FISH COMMUNITY OBJECTIVES FOR LAKE ONTARIO

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Fishery Management Document 2017-01

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Great Lakes Fishery Commission
2100 Commonwealth Blvd., Suite 100
Ann Arbor, MI 48105-1563

FISH COMMUNITY OBJECTIVES FOR LAKE ONTARIO

Thomas J. Stewart[1], Andy Todd[2], and Steven LaPan

Citation (online): Stewart, T.J., Todd, A., and LaPan, S. 2017. Fish community objectives for Lake Ontario [online]. Available from: www.glfc.org/pubs/FisheryMgmtDocs/Fmd17-01.pdf [accessed 27 July 2017].

September 2017

ISSN 2576-1331 (online)

[1]**T.J. Stewart and A. Todd.** Lake Ontario Management Unit, Ontario Ministry of Natural Resources, 41 Hatchery Lane, Picton, ON K0K 2T0, Canada.
[2]**S. LaPan**. Great Lakes Fisheries Section, New York State Department of Environmental Conservation, Cape Vincent, NY 13618, USA.
*Correspondence (e-mail: info@glfc.org).

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EXECUTIVE SUMMARY[3]

This document updates the 1999 goals and objectives for the Lake Ontario fish community established by the Great Lakes Fishery Commission's (GLFC) Lake Ontario Committee (LOC). The document also confirms commitment to *A Joint Strategic Plan for Management of Great Lakes Fisheries* (GLFC 2007) and outlines common principles guiding the development and implementation of fish community objectives. A description of the Lake Ontario ecosystem and food web organizes the fish community into three components for which fish community objectives and status/trend indicators are specified: the nearshore, offshore pelagic, and deep pelagic and offshore benthic zones. Alewife (see Appendix A: Common and Scientific Names of Fish and Invertebrates) for an alphabetical list of common fish and invertebrates names and their corresponding scientific names) is the dominant fish species in Lake Ontario, and their response to ecological change and fisheries-management actions has the potential to change the structure and function of the Lake Ontario food web. Other potentially major influences on the food web, largely outside of the control of fish-management agencies, are nutrient inputs, invasive species, and climate change. The goal of fisheries management is to provide sustainable benefits to humans through the use of fish for food, recreation, culture, ecological function, and aesthetics by sustaining or increasing the abundance of desirable fish. Public consultation clearly indicates support for both a diversity of salmon and trout, dominated by trophy-sized Chinook Salmon, and protection and restoration of native species. The LOC acknowledges that managing for Alewife numbers to sufficiently support Chinook Salmon may limit restoration of some native species to their full potential. The Lake Ontario ecosystem is a mix of native and non-native species and has remained very resilient during the last 25 years. Despite an onslaught of invasions and rapid ecosystem change, Lake Ontario has provided a diversity of fish-related benefits. The LOC believes that maintaining a modest approach to stocking a diversity of trout and salmon species, the implementation of regulations to sustain a diverse mix of fisheries, continued efforts to protect and restore native species, and investing in monitoring and science-based assessment to understand ecosystem change are the best management strategies to ensure continuation of current and future benefits. The fish community objectives outlined here are, however, implicitly adaptive and will be subject to frequent review and change as the ecosystem evolves and our understanding of it improves.

[3]Complete publication including map of place names, other chapters, scientific fish names, and references is available at www.glfc.org/pubs/FisheryMgmtDocs/Fmd17-01.pdf.

INTRODUCTION[4]

Responsibility for Lake Ontario fisheries management is shared by the Ontario Ministry of Natural Resources (OMNR) for the Province of Ontario and the New York State Department of Environmental Conservation (NYSDEC) for the State of New York. As described in the Convention on Great Lakes Fisheries between the United States and Canada, Lake Ontario includes the St. Lawrence River from Lake Ontario to the 45th parallel of latitude, connecting waters, and any tributaries necessary to investigate fish stocks of common concern. Fish community objectives (FCOs) for the Lake Ontario fish community are to be established by the Lake Ontario Committee (LOC) and updated in accordance with *A Joint Strategic Plan for Management of Great Lakes Fisheries* (Joint Plan) (GLFC 2007). The LOC is composed of fishery managers from the NYSDEC and OMNR. The Joint Plan charged the LOC to define objectives for the fish community and to develop means for measuring progress toward their achievement. The LOC previously published FCOs for Lake Ontario in 1991 and 1999 (Kerr and Letendre 1991; Stewart et al. 1999).

The purpose of this document is to provide updated goals and objectives for management of the Lake Ontario fish community, excluding the St. Lawrence River. These objectives are also a starting point for discussions with management agencies, interest groups, and the general public for developing more-specific fisheries, habitat, and watershed management plans. In addition, these objectives will contribute to other management planning initiatives, for example, Remedial Action Plans and the Lakewide Management Plan for Lake Ontario. Scientific and common names of fish and invertebrate species appear in Appendix A: Common and Scientific Names of Fish and Invertebrates.

GOAL STATEMENT[5]

In *A Joint Strategic Plan for Management of Great Lakes Fisheries* (GLFC 2007), a common goal statement was developed for all Great Lakes fishery-management agencies:

> *To secure fish communities based on foundations of stable self-sustaining stocks, supplemented by judicious plantings of hatchery-reared fish, and provide from these communities an optimum contribution of fish, fishing opportunities, and associated benefits for*
>
> - *wholesome food*
> - *recreation*
> - *culture heritage*
> - *employment and income*
> - *a healthy aquatic environment*

[4]Complete publication including map of place names, other chapters, scientific fish names, and references is available at www.glfc.org/pubs/FisheryMgmtDocs/Fmd17-01.pdf.
[5]Complete publication including map of place names, other chapters, scientific fish names, and references is available at www.glfc.org/pubs/FisheryMgmtDocs/Fmd17-01.pdf.

