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Division of Fish, Wildlife and Marine Resources

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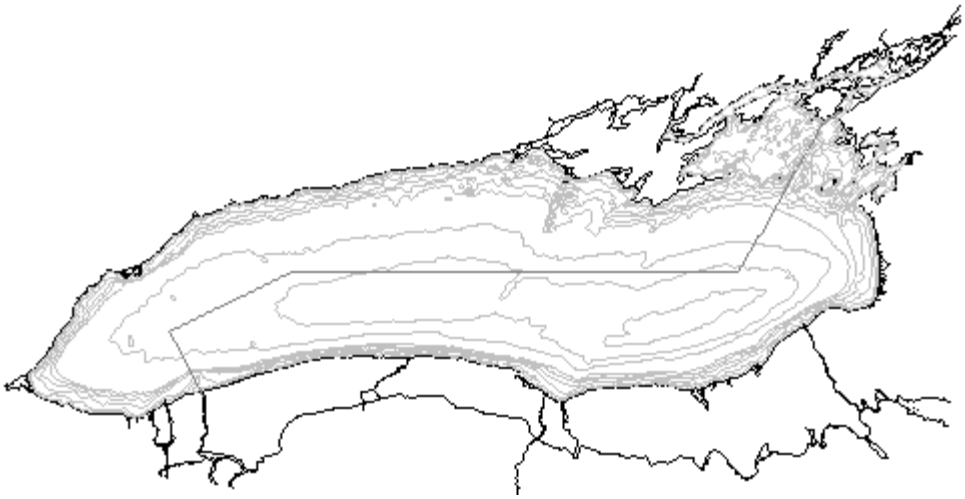
Bureau of Fisheries

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



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

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New York State Department of Environmental Conservation
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SECTION	TITLE & AUTHORS	COOPERATING AGENCIES
1	**New York Lake Ontario and Upper St. Lawrence River Stocking Program 2016** *(Connerton)*	NYSDEC
2	**2015 Lake Ontario Fishing Boat Survey** *(Lantry J., Eckert)*	NYSDEC
3	**Update on Mass Marking of Chinook Salmon in Lake Ontario 2015** *(Connerton, Balk, Prindle, Lantry J., Bowlby, Yuille, Bronte, Holey)*	NYSDEC OMNR USFWS
4	**Eastern Basin of Lake Ontario Warmwater Fisheries Assessment, 1976-2015** *(Lantry J.)*	NYSDEC
5	**Lake Trout Rehabilitation in Lake Ontario, 2015** *(Lantry B., Lantry J.)*	USGS NYDECs
6	**Thousand Islands Warmwater Fish Stock Assessment** *(McCullough, Gordon)*	NYSDEC
7	**2015 Lake St. Lawrence Warmwater Fisheries Assessment** *(Klindt, Gordon)*	NYSDEC
8	**2015 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 2015** *(Prindle, Bishop)*	NYSDEC
10	**2015 New York Cooperative Trout and Salmon Pen-Rearing Projects** *(Sanderson, Prindle, Todd)*	NYSDEC
11	**Sea Lamprey Control in Lake Ontario in 2015** *(Sullivan, Adair)*	DFO USFWS
12	**12a: Status of Alewife and Rainbow Smelt in the U.S. waters of Lake Ontario, 2015** *(Walsh, Weidel, Connerton, Holden)* **12b: Lake Ontario Benthic Preyfish Assessment, 2015** *(Weidel, Walsh, Connerton, Holden)*	USGS NYSDEC
13	**Cormorant Management Activities in Lake Ontario's Eastern Basin** *(McCullough, Mazzocchi)*	NYSDEC
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15	**Acoustic Assessment of Pelagic Planktivores, 2015** *(Connerton, Holden)*	USGS OMNR
16	**2015 Status of the Lake Ontario Lower Trophic Levels** (*Holeck, Rudstam, Hotaling, McCullough, Lemon, Pearsall, Lantry, J., Connerton, LaPan, Biesinger, Lantry, B., Walsh, Weidel)*	Cornell Univ. NYSDEC USFWS USGS
17	**Nearshore Fish Community Sampling in the St. Lawrence River: Summary 2002-2015** (*Klindt, Gordon)*	NYSDEC
18	**Lake Sturgeon Tagging Study and Egg Take 2015** (*Klindt, Gordon)*	NYSDEC
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20	**Lake Ontario Commercial Fishery Summary, 2000-2015** (*LaPan)*	NYSDEC
21	**Lower Niagara River Wamwater Fisheries Assessment** *(Legard)*	NYSDEC
22	**Northern Pike Research, Monitoring and Management in the Thousand Islands Section of the St. Lawrence River** *(Farrell, Augustyn)*	SUNY ESF

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. 2013). 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 the 1990s, the Lake Ontario ecosystem experienced dramatic 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 upper thermal layer declined drastically over the last 30 years (as much as 99% by the early 2000s), attributable to reduced lake productivity and invasive predatory zooplankton (i.e., *Bythotrephes* and *Cercopagis*, discovered in 1985 and 1998, respectively). Since 2005, offshore zooplankton biomass improved but remains well below historic levels. The abundance and distribution of the native deepwater amphipod, *Diporeia* 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 spread throughout Lake Ontario and the St. Lawrence River rapidly. Goby abundance and biomass grew exponentially, then stabilized at lower levels. Round gobies have dominated the diets of Double-crested cormorants from colonies in eastern Lake Ontario and the St. Lawrence River for nearly a decade. 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. The invasive "bloody red shrimp" is a small freshwater shrimp 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.

In the fall of 2014, Salmon River anglers reported numerous occurrences of steelhead swimming

abnormally (e.g., laying on their sides or backs, only to swim strongly away when touched), and a number of dead steelhead were also reported. Subsequent laboratory analyses determined that these steelhead were suffering from low thiamine (vitamin B) levels. Low thiamine levels in Great Lakes fish predators, such as trout and salmon, have been linked to diets dominated by alewife. Alewife are known to produce the enzyme thiaminase, which destroys thiamine, although factors that influence thiaminase production remain unknown. New York State Department of Environmental Conservation (DEC) Salmon River Hatchery staff have historically observed mortality of newly hatched trout and salmon fry due to thiamine deficiency, and began treating salmon eggs with thiamine in the 1990s. This is the first known instance of thiamine deficiency causing mortality in adult Lake Ontario trout and salmon (salmonids), and the DEC is continuing its investigations with the assistance of experts from academia and other agencies. There were no documented instances of thiamine related steelhead mortality in 2015.

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. Although a very strong year class of alewife was produced in 2012, it did not contribute to the adult alewife population at age 2 in 2014 as anticipated. Two consecutive severe winters (2013/2014 and 2014/2015) followed by below average summer water temperatures resulted in very small 2013 and 2014 (record low) alewife year classes, which will result in a markedly reduced adult alewife population in 2016. These changes and potential outcomes are at the forefront of fisheries managers' concerns. This report summarizes cooperative research and monitoring activities conducted on Lake Ontario and the St. Lawrence River by the DEC, U.S. Geological Survey, Ontario Ministry of Natural Resources and Forestry, U.S. Fish and Wildlife Service, Fisheries and Oceans Canada, SUNY College of Environmental Science and Forestry and Cornell University in 2015.

Lower Trophic Level Monitoring

- From 1995-2015, 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 declined in the longer data series (since 1981), but not since the inception of the biomonitoring program in 1995 indicating stable nutrient loading into Lake Ontario for nearly two decades. Phosphorus levels averaged 7.0 parts per billion (ppb) in the nearshore and 4.8 ppb in the offshore in 2015, below the 10 ppb target set by the Great Lakes Water Quality Agreement of 1978 for offshore waters of Lake Ontario.
- Chlorophyll-*a* and Secchi depth values (a measure of water clarity) are indicative of oligotrophic conditions in Lake Ontario's nearshore and offshore habitats. Offshore summer chlorophyll-*a* declined significantly in both the short- (2000-2015) and long-term (1981-2015) time series. Nearshore chlorophyll-*a* increased 1995 - 2004 but then declined 2005 - 2015. Epilimnetic (upper water column) chlorophyll-*a* averaged between 0.9 and 1.9 ppb across sites, and offshore concentrations (1.4 ppb) were significantly higher than nearshore (1.1 ppb). Seasonal Secchi depth ranged from 16.4 ft to 42.7 ft at individual sites and, on average, was greater in offshore sites (31.2 ft) when compared to nearshore (20.3 ft) in 2015.
- Summer nearshore zooplankton density and biomass declined significantly 1995 – 2004 and then increased significantly 2005 – 2015. The decline was due to reductions in bosminids and cyclopoids and the increase was due mostly to a rebound in bosminids. Summer offshore zooplankton density and biomass increased significantly 2005 – 2015. The increase was due to an increase in bosminids and cyclopoids. In 2015, offshore summer epilimnetic zooplankton biomass was 52 mg/m^3 (2005 – 2014 mean=18 mg/m^3).

- Zooplankton density and biomass peaked in September, an atypical pattern. This coincided with peaks in calanoid copepod, daphnid, and *Holopedium* biomass. *Holopedium* biomass in the nearshore has increased significantly since 1995. The predatory cladoceran *Cercopagis* continued to be abundant in the summer, peaking at about 10 mg/m^3 in the offshore. *Bythotrephes* biomass was at its lowest level since 2005 in both offshore and nearshore habitats. Combined biomass of these predatory cladocerans in the offshore was the lowest recorded since 2001.
- In 2015, Apr/May – October epilimnetic zooplankton density, size, and biomass were not different between the offshore and the nearshore, but cyclopoid biomass was higher in the offshore (8.3 mg/m^3 vs 2.0 mg/m^3) and *Bythotrephes* biomass was higher in the nearshore (0.17 mg/m^3 vs 0.04 mg/m^3).
- Whole water column samples show a stable zooplankton biomass but changing community composition since 2010. Most zooplankton biomass was found in the metalimnion in July and in the hypolimnion in September. Cyclopoids and *Limnocalanus* dominated the metalimnion and *Limnocalanus* dominated the hypolimnion. Cyclopoids increased 2013 – 2015 and daphnids declined 2014 – 2015. Nighttime tows taken in mid-July showed a more even distribution of zooplankton above and below the thermocline.

Prey Fish Assessments

- Each year Lake Ontario preyfish populations (primarily alewife, smelt, and sculpins) are assessed with bottom trawls (Section 12a and 12b) and hydroacoustics (sonar; Section 15).
- In spring 2015 bottom trawl surveys, abundance of adult (age-2 and older) alewife increased slightly from 2014 levels, and adult abundance has been fairly stable for five consecutive years. For a second consecutive year, abundance of yearling (age-1) alewife was very low and the lowest observed in the 39-year time series. Severe winter conditions (winters of 2013/2014 and 2014/2015) and below average summer temperatures (2014 and 2015) likely adversely affected reproduction and survival of young alewife in 2014-2015.
- In recent years, the relative body condition or "plumpness" of alewife was high during both spring and fall. Alewife body condition increased from 2014 and was similar to the relatively high values observed during 2003-2013 (Section 12a).
- In 2015, the abundance index for age-1 and older rainbow smelt increased relative to 2014 and was 60% of the previous 10-year average (Section 12a).
- A significant Lake Ontario milestone occurred in May 2015 when a juvenile Bloater was captured during the spring bottom trawl survey at 95m (312 ft) near Oswego, NY. Bloater, a native deep-water prey fish, have not been captured in Lake Ontario survey since 1983. Stocking of bloater began in November 2012 (Section 1) as part of an international, collaborative coregonid restoration effort.
- In 2015, the benthic prey fish bottom trawl survey was expanded to include north shore waters in Ontario. Effort increased from 55 bottom trawl sites to 135 trawl sites at depths from 8 – 225 m (26 – 738 ft). Expanded sampling revealed significantly higher densities of deepwater sculpin than previously detected. Although round goby and slimy sculpin density estimates did not appreciably change with expanded sampling, confidence in lakewide estimates greatly improved as did the representation of nearshore benthic fish community diversity (Section 12b).
- Benthic prey fish surveys showed slimy sculpin abundance in 2015 was similar to 2014 and both values are among the lowest observed across the lake's 38-year time series, but deepwater sculpin increased substantially. Round goby abundance increased but was within the range of recent values (Section 12b).
- The 2015 hydroacoustic survey of Lake Ontario preyfish populations consisted of the typical five cross-lake transects and an Eastern Basin transect. Estimated yearling and older alewife abundance declined by 45% in 2015. Ongoing research comparing hydroacoustic data collected

with a hull-mounted transducer pointing downward (traditional approach; "downlooking") and a transducer at depth pointing upward (new approach; "uplooking") revealed substantial numbers of alewife at or near the surface on some nights. These fish were not previously detectable with "downlooking" hydroacoustics. In addition, three techniques for analyzing hydroacoustic data are under review. All three methods indicate a similar decline in alewife abundance in 2015. The rainbow smelt abundance estimate increased 87% relative to the record low observed in 2014 (Section 15).

Coldwater Fisheries Management

- Fish stocking in the New York waters of Lake Ontario in 2015 included 1.76 million Chinook salmon, 230,760 coho salmon, 607,280 rainbow trout, 975,425 lake trout (520,860 yearling; and 454,565 experimental fall fingerlings), 449,160 brown trout, 152,502 Atlantic salmon, 61,617 bloater, and 100,311 cisco or lake herring. Of these, 76,020 brown trout and 115,460 lake trout were stocked offshore by military landing craft in an ongoing effort to reduce predation on newly stocked fish by double-crested cormorants and predatory fish (Section 1).
- Average weights and condition (a measure of "stoutness") of salmonids at a given age serve as a potential index of relative balance between the number of predators (primarily salmonids) and preyfish; however, water temperatures also influence fish growth and condition. Average weights and condition are calculated for salmonids examined from the open lake fishery (Section 2) and as spawning adults at the Salmon River Hatchery (Section 9).
- Chinook salmon growth was good to excellent in recent years, however, was below average in 2014 and 2015. The August 2015 mean length (35.9 in) of age-3 Chinook salmon from the open lake boat fishery was 0.9 in shorter than the long term average. Chinook salmon condition or relative "stoutness" in 2015 was within the range of values observed for previous years for all lengths evaluated and was above average for the three longest lengths evaluated. These results indicate that the recent long, cold winters (2013-2014 and 2014-2015) followed by below average summer temperatures may have negatively impacted growth in length, however, the good condition of Chinook salmon >28 inches indicated that alewife (the primary forage of Chinook salmon) abundance was sufficient to maintain Chinook condition (Section 2).
- At the Salmon River Hatchery, average weight of age-1 Chinook males (jacks) sampled in 2015 was 3.8 pounds, the second lowest value recorded. Age-2 males (12.3 lbs) were 1.1 pounds below average and age-2 females (12.8 lbs) were 1.9 pounds below average. Age-3 males (15.0 lbs) were nearly 4.0 pounds below average weight and age-3 females (16.7 lbs) were 3.1 pounds below the long-term average (Section 9).
- Chinook salmon condition (based on the predicted weight of a 36 inch long Chinook salmon) in fall 2015 was slightly above the historical average and nearly identical to the previous three years (Section 9).
- Steelhead are sampled in the spring and, unlike Chinook and coho salmon, do not reflect growth during the 2015 growing season. Weights reported here reflect conditions prior to and including 2014. The mean weights of age-3 males and females were 5.3 and 6.8 lbs, respectively, which were both approximately 0.25 pounds more than their respective long-term averages. The mean weights of age-4 males and females were 7.0 lbs and 8.8 lbs, respectively, with males 0.1 lbs and females 0.3 lbs lighter than their long-term averages (Section 9).
- 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. In 2015, the mean peak catch of 608 young of the year Chinook per haul was over double the 2001-2014 average of 283, and was the second highest mean peak catch observed (Section 8).

- The eighteenth year of pen-rearing steelhead and Chinook salmon along the New York shoreline of Lake Ontario was successful due to low fish mortality and a substantial percentage of the Chinook salmon reaching target weights. A total of 39,600 Washington strain steelhead were raised at seven pen sites, comprising 11.2% of DEC's Lake Ontario yearling steelhead stocking allotment in 2015. Seven pen-rearing sites raised a total of 450,580 Chinook salmon, representing 25.6% of DEC's 2015 Chinook salmon stocking allotment (Sections 1 and 10).
- In 2008, the DEC purchased an automated fish marking trailer (AutoFish) capable of adipose clipping and/or applying coded wire tags (CWTs) to salmon and trout automatically at a high rate of speed and accuracy. From 2008-2011, DEC and the Ontario Ministry of Natural Resources and Forestry "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. To evaluate the relative performance of pen-reared and traditional, shore-stocked Chinook salmon, DEC marked sub-samples of Chinooks stocked at pen-rearing sites with CWTs in 2010, 2011, and 2013 (Section 3).
- For the four year classes studied to determine the relative contribution of wild Chinook to the fishery (2008-2011 year classes), percentages of wild Chinook salmon in Lake Ontario varied by year class, age, and among regions from 2009-2015, but overall wild Chinook were an important component of the Lake Ontario fishery averaging 47% of the age 2-and age-3 lake harvest. The percentages of wild Chinook salmon in New York tributaries also varied among regions from 2009-2015 with percentages of age 2-3 wild salmon averaging 7.5% in western region tributaries, 18% in eastern region tributaries, and 58% in the Salmon River.
- Returns of Chinook salmon to the Salmon River Fish Hatchery from 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 12.4%, 8.4%, and 10.9%, respectively.
- Preliminary results from the 2010 and 2011 year classes indicate that pen stocking at eight sites provided an average of 1.9 and 2.4 greater contribution, respectively, to the lake fishery per number stocked than direct stocking. The 2013 year class remains under study, and final results will be reported in spring 2017.
- Chinook salmon stocked at the Salmon River in 2010 provided about 2.1 greater contribution to the lake fishery per number stocked than their direct stocked counterparts.
- Results showed that the majority of fish returning to tributary stocking sites were stocked at those sites indicating good imprinting of both pen and direct stocked Chinook salmon.

Lake Trout Restoration

- Restoration of a naturally reproducing population of lake trout is the focus of a major international effort in Lake Ontario. Each year several surveys measure progress toward lake trout rehabilitation (Section 5).
- Adult lake trout abundance in index gill nets increased each year from 2008-2014, recovering from historic lows recorded during 2005-2007. Adult abundance in 2015 declined by 18% from 2014.
- The sea lamprey wounding rate on lake trout caught in gill nets was 1.94 fresh (A1) wounds per 100 lake trout, below the target of 2.0 wounds per 100 lake trout.
- The survival indices at age 2 for lake trout stocked in 2014 (2013 year class) declined by 32% from the relatively high values observed for the 2010 and 2012 year classes.
- Naturally produced lake trout were produced in 21 years since 1994. The largest catches of naturally produced lake trout occurred in 2014 and 2015.
- Adult lake trout condition has generally remained at a high level during 2007-2015, but has

exhibited a downward trend since 2011. Condition of juvenile lake trout in 2015 was among the lowest values recorded for the 1979-2015 time series.

- In 2015, angler catch (52,294 fish) and harvest (18,780 fish) were more than 2-fold higher than their respective previous 10-year averages, and were more than nine times higher than the lows observed in 2007. Charter catch rate (0.05 lake trout per angler hour) was similar to the long term average (Section 2).

Status of Sea Lamprey Control

- The sea lamprey is a destructive invasive species in the Great Lakes that contributed to the collapse of lake trout 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 is a critical component of Great Lakes fisheries management, facilitating the rehabilitation of important fish stocks by significantly reducing sea lamprey-induced mortality (Section 11).
- In 2015, 19 Lake Ontario tributaries (ten Canada, nine NY) were treated with lampricides. Treatments in New York included Black River, Altmar Creek, Snake Creek, Catfish Creek, Owasco Outlet, Eightmile Creek, Sterling Creek, Red Creek, and Sodus Creek. A total of 4,184 sea lampreys were trapped in eight tributaries, five of which are index locations.
- The estimated population of adult sea lampreys was 10,298, which was less than the fish-community objective target of 11,368.
- Larval assessments were conducted on a total of 96 tributaries (65 Canada, 31 NY). Surveys to estimate abundance of larval sea lampreys were conducted in seven tributaries (five Canada, two NY). Surveys to detect the presence of new larval sea lamprey populations were conducted in 67 tributaries (50 Canada, 17 NY).
- In 2015, two tributaries to the Credit River system were found to be infested for the first time. Multiple age classes including larval and juvenile life stages were found and are scheduled for treatment during 2016. Altmar Creek, a previously uninfested tributary to New York's Salmon River, was found to contain multiple age classes, including juvenile sea lampreys. A report of adult sea lampreys spawning in the Owasco Lake Outlet (Oswego River System) led to the discovery of multiple age classes, including juveniles, in the river.
- Post-treatment assessments were conducted in 16 tributaries (ten Canada, six NY) to determine the effectiveness of lampricide treatments conducted during 2014 and 2015.
- Surveys to evaluate barrier effectiveness were conducted in eight tributaries (six Canada, two U.S.).
- The rate of wounding by sea lamprey on lake trout caught in gill nets was 1.94 fresh (A1) wounds per 100 lake trout was below the target of 2 wounds per 100 lake trout (Section 5). There were an estimated 15.4 lamprey observed per 1,000 trout or salmon caught by anglers, the second lowest estimated since 2002, however, still about 2.6-fold higher than the 1986-1995 average rate (Section 2).

Warmwater Fisheries

- A total of 69,600 fingerling walleye were stocked in the lower Niagara River (23,200), Irondequoit Bay (36,000), and Port Bay (10,400) (Section 1).
- The Eastern Basin warmwater index gill netting survey is conducted annually to assess relative abundance and population characteristics of warm and coolwater fish species. Total catch-per-unit-effort (CPUE or relative abundance) of all species in 2015 was 14.9 fish/gill net, a 51.7% decrease compared to the 2010-2014 (previous five year) average. Cooler summer water

temperatures in 2014 and 2015 may have influenced fish distribution and abundance in assessment nets. White perch (24.7%) and smallmouth bass (29.2%) were the most commonly caught species (Section 4).

- Smallmouth bass abundance was 4.4 fish/net, the lowest catch since 2004 and comparable to (+3.4%) 2000-2004 when abundance was at the lowest levels recorded. Historically, the Eastern Basin smallmouth bass population periodically experienced years of strong natural reproduction, and these individual "year classes" often sustained the population and sportfisheries for many years. For example, fish resulting from strong natural reproduction in 1983 (1983 year class) were still contributing strongly to the sportfishery in 1998 as age 15 fish. In spite of conditions favoring strong reproduction in recent years, data indicate that the Eastern Basin smallmouth bass population is no longer producing strong year classes.
- Walleye CPUE has remained relatively stable for several years, but decreased 46.8% compared to the 2010-2014 average. Strong year classes produced in 2003, 2005 and 2008 remained well-represented in 2015 catches. Catches of age-4 walleye indicate that a strong 2011 year class was produced in both the Bay of Quinte and NY waters of the Eastern Basin.
- Following six years of improved yellow perch catches (2008-2013), yellow perch CPUE declined in 2014 (1.7 fish/net) and 2015 (0.8 fish/net) to the lowest levels observed. This decrease may be partly attributable to water temperature patterns and catch variability; however, angler reports also suggested lower yellow perch abundance during both years.
- In 2008, Eastern Basin white perch abundance reached its highest level since 1991 and was the third most commonly caught species 2008-2013. In 2015, white perch CPUE (3.7) was similar to 2008, but a 27.1% decrease compared to the previous five year average.
- Round gobies first appeared in this assessment in 2005 in both gillnet catches and smallmouth bass diets. In 2015, 71.7% of the 120 non-empty bass stomachs contained goby. Gobies were present in walleye diets each year from 2006-2010 and 2012-2015, and have been found in northern pike, brown trout, lake trout, and lake whitefish.
- At least one lake sturgeon was collected in the Eastern Basin in 15 of the last 21 years, suggesting improved population status.
- Similar to the Eastern Basin index gill netting survey, surveys are conducted annually on the St. Lawrence River to assess warm and coolwater fish populations in the Thousand Islands and Lake St. Lawrence (Sections 6 and 7, respectively). Cooler summer water temperatures in 2014 and 2015 may have influenced fish distribution and abundance in assessment nets.
- Thousand Islands smallmouth bass abundance increased from low 1996-2006 levels, and has varied at relatively high levels from 2007 to 2012. Catch in 2012 reached its highest level since 1988, but declined to a near record low by 2015. 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 has remained low since. From 1996 to 2015, northern pike abundance has remained relatively low. Ongoing poor recruitment of northern pike is likely related to spawning habitat limited by water level regulation, and possibly by Double-crested Cormorant predation (Section 6).
- Lake St. Lawrence yellow perch abundance was variable at a higher level from 2007-2015 as compared to most years during the 1990s and 2000s. Abundance declined 52% from 2012 to 2013 and has been relatively stable since then with numbers near the long-term average. Smallmouth bass catch has been variable since 2005, reached its second highest level in 2013, and was at the long-term average in 2015. The 2011 year class continues to be well represented for the third year. Walleye abundance fell to its lowest level since 2004, and below the long-term average for the first time in seven years (Section 7).
- Abundance of spawning adult and young-of-the-year (YOY) northern pike in the Thousand Islands region of the St. Lawrence River continues to be suppressed likely due to habitat

degradation resulting from long-term management of Lake Ontario/St. Lawrence River water levels. Overall, natural reproduction at natural and managed spawning marshes remains poor, due to low abundance of spawning adults and sex ratio dominance of females. Habitat restoration efforts including excavated channels and spawning pools has shown success for natural reproduction of YOY at many sites. Monitoring of outmigration of YOY at enhancement sites further indicates a strong linkage between higher spring water levels and spawning success (Section 22).

- 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 YOY 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).
- Targeted gill net sampling for lake sturgeon in Lake Ontario, Black River Bay, and the St. Lawrence River in 2015 produced a total catch of 169 fish. Passive integrated transponder (PIT) tags, which allow for future identification of individual fish, were implanted in 145 fish to monitor fish growth, movements, and to manage brood stock genetics in restoration stocking efforts. Twenty-three previously tagged sturgeon were re-captured in 2015. To date four sturgeon have been identified that have either passed through the Moses-Saunders Dam or through the St. Lawrence Seaway Eisenhower and Snell locks to be recaptured at the South Channel sturgeon egg take location (Section 18).
- In an effort to gather baseline data on warm and cool water fishes, an electrofishing survey of the lower Niagara River was conducted during the summer of 2015 to assess the warm water fish community, and evaluate the effectiveness of electrofishing as a method for warm water fisheries surveys in the lower Niagara River. Twenty species were captured, the most abundant species were alewife and smallmouth bass. Walleye, American eel, and four species of suckers were also captured. Average catch rate of smallmouth bass was 76.4 fish per hour (*SD* = 43.3), one of the highest catch rates ever recorded in New York. Smallmouth bass condition as measured by relative weight averaged 96.5, higher than the statewide average of 90.0. Average catch rate of American eel was 3.1 (*SD* = 2.8) fish per hour, higher than a 2002 targeted survey conducted in the lower Niagara River (catch rate of 1.1 fish per hour), and likely attributed to experimental stockings of glass eels into Ontario waters of Lake Ontario and the St. Lawrence River between 2006 and 2010 (Section 21).
- A seining sampling program was conducted in the Thousand Island (Chippewa Bay) and Lake St. Lawrence portions of the St. Lawrence River from 2002-2015. The Thousand Island area tends to be dominated by yellow perch and cyprinids whereas Lake St. Lawrence is dominated by centrarchids and round goby. Esocids are generally caught in higher numbers in Lake St. Lawrence although they represent a small proportion of the catch. Differences in fish species abundance between the two areas surveyed are most likely attributable to habitat differences (Section 17).

Sport Fishery Assessment

- Each year from 1985-2015 the DEC 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 the salmonid fishery and provide valuable information on other fish species (Section 2).
- Fishing quality during 2015 was likely impacted by colder than average water temperatures and atypical weather patterns. During 2015, there were periods and locations of both excellent and poor fishing quality (measured as catch rate, i.e., number of fish caught per hour of angling). The

four most sought after species were Chinook salmon, brown trout, rainbow trout, and coho salmon. The 2015 charter boat catch per angler hour for these four species combined (charter catch per angler hour=0.12) was the lowest recorded since 2002, a 16.2% decrease compared to the long-term average, and a 37.2% decrease compared to the record levels observed 2003-2014. Total trout and salmon catch (154,411 fish) and harvest (77,887 fish) were dominated by Chinook salmon (38.1% and 44.9%, respectively), lake trout (33.9% and 24.1%, respectively), brown trout (13.5% and 16.2%, respectively), and rainbow trout (11.3% and 11.8%, respectively).

