An Analysis of the "Lake Trout Capital of the World"

Stephen Dwyer
Hobart and William Smith Colleges
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Faculty Sponsor: John Halfman
FLI Sponsor: Sarah Meyer
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Abstract

Seneca Lake, located in the center of the Finger Lakes region, is known as the "Lake Trout Capital of the World" and is the eleventh most fished waterbody in New York State (Pearsall et al., 2001). The annual Seneca Lake Trout Derby is the largest and longest running lake trout derby (*Salvelinus namaycush*) in the country (Morehouse), attracting as many as 2,789 anglers during its peak in 1991. Over the course of the three day derby in 1989, anglers brought $335,839 to the local economy (Kenyon, 2006). The success of the recreational lake trout fishing industry in Seneca Lake is entirely dependent upon the health of the lake trout population within the lake. The introduction of the parasitic sea lamprey (*Petromyzon marinus*) and most recently zebra and quagga mussels (*Dreissena polymorpha* and *D. bugensis*) is threatening the health of the lake trout population in Seneca Lake. Sea lamprey can kill between 15 and 40 lbs of fish during its parasitic life phase ("Invasive Fish"). Zebra and quagga mussels are disrupting the food chain within Seneca Lake, removing phytoplankton and zooplankton which are necessary for slimy sculpin (*Cottus cognatus*), alewives (*Alosa pseudoharengus*) and smelt (*Osmerus mordax*), fish which lake trout rely on for food. The New York State Department of Environmental Conservation (NYSDEC) has reacted to the problem of invasive species by establishing a sea lamprey control program, beginning in 1982 and continuing today, as well as lowering the amount of young lake trout stocked into Seneca Lake to allow the forage base to recover. The management performed by the NYSDEC is necessary to ensure a healthy lake trout population and a lucrative recreational fishing industry.

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Introduction

As the signs entering Geneva proclaim, Seneca Lake is the "Lake Trout Capital of the World" and home to the largest and longest running lake trout derby in the country (Morehouse). Its productivity as a fishery makes it the most fished of the 11 Finger Lakes, the eleventh most fished waterbody in New York State, and the fourth most fished non-Great Lake or non-river system in New York (Pearsall et al., 2001). Throughout its history as a prized lake trout (*Salvelinus namaycush*) fishery, Seneca Lake has undergone varying degrees of management from the New York State Department of Environmental Conservation (NYSDEC) in terms of fish stocking regimes and invasive species management, with the goals of restoring native species and enhancing recreational fishing. The specific strain of lake trout found in Seneca Lake is native only to Seneca and Cayuga Lakes, but is used to stock 6 of the 11 Finger Lakes, as well as all 5 Great Lakes and Lake Champlain. While the impacts of invasive species, such as sea lamprey (*Petromyzon marinus*), zebra (*Dreissena polymorpha*) and quagga (*Dreissena bugensis*) mussels, have had deleterious effects on the native lake trout population, natural recruitment of lake trout in Seneca Lake has increased dramatically since 1999 (Hammers). Future management will adapt to the changing fishery so that Seneca Lake can remain the "Lake Trout Capital of the World". This paper will demonstrate that lake trout are a unique resource to Seneca Lake and their health as a population is important ecologically and economically to the recreational fishing industry of the Finger Lakes and Great Lakes.

Seneca Lake

The 11 Finger Lakes of western New York were formed during the Pleistocene Era when glaciers carved out lake basins, creating 11 north-south aligned lakes. Seneca Lake lies in the geographic center of the Finger Lakes, with a maximum depth of 616ft, making it the deepest of all the Finger Lakes. Seneca Lake is approximately 35 miles long and 3.2 miles across at its widest point.

Seneca Lake is an oligotrophic lake, making it appear clear and free of large amounts of macrophytes and algae. The abiotic characteristics which make it a productive lake trout fishery are its cold, oxygen rich bottom waters which lake trout require to survive and reproduce. The lake is dimictic, mixing during the fall and spring; distributing the cold, nutrient rich bottom waters throughout all depths of the lake. During these times of the year, lake trout can be found in both shallow and deep waters.

Seneca Lake supports populations of both cold and warmwater fisheries. Coldwater species include lake trout, rainbow trout (*Onchorhycus mykiss*), brown trout (*Salmo trutta*) and Atlantic salmon (*Salmo salar*), with lake trout constituting 97% of all coldwater species caught by anglers (Hammers, 2005). Warmwater gamefish include largemouth and smallmouth bass (*Micropterus salmoides* and *M. dolomieui*), northern pike (*Esox lucius*), chain pickerel (*Esox niger*) and yellow perch (*Perca flavescens*).

Lake Trout and Spawning

Lake trout are the largest of all the trout species, reaching weights of almost 100 lbs and ages of over 30 years. The largest lake trout caught in New York State was caught in Lake Erie in 2003 and weighed 41 lbs. Lake trout are piscivores, feeding primarily on other fish. In Seneca Lake, they traditionally feed on slimy sculpin (*Cottus cognatus*), alewives (*Alosa pseudoharengus*) and smelt (*Osmerus mordax*) and younger fish feed on mycids.

Seneca Lake trout spawn over a 2 to 3 week period in late September and early October (Sly and Widmer, 1984) at depths ranging between less than 30ft to 300ft. Female lake trout have been found to become ripe with eggs as air temperatures begin to drop in late September, causing lake temperatures to subsequently drop (Sly, 1988). Spawning typically begins in areas of the lake below the thermocline with temperatures less than 50°F. Because of yearly variations in temperature and wind activity, the depths at which these conditions occur are highly variable.

