PFOS concerns, as noted in section 4.8.

The Lake Huron Partnership will work with many others, including watershed management agencies, local public agencies and the public, to address key environmental threats through the implementation of 40 management actions between the years of 2017 to 2021. Management actions will build off of the many achievements already observed from ongoing science, monitoring and binational and domestic initiatives. Actions will focus cooperative, collaborative implementation efforts and reporting under the Lake Huron LAMP, and will be implemented to the extent feasible, given available resources and domestic policy considerations by the agencies with corresponding mandates.

A summary of regional threats is provided (Figure 24) that summarizes chemical contaminants (CC), nutrients and bacterial pollution (N), loss of fish and wildlife habitat and native species (FWH), and invasive species (IS). Climate change impacts are not included in this summary; however, documented climatic trends, such as increasing water temperatures and severe weather events, have implications on the ecology and water quality of Lake Huron.

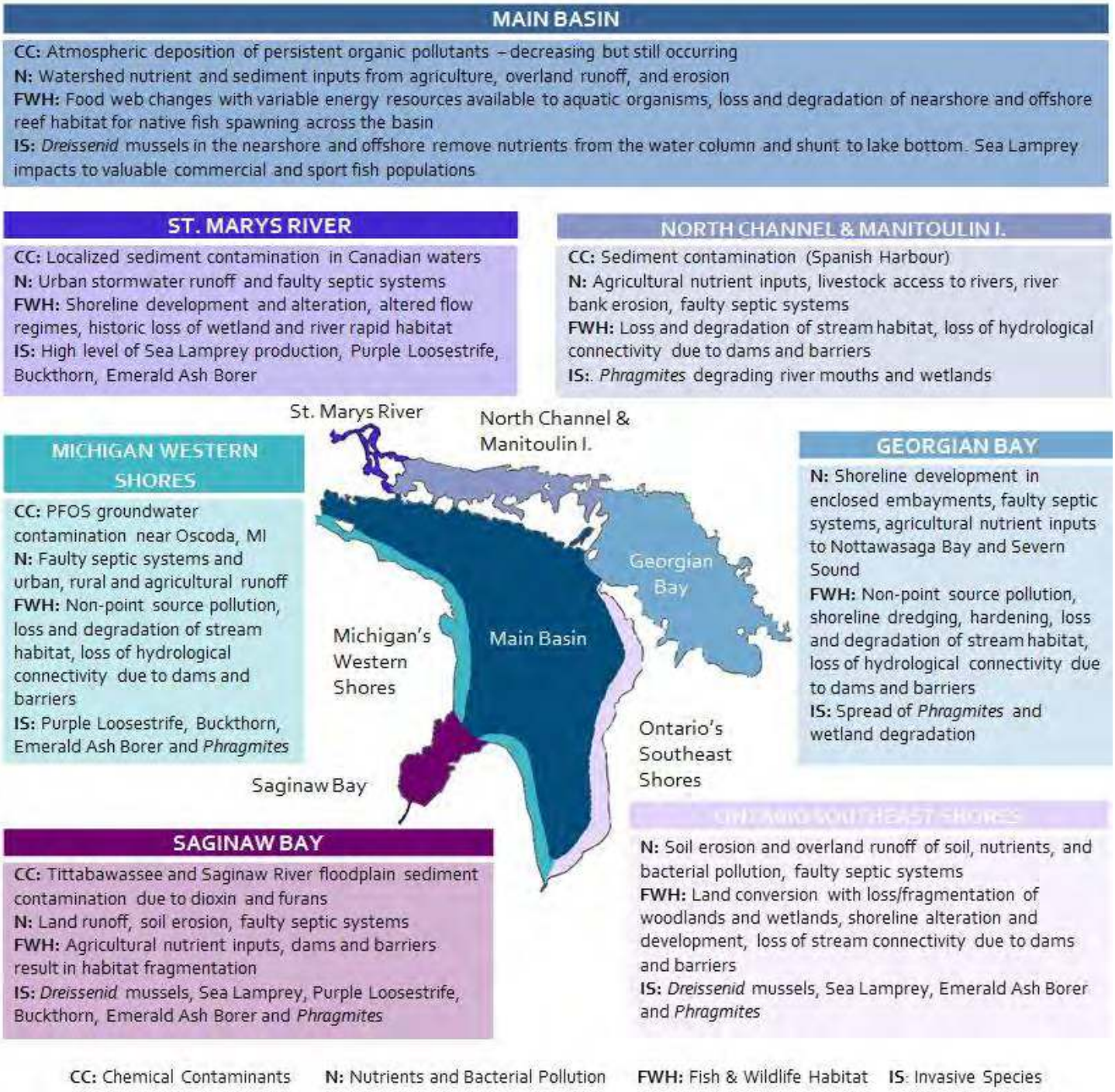


Figure 24. A simplified summary of regional threats to Lake Huron addressed by binational strategies in Chapter 5.

