



2019

PROGRESS REPORT OF THE PARTIES

Pursuant to the 2012 Canada-United States
Great Lakes Water Quality Agreement



Canada 

U.S. spelling is used throughout this report except when referring to Canadian titles. Units are provided in metric or U.S. customary units for activities occurring in Canada or the United States, respectively.

Discussions of funding levels or costs in dollars is provided using Canadian dollars for activities occurring in Canada and U.S. dollars for activities occurring in the United States.

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Executive Summary

The Great Lakes are an invaluable resource, vital to the ecological, social and economic well-being of both Canada and the United States, and the species and people that depend on them.

In 2012, Canada and the United States reaffirmed their joint commitment to protect the lakes through a renewed Great Lakes Water Quality Agreement. Since signing of the renewed agreement, the Governments of Canada and the United States have worked to implement its provisions in cooperation and consultation with state and provincial governments, tribal governments, First Nations, Métis, municipal governments, watershed management agencies, local public agencies, and the public.

The Progress Report of the Parties is issued every three years to report on achievements in restoring and protecting Great Lakes water quality and ecosystem health. A great deal has been accomplished since the issuance of the last Progress Report in 2016. Accomplishments have included:

- Completed all remedial actions required to restore water quality and ecosystem health in five Great Lakes Areas of Concern.
- Eliminated 33 occurrences of environmental damage or human health threats caused by water pollution (collectively called “Beneficial Use Impairments”) in Great Lakes Areas of Concern. Nine more Beneficial Use Impairments are on track to be eliminated by the end of 2019.
- Finalized and initiated implementation of the Binational Phosphorus Reduction Strategy for Lake Erie. This binational strategy is founded on six domestic action plans, including a joint plan for Canada and Ontario, a joint plan for the United States federal and state agencies, and state-specific plans for Indiana, Michigan, Ohio, and Pennsylvania.
- Initiated research to determine the factors that control nuisance growth of Cladophora algae. The information will be used to develop ecological models and test the feasibility of managing Cladophora by limiting phosphorus inputs.

- Finalized binational Strategies for Hexabromocyclododecane (HCB), Polychlorinated Biphenyls (PCBs), and Polybrominated Diphenyl Ethers (PBDEs) and initiated measures to reduce anthropogenic inputs of these designated Chemicals of Mutual Concern into the waters of the Great Lakes.
- Canada completed a nearshore assessment of the Canadian shoreline of Lake Erie and the Huron-Erie Corridor, and the United States continued their use of existing domestic programs to assess nearshore aquatic habitat and further enhance the restoration and assessment of habitats and native species.
- Restored and protected Great Lakes habitat and species on thousands of acres within the Great Lakes watershed.
- Continued robust regulatory regimes in both Canada and the U.S. to manage discharges from vessels, resulting in no significant discharges of polluting substances from vessels or shore side marine transportation-related facilities during this reporting cycle.
- Significantly reduced, in the last decade, the rate at which nonindigenous species have become established in the Great Lakes.
- Prevented Bighead and Silver Carps from becoming established in the Great Lakes, through a variety of prevention and control efforts in the Chicago Area Waterway System.
- Enhanced knowledge of groundwater and climate change impacts to the waters of the Great Lakes.
- Coordinated the applied use of science to support management actions, and assessed the State of the Great Lakes using ecosystem indicators.

Why the Great Lakes are Important




Provide drinking water to
1 in 10 Americans



1 in 4 Canadians



Contains **20%**  of the world's surface **freshwater**



Are home to more than
350 fish species  | **3,500 plant and animal species**  



The Great Lakes-St. Lawrence region accounts for **30%**  of combined
Canadian and U.S. **economic activity and employment**

OUR COMMITMENTS

Great Lakes Water Quality Agreement



Canada and the United States recognize the integral relationship between an environmentally healthy Great Lakes system and the social and economic well-being of both countries, as well as the very direct connection between water quality and human health. Both countries are committed to protecting and restoring the Great Lakes.

For over 45 years, the Canada-United States Great Lakes Water Quality Agreement (Agreement) has provided a binational framework for pursuing cooperative binational and domestic actions to restore and protect the water quality of the Great Lakes.



Progress Report of the Parties

Pursuant to Article 5, Section 2(e), of the Agreement, Canada and the United States agree to produce and release a binational Progress Report of the Parties to document binational and domestic actions relating to this Agreement. The first Progress Report of the Parties was released in 2016 and this report marks the second release of the Progress Report of the Parties.

This Progress Report of the Parties documents binational and domestic actions taken over the 2016 to 2019 time period to fulfill the commitments in the Agreement. While the report is an extensive account of efforts over the last three years in support of the Agreement, this report cannot comprehensively describe all of the restoration and protection efforts being implemented within the Great Lakes basin ecosystem.

OUR PROGRAMS

The Agreement provides the framework for binational cooperation towards restoration and protection of Great Lakes water quality; however, each country uses its own domestic programs to implement the Agreement's commitments



Within Canada, a mix of national, provincial and regional policies, programs and initiatives are applied to restore and protect the Great Lakes. The Great Lakes Protection Initiative is a key federal program that combines science and action to address the most significant threats to Great Lakes water quality and ecosystem health. Since protection and restoration of the Great Lakes is a shared responsibility, Canada also continues to work in close collaboration with the Province of Ontario through the 2014 Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health. The Canada-Ontario Agreement is a targeted five-year action plan for coordinating Great Lakes restoration and protection activities.



Within the United States, legislation at the federal, state, tribal, municipal, and local levels authorizes and directs environmental protection and restoration programs. These programs are the foundation for the restoration and protection of the Great Lakes. In recent years, the Great Lakes Restoration Initiative has greatly increased implementation activities by funding over 4,000 new projects that address the most significant Great Lakes environmental issues, including: restoring Areas of Concern, preventing and controlling invasive species, reducing excess nutrients, and restoring native habitats and species.



Visit the governments of Canada and United States Great Lakes websites for further information:

www.canada.ca/great-lakes-protection

www.epa.gov/greatlakes

www.glri.us

binational.net



Articles

The Articles outlined in the 2012 Canada-United States Great Lakes Water Quality Agreement (Agreement) provide the framework for the Agreement's implementation. The Articles also identify specific commitments of the governments of Canada and the United States. These are presented below, along with related accomplishments.

Implementation

The preamble to the Agreement recognizes that while the United States and Canada are responsible for decision-making under the Agreement, the involvement and participation of a large number of government and non-governmental entities are essential in order to achieve the objectives of the Agreement. Article 3 describes General Objectives and Specific Objectives of the Agreement. Article 4 describes the full range of activities to be implemented under the Agreement to achieve specific objectives. Participation in implementation activities is coordinated by the Great Lakes Executive Committee and Annex Subcommittees, as described below.

Great Lakes Executive Committee

As described in Article 5, the implementation of the Agreement is overseen by the Great Lakes Executive Committee (GLEC). The GLEC is chaired by Environment and Climate Change Canada (ECCC) and United States Environmental Protection Agency (USEPA). Its membership consists of senior representatives of environmental protection and natural resource management agencies within the governments of Canada and the United States, state and provincial governments, Tribal governments, First Nation and Métis peoples, municipal governments, watershed management agencies, and other local public agencies. Over the past three years, GLEC meetings continued to be a valuable forum



The Great Lakes Executive Committee helps coordinate and implement the programs and other measures undertaken to achieve the purpose of the Agreement.

Credit: USEPA. [GLEC Terms of Reference](#).

for coordinating implementation efforts and sharing information relevant to the restoration and protection of the Great Lakes. Summaries of biannual GLEC meetings are available at [binational.net](#).

Agreement Annex Subcommittees, Extended Subcommittees and Task Teams

As described in Article 5, Annex subcommittees are used to assist in the implementation of the programs and other measures described in the ten Annexes of the Agreement. Annex subcommittees are co-led by Canadian and United States federal representatives and have members from a broad range of government departments and agencies, including federal, state, provincial, Tribes, First Nations, Métis, watershed and other local public agencies. In some cases, Annexes also have Extended Subcommittees consisting of non-governmental organizations, and other experts. Over the past three years, Agreement Annex Subcommittees and Extended Subcommittees, have played a critical role coordinating and implementing the necessary activities to deliver on Annex commitments.

2012 Great Lakes Water Quality Agreement General Objectives

- (i) be a source of safe, high-quality drinking water;
- (ii) allow for swimming and other recreational use, unrestricted by environmental quality concerns;
- (iii) allow for human consumption of fish and wildlife unrestricted by concerns due to harmful pollutants;
- (iv) be free from pollutants in quantities or concentrations that could be harmful to human health, wildlife, or aquatic organisms, through direct exposure or indirect exposure through the food chain;
- (v) support healthy and productive wetlands and other habitats to sustain resilient populations of native species;
- (vi) be free from nutrients that directly or indirectly enter the water as a result of human activity, in amounts that promote growth of algae and cyanobacteria that interfere with aquatic ecosystem health, or human use of the ecosystem;
- (vii) be free from the introduction and spread of aquatic invasive species and free from the introduction and spread of terrestrial invasive species that adversely impact the quality of the Waters of the Great Lakes;
- (viii) be free from the harmful impact of contaminated groundwater; and
- (ix) be free from other substances, materials or conditions that may negatively impact the chemical, physical or biological integrity of the Waters of the Great Lakes.

Task Teams, which were established to undertake specific tasks, also continued to play an important role in supporting the delivery of Annex commitments.

Engagement

Beyond formal participation in the Great Lakes Executive Committee and Annex committees, many opportunities provide for engagement in Agreement related activities. Past and present binational engagement opportunities are publicized on binational.net. Annex-specific engagement opportunities are outlined in the following chapters of this report. Pursuant to Article 5, Section 1 and Section 3, of the GLWQA, Canada and the United States also engaged the public and other binational and international governmental organizations through the Great Lakes Public Forum and the Great Lakes Summit, described below:

Great Lakes Public Forum – held every three years to engage the public on the state of the Great Lakes, progress achieved over the past three years, and priorities to guide the science and actions for the next three years.

During this reporting period, a Great Lakes Public Forum was held in October 2016. Through the Forum, the governments of Canada and the United States engaged the public in discussing the State of the Great Lakes, progress achieved over the past three years, and the United States' and Canada's science and action priorities for the next three years.

The Forum also provided an opportunity for the International Joint Commission to hear from the public on

the United States' and Canada's progress in implementing the Agreement. The Commission took into consideration this public input while developing their Triennial Assessment of Progress report, which included recommendations to the United States and Canada with respect to the implementation of the Agreement.

Great Lakes Summit – held every three years in conjunction with the Great Lakes Public Forum, to promote coordination among the United States and Canada, the International Joint Commission and other binational and international governmental organizations, and increase their effectiveness in managing the resources of the Great Lakes.

In October of 2016, a Great Lakes Summit meeting was held with the Great Lakes Commission, the Great Lakes Fishery Commission, and International Joint Commission to promote enhanced coordination and efficiency of efforts among the United States and Canada and other binational governmental organizations.

Meetings between the Commissions and GLEC co-chairs were also held in conjunction with each GLEC meeting. These meetings have been useful mechanisms to better integrate and align the work of the Commissions and the United States and Canadian government agencies during the three-year management cycle.

Celebrate our Great Lakes

Great Lakes Public Forum 2016



Enhancing engagement through the 2016 Great Lakes Public Forum

The 2016 Great Lakes Public Forum:

- Engaged over 700 participants from both sides of the border, including representatives from the governments of Canada and the United States, state and provincial governments, Tribal governments, First Nation and Métis peoples, municipal governments, watershed management agencies, and other local public agencies, as well as the general public, youth, non-governmental and other organizations and academia.
- Invited First Nations, Métis and Tribal government representatives to share their knowledge, perspectives and culture throughout the agenda.
- Created an engaging atmosphere to foster participant interest and discussion on Great Lakes issues:
 - Question and Answer sessions were moderated and facilitated by key Great Lakes stakeholders who brought their own knowledge, experience and insights into the discussions.
 - Several notable dignitaries participated and were engaged through activities such as arm chair discussions.
- Celebrated the Great Lakes by including an opportunity to explore diverse perspectives on why the Great Lakes matter to our culture, environment and economy.

Showcasing of Great Lakes innovation by Ontario

During the 2016 Great Lakes Public Forum, Ontario hosted sessions to learn about innovative technologies and approaches available for wastewater, drinking water and stormwater systems. Technology suppliers, universities and representatives from other organizations attended to share information and exchange ideas. Ontario also supported a Great Lakes Student Summit where 100 student delegates and teachers from across the province participated in experiential learning on the Lake Ontario shoreline. Student delegates then met with senior Great Lakes decision-makers to provide solutions developed by their peers and communities to address Great Lakes issues.

Binational Priorities for Science and Action

Pursuant to the Agreement Article 5, Section 2(c), the United States and Canada established Binational Priorities for Science and Action to guide and prioritize the work under the Agreement over a three-year cycle. These Priorities identify the essential science and actions needed to address current and future threats to the waters of the Great Lakes. The Priorities were developed in consultation with the Great Lakes Executive Committee (GLEC), including GLEC Observers and finalized after considering input from the public.

The current cycle of Priorities cover 2017 to 2019 are listed in Table 1 and can be found on binational.net. In the following chapters of this 2019 Progress Report of the Parties you will find activities and progress documented against the 2017-2019 Binational Priorities for Science and Action.

Table 1 – 2017-2019 Great Lakes Binational Priorities for Science and Action

Annex	Priority for Science	Priority for Action
1. Areas of Concern	Implementation of monitoring and scientific assessments to verify restoration of beneficial uses prior to delisting.	Implementation of remedial actions to restore beneficial uses in Areas of Concern.
2. Lakewide Management	<p>Pilot application and testing of the Nearshore Framework.</p> <p>Lake-specific priorities identified through the Cooperative Science and Monitoring Initiative:</p> <ul style="list-style-type: none"> • Lake Huron 2017: chemicals, nutrients, food web, physical • Lake Ontario 2018: nutrients, aquatic, chemical, habitat • Lake Erie 2019: priorities to be identified 	<p>2017- 2019: Implement Lake Superior Lakewide Action Management Plan (LAMP) identified actions to address</p> <ul style="list-style-type: none"> • aquatic invasive species • climate change • dams/barriers • chemicals/substances • habitats • native species • other threats <p>Lake Huron LAMP will be completed in 2016/2017.</p> <p>Lake Ontario LAMP will be completed in 2017.</p> <p>Lake Erie LAMP will be completed in 2018.</p> <p>Lake Michigan LAMP will be completed in 2019.</p> <p>Lake Ecosystem Objectives.</p> <p>Outreach and Engagement.</p>
3. Chemicals of Mutual Concern (CMCs)	<p>Continue research, monitoring and/or surveillance activities identified in the Binational Strategies to address information needs for CMCs and to support future measurement/indicators work.</p> <p>Coordinate efforts to provide an early warning system for chemicals that could become CMCs.</p>	<p>Continue the development of Binational Strategies that identify cooperative and coordinated measures to reduce anthropogenic inputs of CMCs into the waters of the Great Lakes.</p> <p>Identify and assess additional substances for consideration as CMCs, while seeking to utilize the data, input and expertise of the Annex 3 stakeholder community.</p>
4. Nutrients	<p>Development and implementation of monitoring and modeling to support tracking and reporting on progress towards achievement of binational phosphorus load reduction targets for Lake Erie.</p> <p>Research, monitoring and modeling to support assessment and future actions to address algae problems in Lakes Ontario, Huron and Michigan.</p>	<p>Engagement of stakeholders, First Nations and Métis communities in the development of domestic action plans for the reduction of phosphorus loadings to Lake Erie.</p> <p>Implementation of domestic action plans.</p> <p>Establishment of phosphorus load reduction targets for the eastern basin of Lake Erie.</p>
5. Discharge from Vessels	Develop compatible approaches to sampling and analysis of ships ballast water in connection with the ballast water performance standard in 33 CFR Part 151 and Regulation D-2 of the International Convention for the Control and Management of Ship Ballast Water and Sediments 2004.	<p>Seek consistency and compatibility between the United States and Canada during implementation of United States Coast Guard ballast water discharge standard, United States Environmental Protection Agency's Vessel General Permit requirements and development of regulations implementing International Maritime Organization Ballast Water Management Convention.</p> <p>Working together, with stakeholders towards compatible, fair, practicable and environmentally protective Great Lakes requirements for ballast water management.</p>

Annex	Priority for Science	Priority for Action
6. Aquatic Invasive Species (AIS)	<p>Determine feasibility and effectiveness of AIS eradication and containment methods.</p> <p>Develop technology and methods to achieve effective barriers that prevent the migration of AIS, while allowing the movement of beneficial species.</p> <p>Evaluate and enhance AIS early detection technologies and methods.</p>	<p>Refine and enhance the Early Detection & Rapid Response Initiative.</p> <p>Develop a clearinghouse for AIS species & pathway risk assessments.</p>
7. Habitat and Species	<p>Pilot application and testing of the Baseline Habitat Survey on a regional scale for refining the approach to measure Net Habitat Gain and guide implementation at a Great Lakes-wide scale.</p>	<p>Complete a review of gaps and priorities identified by existing Great Lakes habitat and species conservation strategies and strategic plans and develop a binational framework for prioritizing activities to conserve, protect, maintain, restore and enhance native species and habitat on a Great Lakes-wide scale.</p>
8. Groundwater	N/A	<p>Develop better tools to assess groundwater – surface water interaction and use them to assess regional-scale flow of groundwater to surface waters in the Great Lakes Basin.</p> <p>Undertake a focused assessment of the geographic distribution of known and potential sources of groundwater contaminants relevant to Great Lakes water quality.</p> <p>Advance monitoring, surveillance and assessment of groundwater quality in the Great Lakes basin.</p>
9. Climate Change Impacts	<p>Refine and implement State of the Great Lakes indicators for assessing and reporting on the impacts of climate change.</p>	<p>Identify key areas across the issues of the Agreement where climate change needs to be considered and integrated.</p> <p>Review knowledge gaps identified in State of Climate Change Science report with Annex Co-Leads to identify the priority areas for future action.</p> <p>Continue to regularly deliver climate information through issuance of the “Great Lakes Climate Summaries and Outlooks”.</p>
10. Science	N/A	<p>Implement the Cooperative Science and Monitoring Initiative to coordinate planning, delivery and reporting of science in relation to specific priorities identified through the Lakewide Management Process.</p> <p>Issue the State of the Great Lakes reports (2017); continue to work to improve the suite of Great Lakes ecosystem indicators.</p> <p>Pilot an open data, data management and sharing application system to further the nutrients-related work.</p>

United States and Canada’s Review of the International Joint Commission’s Triennial Assessment of Progress Report

The International Joint Commission (IJC) released their [First Triennial Assessment of Progress on Great Lakes Water Quality](#) (TAP) report on November 28, 2017 pursuant to the Agreement Article 7, Section 1(k). The report assessed governments’ progress in the implementation of the Agreement, and also provided the governments with a number of key findings and recommendations.

Pursuant to the Agreement Article 5, Section 4, Canada and the United States, in conjunction with applicable GLEC member departments and agencies, reviewed the Commission’s TAP report. Both Canada and the United States transmitted formal responses to the TAP report to the IJC in May 2018. Through the government responses and related discussions, the United States and Canada acknowledged the significant efforts by the IJC in producing their report, noted opportunities to enhance future TAP reports, and committed to considering the recommendations as implementation of the Agreement and respective domestic programs continues.

Article 6(c) Notifications

Pursuant to Agreement Article 6(c), Canada and the United States notified each other and other members of the Great Lakes Executive Committee, of planned activities that could lead to a pollution incident or have a significant cumulative impact on the waters of the Great Lakes. Every quarter, Canada and the United States solicit GLEC members for potential notification items. These notifications, which are publicly available at www.binational.net, have ensured that the United States and Canada and GLEC members are aware of significant planned activities in either country, as well as relevant engagement opportunities during applicable review and approval processes.



Lake Superior. Credit: standuppaddle, Pixabay.



Areas of Concern Annex

Overview

The 2012 Canada-United States Great Lakes Water Quality Agreement (Agreement) reaffirms the commitment of the United States and Canada to restore water quality and ecosystem health in the remaining 36 Areas of Concern (AOCs) and two AOCs in Recovery (as seen below in Figure 1).

AOCs are regarded as the most environmentally degraded sites within the Great Lakes based upon a systematic evaluation of fourteen “beneficial use impairments” (BUI). A BUI is a reduction in the chemical, physical or biological integrity of the waters of the Great Lakes that is sufficient to cause any of the following:

1. restrictions on fish and wildlife consumption
2. tainting of fish and wildlife flavor
3. degradation of fish and wildlife populations
4. fish tumors or other deformities

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

To address applicable BUIs, all AOCs have a Remedial Action Plan (RAP) identifying the criteria that must be met to remove the BUI degradation. Each AOC has a formal “RAP Team” that brings together officials from federal, state/provincial, Tribal, and local governments, local stakeholders, and Indigenous communities, to plan, develop and implement remedial and monitoring actions to restore beneficial uses in their respective AOCs.



Figure 1 – Canadian and U.S. Great Lakes Areas of Concern. Credit: ECCC and USEPA.

When all BUI removal criteria at an AOC have been met, the AOCs can be removed from the list of AOCs identified under the Agreement, a process referred to as “delisting”. At the two AOCs in Recovery, all remedial actions have been completed and monitoring plans are in place to track and assess the recovery of beneficial uses.

The purpose of the AOC Annex is to guide the restoration of AOCs designated under the Agreement, as they contribute to environmental degradation on a lakewide and Great Lakes ecosystem-wide basis.

Further information about the Canadian, United States, and binational AOCs can be found at:

www.canada.ca/en/environment-climate-change/services/great-lakes-protection/areas-concern.html
and
www.epa.gov/great-lakes-aocs/list-aocs

Annex Implementation

Implementation of the AOC Annex is co-led by Environment and Climate Change Canada (ECCC) and the United States Environmental Protection Agency (USEPA). Working with respective provincial, state and local governments, Tribes, First Nations, Métis, community members and stakeholders, Canada and the United States have continued to work to restore environmental quality in all remaining AOCs. As illustrated below, significant progress has been made to assess BUIs, advance remedial actions and ultimately remove BUIs at Great Lakes AOCs.

Key Achievements

Canada and the United States have been committed partners in the restoration of water quality and ecosystem health in AOCs and have achieved many successes since the [2016 Progress Report of the Parties](#), including the following milestones:

- 5 AOCs – the number of AOCs where all remedial actions have been completed. An additional one to two AOCs are projected to have all remedial and restoration actions completed by the end of 2019.
- 33 BUIs – the number of BUI removals (designated

Not Impaired) since 2016 following achievement of environmental quality criteria.

- 15 BUIs – the number of BUIs currently undergoing assessment which could be removed (designated Not Impaired) by December 2019.

These achievements represent years focused domestic action and resources by all levels of government and local partners.

Table 2 - Annex Achievements

	2017	2018	2019	
			To Date	Projected
Canada	1 BUI removed	8 BUIs removed	4 BUIs removed	9 BUIs removed
United States	8 BUIs removed	7 BUIs removed	5 BUIs removed	6 BUIs removed
Total	9 BUIs removed	15 BUIs removed	9 BUIs removed	15 BUIs removed

Binational Actions and Achievements

While actions to restore AOCs are primarily carried out domestically, Canada and the United States have continued sharing information on approaches and “lessons learned” to increase the efficiency and effectiveness of AOC remediation efforts in both countries. As an example, the United States and Canada created the Four Agency Management Committee (FAMC) in 1998 as a mechanism to collaborate and communicate on the restoration of three bi-national AOCs (Detroit River, St. Clair River and St. Marys River AOCs) located in the connecting channels of the upper Great Lakes. The FAMC (comprised of ECCC, Ontario Ministry of the Environment, Conservation and Parks (OMECP), USEPA and Michigan Department of Natural Resources continues to:

- meet to help facilitate and coordinate BUI removals between agencies,
- standardize BUI removal criteria,
- collaborate on studies and monitoring, and
- offer expert input on BUI-related reports.

Domestic Actions and Achievements (Canada)

Within Canada, ECCC and the OMECP work jointly to implement RAPs in all AOCs and are supported by other federal departments (e.g., Fisheries and Oceans Canada), provincial ministries (e.g., Ministry of Natural Resources and Forestry), municipalities, conservation authorities, First Nations, Métis, and community stakeholders. Working in collaboration with others, Canada has successfully advanced the planning and implementation of several contaminated sediment management projects, contributed funding and expertise to create and enhance fish and wildlife habitat, supported wastewater improvements and actively engaged local communities.

Since 2016 Canada has:

- Through the **Great Lakes Protection Initiative**, contributed funding support to projects that help eliminate BUIs and restore water quality and aquatic ecosystem health in AOCs.
- **Removed 13 BUIs** (designated to a “Not Impaired” status) and an additional nine BUIs could be removed by the end of 2019 (see Table 2).
- **Completed Stage 1 and initiated Stage 2 of the Randle Reef Project, Canada’s most highly contaminated sediment site on the Great Lakes, in the Hamilton Harbour AOC.** Construction of an engineered containment facility was completed in 2017. The facility encapsulates 140,000 cubic meters of the most contaminated sediment in Hamilton Harbour. Dredging began in 2018 to place a further 445,000 cubic meters of contaminated sediment into the facility. Following dredging, the facility will be capped and turned over to the Hamilton Port Authority for use as port lands.

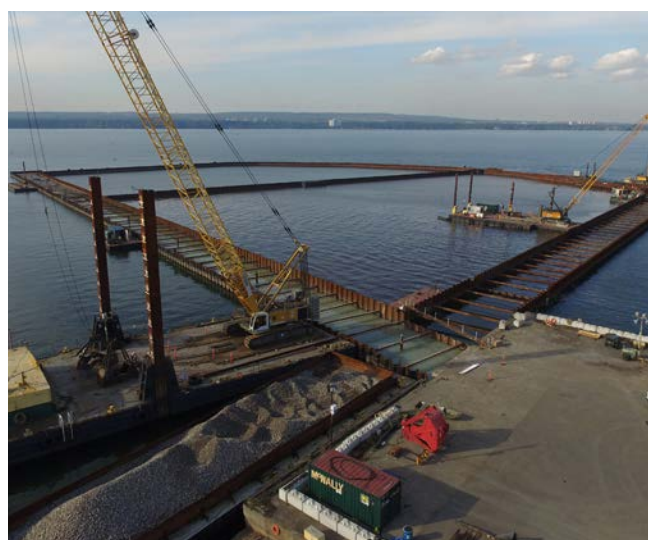
The Randle Reef project – a joint initiative of ECCC, OMECP, Hamilton Port Authority, Stelco Canada, City of Hamilton, City of Burlington and the Regional Municipality of Halton – is a prime example of all levels of government and the private sector working together to restore the environment.

Other notable sediment management accomplishments include:



Aerial shot of the Randle Reef Project, in the Hamilton Harbour AOC. Credit: HyperActive.

- In the St. Marys River AOC, approximately 11,000 cubic meters of contaminated sediment was removed from the Algoma boat slip and an additional 4,300 cubic meters is planned for removal in 2019.
- In the Thunder Bay AOC, work on a Sediment Management Strategy has begun to address the remaining contaminated site in the AOC, North Harbour. A 12-member Working Group has been established to recommend a preferred management option, and includes participation from all levels of government, First Nations and Métis, landowners, and the RAP Public Advisory Committee.



Inserting clean crushed rock in between the inner and outer walls of the containment facility. Credit: Hyper-Active.

- In the Peninsula Harbour AOC, environmental monitoring is demonstrating the effectiveness of the thin-layer cap restoration strategy implemented in Jellicoe Cove, as contaminant concentrations have declined to within the restoration targets established for the Degradation of Benthos BUI.
- In the Port Hope AOC, where the Government of Canada has committed \$1.28 billion over 10 years, the cleanup and safe long-term management of 1.7 million cubic meters of historic low-level radioactive waste is underway. This project will restore the beneficial uses of the ecosystem and result in the delisting of the AOC. The Port Hope Area Initiative is ahead of schedule and the dredging of Port Hope Harbour is scheduled to begin in the fall of 2019. Most of the preparations for the dredging have been completed (e.g. fish removal from the harbour, repair of harbour walls, and installation of silt curtains) to ensure that sediments re-suspended by the cleanup work will be contained within the harbour. Contaminated sediments from the dredging will be securely transported and placed in the new Port Hope long-term waste management facility starting in 2019.
- Created over 100 hectares of fish and wildlife habitat in Canadian AOCs:
 - In the Toronto and Region AOC, a 9.3 hectare wetland was created in Tommy Thompson Park, a 500 hectare wilderness park (created from underutilized lands) that extends five-kilometers into Lake Ontario. This unique restoration project improves fish and wildlife habitat and provides new opportunities for nature-based recreation in the City and further enhances Tommy Thompson Park's reputation as an International Birding Area.
 - In the Niagara River AOC, three coastal wetlands were created totalling 2.5 hectares and efforts are underway to improve 2 kilometers of riparian shoreline habitat, which provides new habitat to help fish and wildlife populations grow.
 - In the Detroit River, a 2 hectare wetland was created and restoration of a highly degraded 50 hectare wetland is underway. These projects will add valuable nesting and feeding habitat for marsh birds and other aquatic wildlife.
 - In the St. Clair River AOC, a 24 hectare coastal wetland was enhanced by Walpole Island First Nation, by excavating new ponds, installing



The newly created 9.3-hectare wetland (foreground) created in Toronto's Tommy Thompson Park. Credit: ECCC.

habitat structures and planting native plants. Fish gates were installed allowing fish access from the St. Clair River to an impounded-71 hectare wetland and a new 15 hectare deep-water pond, providing fish spawning habitat and refuge.

- In the St. Lawrence (Cornwall) AOC, four 60 meter wide ponds have been created, adding deep water fish habitat in Cooper Marsh, a local provincially significant coastal wetland.

Other notable fish and wildlife habitat creation and restoration accomplishments include:

- In the Bay of Quinte AOC, bald eagles returned to nest in the bay in 2016, after an absence of over 70 years.
- Bald Eagles nesting in the Hamilton Harbour AOC



A 24-hectare coastal wetland restored in the St. Clair River AOC. Credit: ECCC.

and have been observed in the Toronto and Region Area of Concern.

- In 2018, Waterfront Toronto initiated the \$1.25 billion Portlands Flood Protection and Don River Mouth Naturalization project, representing a significant commitment to habitat creation in the Toronto and Region AOC. When complete, a new 10 hectare wetland will provide valuable fish and wildlife habitat in the heart of Toronto.
- In the St. Marys River AOC, detailed design plans to naturalize waterways and create underwater reefs to enhance fish spawning and nursery habitat were completed in 2019. The work was funded by ECCC in collaboration with the Batchewana First Nation.
- **Advanced wastewater management in the Toronto and Region AOC.** The City of Toronto started construction of a new three kilometer long outfall for Canada's largest and oldest wastewater treatment plant, Ashbridges Bay. The new outfall is part of a 10 year, municipal wastewater management project to address wet weather flows and sanitary sewer needs in one system. The new outfall is one of several projects identified in the City's Wet Weather Flow Master plan and is part of the Toronto and Region RAP. This \$2 billion project includes construction of integrated underground tunnels and storage shafts to capture, store, and transport stormwater and combined sewer overflows, to a new high-rate



Construction of the new outfall at Ashbridges Bay wastewater treatment plant. Credit: Hatch with CH2M and Baird.

treatment facility, eliminating most of the combined sewer overflows to Lake Ontario when complete, which will significantly improve water quality in the Toronto and Region AOC.

Other notable achievements in wastewater management include:

- In the Bay of Quinte AOC, stormwater management projects are proceeding in the City of Belleville, and in the Detroit River AOC, the City of Windsor completed a study on options to enhance wastewater storage and treatment. The City of Cornwall updated their pollution control plan to include storm water infrastructure upgrades. These

Toronto and Region Area of Concern

Toronto, like most North American cities, has experienced impacts of industrialization and urbanization such as poor water quality, contaminated sediments and loss of wildlife habitat and populations. In 1985, Toronto and Region was classified as an AOC, requiring a series of remedial actions to restore water quality and ecosystem health in the area. The AOC encompasses an area of over 770 square miles and includes 26 miles of waterfront, 11 municipal jurisdictions and over 4 million people.

Over the years, Canada, Ontario, the City of Toronto and the Toronto Regional Conservation Authority have taken action to restore water quality and ecosystem health of the AOC. Controlling contaminants through legislative and voluntary measures was an initial focus. Currently, a number of important efforts are underway to address priorities such as controlling and treating stormwater pollution, eliminating combined sewage overflow (CSO) discharges, revitalizing the waterfront, as well as rehabilitating and enhancing habitat. Over 2,000 acres of habitat and 36 miles of shoreline were created or restored in the AOC in the last decade alone.

The Don River and Central Waterfront Project is the largest and most significant stormwater management infrastructure project undertaken by the City of Toronto. The multi-year effort will advance environmental protection in the AOC by capturing and treating stormwater discharges as well as addressing CSO discharges to the Lower Don River, Taylor-Massey Creek and Toronto's Inner Harbour. The first phase of the project construction of the Coxwell Bypass – began in 2018 and will take seven years to complete.

In addition to restoring water quality and ecosystem health, the range of actions taken to clean up the AOC are also resulting in economic and social benefits such as direct and indirect job creation, significant economic output to the Canadian economy and the generation of tax revenues – proving that investing in environmental restoration yields positive socioeconomic benefits.

initiatives will reduce the need for wastewater treatment plant bypasses during wet weather events and ensure the long-term protection of water quality and ecosystem health in this AOC.

- Applied scientific studies to improve fish habitat design and assess BUIs. In the Hamilton Harbour and Toronto and Region AOCs, small sound-emitting devices called acoustic tags have been surgically implanted in fish to collect information on the behavior and habitat needs of local fishes. Tracking stations equipped with receivers, record the sounds of the implanted acoustic tags. The data collected on fish movement helps to improve our understanding of home ranges seasonal movements, and factors limiting habitat use such as temperature and oxygen fluctuations.

Other notable scientific achievements include:

- Since 2016, over 20 scientific studies of fish, wildlife, benthos, algae and plankton have been instrumental in assessing the current status of BUIs within Canadian AOC. These assessments help determine the need for further remedial actions or monitoring and confirm when delisting criteria have been met allowing for the removal of BUI designations.
- Expanded community engagement tools to enhance local awareness and participation. RAP Teams are using social media including YouTube, Twitter, Facebook and Instagram as efficient and effective means to share information and solicit



Surgically implanting an acoustic transmitter. Credit: ECCC.



First annual St. Clair River AOC Science Symposium, co-hosted by Walpole Island and Aamjiwnaang First Nations, 2016. Credit: Clint Jacobs, Walpole Island First Nation.

participation in events. Special events in the Detroit River, Toronto and Region, St. Clair and Bay of Quinte AOCs are routinely being hosted by RAP Teams as another way of connecting with local AOC communities. Engagement with local First Nations and Métis on fish and wildlife health and habitat BUIs has been instrumental in designing studies and habitat restoration projects. In St. Marys River AOC, for example, the Batchewana First Nation is collaborating with the RAP Team to restore traditional fish habitat. In the St. Clair River AOC, elders and anglers from the Walpole Island First Nation provided valuable traditional knowledge on fish habitat within the delta prior to a Fisheries and Oceans Canada-led fish habitat assessment in 2016. In most AOCs, First Nations and Métis communities are actively engaged by participating on the RAP Implementation Committees, planning and implementing RAP projects, and reviewing and providing input on BUI assessment reports.

Federal-provincial collaboration to review and revise BUI delisting criteria

In 2016, under the 2014 Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health, ECCC and the OMECP established a task team to review BUI delisting criteria and ensure criteria were S.M.A.R.T (Specific, Measurable, Achievable, Realistic and Timely) and in alignment with the Agreement. Following the review, recommendations were developed to aid RAP

Table 3 – Status of Beneficial Use Impairments in the Canadian Great Lakes Areas of Concern

★ BUI Removed
 ■ BUI Impaired
 ◆ Projected for Removal in 2019

AOC	Restrictions on fish & wildlife consumption	Tainting of fish & wildlife flavor	Degraded fish & wildlife populations	Fish tumor or other deformities	Bird & animal deformities or reproduction problems	Degradation of benthos	Restrictions on dredging activities	Eutrophication or undesirable algae	Restrictions - drinking water consumption, taste/odor problems	Beach Closings	Degradation of aesthetics	Added costs to agriculture or industry	Degradation of phyto- and zoo-plankton	Loss of fish and wildlife habitat
Thunder Bay			■			■	★ 2012			■	★ 2019	★ 2004		■
Nipigon Bay (Delisting Pending)		★ 1995		★ 1995		★ 2016	★ 1995	★ 2016			★ 2016			★ 2016
Jackfish Bay (In Recovery)			■	★ 2010		■	★ 1998							■
Peninsula Harbour	■					◆	★ 2012							
St. Marys River	■		■	■		■	◆	★ 2018		★ 2018	★ 2018			■
Spanish Harbour (In Recovery)	■		★ 1999			■	◆			★ 1999		★ 1999		
Severn Sound (Delisted 2003)	★ 2002		★ 2002				★ 2002	★ 2002						★ 2002
Collingwood Harbour (Delisted 1994)	★ 1994		★ 1994		★ 1994	★ 1994	★ 1994	★ 1994		★ 1994	★ 1994		★ 1994	
St. Clair River	■					■	★ 2018		■	★ 2018	★ 2016	★ 2012		■
Detroit River	■	★ 2014	■	◆	■	◆	★ 2019		★ 2010	★ 2016	★ 2016	★ 2010		■
Wheatley Harbour (Delisted 2010)	★ 2010		★ 2010				★ 2010	★ 2010						★ 2010
Niagara River	■		■		★ 2009	■	★ 2009	★ 2019		■				■
Hamilton Harbour	■		◆			■	■	■		■	■			■
Toronto and Region	■		■			★ 2016	★ 2016	■		■	◆			■
Port Hope Harbour							■							
Bay of Quinte	■		★ 2018			★ 2018	★ 2017	■	◆	★ 2019	■		■	★ 2018
St. Lawrence River	■		■			★ 2007	★ 2007	■	★ 1997	◆	★ 1997	★ 1997		■

Table 4 – Status of Actions in the Canadian Great Lakes Areas of Concern

 All Actions Completed (100%)
  Majority of Actions Completed (75+%)
  Actions Well Underway (50+%)

AOC	Sediment Cleanup / Remediation	Habitat Restoration	Municipal / Industrial Wastewater treatment	Non-point-source pollution management
Thunder Bay	◆	■	*	*
Nipigon Bay (Delisting Pending)	*	*	*	*
Jackfish Bay (In Recovery)	■	■	■	
Peninsula Harbour	*	*	*	
St. Marys River	◆	◆	*	*
Spanish Harbour (In Recovery)	*	*	*	*
Severn Sound (Delisted 2003)	*	*	*	*
Collingwood Harbour (Delisted 1994)	*	*	*	*
St. Clair River	◆	*	■	■
Detroit River	*	◆	*	◆
Wheatley Harbour (Delisted 2010)	*	*	*	*
Niagara River	*	■	*	■
Hamilton Harbour	◆	■	■	◆
Toronto and Region	*	■	◆	■
Port Hope Harbour	◆			
Bay of Quinte	*	*	■	■
St. Lawrence River	*	■	*	*

Teams in revising delisting criteria. A parallel task team developed generic delisting criteria and assessment guidance for the restrictions on fish consumption BUI that RAP Teams can consider as they assess this BUI.

Domestic Actions and Achievements (United States)

AOC clean-up efforts in the U.S. are led by the USEPA, with significant contributions from other federal agencies (i.e., the National Oceanic and Atmospheric Administration, the United States Army Corps of Engineers, the U.S. Fish and Wildlife Service, and the U.S. Geological Service), state, tribal, and local governments, communities, and non-governmental organizations.

Table 5 shows that as of spring 2019 a total of 85 beneficial use impairments have been removed and 170 impairments remain. Since the 2016 Progress Report of the Parties, a total of 20 BUIs were removed and 6 more BUIs are anticipated to be removed by the end of 2019.

Table 6 displays the status of management actions for each AOC. From 2016 through 2018, since the 2016 Progress Report of the Parties, management actions have been completed at four U.S. AOCs:

- Lower Menominee River, Michigan and Wisconsin
- River Raisin, Michigan
- St. Marys River, Michigan
- Rochester Embayment, New York

Management actions are sediment remediation and habitat restoration projects necessary to remove BUIs in the AOC. In 2019, one to two additional AOCs are targeted for completion of all management actions necessary for BUI removal. Under the GLRI, cleaning up and restoring AOCs is a priority, and federal agencies have been able to provide over \$800 million in funding to implement this work.

In pursuit of continued community engagement and involvement, the USEPA convened two AOC conferences, in 2017 and 2018. The purpose of these conferences is to provide a forum for federal, state, Tribal, and local stakeholders to transfer knowledge, share information, and discuss key issues related to the AOC program.

Recently Completed or Ongoing Great Lakes Restoration Initiative Sediment Remediation and Habitat Restoration Projects

- **Niagara River Area of Concern: Niagara River Habitat Restoration Project** - Work began in 2018 to restore, enhance and protect coastal and in-river wetlands at Beaver Island State Park, Buckhorn Island State Park, and the New York State Department of Environmental Conservation's Spicer Creek Wildlife Management Area. All of these areas are nationally designated "Important Bird Areas" or areas protected nationally for their important migratory location. These restoration projects, located within the Niagara River AOC, will improve habitat for fish, migrating waterfowl, water birds, and song birds. In addition, wetland and riparian native vegetation will be restored to support the long-term ecological integrity and resilience of the river. The project will be carried out by New York State Office of Parks, Recreation and Historic Preservation, and New York State Department of Environmental Conservation. These projects are expected to be completed in 2021 and will restore 33 acres of wetland habitat.
- **Niagara River Area of Concern: Advanced Wastewater Treatment in Niagara River** - In 2018, the State of New York committed to investing over \$20 million to launch Phase One of a suite of comprehensive infrastructure and operational improvements at the Niagara Falls Wastewater



Habitat work conducted at Buckhorn Island will provide 33 acres of high quality for bird and mammal species alike. Credit: Michael Kuzia-Carmel, New York AOC Coordinator.

Treatment Facility, including \$500,000 to expedite two engineering studies that are evaluating the plant's discharges and treatment systems. A key objective of this effort is to reconstruct the plant (without shutting it down) and convert the treatment process from chemical to biological, which would eliminate all discolored discharges, as well as identify methods to dramatically enhance stormwater capture and reduce combined sewer overflows.

- **St. Louis River Area of Concern: 21st Avenue West and 40th Avenue West Habitat Restoration** - Beginning in 2017, annual harbor maintenance dredge material was used to restore critical aquatic habitat in the St. Louis River AOC. An innovative three-year pilot program was first conducted to determine if navigational material from the Duluth-Superior harbor was clean and safe to recycle back into the water. Dredged material was then placed over a total of 680 acres of river between 21st Avenue West and 40th Avenue West. Approximately 1 million cubic yards of dredge material has contributed to habitat enhancement through the creation of gradually sloped shorelines, the addition of underwater reefs or islands, and the reduction of exposure to excessive wave energy. This work was conducted via partnership with USEPA USACE, Minnesota Pollution Control Agency, Minnesota Department of Natural Resources, and other local agencies.
- **St. Louis River Area of Concern: Minnesota Slip, Slip 3, Slip C Sediment Remediations** - Three slip sediment remediation projects were completed in November 2018 in the Port of Duluth-Superior within the St. Louis River AOC. Through the GLRI and the USEPA's partnership with the Minnesota Pollution Control Agency, the projects remediated a total of 118,500 cubic yards of contaminated sediment by placing a 2 foot protective cap on top of the sediment left in place. This 18 acre remediation project will result in a waterfront that is cleaner for both fish and humans alike and is necessary to remove the Restrictions on Dredging Activities BUI.
- **Muskegon Lake Area of Concern: Zephyr Sediment Remediation and Habitat Restoration** - In October 2018, cleanup and habitat restoration work was completed at the Zephyr oil refinery site, located in the Muskegon Lake AOC. This Great Lakes Legacy Act (GLLA) project remediated approximately



Dredge material sourced from the East Gate Basin was placed at the 40th Avenue Site in the Summer of 2017. Credit: Nelson French, previous AOC coordinator.

50,000 cubic yards of sediment contaminated with total petroleum hydrocarbons, lead, and other heavy metals. The USEPA partnered with Michigan Department of Environmental Quality to remove contaminated sediment and restore 15 acres of productive wetland adjacent to the North Branch of the Muskegon River. The removal of cattail species and other invasives along with the installation of native plants creates a more suitable habitat for game species, migratory birds, and other fish and wildlife. Completing this project was necessary to remove the Degradation of Benthos BUI.

- **Rouge River AOC: Lower Rouge River Old Channel, Detroit, MI Remedial Action Contract Awarded** - In 2018, USACE used GLRI Funds to award a remedial action contract under Great Lakes Legacy Act in the Rouge River Area of Concern located in Detroit, Michigan. The project includes removal and offsite disposal of approximately 70,000 cubic yards of contaminated sediments from the Rouge River. These sediments are contaminated with polycyclic



Removal and offsite disposal of contaminated sediments from the Rouge River AOC. Credit: USACE.



The SS William A. Irvin, which serves as a museum in the Minnesota Slip, is now relocated for sediment remediation. Credit: Minnesota Pollution Control Agency.

aromatic hydrocarbons (PAHs) and non-aqueous phase liquid (NAPL). The project will also stabilize the shoreline in the affected reach. This project is critical to removing the Loss of Fish & Wildlife Habitat and Degraded Fish & Wildlife Populations BUIs in the AOC.