Spawning occurs over a variety of substrate types, with coarse angular cobble gravel (diameters from .7-4in., with occasional blocks of larger size), devoid of fine organic materials, usually preferred (Sly and Widmer, 1984) (Figure 1). Figure 2 shows spawning substrate with too much organic material and too small of rocks to be a successful spawning habitat. Sources of degradable organic matter pose a significant threat to the survival of lake trout embryos. Degradation of organic matter trapped within the substrate involves a number of biochemical reactions which relate to the breakdown of carbon, nitrogen and sulphur compounds. The resulting stressors, biological oxygen demand (BOD), N-ammonia (non-ionized ammonia), CO_2 and H_2S are most likely to retard or kill embryo development (Sly, 1988).

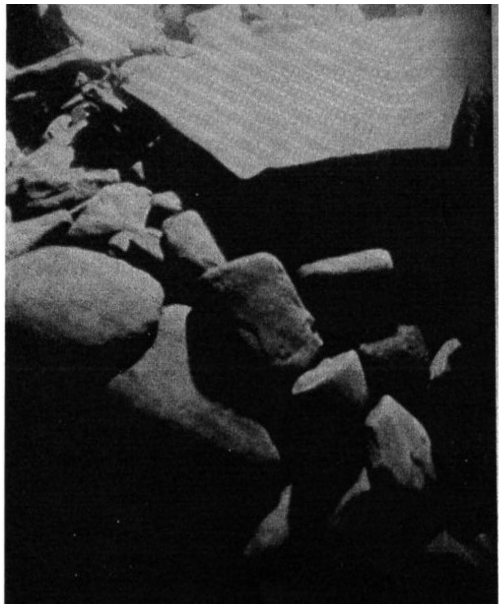

Figure 1. Preferred lake trout spawning substrate (Sly and Widmer, 1984)

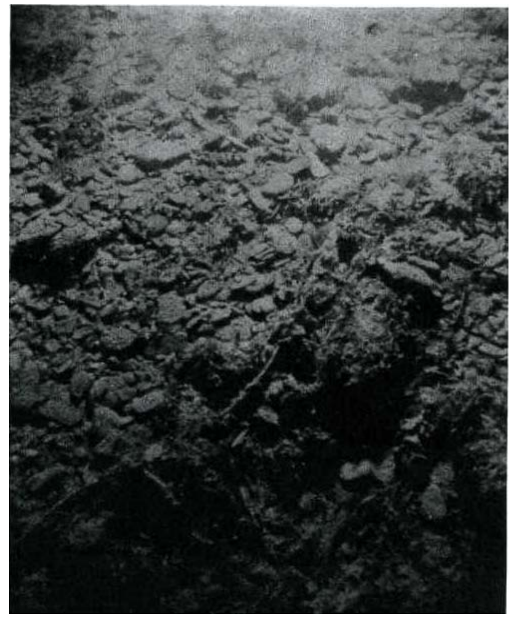

Figure 2. Spawning substrate with too much organic matter (Sly and Widmer, 1984)

A study done by Sly and Widmer (1984) found that the lack of a naturally clean cobble gravel off the mouth of the Keuka Outlet and elsewhere in the northern parts of Seneca Lake suggest that most of the deep water habitat suitable for lake trout spawning is restricted to the southern part of the lake. At the time of the study, the northern half of the Seneca Lake shore primarily consisted of sandy beach gravels, composed of reworked glacial material and some fragments of local bedrock (Sly and Widmer, 1984). Peach Orchard Point, located on the south-eastern side of the lake, is a well known lake trout spawning site (Sly, 1988). Other successful spawning sites in the southern half of the lake, including Curry Creek, Glenora, Rock Stream Point and Hector Falls (Figure 3), are located offshore from stream deltas. The substrate at these sites is generally composed of flat and discoidal bedrock materials from local shales and mudstones. Cobble-gravel fans form at the mouths of streams along steep walls of the lake and extend to water depths in excess of 200ft. Strong currents keep the tips of the fans clear of surface deposits derived from suspended material, thus creating a prime spawning environment.

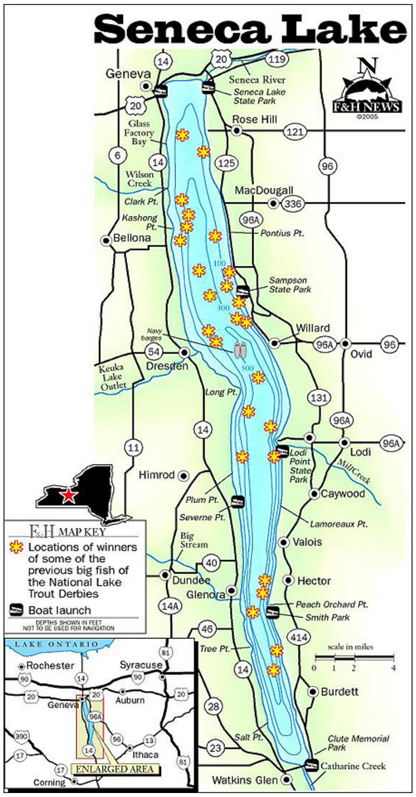

Figure 3. Map of Seneca Lake, New York (Finger Lakes Trout Derby, 2006)

Despite theoretically poor spawning grounds in the northern sections of the lake, long-term Seneca Lake fisherman and lake trout fishing guide, Ron Martino (Hobart ’57) claims that lake trout can be found spawning off of the Long Pier and in front of the Geneva Chamber of Commerce in relatively shallow water where rocky substrate is present. Fishermen are known to catch lake trout during their spawning times as the trout are grouped closely together, depositing eggs and fertilizing them (Martino).

Once an adequate spawning ground is established, the act of spawning occurs. This happens when one or more males press themselves up against a female, depositing both the eggs and milt (sperm) at the same time. The eggs settle down into the rock crevices, forming a redd (nest), hatching 4 or 5 months later.

