Ministry of Natural Resources and Forestry

Ontario

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State of resources reporting

August 2014

State of the Lake Huron food web

Lake Huron supports one of Ontario's most popular recreational fisheries and the second largest commercial fishery in the Great Lakes. Its watershed contains high-quality tributaries that are important for the survival of many species of fish.

Introduction

Lake Huron is a deep, cold and relatively unproductive lake. It lies in the middle of the Great Lakes watershed and has three distinct basins: the main basin, Georgian Bay and the North Channel. In terms of area, Lake Huron is the fourth largest freshwater lake in the world and the second largest of the Great Lakes. With 30,000 islands, it has the most shoreline of all the Great Lakes. One of the islands, Manitoulin, is the largest freshwater island in the world.

Historically, the deep, open waters of Lake Huron were dominated by lake trout, lake whitefish, burbot and several species of cisco. Nearshore areas and bays supported warm and cool-water species, such as walleye, smallmouth bass, yellow perch, lake sturgeon, northern pike and muskellunge.

The Lake Huron fish community has changed dramatically over the past century, largely due to changes in the food web resulting from the arrival of invasive species.

What is a food web?

All living things need food to give them energy for growth and survival. A food web illustrates feeding relationships (who eats whom) and energy flow among organisms in an ecosystem (Figure 1).

A food web groups organisms into levels based on their feeding position in the food web, known as "trophic levels." Within a food web, energy moves from lower to higher trophic levels. Producers form the first trophic level. They primarily get their energy from the sun. In aquatic ecosystems, phytoplankton (microscopic plants) are the producers.

The remaining trophic levels in the food web are occupied by consumers. Consumers eat other organisms to obtain energy. Primary consumers are herbivores; they eat plants. In the aquatic environment, zooplankton (microscopic animals) are an example of primary consumers. Secondary consumers, such as cisco and alewife eat primary consumers. Tertiary consumers occupy the next level of the food web and eat primary and secondary consumers. Examples of tertiary consumers from Lake Huron include lake trout, Chinook salmon, and walleye.