- **Rochester Embayment AOC: Wetland Restoration in Braddock Bay, NY** – In 2018, USACE completed an innovative restoration project at Braddock Bay; one of the largest coastal wetlands on the south shore of Lake Ontario. It is located in Greece, NY. Using GLRI funds, USACE and its project partners (the New York State Department of Environmental Conservation and the Town of Greece) recreated a historic barrier beach that reduces wetland erosion and provides nearshore habitat for shorebirds; increased wetland habitat diversity by excavating an eight-acre network of channels and potholes; and



Contractors complete sediment cleanup work and begin prepping the wetland. Credit: USEPA.

recreated two acres of emergent marsh that were previously lost to erosion. Early data suggests that northern pike have begun to spawn in the marsh, and native plant communities have flourished, with a 255 percent increase to date in native plant diversity following restoration. The barrier beach has already been visited by a variety of shorebirds including the federally-endangered piping plover. Inspired by this project, the Town of Greece has invested \$1.7 million to revitalize recreational uses of the bay.

Table 5 – Status of Beneficial Use Impairments in U.S. Great Lakes Areas of Concern

AOC	Restrictions on fish & wildlife consumption	Tainting of fish & wildlife flavor	Degraded fish & wildlife populations	Fish tumor or other deformities	Bird & animal deformities or reproduction problems	Degradation of benthos	Restrictions on dredging activities	Eutrophication or undesirable algae	Restrictions - drinking water consumption, taste/odor problems	Beach Closings	Degradation of aesthetics	Added costs to agriculture or industry	Degradation of phyto- and zoo-plankton	Loss of fish and wildlife habitat
Waukegan Harbor	■					★ 2018	★ 2014			★ 2011			■	★ 2013
Grand Calumet River	■	■	■	■	■	■	■	■	★ 2012	■	■	★ 2011	■	■
Clinton River	■		■			■	■	■		■	◆			■
Deer Lake	★ 2014				★ 2011			★ 2011						
Detroit River	■	★ 2013	■	■	■	■	■		★ 2011	■	■			■
Kalamazoo River	■		■		■	■	■			★ 2011	★ 2012			■
Manistique River	■					★ 2007	■			★ 2010				★ 2008
Muskegon Lake	★ 2013		■			■	★ 2011	■	★ 2013	★ 2015	■			■
River Raisin	■		★ 2015		■	■	■	★ 2013		★ 2013	★ 2012			★ 2015
Rouge River	■		■	■		■	■	■		■	■			■
Saginaw River & Bay	■	★ 2008	■		■	■	■	■	★ 2008	■	■		■	★ 2014
Torch Lake	■			★ 2007		■								
White Lake	★ 2013		★ 2014			★ 2012	★ 2011	★ 2012	★ 2014		★ 2014			★ 2014
St. Clair River	■	★ 2010			★ 2017	★ 2015	★ 2011		■	★ 2016	★ 2012	★ 2012		★ 2017
St. Marys River	■		◆	■	★ 2014	■	★ 2018	★ 2017		★ 2016	★ 2014			◆
Menominee River	★ 2018		★ 2019			★ 2017	★ 2017			★ 2011				★ 2019
Buffalo River	■	■	■	■	■	■	■				★ 2018			■
Eighteenmile Creek	■		■		■	■	■							
Oswego River	★ 2006		★ 2006					★ 2006						★ 2006
Rochester Embayment	■	★ 2018	■	★ 2015	■	★ 2017	★ 2019	◆	★ 2011	◆	■	★ 2011	★ 2016	■
Niagara River	■		■	★ 2016	■	■	■							■
St. Lawrence River	■		■	■	■	■							★ 2015	■
Ashtabula River	★ 2014		★ 2014	◆		★ 2018	■							★ 2014
Black River	★ 2017		■	■		■	■	★ 2017		■	■			■
Cuyahoga River	★ 2019		■	■		■	■	■		■	★ 2018			■
Maumee River	■		■	■		■	■	■		■	■	★ 2015		■
Presque Isle				★ 2013			★ 2007							
Fox River/ S Green Bay	■	■	■	■	■	■	■	■	■	■	■		■	■
Milwaukee Estuary	■		■	■	■	■	■	■		■	■		■	■
Sheboygan River	■		■	■	■	■	★ 2015	★ 2016					■	■
St. Louis River & Bay	■		■	★ 2019		■	■	■		■	★ 2014			■

Table 6 – Status of Management Actions in U.S. Great Lakes Areas of Concern

AOC	State	Management Action List(s) Created	All Management Actions Completed
Waukegan Harbor	IL	All BUIs	YES
Grand Calumet River	IN	Sediment BUIs Habitat BUIs	NO
Clinton River	MI	All BUIs	NO
Deer Lake (Delisted)	MI		
Detroit River	MI	3: F&W Populations 14: F&W Habitat	NO
Kalamazoo River	MI	3: F&W Populations 14: F&W Habitat	NO
Manistique River	MI	All BUIs	NO
Muskegon Lake	MI	All BUIs	NO
River Raisin	MI	All BUIs	YES
Rouge River	MI	Sediment BUIs Habitat BUIs	NO
Saginaw River & Bay	MI	None Created	NO
Torch Lake	MI	None Created	NO
White Lake (Delisted)	MI		
St. Clair River	MI/ON	All BUIs	YES
St. Marys River	MI/ON	All BUIs	YES
Menominee River	MI/WI	All BUIs	YES
Buffalo River	NY	All BUIs	NO
Eighteenmile Creek	NY	None Created	NO
Oswego River (Delisted)	NY		
Rochester Embayment	NY	All BUIs	YES
Niagara River	NY/ON	None Created	NO
St. Lawrence River	NY/ON	NONE	NO
Ashtabula River	OH	All BUIs	YES
Black River	OH	All BUIs	NO
Cuyahoga River	OH	3: F&W Populations 6: Degradation of benthos 14: F&W Habitat	NO
Maumee River	OH	14: F&W Habitat	NO
Presque Isle (Delisted)	PA		
Fox River/ S Green Bay	WI	None Created	NO
Milwaukee Estuary	WI	Habitat BUIs	NO
Sheboygan River	WI	All BUIs	YES
St. Louis River & Bay	WI/MN	All BUIs	NO



Lakewide Management Annex

Overview

In the Lakewide Management Annex, the United States and Canada commit to establishing Lakewide Action and Management Plans (LAMPs) for each of the five Great Lakes and their connecting river systems, as follows:

- Lake Superior;
- Lake Huron, and the St. Marys River;
- Lake Erie, and the St. Clair River, Lake St. Clair, and the Detroit River;
- Lake Ontario, and the Niagara River and the St. Lawrence River to the international boundary; and
- Lake Michigan, for which the Government of the United States has sole responsibility.

Each LAMP is an ecosystem-based management strategy for restoring and maintaining the water quality of the Lake. The LAMP is developed and implemented by a “Lake Partnership” consisting of federal, state, provincial, Tribal, First Nation, Métis, and local governmental agency partners. The document also benefits from broad public input during the development process. A LAMP is issued for each Great Lake every five years and includes a state of the lake section based on the information from the science-based Great Lakes indicators. LAMPs documents are available at www.binational.net.

As an integral part of the five-year LAMP development and implementation cycle, the Lake Partnership identifies priorities for additional science and monitoring which could better inform future management actions. These science and monitoring priorities are pursued, subject to available resources through the Cooperative Science and Monitoring Initiative (CSMI) implemented by the Agreement Science Annex Subcommittee.

Annual progress on LAMP implementation is

communicated to the public through [Annual Reports](#).

Annex Implementation

The following achievements were supported by the Lakewide Management Annex Subcommittee, co-led by United States Environmental Protection Agency (USEPA) and Environment and Climate Change Canada (ECCC), with members from United States Army Corps of Engineers (USACE), USEPA, United States Geologic Survey (USGS), United States National Oceanic and Atmospheric Administration (NOAA), Chippewa-Ottawa Resource Authority, Great Lakes Indian Fish and Wildlife Commission (GLIFWC), Illinois Department of Natural Resources (IL DNR), Michigan Department of Natural Resources (MDNR), Minnesota Pollution Control Agency (MPCA), New York State Department of Environmental Conservation (NYSDEC), Ohio Environmental Protection Agency (OH EPA), Pennsylvania Department of Environmental Protection (PADEP), Wisconsin Department of Natural Resources (WDNR), Great Lakes-St. Lawrence Cities Initiative (GLSLCI), ECCC, Fisheries and Oceans Canada (DFO), Parks Canada, Chiefs of Ontario (COO), Métis Nation of Ontario (MNO), Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), Ontario Ministry of the Environment, Conservation and Parks (OMECP), Ontario Ministry of Natural Resources and Forestry (OMNRF), and Conservation Ontario (CO). An Extended Subcommittee involves additional non-governmental organizations and experts beyond the GLEC membership.

Key Achievements

The United States and Canada have been committed partners in the strategic planning efforts under the Lakewide Management Annex and have achieved many successes, including:

- The public was engaged on the development of the draft LAMPs for Lake Huron, Lake Ontario, Lake Erie. A draft Lake Michigan LAMP is projected to be available for public engagement in 2019.
- Science and monitoring priorities were identified by the Lake Partnerships for Lake Ontario, Lake Erie, and Lake Michigan. Lake Superior priorities are projected to be completed by the end of 2019. These priorities are used by the Cooperative Science and Monitoring Initiative (CSMI) which is implemented by the Science Annex Subcommittee.
- Both countries have piloted the binational Nearshore Framework within their waters to assess and identify nearshore health and stressors. The purpose of the Nearshore Framework is to equip government agencies, along with their many partners, with the information that supports taking action to reduce the impacts of non-point source runoff, shoreline hardening, habitat loss, invasive species, dredging and contaminated sediment issues, and other threats in the nearshore environment. A summary of the Nearshore Framework assessment approaches and findings are reported in the State of the Nearshore Waters section of the Lake Erie LAMP.
- A binational policy for the strategic use of Lakewide Ecosystem Objectives was established.
- Annual Reports describing LAMP implementation progress have been issued every year for all five Great Lakes.
- In March 2018, the Lake Partnership held a public webinar to share information on the State of Lakes Superior and provided an update on actions being taken to study, restore, and protect the Lake Superior basin ecosystem to meet the goals of the LAMP.
- As part of the five year cycle of the Cooperative Science and Monitoring Initiative, the Lake Partnership shared the results of the 2016 CSMI field year during the International Association for Great Lakes Research's State of Lake Superior conference held October 9 to 12, 2018, in Houghton, Michigan. Approximately 270 people attended and participated in the conference. A public information session on the LAMP was also held at the conference. In 2019, the Lake Partnership will develop science priorities for 2021 CSMI field year.
- The following Annual Reports were produced by the Lake Partnership, which provide a detailed discussion of implementation activities:
 - [Lake Superior Lakewide Action and Management Plan Annual Report 2016](#)
 - [Lake Superior Lakewide Action and Management Plan Annual Report 2017](#)
 - [Lake Superior Lakewide Action and Management Plan Annual Report 2018](#)

In addition to the implementation activities described in the Annual Reports, the Lake Partnership agencies have also identified the following domestic projects, which are particularly relevant to the achievement of the goals of the LAMP:

These achievements represent the participation of numerous governmental partners and engaged members of the public working collaboratively towards a shared vision of lakewide management that improves water quality in the Great Lakes.

Lake Superior - Binational Actions and Achievements

The Lake Partnership continues to implement the [2015-2019 Lake Superior LAMP](#) through its 27 Partnership agencies and the engagement of 170 other organizations. Over the last three years, the Lake Partnership has expanded its outreach and engagement efforts, worked in partnership with the Science Annex on the Cooperative Science and Monitoring Initiative, and produced Annual Reports describing major implementation activities, as described below:

Lake Superior - Domestic Actions and Achievements (United States)

Protection of a critical fish spawning area - The MDEQ, MDNR, USACE, USGS, (GLIFWC), and the Keweenaw Bay Indian Community are leading efforts to reduce the impact of mining wastes on a fish spawning reef offshore from Gay, Michigan. In 2018, the USACE used GLRI funding to award a \$2.7 million dredging contract to strategically dredge approximately 150,000 cubic yards of legacy copper mining waste, known as “stamp sands”, from areas near the 2,200-acre Buffalo Reef in Lake Superior’s Keweenaw Bay. Dredging activities will take place in 2019 and is expected to provide five to seven years of protection for the reef, while the

Table 7 - Annex Achievements

Activity	2017	2018	2019
Lakewide Action and Management Plans	Engaged the Public on the development of the draft Lake Huron LAMP.	Published the Lake Huron LAMP.	Engaged the Public on the development of the draft Lake Ontario LAMP and the draft Lake Erie LAMP. Engaged the Public on the development of the draft Lake Michigan LAMP (projected).
Cooperative Science and Monitoring Priorities	Established Lake Ontario Priorities.	Established Lake Erie Priorities.	Established Lake Michigan Priorities. Established Lake Superior Priorities (projected).
Implementing the Binational Nearshore Framework	In Canada, pilot tested in Lake Erie – Fort Erie to Long-Point, including engaging the Niagara Coastal Community Collaborative (NCCC). LiDAR data collection in Lakes Ontario and Erie.	In Canada, completed the Lake Erie/ St. Clair – Detroit River Corridor assessment and NCCC launched local citizen science Cladophora monitoring. LiDAR data collection in Lakes Superior and in Lake Huron’s main basin and north channel.	Summary of the Canadian and U.S. assessment approaches and findings reported in the State of the Nearshore Waters section of the Lake Erie LAMP. In Canada, completed the Lake Ontario, Niagara and St. Lawrence Rivers assessment and engaged Conservation Authorities and Municipalities in Shoreline Management Planning in Lakes Erie and Ontario. LiDAR data collection in Lake Huron (Bruce Peninsula, Georgian Bay and Manitoulin Island areas).
	In the U.S., existing domestic programs are leveraged for implementation of the Nearshore Framework, including the Clean Water Act, the National Coastal Conditions Assessment, the Coastal Zone Management Program, strategic plans and initiatives by the states, and other nearshore-specific agency strategies.		
Lake Ecosystem Objectives	Binational agreement on the limited and strategic use of LEOs and use of the State of Great Lakes sub-indicators to measure progress toward meeting the General Objectives of the Agreement in each Lake.		
Annual Reports	Published Annual Report for each Great Lake.	Published Annual Report for each Great Lake.	Published Annual Report for each Great Lake (projected).

partners evaluate potential long-term solutions for the stamps sands problem. In addition, an acoustic tagging study is being designed and will be implemented in 2019 to determine which parts of the reef are currently used by spawning lake trout and whitefish.

Controlling invasive species - Lake Superior partners continue to collaborate to control non-native invasive Phragmites (*Phragmites australis* ssp. *australis*). In Wisconsin, three municipalities used the non-native and invasive Phragmites in wastewater treatment plants to absorb nutrients. Originally thought to be contained in these facilities, it was later realized that it could spread via seed and small populations were detected surrounding those facilities. GLIFWC surveyed and treated most of these small populations. In an effort led by the Red Cliff Band of Lake Superior Chippewa, the communities of Red Cliff, Washburn, and Bayfield retrofitted their wastewater facilities to replace the invasive strain with the native strain, *Phragmites australis* ssp. *Americanus*.

Protecting shoreline habitat in Wisconsin - WDNR partnered with the USACE to acquire 59 acres in the Bark Bay Slough State Natural Area along Lake Superior's south shore. This acquisition brought the total acreage of this boreal forest and sedge meadow complex to 705 acres. The project is an effective way to maintain water quality, recreational access, and habitat, and also helps support the Lake Superior Biodiversity Conservation Strategy goal to "preserve large blocks of wilderness". In a separate project, WDNR used GLRI funding to restore 10 acres of sedge meadow habitat at the abandoned Port Wing sewage treatment ponds through land acquisition, non-native invasive species control, and native vegetation plantings.

Tribal monitoring of Lake Superior tributaries - Continuing a program that began in 2011 during the Lake Superior CSMI Field Year, staff from the GLIFWC are monitoring the health of streams and rivers in the Chippewa Ceded Territories in the Lake Superior basin. Early work focused on *nibi* (water) that might be impacted by future hard rock mining development, focusing on providing baseline data to help protect the health of these tributaries to Lake Superior. Using a combination of water quality sampling, flow measurement, and near-continuous monitoring of water temperature and conductivity, GLIFWC developed strong baseline datasets in unimpacted tributaries to

Lake Superior. Since then, GLIFWC has continued and expanded the collection of water quality and quantity data in those watersheds as well as to expand to additional watersheds. GLIFWC now cooperates with four tribes and two federal agencies to monitor water quality in six watersheds in the Ceded Territories. Not only has the project developed a baseline of water quality and flow in generally unimpacted watersheds, but it has also identified cases of increased pollution due to human activities. In recent years, the monitoring program has included watersheds that are experiencing mineral development and pollutant discharges.

Conserving and protecting the Frog Bay watershed and Lake Superior shoreline - In 2017, the Red Cliff Band of Lake Superior Chippewa purchased former reservation lands within the Red Cliff reservation boundaries for conservation purposes. These lands included 0.6 miles of riparian corridor and 33 acres of wetlands at the headwaters of Frog Creek and adjacent to Frog Bay Tribal National Park. To further support coastal wetland protection in the Frog Creek estuary, the last remaining private inholding in Frog Bay, an 86.75-acre property with 40 acres of high quality wetland and freshwater estuary habitat at the mouth of Frog Creek, was added to Frog Bay Tribal National Park for permanent conservation and protection. The property also includes 2,610 feet of undeveloped Lake Superior sand beach. In addition to land acquisition within the Frog Bay watershed, a total of 71 acres in other estuary systems was secured to help protect 12.75 contiguous miles of the reservation's Lake Superior shoreline.



Lake Superior National Marine Conservation Area coastline - free of the invasive non-native plant, *Phragmites*. Credit: Parks Canada.

Monitoring and assessing culturally important species - In 2018, the Red Cliff Band of Lake Superior Chippewa performed an assessment of Historic Lake Trout Shoals around the Apostle Islands. Survey efforts focused on documenting lake trout use of the shoals during the spawning period. The project will also help guide commercial fishing regulations around these shoals to offer improved species protection during the October whitefish harvest. Also in 2018, a multi-year of manoomin (wild rice) monitoring and research project was initiated. Components of this project include, documenting historic seedbank regimes, genetic characterization, sediment sampling, and water chemistry sampling. Result of this project will help guide restorative efforts and management of manoomin in historical areas along the Red Cliff reservation shorelines.

Lake Superior - Domestic Actions and Achievements (Canada)

Engaging Communities in environmental action - EcoSuperior Environmental Programs (EcoSuperior), with funding from the OMECP and ECCC, continues to lead numerous community-wide voluntary efforts to help advance the objectives of the LAMP. Some

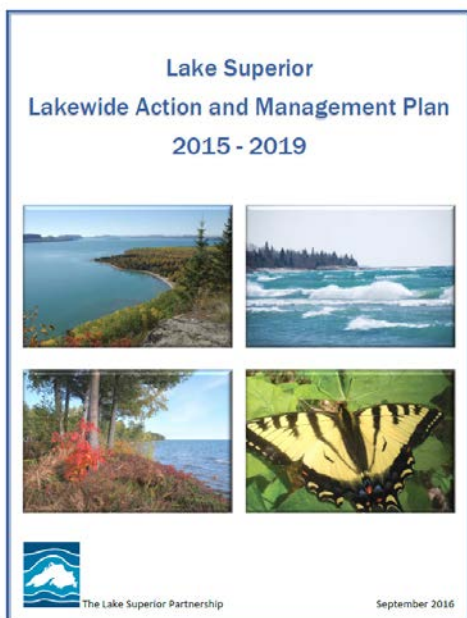


Lake Superior. Credit: Ruthann Wagner, Pixabay.

examples of these voluntary efforts include: working with partners, such as the City of Thunder Bay, to influence over 1,000 people and 28 restaurants to pledge to reduce use of single use plastic products; the collection and recycling of nearly one million cigarette butts; and the installation of over 450 permanent storm drain markers to remind people that products entering storm drains ultimately end up in Lake Superior.

Monitoring and managing natural resources in traditional territory - The Red Rock Indian Band, with funding contributions from the OMECP and ECCC and the support of the Grand Portage Band of the Lake Superior Chippewa and Lakehead University, is identifying vulnerabilities with respect to development and climate change within their traditional territory. The Red Rock Indian Band is building internal capacity to monitor and manage natural resources through activities such as mapping valued ecosystem components, hosting community engagement sessions, defining the geography of the watershed, and designing a Vulnerability and Risk Analysis Methodology to support the development of a Watershed Management and Climate Change Adaptation Plan.

Protecting and enhancing natural habitat and species in Pays Plat First Nation - Pays Plat First Nation, with funding from Ontario's Great Lakes Guardian Fund, is protecting and enhancing local wetlands, shorelines and beaches to improve cultural connections to Lake Superior. Since 2015, an ecological inventory and baseline water quality monitoring have been completed; over 15 kilometers of interpretive trails have been constructed; trees, grasses, shrubs, and



Cover page of the Lake Superior Lakewide Action and Management Plan, 2015 - 2019. Credit: Canada and United States.



Remnants of the original flume that carried stamp sands into Lake Superior. Credit: Steve Casey (retired), Minnesota Department of Natural Resources.

wetland vegetation have been planted; and litter has been removed from the Lake Superior shoreline.

Surveying the coastline for invasive plants - Parks Canada surveyed the coastline of the Lake Superior National Marine Conservation Area and observed no non-native invasive Phragmites (*Phragmites australis* ssp. *australis*). However, a few small patches of Phragmites were detected along the Trans-Canada Highway, as close as 4.5 kilometers from the shoreline. Agencies from all around Lake Superior continue to share information and are working to combat this invasive plant in the basin.

Lake Huron - Binational Actions and Achievements

The Lake Partnership finalized the [Lake Huron LAMP](#) in April 2018 through a multi-year effort by 23 Partnership agencies which included extensive public input over a six week review and comment period which began in July 2017. Over the next five years, the Lake Huron Partnership will undertake 43 actions to help address threats to water quality and ecosystem health.

Over the last three years the Lake Partnership has expanded its outreach and engagement efforts, worked in partnership with the Science Annex Subcommittee on the Cooperative Science and Monitoring Initiative, and produced Annual Reports describing major implementation activities, as described below:

- In November 2018, the Lake Partnership held a public webinar to share information on the LAMP, including the state of Lake Huron and actions being taken to study, restore, and protect the Lake Huron basin ecosystem as part of the Lake Huron LAMP.
- As part of the five-year cycle of the Cooperative Science and Monitoring Initiative, the CSMI field year took place in 2017, which is described in more detail in the Science Annex. The results of the CSMI field year will be discussed at a State of Lake Huron Conference which is planned for fall 2019.
- Annual Reports were produced by the Lake Partnership, which provide a detailed discussion of implementation activities:
 - [Lake Huron Lakewide Action and Management Plan Annual Report 2016](#)
 - [Lake Huron Lakewide Action and Management Plan Annual Report 2017](#)
 - [Lake Huron Lakewide Action and Management Plan Annual Report 2018](#)

In addition to the implementation activities described in the annual reports, the Lake Partnership agencies have also identified the following domestic projects which are particularly relevant to the achievement of the goals of the LAMP:

Lake Huron - Domestic Actions and Achievements (United States)

Increasing Fish Spawning Habitat in Saginaw Bay - In 2018, the Saginaw Reef Restoration project received \$980,000 of Great Lakes Restoration Initiative funding, as well as funding from the State of Michigan and Saginaw Bay Watershed Initiative Network, to restore rock reef habitat at two locations within Saginaw Bay. MDEQ, MDNR, Bay County, and other partners will create reefs that mimic naturally formed reefs by placing approximately 10,000 cubic yards of rock material on the lakebed and restoring two one-acre rock reefs within the bay. When completed in the fall of 2019, this project will help to diversify and create important spawning habitat for many native fish species and help to support a more resilient fishery.

Protecting water quality through green infrastructure - Lake Huron's southwestern shores as well as Saginaw



Lake Huron. Credit: Chapay, Pixabay.

Bay are the priority areas for addressing nutrient and bacterial pollution on the U.S. coast of Lake Huron. To address this problem, Monitor Township, in Bay County, Michigan, with support from the U.S. Forest Service (GLRI), is planting trees and plants to keep soil and nutrients out of the Bay. The Township is reducing runoff to the Bay from agricultural fields, roads, and developed sites by planting 1,200 acres of cover crops and 2.6 miles of buffer strips, as well as 300 trees and shrubs at the 20 acre township park. As a result, over 17,000 gallons of storm water runoff is filtered each year, and soil and nutrient runoff from lands that drain into the Bay is prevented.

Completion of the St. Marys River Little Rapids Restoration Project - The Little Rapids Restoration Project near Sault Ste Marie, Michigan, modified the Sugar Island causeway by replacing two culverts 6 feet in length with a 600 foot bridge. The increased water flow under the new bridge has restored rapids/riffle areas downstream, creating important habitat for fish spawning and invertebrates. The project was completed in late 2016 and post-construction monitoring continued into 2018. Minnows and salmon

were observed in the Little Rapids within days of flow restoration. The new bridge offers a safe pedestrian walkway and fishing access. Native vegetation has been planted to further naturalize the area. This GLRI-funded project completes required restoration actions on the U.S. side of the St. Marys River and is a positive step toward eventually delisting the St. Marys River AOC.

Lake Huron - Domestic Actions and Achievements (Canada)

Implementing Best Management Practices on agricultural lands - Under the Government of Canada's Growing Forward 2 Initiative, Ontario implemented the Great Lakes Agricultural Stewardship Initiative. The Initiative's Priority Sub-watershed Project assessed the effectiveness of on-farm agri-environmental Best Management Practices (BMPs) through continuous flow and event-based water quality monitoring at both the edge-of-field and sub-watershed outlets. This project informed farmer land management decisions and government policy and program development aimed at reducing nutrient losses from agricultural landscapes.

Lake Huron-Georgian Bay Canadian Initiative for Community Action

Examples of projects include:

- The Central Algoma Freshwater Coalition developed a watershed plan to help identify and tackle the algal issue through the promotion of best management practices.
- The Bruce Peninsula Biosphere Association initiated the Six Streams watershed project in which one of the focuses is to exclude cattle from local streams.
- The Ausable Bayfield Conservation Authority initiated a Healthy Headwaters, Wetlands Initiative which assists landowners in restoring or creating wetland habitat.

More information on these and many other projects is available at
www.lakehuroncommunityaction.ca



Lake Huron. Credit: OPaton, Pixabay.

In addition, the Farmland Health Check-Up assessment tool was introduced to support identification of field-specific risks and development of customized BMP solutions to improve soil health and water quality. The Farmland Health Check-Up process engaged Certified Crop Advisors and Professional Agrologists to leverage the industry's technical expertise and increase local capacity to support farmers' land management and BMP adoption decisions.

Stream restoration and floodplain creation - In 2017, the Nottawasaga Watershed Improvement Program committee and the Nottawasaga Valley Conservation Authority completed a large stream restoration and floodplain creation project on Lamont Creek adjacent to Georgian Bay. The project restored 235 meters of stream habitat, constructed two spawning riffles, stabilized 450 meters of stream banks, restored 2,250 square meters of enhanced floodplain, established three wetland cells, removed a barrier to fish migration and planted 2,000 native trees and shrubs. In 2018, they worked with Clearview Township and 220 local students to plant 1,500 native trees along Georgian Bay tributary streams. The project was funded by Environment and Climate Change Canada, the Province

of Ontario, Township of Clearview and TD Tree Days and implemented under the Lake Huron-Georgian Bay Canadian Initiative for Community Action.

Combatting non-native invasive Phragmites - The Nottawasaga Valley Conservation Authority worked in partnership with the Blue Mountain Watershed Trust, Georgian Bay Forever, Town of Collingwood, waterfront ratepayers associations and local community volunteers to harvest 3,900 kilograms of the non-native invasive Phragmites (*Phragmites australis* ssp. *australis*) from an 8,000 square meter area within the Silver Creek Coastal wetland, the largest coastal wetland in Georgian Bay south of the Canadian Shield. Funding support was provided by ECCC, the Province of Ontario, Weston Foundation, Loblaws and the OFAH.

Creating stream habitat for fish - In 2018, the Nottawasaga Valley Conservation Authority and South Simcoe Streams Network retrofitted the Beeton Creek Ice Dam to re-establish a migratory route for Great Lakes fish and provide access to 10 kilometers of stream habitat. Funding support for this project was provided by Bruce Power, DFO and the Town of New Tecumseth.

Preventing nutrients and bacteria from entering local tributaries and Lake - [The Healthy Lake Huron - Clean Water Clean Beaches](#) is continuing its efforts to reduce nutrients and bacteria entering local tributaries and along the southeast shores of Lake Huron. The project, led by the OMECP and OMAFRA, has resulted to date in over 400 best management projects and has invested \$4 million in BMP adoption, research, and education and outreach. Implementation actions include stream buffers, erosion control, cover crops, restricting livestock from streams, septic system upgrades, and shoreline clean ups. Research has focused on BMP effectiveness and impacts from storm events. Outreach and education are another key piece of this initiative and includes annual newsletters, landowner workshops and demonstration sites. Long term monitoring is being conducted in each of these watersheds to help determine the effectiveness of these actions in improving water quality.

Inspiring local action to protect the environment - The Lake Huron-Georgian Bay Canadian Initiative for Community Action is continuing its efforts to connect federal and provincial agencies, municipal governments, First Nations, Métis, watershed management agencies,

non-governmental organizations, and the public to raise awareness and inspire community-based environmental action. Started in 2007, there are many community-based environmental initiatives underway in the areas of education and outreach, stewardship, and monitoring and research.

Lake Ontario - Binational Actions and Achievements

The Lake Partnership is currently developing the Lake Ontario LAMP and will publish a final document in 2019. In June 2017, the public was engaged to provide early input to the drafting of the LAMP, and a draft LAMP was released for public comments and feedback during an eight-week period beginning in April 2019. The current draft of the 2018-2022 LAMP includes actions that address the identified threats, complement various binational strategies, and contribute towards achieving the nine General Objectives of the Agreement. The priority management actions in the 2018-2022 LAMP are grouped by four specific issue areas: (1) Nutrient and bacterial related impacts; (2) Loss of habitat and native species; (3) Invasive species; and (4) Critical and emerging chemical pollutants.

In addition to developing the LAMP, over the last three years the Lake Partnership worked in partnership with the Science Annex Subcommittee on the Cooperative Science and Monitoring Initiative and produced Annual Reports describing major implementation activities, as described below:

- As part of the five-year cycle of the Cooperative Science and Monitoring Initiative, the Lake Partnership developed science priorities for the 2018 CSMI Field Year in August 2017. The CSMI activities that took place in 2018 are described in more detail in the Science Annex section.
- The following Annual Reports were produced by the Lake Partnership, which provide a detailed discussion of ongoing implementation activities:
 - [Lake Ontario Lakewide Action and Management Plan Annual Report 2016](#)
 - [Lake Ontario Lakewide Action and Management Plan Annual Report 2017](#)
 - [Lake Ontario Lakewide Action and Management Plan Annual Report 2018](#)

The Lake Partnership agencies will report on the implementation of domestic projects which are particularly relevant to the achievement of the goals of the new LAMP in the next Progress Report of the Parties.

The following two Lake Ontario projects exemplify successful binational cooperation to restore native fish.

The return of Deepwater Sculpin - Deepwater Sculpin, a native bottom-dwelling prey fish, were once abundant in Lake Ontario and a food source of predator fish such as Lake Trout. In the mid-1900s, Deepwater Sculpin had declined so much that they were believed to have been extirpated from the Lake. In the early 2000s, rare catches during prey fish surveys indicated that Deepwater Sculpin were present in Lake Ontario and the population was beginning to recover. By 2017, Deepwater Sculpin were the most abundant benthic prey fish by weight captured in the cooperative surveys conducted by the USGS, NYSDEC and OMNRF. Populations in Lake Ontario are now similar to those in the other Great Lakes, fulfilling a goal in the [Lake Ontario's Biodiversity Conservation Strategy \(2011\)](#).

Success in Lake Sturgeon restoration and research - Lake Sturgeon can grow up to 7 feet long and weigh over 300 pounds. They also reproduce slowly, taking from 15 to 33 years to reach reproductive maturity. In the late 1800s, lake sturgeon were heavily exploited for their meat and roe (caviar). Overfishing and the impacts of dams and the degradation of tributary spawning areas nearly drove Lake Sturgeon to extirpation by the early 1900s. They are currently identified as "Threatened" in New York and Ontario under endangered species



Lake Ontario. Credit: David Mark, Pixabay.



Deepwater Sculpin from Lake Ontario (left, standard sculpin; right, blue-tinted sculpin). Credit: USGS.

legislation. In the past 25 years, collaborative work has focused on protecting remnant populations and restoring Lake Sturgeon in Lake Ontario, the Niagara and St. Lawrence Rivers, and their tributaries. Contributors have included: federal, Tribal, state and provincial agencies; academic and non-governmental organizations; local volunteers and school children in the United States and Canada. Their efforts involved collecting eggs, raising and stocking young sturgeon, identifying suitable habitat, constructing spawning beds, and studying their behavior and biology. The success of these efforts is now being observed across the Lake Ontario basin. Fish stocked in the 1990s are now reproducing, and remnant wild populations continue to reproduce as well.

In addition to the implementation activities described above and in the Annual Reports, the Lake Partnership agencies have also undertaken the following domestic projects:

Lake Ontario - Domestic Actions and Achievements (United States)

Using advanced methods to estimate flows in the Niagara and St. Lawrence Rivers - Accurate flow measurements are critical for calculating water levels and for estimating the quantity of harmful chemicals, nutrients, and sediment entering and leaving Lake Ontario. In 2017, the USGS and the USACE began a cooperative effort to establish state-of-the-art acoustic Doppler flow measurement (ADVM) stations, which measures water current velocities using the Doppler effect of sound waves scattered back from particles

within the water column. ADVM technology will be deployed at two stations: at the lower Niagara River to measure water flowing into the lake and at the upper St. Lawrence River to measure water leaving the lake. These flow measurements will be used in models to calculate more exact chemical, sediment, and nutrient loading estimates.

Hogansburg dam removal and native mussel rescue - In the summer of 2016, the Saint Regis Mohawk Tribe (SRMT) oversaw the removal of the Hogansburg Dam, a 281-foot dam near the mouth of the St. Regis River, a tributary to the St. Lawrence River. This project marked the first removal of a federally-licensed dam by a U.S. Tribe, as well as the first removal of a hydropower dam in New York State. The removal opened 274 river and stream miles of migration routes to upstream spawning and nursery habitat benefiting walleye, muskellunge, Atlantic salmon, lake sturgeon, American eel, and others. SRMT also rescued nearshore native freshwater mussels in the area above the dam that would have died following the dewatering associated with the dam removal. Surveys found 11 native mussel species present within the project area, 4 of which are considered New York State Species of Greatest Conservation Need (NYS SGCN). In total, 66,539 mussels were relocated, including 6,550 which were assumed to be NYS SGCN. Preventing mussel mortality was important in this river system since the population remains unimpacted by invasive mussel species, and because the mussels have an important ecological function that contributes to water quality.

Lake Ontario - Domestic Actions and Achievements (Canada)

Understanding Nearshore Nutrient Dynamics - Major tributaries draining watersheds of various land uses into the Lake Ontario nearshore are being monitored to understand nutrient loadings from point and non-point sources. The information gathered through in-place monitoring at key tributaries, combined with in-lake instrumented monitoring and vessel surveys, will be complemented with hydrodynamic modeling to provide a region-wide understanding of nutrient dynamics in the nearshore of Lake Ontario. Additionally, the multi-partner Toronto Waterfront 2018 Nearshore Water Quality Reference Study is providing information and



Lake Ontario. Credit: eduard_, Pixabay.

insights needed to manage nutrient impacts related to a growing metropolitan area. This detailed type of nutrient survey improves the understanding of the cause and effect relationships in complex nearshore settings, such as highly-urbanized areas which can place stress on the Lakes.

Hamilton Harbour – Water quality and ecosystem health have improved in Hamilton Harbour. Today, four of six managed colonial waterbird species have reached their restoration target population levels. Fish populations have responded positively to actions taken to improve water quality and habitat, and to reduce the impact of invasive species. PCB concentrations in sport fish have declined by 59 percent to 82 percent from historical levels; however, consumption restrictions remain among the highest of all Great Lake AOCs. (Additional information can be found in the Areas of Concern Annex).

Lake Erie - Binational Actions and Achievements

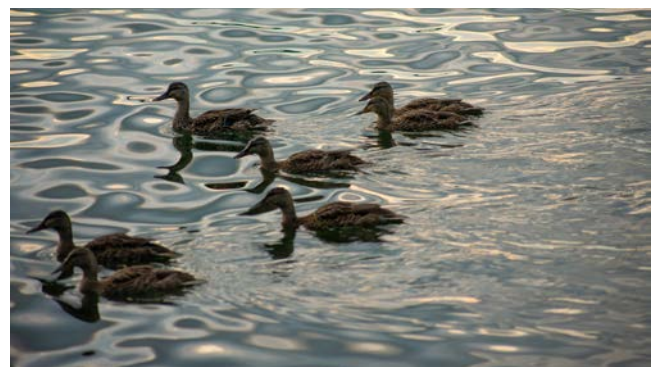
The Lake Erie LAMP is in development and is targeted for completion by the end of 2019.

The draft 2019-2023 LAMP includes actions that address the identified threats and contribute towards achieving the nine General Objectives of the Agreement. The priority management actions in the draft LAMP are grouped by four specific issue areas: (1) Nutrient and bacterial related impacts; (2) Loss of habitat and native species; (3) Invasive species; and (4) Critical and emerging chemical pollutants.

In addition to developing the LAMP, over the last three years the Lake Partnership has expanded its outreach and engagement efforts on nutrient management

in partnership with the Nutrients Annex, worked in partnership with the Science Annex Subcommittee on the CSMI, piloted the application and testing of the binational Nearshore Framework, and produced Annual Reports describing major implementation activities, as described below:

- In November 2018, the Lake Partnership held a public webinar in coordination with the Nutrients Annex to provide an update on nutrient reduction efforts in Lake Erie.
- As part of the five year cycle of the CSMI, a [State of Lake Erie](#) meeting was held for interested parties to share information on the current state of the lake in February 2017. In October 2017, the Lake Partnership and other stakeholders met to discuss science and monitoring priorities for Lake Erie and the St. Clair – Lake St. Clair – Detroit River system. The Lake Partnership developed science priorities for the 2019 CSMI Field Year in February 2018.
- During the last three years, the United States and Canada piloted the application and testing of the binational Nearshore Framework in Lake Erie and is expanding these efforts to the other Great Lakes. In the United States, existing domestic programs are leveraged for implementation of the Nearshore Framework (see information box on next page).
- The following Annual Reports were produced by the Lake Partnership, which provide a detailed discussion of ongoing implementation activities:
 - [Lake Erie Lakewide Action and Management Plan Annual Report 2016](#)
 - [Lake Erie Lakewide Action and Management Plan Annual Report 2017](#)
 - [Lake Erie Lakewide Action and Management Plan](#)



Lake Erie. Credit: Dylan Alvis, Pixabay.

A brief summary of U.S. and Canadian applications of the nearshore framework approaches

In the United States, existing domestic programs are used to implement the Nearshore Framework. Domestic programs include the monitoring and assessment activities under the Clean Water Act, implementation of the Coastal Zone Management Program, the National Coastal Conditions Assessment, strategic plans and initiatives by the states, and other nearshore-specific agency strategies. The NOAA's [National Coastal Zone Management Program](#) partners with coastal states to address some of today's most pressing coastal issues including improving public access, protecting and restoring coastal habitat, and protecting coastal water quality. All eight Great Lakes states have entered into the voluntary partnership. USEPA's Office of Water, in partnership with states and Tribes, conducts the [National Coastal Condition Assessment](#) to assess the condition of nearshore waters and track changes over time. The sample design is based on a random, stratified survey. In Lake Erie, approximately 60 sampling stations are used for the base assessment of ecological conditions in U.S. nearshore waters. Approximately another 30 sites are sampled to allow for sufficiently strong estimates of water quality condition in each basin of the lake (i.e., Western basin, Central basin and Eastern basin).

In Canada, through the Great Lakes Protection Initiative, a pilot assessment of the Fort Erie to Long Point section of the Lake Erie nearshore was completed in 2016 - 2017. The results of the pilot assessment were reviewed binationally by a core team and advisory panel, which led to refinements in advance of completing a full Lake Erie Canadian nearshore assessment in 2017 - 2018. Use of a "weight of evidence" method was incorporated into the overall assessment to integrate data collected under the categories of: nutrients; human uses; physical processes, connectivity and habitat and; water and sediment quality. New methods were developed to confirm the results with an evaluation of biological data (fish and benthos) and their relationship to water and sediment quality conditions. The Canadian portion of the Lake Erie nearshore and the St. Clair - Detroit River Corridor was subdivided into 15 regional units and assessed based on existing data for all of the lines of evidence within the weight of evidence approach. An east-west gradient exists across the north shore of Lake Erie, with the regional units of highest quality in the east and lowest quality in the west. The Western Basin Cyanobacteria blooms (assessed by Cyanobacteria Index using satellite data) exert a strong influence on the overall health of the western basin and the western half of the Central Basin. Highest quality areas included Long Point Bay and the Port Dover to Port Maitland area where large, ecologically significant coastal wetlands remain intact. ECCC and the DFO entered into a partnership to acquire high resolution light detection and ranging (LiDAR) data to improve existing information on the Great Lakes nearshore ecosystem, and in particular, nearshore depth, slope and other physical information such as bottom substrate type. This and other physical data is being integrated into an overall assessment of nearshore aquatic ecosystem health, throughout the Canadian Great Lakes.

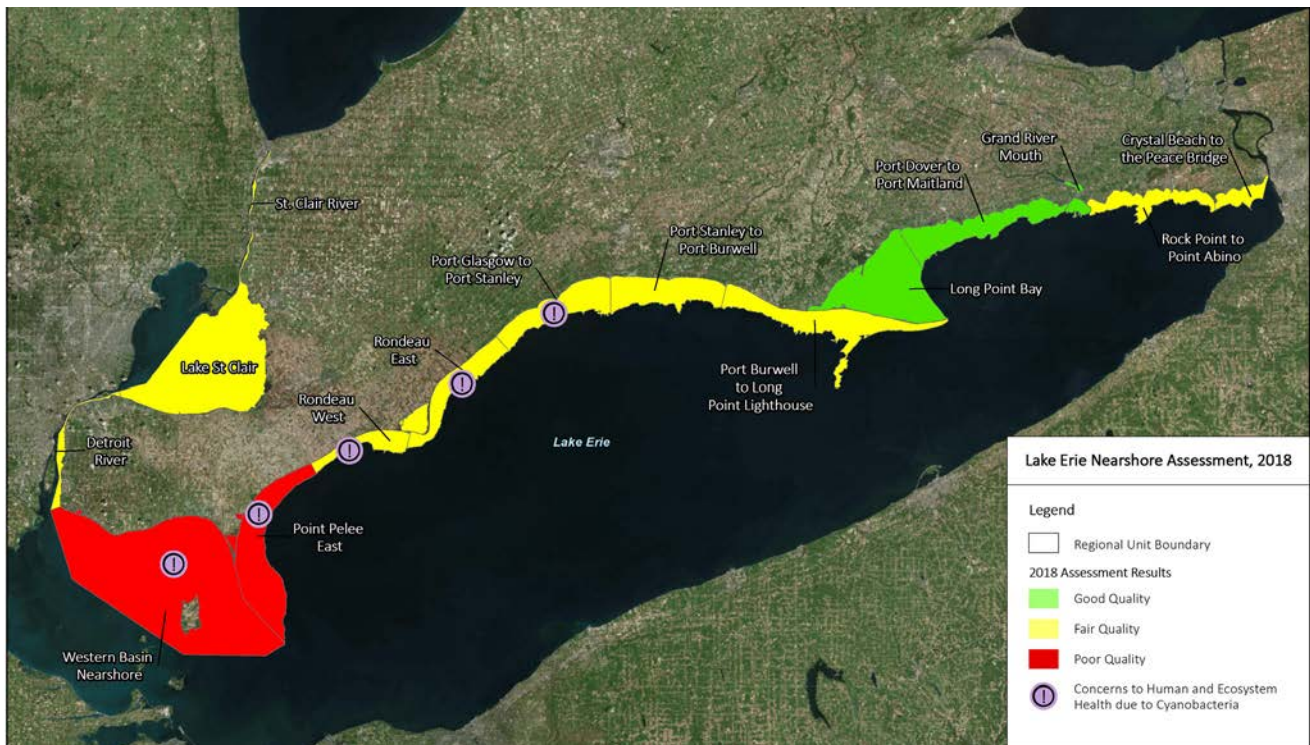
[Annual Report 2018](#)

The Lake Partnership agencies will report on the implementation of domestic projects which are particularly relevant to the achievement of the goals of the new LAMP in the next Progress Report of the Parties. In addition to the implementation activities described in the Annual Reports, the Lake Partnership agencies have also undertaken the following domestic projects:

Lake Erie - Domestic Actions and Achievements (United States)

Reducing phosphorus from Michigan tributaries - Michigan's natural resource agencies are committed to achieving the 40 percent phosphorus reduction goal defined in the Lake Erie domestic action plan and working in collaboration with federal, state and local partners to improve the health of Lake Erie. Actions on farmland are underway by many partners. The Michigan Department of Agriculture and Rural Development

has continued to expand staffing for the Michigan Agriculture Environmental Assurance Program (MAEAP), providing additional technicians to work with farmers to protect water quality through voluntary measures like nutrient management plans. Statewide, the program has reached nearly 5,000 verifications. There has been additional interest from urban farms to be environmentally verified under MAEAP. The Great Lakes Water Authority and farmers are together implementing variable rate biosolids application methods to get nutrients where they are needed on fields in the right proportions. The MSU Institute of Water Research is working on a project to plant cover crops and adopt other conservation practices that reduce phosphorus throughout Southeast Michigan. Cover crops protect water quality by reducing losses of nutrients, sediments, and pesticides. The Adams Township State Game Area in Hillsdale County was awarded grant funding from the MDNR to convert 30 acres of field into prairie habitat with wetland restoration. Work will begin in spring 2019.