Figure 4 shows the sizes of the first few years of a lake trout’s life in Seneca and Cayuga Lakes. Lake trout grow at varying rates, depending on the abundance of a food source, and reach sexual maturity after 6 to 8 years.

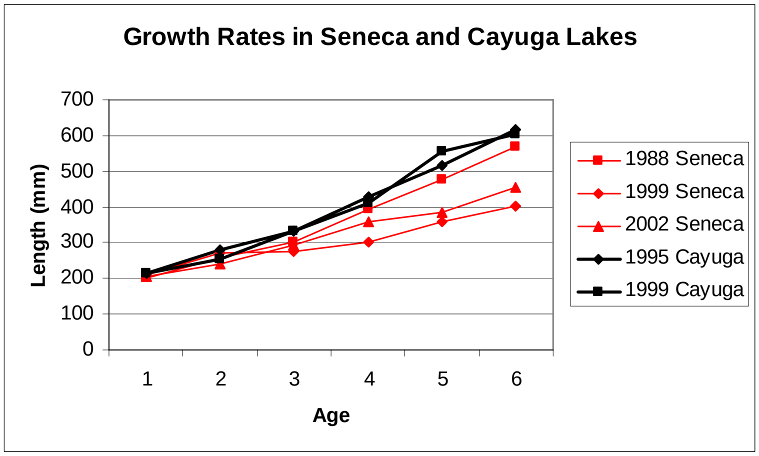

Figure 4. Lake Trout growth rates in Seneca and Cayuga Lakes ("Seneca Lake- Lake Trout")

The studies done by Sly (1988) and Sly and Widmer (1984) on the spawning substrates in Seneca Lake were performed in the 1980s, prior to the invasion of zebra mussels in 1992. Zebra and quagga mussels have now colonized vast areas of the lake, inhabiting both rocky substrates and soft sediments in shallow and deep waters. This has drastically altered the lake floor, which has impacted historic lake trout spawning grounds in the lake. If future studies were conducted on the same areas which Sly and Widmer reported on in the 1980s, they would provide further insight as to how exactly zebra mussels are impacting lake trout spawning grounds in Seneca Lake. The impact of zebra mussels will be further discussed in the Zebra and Quagga Mussel section (pg14).

Lake Trout Derby

The distinguished lake trout fishing of Seneca Lake has allowed the annual Memorial Day Lake Trout Derby to continue into its 42nd year as of 2006. Originally created in 1965 by a group of Geneva businessmen who decided to organize a contest that would promote area tourism and economy, the Seneca Lake Trout Derby is the longest running trout derby in the country (Kenyon, 2006). With 550 fishermen participating in the first annual derby, the derby has grown in popularity over time, with its highest number of participants (2,789) in 1991 (Figure 5). Finger Lakes Sports-O-Rama, which consists of regional business personnel, leaders of not-for-profit organizations and other individuals, supports the annual derby, while Colin Morehouse coordinates the event.

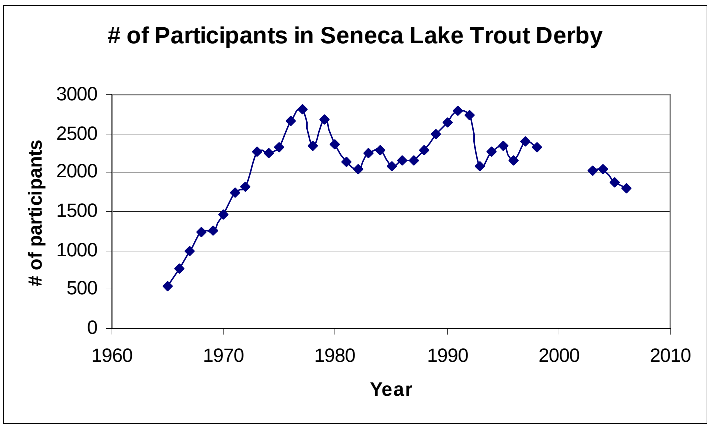

Figure 5. Number of Participants in Seneca Lake Trout Derby ("Derby Registrants")

The derby takes place over a course of 3 days with weigh stations at the Geneva Chamber of Commerce boat launch, Sampson State Park and in Watkins Glen. All contestants must be registered, pay the $25 fee for adults or $10 fee for children, and possess a valid NY State fishing license. Any winner may be required to take a Polygraph Test to prove that he/she caught the winning trout. In 2006, a grand prize of $5,000 was given to the winner of the largest catch, measured by weight. Combined funds from entrance fees, as well as donations from seven different local businesses, totaled $29,325 worth of cash prizes for winning categories. Extra profits not given away as prize money were donated to the local Boys & Girls Club, Finger Lakes Conservation Club and the Servant Volunteer Fire Department.

The derby attracts thousands of people from various different locations. Colin Morehouse, who has been organizing the derby since the 1970s, has a mailing list of recent participants in the derby, totaling over 5,000 people from as many as 26 states and several countries (Morehouse).

Sport fishing brings a large sum of money into the local economy. A 1989 study prepared by Dr. Francis Smith, Professor of Environmental Conservation/Outdoor Recreation at the Finger Lakes Community College, estimated that revenue generated by anglers participating in the derby brought $335,839 to Seneca, Ontario, Yates and Schuyler counties. $178,500 was designated as tourist dollars, money spent on travel, fuel, lodging, food and other expenses. The remaining money, $157,339, was spent on fishing supplies and bait at local stores and bait shops (Kenyon, 2006).

The derby acts as an indicator of the health of the lake trout population in the lake. Through examining the records of the largest lake trout caught, past trends can possibly predict how the future of the lake trout population will stand. Figure 6 shows the trends in largest catch since 1965 and shows that the average size of lake trout being caught have significantly decreased in size over the years ($F=11.08$, $p<0.001$).
There are many factors that contribute to the overall size of a lake trout and health of an entire population, including competition for food resources and predation by the parasitic sea lamprey. These topics will be discussed in the Sea Lamprey (pg 11) and Zebra and Quagga Mussels (pg 14) sections.