- The thirteen highest Chinook salmon catch rates among charter boats occurred during 2003-2015. Fishing quality in 2015 (0.07 fish/hour) was the lowest estimated during this time period and a 25.6% decrease compared to the 2003-2015 mean.
- Charter boat catch rate of coho salmon (0.004 fish/hour) was well below the long-term average (-56.8%).
- Each year from 2008-2014 rainbow trout catch rates were among the highest recorded. In 2015, charter boats caught 0.02 rainbow trout per angler hour, the lowest level since 2005 and a 38.9% decrease compared to the long term average.
- The charter boat catch rate for brown trout in 2015 was 0.03 fish/hour, the lowest recorded since 2008 and 27.2% below the long-term average.
- During 2015, the charter boat catch rate of lake trout was 0.06 fish/hour, 43.8% increase compared to the long term average.
- In 2015, total estimated fishing effort was 53,154 fishing boat trips (980,409 angler hours), among the lowest observed**.** Effort targeting trout and salmon remained relatively stable for more than a decade but was the second lowest on record in 2015. An estimated 46,142 boat trips targeted trout and salmon in 2015 (87% of fishing boat trips), which was an 11.1% decrease compared to the previous 10-year average.
- Smallmouth bass was the most commonly caught species in the survey each year 1985-2006. In 2015, smallmouth bass was the sixth most commonly caught species.
- An estimated 4,868 fishing boat trips targeted smallmouth bass during the 2015 traditional open season (3rd Saturday in June through September 30 when the creel survey ends), a 29.2% decrease from 2014 and the second lowest observed. Bass catch rates were relatively stable from 1985 through the early 1990s (mean=1.0 bass per angler hour), increased to the highest level in 2002 (2.0 bass per angler hour), then declined to record low levels. Smallmouth bass catch rate per angler hour in 2015 was 0.5, a 42.3% increase compared the 2010 record low and comparable to (-0.2%) the previous 5-year average. Several factors may have contributed to poor fishing quality, including expansion of round goby populations and possible smallmouth bass mortality from Viral Hemorrhagic Septicemia virus.
- A NYSDEC angler survey was conducted on 21 major tributaries from September through November 2015 (Section 14). The total estimated effort for 21 tributaries was 763,357 angler hours and 191,331 trips. The Salmon River accounted for 588,498 angler hours (77% of total) and 101,465 angler trips (53% of total). Five other tributaries accounted for at least 10,000 estimated angler hours each: Eighteenmile Creek and Niagara River in Niagara County, Genesee River in Monroe County, South Sandy Creek in Jefferson County, and Oak Orchard Creek in Orleans County.
- Sixteen of 21 tributaries surveyed had reported catches of Chinook salmon. The total estimated catch and harvest of Chinook salmon in 2015 was 43,589 and 26,045, respectively. The 2015 catch of Chinooks declined drastically from the three previous survey (fall 2005, 2006, and 2011) estimates that ranged from 125,180 to 155,960 fish caught.
- Coho salmon were a small component of the 2015 tributary fishery, with an estimated 6,061 fish caught in nine of the 21 tributaries surveyed. Coho catches varied considerably in previous

surveys, ranging from 5,804 in 2006 to 30,676 in 2011. The Salmon River accounted for 95% of the catch (5,738) and 89% of the harvest (2,307).

- Eleven of the 21 tributaries surveyed had reported catches of steelhead with the total estimated catch and harvest of 17,223 and 2,623 fish, respectively. The Salmon River had the highest estimated catch (11,334 or 66% of total) and harvest (1,401 or 53% of total). The release rate for steelhead was 88% on the Salmon River and 85% for all tributaries combined.
- Ten of the 21 waters surveyed had reported catches of brown trout. The total estimated brown trout catch and harvest were 13,650 and 3,441 respectively. The estimated catches from the previous three comprehensive fall surveys ranged from 27,419 in 2006 to 40,192 in 2005.

Double-crested Cormorant Management and Impacts on Sportfish Populations

- Cormorant population management, along with a major cormorant diet shift to round goby, has essentially met objectives related to cormorant predation for protecting fish populations, other colonial waterbird species, private property and other ecological values (Section 13).
- For the 17th consecutive year, cormorant population control was continued through oiling of eggs with food grade vegetable oil at the Little Galloo Island colony. No culling of adult birds was necessary in 2015. Nest destruction was employed to discourage nesting on Gull Island (n=769), 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 2015, cormorant feeding days at the Little Galloo Island colony were estimated at 827,800, 6% above the target of 780,000. Feeding days have been within 12% of target since 2012.
- Despite continued cormorant management and reduced consumption of yellow perch and smallmouth bass, abundance indices for these species declined in 2014 and remained low in 2015 indicating additional factors are currently affecting those populations (Section 4).

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New York Lake Ontario and Upper St. Lawrence River Stocking Program 2015

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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, and the St. Lawrence River upstream of Alexandria Bay. 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 2015 by species, strain, and life stage, and compares those totals with the 2015 New York Department of Environmental Conservation (NYSDEC) stocking policy. Table 2 provides totals by species and life stage, summarizing the New York stocking history from 2000-2015. New York stocking history from 1968-1990 is reported in Eckert (2000). Table 3 provides specific information for each group of fish stocked in 2015. 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).

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:

CC	Casco Fish Hatchery, ME
CV	Cape Vincent Fisheries Station, Jefferson Co.
BH	Bald Hill Fish Culture Station, VT
EW	Ed Weed Fish Culture Station, VT
NAA	Niagara River Anglers Association
PMP	Powder Mill Park Hatchery, Monroe Co.
FC	Fish Creek Club, Point Rock, NY
MC	Morrisville College, Morrisville, NY
TUN	USGS Tunison Laboratory of Aquatic Sciences

U.S. Fish and Wildlife Service Hatcheries:

AL	Allegheny National Fish Hatchery, PA
EI	D.D. Eisenhower National Fish Hatchery, VT
GN	Genoa National Fish Hatchery, WI
IR	Iron River National Fish Hatchery, WI
PT[1]	Pittsford National Fish Hatchery, VT

[1] Pittsford N.F.H. renamed D.D Eisenhower (EI) in 2009

SC Sullivan Creek National Fish Hatchery, MI
WR White River National Hatchery, VT

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

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 2014 are 2015 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 L. inlet.

HPW (Huron Parry Sound Wild): "Lean"-type lake trout strain originated from a remnant population on the Canadian side of Georgian Bay in Lake Huron. A captive HPW broodstock is maintained at SC and is the source eggs for HPW reared at AL for stocking into Lake Ontario. The first HPW lake trout stocking into Lake Ontario occurred in fall 2014. HPW yearlings and fall fingerlings were also stocked in 2015 by AL.

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 included 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 (see SEB below). In 2015, AD stocked SEB/LC hybrids.

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. LCH-D yearlings were reared and stocked by AL in 2013 and EI in 2013-2015. LCH-D spring yearlings and fall fingerlings were stocked by EI in 2015. 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.

LO (Lake Ontario): Wild, self-sustaining populations from Lake Ontario used to describe both cisco and walleye strains. Cisco eggs were collected in Chaumont Bay, Jefferson County and reared at U.S. Geological Survey (USGS) Tunison Laboratory of Aquatic Sciences (TUN) from 2011-present. Walleye eggs were collected from adults netted in Mud Bay, Jefferson County, NY and incubated and reared at the NYSDEC Cape Vincent Fisheries Station in partnership with the Lake Ontario Fisheries Coalition and the Village of Cape Vincent. From 2009-present, however, no walleye production occurred.

LM (Lake Michigan): Wild, self-sustaining population of bloater from Lake Michigan. In each year from 2012-present, eggs were collected from wild fish in Lake Michigan near Dorr County, WI or Milwaukee, WI and were incubated and reared at TUN and stocked into Lake Ontario.

MEP (Lake Mephromagog): A naturalized freshwater strain of landlocked Atlantic salmon originally derived from the West Grand Lake, ME strain, an outlet spawner. Fry stocked by State University of New York College of Environmental Science and Forestry in 2014 were produced from a captive broodstock held at BC.

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 to spawn. 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. Originally the state of Michigan obtained its Chinook eggs mainly from the Green River, WA (Weeder 1997) and its coho eggs from the Cascade River, Oregon and Toutle River, WA initially and later from the Platte River, WA (Keller et al. 1990).

SEB (Sebago): Landlocked strain of Atlantic salmon derived from Maine. SEB were stocked in 2011-2015 by TUN from eggs originating from Ed Weed Fish Culture Station, VT (2011-2015), Casco Fish Hatchery, ME (2013), Bald Hill Fish Culture Station (2015) and from NYSDEC Adirondack Hatchery (2014-2015). In 2015, TUN stocked fry from BH, fall fingerlings from AD, and yearlings from EW.

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 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). Concerns over 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. Production of SEN strain at AL resumed with the 2012 year class, and AL stocked SEN as yearlings in 2013-2015 and as fall fingerlings in 2015. 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.

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.

SKW (Klondike Reef): 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). Stocking of SKW resumed in 2014 with fall fingerlings produced at AL (eggs from broodstock at IR). Stocking of SKW by AL also occurred in 2015 as yearlings and fall fingerlings (2014 and 2015 YCs, respectively). 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.

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 IR and is no longer 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 SAW, and STW in the USFWS stocking database; and as SUP, STW and SAW in the NYSDEC Lake Ontario Unit reports.

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 were derived.

Mos (Months): Age of the fish to the nearest half month from the time the fish 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
SCU	Scute clip (sturgeon)
CWT	coded wire tag
OTC	oxytetracycline - 6 hour immersion
CAL	calcein
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), lake trout or rainbow trout (both 6-digit).

Pen Reared (date, size): Fish held and reared in a pen 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.

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, 2012-2015), 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.

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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 2014, and comparisons with the NYSDEC 2015 stocking policy.

Species	Stage		Strain	DEC Stocking Policy	Actual Number Stocked
Atlantic Salmon	Ylg		SEB/LC	50,000	50,000
	fry	[1]	SEB	-	8,048
	FF	[1]	SEB	-	74,159
	Ylg	[1]	SEB	-	20,295
Atlantic Salmon Total				50,000	152,502
Bloater	FF	[1]	LM	-	61,617
Brown Trout	Ylg	[2]	RL-D	391,755	449,160
Chinook Salmon	SF	[3]	SAL-W	1,761,600	1,761,600
Cisco	FF	[1]	LO	-	100,311
Coho Salmon	FF	[4]	SAL-W	155,000	140,760
	Ylg		SAL-W	90,000	90,000
Coho Salmon Total				245,000	230,760
Lake Sturgeon	FF		SLR	-	1,000
	SF		SLR	-	7500
Lake Sturgeon Total				-	8,500
Lake Trout	FF	[5]	HPW	80,000	58,084
	Ylg		HPW	120,000	119,770
	FF	[5]	LCH-D	120,000	121,965
	Ylg		LCH-D	120,000	115,460
	FF	[5]	SEN	200,000	204,994
	Ylg		SEN	160,000	162,040
	FF	[5]	SKW	150,000	69,522
	Ylg		SKW	120,000	123,590
Lake Trout Total		[5]		1,070,000	975,425
Rainbow Trout	Ylg	[6]	FL-W	7,500	1,000
	Ylg		RA-D	75,000	75,470
	Ylg	[7]	SKA-W	43,000	29,350
	Ylg	[8,9]	WAS-W	497,700	352,650
	FF		WAS-W	-	148,810
Rainbow Trout Total				623,200	607,280
Walleye	PF		ONL-W	69,600	69,600
Salmon and Trout Total				**4,141,555**	**4,176,727**
Grand Total				**4,212,155**	**4,416,755**

[1] Stocked by U.S. Geological Survey- Tunison for research (Atlantic salmon) or restoration (Cisco and Bloater) projects.

[2] Brown trout stocking policy was adjusted to 86.1% of the prior policy (455,000) based on the previous ten-year average of brown trout stocked into Lake Ontario. This new policy reflects a more realistic production capacity of the hatcheries since the 2-year old brown trout program was instituted statewide. In 2015, surplus brown trout were stocked at Stony Point and Sunset Bay to compensate for losses to bird predation during first stocking attempts at those sites. Surplus also stocked at Port Bay.

[3] No Chinook salmon or Rainbow trout (WAS-W) were stocked into pens at Sandy Creek due to high water temperatures in 2015. All fish were direct stocked at this site.

[4] Initially, Salmon River hatchery determined that there would be a stocking shortage of fall fingerlings in 2015, and stocked fall sites at 74.3% of policy number. Later, higher than expected inventory allowed an additional 19,930 to be stocked at one location (Genesee River).

[5] Experimental stocking done in 2015 to evaluate the relative survival of stocking fall fingerling lake trout vs spring yearlings. According to the lake trout management plan adopted in 2013, annual stocking target was set at 800,000 yearling equivalents. Numbers stocked at each location will vary substantially each year depending on experimental objectives.

[6] High mortality at PMP due to merganser predation led to shortfall of rainbow trout in 2015.

[7] Shortage of Skamania strain adults returning to SR in 2014 lead to production shortage in 2015.

[8] New permanent policy in 2014 shifted 3,000 steelhead from Keg Creek to Eighteenmile Creek and 4,000 steelhead from Fourmille Creek to East Branch Twelve Mile Creek to avoid low typical water levels and high stream temperatures at those sites.

[9] Sediment problems during early rearing at SR led to high mortality of steelhead fry in 2014 and a stocking shortfall in 2015.

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 2015. Numbers stocked from 1968-1990 can be found in Eckert (2000).

Species Life Stage	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Co Ylg	97	94	96	92	119	98	95	90	90	99	101	105	95	95	99
Co FF	132	155	100	223	172	196	155	155	137	155	155	155	155	155	155
Co AF	0	290	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
Ck f	2835	2798	1603	1000	1150	1300	1605	1596	1596	1654	1629	1633	1622	1836	1809
Ck FF	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
LT FF	160	0	0	5	0	0	0	0	0	0	0	0	0	0	0
LT Ad	0	0	0	0	0	0	0	<1	0	<1	0	0	0	0	0
BT Ylg	382	415	445	402	382	361	426	426	429	421	405	382	414	367	391
BT FF	0	0	0	0	0	0	0	0	25	0	0	136	39	0	66
BT AF	0	0	0	0	0	0	0	0	0	0	114	0	0	0	10
BT f	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0
RT Ylg	82	85	88	92	24	70	93	92	97	75	60	71	75	64	75
RT FF	0	0	0	0	0	0	0	14	0	0	20	10	0	0	0
RT f	29	0	0	0	0	0	0	0	0	0	0	14	40	0	0
RT Ad	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0
Sthd Ad	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
Sthd Ylg	551	515	454	487	534	543	555	528	521	533	583	535	560	558	570
Sthd FF	40	0	0	0	50	60	110	0	107	0	0	15	0	0	0
Sthd f	175	0	0	0	0	0	0	0	0	0	0	1	6	0	0
ST FF	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
AS Ad	0	0	0	0	2	2	1	4	6	1	<1	<1	<1	1	0
AS Ylg	178	169	135	151	130	97	76	73	84	78	75	75	50	51	50
AS FF	0	0	30	38	34	34	25	25	25	25	25	0	0	0	0
AS AF	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
AS f	0	0	0	0	60	171	73	0	156	84	62	17	32	0	0
Sal Total	5479	5029	3453	2997	3158	3282	3715	3430	3749	3615	3729	3655	3594	3619	3450
Wal AF	122	52	202	100	104	264	250	194	155	129	10	10	211	71	104
Wal FF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stur FF	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Bloater FF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cisco FF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	5601	5081	3655	3097	3262	3546	3964	3623	3904	3745	3739	3665	3807	3691	3555

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
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

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

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 2015. Numbers stocked from 1968-1990 can be found in Eckert (2000).

Species Life Stage	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Co Ylg	110	90	124	95	114	141	120	69	130	141
Co FF	155	155	104	155	155	155	0	155	0	90
Co AF	0	0	0	0	0	0	0	0	0	0
Co f	0	0	0	0	0	0	0	0	0	0
Ck f	1827	1813	799	1757	1531	1769	1511	1772	1970	1762
Ck FF	0	0	0	0	0	0	0	0	0	0
LT Ylg	118	453	501	511	332	488	0	523	443	521
LT FF	0	0	0	0	122	0	123	0	528	455
LT Ad	0	0	0	0	0	0	0	0	0	0
BT Ylg	391	385	370	418	409	424	419	331	397	449
BT FF	0	0	0	70	57	6	0	0	27	0
BT AF	0	0	50	6	116	0	0	0	41	0
BT f	0	0	0	46	0	0	0	0	0	0
RT Ylg	72	68	74	78	80	82	82	83	42	76
RT FF	0	0	0	15	0	27	0	0	0	0
RT f	0	0	0	0	0	30	0	0	0	0
RT Ad	0	0	0	0	0	0	0	0	0	0
Sthd Ad	0	0	0	0	0	0	0	0	0	0
Sthd Ylg	572	538	570	561	702	615	554	546	521	382
Sthd FF	0	0	0	80	188	0	337	0	0	149
Sthd f	0	0	0	0	0	0	0	0	0	0
ST FF	0	0	0	0	0	0	0	0	0	0
*ST SF	0	0	0	54	0	0	0	0	0	0
AS Ad	0	0	0	0	0	0	0	0	0	0
AS Ylg	29	52	49	50	50	50	60	67	65	70
AS FF	0	0	0	24	37	66	73	61	71	74
AS AF	0	0	0	0	0	0	14	0	0	0
AS f	0	0	0	0	0	0	0	0	6	8
Sal Total	3263	3554	2,641	3920	3891	3853	3293	3606	4239	4177
Wal AF	123	31	50	118	12	118	23	149	138	70
Wal FF	0	0	5	0		0	0	0		0
Stur FF	0	0	0	0	0	0	0	1	9	9
Bloater FF	0	0	0	0	0	0	1	7	20	62
Cisco FF	0	0	0	0	0	0	9	9	145	100
TOTAL	3382	3585	2696	4037	3903	3972	3327	3773	4551	4417

Abbreviations:

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f: fry and spring fingerlings, stocked before mid-June
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Table 3. Trout, salmon and other species stocked in New York waters of Lake Ontario and the Upper St. Lawrence River in 2015.

SPECIES	LOCATION	GD/KY	STK_DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Atlantic Salmon	Beaverdam Brook	O.53-8	13-Apr-15	AD	2014	SEB/LC	13.6	Ylg	48.1	none	30,000	
Atlantic Salmon	Trout Brook	O.53-5-BT	7-May-15	TUN	2015	SEB	2.6	fry	1.2	none	2,682	Source of eggs from BH hatchery
Atlantic Salmon	Orwell Brook	O.53-6-BT	7-May-15	TUN	2015	SEB	2.6	fry	1.2	none	2,683	Source of eggs from BH hatchery
Atlantic Salmon	Little Sandy Creek	O.50-3	7-May-15	TUN	2015	SEB	2.6	fry	1.2	none	2,683	Source of eggs from BH hatchery
Atlantic Salmon	Beaverdam Brook	O.53-8	28-Sep-15	TUN	2015	SEB	7.5	FF	12.1	AD	7,989	Stocked Rt 22 to dam, source of eggs from AD hatchery
Atlantic Salmon	Beaverdam Brook	O.53-8	28-Sep-15	TUN	2015	SEB	7.5	FF	12.4	AD	7,982	Stocked below weir to mouth, source of eggs from AD hatchery
Atlantic Salmon	Beaverdam Brook	O.53-8	29-Sep-15	TUN	2015	SEB	7.6	FF	13.2	AD	7,998	stocked below weir to mouth, source of eggs from AD hatchery
Atlantic Salmon	Salmon River	O.53-8	29-Sep-15	TUN	2015	SEB	7.6	FF	10.8	AD	9,421	Stocked behind hatchery downstream of pumphouse, source of eggs from AD hatchery
Atlantic Salmon	Salmon River	O.53-8	30-Sep-15	TUN	2015	SEB	7.6	FF	9.9	AD	9,422	Stocked behind hatchery upstream of pumphouse, source of eggs from AD hatchery
Atlantic Salmon	Salmon River	O.53-8	30-Sep-15	TUN	2015	SEB	7.6	FF	9.8	AD	9,458	Stocked behind hatchery to upper fly zone, source of eggs from AD hatchery
Atlantic Salmon	Salmon River	O.53-8	1-Oct-15	TUN	2015	SEB	7.6	FF	12.2	AD	7,969	Stocked behind hatchery downstream of pumphouse, source of eggs from AD hatchery
Atlantic Salmon	Salmon River	O.53-8	2-Oct-15	TUN	2015	SEB	7.7	FF	12.0	AD	7,964	Stocked behind hatchery upstream of pumphouse, source of eggs from AD hatchery
Atlantic Salmon	Salmon River	O.53-8	5-Oct-15	TUN	2015	SEB	7.8	FF	13.2	AD	5,956	Stocked behind hatchery to upper fly zone, source of eggs from AD hatchery
Atlantic Salmon	Beaverdam Brook	O.53-8	13-Apr-15	TUN	2014	SEB	13.1	Ylg	68.8	AD-VIE	11,378	Stocked above Rt22, Red elastomer tag behind right eye, source of eggs from EW hatchery
Atlantic Salmon	Salmon River	O.53-8	14-Apr-15	TUN	2014	SEB	13.1	Ylg	68.8	AD-VIE	8,917	Stocked at pumphouse, Red elastomer tag behind right eye, source of eggs from EW hatchery
Atlantic Salmon	Point Breeze	713	18-May-15	AD	2014	SEB/LC	14.7	Ylg	53.5	none	20,000	Stocked By Boat
Atlantic Salmon Advanced Fry Total									**1.2**		**8,048**	
Atlantic Salmon Fall Fingerlings Total									**11.6**		**74,159**	
Atlantic Salmon Yearling Total									**55.6**		**70,295**	
Atlantic Salmon Total									**31.3**		**152,502**	
Brown Trout	Black River	O.19	4-May-15	SR	2014	RL-D	16.7	Ylg	75.6	none	4,280	
Brown Trout	Henderson Bay	423	12-May-15	SR	2014	RL-D	17.0	Ylg	68.7	none	14,550	Stocked at Association Island Cut, high mortality due to birds
Brown Trout	Stony Creek	O.40	4-May-15	SR	2014	RL-D	16.7	Ylg	75.5	none	2,570	

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SPECIES	LOCATION	GD/KY	STK_DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Brown Trout	Stony Point	423	3-Jun-15	RM	2014	RL-D	18.2	Ylg	91.3	none	14,400	Surplus to compensate earlier loss to birds at Henderson. Stocked at barge site on Stony Pt.
Brown Trout	Stony Point	423	12-May-15	SR	2014	RL-D	17.0	Ylg	68.7	none	32,520	Too rough for barge, stocked at normal barge pickup site.
Brown Trout	Sunset Bay	623	13-May-15	SR	2014	RL-D	17.0	Ylg	70.9	none	30,810	Stocked at Scriba Town Boat Launch, high mortality due to birds
Brown Trout	Sunset Bay	623	8-Jun-15	CA	2014	RL-D	15.9	Ylg	121.9	none	11,000	surplus to compensate earlier loss to birds, Stocked at Scriba Town Launch
Brown Trout	Oswego	622	14-May-15	SR	2014	RL-D	17.1	Ylg	74.4	none	30,810	Barge/LCM
Brown Trout	Fair Haven	720	5-May-15	SR	2014	RL-D	16.8	Ylg	81.0	none	30,810	Barge/LCM
Brown Trout	Sodus Point	819	1-May-15	SR	2014	RL-D	16.6	Ylg	75.6	none	27,380	
Brown Trout	Port Bay	819	4-Jun-15	RM	2014	RL-D	18.3	Ylg	91.3	none	14,400	surplus
Brown Trout	Pultneyville	818	8-May-15	RM	2014	RL-D	17.4	Ylg	85.7	none	20,540	
Brown Trout	Webster	816	5-May-15	RM	2014	RL-D	17.3	Ylg	88.4	none	15,410	
Brown Trout	Webster	816	6-May-15	RM	2013	RL-D	17.3	Ylg	88.4	none	7,700	
Brown Trout	Irondequoit	815	6-May-15	RM	2014	RL-D	17.3	Ylg	87.1	none	7,700	
Brown Trout	Irondequoit	815	7-May-15	RM	2014	RL-D	17.4	Ylg	89.6	none	15,410	
Brown Trout	Rochester	815	26-May-15	RM	2014	RL-D	18.0	Ylg	87.7	none	15,410	
Brown Trout	Rochester	815	21-May-15	CD	2014	RL-D	17.3	Ylg	141.7	none	7,700	
Brown Trout	Braddocks Bay	815	22-May-15	RM	2014	RL-D	17.8	Ylg	88.2	none	15,410	
Brown Trout	Braddocks Bay	815	21-May-15	CD	2014	RL-D	17.3	Ylg	141.7	none	7,700	
Brown Trout	Hamlin	713	1-Jun-15	CD	2014	RL-D	17.6	Ylg	130.4	none	4,940	
Brown Trout	Hamlin	713	27-May-15	RM	2014	RL-D	18.0	Ylg	89.6	none	18,170	
Brown Trout	Point Breeze	711	2-Jun-15	CD	2014	RL-D	17.7	Ylg	140.0	none	10,540	
Brown Trout	Point Breeze	711	29-May-15	CD	2014	RL-D	17.5	Ylg	127.0	none	4,420	
Brown Trout	Point Breeze	711	4-Jun-15	CD	2014	RL-D	17.7	Ylg	140.9	none	10,480	
Brown Trout	Point Breeze	711	29-May-15	CA	2014	RL-D	18.5	Ylg	94.9	none	6,000	
Brown Trout	Point Breeze	711	2-Jun-15	RA	2014	RL-D	16.2	Ylg	98.6	none	8,000	surplus
Brown Trout	Olcott	708	6-May-15	CD	2014	RL-D	16.8	Ylg	126.7	none	10,700	
Brown Trout	Olcott	708	7-May-15	CD	2014	RL-D	16.8	Ylg	121.0	none	10,690	
Brown Trout	Olcott	708	3-Jun-15	RA	2014	RL-D	17.3	Ylg	94.5	none	13,000	surplus
Brown Trout	Wilson	707	3-Jun-15	CD	2014	RL-D	17.7	Ylg	140.8	none	7,130	
Brown Trout	Wilson	707	8-Jun-15	CA	2014	RL-D	18.8	Ylg	118.2	none	6,000	
Brown Trout	Wilson	707	8-Jun-15	CD	2014	RL-D	17.9	Ylg	139.2	none	1,170	
Brown Trout	Wilson	707	1-May-15	CD	2014	RL-D	16.6	Ylg	112.3	none	7,130	
Brown Trout	Lower Niagara R	O.158	4-May-15	CD	2014	RL-D	16.7	Ylg	112.3	none	4,280	
Brown Trout Yearlings									**92.8**		**449,160**	

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SPECIES	LOCATION	GD/KY	STK_DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Chinook Salmon	Black River	O.19/OB-T0000	11-May-15	SR	2015	SAL-W	4.2	SF	3.5	none	159,000	
Chinook Salmon	South Sandy Creek	O.45/LO-T0000	6-May-15	SR	2015	SAL-W	4.0	SF	3.5	none	100,000	
Chinook Salmon	Salmon River	O.53/LO-T0000	20-Jun-15	SR	2015	SAL-W	5.5	SF	7.2	none	352,000	
Chinook Salmon	Oswego River	O.65	26-May-15	SR	2015	SAL-W	4.7	SF	4.1	none	97,810	
Chinook Salmon	Oswego River	O.65	8-May-15	SR	2015	SAL-W	4.1	SF	4.6	none	41,890	In pens 04/28/15@138.3lb. 46ºF
Chinook Salmon	Little Sodus Bay	O.74	20-May-15	SR	2015	SAL-W	4.5	SF	7.0	none	25,000	In pens 04/29/15 @ 137/lb. 48ºF
Chinook Salmon	Sterling Creek	O.73	5-May-15	SR	2015	SAL-W	4.0	SF	3.6	none	87,200	
Chinook Salmon	Sodus Bay	O.84-P96	18-May-15	SR	2015	SAL-W	4.4	SF	3.5	none	60,000	
Chinook Salmon	Sodus Bay	O.84-P96	16-May-15	SR	2015	SAL-W	4.4	SF	5.8	none	50,000	In pens 04/27/15 @126.9/lb. 47ºF
Chinook Salmon	Genesee River	O.117	27-May-15	SR	2015	SAL-W	4.7	SF	4.1	none	85,250	
Chinook Salmon	Genesee River	O.117	13-May-15	SR	2015	SAL-W	4.3	SF	5.3	none	85,250	In pens 04/21/2015 @135.5/lb. 49ºF
Chinook Salmon	Sandy Creek	O.130	21-May-15	SR	2015	SAL-W	4.5	SF	3.5	none	110,000	
Chinook Salmon	Oak Orchard Creek	O.138	20-May-15	SR	2015	SAL-W	4.5	SF	3.5	none	63,940	
Chinook Salmon	Oak Orchard Creek	O.138	4-May-15	SR	2015	SAL-W	4.0	SF	4.1	none	106,560	In pens 04/22/15@133.2/lb. 51ºF
Chinook Salmon	Eighteenmile Creek	O.148	15-May-15	SR	2015	SAL-W	4.3	SF	3.5	none	67,100	
Chinook Salmon	Eighteenmile Creek	O.148	8-May-15	SR	2015	SAL-W	4.1	SF	7.2	none	67,100	In pens 4/24/2015 @ 140/lb. 50ºF
Chinook Salmon	lower Niagara River	O.158/EN-T0000	27-May-15	SR	2015	SAL-W	4.7	SF	8.2	none	75,000	In pens 5/17/15@130/lb. 45ºF
Chinook Salmon	lower Niagara River	O.158/EN-T0000	29-May-15	SR	2015	SAL-W	4.8	SF	4.1	none	128,500	
Chinook Salmon Spring Fingerling Total									**5.0**		**1,761,600**	
Coho Salmon	Beaverdam Brook	O.53-8	28-May-15	SR	2014	SAL-W	16.5	Ylg	36.9	none	90,000	Moved to smolt release pond 10/15/2014
Coho Salmon	Sodus Bay	O.84	28-Oct-15	SR	2015	SAL-W	9.2	FF	15.1	none	19,320	
Coho Salmon	Genesee River	O.117	28-Oct-15	SR	2015	SAL-W	9.2	FF	15.1	none	16,350	
Coho Salmon	Genesee River	O.117	29-Oct-15	SR	2015	SAL-W	9.3	FF	17.4	none	25,580	
Coho Salmon	Sandy Creek	O.130	29-Oct-15	SR	2015	SAL-W	9.3	FF	15.1	none	19,320	
Coho Salmon	Oak Orchard Creek	O.138	30-Oct-15	SR	2015	SAL-W	9.3	FF	15.1	none	19,320	
Coho Salmon	Eighteenmile Creek	O.148	30-Oct-15	SR	2015	SAL-W	9.3	FF	15.1	none	22,290	
Coho Salmon	lower Niagara River	O.158	30-Oct-15	SR	2015	SAL-W	9.3	FF	15.1	none	18,580	
Coho Salmon Fall Fingerlings									**15.5**		**140,760**	
Coho Salmon Yearlings									**36.9**		**90,000**	
Coho Salmon Total									**23.9**		**230,760**	

