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Chronology of Lake Ontario ecosystem and fisheries

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The Lake Ontario drainage basin has been considered the most productive of all the deepwater Laurentian Great Lakes for fish production and extremely valuable for its historical commercial fisheries catches. Historical accounts are replete with this productivity, especially when referencing Atlantic Salmon populations. In addition to Atlantic Salmon, Lake Ontario contained a diverse coldwater fish community dominated by Lake Trout, whitefishes (Coregoninae), and Burbot along with rich cool and warmwater fish communities. Lake Ontario also contained marine relict species, such as Harbour Seal, Threespine Stickleback, and possibly Sea Lamprey, Rainbow Smelt and Alewife along with the catadromous American Eel. Following European colonization of the watershed, extensive land-use change, overfishing, dam construction, habitat degradation, pollution, and invasive species all contributed to the decline and extirpation of many native species and shifts in aquatic species communities. This chronology is meant to provide context and inform expectations regarding productivity of Lake Ontario and contributing watersheds for developing more comprehensive resource management plans, guidelines, and policy.

Keywords: history, Atlantic Salmon, ecology

Introduction

Throughout much of their historical range, most freshwater fishes and aquatic resources are only a fraction of their former size (Koelz, 1926; Smith, 1972; Hubbs and Lagler, 2004; Eshenroder et al., 2016). As resource agencies implement restoration and recovery measures, it is important that the magnitude of abundance and diversity that once existed in our watersheds is understood. With limited knowledge of historical habitat condition, abundance, productivity, distribution, and diversity of species, most estimates are based on an incomplete understanding of how pre-European contact (circa 1600's) watersheds looked and how present day habitat conditions relate to productivity and abundance. These losses can transcend demographic, evolutionary, and ecological possesses, resulting in an altered community/environmental template for the remaining flora and fauna. Having baseline estimates of historical abundances, distribution, and composition of fish assemblages allows resource agencies to more effectively support meaningful protection, restoration and recovery of fisheries and aquatic resources.

Lake Ontario has a complex history, where the valuable historical natural resources have gradually declined or changed despite high profile concerns about conservation issues over the last 200 years (Wilmot, 1881; Forest and Stream, 1884; Smith, 1892; Huntsman, 1944; Richardson, 1944; Sly, 1991; Montgomery, 2003). These declines often occurred for a longer period of time and were more complex than often appreciated (Tiro, 2016). Many shifts have occurred over timelines

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equivalent to the length of a career (≤40 years), while others have spanned multiple careers (>40 years). Fisheries and aquatic resource practitioners, managers, and researchers are often unaware of the historical perspective linked with Lake Ontario's fish communities and ecosystem. Generally, each new generation of resource manager commonly make decisions based on the status of the fishery they inherited when their professional career began. This leads to what has been called "the shifting baseline syndrome" in which a progressively diminished resource is passed on to each new generation of biologists who come to accommodate and to manage for perpetual resource depletion (Pauly, 1995). The promotion of the shifting baseline syndrome freezes the status quo in place allowing failures of the past to persist and be implemented over and over. This practice hides the magnitude of management's failure to achieve its mission and inhibits real accountability of agency administrators (Lichatowich and Bakke, 2012). Further, through technological advances in communication and electronic archiving, the full scale of decline and ecological changes have often become better known during the past several decades. With the use of the best available information and reasonable assumptions to estimate the cumulative impacts of dams, urbanization, pollution, overfishing, mismanagement and other human, economic and social factors the biology and ecology of the flora and fauna of the Lake Ontario watershed can be added to the evaluation process.

