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The history of the Atlantic Salmon in Lake Ontario

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*The history of the Atlantic Salmon (*Salmo salar*), also referred to as Salmon below, in Lake Ontario is an accumulation of authentic published accounts, which were almost completed by J. R. Dymond before his death. H. H. MacKay completed the work on Dymond's behalf (Dymond and MacKay, unpublished, 1966), but it remained largely unknown. The present authors (MEB, EH, PWB) have sought to present an updated subset of Dymond and MacKay's work as the history of Lake Ontario Salmon is a crucial story in the history of the Great Lakes and its fisheries. The information provided should add materially to the knowledge of the causes that led to the decline and ultimate extirpation of a fascinating and valuable fish, notwithstanding all the efforts that were made to restore it by artificial means.*

Keywords: fisheries, life history, over-fishing, mill dams, deforestation, Alewife

How freshwater populations originate

The Atlantic Salmon did not arise in Lake Ontario because it was prevented from going to sea; it was not a landlocked population until the erection of the Beauharnois Dam in 1929. Atlantic Salmon would have had easy access to Lake Ontario during the marine invasion of the St. Lawrence Valley, which formed the Champlain Sea, 10 000 to 17 000 years ago (Coleman, 1922). Coleman (1922) hypothesized that Lake Ontario was an arm of the Champlain Sea, 24 m above present Lake Ontario. Karrow et al. (1961), however, suggested there was no evidence for this and that Lake Ontario was always fresh and higher than the Champlain Sea. Anderson and Lewis (2012) gave evidence that Lake Ontario was confluent with the Champlain Sea, but isostatic rebound and eastward forcing of freshwater, facilitated by glacial meltwater input to Lake Ontario, likely prevented saltwater invasion. Hladyniuk and Longstaffe (2016) found no evidence that the western end of Lake Ontario was at any time marine. The presence of two other marine species in Lake Ontario, the Threespine Stickleback (*Gasterosteus aculeatus*) and Sea Lamprey (*Petromyzon marinus*), does support a marine invasion, or at least these three species did have access to Lake Ontario at some point. Once there, they would have found an abundant food supply and ideal spawning habitat in its tributaries. Freshwater races of Atlantic Salmon are widespread in eastern North America (Power, 1958) and were recognized as subspecies *Salmo salar sebago* and *Salmo salar ouananiche* (Jordan

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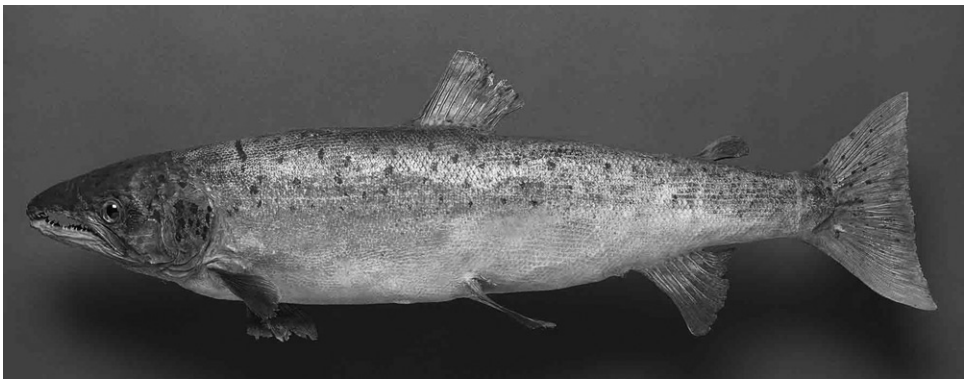

Figure 1. Atlantic Salmon mount from Samuel Wilmot's Newcastle Hatchery (ROM 23235). Courtesy of the Royal Ontario Museum © ROM. Photo Credit: Brian Boyle, MPA, FPPO.

and Evermann, 1896). Both freshwater and seagoing Atlantic Salmon are found in Lower Gambo Lake, Newfoundland (Scott and Crossman, 1964). No obvious morphological distinction is apparent between seagoing Atlantic Salmon and its freshwater subspecies; the only distinguishing character is the latter remains in freshwater during its entire life cycle even though there is no physical barrier to the sea (Power, 1958).