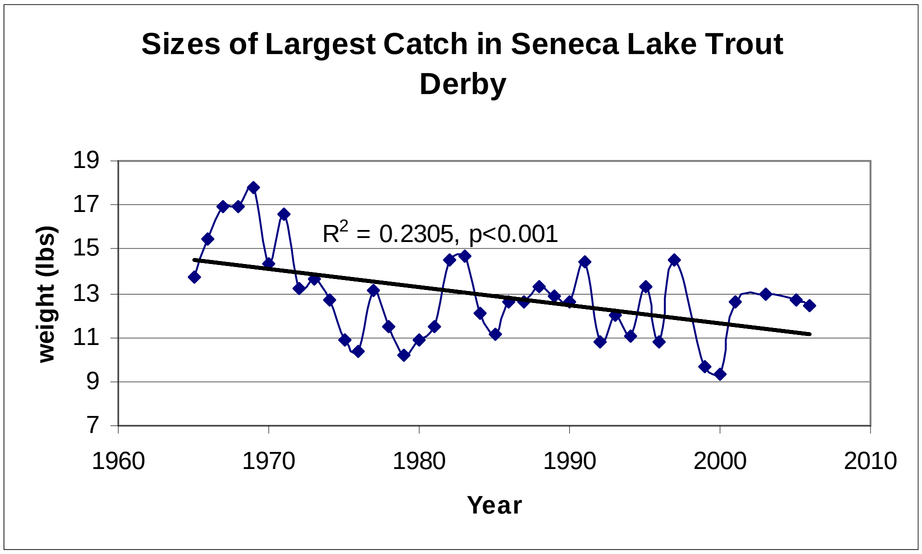

Figure 6. Sizes of Largest Catch in Seneca Lake Trout Derby (Finger Lakes Trout Derby)

Angler Diary Program

The NYSDEC Volunteer Angler Diary Program is another indicator of the productivity of the lake trout population in Seneca Lake. Beginning in 1973 with 76 cooperators the Angler Diary Program has grown to have as many as 152 cooperators in a year. Information anglers record includes: the number of fishing trips they take; the hours for each trip; amount of time to catch the first legal sized salmonid (lake trout, rainbow trout, brown trout or landlocked salmon), the total amount of salmonids kept and the size and weights of each salmonid kept. After 33 years, the Angler Diary Program has provided useful data, from the angler's perspective, that reflects the activities of the Seneca Lake trout fishery. The average weight of lake trout kept has remained between 3 and 4 lbs, varying slightly between years (Figure 7). The average length of lake trout kept has decreased over time ($F=17.01$, $p<0.001$) (Figure 8) with variations of several inches between years. Data from the average time to catch a legal size salmonid shows that anglers spend significantly less time trying to catch fish ($F=75.25$, $p<0.001$)(Figure 9). Anglers spent on average 1.4 hours before catching their first legal sized salmonid in 2005, compared to well over 4 hours during the 1970s. While faster rates of catch are desirable from an angling point of view, it reflects potential changes to the fishery. The faster catch rate is likely due to low forage abundance, thus making hungry fish more willing to strike a fisherman's lure (Hammers, 2005). Lower forage abundance is also a possible explanation for the decreasing sizes of lake trout over the years. These topics will be further discussed in the Sea Lamprey (pg 11) and Zebra and Quagga Mussels (pg 14) sections.

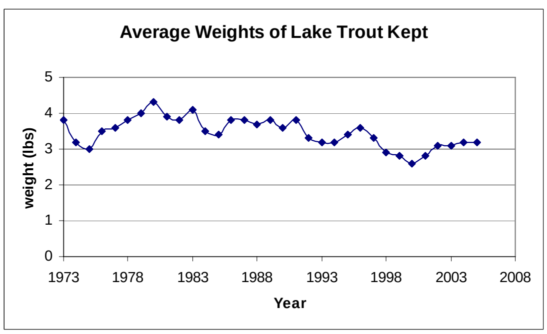

Figure 7. Average Weights of Lake Trout Kept (Hammers, 2005)

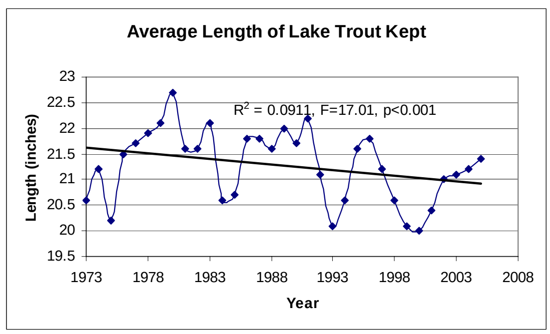

Figure 8. Average Length of Lake Trout Kept (Hammers, 2005)

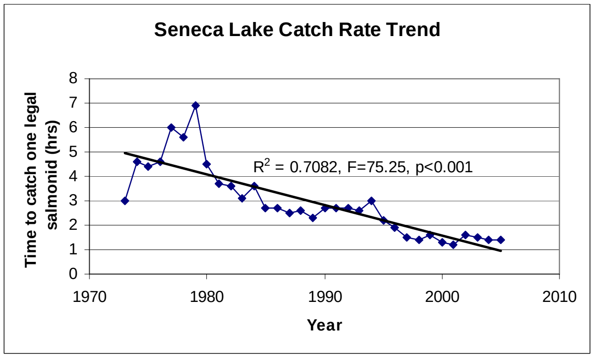

Figure 9. Seneca Lake Catch Rate Trend (Hammers, 2005)

Sea Lamprey

The sea lamprey population in Seneca Lake is not endemic; it is believed that they invaded the lake from the Hudson River via the Erie Canal (Jolliff et al., 1981). The Cayuga-Seneca Canal was connected to the Erie Canal in 1828 (Seneca Falls History), so sea lamprey could have entered Seneca Lake anytime after this date.