A complete summary of the Canadian and United States assessment approaches and findings are reported in the State of the Nearshore Waters section of the Lake Erie LAMP. Credit: ECCC.

Reducing phosphorus from Pennsylvania tributaries - Pennsylvania's Department of Environmental Protection (PADEP) coordinates initiatives that implement the Pennsylvania Lake Erie Phosphorus Reduction domestic action plan and that improve water quality in Great Lakes tributaries. Using GLRI funding provided by PADEP and PADEP Growing Greener grant funding, the Erie County Conservation District implements the the Pennsylvania Vested In Environmental Sustainability PLUS (PA VinES PLUS) Program that promotes sustainable viticulture and grape growing practices on approximately 10,000 acres of juice and wine grapes within the PA Lake Erie Basin. Recently, the Program was expanded to PA VinES PLUS to allow participation of other forms of specialty agriculture in the Basin such as fruit and row crops, silviculture, and animal production facilities. PADEP also provides GLRI funding to the Erie County Department of Health to conduct the Erie County Small Flow Treatment Facility (SFTF) Program that conducts monitoring and inspections of the approximately 290 individual SFTF outfalls in the PA Lake Erie Basin. In addition to helping to correct SFTF operation, maintenance, and administrative problems, the program focuses on education and outreach to SFTF owners to increase knowledge of how their systems

function and tips for proper operation. During the 2018 reporting year, the program reduced the number SFTF in violation from 33 percent down to 7 percent, improving the discharge water quality from 85 outfalls.

New recreational opportunities at Black River in Ohio - Originally called the "river of fish tumors", the Black River in Ohio now boasts sport fishing, kayaking and tour boats eager to view the Great Blue Heron rookery. Since 2010, more than \$23.5 million from the GLRI has been



Lake Erie. Credit: debsie3802, Pixabay.

used to fund 20 projects to remediate and restore this AOC. In FY 2017, the Eutrophication and Restrictions on Fish and Wildlife Consumption Beneficial Use Impairments (BUIs) were removed. The federal, state and local AOC partnership for the Black River are on the path towards completing all management actions in 2019 and continuing to remove Beneficial Use Impairments (BUIs) as a result of these actions.

Lake Erie - Domestic Actions and Achievements (Canada)

Water Management Plans - New water management plans have been developed for the Grand and Thames Rivers, the two largest Canadian tributaries to Lake Erie. A priority of both Plans is improving water quality in order to reduce downstream impacts to the Great Lakes. The Water Management Plan for the Grand River watershed was endorsed by 27 municipalities; Six Nations of the Grand River; Environment and Climate Change Canada (ECCC); the Ontario Ministries of Environment, Conservation and Parks (OMECP), Natural Resources and Forestry (OMNRF), and Agriculture, Food and Rural Affairs (OMAFRA); and the Grand River Conservation Authority. Implementation began in 2015. The Water Management Plan for the Thames River was developed collaboratively by the members of the Thames River Clear Water Revival, including the Upper and Lower Thames River Conservation Authorities, OMECP, OMNRF, OMAFRA, ECCC, Aamjiwnaang First Nation, Walpole Island First Nation, Caldwell First Nation, Chippewas of the Thames First Nation, and the City of London, and will be completed in 2019. The actions implemented under both Plans will help reduce phosphorus loads to Lake Erie.

Lower Grand River Rehabilitation - Historically, the Grand River ecosystem supported large populations of native migratory fish whose populations are now extirpated or significantly restricted. The Southern Grand River Ecosystem Rehabilitation Initiative, comprised of federal, provincial, conservation authority and First Nation partners, looks to restore the ecological function of the river and its important connection to Lake Erie. Using a Decision Analysis approach, the initiative has engaged a broad range of stakeholders to develop a shared vision and assess options for this restoration effort.

Niagara Coastal Community Collaborative - Local citizens interested in the health of the Lake Erie coast in the Niagara Region (Ontario) have come together as the Niagara Coastal Community Collaborative. The Collaborative is supported by ECCC and the Ontario Ministries of the Environment, Conservation and Parks and Natural Resources and Forestry, with the goal of a healthy and resilient Lake Erie coastal ecosystem. It provides a venue for collaboration, ensures that actions of local stakeholders are mutually reinforcing, and ensures the activities of local groups are aligned with broader Lake Erie ecosystem management initiatives such as the LAMP. The Collaborative has identified healthy beaches, nature-based shorelines and habitat and species as its ecological priorities, and in 2018 launched a volunteer Cladophora monitoring program covering 10 beaches in the eastern end of Lake Erie.

Lake Michigan - National Actions and Achievements

The Lake Partnership is currently developing the Lake Michigan LAMP and will publish a final document in 2020. In January 2019, the public was engaged to provide early input to the drafting of the LAMP, and a draft LAMP is planned to be released for public comments later in 2019. The 2020-2024 LAMP will include actions that address the identified threats, complement various domestic strategies, and contribute towards achieving the nine General Objectives of the Agreement. The priority management actions in the draft LAMP are expected to be grouped by four specific issue areas: (1) Nutrient and bacterial related impacts; (2) Loss of habitat and native species; (3) Invasive species; and (4) Chemical pollutants.

In addition to writing the LAMP, over the last three years the Lake Partnership worked in partnership with the Science Annex on the Cooperative Science and Monitoring Initiative and produced Annual Reports describing major implementation activities, as described below:

- As part of the five-year cycle of the CSMI, the Lake Partnership discussed the results of the 2015 CSMI Field Year at the November 2017 International Association for Great Lakes Research's State of Lake Michigan conference. The Lake Partnership held a workshop to explore science priorities for the

2020 CSMI Field Year in October 2018. The Lake Partnership will develop final priorities for the 2020 field Year in 2019.

- The following Annual Reports were produced by the Lake Partnership, which provides a detailed discussion of ongoing implementation activities:
 - [Lake Michigan Lakewide Action and Management Plan Annual Report 2016](#)
 - [Lake Michigan Lakewide Action and Management Plan Annual Report 2017](#)
 - [Lake Michigan Lakewide Action and Management Plan Annual Report 2018](#)

The Lake Partnership agencies will report on the implementation of projects which are particularly relevant to the achievement of the goals of the new LAMP in the next Progress Report of the Parties. The following projects are examples of activities described in the most recent Annual Reports:

Lake Michigan - United States Actions and Achievements

Rocky reef restoration in Grand Traverse Bay - Rocky reefs provide secure spawning habitat for many fish species, including lake trout, whitefish, and cisco. Unfortunately, many important reefs have been degraded due to invasive species (particularly via smothering by dreissenid mussel shells and predation by round gobies and rusty crayfish) and other stressors. Since 2015, The Nature Conservancy, MIDNR, USFWS and Central Michigan University have been improving a Grand Traverse Bay reef by strategically placing limestone on the lake bed, complemented by novel invasive species control methods. Initial results suggest egg survival has dramatically improved. Project partners continue to monitor the reef and assess its outcomes. Lessons learned from this project have been transferred to other reef restoration projects in Saginaw Bay (Lake Huron) and elsewhere.

Solution-oriented research for shoreline management - On a lakewide scale, USACE partners on shoreline management through its Regional Sediment Management (RSM) program. RSM focuses on cost-effective and adaptive regional sediment approaches that increase environmental and social benefits. In Illinois and Indiana, USACE also monitors the effectiveness of nearshore sediment placement

for shoreline protection. Results will inform Lake Michigan practices related to beach nourishment and beneficial use of dredged material. At the state level, the Illinois Department of Natural Resources Coastal Management Program (CMP) partners with the Illinois State Geological Survey (ISGS) to determine the drivers of shoreline change on Lake Michigan's southwest coast. Through a GLRI-funded project, ISGS integrates this data into a vulnerability model to assess habitat loss at Illinois Beach State Park, located near the Illinois-Wisconsin border. By quantifying the threats to coastal habitats and their value, state park and regional managers can prioritize and adapt land use decision making.

W.G. Jackson educational boat tours - The Indiana Department of Environmental Management (IDEM), the Michigan City Sanitary District, Hammond Marina, and Grand Valley State University teamed up each June to provide area residents with hands-on educational opportunities onboard the W.G. Jackson Lake Michigan research vessel. The W.G. Jackson is a specially-outfitted vessel that allows groups of up to 30 people, aged 10 and older, to conduct hands-on water quality sampling and analysis of dissolved oxygen, temperature, water clarity, sediment, and plankton. The crew and/or IDEM staff then educated the attendees on issues impacting Lake Michigan's water quality and food web, as well as programs in place under the Great Lakes Water Quality Agreement to Restoration Initiative (GLRI), reached over 700 people.

The return of Lake Whitefish to Green Bay tributaries - After a 100-year absence, a resurgence of tributary-spawning Lake Whitefish populations has been observed in major tributaries to Green Bay including the Menominee, Fox, Peshtigo, and Oconto Rivers in recent years. Researchers from the University of Wisconsin-Green Bay estimated the extent of larval production from each of the four tributaries. Total production was variable, but approximately 480,000 to 2,000,000 larvae are estimated to have been produced during two sample years. This confirms that Lake Whitefish are successfully spawning in large Wisconsin tributaries along the shores of Green Bay.



Chemicals of Mutual Concern Annex

Overview

Chemicals management in Canada and the United States occurs primarily through a variety of domestic programs driven by legislation at the federal, provincial, state, tribal, and local levels. The Agreement provides a tool for the United States and Canada to coordinate efforts to identify and reduce anthropogenic inputs of chemicals of mutual concern (CMCs) that may require additional measures, including the development of binational risk management strategies, to protect against threats to human and environmental health resulting from their presence in the waters of the Great Lakes.

Under the CMC Annex, Canada and the United States have committed to:

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

In 2016, Canada and the U.S. designated the following chemicals as the first set of CMCs under the Great Lakes Water Quality Agreement:

- Hexabromocyclododecane (HBCD)
- Long-chain Perfluorinated Carboxylic Acids (LC-PFCAs)
- Mercury
- Perfluorooctanoic Acid (PFOA)
- Perfluorooctane Sulfonate (PFOS)
- Polybrominated Diphenyl Ethers (PBDEs)
- Polychlorinated Biphenyls (PCBs)
- Short-Chain Chlorinated Paraffins (SCCPs)

Annex Implementation

These achievements were supported by the Chemicals of Mutual Concern Annex Subcommittee, co-led by Environment and Climate Change Canada (ECCC) and the United States Environmental Protection Agency (USEPA); with members from Ontario Ministry of the Environment, Conservation and Parks (OMECP), Chiefs of Ontario (COO), United States National Oceanic and Atmospheric Administration (NOAA), Great Lakes Indian Fish and Wildlife Commission (GLIFWC), Minnesota Department of Health (MDH), Minnesota Pollution Control Agency (MPCA), and Wisconsin Department of Natural Resources (WS DNR). An Extended Subcommittee involves additional non-governmental organizations and experts beyond the GLEC membership.

Key Achievements

2017: Public review of HBCD and PCB Binational Strategies; Canadian Nuclear Safety Commission and U.S. Nuclear Regulatory Commission analysis of radionuclide candidate CMC nomination.

2018: Finalization of HBCD and PCB Binational Strategies; public review of PBDE and mercury Binational Strategies.

2019: Finalization of mercury and PBDE Binational Strategies; finalization of the binational screening criteria for evaluating chemicals nominated as CMCs (projected); public review and finalization of SCCP Binational Strategy (projected); evaluation and decision on radionuclides and sulfates as candidate CMCs (projected); and public review and finalization of PFOS, PFOA and LC-PFCAs Binational Strategy (projected).

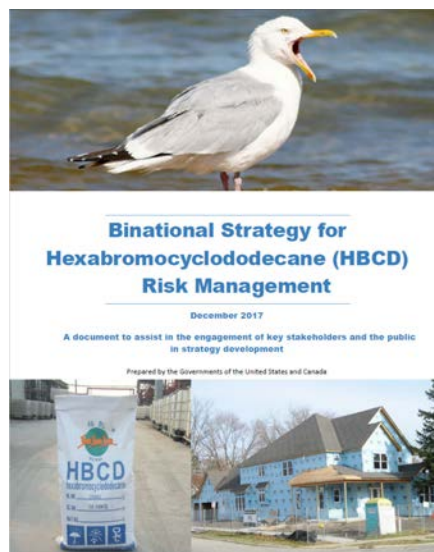
Binational Actions and Achievements

2017 to 2019 Priority for Action: Continue the development of Binational Strategies that identify measures to reduce anthropogenic inputs of CMCs into the waters of the Great Lakes.

The strategies for the risk management of PCBs and HBCD are finalized. It is anticipated that the PBDEs and Mercury strategies will be completed by June 2019, and the SCCPs and PFAS strategies by the end of 2019 (the three perfluorinated CMCs – PFOS, PFOA, and long-chain Perfluorinated Compounds – will be combined into a single strategy). These strategies identify management options to address threats to the Great Lakes by reducing CMC releases. Opportunities for stakeholder and public review and input were provided during the development of each of the Binational Strategies.

2017 to 2019 Priority for Action: Identify and assess additional substances for consideration as CMCs, while seeking to utilize the data, input and expertise of the Annex 3 stakeholder community.

The nomination process for a potential new CMC involves the submission of a proposal, which includes a rationale based on currently available data for why the

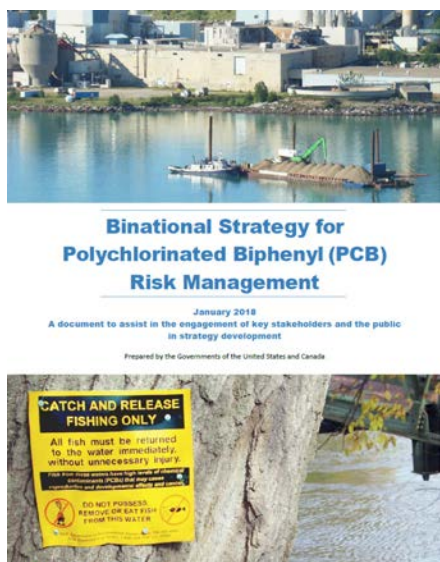


Cover page of the Binational Strategy for Hexabromocyclododecane (HBCD) Risk Management. Credit: Canada and United States.

substance is being put forth for consideration as a CMC. Four substances were nominated for consideration as CMCs. Two chemicals were nominated during the public nomination period for candidate CMCs in 2016 (radionuclides and sulfates) and two chemicals (Lead and Polycyclic Aromatic Hydrocarbons (PAHs)) were nominated by ECCC. Radionuclides and Sulfates have been evaluated against the binational screening criteria for nominated CMCs (projected). Expertise from nuclear regulatory agencies, federal, state, provincial and Tribal governments, non-governmental organizations and industry was considered during the evaluation process. Two chemicals nominated by ECCC (lead and polyaromatic hydrocarbons) have also been evaluated (projected).

2017 to 2019 Priority for Science: Undertake research, monitoring and surveillance activities identified in Binational Strategies in order to address information needs for CMCs in support of future measurement/indicators work.

Through mechanisms such as the Annex 10 monitoring and surveillance activities under the Science Annex, monitoring of CMCs in relevant environmental media of the Great Lakes is being pursued in a collaborative and coordinated manner. As a result of CMC designation, atmospheric deposition, fish tissue, and other monitoring and surveillance programs have incorporated, or are incorporating, HBCD and PFAS into



Cover page of the Binational Strategy for Polychlorinated Biphenyl (PCB) Risk Management. Credit: Canada and United States.

annual monitoring programs as appropriate. Monitoring of CMCs supports the commitments of the CMC Annex, and is also critical for the development of the triennial State of the Great Lakes report, in which levels of these chemicals in the Great Lakes are assessed and reported in the appropriate media (e.g., air, water, fish tissue, sediment, and herring gull eggs).

2017 to 2019 Priority for Science: Coordinate research, monitoring and surveillance activities to provide early warning for chemicals that could become CMCs.

Canada and the United States have comprehensive national monitoring and surveillance programs, as well as regional, Great Lakes-specific programs and activities, which inform the evaluation of a broad suite of chemicals, including chemicals that could potentially become a chemical of mutual concern.

Domestic Actions and Achievements (Canada)

National Chemical Management

The Government of Canada continues to assess and manage the risks posed by chemicals, including CMCs, through its national Chemicals Management Plan. Under the Chemicals Management Plan, over 3,500 substances have been assessed, and 457 existing chemicals have been found to be harmful to the environment and/or human health. For these substances, 90 risk management actions have been implemented, and additional risk management tools are in development.

All designated CMCs are listed as toxic substances in Canada, and their manufacture, use or import are prohibited (with limited exemptions), contributing significantly to reducing releases to the Great Lakes.

The Government of Canada is also taking further action to reduce CMCs in the Great Lakes. Through the Great Lakes Protection Initiative, ECCC is supporting activities that will increase participation in the application of “beyond compliance” measures to reduce releases of CMCs to the Great Lakes from Canadian sources by developing, implementing, assessing and promoting the use of innovative approaches. In 2018, Canada announced support for new partner-led projects that

contribute to this priority, described in the following sections.

The Government of Canada is taking risk mitigation and management actions to directly address all eight CMCs:

Mercury

In February 2017, Environment and Climate Change Canada published the Code of Practice for the environmentally sound management of end-of-life lamps containing mercury, with the objective of providing best practices for collection, storage, transportation and processing of mercury-containing lamps at their end of life, in order to prevent the release of mercury to the environment.

The National Strategy for the Safe and Environmentally Sound Disposal of Lamps Containing Mercury Act was enacted in June 2017. This Act requires ECCC to develop a national strategy by June 2019. Development is underway in collaboration with provinces and territories. A discussion paper on the issue was published in February 2018, and consultations on the development of the national strategy were open until November 2018.

As part of Canada’s climate plan, federal, provincial and territorial governments agreed to work together to increase the amount of electricity generated from renewable and low-emitting sources. To support this goal, the Government of Canada published two final regulations in 2018 that will phase-out conventional coal-fired electricity generation, which is a significant source of mercury, by 2029.

In February 2017, Canada introduced comprehensive restrictions on the export of mercury under the Export of Substances on the Export Controls List Regulations under the Canadian Environmental Protection Act,



Compact fluorescent bulbs contain small amount of mercury. Credit: andreas160578, Pixabay.

1999, which restrict the export of mixtures containing elemental mercury at concentrations of 96 percent or more by weight, with some exemptions. The restrictions are aligned with the Minamata Convention on Mercury, a global agreement to reduce anthropogenic mercury emissions and releases to the environment, which Canada ratified on April 7, 2017.

On February 1, 2018, a consultation document on proposed amendments to the Products Containing Mercury Regulations was published, with the objective of aligning the regulations with the regulatory requirements of the Minamata Convention on Mercury and with recent industry standards and other international regulatory initiatives. ECCC is targeting spring 2019 for publication of proposed amendments and publications of final amendments in 2020.

Polychlorinated Biphenyls (PCBs)

In 2018, under the Great Lakes Protection Initiative, ECCC funded the University of Toronto to provide an updated inventory of Arochlor PCBs 'in-use' and 'in-storage' in the Great Lakes basin. The inventory updates knowledge and understanding of PCBs entering the Great Lakes from these primary sources. The information gathered will be used to improve accuracy and understanding of sources and emissions of PCBs in the Great Lakes basin and determine whether further action is needed.

Hexabromocyclododecane (HBCD) and Polybrominated Diphenyl Ethers (PBDEs)

The Prohibition of Certain Toxic Substances Regulations,



PCBs have been used to make coolants and lubricants for certain kinds of electrical equipment, such as transformers and capacitors. Credit: Th G, Pixabay.

2012, made under the authority of Canadian Environmental Protection Act, 1999, were amended in October 2016 to add HBCD and PBDEs, with the new requirements entering into force on December 23, 2016. The amendments for HBCD prohibit the manufacture, use, sale, offer for sale or import of HBCD as well as expanded and extruded foams and their intermediary products that contain HBCD for building or construction applications. The amendments replace previous regulations and add additional requirements by prohibiting the manufacture, use, sale, offer for sale, and import of PBDEs, including decabromodiphenyl ether (decaBDE), and all products that contain PBDEs except for manufactured items. A notice of intent was published in October 2018 to further restrict HBCD and PBDEs, including removing the exemption for manufactured items containing PBDEs.

Federal Environmental Quality Guidelines for HBCD were published in 2016. Federal Environmental Quality Guidelines provide benchmarks for the quality of the ambient environment, based solely on the hazard of a specific substance. The Guidelines provide targets for acceptable environmental quality, assist in evaluating the concentrations of chemicals in the environment and they can serve as performance measures for risk management activities.

In 2018, ECCC funded a project with Trent University through the Great Lakes Protection Initiative to evaluate the efficiency of removal of brominated flame retardants from municipal wastewater by treatment with ozone. This project will provide valuable information on the efficacy of removal of brominated flame retardants and the cost-effectiveness of this technology for municipalities in the Great Lakes basin that are considering retrofitting or replacing their chlorination disinfection systems.

Perfluorooctane sulfonate (PFOS), Perfluorooctanoic acid (PFOA) and Long-chain Perfluorinated Carboxylic Acids (LC-PFCAs)

The Prohibition of Certain Toxic Substances Regulations, 2012, made under the authority of Canadian Environmental Protection Act, 1999, were amended in October 2016 to add PFOA, PFOS and LC-PFCAs, with the new requirements entering into force on December 23, 2016. The amendments prohibit the manufacture, use, sale, offer for sale, or import of PFOA



For many years, PFOS was a component of aqueous fire-fighting foams. Credit: Marcel Langthim, Pixabay.

and LC-PFCAs and products containing them with a limited number of exemptions, including manufactured items. The amendments replace previous regulations and incorporate Perfluorooctane sulfonate, its salts and precursors (collectively referred to as PFOS) with three changes: (a) the exemption for the use, sale, offer for sale, or import of aviation hydraulic fluids containing PFOS is removed; (b) the exemption for aqueous film-forming foams containing PFOS used in a military vessel deployed before May 2013 for a military operation is removed; and (c) the permitted concentration limit for the use of PFOS in aqueous film-forming foams is increased from 0.5 parts per million to 10 parts per million. Federal Environmental Quality Guidelines for PFOS were published in June 2018.

Research on the toxicity of PFOA has been undertaken under the Federal Contaminated Sites Action Plan.

In 2018, under the Great Lakes Protection Initiative, ECCC provided funding to Trent University to evaluate the efficiency of removal of perfluorinated compounds from municipal wastewater by treatment with ozone. This project will provide valuable information on the efficacy of removal of perfluorinated compounds and the cost-effectiveness of this technology for municipalities in the Great Lakes basin that are considering retrofitting or replacing their chlorination disinfection systems.

Short-Chain Chlorinated Paraffins (SCCPs)

Federal Environmental Quality Guidelines for chlorinated alkanes, including SCCPs, were published in 2016.

In 2018, ECCC provided funding to the University of Toronto through the Great Lakes Protection Initiative to identify sources of SCCPs emitted both indoors and outdoors from SCCP-containing products and materials, and to relate these sources to surface water and wastewater treatment effluent through analytical



Chlorinated paraffins have been used in metalworking fluids, such as cutting oils and high pressure lubricating oils. Credit: gefrorene_wand, Pixabay.

“fingerprinting” analysis coupled with source receptor modeling. The information gained through this study will fill critical knowledge gaps and allow for the development of actions to mitigate the releases of SCCPs into the Great Lakes.

Monitoring and Surveillance

ECCC delivers a foundational ecosystem monitoring and surveillance program in the Great Lakes watershed, which includes contaminant monitoring in water, precipitation, air, sediments, aquatic biota, wastewater and herring gull eggs. These coordinated monitoring and surveillance activities provide information on the status and trends of CMCs as well as priority chemicals identified through Canada’s Chemicals Management Plan. These analyses allow for the assessment of progress at addressing the levels of CMCs in the Great Lakes as well as to track the effectiveness of national and binational pollution prevention and control measures.

CMCs are also monitored under Ontario’s Great Lakes Nearshore Monitoring and Assessment Program and within Canadian Areas of Concern where the federal and provincial governments work collaboratively to implement remedial actions to address specific CMCs.

The OMECP monitors PBDEs, HBCD and other hydrophobic compounds to assess availability to organisms, and to track occurrence in water in the Great Lakes basin. PBDEs and HBCD are present in nearshore waters of western Lake Ontario, with greater concentrations in areas influenced by municipal wastewater discharges. Mercury and PCBs in Great Lakes basin fish are routinely monitored to support the development of fish consumption advisories and works to enhance public outreach and education on how to

obtain and use fish consumption advice. Preliminary studies to quantify the concentration of SCCP and medium-chained chlorinated paraffins in water samples were undertaken. Select samples had detectable amounts of both groups of Chlorinated Paraffins. In addition, a monitoring study was undertaken looking at mercury in funeral home effluents to identify potential sources of mercury to the environment. No mercury was detected in any of the 50 samples taken from eight funeral homes in southern Ontario.

Several monitoring studies have been undertaken in Canadian Areas of Concern to evaluate progress of chemicals-related remedial actions. For instance, preliminary data from the monitoring of the thin layer cap in the Peninsula Harbour AOC in Lake Superior in 2017 suggests a reduction in PCB and mercury exposure to biota and that remedial action goals for this AOC have been successfully met.

A 2018 Niagara River Caged Mussel Biomonitoring survey was completed as part of Ontario's commitment to the Niagara River Toxic Management Plan to identify sources and areas of persistent organic contaminants. Young-of-Year fish are scheduled to be collected in the fall of 2018 for routine monitoring of PCBs and mercury as well as other persistent organic pollutants.

Science and Research

In 2018, ECCC provided funding to the University of Toronto through the Great Lakes Protection Initiative to test the feasibility and effectiveness of mechanical filters on washing machines and dryers to collect and divert lint which contains CMCs that are present in household textiles and subsequent laundering processes. Given that all eight CMCs have been found in laundry lint, this research may provide a practical solution to help reduce discharges of CMCs from wastewater treatment plants into the Great Lakes basin.

Domestic Actions and Achievements (United States)

United States Federal Government

Monitoring and Surveillance

- The USEPA implements a number of monitoring and

surveillance activities in the Great Lakes watershed, including the Great Lakes Fish Monitoring and Surveillance Program, the International Atmospheric Deposition Network, the Great Lakes Sediment Surveillance Program (concluded in 2017) and the Toxics Release Inventory (TRI).

- All eight CMCs have been monitored in Great Lakes media (air, water, fish, sediment, etc.). For this reason, long-term monitoring and surveillance programs, such as the Great Lakes Fish Monitoring and Surveillance Program (GLFMSP) and the Integrated Atmospheric Deposition Network (IADN), develop their core chemical monitoring lists around chemicals that can be routinely and accurately detect. For example, the GLFMSP has added HBCD and PFAS to its routine monitoring lists, but has not added SCCPs due their low concentrations and localized detections. IADN is currently developing methods for HBCD and PFAS analysis. Program results are available from Agency websites, peer reviewed journal articles, the Great Lakes Environmental Database (GLEND), <https://iadnviz.iu.edu>, the State of the Great Lakes Reports and the Science in the Great Lakes (SiGL) mapper (<https://sigl.wim.usgs.gov/sigl/>).
- There are Fish Consumption Advisories across states and tribal lands for PCBs, Mercury, and PFOS.

National Chemicals Management

In the United States, CMCs are regulated under a combination of multiple federal, state, tribal, and local statutes and regulations, depending on the source, use and release of the respective CMC. Activities under the [Toxic Substances Control Act](#) (TSCA) – which provides USEPA with authority to require reporting, record-keeping and testing requirements, and restrictions relating to chemical substances and/or mixtures – are described throughout this section. In addition, the [Toxics Release Inventory](#) (TRI), [Safe Drinking Water Act](#) (SDWA) and [Clean Water Act](#) (CWA) contribute to chemical management, as briefly described below:

Toxic Release Inventory

The Toxics Release Inventory (TRI) tracks the management of certain toxic chemicals that may pose a threat to human health and the environment. United States facilities in different industry sectors must report annually how much of each chemical is released to the environment and/or managed through recycling, energy

recovery and treatment. The information submitted by facilities is compiled in the Toxics Release Inventory and helps support informed decision-making by companies, government agencies, non-governmental organizations and the public. CMC specific activities TRI actions include:

- April 2016, USEPA released a [TRI P2 Spotlight](#) on reducing decaBDE waste.
- November 2016, USEPA [finalized a rule](#) adding an HBCD category to the TRI list of reportable chemicals with a 100-pound reporting threshold. For the first required reporting year, 2017, four facilities nationwide reported releases of HBCD to TRI, one of which is in the Great Lakes Basin. This facility reported emitting 13,485 lbs of HBCD, or 17 percent of total air releases reported nationally. All the reported environmental releases from this facility were to the air.

Safe Drinking Water Act

- The Safe Drinking Water Act (SDWA) protects public drinking water supplies by requiring USEPA to set standards for drinking water quality and working with its partners to implement various technical and financial programs to ensure drinking water safety. USEPA implements the Safe Drinking Water Act's Public Water System Supervision (PWSS) program by protecting drinking water via a multi-barrier approach – preventing contaminants from getting into source waters, treating drinking water appropriately, and ensuring that drinking water consumers are informed. USEPA works with primacy states which implement the PWSS program for public water systems (PWSs) and conducts direct implementation for Tribal PWSs and aircraft PWSs.

Clean Water Act

The Clean Water Act (CWA) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. It includes the following pollution control programs:

- **National Pollutant Discharge Elimination System (NPDES) Permitting** - USEPA NPDES Program and the state NPDES Programs regulate: publicly owned treatment works and industrial facilities

discharging directly to surface waters; industrial facilities discharging to publicly owned treatment works; beneficial reuse of municipal sewage sludge (biosolids); runoff from animal feeding operation; and storm water discharges. USEPA oversees state NPDES programs through real-time review and feedback on state proposed permits as well through a periodic state permit quality review which assesses a state's overall program. USEPA also develops and issues federal NPDES permits for discharges on Tribal lands.

- **Water Quality Standards and Monitoring** - By statute, USEPA is required to review state and Tribal water quality standards to ensure existing uses and designated uses are protected and comply with federal requirements, consistent with the Clean Water Act. This entails providing technical support throughout state/Tribal rulemaking processes to ensure state/Tribal standards are approvable by USEPA when submitted for adoption. The annual National Aquatic Resource Surveys (NARS) are used to assess the changes in water quality of the nation's coastal waters (including the Great Lakes), inland lakes, rivers, streams, and wetlands. Within NARS is the National Coastal Condition Assessment (NCCA) which focuses on coastal waters and the Great Lakes and is conducted every five years (most recently in 2015). The NCCA provides a statistical snapshot of the overall chemistry, biology, physical condition, and impact to human health of the Great Lakes and coastal waters. More information, including available data and reports, can be found here: <https://www.epa.gov/national-aquatic-resource-surveys/ncca>.
- **Impaired Waters** - Under Section 303(d) of the Clean Water Act, states are required to submit lists of impaired waters every even-numbered year to USEPA for approval. States are required to establish priority rankings for waters on the lists and develop Total Maximum Daily Loads (TMDL) for these waters. Under USEPA guidance, states are expected to develop TMDLs within 8-13 years of being identified as impaired. USEPA is required to either approve or disapprove the submitted lists and TMDLs within 30 days from submittal by the state, although actual timeframes may be significantly longer.
- **Non-point Source Program** - Under Section 319 of the Clean Water Act, states and Tribes receive grant money to support nonpoint source control. States are required to use at least 50 percent of their 319 grant

funds on projects that contribute to implementing watershed plans meeting criteria specified in USEPA guidance. Most 319 projects are designed to achieve reductions in nutrient, sediment or bacteria loadings, which are tracked through the Grants Reporting and Tracking System (GRTS).

Some specific efforts to manage CMCs under the TSCA, TRI, SWDA, and CWA regulatory programs include:

Decabromodiphenyl Ether (DecaBDE)

- DecaBDE are used as flame retardants in textiles, plastics, wiring insulation, and building and construction materials, and is subject to TRI reporting requirements.
- DecaBDE is one of five chemicals identified from the TSCA Work Plan for Chemical Assessments: 2014 Update (TSCA Workplan) as meeting the criteria specified in section 6(h) of TSCA. TSCA requires that USEPA take expedited regulatory action for chemical substances (such as DecaBDE) listed in [the TSCA Work Plan](#). More specifically, USEPA/OPPT has completed several activities as part of this process, including:
 - August 2017, USEPA released [Preliminary Information on Manufacturing, Processing, Distribution, Use, and Disposal: Decabromodiphenyl Ether](#).
 - September 2017, USEPA [hosted a webinar](#) on the “Use Information for Persistent, Bioaccumulative and Toxic (PBT) Chemicals under TSCA Section 6(h)”.
 - June 2018, USEPA released [a draft](#) Exposure and Use Assessment of Five Persistent, Bioaccumulative and Toxic Chemicals (including decaBDE) for public comment and peer review. USEPA must propose a rule that addresses the risks of injury to health or the environment that the Agency determines are presented by the PBT chemicals and that reduces exposures to these PBT chemicals to the extent practicable no later than June 22, 2019, with a final rule to follow no more than 18 months later.

Hexabromocyclododecane (HBCD)

- Beginning in Reporting Year 2017, facilities subject to TRI requirements [reported releases](#) of HBCD to

the environment.

- In December of 2016, USEPA designated HBCD as one of the first ten chemicals to undergo risk evaluation under section 6 of TSCA. Section 6 authorizes EPA to issue regulations on the manufacture, processing, distribution, use, or disposal of a chemical to eliminate unreasonable risks.
- In 2017, United States manufacturers have completely replaced [HBCD](#) in their product lines and that the use of stockpiles and export of the chemical ended.
- In June 2017, USEPA published the [Scope of the Risk Evaluation for the Cyclic Aliphatic Bromides Cluster](#) (HBCD Cluster).
- In June 2018, USEPA published the [Problem Formulation for the Cyclic Aliphatic Bromides Cluster](#) (HBCD Cluster).
- In early 2019, USEPA will release for public comment and peer review, the Draft Risk Evaluation for the Cyclic Aliphatic Bromides Cluster (HBCD Cluster).

Mercury

- In August of 2016, as mandated by TSCA, [USEPA released a list of mercury compounds that are prohibited from export](#).
- In March of 2017, as mandated by TSCA, [USEPA published an initial inventory report of mercury supply](#), use and trade in the United States.
- In June and July of 2017, [USEPA issued final technology-based pretreatment standards](#) under the CWA to reduce discharges of mercury from dental offices into municipal sewage treatment plants. The Effluent Limitations Guidelines and Standards for the Dental Category came into effect on July 14, 2017 for new sources; existing sources subject to the rule are to comply with the standards by July 14, 2020.
- In June of 2018, [USEPA issued a final rule to require reporting](#) from persons who manufacture (including import) mercury or mercury-added products, or otherwise intentionally use mercury in a manufacturing process. This final rule supports future, triennial publications of the mercury inventory.
- USGS and USEPA are collaborating to measure mercury methylation and bioaccumulation through the food web in the St. Louis River Area of Concern (AOC), and are using mercury isotopes to determine sources of mercury in fish. This work will identify

mercury sources that are bioaccumulating in fish, and will use this information to efficiently meet public health goals (i.e., BUI removal) by adopting mercury source-specific management goals.

Per- and Polyfluoroalkyl Substances (PFAS)

- USEPA initiated and completed several activities in managing PFAS nationally:
 - In May 2016, USEPA released Drinking Water Health Advisories for PFOA and PFOS of 70 parts-per-trillion (ppt).
 - In May 2018, USEPA outlined drinking water treatment processes for [PFOA](#) and [PFOS](#) in drinking water.
 - In May of 2018, USEPA hosted a PFAS National Leadership Summit in Washington, D.C. to take action on PFAS in the environment.
 - In July of 2018, USEPA updated its [Drinking Water Treatability Database](#) for multiple PFAS.
 - In September of 2018, USEPA developed groundwater cleanup recommendations for PFOA/PFOS.
 - In November of 2018, USEPA released and sought public input on draft toxicity assessments for GenX chemicals and PFBS.
 - In February of 2019, USEPA released the Per- and Polyfluoroalkyl Substances (PFAS) Action Plan, <https://www.epa.gov/pfas/epas-pfas-action-plan>, which includes the following activities:
 - Four Management Actions: 1. Initiating steps to evaluate the need for a maximum contaminant level (MCL) for PFOA and PFOS; 2. Beginning the necessary steps to propose designating PFOA and PFOS as “hazardous substances” through one of the available federal statutory mechanisms; 3. Developing groundwater clean up recommendations for PFOA and PFOSA at contaminated sites; and 4. Developing toxicity values or oral reference doses (RfDs) for Gen X chemicals and perfluorobutane sulfonic acids (PFBS).
 - Additional USEPA Priority Actions; 1. Developing new analytical methods and tools for understanding and managing PFAS risk; 2. Promulgating Significant New Use Rules (SNURs) that require USEPA notification before chemicals are used in new ways that may create human health and ecological concerns; and

3. Using enforcement actions to help manage PFAS risk, where appropriate.

- A number of short and long term actions are also identified in the following categories: 1. Understanding and Addressing PFAS Toxicity and Occurrence; 2. Identifying and Addressing PFAS Exposures; and 3. Risk Communication and Engagement.

Polychlorinated biphenyls (PCBs)

- The Minnesota Pollution Control Agency (MPCA) is currently engaging with 26 utility companies across Minnesota, Wisconsin and Michigan to compile an inventory of transformers currently in operation within the Lake Superior Basin that may contain PCBs at concentrations greater than 50 ppm.

Coordination of State and Federal Chemical Management

- Through and during the development of binational strategies and ensuing actions, the United States Annex 3 workgroup worked to more closely align its actions at the federal level with those at state and local levels to better support CMC-oriented actions that are specific to the Great Lakes basin.
- USEPA worked collaboratively with the Interstate Technology and Regulatory Council (ITRC), which has assembled a team of over 330 PFAS experts to provide state and federal environmental regulators and others with easily [accessible information](#), including [fact sheets](#), to aid them in evaluating risks and selecting appropriate response actions at PFAS release sites.
- Region 5 states developed several large-scale Total Maximum Daily Load (TMDL) projects which establish loading targets which must be met in order to address PCB and mercury impairments. In general, these TMDLs establish the reductions needed in airborne loadings of mercury or PCBs to bring levels in fish to acceptable levels for people and wildlife. The documents describe the relative sources and loadings of the pollutants, and federal, state and other efforts to reduce the loadings. While the Michigan and Minnesota efforts focus on inland waters, addressing the sources contributing to inland water impairments would be expected to also reduce loadings both directly and indirectly to the Great Lakes.

Michigan

- The Michigan statewide PCB TMDL was approved on September 26, 2017. This TMDL effort addresses over 2,100 water bodies in Michigan that are impaired due to fish consumption advisories and/or water column exceedances for PCBs. This project focuses on waters impaired due to air deposition.
- The Michigan statewide Mercury TMDL that was completed by Department of Environmental Quality (MDEQ) in 2013 was approved on September 26, 2018. The water bodies covered by the statewide TMDL are those on Michigan's Year 2012 Section 303(d) list due to high concentrations of mercury in fish tissue and the water column. The TMDL identifies the mercury reductions necessary to meet water quality standards in inland waters. The majority of mercury pollution in Michigan water bodies is a result of atmospheric deposition.

Minnesota

- The Minnesota Statewide Mercury TMDL is updated biennially (e.g., 2014, 2016, 2018, etc.) based on fish tissue concentrations and water column data measured annually. MPCA evaluates mercury fish tissue and mercury water column data and determines which water body segments fall into the range of mercury concentration values which are addressed by implementation efforts of the Statewide Mercury TMDL. Minnesota's implementation efforts include revising air emission permits and NPDES discharge. Air emission permits for sources which contribute mercury to the atmosphere require development and implementation of Mercury Reduction Plans. NPDES permitted facilities which discharge mercury to surface waters must develop a Mercury Minimization Plan. State implementation efforts linked to the Statewide Mercury TMDL target Minnesota facilities and do not apply to out-of-state or international sources of mercury. MPCA recognizes that addressing interstate and international mercury sources will require national and international effort.
- Several waters which drain to Lake Superior are addressed by Statewide Mercury TMDL. Lake Superior has been identified by MPCA as being impaired due to elevated mercury concentrations but the Lake Superior waterbody segment is not covered by the efforts of the Statewide Mercury TMDL. Lake

Superior's mercury impairment will be addressed in the future by a separate TMDL effort.

State Governments

State Chemicals Management

- The State of Michigan created a task force to coordinate actions surrounding PFAS. Launched in 2017, the Michigan PFAS Action Response Team (MPART) is the first multi-agency action team of its kind in the nation. Agencies representing health, environment and other branches of state government have joined together to investigate sources and locations of PFAS contamination in the state, take action to protect people's drinking water, and keep the public informed.
- In 2018, the State of New York announced \$200 million in grant funding to help communities address currently unregulated contaminants in their drinking water supplies. Of the grant funding, \$185 million will be available to communities across the state to upgrade drinking water treatment systems to combat emerging contaminants, with an emphasis on PFOA, PFOS, and 1,4-dioxane. The remaining \$15 million has been awarded to communities already pursuing system upgrades and innovative pilot technologies to treat emerging contaminants.
- In 2018, the State of New York launched an initiative to provide municipalities with resources and tools to proactively protect their drinking water sources, by building a comprehensive, statewide, sustainable Drinking Water Source Protection Program (DWSP2). The goal is to help municipalities develop and implement a drinking water source protection plan for the source of their drinking water. The state will assist municipalities with understanding the risks to their drinking water sources and what protection actions might be appropriate.
- Minnesota issued a law which, beginning on July 1, 2018, banned the manufacture or importation of furniture, upholstery, and children's products containing anything exceeding 0.1 percent of decaBDE. A ban on the sale of such products in Minnesota will take effect on July 1, 2019.
- Clean Sweep Programs are operated across the U.S. side of the Lake Superior basin by multiple jurisdictions including the states of Michigan, Wisconsin, and Minnesota. These programs facilitate

and track the disposal of waste, including pesticides and mercury-containing products.

Monitoring and Surveillance

- The eight Great Lakes states routinely monitor mercury and/or PCBs in Great Lakes basin fish to support the development of fish consumption advisories. These agencies further work to enhance public outreach and educate the public on how to obtain and use fish consumption advice for the Great Lakes based on PCBs and mercury levels. Information on the Great Lakes Consortium for Fish Consumption Advisories can be found [here](#). The states of [Michigan](#), [Minnesota](#), and [Wisconsin](#) have also developed Fish Consumption Advice for PFOS.
- In an effort to better understand the extent of groundwater contamination resulting from past uses of the emerging contaminants PFAS and 1,4-dioxane in the State of New York, these chemicals have been added to the standard list of chemicals that are monitored in groundwater at most new sites that are being remediated under the State Superfund and Brownfield Cleanup Programs.

Science and Research

- Amec Foster Wheeler Environment & Infrastructure, Inc. conducted a remedial investigation (RI) to delineate the nature and extent of PFAS compounds in both soil and groundwater at a former fire training area within the Duluth, MN airport boundary. Data collected during the investigation was used to delineate the site and develop a site model for each site reflecting the extent of PFAS.
- In 2019, The [Agency for Toxic Substances and Disease Registry](#) initiated the [Biomonitoring of Great Lakes Populations](#) (BGLP) program to assess people's exposure to pollutants in local waterways. The BGLP program consists of three phases of cross-sectional studies (looking at exposure during a specific point in time) carried out collaboratively with the Michigan Department of Human Health Services, the Minnesota Department of Health, the New York State Department of Health, and the Wisconsin Department of Health Services. The first two phases of studies (BGLP-I and BGLP-II) were completed in 2015 and 2018, respectively, while the third phase is currently ongoing in Milwaukee, WI. The state programs targeted susceptible adult populations

living in designated areas of contamination, including shoreline anglers, licensed anglers, American Indians, and Burmese refugees and immigrants. A questionnaire collected information including participant demographics, lifestyle factors, and dietary intake, with a focus on locally caught fish consumption.

Tribal Governments

- Fond du Lac Band of Lake Superior Chippewa, Grand Portage Band of Lake Superior Chippewa, and Keweenaw Bay Indian Community have worked together to collect and synthesize mercury monitoring data within the Lake Superior basin to improve the inter-jurisdictional understanding of mercury trends in the Lake Superior ecosystem.
- During 2017-2018, GLIFWC Mercury Program staff were active in the work of Annex 3, Chemicals of Mutual Concern, including using specialized and regionally-focused data and information gathered to provide input into the draft Binational Strategy for mercury that was developed in 2018.
- Clean Sweep Programs are operated by the Bay Mills and Keweenaw Bay Indian Communities in the Lake Superior basin. These programs facilitate and track the disposal of waste, including pesticides and mercury-containing products.
- Developing Culturally-targeted Fish Consumption Advisories - Fish harvest and consumption are vitally important to the Ojibwe tribes in the Great Lakes region, providing subsistence, economic, and cultural value. GLIFWC's Mercury Program helps reduce the health disparities caused by mercury in fish within this subsistence population, which consumes fish at higher rates than the general population. Each year, GLIFWC collects fish species from the Lake Superior basin that are important to its member tribes and tests for mercury levels. The information is used to develop culturally appropriate fish consumption advisories for GLIFWC's member tribes. The advisories are communicated via color-colored, site-specific mercury maps that facilitate continued fish harvest and consumption by Tribal members while providing information to reduce their exposure to mercury.



