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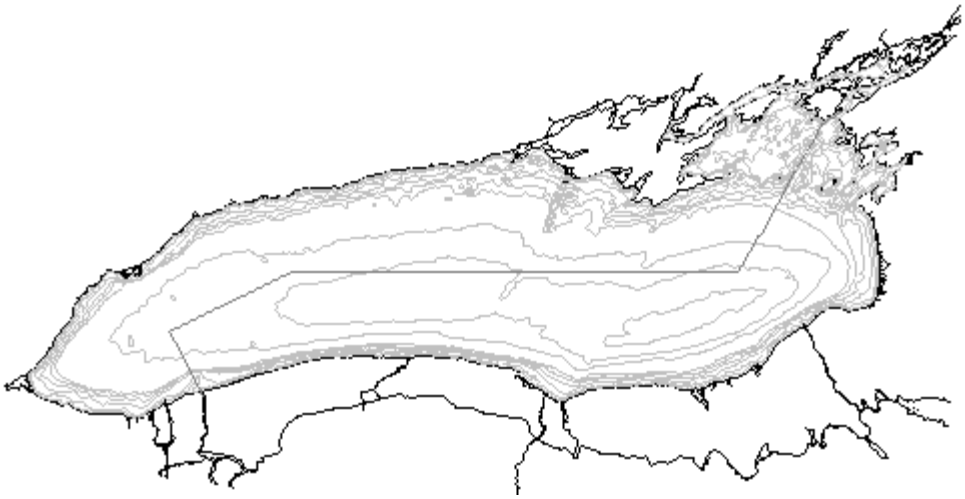
Lake Ontario Unit
and
St. Lawrence River Unit
to the
Great Lakes Fishery Commission's
Lake Ontario Committee



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THE FOLLOWING STUDIES REPORTED IN THIS DOCUMENT ARE SUPPORTED IN WHOLE OR IN PART BY THE FEDERAL AID IN SPORT FISH RESTORATION PROGRAM

SECTIONS 1, 2, 3, 4, 5, 8, 9, 10, 11, 12, 14, 15, 16, 19, 22, 23, AND 24

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SECTION	TITLE – AUTHORS	COOPERATING AGENCIES
1	**New York Lake Ontario and Upper St. Lawrence River Stocking Program 2013** *(Connerton)*	NYSDEC
2	**2013 Lake Ontario Fishing Boat Survey** *(Lantry J., Eckert)*	NYSDEC
3	**2013 Mass Marking of Chinook Salmon in Lake Ontario** *(Connerton, Balk, Prindle, Lantry J., Daniels, Bowlby, Bronte, Holey)*	NYSDEC OMNR USFWS
4	**Eastern Basin of Lake Ontario Warmwater Fisheries Assessment, 1976-2013** *(Lantry J.)*	NYSDEC
5	**Lake Trout Rehabilitation in Lake Ontario, 2013** *(Lantry B., Lantry J.)*	USGS NYDEC
6	**Thousand Islands Warmwater Fish Stock Assessment** *(McCullough, Gordon)*	NYSDEC
7	**2013 Lake St. Lawrence Warmwater Fisheries Assessment** *(Klindt, Gordon)*	NYSDEC
8	**2013 Salmon River Wild Young-of-Year Chinook Salmon Seining Program** *(Bishop, Prindle, Johnson)*	NYSDEC USGS
9	**Population Characteristics of Pacific Salmonines Collected at the Salmon River Hatchery 2013** *(Prindle, Bishop)*	NYSDEC
10	**2013 New York Cooperative Trout and Salmon Pen-Rearing Projects** *(Wilkinson, Sanderson, Prindle)*	NYSDEC
11	**Sea Lamprey Control in Lake Ontario in 2013** *(Sullivan, Adair)*	DFO USFWS
12	**Status of Important Prey Fishes in the U.S. Waters of Lake Ontario, 2013: Introduction and Methods, Alewife, Rainbow Smelt, Sculpins, and Round Goby** *(Walsh, Weidel, Connerton)*	USGS NYSDEC
13	**Cormorant Management Activities in Lake Ontario's Eastern Basin** *(McCullough, Mazzocchi)*	NYSDEC
14	**Double-Crested Cormorant Studies at Little Galloo Island, Lake Ontario in 2013: Diet Composition, Fish Consumption and the Efficacy of Management Activities in Reducing Fish Predation** *(Johnson, McCullough, Mazzocchi)*	USGS NYSDEC

15	**Diet Composition and Fish Consumption of Double-Crested Cormorants from Three St. Lawrence River Colonies in 2013** (*Johnson, Farquhar, Mazzocchi, Bendig)*	USGS NYSDEC OMNR
16	**2013 Status of the Lake Ontario Lower Trophic Levels** (*Holeck, Rudstam, Hotaling, McCullough, Lemon, Pearsall, Lantry, J., Connerton, LaPan, Trometer, Lantry, B., Walsh, Weidel)*	Cornell Univ. NYSDEC USFWS USGS
17	**Progress Report for the Sportfishing Restoration and Spending Plan for the Lake Ontario System** (*Balk)*	NYSDEC
18	**Lake Sturgeon Tagging Study 2013** (*Klindt, Gordon)*	NYSDEC
19	**Monitoring and Management in the Upper St. Lawrence River Muskellunge** *(Farrell, Barry)*	SUNY ESF
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Executive Summary

The Lake Ontario ecosystem has undergone dramatic change since early European settlement, primarily due to human influences on the Lake and its watershed (Smith 1995; Christie 1973). The native fish community was comprised of a diverse forage base underpinned by coregonids (whitefish family) and sculpins, with Atlantic salmon, lake trout and burbot as the dominant piscivores (fish-eaters) in the system. Nearshore waters were home to a host of warmwater fishes including yellow perch, walleye, northern pike, smallmouth bass, lake sturgeon, and American eel. The dominant prey species in nearshore areas included emerald and spottail shiners.

Habitat and water quality degradation, overfishing, and the introduction of exotic species played major roles in the decline of the native fish community. By the 1960's, these impacts culminated in the virtual elimination of large piscivores, the reduction or extinction of other native fishes, and uncontrolled populations of exotic alewife, smelt, and sea lamprey (Stewart et al. 1999). Since the early 1970's, water quality improvements resulting from the Great Lakes Water Quality Agreement (International Joint Commission 1994), sea lamprey control, and extensive fish stocking programs in New York and Ontario have resulted in increased diversity in the Lake Ontario fish community and a robust sportfishery. In 2007, anglers fishing Lake Ontario and its tributaries contributed over $114 million to the New York State economy (Connelly and Brown 2009).

In recent decades, the Lake Ontario ecosystem has experienced continuing changes resulting primarily from the introduction of exotic zebra and quagga mussels. In addition, improvements in wastewater treatment have reduced excessive nutrient concentrations in the open lake to historic, more natural levels, thereby lowering the productive capacity of the Lake Ontario ecosystem. Zooplankton biomass in Lake Ontario's offshore epilimnion declined by 99% over the last 30 years, and populations of the exotic zooplankters *Bythotrephes* and *Cercopagis* were discovered in Lake Ontario in 1985 and 1998, respectively. The abundance and distribution of the deepwater amphipod, *Diporeia* have deteriorated markedly, likely due to range expansion of quagga mussels into deeper waters. The exotic round goby was first documented in New York waters of Lake Ontario in 1998 and was first detected in standard fish surveys in 2002. Since then, goby spread throughout Lake Ontario and the St. Lawrence River. Goby abundance and biomass grew exponentially, then stabilized at lower levels. Round gobies are the dominant prey of cormorant colonies in eastern Lake Ontario and the St. Lawrence River. Gobies have also been identified in the diets of numerous sportfish species including smallmouth bass, yellow perch, walleye, northern pike, brown trout, and lake trout, and are apparently responsible for markedly increased growth rates for some sportfish species including smallmouth bass and yellow perch. The effects of these ecosystem changes on the Lake Ontario fish community have not been manifested completely, nor are they fully understood.

Viral Hemorrhagic Septicemia virus (VHSv) was first documented in the New York waters of Lake Ontario and the St. Lawrence River in 2006. Substantial freshwater drum and round goby mortality events were observed, as well as numbers of dead muskellunge, smallmouth bass, and a moribund burbot. VHSv has also been identified in surveillance testing of healthy fish, including rock bass, bluegill, brown bullhead, emerald shiners and bluntnose minnows. Another exotic species, *Hemimysis anamola*, a small freshwater shrimp, was found near Oswego, NY in 2006, and has since spread in Lake Ontario and the St. Lawrence River. As with other aquatic invasive species in the Great Lakes system, the full impacts of these new invaders are unknown.

Maintaining balance between predators and prey, primarily salmonids (predominately Chinook salmon) and alewife, remains a substantive challenge in the face of lower trophic level disturbances and ongoing

ecosystem changes resulting from invasive species. This report summarizes cooperative research and monitoring activities conducted on Lake Ontario and the Niagara and St. Lawrence rivers by the New York State Department of Environmental Conservation, U.S. Geological Survey, Ontario Ministry of Natural Resources, U.S. Fish and Wildlife Service, Fisheries and Oceans Canada, the SUNY College of Environmental Science and Forestry and Cornell University in 2013.

Lower Trophic Level Monitoring

- From 1995-2013, the biomonitoring program in Lake Ontario has measured indicators of lower food web status at embayments, nearshore and offshore sites. The primary objectives are to evaluate temporal and spatial patterns in total phosphorus, soluble reactive phosphorus, chlorophyll *a*, Secchi depth, and crustacean zooplankton density, biomass, and size structure (Section 16).
- Spring total phosphorus has declined in the longer data series (since 1981), but not since the inception of the biomonitoring program in 1995. It averaged 8.4 µg/L in the nearshore and 5.0 µg/L in the offshore in 2013—below the 10 µg/L target set by the Great Lakes Water Quality Agreement of 1978 for offshore waters of Lake Ontario.
- Offshore summer chlorophyll *a* declined significantly in both the short- (1995-2013) and long-term (1981-2013) time series at a rate of 3-4% per year. Nearshore chlorophyll *a* increased after 2003 but then declined again after 2009. Epilimnetic (upper water column) chlorophyll *a* averaged between 0.5 and 1.3 µg/L across sites with no difference between nearshore and offshore habitats. Average seasonal Secchi disk depth (a measure of water transparency) ranged from 14.7 ft to 34.8 ft and was higher in the offshore (average 26.6 ft) than nearshore stations (20.7 ft). These values are indicative of oligotrophic conditions (relatively low in nutrients and biological productivity) in both habitats.
- Bosminid and cyclopoid copepod biomass (zooplankton biomass) have declined significantly in offshore and nearshore waters. Daphnid biomass has also declined significantly in the nearshore.
- The decline in Daphnid biomass nearshore and *Bythotrephes* biomass offshore and nearshore is indicative of increased planktivory by alewife. Significant declines in Bosminid and cyclopoid copepod biomass is indicative of increased invertebrate predation by *Cercopagis* and *Bythotrephes* in recent years.

Prey Fish Assessments

- In April – May 2013, both the abundance (number) and weight (pounds) indices for adult alewife (age-2 and older) in U.S. waters of Lake Ontario were very similar to 2012 values. The age-1 alewife abundance index in spring 2013 was above the long term mean for the 4th consecutive year, and represents the largest year class observed since the 1980 year class. The index of adult alewife condition (wet weight of a 6.5-in alewife predicted from annual length-weight regressions) in spring and fall 2013 remained high and similar range to recent years (Section 12).
- In 2013, the abundance index for age-1 and older rainbow smelt decreased 69% relative to 2012 (Section 12).
- Slimy sculpin density observed in 2013 was the lowest recorded in 27 years. From 2011-2013 slimy sculpin density has declined by approximately 50% each year (Section 12).
- Deepwater sculpin, once considered extirpated from Lake Ontario, have generally increased over the past eight years, but declined in 2013. The 2013 catch of deepwater sculpin was the 3rd highest recorded since the reappearance of this species in 2005 (Section 12).
- Round gobies were first detected in Lake Ontario bottom trawling assessments in 2002. Goby abundance and biomass expanded exponentially until 2008, and then declined dramatically in 2009. In 2013, round goby abundance increased slightly above 2012 estimates (Section 12).
- The 2013 hydroacoustic survey of Lake Ontario preyfish populations consisted of four (typically

5) cross-lake transects and an Eastern Basin transect. Estimated yearling and older alewife abundance was 681 million fish, 3.5 times higher than 2012 and 3.7 times higher than the previous ten-year average. The rainbow smelt population estimate was 19 million yearling and older fish (Figure 3), the lowest estimate in the history of the survey (Section 24).

Coldwater Fisheries Management

- Fish stocking in the New York waters of Lake Ontario in 2013 included 1.77 million Chinook salmon, 223,600 coho salmon, 628,480 rainbow trout, 522,587 lake trout, 331,480 brown trout, 128,274 Atlantic salmon, 7,310 bloater, and 9,023 lake herring. Over 118,500 brown trout were stocked offshore by military landing craft in a continuing effort to reduce predation on newly stocked fish by double-crested cormorants and predatory fish in the eastern portion of the lake (Section 1).
- The August 2013 mean length (37.5 in) of age-3 Chinook salmon from the open lake boat fishery was the 4th longest observed. Predicted weights for the four largest Chinook length groups examined in 2013 were comparable to respective long-term averages (Section 2).
- At the Salmon River Hatchery, the mean weight of age-1 Chinook males (jacks) sampled in 2013 (5.2 lbs) was very near the long term average. Age-2 males and females were 1.1 pounds above average (males 14.6 lbs, females 16.0). Age-3 males were 0.4 lbs below average (18.8 lbs), but 3.4 pounds heavier than 2012, while females were very near the long-term average (19.5 lbs). (Section 9).
- The condition or relative "plumpness" of Chinook salmon at the Salmon River Hatchery (based on the predicted weight of a 36 inch long Chinook salmon) in fall 2013 was 16.5 lbs, which is also the historical average (Section 9).
- Steelhead are sampled in the spring and, unlike Chinook and coho salmon, do not reflect growth during the 2013 growing season. Weights reported here reflect conditions prior to and including 2012. The mean weights of age-3 males and females were 5.9 and 6.7 lbs, respectively, which were approximately 0.1 and 0.4 pounds more than their respective, long-term averages. The mean weights of age-4 males and females were 8.6 lbs and 7.7 lbs, respectively; with males 0.2 lbs and females 1.5 lbs lighter than their long-term averages.
- Since the institution of seasonal base flows in the Salmon River in 1996, natural reproduction of Chinook salmon continues to be documented by an annual seining index conducted weekly during May and June at four sites. Prior surveys suggested that high flows in October generally resulted in relatively high numbers of Chinook reaching the upper river to spawn, thereby increasing the numbers of young-of-the-year (YOY) Chinook caught the following spring. High flows in May tended to increase YOY outmigration, or decreased their vulnerability to our seine, resulting in lower catches. Similar to fall 2007, drought conditions and low reservoir levels/river flows persisted in fall 2012. YOY catches in 2013 were lower than average through the first 3 weeks of May and above average the last week of May. A high flow event prevented sampling the first week of June, and catches the last 3 weeks of June were lower than average (Section 8).
- The sixteenth year of pen-rearing steelhead and Chinook salmon along the New York shoreline of Lake Ontario was very successful due to low fish mortality at most sites, and a relatively high percentage of fish reaching target weights. A total of 40,690 Washington strain steelhead were raised at six pen sites, comprising 7.5% of NYSDEC's Lake Ontario rainbow trout/steelhead stocking allotment in 2013. Seven pen-rearing sites raised a total of 451,944 Chinook salmon, representing 26% of NYSDEC's 2013 Chinook salmon stocking allotment (Section 10).
- In 2008, the NYSDEC purchased an automated fish marking trailer (AutoFish) capable of adipose clipping and/or applying coded wire tags to salmon and trout automatically at a high rate of speed and accuracy. From 2008-2011, NYSDEC and the Ontario Ministry of Natural Resources "mass-

marked" all stocked Chinook salmon with an adipose fin clip in Lake Ontario to determine the relative contributions of wild and hatchery stocked Chinook salmon to the fishery (Section 3). The percentages of wild Chinook salmon in Lake Ontario in 2013 varied among regions with a significantly higher percentage of wild age-2 fish observed in Ontario waters (56.5%) compared to the NY east (36.5%) and west (29.0%) regions; and a significantly lower percentage of wild age-3 fish observed in the New York west region (64.4%) compared to the NY east (76.2%) and Ontario (70.9%) regions, which were not significantly different (Section 3).

- Percentages of wild Chinook salmon in Lake Ontario varied by year class and age and among regions from 2009-2013, but overall, wild Chinook were an important component of the Lake Ontario fishery averaging 50% of the age 2 and 3 lake harvest.
- In 2013, the percentages of wild Chinook salmon for ages 2-4 at the Salmon River (65.2%, 79.0%, and 90.0%, respectively) were significantly higher than NY west and NY east tributaries. The percentages of wild Chinook salmon in western tributaries were low with 7.2% of age-2, 8.8% of age-3, and 0% of age-4 Chinook salmon unclipped. The percentages of wild Chinook salmon observed in eastern tributaries were higher than western streams with 10.2% of age-2, 19.8% of age-3, and 80% of age-4 Chinook salmon unclipped. These regional differences are consistent with observations from 2010-2012 (Section 3).
- Returns of Chinook salmon at the Salmon River Hatchery from the 2008-2010 year classes suggest a high degree of homing by fish stocked at the Salmon River and a low degree of straying from other stocking sites, with estimated average straying rates of 12.7%, 8.1%, and 10.4%, respectively (Section 3).

Lake Trout Restoration

- Adult lake trout catch per unit effort from the gill net survey recovered from historic lows observed during 2005-2007, and increased each year from 2008-2013 (Section 5).
- The rate of wounding by sea lamprey on lake trout caught in gill nets was 2.26 fresh (A1) wounds per 100 lake trout, slightly above the target of 2.0 wounds per 100 lake trout (Section 5).
- In 2013, five age-1 and three age-2 naturally produced lake trout were collected in trawl surveys, providing first evidence of a 2012 year class and continued evidence of a 2011 year class (Section 5).
- Condition of adult lake trout (indexed from annual length–weight regressions) in 2007-2009 increased from relatively low values observed during 2000-2006, remained nearly constant during 2010-2012 at the highest values observed, but declined in 2013 (Section 5).
- In 2013, angler catch (35,533 fish) and harvest (20,511 fish) were the highest estimated since the mid- to late-1990s. Charter catch rates (0.064 lake trout per angler hour) was the highest estimated since 2002 (Section 2).

Status of Sea Lamprey Control

- In 2013, eight Lake Ontario tributaries (two Canada, seven New York) were treated with lampricides (Section 25). Treatments in New York included South Sandy Creek, Lindsey Creek, Little Sandy Creek, Orwell Brook, Trout Brook, Grindstone Creek, and Fish Creek, Little Salmon River, Catfish Creek, and Sterling Creek.
- Orwell Brook was treated for the seventh consecutive year to address residual populations in numerous beaver impoundments. Construction of a sea lamprey barrier on Orwell Brook was completed in the fall of 2012 (Section 25).
- A total of 6,434 sea lampreys were trapped at 12 sites on 11 tributaries, with the highest U.S. number (n=435) trapped at the Orwell Brook barrier.
- The estimated population of adult sea lampreys was 29,098 (95% CI; 26,352-32,357), within the fish-community objective target range of 31,000 ± 4,000 (Section 25).

- Larval assessments were conducted on a total of 38 tributaries (18 Canada, 20 NY). Surveys to estimate abundance of larval sea lampreys were conducted in 12 tributaries (five Canada, seven NY). Surveys to detect the presence of new larval sea lamprey populations were conducted in five tributaries (4 Canada, 1 US); no new populations were detected (Section 25).
- Post-treatment assessments were conducted in nine tributaries (two Canada, seven U.S.) to determine the effectiveness of lampricide treatments conducted during 2012 and 2013.
- Surveys to evaluate barrier effectiveness were conducted in seven tributaries (six Canada, one U.S.).
- The rate of wounding by sea lamprey on lake trout caught in gill nets was 2.26 fresh (A1) wounds per 100 lake trout and was slightly above the target of 2 wounds per 100 lake trout (Section 5). There were an estimated 17.3 lamprey observed per 1,000 trout or salmon caught, a 60.9% decrease compared to the 2007 high. In 2013, 68.8% of lamprey attacks were on Chinook salmon, 13.6% on brown trout, 10.4% on lake trout, and 5.6% on rainbow trout (Section 2).

Warmwater Fisheries

- A total of 149,200 fingerling walleye were stocked in the lower Niagara River (Section 1).
- Catch-per-unit-effort (CPUE) of warmwater fish in the 2013 Eastern Basin index gill netting survey was 33.1 fish/gill net, comparable (-6.2%) to the previous 5-year average. Yellow perch (31.2%), smallmouth bass (23.1%), and white perch (19.4%) were the most common species captured in 2013 (Section 4).
- In 2013, smallmouth bass abundance in the Eastern Basin as measured by index gill nets was 7.7 fish/net, comparable to (-7.1%) the previous 5-year average, well above record-low levels observed in 2000-2004, but substantially lower than historic levels. In spite of increased growth/condition, reduced Double-crested cormorant predation, and increased summer water temperatures, data indicate that the Eastern Basin smallmouth bass population is experiencing compromised recruitment (Section 4).
- Walleye CPUE has remained relatively stable for several years, but decreased 35.2% compared to the previous 10-year average in 2013. Lower gill net catches may be partly attributable to water temperature and higher alewife abundance altering walleye distribution. (Section 4).
- The 2013 yellow perch CPUE (10.3 fish/net) was below previous 5-year and 10-year averages (-27.2% and -13.6%, respectively).
- Round gobies first appeared in the Eastern Basin assessment in 2005 in both gillnet catches and smallmouth bass diets. Goby occurrence in predator diets increased each year from 2005-2010. In 2013, gobies were present in 84% of the 175 non-empty smallmouth bass stomachs processed. Gobies were present in walleye diets each year from 2006-2010 and 2012-2013, and have been found in northern pike, brown trout, lake trout, and lake whitefish caught in this survey (Section 4).
- In 2008, Eastern Basin white perch abundance reached its highest level since 1991. In 2013, white perch was again the third most commonly captured species (19.4% of total catch) and the CPUE (6.4 fish/net) was a 47.3% increase compared to the previous 5-year average. (Section 4).
- At least one lake sturgeon has been collected in the Eastern Basin in fourteen of the last nineteen years, suggesting improvements in population status (Section 4).
- Thousand Islands smallmouth bass abundance increased from low 1996-2006 levels, and has varied at relatively high levels since. Catch in 2012 reached its highest level since 1988, but declined 28% in 2013. Yellow perch abundance increased substantially in 2006, remained high in 2007 and 2008, and then declined. Perch abundance fell to a record-low level in 2012, and remained low in 2013. From 1996 to 2013, northern pike abundance has remained relatively low. Ongoing poor recruitment is likely related to degraded spawning habitat resulting from water level regulation, and possibly predation by Double-crested cormorants (Section 6).

- Lake St. Lawrence yellow perch abundance declined from 16.7 fish/net in 2012 to 7.94 fish/net in 2013 (52% decline). Diet data from the Strachan/Bergin islands cormorant colonies (Lake St. Lawrence) indicated that approximately 400,000 yellow perch were consumed by cormorants in 2013 (Section 7). Smallmouth bass catch during assessment gill netting has been variable since 2005, and reached its' second highest level in 2013. The 2011 year class was particularly well represented. Walleye abundance remained above the long-term average for the 6th consecutive year. (Section 7).
- Abundance of spawning adult and young-of-the-year northern pike in the Thousand Islands region of the St. Lawrence River continues to be suppressed. Overall, natural reproduction at natural and managed spawning marshes remains poor, likely due to habitat degradation resulting from long-term management of Lake Ontario/St. Lawrence River water levels (Section 23).
- Muskellunge population indices in the Thousand Islands region of the St. Lawrence River continue to show signs of stress. Spring trap net surveys, summer seining surveys and an angler diary index all indicate reduced adult and young-of-the-year abundance. It is plausible that adult muskellunge mortality events attributed to outbreaks of the invasive viral hemorrhagic septicemia virus are contributing to lower adult muskellunge numbers and reduced natural reproduction (Section 19).
- The nearshore fish community in the St. Lawrence River has shifted over the past 35 years. The most commonly caught species (> 50% frequency of occurrence) during seining assessments shifted from yellow perch and tessellated darter in 1976, to round goby, yellow perch, banded killifish and largemouth bass in the most recent period (2009-2010). Frequency of occurrence for tessellated darter and three other species declined significantly, while round goby, bluegill, blackchin shiner, pugnose shiner, and three other species increased. Eleven species were uncommon in the early period, but were absent in 2009-2010. For nearly half of these, their absences were not diagnostic of their populations, because they were caught recently by other methods or in other studies. Four species were uncommon in the recent period and absent in 1976, including yellow bullhead (Section 21).
- Targeted gill net sampling for lake sturgeon in Lake Ontario, Black River and the St. Lawrence River in 2013 produced a total catch of 90 fish. PIT tags were implanted in 83 fish to monitor fish growth, movements, and to manage brood stock genetics in restoration stocking efforts. Ten previously tagged sturgeon were re-captured in 2013 (Section 18).
- The U.S. Fish and Wildlife Service continued a lake sturgeon research program in the Lower Niagara River from 2010 through 2013. A total of 28, 193, 139 and 206 lake sturgeon were captured and PIT tagged in 2010, 2011, 2012, and 2013, respectively. Sturgeon ranged from 12.2 to 62 inches total length, and 1 to 28 years of age. Radiotelemetry tracking of 59 sturgeon suggests the presence of both migratory and resident fish, and that some mature fish frequented the gorge area when water temperatures were appropriate for spawning. Increases in catch rates of sub-adult fish in 2010-2013 relative to 1998-2003 levels may indicate a positive trend in the abundance of mature lake sturgeon in the lower Niagara River (Section 25).

Sport Fishery Assessment

- Total trout and salmon fishing success (charter catch per angler hour=0.23) was the fourth highest in the 28-year data series. Total trout and salmon catch (168,837 fish) and harvest (100,047 fish) were dominated by Chinook salmon (37.1% and 38.3%, respectively), lake trout (21% and 19%, respectively), brown trout (16.5% and 19%, respectively), and rainbow trout (20.5% and 17.2%, respectively) (Section 2).
- The eleven highest Chinook salmon catch rates among charter boats occurred each year 2003-2013. Chinook fishing quality among charter boats in 2013 (0.07 fish/hour) was 25.9% below the previous 10-year average, but 13.2% above the long term average and nearly 1.6 times higher

than during 1985-2002.

- Charter boat catch rate of coho salmon (0.007 fish/hour) was well below the long-term average (-31.6%).
- Charter boats caught 0.04 rainbow trout per angler hour, the sixth highest on record and 29.7% above the long term average (Section 2).
- The charter boat catch rate for brown trout in 2013 was 0.05 fish/hour, 23.6% above the long-term mean.
- In 2013 the charter boat catch rate of lake trout was 0.06 fish/hour, the highest estimate since 2002.
- In 2013, total fishing effort was estimated at 54,605 fishing boat trips (937,822 angler hours), the lowest estimated and primarily attributed to a decrease in effort targeting smallmouth bass since 2001. Effort targeting trout and salmon, however, has remained relatively stable with no declining trend for more than a decade. An estimated 47,520 boat trips targeted trout and salmon in 2013 (87% of fishing boat trips), comparable to the previous 5-year average (Section 2).
- Smallmouth bass was the most commonly caught species in the survey each year 1985-2006. In 2013, smallmouth bass was the 5th most commonly caught species (Section 2).
- Fishing quality for smallmouth bass along the south shore peaked in 2002 and declined to record low levels. Fishing boat trips targeting smallmouth bass during the traditional open season (3rd Saturday in June through September 30 when the creel survey ends) was an estimated 4,273 in 2013, the lowest recorded and a 46.3% decrease compared to the previous 5-year average. Bass catch rates were relatively stable from 1985 through the early 1990s (mean=1.03 bass per angler hour), then increased to the highest level in 2002 (2.02 bass per angler hour). Smallmouth bass catch rate per angler hour in 2013 was 0.59, a 36.8% increase compared to the previous 5-year average, but 71.0% below the 2002 record high. Several factors may have contributed to poor fishing quality, including expansion of round goby populations and possible smallmouth bass mortality form Viral Hemorrhagic Septicemia virus. (Section 2).
- A Lake Ontario black bass angler diary program was initiated in 2010, however, the number of participants needed to detect statistically significant changes in the bass fishery has yet to be achieved. The 2013 catch rate among anglers targeting smallmouth bass in the lake's main basin during the traditional open season was 0.39 smallmouth bass per angler hour, lower than the 2013 NYSDEC Lake Ontario Fishing Boat Survey estimate (0.59 smallmouth bass per angler hour). Due to continued low diarist participation, the open lake portion of this diary survey will be discontinued (Section 22).

Diets of Double-crested Cormorants and Impacts on Sportfish Populations

- Cormorant egg oiling on Little Galloo Island in 2013 reduced both cormorant chick production and chick feeding days by approximately 82%. The resulting reduction in total fish consumption by chicks was 10.0 million fish (Section 14).
- In 2013, smallmouth bass abundance in the Eastern Basin as measured by index gill nets was comparable to the previous 5 year average, but 60.3% below levels observed prior to cormorant impacts and other ecosystem changes (Section 4). Yellow perch abundance increased in 2008 to the highest level since 1984, but the 2013 yellow perch CPUE (10.3 fish/net) was below previous 5-year and 10-year averages (-27.2% and -13.6%, respectively).
- Increased smallmouth bass abundance may be due, in part, to cormorant population management and a shift in cormorant diets to round goby.
- Estimated total fish consumption by cormorants from the Little Galloo Island colony in 2013 was 22.25 million fish, including 20.75 million round goby, 1.39 million alewife, 0.33 million yellow perch, 0.20 million rock bass, 0.03 million pumpkinseed, and 0.04 million sportfish, including smallmouth bass and northern pike (Section 14).

- For the 14th consecutive year, cormorant population control was continued through oiling of eggs with food grade vegetable oil at the Little Galloo Island colony, and culling of adult birds by shooting (n=366) was employed again in 2013. Nest destruction was employed to discourage nesting on Gull Island (n=1,072), but was not necessary on Calf and Bass Islands. After dropping below target for the first time in 2010, the number of cormorant feeding days rebounded to 999,000 in 2011. In 2013, cormorant feeding days were estimated at 874,876, above the management target of 780,000, as measured by the Weseloh and Casselman feeding day model (Section 13).
- Since 1999, the cormorant reproductive suppression program on Little Galloo Island has cumulatively reduced fish consumption by chicks at the colony by 106.6 million fish including approximately 10.0 million yellow perch and 2.6 million smallmouth bass (Section 14).
- Round goby dominated cormorant diets at the three St. Lawrence River colonies surveyed in 2013 (Griswold, McNair, and Strachan islands). The 2013 fish consumption estimates for Griswold, McNair and Strachan island colonies were 5.4 million, 8.4 and 2.4 million fish, respectively. Since 1999, cormorants at three St. Lawrence River colonies have consumed an estimated 145.3 million fish, including 39.9 million yellow perch, 18.4 million rock bass, 50.4 million round goby, 11.5 million pumpkinseed, 1.6 million ictalurids (bullhead/catfish) and 1.1 million smallmouth bass (Section 15).

Sportfishery Restoration and Spending Plan for the Lake Ontario System

- The Sportfishing Restoration & Spending Plan for the Lake Ontario System (Plan) was prepared by the New York State Department of Environmental Conservation in its capacity as Trustee for New York's natural resources. The Plan identifies projects selected to restore injuries to sportfishing in the New York waters of the Lake Ontario system. Project progress updates appear below (Section 17).
- **Projects completed in 2013-14:** 1) Video inspection of Salmon River Hatchery main gravity pipeline (93% complete), infiltration well development, and ground water well survey. 2) Construction of "Lake Ontario at the Isthmus" fishing access/boat launch site (Jefferson County). The site features shoreline fishing access, a two lane boat ramp with floating docks and provides parking for 10 vehicles, as well as 25 vehicles with trailers. 3) The Great Lakes Fishery Commission completed construction of a sea lamprey barrier on Orwell Brook (Oswego Co.) in fall 2012. The barrier was operational in spring 2013, and will greatly reduce the need for chemical control of sea lampreys in the Orwell Brook system. $60,000 of NRD funds will be contributed to this project (Section 17).
- **Project Progress in 2013-14:** 1) Feasibility study undertaken to investigate potential for constructing a water treatment/re-circulation facility at the Salmon River Hatchery. Also, recommended well field equipment improvements are underway. 2) A contract with the NYS Office of Parks, Recreation and Historic Preservation is in development to improve angler access at four Niagara Region park sites. 3) Acquisition of a marina on Sandy/North Pond (Oswego County) for angler access development is nearing completion. 4) A contract with Monroe County to stabilize stream banks and improve stream habitat in Irondequoit Creek is in the final stages of approval. 5) A contract has been awarded to purchase and install new aquaria for the Salmon River Hatchery visitor's center. 6) A contract with the Great Lakes Fishery Commission to continue deepwater coregonid (members of the whitefish family) restoration efforts in Lake Ontario is in development. 7) Placards highlighting life history descriptions for each of the fish species on display at the NYSDEC Cape Vincent Fisheries Station public aquarium have been developed and will be installed in 2014. A phased approach for the development of additional display elements is currently underway (Section 17).

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New York Lake Ontario Stocking Program 2013

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The New York stocking report is prepared annually to summarize information on fish stocked in the most recent calendar year. This report includes all fish stocked into New York waters of Lake Ontario and its tributaries. Fish stocked into tributaries of Lake Ontario which are not expected to contribute to the Lake Ontario open water or associated tributary fisheries (e.g., brook trout, domestic rainbow trout, and brown trout stocked above barriers or in headwaters) are not reported here. Additional information on fish stocked in all New York waters can be found on the Internet at:www.dec.ny.gov/outdoor/7739.html

The report consists of three tables, and a description of stocking terminology and abbreviations. Table 1 provides totals for fish stocked in 2013 by species, strain, and life stage, and compares those totals with the 2013 New York State Department of Environmental Conservation (NYSDEC) stocking policy. Table 2 provides totals by species and life stage, summarizing the New York stocking history from 1991-2013. New York stocking history from 1968-1990 is reported in Eckert (2000). Table 3 provides specific information for each group of fish stocked in 2013. If needed, more detailed information on fish stocked can be obtained from the agencies and/or hatcheries which conducted the work.

TERMINOLOGY AND ABBREVIATIONS

Species: Names follow those in the American Fisheries Society's sixth edition of *Common and Scientific Names of Fishes from the United States, Canada, and Mexico* (Nelson 2004).

Location and **GD/KY** (Grid/Key): Location information for fish stocked in New York waters. Fish stocked in tributaries of Lake Ontario are designated using the name of the water in the location column, and the official NY stream key in the GD/KY column (key = capital O, period, 2 or 3 digit number, plus in some cases, a dash followed by a pond/embayment designation and one or more tributary numbers). Stream keys which are too long to fit within the GD/KY column are completed in the comments column. More specific information about stream stocking sites is not included in Table 3, but is part of the NYSDEC stocking database. Fish stocked directly into Lake Ontario, Lower Niagara and the St. Lawrence Rivers are designated using a shore area description in the location column, and a 3 digit grid number in the GD/KY column (standard grids based primarily on 10 minute blocks of longitude and latitude).

Stk Date (stocked): Date the fish were stocked. For pen reared fish, refers to the date the fish were released from their rearing pen.

Htch (Hatchery): Last hatchery at which the fish were raised for a significant period of time. Hatcheries in Table 3 are designated using the abbreviations shown below.

Abbreviations for NYSDEC hatcheries:

AD	Adirondack
BA	Bath
CA	Catskill
CD	Caledonia
CQ	Chautauqua
CH	Chateaugay
CS	Cedar Springs
RA	Randolph
RM	Rome
SR	Salmon River
SO	South Otselic
VH	Van Hornesville

Abbreviations for other county, state or federal hatcheries, and sportsmen clubs:

NAA	Niagara River Anglers Association
PMP	Powder Mill Park Hatchery, Monroe Co.
TUN	Tunison Laboratory of Aquatic Sciences, NY

U.S. Fish and Wildlife Service Hatcheries:

AL	Allegheny National Fish Hatchery, PA
EI[1]	D.D. Eisenhower National Fish Hatchery, VT
IR	Iron River National Fish Hatchery, WI
SC	Sullivan Creek National Fish Hatchery, MI
WR	White River National Hatchery, VT

[1] Pittsford N.F.H. prior to 2009

YCL (Year Class): Year class of the fish stocked. Year class is defined as the first year spawned for a group of fish, or the first year in which they grew significantly. For spring or summer spawning fish, year class and year spawned will be the same. For fall spawning fish, year class will be one year later than the year spawned (e.g., coho salmon from eggs spawned in October 2004 would be 2005 year class).

Strain: Strain of the fish stocked. Fish stocked in New York waters are shown with strain abbreviations that are defined below. Information is included to determine whether or not terms such as steelhead or landlocked could be applied to a group of fish.

FL (Finger Lakes): Strain of rainbow trout or lake trout from the Finger Lakes, NY. Lake trout descended from a native Seneca Lake population (see SEN). Rainbow trout from a naturalized population in Cayuga Lake, and maintained by collecting eggs from fish in Cayuga Lake inlet.

LC (Little Clear): Landlocked strain of Atlantic salmon. Includes both a feral broodstock maintained in Little Clear Lake, NY, as well as a captive broodstock held at the NYSDEC Adirondack Hatchery and derived from eggs taken from Little Clear Lake. Originally includes Swedish Gull Spang strain, as well as West Grand Lake (outlet spawners) and Sebago (inlet spawners) strains from Maine. Beginning in 2007, Adirondack Hatchery began to transition to Sebago strain only.

LO (Lake Ontario): Wild, self-sustaining population from Lake Ontario. Cisco eggs were collected in Chaumont Bay, Jefferson County and reared at U.S. Geological Survey (USGS) Tunison Laboratory of Aquatic Sciences (TUN) in 2011-2012.

LM (Lake Michigan): wild, self-sustaining population of bloater from Lake Michigan. Eggs were collected from waters of Lake Michigan near Dorr County, WI and Milwaukee, WI and were incubated and reared at TUN.

ONL (Oneida Lake): wild, self-sustaining, population of walleye from Oneida Lake, NY.

RA (Randolph): a fall spawning strain of domestic rainbow trout maintained at the NYSDEC Randolph Hatchery.

RL (Rome Lab): Domesticated, furunculosis resistant, strain of brown trout originated and maintained at the NYSDEC Rome Hatchery with production broodstocks at Randolph and Catskill Hatcheries.

SAL (Salmon River): Lake Ontario populations of coho salmon and Chinook salmon which return to Salmon River for spawning. These populations were originally derived from eggs obtained mainly from Lake Michigan sources, through 1983 for coho salmon, and through 1986 for Chinook salmon. The spawning runs consist of feral fish from Salmon River Hatchery stockings, but may contain some strays from Ontario hatcheries or wild fish.

SEB (Sebago): Landlocked strain of Atlantic salmon derived from Maine. SEB were stocked in 2011-2013 by USGS TUN from eggs originating from Ed Weed Fish Culture Station, VT (2011-2013) and Casco Fish Hatchery, ME (2013). SEB is now also being produced at Adirondack Hatchery.

SEN (Seneca Lake strain): Lake trout descended from a native population that coexisted with sea lamprey in Seneca Lake, NY. Until 2005, a captive broodstock was maintained at the U.S. Fish and Wildlife Service (USFWS) Alleghany National Fish Hatchery (AL), which began rearing lake trout for stocking in Lakes Erie and Ontario beginning with the 1978 year class. Through 1997, eggs were collected from fish in Seneca Lake and used to supplement broodstocks held at the AL and the USFWS Sullivan Creek National Fish Hatchery (SC). Beginning in 1998, SEN strain broodstocks were supplemented using eggs collected from both Seneca and Cayuga Lakes. Since 2003, eggs were collected exclusively from Cayuga Lake. After the 2005 stocking of the 2004 year class, an outbreak of Infectious Pancreatic Necrosis (IPN) required that all fish, including broodstock be destroyed and AL was closed for disinfection and renovation. The 2005 year class originated from eggs collected from Cayuga Lake and fish were reared at the NYSDEC Bath Fish Hatchery. The 2006 year class originated from both the NYSDEC Bath Hatchery egg take in Cayuga Lake and broodstock held at SC, and these fish were raised at the USFWS White River National Fish Hatchery (WR) and USFWS Dwight D. Eisenhower National Fish Hatchery (EI), formerly named the Pittsford National Fish Hatchery. Concerns of potential viral hemorrhagic septicemia virus (VHSv) introduction to WR prevented transfer of eggs from Cayuga Lake to WR following the fall 2005 egg take. SC provided eggs for the 2007 and 2008 year classes stocked in 2008 (reared at WR and EI) and 2009 (reared at WR only). The 2009 year class (stocked as Ylg in 2010) originated from the fall 2008 Cayuga Lake egg take, and was reared at the NYSDEC Bath Hatchery. This strain has been abbreviated as FL and FLW in the NYSDEC stocking database; SLW in the USFWS stocking database; and as SEN and SLW in the NYSDEC Lake Ontario Unit annual reports.

LCH (Lake Champlain strain): Lake trout descended from a feral population in Lake Champlain. The broodstock (Lake Champlain Domestic; LCH-D) is maintained at the Vermont State Salisbury Fish Hatchery and is supplemented with eggs collected from feral Lake Champlain fish. Broodstock eggs were supplied to WR for rearing of the 2008-2010 year classes stocked into Lake Ontario as spring yearlings in 2009-2011, and as fall fingerlings in October 2010 (2010 year class). A portion of the 2009 year class stocked in 2010 was reared at WR from eggs taken directly from feral Lake Champlain fish (Lake Champlain Wild; LCH-W). In 2011, flooding from Hurricane Irene inundated WR, severely damaging the hatchery and potentially contaminating the raceways with *Dydimo* an invasive algae. USFWS determined that lake trout slated to be stocked in 2012 (2011 year class) could not be stocked without posing a risk of spreading *Dydimo* to other waters so these fish were destroyed. Production at AL resumed in 2011, and the hatchery produced surplus fall fingerling LCH-D lake trout (2012 year class; eggs from Salisbury Fish Culture Station, VT which were stocked in October 2012 as fall fingerlings and in May 2013 as yearlings. This strain has been abbreviated as FL-HYB and LC in the NYSDEC stocking database; LC and SLWVT in the USFWS stocking database; and as LCH and SNVT in the NYSDEC Lake Ontario Unit annual reports.

SUP (Lake Superior strains): Captive lake trout broodstock initially developed at the USFWS Marquette Hatchery and derived from "lean" Lake Superior lake trout. Broodstock for the Lake Ontario stockings of the Marquette strain was maintained at AL until 2005. After the 2005 stocking of the 2004 year class, an outbreak of Infectious Pancreatic Necrosis (IPN) at AL required that all fish, including broodstock, be destroyed and the hatchery was closed for disinfection and renovation. The Superior – Marquette strain was no longer available for Lake Ontario stockings. Lake Ontario stockings of "lean" strains of Superior lake trout resumed in 2007 with Traverse Island strain fish (SUP-STW; 2006-2008 year classes) and Apostle Island strain fish (SUP-SAW; 2008 year class). The SUP-STW broodstock was phased out of production at USFWS Iron River National Fish Hatchery (IR) and will no longer be available as a source of eggs for future Great Lakes stockings. The Apostle Island strain broodstock was maintained at IR until after the fall 2011 egg take when production ceased. Disease concerns prevented transfer of eggs from IR to WR in fall 2008. These strains have been referred to as Trav Isl and Apostle Isl in the NYSDEC stocking database; and abbreviated as SMD, SAW, and STW in the USFWS stocking database; and as SUP, STW and SAW in the NYSDEC Lake Ontario Unit reports.

SKW (Klondike Reef): Captive lake trout broodstock held at SC and IR. This strain originated from a native, deep spawning "humper" morphotype of Lake Superior lake trout that are intermediate in fat content to lean and fat (Siscowet) morphotypes. Eggs for the 2008 year class raised at WR were obtained from the broodstock held at SC. Disease concerns prevented transfer of eggs from SC to WR in fall 2008 (2009 year class). This strain has been referred to as Klondike in the NYSDEC stocking database, and abbreviated SKW in the USFWS stocking database and in the NYSDEC Lake Ontario Unit annual reports.

SKA (Skamania): Summer run, anadromous strain of rainbow (steelhead) trout derived from eggs imported from Lake Michigan to New York. Feral Lake Ontario broodstock maintained since 1996 through collection of eggs from spawning runs of fin-clipped adults at NYSDEC Salmon River Hatchery.

SLR: Lake Sturgeon eggs collected from St. Lawrence River near Massena

WAS (Washington): Winter run, anadromous, strain of rainbow (steelhead) trout derived from eggs imported from Washington (Chambers Crk. strain) to New York through 1980. Feral Lake Ontario broodstock maintained through collection of eggs from spawning runs of fin-clipped adults at Salmon River from 1981-2006. Spawning of only fin-clipped Washington strain was discontinued in 2007 and since then, both clipped and unclipped steelhead are spawned, but clipping and selection of fin-clipped Skamania strain was continued to maintain separate steelhead strains.

W (Wild): Broodstock which spends a significant amount of time and achieves most growth in a lake or river, including both fish from natural reproduction as well as feral fish stocked at an earlier life stage. Adult fish may be held in captivity for several weeks or months until eggs are ready to be stripped.

D (Domestic): A captive broodstock which reaches maturity in a hatchery, regardless of the source of the eggs from which they were derived.

Mos (Months): Age of the fish to the nearest half month from the time the lot initiated feeding to the time they were stocked.

Stage: Life stage at which the fish was stocked, based on the convention that the birth date of fish from any particular year class is assumed to be January 1. Fingerlings (fing) are fish in their first year of life (age 0 or young-of-year), and year stocked will equal year class. The terms fry, spring fingerlings (SF), advanced fingerlings (AF), and fall fingerlings (FF), are simply additional designations for portions of the fingerling life stage. The term pond fingerling (PF) is used for fingerling walleye reared outside in ponds, usually without any supplemental food. Yearling fish (Ylg) are fish in their second year of life (age 1), and year stocked will be one more than year class. Yearling fish are most often stocked in the spring, and the term spring yearling (SY) is applied to such fish. The term adult (Ad) is applied to fish stocked in their third or later year of life (age 2 or more), even though these fish have often not reached sexual maturity.

Wt (g) [Weight]: Average weight of the fish in grams. For pen reared fish, refers to their size at the time they were released from their rearing pen.

Mark: Fin clips, tags, or other identifying marks applied to all members of a group before stocking. If more than one mark is applied (i.e. two clips or a clip plus a tag), all will be listed. Standard abbreviations for the various marks and tags are listed below. Tag colors, and numbers or codes, are included under "Comments" in Table 3.

AD	adipose fin clip
LV	left ventral fin clip
LP	left pectoral fin clip
CWT	coded-wire-tag
OTC	oxytetracycline - 6 hour immersion
VIE	visible implant elastomer

Number (stocked): Number of fish stocked at the particular site.

Comments: Significant comments and additional information relating to the rearing, marking, or stocking of the fish. If left blank, it can be assumed that the particular group of fish was released in a direct shore-line or stream-side stocking during daylight hours, without incident or undue mortality. Further descriptions for some of the comments listed in Table 3 are given below.

Barge: Fish transferred to a barge, ship, or other water craft, and transported some distance offshore before being released (LCM=military landing craft).

Boat Stocked: Fish transferred to a smaller boat or water craft and stocked nearshore.

Controls: Marked fish to act as controls in the evaluation of another marked experimental group.

CWT (2- or 6-digit number): Number for the coded wire tag used with each lot of Chinook salmon (2- or 6-digit), or lake trout or rainbow trout (both 6-digit).

Pen Reared (date, size): Fish held and reared in a pen at the release site for a period of time, usually one to four weeks. The date the fish were placed in their pen, and their average size at that time, are shown in the Comments column.

PMP release pond: Outdoor raceway at Powder Mill Park Hatchery (owned by Monroe County) which drains directly into a tributary of Irondequoit Creek. This hatchery raised WAS strain steelhead/rainbow trout until 2005, when concerns about spreading viral hemorrhagic septicemia (VHS) prevented transfer of WAS strain from Salmon River Hatchery. Since then, Bath Hatchery supplied PMP with rainbow trout from a wild Finger Lakes strain (in 2007, 2009, and 2011, 2012-2013), or a Randolph (RA) domestic/wild Finger Lakes hybrid (in 2008 and 2010).

Smolt Release Pond (date): Fish released through the smolt release pond at the NYSDEC Salmon River Hatchery (currently only coho salmon). The fish are regularly monitored and fed. Downstream gates on the pond were removed, allowing the fish to voluntarily migrate into Beaverdam Brook at any time. The date the fish were stocked into the pond is shown in parentheses in the comments section. Date stocked corresponds to the date the smolt release pond was drained, forcing all remaining fish into Beaverdam Brook.

References

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Table 1. Summary of stocking in New York waters of Lake Ontario, the lower Niagara River, and the upper St. Lawrence River during 2013, and comparisons with the NYSDEC 2013 stocking policy.

Species	Stage		Strain	DEC Stocking Policy*	Actual Number Stocked
Atlantic Salmon	Ylg		LC-D	50,000	50,000
	FF	[1]	SEB	-	61,274
	Ylg	[1]	SEB	-	17,000
Atlantic salmon Total				50,000	128,274
Bloater Total	Ylg		LM	-	7,310
Brown Trout Total	Ylg	[2,3]	RL-D	392,000	331,480
Chinook Salmon Total	SF		SAL-W	1,761,600	1,771,664
Cisco Total	FF		LO	-	9,023
Coho Salmon	FF		SAL-W	155,000	155,000
	Ylg		SAL-W	90,000	68,600
Coho Salmon Total				245,000	223,600
Lake Sturgeon	FF		SLR	-	999
Lake Trout	Ylg		LCH-D	185,000	201,550
	Ylg		SAW	75,000	75,990
	Ylg		SEN	240,000	245,047
Lake Trout Total				500,000	522,587
Rainbow Trout	Ylg		RA-D	75,000	75,850
	Ylg		SKA-W	43,000	48,940
	Ylg		WAS-W	497,700	496,590
	Ylg	[3]	FL-W	7,500	7,100
Rainbow Trout Total				623,200	628,480
Walleye Total	PF	[4]	ONL-W	166,000	149,200
Grand Total				3,800,800	3,771,618

[1] Stocked by U.S. Geological Survey-Tunison for research project.

[2] Disease-related losses of brown trout at the NYSDEC Rome Hatchery in 2012 impacted 2013 yearling stocking statewide leading to a 15% reduction in the number of brown trout yearlings stocked into Lake Ontario (reduced from 392,000 to 331,480).

[3] The previous stocking policy for brown trout (455,000) has not been met since the two-year old brown trout stocking program was instituted statewide which reduced hatchery capacity for producing yearlings. The policy shown in this report (392,000) is the previous ten-year stocking average (2003-2013) and reflects a more realistic number based on recent hatchery production.

[4] Domestic strain rainbow trout were stocked by Powdermill Hatchery from 2006-2009 because transfer of Washington strain steelhead from Salmon River Hatchery was restricted due to VHS concerns. Domestic/Wild Hybrid Strain was stocked in 2010. New policy from 2011-13 called for Finger Lakes Wild strain.

[5] Walleye stocking depends on annual hatchery production, and not all sites planned for 2013 received fish.

* Stocking policy as of Mar 28, 2012

Table 2. Approximate numbers (1000s) of trout, salmon, and other species stocked in New York waters of Lake Ontario, the lower Niagara River, and the upper St. Lawrence River from 1991 to 2013. Numbers of salmon, trout, and other species stocked in New York water of Lake Ontario and the St. Lawrence River from 1968-1990 can be found in Eckert (2000).

Spp & Life Stage	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Co Ylg	97	94	96	92	119	98	95	90	90	99	101	105	95	95	99	110	90	124	95	114	141	120	69
Co FF	132	155	100	223	172	196	155	155	137	155	155	155	155	155	155	155	155	104	155	155	155	0	155
Co AF	0	290	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Co f	0	0	0	0	0	0	0	0	0	0	0	4	7	0	0	0	0	0	0	0	0	0	0
Ck f	2835	2798	1603	1000	1150	1300	1605	1596	1596	1654	1629	1633	1622	1836	1809	1827	1813	799	1757	1531	1769	1511	1772
Ck FF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LT Ylg	818	508	501	507	500	350	500	426	476	490	500	500	500	457	224	118	453	501	511	332	488	0	523
LT FF	160	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	122	0	123	0
LT Ad	0	0	0	0	0	0	0	<1	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0
BT Ylg	382	415	445	402	382	361	426	426	429	421	405	382	414	367	391	391	385	370	418	409	424	419	331
BT FF	0	0	0	0	0	0	0	0	25	0	0	136	39	0	66	0	0	0	70	57	6	0	0
BT AF	0	0	0	0	0	0	0	0	0	0	114	0	0	0	10	0	0	50	6	116	0	0	0
BT f	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	46	0	0	0	0
RT Ylg	82	85	88	92	24	70	93	92	97	75	60	71	75	64	75	72	68	74	78	80	82	82	83
RT FF	0	0	0	0	0	0	0	14	0	0	20	10	0	0	0	0	0	0	15	0	27	0	0
RT f	29	0	0	0	0	0	0	0	0	0	0	14	40	0	0	0	0	0	0	0	30	0	0
RT Ad	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0
Sthd Ad	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sthd Ylg	551	515	454	487	534	543	555	528	521	533	583	535	560	558	570	572	538	570	561	702	615	554	546
Sthd FF	40	0	0	0	50	60	110	0	107	0	0	15	0	0	0	0	0	0	80	188	0	337	0
Sthd f	175	0	0	0	0	0	0	0	0	0	0	1	6	0	0	0	0	0	0	0	0	0	0
ST FF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ST SF *	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	54	0	0	0	0
AS Ad	0	0	0	0	2	2	1	4	6	1	<1	<1	<1	1	0	0	0	0	0	0	0	0	0
AS Ylg	178	169	135	151	130	97	76	73	84	78	75	75	50	51	50	29	52	49	50	50	50	60	67
AS FF	0	0	30	38	34	34	25	25	25	25	25	0	0	0	0	0	0	0	24	37	66	73	61
AS AF	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	14	0
AS f	0	0	0	0	60	171	73	0	156	84	62	17	32	0	0	0	0	0	0	0	0	0	0
Sal Total	5479	5029	3453	2997	3158	3282	3715	3430	3749	3615	3729	3655	3594	3619	3450	3263	3554	2641	3920	3891	3853	3293	3557
Wal PF	122	52	202	100	104	264	250	194	155	129	10	10	211	71	104	123	31	50	118	12	118	23	149
Wal FF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0		0	0	0
Stur FF	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1
Bloat FF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7
Cisco FF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	9
TOTAL	5601	5081	3655	3097	3262	3546	3964	3623	3904	3745	3739	3665	3807	3691	3555	3382	3585	2696	4037	3903	3972	3327	3773

Abbreviations:

Ad: Fish age 2 or older (adults)
Ylg: Yearlings, normally stocked between January and June
FF: Fall fingerlings, stocked between September and Dec.
AF: Advanced fingerlings, stocked between mid-June and Sep
PF: pond fingerling walleye stocked in June
f: fry and spring fingerlings, stocked before mid-June
Co: coho salmon
Ck: Chinook salmon
LT: lake trout
BT: brown trout
RT: rainbow trout-domestic strains
Sthd: steelhead-anadromous rainbow trout
ST: brook trout
AS: Atlantic salmon
Sal: all salmonine species
Wal: walleye
Stur: lake sturgeon
Bloat: Bloater

* Surplus fingerling brook trout stockings were previously unreported in LOC annual reports 1991-2008

Table 3. Trout, salmon and other species stocked in New York waters of Lake Ontario and the Upper St. Lawrence River in 2013.

SPECIES	LOCATION	GD/KY	STK_DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Atlantic Salmon	Beaverdam Brook	O.53-8	1-Apr-13	AD	2011	LC-D	13.3	Ylg	44.5	none	30,000	
Atlantic Salmon	Beaverdam Brook	O.53-8	23-Sep-13	TUN	2012	SEB	5.1	FF	7.4	AD	12,912	Source of eggs from Casco Hatchery, ME.
Atlantic Salmon	Beaverdam Brook	O.53-8	23-Sep-13	TUN	2012	SEB	5.1	FF	6.9	AD	11,591	Source of eggs from Casco Hatchery, ME.
Atlantic Salmon	Beaverdam Brook	O.53-8	24-Sep-13	TUN	2012	SEB	5.1	FF	10.5	AD	9,468	Source of eggs from Ed Weed Fish Culture Station.
Atlantic Salmon	Salmon River	O.53-8	25-Sep-13	TUN	2012	SEB	5.2	FF	8.0	AD	9,166	Source of eggs from Casco Hatchery, ME.
Atlantic Salmon	Salmon River	O.53-8	26-Sep-13	TUN	2012	SEB	5.2	FF	10.8	AD	7,137	Source of eggs from Ed Weed Fish Culture Station.
Atlantic Salmon	Salmon River	O.53-8	27-Sep-13	TUN	2012	SEB	5.2	FF	7.2	AD	4,227	Source of eggs from Casco Hatchery, ME.
Atlantic Salmon	Orwell Brook	O.53-6	18-Oct-13	TUN	2012	SEB	5.9	FF	11.2	AD	3,387	Source of eggs from Ed Weed Fish Culture Station.
Atlantic Salmon	Trout Brook	O.53-5	18-Oct-13	TUN	2012	SEB	5.9	FF	11.8	AD	3,386	Source of eggs from Ed Weed Fish Culture Station.
Atlantic Salmon	Salmon River	O.53-8	24-Apr-13	TUN	2011	SEB	12.2	Ylg	34.4	AD CWT VIE	7,000	Yellow elastomer tag behind left eye, source of eggs from Casco Hatchery, ME. 14,353 of total 17,000 with CWT#162502.
Atlantic Salmon	Beaverdam Brook	O.53-8	24-Apr-13	TUN	2011	SEB	12.2	Ylg	34.4	AD CWT VIE	10,000	Yellow elastomer tag behind left eye. Source of eggs from Casco Hatchery, ME. 14,353 of total 17,000 with CWT#162502.
Atlantic Salmon	Point Breeze	713	7-May-13	AD	2011	LC-D	14.4	Ylg	44.5	none	20,000	Stocked By Boat.
Atlantic Salmon Fall Fingerlings Total									**8.7**		**61,274**	
Atlantic Salmon Yearling Total									**43.2**		**67,000**	
Atlantic Salmon Total									**26.1**		**128,274**	
Brown Trout	Black River	O.19	11-Apr-13	SR	2012	RL-D	16.0	Ylg	73.1	none	3,640	Stocked at Dexter.
Brown Trout	Stony Point	423	14-May-13	SR	2012	RL-D	17.1	Ylg	90.7	none	39,990	Barge/LCM. Includes fish for Stony (27,624) + 12,366 fish slated for Henderson shore site.
Brown Trout	Stony Creek	O.40	11-Apr-13	SR	2012	RL-D	16.0	Ylg	73.2	none	2,180	
Brown Trout	Selkirk Shores	623	15-May-13	SR	2012	RL-D	17.1	Ylg	90.7	none	26,180	Barge/LCM
Brown Trout	Oswego	622	16-May-13	SR	2012	RL-D	17.2	Ylg	90.7	none	26,180	Barge/LCM
Brown Trout	Fair Haven	720	16-May-13	SR	2012	RL-D	17.2	Ylg	90.7	none	26,180	Barge/LCM
Brown Trout	Sodus Point	819	9-May-13	SR	2012	RL-D	16.9	Ylg	90.7	none	23,270	
Brown Trout	Pultneyville	818	10-May-13	SR	2012	RL-D	17.0	Ylg	90.7	none	17,450	

Table 3. Trout, salmon and other species stocked in New York waters of Lake Ontario and the Upper St. Lawrence River in 2013.

SPECIES	LOCATION	GD/KY	STK_DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Brown Trout	Webster	816	7-Jun-13	SR	2012	RL-D	17.4	Ylg	107.7	none	19,630	
Brown Trout	Irondequoit	815	4-Jun-13	CD	2012	RL-D	18.7	Ylg	121.6	none	19,630	Rough lake, fish stocked in Irondequoit Channel.
Brown Trout	Rochester	815	24-May-13	CD	2012	RL-D	17.0	Ylg	113.4	none	19,630	Rough lake, fish stocked in Irondequoit Channel.
Brown Trout	Braddocks Bay	815	8-May-13	CD	2012	RL-D	16.5	Ylg	119.4	none	13,080	
Brown Trout	Braddocks Bay	815	14-May-13	CD	2012	RL-D	16.6	Ylg	117.8	none	6,550	
Brown Trout	Hamlin	713	10-May-13	CD	2012	RL-D	16.5	Ylg	101.7	none	9,810	
Brown Trout	Hamlin	713	5-May-13	CD	2012	RL-D	16.4	Ylg	120.3	none	9,820	
Brown Trout	Point Breeze	711	26-May-13	CD	2012	RL-D	17.0	Ylg	113.7	none	13,820	
Brown Trout	Point Breeze	711	31-May-13	CD	2012	RL-D	17.2	Ylg	121.3	none	14,440	An extra 630 fish stocked at site.
Brown Trout	Olcott	708	13-May-13	CD	2012	RL-D	16.6	Ylg	117.8	none	18,180	
Brown Trout	Wilson	707	9-May-13	CD	2012	RL-D	16.5	Ylg	119.7	none	18,180	
Brown Trout	Niagara River	O.158	24-Apr-13	CD	2012	RL-D	16.0	Ylg	125.0	none	3,640	Stocked at Fort Niagara instead of Water street.
Brown Trout Yearlings									**103.2**		**331,480**	
Brown Trout Total									**103.2**		**331,480**	
Chinook Salmon	Black River	OB-T0000	20-May-13	SR	2013	SAL-W	4.0	SF	3.5	none	159,000	Stocked below Dexter Falls.
Chinook Salmon	South Sandy Crk.	LO-T0000	20-May-13	SR	2013	SAL-W	4.0	SF	3.5	none	100,000	
Chinook Salmon	Salmon River	O-T0000	19-Jun-13	SR	2013	SAL-W	5.0	SF	7.3	none	360,000	
Chinook Salmon	Oswego River	O.65	5-May-13	SR	2013	SAL-W	3.5	SF	3.4	AD CWT	97,810	38,673 with CWT#640433 and 59,137 with no mark.
Chinook Salmon	Oswego River	O.65	6-May-13	SR	2013	SAL-W	3.6	SF	3.5	AD CWT	41,890	In pens 5/3/13 @130lb 57 ^{o}F for only 3 days. Released due to high temperatures. 37,741 with CWT#640426 and 4,149 with AD only.
Chinook Salmon	Little Sodus Bay	O.74	17-May-13	SR	2013	SAL-W	3.9	SF	7.1	AD CWT	25,514	In pens 4/29/13 @130.2/lb. 45°F; 25,514with CWT# 640101.
Chinook Salmon	Sterling Crk.	O.73	17-May-13	SR	2013	SAL-W	3.9	SF	3.9	AD CWT	87,150	26,051 with CWT#640434 and 61,099 with no mark.
Chinook Salmon	Sodus Bay	O.84-P96	31-May-13	SR	2013	SAL-W	4.4	SF	4.4	AD CWT	60,000	38,045 with CWT#640435 and 21,955 with no mark.
Chinook Salmon	Sodus Bay	O.84-P96	24-May-13	SR	2013	SAL-W	4.2	SF	4.7	AD CWT	50,000	In pens 5/3/13 @ 138.7lb. 59°F. 37,686 with CWT#640425 and 12,314 with AD only.

Table 3. Trout, salmon and other species stocked in New York waters of Lake Ontario and the Upper St. Lawrence River in 2013.

SPECIES	LOCATION	GD/KY	STK_DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Chinook Salmon	Genesee River	O.117	30-May-13	SR	2013	SAL-W	4.4	SF	3.9	AD CWT	85,250	37,710 with CWT#640430 and 37,583 with CWT#640424, and 9,957 with no mark.
Chinook Salmon	Genesee River	O.117	24-May-13	SR	2013	SAL-W	4.2	SF	5.1	AD CWT	85,250	In pens 5/2/13 @127.9lb. 64°F. 37,570 with CWT#640423; 37,497 with CWT#640422 and 10,183 with AD only.
Chinook Salmon	Sandy Crk.	O.130	2-May-13	SR	2013	SAL-W	3.5	SF	3.2	none	55,000	No pens. Too warm. Stocked @ boat launch.
Chinook Salmon	Sandy Crk.	O.130	28-May-13	SR	2013	SAL-W	4.3	SF	3.5	none	55,000	Stocked at Hamlin Beach
Chinook Salmon	Oak Orchard Crk.	O.138	29-May-13	SR	2013	SAL-W	4.3	SF	4.4	AD CWT	64,753	32,659 with CWT#640431 and 32,094 with CWT#640432
Chinook Salmon	Oak Orchard Crk.	O.138	20-May-13	SR	2013	SAL-W	4.0	SF	5.9	AD CWT	106,553	In pens 5/1/13 @ 132/lb. 62 °F. 37,595 with CWT#640271, 37,742 with CWT#640419, and 31,216 with Ad only.
Chinook Salmon	Eighteenmile Crk.	O.148	24-May-13	SR	2013	SAL-W	4.2	SF	3.7	AD CWT	67,257	33,677 with CWT#640428 and 33,580 with CWT#640429
Chinook Salmon	Eighteenmile Crk.	O.148	15-May-13	SR	2013	SAL-W	3.9	SF	5.5	AD CWT	67,183	In pens 4/30/13/@143lb. 58 °F., 33,418 with CWT#640420 and 33,765 with CWT#640421
Chinook Salmon	Niagara River	EN-T0000	4-Jun-13	SR	2013	SAL-W	4.5	SF	6.3	AD CWT	75,554	In pens 5/6/13 @146/lb. 51 °F. 37,778 with CWT#640427 and 37,776 with CWT#640418
Chinook Salmon	Niagara River	EN-T0000	3-Jun-13	SR	2013	SAL-W	4.5	SF	3.8	AD CWT	128,500	37,532 with CWT#640436, 38,301 with CWT#640437, and 52,667 with no mark.
Chinook Salmon Spring Fingerling Total									**4.8**		**1,771,664**	
Coho Salmon	Beaverdam Brook	O.53-8	7-May-13	SR	2012	SAL-W	15.4	Ylg	45.4	none	68,600	
Coho Salmon	Sodus Bay	O.84	29-Oct-13	SR	2013	SAL-W	9.3	FF	13.3	none	26,000	
Coho Salmon	Genesee River	O.117	29-Oct-13	SR	2013	SAL-W	9.3	FF	13.3	none	22,000	
Coho Salmon	Sandy Crk.	O.130	30-Oct-13	SR	2013	SAL-W	9.3	FF	11.7	none	26,000	
Coho Salmon	Oak Orchard Crk.	O.138	30-Oct-13	SR	2013	SAL-W	9.3	FF	11.7	none	26,000	
Coho Salmon	Eighteenmile Crk.	O.148	31-Oct-13	SR	2013	SAL-W	9.3	FF	11.7	none	30,000	
Coho Salmon	Niagara River	O.158	31-Oct-13	SR	2013	SAL-W	9.3	FF	11.7	none	25,000	
Coho Salmon Fall Fingerlings									**12.2**		**155,000**	
Coho Salmon Yearlings									**45.4**		**68,600**	
Coho Salmon Total									**22.4**		**223,600**	

Table 3. Trout, salmon and other species stocked in New York waters of Lake Ontario and the Upper St. Lawrence River in 2013.

SPECIES	LOCATION	GD/KY	STK_DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Lake Trout	Stony Point	423	14-May-13	AL	2012	SEN	15.5	Ylg	45.3	AD CWT	40,780	Stocked by barge. CWT# 640446
Lake Trout	Stony Point	423	14-May-13	EI	2012	LCH-D	14.5	Ylg	37.8	AD CWT	39,810	Stocked by barge. CWT# 600239
Lake Trout	Oswego	622	15-May-13	AL	2012	SEN	15.5	Ylg	41.0	AD CWT	40,612	Stocked by barge. CWT# 640448
Lake Trout	Oswego	622	15-May-13	AL	2012	SEN	15.5	Ylg	42.8	AD CWT	41,265	Stocked by barge. CWT# 640445
Lake Trout	Oswego	622	15-May-13	EI	2012	LCH-D	14.5	Ylg	33.8	AD CWT	40,840	Stocked by barge. CWT# 600238
Lake Trout	Sodus	819	17-May-13	AL	2012	SAW	15.6	Ylg	43.5	AD CWT	40,660	Stocked by barge. CWT# 640440
Lake Trout	Sodus	819	17-May-13	AL	2012	SEN	15.6	Ylg	44.0	AD CWT	40,400	Stocked by barge CWT# 640447
Lake Trout	Point Breeze	711	22-May-13	AL	2012	LCH-D	15.7	Ylg	43.2	AD CWT	40,070	Stocked by barge. CWT# 600242
Lake Trout	Point Breeze	711	22-May-13	AL	2012	LCH-D	15.7	Ylg	44.0	ADCWT	40,270	Stocked by barge CWT# 600241
Lake Trout	Olcott	708	20-May-13	AL	2012	SEN	15.7	Ylg	36.9	AD CWT	40,270	Stocked by barge. CWT# 640449
Lake Trout	Olcott	708	21-May-13	AL	2012	SEN	15.7	Ylg	30.7	AD CWT	41,720	Stocked by barge. CWT# 640450
Lake Trout	Olcott	708	21-May-13	AL	2012	LCH-D	15.7	Ylg	48.5	AD CWT	15,080	Stocked by barge. CWT# 600240
Lake Trout	Olcott	708	21-May-13	AL	2012	SAW	15.7	Ylg	48.2	AD CWT	35,330	Stocked by barge. CWT# 640441
Lake Trout	Olcott	708	20-May-13	AL	2012	LCH-D	15.7	Ylg	48.5	AD CWT	25,480	Stocked by barge. CWT# 600240
Lake Trout Spring Yearlings									**41.4**		**522,587**	
Lake Trout Total									**41.4**		**522,587**	
Rainbow Trout	Black River	424	11-Apr-13	SR	2011	WAS-W	10.1	Ylg	16.7	none	36,000	
Rainbow Trout	Black River	O.19	11-Apr-13	SR	2011	WAS-W	10.1	Ylg	17.1	none	36,000	
Rainbow Trout	Stony Crk.	O.40	27-Mar-13	SR	2011	WAS-W	9.6	Ylg	22.0	none	20,700	
Rainbow Trout	South Sandy Crk.	O.45	27-Mar-13	SR	2011	WAS-W	9.6	Ylg	22.0	none	28,750	
Rainbow Trout	Beaverdam Brook	O.53-8	6-May-13	SR	2011	WAS-W	10.9	Ylg	42.8	none	120,000	Stocked on 5/6, 5/7, 5/8, 5/14
Rainbow Trout	Beaverdam Brook	O.53-8	7-May-13	SR	2011	SKA-W	11.0	Ylg	45.4	LV	48,940	
Rainbow Trout	Grindstone Crk.	O.54	29-Mar-13	SR	2011	WAS-W	9.7	Ylg	22.0	none	5,000	
Rainbow Trout	Little Salmon River	O.58	10-May-13	SR	2011	WAS-W	11.1	Ylg	37.8	none	3,890	In pens 4/19 @ 16/lb 54 ^{o}F.. Washington strain. No mark
Rainbow Trout	Oswego River	O.66	12-Apr-13	SR	2011	WAS-W	10.2	Ylg	16.3	none	20,000	No pens in 2013. All went in at marina.
Rainbow Trout	Sterling Crk.	O.73	28-Mar-13	SR	2011	WAS-W	9.7	Ylg	22.0	none	4,600	
Rainbow Trout	Sterling Valley Ck	O.73-3	28-Mar-13	SR	2011	WAS-W	9.7	Ylg	22.0	none	4,600	
Rainbow Trout	Little Sodus Bay	O.74	17-May-13	SR	2011	WAS-W	11.3	Ylg	41.2	none	6,000	In pens 4/19@19/lb
Rainbow Trout	Maxwell Crk.	O.85	28-Mar-13	SR	2011	WAS-W	9.7	Ylg	22.0	none	19,950	
Rainbow Trout	Irondequoit Crk.	O.108	24-Apr-13	SR	2011	WAS-W	10.5	Ylg	24.8	none	27,500	
Rainbow Trout	Genesee River	O.117	18-Apr-13	SR	2011	WAS-W	10.4	Ylg	23.9	none	12,100	
Rainbow Trout	Genesee River	O.117	10-May-13	SR	2011	WAS-W	11.1	Ylg	32.1	none	10,000	In pens 4/18@ 19/lb 50 ^{o}F.
Rainbow Trout	Salmon Crk.	O.125	18-Apr-13	SR	2011	WAS-W	10.4	Ylg	23.9	none	5,050	
Rainbow Trout	Sandy Crk.	O.130	18-Apr-13	SR	2011	WAS-W	10.4	Ylg	23.9	none	7,350	

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Rainbow Trout	Sandy Crk.	O.130	1-May-13	SR	2011	WAS-W	10.8	Ylg	34.1	none	7,300	In pens 4/18 @ 19/lb
Rainbow Trout	Oak Orchard Crk.	O.138	19-Apr-13	SR	2011	WAS-W	10.4	Ylg	23.9	none	21,000	No pens. All went to shore.
Rainbow Trout	Marsh Crk.	O.138-1	19-Apr-13	SR	2011	WAS-W	10.4	Ylg	23.9	none	7,100	
Rainbow Trout	Johnson Crk.	O.139	19-Apr-13	SR	2011	WAS-W	10.4	Ylg	23.9	none	6,700	
Rainbow Trout	Keg Crk.	O.146	23-Apr-13	SR	2011	WAS-W	10.5	Ylg	24.8	none	3,000	Water too low at normal site, fish stocked at Burt Dam.
Rainbow Trout	Eighteenmile Crk.	O.148	23-Apr-13	SR	2011	WAS-W	10.5	Ylg	24.8	none	3,500	
Rainbow Trout	Olcott	O.158	14-May-13	SR	2011	WAS-W	11.2	Ylg	39.4	none	3,500	In pens 4/23 @ 18.3/lb 51 ^{o}F.
Rainbow Trout	Twelvemile Crk.	O.152	23-Apr-13	SR	2011	WAS-W	10.5	Ylg	24.8	none	7,500	
Rainbow Trout	East Branch Twelvemile Crk.	O.152A	23-Apr-13	SR	2011	WAS-W	10.5	Ylg	24.8	none	12,000	
Rainbow Trout	Twelvemile Crk. (Wilson)	O.152	23-Apr-13	SR	2011	WAS-W	10.5	Ylg	24.8	none	7,500	No pens in 2013-water too low, Stocked @ 12mi. E Branch
Rainbow Trout	Fourmile Crk.	O.156	23-Apr-13	SR	2011	WAS-W	10.5	Ylg	24.8	none	3,000	Stocked at mouth
Rainbow Trout	Niagara River	O.158	26-Apr-13	SR	2011	WAS-W	10.6	Ylg	23.9	none	37,000	
Rainbow Trout	Niagara River	O.158	21-May-13	SR	2011	WAS-W	11.4	Ylg	34.9	none	10,000	In pens 4/26/@ 19lbs 45 ^{o}F.
Rainbow Trout	Sodus	819	28-May-13	CH	2011	RA-D	17.5	Ylg	114.0	none	20,000	
Rainbow Trout	Webster	816	5-May-13	CS	2011	RA-D	16.4	Ylg	144.0	none	10,000	
Rainbow Trout	Irondequoit Crk.	O.108	10-Apr-13	PMP	2011	FL-W	10.6	Ylg	37.8	none	7,100	Powder Mill Pond release, No WAS strain after 2006.
Rainbow Trout	Hamlin	713	6-Jun-13	CH	2011	RA-D	17.8	Ylg	138.7	none	7,140	
Rainbow Trout	Hamlin	713	1-May-13	CS	2011	RA-D	16.2	Ylg	155.9	none	10,050	
Rainbow Trout	Hamlin	713	9-May-13	BA	2011	RA-D	16.5	Ylg	146.2	none	2,810	
Rainbow Trout	Hamlin	713	12-Jun-13	VH	2011	RA-D	17.6	Ylg	131.3	none	850	
Rainbow Trout	Olcott	708	4-Jun-13	CH	2011	RA-D	17.8	Ylg	138.7	none	3,680	
Rainbow Trout	Olcott	708	3-May-13	CS	2011	RA-D	16.3	Ylg	144.0	none	8,820	
Rainbow Trout	Wilson	707	30-Apr-13	CS	2011	RA-D	16.2	Ylg	158.0	none	12,500	
Washington Steelhead Yearlings											**496,590**	
Skamania Steelhead Yearlings											**48,940**	
Rainbow Trout Yearlings (Randolph strain)											**75,850**	
Rainbow Trout Yearlings (Finger Lakes W strain)											**7,100**	
Rainbow Trout Total											**628,480**	

Walleye	Niagara River	EN-P0000	13-Jun-13	CQ	2013	ONL-W	1.4	PF	0.3	none	23,200	
Walleye	Sodus Bay	O-P0096	14-Jun-13	CQ	2013	ONL-W	1.4	PF	0.4	none	74,000	
Walleye	Irondequoit Bay	O-P0113	12-Jun-13	CQ	2013	ONL-W	1.3	PF	0.4	none	36,000	
Walleye	Blind Sodus Bay	O-P0077	21-Jun-13	SO	2013	ONL-W	1.6	PF	0.5	none	5,600	
Walleye	Port Bay	O-P0089	21-Jun-13	SO	2013	ONL-W	1.6	PF	0.4	none	10,400	
Walleye Fingerling Total									**0.3**		**149,200**	
Bloater	Oswego	621	16-Nov-13	TUN	2013	LM	7.4	FF	10.5	none	7,310	Stocked off Oswego at 100m.
Cisco	Irondequoit Bay	815	14-Nov-13	TUN	2012	LO	9.2	FF	17.0	none	4,739	Stocked by region 8 by pontoon boat in bay.
Cisco	Irondequoit Bay	815	20-Nov-13	TUN	2012	LO	9.4	FF	18.7	none	4,284	Stocked by region 8 by pontoon boat in bay.
Coregonine Total									**14.6**		**16,333**	
Lake Sturgeon	Genesee River	O.117	2-Oct-13	ON	2013	SLR	3.0	FF	50.4	CWT	999	CWT#640421 in snout
Salmonine Total											**3,606,085**	
Total All Species											**3,772,617**	

2013 Lake Ontario Fishing Boat Survey

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New York State Department of Environmental Conservation
Cape Vincent, New York 13618

Each year from 1985-2013 the New York State Department of Environmental Conservation (NYSDEC) surveyed boats operating in New York waters of Lake Ontario's main basin. The data collected from boat counts and interviews of fishing boats are used for management of New York's Lake Ontario trout and salmon fishery and provide valuable information on other fish species (e.g., Eckert 1999). Each year from 1985-2009 the planned start of the survey was April 1 and the survey ended on September 30. Six-month estimates of creel survey results (1985-2009) were reported in previous annual reports (e.g., Eckert 1999, Eckert 2007, Lantry and Eckert 2010). The planned initiation of the survey was permanently changed to April 15 beginning with the 2010 season. To permit comparison of the 2010-2013 5½ month survey results (i.e., April 15- September 30) with previous years when the survey was conducted over six months (i.e., April 1- September 30), April 1985-2009 data were reanalyzed and half-month April (April 1-15) estimates were determined. Data presented and discussed in this report are 5½ month estimates for each survey year (1985-2013). This report focuses on 2013 results and on comparisons of 2013 with data collected during previous years. Appended tables and figures provide additional data (e.g., annual estimates of effort, catch, harvest and biological data) collected from 2004-2013 and a 19-year average for 1985-2003.

Methods

Sampling Design and Data Collection

Methods and procedures have changed little throughout the 29 years surveyed. For 20 of the 29 years the fishing boat survey covered the entire six-month period, April 1 to September 30. For 1995, 2002, 2003, 2008, and 2009 delays in hiring prevented an April 1 start, and sampling was initiated between April 8 and April 26. Beginning with 2010, the scheduled start of the survey was changed to April 15. This angler survey does not include fishing activity from shore, in embayments and tributaries, in the eastern outlet basin (except for those which terminated their trip by returning through the Association Island Cut), boats fishing anywhere in Lake Ontario from October through April 14, or boats returning from the lake between one-half hour after sunset to two hours after sunrise (1.5 hours after sunrise during April and September only).

Boating access to Lake Ontario is limited and occurs mainly through channels associated with embayments and tributaries. Two crews of two agents each were used to survey access channels along approximately 190 shoreline miles from the Niagara River to the Association Island Cut near Henderson (Figure 1). The number of access channels surveyed varied between years from 28 to 30 (28 channels in 2013). Channels were divided each year into three or four sample strata based on estimates of expected fishing boat use (low-, medium-, high-, or super-use) and days were divided into two strata (low- and high-use). A stratified random design was used to proportionately allocate sampling effort among day and channel types for each month. Both crews were scheduled to work all of the designated high-use days (weekend days and holidays) and half of the crew/day combinations were scheduled on low-use week days.

During each time period surveyed, creel agents counted all boats returning from Lake Ontario and interviewed a random sample by anchoring and/or motoring small (18-20 ft) boats at the channel mouth. Time periods surveyed varied in length according to changes in sunrise and sunset, with each crew surveying opposite halves of the time

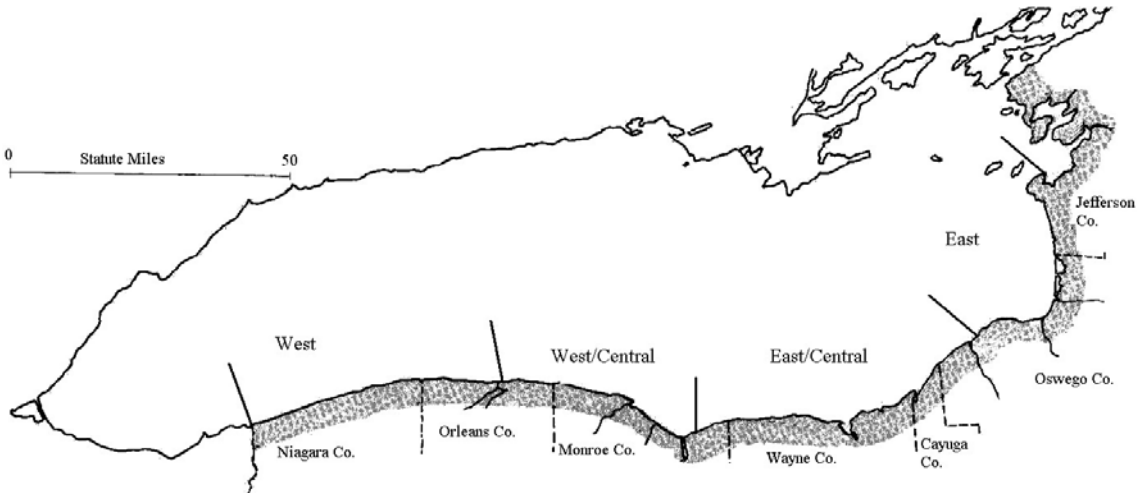

Figure 1. Lake Ontario's New York shoreline (shaded in gray), the seven New York counties that border the lake, and the four geographic areas used in analysis of the survey data.

period from two hours after sunrise (1.5 hours after sunrise during April and September only) and one-half hour after sunset. Interviews were conducted only among boat anglers who had completed their fishing trip, and all data and estimates presented in this report, unless clearly stated otherwise, are from completed fishing boat trips. A fishing boat trip was classified as completed if the anglers were not planning on returning to Lake Ontario within 1.5 hours or if some or all of the fish or fishermen were left onshore before returning. Under these criteria, any completed fishing boat trip could have consisted of more than one excursion to and from Lake Ontario, and the same boat or anglers could have participated in more than one completed fishing boat trip per day. The term harvest is used throughout this report for fish that were actually kept by the anglers, as well as any fish that were intentionally killed and discarded (e.g., round goby). The term catch is used for the sum of fish harvested plus fish intentionally released (intentionally unhooked and returned to the water alive).

Data Analysis

Estimated Effort, Catch and Harvest for 2010-2013

Estimates of fishing boat effort, catch and harvest were calculated for each channel and day surveyed by utilizing data from the sample of interviewed boats expanded by the total count of boats returning from the lake. These individual daily estimates were then multiplied by two to account for the "half day" census periods, and expanded by month using standard formulas for stratified random samples (Cochran 1977) to obtain monthly and seasonal estimates of effort, catch, harvest, and their respective variances. Variance estimates are conservative; therefore, the 95% confidence intervals are broad. To evaluate angling quality between years, species, areas, etc., we adjusted catch and harvest data per unit of fishing effort (e.g., catch and harvest per fishing boat trip). The basic unit sampled was an individual boat; therefore, effort is presented as estimated boat trips, and harvest rates and catch rates are presented per fishing boat trip. Effort in terms of angler trips and angler hours, and harvest and catch per angler trip and angler hour were also determined. Estimates of many variables such as angler residence and characteristics of fish harvested (length, age, etc.) were calculated directly from the interviewed boats assuming they were a random sample of the population. Data were also summarized for charter and noncharter boat trips.

Data Analysis and Calculation of Half-Month April and 5½ Month Estimates (1985-2009)

Beginning in 2010 and for the foreseeable future, the planned initiation of the Lake Ontario Fishing Boat Survey (hereafter "survey") will be April 15 rather than April 1 as was scheduled for 1985-2009 (Lantry and Eckert 2010). To allow for between year comparisons, we reanalyzed 1985-2009 April data to determine half-month (April 15-30)

estimates. This report provides 5½ month estimates for 1985-2009 for all variables examined (e.g., effort, catch, harvest, and catch and harvest rates; regional estimates; and biological data analysis).

We considered survey sampling design, sample variability, heterogeneity and non-normal distribution of data throughout April, among other factors prior to calculation of half-month April estimates for 1985-2009 data. For each year 1985-1994, 1996-2001, and 2004-2007 (20 of the 25 years), data collected from the sample of interviewed boats at each channel and day surveyed were expanded by the total count of boats returning from the lake. These individual daily estimates were then multiplied by two to account for the "half day" census periods. Expanded data were summed for each parameter (fishing boat trips, charter fishing boat trips, coho harvested, coho caught, etc.) for the April 1-30 and April 15-30 periods. Parameter sums for the April 15-30 period divided by the respective sum for the April 1-30 period provided the percentage of the estimate that occurred during the second half of April. In some cases, the sum of adjusted parameters that were components (e.g., charter and noncharter brown trout catch estimates) of another parameter (e.g., total brown trout catch) did not equal the total adjusted estimate. Usually these differences were minor and were attributed to sample size and uneven distribution throughout the month. We proportionally adjusted the component estimates of each parameter so that they would sum to their respective totals (i.e., ratio of the sum of the component parts divided by the total). Summaries of residence data, regional data, and biological data were recalculated using only April 15 - September 30 data for each survey year (1985-2009).

Delays in implementing the 1995, 2002, 2003, 2008, and 2009 surveys resulted in too few samples collected within each of the survey strata (i.e., all channel-type and day-type combinations) to permit statistically valid and unbiased estimation of April effort, catch, and harvest. Expansions of April creel survey data for each of these years to full six-month estimates are described in Lantry and Eckert (2011). We reevaluated the methods used for those expansions prior to recalculating new half-month April and 5½ month estimates.

The 1995 and 2009 surveys were not initiated until late April (April 26 and April 22, respectively), and using the same methodology as was used to make April 1-30 estimates previously (Eckert 1996), we assumed that there was a relationship between what would have been observed April 15-30 and May-September and that the data from previous years could be used to approximate this relationship. For 1995, we used 1992-1994 data to estimate parameters for April 15-30, 1995. For 2009, we were unable to use the three previous years as was done for 1995 since the 2008 survey also started late; therefore, we used 2004-2007 data to estimate April 15-30, 2009. In cases where a given parameter included various component parts (e.g., total complete fishing boat trips included targeted trout and salmon trips, smallmouth bass trips, yellow perch trips, etc.; or total species-specific catch included harvest and catch by various boat types), the total calculated value was multiplied by the average April 1992-1994 or 2004-2007 contribution of each component part, respectively.

To recalculate the half-month April estimate for 2002 (initiated April 13), we used the data collected April 15-30, 2002. To maintain sufficient sample sizes within strata (i.e., a total of eight strata given the two day types and four channel types), we reduced the four channel types surveyed (super-, high-, medium- and low-use) to two channel types by combining data for super- and high-use channels into one channel type and medium- and low-use channels into the second channel type. These two channel type strata were each divided into the two day types (high and low-use days) for a total of four strata. Half-month April estimates were then determined using the same methods described previously for 2010-2013 (see section "Results: Data Analysis: *Estimated Effort, Catch and Harvest for 2010-2013*").

Delayed survey initiation in 2003 and 2008 were relatively minor (initiated April 11 and April 8, respectively) and were accounted for by using the assumed values as described in Lantry and Eckert (2011) and half-month April estimates were determined using the same methods described above for the other years (i.e., calculated the percentage of a parameter that occurred April 15-30 then reduced

the full month estimate accordingly).

Regional comparisons were made by dividing the New York shoreline into four approximately equal areas (Figure 1, Table A1), and combining the daily estimates for access channels within each area for the entire season (i.e., months were eliminated as a strata classification). Boundaries of the four geographic areas and their designated names used throughout this report are: west area - Niagara River to Point Breeze; west/central area - Bald Eagle Creek to Irondequoit Bay; east/central area - Bear Creek to Oswego Marina; and east area - Sunset Bay (Nine Mile Point) to Association Island Cut (Table A1). Regional estimates were recalculated to a 5½ month time period for each year 1985-2009 using only April 15 - September 30 data. Given the survey design, estimating region-specific catch rate and harvest rate for each month was not possible. Lantry and Eckert (2011) did, however, evaluate relative harvest within specific regions and months as compared to previous 5-year averages and general trends, typically observed each year, are reiterated here. For this report we compare 2013 5½ month regional results with general trends observed in previous years of the survey and reported in Lantry and Eckert (2011).

Statistical Analysis

For some parameters, regression analyses were used to examine for trends in the data series (SAS version 8.0, SAS Institute 1999, Lantry and Eckert 2011). Percentage data were arc sine transformed prior to statistical analysis (Kuele 1994). Analyses were statistically significant at $P<0.05$.

Results and Discussion

Fishing and Boating Effort

Fishing effort from April 15-September 30, 2013 was estimated at 54,605 (±12.1%) completed boat trips (Figure 2, Table A2), the lowest estimated and due primarily to a decrease in fishing effort targeting smallmouth bass in recent years. The total estimated number of fishing boat trips increased from 1985-1990, then decreased through 1996. The largest declines in fishing effort occurred shortly after the peak, with declines of 31,751 trips between 1990 and 1991, 42,112 trips between 1991 and 1992, and 12,740 trips between 1995 and 1996. Over the 10-year period from 2004-2013 total fishing effort, as measured by fishing boat trips, continued to show a downward trend; however, effort targeting trout and salmon has remained relatively stable with no declining trend for more than a decade (see "*Trout and Salmon Targeted Effort*" section; Figure 2). The decline in total fishing effort is attributed to a significantly declining trend in effort targeting smallmouth bass in recent years (P-value<0.0001; see "*Smallmouth Bass Targeted Effort,* Traditional Open Season:" section).

Total fishing effort in 2013, as measured by angler trips and angler hours, was 161,620 and 937,822, respectively. The average number of anglers per boat trip ranged from 2.5 (1985) to 3.0 (2013, highest in data series), and averaged 2.8 with an increasing trend during the last 10 years (Table A2). The increased number of anglers per boat trip may have been due to cost-saving efforts given the cost of gas, current status of the economy, and the increase in trout and salmon fishing effort relative to effort targeting smallmouth bass (i.e., boats targeting trout and salmon typically have more anglers onboard than bass trips). The 2013 average trip length of 5.8 hours per boat trip was a slight increase and comparable to previous 5-year (+10.4%) and 10-year averages (+13.6%).

We evaluated the contribution to total seasonal fishing effort for each month April through September (Table A2). Since the early 1990s, the greatest amount of fishing effort occurred during the second half of the open lake fishing season (2004-2013 10-year averages: April 15-April 30: 4.2%, May: 15.0%, June: 12.0%, July: 21.2%, August: 29.3%, and September: 18.3%).

Geographic Area Fishing Effort

We evaluated the regional contribution to total seasonal fishing effort (Table A2). Typically, the greatest amount of fishing effort occurred in the east/central area, where the greatest amount of fishing effort occurred for 26 of the last 29 years (Table A2). In 2013, there were an estimated 17,368 fishing boat trips in the east/central area (31.8% of all fishing effort). Effort in the east and

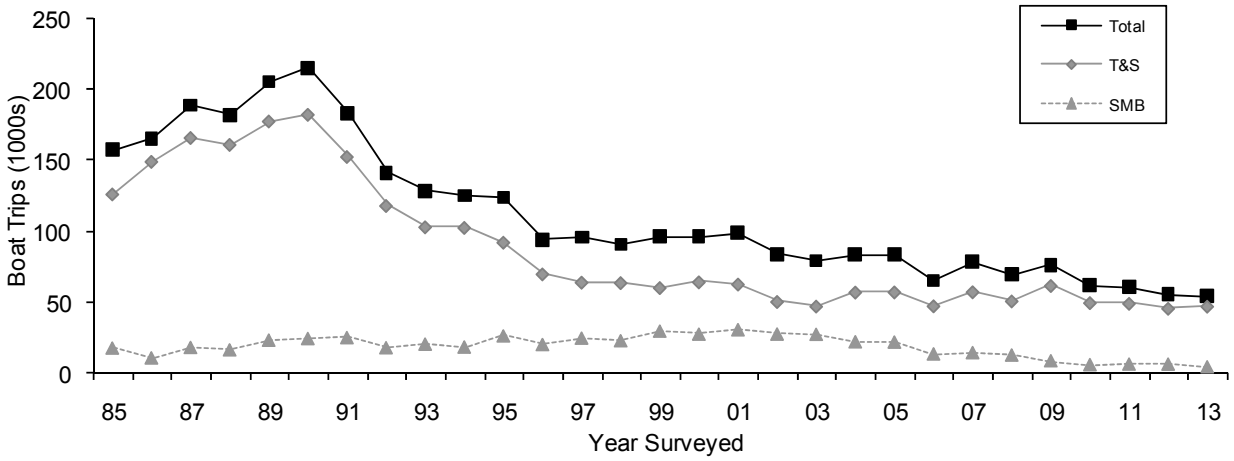

Figure 2. Seasonal (April 15-September 30) estimates of total fishing boat trips, trips targeting trout and salmon (T&S), and trips targeting smallmouth bass (SMB) during the traditional open season (3rd Saturday in June-September 30 when the survey ended), 1985-2013.

west areas was estimated at 14,988 and 14,602 boat trips, respectively. For each of the 29 years surveyed, the lowest fishing effort occurred in the west/central area and, in 2013, there were an estimated 7,648 boat trips (14.0% of total fishing effort) in that portion of the lake.

Power Boat and Sailboat Excursions

This survey was specifically designed to count and interview fishing boat anglers, however, all recreational boats returning from Lake Ontario were also documented. Power boaters who spent at least a portion of their time fishing on Lake Ontario accounted for 55,116 vessel excursions and 33.2% of the total vessel traffic in 2013 (Table A2). Non-fishing power boats were estimated at 89,530 excursions in 2013 (53.9% of the total vessel traffic). Non-fishing power boat traffic peaked and declined similar to that described for fishing boats over the 29-year survey period.

Sailboats, the smallest component of vessel traffic, showed a downward trend over the 29 years surveyed. In 2013, sailboats accounted for 21,432 excursions and represented 12.9% of the vessel traffic. This represented a 42.7% increase over the record lows observed from 2003-2007 (average = 15,022 sailboat trips; Table A2).

Trout and Salmon Targeted Effort

Trout and salmon, as a group, were the primary target of boat anglers interviewed each year since 1985 (1985-2013 range: 90.0% [1986] to 59.7% [2003]; 1985-2013 average = 76.2%; Figure 2, Table A2), and changes in fishing effort were largely due to trout and salmon anglers (1985-late 1990s). Over the last 10 years, however, effort targeting trout and salmon remained relatively stable with no trend (P-value=0.0890) while total fishing effort declined over the same time period. That decline coincided with a significant decline in fishing effort directed at smallmouth bass (P-value<0.0001). In 2013, trout and salmon anglers accounted for 87.0% of the total fishing boat trips, 90.9% of angler trips, and 94.9% of angler hours (Table A2).

In 2013, fishing effort targeting trout and salmon was estimated at 47,520 (±13.0%) boat trips, comparable to the previous 5-year (-8.2%) and 10-year averages (-9.8%; Table A2). In 2013, estimated monthly fishing effort targeting trout and salmon was above the previous 5-year average during June (+36.0%), comparable to the previous 5-year averages in April (-7.9%), July (+1.8%), and August (+3.6%), and below previous 5-year averages in May (-17.3%) and September (-48.2%; Table A2). Unlike most previous years when trout and salmon anglers stated they were targeting a mix

of two or more species, the majority of those interviewed each year since 2005 were specifically targeting Chinook salmon (2005-2012 average=48.9%). During 2013, 50.3% of salmonine anglers were specifically targeting Chinook salmon, 37.7% were targeting a mix of two or more species, and 10.5% were specifically targeting brown trout.

Smallmouth Bass Targeted Effort

Pre-Season Catch and Release Period:

For the seventh consecutive year, few anglers targeted bass during the pre-season catch and release period. Prior to October 1, 2006, NYSDEC fishing regulations established the open bass season in Lake Ontario from the third Saturday in June through November 30 and allowed anglers to harvest a daily limit of five smallmouth bass with a minimum length of 12 inches. The smallmouth bass regulation was changed effective October 1, 2006, establishing pre-season catch and release of bass from December 1 through the Friday preceding the third Saturday in June (except in Jefferson County waters of Lake Ontario's eastern basin). Prior to this regulation change some anglers admitted to targeting smallmouth bass before the traditional season opening (third Saturday in June) and, with the exception of 2006, accounted for nearly 1% of the April 15 - September 30 total smallmouth bass targeted fishing effort (Table A2). In 2006, before the new regulation permitting pre-season catch and release was in effect, 3.5% of total effort occurred pre-season (an estimated 500 boat trips). Since the regulation change, effort targeting bass during the pre-season catch and release period remained low (range: 2.8% [2008] to 7.7% [2012]) and a minor component of the total bass effort occurring April 15 - September 30. In 2013, effort remained low with an estimated 191 boat trips targeting smallmouth bass during the pre-season catch and release period. This represented 4.3% of the total bass effort occurring April 15 - September 30, 2013 (Table A2).

Traditional Open Season:

The traditional open season for bass begins the third Saturday of June. Each year since 1985, smallmouth bass was the primary species targeted by anglers not seeking trout or salmon (Figure 2, Table A2). From 1985-2001 effort targeting smallmouth bass increased significantly (P=0.0004), averaging a gain of 797 boat trips per year. During 2001-2013, however, smallmouth bass effort declined significantly (P-value<0.0001), averaging a loss of 2,375 boat trips per year (Figure 2, Table A2). Effort directed at bass during the traditional open season declined 86.2% (26,762 boat trips) between the 2001 peak and the record low in 2013. Smallmouth bass fishing effort during the traditional open season in 2013 (June 15 to September 30) was an estimated 4,273 (±33.9%) boats trips, the lowest in the 29-year data series and a 46.3% decrease compared to the previous 5-year average (Figure 2, Table A2). Among all fishing boat trips (April 15 – September 30) on Lake Ontario, the percent contribution of smallmouth bass trips during the traditional season varied and ranged from a low of 6.5% of all fishing boat trips in 1986 to a high of 34.8% in 2003. In 2013, smallmouth bass anglers fishing during the traditional open season accounted for 7.8% of all fishing boat trips (April 15 – September 30), 5.6% of angler trips, and 3.4% of angler hours. In 2013, the average number of anglers per bass boat trip (2.1 anglers) was comparable to (-2.1%) the previous 5-year average. The number of hours per boat trip (3.5 hours), however, was the highest since 1998 (also 3.5 hours) and a 20.6% increase compared to previous 5-year average. In 2013, fishing effort for smallmouth bass was below previous 5-year averages for each month June through August (range: -59.9% [August] to -52.3% [July]) and for three geographic areas (west: -66.3%, west/central: -55.3%, and east/central: -65.4%; Table A2). Bass fishing effort increased in the east area compared to 2012 (+13.5%) and was comparable to (-3.2%) the previous 5-year average.

The decline in smallmouth bass effort may be due, in part, to the declining fishing quality experienced by many bass anglers in recent years. Many smallmouth bass anglers interviewed in recent years were dissatisfied with their fishing experiences, in part, because catches were dominated by round gobies (Table A3) and few bass were caught. Some anglers interviewed had changed their fishing strategies, successfully avoided gobies, and continued to catch bass. In 2007, a gillnetting assessment in Lake Ontario near Pultneyville

(between Irondequoit Bay and Sodus Bay) indicated that smallmouth bass abundance in that area was high enough to produce a quality fishery (Sanderson 2008) as was experienced by some anglers interviewed. By 2009, however, some anglers who had experienced good bass fishing through 2008 were no longer experiencing satisfactory catch rates. Declining catch rates likely contributed to the declining fishing effort directed at smallmouth bass (see section "Smallmouth Bass *Fishing Quality*" of this report).

Effort Targeting Other Species

Yellow perch and walleye were the third and fourth most commonly targeted species (preceded by salmonines and smallmouth bass) among open lake boat anglers in 2013, however, trips targeting these species only represented 1.9% of the total fishing boat trips (Table A2). The "all others" category, which represented 2.4% of 2013 fishing boat trips, was primarily composed of anglers who stated that they were fishing for "anything" (Table A2).

Charter Boat Fishing Effort

Charter boats are an important, highly visible component of the Lake Ontario open lake fishery. Charter boats differ from noncharter boats in that charter boats have more anglers onboard (captain and mate included), fish for a longer period of time, are more likely to target trout and salmon, have higher catch rates, and harvest a higher percentage of the catch. In 2013, charter boats accounted for 17.1% of the total number of fishing boat trips (19.5% of trout and salmon fishing boat trips), the highest recorded (Figure 3). With more anglers on board and longer trips, charter boats accounted for 30.1% and 36.1% of the angler trips and angler hours, respectively (captains and mates counted as anglers; Table A2). Although charter boats accounted for only 17.1% of total fishing boat effort, they accounted for 46.1% of the total salmonine catch in 2013. Differences between charter and noncharter catch, harvest, and fishing quality are discussed in the "Total Salmonines: Catch, Harvest, and Fishing Quality" section of this report.

Charter fishing effort was at its highest levels during 1988-1991, then declined and has remained relatively stable over the last 10 years (2004-2014; Figure 3, Table A2). The 2013 estimated charter boat effort was 9,343 (±23.8%) trips, comparable to previous 5-year (+7.5%) and 10-year (+4.2%) averages. Estimated monthly charter fishing effort in 2013 was above the previous 5-year averages each month April through July (range: +14.0% [April] to +29.3% [May]), comparable to the previous 5-year average in August (+2.5%), and below previous 5-year average in September (-25.1%; Table A2).

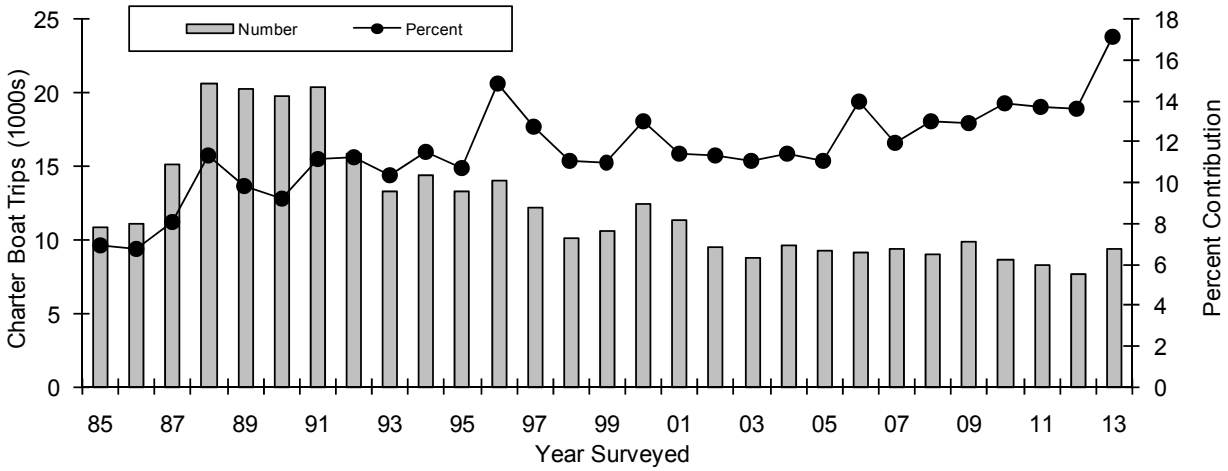

Figure 3. Seasonal estimates of charter fishing boat trips, and their percent contribution to total fishing boat trips, April 15- September 30, 1985-2013.

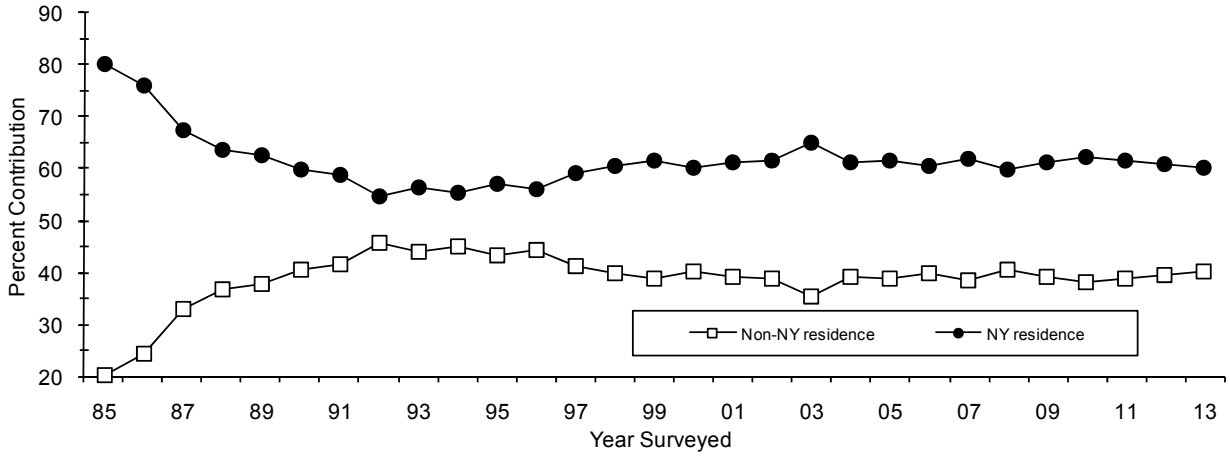

Figure 4. Percent contribution of anglers with and without New York state residency.

Angler Residency

Residency of anglers fishing Lake Ontario changed over the years surveyed, due in part to fishing interest and effort changes associated with the novelty of the trout and salmon fishery (i.e., in the 1980s) and trends in salmonid and smallmouth bass fishing quality. New York State (NYS) anglers consistently dominated the open lake boat fishery (Figure 4, Table A4). The most notable change in angler residency occurred during the first few years of the survey. In 1985 and 1986, NYS residents comprised 79.8% and 75.7% of all anglers interviewed, respectively (Figure 4). There was no trend in the percentage of anglers residing in NYS for the period 1987-2013. Over the last 10 years, an average of 60.8% of Lake Ontario anglers resided in NYS (59.8% in 2013; Table A2).

Contribution of nonresident anglers grew from 1985 through 1992, likely due to increasing awareness of the Lake Ontario trout and salmon sportfishery (Figure 4). Since then the percentage of anglers who reside outside of NYS ranged from 35.2% (2003) to 45.1% (1994). In 2013, non-NYS residents comprised 40.2% of the boat anglers interviewed, comparable to previous 5-year and 10-year averages (+2.7% and +3.9%, respectively; Figure 4; Table A2, Table A4). Pennsylvania represented the largest component of nonresident anglers for each of the 29 years surveyed (20.8% of the all anglers in 2013). The highest proportions of Pennsylvania anglers occurred each year 2010-2013 (the lowest [8.5%] occurred in 1985; Table A4). Other major sources of non-NYS anglers in 2013 were Ohio (4.7%), Massachusetts (2.6%), New Jersey (2.2%), Vermont (2.2%) and Connecticut (1.3%; Table A4).

Throughout the 29-year data series, the majority of NYS anglers resided in the seven counties bordering Lake Ontario (Jefferson, Oswego, Cayuga, Wayne, Monroe, Orleans and Niagara counties; peaked at 66.9% in 2003; Table A4). In 2012 and 2013 the percentages of NYS residents residing in the border counties declined to the lowest levels recorded (57.9% and 58.4% of anglers interviewed, respectively). As was observed each year of the survey, Monroe County remained the most important source of residents in the boat fishery, representing 16.5% of all NYS anglers interviewed in 2013 (Table A4). Other counties representing important components of the open lake boat fishery in 2013 were Oswego (12.8%), Niagara (9.7%), Wayne (8.7%), Onondaga (5.7%), Erie (4.9%), and Orleans (4.8%; Table A4).

Total Salmonines: Catch, Harvest and Fishing Quality

Catch and Harvest

Trout and salmon as a group (salmonines) are the most sought after fish in Lake Ontario. Total catch of all trout and salmon species was estimated at 168,837 (±18.0%) fish, which was a slight decrease (-9.7%) compared to the previous 5-year average and comparable to (-1.0%) the previous 10-year average (Figure 5, Table 1, Table A5a). Each year

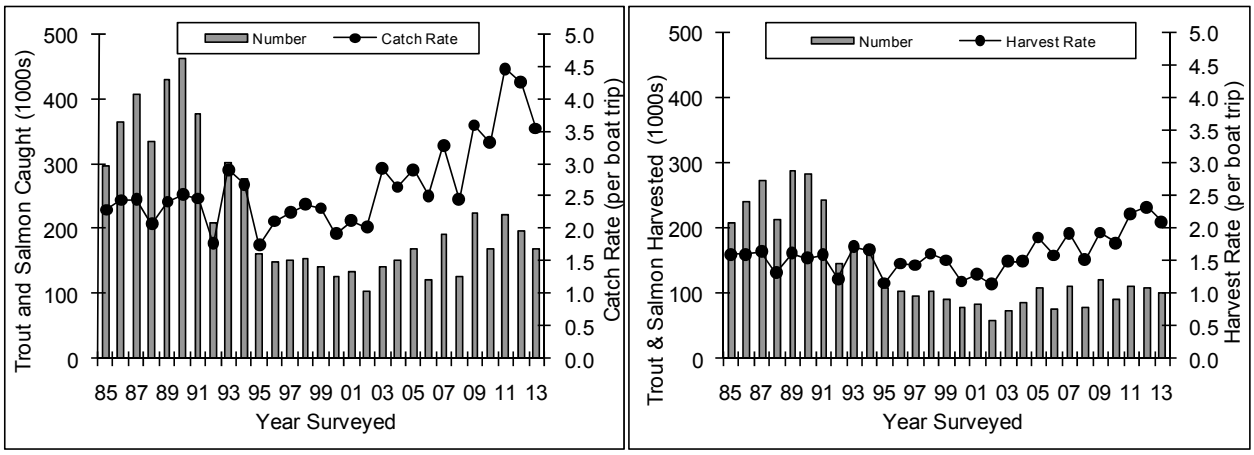

Figure 5. Total trout and salmon catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 – September 30, 1985 - 2013.

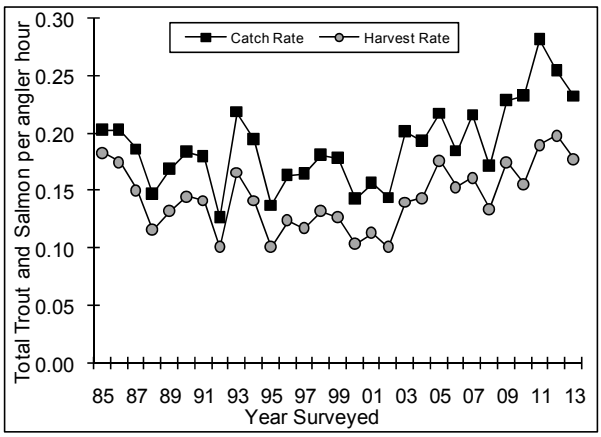

Figure 5b. Charter boat catch rate and harvest rate per angler hour for total trout and salmon, April 15 – September 30, 1985 - 2013.

since 2003, Chinook salmon dominated total trout and salmon catch (2003-2013 average: 79,078 Chinook caught and 46.7% of total catch) and harvest (2003-2013 average: 46,057 Chinook harvested representing 47.9% of total harvest). For seven of those years, brown trout was the second most commonly caught fish. From 2008 to 2010, rainbow trout was the second most commonly caught and harvested salmonine. In 2013, lake trout was the second most commonly caught species representing 21.0% of the total catch (35,533±30.9% fish). Contributions of other salmonines in the 2013 catch were 37.1% Chinook salmon, 20.5% rainbow trout, 16.5% brown trout, 4.6% coho salmon, and 0.4% Atlantic salmon. In 2013, anglers harvested 59.3% of all trout and salmon caught, which was a slight increase compared to (+8.3%) the previous 5-year average. Estimated salmonine harvest was 100,047 (±19.9%) fish, and comparable to (-1.0%) the 2008-2012 average (Figure 5, Table 1, Table A5a). The 2013 percent contributions of each species to the total trout and salmon harvest were 38.3% Chinook salmon, 20.5% lake trout, 19.0% brown trout, 17.2% rainbow trout, 4.9% coho salmon, and 0.2% Atlantic salmon (Table 1).

Fishing Quality

The quality of trout and salmon fishing in Lake Ontario, as measured by catch rate, was variable but relatively stable from 1985-2002; however, increased substantially in 2003 and remained at a higher variable level since (Figure 5). Anglers experienced five consecutive years (2009-2013) of record high trout and salmon catch rates. Catch rate for 2013 was the fourth highest estimated in the survey (3.5 fish caught per boat trip) and comparable to (-1.9%) the previous 5-year average (Figure 5, Table A5b). Eight of the nine highest catch rates occurred between 2003 and 2013. The 2013 seasonal total trout and salmon harvest rate for all boats specifically targeting trout and salmon was 2.1 fish per boat trip and comparable to (+7.5%) to the 2008-2012 average harvest rate (Figure 5, Table A5b). Catch rate and harvest rate data (fish per boat trip) were also evaluated by month. In 2013, catch rates were comparable to previous 10-year averages during each month (range: -5.0% [June] to +6.9%

Table 1. Harvest and catch estimates for April 15 – September 30, 2013 from the NYSDEC Lake Ontario fishing boat survey.

	Number Harvested	Number Caught
Coho salmon	4,871	7,704
Chinook salmon	38,292	62,570
Rainbow trout	17,203	34,611
Atlantic salmon	200	599
Brown trout	18,969	27,793
Lake trout	20,511	35,533
Smallmouth bass (includes pre-season)	7,536	21,446
Yellow perch	6,572	15,345
Walleye	318	388
Round goby	7,546	12,659
Other fish	516	3,521

[August]), with the exception of April (-28.0%) and May (+22.4%; Table A5b).

In 2013, charter boats targeting trout and salmon accounted for 46.0% and 59.4% of all salmonines caught and harvested, respectively, but represented only 19.5% of trout and salmon fishing boat effort, 32.8% of angle trips and 37.6% of angler hours directed at trout and salmon. Charter boat total trout and salmon catch rate (8.4 fish per boat trip; third highest observed) and harvest rate (6.4 fish per boat trip; second highest recorded) were well above the long-term averages (+24.6% and +25.5%, respectively; Table A5b). Charter catch rate per angler hour was 0.23 salmonines, which was the fourth highest in the 29-year data series and comparable to previous 5-year and 10-year averages (-0.8% and +6.4%, respectively; Figure 5b; Table A5b).

Noncharter fishing boats caught an average of 2.4 salmonine per boat trip (0.16 fish per angler hour) in 2013, a 13.4% decrease compared to the previous 5-year average but comparable to (-0.3%) the previous 10-year average (Table A5b). Among noncharter boats fishing for trout and salmon, the seasonal harvest rate was 1.1 salmonines per boat trip, comparable to (+0.3%) the previous 10-year average (Table A5b).

We further evaluated angling quality in the Lake Ontario boat fishery using other parameters, including the percent of boats with zero harvest and catch (indicator of poor angling quality), and the percent of boats that harvested the maximum daily limit of trout or salmon (indicator of good angling quality). These parameters are listed in Table A6, and generally show that harvest and catch rates are inversely correlated with these parameters (e.g., when harvest or catch rates are higher [i.e., better fishing quality], a lower percentage of boats fail to harvest or catch at least one fish, and vice versa). Table A6 reports fishing quality parameters for the 5½ month period, April 15 - September 30, 1985-2013. From 1985-2012, the proportion of boats targeting trout and salmon with zero catch of any salmonine species ranged from 24.3% (2012, indicating excellent fishing quality) to 49.7% (1992, indicating relatively poor fishing quality; Table A6). In 2013, 31.4% of boats targeting trout and salmon caught zero salmonines, which was the fourth lowest and indicates continued good fishing quality. The eight years with the lowest proportions of boats with zero trout and salmon catch occurred since 2003, with the lowest proportion recorded in 2012.

Angler harvest is affected by angler catch rates, harvest regulations, and angler desire to keep or release fish. Inter-annual comparisons of boats that harvested the maximum daily limit were compromised by fishing regulation changes that occurred between the 1996 and 1997 seasons and the 2006 and 2007 seasons; however, they can provide another indication of angling quality (Table A6). From 1985-1996, anglers were allowed a daily limit of five trout and salmon per angler, with no more than three lake trout and no more than one Atlantic salmon. Beginning with the 1996 and 1997 seasons, the daily limit was changed to a maximum of seven trout or salmon, with no more than three lake trout, no more than one Atlantic salmon, and no more than three fish of coho salmon, Chinook salmon, rainbow trout or brown trout in combination (popularly known as the 3-3-1 limit). The most recent regulation changes affected harvest of two trout species. Effective October 1, 2006, the rainbow trout size limit was increased to 21 inches and the lake trout daily limit was reduced to two fish per angler but allowing no more than one within the slot limit (25-30 inches).

In 2013, 14.3% of the charter boats targeting trout and salmon harvested the maximum daily limit of three coho salmon, Chinook salmon, rainbow trout, or brown trout in combination for their paying customers (Table A6). This was a 28.2% decrease compared to the 2008-2012 average. Of the charter boats that harvested the three in any combination limit for their customers, 53.6% went on to harvest additional fish permitted under the fishing licenses held by the boat's captain and mate(s), and 21.3% harvested the limit for all anglers (3.0% of all charter boat trips in 2013). Among noncharter boats fishing for trout and salmon in 2013, 1.3% harvested the maximum daily limit of three coho salmon, Chinook salmon, rainbow trout, or brown trout in combination which was a 38.6% decrease compared to the previous 5-year average.

Limits of lake trout were consistently less common than aggregate limits for the other four species. In 2013, 11.8% of the charter boats interviewed harvested the legal limit of lake trout for their customers. Of the charter boats that harvested the legal limit of lake trout for their customers, 48.0% went on to harvest additional fish permitted under the fishing licenses held by the boat's captain and mate(s), and 15.8% harvested the limit for all anglers (1.9% of all charter boat trips in 2013). Among noncharter boats, 0.4% harvested the maximum daily limit of lake trout. Of all boats interviewed from 1997-2013, none had the maximum aggregate limit of lake trout, Atlantic salmon and the four fish species combination. This included all the charter boats interviewed, even when counting only the charter party as potential anglers (captains and mates excluded from the angler count). In 2012 and 2013 there were, however, charter boat trips with the limit of lake trout and the four fish species combination for each angler in the charter party (147 and 234 trips, respectively).

Coho Salmon

Catch and Harvest

In 2013, coho salmon was the fifth most commonly caught and harvested salmonine in the boat fishery (4.6% and 4.9% of total catch and harvest, respectively; Table 1, Table A7a). Estimated coho salmon catch (7,704 [±43.3%] fish) in 2013 was a 42.3% decrease compared to the long term average (1985-2012; Figure 6). More than 63% of coho salmon caught were harvested. Coho salmon harvest in 2013 was an estimated 4,871 (±43.7%) fish and was a 50.0% decrease compared to the long term average (Figure6, Table A7a). During 2013, estimated catch of coho salmon was below the long-term average each month (range: -89.8% [April] to -10.7% [May]) with the exception of June which was comparable to the long term average (+1.8; Table A7a).

Fishing Quality

Coho salmon catch rates and harvest rates were excellent during six of the eight years from 2006-2013 (Table 7b, Figure 6, Figure 6b). In 2013, coho salmon catch rate (0.16 fish per boat trip) was well below rates observed in recent years, however, was comparable to (-1.1%) the long term average (Figure 6, Table A7b). Harvest rate (0.10 fish per boat trip) was a 12.5% decrease compared to the long term average. In 2013, charter boats targeting trout and salmon caught 31.5% of the coho salmon caught by all trout and salmon fishing boats.

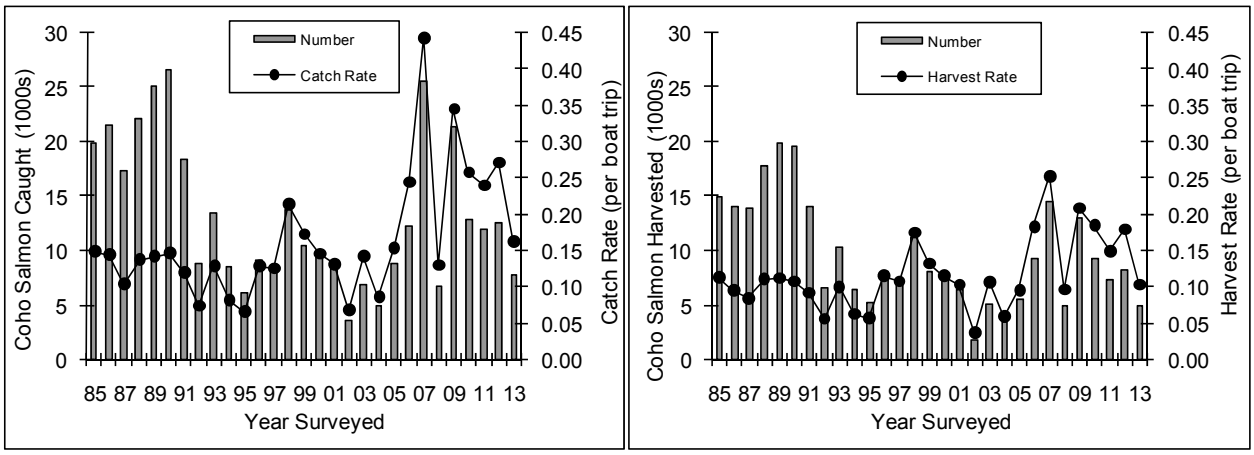

Figure 6. Total coho salmon catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 – September 30, 1985-2013.

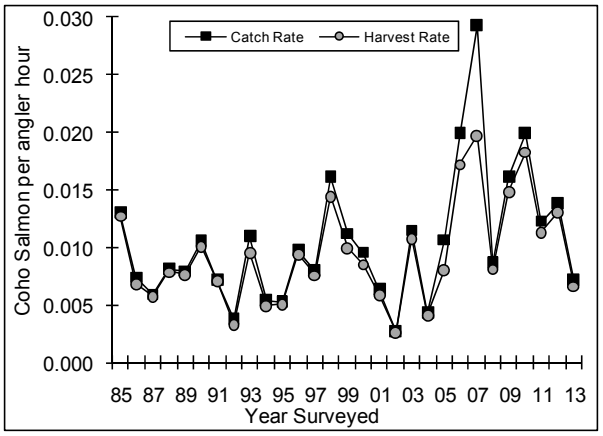

Figure 6b. Charter boat catch rate and harvest rate per angler hour for coho salmon, April 15 – September 30, 1985-2013.

Among charter boats, coho salmon catch and harvest rates (both 0.007 fish per angler hour) were well below long term averages (-31.6% and -29.8%, respectively; Figure 6b, Table A7b). Among noncharter boats, the 2013 catch and harvest rates were 0.010 and 0.005 coho salmon per angler hour, respectively (Table A7b). Coho salmon catch and harvest rates are typically highest during April and May and in the western portion of the lake (Lantry and Eckert 2011; Table A7b). For the sixteenth consecutive year, the west area experienced the highest coho salmon catch rate (0.34 fish per boat trip; more than 4-fold higher than in the east area). The lowest coho salmon catch rate occurred in the east area (0.6 fish per boat trip), and was a 72.4% decrease compared to 2012 (second highest for that area). Catch rate was highest during May (0.40 per boat trip, 56.1% above the May long term average) and September (0.23 per boat trip, and the fourth highest September catch rate recorded and 72.3% above the September long term average). Coho salmon catch rates per boat trip were below respective long term averages during April (-69.6%) and August (-21.8%). Similar trends were observed with harvest rate data (Table A7b).

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 for all survey years (1985-2013). Each year, the majority of coho salmon harvested in the open lake were age 2 (>73.8%; 29-year average=95.4%; Table A8). For the first time since the survey was initiated in 1985, 100.0% of the coho salmon sampled in 2013 were age 2. There were no age-1 coho sampled during 2010-2013. This was the fifth occurrence of zero age-1s observed in the 29-year data series. The contribution of age-3 coho salmon in angler harvest is small and represented ≤2.0% of harvest for 25 out of 29 years surveyed. The age 3 contribution was ≤1.0% for 19 of those years.

Condition indices for coho salmon in 2013, as determined from predicted weights of standard length fish, were below previous 25-year averages (1988-2012; range: -0.5% [18-in] to -8.5% [30-in]; Table A8). Condition of coho in the 24-in group

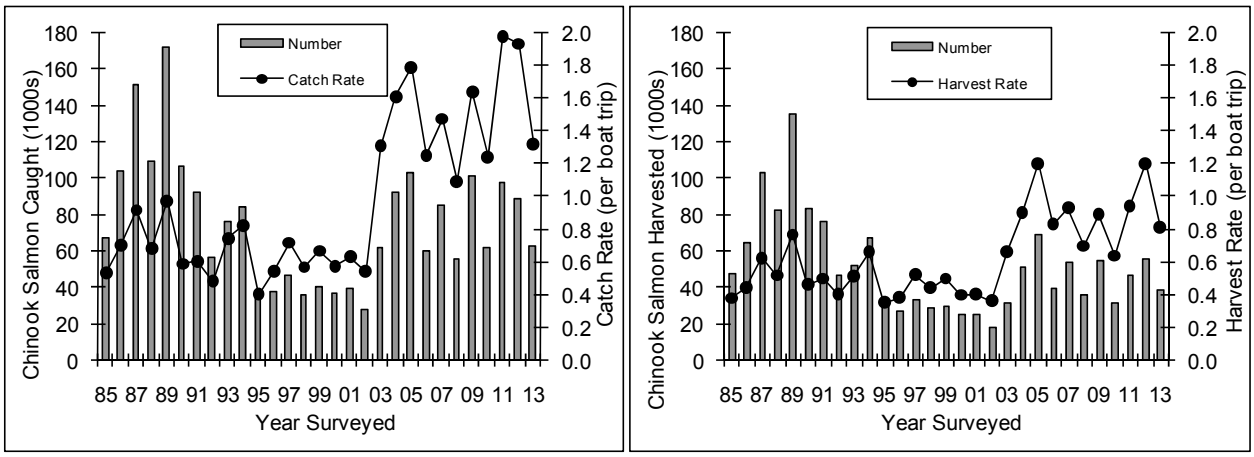

Figure 7. Total Chinook Salmon catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 - September 30, 1985-2013.

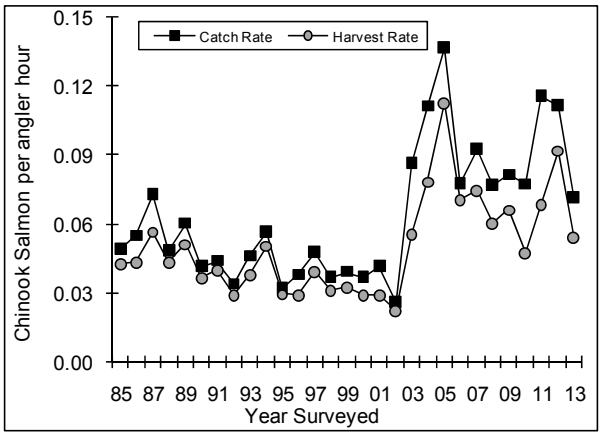

Figure 7b. Charter boat catch rate and harvest rate per angler hour for Chinook salmon, April 15 – September 30, 1985-2013.

was the second lowest in the time series for that length. Condition of coho salmon in the largest size groups (26-in, 28-in, and 30-in) were the lowest in the times series. The mean length of age-2 coho salmon in September was average at 28.1 inches. The average monthly gain in length in 2013 (1.7 inches per month) was equal to the average of the previous 28 years (Table A8).

Chinook Salmon

Catch and Harvest

Chinook salmon dominated the catch and harvest of trout and salmon in New York's Lake Ontario boat fishery annually since 2003, and was the most commonly captured salmonine in 18 of the 29 years surveyed. From 1985-2002 Chinook salmon represented an average of 28.3% of the total salmonid catch among trout and salmon boats. From 2003-2012, 47.6% of all salmonines caught were Chinook salmon. In 2013, Chinook salmon catch was estimated at 62,570 fish (±19.0%), representing 37.1% of the total 2013 salmonine catch (Figure 7, Table 1, Table A9a). Sixty-one percent of Chinook salmon caught in 2013 were harvested (Table A9a). The highest percent harvest occurred in 1995 when 87.3% of all Chinook salmon caught were harvested. Since 2003, anglers have experienced the best Chinook salmon fishing on Lake Ontario and the percentage of Chinook salmon harvested (2003-2013 average percent harvest=58.4%) was 21.0% lower than during the 1985-2002 time period (average=73.9%). The recent decline in percent harvest is likely attributable to both improved catch rates (i.e., with increased catch rates the anglers can be more selective with the fish harvested and still harvest their limit of fish) and increasing numbers of anglers practicing catch and release. Harvest in 2013 was estimated at 38,292 Chinook salmon (±20.3%), which represented 38.3% of the total salmonine harvest (Figure 7, Table 1, Table A9a).

As is typically observed, the majority of the Chinook salmon catch and harvest occurred during August 2012 (30,649 and 20,670, respectively; Table A9a). The highest regional contribution of Chinook salmon catch typically occurs in the west area (51.9% in 2013), followed by the east/central (27.1% in 2013; Lantry and Eckert 2011; Table

A9a).

Fishing Quality

Chinook salmon fishing quality was excellent each year from 2003-2013, with catch rates the highest estimated in the 29-year data series for eleven consecutive years (Figure 7, Figure 7b, Table A9b). From 1985-2002 the catch rate per boat trip for all trout and salmon boats was variable and without trend, but beginning in 2003 seasonal catch rates averaged more than 2.3-fold higher than those observed in years prior to 2003. The 2013 seasonal catch rate among all boats fishing for trout and salmon was 1.3 Chinook salmon per boat trip, a 13.8% decrease compared to the previous 10-year average, but 37.1% above the long term average (Figure 7, Table A9b). In 2013, charter boats targeting trout and salmon caught 38.3% of the Chinook salmon caught by trout and salmon anglers. Among charter boats, the 2013 Chinook salmon catch rate was 2.6 fish per boat trip, the lowest in the 2003-2013 time period and comparable (-2.8%) to 1987 (Table A9b). Charter catch rate per angler hour was 0.07 Chinook salmon, 25.9% below the previous 10-year average, but 13.2% above the long term average and nearly 1.6 times higher than during 1985-2002 (1985-2002 average=0.045; Figure 7b). Among noncharter boats, the 2013 catch rate was 1.0 Chinook salmon per boat trip and 0.07 per angler hour, which were among the highest rates experienced by noncharter anglers (Table A9b).

Chinook salmon harvest rates were at or near record highs in recent years, with the 2003-2013 estimates 84.9% higher, on average, than those prior to 2003 (1985-2002 average = 0.48 fish per boat trip, 2003-2013 average = 0.88; Figure 7, Figure 7b, Table A9b). The 2013 seasonal harvest rate among boats seeking trout and salmon was 0.8 Chinook salmon per boat trip (Figure 7, Table A9b). This was the eighth highest seasonal Chinook salmon harvest rate among the years surveyed and a 29.7% increase compared to the long term average. Among charter boats fishing for trout and salmon, the 2013 seasonal harvest rate of 1.9 Chinook salmon per boat trip was comparable to (+9.9%) the average (Figure 7b, Table A9b). Charter boats harvested 0.05 Chinook salmon per angler hour in 2013 (Figure 7b). Among noncharter boats, the 2013 seasonal harvest rate was 0.5 Chinook salmon per boat trip, a 26.6% increase compared to the long term average (Table A9b).

Spring Chinook salmon catch, harvest and fishing quality are typically highest in the west area and across all areas during the latter half of the open lake fishing season (Lantry and Eckert 2011; Table A9a, Table A9b). In 2013, Chinook salmon catch rates decreased in all four areas surveyed compared to 2012, and the 2008-2012 and 2003-2012 averages. In the west, catch rate was lower than experienced in 2012 (-13.9%), however, was the highest among all areas (2.4 Chinook per boat trip and 44.1% above the long term average; 1.3 harvested per boat trip). The west/central and east/central areas experienced seasonal catch rates (1.0 and 1.1 Chinook per boat trip, respectively) above long term averages (+20.6% and +48.3%, respectively) but below the 2012 (-39.6% and -32.2%, respectively) and previous 10-year (-27.0% and -14.6%, respectively) averages. East area anglers experienced the greatest decrease in catch rate of Chinook salmon (-65.4%, -44.2%, and -12.9% compared to 2012 [highest in the 29-year data series], 2003-2012, and long term averages, respectively). Monthly catch rates were general below average when compared to recent years, however, rates were above respective long term averages May through August (range: +10.9% [May] to +56.5% [August]). Catch rates during April and September were below long term averages (-69.9% and -13.4%, respectively).

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 for years 1985-2013. Each year age composition of Chinook salmon harvested is influenced by several factors, including catchability, year class strength, growth rates, and fishing quality for all salmonines. In 2013, the contribution of age-1 fish in angler harvest (10.7%) was comparable to (-7.5%) to the long term average (Table A10). The 2013 contribution of age-2 Chinook salmon (37.0%) was below the record highs observed in 2011 (68.9%) and 2012 (70.8%), but was comparable to the long term average (-2.4%). Contributions of age-3

Chinook salmon varied without trend from 1985-2010 (average = 49.6%). Age-3 Chinook salmon represented only 8.6% of angler harvest in 2011 and 24.1% in 2012, the lowest and third lowest contributions in the data series. Fifty-two percent of Chinook salmon harvested by anglers in 2013 were age-3, a 10.1% increase compared to the long term average. Age-4 Chinook salmon have represented between 0.0% (2000) and 14.0% (1996) of the Chinook salmon harvested over the 29-year data series (1985-2012 average=3.4%). In 2013, 0.3% of the Chinook salmon harvested were age-4 fish, the sixth lowest in the data series (Table A10).

To evaluate Chinook salmon growth, we determined mean length-at-age by month for samples collected July through September (data collected from 1991-2013; Figure A1, Table A11). Average length of age-1 Chinook salmon in August were at or near the highest in the data series for four consecutive years (2013 mean = 20.9 in and the fourth highest). Of the ten longest age 1s sampled from 1991-2010, eight were collected in 2010, including the top three. No record length age-1 Chinook salmon were sampled in 2012 or 2013, however, an age-1 Chinook salmon measuring 27.7 in and 9.5 lbs was processed during the survey. The longest average length of age-2 Chinook salmon during August occurred each year 2010-2012 (average = 32.6 in). Average length of age 2s in August 2013 was 31.1 in, the ninth highest in the data series and 0.6 in longer than the previous 23-year average. The longest age-2 Chinook salmon sampled in 2013 was 37.8 inches and the sixth longest measured in this data series (Figure A1, Table A11). The August mean length of age-3 Chinook salmon was 37.5 inches, similar to 2012 mean length in August (37.7%), the fourth longest in the data series, and 0.75 inches longer than the 23-year average. The largest Chinook salmon sampled in 2013 was 42.6 in. The oldest Chinook salmon sampled in Lake Ontario are age-4 and comprised a small percentage of the total Chinook salmon sampled (0.3% of all Chinooks processed in 2013; Table A11). Only two age-4 Chinook salmon were processed in 2013. Scale growth patterns suggest that the fastest growing individuals of any year class are more likely to mature and spawn at age 2 or 3, thereby removing themselves from the lake population, and that many of the age-4 fish are among the slower growing members of their cohort.

As an indicator of Chinook salmon condition, we evaluated predicted weights of seven standard lengths (16-in to 40-in length fish by 4-in size increments). The predicted weights were calculated from length-weight regressions of fish harvested in July and August 1988-2013 (Table A10) and showed no statistically significant trends over the 25-year data series. For each length group, predicted weights generally increased from the early 1990s to the late 1990s, then declined through the mid 2000s. In 2013, predicted weights of the three smallest lengths (16-in, 20-in, and 24-in) were at or above their respective 26-year averages (range: 0.0% to +4.1%). Among the 28-in to 40-in standard sizes, the lowest predicted weights all occurred in 2007 (Table A10). Salmon River Hatchery returns of Chinook salmon showed a similar decline in condition in 2007 (Bishop and Prindle 2009). Condition then improved through 2011 for the 28-in to 40-in length groups, when predicted weights were among the highest in the data series for the 28- and 32- inch groups and the highest in the data series for the 36- and 40- inch groups. Chinook salmon predicted weights declined in 2012 to levels comparable to respective long term averages. In 2013, predicted weights remained comparable to respective long term averages for the four largest lengths (28-in, 32-in, 36-in, and 40-in; range: -1.5% to -5.1%).

Angler Returns of Clipped and Tagged Chinook

To determine the contribution of naturally produced Chinook salmon to the sportfishery and to evaluate stocking strategies, NYSDEC and Ontario Ministry of Natural Resources (OMNR) initiated a Chinook salmon mass marking program (Connerton et al. 2014). All Chinook salmon stocked into Lake Ontario (New York and Ontario waters) were adipose fin clipped (AD) and a portion of those fish also had a coded wire tag (CWT) injected into their snout for the 2008 through 2011 year classes. The AD clip permits identification of a hatchery stocked fish and, when present, the CWT permits the identification of year class, raceway of origin, and stocking method/location of the fish. Each Chinook salmon processed during the angler survey was

checked for an AD clip and the presence of a CWT.

Each year Connerton et al. (2011, 2012, 2013, 2014) report the percentages of unmarked (i.e., wild) Chinook salmon determined from data collected during this survey (i.e., Lake Ontario Fishing Boat Survey) and additional sampling efforts conducted in New York and Ontario waters. Age-1 Chinook salmon were not part of the study. The percentage of wild Chinook salmon (ages 2-4) differed between the three regions Connerton et al. (2014) evaluated (i.e., Ontario waters, NY west region [includes Fishing Boat Survey sites in the west and west/central regions], and NY east region [includes Fishing Boat Survey sites in the east/central and east regions]; Table A1). A significantly higher percentage of wild age-2 fish were observed in Ontario waters (56.5%) compared to the NY east (36.5%) and NY west (29.0%) regions. A significantly lower percentage of wild age-3 fish were observed in the NY west region (64.4%) compared to the NY east (76.2%) and Ontario (70.9%) regions which were not significantly different from each other. The percentages of wild age-4 Chinook salmon were not significantly different among regions and samples were combined. Lakewide, 80.4% of age-4 salmon in the lake were wild; however age 4 Chinook are less common in Lake Ontario resulting in a low sample size (n=46). A more detailed discussion of the mass marking program, methods and 2010-2013 results of open lake and tributary collections are reported in Connerton et al. (2011, 2012, 2013, 2014).

Stocking Level Verses Relative Harvest

To permit between year comparisons of harvest-at-age data, we calculated age-specific harvest rates (age-specific numbers of Chinook salmon harvested per 150,000 boat trips April 15 - September 30; Table A12; Eckert 2007), hereafter termed relative harvest. Age compositions of Chinook salmon harvested during 1985-1990 were estimated using monthly length-frequency distributions developed from length-age keys utilizing scales collected in the early 1990s, and age compositions of Chinook salmon harvested during 1991-2013 were estimated using monthly length-age keys derived from fish aged by scales collected in the respective year.

Chinook salmon relative harvest (harvest per 150,000 targeted fishing boat trips; Table A12) was variable and appeared most affected by year class strength. The year class-specific total relative harvest of age-1 through age-4 fish (1984-2009 year classes) varied from a high of 202,709 fish for the 2002 year class (harvested at ages 1 to 4 from 2003 to 2006, respectively) to a low of 20,497 fish for the 1994 year class (harvested at ages 1 to 4 from 1995 to 1998, respectively), a 9.9 fold difference (Table A12). By comparison, survey year-specific total relative harvest (1985-2013 survey years) varied from the high of 179,857 fish in 2005 to a low of 52,112 fish in 1995, only a 3.5 fold difference. Eleven of the thirteen highest total relative harvest estimates occurred during 2003-2013 (Table A9b, Table A12), and based on the age-specific relative harvest, were due to high numbers of returns from each year class 2002-2006 and 2009-2010. These year classes contributed to the seven highest relative harvests of age-2 and age-3 Chinook salmon among the years surveyed, despite the intermediate stocking level of each of these year classes (1,700,374 [2003 year class] – 2,075,169 [2005 year class]; Table A12, Table A13). Stocking levels varied between 862,840 (1981 year class) and 3,368,296 (1987 year class) fingerling equivalents.

The 2013 total relative harvest (120,871 fish) was the eighth highest in the 29-year data series (Table A12). This is primarily attributed to the sixth highest return of age-3 Chinook salmon (2010 year class) which was more than 1.4-fold higher than the long term average. The 2010 year class contributed to the second highest age 1 returns and highest age 2 returns in the 29-year data series (Table A12). The contribution of age-2 fish (44,765 fish from the 2011 year class) was within the relative harvest estimates determined for recent years (2003-2012) and was more than 1.8-fold higher than the average contribution of age 2s during 1985-2002. The contribution of Chinook salmon from the 2009 year class at age-4 (347 fish) was among the lowest for age-4 fish in the data series. The low return of age-4 fish was not unexpected given that each year the majority of Chinook salmon mature and leave the lake by ages 2 or 3, and the 2009 year class experienced excellent growth (based on mean length at ages 1-3) and condition which likely contributed

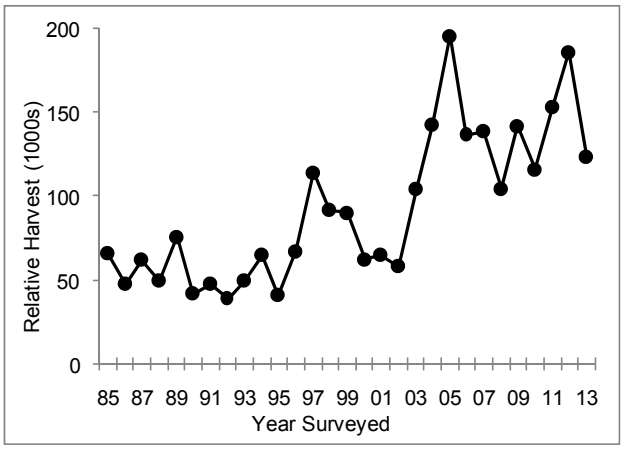

Figure 8. Relative harvest of Chinook salmon per 150,000 boat trips targeting trout and salmon, per 2,000,000 fingerling equivalents stocked.

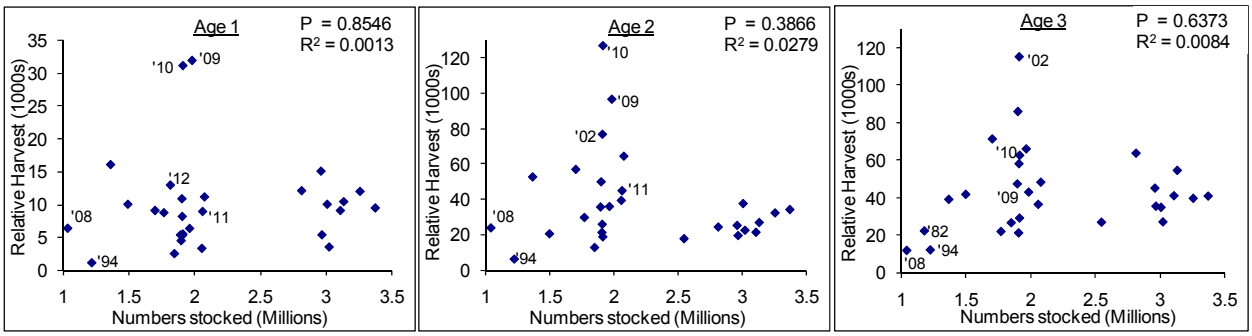

Figure 9. Number of fingerling equivalents stocked and relative harvest of age-1 (1984-2012 year classes), age-2 (1983-2011 year classes), and age-3 (1982-2010 year classes) Chinook salmon.

to a higher percentage maturing at younger ages.

To control for changes in stocking levels and allow for between year comparisons, relative harvest data were adjusted to a common base of 2,000,000 fingerling equivalents stocked (Figure 8). Regression analysis of 1985-2013 data resulted in a statistically significant ($P<0.0001$) upward trend, indicating that in recent years returns to the fishery were higher than expected when both effort and stocking level were accounted for. This could be due, in part, to improved survival of stocked fish and/or increased relative contribution of wild fish. The age-specific relative harvest data per unit number of fingerling equivalents stocked (Figure A2) showed that this trend was due to increased relative harvest of age 1s (2009-2010 year classes), age 2s (2002-2003, 2005-2006, and 2009-2010 year classes), age 3s (2002-2004, 2006, and 2010 year classes) and age 4s (2002-2003 year classes).

We also evaluated number stocked versus age-specific relative harvest and found that there was no relationship between stocking number and future fishing quality. There was no relationship between numbers of fingerling equivalents stocked and relative harvest at age 1 ($P=0.8546$ and $R^2=0.0013$), age 2 ($P=0.3866$ and $R^2=0.0279$), or age 3 ($P=0.63731$ and $R^2=0.0084$; Figure 9). Data patterned into two groups of vertical scatter separated by stocking levels for the 1984-1992 year classes (2.96-3.37 million fingerling equivalents stocked) and the 1993-2012 year classes (1.04-2.08 million fingerling equivalents stocked; Figure 9, Table A13). The lowest and highest age-1 (1994 and 2009 year classes, respectively), age-2 (1994 and 2010 year classes, respectively) and age-3 (2008 and 2002 year classes, respectively) relative

harvest estimates occurred after the 1993 stocking cuts. The 2008 year class was stocked at the lowest level (1,038,844 fingerling equivalents) since the 1981 year class (862,840 fingerling equivalents), yet relative harvests at age 1 and age 2 were well within the range of values determined for other year classes that were stocked at levels as high as approximately 3 million fish (Figure 9, Table A13). By age 3, however, relative harvest (12,123 fish) was the lowest in the data series. Relative harvest of the 2008 year class at age 4 (296 fish) was the third lowest in the data series.