GUIDING PRINCIPLES[6]

The following principles identify resource-management values common to the New York State Department of Environmental Conservation and Ontario Ministry of Natural Resources. The principles underpin the implementation of fisheries-management activities that support attainment of Lake Ontario's fish community objectives.

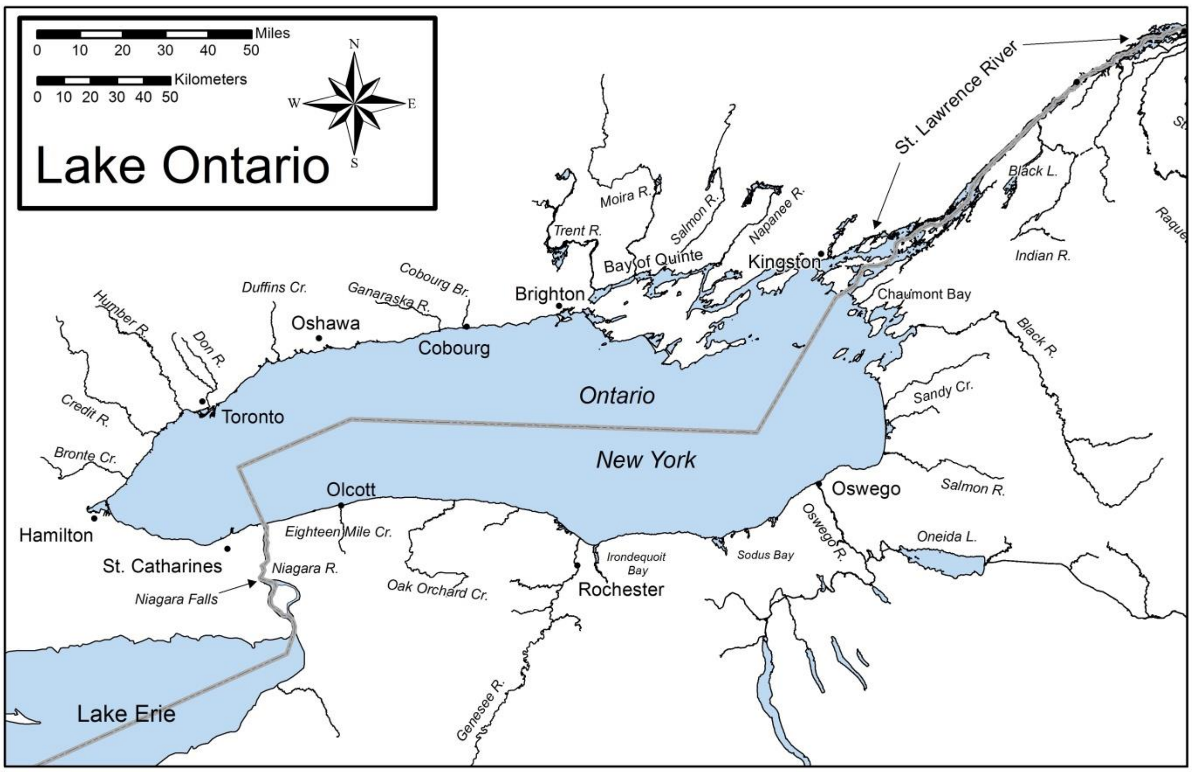
- The lake must be managed as a whole ecosystem because of the complex interrelationship of all species (including humans) and the environment
- Climate change is an important ecological influence that could both positively and negatively affect future Lake Ontario fish communities
- The public has a role to play in ensuring that healthy fish communities and fisheries are passed on to future generations
- Humans are part of the ecosystem—their actions can influence certain aspects of the ecosystem, but their ability to directly set its future course is limited; responsible management, therefore, must continually strive to better understand the structure, function, and limits of the ecosystem
- Stakeholders contribute critical biological, social, economic, and cultural information to fisheries-management agencies in support of fisheries-management decision making. With decision making comes a duty by stakeholders to share accountability and stewardship
- Managing a fish community requires a long-term perspective that recognizes short-term social, cultural, and economic requirements; human use that is not ecologically sustainable cannot yield sustainable economic benefits
- Protection and rehabilitation of fish communities and their habitats are the most-fundamental requirements for productive, long-term fisheries
- The amount of fish that can be produced and harvested from an aquatic ecosystem has ecological limits
- Self-sustaining native and naturalized species support diverse communities that can provide continuing social, cultural, and economic benefits over the long term
- Stocked fish can contribute to the ecological function of the fish community, support the rehabilitation of native fish species, and provide put-grow-take fishing opportunities
- Protecting and rehabilitating native and desirable naturalized species, including individual stocks, are important in supporting biodiversity
- Protecting and rehabilitating rare and endangered species are important for maintaining biodiversity
- Protecting and rehabilitating critical fish habitat, including tributary and inshore spawning and nursery areas, are required to sustain productive fisheries over the long term
- Determining how well the ecosystem is managed depends on the availability of timely scientific information provided through broad-based, long-term monitoring and research

[6]Complete publication including map of place names, other chapters, scientific fish names, and references is available at www.glfc.org/pubs/FisheryMgmtDocs/Fmd17-01.pdf.