The Lake Ontario drainage basin is 70,655 km^2, with a surface water area of 19,477 km^2 (Ryder, 1972). Lake Ontario is a relatively deep lake, with an average depth of 86 meters and a maximum depth of 237 meters (Ryder, 1972; Steward et al., 1999). Approximately 86% of the water in Lake Ontario is contributed from the Upper Great Lakes via the Niagara River, while the remainder is contributed through numerous tributaries (Stewart et al., 1999). Lake Ontario is considered an oligotrophic lake providing habitats for cold, cool, and warmwater aquatic ecosystems supported by both native and introduced species. Historical accounts of the Lake Ontario fishery outline the production of fishes, especially when referencing Atlantic Salmon (*Salmo salar*) populations. In addition to Atlantic Salmon, Lake Ontario contained a diverse coldwater fish community dominated by Lake Trout (*Salvelinus namaycush*), coregonine species, and Burbot (*Lota lota*) along with productive, species-rich warmwater and coolwater fish communities comprised of Bass (*Micropterus* spp.), Walleye (*Sander vitreus*), Yellow Perch (*Perca flavescens*), Northern Pike (*Esox lucius*), and Lake Sturgeon (*Acipenser fulvescens*) (Christie, 1973). Within a simplified context, the coldwater community is generally viewed as inhabiting depths greater than 15 meters of water, while the warmwater community inhabits coastal waters and embayments less than 15 meters deep (Stewart et al., 1999). Lake Ontario also contained or contains marine associated species, including a freshwater subspecies of Harbour Seal (*Phoca vitulina*) (Merriam, 1884; New York Times, 1895), Threespine Stickleback (*Gasterosteus aculeatus*), and possibly Sea Lamprey (*Petromyzon marinus*) (Lark, 1973; Christie,1973; Waldman et al., 2004; Waldman et al., 2009; Tanner, 2019), albeit there is uncertainty, and active debate as to its status (Eshenroder, 2009, 2014). Rainbow Smelt (*Osmerus mordax*) and Alewife (*Alosa pseudoharengus*) are generally believed to be invasive (Ihssen et al., 1982, Bergstedt, 1983; Emery, 1985), but may have also persisted at low population sizes following a post glacial colonization (Ure, 1858; Lark, 1973; Daniels, 2001; Domske and O'Neill Jr., 2003). One catadromous species exists, the American Eel (*Anguilla rostrata*).

The purpose of this paper is to highlight the timing of stressors (e.g. dam construction, deforestation, invasive species), and the concurrent decline or loss of different endemic species that live within the Lake Ontario basin. In addition, the inclusion of qualitative references and quotes about the state of the resource by various observers during different time periods highlights the distribution of certain species, relative abundances, and description of habitat (e.g. water quality). The information within this chronology is meant to augment existing sources that discuss fisheries, habitat and ecosystem changes within Lake Ontario (e.g. Christie, 1973; Morris, 1988; Sly, 1991; Smith, 1995; Holeck and Mills, 2004), by addition of information and context beyond the scientific literature.

The information compiled for this chronology begins in the 1600's, when the first references were available for the Lake Ontario basin, and continues until the present (2010) to document current conditions and species assemblages within the Lake Ontario ecosystem. An exhaustive search for references relating to the fish community and habitat alterations with the Lake Ontario basin was conducted in both the primary literature (e.g. Scholars Portal) and in grey literature. The latter includes searches through government archive resources (e.g. Ontario and New York fisheries annual reports), Ontario libraries, and archival search engines (e.g. www.archive.org; www.biodiversitylibrary.org; ProQuest Periodical Series). This chronology documents events in time, species, distribution, and relative abundance and composition when available. The chronology also documents historical environmental conditions, major land-use and physical habitat changes, construction of barriers, species introductions and extirpations, and social regulatory actions to protect aquatic conditions and species. The declines and shifts in fish species and communities are inherently linked with habitat loss and alteration, and therefore these are presented together within the chronology. This chronology is meant to inform aquatic resource practitioners, managers, researchers, and naturalists on the historical conditions of Lake Ontario and post-European colonization induced changes to the ecosystem in order to calibrate present expectations or previous assumptions regarding productivity of Lake Ontario and contributing watersheds for developing more comprehensive resource management plans, guidelines, and policy. Conclusions regarding the current state of Lake Ontario have not been drawn within this chronology, as the lake is a dynamic ecosystem, with fish communities and habitats poised to further change due to the threat of continued species introduction (e.g. Asian Carp *Hypophthalmichthys* spp.), overfishing, habitat loss or alteration, and other stressors from a growing human population and climate change. This history is based on document review only and therefore should be viewed as an accompaniment for the more scientific offerings on the issue. As such, the author believes this is an open ended list that will continue to grow. All localities are in Ontario unless specified otherwise.