Based on relative harvest, the 2009 and 2010 year classes were two of the strongest produced (Figure 9, Table A12). The 2009 year class contributed to the fishery in 2010 (age 1s), 2011 (age 2s), and 2012 (age 3s). Relative harvest estimates at ages 1 and 2 (31,988 and 96,707 fish, respectively) were the highest in the data series. Hatchery returns of the 2009 year class indicate that a majority may have matured at age 2 (Prindle and Bishop 2014), also consistent with growth and condition data. Relative harvest of the 2009 year class at age 3 (43,212 fish) was the twelfth highest, another indication that a majority may have matured at age 2.

The 2010 year class performed similar to the 2009 year class, in that relative harvest estimates at ages 1 and 2 (31,194 and 127,157 fish, respectively) were the highest in the data series. Similar to the 2009 year class, hatchery returns of the 2010 year class indicate that a majority may have matured at age 2 (Prindle and Bishop 2014), also consistent with growth and condition data. Relative harvest of the 2010 year class at age 3 (62,817 fish) was the sixth highest, another indication that a majority may have matured at age 2. Additionally, the Salmon River wild young-of-year Chinook salmon seining program indicated possible production of a strong 2010 year class of wild Chinook salmon. The high river flow during May 2009 may have reduced sampling efficiency and hindered the ability to detect a strong 2009 year class (Bishop et al. 2011). The cause(s) of record high relative harvest of the 2009 and 2010 year classes is unclear, but may be partly attributable to improved survival of stocked fish (traditional and/or pen reared fish), improved production and/or survival of wild fish, or a combination of these factors.

Several variables were evaluated to determine which, if any, could predict subsequent age-specific harvest, including all reasonable combinations of stocking levels and age-specific relative harvests. Twenty relationships were tested and nine were significant (p-values$\leq$0.0188). The R^2 values for these relationships ranged between 0.2008 and 0.5825, indicating that although some of the variation could be accounted for, approximately 42%-80% of variation was unaccounted for (i.e., additional factors were contributing to data variability and determining age-specific relative harvest).

Factors contributing to the observed increased relative harvest and the lack of relationship between numbers stocked and fishing quality include: 1) improved survival of stocked fish, 2) increased production and contribution of wild fish in recent years, 3) increased catchability of Chinook salmon (e.g., due to changing preyfish populations, improved angling conditions or techniques, or increased numbers of fish available thereby allowing anglers to harvest more fish from a population of the same relative size), or 4) a combination of these factors. Clipping and tagging stocked Chinook salmon will allow us to estimate relative survival of stocked fish and the contribution of wild fish to the population and the fishery (see Connerton et al. 2014). This information is needed to better manage Lake Ontario's fishery.

Rainbow Trout

Catch and Harvest

Rainbow trout was the third most commonly caught and fourth most commonly harvested salmonine in 2013, and represented 20.5% and 17.2% of the total trout and salmon catch and harvest, respectively (Figure 10, Table 1, Table A14a). Estimates peaked in 1989, declined to the lowest levels in 2002, and then showed an upward trend. Rainbow trout catch in 2013 was an estimated 34,611 ($\pm$30.2%) fish. Anglers harvested 49.7% of the rainbow trout that they caught, comparable to previous 5-year and 10-year averages (+5.2% and -3.9%, respectively) and a 28.6% decrease compared to October 1, 2006

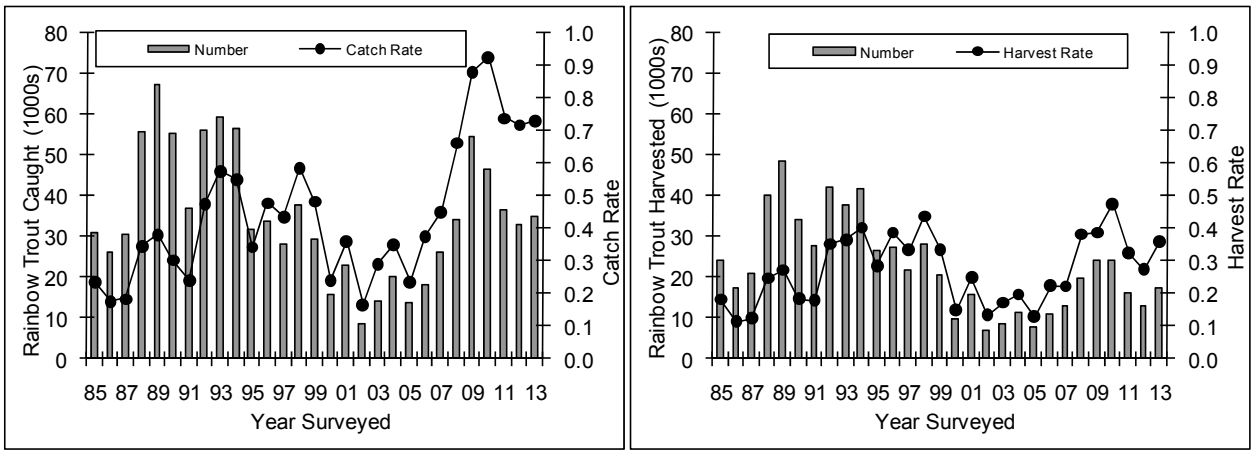

Figure 10. Total rainbow trout catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 - September 30, 1985-2013.

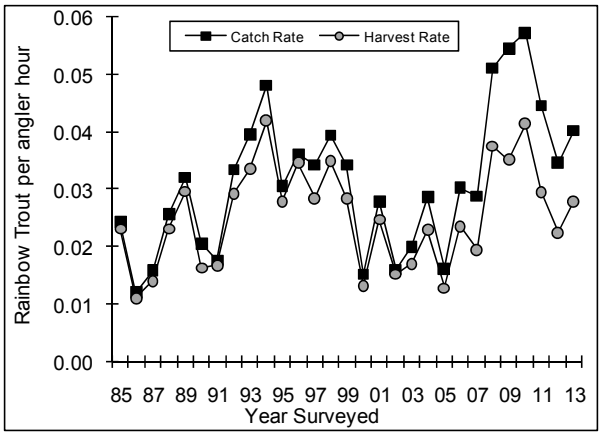

Figure 10b. Charter boat catch rate and harvest rate per angler hour for rainbow trout, April 15 – September 30, 1985-2013.

regulation change. The increased release rate observed in recent years is partly due to a fishing regulation change effective October 1, 2006 which increased the minimum harvestable size from 15 in to 21 in (i.e., it was not legal to harvest rainbow trout less than 21 in). Prior to the regulation change (1985-2006) an average of 69.7% of all rainbow trout caught by anglers (all fishing boat trips) were harvested. In 2002, when catch and catch rate were the lowest estimated, 80.9% of all rainbow trout caught were harvested. Following the 2006 regulation change an average of 47.9% (2007-2013) rainbow trout caught were harvested. In 2013, an estimated 17,203 (±31.6%) rainbow trout were harvested (Figure 10, Table 1, Table A14a).

For 28 consecutive years (1986-2013), the majority of rainbow trout caught and harvested were in the west area (Lantry and Eckert 2011, Table 14a). In 2013, 66.5% of all rainbow trout caught and 66.5% harvested were from the west area. Typically the majority of rainbow trout were caught and harvested during August (2001-2010 averages: 37.1% and 39.5%, respectively). During 2011 and 2012, however, the majority of rainbow trout were caught during July (50.5% and 33.7%, respectively; Table A14a). During 2013, the majority of rainbow trout were caught in August (41.0%) and July (33.2%; Table A14a).

Fishing Quality

For the last six years, Lake Ontario anglers experienced the highest catch per boat trip in the history of the survey. The 2013 rainbow trout catch rate was the fourth highest observed (0.73 rainbow trout per boat trip), was comparable to (-7.0%) the previous 5-year average (i.e., years of the highest rates on record), and a 67.7% increase compared to the long term average (Figure 10, Table A14b). In 2013, charter boats caught 39.0% of all rainbow trout caught by trout and salmon boats. Charter boats caught 1.5 rainbow trout per boat trip and 0.04 per angler hour, the sixth highest on record and 29.7% above the long term average (Figure 10b). Catch rates were the fifth highest on record among noncharter boats (0.6 rainbow trout per boat trip and 0.04 fish per angler hour; Table A14b).

The 2013 seasonal harvest rate among all boats fishing for trout and salmon (0.36 rainbow trout per boat trip) was comparable to (-2.0%) the previous 5-year average and a 34.4% increase compared to the long term average (Figure 10, Table A14b). Among charter boats fishing for trout and salmon, the harvest rate was 1.0 rainbow trout per boat trip (Table A14b). Charter boats harvested 0.03 rainbow trout per angler hour (Figure 10b), a 10.2% increase compared to the long-term average. Among noncharter boats fishing for trout and salmon, the harvest rate was 0.2 rainbow trout per boat trip (0.01 fish per angler hour) which was 26.9% above the long-term average (Table A14b).

Rainbow trout monthly and geographical catch rate and harvest rate trends for most years showed monthly rates highest during the summer and lower in April, and geographical rates highest in the west area, lower in the east/central and west/central areas (both similar through 2008, west/central higher since 2009), and lowest in the east area (Lantry and Eckert 2011; Table A14b). This was also observed in 2013 with catch and harvest rates highest in the west area (1.7 and 0.8 fish per boat trip, respectively) and during July-August (0.9-1.2 and 0.5-0.6 fish per boat trip, respectively; Table A14b). Rainbow trout catch rates were above long term monthly averages during May (+35.3%) and July through September (range: +28.5% [September] to +160.5% [July]), and rates were below the long term averages during April (-27.8%) and June (-41.9%).

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 for years 1985-2013. Lengths of rainbow trout sampled from the open lake boat fishery were dependent on several factors including age and strain composition, stage of maturity, and fishing regulations (i.e., minimum size limit). The 2013 open lake season was the seventh affected by the regulation change that raised the minimum harvestable length of rainbow trout from 15 in to 21 in. The average percent contribution of fish <21.0 in for the seven years since the regulation (2007-2013) was 10.4%, a significantly different value than the seven years prior to the regulation change (2000-2006) when 23.0% of rainbow trout processed were <21.0 in (Chi-square analysis: $X^2 = 76.536 > \chi^2_{[1](.005)} = 7.879$). During 2013, 10.3% of harvested rainbow trout were shorter than the legal 21 in minimum harvestable size.

Weight data were collected each year from 1988-2013 and each year we evaluated rainbow trout condition by determining the predicted weights of standard length fish (Table A15). For each standard length group (18- to 32-in lengths, by 2-in size increments), predicted weights were variable but showed increasing trends from 1988 to about 2002-2003 (trends similar to those observed with Chinook and coho salmon) then declined through 2009 to record and near record lows. Since then rainbow trout condition has been variable. In 2013, condition improved from the record and near record lows observed in 2012. Predicted weights were below their respective previous 25-year averages but were all above respective previous 5-year averages (Table A15).

Atlantic Salmon

In 1990, New York's Lake Ontario Atlantic salmon program changed from a small scale experimental project with an annual stocking target of 50,000 yearlings, to a larger put-grow-take program for trophy fish (>25 in) with an annual stocking target of 200,000 yearlings and fall fingerlings. These stocking increases began in 1991 (1990 year class) with annual stockings ≥160,000 fish for most years up to 1996 (Eckert 2000). Given this increased stocking level, Atlantic salmon catch in the open lake was expected to increase beginning in 1992, however, both catch and harvest declined after 1994 (Figure 11, Table A16; Eckert 1998). In 1996, the objective of a put-grow-take program for trophy fish was maintained and the annual stocking target was reduced to 100,000 yearlings and fall fingerlings. Stocking policy was further reduced to an annual target of 50,000 yearlings effective with the 2002 year class (stocked in 2003) because of continued poor returns, and a NYSDEC and local stakeholders' decision to replace the Atlantic salmon stockings in the Black River with an equivalent number of brown trout. Each year 2009-2013, and in addition to the NYSDEC stockings, the USGS Tunison Lab reared and stocked Atlantic

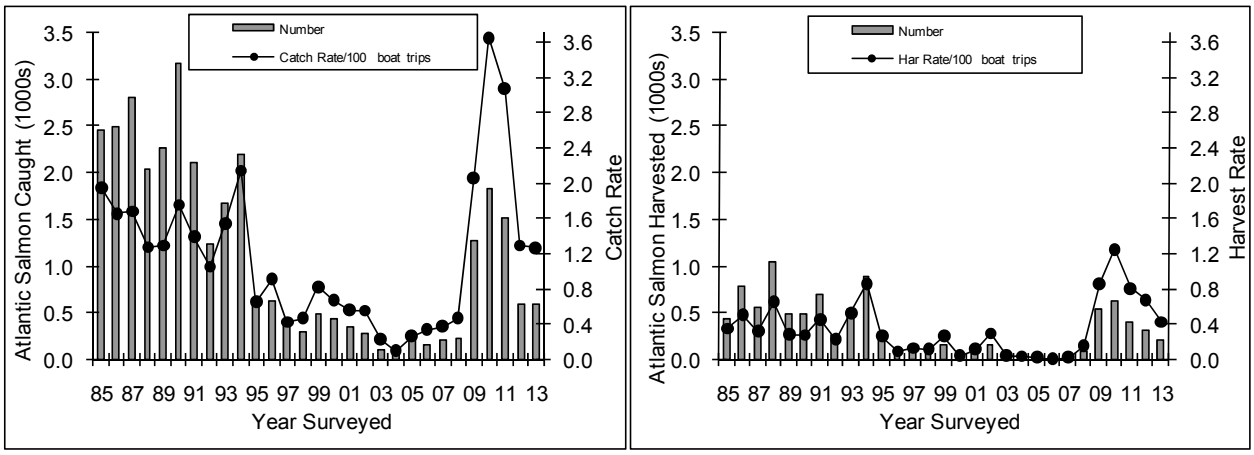

Figure 11. Total Atlantic salmon catch and catch rate, and harvest and harvest rate per 100 boat trips for boats seeking trout and salmon, April 15 – September 30, 1985-2013.

salmon (Connerton 2010, 2011, 2012, 2013, 2014).

Each year from 2003 through 2008, few Atlantic salmon were reported in angler catch or harvest, and ≤1 was observed in the boat fishery by creel agents, resulting in harvest estimates of less than 20 fish per year and catch estimates of less than 300 fish per year (Table A16). In 2008, three Atlantic salmon were processed by creel agents and estimated catch and harvest estimates were 233 and 79, respectively (Figure 11, Table A16). Each year 2009-2011, before initiation of the creel survey, anecdotal reports indicated that anglers were catching Atlantic salmon in greater frequency than what occurred during the previous decade. Each year 2009-2011, creel agents sampled an Atlantic salmon on the first day of the survey (April 22 [2009] and April 15 [2010 and 2011]). Agents continued to document catch and harvest of Atlantic salmon throughout the open lake seasons. For three consecutive years, estimated seasonal lakewide catch and harvest were the highest since 1994 (Figure 11, Table A16).

Fewer Atlantic salmon were caught and harvested in 2012 and 2013 than during 2009-2011, however, those estimates remained well above 1995-2008 levels. During 2013, estimated catch (599 ±50.6%) and harvest (200 [±118.5%]) were 85.7% and 166.7% increases compared to 1995-2008 levels, respectively (Figure 11, Table 1, Table A16). Atlantic salmon catch rate (1.3 fish per 100 boat trips seeking trout and salmon) was comparable to levels observed during the late 1980s-early 1990s and was more than 2.6-fold higher than 1995-2008 average rate (average = 0.48 per 100 boat trips). Harvest rate in 2013 (0.4 fish per 100 boat trips seeking trout and salmon) was nearly 3.8 times higher than the 1995-2008 average (0.11 fish harvested per 100 boat trips).

Many factors may have contributed to the increased occurrence of Atlantic salmon in angler catches. Survival of stocked Atlantic salmon may have improved. Wild, subyearling Atlantic salmon were captured in the Salmon River each year 2009-2011 and 2013 (J.H. Johnson, USGS Tunison Lab, Cortland, NY; personal communication); however, the contribution of naturally reproduced fish to the lake fishery is unknown. Additionally, recent efforts by Canada to restore a self-sustaining population of Atlantic salmon in Lake Ontario included increased stocking levels beginning in 2006. To date, the contribution of the enhanced stocking by Canada to the sport fishery is unknown. Genetic analysis of tissue samples collected during this survey in 2009-2011 indicated that, of the Atlantic salmon sampled, all were from NYSDEC stockings. In 2012 and 2013, the number of fish sampled for genetic analysis during this survey was very low (n=10 and 4, respectively), but results indicated that a portion of those were from the Canadian stockings (Chris Wilson, Ontario Ministry of Natural Resources, personal communication).

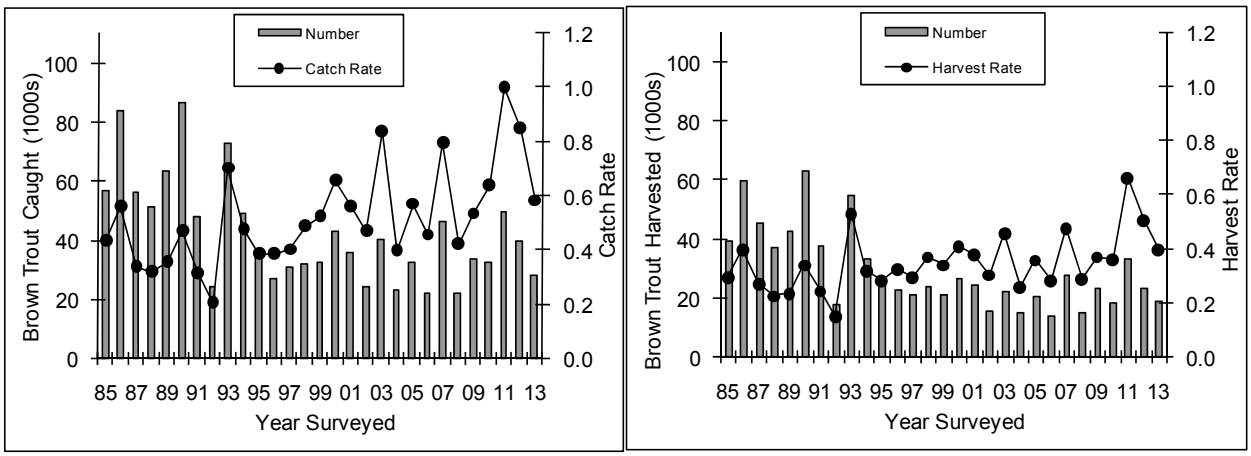

Figure 12. Total brown trout catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 – September 30, 1985-2013.

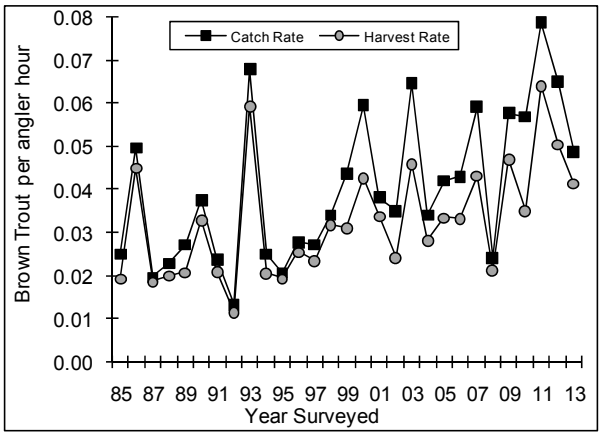

Figure 12b. Charter boat catch rate and harvest rate per angler hour for brown trout, April 15 – September 30, 1985-2013.

Brown Trout

Catch and Harvest

Among trout and salmon species, brown trout was the fourth most commonly caught and third most commonly harvested in 2013. Brown trout accounted for 16.5% and 19.0% of the total salmonine catch and harvest, respectively (Table 1, Table A17a). Both catch and harvest declined from the mid 1980s to the mid 1990s and varied without trend since 1995 (Figure 12, Table A17a). In 2013, seasonal catch and harvest estimates (27,793 [±46.2%] and 18,969 [±61.1%] fish, respectively) were decreases compared to previous 5-year averages (-21.6% and -15.8%, respectively; Figure 12, Table 1, Table A17a). In 2013, 68.3% of brown trout caught were harvested, comparable to previous 5-year (+7.1%) and 10-year (+9.3%) averages. The east/central area typically accounted for the highest proportions of brown trout catch and harvest (1985-2007, 2009-2011, and 2013 average = 54.1% of total catch). In 2008 and 2012 the highest proportion of brown trout catch and harvest occurred in the east area (60.6% and 37.2% of total trout and salmon catch, respectively) where brown trout fishing was good throughout much of the open lake fishing season (Lantry and Eckert 2011). During 2013, 45.8% of all brown trout caught was from the east/central area. The majority of brown trout catch during 2013 occurred during May (33.6% of total catch) and July (18.6% of total; Table A17a).

Fishing Quality

Brown trout catch rates (seasonal, charter and noncharter) were variable over the 29-year data series with no trend (Figure 12, Figure 12b, Table A17b). In 2013, among trout and salmon fishing boats, brown trout catch and harvest rates (0.6 and 0.4 fish per boat trip, respectively) were slightly higher than the long term averages (+12.2% and +14.2%, respectively). Charter boats targeting trout and salmon caught 58.7% of the brown trout caught by trout and salmon anglers in 2013. Catch rate among charter boats was 1.8 brown trout per boat trip in 2013, comparable to (-2.0%) the previous 10-year average and a 23.6% increase compared to the long term average (Figure 12b, Table A17b). The charter boat catch rate per angler hour was 0.05, a 21.8% increase compared to the long term average

(Figure 12b). Conversely, among noncharter boats, the 2013 catch per boat trip (0.3) and catch per angler hour (0.02) were decreases compared to long term averages (-16.2% and -21.9%, respectively; Table A17b).

Brown trout harvest rates (seasonal, charter and noncharter) were also variable and showed no trends over time. (Figure 12, Figure 12b, Table 17b). Among boats seeking trout and salmon, the 2013 seasonal harvest rate was 0.4 brown trout per boat trip, a 14.2% increase compared to the long term average (Figure 12, Table A17b). Among charter boats fishing for trout and salmon, the 2013 harvest rate was 1.5 brown trout per boat trip (0.04 fish per angler hour), comparable to (+0.8%) the previous 5-year average and a 30.0% increase compared to the long term average (Figure 12b, Table A17b). Among noncharter boats fishing for trout and salmon, the 2013 harvest rates were 0.13 brown trout per boat trip and 0.01 fish per angler hour.

Brown trout monthly and geographical catch and harvest rate trends for most years showed rates highest in April and May and declining from April through September, and highest in the east/central area (Lantry and Eckert 2012; Table A17b). During 2013, seasonal trends were typical, with brown trout catch and harvest rates highest in April and May. Fishing boats caught an average of 1.7 brown trout per boat trip in April, a decrease from the record highs observed in 2011 and 2012, and comparable to (+2.8%) the long term average. All four areas surveyed experienced decreased catch rates of brown trout when compared to respective 2012 catch rates (range: -17.0% [east/central] to -46.0% [west]). Anglers fishing the east/central area experienced below average catch rate compared to recent years (-22.7% and -23.5% compared to previous 5-year and 10-year averages, respectively), but catch rate was comparable to (-6.8%) the long term average. Anglers fishing the east and west/central areas experienced catch rates above long term averages (+51.7% and +22.4%, respectively), however, when compared to recent years (2008-2012) the east area catch rate was a slight decrease (-12.4%; Table A17b).

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 for all years 1985-2013 (previous reports, e.g., Lantry and Eckert 2012, presented results for fish processed beginning April 1 each year through 2009). Scales were collected from nearly all brown trout processed by creel agents during 1993-2013 (i.e., 21 years). Each year very few brown trout sampled are age 1 (0.0%-3.3%) because few are caught due to angling strategies (i.e., species targeted, lure type and their small size), and those caught are too small to be legally harvested (i.e., are less than 15 inches in length). Each year 2011-2013, none of the brown trout sampled were age-1 (Table A18); the majority were age 2. During 1993-2012, 66.0% (2004) to 88.8% (1993) of all brown trout harvested were age-2 fish. In 2013, 60.0% were age 2, the lowest percentage and a 22.6% decrease compared to the previous 20-year average. Conversely, the 2013 contribution of age-3 brown trout (34.6%) was the highest in the data series and an 87.7% increase compared to the previous 20-year average. In 2013, 2.7% of brown trout harvested were age-4, comparable to (-8.8%) the long term average. From 1993-2012, age-5 or older brown trout comprised an average of 0.6% of those sampled (Table A18). In 2013, however, 2.6% of brown trout sampled were age 5 and older, the highest in the data series and a 343.8% increase compared to the previous 20-year average. Few brown trout age 6 or older were observed, and in the 21 years that scale samples were aged, only nine age-6 and one age-7 brown trout were observed.

We evaluated brown trout condition by determining predicted weights of seven standard length groups (16-28 in, by 2-in length increments; Table A18). Predicted weights for each inch group were above average for the 16-in, 18-in, 20-in and 22-in standard lengths, and below average for the 24-in, 26-in, and 28-in standard lengths. Predicted weights for all lengths evaluated were within the range of values observed in previous years. Data were variable with no significant trend over the 26-year data series (1988-2013).

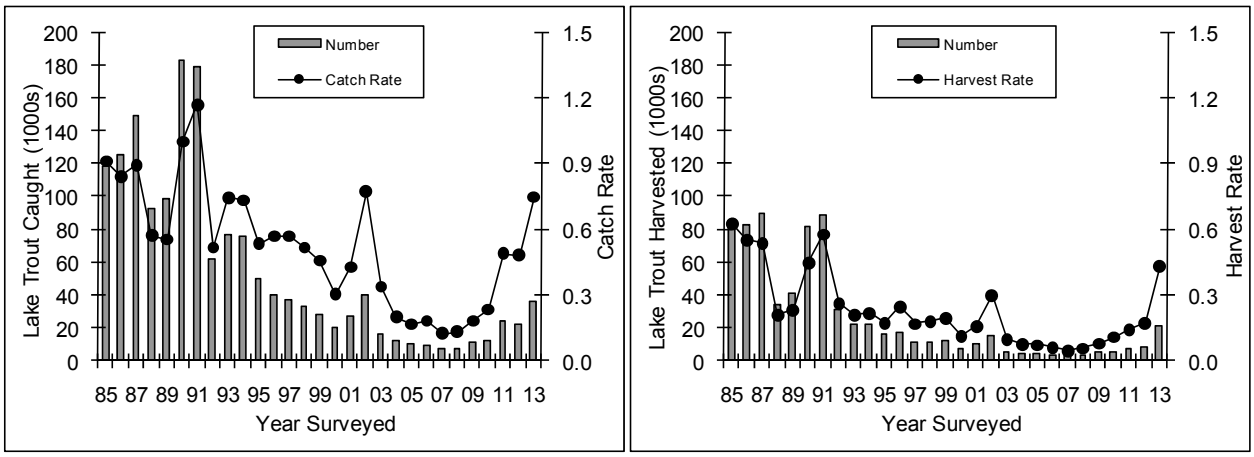

Figure 13. Total lake trout catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 – September 30, 1985-2013.

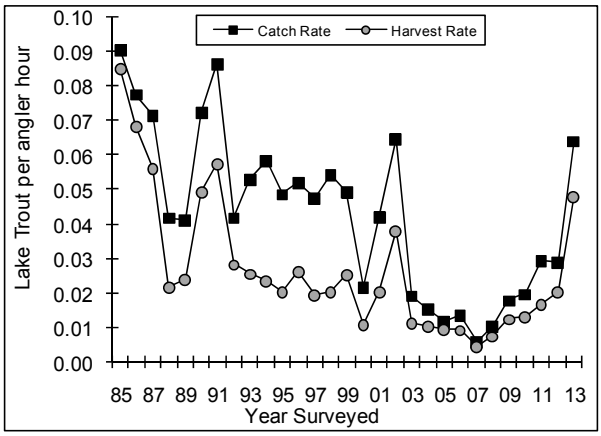

Figure 13b. Charter boat catch rate and harvest rate per angler hour for lake trout, April 15 – September 30, 1985-2013.

Lake Trout

Catch and Harvest

Lake trout fishing regulations for New York waters of Lake Ontario differ from the other salmonines. Since 1988, lake trout harvest has been limited by a slot size limit designed to increase the number and ages of spawning adults. In 1993, the slot limit was set at 25-30 inches total length. Until fall 2006, Lake Ontario anglers could harvest three lake trout outside of the 25-30 inch slot limit. Effective October 1, 2006, the lake trout creel limit was reduced to two fish per day per angler, one of which could be within the 25-30 inch slot. In 2013, lake trout was the second most commonly caught and harvested trout or salmon species, contributing 21.0% and 20.5% of the total salmonine catch and harvest, respectively (Table 1, Table A19a). In 2013, estimated lake trout catch (35,533 [±30.9%] fish) and harvest (20,511 [±31.5%]) were the highest estimated since 2002 and 1994, respectively, and were well above previous 10-year averages (+175.1% and +340.7%, respectively; Figure 13, Table 1, Table A19a). Lake trout catch and harvest increased to levels observed in the early to mid-1990s. Relatively low catch and catch rates of lake trout through much of the 2000s were attributed, in part, to both the excellent fishing quality for other salmonine species (i.e., possibly less effort specifically directed at lake trout) and the relatively low abundance of lake trout in Lake Ontario during the mid-2000s (Lantry and Lantry 2014). The increased catch of lake trout, which began in 2011, is attributed to increased lake trout abundance in recent years (Lantry and Lantry 2014). In 2013, anglers reported specifically targeting lake trout when fishing quality for other species (e.g., brown trout and Chinook salmon) was considered low. This may have contributed to increased lake trout catch and catch rate in 2013.

Prior to 2001, the east area accounted for the highest proportion of lake trout catch and harvest for nearly every survey year (Lantry and Eckert 2011; Table A19a). Since 2001, the majority of lake trout were caught in the west or west/central areas (11 of the 12 years 2001-2012). In 2013 and for the first time since 1997, the majority of lake trout were caught in the east and east/central areas (59.7% of total lake trout catch; Table A19a). The 2013 monthly catch

and harvest estimates were well above previous 10-year averages every month surveyed (catch range: +23.9% [August] to +528.5% [September]; harvest range: +74.9% [August] to +1,069.3% [September]; Table A19a).

Fishing Quality

Low lake trout abundance during the mid 2000s (Lantry and Lantry 2013) and excellent fishing quality for other salmonine species beginning in 2003 contributed to declining lake trout catch rates and harvest rates in angler creel from 2003 to 2007 (2003-2007 average catch rate = 0.20 per boat trip; Figures 13 and 13b, Table A19b). Catch rates increased each year 2008-2011 (0.13 to 0.48 fish per boat trip), then increased again in 2013 (0.75 per boat trip) to the highest rate since 2002, the ninth highest in the data series, and a 43.2% increase compared to the long term average (Figure 13, Figure 13b, Table A19b). The recent increase coincided with low but consecutive increases in the index of lake trout abundance as determined from the USGS/NYSDEC fall lake trout assessment (Lantry and Lantry 2014). In 2013, 60.2% of all lake trout caught by trout and salmon anglers were caught by charters. Among charter boats fishing for trout and salmon, the seasonal catch rates per boat trip (2.3) and per angler hour (0.06) were also the highest since 2002 and well above long term averages (+50.4% and +50.9%, respectively; Table A19b, Figure 13b). Catch rate among noncharter boats fishing for trout and salmon was 0.37 lake trout per boat trip and 0.03 fish per angler hour (Table A19b).

The 2013 seasonal harvest rate among boats seeking trout and salmon was 0.43 lake trout per boat, the highest since 1991 and the sixth highest in the data series (Figure 13, Table A19b). Among charter boats fishing for trout and salmon, the 2013 seasonal harvest rate was 1.7 lake trout per boat trip (0.05 per angler hour; Figure 13b, Table A19b). Among noncharter boats fishing for trout and salmon, the seasonal harvest rate was 0.12 lake trout per boat trip (0.01 per angler hour; Table A19b).

For 15 of the last 17 years (1997-2013), the west/central area experienced the highest lake trout catch of all areas surveyed (Table A19b). In 2013, anglers fishing the west/central area experienced the highest catch rate (1.4 lake trout per boat trip and the second highest in the data series for the west/central area) and harvest rate (0.8 per boat trip) of the four areas (Table A19b). Catch rate per boat trip was a 170.6% increase compared to that area's previous 10-year average and an 87.5% increase compared to the long term average. Anglers fishing the east area experienced a seasonal catch rate of 0.8 lake trout per boat trip, which was the second highest area-specific catch rate in 2013, the highest rate for that area since 1993, and a 40.5% increase compared to the long term average. Lake trout catch rate in the east/central area of the lake was the fifth highest in the data series for that area (0.75 per boat trip), and was well above (+86.4%) the long term average. West area catch rate (0.4 per boat trip) was comparable to (+7.3%) the previous 10-year average, but a 30.9% decrease compared to the long term average. Comparisons by month showed that catch rates were well above their respective long term averages during April-June and in September (range: +10.5% [April] to +414.8%% [September]; Table A19b), and below average in July (-19.3%) and August (-50.3%).

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 for all survey years. Lantry and Eckert (2010) present biological data that include fish processed prior to April 15. The 2013 open lake fishing season was the seventh season affected by the October 2006 regulation change that now permits each angler to keep two lake trout per day with no more than one between 25 and 30 inches. From 1993-2006, 9.8% (1998) to 26.6% (1993) of the lake trout harvested were within the 25-30 inch slot, due in part to measurement errors and location of capture (fish harvested in Ontario waters are exempt from New York regulations, Table A20). Given the regulation change we expected to see increased harvest of slot limit sized fish. During the first six years after the regulation change (2007-2012), an average of 39.4% of lake trout harvested was within the 25-30 inch slot. As was expected, this was well above levels observed during 2002-2006 (17.0%), the most recent five years prior to the regulation change (Table A20). In 2013, 53.4% of all lake trout

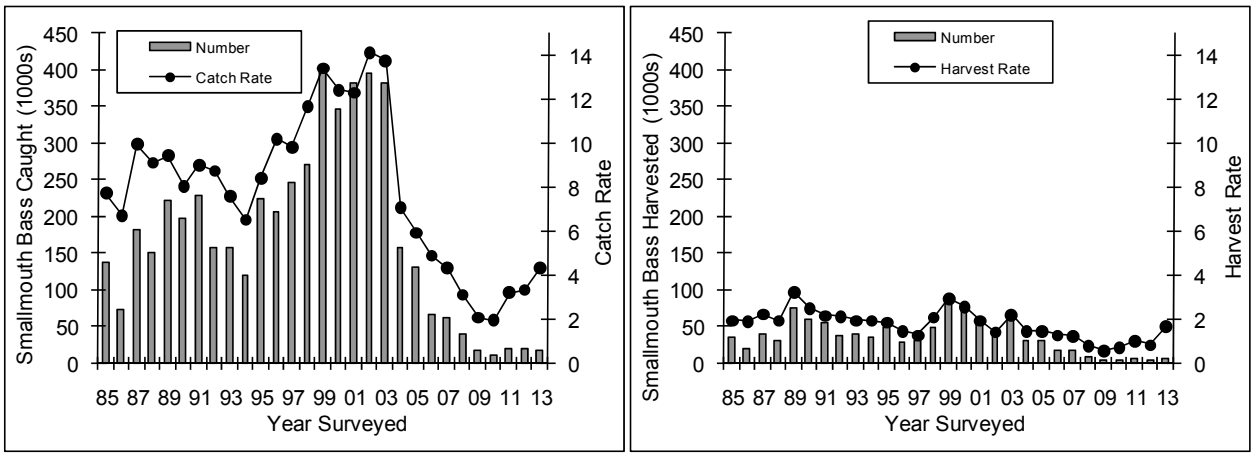

Figure 14. Total smallmouth bass catch and catch rate, and harvest and harvest rate per boat trip for boats seeking smallmouth bass during the traditional open season.

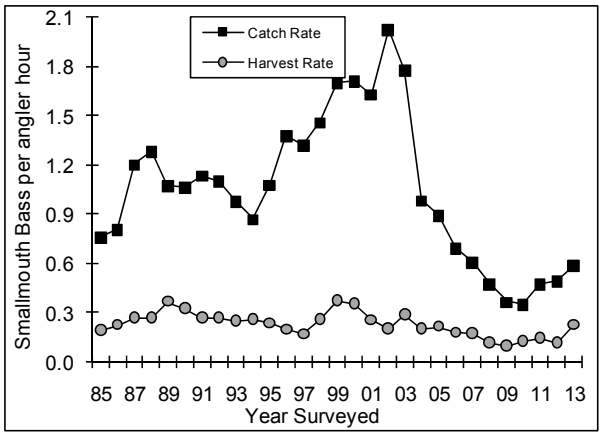

Figure 14b. Smallmouth bass catch rate and harvest rate per angler hour among anglers targeting bass during the traditional open season, 1985-2013.

harvested were within the 25-30 inch slot, the highest observed in the entire 29-year data series. Nearly 36% of the lake trout harvested in 2013 were <25 inches (Table A20). For the fourth consecutive year, the 2006-2008 year classes of lake trout (i.e., ages 5-7 in 2013) represented the majority of tagged lake trout in angler harvest (2010: 78.1% of tagged fish, 2011: 91.8% of tagged fish, 2012: 76.5% of tagged fish, 2013: 68.3%). In 2013, the 2009 (age 4) and 2010 (age 3) represented 15.6 and 10.7% of the tagged lake trout in angler harvest, respectively.

Smallmouth Bass

Catch and Harvest

Prior to October 1, 2006, NYSDEC fishing regulations established the smallmouth bass open season in Lake Ontario from the third Saturday in June through November 30 and allowed anglers to harvest a daily limit of five smallmouth bass with a minimum length of 12 inches. The regulation was changed effective October 1, 2006, establishing pre-season catch and release of smallmouth bass from December 1 through the Friday preceding the third Saturday in June (excluding Jefferson County's Lake Ontario waters). April 15 through June 14, 2013 was the seventh pre-season catch and release period covered by the NYSDEC fishing boat survey. During that period, there were an estimated 191 (±83.8%) fishing boat trips targeting smallmouth bass with all of the effort occurring June 1-14 (Table A2).

During the traditional open season covered by the survey and among all fish species, smallmouth bass was the most commonly caught and harvested species each year 1985 and 1987-2006. In 2007, smallmouth bass became the third most commonly caught species in the open lake boat fishery, preceded by yellow perch and Chinook salmon (Table A21a). Since 2009, smallmouth bass was the fifth or sixth most commonly caught species (fifth in 2013). The 2013 catch estimate of 21,446 fish (±61.8%; April 15 - September 30) was an 18.8% increase compared to the record low estimated in 2010; however, was a 28.1% decrease compared to the previous 5-year average (Table 1, Table A21a). During the traditional open fishing season, 18,531 smallmouth bass were caught and 7,122 of those

were harvested (38.4% caught were harvested; Figure 14, Table A21a).

Fishing Quality

Fishing quality was relatively stable from 1985 through the early 1990s (1985-1994 average catch per boat trip = 8.3 bass; average catch per angler hour = 1.0 bass), then increased to its highest level in 2002 (2002 catch per boat trip = 14.1 bass; catch per angler hour = 2.0 bass; Figure 14, Table A21b). Since then, fishing quality declined. In 2010, both catch rate and harvest rate among boats targeting smallmouth bass during the traditional open season were the lowest recorded (1.9 and 0.7 caught and harvested per boat trip, respectively; Figure 14). Although remaining among the lowest in the data series, catch rate and harvest rates increased in 2013 (4.3 and 1.7 bass caught and harvested per boat trip, respectively; Figure 14, Table A21b) to the highest observed since 2006 and 2003, respectively. Over the 29-year data series the nine lowest smallmouth bass catch rates occurred during the last nine years (2005-2013). Smallmouth bass catch rate per angler hour in 2013 was 0.59, a 36.8% increase compared to the previous 5-year average but a 71.0% decrease compared to the 2002 record high catch rate (Figure 14b, Table A21b).

Comparisons of 2013 month- and area-specific catch and harvest rates with their respective 2008-2012 averages (Table A21b) showed above average fishing quality during July (+217.7%) and September (+35.1%), and rates below previous 5-year averages in June (-27.4%), and August (22.1%). The 2013 seasonal catch rate in the west area was the highest since 2003 (6.5 bass per boat trip and a 129.3% increase compared to 2008-2012). Catch rates in the west/central and east/central areas were the highest observed since 2007, and were increases compared to their respective previous 5-year averages (+46.8% and +111.8%). Smallmouth bass catch rate in the east (4.9 bass per boat trip) declined from 2011 and 2012 rates (8.3 and 5.2 bass per boat trip, respectively) and was comparable to (+0.7%) the 2008-2012 average (Table A21b).

Other measures of fishing quality were evaluated and provided additional evidence of poor bass fishing in Lake Ontario's main basin in recent years. In 2013, 45.8% of boats specifically targeting smallmouth bass during the traditional open season failed to catch at least one bass, the sixth highest value among years surveyed (Table A6, Part B), indicating poor fishing quality. Additionally, among boats targeting smallmouth bass during the traditional open season, 76.5% failed to harvest a single bass in 2013 (Table A6). Each year of the survey a relatively low percentage of boats harvests the daily creel limit of five bass per angler (1985-2003 average=6.3%). Since catch rates began decreasing after 2003, an even lower percentage of bass boats harvested their limit of bass (2004-2013 average=2.5%). In 2013, 2.5% of bass fishing boats harvested the daily creel limit of five bass per angler (Table A6). The reduced percentage of anglers harvesting their creel limit can be influenced by sizes of bass caught and a change in angler attitude toward catch and release (i.e., more anglers may favor release rather than harvest).

Recent, poor fishing quality appears limited to anglers targeting smallmouth bass in Lake Ontario's south shore, however, an angler survey covering Lake Ontario's eastern basin fishery has not been conducted since 2003 (McCullough and Einhouse 2004). Several factor may have influenced smallmouth bass populations and fishing quality along the south shore, including round goby, Viral Hemorrhagic Septicemia virus [VHSv], *Hemimysis*, *Cladaphora* (i.e., commonly called witch's hair), and nutrient and water clarity changes. Many of these factors also affect populations in Lake Ontario's Eastern Outlet Basin, the St. Lawrence River and Lake Erie bass populations. Unlike the southern shore, however, these regions continue to provide acceptable bass catch rates and high quality bass. We will use data from long-term assessment programs in Lake Erie, the eastern basin of Lake Ontario and the St. Lawrence River to evaluate changes in recruitment, adult survival, and other population parameters. The Lake Ontario Fishing Boat Survey will continue to monitor bass angling effort and success in areas outside of the eastern basin. An angler diary program was conducted each year 2010-2013; however, it was discontinued following the 2013 season due to low participation (Sanderson and Lantry 2014).

Yellow Perch

Yellow perch catch and harvest estimates are highly variable because few boats with perch in their creel are interviewed, anglers targeting perch in the lake can have very low to very high catches, and the probability of interviewing perch anglers is low. The 2013 estimated catch (15,345 [±93.3%] fish) and harvest (6,572 [±92.3%] fish) were well below long-term (1985-2012) averages (-49.0% and -50.3%, respectively; Figure 15, Table 1, Table A22). Yellow perch are distributed along much of the Lake Ontario shoreline, however, each year 1996-2013 the greatest proportion of catch occurred in the east/central area by relatively few fishing boats targeting perch (62.1% of total harvest in 2013; Table A22). Coinciding with improved angler catch in recent years (2007-2012), fisheries assessments and anecdotal angler reports suggested that yellow perch populations were sufficient and producing quality fisheries in areas not covered or poorly sampled by the survey, including embayments and tributaries adjacent to the open lake fishery, and in Lake Ontario's eastern basin (e.g., Lantry 2014).

Walleye

Walleye have always been a minor component of the open lake boat survey, although angler interest in this species is high and, as part of management programs, fingerling stocking has occurred in many Lake Ontario embayments (e.g., Eckert 2005, Connerton 2014). Catch and harvest estimates for walleye are highly variable which is partly attributed to catch and harvest being greatest in locations and at times not included in, or poorly covered by, this survey (i.e., harvest in embayments or the eastern basin, and at night). Additionally, as with yellow perch, walleye catch and harvest estimates are influenced by only a few boats specifically targeting walleye and the probability of interviewing those boats is low. In 2013, there were an estimated 388 walleye caught and 318 harvested in Lake Ontario (±167.0% and ±197.2%, respectively; Figure 15, Table A23). Fisheries assessment data (Lantry 2014) and anecdotal angler reports suggest that walleye populations and fisheries are greatly underestimated by this survey.

"Other Fish"

The "other fish" category includes a variety of species, including unidentified fish. In 2013, as in previous years, "other fish" was dominated by warm water species (Table 1, Table A3). Many of these are important components of the nearshore fish community, and although most open lake boat anglers do not actively target these species, the total numbers caught and harvested can be substantial. Game fish included in the "other fish" category in 2013 were: northern pike (130 caught, 0 harvested) and largemouth bass (456 caught, 22 harvested). Lake sturgeon were reported in angler catch during two of the 29 years surveyed, 2001 (44 fish) and 2012 (27 fish), but none were reported in 2013. Chain pickerel were reported in angler catch for the fourth year since the survey began (caught each year 2008-2010, and in 2013 [290 caught, 67 harvested]). Cisco (a.k.a lake herring; 221 caught, 221 harvested) were reported in angler creel for the fourth consecutive year (2010-2013). Prior to that Cisco were rare in this survey but were caught and harvested in low number for eight of ten years from 1985-1994. After 1994, none were reported caught or harvested in this survey until 2010.

From 1985 through 2002, there was a significant decline in the total number of "other fish", due largely to decreases in white perch (12 caught in 2013) and rock bass (Table A3). Despite declines with these species, total harvest and catch of "other fish" increased from 2003 to 2009 as abundance of round goby increased (Walsh et al. 2007, Weidel et al. 2013). Round goby catches were first reported in the NYSDEC fishing boat survey in 2001 (965 fish caught). As round goby increased in abundance and distribution in Lake Ontario (Weidel et al. 2013), its occurrence in angler creel increased dramatically. By 2002, round goby was the most commonly harvested "other species" (most are killed and discarded), and by 2004 it became the most commonly caught "other species" (54.9% of the 2004 "other species" total). In 2009, round goby was the third most commonly caught (58,310 fish) species in Lake Ontario and comprised 89.8% and 98.0% of "other fish" catch and harvest, respectively. Since then estimated catch of goby has declined. In 2013, round goby was the seventh most commonly caught species (12,659 [±61.8%]

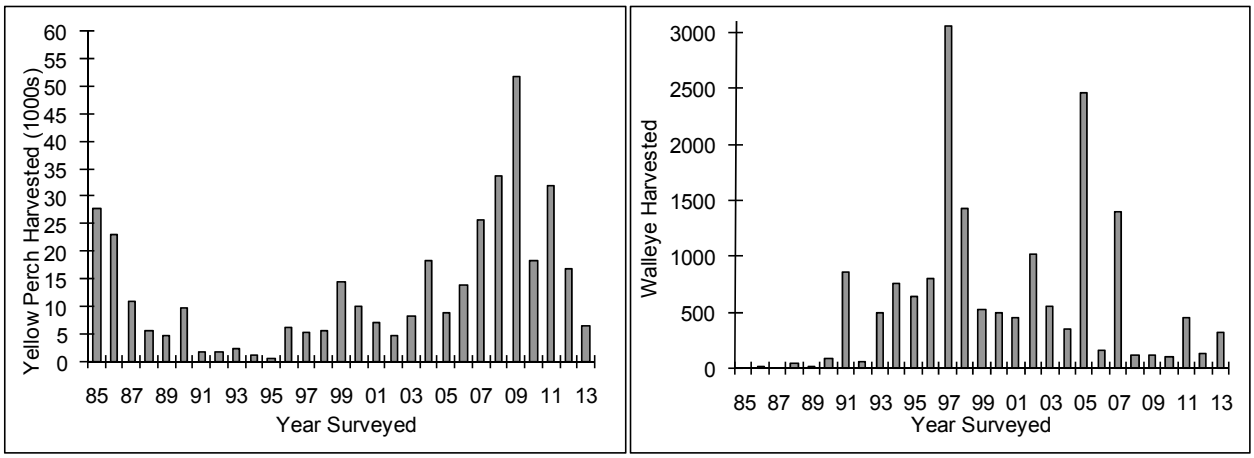

Figure 15. Total yellow perch and walleye harvested by all fishing boats, April 15-September 30 1985-2013.

caught, 7,546 [±107.7%] harvested; Table 1, Table A3).The decrease of round goby in angler catches coincides with a decline in abundance of goby in the lake (Weidel et al. 2013).

Lamprey Observations

Since 1986, all boat anglers were specifically asked if they observed lampreys attached to any of the fish they caught. Follow-up questions confirmed that the anglers observed an actual parasitic phase lamprey (as opposed to a lamprey mark), and determined what species of fish the lamprey was attached to. When saved by anglers, the lampreys were examined and a length measurement taken.

In 2013, there were an estimated 2,927 (±28.2%) lampreys observed in the fishing boat survey (Figure16, Table A24). The number of lampreys observed by anglers per 1,000 trout and salmon caught (hereafter referred to as attack rate) was relatively stable during 1986-1995 and averaged 5.9. After 1995, the attack rate increased, reaching a peak in 2007 when an average of 44.4 lampreys were observed per 1,000 trout and salmon caught. This increase coincides with a decline in abundance of lake trout >17 in, the preferred prey of sea lamprey (Lantry and Lantry 2014). Lamprey attack rate decreased from the 2007 peak and, in 2013, there were an estimated 17.3 lamprey per 1,000 trout or salmon caught (Figure 16, Table A24). This rate is a 60.9% decrease compared to the 2007 high, however, is still nearly 3-fold higher than the 1986-1995 average rate.

For 11 of the last 13 years (2001-2013) the majority of lamprey observations occurred on Chinook salmon (2001-2013 average=57.9%), which was due in part to the large number of Chinook salmon caught by anglers (e.g., 2001-2013 average=43.8% of total trout and salmon catch; Table A5a, Table A9a). In 2013, 68.8% of lamprey attacks were on Chinook salmon (Table A5a, Table A17a, Table A24). Other host salmonines in 2013 were brown trout (13.6% of attacks), lake trout (10.4% of attacks), rainbow trout (5.6% of attacks), and coho salmon (1.6% of attacks; Table A24). There were two anglers reports of lamprey observed on fishing gear in 2013. Among the 28 years of lamprey observation data, there were a total of 34 lampreys reported on fishing gear.

We further examined the data by determining host-specific attack rate (e.g., the seasonal proportion of brown trout caught by anglers with a lamprey attached; Table A24). Prior to 1996, lamprey attack rate on other salmonines (i.e., excluding lake trout) was low and, on average, fewer than 1% of each species caught by anglers was observed with a lamprey attached (range of 1986-1995 averages: 0.02% [coho salmon] – 0.63% [Chinook salmon]). By 1996, the percentage of angler caught salmonines with an attached lamprey increased for all species examined. On average, during 1996-2013, lampreys were observed on 1.1% of coho salmon, 2.6% of Chinook salmon, 1.2% of rainbow trout, 6.4% of Atlantic salmon, and 2.3% of brown trout caught in Lake Ontario. The increase in attack

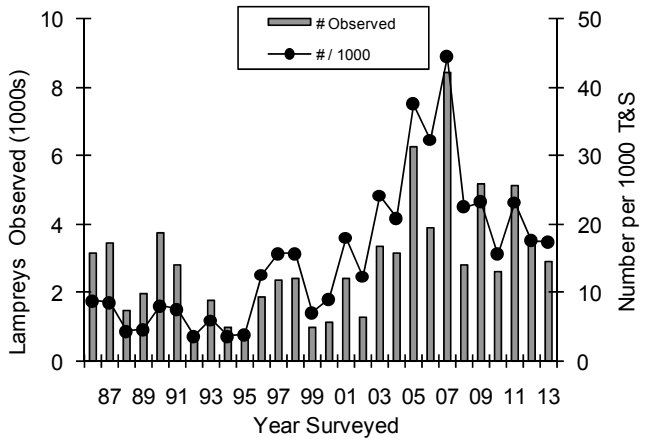

Figure 16. Total lamprey observed, and lampreys observed per 1,000 trout and salmon caught, April 15-September 30, 1985-2013.

rate on these salmonine species coincided with a decrease in abundance of the preferred lamprey prey (i.e., lake trout ≥17 inches; Lantry and Lantry 2014). Since 2007, the decrease in attack rate (Figure 16) coincides with a reduced lake trout wounding rate as determined from September gill netting, fewer lampreys observed attached to lake trout in the creel survey, and five consecutive years of increased lake trout catches in gill nets (Lantry and Lantry 2014).

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2013 Lake Ontario Fishing Boat Survey

Appendix Tables and Figures

Table A1. The four geographic areas (Roman numerals) used in analysis of the 1985-2013 NYSDEC Lake Ontario fishing boat survey data.

I. West geographic area: Niagara River to Point Breeze. Access locations include Williams Marina, Niagara State Park launch ramps (Youngstown), Roosevelt Beach, Wilson, Olcott, Green Harbor Marina, Golden Hills State Park, Johnson Creek, and Point Breeze.

II. West/Central geographic area: Eagle Creek Marina, Sandy Creek, Braddock Bay, Long Pond outlet, Genesee River, Irondequoit Bay.

III. East/Central geographic area: Bear Creek, Pultneyville, Hughes Marina, Sodus Bay, East Bay, Port Bay, Blind Sodus Bay, Little Sodus Bay (Fair Haven), Sterling Creek, Wrights Landing at Oswego, Oswego Marina.

IV. East geographic area: Sunset Bay, Catfish Creek, Dowie Dale Marina, Little Salmon River, Salmon River, Sandy Pond, Lakeview (North and South Sandy), Stony Creek, Association Island Cut.

Table A2. Effort and use statistics collected April 15 - September 30 during the 1985-2013 NYSDEC fishing boat surveys.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Part A: Effort for all fishing boats.											
Seasonal (5½ month) estimates of fishing effort for all fishing boats:											
Fishing Boat Trips	134,627	84,122	84,045	65,495	79,167	69,687	76,838	62,104	60,943	56,182	54,605
Boat Angler Trips	372,070	225,098	225,593	182,153	219,647	194,658	221,925	175,820	171,519	160,363	161,620
Boat Angler Hours	2,027,763	1,089,608	1,101,896	930,174	1,113,767	985,898	1,229,977	905,357	898,339	848,905	937,822
Anglers/Boat Trip	2.75	2.68	2.68	2.78	2.77	2.79	2.89	2.83	2.81	2.85	2.96
Hours/ Boat Trip	5.38	4.84	4.88	5.11	5.07	5.06	5.54	5.15	5.24	5.29	5.80
Monthly estimates of boat trips for all fishing boats:											
April	12,114	3,204	2,524	4,058	3,014	3,131	3,230	2,680	2,529	2,409	2,672
May	20,476	9,279	13,581	8,558	11,796	7,784	15,360	11,111	8,605	9,540	8,368
June	16,281	8,709	11,670	6,941	11,174	8,650	8,351	5,489	6,183	8,128	7,608
July	23,907	15,613	19,512	15,265	16,316	15,507	12,735	12,703	15,024	12,024	11,950
August	37,292	28,151	20,826	18,602	23,131	21,147	19,815	21,764	17,315	15,096	17,404
September	24,557	19,167	15,932	12,071	13,736	13,468	17,346	8,356	11,286	8,986	6,603
Seasonal estimates of boat trips among four geographic areas for all fishing boats:											
West	32,032	13,031	16,734	13,068	18,543	14,276	20,404	16,269	16,248	14,145	14,602
West/Central	19,865	10,327	11,592	9,358	11,461	7,722	10,746	7,011	6,890	7,412	7,648
East/Central	43,569	31,010	31,161	25,153	25,300	25,094	25,448	22,318	19,926	17,410	17,368
East	39,161	29,753	24,558	17,916	23,863	22,594	20,239	16,506	17,879	17,215	14,988
Part B: Seasonal estimates of total boat excursions (traffic).											
Power Boats:											
Fishing Boats	138,890	85,374	85,292	66,243	80,405	70,525	77,410	62,435	61,383	56,979	55,116
Nonfishing Boats	117,653	76,659	86,487	57,544	76,672	80,479	86,372	84,587	69,943	71,318	89,530
Sail Boats	31,185	14,026	12,918	12,186	18,126	19,750	22,224	23,914	23,782	20,703	21,432
Part C: Seasonal estimates of boat angler trips by residence.											
NY Resident	230,705	136,982	138,117	109,629	135,400	115,936	134,954	108,712	105,145	97,153	96,610
Nonresident	141,364	88,116	87,476	72,524	84,247	78,722	86,971	67,108	66,374	63,210	65,010
% NY Resident	61.7%	60.9%	61.2%	60.2%	61.6%	59.6%	60.8%	61.8%	61.3%	60.6%	59.8%
Part D: Effort for boats seeking trout and salmon.											
Seasonal (5½ month) estimates of fishing effort for boats seeking trout and salmon:											
Fishing Boat Trips	106,025	57,397	57,510	47,812	57,620	51,229	62,028	50,059	49,548	46,059	47,520
Boat Angler Trips	306,202	165,299	169,125	142,264	172,001	152,905	189,796	151,747	147,775	138,687	146,900
Boat Angler Hours	1,803,271	902,544	928,097	806,572	968,752	868,237	1,143,095	843,037	831,675	785,271	889,719
Anglers/Boat Trip	2.90	2.88	2.94	2.98	2.99	2.98	3.06	3.03	2.98	3.01	3.09
Hours/ Boat Trip	5.88	5.46	5.49	5.67	5.63	5.68	6.02	5.56	5.63	5.66	6.06
Monthly estimates of boat trips for boats seeking trout and salmon:											
April	11,962	3,204	2,397	4,024	2,998	2,874	3,610	2,610	2,518	2,366	2,575
May	19,523	8,808	12,945	7,959	11,009	7,262	14,731	9,401	8,050	8,388	7,911
June	10,531	4,783	5,363	2,733	5,862	4,760	5,201	3,878	4,313	5,138	6,333
July	14,496	7,154	10,862	8,259	10,212	9,261	8,743	9,233	10,903	9,255	9,651
August	29,207	19,185	14,090	14,496	16,674	16,485	15,192	18,080	14,123	12,910	15,910
September	20,306	14,262	11,853	10,340	10,864	10,586	14,552	6,858	9,642	8,002	5,141
Seasonal estimates of boat trips among four geographic areas for boats seeking trout and salmon:											
West	27,766	11,155	14,363	11,029	16,119	12,440	18,562	14,258	14,715	12,671	13,674
West/Central	14,792	5,852	7,139	6,828	6,962	4,293	7,725	5,574	5,047	5,584	6,634
East/Central	31,371	17,746	17,434	16,768	16,507	17,094	19,173	16,740	15,137	13,596	15,259
East	32,096	22,644	18,574	13,187	18,031	17,403	16,568	13,487	14,649	14,208	11,954
Percent of total seasonal fishing effort by boats seeking trout and salmon:											
Fishing Boat Trips	76.0%	68.2%	68.4%	73.0%	72.8%	73.5%	80.7%	80.6%	81.3%	82.0%	87.0%
Boat Angler Trips	79.8%	73.4%	75.0%	78.1%	78.3%	78.6%	85.5%	86.3%	86.2%	86.5%	90.9%
Boat Angler Hours	87.0%	82.8%	84.2%	86.7%	87.0%	88.1%	92.9%	93.1%	92.6%	92.5%	94.9%

Table A2 (continued). Summary of effort statistics.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Part E: Boats seeking smallmouth bass during the open season.											
Seasonal estimates of fishing effort for boats seeking smallmouth bass during the traditional open season (3rd Saturday in June - September 30):											
Fishing Boat Trips	22,830	22,340	22,108	13,586	14,509	12,786	8,666	5,855	6,257	6,203	4,273
Boat Angler Trips	52,541	50,367	47,220	30,938	33,135	28,548	18,885	12,106	13,758	13,505	9,082
Boat Angler Hours	178,436	160,373	146,449	96,062	103,494	83,434	48,847	32,603	42,718	41,972	31,569
Anglers/Boat Trip	2.30	2.25	2.14	2.28	2.28	2.23	2.18	2.07	2.20	2.18	2.13
Hours/ Boat Trip	3.41	3.18	3.10	3.10	3.12	2.92	2.59	2.69	3.10	3.11	3.48
Monthly estimates of boat trips for boats seeking smallmouth bass during the traditional open season:											
April & May	-	-	-	-	-	-	-	-	-	-	-
June	4,050	2,312	4,626	2,915	2,879	2,325	1,284	634	935	1,525	637
July	8,044	7,413	7,736	5,881	4,738	4,979	2,517	2,212	2,704	2,303	1,403
August	7,129	8,191	6,115	3,743	4,778	3,579	2,878	2,139	1,724	1,646	959
September	3,606	4,423	3,631	1,048	2,114	1,903	1,987	870	894	728	1,275
Seasonal estimates of boat trips among four geographic areas for boats seeking smallmouth bass during the traditional open season:											
West	2,712	1,272	1,623	1,237	1,561	1,001	1,370	1,051	815	984	352
West/Central	3,779	3,710	3,574	1,512	2,621	2,426	1,453	642	784	1,006	564
East/Central	10,505	11,348	11,331	6,912	6,649	5,451	3,638	2,768	2,809	2,289	1,174
East	5,834	6,010	5,580	3,925	3,677	3,908	2,204	1,394	1,849	1,924	2,183
Percent of total seasonal fishing effort by boats seeking smallmouth bass during the traditional open season:											
Fishing Boat Trips	19.5%	26.6%	26.3%	20.7%	18.3%	18.3%	11.3%	9.4%	10.3%	11.0%	7.8%
Boat Angler Trips	16.3%	22.4%	20.9%	17.0%	15.1%	14.7%	8.5%	6.9%	8.0%	8.4%	5.6%
Boat Angler Hours	10.5%	14.7%	13.3%	10.3%	9.3%	8.5%	4.0%	3.6%	4.8%	4.9%	3.4%
Part F: Other species sought.											
Seasonal estimates of fishing boat trips by species sought for boats not seeking salmonids or smallmouth bass during the traditional open season:											
Northern Pike	99	53	0	73	224	0	0	78	46	29	78
SMB pre-opener	202	293	184	500	496	367	644	292	239	521	191
Largemouth Bass	29	0	0	0	52	16	0	0	13	13	197
Yellow Perch	893	955	717	769	1,203	1,914	1,800	1,901	1,794	1,556	779
Walleye	460	326	570	278	1,210	373	270	470	384	233	249
All Other	4,049	2,759	2,957	2,476	3,853	3,003	3,863	3,449	2,662	1,568	1,319
% Northern Pike	0.08%	0.06%		0.11%	0.28%			0.13%	0.08%	0.05%	0.14%
% SMB pre-opener	0.18%	0.35%	0.22%	0.76%	0.63%	0.53%	0.84%	0.47%	0.39%	0.93%	0.35%
% Largemouth Bass	0.05%				0.07%	0.02%			0.02%	0.02%	0.36%
% Yellow Perch	0.65%	1.14%	0.85%	1.17%	1.52%	2.75%	2.34%	3.06%	2.94%	2.77%	1.43%
% Walleye	0.56%	0.39%	0.68%	0.42%	1.53%	0.54%	0.35%	0.76%	0.63%	0.41%	0.46%
% All Other	3.16%	3.28%	3.52%	3.78%	4.87%	4.31%	5.03%	5.55%	4.37%	2.79%	2.42%
Part G: Charter fishing boats.											
Seasonal (5½ month) estimates of fishing effort for charter boats:											
Fishing Boat Trips	13,881	9,589	9,284	9,099	9,448	9,012	9,885	8,612	8,332	7,632	9,343
Boat Angler Trips	69,940	48,045	47,406	45,872	48,726	47,015	50,142	44,773	43,124	38,880	48,694
Boat Angler Hours	517,223	322,531	311,993	310,568	340,751	322,072	347,188	288,231	275,652	256,420	338,688
Anglers/Boat Trip	5.00	5.01	5.11	5.04	5.16	5.22	5.07	5.20	5.18	5.09	5.21
Hours/ Boat Trip	7.37	6.71	6.58	6.77	6.99	6.85	6.92	6.44	6.39	6.60	6.96
Monthly estimates of boat trips for charter boats:											
April	892	129	186	505	401	210	331	428	300	599	426
May	2,427	1,546	1,590	1,572	1,299	1,227	1,712	1,425	1,119	733	1,607
June	1,589	711	1,063	531	1,221	930	974	657	873	648	965
July	2,134	1,568	1,457	2,037	2,237	1,455	1,917	2,112	2,174	1,826	2,252
August	4,506	4,086	3,038	2,791	2,732	3,588	2,949	3,259	2,513	2,622	3,060
September	2,333	1,549	1,950	1,664	1,559	1,602	2,002	731	1,353	1,203	1,032
Seasonal estimates of boat trips among four geographic areas for charter boats:											
West	3,688	2,151	2,759	1,870	2,810	2,371	2,624	2,837	2,658	2,060	2,572
West/Central	1,511	1,217	1,094	954	1,387	472	1,056	933	842	813	1,120
East/Central	4,939	3,477	3,280	4,283	3,292	3,854	4,235	3,512	3,263	2,879	3,935
East	3,742	2,745	2,152	1,993	1,960	2,315	1,971	1,329	1,570	1,880	1,715
Percent of total seasonal fishing effort by charter boats:											
Fishing Boat Trips	10.7%	11.4%	11.0%	13.9%	11.9%	12.9%	12.9%	13.9%	13.7%	13.6%	17.1%
Boat Angler Trips	19.4%	21.3%	21.0%	25.2%	22.2%	24.2%	22.6%	25.5%	25.1%	24.2%	30.1%
Boat Angler Hours	26.7%	29.6%	28.3%	33.4%	30.6%	32.7%	28.2%	31.8%	30.7%	30.2%	36.1%

Table A3. Estimated numbers of fish other than coho salmon, Chinook salmon, rainbow trout, Atlantic salmon, brown trout, lake trout, smallmouth bass, yellow perch, walleye, or sea or silver lamprey, that were harvested and caught April 15 – September 30, 1985-2013.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Seasonal (5½ month) estimates of fish harvested:											
Unidentified Fish	3	0	33	0	0	0	0	0	0	0	0
Bowfin	1	0	0	0	0	0	0	0	0	0	0
American Eel	7	0	0	0	0	0	0	0	0	0	0
Alewife	34	0	31	0	0	0	0	365	0	14	72
Gizzard Shad	4	0	0	0	0	0	0	0	0	0	0
Cisco	28	0	0	0	0	0	0	76	187	247	221
Lake Whitefish	0	0	0	0	0	0	0	11	13	0	0
Pink Salmon	3	16	0	0	23	0	0	0	0	0	0
Unidentified Salmonine	15	0	0	0	0	0	0	0	0	0	0
Northern Pike	89	22	0	135	0	40	0	0	14	132	0
Chain Pickerel	0	0	0	0	0	0	0	0	0	0	67
Common carp	5	0	0	0	0	0	0	0	0	45	0
Unidentified Redhorse	0	0	0	0	15	0	0	0	0	0	0
Yellow Bullhead	1	0	0	0	0	0	0	0	0	0	0
Brown Bullhead	115	70	0	45	0	0	0	0	0	0	0
Channel Catfish	73	0	0	0	0	0	0	0	0	0	0
Threespine Stickleback	1	0	0	0	0	0	0	0	0	0	0
White Perch	1,926	0	0	0	0	0	0	20	0	0	0
White Bass	339	0	0	0	0	0	0	0	0	0	0
Rock Bass	3,346	644	133	473	363	1,115	526	131	135	688	134
Pumpkinseed	501	192	228	658	0	95	29	20	0	0	0
Bluegill	106	0	0	562	29	79	87	140	329	0	0
Largemouth Bass	100	0	0	269	108	149	88	32	0	132	22
Black Crappie	33	0	0	1,301	0	0	0	0	0	26	0
Freshwater Drum	515	194	158	76	0	0	0	0	0	0	0
Round Goby	316	2,865	10,996	16,807	28,974	39,611	36,003	13,138	12,770	9,182	7,546
Seasonal (5½ month) estimates of fish caught:											
Unidentified Fish	36	0	48	0	48	250	213	0	19	24	23
Lake Sturgeon	2	0	0	0	0	0	0	0	0	27	0
Longnose Gar	0	0	43	0	0	0	72	0	0	0	0
Bowfin	22	0	0	45	0	0	0	0	0	0	0
American Eel	93	0	0	0	0	0	0	0	0	0	0
Alewife	455	0	31	32	0	45	43	736	220	27	403
Gizzard Shad	13	0	0	0	0	0	0	0	0	14	0
Cisco	39	0	0	0	0	0	0	181	229	375	221
Lake Whitefish	0	0	0	0	0	0	0	11	13	0	0
Pink salmon	3	16	0	0	23	0	0	0	0	0	0
Unidentified Salmonine	321	20	32	251	31	281	14	106	113	0	0
Rainbow Smelt	11	0	0	0	0	0	0	0	0	0	0
Northern Pike	355	214	44	166	2,191	235	1,370	900	62	204	130
Muskellunge	3	0	0	0	0	0	0	0	0	0	0
Chain Pickerel	0	0	0	0	0	690	422	32	0	0	290
Common Carp	103	0	61	15	19	114	38	62	26	72	70
White Sucker	29	0	0	29	14	14	0	36	13	0	0
Unidentified Redhorse	13	0	0	0	45	0	0	0	0	0	0
Yellow Bullhead	1	0	0	0	0	0	0	0	0	0	0
Brown Bullhead	157	70	0	45	0	0	0	0	0	0	25
Channel Catfish	170	0	0	0	0	198	0	15	0	19	0
Threespine Stickleback	4	0	0	0	0	0	0	0	0	0	0
White perch	5,079	0	0	0	30	606	0	83	101	0	12
White Bass	1,507	16	31	111	72	14	257	20	25	2,533	0
Rock Bass	16,609	3,610	3,381	2,731	4,608	4,495	2,546	991	818	1,840	1,088
Pumpkinseed	1,672	1,040	461	1,994	1,369	2,774	577	222	28	36	322
Bluegill	300	0	429	1,198	306	284	146	349	1,257	77	225
Largemouth Bass	545	311	82	1,306	1,177	1,313	594	190	227	516	456
Black Crappie	83	0	21	1,390	18	0	0	0	0	26	0
Freshwater Drum	8,648	3,072	1,914	1,255	686	360	266	701	240	525	256
Round Goby	441	10,201	20,371	34,336	62,615	63,407	58,310	21,033	25,290	13,484	12,659

Table A4. Residency for boat anglers interviewed April 15 – September 30, 1985-2013. Shown are percent contributions the most common states or provinces, and for the most common counties among New York resident anglers.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
State or Province of Residence - Percent Frequency											
Connecticut	2.1	2.2	1.7	1.8	2.4	1.6	1.7	1.6	1.3	1.5	1.3
Florida	0.3	0.3	0.4	0.3	0.5	0.4	0.4	0.4	0.4	0.4	0.5
Maine	0.7	0.9	1.0	1.3	1.0	0.9	0.9	0.8	0.7	0.7	1.0
Maryland	0.3	0.3	0.2	0.5	0.1	0.2	0.1	0.2	0.2	0.3	0.8
Massachusetts	4.0	3.2	3.3	3.1	2.9	3.3	3.3	3.0	2.7	2.6	2.6
Michigan	0.3	0.2	0.4	0.1	1.2	0.3	0.3	0.4	0.6	0.2	0.6
New Hampshire	1.2	1.0	1.1	1.5	1.3	1.2	1.2	1.1	0.8	0.9	1.0
New Jersey	4.4	4.4	3.3	3.8	3.8	3.3	3.8	3.0	3.0	2.6	2.2
New York	61.7	60.9	61.2	60.2	61.6	59.6	60.8	61.8	61.3	60.6	59.8
Ohio	4.5	2.3	3.2	3.0	2.8	4.5	3.5	2.6	4.0	3.9	4.7
Pennsylvania	16.4	19.8	19.2	19.5	17.6	19.8	18.9	20.4	20.4	21.9	20.8
Province of Ontario	0.2	0.1	0.0	0.0	0.4	0.1	0.4	0.3	0.3	0.1	0.2
Province of Quebec	0.2	0.3	0.1	0.1	0.0	0.2	0.1	0.1	0.1	0.0	0.1
Vermont	2.1	2.6	3.0	2.4	2.8	2.0	2.8	2.3	2.1	2.5	2.2
Virginia	0.2	0.3	0.3	0.2	0.2	0.3	0.2	0.2	0.2	0.1	0.3
West Virginia	0.4	0.3	0.3	0.3	0.3	0.7	0.4	0.3	0.4	0.5	0.4
Total of all Listed States & Provinces:	99.0	99.0	98.7	98.3	98.7	98.5	98.7	98.4	98.4	98.9	98.5
County of Residence Among NY Anglers - Percent Frequency											
County Bordering Lake Ontario:											
Cayuga	2.3	2.6	2.7	3.7	2.9	4.2	3.0	3.3	2.6	2.2	2.2
Jefferson	2.6	1.2	2.4	2.0	2.3	2.4	2.2	1.6	1.5	3.2	3.6
Monroe	24.9	23.4	23.2	20.0	21.9	18.8	20.0	18.7	16.5	16.2	16.5
Niagara	8.8	6.9	9.0	7.9	9.5	6.6	7.3	7.8	10.9	9.4	9.7
Orleans	3.7	4.0	4.0	3.1	2.9	4.0	3.8	4.9	4.2	4.1	4.8
Oswego	10.3	12.0	11.0	13.5	11.3	12.8	13.0	13.1	13.6	12.5	12.8
Wayne	10.6	14.8	11.5	12.4	11.4	11.5	9.5	9.5	9.6	10.3	8.7
Border Co. Total	63.1	64.9	63.9	62.7	62.3	60.4	58.8	58.8	59.0	57.9	58.4
Other NY Counties:											
Albany	1.3	1.4	1.1	1.5	2.0	1.2	1.0	1.1	1.0	1.0	0.8
Broome	1.9	1.8	1.9	2.0	1.6	1.4	2.1	2.5	1.9	1.8	1.5
Dutchess	1.0	1.0	1.3	1.2	0.7	0.5	0.6	0.6	0.3	0.3	0.7
Erie	4.4	2.8	3.5	3.7	4.1	3.4	3.4	3.8	5.8	5.2	4.9
Genesee	1.5	1.2	1.7	1.4	1.1	1.2	1.9	2.1	1.6	2.5	1.8
Livingston	0.8	0.7	0.7	0.7	0.7	0.8	0.7	0.6	0.6	1.0	0.7
Oneida	2.1	1.5	1.0	2.1	1.9	1.9	1.8	1.8	2.1	1.4	2.0
Onondaga	5.7	6.4	5.7	5.5	5.6	6.9	5.4	6.0	6.4	6.4	5.7
Ontario	1.5	1.3	1.6	1.6	1.5	1.1	1.5	1.7	1.6	1.7	2.0
Orange	0.8	1.5	0.8	1.2	1.1	1.7	1.3	1.2	0.5	0.8	0.9
Saratoga	1.0	0.8	0.7	0.7	0.7	0.6	1.0	0.8	0.7	0.6	0.9
Total of all Listed Counties:	85.2	85.4	83.9	84.3	83.1	81.1	79.5	80.9	81.5	80.7	80.3

Table A5a. Trout and salmon catch and harvest data collected April 15 – September 30, 1985-2013.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	159,022	85,471	106,900	76,075	111,200	78,060	120,477	89,092	110,196	107,456	100,047
Catch	247,807	151,737	167,707	120,785	189,916	125,686	223,316	167,405	221,977	196,625	168,837
% Harvested	63.6	56.3	63.7	63.0	58.6	62.1	53.9	53.2	49.6	54.7	59.3
Monthly estimates of harvest for all fishing boats:											
April	18,686	1,410	4,940	5,720	8,197	2,432	6,635	5,939	5,050	10,045	4,580
May	33,884	17,806	27,268	16,436	22,638	12,493	29,432	11,638	16,139	16,015	22,142
June	17,998	7,071	7,949	2,919	12,419	6,896	5,050	8,025	10,387	10,135	11,467
July	24,898	15,217	16,650	14,072	22,507	12,851	24,171	21,904	36,207	22,706	21,311
August	43,816	31,468	28,142	24,148	30,604	28,919	32,685	34,636	29,189	34,770	33,670
September	19,740	12,500	21,949	12,781	14,835	14,471	22,504	6,950	13,225	13,785	6,878
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	53,127	25,593	33,572	24,718	39,131	32,750	49,310	37,266	33,864	32,631	34,524
West/Central	17,807	7,880	10,214	8,650	9,618	2,901	8,174	6,523	8,356	9,216	11,694
East/Central	47,653	29,052	28,760	30,505	37,160	20,158	40,795	29,674	39,819	31,076	34,445
East	40,436	22,945	34,353	12,200	25,291	22,250	22,197	15,629	28,157	34,535	19,382
Monthly estimates of catch for all fishing boats:											
April	28,959	5,081	7,325	9,360	14,246	3,709	11,261	8,804	12,236	19,347	7,328
May	52,491	33,809	46,320	28,660	51,039	24,727	76,635	20,573	35,558	37,204	36,786
June	32,006	12,298	19,353	5,366	20,947	12,552	11,836	18,745	22,222	24,230	20,076
July	45,094	27,887	26,838	22,868	36,489	23,301	35,487	46,270	82,252	42,491	41,130
August	64,094	54,872	41,412	37,709	47,626	41,721	55,836	62,916	50,484	55,996	53,802
September	25,163	17,790	26,458	16,823	19,567	19,676	32,261	10,096	19,225	17,357	9,715
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	87,386	53,922	62,223	46,148	77,192	57,467	103,965	72,072	93,566	73,727	67,993
West/Central	33,876	18,923	23,987	17,028	20,602	7,754	30,121	22,128	22,100	26,231	26,378
East/Central	68,675	47,343	38,344	42,280	57,450	31,072	62,190	51,736	67,426	49,058	49,025
East	57,869	31,550	43,150	15,328	34,674	29,398	27,040	21,471	38,885	47,609	25,440
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.4	99.8	99.9	99.2	99.6	99.8	99.9	99.8	99.9	100.0	100.0
% Catch	99.3	99.8	99.8	99.2	99.7	99.6	99.8	99.6	99.8	99.7	99.9
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	46.0	53.4	50.5	61.0	47.9	53.7	50.5	50.3	47.3	47.5	59.4
% Catch	38.6	40.5	39.7	46.2	37.5	42.6	35.5	39.9	34.8	33.3	46.0

Table A5b. Trout and salmon catch and harvest rate data collected April 15 – September 30, 1985-2013. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	1.460	1.486	1.858	1.578	1.922	1.520	1.940	1.776	2.222	2.332	2.104
Catch/Boat Trip	2.303	2.637	2.910	2.506	3.286	2.444	3.593	3.329	4.473	4.258	3.549
Harv/Angler Trip	0.505	0.516	0.632	0.530	0.644	0.509	0.634	0.586	0.745	0.774	0.681
Catch/Angler Trip	0.796	0.916	0.990	0.842	1.101	0.819	1.174	1.098	1.500	1.414	1.148
Harv/Angler Hour	0.086	0.095	0.115	0.094	0.114	0.090	0.105	0.105	0.132	0.137	0.112
Catch/Angler Hr.	0.136	0.168	0.180	0.149	0.195	0.144	0.195	0.198	0.266	0.250	0.190
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	1.820	0.440	2.061	1.421	2.734	0.847	1.838	2.275	2.006	4.246	1.779
May	1.661	2.010	2.105	2.001	2.056	1.720	1.998	1.238	2.005	1.909	2.799
June	1.603	1.478	1.482	1.035	2.083	1.418	0.949	2.052	2.396	1.973	1.811
July	1.623	2.120	1.529	1.704	2.195	1.386	2.765	2.363	3.321	2.448	2.203
August	1.497	1.640	1.997	1.666	1.828	1.752	2.150	1.971	2.065	2.693	2.116
September	0.915	0.876	1.852	1.236	1.366	1.367	1.546	1.006	1.372	1.723	1.338
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	1.927	2.294	2.336	2.242	2.428	2.630	2.657	2.614	2.300	2.575	2.523
West/Central	1.183	1.347	1.431	1.267	1.377	0.676	1.059	1.170	1.656	1.650	1.763
East/Central	1.500	1.628	1.650	1.787	2.233	1.171	2.128	1.765	2.631	2.282	2.256
East	1.184	1.013	1.847	0.919	1.397	1.277	1.331	1.154	1.919	2.431	1.621
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	3.045	1.586	3.056	2.326	4.752	1.291	3.119	3.373	4.859	8.177	2.837
May	2.611	3.824	3.577	3.498	4.636	3.397	5.201	2.188	4.400	4.435	4.650
June	2.837	2.556	3.581	1.930	3.527	2.568	2.227	4.809	5.117	4.644	3.166
July	2.915	3.888	2.456	2.769	3.564	2.511	4.059	4.948	7.544	4.581	4.252
August	2.212	2.858	2.939	2.600	2.845	2.528	3.668	3.480	3.569	4.335	3.382
September	1.203	1.244	2.232	1.621	1.800	1.859	2.210	1.464	1.994	2.169	1.885
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	3.207	4.830	4.321	4.163	4.789	4.617	5.601	5.055	6.344	5.818	4.967
West/Central	2.485	3.227	3.339	2.485	2.950	1.800	3.898	3.969	4.379	4.697	3.976
East/Central	2.179	2.652	2.200	2.486	3.456	1.801	3.227	3.051	4.448	3.587	3.208
East	1.683	1.393	2.322	1.155	1.918	1.682	1.624	1.586	2.650	3.337	2.126
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	4.847	4.835	5.970	5.239	5.816	4.800	6.170	5.245	6.319	6.690	6.417
Catch/Boat Trip	6.347	6.508	7.365	6.297	7.787	6.136	8.044	7.826	9.359	8.583	8.385
Harv/Angler Trip	0.973	0.968	1.170	1.037	1.131	0.921	1.216	1.006	1.211	1.313	1.233
Catch/Angler Trip	1.271	1.302	1.443	1.247	1.514	1.177	1.585	1.500	1.794	1.685	1.611
Harv/Angler Hour	0.132	0.144	0.176	0.153	0.161	0.134	0.175	0.156	0.190	0.198	0.178
Catch/Angler Hr.	0.173	0.193	0.217	0.184	0.216	0.172	0.229	0.233	0.282	0.254	0.232
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.917	0.827	1.091	0.746	1.187	0.846	1.140	1.062	1.404	1.466	1.060
Catch/Boat Trip	1.642	1.876	2.080	1.644	2.436	1.686	2.750	2.404	3.497	3.399	2.378
Harv/Angler Trip	0.359	0.336	0.430	0.298	0.461	0.335	0.426	0.411	0.554	0.565	0.411
Catch/Angler Trip	0.644	0.762	0.820	0.657	0.945	0.667	1.027	0.931	1.379	1.309	0.922
Harv/Angler Hour	0.067	0.068	0.085	0.058	0.090	0.065	0.075	0.079	0.104	0.107	0.073
Catch/Angler Hr.	0.119	0.154	0.162	0.127	0.185	0.129	0.180	0.179	0.259	0.247	0.164

Table A6. Parameters used to assess angling quality among boats interviewed April 15 – September 30, 1985-2013. Parameters are given separately for boats seeking any or all species of trout and salmon, and for boats seeking smallmouth bass during the traditional open season (begins 3rd Saturday in June). Changes in daily bag limits and size limits for trout and salmon invalidate comparisons of boats harvesting daily bag limits over the entire 29-year data series; therefore, data on bag limits are presented only for 2003-2013.

	Year Surveyed										
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Part A: Boats seeking any or all species of trout and salmon.											
Percent boats with zero harvest of:											
Any Trout or Salmon	54.6%	52.3%	48.1%	57.4%	49.1%	55.6%	51.1%	51.6%	45.3%	44.9%	50.5%
Any Fish Species	54.3%	52.2%	47.9%	57.2%	48.9%	55.3%	50.8%	51.5%	45.2%	44.8%	50.3%
Percent boats with zero catch of:											
Any Trout or Salmon	35.0%	37.3%	32.6%	41.6%	31.5%	41.1%	32.4%	35.1%	26.7%	24.3%	31.4%
Any Fish Species	33.1%	35.1%	30.2%	40.2%	30.8%	39.6%	31.9%	34.5%	26.1%	23.8%	30.5%
Percent boats harvesting the daily bag limit - 3 lake trout per angler in 1998-2006, 2 lake trout per angler in 2007-present:											
Charters-Party Only	0.6%	0.0%	0.3%	0.9%	1.1%	2.1%	3.1%	1.2%	2.6%	5.3%	11.8%
Charters-All Anglers	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	1.9%	0.6%	0.0%	2.0%	1.9%
Noncharter Boats	0.1%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.5%	0.0%	0.4%
Percent boats harvesting the daily bag limit of 3 coho salmon, Chinook salmon, rainbow trout, or brown trout, in aggregate, per angler:											
Charters-Party Only	16.5%	16.0%	22.8%	16.1%	21.8%	12.1%	24.2%	19.5%	21.4%	22.1%	14.3%
Charters-All Anglers	3.3%	3.4%	3.5%	1.9%	3.6%	1.9%	3.1%	4.3%	2.8%	4.6%	3.0%
Noncharter Boats	1.7%	1.5%	2.0%	0.5%	2.7%	0.9%	1.4%	1.9%	3.0%	3.7%	1.3%
Part B: Boats seeking smallmouth bass during the traditional open season.											
Percent boats with zero harvest of:											
Smallmouth Bass	66.5%	71.6%	72.1%	77.2%	77.2%	82.1%	84.7%	79.0%	82.7%	79.7%	76.5%
Any Fish Species	64.0%	68.2%	66.6%	67.8%	59.6%	65.6%	71.2%	65.0%	72.3%	63.9%	67.4%
Percent boats with zero catch of:											
Smallmouth Bass	15.1%	30.8%	29.0%	42.8%	43.1%	50.3%	53.6%	56.2%	58.8%	53.6%	45.8%
Any Fish Species	14.2%	27.5%	24.8%	28.2%	22.4%	27.7%	36.5%	37.6%	35.1%	34.6%	31.4%
Percent boats harvesting the daily bag limit of 5 smallmouth bass per angler:											
All Boats Combined	9.6%	6.8%	3.4%	3.7%	2.8%	1.0%	0.3%	1.2%	2.6%	0.6%	2.5%

Table A7a. Coho salmon harvest and catch data collected April 15 – September 30, 1985-2013.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	10,398	3,376	5,487	9,255	14,541	4,912	12,931	9,223	7,380	8,259	4,871
Catch	13,521	4,935	8,849	12,198	25,510	6,666	21,376	12,908	11,915	12,494	7,704
% Harvested	76.9	68.4	62.0	75.9	57.0	73.7	60.5	71.5	61.9	66.1	63.2
Monthly estimates of harvest for all fishing boats:											
April	2,965	128	673	1,634	1,604	618	1,446	1,178	968	392	266
May	2,072	493	1,820	4,759	6,168	1,176	3,087	1,353	946	1,787	1,646
June	574	50	357	178	2,515	33	441	918	653	163	454
July	437	135	36	214	265	143	476	1,864	2,362	503	235
August	2,482	2,114	439	1,644	2,367	513	1,816	2,860	853	3,437	1,170
September	1,868	456	2,163	824	1,622	2,429	5,666	1,049	1,599	1,978	1,100
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	4,512	1,142	1,816	3,110	9,014	1,310	5,692	5,269	3,635	3,001	2,365
West/Central	1,875	65	565	681	910	111	566	772	765	411	201
East/Central	2,485	709	1,097	3,831	2,702	1,251	2,727	1,537	1,546	1,968	1,594
East	1,524	1,459	2,009	1,633	1,915	2,240	3,945	1,645	1,434	2,880	711
Monthly estimates of catch for all fishing boats:											
April	4,095	155	875	2,269	2,352	976	2,183	1,543	2,324	686	332
May	2,899	932	3,025	6,022	13,798	2,107	9,559	2,164	1,926	4,047	3,145
June	858	50	1,788	698	3,799	255	685	1,542	1,277	734	986
July	661	207	301	263	386	242	686	2,734	3,357	830	627
August	2,875	2,957	591	1,881	3,313	513	2,096	3,652	1,190	3,888	1,434
September	2,134	634	2,268	1,064	1,863	2,573	6,167	1,272	1,840	2,308	1,179
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	6,074	2,273	4,368	5,062	17,668	2,517	12,152	7,285	6,476	5,875	4,642
West/Central	2,878	208	924	876	1,383	304	1,354	1,636	1,837	1,072	592
East/Central	2,915	928	1,495	4,501	3,960	1,506	3,388	2,050	1,922	2,350	1,728
East	1,655	1,526	2,061	1,759	2,499	2,340	4,482	1,937	1,679	3,197	742
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.5	100.0	100.0	94.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% Catch	99.4	100.0	100.0	95.8	100.0	100.0	100.0	100.0	99.5	100.0	100.0
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	40.5	38.8	44.8	56.3	44.8	51.4	39.8	56.9	42.1	40.6	45.6
% Catch	33.8	28.3	36.8	49.4	37.9	40.6	26.2	44.2	28.2	28.5	31.5

Table A7b. Coho salmon harvest and catch rate data collected April 15 – September 30, 1985-2013. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.099	0.059	0.095	0.183	0.252	0.096	0.208	0.184	0.149	0.179	0.103
Catch/Boat Trip	0.127	0.086	0.154	0.244	0.443	0.130	0.345	0.258	0.239	0.271	0.162
Harv/Angler Trip	0.034	0.020	0.032	0.061	0.085	0.032	0.068	0.061	0.050	0.060	0.033
Catch/Angler Trip	0.044	0.030	0.052	0.082	0.148	0.044	0.113	0.085	0.080	0.090	0.052
Harv/Angler Hour	0.006	0.004	0.006	0.011	0.015	0.006	0.011	0.011	0.009	0.011	0.005
Catch/Angler Hr.	0.008	0.005	0.010	0.014	0.026	0.008	0.019	0.015	0.014	0.016	0.009
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.287	0.040	0.281	0.406	0.535	0.215	0.401	0.451	0.384	0.166	0.103
May	0.111	0.056	0.141	0.533	0.560	0.162	0.210	0.144	0.118	0.213	0.208
June	0.055	0.010	0.067	0.065	0.429	0.007	0.085	0.237	0.151	0.032	0.072
July	0.033	0.019	0.003	0.026	0.026	0.015	0.054	0.202	0.217	0.054	0.024
August	0.089	0.110	0.031	0.113	0.142	0.031	0.120	0.158	0.060	0.266	0.074
September	0.084	0.032	0.182	0.080	0.149	0.229	0.389	0.153	0.166	0.247	0.214
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.162	0.102	0.126	0.283	0.559	0.105	0.307	0.370	0.247	0.237	0.173
West/Central	0.111	0.011	0.079	0.100	0.131	0.026	0.073	0.139	0.152	0.074	0.030
East/Central	0.086	0.040	0.063	0.196	0.164	0.073	0.142	0.092	0.102	0.145	0.104
East	0.050	0.064	0.108	0.124	0.106	0.129	0.238	0.122	0.098	0.203	0.059
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.387	0.048	0.365	0.564	0.784	0.340	0.605	0.591	0.923	0.290	0.129
May	0.156	0.106	0.234	0.692	1.253	0.290	0.649	0.230	0.232	0.482	0.398
June	0.082	0.010	0.333	0.255	0.648	0.054	0.132	0.398	0.296	0.143	0.156
July	0.048	0.029	0.028	0.032	0.038	0.026	0.078	0.296	0.308	0.090	0.065
August	0.103	0.154	0.042	0.130	0.199	0.031	0.138	0.202	0.084	0.301	0.090
September	0.099	0.044	0.191	0.103	0.171	0.243	0.424	0.185	0.191	0.288	0.229
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.219	0.204	0.304	0.460	1.096	0.202	0.655	0.511	0.436	0.464	0.339
West/Central	0.177	0.036	0.129	0.129	0.199	0.071	0.175	0.294	0.364	0.192	0.089
East/Central	0.101	0.052	0.086	0.236	0.240	0.088	0.177	0.122	0.127	0.173	0.113
East	0.054	0.067	0.111	0.134	0.139	0.134	0.271	0.144	0.115	0.225	0.062
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.287	0.139	0.272	0.588	0.712	0.289	0.522	0.614	0.377	0.440	0.240
Catch/Boat Trip	0.309	0.148	0.361	0.680	1.056	0.310	0.569	0.668	0.407	0.467	0.261
Harv/Angler Trip	0.058	0.028	0.053	0.116	0.138	0.056	0.103	0.118	0.072	0.086	0.046
Catch/Angler Trip	0.062	0.030	0.071	0.135	0.205	0.059	0.112	0.128	0.078	0.092	0.050
Harv/Angler Hour	0.008	0.004	0.008	0.017	0.020	0.008	0.015	0.018	0.011	0.013	0.007
Catch/Angler Hr.	0.008	0.004	0.011	0.020	0.029	0.009	0.016	0.020	0.012	0.014	0.007
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.067	0.043	0.063	0.091	0.166	0.056	0.149	0.096	0.103	0.128	0.069
Catch/Boat Trip	0.097	0.074	0.115	0.145	0.327	0.093	0.302	0.174	0.206	0.232	0.138
Harv/Angler Trip	0.026	0.018	0.025	0.036	0.064	0.022	0.056	0.037	0.041	0.049	0.027
Catch/Angler Trip	0.038	0.030	0.045	0.058	0.127	0.037	0.113	0.067	0.081	0.089	0.054
Harv/Angler Hour	0.005	0.004	0.005	0.007	0.013	0.004	0.010	0.007	0.008	0.009	0.005
Catch/Angler Hr.	0.007	0.006	0.009	0.011	0.025	0.007	0.020	0.013	0.015	0.017	0.010

Table A8. Total length (inches), weight (lbs), and age statistics for coho salmon sampled April 15 - September 30 during the 1985-2013 NYSDEC Lake Ontario fishing boat surveys.

	Year Sampled										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Mean length and weight data for coho salmon sampled April 15 - September 30:											
Mean Length (in)	23.9	24.5	24.7	24.6	24.6	25.5	23.9	25.1	24.0	26.1	25.0
Mean Weight (lbs)	-	7.1	6.9	6.5	6.6	8.1	6.3	7.2	6.3	8.3	6.7
Estimated weight (lbs) for standard length coho salmon sampled April 15 - September 30:											
Standard Length											
18.0 inches	-	2.01	1.74	1.90	1.80	1.97	1.90	1.84	1.87	2.01	1.97
20.0 inches	-	2.96	2.63	2.81	2.67	2.92	2.82	2.75	2.79	2.92	2.84
22.0 inches	-	4.19	3.82	3.99	3.83	4.16	4.04	3.96	4.01	4.11	3.95
24.0 inches	-	5.77	5.36	5.50	5.32	5.75	5.61	5.52	5.57	5.60	5.35
26.0 inches	-	7.73	7.33	7.40	7.19	7.75	7.59	7.50	7.54	7.45	7.07
28.0 inches	-	10.08	9.74	9.67	9.46	10.15	9.98	9.90	9.92	9.66	9.10
30.0 inches	-	13.03	12.83	12.54	12.33	13.18	13.00	12.96	12.95	12.41	11.61
Percent length composition of coho salmon sampled April 15 - September 30:											
<15.0 in	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
15.0-15.9 in	0.8%	1.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
16.0-16.9 in	0.5%	2.9%	0.0%	0.0%	0.0%	0.9%	0.7%	0.0%	0.0%	0.0%	0.0%
17.0-17.9 in	2.3%	2.9%	0.0%	0.0%	1.5%	1.8%	4.3%	0.0%	1.4%	0.0%	0.0%
18.0-18.9 in	3.5%	7.4%	0.9%	0.0%	2.5%	6.4%	6.1%	0.5%	7.7%	0.8%	2.4%
19.0-19.9 in	6.6%	2.9%	6.6%	0.9%	6.5%	10.1%	7.6%	3.3%	6.3%	3.1%	4.9%
20.0-20.9 in	10.0%	10.3%	13.2%	6.6%	8.5%	2.8%	7.2%	1.9%	10.6%	7.7%	4.9%
21.0-21.9 in	12.5%	2.9%	12.3%	11.9%	15.9%	0.9%	10.1%	12.2%	9.6%	7.7%	8.5%
22.0-22.9 in	10.2%	4.4%	11.3%	17.7%	9.0%	1.8%	10.4%	7.5%	5.3%	7.7%	13.4%
23.0-23.9 in	8.4%	2.9%	7.5%	15.0%	5.0%	3.7%	2.2%	9.9%	6.7%	4.6%	8.5%
24.0-24.9 in	6.4%	7.4%	5.7%	9.7%	3.0%	3.7%	4.0%	15.0%	9.6%	3.8%	9.8%
25.0-25.9 in	5.9%	8.8%	1.9%	6.6%	1.0%	5.5%	6.8%	11.7%	11.1%	5.4%	8.5%
26.0-26.9 in	6.2%	11.8%	0.0%	4.4%	8.0%	15.6%	11.2%	9.9%	5.8%	6.2%	6.1%
27.0-27.9 in	6.8%	16.2%	9.4%	8.4%	11.9%	15.6%	15.5%	8.5%	8.7%	14.6%	11.0%
28.0-28.9 in	7.1%	4.4%	13.2%	8.0%	13.4%	17.4%	9.4%	5.6%	9.1%	16.9%	4.9%
29.0-29.9 in	5.2%	8.8%	9.4%	7.5%	7.5%	8.3%	3.6%	7.5%	4.8%	9.2%	11.0%
30.0-30.9 in	4.0%	1.5%	5.7%	1.3%	6.0%	2.8%	0.7%	3.8%	2.4%	8.5%	1.2%
31.0-31.9 in	1.8%	0.0%	2.8%	1.8%	0.5%	0.0%	0.0%	1.4%	0.5%	3.1%	2.4%
32.0-32.9 in	0.9%	1.5%	0.0%	0.0%	0.0%	1.8%	0.0%	1.4%	0.0%	0.0%	2.4%
>32.9 in	0.3%	1.5%	0.0%	0.0%	0.0%	0.9%	0.4%	0.0%	0.5%	0.8%	0.0%
Percent age composition of coho salmon sampled April 15 - September 30:											
Age-1	4.6%	9.2%	1.0%	2.6%	1.6%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%
Age-2	94.7%	87.0%	97.9%	97.4%	93.8%	93.3%	99.6%	99.9%	99.3%	98.0%	100.0%
Age-3	0.7%	3.8%	1.1%	0.0%	4.6%	6.7%	0.0%	0.1%	0.7%	2.0%	0.0%
Length data (inches) for age-2 coho salmon sampled April 15 - September 30:											
April Mean	20.6	19.0	20.7	21.3	20.6	18.7	18.5	21.4	19.4	21.0	20.5
September Mean	28.1	26.8	28.6	28.6	28.2	27.4	27.2	29.3	28.2	28.2	28.1
Avg Monthly Gain	1.6	1.8	1.7	1.6	1.7	1.9	2.0	1.7	1.9	1.6	1.7

Table A9a. Chinook salmon harvest and catch data collected April 15 – September 30, 1985-2013.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	53,168	51,443	68,957	39,439	53,336	35,520	54,964	31,676	46,333	55,137	38,292
Catch	72,769	92,042	102,792	59,606	84,842	55,776	101,427	61,960	97,899	88,851	62,570
% Harvested	72.7	55.9	67.1	66.2	62.9	63.7	54.2	51.1	47.3	62.1	61.2
Monthly estimates of harvest for all fishing boats:											
April	2,044	176	80	381	15	117	200	156	86	2,180	115
May	7,190	8,471	14,209	4,513	4,422	4,385	12,978	3,932	1,594	5,358	4,102
June	2,377	1,314	1,747	586	3,584	1,334	887	3,804	2,166	4,858	2,277
July	6,559	9,540	11,931	8,241	13,883	5,293	16,984	5,282	17,509	11,004	8,560
August	21,604	21,472	22,685	18,228	20,112	16,195	13,086	13,909	16,885	21,746	20,670
September	13,394	10,470	18,304	7,489	11,320	8,195	10,829	4,592	8,093	9,991	2,568
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	22,895	16,461	24,747	14,083	17,947	14,790	23,605	10,927	14,042	17,459	17,417
West/Central	5,881	3,032	5,601	3,643	4,072	880	2,957	1,750	2,047	3,277	2,223
East/Central	11,606	14,336	16,211	15,177	16,863	11,126	18,057	12,160	17,550	16,097	13,258
East	12,785	17,614	22,398	6,535	14,454	8,724	10,345	6,839	12,694	18,305	5,394
Monthly estimates of catch for all fishing boats:											
April	2,890	491	195	591	45	117	448	156	267	3,781	164
May	11,130	16,846	23,378	10,597	11,611	9,057	40,831	5,866	4,511	11,827	6,948
June	5,232	3,622	7,880	1,425	7,531	2,999	3,537	10,250	8,483	10,058	5,200
July	10,140	19,234	17,884	12,689	20,033	9,946	23,944	16,280	42,582	19,848	15,682
August	27,525	37,862	31,298	25,089	31,108	21,965	19,623	23,084	31,239	31,097	30,649
September	15,851	13,987	22,157	9,216	14,514	11,692	13,043	6,307	10,817	12,239	3,926
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	35,268	34,419	41,953	26,022	35,059	26,841	53,358	23,577	43,599	34,937	32,474
West/Central	9,461	9,133	13,027	6,333	8,209	2,810	9,887	9,774	7,038	9,223	6,622
East/Central	14,187	23,783	21,049	19,532	22,138	14,994	26,077	20,061	30,606	22,321	16,963
East	13,852	24,707	26,763	7,719	19,436	11,132	12,105	8,548	16,657	22,370	6,511
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.8	100.0	99.9	100.0	99.9	100.0	100.0	100.0	100.0	100.0	100.0
% Catch	99.8	100.0	99.8	99.9	99.9	100.0	100.0	100.0	99.9	100.0	100.0
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	39.8	48.2	49.9	53.9	46.1	52.8	41.6	42.8	40.2	42.7	47.1
% Catch	35.3	38.3	40.7	39.3	36.0	43.0	27.8	35.8	32.3	32.3	38.3

Table A9b. Chinook salmon harvest and catch rate data collected April 15 – September 30, 1985-2013. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.484	0.896	1.198	0.825	0.925	0.693	0.886	0.633	0.935	1.197	0.806
Catch/Boat Trip	0.680	1.603	1.784	1.246	1.472	1.089	1.635	1.238	1.975	1.928	1.316
Harv/Angler Trip	0.167	0.311	0.407	0.277	0.310	0.232	0.290	0.209	0.314	0.398	0.261
Catch/Angler Trip	0.235	0.557	0.607	0.419	0.493	0.365	0.534	0.408	0.662	0.640	0.426
Harv/Angler Hour	0.029	0.057	0.074	0.049	0.055	0.041	0.048	0.038	0.056	0.070	0.043
Catch/Angler Hr.	0.040	0.102	0.111	0.074	0.088	0.064	0.089	0.073	0.118	0.113	0.070
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.125	0.055	0.033	0.095	0.005	0.041	0.055	0.060	0.034	0.921	0.045
May	0.323	0.959	1.098	0.567	0.402	0.604	0.881	0.418	0.198	0.639	0.519
June	0.197	0.275	0.326	0.214	0.611	0.280	0.171	0.981	0.502	0.946	0.360
July	0.434	1.334	1.095	0.998	1.359	0.572	1.943	0.572	1.606	1.189	0.886
August	0.731	1.119	1.610	1.257	1.204	0.982	0.860	0.769	1.196	1.684	1.299
September	0.604	0.734	1.544	0.724	1.042	0.774	0.744	0.670	0.839	1.249	0.500
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.756	1.476	1.723	1.277	1.113	1.189	1.272	0.766	0.954	1.378	1.274
West/Central	0.330	0.518	0.784	0.534	0.580	0.205	0.383	0.314	0.406	0.587	0.335
East/Central	0.368	0.807	0.930	0.905	1.022	0.651	0.941	0.726	1.159	1.184	0.868
East	0.411	0.778	1.204	0.496	0.802	0.501	0.624	0.507	0.867	1.288	0.451
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.189	0.153	0.081	0.147	0.015	0.041	0.124	0.060	0.106	1.598	0.064
May	0.498	1.910	1.806	1.331	1.055	1.247	2.772	0.624	0.560	1.410	0.878
June	0.430	0.757	1.445	0.521	1.285	0.630	0.680	2.643	1.967	1.958	0.821
July	0.719	2.689	1.643	1.536	1.962	1.074	2.739	1.763	3.906	2.145	1.624
August	0.956	1.974	2.221	1.731	1.864	1.332	1.291	1.278	2.208	2.407	1.926
September	0.740	0.981	1.869	0.888	1.334	1.104	0.896	0.920	1.122	1.529	0.764
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	1.222	3.086	2.911	2.359	2.175	2.158	2.875	1.654	2.959	2.757	2.375
West/Central	0.577	1.561	1.825	0.928	1.172	0.655	1.280	1.753	1.394	1.652	0.998
East/Central	0.465	1.339	1.207	1.163	1.341	0.877	1.359	1.198	2.022	1.640	1.111
East	0.452	1.091	1.439	0.585	1.078	0.640	0.731	0.634	1.137	1.575	0.545
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	1.403	2.629	3.808	2.403	2.685	2.148	2.319	1.588	2.260	3.087	1.946
Catch/Boat Trip	1.723	3.733	4.628	2.645	3.335	2.749	2.859	2.596	3.838	3.765	2.588
Harv/Angler Trip	0.280	0.526	0.746	0.476	0.522	0.412	0.457	0.304	0.433	0.606	0.374
Catch/Angler Trip	0.345	0.747	0.907	0.524	0.649	0.527	0.563	0.498	0.736	0.739	0.497
Harv/Angler Hour	0.038	0.078	0.112	0.070	0.074	0.060	0.066	0.047	0.068	0.092	0.054
Catch/Angler Hr.	0.047	0.111	0.137	0.077	0.092	0.077	0.081	0.077	0.116	0.112	0.072
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.339	0.555	0.712	0.466	0.593	0.395	0.615	0.436	0.670	0.822	0.529
Catch/Boat Trip	0.513	1.184	1.254	0.928	1.120	0.748	1.403	0.958	1.603	1.564	1.009
Harv/Angler Trip	0.133	0.225	0.281	0.186	0.230	0.156	0.230	0.169	0.264	0.316	0.205
Catch/Angler Trip	0.202	0.481	0.494	0.371	0.434	0.296	0.524	0.371	0.632	0.602	0.391
Harv/Angler Hour	0.025	0.045	0.055	0.036	0.045	0.030	0.040	0.033	0.050	0.060	0.036
Catch/Angler Hr.	0.038	0.097	0.098	0.072	0.085	0.057	0.092	0.072	0.119	0.114	0.070

Table A10. Total length (inches), weight (lbs), and age statistics for Chinook salmon sampled April 15 - September 30 during the 1985-2013 NYSDEC Lake Ontario fishing boat surveys.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Mean length and weight data for chinook salmon sampled April 15 - September 30:											
Mean Length (in)	32.0	30.3	32.4	32.9	32.6	32.1	31.6	29.7	29.6	31.4	32.6
Mean Weight (lbs)	-	12.8	15.3	15.9	14.5	15.4	14.5	13.4	12.8	14.1	15.6
Estimated weight (lbs) for standard length chinook salmon sampled July & August:											
Standard Length:											
16.0 inches	-	1.39	1.37	1.42	1.37	1.47	1.31	1.47	1.36	1.34	1.47
20.0 inches	-	2.90	2.85	2.90	2.81	3.01	2.77	3.04	2.89	2.82	2.98
24.0 inches	-	5.33	5.22	5.24	5.07	5.47	5.15	5.55	5.39	5.23	5.34
28.0 inches	-	8.87	8.66	8.59	8.33	9.00	8.65	9.18	9.09	8.76	8.72
32.0 inches	-	13.86	13.48	13.25	12.84	13.92	13.62	14.27	14.35	13.77	13.38
36.0 inches	-	20.52	19.93	19.40	18.82	20.44	20.32	21.04	21.46	20.50	19.52
40.0 inches	-	29.06	28.17	27.21	26.40	28.74	28.97	29.69	30.64	29.17	27.27
Percent length composition of chinook salmon sampled April 15 - September 30:											
<16.0 in	1.4%	0.7%	0.4%	0.1%	0.6%	0.3%	0.3%	0.2%	0.9%	0.5%	0.5%
16.0-17.9 in	3.0%	1.8%	1.3%	0.7%	0.3%	1.2%	1.3%	2.4%	3.5%	0.8%	1.7%
18.0-19.9 in	3.5%	2.7%	2.1%	3.4%	0.8%	1.9%	3.1%	9.1%	7.8%	1.6%	2.8%
20.0-21.9 in	3.3%	3.4%	0.6%	3.7%	0.8%	1.9%	2.1%	8.9%	5.7%	3.5%	2.8%
22.0-23.9 in	3.5%	3.9%	2.2%	3.4%	1.7%	3.6%	3.0%	8.7%	3.9%	3.0%	2.8%
24.0-25.9 in	4.4%	6.1%	4.5%	3.2%	3.8%	6.3%	5.6%	5.5%	4.3%	5.3%	2.6%
26.0-27.9 in	6.1%	10.8%	6.7%	4.8%	6.0%	7.0%	6.4%	5.9%	5.8%	6.8%	4.9%
28.0-29.9 in	6.9%	14.0%	6.2%	7.2%	8.6%	6.4%	7.9%	5.7%	6.7%	12.8%	9.2%
30.0-31.9 in	7.6%	15.8%	10.7%	7.3%	15.2%	12.1%	12.6%	6.3%	13.7%	14.0%	9.9%
32.0-33.9 in	10.6%	13.3%	17.6%	9.9%	17.5%	12.6%	17.5%	10.2%	21.2%	17.7%	14.4%
34.0-35.9 in	13.8%	12.0%	22.0%	16.6%	22.1%	17.1%	19.9%	12.9%	16.2%	15.9%	15.5%
36.0-37.9 in	17.7%	11.2%	19.4%	23.1%	15.7%	17.1%	14.7%	12.6%	7.5%	9.6%	16.2%
38.0-39.9 in	12.6%	4.1%	5.5%	12.4%	6.1%	11.1%	4.7%	7.0%	1.9%	6.1%	12.3%
40.0-41.9 in	4.7%	0.3%	0.8%	4.1%	0.7%	1.3%	0.8%	4.3%	0.8%	2.2%	3.8%
42.0-43.9 in	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.4%	0.0%	0.1%	0.5%
>43.9 in	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Percent age composition of chinook salmon sampled April 15 - September 30:											
Age-0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Age-1	12.3%	6.7%	3.5%	9.0%	3.2%	3.1%	4.8%	33.7%	22.2%	5.0%	10.7%
Age-2	34.6%	57.1%	31.6%	28.9%	46.4%	47.9%	29.5%	24.9%	68.9%	70.8%	37.0%
Age-3	49.1%	35.4%	64.1%	57.8%	47.7%	46.6%	64.8%	38.6%	8.6%	24.1%	52.0%
Age-4	4.0%	0.7%	0.7%	4.3%	2.7%	2.3%	0.9%	2.8%	0.2%	0.2%	0.3%
Age-3&4 combined	53.1%	36.1%	64.9%	62.1%	50.4%	49.0%	65.7%	41.4%	8.8%	24.2%	52.3%

Table A11. Mean length at age data (total length in inches) for Chinook salmon sampled July-September during the 1991-2013 NYSDEC Lake Ontario fishing boat surveys.

	Year	July		August		September	
Age	Sampled	Mean Length	(n)	Mean Length	(n)	Mean Length	(n)
Age-1	1991	18.74	(8)	19.23	(22)	22.52	(9)
	1992	18.93	(38)	20.49	(53)	22.04	(35)
	1993	18.44	(9)	18.14	(61)	19.37	(33)
	1994	16.40	(1)	17.79	(9)	18.59	(12)
	1995	18.62	(6)	20.53	(4)	-	(0)
	1996	18.58	(15)	19.66	(74)	21.85	(24)
	1997	19.06	(9)	19.18	(45)	20.43	(23)
	1998	20.12	(10)	19.63	(22)	21.13	(3)
	1999	20.58	(19)	20.08	(26)	23.69	(12)
	2000	20.53	(24)	20.56	(17)	23.20	(10)
	2001	18.75	(25)	19.33	(22)	21.65	(10)
	2002	17.86	(10)	19.94	(9)	21.75	(6)
	2003	18.83	(3)	17.48	(10)	21.20	(6)
	2004	18.00	(6)	18.00	(36)	19.84	(23)
	2005	18.12	(25)	18.98	(14)	19.93	(3)
	2006	19.61	(37)	20.97	(38)	23.57	(9)
	2007	18.82	(6)	20.82	(9)	21.84	(14)
	2008	18.51	(8)	19.62	(6)	21.10	(1)
	2009	19.34	(13)	19.05	(25)	22.40	(1)
	2010	20.53	(55)	21.56	(67)	23.42	(30)
	2011	19.31	(77)	20.88	(49)	22.11	(20)
	2012	19.61	(11)	21.48	(12)	24.30	(1)
	2013	19.46	(14)	20.94	(26)	24.98	(5)
	91-'13 avg	19.36	(429)	19.85	(656)	21.57	(290)
Age-2	1991	27.40	(30)	28.96	(75)	31.58	(24)
	1992	28.69	(32)	30.00	(122)	32.42	(47)
	1993	29.57	(22)	30.98	(121)	31.61	(43)
	1994	27.27	(60)	28.77	(80)	28.85	(100)
	1995	28.14	(42)	28.74	(49)	31.94	(7)
	1996	31.90	(2)	29.50	(27)	30.52	(12)
	1997	29.95	(61)	30.45	(239)	32.14	(52)
	1998	30.93	(32)	31.68	(77)	33.87	(15)
	1999	29.68	(12)	31.17	(38)	32.95	(41)
	2000	30.28	(28)	32.17	(49)	33.82	(17)
	2001	30.14	(61)	31.86	(67)	32.34	(32)
	2002	30.35	(6)	31.52	(55)	32.54	(36)
	2003	28.64	(56)	29.98	(35)	31.93	(26)
	2004	28.26	(126)	29.48	(203)	30.71	(106)
	2005	28.18	(102)	29.60	(118)	31.65	(78)
	2006	29.15	(75)	29.96	(106)	30.93	(30)
	2007	29.87	(131)	30.29	(163)	32.09	(91)
	2008	27.62	(68)	30.36	(102)	32.13	(82)
	2009	27.33	(80)	29.04	(68)	31.12	(33)
	2010	29.64	(39)	32.39	(36)	33.73	(20)
	2011	30.80	(185)	32.92	(180)	34.09	(86)
	2012	30.33	(121)	32.34	(155)	34.02	(76)
	2013	30.49	(48)	31.12	(75)	33.09	(18)
	91-'13 avg	29.25	(1419)	30.62	(2238)	31.98	(1072)

Table A11 (continued). Mean length at age data (total length in inches) for Chinook salmon.

	Year	July		August		September	
Age	Sampled	Mean Length	(n)	Mean Length	(n)	Mean Length	(n)
Age-3	1991	36.81	(44)	37.47	(105)	38.15	(148)
	1992	36.12	(40)	37.24	(124)	37.74	(129)
	1993	37.09	(20)	37.42	(211)	36.90	(110)
	1994	35.86	(91)	36.30	(204)	36.24	(107)
	1995	35.97	(74)	36.34	(134)	36.96	(113)
	1996	36.39	(9)	37.15	(98)	37.89	(76)
	1997	35.21	(7)	36.87	(58)	37.72	(18)
	1998	36.92	(41)	37.33	(194)	37.35	(31)
	1999	36.67	(15)	38.35	(111)	38.29	(85)
	2000	36.20	(23)	37.49	(108)	37.96	(37)
	2001	36.23	(42)	37.26	(51)	37.77	(20)
	2002	38.70	(1)	37.21	(51)	37.17	(42)
	2003	35.14	(28)	35.57	(64)	35.71	(112)
	2004	34.78	(52)	36.12	(160)	35.88	(69)
	2005	34.65	(111)	35.90	(278)	35.86	(172)
	2006	35.77	(107)	36.93	(231)	36.71	(121)
	2007	35.19	(127)	35.63	(168)	35.95	(127)
	2008	35.24	(44)	36.51	(132)	37.09	(83)
	2009	34.35	(147)	35.19	(148)	35.59	(141)
	2010	35.53	(23)	37.41	(79)	37.97	(27)
	2011	36.18	(28)	37.58	(17)	38.79	(12)
	2012	36.66	(35)	37.69	(71)	38.37	(21)
	2013	36.72	(64)	37.50	(124)	37.32	(27)
	91-'13 avg	35.60	(1173)	36.75	(2921)	36.86	(1828)
Age-4	1991	39.42	(6)	39.87	(21)	39.77	(10)
	1992	40.78	(4)	39.74	(9)	39.25	(12)
	1993	37.37	(3)	38.27	(22)	39.06	(7)
	1994	38.40	(5)	38.55	(15)	39.05	(4)
	1995	38.57	(9)	37.83	(15)	37.78	(5)
	1996	37.50	(2)	39.14	(29)	40.37	(23)
	1997	-	(0)	39.52	(18)	39.68	(4)
	1998	-	(0)	37.97	(6)	-	(0)
	1999	-	(0)	39.73	(6)	39.30	(5)
	2000	-	(0)	-	(0)	-	(0)
	2001	37.20	(2)	-	(0)	41.40	(1)
	2002	-	(0)	36.75	(2)	42.10	(1)
	2003	-	(0)	-	(0)	37.00	(1)
	2004	36.10	(1)	37.36	(5)	37.80	(1)
	2005	35.80	(2)	38.63	(4)	36.00	(2)
	2006	37.54	(7)	38.68	(21)	37.10	(2)
	2007	37.13	(3)	36.63	(11)	37.71	(8)
	2008	36.67	(3)	37.69	(9)	37.20	(2)
	2009	39.50	(1)	36.68	(4)	-	(0)
	2010	37.60	(2)	37.08	(4)	39.85	(2)
	2011	36.70	(1)	-	(0)	-	(0)
	2012	-	(0)	40.00	(1)	-	(0)
	2013	40.5	(1)	-	(0)	-	(0)
	91-'13 avg	38.15	(52)	38.61	(202)	39.24	(90)

Table A12. Chinook salmon relative harvest (age-specific harvest per 150,000 boat trips) by year class and year sampled, from the 1985-2013 NYSDEC Lake Ontario fishing boat surveys.

Year	Fing Equiv	Chinook Salmon Harvested Per 150,000 Boat Trips				
Class	Stocked	Age-1	Age-2	Age-3	Age-4	Total
1981	862,840				1,594	
1982	1,175,354			22,529	1,177	
1983	2,544,180		17,511	27,129	3,802	
1984	2,957,230	15,066	25,040	45,305	3,555	88,996
1985	3,252,830	11,971	32,146	39,890	7,435	91,443
1986	2,810,771	12,077	24,115	63,952	3,337	103,481
1987	3,368,296	9,445	34,039	41,097	5,713	90,330
1988	3,104,104	9,050	21,120	41,277	2,353	73,891
1989	3,018,754	3,483	22,269	27,327	3,714	56,794
1990	2,964,722	5,336	19,283	35,704	3,651	63,974
1991	3,129,453	10,412	26,706	54,789	3,464	95,371
1992	3,004,329	10,003	37,467	35,071	7,934	90,637
1993	1,846,892	2,465	12,505	26,866	3,170	45,006
1994	1,221,491	1,072	5,928	12,405	1,092	20,497
1995	1,364,090	16,070	52,594	39,323	2,384	110,370
1996	1,495,138	10,003	20,263	42,021	0	72,287
1997	1,911,040	5,462	18,568	29,401	453	53,884
1998	1,903,929	10,849	21,047	21,477	627	54,000
1999	1,767,524	8,722	29,542	22,215	193	60,671
2000	1,906,543	8,149	25,685	58,334	977	93,144
2001	1,893,686	5,322	35,518	47,586	1,320	89,858
2002	1,908,002	5,254	76,817	115,363	5,275	202,709
2003	1,700,374	9,060	56,861	71,548	3,785	141,254
2004	1,962,565	6,310	35,774	66,249	2,437	110,770
2005	2,075,169	11,131	64,365	48,487	1,196	125,180
2006	1,898,083	4,449	49,807	86,156	2,618	143,031
2007	2,055,075	3,270	39,227	36,675	244	79,415
2008	1,038,844	6,339	23,630	12,123	296	42,388
2009	1,981,055	31,988	96,707	43,212	347	172,254
2010	1,911,756	31,194	127,157	62,817		
2011	2,060,874	8,899	44,765			
2012	1,816,778	12,942				

Table A12 (continued). Chinook salmon relative harvest by year class and year sampled.

Year Sampled	Salmonid Boat Trips	Chinook Salmon Harvested Per 150,000 Boat Trips				
		Age-1	Age-2	Age-3	Age-4	Total
1985	126,155	15,066	17,511	22,529	1,594	56,700
1986	148,950	11,971	25,040	27,129	1,177	65,316
1987	165,678	12,077	32,146	45,305	3,802	93,366
1988	160,805	9,445	24,115	39,890	3,555	77,097
1989	177,223	9,050	34,039	63,952	7,435	114,477
1990	181,867	3,483	21,120	41,097	3,337	69,038
1991	152,357	5,336	22,269	41,277	5,713	74,594
1992	118,054	10,412	19,283	27,327	2,353	59,536
1993	103,125	10,003	26,706	35,704	3,714	76,125
1994	102,718	2,465	37,467	54,789	3,651	98,372
1995	92,346	1,072	12,505	35,071	3,464	52,112
1996	70,151	16,070	5,928	26,866	7,934	56,796
1997	64,351	10,003	52,594	12,405	3,170	78,174
1998	64,060	5,462	20,263	39,323	1,092	66,138
1999	60,573	10,849	18,568	42,021	2,384	73,825
2000	64,589	8,722	21,047	29,401	0	59,170
2001	63,026	8,149	29,542	21,477	453	59,730
2002	50,826	5,322	25,685	22,215	627	53,848
2003	47,622	5,254	35,518	58,334	193	99,298
2004	57,397	9,060	76,817	47,586	977	134,440
2005	57,510	6,310	56,861	115,363	1,320	179,857
2006	47,812	11,131	35,774	71,548	5,275	123,731
2007	57,620	4,449	64,365	66,249	3,785	138,848
2008	51,229	3,270	49,807	48,487	2,437	104,005
2009	62,028	6,339	39,227	86,156	1,196	132,917
2010	50,059	31,988	23,630	36,675	2,618	94,916
2011	49,548	31,194	96,707	12,123	244	140,267
2012	46,059	8,899	127,157	43,212	296	179,564
2013	47,520	12,942	44,765	62,817	347	120,871

Table A13. Number of fingerling equivalents and average size (grams) of Chinook salmon stocked into Lake Ontario from 1981-2013 by NYSDEC, Ontario Ministry of Natural Resources and pen-rearing cooperators. Calculations previously described in Eckert (2007).

	DEC Stocked Fish						OMNR Stocked Fish				Total Lake Ontario	
	Salmon River		Caledonia		Pen Reared		OMNR Hatchery		Pen Reared		Chinook Salmon	
Year Class	Number Stocked	Avg Size	Number Stocked	Avg Size	Number Stocked	Avg Size	Number Stocked	Avg Size	Number Stocked	Avg Size	Number Stocked	Avg Size
1981	379,941	1.8	479,300	3.1			3,599	2.3			862,840	2.4
1982	888,400	2.1	184,000	3.7			102,954	2.5			1,175,354	2.3
1983	2,064,260	3.8	455,000	4.2			24,920	1.8			2,544,180	3.8
1984	2,609,750	3.5	195,000	2.0			152,480	2.0			2,957,230	3.1
1985	2,957,800	4.8					295,030	4.4			3,252,830	4.7
1986	1,848,800	4.2	663,200	4.5			298,771	4.9			2,810,771	4.4
1987	2,495,000	4.9	616,330	4.6			256,966	4.2			3,368,296	4.8
1988	2,305,000	4.5	543,000	4.5			256,104	5.1			3,104,104	4.6
1989	2,212,200	4.5	540,000	4.9			266,554	4.4			3,018,754	4.6
1990	2,180,000	5.3	540,000	4.5			244,722	4.1			2,964,722	5.0
1991	2,794,000	5.1			41,000	4.1	294,453	4.8			3,129,453	5.1
1992	2,655,691	4.6			46,260	3.9	302,378	5.0			3,004,329	4.7
1993	1,557,300	4.5			40,000	3.8	249,592	5.1			1,846,892	4.6
1994	944,000	5.0			40,000	3.9	237,491	4.5			1,221,491	4.8
1995	1,136,666	4.6					227,424	4.3			1,364,090	4.5
1996	1,300,000	4.6					195,138	3.8			1,495,138	4.4
1997	1,604,980	5.1					306,060	4.6			1,911,040	4.9
1998	1,546,000	5.0			49,763	7.6	308,166	4.6			1,903,929	4.9
1999	1,183,000	4.7	90,000	4.5	315,000	4.5	179,524	4.3			1,767,524	4.6
2000	1,252,300	4.7	90,000	4.1	300,000	4.8	264,243	4.1			1,906,543	4.5
2001	1,202,800	4.9	118,610	3.9	300,000	5.0	272,276	4.0			1,893,686	4.6
2002	1,211,000	5.3	123,000	4.3	299,496	5.4	274,506	4.4			1,908,002	5.0
2003	1,167,240	4.7	110,400	3.5	189,356	4.5	223,233	3.9	10,145	5.4	1,700,374	4.4
2004	928,160	4.7	451,030	3.9	322,269	5.3	251,103	4.1	10,004	5.2	1,962,565	4.5
2005	994,660	5.3	421,280	4.1	386,599	5.3	262,621	4.7	10,010	6.0	2,075,169	5.0
2006	1,035,680	3.9	342,200	3.5	313,100	6.1	197,107	3.9	9,997	5.7	1,898,083	4.1
2007	1,477,670	5.1			313,100	6.7	254,307	4.7	9,998	5.7	2,055,075	5.2
2008	559,524	6			224,702	5.9	241,875	4.1	12,743	6.6	1,038,844	5.3
2009	1,411,957	4.9			313,600	7.2	233,820	4.5	21,678	4.4	1,981,055	5.1
2010	1,024,046	5.6			506,560	6.4	341,390	4.9	39,820	8.9	1,911,756	5.7
2011	1,260,584	5.3			508,670	6.4	249,079	4.3	42,541	7.7	2,060,874	5.4
2012	1,013,110	6.6			497,970	6.3	245,758	6.5	59,940	10.7	1,816,778	6.7

Table A14a. Rainbow trout harvest and catch data collected April 15 – September 30, 1985-2013.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	26,128	11,376	7,557	10,750	12,861	19,685	24,060	23,856	16,131	12,617	17,203
Catch	36,560	20,182	13,528	17,959	25,892	33,943	54,501	46,249	36,533	32,975	34,611
% Harvested	71.6	56.4	55.9	59.9	49.7	58.0	44.1	51.6	44.2	38.3	49.7
Monthly estimates of harvest for all fishing boats:											
April	1,367	106	259	186	228	262	473	463	56	199	76
May	5,782	3,986	1,320	1,872	2,619	2,481	1,698	1,548	410	939	2,099
June	3,935	653	1,038	526	1,112	978	813	2,406	1,095	2,156	965
July	3,304	1,376	1,584	1,901	3,666	2,889	5,816	4,831	7,299	4,301	5,488
August	8,966	3,752	2,274	1,948	3,613	9,800	10,096	13,568	4,587	4,381	7,567
September	2,775	1,504	1,082	4,318	1,622	3,275	5,164	1,040	2,684	640	1,009
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	15,487	6,483	5,144	6,763	8,537	14,945	19,388	18,973	11,637	8,622	11,437
West/Central	3,012	1,069	594	1,516	1,578	760	1,728	1,447	2,023	1,245	2,333
East/Central	6,283	3,570	1,171	2,102	2,335	3,603	2,221	3,065	2,340	1,852	3,036
East	1,346	255	648	369	411	377	722	370	131	898	397
Monthly estimates of catch for all fishing boats:											
April	2,298	371	415	399	429	565	1,197	867	305	442	379
May	8,319	7,794	3,100	3,736	7,264	5,840	7,418	2,724	2,060	3,100	4,824
June	5,674	928	2,567	787	2,708	2,197	2,676	4,828	1,813	6,515	2,077
July	4,496	2,169	2,291	3,004	6,504	6,026	9,053	8,856	18,448	11,100	11,489
August	11,869	6,665	3,628	3,912	6,520	14,823	22,335	27,121	9,037	10,858	14,198
September	3,904	2,255	1,526	6,120	2,467	4,492	11,822	1,851	4,869	960	1,644
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	21,386	11,616	9,664	10,945	16,537	23,556	35,347	36,512	26,897	22,064	23,021
West/Central	5,200	2,234	1,437	3,383	3,130	1,727	12,065	3,891	3,377	5,355	5,055
East/Central	8,317	5,993	1,595	3,249	5,382	8,040	5,824	5,166	5,164	4,195	5,957
East	1,658	339	832	382	843	620	1,266	681	1,096	1,361	578
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.7	100.0	99.8	100.0	100.0	99.8	100.0	100.0	99.8	100.0	100.0
% Catch	99.6	99.3	99.9	100.0	99.9	99.7	99.8	99.9	99.9	100.0	99.9
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	49.4	63.9	52.0	66.3	50.0	59.4	50.7	49.8	50.2	45.9	54.3
% Catch	40.0	45.0	36.8	51.1	36.8	47.0	34.7	35.5	33.5	27.1	39.0

Table A14b. Rainbow trout harvest and catch rate data collected April 15 – September 30, 1985-2013. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.259	0.198	0.131	0.225	0.223	0.384	0.388	0.477	0.325	0.274	0.362
Catch/Boat Trip	0.360	0.349	0.235	0.376	0.449	0.661	0.877	0.923	0.737	0.716	0.728
Harv/Angler Trip	0.089	0.069	0.045	0.076	0.075	0.129	0.127	0.157	0.109	0.091	0.117
Catch/Angler Trip	0.123	0.121	0.080	0.126	0.150	0.221	0.287	0.305	0.247	0.238	0.235
Harv/Angler Hour	0.015	0.013	0.008	0.013	0.013	0.023	0.021	0.028	0.019	0.016	0.019
Catch/Angler Hr.	0.021	0.022	0.015	0.022	0.027	0.039	0.048	0.055	0.044	0.042	0.039
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.119	0.033	0.108	0.046	0.076	0.091	0.131	0.177	0.022	0.084	0.030
May	0.294	0.453	0.101	0.235	0.238	0.342	0.115	0.165	0.051	0.112	0.265
June	0.379	0.137	0.194	0.192	0.190	0.199	0.156	0.620	0.254	0.420	0.152
July	0.231	0.192	0.146	0.230	0.359	0.312	0.665	0.523	0.669	0.465	0.569
August	0.319	0.196	0.161	0.134	0.217	0.594	0.665	0.750	0.323	0.339	0.476
September	0.140	0.105	0.091	0.418	0.149	0.309	0.355	0.152	0.278	0.080	0.196
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.674	0.581	0.357	0.613	0.530	1.201	1.044	1.331	0.789	0.680	0.836
West/Central	0.166	0.183	0.083	0.222	0.227	0.177	0.224	0.260	0.401	0.223	0.352
East/Central	0.193	0.201	0.067	0.125	0.141	0.209	0.116	0.183	0.155	0.136	0.199
East	0.036	0.011	0.035	0.028	0.023	0.022	0.044	0.027	0.009	0.063	0.033
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.211	0.116	0.173	0.099	0.143	0.197	0.332	0.332	0.121	0.187	0.147
May	0.428	0.885	0.238	0.469	0.660	0.804	0.504	0.290	0.256	0.370	0.610
June	0.553	0.179	0.479	0.288	0.459	0.449	0.515	1.238	0.417	1.268	0.328
July	0.301	0.300	0.211	0.364	0.637	0.647	1.035	0.959	1.692	1.199	1.188
August	0.416	0.345	0.257	0.270	0.391	0.899	1.465	1.500	0.638	0.841	0.892
September	0.197	0.158	0.129	0.592	0.227	0.424	0.811	0.270	0.505	0.120	0.320
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.912	1.041	0.672	0.992	1.026	1.893	1.904	2.561	1.826	1.741	1.682
West/Central	0.310	0.376	0.201	0.495	0.447	0.399	1.559	0.698	0.669	0.959	0.762
East/Central	0.260	0.332	0.091	0.194	0.326	0.466	0.300	0.307	0.340	0.309	0.390
East	0.044	0.015	0.045	0.029	0.047	0.036	0.076	0.050	0.075	0.096	0.048
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.913	0.771	0.435	0.805	0.702	1.340	1.236	1.391	0.981	0.759	1.008
Catch/Boat Trip	1.030	0.963	0.551	1.035	1.040	1.828	1.919	1.925	1.484	1.169	1.455
Harv/Angler Trip	0.181	0.154	0.085	0.159	0.136	0.257	0.244	0.267	0.188	0.149	0.194
Catch/Angler Trip	0.205	0.193	0.108	0.205	0.202	0.351	0.378	0.369	0.284	0.230	0.280
Harv/Angler Hour	0.024	0.023	0.013	0.024	0.019	0.037	0.035	0.041	0.030	0.023	0.028
Catch/Angler Hr.	0.028	0.029	0.016	0.030	0.029	0.051	0.055	0.057	0.045	0.035	0.040
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.148	0.086	0.074	0.093	0.133	0.187	0.227	0.289	0.194	0.178	0.206
Catch/Boat Trip	0.246	0.228	0.176	0.226	0.337	0.421	0.680	0.717	0.587	0.626	0.552
Harv/Angler Trip	0.058	0.035	0.029	0.037	0.052	0.074	0.085	0.112	0.077	0.068	0.080
Catch/Angler Trip	0.096	0.093	0.069	0.090	0.131	0.167	0.254	0.278	0.232	0.241	0.214
Harv/Angler Hour	0.011	0.007	0.006	0.007	0.010	0.014	0.015	0.022	0.014	0.013	0.014
Catch/Angler Hr.	0.018	0.019	0.014	0.017	0.026	0.032	0.045	0.054	0.044	0.046	0.038

Table A15. Length (total length in inches) and weight (lbs) statistics for rainbow trout sampled April 15 – September 30 during the 1985-2013 NYSDEC Lake Ontario fishing boat surveys.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Mean length and weight data for rainbow trout sampled April 15 - September 30:											
Mean Length (in)	24.3	24.4	24.4	24.2	24.9	25.1	25.0	25.3	24.7	24.9	24.5
Mean Weight (lbs)	-	6.2	6.0	5.9	6.0	6.2	6.0	6.8	6.1	5.9	6.0
Estimated weight (lbs) for standard length rainbow trout sampled April 15 - September 30:											
Standard Length:											
18.0 inches	-	2.28	2.42	2.43	2.07	2.22	2.10	2.40	2.09	2.05	2.21
20.0 inches	-	3.12	3.25	3.26	2.86	3.02	2.89	3.26	2.92	2.83	3.04
22.0 inches	-	4.15	4.25	4.25	3.83	3.99	3.85	4.30	3.95	3.80	4.06
24.0 inches	-	5.37	5.41	5.42	5.00	5.13	5.00	5.53	5.21	4.97	5.28
26.0 inches	-	6.80	6.77	6.78	6.38	6.47	6.36	6.97	6.71	6.35	6.73
28.0 inches	-	8.44	8.29	8.30	7.97	7.99	7.92	8.60	8.46	7.94	8.39
30.0 inches	-	10.36	10.05	10.06	9.85	9.77	9.75	10.51	10.53	9.82	10.34
32.0 inches	-	12.54	12.03	12.04	12.00	11.78	11.84	12.67	12.92	11.98	12.58
Percent length composition of rainbow trout sampled April 15 - September 30:											
<15.0 in	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
15.0-15.9 in	0.3%	0.0%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
16.0-16.9 in	1.1%	1.3%	0.0%	0.5%	0.0%	0.3%	0.2%	0.0%	0.0%	0.0%	0.0%
17.0-17.9 in	2.3%	1.3%	1.5%	1.0%	0.4%	0.3%	1.5%	0.3%	1.3%	0.5%	0.5%
18.0-18.9 in	4.6%	5.2%	3.7%	2.9%	3.5%	3.8%	1.2%	1.1%	1.3%	0.5%	0.5%
19.0-19.9 in	6.8%	7.7%	5.2%	5.4%	2.6%	1.4%	3.2%	1.6%	3.3%	1.6%	1.1%
20.0-20.9 in	8.3%	5.8%	7.5%	8.3%	7.5%	4.8%	5.4%	4.1%	4.6%	5.3%	8.1%
21.0-21.9 in	9.2%	9.7%	5.2%	9.3%	9.7%	8.7%	8.2%	8.5%	12.8%	7.4%	9.7%
22.0-22.9 in	8.7%	9.0%	17.9%	7.8%	8.4%	10.4%	9.2%	11.8%	12.1%	10.1%	14.1%
23.0-23.9 in	8.6%	10.3%	9.0%	15.6%	15.4%	6.2%	9.9%	11.5%	10.8%	16.0%	15.1%
24.0-24.9 in	7.6%	8.4%	9.0%	13.2%	5.3%	9.3%	7.7%	10.4%	7.5%	12.2%	9.2%
25.0-25.9 in	6.8%	8.4%	6.7%	8.3%	5.3%	8.7%	12.6%	8.5%	7.9%	11.2%	10.8%
26.0-26.9 in	6.3%	3.2%	8.2%	5.4%	7.5%	12.5%	10.1%	11.8%	11.1%	7.4%	8.1%
27.0-27.9 in	6.8%	7.7%	8.2%	6.8%	8.4%	12.5%	9.4%	9.0%	8.2%	12.8%	7.6%
28.0-28.9 in	6.0%	4.5%	4.5%	6.3%	10.1%	9.3%	9.9%	7.4%	9.5%	5.3%	5.4%
29.0-29.9 in	5.1%	4.5%	6.7%	4.4%	6.2%	6.6%	5.0%	4.9%	4.3%	3.7%	5.9%
30.0-30.9 in	4.4%	4.5%	1.5%	2.4%	4.4%	2.8%	4.0%	4.9%	3.6%	3.2%	1.1%
31.0-31.9 in	3.1%	5.8%	2.2%	1.5%	2.6%	1.4%	1.7%	1.4%	1.3%	1.1%	0.5%
32.0-32.9 in	2.0%	0.6%	1.5%	0.0%	1.8%	0.0%	0.7%	1.9%	0.0%	0.5%	0.5%
33.0-33.9 in	1.0%	0.6%	1.5%	0.5%	0.4%	0.3%	0.0%	0.5%	0.3%	1.1%	0.5%
>33.9 in	0.8%	1.3%	0.0%	0.5%	0.0%	0.7%	0.0%	0.3%	0.0%	0.0%	1.1%

Table A16. Atlantic salmon harvest and catch data collected April 15 – September 30, 1985-2013.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	372	19	15	0	14	79	532	624	398	310	200
Catch	1,369	50	270	158	214	233	1,273	1,826	1,519	592	599
% Harvested	27.0	38.0	5.6	0.0	6.5	33.9	41.8	34.2	26.2	52.4	33.4
Monthly estimates of harvest for all fishing boats:											
April	69	19	15	0	0	0	105	98	128	29	0
May	162	0	0	0	0	28	222	79	95	183	175
June	55	0	0	0	14	0	15	24	54	46	0
July	32	0	0	0	0	16	66	301	76	51	25
August	47	0	0	0	0	0	124	108	25	0	0
September	7	0	0	0	0	35	0	15	21	0	0
Seasonal estimates of harvest among four geographic areas for all fishing boats:											
West	93	0	0	0	14	51	226	205	236	126	51
West/Central	63	0	0	0	0	0	161	182	0	0	44
East/Central	105	19	15	0	0	0	74	204	106	93	105
East	112	0	0	0	0	28	71	33	56	91	0
Monthly estimates of catch for all fishing boats:											
April	253	19	15	31	0	0	201	273	296	56	48
May	446	30	0	17	72	88	430	223	439	387	251
June	180	0	47	0	114	64	66	231	171	46	77
July	223	0	171	0	28	16	211	648	212	90	165
August	188	0	37	110	0	30	365	372	340	13	58
September	79	0	0	0	0	35	0	79	62	0	0
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	320	31	34	72	116	52	363	560	526	242	186
West/Central	237	0	131	31	70	36	337	397	366	46	77
East/Central	420	19	60	0	0	47	509	650	339	211	255
East	392	0	44	55	28	98	63	219	287	93	81
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	98.6	100	100		100	100	100	100	100	100	100
% Catch	97.7	100	54.81481	100	100	100	100	100.0	100	100	100
Seasonal rates of harvest and catch per 100 trips for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.302	0.033	0.026	0.000	0.024	0.154	0.858	1.247	0.803	0.673	0.421
Catch/Boat Trip	1.098	0.087	0.257	0.330	0.371	0.455	2.052	3.648	3.066	1.285	1.261
Harv/Angler Trip	0.105	0.011	0.009	0.000	0.008	0.052	0.280	0.411	0.269	0.224	0.136
Catch/Angler Trip	0.383	0.030	0.088	0.111	0.124	0.152	0.671	1.203	1.028	0.427	0.408
Harv/Angler Hour	0.019	0.002	0.002	0.000	0.001	0.009	0.047	0.074	0.048	0.039	0.022
Catch/Angler Hr.	0.068	0.006	0.016	0.020	0.022	0.027	0.111	0.217	0.183	0.075	0.067

Table A17a. Brown trout harvest and catch data collected April 15 – September 30, 1985-2013.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	33,329	14,991	20,702	13,667	27,855	14,989	23,148	18,311	32,937	23,305	18,969
Catch	46,910	23,003	32,709	21,957	46,258	22,030	33,484	32,604	49,661	39,507	27,793
% Harvested	70.8	65.2	63.3	62.2	60.2	68.0	69.1	56.2	66.3	59.0	68.3
Monthly estimates of harvest for all fishing boats:											
April	9,058	845	3,912	3,304	5,795	1,420	4,023	3,855	3,558	5,802	2,730
May	11,788	4,382	9,655	4,117	9,083	3,828	11,256	2,266	12,255	5,436	7,810
June	4,386	4,497	3,867	1,068	4,052	4,164	2,393	611	4,941	1,456	3,315
July	4,065	1,853	2,187	3,630	4,570	3,280	576	7,782	6,695	5,631	2,656
August	3,405	3,390	744	1,398	4,100	1,945	4,538	3,543	4,968	4,307	2,197
September	627	24	337	150	256	352	362	255	519	672	259
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	2,759	834	1,376	453	2,633	1,052	209	1,153	2,563	2,006	1,649
West/Central	3,216	2,874	1,713	1,164	2,667	541	1,744	1,487	2,163	2,792	1,566
East/Central	18,318	9,864	9,905	9,322	15,145	3,969	17,399	11,156	16,327	8,932	9,850
East	9,035	1,418	7,708	2,727	7,410	9,427	3,796	4,515	11,883	9,575	5,903
Monthly estimates of catch for all fishing boats:											
April	12,259	2,556	5,795	4,342	10,656	1,996	5,997	5,501	8,160	10,558	4,450
May	15,975	6,448	14,907	5,181	15,302	5,983	15,838	3,913	17,584	9,446	9,329
June	5,817	6,001	5,442	1,262	5,337	6,110	3,463	1,342	6,658	3,345	3,918
July	6,320	2,575	4,025	5,225	9,167	4,692	888	14,421	10,026	7,751	5,169
August	5,592	5,115	2,163	5,567	5,347	2,654	6,720	6,993	6,193	7,236	4,284
September	947	308	377	381	449	595	579	434	1,041	1,171	643
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	4,299	1,458	2,829	828	3,828	1,408	344	2,043	4,760	4,122	2,451
West/Central	6,399	4,984	5,688	2,273	6,652	1,162	3,182	3,005	5,710	6,836	4,933
East/Central	24,641	14,930	13,170	14,537	25,705	6,117	25,272	20,730	22,945	13,860	12,722
East	11,571	1,632	11,022	4,319	10,073	13,344	4,686	6,826	16,246	14,689	7,687
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	98.8	99.1	100.0	99.3	98.6	98.9	99.4	98.9	99.8	99.8	99.8
% Catch	98.4	99.1	100.0	99.1	98.9	98.3	98.9	97.8	99.8	98.8	99.5
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	43.9	59.5	49.4	73.2	51.1	43.9	70.3	54.7	53.3	55.6	72.9
% Catch	37.2	46.9	39.2	59.1	42.2	34.1	59.6	49.8	43.4	42.3	58.7

Table A17b. Brown trout harvest and catch rate data collected April 15 – September 30, 1985-2013. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.326	0.259	0.360	0.284	0.477	0.289	0.371	0.362	0.664	0.505	0.398
Catch/Boat Trip	0.467	0.397	0.568	0.455	0.794	0.423	0.534	0.637	1.000	0.848	0.582
Harv/Angler Trip	0.113	0.090	0.122	0.095	0.160	0.097	0.121	0.119	0.223	0.168	0.129
Catch/Angler Trip	0.162	0.138	0.193	0.153	0.266	0.142	0.175	0.210	0.335	0.282	0.188
Harv/Angler Hour	0.019	0.016	0.022	0.017	0.028	0.017	0.020	0.021	0.040	0.030	0.021
Catch/Angler Hr.	0.028	0.025	0.035	0.027	0.047	0.025	0.029	0.038	0.060	0.050	0.031
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	1.023	0.264	1.632	0.821	1.933	0.494	1.114	1.477	1.413	2.452	1.060
May	0.637	0.488	0.746	0.517	0.825	0.527	0.764	0.241	1.522	0.648	0.987
June	0.425	0.940	0.721	0.357	0.655	0.851	0.438	0.140	1.134	0.283	0.523
July	0.301	0.252	0.201	0.440	0.438	0.352	0.066	0.834	0.614	0.603	0.272
August	0.125	0.177	0.053	0.096	0.240	0.116	0.298	0.196	0.352	0.334	0.138
September	0.032	0.002	0.028	0.015	0.024	0.033	0.025	0.029	0.054	0.084	0.050
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.114	0.075	0.096	0.041	0.163	0.082	0.011	0.081	0.174	0.158	0.119
West/Central	0.261	0.491	0.240	0.170	0.383	0.126	0.226	0.267	0.429	0.500	0.236
East/Central	0.601	0.548	0.568	0.556	0.899	0.226	0.908	0.658	1.079	0.653	0.645
East	0.272	0.063	0.415	0.200	0.406	0.541	0.220	0.330	0.808	0.674	0.494
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	1.410	0.798	2.418	1.079	3.555	0.695	1.661	2.108	3.241	4.462	1.719
May	0.884	0.720	1.152	0.644	1.390	0.816	1.074	0.416	2.184	1.126	1.179
June	0.562	1.255	1.012	0.428	0.867	1.228	0.617	0.329	1.518	0.579	0.615
July	0.463	0.353	0.371	0.633	0.888	0.505	0.102	1.498	0.920	0.827	0.529
August	0.212	0.267	0.154	0.383	0.312	0.158	0.441	0.387	0.439	0.560	0.269
September	0.051	0.019	0.032	0.034	0.041	0.056	0.035	0.056	0.108	0.146	0.120
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.178	0.127	0.197	0.075	0.237	0.111	0.019	0.143	0.323	0.325	0.176
West/Central	0.553	0.852	0.794	0.324	0.955	0.268	0.413	0.539	1.131	1.224	0.744
East/Central	0.819	0.833	0.755	0.865	1.533	0.345	1.306	1.201	1.513	1.000	0.830
East	0.349	0.072	0.593	0.320	0.554	0.760	0.274	0.501	1.105	1.020	0.641
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	1.051	0.946	1.132	1.129	1.556	0.754	1.650	1.174	2.128	1.698	1.492
Catch/Boat Trip	1.270	1.142	1.421	1.465	2.131	0.862	2.022	1.903	2.611	2.187	1.760
Harv/Angler Trip	0.210	0.189	0.222	0.224	0.302	0.145	0.325	0.225	0.408	0.333	0.287
Catch/Angler Trip	0.254	0.229	0.278	0.290	0.414	0.165	0.398	0.365	0.500	0.429	0.338
Harv/Angler Hour	0.029	0.028	0.033	0.033	0.043	0.021	0.047	0.035	0.064	0.050	0.041
Catch/Angler Hr.	0.035	0.034	0.042	0.043	0.059	0.024	0.057	0.057	0.079	0.065	0.049
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.204	0.124	0.216	0.092	0.273	0.194	0.129	0.195	0.371	0.268	0.134
Catch/Boat Trip	0.330	0.251	0.410	0.226	0.542	0.332	0.253	0.377	0.678	0.582	0.297
Harv/Angler Trip	0.080	0.050	0.085	0.037	0.106	0.077	0.048	0.075	0.146	0.103	0.052
Catch/Angler Trip	0.130	0.102	0.161	0.090	0.210	0.131	0.094	0.146	0.267	0.224	0.115
Harv/Angler Hour	0.015	0.010	0.017	0.007	0.021	0.015	0.008	0.015	0.027	0.020	0.009
Catch/Angler Hr.	0.024	0.021	0.032	0.017	0.041	0.025	0.017	0.028	0.050	0.042	0.020

Table A18. Length (inches), weight (lbs), age, and fin clip statistics for brown trout sampled April 15 – September 30 during the 1985-2013 NYSDEC Lake Ontario fishing boat surveys.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Mean length and weight data for brown trout sampled April 15 - September 30:											
Mean Length (in)	20.0	20.8	19.9	20.5	20.0	20.0	19.0	20.8	20.7	20.4	21.1
Mean Weight (lbs)	-	5.39	4.39	5.33	4.62	4.59	3.70	5.39	5.30	4.92	5.87
Estimated weight (lbs) for standard length brown trout sampled April 15 - September 30:											
16.0 inches	-	2.18	2.04	2.33	2.01	2.11	1.99	2.32	2.16	1.96	2.32
18.0 inches	-	3.13	2.97	3.32	2.98	3.06	2.88	3.30	3.15	2.89	3.30
20.0 inches	-	4.36	4.18	4.61	4.28	4.30	4.05	4.54	4.44	4.13	4.56
22.0 inches	-	5.88	5.70	6.18	5.94	5.83	5.50	6.06	6.06	5.70	6.10
24.0 inches	-	7.72	7.56	8.09	8.01	7.71	7.27	7.89	8.04	7.64	7.96
26.0 inches	-	9.92	9.81	10.36	10.55	9.96	9.41	10.06	10.44	10.00	10.16
28.0 inches	-	12.46	12.42	12.97	13.54	12.58	11.89	12.54	13.23	12.78	12.69
Percent length composition of brown trout sampled April 15 - September 30:											
<15.0 in	1.6%	0.0%	0.0%	0.6%	0.0%	0.0%	0.4%	0.2%	0.1%	0.0%	0.3%
15.0-15.9 in	2.1%	1.1%	0.4%	0.3%	1.7%	1.3%	3.3%	0.2%	0.1%	1.7%	1.7%
16.0-16.9 in	6.2%	4.4%	3.4%	4.8%	5.0%	7.0%	16.7%	3.1%	1.6%	4.8%	3.5%
17.0-17.9 in	12.6%	5.9%	15.3%	10.3%	11.6%	11.4%	21.1%	8.3%	7.0%	17.4%	8.7%
18.0-18.9 in	17.5%	22.1%	27.5%	17.0%	17.5%	17.8%	20.7%	14.0%	16.6%	15.7%	16.7%
19.0-19.9 in	15.9%	18.0%	17.9%	12.8%	18.0%	16.9%	10.3%	14.0%	19.3%	14.8%	14.2%
20.0-20.9 in	12.3%	12.1%	11.1%	13.1%	17.0%	14.1%	8.6%	18.8%	16.9%	10.2%	10.4%
21.0-21.9 in	9.3%	6.6%	5.8%	14.1%	11.0%	10.8%	4.4%	13.3%	11.4%	7.6%	7.6%
22.0-22.9 in	7.0%	5.1%	6.6%	8.7%	6.6%	7.7%	4.2%	10.2%	10.1%	5.7%	6.3%
23.0-23.9 in	4.8%	8.5%	3.8%	5.1%	4.6%	3.5%	3.9%	7.1%	6.9%	6.3%	9.0%
24.0-24.9 in	3.6%	4.4%	3.0%	5.4%	2.9%	4.2%	3.3%	2.4%	3.9%	5.9%	6.9%
25.0-25.9 in	2.7%	4.4%	2.1%	4.5%	2.0%	3.1%	1.7%	2.6%	2.0%	3.9%	5.6%
26.0-26.9 in	2.1%	2.9%	1.3%	2.2%	1.1%	2.0%	0.9%	3.8%	2.0%	1.7%	4.5%
27.0-27.9 in	1.0%	0.7%	1.1%	0.6%	0.5%	0.2%	0.4%	1.0%	1.0%	2.0%	2.8%
28.0-28.9 in	0.7%	1.5%	0.4%	0.0%	0.1%	0.0%	0.0%	0.7%	0.6%	1.5%	0.7%
>28.9 in	0.5%	2.2%	0.4%	0.3%	0.4%	0.0%	0.2%	0.2%	0.4%	0.7%	1.0%
Percent fin clip composition of brown trout sampled April 15 - September 30:											
No Clips	75.4%	65.1%	67.2%	80.4%	86.6%	88.4%	81.4%	87.6%	88.7%	92.4%	91.0%
LV	1.9%	4.0%	5.5%	2.9%	2.0%	0.2%	3.0%	2.9%	1.2%	0.4%	1.0%
LV-Ad	4.0%	4.8%	7.5%	3.5%	1.9%	3.1%	6.1%	2.6%	0.6%	1.7%	1.0%
LP	2.8%	6.6%	3.6%	1.0%	0.3%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%
LP-Ad	4.1%	7.0%	4.1%	3.5%	2.6%	1.7%	1.1%	2.6%	4.3%	2.2%	2.1%
Ad	1.8%	6.3%	2.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
RV	4.0%	1.5%	4.0%	3.5%	2.8%	4.8%	4.4%	2.1%	0.6%	0.7%	3.5%
RV-Ad	0.4%	0.0%	0.8%	1.3%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
RP	4.4%	3.3%	3.0%	2.9%	2.0%	1.4%	2.6%	1.0%	2.6%	1.5%	1.0%
RP-Ad	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.2%	0.0%	0.1%	0.0%	0.0%
Misc.	1.2%	1.5%	2.1%	1.0%	1.7%	0.4%	0.9%	1.2%	1.9%	1.1%	0.3%
Percent age composition of brown trout sampled April 15 - September 30:											
Age-1	-	0.0%	0.0%	0.5%	0.0%	0.0%	0.2%	0.4%	0.0%	0.0%	0.0%
Age-2	-	66.0%	81.9%	72.5%	85.6%	78.9%	80.0%	80.6%	78.7%	74.6%	60.0%
Age-3	-	26.3%	14.4%	23.6%	11.6%	19.6%	17.2%	15.2%	17.2%	21.3%	34.6%
Age-4	-	5.3%	3.2%	3.4%	2.2%	1.0%	2.4%	3.4%	3.9%	3.3%	2.7%
Age-5+	-	2.4%	0.5%	0.0%	0.5%	0.5%	0.2%	0.4%	0.3%	0.7%	2.6%
Mean length (inches) of aged brown trout sampled in April 15-30:											
Age-2	-	17.9	18.1	17.8	18.4	17.7	17.4	18.2	18.6	17.9	18.0
Age-3	-	22.0	23.1	22.5	21.7	23.2	21.8	23.1	22.8	23.1	23.3

Table A19a. Lake trout harvest and catch data collected April 15 – September 30, 1985-2013.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	35,611	4,250	4,181	2,964	2,570	2,875	4,842	5,403	7,017	7,829	20,511
Catch	76,354	11,490	9,527	8,656	7,147	6,757	11,241	11,753	24,336	22,206	35,533
% Harvested	41.9	37.0	43.9	34.2	36.0	42.5	43.1	46.0	28.8	35.3	57.7
Monthly estimates of harvest for all fishing boats:											
April	3,179	136	0	215	555	15	388	188	255	1,442	1,393
May	6,891	473	264	1,173	345	594	190	2,461	840	2,311	6,311
June	6,670	557	940	560	1,142	387	501	262	1,478	1,456	4,455
July	10,501	2,298	913	86	122	1,229	254	1,845	2,266	1,216	4,346
August	7,301	739	2,000	930	390	465	3,026	648	1,871	899	2,066
September	1,068	47	64	0	15	184	483	0	308	505	1,941
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	7,377	657	489	309	963	602	190	739	1,751	1,417	1,605
West/Central	3,759	840	1,741	1,646	391	609	1,018	885	1,358	1,491	5,327
East/Central	8,843	554	361	73	115	209	317	1,552	1,950	2,134	6,602
East	15,633	2,199	1,590	936	1,101	1,454	3,318	2,227	1,959	2,786	6,977
Monthly estimates of catch for all fishing boats:											
April	7,110	1,490	30	1,728	765	15	1,235	464	885	3,823	1,955
May	13,614	1,759	1,910	2,855	2,993	1,539	2,558	5,660	8,956	8,397	12,288
June	14,206	1,696	1,615	1,193	1,457	927	1,395	552	3,789	3,533	7,818
July	23,230	3,685	2,166	1,688	371	2,276	705	3,247	7,626	2,871	7,971
August	15,970	2,253	3,676	1,151	1,285	1,712	4,699	1,678	2,484	2,903	3,178
September	2,224	606	129	40	275	288	649	151	596	679	2,323
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	19,922	4,107	3,362	2,968	3,962	2,924	2,387	2,095	11,226	6,487	5,219
West/Central	9,628	2,346	2,780	4,132	1,158	1,681	3,296	3,346	3,772	3,699	9,099
East/Central	18,132	1,690	956	461	265	289	1,120	3,079	6,419	6,121	11,400
East	28,673	3,346	2,428	1,094	1,763	1,864	4,438	3,233	2,920	5,899	9,815
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% Catch	99.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	59.1	77.7	69.7	93.7	56.7	81.3	88.7	69.6	64.9	67.2	77.9
% Catch	43.3	42.7	38.0	47.4	26.7	48.0	55.0	48.1	33.1	33.5	60.2

Table A19b. Lake trout harvest and catch rate data collected April 15 – September 30, 1985-2013. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.288	0.074	0.073	0.062	0.045	0.056	0.078	0.108	0.142	0.170	0.432
Catch/Boat Trip	0.654	0.200	0.166	0.181	0.124	0.132	0.181	0.235	0.491	0.482	0.748
Harv/Angler Trip	0.101	0.026	0.025	0.021	0.015	0.019	0.026	0.036	0.047	0.056	0.140
Catch/Angler Trip	0.227	0.070	0.056	0.061	0.042	0.044	0.059	0.077	0.165	0.160	0.242
Harv/Angler Hour	0.017	0.005	0.005	0.004	0.003	0.003	0.004	0.006	0.008	0.010	0.023
Catch/Angler Hr.	0.039	0.013	0.010	0.011	0.007	0.008	0.010	0.014	0.029	0.028	0.040
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.259	0.042	0.000	0.053	0.185	0.005	0.107	0.072	0.101	0.609	0.541
May	0.289	0.054	0.020	0.147	0.031	0.082	0.013	0.262	0.104	0.276	0.798
June	0.542	0.116	0.175	0.205	0.195	0.081	0.096	0.068	0.343	0.283	0.703
July	0.623	0.321	0.084	0.010	0.012	0.133	0.029	0.200	0.208	0.131	0.450
August	0.231	0.039	0.142	0.064	0.023	0.028	0.199	0.036	0.132	0.070	0.130
September	0.054	0.003	0.005	0.000	0.001	0.017	0.033	0.000	0.032	0.063	0.378
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.217	0.059	0.034	0.028	0.060	0.048	0.010	0.052	0.119	0.112	0.117
West/Central	0.311	0.144	0.244	0.241	0.056	0.142	0.132	0.159	0.269	0.267	0.803
East/Central	0.249	0.031	0.021	0.004	0.007	0.012	0.017	0.093	0.129	0.157	0.433
East	0.412	0.097	0.086	0.071	0.061	0.084	0.200	0.165	0.134	0.196	0.584
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.820	0.465	0.013	0.429	0.255	0.005	0.342	0.178	0.351	1.616	0.759
May	0.621	0.200	0.148	0.359	0.272	0.212	0.174	0.602	1.113	1.001	1.553
June	1.193	0.355	0.301	0.437	0.249	0.195	0.268	0.142	0.879	0.688	1.234
July	1.370	0.515	0.199	0.204	0.036	0.246	0.081	0.352	0.699	0.310	0.826
August	0.516	0.117	0.261	0.079	0.077	0.104	0.309	0.093	0.176	0.225	0.200
September	0.112	0.042	0.011	0.004	0.025	0.027	0.045	0.022	0.062	0.085	0.452
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.661	0.368	0.234	0.269	0.246	0.235	0.129	0.147	0.763	0.512	0.382
West/Central	0.847	0.401	0.389	0.605	0.166	0.392	0.427	0.600	0.747	0.662	1.372
East/Central	0.521	0.095	0.055	0.027	0.016	0.017	0.058	0.184	0.424	0.450	0.747
East	0.772	0.148	0.131	0.083	0.098	0.107	0.268	0.240	0.199	0.415	0.821
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	1.187	0.350	0.323	0.314	0.159	0.268	0.435	0.440	0.552	0.690	1.724
Catch/Boat Trip	1.989	0.520	0.401	0.463	0.208	0.372	0.626	0.662	0.976	0.975	2.309
Harv/Angler Trip	0.242	0.070	0.063	0.062	0.031	0.051	0.086	0.084	0.106	0.135	0.331
Catch/Angler Trip	0.400	0.104	0.079	0.092	0.041	0.071	0.123	0.127	0.187	0.191	0.444
Harv/Angler Hour	0.033	0.010	0.010	0.009	0.004	0.007	0.012	0.013	0.017	0.020	0.048
Catch/Angler Hr.	0.054	0.015	0.012	0.014	0.006	0.010	0.018	0.020	0.029	0.029	0.064
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.156	0.020	0.026	0.005	0.023	0.013	0.010	0.040	0.060	0.067	0.119
Catch/Boat Trip	0.443	0.137	0.122	0.117	0.108	0.083	0.097	0.147	0.394	0.384	0.370
Harv/Angler Trip	0.061	0.008	0.010	0.002	0.009	0.005	0.004	0.015	0.024	0.026	0.046
Catch/Angler Trip	0.173	0.056	0.048	0.047	0.042	0.033	0.036	0.057	0.155	0.148	0.143
Harv/Angler Hour	0.011	0.002	0.002	0.000	0.002	0.001	0.001	0.003	0.004	0.005	0.008
Catch/Angler Hr.	0.032	0.011	0.009	0.009	0.008	0.006	0.006	0.011	0.029	0.028	0.025

Table A20. Length and weight statistics for lake trout sampled April 15 - September 30 during the 1985-2013 NYSDEC Lake Ontario fishing boat surveys.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Mean length and weight of lake trout sampled April - September:											
Mean Length (in)	25.0	25.7	26.8	24.5	26.8	26.5	25.1	23.4	25.5	26.3	25.9
Mean weight (lbs)	-	7.21	8.24	6.28	8.61	8.03	6.81	5.71	7.37	8.00	7.41
Percent length composition of lake trout sampled April - September:											
<15.0 inches	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.0%	0.0%	0.0%
15-15.9 inches	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.0%	0.0%	0.0%
16-16.9 inches	0.4%	0.0%	0.0%	0.0%	1.9%	0.0%	1.3%	1.6%	0.0%	0.0%	0.4%
17-17.9 inches	1.2%	0.0%	2.6%	0.0%	1.9%	0.0%	0.0%	4.1%	0.8%	0.9%	2.5%
18-18.9 inches	1.6%	2.8%	0.0%	2.6%	1.9%	0.0%	3.8%	7.3%	2.5%	3.4%	2.9%
19-19.9 inches	3.6%	4.2%	2.6%	10.3%	3.8%	2.0%	10.1%	2.4%	4.2%	1.7%	2.5%
20-20.9 inches	4.9%	7.0%	2.6%	7.7%	5.7%	0.0%	7.6%	10.6%	4.2%	2.6%	3.6%
21-21.9 inches	8.7%	7.0%	2.6%	5.1%	5.7%	6.0%	3.8%	13.0%	6.7%	6.8%	4.7%
22-22.9 inches	10.9%	12.7%	10.5%	2.6%	3.8%	14.0%	3.8%	9.8%	7.5%	4.3%	4.3%
23-23.9 inches	13.5%	14.1%	5.3%	20.5%	3.8%	14.0%	3.8%	14.6%	10.8%	3.4%	6.1%
24-24.9 inches	13.9%	11.3%	18.4%	15.4%	5.7%	6.0%	10.1%	4.9%	8.3%	6.8%	8.7%
25-25.9 inches	9.8%	5.6%	7.9%	17.9%	3.8%	6.0%	11.4%	3.3%	15.0%	14.5%	10.5%
26-26.9 inches	6.1%	0.0%	7.9%	2.6%	3.8%	6.0%	5.1%	5.7%	7.5%	11.1%	8.7%
27-27.9 inches	3.1%	0.0%	2.6%	0.0%	9.4%	10.0%	17.7%	1.6%	11.7%	15.4%	15.5%
28-28.9 inches	2.4%	1.4%	0.0%	0.0%	13.2%	12.0%	8.9%	7.3%	1.7%	5.1%	10.8%
29-29.9 inches	3.5%	11.3%	2.6%	0.0%	11.3%	6.0%	1.3%	4.1%	2.5%	4.3%	7.9%
30-30.9 inches	6.1%	1.4%	7.9%	5.1%	9.4%	4.0%	3.8%	4.1%	4.2%	7.7%	4.7%
31-31.9 inches	4.6%	8.5%	7.9%	2.6%	7.5%	0.0%	2.5%	1.6%	3.3%	7.7%	1.8%
32-32.9 inches	2.3%	2.8%	7.9%	2.6%	0.0%	6.0%	3.8%	2.4%	5.0%	0.9%	2.2%
33-33.9 inches	1.9%	5.6%	2.6%	2.6%	0.0%	4.0%	1.3%	0.0%	1.7%	0.0%	1.1%
34-34.9 inches	0.9%	2.8%	7.9%	0.0%	1.9%	2.0%	0.0%	0.0%	1.7%	2.6%	1.1%
>34.9 inches	0.3%	1.4%	0.0%	2.6%	5.7%	2.0%	0.0%	0.0%	0.8%	0.9%	0.0%
30.0+ inches	16.2%	22.5%	34.2%	15.4%	24.5%	18.0%	11.4%	8.1%	16.7%	19.7%	10.8%
25.0-29.9 inches	24.8%	18.3%	21.1%	20.5%	41.5%	40.0%	44.3%	22.0%	38.3%	50.4%	53.4%

Note: Size groups enclosed by the box indicate lake trout theoretically protected from harvest in New York waters of Lake Ontario by the NYSDEC slot limit (25 to <30 inches). Most of these "illegal" fish are within one inch of either side of the slot limit and likely result from measurement errors by the anglers. Also, the fishing boat survey does sample a few fish captured in Canadian waters but landed at New York locations, and which are not protected from harvest by the DEC slot limit. From 1985-1992 a variety of size limits were in effect in New York waters. In 1985-1987, there was only a small minimum size limit in effect. In 1988, and the first half of the 1989 fishing season, the 25 to <30 inch slot limit was in effect. During the second half of the 1989 fishing season, and from 1990-1992, there was a 27 to <30 inch slot limit. From 1993-2006, the 25 to <30 inch slot limit was reinstated. In October 2006, the lake trout creel limit was reduced from three fish per angler per day to two fish, while allowing one of the two fish per angler to be between 25 to <30 inches.