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SPECIES	LOCATION	GD/KY	STK_DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Lake Trout	Association Isl. Cut	423	12-May-15	AL	2014	SKW	16.5	Ylg	54.1	AD CWT	41,240	CWT#640589, weather too rough for barge, stocked from shore
Lake Trout	Association Isl. Cut	423	12-May-15	AL	2014	SEN	14.9	Ylg	30.0	AD CWT	40,190	CWT#640605, weather too rough for barge, stocked from shore
Lake Trout	Oswego	622	14-May-15	EI	2014	LCH-D	14.0	Ylg	25.4	AD CWT	33,830	CWT#640586, Barge/LCM
Lake Trout	Scriba	623	13-May-15	AL	2014	SEN	14.6	Ylg	27.4	AD CWT	41,100	CWT#640602, shore stocked
Lake Trout	Scriba	623	13-May-15	AL	2014	SKW	16.6	Ylg	51.8	AD CWT	40,950	CWT#640588, shore stocked
Lake Trout	Sodus	819	15-May-15	AL	2014	SKW	16.6	Ylg	50.2	AD CWT	41,400	CWT#640587,water too low for barge, fish stocked from shore off pier into Lake
Lake Trout	Sodus	819	15-May-15	AL	2014	HPW	14.5	Ylg	31.7	AD CWT	40,970	CWT#640687,water too low for barge, fish stocked from shore off pier into Lake
Lake Trout	Oak Orchard	711	19-May-15	EI	2014	LCH-D	14.0	Ylg	25.5	AD CWT	41,610	CWT#640584, Barge/LCM
Lake Trout	Oak Orchard	711	19-May-15	EI	2014	LCH-D	14.0	Ylg	25.5	AD CWT	40,020	CWT#640585, Barge/LCM
Lake Trout	Olcott	708	18-May-15	AL	2014	SEN	14.8	Ylg	32.4	AD CWT	40,680	CWT#640603
Lake Trout	Olcott	708	18-May-15	AL	2014	SEN	14.8	Ylg	32.9	AD CWT	40,070	CWT#640684
Lake Trout	Olcott	708	18-May-15	AL	2014	HPW	14.6	Ylg	30.9	AD CWT	38,000	CWT#640685
Lake Trout	Olcott	708	18-May-15	AL	2014	HPW	14.6	Ylg	30.4	AD CWT	40,800	CWT#640686
Lake Trout	Association Isl. Cut	423	22-Oct-15	AL	2015	SKW	9.9	FF	13.9	AD CWT	40,514	CWT#640699
Lake Trout	Association Isl. Cut	423	22-Oct-15	AL	2015	SEN	7.6	FF	9.0	AD CWT	41,250	CWT#640710
Lake Trout	Association Isl. Cut	423	22-Oct-15	AL	2015	SEN	7.6	FF	9.0	AD CWT	40,902	CWT#640709
Lake Trout	Oswego	622	21-Oct-15	AL	2015	SEN	7.5	FF	7.9	AD CWT	41,244	CWT#640726, Dowie Dale
Lake Trout	Oswego	622	21-Oct-15	AL	2015	SEN	7.5	FF	7.9	AD CWT	40,768	CWT#640725, Dowie Dale
Lake Trout	Oswego	622	21-Oct-15	AL	2015	SEN	9.9	FF	7.9	AD CWT	40,830	CWT#640723, Dowie Dale
Lake Trout	Pultneyville	817	28-Oct-15	AL	2015	SKW	10.1	FF	13.8	AD CWT	29,008	CWT#640701
Lake Trout	Pultneyville	817	28-Oct-15	AL	2015	HPW	9.1	FF	18.0	AD CWT	29,514	CWT#640707
Lake Trout	Pultneyville	817	28-Oct-15	AL	2015	HPW	9.1	FF	18.6	AD CWT	28,570	CWT#640708
Lake Trout	Oak Orchard	711	27-Oct-15	EI	2015	LCH-D	8.5	FF	10.1	AD CWT	40,520	CWT#640727County Launch
Lake Trout	Oak Orchard	711	27-Oct-15	EI	2015	LCH-D	8.5	FF	10.1	AD CWT	40,650	CWT#640693County Launch
Lake Trout	Oak Orchard	711	27-Oct-15	EI	2015	LCH-D	8.5	FF	10.1	AD CWT	40,795	CWT#640694County Launch
Lake Trout Fall Fingerlings									**10.9**		**454,565**	
Lake Trout Spring Yearlings									**34.7**		**520,860**	
Lake Trout Total									**23.6**		**975,425**	
Rainbow Trout	Black River	424	30-Apr-15	SR	2014	WAS-W	10.3	Ylg	22.7	none	25,520	Sackets Harbor
Rainbow Trout	Black River	O.19	30-Apr-15	SR	2014	WAS-W	10.3	Ylg	22.7	none	25,520	below Dexter Falls
Rainbow Trout	Stony Creek	O.40	14-Apr-15	SR	2014	WAS-W	9.8	Ylg	20.6	none	14,670	

Table 3. Trout, salmon and other species stocked in New York waters of Lake Ontario and the Upper St. Lawrence River in 2015.

SPECIES	LOCATION	GD/KY	STK_DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Rainbow Trout	South Sandy Creek	O.45	14-Apr-15	SR	2014	WAS-W	9.8	Ylg	20.6	none	20,380	
Rainbow Trout	Beaverdam Brook	O.53-8	12-May-15	SR	2014	WAS-W	10.7	Ylg	28.4	none	85,060	Stocked from 5/7-5/12/15
Rainbow Trout	Beaverdam Brook	O.53-8	15-Sep-15	SR	2015	WAS-W	3.0	FF	3.2	none	148,810	surplus
Rainbow Trout	Beaverdam Brook	O.53-8	28-May-15	SR	2014	SKA-W	11.2	Ylg	18.9	AD	29,350	
Rainbow Trout	Grindstone Creek	O.54	20-Apr-15	SR	2014	WAS-W	10.0	Ylg	20.6	none	3,540	
Rainbow Trout	Little Salmon River	O.58	8-May-15	SR	2014	WAS-W	10.5	Ylg	30.2	none	3,410	In pens 4/29/15 @20/lb 52deg
Rainbow Trout	Oswego River	O.66	20-Apr-15	SR	2014	WAS-W	10.0	Ylg	20.6	none	14,180	
Rainbow Trout	Sterling Creek	O.73	13-Apr-15	SR	2014	WAS-W	9.7	Ylg	20.6	none	3,260	
Rainbow Trout	Sterling Valley Ck	O.73-3	13-Apr-15	SR	2014	WAS-W	9.7	Ylg	20.6	none	3,260	
Rainbow Trout	Little Sodus Bay	O.74	20-May-15	SR	2014	WAS-W	10.9	Ylg	31.1	none	4,250	In pens 4/29/15@ 20/lb 48ºF
Rainbow Trout	Maxwell Creek	O.85	29-Apr-15	SR	2014	WAS-W	10.3	Ylg	22.7	none	14,140	
Rainbow Trout	Irondequoit Creek	O.108	28-Apr-15	SR	2014	WAS-W	10.2	Ylg	22.7	none	19,490	
Rainbow Trout	Genesee River	O.117	21-Apr-15	SR	2014	WAS-W	10.0	Ylg	20.6	none	8,580	
Rainbow Trout	Genesee River	O.117	13-May-15	SR	2014	WAS-W	10.7	Ylg	32.3	none	7,090	In pens 4/21/15@ 22/lb 49ºF
Rainbow Trout	Salmon Creek	O.93	30-Apr-15	SR	2014	WAS-W	10.3	Ylg	22.7	none	3,580	
Rainbow Trout	Sandy Creek	O.130	30-Apr-15	SR	2014	WAS-W	10.3	Ylg	22.7	none	10,380	Pen cancelled/both stocked shore
Rainbow Trout	Oak Orchard Creek	O.138	22-Apr-15	SR	2014	WAS-W	10.0	Ylg	20.6	none	4,960	
Rainbow Trout	Oak Orchard Creek	O.138	4-May-15	SR	2014	WAS-W	10.4	Ylg	27.8	none	9,920	In pens 4/22/15@22/lb 51ºF
Rainbow Trout	Marsh Creek	O.138-2	30-Apr-15	SR	2014	WAS-W	10.3	Ylg	22.7	none	5,030	
Rainbow Trout	Johnson Creek	O.139	30-Apr-15	SR	2014	WAS-W	10.3	Ylg	22.7	none	4,750	
Rainbow Trout	Eighteenmile Creek	O.148	24-Apr-15	SR	2014	WAS-W	10.1	Ylg	22.7	none	4,610	
Rainbow Trout	Eighteenmile Creek	O.158	7-May-15	SR	2014	WAS-W	10.5	Ylg	28.5	none	2,480	In pens 4/24/15@20/lb 50ºF
Rainbow Trout	Twelvemile Creek E Br	O.152	27-Apr-15	SR	2014	WAS-W	10.2	Ylg	22.7	none	7,440	
Rainbow Trout	Twelvemile Creek	O.152A	27-Apr-15	SR	2014	WAS-W	10.2	Ylg	22.7	none	8,510	
Rainbow Trout	Twelvemile Crk (Wilson)	O.152	7-May-15	SR	2014	WAS-W	10.5	Ylg	32.4	none	5,320	In pens 04/27/2015 @20/lb 53ºF
Rainbow Trout	lower Niagara River	O.158	7-May-15	SR	2014	WAS-W	10.5	Ylg	18.1	none	26,230	
Rainbow Trout	lower Niagara River	O.158	26-May-15	SR	2014	WAS-W	11.1	Ylg	54.4	none	7,090	In pens 5/07/2015 @25/lb 45ºF
Rainbow Trout	Irondequoit Creek	O.108	9-Apr-15	PMP	2014	FL-W	10.1	Ylg	20.6	none	1,000	Powder Mill Pond release, No WAS strain after 2006, lost fish due to predators
Rainbow Trout	Sodus	819	21-May-15	CH	2014	RA-D	17.3	Ylg	115.4	none	20,000	Stocked at Pultneyville 13,035 on 5/21/15 and 6,965 on 5/26/2015
Rainbow Trout	Braddocks Bay	815	11-Jun-15	VH	2014	RA-D	17.5	Ylg	111.2	none	5,380	Stocked at Braddocks Bay due to lack of suitable access at normal site at Webster
Rainbow Trout	Hamlin	713	11-May-15	CH	2014	RA-D	17.0	Ylg	112.8	none	6,175	
Rainbow Trout	Hamlin	713	26-May-15	CH	2014	RA-D	17.5	Ylg	112.8	none	8,825	
Rainbow Trout	Olcott	708	30-Apr-15	CS	2014	RA-D	16.6	Ylg	154.8	none	9,400	
Rainbow Trout	Olcott	708	10-Jun-15	VH	2014	RA-D	17.5	Ylg	121.0	none	3,100	

Table 3. Trout, salmon and other species stocked in New York waters of Lake Ontario and the Upper St. Lawrence River in 2015.

SPECIES	LOCATION	GD/KY	STK_DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Rainbow Trout	Olcott	708	3-Jun-15	CH	2014	RA-D	17.7	Ylg	158.6	none	10,000	surplus
Rainbow Trout	Wilson	707	10-Jun-15	VH	2014	RA-D	17.5	Ylg	120.9	none	9,890	
Rainbow Trout	Wilson	707	1-May-15	CS	2014	RA-D	16.6	Ylg	158.1	none	2,700	
Washington Steelhead Yearlings									**24.6**		**352,650**	
Washington Steelhead Fall Fingerlings									**3.2**		**148,810**	
Skamania Steelhead Yearlings									**18.9**		**29,350**	
Rainbow Trout Yearlings (Randolph strain)									**127.7**		**75,470**	
Rainbow Trout Yearlings (Finger Lakes W strain)									**20.6**		**1,000**	
Rainbow Trout Total									**32.7**		**607,280**	
Walleye	Irondequoit Bay	O-P0113	10-Jun-15	CQ	2015	ONL-W	1.1	PF	0.4	none	36,000	
Walleye	lower Niagara River	EN-P0000	8-Jun-15	CQ	2015	ONL-W	1.1	PF	0.3	none	23,200	
Walleye	Port Bay	O-P0089	25-Jun-15	ON	2015	ONL-W	1.5	PF	0.7	OTC	10,400	
Walleye Fingerling Total									**0.4**		**69,600**	
Bloater	Oswego	621	3-Nov-15	TUN	2015	LM	6.8	FF	7.1	CAL	30,120	Stocked off Oswego at 100m contour by USGS RV/Kaho
Bloater	Oswego	621	4-Nov-15	TUN	2015	LM	6.8	FF	8.2	CAL	31,497	Stocked off Oswego at 100m contour by USGS RV/Kaho
Cisco	Irondequoit Bay	815	1-Sep-15	TUN	2015	LO	6.8	FF	9.6	CAL	33,825	Stocked by boat, single marked with calceine
Cisco	Irondequoit Bay	815	2-Sep-15	TUN	2015	LO	6.9	FF	9.6	CAL	35,410	Stocked by boat, single marked with calceine
Cisco	Irondequoit Bay	815	2-Nov-15	TUN	2015	LO	8.8	FF	17.6	CAL	20,654	double marked with calceine
Cisco	Chaumont Bay	324	29-Oct-15	TUN	2015	LO	8.7	FF	16.8	CAL	10,422	double marked with calceine
Bloater Total									**7.7**		**61,617**	
Cisco Total									**12.0**		**100,311**	
Coregonine Total									**10.3**		**161,928**	
Lake Sturgeon	Genesee River	O.117	16-Oct-15	ON	2015	SLR	4.1	FF	19.2	CWT	300	CWT in snout (055380,431907) and CWT in 3rd dorsal scute (431959, 431951,434289)
Lake Sturgeon	Genesee River	O.117	16-Oct-15	ON	2015	SLR	4.1	FF	19.2	CWT-SCU	480	CWT in snout (055380,431907) and CWT in 3rd dorsal scute (431959, 431951,434289), Scute Clip on 1st and 2nd scute on the right side
Lake Sturgeon	Genesee River	O.117	16-Oct-15	ON	2015	SLR	4.1	FF	19.2	CWT-VIE-SCU	110	CWT in snout (055380,431907) and CWT in 3rd dorsal scute (431959, 431951,434289), Scute Clip on 1st and 2nd scute on the right side, red VIE on

Table 3. Trout, salmon and other species stocked in New York waters of Lake Ontario and the Upper St. Lawrence River in 2015.

SPECIES	LOCATION	GD/KY	STK_DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
												the left side of snout
Lake Sturgeon	Genesee River	O.117	16-Oct-15	ON	2015	SLR	4.1	FF	19.2	CWT-VIE-SCU	110	CWT in snout (055380,431907) and CWT in 3rd dorsal scute (431959, 431951,434289), Scute clip on 1st and 2nd scute on the right side, red VIE on the right side of snout
Lake Sturgeon	Chaumont Bay	324	10-Aug-15	GN	2015	SLR	1.8	FF	6.2	CWT	7,500	CWT in 3rd dorsal scute (431959,431951,434289)
Lake Sturgeon Total									**5.5**		**8,500**	
Salmonine Total											**4,176,727**	
Total All Species											**4,416,755**	

2015 Lake Ontario Fishing Boat Survey

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Lake Ontario provides anglers with a diverse world-class trout and salmon fishery and ample fishing opportunities for a variety of warm- and cool-water species (e.g., smallmouth bass, walleye, yellow perch). Each year from 1985-2015 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. Data presented and discussed in this report are 5½ month estimates for each survey year (1985-2015). This report focuses on 2015 results and on comparisons of 2015 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 each year 2006-2015 and a 21-year average for 1985-2005.

Methods

Sampling Design and Data Collection

Methods and procedures have changed little throughout the 31 years surveyed. For 20 of the 31 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 (29 channels in 2015). 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 period from two hours after sunrise (1.5 hours

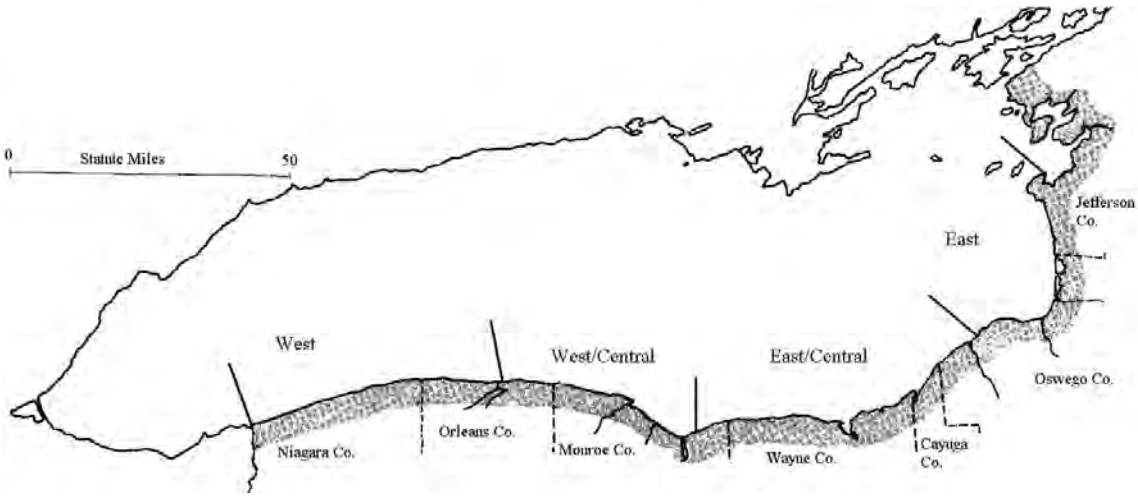

Figure 1. Lake Ontario's New York shoreline (shaded in gray), the seven New York counties that border the lake, and the four geographic areas used in analysis of the survey data.

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 2010-2015

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 5.5-month 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 (see Lantry and Eckert 2013 for detailed methods).

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). 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 2015 5½ month regional results with general trends observed in previous years of the survey 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 9.3, SAS Institute 2011, 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

Total fishing effort from April 15-September 30, 2015 was estimated at 53,154 ($\pm$13.7%) completed boat trips (Figure 2, Table A2), the lowest estimated and due primarily to a significant decrease in fishing effort targeting smallmouth bass in recent years (P-value<0.0001; see "*Smallmouth Bass Targeted Effort,* Traditional Open Season:" section). 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 last 10 years 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).

Total fishing effort in 2015, as measured by angler trips and angler hours, was 157,151 and 879,681, respectively (Table A2). The average number of anglers per boat trip ranged from 2.5 (1985) to 3.0 (2014, highest in data series), and averaged 2.9 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 2015 average trip length of 5.6 hours per boat trip was comparable to previous 5-year (+3.2%) and 10-year averages (+6.0%).

We evaluated the contribution to total 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 (2006-2015 10-year averages: April 15-30: 4.4%, May: 15.5%, June: 11.9%, July: 21.1%, August: 29.6%, and September: 17.5%). In 2015, total fishing effort estimates for June, July, and August were the lowest in the 31-years surveyed and well below respective 10-year averages (range: -36.9% to -27.7%). This decrease coincides with reduced fishing quality for Chinook salmon, coho salmon, rainbow trout, and smallmouth bass during the same months, which is a likely contributing factor to reduced fishing effort.

Geographic Area Fishing Effort

We evaluated regional contributions to total 5.5-month fishing effort (Table A2). The greatest amount of fishing effort occurred in the east/central area for 27 of the last 31 years (Table A2). In 2015,

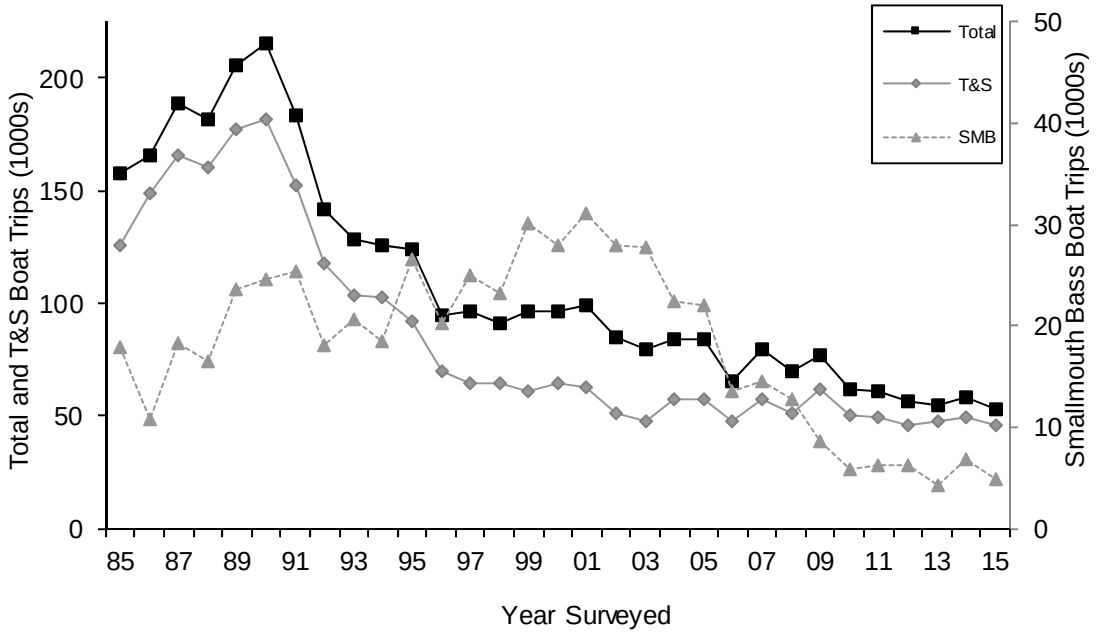

Figure 2. Estimated number of total fishing boat trips, trips targeting trout and salmon (T&S; April 15-September 30), and trips targeting smallmouth bass (SMB) during the traditional open season (3rd Saturday in June-September 30 when the survey ended), 1985-2015.

the greatest effort occurred in the east/central area (16,964 boat trips, the lowest for that area, 31.9% of all fishing effort) and east area (16,240 boat trips, and 30.6% of all effort). Effort in the west was estimated at 12,543 boat trips (lowest for that area). For each of the 31 years surveyed, the lowest fishing effort occurred in the west/central area (7,407 boat trips in 2015 and 13.9% of total fishing effort).

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 53,812 vessel excursions and 32.7% of the total vessel traffic in 2015 (Table A2). Non-fishing power boats were estimated at 97,066 excursions in 2015 (58.9% of the total vessel traffic). Non-fishing power boat traffic peaked and declined similar to that described for fishing boats over the 31-year survey period.

Sailboats, the smallest component of vessel traffic, showed a downward trend through much of the time series (1985-2006; highest in 1987 [48,272 trips], lowest in 2006 [12,186 trips]), increased in recent years to 20,703-23,914 trips during 2009-2013, but most recently declined). In 2015, sailboats accounted for 13,905 excursions and represented 8.4% of vessel traffic. This is similar to (+6.6%) the record lows observed from 2004-2006 (average = 13,043 sailboat trips; Table A2).

Trout and Salmon Targeted Effort

Trout and salmon were the primary target of boat anglers interviewed each year since 1985 (1985-2015 average = 76.8%; range: 59.7% [2003] to 90.0% [1986]; Figure 2, Table A2), and trends in total fishing effort were largely attributed to trout and salmon anglers from 1985 through the late 1990s. Over the last 10 years, however, effort targeting trout and salmon remained relatively stable with no trend. In 2015, trout and salmon anglers accounted for 86.8% of total fishing boat trips, 90.9% of angler trips, and 95.3% of angler hours (Table A2).

In 2015, fishing effort targeting trout and salmon was estimated at 46,142 (±15.3%) boat trips, comparable to the previous 5-year average (-4.9%),

but a slight decrease compared to the previous 10-year average (-11.1%; Table A2). Estimated monthly fishing effort targeting trout and salmon was comparable to the previous 5-year averages in April (-6.9%) and May (+2.6%), was above average in September (+39.1%), and was below the previous 5-year averages June through August (-20.8% to -14.1%; Table A2). Trout and salmon fishing effort estimates for July and August were the lowest in the 31-years surveyed, and coincide with reduced fishing quality for Chinook salmon, coho salmon, rainbow trout, and brown trout during the same months. The majority of anglers interviewed each year since 2005 were specifically targeting Chinook salmon (2005-2014 average=48.7%). During 2015, 40.3% of salmonine anglers interviewed were specifically targeting Chinook salmon, 35.5% were targeting a mix of two or more species, and 10.2% were specifically targeting brown trout.

Smallmouth Bass Targeted Effort

Pre-Season Catch and Release Period:

Fishing effort targeting smallmouth bass before the traditional open lake season (i.e., beginning the third Saturday of June) has remained low since it became legal to do so. An October 1, 2006 regulation change established a catch and release bass season 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 fishing effort (Table A2). In 2006, prior to the new pre-season catch and release regulation taking 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: 164 boat trips [2015] – 644 trips [2009]) and a minor component of total bass effort occurring from April 15 - September 30 (range: 2.8% [2008] to 7.7% [2012]). Pre-season effort targeting smallmouth bass in 2015 (164 boat trips, 3.3% of total bass effort) was the lowest since 1999, i.e., eight years before it was legal to target bass during the preseason period (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 Lake Ontario anglers not seeking trout or salmon (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 2015, smallmouth bass anglers fishing during the traditional open season accounted for 9.2% of all fishing boat trips (April 15 – September 30), 6.3% of angler trips, and 3.2% of angler hours. The total number of angler hours spend targeting bass on Lake Ontario in 2015 was the lowest on record (28,115 hr), a 10.9% decrease compared to the previous record low, and an 88.0% decrease compared to the record high. In 2015, the average number of anglers per bass boat trip (2.0 anglers) was comparable to (-4.4%) the previous 5-year average. The number of hours per boat trip (2.8 hours) was the shortest since 2010 when smallmouth bass catch rates were at the lowest recorded level.

From 1985-2001 effort targeting smallmouth bass increased significantly (P=0.0004), averaging a gain of 797 boat trips per year. During 2001-2010, however, smallmouth bass effort declined significantly (P-value<0.05; Figure 2, Table A2). These trends in fishing effort coincide with a similar declining trend in fishing quality through 2010 (see section "Smallmouth Bass *Fishing Quality*" of this report). Since 2010, effort remained low and at a level 81.6% below the 2001 peak (2011-2015 average = 5,696). In 2015, smallmouth bass fishing effort during the traditional open season (June 20 to September 30) was an estimated 4,868 ($\pm$25.6%) boats trips, the second lowest and a 17.4% decrease compared to the previous 5-year average (Figure 2, Table A2). Fishing effort for smallmouth bass was below previous 5-year averages during each month (range: -51.8% [June] to -13.8% [September]) except July (+14.1%) when it was slightly above

average (Table A2). Effort was comparable to previous 5-year averages in the west area (-7.9%) and east/central area (+3.0%), and was below average in the west/central (-48.7%) and east (-50.9%) areas (Table A2).

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 2015, however, trips targeting these species only represented 1.8% of the total fishing boat trips on Lake Ontario (Table A2). The "all others" category, which represented 1.8% of 2015 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 2015, charter boats accounted for 18.5% of the total number of fishing boat trips, the highest on record (21.2% of trout and salmon fishing boat trips; Figure 3). With more anglers on board and longer trips, charter boats accounted for 32.7% and 38.0% of the angler trips and angler hours, respectively (captains and mates counted as anglers; Table A2). Although charter boats accounted for only 18.5% of total fishing boat effort, they accounted for 40.1% of the total salmonine catch in 2015. 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.

The highest charter fishing effort occurred 1988-1991, then declined and has remained relatively stable for over ten years (Figure 3, Table A2). The 2015 estimated charter boat effort was 9,831 (±24.1%) trips, slightly above previous 5-year (+12.6%) and 10-year (+8.8%) averages. Estimated monthly charter fishing effort in 2015 was below the previous 5-year averages for April, June and July (range: -17.9% [July] - 13.2% [April]), and above average in May, August and September (range: +13.0% [August] to +54.4% [May]; Table A2).