Sea lamprey attach to a host with a tooth-studded oral disk, which make it very difficult for a lamprey to become dislodged. Once attached, the lamprey then feeds on the blood and tissue of its host, severely weakening the fish, with death a likely end result. It has been estimated that a single lamprey during its parasitic life phase will kill between 15 and 40 lbs of fish ("Invasive Fish").

It was not until the 1970s that lamprey parasitism was noted on a large scale in Seneca Lake trout. Anglers referred to this time as the "lamprey lull" and to Seneca Lake as the "Dead Sea" (Maguire, 1989) because of the long periods of time spent trying to catch fish (Figure 9) and the large numbers of fish with lamprey wounds. This problem prompted the NYSDEC to carry out numerous monitoring efforts, including sampling trout caught during the annual derby for lamprey wounds and finding the breeding grounds for the sea lamprey.

The NYSDEC established that the sea lamprey spawned in Catharine Creek and the Keuka Lake Outlet. Once spawning occurs in the spring, the larvae, known as ammocoetes, live and develop in the sandy bottoms of the streams for several years. Once they complete metamorphosis and become adults, they enter the lake during spring or fall and enter their adult parasitic phase. They stay in the lake, feeding on lake trout until spring, when they return to the streams to spawn and subsequently die.

Beginning in the fall of 1982 and 1983, and continuing on average every 3 or 4 years until today, the NYSDEC treated the lamprey's spawning grounds in Keuka Outlet and Catharine Creek with the chemical lampricide 3 Trifluoromethyl-4-nitrophenol (TFM). This chemical was developed during the 1950s by the US Fish and Wildlife Service and has been found to be very effective at targeting only lamprey ammocoetes, remaining non-toxic to other fish. Two deltaic areas off the mouths of both streams were treated with 5% granular Bayluscide (Bayer 73) in the late summer of 1982 and again in 1986. A sea lamprey barrier was also installed in upper Catharine Creek in 1982 to prevent adult lamprey from utilizing the spawning habitat and nursery habitat upstream of this structure (Kosowski, 2000). The sea lamprey control efforts using TFM are ongoing, with Keuka Outlet treated last in 2004 and Catharine Creek in 2005. Lampreys are still found in the lake as well as ammocoetes in the tributary stream systems.

The amount of sea lamprey marks per lake trout sized 600-699mm in length taken during the annual Lake Trout Derby has varied since the beginning of the lampricide applications. Figure 10 shows that in the first six or seven years of applications, the number of attacks per fish steadily decreased from 2.5 to less than 1, but began to increase and vary after 1988. In 2002, there was an average of 2 attacks per fish, only slightly lower than when the lampricide applications began. While this shows a decrease in lamprey predation, the overall results do not suggest a lot of success in reducing lamprey predation.

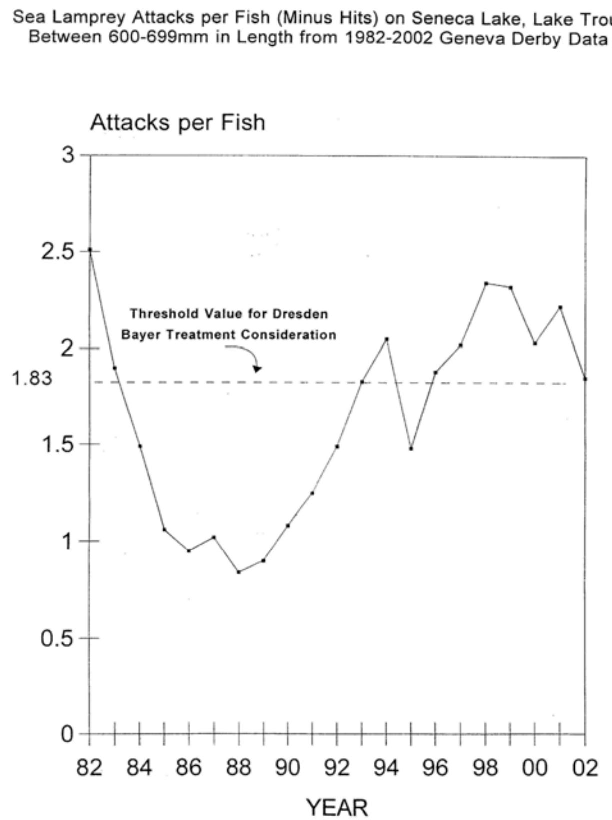

Figure 10. Sea Lamprey Attacks per Fish (Minus Hits) on Seneca Lake, Lake Trout between 600-699mm in Length from 1982-2002 Geneva Derby Data

Long time Seneca Lake trout fisherman and guide, Ron Martino, has kept records of his fishing trips and frequently recorded his sightings of fish with lamprey wounds since the 1970s. Table 1 shows that the percent of lake trout he has caught with lamprey wounds has decreased since the mid 1970s, suggesting that the lampricide applications are having beneficial impacts to the lamprey problem. While these numbers only represent one fisherman's observations, it provides another view of the changing relationship of sea lamprey and lake trout.