Life history

Lake Ontario Salmon followed a similar life history pattern to those of sea Salmon except that when young Salmon left the stream they migrated downstream to Lake Ontario instead of the sea (Blair, 1938; Guiry et al., 2017). Some of these young Salmon stayed in the lake for only one summer's growth, feeding on abundant Cisco (*Coregonus artedi*) and then returned to tributaries as grilse weighing 1 – 1.5 kg. These precocious grilse were nearly all males (Wilmot, 1868). More frequently, young Salmon stayed in the lake for two summer's growth before migrating upstream to spawn. Salmon grew rapidly in Lake Ontario and sometimes reached a weight of 18 kg. Spawning occurred in streams over gravel shoals from mid-October into November depending on temperature. Eggs hatched in late April to early May, and yolk sacs were absorbed in 4-6 weeks. The young parr stayed in the creek for one or two years, becoming smolts at about 13 cm and then migrated downstream to Lake Ontario. Blair (1938) and McCrimmon (1950) concluded that Lake Ontario Salmon more often spent two years in streams before migrating down to the lake.

Unlike Pacific Salmon, Atlantic Salmon may spawn more than once, most often spawning in alternate years. Wilmot (1870) reported that many Salmon entering Grafton Creek bore marks that he had placed there two years previously. From examining dried mounts at the Royal Ontario Museum (Figure 1), Blair (1938) concluded that these specimens had spent two years in the lake before returning to the stream to spawn.

Lake Ontario Salmon was often observed entering streams in spring, likely in response to freshets (Kumlien in Goode, 1884). Salmon runs occurred in the Oswego River in June if the water was sufficiently high (Smith, H., 1892). Fishing for Salmon was considered at its best on the Credit River in spring with fish "firm and full of curd" (Magrath, 1833). Simcoe (1796) wrote in her diary "numbers of Indians resort here [Credit River] at this season [spring] to fish for Salmon." Bonnycastle (1842) reported that a conspicuous run took place in the Salmon River, Ontario each spring and summer.

Tributary habitat suitability

In Ontario, Atlantic Salmon was more abundant in Lake Ontario's northwest tributaries (King, 1866). This was due, in part, to Ontario's Oak Ridges Moraine, which was formed approximately 12 000 years ago during the retreat of the

Wisconsin glacier. This ridge parallels Lake Ontario 16 to 40 km to the north. The ridge extends from the Niagara Escarpment in the west to the Trent Valley in the east. Water falling on the surface of the moraine drains vertically through sand and gravel, reappearing as cool, clear springs along the slopes. The substrate in the streams makes excellent spawning beds for Salmon, and cover for juveniles. The general altitude of the moraine is over 300 m above sea level or about 230 m above Lake Ontario resulting in an average fall of about 60 m per km. This rapidity of flow contributes to the value of the streams. The Credit River was considered the salmon river par excellence (Fox, 1930).

In New York, large cold-water systems, such as the Salmon River (NY) and Oswego River were among the most productive, supporting large runs of Atlantic Salmon (De Kay, 1842; Edmunds, 1874). The Salmon River was considered to be the largest cold-water Lake Ontario tributary and is associated with the significant Tug Hill aquifer. Collins (1885) described the Salmon River as being exceedingly clear and transparent with a rapid current between flat stretches. Schultz (1810) noted that Fish Creek had abundant Salmon and significant springs. The so-called 'June run' of Salmon in the Oswego River was likely aided by sustained summer flows from the Finger Lakes (Smith H., 1892).

Spawning tributaries

The consensus from historians was that Salmon teemed in every little stream, creek, and river (Wilmot, 1869; Green, 1874). Adamson (1857) stated "twenty five or thirty years ago every stream tributary to the St. Lawrence from Niagara to Labrador on the north side and to the Gaspe Basin on the south abounded with Salmon." Henry (1838) wrote that they were speared on the shores of the Bay of Quinte, at the Trent River mouth, around Toronto, and the streams in northwestern Lake Ontario. There was some contention regarding Salmon running up the Niagara River. Henry (1838) and Richardson (1836) agreed that Salmon had never been found around the mouth or upstream. However, Maude (1826) reported that Salmon had been seen at the foot of the falls. Figure 2 depicts historic Atlantic Salmon tributary occurrence, and watershed numbers correspond to Table 1.