5.1 CHEMICAL CONTAMINANTS

5.1.1 BACKGROUND

While most areas of Lake Huron are not significantly impacted by chemical contaminants, environmental concentrations of some compounds are an ongoing problem and may limit the full achievement of the following General Objectives in the waters of Lake Huron:

- #3: Allow for human consumption of fish and wildlife unrestricted by concerns due to harmful pollutants;
- #4: 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; and
- #8: Be free from harmful impact of contaminated groundwater.

Numerous environmental programs have been established over the last several decades to control the release of municipal and industrial chemicals into the environment and remediate contaminated sites. As a result, environmental concentrations of most chemicals taken from air, water, sediment, fish and wildlife samples are declining and at low levels. Further reductions in chemical contaminants will be achieved by a combination of in-basin and out-of-basin programs. The following section describes actions that will be taken to reduce chemical contaminants in Lake Huron and how reductions in the environment will be monitored.

CHEMICAL CONTAMINANTS: ACTIONS AT A GLANCE

- Continue to implement regulations to control end-of-pipe sources of pollution
- Continue national and international efforts to reduce atmospheric inputs of chemical contaminants
- Continue work developing a sediment management plan for the Canadian portion of the St. Marys river
- Pursue site specific remediation to address contaminated sediments
- Pursue site specific remediation to address contaminated groundwater
- Assess effectiveness of actions through surveillance and monitoring
- Note: actions described in Chapter 5.2 to address non-point sources of nutrients will also address diffuse sources of chemical contaminants

5.1.2 MAJOR POLLUTANT SOURCES

Chemical pollutants enter Lake Huron in many different ways including: atmospheric deposition; point source; non-point source; and existing contaminated bottom sediments. Continued efforts by Canada and the U.S. are needed to coordinate action at the regional and international levels, supported by sustained monitoring efforts within the Great Lakes basin to determine program effectiveness.

Figure 25. Great Lakes atmospheric pollutant sampling stations in Canada.

Atmospheric Pollution

Atmospheric deposition has been recognized as a significant source of certain toxic pollutants to the Great Lakes since the 1970s. Canada and the United States acted on a Great Lakes regional scale by establishing the Integrated Atmospheric Deposition Network in 1989 as a joint effort in support of the Agreement. The Network measures atmospheric concentrations of toxic chemicals to determine temporal and spatial trends and the effectiveness of national and international control measures. Two sampling stations are located within the Lake Huron basin (Figure 25).

Atmospheric pollutant deposition is also evaluated and regulated on an out-of-basin regional or international scale. Examples of actions include the Stockholm Convention on Persistent Organic Pollutants and the United Nations' Economic Commission for Europe's Convention on Long Range Transboundary Air Pollution. Reducing atmospheric deposition requires continued permitting and enforcement of air discharges in North America and participation with international efforts to reduce chemical contaminants worldwide.

Point Source Pollution

Few high-density areas of industrial activity exist in the Lake Huron watershed, and therefore pollutant loadings are low. Several Acts and pieces of legislation support compliance (permitting) and enforcement programs that prevent the creation of contaminants at the source, control the direct discharge of contaminants, and reduce public and environment risks posed by chemicals (Table 18).

Table 18. Regulatory chemical contaminant reduction initiatives by different government levels.

REGULATORY CONTAMINANT PROGRAMS AND REDUCTION MEASURES	
Canada Shipping Act, 2001	Prevention of pollution from ships.
Canada Environmental Protection Act, 1999	Pollution prevention and the protection of the environment and human health to contribute to sustainable development.
Canada Fisheries Act, 2016	Section 36 prohibits the deposit of deleterious substances into waters frequented by fish, unless authorized. The 2015 Wastewater Systems Effluent Regulations is Canada's first national standards for wastewater treatment.
U.S. Clean Air Act, 1990	Federal law regulates air emissions from stationary and mobile sources and establishes National Ambient Air Quality Standards to protect public health.
U.S. Clean Water Act, 1972	Regulates discharges of pollutants into the waters of the U.S. and establishes water quality standards for surface waters.
Ontario Water Resources Act, 1990, and Environmental Protection Act, 1990	Provincial regulation of wastewater discharges. The *Municipal-Industrial Strategy for Abatement* regulates industrial discharges of contaminants from prescribed industrial sectors into surface waters.
Michigan Natural Resources and Protection Act, 1994	Establishes permitting and regulatory programs for water quality.