Nutrients Annex

Overview

The purpose of the Nutrients Annex of the 2012 Canada-United States Great Lakes Water Quality Agreement (Agreement) is to coordinate binational actions to manage phosphorus concentrations and loadings, and other nutrients if warranted, in the waters of the Great Lakes. Nutrient levels must be managed to achieve desired Lake Ecosystem Objectives, which include maintaining cyanobacteria biomass at levels that do not produce harmful concentrations of toxins, reducing the extent of hypoxic zones and maintaining algal species in the nearshore waters consistent with healthy aquatic ecosystems. Since the [2016 Progress Report of the Parties](#), harmful and nuisance algal blooms continue to be of concern in the Great Lakes, with Lake Erie experiencing the most significant environmental and socio-economic impacts. In recognition of the magnitude of the threat to Lake Erie, much of the effort under this Annex continues to be directed towards strategies to significantly reduce phosphorus loading to Lake Erie.

Annex Implementation

Annex implementation was supported by the Nutrients Annex Subcommittee, co-led by the United States Environmental Protection Agency (USEPA) and Environment and Climate Change Canada (ECCC); with members from United States Department of Agriculture (USDA), USEPA, United States Geological Survey (USGS), United States National Oceanic and Atmospheric Administration (NOAA), Indiana Department of Environmental Management (IDEM), Michigan Department of Agriculture & Rural Development (MDARD), Michigan Department of Environmental Quality (MDEQ), New York Department of Environmental Conservation (NYSDEC), Ohio

Lake Erie Commission (OLEC), Ohio Department of Agriculture (ODA), Ohio Environmental Protection Agency (OEPA), Pennsylvania Department of Environmental Protection (PADEP), Great Lakes and St. Lawrence Cities Initiative (GLSLCI), Agriculture and Agri-Food Canada (AAFC), ECCC, Ontario Ministry of Agriculture Food and Rural Affairs (OMAFRA), Ontario Ministry of the Environment, Conservation and Parks (OMECP), Ontario Ministry of Natural Resources and Forestry (OMNRF), and Conservation Ontario (CO).

Key Achievements

Domestic Action Plans to Achieve Phosphorus Reductions in Lake Erie

In 2016, the United States and Canada adopted new binational phosphorus load reduction [targets](#) for Lake Erie's western and central basins and nearshore priority areas. In 2018, the United States and Canada released [domestic action plans](#) that outline strategies for meeting these targets.

The plans describe the specific measures each jurisdiction will implement with its partners to achieve progress towards binational phosphorus loading reduction targets for Lake Erie and ultimately, curb the growth of excess algae that threaten the ecosystem and human health.

Actions to implement these plans and reduce phosphorus loads to Lake Erie are underway.

2017 to 2018:

- A binational Cladophora research plan was developed in 2017; implementation is underway.
- Over 2017 and 2018, a total of six domestic action plans for achieving phosphorus reductions to Lake Erie were developed. This includes a joint plan for Canada and Ontario, a joint plan for the United

States state federal agencies, and state-specific plans for Indiana, Michigan, Ohio, and Pennsylvania.

- All Lake Erie jurisdictions participated in the development of the ErieStat pilot for tracking progress.

What is ErieStat?

The Great Lakes Commission's ErieStat pilot project developed a binational information platform to track progress toward meeting phosphorus load reduction targets established for Lake Erie in 2016. The ErieStat online tool tracks total and dissolved phosphorus entering these basins from select "priority" tributaries, and shares strategies and investments intended to achieve targets.

2018:

- The United States and Canada finalized and began implementation of domestic action plans.
- The Nutrients Annex Subcommittee created an Adaptive Management Task Team to provide recommendations for tracking progress towards achieving the binational phosphorus load reduction targets in Lake Erie and reducing algal blooms and hypoxia in Lake Erie.
- The United States and Canada improved the calculation of phosphorus loads and issued first annual report on phosphorus loadings and algal conditions.

2019: The Nutrients Annex Subcommittee finalized the Lake Erie Binational Phosphorus Reduction Strategy, which was developed to support the domestic action plans and the need for coordinated monitoring, research and evaluation to track progress toward binational targets (projected).

Binational Actions and Achievements

The following is a synopsis of the key activities taken in support of the Nutrients Annex's 2017 to 2019 Binational Priorities for Science and Action. These priorities were established to address current and future threats to the quality of the water of the Great Lakes and to help meet the binational commitments of the Agreement.

2017 to 2019 Priority for Action: Engage all levels of government, stakeholders, Tribes, First Nations and Métis communities in the development of domestic action plans for the reduction of phosphorus loadings to Lake Erie.

The United States and Canada, in collaboration with the Great Lakes states and the Province of Ontario, led extensive engagement efforts with municipalities, Tribes, First Nations, Métis, the agricultural sector, industry stakeholders, watershed and other non-governmental organizations and the public before the release of the domestic action plans in February, 2018. The purpose of the engagement was to: understand the issues of concern to the groups involved; develop support for phosphorus reductions; receive input on types of actions thought to be effective; and develop collaborations for implementation algal blooms and hypoxia in Lake Erie.

2017 to 2019 Priority for Action: Implement domestic action plans.

The domestic action plans are five-year plans developed by multiple jurisdictions in the Lake Erie watershed to achieve their allocated portion of the binational Lake Erie phosphorus reduction targets. Together, the domestic action plans represent a strategy to reduce phosphorus inputs to the western and central basins of Lake Erie by 40 percent. The Canada-Ontario domestic action plan and the United States domestic action plan also include actions to reduce phosphorus in the eastern basin of Lake Erie.

The plans contain hundreds of actions to reduce phosphorus loadings from rural agricultural and urban non-point sources, as well as point sources of phosphorus loads to Lake Erie. In addition, the domestic action plans contain commitments related to research and monitoring, tracking progress, reporting, and outreach to increase the involvement of stakeholders and partners in the plan.

All of the plans contain commitments to report on phosphorus loadings and algal conditions annually through domestic reports. To enhance engagement opportunities for the Lake Erie community, the United States and Canada have also committed to an annual binational webinar. The first webinar was held in November 2018.

Starting in 2023, each jurisdiction will evaluate the effectiveness of their actions and report on phosphorus load reductions achieved through the implementation of their domestic action plans; and the plans will be revised as necessary based on this evaluation.

2017 to 2019 Priority for Action: Establish phosphorus load reduction targets for the eastern basin of Lake Erie.

Phosphorus reduction targets have not been established for the eastern basin of Lake Erie as there is currently insufficient evidence to support a science-based target. Specifically, the extent to which the excessive growths of *Cladophora* in the nearshore area of the eastern basin are driven by open lake phosphorus concentrations and/or by local tributary phosphorus loading to the nearshore area is currently unknown. The complex interactions between the substrata, presence of invasive mussels, and hydrodynamics hinder the ability to predict with confidence if and how reductions in phosphorus loading from eastern basin sources would affect nuisance *Cladophora* growth. Ongoing research and modeling efforts are bringing us closer to answering these questions.

In 2017, to maintain levels of algal biomass below the level constituting a nuisance condition in the nearshore waters of the eastern basin, the United States and Canada agreed to take the following precautionary actions until such time that science can better support the development of phosphorus targets:

The United States will:

- Begin work to develop a watershed-based restoration plan for Cattaraugus Creek, New York, and design the plan to meet both watershed and nearshore water quality goals.
- Conduct monitoring and assessments to better understand phosphorus contributions from other United States tributaries.

Canada will:

- Continue work to reduce phosphorus concentrations in the Grand River watershed, through the implementation of the Grand River Watershed Management Plan and determine the impact such reductions have on nearshore *Cladophora* growth.
- Pursue opportunities to reduce spring phosphorus concentrations in the nearshore.

In the spirit of adaptive management, the United States and Canada are also undertaking targeted research aimed at improving scientific understanding of how to effectively manage the *Cladophora* problem in the eastern basin and elsewhere in the Great Lakes and to assess the viability of setting science-based numeric targets for the eastern basin of Lake Erie in 2020.

2017 to 2019 Priority for Science: Develop and implement monitoring and modeling activities within an adaptive management framework to support tracking and reporting on progress towards achievement of binational phosphorus load reduction targets for Lake Erie. Efforts will include establishing and coordinating comparable monitoring techniques in tributaries and in the Lake, and improving knowledge on approaches for reducing phosphorus loads from the watershed to Lake Erie.

The Nutrients Annex has engaged numerous scientists and technical experts on various Task Teams to provide recommendations on monitoring, research and evaluation activities for tracking progress towards achieving the binational phosphorus load reduction targets in Lake Erie. Initial efforts have been focused on two immediate priorities:

- Developing a coordinated monitoring strategy and network for collecting compatible tributary data to evaluate progress towards achievement of the new phosphorus targets; and,
- Developing a system to routinely and reliably track and report phosphorus loads.

Many Task Team recommendations were adopted and are reflected in the domestic action plans and the Lake Erie Binational Phosphorus Reduction Strategy.

In 2018, a new Nutrients Annex Task Team was established to implement the adaptive management framework for Lake Erie. The Adaptive Management Task Team guides the development of scientific information to: (1) support the evaluation of the outcomes of actions and the ecosystem response, and (2) identify adjustments that may be required along the way to ensure that actions are effective.

2017 to 2019 Priority for Science: Research, monitoring and modeling activities to support the assessment and future actions to address algae problems in Lakes

Ontario, Huron and Michigan. Will include addressing gaps in our knowledge of nutrient dynamics in these lakes to better understand the distribution and movement of nutrients between nearshore and offshore zones, and the influence of climate change on nutrient inputs or ecosystem response.

A Task Team has been established and is working to review and synthesize the available research and monitoring on nutrients and algal conditions in Lake Ontario. These findings were delivered in the Nutrient Science Synthesis for Lake Ontario, summarizing what is known, as well as the gaps in knowledge. This synthesis was used to develop, in consultation with scientists at the partner agencies and other research organizations, a set of recommendations for further research and monitoring to address knowledge gaps. The recommendations were also used in the development of the Cladophora Research Plan.

Domestic Actions and Achievements

While not a comprehensive list, the following summary is intended to provide an overview of nutrient management efforts by federal, state and provincial departments and agencies since the [2016 Progress Report of the Parties](#).

Domestic Actions and Achievements (United States)

Nutrient Reductions on the Ground

Federally-led efforts

Since 2016, Great Lakes Restoration Initiative (GLRI) partners have funded hundreds of nutrient and sediment reduction projects on agricultural lands. GLRI funds have provided targeted technical and financial assistance to implement conservation practices on over 350,000 acres, which is projected to reduce over 950,000 pounds of phosphorus from washing off cropland annually.

The Western Lake Erie Basin Partnership (WLEB) continues to facilitate collaboration across federal, state, local and non-governmental organizations. With new state leadership in two of the three partnership

states, the WLEB recently brought everyone together to reorganize membership and develop a new two-year action proposal. The various partners have been active in increasing 4R Nutrient Stewardship activities in the three states within the Western Basin watershed, increasing edge of field monitoring, and hosting numerous farmer field days, farmer Lake Erie visits, and technical training for field staff. The partnership is one of few entities that brings together in the same room federal, state, local, agricultural and non-governmental organization leaders on a regular basis.

The next round of funding is now available as part of the Regional Conservation Partnership Program, a tri-state, five-year, \$17.5 million program funded by the USDA's Natural Resource Conservation Service. In the first four years of the project, over \$8 million dollars have been allocated on over 148 contracts on nearly 30,000 acres in Ohio. In 2018 to 2019, Ohio livestock producers will receive priority funding. Nutrient management practices that allow for proper storage, timing, and placement of nutrients will help livestock producers comply with Ohio's nutrient management laws.

For the Lake Erie Conservation Reserve Enhancement Program (LE-CREP), USDA-Farm Service Agency and ODA signed Agreement Amendment #8, which removes obstacles for more than 700 LE-CREP contract renewals in the Lake Erie watershed. Approximately 52,000 acres have been enrolled to date, which has resulted in 4,500 miles of buffered streams, and 19,480 miles of waterways.

State and locally-led efforts

Ohio

Implementation of nonpoint source projects - In Fiscal Year 2017, OEPA received a Lake Erie Tributary Water Quality Restoration Grant from the Great Lakes Restoration Initiative in the amount of nearly \$2 million for implementing 10 non-point source management projects to reduce nutrients and improve water quality in tributaries draining to Lake Erie. This suite of projects includes nutrient reduction, stream and wetland restoration and demonstration of green alternatives to traditional stormwater management.

Targeting agricultural management within priority watersheds - ODA recently completed a nearly \$3

million GLRI grant targeted to priority sub-watersheds within the Western Lake Erie Basin resulting in 57,296 acres of soil tests; 32,359 acres of cover crops; 66 drainage management structures; 7,593 acres of system application of soil tests and sub-surface placement of manure with cover crops; 11,223 acres of system application of soil tests and sub-surface placement of manure without cover crops; and 6 manure management structures.

Michigan

Reducing nutrients from wastewater treatment plants – MDEQ re-issued National Pollutant Discharge Elimination System permits for four key wastewater treatment plants that were shown to contribute about 90 percent of the point source load to the western basin of Lake Erie – the Great Lakes Water Authority Water Resource Recovery Facility (also known as the Detroit Wastewater Treatment Plant), the Downriver Wastewater Treatment Facility, the Monroe Metro Wastewater Treatment Plant, and the Ypsilanti Community Utilities Authority Wastewater Treatment Plant. Total phosphorus limits were tightened from 1.0 milligram/liter to 0.6 milligram/liter in the growing season. The Great Lakes Water Authority Water Resource Recovery Facility and Ypsilanti Community Utilities Authority Wastewater Treatment Plant permits already meet these tighter limits; the other two plants will meet reductions in 2020. From the Great Lakes Water Authority Water Resource Recovery Facility alone, the total phosphorus load has been reduced about 400 metric tons per year.

Reducing nutrient loads from combined sewer overflows – MDEQ is continuing efforts to reduce wet weather pollution from combined sewer overflows that flow into the Western Lake Erie Basin. Water from combined sewers are being treated to reduce phosphorus concentration by storing excess flow and sending it back to wastewater treatment plants for full treatment. For larger rain events when there is a discharge from the combined sewer overflow treatment facilities, on-site settling will be used to further reduce phosphorus discharge. To date, 95 percent of the annual combined sewer overflow volume from the City of Detroit has been treated. All combined sewer overflows in Oakland and Macomb Counties have been treated.

Reducing nutrient loadings with the River Raisin

watershed – The Lenawee Conservation District received a \$769,000 MDEQ Nonpoint Source grant in the fall of 2017 to implement practices including saturated buffers, drainage water management, and blind inlets in the River Raisin watershed. The goal of the project is to reduce phosphorus and nitrogen loadings to surface waters. The project is expected to continue through the fall of 2020.

Indiana

Implementing Indiana's domestic action plan – Indiana developed the Lake Erie domestic action plan in partnership with several local and non-governmental partners. Key actions to reduce loads to the western Lake Erie basin in 2018 to 2019 include:

- The City of Fort Wayne has commenced its Tunnel Works project to address combined sewer overflows to the St. Marys and Maumee Rivers.
- An emergency manure storage lagoon has been constructed in Adams County, Indiana, where the availability of land for manure application, particularly in the winter months, has been lacking.
- Sewers have been extended to the town of Pleasant Mills, Indiana, which had previously experienced major septic system malfunctions.

Pennsylvania

Reducing nutrients from stormwater, grape farming, and residential sources – PADEP continues to: (1) work with Erie County government to assist Lake Erie MS4 (municipal separate storm sewer system) municipalities to plan for future stormwater infrastructure needs; (2) work with grape farmers to improve environmental and economic sustainability of their agricultural operations through the Pennsylvania Vested in Environmental Sustainability Program; and (3) reduce sewage pollution from residential sources through the Small Flow Treatment Facility Program.

Wisconsin

Promoting demonstration farms and improving wastewater treatment – Partners continue efforts to address nutrients in Green Bay through the success of the [Lower Fox Demonstration Farms](#). This is a multi-partner effort, which includes local, university, state, federal, and non-governmental organizations. In addition, GLRI is funding a [collaborative project](#) led by

the Nature Conservancy to design, build, and monitor treatment wetlands in the Fox River Basin to better understand phosphorus cycling in these systems.

Developing Enhanced Research, Monitoring and Forecasting Tools

Federally-led efforts

Measuring tributary nutrient loading – USGS scientists collect water-flow and water-quality data from 26 tributaries to the Great Lakes. The Great Lakes National Monitoring Network continues to be enhanced through the use of automated samplers and water quality multi-sensor probes, to provide better baseline information on nutrient loads and demonstrate the ability to reduce monitoring costs through the use of real-time sensors. Two tributaries were added to this network during 2017 to support specific needs of the Nutrients Annex Subcommittee.

Edge-of-field monitoring and research – Federal agencies and partners continue to expand edge of field monitoring and research. USGS is leading a GLRI-funded effort with NRCS and other partners to conduct edge-of-field monitoring on 22 farm sites in the Maumee River, Fox River, Saginaw River and Genesee River watersheds. These watersheds were selected because of the high density of agricultural land use and their ecosystem impairments. In addition, two new study sites have been added in order to assess new and innovative practices that are not currently in common usage across the basin. The NRCS, the USGS, and local partners are conducting one of the first large-scale attempts to directly link in-field measurements of soil health on producer fields with intensive edge-of-field water quality monitoring. The project monitors sediment and nutrient export in surface and tile runoff from select farm fields in four priority watersheds of the Great Lakes. Baseline assessments are complete and as producers implement conservation actions, the project teams are monitoring soil health and water quality responses.

Tools for agricultural nutrient applicators – The NOAA National Weather Service, in partnership with the GLRI federal agencies and the states of Minnesota, Wisconsin, Michigan and Ohio, have implemented decision support tools for agricultural nutrient application management.

These tools will alert applicators of future unsuitable conditions caused by rainfall or snowmelt that could result in undesired transport of recently applied manure and fertilizer from their fields in to nearby water bodies. The tools are designed to be incorporated into the daily and weekly planning activities of all nutrient applicators.

Forecasting Microcystis blooms in Lake Erie – NOAA combines remote sensing, monitoring from a number of GLRI and partner programs, and modeling to produce weekly forecasts of Microcystis bloom concentration and transport in Lake Erie, which are distributed to regional stakeholders. NOAA National Ocean Service researchers, with their partners at Heidelberg University, have continued forecasts of the likely severity of the cyanobacterial harmful algal bloom in western Lake Erie. This includes a weekly update through May and June, and the final forecast in early July. The NOAA National Ocean Service has also incorporated the new European Union Sentinel-3 series satellites into the monitoring program and is reviewing the product to assure continuity of the satellite monitoring program well into the future.

Improvements to the experimental “HAB Tracker” forecast model – GLRI-funded research, led by the NOAA Great Lakes Environmental Research Laboratory and the Cooperative Institute for Great Lakes Research, led to the development of an improved experimental [Lake Erie Harmful Algal Bloom forecast model \(HAB Tracker\)](#) that provides daily updates of bloom location and five-day forecasts of bloom transport. Daily updates were provided to stakeholders and the public through the NOAA Great Lakes Environmental Research Laboratory (GLERL) website during the summers of 2016 to 2018. Harmful algal bloom (HAB) forecasts enable stakeholders to maximize the benefits they receive from Lake Erie by avoiding negative impacts of harmful algal blooms and maintain public awareness of the present state of the environment. The experimental model incorporates remote sensing data from NOAA National Ocean Service, builds on NOAA’s Lake Erie Operational Forecast System, and is being transitioned into NOAA’s operational product, the Lake Erie HAB Bulletin.

Developing a Lake Erie hypoxia forecast model – The NOAA-GLERL and the Cooperative Institute for Great Lakes Research are developing an experimental Lake Erie hypoxia forecast model, in a five-year (2016 to

2021), \$1.4 million project funded by NOAA National Centers for Coastal Ocean Science. The experimental model provided daily information on the location of low dissolved oxygen (hypoxic) zones in Lake Erie, and five-day forecasts of hypoxic zone movement, in the summers of 2017 and 2018 through NOAA-GLERL's website. The experimental forecast provided advance notice of upwelling events that can introduce hypoxic water into drinking water treatment plants along Lake Erie that serve more than 1.8 million people. With advance notice of such events, drinking water plant personnel can be prepared to adjust treatment processes in response to sudden changes in water quality at the intake, and thereby maintain the quality of treated water. The model builds on NOAA's Lake Erie Operational Forecast System and leverages investments in real-time sensor networks developed by the Great Lakes Observing System and partners.

Developing new tools for monitoring plankton and aquatic plants – GLRI-funded research led by the NOAA-GLERL includes flying a hyperspectral camera over the Great Lakes to monitor harmful algal blooms (since 2015) and submerged aquatic vegetation starting in 2018. The imagery is collected weekly and processed for cyanobacteria levels using the same algorithm as the harmful algal bulletin produced by NCCOS. The images are mapped and distributed to the Ohio USEPA and the Monroe drinking water intake managers. Newly developed hyperspectral image analysis of phytoplankton types in Lake Erie are under development.

Assessing the effects of agricultural conservation practices – The USDA-NRCS, and USDA Agricultural Research Service, with other partners, continues to assess the effects of conservation practices under the USDA-led Conservation Effects Assessment Project (CEAP). In 2016, NRCS released a major assessment of the edge-of-field water quality and soil effects of conservation practices implemented on cultivated cropland in the Western Lake Erie Basin (WLEB). This analysis documented the benefits from current conservation in place, and analyzed scenarios for additional conservation treatments that would improve outcomes of efforts. This report was followed in 2017 by a watershed-scale assessment of in-stream conservation practice effects in the WLEB, containing additional insights on benefits and effective strategies.

These assessments utilize an inventory, survey and modeling-based approach.

Assessment of the Blanchard River watershed – In addition, in 2018, the USDA-NRCS established a new CEAP Watershed Assessment Study in the Blanchard River Watershed in Ohio, which drains into the Maumee River Basin. This assessment will utilize innovative watershed assessment and planning tools, apply results to conservation planning, and monitor and assess water quality and soil outcomes of conservation implementation. Outreach opportunities will occur in conjunction with the Blanchard River Watershed Partnership and the Blanchard River Demonstration Farm Network. Edge-of-field water quality monitoring of practice effectiveness continues at 20 pairs of fields on farms within the WLEB and watershed assessment continues in the St. Joseph River Watershed in Indiana, under CEAP Watersheds and with other partners. Lastly, innovative conservation practices continued to be developed and evaluated under CEAP, such as blind inlet, phosphorus removal structure, two-stage ditches, drainage water management, wetland restoration, as well as 4R nutrient management strategies.

State and locally-led efforts

Ohio

Optimizing treatment plants to protect drinking water – Ohio's HAB Rules (first in the nation) became effective on June 1, 2016 and were designed to provide public water systems and the public with certainty and consistency in response to HAB events and provided preventative tools by requiring development of treatment optimization protocols and general plans to assure water systems are better prepared for current and future events. Under Ohio's HAB rules, over 23 public water systems with intakes on Lake Erie have triggered development of Treatment Optimization Plans and nine systems are now working on Cyanotoxin General Plans. These requirements and routine monitoring have led to earlier identification of toxin producing blooms and rapid response at these public water systems. Ohio and other states continue to coordinate with USEPA, USGS, NOAA and others to address science gaps, readily share knowledge with state and local partners, and connect Ohio public water systems with the tools they need to assure safe drinking water. To assist communities in detecting and treating harmful algal blooms, OEPA

provided monitoring equipment grants and allocated \$150 million for zero percent loans. In 2018, Toledo received a \$40 million zero percent loan for its ozone treatment and nearly all of Ohio's Lake Erie systems received monitoring equipment grants up to \$30,000.

Monitoring nutrients loads in the Maumee River – OEPA was awarded a \$1.54 million GLRI grant to expand the Maumee River tributary monitoring network in late 2014. In 2016, the work plan of this grant was revised to include seven sites that are frequently monitored by the USGS for nitrogen, phosphorus and streamflow through automated monitoring. USGS then calculates daily nutrient loads for each of these sites. Four additional sites have flow monitoring supported by this grant. Other parties are sampling and calculating nutrient loads (see paragraph below) for these additional sites. This grant funds this work through June of 2019.

Expanding tributary load monitoring – OEPA and the Ohio State University Sea Grant College Program entered into a \$1 million grant agreement with Heidelberg University's National Center of Water Quality Research to expand that program's tributary loading program. This involved installing automatic samplers at five stream gaging sites all with multi-parameter sondes starting in 2017. Another sonde was installed at an existing program monitoring site. Expanded laboratory equipment, a vehicle and personnel additions were also included in this grant agreement. Finally, daily water quality monitoring at these sites is funded through approximately November 15, 2019. OEPA's Surface Water Improvement Fund funded half of this project.

Nutrient mass balance studies – OEPA has published two Nutrient Mass Balance studies, in 2016 and 2018, that characterize the total load of nutrients by year for key basins throughout Ohio. Most of the basins in these reports drain to Lake Erie [<https://www.epa.ohio.gov/dsw/wqs/NutrientReduction#146065085-nutrient-mass-balance>].

Nearshore monitoring - OEPA has carried out a nearshore Lake Erie monitoring program every year during this reporting cycle. This includes ambient water quality data collection with sonde profiles. Mayfly surveys and Central Basin hypoxia transects are also collected. OEPA also partners with Ohio State University, University of Toledo and Bowling Green

State University, supporting their various research data collections in Lake Erie, as well as providing laboratory support In 2018 [and in 2019] for chlorophyll-a and Microcystin toxicity samples collected by these universities.

Forecasting tools - The Ohio Department of Higher Education has funded the development of enhanced forecasting tools in 2016 to 2018, including the further refinement of predictive watershed models. This work evaluates how changes in agriculture and other land management practices are likely to affect water quality.

ODA Division of Plant Health hosts the [Ohio Applicator Forecast](#) on the division's web site. The tool is designed to help nutrient applicators identify times when the weather-risk for applying is low. The risk forecast is created by the National Weather Service and takes snow accumulation and melt, soil moisture content, and forecast precipitation and temperatures into account. The chances of surface runoff in the next 24 hours are displayed on the overview map of the state.

Michigan

Monitoring nutrients in tributaries of the Maumee River – MDEQ monitored nutrient concentrations in Michigan's portion of tributaries to the Maumee River (e.g., Bean Creek [Tiffin River], St. Joseph River, and their tributaries) from 2016 to 2018 through funding by a Great Lakes Restoration Initiative grant and MDEQ funds. A report on this monitoring work is expected sometime in 2019 and will help prioritize sub-watersheds where future nutrient reduction efforts should be focused. Separately, MDEQ and the MDARD recently provided some advisory support towards USGS locating and installation of three new stream gages and water quality (nutrient) monitoring stations on these tributaries near the Michigan-Ohio border (much of the funding for these gages came from the Great Lakes Restoration Initiative).

Assessing the effectiveness of management practices – In the fall of 2017, MDEQ, MDARD, Michigan State University, and the Lenawee Conservation District began an approximately \$1.5 million, five-year monitoring project to determine the effectiveness of best management practices in the Western Lake Erie Basin. Drainage water management and saturated buffers are two best management practices that are

being evaluated for flow and nutrient load reductions.

Reducing pollutants from LaPoint Drain – In the fall of 2017, the River Raisin Institute completed watershed management plan for LaPointe Drain, which discharges directly to the western Lake Erie basin. The pollutants addressed in the watershed management plan include E. coli, phosphorus, and sediment, with the primary sources identified as agriculture and septic systems. The plan was approved by the MDEQ and the USEPA, which makes its implementation eligible for state and federal non-point source grant program funding.

Development of the Bean Creek watershed management plan – The Bean Creek watershed management plan is expected to be approved by the MDEQ and the USEPA in 2019. The planning area includes the Michigan portion of Bean Creek, a tributary to the Maumee River. Two innovative approaches were used to develop the watershed management plan. An agricultural field inventory was conducted in three priority sub-watersheds to identify crop fields without buffers near surface waters, fall tillage practices and spring crop residue conditions in two growing seasons, and crop fields with the potential to receive manure applications from concentrated animal feeding operations. In addition, LiDAR (Light Detection and Ranging – a remote sensing method used to examine the surface of the Earth) data was used in conjunction with the United States Department of Agriculture’s Agricultural Conservation Planning Framework to identify runoff flow paths, slope for each crop field, and potential locations of grassed waterways. The inventory and Agricultural Conservation Planning Framework information will collectively be used to prioritize crop fields for best management practice implementation.

New York

Watershed Plan Development in the Eastern Basin - The Lake Erie Watershed Protection Alliance, in concert with New York State and the support of the USEPA, has begun the 9 Element watershed plan development for eastern Lake Erie. Monitoring has begun for the watershed, which will take place over the course of the next two years. The goal is to complete the 9 Element Plan in 2020.

Monitoring in the Finger Lakes - In 2017, New York State established the Finger Lakes Watershed Hub, a core

team of NYSDEC scientists who work collaboratively with stakeholders throughout the Finger Lakes region to better understand, protect and address the water quality issues confronting the lakes, which are part of the larger Lake Ontario watershed in New York.

Pennsylvania

HABS monitoring at Presque Isle - In coordination with the Pennsylvania Lake Erie Harmful Algae Bloom Task Force, the PADEP continued a strategic partnership with the Regional Science Consortium at Presque Isle to complete comprehensive monitoring of Pennsylvania Lake Erie beaches and public areas for the presence of harmful algal bloom conditions.

New Nutrient Strategies, Policies and Legislative Actions

National

In February 2019, USEPA issued the “[Water Quality Trading Policy to Promote Market-Based Mechanisms for Improving Water Quality](#)”, designed to help states, tribes and stakeholders think more broadly about the types of non-regulatory, market-based and community-driven programs which could be implemented to reduce excess nutrients and improve water quality.

Regional

Ohio, Michigan, Indiana, and Pennsylvania each issued state-specific domestic action plans, outlining actions the state will take to reduce nutrients going to Lake Erie in order to meet the established phosphorus reduction targets. The USEPA incorporated the state domestic action plans into the basin-wide United States Action Plan for Lake Erie, published in February 2018.

Ohio

Ohio Senate Bill 150 became effective in 2014, and provisions from this legislation came into effect during this reporting period. Since September 31, 2017, approximately 17,500 fertilizer applicators have been certified and educated on the handling and application of fertilizer. The law also authorizes a person who owns or operates agricultural land to develop a voluntary nutrient management plan or request that one be developed for him or her.

Ohio Senate Bill 1 became effective in 2015, and provisions from this legislation came into effect during this reporting period. These include requiring major publicly-owned treatment works to conduct technical and financial capability studies to achieve 1.0 milligram per liter total phosphorus; establishes regulations for fertilizer or manure application for persons in the western basin; designates the director of OEPA as coordinator of harmful algae management and response and requires the director to implement actions that protect against cyanobacteria in the western basin and public water supplies; prohibits the director of OEPA from issuing permits for sludge management that allow placement of sewage sludge on frozen ground; and prohibits the deposit of dredged material in Lake Erie on or after July 1, 2020, with some exceptions.

Ohio Senate Bill 299 – Clean Lake 2020 Plan – was passed in 2018. This bill provides roughly \$36 million in funding toward a variety of programs aimed at supporting Lake Erie and reducing toxic algae, including funding of \$3.5 million to support county soil and water conservation districts in the Western Lake Erie basin for staffing and to assist in soil testing, nutrient management plan development, enhanced filter strips and water management and other conservation support and funding of up to \$20 million for ODA to establish programs to reduce total phosphorus and dissolved reactive phosphorus in subwatersheds of the Western Lake Erie basin.

In July 2018, Ohio Governor John Kasich signed Executive Order 2018-09K that directs the ODA, in consultation with the Ohio Soil and Water Conservation Commission, to evaluate the designation of eight watersheds within the Maumee River Basin as watersheds in distress due to nutrients. If so designated, the Executive Order further directs the ODA, the ODNR and OEPA, to work on: (1) regulations that establish nutrient management requirements for all nutrient sources, development of associated management plans for agricultural land and operations within the designated watershed boundaries; and (2) requirements for the storage, handling, land application and control of residual farm products, manure and erosion of sediment and substances attached thereto within the designated watershed boundaries.

Michigan

In October 2017, Michigan leaders announced the formation of a unique new partnership to collaboratively work on finding common solutions for improving water quality in the Western Lake Erie Basin. The Michigan Cleaner Lake Erie through Action and Research (MI CLEAR) Collaboration includes farmers, agricultural and environmental leaders, universities, conservationists, energy leaders, tourism and economic development interests, and more. This diverse membership has been called to the table as a new way to tackle the ongoing water quality challenges affecting the basin. The goal of the MI CLEAR Collaboration is to improve the long-term water quality of the Western Lake Erie Basin through open discussion among regional leaders, a coordinated perspective to existing efforts, support for research that builds understanding of science around water quality issues, and actions that bring meaningful change. The MI CLEAR Collaboration will promote awareness of science and research-based efforts aimed at improving the health and quality of Lake Erie. The collaboration members will share their quantifiable metrics and unbiased information about Michigan's efforts to preserve and protect the Western Lake Erie Basin with the partnership and the community.

Wisconsin

Wisconsin continues to implement their [water quality standard \(rule\) for phosphorus](#). Wisconsin estimated loads and development of reduction targets (Total Maximum Daily Loads or TMDLs) includes:

- The Milwaukee River Basin (Lake Michigan), where local partners have begun implementation planning;
- Implementation of Lower Fox TMDL, which is ongoing; and
- A TMDL for Upper Fox and Wolf Basins is being developed (<https://dnr.wi.gov/water/tmdlDetail.aspx?key=128283352>).

With the Great Lakes Commission and Fox-Wolf Watershed Alliance, continued exploration of water quality trading in Lower Fox Basin following completion of the 2013 to 2016 Fox P trade project completion of [some trades](#).

Wisconsin developed a state-wide Nutrient Reduction Plan and published a [progress report in 2017](#).

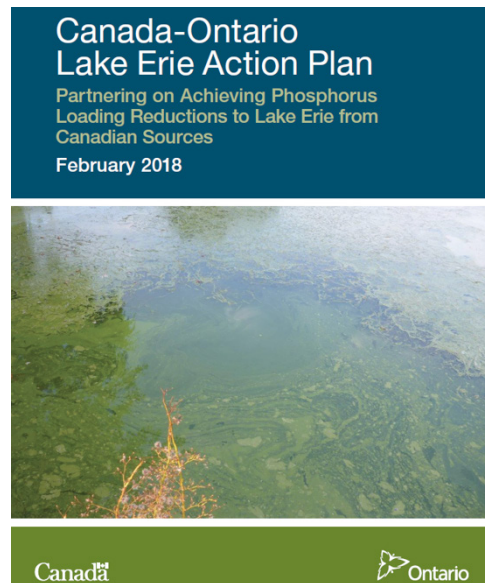
New York

In 2018, New York State Governor Cuomo announced a \$65 million, four-point initiative to aggressively combat HABs in twelve priority lakes, including five Finger Lakes that are in the Lake Ontario watershed: Conesus, Honeoye, Cayuga, Owasco, and Skaneateles Lakes. The components of the initiative include: convening four regional summits of agency representatives, stakeholders, and national water quality/HAB experts; developing Action Plans and providing nearly \$60 million in grant funding for implementation; in-lake mitigation pilot projects; and, conducting advanced research and monitoring. The Action Plans for the Finger Lakes were released in June 2018 and priority actions include wastewater treatment upgrades, sewer expansions, and septic system upgrades and replacements, streambank erosion prevention, stormwater best management practices, agricultural nutrient reduction measures, and open space buffer preservation projects. For the remaining Finger Lakes not included in the HAB initiative, other types of Clean Water Plans (TMDL or watershed plan) are being developed.

Domestic Actions and Achievements (Canada)

The Canada-Ontario Lake Erie Action Plan is a joint plan between Canada and Ontario which identifies more than 120 actions, including partner actions, to be taken over the next five years to make progress towards achieving phosphorus reduction targets for the Canadian side of Lake Erie, which include a reduction of 40 percent (212 metric tonnes) from Canadian sources to the central basin, and reductions of 40 percent in each of the Thames and Leamington watersheds to address localized algae problems. The plan includes commitments to undertake actions by ECCC, AAFC, the OMECP, the OMAFRA, the OMNRF, Lake Erie conservation authorities, numerous agricultural sector organizations, municipalities and non-governmental organizations.

During the development of the Canada-Ontario Lake Erie Action Plan, Canada and Ontario established a multi-sectoral Lake Erie Nutrients Working Group, and also engaged First Nations and Métis communities, municipalities, members of the agricultural community, conservation authorities, non-governmental organizations, and the public. The public was provided



Cover page of the Canada-Ontario Lake Erie Action Plan. Credit: Canada and Ontario.

with an opportunity to comment on a draft plan through Canada's online platform and Ontario's Environmental Registry. Significant input was also gathered through in-person engagement sessions and written submissions. The feedback gathered was used to enhance the plan and encourage new partner-led actions.

Under the Great Lakes Protection Act, the Province of Ontario also adopted a target of 40 percent phosphorus load reduction by 2025 (from 2008 levels), using an adaptive management approach, for the Ontario portion of the western and central basins of Lake Erie, as well as an aspirational interim goal of a 20 percent reduction by 2020 in order to address algal blooms.

Nutrient Reductions on the Ground

Through the Great Lakes Protection Initiative, ECCC is taking action to prevent toxic and nuisance algae through supporting on the ground action to decrease loadings of phosphorus to Lake Erie from Canadian sources. In 2018, ECCC provided new funding for partner-led projects that are increasing participation in the application of phosphorus load reduction measures by implementing innovative approaches and best management practices, and promoting their broad uptake and application by others.

Project funding is supporting organizations such as

ALUS Canada, the Ontario Federation of Agriculture and Farm and Food Care in adopting innovative measures to reduce phosphorus loading to Lake Erie from agricultural lands (e.g., installing new natural features; using new technologies that reduce loading from agricultural tile drainage systems; applying practical alternatives to the winter spreading of manure on agricultural lands), monitoring their effectiveness, as well as engaging their networks to encourage widespread uptake of those measures.

Other partner-led projects are targeting specific geographic areas in the Lake Erie basin where phosphorus loading is of greatest concern. Ostara Nutrient Recovery Technologies Inc., for example, is applying an innovative phosphorus recovery and recycling technology to reduce known sources of phosphorus loading to the Grand River watershed. This technology recovers phosphorus from a wastewater treatment plant, and converts it to a slow-release fertilizer that can be precisely applied, leading to significant reductions in fertilizer application and phosphorus losses from farm runoff. Conservation Authorities, including, in Essex Region, the Upper Thames River and the Lower Thames Valley, are also partnering with farmers to reduce agricultural runoff through BMPs and are engaging with others to increase wider uptake.

Conservation Authorities in Ontario are developing and implementing watershed based phosphorus management plans for priority tributaries that are the highest contributors of Canadian phosphorus loads to Lake Erie, with funding support from ECCC's Great Lakes Protection Initiative. The plans identify the most significant sources of phosphorus loads to Lake Erie from key sub-watersheds, establish priorities for the application of phosphorus reduction measures, and identify best management practices to be applied in these areas. The outcomes of these projects are also guiding Canada, other levels of government and landowners in priority setting and identifying effective phosphorus reduction measures.

ECCC also provided support to Six Nations of the Grand River to reduce phosphorus load reductions from their lands by promoting the protection and rehabilitation of natural heritage features on Six Nations land that trap, store and process phosphorus, and result in improvements to water quality.

It is anticipated these new Great Lakes Protection Initiative projects alone could result in an approximate 18 tonnes per year reduction in phosphorus loading to Lake Erie from Canadian sources.

Through the \$180 billion Investing in Canada Plan, Infrastructure Canada supports a number of green infrastructure programs that have direct benefits for the Great Lakes region, such as the Clean Water and Wastewater Fund. In 2018, Canada and Ontario entered into an Integrated Bilateral Agreement for the Investing in Canada Infrastructure Program. The Agreement includes a commitment by Canada to provide \$2.25 billion to support green infrastructure projects including those that increase capacity to treat/manage wastewater and stormwater or reduce/remediate soil and/or air pollutants. Infrastructure projects funded under these priorities will support efforts to reduce phosphorus loading to the Great Lakes.

Canada and Ontario signed a bilateral agreement for implementing the Canadian Agricultural Partnership on February 15, 2018. Under the agreement, Ontario has notionally allocated \$61.2 million over 5-years (2018-2023) to address the priority of environmental sustainability and climate change. This includes cost-share funding for farmers to implement best practices beneficial to soil health and reducing phosphorus losses from agricultural land.

Ontario and the agriculture sector have collaborated extensively on developing initiatives to reduce phosphorus loss from agricultural sources, improve soil health and advance science and technologies for removing phosphorus. This has resulted in industry-led actions to improve nutrient management practices including: the implementation of the voluntary 4R Nutrient Stewardship program led by 4R Ontario; an initiative led by Ontario's livestock and poultry sectors to provide education and awareness to producers about the risks of nutrient application on frozen or snow covered ground (Timing Matters); the implementation of the Ontario Cover Crops Strategy led by Grain Farmers of Ontario; the implementation of the Ontario Greenhouse Environmental Strategy led by the Ontario Greenhouse Vegetable Growers; and the Thames River Phosphorus Reduction Collaborative efforts to promote land management and drainage solutions led in partnership by the Ontario Federation of Agriculture. These and other initiatives continue to be implemented



Cover page of Ontario's Agricultural Soil Health and Conservation Strategy. Credit: Province of Ontario.

under the Canada–Ontario Lake Erie Action Plan.

Released in April 2018, “Ontario’s Agricultural Soil and Conservation Strategy” guides collaborative soil health research, investments and activities. A goal of the strategy is for agricultural soil management practices to sustain and enhance soil health and productivity for economic, environmental and societal needs, which includes water quality.

Ontario continues to work with municipalities in the Lake Erie basin to improve wastewater effluent quality and reduce phosphorus loadings to achieve the Great Lakes Water Quality Agreement’s recommendation that large facilities achieve a maximum effluent concentration of 0.5 milligrams per liter of total phosphorus. All of Ontario’s municipal wastewater treatment plants in the basin currently provide at least secondary treatment. A significant number of tertiary (advanced) treatment plants discharging to sensitive surface waters also provide enhanced phosphorus removal, below the 0.5 milligrams per liter monthly average limit. Ongoing treatment plant upgrades and treatment process optimization across Ontario municipalities have reduced total phosphorus loadings from these sources.

Ontario and the Grand River Conservation Authority continue to partner with municipalities to deliver the Grand River Watershed-wide Wastewater Optimization Program. This program provides assistance to municipalities to optimize their wastewater treatment plants and improve effluent quality. Participants are aiming to achieve voluntary targets for phosphorus (and

ammonia) beyond legal requirements.

Ontario is also piloting a wastewater treatment optimization program in southwest Ontario. Through this program Ontario supported three projects in the Lake Erie watershed that involved optimizing phosphorus removal using existing infrastructure.

In the Leamington priority tributaries and elsewhere, Ontario is helping improve agricultural practices and competitiveness while protecting the Great Lakes by implementing an environmental strategy to effectively manage greenhouse wastewater. Through this strategy, Ontario is collaborating with associations representing greenhouse operations to ensure environmental protection, while helping to address business challenges. The sector is working to improve the management of wastewater discharged into the natural environment, and take action to manage nutrients in each greenhouse. Through enhanced compliance efforts, Ontario is holding greenhouse facilities accountable for properly managing discharges and improving water quality.

Through Ontario’s Great Lakes education model, school boards, teachers and conservation authorities are working together to educate students on their watershed’s connection to Lake Erie, including through student visits to the shoreline, as well as discussions with First Nations and Métis on the importance of a healthy Lake Erie. Ontario has also provided funding for other educational projects such as the Upper Thames River Conservation Authority’s virtual reality sandbox that demonstrates the impact of local runoff on Lake Erie, as well as the Antler River Guardians From The 4 Directions’ effort to share Traditional Knowledge with First Nation youth to encourage stewardship of the Thames River.

New Nutrient Strategies, Policies and Legislative Actions

The Thames Clear Water Revival is a long-term partnership between First Nations, federal and provincial agencies, conservation authorities and the City of London committed to a healthy and vital Thames River, a priority Lake Erie tributary. The partnership developed a plan – The Thames River (Deshkan Ziibi) Shared Waters Approach to Water Quality and Quantity to address water quality and quantity issues that affect stream health.

Enhanced Research, Modelling and Monitoring

Canada has increased its research, modelling and monitoring to better understand nutrients in Lake Erie. ECCC continues to conduct water quality monitoring at key locations in the Lake Erie basin (Detroit River, the Thames River, the Sydenham River, and the Grand River) in order to measure phosphorus concentrations and loads from these tributaries. For the Thames River and Sydenham River, a watershed model (CanSWAT) is being developed and used to estimate total phosphorus loading using unified and consistent data from ECCC and external research partners.

Canada has also developed and applied models to: assess the effectiveness of best management practices in reducing phosphorus loads; link tributaries and lake models; quantify the effects of invasive mussels in nutrient cycling; and, provide estimates of whole basin phosphorus loads.