Angler Residency

Lake Ontario's worldclass sportfishery has attracted anglers from all 50 states (35 in 2015) and many different countries (9 in 2015) over the last 31 years. 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 1987-2015. Over the last 10 years, an average of 60.7% of Lake Ontario anglers resided in NYS (60.3% in 2015; Table A4).

Contribution of nonresident anglers increased after 1985 when 20.2% of Lake Ontario open lake anglers were not NYS residents. This increase was likely due to increasing awareness of the Lake Ontario trout and salmon sport fishery (Figure 4). Since the early 1990s the percentage of anglers who reside outside of NYS ranged from 35.2% (2003) to 45.6% (1992). In 2015, non-NYS residents comprised 39.7% of the boat anglers interviewed, comparable to previous 5-year and 10-year averages (+1.5% and +1.2%, respectively; Figure 4; Table A2, Table A4). Pennsylvania represented the largest component of nonresident anglers for each of the 31 years surveyed (20.6% of the all anglers in 2015). The highest percentage of anglers residing in Pennsylvania occurred in 2012 (21.9%) and the lowest (8.5%) occurred in 1985 (Table A4). Other major sources of non-NYS anglers in 2015 were Ohio (4.6%), New Jersey (3.5%), Massachusetts (2.5%), Vermont (2.1%), Connecticut (1.2%), and New Hampshire (0.9%;

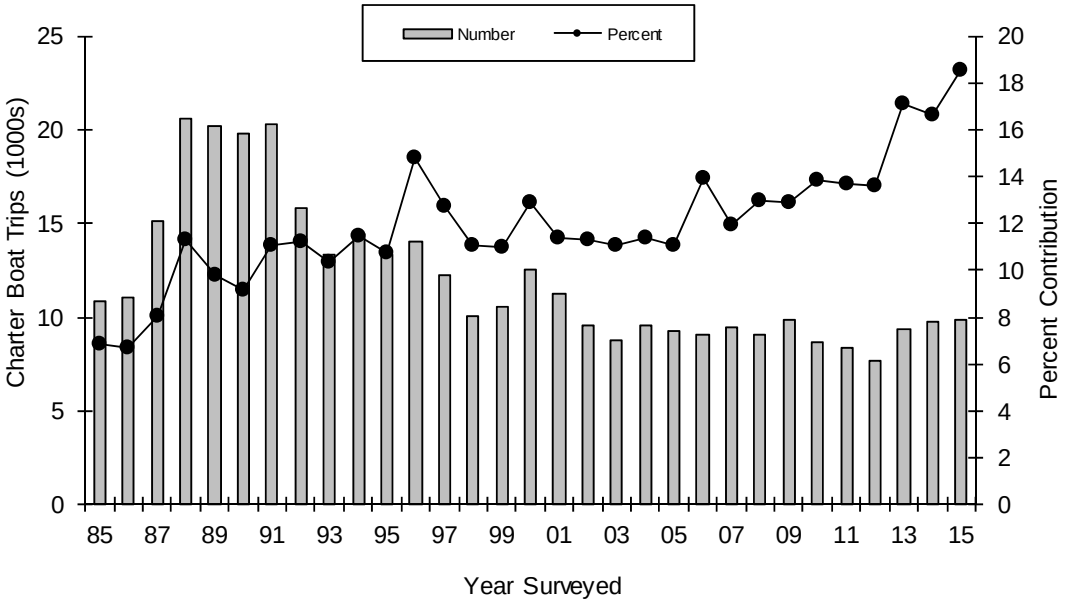

Figure 3. Estimated number of charter fishing boat trips and their percent contribution to total fishing boat trips, April 15- September 30, 1985-2015.

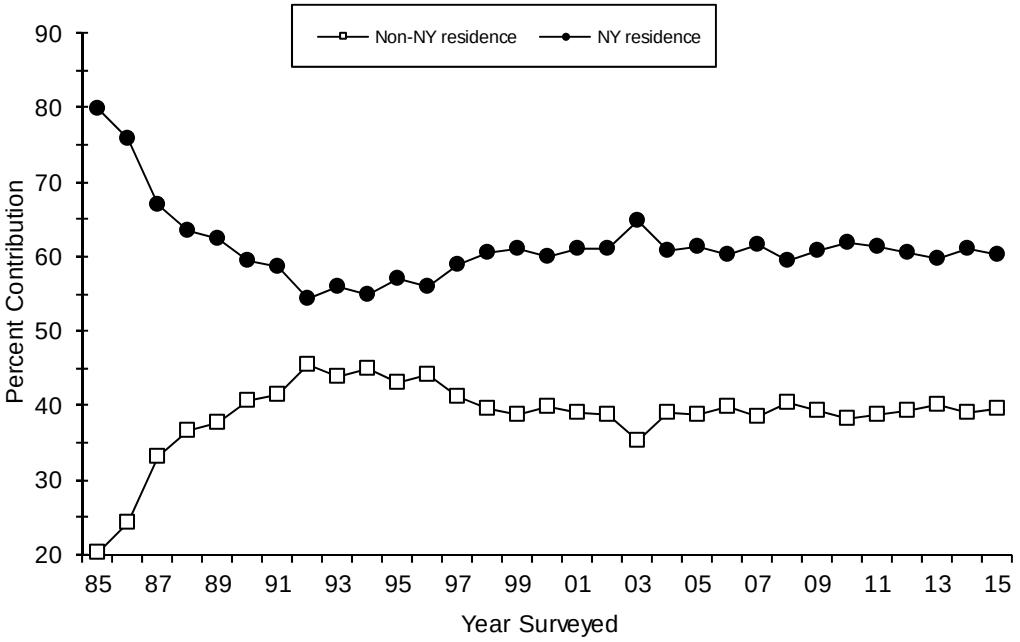

Figure 4. Percent contribution of anglers with and without New York state residency.

Table A4).

Throughout the 31-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). The percentage of NYS residents residing in the border counties declined in recent years, with 2014 and 2015 the lowest levels recorded (56.0% and 57.7%

of NY 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 15.7% of all NYS anglers interviewed in 2015 (Table A4). Other counties representing important components of the open lake boat fishery in 2015 were Oswego (13.1%), Wayne (9.4%), Niagara (9.1%), Onondaga (5.9%), Orleans (4.7%), and Erie (4.0%; Table A4).

Total Salmonines: Catch, Harvest and Fishing Quality

Catch and Harvest

Trout and salmon are the most sought after fish in Lake Ontario. The six species provide anglers with a diverse trout and salmon fishery throughout the open lake season and along the entire NY shoreline. This variety gives anglers the opportunity to target another species when their preferred target is not available. Total catch of all trout and salmon species was estimated at 154,411 (±26.4%) fish, the lowest estimated since 2008 (Figure 5, Table 1, Table A5a). Each year since 2003, Chinook salmon dominated trout and salmon catch (2015: 58,870 fish, 38.1% of total catch) and harvest (2015: 34,951 fish, 44.9% of total harvest). In most recent years, brown trout or rainbow trout represented the second most commonly caught and harvested species, and lake trout represented a relatively minor component of the fishery. In 2015, however, lake trout represented the second most commonly caught and harvested species (52,294 and 18,780 fish, respectively), representing 33.9% of catch and 24.1% of angler harvest (the highest percentages since 2002). Brown trout was the 3rd most commonly caught species, although the estimated catch (20,780 fish) was the lowest observed. Rainbow trout represented 11.3% of angler trout and salmon catch (17,509 fish, the lowest estimate since 2005). Coho salmon and Atlantic salmon each represented relatively small components of the fishery (2.8% and 0.4% of total, respectively).

In 2015, anglers harvested 50.4% of the catch, the second lowest percentage. Estimated salmonine harvest was 77,887 (±18.3%) fish, a 24.2% decrease comparable to the 2010-2014 average (Figure 5, Table 1, Table A5a). Reduced percent harvested and total numbers harvested is likely partly attributed to the reduced size of most trout and salmon species in 2015 (e.g., greater frequency of sublegal length fish and, among those of legally harvestable length, a desire for larger fish). The 2015 percent contributions of each species to the

Table 1. Harvest and catch estimates for April 15 – September 30, 2015 from the NYSDEC Lake Ontario fishing boat survey.

	Number Harvested	*Number Caught*
Coho salmon	2,078	4,260
Chinook salmon	34,951	58,870
Rainbow trout	9,212	17,509
Atlantic salmon	275	638
Brown trout	12,590	20,780
Lake trout	18,780	52,294
Smallmouth bass (includes pre-season)	2,942	16,821
Yellow perch	6,960	17,384
Walleye	350	446
Round goby	4,683	6,297
Other fish	93	1,630

total trout and salmon harvest were 44.9% Chinook salmon, 24.1% lake trout, 16.2% brown trout, 11.8% rainbow trout, 2.7% coho salmon, and 0.4% Atlantic salmon.

Fishing Quality

Each year trout and salmon catch rates vary by month and region and similar trends tend to occur each year. Fishing quality is influenced by many factors including, experience, water temperatures, recent wind patterns, lures used, depths fished, distance from shore, fish distribution, and species targeted. Quality experienced also varies with when (e.g., specific day, week, month, year) and where they are fishing (e.g., west, west/central, east/central, east). During 2015, there were periods and locations of excellent fishing quality and periods and locations of poor fishing quality. With the variety of trout and salmon species present in Lake Ontario, anglers were able to target another species when catch rates for their preferred target declined. This resulted in a good catch rate for all trout and salmon combined (3.3 fish per boat trip) in 2015; however, this relatively high rate is largely attributed to the high catch rate of lake trout (e.g., 1.1 lake trout per boat trip and the second highest in the entire data series). Species specific rates are discussed in greater detail in the species-specific sections of this report. In addition to determining catch rates, we evaluated other measures of fishing quality that indicated that fewer charter boats harvested their limit of fish in 2015 compared to recent years (see below).

The quality of trout and salmon fishing in Lake Ontario, as measured by catch rate of all species combined, 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 seven consecutive years (2009-2015) of record high trout and salmon catch rates. The catch per boat trip in 2015 was the sixth highest estimated in the survey (3.3 fish caught per boat trip) but a 15.0% decrease compared to the previous 5-year average (Figure 5, Table A5b). Ten of the eleven highest catch rates occurred between 2003 and 2015. During this time period anglers experienced high species-specific catch rates (Chinook salmon 2003-2015; coho salmon 2006-2007 and 2009-2012; rainbow trout 2008-2014; brown trout 2007, 2011-2012, and 2014; and lake trout 2013-2015). The 2015 total trout and salmon harvest rate for all boats targeting trout and salmon was 1.7 fish per boat trip, a 20.3% decrease compared to the 2010-2015 average harvest rate (Figure 5, Table A5b). Catch and harvest rate data (fish per boat trip) were also evaluated by month. In 2015, catch rate was above the previous 5-year average during May (+56.3%), but rates were below average during all other months (range: -41.4% [July] to -21.3% [April]; Table A5b).

In 2015, charter boats targeting trout and salmon accounted for 40.1% and 60.2% of all salmonines caught and harvested, respectively, but represented only 21.1% of trout and salmon fishing boat effort,

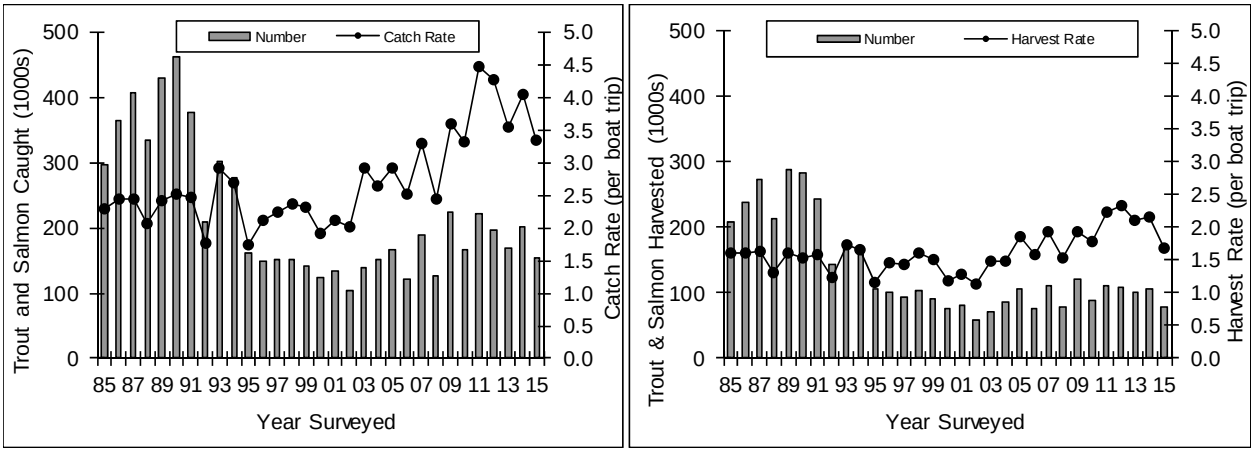

Figure 5. Total trout and salmon catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 – September 30, 1985 - 2015.

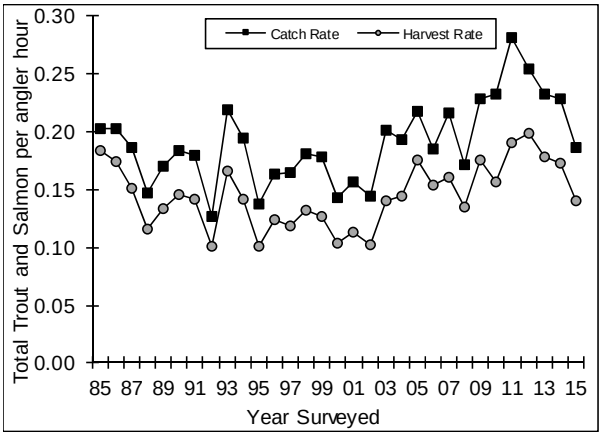

Figure 5c. Charter boat catch rate and harvest rate per angler hour for total trout and salmon, April 15 – September 30, 1985 - 2015.

35.7% of angler trips and 39.7% of angler hours directed at trout and salmon. Charter boat total trout and salmon catch rate (6.3 fish per boat trip) and harvest rate (4.8 fish per boat trip) were slight decreases compared to long-term averages (-7.5% and -7.7%, respectively) and nearly 19% below rates observed during the previous 10-years (Table A5b). Charter catch rate per angler hour was 0.19 salmonines, comparable to the longterm average (-2.6%) but a 17.3% decrease compared to the the previous 10-year average (Figure 5c; Table A5b).

Noncharter fishing boats caught an average of 2.5 salmonines per boat trip (0.18 fish caught per angler hour) in 2015, comparable to (+0.4%) the previous 10-year average (Table A5b). Among noncharter boats fishing for trout and salmon, the 2015 lake-wide harvest rate was 0.9 salmonines per boat trip, which was a 23.8% decrease compared to the previous 10-year average (Table A5b).

Additional metrics reflect angling quality, such as percentage of boats with zero catch (indicator of poor angling quality), and percentage of boats that harvested the maximum daily limit of trout or salmon (indicator of good angling quality; Table A6). These variables 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 catch or harvest at least one fish, and vice versa). 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 2015, 34.3% of boats targeting trout and salmon caught zero salmonines, the highest since 2010 indicating a worse quality of fishing compared to the previous 5 years. The ten years with the lowest proportions of boats with zero trout and salmon catch occurred since 2003. This indicates that, in recent years, fishing quality was good relative to the years prior to 2003.

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 three fish of coho salmon, Chinook salmon, rainbow trout or brown trout in combination; and no more than one Atlantic salmon (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).

Some variables examined did indicate that angling quality was lower in 2015. In 2015, only 5.8% of charter boats targeting trout and salmon harvested the maximum daily limit of the three in any combination species for their customers (i.e., coho salmon, Chinook salmon, rainbow trout, and/or brown trout (Table A6). This was the lowest percentage since 2002 and a 68.8% decrease compared to the previous 10-year average. Charter boat catch rate of these four species was also the lowest since 2002 and a 37.2% decrease compared to the record high levels during 2003-2014. The

highest percentage of charters with the maximum daily limit occurred in 2009, when 24.2% of all charter boats interviewed harvested the three in combination limit for their customers (i.e., indicating excellent fishing quality). Among all charter boat trips, 29.9% went on to harvest additional fish on the captain and mate licenses, but only 0.4% harvested the three in any combination limit for all anglers (i.e. fishing licenses) on the boat, which was the lowest since the regulation change to the three in any combination. Among noncharter boats fishing for trout and salmon in 2015, 0.8% harvested the maximum daily limit of three coho salmon, Chinook salmon, rainbow trout, or brown trout in combination, a 59.7% decrease compared to the previous 10-year average.

Limits of lake trout were consistently less common than aggregate limits for the other four species through 2014. In 2015, however, 11.1% of charter boats interviewed harvested the legal limit of lake trout for their customers (compared to only 5.8% with the limit of the three in any combination species; Table A6). Of the charter boats that harvested the legal limit of lake trout for their customers, 48.6% went on to harvest additional lake trout on the captain and mate licenses, and 3.6% of charter boats harvested the limit for all anglers (3.6% of all charter boat trips). Among noncharter boats, 0.2% harvested the maximum daily limit of lake trout in 2015.

In 2012 and 2013, some charter boat trips harvested the limit of lake trout and the three fish in any combination for each angler in the charter party (147 and 234 trips, respectively), none did so in 2014, but 14 boats did in 2015. No boats interviewed during 1997-2015 harvested the maximum aggregate limit of lake trout, Atlantic salmon and the three fish in any combination, including charter boats when counting only the charter party as potential anglers (i.e. excluding captains and mates).

Coho Salmon

Catch and Harvest

In 2015, coho salmon was the fifth most commonly caught and harvested salmonine in the boat fishery (2.8% and 2.7% of total catch and harvest, respectively; Table 1, Table A7a). Estimated coho salmon catch (4,260 [±44.3%] fish) in 2015 was a 67.2% decrease compared to the long-term average (1985-2013; Figure 6). Approximately 49% of coho salmon caught were harvested. Coho salmon harvest in 2015 was an estimated 2,078 (±65.0%) fish and a 78.0% decrease compared to the long-term average (Figure 6, Table A7a). During 2015, estimated catch of coho salmon was below the long-term average each month April through September (range: -93.6% [June] to -29.2% [September]; Table A7a).

Fishing Quality

Coho salmon catch rates and harvest rates were excellent during six of the ten years from 2006-2015 (Table 7b, Figure 6, Figure 6b). In 2015, coho salmon catch rate (0.09 fish per boat trip) was the lowest since 2004 and a 43.8% decrease compared to the long-term average (Figure 6, Table A7b). Harvest rate (0.05 fish per boat trip) was also a decrease compared to (-61.4%) the long-term average. In 2015, charter boats targeting trout and salmon caught 35.0% of the coho salmon caught by trout and salmon fishing boats. Among charter boats, coho salmon catch and harvest rates (0.004 and 0.003 fish per angler hour, respectively) were well below long-term averages (-56.8% and -62.9%, respectively; Figure 6b, Table A7b). Among noncharter boats, the 2015 catch and harvest rates were 0.005 and 0.002 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; Figures 6c and 6d). For the eighteenth consecutive year, the west area experienced the highest coho salmon catch rate among all regions (0.19 fish per boat trip), however, catch rates were below long-term averages in all areas surveyed (range: -89.1% [west/central] to -55.9% [east/central]; Figure 6d). The lowest coho salmon catch rate occurred in the west/central area (0.04 fish per boat trip; a 78.9% decrease compared to the long-term average; Figure 6d). Although highest in April and May (0.20 and 0.14 per boat trip, respectively; Figure 6c), coho salmon catch rates per boat trip were well below respective long-

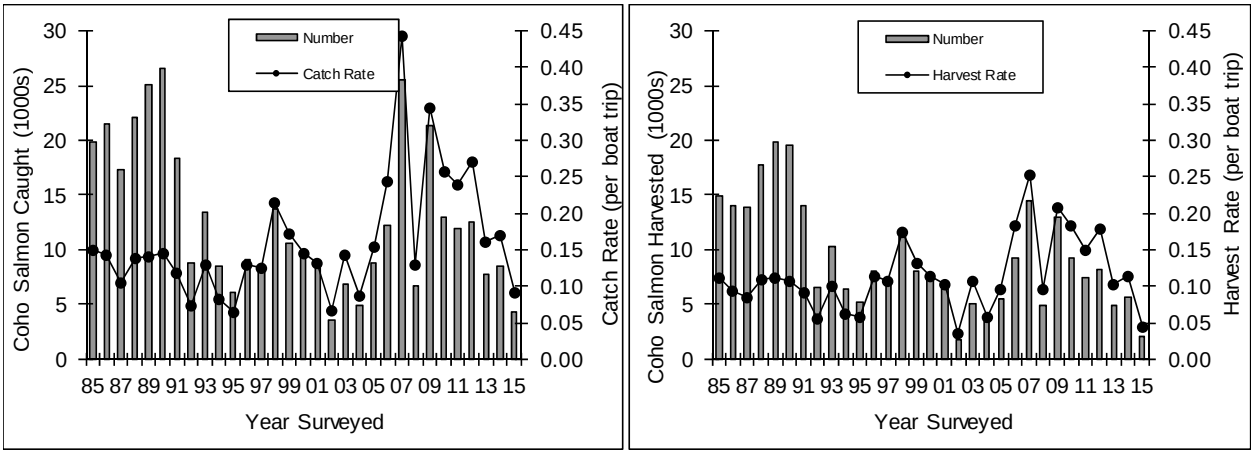

Figure 6. Total coho salmon catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 – September 30, 1985-2015.

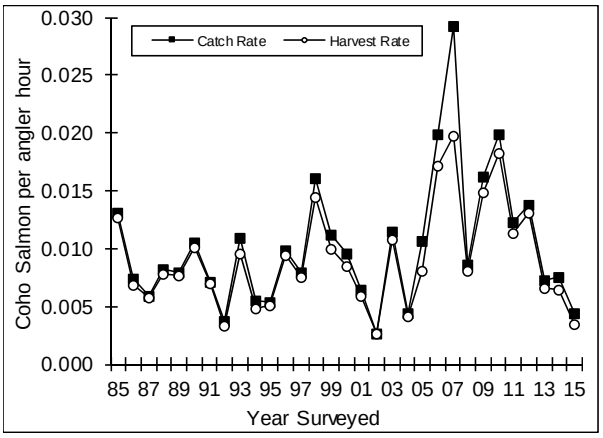

Figure 6b. Charter boat catch rate and harvest rate per angler hour for coho salmon, April 15 – September 30, 1985-2015.

term averages each month April - August (range: -89.6% [June] to -38.4% [May]; Table A7b).

Biological Data

Biological data analysis presented below includes fish processed during April 15 - September 30 (length: 1985-2015, weight: 1988-2015, scale samples for age determination: 2000-2015). Coho salmon scale samples for aging were not collected regularly until 2000. To determine percent contribution by age for 1985-1999, we assigned age to fish of unknown age (i.e., fish processed 1985-1999) using monthly length frequency distributions from fish of unknown age, and age and length data from fish of known age (i.e., those sampled after 1999). Ages of coho salmon for which no scale samples were collected during 2000-2015, were determined using monthly length frequency distributions, and age and length data derived from fish aged by scales collected in the respective year.

During spring 2015, many anglers remarked that the coho caught seemed small, and release rates were relatively high, likely due to sub-legal fish. In most years, age-2 coho salmon harvested in April and May average 18-22 inches in length and the number of coho salmon processed for biological information is reasonable. In 2015, coho salmon catch and harvest rates were very low and very few were processed for biological data during this survey (n=38 fish). During April 15 - July 31, 2015, only two coho salmon were processed (one in April, one in July) and both were small. The fish processed in April was 14.1 inches long, well below lengths recorded in previous years and shorter than the minimum length regulation of 15 inches. The coho salmon processed in July was 18.6 inches, well below average lengths typically recorded for July (approximately 24 to >26 inches total length).

Typically, we evaluate growth over 5.5 months, however, this was not possible in 2015 because 36 of the 38 fish processed were from August and September. The average lengths of age-2 coho salmon in August and September (both averages = 24.1 inches) in 2015 were the shortest recorded in the data series for those months, which typically

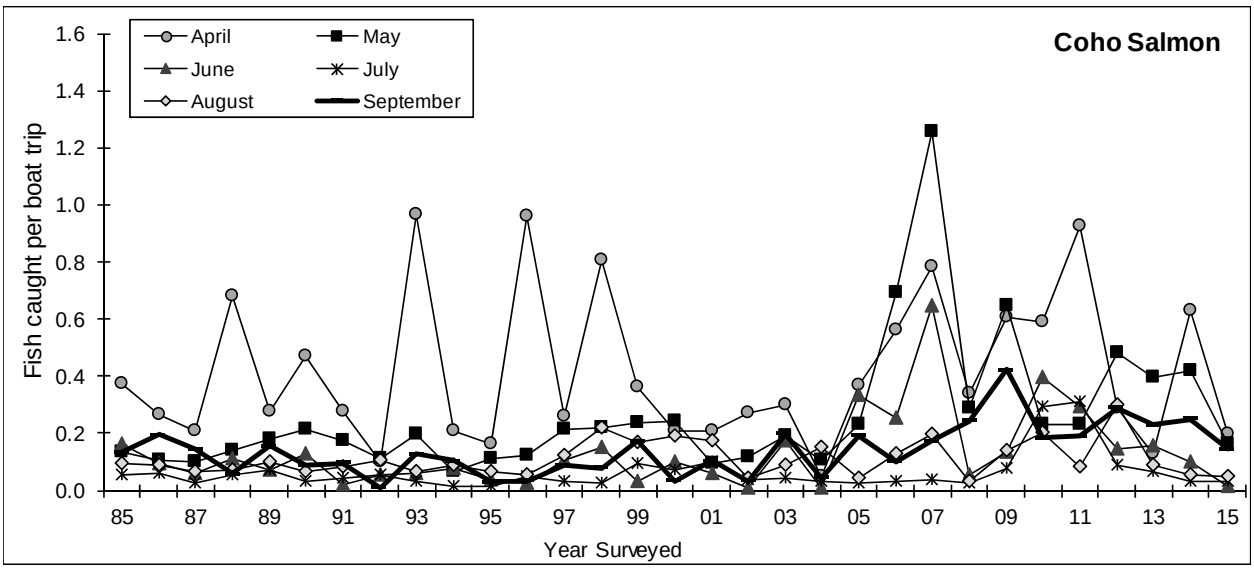

Figure 6c. Coho salmon caught per boat trip April through September, 1985-2015. Note: Catch rate varied by region within each month surveyed.

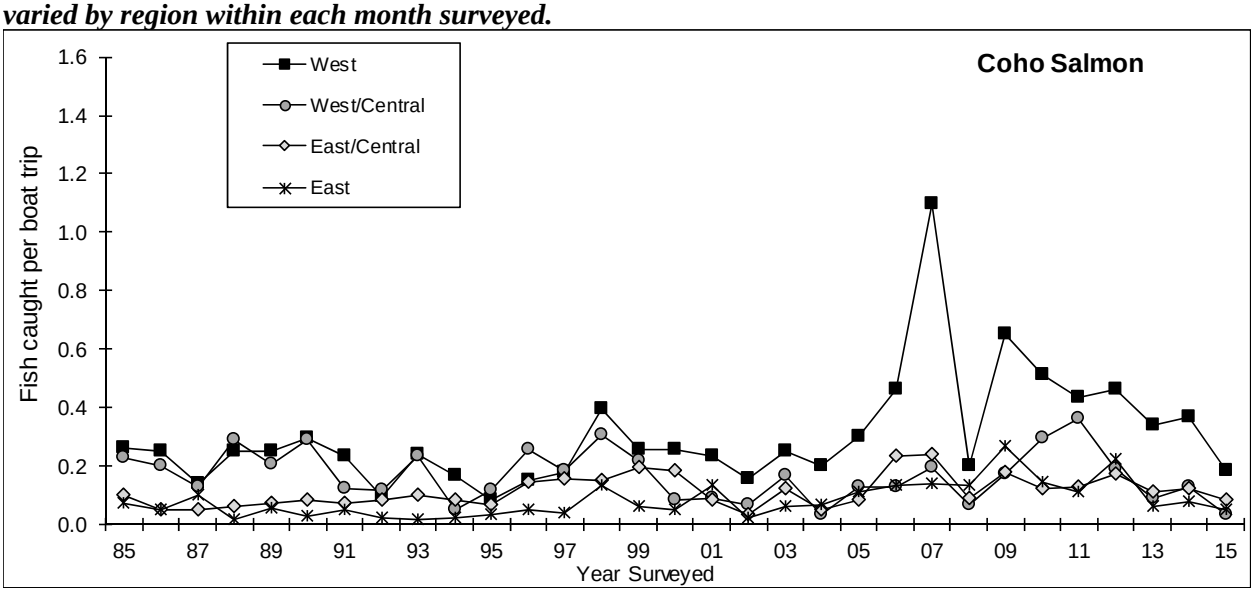

Figure 6d. Coho salmon caught per boat trip in the west, west/central, east/central and east areas surveyed, April 15 – September 30, 1985-2015. Note: Catch rate varied by month within each area surveyed.

average 26 and 29 inches total length, respectively. Two consecutive long, cold winters (2013/2014 and 2014/2015) followed by below average water temperatures during summers of 2014 and 2015 likely contributed to reduced metabolism and growth of coho salmon, resulting in shorter fish as compared to previous years.