Year	% lake trout with lamprey wounds
1975	0
1976	31.5
1978	28.5
1983	12.5
2002	11.1
2005	19.4
2006	0

Table 1. Percent of Lake Trout with Lamprey Wounds (Martino, 2006)

The 1999 application of TFM to Keuka Outlet killed an estimated 250 ammocoetes, a marginally effective result (Kosowski, 2000). The 2000 application of TFM to Catharine Creek killed an estimated 5,000 plus ammocoetes; this was considered to be highly effective, killing many more than the 1996 and 1993 applications. Shortly after the 1999 and 2000 treatments of Keuka Outlet and Catharine Creek, no lampreys were found swimming from the streams to the lake, leaving the NYSDEC confident that the TFM applications were successful in preventing out-migration of sea lamprey. The total cost of the treatments to Keuka Outlet in 1999 and Catherine Creek in 2000 was approximated at $86,000. Since lampreys are still being found predating upon lake trout and ammocoetes are still found in streams, the NYSDEC will continue to apply TFM to Keuka Outlet and Catharine Creek at 3 or 4 year intervals (Kosowski, 2000).

Zebra and Quagga Mussels

Zebra mussels were first found in Seneca Lake in 1992, followed by quagga mussels several years later. The exact date that quagga mussels entered the lake is not known because the two species of mussels have very similar appearances and can be hard to distinguish. These invasive mussels are indiscriminate filter feeders, colonizing vast areas of the lake. The mussels are found in varying depths, ranging from very shallow waters to over 300ft in depth. It has been observed in Seneca Lake that quagga mussels are colonizing deeper, colder waters with softer sediment than zebra mussels. As filter feeders, zebra and quagga mussels filter the water surrounding them, processing between 4 and 10 liters of water per day (Halfman, 2006). This filtering activity removes phytoplankton and zooplankton from the water. Phytoplankton are the base of the food chain in aquatic ecosystems, so zebra and quagga mussels are reducing this vital food source, making it less available to the native zooplankton and fish. Figure 11 shows the food chain with the introduction of zebra mussels and how it is being redirected from fish and other organisms to the invasive mussels.

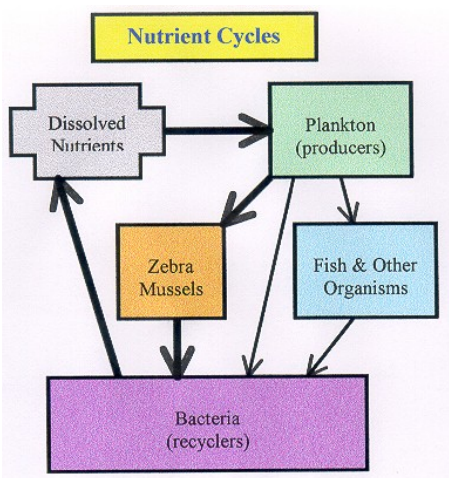

Figure 11. Food Web-Nutrient Cycle Zebra Mussel Impact (Halfman, 2006)

With less plankton in the water, light is able to penetrate deeper into the water column. Figure 12 shows average secchi disk depths from 1991 until the present, showing a several meter increase in light penetration. Since zebra mussel introduction in 1992, secchi disk depths have increased.

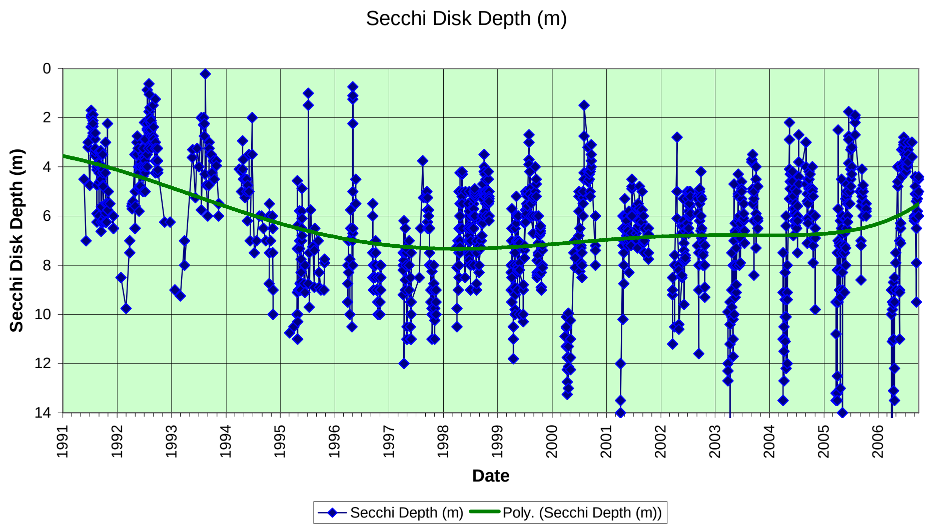

Figure 12. Secchi Disk Depth from Seneca Lake (Halfman, 2006)

The less turbid water conditions of Seneca Lake may be having an influence on sea lamprey predation of lake trout. Sea lampreys locate their prey visually, thus clearer waters make it easier to find and attack lake trout. The recent increase in sea lamprey attacks per fish (Figure 10) may possibly be attributed to being able to locate their prey more efficiently.

The effects of invasive mussels are being passed up the food chain in the form of a reduced forage base for lake trout. The first fish to feel the effects of zebra mussels in Seneca Lake are smelt and alewives because both rely on zooplankton for the majority of their food, especially when young (Pearsall and Richardson, 2001). The NYSDEC does annual standard gang gill nettings in Seneca Lake to retrieve lake trout, taking their eggs and sperm for hatchery reproduction and returning the trout to the lake. Since 1999, no smelt have been found in any of the nets or stomachs of lake trout, suggesting they are nearly absent in Seneca Lake. This has both positive and negative effects for the lake trout.