1600's

The earliest written records of the region, and a period of first contact with European colonizers mark this era. Indigenous fisheries are prominent for a range of species, such as Atlantic Salmon on the Credit River (Dunfield, 1985). Early missionaries and Jesuits remark upon the abundance of principally Atlantic Salmon, Trout and American Eel. For example, Onondaga Lake (Oswego River drainage, NY) "abounds with fish – with salmon, trout and other fish" (Beauchamp, 1908: 44), and in Onondaga Lake, NY "the eel is so abundant there in the autumn that some take with a harpoon as many as a thousand in a single night" (Beauchamp, 1908: 44). Early Europeans also participated in these fisheries, capturing Atlantic Salmon, Catfishes and Eel on the Oswego River, NY (Webster, 1982). It was also noted on the Oswego River that "after taking twenty large salmon in the night, next day our men took, in going along, thirty-four other salmon by strokes of oars and swords; there was so great a quantity of them we could strike them without trouble" (Beauchamp, 1908: 44). Additionally, various traditional means and locations of harvesting fish are recorded, such as in the Oswego River, NY "the fish which are most common here are the eel and salmon, which are fished from the spring till the end of autumn, our savages managing so well their dykes and their weirs that they take there at the same time the eel which is going down, and the salmon which is going up" (Beauchamp, 1908: 44), and an abundant fishery of several kinds of fishes at the mouth of the Niagara River entering Lake Ontario, among which is the Lake Whitefish (*Coregonus clupeaformis*) (Whitaker, 1892).

1700's

The eighteenth-century is marked by increasing records of the historical abundance of the resource, as well as the first wave of significant ecological impacts to the region. The fur trade brought substantial impact to the region, with local extirpation of beaver populations resulting in the first major ecological change of salmonid/riverine habitat by humans (Naiman et al., 1988). Abundance of non-fish species is also noteworthy, where on Oneida Lake it is noted "The lake was now covered as with a white cloak of hundred thousand millions of insects, which we call Haft (*Hexagenia* sp.) … which lay in some parts of the shore one and two inches deep" (Beauchamp, 1908: 46), and an observer called a tributary to Oneida Lake, NY "the Fresh Lobster creek, from the numbers (of crayfish) we caught there ... " (Beauchamp, 1908). The habitat complexity of tributaries are also recorded, where in 1743 the Onondaga River, NY, the river is 2 - 4 feet deep, very full of trees fallen across, or drove on heaps by the torrents (July 21st) (Bartram, 1751), and the Don River was very shallow in many parts and obstructed by fallen trees (Robertson, 1911) indicating high levels of woody material in a pre-degradation state of rivers. Prominent fishing locations are also documented, such as the Niagara River below the falls, where it is recorded "Below the Falls in the holes of the rocks, are great plenty of Eels, which the *Indians* and *French* catch with their hands without other means; I sent down two *Indian* boys, who directly came up with about twenty fine ones" (Bartram, 1751:92), and an eel fishery Oneida (Oswego) River, NY at the falls (Bartram, 1751). This is also the beginning of an era of dam construction, with dams being erected on the Cataraqui River north of Kingston and Four Mile Creek in the Niagara District, Meyer's Creek (Moira River), Humber River, and the Ganaraska River (Dymond, Royal Ontario Museum, 1965), resulting in impacts to adfluvial species such as Atlantic Salmon. This era also helps depict spatial or temporal use of habitats or watersheds by various species, such as a 1796 record of small red-trout (Brook Trout) (*Salvelinus fontinalis*) were caught through holes in the ice on the Don River at Castle Frank (January 23rd) (Robertson, 1911), where Brook Trout are now absent from this watershed, or large numbers of Black Bass, probably Smallmouth Bass (*Micropterus dolomieu*) observed around the Thousand Islands area (Robertson, 1911). The cultural and economic importance of fish abundance is also esteemed, as reported in one Toronto newspaper announcing a farm sale extolled the property, "above all, it affords an excellent salmon fishery, large enough to support a number of families ... " (Bogue, 2000:23).