Each year, the majority (>73.8%) of coho salmon harvested in the open lake were age 2 (31-year average = 95.5% of those harvested were age 2; Table A8). For the second consecutive year, 100.0% of coho salmon sampled in 2015 were age 2 (2013 was the first). There were no age-1 coho sampled during 2010-2015. This was the seventh occurrence of zero age-1s observed during this survey. Harvest of age 1s is influenced by harvest regulations (i.e., 15 inch minimum harvestable size). Additionally, most anglers prefer to release the smaller age-1 fish even when they are longer

than 15 inches. The contribution of age-3 coho salmon in angler harvest is small and represented ≤2.0% of harvest for 26 out of 31 years surveyed.

Despite the smaller size of coho salmon in 2015, condition ("plumpness") of those fish was within the range of values observed over the time series. Condition indices for coho salmon in 2015, as determined from predicted weights of standard length fish, were comparable to previous 27-year averages for smaller sized fish (1988-2014; range: +1.0% [18-in] to +5.8% [20-in]), but were above average for larger sized fish (1988-2014; range: +10.4% [22-in] to +26.4% [30-in]; Table A8). Good condition of the coho salmon sampled indicated sufficient prey availability during the open lake season.

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 20 of the 31 years surveyed. From 1985-2002 Chinook salmon represented an average of 28.3% of the total salmonid catch among trout and salmon boats. From 2003-2014, 46.0% of all salmonines caught were Chinook salmon. In 2015, Chinook salmon catch was an estimated 58,870 fish (±28.9%), representing 38.1% of the total salmonine catch (Figure 7, Table 1, Table A9a).

Of Chinook salmon caught in 2015, 59.4% 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 quality on Lake Ontario and the percentage of Chinook salmon harvested (2003-2015 average percent harvest=58.8%) was 20.4% 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 2015 was estimated at 34,951 Chinook salmon (±24.4%), which represented 44.9% of the total salmonine harvest (Figure 7, Table 1, Table A9a).

Typically, the majority of the Chinook salmon catch and harvest occurs during August (Table A9a), however, in 2015 the highest estimated catch occurred in May (18,854), a 54.6% increase compared to the long-term average. Catch estimates were well below respective monthly averages for all other months (range: -87.2% [April] to -22.1% [July]). The highest regional contribution of Chinook salmon catch typically occurs in the west area (27 of 30 years 1985-2014). In 2015, estimated catch was again highest in the west area (28,640 fish, 48.6% of all Chinook salmon caught), however, the estimate for that area was an 18.0% decrease compared to the long-term average. Estimated catches for the other areas surveyed were also below average (Table A9a).

Fishing Quality

The highest Chinook salmon fishing quality occurred the last 13 consecutive years (2003-2015; Figure 7, Figure 7b, Table A9b). From 1985-2002 catch rate of Chinook salmon per boat trip for all trout and salmon boats was variable and without trend, but beginning in 2003 lake-wide catch rates averaged more than 2.3-fold higher than those observed in years prior to 2003. The 2015 lake-wide catch rate among all boats fishing for trout and salmon was 1.3 Chinook salmon per boat trip, a 16.2% decrease compared to the previous 10-year average and 28.6% above the long-term average (Figure 7, Table A9b).

In 2015, charter boats targeting trout and salmon caught 39.4% of the Chinook salmon caught by all trout and salmon anglers. Among charter boats, the 2015 Chinook salmon catch rate was 2.4 fish per boat trip, a 26.1% decrease compared to the previous 10-year average but comparable to (+3.7%) the long-term average (Table A9b). Chinook salmon 5.5-month lake-wide catch rates (charter boat catch per angler hour) were at the highest levels during 2003-2015 (average = 0.9; Fig. 4). The 2015 catch rate (0.07), however, was the lowest estimated during this time period, and a 25.6% decrease compared to the 2003-2014 average (Figure 7b). Among noncharter boats, the

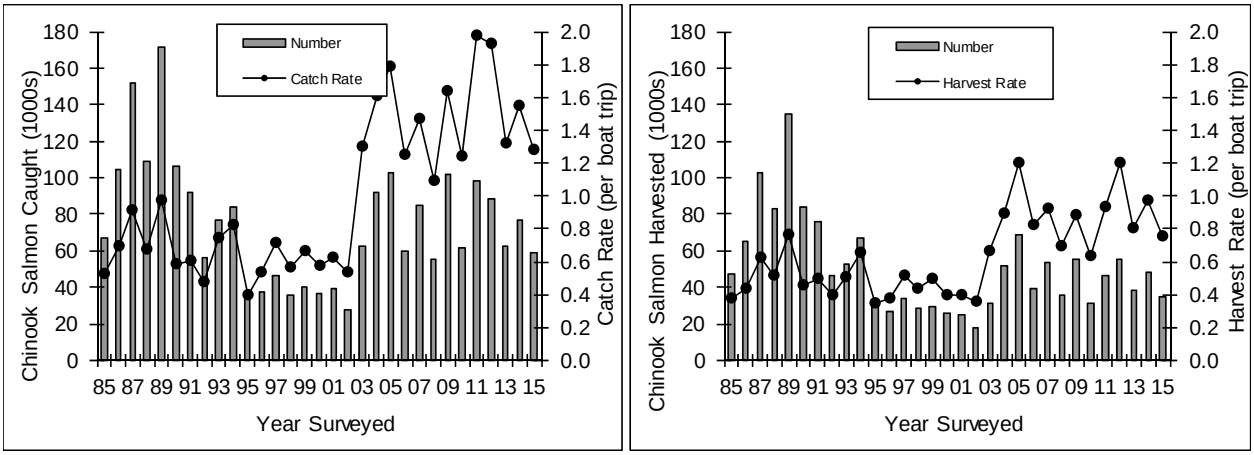

Figure 7. Total Chinook Salmon catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 - September 30, 1985-2015.

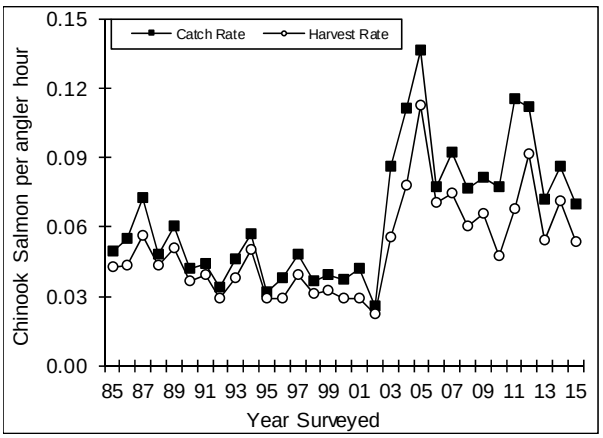

Figure 7b. Charter boat catch rate and harvest rate per angler hour for Chinook salmon, April 15 – September 30, 1985-2015.

2015 catch rate was 1.0 Chinook salmon per boat trip and 0.07 per angler hour, which were decreases (-16.5% and -17.9%, respectively) compared to previous 10-year averages (Table A9b).

Similar to catch rates, the highest Chinook salmon harvest rates occurred during 2003-2015 (i.e., an average of 84.4% higher than those prior to 2003; 1985-2002 average = 0.48 fish per boat trip, 2003-2015 average = 0.88; Figure 7, Figure 7b, Table A9b). The 2015 lake-wide harvest rate among boats seeking trout and salmon was 0.8 Chinook salmon per boat trip, a 16.5% decrease compared to the previous 10-year average (Figure 7, Table A9b). Among charter boats, the 2015 harvest rate (1.8 Chinook salmon per boat trip) was a 26.6% decrease compared to the previous 10-year average (Figure 7b, Table A9b). Charter boats harvested 0.05 Chinook salmon per angler hour in 2015 (Figure 7b). Among noncharter boats, the harvest rate was 0.47 Chinook salmon per boat trip, a 20.5% decrease compared to the previous 10-year average (Table A9b).

As with other salmonids, Chinook salmon catch rates vary by region and season. Typically, April-June catch rates of Chinook salmon in the western half of the lake are relatively higher than those toward the eastern half (Lantry and Eckert 2011; Figures 7c and 7d). For the rest of year and in all areas, Chinook salmon catch rates are typically higher than in the spring. These higher rates last into early September in some years. It is important to note that Chinook salmon fishing quality in 2015 was highly dependent on where and when anglers were fishing. While chartered anglers have experienced good to excellent fishing quality (i.e., catch rate = charter boat catch per angler hour) in recent years, Chinook salmon catch rates declined in most months and lake areas during 2015. The 5.5 month average catch rate was positively influenced by good to excellent fishing during May in all areas, particularly the west area, where excellent catch rates strongly influenced the overall average rate.

The 2015, Chinook salmon catch rate in the west area was comparable to (+3.7%) the previous 10-year average (Figure 7d). For only the fourth time

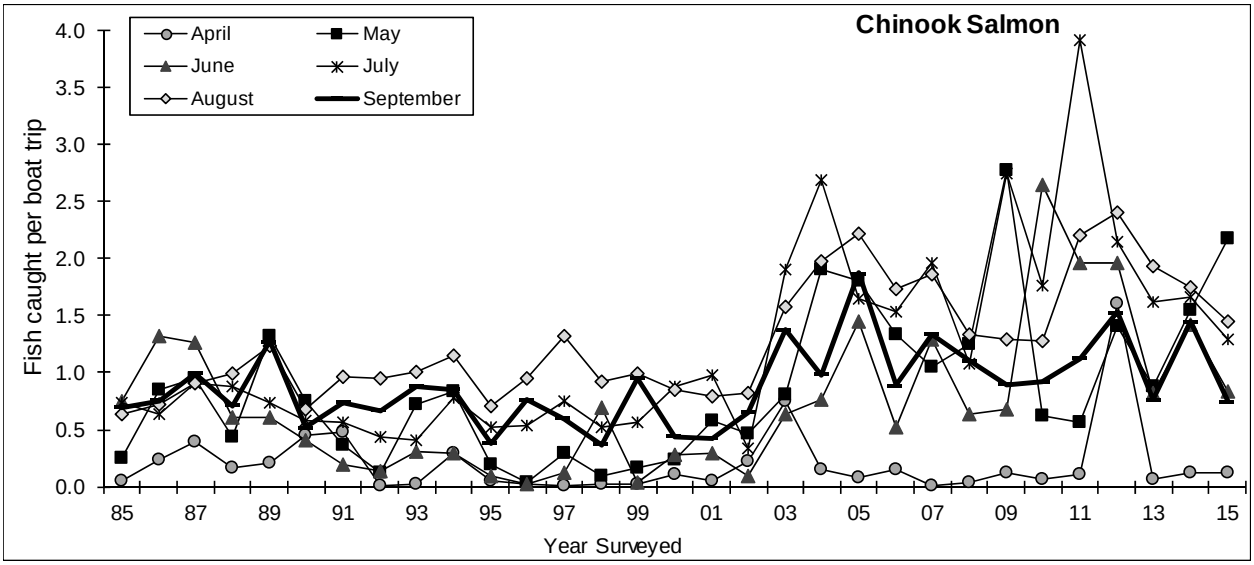

Figure 7c. Chinook salmon caught per boat trip April through September, 1985-2015. Note: Catch rate varied by month within each area surveyed.

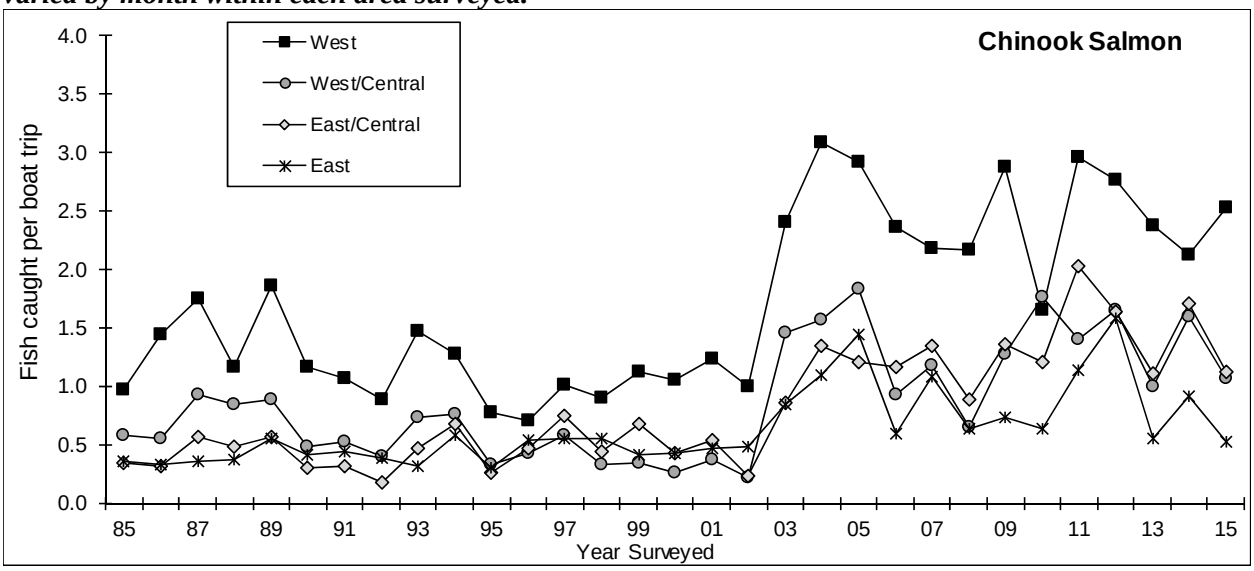

Figure 7d. Chinook salmon caught per boat trip in the west, west/central, east/central and east areas surveyed, April 15 – September 30, 1985-2015. Note: Catch rate varied by month within each area surveyed.

in the 31 years surveyed, the highest Chinook salmon catch rate occurred in May (2.2 Chinook salmon caught per boat trip), when the rate was a 64.6% increase compared to the previous 10-year average (Figure 7c). Monthly west area catch rates were well below respective previous 10-year averages for all other months (range: -50.8% [April] to -19.8% [August]; Table A9b, Figure 7c). Catch rates were below respective previous 10-year averages for the other areas surveyed (range: -43.0% [east] to -17.3% [east/central]).

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 (length: 1985-2015, weight: 1988-2015, scale samples for age determination: 1991-2015). Chinook salmon scale samples for aging were not collected regularly until 1991. To determine

percent contribution by age for fish processed 1985-1990, we assigned age to fish of unknown age (i.e., Chinook salmon processed 1985-1990) using monthly length frequency distributions from fish of unknown age, and age and length data from fish of known age (i.e., those sampled in the early 1990s). Ages of Chinook salmon for which no scale samples were collected during 1991-2015, were determined using monthly length frequency distributions, and age and length data derived from fish aged by scales collected in the respective year.

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. For 28 of the 31 years surveyed, Chinook salmon sampled from angler harvest were dominated by age-2 and age-3 fish (1985-2015 averages: age 2 = 38.7%, age 3 = 47.1% of fish sampled; Table A10). In 2015, angler harvest consisted of 46.5% age-2 fish and 49.1% age-3 fish. Ages 1 and 4 typically represent small components of angler harvest. In 2015, 3.7% of Chinook salmon processed were age 1, the sixth lowest in the data series. The oldest Chinook salmon sampled in Lake Ontario are age-4 and comprised a small percentage of the total Chinook salmon sampled in 2015 (n=3 or 0.7% of all Chinooks processed; Table A10). 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.

To evaluate Chinook salmon growth, we determined mean length-at-age by month for samples collected July through September (data collected from 1991-2015; Figure A1, Table A11). Growth was good to excellent in 2010-2013, however, was below average in 2015. Age-1 Chinook salmon were well below average length and among the shortest recorded each month July-September. The 2015 August mean length of age-1 fish was 17.3 inches, 2.5 inches shorter than the long-term (1991-2014) mean and the shortest ever recorded. Of the 18 age-1 fish processed during July-September 2015, the largest was just 22.1 inches long (5.2 lbs). The shorter length of age-1s in 2015 likely contributed to the low contribution of that age in angler harvest (i.e., fewer Chinook may have been of minimum harvestable size during a portion of the year).

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 declined each year since, falling to 29.4 inches in 2015 and 1.2 inches shorter than the long-term average (Figure A1, Table A11). Mean length of age 3s was also below average in 2015 (August mean 35.9 in, 0.9 in shorter than the long-term mean). The shorter length of Chinook salmon in 2015 is likely attributed primarily to the two consecutive long and cold winters (2013-2014 and 2014-2015) followed by below average temperatures the following summers.

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 1988-2015 (Table A10) and showed no statistically significant trends over the 28-year data series. Predicted weights of Chinook salmon calculated in 2015 were within the range of values observed for previous years for all lengths evaluated. Estimates for the three smallest lengths were all slightly below their respective long-term averages (range: -5.5% [16-in] to -1.5% [24.0-in]; Table A10). Predicted weight of a 28 inch fish was equal to (0.0% change) the long-term average. Predicted weights for the three longest lengths evaluated were above respective long-term averages (range: +1.3% [32-in] to +3.6% [40-in]). These results indicate that the recent long, cold winters may have negatively impacted growth in length, however, the good condition of Chinook salmon >28 inches indicates that alewife (the primary forage of Chinook salmon; Lantry 2001) abundance was sufficient to maintain Chinook weight.

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 and Forestry (OMNRF) initiated a Chinook salmon mass marking program beginning with the 2008 stockings (Connerton et al. 2011). 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 2008-2011 and 2013 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. (e.g., 2011, 2016) report results of the Chinook salmon mass-marking program as determined from data collected during the Lake Ontario Fishing Boat Survey and additional sampling efforts conducted in New York and Ontario waters. Determination of the contribution of wild Chinook salmon to the fishery was completed in 2015. Among the year classes studied (2008-2011), wild Chinook were an important component of the Lake Ontario fishery averaging 47% of the age-2 and -3 Chinooks harvested in the lake from 2010-2014. Preliminary results of pen-reared vs. traditional shore stocking evaluations indicated that the 2010 and 2011 Chinook salmon year classes stocked into pens had relatively higher contributions to the lake harvest than their shore-stocked counterparts (about 2:1). More detailed discussions of the mass marking program, methods, and 2010-2015 results of open lake and tributary collections are reported in Connerton et al. (2016).

Stocking Level Verses Relative Harvest

To permit between year comparisons of harvest-at-age data, we calculated age-specific harvest rates, hereafter termed relative harvest (age-specific numbers of Chinook salmon harvested per 50,000 boat trips April 15 - September 30; Table A12). Relative harvest is now calculated as the age-specific number of Chinook salmon harvest per 50,000 boat trips (i.e., as compared to adjustments of harvest to 150,000 boat trips reported previously; e.g., Eckert 2007, Lantry and Eckert 2015) because estimated fishing effort was near approximately 50,000 boat trips for more than a decade, and is not expected to increase to the relatively high levels observed in earlier surveys (Figure 2). Determination of percent contribution by age of Chinook salmon harvested during 1985-2015 was described above.

Chinook salmon relative harvest (harvest per 50,000 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 (1984-2011 year classes) varied from a high of 74,929 fish for the 2010 year class (harvested at ages 1 to 4 from 2011 to 2014, respectively) to a low of 6,832 fish for the 1994 year class (harvested at ages 1 to 4 from 1995 to 1998, respectively), a 10.9 fold difference (Table A12). By comparison, survey year-specific total relative harvest (1985-2015 survey years) varied from the high of 59,952 fish in 2005 to a low of 17,371 fish in 1995, only a 3.5 fold difference. Thirteen of the fifteen highest total relative harvest estimates occurred during 2003-2015 (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 2009-2012. These year classes contributed to the some of the 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] fish stocked; Table A12, Table A13). Stocking levels varied from 862,840 (1981 year class) and 3,368,296 (1987 year class) fingerling equivalents. The 2015 relative harvest (37,873 fish) was the eleventh highest in the 31-year data series (Table A12). To date, returns of age-1 to age-4 fish from the 2010 year class was the highest on record (74,929 fish) and was 10.9% higher than returns of the 2002 year class (67,570 fish and the previous record high; Table A12).

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).

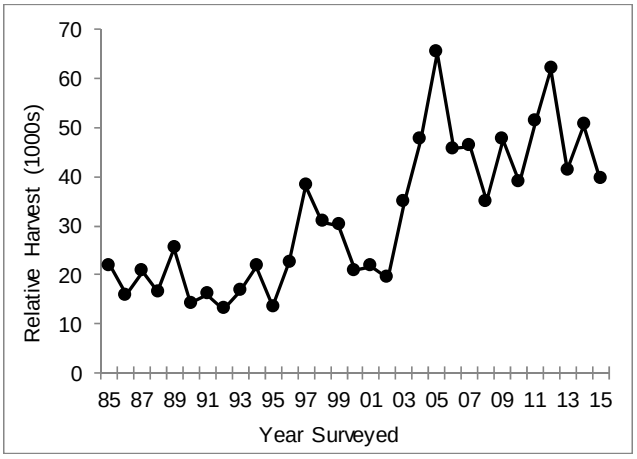

Figure 8. Relative harvest of Chinook salmon per 50,000 boat trips targeting trout and salmon, per 2,000,000 fingerling equivalents stocked.

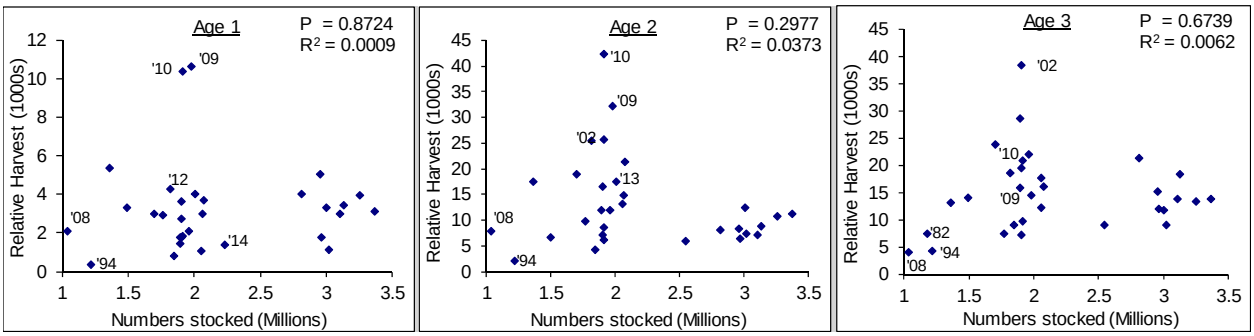

Figure 9. Number of fingerling equivalents stocked and relative harvest of age-1 (1984-2014 year classes), age-2 (1983-2013 year classes), and age-3 (1982-2012 year classes) Chinook salmon.

Regression analysis of 1985-2015 data resulted in a 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 (e.g., improved surivival of pen-reared fish; Connerton et al. 2016) 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, 2009-2010, and 2012 year classes), and age 3s (2002-2004, 2006, 2010 and 2012 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=0.8724 and R^2=0.0009), age 2 (P=0.2977 and R^2=0.0373), or age 3 (P=0.6739 and R^2=0.0062; 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 1993-2014 year classes (1.04-2.23 million fingerling equivalents stocked; Figure 9, Table A13). The lowest and highest age-1 (1994 and 2010 year classes, respectively) and age-2 (1994 and 2010 year classes, respectively) relative harvest estimates occurred after the 1993 stocking cuts. For age-3s the lowest relative harvest occurred before stocking cuts (1989 year class) but the highest (2002 year class) occurred after the 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 of the 2008 year class (4,041 fish) was the lowest in the data series and relative harvest at age 4 (99 fish) was the fourth lowest. The 2008 year class were among the fastest growing fish in the data series as indicated by mean size at age 2 (2010) and age 3 (2011; Figure A1).

Based on relative harvest, the 2009 and 2010 year classes were two of the strongest produced (Figure 9, Table A12). Relative harvest estimates for the 2009 year class at age 1 (10,663 fish) was the highest in the data series, and at age 2 (32,236 fish) was the second highest in the data series. Relative harvest of the 2009 year class at age 3 (14,404 fish) was the fourteenth highest.

The 2010 year class performed similar to the 2009 year class, in that relative harvest estimate at age 1 (10,398 fish) was the second highest in the data series, and the age 2 estimate (42,386 fish) was the highest for that age. Relative harvest of the 2010 year class at age 3 (20,939 fish) was the sixth highest. The Salmon River wild young-of-year Chinook salmon seining program indicated possible production of a strong 2010 year class. 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 (shore stocked and/or pen reared fish; Connerton et al. 2016), 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 ten were significant (p-values$\leq$0.0373). The R^2 values for these relationships ranged between 0.4523 and 0.9731, indicating that although some of the variation could be accounted for, approximately 3%-54% 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 allows us to estimate relative survival of stocked fish (e.g., shore stocked vs. pen reared fish) and the contribution of wild fish to the population and the fishery (see Connerton et al. 2016). This information is needed to better manage Lake Ontario's fishery.

Rainbow Trout

Catch and Harvest

Rainbow trout was the fourth most commonly caught and harvested salmonine in 2015, and represented 11.3% and 11.8% 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 the early 2000s, then improved. Rainbow trout catch in 2015 was an estimated 17,509 ($\pm$29.3%) fish, a 49.9% decrease compared to the long-term average. Anglers harvested 9,212 ($\pm$ 33.7%) rainbow trout (52.6% of those caught), a 58.7% decrease compared to the long-term average. These were the lowest catch and harvest estimates since prior to the October 1, 2006 regulation change that increased the minimum harvestable size from 15 in to 21 in. Reduced catches of rainbow trout may have been due to a reduced population size in the lake during the 2015 open lake season. A prolonged rainbow trout mortality event attributed to thiamine deficiency occurred in the Salmon River, NY beginning as early as November 2014

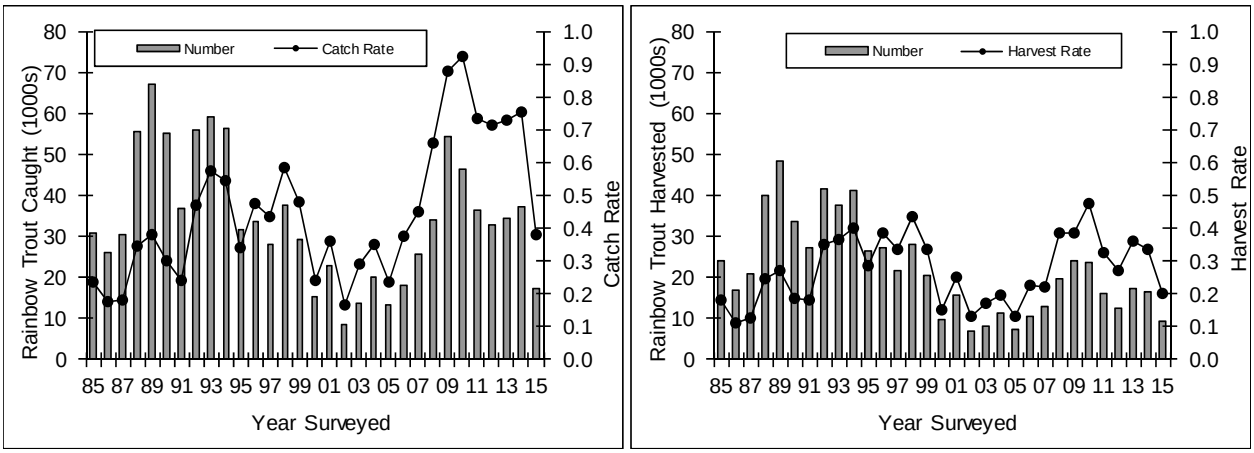

Figure 10. Total rainbow trout catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 - September 30, 1985-2015.

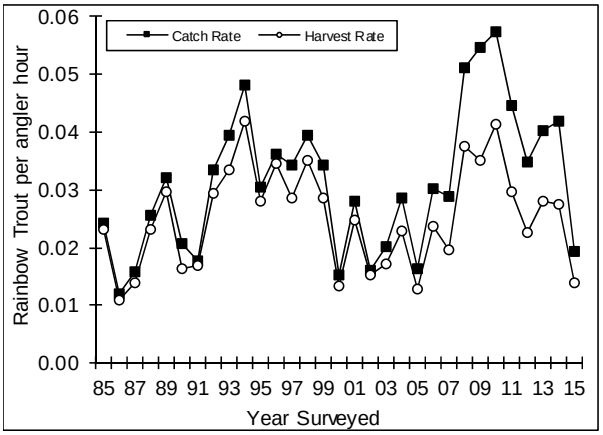

Figure 10b. Charter boat catch rate and harvest rate per angler hour for rainbow trout, April 15 – September 30, 1985-2015.

and lasting through much of the winter. This event and possibly additional mortality in the lake may have reduced the numbers of rainbow trout in the lake. The rainbow trout run at the Ganaraska Fishway in Ontario has traditionally been used as an index of abundance, which was markedly lower in spring 2014 and 2015 (ONMRF 2016).