The western-most native Salmon stream in Ontario was likely Grindstone Creek, a tributary of Burlington Bay, as observed by Simcoe (1796). Salmon appear to have been ubiquitous in the streams of the western basin and extending eastward to the Bay of Quinte. These included Bronte Creek, Sixteen Mile Creek, Credit River, Etobicoke Creek, Humber River, Don River, Highland Creek, Rouge River, Duffins Creek, Lynde Creek, Oshawa Creek, Black Creek, Bowmanville Creek, Wilmot Creek, Cobourg Creek, Ganaraska River, Grafton Creek, Trent River, Moira River and Salmon River (Figure 2). Etobicoke Creek and the Humber River abounded in Salmon (Smyth, 1799). Lynde Creek was "at one time widely known for its Salmon abundance" (Wilmot, 1873). Samuel Wilmot had a reception house at Grafton Creek that was important for procuring parent fish (Wilmot, 1873). The Moira and Credit rivers were identified as important Salmon nursery areas to protect (King, 1866). Smaller streams that were also likely utilized by Salmon, but were not noted explicitly include Spencer, Mimico, Carruthers, and Gages creeks. That Salmon entered very small streams is indicated by Scadding's (1873) statement "In the rivulet below [Garrison Creek], for some distance up the valley, before the clearing away of the woods, Salmon used to be taken at certain seasons of the year". Old men told of having speared Salmon in the upper tributaries of the Rouge where they crossed the townline between Markham and Whitchurch townships, at least 24 km upstream from the lake (Brodie, 1902).

In New York, Twelve mile Creek is the first stream east of the Niagara River in which Salmon were reported (Smith H., 1892). Little Sandy Creek and all tributaries between the Genesee and Niagara rivers were considered Salmon streams (Edmunds, 1874; Smith H., 1892). Green (1874) indicated that Salmon were native to all or most Lake Ontario tributaries, but was adamant that Salmon never occurred in the Genesee River prior to plantings. There are many reports of the occurrence of Salmon in the Oswego River (e.g., Edmunds, 1874; Smith H., 1892; Greeley, 1940). Jackson (2016) reported that both a spring and fall spawning run occurred