1800's

The nineteenth-century contains more detailed written accounts of the resource, with more species records, qualitative descriptions of abundance, continuing habitat degradation, species introductions, over exploitation, and rapid species declines and loss. This period also has the first recognition of human impacts to the resource, and management actions enacted to help curtail these stressors.

Watersheds not currently regarded for Atlantic Salmon production are noted, such as the Kawartha-Trent watersheds, which are analogous to the Finger Lakes, NY. The Kawartha-Trent watersheds were mainstays of the Mississauga First Nations diet, utilizing Lake Whitefish, Atlantic Salmon, Bass, Trout, Muskellunge (*Esox masquinongy*), American Eel and other fishes (Forkey, 2003; Williams, 2018, with Atlantic Salmon captured in Stony Lake (Corcao, University of Toronto, 1986, Williams, 2018) up to 20lbs, and noted from the lakes of Peterborough County (Creighton, 1892). Atlantic Salmon were stated to run as far as Fenelon Falls (Dunfield, 1985).

High levels of abundance are still recorded for the early part of this century, with a prevailing attitude, as expressed by the Superintendent of Fisheries for Upper Canada (Mr. John McCuaig) describing the fishery resource near Port Credit as, "literally inexhaustible riches" (Department of Marine and Fisheries, 1898:53). The quantity of Lake Whitefish and other species taken in seines was described as "immense." Lake Whitefish were used as fertilizer, and small Lake Whitefish, ciscoes (*Coregonus* spp.), and Lake Sturgeon were "destroyed as nuisances" (Smith, 1995). Atlantic Salmon noted to be extremely abundant along Wilmot Creek. Observers note, "they were so plentiful ... that men slew them with clubs and pitchforks – women seined them with flannel petticoats ... later they were taken by nets and spears over one thousand being often caught in the course of one night" (Bouge, 2000:25), and Atlantic Salmon were so plentiful at the annual spawning time, an individual paddled his canoe across the stream in Port Oshawa, when the salmon partly raised his boat out of the water, and were so close together that it was difficult for him to get his paddle below the surface (Conant, 1903). Brook Trout were also plentiful; they were caught with a bucket in Orono Creek (tributary of Wilmot Creek) (Schmid and Rutherford, 1976). Huge quantities of fish were being harvested, for example, in 1836 2,000 Atlantic Salmon could be taken in one night's spearing, largest being $44^{3/4}$ lbs in Salmon River, NY (Dunfield, 1985).

Early fisheries regulations were implemented early in this century, such as regulations imposing a closed season for Atlantic Salmon from October 25 to January 1, along with fishing within 100 yards of a dam and netting at river mouths in the Home District (Dunfield, 1985). By mid to late century, warnings were being voiced about declines, prominently towards Atlantic Salmon. Canadian Samuel Wilmot suggested in 1864 that certain salmon streams in Ontario should be set apart specifically and solely for natural propagation purposes, with the Moira and Credit Rivers being recommended (Dunfield, 1985). Two years later, Wilmot creates first Canadian hatchery for Atlantic Salmon on Wilmot Creek (Crawford, 2001). Concurrent with Wilmot's efforts to curtail declines of Atlantic Salmon he describes the current state of Whitefish "These rich and beautiful fish at one time so numerous in Lake Ontario, are now almost wholly gone" (Department of Marine and Fisheries, 1869). Wilmot notes broad environmental change on land through removal of trees, cultivation of land, runoff from farms, construction of dams, and the addition of industrial and human sewage. In 1881, Wilmot gives up trying to rehabilitate Lake Ontario's salmon, lamenting that, "I cannot disguise from myself that the time is gone by forever for the growth of salmon and speckled trout in the frontier streams of Ontario" (Bogue, 2000:27) and, "a few years ago Parrs and Smolts could be seen in large numbers, it is now quite an exceptional occurrence to see them anywhere" (Wilmot, 1881:348). This was only 15 years after initiating his efforts. Atlantic Salmon were considered extirpated by 1898 (COSEWIC, 2010). Other species show considerable decline, such as Lake Trout, which were considered essentially gone from Lake Ontario by the 1890's (Christie, 1973). For example, Lake Trout and Lake Whitefish were noted as being very scarce on the American shores of Lake Ontario by this time (Smith, 1892). Wilmot also states that "shoals of herring (probably Cisco, *Coregonus artedi*) do not, as formerly, come so near the shore because the gravel which composed the bottom almost to the shore has gradually become covered with sand" (Dymond, Royal Ontario Museum, 1965, 16).