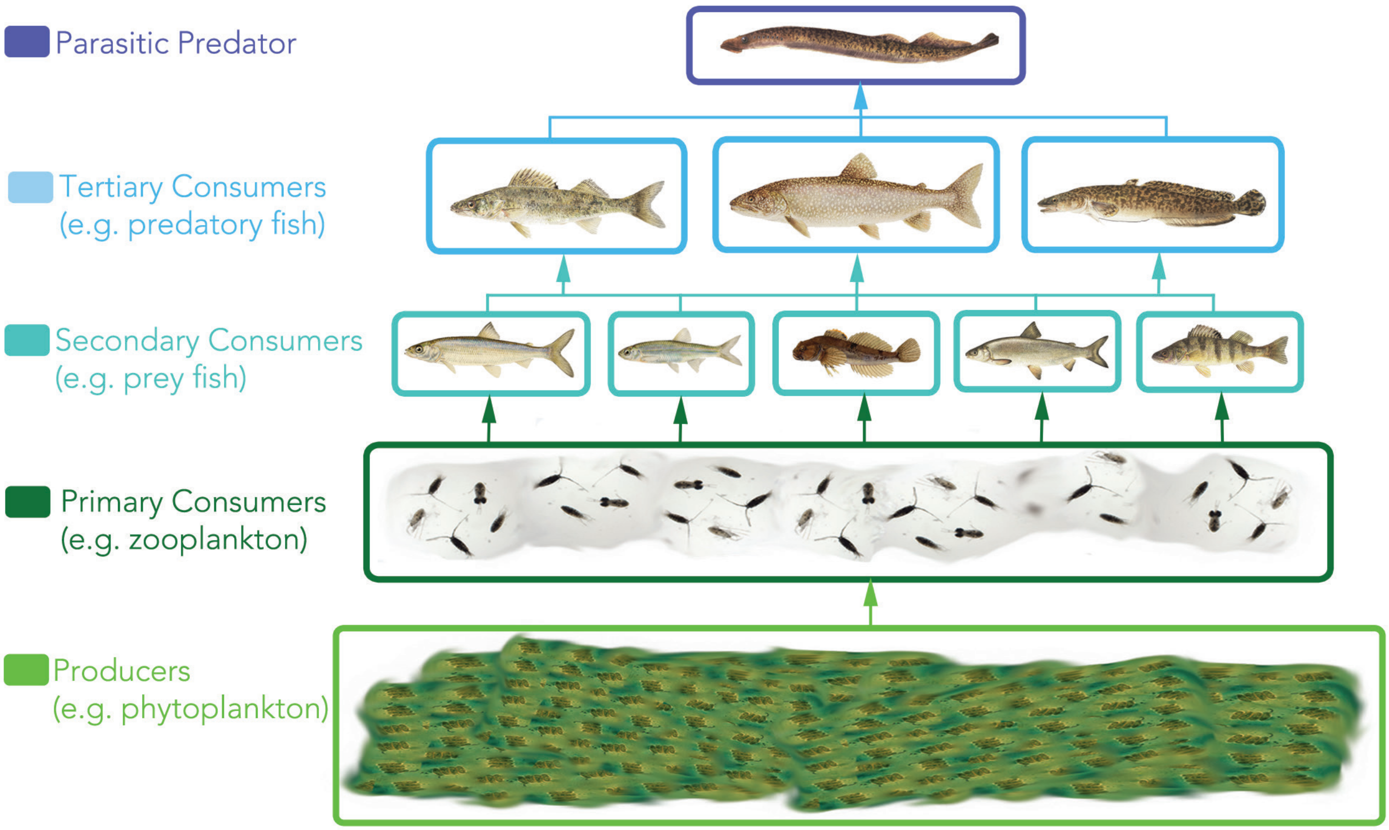

Figure 1: Simplified aquatic food web. Since energy is lost as it moves from one trophic level to the next, each level supports fewer organisms. Photos: E. Edmunson and H. Chrisp, New York Department of Environmental Conservation; G. Fahnenstiel; J. Liebig, NOAA GERL.

The state of the Lake Huron food web

Overview of major changes to Lake Huron's food web (1800s-2004)

The first major change to the Lake Huron ecosystem was the clearing of forests in the Great Lakes watershed in the mid-1800s by early settlers. Around the same time canals were made to connect waterways to ease transportation. By connecting formerly separated water bodies and facilitating the growth of the Great Lakes shipping industry, these canals allowed exotic invasive species to enter the Lake Huron ecosystem.

The arrival of sea lamprey, alewife, and rainbow smelt in the 1930s had a dramatic impact on Lake Huron's fish community composition (Figure 2). Lake trout, lake whitefish and cisco populations dropped significantly as a result of lamprey-induced mortality. With fewer fish to feed on them, non-native alewife and rainbow smelt populations increased to nuisance proportions.

What are exotic and invasive species?

Exotic species are organisms that are able to survive in areas outside their native habitats. Invasive species are exotic species that spread quickly and cause harm to the environment, the economy, or human health.

Restoration efforts for lake trout began in the 1960s with chemical control programs for sea lamprey, controls on overfishing, and lake trout stocking. Around the same time, Chinook and Coho salmon were introduced by the State of Michigan to control the overly abundant alewife and rainbow smelt populations and to create a recreational fishery on Lake Huron.

The Lake Huron fish community remained relatively stable from the early 1970s through to the early 2000s. Stocked trout and salmon supported popular recreational fisheries and were the dominant predators in the lake, while alewife was the most abundant prey fish. In the late 1990s, *Diporeia* (pronounced Dye-pore-eye-ah), an organism that historically formed the base of the food web, began to decline.

In 2003 the alewife population collapsed. Declines in zooplankton and *Diporeia*, attributed to zebra and quagga mussels, reduced the amount of food available for alewives, which led to a decline in their abundance. At the same time, salmon preyed heavily on the remaining alewives. Because chinook salmon fed almost exclusively on alewife, declines in the salmon population followed. By 2005, the Chinook salmon population had collapsed.

The current Lake Huron ecosystem

While Chinook salmon have suffered as a result of the alewife collapse, many native fish have benefited. For example, alewives had been inhibiting the natural reproduction of walleye. In the absence of alewife, walleye populations have increased across the lake, and have reached record levels in Saginaw Bay.

Lake trout have also benefited from the alewife collapse. This is because lake trout that eat a lot of alewife can develop a thiamine deficiency. Because thiamine is important for egg and fry development, low levels of thiamine can affect fish reproduction and survival. With few alewife left in the lake to feed on, natural reproduction of lake trout has increased.