Table A21a. Smallmouth bass harvest and catch data collected April 15 – September 30, 1985-2013.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	51,753	34,380	32,816	17,759	19,058	11,104	6,833	4,892	6,442	5,683	7,536
Catch	265,962	178,472	145,172	73,781	78,661	50,727	30,494	18,048	25,795	24,032	21,446
% Harvested	20.7	19.3	22.6	24.1	24.2	21.9	22.4	27.1	25.0	23.6	35.1
Monthly estimates of harvest for all fishing boats:											
April	1	0	34	0	0	0	2	0	0	0	0
May	64	0	0	0	0	0	0	0	0	0	0
June	8,578	4,281	7,186	3,392	2,651	4,721	1,565	1,258	268	1,178	1,073
July	15,424	7,817	8,571	6,240	7,280	2,084	647	1,643	668	2,702	3,846
August	17,928	16,442	10,012	7,139	5,987	2,687	1,695	1,727	3,331	1,377	853
September	9,758	5,840	7,013	989	3,139	1,612	2,923	265	2,176	426	1,764
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	4,095	231	382	384	1,048	882	163	182	254	800	556
West/Central	3,692	438	2,105	320	626	376	108	43	261	36	48
East/Central	26,366	16,404	22,220	5,864	9,579	3,522	3,250	1,785	700	1,940	1,214
East	17,601	17,306	8,109	11,191	7,805	6,324	3,312	2,882	5,227	2,907	5,718
Monthly estimates of catch for all fishing boats:											
April	483	395	236	1,955	91	979	240	136	22	82	438
May	6,770	3,744	5,883	691	915	1,180	1,264	483	1,299	1,558	350
June	33,965	20,491	30,540	11,643	15,557	16,685	5,734	2,159	1,604	4,987	2,859
July	84,846	47,252	40,646	28,348	19,726	12,168	3,983	4,437	8,026	9,561	10,239
August	95,908	62,295	43,948	24,084	32,958	13,757	11,115	8,571	10,407	5,611	2,732
September	43,990	44,294	23,919	7,060	9,414	5,958	8,159	2,263	4,437	2,234	4,829
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	25,729	7,239	3,204	2,825	6,354	6,400	1,610	2,565	2,459	5,768	3,009
West/Central	39,397	22,412	21,694	3,664	10,043	2,140	2,143	384	799	1,048	634
East/Central	133,688	86,978	83,054	40,039	42,400	22,653	15,862	9,462	5,830	6,648	5,916
East	67,148	61,843	37,219	27,253	19,864	19,534	10,878	5,638	16,706	10,567	11,888
Percent of seasonal harvest and catch made by boats seeking smallmouth bass during the **traditional open season**:											
% Harvest	92.0	93.3	96.1	96.4	92.8	87.6	69.0	83.8	96.4	88.5	94.5
% Catch	87.4	88.2	89.9	89.7	79.7	77.7	58.2	62.6	78.1	85.9	86.4
Estimates of catch by boats seeking smallmouth bass during the **catch and release season**:											
April		-	-	-	0.0	0.0	0.0	0.0	0	0	0
May		-	-	-	0.0	196	422	28	0	196	0
June		-	-	-	3482.0	88	24	55	502	24	146
Total		-	-	-	3482	284	446	83	502	220	146
Percent of seasonal catch made by boats seeking smallmouth bass during the **catch and release season**:											
% Catch		-	-	-	4.42659	0.6	1.5	0.5	1.9	0.9	0.7

Table A21b. Smallmouth bass harvest and catch rate data collected April 15 – September 30, 1985-2013.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Seasonal rates of harvest and catch for boats seeking smallmouth bass during the **traditional open season**:											
Harv/Boat Trip	2.074	1.435	1.426	1.260	1.219	0.760	0.544	0.700	0.992	0.811	1.667
Catch/Boat Trip	9.935	7.044	5.905	4.873	4.323	3.082	2.047	1.928	3.219	3.327	4.337
Harv/Angler Trip	0.897	0.637	0.668	0.553	0.534	0.341	0.250	0.339	0.451	0.372	0.784
Catch/Angler Trip	4.327	3.125	2.765	2.140	1.893	1.380	0.939	0.933	1.464	1.528	2.040
Harv/Angler Hour	0.264	0.200	0.215	0.178	0.171	0.117	0.097	0.126	0.145	0.120	0.226
Catch/Angler Hr.	1.279	0.981	0.891	0.689	0.606	0.472	0.363	0.346	0.471	0.492	0.587
Monthly harvest rates per boat trip for boats seeking smallmouth bass during the **traditional open season**:											
April & May	-	-	-	-	-	-	-	-	-	-	-
June	1.860	1.679	1.474	1.069	0.885	1.807	0.877	1.948	0.259	0.701	1.188
July	1.783	0.920	1.078	1.006	1.460	0.401	0.125	0.694	0.225	0.943	2.716
August	2.323	2.003	1.554	1.907	1.152	0.702	0.399	0.498	1.886	0.829	0.823
September	2.371	1.122	1.889	0.902	1.283	0.530	1.070	0.305	2.353	0.585	1.384
Seasonal harvest rates per boat trip among geographic areas for boats seeking smallmouth bass during the **traditional open season**:											
West	1.326	0.189	0.233	0.314	0.521	0.783	0.118	0.169	0.312	0.605	1.577
West/Central	0.929	0.109	0.608	0.144	0.238	0.107	0.074	0.065	0.333	0.000	0.085
East/Central	2.203	1.352	1.857	0.862	1.306	0.538	0.584	0.388	0.209	0.720	0.991
East	2.797	2.675	1.422	2.688	2.055	1.470	1.053	2.013	2.761	1.449	2.454
Monthly catch rates per boat trip for boats seeking smallmouth bass during the **traditional open season**:											
April & May	-	-	-	-	-	-	-	-	-	-	-
June	6.197	5.979	5.725	3.625	2.514	6.279	2.796	2.907	0.612	2.940	2.256
July	9.589	5.450	5.057	4.568	3.690	2.148	0.932	1.581	2.871	3.766	7.177
August	11.986	7.535	6.861	6.221	6.358	2.628	2.236	2.058	4.803	3.210	2.326
September	10.230	9.367	6.334	5.235	3.606	2.473	2.701	1.779	3.944	3.016	3.759
Seasonal catch rates per boat trip among geographic areas for boats seeking smallmouth bass during the **traditional open season**:											
West	7.260	4.584	1.681	1.463	2.758	5.000	0.796	1.605	1.450	5.397	6.534
West/Central	8.507	6.209	6.088	1.470	2.292	0.732	1.031	0.514	0.739	0.534	1.043
East/Central	10.709	6.140	6.285	5.278	5.434	2.881	2.499	1.545	1.103	2.086	4.285
East	10.137	9.788	6.246	6.545	4.428	4.329	2.748	3.585	8.264	5.204	4.862
Seasonal catch rates for boats seeking smallmouth bass during the **catch and release season**:											
Catch/Boat Trip		-	-	-	7.020	0.774	0.693	0.284	2.100	0.422	0.764
Catch/Angler Trip		-	-	-	3.831	0.402	0.417	0.153	1.887	0.170	0.327
Catch/Angler Hr.		-	-	-	1.625	0.151	0.181	0.099	1.035	0.072	0.188
Monthly catch rates per boat trip for boats seeking smallmouth bass during the **catch and release season**:											
April		-	-	-	-	-	-	-	-	-	-
May		-	-	-	0.000	5	1.323	0.118	0.000	1	0.000
June		-	-	-	9.949	0.272	0.074	1.000	2.523	0.127	1.390

Table A22. Yellow perch harvest and catch data collected April 15 – September 30, 1985-2013.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	7,972	18,380	8,942	13,858	25,630	33,589	51,653	18,405	31,830	16,701	6,572
Catch	16,333	39,026	33,209	39,801	87,736	67,342	102,442	61,816	65,394	35,836	15,345
% Harvested	55.7	47.1	26.9	34.8	29.2	49.9	50.4	29.8	48.7	46.6	42.8
Monthly estimates of harvest for all fishing boats:											
April	10	0	0	0	0	29	0	1,198	0	2,653	972
May	1,040	29	1,588	0	1,220	1,357	0	7,656	112	4,203	2,016
June	1,347	1,464	2,933	7,360	7,566	10,349	34,963	3,665	2,194	6,116	973
July	2,062	2,202	486	1,476	5,039	3,612	2,810	1,906	5,637	1,913	304
August	1,296	8,617	232	2,233	5,149	6,114	7,816	3,648	16,979	1,755	2,040
September	2,216	6,069	3,703	2,789	6,656	12,128	6,064	332	6,908	61	267
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	2,119	119	3,575	521	15	61	0	468	0	14	0
West/Central	780	3,420	110	1,240	908	3,824	1,035	1,080	30	2,816	1,136
East/Central	3,489	14,564	4,979	8,499	24,252	26,845	19,372	9,762	22,363	7,814	4,227
East	1,584	277	278	3,598	454	2,858	31,246	7,094	9,438	6,057	1,209
Monthly estimates of catch for all fishing boats:											
April	50	0	30	186	0	69	143	1,962	0	5,293	2,172
May	1,641	145	6,152	462	5,980	3,443	95	37,864	112	10,211	4,420
June	3,196	5,773	12,984	16,614	17,363	25,153	52,025	5,287	5,055	13,440	1,921
July	3,698	6,154	7,733	10,323	16,158	8,637	10,792	4,371	14,419	2,508	923
August	3,417	14,488	1,261	3,631	18,513	10,494	23,739	11,735	29,676	4,298	5,642
September	4,332	12,466	5,049	8,585	29,722	19,545	15,648	596	16,132	86	267
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	2,824	465	5,263	1,737	1,405	77	2,444	906	0	49	0
West/Central	1,594	7,209	2,314	3,232	2,878	5,999	1,749	2,026	193	4,384	3,890
East/Central	8,732	30,324	23,855	26,915	78,438	51,333	58,517	40,091	50,878	20,510	9,527
East	3,182	1,027	1,777	7,917	5,016	9,933	39,732	18,793	14,323	10,893	1,928

Table A23. Walleye harvest and catch data collected April 15 – September 30, 1985-2013.

	Year Surveyed										
	1985-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	595	352	2,465	164	1,403	116	123	106	458	130	318
Catch	733	443	2,715	408	4,508	130	147	301	531	130	388
% Harvested	74.0	79.5	90.8	40.2	31.1	89.2	83.7	35.2	86.3	100.0	82.0
Monthly estimates of harvest for all fishing boats:											
April	0	0	0	0	0	0	0	0	0	0	0
May	110	0	106	73	0	28	14	0	16	50	0
June	49	280	0	0	1,112	32	0	0	26	0	23
July	53	0	0	15	114	28	0	0	88	80	0
August	274	72	2,340	15	77	28	109	44	160	0	27
September	108	0	19	62	101	0	0	62	168	0	267
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	61	29	0	72	187	29	44	106	86	84	0
West/Central	2	0	0	0	45	32	0	0	0	22	21
East/Central	59	0	24	77	34	56	14	0	0	0	0
East	473	323	2441	15	1137	0	66	0	372	24	297
Monthly estimates of catch for all fishing boats:											
April	9	91	0	31	0	0	10	0	15	0	0
May	128	0	146	286	0	28	28	0	16	50	0
June	59	280	0	0	3,991	32	0	0	26	0	23
July	92	0	47	15	142	28	0	0	147	80	70
August	326	72	2,458	15	199	42	109	213	160	0	27
September	119	0	64	62	176	0	0	87	168	0	267
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	92	29	132	286	413	43	47	180	142	84	59
West/Central	4	0	0	0	62	32	0	0	0	22	22
East/Central	86	92	24	107	66	55	29	0	20	0	0
East	550	322	2559	15	3967	0	71	121	369	24	306

Table A24. Estimates of sea and silver lampreys observed by boat anglers April 15 – September 30, 1986-2013.

	Year Surveyed										
	1986-03 avg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Monthly and seasonal estimates of lampreys observed:											
April	223	31	355	138	564	87	218	429	558	575	68
May	558	624	2,033	731	2,117	688	1,769	551	1,618	1,266	835
June	315	330	800	178	1,059	296	150	372	769	294	353
July	306	636	891	1,288	2,147	390	1,358	486	1,155	460	789
August	511	1,170	1,120	1,173	2,009	954	1,142	697	842	707	829
September	115	356	1,072	381	528	399	526	64	184	138	53
Total	2,029	3,147	6,272	3,889	8,423	2,814	5,164	2,599	5,125	3,441	2,927
Seasonal estimates of lampreys observed among four geographic areas:											
West	864	1,146	1,881	1,381	2,830	1,194	2,026	946	1,163	1,147	969
West/Central	266	283	654	530	713	18	540	338	565	609	396
East/Central	514	804	1,865	1,572	3,051	845	2,126	799	1,812	1,007	1,242
East	385	914	1,872	406	1,829	757	472	516	1,585	678	320
Percentage of lampreys observed that were attached to angler caught trout and salmon:											
Percent	99.1%	100.0%	98.5%	98.3%	98.5%	98.3%	97.0%	98.9%	96.8%	97.9%	98.4%
Monthly and seasonal estimates of lampreys attached to angler caught trout & salmon, per 1000 trout & salmon caught:											
April	8.96	6.10	48.50	14.74	39.57	23.32	19.36	48.73	45.60	29.72	9.28
May	11.60	18.46	43.89	25.51	41.48	27.82	23.08	26.78	45.50	34.03	22.70
June	10.40	26.83	41.34	33.17	50.56	23.58	12.67	19.85	34.61	12.13	17.58
July	9.01	22.81	33.20	56.32	58.84	16.74	38.27	10.50	14.04	10.83	19.18
August	9.07	21.32	27.05	31.11	42.18	22.87	20.45	11.08	16.68	12.63	15.41
September	5.92	20.01	40.52	22.65	26.98	20.28	16.30	6.34	9.57	7.95	5.46
Total	9.60	20.74	37.40	32.20	44.35	22.39	23.12	15.53	23.09	17.50	17.34
Seasonal estimates of lampreys attached to angler caught trout & salmon by geographic area, per 1000 trout & salmon caught:											
West	11.3	21.3	30.2	29.9	36.7	20.8	19.5	13.1	12.4	15.6	14.3
West/Central	10.1	15.0	27.3	31.1	34.6	2.3	17.9	15.3	25.6	23.2	15.0
East/Central	8.4	17.0	48.6	37.2	53.1	27.2	34.2	15.4	26.9	20.5	25.3
East	8.5	29.0	43.4	26.5	52.7	25.8	17.5	24.0	40.8	14.2	12.6
Seasonal percent composition of salmonine host species to which the lampreys were attached:											
Coho Salmon	2.6%	1.0%	1.6%	2.7%	3.4%	4.3%	2.6%	3.2%	3.4%	2.9%	1.6%
Chinook Salmon	34.6%	74.3%	60.4%	78.8%	58.6%	64.3%	73.1%	51.6%	37.4%	60.0%	68.8%
Rainbow Trout	7.4%	8.9%	5.2%	3.5%	5.6%	10.4%	10.9%	14.0%	5.6%	8.6%	5.6%
Atlantic Salmon	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.2%	0.0%	2.1%	0.0%
Brown Trout	16.6%	13.9%	28.6%	14.2%	31.7%	20.0%	13.5%	26.9%	47.5%	22.1%	13.6%
Lake Trout	38.2%	2.0%	4.2%	0.9%	0.7%	0.9%	0.0%	1.1%	6.1%	4.3%	10.4%
Seasonal proportion of total host-specific angler catch with attached lampreys:											
Coho Salmon	0.56%	0.63%	1.09%	0.83%	1.08%	1.76%	0.59%	0.64%	1.40%	0.77%	0.59%
Chinook Salmon	1.15%	2.54%	3.63%	5.05%	5.69%	3.11%	3.54%	2.14%	1.90%	2.27%	3.14%
Rainbow Trout	0.62%	1.39%	2.38%	0.75%	1.78%	0.83%	0.98%	0.78%	0.76%	0.88%	0.46%
Atlantic Salmon	5.52%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.54%	0.00%	12.19%	0.00%
Brown Trout	0.85%	1.90%	5.41%	2.46%	5.65%	2.45%	1.97%	2.12%	4.74%	1.89%	1.40%
Lake Trout	1.19%	0.54%	2.70%	0.39%	0.86%	0.35%	0.00%	0.24%	1.25%	0.65%	0.84%

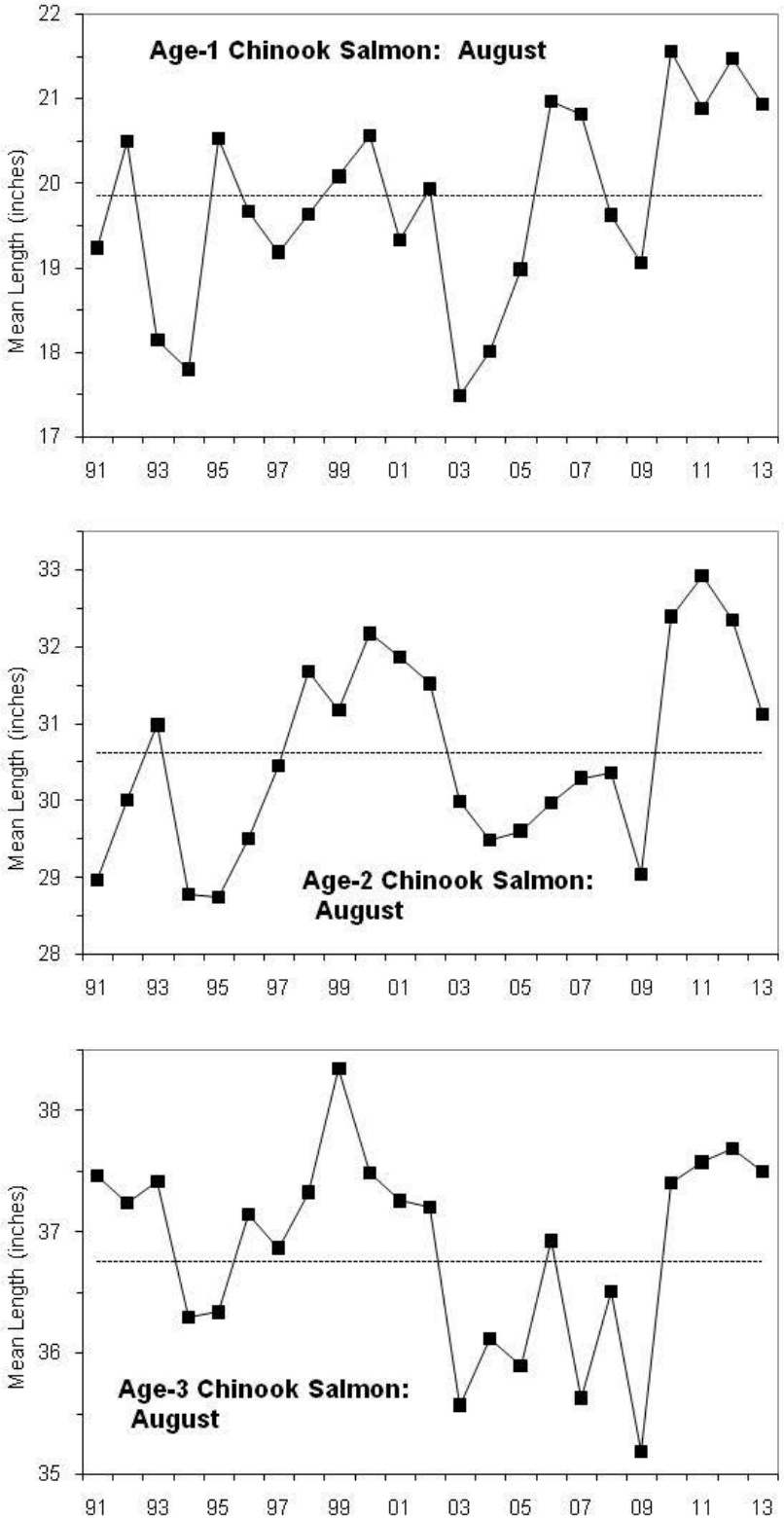

Figure A1. Mean length (total length in inches) of age-1, age-2, and age-3 Chinook salmon sampled in August during the 1991-2013 NYSDEC Lake Ontario fishing boat surveys.

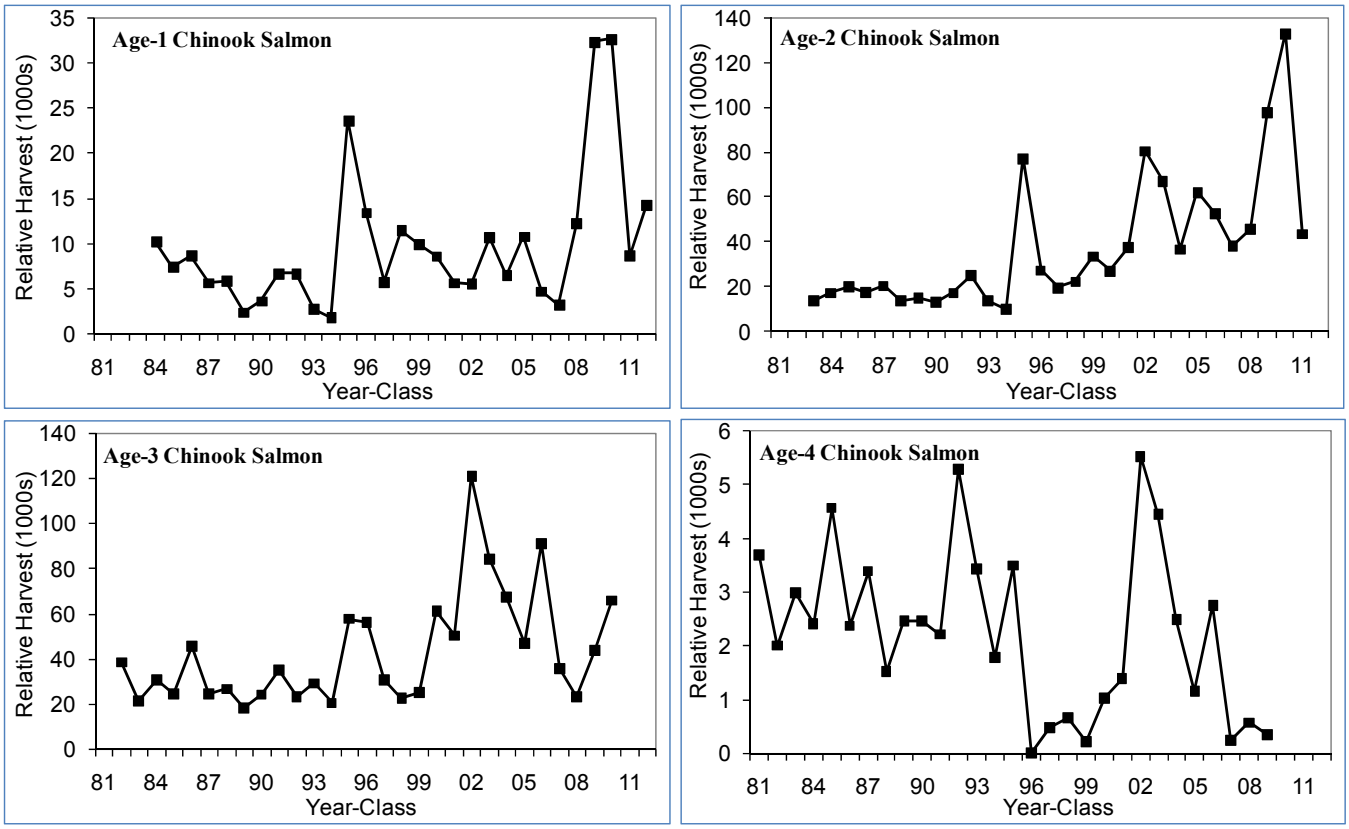

Figure A2. Relative harvest (age-specific harvest per 150,000 fishing boat trips, per 2,000,000 fingerling equivalents stocked) of age-1, age-2, age-3, and age-4 Chinook salmon from the 1985-2013 NYSDEC Lake Ontario fishing boat surveys.

Update on Mass Marking Studies of Chinook Salmon in Lake Ontario 2013

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Chinook salmon (*Oncorynchus tshawytscha)* is the top predator in Lake Ontario and supports a multi-million dollar sportfishery in New York State and the Province of Ontario, Canada. Each year the New York State Department of Environmental Conservation (NYSDEC) and the Ontario Ministry of Natural Resources (OMNR) stock 2.3 million Chinook salmon into Lake Ontario at dozens of sites around the lake. An unknown number of wild smolts are also produced in tributaries from natural spawning, but it was unknown how many of these wild fish survive and contribute to the sportfishery (Everitt 2006, Bishop et al. 2010). It is important for fisheries managers to know the relative contributions of hatchery and wild salmon in the lake to better understand how their stocking decisions can influence Chinook salmon population dynamics and predator/prey balance in Lake Ontario.

Each fall, adult Chinook salmon return to Lake Ontario tributaries for spawning. NYSDEC maintains a "broodstock" collection site at the Salmon River Hatchery (SRH) near Altmar, NY (Figure 1) where eggs are collected from adult salmon after they enter the hatchery through a series of fish ladders. Fertilized eggs are incubated and typically hatch in late December, and the salmon fry are raised until springtime when they are stocked as fingerlings at sites around the lake. NYSDEC aims to stock fingerlings prior to smolting, a stage when the fish undergo a physical transformation and "imprint" or memorize a complex map of smells that helps them return to spawn at the site where they smolted. NYSDEC stocking strategies attempt to balance the assumed benefits of higher survival gained by stocking larger fish against stocking fish prior to smolting so these fish will imprint and later "home to" their stocking sites rather than to the hatchery. Maximizing homing and minimizing straying is very important for providing a late-summer lake fishery and a fall tributary fishery at stocking sites around the lake.

NYSDEC must also maintain a sufficient number of spawners returning to the SRH so that egg collection and stocking targets can be sustained. NYSDEC stocks about 350,000 Chinook salmon at the Salmon River annually to maintain runs that provide eggs. Fingerlings for Salmon River broodstock are held at the hatchery until after smolting occurs to increase imprinting to the hatchery, and these are stocked at the mouth of the River in June. Fingerlings stocked at other sites around the lake are stocked in April-May, prior to smolting. The degree that stocked fish stray or home to broodstock waters or to other stocking sites in Lake Ontario and the inter-annual or among-site variation is unknown. This information is, however, important for fisheries managers to evaluate current stocking strategies in meeting fisheries objectives.

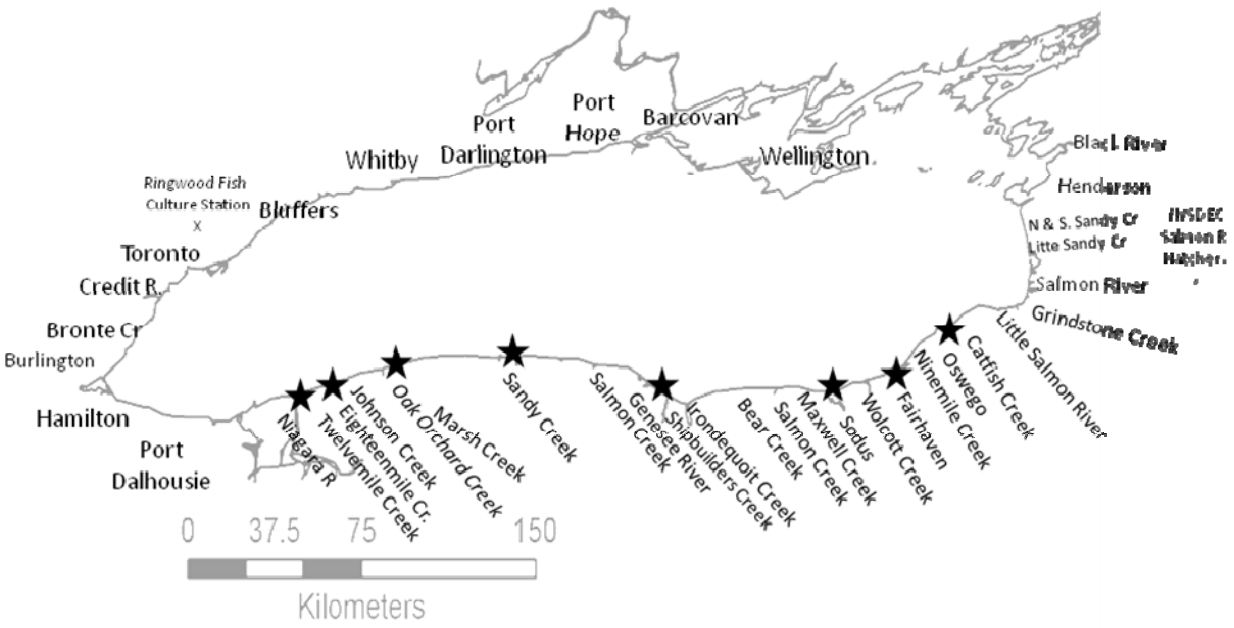

Figure 1. Map of Lake Ontario showing sampling regions and other locations in this report. Sites where Chinook salmon were raised in pens are noted with stars.

One strategy that NYSDEC has been using since 1998 to increase imprinting and survival of stocked fish is pen stocking, a technique in which small Chinook salmon (140 fish/lb, ~3.0 g.) are transported from the hatchery to net pens at sites around the lake, and raised for about 3 weeks until they reach a target size (i.e., 90 fish/lb, ~5 g). Chinook salmon pen projects exist at eight sites in New York (Figure 1) at which volunteers feed and care for the fish during the pen--rearing period (see Wilkinson et al. 2014). Chinook salmon raised in net pens are typically released at larger sizes than salmon stocked directly from the hatchery on about the same date because temperatures and rearing densities in pens are better for growth. Pen-reared salmon also become better acclimated to environmental conditions at stocking sites and are assumed to exhibit higher survival and better imprinting to the stocking site. Evaluations of pen stocked Chinook salmon in New York were conducted at Oak Orchard and Niagara from 1999-2002 and showed pen fish returned significantly better than direct stocked fish at Oak Orchard, but not at Niagara (Bishop et al. 2006). The experimental design of that study was somewhat restricted because fish were manually fin clipped for stocking at only one of the two sites for each year class (YC) studied (1999 and 2001 YC at Oak Orchard, 2000 and 2002 YCs at Niagara River), prohibiting comparisons between sites for the same YC. Furthermore salmon were only recovered at Oak Orchard Creek and the Niagara River, so relative contributions to the lake fishery (i.e. relative survival of pen and shore stocked fish) were not determined. It was unknown whether returns to the tributaries were due to higher survival or better imprinting, or both. This study is the first comprehensive evaluation of New York's eight pen projects (locations in Figure 1).

In 2008, NYSDEC purchased an automated fish-marking trailer (AutoFish) from Northwest Marine Technology Incorporated. The AutoFish system is capable of clipping the adipose (AD) fin and/or applying coded wire tags (CWTs) to salmon and trout automatically at a high rate of speed and accuracy (referred to as "mass marking"). Mass marking allows agencies to quickly mark millions of salmon and trout with relatively little effort, enabling the execution of studies that were previously not feasible. Study objectives were: 1) to determine the relative proportion of wild and hatchery Chinook salmon in the Lake Ontario angler harvest; 2) to determine the relative degree of homing and straying to the SRH; and 3) to compare the relative contributions of pen vs. direct stocked Chinook salmon to the lake and tributary fisheries.

The results reported here provide preliminary observations on the relative contributions of wild and hatchery Chinook salmon to the Lake Ontario fishery for the 2008-2011 year classes; the degree of homing and straying by stocked and wild fish to the SRH (2008-2010 YC); and the relative contributions of pen vs. direct stocked salmon for the 2010 YC (results for the 2011 and 2013 YCs will be presented in future years). A better understanding of the range and variability of wild reproduction, homing and straying will develop as these YC of marked fish are examined throughout their entire life cycle.

Methods

To determine the proportions of wild and hatchery Chinook salmon in Lake Ontario, all Chinook salmon stocked by New York and Ontario of the 2008-2011 YCs were marked with an adipose fin (AD) clip[1]. Those fish captured later in the fishery or in the hatchery without an AD clip were considered wild. The combined annual stocking target for Lake Ontario was 2.3 million Chinook salmon during the study period (NY: 1.76 million from SRH; ON: 550K from Ringwood Hatchery); however, conditions at SRH led to unplanned stocking reductions in 2008 and 2010, with 799,000 and 1.583 million Chinook salmon stocked by New York in 2008 and 2010, respectively (Bishop and Prindle 2008, Connerton 2012). OMNR stocked their annual target of approximately 550,000 in 2008 and 2009, and stocked 669,442 fish in 2010 that included an additional 96,653 surplus fish (marked with AD clip and CWT) stocked in the Niagara River (OMNR 2011). CWTs are 1/25 inch (1.1 mm) long and are inserted into the salmon's snout prior to stocking. A number engraved on the CWT identifies a fish's stocking origin.

To determine the degree of homing and straying to SRH (i.e. the broodstock water), fish stocked at the Salmon River, NY received AD clips and unique CWTs from 2008-2010. Fish stocked at other stocking sites in NY and ON were marked with an AD clip only or an AD clip and some other unique CWT. Despite the unplanned stocking reductions in New York in 2008 (by 50%) and in 2010 (by 12%), stocking levels at Salmon River were maintained in those years at about 350,000 fish to ensure adequate future broodstock returns to SRH and consistency across study years (Table 1).

Table 1. Numbers (1000s) of mass marked Chinook salmon stocked by Ontario and New York in Lake Ontario from 2008-2013. (AD=adipose clip, AD-CWT=adipose clip+tag).

Stocking	Mark	2008	2009	2010	2011	2012	2013
New York						-	
Salmon R.	AD-CWT	356	360	339	-	-	-
	AD	-	-	-	356	-	-
	No Mark	-	-	-	-	360	360
Pen Sites	AD-CWT	-	-	431	433	-	394
	AD	233	314	76	75	-	58
	No Mark	-	-	-	-	498	55
Direct Sites	AD-CWT	-	-	420	418	-	386
	AD	210	1084	264	487	-	-
	No Mark	-	-	-	-	653	519
Ontario							
Credit R.	AD-CWT	85	20	21	21	-	-
	AD	-	75	65	78	-	-
	No Mark					97	100
Other Sites	AD	442	351	381	380	-	-
	AD-CWT	-	101	202	104	-	-
	No Mark	-	-	-	-	514	607
Total		1326	2305	2200	2352	2122	2479

Note: For details regarding numbers stocked at individual sites see OMNR Lake Ontario Management Unit and NYSDEC Lake Ontario Unit Annual Reports 2008-2013.

To evaluate the relative contribution of pen and direct stocked Chinook salmon to the lake and tributary fisheries in New York, salmon were AD clipped and tagged with unique CWTs at each of eight pen and direct stocked sites (16 total) from 2010-2011, and in 2013 (Table 2). Different sites have different numbers of salmon allocated to pen and direct stocking, and different numbers of pens. NYSDEC regional managers established allocations at sites years prior to conducting the study. Allocations depended on the site conditions, the size of local fisheries, and abilities of volunteers to care for fish and pens. In the hatchery, Chinook parr were normally held at 37,500 fish per raceway tank which also constrained our design somewhat. We designed the study so that the initial numbers of marked fish between treatments were approximately 1:1 to minimize recapture sample size requirements (Elrod and Frank 1990), and to maintain consistency with usual hatchery practices and stocking allocations.

[1]Fish stocked in pens in the Province of Ontario from 2008-2011 were hand-clipped because the marking trailer was transported to Ontario after the normal pen stocking period in early April. All other hatchery fish in Ontario waters and NY were processed by the AutoFish trailer. Total number of fish stocked into pens in Ontario was 25,485 fish in 2008, 39,148 in 2009, 81,141 in 2010, and 72,603 in 2011.

Table 2. Approximate[+] numbers of AD clipped and coded-wire-tagged Chinook salmon stocked into pens or directly from the hatchery each year 2010-2011, and in 2013 for evaluating pen- vs. direct stocking methods.

	Pen Stocked						Direct Stocked				
Site	**# CWT fish**	**AD only**	**Pen Total**	**#lots**	**# Pens**	**Pen Density**	**#CWT Fish**	**AD only**	**Direct Total**	**#lots**	**Total**
Black River	-	-	-	-	-	-	-	159,000	159,000	-	159,000
South Sandy	-	-	-	-	-	-	-	100,000	100,000	-	100,000
Salmon River	-	-	-	-	-	-	-	352,000	352,000	-	352,000
Oswego River	37,500	4,390	41,890	1	2	20,945	37,500	60,310	97,810	1	139,700
Fairhaven	25,000		25,000	1	1	25,000	25,000	62,200	87,200	1	112,200
Sodus Bay	37,500	12,500	50,000	1	2	25,000	37,500	22,500	60,000	1	110,000
Genesee R	75,000	10,250	85,250	2	4	21,313	75,000	10,250	85,250	2	170,500
Sandy Cr	37,500	17,500	55,000	1	2	27,500	37,500	17,500	55,000	1	110,000
Oak Orchard	75,000	31,653	106,653	2	5	21,313	63,937	0	63,937	2	170,590
Eighteenmile	67,100		67,100	2	3	22,367	67,100	0	67,100	2	134,200
Niagara River	75,000	-	75,000	2	1	75,000*	75,000	53,500	128,500	2	203,500
Total	**429,600**	**76,293**	**505,893**	**12**	**19**		**418,537**	**837,260**	**1,255,797**	**12**	**1,761,690**

* Pen dimensions are nearly identical at all sites except Niagara where all fish are held in one large holding pen.

[+] Actual stocking numbers varied slightly and these numbers are provided in Connerton (2011, 2012, and 2014).

We also planned for adequate numbers of marked fish to maximize the chances of recapturing enough fish to show at least a 20% difference (if one exists) between treatments at α=0.05 with a power of at least 80%. This level of difference and confidence level was set after consultation with fisheries managers who decided that 20% poorer performance of pen-reared fish would warrant discontinuation of a pen project.

Considering the above and hatchery limitations for holding tagged fish lots separately, not all fish at all sites were tagged, and stocking equal numbers of pen and direct stocked fish was not feasible at most sites. Fish were tagged in lots of 37,500 or less, and then depending on the stocking policy for the site, some fish with only an AD clip were added to meet the stocking policy (i.e., stocking target) for that site (Table 2). Pen and direct stocked fish were also not typically released on the same day and were not always released at the same location. Numbers stocked, stocking time and site conditions were different and may have influenced study outcomes but these differences were consistent with usual stocking practices and evaluating the outcomes of these practices was the aim of this study.

There were three NY sites that were not part of the pen study (Black River, South Sandy Creek, and Salmon River). At Black River and South Sandy Creek, fish were marked with AD clip only in 2010-2011 for the wild study and they were not marked in 2012-2013. At Salmon River, fish were marked with AD-CWT in 2010 for the SRH homing study, were AD clipped for the wild study in 2011 and were not marked in 2012-2013.

Pen and direct stocked fish were tagged in 2010-2011, and 2013. Marking and tagging of pen and direct stocked salmon in NY was planned for 2012; however, it was postponed until 2013 due to unusually high temperatures at pen sites in April, 2012. In 2013, temperatures at the Sandy Creek pen site were too warm so fish were not stocked into pens and no fish were clipped or tagged for this site. At Oswego in 2013, AD-CWT fish in pens were released three days after being stocked into pens because of warm temperatures. The approximate numbers of marked fish for this study are provided in Table 2, but actual stocking numbers varied slightly and these numbers are provided in Connerton (2011, 2012, and 2014).

Marking Quality Control

The AutoFish system's built-in quality control features verified removal of the adipose fin and checked for the presence of a CWT for each fish. Fish marked AD-CWT were returned to the hatchery, but fish without an AD clip and/or CWT were rejected and sent to a holding area where they were clipped and tagged manually. In addition, marking quality was manually verified by agency staff during AutoFish operation from 2008-2013. Each raceway of fish received a unique CWT code. For each raceway, the operator checked 100 fish from each of the six marking lines to ensure clip quality and CWT presence, and to detect any problems with individual marking lines. Samples of fish were also checked when exiting the trailer prior to entering the hatchery (100 fish per day), in raceways after entering the hatchery (100 fish per raceway), and at pens prior to release (approximately 100 fish per pen per year 2010-2011, 2013).

Although rare, tagged fish are most likely to shed their CWTs up to 30 days after initial tagging. To estimate CWT retention for this study and to check clip quality each year, samples of Chinook salmon at SRH and at stocking sites were checked for an AD clip and a CWT at least 30 days post tagging and prior to stocking using a portable CWT detector. At pen and direct stocking sites from 2010-2011, and in 2013, clipping quality and CWT retention was monitored by NYSDEC regional biologists prior to stocking. Samples of 50-100 fish per pen were checked for AD clip and CWT. Since not all fish at sites were tagged (Table 2), the percentages of tagged fish at each site were compared against expected percentages. The expected percentages of tagged fish were calculated for each stocking site based on the numbers tagged and the numbers marked with AD only. For example at the Oswego River pen site, 37,500 salmon were marked with AD-CWT, and 4,390 salmon were marked AD clip, so the expected percentage of AD-CWT fish at that site was 89.5%.

We collected 30-100 fish from each pen and direct-stocked site prior to stocking to read to verify CWT codes at each site. In 2010 and 2011, samples for CWT code verification were collected from tanks at the hatchery during loading of hatchery trucks, and in 2013 samples were collected at the stocking site from the stocking truck during stocking. Other measures to ensure that tagged fish went to the correct site included: 1) placing the name of the site on hatchery tanks after clipping and tagging; 2) numbering each tank in the hatchery and recording tank numbers and site names on Autofish forms; 3) recording tank numbers, site names, stocking date, and CWT codes on tank house movement sheets at time of stocking; and 4) retaining samples of CWT wire from each lot while marking. Tagged fish that died in the hatchery prior to stocking were subtracted to adjust stocking numbers.

Field Sampling

In New York, angler harvested Chinook salmon were sampled as part of the New York Lake Ontario Fishing Boat Survey from April - September, 2009-2013 (Lantry and Eckert 2014). Two technicians were also deployed by the U.S. Fish and Wildlife Service (Service) from July-October 2010-2011 (hereafter referred to as 'headhunters'), specifically to process Chinook salmon for clip and CWT recovery during the lake and tributary angling seasons. In 2012 and 2013, NYSDEC deployed two headhunters from June-October, and an additional two headhunters from July-October particularly to increase sampling effort for recovery of CWTs. In each year of the study, Chinook salmon were measured for total length (TL) and weight, examined for fin clips and CWTs, and a sample of scales was collected from each fish for determining age. Headhunters focused on high-use angling ports, fishing derbies, cleaning stations, and pen evaluation sites. At some ports, groups of anglers at marinas were contacted periodically by phone and arrangements were made to sample the day's harvest at private docks.

During fall tributary fishing (Sept. 15-Nov. 5, 2010-2013), headhunters focused on major tributaries and pen evaluation sites in New York including the Niagara River, Eighteenmile Creek, Oak Orchard Creek, Sandy Creek, and Genesee River in the western region, and Maxwell Creek, Sodus Bay tributaries (Sodus Creek and Second Creek), Sterling Creek, Oswego River, South Sandy Creek and Salmon River in the east (Figure 1). Since most fish were sampled from cleaning stations, anglers were asked where their fish were caught to identify and record capture locations. Recovery efforts also included walking streams to sample anglers' harvest, sampling salmon carcasses in the streams (2012-2013), and electrofishing some streams (2013).

Most Chinook salmon collected in New York waters were aged from impressions of fish scales on acetate film by counting annuli using 2x-10x magnification (n= 3,593 in 2010, 4,587 in 2011, 4,485 in 2012, and 3,102 in 2013). In 2012 and 2013, increased sampling effort led to additional samples (n=2,003 in 2012, n=2000 in 2013), and these were aged using monthly stratified age-length keys. Fish containing CWTs were aged using their tag's unique code which identified age and stocking location (n=330 in 2011, n=1,527 in 2012, n=2,487 in 2013). All Salmon River-stocked fish (2008-2010 YC, Table 1) contained CWT code 23 for all YCs, so scales were used to age these fish. Some fish already cleaned and filleted by anglers were brought to headhunters for sampling. In these cases (n=30 in 2010, n=188 in 2011, n=169 in 2012, n=172 in 2013), only total lengths were measured, the fish were checked for fin clips and tags, and ages for these fish were determined using monthly stratified age-length keys established from each year's scale ageing. Sampled carcasses (2012: n=683, 2013: n=283) were measured for TL, checked for AD clips and CWTs. Those without CWTs (2012: n=530, 2013: n=128) were

aged using monthly stratified age-length keys created based on each year's scale ageing. Also in 2011-2013, freezers were placed at six locations along the lake for cooperating anglers to place Chinook salmon heads. Freezers were checked periodically all snouts were scanned for the presence of a CWT and if present, were sent to the Service's Great Lakes Fish Tag and Recovery Laboratory in New Franken, WI (GLFTRL) for processing. These samples were only included in analyses of CWT recoveries.

In Ontario, samples came from three sources: 1) angler caught fish sampled at high-use ports from June 25-September 4, 2010; 2) OMNR's western Lake Ontario angler survey conducted from May-August, 2011-2013 at selected ports; and 3) tournaments and derbies throughout the summer 2011-2013 (for details of these programs, see OMNR 2014). In 2010-2013, Chinook salmon were measured for fork length (FL) and weight, and examined for fin clips and CWTs (n= 404, 499, 877, and 731, respectively). FL was converted to TL by TL= 1.052(FL) + 18.939 (OMNR unpublished data). A subsample of Chinook salmon otoliths was collected for ageing in 2010-2013 (n=204, 241, 171, and 248, respectively), and ages were determined by counting annuli on thin-sectioned otoliths. Ages of the remaining fish were determined based on CWTs or with monthly stratified age-length keys established from otoliths, CWTs and scale ageing in 2011-2013.

Salmon River Hatchery Sampling

To determine the degree of homing to and straying to the SRH, samples of Chinook salmon were checked for an AD clip and CWT as they entered the hatchery during egg-take operations in October of 2009-2013. For spawning purposes, Chinook salmon were sorted daily by sex, and males were further sorted into "jack"-sized males (age-1) and older-sized males (ages 2-4). Jack-sized males were counted but not spawned. Older males (ages 2-4) were spawned, measured for TL and weight, examined for fin clips and CWTs, and scales were collected for ageing. Females were similarly sampled prior to stripping their eggs (see Prindle and Bishop [2014] for TL, weight and age distribution results). Each year in 2010 and 2011, and on 2 to 4 occasions, jacks were sampled (total of 93 in 2010 and 174 in 2011) and measured for TL and weight, and checked for an AD clip and CWT. Scales were also collected for ageing to identify small age-2 males in the samples. Also in these years, 4-6 additional collections of 38-100 jacks <27 inches TL were examined for the presence of an AD clip and CWT, but were not sampled for scales. Age was assumed for these samples using the 27 inch TL cutoff, which was later verified by ageing the fish collected in the initial samples (i.e., no age-2 males were found to be <30.1 inches TL in 2010 and <27.7 in TL in 2011). In 2012, age-1 jacks (2011 YC) were not part of the SRH homing study; however, sampling of these fish was conducted as part of regular annual reporting of biological characteristics of salmon at the hatchery (see Prindle and Bishop 2013) and they were checked for the presence of an AD clip (indicating fish stocked at Salmon River or some other site) and AD-CWTs (indicating a stray from another site). In 2013, jacks (2012 YC) entering the hatchery were not clipped or tagged because no marking occurred in 2012. For all sampling from 2009-2013, snouts were collected from all fish containing CWTs, and CWTs were extracted and read at GLFTRL.

Data Analysis

We determined the proportion of angler caught Chinook salmon that were wild and stocked in each year of sampling from 2009-2013 stratified by capture location (lake or tributary), by region (Ontario, NY east, and NY west, Figure 1), and by year class. To calculate 95% confidence intervals for each stratum, we used the Agresti-Coull method to approximate the binomial distribution (Agresti and Coull 1998). Confidence intervals were computed using R software version 2.14.2 with the binom package (R Core Development Team 2012, Sundar Dorai-Raj 2009). The proportions of wild salmon in each year class were compared among regions (NY west, NY east and Ontario in lake; NY west, NY east and Salmon River in NY streams) with a Pearson chi-square test for homogeneity (χ^2) to test the null hypothesis that the proportions of wild fish observed in regions within each year class were equal. Post-hoc tests to compare proportions between individual regions within each year class were done using the Scheffe-Marascuilo procedure (Marascuilo 1966). Statistical results were considered significant at alpha=0.05. Chi-square and post hoc tests were done with StatsToDo online (www.statstodo.com).

To estimate homing and straying of mature fish to the Salmon River Hatchery, the proportions of Salmon River broodstock returning to the hatchery in the fall of each year were calculated for each year-class (i.e., 2008-2010YCs) from 2009-2013. Salmon River broodstock were identified by their unique CWT code (i.e., CWT #23 for Chinook salmon stocked at

the mouth of the Salmon River). Fish stocked at other sites (hereafter referred to as "strays") were identified either by the presence of AD clip only or by an AD clip and the CWT code used at another site (i.e., all codes other than 23). Salmon River broodstock were tagged from 2008-2010, therefore proportions of homing and straying fish were calculated for age-1 salmon in 2009, for ages 1 and 2 in 2010, for ages 1-3 in 2011, for ages 2-4 in 2012, and for ages 3-4 in 2013. To estimate the percent of fish stocked at all other sites that strayed to the SRH as adults (i.e., estimated straying rate), we used stocking ratios of Salmon River to other sites for each year class (Table 1, stocked in 2008-2010) divided by the homing/straying ratios of each year class (i.e., observed in the hatchery returns, Table 6) and we assumed equal survival and straying rates at all stocking sites. We note that it is unlikely that salmon survive at and stray from all sites equally, and future results from ongoing studies on the relative performance of direct stocked vs. pen-reared fish will provide additional insights into relative straying rates from individual sites to the hatchery.

To compare the relative contributions of pen vs. direct stocked Chinook salmon to lake and tributary fisheries, CWTs recovered from age-1 and older Chinook salmon from 2011-2013 were grouped by unique codes which identified the fish's stocking origin (i.e., year, site, and pen or direct). Total recaptures for each origin were tabulated from 2011-2013 for lake and tributary sites. Pooling samples across years (i.e., across ages within treatments) would not be appropriate if survival or catchability of the fish from the treatment (pen) or control (direct) groups changed relative to each other because tag recovery ratios would not be constant through time (Elrod and Frank 1990); therefore prior to pooling samples from paired releases across years, chi-square tests for homogeneity were performed and samples were pooled (i.e., across ages, within treatments) if the null hypothesis of homogeneity was not rejected.

The 2010-2011 and 2013 year classes of fish were marked for the pen study. Only the 2010 year class was fully recruited to the fishery in 2013 (as ages 1-3); therefore at this time, it is the only year class for which we can report on recoveries of pen and direct stocked fish. Future reports will provide analyses of 2011 and 2013 YCs. For the 2010 YC at each of eight sites, observed recovery ratios of pen vs. direct salmon were compared to expected (based on initial stocking ratios) using chi square Goodness-of-Fit tests. Logically, recovery ratios should equal stocking ratios if no differences in survival exist between the stocking methods. We assumed that recoveries are not biased toward fish of either group and that early hatchery rearing was identical prior to stocking (Elrod and Frank 1990). Only lake returns were compared in 2013 for the 2010 YC in this report. Tributary returns for 2010-2011, and 2013 YCs will be compared in future reports.

Table 3. Manual quality control results during operation of the AutoFish trailer at Salmon River Hatchery from 2008-2013.

Quality Control	**Year***				
	2008	2009	2010	2011	2013
# fish checked for AD	9,483	17,636	17,620	22,978	7,157
% AD clipped	99.0	99.3	99.2	99.7	99.5
# fish checked for CWT	3,636	3,684	13,539	12,097	7,157
% with CWT	99.6	99.7	99.6	99.8	99.8
% no AD clip, no CWT	0.3	0.2	0.04	0.12	0.17
% AD clipped, no CWT	0.1	0.12	0.13	0.04	0.18
30 Days Post-Tagging (Salmon R stocking)					
# of Fish Checked CWT	698	1174	1000	NT	NT
% AD Clipped	99.7	99.1	ND	ND	NM
% with CWT	98.7	98.6	99.1	NT	NM
% no AD clip,no CWT	0.3	0.1	ND	NT	NM
% AD clipped, no CWT	1.4	1.3	ND	NT	NM

NT= Salmon River broodstock were not tagged in 2011
ND= No data
NM=Not Marked
* No fish were marked in 2012

Results and Discussion

Quality Control

Manual quality control (QC) checks during the marking and tagging process showed excellent results with greater than 99% of the fish sampled having an AD clip and greater than 99.6% of tagged fish sampled having a CWT (Table 3). Clipping quality and tag retention remained high when checked thirty days after tagging, with greater than 99% of fish AD-clipped and 98.6% of the Salmon River broodstock fish retaining their tags (2008-2010; Table 3).

At pen sites from 2010-2011 and in 2013, clipping quality and tag retention was monitored by NYSDEC regional biologists prior to stocking. Approximately 50-150 fish per pen were checked for an AD clip and CWT in each year of tagging. Clipping quality at pen sites was excellent: in 2010 2,537 fish were examined in 19 pens with an average clipping percentage of

99.6% (standard deviation (σ) =1.0%); in 2011 1,932 fish were examined in 18 pens with average clipping percentage of 98.9% (σ=1.7%); and in 2013 1,331 fish were examined in 15 pens with an average of 98.0% (σ=1.0%). Tag retention was also high. As previously described, not all Chinook stocked at pen and direct stocked sites were tagged (Table 2); therefore the percentages of tagged fish recorded at each site during QC checks were compared against expected. For all sites in all years the percentages of tagged fish were within +/- 1% of expected indicating high tag retention (99%).

In 2011 and 2013, samples of 100 fish per direct-stocked site were checked for clip quality and tag retention in hatchery tanks prior to adding AD only fish and stocking. In 2011, average clipping percentage was 99.4% among tanks (n=12 tanks, 1,201 fish, σ=0.9%), and average tag retention was 99.0% (σ = 1.1%) when checked 30 days post tagging. In 2013, average clipping percentage among tanks was 99.1% (n=11 tanks, 1,100 fish, σ=1.1%), and average tag retention was 99% (σ=1.0%) when checked approximately 21 days post tagging.

Samples of tagged fish collected during pen and direct stockings to verify that CWT codes went to the correct site indicated that all fish went to the correct sites in all years; however in 2010, three samples taken at SRH contained fish from another site. The Sodus pen sample contained 5 out of 40 fish from Fairhaven Pen; the Sodus Direct sample contained 1 out of 52 fish from Oak Orchard Direct; and the Fairhaven Pen sample contained 1 out 30 fish from Oswego Direct site. After reviewing all marking, hatchery and stocking records and evaluating all potential error sources, it is most likely that mixing occurred during sampling at SRH (residual fish in dip nets used to sample raceways) or during GLFTRL CWT processing/reading, and it is unlikely that fish were mixed during loading of hatchery trucks. Sampling and lab procedures were modified and in 2011 and 2013, no discrepancies were found thereafter.

Percent Wild in the Lake Ontario Fishery

Mass-marking to determine the proportion of wild Chinook salmon was conducted from 2008-2011 and data collection is now completed for two YCs (2008-2019), with one year of data collection remaining for the 2010 YC (age 4), and two years for the 2011 YC (age 3 and 4). The percentages of unclipped (wild) Chinook salmon are presented in Table 4 for each year class sampled from 2009-2013.

For details about 2010-2012 sample collection and sample distributions among ages, see Connerton et al. (2011, 2012 and 2013, respectively). In 2013, a total of 3,757 Chinook salmon harvested by anglers in the open lake were sampled in Ontario and New York from April 15-September 15. Of these, 371 fish (10%) were age-1 (2012 YC), 1,276 (34%) were age-2 (2011 YC), 2,064 (55%) were age-3 (2010 YC), and 46 (1%) were age-4 (2009 YC).

Proportions of wild Chinook salmon were calculated for ages 2-4 in 2013 (Table 4). Age-1 fish were not part of the study. The percentage of wild age-2 Chinook salmon were significantly different among regions in 2013, (χ^2=44.8, df=2, P<0.0001), with the percentage of wild Chinook salmon in the Ontario region (56.8%) significantly higher than the NY east (36.4%, χ^2=24.2, P<0.0001) and NY west regions (29.0%, χ^2=44.3, P<0.0001), which were also significantly different (χ^2=6.9, P=0.03) from each other. Significant differences were observed among regions for age-3 Chinook salmon as well (χ^2=23.3, df=2, P<0.0001), with significantly lower percentages of wild Chinook observed in the NY west region (64.4%) compared to the NY east region (76.2%, χ^2=20.6, P<0.0001). The Ontario region (70.9%) was not significantly different from either NY region (west: χ^2=4.2, P=0.12; east: χ^2=4.2, P=0.12). The proportions of wild age-4 Chinook salmon were not significantly different among regions (χ^2=2.1, df=2, P=0.35).

Differences among regions in 2013 were consistent with results in 2010-2012 (Connerton et al. 2013), and may relate to regional differences in wild reproduction in tributaries, distribution patterns of wild age-1 salmon, or distribution of wild adults returning to natal tributaries prior to spawning. For example, the ON and NY east regions consistently had higher proportions of wild age-1 fish in the lake fishery for the 2009-2011 YCs and these regions, especially the Salmon River, are likely the largest sources of wild Chinook. The proportions of wild fish at ages 2 and 3 in the NY east region significantly increased in August/September, corresponding to mature fish returning to natal tributaries, compared to June/July and significantly decreased in the NY west region, where wild production is likely lower (Connerton et al. 2013). More research is needed to

understand dispersal and distribution of wild and hatchery Chinook salmon.

The percentages of wild Chinook also varied by year class and age from 2009-2013 with age-1 ranging from 17.1% to 59.8%, age-2 from 29.0% to 64.1%, age-3 from 33.3% to 76.2% and age-4 from 59.0% to 80.1% (Table 4). Some year classes had higher proportions of wild at each age than other year classes. The 2010 year class was a particularly strong year for wild reproduction (Bishop et al. 2014) in the Salmon River and this was reflected in the proportions of wild fish in the lake data (Table 4). Similarly, 2008 was a particularly weak year for wild reproduction at Salmon River (Bishop et al. 2014) and this year class was also poorly represented in the lake. Noteworthy is that only 50% of the stocking target were stocked by New York in 2008 which would have inflated the proportion of wild fish in that year class compared to the other marked year classes assuming equal survival. On the other hand, a higher proportion of pen fish were stocked by New York in 2008 and pen fish may survive better (based on preliminary results of the 2010 YC) so equal survival may not be assumed. While mass marking provides valuable information, unfortunately proportions of wild and hatchery fish vary for several reasons including varying wild and hatchery production, and differing survival of hatchery and wild smolts. More research is needed to estimate numbers of wild Chinook and survival rates of hatchery and wild fish, and to evaluate factors impacting that variability.

Another interesting pattern apparent in the data may relate to size differences between hatchery and wild Chinook at early ages (Connerton et al. 2012). For example, in each year class marked for the wild study, the percentage of wild Chinook in the open lake angler catch increased from age-1 to age-2 within a year class. The percentage wild at age-1 is likely biased low because wild fish start out smaller (Everitt 2006) and presumably recruit to a harvestable size (>15 in.) later than hatchery Chinook, which would under-represent wild fish in sampling at age-1 (Connerton et al. 2010). The percentages of wild fish also increased from age-2 to age-3 in two of the year classes examined. Hatchery Chinook were significantly larger than wild Chinook at age-2 by 1.5 inches in June-July, but not always in subsequent months and never at age 3 (Connerton et al. 2012). The proportions of wild Chinook may change from age-2 to age-3 for two reasons: higher proportions of hatchery Chinook may mature at earlier ages because of their size and leave the population at age 1 or age 2 in higher proportion than wild fish, and/or hatchery fish may be harvested in greater proportion at younger ages because of their size leaving more wild fish in the year class at ages 2 and 3. More research is needed to understand if size at stocking, harvest and age at maturity influences the proportion of wild fish in the population.

Overall from 2009-2013, wild Chinook salmon represented an important component of the Lake Ontario boat fishery representing an average of 50% of the harvest of age-2 and age-3 Chinook across all years and regions sampled. These ages make up the majority of the Chinook harvest each year. Results of this study are important for fisheries managers when considering how their stocking decisions can influence population dynamics and predator prey balance in Lake Ontario.

Percent Wild in New York Tributaries

In New York, major tributaries were sampled during the fall Chinook salmon spawning season from September 15-October 31 each year from 2010 to 2013. Some sampling was also done in fall 2009 in the Salmon River. For details about 2010-2012 sample collection and sample distributions among ages and tributaries, see Connerton et al. (2011, 2012 and 2013, respectively). The percentages of unclipped (wild) Chinook salmon are presented in Table 5 for each year class sampled from 2009-2013.

In 2013, a total of 3,863 Chinook salmon were sampled from 26 NY tributaries including 281 salmon carcasses sampled directly from streams. Of the 3,863 salmon, 128 (3%) were age-1, 1,632 (42%) were age-2, 2,074 were age-3 (54%), and 29 (1%) were age-4. All fish were fin-clipped from 2008-2011, therefore the proportions of wild Chinook salmon in 2013 were calculated for ages 2-4 (Table 5).

Table 4. Numbers of clipped (stocked) and unclipped (presumed wild) angler-caught Chinook salmon observed by year class and region in the open waters of Lake Ontario, and estimated percent wild from 2009-2013. All stocked Chinook salmon were adipose clipped from 2008-2011 and only data from marked year classes and ages recruited to the fishery are shown.

		2008 Year Class					2009 Year Class					2010 Year Class					2011 Year Class				
Year Sampled	**Region**	**Age (yrs)**	**No Clip**	**AD Clip**	**% Wild**	**[95 %CI]**	**Age (yrs)**	**No Clip**	**AD Clip**	**% Wild**	**[95% CI]**	**Age (yrs)**	**No Clip**	**AD Clip**	**% Wild**	**[95% CI]**	**Age (yrs)**	**No Clip**	**AD Clip**	**% Wild**	**[95% CI]**
2009	NY	1	9	36	20.0	[9.3, 34.0]															
	ON[1]		-	-	-	-															
2010	NY west[2]	2	64	137	31.8	[25.8, 38.6]	1	83	301	21.6	[17.8, 26.0]										
	NY east[2]		114	198	36.5	[31.4, 42.0]		63	225	21.9	[17.5, 27.0]										
	ON		42	53	44.2	[34.6, 54.2]		56	102	35.4	[28.4, 43.2]										
Regions Combined			**220**	**388**	**36.2**	**[32.5, 40.1]**		**a**	**A**	**a**	**a**										
2011	NY west	3	46	92	33.3	[26.0, 41.5]	2	337	553	37.9	[34.7, 41.1]	1	83	143	36.7	[30.7, 43.2]					
	NY east		92	154	37.4	[31.6 43.6]		438	775	36.1	[33.5 38.9]		152	173	46.7	[41.4, 52.2]					
	ON		35	72	32.7	[24.5, 42.1]		104	152	40.6	[34.7, 46.7]		73	49	59.8	[50.9, 68.1]					
Regions Combined			**173**	**318**	**35.2**	**[30.9, 39.3]**		**881**	**1480**	**37.3**	**[35.5, 39.4]**		**a**	**a**	**a**	**a**					
2012	NY west	4	18	8	69.2	[49.9, 83.7]	3	189	238	44.3	[39.1,49.0]	2	610	543	52.9	[50.0,55.8]	1	34	109	24.3	[18.0, 32.0]
	NY east		31	26	54.4	[41.6,66.6]		292	220	56.9	[53.3, 60.5]		1286	720	64.1	[62.0, 66.2]		24	117	17.0	[11.7, 24.1]
	ON		-	-	-	-		147	114	59.3	[53.1,65.2]		263	176	59.9	[55.3,64.4]		61	116	34.5	[27.9,41.7]
Regions Combined			**49**	**34**	**59**	**[48.3,69.0]**		**a**	**A**	**a**	**a**		**a**	**a**	**a**	**a**		**a**	**a**	**a**	**a**
2013	NY west						4	7	0	100.0	[59.0, 100.0]	3	278	154	64.4	[59.7,68.7]	2	143	351	29.0	[25.1,33.1]
	NY east							22	7	75.9	[57.6,88.0]		934	292	76.2	[73.7,78.4]		218	381	36.4	[32.6,40.3]
	ON							8	2	80.0	[47.9,95.4]		288	118	70.9	[66.3,75.1]		104	79	56.8	[49.8, 63.8]
Regions Combined								**37**	**9**	**80.4**	**[66.6,89.5]**		**a**	**a**	**a**	**a**		**a**	**a**	**a**	**a**

95 %CI=95% confidence intervals of % wild.

[1] ON: Most samples were collected from Port Credit, Bluffers, and Whitby where angling effort was highest, with additional samples from Port Hope, Wellington, and Hamilton. See OMNR (2014) for program details.

[2] NY west: Niagara River to Irondequoit Bay, NY east: Bear Creek Harbor to Black River (Figure 1).

a. Data were not combined because the proportions among regions were not homogeneous (see text for explanation).

Table 5. Numbers of clipped and unclipped angler-caught Chinook salmon observed by year class and region in the New York tributaries of Lake Ontario, and estimated percent wild from 2009-2013. All stocked Chinook salmon were adipose clipped from 2008-2011 and only data from marked year classes and ages recruited to fishery are shown.

		2008 Year Class					2009 Year Class					2010 Year Class					2011 Year Class				
Year Sampled	**Tributaries**	**Age (yrs)**	**No Clip**	**AD clip**	**% Wild**	**[95 %CI]**	**Age (yrs)**	**No Clip**	**AD Clip**	**% Wild**	**[95% CI]**	**Age (yrs)**	**No Clip**	**AD Clip**	**% Wild**	**[95% CI]**	**Age (yrs)**	**No Clip**	**AD Clip**	**% Wild**	**[95% CI]**
2009	* Salmon R.	1	8	17	32	[17.1, 51.7]															
2010	NY west[1]	2	33	166	16.5	[12.0, 22.4]	1	19	139	12	[7.8, 18.1]										
	NY east[1]		8	25	24.2	[12.6, 41.3]		2	47	4.1	[0.3, 14.5]										
	NY east & west		**41**	**191**	**17.6**	**[13.2, 23.1]**		**21**	**186**	**10.1**	**[6.7, 15.1]**										
	Salmon River		**99**	**73**	**57.5**	**[50.1, 64.7]**		**49**	**50**	**50.5**	**[40.7, 60.3]**										
2011	NY west	3	6	155	3.7	[1.5, 8.1]	2	19	562	3.3	[2.1, 5.1]	1	9	61	12.9	[6.7, 22.8]					
	NY east		5	48	9.4	[3.7, 20.7]		12	209	5.4	[3.0, 9.3]		5	20	20	[8.4, 39.5]					
	NY east & west		**11**	**203**	**5.1**	**[2.8, 9.1]**		**31**	**771**	**3.9**	**[2.7, 5.4]**		**14**	**81**	**14.7**	**[8.8, 23.4]**					
	Salmon River		**57**	**143**	**28.5**	**[22.6, 35.1]**		**141**	**174**	**44.7**	**[39.3, 50.2]**		**60**	**19**	**75.9**	**[65.3, 84.1]**					
2012	NY west	4	0	14	0	[0, 16.2]	3	22	498	4.2	[2.8, 6.4]	2	47	764	5.7	[4.4,7.6]	1	2	32	5.9	[0.06, 20.1]
	NY east		4	9	30.8	[12.4,58.0]		68	258	20.9	[16.8, 25.6]		166	532	23.8	[20.8 27.1]		2	26	7.1	[0.01, 23.7]
	NY east & west		**A**	**a**	**a**	**a**		**a**	**a**	**a**	**a**		**a**	**a**	**A**	**a**		**4**	**58**	**6.4**	**[2.5, 15.5]**
	Salmon River		**7**	**1**	**87.5**	**[50.8, 99.9]**		**296**	**194**	**60.4**	**[56.0, 64.6]**		**638**	**215**	**74.8**	**[71.8, 77.6]**		**0**	**2**	**0**	**[0, 57.5]**
2013	NY west						4	0	4	0	[0.0,0.6]	3	69	716	8.8	[7.0,11.0]	2	59	763	7.2	[5.6, 9.2]
	NY east							4	1	80.0	[35.9, 97.9]		125	506	19.8	[16.9,23.1]		61	537	10.2	[8.0, 12.9]
	NY east & west							**a**	**a**	**a**	**A**		**a**	**a**	**A**	**a**		**120**	**1300**	**8.4**	**[7.1, 10.0]**
	Salmon River							**18**	**2**	**90.0**	**[68,6, 98.4]**		**537**	**143**	**79.0**	**[75.7,81.9]**		**124**	**66**	**65.2**	**[58.2,71.7]**

95 CI=95% confidence intervals.

* Limited data available in 2009 from sampling conducted in the Salmon River

[1] NY west: Niagara River to Irondequoit Bay, NY east: Bear Creek Harbor to Black River (Figure 1)

a Data were not combined because the proportions among regions were not homogeneous (see text for explanation)

In western tributaries (total n=1,673), most samples came from Eighteenmile Creek (30.9%), Oak Orchard Creek (18.2%), the Niagara River (18.2%), and Sandy Creek (14.9%), with smaller samples collected from Genesee River (6.2%), Johnson Creek (5.9%), Irondequoit Creek (2.2%), Shipbuilders Creek (1.1%), Twelvemile Creek (1.2%), Marsh Creek (0.8%), and Salmon Creek west of Genesee River (0.2%). The proportions of wild Chinook salmon in western tributaries were low in 2013 (Table 4), with 7.2% of age-2, 8.8% of age-3, and 0% of age-4 Chinook salmon unclipped.

Samples from eastern Lake Ontario tributaries (total n=1,279) were from the Oswego River (38.4%), Sterling Creek (12.7%), Maxwell Creek (9.5%), South Sandy Creek (8.8%), Wolcott Creek (8.7%), Sodus Creek (6.5%), Little Salmon River (6.1%), and the Black River (3.2%), with smaller samples from Second Creek (2.4%), Salmon Creek east of Genesee River (0.4%), North Sandy Creek (0.9%), and Catfish Creek (0.8%). The proportions of wild Chinook salmon observed in eastern tributaries were generally higher than western streams with 10.2% of age-2, 19.8% of age-3, and 80% of age-4 Chinook salmon unclipped (Table 5). Small sample sizes of age-4 fish in all sampling resulted in wide confidence intervals (Table 5).

In 2013, the percentages of wild Chinook salmon ages 2-4 in tributaries were significantly different among regions (age-2: χ^2=423.1, df=2, P<0.0001; age-3: χ^2=880.4, df=2, P<0.0001; age-4: χ^2=14.8, df=2, P=0.0006). In particular, the percentages of wild Chinook salmon for ages 2-4 at the Salmon River (65.2%, 79.0%, and 90.0%, respectively) were significantly higher than NY west tributaries (age-2: χ^2=264.8, P<0.0001; age-3: χ^2=1422.1, P<0.0001; age-4: χ^2=180.0, P<0.0001) and for ages 2-3 in NY east tributaries (age-2: χ^2=225.2, P<0.0001; age-3: χ^2=705.7, P<0.0001; age-4: χ^2=0.274, P=0.87). In addition, the percentages of wild fish in NY west were significantly lower than the NY east region for age 3-4 salmon (age-3: χ^2=34.3, P<0.0001; age-4: χ^2=20.0, P<0.0001) but not for age-2 (χ^2=3.96, P=0.14). Age-1 fish in 2013 were not part of this study.

Relatively low proportions of wild fish in western streams compared with other regions were consistent with results in 2010-2012 (Table 5) and may result from several factors including warm temperatures, limited habitat and impassible barriers present in many western NY region tributaries. High angling pressure in these tributaries may also negatively affect levels of natural reproduction, either directly by harvest or as a result of high pre-spawn mortality caused by catch and release angling in warm streams (Everitt 2006). Significantly higher percentages of wild fish in the Salmon River compared to other NY tributaries were also consistent with results in 2010-2012 (Connerton et al. 2011, 2012, 2013). The Salmon River is likely the largest single source of wild Chinook salmon in New York considering its large size, extensive quality habitat, and large runs of salmon of which most are wild fish. Everitt (2006) estimated that 5 million Chinook salmon parr were produced in the Salmon River watershed in 2005; however, it was unknown whether these parr survived. Apparently some portion does survive and represents an important component of both the lake and Salmon River sportfishery. More research is needed, however, to understand the cumulative wild production of all tributaries including in the Province of Ontario. For example, 99% of salmon sampled at Bowmanville Creek, ON in 2013 were unclipped (OMNR 2014) and this tributary is not stocked.

<u>Straying and Homing to Salmon River Hatchery</u>

Returns of Chinook salmon to the SRH from 2009-2013 suggested a high degree of homing to SRH by Salmon River broodstock fish and a low degree of straying to the hatchery by fish stocked at other NY sites (Table 6). For each year from 2009-2013, Chinook salmon were examined for an AD clip and CWT during egg take operations at the SRH. Percentages of homing and straying fish in the hatchery varied by age and year class(Table 6) with weighted averages of 84.6%, 74.3% and 62.1% of the samples made up of homing fish, and 13.4%, 23.6%, and 23.0% made up of straying fish for the 2008-2010 year classes, respectively (Table 6). These percentages corresponded to average homing:straying ratios of 6.3, 3.2 and 2.6 homing salmon to every 1 straying salmon for these year classes (2008-2010), respectively (Table 6).

Table 6. Percent of sample from homing (%H), straying (%S) and wild (%W) Chinook salmon observed in the NYSDEC Salmon River Hatchery, New York from 2009-2013. Estimated straying rates (SR) from other stocking sites to the hatchery were calculated for each year class (at age) based on observed homing:straying ratios, stocking ratios, and assuming equal survival and straying from all sites (see text for further explanation).

	2008 Year Class					2009 Year Class					2010 Year Class				
Age	**%H**	**%S**	**%W**	**n**	**SR**	**%H**	**%S**	**%W**	**n**	**SR**	**%H**	**%S**	**%W**	**n**	**SR**
1	88.6	8.6	2.8	175	7.7	74.1	25.3	0.9	451	9.0	67.7	26.7	5.7	405	10.8
2	83.4	15.5	0.1	446	15.0	74.8	23.2	2.0	552	8.2	64.5	20.0	14.0	400	9.0
3	81.9	11.5	6.6	61	6.5	75.6	18.6	5.8	107	5.9	51.4	22.0	26.5	306	13.2
4	80.0	20.0	0.0	5	20.0	20.0	20.0	60.0	5	25.7	TBD	TBD	TBD	TBD	TBD
Avg	**84.6**	**13.4**	**1.4**		**12.4**	**74.3**	**23.6**	**2.2**		**8.4**	**62.1**	**23.0**	**14.4**		**10.1**

Avg= weighted average for yearclass (weighted by sample size for each yearclass, age)
n= sample size. TBD=to be determined in 2014.

Considering that the number of salmon stocked at other sites combined is higher than the number stocked at the Salmon River (Table 1), we would have expected much lower homing:straying ratios if all Chinook salmon strayed from other NY stocking sites to the hatchery. Clearly this was not the case based on observed homing:straying ratios (Table 6). We estimated that an average of 12.4%, 8.4%, and 10.1% of Chinook salmon stocked at other sites from the 2008-2010 YCs respectively, strayed to the SRH (Table 6). It should be noted that since the homing and straying values shown in Table 6 were calculated as a percent of the whole sample, these values influenced each other, i.e., as the percentage of wild fish increased in the sample, the other percentages went down. This did not affect the straying rates presented, however, because only clipped fish were considered in these calculations. Only one cohort marked for this study remains in the lake in 2014 (i.e., 2010 YC; age-4 in 2014). We will continue to track tagged strays returning to the hatchery from pen and direct study sites until 2017.

Tagging of pen and direct stocked fish began in 2010. In each year from 2011-2013, some portion of the 2010 YC returning to the hatchery were tagged strays (Table 6) which afforded us a glimpse at the origin of straying fish (Table 7). Straying of both pen and direct stocked fish was generally low. In 2011, a total of 405 age-1 jacks were examined for a clip and tag, and 61 out of 108 strays contained tags. Of these tags, 46 originated from pen-stocked sites, including at least 2 fish from each of eight sites. The other 15 tagged strays came from direct sites including Sodus, Genesee River, Oswego, Sandy Creek and Fairhaven. In 2012, a total of 400 age-2 Chinook were checked for clip and tag and 70 out of 142 strays contained tags. Of these, 34 tags came from seven pen sites (none from Eighteenmile Creek), and 36 from all eight direct sites. In 2013, a total of 306 age-3 salmon were checked for a clip and tag, and 35 out of 65 strays contained tags. Of these, 17 originated from pen sites except Fairhaven and 18 originated from direct sites except Eighteenmile and Oswego.

The ratios of pen stocked to direct stocked fish were homogenous across samples years so samples recovered from 2011-2013 were pooled for each site except Niagara where they were significantly different in 2011 and 2012 and only samples from 2012 and 2013 were combined. For each site, we tested whether the return ratios of pen to direct stocked Chinook salmon recovered at Salmon River Hatchery were different than stocking ratios (Table 7). The ratios of pen to direct stocked fish were not significantly different from stocking ratios for any sites except Oak Orchard where the ratio of pen to direct stocked fish was significantly higher than expected. The relative recovery of pen stocked to direct stocked fish was also greater in the lake for this site (Table 8). Numbers returning to both the lake and hatchery may be due to higher post-stocking survival and returns to the hatchery are not necessarily a result of higher straying by pen stocked fish from this site.

<u>Wild Chinook Straying to the Salmon River Hatchery</u>
The percentages of wild fish in the hatchery from 2009-2013 varied by age and year class but were generally low with weighted (by sample size at each age) averages of 1.4%, 2.2% and 14.4% for the 2008-2010 year classes, respectively (Table 6). The 2010 year class showed the highest percentages of wild

Table 7. The number of straying Chinook salmon from 2010 pen and direct stocking sites recovered during sampling at the Salmon River Hatchery 2011-2013. For sites with P-values <0.05, returns of pen-stocked and direct stocked fish were significantly different at α=0.05.

	# Stocked in 2010		# Recovered 2011		# Recovered 2012		# Recovered 2013		# Recovered per 50,000 stocked			
Stocking Site	Pen	Direct	Pen	Direct	Pen	Direct	Pen	Direct	Pen	Direct	χ^2	*P*
Sodus	37,800	37,900	13	4	6	10	3	4	29.1	23.7	0.2	0.630
Genesee	75,300	75,066	6	4	4	8	3	5	8.6	11.3	0.3	0.578
Oswego	37,900	37,650	5	3	8	3	3	0	21.1	8.0	3.6	0.057
Niagara	75,650	75,400	5	0	3	7	1	2	5.9	6.0	a, b	0.178
Oak Orchard	75,600	63,900	6	0	6	1	5	1	11.2	1.6	8.2	0.004
Sandy Creek	37,900	37,700	4	3	3	4	1	5	10.6	15.9	0.5	0.495
Fairhaven	24,200	25,300	5	1	4	1	0	1	18.6	5.9	2.3	0.128
Eighteenmile	66,310	67,300	2	0	0	2	1	0	2.3	1.5	b	0.685

[a] Proportions among sample years in 2011-2013 for Niagara were not homogenous (χ^2=6.9, df=2, *P*=0.03); with proportions in 2011 significantly different from proportions in 2012 (χ^2=23.3,*P<0.001);* only samples from 2012-13 were pooled for this site. [b] marginal cell totals were <5, so Fisher Exact test was used instead of chi-square.

fish entering the hatchery which is consistent with higher wild percentages observed in the lake and in the Salmon River (Tables 4 and 5). Similarly, the 2008 year class showed low proportions of wild fish entering the hatchery, and low proportions of wild fish in the lake and River. Apparently more wild fish may "stray" into the hatchery in years with higher proportions of wild fish in the population. Another pattern that emerges from the data which requires more research is that the proportion of wild fish observed within a year class increased with age. This pattern was also observed in the lake data, and may be related to differences in maturity schedules between hatchery and wild fish due to differences in growth rates at early ages (Connerton et al. 2010).

The low proportions of unclipped, wild fish in the hatchery were in sharp contrast to the high proportions of wild Chinook salmon found in the Salmon River angler harvest sample, suggesting that wild fish display a low degree of straying into the SRH. Although wild fish are a substantial component of the Salmon River fishery, they do not contribute much to the hatchery broodstock; therefore, stocking at Salmon River is vital for maintaining current egg collection targets.

Straying and Homing to Salmon River and tributaries

In 2013, only the 2009 and 2010 year classes remained as part of the SRH homing study: 34.1% (CI= [26.8, 42.6], n= 137) of age-3 clipped salmon and 50% (CI=[9.4, 90.5], n=2) of age-4 clipped salmon in the Salmon River harvest sample were strays. Age-4 salmon were rare and only 2 of 20 salmon observed in the Salmon River sample in 2013 were AD clipped so no more analyses were done for this age class. When the stocking ratio of the 2010 year class was considered (as done in the hatchery sample, Table 6), the estimated straying rate for age-3 was 14.8% compared to 13.2% in the SRH.

Overall, samples from angler-harvested fish in the Salmon River and its tributaries from 2010-2013 indicated similar proportions of strays compared to results at the SRH. Only the proportions of strays for age-2 were significantly higher in the river compared to the hatchery (Connerton 2012, 2013). Even so, the estimated straying rates from other sites to the river for age-2 Chinook were 7.0%, 14.3% and 16% for the 2008-2010 year classes, respectively, based on the harvest sample. Straying to the Salmon River certainly occurs but both straying rates in the SRH and Salmon River harvest do not indicate that it is a concern for fisheries managers. We will continue to track tagged pen and direct stocked fish returning to the hatchery until 2017 which will provide a more complete picture of the sources of these strays.

Fish stray not only *to* the Salmon River to spawn, but at least some also *from* the Salmon River to other tributaries. In 2013, only age 3-4 salmon from the SRH tagging study remained in the population. A total of 1,222 age-3 AD-clipped salmon were sampled in other tributaries and of these, eight were strays from the Salmon River found at Oswego River (n=4), Fairhaven (n=2), Genesee River (n=1) and Eighteenmile Creek (n=1). One age-4 salmon was found at Maxwell Creek in 2013. A total of 2,102 AD clipped salmon were sampled by headhunters in 2012, and of these, 108 strays (5.0%) from SRH broodstock stockings were found in other tributaries including: 3 from the 2008 year class at Little Salmon River (n=2) and Salmon Creek (n=1); 48 from the 2009 year class including at the Black River (n=1), Mill Creek, (n=5), North Sandy Creek (n=1), South Sandy (n=6), Little Salmon River (n=23), Oswego River (n=5), Sterling Creek (1), Salmon Creek (n=1), Bear Creek (1), Genesee River (n=1), Shipbuilders Creek (n=1), Oak Orchard Creek (n=1), and Marsh Creek (n=1); and 57 from the 2010 year class including at Black River (n=3), Mill Creek (n=11), North Sandy Creek (n=6), Little Salmon River (n=28), Grindstone Creek (n=3), Oswego River (n=3), Oak Orchard (n=1), Sandy Creek (n=1) and the Niagara River (n=1). In 2010-2011, the number of SRH strays recovered in other tributaries was low, i.e., 18 were recovered by headhunters in 2011 out of 1,055 AD clipped fish sampled (1.7%), and three out of 500 AD clipped fish sampled (0.6%) in 2010 (Connerton et al. 2011, 2012).

The highest proportions of SRH strays in 2012 were recovered in the Little Salmon River, where 34% of age-2 (out of 79 AD clipped salmon sampled) and 47.9% of age-3 (n= 48) were strays from the Salmon River. This site also contained a high proportion of strays from other sites with 36.7% of age-2 AD clipped salmon (n=79) originating from various sites including the Niagara River, Oak Orchard Creek, Sandy Creek, Genesee River, Sodus, Fairhaven, and the Oswego River. The Little Salmon River is not a Chinook stocking site, however it is only 6 miles from the Salmon River and apparently receives fish straying from both the SRH and fish stocked throughout the lake, possibly due to its proximity to the hatchery. Spatial patterns of straying and homing may become clearer as more tagged fish from the pen evaluation study return to streams in 2014-2017.

Evaluation of Pen and Direct Stocking

Since fish were marked for the pen study in 2010-2011 and 2013, only the 2010 YC was sufficiently recruited to the fishery in 2011-2013 (as ages 1-3) for analysis comparing recoveries of pen and direct

Table 8. Recoveries per 50,000 stocked of coded-wire tagged Chinook salmon stocked into Lake Ontario by pen and direct stocking methods at eight sites in New York in 2010. For sites with P-values <0.05, returns of pen-stocked and direct stocked fish were significantly different at α=0.05.

Site	Stocking Method	Number Stocked	Recoveries per 50,000 stocked in Year 2011	2012	2013	Total	X^2 Test for Homogeneity Across Years X^2	P	X^2 Test for Differences Pen vs Stocked X^2	P	Recovery Ratio (Pen:Direct)
Niagara	Pen	75,650	8	29	17	54	0.08	0.9613	2.78	0.0956	1.3
	Direct	75,400	6	21	14	41					
Eighteenmile	Pen	66,310	10	53	13	76	1.81	0.4039	19.36	<0.0001*	2.2
	Direct	67,300	3	23	9	35					
Oak Orchard	Pen	75,600	8	32	14	54	1.88	0.391	9.02	0.0016*	1.9
	Direct	63,900	4	14	11	29					
Sandy Creek	Pen	37,900	11	38	21	70	0.20	0.905	2.78	0.0954	1.4
	Direct	37,700	7	29	13	49					
Genesee River	Pen	75,300	13	52	18	83	6.44	0.0400	5.27	0.0216*+	1.5
	Direct	75,066	5	29	20	54					
Sodus Bay	Pen	37,800	24	66	24	114	7.23	0.0297*	7.98	0.0048*+	2.0
	Direct	37,900	5	28	24	57					
Fairhaven	Pen	24,200	8	52	19	79	1.59	0.4514	13.89	0.0002*	3.3
	Direct	25,300	0	16	8	24					
Oswego	Pen	37,900	11	20	45	75	0.18	0.9127	4.68	0.0305*	1.6
	Direct	37,650	8	13	27	48					
										Average Recovery Ratio (Pen:Direct)=	**1.9**

* Significant at α=0.05

+Sodus and Genesee recoveries of pen and direct were not homogenous among years, with year 2011 and 2013 significantly different, so only recoveries from ages 2012-2013 were pooled and tested for differences between pen and direct.

stocked fish (Table 8). Future reports will provide analyses of the 2011 and 2013 YCs and will examine returns to tributaries. From 2011-2013, a total of 1,954 tagged Chinook salmon from the 2010 pen and direct stockings were recovered from the Lake Ontario recreational boat fishery. All recoveries were adjusted for numbers stocked by each stocking method at each site. Results from the 2010 YC indicated that pen stocking provided an average of about 2-fold greater contribution to the lake fishery per number stocked than direct stocking (Table 8). Ratios of pen to direct recoveries ranged from 1.3 to 3.3 for the eight sites evaluated. Recovery ratios of pen to direct were significantly different than stocking ratios for six of eight sites evaluated including Eighteenmile, Oak Orchard, Genesee, Sodus, Fairhaven and Oswego (Table 8). For Niagara and Sandy Creek sites, pen to direct recovery ratios were 1.3 and 1.4, respectively; however there was not enough evidence to reject the null hypothesis of no difference between the stocking methods for these sites at α=0.05. Results at Oak Orchard showing higher relative recoveries of pen fish, and at Niagara showing no difference between stocking methods are consistent with the previous study by Bishop et al. (2006). That study was conducted by sampling salmon in tributaries and not from the open lake fishery. Returns to the tributaries by pen or direct stocked salmon could have resulted from differences in survival or imprinting. Results from the open lake fishery showing higher recoveries of 2010 YC pen fish may result from differences in vulnerability to capture or survival; however after age 1, both groups are fully recruited to the fishery and equally vulnerable, suggesting pen fish may have higher survival in the first year in the lake after stocking. These results are based on one year class however with two other year classes remaining to be evaluated so no conclusions can be drawn at this time.

It is important to note that comparisons between the numbers of recoveries of fish from different pen rearing sites is not valid and is not an objective of this study because sampling relied on angler caught fish, and fish distribution, fishing effort and success varied by location. Sampling effort was often directed primarily at sites with the greatest fishing effort and success varied so the total numbers of recoveries from each site may not indicate relative survival.

Summary

1. The percentages of wild Chinook salmon in Lake Ontario in 2013 varied among regions with a significantly higher percentage of wild age-2 fish observed in Ontario waters (56.5%) compared to the NY east (36.5%) and west (29.0%) regions; and a significantly lower percentage of wild age-3 fish observed in the New York west region (64.4%) compared to the NY east (76.2%) and Ontario (70.9%) regions which were not significantly different.

2. Percentages of wild Chinook salmon in Lake Ontario varied by year class and age and among regions from 2009-2013, but overall wild Chinook were an important component of the Lake Ontario fishery averaging 50% of the age 2-3 lake harvest.

3. In 2013, the percentages of wild Chinook salmon for ages 2-4 at the Salmon River (65.2%, 79.0%, and 90.0% respectively) were significantly higher than NY west and NY east tributaries. The percentages of wild Chinook salmon in western tributaries were low with 7.2% of age-2, 8.8% of age-3, and 0% of age-4 Chinook salmon unclipped. The percentages of wild Chinook salmon observed in eastern tributaries were higher than western streams with 10.2% of age-2, 19.8% of age-3, and 80% of age-4 Chinook salmon unclipped. These regional differences are consistent with observations from 2010-2012.

4. Returns of Chinook salmon at the SRH from 2008-2010 YCs suggest a high degree of homing by fish stocked at the Salmon River and a low degree of straying from other stocking sites with estimated average straying rates of 12.4%, 8.1%, and 10.4%.

5. Preliminary results from the 2010 YC indicated that pen stocking at eight sites provided an average of about 2-fold greater contribution to the lake fishery per number stocked than direct stocking. There are still two other year classes to evaluate for this study so final conclusions cannot be drawn.

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Eastern Basin of Lake Ontario Warmwater Fisheries Assessment, 1976-2013

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Each year the New York State Department of Environmental Conservation (NYSDEC) assesses the warmwater fish community in New York waters of Lake Ontario's eastern basin. This long-term assessment program was initiated in 1976 to establish abundance indices for warmwater fishes, with emphasis on smallmouth bass (*Micropterus dolomieu*), walleye (*Sander vitreus*), yellow perch (*Perca flavescens*), and white perch (*Morone americana*). Data collected allow for evaluations of other population parameters including growth, age structure, year class strength, survival rates, and diet composition for some of the target species. This long-term dataset has been used to evaluate impacts of Double-crested cormorant (*Phalacrocorax auritus*; DCC) predation on smallmouth bass and yellow perch populations in the eastern basin (O'Gorman and Burnett 2001, Lantry et al. 2002). This report focuses on 2013 abundance indices as they relate to previous years, and summarizes occurrence of round goby (*Neogobius melanostomus*) in predator diets, smallmouth bass age and growth trends, and age structure of walleye caught 2011-2013.

Methods

A standardized, stratified random design gillnetting assessment was conducted annually from 1976 through 2013 in the New York waters of Lake Ontario's eastern basin to assess the warmwater fish community. Sampling was initiated as early as July 29 and completed as late as August 25, typically occurring during the first two weeks of August. Since 1980, standardized net gangs (nine 50 ft panels, 8 ft deep, and stretch-mesh sizes ranging from 2-6 in by ½ in increments) were set overnight, on bottom and parallel to depth contours at predetermined, randomly selected sample locations. Detailed assessment methods and corrections for 1980, 1989, and 1993 survey and gear design changes were described previously (Eckert 1986, 1998, and 2006). A net set was deemed biased when there was any indication of net fouling or tampering and data from that set were excluded from analyses. In 1993, gear changed from multifilament gill nets to monofilament gill nets and correction factors were determined, applied to multifilament catch data, and "monofilament equivalents" were calculated (Eckert 1998). The random survey design was stratified by three depth strata (Stratum 1: 12-30 ft; Stratum 2: 31-50 ft; Stratum 3: 51-100 ft) and five area strata (Grenadier Island, Chaumont Bay, Black River Bay, Henderson Bay, and Stony Island Areas; Figure 1). Area strata were used primarily to ensure that all major geographic areas within depth strata 1 and 2 were sampled each year in proportion to their surface areas. Each year 10 net sets were scheduled for depth stratum 3.

Prior to 1996 a net set was canceled and the catch of warmwater fish was assumed zero when the scheduled set location had stable water temperatures <50°F. Experience had shown that catches of warmwater fish were consistently zero in areas inundated by cold hypolimnetic waters (Eckert 2006). From 1996-2005 all scheduled net sets were completed regardless of temperature given the potential for a shift in fish depth distribution related to increased water clarity resulting from dreissenid mussel colonization. Similar shifts were observed with alewives, rainbow smelt and lake trout (e.g., O'Gorman et al. 2000). During that time period, 18 nets were set and pulled at temperatures <50°F. Sixteen out of 18 nets captured coldwater fish species (mean=10.5 coldwater fish per net, most of which were lake trout [*Salvelinus namaycush*]) and

only seven of those 16 captured warmwater species (mean=3.7 warmwater fish per net). Two of the 18 nets captured no fish. Beginning again in 2006, a net set was canceled and catch of warmwater fish was assumed zero when scheduled at a location with stable water temperatures <50°F for at least 9 ft off bottom.

In 2013, 29 randomly chosen netting locations were determined prior to initiation of the assessment on July 30. From July 30 through August 9, we completed 29 unbiased net sets. Mean stratified catch-per-unit-effort (CPUE = fish per overnight net set) was calculated for the total warmwater fish catch and each fish species captured. The 95% confidence intervals were also determined for each mean stratified CPUE estimate. Relative standard error (RSE = 100% * [standard error/mean]) was calculated to examine variability in CPUE between years.

For fish collected, we determined species, total length (TL) and weight, and when possible sex and maturity (with the exception of longnose gar [*Lepisosteus osseus*]). Stomach contents of all predators (i.e. smallmouth bass, walleye, northern pike [*Esox lucius*], and muskellunge [*Esox masquinongy*]) were identified each year beginning in 2000. For each assessment year, scales were collected from all species with the exception of ictalurids and longnose gar. We removed cleithra from all esocids and pectoral spines from all ictalurids. From 2003-2013 and in addition to scales, we collected otoliths from smallmouth bass >13.8 in, yellow perch >8.7 in, and all walleye and freshwater drum (*Aplodinotus grunniens*).

Species composition, depth stratum-specific species diversity and CPUE, and trends in abundance indices were described. Additional data analyses were completed for smallmouth bass including: 1) scales (1976-2003 and 2006-2009) and otoliths (2006-2009) were aged and mean length-at-age was determined; 2) for each sample year, condition (Fulton's K) was calculated for each inch increment (7-19 in); 3) the age composition of bass fully vulnerable to our gill nets was determined (i.e. ≥12 in) for each year 1976-2003 and 2006-2009, and 4) age-specific CPUE (1976-2003, and 2006-2009). Smallmouth bass samples collected in 2004-2005 and 2010-2013 were not aged.

Results and Discussion

2013 Water Temperature

In 2013, bottom temperatures for all nets set in depth strata 1 (12-30 ft) and 2 (31-50 ft) ranged from 72.9°F-75.9°F and 72.3°F-76.8°F, respectively. For nets set in stratum 3 (51-100 ft) bottom temperatures ranged from 54.3°F-73.0°F. Mid-70 degree water temperatures occurred as deep as approximately 70 ft during the 2012 survey. Low-70 degree water temperatures occurred as deep as 95 ft during the 2013 survey. Only one of the 29 net sets was in water colder than 70°F. That net, in water temperatures 54.3°F to 58°F caught no warmwater species, and only seven coldwater fish (three species).

Species Composition

Since 1976, 45 fish species (34 warm and cool water species) were captured during the eastern basin gillnetting assessment (Table 1). In 2013, 1,218 fish were captured in unbiased net sets, representing 21 warm and cool water species (1,211 fish) and three coldwater species (7 fish). The greatest species diversity (20 species; CPUE=58.7) occurred in depth stratum 1, followed by depth strata 2 (16 species; CPUE=47.3) and 3 (5 species; CPUE=19.8). The lowest warm and cool water species diversity and catch typically occurs in depth stratum 3 (Eckert 2006).

Dominant species in the catch has changed over time. From 1976-1979 white perch, yellow perch and gizzard shad (*Dorosoma cepedianum*) were the most commonly caught species and represented an average of 37.2%, 22.1% and 14.3% of the total catch, respectively (Table 1). Through the 1980s smallmouth bass (mean=25.2%), yellow perch (mean=25.0%) and white perch (mean=22.5%) dominated gill net catches. Since 1990, smallmouth bass and yellow perch were the most common species, averaging 30.5% and 31.6% of the total warmwater catch, respectively. From 1995-2007 catches of white perch remained low (mean=3.7%); however, each year 2008-2011 and 2013 it was the third most commonly caught species and

represented an average of 13.0% of the catch during those years. In 2013, yellow perch (31.2%), smallmouth bass (23.1%), and white perch (19.4%) were the three most common species captured (Table 1).

Round goby is an invasive species first reported in southwestern Lake Ontario in 1998 and in the Bay of Quinte in 1999 (Mills et al. 2005). Gobies increased in distribution, abundance, and biomass throughout Lake Ontario, peaking in 2008, and remaining at a variable, lower level since (Walsh et al. 2007, Weidel et al. 2014). Although present in Lake Ontario for some time, gobies did not appear in this assessment until 2005 when two were captured. They have appeared in low numbers each year since (Table 1). This assessment will not provide an index of goby abundance due to their relatively small size and the size-selective nature of the assessment gill nets. We are, however, able to gain insight into the importance of gobies in predator diets during early August from examination of predator stomachs.

Occurrence of Round Goby in Predator Diets

Stomach contents from all predators captured were identified from 2000-2013. We first observed round gobies in predator diets in 2005 (i.e., a total of 16 gobies observed in bass stomachs). Their occurrence in smallmouth bass stomachs increased each year since. In 2013, 84.0% of the 175 non-empty bass stomachs contained goby. Gobies were present in walleye diets each year from 2006-2010 and 2012-2013 but none were observed in walleye diets during the 2011 assessment. Round gobies were also observed in the diets of northern pike, brown trout (*Salmo trutta*), lake trout, and lake whitefish (*Coregonus clupeaformis*) caught in this survey. Although not quantified, round gobies were observed in stomachs of other fish species including rock bass (*Ambloplites rupestris*), yellow perch and white perch. DCC in the eastern basin are also consuming round goby. This species first appeared in DCC diets at the Snake and Pigeon Island colonies in 2002 (Ross et al. 2003) and at the Little Galloo Island colony in 2004 (Johnson et al. 2005). Gobies were consumed each year since then and dominated DCC diets by 2004 and 2005 at the Snake and Pigeon Island colonies, and Little Galloo Island colony, respectively (Ross et al. 2005, Johnson et al. 2006, Johnson et al. 2010, Johnson et al. 2012, Johnson et al. 2013, Johnson et al. 2014).

Occurrence of Lake Sturgeon

Lake Sturgeon (*Acipenser fulvescens*) is designated as a threatened species in New York State. Prior to 1995, this species was extremely rare in this assessment, with only one lake sturgeon captured in 19 years (1976-1994; Table 1). From 1995-2013, at least one sturgeon was collected in 14 of the 19 years. Lake sturgeon remain rare in the survey (none caught in 1996, 2002, 2008, 2009, or 2012; Table 1).

Occurrence of Chain Pickerel

Chain pickerel (*Esox niger*) was captured for the first time in this assessment in 2013 when three were caught in two nets, each set in 15 ft. water depth. There were reports of this species in the eastern basin prior to 2013 (Hoyle and Lake 2011), however, they were likely not captured in this assessment because nets are distributed at water depths 12-100 ft, deeper than where chain pickerel are most abundant. Chain pickerel presence in Ontario waters was confirmed in 2008 (Hoyle and Lake 2011). It was also reported in angler catch during the Lake Ontario Fishing Boat Survey each year 2008-2010 and 2013 (Lantry and Eckert 2014). Occurrence of chain pickerel in recent years is attributed to range expansion (Hoyle and Lake 2011).

Index of Abundance: Total Warmwater Catch

The abundance index for warmwater fish in the New York waters of Lake Ontario's eastern basin was highest during the early years of the assessment (1976-1979 mean stratified CPUEs: 209-257) then declined (1984-1986 mean CPUE=68.7; Table 1, Figure 2). The decline in warmwater fish abundance was primarily due to declining indices for white perch (1976-1979 mean CPUE=90.1, 1984-1986 mean CPUE=15.7), yellow perch (1976-1979 mean CPUE=51.8, 1984-1986 mean CPUE=17.6), gizzard shad (1976-1979 mean CPUE=34.7, 1984-1986 mean CPUE=0.6), and rock bass (1976-1979 mean CPUE=13.5, 1984-1986 mean CPUE=6.2; Table 1, Figures 3-6). The mean stratified CPUE for all warmwater species reached a

record low level in 1995 when CPUE was 14.9 and 94% lower than the 1976-1979 average (Table 1, Figure 2). Since 1996, mean stratified CPUE for total warmwater fish varied without trend averaging 26.9 and ranging between 14.9 (1995) and 44.4 (2008; Table 1, Figure 2). In 2013, the mean stratified CPUE of 33.1 was comparable to (-6.2%) the previous 5-year (2008-2012) average.

Alewife (*Alosa pseudoharengus*), walleye, and smallmouth bass also influenced trends in the total warmwater CPUE. Alewife was relatively common in the assessment and varied without trend through 1988 before declining to low levels (Table 1, Figure 7). Walleye catches increased from low levels observed prior to the mid-1980s (Figure 8). Smallmouth bass catches were relatively high and increased as strong year classes recruited into the gill nets (1980 CPUE=38.0; 1989 CPUE=39.1), then declined to the lowest levels during 2000-2004 (average CPUE=4.2; Figure 9). Catches of other species (i.e. white sucker [*Catostomus commersonii*], brown bullhead [*Ameiurus nebulosus*], channel catfish [*Ictalurus punctatus*], pumpkinseed sunfish [*Lepomis gibbosus*], freshwater drum, northern pike, and common carp [*Cyprinus carpio*]) were low and variable across the entire data series (Table 1, Figures 10-16).

White Perch Index of Abundance

The most notable declines in species abundance between the late 1970s and mid 1980s occurred with white perch and gizzard shad, the two most abundant species in 1977 and 1978. White perch declined 83% from the 1976-1979 and 1984-1986 time periods (Table 1, Figure 3). Abundance indices declined further, reaching a low CPUE of 0.06 in 1995, and remained low through 2007. In 2008, white perch CPUE was 7.7, a more than 6-fold increase over the previous 5-year average and the highest observed since 1991. Each year from 2008-2011 white perch was the third most common species in the assessment, representing 9.6%-17.5% of the total warm water fish catch. The 2012 CPUE (1.0) was a 79.8% decrease compared to the 2008-2011 time period (Table 1, Figure 3). In 2013, white perch was again the third most commonly captured species (19.4% of total catch) and the CPUE (6.4) was a 47.3% increase compared to the previous 5-year average.

Yellow Perch Index of Abundance

Yellow perch were commonly caught since the assessment began in 1976, however, abundance declined significantly through the early to mid-1980s reaching a low CPUE of 2.2 in 1988 (Table 1, Figure 4). Subsequently, CPUE varied without trend and averaged 7.4 from 1989-2006 (range: 2.8 [1993] - 13.6 [1990]). Yellow perch CPUE increased in 2008 to the highest level (16.9) since 1984. The 2013 CPUE (10.3) was below previous 5-year and 10-year averages (-27.2% and -13.6%, respectively). Variability of yellow perch catch in gill nets is relatively high (long-term average RSE=37.1%) when compared to another common species (e.g., smallmouth bass long-term average RSE=21.2%), and is likely attributable to the schooling nature of perch. For 2013, yellow perch RSE (46.7%) was 25.8% above the long term average.

As was documented for smallmouth bass (Chrisman and Eckert 1999, Lantry et al. 2002), the yellow perch population in the eastern basin was impacted by DCC predation (O'Gorman and Burnett 2001). Fall trawl sampling conducted in the eastern basin showed that relatively strong year classes of yellow perch were produced in the early 1990s, however, anticipated increases in assessment CPUE at older ages did not occur. Analyses indicated increased mortality of age 0-2 perch during that time period which was attributed, in part, to increased predation by DCC (O'Gorman and Burnett 2001). Since then, management of the DCC population reduced both the number of DCC feeding days (the measure used to evaluate management efforts) and the number of fish consumed (Johnson et al. 2010). Over the same time period round goby abundance increased. Round goby is now the species most commonly consumed by DCC, further reducing predation pressure on yellow perch in recent years (Johnson et al. 2014).

In 2013, yellow perch total lengths ranged between 6.8 in and 13.3 in, and averaged 8.8 in. Approximately 34% of perch captured were $\geq$ 9 in (Figure 17). Weights of yellow perch captured in 2013 ranged from 2.3 oz to 1.1 lb.

Gizzard Shad Index of Abundance

Gizzard shad was one of the most abundant species at the start of the warmwater assessment program (Table 1, Figure 5). Abundance declined 98% from the 1976-1979 (mean CPUE=34.7) to 1984-1986 (mean CPUE=0.6) time periods. Since then, gizzard shad abundance remained low, with CPUEs of zero or <1 in 23 of the 26 years from 1987-2012 (Table 1). In 2013, gizzard shad CPUE (2.01) was the highest since 1981 (CPUE=2.8). This increase is likely attributable to the warm winters experienced the last two years.

Rock Bass Index of Abundance

Rock bass CPUE peaked in 1978 at 22.1, declined through the early 1980s, varied without trend through the early 1990s, then declined again to a relatively stable level through 2013 (Figure 6). In 2013, the rock bass CPUE (1.2) was a 35.3% decrease compared to the previous 5-year average.

Alewife Index of Abundance

Alewife CPUE varied without trend through 1988, averaging 9.0 (Figure 7). CPUE subsequently declined and was ≤1 each year 1993-2008. In 2009, alewife CPUE (1.2) was the highest observed since 1992, but well below levels observed through the 1970s and 1980s. No alewives were caught during the 2010 or 2013 assessments. Although alewife is not fully vulnerable to our gear, the overall trends we observed were similar to those in Lake Ontario bottom trawl surveys (O'Gorman et al. 2000, Walsh et al. 2010). The declining trends in alewife abundance and a shift in temporal distribution were particularly evident in the eastern basin (O'Gorman et al. 2000, O'Gorman et al. 2005).

Walleye Index of Abundance and Age Structure

Walleye is the only relatively common species that increased in abundance since the assessment was initiated in 1976 (Figure 8). Catches were lowest from the late 1970s through the mid-1980s (mean CPUE 1976-1986=0.2) and increased through the early 1990s with a peak CPUE of 3.8 in 1993 (Table 1). Subsequently, CPUE declined through the late 1990s, and has fluctuated without trend (Figure 8). The 2013 CPUE of 1.3 was a 35.2% decrease compared to the previous 10-year average. Lower gill net catches in 2013 may be partly attributable to water temperature and improved alewife abundance altering walleye distributions. Variability of gill net catches was highest when CPUE was low (Figure 8) with RSE averaging 44.6% during the 1980-1989 time period. RSE fluctuated at a lower level without trend from 1990-2013 (average RSE=26.9%).

Otoliths collected from walleye were aged and indicated that strong year classes were produced in 2003, 2005, and 2008 (Figure 18). In 2013, these year classes (ages 10, 8, and 5, respectively in 2013) dominated the catch and represented 20.8%, 13.2%, and 15.1% of the catch, respectively (Figure 18). The 2003 year class were first captured as age 1s in 2004 when they represented 25.9% of the walleye catch (n=21 age-1 fish a record-high; Eckert 2005). Prior to 2004, age 1 walleye were rare in this assessment (n=17 during 1976-2003). Assessments in Ontario waters of Lake Ontario and New York waters of Lake Erie also identified a strong 2003 walleye year class (Einhouse et al. 2010, Ontario Ministry of Natural Resources [OMNR] 2011a and 2011b). Good to strong 2005 and 2008 year classes were also produced in Ontario waters (OMNR 2009, 2010, 2011a, 2012). Fall bottom trawling in the Bay of Quinte indicated that a good 2011 year class was produced there (OMNR 2012). We did not capture any of the 2011 year class as age 1s in 2012 and it represented only 5.7% of the 2013 catch as age 2s, suggesting the 2011 year class was not strong in New York waters of the eastern basin (Figure 18).

In 2013, walleye total lengths ranged between 14.8 in (377 mm) and 29.3 in (743 mm), and averaged 24.0 in (609 mm; Figure 17). Walleye weights ranged from 1.0 lb (456 g) to 10.8 lb (4,908 g) and averaged 6.2 lb (2,803 g).

Smallmouth Bass Growth and Condition, and Index of Abundance

Smallmouth bass have provided an important sport fishery in Lake Ontario's eastern basin for decades (Jolliff and LeTendre 1967, Panek 1981, NYDEC 1989, McCullough and Einhouse 1999, McCullough and Einhouse 2004). It was always a relatively common species in this assessment and was the most or second most commonly captured species in

the assessment since 1986, following significant declines of previously dominant species (i.e., white perch and gizzard shad; Table 1). In 2013, smallmouth bass was the second most commonly captured species, representing 23.1% of the total catch.

Growth and Condition

Prior to the mid 1990s, assessment gill nets did not effectively sample age-2, -3, and -4 smallmouth bass because of their relatively small size, and bass were considered fully vulnerable to assessment nets at approximately 12 in TL (generally age 5 or 6). Evidence of increased growth rates were observed in the mid 1990s, and by the mid to late 1990s age-specific annual mean TLs have generally been above age-specific long term means for all ages (2-13; Figure 19). Age-1 bass first appeared in the assessment in 1994 and appeared in low numbers most years since. Beginning in 1997, at least a portion of bass as young as age 3 reached 12 in TL (Figure 19, Figure 20) and for the majority of subsequent years, bass averaged over 12 in TL by age 4. In 2009, the most recent year with age determinations, mean length-at-age remained at or near record high for all ages 2-10. Gill nets now effectively sample many age-2 and age-3 bass, and likely all age-4 bass. These changes confound comparisons of "historic" (prior to mid 1990s) bass data with more recent data, including age-specific CPUE and survival. In addition, increased growth rates likely reduce age-at-maturity and longevity, further compounding population structure comparisons.

Age composition of bass fully vulnerable to our gear and of legally harvestable size (i.e. ≥ 12 in) changed as mean length-at-age increased (Figure 19, Figure 20). For years prior to 1997, 98.1% (1976-1996 mean) of bass ≥ 12 in were age 5 and older, which declined to 80.3% from 1997 through 2003. Concurrently, catches of age 3 and 4 bass ≥ 12 in rose from 1.9% to 19.7%. Analysis of CPUE by size group may improve our ability to compare historic and recent year class recruitment and population trends.

Increased bass growth rates began prior to first reports of round goby in Lake Ontario which occurred in 1998 (southwestern area) and 1999 (Bay of Quinte). Increased growth may be due to system changes associated with Dreissenid mussel proliferation and/or compensatory growth associated with a declining bass population through the early 1990s due to DCC predation (Figure 9).

Smallmouth diet data indicate a shift from crayfish dominance and no gobies to one clearly dominated by round goby and very low occurrence of crayfish by 2007. This dietary shift coincides with recent increased condition of smallmouth bass in the eastern basin, and strongly suggests bass ages ≥ 2 are not limited by prey availability. Smallmouth bass condition varied about the long term mean from 1976-2005, then increased for each length group from 7-12 in (Figure 21). Condition of the 16-18 in length groups has trended upward since the early to mid 1990s. In 2013, condition remained at or near the highest levels observed in the survey for the 12-18 in length groups. Condition of smaller bass (9-11 in) remained above the long term average (Figure 21).

In 2013, 17.9% of all smallmouth bass caught (n=252) were ≥4 lbs, the highest contribution on record (Figure 22). Approximately 6% of all smallmouth caught weighted ≥5 lbs. Bass ≥6 lbs were first caught in the 2011 survey, and again in 2012 and 2013 (0.3% and 0.4% of total catch, respectively). These increases are attributed to good growth and condition (Figures 19-21) and are not due to increased abundance of older aged bass (Figure 23).

In 2013, smallmouth bass total lengths ranged between 7.1 in (181 mm) and 21.1 in (537 mm), and averaged 13.5 in (344 mm; Figure 17). Bass weights ranged from 0.15 lb (66 g) to 6.8 lb (3,076 g) and averaged 2.0 lb (920 g).

Abundance Trends

CPUE peaked during the 1979-1980 and 1989-1991 periods (1979-1980 average CPUE = 36.9, 1989-1991 average CPUE = 30.1; Table 1, Figure 9), attributable to strong representation of the 1973 and 1983 year classes during these respective time periods. These strong year classes persisted for several years and were well represented in gillnet

catches through at least age 9 (Chrisman and Eckert 1999).

Smallmouth bass CPUE declined through the early 1990s and reached record-low levels during 2000-2004 (2000-2004 mean CPUE=4.2; Figure 9). Relatively high CPUE of young fish indicated that strong year classes had been produced in 1987, 1988, 1995, and 1997 (Chrisman and Eckert 1999, Eckert 2000, Casselman et al. 2002); however, increased CPUE of these year classes at larger sizes (>12 in) or older ages was not evident (Figures 9, 23). Analysis of year class-specific catch curves indicated increased mortality of age-3 to age-6 bass through the 1990s (Chrisman and Eckert 1999, Lantry et al. 2002) which coincided with documented increases in DCC numbers (Johnson et al. 1999, Johnson et al. 2000). This, combined with DCC diet data, corroborated substantial predation on smallmouth bass (Johnson et al. 1999, Johnson et al. 2000, Lantry et al. 2002).

Smallmouth bass CPUE in 2005 increased substantially (CPUE=11.3) from 2000-2004 record lows (mean CPUE=4.2), and since then CPUE remained relatively stable near 1994-1999 levels (i.e., years when there were concerns about the status of the bass population; Figure 9). The 2013 CPUE was 7.7, comparable to (-7.1%) the previous 5-year average and well above (+81.9%) lows observed 2000-2004. The 2005-2013 average CPUE is, however, 60.3% below the levels observed before DCC impacts and other ecosystem changes (1976-1994; Figure 9). During the entire time series smallmouth bass RSE fluctuated without trend, ranging from 13.2% (2005) to 29.0% (1989). RSE was 18.7% in 2013 (long-term average RSE = 21.2%).

Increased smallmouth bass CPUEs, beginning in the mid-2000s relative to 2000-2004 levels, may be due to several factors including DCC management practices and a DCC diet shift to round goby that reduced predation pressure on smallmouth bass (Ross et al. 2003, Johnson et al. 2005, McCullough and Mazzocchi 2014, Johnson et al. 2014), and increased growth causing improved bass catchability in gill nets. Ongoing DCC population management in the New York waters of the eastern basin has effectively reduced DCC numbers and, since 2006, has maintained the number of DCC feeding days to near-target levels (McCullough and Mazzocchi 2014, Johnson et al. 2014). The decline in number of cormorant feeding days combined with their dietary shift to round goby by 2005 (Johnson et al. 2014) appear to have reduced predation pressure on smallmouth bass. DCC mortality on bass, which escalated through the 1990s, was dramatically reduced by the mid 2000s. Finally, increased CPUE is due, in part, to increased growth beginning in the mid-1990s which increased catchabilty of the more abundant, younger ages (i.e., younger ages were more vulnerable to capture in recent years relative to the mid-1990s).

Mean summer (June-August) water temperatures are positively correlated with smallmouth bass recruitment (e.g., Casselman et al. 2002, Einhouse et al. 2002). Increased summer water temperatures during the survey period in recent years should have contributed to improved bass recruitment during 2012 and 2013 (i.e. ages 1 and 0 in 2013); however, evidence from this survey will not be available until at least 2014, when the 2012 year class of bass are age 2.

Increased growth and increased mortality of bass ages 3-6 (Lantry et al. 2002) altered age structure of the catch from one dominated by bass $\geq$ age 5 prior to the 1990s (76%) to one dominated by younger bass (Figure 20, Figure 23). During the 1990s and early 2000s bass < age 5 represented an average of 52% of the total catch and ages $\geq$5 represented 48% of the catch (Figure 20, Figure 23). Since the mid-2000s, only the samples from 2006-2009 were aged and younger bass continued to dominate catches (2006-2009 average percent contribution: ages $\geq$5 = 45.1%, and ages <5 = 54.9%; Figure 19). There is no evidence of a strong year class recruiting to ages $\geq$5 since the 1983 year class (Figure 23).

Ongoing changes in the Lake Ontario ecosystem confound predictability; however, it is unlikely that the system will support bass abundance at pre-1990s levels. In spite of increased growth and condition, reduced DCC predation, and increased summer water temperatures, data indicate that the eastern basin smallmouth bass population is experiencing

compromised recruitment. Given these changes, a more thorough evaluation of the status of smallmouth bass in New York water's of the eastern basin is recommended.

A number of factors can impact bass recruitment including condition of spawning habitat, predation on bass eggs or fry by round goby, prey availability for young-of-year bass, maturity and longevity, and viral hemorrhagic septicemia virus (VHSv). Increased *Cladophora* growth in nearshore areas may impact the condition of spawning habitat and consequently bass recruitment; however, impacts are unknown, as are potential impacts of round goby predation. Prey availability from fry to age 1 is unknown and may be impacted, through competition for prey, by the invasive macroinvertebrate *Hemimysis* sp. Fish populations experiencing increased growth and improved condition typically mature at earlier ages and live for fewer years than those that mature at older ages, however, this analysis has not yet been applied to the eastern basin bass population. Finally, a VHSv induced mortailty event could reduce the spawning stock. In 2006 bass die-offs in Lake Ontario's main basin and eastern basin, and in the St. Lawrence River were attributed to VHSv. It is unclear if VHSv mortality events have occurred since or will occur in the future.

A more complete evaluation of assessment data is needed to better understand current population dynamics of New York's eastern basin bass population, including: 1) age determination for bass caught during 2004-2005 and 2010-2013; and 2) evaluation of size-specific CPUE data to allow comparisons of recent population dynamics (i.e. year class strength, abundance, recruitment dynamics, growth, survival, maturity, longevity) with historic data.

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Table 1. Stratified mean catch per unit effort data from the 1976-2013 warmwater assessment netting conducted late July through mid August in New York waters of Lake Ontario's eastern basin.

	Stratified Mean Catch per 450 ft Monofilament Gill Net Gang												
	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Lake Sturgeon	0	0	0	0	0	0.02	0	0	0	0	0	0	0
Longnose Gar	0	0	0	0	0.04	0	0	0.04	0	1.19	0.04	0	0
Bowfin	0	0	0	0	0.02	0.02	0	0	0	0	0	0	0
American Eel	0	0	0.06	0.03	0	0	0	0	0	0	0	0	0
Alewife	20.96	2.07	14.83	11.57	4.30	8.18	7.53	6.90	17.65	3.35	7.61	2.32	9.64
Gizzard Shad	17.82	53.45	47.38	19.95	4.52	2.78	0.10	0.29	0.87	0.50	0.48	0.44	0.24
Northern Pike	0.83	1.04	0.93	0.16	0.08	0.02	0.04	0.06	0.02	0.17	0.17	0.08	0
Chain Pickerel	0	0	0	0	0	0	0	0	0	0	0	0	0
Muskellunge	0	0	0	0	0	0	0	0	0	0	0	0	0
Goldfish X Carp	0	0	0	0.17	0	0	0	0	0	0	0	0	0
Common Carp	0.25	0.55	0.33	0.45	0.17	0.10	0.35	0.21	0.17	0.17	0.10	0.20	0.23
Golden Shiner	0	0	0	0	0.02	0	0	0	0.04	0.02	0	0	0
Spottail Shiner	0	0	0	0	0	0	0	0.15	0	0	0	0	0
Quillback	0	0	0	0.31	0.04	0.06	0	0.04	0	0	0.02	0	0.02
Longnose Sucker	0	0	0	0	0.02	0	0	0	0	0	0	0	0
White Sucker	4.04	0.63	2.90	3.11	1.84	1.42	4.34	1.40	1.58	0.93	2.47	1.49	0.91
Silver Redhorse	0.06	0.05	0.20	0.43	0.04	0.10	0.15	0.38	0.06	0	0.02	0.02	0.07
Shorthead Redhorse	0	0	0	0	0	0	0	0	0	0	0	0	0
Brown Bullhead	1.12	0.2	1.41	4.17	0.66	0.23	1.29	0.76	0.86	1.70	2.14	1.96	0.61
Channel Catfish	0.41	1.03	1.75	3.64	0.6	0.56	1.27	0.86	0.29	0.63	1.25	0.77	0.97
Stonecat	0	0.04	0.26	0.08	0	0.23	0.30	0.02	0.04	0.06	0.04	0	0
Trout-perch	0	0	0	0	0	0.15	0.15	0	0.08	0	0	0.08	0.15
White Perch	63	136.42	74.11	86.98	26.2	44.53	25.98	34.02	20.78	12.23	13.94	11.14	4.87
White Bass	0	0	0.13	0	0.02	0.06	0.26	0	0.06	0.02	0.06	0.06	0.13
Rock Bass	7.10	10.75	22.13	13.94	14.69	10.09	7.06	4.69	6.99	3.96	7.58	4.76	4.94
Pumpkinseed	0	0.44	0.06	3.06	0.14	0.32	0.73	0.43	0.09	0.59	0.57	0.40	0.25
Bluegill	0	0	0	0	0	0	0.04	0	0	0	0	0	0
Smallmouth Bass	24.51	24.05	26.04	35.74	38.02	23.47	14.55	14.96	12.44	9.76	18.14	10.89	15.92
Largemouth Bass	0	0	0	0	0	0	0	0	0	0	0	0	0
Black Crappie	0	0	0	0.04	0.02	0.02	0.02	0.06	0.02	0.1	0	0	0.02
Yellow Perch	69.09	26.20	44.44	67.32	27.63	43.81	36.07	50.85	24.02	15.35	13.32	8.36	2.19
Walleye	0.05	0.20	0.12	0.27	0.28	0.12	0.59	0.09	0.09	0.41	0.19	0.75	0.80
Freshwater Drum	0.19	0	0.74	1.43	0.34	0.09	0.34	0.59	0.31	0.25	0.16	0.25	0.45
Round Goby	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	209.4	257.13	237.8	252.8	119.7	136.4	101.2	116.8	86.50	51.38	68.30	43.98	42.42

Table 1 (continued). Stratified mean catch per unit effort data from the 1976-2013 warmwater assessment netting conducted late July through mid August in New York waters of Lake Ontario's eastern basin.

	Stratified Mean Catch per 450 ft Monofilament Gill Net Gang												
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Lake Sturgeon	0	0	0	0	0	0	0.02	0	0.02	0.06	0.04	0.10	0.02
Longnose Gar	0	0.08	0	0	0.48	0.35	0	0	0.02	0.02	0.08	0	0.02
Bowfin	0	0	0	0.02	0	0	0	0	0	0	0	0	0
American Eel	0	0.02	0	0	0	0	0	0	0	0	0	0	0
Alewife	0.59	1.29	1.27	2.26	0.18	0	0.48	0.92	0	0.06	0.12	0.26	0.95
Gizzard Shad	0.69	1.26	1.39	1.79	0.12	0.06	0	0	0	0.08	0.08	0.13	0
Northern Pike	0.02	0	0.15	0.04	0.10	0.06	0.04	0.04	0.08	0.06	0.06	0.08	0.07
Chain Pickerel	0	0	0	0	0	0	0	0	0	0	0	0	0
Muskellunge	0	0	0	0	0	0	0	0	0	0	0	0	0
Goldfish X Carp	0	0	0	0	0	0	0	0	0	0	0	0	0
Common Carp	0.37	0.35	0.29	0.33	0.35	0.06	0.10	0.15	0.12	0.10	0.33	0.04	0
Golden Shiner	0	0	0	0	0	0	0	0	0	0	0	0	0
Spottail Shiner	0	0	0	0.06	0	0	0	0	0	0	0	0	0
Quillback	0.04	0.04	0.08	0	0.04	0	0	0.04	0	0.04	0	0	0
Longnose Sucker	0	0	0	0	0	0	0	0	0	0	0	0	0
White Sucker	0.75	3.47	0.41	0.88	1.18	0.81	1.13	2.01	1.31	1.02	1.02	0.35	0.38
Silver Redhorse	0.17	0.29	0.22	0.18	0	0.08	0.12	0.02	0.13	0.12	0.10	0.12	0.05
Shorthead Redhorse	0	0	0	0	0	0.02	0	0	0.02	0	0	0	0.02
Brown Bullhead	0.84	0.66	0.86	0.87	0.35	0.35	0.06	0	0.83	0.06	0.21	0.21	0.32
Channel Catfish	2.40	3.34	1.20	1.35	1.12	0.35	0.19	0.47	1.42	0.75	0.68	0.54	0.09
Stonecat	0.02	0	0.02	0	0	0	0	0	0	0	0	0	0
Trout-perch	0	0	0.12	0	0	0	0	0	0	0	0	0	0
White Perch	7.95	4.36	7.83	5.49	5.04	6.01	0.06	0.31	0.48	0.29	1.36	0.92	1.04
White Bass	0.08	0	0.10	0	0.02	0	0	0	0	0.04	0	0	0
Rock Bass	7.53	8.08	6.86	3.09	6.99	3.99	1.41	3.79	2.33	2.13	3.08	1.47	1.22
Pumpkinseed	0.64	0.78	0.14	0.34	0.23	0.04	0.06	0.04	0.08	0.29	0.27	0.31	0.28
Bluegill	0	0	0	0	0	0	0	0	0	0	0	0	0
Smallmouth Bass	39.05	21.72	29.4	19.13	19.91	11.99	5.01	6.98	6.03	9.36	10.68	5.01	2.99
Largemouth Bass	0	0	0	0	0	0	0	0	0	0.02	0	0	0
Black Crappie	0.02	0.06	0	0	0.04	0	0	0	0	0.02	0	0	0
Yellow Perch	10.06	13.61	6.97	6.72	2.78	5.87	3.68	8.76	5.53	5.01	4.47	8.58	6.37
Walleye	0.96	1.31	1.68	1.59	3.84	3.29	1.91	2.97	1.76	2.13	1.32	1.53	1.70
Freshwater Drum	0.53	0.62	0.34	0.43	0.52	0.74	0.63	0.23	0.41	0.25	0.50	0.25	0.20
Round Goby	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	72.71	61.35	59.34	44.57	43.32	34.08	14.91	26.73	20.58	21.94	24.40	19.92	15.73

Table 1 (continued). Stratified mean catch per unit effort data from the 1976-2013 warmwater assessment netting conducted late July through mid August in New York waters of Lake Ontario's eastern basin.