Other species are first recorded this century, such as landlocked Harbour Seal, noted from Onondaga Lake (Forest and Stream, 1882), Lake Ontario (New York Times, 1895), possibly Rice Lake (Lizars, 1913), and the Ottawa River as far up as present day Ottawa (COSEWIC, 2007). The Harbour Seal recorded in 1895 from Onondaga Lake "measures just six feet from tip to tip, and will weight about 100 pounds" (New York Times, 1895). Harbour Seal were considered extirpated from the Lake Ontario basin in the 1880's (COSEWIC, 2007) despite records of them in the basin after this time. Sea Lamprey were noted to be present by at least the 1830's (MacCrimmon, 1977), with Sea Lamprey recorded in Duffin's Creek in 1835 (Smith, 1995). In 1851 evidence of Sea Lamprey parasitizing Atlantic Salmon was observed (MacCrimmon, 1977), and by 1858, Sea Lamprey were considered common in the lake, where it was a known parasite on Atlantic Salmon (Ure, 1858). In Cayuga Lake, a "Kennebec" salmon, eighteen inches long, was captured "nearly done to death by a lamprey eel" (Forest and Stream, 1877). Sea Lamprey were also observed parasitizing Walleye in 1886, and noted "some years since, a 20 pound salmon taken from a gill net in Lake Ontario, and having a two inch hole in its side which had been made by a lampreys suction" (Forest and Stream, 1886). This author also recorded Sea Lamprey spawning among the gravel at the mouths of streams emptying into the lake, with "many bowls worked out, each about the size of a hen's nest, and each containing one or more lampreys coiled around and apparently spawning". By 1875 Sea Lamprey were known to occur in abundance in Cayuga Lake (Smith, 1995). In 1858, it was noted that there is a species of the true shad (*Clupea alosa* – taken in Lake Ontario, but it is very rare (Ure, 1858). Whether this represents Alewife, which may have survived in a lower population density with high predator pressures and an intact Coregoninae community is unknown. Seth Green introduces American Shad (*Alosa sapidissima*) fry until 1872 (total of 80,000) into Genesee River and Lake Ontario (United States Commission of Fish and Fisheries, 1874; Smith, 1995). Alewife may have been introduced at this time (Scott and Crossman, 1998). By 1869, Alewife reported to be abundant in Seneca and Cayuga Lakes (Smith, 1995) and by1873, Alewife reported in abundance in Lake Ontario (Smith, 1995). Other species recorded during this era include Lyons (Lynde) Creek, Duffin's Creek, Rouge River, Don River, Humber River and Credit River have Atlantic Salmon that migrate up stream in the fall (except the Don) and Suckers, Redhorses (*Moxostoma* spp.), Northern Pike (*Esox lucius*), Walleye (*S. vitreus*) and Bass spawn up the streams in spring; Suckers, Redhorses, Bass and Walleye frequent the streams in spring for spawning at Mimico, Oakville, Bronte and Port Nelson (Burlington) (Regier, Ministry of Natural Resources, 1975). Additionally, "… herring (probably Cisco), Bass (of the various kinds), Pike (Northern Pike), Pickerel (Walleye), Whitefish (Coregoninae), and Salmon Trout (Lake Trout), Maskinonge (Muskellunge) and all the various kinds of fishes of a less valuable description, including eels, are at all seasons in Burlington Bay, and frequent the waters of Burlington Bay and Dundas Marsh in great quantities at all times, … for the purposes, amongst other things, of spawning and increasing their species, etc., etc. …" (Regier, Ministry of Natural Resources, 1975:84). Abundances of invertebrates were also recorded, in 1873, Lake Ontario said to "abound to an enormous extent" in minute crustaceans, especially the genus *Mysis* (United States Commission of Fish and Fisheries, 1874:78). Crayfish were also noted as being abundant in Lake Ontario during the 1890's (Smith, 1892).