The abundance, growth, and body condition of lake whitefish decreased shortly after the *Diporeia* decline. Lake whitefish have since turned to alternative food sources, including invasive mussels and the round goby. As a result, their growth and condition appear to be improving. Many other native species, including lake trout, burbot and walleye, have also exploited invasive species, particularly the round goby, as a food source since the alewife collapse.

Native prey fish species now make up a larger proportion of the lake biomass than in previous years. While no single species has filled the niche left by alewife, several native species, including bloater, yellow perch, cisco and emerald shiner have all experienced population increases. However, overall preyfish biomass has declined, creating a potential imbalance in the food web.

Current factors affecting the Lake Huron food web

There are approximately 185 exotic species in the Great Lakes and at least 10 per cent are considered to be invasive species. Almost all changes to the Lake Huron food web can be linked to invasive

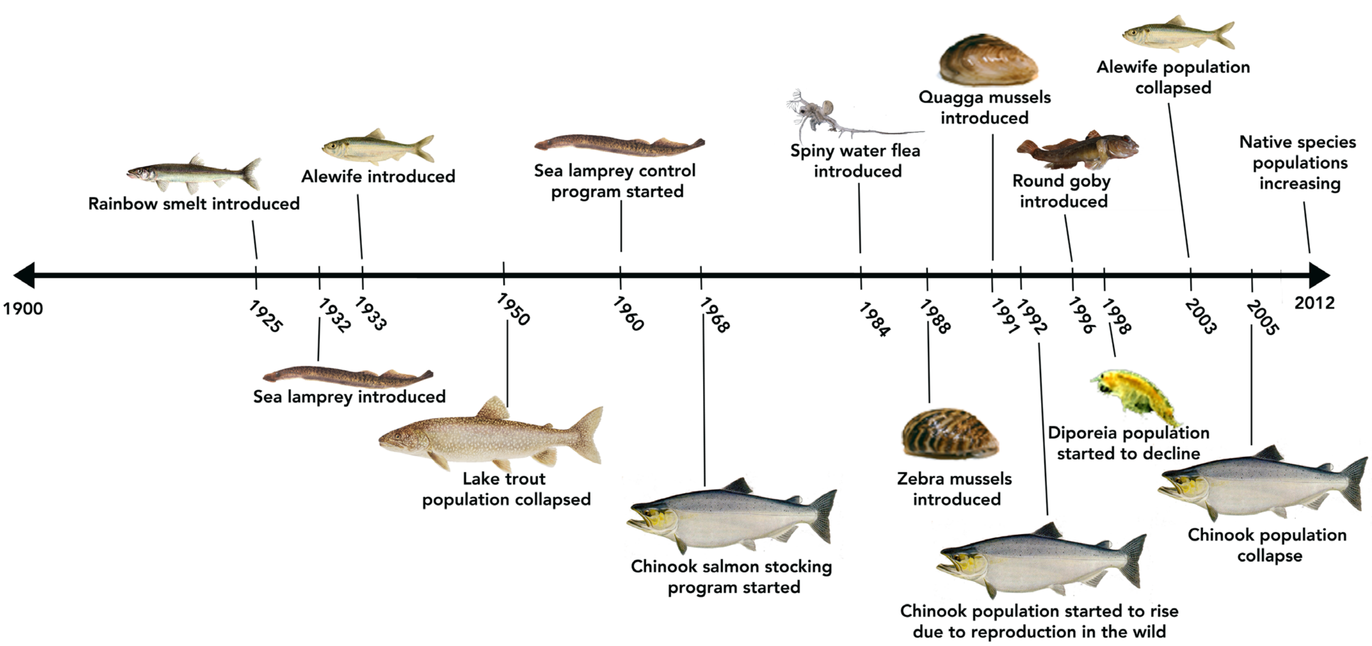

Figure 2: Timeline representing the sequence of major changes to Lake Huron's food web. Photos: E. Edmunson and H. Chrisp, New York Department of Environmental Conservation; Michigan Sea Grant; D. Copplestone; M. Quigley; P. Turko.

species. Key invasive species that have arrived relatively recently and are having serious impacts on the lake's ecosystem include zebra and quagga mussels, the spiny water flea, and the round goby. All four of these invaders arrived in the Great Lakes through ballast water. While sea lampreys are still prevalent in Lake Huron, intensive control efforts have reduced the impacts of lamprey predation on trout and salmon. The vulnerability of the ecosystem to invasive species is elevated by factors such as climate change, development, and previous exotic species introductions.