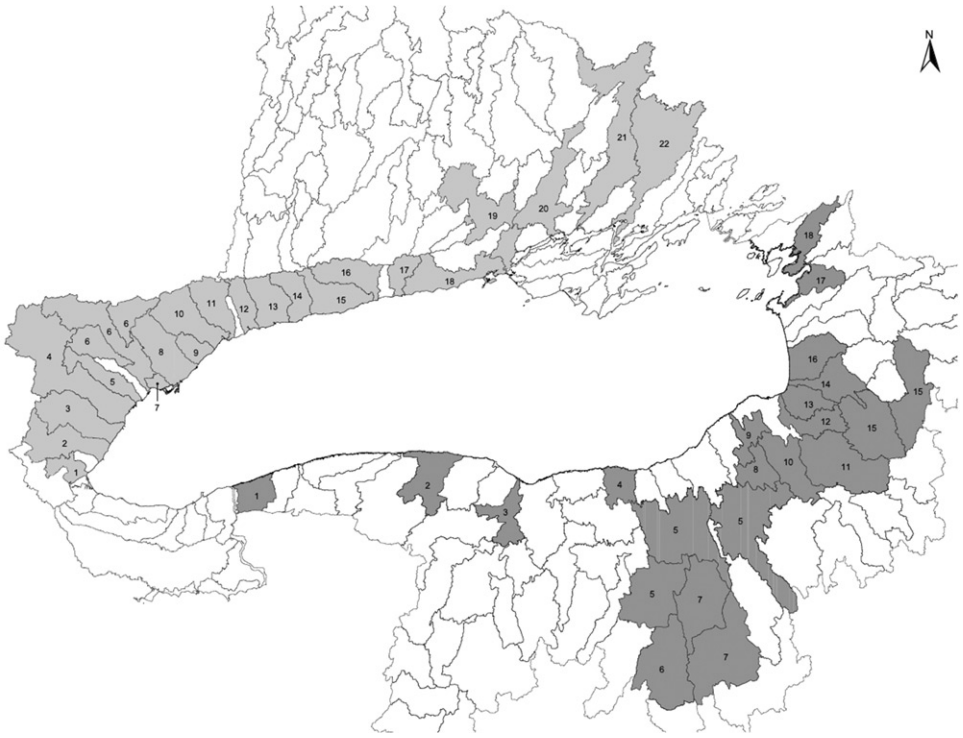

Figure 2. Lake Ontario watersheds in Ontario (light grey) and New York (dark grey) in which Atlantic Salmon were known/purported to have historically occurred. Quaternary watersheds are highlighted for reference, but do not reflect distribution within a watershed (eg., Salmon would have only utilized habitat below waterfalls on tributaries such as the Credit River, ON and Salmon River, NY). Source of watershed mapping: Ontario Ministry of Natural Resources and Forestry and United States Department of Agriculture.

into Oneida Lake. According to Morgan (1883), Salmon disappeared from the Oswego by the 1850's. De Kay (1842) reported Salmon from Oneida Lake weighing 4.5 to nearly 7 kg, while Schultz (1810) noted that some exceeded 13 kg. Salmon were also harvested from the Oneida Lake tributary of Fish Creek as well as nearby Wood Creek (Schultz, 1810). The Salmon River was famous for Salmon on the U.S. side of Lake Ontario (Smith, H., 1892). Cobb (1900) stated that Salmon had been especially abundant in this river 60 or 70 years ago. Salmon only had access from its mouth to Salmon River Falls (over 30 m high) a distance of about 30 km. The Black and Chaumont rivers had once been Salmon streams, although the Black had long ceased to have Salmon by 1874 (Edmunds, 1874; Smith H., 1892). Salmon had never been common near Chaumont Bay and they were only occasionally caught at Cape Vincent (Bonnycastle, 1842).

Causes of the disappearance of the Salmon

Although Atlantic Salmon did not become extirpated in Lake Ontario until the end of the nineteenth century, evidence of decline in abundance was observed soon after settlement began. As early as 1798, a bill for the preservation of Salmon was introduced in the parliament of Upper Canada, although the first act was not passed until 1807. By 1865, Samuel Wilmot snatched "a scanty remnant from extinction" (Whitcher and Venning, 1870). Alexander (1860) stated, "extermination of this noble fish has been commensurate with the civilization and settlement of the country". More specifically, causes for decline and final extirpation of the Salmon may include the erection of numerous mill dams, excessive and ill-timed fishing, deforestation, pollution of streams, and sudden rise of the Alewife *Alosa pseudoharengus* population in Lake Ontario.

Table 1. Historic Lake Ontario Atlantic Salmon streams. Although other Lake Ontario tributaries were likely also utilized, this list includes those streams that were explicitly noted as Salmon streams. Numbers correspond to Figure 2.

Ontario		New York	
1	Grindstone Creek	1	Twelvemile Creek
2	Bronte Creek	2	Sandy Creek
3	Sixteen Mile Creek	3	Genesee River
4	Credit River	4	Salmon Creek
5	Etobicoke Creek	5	Seneca River
6	Humber River	6	Seneca Lake
7	Garrison Creek	7	Cayuga Lake
8	Don River	8	Oswego River
9	Highland Creek	9	Lower Oswego River
10	Rouge River	10	Oneida River
11	Duffins Creek	11	Oneida Lake
12	Lynde Creek	12	Little Salmon River
13	Oshawa Creek	13	Grindstone Creek
14	Bowmanville Creek	14	Salmon River
15	Wilmot Creek	15	Fish Creek
16	Ganaraska River	16	Little Sandy Creek
17	Cobourg Creek	17	Black River
18	Grafton Creek	18	Chaumont River
19	Trent River		
20	Moira River		
21	Salmon River		
22	Napanee River		

Mill Dams

Initially, grist and sawmills were built for grinding grain and cutting wood, and later for a variety of other manufacturing processes. Until 1850, when steam power was introduced, all mills required water for power, which entailed building a dam across part, or all, of the stream for the creation of a reservoir.

In Upper Canada, the first gristmills were built on the Cataraqui River north of Kingston in 1782–1783, on Four Mile Creek in the Niagara District in 1783, on Meyer's Creek (Moira River) in 1789–1790, on the Don River at least by 1795, and the Humber River in 1793 (Guillet, 1933). In these early days, trips by settlers to mills often took days or even weeks, encouraging the proliferation of local mills. Therefore, by mid-century, numerous dams were found on most streams in Upper Canada (Table 2).