Canada continues to undertake research on the role that mussels play in promoting the development of algal blooms, particularly cladophora, as well as to assess the potential role of nitrogen in controlling harmful algal blooms biomass and toxicity in the nearshore and the western basin of Lake Erie.

Canada is developing tools using remote sensing technologies for algal bloom detection and forecasting in Lake Erie.

Canada continues to invest in research that improves our understanding of phosphorus uptake and movement as well as improving Best Management Practices such as technologies to improve crop nutrient use efficiency and reduce phosphorus losses from agricultural production to the Great Lakes. Lake Erie has been identified as a priority basin for research under the Agro-Ecosystem Resilience strategy, which is one of the sector science strategies guiding AAFC investment in research. Over the past three years, projects funded by AAFC have worked to identify critical source areas for phosphorus losses at the field and regional scale; developed indicators related to the risk of agricultural phosphorus loss to water; and, investigated agricultural legacy phosphorus storage in the Lake Erie basin.

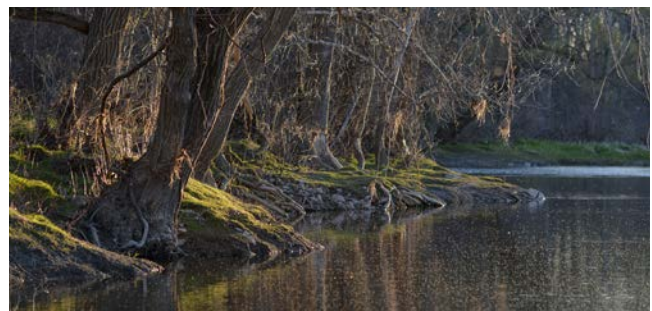
Ontario is investing in environmental sustainability

research projects that support environmental stewardship and competitiveness of the agri-food sector through funding for research partnerships, knowledge transfer and commercialization, training highly qualified personnel and research laboratory/station maintenance. These projects are supporting the development of new knowledge, policy, program, practices and technology in areas such as: protecting soil (e.g. soil health initiatives such as cover crop, reduced tillage, erosion, digital soil mapping) and biodiversity; improving soil carbon and nutrient use efficiency (e.g. slow released fertilizer, organic matter management, manure management, bio-fertilizer); and, nutrient loss reduction from field and water quality improvement in streams and groundwater (e.g. phosphorus loss, anaerobic digestion, waste-water treatment technologies and systems, non-point sources, precision feeding of animals).

The Thames River is identified as a priority tributary for nearshore blooms in Lake St. Clair. Ontario is leading in partnership with Canada a project to assess water quality conditions in Lake St. Clair with an emphasis on the Thames River area; to assess the extent of harmful algal blooms in Lake St. Clair and the Thames River; to determine water quality and cyanobacterial bloom patterns in Lake St. Clair; and to determine the effect of the Thames River on the water quality conditions of Lake St. Clair and its relative contribution to Detroit River and Lake Erie west basin.

The Essex Region Conservation Authority, with funding from Ontario, monitored nutrients and metals in greenhouse and non-greenhouse influenced streams in the Kingsville and Leamington area from 2012 to 2018.

Ontario's Multi-Watershed Nutrient Study continues to examine how agricultural land management and features of the landscape relate to nutrient losses in



Thames River, London, Ontario. Credit: Ryan Hodnett, Wikimedia.org.



Agricultural crop land adjacent to Lake Erie. Credit: Ken Lund, Flickr.com.

agriculturally dominated areas of the Canadian Great Lakes basin. Eleven headwater sentinel watersheds in the basins of Lakes Huron, Erie and Ontario have been selected for detailed study, including two in the Thames River Watershed. These watersheds are representative of the range of agricultural areas in Southern Ontario. Study of these watersheds includes monitoring of stream discharge, water quality and weather. An associated effort exists to survey the land management in these watersheds and to conduct regional-scale modelling to support this work (led by University of Windsor and Ryerson University).

Ontario has engaged in projects to assess surface water monitoring program focused on urban areas. The first phase of this work was to estimate the relative magnitude of non-point phosphorus loads from urban areas and to identify priority watersheds for monitoring. The second phase focused on assessing existing monitoring programs focused on urban areas and identifying gaps.

Ontario provided funding support to Upper Thames River Conservation Authority to develop a standardized water information system to store and report hydrometric, water quality and ecological data. This will save time importing, analyzing and reporting nutrient conditions across the watershed, and across neighboring watersheds in south western Ontario. The collaboration among users will also foster resource and cost sharing amongst the conservation authorities and others.

Ontario is supporting innovative approaches and technologies in phosphorus removal and recovery. Through a partnership with the Everglades Foundation's George Barley Water Prize, nine innovative technologies were tested in the Holland Marsh in Bradford, Ontario. Each was evaluated for cold climate performance,

cost-effectiveness, environmental sustainability and ability to reduce phosphorus to 10 ppb. OMECP, in collaboration with provincial and federal government partners, is also coordinating the development of the foundational pillars for a National Nutrient Reuse and Recovery Framework. The purpose of the framework is to create a circular nutrient economy and ensure a sustainable supply of nutrients. A forum was convened to discuss current technologies, BMP approaches and research, and to identify challenges and solutions to developing a framework.

OMNRF and Ducks Unlimited Canada are working with community partners to develop wetland restoration projects in the Lake Erie basin that restore lost wetland features or enhance those negatively impacted by competing land use pressures. To date, efforts have focused on improving wetlands in the priority areas identified in the Canada Ontario Lake Erie Action Plan. The Ministry and Ducks Unlimited Canada are also conducting wetland research to increase understanding of the role that restored wetlands play in capturing and processing non-point source phosphorus in southwestern Ontario. Data collected will inform the development of a predictive model, enabling resource managers to better predict how new and restored wetlands will behave once incorporated into the landscape and identify their potential water quality benefits.

OMNRF is partnering with the University of Windsor to research the impacts of phosphorus-driven algal blooms on fish recruitment, foodweb structure and dynamics and ecosystems of Lake Erie. Results will be used to develop a spatial ecosystem model simulating the flow of energy and matter within each basin's food webs along with exchanges among the basins. The model will improve lake managers' understanding of the dynamics of commercially important species and will also be used to simulate the impacts of algal blooms on fish and fisheries in Lake Erie.

Socioeconomic Analysis

Canada has supported projects to better analyze and understand socioeconomic factors associated with phosphorus loss and mitigation including consideration of use of economic instruments to increase economy and on ecological goods and services.



Discharges from Vessels Annex

Overview

Under the Great Lakes Water Quality Agreement of 1972, 1978 and the Protocol of 1987, Canada and the United States undertook measures for the abatement and control of pollution from shipping sources. The most recent 2012 Canada-United States Great Lakes Water Quality Agreement (Agreement) commits the responsible authorities in Canada and the United States to limit and control the following vessel discharges that may be harmful to the waters of the Great Lakes:

- Oil and Hazardous Polluting Substances;
- Garbage;
- Wastewater and Sewage
- Biofouling;
- Antifouling Agents; and
- Ballast Water.

The agencies responsible for the implementation of the Discharges from Vessels Annex are Transport Canada (TC), Fisheries and Oceans Canada (DFO), the Canadian Coast Guard (CCG), the United States Coast Guard (USCG) and the United States Environmental Protection Agency (USEPA). In the United States, several States regulate vessel discharges, in addition to the Federal agencies. These agencies met annually to review progress in adopting programs and measures that aim to:

- Protect the quality of the waters of the Great Lakes;
- Ensure due regard for safety of life at sea;
- Take into account the standards and guidance of the International Maritime Organization;
- Implement domestic laws and regulations regarding vessel discharge taking into account the best available science; and
- Prohibit, and make subject to appropriate enforcement, discharges from vessels that are



Ship's wake. Credit: pisanodanie, Pixabay.

harmful to the quality of the Great Lakes.

This report catalogues the progress from 2017 to 2019 in achieving these goals through the adoption and implementation of regulations, programs, and other measures to facilitate coordinated and cooperative implementation and enforcement, where necessary.

Annex Implementation

During the 2017-2019 period, Annex implementation was supported by the Ontario Ministry of Natural Resources and Forestry (OMNRF), Ontario Ministry of Transportation (MTO), Wisconsin Department of Natural Resources (WDNR), the Lake Carriers' Association, the Chamber of Maritime Commerce, and the Shipping Federation of Canada through the Discharges from Vessels Annex Subcommittee, co-led by Transport Canada and the United States Coast Guard.

Key Achievements

2017 - 2019: Through a combination of initiatives monitored through the Discharges from Vessels Annex Subcommittee, including the existing international



Cargo ship in Green Bay, Michigan. Credit: iStock.

regulatory conventions, as well as the Canadian and United States domestic pollution prevention, compliance and preparedness regime, there were no significant discharges of pollution substances from vessels or shore side marine transportation-related facilities during this reporting cycle. The regulatory regime for both countries is robust and both the domestic and international fleet are fitted with appropriate equipment and operational training for Oil and Hazardous Polluting Substances, Garbage, Wastewater and Sewage. No tributyltin has been discovered in use in antifouling paint for some years. The primary outstanding issue of importance to stakeholders is the threat of further introduction of aquatic invasive species in the Great Lakes.

In existence since 2006, the binational Ballast Water Working Group continues to meet the objective of ensuring the examination of the ballast water of every vessel entering the Great Lakes from outside the Exclusive Economic Zone (200 nautical miles (nmi) from its coast).

Binational Actions and Achievements

Throughout this reporting period, the United States and Canada continued to engage stakeholders at multiple settings such as the Great Lakes Waterways Conference, Regional and National meetings of the Canadian Marine Advisory Council and through the Discharges from Vessels Annex Subcommittee. These engagement opportunities ensured the necessary agencies, organizations, and individuals were

positioned to support a compatible, fair, practicable and environmentally protective regulatory environment regarding ballast water management on the Great Lakes. Meetings of the Discharges from Vessels Annex Subcommittee served as opportunities to share information about international, federal, and state regulatory initiatives and ballast water treatment technologies and challenges.

Ballast water discussions among TC, the USEPA and the USCG have continued throughout this reporting period to seek consistency and compatibility for the current and forthcoming amendments to the implementation of their respective ballast water regimes.

During this reporting period, coordination and alignment of efforts, as well as the sharing of information, between the Discharges from Vessels Annex and the Aquatic Invasive Species Annex continued given the strong linkages among the commitments of the two Annexes.

2017 to 2019 Priorities for Science: Develop compatible approaches to sampling and analysis of ships ballast water in connection with the ballast water performance standard in 33 CFR Part 151 and Regulation D-2 of the International Convention for the Control and Management of Ship Ballast Water and Sediments 2004.

Develop a compatible approach to collecting and analyzing data concerning the implementation of the ballast water performance standard on the Great Lakes.

2017 to 2019 Priorities for Action: Seek consistency and compatibility between the United States and Canada during implementation of USCG ballast water discharge standard, USEPA's Vessel General Permit requirements and development of regulations implementing IMO BW Management Convention.

Work together, with stakeholders towards compatible, fair, practicable and environmentally protective Great Lakes requirements for ballast water management.

Ballast Water

Dialogue among TC, the USCG, the USEPA, seeking consistency and compatibility for their respective ballast water management regulatory regimes continued throughout the reporting period through annual meetings. Canadian Coast Guard, Department

of Fisheries and Oceans, and Department of Global Affairs were participants in these meetings, along with the United States Department of State.

The USCG continued to implement its ballast water discharge standard, while TC continued to implement its existing ballast water management regulations and is developing new regulations to bring the international ballast water management convention into force in Canada.

In December 2018, the United States Vessel Incidental Discharge Act (VIDA) was signed into law, establishing a new framework for the regulation of vessel incident discharges. Over the next four years, the USEPA will develop performance standards for discharges, following which the USCG will develop implementation, compliance, and enforcement regulations. The 2013 Vessel General Permit, issued by the USEPA, remains in effect until USCG standards are finalized. Regular discussions between countries will continue as the regulatory regime of each country is developed and implemented.

Canada, through DFO, and the United States, through the Naval Research Laboratory, continue to work on compatible sampling and analysis of ballast water samples, as well as data collection and analysis. This information will assist both countries to assess the performance of technology and progress in protection of the environment and inform binational discussions on cooperative implementation.

Ballast Water Working Group

Ballast water aboard vessels arriving from outside Canada's Exclusive Economic Zone (EEZ) continued to be overseen by the binational Great Lakes Seaway Ballast Water Working Group. The Working Group, which is comprised of representatives from TC, the USCG, the St. Lawrence Seaway Development Corporation (United States), and the St. Lawrence Seaway Management Corporation (Canada), continued to develop, enhance, and coordinate binational compliance and enforcement efforts to reduce the introduction of aquatic invasive species via ballast water and residuals.

During the 2016-18 reporting period, the Ballast Water Working Group continued to report that 100 percent of vessels bound for the Great Lakes Seaway from outside



Ship's ballast water. Credit: International Maritime Organization, Flickr.com.

the EEZ received ballast management exams on each Seaway transit. Every year, several thousand ballast tanks are assessed during vessel transits. Vessels that do not exchange their ballast water or flush their ballast tanks are required to either: retain the ballast water and residuals on board, treat the ballast water in an environmentally sound and approved manner, or return to sea to conduct a ballast water exchange. Vessels that are unable to exchange their ballast water or residuals, and which are required to retain them onboard, receive a verification exam during their outbound transit prior to exiting the Seaway.

The Summary of Great Lakes Seaway Ballast Water Working Group reports made during the last three years are available at:

- [2018 Summary of Great Lakes Seaway Ballast Water Working Group](#)
- [2017 Summary of Great Lakes Seaway Ballast Water Working Group](#)
- [2016 Summary of Great Lakes Seaway Ballast Water Working Group](#)

Great Lakes Annex to Canada-United States Joint Marine Pollution Contingency Plan

Through the Canada-United States Joint Marine Pollution Contingency Plan, Canada and the United States continue to coordinate planning, preparedness, and response to harmful substance incidents in the contiguous waters along shared marine borders. This joint plan supplements each country's national response systems and provides the mechanisms for a coordinated interface of the respective domestic response systems for boundary areas.

The Canadian and United States Coast Guards chair Joint Response Teams for each geographic area, which include appropriate government representatives to

provide advice and counsel to facilitate coordinated planning, preparedness, and response to a harmful substance incidents.

The Great Lakes Geographic Annex (CANUSLAK) to the Joint Marine Pollution Contingency Plan covers the boundary waters of the Great Lakes between Canada and the United States. The Annex defines the CANUSLAK Joint Response Teams and is regularly tested and improved in an ongoing series of CANUSLAK exercises.

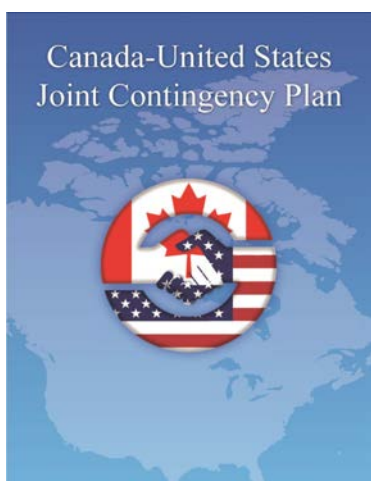
The CANUSLAK Annex was last exercised in October 2017 during a full-scale exercise at the Shell Canada facility in Sarnia, Ontario. The scenario involved a hypothetical spill at the facility's tank farm that impacted the St. Clair River, a binational waterway.

Domestic Actions and Achievements (Canada)

Ballast Water

The Government of Canada supports effective ballast water management standards to reduce the risk of introducing invasive species.

Canada established a robust regulatory regime in 2006. In 2010, Canada acceded to the International Maritime Organization's International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 ("2004 Convention").



Cover page of the 2017 Canada-United States Joint Contingency Plan. Credit: Canada and United States.

Seventy-seven countries, including Canada, have ratified and are moving forth with the Convention, which entered into force on September 8, 2017.

Regulatory amendments are needed to give full effect to the Convention in Canada and further reduce the risk that ships will introduce and spread aquatic invasive species in Canadian waters. Canada and the United States continue to work closely together bilaterally and at the International Maritime Organization towards compatible, practicable and environmentally protective ballast water requirements.

Fisheries and Oceans Canada Research on Ballast Water

Research and development of additional practical measures to further reduce the risk of introduction or spread of Aquatic Invasive Species via ships within the Great Lakes continues. Fisheries and Oceans Canada continues to actively conduct research on the ballast water vector relevant to the Great Lakes, in collaboration with TC. Research projects conducted between 2016 to 2019 focused on evaluating temperature effects of potential ballast water management strategies (e.g., UV and chlorination) when used during winter conditions, and evaluating new sampling methods and analysis tools for measuring plankton abundances in ballast water according to Regulation D-2 in the international ballast water management convention. Further detail on research projects conducted in Canada can be found in the following publications:

- Beyond propagule pressure: importance of selection during the transport stage of biological invasion. [Frontiers in Ecology and the Environment 16 \(6\): 345-353.](#)
- Is salinity an obstacle for biological invasions? [Global Change Biology 24 \(6\):2708-2720.](#)
- Examination of a High Resolution Laser Optical Plankton Counter and FlowCAM for measuring plankton density and size. [Journal of Sea Research 133:2-10.](#)
- A shipboard comparison of analytic methods for ballast water compliance monitoring. [Journal of Sea Research 133: 11-19.](#)
- Evaluating efficacy of filtration + UV-C radiation for ballast water treatment at different temperatures. [Journal of Sea Research 133:20-28.](#)
- Examination of an indicative tool for rapidly

estimating viable organism abundance in ballast water. [Journal of Sea Research 133: 29-35.](#)

- Catch me if you can: Comparing ballast water sampling skids to traditional net sampling. [Journal of Sea Research 133: 81-87.](#)
- Modelling the distribution of colonial species to improve estimation of plankton concentration in ballast water. [Journal of Sea Research 133: 166-176.](#)
- Detection of UV-treatment effects on plankton by rapid analytic tools for ballast water compliance monitoring immediately following treatment. [Journal of Sea Research 133: 177-184.](#)
- Optimizing methods to estimate zooplankton concentration based on generalized patterns of patchiness inside ballast tanks and ballast water discharges. [Ecology and Evolution 7 \(22\): 9689-9698.](#)
- Optimizing performance of non-parametric species richness estimators under constrained sampling. [Ecology and Evolution 6 \(20\): 7311-7322.](#)
- Comparison of three techniques to evaluate the number of viable phytoplankton cells in ballast water after ultraviolet irradiation treatment. [Journal of Applied Phycology 28 \(5\): 2821-2830.](#)

In addition, TC and DFO are undertaking research to confirm the biological efficacy of ballast water management systems, including the use of exchange plus treatment, and are continuing support for international efforts related to the [GloFouling Partnerships](#). TC has also published the Transactions on Ballast Water Treatment Systems for the Great Lakes. [Transactions on Ballast Water Treatment Systems for the Great Lakes.](#)

Domestic Actions and Achievements (United States)

Ballast Water Regulations and Supporting Research

The USCG continues to implement its regulation that established a performance standard for the allowable concentration of living organisms in ballast water discharged from ships in waters of the United States. Several independent laboratories are in the process of testing many systems for type approval. As of January 2019, 17 ballast water management systems (BWMS) have been [type-approved](#) by the United States Coast Guard, 9 are pending, with 33 additional vendors submitted a Letter of Intent and their systems are in the process of testing. Additionally, as of January

2019, the USCG currently has accepted 114 foreign-approved ballast water treatment systems as Alternate Management Systems. These designations are intended as a bridging strategy to allow for the use of ballast water treatment systems that are type approved by foreign administrations in accordance with the 2004 Convention.

United States research on ballast water also continued during this reporting period, as is outlined below:

- Practicability/Appropriateness of Modeling to Extrapolate Type Approval Test Results for Multiple BWMS Configurations; United States Naval Research Laboratory, May 2015.
- Practicability Review of Ballast Water Discharge Standards; United States Naval Research Laboratory, October 2016.
- Scalability of Ultraviolet-based Ballast Water Management Systems; United States Naval Research Laboratory, June 2017.

Ballast Water Technology Research and Development

In 2017, with funding from the United States Maritime Administration, the Great Waters Research Collaborative (GWRC) was formed. Managed by the Lake Superior Research Institute (LSRI, University of Wisconsin-Superior), the collaborative is comprised of scientists from LSRI and the University of Minnesota-Duluth's Natural Resources Research Institute, and others. The GWRC is advised by numerous stakeholders, including: United States and Canadian regulatory agencies; representatives from United States ports and Great Lakes states; representatives from the United States and Canadian shipping industry; and non-governmental organizations working on Great Lakes policy issues.

The GWRC is devoted to the conduct of high-quality environmental research and to providing independent testing services to support green shipping and promote the sustainable industrial, commercial, and public use of the Great Lakes. The current focus of GWRC is ballast water technology testing, Great Lakes port monitoring, generating Great Lakes-relevant data to inform ballast water management system testing requirements and methods, and education and outreach.



Laboratory-Based Testing Conducted by Great Waters Research Collaborative in 2018. The objective of this testing was to determine the biological efficacy of a ballast water treatment technology to the freshwater algal species *Selenastrum capricornutum*. Credit: Great Water Research Collaborative.



Scientists from Great Waters Research Collaborative Collecting Ballast Uptake Samples Onboard the M/V Edgar B. Speer in August 2017 as part of the Great Lakes Ship Ballast Monitoring Study. Credit: Great Water Research Collaborative.

Additional details on GWRC's research and testing activities can be found in the following publications:

- Great Waters Research Collaborative: Great Lakes Ship Ballast Monitoring Project Technical Report. [Available on the GWRC Website, 88 pp.](#)
- Lake Superior Research Institute Documents Non-Native Zooplankton in Western Lake Superior. [Press Release Issued 09 October 2018.](#)
- Great Waters Research Collaborative Request for Applications for Bench-Scale Testing Services. [Call for Technologies with Great Lakes Applicability to Receive Independent Testing.](#)
- Validation Report Supporting the Use of SMART™ II Cholerae O1 and O139 Water Tests for the Detection of Toxigenic *Vibrio cholerae* in Ballast Water. Not available for public release.



Aquatic Invasive Species Annex

Overview

The 2012 Agreement commits the United States and Canada, in collaboration with state and provincial governments, tribal governments, First Nations, Métis, municipal governments, watershed management agencies, other local public agencies, and the public, to address the continuing threat posed by aquatic invasive species (AIS) to Great Lakes water quality.

There has been a long history of non-native species invading the Great Lakes. Invaders, like zebra and quagga mussels have had significant impacts on water quality. Government agencies have responded with strategic actions, which have had notable success. However, the threat of new AIS remains while existing AIS continue to negatively impact water quality. Thus, the need for continued prevention, response, and adaptive management actions continues.

The Aquatic Invasive Species Annex of the Agreement supports: (1) preventing the introduction of new AIS; (2) controlling or reducing the spread of existing AIS; and (3) eradicating, where feasible, existing AIS within the ecosystem. Work under the Annex recognizes, leverages and supports strategic planning and management, as well as the science and accomplishments, of existing partnerships and initiatives focused on AIS prevention and control in the Great Lakes basin.

Efforts are focused on:

- Preventing or minimizing significant social and economic impacts of AIS to Great Lakes water quality;
- Recognizing prevention as the most strategic AIS management option;
- Utilizing early detection and rapid response to minimize need for challenging and costly control of AIS after introduction and establishment;

- Facilitating the exchange of information between collaborators on AIS within the Great Lakes basin;
- Evaluating ecological trends and actions to identify and manage AIS; and
- Supporting a global approach to understanding and evaluating risks of AIS to North America and the Great Lakes through species assessments, pathway and vector analyses, incorporation of climate and other habitat science.

Annex Implementation

Interjurisdictional collaborations to protect against AIS are well established in the Great Lakes and progress toward the commitments under this Annex owes much to the efforts of those critical bodies. The Aquatic Invasive Species Annex Subcommittee, co-led by the United States Fish and Wildlife Service (USFWS) and Fisheries and Oceans Canada (DFO), works closely with these collaborations on their shared objectives to prevent AIS. Chief among these collaborations is the Great Lakes Panel on Aquatic Nuisance Species (GLP), established to coordinate AIS prevention and control activities in the Great Lakes region and support the United States Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (reauthorized as the National Invasive Species Act in 1996). The GLP is supported by the Great Lakes Commission (GLC) and the USFWS. The Asian Carp Regional Coordinating Committee (ACRCC), with membership from the United States and Canada, has a lead role in actions regarding Asian carps. The Great Lakes and St. Lawrence Governors and Premiers' Aquatic Invasive Species Task Force has also been an important collaborator in establishing the framework for mutual aid and coordination between the states and provinces.

Organizations involved in the Aquatic Invasive Species Annex Subcommittee and Extended Subcommittee

include: United States Environmental Protection Agency (USEPA), USFWS, United States Geological Survey (USGS), United States National Oceanic and Atmospheric Administration (NOAA), 1854 Treaty Great Lakes, Chippewa Ottawa Resource Authority, Illinois Department of Natural Resources (ILDNR), Indian Fish and Wildlife Commission (IFWC), Michigan Department of Environmental Quality (MDEQ), Office of the Great Lakes, Michigan Department of Natural Resources (MDNR), Minnesota Department of Natural Resources (MN DNR), New York Department of Environmental Conservation (NYSDEC), Ohio Department of Natural Resources (ODNR), Wisconsin Department of Natural Resources (WDNR), Great Lakes and St. Lawrence Cities Initiative (GLSLCI), GLC, Great Lakes Fishery Commission (GLFC), The Nature Conservancy, Environment and Climate Change Canada (ECCC), DFO, Ontario Ministry of Natural Resources and Forestry (OMNRF), and the Ontario Federation of Anglers and Hunters (OFAH).

Key Achievements

Real success in prevention of new aquatic invasive species in the Great Lakes

Figure 2 illustrates a significant reduction in the last decade of the rate at which nonindigenous species have become established in the Great Lakes. The current rate of 0.3 new species per year is also significantly less than the rate of invasion prior to 1950 after which

the St. Lawrence Seaway came into full function. As described in the Discharges from Vessel Annex chapter, implementation of binational enforcement of at-sea ballast water exchange for all ships entering the St. Lawrence Seaway since 2006 has greatly contributed to this reduction. Concerted efforts in the United States and Canada are also preventing the establishment of Asian carps in the Great Lakes.

The job of prevention is far from complete with existing pathways still allowing new species to enter and become established in the Great Lakes. During the last decade four new zooplankton species have been discovered and three are considered established in parts of the Great Lakes. The route of entry of the first three species, *Thermocyclops crassus* (found in 2014), and *Diaphanosoma fluviatile* (found in 2015), *Brachionus leydigii* (found in 2016) is unknown, but the most recent, *Mesocyclops pehpeiensis* (found in 2016) is thought to be a hitchhiker on aquatic plants. At least two of these species have spread among the lakes: *Thermocyclops crassus* was first discovered in Lake Erie was recently found in Lake Superior, and *Diaphanosoma fluviatile* was recently found in lakes Michigan and Superior. Other new species that have been discovered but are not established include the first observation of the Tench, *Tinca tinca*, a large member of the minnow family, in Lake Ontario (found in 2018).

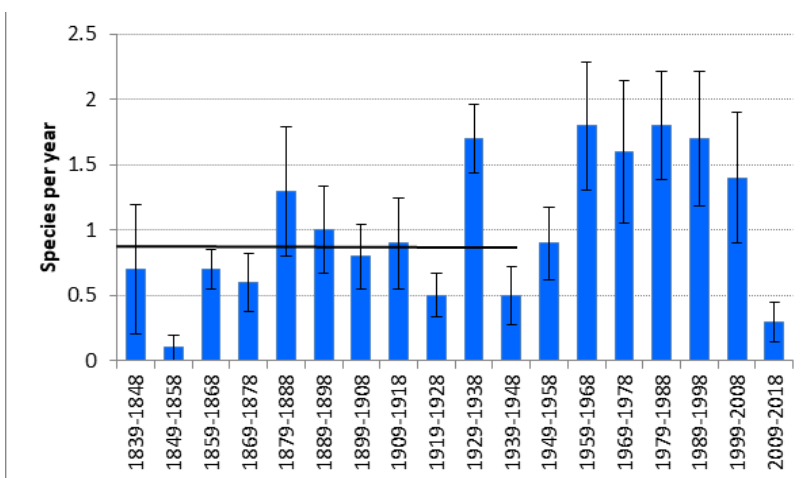


Figure 2 – Rate of invasion of aquatic non-indigenous species by decade. Solid line indicates the pre-1950 average. Credit: NOAA, Great Lakes Environmental Research Laboratory, 2019.

Annex Achievements

In Summary, the member Agencies of the Annex subcommittee and their partners have:

- Continued extensive early detection programs focused on Asian carps that are coordinated between Canada and the United States;
- Developed and implemented detection protocols for silver carp in the Chicago Area Waterway and Grass Carp in Canadian waters;
- Undertook binational response exercises to address grass carp in Lake Erie;
- Expanded efforts to further reduce the risk of Asian carps invading through the Chicago Area Waterway System, including plans for a new state-of-the-art control structure at the Brandon Road Lock and Dam;
- Established the framework for a clearinghouse of species risk assessments to support regulation and management actions;
- Identified aquatic species from other continents that present a risk of invasion and establishment in North America, using scientific modeling and current climate science;
- Increased research and development of new tools and technologies to detect, control and eradicate AIS;
- Developed new sub-indicators to: (1) evaluate the movement of species between Great Lakes; and (2) evaluate the rate of AIS introductions;
- Expanded identification, evaluation and incorporation of human dimension and socio-economic information to inform AIS strategies and policies;
- Refined and implemented early detection monitoring tools and networks;
- Developed interagency rapid response plans focused on key AIS, including Asian carps; and
- Established the Council of Great lakes Fishery Agencies Invasive Fishes Committee to facilitate coordination, communication, and advice about fishery management priorities for invasive fishes, including Grass Carp in Lake Erie.
- Implementation of federal Aquatic Invasive Species regulations, and comprehensive provincial invasive species legislation and regulations supporting prevention, response and management efforts in Canada and Ontario respectively.

These achievements are described in more detail in the

following description of actions and achievements that met the Annex's 2017 to 2019 Priorities for Science and Action.

Actions and Achievements

2017 to 2019 Priority for Action: Refine and enhance the Early Detection and Rapid Response Initiative.

The United States and Canada continue to refine and enhance robust AIS early detection and rapid response mechanisms in the Great Lakes basin, including the following:

- Establishment and continued use of AIS watch lists of species of highest priority and likelihood of invading the Great Lakes endorsed by the Great Lakes and St. Lawrence River Governors and Premiers;
- Identification of priority locations in the Great Lakes basin at which to undertake targeted surveillance for the potential introduction of watch list species, and regular evaluation of potential additional pathways to inform priority locations;
- Development and use of protocols for strategically conducting monitoring using methodologies that target invertebrates and all life stages of fish species to optimize detection of a potential invader;
- Implementation of an adaptive strategy to improve the efficiency of sampling and maximize the potential for detecting newly introduced species in a complex aquatic system while it is still geographically focused;
- Continued coordination of contingency plans and preparation for response actions necessary to prevent the establishment of newly detected AIS, including:
 - The Great Lakes states and Provinces of Ontario and Quebec continue to use the Mutual Aid Agreement for Combating Aquatic Invasive Species Threats to the Great Lakes-St. Lawrence River Basin as the basis for coordinated planning and response.
 - The Council of Great Lakes Fishery Agencies established an Invasive Fish Executive Committee to coordinate among management agencies in the basin on emerging invasive fish threats, including grass carp. The Committee drafted a Communication Protocol to guide the timely distribution of key information related to new non-native fish detections.

- The USFWS has developed a draft communications protocol for the timely dissemination of new findings from the Early Detection Monitoring Program for AIS in the Great Lakes.
- The Great Lakes states developed an AIS Interstate Surveillance Framework for the U.S. Waters of the Great Lakes and a draft Great Lakes Basin AIS Interstate Response Framework. The states are also currently developing an interstate communications protocol to compliment the frameworks.
- Responsible agencies are working collaboratively to ensure the timely sharing of relevant information and prompt communication of AIS and subsequent coordinated response actions.

AIS Annex agencies have initiated the process for scoping and developing a federal United States and Canadian interagency mutual aid agreement, reflecting the model agreement in use by states and provinces under the Great Lakes and St. Lawrence Governors and Premiers. The mutual aid agreement will originate between USFWS and DFO, and will eventually expand to include USGS, NOAA, and other Canadian federal agencies.

Coordinated binational response efforts were conducted on Lake Erie to address the risk of Grass Carp establishment in the lake basin. In 2018, ODNR led a response exercise with teams from DFO, OMNRF, Quebec’s ministère des Forêts, de la Faune et des Parcs, NYSDEC, USFWS, USGS, University of Toledo, ODNR, and MDNR. The three-day Grass Carp Planned Action was conducted on the Sandusky and Maumee Rivers from June 12 – 14, 2018, resulting in the collection of 30 Grass Carp. The multiagency effort will continue to utilize targeted removal in the future.

In conjunction with the Lake Superior Lakewide Action and Management Plan, United States federal, state, and tribal agencies and the Province of Ontario continue a binational lake-wide early detection program. This coordinated effort is directed at highest risk sample locations and uses the findings from the USFWS evaluations to deliver sampling to best detect newly-introduced species.

Domestic Actions and Achievements (United States)

The ACRCC’s Monitoring and Response Work Group previously developed the Upper Illinois River Contingency Response Plan focused on preventing the introduction and establishment of Asian carp in the Great Lakes in the event of detection in upstream locations (upstream Illinois Waterway navigation pools or above the Electric Dispersal Barrier). Agency partners conducted scenario-based response planning through regular evaluation, including tabletop exercises. Contingency response efforts were implemented following the capture of an adult Silver Carp on June 2017 in the Chicago Area Waterway System approximately 9 miles from Lake Michigan. The intensive response effort covered a 13-mile section of the waterway, concluding after approximately two consecutive weeks with no additional Asian Carp collected.

Michigan and Ohio resource management agencies, working with university partners (Michigan State University – Quantitative Fisheries Center), led efforts to collect and utilize key Grass Carp population and life history data to better inform a structured decision process for identifying high-priority targeted detection and control actions for implementation within a comprehensive Lake Erie strategy. The Lake Erie Committee of the GLFC completed the [Lake Erie Grass Carp Adaptive Response Strategy: 2019-2023](#), which informs the identification, prioritization, selection, and sequencing of key strategic actions. In support of this strategy, the ODNR and MDNR conducted focused response actions in 2017 and 2018 with the goal of removing invasive Grass Carp, assessing capture techniques and collecting critical information on Grass Carp population status in the Sandusky River and Maumee River. ODNR Division of Wildlife also recently completed the [Lake Erie Grass Carp Response Strategy: 2019-2023](#). Efforts were conducted under the Great Lakes and St. Lawrence River Governors and Premiers’ Mutual Aid agreement and included support from United States and Canadian agencies and organizations.

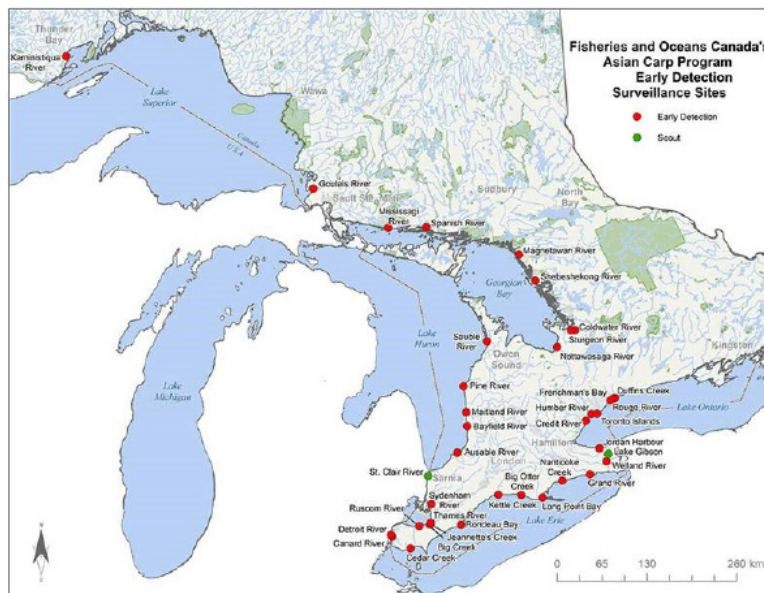
Domestic Actions and Achievements (Canada)

Canada and Ontario have worked collaboratively to support early detection and response efforts to high risk aquatic invasive species within the Great Lakes basin. The following provides a summary of these collective and agency specific efforts:

- In 2017, Canada renewed its commitment with new ongoing investments in efforts to prevent aquatic invasive species. These investments included continuing the Asian carp program, increasing Sea Lamprey control efforts, and investing in a national Aquatic Invasive Species program to enhance prevention and control efforts across Canada.
- DFO's renewed Asian carp program includes expanded early detection efforts with five field crews undertaking early detection surveillance activities at 34 early detection locations with over a thousand individual sites in the Canadian waters of the Great Lakes. These crews sample sites determined in the binational risk assessments for the Asian carp species as most likely habitats for the fishes in tributaries and wetland areas in Lake Huron, Lake Erie, and Lake Ontario. The crews continue to evaluate potential new areas to survey. The DFO survey crews use a combination of traditional fishing gears including

boat electrofishing, trap nets, fyke nets, large and small hoop nets, gill and trammel nets, and bag seine to focus detection efforts on Asian carp species. The DFO detection efforts have been expanded to include efforts to detect possible reproduction by sampling for eggs and larvae in potential spawning rivers.

- OMNRF works with DFO to undertake strategic surveillance activities for Asian carps within the Lake Erie and Lake Huron basins. Their efforts focus on the use of environmental DNA (eDNA) as an added strong surveillance tool for the detection of species at low abundance. OMNRF samples approximately 100 sites within Lake Erie, southern Lake Huron and their tributaries. The eDNA early detection surveys target key habitats suitable for Asian carps informed by the binational risk assessments and incorporating information about detections from previous years. The eDNA surveillance has also been expanded to Lake St. Francis and areas immediately upstream in the St. Lawrence River, and in the Bay of Quinte, Lake Ontario.
- Findings of Grass Carp in Ontario waters of Lakes Erie, Ontario, and Huron have triggered successful coordinated responses led by DFO with OMNRF and municipal partners. These responses have followed scaled incident command system protocols coordinating the actions of all groups involved. Since 2013, 28 Grass Carp have been captured in the



Early detection sampling locations for Asian carps (in Canada and the United States) and other species in the United States carried out by the USFWS, DFO and OMNRF. Credit: USFWS, DFO and OMNRF.

Canadian waters of the Great Lakes. The resulting responses have delivered effective focused capture efforts to ensure that risks of any additional fertile fish being present are minimized.

- DFO and OMNRF continue to refine their joint Asian Carp Response Plan, first developed in 2011, to ensure that domestic response to early detections of Asian carp species will be effective. As well as the active responses to real-world captures of Grass Carp, DFO led a coordinated field response exercise on the Grand River in Ontario with OMNRF and other provincial and municipal partners during the spring of 2017. This exercise tested all aspects of the response protocol from incident command system implementation, to field sampling coordination, to public communication. Results of the mock effort contributed to refinements in agency and shared response protocols.
- Determining whether Asian carp are fertile or infertile is a first step in evaluating risk posed by any fish captured. DFO leads a coordinated analysis of fertility for all Asian carps captured in Ontario waters at their Asian Carp Lab in Burlington. DFO also provides support for the Province of Quebec if fish are captured in Quebec waters, as well as provides support to the USFWS should they require additional help with ploidy testing.
- Ontario continues to strengthen its binational partnerships with other jurisdictions to facilitate improved coordination of efforts to address AIS. Most recently, in 2017, Ontario renewed its commitment to work in partnership with the U.S. states and Quebec within the Great Lakes basin to prevent the introduction of high-risk invaders to shared waters and supported the expansion of the Great Lakes and St. Lawrence Governors and Premiers' Least Wanted List.
- OMNRF works with the OFAH to support the operation of the [Early Detection and Distribution Mapping System](#) (EDDMapS Ontario), which provides an on-line and mobile platform for the public and agencies to report sightings of invasive species in Ontario. Since its launch in 2014, invasive species data collection by agencies and citizen scientists in the province has increased exponentially with more than 27,000 occurrence records being added to the Ontario invasive species data set.
- OMNRF responded to incidental captures of Tench by commercial fishers in the Ontario waters of

Lake St. Francis of the St. Lawrence River (one in 2016, two in 2017, three in 2018), and in eastern Lake Ontario (one in 2018). Surveillance has been undertaken through the OMNRF's Lake Ontario Management Unit's assessment program, collection of environmental DNA samples and engagement with local partners including the St. Lawrence River Institute of Environmental Studies and the Akwesasne First Nation.

- In the Upper Great Lakes, OMNRF carries out a nearshore biodiversity and invasive fish monitoring program in 12 different locations around Lake Huron using both fyke and small mesh gill nets to cover the various depth and habitat types (2015-2020). Each year, in partnership with the USFWS, OMNRF conducts early detection assessments in the lower St. Mary's river using three different assessment types including electrofishing, trawling and fyke nets. In 2017 to 2018 during the Lake Huron Coordinated Science and Monitoring Initiative, the nearshore biodiversity project was expanded to include specific actions to examine Round Goby numbers, habitat use and effects on the food web.
- OMNRF is leading eradication of water soldier in the Trent Severn Waterway and the Black River (near Lake Simcoe) working with partners such as the OFAH, Parks Canada, and Trent University. After several years of control, significant reductions in the population have occurred within the Trent Severn Waterway, and there have been no observations of plants in the Black River since 2016. Extensive public outreach, in combination with monitoring and surveillance continues to be undertaken to detect new infestations.
- OMNRF continues efforts to eradicate European water chestnut at Voyageur Provincial Park on the Ottawa River via manual removal and the use of specially designed boats that cut and collect the plants. In the Lake Ontario watershed (Wolfe Island, Rideau River) and the St. Lawrence River, the OMNRF has partnered with Ducks Unlimited Canada to implement a control and eradication plan for European water chestnut.
- Ducks Unlimited Canada in collaboration with OMNRF and the Invasive Species Centre also successfully eradicated parrot feather, an invasive perennial aquatic plant, from a private pond in eastern Ontario.

2017 to 2019 Priority for Action: Develop a clearinghouse for AIS species and pathway risk assessments.

Key to responding to and managing new species is understanding the risk posed by those potential invaders. The GLP Ad Hoc Risk Assessment Committee is leading the development and establishment of a clearinghouse of risk assessments for the basin. In support of this effort, NOAA is expanding the Great Lakes Aquatic Nuisance Species Information System (GLANSIS) to include an extensive interactive database of risk assessments to serve as the clearinghouse. The [GLANSIS Risk Assessment Clearinghouse](#) is a source for comprehensive risk assessment information including summary descriptions of applicable risk assessment protocols, as well as completed risk assessments conducted by agencies within the Great Lakes region and by other non-Great Lakes jurisdictions for key species of interest.

The GLANSIS website links to USFWS Ecological Risk Screening Summaries for fish, invertebrates and plants; and provides access to the Invasive Species Centre of Ontario's Risk Assessment Database, a database of risk assessments relevant to the Great Lakes region. With support from OMNRF and DFO, the Invasive Species Centre has been developing the Canadian node of the risk assessment clearinghouse, including developing an inventory of risk assessments across taxa including aquatic invasive species with focus on Ontario to support regulatory and policy actions in Canada. The Invasive Species Centre project links to NOAA's Great Lakes Aquatic Nuisance Species Information System, and basin-wide risk assessment clearinghouse.

2017 to 2019 Other Actions: Programs to prevent the introduction of AIS by conducting proactive, binationally coordinated, risk assessments of pathways and species.

A binational assessment of the potential ecological risks for Black Carp has been developed by DFO, USFWS, USGS, and GLFC authors (risk assessments already exist for the other three Asian carp species that potentially threaten the Great Lakes). The risk assessment defines the risk of Black Carp entering the Great Lakes from their established range in the middle Mississippi River basin. It also defines the risks of Black Carp establishment, and potential impacts for Great Lakes biodiversity given their diet of clams and

snails. The risk assessment has been peer-reviewed by experts from both countries at a Canadian Science Advisory Secretariat meeting, and was submitted for U.S. federal review within the USGS. When finalized in 2019, the Black Carp ecological risk assessment will be presented to Great Lakes managers in both the United States and Canada, and be used to inform prevention, early detection, monitoring, response, and management activities for the species.

DFO, in close collaboration with subject matter experts from GLFC and OMNRF completed a binational socio-economic risk assessment for Grass Carp in 2018 as a companion piece to the binational ecological risk assessment for Grass Carp released in January 2017. The study estimates the impact on the Great Lakes commercial and recreational fishing industry from Grass Carp. The results of the study will be used to set priorities for prevention and mitigation and help regulatory initiatives for Grass Carp in the Great Lakes basin.

Domestic Actions and Achievements (United States)

USFWS, USACE, and USGS previously identified and evaluated the potential risk of the inadvertent entrainment and transport of small fish by barges transiting upstream in the Chicago Area Waterway System and Upper Illinois Waterway. Additional studies were conducted to assess the susceptibility of actual small (juvenile) Asian carp to become entrained and transported upstream, including through lockages, under realistic conditions. Additional work was conducted in 2018 to determine the movement of small Asian carp (less than six inches) in the wild and their interactions with barges, including entrainment. Future evaluations will assess potential methods and technologies to clear entrained small fish from barge-to-barge junction spaces.