Tiny Diporeia has a big impact on Great Lakes food web

Diporeia, a tiny shrimp-like invertebrate, is one of the most important organisms in the Great Lakes food web (Figure 3). They are a key food source for many fish species, including lake whitefish. *Diporeia* have a high fat content and as a result are rich in calories and a good source of energy for fish.

Figure 3: *Diporeia* (actual size 7.8 mm). Photo: M. Quigley.

Diporeia are in a state of decline in all the Great Lakes except Lake Superior. The decline is thought to be related to the arrival and expansion of zebra mussels, although how mussels may be affecting *Diporeia* is not yet known. One theory is that invasive mussels out-compete *Diporeia* for available food.

Diporeia usually make up over 70 per cent of the living biomass in healthy lake bottoms. Their decline in the Great Lakes has negatively affected a variety of fish species that depend on them for food (Figure 4).

Figure 4: Following declines in *Diporeia*, many lake whitefish have showed signs of starvation. Photo: J. Hoyle, Ministry of Natural Resources and Forestry.

In 2007, a survey of Lake Huron's main basin showed that overall abundance of *Diporeia* had decreased by more than 90 per cent compared to 2000 (Figure 5). *Diporeia* are now completely gone or rare at lake depths of less than 90 metres and continue to decline at depths greater than 90 metres.

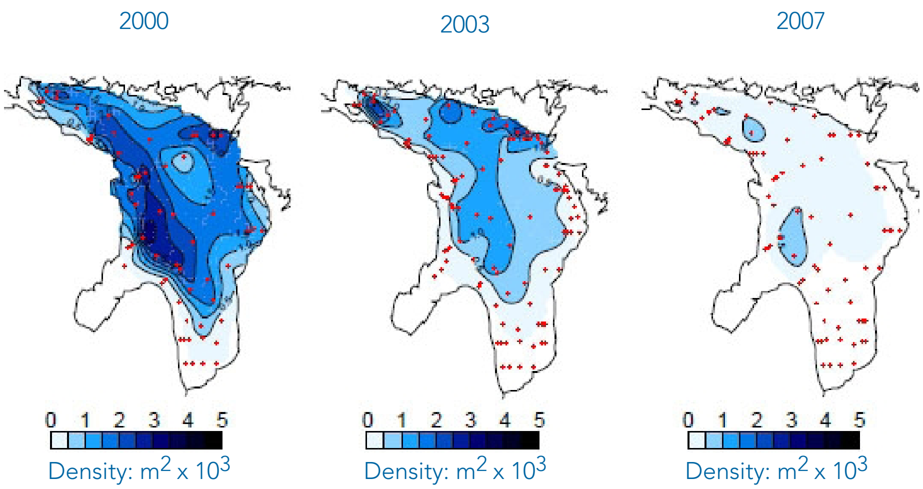

Figure 5: Distribution and abundance (number per square metre) of *Diporeia* in Lake Huron. Small crosses indicate sampling locations. Photo: National Oceanic & Atmospheric Administration Great Lakes Environmental Research Laboratory.

Figure 6: Quagga mussel (left) and zebra mussel (right). Photo: Michigan Sea Grant.

Zebra and quagga mussels

Mussels compete with native species for food

Zebra mussels and quagga mussels are both native to the Black Sea region of Eurasia (Figure 6). The invasive mussels are filter-feeders that remove large amounts of phytoplankton and suspended particles from the water. Phytoplankton is the primary source of food for many zooplankton species and small invertebrates, such as *Diporeia*. Because it forms the first level of the food web, the removal of large amounts of phytoplankton can disrupt the food web from the bottom-up.

Frenzied filtering restricts phosphorous movement

Phosphorous is a limiting nutrient for primary producers. However, excessive phosphorous increases the growth of aquatic plants and algae, which can result in toxic blooms of blue-green algae. Controls on phosphorous levels were implemented in the 1970s to address water quality issues and algal blooms fed by excessive amounts of phosphorous.