It was realized early on that mill dams blocked Salmon from reaching its spawning grounds, and many accounts blame dams as the leading cause for the Salmon's disappearance (De Kay, 1842; Smith W., 1846; Strickland, 1853; Adamson, 1857; Alexander, 1860; King, 1866; Baird, 1874; Smith H., 1892; Kendall, 1924). In 1800, a New York law banned all obstructions, including seines and weirs, in several important spawning rivers and mandated that all dams have fishways (Tiro, 2016). In 1828, a Bill was passed in Upper Canada concerning the better construction of aprons and dams "to facilitate the descent of lumber and the ascent of fish." Adamson (1857) suggested a fishway that consisted of a series of wooden boxes at increasing levels.

In New York State, construction of a canal to connect the Hudson River to Lake Erie resulted in locks being built. This canal system obstructed migrating fish from entering Oneida Lake and was considered a major cause in the disappearance of Atlantic Salmon from Oneida Lake by the mid-1800s (Jackson, 2016).

That Salmon disappeared from streams due to causes other than dams was evident. Although there were no dams on the lower portions of

Table 2. Total number of mills on six Lake Ontario tributaries from 1795 to1872.

Year	Credit	Humber	Don	Rouge	Ganaraska	Moira
1795		1	1			
1826		13	25		6	
1846		60			24	40
1860	87	90	50		36	40
1872	87	90	50	52	36	40

Wilmot Creek, the Salmon were so reduced in numbers in 1866 that when Wilmot began fish-cultural operations he was only able to secure 15 Salmon (male and female), in spite of the fact that all ascending fish were trapped by a temporary barrier across the channel (Wilmot, 1868).

Extent and nature of fishing

It is clear from descriptions of fishing methods written during and since the time of Salmon abundance that spearing was the most common method of capture in Lake Ontario. Smith, H. (1892) estimated that 90 percent of the Salmon were speared on the New York side of the lake. Wilmot (1880) said that the great bulk of Salmon taken in Ontario had been by means of spears. According to Pickering (1831), two persons in a canoe could spear up to 10 barrels of Salmon in the Credit River in one night.

In New York, in 1817, Van der Kemp blamed the diminution of Salmon on "fishing in the improper season" (Tiro, 2016). Wilmot (1869) at first blamed overfishing, the "untimely destruction" on the spawning grounds and the excessive demand and greed for the fish. Kendall (1924) wrote, "Those inhabitants usually did their fishing at times when the fish could be most easily caught in the greatest numbers. Accordingly, the principal fishing operations were at or near the spawning time, when the fish were often wastefully slaughtered." Edmunds (1874) was quite certain that trap and pound nets had entirely exterminated Salmon from the south shore of Lake Ontario. He stated categorically that neither sawdust nor other foreign matter had anything to do with their extermination. Huntsman (1944), in discussing the causes of the disappearance of Ontario Salmon, concluded "Overfishing could not have been the cause of the disappearance of these fish, and indeed Salmon have such a high power of reproduction that they continue under very intensive fishing. Only very thorough removal of the fish in the confined waters of the streams would eliminate the stock."

Deforestation

The clearing and cultivation of arable land by removal of forests was detrimental to Salmon as this reduced volume of stream flow and decreased shade, resulting in higher water temperatures and low flows. Wilmot (1882) concluded that the disappearance of the Salmon "has been brought by the almost total clearing up of the country, causing many streams to become almost dried up in midsummer, and all others to be greatly reduced in their volume of water". Wright (1892) stated that the disappearance of Salmon was "unquestionably due to the drying-up of streams consequent on the altered conditions of the land drained by them, to obstacles like mill dams preventing the ascent of fish toward the headwaters, and to pollution of the streams by sawdust and other refuse." Watson (1876) commented that Salmon were running into rivers "precisely at the usual occurrence of the lowest flow of the streams." Reduced volume of stream flow began to cause other problems. Wilmot (1873) stated that long, narrow, gravelly beaches at the mouths of streams prevented Salmon from entering. Formerly, strong downstream currents kept a passage open through the gravel. Kerr (1874) observed that Salmon were prevented from entering streams because of the accumulation of sand at their mouths. Another detrimental feature of low water levels is that eggs deposited in the gravel were often exposed to freezing. Spring flooding due to a lack of tree cover caused gravel to be washed out and eggs