Smelt, since their introduction into Seneca Lake in 1909, have provided a constant and abundant food source for lake trout. Their disappearance results in a loss of the principle forage of adult lake trout. A less abundant forage base correlates to fisherman spending less time to catch a lake trout, showing that the lake trout are hungry and more willing to strike a lure. With less food to eat, trout are not able to grow as large as they historically have when abundant food was present. Figure 7 and 8, from the Angler Diaries, show that after 1995, just three years after the establishment of zebra mussels in the lake, both average weight and length of lake trout decreased steadily until 2000. After 1995 the average time to catch a legal sized salmonid was cut in half, dropping from three hours to 1.4 hours in 2005. All of this data reiterates how a reduced forage base is negatively impacting the size of the lake trout in Seneca Lake.

A positive aspect of the decline in smelt is that smelt are a voracious predator on lake trout eggs and fry, allowing an increased survival of Seneca Lakes' wild like trout population. This has been documented by the NYSDEC within the last decade. From 1977 to 1988, less than 20% of lake trout caught during the gill nettings were wild. The difference between wild and hatchery reared lake trout can be determined from fin clippings of hatchery reared trout. By 1999, 70% of the trout caught in the gill netting were wild, and by 2002, 75% of the trout were presumed to be wild. This increase in natural reproduction within the lake may be attributed to an increase in suitable spawning habitat or less predation of lake trout eggs and fry from smelt, both of which have occurred from the recent introduction of invasive mussels in Seneca Lake (Hammers).

Bath Fish Hatchery

The Bath Fish Hatchery, located in Bath, NY, has been stocking Seneca Lake with lake trout since the 1950s and currently stocks six of the eleven Finger Lakes, Lake Ontario, Lake Erie and Lake Champlain with lake trout. The parents of the fish that they are stocking into these lakes are of the Seneca Lake strain, which only occur naturally in Seneca and Cayuga Lakes. Historically, the NYSDEC obtained the eggs and milt from lake trout taken offshore from Peach Orchard Point in Seneca Lake by the process of gill netting. However, beginning in 1999, the NYSDEC began obtaining lake trout from Peach Orchard Point as well as offshore from Taughannok Falls in Cayuga Lake. Currently the entire parent stock of the Seneca Lake strain of lake trout is taken from Cayuga Lake because the NYSDEC is able to obtain the quota of 333,000 eggs from female lake trout with one week of gill netting, a process which used to take two weeks when done in Seneca Lake alone (Osika). Kenneth Osika, manager of the Bath Fish Hatchery, attributes the quicker time to obtain lake trout and their eggs from Cayuga Lake to a possibly larger population of lake trout in Cayuga Lake compared to Seneca Lake.

The amount of lake trout stocked in Seneca Lake has varied greatly over time (Figure 13). Fingerlings (young fish three to five inches in length) and yearlings (fish one year or older, six to nine inches in length) are stocked in the lake at different numbers. Fingerlings are stocked in higher numbers because of a higher presumed mortality rate. The number of fish that the NYSDEC stocks each year is based on a calculation called the Morpho-Edaphic Index (MEI), which relates lake chemistry to fish production.

During the 1950s and 1960s, over 150,000 fingerlings were stocked into Seneca Lake. However, during the 1970s, fingerling stocking was discontinued because a study of fingerlings in Cayuga Lake, which is very similar to Seneca Lake in terms of morphology and lake trout populations, showed that they did not survive as well as the larger yearlings. The NYSDEC has since realized that fingerlings did survive well in Seneca Lake, so their stocking was resumed in the 1980s (Maguire, 1989). The drastic shift in management of the lake trout stocking program occurring during the "lamprey lull" has caused large changes to the lake trout population in Seneca Lake.

In 2005, the NYSDEC reduced the numbers of fingerlings and yearlings they stock into the lake to 20,000 and 13,400, respectively, because findings through gill netting have shown that the lake trout within Seneca Lake are reproducing naturally. The absence of smelt in Seneca Lake is allowing lake trout eggs and fry to develop without being predated upon. Another reason for the reduction of fingerlings and yearlings is that the larger lake trout in the lake are believed to be eating the young stocked trout because of a lack of another food source (Hammers). Continuing to stock quantities of young lake trout would only supply the larger lake trout with a food source, rather than influencing the growth of stocked trout reaching adulthood.

The NYSDEC is adapting to the changing circumstances in Seneca Lake and will continue to stock low numbers of lake trout into Seneca Lake as long as the fish show signs of natural reproduction. If hatchery assistance is no longer needed, the Seneca Lake lake trout population may one day be able to naturally reproduce itself without assistance from the NYSDEC.

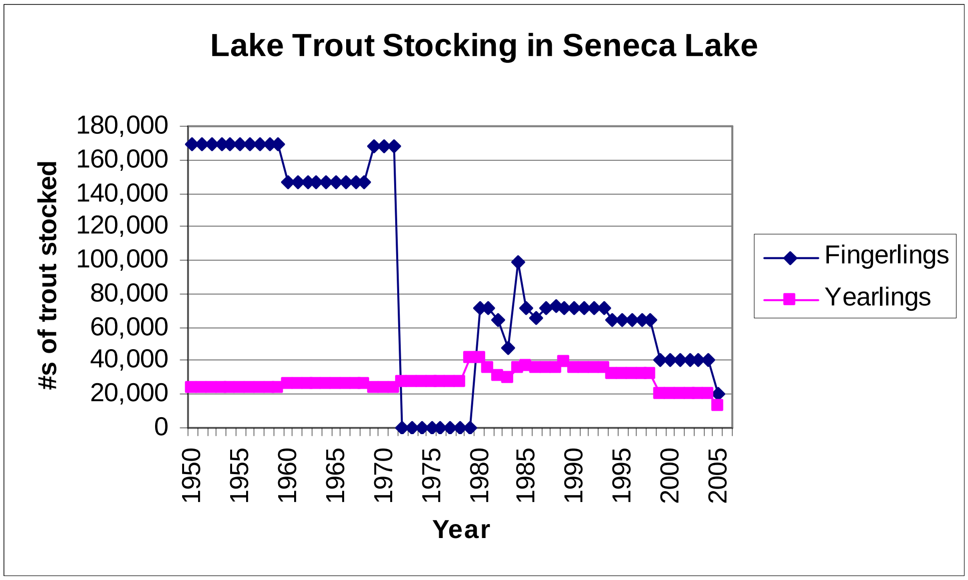

Figure 13. Lake Trout Stocking in Seneca Lake (compiled from "Environmental Impact Statement on Use of Lampricides in an Experimental Program to Reduce Sea Lamprey Abundance in Seneca Lake, New York", "Seneca Lake Stocking History by Year Class")