For 30 consecutive years (1986-2015), the majority of rainbow trout caught and harvested were in the west area (Lantry and Eckert 2011, Table 14a). In 2015, 56.5% of all rainbow trout caught and 66.7% of those harvested were from the west area. In 2015, the majority of rainbow trout catch (32.6% and harvest occurred during August (42.1; Table A14a).

Fishing Quality

For seven consecutive years (2008-2014), anglers experienced the highest rainbow trout catch per boat trip in the history of the survey. The 2015 rainbow trout catch rate (0.38 fish per boat trip) was the lowest since 2006 and was a 50.9% decrease compared to the previous 5-year average (i.e., years of the highest rates on record), and a 16.5% decrease compared to the long-term average (Figure 10, Table A14b). In 2015, charter boats caught 36.8% of all rainbow trout caught by trout and salmon boats. Charter boats caught 0.66 rainbow trout per boat trip (0.02 per angler hour), the lowest since 2005 and a 42.6% decrease compared to the long-term average (Figure 10b). Catch rates also declined among noncharter boats to the lowest levels since 2006 (0.3 rainbow trout per boat trip and 0.02 fish per angler hour in 2015; Table A14b).

The 2015 lake-wide harvest rate among all boats fishing for trout and salmon (0.2 rainbow trout per boat trip) was a 27.3% decrease compared to the long-term average (Figure 10, Table A14b). Among charter boats fishing for trout and salmon, the harvest rate was 0.47 rainbow trout per boat trip (Table A14b). Charter boats harvested 0.01

rainbow trout per angler hour (Figure 10b), a 45.7% decrease compared to the long-term average. Among noncharter boats fishing for trout and salmon, the harvest rate was 0.13 rainbow trout per boat trip (0.02 fish per angler hour) which was 19.1% below 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; Figures 10c and 10d). As compared to the previous 5-year averages, the 2015 rainbow trout catch rate was average in May (-3.3%), but below average during all other months (range: -60.2% [July] to -23.6% [April]; Table A14b). Regional catch rates were

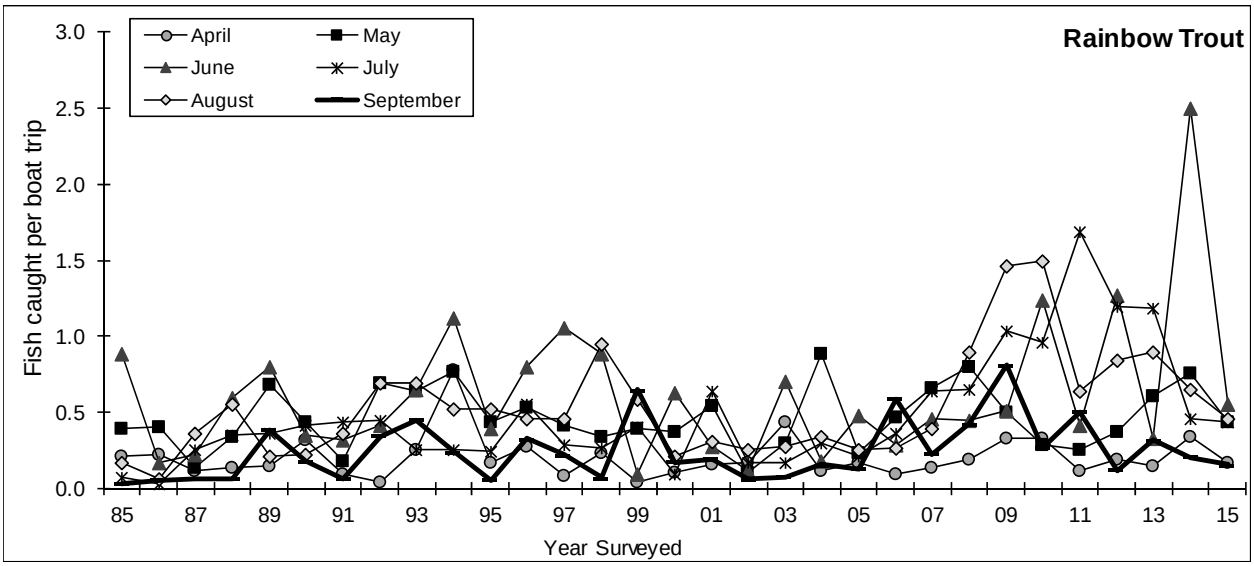

Figure 10c. Rainbow trout caught per boat trip April through September, 1985-2015. Note: Catch rate varied by month within each area surveyed.

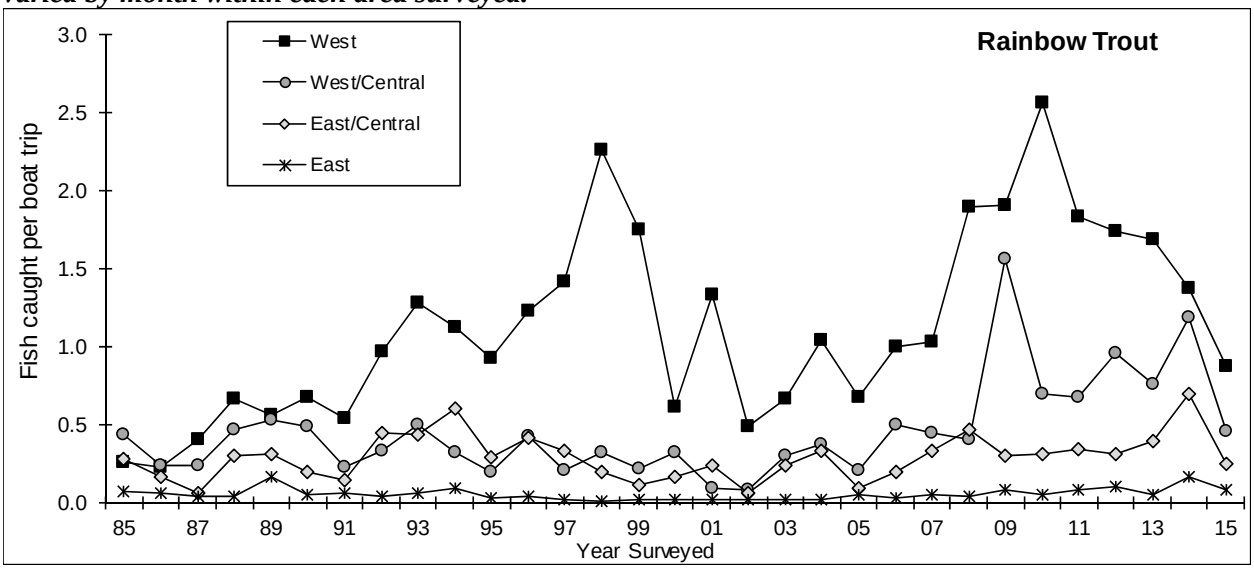

Figure 10d. Rainbow trout caught per boat trip in the west, west/central, east/central and east areas surveyed, April 15 – September 30, 1985-2015. Note: Catch rate varied by month within each area surveyed.

average in the east (-2.7%), but below average in the west, west/central, and east/central (range: -52.5 [west] to -39.2% [east/central]; Figure 10d).

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 (length: 1985-2015, weight: 1988-2015). Scale samples were collected from rainbow trout processed for biological data each year 1996-2015; however, they are not yet aged. 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 2015 open lake season was the ninth affected by the increased minimum harvestable length of rainbow trout from 15 in to 21 in. The average percent contribution of fish <21.0 in for the nine years since the regulation (2007-2015) was 10.5%, and significantly lower than the previous nine years (1998-2006) when 16.5% of rainbow trout processed were <21.0 in (Chi-square analysis: $X^2 = 30.877 > \chi^2_{[1](.005)} = 7.879$). During 2015, 7.84% of harvested rainbow trout were below the legal 21 in minimum harvestable size.

Weight data were collected each year from 1988-2015 and rainbow trout condition was calculated as 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 2015, condition of rainbow trout was below average for all size groups evaluated.

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 2009-2015, and in addition to the NYSDEC stockings, the USGS Tunison Laboratory of Aquatic Sciences reared and conducted experimental stockings of Atlantic salmon (Connerton 2010, 2016).

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 80 fish per year and catch estimates of less than 250 fish per year (Figure 11, Table A16; Lantry and Eckert 2010). Beginning in 2009, and before initiation of the creel survey, anecdotal reports indicated that anglers were catching Atlantic salmon in greater frequency than in the previous decade. For three consecutive years (2009-2011), estimated lake-wide catch and harvest were the highest since 1994 (Figure 11, Table A16).

Fewer Atlantic salmon were caught and harvested 2012-2015 than during 2009-2011, however, estimates remained well above 1995-2008 levels. During 2015, estimated catch (638 ±57.8%) was a 97.8% increase compared to the 1995-2008 time period when estimated catch was the lowest on record (Figure 11, Table 1, Table A16). Anglers harvested an estimated 275 [±97.1%] Atlantic salmon in 2015. The 2015 Atlantic salmon catch rate (1.4 fish per 100 boat trips seeking trout and salmon) was comparable to levels observed during

the late 1980s-early 1990s and was more than 2.8-fold higher than the 1995-2008 average rate (average = 0.48 per 100 boat trips). Harvest rate in 2015 (0.60 fish per 100 boat trips seeking trout and salmon) was 5.3-fold 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, young-of-year Atlantic salmon were captured in the Salmon River each year 2009-2011 and 2013 (none were captured in 2014 or 2015; 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 OMNRF to restore self-sustaining populations of Atlantic salmon in several Lake Ontario tributaries included increased stocking levels beginning in 2006. To date, the contribution of the enhanced stocking by OMNRF 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. For 2012-2014, the numbers of fish sampled for genetic analysis during this survey was very low (n=10, 4, and 10, respectively), but results indicated that a portion of those were from the OMNRF stockings (Chris Wilson, OMNRF, personal communication).

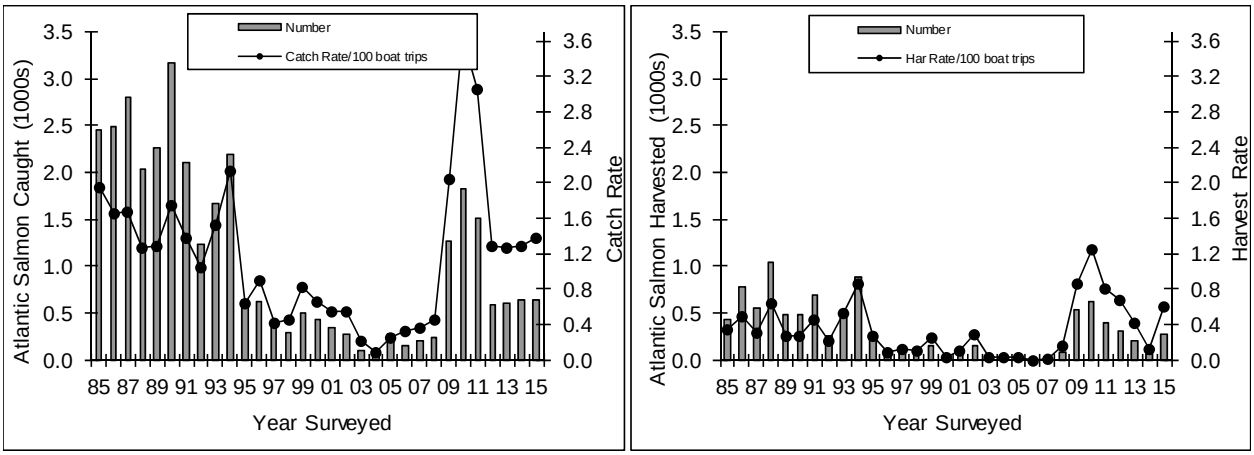

Figure 11. Total Atlantic salmon catch and catch rate, and harvest and harvest rate per 100 boat trips for boats seeking trout and salmon, April 15 – September 30, 1985-2015.

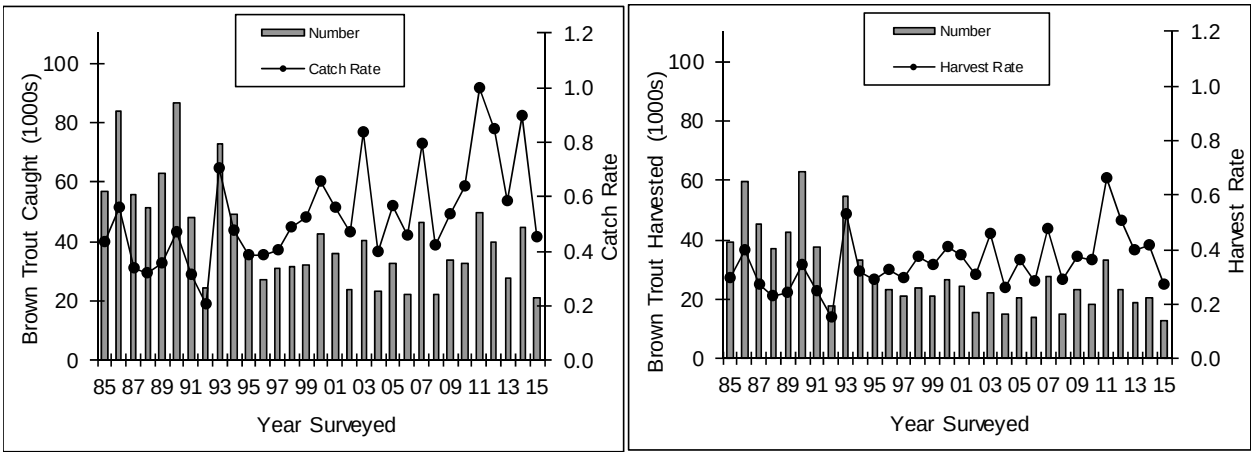

Figure 12. Total brown trout catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 – September 30, 1985-2015.

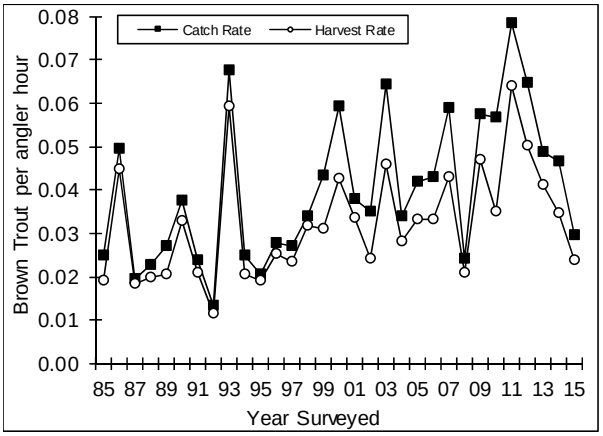

Figure 12b. Charter boat catch rate and harvest rate per angler hour for brown trout, April 15 – September 30, 1985-2015.

Brown Trout

Catch and Harvest

Brown trout was the third most commonly caught and harvested salmonine in 2015, accounting for 13.5% and 16.2% of the total 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 2015, estimated catch (20,780 fish [±33.2%]) was the lowest recorded and a 50.7% decrease compared to the long-term average. Estimated harvest (12,590 fish [±38.0%]) was a 56.2% decrease compared to the long-term average (Figure 12, Table 1, Table A17a). In 2015, 60.6% of brown trout caught were harvested, comparable to the previous 5-year (+2.3%) and 10-year averages (-2.1%).

The majority of brown trout catch typically occurred during April and May. Nearly 56% of the 2015 brown trout catch occurred during April and May (Table A17a). The east/central area typically accounted for the highest proportions of brown trout catch and harvest (1985-2007, 2009-2011, and 2013-2015 average = 53.6% of total catch; 58.9% in 2015). 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).

Fishing Quality

Brown trout catch rates (lake-wide, charter and noncharter) were variable over the 31-year data series with no trend (Figure 12, Figure 12b, Table A17b). In 2015, among trout and salmon fishing boats, brown trout catch rate (0.45 fish per boat trip) was a 15.8% decrease compared to the long-term average. Charter boats targeting trout and salmon caught 47.5% of all brown trout in 2015. Catch rate among charter boats was 1.0 brown trout per boat trip in 2015, a 30.2% decrease compared to the long-term average (Figure 12b, Table A17b). The charter boat catch rate per angler hour was 0.03, a 26.9% decrease compared to the long-term average and the lowest recorded since 2008 (Figure 12b). Noncharter boats caught an estimated 0.30 brown trout per boat trip (0.02 per angler hour), a 17.8% decrease compared to the long-term average (Table 17b).

Brown trout harvest rates (lake-wide, charter and noncharter) were also variable, showed no trends over time, and declined in 2015. (Figure 12, Figure 12b, Table 17b). Among all boats seeking trout and salmon, the 2015 lake-wide harvest rate was 0.27 brown trout per boat trip, a 22.7% decrease compared to the long-term average (Figure 12, Table A17b). Among charter boats fishing for trout and salmon, the 2015 harvest rate was 0.81 brown trout per boat trip (0.02 fish per angler hour; Figure 12b, Table A17b). Among noncharter boats fishing for trout and salmon, the 2015 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 through September, and highest in the east/central area (Lantry and Eckert 2013; Table A17b, Figures 12c and 12d). During 2015, brown trout catch rates were highest in April (3.1 per boat trip, highest observed) and June (1.0 fish per boat trip, second highest observed). The May 2015 catch rate (0.5 fish per boat trip) was the lowest recorded for that month since 2011 and was a 45% decrease compared to the long-term May average. Catch rates during July and August remained low and

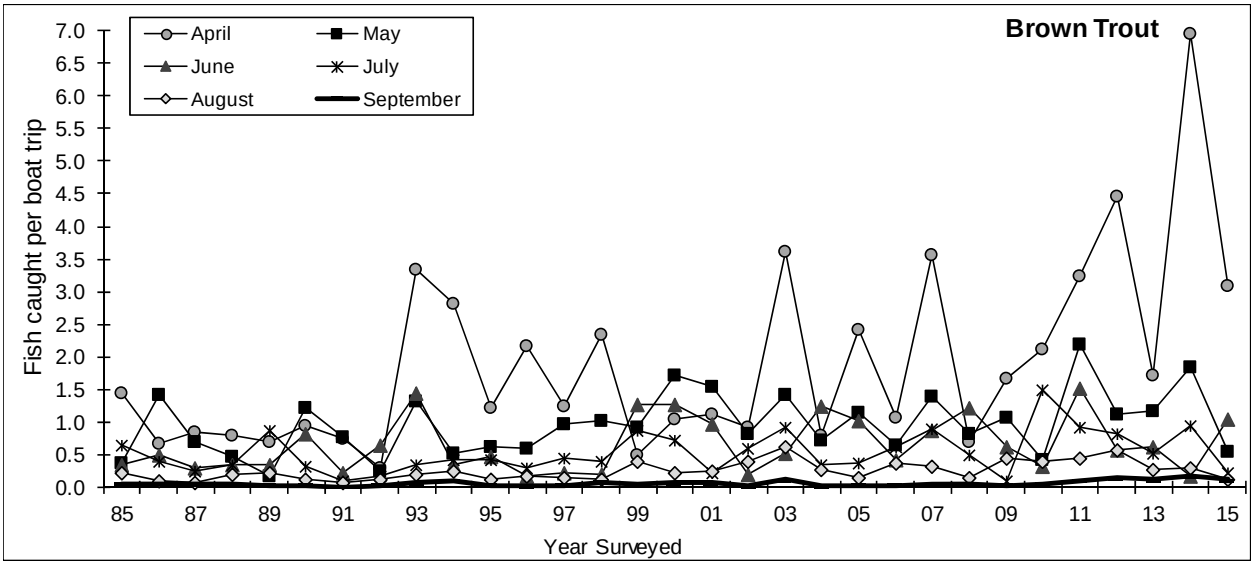

Figure 12c. Brown trout caught per boat trip April through September, 1985-2015. Note: Catch rate varied by month within each area surveyed.

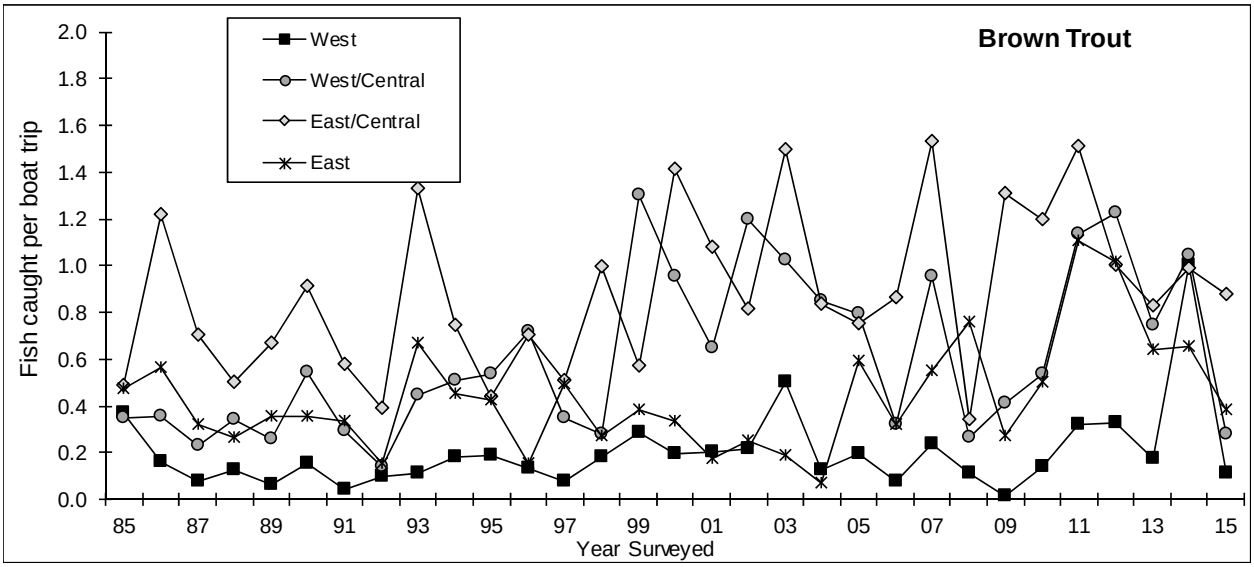

Figure 12d. Brown trout caught per boat trip in the west, west/central, east/central and east areas surveyed, April 15 – September 30, 1985-2015. Note: Catch rate varied by month within each area surveyed.

below average (Figure 12c; Table A17).

As is typically observed, the highest brown trout catch rates in 2015 occurred in the east/central area (0.88 fish per boat trip and comparable to [-1.6%] the long-term average) and the second highest occurred in the east area (0.38 fish per boat trip, a 12.9% decrease compared to the long-term average; Table A17b; Figure 12d). Unlike 2014 when anglers fishing the western half of Lake Ontario experienced record brown trout catch rates, rates in 2015 in that area were among the lowest recorded and well below the long-term average (west area: 0.11 fish per boat trip and a 46.0% decrease; west/central area: 0.28 fish per boat trip and a 55.8% decrease; Table A17b; Figure 12d).

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 (length: 1985-2015, weight: 1988-2015). Scales were collected from nearly all brown trout processed by creel agents during 1993-2015 (i.e., 23 years). Each year very few brown trout sampled are age 1 (0.0%-3.3%) due to their small size (under 15 inch minimum length limit) and angling strategies (e.g. species targeted, lure type). Each year 2011-2015, 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. Each year 2013-2015, age-2 brown trout dominated angler harvest, however, age 2s represented the lowest percentages observed from 1993-2015 (range: 58.3%-62.6% were age 2). The lowest percentage in the data series occurred in 2015 (58.3%). Conversely, the 2013-2015 contributions of age-3 brown trout (range: 28.8%-34.6%) were the highest observed from 1993-2015. For nearly all years, <4% of brown trout harvested were age-4 fish; however, in 2014 and 2015 the percentages of brown trout that were age 4 were the highest recorded (7.8% and 9.2%, respectively). From 1993-2015, age-5 or older brown trout comprised an average of 0.7% (1.6% in 2015; Table A18). Few brown trout age 6 or older were observed, and in the 23 years that scale samples were aged, only ten age-6 and one age-7 brown trout were observed.

Each year we determine the mean length of brown trout sampled April 15-30. In 2015, average length in April was 17.0 in, the shortest recorded since we began collecting length data in 1993 (Table A18). Additionally, nearly 48% of all brown trout processed during 2015 were less than 19 in (minimum harvestable size is 15 in), the third highest percentage in the last 20 years (1997 and 2009 were higher). The shorter lengths of brown trout in 2015 is likely due, in part, to two consecutive winters and summers of below average water temperatures.

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 the 16-24 inch groups were record low values among the 28 years where weight data were collected. Condition of 26 inch brown trout was unchanged from 2014. Condition of 28 inch brown trout was slightly improved compared to 2014, however, was nearly 0.8 pounds lighter than the long-term average. Reduced condition was also observed for rainbow trout.

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

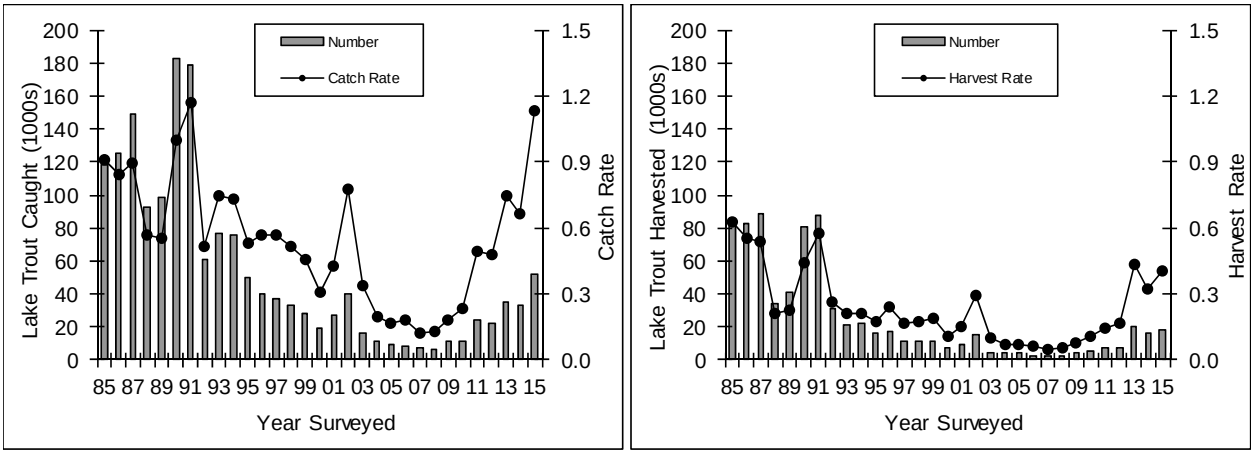

Figure 13. Total lake trout catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 – September 30, 1985-2015.

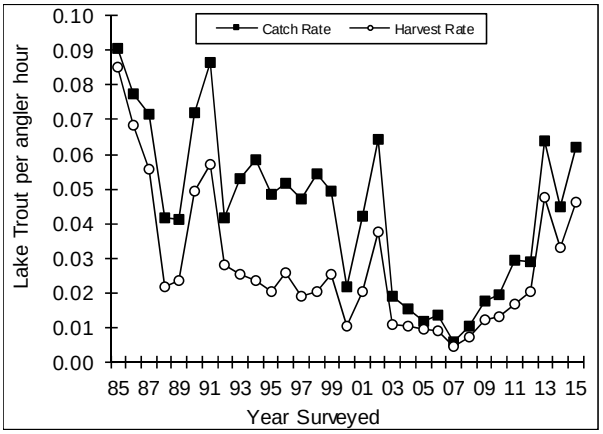

Figure 13b. Charter boat catch rate and harvest rate per angler hour for lake trout, April 15 – September 30, 1985-2014.

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 2015, lake trout was the second most commonly caught and harvested trout or salmon species, contributing 33.9% and 24.1% of the total salmonine catch and harvest, respectively (Table 1, Table A19a). In 2015, estimated lake trout catch (52,294 [±46.9%] fish) and harvest (18,780 [±32.9%]) were 207.1% and 153.6% increases compared to previous 10-year averages, respectively (Figure 13, Table 1, Table A19a). Catch was the highest estimated since 1994. 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 relatively low lake trout abundance during the mid-2000s (Lantry and Lantry 2016). Increased lake trout catch, which began in 2011, is most likely attributed to increased lake trout abundance in recent years (Lantry and Lantry 2016).

Additionally, some anglers reported specifically targeting lake trout when fishing quality for other species (e.g., brown trout and Chinook salmon) was considered low during 2013-2015. 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 (12 of the 14 years 2001-2014). In 2015, the majority of lake trout were caught in the west area (28,107 fish, 53.7% of all lake trout), the highest estimated for that area since 1991 (+95.6% compared to the long-term average; Table A19a). The 2015 monthly catch and harvest estimates were above previous 10-year averages each month April-September except during June when estimates were slightly below average (-7.1% and 16.2%, respectively; Table A19a).