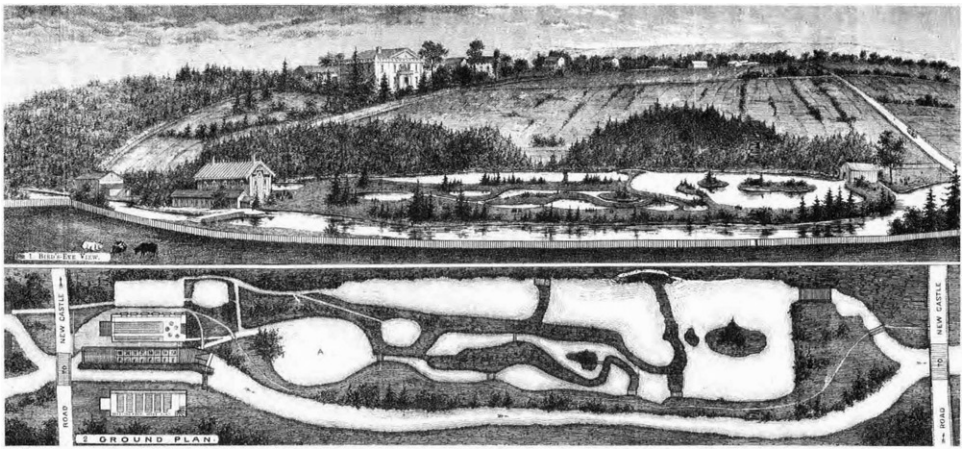

Figure 3. Bird's-eye view and ground plan of Samuel Wilmot's hatchery at Newcastle, Ontario (Wilmot, 1877).

were carried away (Wilmot, 1873). Increased temperatures in the summer may also have contributed to the decline of Salmon. McCrimmon (1950, 1954), reporting on a 3-year study of juvenile survival in a section of Duffins Creek, found that lethal summer temperatures each year resulted in the complete disappearance of Salmon in the same section of the creek, in all years.

Pollution

The first foreign material placed in streams flowing into Lake Ontario was waste from sawmills, including sawdust. However, as industry grew, more and more kinds of waste, including tanbark and lime, found their way into the streams. One observer wrote, "Vats of refuse lime have been emptied when the river was full of fish and upon the next day they were gone." (Goode, 1884). Low water further aggravated pollution. A pollutant that may not be injurious if diluted by a large volume of water may be seriously harmful if only slightly diluted because of low water in a stream.

Attempts to restore Ontario Salmon by artificial propagation

Although Richard Nettle was the first to propagate young Salmon in Canada in 1858, Samuel Wilmot founded the federal government's hatchery system. Beginning as a private venture in 1865, Wilmot built a very successful hatchery at Newcastle on the banks of Newcastle Creek, now Wilmot Creek (Figure 3). After an inspection of the hatchery in 1869, Whitcher and Venning (1869) reported: "Directly, we count upon a cheap and immediate increase capable of almost indefinite extension in the supply of Salmon to our markets; and the restoration of this fish to many of our rivers throughout Canada which are now in an exhausted or deserted state."

The belief in the efficacy of artificial propagation was not universal. Robson (1880) resident of Newcastle and close observer of Salmon in Newcastle Creek from boyhood wrote, "Many persons are of the opinion that more fish can be produced by watching the creeks during spawning season, and thereby preventing poaching and allow fish to deposit their ova naturally than by Mr. Wilmot's process."

For a few years after Wilmot began planting hatchery-reared young Salmon in several streams, the number of adult Salmon re-entering streams increased. Salmon numbers were also increasing elsewhere, however, as indicated by reports of the Department of Marine and Fisheries (1869, 1870). In the St. Francis Division of the St. Lawrence, it is reported that in both years, Salmon were on the increase in an area from which they had been almost exterminated. Wilmot (1870) reported: "The numbers of Salmon and grilse that entered [Wilmot Creek] during the fall of 1869 were far greater than the

most sanguine in their expectations had anticipated." The increase in Wilmot Creek was generally attributed to planting of hatchery-reared young, but no such explanation accounts for the increase in the St. Francis Division.