DESCRIPTION OF LAKE ONTARIO[7]

Lake Ontario (Fig. 1) is the twelfth largest lake in the world, but it is the smallest of the Great Lakes. It has a surface area of 18,960 km^2 (7,340 mi^2) and a drainage area of 64,030 km^2 (24,720 mi^2). Of the lake's surface area, 52% is within the Province of Ontario, and the remainder is in the State of New York. Major urban industrial centers—Hamilton, Toronto, and Rochester—are located on Lake Ontario's shore. The New York shore is less urbanized and is not intensively farmed, except for a narrow coastal plain. Over 10 million people live in the basin, and nearly 67% reside in Ontario (Environment Canada and United States Environmental Protection Agency 2009). The Canadian population at the west end of Lake Ontario is the most rapidly expanding population in the Great Lakes basin. The population in this region has grown by over 40% in the last two decades, and it is projected to grow by an additional 3.7 million people (from 2001) by 2031 (Ontario Ministry of Public Infrastructure Renewal 2006). In New York, population density is highest in the Rochester and Syracuse-Oswego areas.

Fig. 1. Map of Lake Ontario.



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[7]Complete publication including map of place names, other chapters, scientific fish names, and references is available at www.glfc.org/pubs/FisheryMgmtDocs/Fmd17-01.pdf.

THE LAKE ONTARIO ECOSYSTEM[8]

The Lake Ontario ecosystem consists of the physical, chemical, and biological (including humans) components that interactively move among the nearshore and offshore zones of the lake and its watershed. The nearshore zone includes the shallower (in general, approximately <15-m water depth) exposed coastal zone and sheltered embayments. The offshore zone is the main body of the lake. Lake Ontario receives 86% of its water from the upper Great Lakes and Lake Erie via the Niagara River and drains to the St. Lawrence River. Dams on the St. Lawrence River regulate water levels. Human activities in the watershed produce a mixture of organic and inorganic materials (nutrients, bacteria, natural and man-made chemicals, etc.) that are carried by wastewater treatment plants, combined sewer overflows, and runoff water through tributaries to Lake Ontario. The water and materials can initially accumulate near input sources, but they are eventually mixed with the rest of the lake by waves and currents.

The nearshore and offshore zones have unique characteristics important to understanding the Lake Ontario ecosystem. In the nearshore zone, the lake bottom is often visible. Features in the coastal/lake interface may change as water levels and other conditions change seasonally. The nearshore zone is most accessible to humans for swimming and water withdrawal for drinking or industrial use. Aquatic plants, attached to the lake bottom, thrive in this zone because sufficient light reaches the bottom. Coastal wetlands in this zone are productive fish habitats, and their functioning is highly dependent upon adequate water levels. Many fish species use this zone for spawning and to support early life stages. However, water-level regulation has reduced the inter-annual range of water levels as well as altering the timing, magnitude, and duration of seasonal levels. These alterations to natural water-level cycles have reduced wetland-plant-community diversity (affecting fish habitat) and seasonal fish access to critical spawning habitats. Tributaries have their own resident fish communities, but many Lake Ontario fish species use tributaries for spawning and juvenile habitat.

The offshore zone contains most of the water and living components of the Lake Ontario ecosystem. The offshore zone is important habitat for Alewife and other prey fishes as well as trout and salmon and other cold-water fishes. The vast size and depth of this zone make it difficult to comprehend and appreciate. An important ecological feature of the offshore zone is its summertime organization into a warmer upper layer (epilimnion) and a deeper, cooler layer (metalimnion), which when combined can be considered the pelagic (open-water) zone. The upper layer receives the most light and nutrients and produces the free-floating algae or phytoplankton that supports all other forms of life in Lake Ontario. The deepest layer of water, below the metalimnion, is called the hypolimnion, and it sits overtop a large offshore bottom area in which fish and other benthic (bottom-dwelling) animals (mussels, worms, clams, amphipods, and shrimp) reside. This deeper area, including the bottom, is known as the benthic zone.

[8]Complete publication including map of place names, other chapters, scientific fish names, and references is available at www.glfc.org/pubs/FisheryMgmtDocs/Fmd17-01.pdf.

THE LAKE ONTARIO FOOD WEB[9]

The interacting living components in the nearshore, offshore pelagic, and benthic zones of Lake Ontario are referred to as a food web because they can be envisioned as a complex web of feeding relationships. Aquatic food webs are based on sunlight and dissolved nutrients in the water. In Lake Ontario, the most-influential nutrient is phosphorus. Phosphorus comes primarily from the upper Great Lakes/Lake Erie, watershed runoff, and direct discharge of wastewater (treated and untreated) into the lake. The rate of growth of aquatic plants and algae is determined primarily by the amount of phosphorus dissolved in the water and the amount of sunlight that penetrates into the water column (transparency). Some species of algae are attached to the lake bottom (benthic algae), whereas others are microscopic, free-floating forms (phytoplankton). Aquatic plants and algae provide habitat for fish and other aquatic animals. Living and dead algae are also food for bacteria and small animals that either live on the lake bottom (benthos) or swim in the water column (zooplankton). Larger zooplankton feed on their smaller counterparts, and zooplankton and benthos are important in the diets of fish, including Alewife, and for the early life stages of many fish species. Alewife and other prey fish provide food for larger fish predators. Many factors outside the direct control of fish-management agencies alter fish habitat or feeding relationships and can disrupt the food web, resulting in unpredictable and uncontrollable shifts in the fish community. In Lake Ontario, major food-web influences include nutrient inputs and invasive species (see Appendix B: Bibliography and Further Reading).