Fishing Quality

Low lake trout abundance during the mid-2000s (Lantry and Lantry 2016) and excellent fishing quality for other salmonine species beginning in 2003 contributed to declining lake trout catch and harvest rates from 2003 to 2007 (2003-2007 average catch rate = 0.20 per boat trip; Figures 13 and 13b, Table A19b). Since then, catch rates increased reaching 1.1 per boat trip in 2015, the second highest on record (highest occurred in 1991; Figure 13, Table A19b). This increase coincided with an increased population of adult lake trout in recent years as well as a likely increase in angler effort targeting lake trout during periods of relatively lower catch rates for other species (2014 and 2015). In 2015, 39.5% of all lake trout caught by trout and salmon anglers were caught by charters. Among charter boats fishing for trout and salmon, the lake-wide catch rates per boat trip (2.11) and per angler hour (0.06) and were 35.0% and 43.8% increases compared to long-term averages, respectively; Table A19b, Figure 13b). Catch rate among noncharter boats fishing for trout and salmon was 0.87 lake trout per boat trip and 0.06 fish per angler hour (Table A19b).

The 2015 lake-wide harvest rate among boats seeking trout and salmon was 0.41 lake trout per boat, the seventh highest in the data series (Figure 13, Table A19b). Among charter boats fishing for trout and salmon, the 2015 harvest rate was 1.6 lake trout per boat trip (0.05 per angler hour; Figure 13b, Table A19b). Among noncharter boats fishing for trout and salmon, the harvest rate was

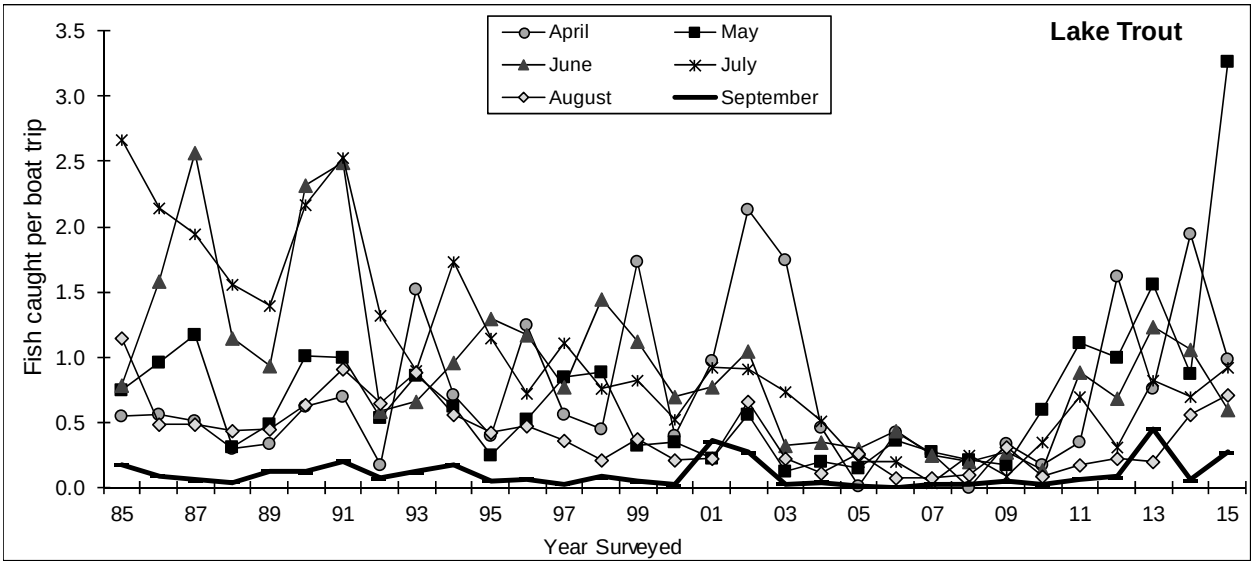

Figure 13c. Lake trout caught per boat trip April through September, 1985-2015. Note: Catch rate varied by month within each area surveyed.

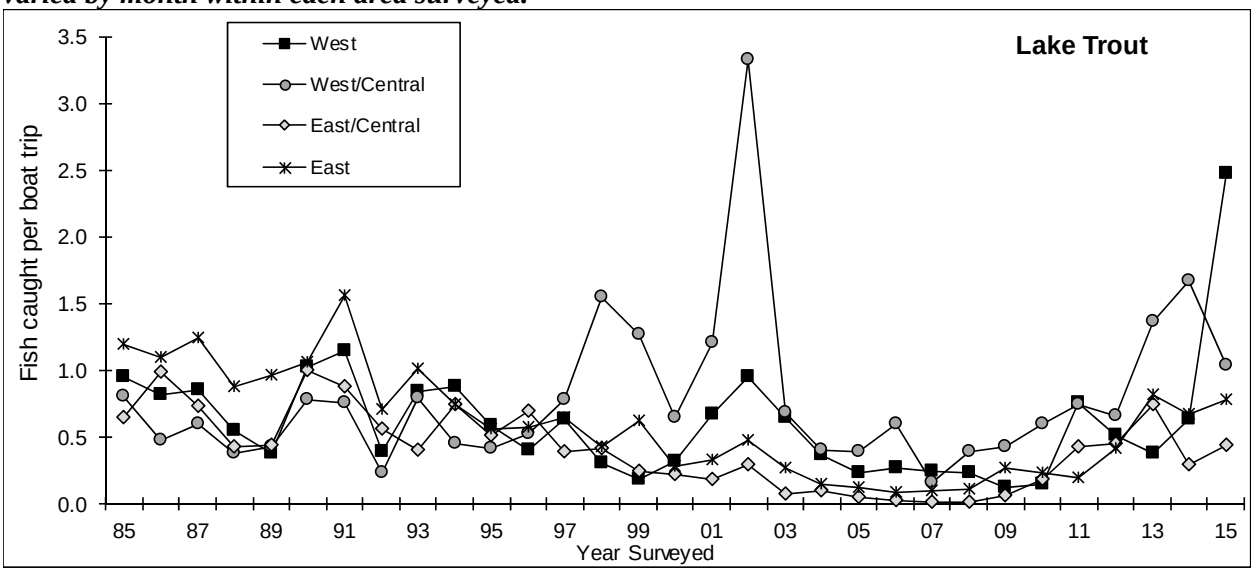

Figure 13d. Lake trout caught per boat trip in the west, west/central, east/central and east areas surveyed, April 15 – September 30, 1985-2015. Note: Catch rate varied by month within each area surveyed.

0.09 lake trout per boat trip (0.01 per angler hour; Table A19b).

Comparisons by month showed that catch rates were well above their respective long-term averages during April-May and August-September (range: +34.5% [April] to +434.9% [May]; Table A19b), and were below average in June (-36.9%) and July (-7.8%; Figure 13c). Catch rates of lake trout have improved in all areas of the lake in recent years. Each year from 1997 to 2014, the west/central area experienced the highest lake trout catch rate (Table A19b, Figure 13d). In 2015, anglers fishing the west area experienced the highest catch rate (2.5 lake trout per boat trip and the highest recorded for the west area). The highest harvest rate, however, occurred in the west/central area (0.63 per boat trip; Table A19b). Catch rate per boat trip in the west area was nearly 600% higher compared to that area's previous 10-year

average and a 350.9% increase compared to the long-term average. Anglers fishing the east area experienced a catch rate of 0.8 lake trout per boat trip, a 32.3% increase compared to the long-term average. East/central area catch rate (0.44 per boat trip) declined from 2014 and was comparable to (+7.4%) the long-term average.

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 (length: 1985-2015, weight: 1988-2015). The 2015 fishing season was the ninth season affected by the October 2006 regulation change permitting 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; 1993-2006 average = 17.0%) 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 five years after the regulation change (2007-2011), an average of 37.2% of lake trout harvested were 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). Since 2012, over 50% of lake trout harvested were within the slot limit (2012-2015 average=54.9%). In 2015, 55.7% of all lake trout harvested were within the 25-30 inch slot.

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. A regulation change effective October 1, 2006 established a pre-season catch and release period for 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 19, 2015 was the ninth pre-season catch and release period covered by this survey. During that period, there were an estimated 164 (±76.2%) fishing boat trips targeting smallmouth bass with effort occurring during May (104 boat trips) and June 1-19 (60 boat trips; Table A2).

Among all fish species, smallmouth bass was the most commonly caught species each year 1985 and 1987-2006. Fishing effort targeting smallmouth bass began declining in the early 2000s and, since 2010, has remained relatively stable at the lowest levels recorded (Figure 2). 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).

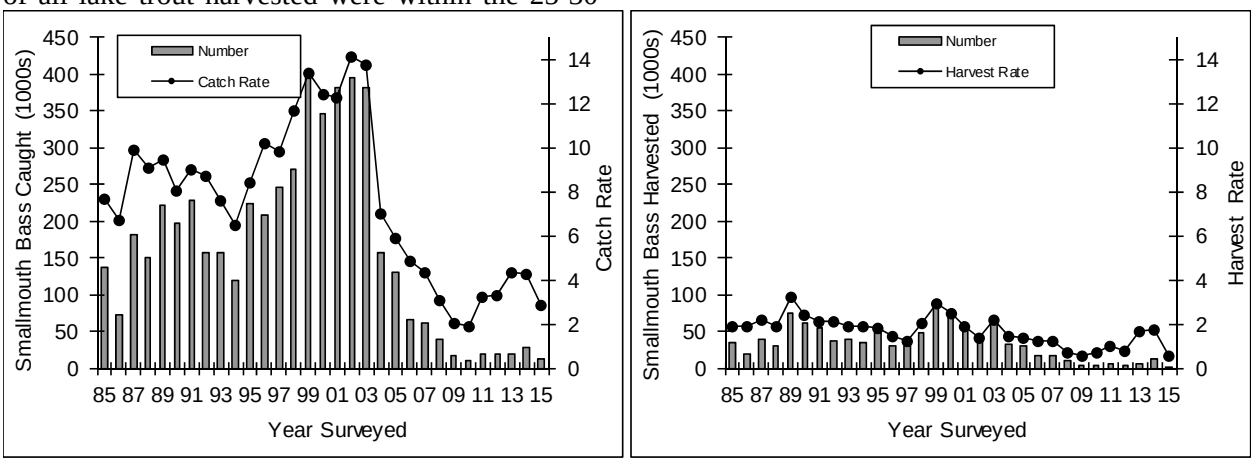

Figure 14. Total smallmouth bass catch and catch rate, and harvest and harvest rate per boat trip for boats seeking smallmouth bass during the traditional open season.

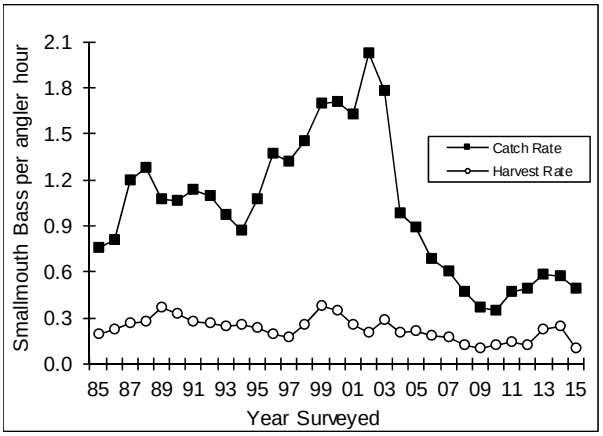

Figure 14b. Smallmouth bass catch rate and harvest rate per angler hour among anglers targeting bass during the traditional open season, 1985-2015.

Each year 2009-2014 smallmouth bass was the fifth most commonly caught species. In 2015, smallmouth bass was the sixth most commonly caught species with an estimated catch of 16,821 fish (±35.3%; April 15 - September 30), the second lowest on record and a 30.6% decrease compared to the previous 5-year average (Table 1, Table A21a). During the traditional open fishing season, 13,857 smallmouth bass were caught and 21.1% of those were harvested (2,918 fish; 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), increased to its highest level in 2002 (14.1 per boat trip and 2.0 per angler hour; Figure 14, Table A21b; Eckert 2005), then declined to the lowest level recorded in 2010 (1.9 per boat trip and 0.35 per angler hour; Figure 14). Fishing quality in 2015 remained among the lowest rates observed (2.8 and 0.6 bass caught and harvested per bass boat trip, respectively; Figure 14, Table A21b). Smallmouth bass catch rate per angler hour in 2015 was 0.49, slightly lower than (-10.2%) the previous 5-year average but 75.6% below the 2002 record high (Figure 14b, Table A21b).

Comparisons of 2015 month- and area-specific catch and harvest rates with their respective 2010-2014 averages (Table A21b) showed above average fishing quality during August (+22.1%), slightly above average quality in June (+12.2%) and September (+9.2%), and rates below the previous 5-year average in July (-46.0%). The 2015 catch rate was below previous 5-year averages in the west (-13.1%), west-central (-83.1%) and east (-40.4%) areas, and was above average in the east-central area (+31.4%; Table A21b).

Additional measures of fishing quality were evaluated. In 2015, 50.2% of boats specifically targeting smallmouth bass during the traditional open season failed to catch at least one bass, the sixth highest value observed (Table A6, Part B), indicating continued poor fishing quality (Table A6). Each year a relatively low percentage of bass boats harvest 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 (2004-2015 average=2.8%). In 2015, 1.5% of bass fishing boats harvested the daily creel limit of five bass per angler (Table A6). This metric 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).

Fishing quality along Lake Ontario's south shore since the mid-2000s may have been influenced by several factors 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 have generally continued to provide acceptable bass catch rates.

A Lake Ontario bass angler diary program, conducted 2010-2013, surveyed bass anglers fishing Lake Ontario and its embayments and tributaries. Catch rates experienced by diarists (0.39-0.63 bass per angler hour) were similar to

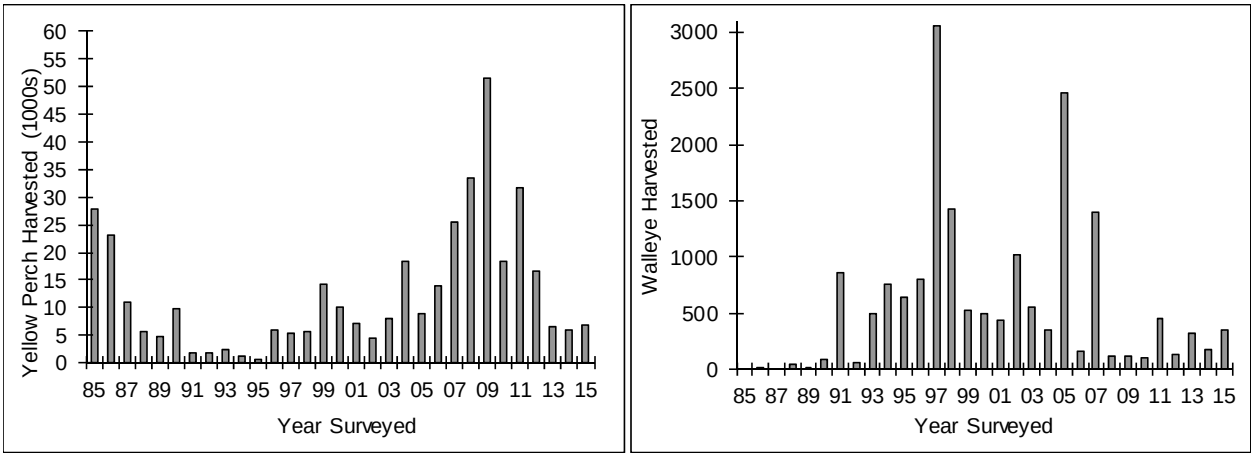

Figure 15. Total yellow perch and walleye harvested by all fishing boats, April 15-September 30 1985-2015.

rates reported in this survey for the same time period (0.35-0.59 bass per angler hour; Table A21b; Sanderson and Lantry 2014). The angler diary program 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 2015 estimated catch (17,384 [±330.1%] fish) and harvest (6,960 [±364.2%] fish) were well below long-term (1985-2014) averages (-40.5% and -45.5%, respectively; Figure 15, Table 1, Table A22). Yellow perch are distributed along much of the Lake Ontario shoreline, however, each year 1996-2015 the greatest proportion of catch occurred in the east/central area by relatively few fishing boats targeting perch (81.3% of total catch in 2015; Table A22). Improved angler catch during 2007-2012 coincided with increased catch in gillnetting 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 2016). Similarly, lower estimated catches during 2013 through 2015 coincide with reduced catches in gillnetting surveys and anecdotal angler reports of lower catches in areas not covered by this survey.

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 2016). 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 2015, there were an estimated 446 walleye caught and 350 harvested in Lake Ontario (±207.0% and ±201.4%, respectively; Figure 15, Table A23). Fisheries assessment data (Lantry 2016) 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 2015, 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 2015 were: northern pike (36 caught, 0 harvested) and largemouth bass (425 caught, 0 harvested). Lake sturgeon were reported in angler catch during only two of the 30 years surveyed, 2001 (44 fish) and 2012 (27 fish). Chain pickerel were only recently reported in angler catch (caught each year 2008-2010, and in 2013) but none were reported in 2014 or 2015. Cisco (a.k.a lake herring; 120 caught, 48 harvested) were reported in angler creel for the sixth consecutive year (2010-2015). 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 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 2015, round goby was the eighth most commonly caught species (6,297 ±44.7% caught, 4,683 ±54.6% harvested; Table 1, Table A3).

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 2015, there were an estimated 2,375 (±37.3%) lampreys observed in the fishing boat survey, a 30.5% decrease compared to the previous 5-year average and a 71.8% decrease compared to the 2007 record high (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 2016). Lamprey attack rate decreased from the 2007 peak and, in 2015, there were an estimated 15.4 lamprey per 1,000 trout or salmon caught (Figure 16, Table A24). This rate is was the second lowest estimated since 2002 (2014 was the lowest), however, was still about 2.6-fold higher than the 1986-1995 average rate.

For 12 of the last 15 years (2001-2015) the majority of lamprey observations occurred on Chinook salmon (2001-2015 average=58.4%), which was due, in part, to the large number of Chinook salmon caught by anglers (e.g., 2001-2015 average=43.1% of total trout and salmon catch; Table A5a, Table A9a). In 2015, 64.8% of lamprey observed by anglers were on Chinook salmon (Table A5a, Table A17a, Table A24). Other host salmonines in 2015 were lake trout (13.0% of observations), rainbow trout (10.2% of observations), and brown trout (12.0% of observations; Table A24). There was one report of lamprey observed on fishing gear in 2015. Among the 30 years of lamprey observation data, there were a total of 37 lampreys reported on fishing gear.

We further examined the data by determining host-specific attack rate (e.g., the 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 the "other" salmonines. On average, during 1996-2015, lampreys were observed on a much higher percentage of angler catch (range: 1.0% [coho salmon] to 5.7% [Atlantic salmon]). The 2015 attack rates for lake trout (0.6% of total catch), brown trout (1.4% of total catch), and Chinook salmon (2.6% of total catch) were higher than those observed in 2014 (0.2%, 1.2%, and 2.2%, respectively). The increase in attack 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 2016). The lower attack rates since 2007 (Figure 16) coincide 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 an increased lake trout population (Lantry and Lantry 2016).

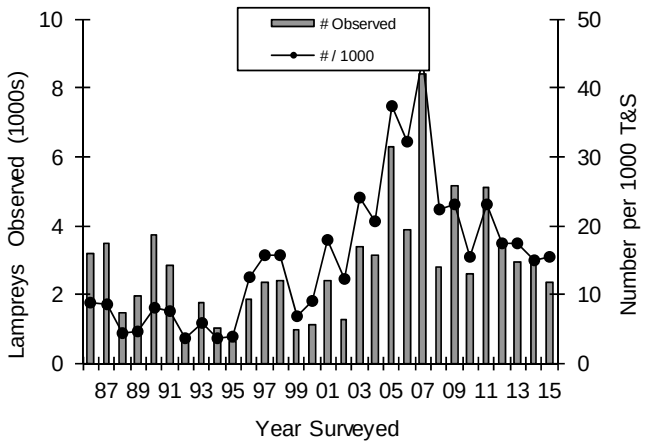

Figure 16. Total lamprey observed, and lampreys observed per 1,000 trout and salmon caught, April 15-September 30, 1985-2015.

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2015 Lake Ontario Fishing Boat Survey

Appendix Tables and Figures

Table A1. The four geographic areas (Roman numerals) used in analysis of the 1985-2015 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 1985-2015 NYSDEC fishing boat surveys.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Part A: Effort for all fishing boats.											
Seasonal (5½ month) estimates of fishing effort for all fishing boats:											
Fishing Boat Trips	129,814	65,495	79,167	69,687	76,838	62,104	60,943	56,182	54,605	58,554	53,154
Boat Angler Trips	358,096	182,153	219,647	194,658	221,925	175,820	171,519	160,363	161,620	174,079	157,151
Boat Angler Hours	1,939,000	930,174	1,113,767	985,898	1,229,977	905,357	898,339	848,905	937,822	980,409	879,681
Anglers/Boat Trip	2.74	2.78	2.77	2.79	2.89	2.83	2.81	2.85	2.96	2.97	2.96
Hours/ Boat Trip	5.33	5.11	5.07	5.06	5.54	5.15	5.24	5.29	5.80	5.63	5.60
Monthly estimates of boat trips for all fishing boats:											
April	11,233	4,058	3,014	3,131	3,230	2,680	2,529	2,409	2,672	1,935	2,251
May	19,614	8,558	11,796	7,784	15,360	11,111	8,605	9,540	8,368	8,652	9,147
June	15,701	6,941	11,174	8,650	8,351	5,489	6,183	8,128	7,608	8,002	5,190
July	23,303	15,265	16,316	15,507	12,735	12,703	15,024	12,024	11,950	11,234	10,904
August	36,072	18,602	23,131	21,147	19,815	21,764	17,315	15,096	17,404	19,666	14,085
September	23,890	12,071	13,736	13,468	17,346	8,356	11,286	8,986	6,603	9,061	11,577
Seasonal estimates of boat trips among four geographic areas for all fishing boats:											
West	30,399	13,068	18,543	14,276	20,404	16,269	16,248	14,145	14,602	13,674	12,543
West/Central	19,017	9,358	11,461	7,722	10,746	7,011	6,890	7,412	7,648	7,210	7,407
East/Central	42,380	25,153	25,300	25,094	25,448	22,318	19,926	17,410	17,368	18,455	16,964
East	38,018	17,916	23,863	22,594	20,239	16,506	17,879	17,215	14,988	19,215	16,240
Part B: Seasonal estimates of total boat excursions (traffic).											
Power Boats:											
Fishing Boats	133,789	66,243	80,405	70,525	77,410	62,435	61,383	56,979	55,116	59,149	53,812
Nonfishing Boats	114,217	57,544	76,672	80,479	86,372	84,587	69,943	71,318	89,530	70,311	97,066
Sail Boats	29,498	12,186	18,126	19,750	22,224	23,914	23,782	20,703	21,432	19,104	13,905
Part C: Seasonal estimates of boat angler trips by residence.											
NY Resident	221,833	109,629	135,400	115,936	134,954	108,712	105,145	97,153	96,610	106,088	94,785
Nonresident	136,263	72,524	84,247	78,722	86,971	67,108	66,374	63,210	65,010	67,991	62,366
% NY Resident	61.6%	60.2%	61.6%	59.6%	60.8%	61.8%	61.3%	60.6%	59.8%	60.9%	60.3%
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	101,399	47,812	57,620	51,229	62,028	50,059	49,548	46,059	47,520	49,434	46,142
Boat Angler Trips	292,965	142,264	172,001	152,905	189,796	151,747	147,775	138,687	146,900	155,656	142,816
Boat Angler Hours	1,718,704	806,572	968,752	868,237	1,143,095	843,037	831,675	785,271	889,719	917,662	838,730
Anglers/Boat Trip	2.90	2.98	2.99	2.98	3.06	3.03	2.98	3.01	3.09	3.15	3.10
Hours/ Boat Trip	5.84	5.67	5.63	5.68	6.02	5.56	5.63	5.66	6.06	5.90	5.87
Monthly estimates of boat trips for boats seeking trout and salmon:											
April	11,089	4,024	2,998	2,874	3,610	2,610	2,518	2,366	2,575	1,920	2,251
May	18,699	7,959	11,009	7,262	14,731	9,401	8,050	8,388	7,911	8,417	8,656
June	10,011	2,733	5,862	4,760	5,201	3,878	4,313	5,138	6,333	5,489	4,322
July	13,974	8,259	10,212	9,261	8,743	9,233	10,903	9,255	9,651	8,827	8,140
August	28,010	14,496	16,674	16,485	15,192	18,080	14,123	12,910	15,910	16,917	12,340
September	19,616	10,340	10,864	10,586	14,552	6,858	9,642	8,002	5,141	7,864	10,433
Seasonal estimates of boat trips among four geographic areas for boats seeking trout and salmon:											
West	26,336	11,029	16,119	12,440	18,562	14,258	14,715	12,671	13,674	12,092	11,350
West/Central	14,002	6,828	6,962	4,293	7,725	5,574	5,047	5,584	6,634	6,251	6,447
East/Central	30,059	16,768	16,507	17,094	19,173	16,740	15,137	13,596	15,259	15,852	13,937
East	31,002	13,187	18,031	17,403	16,568	13,487	14,649	14,208	11,954	15,239	14,408
Percent of total seasonal fishing effort by boats seeking trout and salmon:											
Fishing Boat Trips	75.2%	73.0%	72.8%	73.5%	80.7%	80.6%	81.3%	82.0%	87.0%	84.4%	86.8%
Boat Angler Trips	79.3%	78.1%	78.3%	78.6%	85.5%	86.3%	86.2%	86.5%	90.9%	89.4%	90.9%
Boat Angler Hours	86.7%	86.7%	87.0%	88.1%	92.9%	93.1%	92.6%	92.5%	94.9%	93.6%	95.3%

Table A2 (continued). Summary of effort statistics.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
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	22,772	13,586	14,509	12,786	8,666	5,855	6,257	6,203	4,273	6,878	4,868
Boat Angler Trips	52,184	30,938	33,135	28,548	18,885	12,106	13,758	13,505	9,082	14,223	9,900
Boat Angler Hours	176,053	96,062	103,494	83,434	48,847	32,603	42,718	41,972	31,569	51,006	28,115
Anglers/Boat Trip	2.29	2.28	2.28	2.23	2.18	2.07	2.20	2.18	2.13	2.07	2.03
Hours/ Boat Trip	3.39	3.10	3.12	2.92	2.59	2.69	3.10	3.11	3.48	3.59	2.84
Monthly estimates of boat trips for boats seeking smallmouth bass during the traditional open season:											
April & May	-	-	-	-	-	-	-	-	-	-	-
June	3,994	2,915	2,879	2,325	1,284	634	935	1,525	637	1,900	543
July	8,000	5,881	4,738	4,979	2,517	2,212	2,704	2,303	1,403	1,786	2,376
August	7,132	3,743	4,778	3,579	2,878	2,139	1,724	1,646	959	2,312	1,148
September	3,646	1,048	2,114	1,903	1,987	870	894	728	1,275	880	801
Seasonal estimates of boat trips among four geographic areas for boats seeking smallmouth bass during the traditional open season:											
West	2,591	1,237	1,561	1,001	1,370	1,051	815	984	352	1,101	793
West/Central	3,766	1,512	2,621	2,426	1,453	642	784	1,006	564	609	370
East/Central	10,585	6,912	6,649	5,451	3,638	2,768	2,809	2,289	1,174	1,801	2,233
East	5,831	3,925	3,677	3,908	2,204	1,394	1,849	1,924	2,183	3,367	1,473
Percent of total seasonal fishing effort by boats seeking smallmouth bass during the traditional open season:											
Fishing Boat Trips	19.8%	20.7%	18.3%	18.3%	11.3%	9.4%	10.3%	11.0%	7.8%	11.7%	9.2%
Boat Angler Trips	16.6%	17.0%	15.1%	14.7%	8.5%	6.9%	8.0%	8.4%	5.6%	8.2%	6.3%
Boat Angler Hours	10.7%	10.3%	9.3%	8.5%	4.0%	3.6%	4.8%	4.9%	3.4%	5.2%	3.2%
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	92	73	224	0	0	78	46	29	78	22	0
SMB pre-opener	205	500	496	367	644	292	239	521	191	295	164
Largemouth Bass	26	0	52	16	0	0	13	13	197	62	29
Yellow Perch	887	769	1,203	1,914	1,800	1,901	1,794	1,556	779	712	623
Walleye	459	278	1,210	373	270	470	384	233	249	137	348
All Other	3,935	2,476	3,853	3,003	3,863	3,449	2,662	1,568	1,319	1,015	980
% Northern Pike	0.08%	0.11%	0.28%			0.13%	0.08%	0.05%	0.14%	0.04%	0.00%
% SMB pre-opener	0.19%	0.76%	0.63%	0.53%	0.84%	0.47%	0.39%	0.93%	0.35%	0.50%	0.31%
% Largemouth Bass	0.05%		0.07%	0.02%			0.02%	0.02%	0.36%	0.11%	0.05%
% Yellow Perch	0.68%	1.17%	1.52%	2.75%	2.34%	3.06%	2.94%	2.77%	1.43%	1.22%	1.17%
% Walleye	0.56%	0.42%	1.53%	0.54%	0.35%	0.76%	0.63%	0.41%	0.46%	0.23%	0.65%
% All Other	3.19%	3.78%	4.87%	4.31%	5.03%	5.55%	4.37%	2.79%	2.42%	1.73%	1.84%
Part G: Charter fishing boats.											
Seasonal (5½ month) estimates of fishing effort for charter boats:											
Fishing Boat Trips	13,457	9,099	9,448	9,012	9,885	8,612	8,332	7,632	9,343	9,718	9,831
Boat Angler Trips	67,824	45,872	48,726	47,015	50,142	44,773	43,124	38,880	48,694	51,351	51,311
Boat Angler Hours	498,179	310,568	340,751	322,072	347,188	288,231	275,652	256,420	338,688	345,925	334,663
Anglers/Boat Trip	5.00	5.04	5.16	5.22	5.07	5.20	5.18	5.09	5.21	5.28	5.22
Hours/ Boat Trip	7.30	6.77	6.99	6.85	6.92	6.44	6.39	6.60	6.96	6.74	6.52
Monthly estimates of boat trips for charter boats:											
April	854	505	401	210	331	428	300	599	426	281	353
May	2,383	1,572	1,299	1,227	1,712	1,425	1,119	733	1,607	1,401	1,941
June	1,545	531	1,221	930	974	657	873	648	965	1,028	707
July	2,105	2,037	2,237	1,455	1,917	2,112	2,174	1,826	2,252	2,141	1,724
August	4,485	2,791	2,732	3,588	2,949	3,259	2,513	2,622	3,060	3,620	3,407
September	2,294	1,664	1,559	1,602	2,002	731	1,353	1,203	1,032	1,247	1,700
Seasonal estimates of boat trips among four geographic areas for charter boats:											
West	3,611	1,870	2,810	2,371	2,624	2,837	2,658	2,060	2,572	2,234	2,401
West/Central	1,497	954	1,387	472	1,056	933	842	813	1,120	1,321	1,283
East/Central	4,866	4,283	3,292	3,854	4,235	3,512	3,263	2,879	3,935	4,254	3,732
East	3,692	1,993	1,960	2,315	1,971	1,329	1,570	1,880	1,715	1,910	2,415
Percent of total seasonal fishing effort by charter boats:											
Fishing Boat Trips	10.7%	13.9%	11.9%	12.9%	12.9%	13.9%	13.7%	13.6%	17.1%	16.6%	18.5%
Boat Angler Trips	19.6%	25.2%	22.2%	24.2%	22.6%	25.5%	25.1%	24.2%	30.1%	29.5%	32.7%
Boat Angler Hours	27.0%	33.4%	30.6%	32.7%	28.2%	31.8%	30.7%	30.2%	36.1%	35.3%	38.0%