Habitat degradation intensified, with 75-80% of forests in southern Ontario having been cleared for farming and urban uses (Bacher, 2011). Dam construction, intensified with a total of 7,406 water-powered sawmills were being operated in the state of New York by 1845 (Smith, 1995) and 87 Mills occurred on the Credit River alone in the 1850's (Corcao, University of Toronto, 1986). Within the lake, stone hooking became prominent, and by the 1830's was removing as much as 43,000 tonnes (47,000 tons) annually accelerating lakeshore erosion (Ontario Waterfront Regeneration Trust, 1996) and removing spawning and rearing habitats. New watershed connections were also formed, with the Erie Barge Canal connected to Lake Ontario watershed in 1825 (Sly, 1991), and in 1832 the Rideau Canal Waterway opens connecting Kingston to Ottawa.

Other anecdotes from this century include the first evidence of tributary specific local adaptations in Atlantic Salmon, "In Deer Creek the fish were long and slim, in Grindstone short and chubby, and in Salmon River large and heavy" (Bogue, 2000:21). Observers also note watershed specific run timing, with Smith (1892) recording a run of Atlantic Salmon in the Oswego River called the "June run", which was usually two or three weeks earlier than the appearance of fish in the Salmon River, NY, and seasonal run timing within a watershed "In the months of June and September, the salmon ascend the main stream (of Oak Orchard Creek, NY) and its small tributaries, in great numbers, … ".

Intentional species introductions were initiated, with Common Carp (*Cyprinus carpio*) introduced (Scott and Crossman, 1998) in the 1870's, Chinook Salmon (*Oncorhynchus tshawytscha*), in 1873 (Parsons, 1973), Rainbow Trout (*O. mykiss*) 1874 (Crawford, 2001), Striped Bass (*Morone saxatilis*) in 1878 (Regier, Ministry of Natural Resources, 1975), and Brown Trout (*Salmo trutta*), in 1883 (Crawford, 2001).

Non commercial/subsistence forms of fishing were also documented in 1848 "[I]n the upper province of Canada… [salmon] are very rarely fished for or taken with the fly, and it is said confidently that in the lake itself they will not take the fly under any circumstances." (Knight, 2007:81). In, 1890 an Atlantic Salmon weighing 12 pounds was taken on a fly rod below the first dam on the Oswego River (Smith, 1892). This is the first recorded catch of Atlantic Salmon by angling in the Lake Ontario basin.

1900s

The 20th century marks a junction for management in the Lake Ontario ecosystem. Some species, such as American Eel still thrive in the early part of the century. American Eel are noted below Niagara Falls, "at the proper season and you will find them by cartloads, by millions upon millions" (Gill, 1908:121). Concurrently, habitat declines continue, with loss of wetlands occurring in addition to the aforementioned impacts. The Toronto Harbour (mouth of Don River) noted to have significant loss of wetland area due to increased sedimentation, loss of vegetation, and altered bathymetry resulting in declines in fish abundance (Whillans, 1977). Industrial contamination from dioxins and similar chemicals were high enough throughout the lake to eliminate all natural reproduction in Lake Trout in the 1940's (Cook et al., 2003). Additional canal systems were completed, with the Trent-Severn Canal in 1920 (Angus, 1988), and the Moses-Saunders Hydroelectric Dam in the St. Lawrence River near Kingston was completed in 1958, regulating water levels within the lake (OPG website: http://www.opg.com/generating-power/hydro/ottawa-st-lawrence/Pages/rh-saunders-station.aspx - accessed May 18, 2014).