	Stratified Mean Catch per 450 ft Monofilament Gill Net Gang											
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Lake Sturgeon	0	0.04	0.02	0.02	0.09	0.10	0	0	0.08	0.02	0	0.02
Longnose Gar	0	0	0.06	0.17	0.12	0.08	0.10	0.21	0.75	0.62	0.02	0.23
Bowfin	0	0	0	0	0	0	0	0	0	0	0	0
American Eel	0	0	0	0	0	0	0	0	0	0	0	0
Alewife	0.02	0.08	0	0	0.07	0.14	0.19	1.19	0	0.16	0.46	0
Gizzard Shad	0.06	0	0	0	0	0	0	0.10	0	0.12	0.19	2.08
Northern Pike	0.19	0.15	0.17	0.19	0.08	0.06	0.23	0.09	0.10	0.02	0.02	0.12
Chain Pickerel	0	0	0	0	0	0	0	0	0	0	0	0.06
Muskellunge	0	0	0.02	0.02	0	0	0	0	0	0	0	0
Goldfish X Carp	0	0	0	0	0	0	0	0	0	0	0	0
Common Carp	0	0.02	0.15	0.14	0.11	0.02	0.05	0.10	0.02	0.02	0	0.15
Golden Shiner	0	0	0	0	0	0	0	0	0	0	0	0
Spottail Shiner	0	0	0	0	0	0	0	0	0	0	0	0
Quillback	0	0	0	0	0	0	0	0	0	0	0	0.08
Longnose Sucker	0	0	0	0	0	0	0	0	0	0	0	0
White Sucker	0.78	1.66	0.41	1.03	0.72	0.573	0.65	1.31	0.48	0.25	2.35	0.19
Silver Redhorse	0.17	0.10	0.42	0.33	0.02	0.02	0.08	0.07	0.04	0	0.06	0.06
Shorthead Redhorse	0	0	0	0	0	0	0	0	0	0	0	0
Brown Bullhead	0.21	0.40	0.35	0.48	0.31	0.54	2.12	0.81	1.48	0.42	0.82	1.97
Channel Catfish	0.21	0.12	0.79	0.81	0.15	0.12	0.57	0.54	0.42	0.17	0.21	0.42
Stonecat	0	0	0	0.06	0.02	0	0	0	0.04	0.02	0.02	0
Trout-perch	0	0	0	0	0	0	0	0	0	0	0	0
White Perch	1.09	0.42	1.18	1.94	0.92	0.81	7.75	3.02	6.22	3.72	1.04	6.41
White Bass	0	0	0	0	0	0	0	0	0	0	0	0.00
Rock Bass	1.10	1.84	2.09	2.70	2.43	0.70	3.27	2.52	1.54	1.31	0.75	1.21
Pumpkinseed	0.46	0.46	0.52	0.50	1.15	0.21	0.10	0.28	0.04	0.21	0.29	0.38
Bluegill	0	0	0	0	0	0	0	0	0	0	0	0
Smallmouth Bass	3.76	5.43	3.84	11.33	10.45	6.39	9.27	9.81	7.90	6.09	8.12	7.65
Largemouth Bass	0	0	0.02	0.02	0.02	0	0	0.03	0.02	0	0	0.02
Black Crappie	0.06	0	0.02	0.06	0	0.04	0.05	0.03	0.04	0.04	0.02	0.06
Yellow Perch	9.65	9.82	6.74	8.93	9.13	13.95	16.91	7.37	16.31	15.29	14.99	10.32
Walleye	1.08	2.12	1.69	2.38	1.94	1.33	2.33	2.65	1.91	1.97	2.38	1.34
Freshwater Drum	0.23	0.27	0.60	0.19	0.32	0.23	0.26	0.36	0.08	0.19	0.19	0.29
Round Goby	0	0	0	0.04	0.10	0.26	0.42	0.95	0.36	0.08	0.07	0.02
Total	19.06	22.92	19.1	31.36	28.16	25.6	44.36	31.44	37.84	30.73	32.02	33.09

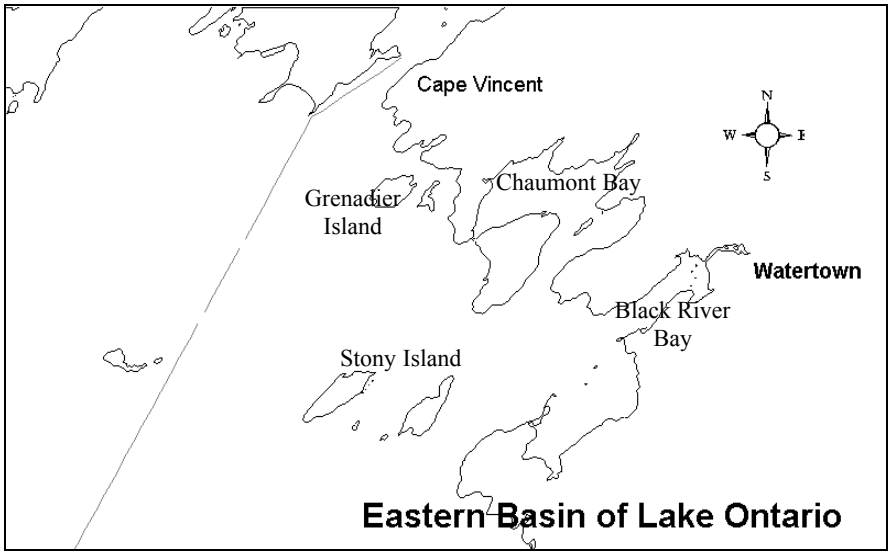

Figure 1. Map of New York waters of Lake Ontario's eastern basin showing five area strata used in the 1980-2013 warmwater assessment.

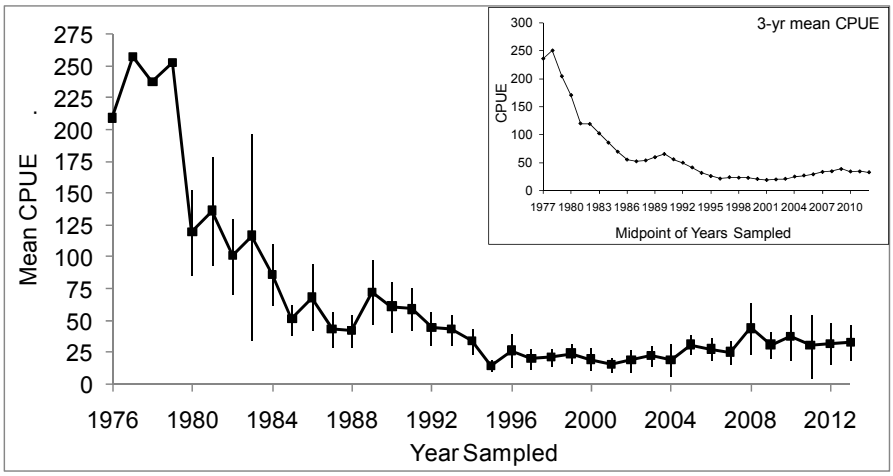

Figure 2. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for all warmwater fish from the 1976-2013 assessments.

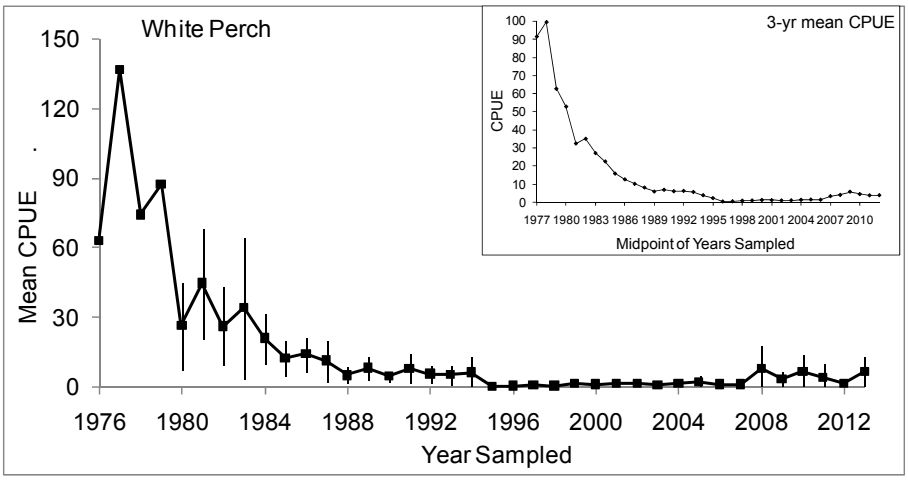

Figure 3. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for white perch, 1976-2013.

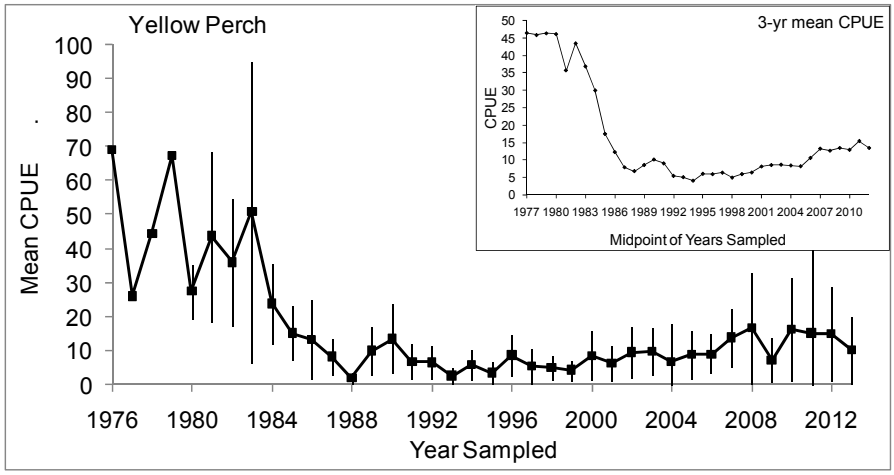

Figure 4. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for yellow perch, 1976-2013.

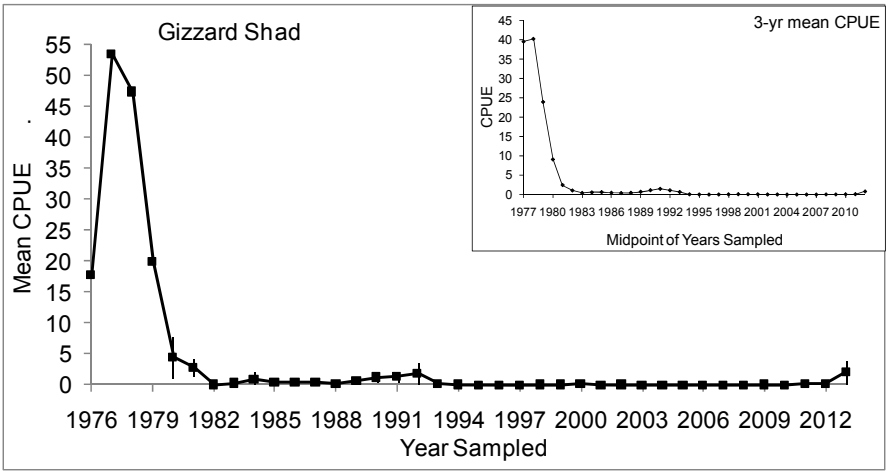

Figure 5. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for gizzard shad, 1976-2013.

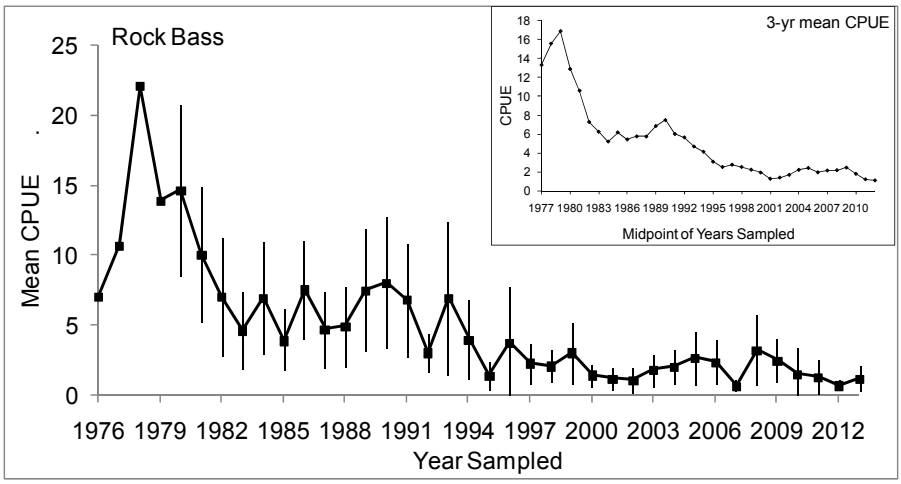

Figure 6. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for rock bass, 1976-2013.

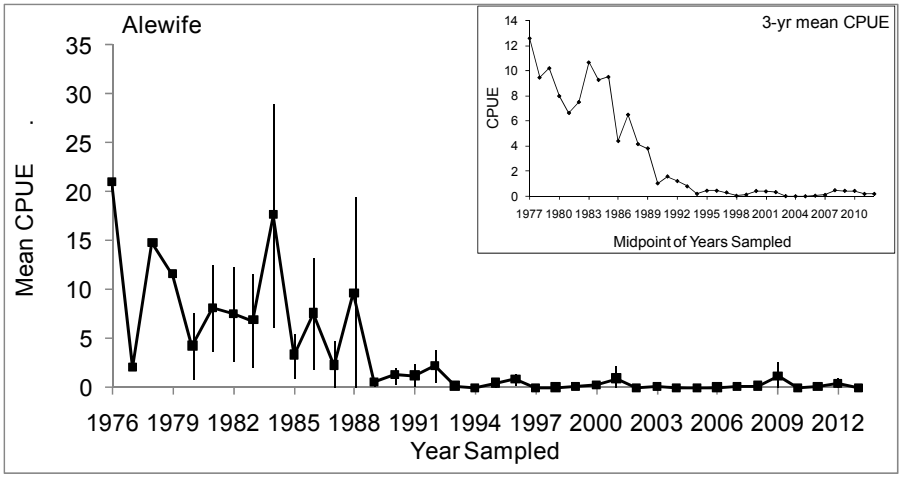

Figure 7. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for alewife, 1976-2013.

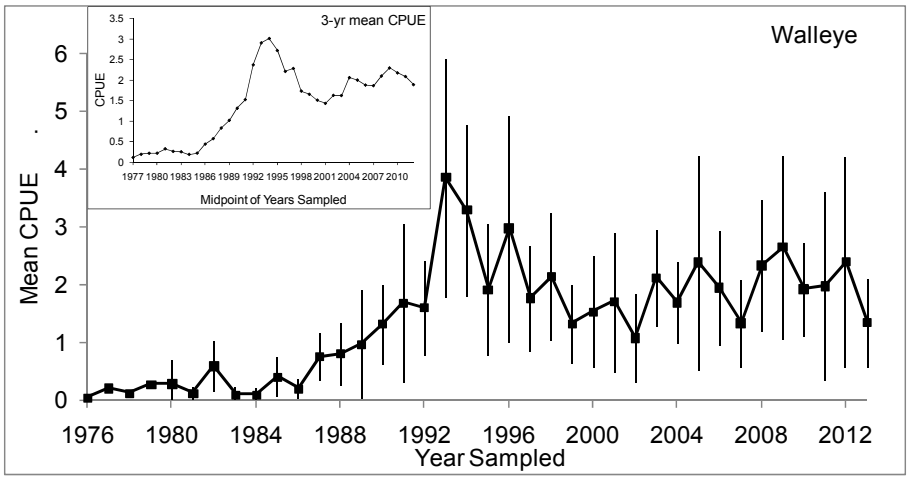

Figure 8. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for walleye, 1976-2013.

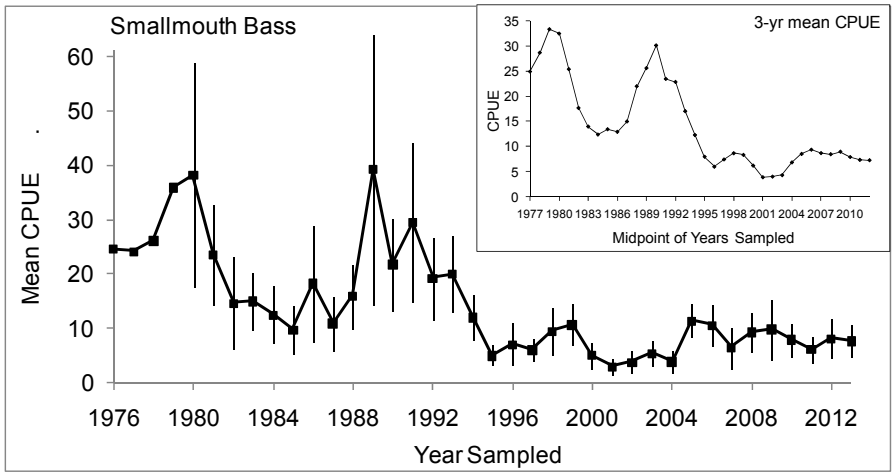

Figure 9. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for smallmouth bass, 1976-2013.

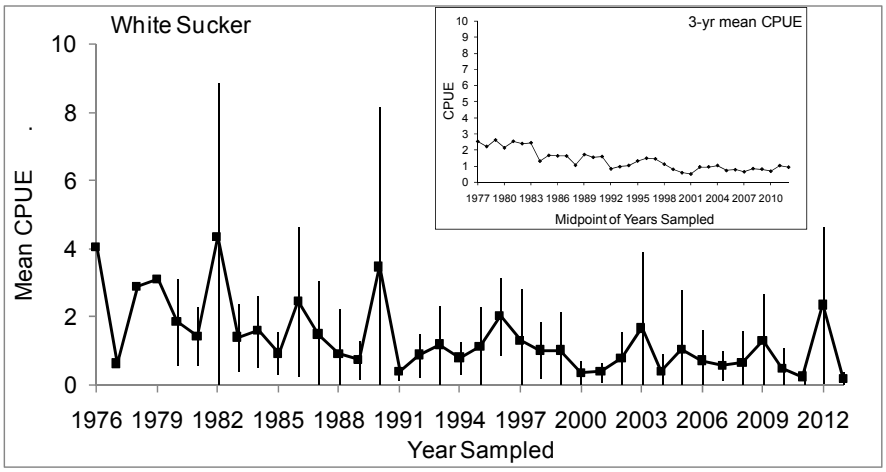

Figure 10. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for white sucker, 1976-2013.

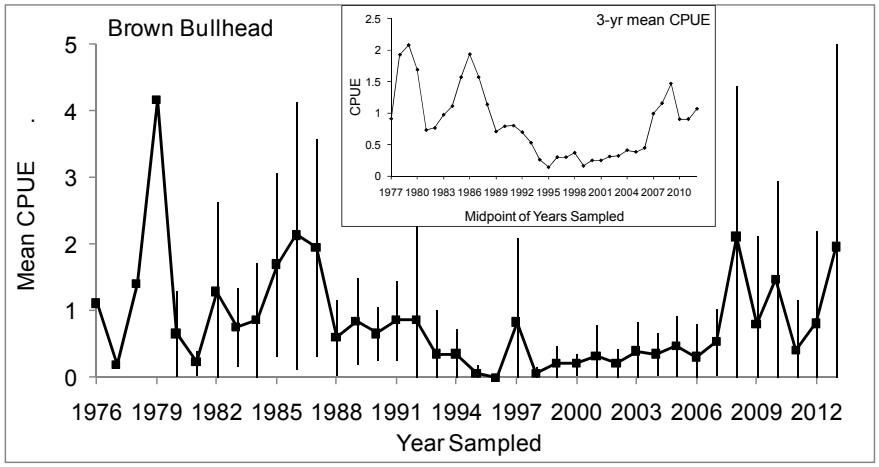

Figure 11. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for brown bullhead, 1976-2013.

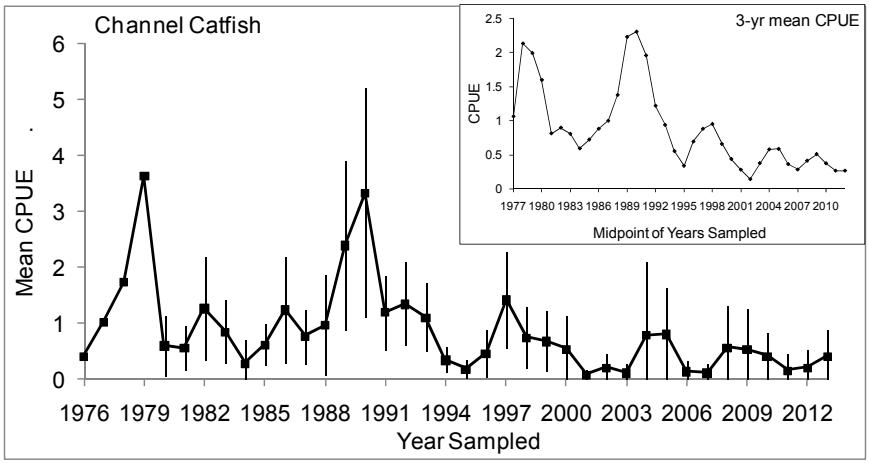

Figure 12. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for channel catfish, 1976-2013.

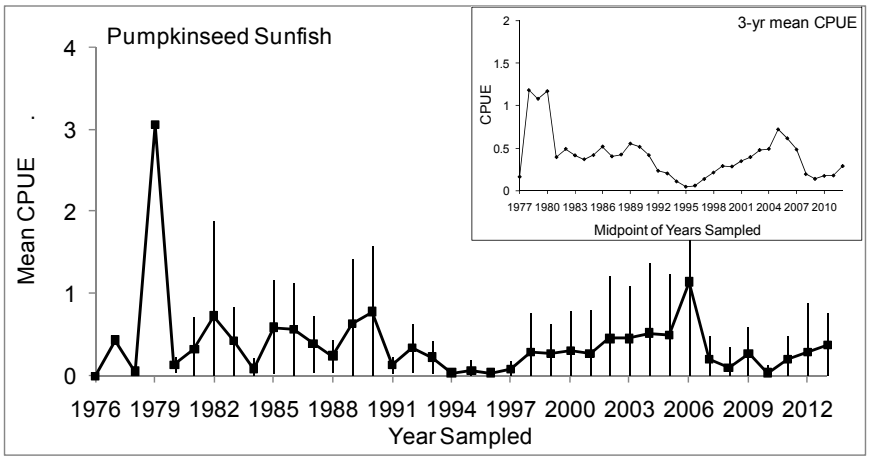

Figure 13. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for pumpkinseed sunfish, 1976-2013.

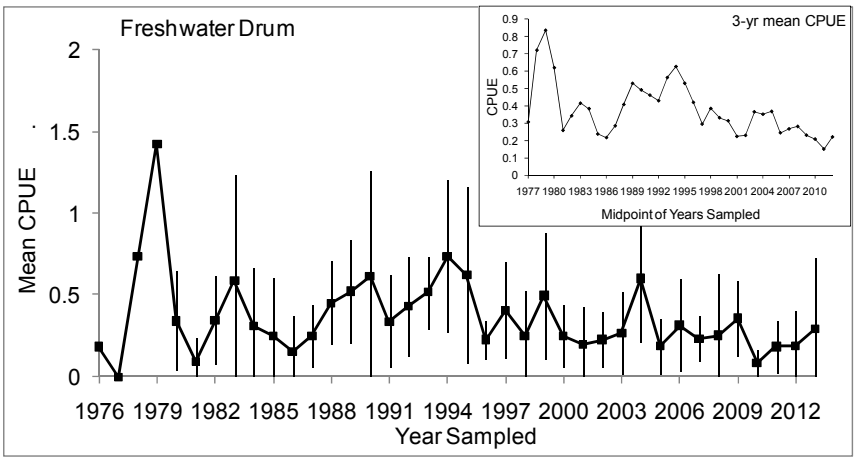

Figure 14. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for freshwater drum, 1976-2013.

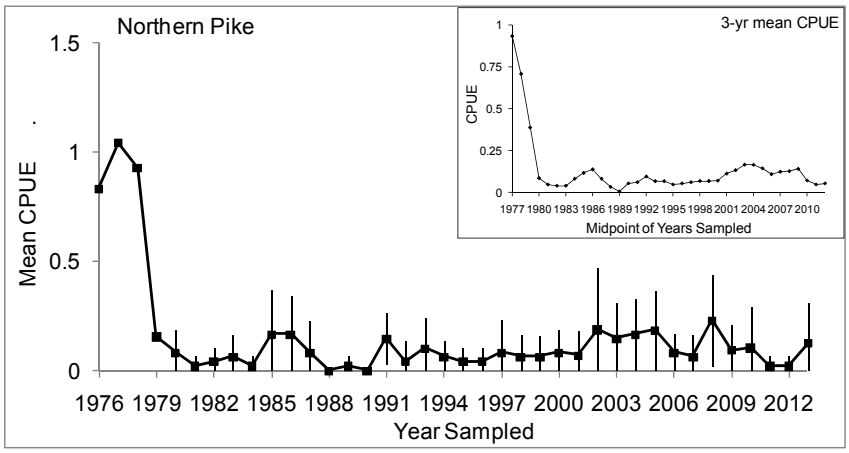

Figure 15. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for northern pike, 1976-2013.

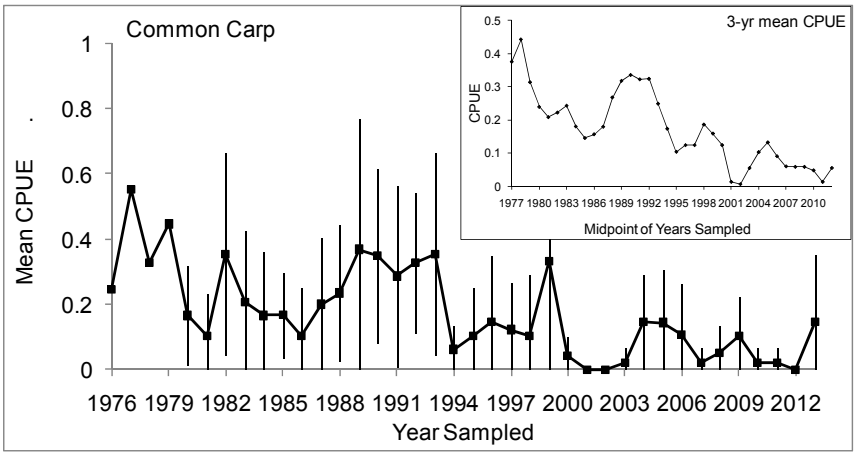

Figure 16. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for common carp, 1976-2013.

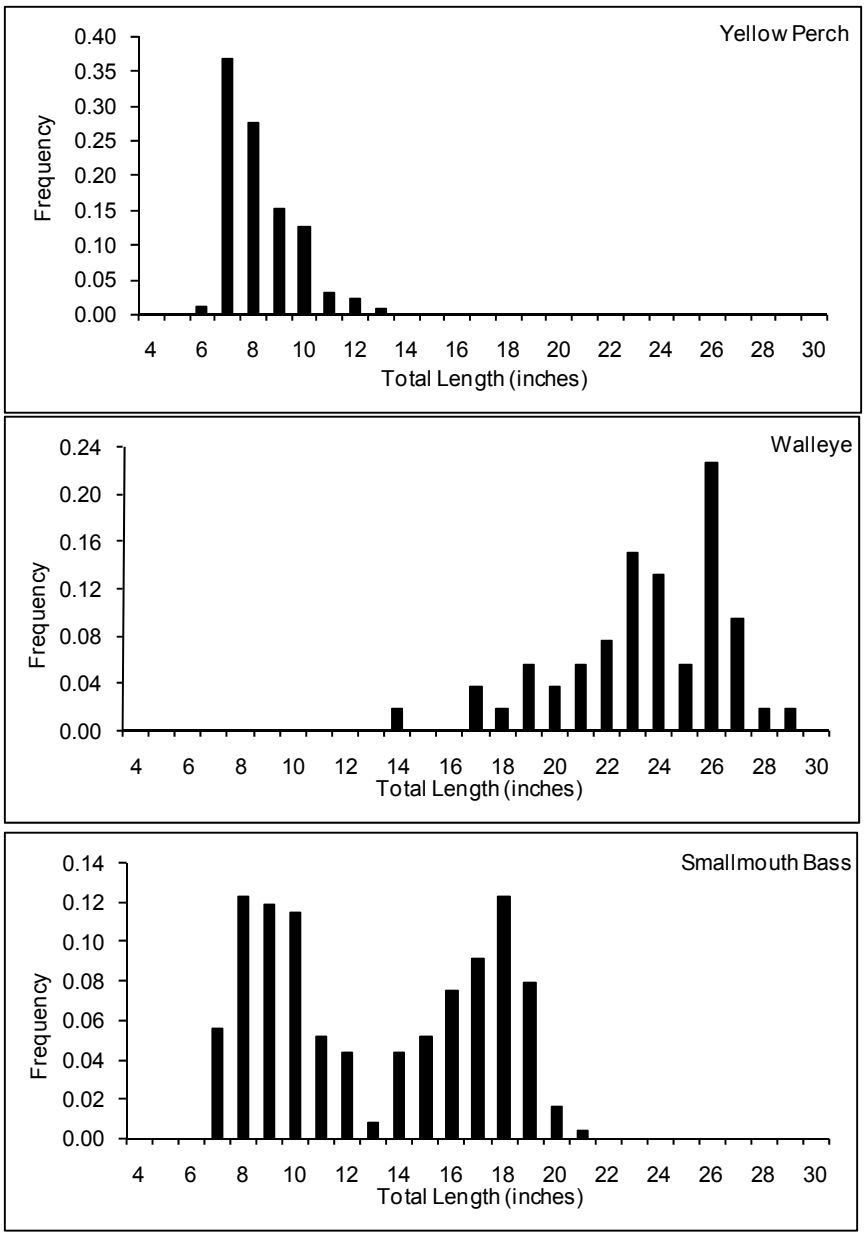

Figure 17. Length frequency distribution of yellow perch, walleye, and smallmouth bass collected during the warmwater assessment in 2013.

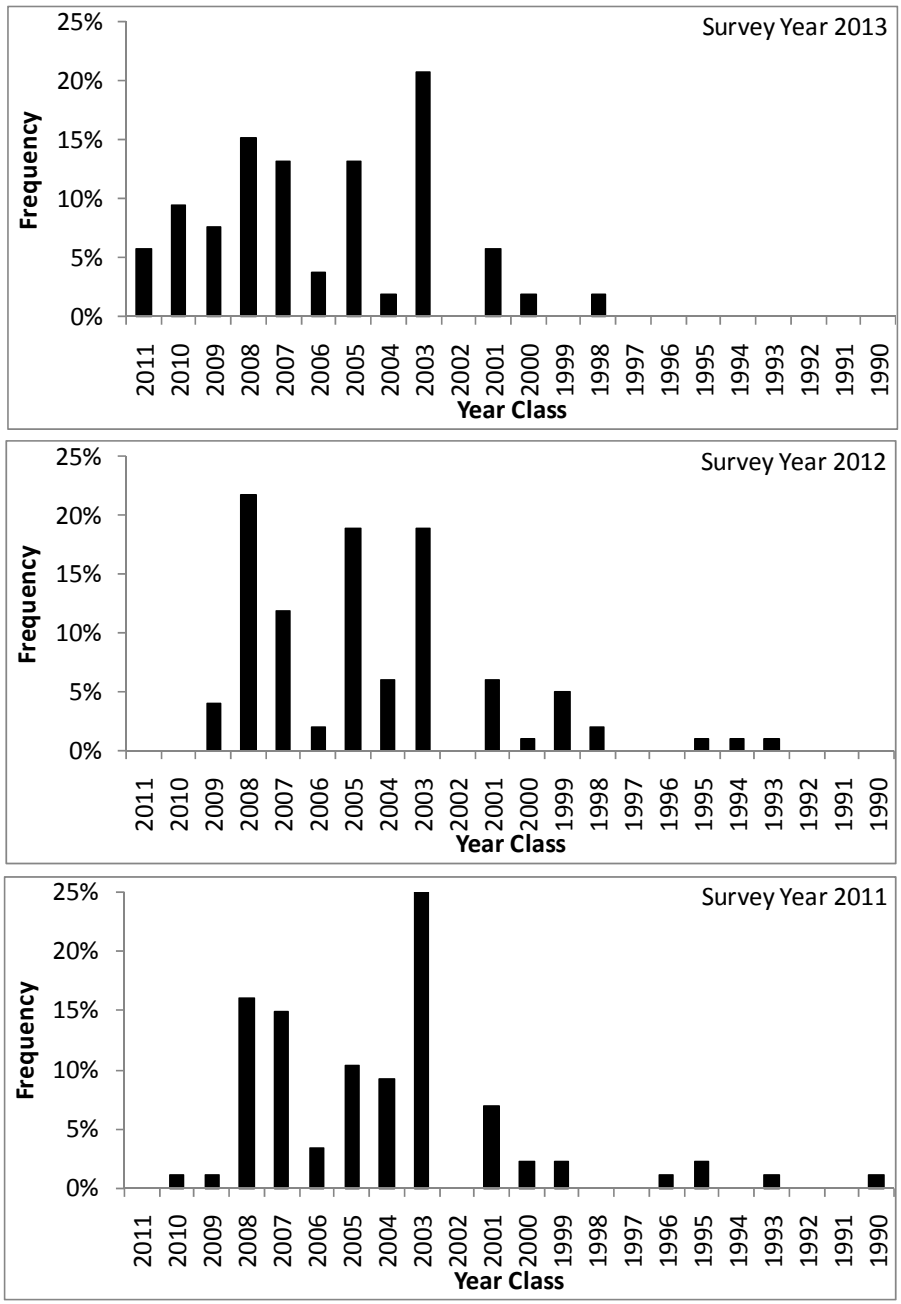

Figure 18. Year class frequency distribution of walleye collected during the warmwater assessment in 2011-2013.

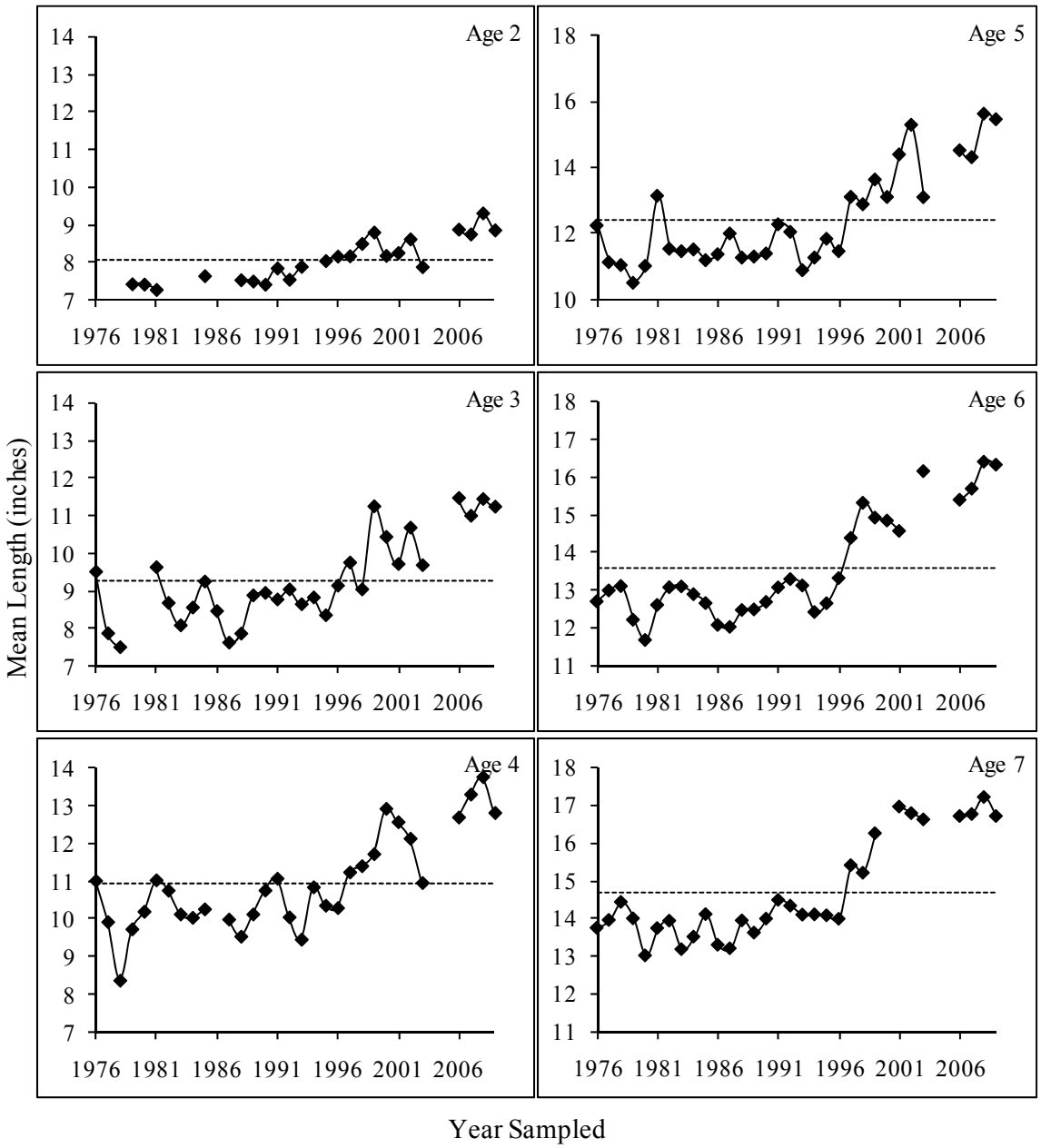

Figure 19. Mean length at age (age 2-13) by year sampled (1976-2003 and 2006-2009) for smallmouth bass collected during the warmwater assessment (continued on next page). Samples collected in 2004-2005 and 2010-2013 were not aged. Dotted lines represent the age-specific long term mean lengths.

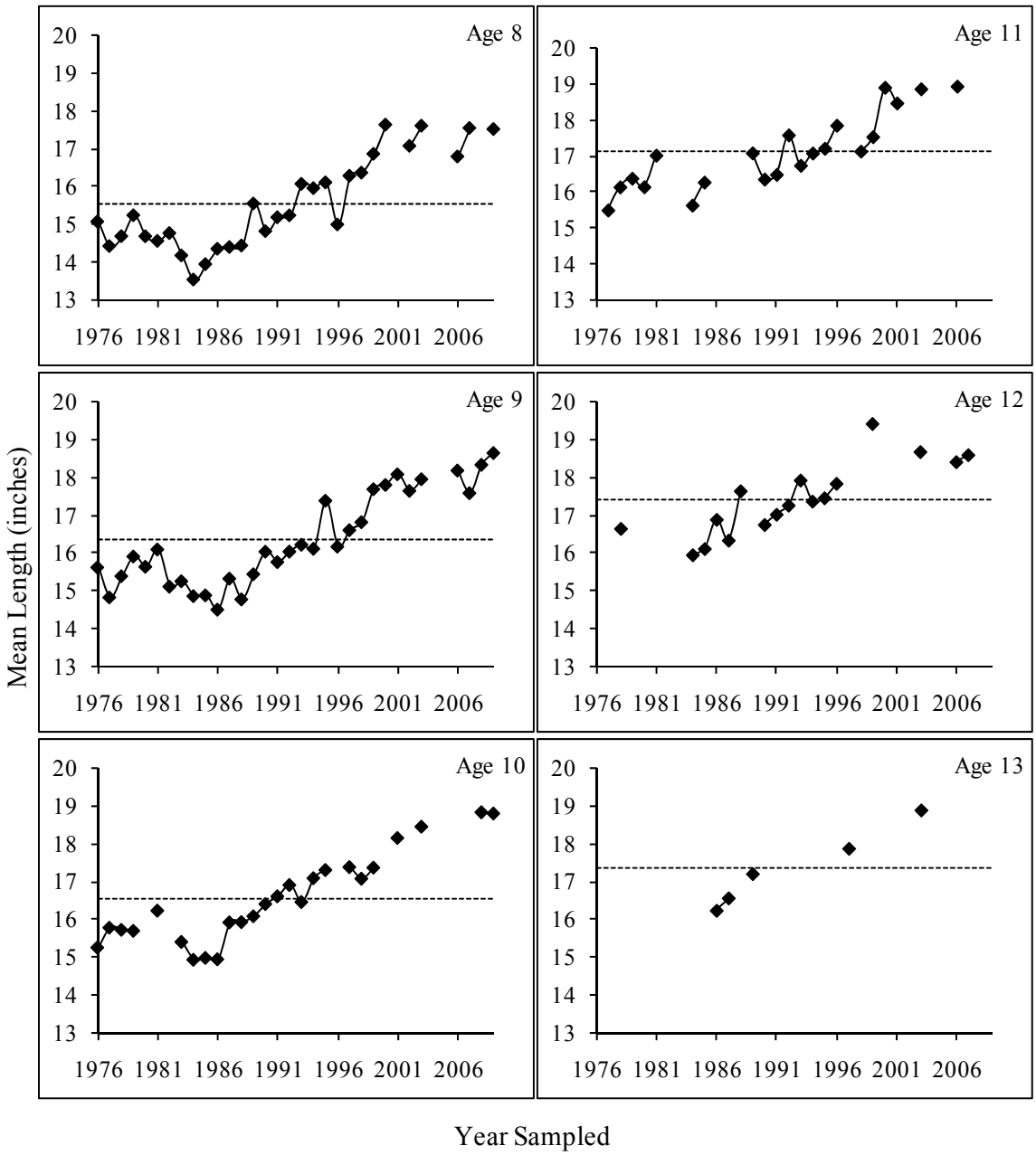

Figure 19 (continued). Mean length at age (age 2-13) by year sampled (1976-2003 and 2006-2009) for smallmouth bass collected during the warmwater assessment. Samples collected in 2004-2005 and 2010-2013 were not aged. Dotted lines represent the age-specific long term mean lengths.

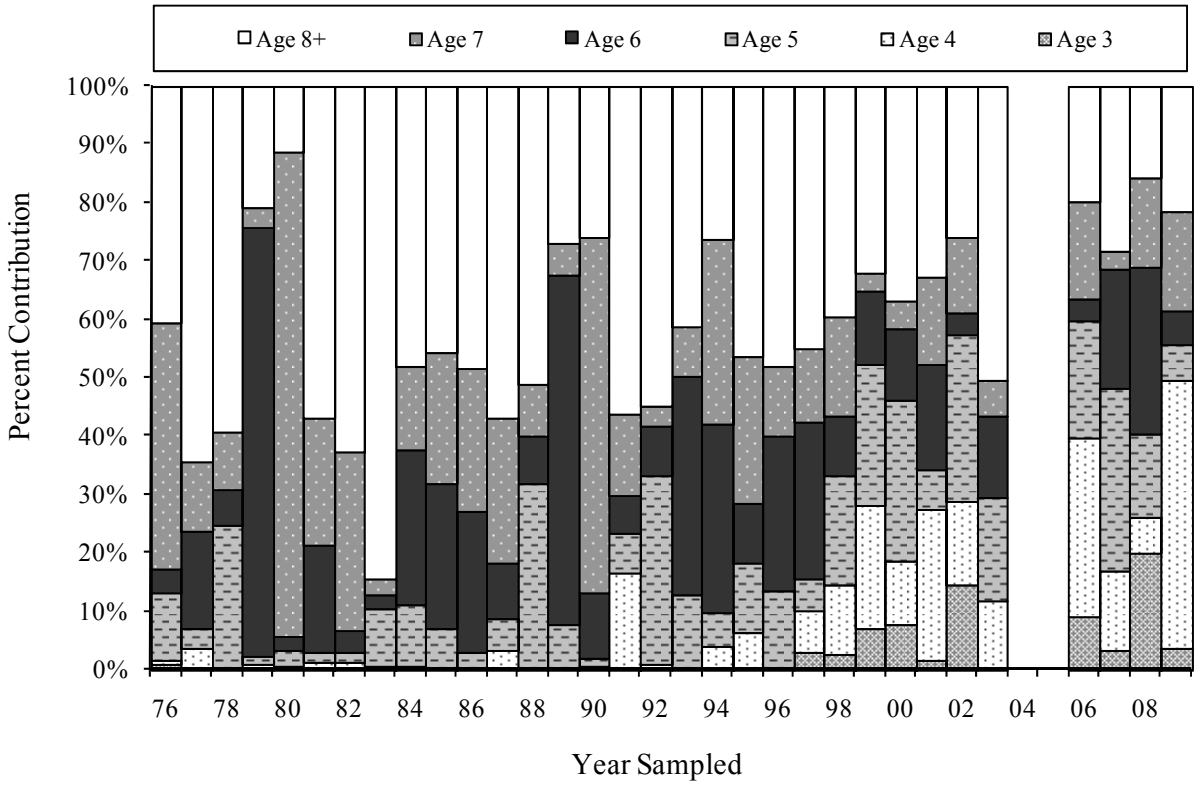

Figure 20. Age composition of smallmouth bass ≥ 12 inches in the warmwater assessment (1976-2003 and 2006-2009). Samples collected in 2004-2005 and 2010-2013 were not aged.

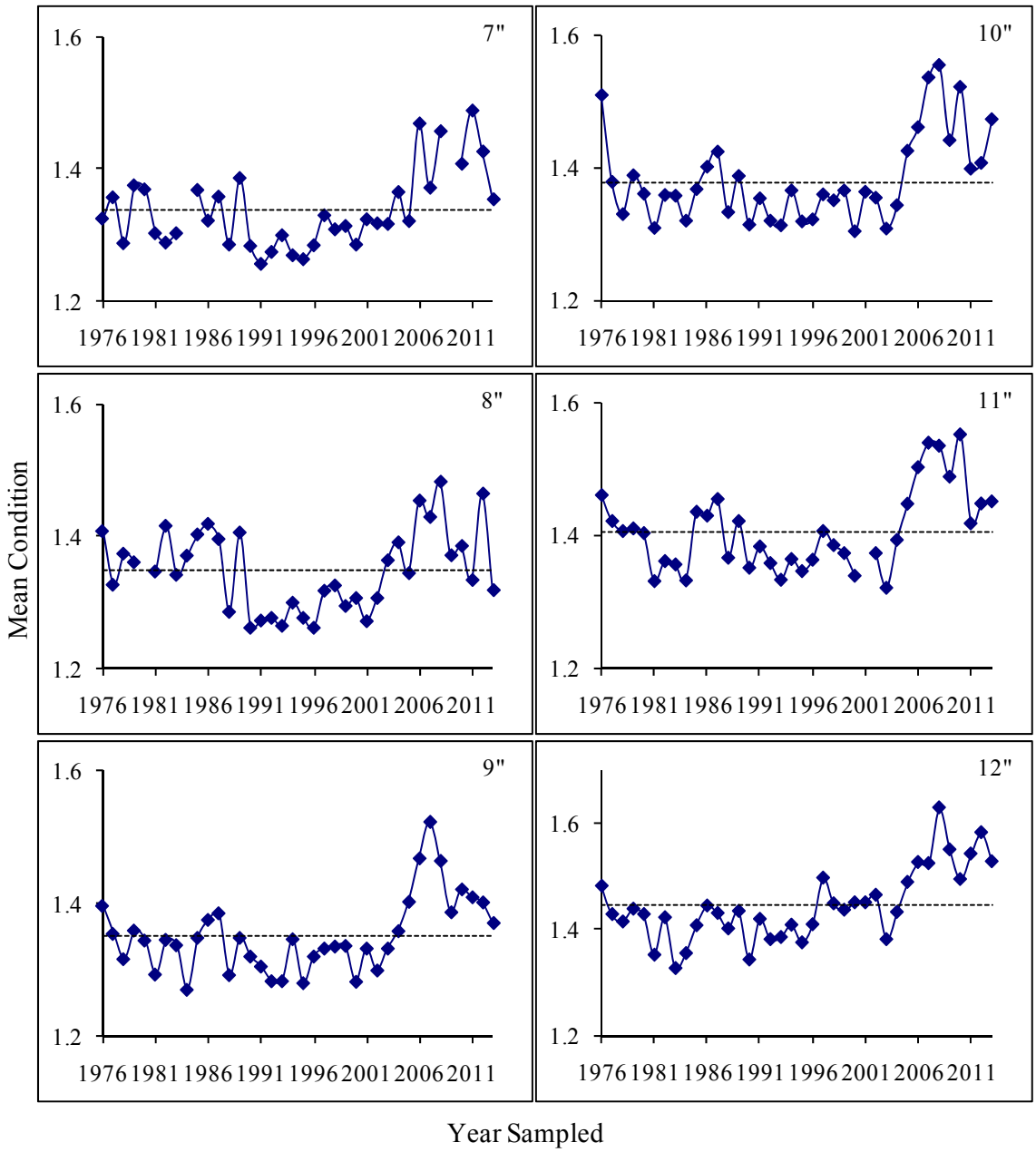

Figure 21. Mean condition (7-18 inch increments) by year sampled (1976-2013) for smallmouth bass collected during the warmwater assessment (continued on next page).

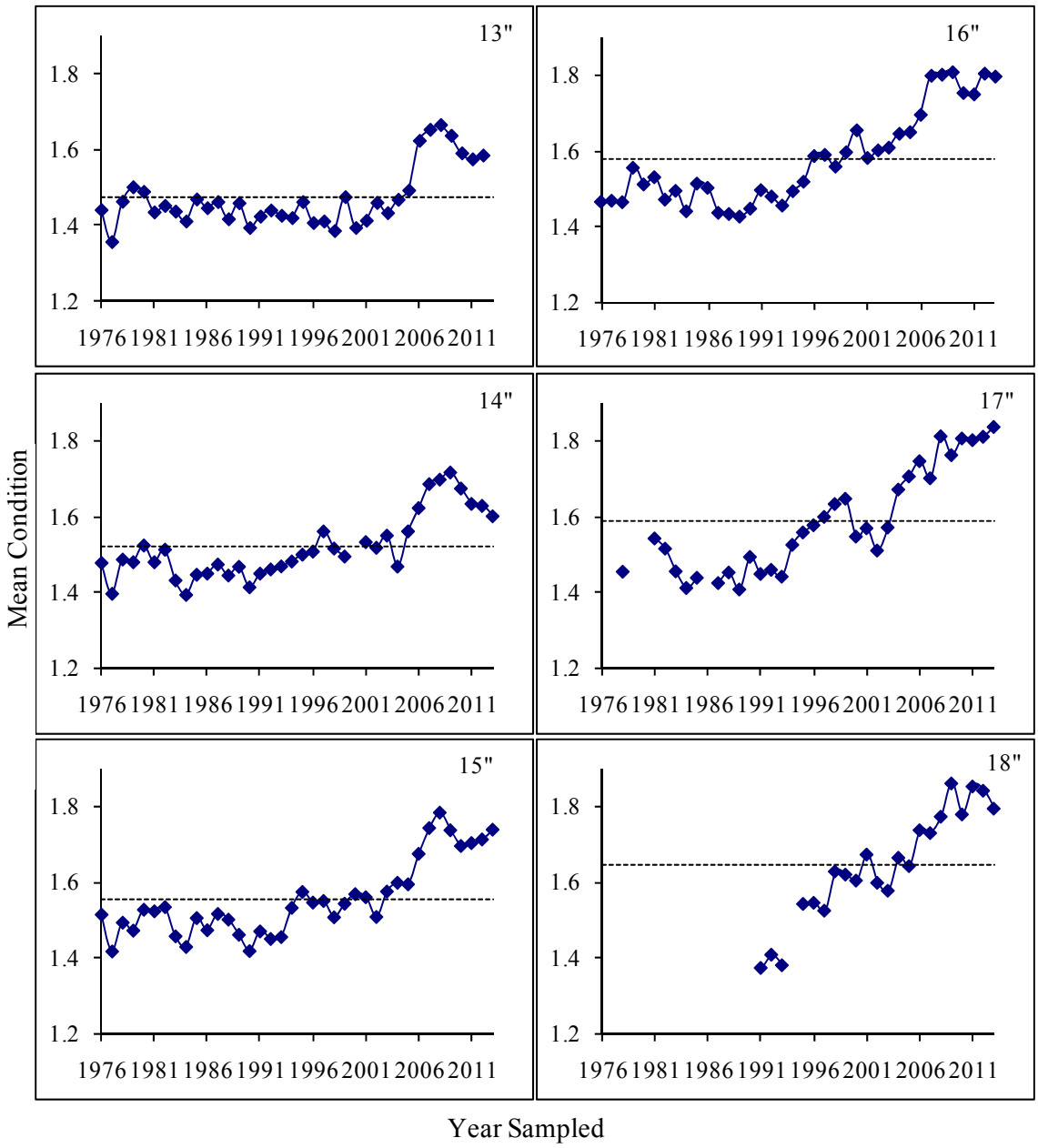

Figure 21 (continued). Mean condition (7-18 inch increments) by year sampled (1976-2013) for smallmouth bass collected during the warmwater assessment.

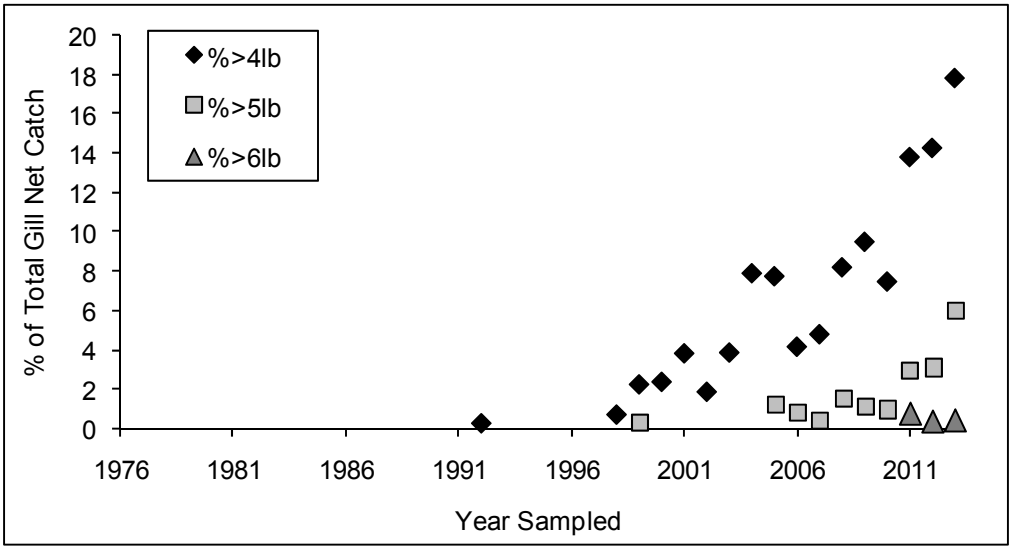

Figure 22. Percentage of total smallmouth bass catch during the warmwater assessment that were >4lb, >5lb, and >6lb.

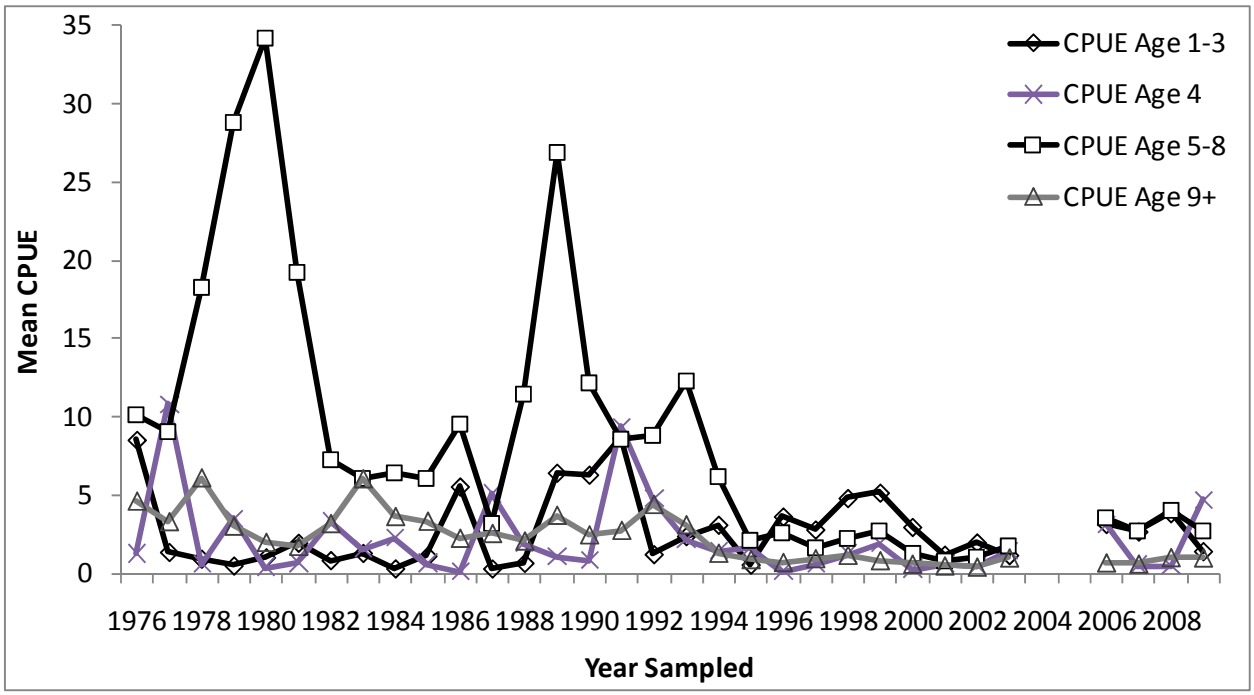

Figure 23. Stratified mean catch per 450 ft gill net gang for smallmouth bass ages 1-3, 4, 5-8, and ≥ 9, 1976-2003 and 2006-2009 (2004-2005 and 2010-2013 are not yet aged).
******* Increased growth and changes in net catchability confound inter-annual comparisons of age-specific CPUE.***

Lake Trout Rehabilitation in Lake Ontario, 2013

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Abstract

Each year we report on the progress toward rehabilitation of the Lake Ontario lake trout (Salvelinus namaycush) *population, including the results of stocking, annual assessment surveys, creel surveys, and evidence of natural reproduction observed from all standard surveys performed by USGS and NYSDEC. No lake trout from the 2011 year class were stocked into Lake Ontario during October 2011 or May 2012; therefore, no stocked age-2 lake trout were available to bottom trawls during 2013. The catch per unit effort of adult lake trout in gill nets increased each year from 2008-2013, recovering from historic lows recorded during 2005-2007. Adult abundance in 2013 exceeded the level of the 1999-2004 mean which at the time appeared to be the new stable abundance following from the 1993 stocking cuts. The 2013 rate of wounding by sea lamprey* (Petromyzon marinus) *on lake trout caught in gill nets was 2.26 fresh (A1) wounds per 100 lake trout and was slightly above target (2 wounds per 100 lake trout). Estimates from the NYSDEC fishing boat survey indicated 2013 angler catch and harvest rates were the highest estimated in more than 10 years. Adult lake trout condition (indexed from annual length–weight regressions) increased in 2007-2009 from relatively low values observed during 2000-2006, remained nearly constant during 2010-2012 at the highest values observed for the 30 year time-series, but declined in 2013. The low condition values observed for juvenile lake trout during 2010-2012 continued during 2013. Reproductive potential for the adult stock, determined from the annual egg deposition index, rebounded from the 2007-2008 values that were the lowest observed since 1985 and stabilized during 2009-2013 at a mean value of 20.7. In 2013, five age-1 and three age-2 naturally produced lake trout were collected from trawl survey catches providing first evidence of a 2012 year class and continued evidence of a 2011 year class.*

Introduction

Restoration of a naturally reproducing population of lake trout (*Salvelinus namaycush*) is the focus of a major international effort in Lake Ontario. Coordinated through the Lake Ontario Committee of the Great Lakes Fishery Commission, representatives from cooperating agencies (New York State Department of Environmental Conservation [NYSDEC], United States Geological Survey [USGS], United States Fish and Wildlife Service [USFWS], and Ontario Ministry of Natural Resources [OMNR]) developed the Joint Plan for Rehabilitation of Lake Trout in Lake Ontario (Schneider et al. 1983, 1997), identifying a goal, interim objectives, and strategies. The present report documents progress towards restoration through 2013.

Methods

Adult Gill Net Survey

During September 1983-2013, adult lake trout were collected with gill nets at random transects within each of 14 to 17 geographic areas distributed uniformly within U.S. waters of Lake Ontario. Survey design (size of geographic areas) and gill net construction (multi- vs. mono-filament netting) has changed through the years. For a description of survey history including gear changes and corrections see Elrod et al.

(1995).

During September 2013, USGS R/V *Kaho* and NYSDEC R/V *Seth Green* fished standard monofilament gill nets for adult lake trout at 14 geographic locations encompassing the entire U.S. shore in Lake Ontario. Survey gill nets consisted of nine, 15.2- x 2.4-m (50 x 8 ft) panels of 51- to 151-mm (2- to 6-in stretched measure) mesh in 12.5-mm (0.5in) increments. At 11of 12 sites in the lake's main basin, four survey nets were fished along randomly chosen transects, parallel to contours beginning at the 10ºC (50ºF) isotherm and proceeding deeper in 10-m (32.8-ft) increments (1 of the 12 sites had 3 sets due to thermocline depth). At each of two sites in the eastern basin, one to three nets were fished in waters from 30 to 50 m due to an unusually deep thermocline.

For all lake trout captured, total lengths and weights were measured, body cavities were opened and prey items were removed from stomachs and enumerated. Presence and types of fin clips were recorded, and when present, coded wire tags (CWTs) were removed. Sex and maturity of lake trout were determined by visual inspection of gonads. Sea lamprey(*Petromyzon marinus*) wounds on lake trout were counted and graded according to King and Edsall (1979) and Ebener et al. (2006).

A stratified catch per unit effort (CPUE) was calculated using four depth based strata based representing net position from shallowest to deepest. The unit of effort was one overnight set of one net. Depth stratification was used because effort was not equal among years and catch per net decreased uniformly with increasing depth below the thermocline. To examine variability in CPUE between years, the relative standard error was calculated (RSE = 100 * {standard error / mean}).

Survival of various year classes and strains was estimated by taking the antilog of the slope of the regression of ln(CPUE) on age for fish ages 7 to 11 that received coded wire tags. Catches of age-12 and older lake trout were not used in calculations because survival often seemed to greatly increase after age 11 and catch rates were too low to have confidence in estimates using those ages (Lantry et al. 2006).

Adult condition was indexed from both the predicted weights of a 700-mm fish calculated from annual length-weight regressions based on all lake trout caught that were not deformed, and from Fulton's *K* (Ricker 1975, Nash et al. 2006) for age-6 males:

$K = (WT/ TL^3)*100{,}000;$

where WT is weight (g) and TL is total length (mm). We grouped data across strains because Elrod et al. (1996) found no difference between strains in the slopes or intercepts of annual length-weight regressions in 172 of 176 comparisons for the 1978 through 1993 surveys.

Lake trout fecundity changes with age and length (O'Gorman et al. 1998), both mean age and mean length increased after effective control of sea lamprey (achieved during the mid-1980s) reduced size-selective mortality on lake trout ≥432 mm. Also, sea lampreys kill mature lake trout each fall, mostly between our September assessment and November spawning (Bergstedt and Schneider 1988, Elrod et al. 1995). The numbers of lake trout killed have varied through time, and not all strains of lake trout are equally vulnerable to attack by sea lampreys or are as likely to succumb to an attack (Schneider et al. 1996). Thus, change in age and strain composition of mature females has to be considered when judging reproductive potential from September gill net catches.

Population reproductive potential was estimated by calculating annual egg deposition indices (O'Gorman et al. 1998) from catches of mature females in September gill nets, length/age-fecundity relationships, and observed differences in mortality rates among strains. Length-fecundity relationships were determined from the fecundity of individual lake trout collected with gill nets in September and early October each year during 1977-1981 and in September 1994 (O'Gorman et al. 1998). Results from the two examinations indicated that at some point between the early 1980s and the mid-1990s, age-related factors began to influence fecundity. During 1977-1981, fecundity-length relationships were not different among fish of various ages, but in 1994, age-5 and age-6 fish had fewer eggs per unit length ($P<0.003$) than age-7 fish, and age-7 fish had fewer eggs per unit length ($p<0.003$) than fish of ages 8, 9, or

10. The lake trout population in the earlier period was small with few mature fish whereas the population in the 1990s was relatively large with many mature fish (Elrod et al. 1995).

Elrod et al. (1996) demonstrated that the weight of a 700-mm mature female lake trout was much greater during 1978-1981 than during 1982-1993. They attributed the better condition during 1978-1981 to a lack of competition for food or space at low population levels. Therefore, we used the fecundity-length regression for 1977-1981 to calculate indices of egg deposition during 1980-1981 and the fecundity-length regressions for 1994 to calculate indices of age and size related egg deposition during 1982-2013. To account for sea lamprey-induced mortality that occurred between September gill net sampling and November spawning, we reduced catches of mature females by factors representing strain related differences in susceptibility to sea lamprey predation developed in O'Gorman et al. (1998).

Creel Survey

Catch and harvest by anglers fishing from boats is measured by a direct-contact creel survey, which covers the open-lake fishery from the Niagara River in the western end of the lake to Association Island near Henderson in the eastern basin (Lantry and Eckert 2014). The survey uses boat trips as the primary unit of effort. Boat counts are made at boat access locations and interviews are based on completed trips. During 1985-2009 survey estimates were based on a 6 month sampling interval from April 1-September 30. In 2010 the sampling interval was officially reduced to 5.5 months (April 15 – September 30). In previous reports, results were based on the 6 month sampling interval. In this and future reports, results from all survey yearswill reflect an April 15 – September 30 sampling interval. For detailed description on how survey results were adjusted to the 5.5 month interval, see Lantry and Eckert (2014).

Juvenile Trawl Survey

From mid-July to early-August 1980-2012, crews from USGS and NYSDEC used the R/V *Kaho* and the R/V *Seth Green* to capture juvenile lake trout (targeting age-2 fish) with bottom trawls. Trawling was conducted at 14 locations in U.S. waters distributed evenly along the southern shore and within the eastern basin, and at one location in Canadian waters off the mouth of the Niagara River. A standard tow was 10 min long. From 1980 to 1996, trawling was conducted with a 12-m (39.4-ft, headrope) trawl at 5-m (16.4-ft) depth intervals, beginning at the metalimnion (15°C, 59°F isotherm) and progressing into deeper water until few or no lake trout were captured. Because of an abrupt shift in the depth distribution of juvenile lake trout to deeper waters in 1993 (O'Gorman et al. 2000) and fouling of the gear by dreissenid mussels in 1996, the sampling scheme and gear were changed. In 1997 the 12-m (39.4-ft) trawl was replaced with a 3-in-1 trawl (18-m or 59-ft headrope, 7.6-m or 24.9-ft spread) equipped with roller gear along the footrope. In addition, effort was decreased at depths < 55 m (180.4 ft) and increased at depths > 70 m (229.6 ft). For years after 1997, the sampling protocol was modified by alternating between odd and even depths (5-m or 16.4-ft increments) between adjacent sites and adjacent years. At four sites where depth did not exceed 75 m (246.1 ft), all 5-m (16.4-ft) contours at and below the 15°C (59°F) isotherm were fished.

Effort in 2013 was reduced because no lake trout from the 2011 year class were stocked in U. S. waters during 2012 (Lantry and Lantry 2013; Connerton 2014) and thus no U. S. stocked age-2 lake trout were present in 2013. During July 6-25, 2013, trawling was conducted only at 9 locations. Data collection from trawl-captured lake trout was the same as that described above for fish captured with gillnets.

Survival indices were calculated from catches of age-2 lake trout that were stocked in U.S. waters and caught in the bottom trawl survey. Survival was assessed at age-2 because the trends in index were similar for age-2 lake trout caught in this survey and age-3 lake trout from the same year class caught in the gill net survey. This indicated that recruitment of hatchery fish to the population was governed by survival during their first year in Lake Ontario. For 1981 to 1996 (1979-1994 year classes), survival indices were calculated by adjusting total catch for strain, stocking location, and to reflect a total of 500,000 spring yearlings stocked (total catch *500,000 / the number stocked). Data obtained

on the 1995 year class were not adjusted for strain or stocking location because of poor retention rates of CWTs. Among the age-2 lake trout caught in trawls in 1997, 36% of adipose-fin clipped individuals did not have tags. Data for year classes stocked since 1997 were not adjusted for strain or stocking location because from 36% to 84% of fish stocked during 1997-2003 did not receive CWTs and stockings thereafter did not include the strain (CWL) or the stocking location (Niagara River) that necessitated catch adjustment. Catches of the 1995 through 2010 year classes were, however, adjusted for numbers stocked. Most untagged fish stocked since 1997 received paired fin clips that facilitated year class identification through at least age 4. The ages of unmarked fish and fish with poor clips were estimated with age-length plots developed from CWT tagged fish.

To assess the condition of juvenile lake trout, we used the predicted weight of a 400-mm (15.8 in) fish. A 400-mm fish would be age 2 or age 3. Weights were estimated each year from length-weight regressions calculated from annual trawl catches of lake trout ranging in total length from 250 mm to 500 mm (9.8 in to 19.7 in).

Results and Discussion

Stocking

From 1973 to 1977 lake trout stocked in Lake Ontario were raised at several NYSDEC and USFWS (Michigan and Pennsylvania) hatcheries with annual releases ranging from 0.07 million for the 1973 year class to 0.28 million for the 1975 year class (Figure 1). By 1978 (1977 year class) the USFWS Alleghany National Fish Hatchery (Pennsylvania) was raising all lake trout stocked in U.S. waters of Lake Ontario and annual releases exceeded 0.60 million fish. In 1983, the first official Lake Ontario lake trout rehabilitation plan (Schneider et al. 1983) was formalized and it called for a target of 1.25 million yearlings to be stocked annually in U.S. waters. The stockings of the1979-1986 year classes approached that level,

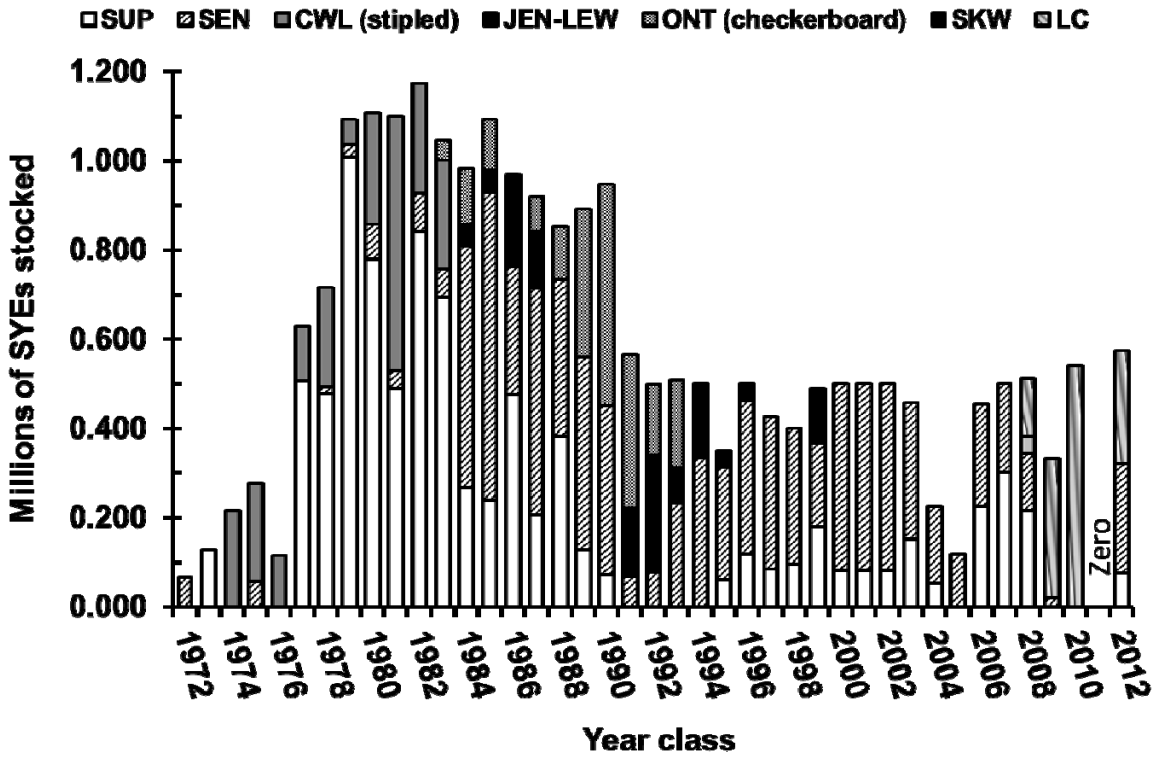

Figure 1. Total spring yearling equivalents (SYE) for lake trout strains (strain descriptions for ONT, JEN-LEW, CWL, SEN, LC, SUP, and SKW appear in Appendix 1) stocked in U.S. waters of Lake Ontario for the 1972 – 2012 year classes. MIX were unknowns. SYE = 1 spring yearling or 2.4 fall fingerlings (Elrod et al. 1988). No lake trout from the 2011 year class were stocked in 2012.

number of yearling equivalents released declined by about 22% between the stockings of the 1981 and 1988 year classes. Stocking declined by 47% in 1992 (1991 year class) due to problems encountered at the hatchery.

In 1993, fishery managers reduced the lake trout stocking target to the current level of 500,000 yearlings because of a predator-prey imbalance in Lake Ontario, and following recommendations from an international panel of scientists and extensive public review. In the 21 years since the stocking cuts (1992-2012 year classes), the annual stockings were near the target level in only fourteen years (Figure 1). The USFWS Alleghany National Fish Hatchery (ANFH) was closed in 2005 due to an outbreak of infectious pancreatic necrosis and remained closed for fish production through summer 2011. Completion of disinfection, renovation and disease trials permitted fish production to resume at ANFH in fall 2011. Lake trout stocked in 2006 were raised at the NYSDEC Bath Fish Hatchery. Lake trout for 2007 and 2008 stockings were raised at the USFWS Pittsford (the name was changed in 2009 to Eisenhower (ENFH)) and White River National Fish Hatcheries (WRNFH) in Vermont. In 2010, 94% of the stocked lake trout were raised at WRNFH and 6% were raised at NYSDEC Bath Fish Hatchery. All lake trout from stockings in 2009 and 2011 were raised at the USFWS WRNFH. In late August 2011, flooding of WRNFH from the adjacent White River during tropical storm Irene led to the USFWS decision to depopulate the hatchery over serious concerns of raceway contamination with didymo (*Didymosphenia geminate*) from the adjacent White River. As a result, no lake trout from the 2011 year class were stocked into Lake Ontario in May 2012. Combined production of the 2012 year class at ANFH and ENFH resulted in stocking of nearly 123,000 fall fingerlings and over 520,000 spring yearlings (Connerton 2014).

Survival to age-2

The first-year survival index was relatively high for the 1979-1982 year classes but then declined by about 32% and fluctuated without trend for the 1983-1989 year-classes (Figure 2). The index declined further for the 1990 year class and continued to decline for the 1991-1996 year classes. The average index value for the 1994-1996 year classes at age 2 was only 6% of the average for the 1979-1982 year classes and only 9% of the average for the 1983-1989 year classes. The survival index was quite variable during 1995 to 2011 (1993 – 2009 year classes) fluctuating by greater than 40-fold with no general trend apparent. The survival index for the 2010 year class sampled in 2012 was the greatest observed since the 1990 year-class was sampled in 1992. No lake trout from the 2011 year class were stocked in U. S. waters during 2012 and thus no-U. S. stocked age-2 lake trout were present/captured in 2013.

Abundance of age-3 and older Lake Trout

A total of 780 lake trout were captured in the September 2013 gill net survey resulting in a total CPUE of mature adults of 12.5 (Figure 3). Catches of lake trout among sample locations were similar within years with the RSE for the CPUE of adult males and females (generally ages 5 and older) averaging only about 9.2% and 10.9%, respectively, for the entire data series (Figure 4). The CPUE of mature lake trout had remained relatively stable from 1986 to 1998, but then declined by 31% between 1998 and 1999 due to the poor recruitment of the 1993 year class. Declines in adult numbers after 1998 were likely due to poor survival of hatchery fish in their first year post-stocking and lower numbers of fish stocked since the early 1990's. After the 1998-1999 decline, the CPUE for mature lake trout remained relatively stable during 1999-2004 (mean = 11.0) appearing to reflect a new stable equilibria established subsequent to the stocking reductions in 1993, but then abundance declined further (by 54%) in 2005. The 2005-2007 CPUEs of mature lake trout were similar to the 1983-1984 values which pre-dated effective sea lamprey control. The CPUE of mature lake trout, however, increased each year 2008-2013. Adult abundance in 2013 (CPUE: 12.5) exceeded the 1999-2004 average (CPUE: 11.1). Similar to the catch of age-2 lake trout from bottom trawls, theCPUE for immature lake trout captured in gill nets (generally ages 2 to 5) declined by 64% between the 1989-1993 (CPUE: 8.0) and the 1995-2004 intervals (CPUE: 2.9). Low CPUEs continued in 2013 (CPUE: 2.3).

Schneider et al. (1983, 1997) established a target

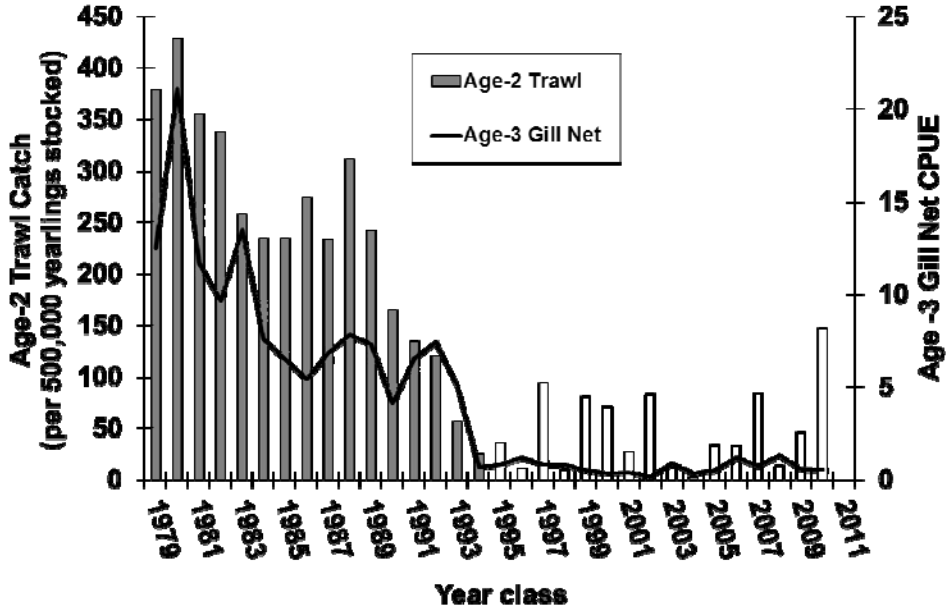

Figure 2. Survival indices for age-2 lake trout stocked in U.S. waters of Lake Ontario in 1980 – 2013 (no 2011 year-class lake trout were stocked into U. S. waters in 2012). Survival was indexed at age 2 as the total catch from bottom trawls (BTR) fished in July-August per 500,000 fish stocked (Note: White bars represent data collected with a new trawl configuration which employed roller gear on the footrope and did not fish as hard on the lake bottom as the old trawl).

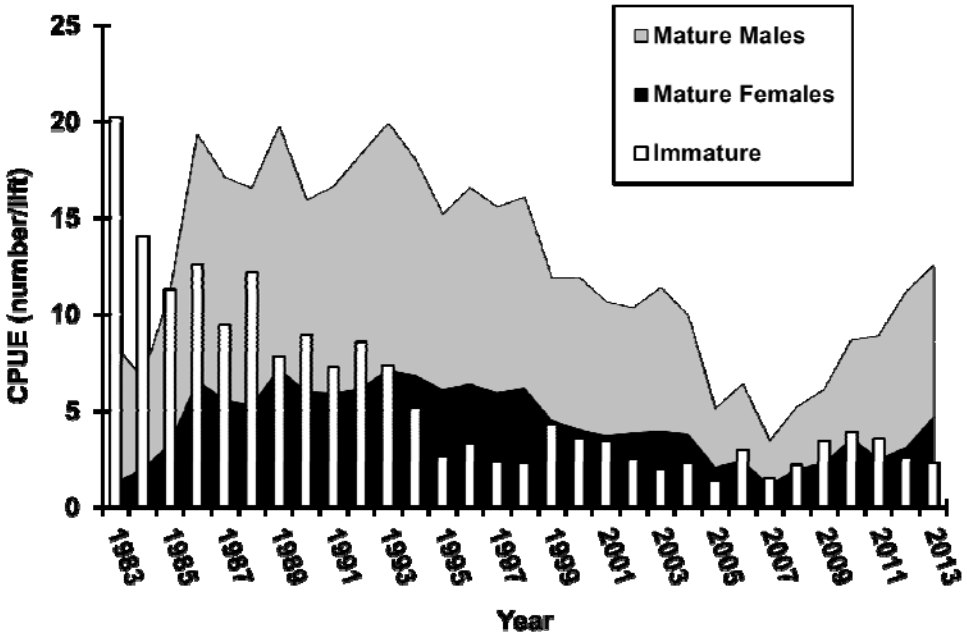

Figure 3. Abundance of mature (generally males ≥ age 5 and females ≥ age 6) and immature (sexes combined) lake trout calculated from catches made with gill nets set in U.S. waters of Lake Ontario, during September 1983-2013. CPUE (number/lift) was calculated based on four strata representing net position in relation to depth of the sets.

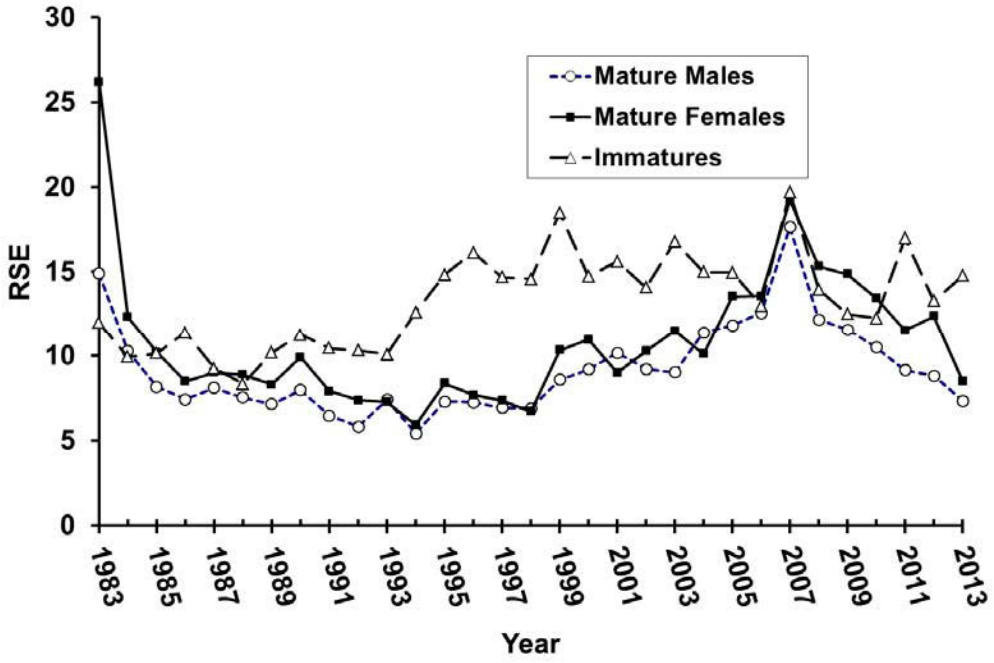

Figure 4. Relative standard error (RSE = {SE / Mean}*100) of the annual CPUE for mature and immature (sexes combined) lake trout caught with gill nets set in U.S. waters of Lake Ontario, during September 1983 – 2013.

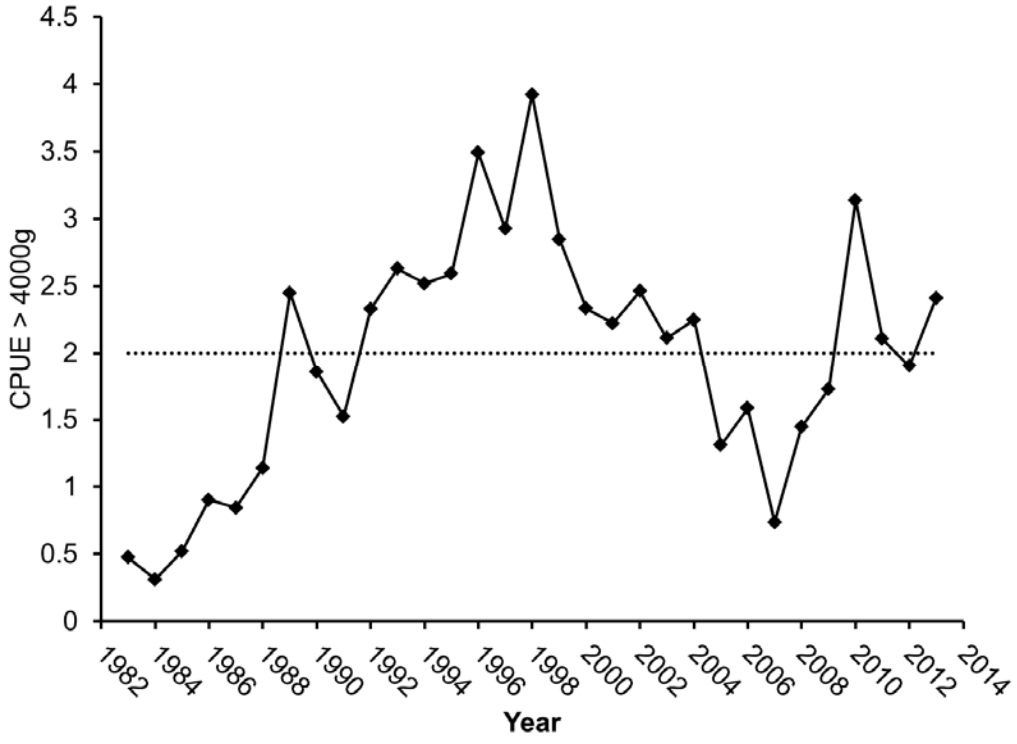

Figure 5 Abundance of mature female lake trout>3999g calculated from catches made with gill nets set in U.S. waters of Lake Ontario, during September 1983-2013. The dashed line represents the target CPUE from Schneider et al. (1997).

gillnet CPUE of 2.0 for sexually mature female trout ≥ 4,000 g reflecting the level of abundance at which successful reproduction became detectable in the early 1990s. The CPUE for mature females reached the target value in 1989 and fluctuated about the value until 1992 (Figure 5). From 1992 until 2004, the CPUE exceeded the target, but fell below target during 2005 to 2009, coincident with the decline of the entire adult population. As the adult population abundance increased during 2008-2013, the CPUE of mature females ≥ 4,000 g also increased and during 2010-2013 CPUEs have remained near or above target.

Angler Catch and Harvest

The annual harvest of lake trout from U.S. waters of Lake Ontario (Figure 6) declined over 90% since the protected slot limit was re-instated in 1992 compared to years without size limits (Lantry and Eckert 2010). The protected slot regulation was a limit of three lake trout harvested outside of the protected length interval of 635 to 762 mm (25 to 30 in). In October 2006, this regulation was changed reducing the creel limit to two fish per angler and allowed for one of those fish to be within the 635 to 762 mm slot. Angler harvest rates of lake trout in U.S. waters declined immediately during 1991-1992- as a result of the 1992 regulation. Angler harvest and catch rates declined further from the early to mid-2000s, coinciding with the lake trout population decline (Figure 3) and good fishing quality for other salmonids (i.e., anglers targeted other salmonids more frequently because of their relatively high catch rates; Lantry and Eckert 2014). In 2007, catch and harvest rates (0.12 and 0.05 lake trout per boat trip, respectively) and total harvest (2,570 fish) reached the lowest levels in the NYSDEC Fishing Boat Survey data series (Lantry and Eckert 2014). Harvest at that time was 85% below mean for the 1992-1999 levels. Since then, catch and harvest rates increased for five consecutive years. In 2013, angler catch (35,533 fish) and harvest (20,511 fish) were the highest estimated since the mid- to late-1990s. Catch and harvest rates (0.75 and 0.43 lake trout per boat trip, respectively) were the highest estimated since 2002 and 1991, respectively. The 2013 catch and harvest rates were more than six times higher than the lows observed in 2007 (Lantry and Eckert 2014). This increase was due, in part, to an increased number of fish

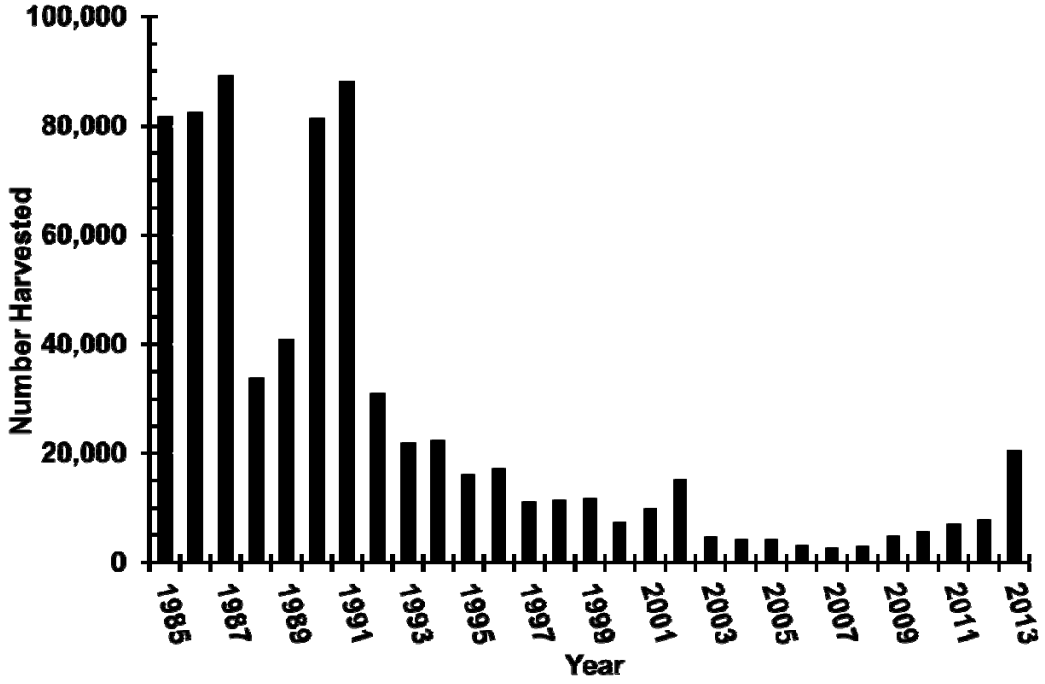

Figure 6. Estimated numbers of lake trout harvested by boat anglers from U.S. waters of Lake Ontario, during April 15 – September 30, 1985 – 2013 (Lantry and Eckert 2014). Beginning with the 2012 report, all harvest values have been reported reflecting a 5.5 month sampling interval. Prior reports were based on a 6 month sampling interval (April 1 – September 30).

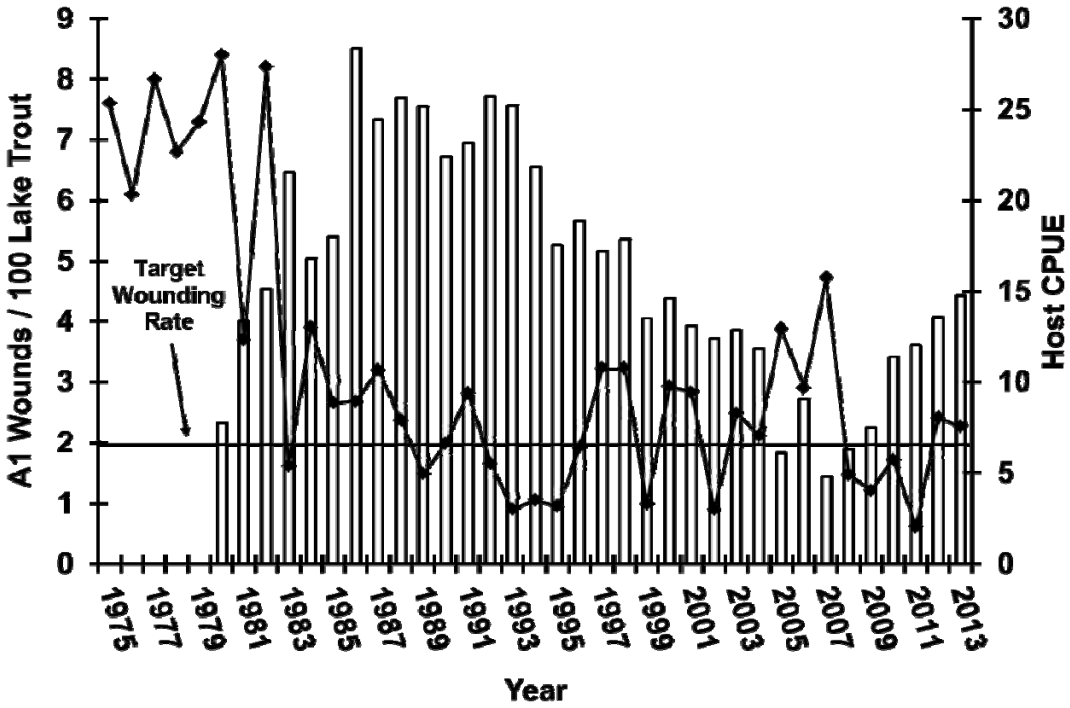

Figure 7. Wounding rates (A1 wounds per 100 lake trout, line) inflicted by sea lamprey on lake trout ≥ 433 mm (17.1 in) TL and the gill net CPUE of lake trout hosts (≥ 433 mm TL, bars) collected from Lake Ontario in fall, 1975 – 2013.

recruiting into the fishery in recent years (Figure 3), and a fishing regulation change. Prior to October 2006, anglers were permitted to harvest three lake trout outside of a protected length interval of 635 to 762 mm (25 to 30 in). The October 2006 regulation change reduced the creel limit to two fish per angler, but allowed for one of those fish to be within the 635 to 762 mm slot.

Sea Lamprey Predation

Percentage of fresh (A1) sea lamprey marks on lake trout has remained low since the mid-1980s, however, wounding rates (Figure 7) in 9 out of 11 years between 1997 and 2007 were above the target level of 2 wounds per 100 fish ≥433 mm (17.1 in). Wounding rate rose above target in 2005, reaching a maximum of 4.7 wounds in 2007 which was 2.35 times the target level. Rates fell below target again in 2008 (1.47) and remained there through 2011 (0.62). However, the rate rose above target again in 2012 (2.41) and 2013 (2.26).

Adult Survival

Survival of Seneca strain lake trout (ages 7 to 11) had been consistently greater (20-51%) than that of the Superior strain for the 1980-1995 year classes (Table 1). Lower survival of SUP strain lake trout was likely due to higher mortality from sea lampreys (Schneider et al. 1996). Survival of both JEN and LEW strains was similar to the SUP strain, suggesting that those strains may also be highly vulnerable to sea lampreys. Ontario strain (ONT) lake trout were progeny of SEN and SUP strains (Appendix 1) and their survival was intermediate to that of their parent strains.

Survival for all strains combined (hereafter referred to as population survival) was based on all fish captured for the 1983-1995 cohorts as all fish stocked during that period received coded wire tags. Population survival was not calculated for the 1978-1982 and 1996-2002 cohorts because only a portion of those stockings received coded wire tags. Population survival generally increased with successive cohorts through the 1985 year class, exceeded the restoration plan target value of 0.60 beginning with the 1984 year class, and remained above the target for most year classes

Table 1. Annual survival of various strains (strain descriptions appear in Appendix 1) of lake trout, U.S. waters of Lake Ontario, 1985-2013. Dashes represent missing values due to no or low numbers of tagged lake trout stocked for those strains. ALL is population survival of all strains combined using only coded wire tagged fish.

YEAR		STRAIN					
CLASS	AGES	SEN	ONT	SUP	JEN	LEW	ALL
1978	7-10	-	-	0.40	-	-	
1979	7-11	-	-	0.52	-	-	
1980	7-11	0.85	-	0.54	-	-	
1981	7-11	0.92	-	0.45	-	-	
1982	7-11	0.82	-	0.44	-	-	
1983	7-11	0.90	0.61	0.54	-	-	0.57
1984	7-11	0.70	0.61	0.48	0.39	-	0.65
1985	7-11	0.77	0.80	0.47	-	-	0.73
1986	7-11	0.81	-	0.43	0.57	-	0.62
1987	7-11	0.80	-	0.50	0.50	-	0.73
1988	7-11	0.73	0.77	0.61	-	-	0.68
1989	7-11	0.86	0.78	0.59	-	-	0.81
1990	7-11	0.75	0.64	0.60	-	-	0.68
1991	7-11	0.70	0.62	-	-	0.56	0.70
1992	7-11	0.81	-	-	-	0.51	0.60
1993	7-11	0.72	-	-	-	0.64	0.71
1994	7-11	0.45	-	-	-	0.73	0.56
1995	7-11	0.76	-	-	-	0.50	0.72
1996	7-10	-	-	0.43	-	-	
1999	7-11	0.60	-	-	-	-	
2000	7-11	0.60	-	-	-	-	
2001	7-11	0.58	-	-	-	-	
2002	7-10	-	-	0.77	-	-	
2003	7-10	0.69	-	0.68	-	-	0.66

thereafter. The population survival of the 2003 year class is currently based only on ages 7-10 fish from stockings of 67% SEN and 33% SUP strains.

Growth and Condition

The predicted weight of a 700-mm lake trout (from length-weight regressions) decreased during 1983 to 1986, but increased irregularly from 1986 to 1996 and remained relatively constant through 1999 (Figure 8). Predicted mean weight declined by 158.8 g (5.6 oz) between 1999 and 2006, but increased again in 2007 and was relatively stable through the 2009 value of 3647.1 g (8.0 lb). The 2007-2009 mean (3653.4g, 8.0 lb) was similar to the 1996-1999 mean (3679.6 g, 8.1 lb). Predicted mean weight rose sharply after 2009, and remained nearly constant during 2010-2012 at highest values observed for the time series (2010-2012 mean =3734.0 g). The trend of improving condition through 1996 corresponded to increased abundance of older lake trout in the population. Our data suggested that for lake trout of similar length, older fish were heavier. To examine condition while removing the effects of age and sex, we calculated annual means for Fulton's *K* for age-6 mature male lake trout (Figure 8). Values of *K* for age-6 males followed a similar trend as predicted weights, which were calculated using data from all fish captured and indicated that age alone was not the determinant of condition for this population. Both predicted weight and condition in 2013 fell below values from 2007-2012.

Predicted weights of 400-mm lake trout, based on bottom trawl catches of 250-500 mm fish, (Figure 9) appeared to be related to both total numbers stocked and the CPUE of immature fish captured with gill nets in September (Figures 1 and 3). Early stockings during 1973-1979 ranged from 66,000 to 728,240 yearling equivalents (Figure 1) and immature lake trout condition was high during 1979-1981. Stocking first exceeded 1,000,000 yearling equivalents in 1980 and between 1980 and 1981 the CPUE of immature lake trout from gill net catches doubled. From 1981 to 1983 predicted weight fell by 69 g (2.4 oz) and remained relatively constant (mean = 576 g, 1.3 lb) through 1992. Stocking rate remained at a relatively constant level from 1980 to 1991 (846,260 to 1,165,530 fish) and then declined to its' current target level (500,000 fish) in 1992. Predicted weight rose in 1993 and the 1993-1998 mean was 4% (22 g, 0.8 oz) higher than the mean for 1983-1992. Increased condition of young lake trout during 1993-1998 occurred after stocking was reduced and immature abundance declined in both bottom trawl and gillnet catches. During 1999-2005, condition declined to a level similar to the mid-1980's without associated changes in stocking or abundance, but paralleling declines in native benthic prey resources (Weidel et al. 2014). Predicted weight increased during 2005-2008 paralleling increases in round goby (*Neogobius melanostomus)* abundance (Weidel et al. 2014) which are now common in lake trout diets. Condition of immature fish fell again in 2009 (591.3 g, 1.3 lb.) to a level near the long term mean for the data series, but condition during 2010 - 2013 (2010-2013 mean = 555.53 g or 1.22 lb) was among the lowest recorded for the data series.

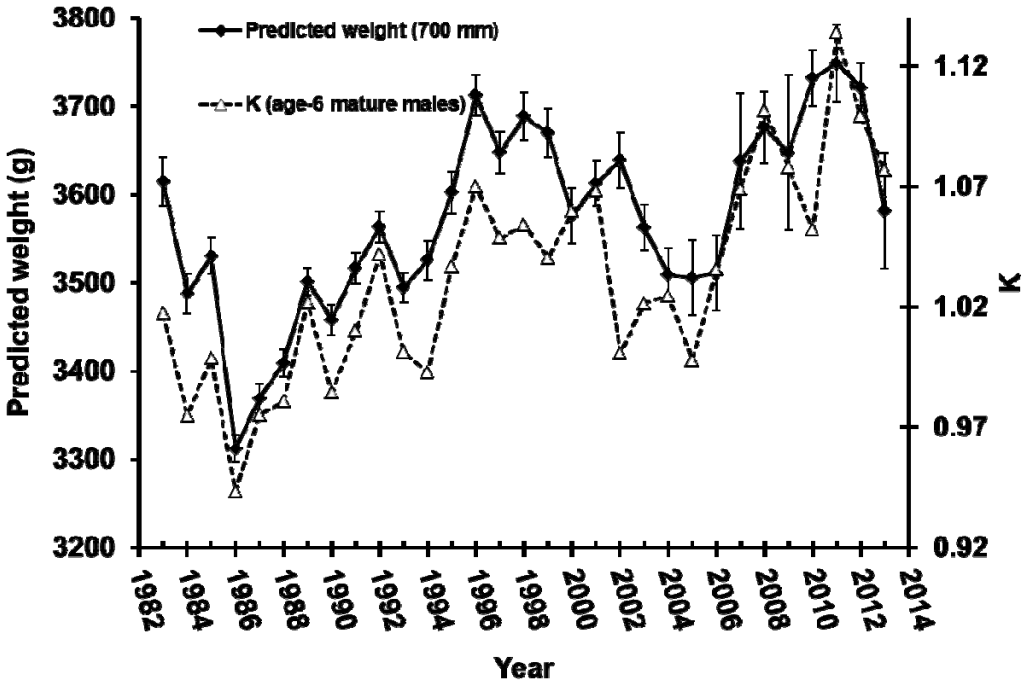

Figure 8. Lake Ontario lake trout condition (K) for age-6 mature males and predicted weight at 700-mm (27.6 in) TL from weight-length regressions calculated from all fish collected during each annual gill net survey, September 1983 – 2013. Error bars represent the regression confidence limits for each annual value.

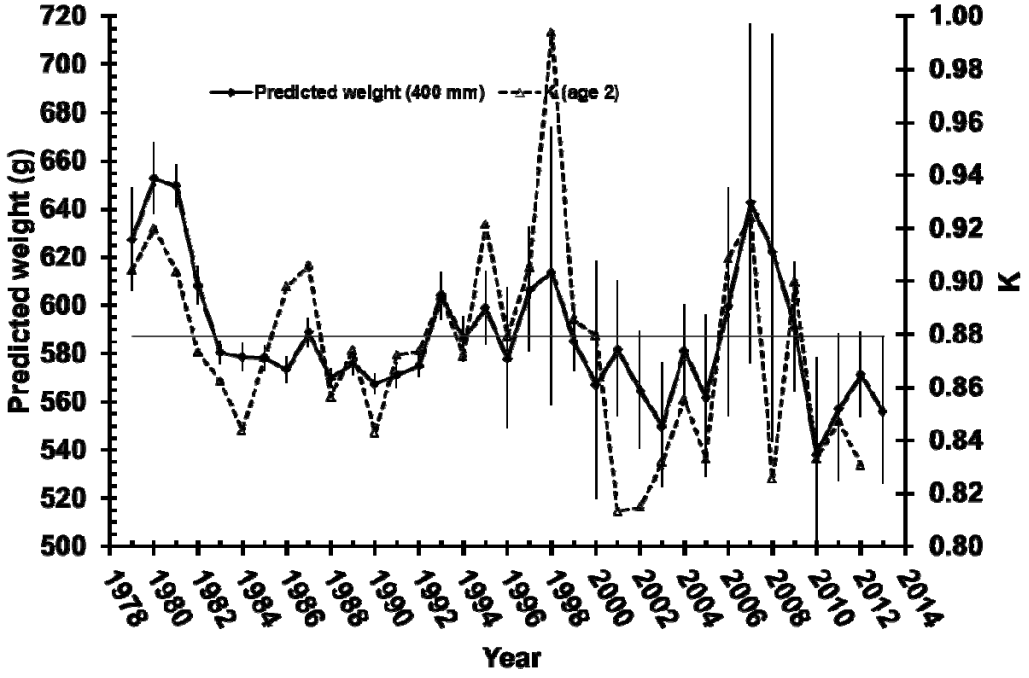

Figure 9. Lake Ontario lake trout predicted weight at 400-mm (15.8 in) TL from annual weight-length regressions calculated from fish 250 mm-500 mm (9.8 to 19.7 in). All lake trout were sampled from bottom trawls, July -August 1978 – 2013. The horizontal line represents the mean predicted weight across all years. Sample sizes for regressions were ≥ 39 except for 1997, 2000, 2005, 2006, 2007, 2008 and 2013 (n = 13, 15, 19, 11, 14, 20 and 12, respectively). Error bars represent the regression confidence limits for each annual value.

Reproductive Potential

Temporal patterns in the egg deposition index (Figure 10) differed considerably from temporal abundance patterns in the CPUE of all mature females (Figure 3). The CPUE of all mature females suggested that reproductive potential quadrupled from 1983 to 1986 and then fluctuated around a high level through 1998. In contrast, the egg index suggested that reproductive potential quadrupled from 1985 to 1993 and then remained high through 1999. The CPUE of mature females declined by 31% between 1998 and 1999, yet a change in reproductive potential was delayed by one year, dropping by 27% between 1999 and 2000. Trends more closely agreed between the egg deposition index and the CPUE of mature females ≥ 4,000 g than between the index and the CPUE of all females, reflecting the effects of population age structure on fecundity. Strain composition of the eggs was mostly SUP during 1983-1990 and mostly SEN during 1991-2002. After 2002, it became increasingly difficult to assess strain-specific contribution to the egg deposition index because many fish stocked since 1997 were not marked with coded wire tags. In most recent years SEN strain dominated stockings and we assumed that they continued to contribute the greatest proportion to the egg index. The first predominantly untagged cohort since 1983 was stocked as spring yearlings in 1997 and was first captured in substantial numbers as mature females at age 5 in 2001. For 2001 and later indices, we calculated size and age-specific fecundities for untagged fish with paired fin clips that facilitated age estimation. We then applied strain-specific mortality correction factors to fecundity estimates of untagged fish and weighted them based on strain composition for specific cohorts at stocking.

The egg deposition index changed little between 2001 and 2004 and the average for those years was 42% lower than the average for 1993 to1999. In 2005, the index dropped by 40% below the 2001-2004 mean and during 2007-2008 values dropped to the lowest observed since 1985. The index value increased in 2009 and remained relatively constant through 2012. The 2009-2012 mean was 25% below the

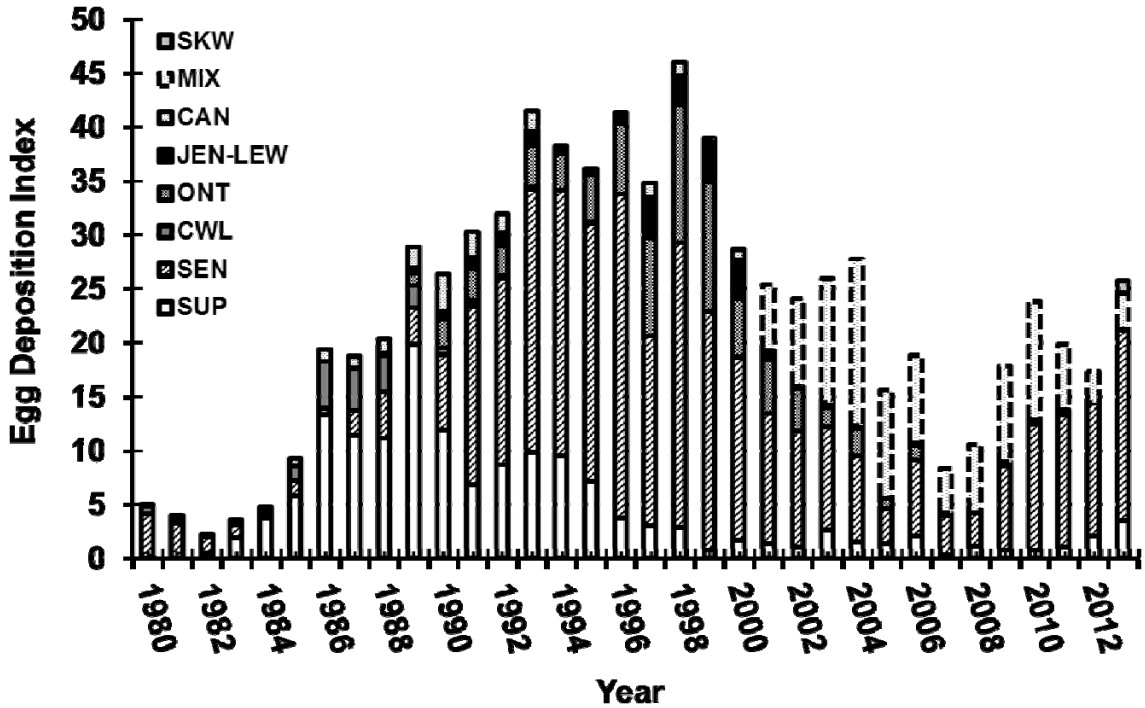

Figure 10. Egg deposition indices by strain (strain descriptions for ONT, JEN-LEW, CWL, SEN, SUP and SKW appear in Appendix 1) for lake trout in U.S. waters of Lake Ontario during 1980-2013. CAN represents a mix of the strains stocked by OMNR and MIX represents values for untagged females stocked since 1997 for which strain could not be determined.

mean for 2001-2004. In 2013 egg deposition was similar to 2001-2004 level and, for the first time, included contributions from age-5 Klondike strain (SKW) lake trout from the 2008 year class (see appendix 1 from strain descriptions).

Natural Reproduction

In 2013, five age-1(85-123 mm, 3.35-4.84 in) and three age-2 naturally produced (wild) lake trout (185-192 mm, 7.28-7.56 in) were caught bottom trawling. Survival of naturally produced lake trout older than the fingerling stage in summer and fall occurred each year during 1993-2012 (Figure 11) except 2008, representing production of 19 year classes. No wild lake trout were caught as of yet from the 2008 year class. The wild yearlings captured in 2010-2013 were the first wild yearlings caught since 2005. Low numbers of small (<100 mm, 3.9 in), wild fish captured in recent years (1997-2012) may be due in part to a change in our trawl gear that was necessary to avoid abundant dreissenid mussels. Our new bottom trawls are not as efficient at capturing small benthic fishes.

The distribution of catches of wild fish suggests that lake trout are reproducing throughout New York waters of Lake Ontario (Figure 12). Catches from at least 19 cohorts of wild lake trout since 1994 and survival of those year classes to older ages meets the plan objective to demonstrate the feasibility of lake trout rehabilitation in Lake Ontario (Schneider et al. 1997). Although recent evidence of wild reproduction is encouraging, achieving the goal of a self-sustaining population requires improvement in production of wild lake trout.

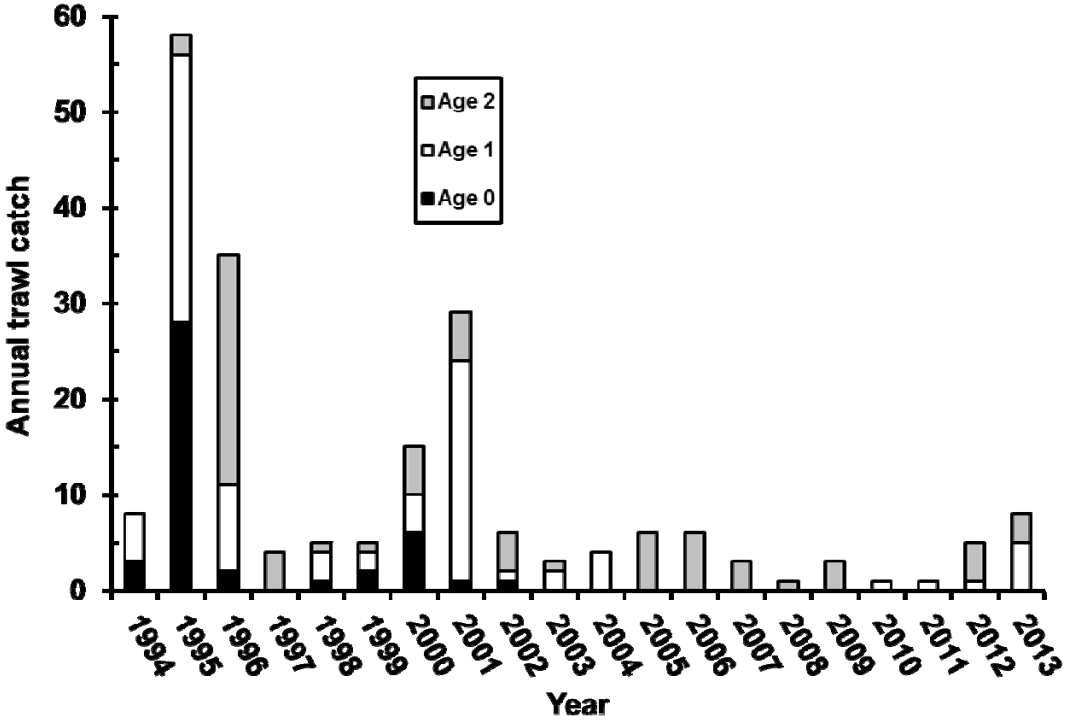

Figure 11. Numbers and ages of naturally produced (wild) lake trout captured with bottom trawls in Lake Ontario by NYSDEC and USGS, 1994-2013. During 1980-1993, only one naturally produced lake trout was captured with bottom trawls.

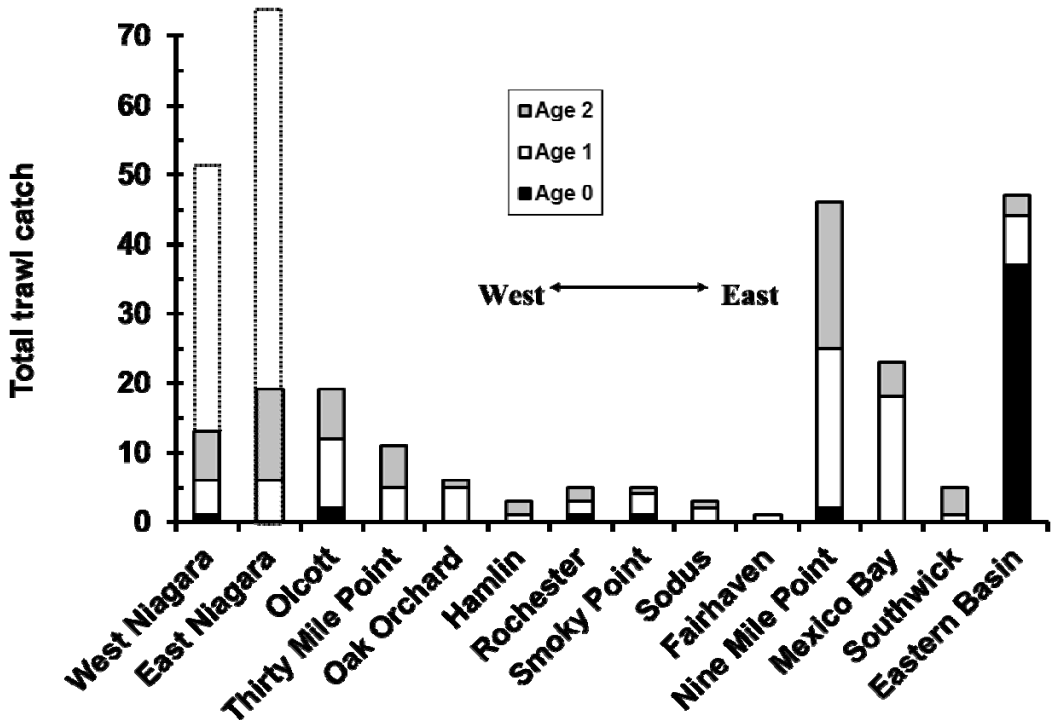

Figure 12. Numbers of wild lake trout (age 0 to 2) captured with bottom trawls at various locations in Lake Ontario by NYSDEC and USGS, 1994 – 2013. (Note: east and west Niagara are only sampled once per year whereas the other locations are usually sampled four times per year. Dashed lines show these catches adjusted for effort).

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Appendix 1.

Strain Descriptions

SEN -Lake trout descended from a native population that coexisted with sea lamprey in Seneca Lake, NY. A captive broodstock was maintained at the USFWS Alleghany National Fish Hatchery (ANFH) which reared lake trout for stocking in Lakes Erie and Ontario beginning with the 1978 year class. Through 1997, eggs were collected directly from fish in Seneca Lake and used to supplement SEN brood stocks at the USFWS Alleghany National Fish Hatchery (ANFH) and USFWS Sullivan Creek National Fish Hatchery (SCNFH). Beginning in 1998 SEN strain broodstocks at ANFH and SCNFH were supplemented using eggs collected from both Seneca and Cayuga Lakes. Since 2003 eggs were collected exclusively from Cayuga Lake.

LC -Lake trout descended from a feral population in Lake Champlain. The brood stock (Lake Champlain Domestic; LCD) is maintained at the State of Vermont's Salisbury Fish Hatchery and is supplemented with eggs collected from feral Lake Champlain fish. Eggs taken directly from feral Lake Champlain fish (Lake Champlain Wild; LCW) were also reared and stocked.

SUP - Captive lake trout broodstocks derived from "lean" Lake Superior lake trout. Broodstock for the Lake Ontario stockings of the Marquette strain (initially developed at the USFWS Marquette Hatchery; stocked until 2005) was maintained at the USFWS Alleghany National Fish Hatchery until 2005. The Superior – Marquette strain is no longer available for Lake Ontario stockings. Lake Ontario stockings of "lean" strains of Lake Superior lake trout resumed in 2007 with Traverse Island strain fish (STW; 2006-2008 year classes) and Apostle Island strain fish (SAW; 2008 year class). Traverse Island strain originated from a restored "lean" Lake Superior stock. The STW broodstock was phased out of production at USFWS Iron River National Fish Hatchery (IRNFH) and will no longer be available as a source of eggs for future Great Lakes stockings. The Apostle Island strain is similar to Traverse Island strain and was derived from a remnant "lean" Superior stock, restored through stocking efforts. The SAW brood stock is held at IRNFH.

SKW -Originated from a native, deep spawning "humper" morphotype of Lake Superior lake trout that are intermediate in fat content to lean and fat (siscowet) morphotypes. Captive brood stocks are held at the USFWS Sullivan Creek National Fish Hatchery and USFWS Iron River National Fish Hatchery.

CWL - Eggs collected from lake trout in Clearwater Lake, Manitoba, Canada and raised to fall fingerling and spring yearling stage at the USFWS Alleghany National Fish Hatchery in Warren, Pennsylvania (see Elrod et al. 1995).

JEN-LEW - Northern Lake Michigan origin stocked as fall fingerlings into Lewis Lake, Wyoming in 1890. Jenny Lake is connected to Lewis Lake. The 1984-1987 year classes were from brood stock at the Jackson (Wyoming) National Fish Hatchery and the 1991-1992 year classes were from broodstock at the Saratoga (Wyoming) National Fish Hatchery

ONT -Mixed strains stocked into and surviving to maturity in Lake Ontario. The 1983-1987 year classes were from eggs collected in the eastern basin of Lake Ontario. The 1988-1990 year classes were from broodstock developed from the 1983 egg collections from Lake Ontario. Portions of the 1991-1992 year classes were from ONT strain broodstock only and portions were developed from crosses of ONT strain broodstock females and SEN males (see Elrod et al. 1995).

For further discussion of the origin of strains used in Lake Ontario Lake Trout Restoration see Krueger et al. (1983), Visscher, L. (1983), and Page et al. (2003).

Thousand Islands Warmwater Fish Stock Assessment

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Warmwater fish stock assessment on the St. Lawrence River began in 1977 as an outgrowth of environmental assessment projects related to proposed St. Lawrence Seaway navigation season extension. This program provides standardized indices of abundance for major gamefish and panfish stocks, information on year class strength, and age and growth relationships of these stocks. Information obtained is used to evaluate and, if necessary, modify existing fishing regulations. It also provides baseline information for evaluation of environmental disturbances.

Methods

Warmwater fish stock assessment in New York waters of the Thousand Islands is conducted from the upstream end of Grindstone Island (near Clayton, New York) downstream to the Morristown area (opposite Brockville, Ontario), a water surface area of approximately 43,000 acres (17,400 ha). The term warmwater fish stock assessment is applied to this project in keeping with NYS Bureau of Fisheries administrative structure, but many of the species of interest would normally be considered coolwater fishes (e.g. Northern Pike [*Esox lucius*], Walleye [*Sander vitreum*] [Eaton et al. 1995]). Sampling was conducted from the third week of July through the first week of August each year. Sampling effort consisted of 32 overnight gill net sets (16 sets prior to 1982) at standard sites. Multifilament nylon nets were used from 1977 through 2003; monofilament nets were used beginning in 2004. Based on 24 paired nets, catch rates of Rock Bass (*Ambloplites rupestris*) and Yellow Perch (*Perca flavescens*) in the two net types were significantly different ($\propto$ = .05). To correct monofilament catches to the multifilament standard, rock bass catches were multiplied by 1.7 and yellow perch catches by 0.74. Both types of net are 200 ft (61 m) long by 8 ft (2.4 m) deep and contain eight 25 ft (7.6 m) panels. Stretch measure mesh sizes range from 1.5 in (38 mm) to 6 in (152 mm). Sampling was confined to the mid-depths of the river, from 10 to 60 ft (3 to 20 m). Nets were set on bottom, half in relatively shallow water, less than 30 ft (9 m) deep, and the other half at 33 to 60 ft (10 to 20 m).

All fish were identified, weighed and measured (total length). All game fish and sub-samples (Ketchen 1949) of panfish were examined for sex and maturity, and had scales (or cleithra for esocids) removed for age determination. Ages were determined from projections of scales or from direct examination of cleithra.

Results and Discussion

Environmental conditions

The mid-summer sampling period was chosen to minimize intra- and inter-annual variation in environmental conditions, chiefly water temperature. Surface water temperatures have varied from 64°F (18°C) during the 1982 sampling period to 79°F (26°C) in 1979. Bottom temperatures are generally within 2°F (1°C) of surface temperatures. Surface temperature was relatively warm at 73-75°F (23-25°C) in 2013. Mean bottom temperature at 47 ft (14.3 m) was 74.5°F (23.6°C). Prior to colonization by dreissenid mussels, summer water transparency (Secchi depth) ranged down to about 10 ft (3 m , S. LaPan, pers. communication) and was not considered a significant influence on catchability. By 1995 it was apparent that significant increases in transparency had occurred, and transparency data are now collected during fish sampling. Secchi depths during the sampling period have ranged from 55 ft (16.8 m) in 1999 to 14.1 ft (4.3 m) in 1997. In 2013, mean Secchi depth was 21.3 ft (6.5 m) (Table 1).

Stock composition

A total of 37 species have been represented in Thousand Islands gill net sampling between 1977

and 2013 (Table 2). These nets were not designed to catch small-bodied species so that cyprinids, other than carp, are rarely captured. Annual catch (for 32 net sets) has historically ranged from 932 fish of 17 species in 2001 to 2,080 fish of 19 species in 1988. In 2013 the catch was somewhat low at 1,017 individuals (adjusted to multifilament standard); diversity was moderate, with 17 species sampled (Table 2). Although they had been detected in predator stomachs for several years, Round Goby (*Neogobius melanostomus*) were captured in assessment nets for the first time in 2007. Gobies have been caught each year since. Historically, more than 90 percent of the catch consisted of six species: Northern Pike, Brown Bullhead (*Ameiurus nebulosus*), Rock Bass, Pumpkinseed Sunfish (*Lepomis gibbosus*), Smallmouth Bass *(Micropterus dolomieui*), and Yellow Perch (Figure 1). In recent years, abundance of Pumpkinseed Sunfish and Brown Bullhead have declined, leaving Northern Pike, Rock Bass, Smallmouth Bass, Yellow Perch, Walleye (*Sander vitreus*) and White Sucker (*Catostomous commersonii*)comprising 90% of the sample in 2013 (Figure 1).

Primary recreational fishery targets

Smallmouth Bass. Smallmouth Bass are the most sought-after sport fish in the New York Thousand Islands fishery (McCullough 1987, Klindt 2011). Abundance of Smallmouth Bass was relatively high in the late 1970's, declined through 1982, then increased to its highest recorded level in 1988. After 1988 bass abundance generally declined and was low from 1996 through 2004 (Figure 2). The 2005 catch increased and has varied at relatively high levels since. Catch in 2012 reached its highest level since 1988, but this apparent increase did not persist in 2013. The trend in Smallmouth Bass abundance is complicated by a disproportionate representation of younger fish since 2006. Abundance of age-5 and older fish, which have historically constituted the bulk of the catch, has generally remained low in recent years. (Figure 3). An expanding Double-crested Cormorant (*Phalacrocorax auritus*) population was implicated in suppression of Smallmouth Bass recruitment in the nearby Eastern Basin of Lake Ontario (Lantry et al. 1999). Cormorants may also have affected Thousand Islands bass. Cormorant predation pressure has lessened since 2005 due to lower cormorant numbers and a cormorant diet shift to predominantly Round Goby at St. Lawrence River cormorant colonies (Johnson et al. 2008). Younger bass, ages 3-4 have generally been more abundant since 2006 relative to earlier years. This may indicate increased abundance of these fish, but more likely reflects a change in catchability of young bass due to increased growth rates. The 2007 year class, which appeared to be very strong in 2012, was apparently of average abundance in 2013 (Figure 4).

Smallmouth Bass growth changed little between 1977 and 1998. Since then, faster growth has produced an overall increasing trend in size of age-5 bass. Bass are now generally reaching legal size, 12" (305 mm), before age-5. In 2013 age-5 bass averaged a record 15.4 inches (390 mm) (Figure 5). Smallmouth Bass growth has also increased recently in Lake Ontario's Eastern Basin (Lantry 2010), in Lake St. Lawrence (Klindt 2010) and in Lake Erie (Einhouse et al. 2005). The most recent increase in growth is probably related to abundance of round goby as prey, although a density dependent effect may also be involved, particularly in Lake Ontario.

Northern Pike. Northern Pike are an important part of the New York fishery (Klindt 2011) and have been the most highly sought-after fish in the Province of Ontario Thousand Islands fishery (Bendig 1995). Their abundance peaked in 1981, generally declined through 1996 and varied without trend through 2001 (Figure 6). From 2001 through 2005 abundance again generally declined and has varied without trend since. Evidence suggests that spawning habitat changes resulting from reduced water level fluctuation may be impairing recruitment (Farrell 2001, Farrell et al. 2006, Smith et al. 2007). Cormorant predation on young fish has also been implicated as a factor interfering with pike recruitment (Connerton 2003). Pike have been less abundant recently, particularly at ages 3 and 4. Older fish have thus far shown little decline, suggesting that survival of recruited fish has improved relative to earlier years (Figure 7).

Northern Pike growth varies over the data series with the highest mean total length of age-4 fish occurring prior to 1983 and the lowest in 1994 (Figure 8). Mean length increased through the late 1990s and mid 2000s. Total length of age-4 pike has generally experienced a moderate decline since 2004 (Figure 8).

Yellow Perch. Yellow Perch abundance peaked in the late 1970's then went into an irregular decline through 1992. The general decline through the early 1990's may have been connected with relatively high Alewife populations at that time, which have been linked to high Yellow Perch larval mortality (Abraham 1994). From 1992 through 1999, yellow perch abundance tended to increase. After 1999, Yellow Perch catch generally declined, falling to its lowest recorded (adjusted) level, up to that time, in 2005. Catches increased in 2006 and remained moderately high in 2007 and 2008. Abundance then declined to a new record low in 2012 and remained relatively low in 2013 (Figure 9).

There have been several reasonably strong Yellow Perch year classes since 2000. A moderately strong 2007 year class appeared to be present in 2010 but was about average, for recent years, since then. The 2008 year class was unusually well represented in the 2011 sample and, given the generally low 2012 catch rate, reasonably well represented in 2012. There were no noticeably strong year classes apparent in the 2013 sample (Figure 10).

Growth rate has generally increased since 1994 (Figure 11). Mean length at age-4 increased substantially in recent years, and was at or near 7.1 in (180 mm) in 2007-2009. Mean length at age-4 was unusually high in 2010 and reached a record 7.9 inches (210 mm) in 2011. Increased growth may be attributable to the availability of round goby as forage. Mean total length of age-4 perch reached a record high of 8.6 inches (218 mm) in 2013.

Walleye. Walleye were first captured in 1982 and were caught regularly in low numbers throughout the 1980s and 1990s (Figure 12). Abundance increased in the early 2000s and, while still relatively uncommon, Walleye were caught at substantially higher rates in the 2005 to 2011 period. Walleye catch was unusually low in 2012, but returned to its recent higher level in 2013(Figure 12).

Other species of interest

Sturgeon. Lake Sturgeon (*Acipenser fulvescens*) is listed as a threatened species by New York State. Sturgeon generally survive gillnetting and all sturgeon captured during this project have been released alive. Most recently, one Lake Sturgeon was caught in 2009. Six of eight sturgeon caught in this project have been caught since 1999. During the 1990s sturgeon were stocked in St. Lawrence River tributaries (Grass River 1993, Oswegatchie River 1993-99); however, natural spawning has been observed in the upper St. Lawrence River (LaPan et al. 1997) and is thought to be the major source of recruitment to this population.

River Herrings. Alewives were frequently captured during the 1970s and 1980s. They were detected at very low levels from 1989 through 2006. The catch rate in 2009 was the highest yet recorded (Figure 13) but declined to a more moderate level in 2010 and 2011, and was closer to the background level in 2012-2013. Alewives in the Thousand Islands are commonly regarded as strays from Lake Ontario. Gizzard Shad (*Dorosoma cepedianum)* were collected sporadically from 1978 through 1999.

Salmon, Trout and Smelt. Salmonids are not targeted in this assessment but have been collected incidentally. Coho Salmon (*Oncorhyncus kisutch*), Brown Trout (*Salmo trutta*) and Lake Trout (*Salvelinus namaycush*) were captured occasionally in the 1980s and early 1990s. Rainbow Smelt (*Osmerus mordax*) were captured in 1979. All of these species were considered strays from Lake Ontario.

Pikes. Like Northern Pike, Muskellunge (*Esox masquinongy*) is an important sport fish in the St. Lawrence River. They are thought to occur at low density and historically approximately 50% of muskies tagged in the Thousand Islands migrated to eastern Lake Ontario in summer (LaPan et al. 1995). They have been caught in low numbers seven times since 1989. A possible Chain Pickerel was caught in 2010 and the presence of Chain Pickerel in the Thousand Islands has been confirmed by other investigators (J. Farrell, personal communication).

Carp and Minnows. Common Carp (*Cyprinus carpio*) have been caught regularly since 1982. They are caught in low numbers, usually one to six individuals per year. Other minnows are usually not vulnerable to this sampling gear but a few, such as Fallfish (*Semotilus corporalis*) or Golden Shiner (*Notemigonus crysoleucas*), are caught occasionally. A single Rudd (*Scardinius erythropthalmus*) was caught in 2000.

Suckers. White Suckers (*Catostomus commersoni*) have been caught in substantial numbers (30-90 individuals) every year since 1977. White Suckers have been in general decline since 1990 and are now found at about one third of their previous abundance (Figure 14). Silver (*Moxostoma anisurum*) and Greater Redhorse (*M. valenciennessi*) have been detected at low levels sporadically since they were first identified to the species level in 1987. A few Shorthead Redhorse (*M. macrolepidotum*) were caught in 1989, 1997 and 1998, and Longnose Suckers (*Catostomus catostomus*) in 1982 and 1984.

Catfishes. Brown Bullhead have experienced several cycles of abundance since 1977 (Figure 15). They were abundant during the 1970s and 1980s, declined through the mid-1990s and increased again into the early 2000s. Brown Bullhead are now in a period of low abundance. Channel Catfish have been sampled regularly throughout the survey period. They have generally been present at about one fourth the abundance of Brown Bullhead, but this has changed with the decline in bullhead abundance in recent years (Figure 14). Channel Catfish were most abundant during the 1980s and may be increasing in abundance again. For the first time, Channel Catfish were more abundant than Brown Bullhead in 2010 and the two species were about equally abundant in 2013. Yellow Bullhead (*Ameiurus natalis*) were caught for the second time in 2012. Stonecat (*Noturus flavus*) were caught twice during this project, most recently in 2000.

Sunfishes. Rock Bass and Pumpkinseed sunfish have typically been the most common sunfishes in Thousand Island gillnet sampling. Abundance of these species has tended to vary inversely ($r = -.40$, $P = 0.02$). From 1977 through 1999 abundance of Rock Bass and Pumpkinseed varied at somewhat comparable levels (Figure 16). Since 2000, however, Rock Bass have generally increased while Pumpkinseed have decreased in abundance. In 2013 Rock Bass were an order of magnitude more abundant than Pumpkinseed.

Both Bluegill (*Lepomis macrochirus*) and Largemouth Bass (*Micropterus salmoides*) are captured regularly. Typically they are caught in low numbers (fewer than 10 individuals) although over 30 Bluegills were caught in 1981, 1983 and 1992. Sixteen Largemouth bass were caught in 1983. The sample nets are probably set too deep to sample these species effectively in most years. Black Crappie (*Pomoxis nigromaculatus*) are sampled in very low numbers in about half the sample years.

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Table 1. Water temperature and secchi depth.

Sample Year	Water Temperature Range °C (°F)	Secchi Depth m (ft)	Sample Year	Water Temperature Range °C (°F)	Secchi Depth m (ft)
1977	22-23 (72-73)		1996	21-21 (70-70)	8.8 (29)
1978	21-22 (70-72)		1997	20-22 (68-72)	4.3 (14)
1979	25-26 (77-79)		1998	22-24 (72-75)	8.0 (27)
1980	20-22 (68-72)		1999	23-24 (74-76)	16.8 (55)
1981	20-22 (68-72)		2000	21-22 (70-71)	13.4 (44)
1982	18-19 (64-66)		2001	20-24 (68-75)	6.2 (20)
1983	22-23 (72-73)		2002	21-23 (70-73)	7.3 (24)
1984	19-21 (66-70)		2003	21-24 (69-76)	6.5 (21)
1985	20-21 (68-70)		2004	21-22 (69-71)	8.1 (26.5)
1986	19-21 (66-70)		2005	22-24 (72-75)	11 (36)
1987	19-21 (66-70)		2006	22-24 (72-75)	8.8 (29)
1988	22-24 (72-75)		2007	21-22 (69-72)	7.8 (22.5)
1989	19-22 (66-72)		2008	20-24 (68-75)	10.4 (34)
1990	22-24 (72-75)		2009	21-23 (69-73)	9.5 (31)
1991	23-23 (73-73)		2010	23-25 (74-77)	6.0 (20)
1992	18-19 (64-66)		2011	23-24 (74-76)	8.8 (29)
1993	21-24 (70-75)		2012	23-25 (73-75)	9.3 (30.5)
1994	21-24 (70-75)		2013	23-25 (73-75)	6.5 (21.3)
1995	22-24 (72-75)				

Table 2. Total annual abundance index (catch/net-night), number of species sampled and number of individuals caught.

Year	Index*	Species**	Individuals	Year	Index*	Species**	Individuals
1977	44.3	13	709	1996	36.7	17	1,174
1978	59.7	16	955	1997	36.4	17	1,165
1979	57.7	12	923	1998	32.6	17	1,044
1980	47.5	13	760	1999	44.9	19	1,437
1981	38.1	14	610	2000	30.0	18	959
1982	41.5	17	1,328	2001	29.1	17	932
1983	39.0	16	1,249	2002	34.9	16	1,077
1984	39.7	18	1,271	2003	35.5	18	1,137
1985	40.4	17	1,292	2004	30.3a	15	970a
1986	50.7	12	1,622	2005	27.5a	16	880a
1987	51.9	17	1,661	2006	41.9a	15	1,352a
1988	65.0	19	2,080	2007	40.4a	18	1,293a
1989	45.3	19	1,450	2008	39.1a	14	1,196a
1990	49.2	19	1,574	2009	36.7a	16	1,160a
1991	41.5	18	1,328	2010	36.2a	18	1,158a
1992	31.7	19	1,014	2011	37.9a	16	1,214a
1993	38.6	15	1,235	2012	26.5a	19	847a
1994	35.1	16	1,123	2013	31.8a	17	1,017a
1995	37.4	13	1,197				

* 16 net-nights 1977-81, 32 net-nights thereafter. Change to monofilament nets in 2004.
**Prior to 1987 redhorse suckers were not identified to species.
a - adjusted to multifilament standard

Table 3. Abundance index (catch/net night) by species (* net type correction applied).

Species	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Lake Sturgeon	0	0	.06	.06	0	0	0	0	0	0	0	0	0	0
Bowfin	0	0	0	0	0	.06	0	0	.03	0	0	.03	0	.09
Alewife	1.5	1.1	2.3	2.6	5.0	0	2.0	1.5	1.0	6.5	2.2	1.5	.30	.28
Gizzard Shad	0	6	0	.06	0	0	0	0	0	0	0	0	0	0
Coho Salmon	0	0	0	0	0	0	0	.03	0	0	0	0	0	0
Brown Trout	0	0	0	0	0	.06	0	0	0	0	0	0	0	0
Lake Trout	0	0	0	0	0	0	0	0	0	0	0	0	.16	0
Rainbow Smelt	0	.18	0	0	0	0	0	0	0	0	0	0	0	0
Northern Pike	3.20	2.30	2.50	4.10	7.30	4.90	4.50	3.90	4.80	3.70	3.63	4.03	5.31	4.38
Muskellunge	0	0	0	0	0	0	0	0	0	0	.03	0	.03	0
carp	0	0	0	0	0	.20	.10	.10	.03	0	.19	.09	.16	.31
Golden Shiner	0	0	0	0	0	0	0	0	0	0	0	.03	.03	0
Fallfish	0	0	0	0	.12	0	0	0	0	0	0	0	0	.03
Longnose Sucker	0	0	0	0	0	.39	0	.13	0	0	0	0	0	0
White Sucker	2.40	3.60	2.40	2.00	1.80	.80	1.40	1.30	2.10	1.70	1.81	2.50	3.03	3.06
Silver Redhorse	.10	.10	.20	0	.20	.10	.10	.10	.30	0	.16	1. 0	.09	.16
Shorthead Redhorse	*	*	*	*	*	*	*	*	*	*	0	.03	0	0
Greater Redhorse	*	*	*	*	*	*	*	*	*	*	0	0	0	0
Brown Bullhead	2.4	3	1.4	6.7	1.6	2.1	2.7	3.4	2.6	2.6	4.25	5.69	3	3.69
Yellow Bullhead	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Channel Catfish	.10	1.00	0	.20	0	.20	.40	.80	4.80	1.40	.41	1.31	.16	.97
Stonecat	0	0	0	0	0	0	0	.13	0	0	0	0	0	0
Burbot	0	0	0	0	0	0	.0 3	0	0	0	0	0	0	0
White Perch	.10	.80	.10	0	.10	.10	.10	0	.10	0	.03	.13	.16	.03
White Bass	0	0	0	0	0	0	0	0	.06	0	0	0	0	.09
Rock Bass	6.00	10.1	9.00	7.40	6.10	6.20	5.50	5.50	5.60	6.50	6.88	11.3	5.59	4.78
Pumpkinseed	6.30	5.20	8.30	4.50	11.5	9.30	12.3	7.80	5.70	6.40	10.3	10.2	9.66	11.8
Bluegill	.90	1.10	0	.60	2.80	.30	1+.30	.60	.60	.60	.59	.09	.59	.78
Smallmouth Bass	6.20	7.40	6.60	5.10	2.90	3.50	5.20	4.60	5.90	5.90	7.66	9.84	5.69	6.66
Largemouth Bass	0	.10	0	0	.10	0	.50	.10	0	.10	.28	.22	.09	.09
Black Crappie	.40	.20	.10	.10	.20	.10	0	0	.10	0	.13	.09	.06	.03
Yellow Perch	21.9	30.8	32.2	22.9	12.8	19.6	10.9	19.7	14.8	26.9	15.3	16.9	11.4	11.6
Walleye	0	0	0	0	0	.10	.10	.10	.10	.30	.03	.31	.09	.34
Freshwater Drum	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3. Abundance index (catch/net night) by species (continued).

Species	91	92	93	94	95	96	97	98	99	00	01	02	03	04
Lake Sturgeon	0	0	0	0	0	0	0	0	.03	.03	.06	0	0	0
Longnose Gar	0	0	0	0	0	0	0	0	0	0	0	0	.03	0
Bowfin	.03	0	.03	.03	0	.03	0	.03	0	0	.03	0	0	0
Alewife	.91	.19	.07	.38	0	.63	.22	0	.09	.03	.18	.09	0	.03
Gizzard Shad	.06	.03	0	0	0	0	0	0	.03	0	0	0	0	0
Coho Salmon	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brown Trout	0	.03	0	0	0	0	0	0	0	0	0	0	0	0
Lake Trout	0	.06	0	0	0	0	0	0	0	0	0	0	0	0
Rainbow Smelt	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Northern Pike	5. 28	3. 84	3. 87	3. 22	2. 90	2. 00	2. 53	2. 28	2. 50	2. 21	2.78	3.22	1.94	1.69
Muskellunge	0	0	0	0	.03	.03	.03	0	.03	0	0	0	.06	.03
Carp	0	.06	.20	.09	.06	.16	.06	.06	.03	.03	.03	.03	.06	.03
Rudd	0	0	0	0	0	0	0	0	0	.03	0	0	0	0
Golden Shiner	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fallfish	0	0	0	0	0	0	0	0	0	0	.03	0	0	0
Longnose Sucker	0	0	0	0	0	0	0	0	0	0	0	0	0	0
White Sucker	1. 16	2. 06	1. 07	1. 28	1. 50	. 81	1. 30	1. 28	1.0	.97	1.34	1.13	1.41	1.03
Silver Redhorse	.09	.03	.03	0	.06	.13	0	.03	.03	.03	0	0	.06	0
Shorthead Redhorse	0	0	0	0	0	0	.06	.03	0	0	0	0	0	0
Greater Redhorse	.03	.03	0	.03	0	0	0	.03	0	.03	0	.06	0	0
Brown Bullhead	3.09	3.97	1.43	1.06	1.00	.44	.69	1.47	2.50	1.59	2.84	2.53	4.66	1.22
Yellow Bullhead	0	0	0	.03	0	0	0	0	0	0	0	0	0	0
Channel Catfish	.19	.13	.63	.22	.30	.13	.19	.31	.13	.06	.06	.03	.22	.22
Stonecat	0	0	0	0	0	0	0	0	0	.03	0	0	0	0
Burbot	0	0	0	0	0	0	0	0	0	0	0	0	0	0
White Perch	.09	.03	0	0	0	0	0	0	0	.03	0	.03	.03	0
White Bass	0	0	0	0	0	0	0	.03	.03	0	0	0	0	0
Rock Bass	5.06	3. 13	5. 17	7. 44	6. 40	9. 00	6. 31	5. 38	7. 80	8. 38	5.69	5.53	7.84	11.3*
Pumpkinseed	6. 94	6. 28	5. 43	5. 81	6. 20	4. 10	4. 65	4. 13	6. 80	2. 19	2.59	4.13	1.91	1.72
Bluegill	.72	1. 03	.20	.34	.50	.16	.06	.12	0.30	0	.06	.09	.03	0
Smallmouth Bass	6. 91	2. 47	5. 33	4. 53	5. 50	2. 94	2. 34	2. 91	3.30	1.84	3.06	2.16	2.78	3.13
Largemouth Bass	.16	.09	.10	.09	0	.03	.03	.06	.06	.03	.15	.06	.03	.06
Black Crappie	.09	0	0	0	0	.03	.03	0	.03	0	.06	0	.03	0
Yellow Perch	10.4	8. 16	14.8	10.4	12.8	15.7	17.2	14.4	20.7	12.2	9.81	14.4	14.0	10.6*
Walleye	.25	.09	.23	.13	.30	.25	.09	.06	.13	.19	.31	.5	.34	.28
Freshwater Drum	0	0	0	0	0	.03	0	0	0	0	0	0	.03	.06

Table 3. Abundance index (catch/net night) by species (continued).

Species	05	06	07	08	09	10	11	12	13	14	15	16	17	18
Lake Sturgeon	.03	0	0	0	.03	0	0	0	0					
Longnose Gar	0	0	0	0	0	0	0	0	0					
Bowfin	.03	0	0	0	0	.03	0	.03	.03					
Alewife	.09	.03	2.25	.59	8.78	2.13	2.56	.50	.41					
Gizzard Shad	0	0	0	0	0	0	0	0	0					
Coho Salmon	0	0	0	0	0	0	0	0	0					
Brown Trout	0	0	0	0	0	0	0	0	0					
Lake Trout	0	0	0	0	0	0	0	0	0					
Rainbow Smelt	0	0	.06	0	0	0	0	0	0					
Northern Pike	1.63	1.84	2.06	1.34	1.38	2.34	1.44	2.19	2.0					
Muskellunge	0	0	0	0	0	0	0	0	0					
carp	.12	.19	.16	.19	.09	.06	.16	.160	.22					
Rudd	0	0	0	0	0	0	0	0.22	0					
Golden Shiner	0	0	.03	0	.03	.03	.03	0	0					
Fallfish	0	0	0	0	0	0	0	.03	.06					
Longnose Sucker	0	0	0	0	0	0	0	0	0					
White Sucker	1.10	1.16	.88	.81	.63	.34	.69	.53	.78					
Silver Redhorse	.03	.06	.03	.03	.03	.19	.03	.03	.03					
Shorthead Redhorse	0	0	0	0	0	0	0	0	0					
Greater Redhorse	0	0	0	0	.16	0	0	0	.03					
Brown Bullhead	1.53	2.47	1.22	.81	1.56	.72	.75	.97	.50					
Yellow Bullhead	0	0	0	0	0	0	0	.03	0					
Channel Catfish	.38	.44	.25	.31	.84	1.06	0.03	.31	.34					
Stonecat	0	0	0	0	0	0	0	0	0					
Burbot	0	0	0	0	0	0	0	0	0					
White Perch	0	.03	0	0	0	0	0	0	0.13					
White Bass	0	.03	0	0	0	0	0	0	0					
Rock Bass	8.23*[*]	11.3*	9.03*	8.87*	8.82*	10.46*	11.63*	5.47*	10.72*					
Pumpkinseed	1.88	2.41	.97	.88	.81	.72	.69	.47	.94					
Bluegill	.06	.03	.13	.06	0	.06	.09	.25	.09					
Smallmouth Bass	4.75	7.84	5.13	6.69	4.19	7.5	5.0	8.91	6.41					
Largemouth Bass	0	0	.19	0	0	.03	0	.31	.06					
Black Crappie	0	0	0	0	0	0	0	0	0					
Yellow Perch	6.82*[*]	12.95*	16.44*	15.4*	7.70*	9.48*	12.93*	5.7*	8.31*					
Walleye	.75	.81	1.34	.84	1.03	.84	1.06	.47	.81					
Freshwater Drum	.06	0	.13	0	0	0	.09	.06	0.03					
Round Goby	0	0	.09	.53	.19	.16	.75	.06	0					

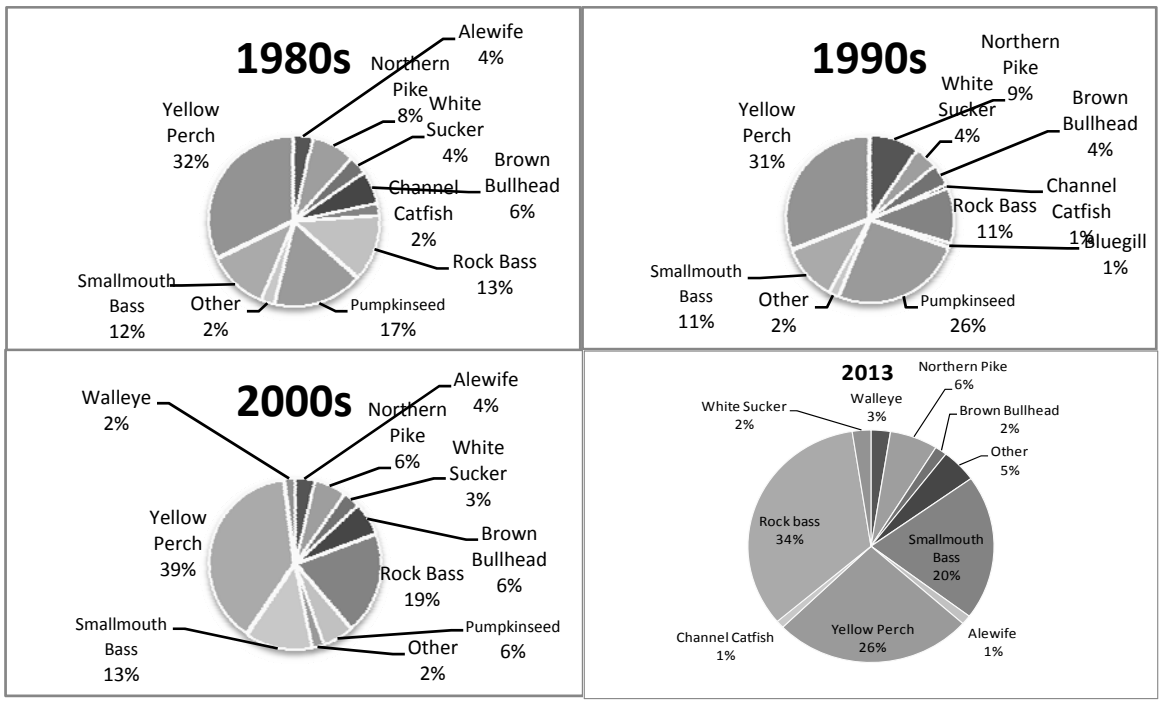

Figure 1. Composition of the warm/coolwater fish stock assessment sample from mid- depths of the St. Lawrence River Thousand Islands area.