Great Lakes Rehabilitation Program

In the last century, lake trout throughout the upper Great Lakes were decimated by the synergistic effects of overfishing, habitat degradation and increased parasitism from sea lampreys. Lake trout populations disappeared from nearly all of the upper Great Lakes except portions of Lake Superior and very small portions of Lake Huron (Page et al., 2003). Because of the diversity of physical characteristics of the Great Lakes, lake trout populations were biologically diverse and exhibited a variety of physical forms, spawning times and habitat preferences. Currently, the lake trout diversity of the upper Great Lakes is limited to a few remnant wild populations within Lake Superior and Lake Huron and the rest is made up of hatchery strains stocked in the lakes. One of the strains frequently used in Great Lakes Rehabilitation programs is the Seneca Lake strain of lake trout. The Seneca Lake strain has proven to out-perform several strains that have been used in the lake trout rehabilitation efforts since the 1970s.

A study by Madenjian et al. (2004) demonstrated that the annual mortality rate in Lake Huron for the Seneca Lake strain was significantly lower than that for the Superior-Marquette (ANCOVA; $F=18.45$, $df=1,7$, $p<0.01$) and Lewis Lake strains (ANCOVA; $F=15.48$, $df=1,7$, $p<0.01$). The lamprey wounding rate for the Seneca Lake strain (5.6 wounds per 100 fish) was also significantly lower than that for the Superior-Marquette strain (12.9 wounds per 100 fish). In addition, the Seneca Lake strain reached sexual maturity after 4.7 years, compared to 5.1 and 5 years for the Superior-Marquette and Lewis Lake strains, respectively. The higher survival rates of the Seneca Lake strain are likely due to its ability to better avoid sea lamprey predation than other strains. Because of the higher adult survival of the Seneca Lake strain, they are able to yield a larger stock of older spawning fish, producing more young. In fact, over 80% of the naturally reproduced age-0 lake trout captured in the study by Madenjian et al. (2004) were of the Seneca Lake strain. Because the Seneca Lake strain was able to outperform all other strains stocked, the conclusion of their study was that stocking of the Seneca Lake strain should be continued in Lake Huron. It is recommended that genetic diversity should be promoted by stocking a variety of strains, including strains native to the Great Lakes, so that sea lamprey do not increase their attacks on Seneca Lake strain lake trout.

Future of Lake Trout in Seneca Lake

The future success of the lake trout population within Seneca Lake is entirely dependent upon maintaining superior water quality, the presence of an abundant forage base and controlling invasive species. Should all of these requirements be met, Seneca Lake will remain one of the top destinations for anglers in New York State, supplying millions of dollars to the local economy. An angler survey distributed by the NYSDEC in 1988 concluded that anglers spent $6,043,240 while fishing Seneca Lake over the course of one year (Connelly et al., 1990). These expenditures grew to $9,036,070 by 1996 (Connelly et al., 1997). An abundant and self-reproducing lake trout population will continue to bring more money to the local economy and at the same time reduce the input of the NYSDEC in terms of stocking regimes.

All of the Finger Lakes, including Seneca Lake, are being subjected to a variety of environmental threats including point and non-point sources of pollutants, shoreline housing development, increasing recreational use and the introduction of exotic species, such as sea lamprey, zebra and quagga mussels, spiny and fishhook waterfleas and Eurasian milfoil. The control of these various threats is critical to maintaining the Class AA drinking water derived from Seneca Lake (Halfman and Bush, 2006). Future nutrient loading from organic, agricultural and industrial wastes is a concern in Seneca Lake. If eutrophication of the lake is avoided, Seneca Lake will be able to maintain its clean and oxygen-rich waters which allow lake trout to survive.

Control of the invasive sea lamprey by the NYSDEC will continue into the future as long as the lake trout appear to be negatively impacted by their predation. While lampricide applications have been successful at killing lamprey ammocoetes, future control is still needed at this time to reduce their negative impacts on lake trout health.

The effects of zebra and quagga mussels on the plankton communities within Seneca Lake will need to be monitored into the future in order to gain a better understanding of their long term effects on lake biology. Currently, their impacts have reduced the abundance of plankton communities within the lake, an effect which is being passed on to the fish communities in the lake. While the absence of smelt has allowed natural reproduction of lake trout to dramatically increase since 1999, lake trout are now missing an important food source. Reduced stocking efforts for several years will allow a better understanding of the interactions between forage base populations and naturally reproduced lake trout.

Indicators of the health of the Seneca Lake trout population will continue to be useful tools during these times of shifting lake biota. The Lake Trout Derby and Angler Diary Program will continue to show size and weight trends as well as the extent of lamprey predation. Annual gill nettings by the NYSDEC will be able to confirm the presence or absence of naturally reproduced fish and the abundance of the forage base. If overall health declines, the NYSDEC must find a way to reverse the trends, either by stocking native alewives or other forage base, or encouraging the harvest of more fish per angler to allow the forage base to recover. If the lake trout of Seneca Lake continue to naturally reproduce and exhibit positive growth rates, their management can be reduced to natural processes and harvesting from licensed fishermen. If the latter condition prevails, Seneca Lake will retain its title as the “Lake Trout Capital of the World”.

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