Improved wastewater treatment programs have enhanced Lake Ontario's water quality, and phosphorus levels have been declining in the offshore zone. Currently, the nutrient and algae levels in offshore Lake Ontario are characteristic of an oligiotrophic (low productivity) system. Invasive dreissenid (zebra and quagga) mussels are efficient filter-feeders, removing large amounts of phytoplankton from the water column and re-directing this energy source away from zooplankton and fish. Dreissenid mussels feeding on phytoplankton also results in increased water transparency/light penetration and may also increase dissolved phosphorus levels in the nearshore zone. Both increased transparency and increased dissolved phosphorus levels may explain the observed increase in growth of aquatic plants and benthic algae in the nearshore zone causing fouled shorelines or clogged water intakes in some areas. In contrast, the decline of phosphorus and phytoplankton in the offshore has caused declines in the abundance of zooplankton and prey-fish species, including Alewife.

The Great Lakes, including Lake Ontario, have had a long history of species invasions. Invasive species colonization has resulted in dramatic ecosystem disruptions and has increased the levels of uncertainty in our understanding of the Lake Ontario food web. Recent invasions include the dreissenid mussels, two species of invasive predatory zooplankton (spiny water flea and fishhook water flea), Round Goby, bloody red shrimp, Tubenose Goby, and Viral Hemorrhagic Septicemia virus (VHSv). Invasives often cause changes in the ecosystem that can be rapid and difficult to understand and often (but not always) negatively impact desired species. Invasive species are most often impossible to eradicate or control once they are established.

The invasion of dreissenid mussels has resulted in increased water clarity and has changed the way nutrients are cycled in the nearshore and offshore zones. The dreissenid mussels invasion also coincided with the loss of the native offshore deepwater amphipod (small, shrimp-like animal), *Diporeia* spp., in large areas of Lake Ontario, although the mechanism of this decline has not been established. *Diporeia* spp. played an important role in the offshore food web at one time providing an abundant source of food for young Lake Trout and Lake Whitefish and deepwater cisco species (now absent from the lake).

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[9]Complete publication including map of place names, other chapters, scientific fish names, and references is available at www.glfc.org/pubs/FisheryMgmtDocs/Fmd17-01.pdf.

Invasive predatory zooplankters are now integrated into the food web and eat smaller native zooplankton while also providing an alternative food source for Alewife and other fish. Alewife predation on invasive predatory zooplankton can suppress their numbers and reduce their potentially disruptive impact on the food web. Round Goby has become a dominant nearshore prey species and has expanded offshore. Round Goby feed on dreissenid mussels and is a common diet item for most nearshore fish predators and, to some degree, in the offshore as well (e.g., Lake Trout). While no definitive evidence exists to substantiate the negative effects of Round Gobies on the Lake Ontario fish community, they may be involved in the transfer of type E botulism upward through the food web, resulting in fish and wildlife die-offs. The bloody red shrimp is a recent invader and continues to expand its range, but the future food-web consequences of its presence are unknown.

VHSv was first documented in Lake Ontario in the Bay of Quinte in 2005 where it was linked to a large-scale die-off of Freshwater Drum (Lumsden et al. 2007). Vulnerability to VHSv appears to be highly variable among fish species with some species apparently unaffected but acting as carriers of the virus. Other noteworthy VHSv mortalities include Muskellunge (2005 and 2006 in the Thousand Islands) and Round Gobies (2006 and 2007). Whereas large-scale die-offs of sport fish in Lake Ontario have not been documented, it is possible they have been undetected. In addition, physiological stressors (temperature, poor condition, spawning stress, and other fish pathogens) in a fish population could trigger VHSv related mortality.

THE LAKE ONTARIO FISH COMMUNITY AND FISHERIES[10]

Early changes to the Lake Ontario fish community are well documented (see Appendix B: Bibliography and Further Reading). Prior to European colonization, Atlantic Salmon, Lake Trout, and Burbot were the most-abundant top predators in offshore waters. Lake Whitefish, Lake Herring, and Slimy Sculpin were abundant in shallower, offshore waters while four species of deepwater ciscoes and Deepwater Sculpin were abundant in deeper, offshore waters. In warmer, nearshore areas, Yellow Perch, Walleye, Northern Pike, American Eel, and Lake Sturgeon were abundant and supported important fisheries, and Emerald Shiners and Spottail Shiners were important prey fishes. The likely major factors leading to destabilization of the historical fish community were habitat loss or degradation, overfishing, interactions with invasive Alewife and Rainbow Smelt, and predation by Sea Lamprey. By the 1970s, Atlantic Salmon, Lake Trout, Burbot, Deepwater Sculpin, deepwater ciscoes, and Lake Sturgeon had either disappeared or their populations had substantially decreased in abundance, whereas the abundance of invasive Alewife, White Perch, and Rainbow Smelt had increased.