The Ecological Risk Screening Summary (ERSS), developed and deployed by USFWS, is being used to assess the invasiveness of imported, nonnative species. To date, approximately 950 risk assessments have been conducted by the United States and are published on www.fws.gov. These risk assessments have identified global high-risk aquatic species that thrive in climates similar to the Great Lakes basin and could become

established if they are introduced in large enough numbers. USFWS and agency partners are working to improve the utility of results generated from ERSS reports to identify select target species and subsequently optimize and target field sampling for those species in highest-risk locations. For example, bloody red shrimp had been previously identified through ERSS reports and included on Great Lakes states' AIS "Watch Lists". Subsequent AIS sampling informed by the screening process and conducted by USFWS in Lake Superior (St. Louis River) led to the detection of bloody red shrimp in May 2017, the first finding of this species within the lake basin. The Great Lakes AIS Risk Assessment Team has spearheaded large-scale implementation of the tool for use within the basin, including development of a standard protocol for use. The approach has directly informed policy decisions and legislation for prohibiting species at both state and national levels.

Building on the binational risk assessments for the Asian carp species, new modelling has been done to improve predictions of their potential impacts on ecosystems. NOAA conducted ecological modelling to assess the possible impacts of Bighead, Silver, Black, and Grass carp introductions on Great Lakes food webs and fisheries. Their work incorporated several different modeling approaches for analyses of Lake Michigan, Lake Huron (Saginaw Bay and main lake basin), Lake Erie and Lake Ontario. A specific application of the modelling effort was to simulate the effects of Bighead carp and Silver carp on the nearshore aquatic communities of Lake Huron, Lake Erie and Michigan. Ecological modeling has demonstrated the potential magnitude and duration of impacts that could occur in the event of an Asian carp introduction into the Great Lakes and predicted impacts on individual native fish species.

Domestic Actions and Achievements (Canada)

OMNRF's Guidance for Invasive Species Assessments under the Invasive Species Act, 2015 released in 2016, describes the science-based process that Ontario is using to assess the risk that species pose to Ontario's natural environment, society and economy for regulatory consideration under the Act.

In 2017, OMNRF developed and tested a science-based ecological risk assessment tool for aquatic invasive

species in Ontario with input and peer review by DFO and academic experts. The tool provides a standardized means of evaluating the likelihood of invasion and adverse impacts for invasive species of concern for the province and is designed to minimize subjective bias and incorporate uncertainty in risk assessments. OMNRF has completed 26 risk assessments for non-native fishes, aquatic invertebrates and plants to support regulatory consideration of species under the Invasive Species Act, 2015.

2017 to 2019 Other Actions: Programs to prevent the introduction of AIS by developing regulations or management strategies.

State and provincial fisheries management agencies on the Lake Erie Committee (Ohio, Michigan, Pennsylvania, New York, and Ontario) are using a collaborative, science-based process to support strategic interagency grass carp detection and control efforts. In 2016, Michigan DNR, collaborating with state, federal, and university partners, initiated development of an Adaptive Management Framework for Grass Carp Control in Lake Erie to inform the identification, prioritization, selection, and sequencing of key strategic actions. Lake Erie management and research agencies are now utilizing this structured decision making model to serve as a baseline process to inform development of new actions. This work is being done under the auspices of the Council of Great Lakes Fishery Agencies Invasive Fishes Committee, in support of the Joint Strategic Plan for Management of Great Lakes Fisheries. In March 2019, ODNR finalized the Lake Erie Grass Carp Response Strategy (2019 – 2023), focused on controlling the expansion of Grass Carp from the western basin of Lake Erie. The strategy includes measures to detect and remove Grass Carp in priority locations, including the Sandusky River and Maumee River; and key research to better inform agencies on grass carp life history, movement, and habitat use within the Lake Erie basin.

The Asian Carp Regional Coordinating Committee, with United States federal and state agencies and Canadian participants continues to refine and update its Action Plan. The 2018 edition of the Asian Carp Action Plan is available at www.asiancarp.us.

Domestic Actions and Achievements (United States)

To protect the Great Lakes from continued invasions, the USFWS Service identified 11 (10 fish and one crayfish species) non-native freshwater organisms as injurious species under the Lacey Act through a final rule published in 2016. Based on analyses of their potential for introduction into the basin and the species' history of invasiveness, the identification of these species makes them subject to regulation under the Lacey Act. None of the listed species are currently found within the Great Lakes basin. They include the Crucian Carp, Eurasian Minnow, Prussian Carp, Roach, Stone Moroko, Nile Perch, Amur Sleeper, European Perch, Zander, Wels Catfish; and the common yabby (a crayfish).

Domestic Actions and Achievements (Canada)

Beginning in April 2019, DFO allocated new staff and resources within its Conservation and Protections branch to provide more on the ground enforcement of the federal Aquatic Invasive Species Regulations in the Great Lakes. The national AIS regulations, which came into effect in 2015, prohibit the import, transport, possession, sale, and control of high-risk AIS. These regulations complement provincial regulations and strengthen Canada's collaborative ability, along with the United States, to protect the Canadian waters of the Great Lakes from AIS, including Asian carps.

DFO continues to gather data on current live trade of Asian carps through a joint project ("Single Window Initiative") between DFO and the Canada Border Services Agency. This information will be used to provide support to enforcement agencies in both Canada and the United States to prevent movement of live Asian carps through trade, and potential introduction into the Great Lakes.

On November 3, 2016, Ontario's Invasive Species Act, 2015 came into force. The Act is Canada's first stand-

The Government of Canada's Auditor General undertook an extensive audit of DFO's National AIS Program in April 2019 ([Report 1 – Aquatic Invasive Species](#)) noting that DFO had "taken significant action to prevent Asian carp species from becoming established in the Great Lakes".

alone invasive species legislation and provides an enabling legislative framework to regulate invasive species that threaten Ontario's natural environment, to prevent their introduction and spread and to support early detection, response, and eradication efforts. The first suite of regulations under the Invasive Species Act (Ontario Regulation 354/16), included the regulation of the Great Lakes and St. Lawrence Governors and Premiers' Least Wanted List (16 species) as prohibited invasive species. Four additional species were classified as restricted invasive species including Phragmites. These regulations are supporting binational efforts to prevent the invasion of these high-risk species within the Great Lakes basin.

2017 to 2019 Other Actions: Programs to prevent the introduction of AIS by undertaking education and outreach efforts.

United States and Canadian agencies and their partners continue to maintain web-based outreach platforms focused on Asian carps and other key AIS. On behalf of the participating agencies in the ACRCC, USFWS administers the www.asiancarp.us website, which is the primary interface with the public and a component of the ACRCC's overall communications strategy. In 2018, the website was revised and re-launched, making it mobile device friendly, easier to navigate, and compliant with Section 508 of the United States Workforce Rehabilitation Act (1973). New content included emerging topics related to Asian carps, such as grass carp and black carp issues, and federal and state actions in the Upper Mississippi River and Ohio River basins.

Outreach work in both countries connected citizens with opportunities to learn about what they can do to prevent new invaders. The GLP Information/Education Committee continued its work as a forum for outreach leaders in government and non-government organizations in both countries to share resources and best practices. Blue Accounting, initiated by Great Lakes governors and led by the Great Lakes

AsianCarp.us and AsianCarp.ca provide Great Lakes stakeholders and decisionmakers with:

- Breaking News/Emerging Issues
- Asian Carp Strategies and Plans
- Overview of the Threat
- Guidance on How to Help
- Images, Videos and Other Outreach Materials

Commission, has developed an issue focus on AIS, which is available at www.blueaccounting.org, that provides additional opportunity to communicate to and engaging with publics on the progress being made to address AIS across the region. NOAA's Sea Grant programs in the Great Lakes States continued strategic efforts to inform resource users and other stakeholders on opportunities to prevent accidental AIS transport, introduction and establishment, including best-practices and AIS species identification.

Domestic Actions and Achievements (Canada)

DFO and OMNRF continue to support the Invasive Species Centre (ISC). With DFO, the ISC, is continuing to advance the www.asiancarp.ca website as a central repository for public and agency information about Asian carps. They have developed new webinar content on a range of topics from incident command to binational cooperation.

The Invasive Species Centre hosted public information sessions, webinars, and a partnership meeting with other Asian carp Canada partners, and ran social media campaigns.

With coordinated input from DFO and OMNRF, and leadership from the Invasive Species Centre, a new Asian Carp Exhibit at the Toronto Zoo opened in February 2018, which offers a focal point for public awareness in Southern Ontario.

The ISC is also coordinating surveys to understand public awareness to better target outreach.

The [Invasive Species Centre \(ISC\)](#) in Sault Ste. Marie is a Canadian non-profit organization that builds partnerships and supports collaborative projects in natural and applied science, policy research, outreach and education to protect Canada's forests and waterways from the effects of invasive species. The ISC serves as a clearinghouse for authoritative information on invasive species and brings stakeholders together to help coordinate investments in research in early detection methods, implementation of response actions to new invasive species, support into control and management actions, and capacity building within all levels of government, industry sectors and the environmental community.

DFO and OMNRF have advanced community engagement through continued strong partnerships with the OFAH, Invasive Species Centre, the Ontario Invasive Plant Council, the Federation of Ontario Cottagers' Associations, and the Ontario Commercial Fisheries Association, to raise public awareness of invasive species, and to engage citizens in prevention measures.

DFO has undertaken a variety of outreach activities to prevent the introduction and establishment of Asian carps in Canadian waters. In 2018, Fisheries and Oceans Canada created a mobile application version of its updated "The Baitfish Primer" that includes a new dichotomous key baitfish identification feature to help ensure Asian carps and other invasive fish are not part of this pathway. They have participated in community events, Indigenous community Pow Wows, provided, with the Invasive Species Centre and OFAH, Asian carps public information sessions. Working with their partners, DFO is developing new film and web-based communication tools to inform the public.

OMNRF's InvasionON campaign, launched in 2015, continues to grow in success with more than 3.5 million impressions in 2016 and more than 10 million impressions in 2017. InvasionON is an integrated digital marketing campaign to educate and empower Ontarians with action plans and resources to combat and prevent the spread of invasive species. The campaign targets outdoor hobbyists: anglers, hunters, boaters, hikers, campers, cottagers and gardeners.

2017 to 2019 Priority for Science: Determine feasibility and effectiveness of AIS eradication and containment methods to inform rapid response decision making.

2017 to 2019 Priority for Science: Research and develop technologies and methods for control and eradication of AIS.

The binational ACRCC continued to provide a forum for coordination of new research about how to control or contain Asian carps in order to help ensure that science being undertaken in the United States and in Canada is complementary and synergistic.

Lake Erie fishery management agencies and university partners are utilizing a structured decision making model to inform strategic implementation of key

detection and control actions to address grass carp populations in the lake's western basin.

Species-focused collaboratives are coordinating and conducting research focused on detection, response, management and control of priority species. Collaboratives have been established to address the threats to the ecosystem from invasive plants and algae, including Phragmites, Hydrilla, Starry Stonewort, as well as other crayfish and mussel species:

- The [Great Lakes Phragmites Collaborative](#) (GLPC) is an initiative to connect people, information and action on invasive Phragmites management and is coordinated jointly by the GLC and USGS. The GLPC facilitates information-sharing and development of partnerships among private landowners, lake associations, road commissions, state and federal agencies, conservation organizations, and researchers. Resources are centralized through an information hub (www.greatlakesphragmites.net), and the Collaborative maintains communication across the Phragmites community through a webinar series, listerv, and newsletter. With the support of partners and an Advisory Committee, the Collaborative is developing tools, guidance materials and science-based best management practices for invasive Phragmites.
- The [Great Lakes Hydrilla Collaborative](#) conducted control efforts after discovery of the invasive aquatic plant, Hydrilla (*Hydrilla verticillata*), in the Cayuga Lake Inlet and Erie Canal in New York State. Aggressive eradication projects were started at both of these locations in response to concerns about the spread of this invasive plant species throughout the Great Lakes basin. Both projects have dramatically reduced the presence of Hydrilla, however, a second infestation was identified on Cayuga Lake near Aurora, New York. Members of the Hydrilla Collaborative were able to respond to the new infestation on Cayuga Lake in 2017 using methods that were refined at existing sites, offering an opportunity to prevent further spread.
- Development of the [Invasive Crayfish Collaborative](#) was led by Illinois-Indiana Sea Grant, and includes stakeholders and experts from government agencies, universities, non-profit organizations, and private businesses to address priority invasive crayfish research and outreach opportunities.

- The [Invasive Mussel Collaborative](#), coordinated by the GLC, USGS, GLFC and NOAA, with additional United States and Canadian agency, non-government, and academic participation, is leading efforts to coordinate science and management around the potential of open-water control techniques for zebra and quagga mussels. Available and emerging control methods, including the commercial product “Zequanox” and other potential tools, are being researched and tested by agencies and others for their feasibility and effectiveness for use within a management strategy. As an example of this work, the USGS and partners have undertaken work to extensively evaluate Zequanox use in open water systems, as well as to expand the non-target animal impacts database. Recent research has also been conducted to evaluate Zequanox avoidance by freshwater fish. This research will provide potential real-world exposure patterns during open water applications. Other control methods are also being evaluated and implemented in the United States and Canada. The Collaborative was established as a forum to share lessons learned from these activities, and to align and set priorities for future research and management activities to advance effective and beneficial management approaches. The Collaborative released a strategy identifying these priorities in November 2018.

Domestic Actions and Achievements (United States)

Partner agencies in the United States are implementing and evaluating new methods and tools to respond to and remove Asian carps as part of broader control strategies. Ongoing efforts include the design, construction, and use of new sampling and collection gear (newly designed or adapted commercial fishing gear, electrified nets, etc.); and adapted mass harvest methods used by traditional fishers for Asian carps in China (e.g., Unified Fishing Method). Evaluations of the efficacy of these gears and techniques and impacts on populations are being conducted as a regular component of field implementation for Asian carp removal in the Illinois River and other locations.

The USFWS, in partnership with the Asian Carp Regional Coordinating Committee, is further developing and refining a fishery population model, known as SEACARP,

for use as a tool for guiding and maximizing fishing effort focused on harvesting and reducing numbers of adult Asian carps in the Illinois River. The model is being used to optimize the location and timing of directed large-scale harvest efforts on the water as a means of control and risk reduction in support of a comprehensive management approach. In addition to quantifying the population level effects from mass removal, the model also incorporates long-term Asian carp population impacts attained from the deployment of barriers to fish movement (e.g., complex sound, carbon dioxide) at strategic “choke points” in the river system.

USGS Upper Mississippi Environmental Science Center conducted research and testing for the development of a system to selectively deliver a pesticide (Antimycin) that can kill bighead and silver carps while not harming other fishes. This technology could potentially be used within a comprehensive management approach to strategically reduce populations of Asian carps when newly detected in select waterbodies before they become fully established.

USGS Great Lakes Science Center has initiated greenhouse and field testing of novel control treatments for the non-native Phragmites (*Phragmites australis* – common reed). These new approaches are based on the close relationship between microorganisms (bacteria, fungi) and their host plants and can be modified to target other plants.

Significant advances were made in evaluating the potential use of carbon dioxide as both a lethal control and non-lethal barrier to the movement of aquatic invasive species under laboratory and field settings. USGS, in collaboration with MDNR, completed field trials using carbon dioxide for invasive crayfish (red swamp crayfish) control at newly infested water retention ponds in southeast Michigan in 2018. Additional laboratory experiments conducted in 2018 demonstrated the effectiveness of carbon dioxide as a dreissenid mussel (zebra mussel) lethal control strategy. Field trials are planned for 2019 at a lock near Kaukauna, Wisconsin, to better determine the feasibility and costs of an operational carbon dioxide deterrent system for Asian carp containment at Great Lakes basin navigational structures.

Domestic Actions and Achievements (Canada)

DFO is supporting research about how to contain Asian carps to prevent establishment and spread. New science by the University of Toronto is building on previous laboratory research investigating avoidance responses of Common Carp, a surrogate species, to acoustic, strobe-light and carbon dioxide stimuli. Field and laboratory testing in collaboration with the Royal Botanical Gardens is investigating the efficacy of acoustic and strobe-light barriers in preventing the movement of surrogate species into wetland areas. OMNRF with conservation groups such as Nature Conservancy Canada and Ducks Unlimited Canada, are implementing a large-scale wetland restoration pilot within the coastal wetlands of Rondeau Provincial Park and the Long Point region in southwestern Ontario. This has involved an emergency registration of an overwater herbicide for the control of Phragmites from Health Canada’s Pest Management Regulatory Agency. The use of this herbicide is considered integral to efforts to restore these globally significant wetlands and recover critical habitats for species at risk threatened with extirpation by the invasion of Phragmites. The pilot project included an extensive environmental survey led by the University of Waterloo, to assess the efficacy of the control program, and its effects on the environment. Preliminary results have been extremely promising and early signs of ecosystem restoration from Phragmites are being observed. From its beginning in 2016, the project has been a success on many fronts, including unprecedented support from the public, environmental and recreational stakeholder groups.

Through programs like the OMNRF’s Land Stewardship and Habitat Restoration Program, and OMECP’s Great Lakes Guardian program, Ontario has supported community groups and municipalities to undertake a variety of initiatives to control and manage invasive species such as Phragmites within Great Lakes wetlands.

An example of such community efforts is the extensive work of Georgian Bay Forever, Georgian Bay Forever, a non-profit focused on the health of the aquatic ecosystem. Georgian Bay Forever has coordinated best practice Phragmites control efforts by training and sharing information with over 30 communities and partners over the last six years removing tonnes of this

invasive plant from Georgian Bay shorelines.

OMNRF is also supporting investigation of new biological control tools for Phragmites and other invasive plants in Canada, which is being led by Agriculture and Agri-food Canada AFC, and the University of Toronto. While this work is still in a research phase, it is hoped that a control agent will be identified in the near future.

OMNRF with university collaborators are carrying out research to determine the efficacy of decontamination measures for recreational and agency equipment. The project is investigating the efficacy of the “clean, drain, dry” methods that OMNRF and its partners use in public outreach materials to help prevent the spread of AIS in Ontario. The results will support a “good, better, best” approach to decontamination protocols, identifying the actions, if taken, that will result in the greatest reduction of the risk of spreading AIS on contaminated boating and other agency equipment. The results will also support further analysis of the relative risk of the recreational boating pathway.

DFO supports Transport Canada and Discharges from Vessels Annex, with science about the effectiveness of techniques to support implementation of the International Convention for the Control and Management of Ships’ Ballast Water and Sediments, which entered into force on September 8, 2017. The DFO ballast water science includes tools for monitoring, effectiveness of treatment systems, and predicting risks.



Barkley Lock, site of Asian carp sound deterrent pilot project starting in 2019. Credit: ACRCC.

2017 to 2019 Priority for Science: Develop technology and methods to achieve effective barriers that prevent the spread of AIS while allowing the movement of other ecosystem components through canals and waterways.

A new multi-agency, binational project to study the effectiveness of barrier systems has been developed by the GLFC. FishPass is a novel, instream research facility that is a collaboration between United States federal, state, local, and tribal interests and which also involved Canadian federal and provincial participants (www.glfcc.org/fishpass.php). The facility, planned for the Boardman River, in Traverse City, Michigan, brings together scientists and engineers from both countries to research how best to block invasive species, like the Sea Lamprey, while allowing native fishes to pass.

Domestic Actions and Achievements (United States)

United States federal and state ACRCC partner agencies have identified and advanced the development of potential new fish deterrent technologies for use within comprehensive Asian carp management strategies. Building on preliminary laboratory studies, the effectiveness of underwater sound and carbon dioxide to serve as barriers to Asian carp movement is being rigorously evaluated under real-world scenarios (e.g., deployment in river, lock and dam systems occupied by Asian carps with active commercial navigation) in large-scale pilot studies starting in 2019. Initial laboratory and pond trials have demonstrated that Asian carps strongly avoid both underwater carbon dioxide and sound, and has the potential to prevent upstream fish migration into new uncolonized waters. Impacts to local populations of non-target native species can be minimized, if deployed in strategic “pinch points” (e.g., lock chambers, confined channels or confluences). The ACRCC is collaborating closely with partner agencies in the Ohio River (Kentucky) and Fox River (Wisconsin) watersheds on the pilot deterrent studies. Results will inform prevention and control strategies focused on protection of the Great Lakes and other watersheds.

The State of Michigan convened the first-ever Great Lakes Invasive Carp Challenge, a contest open to all parties that invited innovative new solutions to address the threat of Asian carp introduction and establishment. A total of 353 proposals from 27 countries were

submitted under the Challenge. In March 2018, a panel of representatives (including Governor Rick Snyder) judged the four finalists and awarded prize funding to support advancement of the projects. Projects included research and development of a cavitation barrier to deter Asian carps, evaluation of a potential AIS lock treatment system, evaluation of potential physical velocity barriers designed to concentrate water flow to prevent AIS migration, and development of an automated imaging and sorting system to divert invasive carp for removal in select locations.

Domestic Actions and Achievements (Canada)

DFO is building on research carried out on how fish move through the Welland Canal system between Lake Erie and Ontario to better understand the potential to block spread of Asian carps and other AIS between these lakes. The Niagara River is a route for fish to flow downstream from Lake Erie. To tackle the question of how many fish move downstream over Niagara Falls, the University of Toronto is using state-of-the-art genomic techniques to see if populations of native fish are connected genetically suggesting movement downstream.

2017 to 2019 Other Actions: Programs to prevent the introduction of AIS by establishing effective barriers to prevent the spread of AIS.

Domestic Actions and Achievements (United States)

Significant actions have been undertaken to reduce risks posed from hydrologic pathways allowing for the potential movement of AIS between the Great Lakes and Mississippi River basins. The Great Lakes and Mississippi River Interbasin Study (GLMRIS) identified 18 Secondary Pathways where temporary connections are formed between the watersheds during flooding events, providing a potential corridor for AIS movement. State, federal and non-governmental partners have completed or are initiating large-scale projects to mitigate the threat of introduction at three of the highest-priority Secondary Pathways. Actions include construction in 2016 of an earthen berm, fencing, and other structures to prevent the upstream

movement of Asian carps toward the Lake Erie basin at Eagle Marsh (Indiana); engineering, pre-planning, and award of a contract for construction for work focused on separation of the Great Lakes and Ohio River basins at the Ohio-Erie Canal; and preliminary design, scoping and coordination with local landowners to address connectivity at Little Killbuck Creek (Ohio). These three sites were more highly ranked (higher risk) among all identified Secondary Pathways.

The Upper Illinois Waterway and Chicago Area Waterway System is identified in GLMRIS as the highest-risk pathway for the potential introduction of AIS into the Great Lakes from the Mississippi River basin. The USACE continued actions to scope and design a new state-of-the-art lock structure at the Brandon Road Lock and Dam near Joliet, Illinois. Based in part on regional hydrology and existing navigation infrastructure, the GLMRIS report identified the Brandon Road site as the most strategic location for implementation of structural and other measures to prevent the migration of Asian carps upstream toward Lake Michigan. USACE previously evaluated six alternative designs and subsequently selected the “Technology Option” as the Tentatively Selected Plan to develop into a final USACE Chief’s Report in 2019. The [Brandon Road Tentatively Selected Plan](#) proposes a suite of structural components, including an engineered channel, electric fish dispersal barriers, underwater sound deterrents, flushing lock system, and other deterrents, with the potential to add in new prevention technologies, as they become available. The Tentatively Selected Plan also includes the implementation of supporting non-structural components such as upstream harvest and removal of Asian carps to reduce likelihood of downstream passage, fishery monitoring (electrofishing, netting, hydroacoustics, and telemetry), and stakeholder education and outreach.

Domestic Actions and Achievements (Canada)

Canada made significant new investments in infrastructure to restore and construct barriers to aquatic invasive species with a focus on Sea Lamprey. A highlight of these investments is the restoration of the Denny’s Dam on the Saugeen River, a long-standing and critical project to protect that river from infestation by Sea Lampreys and other potential invasive species.

A close collaboration between the Saugeen Ojibwa Nation, the Province of Ontario, DFO, and the GLFC brought this project to its completion during 2018.

2017 to 2019 Priority for Science: Develop and evaluate early AIS detection technologies and methods.

An inter-governmental environmental DNA (eDNA) working group is coordinating and sharing eDNA markers, tools, and techniques to advance the use of these detection tools. As an example, OMNRF researchers are testing eDNA detection of species assemblages using community metabarcoding from water samples, testing published markers from several mitochondrial coding regions. The results of this work have been shared with DFO, USFWS and other United States agencies through the working group.

Domestic Actions and Achievements (United States)

New molecular genetic techniques are being developed for detecting rare invasive species. Current research efforts funded by the Great Lakes Restoration Initiative have focused on: (1) expanding the use of environmental DNA; (2) genetic analyses of larval fish samples to detect the reproduction of invasive fishes; and (3) genetic analyses of lake sediments or benthos for detection of invasive species such as the zebra mussel, quagga mussel, and New Zealand mudsnail. The current trend of advancing molecular genetic methods coupled with decreasing costs is highly promising.

Domestic Actions and Achievements (Canada)

New research into how to sample early life stages of AIS is underway. Early life stages of AIS are more numerous and broadly dispersed in the environment than adults – making them ideal targets for early detection – yet precisely identifying fish eggs and larvae is often impossible. To address this, DFO funded research at the University of Toronto is developing new genomic ‘barcode’ methods to analyze mixed species samples of fish eggs and larvae to identify if they include invasive species.

DFO is supporting research to refine predictions from the binational risk assessments about which streams

will support spawning of Asian carp species in Ontario. Assessments of the detailed suitability of flow rates and temperatures are being gathered and analyzed. Additionally, DFO supported research is applying models developed by the USGS about how eggs from spawning events would move to Canadian rivers. By understanding water movement under the variable river flows during which Asian carps are known to spawn, sampling for eggs can be targeted with more accuracy.

Since 2013, OMNRF has been conducting research into methods development, validation, and science transfer of environmental DNA testing (eDNA) for early detection of aquatic invasive species. Their research efforts include expanding the set of genetic tools available for early detection of aquatic invasive species by developing new eDNA markers to detect watchlist “least wanted” species of management concern. Markers were developed and eDNA surveillance for Tench has been carried out in Lake St. Francis in the summer of 2018, and in the Bay of Quinte in 2018 in response to the capture individuals of this new potential invader.

2017 to 2019 Priority for Science: Determine the effects of habitat and climate change on risks of AIS establishment and distribution in the Great Lakes, connecting channels, and tributaries.

U.S. and Canadian agency partners have developed and are utilizing climate change projection tools to assess invasive species risk of establishment in the Great Lakes basin, including connecting channels and tributaries. The models incorporate known climate data to predict potential invasive species survival in the Great Lakes, and utilize predicted Intergovernmental Panel on Climate Change (IPCC) future scenarios for forecasting future risk of species establishment.

Domestic Actions and Achievements (United States)

The USFWS continued to implement the Ecological Risk Screening Summary (ERSS) tool (see Programs to prevent the introduction of AIS by conducting proactive, coordinated, risk assessments of pathways and species) by incorporating international databases, scientific literature, and a climate model. The climate model matches the basic climate requirements

(temperature and precipitation) of a species in its native and known invasive ranges with similar climates in the United States to assess risk of establishment. The result provides an approximate geographic range in the United States where the climate is similar to where the species survives elsewhere; this is referred to as the species' "climate match." USFWS has developed and peer reviewed a climate-matching program called the Risk Assessment Mapping Program to conduct these climate matches for the Great Lakes basin and for future climate scenarios.

RAMP is also used to obtain a quantitative measure of climate match that serves as input to the Freshwater Fish Injurious Species Risk Assessment Model (FISRAM). More information and standard operating procedures for both ERSS and FISRAM tools are available at https://www.fws.gov/fisheries/ans/species_erss.html and https://www.fws.gov/fisheries/ans/erss_supporting_documents.html.

NOAA and University of Michigan scientists are simulating the effects of climate change on potential habitat, distribution and growth of bighead and silver carp in Lake Michigan. Preliminary results suggest climate warming will increase habitat suitability of bighead carp in Lake Michigan compared to current climate conditions.

Domestic Actions and Achievements (Canada)

OMNRF, in collaboration with DFO, is undertaking a comprehensive risk assessment of the cumulative effects of climate change, human movement, and water connectivity and the spread of aquatic invasive species. This project is building on past risk assessments and models to develop a decision support tool (model) to identify areas within the Great Lakes and province of Ontario where the risk of AIS is greatest. The framework incorporates climate change scenarios, coupled with projected changes in human distribution and pathways for dispersal of AIS to understand how risk may change in the future. The framework will consider invasive fish, invertebrates and plants to provide maximum flexibility in predicting species and pathway risk. Once complete, the tool will enable managers and researchers to identify AIS pathways (e.g., aquarium trade, angling, commercial navigation, etc.) and geographic areas

(projected at a 10 kilometer by 10 kilometer grid for the entire province and Great Lakes waters) where risk of AIS establishment and impact is likely to be greatest under different climate and human population growth scenarios.



Habitat and Species Annex

Overview

The Great Lakes basin is a vast freshwater system consisting of a wide range of habitats, including forests, uplands, streams, beaches, sand dunes and coastal wetlands. The 2012 Canada-United States Great Lakes Water Quality Agreement (Agreement) commits the two countries to restore and conserve Great Lakes habitat and species that support Great Lakes water quality. The Great Lakes basin is home to a great wealth of biodiversity including many globally rare and endangered species. This ecological diversity is an important resource to the region providing valuable ecosystem services (e.g., safe drinking water, fish, wildlife and recreational opportunities) that contribute to the well-being of Great Lakes basin residents.

Canada and the United States are working to conserve, protect, maintain, restore and enhance the resilience of native species and their habitat, as well as supporting essential ecosystem services in the basin.

Annex Implementation

This Annex's achievements were supported by the Habitat and Species Annex Subcommittee, co-led by Environment and Climate Change Canada (ECCC) and the United States Fish and Wildlife Service (USFWS); with members from ECCC, Fisheries and Oceans Canada (DFO), Parks Canada (PC), Ontario Ministry of Natural Resources and Forestry (OMNRF), Chiefs of Ontario (COO), United States Army Corps of Engineers (USACE), United States Environmental Protection Agency (USEPA), United States Fish and Wildlife Service (USFWS), United States Geological Survey (USGS), United States National Oceanic and Atmospheric Administration (NOAA), United States National Park Service (USNPS), Indiana Department of Environmental Management (IDEM), Michigan Department of Natural

Resources (MDNR), New York State Department of Environmental Conservation (NYSDEC), Wisconsin Department of Natural Resources (WDNR). An Extended Subcommittee involves additional non-governmental organizations and experts beyond the GLEC membership.

Key Achievements

2017:

- Canada and the United States agreed to use domestic approaches to meet the provisions of the binational Nearshore Framework Assessment. Canada completed a nearshore assessment of the Canadian shoreline of Lake Erie and the Huron-Erie Corridor which informs the baseline survey of existing habitat.
- Through the [Great Lakes Coastal Wetlands Monitoring Program](#), federal, state and academic partners on both sides of the Great Lakes initiated a second five-year cycle of binational coastal wetland monitoring to provide baseline condition information.

2018:

- Canada launched an assessment of coastal wetland vulnerability to climate change impacts, development of adaptive measures, and tools to enhance wetland resilience.

2019:

- Ontario continued classification, mapping, and tracking of coastal habitats along Canadian shorelines of Lakes Erie, Ontario and southern Huron to establish foundational knowledge of characteristics and health.

Binational Actions and Achievements

2017 to 2019 Priority for Science: Pilot application and testing of the Baseline Habitat Survey on a regional scale in order to refine the approach to measure Net Habitat Gain and guide implementation at a Great Lakes wide scale.

During the last three-year cycle, Canada and the United States agreed that nearshore baseline habitat surveys will be conducted using domestic approaches to meet the provisions of the binational Nearshore Framework Assessment.

Domestic baseline habitat survey efforts

In 2017, Canada piloted a regional scale nearshore assessment of eastern Lake Erie and subsequently completed an assessment for the Canadian shoreline of Lake Erie and the Huron-Erie Corridor. This nearshore condition assessment is being expanded to the other Canadian Great Lakes nearshore areas and informs the baseline survey of existing habitat.

In the United States, existing domestic programs are used to assess nearshore aquatic habitat and the Great Lakes Restoration Initiative has further enhanced the restoration and assessment of habitats and native species.

Additional information in the Lakewide Management Annex chapter.

2017 to 2019 Priority for Science: Support continued implementation of the binational Great Lakes Coastal Wetlands Monitoring Program and integrate data into the development of the Baseline Habitat Survey for coastal wetland systems.

The [Great Lakes Coastal Wetlands Monitoring Program](#) is a collaboration of federal agencies, states, and academic partners in both the United States and Canadian sides of the Great Lakes. This basin-wide, collaborative approach allows for significant coastal wetlands throughout the entire Great Lakes to be sampled on a rotating basis over five years using a comprehensive, standardized procedure. Under this program the monitoring of coastal wetland habitat,

biota and water quality continued in Canada and the United States for a second five-year cycle. 192 wetlands were surveyed in 2016 and an additional 209 wetlands surveyed in 2017. With most of the medium-to-large wetlands sampled, data is now available to establish a baseline of information to detect trends in wetland conditions. Wetland information is also integrated into the development of a Canadian nearshore baseline habitat survey and climate change vulnerability assessment. An enhanced Coastal Wetlands Monitoring Program website provides an updated version of the [Great Lakes Coastal Wetland Monitoring Program Site Mapping Tool](#) and allows users to interact with a variety of information relevant to coastal wetland conservation and management. These efforts contribute to the understanding of local conditions and areas to prioritize conservation.

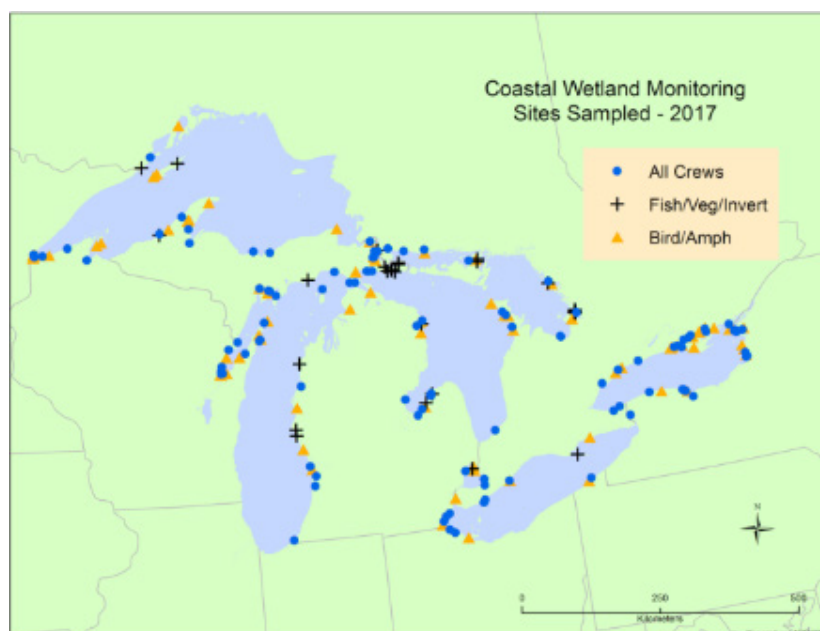
Related domestic wetland efforts

In Canada, other wetland monitoring including efforts to sample Georgian Bay coastal wetlands have been ongoing for 20 years by McMaster University with the help of local residents and funding from foundations and government agencies.

2017 to 2019 Priority for Action: Complete a review of gaps and priorities identified by existing Great Lakes habitat and species conservation strategies and strategic plans and develop a binational framework for prioritizing activities to conserve, protect, maintain, restore and enhance native species and habitat on a Great Lakes wide scale.

Domestic Actions and Achievements

Federal, state and provincial agencies, Tribes, First Nations, Métis, regional and local conservation entities, non-governmental organizations, and other conservation partners continue to plan and implement a variety of projects to protect, restore and enhance fish and wildlife and their habitats under their own authorities and funding mechanisms. Other projects have been implemented through the Lakewide Action and Management Plans and biodiversity conservation strategies (Lakewide Management Annex), as well as



Locations of the 209 Great Lakes coastal wetlands sampled in 2017, color-coded by taxonomic groups. Taken from Figure 3 of the [Great Lakes Coastal Wetland Monitoring Program, Semiannual Progress Report, April 1, 2017 – September 30, 2017](#). Credit. USEPA.

in areas of the Great Lakes basin where habitat and species populations have been degraded by human activities at a local level (Areas of Concern Annex). These achievements can be found in other sections of this report and represent a direct benefit to the Habitat and Species Annex. In Canada, ECCC's Great Lakes Protection Initiative was established in 2017 to address the most significant environmental challenges affecting Great Lakes water quality and ecosystem health, which also directly benefits the Habitat and Species Annex. In the United States, in addition to domestic activities conducted by government agencies and others, the

Great Lakes Restoration Initiative established in 2010, has continued to address high priority needs for native fish, wildlife and habitat in the Great Lakes. While not an exhaustive list, a few examples of implementation actions that have occurred during this reporting period are summarized below.

Domestic Actions and Achievements (Canada)

The Canadian federal government continues to administer programs to address the protection and recovery of habitat and species at risk, as well as support others in taking action, which are outlined below.

Related domestic efforts

Through the Great Lakes Protection Initiative, Canada is taking action to restore and protect Great Lakes water quality and ecosystem health, including by assessing and enhancing the resilience of Great Lakes Coastal wetlands as well as evaluating and identifying at risk nearshore waters.

In the United States, Great Lakes Restoration Initiative prioritizations are ongoing under the Habitat and Species Focus Area to protect, restore and enhance habitats to help sustain healthy populations of native species and to maintain, restore and enhance populations of native species.

The Canada Nature Fund

To support Canada's biodiversity and protect species at risk, the Government of Canada made one of the most significant investments in nature conservation in Canadian history, totalling \$1.3 billion over five years to protect Canada's nature, parks, and wild spaces. This investment includes \$500 million from the federal government to create a new \$1 billion [Canada Nature Fund](#) in partnership with corporate, not-for-profit, provincial, territorial and other partners.

In collaboration with partners, the Canada Nature Fund makes it possible to secure private land, support provincial and territorial species protection efforts, and help build Indigenous capacity to conserve land and species, for our benefit and the benefit of future generations. The Fund will support Canada's work towards its 2020 Biodiversity conservation target of protecting 17 percent of Canada's lands and in-land waters.

Through the support of the Nature Fund, the Government of Canada officially took ownership of the Driftwood Cove property near Tobermory, Ontario, in 2018. The land acquisition grew the size of Bruce Peninsula National Park by 3,272 acres, bringing the park to 90 percent complete. The property includes 6.5 kilometers of uninterrupted Georgian Bay shoreline, home to a globally rare ancient cliff-edge ecosystem and 10 federally listed species at risk. The Bruce Trail Conservancy also provided significant funding to support the preservation of Driftwood Cove.

ECCC also supports organizations that conserve, protect and preserve biodiversity and build networks of protected areas. With support from Canada's Natural Areas Conservation Program and numerous binational partners, the Nature Conservancy of Canada secured a 1,018 hectare property on Big Trout Bay on the north shore of Lake Superior in 2016. The property protects 21 kilometers of undeveloped shoreline and ensures it will remain one of the last undeveloped stretches of shoreline between Duluth, Minnesota, and Thunder Bay, Ontario. In 2018, a new 3,170 hectare protected



Black Bay, Lake Superior, Ontario. Credit: Coastal Productions.

area in Black Bay on the north shore of Lake Superior was secured, protecting an additional 1,300 hectares of coastal wetlands, 1,900 of coastal forest as well as many native species, including rare and at-risk species. An additional 93 hectares and 2.5 kilometers of undeveloped Lake Ontario shoreline and intact coastal wetland have been protected near Brighton, Ontario.

ECCC's Great Lakes Protection Initiative – Through the Great Lakes Protection Initiative, ECCC is addressing priorities that will directly benefit Great Lakes habitats and species, such as enhancing the resilience of coastal wetlands; evaluating and identifying nearshore waters; and, engaging First Nations and Métis in addressing Great Lakes issues. Examples of activities supported by the Great Lakes Protection Initiative are outlined below:



Lake St. Clair coastal marsh. Credit: ECCC.

- **Protecting Great Lakes coastal wetlands** – Through its priority to enhance Great Lakes coastal wetland resilience, under the Great Lakes Protection Initiative, ECCC is conducting wetland monitoring, climate and water level modelling, spatial analysis and integrated ecosystem response modelling to understand where and why Canadian coastal wetlands are most vulnerable to projected climate variability and change. Study findings will be shared with partners and stakeholders and used to develop priorities for enhancing coastal wetland resilience. First Nations, including Wikwemikong, Walpole Island, and the Mohawks of the Bay of Quinte, are also working with ECCC to better understand the potential impacts of climate change on coastal wetland through the collection of physical and biological information.

- **Comprehensive assessment of Canadian nearshore waters** – ECCC is conducting science under the Great Lakes Protection Initiative to evaluate nearshore waters and identify areas subject to high stress or that are of high ecological value. This information will guide governments and other partners in setting priorities for action. To date, ECCC and DFO have partnered to acquire high resolution light detection and ranging (LiDAR) data to improve information on nearshore depth, slope and other physical information – a foundational dataset for Great Lakes shoreline and coastal wetland conservation.
- **Supporting Indigenous capacity to protect the Great Lakes** – ECCC is also enhancing Indigenous capacity to address Great Lakes issues by providing project funding through the Great Lakes Protection Initiative. Many of the funded projects benefit habitat and native species and include a focus on community engagement and education. Henvey Inlet First Nation is monitoring 40 local coastal wetlands to survey fish and plant populations, as well as monitor nutrient concentration and water chemistry. Walpole Island First Nation is controlling and reducing the invasive plant Common Reed (*Phragmites*) in their community.

Ecological Gifts Program – Through the [Ecological Gifts Program](#), Canadians, between 2016 and 2018, completed 63 Ecological Gifts in the Great Lakes Basin, for a total of 2,043 hectares of ecologically sensitive land, or partial interest of the land, being donated to protect nature and for conservation. This innovative program in return provides tax benefits for the donors and the recipients of the land ensure that the land's biodiversity and environmental heritage are conserved in perpetuity.

Restoring, protecting and conserving wetlands – Through the National Wetland Conservation Fund, ECCC provided funding to 23 projects over 2016 to 2018 in the province of Ontario to support actions that restore, protect, and conserve habitats for waterfowl, waterbirds and shorebirds valued at \$3.42 million. Approximately 1,762 hectares of wetland habitat were restored, 989 hectares enhanced, and 262 hectares secured.

Protecting Species at Risk – ECCC provided funding for projects that conserve and protect species at risk and their habitats through the Aboriginal Fund for Species at Risk and the Habitat Stewardship Program for

Species at Risk. From 2016 to 2019, these two programs supported 90 projects at a total value of \$7,908,589 within the Great Lakes Basin, improving approximately 3,500 hectares of habitat.

Restoring and enhancing fish habitat – DFO supported habitat restoration and enhancement through its Recreational Fisheries Conservation Partnerships Program by funding multi-partner local projects that restore recreational fisheries habitat. From 2016 to 2019, \$4,562,340 was invested in 43 projects that improved 818 hectares and 311,363 kilometers of fisheries habitat.

In addition to federal efforts, the Province of Ontario administers programs to address habitat and species – examples are outlined below.

Ontario's Wetland Conservation Strategy – In 2017, the Province of Ontario released A Wetland Conservation Strategy for Ontario 2017-2030, providing a framework to guide wetland conservation across the province. The Strategy identifies three priority actions (i.e. improving Ontario's wetland inventory and mapping; improving guidance for the evaluation of significant wetlands; and, creating a no net loss policy for Ontario's wetlands), which are currently being supported by a number of projects. The Strategy will measure success of wetland conservation using two overarching targets: (1) By 2025, the net loss of wetland area and function is halted where wetland loss has been the greatest; and, (2) By 2030, a net gain in wetland area and function is achieved where wetland loss has been the greatest.

Great Lakes shoreline inventory and mapping – Through its Great Lakes Shoreline Ecosystem inventory and mapping project, the OMNRF is classifying and mapping a 2 kilometer band along all Canadian Great Lakes to provide an inventory capturing both landscape-scale information for broader analyses and site-specific information describing coastal habitats. This is a complementary effort to Canada's work to assess the waters of the Great Lakes through the nearshore framework (Lakewide Management Annex) and to measure progress towards a target of net habitat gain. Mapping and classification methodologies will be made public to help practitioners focus conservation efforts.

OMNRF in collaboration with ECCC and other binational partners conducted an assessment regarding

the use of remote sensing tools to track the spatial extent of coastal wetland vegetation influenced by water levels. This work supports the International Joint Commission's monitoring of water level and flow regulation through the [Great Lakes-St. Lawrence River Adaptive Management Committee](#).

Ontario Eastern Habitat Joint Venture – Through the Ontario Eastern Habitat Joint Venture, coordinated by the OMNRF, conservation projects are implemented to help conserve wetlands and other habitats in priority areas across the province. Between 2016 and 2018, this venture secured 4,447 hectares of wetland and associated upland habitat in the Great Lakes Basin through agreements ranging from 10 years to permanent securement, at a value of \$1,225,939. Through additional short-term (<10 years) agreements, an additional 19,452 hectares of wetland and associated upland habitat were protected.

Since 2017, the OMNRF has invested in 35 projects focused on restoring and rehabilitating Great Lakes habitats. Through these projects, 1,078 hectares of habitat and 24.5 kilometers of shoreline were rehabilitated, including improvements to wetlands and associated upland areas, riparian buffers, invasive species control, vegetative plantings, as well as taking land out of agricultural production.