Today, despite lower phosphorous levels, algal blooms cloud the nearshore waters of Lake Huron (Figure 7). At the same time, the amount of phosphorous in the lake's open offshore waters has dropped. Researchers believe zebra and quagga mussels are to blame for the change in phosphorous dynamics. Zebra and quagga mussels absorb the nutrient when they filter water, and then excrete any excess phosphorous into the sediment. Since the mussels capture phosphorus as it enters the lake, much of the nutrient is retained along the lake's shallow shoreline, so there is less phosphorous available for the offshore food web. Reduced concentrations of phosphorous in the offshore waters of the lake limit productivity and reduce the food available to fish and other offshore species.

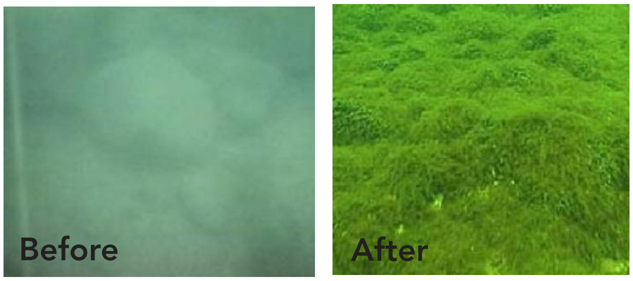

Figure 7: Changes in water clarity and algal growth before and after the invasion of mussels in Lake Huron. Photo: J. Janssen

Bird and fish die-off in southern Georgian Bay, Fall 2011

During the fall of 2011, thousands of dead birds and fish were found washed ashore in the southern part of Georgian Bay, particularly near Wasaga Beach (Figure 8). Samples sent to the University of Guelph for testing confirmed that this die-off was the result of Type-E botulism, a form of food poisoning that occurs when animals ingest the toxin produced by the bacterium *Clostridium botulinum* Type E.

Fish and bird die-offs from Type-E botulism are becoming more common in the Great Lakes. Researchers suspect that zebra and quagga mussels as well as round gobies play a role in promoting its spread. Mussels are thought to accumulate the toxin through filter-feeding and then pass it up the food web when they are eaten by fish. Round gobies feed heavily on zebra and quagga mussels. The infected gobies are in turn eaten by larger predatory fish and waterfowl, resulting in large die-offs.

Figure 8: Dead waterfowl at Wasaga Beach. Photo: J. Fisher, Ministry of Natural Resources and Forestry.

Round goby

The round goby is a small, bottom-dwelling fish native to the Caspian Sea (Figure 9). Gobies consume large quantities of invasive mussels and a variety of other organisms found on the lake bottom. They also eat several small, native fish species, as well as the fry and eggs of lake trout and walleye. In addition, round gobies are very aggressive and will chase other fish away from their feeding and spawning sites. The females spawn repeatedly during the summer months and can lay up to 5,000 eggs each time.

Their large appetite, aggressive behaviour, and rapid reproduction have allowed round goby populations to grow and spread quickly.

Figure 9: Round goby. Photo: G.A. Coker

Spiny water flea

The spiny water flea is a relatively large species of zooplankton that is native to northern Europe and Asia (Figure 10). It eats smaller species of zooplankton that are an important source of food for juvenile sport fish and small prey fish. Like many other invasive species, they reproduce quickly, which allows them to easily out-compete native species for food. Although many native fish species will eat spiny water flea, small fish (less than 10 centimetres long) that attempt to eat this water flea will cough it up because the tail spine gets caught in their throats.

Figure 10: Microscopic image of a spiny water flea.
Photo: J.Pokorny.

Management of Lake Huron

The Great Lakes span a large geographic area of both Canada and the United States. Since the signing of the Boundary Waters Treaty in 1909, the two countries have worked together to protect and manage the Great Lakes. The Great Lakes Water Quality Agreement, first signed in 1972 under the Boundary Waters Treaty, is an international agreement between Canada and the United States that sets out the overall commitments of both countries to restore and maintain water quality and aquatic ecosystem health.

Many restoration and recovery efforts have since been carried out, including the development of fish community and environmental objectives, lake wide management plans, and species-specific rehabilitation plans. This agreement was amended in 1978, 1987 and most recently in 2012 to address current and emerging issues affecting the Great Lakes.