Currently, the Lake Ontario fish community is a mix of non-native and remaining native species. Native species are defined here as those that maintained self-sustaining populations in Lake Ontario prior to European colonization of the watershed. Non-native species are those that were intentionally introduced after European colonization or those that entered the system unintentionally (invasives). Non-native fish species intentionally introduced to Lake Ontario include Brown Trout, Coho Salmon, Rainbow Trout, and Chinook Salmon. All of these species have become "naturalized" (naturally producing young wild fish to varying degrees). Invasive fish species include Alewife, Rainbow Smelt, White Perch, Common Carp, Round Goby, Tubenose Goby, and possibly Sea Lamprey.

Pacific salmon (mainly Chinook and Coho Salmon) were stocked beginning in 1968 to suppress an over-abundant Alewife population, provide a recreational fishery, and restore predator-prey balance to the fish community. Efforts to rehabilitate the fish community continued in the early 1970s. To rehabilitate native Lake Trout, stocking was increased, and Sea Lamprey control (treating tributaries with lampricide and preventing upstream movement of adults) was initiated. Currently, additional management initiatives are underway to protect and enhance existing populations of native Lake Sturgeon and American Eel. Adult transfers from existing populations of Walleye and Lake Herring are ongoing or being proposed to expand their populations to other regions of Lake Ontario. Following a period of research that confirmed feasibility, efforts to restore Atlantic Salmon in the Province of Ontario increased in intensity and scope with the launch of a major public/private partnership in 2006. New York State continues to stock Atlantic Salmon to support restoration and a put-grow-take recreational fishery. To diversify the offshore prey-fish community, technical options are being evaluated to enable the successful reintroduction of native deepwater ciscoes. Native Deepwater Sculpin and Threespine Stickleback have shown some signs of recovery without direct management intervention.

The Lake Ontario fish community supports sustainable recreational, commercial, and aboriginal fisheries (see Appendix B: Bibliography and Further Reading). The warm-water recreational fishery is concentrated in the nearshore and embayments and primarily targets Walleye, Largemouth Bass, Smallmouth Bass, Yellow Perch, sunfish, Northern Pike, and Muskellunge. Fisheries for Lake Sturgeon are closed in New York and Ontario due to low abundance. The New York State Department of Environmental Conservation closed American Eel fisheries in 1982 due to high contaminant levels, and the Ontario Ministry of Natural Resources closed eel fisheries in 2005 due to low abundance. The offshore recreational fishery largely targets Chinook Salmon and Rainbow Trout and takes advantage of other less-common species of trout and salmon. A seasonal tributary

[10]Complete publication including map of place names, other chapters, scientific fish names, and references is available at www.glfc.org/pubs/FisheryMgmtDocs/Fmd17-01.pdf.

fishery primarily targets Chinook Salmon and Rainbow Trout during staging and spawning runs. The commercial fishery is concentrated in eastern Lake Ontario’s nearshore and embayments. The major species commercially harvested are Yellow Perch, sunfish, Lake Whitefish, Brown Bullhead, Northern Pike, and Walleye. The aboriginal fishery is concentrated on Walleye in the Bay of Quinte and its tributaries.

THE CHALLENGE AND RISKS OF MANAGING FISH COMMUNITIES[11]

The goal of fisheries management is to provide sustainable benefits to humans through the use of fish for food, recreation, culture, ecological function, and aesthetics by sustaining or increasing the abundance of desirable fish. These goals are achieved by regulating fishery harvests, fish stocking, reducing Sea Lamprey numbers, protecting/restoring and creating fish habitat, reducing disease transfer and spread, and reducing the influence of Double-crested Cormorants (*Phalacrocorax auritus*) in New York waters. Fish-production potential (maximum abundance and growth) in Lake Ontario is determined by a number of factors, including phosphorus concentration, the structure of the food web (including phytoplankton, zooplankton, and benthic communities), the impacts of invasive species on feeding relationships in the food web, survival of stocked and naturally produced fish, numbers of Double-crested Cormorants, water-level regulation impacts on fish-spawning and nursery habitats, and recreational and commercial fish harvest. There is also a high degree of interconnectedness among the many factors that influence Lake Ontario's capacity to produce fish and also a high degree of uncertainty in our understanding of the relationships between these factors and how ecological changes will affect different elements of the lake's food web. For example, increasing phosphorus levels with the intent of producing more offshore phytoplankton, zooplankton, and Alewife to produce more Chinook Salmon could result in only more nearshore nuisance benthic algae and more and/or larger dreissenid mussels. Ecological uncertainty is also potentially exacerbated by the impacts of climate change.

Alewife is the dominant prey-fish species in Lake Ontario, and their response to ecological change and fisheries-management actions has the potential to change the structure and function of the Lake Ontario food web. The historic loss of several native prey species means Alewife are the dominant food of many top predators, particularly Chinook Salmon. Alewife feed primarily on zooplankton, including the invasive fishhook water flea and spiny water flea, and likely prevents these species from becoming over-abundant, but Alewife also consume large amounts of zooplankton that is important food for other fish. Alewife also eat the young of native Lake Trout and compete with or prey directly upon the young of many native species, including Yellow Perch. Bacteria in the digestive tracts of Alewife produce thiaminase, an enzyme that destroys thiamine (vitamin B1) causing a thiamine deficiency in fish that eat Alewife. The impacts of thiamine deficiency vary among fish species that eat Alewife, and can range from impaired natural reproduction (Lake Trout) to mortality of adult fish (Atlantic Salmon).