Stocking was extended to streams other than Wilmot Creek. The Rouge River, and Highland, Duffins, Lynde, Bowmanville, Wilmot, and Grafton creeks, were all identified as streams for natural and artificial Salmon propagation (Wilmot, 1873). By 1871, it was reported that Salmon were again observed in streams from which they had disappeared (Wilmot, 1871). Kerr (1871), a fishery inspector from Lake Ontario, was encouraged that "should the fish-breeding experiments begun at Newcastle be continued as successfully to heretofore, they will again have become as plentiful as in days past." In 1874, Wilmot reported that Salmon fry had also been planted in the Moira, Trent, and Credit rivers, unspecified streams farther west of the Credit, a tributary of the Ottawa River, and in the Saugeen River; a tributary of Lake Huron. In 1874, Wilmot was still expecting "almost unlimited increase in the present and future years" (Wilmot, 1874)

Reports for 1877 and 1878 contain the first indication of a decline in numbers (Wilmot, 1877; Kerr, 1874). Robson (1880) referred to the "extraordinary decline in Salmon populations of Wilmot Creek in 1879-1880." In 1879, Wilmot reported "this season they are very much reduced from last year with the peculiarity of all being very large females and no grilse". In 1881, "only half a dozen adult fish and a few dirty discoloured grilse" were seen (Wilmot, 1881). All evidence suggests that this was the last of a dominant year-class.

Statistics of the commercial catch of Salmon on the Atlantic coast show that from 1870 (the first year for which statistics are available) until 1874, Salmon were increasing in abundance. After 1874, a steep decline occurred resulting in a catch of less than a million pounds in 1881 compared to a catch of over five million pounds in 1874 (Dymond and MacKay, 1966).

It is reasonable to ascribe some of the increase of Salmon in Lake Ontario between 1868 and 1873 to the planting of hatchery-reared young. That not all of the increase was due to the hatchery is indicated by the increase in eastern Canada. It is certain, however, that planting of artificially-reared young was unable to maintain the Salmon in the face of unfavourable natural conditions. Wilmot (1884) accounted for the failure of the hatchery-reared young as follows: "These breeding streams have become so changed of late in temperature and purity during the hot summer months as to cause the death of young Salmon; hence the discontinuance of artificial breeding of fish in this nursery that practical experience has shown cannot withstand the climatic effects upon the generally reduced flow of water in the streams of Ontario."

Alewife

Alewife has a high concentration of thiaminase and adult Salmon females feeding on them develop a thiamine deficiency reducing their survival, reproduction, or both (Ketola, 2000). Alewife entered Lake Ontario via three possible pathways: 1) the St. Lawrence River; 2) the opening of the Erie Canal - Oswego river system in 1819; 3) intentional introduction by Seth Green in early 1870 (Regier, unpublished, 1975; Ketola, 2000). Alewife increased rapidly after its first discovery in Lake Ontario in 1873. J. W. Kerr wrote in 1877 that Gasperaux (also known as Alewife) was found in the millions in Lake Ontario; 2 000 were caught along with 5 500 ciscoes and a few small Salmon in Burlington Bay (Regier, Ministry of Natural Resources, unpublished, 1975). Smith, S. (1970) and later Ketola (2000) proposed that Alewife likely negatively impacted the already declining Atlantic Salmon in Lake Ontario.

Last appearance of the Lake Ontario Salmon

It is impossible to associate a date with the last native Salmon taken in Lake Ontario or its tributaries. Available evidence suggests, however, that some were in existence during the 1890's but disappeared towards the end of the decade. In 1890, one of the last Salmon was recorded: a 5 kg specimen taken on a fly rod below the first dam on the Oswego River (Smith W., 1892). The latest report is by Cobb (1900) who reported, "A Salmon, weighing about 4 lbs. caught in 1899 in gill-net set for whitefish in Lake Ontario". This

fish was caught opposite the village of Wilson, NY near Twelvemile Creek.

Summary

This is a summary of relevant information on the history of the Lake Ontario Atlantic Salmon from a 1966 report by Dymond and McKay and review of studies since then. Discussed is the origin of Atlantic Salmon in Lake Ontario, conditions for its success, life history, evidence for early abundance, causes of decline and final extirpation, and early reintroduction efforts.

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