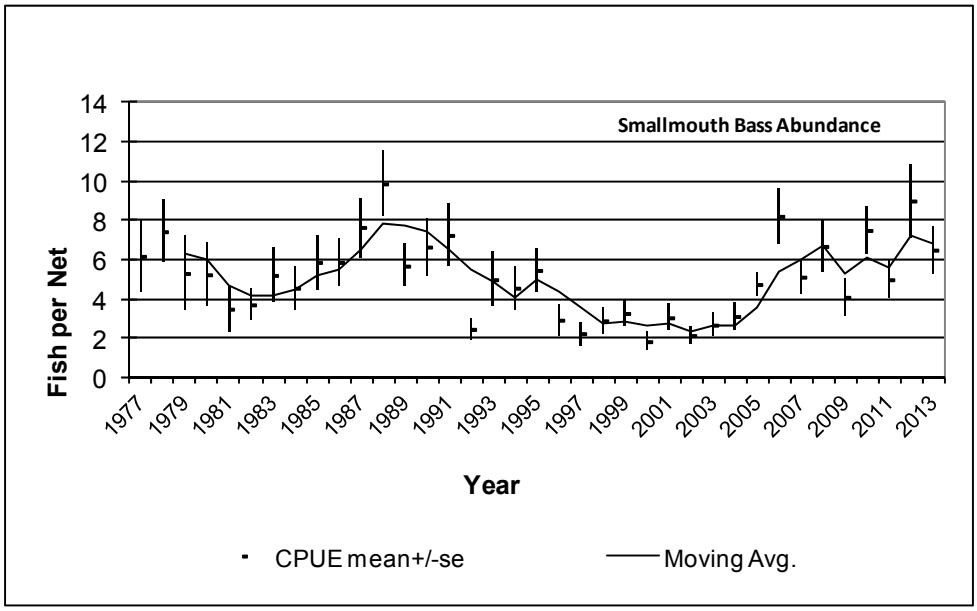

Figure 2. Smallmouth bass abundance index in the St. Lawrence River Thousand Islands area (Catch per Unit Effort +/- SE and 3-year moving average).

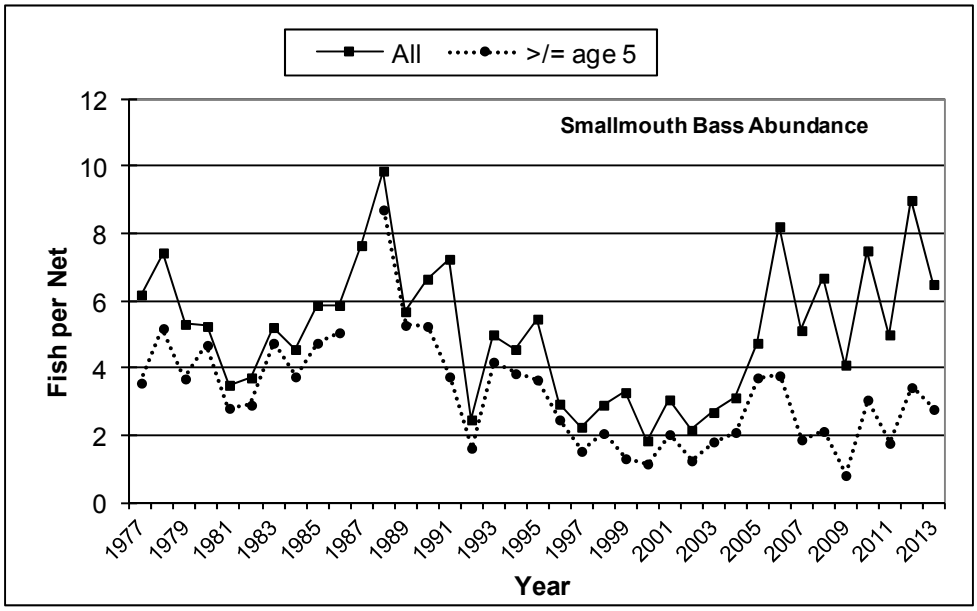

Figure 3. Smallmouth Bass abundance index in the St. Lawrence River Thousand Islands area (all bass sampled and bass greater than or equal to age 5).

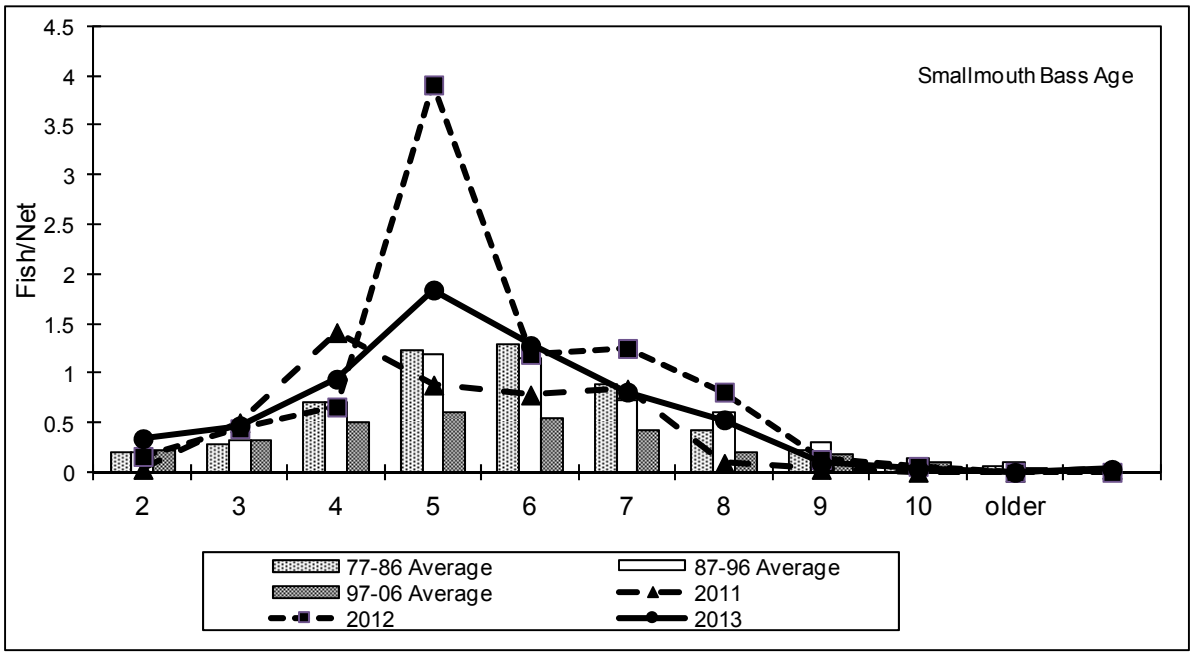

Figure 4. Smallmouth Bass age distribution in the St. Lawrence River Thousand Islands area.

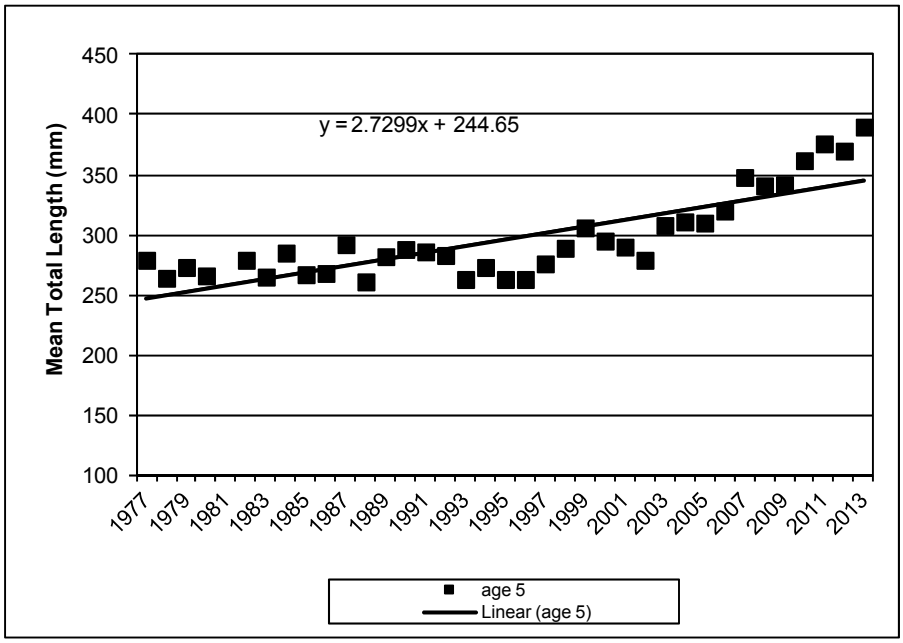

Figure 5. Mean total length of Smallmouth Bass at age 5 in the St. Lawrence River Thousand Islands area.

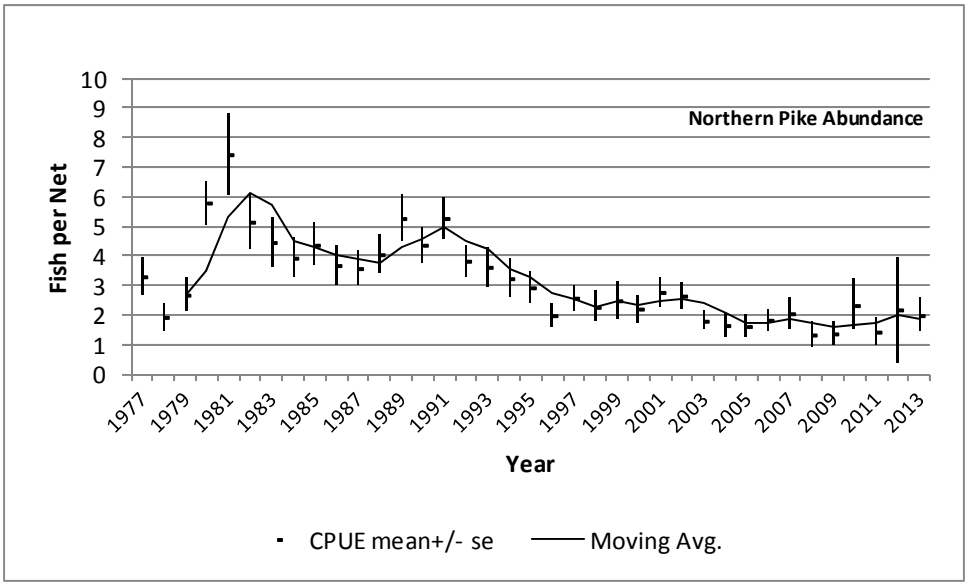

Figure 6. Northern Pike abundance index in the St. Lawrence River Thousand Islands area.

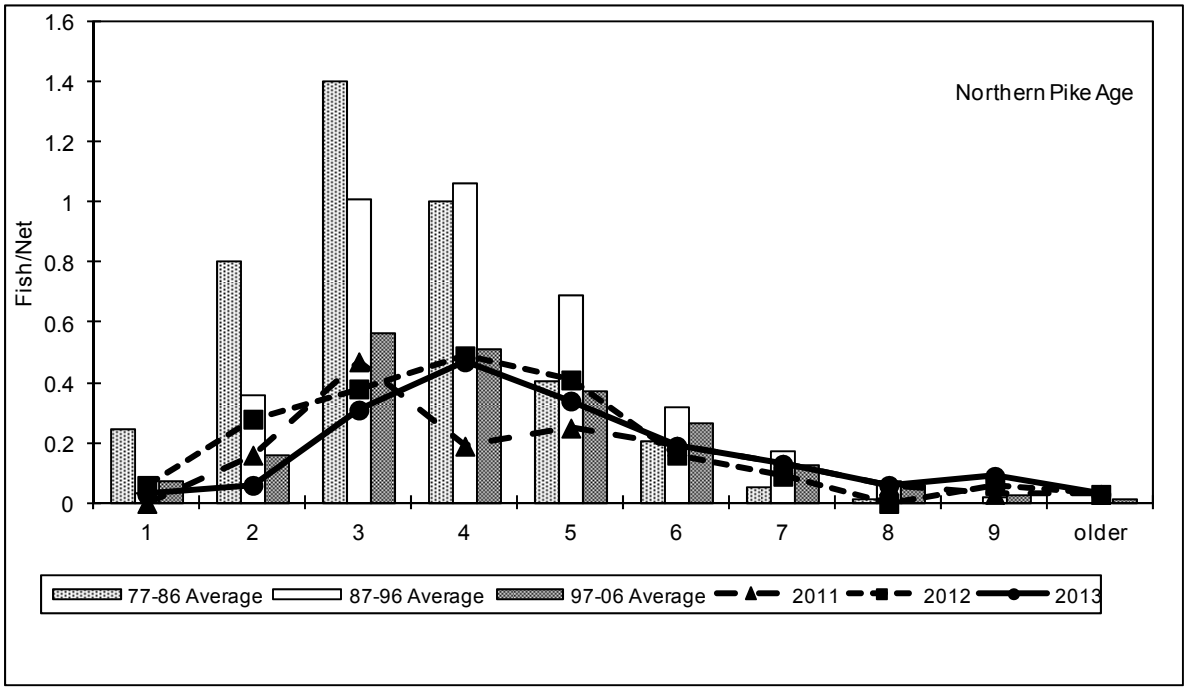

Figure 7. Northern Pike age distribution in the St. Lawrence River Thousand Islands area.

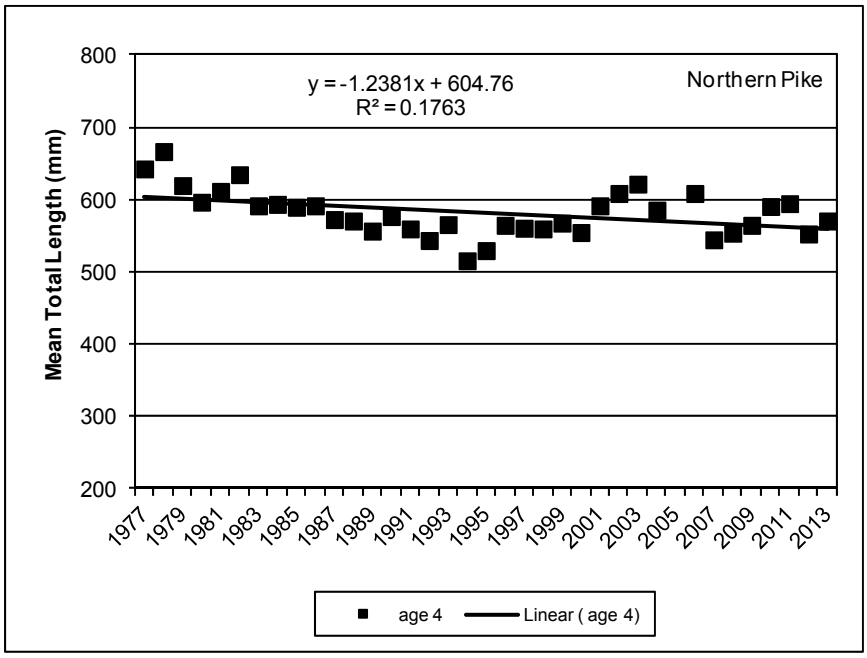

Figure 8. Mean total length of Northern Pike at age 4 in the St. Lawrence River Thousand Islands area.

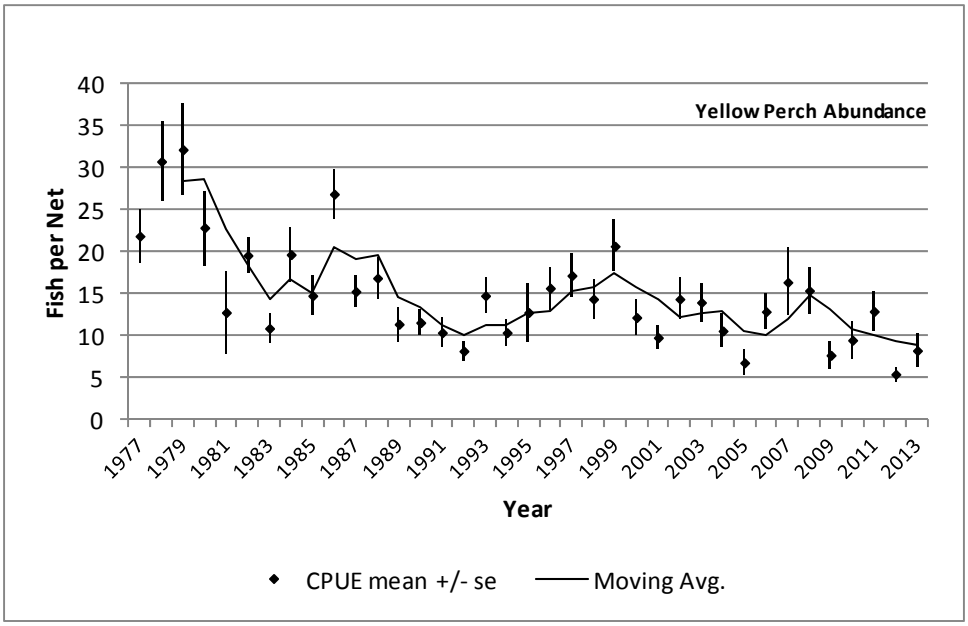

Figure 9. Yellow Perch abundance index in the St. Lawrence River Thousand Islands area.

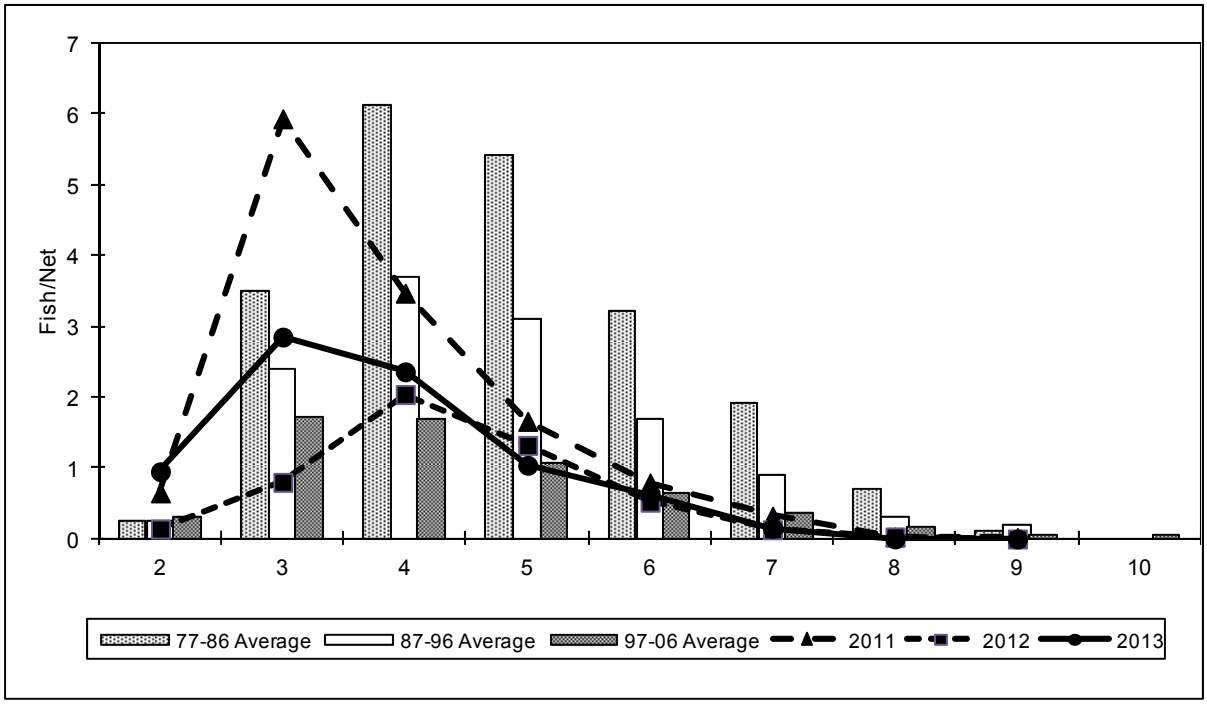

Figure 10. Yellow Perch age distribution in the St. Lawrence River Thousand Islands area.

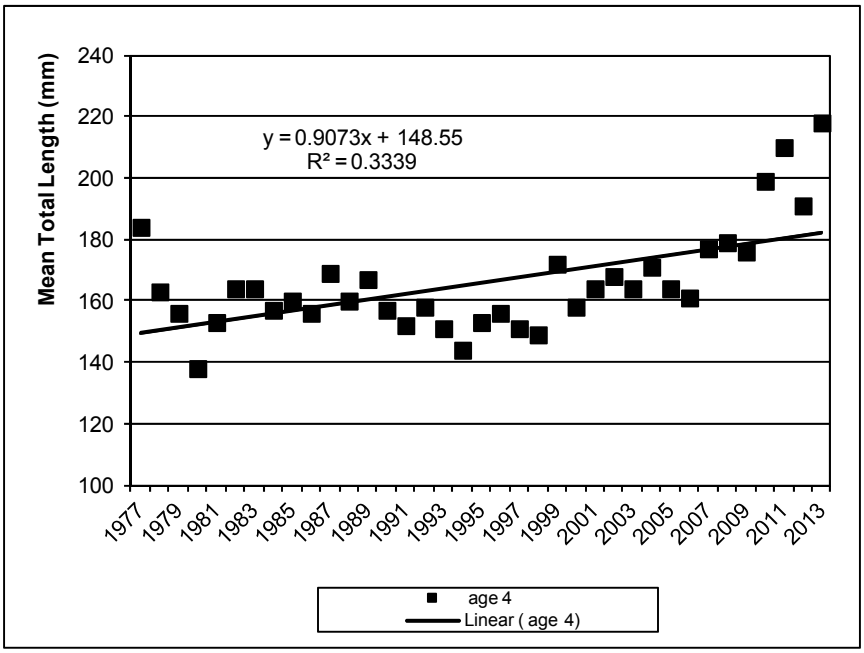

Figure 11. Mean total length at age 4 for Yellow Perch in the St. Lawrence River Thousand Islands area.

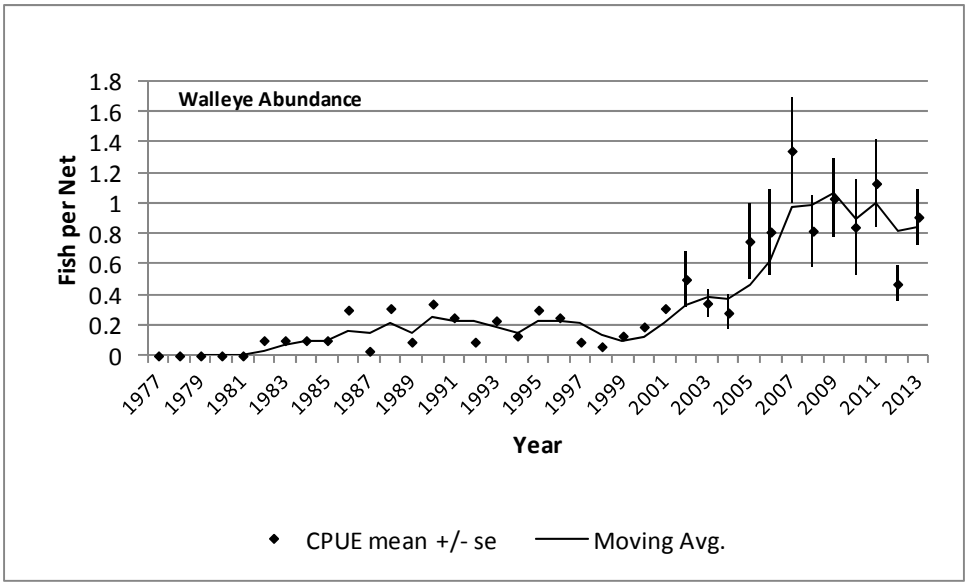

Figure 12 Walleye abundance index in the St. Lawrence River Thousand Islands area.

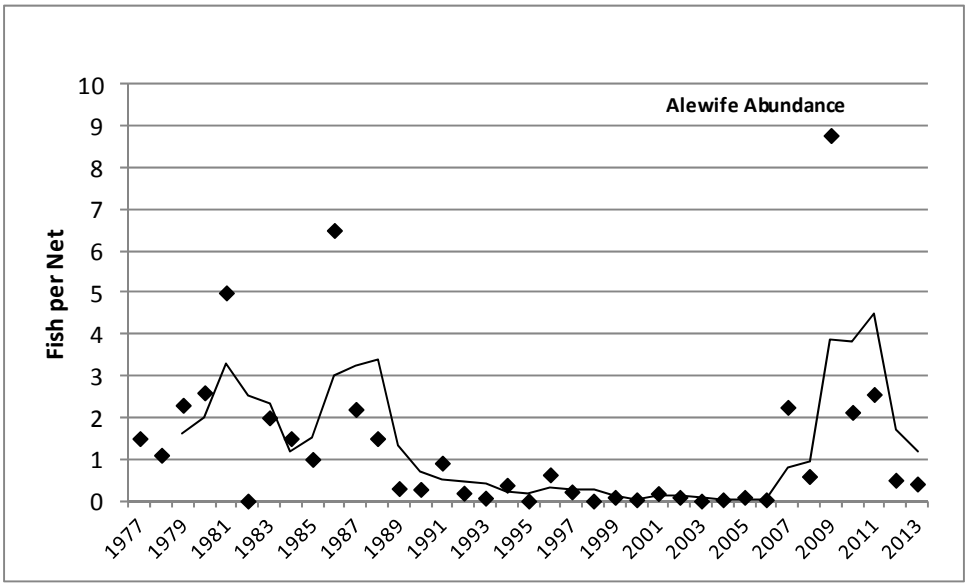

Figure 13. Abundance index for Alewife in the St. Lawrence River Thousand Islands area (with 3-year moving average).

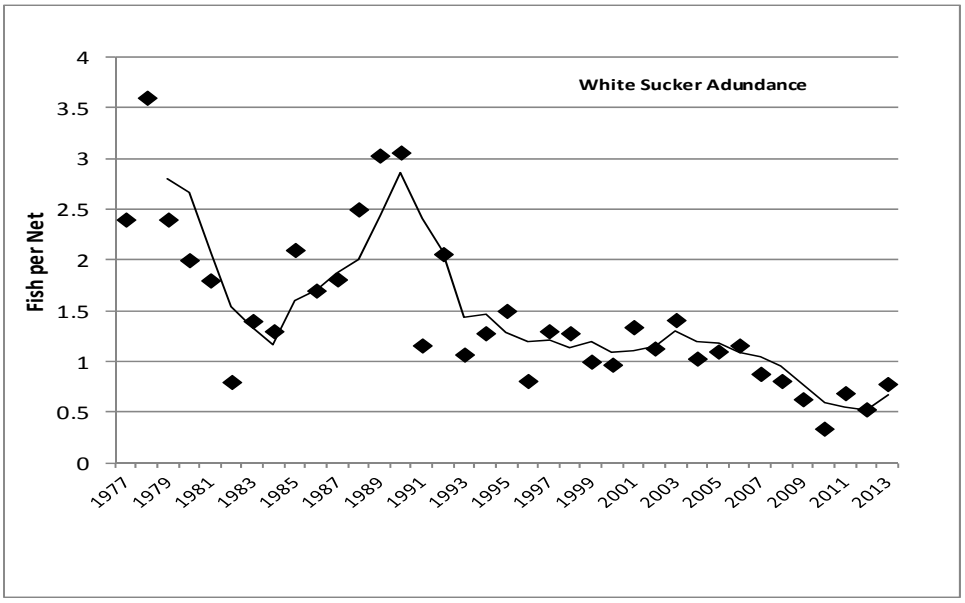

Figure 14. Abundance index for White Sucker in the St. Lawrence River Thousand Islands area (with 3-yr moving average).

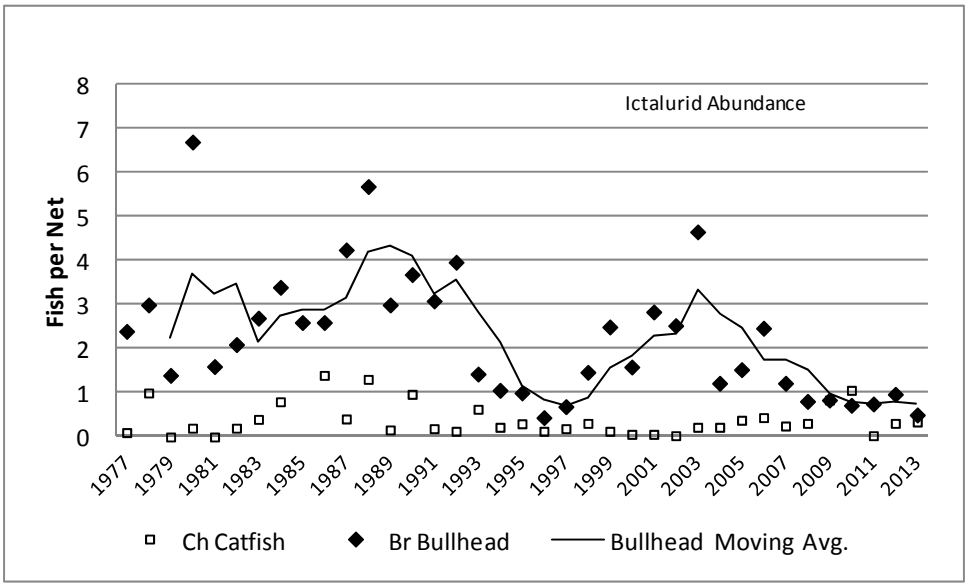

Figure 15. Abundance index for Brown Bullhead and channel catfish in the St. Lawrence River Thousand Islands area.

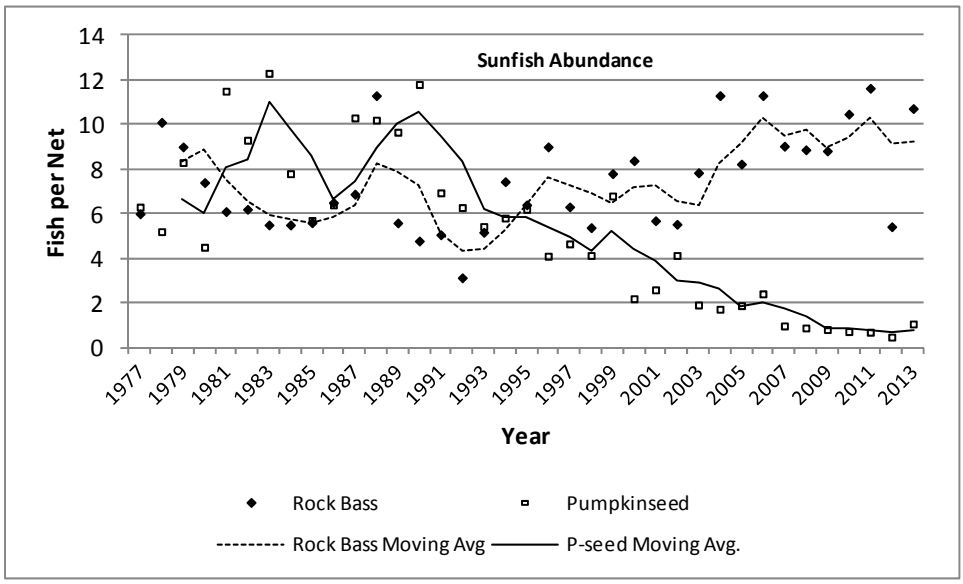

Figure 16. Abundance index for Rock Bass and Pumpkinseed sunfish in the St. Lawrence River Thousand Islands area (with 3-year moving average).

2013 Lake St. Lawrence Warmwater Fisheries Assessment

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A cooperative fisheries assessment program for Lake St. Lawrence was initiated between the New York State Department of Environmental Conservation (NYSDEC) and the Ontario Ministry of Natural Resources (OMNR) in 1986. This program originated as an extension of the Thousand Islands and Middle Corridor assessment programs and is intended to measure long term trends in relative abundance, growth, age structure and condition of the fish community. Since 1996 the Lake St. Lawrence program has been maintained by NYSDEC.

Methods

In 2005 gill nets were converted from multifilament to monofilament utilizing the same mesh dimensions, hanging ratios, and panel height/length of the previous net. Monofilament gill nets measuring 200 ft (61 m) long by 8 ft (2.4 m) deep having eight panels measuring 25 ft (7.6 m), with mesh arranged in increasing size from 1.5-6 in (38-152 mm) stretch measure were used for this assessment.

Gill nets were set overnight and fished an average of 18.6 hours (SD=0.79) at standard New York (n=16) and Ontario (n=16) sites described by Klindt and Town (2002). Net sites were stratified in equal number by depth as shallow and deep (12-25 ft. and 30-50 ft., respectively).

Data collected from fish included total length (TL), weight, sex, and stage of maturity. Scale samples were taken from percids and centrarchids for age analysis. Cleithra were removed from northern pike for more reliable age determination. Data were entered into the NYSDEC Statewide Fisheries Database.

Total, and species specific, catch per unit effort (CUE; catch per gill net night) were calculated. Other metrics calculated include length-frequency and age-frequency. Yellow perch and smallmouth bass growth rates were plotted by year class using logarithmically transformed mean length at age.

Results and Discussion

The 2013 Lake St. Lawrence assessment was conducted from 16 to 19 September. Surface water temperatures ranged from 64-65°F (17.8-18.3^{o}C). A sample of 732 fish comprising 21 species was collected (Table 1). The catch was dominated by yellow perch (34.4%), rock bass (17.5%) and smallmouth bass (13.6%).

While overall diversity of the fish community in Lake St. Lawrence remains relatively stable, the contribution of individual species appears to have changed over time. Figure 1 shows species that comprised at least 3% of the total catch over three decades. Over time the yellow perch contribution has increased, while other common species such as rock bass, smallmouth bass and walleye have remained relatively stable. Species less often encountered in the survey make up smaller proportions of the overall assemblage over time.

Total CUE decreased by 31.7% from 33.2 in 2012 to 22.93 in 2013, which is the fourth highest catch since 1985 (Figure 2). Total CUE is generally driven by fluctuations in the yellow perch population.

Yellow perch CUE decreased by 52% from 16.7 in 2012 to 7.94 in 2013 (Figure 3). Since 2008 the perch catch has shown large annual fluctuations. Few perch <6” were collected in this assessment, while a high proportion of fish >9” (28.0%) were present (Figure 4). From 2006 to present, perch >9” have comprised 19.8-33.9% of the catch. The age structure of perch shows that the majority of fish collected were ages 2-3 (Figure 5).

Localized impacts on yellow perch populations from predation by Double-crested cormorants (*Phalacrocorax auritus*) have been reported previously in Lake St. Lawrence (Klindt 2006, 2007, Klindt and Gordon 2008, 2009, 2010, 2011, 2012, 2013, Klindt and Town 2004). Regurgitated cormorant pellets were collected in

2013 from Bergin Island, located in the lowermost portion of the fisheries assessment area. Pellets had previously been collected from Strachan Island, approximately 2.2 miles to the east. A larger portion of the cormorant population now resides on the Bergin Island complex making collection of pellets at that location more efficient. Pellet analysis, described by Johnson et al. (2014), indicated that diet was comprised predominantly of round goby (64.4%) and yellow perch (17.2%; estimated 400,000 fish). Yellow perch had been the dominant forage until 2005, comprising from 50-60% of the diet (Johnson et al. 2005, 2006). Round goby have since become an important forage fish in the lower St. Lawrence River as demonstrated by cormorant consumption increase documented by Johnson et al. (2007, 2008, 2009, 2010, 2011, 2012, 2013).

The number of active nests at Strachan Island increased from 230 in 2012 to 270 in 2013 (I. Mazzocchi, NYSDEC, pers. communication). The Strachan-Bergin islands complex of nesting cormorants has been relatively stable at approximately 1,000 from 2009-2011, but dropped in 2012 to 885 total nests (Figure 6).

Gill net sites were stratified by distance from the nesting colony as described by Klindt and Lantry (2001). Yellow perch CUEs for "upriver" (>7.75 mi) and "colony" (within 7.75 mi) net strata were 8.3 and 7.5, respectively (Figure 6). The CUE differential between the upriver and colony strata for the last five years is similar to that expressed from 1986-1994, prior to the influence of cormorant predation. Catch differential between the upriver and colony strata in 2013 was minimal possibly do to higher predation on yellow perch by cormorants as shown in the most recent pellet analysis. Round goby consumption had risen sharply once they became well established in the area, with the highest percent composition recorded (75.4%) in 2009 (Johnson et al. 2010). Localized round goby declines may have attributed to the increase in yellow perch consumption in 2013.

Growth rates of yellow perch were determined by year class for fish ages 2-7 years. The slope of the regression line of log transformed mean length at age for each year class is illustrated in Figure 7. A minimum of four data points is needed to plot an individual year class to decrease variability. Although variability remains high within the series (r^2=0.48), an increasing growth rate trend remains apparent overall. Round goby have become a forage source for most piscivorous species in the river, and it is probable that increased growth rates seen since the expansion of gobies (circa 2000) are a result of perch exploiting gobies as a primary forage species.

Smallmouth bass CUE had been relatively stable from 1998-2004, but has gone through a period of substantial fluctuations from 2005 to the present. Smallmouth bass CUE was above the long term average of 2.27 in 2013 and marked the second highest catch on record (Figure 8). The majority of the 2013 catch were bass >16" in length (Figure 9). An uncharacteristically high number of age-2 fish (2011 year class) were collected potentially indicating a strong year class will recruit to the fishery. Previously reported bass in the 2009 year class did not recruit as well as expected to age-4 (Figure 10). Predicting year class strength of smallmouth bass has been difficult within this program as small fish are sporadically encountered.

Growth rates of smallmouth bass were determined by year class for fish ages 3-7 years. The slope of the regression line of log transformed mean length at age for each year class is presented in Figure 11. The relationship continues to be weak (r^2=0.27), however it shows an overall increase in growth rate. Data points for the 1998, 1999 and 2001-2004 year classes demonstrate a marked increase in growth rate, likely due to foraging on round goby. Mean length at age-6 is also illustrated in Figure 11 to demonstrate a similar trend of increasing growth. Since this method requires only a single year class of fish, it exhibits considerably less variability. When considering only year classes 2000-2007, it appears that growth rate may be stabilizing.

Walleye CUE (2.06) was almost identical to 2012 and represents a relatively high catch for this assessment (Figure 12). Length-frequency distribution of the walleye catch (Figure 13) was dominated by 11-13.9 inch fish. Catch was dominated by age 1&2 fish, which both appear to

be strong year classes at this point (Figure 14). All walleye to date have been aged using scales which may have led to some inconsistencies in reporting age of older fish. Future surveys will incorporate otoliths as aging structures since many researchers report improved accuracy (Beamish and McFarlaine 1987).

Northern pike CUE (0.28) in 2013 increased slightly from 2012, however, the overall trend in abundance remains extremely low (Figure 15). Total length of northern pike ranged from 23.3-34.0 inches (Figure 16). Fish ages 0-6 were represented in the catch (Figure 17). Age 0 fish were collected in record numbers (N=5), however, they were all collected at a single site. Northern pike CUE has been in a general state of decline since 2002. Netting strata were not designed to take advantage of limited littoral zone habitat in Lake St. Lawrence, therefore northern pike are poorly represented in this assessment.

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Table 1. Relative abundance (number of fish per net night) and long term average (LT Avg.) of primary species collected in the assessment of Lake St. Lawrence, 1983-2013.

	Year	1983	1985	1986	1987	1988	1989	1990	1991	1992
SPECIES	**# Nets**	48	47	32	47	32	46	32	47	32
Lake Sturgeon		0.02	0.02	x	x	x	x	x	x	x
Bowfin		x	x	x	x	0.03	x	x	x	x
Alewife		0.73	1.15	1.50	0.11	0.06	0.06	0.34	0.04	0.66
Gizzard Shad		x	x	x	0.26	0.09	0.33	0.13	0.21	x
Rainbow Trout		x	x	0.03	x	x	x	x	x	x
Brown Trout		x	x	0.09	0.02	x	x	x	x	x
Lake Trout		x	x	x	x	x	0.06	x	0.02	x
Rainbow Smelt		x	x	x	x	x	x	x	x	0.02
Northern Pike		0.23	0.62	0.94	0.04	0.63	0.85	0.69	0.66	0.53
Muskellunge		x	x	x	0.02	x	0.02	x	x	0.03
Lake Chub		x	x	x	0.02	x	x	x	x	x
Carp		1.46	0.23	1.94	1.06	0.66	0.72	1.06	0.87	1.13
Golden Shiner		x	x	x	x	x	x	x	0.02	x
Fallfish		0.17	0.21	0.25	0.32	0.19	0.15	0.19	0.09	0.09
White Sucker		1.54	1.45	0.91	1.04	1.41	1.43	1.47	0.89	1.06
Silver Redhorse		0.58	0.21	0.06	0.23	0.44	0.15	0.31	0.15	0.50
Shorthead Redhorse		x	x	x	x	x	x	x	x	x
Greater Redhorse		x	x	0.03	x	x	x	x	x	x
Yellow Bullhead		x	x	x	x	x	x	x	x	x
Brown Bullhead		1.25	2.15	0.63	0.79	0.97	1.61	2.06	2.55	2.28
Channel Catfish		0.04	0.09	x	x	0.09	0.02	0.03	x	0.03
White Perch		1.23	1.06	0.38	0.96	3.00	0.87	1.50	1.09	0.91
White Bass		0.06	0.13	x	0.02	x	0.04	0.03	0.11	x
Rock Bass		2.19	1.23	2.41	1.36	1.84	1.02	2.03	1.17	2.00
Pumpkinseed		0.33	0.21	0.13	0.26	0.28	0.74	0.19	0.21	0.34
Bluegill		x	x	x	x	x	x	x	x	x
Smallmouth Bass		3.77	2.15	2.03	2.36	2.28	2.65	1.97	1.68	2.94
Largemouth Bass		x	x	x	x	x	0.02	0.03	0.04	x
Black Crappie		0.08	0.09	x	0.02	0.16	0.13	0.09	0.04	0.22
Yellow Perch		7.60	11.3	9.63	8.61	6.94	4.41	4.34	5.83	4.72
Walleye		0.42	1.38	0.53	1.04	1.38	0.83	1.34	1.21	0.94
Freshwater Drum		0.02	0.02	x	x	x	0.06	x	x	0.03
TOTAL CATCH		21.7	25.9	21.5	18.9	20.4	16.2	17.8	16.9	18.5

Table 1. Relative abundance (number of fish per net night) and long term average (LT Avg.) of primary species collected in the assessment of Lake St. Lawrence, 1983-2013 (continued).

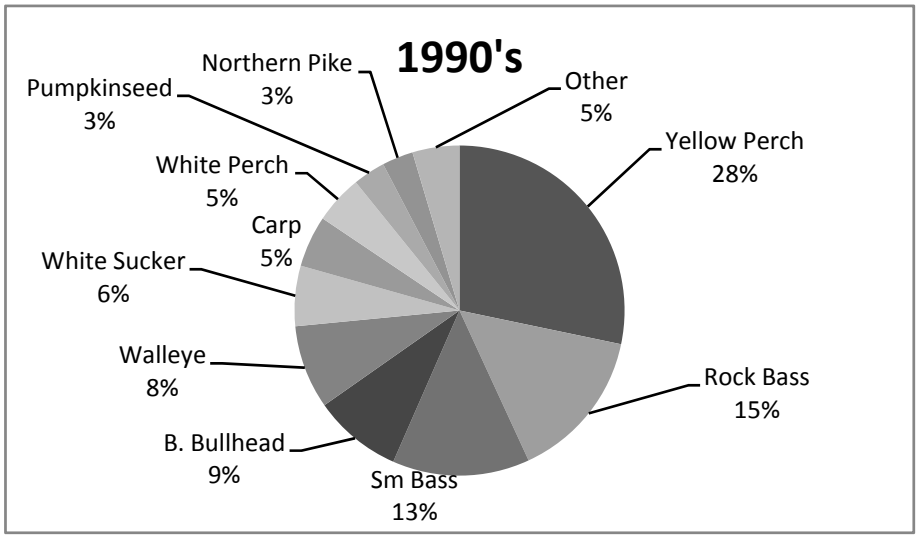
	Year	1993	1994	1995	1996	1997	1998	1999	2000	2001
SPECIES	**# Nets**	47	32	47	32	32	32	32	32	32
Lake Sturgeon		x	0.03	x	x	0.09	x	x	x	x
Bowfin		x	x	x	x	x	x	x	0.03	0.03
Alewife		0.02	0.28	0.43	x	x	x	x	0.03	x
Gizzard Shad		0.32	x	x	0.09	x	x	0.13	0.03	x
Rainbow Trout		x	x	x	x	x	x	x	x	x
Brown Trout		0.02	x	0.21	x	x	x	x	x	x
Lake Trout		0.02	x	x	x	x	x	x	x	x
Rainbow Smelt		x	x	x	x	x	x	x	x	x
Northern Pike		0.32	0.31	0.36	0.22	0.41	0.50	0.91	0.44	0.59
Muskellunge		x	x	x	x	x	x	x	x	x
Lake Chub		x	x	x	x	x	x	x	x	x
Carp		0.64	0.75	0.43	0.56	0.41	1.16	0.78	0.38	0.47
Golden Shiner		x	x	x	x	x	x	x	x	x
Fallfish		0.06	0.63	0.13	0.09	0.06	x	0.03	0.09	0.06
White Sucker		0.87	0.94	0.55	1.28	0.47	0.53	1.16	0.69	0.66
Silver Redhorse		0.17	0.28	0.13	0.53	0.53	0.94	1.19	1.06	0.94
Shorthead Redhorse		x	x	x	x	x	x	0.28	0.03	0.13
Greater Redhorse		x	0.03	x	x	x	x	x	0.03	x
Yellow Bullhead		x	x	x	x	x	x	0.03	x	x
Brown Bullhead		0.21	0.31	0.36	0.63	0.81	1.34	2.69	0.56	2.94
Channel Catfish		x	0.16	0.02	0.06	0.03	0.09	0.03	0.06	0.41
White Perch		0.70	1.19	0.06	0.69	0.31	0.50	0.44	0.28	0.03
White Bass		x	x	x	0.06	x	x	x	0.13	x
Rock Bass		1.34	1.69	1.21	2.75	2.40	3.44	3.09	3.38	2.72
Pumpkinseed		0.02	0.31	0.36	0.28	0.63	1.16	0.78	0.56	0.75
Bluegill		x	x	x	x	x	x	0.03	x	0.03
Smallmouth Bass		1.51	2.41	1.47	1.22	1.09	2.78	3.28	2.56	2.31
Largemouth Bass		0.02	x	x	x	x	x	x	0.03	x
Black Crappie		0.11	0.03	0.04	x	x	0.06	x	0.03	x
Yellow Perch		4.62	4.56	4.57	4.19	4.59	6.97	3.66	2.59	2.44
Walleye		1.64	0.75	0.94	1.72	1.38	1.34	2.09	1.69	1.06
Freshwater Drum		0.06	x	0.21	x	x	x	0.03	x	x
TOTAL CATCH		12.7	14.1	11.7	14.4	13.2	20.9	20.6	14.7	15.6

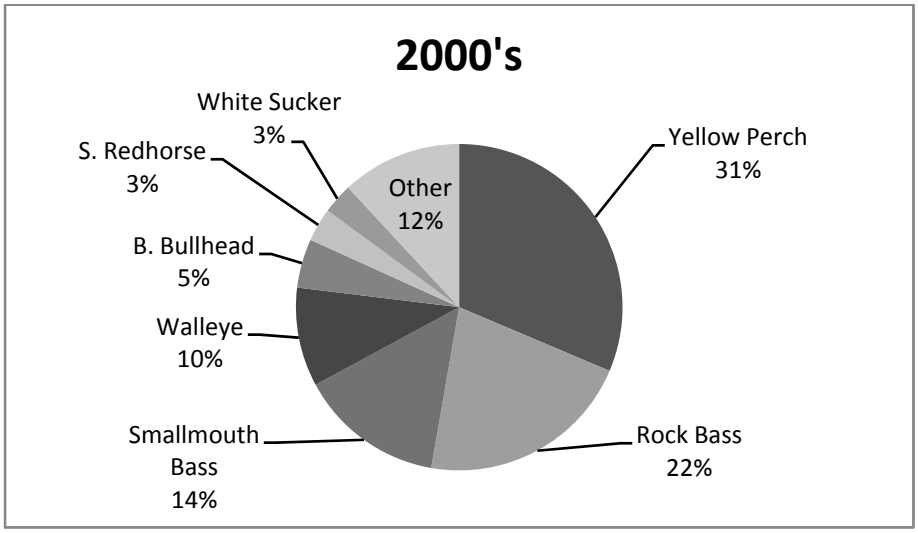
Table 1. Relative abundance (number of fish per net night) and long term average (LT Avg.) of primary species collected in the assessment of Lake St. Lawrence, 1983-2013 (continued).

	Year	2002	2003	2004	2005	2006	2007	2008	2009
SPECIES	**# Nets**	32	32	32	32	32	32	32	32
Lake Sturgeon		x	0.06	0.03	x	x	0.06	x	x
Bowfin		0.06	x	0.03	x	x	x	0.06	x
Alewife		0.06	x	x	x	x	x	x	x
Gizzard Shad		0.03	x	0.06	0.06	0.06	x	0.53	0.06
Rainbow Trout		x	x	x	x	x	x	x	x
Brown Trout		x	x	x	x	0.03	x	x	x
Lake Trout		x	x	x	x	x	x	x	x
Rainbow Smelt		x	x	x	x	x	x	x	x
Northern Pike		0.63	0.56	0.47	0.44	0.59	0.41	0.28	0.31
Muskellunge		x	x	x	x	x	x	x	x
Lake Chub		x	x	x	x	x	x	x	x
Carp		0.91	0.41	0.19	0.50	0.25	0.31	0.41	0.06
Golden Shiner		x	x	x	x	x	x	x	x
Fallfish		0.03	x	x	x	0.06	0.16	x	0.25
White Sucker		0.66	0.25	0.16	0.25	0.31	0.44	0.81	0.59
Silver Redhorse		0.88	0.28	0.53	0.53	0.25	0.25	0.28	0.31
Shorthead Redhorse		0.06	0.03	0.03	0.06	x	0.09	x	x
Greater Redhorse		x	x	x	x	x	x	0.03	0.03
Yellow Bullhead		x	x	x	x	x	x	x	x
Brown Bullhead		2.47	0.56	0.44	0.22	0.22	0.19	0.06	0.09
Channel Catfish		0.06	0.09	0.16	0.03	0.03	0.09	0.09	0.09
White Perch		0.09	x	0.19	x	1.75	x	0.25	1.22
White Bass		x	x	x	0.06	x	0.06	x	0.09
Rock Bass		2.59	2.63	2.5	3.38	2.50	4.03	6.38	4.19
Pumpkinseed		0.56	1.41	0.09	0.03	0.16	0.16	0.16	0.13
Bluegill		x	0.03	x	x	x	x	x	x
Smallmouth Bass		2.53	2.06	2.22	4.28	1.63	1.44	3.03	1.00
Largemouth Bass		0.06	x	0.03	0.28	0.13	x	0.13	0.03
Black Crappie		0.03	x	x	x	x	x	0.06	0.03
Yellow Perch		4.53	4.34	1.78	4.44	3.78	7.13	11.22	8.16
Walleye		1.75	1.28	0.72	1.44	1.91	1.09	1.94	3.03
Freshwater Drum		x	x	x	0.13	0.06	0.06	x	0.03
TOTAL CATCH		17.9	14.0	9.69	16.19	13.78	15.96	25.75	19.67

Table 1. Relative abundance (number of fish per net night) and long term average (LT Avg.) of primary species collected in the assessment of Lake St. Lawrence, 1983-2013 (continued).

	Year	2010	2011	2012	2013	LT Avg.
SPECIES	**# Nets**	32	32	32	32	
Lake Sturgeon		0.06	0.03	x	x	0.01
Bowfin		0.03	x	x	0.03	0.01
Alewife		x	0.03	0.09	x	0.19
Gizzard Shad		0.06	0.03	0.63	0.44	0.12
Rainbow Trout		x	x	x	x	0.00
Brown Trout		x	x	x	x	0.01
Lake Trout		x	x	x	x	0.00
Rainbow Smelt		x	x	x	x	0.00
Northern Pike		0.28	0.31	0.19	0.28	0.47
Muskellunge		x	0.03	x	x	0.00
Lake Chub		x	x	x	x	0.00
Carp		0.19	0.16	0.41	0.25	0.63
Golden Shiner		x	x	0.03	x	0.00
Fallfish		0.19	0.19	0.16	0.47	0.14
White Sucker		0.44	0.53	1.22	0.72	0.82
Silver Redhorse		0.19	0.63	0.44	0.38	0.44
Shorthead Redhorse		x	x	x	0.03	0.02
Greater Redhorse		0.06	0.03	x	0.03	0.01
Yellow Bullhead		x	x	x	x	0.00
Brown Bullhead		0.16	0.22	0.66	0.31	0.99
Channel Catfish		0.03	0.09	0.09	0.09	0.07
White Perch		0.41	1.03	1.75	2.16	0.80
White Bass		x	x	x	x	0.03
Rock Bass		8.03	3.41	5.16	3.97	2.87
Pumpkinseed		0.19	0.09	0.16	0.38	0.37
Bluegill		x	x	x	x	0.00
Smallmouth Bass		2.22	1.34	2.66	3.09	2.27
Largemouth Bass		0.22	0.22	0.69	0.09	0.07
Black Crappie		x	x	x	0.03	0.04
Yellow Perch		18.78	9.03	16.69	7.94	6.65
Walleye		2.75	1.81	2.09	2.06	1.45
Freshwater Drum		0.03	x	0.03	0.03	0.03
TOTAL CATCH		34.25	19.34	33.16	22.93	18.81





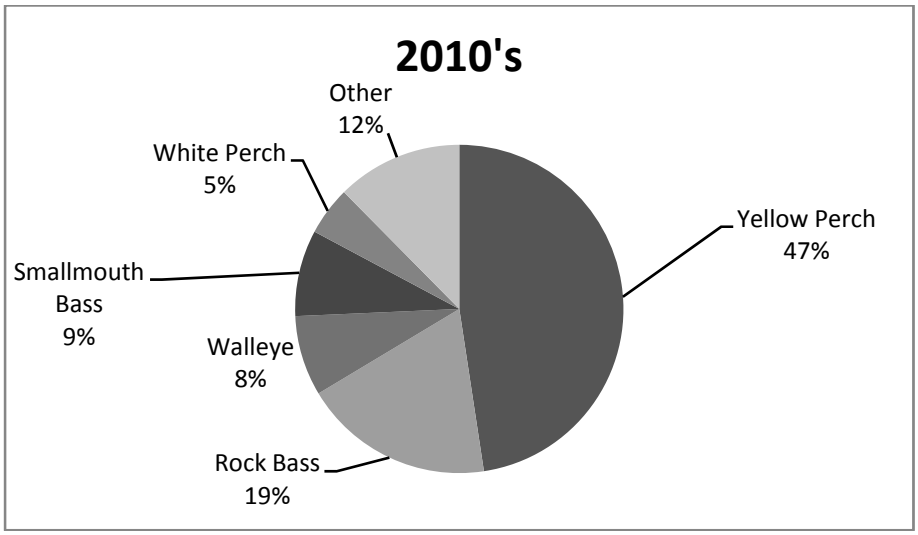


Figure 1. Composition of the Lake St. Lawrence fish community sampled by gill nets and presented by decade.

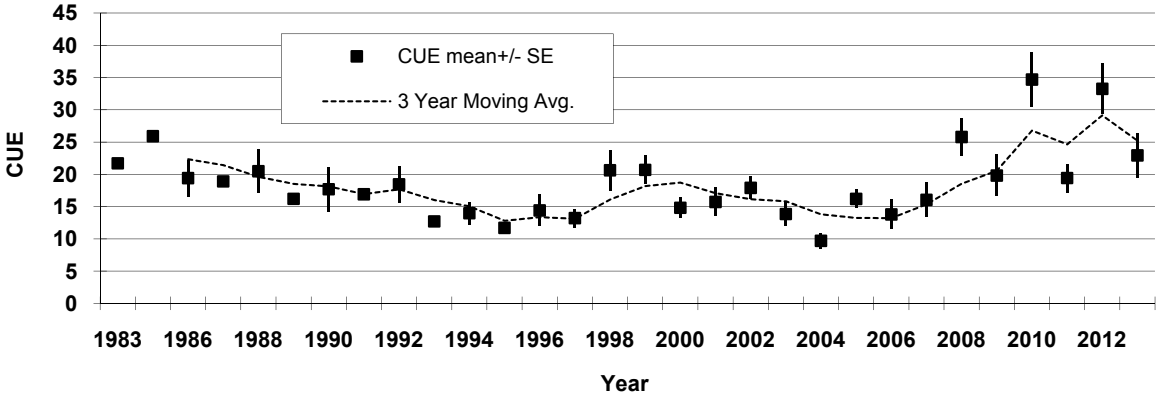


Figure 2. Total catch per gill net night (CUE) for Lake St. Lawrence, 1983-2013.

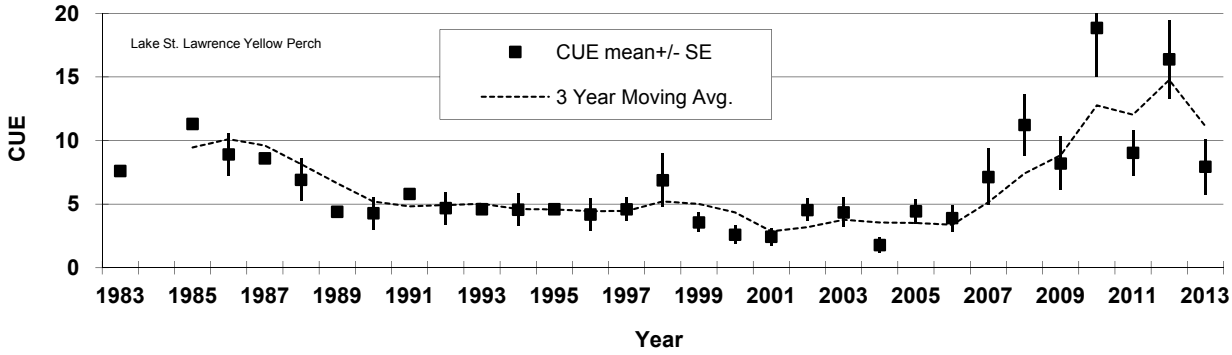


Figure 3. Yellow perch total catch per gill net night (CUE) for Lake St. Lawrence, 1983-2013.

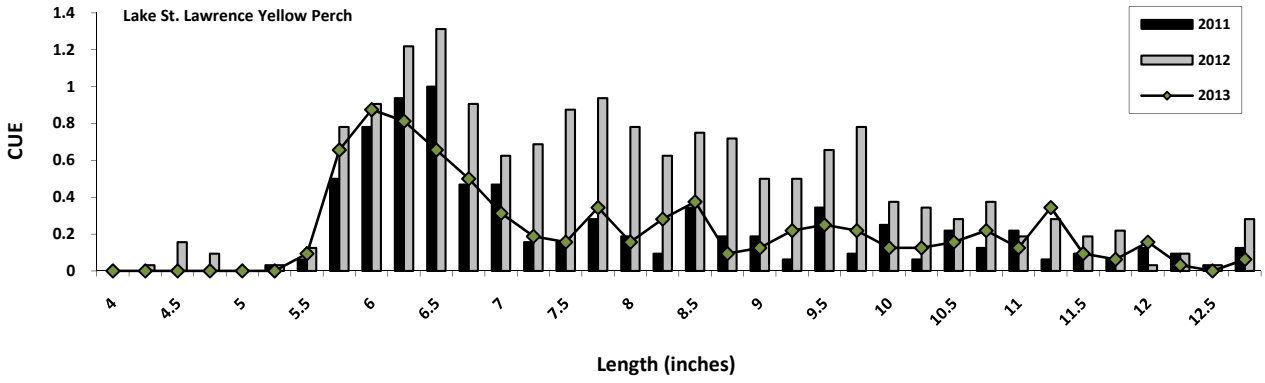


Figure 4. Yellow perch length-frequency distribution for Lake St. Lawrence.

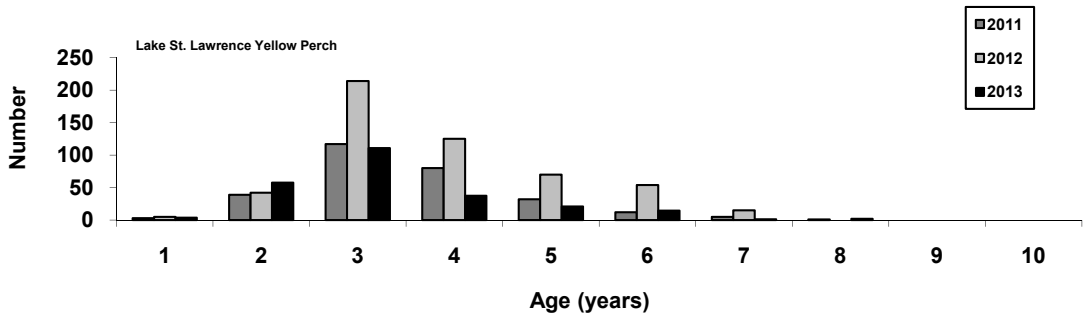


Figure 5. Yellow perch age-frequency distribution for Lake St. Lawrence.

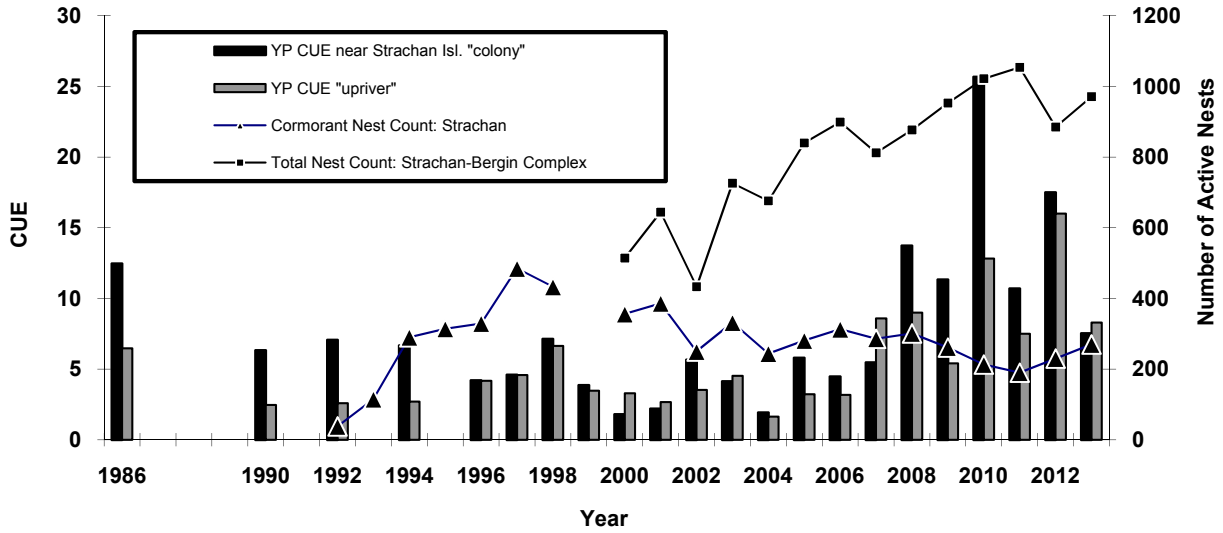


Figure 6. Yellow perch catch per gill net night (CUE) separated by distance from the Strachan Island cormorant colony. The "colony" designation incorporates net sites within 7.75 mi. of Strachan Island, "upriver" incorporates net sites greater than 7.75 mi. from the colony in a given year. A total of all nest counts in lower Lake St. Lawrence is illustrated by "Strachan – Bergin Complex".

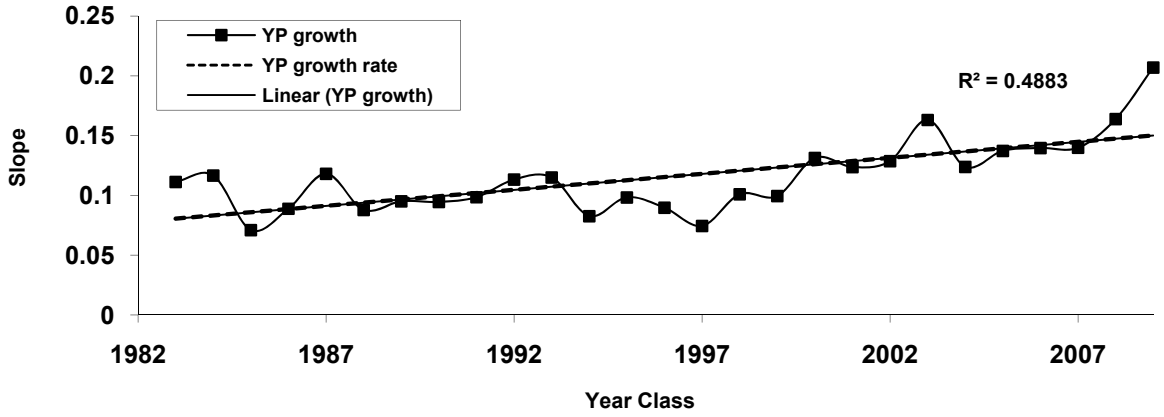


Figure 7. Yellow perch growth rates by year class using fish ages 2-7.

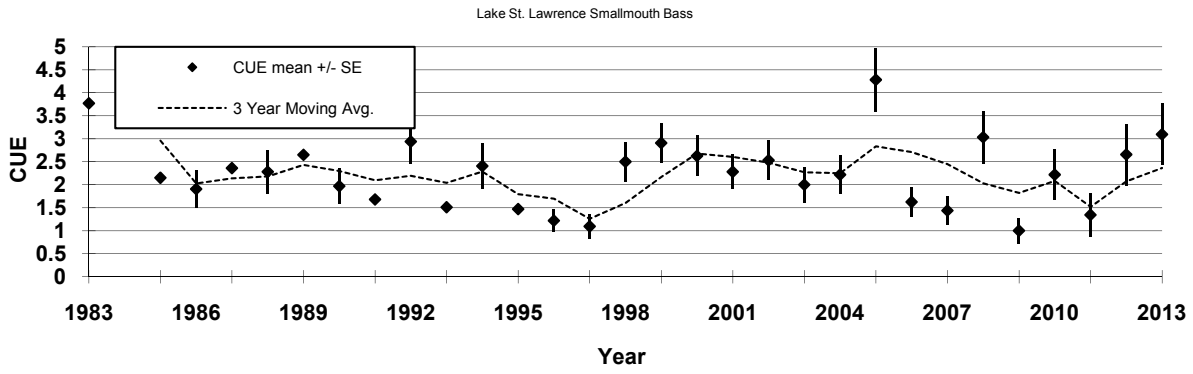


Figure 8. Total catch per gill net night (CUE) for smallmouth bass in Lake St. Lawrence, 1983-2013.

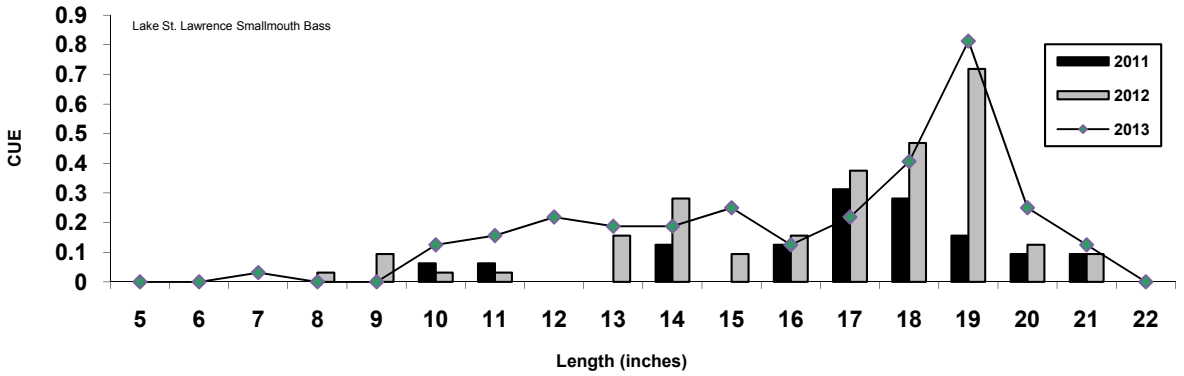


Figure 9. Smallmouth bass length-frequency distribution for Lake St. Lawrence.

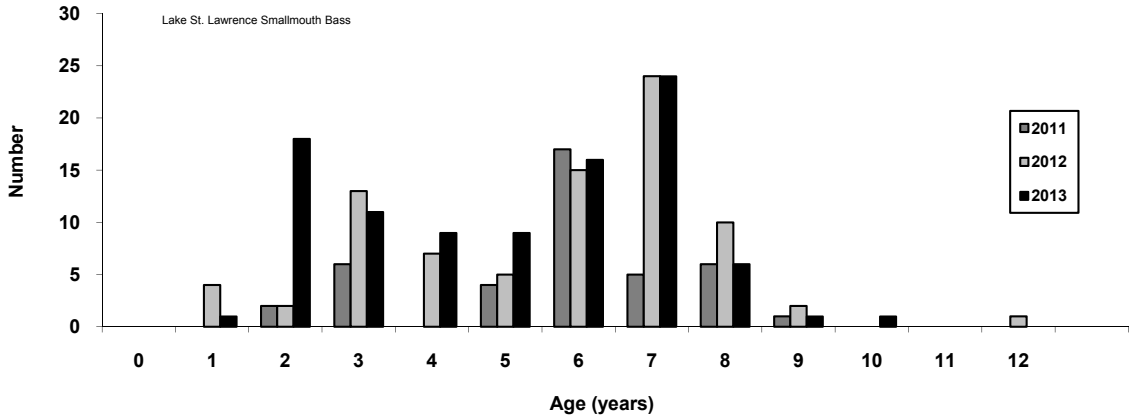


Figure 10. Smallmouth bass age-frequency distribution for Lake St. Lawrence.

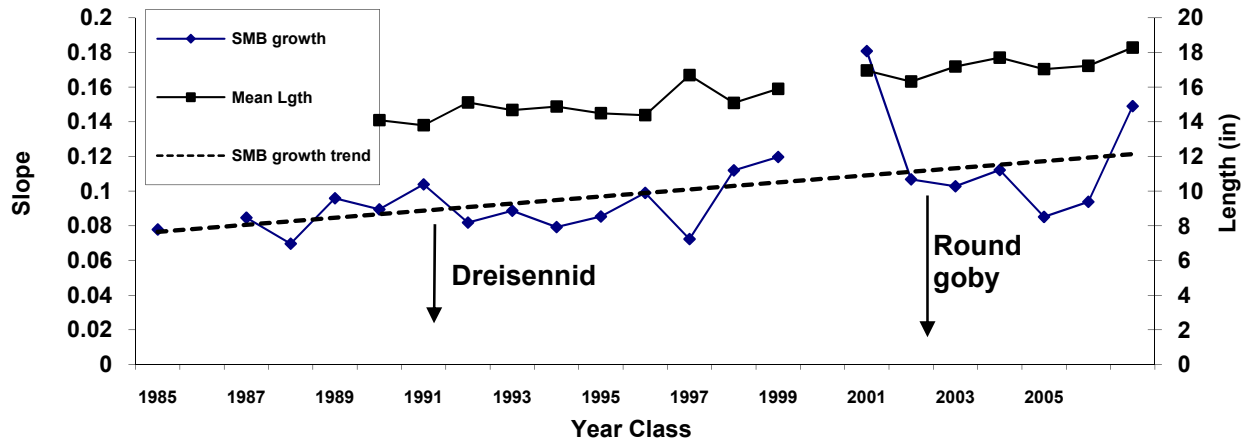


Figure 11. Smallmouth bass growth by year class described using two methods: growth rate (slope) using fish ages 3-7 and mean length (in) at age-6.

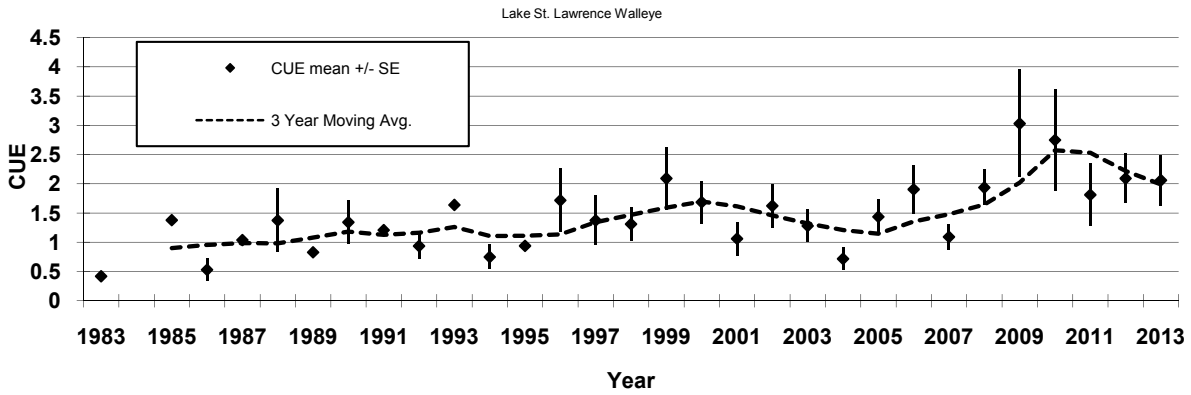


Figure 12. Total catch per gill net night (CUE) for walleye in Lake St. Lawrence, 1983-2013.

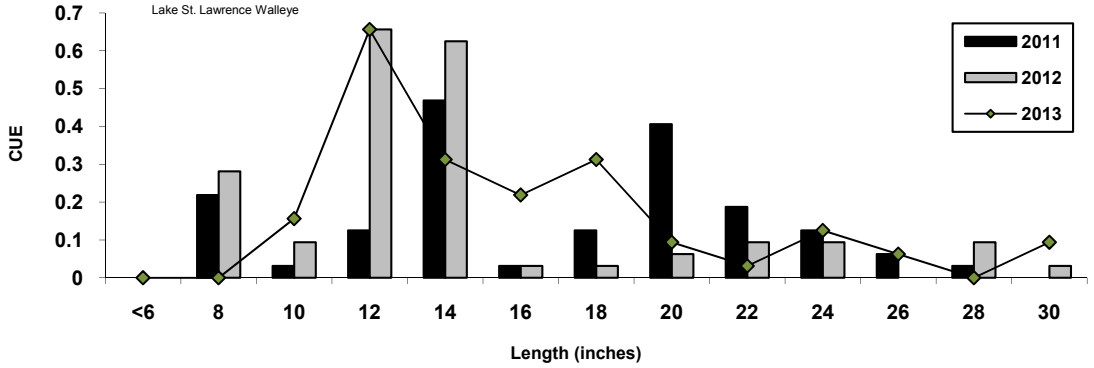


Figure 13. Walleye length-frequency distribution for Lake St. Lawrence.

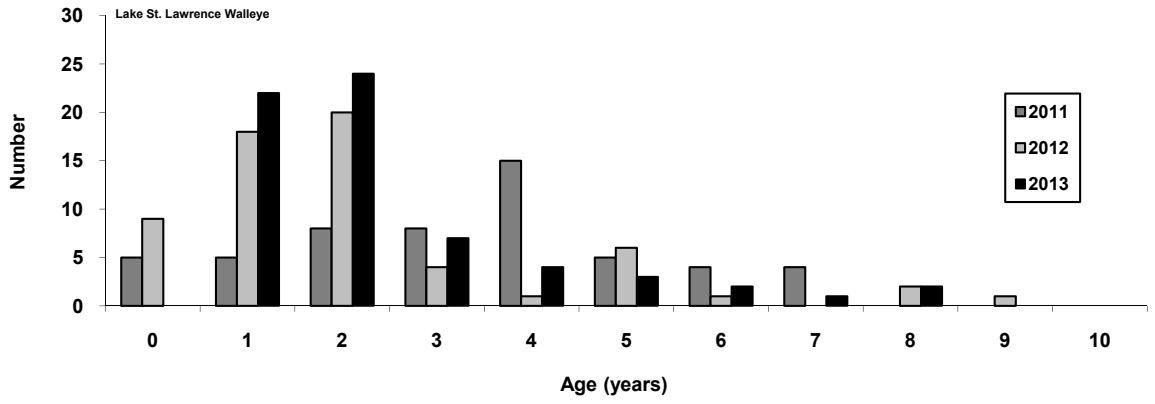


Figure 14. Walleye age-frequency distribution for Lake St. Lawrence.

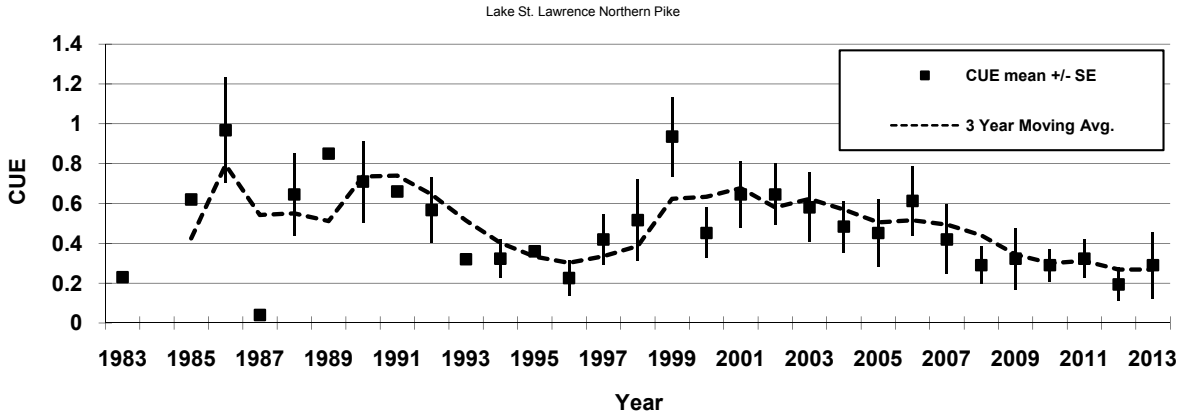


Figure 15. Total catch per gill net night (CUE) for northern pike in Lake St. Lawrence, 1983-2013.

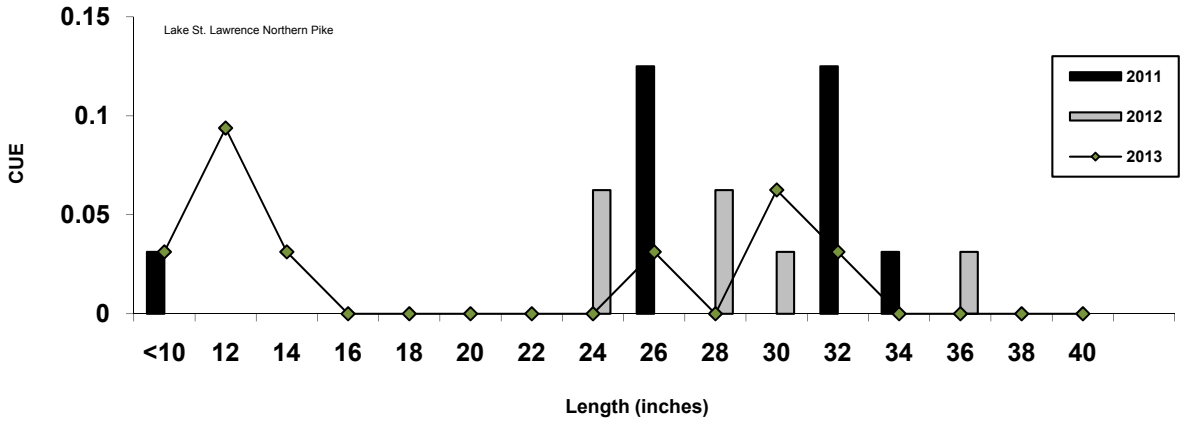


Figure 16. Northern pike length-frequency distribution for Lake St. Lawrence.

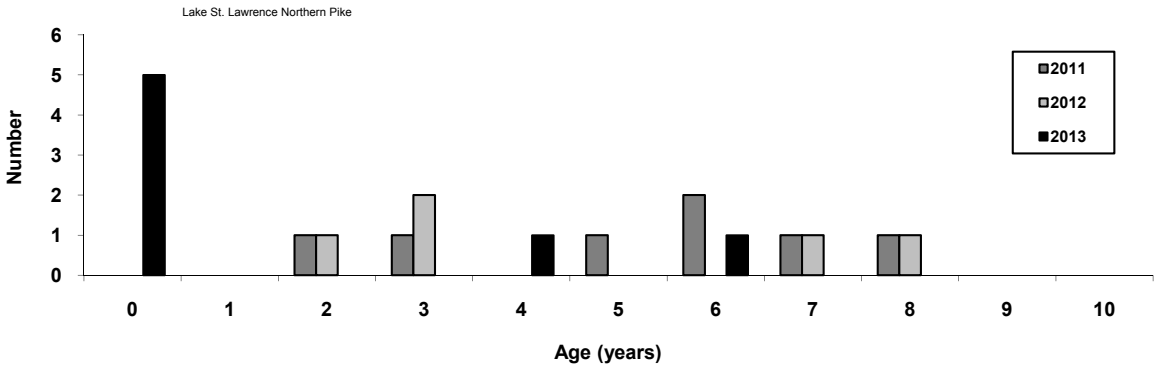


Figure 17. Northern pike age-frequency distribution for Lake St. Lawrence.

2013 Salmon River Wild Young-of-Year Chinook Salmon Seining Program

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A cooperative index seining program was initiated in the spring of 1999 by the U.S. Geological Survey (USGS) and the New York State Department of Environmental Conservation (NYSDEC) to assess spatial and temporal aspects of relative abundance, size structure, and distribution of wild young-of-year (YOY) Chinook salmon in the Salmon River, NY. The survey design was refined to its current form in 2001.

Methods

Weekly seine hauls were conducted at four sites (Altmar, Pineville, CO. RT. 2A, and Douglaston, Figure 1) from 8 May through 25 June. The bag seine was 20 feet wide by 6 feet deep with 1/8 inch bar mesh. Hauls were made by stretching the seine perpendicular to the current and sweeping toward one bank to a suitable landing area. A sample consisted of one seine haul per site. Obstacles on the river bottom and differences in the lengths of the hauls prevented the use of catches per unit of effort as precise density estimates but the range of numbers captured between sites and dates do provide a relative estimate of abundance. All species captured were counted and sub-samples of up to 30 Chinook salmon were measured (total length) for each haul.

We calculated "mean peak catches" for each year from 2001 to the present to provide an index of relative abundance. We used the average number of YOY Chinook caught per haul for the three consecutive weeks with the highest catches in each year. High flows prevented sampling the third week of May in 2011, which was likely the week of peak catch, so we used the average of the second and fourth weeks in May to generate a relatively high, but likely conservative, mean peak catch estimate Catches likely peaked in the fourth week of May 2013, and we were unable to sample the first week of June. We therefore used the mean from the second through fourth weeks of May to estimate mean peak catch. Historical mean peak catches are presented in Figure 2. Flow events referenced in this report are mean daily discharges to the Salmon River from the Lighthouse Hill Reservoir available at: (http://www.h2oline.com/365123.asp).

Results and Discussion

Similar to fall 2007, drought conditions and low reservoir levels/river flows persisted in fall 2012. Prescribed Salmon River baseflow for October is 335 cfs (FERC 1996) but was not achieved during most if not all of the key spawning periods in both 2007 and 2012 (Figure 3). We attributed low mean peak catches of YOY Chinook in spring 2008 to low flows in October 2007, which likely prevented spawning fish from reaching the prime spawning habitat/refuge area above Altmar. Low flows also prevented adequate numbers of fish from reaching the Salmon River Hatchery at Altmar, resulting in sub-target egg collections in 2007. Higher reservoir releases in October 2012 likely contributed to the improved access to prime spawning habitat, resultant wild YOY production, and reaching hatchery egg collection targets.

Catches in 2013 were lower than average through the first 3 weeks of May and above average the last week of May (Figure 4). A high flow event prevented sampling the first week of June and catches the last 3 weeks of June were lower than average. The single highest catch was 1,282 at Altmar during the last week of May (Figure 5).

The mean peak catch in 2013 (249 YOY per haul) is slightly below the survey average (282 YOY per haul, 2001-2012).

Prior to the record high catches in 2012, mean peak catches were highly correlated with flows from the prior fall ($r = 0.80$, $p < 0.01$). We interpreted this as high flows better allowing fish to access the spawning/refuge area above Altmar. Fall flows, however, were not nearly high enough in 2011 to explain the large catches in the spring of 2012. We also observed that there was not one flow event high enough to presumably disturb redds through the entire incubation to hatching period. As a result, we investigated maximum flows from October through May as a predictor of catches and found that these explained 62% of the variability (Figure 6). This suggests that the main factors contributing to relatively high YOY Chinook catches are adequate fall flows improving spawning conditions, followed by a lack of high flow events that likely damage redds during the incubation period. More research is needed to understand how other factors influence wild production of Chinook salmon including spawner abundance, harvest escapement, water temperature and habitat (Everitt 2006).

We are rapidly gaining an understanding of the role of naturally reproduced fish in the Lake Ontario and Salmon River systems. Results of the mass marking study have shown that wild fish comprise a substantial portion of the angler harvest in the Lake and Salmon River systems (Connerton et al, 2014, section 3 of this report). For example in 2013, 33% of age-2 and 70% of age-3 Chinook salmon in the Lake Ontario harvest were wild. In the Salmon River, 59% of age-2 and 82% of age-3 Chinook salmon harvested by anglers were wild. The proportions of wild age-2 and -3 Chinook salmon in other New York tributaries was low (7-20%) suggesting that the Salmon River is the largest single source of wild Chinook production in New York. More research is needed to understand the cumulative contribution of all tributaries including in the Province of Ontario where little information exists; however mass marking results to date demonstrate that wild Chinook salmon produced in the Salmon River are surviving and are an important component of the Lake Ontario sportfishery.

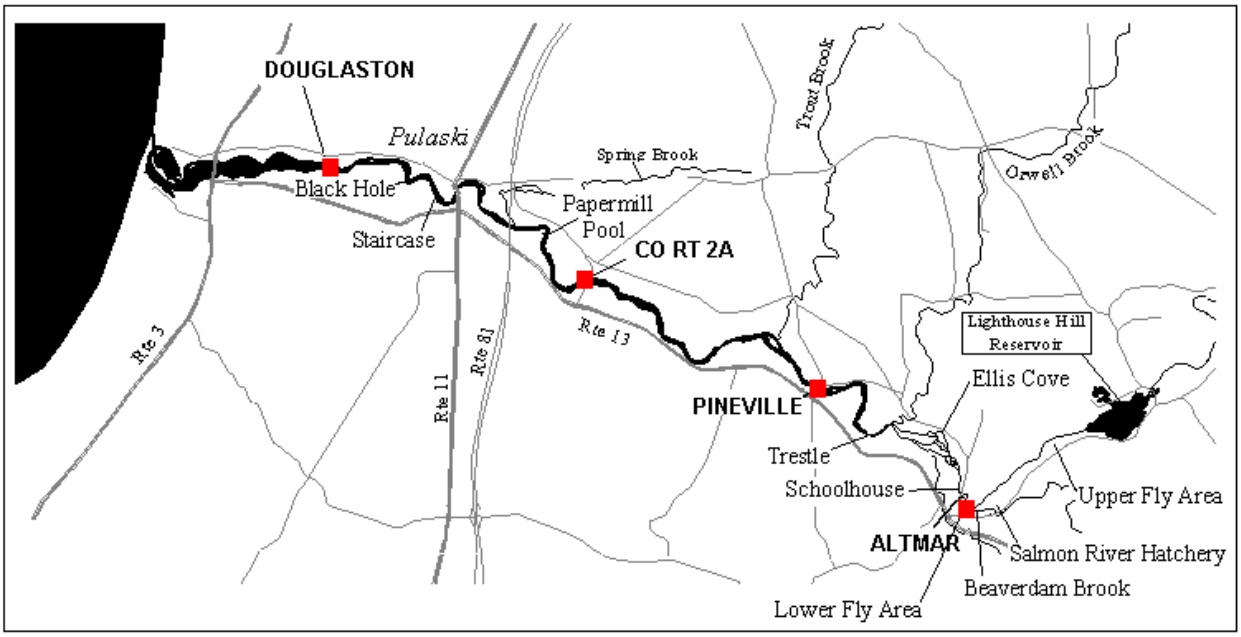

Figure 1. Sampling sites for the USGS/DEC Salmon River seining program.

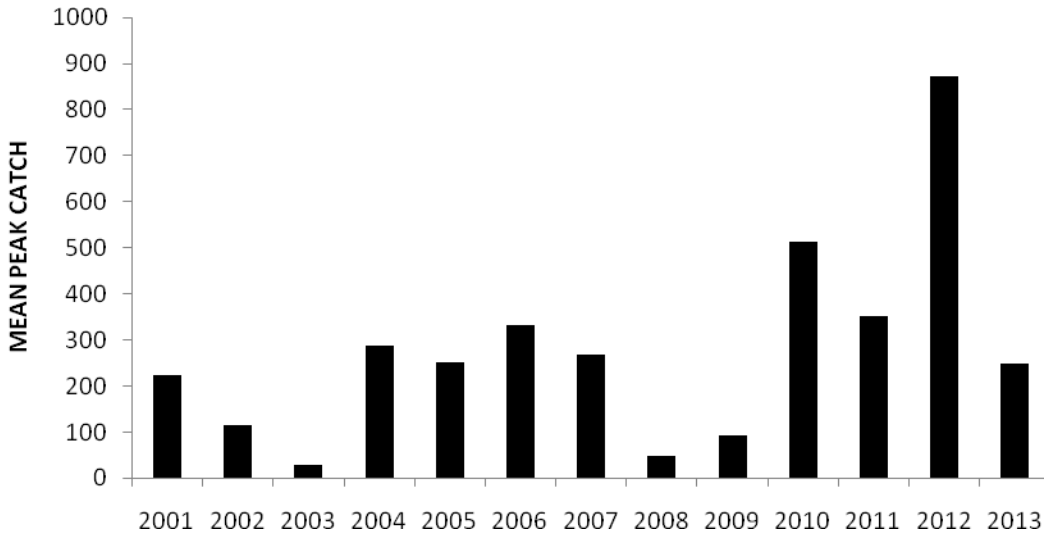

Figure 2. Mean peak catches of YOY Chinook salmon (mean number per seine haul) captured in the three consecutive weeks with the highest catches from the USGS/DEC Salmon River seining program 2001-2013.

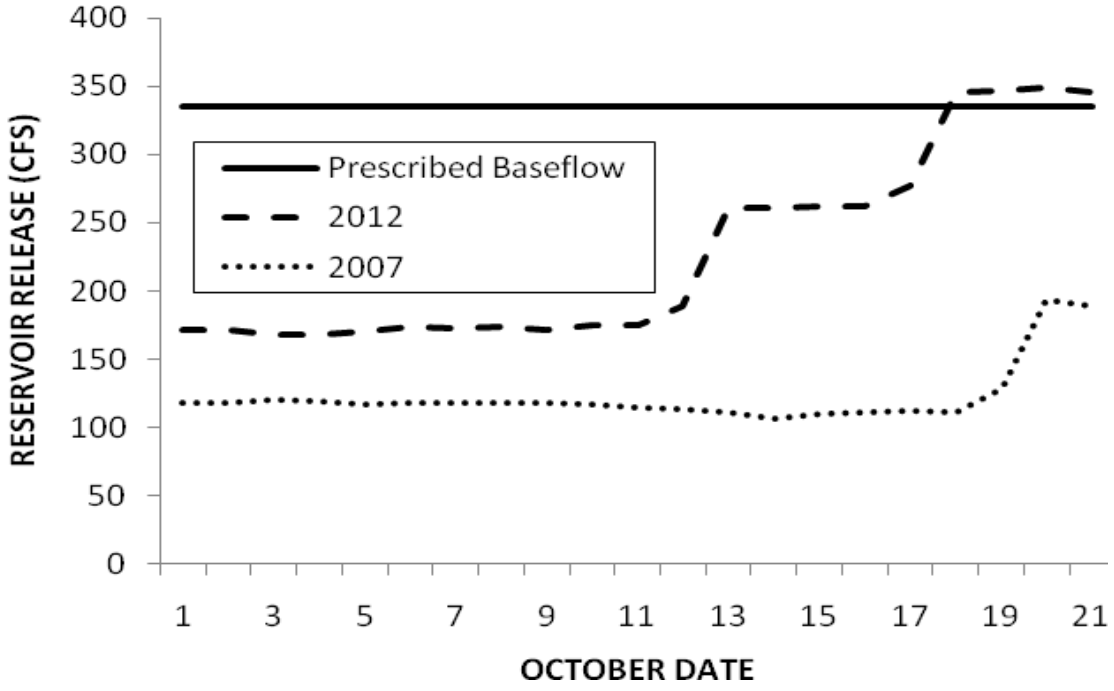

Figure 3. October releases from the Lighthouse Hill Reservoir to the lower Salmon River, 2007 and 2012.

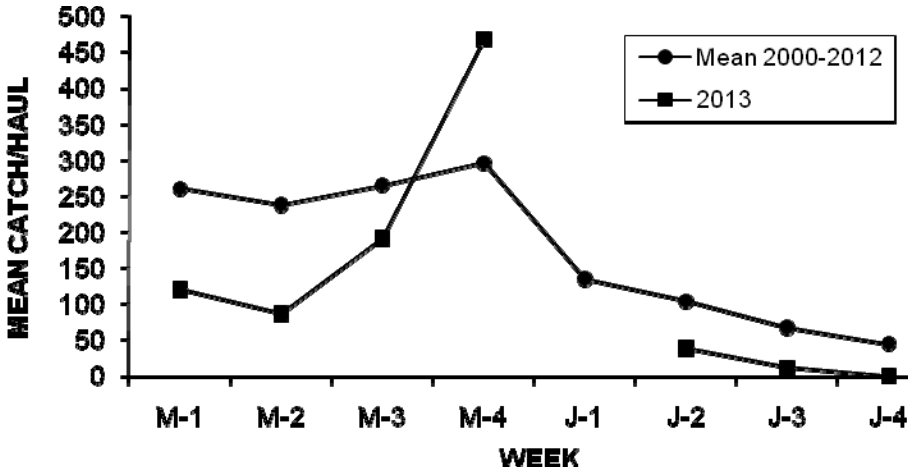

Figure 4. Mean numbers of YOY Chinook salmon captured per seine haul by week in the USGS/DEC Salmon River seining program for 2000-2012 and 2013 (M=May, J=June).

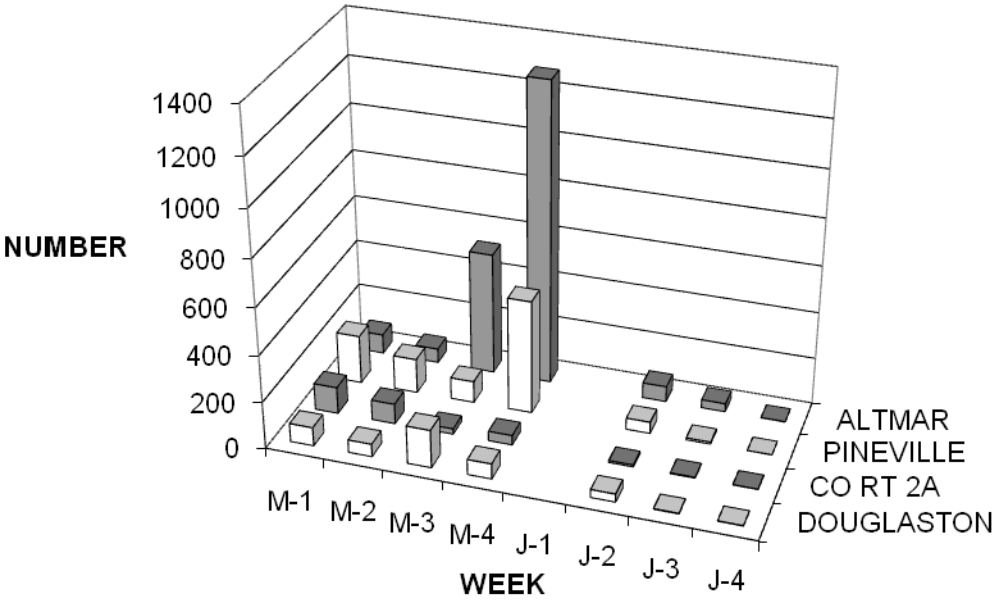

Figure 5. Numbers of YOY Chinook caught by week and site from the USGS/NYSDEC seining program 2013.

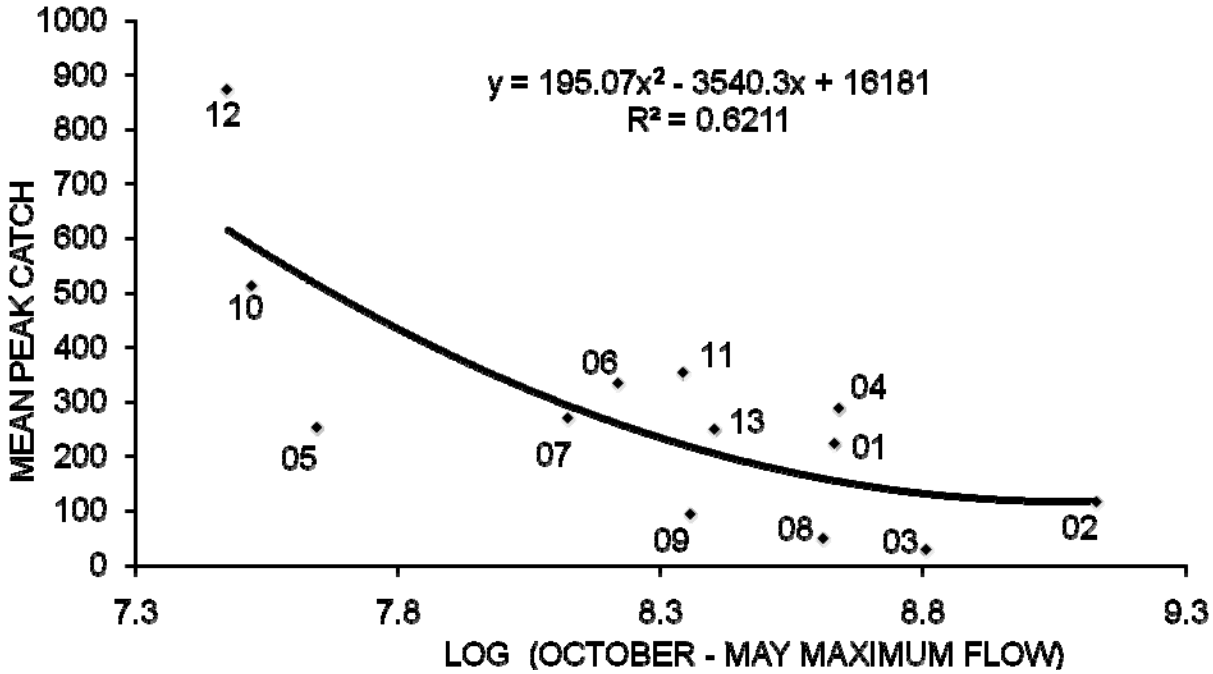

Figure 6. Maximum flow events, October through May, predicting mean peak catches of YOY Chinook salmon from the USGS/NYSCEC seining program 2001-2013 (r^2 = 0.62, p = 0.01).

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Population Characteristics of Pacific Salmonines Collected at the Salmon River Hatchery 2013

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Spawning populations of Lake Ontario Chinook and coho salmon (fall) and steelhead rainbow trout (spring) have been monitored annually since the mid-1980s at the NYS Department of Environmental Conservation's Salmon River Hatchery in Altmar, NY. This report documents the biological characteristics of these populations.

Methods

Staff at the Salmon River Hatchery processed 1,884 steelhead during spring 2013 spawning operations (Nelson 2013). Washington strain (Chamber's Creek) winter run fish comprised 89% (1,682) of the returns. Marked Skamania strain summer run fish (left pelvic) accounted for the remaining 11% (202).

A total of 2.2 million Washington strain steelhead eggs were taken from 795 females. The Skamania egg total was 72,500 from 32 females. Biological data were collected from 202 Washington strain steelhead.

Returns of Pacific salmon in fall 2013 included 4,422 Chinook salmon (1,236 females) and 5,055 coho salmon. Biological data were collected from 585 Chinook salmon and 81 coho salmon. Egg totals were 4.12 million Chinook salmon from 890 females and 1.68 million coho salmon from 697 females (Nelson 2013a).

All statistical analyses were done with PC-SAS rel. 9.3 (SAS Institute 2012). ANOVAs of all weight at age comparisons over a series of years were done with the SAS PROC GLM-Tukey's Studentized Range test multiple comparison procedure with the type I experiment-wise error rate set at $\alpha = 0.05$.

Results and Discussion

Chinook Salmon

Growth

The mean weight of age-1 Chinook males (jacks) sampled in 2013 was very near the long term average (5.2 pounds; Table 1, Figure 1). Age 2 males were 1.1 pounds above average (14.6 lbs) with only one year being significantly heavier (2000 – 16.8 lbs.). Age 2 females were also 1.1 pounds above average (16.0 lbs), with no other years being significantly heavier (Figure 2). Age-3 males were 0.4 lbs below average (18.8 lbs), but 3.4 pounds heavier than 2012. Age-3 females were very near the long term average (19.5 lbs) with only 1987, 1999, and 2000 being significantly heavier in the time series. Mean lengths and weights at age for all species sampled in 2013 are provided in Table 1.

Wet weight condition of large Chinook was measured by predicting the weight of a 36 inch fish from linear regressions on natural log transformed lengths and weights. The predicted weight was 16.5 pounds in 2013, which is also the historical average. This is the sixth consecutive year of at or above average condition, following six consecutive years of below average condition (Figure 3).

A likely explanation for the noticeable increase in Chinook sizes over 2012, particularly age-3 males, is the low water levels experienced during the 2012 salmon run. The water level was sufficient to draw fish into the river, but also allowed for effective "sight fishing," likely resulting in selective harvest of larger fish. Disproportionate harvest of larger individuals may have biased the age/size distribution of fish reaching the hatchery in 2012.

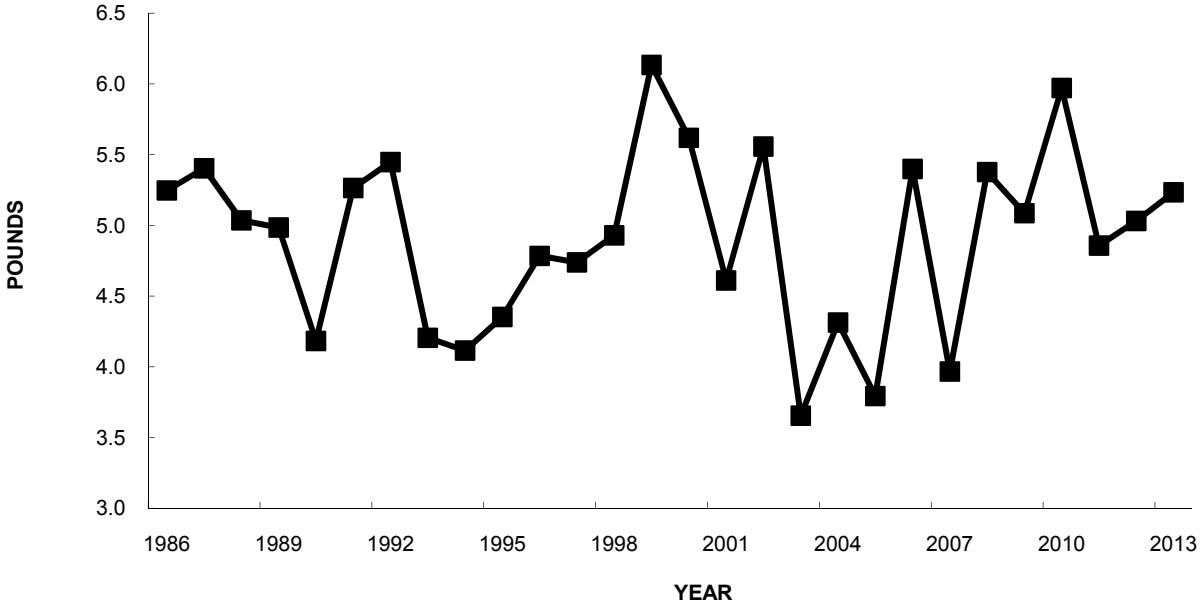

Figure 1. Mean weights of Chinook jacks at Salmon River Hatchery, 1986-2013.

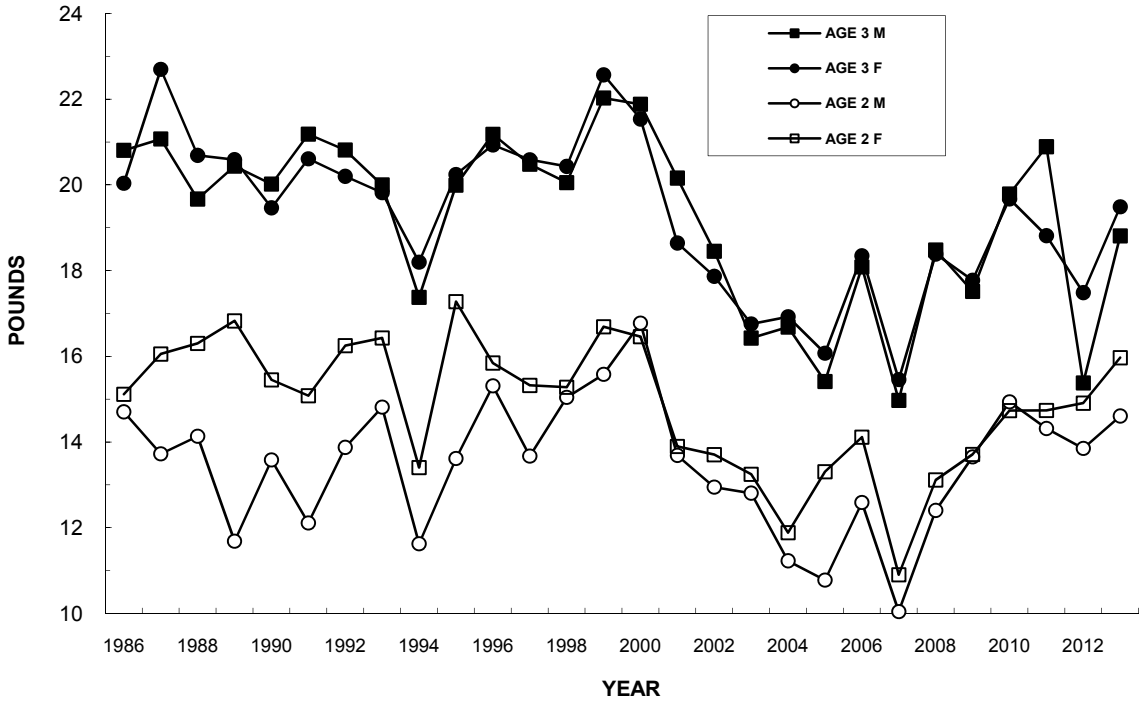

Figure 2. Mean weights of Chinook salmon ages 2-3 at Salmon River Hatchery, 1986-2013.

Table 1. Mean lengths and weights of Chinook salmon, coho salmon and Washington steelhead sampled at Salmon River Hatchery 2013 (STD= standard deviation).

AGE	SEX	N	MEAN LENGTH (in)	STD	MEAN WEIGHT (lbs)	STD
			CHINOOK SALMON			
1	M	64	24.1	1.5	5.2	1.2
2	M	174	34.5	2.2	14.6	2.9
2	F	47	34.6	2.1	16.0	2.8
3	M	107	38.0	2.4	18.8	3.6
3	F	184	37.7	1.8	19.5	3.0
			COHO SALMON			
1	M	7	15.1	2.3	1.5	0.6
2	M	40	27.3	2.5	6.9	2.1
2	F	34	27.3	1.7	7.4	1.4
			WASHINGTON STEELHEAD			
3	M	63	25.9	3.1	5.9	2.1
3	F	90	26.3	2.6	6.7	2.0
4	M	12	29.2	2.7	8.6	2.5
4	F	32	27.7	1.8	7.7	1.4
5	M	1	31.1	---	10.2	---
5	F	2	30.3	1.5	8.7	1.1

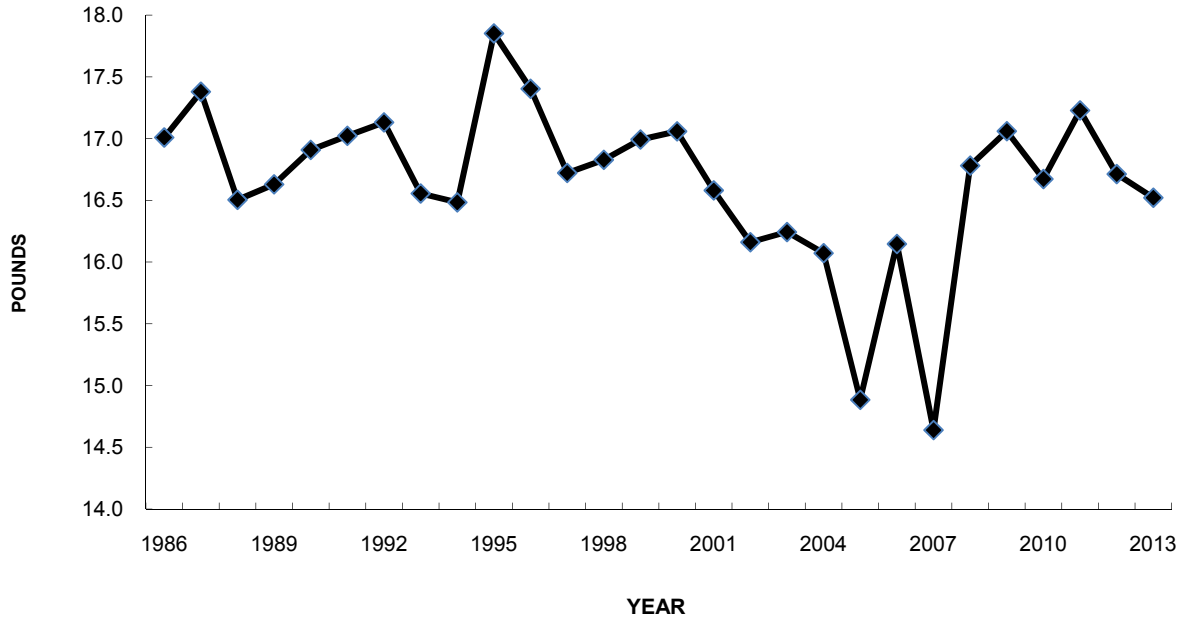

Figure 3. Estimated weights of a 36-inch Chinook salmon from the Salmon River Hatchery fall (October) collections 1986-2013.

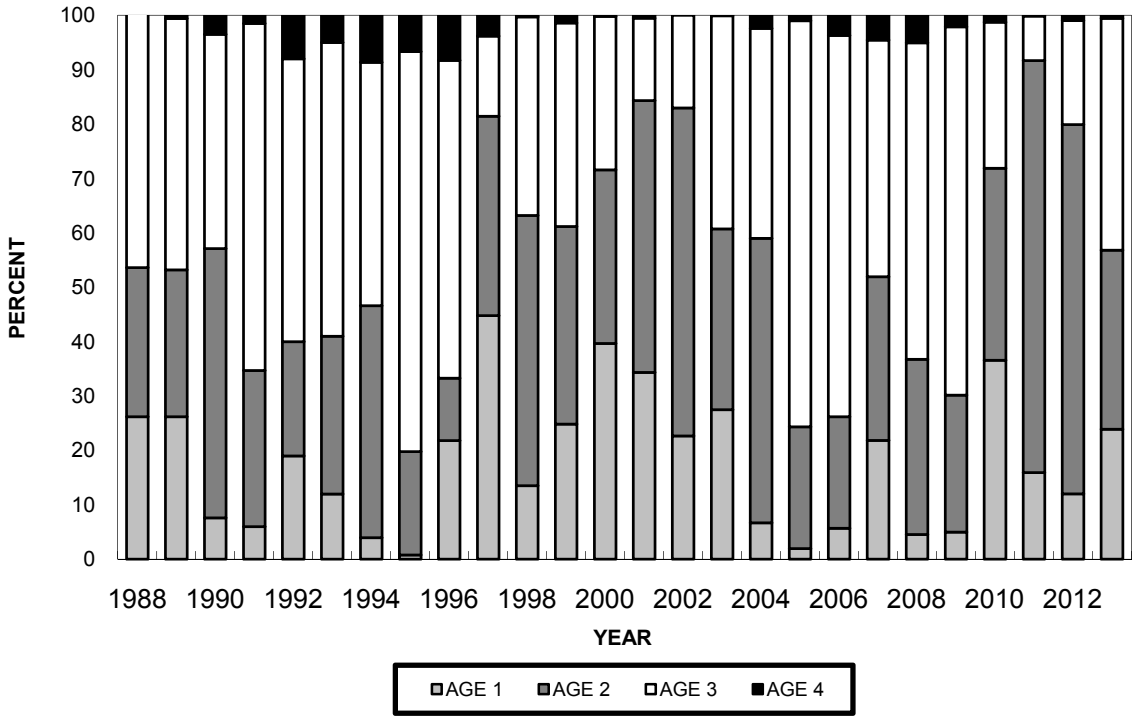

Figure 4. Estimated age structures of Chinook salmon runs at Salmon River Hatchery 1989-2013.

Age Structure

The estimated age structure of the 2013 Chinook salmon run to the Salmon River Hatchery was 24% age-1 males, 33% age-2, 43% age-3, and <1% age-4 (Figure 4). This represents a return to the normal pattern of age-3 fish being most abundant in the run. The high percentage of age-2 fish in the 2012 run may have been due to the previously noted low water levels in fall 2012, which may have encouraged "sight fishing" and selective harvest of larger, age-3 fish before they reached the hatchery. Low flow conditions in 2013 were not an issue.

Coho Salmon

Growth

The average weight of age-2 female coho salmon in 2013 (7.4 pounds) was approximately 1.1 pounds less than the long term average (8.5 pounds, Figure 5). Age-2 males (6.9 pounds) weighed 1.4 pounds less than the long term average (8.3 lbs., Figure 5). While males were smaller than average, they were not significantly different from those sampled in 15 of the 29 years in the time series, including 2012. Similarly, females were not significantly different from fish sampled in 16 of 29 years, including 2012.

Washington Steelhead

Growth

Steelhead are sampled in the spring and, unlike Chinook and coho salmon, do not reflect growth during the 2013 growing season. Weights reported here reflect conditions prior to and including 2012. Mean weights of age-3 males (5.9 lbs) and females (6.7 lbs) were 1.2 and 0.5 lbs heavier than 2012, respectively (approximately <0.1 and 0.4 pound more than their respective long-term averages; Figure 6). Mean weights of age-4 males (8.6 lbs) and females (7.7 lbs) were 0.2 lbs and 1.5 lbs lighter than their long-term averages, respectively. Only age-3 females in 2001(8.7 lbs.) were significantly heavier than those in 2013. Age-3 males in 2013 were near the middle of the weight series, weighing significantly more than those in eight years, but significantly less than

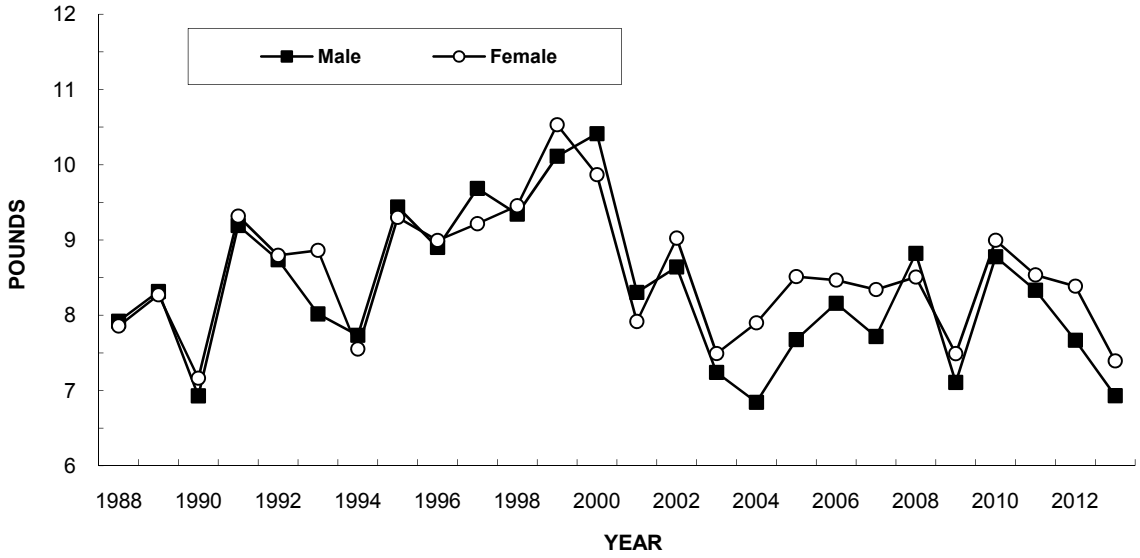

Figure 5. Mean weights of age-2 coho salmon at Salmon River Hatchery, 1988-2013.

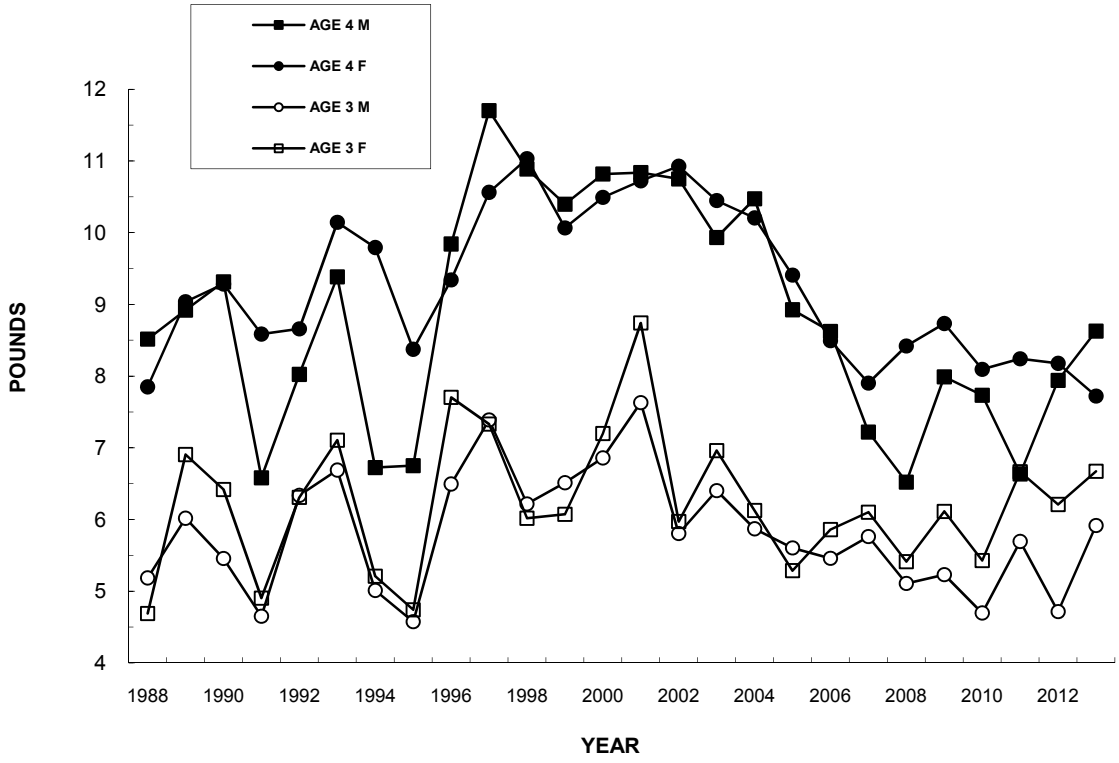

Figure 6. Mean weights of Washington steelhead ages 3-4 at Salmon River Hatchery, 1988-2013.

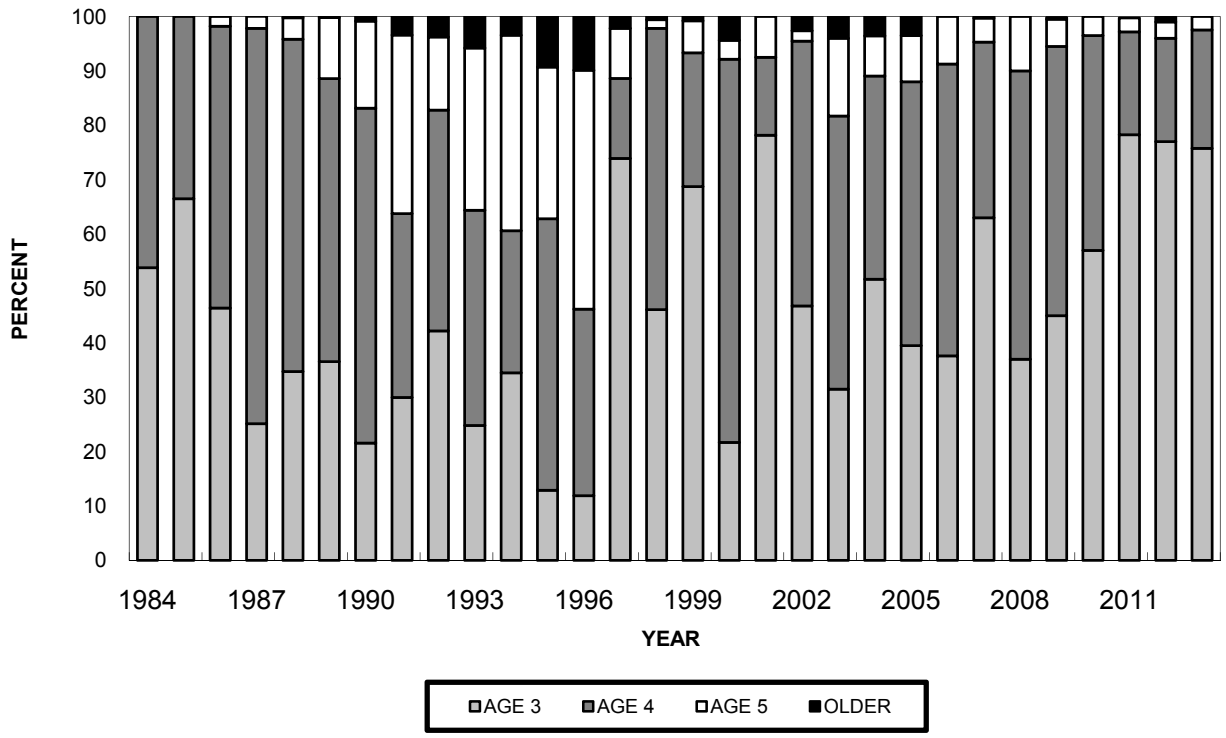

Figure 7. Age structures of Washington steelhead samples at Salmon River Hatchery, 1989-2013.

those in six years. Age-4 males were significantly heavier than those in four years, but lighter than those in seven years. Age-4 females were the lightest in the time series, but not significantly different than five of the 25 years.

Age Structure

Similar to age structures observed in recent years, age-3 and age-4 steelhead dominated the run again in 2013 (Figure 7). As in 2011 and 2012, age-3 fish comprised a noticeably higher proportion of the run compared to the previous 10 years. The age structure of the fish sampled was 76% age-3, 22% age-4, and 2.5% age-5.

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Nelson, R.M. 2012a. Fall 2013, Pacific salmon egg collection: spawning through eyeup. NYSDEC Salmon River Hatchery, Altmar, NY.

SAS Institute Inc., 2012. Release 9.3 TS level 00M0. Cary, NC, USA

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In 1998, concerns over post-stocking survival and imprinting of steelhead (*Onchorynchus mykiss*) and Chinook salmon (*O. tshawytscha*) to stocking sites led to the formation of several cooperative sportsmen's groups interested in pen rearing (Bishop and Pearsall 1999). Concerns from the eastern basin of Lake Ontario centered on predation of stocked steelhead trout by cormorants. Western basin concerns included the apparent lack of imprinting and subsequent impaired homing of Chinook salmon and steelhead to the stocking streams.

After the successful completion of pen-rearing projects at Oswego Harbor and Oak Orchard Creek in 1998, a number of other sportsmen's groups expressed interest in pen-rearing. New sites were added in 1999 including the Lower Niagara River, Sandy Creek, Genesee River and Sodus Bay. No additional sites were added until 2003, when a new pen project for Skamania steelhead was initiated at the Little Salmon River. In 2005, a Chinook salmon pen-rearing project was initiated at Olcott Harbor on Eighteenmile Creek, and steelhead were added there in 2006. Also in 2006, a steelhead-rearing project was initiated at Wilson Harbor on East Branch Twelvemile Creek. In 2009, a new pen site was added at Anchor Resort and Marina on Little Sodus Bay where both steelhead and Chinook salmon were reared. In 2010, Chinook salmon were raised at the Sandy Creek pen project site for the first time since 2002. Steelhead pen-rearing at Little Salmon River resumed in 2011 after a one-year hiatus; however, Washington strain steelhead were reared instead of Skamania strain. Washington strain steelhead were also reared at Little Salmon River pen site in 2012 and 2013. This report summarizes pen-rearing activities and results for 2013, the sixteenth year of pen projects along the New York shoreline of Lake Ontario.

Methods

Pen rearing was conducted at nine sites along New York's coastline of Lake Ontario in 2013. The project sites, along with a description of site locations and project sponsors, are listed from east to west in Table 1.

All sites used similar pen materials, design and netting as described for the 1998 Oak Orchard Creek Project in Bishop and Pearsall (1999). Standard operating procedures for stocking, maintaining, feeding, and releasing penned salmon and trout were developed and refined by the NYS Department of Environmental Conservation (Wilkinson 1999, Sanderson 2006). Rearing methods have remained very similar at most sites from year to year, with the exception of the lower Niagara River where in 2004 conventional floating pens were switched to two larger fixed pens located within a bulkheaded boat slip (Wilkinson et al. 2005). Additional information about methods used at pen sites in 2013 is provided in Table 2.

Water temperature monitoring was done mostly using hand-held and digital thermometers, with manual recording of observations. Frequency of temperature measurements is provided in Table 2. Dissolved oxygen was measured at the Olcott

Harbor site using a YSI 55 Dissolved Oxygen Meter.

During 2010 and 2011, all eight Chinook salmon rearing sites were part of a three-year study to assess the relative performance of pen-reared and direct-stocked salmon in open lake and tributary sportfisheries. The third and final year of marking for this project was scheduled for 2012; however, salmon-rearing densities at the hatchery were not consistent with the previous two years. Hatchery procedures in 2013 duplicated those in 2010 and 2011, and Chinooks pen-reared and direct stocked at seven sites in spring 2013 received an adipose fin-clip and a coded wire tag. Due to high water temperatures, Chinooks at Sandy Creek in 2013 were not tagged and were direct stocked only.

Observed mortalities for all projects were based on the number of dead fish collected from the pens during captivity and from the bottom of the pens after release. Both sources of mortality were noted by cooperators, except where listed otherwise. Mortality does not include fish lost to cannibalism or from predators that may have gained access to pens.

Results and Discussion

A total of 40,690 Washington strain steelhead were raised at six pen sites, comprising 7.5% of NYSDEC's Lake Ontario steelhead stocking allotment in 2013. Three sites that normally pen steelhead did not due to low water and high water temperatures at these sites (Table 3). Observed mortalities were relatively low at most steelhead pen sites, ranging from 0 to 0.54%. Results for all steelhead pen projects are summarized in Table 3.

Seven pen-rearing sites raised a total of 451,944 Chinook salmon fingerlings, representing 26% of NYSDEC's 2013 Chinook salmon stocking allotment. At sites where salmon were penned, observed mortalities were also low ranging from 0.028 to 0.36%. Results for all Chinook salmon pen projects are provided in Table 3.

At the Sandy Creek, Genesee River and Oswego Harbor pen sites, water temperatures exceeded the threshold (65°F) established for pen projects. These instances are discussed further as part of individual project results, and arranged below by site location from east to west.

Little Salmon River

Washington strain steelhead for the Little Salmon River project were placed in a pen on 19 April at 16 fish per lb. The steelhead were released 22 days later on 11 May at a weight of 12 fish per lb. No mortalities were observed.

Oswego Harbor

Pen cooperators at Oswego decided in 2013 to no longer rear steelhead. Chinook salmon were delivered to the pen site on 3 May, weighing 130 fish per lb. Salmon were released on 6 May after substantial mortalities occurred and water temperatures were observed in the 65°F threshold. The decision to release salmon after three days in pens was made to reduce the risk of additional mortalities.

Little Sodus Bay

At Little Sodus Bay**,** steelhead weighing 19 fish per lb were delivered to pens on 19 April. Steelhead were released on 18 May weighing 11 fish per lb. Pens were towed to the bay outlet for fish release.

Chinook salmon were delivered to the pen site on 29 April. Salmon weighed 130 fish per lb when delivered and weighed 63 fish per lb when released on 18 May. Salmon pens were towed to the bay outlet for fish release.

Sodus Bay

Low water levels in spring 2013 necessitated adjusting the pens' location to deeper water within Arney's Marina. Chinook salmon were placed into pens on 3 May and grew from 139 to 96 fish per lb after 21 days. Average length of released salmon was 3.2 in. The salmon were released on 24 May at a water temperature of 63°F

Genesee River

Steelhead were placed into pens on 18 April and held for 22 days. They were released on 10 May weighing 14 fish per lb, compared to a delivery weight of 19 fish per lb. Steelhead averaged 6.2 in. in length at release.

Chinook salmon were delivered to Shumway Marina at a weight of 128 fish per lb on 2 May. They were held in pens for 22 days and released on 24 May weighing 89 fish per lb. Water temperature on 24 May was 66°F. Average total length of salmon was 3.4 in.

Sandy Creek
Steelhead were delivered at a weight of 19 fish per lb on 18 April. They were held in the pen for 13 days and released on 1 May weighing 13 fish per lb. Steelhead averaged 5.6 in. in length at release. Water temperature at release was 67°F, slightly above the emergency release threshold.

Chinook salmon were delivered on 2 May at a weight of 143 fish per lb. Water temperatures exceeded 65°F prior to the delivery date, so the salmon were stocked at the boat launch facility.

Oak Orchard Creek
Steelhead were not placed into pens in spring 2013 for reasons related to timing of fish delivery and pen site logistics.

Chinook salmon were delivered at a weight of 132 fish per lb on 1 May. They were held for 19 days and released on 20 May weighing 76 fish per lb with an average total length of 3.3 in. Salmon pens were towed to the lake to release fish. Water temperature was 65°F on the release date.

Olcott Harbor
Steelhead were released on 14 May after 21 days in the pen. Initial weight of steelhead was 18 fish per lb, and final weight was 12 fish per lb. Fish were released at the pen site, and water temperature was approximately 59°F at release time.

Chinook salmon were delivered at a weight of 143 fish per lb on 30 April. Water temperatures rose into the low 60°F range only 2-3 days after delivery which prompted additional water quality monitoring at the pen site. Dissolved oxygen values in pens on 3 May ranged from 8.78 to 9.08 ppm and on 6 May ranged from 8.59 to 9.54 ppm. These values were substantially greater than the 5 ppm guidance value for mandatory fish release. Interestingly, a number of dead gizzard shad were present in Olcott Harbor during the penning period, probably the result of a large-scale shad die-off that occurred in Great Lakes waters. The dead shad were also present in the vicinity of the pens and may have degraded water quality. A spike in mortalities in all three pens prompted the release of Chinook salmon on 15 May, several days earlier than normal, to reduce risk of additional mortalities. The final fish weight was 83 fish per lb after 15 days or rearing. Water temperature was approximately 61°F at release. During the project, water temperatures approached, but never exceeded 65°F.

Wilson Harbor
Steelhead were not pen-reared in Wilson Harbor in 2013 due to concerns about adequate water depths for floating pens and for ensuring adequate water volumes within pens to safely rear fish. The 7,500 steelhead destined for pens were instead stocked into East Branch Twelve Mile Creek on 23 April.

Lower Niagara River
The lower Niagara River pen site is typically last to receive fish due to slowly warming water temperatures. In 2013, 10,000 steelhead were delivered into a single large pen on 26 April, weighing about 19 fish per lb. Steelhead were released 25 days later on 21 May at the pen site, weighing 13 fish per lb. Approximately 10 steelhead mortalities were observed.

Chinook salmon were loaded into a single large pen on 6 May, and the salmon weighed 146 fish per lb. on delivery. Salmon were released 29 days later on 4 June weighing 72 fish per lb. Water temperatures were not routinely monitored at the lower Niagara River pen site, however, water temperature was approximately 58°F when Chinook salmon were released.

Conclusions

Of the six locations where steelhead were penned, target weights (12-15 fish per lb) were reached at all of the pen sites in 2013.

Chinook target weights (90 fish per lb) were exceeded at five of seven sites. One of the sites that did not reach the target weight, i.e., Oswego, released their fish after three days due to high temperatures. At the five successful sites, it is likely that a large percentage of the penned salmon imprinted to water at their respective pen sites, increasing the likelihood that salmon will return as spawning adults to their respective pen site tributaries.

The sixteenth year of pen-rearing steelhead and Chinook salmon along the New York shoreline of Lake Ontario was successful due to low fish mortality, substantial percentages of steelhead and

Chinook salmon reaching target weights, and the goodwill generated through partnerships in the projects.

Acknowledgments

We wish to express our very sincere appreciation to the many individuals, businesses, municipalities and organizations that made these pen projects possible. Their dedicated efforts demonstrate a deep commitment to the Lake Ontario sportfishery and provide a management technique that would not be available without their valuable help.

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Table 1. Description of 2013 Lake Ontario pen project locations and sponsors.

Pen Site	Location	Project Sponsors
Little Salmon River	Salmon Country Marina	Salmon Country Marina
Oswego Harbor	Oswego Marina	Oswego Harbor Charter Captains Oswego Marina
Little Sodus Bay	Anchor Resort and Marina	Anchor Resort and Marina Jim Jared
Sodus Bay	Sodus Bay near First Creek	Arney's Marina Lake Ontario Charter Boat Association Prime Time Storage Wayne County Tourism Wayne County Pro-Am
Genesee River	Shumway Marina	Genesee Charter Association Greater Rochester Sportfishing Association Irondequoit Bay Fish and Game Club Shumway Marina
Sandy Creek	Sandy Creek Marina	Boy Scouts Genesee Charter Association Sandy Creek Marina Sandy Creek Shoot - Out Fishing Tournament S.U.N.Y. at Brockport
Oak Orchard Creek	Lake Breeze Marina	Lake Breeze Marina Oak Orchard Pen-Rearing Association Orleans County Department of Tourism
Olcott Harbor	Town of Newfane Marina	Lake Ontario Trout and Salmon Association Slippery Sinker Bait and Tackle Tim and Hank Condes Town of Newfane (including Town Marina)
Lower Niagara River	Constitution Park, Youngstown	Fox Fence Company Niagara River Anglers Association Village of Youngstown

Table 2. Methods used at 2013 Lake Ontario pen project sites.

Pen Site	Pen Stocking Method	Feeding Frequency (times per day)	Water Temperature Measurement (times per day)	Pen Cleaning Frequency	Fish Release Method
Little Salmon River	Hydraulic transfer	5	1	not noted	Pen towed to river mouth for fish release
Oswego Harbor	Hydraulic transfer	5	5	not needed	Fish released at pen site.
Little Sodus Bay	Hydraulic transfer	5	1-5	twice	Pens towed to bay outlet for fish release.
Sodus Bay	Hydraulic transfer	5	5	weekly	Pens towed to lake for fish release, pens inverted.
Genesee River	Hydraulic transfer	5	daily	weekly	Fish released at pen site.
Sandy Creek	Hydraulic transfer	5	5	weekly	Pens towed to mouth of creek Cable ties cut to release fish.
Oak Orchard Creek	Hydraulic transfer	5	2	every five days	Pens towed to lake. Cable ties cut to release fish
Olcott Harbor	Hydraulic transfer	5	5	not available	Fish released at pen site
Lower Niagara River	Hydraulic transfer	5	0	not available	Fish released at pen site

Table 3. Results of 2013 Lake Ontario trout and salmon pen-rearing projects.

Pen Site	Species	Number Stocked (into pens)	Number of pens	Date Stocked	Size at Stocking (#/ Lb)	Date Released (Days Held)	Size at Release (#/ Lb)	Mortality (# Fish)	Mortality (%)
Genesee	Chinook	85,250	4	2 May	128	24 May (22)	89	50[A]	0.059
Little Sodus	Chinook	25,514	1	29 Apr	130	18 May (19)	63	7	0.028
Lower Niagara	Chinook	75,554	1	6 May	146	4 Jun (29)	72	57	0.076
Oak Orchard	Chinook	106,553	5	1 May	132	20 May (19)	76	142	0.13
Olcott	Chinook	67,183	3	30 Apr	143	15 May (15)	83	162	0.24
Oswego	Chinook	41,890	2	3 May	130	6 May (3)	na	150[A]	0.36
Sandy Creek	Chinook	none	-	-	-	-	-	-	-
Sodus	Chinook	50,000	2	3 May	139	24 May (21)	96	32	0.064
Genesee	steelhead	10,000	2	18 Apr	19	10 May (22)	14	15[A]	0.15
Little Salmon	steelhead	3,890	1	19 Apr	16	11 May (22)	12	0	0
Little Sodus	steelhead	6,000	1	19 Apr	19	18 May (29)	11	0	0
Lower Niagara	steelhead	10,000	1	26 Apr	19	21 May (25)	13	10	0.1
Oak Orchard	steelhead	none	-	-	-	-	-	-	-
Olcott	steelhead	3,500	1	23 Apr	18	14 May (21)	12	19	0.54
Oswego	steelhead	none	-	-	-	-	-	-	-
Sandy Creek	steelhead	7,300	1	18 Apr	19	1 May (13)	13	9	0.12
Wilson	steelhead	none	-	-	-	-	-	-	-

na not available
[A] mortalities estimated

Sea Lamprey Control in Lake Ontario 2013

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Introduction

This report outlines the actions undertaken during 2013 by Fisheries and Oceans Canada (Department) and the U.S. Fish and Wildlife Service (Service) as partners of the Great Lakes Fishery Commission (Commission) to control sea lamprey (*Petromyzon marinus*) populations in Lake Ontario.

The sea lamprey is a destructive invasive species in the Great Lakes that contributed to the collapse of lake trout (*Salvelinus namaycush*) and other native species in the mid-20th century and continues to affect efforts to restore and rehabilitate the fish-community. Sea lampreys attach to large bodied fish and extract blood and body fluids. It is estimated that about half of sea lamprey attacks result in the death of their prey and an estimated 18 kg (40 lbs) of fish are killed by every sea lamprey that reaches adulthood. The Sea Lamprey Control Program (SLCP) is a critical component of fisheries management in the Great Lakes because it facilitates the rehabilitation of important fish stocks by significantly reducing sea lamprey-induced mortality.

Fish Community Objectives

As part of *A Joint Strategic Plan for Management of Great Lakes Fisheries*, the lake committees developed fish-community objectives for each of the Great Lakes. The fish-community objectives include goals of the SLCP that, if achieved, should establish and maintain self-sustaining stocks of lake trout and other salmonines by minimizing sea lamprey impacts on these stocks.

The Lake Ontario Committee established the following goal for sea lamprey control in Lake Ontario:

- *Suppression of sea lamprey populations to early-1990s levels.*

The Lake Ontario Committee recognized that continued control of sea lampreys is necessary for lake trout rehabilitation and stated a specific objective for sea lampreys:

- *Control sea lampreys so that fresh wounding rates (A1) of lake trout larger than 431 mm is less than 2 marks/100 fish.*

This objective is intended to maintain the annual lake trout survival rate of 60% or greater to support a target spawning stock of 0.5 to 1.0 million adults of multiple year classes. Along with sea lamprey control, angler and commercial exploitation will also be controlled so that annual harvest does not exceed 120,000 fish in the near term.

The target for Lake Ontario sea lamprey abundance was first calculated using the same marking statistics as the other lakes (A1-A3 marks). During 2006, the target and range were revised using A1 marks exclusively, which have been more consistently recorded on Lake Ontario. Also, the target marking rate of less than 2 A1 marks per 100 fish was explicitly identified as producing tolerable mortality in the lake trout rehabilitation plan. The target and range of adult sea lamprey for Lake Ontario was calculated from the average abundance estimated for the 5-year period, 1993-1997, when marking rates were closest to 2 marks per 100 lake trout >431 mm (1.6 A1 marks per fish >431 mm). The calculated target adult abundance in Lake Ontario is 31,000 ± 4,000 sea lampreys.
The performance of the SLCP is annually evaluated by contrasting adult sea lamprey abundance with the lake trout marking rates against these targets. Lake-

wide adult abundance is estimated by the Service and Department using a combination of mark-recapture and trapping efficiency estimates of adults in streams with traps, and regression model-predicted estimates in streams without traps. Lake trout marking rates are assessed and collected by the member agencies that comprise the lake committees and their technical committees.

During 2013, adult sea lamprey abundance in Lake Ontario was estimated to be 29,098 (95% CI; 26,352-32,357), which was within the fish-community objective target range. The number of A1 marks on lake trout from standardized fall assessments in 2013 has not yet been analyzed.

Lampricide Control

Tributaries harboring larval sea lampreys are treated periodically with lampricides to eliminate or reduce larval populations before they recruit to the lake as feeding juveniles. Service and Department treatment units administer and analyze TFM, or TFM/Niclosamide mixtures (TFM augmented with Bayluscide 70% wettable powder or 20% emulsifiable concentrate) during stream treatments, and apply 3.2% granular Bayluscide (GB) to control populations inhabiting lentic areas. Specialized equipment and techniques are employed to provide concentrations of lampricides that eliminate about 95% of the sea lamprey larvae while minimizing the risk to non-target organisms.

Lake Ontario has 659 tributaries (405 Canada, 254 U.S.). Sixty-six tributaries (31 Canada, 35 U.S.) have historical records of larval sea lamprey production, and of these, 38 tributaries (17 Canada, 21 U.S.) have been treated with lampricides at least once during 2004-2013. Twenty-eight tributaries (14 Canada, 14 U.S.) are treated on a regular cycle. Table 1 and Figure 1 provide details on the application of lampricides to Lake Ontario

Table 1. Details on the application of lampricides to tributaries of Lake Ontario during 2013 (letter in parentheses corresponds to location of stream in Figure 1).

Tributary	Date	Discharge (m^3/s)	TFM (kg)[1,2]	Bayluscide (kg)[1,3]	Distance Treated (km)
Canada					
Bronte Cr. (A)	May 31	3.6	1,377.5	0.0	41.4
Covert Cr. (B)	Jun 5	0.1	59.7	0.0	6.1
Total (Canada)		**3.7**	**1,437.2**	**0.0**	**47.5**
United States					
South Sandy Cr. (C)	Apr 29	5.8	366.4	4.7	13.5
Lindsey Cr. (D)	Apr 23	0.7	131.1	0.0	18.4
Little Sandy Cr. (E)	May 26	1.0	91.3	0.0	10.3
Salmon R. (F)					
Orwell Br.	Apr 25	2.0	220.2	0.0	11.2
Trout Br.	Apr 27	1.5	139.4	0.0	20.4
Grindstone Cr. (G)	Apr 18	3.2	384.6	0.0	43.6
Oswego R. (H)					
Fish Cr.	May 27	8.7	1,557.2	0.1	57.4
Total (United States)		**22.9**	**2,890.2**	**4.8**	**174.8**
Total for Lake		**26.6**	**4327.4**	**4.8**	**222.3**

[1] Lampricide quantities are reported in kg of active ingredient.
[2] Includes a total of 45 TFM bars (9.4 kg active ingredient) applied in 7 streams.
[3] Includes 3.2% granular Bayluscide applied in spot treatments or to lentic areas.