Starting in the 1940s, Atlantic Salmon were restocked into Wilmot Creek (Ontario Game and Fish Department, 1941), and later in other watersheds in an attempt to restore populations (McCrimmon, 1949; McCrimmon, 1950; Parson, 1973). Concurrently, significant strides were being made towards restoring watersheds through large reforestation efforts (Richardson, 1944). Binational efforts to restore fisheries in the Great Lakes gained momentum, and culminating with the formation of the Great Lakes Fishery Commission in 1955 (GLFC website: http://www.glfc.org/aboutus/brief.php - accessed May 18, 2014) and the Great Lakes Water Quality Agreement in 1972 (Environment Canada website: http://www.ec.gc.ca/grandslacs-greatlakes/default.asp?lang=En&n=E615A766-1 - accessed May 18, 2014). Despite these efforts to curtail further loss, species extirpations continued, with the loss of the Lake Ontario Kiyi (*Coregonus kiwi*) in 1964 and the Blue Pike (*S. vitreus glaucus*) in the 1970's (Miller et al., 1989). Additional introduced species arrive, such as zebra mussel (*Dreissena polymorpha*) and Round Goby (*Neogobius melanostomus*), keeping the Lake Ontario system in a state of flux. Introduced Pacific Salmon (*Oncorhynchus* spp.) have developed naturalized populations, and exert a strong ecosystem effect on regulating preyfish abundance (Connerton et al., 2009).

Discussion

Lake Ontario's fisheries have moved from a period of extreme abundance, of which, the wealth of the fisheries supported the rapid industrial growth of communities by European colonizers, to near collapse or loss of all commercial and recreational species. Rapid exploitation, habitat loss, pollution and species introduction shifted the structure and composition of the lake, into one dominated by naturalized top predators (*Oncorhynchus* spp) (NYDEC, 2018). The general attitude had moved from, at best, general apathy towards preserving this abundance transitioning into, at worst, outright contempt, greed, and fatalism (e.g. abundant Whitefish used as fertilizer or Lake Sturgeon destroyed for being a nuisance (Smith, 1995)). For example, Lizars (1913, pg. 124) states in reference to Atlantic Salmon "They were doomed to destruction, because every settlement demanded a grist and sawmill, the mills required dams, and no salmon could pass to the spawning ground, except the few that survived the gauntlet of the mill races. They crowded at the foot of the dams, and as every settler had a spear they were slaughtered wholesale. These that escaped the spear were taken by gill net in thousands; the numbers gradually decreased; and in the "sixties they were exterminated". Similarly, Marsh (1864) highlighted the relationship between forest cover and stream flows, and was previously documented by von Humboldt earlier in the 1800's (Wulf, 2015). The belief that prior knowledge recognizing the effects of landuse change and exploitation on aquatic resources was lacking is arguable when reflecting upon what had occurred elsewhere (Montgomery, 2003), or those who watched this history unfolding (sensu Wilmot, 1881). Only once the resources transitioned into a poor condition did general reverence and nostalgia for what once was became a more prominent attitude. Similar trends have occurred as Europeans colonized and industrialized across North America, as highlighted for salmonid populations (Salmo/Oncorhynchus), in Montgomery (2003) and Lichatowish (1999).

Conclusions

Despite dramatic negative changes, monumental strides towards recovery have been made; on a trophic level (e.g. introduction and naturalization of *Oncorhynchus* spp.), a physical level through habitat protection, restoration activities, and reconnection of tributaries and the lake, a chemical level with reductions of contaminants like DDT and PCB's and Areas Of Concern being delisted, and on a political level with binational agreements, and the formation of the Great Lakes Fishery Commission (see supplemental information for more detailed outline). Not all activities related to restoration have resulted in successes to date, like Atlantic Salmon and Lake Trout restoration activities, and different levels of trophic restoration have not entered the sphere of management discussion (e.g. Harbour Seal reintroduction). The establishment of Pacific Salmon (*Oncorhynchus* spp.) as a top level piscivore has provided stability against prey fish overabundance, and provides a valuable recreational fishery, but is predicated on non-native species providing this stability (Tanner, 2019). The path forward for Lake Ontario will look different than its past, but it is hoped that this concise history, along with a more detailed supplemental section will provide some context around productivity, potential abundance, spatial and temporal habitat use by various species and the natural wealth that may occur once again.

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Supplemental Material

Supplemental data for this article can be accessed on the publisher's website.

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