Land Stewardship and Habitat Restoration Program – Ontario also provides annual funding through the Land Stewardship and Habitat Restoration Program to habitat enhancement and ecological restoration efforts. Since 2016, the program provided \$715,452 in funding to help improve, restore or create more than 2,400 acres of habitat including plantings of over 15,000 trees and shrubs, supporting the hiring of 156 people and leveraging over \$2.2 million in project-partner funding.

Ontario's Species at Risk Stewardship Fund – From 2016 to 2018, Ontario's Species at Risk Stewardship Fund supported 125 projects in the Great Lakes Basin, which helped create or maintain over 4,050 hectares of habitat for more than 150 species at risk. An additional 1,170 hectares were managed, enhanced or created through partnership agreements.

Targeted native biodiversity conservation efforts – Over the last three years, the OMNRF has implemented targeted conservation efforts and adaptive

management approaches to protect and enhance native biodiversity in the Canadian Great Lakes through: (1) the rehabilitation of Lake Trout and population assessment of Brook Trout; (2) improved rearing techniques for the re-establishment of Bloater, Walleye and Lake Trout; (3) tracking the movements of Lake Trout, Lake Whitefish, Lake Sturgeon, Walleye, Muskellunge, American Eel and Atlantic Salmon to understand population dynamics and habitat use; and, (4) the development of a basin-wide (cross-lake) comparative study of energy flow through the entire food web in each Great Lake as well as the relative influence of key drivers.

Ontario continues to implement research and monitoring projects to improve our understanding of the complex ecosystems in the Great Lakes to support management decisions. For example, research is underway to better understand the impacts of algal blooms on the fisheries and ecosystems of Lake Erie along with research to improve our understanding of constraints to healthy Great Lakes food webs.

Domestic Actions and Achievements (United States)

In 2017-2018, federal, state, and Tribal governments, and their partners implemented a variety of projects re-establishing connectivity to 674 miles of Great Lakes tributaries for a variety of native fish species, including brook trout and lake sturgeon. During that same time, partners protected, restored, and enhanced almost 35,000 acres of coastal wetlands. Both connectivity and coastal wetland work will continue in 2019. An additional 200,000 acres of inland habitat is expected to be protected, restored, and enhanced over 2017-2019. Efforts to protect and restore habitats targets the improvement of critical fish and wildlife species including native prey fish, piping plover, pitcher's thistle, colonial water birds, native fluvial mussels, lakeside daisy, Mitchell's satyr, moose, and other Great Lakes species of importance.

A few examples of the hundreds of habitat and species projects implemented through base program funding and the [GLRI](#) over the last three years is described below:

Cat Island: rebirth of critical habitat and recovery of an endangered species - Over the past three



Cat Island Restoration Project, Green Bay, Wisconsin.
Credit: USACE.

years, the piping plover returned to lower Green Bay following the completion of the Cat Island Dredge Materials Management Area, placement of dredged sediments, and creation of new habitat for fish and wildlife. A federally endangered shorebird, the piping plover, has now returned to nest in this portion of lower Green Bay for the first time in 75 years. Cat Island piping plover successful fledged chicks in 2017 and 2018. Collaboration between stakeholders in lower Green Bay is expected to continue to illustrate successful integration of ecosystem restoration and harbor maintenance. The entire Great Lakes Piping Plover population reached several important recovery milestones in 2017-2018 including a record number of pairs across the Great Lakes basin in 2017. Plovers nested on all five Great Lakes in 2017, the first time this has occurred in decades.

Native fish populations recover due to sustained science and stocking - Populations of lake trout, a native offshore predator, continued to be restored through enhanced stocking and monitoring in Lakes Michigan, Huron, Erie, and Ontario. In Lake Huron, approximately 50 percent of the lake trout captured during monitoring surveys were of wild origin. Catch rates of wild lake trout have increased markedly since 2008 and continued recruitment of wild fish is evident in summer surveys. More than ten year classes of wild fish (i.e., years when a significant number of young fish survived, which often leads to increase reproduction in later years) are now contributing to the spawning stock. Wild fish now compose a significant portion (>50 percent) of the offshore spawning population. Given



Lake Huron coast. Credit: ECCC.

these results, stocking of yearling lake trout in Lake Huron was reduced by 67 percent beginning in 2018. Continued science and tracking of stocked lake trout is expected to further increase the resilience of this top predator and while providing new opportunities to restore native prey species as well.

Native fish restoration activities are occurring throughout the Great Lakes. Lake herring eggs collected from Lakes Huron and Ontario and Bloater eggs were collected from Lake Michigan to create future brood lines and production groups of fish for stocking. In 2018 and for the first time ever, more than 1 million lake herring were stocked as part of a ten-year restoration study initiated in Saginaw Bay, Lake Huron and several hundred thousand fish were stocked into Lake Ontario. Early life history work for determining distribution of coregonids (Cisco and Bloater) was ongoing in Lake Michigan, Huron, and Ontario as well as fish health assessments and disease susceptibility studies. A combination of FWS base funds and GLRI funds supported this work, which will continue in 2019 working towards improving the native species balance in the Great Lakes.

Historic partnerships formed to tackle large scale dam removals and river restoration - In 2018, two large dams were removed in the Great Lakes basin. The Ottaway-Boardman River returned to its historic channel and free flowing conditions following the removal of the Sabin Dam in Traverse City, Michigan (this dam removal was preceded in 2017 by the removal of the Boardman Dam immediately upstream). This restoration project meets the goals of the numerous project partners, including the MDNR, MDEQ, Bureau of Indian Affairs, Grand Traverse Band of Ottawa and Chippewa Indians, City of Traverse City, Grand Traverse County and the GLC. Similarly, the Sandusky River was restored



Boardman River Dams Ecosystem Restoration Project.
Credit: USACE

following the removal of the Ballville Dam in Fremont, Ohio by partners including USFWS, USACE, ODNR, and the City of Fremont. As part of the permitting process, the City of Fremont also had to relocate mussels that were exposed as the old reservoir returned back into a river. Over a five-day period, volunteers helped move 11,500 mussels upstream. The removal of the two dams increases connectivity for native fish in these tributaries to Lakes Michigan and Lake Erie, respectively, and opens an adjacent riparian corridors for aquatic and terrestrial wildlife, fishers, paddlers, and naturalists. Restoration activities will enhance the local economy and allow natural movement of wood and sediment through the river system, and restoring essential habitats for various species of trout, walleye, and other fishes.

Reconnecting western Lake Erie and historic coastal wetlands - Multiple partners in Lake Erie continued efforts to reconnect and restore coastal wetlands including wetlands at the Ottawa National Wildlife Refuge. In partnership with the Nature Conservancy and Ducks Unlimited. USFWS restored Lake Erie hydrology to more than 340 acres of diked coastal wetlands. A coastal reconnection (i.e., fish passage structure) was established between a coastal wetland and Lake Erie benefiting fish communities, migratory birds, and water quality. The restoration project has provided improved wetland filtration helping with the reduction and retention of phosphorus and other nutrients that contribute to poor water quality in Lake Erie. Lesson learned from this project are being used to develop strategies to reconnect additional coastal wetlands for both water quality benefits to Lake Erie and fish and wildlife benefits. ODNR continues to

support management of wetlands and contributes to Ducks Unlimited through their sales of Ohio Wetlands Habitat Stamps.

Coastal wetland work is occurring throughout the Great Lakes watershed - From 2017 to 2019, FWS worked with states, Tribes, universities, and non-governmental partners to implement the Great Lakes Coastal Program through 35 projects that restored or enhanced nearly 4,500 acres of coastal habitats including 1,700 acres of coastal wetlands. Funding from the GLRI supported about 44 percent of the accomplished acres.

Strategic use of protected lands and habitat inventories - In 2017, the State of New York acquired more than 6,000 acres of protected lands in Oswego County, the largest additions to state lands in Central New York in 45 years. These areas include approximately 2,825 acres of lands along the Salmon River and 3,236 acres of additional forestland in the adjacent Tug Hill region. The Salmon River is one of the major tributaries to Lake Ontario in New York and is an internationally acclaimed fishing destination. In 2018, NYSDEC and State University of New York College of Forestry & Environmental Science developed an interactive, geo-spatial atlas of Lake Ontario coastal wetlands. The Atlas distinguishes the various categories of wetlands, identifies biodiversity species of greatest concern and evaluates each wetland in risk of deterioration due to encroachment and other threats. NYSDEC is using the Atlas to prioritize potential coastal wetland restoration opportunities.

Enhancing stream and river functions in urban areas - In 2018, the USACE restored the narrow and hydraulically restricted concrete-lined channel of Underwood Creek in the City of Milwaukee, WI. Historically, channels were modified by local municipalities in heavily urbanized areas across the Great Lakes in an attempt to abate local flooding. This project removed more than 4,000 linear feet of concrete lining and reconnected the restored channel to the available floodplains to allow urban runoff to naturally infiltrate the ground rather than be pushed downstream and enter Lake Michigan. Ecological benefits from reconnecting the water that flows through this system include providing fish passage and aquatic habitat, restoring wetlands and establishment of native plant communities. This project ties into Milwaukee's larger watershed approach where



New Tools, Better Habitat in Northwest Ohio. Credit: USFWS.

wetland complexes and stream corridors in urban areas are restored to help naturally mitigate development pressures.

Protecting threatened Pitcher’s Thistle in Great Lakes National Parks and Lakeshores - In 2017, the National Park Service and USGS re-established monitoring of Pitcher’s Thistle, a federally-threatened plant, at Sleeping Bear Dunes National Lakeshore, Pictured Rocks National Lakeshore and Indiana Dunes National Lakeshore. The information obtained from these surveys provide an up-to-date status and trend of Pitcher’s thistle across its range of occurrence in Great Lakes sand dunes. Sleeping Bear Dunes National Lakeshore was found to be home to 95 percent of the world’s population of Pitcher’s Thistle. New threats to these endangered plant were also documented for the first time at these locations leading to development of new protection strategies for this threatened representative of the unique and beautiful shifting sand dunes.

Calumet Prairie Ivanhoe South ecosystem restoration project - In 2017, the USACE completed the Calumet Prairie Ivanhoe South project. The completed project resulted in the restoration of a 164-acre parcel of remnant sand prairie at the Indiana DNR’s Calumet



Pitcher’s Thistle Sleeping Bears Dunes Credit: NPS.



Calumet Prairie and Ivanhoe South Restoration. Credit: USACE.

Prairie natural area, and a 34-acre parcel of remnant globally imperiled ridge and swale landscape at the Shirley Heinze Land Trust’s Ivanhoe South Nature Preserve. Citizens and inner city children of the surrounding area of Gary as well as residents and visitors to northwest Indiana, now have access to two restored ecosystems indicative of Northwest Indiana’s native environment. The primary restoration activities included removal of invasive tree, shrub and grass species that negatively impact local suppressed hydrology and the native seed bank. This restored area now provides critical habitat for the Federally Endangered Karner Blue Butterfly, State Endangered Spotted Turtle, and three state-ranked ant species.

Lake Sturgeon make their first return in the Great Lakes after enhanced rearing efforts - On April 12, 2018 the Little River Band of Ottawa Indians (LRBOI) Natural Resources Department staff recaptured a 10 year-old lake sturgeon from Manistee Lake that was released in September 2008 at Rainbow Bend on the Manistee River, having been raised at the nearby LRBOI sturgeon Streamside Rearing Facility. The sturgeon is thought to have been making its way upstream to spawn. To the Band’s knowledge, not only is this the first released sturgeon that has been documented returning to the Manistee River system from the LRBOI rearing facility, but it may be that this is the first documented lake sturgeon from a streamside rearing facility to return to its natal stream within the entire Great Lakes Basin. Since 2012, the Great Lakes Restoration Initiative has boosted the LRBOI’s and other Tribal lake sturgeon restoration efforts. Another important part of the LRBOI’s lake sturgeon (nmé in the Anishinaabe language) restoration strategy is outreach. Outside of

the classroom, LRBOI conducts traditional nmé release ceremonies.

Basinwide Lake Sturgeon restoration projects - Sturgeon projects are occurring throughout the Great Lakes. Streamside rearing facilities are being used in a Lake Superior tributary, a Lake Erie tributary, and on multiple tributaries of Lake Michigan. Fall fingerling lake sturgeon were stocked into the Saginaw River system in Michigan and the Maumee River system in Ohio for the first time ever. Lake sturgeon spring adult and juvenile assessments are conducted across the Great Lakes in coordination with state, tribal, and federal partners.

Supporting restoration work on private lands - From 2017 to 2019, working with numerous partner organizations, the Fish and Wildlife Service's Partners for Fish and Wildlife Program completed 200 upland habitat projects totaling 4,645 acres, as well as 213 wetland projects totaling 3,664 acres. GLRI funding supported 38 of those acres. All projects were conducted on private lands (non-state and non-federal) using a 10-year agreement between the Service and landowner. In addition to building partnerships in rural communities in the basin, projects were strategically located to provide benefits to countless species of wildlife that rely on the Great Lakes ecosystem.

Increasing connectivity and recreation opportunities in urbanized landscapes - During 2018 and 2019, the USACE restored 50 acres of habitat on lands in Chicago, Illinois, including increasing aquatic connectivity for over 48 miles of riverine habitat by the removal of a concrete dam in the Chicago River. The restoration provides suitable habitat for migratory birds along the globally significant Lake Michigan flyway by providing high calorie, high protein food such as seeds, fruits and insects along with a place to rest and avoid hazards. Finally, the project has 41 miles of trails that connect to a total of 950 miles of trails to downtown Chicago, Lake Michigan, Wisconsin, Indiana and Iowa. These ecosystem benefits and compatible recreation improve the quality of life for over 460,000 people that live within 3 miles of this project.

Restoring pollinator and migratory bird habitat - In 2018, FWS worked with the U.S. Forest Service to enhance more than 2,000 acres of pollinator and migratory bird habitat on the Moquah Barrens. Located on the Bayfield Peninsula in Wisconsin near the shores

of Lake Superior, the Moquah Barrens are an important migratory stopover site for species navigating across or around Lake Superior. This coastal habitat enhancement project was achieved through collection and planting of native seed. The Red Cliff Band of Lake Superior Chippewa provided staff assistance in these efforts by helping with seed collection. The Moquah Barrens are part of the 1842 Treaty Ceded Territory and ancestral home to the Ojibwe people.

Managing water flows at the Compensating Works to support fish spawning in St. Marys River - The "United States Compensating Works" is a structure that was originally built in 1921 in the St. Marys River to compensate for the increased diversion of water for hydropower production. In 2017 and 2018, the USACE automated six of the eight Compensating Works gates near the Soo Locks in Sault Ste. Marie, Michigan. Automation of the gates will allow for gate position adjustments to be made over longer periods of time, resulting in measured fluctuations of flow rates and water level elevations. Measured gate position changes would more closely mimic natural fluctuations in flow rates and enhance fish habitat. This project will help restore 80 acres of optimum habitat conditions for fish spawning and egg hatching in the rapids of the St. Marys River, contributing to the overall improvement of fish populations, including the Lake Sturgeon.



Groundwater Annex

Overview

The purpose of the 2012 Canada-United States Great Lakes Water Quality Agreement's (Agreement) Groundwater Annex is to coordinate groundwater science and management actions that support Great Lakes water quality.

This is accomplished by coordinating binational activities related to groundwater science and management actions, together with the implementation of domestic programs, to understand and assess, protect, and manage groundwater and groundwater-related stressors affecting the waters of the Great Lakes.

The work undertaken through the Groundwater Annex during this reporting period is organized by the three 2017 - 2019 Binational Priorities for Science:

1. Advance the monitoring, surveillance and assessment of groundwater quality in the Great Lakes basin.
2. Undertake a focused assessment of the geographic distribution of known and potential sources of groundwater contaminants relevant to Great Lakes water quality, with a focus on nearshore contaminant sources and impacts.
3. Develop better tools to assess groundwater-surface water interaction, including scaled-up models based on local scale assessments, and use them to assess regional-scale flow of groundwater to surface waters in the Great Lakes basin.

Annex Implementation

The implementation of this Annex was supported by the Groundwater Annex Subcommittee, co-led by the United States Geological Survey (USGS) and Environment and Climate Change Canada (ECCC), with members from the USGS, Michigan Department of Environmental

Quality, Office of the Great Lakes (MDEQ), Minnesota Department of Health (MN DH), New York State Department of Environmental Conservation (NYSDEC), Ohio Environmental Protection Agency (OEPA), ECCC, Ontario Ministry of the Environment, Conservation and Parks (OMECP), Chiefs of Ontario (COO), and Conservation Ontario (CO).

Key Achievements

2017: The State of Michigan established a PFAS Action Response Team in 2017 consisting of agencies representing health, environment, and other branches of state government to respond, in part, to PFAS-contaminated groundwater.

2017 and ongoing: Work continued over the reporting period to update the State of the Great Lakes' Groundwater Quality sub-indicator to address spatial data gaps and trends in nitrates and chlorides, which are being used to assess groundwater quality.

2018: Work was initiated through a Canadian federal and provincial effort to develop an inventory and map potential point sources of groundwater contamination for Southern Ontario.

Binational and Domestic Actions and Achievements

2017 to 2019 Priorities for Science: Advance the monitoring, surveillance and assessment of groundwater quality in the Great Lakes basin.

Undertake a focused assessment of the geographic distribution of known and potential sources of groundwater contaminants relevant to Great Lakes water quality, with a focus on nearshore contaminant sources and impacts.

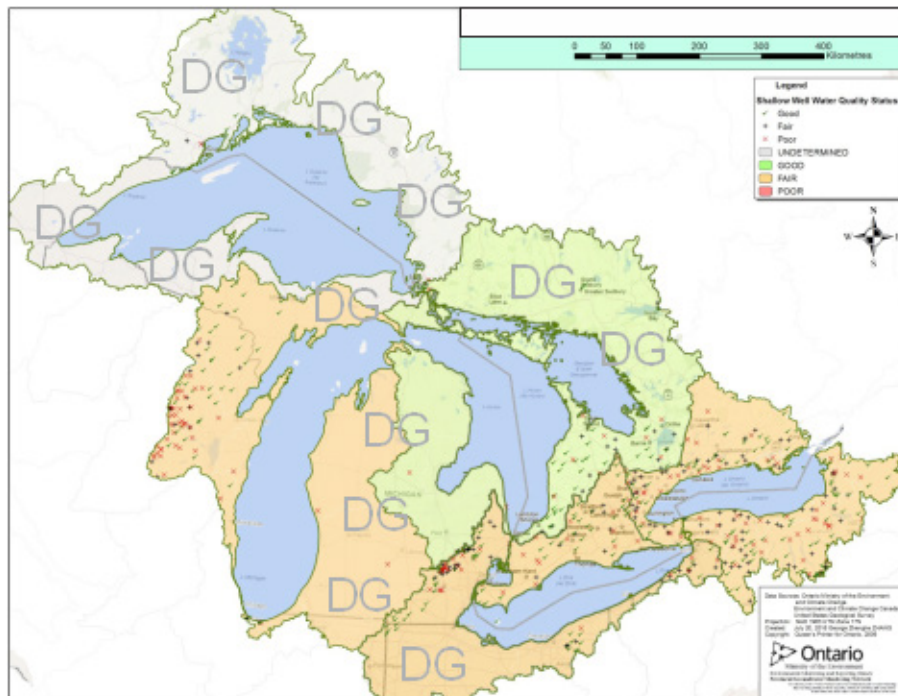


Figure 3 - Groundwater quality status in Great Lakes basin (2017): Based on nitrate and chloride concentrations in shallow groundwater (≤ 40 m below ground), using monitoring well data from OMECP, and USGS. Symbols indicate the results for individual monitoring wells, and shaded areas indicate the generalized results for each lake basin. Credit: Province of Ontario.

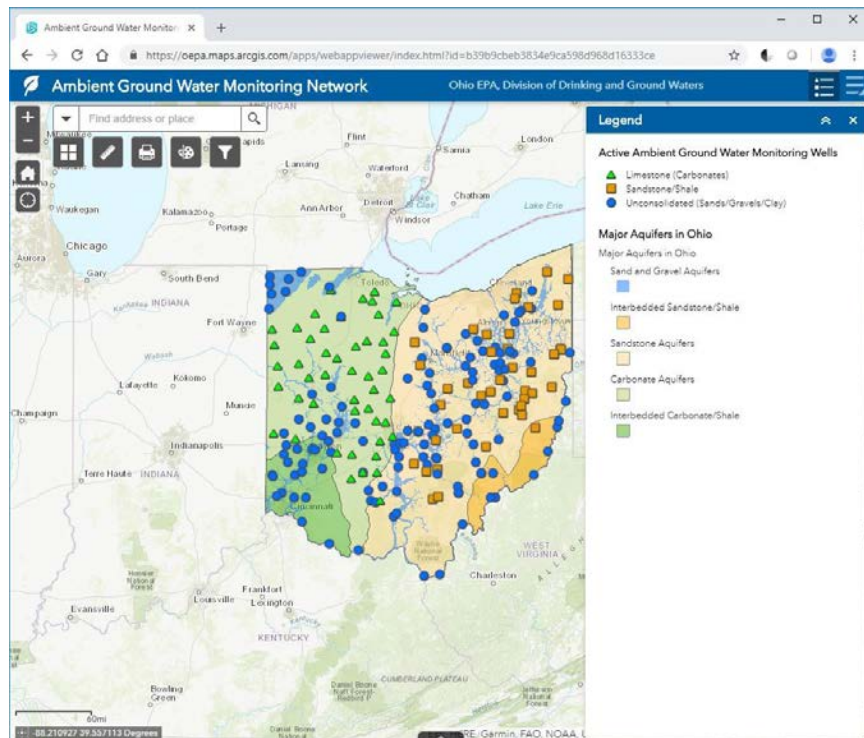
Groundwater Quality Sub-Indicator - An update of the Groundwater Quality sub-indicator that was first developed in 2017 for State of the Great Lakes reporting was initiated in order to address the spatial data gaps (Figure 3), and to assess trends in the two constituents that are measured and being used to assess groundwater quality – nitrate (primarily from agricultural practices) and chloride (mainly from the urban use of de-icing salt).

Improving the State of Great Lakes Groundwater Quality Sub-Indicator - In support of binational reporting on the State of the Great Lakes, in 2018 ECCC funded a project to develop a methodology to analyze long-term and short-term temporal trends in nitrate and chloride data. The report that was generated included a number of recommended steps that will help support reporting for the Groundwater Quality sub-indicator. This project was conducted in collaboration with the OMECP.

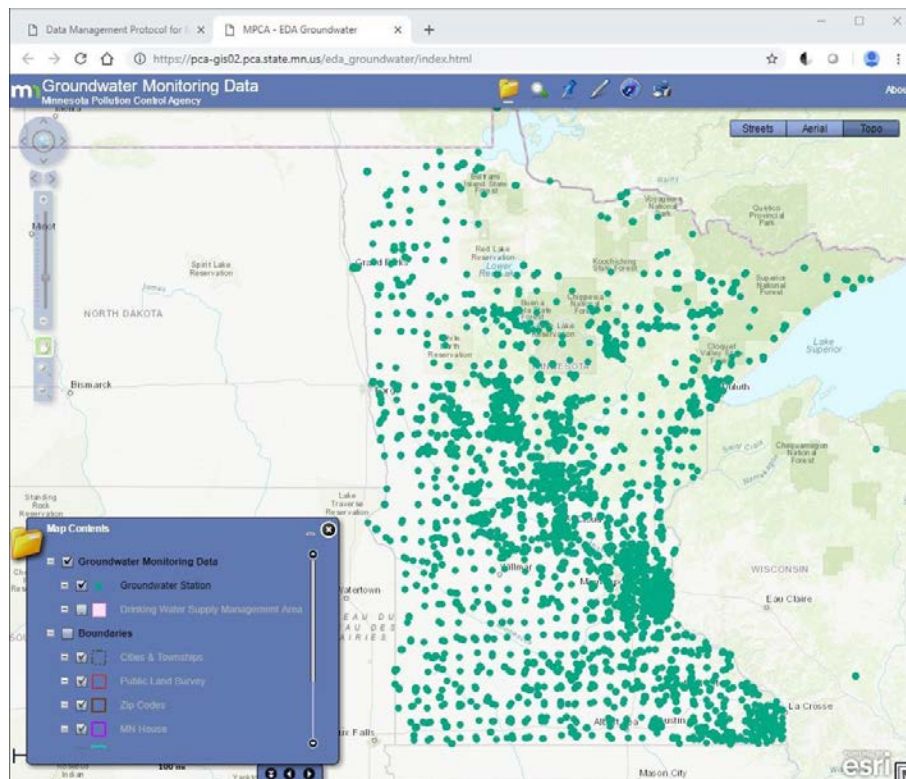
Implementing domestic programs to monitor, assess, and address groundwater quality-The USEPA is working with other federal, state, tribal, and local agencies to monitor and address contaminated groundwater at sites across the Great Lakes Basin. A number of environmental programs have been established by

Congress (including the Resources Conservation and Recovery Act, the Underground Storage Tanks program, Superfund, and the Brownfields Revitalization Act) to remediate sites with contaminated groundwater. Information on contaminated sites, including those sites with groundwater contamination, is available at [Cleanups in My Community](#).

Monitoring groundwater in the State of Ohio - The State of Ohio has established an ambient groundwater monitoring program for a network of over 200 wells. The network includes public water supply systems (85 percent of the network), and a mix of industrial, commercial and residential wells (the remaining 15 percent). Water samples are analyzed for inorganic compounds at a 6-, 18-, or 36-month intervals depending on the number of samples collected at each site and the historic stability of these compounds for each site. Volatile organic compounds are analyzed once every 18 or 36 months. Some sites have semi-volatile organic compound or pesticide data. Most of the wells are completed in unconsolidated deposits. About one-third are completed in bedrock aquifers. The goal of the [ambient groundwater monitoring network](#) is to provide reliable, long-term data for water-resource planning



Screenshot of Ohio Environmental Protection Agency's Ambient Ground Water Monitoring Network Web Map. Available at www.epa.ohio.gov. Credit: Ohio Environmental Protection Agency.



Screenshot of Minnesota Pollution Control Agency's Environmental Data Access - Groundwater Monitoring Data. Available at www.pca.state.mn.us. Credit: Minnesota Pollution Control Agency.

and protection.

Monitoring groundwater in the State of Minnesota

- The State of Minnesota provides information on groundwater quality through an on-line map interface. In 2017, the network consisted of 266 regularly sampled wells ([Data Management Protocol for the Minnesota Pollution Control Agency's Ambient Groundwater Monitoring Network](#), MPCA, July 2017). Samples from these wells are analyzed for over 100 different chemicals including nutrients, major ions, volatile organic compounds, and trace metals. Field parameters including pH, specific conductance, dissolved oxygen concentration, and temperature also are collected. About 40 wells from the network are sampled each year.

Protecting municipal drinking water supplies in Ontario

- Ontario's Clean Water Act establishes the legal framework to ensure communities are able to protect their municipal drinking water supplies by developing collaborative, locally driven, science-based protection plans. The Drinking Water Source Protection Program is established under the Clean Water Act, to identify areas where municipal drinking water sources may be at risk from both quantity and quality perspectives, assess the level of risk, and put in place measures to eliminate or manage the risks. Groundwater and surface water flow systems associated with drinking water

sources (aquifers, lakes, and rivers supplying municipal drinking water systems) are documented and assessed, including flows into the Great Lakes. Protection zones are delineated for vulnerable areas around municipal surface water intakes in the Great Lakes, inland lakes and rivers, and municipal wellheads. There are four types of vulnerable areas:

1. Wellhead protection areas are areas around municipal wells where the groundwater is travelling toward that well when the well is being pumped. These areas should be protected from risks to the quality and quantity of the drinking water source.
2. Intake protection zones are areas of land and water around surface water intakes that should be protected from risks to the quality and quantity of the drinking water source.
3. Significant groundwater recharge areas are areas where a relatively high percentage of precipitation seeps into the ground to help maintain the water level in an aquifer that supplies a community or private residence with drinking water.
4. Highly vulnerable aquifers are areas that are particularly susceptible to contamination based on factors such as the aquifer depth underground, the soil types, soil permeability and other characteristics of the surrounding soil or rock.

Perfluoroalkyl and polyfluoroalkyl substances, perfluorooctanoic acid, and perfluorooctanesulfonic acid in drinking water supplies

Perfluoroalkyl and polyfluoroalkyl substances (PFAS), perfluorooctanoic acid (PFOA), and perfluorooctanesulfonic acid (PFOS) are synthetic chemicals used in a variety of industrial and commercial applications including firefighting foams, packaging and waterproofing. They are water soluble and, once introduced to the environment, are found to be transported by moving groundwater and to degrade only very slowly (see, for example, USGS, 2017; and USEPA, 2017). Federal and state agencies are expanding efforts in sampling and analysis, determining potential public-health impacts, and working to determine options to protect public health from these compounds (State of Michigan, 2017; USEPA, 2018).

Additional sources of information:

- State of Michigan, 2017. Michigan PFAS Action Response Team: State of [Michigan Executive Office, Executive Directive 2017-4](#).
- State of Michigan, 2017. About [Michigan PFAS Action Response Team](#).
- United States Environmental Protection Agency, 2017. [Technical Fact Sheet – Perfluorooctane Sulfonate \(PFOS\) and Perfluorooctanoic Acid \(PFOA\): USEPA Fact Sheet EPA 505-F-17-001](#).
- United States Environmental Protection Agency, 2018. [News Release – Historic USEPA summit provides active engagement and actions to address PFAS](#).
- United States Environmental Protection Agency, 2018. [Per- and Polyfluoroalkyl Substances \(PFAS\)](#).
- United States Environmental Protection Agency, 2019. [Per- and Polyfluoroalkyl Substances \(PFAS\) Action Plan](#).
- United States Geological Survey, 2017. [USGS Science Feature – Poly- and Perfluoroalkyl substances from firefighting and domestic wastewater remain in groundwater for decades](#).
- Interstate Technology and Regulatory Council. [PFAS – Per- and Polyfluoroalkyl Substances \(Fact Sheets\)](#).

If a water quality issue is identified by source protection committees under the Clean Water Act, issue contributing areas can be delineated within the vulnerable areas. Examples of issues identified in Ontario include nitrate and sodium. Mandatory policies apply within issue contributing areas in order to ensure that the source water quality is protected or improved.

The source protection plan policies were developed to address threat activities identified as risks to our municipal drinking water sources. Plan policies may prohibit activities in limited areas, and manage through best management practices such as road salt management and nutrient runoff prevention. The policies that apply within vulnerable areas protect the Great Lakes, inland lakes, rivers and aquifers as a source of drinking water. For example, in the Credit Valley – Toronto and Region – Central Lake Ontario Source Protection Region municipalities are working closely with the Ministry of the Environment, Conservation and Parks to review and update spill notification protocols in the event of potential spills along highways, shipping lanes, and railways.

Every five years Conservation Authorities in Ontario collaborate to produce [watershed report cards](#). The most recent report cards were released in 2018. These report cards assess the health of the watersheds, including indicators for groundwater quality (nitrate and chloride) monitored through the Provincial Groundwater Monitoring Network operated by the OMECP in partnership with the Conservation Authorities. The next Watershed Report Cards are planned for release in 2023.

Contaminants in Groundwater

Estimating the speed of groundwater flows in the Great Lakes basin - Through the National Water Quality Project, the USGS is estimating travel times in groundwater systems. Travel times are estimated from areas where water enters the groundwater system, called “recharge areas”, to places where groundwater leaves the system, primarily through discharges into streams and the Great Lakes. These estimates help predict nutrient transport by groundwater. Systems with long travel times are more likely to degrade nutrients before they arrive at discharge areas.

National dialog that informs PFAS activities in the Great Lakes-The presence of perfluoroalkyl and polyfluoroalkyl substances (PFAS), such as perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) in drinking water supplies across the basin has prompted response by state and federal agencies, governmental leaders, and the public. At the federal level, USEPA hosted a National Leadership Summit in Washington, D.C. in May, 2018 to discuss ongoing efforts to characterize risks, identify specific short-term actions, and develop risk communication information to help affected communities.

PFAS Response by the State of Michigan – In 2017, the State of Michigan assembled a [PFAS Action Response Team](#) consisting of agencies representing health, environment and other branches of state government. This team has joined together with public and private sector to investigate sources and locations of PFAS contamination in the state and act to protect drinking water. Current work includes field survey of an impacted lake using aerial drone technology to identify areas of significant groundwater input to the lake for subsequent sampling and analysis for PFAS and related contaminants.

In support of efforts to address excessive nutrients in Lake Erie, ECCC is assessing the role of groundwater in delivery of nutrients to streams in the Thames River basin. ECCC and OMECP are also providing support for a study led by the University of Western Ontario examining: the contribution of phosphorus from groundwater to agricultural streams in the Thames River basin; the influence of riparian areas to mitigate these inputs; and the potential impacts of groundwater phosphorus inputs on stream ecology.

ECCC and the OMECP are supporting the University of Western Ontario and the University of Waterloo to study the contribution of phosphorus from septic systems. A field study was completed in three subwatersheds in the Lake Erie Basin to determine the percent of septic effluent generated in a subwatershed that ultimately reaches tributaries. For this field study, artificial sweeteners were used as a tracer for wastewater from septic systems. Information from this field study informed the development of a geospatial modeling tool that has been applied across the Canadian Lake Erie Basin to locate land parcels with septic systems using publically available data and provide estimates of

phosphorus loads from septic systems at the watershed scale.

In related research, in 2017, ECCC completed an assessment of groundwater nutrient transport to Georgian Bay from septic systems, in partnership with University of Waterloo and Ontario Provincial Parks.

ECCC initiated a wetland-focused study of mercury (a Chemical of Mutual Concern) in the Lake Superior Basin, which includes sampling of groundwater, in order to determine if summer droughts cause forested wetlands to release mercury and other heavy metals, and, if so, whether this affects downstream aquatic life. By acting somewhat like sponges, some wetlands have been shown to protect downstream aquatic areas from contamination. However, more intense drought-storm cycles caused by climate change may cause wetlands to release contaminants that have been previously stored.

With funding support from OMECP, ECCC is investigating the threat to Great Lakes surface waters (streams, rivers, lakes) posed by emerging contaminants and phosphorus in groundwater affected by old closed and operational landfills in Ontario.

ECCC, in partnership with University of Toronto, assessed and reported on the likely importance of the source-to-stream transport of benzotriazoles in urban and agricultural watersheds of the Lake Ontario Basin.

Benzotriazoles are a group of widely used synthetic chemicals (used for example in anticorrosive, deicing and anti-icing fluids, vehicle antifreeze, dishwashing detergent, and dyes) that have now been detected widely in the environment.

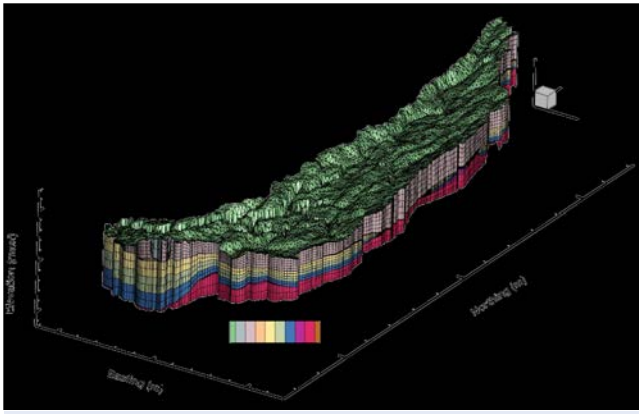
In support of a commitment under the 2014 Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health to identify priority sites or areas where point sources may impact the water quality and ecosystem health of the Great Lakes, including nearshore areas, hydrogeologists from the OMECP and ECCC worked with the Ontario Provincial Geomatics Services Centre to undertake an inventory and mapping of potential point sources of groundwater contamination for Southern Ontario. Nineteen activities (such activities as storage of fuel, waste disposal sites,



Use of a temporary drive-point system (right) to sample shallow groundwater along the shore of Georgian Bay, Lake Huron. The samples were analyzed to assess groundwater nutrient transport to the bay from septic systems. Credit: John Spoelstra, ECCC.

salt storage, and storage and handling of pesticides, PCBs, and organic solvents) were identified that have the potential to be point sources of groundwater contamination should leaks or discharges occur. A data inventory was designed to consider any, and all, available geospatial data related to point source activities that pose a potential concern to groundwater quality. The impact of the potential point sources was determined as a function of exposure (defined as being the density of locations) and sensitivity (defined by baseflow index and proximity to a surface water course). Map overlays were developed and analyzed to identify areas and levels of potential impact, which emphasize areas for further assessment.

The [Oak Ridges Moraine Groundwater Program](#) is a coalition of 13 agencies from Ontario municipalities and Conservation Authorities working together to better understand and manage water resources along the 160 kilometer length of the Oak Ridges Moraine in Southern Ontario. The program maintains one of Canada's largest, actively-managed groundwater databases and has produced geologic interpretations for the area, as well as assessments of the regional groundwater flow system and its linkage to the region's surface waters. The interpretations are continually being refined and improved through integrated groundwater and surface water flow models.



The different layers of the surface water-groundwater model (HydroGeoSphere) for the Parkhill Creek project. Credit: Elisha Persaud, University of Guelph School of Engineering.

2017 to 2019 Priority for Science: Develop better tools to assess groundwater-surface water interaction, including scaled-up models based on local scale assessments, and use them to assess regional-scale flow of groundwater to surface waters in the Great Lakes basin.

The Geological Survey of Canada initiated a regional groundwater synthesis study in southern Ontario in 2014 as a collaborative project with the Ontario Geological Survey, which continued over this reporting period and is wrapping up in March 2019. Emerging products are regional geological models, a numeric groundwater-surface water model, and a conceptual framework on groundwater-surface water interaction.

The OMECP in collaboration with the OMNRF, Water Survey of Canada, and various Conservation Authorities have established seven long-term integrated water and climate change monitoring stations across the province. The integrated surface and groundwater monitoring stations were established in the year 2012. The primary objective of these stations is to support climate change detection and adaptation planning in the province. The overall objective of this project is to increase the current understanding of climate change impacts on water cycle components, such as stream flow and groundwater levels, through use of an integrated monitoring and modelling approach. Past and newly acquired climate and hydrologic data collected from Parkhill Creek Integrated Water and Climate Monitoring Station in Southwestern Ontario (Ausable-Bayfield Conservation Authority) is being used to develop a surface water-



Low flow in Parkhill Creek during the summer. Credit: Elisha Persaud, University of Guelph School of Engineering.

groundwater numerical model for which current and future climate scenarios will be explored. This approach will allow for the identification of climate change consequences and possible adaptation options, as well as the evaluation of methodologies related to climate change impact assessment. Furthermore, this study will facilitate a detailed baseline water cycle analysis for a hydrologic setting that is typical to that encountered in the Great Lakes basin.



Comparison of winter (January 23, 2018) flood conditions (upper) and summer (bottom) growing conditions for Parkhill Creek. Credit: Sarah Rixon, University of Guelph School of Engineering.



Climate Change Impacts Annex

Overview

Changes in climate impact naturally occurring physical, chemical and biological systems such as runoff and erosion patterns, nutrient cycling, and wetland development in the Great Lakes. Climate change impacts such as warming temperatures, changing precipitation patterns, decreased ice coverage, and alterations to water levels are being observed across the Great Lakes basin. Understanding how climate change affects these processes now and in the future is important for making informed management decisions for the Great Lakes.

Recognizing that climate change has an impact on the quality of waters of the Great Lakes, a new Climate Change Impacts Annex was incorporated into the 2012 Canada-United States Great Lakes Water Quality Agreement (Agreement).

The purpose of the Climate Change Impacts Annex is to coordinate efforts in order to identify, quantify, understand, and predict the climate change impacts on the quality of the waters of the Great Lakes, and share information that Great Lakes resource managers need to proactively address these impacts.

Annex Implementation

The implementation of this Annex is supported by a Subcommittee, co-led by Environment and Climate Change Canada (ECCC) and the United States National Oceanic and Atmospheric Administration (NOAA), with members from, Fisheries and Oceans Canada (DFO), Parks Canada (PC), Conservation Ontario (CO), Ontario Ministry of the Environment, Conservation and Parks (OMECP), Ontario Ministry of Natural Resources and Forestry (OMNRF), Chiefs of Ontario (COO), United States Army Corps of Engineers (USACE), United States Environmental Protection Agency (USEPA), United

States Fish and Wildlife Service (USFWS), United States National Park Service (USNPS), and Oneida Tribe of Indians of Wisconsin (OTIW). Additional organizations and experts from research and academia and other organizations with climate change expertise and interests also participate.

Annex 2017 to 2019 Key Achievements

- **2017-2019:** Produced [Quarterly Climate Impacts and Outlook for the Great Lakes Region](#) to provide climate information to decision-makers and the public.
- **2018:** A new [2017 Annual Climate Trends and Impacts Summary for the Great Lakes Basin](#) was developed to provide an overview of the climate trends and impacts in the basin for the 2017 reporting year to be used by managers and practitioners at the federal, state, provincial regional, and local levels, as well as stakeholders and the public.
- **2018:** Reviewed the climate change knowledge gaps identified in the [2015 State of Climate Change Science in the Great Lakes Basin](#) report to help identify gaps that could be prioritized in the future.
- **2018:** [Approaches for Conducting Vulnerability Assessments in the Great Lakes Basin: A Review of the Literature](#) was released to help inform and assist members of the Great Lakes research community, resource managers, practitioners and decision-makers undertaking Vulnerability Assessments in the Great Lakes Basin.
- **2017-2019:** Implemented domestic programs to understand the impacts of climate change to the waters of the Great Lakes and share this information with decision-makers.

Binational Actions and Achievements

2017 to 2019 Priority for Science: Refine and implement State of the Great Lakes indicators for assessing and reporting on the impacts of climate change.

Work being undertaken through the Climate Change Impacts Annex and the Science Annex continues to refine the State of the Great Lakes Climate Trend sub-indicators (Precipitation Amounts, Surface Water Temperature, Ice Cover, Water Levels).

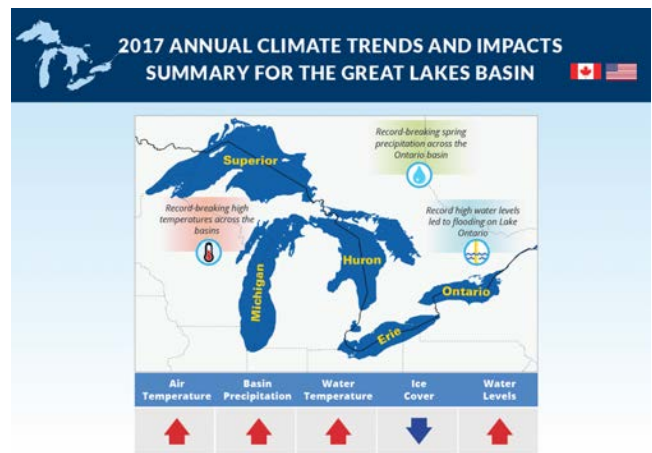
2017 to 2019 Priorities for Action: Identify key areas across the issues of the Agreement where consideration of climate change needs to be considered and integrated into issue strategies and actions.

Review the State of Climate Change Science report with Annex Co-Leads to identify the priority knowledge gaps to be addressed.

Continue to regularly deliver climate information through issuance of the “Great Lakes Climate Summaries and Outlooks”.

In July 2018, Canada and the United States issued the first binational annual climate summary document, titled the [2017 Annual Climate Trends and Impacts Summary for the Great Lakes Basin](#). The product provides a summary of 2017’s major climate trends, notable climate-related events, and relevant new research, assessments, and activities of relevance to the Great Lakes. This summary was produced by Canadian and United States agencies and organizations including ECCC, the United States National Oceanic and Atmospheric Administration (NOAA), the Midwest Regional Climate Center, the NOAA Great Lakes Environmental Research Laboratory, and the Great Lakes Integrated Sciences and Assessments partnership. The document is intended for use by other Agreement Annexes, the Great Lakes Executive Committee, and policy and decision makers at federal, state, provincial, regional, and local levels in the Great Lakes, as well as stakeholders and the general public.

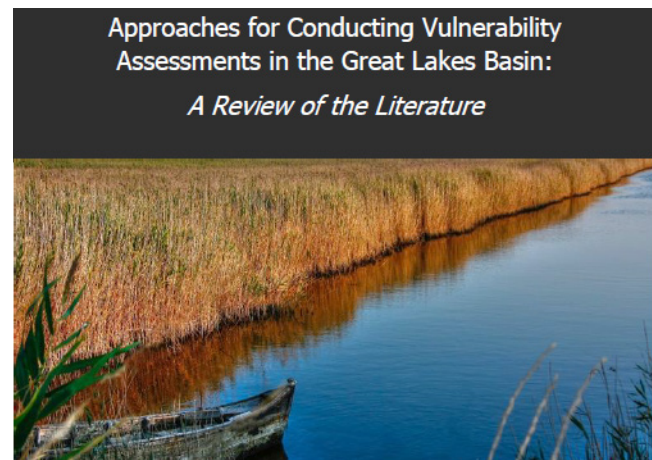
A synthesis of the approaches for assessing climate vulnerability in the Great Lakes Basin was produced titled, [Approaches for Conducting Vulnerability](#)



2017 Annual Climate Trends and Impacts Summary for the Great Lakes Basin. Credit: Canada and United States.

[Assessments in the Great Lakes Basin: A Review of the Literature](#), and released in November 2018. The report compiles information on the various types and approaches of assessments, processes, frameworks, methods, tools, models, data and other aspects of conducting a vulnerability assessment. The purpose of the report is to inform the development and implementation of vulnerability assessments by members of the Great Lakes research community, resource managers, practitioners and decision-makers

Binational quarterly newsletters, [Great Lakes Climate Quarterly Impacts and Outlook newsletters](#), were published through this reporting period, providing an



Approaches for Conducting Vulnerability Assessments in the Great Lakes Basin: A Review of the Literature, 2018. Credit: ECCC, NOAA and the Ontario Centre for Climate Impacts and Adaptation Resources.

easy to understand overview of the latest season's weather, climate, and water level conditions, weather, climate, and water level-related impacts, and an outlook for the upcoming quarter. These newsletters are produced by Canadian and United States experts from federal governments, as well as regional and research climate centers and hubs, for use by managers and practitioners at federal, state, provincial, regional, and local scales as well as stakeholders and the general public.