Canada meets its international commitments by working collaboratively with ministries of the Ontario government under the Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem. This agreement identifies the roles and responsibilities of federal and provincial governments in the protection and restoration of the Great Lakes Basin. The Ministry of Natural Resources and Forestry and partners are responsible for managing the Great Lakes fishery, while the Ministry of the Environment and Climate Change's role is to protect and improve Great Lakes water quality.

One agency that plays an important role in managing Lake Huron and its fish community is the Great Lakes Fishery Commission. The commission was established by Canada and the United States in 1955 to coordinate the fisheries management activities of the Great Lakes. A guiding document, A Joint Strategic Plan for Management of Great Lake Fisheries, was developed to provide direction for fisheries management in the lakes. The Ontario Ministry of Natural Resources and Forestry is one of many participants in this plan and has a lead role in its implementation. Using direction provided by the plan, the ministry works with American agencies, the public and Aboriginal groups to:

- Protect and restore spawning and nursery habitats.
- Protect and rehabilitate nearshore fish habitats.
- Enhance and restore native species such as lake trout, lake sturgeon, and walleye.
- Protect and restore water quality.

Detailed information on how the ministry and its partners are moving towards achieving these goals can be found in the following documents:

- Fish-community objectives for Lake Huron
- Environmental objectives for Lake Huron
- Lake Huron Binational Partnership annual reports
- The sweetwater sea: An international biodiversity conservation strategy for Lake Huron
- Canada-Ontario Agreement respecting the Great Lakes Basin ecosystem (COA)

To keep up with the ever-changing Great Lakes ecosystem of today, management strategies must constantly adapt. Future management actions for Lake Huron will focus on protecting and restoring the food web, mitigating the impact of invasive species, and preventing new invasive species from entering the lake.

Outlook for the Lake Huron food web

Ongoing changes to the Lake Huron food web present new challenges for fisheries managers. Ecological changes that formerly occurred over decades are now happening in just a few years. Many questions remain unanswered, and researchers will continue to monitor the Lake Huron food web in an effort to understand this dynamic system. Because these changes are so profound and are happening rapidly, developing new strategies for managing Lake Huron will be an ongoing challenge for resource agencies. Since 2004, wild production of many native species has increased and the future for native species recovery appears bright.

What can you do to help?

- Help prevent the spread of aquatic invasive species through the Invading Species Awareness Program. www.invadingspecies.com
- Protect fish habitat. http://www.dfo-mpo.gc.ca/pnw-ppe/measures-mesures/index-eng.html
- Help the Ministry of Natural Resources and Forestry develop fisheries management strategies by participating in fisheries management zone councils.
- Respect current fishing regulations. https://www.ontario.ca/travel-and-recreation/ontario-fishing-regulations-summary
- Learn about climate change and the impacts on the Lake Huron ecosystem and food web by reading a summary of the effects of Climate Change on Ontario's aquatic ecosystems and the Ministry of Natural Resources Forestry's climate change website. https://www.ontario.ca/environment-and-energy/climate-change-and-natural-resources

Iroquois Bay – north channel, Lake Huron. Photo: D.M. Reid, Lake Huron manager, Ministry of Natural Resources and Forestry

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Related information

A joint strategic plan for management of Great Lakes fisheries
http://www.glfc.org/fishmgmt/jsp97.pdf

Environmental objectives for Lake Huron
http://www.glfc.org/lakecom/lhc/lheo.pdf

Fish community objectives for Lake Huron
http://www.glfc.org/pubs/SpecialPubs/Sp95_1.pdf

Lake Huron – Georgian Bay Watershed: A Canadian framework for community action
http://www.lakehuroncommunityaction.ca

State of resources reporting: Lake Trout in the upper Great Lakes
http://www.ontario.ca/environment-and-energy/lake-trout-upper-great-lakes

State of the Great Lakes 2005: What are the current pressures impacting Lake Huron?
http://binational.net/solec/English/SOLEC%202004/Indicator%20Summary%20Series/Lake%20Huron%20-%20tagged.pdf

The sweetwater sea: An international biodiversity conservation strategy for Lake Huron
http://www.conservationgateway.org/ConservationByGeography/NorthAmerica/wholesystems/greatlakes/Pages/lakehuron.aspx

More information

For more information on the status of the Lake Huron food web, please contact:

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ISBN Print 978-1-4606-4655-7
ISBN PDF 978-1-4606-4656-4