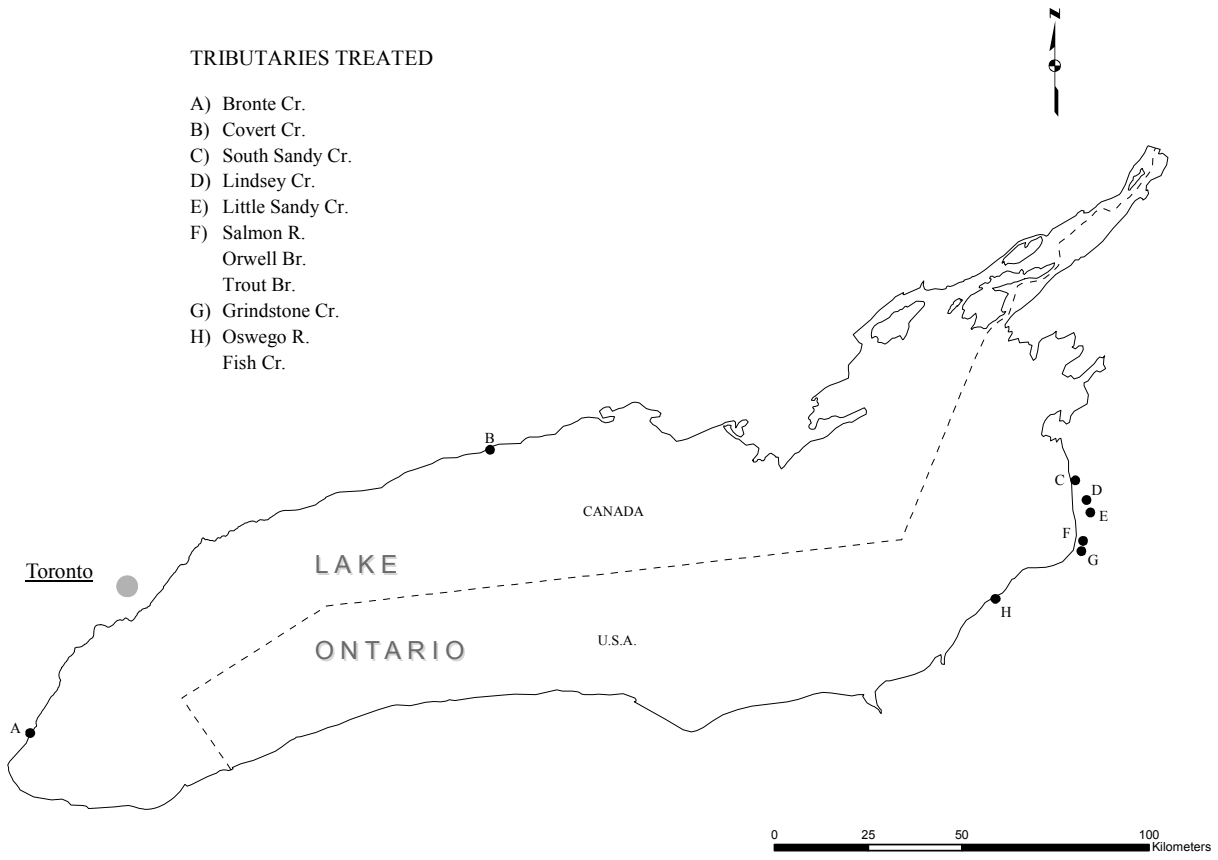

Figure 1. Location of Lake Ontario Tributaries treated with lampricides (corresponding letters in Table 1) during 2013.

tributaries and lentic areas during 2013.

- Lampricide applications were conducted in eight streams (two Canada, six U.S.).
- Larval sea lamprey were detected upstream of the dam at Cedar Springs on Bronte Creek necessitating a treatment from Carlisle, Ontario.
- Covert and Grindstone creeks and Trout Brook were treated further upstream from the historical upper distribution of larvae.
- Orwell Brook was treated for the first time since construction of the sea lamprey barrier was completed in 2012. This stream will be treated again in 2014 due to concerns of residual populations resulting from beaver impoundments located upstream from the barrier.

Alternative Control

The Commission and its partners continue to research and develop alternatives to lampricide treatments to provide a broader spectrum of strategies to control sea lampreys. During 2013, barriers were the only operational alternative control method. Alternative control methods that are currently being investigated include the use of attractants (e.g. pheromones), repellents (e.g.

necromones), juvenile trapping, and new trapping designs.

Barriers

The Sea Lamprey Barrier Program priorities are to:

a) Operate and maintain existing sea lamprey barriers that were built or modified by the SLCP.
b) Ensure sea lamprey migration is blocked at important non-SLCP barrier sites.
c) Construct new structures in streams where they
   a. provide a cost-effective alternative to lampricide control;
   b. provide control where other options are impossible, excessively expensive, or ineffective;
   c. improve cost-effective control in conjunction with attractant and repellent based control, trapping, and lampricide treatments; and
   d. are compatible with a system's watershed plan.

The Commission has invested in 16 barriers on Lake Ontario (Figure 2). Of these, 10 were purpose-built as sea lamprey barriers and 6 were constructed for other purposes, but have been modified to block sea lamprey migrations.

Beginning in 2007, an intensive effort to inventory and ground truth the information contained in the National Inventory of Dams was conducted to assess the sea lamprey blocking potential of barriers located on U.S. tributaries to the Great Lakes. This information is recorded in the SLCP's Barrier Inventory and Project Selection System (BIPSS) and barrier sites are monitored on a rotating schedule. The data contained in BIPSS are used to select barrier projects, monitor the frequency of inspections and schedule upstream larval assessments. Further, the information is used to assess the effects of barrier removal or modification requests on sea lamprey populations and identify structures that are important in controlling sea lampreys.

Barrier Inventory and Project Selection System

- Field crews visited 136 structures on tributaries to Lake Ontario to assess sea lamprey blocking potential and to improve the information in the BIPPS.

Operation and Maintenance

- Routine maintenance, spring start-up, and safety inspections were performed on 11 barriers (9 Canada, 2 U.S.).

- Repairs or improvements were conducted on four Canadian barriers:

  - Humber River –Handrails around the working platform were fabricated and installed in spring 2013. They were removed following the sea lamprey migration period to avoid damage from early spring flood debris and ice.

  - Graham Creek – The water intake in the trap was replaced with a Johnson screen in 2012, but it has clogged frequently during operation. In the spring of 2014, the screen will be relocated to mitigate this problem.

  - Duffin's Creek – The downstream flow monitoring gauge was repaired in October 2013.

  - Shelter Valley – A deteriorating concrete toe wall of unknown origin, located approximately 30m downstream from the sea lamprey barrier, has been removed and the stream bed restored to a natural state.

  - Cobourg Creek – Efforts were undertaken to correct hydrological patterns that resulted in chronic clogging of the water intake screen and insufficient flow through the fishway that has existed for several years. In early spring 2013, this problem became more serious, and was likely having a negative effect on trapping and fish passage. Remedial work included the placement of boulders to fill in the scour located along the west bank and the removal of sediments that had accumulated along the east bank adjacent to the fishway. The channel cross-section was returned to the more uniform shape that existed after the barrier was first constructed so that flow is evenly distributed across the stream bed and sufficient water is provided through the

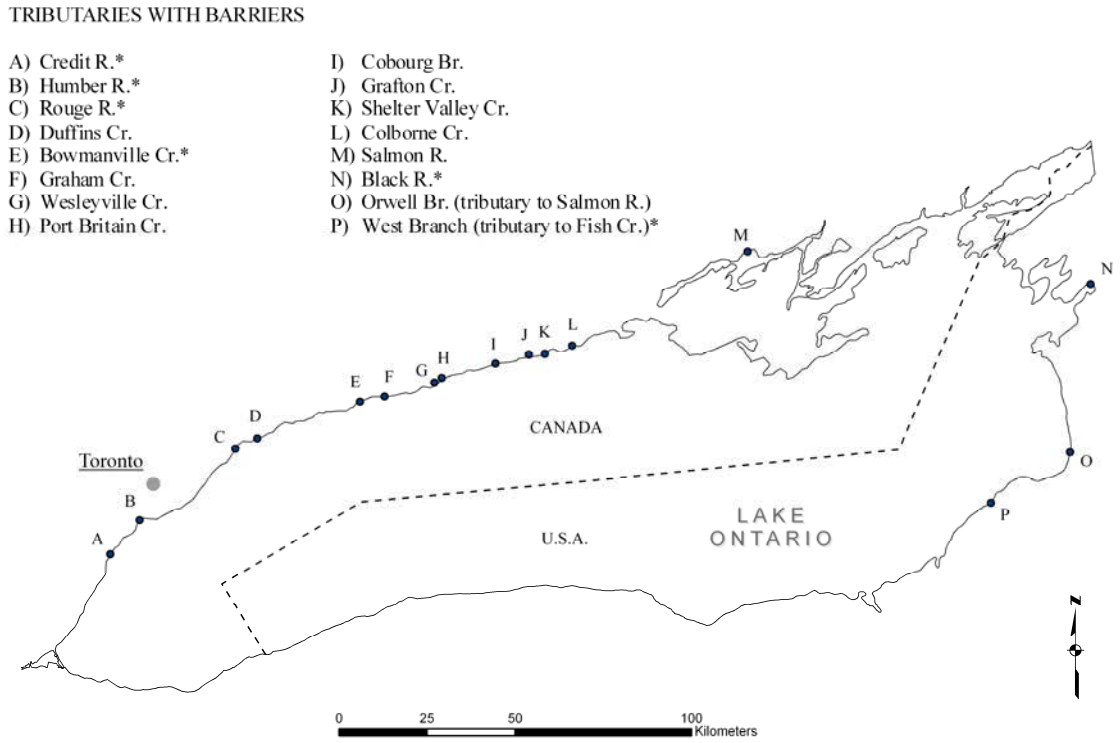

Figure 2. Location of Lake Ontario tributaries with sea lamprey barriers. Structures that were not constructed by the Commission, but have been modified to prevent the upstream migration of sea lampreys are indicated by an asterisk (*).

fishway. The screen will be monitored for blockage in the future, and replaced with a self-cleaning Johnson screen, if required.

Ensure Blockage to Sea Lamprey Migration

- Duffins Creek – An investigation is underway to improve safety around the dam while restoring the sea lamprey control function of the barrier.

- Credit River – Efforts are underway to address sea lamprey escapement at the Kraft Mill Dam and through the fishway. Redesign and replacement of an overhanging plate that was lost as a result of ice damage in main weir section has been completed. Consultation with the Ontario Ministry of Natural Resources (OMNR) to address escapement at the fishway is underway.

New Construction

- Orwell Brook – Construction of the sea lamprey barrier and trap on Orwell Brook was completed. Trapping operations began in spring 2013 and a total of 435 sea lampreys were captured, the most from any trap operated on the U.S. side of Lake Ontario. Two level loggers have been installed up- and downstream of the dam to monitor flow characteristics and evaluate the hydraulic performance of the barrier. Larval assessment surveys conducted during August

2013 revealed no young-of-year larvae upstream of the dam.

Assessment

The Assessment Program has three components, which are described as follows:

1. Larval Assessment determines the relative abundance and distribution of sea lamprey larvae in streams and lentic areas. These data are used to predict where larvae greater than 100 mm total length will most likely be found by the end of the growing season during the year of sampling. These predictions are used to prioritize lampricide treatments for the following year.

2. Juvenile Assessment evaluates the lake-specific rate of lake trout marking inflicted by sea lamprey. These time series data are used in conjunction with adult assessment data to assess the effectiveness of the SLCP for each lake. In addition, several indices of relative abundance of feeding juveniles are used in some lakes to monitor sea lamprey populations over time.

3. Adult Assessment annually estimates the stock size of adult sea lampreys in each lake. Because this life stage is comprised of individuals that have either survived or avoided exposure to lampricides, the time series of adult abundance is the primary metric used to evaluate the effectiveness of the SLCP.

Larval Assessment

Tributaries considered for lampricide treatment during 2014 were assessed during 2013 to define the distribution and estimate the density and size structure of larval sea lamprey populations. Assessments were conducted with backpack electrofishers in waters <0.8 m deep, while waters ≥0.8 m in depth were surveyed with GB. Survey sites were randomly selected in each tributary, larval sea lamprey catches were adjusted for gear efficiency, and lamprey lengths were forecast to the estimated end of the growing season. The number of large larval sea lampreys in each infested area was estimated by multiplying the mean density of larvae ≥100 mm (number per m^2) by an estimated area of suitable habitat (m^2). Infested areas were ranked for treatment during 2014 based on the lowest cost per kill of larval sea lampreys ≥100 mm, as estimated using this index of abundance and average treatment costs. Additional surveys are used to define the distribution of sea lampreys within a stream, detect new populations, evaluate lampricide treatments, and to establish the sites for lampricide application.

- Larval assessments were conducted on a total of 38 tributaries (18 Canada, 20 U.S.). The status of larval sea lampreys in historically infested Lake Ontario tributaries and lentic areas is presented in Tables 2 and 3.

- Surveys to estimate abundance of larval sea lampreys were conducted in 12 tributaries (5 Canada, 7 U.S.).

- Surveys to detect the presence of new larval sea lamprey populations were conducted in five tributaries (four Canada, one U.S.). No new populations were detected.

- Post-treatment assessments were conducted in nine tributaries (two Canada, seven U.S.) to determine the effectiveness of lampricide treatments conducted during 2012 and 2013.

- Surveys to evaluate barrier effectiveness were conducted in seven tributaries (six Canada, one U.S.).

Juvenile Assessment

The effect of the juvenile stage is indirectly assessed through the interpretation of sea lamprey marking rates on lake trout, estimated from assessment operations conducted by state, provincial, tribal and federal fishery management agencies associated with each lake. Marking rates are used in conjunction with adult sea lamprey abundance to evaluate the performance of the SLCP. The target lake trout marking rate in Lake Ontario is 2 A1-A3 marks per 100 lake trout.

Recently, the Commission created an updated fish marking database that incorporates marking data from lake trout and other species for a more holistic analysis of sea lamprey/host population dynamics.

Table 2. Status of larval sea lampreys in Lake Ontario tributaries with a history of sea lamprey production and estimates of abundance from tributaries surveyed during 2013.

Tributary	Last Treated	Last Surveyed	Status of Larval Lamprey Population (surveys since last treatment) Residuals Present	Recruitment Evident	Estimate of Overall Larval Population	Abundance Estimate of Larvae >100mm	Expected Year of Next Treatment
Canada							
Niagara R.	Never	Jul-10	---	Yes			Unknown
Ancaster Cr.	May-03	Aug-13	No	Yes			Unknown
Grindstone Cr.	Never	Sep-11	No	No			Unknown
Bronte Cr.	Jun-13	Aug-13	Yes	Yes			2016
Sixteen Mile Cr.	Jun-82	Sep-11	No	No			Unknown
Credit R.	Jul-11	Jul-12	Yes	No			2015
Humber R.	Never	Aug-13	---	No			Unknown
Rouge R.	Jun-11	Aug-13	No	Yes	663	0	Unknown
Petticoat Cr.	Sep-04	Jul-11	No	No			Unknown
Duffins Cr.	May-12	Aug-12	No	Yes			2015
Carruthers Cr.	Sep-76	Jul-13	No	No			Unknown
Lynde Cr.	May-12	Aug-12	No	Yes			2015
Oshawa Cr.	May-12	Aug-12	No	Yes			2015
Farewell Cr.	Jun-12	Aug-12	No	No			2015
Bowmanville Cr.	May-11	Aug-13	Yes	No			**2014**[1]
Wilmot Cr.	May-12	Aug-12	No	Yes			2015
Graham Cr.	May-96	Jul-13	No	No			Unknown
Wesleyville Cr.	Oct-02	Aug-12	No	No			Unknown
Port Britain Cr.	Apr-12	Aug-12	No	No			2015
Gage Cr.	May-71	Jul-13	No	No			Unknown
Cobourg Br.	Oct-96	Aug-13	No	No		0	Unknown
Covert Cr.	Jun-13	Sep-13	Yes	Yes			2016
Grafton Cr.	Oct-07	Sep-13	No	Yes	1,(	7	**2014**[2]
Shelter Valley Cr.	Sep-03	Jul-13	No	No			Unknown
Colborne Cr.	May-09	Sept-13	No	Yes	1,(	7	**2014**
Salem Cr.	Apr-12	Aug-12	No	Yes			2015
Proctor Cr.	Apr-12	Aug-12	No	Yes			2015
Smithfield Cr.	Sep-86	Jun-12	No	No			Unknown
Trent R. (Canal System)	Sep-11	Jun-12	No	No			Unknown
Mayhew Cr.	Apr-12	Jun-12	No	---			2015
Moira R.	Jun-11	Jun-12	Yes	Yes			Unknown
Salmon R.	Jun-00	Jun-12	No	Yes			Unknown
Napanee R.	Never	Jul-13	---	No			Unknown
United States							
Black R.	Aug-12	Jul-13	Yes	No			2016
Stony Cr.	Sep-82	May-11	No	No			Unknown
Sandy Cr.	Never	Apr-12	---	No			Unknown
South Sandy Cr.	Apr-13	Jul-13	Yes	Yes	---	---	2016
Skinner Cr.	Apr-05	Jul-13	No	No			Unknown

Tributary	Last Treated	Last Surveyed	Status of Larval Lamprey Population (surveys since last treatment) Residuals Present	Recruitment Evident	Estimate of Overall Larval Population	Abundance Estimate of Larvae >100mm	Expected Year of Next Treatment
Lindsey Cr.	Apr-13	Aug-13	Yes	No	4,119	3,733	**2014**
Blind Cr.	May-76	Jul-10	No	No			Unknown
Little Sandy Cr.	May-13	Aug-13	Yes	Yes			2016
Deer Cr.	Apr-04	Apr-12	No	No			Unknown
Salmon R.	May-11	Aug-12	Yes	Yes			**2014**[1]
Orwell Brook	Apr-13	Aug-13	Yes	No			**2014**[1]
Trout Brook	Apr-13	Aug-13	Yes	Yes			**2014**[1]
Grindstone Cr.	Apr-13	Aug-13	Yes	Yes			2016
Snake Cr.	May-11	Aug-12	No	No			2015
Sage Cr.	May-78	Jul-13	No	No			Unknown
Little Salmon R.	Apr-12	Aug-13	Yes	Yes	85,071	13,683	**2014**
Butterfly Cr.	May-72	Apr-12	No	No			Unknown
Catfish Cr.	Apr-12	Jul-13	Yes	Yes			2015
Oswego R.							
Black Cr.	May-81	Jun-11	No	No			Unknown
Big Bay Cr.	Sep-93	Apr-12	No	No			Unknown
Scriba Cr.	Jun-10	Apr-12	No	No			Unknown
Fish Cr.	Jun-13	Jul-13	No	No			2016
Carpenter Br.	May-94	Apr-12	No	No			Unknown
Putnam Br./ Coldsprings Cr.	May-96	Jul-13	No	No			Unknown
Hall Br.	Never	Oct-10	---	No			Unknown
Crane Br.	Never	Apr-12	---	No			Unknown
Skaneateles Cr.	Never	Oct-10	---	No			Unknown
Rice Cr.	May-72	Jul-13	No	No			Unknown
Eight Mile Cr.	Apr-07	Apr-12	No	No			Unknown
Nine Mile Cr.	May-11	Aug-13	Yes	Yes	57,774	37,250	**2014**
Sterling Cr.	May-12	Aug-12	No	No			2015
Blind Sodus Cr.	May-78	Jul-13	No	No			Unknown
Red Cr.	Apr-10	Aug-12	No	No			2015
Wolcott Cr.	May-79	Apr-11	No	No			Unknown
Sodus Cr.	May-10	Aug-12	No	Yes			Unknown
Forest Lawn Cr.	Never	Aug-13	---	Yes	103	70	Unknown
Irondequoit Cr.	Never	Aug-12	---	No			Unknown
Larkin Cr.	Never	Aug-12	---	No			Unknown
Northrup Cr.	Never	Aug-12	---	No			Unknown
Salmon Cr.	Apr-05	Aug-13	No	Yes		792	Unknown
Sandy Cr.	Apr-09	Aug-13	No	Yes	17,82	14,616	Unknown
Oak Orchard Cr. Marsh Cr.	May-08	Aug-13	No	Yes	3,878	1,473	**2014**[2]
Johnson Cr.	Apr-10	Aug-13	No	No			Unknown
Third Cr.	May-72	Oct-11	No	No			Unknown
First Cr.	May-95	Apr-11	No	No			Unknown

[1]Stream is being treated based on expert knowledge.
[2]Stream being treated based on geographic efficiency

Table 3. Status of larval sea lampreys in historically infested lentic areas of Lake Ontario during 2013.

Tributary	Lentic Area	Last Surveyed	Last Survey Showing Infestation	Last Treated
Canada				
Duffins Cr.	Duffins Cr. - lentic	Aug-12	Aug-12	Never[1]
Oshawa Cr.	Oshawa Cr. - lentic	Jul-13	Oct–81	Never[1]
Wilmot Cr.	Wilmot Cr. - lentic	Aug-11	Aug-11	Never[1]
United States				
Black R.	Black River Bay	Oct-10	Jul-10	Never[1]

[1] Low-density larval population monitored with 3.2% granular Bayluscide surveys.

The most recent analysis is presented in Figure 3. Previous marking rate graphs may not have incorporated all available data and may have been generated using analyses that weighted the data. Consequently, the current graphs may differ from those presented in previous reports.

- Lake trout marking data for Lake Ontario are provided by the U.S. Geological Survey, the OMNR, and the New York State Department of Environmental Conservation, and analyzed by the Service's Green Bay, Wisconsin, Fish and Wildlife Conservation Office.

- The number of A1 marks per 100 lake trout >431 mm from standardized fall assessments during 2013 has not yet been analyzed.

- Based on standardized fall assessment data, the marking rate during 2012 was 2 A1 marks per 100 lake trout >431 mm. The marking rate is less than the target and has been for the previous four years (Figure 3).

Adult Assessment

The long-term effectiveness of the SLCP has been measured by the annual estimation of the lake-wide populations of adult sea lampreys. Traps and nets are operated to capture migrating adult sea lampreys during the spring and early summer. Abundance is estimated using a combination of mark-recapture and trapping efficiency estimates of adults in streams with traps, and regression model-predicted estimates in streams without traps.

- A total of 6,434 sea lampreys were trapped at 12 sites on 11 tributaries (Table 4, Figure 4).
- The estimated population of adult sea lampreys was 29,098 (95% CI; 26,352-32,357), which was within the target range of 31,000 ± 4,000 (Figure 4).

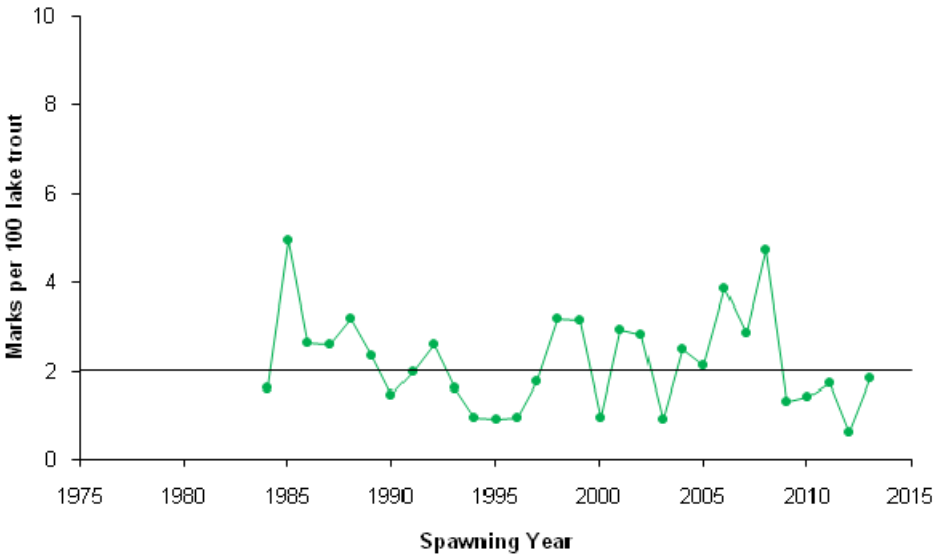

Figure 3. Number of A1 marks per 100 lake trout >431 mm from standardized fall assessments, plotted in the year that the juvenile cohort returned as adults (marking recorded in the fall is inflicted by the cohort of sea lampreys that spawns the next spring). The horizontal line represents the target of 2 A1 marks per 100 fish.

Table 4. Tributary name, number caught, adult sea lamprey estimate, trap efficiency, number sampled, percent males, and biological characteristics of adult sea lampreys captured in assessment traps or nets in tributaries of Lake Ontario during 2013 (letter in parentheses corresponds to location of stream in Figure 4).

Tributary	Number Caught	Adult Estimate	Trap Efficiency	Number Sampled[1]	Percent Males[2]	Mean Length (mm)		Mean Weight (g)	
						Males	Females	Males	Females
Canada									
Humber R. (A)	3,674	4481	82	374	46	491	488	280	284
Duffins Cr. (B)	763	953	80	76	45	524	505	310	294
Bowmanville Cr. (C)	211	984	21	69	36	511	503	289	292
Graham Cr. (D)	306	561	55	99	48	513	498	287	281
Cobourg Cr. (E)	272	554	49	19	37	510	484	---	---
Salmon R. (F)	58	167	35	---	---	---	---	---	---
Total or Mean (Canada)	**5,284**	**---**	**---**	**637**	**45**	**501**	**493**	**286**	**286**
United States									
Black R. (G)	341	2,100	16	16	62	451	485	221	294
Salmon R.(H)									
Orwell Br.	435	908	48	91	49	517	514	308	302
Grindstone Cr. (I)	4	---	---	---	---	---	---	---	---
Little Salmon R. (J)	24	---	---	---	---	---	---	---	---
Sterling Cr. (K)	280	938	30	54	65	505	507	280	284
Sterling Valley Cr.	66	---	---	1	0	---	439	---	238
Total or Mean (U.S.)	**1,150**	**---**	**---**	**162**	**56**	**505**	**508**	**288**	**296**
Total or Mean (for lake)	**6,434**	**---**	**---**	**799**	**47**	**502**	**496**	**287**	**288**

[1] The number of sea lampreys used to determine percent males, mean length, and mean weight.
[2] Gender was determined using external characteristics.

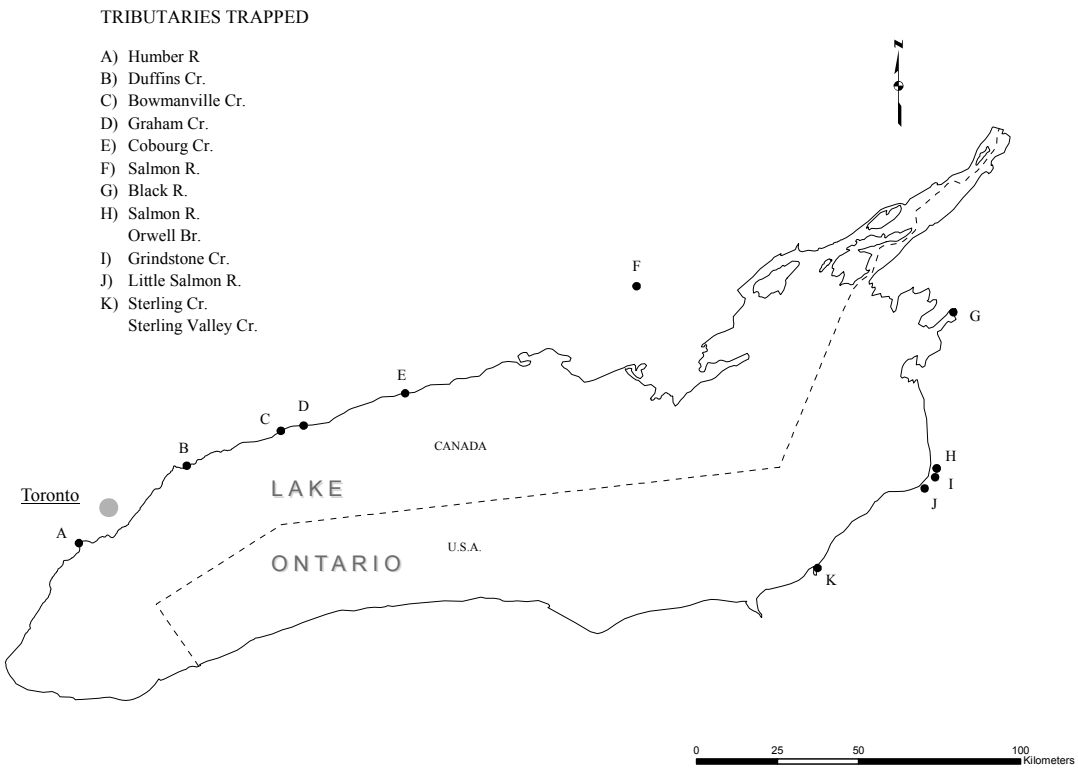

Figure 4. Location of Lake Ontario tributaries where assessment traps were operated (corresponding letters in Table 4) during 2013.

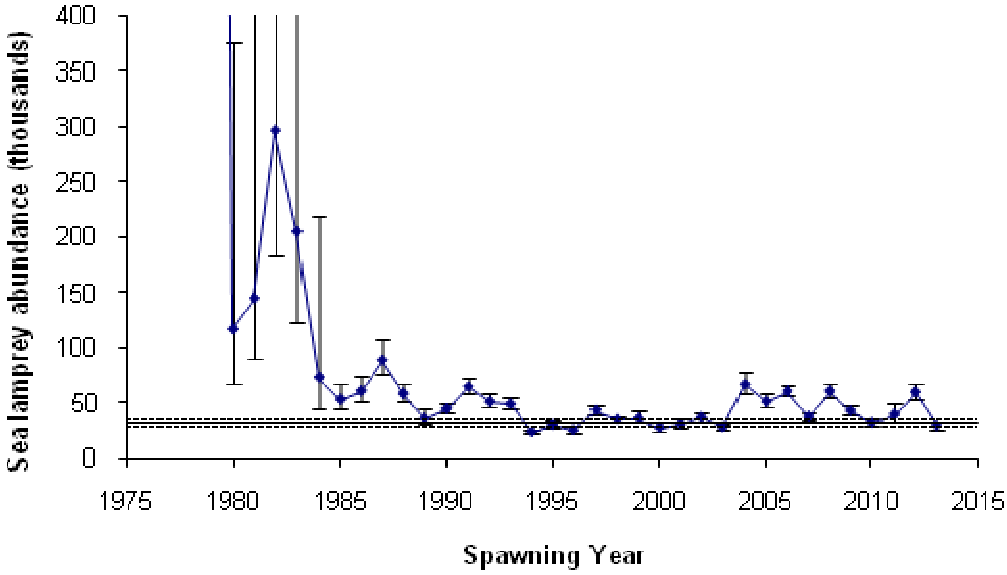

Figure 5. Annual lake-wide population estimates of adult sea lampreys in Lake Ontario, 1980 – 2013 with 95% confidence intervals (vertical error bars). Target abundance is indicated by the solid horizontal line with 95% confidence intervals (dashed horizontal lines).

Lake Ontario Prey Fish Assessments, 2013
Introduction and Methods

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Important Changes

- Addition of video camera to inform trawl configuration and fish behavior around trawl
- Hydroacoustics capabilities on R/V Kaho

History and Description

Lake Ontario has a mean depth of 86 m (282 ft) and a maximum depth of 244 m (801 ft) (Herdendorf 1982). The southern, New York portion of the lake has the deepest water (Figure 1). In New York waters, about 67% of the lake is <160 m (525 ft) deep and about 82% of the lake is <180 m (591 ft) deep. The U.S. Geological Survey (USGS) and New York State Department of Environmental Conservation (NYSDEC) have cooperatively assessed Lake Ontario prey fishes each year since 1978. Bottom trawl assessments were initially focused on Alewife *Alosa pseudoharengus* (April), Rainbow Smelt *Osmerus mordax* (June), and Slimy Sculpin *Cottus cognatus* (October). Seasonal survey timing corresponded to the peak catches in 1972 when collections were made every month May to October (Owens et al. 2003). Twelve transects were established at approximately 25-km intervals along the U.S. shoreline (Figure 2). Alewife assessment was conducted at all transects, Rainbow Smelt assessment at all transects except Fair Haven, and six transects representing eastern, southern, and western lake areas were sampled for Slimy Sculpin (Figure 2). Changes in the Lake Ontario ecosystem (species invasion, oligotrophication, native species rebound) require ongoing evaluation of current methods which sometimes necessitate redistribution of trawl effort, or changes in sampling designs and/or gear. For instance, the spring Alewife assessment is now used also to assess invasive Round Goby *Neogobius melanostomus* population dynamics. Likewise, the fall benthic fish assessment (formerly sculpin assessment) now also tracks dynamics of the rebounding native Deepwater Sculpin *Myoxocephalus thompsonii* population, the apparent declining population of Slimy Sculpin, and fall distribution of Round Goby.

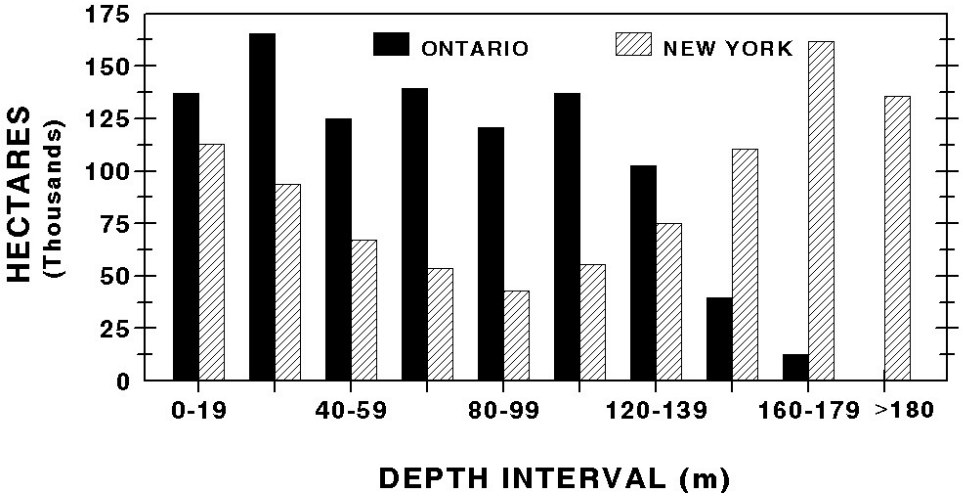

Figure 1. Area of Lake Ontario in various depth strata in the province of Ontario and the state of New York. 1 m = 3.28 ft and 1 hectare = 2.47 acres.

Sampling Design

Abundance indices for Alewife, Rainbow Smelt, and Round Goby are depth-stratified to target species of interest on each assessment (see individual species reports for more details). Fixed-station sampling designs are commonly used for assessing fish populations in the Great Lakes and in northern Europe (ICES 2004). The underlying assumption is that changes in relative abundance at the fixed stations are representative of the whole population. Mean abundance from fixed-station surveys will not be biased if the fish are randomly distributed. Acoustic sampling conducted during the 2004-2006 spring bottom trawl assessments supported our assumption of random distribution of Alewife within geographic areas (New York State Department of Environmental Conservation and Ontario Ministry of Natural Resources, unpublished data). Furthermore, comparisons between acoustic density measures of alewife-strength targets and densities measured by bottom trawls were consistent among geographic areas. However, there is no assurance that this has always been true given the large-scale shifts in fish distribution observed over the recent decades (e.g., O'Gorman et al. 2000). Although random sampling is preferable for estimating precision, the systematic, fixed-station sampling that we employ in Lake Ontario will often be optimal for generating the most precise estimate of relative abundance even though the variance of the estimated relative abundance will be biased (ICES 2004).

Trawl area swept estimates have been used to improve our understanding of Slimy and Deepwater Sculpin density changes throughout the time series. We found that changes in Slimy Sculpin depth distribution invalidated previous indices of abundance. The depth-stratified approaches did not reflect the new depth distribution and thus a significant portion of the slimy sculpin population was outside of the sample area. Current assessments continue to use a fixed station sampling design, however, Slimy Sculpin density is based on the mean density in trawls from 8m to 150m and Deepwater Sculpin density is based on tows from 55 m to 150 m. Although both Slimy and Deepwater Sculpin are captured at depths greater than 150 m these areas were not trawled during the previous years and therefore are not included in the current mean density estimates.

Surveillance Transects

In 2012, surveillance transects were established at three locations (Thirty Mile Point, Rochester, Oswego) in Lake Ontario to provide more complete sampling of available depths. Depth stratified bottom trawl samples are taken at depths ranging from 8m to 175m four times a year in conjunction with the three prey fish

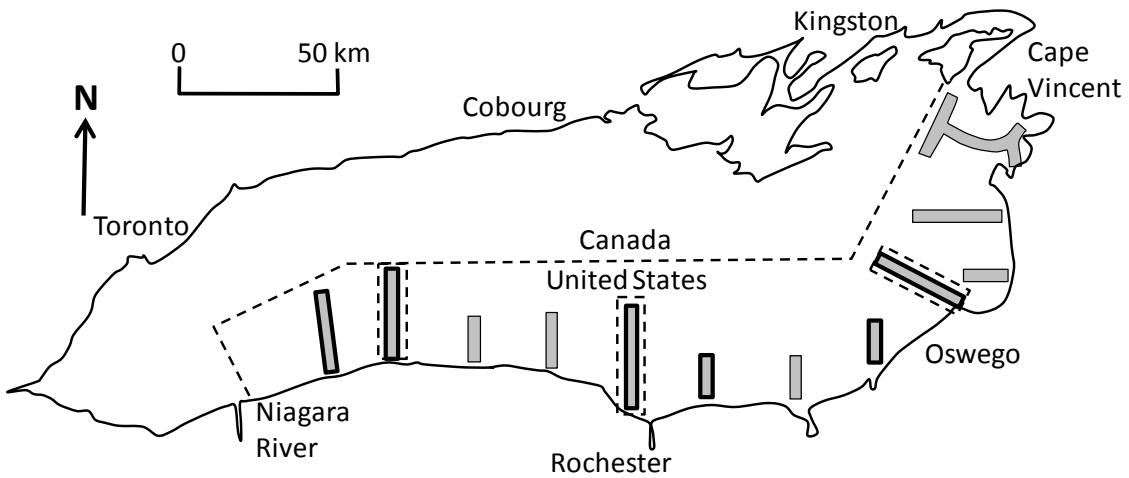

Figure 2. Lake Ontario showing 12 transects sampled by USGS and NYSDEC with bottom trawls. Transect names, from west to east: Olcott, Thirty Mile Point, Oak Orchard, Hamlin, Rochester, Smoky Point, Sodus, Fair Haven, Oswego, Mexico Bay, Southwick, and Cape Vincent. Six benthic prey fish assessment transects (sculpin) are denoted by the thicker outline. The dashed outline denotes the three surveillance transects.

assessments and the juvenile Lake Trout assessment. The original sampling designs of these assessments concentrated sampling effort in depths where the target species were most abundant. While this approach reduced variability in species-specific abundance indices, large areas of the lake and specific depths were not regularly sampled, which reduced the ability to quantify changes in the fish community. For instance, effort on the spring assessment targeting alewife is concentrated at depths greater than 70m. As Round Goby proliferated in the early 2000's we had little information about how they were distributed in the lake during the spring because we did not sample in shallower depths. Similarly, the understanding of the Deepwater and Slimy sculpin distribution shifts was impeded by a benthic fish survey that sampled a maximum depth of 150m. Addition of shallower and deeper trawl sites at surveillance transects eliminates the limitations of only using species-specific sampling plans; and surveillance transects efficiently maximize the potential for bottom trawl samples to illustrate future and unexpected changes in the Lake Ontario fish community.

Vessels

Vessels used in prey fish assessments have been relatively consistent over time. Two vessels participated in prey fish surveys during 1978-1982, the 19.8-m (65 ft), steel hull R/V *Kaho* (USGS) and the 12.8-m (42 ft), fiberglass hull R/V *Seth Green* (NYSDEC). During 1983-1985, all assessment trawling was conducted by the *Kaho* only (the fiberglass *Seth Green* was permanently retired in fall 1982). In 1985, the NYSDEC accepted delivery of the new, 14-m (46 ft) steel-hull R/V *Seth Green* which replaced the former vessel and resumed participation with the *Kaho* in prey fish surveys during 1986-2002 and 2004-present. Catch comparisons between vessels indicated that, for Alewife and Rainbow Smelt, the fishing power of the *Kaho* did not differ from that of either the fiberglass or steel *Seth Green*. In 2012, the USGS received a new, state-of-the-art, 70ft, aluminum hull, research vessel (Figure 3). This new vessel, named the "*RV Kaho",* was used during all 2013 bottom trawl assessments. We used trawl mensuration gear to evaluate trawl behavior and morphometry while fishing to confirm consistent effort among years and vessels.

Figure 3. RV Kaho, a 21.2m (70 ft), aluminum hull research vessel has replaced the aging, steel hull Kaho 19.8-m (65 ft) in 2011. This new vessel has a shallower draft and enhanced sampling capabilities.

Bottom Trawls

The original bottom trawl used on all the assessments was a nylon Yankee bottom trawl with a 11.8-m (39 ft) headrope and flat, rectangular wooden trawl doors (2.12m x 0.95m). In 1997, overly abundant catches of dreissenid mussels led to a change to a polypropylene 3N1 bottom trawl with an 18-m (59 ft) headrope and slotted, metal, cambered V-doors. Paired tows were used to calibrate catches between the two sets of gears for Alewife and Rainbow Smelt. From 2004 to 2010, alternate bottom trawls and configurations were used to assess Slimy Sculpin although shallow depths where dreissenid density was highest were avoided. Comparison trawling in 2011 between the most promising alternate trawl design and the original Yankee trawl indicated these alternate trawls had extremely low catchability for benthic fishes and were ineffective at capturing the full size ranges of benthic prey fish known to be present. Since 2011, the program returned to using the standard 11.8-m Yankee trawl for the benthic fish assessment and reduced tow times to reduce dreissenid caches (from 10 minutes to 5 or 3 minutes).

In 2013, the number of trawl hauls made for assessment of Alewife, Rainbow Smelt, and benthic prey fish totaled 225. During the Alewife assessment cruise, 77 bottom trawl tows were conducted, 96 during the Rainbow smelt assessment, and 52 tows during the fall benthic fish assessment. Bottom trawl effort among cruises has been consistent in recent years, however, Alewife cruise effort in 2013 was reduced due to mechanical issues (see Status of Alewife, this report), which led to a decrease in total bottom trawl effort during 2013.

Remote sensors, known as trawl mensuration gear, have been used over the past 5-10 years to understand how the shape of the bottom trawl changes as it is deployed and fished. Sensors are attached at various points on the trawl or trawl doors and relay data back to the ship, such as the trawl wing spread, trawl door spread, or trawl headline height. Data acquired from the sensors deployed on the 11.8 m Yankee bottom trawl have enabled us to estimate time on bottom and area swept by the trawl, and evaluate these variables relative to fishing depth (Weidel and Walsh 2013). The data suggest the Yankee trawl is in contact with the lake bottom and pulled at effective speeds to capture fish for longer periods of time than previously thought. This is due to the net making bottom contact before the trawl time is started, and remaining on bottom for a period of time after the recorded trawl time is technically stopped. This additional time and area swept increases with

fishing depth such that the area covered by a trawl towed at 170m is three times greater than the area covered by the trawl at 8 m when towed for the same amount of time. The relationships between area swept and fishing depth allow us to calculate more precise estimates of fish density over different depth habitats. A GoPro Hero 3 camera with diving torches was used for the first time in 2013 to confirm time on bottom as estimated by mensuration sensors.

Hydroacoustics

The R/V Kaho is equipped with dual frequency (120 and 430 kHz) transducers that expand our capability to evaluate populations of pelagic prey fishes, *Mysis diluviana*, and other zooplankton. The equipment was used during 2013 to address targeted research questions. Further investigation is ongoing to evaluate best ways to integrate this technology into lakewide research and assessment programs.

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Weidel, B and M. Walsh. 2013. Estimating the area-swept by the 11.8 m Yankee bottom trawl in Lake Ontario. Section 12, pages 25-32, *In* 2012 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to Great Lakes Fishery Commission's Lake Ontario Committee.

Status of Alewife in the U.S. Waters of Lake Ontario, 2013

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Abstract

The adult Alewife abundance and weight indices in 2013 were very similar to 2012 levels. Condition of adult Alewives decreased relative to 2012, but remained relatively high and within the range of recent years. Yearling abundance was above average for the fourth consecutive year, and represents the strongest year class in this time series. Alewife year class strength at age-1 is related to the number of spawners, summer temperatures and winter duration in the first year after hatching. The number of spawners increased from 2012, but summer temperatures in 2013 were slightly below average and we anticipate a high winter severity so year class size could be well below average for 2013. Because of moderate year classes in 2007-2008, above average year classes in 2009-2011, and the very large year class in 2012, we expect adult Alewife abundance and biomass to continue to increase in 2014, barring significant impacts of the harsh winter.

Status of Alewife

The sampling frame for Alewife was last modified in 2004, when it was expanded to include the 160-179 m (525-587 ft) depth stratum in subsequent years; calculation of the indices were concurrently modified. See Walsh and Connerton (2011) and previous years for more detailed explanation of analytical methods for the sampling frame expansion, index calculations, and catch estimates for 2001, when the spring assessment could not be completed due to mechanical difficulties. All indices are expressed as depth stratified catch per unit effort for a 10-min bottom trawl tow. In our depth-stratified design, effort is allocated equally into western areas (Rochester and West, 5 transects) and eastern areas (Smoky Point and east, 4 full transects, 2 transects with depths available ≤70 m, and eastern basin sites ≤40 m). Sampling at ≤70 m is randomly allocated among depth strata within western and eastern areas. At all transects where depths are available, the following depths are sampled: 70, 85, 95, 105, 115, 125, 135, 150, 170 m. In 2013, standard sampling conducted annually by the USGS was reduced due to hydraulic system failure on the USGS R/V *Kaho* and delays getting the system adequately repaired to resume sampling. The R/V *Seth Green* was able to assist and allow completion of Rochester and Thirty Mile transects, but transects at Olcott, Smoky Point, and Fair Haven were not sampled. Four of five of the western transects were sampled, but only two eastern transects (Sodus and Oswego) were sampled where depths exceed 70 m. For depths <70 m, surveillance collections could be substituted for missed random tows within depth strata. Therefore, to avoid bias of the index estimates owing to greater effort at western transects, we decided to post-stratify the lake further into west and east regions, as well as the nine depth strata, for a total of 18 strata. We weighted mean catches for each strata accordingly by lake area. Our intent with the modifications to stratification was to equalize the weight of data from the two lake areas and generate the least biased index with the available data.

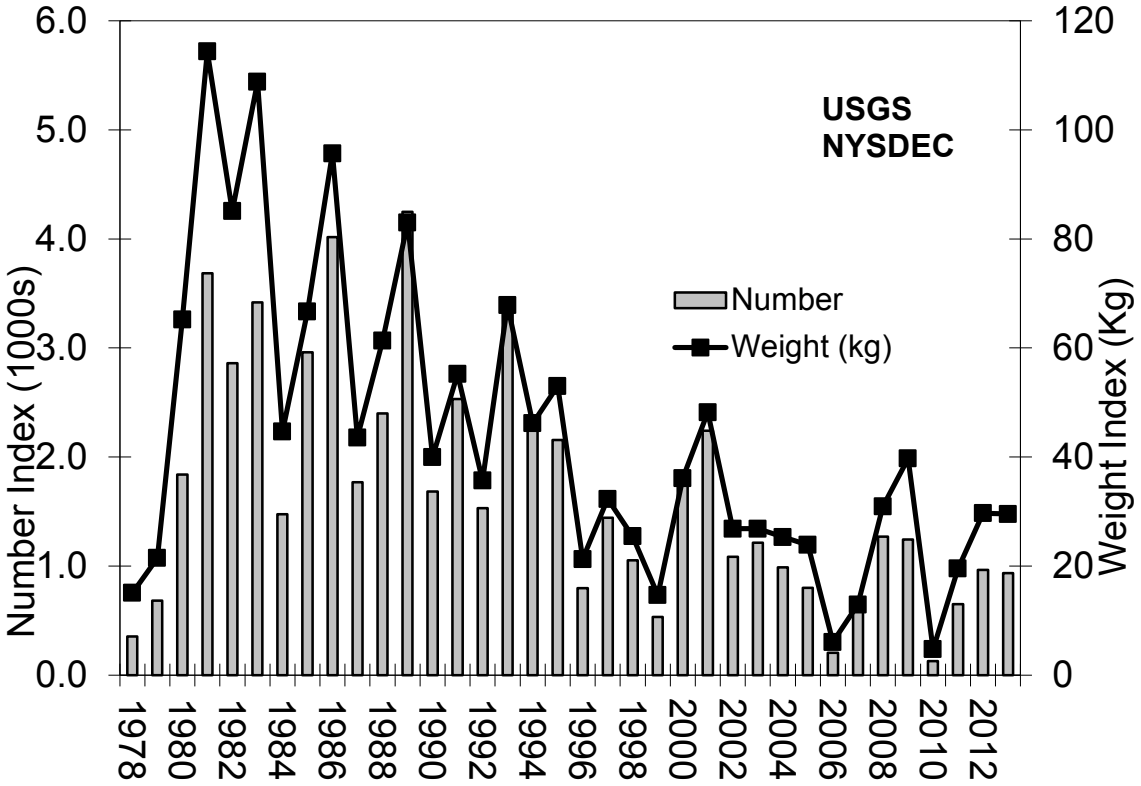

Figure 1. Abundance and weight indices for adult (age-2 and older) Alewife in the U.S. waters of Lake Ontario during late April – early May, 1978-2013. 1 kg = 2.205 lbs.

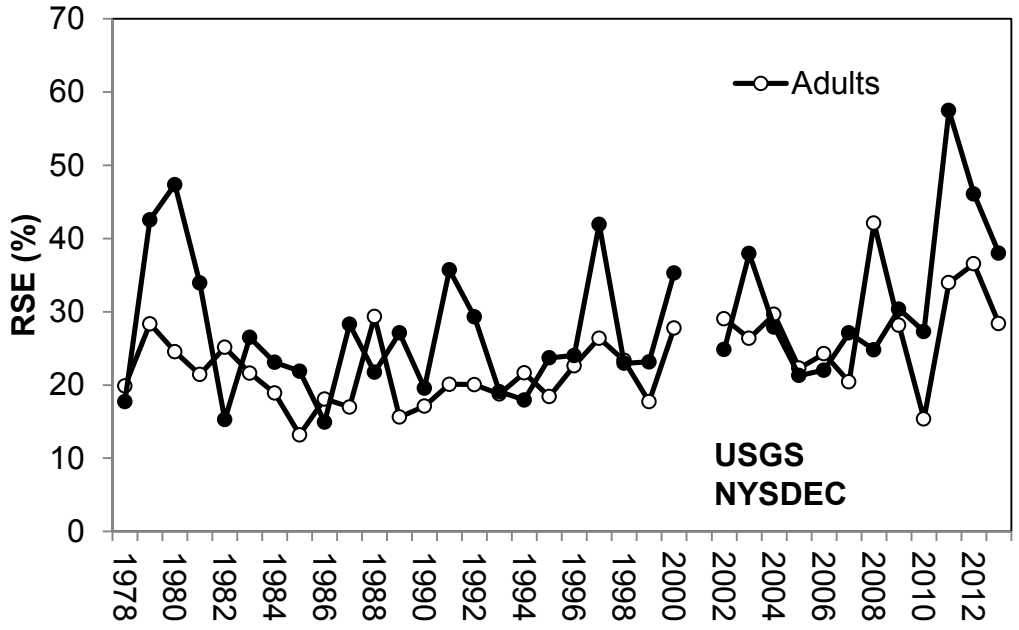

Figure 2. Relative standard error (RSE) for the yearling and adult Alewife abundance indices in U.S. waters of Lake Ontario, 1978-2013. The RSE (RSE = 100 * {standard error of the index / the index}) is a measure of variability in the indices.

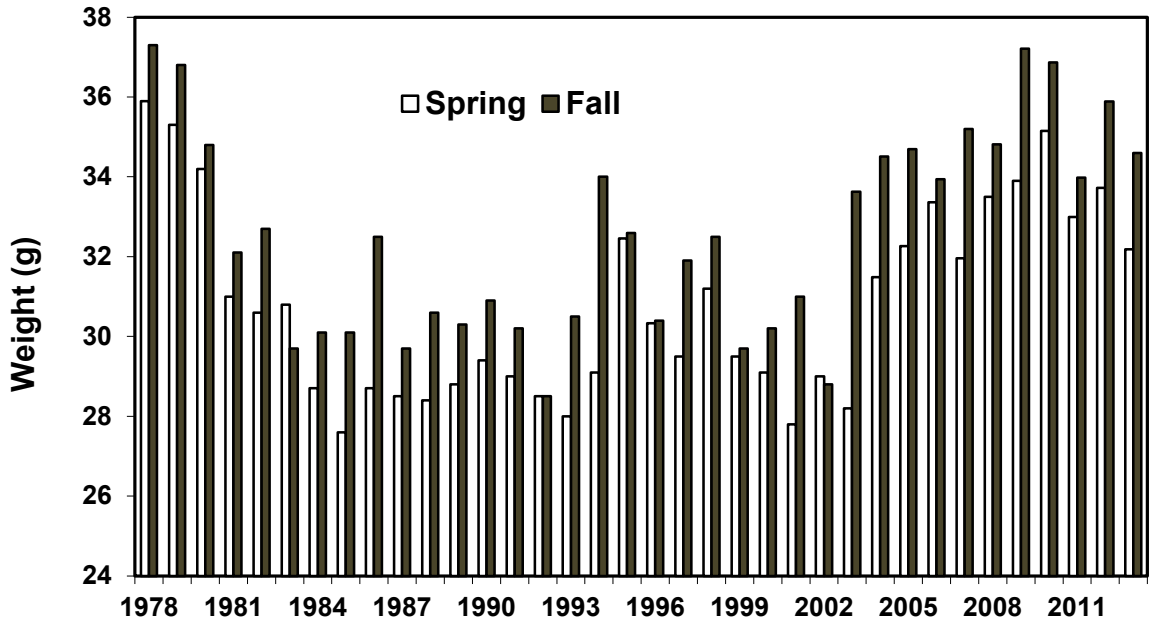

Figure 3. Wet weight of a 165-mm (6.5 in) Alewife (predicted from annual length-weight regressions) in spring and fall, Lake Ontario, 1978-2013. 1 gram = 0.035 ounce. Note that x-axis is truncated to highlight relatively small differences among years.

In April – May 2013, both the abundance (number) and weight (kg) indices for adult Alewife (age-2 and older) in U.S. waters of Lake Ontario were similar to 2012 values (Figure 1). The 2013 abundance index (935) was equal to 55% of the long-term mean (1702), 25% of the record high of 1989 (4247), and is seven times higher than the record low from 2010 (128). The 2013 biomass index (30) was equal to 68% of the long-term mean (43), 26% of the record high of 1981 (114), and is six times higher than the record low from 2010 (5). We use the relative standard error (RSE; RSE = 100 * {standard error of the index / the index}) as a measure of variability in abundance and weight indices. In 2013, the RSE of the adult (28%) and yearling (38%) abundance indices both exceeded the long term means (24% and 29%, respectively) but were in the range of other recent years (Figure 2).

Our index of adult Alewife condition is the wet weight of a 165-mm (6.5-in) Alewife predicted from annual length-weight regressions collected in spring and fall. The predicted weight in spring and fall 2013 remained relatively high and within the range of recent years, but was less than peak values observed during 2009-2010 (Figure 4). Generally since 2004, condition in spring and fall has been higher than in any other period since the late 1970's. Persistent high condition of adult alewives indicates that food availability is not limiting the population at current densities.

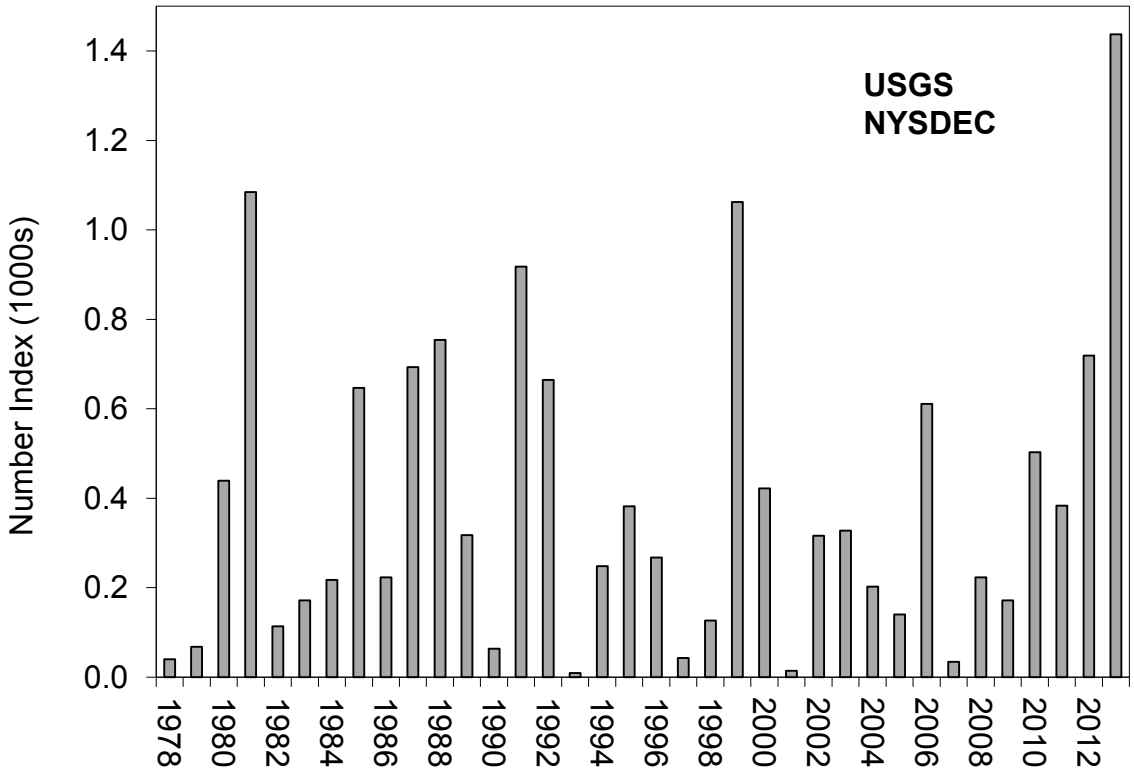

Figure 4. Abundance index for yearling (age-1) Alewife in the U.S. waters of Lake Ontario during late April – early May, 1978-2013.

The age-1 Alewife abundance index in spring 2013 (1428) was well above the long term mean (390) and represents the largest year class ever observed in this time series (Figure 3). The year class exceeded predictions from our recruitment model (O'Gorman et al. 2004, Walsh et al. 2013). With moderate year classes in 2007 and 2008, above average year classes in 2009-2011, and this large 2012 year class, the adult stock should continue building.

Strength of Alewife year classes at age 1 is related to a summer temperature index [heating degree days >10° C (50° F) before 1 August], a winter duration index [the number of days nearshore water is < 4° C (39° F)] during the first winter after hatch, and the number of spawners (adults >150 mm) (O'Gorman et al. 2004). In 2013, the summer temperature index (341) was slightly below the long-term average (359), indicating moderate conditions for reproduction and larval survival. Spawning stock has increased the last three years following low levels in 2010. However, harsh winter conditions during 2013-2014 could adversely affect the 2013 year class. Twenty days in December 2013 had water temperature < 4° C, as well as likely all days in January-March, leading to a predicted winter index in the range of 109-139 days. Only five winters since 1977 have exceeded a winter duration index of 120 days. Our spawn recruit model predicts a below average year class based on anticipated winter severity.

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Status of Rainbow Smelt in the U. S. Waters of Lake Ontario, 2013

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Abstract

Rainbow Smelt Osmerus mordax *are the second most abundant pelagic prey fish in Lake Ontario after Alewife* Alosa psuedoharengus*. The 2013, USGS/NYSDEC bottom trawl assessment indicated the abundance of Lake Ontario age-1 and older Rainbow Smelt decreased by 69% relative to 2012. Length frequency-based age analysis indicated that age-1 Rainbow Smelt constituted approximately 50% of the population, which is similar to recent trends where the proportion of age-1 has ranged from 95% to 42% of the population. While they constituted approximately half of the catch, the overall abundance index for age 1 was one of the lowest observed in the time series, potentially a result of cannibalism from the previous year class. Combined data from all bottom trawl assessments along the southern shore and eastern basin indicate the proportion of the fish community that is Rainbow Smelt has declined over the past 30 years. In 2013 the proportion of the pelagic fish catch (only pelagic species) that was Rainbow Smelt was the second lowest in the time series at 3.1%. Community diversity indices, based on bottom trawl catches, indicate that Lake Ontario fish community diversity, as assessed by bottom trawls, has sharply declined over the past 36 years and in 2013 the index was the lowest value in the time series. Much of this community diversity decline is driven by changes in the pelagic fish community and dominance of Alewife.*

Results and Discussion

The USGS-NYSDEC Rainbow Smelt assessment conducted in June 2013, consisted of 96 bottom trawls at 11 transects extending from Olcott, NY into the eastern basin and covered a depth range of 8 - 170m. In 2013, the abundance index for age-1 and older Rainbow Smelt fell relative to 2012 and abundance was similar to 2011 observations (Figure 1). The abundance index was approximately half of the 10-year average. Only 1.4% of the Rainbow Smelt caught on the assessment were greater than 150mm (approximately 6 inches). The percentage of Rainbow Smelt over 150 mm varied from 6-28% during the period 1978-1985 however, since 1986 the percentage of Rainbow Smelt over 150 mm has been consistently low, averaging slightly higher than 2% of the population.

The relative standard error (RSE =100*[standard error of abundance index/abundance index]) of the Rainbow Smelt abundance index increased in value and variability over the past 20 years but has leveled off over the past five years (Figure 2). Reduced Rainbow Smelt abundance and increased variability coincides with reduced lake productivity, dreissenid mussel colonization, and a shift by Rainbow Smelt to deeper depths. Bottom trawling effort was altered to deeper lake areas in 2000 and again in 2006 to reduce variability in trawl catches after it was observed that Rainbow Smelt inhabited deeper depths than when the survey began in 1978 (O'Gorman et al. 2000; Walsh et al. 2007).

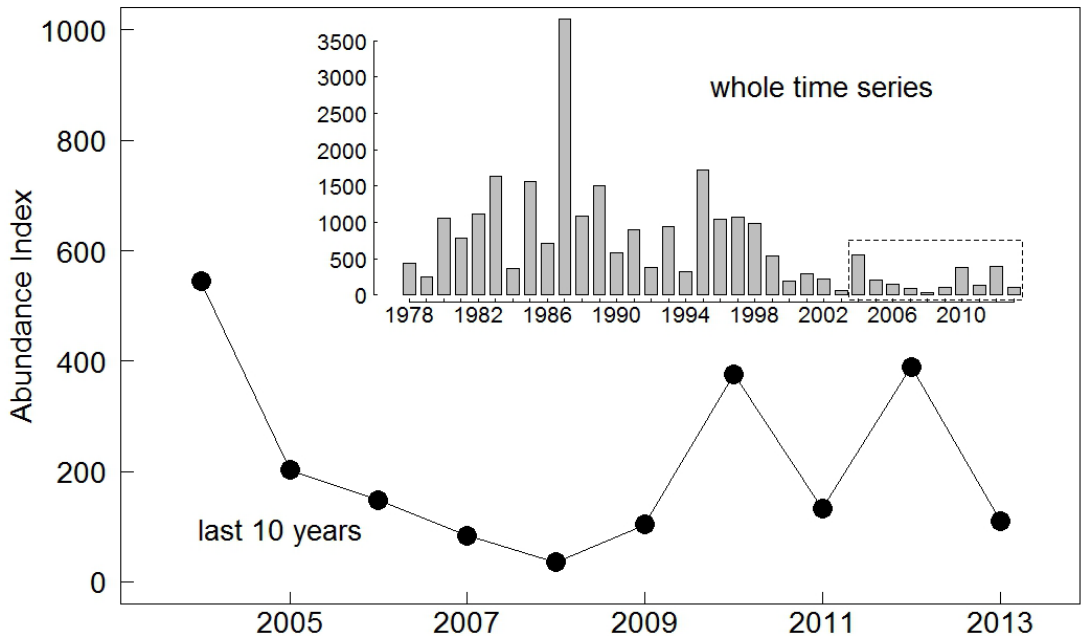

Figure 1. Stratified mean catch of Rainbow Smelt (age-1 and older) from bottom trawls in U.S. waters of Lake Ontario shoreward of the 140-m (459-ft) bottom contour in late May-early June, 2004 - 2013. The abundance index represents the area weighted average number of Rainbow Smelt caught in a 10 minute trawl. The inset portion shows the entire time series (1978-2013) and the dashed rectangle delineates the last 10 years depicted in the main figure. The abundance index represents the average number of Rainbow Smelt caught in a 10 minute bottom trawl.

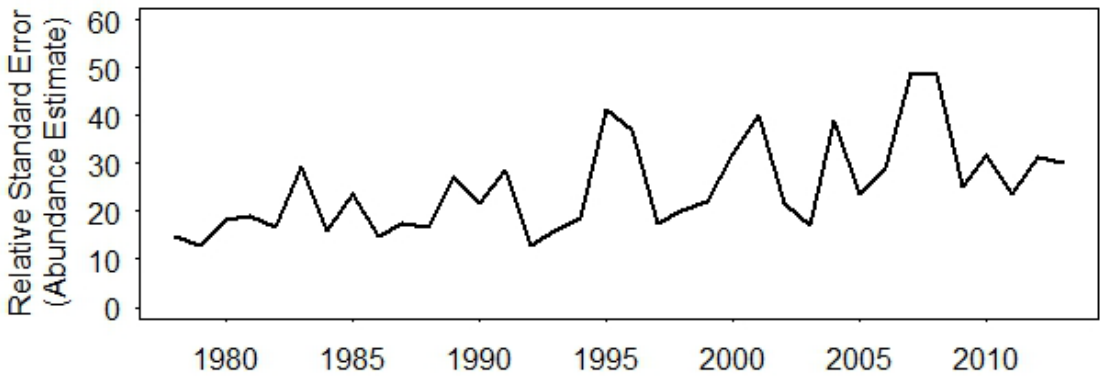

Figure 2. Relative standard error (RSE) for age-1 and older Rainbow Smelt abundance index (Figure 1) in U.S. waters of Lake Ontario, 1978 - 2013.

Rainbow Smelt year-class strength in Lake Ontario is calculated as the product of the proportion of age-1 Rainbow Smelt in the total catch and the stratified mean abundance index. In an effort to standardize age proportioning methods, the proportions of age-1 fish were estimated by statistically fitting distributions representing ages, to the length frequency data for every year in the time series using the *mixdist* package in R (R Core Team 2013). On average, 4,300 randomly sampled Rainbow Smelt are measured each year which provide excellent sample sizes to use distribution mixture analyses to fit age distributions to the

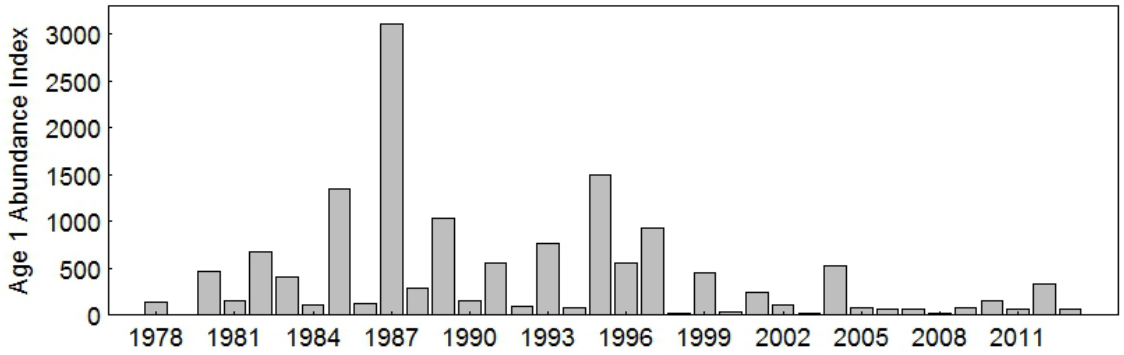

Figure 3. Stratified mean catch of age-1 Rainbow Smelt from bottom trawls in U.S. waters of Lake Ontario shoreward of the 140-m (459-ft) bottom contour in late May-early June, 1978 - 2013.

length data and calculate the proportion of age-1 fish in the population. Age-1 abundance index estimates from aging structure methods (fin rays) and length frequency distribution mixture analysis, were significantly correlated (adjusted r^2= 0.96, n=28, Weidel et al. 2011).

Length frequency-based age analysis indicated that age-1 Rainbow Smelt abundance index declined in 2013 relative to 2012, and was among the lowest age-1 abundance indices measured (Figure 3). The low abundance of the yearlings in 2013 is likely a result of cannibalism by abundant age-1 smelt in 2012. The two year cyclic pattern of smelt abundance is common for species such as Rainbow Smelt when abundant age-1 fish reduce the following year class abundance (Lantry and Stewart 2000).

Diversity in the pelagic prey fish community has been identified as a Lake Ontario fisheries management objective. For instance, in the most recent version of the Lake Ontario fish community objectives Stewart et al. (2012) included the offshore pelagic objective 2.3 which addresses prey fish diversity in the lake: "*Increase prey-fish diversity - maintain and restore a diverse prey-fish community that includes Alewife, Lake Cisco, Rainbow Smelt, Emerald Shiner, and Threespine Stickleback*". Generally fish community diversity and especially pelagic prey fish community diversity has declined over the past 30 years. Weidel et al. (2013) highlighted the declining diversity in Lake Ontario bottom trawl catches and specifically noted changes in the previously prevalent Rainbow Smelt population. In 2013, the proportion of Rainbow Smelt in all trawls was near the lowest in the 36 year time series (3.1%, Figure 4). This decline follows a similar decline in the diversity of all species caught, which is heavily influenced observed changes in the pelagic fish community where Rainbow Smelt are increasingly rare and catches are dominated by Alewife (Figure 5). We will continue to report fish community diversity statistics as one potential means to evaluate the current restoration projects such as those focused on deep water coregonid resotration.

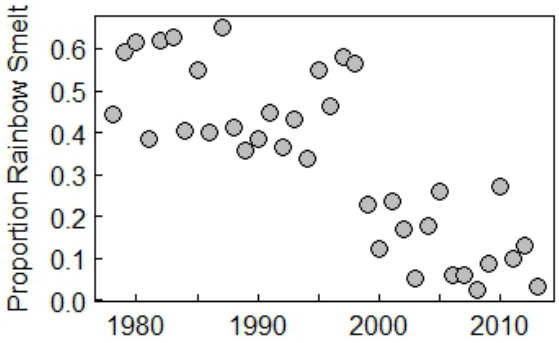

Figure 4. Proportion of Rainbow Smelt in the total pelagic prey fish catch (by number) in all bottom trawls collected on USGS and NYSDEC Lake Ontario four bottom trawl assessments.

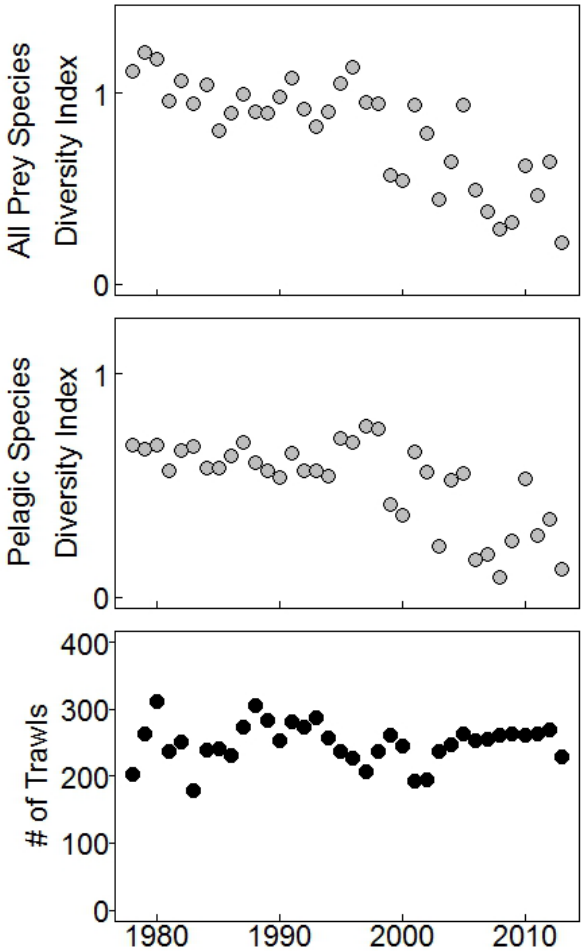

***Figure 5. Diversity indices (Shannon Diversity Index, see Weidel et al. 2013 for methods) for the most common 20 prey fishes collected in bottom trawls (top panel), the 14 pelagic species (middle panel), and the total number of trawls collected each year (bottom panel) in USGS and NYSDEC three prey fish bottom trawling assessments, Lake Ontario 1978-2013. Primary pelagic prey fish species include Alewife, Rainbow Smelt, Cisco* Coregonus artedi*, Threespine Stickleback* Gasterosteus aculeatus*, Emerald Shiner* Notropis atherinoides*, and Gizzard Shad* Dorosoma cepedianum.**

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Benthic Prey Fish Assessment, Lake Ontario 2013

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Abstract

The 2013 benthic fish assessment was delayed and shortened as a result of the U.S. Government shutdown, however the assessment collected 51 of the 62 planned bottom trawls.

Over the past 34 years, Slimy Sculpin abundance in Lake Ontario has fluctuated, but ultimately decreased by two orders of magnitude, with a substantial decline occurring in the past 10 years. The 2013 Slimy Sculpin mean bottom trawl catch density (0.001 ind.·m^{-2}, s.d.= 0.0017, n = 52) and mean biomass density (0.015 g·m^{-2} , s.d.= 0.038, n = 52) were the lowest recorded in the 27 years of sampling using the original bottom trawl design. From 2011-2013, the Slimy Sculpin density and biomass density has decreased by approximately 50% each year. Spring bottom trawl catches illustrate Slimy Sculpin and Round Goby Neogobius melanostoma winter habitat overlaps for as much as 7 months out of a year, providing opportunities for competition and predation. Invasive species, salmonid piscivory, and declines in native benthic invertebrates are likely all important drivers of Slimy Sculpin population dynamics in Lake Ontario.

Deepwater Sculpin Myoxocephalus thompsonii*, considered rare or absent from Lake Ontario for 30 years, have generally increased over the past eight years. For the first time since they were caught in this assessment, Deepwater Sculpin density and biomass density estimates declined from the previous year. The 2013 abundance and density estimates for trawls covering the standard depths from 60m to 150m was 0.0001 fish per square meter and 0.0028 grams per square meter. In 2013, very few small (< 80 mm) Deepwater Sculpin were caught and most sculpin were at sites of 150 meters or greater, which is in contrast to previous years when juvenile fish were caught around 80-100 meters. The reduced effort and late seasonal timing of the 2013 assessment make it difficult to have high confidence in declines observed in 2013, however observed Alewife* Alosa psuedoharengus *abundance increases and reduced juvenile Deepwater Sculpin catches are consistent with the hypothesis that Alewife negatively influence Deepwater Sculpin recruitment.*

Nonnative Round Gobies were first detected in the USGS/NYSDEC Lake Ontario spring Alewife assessment in 2002. Since that assessment, observations indicate their population has expanded and they are now found along the entire south shore of Lake Ontario, with the highest densities in U.S. waters just east of the Niagara River confluence. In the 2013 spring-based assessment, both the abundance and weight indices increased slightly as compared to 2012. The number index value of 16.6 was 30% of the maximum number observed in 2008 when the number index was 95.2. Round Goby density estimates from the 2013 fall benthic prey fish survey were 33 times greater than fall Slimy Sculpin density, indicating Round Goby are now the dominant Lake Ontario benthic prey fish.

Slimy Sculpin – Results and Discussion

The 2013 Slimy Sculpin density and biomass density were the lowest recorded in the time series using the standard Yankee trawl (density mean = 0.0009 $g \cdot m^{-2}$, s.d. = 0.0017, n= 52; biomass density = 0.0160, s.d. = 0.0389, n=52). For comparison, these statistics are relatively similar to Slimy Sculpin bottom-trawl based biomass density estimates for Lake Michigan in 2012 (mean =0.021 $g \cdot m^{-2}$), where time series indicate Slimy Sculpin have experienced a substantial decline over the past 8-10 years (Bunnell et al. 2013). Interestingly, the maximum biomass densities observed in Lake Michigan were similar to those observed in Lake Ontario (approximately 0.15 $g \cdot m^{-}2$), yet in Lake Michigan those maximums were observed in 1976 and 2006 (Bunnell et al. 2013), where Lake Ontario maxima were observed in the 1980's and 1990 (Figure 1).

The apparent Slimy Sculpin density decline is most drastic between 2003 and 2004, but our understanding of this decline is confounded by the fact that from 2004 -2010 the assessment used alternative bottom trawl designs which have different catchability for Slimy Sculpin relative to the standard Yankee bottom trawl. Since 2011, the assessment returned to the original trawl gear, and over those three years, catches indicated Slimy Sculpin density has declined, by approximately 50% each year (Figure 2). To help demonstrate this density change, in the area encompassed in an American football field there would have been 750 Slimy Sculpin in the 1980's, in 2013 there would have been 5 Slimy Sculpin.

Evidence exists for both top-down and bottom-up forces driving the Slimy Sculpin density changes. Previous studies suggested that predation by ever-increasing numbers of stocked juvenile Lake Trout accounted for sculpin declines in the early 1980's (Elrod and O'Gorman 1991; Owens and Bergstedt 1994). The correlative evidence cited observations where stocked Lake Trout were prevalent at depths <70m , Slimy Sculpin declines were greatest, while at depths greater than 70m, few stocked Lake Trout were captured and Slimy Sculpin density did not decline (Owens and Bergstedt 1994). While it is likely that Lake Trout predation has influenced Slimy Sculpin populations over short time scales, during the past 20 years juvenile Lake Trout abundance has declined (Lantry and Lantry 2010) concurrently with Slimy Sculpin declines.

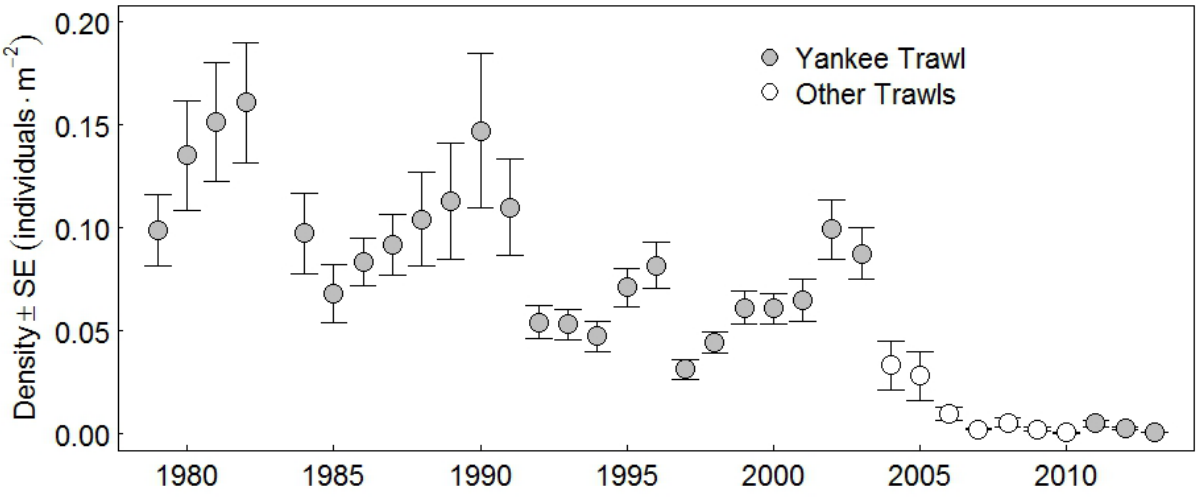

Figure 1. Slimy Sculpin density for U.S. waters, of Lake Ontario, covering depths from 8-175m, 1978–2013. Open circles denote years when alternative bottom trawls were used. The standard, 11.8m Yankee bottom trawl, has been used since 2011.

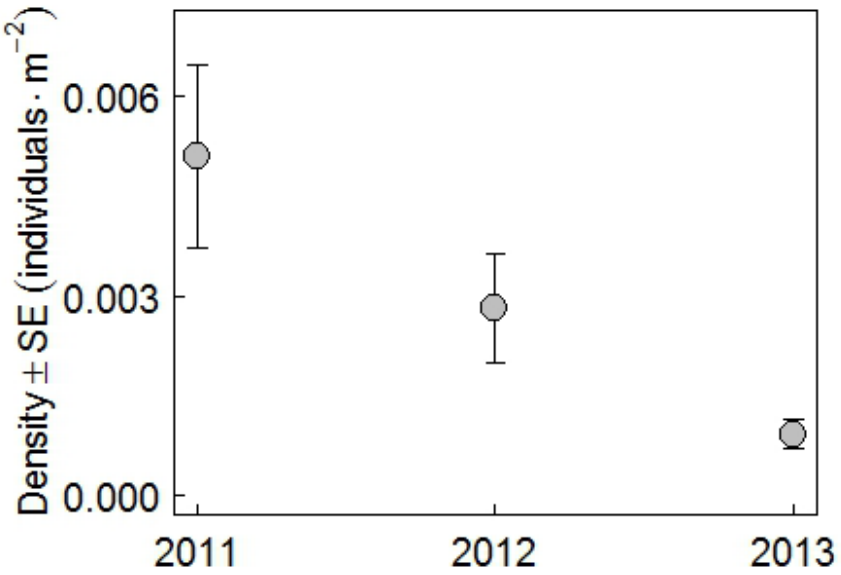

Figure 2. The three most recent Lake Ontario Slimy Sculpin density estimates from fall USGS assessments indicate the density has decreased by approximately 50% each year.

Owens and Weber (1995) suggested that the Slimy Sculpin density decrease between 1991 and 1992 was attributed to a collapse in their preferred food resource, the burrowing amphipod *Diporeia*. This bottom-up effect was most evident in southeastern Lake Ontario which contained the highest densities of poor physiological conditioned Slimy Sculpin. Sharp sculpin density declines in this region coincided with a collapse in the local *Diporeia* population in 1990's (Owens et al. 2003). When abundant, energy rich *Diporeia* were the primary Slimy Sculpin forage item, however in 1992 following *Diporeia* decline, this item was rare in sculpin diets (Owens and Dittman 2003).

An alternative explanation for sculpin declines, especially those observed within the past 13 years, implicates nonnative Round Goby. In laboratory trials, Bergstrom and Mensinger (2009) found Round Goby were superior competitors to Slimy Sculpin for limited benthic invertebrate resources. The timing of the sharp Slimy Sculpin density decline in 2003-2004 coincides with an increase in nonnative Round Goby density (Figure 3 and Figure 8) Figure 3 illustrates how Round Goby and Slimy Sculpin habitat overlaps in early spring. Weidel et al. (2013) provided data to suggest Round Goby inhabit these deeper waters beginning in October, suggesting these two species may overlap in their distribution for up to seven months of a given year. Comparing fall Round Goby density estimates with Slimy Sculpin provides additional evidence for the negative influence of Round Goby on Slimy Sculpin in Lake Ontario (Figure 8, Round Goby - Results and Discussion section).

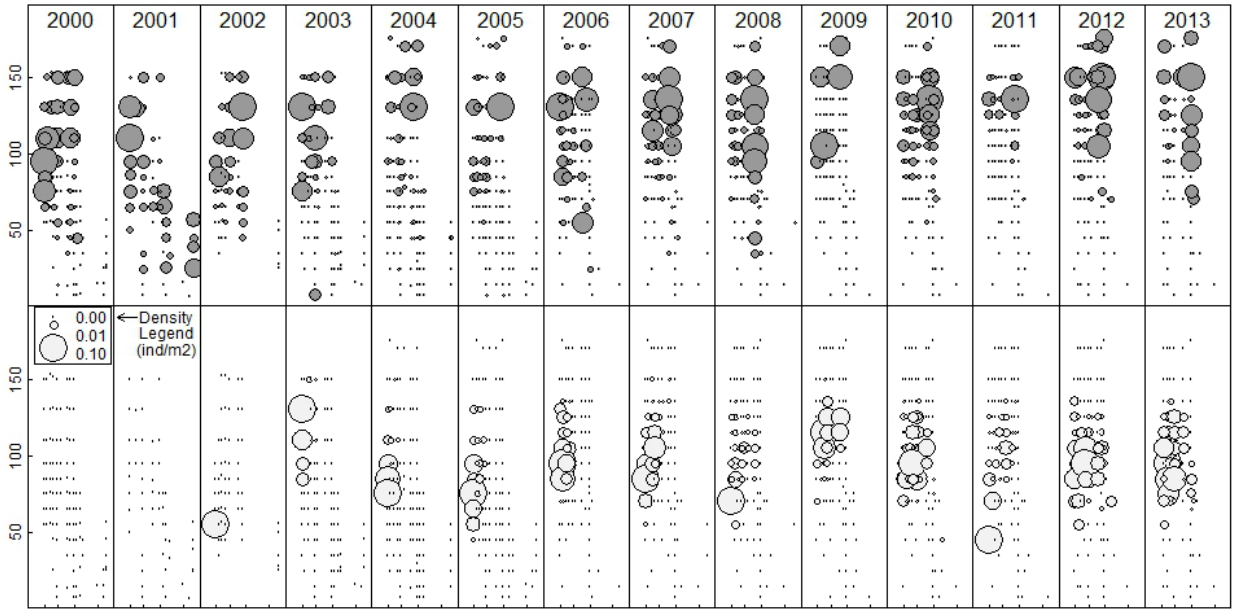

Figure 3. October density estimates expressed as bubble size for Slimy Sculpin (top panels) and Round Goby (bottom panels). Each panel represents a year and bubbles are plotted along a depth gradient (y-axis) and a West to East gradient of transects that extend from Olcott, NY (western or left edge) to the Eastern Basin (eastern or right edge). Prior to Round Goby appearance in 2002, Slimy Sculpin were commonly found from depths to 30 to 150 meters, but are now restricted to deeper depths and most commonly found on the Oswego NY transect.

Deepwater Sculpin – Results and Discussion

Deepwater Sculpin, once considered extirpated from Lake Ontario, have increased substantially over the past seven years. These native, deep water prey fish were absent or rare in all USGS and NYSDEC bottom trawls surveys from 1979-2004 and were first captured on the fall prey fish assessment in 2005 (Lantry et al. 2007). In the 2013 USGS fall benthic assessment, density and biomass density declined to 0.0001 individuals$\cdot$m^{-2} and biomass density of 0.0028 g$\cdot$m^{-2} (Figure 4).

For comparison, Lake Michigan Deepwater Sculpin biomass density ranged from 2.0 to 0.5 g$\cdot$m^{-2} from the 1970's through the early 2000's, but have declined recently (Bunnell et al. 2013). Bunnell et al. (2013) attribute this recent decline to depth distribution change rather than a true lake wide density decline. It should be noted the 2013 benthic fish assessment was delayed and shortened as a result of the U.S. Government shutdown, however the assessment collected 51 of the 62 planned bottom trawls. The reduced effort and late seasonal timing of the 2013 assessment made it difficult to have high confidence in declines observed in 2013.

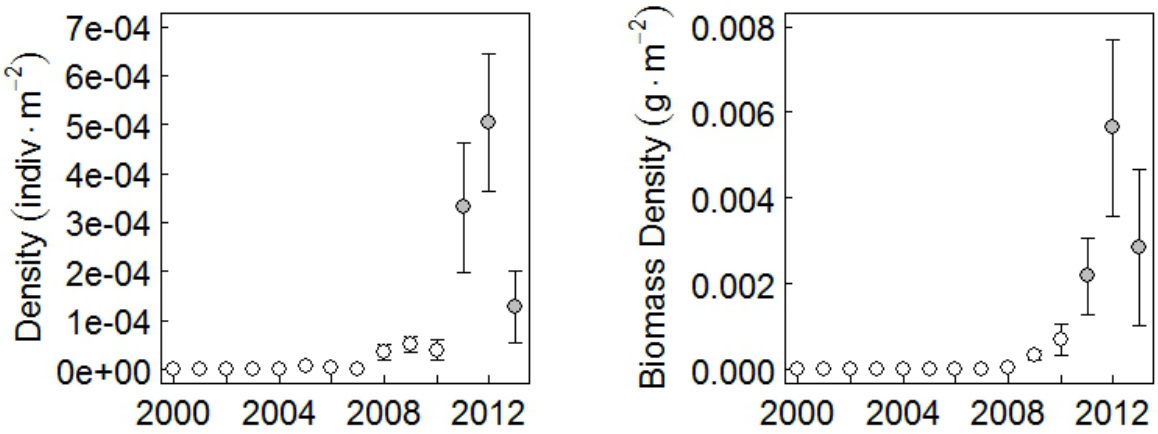

Figure 4 Deepwater Sculpin biomass density and density estimated for U.S. waters, of Lake Ontario, as assessed by the USGS fall benthic prey fish survey(2005–2013). Open circles represent data from alternate bottom trawl designs, the grey filled circles indicate years when the standard, Yankee bottom trawl was used.

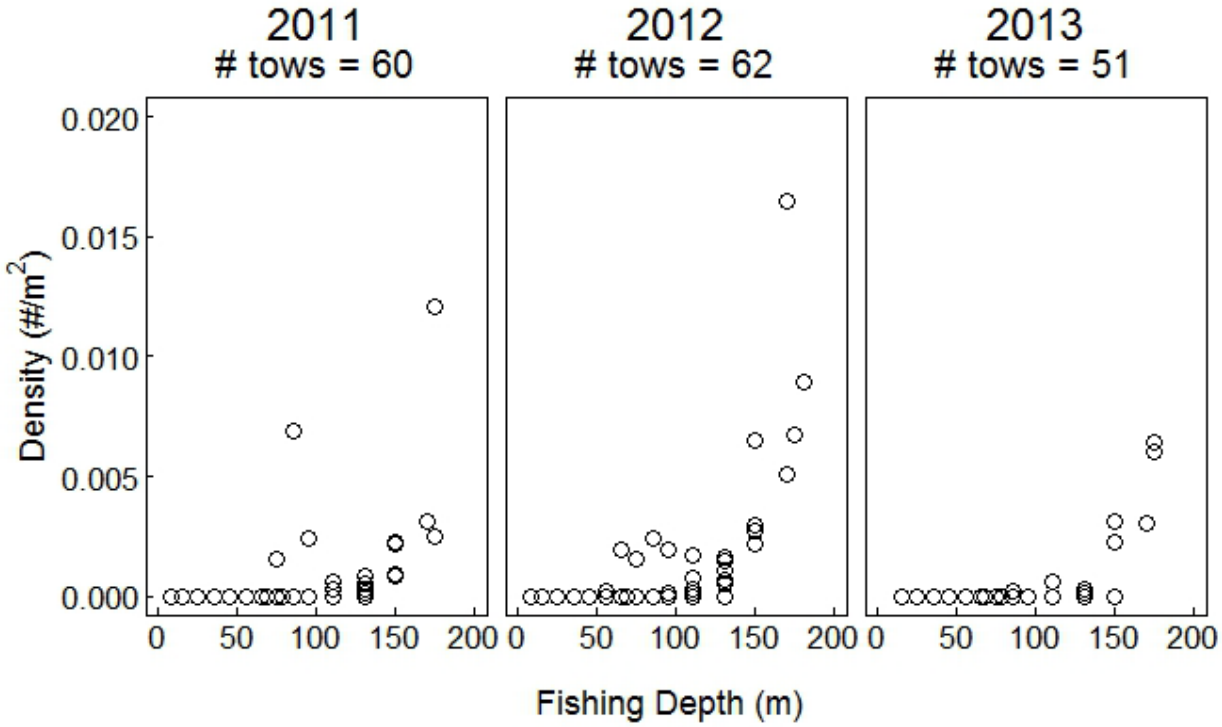

Figure 5. Deepwater Sculpin density based on fishing depth during the Lake Ontario USGS Benthic Prey Fish Assessment, 2011-2013.

This species has been described as an "indicator of well being of the deepwater ecosystem" (COSEWIC 2006). The presence of juvenile Deepwater Sculpin in the 2010-2012 assessments indicated favorable conditions for young Deepwater Sculpin survival, which are often caught in depths of 70-100m (Weidel et al. 2013). That increase in juveniles may have been a result of reduced Lake Ontario Alewife abundance, which has been linked to depression of Deepwater Sculpin in Lake Michigan (Madenjian et al. 2005). The lack of such young fish or catches in the 70-100m range in the 2013 assessment (Figure 5) is consistent with the hypothesized negative influence of Alewife, as Alewife abundance has increased over the past 2 years. Figure 5 consistently illustrates that across all years of observation Deepwater Sculpin densities are increasing at the deepest depth surveyed. For accurate lake-wide density estimates and better understanding of Deepwater Sculpin behavior, depths greater than 180m must be sampled with bottom trawls.

Deepwater Sculpin yearly statistics are based on the fall benthic prey fish assessment bottom trawls, from 60 m to 150 m, at six transects along the south shore of Lake Ontario extending from Olcott, NY to Oswego, NY. Although depths greater than 150m are fished, these catches are not included in yearly statistics as they were not sampled from 2005 to 2010. Since 2005, the number of trawls in these depths for a given year has ranged from 35 to 45 and yearly catch rates are not lake-area weighted as with other Lake Ontario prey fish assessments. From 2004-2010 various bottom trawls were used on this survey in an attempt to reduce *Dreissena* mussel catch. Deepwater Sculpin catchability likely differed between these alternate gears and the standard Yankee bottom trawl. This gear change limits our confidence in estimating the rate of Deepwater Sculpin increase for these years however the continued increasing catches are strong evidence the population is increasing.

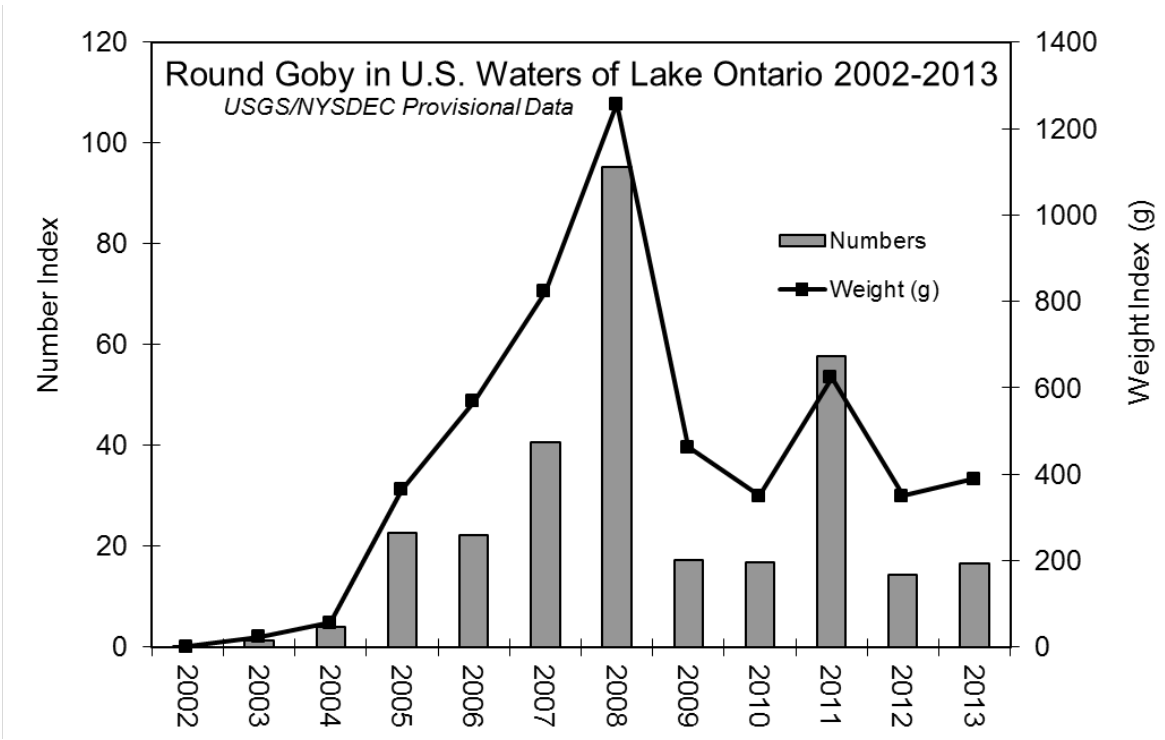

Figure 6. Area-stratified, Round Goby abundance and weight indices based on spring bottom trawl assessment in U.S. waters of Lake Ontario shoreward of the 160-m bottom contour (no Round Gobies were caught prior to 2002). The weight index is calculated as the product of the numbers index and the average weight of all Round Gobies measured.

Round Goby – Results and Discussion

Round Goby a suspected ballast water introduction, were first detected in the Great Lakes Basin in the St. Clair River between Lakes Huron and Erie in 1990 (Jude et al. 1992). Round Goby were first reported in southwestern Lake Ontario in 1998 near the entrance to the Welland Canal (Owens et al. 2003). The first collection of Round Gobies in the standard USGS/NYSDEC spring assessment trawling occurred in 2002. Since then, the Round Goby population has expanded substantially and Round Gobies are now found along the entire south shore of Lake Ontario, with the highest population densities in U.S. waters just east of the Niagara River mouth (Walsh et al. 2006, 2007)

Given the growing importance of Round Goby as a member of offshore and nearshore fish communities in Lake Ontario, depth-stratified and area weighted abundance and weight indices were developed. (Walsh et al. 2006). Both indices peaked in 2008, followed by a sharp drop in both abundance and weight indices (Figure 6). This pattern of exponential growth followed by a population crash is characteristic of expanding populations, and suggests that the Round Goby population may have exceeded a carrying capacity. Mechanisms driving the sharp reductions between 2008 and 2009 are unknown, however Round Goby can be affected by botulism and VHS, so it is also possible that diseases impacted the species when density increased. We believe that the Round Goby peak abundance observed in 2008 may represent the maximum density for Round Goby in Lake Ontario. The relative standard error of the abundance index was initially high when catches were sporadic but has since decreased and remained relatively stable indicating the species is more uniformly distributed (Figure 7).

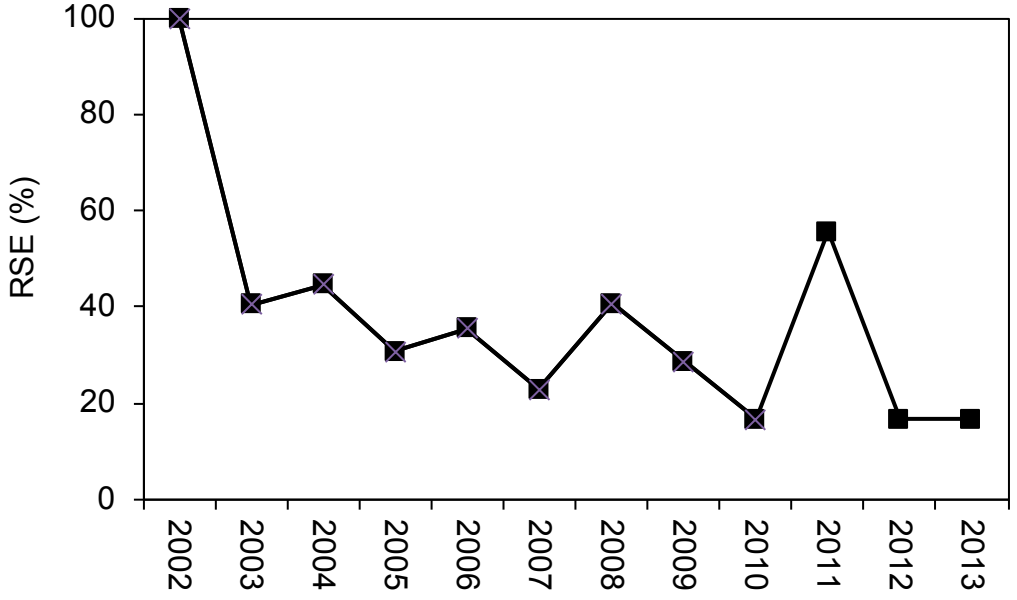

Figure 7. Relative standard error (RSE) for Round Goby abundance index in U.S. waters of Lake Ontario, 2002-2011 (no Round Goby were collected before 2002). RSE is calculated as 100*(standard error of the index/the index) and represents abundance index variability.

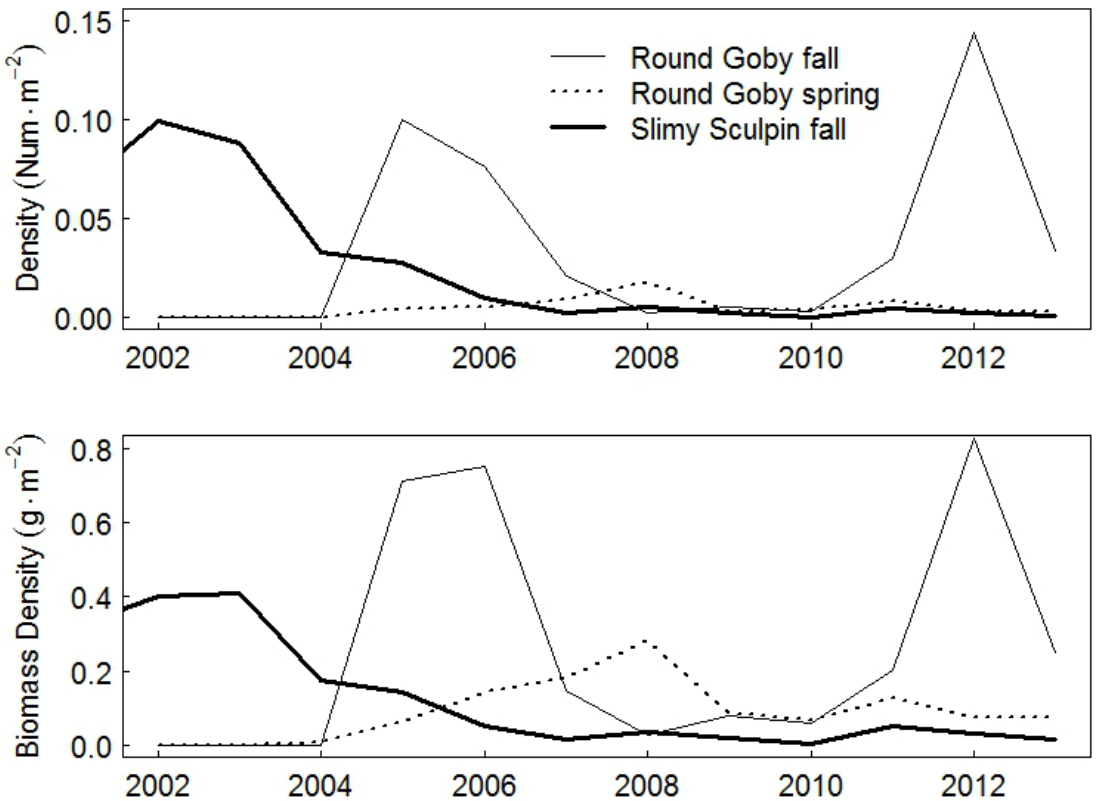

Figure 8. Round Goby density and biomass density comparisons for spring and fall bottom trawl assessments. We expect fall value to be higher than the spring assessement due to the use of different bottom trawl that is more efficient at collection benthic fishes. A time series for Slimy Sculpin, which were previously the most abundant benthic prey fish, is included for reference.

Contrasting Round Goby abundance with other common benthic prey fishes illustrates the role of this nonnative in the Lake Ontario fish community. In addition to estimating Round Goby abundance using spring bottom trawl assessment data we can also use data from the fall benthic prey fish assessment conducted in October. This fall assessment uses a different trawl design that is more effective at capturing benthic fishes than the trawl used in the spring assessment, resulting in higher density and biomass density estimates (Figure 8). Based on the basic mean density observed in all trawl catches during the fall assessment Round Goby were 33 times more dense than Slimy Sculpin (0.033 and 0.001 fish per square meter, respectively). In addition, the fall assessment-based time series for Round Goby shows a different pattern of peak abundance than the spring assessment data. Future study is focused on explaining the different patterns observed between these seasonal assessments and quantifying the role of this now-important benthic prey fish in the Lake Ontario food web.

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Cormorant Management Activities in Lake Ontario's Eastern Basin

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Double-crested cormorants (*Phalacrocorax auritus*) on the Great Lakes have undergone large population changes in the past half century (Hatch 1995). The Great Lakes population had declined throughout the 1960s and early 1970s, from about 900 nests in 1950 to 114 in 1973 (Weseloh and Collier 1995, Weseloh et al. 1995, Weseloh and Pekanik 1999). This decline, along with that of other fish-eating birds, was associated with high levels of toxic contaminants, particularly DDE and PCBs, found in the Great Lakes ecosystem (Miller 1998). Due to pollution control programs, contaminant levels were reduced and cormorant numbers made a remarkable recovery in the Great Lakes and elsewhere (Price and Weseloh 1986). In 2004, there were over 9,800 pairs of cormorants in Lake Ontario's eastern basin, on six active Canadian sites and Little Galloo Island (nests were removed from three other potentially active American sites).

Little Galloo Island, in the eastern basin of Lake Ontario, was first colonized by cormorants in 1974. Peak abundance at Little Galloo Island, in 1996, reached over 8,400 nests. Concerns about the impacts cormorants have on fish populations, other colonial waterbird species, private property and other ecological values followed this population expansion. Little Galloo Island currently supports the largest cormorant colony and one of two Caspian tern (*Sterna caspia*) colonies in New York State, along with a major ring-billed gull *(Larus delawarensis)* colony.

The New York State Department of Environmental Conservation (NYSDEC) and the U.S. Fish and Wildlife Service (USFWS) began to examine the impacts of cormorants in 1992. In 1998, analyses by the NYSDEC and the United States Geological Survey (USGS) identified a connection between cormorant numbers and increased mortality of young smallmouth bass (*Micropterus dolomieui*) (Adams et al. 1999, Lantry et al. 2002).

Implementation of a cormorant management plan for U.S. waters of the eastern basin of Lake Ontario began in 1999. The goal of this management plan was to improve the benefits people derive from Lake Ontario's eastern basin ecosystem primarily by reducing the negative impacts of abundant double-crested cormorants on the structure and function of the warmwater fish community, on nesting habitats, and on other colonial waterbird species.

The plan's major objective required reaching and maintaining a target cormorant population associated with 1,500 breeding pairs, including chicks and non-breeding birds, on Little Galloo Island. This was the maximum cormorant population level prior to the increase in mortality of young bass. It is important to note that this objective doesn't focus on numbers of nesting birds only, but on reducing the total number of cormorant feeding days, a measure by which fish consumption is assessed (Weseloh and Casselman unpublished report). The feeding day target (which involves nesters, chicks, and non-breeding birds) is 780,000.

Methods

Cormorant management in the New York waters of Lake Ontario's eastern basin has focused on Bass, Calf, Gull and Little Galloo Islands. These islands are located in Jefferson County, New York. Gull and Little Galloo Islands are owned by NYSDEC. Bass and Calf Islands are privately owned. The islands contain several colonial waterbird colonies (Table 1), some, but not all, of which were monitored annually. Management and monitoring activities were carried out by Region 6 NYSDEC staff, sometimes with assistance of U.S. Department of Agriculture, Wildlife Services personnel.

Nest removal began on Gull and Bass Islands in 1994. Calf Island was included in removal activities following an attempt by cormorants to

establish a colony there in 1997. Nest removal teams included two to four people. Ground nests were removed by hand while tree nests were removed with a telescoping pole or shotgun. Each nest removed was scattered as much as possible to discourage rebuilding. Cormorants that nested too high in trees for nest removal or repeatedly rebuilt destroyed nests were culled (Table 2).

Annual treatment of accessible cormorant nests on Little Galloo Island with food grade vegetable oil began in spring 1999 following methods similar to those of a study conducted in Ontario (Shonk 1998). Vegetable oil was applied from a backpack sprayer unit in sufficient volume to cover the exposed surface of each egg, approximately 0.2 oz (6 ml)/egg. Oil was applied three to five times per season, at roughly two week intervals, to eggs in nests accessible from the ground. Oiling at two week intervals ensured that most nests would be treated at least twice during the incubation period. Each nest or group of nests treated was marked with spray paint to minimize missed or repeat treatment. Two or three teams, of two to three persons each, completed the oiling in three hours or less (not including travel time). Each team effectively oiled 500 to 700 nests per hour, depending on nest density. Oiling teams recorded the number of nests treated, the number of eggs in each nest, the number of chicks observed and the number of nests not treated (tree or control nests).

Limited culling of cormorants was conducted in 2004 in order to determine the efficacy of the technique, assess non-target species disturbance and add to the effect of non-lethal removal efforts. Beginning in 2005 culling was used as a full scale management technique. Most culling was done using .22 or .17 caliber rimfire rifles. Culling teams consisted of at least two people. Carcasses were disposed of by burial or composting.

In addition to nest removal, oiling and culling activities, the NYSDEC continued cormorant diet studies, begun in 1992, by collecting regurgitated pellet samples at Little Galloo Island from mid-April through mid-October. All samples were analyzed by the U. S. Geological Survey Great Lakes Science Center (Johnson et al. 2013). The final collections of this series were made in 2013.

Colony feeding days for Little Galloo Island cormorants were calculated according to the Casselman-Weseloh model (1992) modified for culling where:

Colony Feeding Days = N Adults x 158 + N Subadults x 112 = N Chicks x 92

and:

N Adults = (peak nest count x 2)-(N birds culled/2)

N Subadults = peak nest count/5

N Chicks = untreated nests x nest productivity rate

No correction was made for in-season bird movements or mortality.

Results

Since the nest removal program began on Gull, Bass and Calf Islands in 1994, nesting attempts (including re-nests) on these islands have varied from year to year with a peak of 1,367 nests in 2000 (Table 2).

Since 2007, greatly increased landowner activity on Bass Island has prevented significant waterbird production and made active cormorant management unnecessary. No cormorant nesting attempts were observed on Calf Island this year (Table 2.)

On Gull Island a total of 1,072 nests were removed over seven visits between May and July 2013, and no birds were culled. Peak one day nest removal was 276 (Table 2). The total count of nests removed increased by 50% while the peak count decreased 29% relative to 2012.

Eggs were oiled on four occasions at Little Galloo Island between May and July 2013. The peak number of nests oiled on Little Galloo Island was 2,387 (Table 2),and 366 cormorants were culled in 2013. There were 364 unoiled tree and control nests. Peak nest count was 2,387, including control subcolonies, tree, and “empty” but apparently occupied, nests (Table 1). Both total and peak nest counts were approximately 160 nests higher than in 2012. Note that peak nest counts do not necessarily correspond to nest numbers reported in Canadian Wildlife Service trend reports, which may or may not represent peak nesting. Hatching success (number of chicks hatched per number of eggs counted) for oiled

nests was estimated to be less than 1%.

We estimated that approximately 730 cormorants fledged on Little Galloo Island this year, mostly from a control (unoiled) subcolony, some from tree nests, and a few from incidentally untreated ground nests.

We estimated 874,876 feeding-days in 2013 which was above the target of 780,000, but well below the 999,400 estimate in 2011 (Figure 1). Since nest counts and feeding day estimates showed a moderate increase this year (Figure 1), an increase in management effort may be needed in 2014.

Discussion

In April 2000, NYSDEC accepted a Final Environmental Impact Statement (NYSDEC 2000) regarding eastern Lake Ontario cormorant management. The statement outlined a five year process of reducing the Little Galloo Island cormorant population to a target level described as a population associated with 1,500 nesting pairs. This target population would produce approximately 780,000 feeding days, including contributions of sub-adults and young-of-the-year. It was expected that less intensive control would then maintain the population at or near the target level. Using techniques available at the time, population objectives were not reached within the five years projected. The U.S. Fish and Wildlife Service 2003 Federal Public Resource Depredation Order (USFWS 2003) allowed lethal control (culling), which was used to reduce cormorant numbers more rapidly, beginning in 2004. The population has been near the feeding-day target since 2006 and dropped below the target for the first time in 2010. The project has been operating at maintenance level since 2007.

Reduced population levels at Little Galloo Island, probably related to egg oiling, became noticeable in 2002. Johnson et al. (2004) reported a substantial decline in fish consumption at this colony due both to lack of consumption by chicks and lower numbers of feeding adults resulting from reduced recruitment. This reduction has continued (Johnson and Farquhar 2008). Radiotelemetry studies indicated that nest oiling also reduced the residence time of nesting adults on the colony, further reducing consumption (Mazzocchi 2003).

Managing by nest oiling only, nesting pairs of cormorants on Little Galloo Island were reduced by about 15% annually due to attrition. The use of adult culling reduced the breeding population more quickly, by increasing the rate at which adults are removed from the population (Figure 1). In addition to the direct effect of removing adults, experience with culling at Presqu'ile Provincial Park (Ontario), the Niagara River, and on Bass Island in the eastern basin of Lake Ontario, suggests that about half of nests will be abandoned and not re-occupied after removing one adult, increasing the overall rate of population reduction.

Impacts on fish species of interest have declined faster than fish consumption as a whole, because cormorant diet has become dominated by round goby (*Neogobius melanostomus*) (Johnson et al. 2009). Management, along with the major dietary shift, has moved the system towards meeting objectives for protecting fish communities by substantially reducing consumption of smallmouth bass by cormorants on Little Galloo Island (Johnson et al. 2006).

Many variables can influence the results of cormorant management over time (NYSDEC 2000). Immigration and emigration rates to and from sites within the eastern basin are perhaps the most likely factors to consider. Although eastern basin cormorant numbers have generally declined, at times immigration has exceeded emigration within New York waters of the basin.

Site-specific management is a moderately labor intensive undertaking, although not particularly expensive in comparison to other predation management projects, such as sea lamprey (*Petromyzon marinus*) management (Schiavone and Adams 1995). These management actions can be effectively implemented to resolve conflicts on the local scale. The efforts undertaken in New York over the past few years have successfully met objectives for limiting production of cormorants on New York's Lake Ontario eastern basin islands.

Cormorant management, whether implemented

locally, regionally, or range-wide, should be considered in a broad, long term context to ensure that management actions remain sound, integrated and effective.

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Table 1. Estimated breeding pair numbers for colonial waterbirds on eastern basin Lake Ontario islands. Numbers for cormorants are for active nests after management activity and may not match Canadian Wildlife Service trend numbers (dash indicates not checked for given species).

Species	Island	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Double-crested Cormorant	Little Galloo Isl	5,681	5,119	5,440	4,780	4,251	3,967	3,401	2,692	2,959	2,492	2,751	1,758	2,831	2,227	2,387
	Gull Island	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	Bass Island	0	0	0	0	35	12	5	5	5	0	0	0	0	0	0
	Calf Island	-	-	-	-	-	0	-	-	-	0	0	0	0	0	0
Ring-billed Gull	Little Galloo Isl	53,000	-	-	-	60,000	-	-	-	-	37500	-	-	-	43324	-
	Gull Island	0	-	-	-	0	-	-	-	-	0	-	0	-	0	0
	Bass Island	2,300	-	-	-	2,500	-	-	-	-	0	-	0	-	0	0
Herring Gull	Little Galloo Isl	275	-	-	-	313	-	-	367	0	375	356	364	459	512	645
	Gull Island	45	-	-	-	42	-	-	40	67	58	42	89	91	52	89
	Bass Island	10	-	-	-	10	-	-	10	16	0	0	0	0	0	0
Great Black-backed Gull	Little Galloo Isl	8	-	19	15	12	-	-	4	1	1	0	0	0	0	0
	Gull Island	0	-	0	1	0	-	-	0	0	9	0	0	0	0	0
	Bass Island	0	-	0	0	0	-	-	0	0	9	0	0	0	0	0
Caspian Tern	Little Galloo Isl	1,445	1,350	1,590	1,585	1,658	1,560	1,788	1,589	1,580	1,376	1,499	1,472	1,934	2,332	1848
Black-crowned Night Heron	Little Galloo	1	1	1	1	3	3	4	0	0	1	0	0	0	0	0
	Gull Island	41	20	50	24	35	78	81	77	127	78	78	105	151	44	56
	Bass Island	9	36	13	36	47	17	46	32	0	0	0	0	0	0	0
	Calf Island	6	-	0	-	-	0	-	-	-	-	13	0	0	0	0

Table 2. Number of cormorant nests removed or oiled and adults culled; nests with no intact eggs were not oiled. [2]Cumulative nests removed. Number in ( ) is peak one day count

Island	Activity	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Little Galloo Island	Peak nests oiled	5,627	4,301	3,865	3,707	3,389	3,359	2,896	2,275	2,502	1,804	2,166	1,104	2,000	2,227	2,387
	Nests removed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	DCCO culled	-	-	-	-	-	18	686	620	709	382	798	145	569	362	366
Bass Island [2]	Peak nests oiled	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nests removed	37 (37)	793 (757)	0 (0)	986 (279)	260 (117)	959 (348)	935 (600)	477 (174)	470 (110)	0 (0)	0(0)	0(0)	0(0)	0 (0)	0 (0)
	DCCO culled	-	-	-	-	-	167	281	200	124	0	0	0	0	0	0
Gull Island [2]	Peak nests oiled	0	0	0	0	0	0	0	0	0	0		0	0	0	0
	Nests removed	146 (111)	574 (478)	21 (21)	157 (77)	1,427 (486)	485 (188)	0 (0)	113 (110)	273 (137)	671 (266)	741 (261)	604 (275)	659 (302)	711 (391)	1,072 (276)
	DCCO culled	-	-	-	-	-	3	0	0	20	2	0	0	0	29	0
Calf Island [2]	Peak nests oiled	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nests removed	0	0	0	0	0	415 (539)	0	0	0	161 (111)	55 (52)	0	0	0	0
	DCCO culled	-	-	-	-	-	37	0	0	0	6	2	0	0	0	0

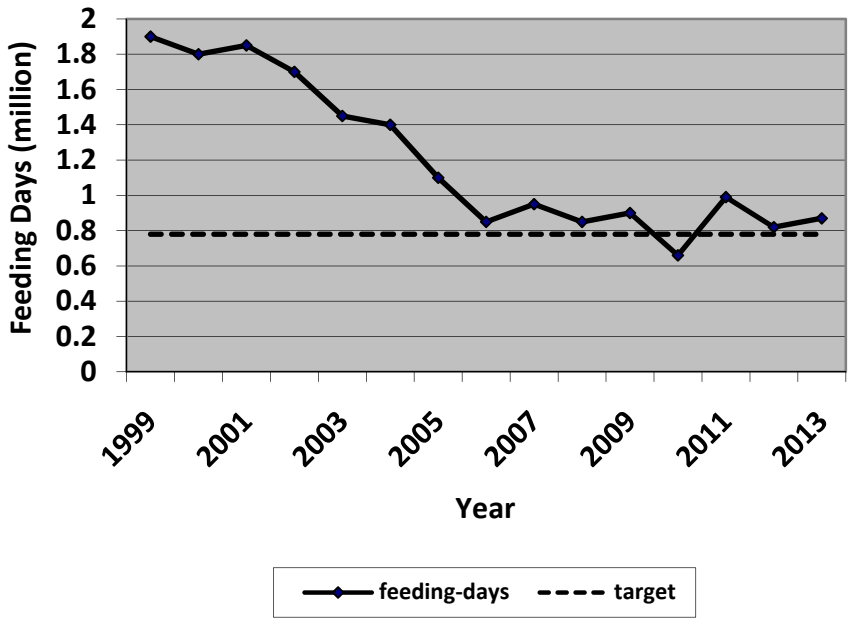

Figure 1. Trend in cormorant feeding days for the Little Galloo Island colony.

Double-Crested Cormorant Studies at Little Galloo Island, Lake Ontario in 2013: Diet Composition, Fish Consumption and the Efficacy of Management Activities in Reducing Fish Predation

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For almost two decades Little Galloo Island (LGI) has supported a large colony of Double-crested Cormorants (*Phalacrocorax auritus*) in the eastern basin of Lake Ontario. Cormorant nest counts on the island since the early 1990's have averaged 4,297 per year. However, less than 2,000 pairs have nested on the island in three of the past five years. The highest count was reached in 1996 with 8,410 nesting pairs on the island. Johnson et al. (2013) estimated that cormorants from LGI alone have consumed 504 million fish since 1992. The proliferation of cormorants in the eastern basin of Lake Ontario coincided with declines in two important recreational fish species, smallmouth bass (*Micropterus dolemieu*) and yellow perch (*Perca falvescens*). Lantry et al. (2002) and Burnett et al. (2002) provide convincing evidence linking cormorant population increases to declining eastern basin smallmouth bass and yellow perch stocks. Decline of these fish stocks was evident only in the eastern basin, suggesting a localized problem, which is consistent with the halo effect where large piscivorous waterbird colonies may deplete local fish stocks (Birt et al. 1987).

The year 2013 marked the twenty second consecutive year of study of the food habits and fish consumption of LGI cormorants and the fifteenth consecutive year evaluating the efficacy of management activities to control the reproductive success of cormorants nesting at LGI. The program consists mainly of spraying cormorant eggs with food grade vegetable oil as well as the culling of adult and immature birds. This paper reports the findings of work carried out in 2013 at LGI.

Methods

Diet Examination

Diagnostic prey remains recovered in regurgitated pellets were used to describe the diet of Double-crested Cormorants on LGI in 2013. A total of 250 pellets were collected during the pre-chick feeding period (5/1/13 and 5/17/13), chick feeding period (7/16/13) and post-chick feeding period (8/23/13). In the laboratory, diagnostic bones, all otoliths, and representative scales were removed from the pellets and identified under magnification. Eye lenses were also enumerated and, although they could not be used in species identification, their total number (i.e. number of lenses/2) generated fish counts that exceeded those based on bones or otoliths in some pellets. For prey species identified, diagnostic fish material recovered from cormorant pellets were compared with bones, scales, and otoliths from known specimens de-fleshed in a concentrated potassium hydroxide solution. Species were identified to the lowest practical taxonomic level.

Fish Consumption Estimation

To estimate number of fish consumed by cormorants from the LGI colony, we used a model similar to that of Weseloh and Casselman (1992). This model incorporated cormorant age-class, population size, and seasonal residence time (time spent feeding in area) to estimate the number of cormorant feeding days, mean daily fish ingestion

rates, and a fecal pathway correction factor for fish not detected in pellets (Johnson and Ross 1996). To estimate the number of cormorants feeding we used annual nest counts (all nests counted) provided by the New York State Department of Environmental Conservation (NYSDEC) and assumed that (1) residence time for breeding adults, immatures, and young-of-year (YOY) was 158, 112, and 92 days, respectively (Weseloh and Casselman, unpublished report); (2) number of immatures was about 10% of the adult population which was taken as twice the number of nests; and (3) the number of YOY cormorants is the product of the fledgling productivity estimate for the year and the number of active nests. Residence times at LGI may actually be shorter because of annual management activities at the colony. Mazzocchi et al. (2003) found that the departure date of cormorants was 16 days later for a sub-colony of cormorants at LGI where no management activities occurred, compared to a sub-colony in the managed area. We did not account for bird mortality during the time of residence or the migrant Double-crested Cormorant population (transient birds that stay an unknown amount of time on Lake Ontario). Incorporating bird mortality estimates into the model would reduce fish consumption estimates, whereas including migrant birds would increase estimated consumption. Although YOY cormorants are generally present for about 113 days, consumption by chicks during the first three weeks post-hatch is considered minimal, and for the remainder of the season their daily food intake approximates that of adults (Weseloh and Casselman, unpublished report). Although immature cormorants are essentially fully grown, they are non-reproductive birds.

Because of the apparent differences in feeding patterns of cormorants over the season, we identified three separate feeding phases, pre-chick (prior to chick hatch), chick (chicks present and being fed by adults), and post-chick (cessation of feeding chicks by adult) feeding. These phases were characterized by differences in diet composition and daily fish consumption (i.e. the number of fish per pellet). Pre-chick feeding was from late April to early June, the chick feeding period from mid June to late July, and the post-chick feeding period from early August to early October. To examine cormorant fish consumption by feeding period (i.e. pre-chick, chick, and post-chick) we further broke down the number of cormorant feeding days by age-class as follows:

	Days			
	Pre-chick	Chick	Post-chick	Total
Adults	64	42	52	158
Immatures	18	42	52	112
YOY	0	42	50	92

To estimate the number of fish consumed by cormorants during each feeding period we multiplied the number of Double-crested Cormorant feeding days by mean daily ingestion rates for that period. For estimates of mean daily ingestion rates, we used the mean number of fish per pellet multiplied by a fecal correction factor of 1.042 (Johnson and Ross 1996). Although variation in pellet production rates have been observed in cormorants (Carss et al. 1997) many researchers consider that a single pellet is typically produced by adult cormorants each day (Craven and Lev 1987, Orta 1992, Derby and Lovvorn 1997). Pellet production rates greater than one per day would increase our fish consumption estimates for the LGI colony whereas rates less than one per day would reduce our estimates. Fish consumption estimates for each of the three feeding periods were summed to provide an annual fish consumption estimate. Specific fish consumption was estimated by multiplying the percent composition by number for a species in the diet for each feeding period by the total fish consumption estimate for that period. Consumption estimates were then summed for all three periods to provide annual consumption estimates for each species or taxon. The use of the Weseloh and Casselman model, which did not include variance estimates associated with the number of feeding days for each life stage, precluded us from generating standard error estimates for fish consumption estimates. To estimate the biomass of fish eaten, we assumed that cormorants consumed 0.47 kg (approximately 1 pound) of fish per day (Schramm et al. 1984, 1987; Weseloh and Casselman 1992), representing

about 25% of their body weight (Dunn 1975).

We estimated the size (total length) of key species including yellow perch, rock bass (*Ambloplites rupestris*) and pumpkinseed sunfish (*Lepomis gibbosus*) consumed during each cormorant feeding period by measuring otoliths from each species/period to the nearest 3.9 X 10^{-3} in (0.1 mm) with calipers (Burnett et al. 2001, Ross et al. 2005). Broken or chipped otoliths were not considered for measurement. To estimate the weight of these species consumed by cormorants we used length-weight regressions for eastern Lake Ontario populations (unpublished data).

Control Measures

NYSDEC staff began treating accessible Double-crested Cormorant nests on LGI with corn oil beginning on May 1 and ending July 16, 2013. The oiling process was conducted four times over the season on each reachable nest with eggs, excluding a designated untreated sub-colony. Oil was applied from a backpack sprayer unit in sufficient volume to cover the exposed surface of each egg (approximately 6 ml/egg or 0.2 oz/egg). The number of eggs treated per nest was recorded and each nest or group of nests was marked with spray paint to facilitate efficient movement throughout the colony as well as complete nest coverage. Also recorded were the number of nests not treated and the number of chicks present per visit. We adjusted the number of cormorant feeding days and total number of fish consumed to account for 366 cormorants culled at LGI on 5 June.

We estimated reductions in cormorant feeding days and fish consumption annually from egg oiling. For chicks, these estimates were determined from 1999-2013; for immature cormorants, from 2000-2013; and for adult cormorants, from 2002-2012. These time periods assume that the effects on chicks began immediately (1999), the effects on immature birds began one year post initial treatment (2000), and effects on adult cormorants began when they reach maturity at age 3 (2002). To derive projected estimates, a standard of 5,681 nests from 1999 when egg oiling was first started was used. For each subsequent year, that nest count was subtracted from 5,681 (example: 2005 was 5,681-3,401=2,280 fewer nests). That nest count figure was then used to derive adult, immature, and YOY reductions in both feeding days and fish consumption using the standard Weseloh and Casselman model. This estimate plus the annual estimated reduction in feeding days from chicks alone and the actual number of feeding days for each year for the entire colony were summed to provide the projected estimate. Projected feeding day estimates were multiplied by the annual number of fish per pellet (i.e. daily fish consumption) to provide the projected estimate for fish consumption.

Results

Diet Composition

Round goby (*Neogobius malanostomus*) (90.8%) were the major prey of LGI cormorants in 2013 and dominated the diet during all feeding periods (Table 1). Alewife (6.1%), and yellow perch (1.4%) were the only other species that contributed at least 1% of the diet. For the entire season forage species (i.e. round goby, alewife (*Alosa pseudoharengus*), cyprinids, etc.) contributed 97.3% of the diet of LGI cormorants, while panfish (i.e. yellow perch, pumpkinseed, rock bass, etc.) and gamefish (smallmouth bass), composed 2.6% and 0.1%, respectively.

Fish Consumption

The number of fish per pellet (adjusted for fecal loss) was highest during the post-chick feeding period (51.1) and averaged 27.4 for the season (Table 1). The number of fish per pellet was the third highest observed in the 22 years of investigations at LGI and was the result of cormorants consuming small round gobies. A peak count of 2,387 cormorant nests was observed on LGI in 2013 and chick productivity was estimated at about 0.33 chicks per nest. To account for birds that were shot on 5 June in the fish consumption model, the adult bird estimate was reduced by 15,372 and 19,032 feeding days, respectively for the chick and post-chick feeding periods. Using the Weseloh and Casselman model we estimate about 0.84 million cormorant feeding days for the LGI colony in 2013 and about 0.84 million pounds of fish consumed (Figure 1).

Numbers of fish consumed by feeding period in 2013 included 5.09 million during the pre-chick feeding period, 2.92 million during the chick feeding period, and 14.85 million during the post-chick feeding period.

In 2013, LGI cormorants consumed 22.25 million forage fish including 20.75 million round goby and 1.39 million alewife (Figure 2). About 0.57 million panfish were eaten, including 0.33 million yellow perch, and 0.20 million rock bass. Cormorants consumed about 0.04 million game fish, esocids and smallmouth bass (Figure 2).

Size of Fish Consumed

A total of 144 otoliths recovered from cormorant pellets were measured in 2013. The average size of yellow perch consumed by LGI cormorants in 2013 (5.0 in) was the largest observed at the colony ($\bar{x}$ (2001 – 2012) = 4.3 in). The average weight of yellow perch, rock bass, and pumpkinseed (computed from length-weight regression) for each feeding period is provided in Table 2. For the entire feeding season on LGI cormorants consumed an estimated 19,000 pounds of rock bass, 16,000 pounds of yellow perch, and 3,000 pounds of pumpkinseed.

Effects of Control Measures

The removal of 366, mostly adult, cormorants from the LGI population reduced the number of cormorant feeding days by about 34,404 and reduced total fish consumption by an estimated 1.2 million. Consequently, these feeding days and number of fish were not considered in estimating the effects of egg oiling. Chicks accounted for 67,160 cormorant feeding days from early June to mid-October (Table 3). The total number of cormorant feeding days by the LGI colony in 2013 was estimated at 0.84 million (Table 3). We estimated that 3,967 chicks would have been produced on LGI from 2,387 nests in 2013 in the absence of reproductive suppression (i.e. egg oiling) by using the chick productivity estimate of 1.8 chicks per nest. Egg oiling limited cormorant chick production to about 730 chicks, which is an 82% reduction in chick numbers and feeding days. For the entire LGI colony in 2013, reproductive suppression reduced the total number of cormorant feeding days from 1.14 million to 0.84 million (26.3%) and the number of fish consumed from 32.8 million to 22.9 million (30.2%) (Table 3). The relative magnitude of the reduction in fish consumption caused by reproductive suppression at LGI in 2013 was consistent with what was achieved in the previous seven years (Figure 3).

We estimate that the 730 cormorant chicks produced on LGI in 2013 consumed about 2.25 million fish (Table 4). If egg oiling was not carried out and 3,967 cormorant chicks were produced on LGI in 2013, we estimate that these chicks would have consumed 12.2 million fish (Table 4). Consequently, egg oiling reduced fish consumption by approximately 10.0 million fish in 2013. Using diet composition information for the chick and post-chick feeding periods, the reduced fish consumption represented 9.45 million round goby, 0.34 million alewife, 0.08 million yellow perch, and 0.08 million rock bass (Table 4).

Discussion

Since the egg oiling program was initiated in 1999 the number of cormorant nests at LGI has been lower than the pre-control level (5,681). Results achieved by the Double-crested Cormorant reproductive suppression program on LGI since 1999 have been remarkably consistent. Chick productivity has been reduced from an average of about 2.00 chicks per nest (1992-1998) to 0.18 chicks per nest (1999-2013), a 91% reduction. Since initiated in 1999, egg oiling has resulted in: (1) a 90.4% (annual range 76.0% to 98.0%) reduction in cormorant chick production, (2) a 28.8% (annual range 23.9% to 32.7%) reduction in cormorant feeding days, and (3) a 28.1% (annual range 19.1% to 34.8%) reduction in total fish consumption (Johnson et al. 2006, 2007, 2008, 2009, 2010, 2011, 2012). A Double-crested Cormorant milestone was reached in 2010 when, for the first time, the number of feeding days (650,000) was below the management target of 780,000 that has been set for the LGI colony (McCullough et al. 2011).

We estimate that the cormorant reproductive suppression program on LGI has reduced fish consumption by chicks at the colony by 106.6 million fish since it was initiated in 1999.

Included in this estimate are approximately 10.0 million yellow perch and 2.6 million smallmouth bass that were not consumed by cormorants. These two species are especially important since declines in their abundance in the eastern basin of Lake Ontario have been associated with cormorant population increases (Burnett et al. 2002, Lantry et al. 2002).

Cumulative Effects of Egg Oiling

The annual reduction in chick productivity at LGI provides only partial insight into the overall cumulative effects in terms of the reduction in both cormorant feeding days and fish consumption at the colony. Full consideration of the effects of egg oiling on these parameters should include projections for the immature and adult birds that would have been produced annually at the colony in the absence of egg oiling. Since egg oiling was initiated at LGI in 1999, about 6,820 chicks have been fledged compared to an estimated 85,379 if egg oiling had not occurred. If these 78,559 chicks had survived we estimate that fish consumption by chicks alone would increase by 163.2 million (Figure 4). In addition, the number of projected cormorant feeding days declined by 69% (3% attributed to cull; 2.71 million to 0.84 million from 1999 to 2013) (Figure 5) and projected annual fish consumption decreased by 71% (3% attributed to cull; 77.72 million to 22.9 million) during the same period (Figure 6).

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Table 1: Seasonal and total percent diet composition of Double-crested Cormorants from Little Galloo Island, 2013. Sample dates were 5/1/13 and 5/7/13 (pre-chick feeding period,) 7/16/13 (chick feeding period), and 8/23/13 (post-chick feeding period).

	Pre-chick	Chick	Post-chick	Total
No. of pellets	70	90	90	250
Fish/pellet (adjusted x 1.042)	16.2	12.4	51.1	27.4
Round Goby	75.9	79.4	98.1	90.8
Alewife	15.8	16.5	0.7	6.1
Yellow Perch	3.8	2.1	0.5	1.4
Rock Bass	1.3	1.1	0.7	0.9
Cyprinid	1.4	0.5	---	0.4
Esocid	0.6	0.1	---	0.1
Pumpkinseed	0.6	---	---	0.1
Catostomid	0.2	---	---	<0.1
Smallmouth Bass	---	0.3	---	<0.1
White perch	0.1	---	---	<0.1
Ictalurid	0.2	---	---	<0.1
Total	100.0	100.0	100.0	100.0

Table 2. Estimated total length (TL, inches), mean weight (Wt., pounds), and number examined (No.), of yellow perch, rock bass, and pumpkinseed consumed by Double-crested Cormorants during each feeding period on Little Galloo Island in 2013. (SD = standard deviation).

	Feeding Period								
	Pre-chick			Chick			Post-chick		
	TL(SD)	Wt.	No.	TL(SD)	Wt.	No.	TL(SD)	Wt.	No.
Yellow Perch	5.1 (1.4)	0.05	40	4.5 (1.0)	0.03	22	5.5 (0.6)	0.06	16
Rock Bass	5.2 (1.2)	0.10	41	5.0 (1.2)	0.09	12	5.0 (1.0)	0.09	32
Pumpkinseed	4.7 (0.5)	0.08	8	----	----	----	----	----	----

Table 3. Estimated number of chicks produced, chick feeding days, total cormorant feeding days, and the number of fish eaten based on chick productivities of 0.33 (control = egg oiling) and 1.8 chicks per nest (no control) on Little Galloo Island in 2013.

Action	No. of chicks	No. of chick feeding days	Total cormorant feeding days	No. of fish eaten
No control	3,967	364,964	1,138,388	32,818,475
Control (egg oiling)	730	67,160	840,584	22,862,110
Difference	3,237	297,804	297,804	9,956,365

Table4. Fish consumption estimates for Double-crested Cormorant chicks based on chick productivities of 0.33 (control = egg oiling) and 1.8 chicks per nest (no control) on Little Galloo Island in 2013.

	Number of fish consumed		
Species	Control	No. control	Difference
Round Goby	2,131,580	11,583,522	9,451,942
Yellow Perch	17,310	94,064	76,754
Alewife	75,787	411,842	336,055
Rock Bass	17,238	93,676	76,438
Cyprinid	1.901	10,330	8,429
Smallmouth Bass	1,141	6,198	5,059
Esocid	380	2,066	1,686
	2,245,337	12,201,698	9,956,363

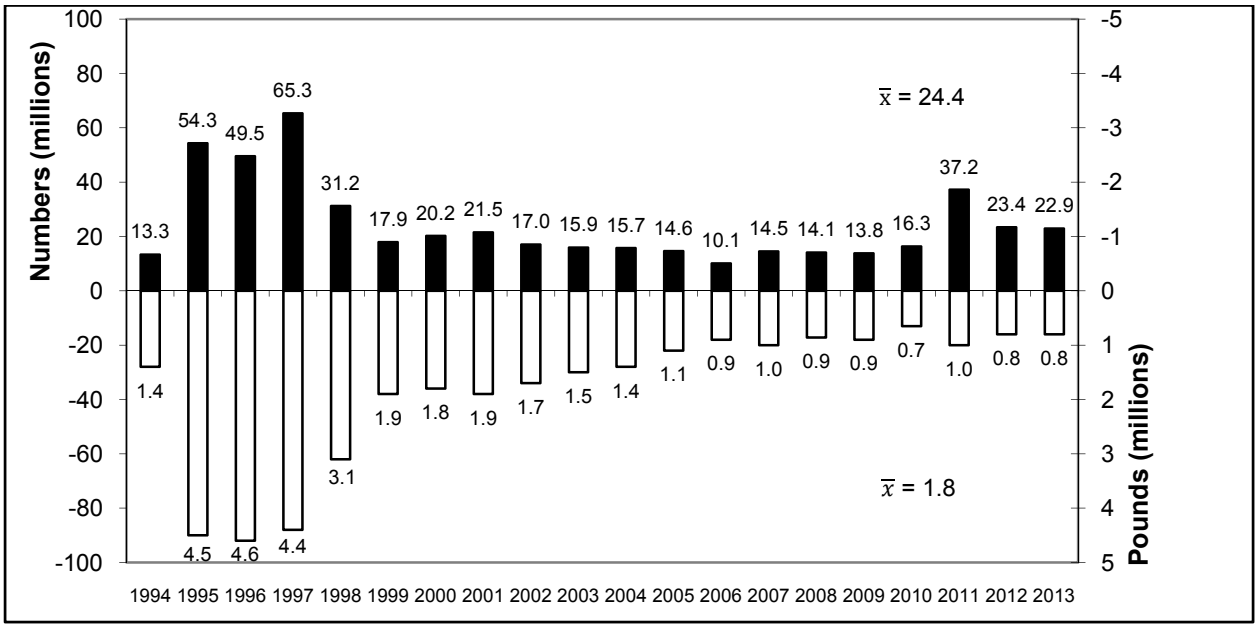

Figure 1. Estimated annual fish consumption in terms of numbers (top) and pounds (bottom) by the Little Galloo Island Double-crested Cormorant colony, 1994-2013.

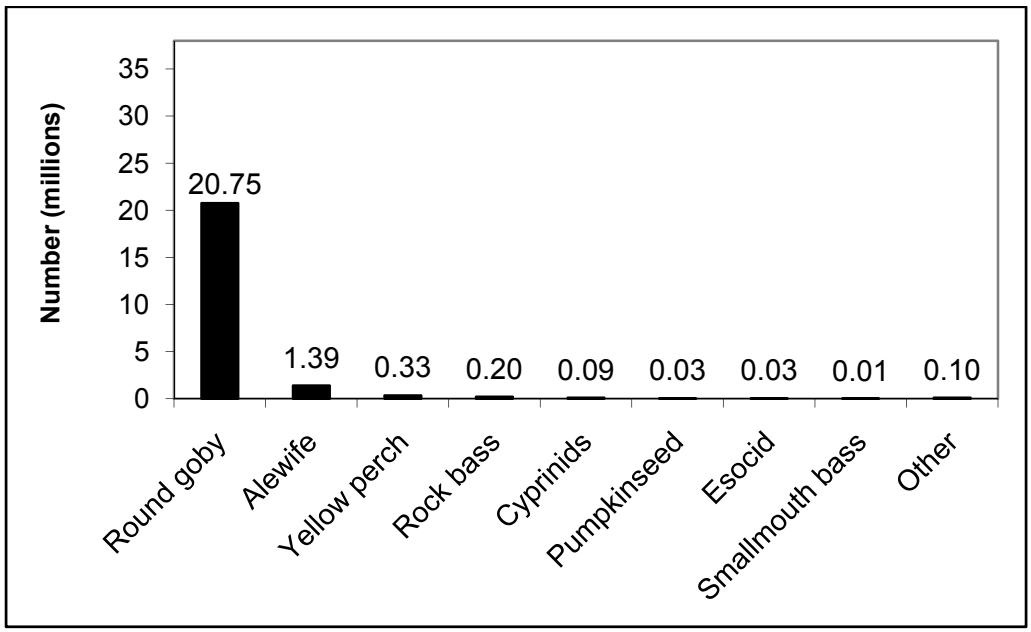

Figure 2. Estimated species-specific fish consumption by Double-crested Cormorants at the Little Galloo colony, 2013.

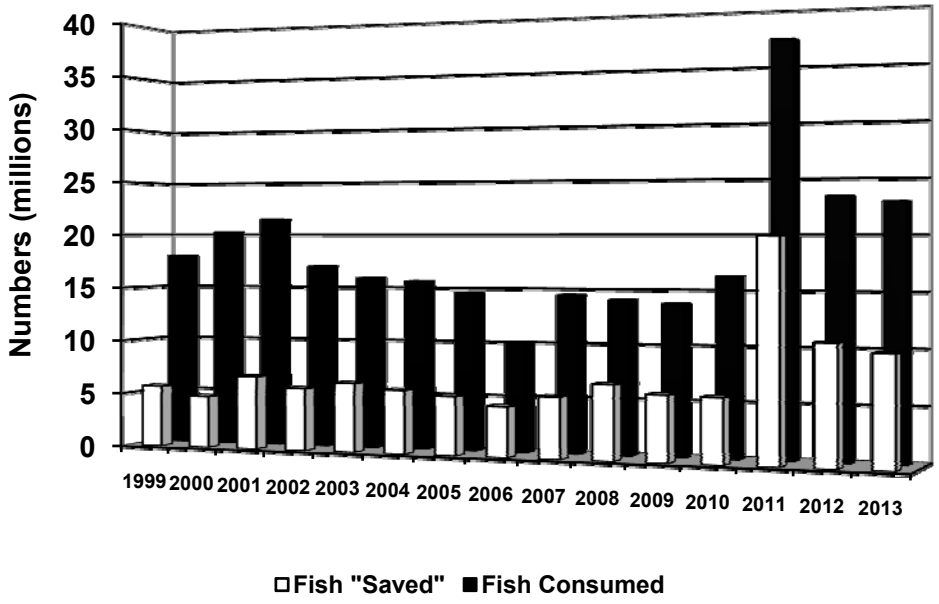

Figure 3. Estimated numbers of fish consumed by Double-crested Cormorant chicks and estimated number of fish "saved" by cormorant reproductive suppression since 1999 on Little Galloo Island.

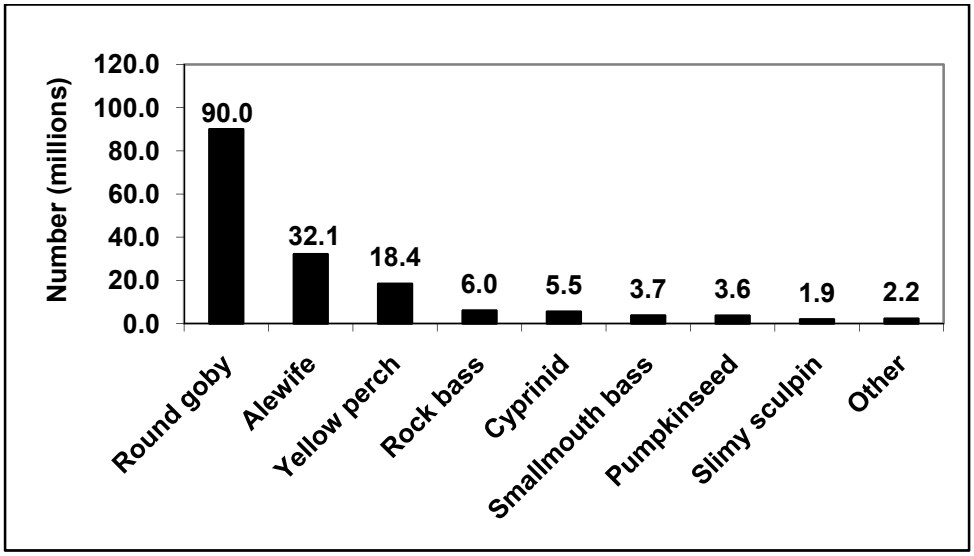

Figure 4. Total number (millions) of fish "saved" by egg oiling program at Little Galloo Island, 1999-2013.

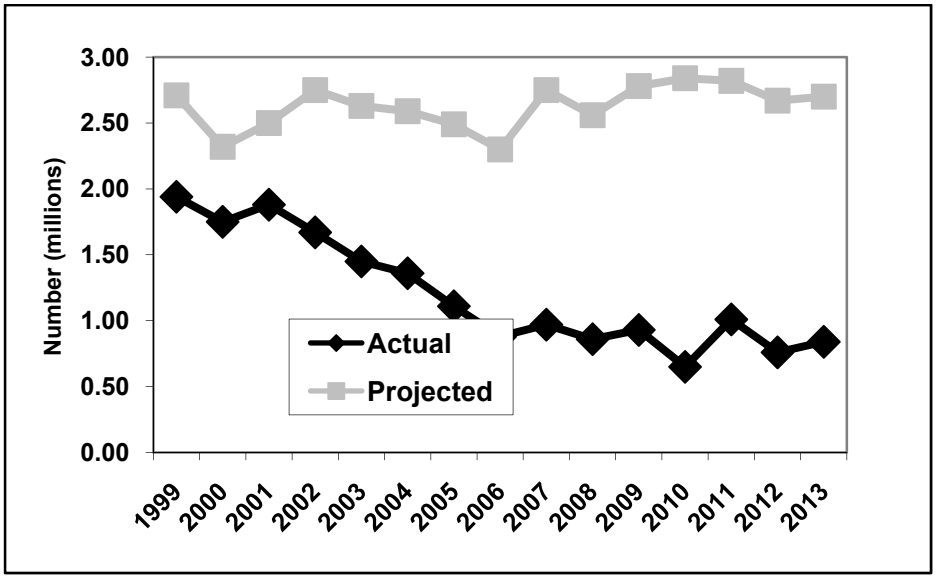

Figure 5. Actual (control-egg oiling) and projected (no control) Double-crested Cormorant feeding days at Little Galloo Island, Lake Ontario, 1999-2013.