Non-Point Source Pollution

Diffuse chemical pollution from agricultural, forestry, and urban activities can occur throughout the Lake Huron watershed. Non-point source pollution programs, described in Chapter 5.2 – *Nutrients and Bacterial Pollution*, will also help reduce chemical loadings to Lake Huron.

Contaminated Bottom Sediments

Before modern pollution laws went into effect, pollutants were released to surface waters and settled into sediment at the bottom of rivers and harbours. Sediment is most often contaminated with toxic chemicals such as PCBs, dioxins, heavy metals like mercury, as well as oil, grease or other petroleum byproducts. In Lake Huron, this has been a focus at the Saginaw River and Bay Area of Concern, the St. Marys River Binational Area of Concern, and the Spanish Harbour Area of Concern in Recovery. Ongoing work within these Areas of Concern is reducing the impact of contaminated sediments, and other site-specific remediation efforts will remove contaminant sources. Communities are seeing success from federal, state, provincial, municipal and industry funding partnerships and regulations, including:

- Dow Chemical Superfund site within the Tittabawassee and Saginaw Rivers, a multi-year effort to clean up dioxin-contaminated soil in the floodplain;
- Clean up of the U.S. St. Marys River manufactured gas plant site as part of the Great Lakes Legacy Act, wherein 26,000 cubic yards of PAH–contaminated sediment were removed from the site;
- Clean up of the Canadian St. Marys River by Essar Algoma Steel, wherein process changes and upgrades reduced oil and grease (96%) and suspended solids (94%); and
- A Canadian multi-agency technical team has been working toward developing a sediment management plan appropriate for the St. Marys River in Ontario.

Investigating Groundwater Contaminants

The 5,223-acre former Wurtsmith Air Force Base is located on the northeastern part of Michigan's Lower Peninsula. Leaking chemical storage tanks and waste disposal operations have contaminated soil and groundwater with hazardous chemicals. Clean up, operation and maintenance activities are ongoing with some areas still under investigation, including U.S. federal and state efforts to address perfluorinated chemical contamination originating from the former Wurtsmith Air Force Base.

5.1.3 MANAGEMENT LINKAGES WITH THE *AGREEMENT*

Article 4 of the 2012 Agreement commits the Parties to implement programs for pollution abatement, control, and prevention for industrial sources, contaminated sediments, and radioactive materials. Article 6 commits the Parties to notification and response under the Canada-United States Joint Inland Pollution Contingency Plan to advise each other of threats of a pollution incident, or planned activities that could lead to a pollution incident. To address chemical contaminants, binational efforts are also being taken through the Agreement's Chemicals of Mutual Concern (CMC) Annex, such as:

- Preparing binational strategies for CMCs;
- Coordinating the development and application of water quality standards, objectives, criteria, and guidelines;
- Reducing releases and products containing CMCs throughout entire life cycles; and
- Promoting the use of safer chemicals.

Canada and the United States have designated a list of eight chemicals as the first set of CMCs:

- Hexabromocyclododecane (HBCD);
- Long-Chain Perfluorinated carboxylic acids (LC-PFCAs);
- Mercury;
- Perfluorooctanoic acid (PFOA);
- Perfluorooctane sulfonate (PFOS);
- Polybrominated Diphenyl Ethers (PBDEs);
- Polychlorinated Biphenyls (PCBs); and
- Short-Chain Chlorinated Paraffins (SCCPs).

The 2012 Agreement reaffirms the commitment to restore water quality and ecosystem health in Great Lakes ***Areas of Concern (AOCs)***. Federal, provincial, and state agencies, continue to work with local stakeholders to implement Remedial Action Plans for the St. Marys River, Saginaw River and Bay AOCs, and the Spanish Harbour AOC in Recovery– available at http://www.michigan.gov/deq/0,4561,7-135-3313_3677_15430-240913--,00.html and http://www.ec.gc.ca/raps-pas/.

5.1.4 ASSESSING CONTAMINANT TRENDS

Chemical contaminant monitoring and surveillance programs assess the status and trends of chemical contaminants and demonstrate the presence or absence of new compounds. Examples of domestic and binational surveillance and monitoring programs include:

- ***Open Water Chemical Monitoring Programs*:** ECCC and the USEPA conduct ship-based open water monitoring of chemicals in water, fish and bottom sediment as part of Great Lakes surveillance.
- ***Wildlife Contaminants*:** ECCC annually monitors concentrations of persistent organic pollutants and metals in Herring Gull eggs from three U.S. and Canadian colonies in Lake Huron. Three additional colonies are monitored by the MDEQ in Michigan.
- ***Fish Contaminants*:** The Ontario Ministry of Natural Resources and Forestry and the MDNR collect fish samples for analysis by the OMOECC and the Michigan Department of Community Health, who then release public fish consumption advisories. Top predator fish are also sampled by the USEPA's Great Lakes National Program Office and ECCC's Fish Contaminants Monitoring and Surveillance Program.
- ***Michigan DEQ's Surface Water Quality Monitoring Program:*** Assesses for impaired waters (303d list), Total Maximum Daily Load (TMDL), biological status, trend and targeted contaminant levels, water chemistry, and fish contaminants.