Alewife are also prone to dramatic population changes that can result from environmental conditions (prolonged, cold, winter conditions), excessive predatory pressure (too many salmon and trout), inadequate food supply, or combinations of these. In both Lake Michigan (1980s) and Lake Huron (2000s), Alewife declined to very-low levels of abundance. The decline was more gradual in Lake Michigan but very abrupt in Lake Huron. The prey-fish communities of both lakes are more diverse than that of Lake Ontario, but the decline of Alewife in these ecosystems produced dramatic results. In both lakes, Alewife dependent species like Chinook Salmon declined, and Rainbow Trout, with a more-diverse diet, increased. In Lake Huron, the abundance of Lake Trout, Walleye, and Lake Herring increased after Alewife declined, suggesting Alewife were limiting their production. The dominance of Alewife in the Lake Ontario food web and its ability to both positively and negatively affect the Lake Ontario fish community means that fisheries-management actions that may impact Alewife are unpredictable and have risks.

Public consultation very clearly indicates that stakeholders greatly value both the diversity of Lake Ontario's salmon and trout fisheries and an abundance of trophy-sized fish. In addition to the strong interest in

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[11]Complete publication including map of place names, other chapters, scientific fish names, and references is available at www.glfc.org/pubs/FisheryMgmtDocs/Fmd17-01.pdf.

maintenance of the salmon and trout fishery, many stakeholders support protection and restoration of native species, including expansion of their ranges and achieving an increased role for wild fish. Alewife are required in sufficient abundance to provide food for salmon and trout, especially Chinook Salmon, but, as previously noted, abundant Alewife suppress production of many native fish species.

Currently, the growth and condition of Chinook Salmon and the record high angling catch rates for trout and salmon suggest that recent stocking levels and natural reproduction are sufficient to maintain a quality fishery without putting excessive predation pressure on Alewife. In the absence of any further sustained change in growth or condition of Chinook Salmon, the Lake Ontario Committee (LOC) has agreed to maintain trout and salmon stocking at approximately (+ 5%) current levels (see Appendix C: New York and Ontario Stocking Policy by Species and Life Stage) in an attempt to sustain Alewife and maintain predator-prey balance. Deviations from these policies will only be considered based on mutual agreement by the New York State Department of Environmental Conservation and Ontario Ministry of Natural Resources in consultation with stakeholders.

The LOC will continue with programs to protect and restore native species with an emphasis on Lake Trout, Atlantic Salmon, American Eel, Lake Sturgeon, Lake Herring, Round Whitefish, Deepwater Sculpin and deepwater ciscoes. The LOC recognizes that maintaining sufficiently abundant Alewife to support a quality salmon fishery may limit the capacity to restore some of these species to their full potential.

Despite maintaining current levels of salmon and trout stocking, there is a substantial risk that ecosystem change could cause a severe decline in Alewife populations similar to what happened in Lakes Michigan and Huron. The food-web and fish-community consequences of a severe decline in Alewife in Lake Ontario are impossible to predict. Experience in Lakes Michigan and Huron suggests that Chinook Salmon populations would decline, whereas other salmon and trout species may do better, and native species, such as Walleye, Lake Trout, and Lake Herring, may benefit. The LOC acknowledges the unpredictability and risk associated with such an outcome.

The Lake Ontario ecosystem is a mix of native and non-native species and has remained very resilient during the last 25 years. Despite an onslaught of invasions and rapid ecosystem change, Lake Ontario has provided a diversity of fish-related benefits. The LOC believes that maintaining a modest approach to stocking a diversity of trout and salmon species, the implementation of regulations to sustain a diverse mix of fisheries, continued efforts to protect and restore native species, and investing in monitoring and science-based assessment to understand ecosystem change are the best management strategies to ensure the continuation of benefits. The fish community objectives outlined here are, however, implicitly adaptive and will be subject to frequent review and change as the ecosystem evolves and our understanding of it improves.

LAKE ONTARIO FISH COMMUNITY GOALS AND OBJECTIVES[12]

The Lake Ontario Committee endorses the following objectives for the three major components of the Lake's fish community. We acknowledge that some fish species cannot be categorized as occupying only one ecological zone (e.g., nearshore, offshore); however, we have done so in the interest of simplicity. The objectives are not presented in order of priority. Indicators provide insight into whether or not progress is being made towards achievement of objectives. Two types of indicators are used to assess and report on the achievement of fish community objectives and apply to both New York and Ontario waters of Lake Ontario unless otherwise noted:

1. Progress indicators are useful to assess advances towards achieving longer term fish-population objectives where the desired fish population does not currently exist. It may take decades before status/trend indicators will be useful.

2. Status/trend indicators are used to assess fish communities that currently exist or are expected to develop in the short term through management actions.

1.0 Nearshore Zone Goal

Protect, restore, and sustain the diversity of the nearshore fish community, with an emphasis on self-sustaining native fishes, such as Walleye, Yellow Perch, Lake Sturgeon, Smallmouth Bass, Largemouth Bass, sunfish, Northern Pike, Muskellunge, and American Eel.

Nearshore Zone Objectives

1.1 Maintain healthy, diverse fisheries—maintain, enhance, and restore self-sustaining local populations of Walleye, Yellow Perch, Smallmouth Bass, Largemouth Bass, sunfish, Muskellunge, and Northern Pike to provide high-quality, diverse, fisheries.

Status/trend indicator:	Maintaining or increasing fisheries, populations and recruitment of Walleye, Yellow Perch, Northern Pike, and bass.