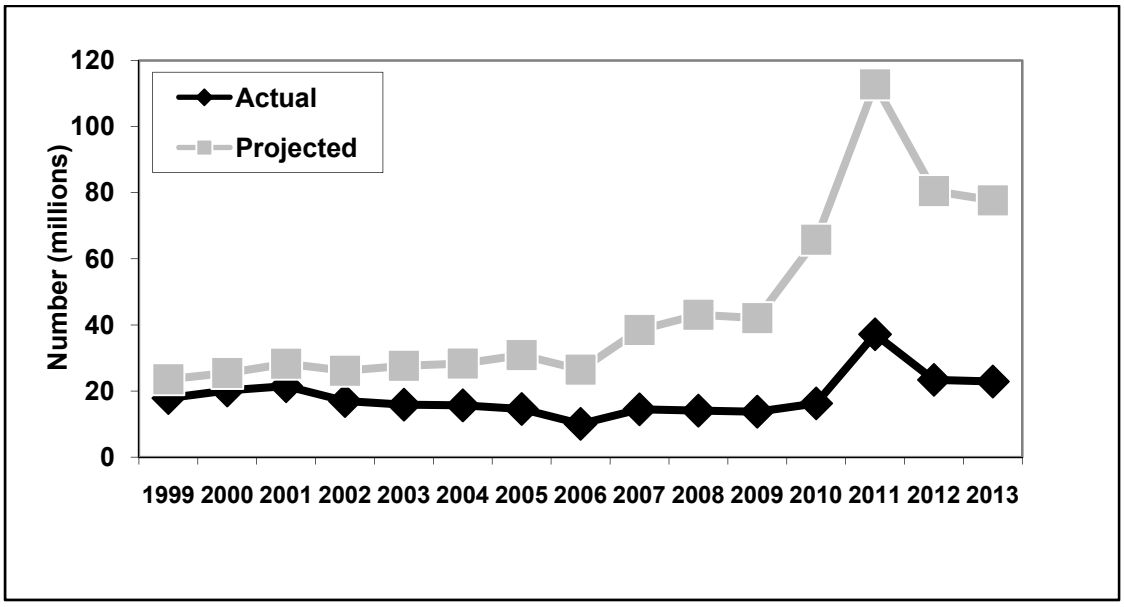

Figure 6. Actual (control-egg oiling) and projected (no control) estimates of Double-crested Cormorant fish consumption at Little Galloo Island, Lake Ontario, 1999-2013.

Diet Composition and Fish Consumption of Double-Crested Cormorants from Three St. Lawrence River Colonies in 2013

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Double-crested Cormorants (*Phalacrocorax auritus*) were first observed nesting in the upper St. Lawrence River at Strachan Island in 1992. Cormorants now nest at a number of islands in the Thousand Islands section of the river. Griswold, McNair, and Strachan islands are among the largest colonies in the upper river. Until 2011, nest counts had remained relatively stable, ranging from 200 to 603 nests per colony. However, since 2011 the number of nests at McNair Island have exceeded 700 each year. Although the size of cormorant colonies in the upper St. Lawrence River is smaller than those in the eastern basin of Lake Ontario, the close proximity of islands in the upper river that have colonies may cause a cumulative fish consumption effect similar to a larger colony.

Because of increasing numbers of Double-crested Cormorants in the upper St. Lawrence River and the possible effects on fish populations, studies were initiated in 1999 to quantify cormorant diet and fish consumption at the three largest colonies. From 1999 to 2012, these studies have shown that cormorants consumed about 128.6 million fish including 37.5 million yellow perch (*Perca flavescens*), 17.4 million rock bass (*Ambloplites rupestris*) and 1.0 million smallmouth bass (*Micropterus dolemieu)* (Johnson et al. 2012). During this same time period fish assessment studies near some of these islands have shown a major decrease in yellow perch populations (Klindt 2007). This occurrence is known as the halo effect and happens when piscivorous birds deplete local fish populations in areas immediately surrounding the colony (Ashmole 1963). This paper describes the diet and fish consumption of cormorants in the upper St. Lawrence River in 2013.

Methods

Diagnostic prey remains recovered in regurgitated pellets were used to describe the diet of Double-crested Cormorants at St. Lawrence River colonies in 2013. Pellets were collected beginning in mid-June and ending in early August. In the laboratory, diagnostic bones, all otoliths, and representative scales were removed from the pellets and identified under magnification. Eye lenses were also enumerated because, although they could not be used in species identification, their total number (i.e., number of lenses/2) generated fish counts that exceeded those based on bones or otoliths in some pellets. For prey species identified, diagnostic fish material recovered from cormorant pellets were compared with bones, scales, and otoliths from known specimens defleshed in a concentrated sodium hydroxide solution. Species were identified to the lowest practical taxonomic level.

To estimate the number of fish consumed by cormorants from each colony, we used a model similar to that of Weseloh and Casselman (1992)

to estimate the number of fish eaten by cormorants annually. This model incorporated cormorant age-class population size and seasonal residence time (time spent feeding in area) to estimate the number of cormorant feeding days, mean daily fish ingestion rates, and a fecal pathway correction factor for fish not detected in pellets (Johnson and Ross 1996). To estimate the number of cormorants feeding we used annual nest counts (all nests counted) provided by the Canadian Wildlife Service and the NYS Department of Environmental Conservation and assumed that (1) residence time for breeding adults, immatures, and young-of-year (YOY) was 158, 112, and 92 days, respectively (Weseloh and Casselman, unpublished report); (2) number of immatures was about 10% of adult population which was taken as twice the number of nests; and (3) the number of YOY cormorants is the product of the fledgling productivity estimate for the year and the number of active nests. We did not account for bird mortality during the time of residence or the migrant Double-crested Cormorant population (transient birds that stay an unknown amount of time). Incorporating bird mortality estimates into the model would reduce fish consumption estimates whereas including migrant birds would increase estimated consumption. Although YOY cormorants are generally present for about 113 days, consumption by chicks during the first 3 weeks post-hatch is considered minimal, and for the remainder of the season their daily food intake approximates that of adults (Weseloh and Casselman, unpublished report). Immature cormorants are essentially fully grown but non-reproductive birds.

Because of the apparent differences in feeding patterns of cormorants over the season, we identified three separate feeding periods, pre-chick (prior to chick hatch), chick (chicks present and being fed by adults), and post-chick (cessation of feeding chicks by adult) feeding. These phases are characterized by differences in diet composition and daily fish consumption (i.e., the number of fish per pellet). Pre-chick feeding occurs from early April to early June, the chick feeding period from mid-June to late July, and the post-chick feeding period from early August to late September. To examine cormorant fish consumption by feeding period we further broke down the number of cormorant feeding days by age-class as follows:

	Days			
	Pre-chick	Chick	Post-chick	Total
Adults	64	42	52	158
Immatures	18	42	52	112
YOY	0	42	50	92

To estimate the number of fish consumed by cormorants during each feeding period we multiplied the number of Double-crested Cormorant feeding days by mean daily ingestion rates for that period. For estimates of mean daily ingestion rates, we used the mean number of fish per pellet multiplied by a fecal correction factor of 1.042 (Johnson and Ross 1996). Although variation in pellet production rates has been observed in cormorants (Carss et al. 1997), many researchers consider that a single pellet is typically produced by adult cormorants each day (Craven and Lev 1987, Orta 1992, Derby and Lovvorn 1997). Pellet production rates greater than one per day would increase our fish consumption estimates for each colony whereas rates less than one per day would reduce our estimates. Fish consumption estimates for each of the three feeding periods were summed to provide an annual fish consumption estimate. Specific fish consumption was estimated by multiplying the percent composition by number for a species in the diet for each feeding period by the total fish consumption estimate for that period. Consumption estimates were then summed for all three periods to provide annual consumption estimates for each species or taxon. When pellets were not collected during a single feeding period a mean value was calculated from the two feeding periods to estimate total fish consumption. The use of the Weseloh and Casselman model, which did not include variance estimates associated with the number of feeding days for each life stage, precluded us from generating standard error estimates for fish consumption estimates. To estimate the biomass of fish eaten, we assumed that cormorants consumed 1 lb fish per day (Schramm et al. 1984,

1987; Weseloh and Casselman 1992), representing about 25% of their body weight (Dunn 1975).

We estimated the size (total length) of key species including yellow perch, rock bass and pumpkinseed sunfish (*Lepomis gibbosus*) consumed during each cormorant feeding period by measuring otoliths from each species each period to the nearest 3.9 X 10^{-3} in (0.1 mm) with calipers (Burnett et al. 2001, Ross et al. 2005). Broken or chipped otoliths were not considered for measurement. To estimate the weight of these species consumed by cormorants we used fish length-weight regressions for eastern Lake Ontario populations (unpublished data).

Spatial and temporal similarity in diet composition for the Griswold, McNair and Strachan Island colonies was determined by using the equation of Morisita (1959) as modified by Horn (1966). Overlap values can range from 0, when samples contain no food in common, to 1, when there is identical representation of food between samples. When using this formula, overlap values ($C\lambda$) ≥ 0.60 are considered biologically significant (Zaret and Rand 1971).

Results

A total of 675 pellets were used to describe the feeding ecology of cormorants from Griswold (225 pellets), McNair (225 pellets), and Strachan (225 pellets) Islands in 2013 (Tables 1-3). Over the entire season, the number of fish per pellet was highest at McNair Island (20.8) and was followed by Griswold Island (18.0) and Strachan Island (17.5) (Tables 1-3).

Diet Composition

Round gobies (*Neogobius melanostomus*) were the primary prey of cormorants at Griswold Island (64.0%) and yellow perch (21.3%) and rock bass (6.9%) were the second and third ranked prey (Table 1). Pumpkinseed (4.5%) was the only other species that contributed at least 2% of the diet of Griswold Island cormorants. For the entire season, panfish (i.e., yellow perch, rock bass, pumpkinseed, ictalurids) contributed 33.7% of the diet, forage fish (round goby, cyprinids, darters) composed 65.9%, and gamefish (mainly smallmouth bass and esocids) comprised 0.4% of the diet of Griswold Island cormorants.

Round goby (75.7%), yellow perch (9.8%), pumpkinseed (6.8%) and rock bass (5.5%) were the dominant prey in the diet of cormorants at McNair Island (Table 2). For the season, panfish made up 22.5% of the diet of McNair Island cormorants, forage fish 76.9%, and gamefish (smallmouth bass and esocids) 0.6% (Table 2).

Round goby (64.4%), yellow perch (17.2%), and rock bass (8.1%) were the main prey of Strachan Island cormorants (Table 3). Pumpkinseed (4.5%) and cyprinids (2.4%) were the only other prey species that contributed at least 2% of the diet. Panfish made up 30.7% of the seasonal diet, forage fish 69.1%, and gamefish 0.2% at Strachan Island in 2013 (Table 3).

Diet Overlap

Mean diet overlap for the entire season among all three upper St. Lawrence River colonies in 2013 was high, from 0.95 to 0.98 (Table 4). Diet was the most similar between cormorants from Strachan and McNair Islands ($C\lambda$= 0.98). There was little temporal variation in diet composition between the two feeding periods at any of the three colonies (Table 5).

Fish Consumption

Based on nest counts of 634 on Griswold Island, 796 on McNair Island, and 270 on Strachan Island, and fledgling productivities of 1.8 chicks per nest, we estimated 0.32, 0.39 and 0.15 million cormorant feeding days for Griswold Island, McNair Island, and Strachan Island, respectively. Fish consumption for the Griswold Island colony was estimated at 5.4 million fish and 0.32 million pounds, for the McNair Island colony at 8.4 million fish and 0.39 million pounds, and for the Strachan Island colony at 2.4 million fish and 0.15 million pounds (Table 6).

We estimate that during 2013, cormorants from Griswold Island consumed 1.84 million panfish (including 1.16 million yellow perch, 0.37 million rock bass and 0.25 million pumpkinseed), 3.55 million forage fish (including 3.48 million round goby) and 0.01 million gamefish

(smallmouth bass) (Figure 1). We estimate that cormorants from McNair Island consumed 1.88 million panfish (mainly 0.82 million yellow perch, 0.57 million pumpkinseed, and 0.46 million rock bass), 6.43 million forage fish (including 6.36 million round goby and 0.03 million cyprinids), and 0.04 million gamefish (smallmouth bass and esocids). Cormorants from Strachan Island consumed 0.71 million panfish (including 0.40 million yellow perch, 0.19 million rock bass, 0.11 million pumpkinseed, and 0.01 million ictalurids), 1.64 million forage fish (mainly 1.52 million round goby and 0.06 million cyprinids), and 0.01 million gamefish (smallmouth bass) (Figure 1). The size of rock bass consumed by cormorants at Griswold Island and Strachan Island declined over the season, as did the size of yellow perch at McNair Island (Table 7).

Discussion

Of the six Double-crested Cormorant colonies (three eastern Lake Ontario, three St. Lawrence River) where diets have been examined, Griswold was the last colony to have round goby become the main fish prey (2009). Prior to 2009, yellow perch (55.5%) were the main prey of cormorants at Griswold Island (Johnson et al. 2012). Since 2009, round goby have contributed 62.6% and yellow perch 19.8% of the diet of cormorants at Griswold Island.

Round gobies first appeared in the diet of cormorants nesting in 2003 when they contributed about 2% of the diet of birds at McNair Island (Johnson et al. 2004). In 2004, cormorants at all three colonies consumed round gobies with the diet contribution at McNair increasing to 15% and the contribution at Griswold Island and Strachan Island being 1.2% and 1.7%, respectively. In 2005, gobies were almost non-existent (0.1%) in the diet of cormorants at Griswold Island but were the second most consumed prey and represented 24.3% and 19.6% of cormorant diets at McNair and Strachan Island, respectively. Since 2004, when round gobies first appeared in cormorant diets at all St. Lawrence River colonies, they have comprised 48.4% of the fish consumed at Strachan, 51.9% at McNair, and 36.8% at Griswold. The possible halo effect relative to yellow perch populations surrounding Strachan Island observed by Klindt (2007) has not been evident since round goby became abundant in the diet (Klindt and Gordon 2010).

From 1999 to 2004, panfish composed 78.6% and forage fish only 19.3% of cormorant diets at the three St. Lawrence River colonies. Since 2004, panfish have made up 42.7% and forage fish 56.4%, of cormorant diets in the upper St. Lawrence River. Over this same period, game fish have made up 0.9% of cormorant diets at these three river colonies (Johnson et al. 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012). As noted for panfish, reduced consumption of gamefish could be related to the dominance of round gobies in cormorant diets at these colonies.

Since 1999, we estimate that cormorants from these colonies have consumed 145.3 million fish (Figure 2). This includes 61.8 million round goby, 39.9 million yellow perch, 18.4 million rock bass, 11.5 million pumpkinseed, 1.6 million ictalurids, and 1.1 million smallmouth bass (Figure 2).

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Table 1. Seasonal and total percent diet composition by number of Double-crested Cormorants from Griswold Island, 2013. Pre-chick feeding period includes pellets collected on 5/14/13, chick feeding period includes pellets collected on 6/20/13 and post-chick feeding period collected on 8/8/13.

	Pre-chick	Chick	Post-chick	Total
No. of pellets	75	75	75	225
Fish/pellet (adjusted x 1.042)	22.3	22.3	9.5	18.0
Round Goby	73.2	54.5	68.9	64.0
Yellow Perch	12.5	34.5	9.1	21.3
Rock Bass	6.1	5.8	10.1	6.9
Pumpkinseed	4.7	3.0	7.1	4.5
Cyprinid	1.4	0.9	1.0	1.1
Ictalurid	0.4	0.3	3.3	1.0
Smallmouth Bass	0.3	0.5	0.2	0.3
Banded killifish	0.2	0.2	----	0.2
Catostomid	0.4	----	----	0.2
Alewife	----	0.2	0.3	0.2
Darter	0.6	0.1	----	0.2
Esocid	0.2	----	----	0.1
Total	100.0	100.0	100.0	100.0

Table 2. Seasonal and total percent diet composition by number of Double-crested Cormorants from McNair Island, 2013. Pre-chick period includes pellets collected on 5/15/13 and chick feeding period includes pellets collected on 6/20/13 and post-chick feeding period collected on 8/8/13.

	Pre-chick	Chick	Post-chick	Total
No. of pellets	75	75	75	225
Fish/pellet (adjusted x 1.042)	18.2	26.6	17.7	20.8
Round Goby	73.4	74.6	80.2	75.7
Yellow Perch	9.1	15.3	3.6	9.8
Pumpkinseed	9.3	3.8	7.5	6.8
Rock Bass	5.4	4.4	7.1	5.5
Catostomid	0.3	0.7	0.4	0.5
Smallmouth Bass	0.5	0.4	0.2	0.4
Cyprinid	0.7	0.2	0.2	0.3
Ictalurid	0.2	0.2	0.4	0.3
Banded Killifish	0.4	----	0.2	0.2
Darter	0.2	0.2	0.2	0.2
Esocid	0.5	----	----	0.2
White Perch	----	0.2	----	0.1
Total	100.0	100.0	100.0	100.0

Table 3. Seasonal and total percent diet composition by number of Double-crested Cormorants from Strachan Island, 2013. Pre-chick feeding periods includes pellets collected on 5/30/13 and chick feeding period includes pellets collected on 7/1/13, and post-chick feeding period includes pellets collected on 8/9/13.

	Pre-chick	Chick	Post-chick	Total
No. of pellets	75	75	75	22.5
Fish/pellet (adjusted x 1.042)	22.8	9.7	20.1	17.5
Round Goby	65.4	45.5	71.3	64.4
Yellow Perch	17.1	31.3	11.6	17.2
Rock Bass	6.0	15.6	6.6	8.1
Pumpkinseed	6.5	3.4	3.4	4.5
Cyprinid	1.4	0.9	3.8	2.4
Catostomid	0.6	0.6	2.2	1.4
Banded Killifish	0.1	1.8	0.2	0.5
Ictalurid	0.6	0.2	0.6	0.5
Darter	0.9	0.2	0.2	0.4
White Perch	1.1	0.3	----	0.4
Smallmouth Bass	0.3	0.2	0.1	0.2
Total	100.0	100.0	100.0	100

Table 4. Spatial diet overlap among three St. Lawrence River cormorant colonies, 2013.

	Colonies		
Feeding period	Griswold I.-McNair I.	Griswold I.-Strachan I.	McNair I.-Strachan I.
Pre-chick	0.99	0.99	0.99
Chick	0.92	0.86	0.97
Post-chick	0.98	0.99	0.99
Average	0.96	0.95	0.98

Table 5. Temporal diet overlap at each of the three St. Lawrence River cormorant colonies, 2013.

Feeding period	Griswold I.	McNair I.	Strachan I.
Pre-chick feeding-Chick feeding	0.92	0.99	0.91
Pre-chick feeding-Post-chick feeding	0.99	0.99	0.99
Chick feeding-Post-chick feeding	0.90	0.99	0.86
Average	0.94	0.99	0.92

Table 6. Fish consumption estimates in millions for cormorants at each of the three St. Lawrence River colonies, 2013.

	Griswold Island		McNair Island		Strachan Island	
Period	Number	Pounds	Number	Pounds	Number	Pounds
Pre-chick feeding	1.8	0.08	1.9	0.10	0.8	0.04
Chick feeding	2.4	0.11	3.6	0.13	0.5	0.05
Post-chick feeding	1.2	0.13	2.9	0.16	1.1	0.06
Total	5.4	0.32	8.4	0.39	2.4	0.15

Table 7. Estimated mean total length (TL, inches), weight (Wt., pounds), and number of otoliths examined (No.) for yellow perch, rock bass, and pumpkinseed consumed by double-crested cormorants during the pre-chick and chick feeding periods on Griswold, McNair, and Strachan Islands in 2013. (SD = standard deviation).

	Griswold			McNair			Strachan		
				Pre-chick					
	TL (SD)	Wt.	No.	TL (SD)	Wt.	No.	TL (SD)	Wt.	No.
Yellow perch	4.6 (1.0)	0.04	100	4.6 (1.2)	0.04	100	3.9 (1.0)	0.02	100
Rock bass	4.7 (1.0)	0.07	100	4.2 (1.3)	0.05	100	4.1 (1.1)	0.05	100
Pumpkinseed	4.4 (1.4)	0.07	100	3.9 (1.4)	0.04	89	2.8 (0.9)	0.01	72
				Chick					
Yellow perch	4.1 (1.1)	0.03	100	3.6 (1.0)	0.02	100	3.7 (1.1)	0.02	100
Rock bass	4.2 (1.2)	0.05	100	3.9 (1.3)	0.04	100	3.6 (1.3)	0.03	100
Pumpkinseed	4.1 (1.2)	0.05	46	4.0 (1.6)	0.05	89	2.7 (1.1)	0.01	23
				Post-chick					
Yellow perch	4.2 (1.1)	0.03	72	3.4 (1.2)	0.02	66	4.1 (1.1)	0.03	100
Rock bass	3.6 (1.1)	0.03	98	4.0 (1.2)	0.04	100	2.8 (1.2)	0.01	76
Pumpkinseed	4.3 (1.1)	0.06	60	3.2 (0.8)	0.02	80	3.6 (1.3)	0.03	100

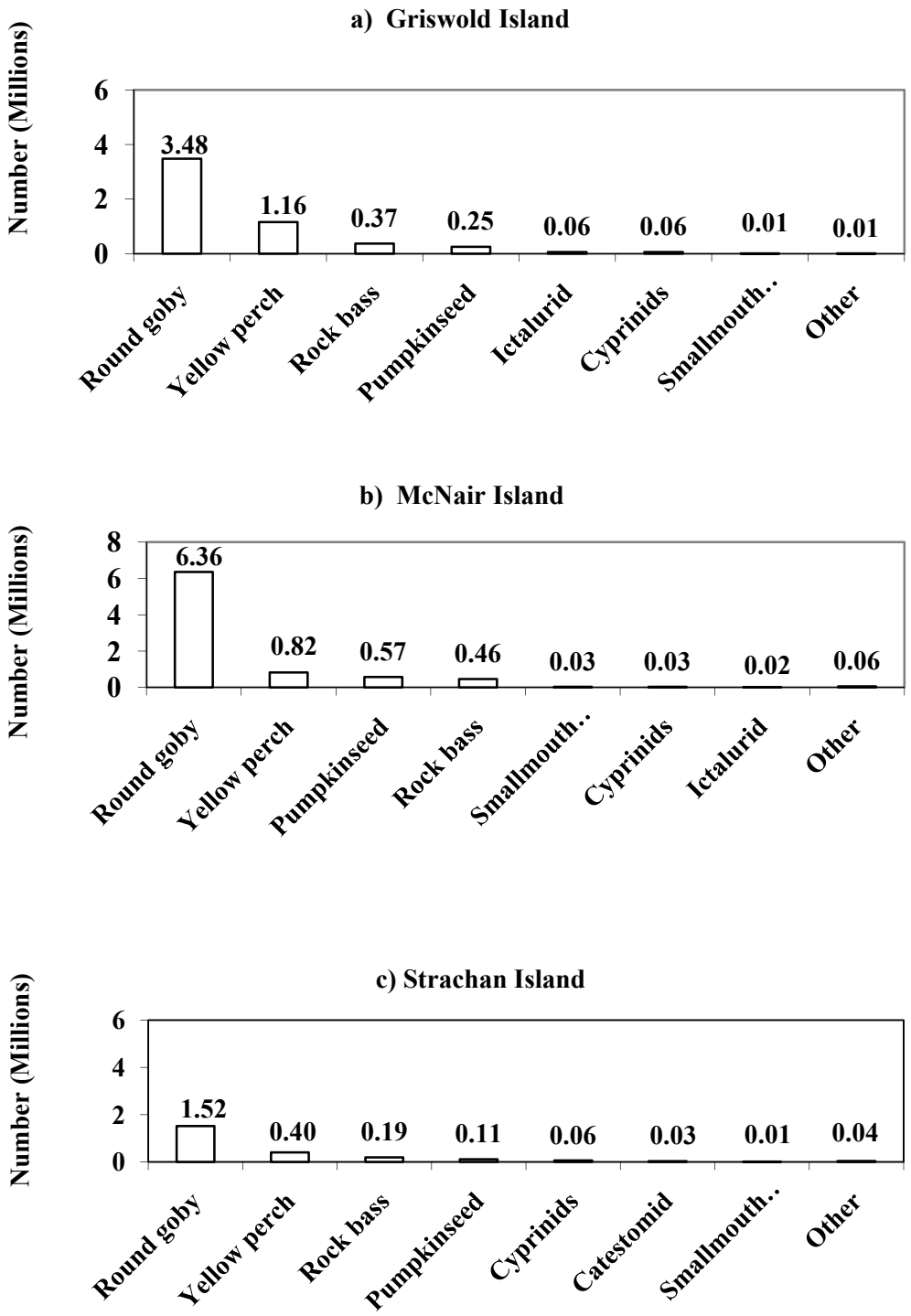

Figure 1. Estimated number of fish, in millions, consumed by cormorants from colonies at (a) Griswold, (b) McNair and (c) Strachan Islands in the St. Lawrence River in 2013.

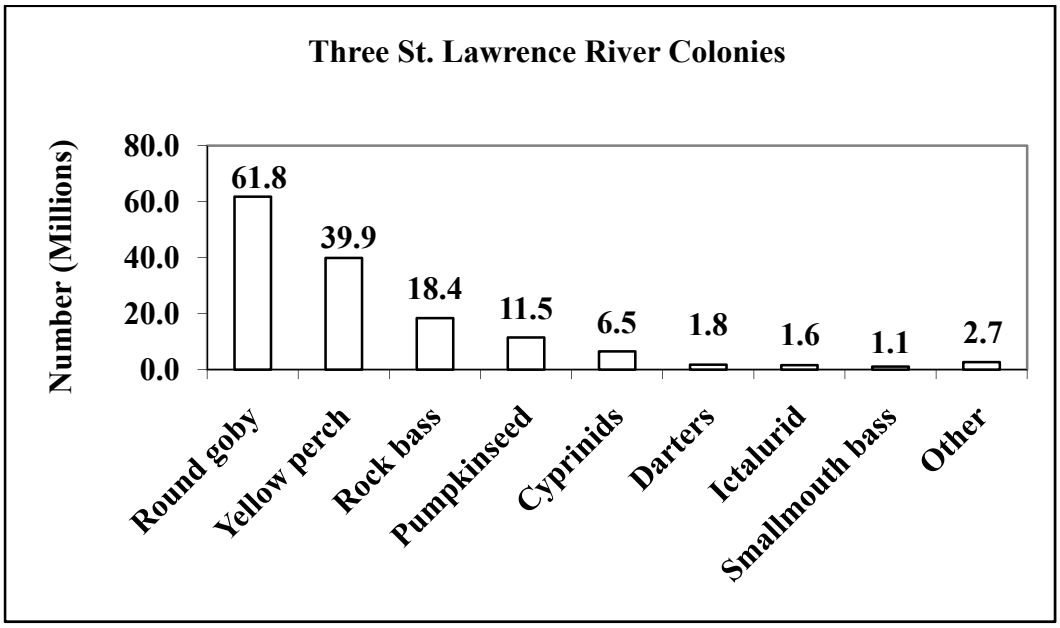

Figure 2. Estimated number of fish, in millions, consumed by cormorants at the three St. Lawrence River colonies 1999 to 2013.

2013 Status of the Lake Ontario Lower Trophic Levels

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Significant Findings for Year 2013:

1) Phosphorus showed high variation across nearshore (10 m depth) sites but was more stable at offshore (20 m and deeper) stations. In June and July, sites at the mouth of the Niagara River and at Oak Orchard had high phosphorus concentrations (20 – 46 µg/L). Epilimnetic average April-Oct total phosphorus (TP) ranged between 6.9 and 19.9 µg/L in the nearshore and between 5.8 and 10.2 µg/L in the offshore. Average April-Oct soluble reactive phosphorus (SRP) ranged from 0.9 to 7.3 µg/L in the nearshore and 0.8 to 1.4 µg/L in the offshore. TP and SRP were significantly higher in the nearshore than in the offshore.
2) Spring TP has declined in the longer data series (since 1981), but not since 1995. It averaged 8.4 µg/L in the nearshore and 5.0 µg/L in the offshore in 2013—below the 10 µg/L target set by the Great Lakes Water Quality Agreement of 1978 for offshore waters of Lake Ontario.
3) Offshore summer chlorophyll-*a* declined significantly in both the short- (1995-2013) and long-term (1981-2013) time series at a rate of 3-4% per year. Nearshore chlorophyll-*a* increased after 2003 but then declined again after 2009. Epilimnetic chlorophyll-*a* averaged between 0.5 and 1.3 µg/L across sites with no difference between nearshore and offshore habitats. Average seasonal Secchi disk depth ranged from 4.5 m to 10.6 m and was higher in the offshore (average 8.1 m) than nearshore stations (6.3 m). These values are indicative of oligotrophic conditions in both habitats.
4) In 2013, Apr/May – Oct epilimnetic zooplankton size and total biomass were significantly higher in the offshore than the nearshore. However, with the exception of *Limnocalanus* (higher in offshore), there were no differences between habitats for any of the zooplankton groups.
5) Most of the zooplankton biomass was in the metalimnion and hypolimnion during the day in 2013. Between 65 and 98% of zooplankton biomass was found below the thermocline throughout the year.
6) The predatory cladoceran *Cercopagis* continued to be abundant in the summer, peaking at ~7 mg/m^3 in the offshore. *Bythotrephes* peaked in October (~0.7 mg/m^3), but *Bythotrephes* biomass was at its lowest biomass in both offshore and nearshore stations since 2005.
7) Summer nearshore zooplankton density and biomass have declined significantly since 1995 at rates of 9-10% per year. Nearshore epilimnetic zooplankton density and biomass have remained stable since 2005 at low levels relative to previous years.
8) Summer offshore zooplankton density and biomass in the epilimnion of Lake Ontario have also declined since 1995 at rates of 10-14% per year, but those declines are marginally significant; density declined significantly in the long-term (since 1981) but has remained at a lower stable level since 2005.
9) Bosminid and cyclopoid copepod biomass declined significantly in nearshore waters. The same pattern occurred in the offshore but declines were significant for bosminids and marginally significant for cyclopoid copepods. Daphnid biomass has also declined significantly in the nearshore.
10) The decline in Daphnid biomass nearshore and *Bythotrephes* biomass offshore and nearshore is

indicative of increased planktivory by alewife. Significant declines in Bosminid and cyclopoid copepod biomass is indicative of increased invertebrate predation by *Cercopagis* and *Bythotrephes* in recent years.

Introduction

This report presents data on the status of lower trophic level components of the Lake Ontario ecosystem (zooplankton, phytoplankton, nutrients) in 2013 and compares the 2013 data with available time series. Lower trophic levels are indicators of ecosystem health (as identified by the Lake Ontario Pelagic Community Health Indicator Committee [EPA 1993] and presented in the biennial State of the Lake Ecosystem Conference [SOLEC] reports) and determine the lake's ability to support the prey fish upon which both wild and stocked salmonids depend. Understanding the production potential of lower trophic levels is integral to ecosystem-based management. There is a concern about the ability of the lake to support current alewife production in the offshore due to declining production at lower trophic levels at the same time as there is a concern about excessive attached algal production (e.g., *Cladophora*) in some beach areas. The collapse of the alewife population and decline in Chinook salmon fishery in Lake Huron in 2003 may have been due to declines in lower trophic levels (Barbiero et al. 2011, Bunnell et al. 2012). Alewives have not returned to Lake Huron as of 2013 (Gorman and Weidel 2014), and concerns of a similar crash in Lake Michigan led to a decision to decrease Chinook stocking rates by about 50% in that lake.

From 1995-2013 we conducted a research program (hereafter referred to as the biomonitoring program, BMP) in Lake Ontario with the primary objective of evaluating temporal and spatial patterns in a number of ecological indicators: total phosphorus (TP), chlorophyll *a* (chl-*a*), Secchi depth, and crustacean zooplankton (density, biomass, species composition, and size structure). Samples were collected from late April through early October. These indicators are assessed from spring through fall because each indicator has particular importance at a specific time of the year. Springtime (Apr-May) represents a time of peak nutrient levels in many systems; nutrients that will be available for biological activity during the year. This makes spring TP a logical indicator choice for nutrient levels in the lake. The summer stratified period characterizes the peak production period for phytoplankton and many zooplankton species; therefore, summer chl-*a* and summer zooplankton biomass were chosen as indicators. The September-October time period is useful to track species such as *Bythotrephes* whose biomass typically peaks later in the year. The BMP is a collaborative project that, in 2013, included the New York State Department of Environmental Conservation (NYSDEC) Lake Ontario Unit and Region 6, 7 and 8 at Watertown, Cortland, and Avon; the U.S. Fish & Wildlife Service Lower Great Lakes Fishery Resources Office (USFWS); the U.S. Geological Survey–Lake Ontario Biological Station (USGS); and Cornell University.

The year 2013 was also the Cooperative Science and Monitoring Initiative (CSMI) year for Lake Ontario. Several of the groups involved in the BMP therefore collected additional data on lower trophic levels primarily in the offshore region. This sampling also involved additional partners from Canada (DFO, EC and OMNR, Weidel et al. 2014). The CSMI 2013 data are being analyzed but are not yet ready to be incorporated in this report. Instead the results in this report from the BMP will be incorporated with the CSMI data for a more complete picture of the lower trophic levels in Lake Ontario during 2013 in the coming months.

Report Objectives

Using data from 1995 to 2013, we address the following questions:

(1) What is the status of Lake Ontario's lower trophic levels in 2013, and what differences

exist between nearshore and offshore sites this year?

(2) What are the time trends in key indicators, and are there sudden changes in these trends (regression and change-point analysis). How does the year 2013 compare to these time trends (using BMP data and other long-term data sets)?

(3) What is the status of the two non-native predatory cladocerans, *Bythotrephes* and *Cercopagis*?

(4) Are there changes in zooplankton community structure (biomass, size, species composition) that could be indicative of changes in alewife predation, changes in predatory invertebrates (*Cercopagis, Bythotrephes, Mysis, Hemimysis*) or decreased overall productivity of the lake?

(5) Are the changes observed in the epilimnetic zooplankton indicative of changes in zooplankton in the whole water column?

Methods

Sampling

We measured total phosphorus (TP), soluble reactive phosphorus (SRP), chlorophyll-*a* (chl-*a*), water temperature, Secchi depth, and zooplankton density, size, and biomass by species at offshore and nearshore sites in Lake Ontario (Figure 1). Samples were collected from seven nearshore sites biweekly from May through October 2013 (12 potential sampling weeks). Inclement weather precluded sampling during one week at Niagara West Lake (NWL) and Niagara East Lake (NEL), during two weeks at Oak Orchard Lake (OOL), and on three occasions at Sandy Pond Lake (SPL); all sites were sampled on at least 9 occasions. Offshore samples were collected during April-May, June, July, and September by the R/V Seth Green, and approximately monthly (April–October) by the R/V Kaho. In addition, five stations were sampled at night in July during the hydroacoustic survey conducted by the R/V Seth Green. Nearshore sites had depths ranging from 9.7 m to 14.5 m (32 to 48 ft), and offshore sites ranged from 22 m to 209 m (72 to 686 ft). Offshore sampling totaled 26 daytime samples taken from seven sites and five nighttime samples from five sites.

Water Chemistry

Water samples were collected for analysis of chl-*a*, TP, and SRP. Each sample was obtained by using an integrated water sampler (1.9 cm inside diameter Nalgene tubing) lowered to a depth of 10 m or bottom minus 1 m where site depth was 10 m or less. The tube was then closed off at the surface end and the column of water transferred to 2 L Nalgene containers. From each sample, a 100 mL unfiltered aliquot was frozen for later analysis of TP (Menzel and Corwin 1965). We also filtered 1-2 L of water through a Whatman 934-AH glass fiber filter that was frozen for later analysis of chl-*a* using acetone extraction followed by fluorometry (EPA 2013). A 100 mL aliquot of filtered water was frozen for later analysis of SRP (Strickland and Parsons 1972). TP and SRP samples were analyzed at the Upstate Freshwater Institute (UFI). Chl-*a* was analyzed at CBFS.

Quality Control and Variability

To measure analytical precision we, processed replicate samples for TP and SRP. In July, six aliquots of water were taken from the same sample at each nearshore site.

In 2013, we collected replicate samples to determine within-site variability of TP, SRP, and chl-*a*. Triplicate samples were collected at each nearshore location once in August. From each of the three samples, one aliquot was taken for TP, one for SRP, and one for chl-*a* analysis. TP and SRP samples were analyzed at UFI. Chl-*a* was analyzed at CBFS.

Duplicate samples for TP, SRP, and chl-*a* were collected at each offshore site throughout the year. Mean values from those duplicates were used in the analyses.

Zooplankton

Zooplankton samples were collected with a standard 0.5 m diameter, 153 µm-mesh nylon net equipped with a calibrated flowmeter. At nearshore sites, tow depths ranged from 5 to 11 m. At offshore sites, tow depths ranged from 8 to 50 m (to the thermocline when stratification was present, epilimnetic sample). At offshore sites less than 100 m bottom depth (one daytime site and three nighttime sites) a total water column sample (bottom minus 2 m) was

collected in addition to the epilimnetic sample. At sites greater than 100 m bottom depth (three daytime sites and one nighttime site), one 50 m and one 100 m tow were obtained in addition to the standard epilimnetic sample. Zooplankton were anesthetized with antacid tablets and then preserved in the field with 95% ethyl alcohol. At nearshore sites, single samples were collected on a biweekly basis from May to October with the exception of July and August during which duplicate samples were collected on each sampling date. Mean values from these duplicates were used in all analyses.

At CBFS, each sample was strained through a 1.02 mm mesh cup to separate *Cercopagis* and other larger organisms (>1 mm in length) from smaller zooplankton (<1 mm). This was done because *Cercopagis* and *Bythotrephes* form clumps in the sample, making the usual random sub-sampling of 1 mL samples inappropriate. For each sample that contained clumps of *Cercopagis* or *Bythotrephes*, two analyses were performed - one on the smaller zooplankton and one on the larger zooplankton (including *Cercopagis* and *Bythotrephes*) that were caught in the 1.02 mm mesh strainer. At least 100 larger zooplankton (or the whole sample) were measured and enumerated by sub-sampling organisms from a gridded, numbered Petri dish in which the sample had been homogeneously separated. In some cases different subsamples were used for *Bythotrephes* and *Cercopagis*. To calculate the total number of large crustaceans and *Cercopagis* in the clumped part of the sample, we used a ratio of wet weights of the sub-sample to wet weights of the total sample. Wet weights were determined using a Sartorius balance.

For smaller-sized zooplankton, we counted and measured at least 100 organisms from one or more 1 mL random sub-samples. The sub-sample was examined through a compound microscope at 10-40X magnification. Images from the sample were projected onto a digitizing tablet that was interfaced with a computer. Zooplankton were measured on the digitizing tablet and identified to species (with the exception of nauplii and copepodites) (Pennak 1978, Balcer et al. 1984). In earlier years of this project an electronic touch screen (1995-1997) and a 20X microprojector (1998-2000) were used for measuring the zooplankton (Hambright and Fridman 1994). We then used length:dry-weight regression equations (CBFS standard set, Watkins et al. 2011) to estimate zooplankton biomass. Densities from all counts of the same sample (large and small animals) were summed to yield an overall density of all organisms in each sample.

Data Analyses

We compared April/May to October mean TP, SRP, chl-*a*, water temperature (top 10 m), Secchi depth, zooplankton density, size, and biomass, and zooplankton group biomass between the two habitats by first averaging across sites for each month (nearshore, n=7; offshore, n=7) and then comparing the two habitats using a paired t-tests (paired by month, n=5). Logarithmic transformations were needed for TP, SRP and zooplankton to reduce heteroscedasticity. We divided zooplankton into the following six groups: daphnids (*Daphnia mendotae*, *D. pulicaria*, *D. retrocurva*); bosminids (*Bosmina longirostris*, *Eubosmina coregoni*); calanoid copepods (*Leptodiaptomus minutus*, *Skistodiaptomus oregonensis*, *Leptodiaptomus sicilis*, *Leptodiaptomus ashlandi*, *Epischura lacustris*, *Eurytemora affinis*); cyclopoid copepods (*Acanthocyclops vernalis*, *Diacyclops thomasi*, *Mesocyclops edax*, *Tropocyclops prasinus*); other cladocera (*Ceriodaphnia quadrangula*, *Chydorus sphaericus*, *Diaphanosoma sp.*, *Alona sp.*, *Holopedium gibberum*, *Camptocercus sp.*, *Scapholeberis sp.*); and nauplii. Five individual species were analyzed separately from the groups. Those species are: *Bythotrephes longimanus*; *Cercopagis pengoi*, *Leptodora kindtii, Polyphemus pediculus,* and *Limnocalanus macrurus.* Differences were considered significant at $p<0.05$.

Change point analyses (Taylor Enterprises, Inc. 2003) were performed on long-term trends in two time stanzas (1995–2013 and 1981–2013) to test for breaks in the data. These were performed on spring TP, summer chl-*a*, summer epilimnetic zooplankton density and biomass, and on zooplankton group biomass. Change point analysis uses cumulative deviations from the mean to assess if there are significant

changes in time trends and when those changes occurred. This is done by resampling the data series 10,000 times to construct confidence intervals based on the inherent variability in the data series, and testing if and when the observed data series differ significantly from these confidence intervals. Regression analyses (JMP Pro v10.0.2, SAS Institute Inc. 2012) were performed on the same two time stanzas (1995–2013 and 1981–2013) using spring TP, summer chl-*a*, summer epilimnetic zooplankton density and biomass, and zooplankton group biomass. We note that previous year's reports incorporated nighttime zooplankton data from 1995 – 1999 in the regression and change point analyses; nighttime samples have been removed from those analyses in this report.

Results

Quality Control and Variability

To estimate analytical precision (i.e. within sample variability), we analyzed 36 TP samples 36 SRP samples (6 sites x 6 samples per site). Coefficients of variation (CV=SD/mean) ranged from 3 to 36% (mean of 15%) for TP and from 8 to 50% (mean of 29%) for SRP. Values from replicated sampling occasions were averaged for all analyses. One site (Galloo Island Lake [GIL]; 7/3/13) had SRP values that were higher than TP values for all six replicates. Those values were excluded from all analyses.

The analysis of August nearshore TP, SRP, and chl-*a* triplicate samples showed that the CV for TP ranged from 3 to 37% (mean of 18%), the CV for SRP ranged from 13 to 73% (mean of 36%), and the CV for chl-*a* ranged from 5 to 56% (mean of 25%). Within site variability for TP and SRP were similar to analytical precision. Ranges represent typical variation observed in previous years. Values were averaged for later analyses.

2013 Water Quality

The nearshore sites east and west of the Niagara River and at Sandy Pond had lower water clarity compared with other nearshore sites and slightly higher chl-*a* concentrations; average May through October Secchi depth was 5 m or less at those locations. Average Secchi depths at other nearshore and offshore sites were between 6 m and 8 m (Table 1, Figure 2a). May - Oct chl-*a* concentrations were low; all sites averaged below 1.5 µg/L, and several averaged below 1 µg/L (Table 1, Figure 3a). Average spring TP concentrations at nearshore (8.4 µg/L) and offshore (5.0 µg/L) sites were below the 10 µg/L target established by the Great Lakes Water Quality Agreement (IJC 1988) for offshore waters (Figure 4a). The nearshore sites east and west of the Niagara River and at Oak Orchard had the highest TP levels (16-20 µg/L) while offshore sites (with the exception of Oak Orchard-N; 10.2 µg/L) had the lowest (Table 1). Nearshore and offshore sites both had highest TP concentrations in June (Figure 4a). High mean nearshore TP concentrations in June and July were due to extremely high values measured at NEL, NWL, and OOL. High concentrations at these sites (e.g. NEL 6/18 = 70 µg/L) likely occurred as a result of inputs from the Niagara River. Nearshore SRP concentrations mirrored the TP pattern with higher values at NEL, NWL, and OOL and low ($\leq$2.5 µg/L) concentrations at other nearshore sites and in the offshore (Table 1, Figure 5). May - Oct water temperatures (top 10 m) ranged from 16-18ºC at nearshore sites and from 12-20 at offshore sites (Table 1). Annual (Apr/May – Oct) mean water temperature was not different between nearshore and offshore sites (Table 2), but offshore sites were slightly warmer than nearshore sites in July and September (Figure 6).

Total phosphorus, chl-*a*, and Secchi depths are typically correlated, as all are potential indicators of phytoplankton abundance. This was evident at the individual sites in 2013 (higher TP, SRP, chl-*a*, and lower Secchi depth at NEL, NWL, and OOL), but not in the comparison of annual mean values between habitats; annual mean TP and SRP were significantly higher in the nearshore, but there were no differences between chl-*a* and Secchi depth between nearshore and offshore habitats (Tables 1 and 2).

Water Quality Trends Since 1995

Comparisons with data collected since 1995 show that 2013 had average concentrations of spring TP and SRP (Figure 4b). Offshore summer chl-*a* concentrations were the lowest on record, but nearshore concentrations were

similar to those from the past five years (Figure 3b). Summer Secchi depths were similar to values since 2004 (Figure 2b). Offshore summer chl-*a* concentrations have decreased significantly, but in the nearshore they have not (Table 3).

2013 Zooplankton

In 2013, mean (May-Oct) zooplankton density did not differ significantly between nearshore and offshore sites (Table 2, Figure 7). Density and biomass were highest during September in both habitats (Figure 7) with the exception of one station sampled in November (Smoky Point Offshore [SPO]). Zooplankton biomass and mean size were significantly higher in the offshore (Table 2, Figure 7).

Although Apr/May - October total epilimnetic zooplankton biomass was significantly higher in the offshore than the nearshore, the differences for individual groups were not (with the exception of higher *Limnocalanus* biomass in the offshore (Table 2; Figure 8). Cyclopoid copepods (primarily *Diacyclops thomasi*) represented the greatest proportion of biomass in both the offshore (36%) and nearshore (35%) followed by calanoid copepods, daphnids and bosminids.

In 2013, *Cercopagis* and *Bythotrephes* were detected in samples from both habitats (Figures 8 and 9, Table 2). *Cercopagis* was first detected in early July at nearshore and offshore sites. *Cercopagis* peaked initially during mid-July in the offshore and nearshore and exhibited a secondary peak in the nearshore in late August (Figure 8). *Bythotrephes* was present in April in the offshore and then was absent until September. It was first detected in early August at nearshore locations. Peak *Bythotrephes* biomass occurred in early September in both habitats (Figure 8). Combined biomass of *Cercopagis* and *Bythotrephes* represented 3% of the zooplankton community at nearshore sites and 5% at offshore sites.

Scapholeberis sp. was caught in the epilimnetic sample taken at Smoky Point-O on 7/15/2013. That was the first occurrence of this species in this sampling program. *Scapholeberis* sp. is typically found in weedy littoral areas and feeds at the water's surface, making it susceptible to wind driven movements which likely explains its presence in the offshore.

Zooplankton Trends Since 1995

Total summer epilimnetic zooplankton biomass at nearshore sites declined significantly from 1995 to 2013 (Figure 10, Table 3). The trend in offshore waters was the same but marginally significant. Declines in biomass in both habitats were primarily due to significant decline in bosminids and cyclopoid copepods (Table 3). At the same time, *Bythotrephes* biomass increased in both habitats (marginal in offshore), and *Cercopagis* biomass increased significantly in the offshore but not in the nearshore. However, *Bythotrephes* biomass was low in both 2012 and 2013, with the 2013 average biomass the lowest observed since 2004.

A change point analysis using data from 1995–2013 showed that a break occurred in offshore total zooplankton density and biomass in 2005 (Figures 10 and 11, Table 3), in nearshore density in 1998 and 2005, and in nearshore biomass in 1998 and 2006. The offshore break in 2005 was also evident in cyclopoid copepods (2005) and bosminids (2004), and may be related to the positive break point for *Bythotrephes* at about the same time (2006). In the nearshore, the negative break point in 1998 was related to declines in calanoids, bosminids and cyclopoids and coincided with an increase in *Cercopagis* (see also Warner et al. 2006). The 2006 break point in the nearshore biomass was related to a further decrease in nearshore cyclopoid biomass and a decrease in *Cercopagis* biomass. *Bythotrephes* and calanoid biomass also increased in the nearshore in 2006-2007 (Table 3).

Changes in lower trophic indicators were similar between the two habitats (regression analysis), but the timing of changes varied (change point analysis). In both habitats, spring TP was stable from 1995 – 2013 while zooplankton density and biomass declined. The decline in total zooplankton biomass was due to declines in bosminid and cyclopoid biomass in both habitats, and to a lesser degree, daphnids in the nearshore. Summer chl-*a* declined significantly in the offshore, but remained stable in the

nearshore. In nearshore waters, there was a positive break in chl-*a* concentration after 2003 and a negative break after 2009, while there were no such breaks in the offshore. Breaks in cyclopoid biomass occurred at the same time (2005) in nearshore and offshore waters. Despite the lack of significant trends, a negative break occurred in nearshore calanoid copepod biomass after 1997 and a positive break occurred after 2007. These breaks coincided with the opposite pattern in *Cercopagis* biomass—positive break after 1999 and a negative break after 2007 (Table 3).

Longer term trends (1981-2013) were significant for several offshore lower trophic level indicators. These trends were evaluated by adding BMP data to available data series from the Department of Fisheries and Oceans Canada, and point data from the Lake Ontario Trophic Transfer and Lake Ontario Lower food web Assessment studies (Table 3). Significant long-term trends were a decrease in spring TP, a decrease in summer chl-*a*, and a decrease in summer zooplankton density (Figures 3b, 4b, and 11; see also Mills et al. 2003, Holeck et al. 2008).

Stratified Zooplankton Hauls

Comparison of epi-, meta-, and hypolimnetic zooplankton tows showed that zooplankton were concentrated in the hypolimnion throughout the year (Figure 12). Epilimnetic biomass represented only 2 – 35% of total water column biomass (Figure 12), and this pattern was even more pronounced during stratified summer conditions when only 2 – 4% of the biomass was found in the epilimnion. In July and September, 85% of the zooplankton biomass of Lake Ontario resided below the thermocline. Cyclopoid copepods and daphnids (primarily *D. retrocurva*) accounted for most of the metalimnetic biomass, and calanoid copepods (*L. macrurus* and *L. sicilis*) accounted for most of the hypolimnetic biomass during this time (Table 4).

Nighttime tows taken in mid-July show a more even distribution of zooplankton above and below the thermocline at two of the four sites, but a similar pattern to daytime at the other two sites (Figure 13). The nighttime site at Rochester/Sodus (7/21) shows a similar distribution to that of the nearby Smoky Point daytime site (7/15). Nighttime sampling in 2013 occurred near the time of a full moon (7/21) and this could account for the similarity between daytime and nighttime samples. Preliminary analysis of CSMI divided tows show strong vertical migration of zooplankton towards the epilimnion at night in both July and September of 2013.

Results of the hypo-, meta-, and epilimnetic tows from summer and fall deep sites (>100m) showed most groups had the greatest biomass in the metalimnion than in either the epilimnion or hypolimnion (Table 4). The groups 'other cladocerans', 'bosminids', and *Bythotrephes* had the greatest biomass in the epilimnion; daphnids and cyclopoids dominated the metalimnion; and calanoid biomass was highest in the hypolimnion.

Discussion

Secchi depth, chl-*a* and total phosphorus are often used as trophic level indicators (Carlson 1977). Average Apr-Oct values by site ranged from 0.5 to 1.3 µg/L for chl-*a*, 5.8 to 19.9 µg/L for TP, 0.8 to 7.3 µg/L for SRP, and 4.5 to 10.6 m for Secchi depth for both the nearshore and offshore sites. These values are within the range for oligotrophic (low productivity) systems (0.3-3 µg/L chl-*a*, 1-10 µg/L TP; Wetzel 2001). We note that offshore chl-*a* concentrations decreased significantly since 1995 and were at record low levels in 2013. This coincided with significantly lower TP and SRP concentrations in the offshore and marginally higher Secchi depth. Despite differences between nearshore and offshore sites, Lake Ontario should be classified as oligotrophic in both habitats. However, there were high TP levels in certain nearshore areas of the lake in 2013.

Phosphorus levels can be substantially higher in the shoreside habitat (<5 m depth). Makarewicz et al. (2012) reported high nutrient levels (often over 50 µg/L TP) in this habitat at several stations along the US southern shore, and these levels can result in nuisance algal blooms and proliferation of attached algae (Malkin et al. 2010). We observed high TP (in excess of those

reported by Makarewicz et al. 2012) and SRP concentrations in June and July at sites near the mouth of the Niagara River and along the southern shore of the lake. These sites are deeper (~10-12 m bottom depth) than most sites sampled by Makarewicz et al. (2012). Increased runoff from a wet spring likely contributed to increased phosphorus input from Lake Erie resulting in higher phosphorus concentrations in the Niagara River plume and along the south shore where water from the Niagara River is moved by currents and wind. Makarewicz et al. (2012) also showed that nutrient levels decrease with distance from shore and reach values presented in this report (eastern nearshore sites, 7 – 9 µg/L) at 1-4 km from shore depending on season and station. This is consistent with our findings from other nearshore stations throughout the year and from Niagara River mouth stations and south shore station in May and August – October. Further analysis of nutrient loading from the Niagara River is part of the CSMI analyses for 2013.

Spring TP is a good indicator of summer phytoplankton production (Dillon and Rigler 1975), and the low chl-*a* levels observed in both the offshore and nearshore are consistent with the low spring TP values. Spring TP declined from values between 20 and 25 µg/L in the 1970s to values between 4 and 7 ug/L in the 2000s in the offshore and 5-11 µg/L in the nearshore (Figure 4b). These values are consistent with data from the Canadian Surveillance Program and EPA's lower trophic level assessments in 2003 and 2008. Spring TP has been below the goal of 10 µg/L set by the Great Lakes Water Quality Agreement of 1978 in the offshore sites since 1995 (not all years available) and around that goal in the nearshore sites (Figure 4b). Interestingly, spring TP has not declined further since 1995, but offshore summer chl-*a* has declined during the same time period. This paradox may be associated with phosphorus being retained in the deep chlorophyll layer (see below) or retained in the bottom waters by quagga mussels. In any case, the lack of change in epilimnetic TP since 1995 is indicative of stable nutrient loading into Lake Ontario over the last 18 years.

Epilimnetic crustacean zooplankton density and biomass were low at nearshore and offshore sites in 2013 compared to the long-term mean (Figures 9 and 10). Epilimnetic zooplankton biomass has been particularly low since 2005 in both the nearshore and offshore, and there is a significant change point after 2005 in offshore density and biomass. Nearshore data shows a similar trend with a change point in density after 2005 and a change point in biomass after 2006. Density and biomass also show change points in 1998, the year *Cercopagis* was first abundant. Average size shows no trend in time (not shown) although nearshore sites have smaller average sizes than the offshore. Average size in the nearshore was smallest in late June-early July, coinciding with alewife concentrating in the nearshore to spawn (O'Gorman et al. 1991, Klumb et al. 2003).

The decline in epilimnetic zooplankton biomass is primarily the result of significant declines in bosminids and cyclopoids (mainly *Diacyclops thomasi*) in the nearshore and offshore. Daphnids showed no significant change in the offshore, but did decline significantly in the nearshore. The two groups with significant increases over time in the epilimnion are the invasive predatory cladocerans *Cercopagis* and *Bythotrephes.* We do not think this is a coincidence. The decline in smaller zooplankton is consistent with observed effects of these predatory zooplankton in Lake Ontario and elsewhere (Lehman and Caceres 1993, Yan et al. 2001, Pangle et al. 2007, Bunnell et al. 2011, Benoit et al. 2002, Laxson et al. 2003, Warner et al. 2006). In addition, we note that the majority of the biomass of these invertebrate predators is in the epilimnion, whereas the majority of the zooplankton biomass is in the metalimnion and hypolimnion (see below). These metalimnetic zooplankton migrate into the epilimnion at night (Rudstam et al. 2012, CSMI 2013 unpubl data), a behavior which has also been observed in Lake Michigan (Vanderploeg, NOAA Great Lakes Laboratory, Ann Arbor, pers. comm.). *Bythotrephes* is known to induce migration in daphnia in the laboratory (Pangle and Peacor 2006).

This year, we also sampled the meta- and hypolimnetic layers for zooplankton by using depth stratified tows (different tow depths). We

then calculated densities in deeper water through subtraction. Although this procedure introduces additional errors compared to an opening and closing net, it is simpler logistically in the field. The results are interesting. Areal biomass (mg/m^2) was higher in deeper water on all 12 sampling occasions with depth-stratified net hauls. This is not unexpected since the volume of water sampled in the metalimnion and hypolimnion was greater than that in the epilimnion; depth-stratified tows typically sampled 20 m of epilimnion, 30 m of metalimnion, and 50 m of hypolimnion. However, zooplankton biomass dominated the hypolimnion on a volumetric basis as well; hypolimnetic waters averaged 60 mg/m^3, while metalimnetic and epilimnetic waters each averaged 30 mg/m^3. We found 65 - 98% of the zooplankton biomass to be below the thermocline during the day throughout the year. Species composition in the hypolimnion was dominated by larger calanoids (i.e., *Limnocalanus macrurus* and *Leptodiaptomus sicilis*). The smaller cyclopoid, *Diacyclops thomasi*, daphnids, and *Cercopagis* (summer only) dominated metalimnetic waters. Bosminids and *D. retrocurva* were dominant in the epilimnion. Further analyses of CSMI data using opening and closing nets is forth coming. It is clear that future sampling in offshore water must include deep tows.

Total abundance and biomass of zooplankton in Lake Ontario may not have declined to the extent suggested by the epilimnetic tows as the proportion of biomass in deep water may have increased over time. These deep zooplankton can and do migrate into the epilimnion during the night or may remain in deep water to feed on the deep chlorophyll layer. Deep chlorophyll maxima are common in the upper Great Lakes (Barbiero et al. 2012; Barbiero and Tuchman 2004, Watkins et al. in press). Such maxima develop when nutrients are limiting and water clarity is sufficient to allow for positive algal growth at depth with elevated nutrient concentrations. Understanding the identity and productivity of this layer and the extent it is utilized by zooplankton was a major thrust of the research during the 2013 CSMI sampling. Deep zooplankton may be a contributing factor for the increased adult alewife condition observed in the lake in recent years (O'Gorman et al. 2008, Walsh et al. 2011). In 2013, condition of adult alewife remained high and within the range observed in recent years, indicating that the alewife population is not limited by food availability (Walsh and Connerton 2014). Changes in zooplankton community structure (e.g. biomass, species composition), including the decline in Daphnid biomass nearshore and *Bythotrephes* biomass offshore and nearshore indicate possible increased planktivory by alewife in 2013. This is consistent with the presence of four consecutive strong year classes of alewife, including the 2012 year class which was the strongest in the 36-year time series of alewife assessment (Walsh and Connerton 2014). The significant decline in Bosminid and cyclopoid copepod biomass is indicative of increased invertebrate predation by *Cercopagis* and *Bythotrephes* in recent years.

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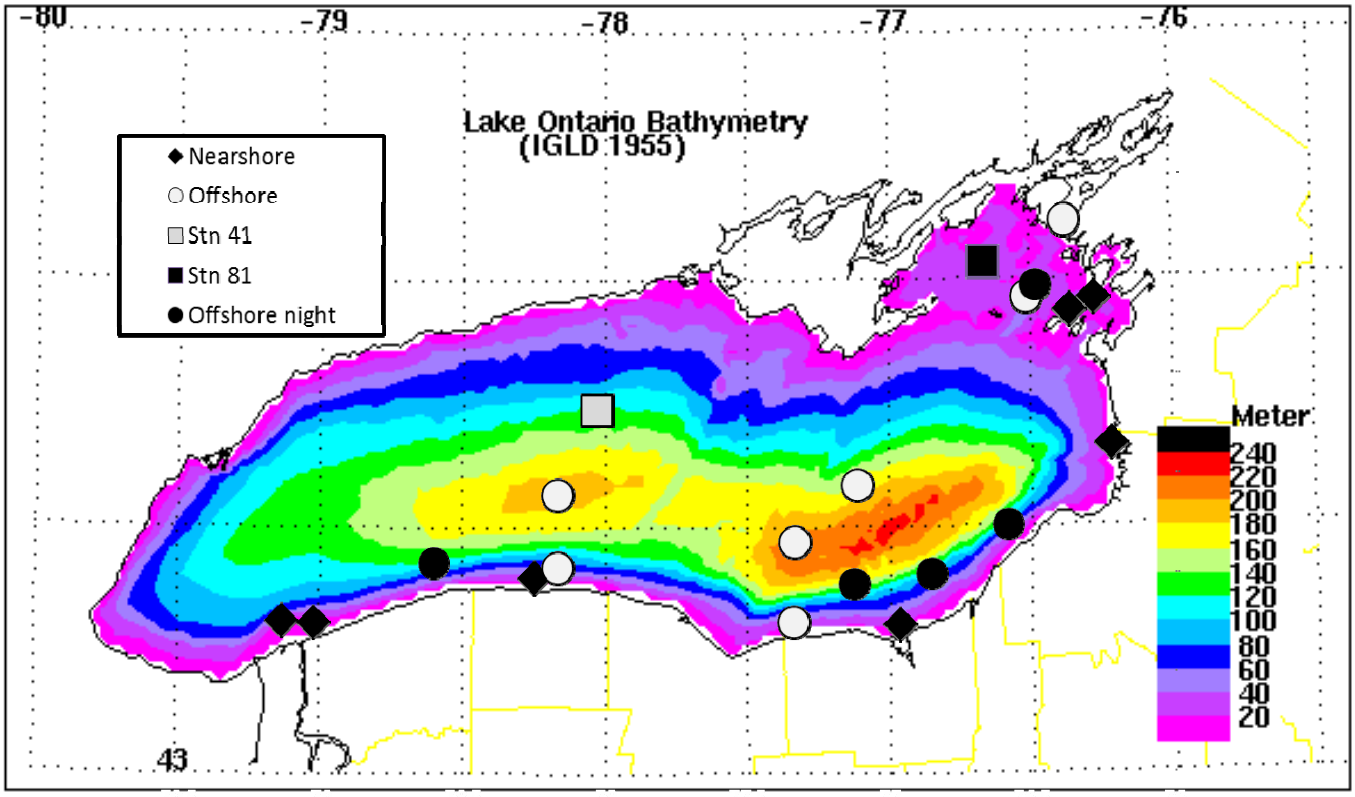

Figure 1. Map of Biomonitoring Program sites, 2013. Station 41 and station 81 are locations sampled by the Department of Fisheries and Oceans Canada's Biomonitoring Program (1981 – 1995) and are included here as reference for long-term data included in subsequent figures.

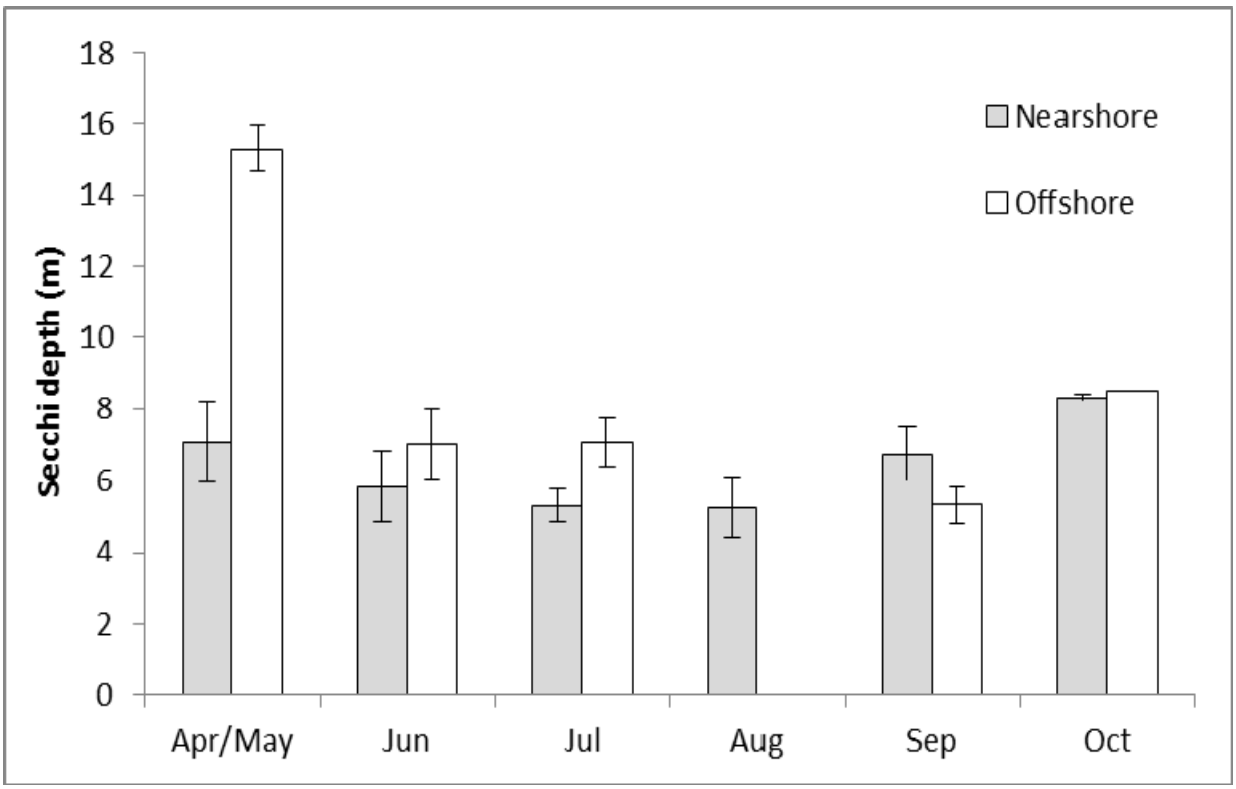

Figure 2a. Mean monthly Secchi depth (meters) for nearshore and offshore habitats in Lake Ontario, Apr/May - October, 2013. Error bars are ± 1SE.

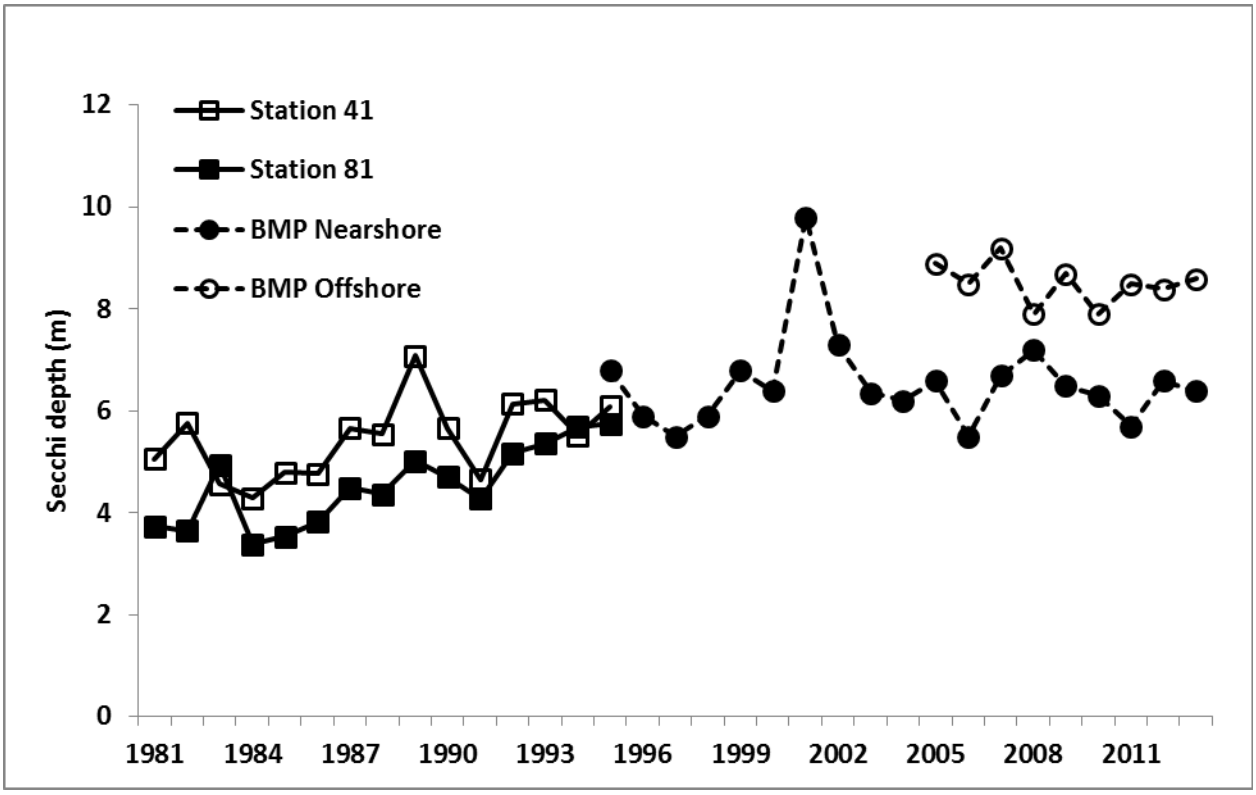

Figure 2b. Long-term mean Apr/May – Oct Secchi depth (meters) in Lake Ontario, 1981 – 2013. Station 41 and Station 81 are from the Department of Fisheries and Oceans Canada's Bioindex Program. Data from 1995 – 2013 are from the US Biomonitoring Program (BMP).

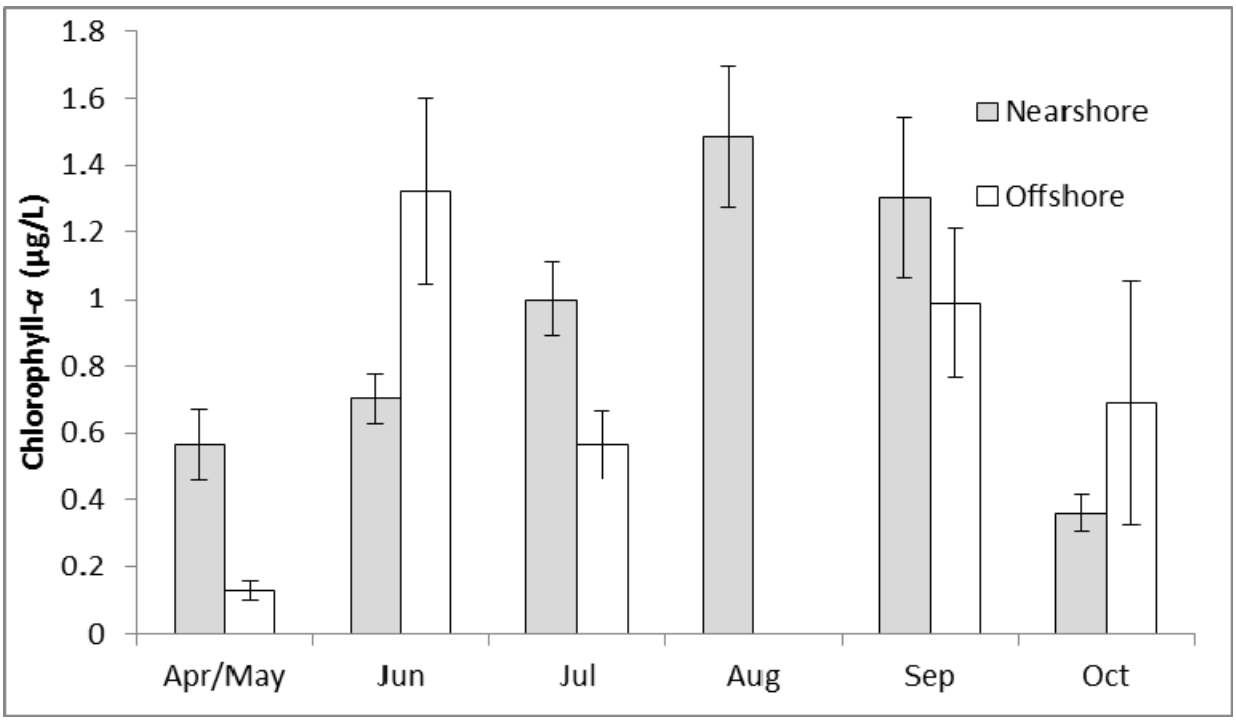

Figure 3a. Mean monthly epilimnetic chlorophyll-a concentrations for nearshore and offshore habitats in Lake Ontario, Apr/ May - October, 2013. Error bars are ± 1SE.

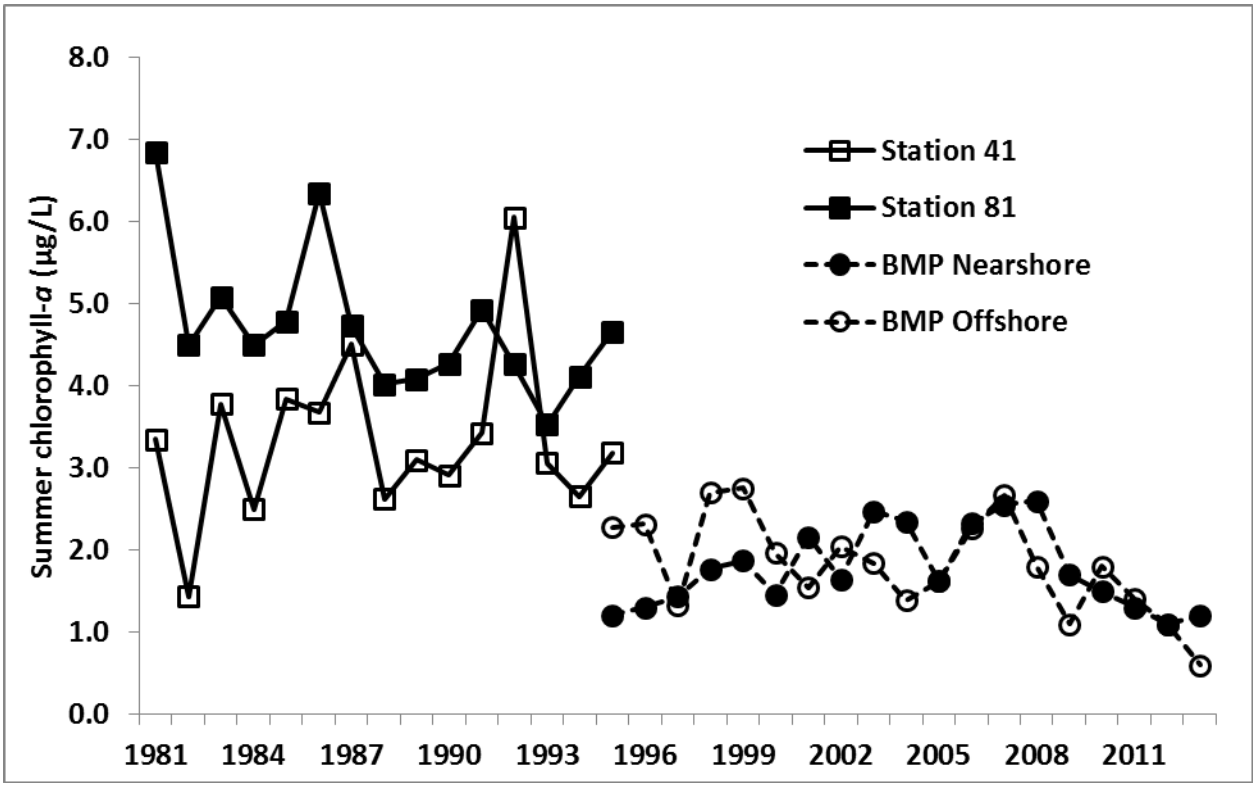

Figure 3b. Long-term summer (Jul – Aug) epilimnetic chlorophyll-a concentrations in Lake Ontario, 1981 - 2013. Station 41 and Station 81 are from the Department of Fisheries and Oceans Canada's Bioindex Program. Data from 1995 – 2013 are from the US Biomonitoring Program.

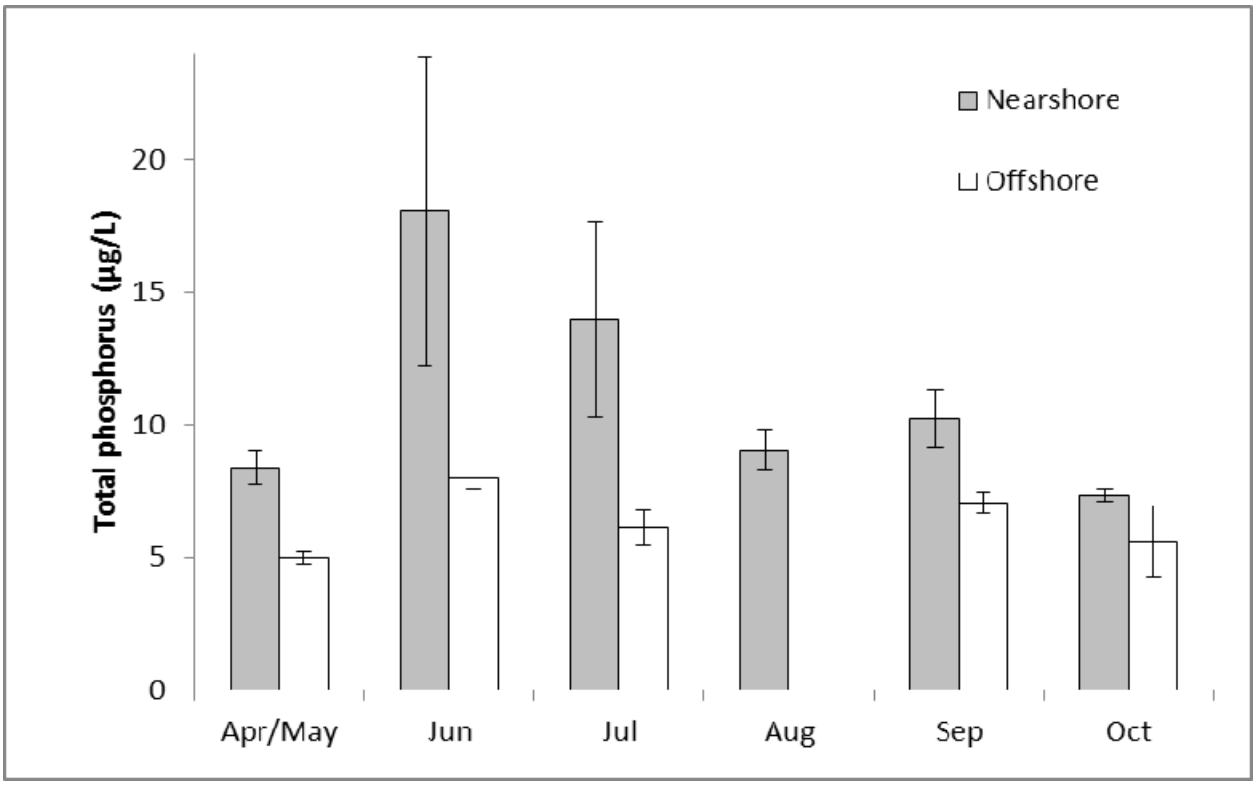

Figure 4a. Mean monthly total phosphorus concentrations for nearshore and offshore habitats in Lake Ontario, Apr/May - October, 2013. Error bars are ± 1SE.

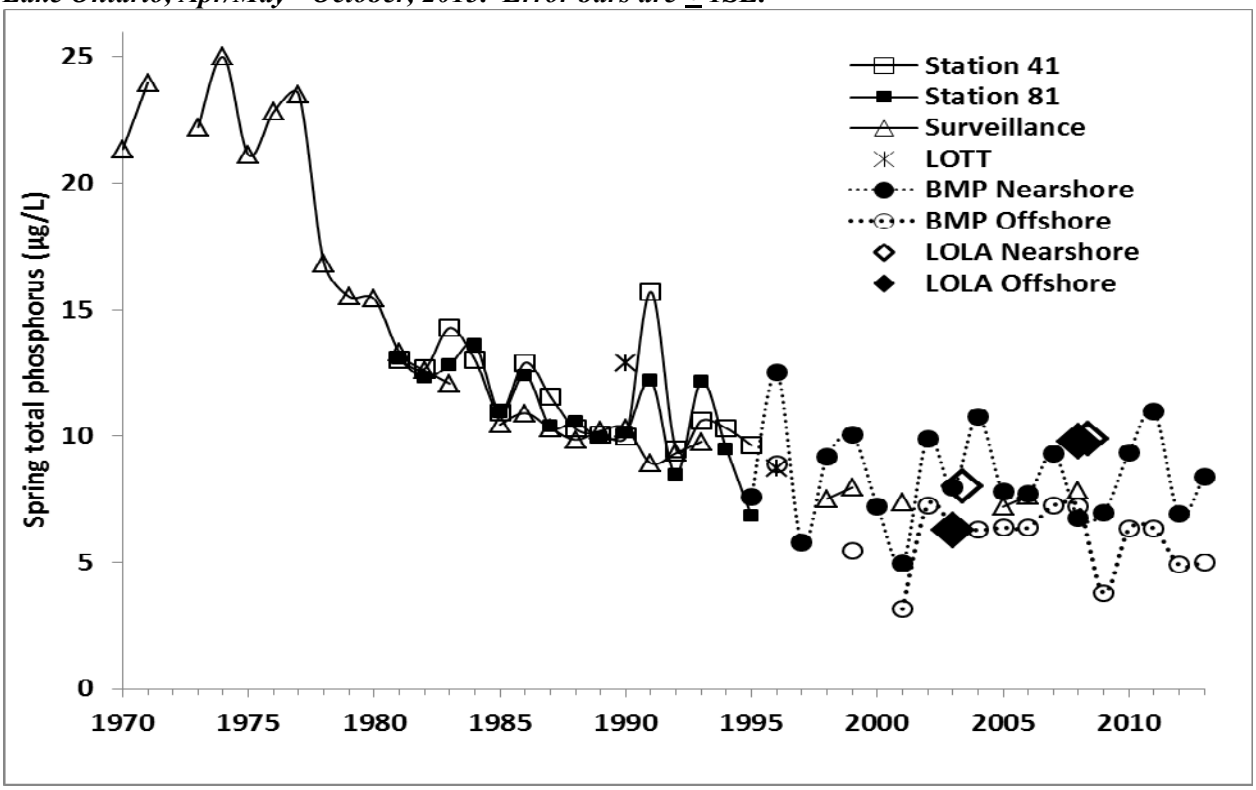

Figure 4b. Long-term spring (Apr – May) epilimnetic total phosphorus concentrations in Lake Ontario, 1970 - 2013. Data from 1970 – 2001 are from Environment Canada's Surveillance Program. Station 41 and 81 are from the Department of Fisheries and Oceans Canada's Bioindex Program. LOTT data is from the Lake Ontario Trophic Transfer Project. LOLA data is from the Lake Ontario Lower Food Web Assessment. Data from 1995 – 2013 are from the US Biomonitoring Program.

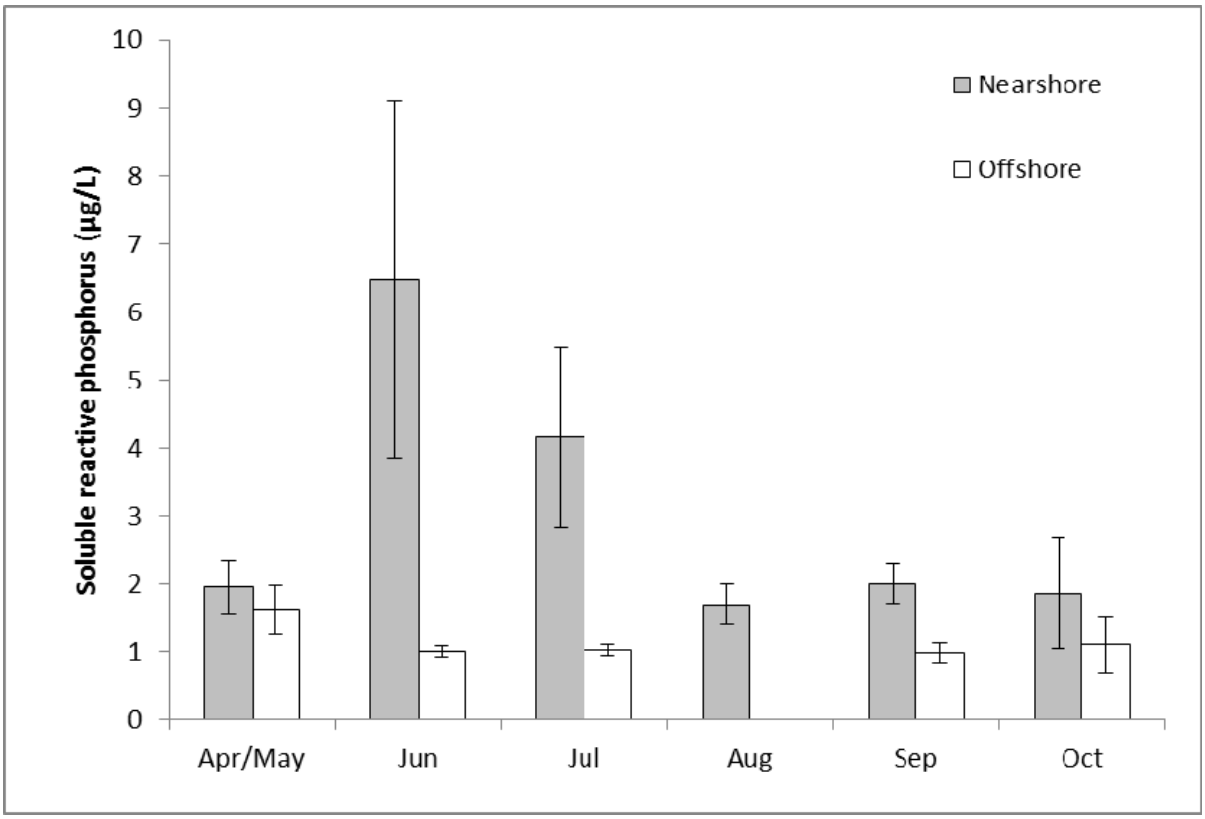

Figure 5. Mean monthly soluble reactive phosphorus concentrations for nearshore and offshore habitats in Lake Ontario, Apr/May - October, 2013. Error bars are ± 1SE.

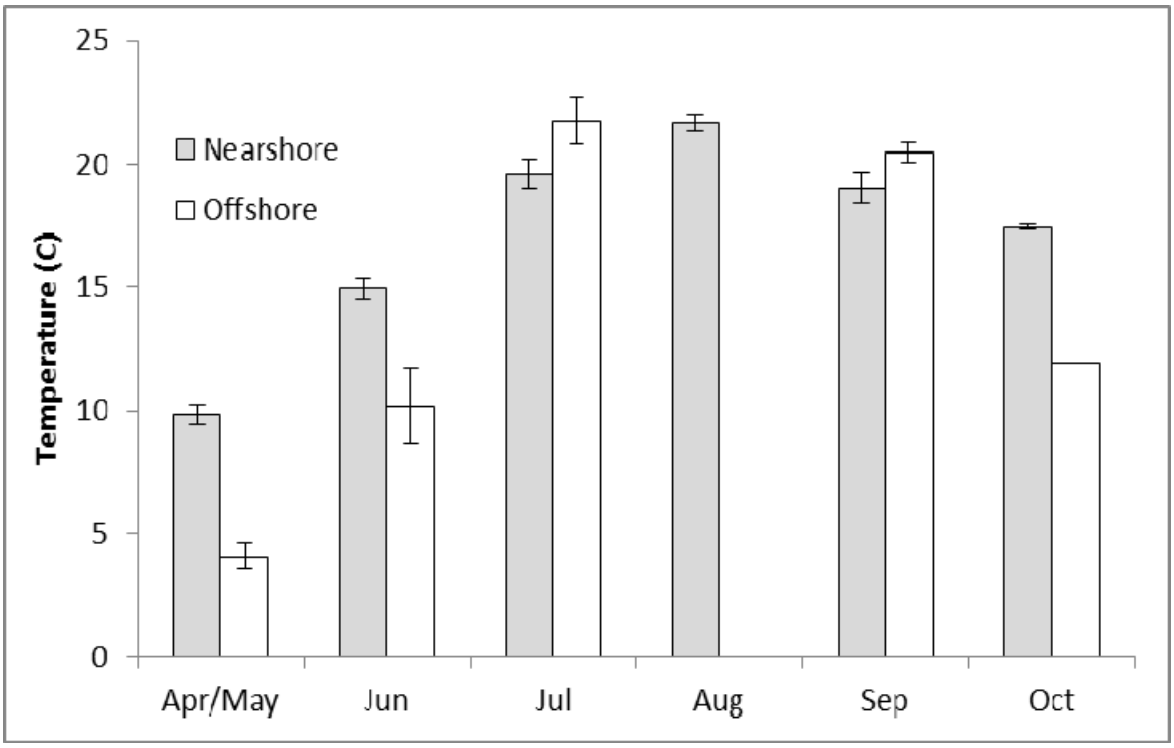

Figure 6. Mean monthly water temperatures in nearshore and offshore habitats in Lake Ontario, Apr/May - October, 2013. Error bars are ± 1SE. Nearshore site depths ranged from 9-12m. At offshore sites, temperatures are averages of readings taken every meter from the surface to 10m.

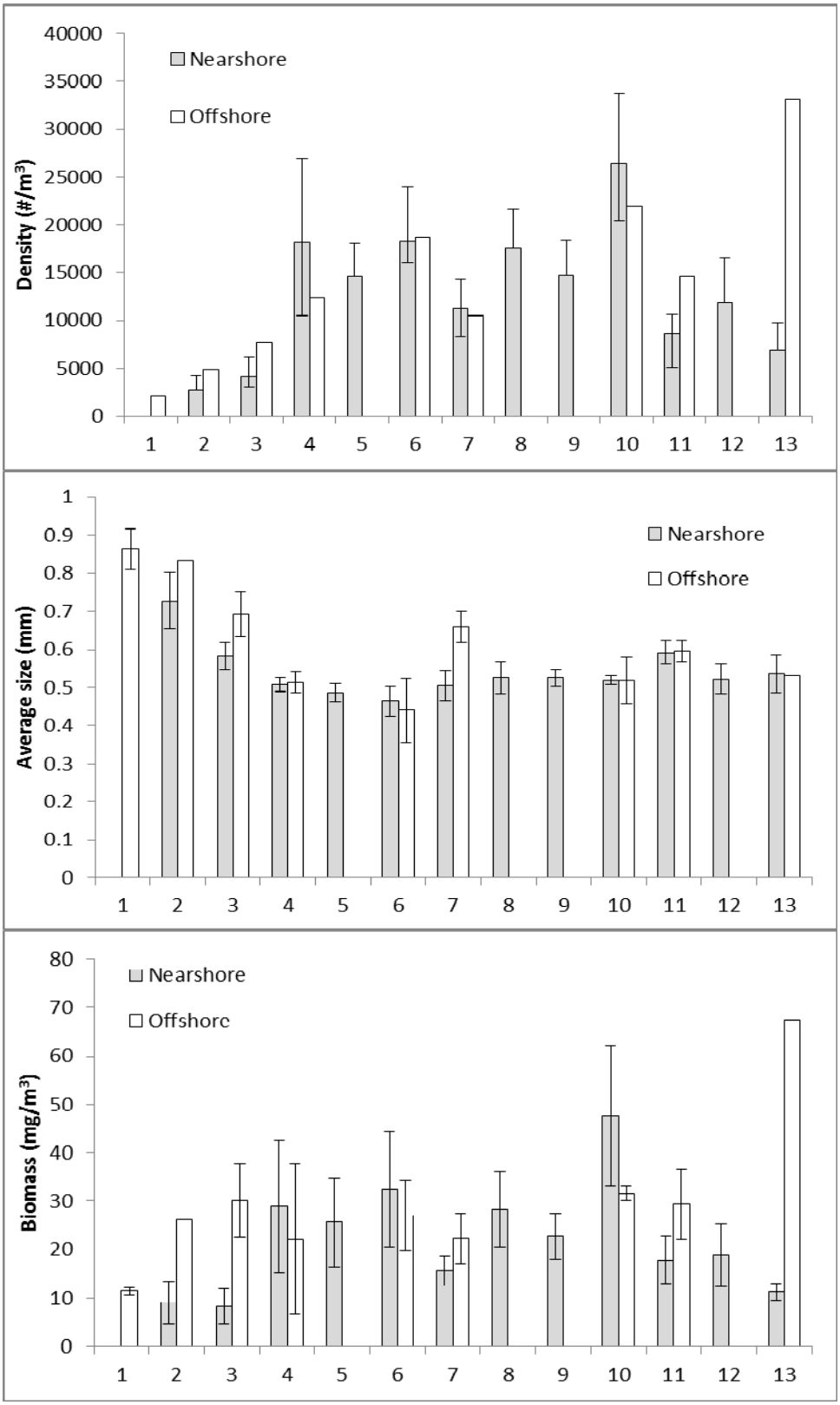

Figure 7. Biweekly means (± 1 SE) of epilimnetic zooplankton density, size, and dry biomass for April through October 2013, nearshore and offshore sites on Lake Ontario. On the x-axis, biweeks are designated by the numbers 1-13.

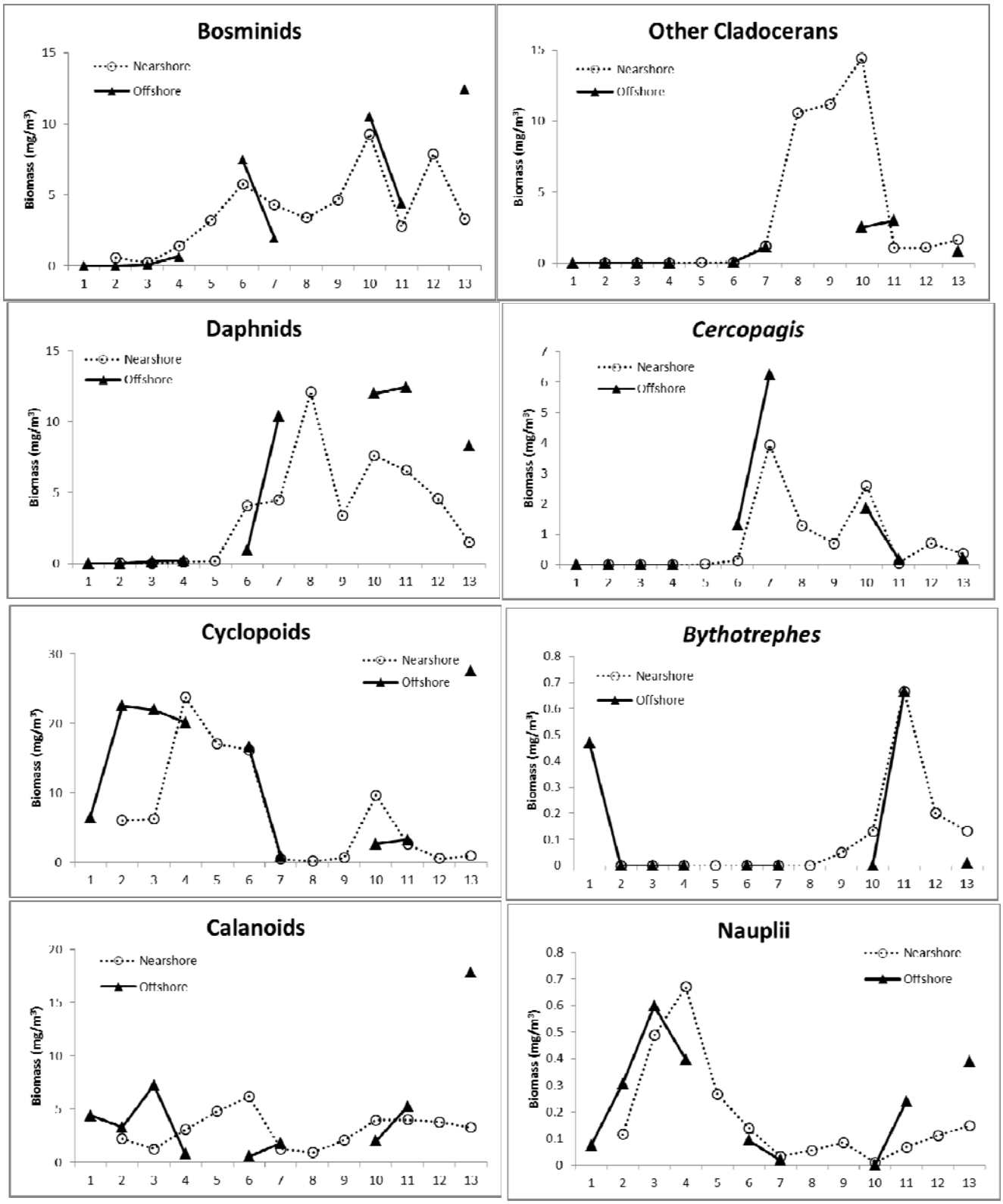

Figure 8. Epilimnetic dry biomass of zooplankton community groups for nearshore and offshore areas of Lake Ontario, Apr - October 2013 (biweeks 1-13 on x-axis). Note different y-axis scales.

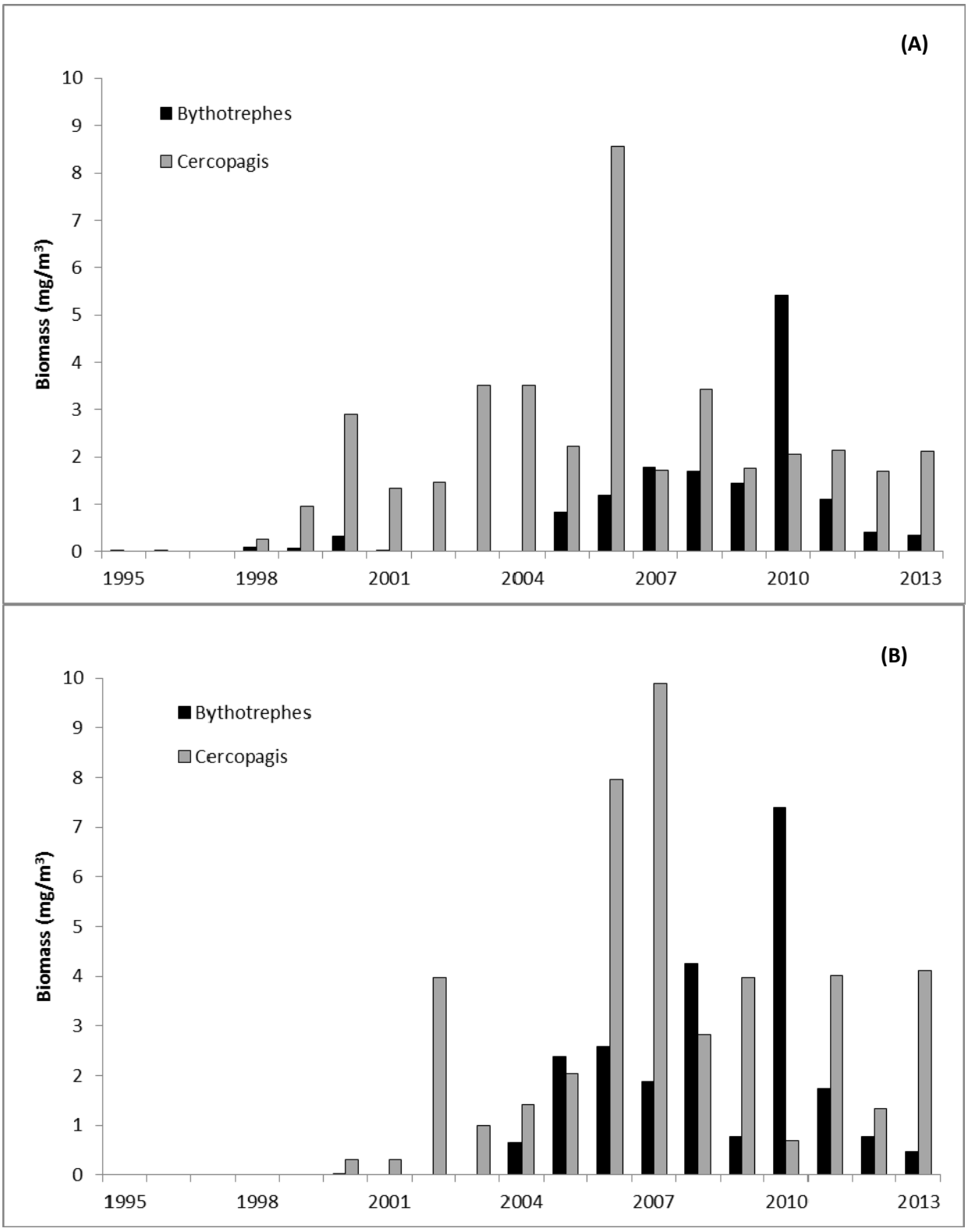

Figure 9. Daytime nearshore (A) and offshore (B) fall (September and October) Bythotrephes and summer (July) Cercopagis biomass in Lake Ontario, 1995 – 2013.

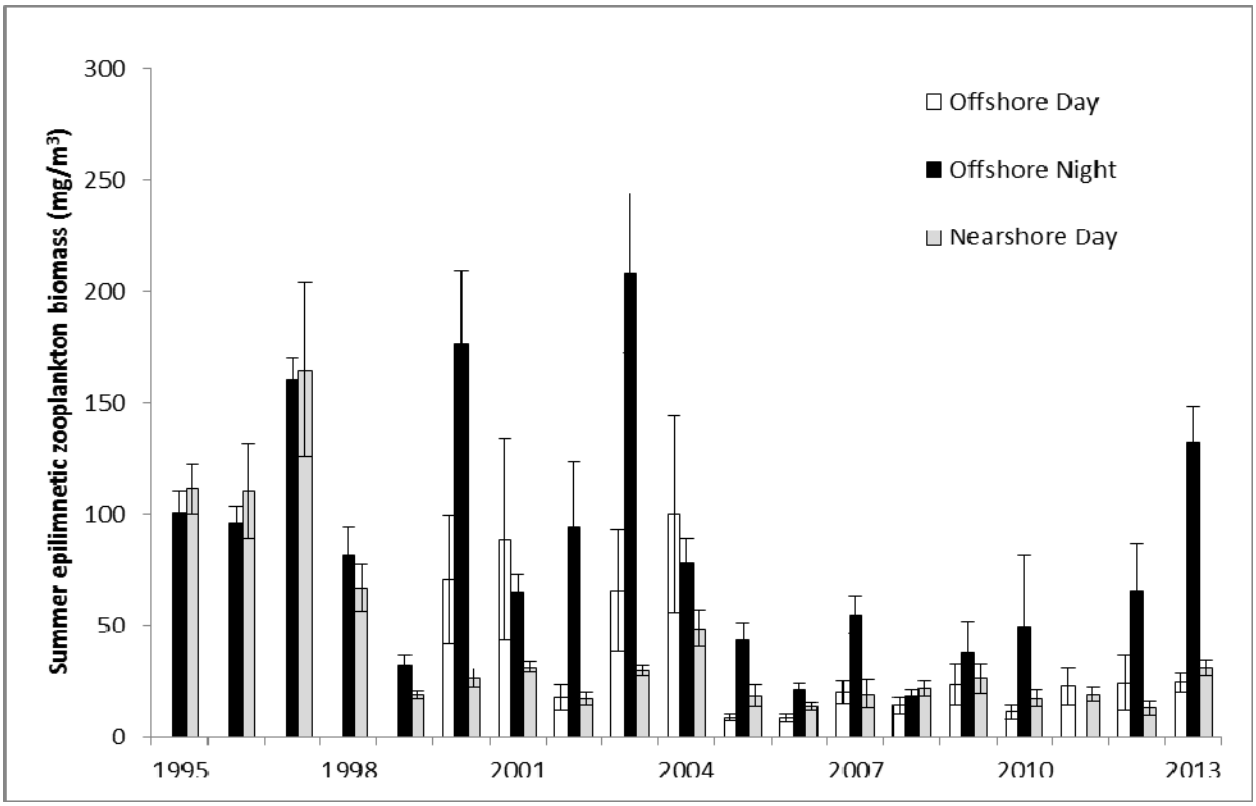

Figure 10. Mean summer (Jul – Aug) epilimnetic zooplankton biomass in nearshore and offshore habitats in Lake Ontario, 1995 - 2013.

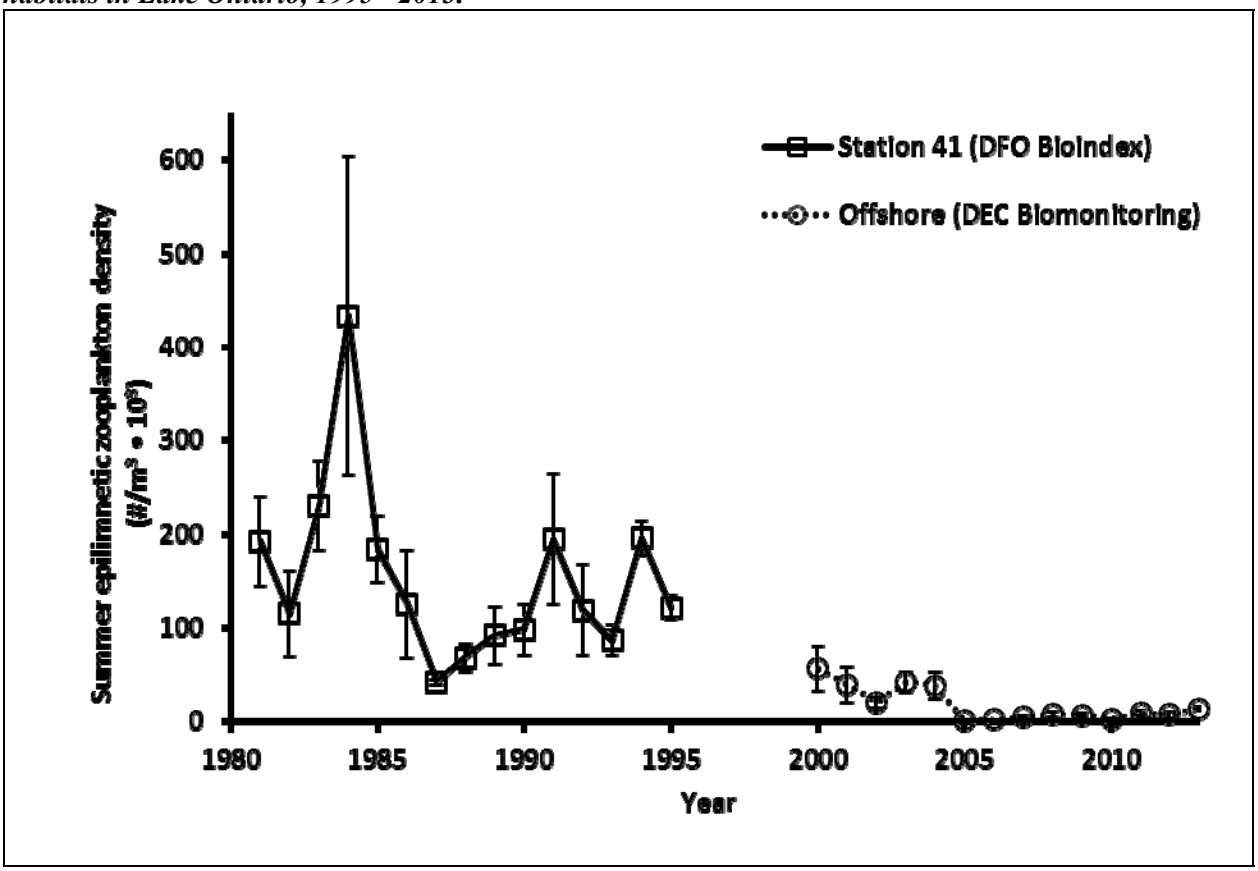

Figure 11. Mean daytime summer (Jul-Aug) epilimnetic zooplankton density in Lake Ontario's offshore, 1981 – 2013.

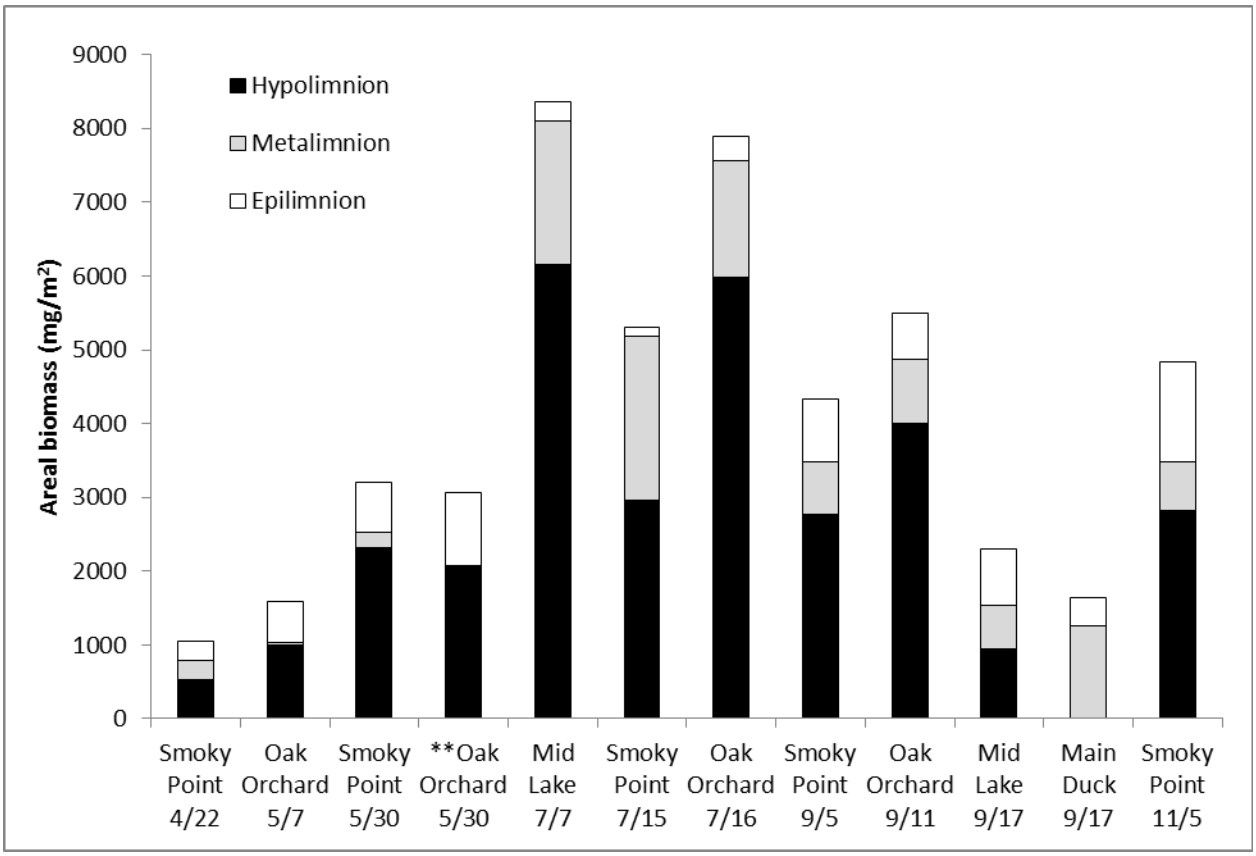

Figure 12. Epilimnetic, metalimnetic, and hypolimnetic zooplankton dry biomass in Lake Ontario's offshore, 2013. Epilimnetic values determined directly from the epilimnetic tow. Metalimnetic values determined by subtracting epilimnetic tow values from the metalimnetic tow. Hypolimnetic values determined by subtracting metalimnetic tow values from the hypolimnetic tow. Stations without hypolimnetic values are from shallower stations where only two tows were performed. **indicates a site where metalimnetic values were negative (not shown) due to variation in catch of zooplankton between metalimnetic and hypolimnetic tows.

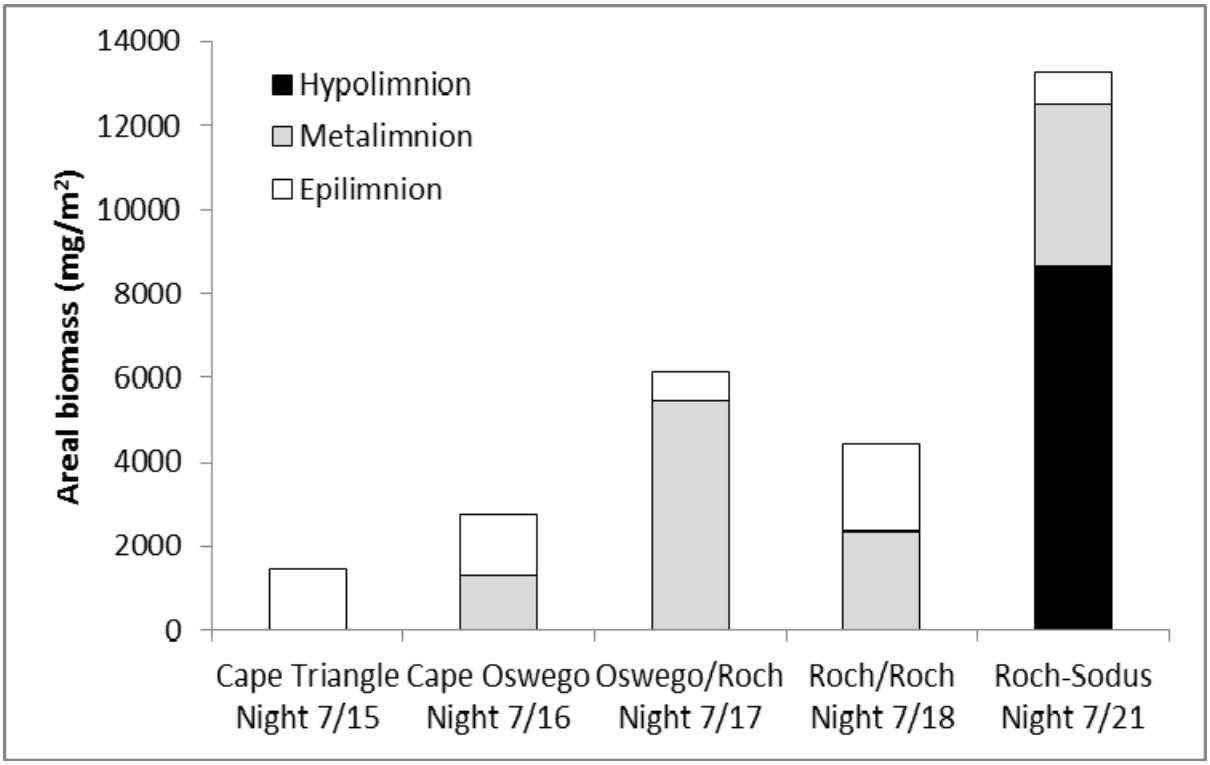

Figure 13. Nighttime epilimnetic, metalimnetic, and hypolimnetic zooplankton dry biomass in Lake Ontario, July 2013. Epilimnetic values determined directly from the epilimnetic tow. Metalimnetic values determined by subtracting epilimnetic tow values from the metalimnetic tow. Hypolimnetic value determined by subtracting metalimnetic tow value from the hypolimnetic tow. At Cape Triangle station only an epilimnetic tow was performed.

Table 1. Mean chl a, TP, SRP and water temperature (±SE) for nearshore and offshore sites, Apr – Oct 2013.

	Mean ± 1 SE				
Sites	Chlorophyll *a* (µg/L)	Total phosphorus (µg/L)	Soluble reactive phosphorus (µg/L)	Secchi depth (m)	Water temperature (^{o}C)
Nearshore					
Chaumont Lake (CBL)	0.9± 0.2 (n=12)	8.7± 0.5 (n=12)	1.9± 0.2 (n=12)	6.9± 0.5 (n=12)	18.4± 1.3 (n=12)
Galloo Island (GIL)	0.8± 0.2 (n=12)	6.9± 0.3 (n=12)	2.5± 0.4 (n=11)	7.7± 0.6 (n=12)	17.8± 1.4 (n=12)
Oak Orchard (OOL)	1.1± 0.2 (n=10)	19.9± 5.2 (n=10)	7.3± 3.3 (n=11)	6.1± 1.0 (n=11)	17.8± 1.8 (n=9)
Sodus Lake (SOL)	0.7± 0.2 (n=12)	7.2± 0.5 (n=12)	0.9± 0.1 (n=12)	7.8± 0.8 (n=12)	17.1± 1.5 (n=12)
Sandy Pond Lake (SPL)	1.1± 0.2 (n=9)	7.8± 0.7 (n=9)	2.0± 0.5 (n=9)	4.5± 0.7 (n=9)	16.1± 1.9 (n=7)
Niagara East Lake (NEL)	1.3± 0.2 (n=11)	19.3± 5.6 (n=11)	4.5± 1.2 (n=11)	5.0± 0.7 (n=10)	17.8± 1.9 (n=8)
Niagara West Lake (NWL)	1.1± 0.3 (n=11)	16.4± 2.0 (n=11)	4.5± 1.1 (n=11)	4.5± 0.6 (n=11)	16.2± 1.9 (n=8)
Offshore					
Kaho					
Oak Orchard-N	1.3± 0.3 (n=3)	10.2± 0.8 (n=3)	1.2± 0.3 (n=3)	4.8± 0.8 (n=3)	20.4± 3.1 (n=3)
Oak Orchard-O	0.8± 0.5 (n=4)	5.8± 1.0 (n=4)	0.8± 0.1 (n=4)	10.6± 2.5 (n=4)	13.6± 4.6 (n=4)
Smoky Point-N	0.7± 0.2 (n=3)	6.6± 0.5 (n=3)	1.3± 0.3 (n=3)	6.0± 0.8 (n=3)	20.1± 2.9 (n=3)
Smoky Point-O	0.8± 0.2 (n=5)	6.8± 0.4 (n=5)	1.3± 0.3 (n=5)	8.1± 1.9 (n=5)	13.2± 3.7 (n=5)
Seth Green					
Main Duck	0.8± 0.3 (n=4)	6.2± 0.5 (n=4)	1.2± 0.2 (n=4)	7.8± 1.8 (n=4)	13.2± 4.0 (n=4)
Mid Lake	0.5± 0.1 (n=4)	6.4± 0.5 (n=4)	1.4± 0.4 (n=4)	9.2± 2.6 (n=4)	12.4± 4.3 (n=4)
Tibbetts Point	0.9± 0.6 (n=3)	6.7± 1.0 (n=3)	0.8± 0.0 (n=3)	10.2± 2.6 (n=3)	14.8± 4.4 (n=3)

Table 2. Comparison of nearshore and offshore sites Apr/May-October, 2013 using paired t-tests on log-transformed (TP, SRP, zooplankton density, and zooplankton biomass) or untransformed (Chl-a, Secchi depth, temperature, and zooplankton size) seasonal mean values. The Wilcoxon test was used on zooplankton group biomass components because data could not be normalized by transformation. Values shown are arithmetic means across months 4/5, 6, 7, 9, and 10. Month 8 was removed from the analysis because the offshore was not sampled during that time. All offshore data are for the epilimnion (zooplankton) or the top 10 m (water chemistry).

Parameter		Mean		
		Nearshore	Offshore	p-value
	Total phosphorus (µg/L)	12.6	6.0	**0.0094**
	Soluble reactive phosphorus (µg/L)	3.7	1.0	**0.0091**
	Chlorophyll *a* (µg/L)	0.9	0.7	0.1
	Secchi depth (m)	6.3	8.1	0.1
	Temperature (C)	15.8	15.4	0.8
Total zooplankton:				
	Density (#/m^3)	12206	10432	0.96
	Size (mm)	0.55	0.63	**0.0009**
	Biomass (mg dw/m^3)	23.7	26.2	**.0437**
Group biomass (mg dw/m^3):				z-value
	Bosminids	3.2	2.3	0.3
	Daphnids	5.5	4.0	0.9
	Calanoid copepods (excluding *Limnocalanus*)	4.8	7.3	0.3
	Cyclopoid` copepods	8.2	9.5	0.9
	Other cladocerans	0.5	0.4	0.4
	Nauplii	0.3	0.3	0.7
	Cercopagis pengoi	0.7	1.0	0.8
	Bythotrephes longimanus	0.1	0.3	0.2
	Leptodora kindtii	0.05	0.04	0.4
	Polyphemus pediculus	0.2	0.3	0.2
	Limnocalanus macrurus	0.1	0.8	**0.01**

Table 3. Results of regression and change point analyses performed on data from two time stanzas in Lake Ontario, 1995 - 2013 and 1981 – 2013. All data were log-transformed prior to analysis. Trends are indicated by (+) or (-). Significant p-values and change points are indicated in bold. % change is average annual change.

	Regression				Change Point Analysis	
Offshore	1995 – 2013[a]	% change	1981 – 2013[b]	% change	1995 – 2013[a]	1981 - 2013
Spring TP (µg/L)	ns		**(-) p<0.0001**	**3**	no breaks	**(-) 1999**
Summer chlorophyll *a* (µg/L)	**(-) p=0.0062**	**4**	**(-) p<0.0001**	**3**	no breaks	**(-) 1995**
Summer epilimnetic zooplankton density (#/L)	(-) p=0.0846	14	**(-) p<0.0001**	**13**	**(-) 2005**	**(-) 1986, (-)2005**
Summer epilimnetic zooplankton biomass (µg/L)	(-) p=0.0547	10	not tested		**(-) 2005**	not tested
Summer epilimnetic zooplankton group biomass						
Bosminids	**(-) p=0.033**	**21**	not tested		**(-) 2004**	not tested
Bythotrephes longimanus	(+) p=.107	29	not tested		**(+) 2006**	not tested
Calanoid copepods	**(+) p=0.0495**	**19**	not tested		**(+) 2007**	not tested
Cercopagis pengoi	**(+) p=0.0393**	**13**	not tested		no breaks	not tested
Cyclopoid copepods	(-) p=0.083	25	not tested		**(-) 2005**	not tested
Daphnids	ns		not tested		no breaks	not tested
Other Cladocera	**(+) p=0.0406**	**24**	not tested		no breaks	not tested

[a]2000 – 2013 for zooplankton density, biomass, and group biomass

[b]no data 1995 – 1999 for zooplankton

	Regression		Change Point Analysis
Nearshore	1995 - 2013	% change	1995 - 2013
Spring TP (ug/L)	ns		no breaks
Summer chlorophyll *a* (µg/L)	ns		**(+) 2003, (-) 2009**
Summer epilimnetic zooplankton density (#/L)	**(-) p=0.0002**	**10**	**(-) 1998, (-) 2005**
Summer epilimnetic zooplankton biomass (µg/L)	**(-) p=0.0008**	**9**	**(-) 1998, (-) 2006**
Summer epilimnetic zooplankton group biomass			
Bosminids	**(-) p=0.0004**	**12**	**(-) 1998**
Bythotrephes longimanus	**(+) p=0.0275**	**3**	**(+) 2006**
Calanoid copepods	ns		**(-) 1997, (+) 2007***
Cercopagis pengoi	ns		**(+) 1999, (-) 2007**
Cyclopoid copepods	**(-) p<0.0001**	**26**	**(-) 1998, (-) 2005**
Daphnids	**(-) p=0.0427**	**7**	no breaks
Other Cladocera	**(+) p=0.0099**	**8**	no breaks

*data violate the assumption of independent errors; an analysis performed on means of years grouped by 2 showed a break only after 1997.

Table 4. Comparison of mean zooplankton biomass (dry) in epilimnetic, metalimnetic, and hypolimnetic samples taken from deep (>100m) sites in Lake Ontario's offshore, July and September, 2013. The epilimnetic strata includes zooplankton from the thermocline (10 – 28 m) up to the surface, the metalimnetic strata includes zooplankton from 50 m up to the thermocline, and the hypolimnetic strata contains zooplankton from 100 m up to the bottom metalimnion (50 m). Abbreviations are BOS=bosminids, BYTH=Bythotrephes, CAL=calanoid copepods excluding Limnocalanus and Leptodiamptomus sicilis, CYC=cyclopoid copepods, D. MEN=Daphnia mendotae, D. RET=Daphnia retrocurva, LIMNO=Limnocalanus macrurus, NAUP=nauplii, OCL=other cladocerans, SICIL=Leptodiaptomus sicilis. *indicates where values were negative (not shown) due to variation in catch of zooplankton between metalimnetic and hypolimnetic tows.

	Areal Biomass (mg/m^2)										
Month-Strata	**BOS**	**BYTH**	**CAL**	**CERC**	**CYC**	**D. MEN**	**D. RET**	**LIMNO**	**NAUP**	**OCL**	**SICIL**
July-Epilimnion	57.2	0	15.6	25.3	34.2	9.7	76.7	0	0	12.0	0
July-Metalimnion	86.1	0	106.7	257.7	2325.2	16.5	442.7	149.4	1.1	0*	24.0
July-Hypolimnion	5.3	0	47.8	0*	0*	26.8	0*	621.0	3.0	0*	122.1
September-Epilimnion	118.7	11.7	147.0	0.6	151.0	29.9	214.6	0	3.4	66.7	0
September-Metalimnion	39.8	0*	8.5	0.5	713.4	192.4	219.1	0.0	0.0	51.3	61.8
September-Hypolimnion	13.8	8.9	93.5	0*	56.2	29.8	21.1	502.3	4.9	0*	197.8

Progress report for the Sportfishing Restoration & Spending Plan for the Lake Ontario System

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Background

In June of 2006, New York State (NYS) announced that the Department of Environmental Conservation and the Office of the Attorney General had reached a settlement with Occidental Chemical Corporation (OCC) on the State's Natural Resources Damages (NRD) claim for the Lake Ontario system. The claim was originally filed in 1983 against Hooker Chemical, the predecessor of Occidental Chemical Corporation, for compensation for the release of harmful chemical contaminants into the Lake Ontario system, which includes the Lower Niagara River, Lake Ontario, the St. Lawrence River, and tributaries to these waters upstream to the first barrier impassable to fish (hereafter referred to as the Lake Ontario system).

There are several federal statutes, as well as NYS law, that authorize federal and NYS officials to act on behalf of the public to restore natural resources affected by releases of contaminants. This claim arose under the federal *Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)* of 1980, and NYS common law, holding parties accountable for contaminating the environment and causing injury to natural resources. NRD funds provide compensation for the injury to, loss of, loss of the use of, or destruction of New York's natural resources, including land, biota, air, surface and ground waters.

Natural Resources Damages Assessment

The NRD assessment process seeks to ensure that the public is compensated for losses experienced as a result of injuries to their natural resources resulting from environmental contamination. This process determines the nature and extent of injury to the natural resources, and then aims to restore the use and enjoyment of either the injured or lost natural resources, or the services provided by these resources.

Funds recovered as a result of a NRD claim are to be used to restore/enhance either the injured natural resources themselves, or the services provided by the lost or injured natural resources. The general hierarchy for the use of NRD funds, in order of greatest to least preference, is to restore or replace the injured resources. If neither of these approaches is possible or practical, then equivalent resources could be acquired.

In this case, restoring the injured resource by reducing contaminant levels in fish to pre-contamination levels would be impracticable and cost prohibitive. A restoration effort of this magnitude would require extensive sediment dredging/disposal that would far exceed the resources available through the Lake Ontario NRD (LONRD) program, as these contaminants now reside in sediments and biota throughout the entire system. In addition, toxic "hot spots" within the Lake Ontario system have already been identified, and efforts to remediate contamination in these areas are being coordinated through individual Remedial Action Plans (RAPs).

The settlement was based on an assessment of lost recreational fishing benefits resulting from the imposition of fish consumption advisories due to the presence of contaminants in the fish. The damages were calculated by measuring the difference between the value to anglers for fishing for contaminated fish in the Lake Ontario system, and what the value would have been if the fish had not been contaminated. This $12 million

settlement is one of the largest NRD claim settlements in the nation based on lost recreational fishing use.

Restoration Planning and Public Outreach

The Sportfishing Restoration & Spending Plan for the Lake Ontario System (the *Plan*) was prepared by the New York State Department of Environmental Conservation (NYSDEC) in its capacity as Trustee for New York's natural resources. Its purpose is to describe the use of funds from the Lake Ontario NRD claim settlement. More specifically, it describes projects selected to restore injuries to sportfishing in the New York waters of the Lake Ontario system. This *Plan* also describes the public role in its development and provides reasons why some proposed projects are unlikely to be implemented.

Department staff developed four basic project proposal categories to restore/enhance recreational sportfisheries: fisheries management enhancement, fishing access improvements, aquatic habitat restoration, and education/outreach projects.

A 60-day notice period was offered following the release of the *Plan* to afford the public an opportunity to review the *Plan* prior to public meetings and to submit their thoughts subsequent to the meetings. The public meetings, one each in NYSDEC Regions 7, 8, and 9, and two in Region 6, were scheduled approximately half-way through the review period. Copies of the draft *Plan* were provided to the New York State Library Document Distribution Center, as well as NYSDEC Headquarters in Regions 6 (Watertown), 7 (Syracuse), 8 (Avon), and 9 (Allegany).

Notices of opportunities for review of the *Plan* were provided both formally and informally. A formal notice was posted in the New York State *Environmental Notice Bulletin (ENB* were published weekly from 1-17-2007 to 3-20-2007). Additionally, notices were provided on the Department's website, through press releases, and by direct mailings (see Appendix B, *Public Participation Plan for the Development of the Sportfishing Restoration and Spending Plan for the Lake Ontario System*). A constituent letter and fact sheet summarizing the *Plan* and announcing public meetings and comment periods was posted on the Department website, and these documents were also mailed to interested constituents including non-governmental organizations, individuals, local government officials, elected state and federal officials, federally recognized native American tribal authorities, and NYS and federal natural resource agencies (U.S. Fish and Wildlife Service, U.S. Army Corp of Engineers, U.S. Geological Survey, Bureau of Indian Affairs, U.S. Environmental Protection Agency, National Oceanic and Atmospheric Administration).

Project Lists

Of approximately 150 project proposals received from stakeholders, 80 were scored by the review committee. The remainder included comments rather than project proposals (not scored), or were rejected based on lack of merit. The Project Evaluation Team produced the following lists; *Selected Projects, Other Scored Projects,* and the *Rejected list.* To see the complete lists, please visit: http://www.dec.ny.gov/outdoor/40068.html

The projects listed on the Selected Projects list are in order of rank with the best scoring proposal listed first. The estimated costs for each of the proposals are preliminary and used for planning purposes only, are in no way a guarantee of funding, and are subject to change. More detail on the actual costs will be determined as implementation proceeds.

The $12 million settlement has been apportioned to include $10.8 million for projects and $1.2 million for fund administration. The cost estimates were developed to approximate how many projects the $10.8 million can accommodate. As project implementation begins, detailed spending plans for each project will be developed as needed. Matching funds and contributions to this program from other agencies, non-governmental organizations and programs

such as RAPs, the Open Space Plan and the Fisheries Enhancement, Mitigation and Research Fund (FEMRF, as detailed in the following project descriptions) will be actively sought out to increase the longevity of this fund. This effort will also reduce redundancy of restoration efforts.

Project Implementation

As discussed in the *Plan*, the project implementation schedule should give priority to the assigned project ranking, however, the implementation schedule has been influenced by issues including, permitting, availability of other funding sources, land acquisition, contract bidding, planning and development, and other practical concerns. While project implementation has not followed exact rank order, emphasis has generally been placed on the highest-ranked projects.

Projects at Impasse

Two projects have met impasse for implementation. The Port Bay (west) access road project (Project #38), which proposed measures to improve access road conditions during winter, will not be implemented. After reviewing the project description and site conditions, NYSDEC engineers have determined that the scope and costs of this project far exceed its' $500,000 allocation. Additionally, there are significant regulatory hurdles that would make this project extremely difficult, if not impossible, to undertake.

The other project at impasse is the Waterport Dam tailrace reconfiguration (Project #41), that proposed reconfiguration of the dam tailrace and bypassed reach to alleviate fish stranding. During periods of high water flow, water crests the dam and increases flow in the bypassed reach, which attracts migrating fish into that reach. Once flows attenuate to normal operational levels, fish in the bypassed reach can become stranded. The fish are then subjected to unsportsmanlike fishing practices, or perish due to lack of water flow. While this project was deemed worthy in the project review process, legal counsel has determined that it would be inappropriate to use New York State funds to fix a problem that arises at a facility owned and operated by one of the Department's regulated entities. The funds allocated to these projects will now be used to implement other projects on the Selected Projects list.

2013-2014 Program update

The following describes what has been done in the 2013-2014 fiscal year to implement the list of selected projects in the Final Sportfishing Restoration & Spending Plan for the Lake Ontario System. The previous year's updates can be viewed at:
http://www.dec.ny.gov/outdoor/27068.html

Projects Completed in 2013-14

Improve the NYSDEC Salmon River Fish Hatchery (Project #1).

- Main Gravity Pipeline - A tethered video inspection probe was used to investigate the cause of reduced flow in the main pipeline from the Salmon River Reservoir. A partial inspection (93%) was completed May 2013. There is a 550 foot section that remains to be inspected, and is tentatively scheduled to be completed in May/June 2015. The cost of the inspection to date is approximately $92,669.
- Infiltration well development – Hatchery Staff installed a new infiltration well in January 2014 at an approximate cost of $11,305.
- Well field survey and maintenance - A comprehensive survey of the hatchery's existing ground water wells and identification of well maintenance needs was completed August 2013 at a cost of $18,900.

Golden's Marina Renovation Project (#7). This fishing access site is located on County Rt. 57 in the Town of Lyme, Jefferson County. It features shoreline fishing access, a two lane boat ramp with floating docks and provides parking for 10 vehicles as well as 25 vehicles with trailers. It was re-named Lake Ontario Access at the Isthmus and opened to the public May 14, 2013. Total project cost was $648,486.

Sea Lamprey Control Barrier on Orwell Brook (#39). The Great Lakes Fishery Commission completed construction of a sea lamprey barrier on Orwell Brook (Oswego Co.) in fall 2012. The barrier was operational in spring 2013, and will greatly reduce the need for chemical control of sea lampreys in the Orwell Brook system. $60,000 of NRD funds will be contributed to this project.

Project Progress in 2013-14

Improve the NYSDEC Salmon River Fish Hatchery (#1).

- Recirculation System - A feasibility study is in development to investigate the potential for building a water treatment system that would re-circulate our limited well water supply, thereby improving fish growth and health.
- Well field survey and maintenance - Department engineers have reviewed the survey report and identified several equipment improvements that may yield as much as 200 - 250 gallons per minute of additional ground water supply. The equipment improvements based on this study are in development.

Four fishing access related projects in New York State Parks of the Niagara Region (#s 4, 11, 20 & 32). These access improvement projects include Artpark's river trails as well as trails associated with the Whirlpool area and the Schoelkopf ruins site (also known as the recently constructed dry dock facility for Maid of the Mist boats). A Memorandum of Understanding with the New York State Office of Parks, Recreation and Historic Preservation is in the final stages of approval. The combined NRD funding for these projects is $425,000.

Sandy/North Pond boat launch acquisition (#8). A closing date is expected in spring 2014 for the acquisition of a suitable parcel located on Sandy/North Pond in the Town of Sandy Creek, Oswego County. This land acquisition will use $210,000 in NRD funds.

Lake Ontario Watershed Display at the Aquarium of Niagara (#22). A State Assistance Contract is in the final stages of approval, and work is expected to begin in 2014. NRD funding for the project is $300,000.

Irondequoit Creek Stream Bank Stabilization Project (#25). In partnership with the US Fish and Wildlife Service and the NYSDEC, the County of Monroe Parks Department will improve over 2,000 lineal feet of stream bank and stream habitat. Contract documents have been finalized and are awaiting final approval. Work is tentatively set to commence in summer/fall 2014. NRD funding for the project is $250,500.

Salmon River Hatchery Aquaria and Interpretive Displays (#30). The contract for the purchase and installation of new aquaria and associated equipment has been awarded, with work set to commence in May 2014. NRD funding for this project is $100,000.

Deepwater Cisco Reintroduction in Lake Ontario (#26). Until the mid 1950's, Lake Ontario was home to four species of deepwater ciscoes which represented the main prey fish in Lake Ontario. The NYSDEC in partnership with the Great Lakes Fishery Commission (GLFC), Ontario Ministry of Natural Resources, the U.S. Geological Survey and the U.S Fish and Wildlife Service are continuing efforts to re-establish self-sustaining deepwater cisco populations in Lake Ontario. In support of ongoing deepwater cisco egg collections in Lake Michigan, a soon to be executed contract will contribute $50,000 in NRD funds to the GLFC for this project.

Cape Vincent aquaria and interpretive display improvements (#35). Placards highlighting life history descriptions for each of the fish species on display at the aquarium have been developed and are planned to be installed this year. A phased approach for the development of additional display elements is currently underway.

Projects for 2014-15

Planning efforts continued in 2013 for the projects listed below.

- Cranberry Creek Marsh water control structure. Renovate or rebuild the structure to restore its functionality and resume its use with enhanced fish

passage.

- Upgrade hatchery pond complex at Lisbon, NY.
- Locate lake trout spawning areas in the Lower Niagara River.
- Walleye spawning habitat enhancements.

Other Ongoing Projects

Pen Rearing Program Assistance (#29) has been available to cooperators who have requested funding for new nets for the pens, supplies, and materials, etc. NRD funding for this program totaled $20,000, and $12,750 has been expended as of spring 2014.

AutoFish Marking Trailer (#2). The AutoFish system was used in October 2013 to mark all Skamania steelhead for the 2014 stocking. The AutoFish system was also used to mark and tag all lake trout stocked into the NY waters of Lakes Erie and Ontario.

Lake Sturgeon Tagging Study 2013

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Lake Sturgeon (*Acipenser fulvescens*) were historically an abundant and widely distributed species in New York State (NYS). Overharvest, habitat degradation, and migratory impediments (dams) resulted in drastic decline of the species by the early 1900s. Due to severely depleted stocks, the Lake Sturgeon fishery was closed in NYS in 1976. Lake Sturgeon are currently listed as a threatened species in NYS, with lost, sparse or declining populations in 6 of the 9 watersheds where they historically occurred.

Currently, little is known about Lake Sturgeon in the upper St. Lawrence River and the Eastern Basin of Lake Ontario. The ability to identify individual fish for more than a few years has generally been lacking. As restoration efforts increase, including stocking and habitat enhancement, having a long term tagging methodology has become important when considering brood stock genetics, understanding spawning site fidelity and gaining general biological knowledge.

This was the fourth year of a five year project funded in part by the U.S. Fish and Wildlife Service's Fish Enhancement, Mitigation and Research Fund (FEMRF) to tag Lake Sturgeon with permanent individual markers. Lake Sturgeon will be collected annually (2010-2014) at various sites in the St. Lawrence River and Eastern Basin of Lake Ontario. Fish are evaluated for basic biological information and then scanned for Passive Integrated Transponder (PIT) tags to determine if they have been previously tagged. A PIT tag is applied to untagged fish for permanent individual identification. The goal is to create a long term database of individual fish that will be used to support ongoing species rehabilitation.

Methods

Geographic Area

Project boundaries encompass the U.S. portions of the St. Lawrence River and the Eastern Basin of Lake Ontario. The U.S. portion of the St. Lawrence includes approximately 84 mi^2 of water, of which a very small portion is both suitable for netting activity and overlaps with suitable sturgeon habitat.

Near shore areas of eastern Lake Ontario encompass waters from the southern boundary of Jefferson County near Montario Point, north to the beginning of the St. Lawrence River at Cape Vincent, approximately 800 mi^2. Water less than 100 feet in depth was considered for sampling.

Collection

Lake Sturgeon were collected from May-August in 2013. Collection and tagging of sturgeon was a combination of netting targeting sturgeon, miscellaneous surveys, and existing annual fish stock assessment projects where sturgeon are encountered periodically.

Sampling for spawning sturgeon in occurred in the Black River below the first barrier, in the upper St. Lawrence at the mouth of the Oswegatchie River, and in the St. Lawrence River immediately downstream of the Moses Power Dam at Massena, NY. Post spawning period netting targeted adult sturgeon in Black River Bay (Lake Ontario) in late August. Existing, long term index gill netting programs include two on the St. Lawrence River (Thousand Islands and Lake St. Lawrence) and one in the Eastern Basin of Lake Ontario gill net index. St. Lawrence and Black River netting sites are shown in Figure 1.

All fish were collected with monofilament gill nets fished from 21.5 – 25.5 hours in waters from 12-60 feet in depth. Several gill net configurations used are described in Table 1.

Lake Sturgeon collected were measured to the nearest millimeter total length, weighed, and scanned for existing PIT or Floy® tags. Sex was also evaluated at the time of capture

predominantly by external palpation. Some fish captured for potential egg take were examined internally with a hypodermic extractor (Candrl et al. 2010) for confirmation that they were late stage gravid females.

PIT tags were applied to fish captured for the first time. The tag was placed under the fourth dorsal scute, which is the standard location for the New York State Department of Environmental Conservation (NYSDEC), Ontario Ministry of Natural Resources (OMNR), and U.S. Geological Survey (USGS). Floy® tags were applied when available to serve as both a quick visual marker and to aid in determination of tag retention. All fish, with the exception of those held for egg take, were released immediately after tagging within 0.1 miles of their capture location. PIT tag data were shared with the Great Lakes Lake Sturgeon Database (USFWS) which will allow researchers to acquire information related to individual sturgeon they may encounter.

Results and Discussion

The NYSDEC has sampled St. Lawrence River Lake Sturgeon since the early 1990's below the Moses Power Dam. Collections initially focused on documenting presence of sturgeon and acquiring basic biological information. Beginning in 1996, sturgeon were collected for use as brood stock in restoration efforts. As restoration efforts intensified and genetic investigations have revealed distinct spawning stocks of sturgeon (Welsh et al. 2008), the need for reliable and permanent identification of individual fish became clear.

Use of PIT tags began in 2008-2009 when a limited number of tags were made available to NYSDEC Region 6. In 2010 a FEMRF grant provided 1,000 tags and related equipment for large scale tagging of sturgeon in the St. Lawrence River and Eastern Basin of Lake Ontario.

NYSDEC personnel captured a total of 90 Lake Sturgeon throughout the sampling area in 2013. PIT tags were applied to 83 sturgeon, ranging in length from 38.6-65.0 inches and weighing from 13.2-71.6 pounds. Length-weight relationships were constructed using combined data from all sturgeon collected from 2010-2013 (Figure 2) and separated by sex (Figure 3). A total of 10 recaptures were recorded in 2013, two from historic collections (SUNY College of Environmental Science and Forestry (ESF), 1995-1998) and eight from collections dating from 2005-2011. Seven recaptures were below the Moses Power Dam and three from the Black River.

Males (N=62) accounted for 71.3% of the catch while females (N=8) constituted 9.2%. The remainder of the catch were either immature or of undetermined sex (19.5%). Sex could only be reliably verified in fish captured during the spawning period through extrusion of gametes.

Black River

Spawning of Lake Sturgeon in the Black River was first documented in 2005 (Klindt and Adams 2006). Annual sampling since 2005 has targeted spawning fish to acquire biological information and apply Floy® or PIT tags.

Discharge in the Black River ranged from 4,000-17,000 cfs (USGS gage 04260500, Watertown) during April, 2013. The effective netting limit of 6,000 cfs was exceeded for most of the month which curtailed sampling. Two days were suitable at the beginning of May (flow 4,100-4,650 cfs) for sampling prior to the opening of the walleye and northern pike angling season.

A total of 13 lake sturgeon were captured in the Black River on May 1-2. Water temperature was ideal at 54-56° F for upstream migration and staging prior to spawning. A total of 47.0 net-hrs (2 net nights) of effort were expended giving a Catch per Unit Effort (CUE) = 0.28 fish/hr (Table 2). Sturgeon ranged in length from 49.6-59.0 in and weight from 29.7-55.3 lbs. All fish for which sex and stage could be determined were ripe males (N=12). Sex could not be assigned for one fish.

Three fish that were originally tagged in either the Black River or in the vicinity of Black River Bay during 2005-2011 were recaptured in 2013.

St. Lawrence River: Moses Power Dam

The confluence of the bypassed reach of the Moses Power Dam or "South Channel" and the main stem of the St. Lawrence River has been used as a Lake Sturgeon brood stock source for the NYSDEC since 1996 (LaPan et al. 1999). This area is considered a staging area for sturgeon spawning at the base of the power dam. Net sites used for this collection typically capture large numbers of fish, both potential migrating spawners and resident fish.

A total of 58 sturgeon were collected from May 30-June 4, 2013 at four net sites with an effort of 204.6 net-hrs (Table 2). Water temperature in the South Channel ranged from 56-58°F during the sampling period. The overall netting effort was lower than in previous years. Catch rate in 2013 (0.28 fish/hr) was lower than in the previous four years (CUE range 2009-12; 0.37-0.59 fish/hr). Ripe males (N=40) represented 63.8% of the catch whereas gravid females (N=7) represented 12.1%. Sturgeon collected in 2013 ranged in length from 38.9-65.0 in and in weight from 13.2-71.6 lb. Fish used for the 2013 egg take (females N=3, males N=8) were taken from this group.

There were 17 recaptures at this location in 2013 which were classified as historic (N=1) and recent (N=16). Historic recaptures were fish originally Floy® tagged from 1995-1998 by researchers from the SUNY ESF. Recent recaptures included fish tagged (Floy® or PIT) by NYSDEC from 2003-2010. A fish recaptured from 2003 was a stocked fish from the St. Regis River that was tagged by USGS.

The use of PIT tags below the Moses Power Dam is particularly critical to effective management of broodstock genetics, as well as elucidating insights into sturgeon biology, including spawning periodicity, growth rates, and population mixing.

St. Lawrence River Above Moses Power Dam

In contrast to the Moses Power Dam netting site, targeted sturgeon sampling upstream of the power dam has been limited. Occasional catches have been made in index gill netting index projects in the Thousand Islands (N=6) and Lake St. Lawrence (N=13) (NYSDEC regional Warm Water Assessment database).A contaminant collection at Ogdesnburg on May 14 utilized a standard sturgeon net (GN1 or GN2, Table 1) plus two GN3 nets with a total effort of 70.8 net-hrs (3 net-nights). Seventeen sturgeon were collected, 15 of which were taken at the mouth of the Oswegatchie River. Sturgeon were generally found to be in spawning condition. Fish were classified as males (N=12), unknown (N=4) and one fish was presumed to be a gravid female based on body form and vent characteristics consistent with late stage gravid females.

Existing index gill netting projects consisted of 1,233.14 net-hrs (62 net-nights) in U.S. waters of the Thousand Islands and the International waters of Lake St. Lawrence. Although sturgeon have been consistently caught in several areas of the upper river since 2003, none were collected in 2013 (Table 2).

Lake Ontario

There was a single targeted effort to collect lake sturgeon in Lake Ontario in 2013. Black River Bay was sampled with standard large mesh gill nets (GN1 or GN2, N=10, 240 net-hrs) in late August, resulting in a catch of one sturgeon.

The annual index gill netting survey conducted by NYSDEC in the Eastern Basin collected one sturgeon. Nets (GN4) were fished at 29 sites with total soak time of 551.7 net-hrs.

Conclusions

Collection and tagging of lake sturgeon in 2013 was moderately successful, however most of the effort targeted known populations of sturgeon in either the Black River or below the Moses Power Dam. Lower catch and catch rate below the Moses Power Dam in 2013 reduced overall sturgeon catch from previous years.

A total of 90 sturgeon were captured with 83 fish receiving new PIT tags. St. Lawrence River fish received the bulk of the tags (92%), sturgeon in waters associated directly with Lake Ontario received the remainder (8%).

Recaptures of tagged sturgeon are slowly increasing, primarily in the Black River. In this case it may be indicative of a relatively small spawning population using the Black River.

Recommendations

1. Continue focused effort on known spawning concentrations: Black River, SLR below the Moses Power Dam.

2. Continue efforts to collect juvenile sturgeon in Black River Bay and the Coles Creek area utilizing gill nets and trawls.

3. Continue to focus effort on areas of the St. Lawrence River with demonstrated concentrations of Lake Sturgeon such as Oak Point, Morristown, and Coles Creek.