5.1.5 LAKE HURON PARTNERSHIP ACTIONS THAT ADDRESS CHEMICAL MANAGEMENT

In consideration of the chemical contaminant trends, the main contaminant sources, and localized impacts as explained in Chapters 4.3 and 4.4 and above, the member agencies of the Lake Huron Partnership have developed chemical management actions and the agencies who will lead project implementation (Table 19).

Over the next five years, member agencies of the Lake Huron Partnership will encourage and support chemical contaminant reduction efforts and work with scientists and Great Lakes experts to understand and reduce the impacts of chemicals in the waters of Lake Huron. This will be achieved by a combination of binational and domestic programs and other measures.

Project tracking and reporting on the status and achievements of chemical contaminant monitoring and site remediation will be undertaken by the Lake Huron Partnership. Not all of the member agencies of the Lake Huron Partnership are responsible for contaminant monitoring, surveillance, and implementation. Actions will be undertaken to the extent feasible, by agencies with the relevant mandates.

Table 19. Lake Huron Partnership actions that address chemical contaminants over the next five years.

#	LAKE HURON PARTNERSHIP ACTIONS 2017-2021	AGENCIES INVOLVED
ADDRESSING POINT SOURCE CHEMICAL CONTAMINANTS		
1	Federal, provincial, state and regulatory partners monitor and ensure compliance with clean water laws and regulations (see Table 18 above).	
ADDRESSING SEDIMENT CHEMICAL CONTAMINANT REMEDIATION		
1	Continue the multi-year sediment remediation on the Tittabawassee River Floodplain – Dow Chemical Superfund site. The dioxin-contaminated floodplain includes approximately 4500 acres (1821 ha) and extends 21 miles (34 km) from Midland, Michigan, through several counties to Saginaw Bay.	USEPA, MDEQ, Saginaw Chippewa Indian Tribe of Michigan (SCIT)
2	Continue efforts to develop a sediment management plan appropriate for the Canadian portion of the St. Marys River.	OMOECC, ECCC
ADDRESSING NON-POINT SOURCE CHEMICAL CONTAMINANTS		
1	Refer to Chapter 5.2 – *Nutrients and Bacterial Pollution* for non-point source pollution actions.	
ADDRESSING CONTAMINATED GROUNDWATER		
1	Continue investigation and mitigation of perfluorinated chemicals in groundwater at the former Wurtsmith Air Force Base in Oscoda, Michigan.	United States Air Force (USAF), MDEQ
ADDRESSING CHEMICAL CONTAMINANT MONITORING		
1	Continue long-term monitoring and periodic reporting on atmospheric pollutant deposition at Great Lakes stations.	USEPA
2	Conduct long-term sediment contaminant monitoring in the Spanish Harbour Area of Concern in Recovery to track recovery.	ECCC, OMOECC
3	Conduct a Lake Huron basin-wide sediment contaminant survey to examine legacy organics, PAHs, trace metals, Hg, and selected new and emerging compounds.	ECCC
4	Conduct fish contaminant monitoring in each year between 2017 and 2021.	USEPA, MDNR, SCIT, CORA, GLIFWC, MDHHS
5	Conduct annual Herring Gull monitoring in each year between 2017 and 2021 at sampling locations within the Lake Huron basin.	ECCC, MDEQ

5.1.6 ACTIVITIES THAT EVERYONE CAN TAKE

The public is encouraged to do its part to prevent chemical contaminants from entering the Lake Huron ecosystem, including watershed streams, lakes, wetlands and groundwater by undertaking the following actions:

- Follow the 6 R's: rethink, refuse, reduce, reuse, repair, and recycle (Figure 26);
- Take household hazardous materials to hazardous waste collection depots;
- Never burn garbage in barrels, open pits, or outdoor fireplaces, to prevent the release of toxic compounds like dioxins, mercury, lead, etc.;
- Use pharmaceutical take-back programs to properly dispose of unused or expired medication;
- Choose eco-friendly household cleaning and personal care products;
- Use more environmentally-friendly asphalt-based sealants as an alternative to those with coal tar, which contain toxic substances;
- Consider using natural pest-control methods – not toxic chemicals; and
- Always follow the recommendations found in provincial and state guides/advisories to eating sport fish, especially children and pregnant women.

Figure 26. The 6 R's to sustainability.