1.2. Restore Lake Sturgeon populations—increase abundance of naturally produced Lake Sturgeon to levels that would support sustainable fisheries.

Progress indicator (within the next 20 years):	Increasing abundance of Lake Sturgeon.
Progress indicator (long term):	Progress in establishing at least 750 sexually mature Lake Sturgeon re-established in at least four historical spawning areas, such as Amherst Island Shoal, Don River, Ganaraska River, Napanee River, Salmon River, and Trent River.

[12]Complete publication including map of place names, other chapters, scientific fish names, and references is available at www.glfc.org/pubs/FisheryMgmtDocs/Fmd17-01.pdf.

1.3. Restore American Eel abundance—increase abundance (recruitment and escapement) of naturally produced American Eel to levels that support sustainable fisheries.

Progress indicator:	Increasing levels of recruitment to the upper St. Lawrence River/Lake Ontario as measured at the Moses-Saunders Dam eel ladders with a long-term target of at least one million eels ascending the ladders annually.
Progress indicator:	Increasing escapement of silver-phase female eels from the St. Lawrence River with a long-term target of at least 100,000 silver-phase eels escaping annually.

1.4. Maintain and restore native fish communities—maintain and restore native nearshore fish communities.

Status/trend indicator:	Maintaining or increasing native-fish species richness and diversity in nearshore areas and embayments.

2.0 Offshore Pelagic Zone Goal

Maintain the offshore pelagic fish community that is characterized by a diversity of trout and salmon species, including Chinook Salmon, Coho Salmon, Rainbow Trout, Brown Trout, and Atlantic Salmon, in balance with prey-fish populations and lower trophic levels.

Offshore Pelagic Zone Objectives

2.1 Maintain the Chinook Salmon fishery—maintain Chinook Salmon as the top offshore pelagic predator supporting trophy recreational lake and tributary fisheries through stocking, accounting for natural reproduction.

Status/trend indicator:	Maintaining Chinook Salmon average growth and condition at or above levels observed during 2007.
Status/trend indicator:	Maintaining or increasing catch rates of Chinook Salmon in the lake and tributary fisheries.

2.2 Restore Atlantic Salmon populations and fisheries—restore self-sustaining populations to levels supporting sustainable recreational fisheries in the lake and selected tributaries and also provide recreational fisheries, where appropriate, through stocking.

Status/trend indicator (Ontario):	Increasing adult spawning returns and wild production of Atlantic Salmon in selected restoration streams, including Credit River, Duffins Creek, Cobourg Brook, and Humber River.
Progress indicator (Ontario):	Establishing self-sustaining wild Atlantic Salmon populations in selected restoration streams, including the Credit River, Duffins Creek, Cobourg Brook, and Humber River.
Status/trend indicator:	Increasing angler-catch of wild and stocked Atlantic Salmon in Lake Ontario and in the Salmon River, New York.
Progress indicator (New York):	Increasing wild production of Atlantic Salmon in the Salmon River system and increasing returns of wild mature adults to Beaverdam Brook.

2.3 Increase prey-fish diversity—maintain and restore a diverse prey-fish community that includes Alewife, Lake Herring, Rainbow Smelt, Emerald Shiner, and Threespine Stickleback.

Status/trend indicator:	Maintaining or increasing populations and increasing species diversity of the pelagic prey-fish community, including introduced species (Alewife and Rainbow Smelt) and selected native prey-fish species (Threespine Stickleback, Emerald Shiner, and Lake Herring).
Status/trend indicator	Increasing spawning populations of Lake Herring in the Bay of Quinte, Hamilton Harbor, and Chaumont Bay.

2.4 Maintain predator/prey balance—maintain abundance of top predators (stocked and wild) in balance with available prey fish.

Status/trend indicator:	Maintaining Chinook Salmon average growth and condition at or above levels observed during 2007.

2.5 Maintain Rainbow Trout (Steelhead) fisheries—maintain fisheries through stocking and, where appropriate, enhance naturally produced populations supporting recreational lake and tributary fisheries for Rainbow Trout.

Status/trend indicator:	Maintaining or increasing catch rates of Rainbow Trout in the lake and tributary fisheries.
Status/trend indicator:	Maintaining or increasing population, recruitment, and growth of adult Rainbow Trout in selected tributaries (Salmon River, New York, and Ganaraska River, Ontario).

2.6 Maintain Brown Trout and Coho Salmon fisheries—maintain the recreational lake and tributary fisheries for Brown Trout and Coho Salmon through stocking.

Status/trend indicator:	Maintaining or increasing catch rates of brown trout and coho salmon in the lake and tributary fisheries.

3.0 Deep Pelagic and Offshore Benthic Zone Goal

Protect and restore the diversity of the offshore benthic fish community composed of a mix of self-sustaining native species, including Lake Trout, Burbot, Lake Whitefish, Round Whitefish, deepwater ciscoes, Slimy Sculpin, and Deepwater Sculpin.

Deep Pelagic and Offshore Benthic Zone Objectives

3.1 Restore Lake Trout populations—restore self-sustaining populations to function as the top deep-water predator that can support sustainable recreational fisheries.

Status/trend indicator:	Increasing abundance of stocked Lake Trout across a range of age groups.
Status/trend indicator:	Catch/harvest rates of Lake Trout in the lake fishery at levels that permit lake trout rehabilitation.
Progress indicator:	Increasing populations of wild Lake Trout across a range of age-groups sufficient to maintain self-sustaining populations.