4. Continue to explore areas of Lake Ontario around Point Peninsula, Grenadier Island, and Henderson Bay.

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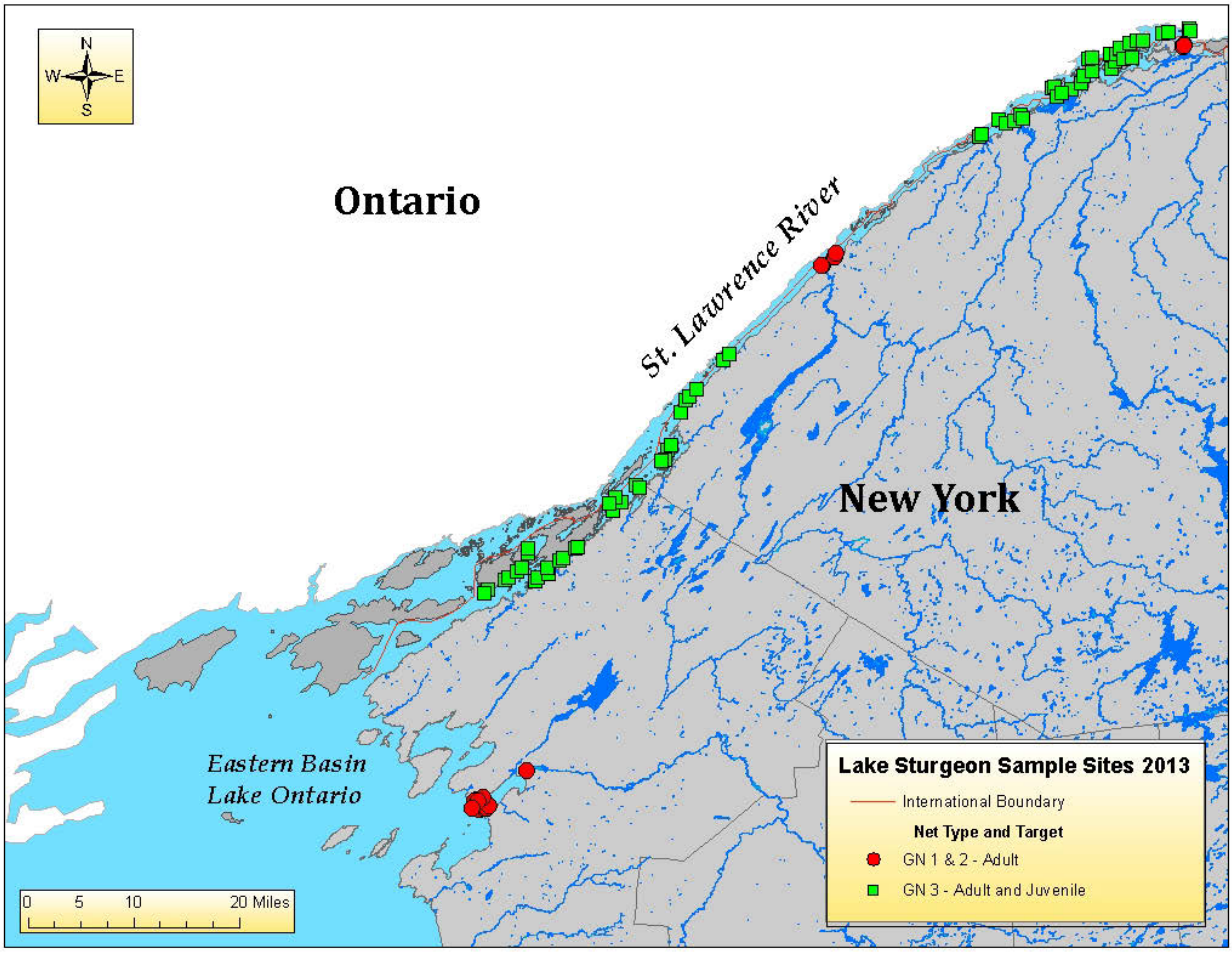

Figure 1. Lake sturgeon collection locations and targets for 2013. Adults were targeted with large mesh gill nets only (GN1 & 2). Existing index projects in the Thousand Islands and Lake St. Lawrence and contaminant collections potentially targeted "Both", juveniles and adults, utilizing primarily experimental gill nets (GN3) with minor use of large mesh nets (GN1 & 2). Net site location data for the Eastern Basin Lake Ontario gill net assessment (GN4) were not available for this figure.

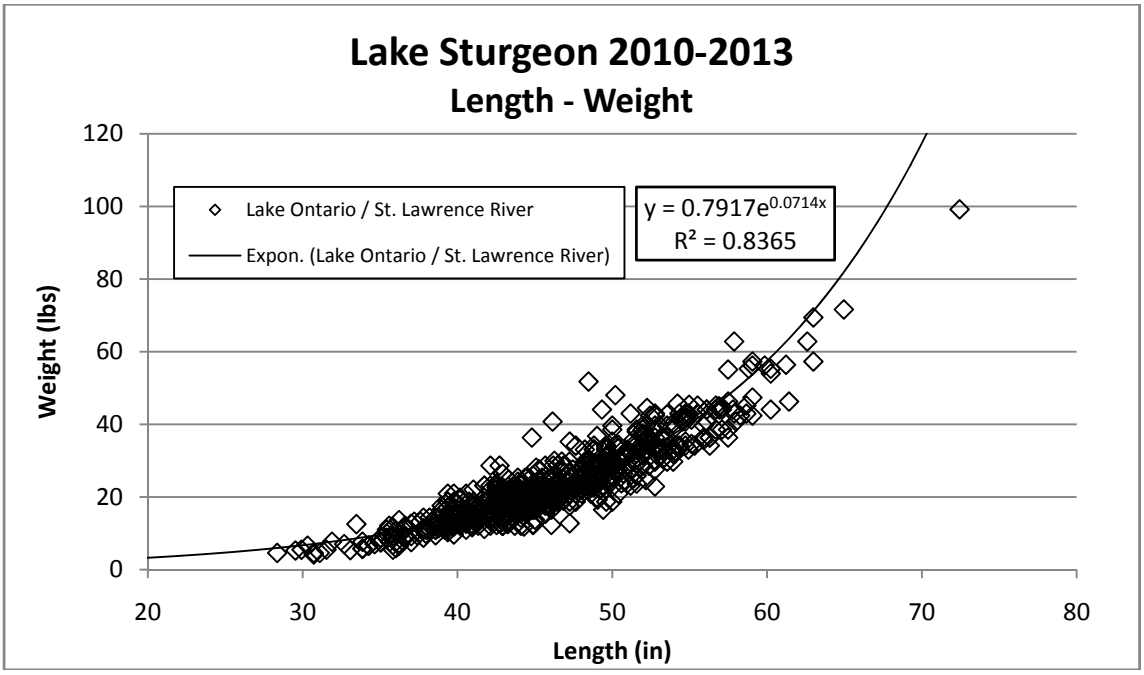

Figure 2. Length-weight relationship for Lake Sturgeon collected by NYS DEC from 2010-2013. Fish from the St. Lawrence River, Lake Ontario, and the Black River were combined with no differentiation to sex.

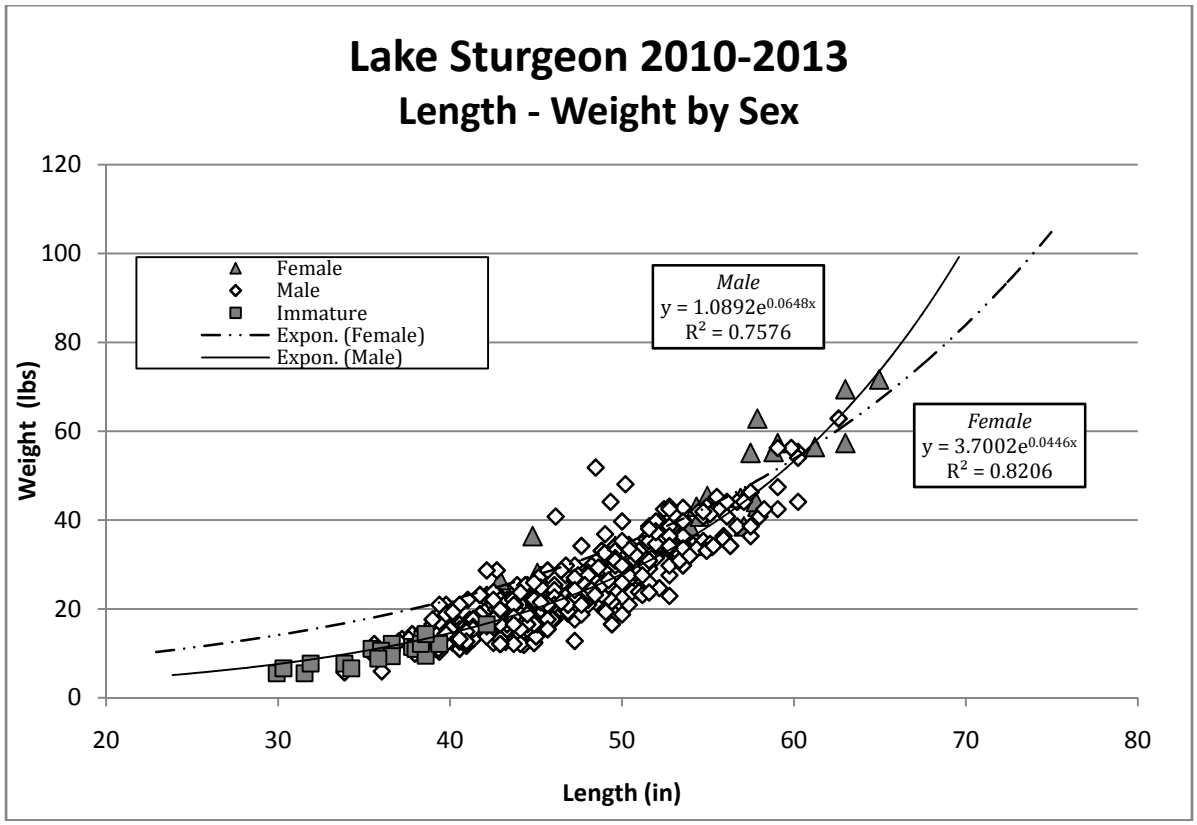

Figure 3. Length-weight relationship for Lake Sturgeon collected by NYS DEC from 2010-2013separated by sex. Fish from the St. Lawrence River, Lake Ontario, and the Black River were combined.

Table 1. Net specifications used for collecting lake sturgeon in 2013. Net target refers to the general size of sturgeon anticipated to be collected: A=adult or B=both adult and juvenile.

Name	Net Target	Net Code	Length(ft)	Depth (ft)	Stretch Mesh (in)	Material
R6 Sturgeon	A	GN1	300	8	10	monofilament
R6 Sturgeon	A	GN2	300	8	12	monofilament
SLR	B	GN3	200	8	1.5-6 (8 panel)	monofilament
LO	B	GN4	400	8	2-6 (8 panel)	monofilament

Table 2. Relative effort and success rate of lake sturgeon collection attempts on the St. Lawrence River and Black River in 2013. Targeted surveys specifically attempted to collect sturgeon. Existing and ancillary project surveys targeted the major fish assemblage with sturgeon as a possible component. The St. Lawrence is referenced as SLR- down or SLR-up, referring to the position either downstream or upstream of the Moses Power Dam, Massena NY.

Location	Dates	# Sites	Target	Net Code	Effort (hrs)	Catch	CUE (fish/hr)
Targeted							
Black River	5/1-2/2013	1	A	GN1	47.0	13	0.28
SLR- Down	5/30-6/4/2013	4	A	GN1	204.6	58	0.28
Black River Bay	8/21-22/2013	10	A	GN1 & GN2	240.0	1	<0.01
Ancillary project							
SLR- Up	5/14/2013	3	B	GN1 & GN3	70.8	17	0.24
Existing project							
SLR- TI	7/22-25/2013	32	B	GN3	638.13	0	0.00
LO Gill Net	7/29-8/9/2013	29	B	GN4	551.7	1	<0.01
SLR- LSL	9/16-19/2013	32	B	GN3	595.01	0	0.00

Monitoring and Management of Upper St. Lawrence River Muskellunge

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The upper St. Lawrence River is well known for its world-class Great Lakes strain muskellunge (*Esox masquinongy*, Mitchell) fishery. This population has been proactively managed through the efforts of an international St. Lawrence River Esocid Working Group and guidance by muskellunge management plans (Panek 1980, LaPan and Penney 1991, Farrell et al. 2003). The goal for management is: "To perpetuate the muskellunge as a viable, self-sustaining component of the fish community in the St. Lawrence River and to provide a quality trophy fishery" (with a catch rate of 0.1 fish per hour). The Esocid Working Group, composed of resource managers from the US and Canada, meets periodically to discuss recently completed studies, research needs, and potential management actions. Attention to muskellunge management and research needs has served as a long-term management model (Farrell et al. 2007) that is now focused on trends related to significant population reductions subsequent to an invasive viral hemorrhagic septicemia (VHSv) outbreak in the mid-2000s.

As recommended by management plans, monitoring of adult and young-of-year (YOY) muskellunge has been ongoing since 1990 and recent population changes have been detected using this data series. The first was an apparent positive response to the improved management strategies of the late 1990s and early 2000s with increased numbers of YOY on nursery grounds and higher adult catch rates. Beginning in 2005, however, widespread mortality of adult muskellunge was observed and attributed to VHSv recently introduced to the Great Lakes (Elsayed et al. 2006). Since these adult muskellunge mortality events, substantial declines have been observed in adult catch rates in the spring spawning survey and YOY abundance on the nursery grounds later in the summer.

Monitoring is important to understanding the population's response to perturbations such as disease-induced mortality as well as changes to habitat such as vegetation or fish community structure. For example, invasions by nonnative species such as round goby, (*Neogobius melanostomus*) are now known to include littoral nursery habitats of muskellunge. Maintenance of productive critical habitats is imperative to ensure sustained natural muskellunge reproduction (Dombeck et al. 1986). In order to address these needs, monitoring in nursery areas and research targeting factors influencing reproductive success continues to be of high importance. Significant progress has been made in these areas in previous work (summarized in Farrell et al. 2007), including studies of spawning ecology (LaPan et al. 1995, Farrell 1991, Farrell et al. 1996), nursery habitat requirements (Werner et al. 1990, Clapsadl 1993, Jonckheere 1994, Farrell and Werner 1999, Murry and Farrell 2007, Woodside 2008), dietary characteristics of YOY (Kapuscinski et al. 2012), and their response to invasions by non-native prey fish (Kapuscinski and Farrell, in press). The information obtained in these studies will be used to develop a more comprehensive understanding of muskellunge habitat and population dynamics, and guide enhancement strategies.

Our objective here is to report current research and monitoring efforts with annual updates pertinent to muskellunge management.

Methods

Spring trapnetting survey

Standardized trapnet surveys to monitor adult muskellunge at a set of spawning bays were conducted in 1997-2000, 2003, and since 2006 for a minimum of four weeks during the spawning period. In 2013, sixteen nets, including 3' hoop nets and 6' Oneida trap nets were fished near shore in eleven

known muskellunge spawning bays from May 5th to June 16th (Table 1). An additional sixteen sites were surveyed using a roving net design in an attempt to increase catch of spawning muskellunge.

Data collected include total length (TL), sex, spawning condition, and weight when possible (Table 2). All adult muskellunge were tagged with Passive Integrated Transponder (PIT) tags. A fin tissue sample was retained for future genetic analysis. Catch data are used to monitor trends in abundance, size and age distribution, and sex ratios of spawning muskellunge. Data on muskellunge recaptured in this survey and by angler collaborators are used to examine growth and fish movements, particularly as it may pertain to spawning site fidelity. To estimate survival of YOY muskellunge in nursery sites we repeated the stocking study conducted in the 1990s (Farrell and Werner 1999) to compare contemporary patterns to the 5 years of evaluation conducted during 1990-92, 1994 and 1996. Eggs were stripped and fertilized from adult muskellunge captured in the monitoring phase of the contract, when possible. In addition to collecting muskellunge-specific data, all other fishes are identified and enumerated to characterize fish assemblages present at muskellunge spawning sites.

Summer seining surveys

In 1990, a standardized seining procedure was initiated at six sites to monitor YOY muskellunge in the upper St. Lawrence River. Since 1997, monitoring the relative abundance of YOY muskellunge during the nursery period has continued with two surveys per year at each of eleven sites between Cape Vincent and Alexandria Bay, NY. Survey procedures are further detailed in Farrell and Werner (1999). Data collected include geographic coordinates detailing the location of each haul and habitat features (depth, temperature, vegetation type, and coverage). Juvenile esocid data comprises abundance, distribution, and total length (mm). Seining survey data are used to monitor trends in abundance, growth between periods, and monitor fish assemblage/habitat relationships at muskellunge nursery locations.

In addition to the standardized survey at index sites, continued identification of critical habitats is conducted at *exploratory* sites. These are areas where muskellunge were not previously detected (habitats in Eastern Lake Ontario downstream through Lake St. Lawrence) or have not been sampled in recent years using the standardized procedures for seining and data collection.

Angler diary program

Thousand Islands Biological Station (TIBS) staff continue to maintain an angler diary program with participants ranging in angling frequency from casual though dedicated muskellunge anglers to a professional guide with multiple record catches to his credit. Cooperators are selected based on quality of information volunteered in previous diary projects. They are asked to record information on daily effort (rod hours), catch and harvest rates, total lengths, and approximate location of angled muskellunge. We are working towards creating a website where participants can access current program information, join the program, and enter their diary information.

Muskellunge Catch and Release Program

A partnership with a local environmental advocacy group, Save the River, continued through 2013 sponsoring the Muskellunge Catch and Release Program. This program aims to both educate and involve the angling community in the conservation of the local adult muskellunge population by rewarding anglers who release a legal-size muskellunge with a limited edition, signed muskellunge print by St. Lawrence River artist Michael Ringer. Data are collected on each participant's total muskellunge catch and effort expended in hours, as well as information for the specific released fish submitted for the reward. Those details include location caught, water depth, weather conditions, date, time of day, weight of line used, bait or lure type, and total length of the muskellunge.

Muskellunge mortality

Throughout the field season, TIBS staff, collaborators, and other members of the Thousand Islands community who are familiar with the TIBS's mission, contribute to muskellunge mortality monitoring by reporting and/or collecting dead fish. When possible, dead and moribund fish are processed to record details on size, weight, potential cause of death, and stomach contents. During this necropsy, the cleithrum bone is removed and preserved for later age determination by Drs. John Farrell, or John Casselman of Queen's University as part of the Ontario Ministry of Natural Resources (OMNR) Cleithrum Project.

Results and Discussion

Spring trapnetting survey

A total of only 13 muskellunge were captured (catch rate = 0.022 fish/net night) in 2013, continuing a trend of decline since the 2005 outbreak of VHSv (Figure 1). The mean number of muskellunge caught in the spring trapnetting survey before the VHSv outbreak was 28.0 (SD=10.5), but a mean of 11.0 (SD=6.2) muskellunge have been captured in subsequent years. The 2013 catch rate of 0.022 muskellunge per trap net night (Table 1) was higher than in 2011 and 2012, but lower than historic levels. There were no recaptured muskellunge in 2013.

Eggs were stripped and fertilized from a pair of spawning adult muskellunge captured (Blind Bay 6/5) in the spawning adult monitoring phase of the contract (82,016 eggs estimated. Eggs were incubated, and fry continuously fed live brine shrimp for 2 weeks to an advanced fry stage at the TIBS (mean length 26.2mm or 1.0 in). Prior to release, fry were immersed in 700 ppm oxytetracycline for 8 hours to produce an identifiable mark in the otolith. Subsamples of immersed fry were retained to evaluate mark quality. Prior to release sac fry were sent to the NYSDEC Rome Fish Pathology Lab for pathology testing prior to release to the wild. Muskellunge sac fry were tested for the presence of three viral pathogens (via cell culture) and two bacterial pathogens (via plate culture) using AFS Blue Book standards. No pathogens were detected (insp. BD13-21). On July 8th, 2013 a total of 5,148 fry were stocked at a mean size of 26.2 mm or 1.0 in in four bays (Affluence – 790; Boscobel – 914; Deer – 522; and Rose – 2,960).

Summer seining surveys

The seventeenth consecutive annual standardized YOY muskellunge seining index was completed in 2013 (Table 3, Figure 2). A total of 11 bays were sampled during July with a fine-mesh seine (93 hauls) and during August with a large-mesh seine (90 hauls). A total of 38 (23 at stocked sites) YOY muskellunge (CPUE = 0.41 fish/haul) were captured in the fine-mesh index seine survey. The large-mesh seining series in August resulted in a catch of 19 YOY muskellunge in 90 seine hauls (CPUE = 0.21).

For the exploratory seining series, a total of 76 hauls were completed in the Thousand Islands during July, resulting in a catch of 25 YOY muskellunge from five sites (CPUE = 0.329) (Table 3). Two YOY muskellunge were captured at two sites where they had previously not been detected (west of Oak Point (middle corridor) and Wellesley Island State Park).

YOY muskellunge abundance within nursery areas remains suppressed even though catch rates were higher this year. This is the first year since 2008 where there has been an increase in catch rates, however catch rates still remain significantly lower than historical values. The difference could be due to stocking, but non-stocked sites (CPUE=0.24) had somewhat lower catch rates relative to exploratory sites (CPUE=0.34). This six-year decline in YOY abundance appears to signal a series of weak year-classes and potentially poor recruitment to the adult population.

Angler diary program

In 2013, angler diary program anglers spent 631 hours of effort for 23 muskellunge captured (0.036 fish/hour; Figure 3). The catch rate was a slight improvement over 2012 where 9 muskellunge where captured in 271 hours of effort (0.033 fish/hour), but continues greatly reduced quality of the muskellunge fishery.

The number of diary participants nearly doubled this year by providing incentives to fishermen and an increased outreach effort. Regardless of the increase in participants, catch rates remain well below the management goal of 0.1 fish per hour.

Muskellunge Catch and Release Program

In 2013, nine anglers participated in the Muskellunge Catch and Release program with TIBS and Save the River. Catches ranged in size from 52 to 58 inches. By the point in the season at which the anglers participated in this program, their angling effort ranged from 1 to 140 hours, with an average of 35.6 angler hours.

Muskellunge mortality

There was no evidence of disease-related muskellunge mortality during the 2013 season. The VHS virus, to which significant muskellunge mortality was attributed beginning in 2005, appears to be in a latent stage based on samples analyzed in 2013. Samples were isolated from thirteen adult muskellunge in late spring along with a subset of prey species to test for the presence of VHSv. Dr. Rod Getchell of the Cornell College of Veterinary Medicine, using qRT-PCR, analyzed all samples and found no presence of VHSv. Two species, yellow perch and rock bass, caught with muskellunge

did test positive for the virus indicating that adult muskellunge could have developed viral immunity.

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Table 1. Locations, site type, sampling period, trapnet effort (net nights), muskellunge catch, and CPUE in St. Lawrence River bays, 2013.

Site	Type	Effort	Musky	CPUE
Blind	Index	88	4	0.045
Cobb	Index	38	0	0.000
Densmore	Index	67	0	0.000
Flynn	Index	55	2	0.036
Frinks	Index	34	0	0.000
Garlock	Index	35	0	0.000
Lindley	Index	35	1	0.029
Millens	Index	33	0	0.000
Peos	Index	33	2	0.061
Rose	Index	33	3	0.091
Swan	Index	34	0	0.000
Site	Type	Effort	Musky	CPUE
Birch Isl.	Roving	7	0	0.000
Delaney	Roving	16	0	0.000
Escanaba	Roving	5	0	0.000
French Bay	Roving	5	0	0.000
Grass Point	Roving	7	0	0.000
Long Pt	Roving	20	0	0.000
Number 9	Roving	7	0	0.000
Pt Marg.	Roving	7	0	0.000
Pt Vivian	Roving	2	0	0.000
Rock Pile at Pt Marg. Marsh	Roving	7	0	0.000
Thurso	Roving	10	1	0.100
White House	Roving	6	0	0.000
Sub-Total	Index	485	12	0.025
Sub-Total	Roving	107	1	0.009
Total		**592**	**13**	**0.022**

Table 2. Summary of location of catch, total length (TL-mm), weight (kg), sex, reproductive stage, and tag number, and recapture history of spawning adult muskellunge in trapnets in St. Lawrence River bays, 2013. The tag entry number is for PIT type tags. No previously tagged muskellunge were recaptured this year.

Date	Location	Sex	Stage	TL (mm)	Weight (kg)	Recap Tag no.	Tag No.
5/11/2013	Rose	M	R	1020	7.86	-	900118001356930
5/13/2013	Flynn	F	H	1080	n/a	-	900118001354776
5/14/2013	Blind	F	R	1470	20.99	-	900118001105076
5/14/2013	Blind	F	R	1350	>25	-	900118001355082
5/14/2013	Thurso	F	S	1320	n/a	-	900118001106638
5/15/2013	Rose	M	R	1040	n/a	-	900118001105674
5/17/2013	Rose	M	R	1000	n/a	-	900118001357410
5/17/2013	Flynn	M	R	1140	n/a	-	900118001105988
6/4/2013	Peos	M	R	1200	28	-	900118001102006
6/4/2013	Peos	M	S	950	12	-	900118001104583
6/4/2013	Lindley	M	R	1240	34	-	900118001106135
6/5/2013	Blind	F	R	1350	n/a	-	900118001353286
6/5/2013	Blind	M	R	1311	34	-	900118001106147

Table 3. Seining catch summary for 2013 sampling using a 1/16" fine-mesh 30' bag seine in index sites (top), exploratory sites (middle), and a1/4" large-mesh bag seine targeting esocids. Highlighted lines represent sites that were stocked.

2013 30' Index Seining					
Bay	Hauls	Muskie	NP	CPUE Muskie	CPUE NP
Affluence Bay	6	8	0	1.33	0.00
Boscobel	7	1	0	0.14	0.00
Cobb Shoal	12	2	0	0.17	0.00
Deer Island	6	12	0	2.00	0.00
Frinks	10	3	0	0.30	0.00
Garlock	10	1	2	0.10	0.20
Lindley	6	8	0	1.33	0.00
Millens	10	0	0	0.00	0.00
Peos	8	1	0	0.13	0.00
Rose	12	2	0	0.17	0.00
Salisbury	6	0	1	0.00	0.17
Total	**93**	**38**	**3**	**0.409**	**0.032**

Table 3 Continued. Highlighted lines represent sites that were stocked.

2013 60' Index Seining					
Bay	Hauls	Muskie	NP	CPUE Muskie	CPUE NP
Affluence Bay	6	2	0	0.33	0.00
Boscobel	6	1	0	0.17	0.00
Cobb Shoal	12	4	0	0.33	0.00
Deer Island	6	4	4	0.67	0.67
Frinks	10	0	0	0.00	0.00
Garlock	10	1	0	0.10	0.00
Lindley	6	1	0	0.17	0.00
Millens	10	0	0	0.00	0.00
Peos	8	3	0	0.38	0.00
Rose	10	3	0	0.30	0.00
Salisbury	6	0	2	0.00	0.33
Total	**90**	**19**	**6**	**0.211**	**0.067**
2013 30' Exploratory Seining					
Bay	Hauls	Muskie	NP	CPUE Muskie	CPUE NP
A1	3	4	0	1.33	0.00
A2	3	1	0	0.33	0.00
Blind Bay	5	0	2	0.00	0.40
Bradley Point	2	0	2	0.00	1.00
Buck Bay	3	1	0	0.33	0.00
Cedar Point	2	0	0	0.00	0.00
CYC Bay	2	0	2	0.00	1.00
Delaney	12	1	3	0.08	0.25
Densmore	4	1	2	0.25	0.50
Dodge Bay	1	0	0	0.00	0.00
E. Side Waterson Point Rd	1	0	0	0.00	0.00
Escanaba	1	0	0	0.00	0.00
Flynn E	8	8	0	1.00	0.00
Flynn W	5	4	0	0.80	0.00
Long Point	4	0	1	0.00	0.25
Mead Island	2	2	0	1.00	0.00
Reed Point	2	0	0	0.00	0.00
Sand Bay	2	0	0	0.00	0.00
Sawmill Bay	1	0	0	0.00	0.00
Thurso	3	1	0	0.33	0.00
Wellesley State Park	1	1	0	1.00	0.00
Whitehouse Bay	4	0	0	0.00	0.00
Sucker Point	1	0	0	0.00	0.00
Oak Point West Bay	1	1	0	1.00	0.00
Fergusons Cove	2	0	0	0.00	0.00
Crows Nest	1	0	0	0.00	0.00
Total	**76**	**25**	**12**	**0.329**	**0.158**

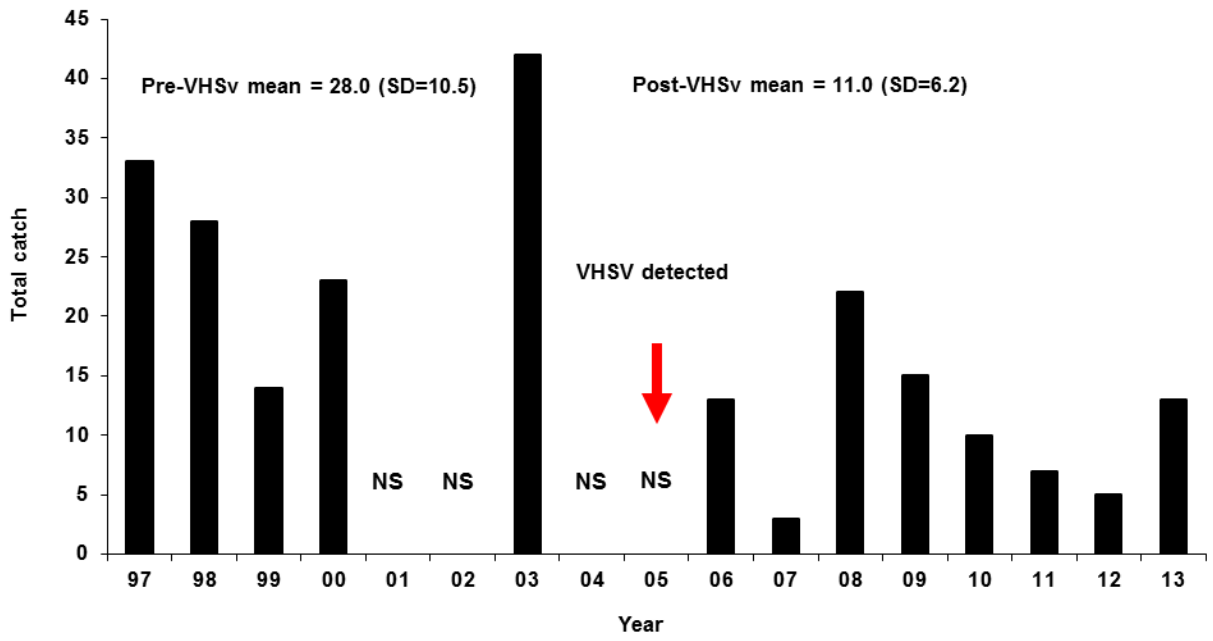

Figure 1. Total catch of muskellunge during spring trapnet sampling during 1997- 2013. Sites and effort are approximately equal over the series. Samples were not collected in 2001-02 and 2004-05 (NS) because of a decision of the Esocid Working Group to monitor muskellunge every third year. Following VHSv outbreak it was decided to resume annual monitoring.

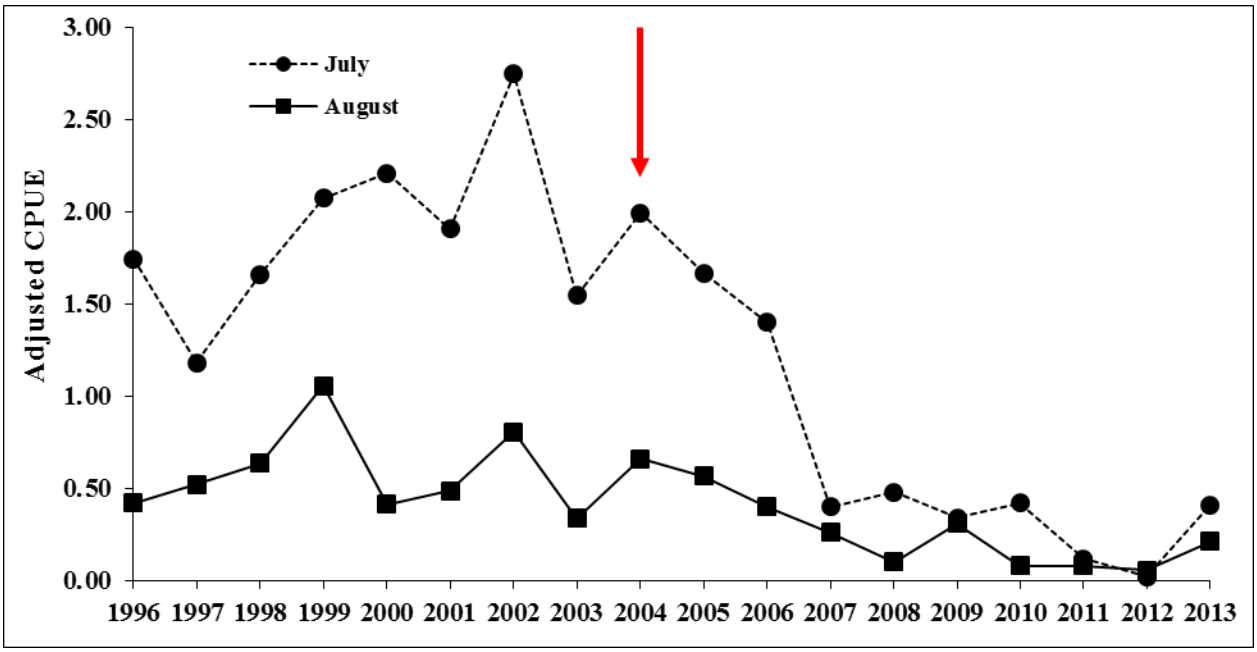

Figure 2. Catch per unit effort of YOY muskellunge captured in standardized seine hauls in eleven upper St. Lawrence River nursery sites from 1996 to 2013. A 9.14 m fine-mesh seine was used from July 15-31 and an 18.3 m large-mesh seine was used from August 15-31. The fine-mesh seine CPUE was doubled to standardize the area swept among the two gears. The arrow indicates the year prior to detection of VHSv (2004) and widespread mortality of muskellunge in the upper River.

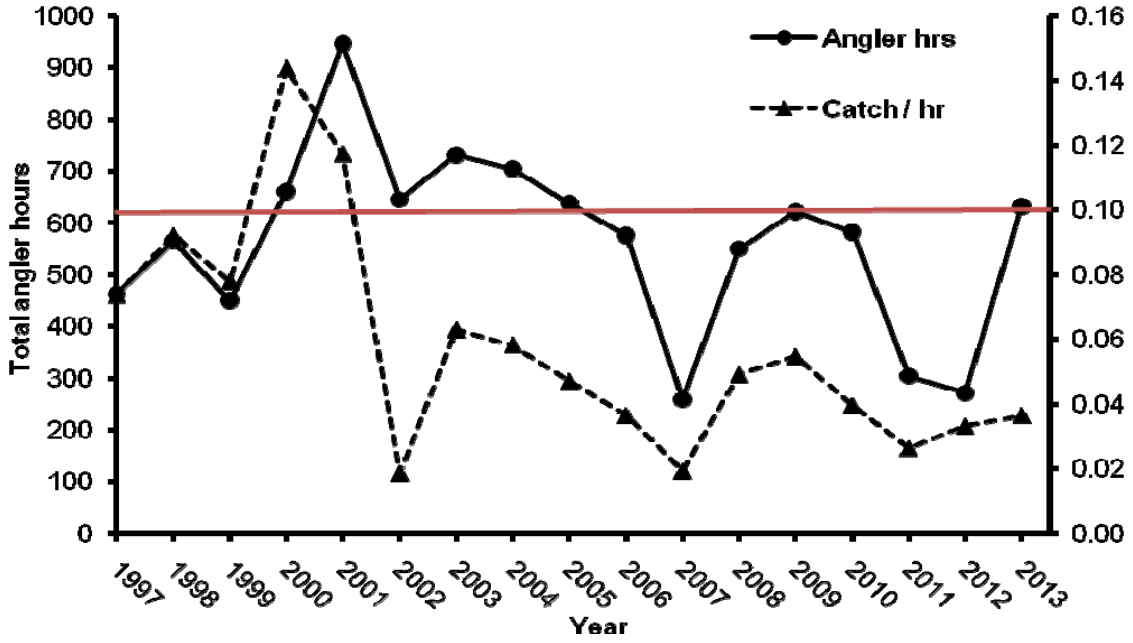

Figure 3. Angler hours compared to catch per angler hour. Red line denotes the target goal of 0.1 fish per angler hour.

Lake Ontario Commercial Fishery Summary, 2000-2013

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Commercial fishing activity in the New York waters of Lake Ontario is limited to the embayments and nearshore open waters of the eastern basin. Commercial fishing gear includes gill nets, trap nets, and fyke nets, however, only gill nets were actively fished in 2013. Commercial harvest generally targets yellow perch (*Perca flavescens*) and brown bullhead (*Ameurus nebulosus*), however, harvest of lake herring (*Coregonus artedii*), and white perch (*Morone Americana)* was also reported in 2013. Herring harvest in recent years went unreported, and fishers were reminded of reporting requirements (all fish caught, whether sold or not) in 2009. Of five licensed commercial fishermen, only three actively fished on two licenses (Table 2) in 2013. Data from previous years are reported by LaPan (2005).

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Table 1. Approximate reported value ($US) of the 2013 commercial catch from the New York waters of Eastern Lake Ontario (*estimated mean value, as price fluctuates throughout the year).

SPECIES	TOTAL POUNDS	PRICE/POUND*	TOTAL VALUE
Yellow Perch	20,589	$1.55	$ 31,913
White Perch	1,820	$ .60	$ 1,092
		Estimated Total Value	**$ 33,005**

Table 2. Reported* commercial fish catch in pounds from the New York waters of Eastern Lake Ontario, 2000-2013.

	# Lic.	YP	BBH	WP	RB	SF	CRP	WTF	CAT	DRM	CSCO
2000	7	59,928	5,709	383	280	3,571	308	-	-	-	-
2001	6	40,323	5,875	442	15	16	-	-	-	-	-
2002	6	37,223	4,435	-	-	-	-	-	-	-	-
2003	6	6,153	5,815	-	-	-	-	-	-	-	-
2004	3	37,066	1,200	-	-	-	-	-	-	-	-
2005	3	6,354	1,040	-	-	-	-	-	-	-	-
2006	3	4,274	500	-	-	-	-	-	-	-	-
2007	3	34,343	535	-	-	-	-	-	-	-	-
2008	3	14,428	735	-	-	-	-	-	-	-	-
2009	3	41,338	31	-	20	-	-	-	-	-	347**
2010	2	44,008	75	546	-	-	-	16	-	-	465
2011	3	77,238	105	3,736	-	-	-	-	-	-	613
2012	3	59,989	105	1,130	-	-	-	18	-	-	44
2013	3	20,589	0	1,820	-	-	-	-	-	-	12

*does not include documented illegal and/or unreported harvest
**known harvest in previous years was not reported

# Lic. = number of active fishers
YP = Yellow Perch
BBH = Brown Bullhead
WP = White Perch
RB = Rock Bass
SF = sunfish (Pumpkinseed, Bluegill)
CRP = Black Crappie
WTF = Whitefish
CAT = Channel Catfish
DRM = Freshwater Drum
CSCO= Lake Herring

Comparison of Fishes in Nearshore Areas of the St. Lawrence River, New York Over 35 Years

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Fishes of the nearshore waters of the St. Lawrence River provide forage for valuable sport fisheries and are important biological indicators of condition and change. This fish community differs slightly among various reaches of the St. Lawrence River from New York to Quebec (Carlson et al. 2006, Eckert and Hanlon 1977, Kapuscinski 2011, LaViolette et al. 2003, Mandrak et al. 2006, McKenna et al. 2005). Nearshore habitat has been described by McKenna et al. (2012), and others have suggested that there were changes over the last few decades (Clapsadl 1993, Kapuscinski and Farrell 2013). More definitive work needs to be completed on submerged aquatic vegetation habitats. In this paper, changes in the nearshore fish species composition for the New York reach from Cape Vincent to Moses-Saunders Dam are examined through comparison of results from 2009-2010 (McKenna et al. 2012) and 1976 surveys (Eckert and Hanlon 1977).

Methods and Study Area

Fish collections were made with seines, and were restricted to shallow water with flow conditions and bottom types suitable for wading. The 1976 study included 357 seine hauls from June 29 to November 19, with reduced effort after October 20, and revisited the river segments in a rotating time schedule to account for seasonal differences in catchability (Eckert and Hanlon 1977). Sampling in 2009-2010 comprised one sampling event at each of 89 sites from April 12 to October 6 (McKenna et al. 2012). The seine used in 1976 was 36'x6' with ¼" bar mesh; the seine used in 2009-10 was 30' by 4' with ¼" mesh wings and an 1/8" mesh bag. Voucher specimens were sent to the New York State Museum to verify identification in both studies. Species composition was examined using frequency of occurrence data. These data were compared by Fisher's Exact Test (Chi square), using a Bonferroni adjustment.

The river has two distinct habitat segments. The uppermost 74 km segment, extending from the river's source at Cape Vincent downstream to Jacques Cartier State Park (Figure 1), included the Thousand Islands region with many shallow areas and a diversity of submerged aquatic vegetation. The lower 91 km segment extended downstream through Lake St. Lawrence to the Moses-Saunders Dam near Massena. There are some quantitative differences in the fish assemblages inhabiting these two areas (Edwards et al. 1989, Carlson and LaPan 1997, LaPan et al. 2001), and nearshore littoral zone vegetation is more limited in the lower river segment.

Results and Discussion

The most commonly caught species (> 50% frequency of occurrence) shifted from Yellow Perch (*Perca flavescens*) and Tessellated Darter (*Etheostoma olmstedi*) in 1976, to Round Goby (*Neogobius melanostomus*), Yellow Perch, Banded Killifish (*Fundulus diaphanus*) and Largemouth Bass (*Micropterus salmoides*) in the most recent period (2009-2010, Table 1). Frequency of occurrence for Tessellated Darter and three other species declined significantly, while Round Goby, Bluegill (*Lepomis macrochirus*), Blackchin Shiner (*Notropis heterodon*), Pugnose Shiner (*Notropis anogenus*), and three other species increased

(Table 1). Eleven species were uncommon in the early period, but were absent in 2009-2010. For nearly half of these, their absences were not diagnostic of their populations, because they were caught recently by other methods or in other studies. Four species were uncommon in the recent period and absent in 1976, including Yellow Bullhead (*Ameiurus natalis*) (Table 1).

Some of the species that increased were habitat generalists, like Banded Killifish, and others have specialized relationships to submerged aquatic vegetation, like Bluegill and Largemouth Bass (Smith 1985). Round Goby, an invasive Eurasian benthic species was not known in this area until 2004 (pers. obs.). Shiners associated with submerged aquatic vegetation, e.g., Bridle Shiner (*Notropis bifrenatus*), Blackchin Shiner, Blacknose Shiner (*Notropis heterolepis*), and Pugnose Shiner, are known to be sensitive to environmental disturbances, and they increased. The increase for Pugnose Shiner was noteworthy because this species is classified as Endangered in New York and Threatened in Canada; range expansion might be associated with favorable habitat changes (Mandrak et al. 2011). We have no explanation for the decline in Spottail Shiner (*Notropis hudsonius*) and Fallfish (*Semotilus corporalis*). The decline in Tessellated Darter is likely associated with Round Goby increase, as similar to findings reported by Reid and Mandrak (2008).

The total number of species caught was 48 in 1976 and 46 in 2009-2010, and this similarity was not expected with the lesser number of sites in 2009-2010 (only1/4th as many sites) (Table 1). Species richness within each sample (α) averaged 4.5 in 1976 and 6 for 2009-2010.

Acknowledgements

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Table 1. Comparison of fish assemblage composition, as percent frequency occurrence, between 1976 and 2009-2010 using Fisher's Exact Test. Fisher's Exact Test for significance (total number of species represented:53, Bonferroni inequality correction for significance: 0.05/53=0.0009) is indicated in bold.

Name	1976	2009-10	Fisher's Exact Test *p*-value	Name	1976	2009-10	Fisher's Exact Test *p*-value
Longnose Gar	1	3	0.057	Creek Chub	0.3		1
Bowfin	1	1	0.488	Fallfish	22		**<.0001**
Alewife	16	1	**<.0001**	White Sucker	11	3	0.039
Gizzard Shad	1		0.589	Shorthead Redhorse		1	0.2
Rainbow Smelt	2		0.604	Yellow Bullhead		2	0.04
Central Mudminnow	1	1	1	Brown Bullhead	7	3	0.323
Grass Pickerel	3	3	0.302	Tadpole Madtom	0.3	2	0.103
Northern Pike	5	3	0.779	Trout Perch	1		0.589
Muskellunge	1	2	0.261	Banded Killifish	29	52	**<.0001**
Common Carp	2		0.604	Brook Silverside	3	12	**0.0004**
Cutlip Minnow	2		0.604	Brook Stickleback	1	4	0.032
Brassy Minnow	1	2	0.344	Threespine Stickleback	0.3		1
Eastern Silvery Minnow	7		0.007	White Perch	3		0.136
Golden Shiner	11	24	0.0051	Rock Bass	24	36	0.021
Pugnose Shiner	0.3	4	**0.0007**	Pumpkinseed	26	38	0.026
Emerald Shiner	2	6	0.069	Bluegill	0.3	19	**<.0001**
Bridle Shiner	1	3	0.057	Smallmouth Bass	17	13	0.522
Common Shiner	1	6	0.001	Largemouth Bass	18	44	**<.0001**
Blackchin Shiner	1	18	**<.0001**	Black Crappie	9	8	0.67
Blacknose Shiner	2	9	0.002	Johnny Darter		1	0.2
Spottail Shiner	37	1	**<.0001**	Tessellated Darter	54	10	**<.0001**
Rosyface Shiner	0.3	1	0.36	Yellow Perch	64	58	0.328
Spotfin Shiner	9	15	0.111	Logperch	2	4	0.241
Sand Shiner	4	6	0.585	Round Goby		76	**<.0001**
Mimic Shiner		1	0.2	Mottled Sculpin	3	1	0.474
Bluntnose Minnow	42	40	0,904				
Fathead Minnow	1	2	0.631	no. species	48	46	
Longnose Dace	1		0.589	no. sites	357	89	

Figure 1. St. Lawrence River study area from Cape Vincent to Moses Saunders Dam at Massena, Thousands Islands and below.

Assessment of the Lake Ontario Black Bass Fishery Using Cooperator Angler Diaries

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Nearshore waters of Lake Ontario's main basin produced exceptional smallmouth bass fishing from about 1996 to 2003 (Eckert 2004, Eckert 2006). In recent years, the NYS Department of Environmental Conservation (NYSDEC) Regional Fisheries Units and the Lake Ontario Unit received many angler complaints about a decline in smallmouth bass catch rates in areas where quality bass fisheries once existed. The Lake Ontario Fishing Boat Survey documented this decline (Eckert 2006, Lantry and Eckert 2013). In recent years, the majority of interviewed smallmouth bass anglers were catching few bass and primarily catching round goby, an invasive species first reported in angler catches in 2001. Through 2008, however, some interviewed bass anglers continued to experience high quality bass angling by successfully avoiding gobies. During 2009-2012, angler complaints continued, prompting additional gill net surveys in 2010 and 2011.

The cause(s) for the recent decline in bass fishing quality is not fully understood nor is the current status of the bass population along the southern shore of Lake Ontario. Additional sampling was conducted during the 2010 season, including gill netting assessments at four sites (Webster, Pultneyville, Fairhaven and Mexico) and initiation of an angler diary program. Further sampling was conducted at Pultneyville in 2011 (Sanderson 2012). A Lake Ontario Black Bass Angler Diary Program (Program) was initiated to provide additional information on fishing quality experienced by anglers targeting smallmouth and largemouth bass in Lake Ontario, its embayments, and tributaries to the first impassable barrier, as well as biological characteristics of bass caught. This report provides a summary of 2013 angler diary results.

Methods

The NYSDEC recruited volunteer bass anglers to participate in the Program. A variety of media were used to notify potential diary keepers of the Program, including the NYSDEC web page, fishing web sites, press releases, newspaper and magazine articles, presentations at sportsman shows, and at meetings of angler groups. Anglers interested in participating sent their name, address, and e-mail address to fwfishlo@gw.dec.state.ny.us. NYSDEC provided each participant with data collection instructions and a NYSDEC angler diary in which the participant would record fishing activity (e.g. date, time, location, length of each bass kept and released) for each bass fishing trip. At the season's end each participant returned their diary to NYSDEC. The diary program began at the start of the traditional open season on June 15, 2013. Diary keepers were instructed to record only trips in which they targeted bass; therefore, catch rates are based on directed effort.

Results and Discussion

In 2013, 46 angler cooperators participated in the diary program and 27 returned diaries to NYSDEC. Five diarists sent letters or e-mails saying they did not fish for bass in 2013. All 27 diarists targeted bass during the 2013 season, and reported a combined total of 201 fishing trips comprising 1,280.3 angler hours. Participation and angling effort in the Program grew from 2010 (46 cooperators, 30 returned diaries, 191 trips, and 1,329 hours) to 2011 (55 angler cooperators, 34 returned diaries, 305 fishing trips, 1,670 hours), and remained relatively unchanged in 2012. Participation and effort in the Program returned to 2010 levels in 2013 (Figure 1). The 2013 sample

size remains lower than that required to detect a statistically significant change in the fishery. Bishop (1993) estimated that 110 angler diary keepers making 1,700 trips on Seneca Lake were needed to detect changes in the salmonid fishery.

During 2013, 130 trips (65%) were made on Lake Ontario, 52 trips (26%) were made on five bays, and 19 trips (9%) were made on three tributaries. No fish were caught on 57 trips (28%), smallmouth bass were caught on 84 trips (41%), largemouth bass were caught on 66 trips (32%), and both species were caught on 6 trips. Among smallmouth bass trips in the open waters of Lake Ontario, 33.1% caught no smallmouth bass (Figure 2). This is lower than that observed during 2010 (55.2%), and similar to 2011 and 2012 (34.6% and 30.4, respectively) (Sanderson and Lantry 2011, 2012, and 2013). In 2011, 58.8% of boats specifically targeting smallmouth bass surveyed in the Lake Ontario Fishing Boat Survey during the traditional open season failed to catch at least one bass, the highest value among years surveyed (Lantry and Eckert 2012). This value declined to 53.6% in 2012, and declined further to 45.8% in 2013 (Lantry and Eckert 2014).

The majority of 745 bass caught were of legal size (61% ≥ 12”), but 95.8% of those were released. Of 409 largemouth bass caught, all were released and 56% of the released fish were of legal size (≥12”). Of 336 smallmouth bass caught, 91% were released, and 65% of the released fish were of legal size (>12”). The high bass release rate in 2013 is consistent with 2010 through 2012 results, as well as those observed during creel surveys conducted on Irondequoit Bay (2007), Sodus Bay (2008), and Lake Ontario (Sanderson and Lantry 2011, 2012, and 2013, Sanderson 2009, Sanderson 2010, Lantry and Eckert 2012).

The mean length of harvested smallmouth bass was 15.6 inches. Mean lengths of released, legal sized smallmouth and largemouth bass were 15.2 inches and 14.2 inches, respectively. Nearly all (97.1%) of the smallmouth bass were caught from a boat using artificial lures or live bait, and 96.8% of those were caught in Lake Ontario. Nearly all (98%) of the largemouth bass were caught using artificial lures.

Individual trip catch rates ranged from 0.00 to 3.67 smallmouth bass per angler hour. Smallmouth bass catch rates were determined for lake, embayment, and tributary anglers (Table 1). Lake Ontario bass anglers accounted for 66.2% of the total angler hours and 97.3% of the smallmouth bass catch reported, resulting in a directed effort catch rate of 0.39 smallmouth bass per angler hour, the lowest observed in the Program (Figure 3). This was lower than the catch rate (0.59 bass per angler hour) determined for traditional season, open lake bass anglers interviewed for the 2013 Lake Ontario Fishing Boat Survey (Lantry and Eckert 2014). Smallmouth bass catch rate in embayments in 2012 was 0.02, similar to previous years of the Program and rates reported by Sanderson (2009 and 2010) for Irondequoit Bay and Sodus Bay. This low rate, relative to that of lake anglers, was expected given that bass fishing in embayments primarily targets largemouth bass. Smallmouth bass catch rate in tributaries was 0.01 bass per angler hour, the lowest observed in the Program (Sanderson and Lantry 2011, 2012, and 2013).

In 2013, 68% of largemouth bass were caught in embayments and 16.2% were caught in tributaries. From 2010 to 2012, between 55.7% and 70% of largemouth bass were caught in embayments. During those years, between 37.8% and 12.5% were caught in tributaries (Sanderson and Lantry 2011, 2012, and 2013). Individual trip catch rates ranged from 0.00 to 6.00 largemouth bass per angler hour. Largemouth bass catch rates were determined for lake, embayment, and tributary directed effort (0.01, 0.93, and 0.93 largemouth bass per angler hour, respectively; Table 2). In 2013, cooperators caught largemouth bass at an excellent directed effort rate of 2.63 bass per angler hour in Port Bay. Cooperators caught largemouth bass at a directed effort rate of 0.92 bass per angler hour in East Bay, 0.33 bass per angler hour in Irondequoit Bay, and 0.32 bass per angler hour in Sodus Bay during 2013. The rates from 2010 to 2012 ranged from 0.26 to 0.73 largemouth bass per hour in Irondequoit Bay and from 0.51 to 0.68 largemouth bass per hour in Sodus Bay. Previous direct contact creel surveys found that fishing quality for anglers targeting bass on Sodus Bay in 2008 was excellent (1.09 bass per angler hour) and the targeted catch rate was 0.80 largemouth bass per hour in Irondequoit Bay in 2007 (Sanderson 2009 and 2010). In 2012 a creel survey was conducted on Port and East Bays and the estimated directed effort catch rates for largemouth bass were 1.16 and 0.75 bass per

hour, respectively (Sanderson in preparation). These rates greatly exceed the directed effort catch rates of all size largemouth bass from selected waters in New York State (0.24 bass per hour; Green et al. 1986).

A few diary cooperators experienced good quality smallmouth bass fishing in Lake Ontario from 2010 to 2013; however, the majority did not. A close examination of individual cooperator data revealed that relatively few successful anglers accounted for the vast majority of the smallmouth and largemouth bass catch in 2010-2013, with five or fewer cooperators accounting for >70% of the reported catch.

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Table 1. Smallmouth bass catch, effort, and catch rate by water and month of cooperating angler diary keepers in 2013.

Month	# Fish Caught	Hours	Catch Rate
	Lake Ontario		
May	0	0.00	0.00
June	53	159.75	0.33
July	105	348.13	0.30
August	98	248.75	0.39
September	69	73.08	0.94
October	2	17.25	0.12
November	0	0.00	0.00
	327	846.97	0.39
	Embayments		
May	0	0.00	0.00
June	1	58.25	0.02
July	1	97.17	0.01
August	4	59.33	0.07
September	1	42.00	0.02
October	0	42.00	0.00
November	0	0.00	0.00
	7	298.75	0.02
	Tributary		
May	0	0.00	0.00
June	1	12.00	0.08
July	0	53.25	0.00
August	1	44.33	0.02
September	0	25.00	0.00
October	0	0.00	0.00
November	0	0.00	0.00
	2	134.58	0.01
Total	336	1280.30	0.52

Table 2. Largemouth bass catch, effort, and catch rate by water and month of cooperating angler diary keepers in 2013.

Month	# Fish Caught	Hours	Catch Rate
		Lake Ontario	
May	0	0.00	0.00
June	0	159.75	0.00
July	2	348.13	0.01
August	3	248.75	0.01
September	0	73.08	0.00
October	1	17.25	0.06
November	0	0.00	0.00
	6	846.97	0.01
		Embayments	
May	0	0.00	0.00
June	51	58.25	0.88
July	165	97.17	1.70
August	46	59.33	0.78
September	10	42.00	0.24
October	6	42.00	0.14
November	0	0.00	0.00
	278	298.75	0.93
		Tributary	
May	0	0.00	0.00
June	14	12.00	1.17
July	45	53.25	0.85
August	43	44.33	0.97
September	23	25.00	0.92
October	0	0.00	0.00
November	0	0.00	0.00
	125	134.58	0.93
Total	409	1280.30	0.32

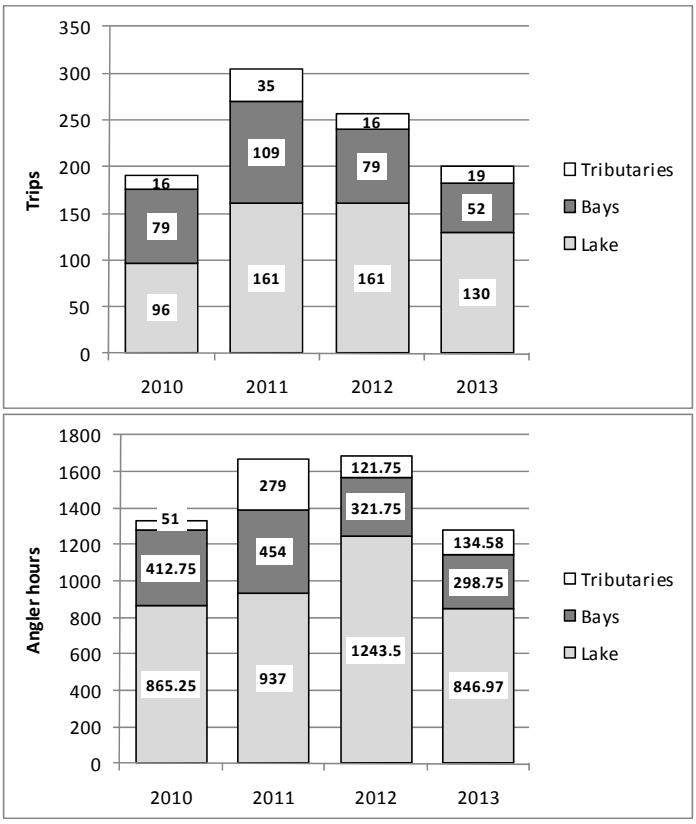

Figure 1. Number of trips and fishing effort of cooperating angler diary keepers fishing on Lake Ontario, bays, and tributaries from 2010 to 2013.

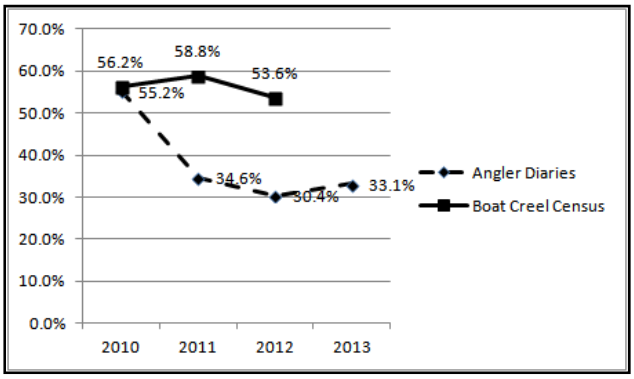

Figure 2. Percent of boat trips on Lake Ontario where no bass were caught from 2010 to 2013.

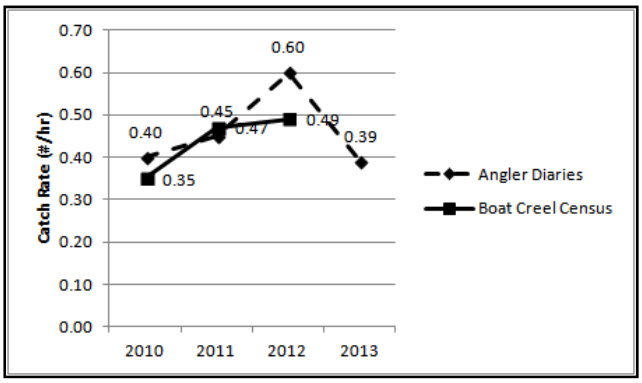

Figure 3. Catch rate of boat anglers targeting smallmouth bass on Lake Ontario from 2010 to 2013.

Northern Pike Monitoring and Management in the Thousand Islands Section of the St. Lawrence River

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Northern pike abundance in the NYS Department of Environmental Conservation's (DEC) Thousand Islands Warmwater Fish Stock Assessment (McCullough and Gordon 2013) continues to show population suppression. Smith et al. (2007) demonstrated an overall dampening in the strength of Thousand Islands northern pike year classes beginning in the 1990s. Models of northern pike young of the year (YOY) production developed as part of the International Joint Commission (IJC) St. Lawrence River Water Levels Study indicated a negative effect of water level regulation on reproduction (Farrell et al. 2006). Water level regulation and spawning habitat changes appear to have promoted deep-water pike spawning (over ~5 meters (16.4 ft) water-depth) and 4-6 week delays in the egg deposition period (Farrell 2001). Deep water spawning behavior is believed to be maladaptive and has created a significant reproductive sink, as field studies and simulations indicate poor growth and survival of pike in this habitat (Farrell et al. 2006). Nearshore pike spawning has been negatively affected by water level regulation by preventing spawner access to wetlands and via the expansion of hybrid cattail (Typha *x* glauca) into riparian wet meadow habitats (Farrell et al. 2010).

To provide improved spawning habitat conditions at the local scale, water level controlled spawning marshes have been used in an attempt to increase natural recruitment (Forney 1968). Three natural spawning marshes have been managed in the Thousand Islands region to provide improved spring water level conditions with a goal of enhancing regional pike reproduction. Despite some early indications of success with managed marshes demonstrating significant production of emigrating fingerlings (Farrell et al. 2003), it is hypothesized that low numbers of spawning adults and female skewed sex ratios have resulted in low levels of YOY production at managed marshes.

Northern pike YOY have been monitored in eleven seining survey sites also used to index muskellunge (see Farrell and Barry 2012) and more recently in larger bays and in tributaries. Overall YOY production has declined significantly from levels observed in the 1980s and early 1990s. Continued monitoring is necessary to track pike reproductive success and evaluate responses to management activities (managed marshes and habitat enhancements). Other needs fulfilled by the project include a better understanding of early life history processes for northern pike in tributary systems, and the influence of IJC regulated water levels on habitat dynamics and northern pike recruitment processes. Research regarding habitat restoration efforts, in addition to providing options for northern pike management, will be critical to maintaining future populations.

Our objective is to provide an update of current research and monitoring activities related to northern pike management.

Methods

Spawning run trapnet survey

Monitoring of adult northern pike during spring spawning occurred in five index tributaries and two managed spawning marshes. Tributaries included French Creek, Cranberry Creek, Cranberry Creek extension (tributary), Little Cranberry Creek, and Chippewa (Creek) Tributary. The managed marshes were Carpenters Branch of French Creek and Butterfield Marsh of Crooked Creek (Figure 1).

Pike were captured in trapnets and assessed for sex/spawning condition, examined for fin-clips or tags, measured for total length (TL), and tagged with

a monel metal jaw tag with an unique alphanumeric code and "RTN TO NYSDEC WAT NY 13601" in the left maxillary of fish greater than 500 mm TL (19.7 in). Recaptured fish yielded information on distribution, individual growth, and spawning site fidelity. A scale sample was retained from each fish and notes on any physical abnormalities were recorded. Captured pike were transferred upstream of each net following processing. The sex ratio (females to each male) was compared for each site.

Water levels were held intentionally higher (~0.6 m or 2 feet) at Carpenters Branch, Butterfield Marsh and Delaney Marsh. Delaney was not included in the spring spawning survey, but was surveyed through the rest of the season for emigrating YOY pike, wetland vegetation, and other indices. This water level management strategy is intended to prevent the fall drawdown associated with the IJC's water level regulation Plan 1958D (Farrell et al. 2010). Managing for higher water levels promotes more natural muskrat populations within sites, resulting in the creation of openings in dense invasive cattail mats within the marsh (Toner et al. 2010). Higher water levels also provide improved spring water level conditions for spawning pike.

Spawning run egg survey

A northern pike egg survey was conducted in the deep littoral shoal habitat at Governors Island (Figure 1). Eggs were collected in an array of 12 egg traps (Farrell 2001) set and checked weekly during April and early May. Data on GPS position of each egg trap, egg abundance, viability, and hatching success were recorded for each egg trap location.

Emigration of northern pike from managed marshes

In 2013, surveys for emigrating YOY pike from marshes used spillway traps set at Delaney marsh from 6/6-7/2, at Butterfield marsh from 6/4-7/2 and at Carpenter's Branch from 6/3-7/2. All fish captured were identified and counted. Pike were measured for total length, and a pelvic fin was removed to evaluate the presence of marsh-origin fish in subsequent summer seining surveys and future spring adult trapnetting.

YOY outmigration data from the spillway trap at Carpenter's Branch in 2003-2013 and at Delaney Marsh were compared to the abundance of female pike captured in spring trapnetting to test for presence of a stock-recruitment relationship. Data were fit with a power function.

Summer seining surveys

Standardized seining for YOY northern pike was conducted in conjunction with YOY muskellunge monitoring. A total of 11 bays were sampled during July with a fine-mesh 9.1 m (30') seine (90 hauls) and during August with a large-mesh 18.3 m (60ft) seine (90 hauls) (for methods details see Murry and Farrell 2007). In addition, 22 bays were sampled in an exploratory series with the fine-mesh seine. This exploratory series is also used to compare to the long-term index seining results.

Results and Discussion

Spawning run trapnet survey

A total of 68 northern pike were captured at five index sites from April 1st to April 19th, 2013, comprising an effort of 120 net nights, and resulting in a catch per unit of effort (CPUE) of 0.57 fish/night (Table 1). The catch of spawning northern pike at index sites remains low since a significant peak in 2008 (3.36 fish per night; n=5; Figure 2). Catches were relatively higher at Cranberry Creek (42 pike in 18 net-nights, 2.33 fish per night).

Only eight northern pike were captured in Carpenter's Branch and none were captured at Butterfield Marsh. Current and past trapnet catches indicate a remarkable dominance of female pike in the spawning run at these sites (Figure 5). For 540 pike of known sex captured at Carpenter's Branch in eleven seasons since 2003, 380 were female or 2.38 females to each male. Similarly at Delaney Marsh, in five seasons from 2007 to 2011, 71 of 95 pike were female for a 2.96 female to male ratio.

One fin-clipped northern pike adult (that would indicate they were fin-clipped as emigrating YOY) was captured during spring trapnetting at Cranberry Creek in 2013.

Spawning run egg survey

Egg traps yielded one egg over an approximately 2.5 week sampling period in May and early June. This sampling provided an index of deep and protracted spawning that is thought to be associated with habitat changes and water levels management (Farrell et al. 2006). However, increases in invasive round goby (*Neogobius melanostomus*), a known

egg predator, are now believed to influence the egg catch rates and this effect needs to be assessed.

Emigration of northern pike from managed marshes
The Delaney Marsh site yielded low productivity again in 2013, yielding 63 northern pike YOY over 17 days on monitoring (Table 2). At Carpenter's Branch in contrast, only 11 northern pike YOY were captured over 23 days of monitoring. All fish over 80mm were marked by removal of the left ventral fin. Overall catch per unit effort at Carpenter's Branch was 0.48 fish emigrating per day for northern pike, similar to 2012. Delaney catch rate increased to 3.71 fish emigrating per day, higher catches than any of the other sites, yet still much lower than observed at similar sites early in the program. Catch in Butterfield Marsh was nearly half of Delaney at 1.50 fish per night. Low production of northern pike from the Carpenter's and Delaney spawning marshes has continued for a sixth consecutive year (Figure 3).

The number of out-migrating YOY northern pike from Carpenters Branch and Delaney Marsh for all years when data are available was plotted against the number of females captured entering marshes during spring spawning. Data were fitted with a power function and suggest the presence of a stock-recruitment relationship, demonstrating increasing YOY production with increasing female spawner density (Figure 4).

Summer seining surveys
The YOY seining survey at eleven index sites targeting muskellunge produced 3 northern pike YOY from the 30' seine series in 93 hauls (standardized CPUE = 0.032 fish; Table 3) and 6 in the 60' seine series in 90 hauls (standard CPUE = 0.067 fish/haul). Twenty two upper St. Lawrence River bays were sampled by seining and 12 YOY pike were captured (N=76 hauls; CPUE=0.158). Seine hauls at Delaney Bay (N=12) resulted in a catch of three YOY pike (CPUE = 0.25).

Conclusions and Recommendations

Continued low density of adult and YOY northern pike on spawning/nursery grounds suggests that system wide water level regulation induced changes to wetland/nearshore habitats is suppressing natural reproduction. Problems with low adult stock size and skewed sex ratios continue and may confound development of strong pike year classes. Spawning marsh management is a tool to enhance YOY production, but pike runs and marsh production are declining. Relationships of low spawner density and YOY out-migrants were the impetus for transplanting fish in a 1:1 M:F ratio from French Bay to increase numbers at the Carpenter's Branch marsh in 2011; however, techniques employed failed to improve production of YOY. In 2013 no transfers occurred and strength of adult runs and YOY production was low.

Steps continue to be taken by DEC, the US Fish and Wildlife Service (FWS) and Ducks Unlimited (DU) to restore critical spawning and nursery habitat. Steps have also been taken to improve existing water level controlled spawning marshes. The Butterfield Marsh was repaired by FWS during late fall of 2012 and the fish ladder at the Carpenters Branch spawning marsh was repaired by DU in late winter 2013. It is recommended that fish handling during trap and transfer operations be limited to only collecting length, sex and condition data to reduce fish stress, or to consider allowing fish passage systems to operate without trapping and only monitor outmigration of young pike. It is also recommended that managed marshes be drained in mid-summer to reflect natural drought periods.

Northern pike sex ratio imbalance as a factor in the decline needs more research focus; a College of Environmental Science and Forestry graduate student is completing an investigation of potential mechanisms of this anomaly. Stocking of marked, early life stages of pike in managed marshes and "control" sites should be considered to test for differential survival rates.

Sex determination and gender ratio within fish populations can be influenced by environmental factors and selective mortality and therefore represents an important marker of population health. Another M.S. student is continuing investigation of the sex ratio in the St. Lawrence River northern pike population. A molecular gender diagnostic tool is being developed at the Cornell University Genomics Facility to determine gender of northern pike at any life stage. This tool will be used in experiments to examine factors potentially influencing sex ratio and in testing wild fish during early life.

A third student is testing if spawning site fidelity represents a natal homing instinct in northern pike. A comparison of otolith microchemistry in spawning

adults and YOY pike with water chemistry of spawning sites, in addition to analysis of genetic differentiation between spawning populations, will be used to resolve if fine-scale natal imprinting exists. Additionally the tools will allow for determining spawning site identity (bay vs. tributary wetland) of fish captured in the main river during DEC's Warmwater Assessment.

The long-term monitoring developed in this study will serve as an important indicator to assess effects of a water level regulation plan change, if adopted, and to help guide the IJC adaptive management process.

Acknowledgements

Funding for this project was provided by NYSDEC Federal Aid Grant F-61-R Study 9. Many technicians, students and volunteers provided significant efforts to collect and maintain this field data. We are also indebted to the Thousand Islands Land Trust for their assistance in terms of personnel, equipment, and access to the Delaney Marsh. We thank NYSDEC for support of this research and for reviews conducted by Steve LaPan. This research was conducted at the Thousand Islands Biological Station.

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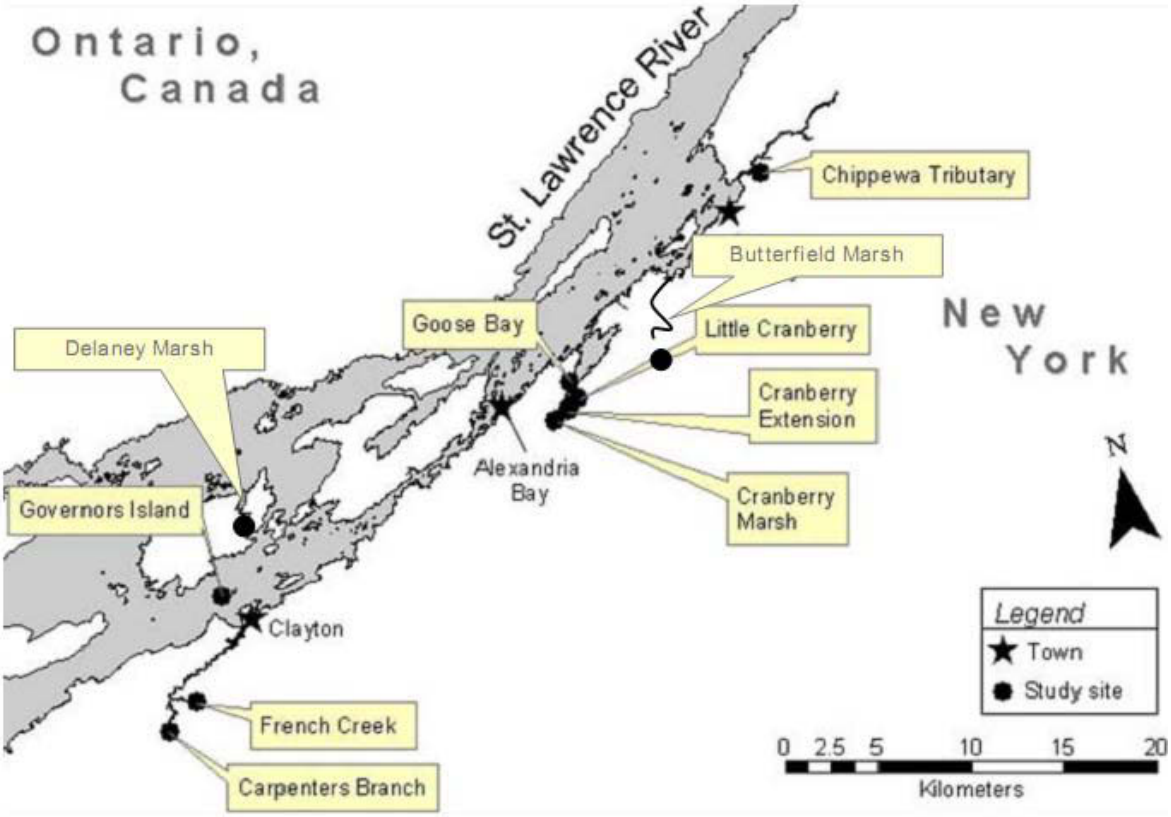

Figure 1. Study sites in the Thousand Islands Region of the upper St. Lawrence River in Clayton and Alexandria Bay, New York, including spawning marshes at Carpenters Branch (French Creek Wildlife Management Area) and Delaney Marsh (Grindstone Island) and sampling index locations at French Creek, Little Cranberry Creek, Cranberry Extension, and Chippewa (Creek) Tributary. Governors Island is the location of the Thousand Islands Biological Station. A spawning marsh at Butterfield Marsh at Crooked Creek has been repaired by the US Fish and Wildlife Service. Additional seining locations (not shown) are index YOY muskellunge monitoring sites and other regional embayments including Goose Bay.

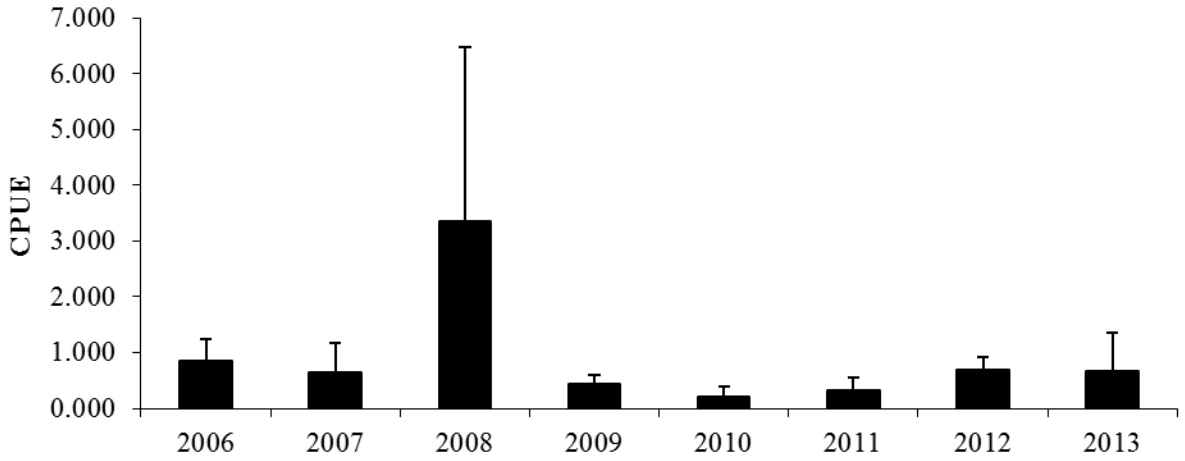

Figure 2. Average catch per net-night of northern pike in five spring spawning index trapnetting locations from 2006 to 2013 with 90% confidence limits.

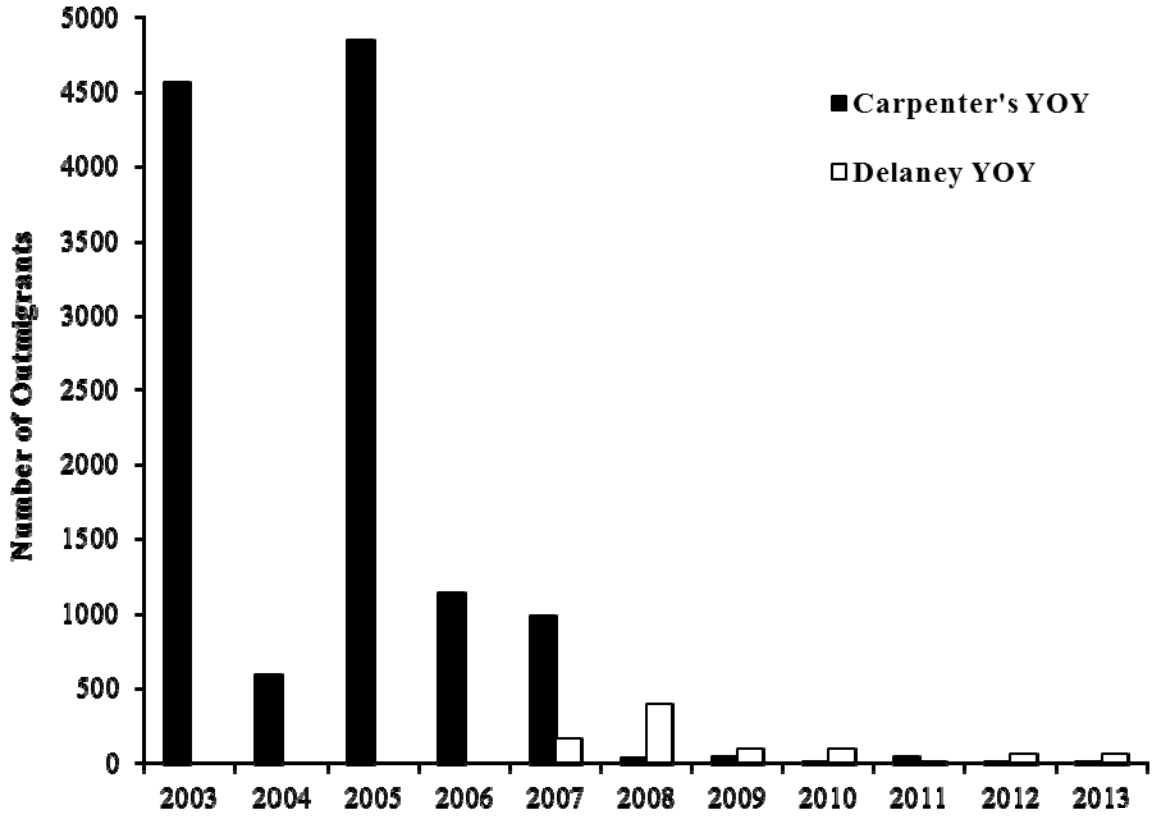

Figure 3. Number of out-migrant northern pike YOY from managed spawning marshes at Carpenter's Branch (2003 to 2012) and Delaney Marsh (2007 to 2013).

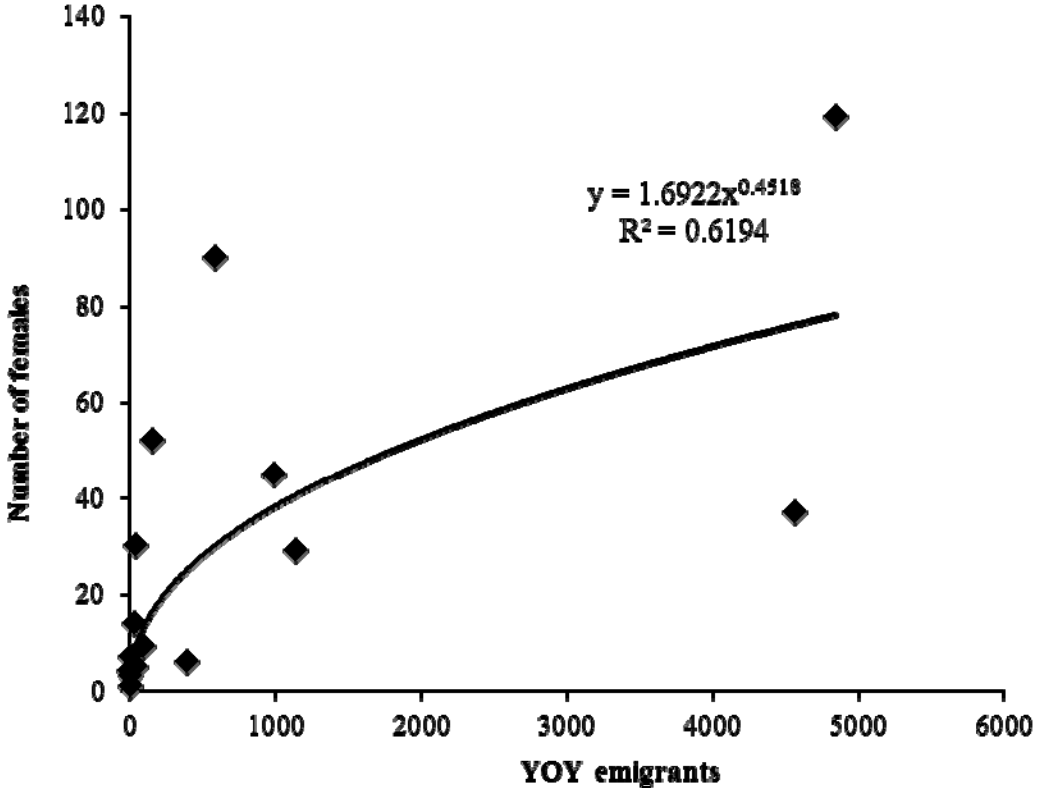

Figure 4. The number of outmigrating YOY northern pike from Carpenters Branch (2003-2013) and Delaney Marsh (2007, 2008, 2010-2011) plotted against number of females captured entering marshes during spring spawning and fitted with a power function.

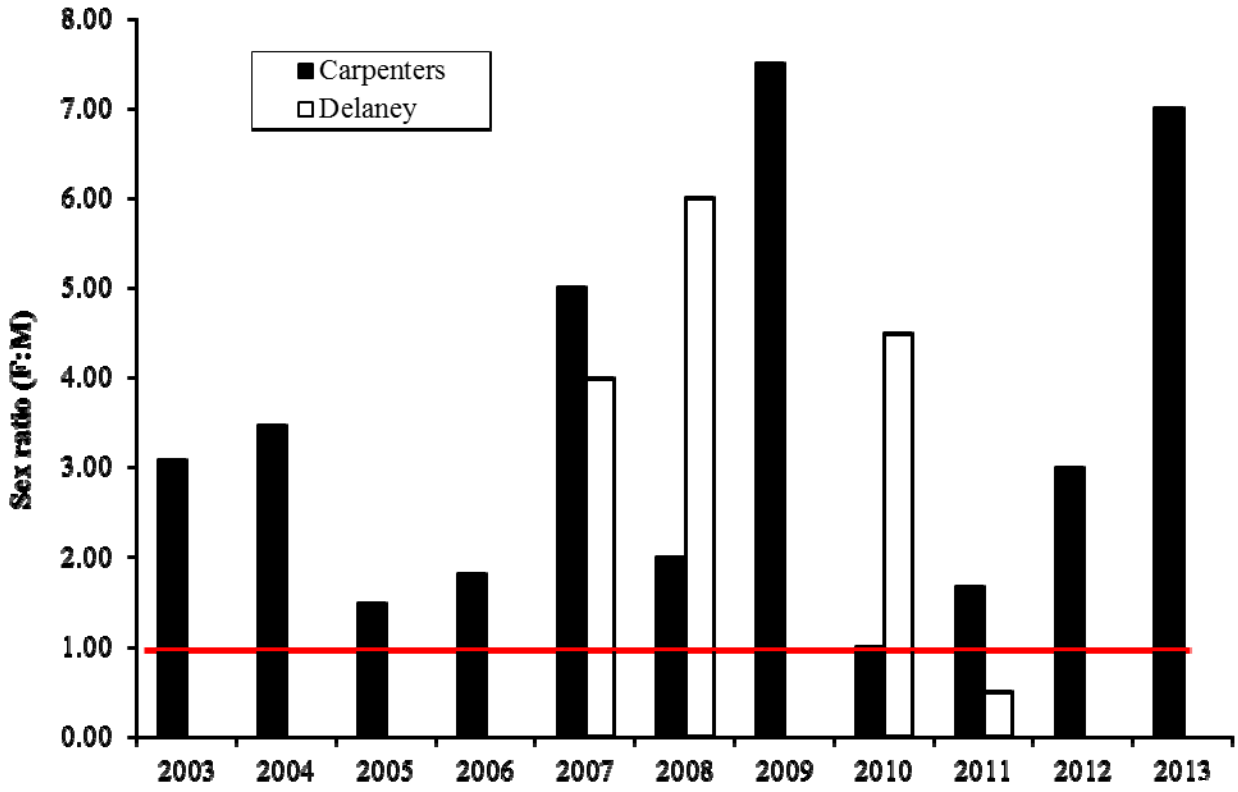

Figure 5. Adult northern pike sex ratios (female to each male) from fish captured in trapnets at Carpenters Branch (2003-2013) and Delaney Marsh (2007-2008, 2010-2011). The red line denotes a 1:1 female to male sex ratio.

Table 1. 2013 upper St. Lawrence River northern pike spawning survey effort and results by site. Two managed marshes were sampled in 2013; Carpenters Branch and Butterfield Marsh.

2013 NP Spawning						
Site	**Gear**	**Start Date**	**End Date**	**Net Nights**	**NP Catch**	**CPUE**
Chippewa Tributary	Hoop	4/1/2013	4/19/2013	18	10	0.56
Cranberry Creek	Oneida	4/1/2013	4/19/2013	18	42	2.33
Cranberry Ext.	Hoop	4/1/2013	4/19/2013	18	3	0.17
French Creek	Hoop	4/1/2013	4/19/2013	18	4	0.22
Little Cranberry	Hoop	4/1/2013	4/19/2013	18	1	0.06
Managed Marsh						
Butterfield Marsh	Hoop	4/5/2013	4/17/2013	12	0	0.00
Carpenters Branch	Hoop	4/1/2013	4/19/2013	18	8	0.44
Total				**120**	**68**	**0.57**

Table 2. Catch of YOY northern pike in emigration traps set at spillways associated with three managed spawning marshes at Carpenters Branch of French Creek, Delaney Marsh on Grindstone Island, and the Butterfield Marsh of Crooked Creek.

2013 NP Emigration					
Location	**Set Date**	**End Date**	**Net Nights**	**NP Catch**	**CPUE**
Butterfield Marsh	6/4/2013	7/2/2013	28	42	1.50
Carpenter's Branch *	6/3/2013	7/2/2013	23	11	0.48
Delaney Marsh *	6/6/2013	7/2/2013	17	63	3.71
Total			**68**	**116**	**1.71**
* Nets pulled due to high flow: Carpenters = - 6 net nights, Delaney = -9 net nights					

Table 3. Seining catch summary for 2013 sampling using a 1/16" fine-mesh 30' bag seine in index sites (top), exploratory sites (middle), and a1/4" large-mesh bag seine targeting esocids. Grey lines represent sites that were stocked with YOY muskellunge in 2013.

2013 30' Index Seining					
Bay	Hauls	Muskie	NP	CPUE Muskie	CPUE NP
Affluence Bay	6	8	0	1.33	0.00
Boscobel	7	1	0	0.14	0.00
Cobb Shoal	12	2	0	0.17	0.00
Deer Island	6	12	0	2.00	0.00
Frinks	10	3	0	0.30	0.00
Garlock	10	1	2	0.10	0.20
Lindley	6	8	0	1.33	0.00
Millens	10	0	0	0.00	0.00
Peos	8	1	0	0.13	0.00
Rose	12	2	0	0.17	0.00
Salisbury	6	0	1	0.00	0.17
Total	**93**	**38**	**3**	**0.409**	**0.032**
2013 60' Index Seining					
Bay	Hauls	Muskie	NP	CPUE Muskie	CPUE NP
Affluence Bay	6	2	0	0.33	0.00
Boscobel	6	1	0	0.17	0.00
Cobb Shoal	12	4	0	0.33	0.00
Deer Island	6	4	4	0.67	0.67
Frinks	10	0	0	0.00	0.00
Garlock	10	1	0	0.10	0.00
Lindley	6	1	0	0.17	0.00
Millens	10	0	0	0.00	0.00
Peos	8	3	0	0.38	0.00
Rose	10	3	0	0.30	0.00
Salisbury	6	0	2	0.00	0.33
Total	**90**	**19**	**6**	**0.211**	**0.067**

Table 3 Continued.

2013 30' Exploratory Seining					
Bay	Hauls	Muskie	NP	CPUE Muskie	CPUE NP
A1	3	4	0	1.33	0.00
A2	3	1	0	0.33	0.00
Blind Bay	5	0	2	0.00	0.40
Bradley Point	2	0	2	0.00	1.00
Buck Bay	3	1	0	0.33	0.00
Cedar Point	2	0	0	0.00	0.00
CYC Bay	2	0	2	0.00	1.00
Delaney	12	1	3	0.08	0.25
Densmore	4	1	2	0.25	0.50
Dodge Bay	1	0	0	0.00	0.00
E. Side Waterson Point Rd	1	0	0	0.00	0.00
Escanaba	1	0	0	0.00	0.00
Flynn E	8	8	0	1.00	0.00
Flynn W	5	4	0	0.80	0.00
Long Point	4	0	1	0.00	0.25
Mead Island	2	2	0	1.00	0.00
Reed Point	2	0	0	0.00	0.00
Sand Bay	2	0	0	0.00	0.00
Sawmill Bay	1	0	0	0.00	0.00
Thurso	3	1	0	0.33	0.00
Wellesley State Park	1	1	0	1.00	0.00
Whitehouse Bay	4	0	0	0.00	0.00
Sucker Point	1	0	0	0.00	0.00
Oak Point West	1	1	0	1.00	0.00
Fergusons Cove	2	0	0	0.00	0.00
Crow's Nest	1	0	0	0.00	0.00
Total	**76**	**25**	**12**	**0.329**	**0.158**

Acoustic Assessment of Pelagic Planktivores, 2013

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Alewife (*Alosa pseudoharengus*) and rainbow smelt (*Osmerus mordax*) are the most abundant pelagic planktivores in Lake Ontario, and the most important prey for salmon and trout. Alewife is also important prey for warm water predators, notably walleye, and for double-crested cormorants. Abundance of alewife and smelt has declined over the past decade, likely due to reduced nutrient loading, proliferation of non-native dreissenid mussels, and predation by stocked salmon and trout. More recently, the presence of invasive round goby (*Neogobius melanostoma*) may also be affecting the pelagic fish community.

Concerns over declining numbers of prey fish were addressed by Canadian and U.S. fish management agencies in 1993, when the number of salmonines stocked was reduced to a level that would reduce prey demand by approximately one-half. Since that time, following public consultation in New York and Ontario, NY stocking levels were moderately increased in 1997, and again in 2001. Furthermore, natural reproduction of Chinook salmon has been documented for many years (Bishop et al. 2007), and approximately 50% of Chinook salmon harvested in the sportfishery in recent years were wild (Connerton et al. 2014). Thus alewife and rainbow smelt populations may be experiencing substantial predatory pressure.

Sound management decisions regarding predator-prey balance require continued monitoring of prey fish populations. Hydroacoustic surveys to estimate lake-wide abundance of pelagic prey fish have been conducted jointly by the Ontario Ministry of Natural Resources (OMNR) and the New York State Department of Environmental Conservation (NYSDEC) starting in 1991. Results from the hydroacoustic surveys complement information obtained in spring bottom trawling surveys conducted jointly by NYSDEC and the U.S. Geological Survey (USGS) in the U.S. waters of the lake.

Methods

Before 2005, surveys followed established transects with only minor yearly modifications due mostly to logistics. This was a practical approach dictated by harbor locations, running time, and limited periods of darkness in the summer. In 2005, we modified the fixed transect design to include a statistically preferable random element. Five fixed cross-lake corridors approximately 15 km wide were established (Figure 1) based on logistical constraints, but within these corridors transects are selected at random. A single east-west offset is randomly chosen, determining the relative position of all transects within their respective corridors, and thus the survey is essentially a systematic survey with a random start. The randomly chosen offset in 2013 was 0, meaning that transects were offset 0 times the width of the corridors from their eastern boundaries. In addition to the 5 cross-lake transects, a U-shaped transect is surveyed each year in the eastern basin (Figure 1); however, no offset is applied to this transect.

In 2003, the Simrad EY500 120 kHz split beam echosounder was upgraded to a Biosonics DTX 120 kHz split beam, as well as new analytical software. Comparisons between the two systems suggested that the new sonar/software combination yielded lower estimates than the previous system (by as much as 30%, but generally less). The potential bias of this magnitude does not substantially alter the interpretation of the population trends, and therefore the results from the two time periods have been reported without corrections (Schaner and LaPan 2006).

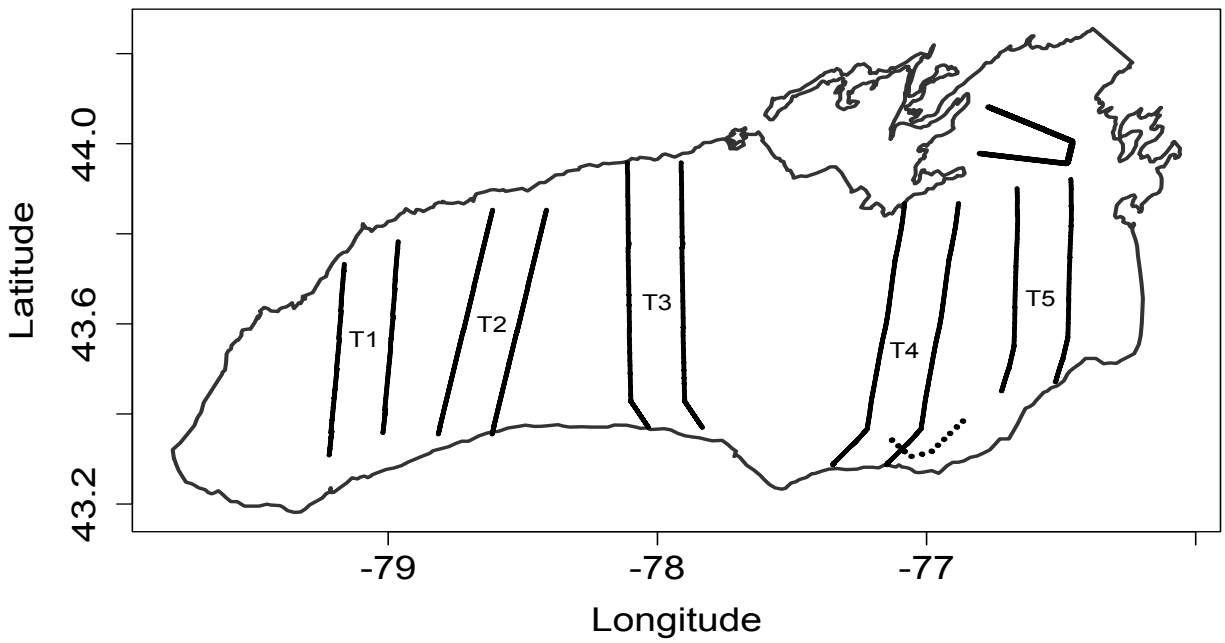


Figure 1. The Lake Ontario Lake-wide prey fish survey uses cross-lake hydroacoustic transects. Transect corridors are logistically constrained but utilize a random starting point within the corridor for each annual survey.

The 2013 survey was conducted from July 14-21 consisting of four, north-to-south, shore-to-shore transects in the main lake, and one U-shaped transect in the Kingston Basin (Figure 1) using two vessels- the OMNR *RV Ontario Explorer* and the NYSDEC *RV Seth Green*. Weather and vessel impairments reduced the available survey time and as a result transects 1 and 2 were compressed into a single, modified transect (see cruise path in Figure 4).

Acoustic data used to estimate population densities were collected using a Biosonics 120 kHz split-beam echosounder set at a rate of 1 ping per second and a pulse width of 0.4 milliseconds. Each night, sampling began approximately one hour after sunset at the 10 m (33 ft) depth contour on one end of the transect, and continued across the lake to the 10 m depth contour on the opposite end or one hour before sunrise. A temperature profile was measured at several points along each transect.

Raw acoustic data were stratified based on thermal layer, bottom depth and geographical zone. The data were processed with Echoview software by Sonardata (version 4.9), using -64 dB volume backscattering strength and target strength thresholds. The resulting scaled, integrated voltage estimates of total target abundance were split into 1 dB target strength (TS) bins according to results of single-target analysis. The abundances of yearling and older fish (YAO) were apportioned from the resulting target strength histograms by fitting normal curves to the three modes of the histogram, and then calculating the proportions of each curve relative to the total target strength frequency distribution. In the upper layer (epilimnion plus metalimnion) the histograms were processed to identify the proportions of targets in the mode at or around -41.4 dB (+/- 3.8 dB), which were assumed to be yearling and older (YAO) alewife. In the lower layer (hypolimnion), we assume all targets greater than -55 dB to be YAO smelt. Floating, vertical gill nets were used to collect fish to ground-truth the acoustic information and to confirm assumptions about fish distribution. Four monofilament nets were set per night on 3 nights: 2-nets with 38mm [1.5 inch] stretch mesh and 2-nets with 19mm [0.75 inch] stretch mesh. Nets of each mesh [one-1.5 inch mesh net and one-0.75 inch mesh net] were set at two depths: offshore sets consisted of 9 panels each, and were set floating adrift above 60 m bottom depth; nearshore sets consisted of 6 panels each, were anchored and floating at the surface in 20 meters of bottom depth. Panels were each 1.6m x 2.9m (5.25 x 9.5 ft) separated by 1.8m (5.9 ft) gaps.

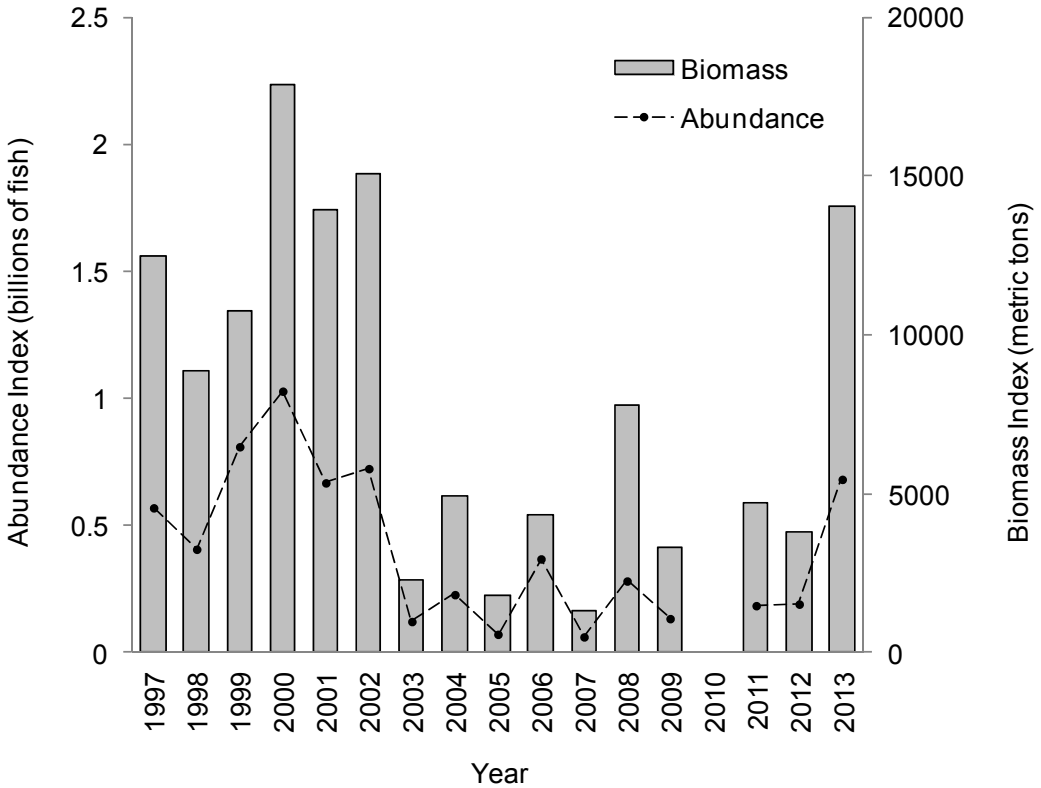


Figure 2. Abundance and biomass of yearling-and-older alewife from 1997-2013. Abundance estimates were obtained directly from hydroacoustic surveys. Biomass estimates were obtained by multiplying average weights of alewife measured during spring bottom trawling surveys for alewife in each year from 1997-2013 (Walsh and Connerton 2014).

Mean alewife and rainbow smelt size were determined from the NYSDEC and US Geological Survey (USGS) spring trawling surveys from 1997-2013. Biomass values for both alewife and smelt were estimated by multiplying acoustic abundance estimates by the average weight of an alewife or smelt calculated from fish collected during spring bottom trawling in each year from 1997-2013. Note that in past reports, average weights of alewife and smelt were obtained using various sources including catches of alewife and smelt from midwater trawls or vertical gillnets conducted during the acoustic surveys, from spring trawling, or from averaging weights obtained from the previous 5-years when sampling was not possible in the survey year due to logistical or time constraints. Using average weights obtained in spring to estimate biomass is probably conservative because fish growth from May-July is not accounted for; however, it is an overall more consistent approach through time and will be used in the future.

Results and Discussion

Alewife

The 2013 YAO alewife abundance index was 681 million yearling-and-older fish, 3.5 times higher than 2012 and 3.7 times higher than the previous ten-year average (Figure 2). The alewife index in 2013 was similar to levels observed from 1997-2002 (mean=701 million fish). Higher alewife abundance is likely due to the strong 2012 year class, as well as moderate to strong year classes in 3 of the last 5 years (Walsh et al. 2014). The increase in the biomass index (14,034 metric tons; 15,470 tons) mostly reflects increased abundance and not an increase in alewife size, as the mean alewife size varied only slightly between 2012 and 2013 (20.0 and 20.6 g or 0.71 and 0.73 oz, respectively).

During the survey period alewife appeared to be distributed largely along the north shore of Lake Ontario (Figure 4a). The spatial distribution and abundance index at a whole lake scale is a unique product provided by the hydroacoustic survey and is

new to this report. Ongoing research is exploring factors that influence alewife distribution seasonally.

Overall, trends generally show an alewife population fluctuating at lower levels since 2003, with a sharp increase in 2013. Results from spring 2013 bottom trawl surveys also indicated an increase in both abundance of adult (age-2 and older) alewife compared to 2012 and a very high yearling abundance index (Walsh and Connerton 2014) which was reflected in the YAO acoustic survey in 2013.

Rainbow smelt

The rainbow smelt abundance index is estimated from all targets greater than -55dB below the thermocline. The 2013 estimate of YAO rainbow smelt was 19 million fish, the lowest estimate in the time series (Figure 3). Rainbow smelt lake-wide biomass was estimated at 110 metric tonnes (121.3 tons) based on a mean rainbow smelt weight of 5.8 grams (0.19 oz). The highest densities of smelt were observed in the eastern portion of the lake (Figure 4b), and with the absence of the usual westernmost transect (T1, Figure 1), it is possible that the lake-wide estimate is biased high. Alewife seemed to be more distributed in the central to western part of the lake (Figure 4a) so the lack of the westernmost transect might have biased this estimate low. Overall rainbow smelt importance continues to decline in Lake Ontario, consistent with bottom trawl surveys (Weidel and Connerton 2014).

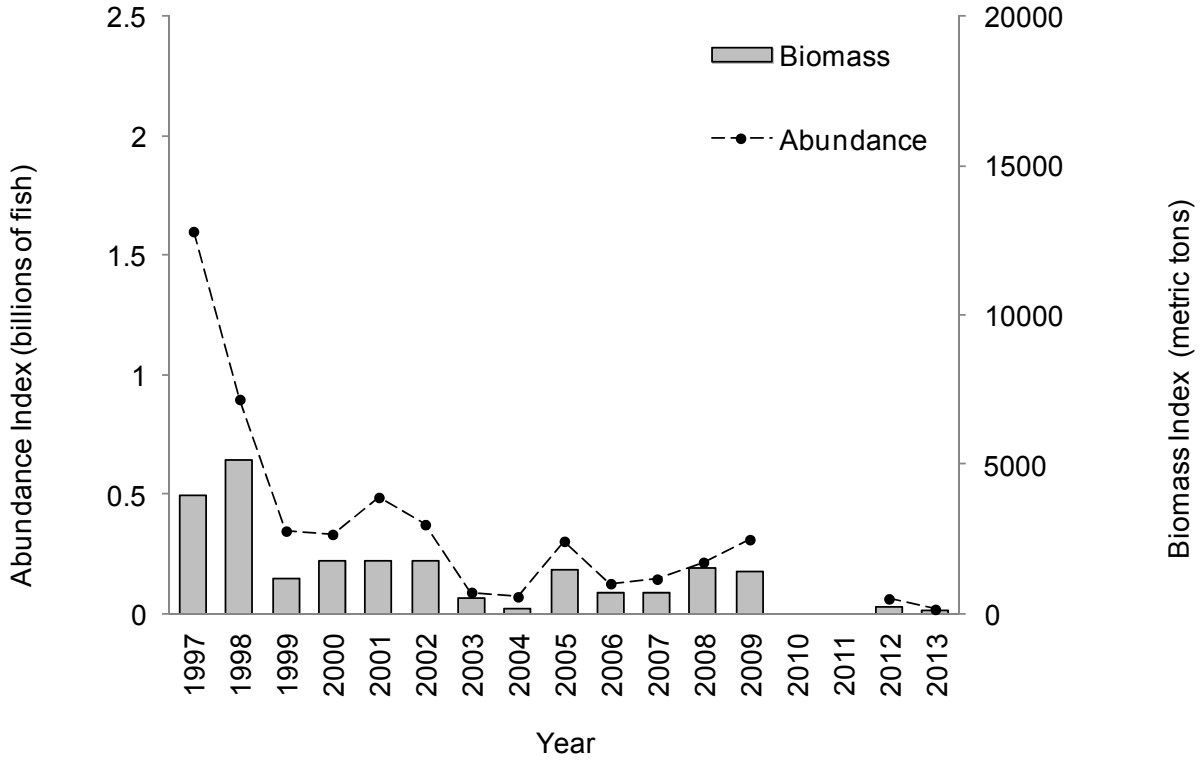
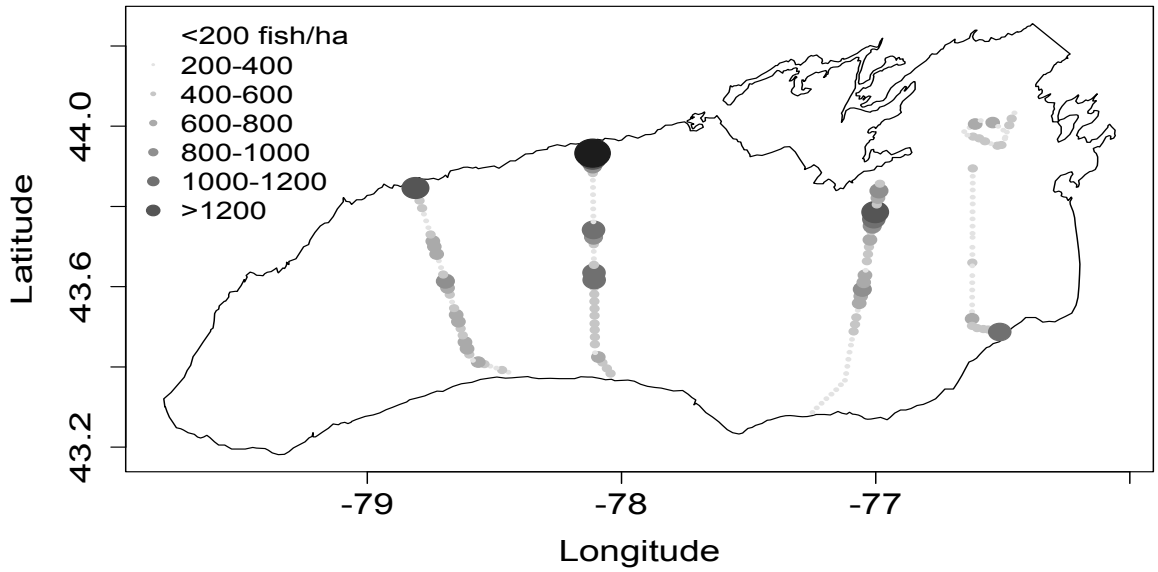


Figure 3. Abundance and biomass of yearling-and-older rainbow smelt from 1997-2013. Abundance estimates were obtained directly from hydroacoustic surveys, biomass estimates were obtained by multiplying average weights of smelt measured during spring bottom trawling surveys for smelt (Weidel and Connerton 2014).

(a)



(b)

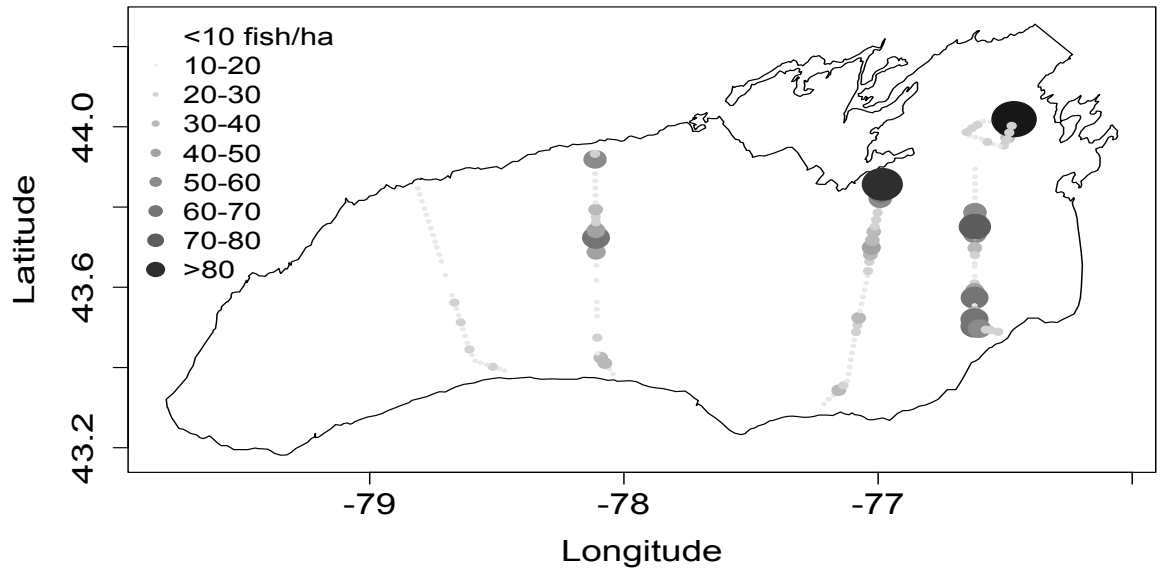


Figure 4. Relative distribution of alewife (a) and rainbow smelt (b) observed during the hydroacoustic survey in July 2013. The standard survey design was modified in 2013 due to logistical constraints which resulted in a single western transect.

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Population Assessment of Lake Sturgeon in the Lower Niagara River

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Prior to European settlement, Lake Sturgeon (*Acipenser fulvescens*) was a dominant species of large rivers and nearshore areas throughout the Great Lakes. Due to a variety of issues including overfishing and degradation of spawning habitat, the species has been greatly reduced compared to historic levels (Carlson 1995). The lower Niagara River is home to one of the remaining populations of Lake Sturgeon in Lake Ontario, where they are officially listed as "threatened" in New York State and the Province of Ontario. Ecologically, high Lake Sturgeon abundance is indicative of a healthy ecosystem. Many of the Great Lakes states and the Provinces of Ontario have or are developing Lake Sturgeon management plans promoting inventory, protection, stocking and habitat restoration for this species.

Assessing Lake Sturgeon population status is labor-intensive and requires comprehensive datasets including information on all life stages. A population assessment of Lake Sturgeon in the lower Niagara River conducted from 1998 to 2003 indicated that the population may be recovering, but due in part to a lack of continued monitoring, their current status is not well known. In order to effectively understand, manage and guide restoration efforts for this population, this study seeks to estimate population parameters including abundance, age structure, growth, reproductive age structure/sex ratios, and movement patterns.

Methods

Collection

Lake Sturgeon were captured in the lower Niagara River between June and September of 2010, and between March and September of 2011, 2012 and 2013. Sampling was performed across presumed foraging, staging, and spawning areas in the lower Niagara River and Niagara Bar in Lake Ontario using 80 m setlines, set on the bottom between 7 and 12 m depth, with baited 12/0 circle hooks following methods of Thomas and Haas (1999) and Hughes et al. (2005). Rainbow Smelt (*Osmerus mordax*), Emerald Shiners (*Notropis atherinoides*), Round Goby (*Neogobius melanostomus*) and Alewife (*Alosa pseudoharengus*) were the primary baits used, although Common Shiners (*Luxilis cornutus*), Golden Shiners (*Notemigonus crysoleucas*), White Suckers (*Catostomus commersoni*), and crayfish (Cambaridae) were used infrequently. Locations of setlines were based on those selected during 1998-2003 and effort was systematically distributed across the lower Niagara River from the Niagara Bar (Lake Ontario) to Lewiston, NY/Queenston, ON.

Measurement, tissue collection, and tagging

Each captured fish was marked with a passive integrated transponder (PIT) tag under the third dorsal scute (12.5 mm, 134.2 kHz, full duplex, Biomark) and an external T-bar tag (2010-2011, 2013) or cinch tag (2011-2013) at the base of the dorsal fin. Upon capture, total length, fork length, weight, girth, and any injuries, lamprey wounds or deformities were recorded for all Lake Sturgeon. Length and girth were measured to the nearest millimeter, and weight to the nearest 0.5 kilograms. A fin ray sample from the caudal fin was taken for genetic analysis and a section of the leading left pectoral fin ray was removed for age estimation. Upon recapture, a section of the right pectoral fin ray was taken for comparison.

In 2012 and 2013, a subset of 30 individuals each year was tagged with internal, trailing-whip, very high frequency (VHF) radio transmitter tags (150 - 152 MHz, 27 g, F1850B, ATS, Isanti, MN). Each fish was placed under anesthesia using a buffered MS-222 solution of 200 mg/L for 5 minutes, and then switched to a maintenance dose of 87 mg/L. Tags and surgical tools were sterilized in a 2% Chlorohexadine bath solution overnight. Metal tools were field-autoclaved. Tags were then rinsed with de-ionized (DI) water prior to insertion. The incision site was carefully dabbed using sterile gauze and 2% Chlorohexadine solution followed by DI water rinse. Transmitters were implanted through a 5 cm incision to the left side of the ventral mid-line between the third and fifth scute anterior to the pelvic girdle. The anterior ends of radio tags were affixed to the inside of the body wall using a single suture to minimize tag migration and risk of expulsion. Incisions were closed with 3-4 sutures of PDS II absorbable monofilament with a CT-0 or CT-1 needle. Fish were held in a nearshore net pen and released on-site after equilibrium was restored (approx. 15-30 minutes).

Age estimation

Cross-sections were cut from the proximal end of pectoral fin ray samples (4-6 sections, 0.1 – 0.3 mm width) using a low-speed saw (TechCut 4, Allied High Tech Products, Inc.) and mounted on microscope slides for processing. Spine sections were photoarchived using a Jenoptik ProgRes CT3 CMOS Digital Microscope Camera mounted on a Zeiss compound microscope under 0.63x magnification. Ages were assigned by Greg Jacobs at the USFWS Northeast Fishery Center, and a subset of 49 age estimates were independently aged by an outside reader experienced in aging Lake Sturgeon (Ed Baker, Michigan DNR, Marquette, MI) to test for systematic bias. Of these 49 fish, 51% of estimated ages were identical, 84% of ages were within 1 year, and 92% of ages were within 2 years. We found no trend in aging error between the two readers' age estimates.

Sex and stage monitoring

In 2012 and 2013 we collected 0.5 cm^3 gonadal biopsies for histological sex and maturation stage determination. To minimize the number of surgeries and to confirm sex and stage of radio-tagged fish, biopsy samples were taken from radio-tagged fish during tag implantation. For biopsies from non-radio-tagged fish, gonad tissue samples were retrieved though a 1.5 cm incision. Anesthesia, incision site, suturing, and recovery methods were identical to those for radio-tag implant surgeries.

In 2012 and 2013, we implemented minimally-invasive methods for sex and maturity determination based on blood plasma concentration of sex steroids, validated using gonadal tissue processed histologically (Allen et al. 2009, Webb et al. 2002, Webb and Doroshov 2011). Six ml blood samples were taken from the caudal vasculature of each fish using a heparinized vacutainer. Lake Sturgeon are believed to begin spawning once water temperatures exceed 11°C, so blood collected below this temperature was assumed to be from pre-spawned individuals. In the field, blood samples were centrifuged at 3,400 rpm for 5 minutes, and blood plasma was separated and stored at -20°C until analysis. The steroids testosterone (T) and 17ß-estradiol (E2) were extracted from plasma following the method of Fitzpatrick et al. (1987) and plasma concentrations of T and E2 were measured by radioimmunoassay as described in Fitzpatrick et al. (1986) as modified by Feist et al. (1990). All samples were analyzed in duplicate. A charcoal solution (6.25 g charcoal and 4.0 g dextran/L PBSG) was used for all assays to reduce non-specific binding. The intra- and inter-assay coefficients of variation for all assays were less than 5 and 10%, respectively. Steroid levels were validated by verifying that serial dilutions were parallel to standard curves.

Gonad biopsies, paired with blood samples, were used to determine population specific relationships between sex steroid concentration and sex and stage of maturity. Gonadal tissue was processed histologically by embedding in paraffin, sectioning at 5 µm, and staining by Periodic Acid Schiff stain (PAS; Luna 1968). Slides were examined under a compound microscope (10-100x, Leica DM2000), and the germ cells were scored for stage of maturation (Table 1) according to the modified protocol of Webb and Erickson (2007).

Radio-telemetry

Lake Sturgeon tagged with radio transmitting tags were released between April 15 and May 7, 2012, and between April 15 and May 28, 2013. Eight ATS

R4500 data logging radio-telemetry receivers with paired 2 m Yagi antennas (fixed stations, hereafter) were deployed along the lower Niagara River from the U.S. Coast Guard station at the mouth of the Niagara River in Youngstown, NY, to just downstream of the Whirlpool in Whirlpool State Park, Niagara Falls, NY (Figure 1). Fixed stations provided 24-hour surveillance for presence of tagged Lake Sturgeon from April 19 to December 13, 2012 (Sites: A, C, F, and H), or from May 9 to December 13, 2012 (Sites: B, D, E, and G). For the purposes of this report, the start day for all receivers is assumed to be May 9, 2012. The fixed stations were also deployed from April 25 to November 19, 2013.

Data Analysis

Length, weight, and age data from 2010-2013 captured fish were compared against data collected from 1998 to 2003 to test for differences in von Bertalanffy growth parameters. Catch per unit effort (CPUE, fish·hour^{-1}·1000hooks^{-1}), catch-at-age, and age structure were compared among sampling periods to investigate population trends. Sampling conducted from 1998 to 2003 used several different collection techniques including setlines, gillnets, and diver captures to provide sturgeon for population analysis. We compared biological data from all fish captured from that sampling period with fish sampled from 2010-2013 except for CPUE. When comparing CPUE, only sturgeon catches from setlines of similar design were used for analysis.

A discriminant function analysis (DFA) was used to develop a set of discriminating functions to predict sex and maturity (Webb et al. 2002). Quadratic DFA was conducted using log-transformed T and E2 concentration to determine the number of observations and percent classified into groups of sex and stage of maturity. The error rate associated with predicting sex and maturity using the DFA was accomplished through cross-validation (see Khattree and Naik 2000).

For preliminary mark-recapture analysis, we constructed an annual capture history for 2010-2012. Capture probability and mortality were estimated using a Cormack-Jolly-Seber (CJS) model framework in program MARK. Selection of the most parsimonious CJS model between parameterizations with time-variant and time-invariant catch probability parameters was conducted using AIC. Due to the short study duration, only parameterizations with time-invariant mortality were investigated. Second, population size was estimated using the POPAN formulation of the Jolly-Seber (JS) model in program MARK, the parameter set for which included time-variant and time-invariant capture probabilities, and 4 parameterizations of mortality: time-variant, time-invariant, fixed at CJS-estimated mortality, and fixed at catch-curve-estimated mortality. This unfinished analysis excludes 2013 data.

Results and Discussion

We captured, PIT-tagged, and released 566 Lake Sturgeon from 2010 to 2013. Of these, 30 were recaptured (Table 2). During 1998-2003, 122 Lake Sturgeon were collected. The CPUE for 2010 was 0.94 fish·hour^{-1}·1000 hooks^{-1}and was similar to the highest value observed (2002: 0.91 fish·hour^{-1}·1000 hooks^{-1}) during the earlier sampling period (Figure 2). The CPUE for 2011, 2012 and 2013 were 1.51, 0.98 and 2.19 fish·hour^{-1}·1000 hooks^{-1}, respectively. Although catch per unit effort has increased, this result may be driven by the presence of a few large cohorts that have only recently become fully recruited to our sampling gear.

Lake Sturgeon sampled with gill nets and set lines from 1998-2003 had a mean total length of 1,019 mm (range 311 to 1,573 mm; n=122) and a mean age of 8 years (range 1 to 28 years; n=122). Lake Sturgeon caught on setlines only during 1998-2003 had a mean total length of 1,028 mm (range 695 to 1,436 mm; n = 361) and a mean age of 7.6 years (range 3 to 22 years; n = 85). The mean total length for Lake Sturgeon from 2010-2013 was 1,339 mm (range 760 to 1,757 mm; n=564) (Figure 3). The mean age of Lake Sturgeon sampled in 2010-2013 was 13.9 years (range 4 to 34 years; n=343). There is a significant relation between age and length using the von Bertalanffy growth equation (r^2=0.68). The growth parameters from the von Bertalanffy growth equation for all (1999-2003, 2010-2012) Lake Sturgeon are L_∞=1470 (SE=19.8690, t=73.9792, p<0.0001) and k=0.1664 (SE=0.0068, t=24.6318, p<0.0001). The parameter t_0 was assumed to be 0. Comparison between von Bertalanffy growth parameters between early 2000s and 2010-2013 catch data show no statistical differences (Figure 4) suggesting that growth of Lake Sturgeon from the

lower Niagara River did not change between sampling periods.

The inclusion of gill nets in 1998-2003 likely resulted in increased catch of smaller, younger Lake Sturgeon, relative to 2010-2013 setline surveys. Thus, we would expect to observe a higher proportion of smaller, younger fish in 1998-2003 versus 2010-2013, even if there was no difference in true population age structure. However, there has been a decline in spring setline CPUE of age-5, 6, and 7 Lake Sturgeon between time periods, which may indicate reduced recruitment of year classes produced after the 1990s, though more research is required to test this.

In addition, only 13 Lake Sturgeon age 20 or older were captured during both periods combined, indicating that this population has a much lower proportion of large spawning adults than other more established Lake Sturgeon populations (Craig et al. 2005; Dieterman et al. 2010; Smith and Baker 2005). This suggests that this population is dominated by relatively few cohorts from the mid- to late-1990s. During the early 2000's sampling, a larger proportion of the catch was made up of 5, 6, and 7 year old fish whereas in the 2010-2013 sampling, the largest proportion of the catch is made up of 12-16 year old fish. The modes of these distributions may correspond to common year classes, as estimated year classes indicated that the majority of the Lake Sturgeon were from the 1992 to 2002 year classes (Figure 5).

Fifty-eight of the 84 gonadal biopsies contained germ cells. There were 20 non-reproductive (Stage 2), 4 early vitellogenic (Stage 3), 5 mid-vitellogenic (Stage 4), and 7 ripe (Stage 5) females. Twenty-one males were spermiating/ripe (Stage 5) and another male was non-reproductive (Stage 1). The small number of non-reproductive males (Stages 1 and 2) in the sampled population is most likely due to a failure to collect germ cells from these individuals; collecting gonads from immature males is the most difficult.

The reproductive structure of this subsampled female population was 56% non-reproductive (2+ years away from spawning), 25% vitellogenic (1 year away from spawning), and 19% spawning. The average age of mature males was 14 years (range: 12-18; n = 11) and of mature females was 19 years (range: 15-30; n = 6). Age at first maturity is 14 and 21 years for males and females, respectively (Bruch 2008).

Due to low sample sizes and the near-absence of the immature male class in our data, DFA results are considered preliminary for the purposes of this report. For the discrimination of lake sturgeon using log-transformed plasma T and E2, cross-validated quadratic discriminant function analysis led to the correct classification of 95% of immature fish (male or female), 100% of early- to mid-vitellogenic females, 83% of mature females, and 95% of mature males (Table 3). Expected paired hormone-histology samples from planned 2014 and 2015 field work, including the successful collection of additional immature males, will strengthen our ability to accurately identify sex and maturity of lower Niagara River Lake Sturgeon using only blood plasma sex steroid concentration.

During 2012, 29 of 30 radio-tagged fish were detected by fixed stations in the lower Niagara River between May 9 and December 13. During 2013, all 30 individuals were detected between April 25 and November 19. Nine individuals tagged in 2012 were also detected in 2013. Tagged fish averaged 1,436 mm total length, 23.5 kg weight, and 15 years of age. We tagged 7 mature and 15 immature females, 18 mature and 1 immature males, and 19 unidentified individuals. Among the 59 detected fish, there were 24,476 detections. Thirty-one fish had fewer than 100 detections each, 18 more had fewer than 1,000 detections and one fish was detected 5,738 times (Table 4). There was considerable among-individual variation in the number of observations, number of days, and number of locations where sturgeon were located.

When temperatures were appropriate for spawning, receiver stations G and H recorded the presence of many mature fish in the gorge. Some of these mature fish were not subsequently recorded at any receiver for the remainder of the deployment period, suggesting that these fish were migratory spawners. In contrast, some immature fish were only detected lower in the river at sites A, B, and C more consistently throughout the year, which implies that these fish were not migrants and that their occupancy in the river was based on something other

than spawning. However, individual heterogeneity in movement behavior among our tagged fish was quite high; some mature fish were never observed near suspected spawning sites, for example, whereas some immature fish seemed to have a preference for it. Mixed effects modeling of movement dynamics will be required to explicitly partition individual heterogeneity from population level trends in movement and habitat use, and will incorporate additional radio-telemetry tagging and monitoring in 2013.

For mark-recapture analysis unfinished 2013 data were excluded. The best CJS model was a time-invariant model where estimated apparent survival was 96.3%, and estimated capture probability was 4.2%. As a caveat, deviance/degrees of freedom for this model were less than 1, indicating underdispersion. Jolly-Seber models with within-model-estimated survival probabilities had a lower AICc value than fixed-survival-parameter models, as CJS-model-estimated mortality differed markedly from JS model estimates; the best JS model estimated 56.8% annual survival, 7.4% capture probability, and an estimated super-population size of 2,856 (Table 5). Though there is some uncertainty associated with survival and abundance estimates, these preliminary results can provide useful baseline information that may inform future research, and may be used to build hypothetical population models of Lake Sturgeon in the lower Niagara River.

Increases in catch rates of sub-adult fish in 2010-2013 from 1998-2003 levels may indicate a positive trend in the abundance of mature Lake Sturgeon in the lower Niagara River. However, additional research is necessary to improve upon preliminary survival, abundance, and movement analysis, and to investigate recruitment. Although some concerns still exist, such as the possibility of reduced recruitment over the last ten years and continued low catch rates of old mature adult sturgeon, strong cohorts from the late 1990's are reaching sexual maturity and may eventually contribute additional large pulses of recruitment.

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Table 1. Stages of gonadal development in lake sturgeon from Webb and Erickson (2007).

	Developmental Stage	Description
Females		
Differentiation	1	Clusters of oogonia
Previtellogenic	2	Endogenous growth of oocyte, small translucent oocytes
Early vitellogenic	3	Enlarged oocytes with thin vitelline envelope surrounded by granulosa cell layer and yolk globules, cream to grey colored
Mid-vitellogenic	4	Fully differentiated follicular layer and yolk platelets, pigmented ovarian follicles
Post-vitellogenic	5	Fully grown ovarian follicles with differentiated chorion and germinal vesicle displaced to animal pole, fully pigmented ovarian follicles
Oocyte maturation	6	Ovulated oocytes that have undergone germinal vesicle breakdown
Post-ovulatory	7	Ovaries contain numerous postovulatory follicles and the next generation of oocytes similar to Stage 2
Atretic	8	Atreticvitellogenic follicles containing residual yolk, atretic mature follicles containing residual yolk and dark pigment, presence of atretic bodies
Males		
Differentiation	1	Clusters of primary spermatogonia
Pre-Meiotic	2	Spermatogonia undergoing mitosis
Onset of Meiosis	3	Spermatogonia (~50%) and spermatocytes
Meiotic	4	Majority of cysts contain spermatocytes and spermatids, less than 25% of cysts contain spermatogonia
Spermiation	5	Cysts and ducts contain spermatozoa
Post-spermiation	6	Residual spermatozoa in testicular lobules

Table 2. Capture and recapture numbers of Lake Sturgeon in the Niagara river.

Capture Year	Number Captured	Number Recaptured			
		Original Capture Year			
		2010	2011	2012	2013
2010	28				
2011	193	1	1		
2012	139	1	9	6	
2013	206	2	7		3

Table 3. Classification summary for determination of sex and stage of maturity in 4 classes of Lake Sturgeon captured in the Niagara River in 2012 and 2013 using log-transformed plasma testosterone and estradiol concentrations. Values in bold are percentage of fish correctly classified, while values not in bold are percentage of fish misclassified (see Table 1 for the description of developmental stages).

True Sex	Classified Using Predictors				
	Stage 2 Combined	Stage 3+4 Female	Stages 5 Female	Stage 5 Male	Total
Stage 2 Combined	**95** (n=20)	5 (n=1)	0 (n=0)	0 (n=0)	100 (n=21)
Stage 3+4 Female	0 (n=0)	**100 (n=9)**	0 (n=0)	0 (n=0)	100 (n=9)
Stages 5 Female	0 (n=0)	17 (n=1)	**83** (n=5)	0 (n=0)	100 (n=6)
Stage 5 Male	0 (n=0)	0 (n=0)	5 (n=1)	**95** (n=19)	100 (n=20)

Table 4. Summary statistics for lower Niagara River lake sturgeon fixed station telemetry during from May 9 to December 13, 2012 and from April 25 to November 25, 2013. Median river kilometer observed was calculated for each fish individually, and by-group summary statistics are listed below.

	Mean	n	SD	Range
Age	15.4	36	3.3	12 – 30
TL (mm)	1434.2	60	107.1	1280 – 1757
Wt (kg)	23.3	59	8.0	14 – 61
Girth (mm)	635.6	60	82.1	506 – 786
Julian Day Tagged	116	60	–	106 – 149
Observations	422	58	–	2 – 5738
Days Observed	22.6	58	–	1 – 122

Median River Kilometer Observed

	Mean River Kilometer	n	SD
Mature Males	8.8	18	4.8
Immature Males	4.8	1	–
Mature Females	11	7	3.5
Immature Females	6.4	15	3.9
Unknown	6.6	18	4.3

Table 5. Best Jolly-Seber model (POPAN formulation) of the lower Niagara River lake sturgeon population from 2010 to 2012. Model parameters include φ (survival), p (capture probability), b_1 (probability of entry from super-population between time period 1 and 2), and N (super-population size).

Parameter	Estimate	SE	95% Confidence Interval
φ	0.568	0.065	0.439 - 0.688
p	0.074	0.023	0.040 - 0.134
b_1	0.871	0.025	0.813 - 0.913
N	2,825.8	846.2	1,636.9 - 5,093.4

The b_2 parameter is confounded in this model formulation.

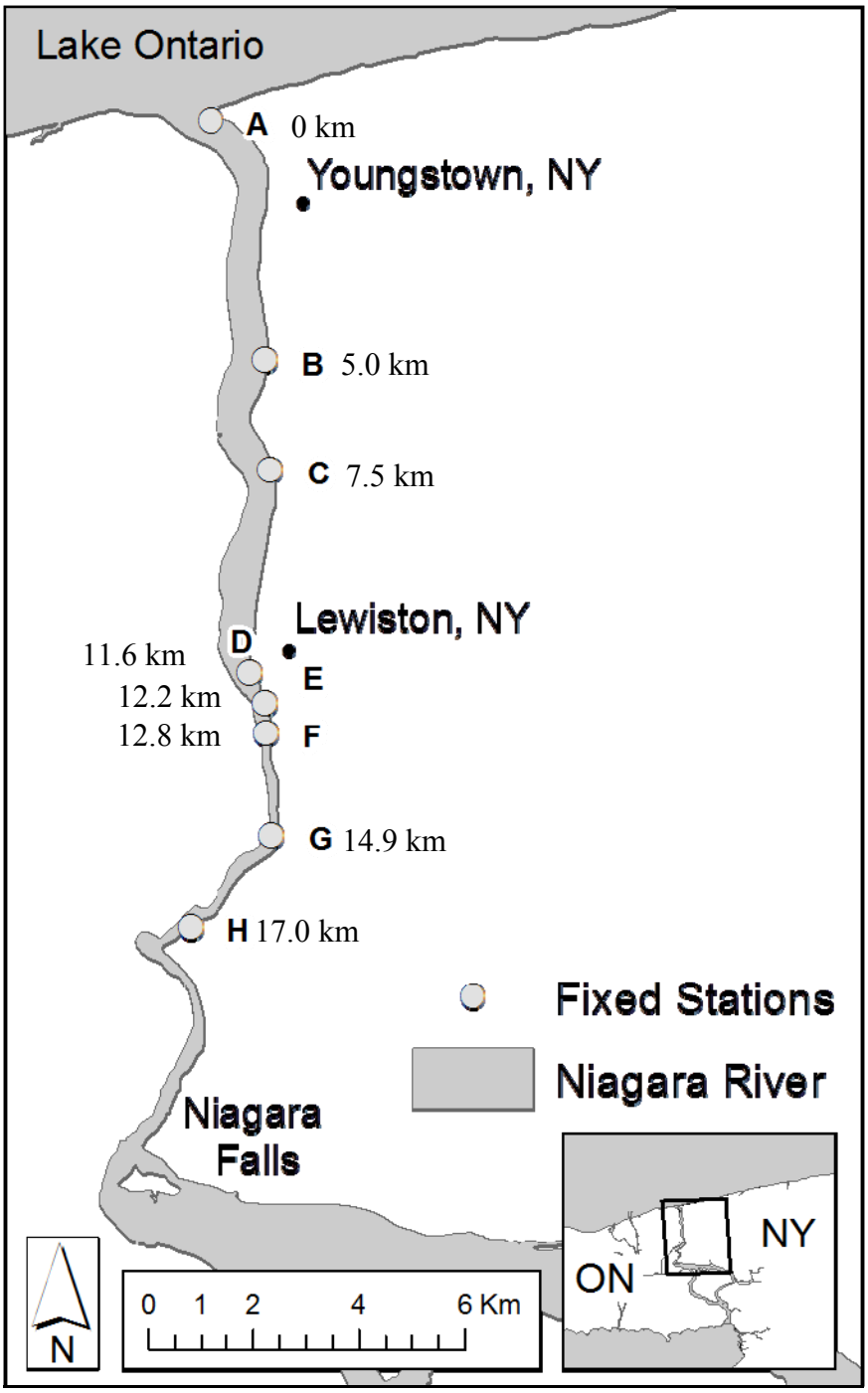

Figure 1. Locations of 8 fixed radio-telemetry receivers along the lower Niagara River, with their distance from the river mouth.

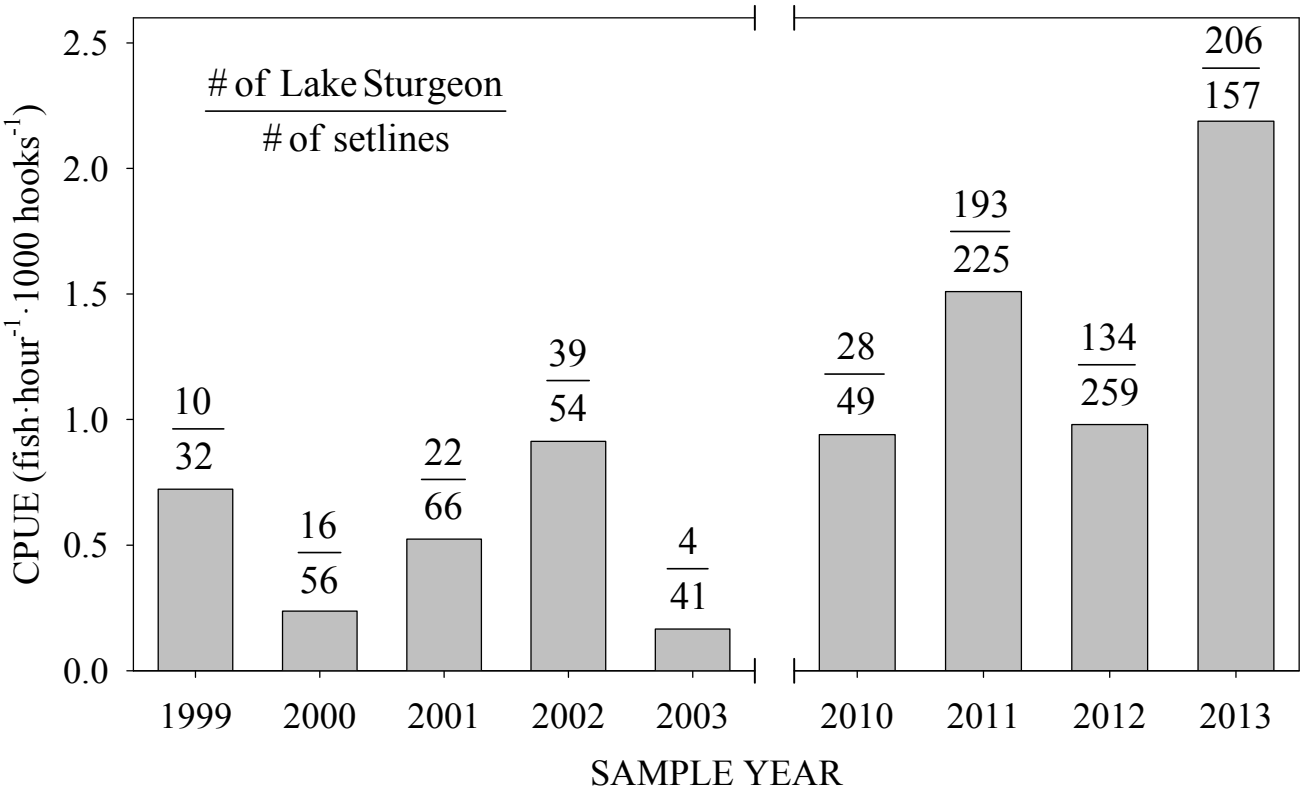

Figure 2. Catch per unit effort (fish•hour^{-1}•1000 hooks^{-1}) for each sampling year restricted to setline catch data only.

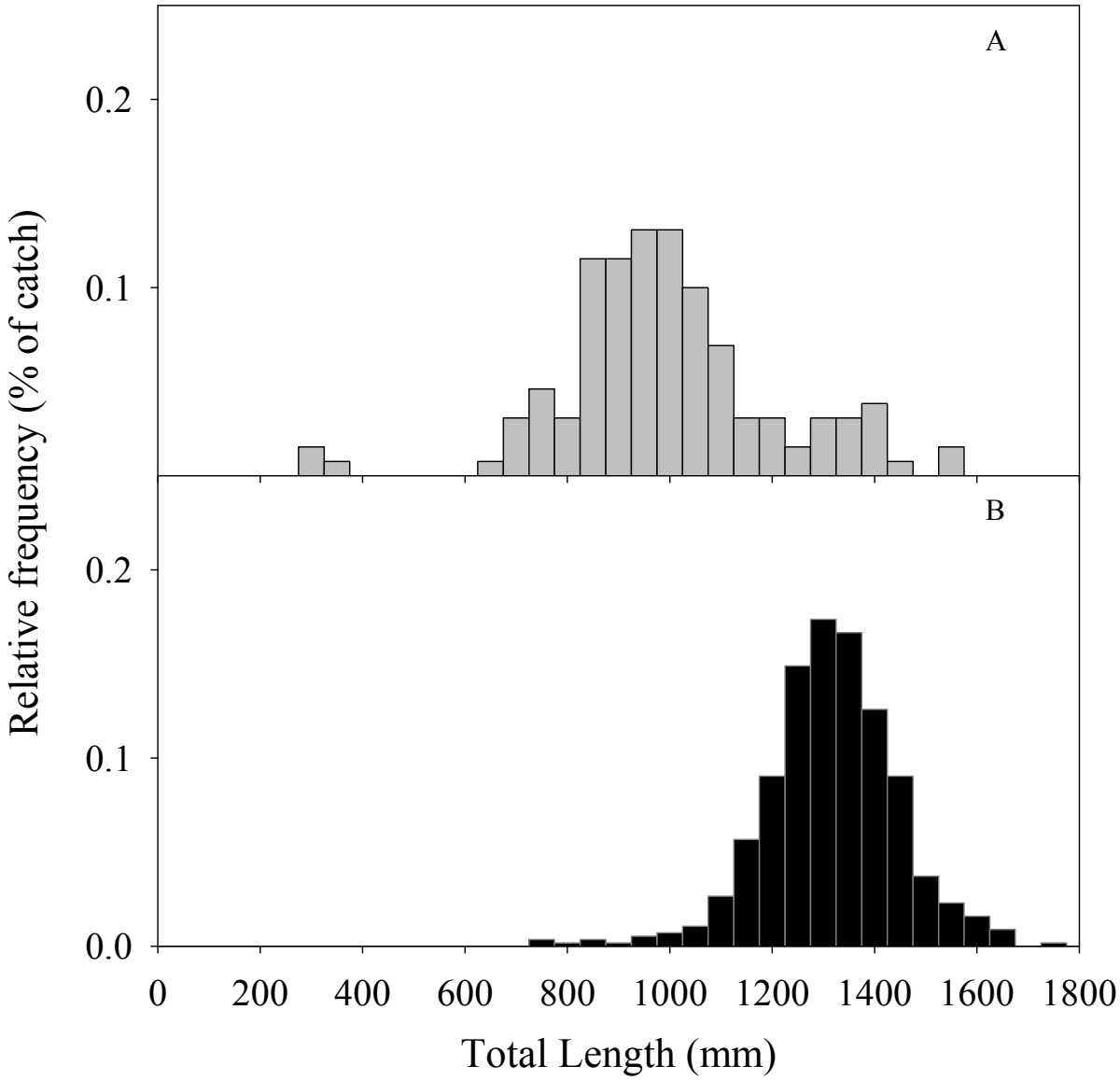

Figure 3. Total length distributions of Lake Sturgeon captured from (A) 1998-2003 (gillnets and set lines; n=122) and (B) 2010-2013 (set lines only; n=564).

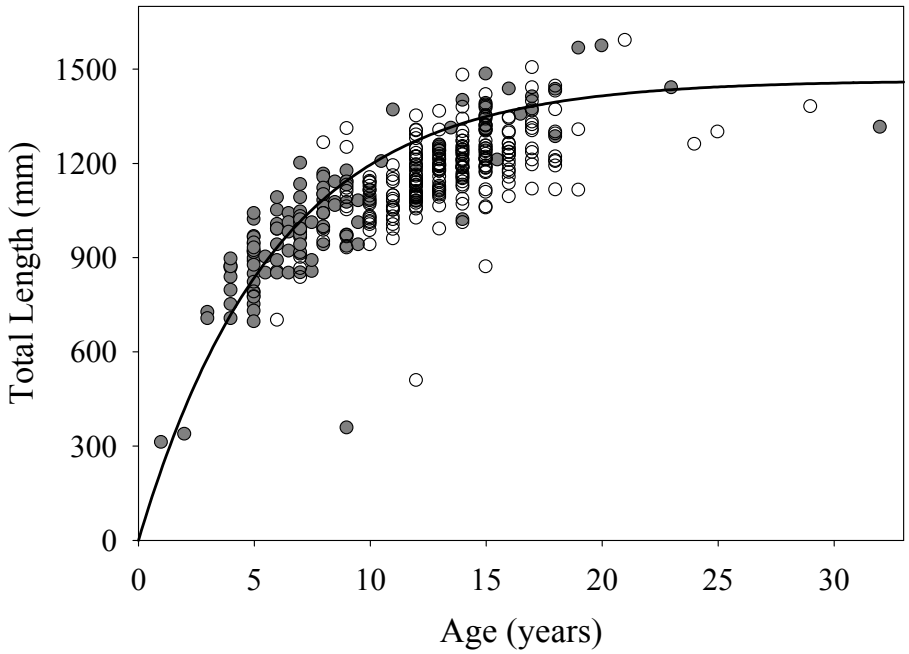

Figure 4. Length-at-age data for Lake Sturgeon captured during 1999-2003 (closed circles) and 2010-2013 (open circles) sampling periods. There was no significant difference in length-at-age between time periods. Model parameters are reported in the text.

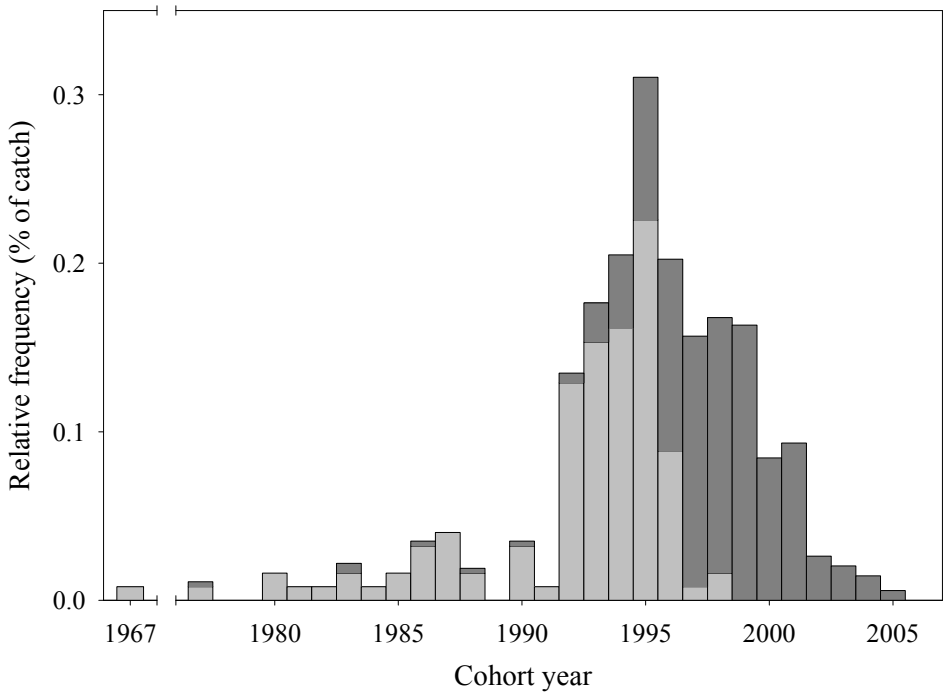

Figure 5. Frequency distribution of the cohort year of Lake Sturgeon caught during both the 1999-2003 (light bars) and 2010-2013(dark bars) sampling periods based on the year of recruitment estimated from fin-ray aging.