In 2017 and 2018, all of the Agreement Annex Co-Leads and their Extended Subcommittee members were engaged through an online survey, an interactive webinar, and a series of interviews in order to target and refine the 43 knowledge gaps previously identified in the 2015 report, [State of Climate Change Science in the Great Lakes basin: A Focus on Climatological, Hydrological and Ecological Effects](#), as well as document new knowledge gaps since development of that report. Through the engagement process, 15 shorter-term priorities were identified, in addition to 28 longer-term priorities for climate research necessary to support the deliverables within Agreement Annexes.

Other binational and domestic efforts contributing to the understanding and communicating climate change impacts on the Great Lakes

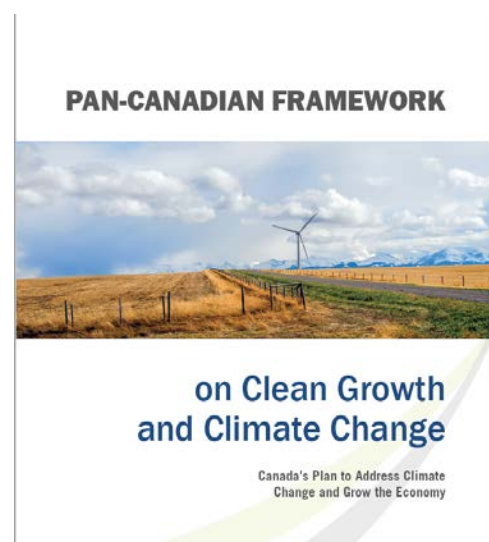
- The USACE and the NOAA's Great Lakes Environmental Research Laboratory developed a tool that addresses the uncertainty in the water balance (the flow of water in and out of the lakes) for each of the Great Lakes. The USACE started running this tool operationally this past year to provide estimates of precipitation, evaporation, runoff, and connecting channel flows for the [Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data](#) that can be analyzed for trends or changes due to changing climate.
- The USACE and ECCC through the [Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data](#) are providing monthly updates of measured hydro climate variables including comparisons of all available methods of measuring precipitation, evaporation, and runoff to the participating Federal agencies in the committee in order to provide decision makers with a complete understanding of recent basin conditions.
- The USACE has developed routine hydro climate

data analyses in support of the [Great Lakes-St. Lawrence River Adaptive Management Committee](#). These analyses involve monitoring trends of hydro climate variables, including monthly precipitation, monthly evaporation, monthly runoff, surface water temperatures, among others. These hydro climate data analyses are accomplished through routine updating of standard plots and trend lines, which are analyzed annually to support the Adaptive Management Committee.

Water levels in the Great Lakes: Water levels in the Great Lakes are monitored by Canadian and United States agencies through a network of water level monitoring stations. The data collected at these stations is used to provide current and historical water level conditions, as well as future projections for Great Lakes water levels. For more information visit [Great Lakes Environmental Research Laboratory Great Lakes Water Level](#).

Domestic Actions and Achievements (Canada)

The Government of Canada, along with provinces and territories and in consultation with Indigenous peoples, are taking action to address climate change through the [Pan-Canadian Framework on Clean Growth and Climate Change](#). The Pan-Canadian Framework is a



Cover of the Pan-Canadian Framework on Clean Growth and Climate Change. Available at: www.canada.ca. Credit: ECCC.

plan to meet emissions reduction targets, grow the economy, and build resilience to climate change. Under the Framework, the Government of Canada launched the [Canadian Centre for Climate Services](#) in October 2018 to deliver trusted climate information, data and tools through an online climate information portal. An example of data available on the website includes ECCC's ensemble of high resolution (statistically downscaled) climate projections of temperature and precipitation for all of Canada, which may be applied to the Great Lakes region.

Downscaling: a method that allows climate model output to be delivered at a finer resolution than the one generally obtained from relatively coarse-resolution global climate models.

Canada's Great Lakes Protection Initiative includes a priority focused on, "assessing and enhancing the resilience of Great Lakes coastal wetlands" to climate change. In support of this 5 year program (2017-2022), ECCC is developing future projections of Great Lakes water levels using information from the North American Coordinated Regional Climate Downscaling Experiment (CORDEX-NA). ECCC is also developing Great Lakes basin wide climate scenarios using an ensemble of outputs from the Canadian Regional Climate Model 5 (CRCM5). These analyses will provide a better understanding of changes to the hydrological cycle under future climate conditions and how this might affect the Great Lakes and coastal wetland habitat. The water level projections will be used to drive coastal wetland response models whose outputs will contribute to the identification and development of actions and strategies to enhance wetland resilience. Further information on the project can be found in the Habitat and Species Annex Chapter.

A project is underway to obtain a hindcasted precipitation reanalysis dataset back to 1980 based on the Canadian Precipitation Analysis (CaPA). CaPA helps to estimate precipitation even in areas with limited gauge and radar coverage and can provide accurate and consistent estimates of precipitation and surface state (including all major components and fluxes of the surface water cycle). This CaPA system is based on components of ECCC's operational weather and environmental prediction system, but it has been

modified in order to be able to simulate any period in time between 1980 and 2018. An initial reanalysis has been done for the years 2010 to 2014 and the results are currently being analyzed before starting the full 38 year run. This improved hindcast will allow for future climate change projections to be better calibrated to historical records including overlake precipitation and evaporation which are important climate components in the Great Lakes region.

Reanalysis: a scientific method for developing a comprehensive record of how weather and climate are changing over time by combining past observations with models to generate consistent time series of climate variables.

Hindcast: a way of testing a mathematical model by entering data for past events into the model to see how well the output matches the known results.

Parks Canada completed a Great Lakes regional climate change assessment for Canada's national parks and marine conservation areas. These protected lands and waters provide a [natural solution](#) for climate change by conserving biodiversity, protecting ecosystem services, connecting landscapes, capturing and storing carbon, as well as providing a place to build knowledge and understanding and inspire people to continue to mitigate adapt to the effects of climate change. More detailed site-specific vulnerability assessments are underway and are supported through an internally developed database that includes a literature review of more than 130 adaptation options specific to biodiversity. The database is not a prescriptive tool, rather it serves to provide examples that inspire and inform place-based actions.

ECCC produced a suite of climate indices based on statistically downscaled temperature and precipitation projections. These projections (e.g., changes in temperature extremes, precipitation intensity) will be made available online and will contribute to understanding future changes to climate conditions in the Great Lakes basin.

ECCC produced a drought indicator using climate projections from the Coupled Model Intercomparison Project Phase 5. This dataset will be used to inform changes in water availability and will be made available

to the public through the [Canadian Climate Data and Scenarios](#) site.

From 2016 through 2017, Ontario supported the building of climate change knowledge and capacity in 27 Great Lakes communities. Led by International Council for Local Environmental Initiatives – Local Governments for Sustainability, representatives from 16 municipalities were trained in the early stages of adaptation planning. Further, 12 municipalities were brought together to work on implementing adaptation actions such as low impact developments, a resilient home pilot, local improvement charges, and community engagement tools. Through this process, Ontario also supported the development of a [Climate Change Adaptation Strategy for the City of Thunder Bay](#) that provides direction for the City to develop new programs or practices where gaps exist and undertake the steps necessary to integrate climate adaptation as a core function within the organization.

In 2017 to 2018, Ontario developed a Great Lakes Basin Hydrologic Function Framework to enable the development of baseline conditions that will improve understanding of climate change impacts in the Great Lakes. The Framework consists of regional and local indicators of surface water, groundwater and land use.

Ontario also funded projects to develop high resolution regional climate projections in support of climate impact assessments on various sectors in Ontario and the Great Lakes basin since 2008. In 2018, these regional climate projections were updated with the latest Coupled Model Intercomparison Project Phase 5 data and distributed through the [Ontario Climate Data Portal](#).

In 2017, the OMNRF released [Naturally Resilient: MNRF's Natural Resource Climate Adaptation Strategy \(2017-2021\)](#), which provides a strategic framework that will enable the Ministry to fulfill its sustainable natural resource management mandate in a changing climate. This includes taking actions to mainstream adaptation into decision-making such as developing policy and technical guidance that considers climate change, building resilience of species and ecosystems such as combatting invasive species in the Great Lakes and inland waters, and undertaking research on climate change including examination of multiple stressors on aquatic ecosystems and Great Lakes-focused climate

vulnerability assessments.

The OMNRF also undertook various other scientific efforts relevant to climate change during this reporting period, including:

- Development of a decision support tool (model) to identify areas within the Great Lakes and Province of Ontario where the risk of aquatic invasive species is greatest. The framework, which incorporates climate change scenarios, coupled with projected changes in human distribution and pathways for dispersal of aquatic invasive species, will help understand how risk may change in the future.
- Development of a modelling tool to simulate and study how climate change may affect the development of Lakewide hypoxia (no oxygen) zones, which modify habitats and influence the population dynamics of important fish species in Lake Erie. The results of this project will help fishery managers assess current and future potential threats (i.e. climate changes and hypoxia conditions) to Lake Erie fish and fisheries.
- Research to understand potential vulnerabilities of hydrological processes and water balances to a changing climate for watersheds in the Great Lakes basin.
- Research assessing the adaptive potential (ecological and functional genetics) of lake trout and brook trout is showing that environmental temperatures experienced by adults influence offspring thermal physiology (metabolic rate, energy budget, gene expression, and temperature performance and preference) in both species.

Domestic Actions and Achievements (United States)

Supporting information sharing by educators, conservation professionals, natural resource managers, and outreach professionals - The Midwestern Regional Climate Center and NOAA's Great Lakes Regional Collaboration Team partnered to provide a 2018 Great Lakes Regional Climate Services Workshop on August 21 to 23 in Michigan. Topics for the Climate Services Workshop included regional climate services, hands-on experience with online tools, interactions with state climatologists and other climate services partners, and networking opportunities with neighboring offices. This workshop provided a forum for

building partnerships and a network among the various people and organizations across the Great Lakes Region that provide climate services and information in the region.

Sharing strategies and approaches for climate adaptation - In even-numbered years when the [National Adaptation Forum](#) is not occurring, regional forums are hosted across the United States to provide an opportunity for adaptation practitioners to come together. In 2016 and 2018, the [Great Lakes Adaptation Forum](#) brought together more than 150 scholars and practitioners in Ann Arbor, Michigan to share strategies and approaches to climate adaptation in an engaged learning program. The Great Lakes Adaptation Forum uniquely brings together partners from Canada and the United States to share lessons learned in our shared region.

Improving five-year water level forecasts - The USACE and the NOAA's Great Lakes Environmental Research Laboratory developed a method to produce a five-year Great Lakes water level forecast that includes downscaled [Coupled Model Intercomparison Project Phase 5 climate projections](#). This tool provides decision makers with a range of forecasted water levels driven by multiple forecasting models and methods.

Modeling sediment movement and ecosystem impacts due to intense storms in Lake Superior - The [Lake Superior National Estuarine Research Reserve](#) has operated a Sentinel Site located in Pokegama Bay, Lake Superior since 2013. With funding support from NOAA, this Sentinel Site includes: (1) a weather/meteorological station with instrumentation monitoring parameters such as temperature, relative humidity, precipitation, wind speed and direction; (2) a water quality sonde to measure water quality parameters such as pH, conductivity, temperature, turbidity, and dissolved oxygen; (3) surface elevation tables, which are devices for measuring the relative elevation change of wetland sediments; (4) permanent vegetation transects, which are permanent sampling plots along fixed transects to monitor vegetation; (5) geodetic vertical referencing benchmarks to provide a consistent and integrated reference surface for data analysis; and (6) an acoustic Doppler current profiler installation used to measure water current velocities. This site is now recording monthly water quality sampling for nutrients and chlorophyll. The primary goal is to understand sediment

movement and how sediment transfer is impacting nearshore marsh environments with increased frequency and intensity of storm events.

Sustaining Lake Superior tributaries in a changing climate - In a collaborative project supported by NOAA with Great Lakes Restoration Initiative funds, coastal managers in Minnesota's Lake Superior Coastal Program modeled current and future conditions in three test watersheds, resulting in the release of the report, [Sustaining Minnesota's Lake Superior Tributaries in a Changing Climate](#), which includes recommendations for protecting and preserving Lake Superior's streams. Other project partners included the University of Minnesota Duluth's Natural Resources Research Institute, The Nature Conservancy, and Minnesota Sea Grant. Work to hone and implement these recommendations is ongoing. The Lake's tributaries have some of the state's most economically significant cold-water trout habitats. The current threats of warmer waters, dwindling spawning habitat, and reduced stream connectivity, coupled with continuously changing climate and land use, have made the tributaries' aquatic life highly vulnerable.

State of Wisconsin climate service summit - NOAA conducted a Wisconsin State Climate Service Summit in June of 2018. This was a state focused meeting involving various NOAA entities including the National Weather Service, National Centers for Environmental Information, Great Lakes Integrated Sciences and Assessments (GLISA) partnership, Midwest Regional Climate Center and Sea Grant. The meeting was designed to bring federal, state, local and Tribal governments together to collaborate on climate service issues, including climate and drought monitoring, and value added regional and local services (interpretation, translation). The meeting produced a gap analysis which identified needs for better state climate office recognition, improvements to predictions at various scales, and better climate change information for adaptation responses. A similar summit will be conducted in Ohio in 2019.

Michigan Tribal climate adaptation workshop and extreme storm event vulnerability analysis - The Inter-Tribal Council of Michigan (ITCM) and the GLISA partnership hosted a Climate Adaptation Workshop in October 2016 for nine member Tribes of the ITCM. The workshop spanned over three days where participants shared insights and challenges regarding their

adaptation efforts, and they participated in a simulation where each participant was assigned a role to create a vulnerability assessment for a flooding scenario and decide as a community on adaptation actions. The workshop provided a much-needed opportunity for member Tribes to come together to share and discuss ongoing work and needs specifically for adaptation to climate change. As a result of the workshop, the GLISA partnership and five member Tribes applied for and received funding to apply the USEPA's [National Stormwater Calculator](#) to their reservations in order to better understand stormwater management and prepare for future extreme events. GLISA also worked with the Inter-Tribal Council of Michigan in 2018 to assess and address the susceptibility of Tribal communities to increased rainfall and extreme precipitation events on the lands of five Indigenous Tribes within the State of Michigan (Keweenaw Bay Indian Community, Lac Vieux Desert Band of Lake Superior Chippewa Indians, Grand Traverse Band of Ottawa and Chippewa Indians, Little Traverse Bay Bands of Odawa Indians and Saginaw Chippewa Indian Tribe of Michigan). The assessments will allow participating Tribes to identify vulnerabilities and consider potential best management practices specific to their infrastructure and aquatic resources. The assessments will also provide quantitative information valuable for seeking funding to implement the management practices assessed through this work.

Lac du Flambeau Tribe of Lake Superior Chippewa Indians climate vulnerability assessments - Building from past collaboration with Adaptation International, the GLISA is working with Adaptation International and the Lac du Flambeau Tribe of Lake Superior Chippewa Indians to help the Tribe with its Climate Vulnerability Assessment in 2018 and 2019. The climate information provided included historical observations and future projections of temperature, precipitation, and other variables around Lac du Flambeau, Wisconsin and the Great Lakes region. Project partners include International Council for Local Environmental Initiatives – Local Governments for Sustainability and Bullock & Haddow LLC, with funding support from the United States Department of Energy and the Federal Emergency Management Agency.

Bad River Band of Lake Superior Chippewa Indians hazard mitigation planning - GLISA worked with the Bad River Band of Lake Superior Chippewa Indians in

2018 to customize climate information for the Tribe's Federal Emergency Management Agency Hazard Mitigation Plan. Most of this information contained historical observations and future projections in the form of summary tables and maps for the Bad River Band reserved lands and the Great Lakes region.

Integrating Traditional Ecological Knowledge with climate vulnerability assessments - The Great Lakes Indian Fish and Wildlife Commission (GLIFWC) released Version I of a Vulnerability Assessment in April of 2018, which integrates Traditional Ecological Knowledge (TEK) with scientific research to assess the impact of climate change on treaty resources in the Ceded Territories of Minnesota, Wisconsin, and Michigan. This first version of the Vulnerability Assessment includes vulnerability data for eleven plant, fish, and animal species endemic to the Great Lakes region that were identified as culturally important by elders, harvesters, and knowledge holders from GLIFWC's 11 member Ojibwe Tribes. A second version, containing data on over 60 species, is slated for completion in 2019. In a collaborative project begun in 2017, GLIFWC Climate Change Program staff, with partners from the 1854 Treaty Authority, Inter-Tribal Council of Michigan, Michigan Technological University, College of Menominee Nation's Sustainable Development Institute, Keweenaw Bay Indian Community, Red Cliff Band of Lake Superior Chippewa, Lac du Flambeau Band of Lake Superior Chippewa, Northern Institute of Applied Climate Science, and the USDA Forest Service, continued working on a Tribal Adaptation Menu designed to facilitate climate adaptation in indigenous communities. This menu, based on similar NIACS forest adaptation menus, is also useful as a stand-alone resource and is designed to utilize indigenous culture, history, and knowledge to inform adaptation planning by Tribal staff and non-indigenous partner agencies. In workshops that were held in 2018, a draft version of the menu was used by GLIFWC and Tribal natural resources staff to evaluate wild rice, forestry, and fisheries adaptation projects. An initial version of the Tribal Adaptation Menu will be released in early 2019.



Science Annex

Overview

The purpose of the 2012 Canada-United States Great Lakes Water Quality Agreement's (Agreement) Science Annex is to enhance the coordination, integration, synthesis, and assessment of science activities.

Science provides the foundation for implementing management decisions, policies and programs. Science is conducted under this Annex and also through the work of the other issue-focused Agreement Annexes. Science and knowledge relevant to the Great Lakes is conducted and held by Federal, State/Provincial, Tribes, First Nations, Métis, and local governments, , as well as non-governmental organizations, and individuals. The Science Annex plays a critical role in coordinating Great Lakes science activities through efforts such as the Cooperative Science and Monitoring Initiative (CSMI) and reporting on ecosystem conditions and trends through the State of the Great Lakes (SOGL) report.

Annex Implementation

The implementation of this Annex was supported by a Subcommittee, co-led by the United States Environmental Protection Agency (USEPA) and Environment and Climate Change Canada (ECCC), with members from National Oceanic and Atmospheric Administration (NOAA), United States Army Corps of Engineers (USACE), United States Geological Survey (USGS), National Park Service (USNPS), Wisconsin Department of Natural Resources (WDNR), Agriculture and Agri-Food Canada (AAFC), Department of Fisheries and Oceans (DFO), Natural Resources Canada (NRCAN), Ontario Ministry of the Environment, Conservation and Parks (OMECP), Ontario Ministry of Natural Resources and Forestry (OMNRF), Conservation Ontario (CO), Grand River Conservation Authority (GRCA), and Chiefs of Ontario (COO). Additional organizations and experts

from research and academia and other organizations with Great Lakes science interests also participate.

Key Achievements

Over the last three years, the Annex subcommittee and its partners:

2017: Released the State of the Great Lakes 2017 Highlights and Technical reports; Implemented Cooperative Science and Monitoring Initiative field year in Lake Huron.

2018: Implemented Cooperative Science and Monitoring Initiative field year in Lake Ontario; Released Cooperative Science and Monitoring Initiative Lake Michigan 2015 Report.

2019: Developed the State of the Great Lakes 2019 Highlights and Technical reports to be released in 2019; Implemented the Cooperative Science and Monitoring Initiative field year in Lake Erie; Released Cooperative Science and Monitoring Initiative Lake Superior 2016 Report (projected).

Binational Actions and Achievements

2017 to 2019 Priority for Action: Implement the Cooperative Science and Monitoring Initiative to coordinate planning, delivery and reporting of science in relation to the specific priorities identified through the Lakewide Management process.

Cooperative Science and Monitoring Initiative

The **Cooperative Science and Monitoring Initiative (CSMI)** is a binational effort to coordinate Great Lakes

research and monitoring activities to provide Great Lakes resource managers with the science necessary to support management decisions. The CSMI follows a five-year rotating cycle in which for any given year there is an intensive CSMI field year focused on one of the Great Lakes. The emphasis on a single lake per year allows for coordination of research and monitoring activities focused on science priorities identified by the Lake Partnerships under the Lakewide Management Annex.

2016 Lake Superior CSMI Intensive Field Year

The preliminary findings from the 2016 CSMI intensive field year were reported at the International Association of Great Lakes Research Conference in 2017. Final results were shared at the State of Lake Superior Conference in the fall of 2018. A report summarizing the finding of the 2016 CSMI year will be released in 2019.

2017 Lake Huron CSMI Intensive Field Year

In 2016, the Lake Huron Partnership identified three overarching science priorities related to chemical contaminants, nutrients, and the lower and upper food web. In 2016-17, opportunities for addressing these science priorities were thoroughly evaluated by determining how ongoing and planned programs, as well as new science and monitoring projects, could contribute to the priorities.

Ongoing United States and Canadian long-term monitoring programs for contaminants, nutrients, lower foodweb, prey fish and fish communities substantially addressed the Lake Huron Partnership's three overarching science priorities. Other ongoing monitoring efforts also contributed to addressing the priorities, including GLRI-funded efforts to measure nutrient loads at two Lake Huron tributaries and monitor Saginaw Bay for nutrients, phytoplankton and algal toxins. In addition, new science and monitoring projects were initiated during the 2017 CSMI intensive field year to address other science priorities, including:

- A collaborative study by the USEPA, NOAA, and the USGS was undertaken to better understand young fish survival (the larval fish bottleneck), the spatial variation in plant and animal productivity (primary and secondary production), and limitations

on the growth of small fish (energetic stress on planktivorous fishes).

- The USGS in partnership with MDNR evaluated the efficiency and biases of non-traditional goby sampling techniques with the goal of arriving at the best suite of methods for quantifying goby abundance across a wide range of habitat types and at different times of year.
- USGS and USFWS performed an assessment of piscivore diets in Lake Huron.
- MDNR conducted a creel survey on the St. Marys River.
- NOAA conducted a year-long field experiment in four locations in Lake Huron to assess seasonal quagga mussel growth.
- MDEQ collected sediment samples near Saginaw Bay to assess dioxin concentrations in surficial and core sediments.
- ECCC assessed the health and deformities of herring gulls from Lake Huron colonies, plus chemical analyses of persistent organic pollutants.
- ECCC conducted lake-wide monitoring activities in Lake Huron to assess sediment and water quality.
- OMECP conducted nearshore surveys to analyze a variety of contaminants including mercury, polychlorinated biphenyls, dioxins/furans and emerging contaminants.
- OMECP conducted spatially-detailed (mapping) water quality surveys over the coastal fringe of eastern Georgian Bay and assessed coastal circulation in the nearshore waters of the Georgian Bay.
- OMNRF investigated the characteristics of early life history stages of Lake Whitefish in Ontario waters of Lake Huron.

The preliminary findings of these new science and monitoring projects were reported at the International Association of Great Lakes Research Conference in 2018. It is expected that final results will be shared at the State of Lake Huron Conference in the fall of 2019.

2018 Lake Ontario CSMI Intensive Field Year

In 2016, the Lake Ontario Partnership identified six overarching science priorities related to nutrients, Cladophora, the lower aquatic food web, fish dynamics, contaminants, and coastal wetlands. Later in 2016, the priorities were further refined at a binational Lake Ontario CSMI workshop, and approved by the

Partnership Management Committee. In 2017-18, opportunities for addressing these science priorities were thoroughly evaluated by determining how ongoing and planned programs, as well as new science and monitoring projects, could contribute to the priorities.

Ongoing United States and Canadian long-term monitoring programs and other planned monitoring projects for contaminants, nutrients, lower foodweb, prey fish and fish communities substantially address many of the Lake Ontario Partnership's overarching science priorities. New science and monitoring projects, funded under the Great Lakes Restoration Initiative (GLRI) and the Canadian Great Lakes Protection Initiative, were initiated during the 2018 CSMI intensive field year to address other science priorities, including:

- Intensive sampling of nearshore and offshore waters and tributaries for nutrients was conducted by USGS, ECCC, and local partners designed to support the Lake Ontario Partnership's goal of developing a whole-lake nutrient transport model to support future Annex 4 decision making regarding current Lake Ontario nutrient concentration and loadings targets.
- The 2018 CSMI intensive field year also leveraged ongoing work by USGS and ECCC to better understand the factors that control *Cladophora* growth in the nearshore zone using coordinated binational diver surveys.
- A whole-lake comprehensive benthic survey of historic stations was conducted by USEPA, Buffalo State College and NOAA. Physical samples as well as underwater images are currently being analyzed. NOAA GLERL also conducted a year-long field experiment to assess quagga mussel growth at three locations in eastern Lake Ontario.
- USEPA, USGS, DFO, NYSDEC and OMNRF conducted three coordinated seasonal lakewide assessments of Lake Ontario's lower foodweb including microbes, phytoplankton, zooplankton, mysids and larval fish.
- USGS in collaboration with the USFWS, Cornell University, OMNRF, and NYSDEC collected data to support on-going efforts to restore Lake Ontario native prey fish, a key goal in the Lake Ontario Biodiversity Conservation Strategy. The primary objectives of the study were to (1) enhance coregonid (a group of fish that include Cisco, Bloater, and Whitefish) abundance estimates; (2) characterize

habitats used by juvenile and adult coregonids; and (3) assess impediments to coregonid survival.

- USGS, NYSDEC, USFWS, OMNRF, SUNY Brockport and the University of Windsor conducted a collaborative study to evaluate lake trout reproductive health and dietary history using stable isotope and fatty acid signatures.
- An improved assessment of Lake Ontario coastal wetland plant communities, topography and bathymetry was conducted in 2018 through coordinated LIDAR/Hyperspectral aerial surveys and on-the-ground biologist assessments.

A Lake Ontario data synthesis workshop is planned for the summer of 2019.

2019 Lake Erie CSMI Intensive Field Year

In 2018, the Lake Erie Partnership identified three overarching science priorities related to nutrient load and cycling, the foodweb and contaminants. The nutrient priorities are inclusive of watershed and in-lake priorities to address eutrophication. In 2018-19, opportunities for addressing these science priorities were thoroughly evaluated by determining how ongoing and planned programs, as well as new science and monitoring projects, could contribute to the priorities. The Lake Erie Millennium Network also organized a CSMI Field Planning meeting in February 2019 to enhance the coordination of research and monitoring activities.

Ongoing United States and Canadian long-term monitoring programs for contaminants, nutrients, lower foodweb, prey fish and fish communities substantially address the Lake Erie Partnership's overarching science priorities. Other ongoing monitoring and research projects, including those funded by the Great Lakes Restoration Initiative and Canadian Great Lakes Protection Initiative, also address the priorities, including:

- assessing effectiveness of agriculture best management practices via edge-of field and downstream stream monitoring for sediments and nutrients;
- measuring nutrient loads;
- studying/forecasting the onset, scale and toxicity of harmful algal blooms;
- monitoring the extent of hypoxia; and
- determining the distribution of *Cladophora* and the

factors that drive its growth.

Many other new science and monitoring projects have been identified that address the priorities and researchers are working to fill the remaining scientific gaps.

2017 to 2019 Priority for Action: Issue the State of the Great Lakes reports (2017); continue to work to improve the suite of Great Lakes indicators.

State of the Great Lakes

The United States and Canada continue to maintain comprehensive, science-based ecosystem indicators to assess the state of the Great Lakes, anticipate emerging threats, and measure progress in relation to the Agreement's General and Specific Objectives. There are nine State of the Great Lakes indicators, which are supported by 45 sub-indicators. These indicators are aligned to, and help report progress on, the nine General Objectives of the Agreement.

In 2017, following the 2016 Great Lakes Public Forum, the State of the Great Lakes 2017 Highlights Report, Technical Report and a 4-page summary were released on www.binational.net.

Canada and the United States have worked to improve the sub-indicator reports to make them more comprehensive by including additional information and refinements, such as:

- Incorporating additional information on what is being measured and identifying any limitations of the data;
- Adding definitions for “Good”, “Fair”, and “Poor”, which are used to describe the status of an indicator, as well as definitions for “Improving” and “Deteriorating”, which are used to describe the indicator trend;
- Implementing 10-year and long-term trends across all Indicators where possible to bring improved consistency to trend assessments;
- Separating the Impacts of Aquatic Invasive Species sub-indicator into 2 reports to better address and report on rate of invasion and impact of invasive species (further described in the Aquatic Invasive Species Annex Chapter);
- Including Chemicals of Mutual Concern-focused assessments in the toxic chemical sub-indicator reports where possible (further described in the

Chemicals of Mutual Concern Annex Chapter); and

- Implementing an anomaly-based approach for the Climate Trend sub-indicator reports (further described in the Climate Change Impacts Annex Chapter).

In 2018, over 100 Great Lakes experts representing federal, provincial, state, and tribal governments, as well as academia and non-governmental organizations, participated in the 2019 reporting cycle by assembling and assessing relevant data and preparing draft sub-indicator reports. Nine scientific confirmation webinars were held in November 2018 to review the draft sub-indicator reports and confirm consensus on the sub-indicator reports and overall assessments.

Improvements enabling easier accessing of the State of the Great Lakes indicator and sub-indicator information on www.binational.net were completed in 2019. These improvements include allowing the user to more easily find the supporting information for each indicator, creating a more engaging and interactive user experience, and ultimately leading to a greater understanding by the public of the conditions and challenges in the Great Lakes.

The State of the Great Lakes 2019 Highlights Report will be released at the [2019 Great Lakes Public Forum](#) in June 2019, where information from the Highlights Report will be presented for discussion. The State of the Great Lakes 2019 Technical Report will be released later in 2019.

2017 to 2019 Priority for Action: Examine the application of open data, and data management and sharing for nutrients.

Data Management and Sharing

Over the 2016 to 2019 reporting period, an assessment tool was developed to assist Agreement practitioners in evaluating data-sharing platforms, which takes into consideration the design and usability of the platform of interest, how the content is managed, how functional it is, and how the platform is maintained. In addition, an inventory of almost 40 Great Lakes data systems and/or databases was developed.

Preliminary work was also undertaken under the Science Annex and the Nutrients Annex to identify the relevance and usability of both the data platform

assessment tool and the inventory of Great Lakes data systems.

2017 to 2019 Priority for Action: Increase understanding of Traditional Ecological Knowledge and opportunities for application to Agreement activities.

Traditional Ecological Knowledge

Traditional ecological knowledge (TEK) can offer profound historical and place-based observational knowledge about the health of local ecosystems and changes to fish, wildlife and other resources over time. A TEK Task Team was created under the Annex 10 Science Subcommittee to provide opportunity for both Indigenous and western knowledge to contribute to science in support of the Agreement. A United States caucus of the TEK Task Team has developed a draft summary paper to offer a common understanding of TEK, including how it is appropriately gathered and transmitted. The summary paper also includes examples of how TEK is currently integrated into natural resource management in the Great Lakes basin and provides suggestions about how TEK can be incorporated into work already occurring under the Agreement. The summary paper is expected to be finalized later in 2019.

Discussions have been ongoing with Indigenous organizations in Canada on how best to incorporate traditional ecological knowledge (TEK) in efforts to protect the Great Lakes. Most recently, ECCC supported a TEK symposium that brought together representatives from First Nations and First Nation organizations to discuss how TEK is currently being applied in activities to protect the Great Lake, as well as how to more effectively work with TEK when undertaking such activities.

Additionally, Canada and Ontario are supporting TEK-related projects led by First Nations and Métis communities and organizations that aim to build local capacity to address Great Lakes issues and better understand the state of the Great Lakes through existing domestic programs.

Domestic Actions and Achievements (United States)

Assessing bottom-dwelling organisms in the Great



USGS scuba divers collect *Cladophora* algae and zebra and quagga mussels at the bottom of Lake Huron. Credit: Meredith Nevers, USGS.

Lakes - Comprehensive assessments of total benthic community composition have been completed across Lakes Huron, Ontario, and Erie. These assessments, led by NOAA, Buffalo State College, and USEPA, will include total abundance of *Diporeia* and dreissenids for all sites, and abundance and diversity of other benthos (with a focus on oligochaetes and chironomids) for a subset of the sites. It will also include dreissenid mussel in situ field growth experiments to improve year-round estimates of mussel growth in an effort to better understand dreissenid population trends. Efforts will be made to better sample hard and rocky substrates using a combination of video surveys and diver-collected benthic samples.

Great Lakes *Cladophora* project - In 2018, an interagency federal research team led by USGS began a project to determine whether phosphorus can be reduced to a level that prevents nuisance growth of *Cladophora* algae. Information gathered by the team will be used to validate and expand existing ecological models and test the feasibility of managing *Cladophora* by limiting phosphorus inputs. This large-scale, complex effort was supported by the USEPA, National Park Service, state agencies, and universities and was carried out in sync with similar activities by ECCC in Lakes Erie and Ontario. During the summer growing season, numerous small research vessels were deployed across hundreds of miles in support of scientists and divers to collect samples each month in Lakes Michigan, Huron, Erie, and Ontario. Scientists examined the influence of nutrient concentrations and invasive zebra and quagga mussels on *Cladophora* growth. Even though 2018 seems to have been a low-growth season, initial results indicate a relationship between bottom water phosphorus concentration and *Cladophora* biomass.

Traditional Ecological Knowledge (TEK) in Canada

Through the Great Lakes Protection Initiative, Canada is supporting various First Nations and Métis community projects that include TEK components:

- The **Anishinabek Coastal Wetland Monitoring Project** is engaging Henvey Inlet First Nation community members in the development and implementation of a coastal wetland monitoring program that incorporates TEK. The program includes surveys of fish and plant populations, and monitoring of nutrient concentration and water chemistry in 40 wetlands. Community participants, including youth, will take part in data collection and report back to the community on results.
- The **Neyaashiinigiing Water Protection Program** is engaging community members of the **Chippewas of Nawash Unceded First Nation** in the development and implementation of a community focused water protection plan. The plan will focus on the waters of Lake Huron/Georgian Bay around the First Nation's traditional territory. Through the project, community members will gain a greater understanding of water protection and will have opportunities to participate in water cleanup activities.
- The **Pays Plat First Nation** is engaging its community members in the development of a database that will detail information on Lake Superior's nearshore waters, shorelines and wetlands in the First Nation's traditional territory. Capturing both TEK and western scientific information, the database will help the community identify and prepare for future local changes in the environment.

Under the 2014 Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health and with support from Environment and Climate Change Canada:

- The **Métis Nation of Ontario (MNO)** undertook the production of a Guidance Document for Integrating Métis Traditional Knowledge, to support Métis communities' participation in consultation activities and inform government on how policies, planning, projects and developments might impact Métis rights, interests and way of life.
- The **North Shore Tribal Council**, representing seven First Nations along the North Shore of Georgian Bay's North Channel, implemented a water study incorporating TEK in the planning and execution of a sampling program.

In addition, through funding support from Ontario, the M'Chigeeng First Nation held community events (an elders' workshop on water care-taking, a youth gathering on inheriting lakes and a technical seminar on water science) to increase the understanding of how TEK can be utilized to support Great Lakes protection. The knowledge shared was used to develop a Source Water Protection tool for the community.

Traditional Ecological Knowledge (TEK) in the United States

One example of the use of TEK in management decisions comes from Buffalo Reef, in the Keweenaw Bay. The reef is an important spawning habitat for whitefish and lake trout and is estimated to supply 23 percent of the Tribal commercial harvest of lake trout. In the late 1990s/early 2000s, Tribal fishermen began to express concern about the health of the reef based on changes they were seeing in the health and abundance of the lake trout and whitefish populations in that area compared to what they saw in years and generations past. The information led to GLIFWC to initiate a project in 2005 to obtain sonar imaging of the reef. This imaging showed that the reef was being covered by "stamp sands" (i.e., mining waste) that was dumped into Lake Superior and on its shoreline during the late 1800s and early 1900s. At present, approximately 35 percent of the reef is no longer viable because it is covered with an inch or more of stamp sands; modeling predicts that by 2025, 60 percent of the reef will no longer be viable for lake trout and whitefish spawning. After twelve years of interjurisdictional coordination, cooperative efforts by KBIC, GLIFWC, Michigan Tech University, the USGS, the USEPA, and the State of Michigan developed a short-term dredging and disposal plan. A task force has been developed to work on long-term plans for protecting the reef. If not for the initial information provided by Tribal fishermen, management agencies may not have investigated the reef for many more years, until the fish population was degraded to a significant degree.



Assessing bottom-dwelling organisms including Diptera and Dreissena, and other benthic organisms. Credit: USEPA.

The basin-wide Great Lakes Restoration Initiative-funded assessment will continue in 2019 which may prove to be a higher growth season. The data collected will be used in lakewide models to identify Cladophora management options that are not currently available to lake managers.

Science support for the restoration of prey fish in the Great Lakes - Managers in several of the Great Lakes have begun active restoration efforts of native prey

fishes (e.g., bloater, cisco) to provide a more diverse prey fish community to support key salmon and trout fisheries. The Great Lakes Restoration Initiative funds a multi-agency effort to provide science support to the restoration, guided by a basinwide adaptive management framework that secured binational and Tribal support in 2018 under the auspices of the Great Lakes Fishery Commission. One project has identified historical habitat for native prey fish species that can be used to identify priority habitat restoration sites and inform locations for potential supplemental stocking or reintroduction. Another project has used genetics to identify young native prey fishes (that are otherwise indistinguishable by visual inspection), such that their abundance, distribution, and recovery can be documented. A related project is studying gene expression to help delineate native fish population structure, which is a requirement of restoration planning. Finally, several studies are developing new field monitoring techniques targeting undersampled life stages of these native prey fishes. In total, the science support provided by these projects informs a common



Birds-eye rendering of the 65 percent engineering design of FishPass featuring an adaptive fish-sorting channel (right) and nature-like bypass channel (left). Fish passage and flow is ultimately regulated at FishPass by an arced-labyrinth weir (lower left) and dual hydraulic gate system (lower right). Credit: USACE, City of Traverse City, GLFC and AECOM.



Native preyfishes (e.g., bloater, cisco) sampled in a spring 2018 Grand Traverse Bay, Lake Michigan monitoring survey seeking to develop new techniques to index undersampled young life-stages. Credit: David Bunnell.

framework that seeks to ensure that limited native prey fish restoration dollars are wisely invested.

The selective bi-directional fish passage (FishPass) project - seeks to solve the tension between connectivity and invasive species control by developing solutions to provide up- and down-stream passage of desirable fishes while simultaneously blocking and/or removing undesirable fishes at a first-of-its-kind research facility located on the Boardman (Ottaway) River, Traverse City, MI. The lower-most barrier to fish movement on the river, the Union Street Dam, will be replaced with an adaptive fish-sorting channel to allow for optimization of an integrated suite of technologies and techniques for selective fish passage and invasive species control, and a nature-like river channel to convey river flows and accommodate public use. Once constructed, FishPass will be a world-class technology and research center paired with a restored nature-like channel in an urban center to tackle one of the greatest fishery management challenges of our time—selective fish passage. Led by the Great Lakes Fishery Commission, the design of FishPass has been a three year collaborative effort of over 50 fish passage experts, fish behavior and ecology experts, engineers, and hydrologists representing the City of Traverse City, the Grand Traverse Band of Ottawa and Chippewa Indians, the Great Lakes Fishery Trust, the MDNR, the USACE, the USFWS, the USGS, and collaborating academic institutions.

Domestic Actions and Achievements (Canada)

During this reporting period, Canada and Ontario continued to undertake research, monitoring and surveillance to support decision making under the Agreement and under the 2014 Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health.

Government of Canada's Open Data Initiative - The Government of Canada continues its commitment to open, accountable and transparent government through its 4th National Action Plan on Open Government 2018-2020. Its Open Government Portal provides one-stop access to the Government of Canada's searchable open data and open information. ECCC continues to contribute to the Data Catalogue and Federal Geospatial Platform of the Portal to make scientific research data accessible through open data and open maps. The past and current monitoring and several research data sets related to the Great Lakes are available from [the open data platform](#).

Freshwater Quality Monitoring and Surveillance Program - The Freshwater Quality Monitoring and Surveillance Program of ECCC conducts water quality surveys of nutrients and contaminants in water, sediment and aquatic biota in the open lakes, tributaries, Areas of Concern and in the connecting channels.

During 2017-2019, ECCC undertook a broad range of monitoring activities in the Great Lakes targeting water, sediment and fish. Water quality samples were collected routinely at these sites for physical and chemical water quality parameters such as temperature, pH, alkalinity, turbidity, major ions, nutrients and metals. Pesticides and additional parameters of concern were also monitored where site-specific water quality issues exist. Other work in the Great Lakes included monitoring a number of chemical pollutants, as well as the first basin-wide monitoring of flame retardants. ECCC also conducted water and sediment monitoring in some Areas of Concern to establish baseline conditions and measure the effectiveness of sediment remediation activities.

Monitoring under Canada's Chemicals Management Plan - ECCC conducted multi-media monitoring

(water, aquatic biota, precipitation and suspended sediment) at regular intervals to identify and report on status and trends of priority and emerging pollutants; and to measure progress towards risk management objectives. ECCC also conducted research for improved understanding of the sources, fate and impacts of harmful pollutants in the Great Lakes Basin.

Monitoring and applied research investigations were conducted on physical, chemical and biological sediment assessments in Areas of Concern, as necessary, to complete sediment management strategies and report on restoration of beneficial uses of the ecosystem.

Great Lakes Protection Initiative – As part of the Great Lakes Protection Initiative, ECCC conducts research, monitoring and modelling to support and assess management actions in the restoration of the ecological health of Lake Erie and its tributaries. ECCC is conducting monitoring and assessments of Canadian phosphorus loads to Lake Erie in order to assess and report on progress towards achieving targets. The ongoing monitoring and research contributes to the development of best management practices for phosphorus reductions in major watersheds of Lake Erie tributaries and contribute science to the development of the nearshore framework. ECCC has conducted science activities to enhance our understanding of the causal factors affecting the development of algal blooms in the Great Lakes and assess the effectiveness of phosphorus reductions on the prevalence of algal blooms and algal toxins.

ECCC is contributing to the assessment of the effects of climate change on nutrient loading and the ecological health of the Great Lakes by maintaining the existing long-term stations to obtain in-lake temperature, dissolved oxygen and other water quality parameters, and maintain bi-national evaporative network stations at selected locations. Using downscaled climate outputs from General Circulation Models and Lake models, ECCC is assessing climate change impacts (e.g., early spring, increased frequency of storm events, droughts) on the timing, quantity and quality of water, sediment and nutrient influxes to Lake Erie. ECCC is also identifying high pollutant upstream source areas (i.e. hotspots) and assess the impacts of combined effects of Best Management Practices and climate change on watershed nutrient loadings.

Canada-Ontario Science Workshop – In 2018, Canada and Ontario examined the science commitments and corresponding science activities of the Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health. Through the 2-day workshop, areas and issues where there is a need for additional data and information, as well as possible future science priorities were identified. In addition to the workshop, a science inventory of projects that have been led or funded by the Province of Ontario and/or the Government of Canada was created.

Supporting Innovative Solutions to Water Issues – The Government of Canada is supporting innovative solutions to using science and technology to address freshwater issues. The [AquaHacking Challenge](#) was established in 2015 with a mission to bring together people and organizations from the tech, environment, business, academia and government sectors to solve some of the water issues in the Great Lakes region. Water challenges are identified by water experts and potential end-users of the solutions, teams of young innovators are supported by mentors and coaches from various fields of expertise as they work to find solutions to a water issue, and selected teams are provided support to develop their innovative solution in incubators and accelerators. ECCC participated in the advisory committee for the 2017, 2018 and 2019 AquaHacking Challenges. ECCC is supporting the development of an evaluation framework model to measure the impact AquaHacking Challenges are having on the Great Lakes ecosystem, to encourage engagement of young innovators, and promote application in other freshwater systems across Canada.

Supporting Citizen Science – Through the [Great Lakes Protection Initiative](#), the Government of Canada is supporting the Great Lakes Communities Recreational Waters Monitoring Initiative – a four-year demonstration project to engage citizen scientists in water quality monitoring in Great Lakes beaches. The Initiative involves 6 pilot communities, including 3 First Nations communities, and is engaging 400 citizen scientists. Participants will contribute to the monitoring of Great Lakes water quality by collecting and analyzing samples from previously unmonitored local beaches to determine whether they are safe for swimming and other recreational use. The project will develop web-based tools to share water quality sampling results and

other information with the public through the [Swim Drink Fish Swim Guide app](#). Through this effort, citizens, including First Nations communities, will build capacity and be empowered to monitor, enjoy and protect their water by directly being engaged in water quality monitoring, data sharing and stewardship.

Fisheries Science – Ontario has continued to focus on the mechanisms behind the on-going decline in growth and production of Lake Whitefish in the Great Lakes basin. Many agencies (including OMNRF) involved in CSMI activities across the lakes have been investigating early life survival and distribution of coregonids (Lake Whitefish and ciscoes) in response to changes in the abundance and growth of different coregonid species and stocks among the lakes.