3.2 Increase Lake Whitefish abundance—increase abundance in northeastern waters and re-establish historic spawning populations in other areas.

Status/trend indicator:	Increasing populations of Lake Whitefish across a range of age-groups sufficient to maintain self-sustaining populations and increasing spawning populations in the Bay of Quinte and eastern Lake Ontario.

3.3 Increase prey-fish diversity—maintain and restore a diverse prey-fish community that includes deepwater ciscoes, Slimy Sculpin, and Deepwater Sculpin.

Status/trend indicator:	Increasing populations of native prey fish (e.g. Slimy Sculpin and Deepwater Sculpin).
Status/trend indicator:	Maintaining or increasing populations and increasing species diversity of the deep-water and benthic prey-fish community, including Deepwater Sculpin, Slimy Sculpin, and deepwater ciscoes.
Progress indicator:	Detecting stocked adult and wild juvenile deepwater ciscoes.

3.4 Control Sea Lamprey—suppress abundance of Sea Lamprey to levels that will not impede achievement of objectives for Lake Trout and other fish.

Status/trend indicator:	Spawning-phase adult Sea Lamprey abundance in Lake Ontario tributaries below targets identified in the Sea Lamprey Management Plan.
Status/trend indicator:	Number of A-1 marks on Lake Trout and other species below targets.

ACKNOWLEDGMENTS

We gratefully acknowledge the many biologists, scientists, concerned citizens, technical experts, and supporting agencies in both New York and Ontario who offered their knowledge, expertise, and perspective and provided helpful comments on early drafts. A review by John Dettmers and Chuck Krueger helped to improve the manuscript.

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APPENDICES

Appendix A: Common and Scientific Names of Fish and Invertebrates

Fish

Common Name	Scientific Name
Alewife	*Alosa pseudoharengus*
American Eel	*Anguilla rostrata*
Atlantic Salmon	*Salmo salar*
Burbot	*Lota lota*
Brown Bullhead	*Ameiurus nebulosus*
Brown Trout	*Salmo trutta*
Chinook Salmon	*Oncorhynchus tshawytscha*
Coho Salmon	*Oncorhynchus kisutch*
Common Carp	*Cyprinus carpio*
Deepwater Ciscoes	*Coregonus* spp.
Deepwater Sculpin	*Myoxocephalus thompsonii*
Emerald Shiner	*Notropis atherinoides*
Freshwater Drum	*Aplodinotus grunniens*
Lake Herring	*Coregonus artedi*
Lake Sturgeon	*Acipenser fulvescens*
Lake Trout	*Salvelinus namaycush*
Lake Whitefish	*Coregonus clupeaformis*
Largemouth Bass	*Micropterus salmoides*
Muskellunge	*Esox masquinongy*
Northern Pike	*Esox lucius*
Pacific Salmon	*Oncorhynchus* spp.
Rainbow Smelt	*Osmerus mordax*
Rainbow Trout (Steelhead)	*Oncorhynchus mykiss*
Round Goby	*Neogobius melanostomus*
Sea Lamprey	*Petromyzon marinus*
Slimy Sculpin	*Cottus cognatus*
Smallmouth Bass	*Micropterus dolomieu*
Sunfishes	Centrarchidae
Threespine Stickleback	*Gasterosteus aculeatus*
Tubenose Goby	*Proterorhinus semilunaris*

Fish, continued

Common Name	Scientific Name
Walleye	*Sander vitreus*
White Perch	*Morone americana*
Yellow Perch	*Perca flavescens*
Invertebrates	
Bloody red shrimp	*Hemimysis anomala*
Fishhook Water Flea	*Cercopagis pengoi*
Invasive Mussels	
Quagga Mussels	*Dreissena bugensis*
Zebra Mussels	*Dreissena polymorpha*
Deepwater Amphipod	*Diporeia* spp.
Spiny Water Flea	*Bythotrephes longimanus*

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Appendix C: New York and Ontario Stocking Policy by Species and Life Stage

Species	Life Stage	New York State Department of Environmental Conversation Stocking Policy (2013)	Ontario Ministry of Natural Resources Stocking Policy (2013)
Chinook Salmon	Spring yearlings	1,761,600	600,000
Lake Trout	Yearling equivalents	800,000	440,000
Rainbow Trout	Spring yearlings	615,700	140,000
Brown Trout	Spring yearlings	391,755	165,000
Atlantic Salmon	Fry	0	400,000
	Fall fingerlings	0	100,000
	Spring yearlings	50,000	90,000
Coho Salmon	Fall fingerlings	155,000	80,000
	Spring yearlings	90,000	0

Fishery Management Documents

2017-01 Fish community objectives for Lake Ontario. Thomas J. Stewart, Andy Todd, and Steven LaPan.

Cover photograph: ©Federal Publications, Inc., 1998-2008. A natural coloured view of Lake Ontario and surrounding regions generated from eight Landsat satellite images mosaicked together and enhanced with a digital elevation model to provide a sense of 3-D relief. The Landsat satellites orbit the earth at an altitude of 700 kilometers (450 miles). The portrait of Lake Ontario extends from Georgian Bay in the northwest across cottage country to the Thousand Islands area and from Long Point in the middle of the North Shore of Lake Erie through the Fringe Lakes in upstate New York ending at the Appalachian Mountains.