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, 1985-2015.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seasonal (5½ month) estimates of fish harvested:											
Unidentified Fish	4	0	0	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	32	0	0	0	0	365	0	14	72	0	20
Gizzard Shad	4	0	0	0	0	0	0	0	0	0	0
Cisco	25	0	0	0	0	76	187	247	221	270	48
Lake Whitefish	0	0	0	0	0	11	13	0	0	0	0
Pink Salmon	3	0	23	0	0	0	0	0	0	0	0
Unidentified Salmonine	13	0	0	0	0	0	0	0	0	0	0
Northern Pike	81	135	0	40	0	0	14	132	0	35	0
Chain Pickerel	0	0	0	0	0	0	0	0	67	0	0
Common carp	5	0	0	0	0	0	0	45	0	0	0
Unidentified Redhorse	0	0	15	0	0	0	0	0	0	0	0
Yellow Bullhead	1	0	0	0	0	0	0	0	0	0	0
Brown Bullhead	107	45	0	0	0	0	0	0	0	53	0
Channel Catfish	66	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	1,743	0	0	0	0	20	0	0	0	115	0
White Bass	307	0	0	0	0	0	0	0	0	22	0
Rock Bass	3,064	473	363	1,115	526	131	135	688	134	478	12
Pumpkinseed	474	658	0	95	29	20	0	0	0	0	0
Bluegill	96	562	29	79	87	140	329	0	0	368	13
Largemouth Bass	90	269	108	149	88	32	0	132	22	26	0
Black Crappie	30	1,301	0	0	0	0	0	26	0	151	0
Freshwater Drum	482	76	0	0	0	0	0	0	0	151	0
Round Goby	946	16,807	28,974	39,611	36,003	13,138	12,770	9,182	7,546	4,222	4,683
Seasonal (5½ month) estimates of fish caught:											
Unidentified Fish	35	0	48	250	213	0	19	24	23	0	41
Lake Sturgeon	2	0	0	0	0	0	0	27	0	0	0
Longnose Gar	2	0	0	0	72	0	0	0	0	0	0
Bowfin	20	45	0	0	0	0	0	0	0	0	24
American Eel	85	0	0	0	0	0	0	0	0	0	0
Alewife	413	32	0	45	43	736	220	27	403	163	127
Gizzard Shad	11	0	0	0	0	0	0	14	0	0	13
Cisco	35	0	0	0	0	181	229	375	221	297	120
Lake Whitefish	0	0	0	0	0	11	13	0	0	0	0
Pink salmon	3	0	23	0	0	0	0	0	0	0	0
Unidentified Salmonine	293	251	31	281	14	106	113	0	0	0	60
Rainbow Smelt	10	0	0	0	0	0	0	0	0	0	0
Northern Pike	333	166	2,191	235	1,370	900	62	204	130	255	36
Muskellunge	2	0	0	0	0	0	0	0	0	0	0
Chain Pickerel	0	0	0	690	422	32	0	0	290	0	0
Common Carp	96	15	19	114	38	62	26	72	70	0	0
White Sucker	26	29	14	14	0	36	13	0	0	26	0
Unidentified Redhorse	12	0	45	0	0	0	0	0	0	0	0
Yellow Bullhead	1	0	0	0	0	0	0	0	0	0	0
Brown Bullhead	145	45	0	0	0	0	0	0	25	53	0
Channel Catfish	154	0	0	198	0	15	0	19	0	0	0
Threespine Stickleback	3	0	0	0	0	0	0	0	0	0	0
White perch	4,595	0	30	606	0	83	101	0	12	115	0
White Bass	1,365	111	72	14	257	20	25	2,533	0	49	0
Rock Bass	15,360	2,731	4,608	4,495	2,546	991	818	1,840	1,088	5,371	596
Pumpkinseed	1,585	1,994	1,369	2,774	577	222	28	36	322	436	0
Bluegill	292	1,198	306	284	146	349	1,257	77	225	869	25
Largemouth Bass	512	1,306	1,177	1,313	594	190	227	516	456	106	425
Black Crappie	76	1,390	18	0	0	0	0	26	0	0	0
Freshwater Drum	8,062	1,255	686	360	266	701	240	525	256	388	163
Round Goby	1,855	34,336	62,615	63,407	58,310	21,033	25,290	13,484	12,659	6,704	6,297

Table A4. Residency for boat anglers interviewed April 15 – September 30, 1985-2015. Shown are percent contributions of the most common states or provinces, and for the most common counties among New York resident anglers.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
State or Province of Residence - Percent Frequency											
Connecticut	2.1	1.8	2.4	1.6	1.7	1.6	1.3	1.5	1.3	0.8	1.2
Florida	0.3	0.3	0.5	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.4
Maine	0.8	1.3	1.0	0.9	0.9	0.8	0.7	0.7	1.0	0.5	0.7
Maryland	0.3	0.5	0.1	0.2	0.1	0.2	0.2	0.3	0.8	0.4	0.5
Massachusetts	3.9	3.1	2.9	3.3	3.3	3.0	2.7	2.6	2.6	2.8	2.5
Michigan	0.3	0.1	1.2	0.3	0.3	0.4	0.6	0.2	0.6	0.5	0.3
New Hampshire	1.2	1.5	1.3	1.2	1.2	1.1	0.8	0.9	1.0	1.3	0.9
New Jersey	4.4	3.8	3.8	3.3	3.8	3.0	3.0	2.6	2.2	2.9	3.5
New York	61.6	60.2	61.6	59.6	60.8	61.8	61.3	60.6	59.8	60.9	60.3
Ohio	4.3	3.0	2.8	4.5	3.5	2.6	4.0	3.9	4.7	3.6	4.6
Pennsylvania	16.7	19.5	17.6	19.8	18.9	20.4	20.4	21.9	20.8	21.0	20.6
Province of Ontario	0.2	0.0	0.4	0.1	0.4	0.3	0.3	0.1	0.2	0.2	0.1
Province of Quebec	0.2	0.1	0.0	0.2	0.1	0.1	0.1	0.0	0.1	0.3	0.2
Vermont	2.2	2.4	2.8	2.0	2.8	2.3	2.1	2.5	2.2	2.3	2.1
Virginia	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.1	0.3	0.1	0.3
West Virginia	0.4	0.3	0.3	0.7	0.4	0.3	0.4	0.5	0.4	0.3	0.4
Total of all Listed States & Provinces:	99.0	98.3	98.7	98.5	98.7	98.4	98.4	98.9	98.5	98.4	98.7
County of Residence Among NY Anglers - Percent Frequency											
County Bordering Lake Ontario:											
Cayuga	2.3	3.7	2.9	4.2	3.0	3.3	2.6	2.2	2.2	2.6	3.1
Jefferson	2.5	2.0	2.3	2.4	2.2	1.6	1.5	3.2	3.6	3.3	2.5
Monroe	24.7	20.0	21.9	18.8	20.0	18.7	16.5	16.2	16.5	15.7	15.7
Niagara	8.7	7.9	9.5	6.6	7.3	7.8	10.9	9.4	9.7	8.6	9.1
Orleans	3.7	3.1	2.9	4.0	3.8	4.9	4.2	4.1	4.8	5.3	4.7
Oswego	10.4	13.5	11.3	12.8	13.0	13.1	13.6	12.5	12.8	12.8	13.1
Wayne	10.8	12.4	11.4	11.5	9.5	9.5	9.6	10.3	8.7	7.7	9.4
Border Co. Total	63.2	62.7	62.3	60.4	58.8	58.8	59.0	57.9	58.4	56.0	57.7
Other NY Counties:											
Albany	1.3	1.5	2.0	1.2	1.0	1.1	1.0	1.0	0.8	1.9	1.2
Broome	1.9	2.0	1.6	1.4	2.1	2.5	1.9	1.8	1.5	1.8	1.8
Dutchess	1.0	1.2	0.7	0.5	0.6	0.6	0.3	0.3	0.7	0.7	0.8
Erie	4.3	3.7	4.1	3.4	3.4	3.8	5.8	5.2	4.9	4.1	4.0
Genesee	1.5	1.4	1.1	1.2	1.9	2.1	1.6	2.5	1.8	2.3	0.9
Livingston	0.8	0.7	0.7	0.8	0.7	0.6	0.6	1.0	0.7	0.8	0.7
Oneida	2.0	2.1	1.9	1.9	1.8	1.8	2.1	1.4	2.0	2.0	2.2
Onondaga	5.8	5.5	5.6	6.9	5.4	6.0	6.4	6.4	5.7	5.9	5.9
Ontario	1.5	1.6	1.5	1.1	1.5	1.7	1.6	1.7	2.0	1.8	1.7
Orange	0.9	1.2	1.1	1.7	1.3	1.2	0.5	0.8	0.9	1.2	1.4
Saratoga	1.0	0.7	0.7	0.6	1.0	0.8	0.7	0.6	0.9	0.9	1.1
Total of all Listed Counties:	85.1	84.3	83.1	81.1	79.5	80.9	81.5	80.7	80.3	79.4	79.4

Table A5a. Trout and salmon catch and harvest data collected April 15 – September 30, 1985-2015.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	153,038	76,075	111,200	78,060	120,477	89,092	110,196	107,456	100,047	106,880	77,887
Catch	239,418	120,785	189,916	125,686	223,316	167,405	221,977	196,625	168,837	200,763	154,411
% Harvested	63.3	63.0	58.6	62.1	53.9	53.2	49.6	54.7	59.3	53.2	50.4
Monthly estimates of harvest for all fishing boats:											
April	17,208	5,720	8,197	2,432	6,635	5,939	5,050	10,045	4,580	6,329	4,151
May	32,804	16,436	22,638	12,493	29,432	11,638	16,139	16,015	22,142	20,118	20,314
June	16,999	2,919	12,419	6,896	5,050	8,025	10,387	10,135	11,467	11,777	6,361
July	24,045	14,072	22,507	12,851	24,171	21,904	36,207	22,706	21,311	22,955	13,148
August	42,482	24,148	30,604	28,919	32,685	34,636	29,189	34,770	33,670	33,092	23,111
September	19,501	12,781	14,835	14,471	22,504	6,950	13,225	13,785	6,878	12,609	10,800
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	50,884	24,718	39,131	32,750	49,310	37,266	33,864	32,631	34,524	31,103	24,548
West/Central	16,973	8,650	9,618	2,901	8,174	6,523	8,356	9,216	11,694	13,696	9,191
East/Central	45,868	30,505	37,160	20,158	40,795	29,674	39,819	31,076	34,445	37,861	25,431
East	39,313	12,200	25,291	22,250	22,197	15,629	28,157	34,535	19,382	24,217	18,715
Monthly estimates of catch for all fishing boats:											
April	26,791	9,360	14,246	3,709	11,261	8,804	12,236	19,347	7,328	19,368	10,395
May	51,308	28,660	51,039	24,727	76,635	20,573	35,558	37,204	36,786	46,026	57,178
June	30,465	5,366	20,947	12,552	11,836	18,745	22,222	24,230	20,076	28,848	13,203
July	43,406	22,868	36,489	23,301	35,487	46,270	82,252	42,491	41,130	33,587	23,984
August	62,575	37,709	47,626	41,721	55,836	62,916	50,484	55,996	53,802	56,224	34,527
September	24,873	16,823	19,567	19,676	32,261	10,096	19,225	17,357	9,715	16,710	15,123
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	84,594	46,148	77,192	57,467	103,965	72,072	93,566	73,727	67,993	66,682	70,100
West/Central	32,693	17,028	20,602	7,754	30,121	22,128	22,100	26,231	26,378	35,306	18,565
East/Central	66,215	42,280	57,450	31,072	62,190	51,736	67,426	49,058	49,025	60,635	39,116
East	55,915	15,328	34,674	29,398	27,040	21,471	38,885	47,609	25,440	38,141	26,630
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.5	99.2	99.6	99.8	99.9	99.8	99.9	100.0	100.0	99.9	100.0
% Catch	99.4	99.2	99.7	99.6	99.8	99.6	99.8	99.7	99.9	99.9	100.0
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	46.5	61.0	47.9	53.7	50.5	50.3	47.3	47.5	59.4	56.0	60.2
% Catch	38.7	46.2	37.5	42.6	35.5	39.9	34.8	33.3	46.0	39.2	40.1

Table A5b. Trout and salmon catch and harvest rate data collected April 15 – September 30, 1985-2015. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	1.480	1.578	1.922	1.520	1.940	1.776	2.222	2.332	2.104	2.159	1.688
Catch/Boat Trip	2.347	2.506	3.286	2.444	3.593	3.329	4.473	4.258	3.549	4.056	3.345
Harv/Angler Trip	0.512	0.530	0.644	0.509	0.634	0.586	0.745	0.774	0.681	0.686	0.545
Catch/Angler Trip	0.811	0.842	1.101	0.819	1.174	1.098	1.500	1.414	1.148	1.288	1.081
Harv/Angler Hour	0.088	0.094	0.114	0.090	0.105	0.105	0.132	0.137	0.112	0.116	0.093
Catch/Angler Hr.	0.140	0.149	0.195	0.144	0.195	0.198	0.266	0.250	0.190	0.219	0.184
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	1.766	1.421	2.734	0.847	1.838	2.275	2.006	4.246	1.779	3.296	1.844
May	1.699	2.001	2.056	1.720	1.998	1.238	2.005	1.909	2.799	2.390	2.347
June	1.591	1.035	2.083	1.418	0.949	2.052	2.396	1.973	1.811	2.131	1.472
July	1.643	1.704	2.195	1.386	2.765	2.363	3.321	2.448	2.203	2.595	1.614
August	1.527	1.666	1.828	1.752	2.150	1.971	2.065	2.693	2.116	1.956	1.873
September	0.958	1.236	1.366	1.367	1.546	1.006	1.372	1.723	1.338	1.603	1.035
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	1.964	2.242	2.428	2.630	2.657	2.614	2.300	2.575	2.523	2.572	2.163
West/Central	1.203	1.267	1.377	0.676	1.059	1.170	1.656	1.650	1.763	2.191	1.426
East/Central	1.513	1.787	2.233	1.171	2.128	1.765	2.631	2.282	2.256	2.385	1.825
East	1.207	0.919	1.397	1.277	1.331	1.154	1.919	2.431	1.621	1.584	1.298
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	2.976	2.326	4.752	1.291	3.119	3.373	4.859	8.177	2.837	10.088	4.618
May	2.715	3.498	4.636	3.397	5.201	2.188	4.400	4.435	4.650	5.458	6.606
June	2.859	1.930	3.527	2.568	2.227	4.809	5.117	4.644	3.166	5.241	3.044
July	2.940	2.769	3.564	2.511	4.059	4.948	7.544	4.581	4.252	3.799	2.945
August	2.277	2.600	2.845	2.528	3.668	3.480	3.569	4.335	3.382	3.322	2.798
September	1.254	1.621	1.800	1.859	2.210	1.464	1.994	2.169	1.885	2.123	1.450
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	3.337	4.163	4.789	4.617	5.601	5.055	6.344	5.818	4.967	5.506	6.176
West/Central	2.561	2.485	2.950	1.800	3.898	3.969	4.379	4.697	3.976	5.644	2.880
East/Central	2.203	2.486	3.456	1.801	3.227	3.051	4.448	3.587	3.208	3.822	2.803
East	1.700	1.155	1.918	1.682	1.624	1.586	2.650	3.337	2.126	2.498	1.847
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	4.900	5.239	5.816	4.800	6.170	5.245	6.319	6.690	6.417	6.162	4.792
Catch/Boat Trip	6.403	6.297	7.787	6.136	8.044	7.826	9.359	8.583	8.385	8.115	6.321
Harv/Angler Trip	0.982	1.037	1.131	0.921	1.216	1.006	1.211	1.313	1.233	1.167	0.919
Catch/Angler Trip	1.280	1.247	1.514	1.177	1.585	1.500	1.794	1.685	1.611	1.536	1.212
Harv/Angler Hour	0.135	0.153	0.161	0.134	0.175	0.156	0.190	0.198	0.178	0.173	0.141
Catch/Angler Hr.	0.176	0.184	0.216	0.172	0.229	0.233	0.282	0.254	0.232	0.228	0.186
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.921	0.746	1.187	0.846	1.140	1.062	1.404	1.466	1.060	1.182	0.852
Catch/Boat Trip	1.674	1.644	2.436	1.686	2.750	2.404	3.497	3.399	2.378	3.064	2.544
Harv/Angler Trip	0.361	0.298	0.461	0.335	0.426	0.411	0.554	0.565	0.411	0.450	0.338
Catch/Angler Trip	0.658	0.657	0.945	0.667	1.027	0.931	1.379	1.309	0.922	1.166	1.008
Harv/Angler Hour	0.068	0.058	0.090	0.065	0.075	0.079	0.104	0.107	0.073	0.082	0.061
Catch/Angler Hr.	0.123	0.127	0.185	0.129	0.180	0.179	0.259	0.247	0.164	0.213	0.183

Table A6. Parameters used to assess angling quality among boats interviewed April 15 – September 30, 1985-2015. 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 30-year data series; therefore, data on bag limits are presented only for 2004-2015.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Part A: Boats seeking any or all species of trout and salmon.											
Percent boats with zero harvest of:											
Any Trout or Salmon	54.2%	57.4%	49.1%	55.6%	51.1%	51.6%	45.3%	44.9%	50.5%	46.5%	52.4%
Any Fish Species	53.8%	57.2%	48.9%	55.3%	50.8%	51.5%	45.2%	44.8%	50.3%	46.4%	52.3%
Percent boats with zero catch of:											
Any Trout or Salmon	41.4%	41.6%	31.5%	41.1%	32.4%	35.1%	26.7%	24.3%	31.4%	29.4%	34.3%
Any Fish Species	39.0%	40.2%	30.8%	39.6%	31.9%	34.5%	26.1%	23.8%	30.5%	29.0%	33.7%
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	-	0.9%	1.1%	2.1%	3.1%	1.2%	2.6%	5.3%	11.8%	8.5%	11.1%
Charters-All Anglers	-	0.0%	0.0%	0.7%	1.9%	0.6%	0.0%	2.0%	1.9%	0.8%	3.6%
Noncharter Boats	-	0.0%	0.1%	0.1%	0.0%	0.0%	0.5%	0.0%	0.4%	0.0%	0.2%
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	-	16.1%	21.8%	12.1%	24.2%	19.5%	21.4%	22.1%	14.3%	11.5%	5.8%
Charters-All Anglers	-	1.9%	3.6%	1.9%	3.1%	4.3%	2.8%	4.6%	3.0%	0.9%	0.4%
Noncharter Boats	-	0.5%	2.7%	0.9%	1.4%	1.9%	3.0%	3.7%	1.3%	1.5%	0.8%
Part B: Boats seeking smallmouth bass during the traditional open season.											
Percent boats with zero harvest of:											
Smallmouth Bass	62.9%	77.2%	77.2%	82.1%	84.7%	79.0%	82.7%	79.7%	76.5%	71.1%	86.3%
Any Fish Species	60.9%	67.8%	59.6%	65.6%	71.2%	65.0%	72.3%	63.9%	67.4%	63.5%	70.6%
Percent boats with zero catch of:											
Smallmouth Bass	24.7%	42.8%	43.1%	50.3%	53.6%	56.2%	58.8%	53.6%	45.8%	40.0%	50.2%
Any Fish Species	21.0%	28.2%	22.4%	27.7%	36.5%	37.6%	35.1%	34.6%	31.4%	27.6%	37.6%
Percent boats harvesting the daily bag limit of 5 smallmouth bass per angler:											
All Boats Combined	6.1%	3.7%	2.8%	1.0%	0.3%	1.2%	2.6%	0.6%	2.5%	5.8%	1.5%

Table A7a. Coho salmon harvest and catch data collected April 15 – September 30, 1985-2015.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	9,830	9,255	14,541	4,912	12,931	9,223	7,380	8,259	4,871	5,653	2,078
Catch	12,890	12,198	25,510	6,666	21,376	12,908	11,915	12,494	7,704	8,442	4,260
% Harvested	75.7	75.9	57.0	73.7	60.5	71.5	61.9	66.1	63.2	67.0	48.8
Monthly estimates of harvest for all fishing boats:											
April	2,721	1,634	1,604	618	1,446	1,178	968	392	266	349	12
May	1,985	4,759	6,168	1,176	3,087	1,353	946	1,787	1,646	2,101	94
June	539	178	2,515	33	441	918	653	163	454	369	37
July	403	214	265	143	476	1,864	2,362	503	235	238	121
August	2,367	1,644	2,367	513	1,816	2,860	853	3,437	1,170	691	417
September	1,814	824	1,622	2,429	5,666	1,049	1,599	1,978	1,100	1,906	1,397
										5,653	
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	4,224	3,110	9,014	1,310	5,692	5,269	3,635	3,001	2,365	2,541	458
West/Central	1,727	681	910	111	566	772	765	411	201	310	0
East/Central	2,335	3,831	2,702	1,251	2,727	1,537	1,546	1,968	1,594	1,566	959
East	1,544	1,633	1,915	2,240	3,945	1,645	1,434	2,880	711	1,235	661
Monthly estimates of catch for all fishing boats:											
April	3,754	2,269	2,352	976	2,183	1,543	2,324	686	332	1,209	440
May	2,811	6,022	13,798	2,107	9,559	2,164	1,926	4,047	3,145	3,537	1,412
June	863	698	3,799	255	685	1,542	1,277	734	986	547	61
July	622	263	386	242	686	2,734	3,357	830	627	286	261
August	2,770	1,881	3,313	513	2,096	3,652	1,190	3,888	1,434	897	584
September	2,069	1,064	1,863	2,573	6,167	1,272	1,840	2,308	1,179	1,965	1,502
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	5,812	5,062	17,668	2,517	12,152	7,285	6,476	5,875	4,642	4,450	2,119
West/Central	2,658	876	1,383	304	1,354	1,636	1,837	1,072	592	801	238
East/Central	2,753	4,501	3,960	1,506	3,388	2,050	1,922	2,350	1,728	1,955	1,194
East	1,668	1,759	2,499	2,340	4,482	1,937	1,679	3,197	742	1,237	709
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.6	94.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% Catch	99.5	95.8	100.0	100.0	100.0	100.0	99.5	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	40.6	56.3	44.8	51.4	39.8	56.9	42.1	40.6	45.6	39.2	55.0
% Catch	33.7	49.4	37.9	40.6	26.2	44.2	28.2	28.5	31.5	30.9	35.0

Table A7b. Coho salmon harvest and catch rate data collected April 15 – September 30, 1985-2015. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.097	0.183	0.252	0.096	0.208	0.184	0.149	0.179	0.103	0.114	0.045
Catch/Boat Trip	0.127	0.244	0.443	0.130	0.345	0.258	0.239	0.271	0.162	0.171	0.092
Harv/Angler Trip	0.033	0.061	0.085	0.032	0.068	0.061	0.050	0.060	0.033	0.036	0.015
Catch/Angler Trip	0.044	0.082	0.148	0.044	0.113	0.085	0.080	0.090	0.052	0.054	0.030
Harv/Angler Hour	0.006	0.011	0.015	0.006	0.011	0.011	0.009	0.011	0.005	0.006	0.002
Catch/Angler Hr.	0.008	0.014	0.026	0.008	0.019	0.015	0.014	0.016	0.009	0.009	0.005
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.275	0.406	0.535	0.215	0.401	0.451	0.384	0.166	0.103	0.182	0.005
May	0.110	0.533	0.560	0.162	0.210	0.144	0.118	0.213	0.208	0.250	0.011
June	0.053	0.065	0.429	0.007	0.085	0.237	0.151	0.032	0.072	0.067	0.009
July	0.031	0.026	0.026	0.015	0.054	0.202	0.217	0.054	0.024	0.027	0.015
August	0.087	0.113	0.142	0.031	0.120	0.158	0.060	0.266	0.074	0.041	0.034
September	0.087	0.080	0.149	0.229	0.389	0.153	0.166	0.247	0.214	0.242	0.134
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.158	0.283	0.559	0.105	0.307	0.370	0.247	0.237	0.173	0.210	0.040
West/Central	0.104	0.100	0.131	0.026	0.073	0.139	0.152	0.074	0.030	0.050	0.000
East/Central	0.083	0.196	0.164	0.073	0.142	0.092	0.102	0.145	0.104	0.099	0.069
East	0.054	0.124	0.106	0.129	0.238	0.122	0.098	0.203	0.059	0.081	0.046
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.370	0.564	0.784	0.340	0.605	0.591	0.923	0.290	0.129	0.630	0.195
May	0.157	0.692	1.253	0.290	0.649	0.230	0.232	0.482	0.398	0.420	0.163
June	0.090	0.255	0.648	0.054	0.132	0.398	0.296	0.143	0.156	0.100	0.014
July	0.046	0.032	0.038	0.026	0.078	0.296	0.308	0.090	0.065	0.032	0.032
August	0.102	0.130	0.199	0.031	0.138	0.202	0.084	0.301	0.090	0.053	0.047
September	0.101	0.103	0.171	0.243	0.424	0.185	0.191	0.288	0.229	0.250	0.144
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.222	0.460	1.096	0.202	0.655	0.511	0.436	0.464	0.339	0.368	0.187
West/Central	0.168	0.129	0.199	0.071	0.175	0.294	0.364	0.192	0.089	0.128	0.037
East/Central	0.098	0.236	0.240	0.088	0.177	0.122	0.127	0.173	0.113	0.123	0.086
East	0.058	0.134	0.139	0.134	0.271	0.144	0.115	0.225	0.062	0.081	0.049
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.279	0.588	0.712	0.289	0.522	0.614	0.377	0.440	0.240	0.228	0.117
Catch/Boat Trip	0.304	0.680	1.056	0.310	0.569	0.668	0.407	0.467	0.261	0.269	0.152
Harv/Angler Trip	0.056	0.116	0.138	0.056	0.103	0.118	0.072	0.086	0.046	0.043	0.022
Catch/Angler Trip	0.061	0.135	0.205	0.059	0.112	0.128	0.078	0.092	0.050	0.051	0.029
Harv/Angler Hour	0.008	0.017	0.020	0.008	0.015	0.018	0.011	0.013	0.007	0.006	0.003
Catch/Angler Hr.	0.008	0.020	0.029	0.009	0.016	0.020	0.012	0.014	0.007	0.008	0.004
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.066	0.091	0.166	0.056	0.149	0.096	0.103	0.128	0.069	0.086	0.026
Catch/Boat Trip	0.097	0.145	0.327	0.093	0.302	0.174	0.206	0.232	0.138	0.147	0.076
Harv/Angler Trip	0.026	0.036	0.064	0.022	0.056	0.037	0.041	0.049	0.027	0.033	0.010
Catch/Angler Trip	0.038	0.058	0.127	0.037	0.113	0.067	0.081	0.089	0.054	0.056	0.030
Harv/Angler Hour	0.005	0.007	0.013	0.004	0.010	0.007	0.008	0.009	0.005	0.006	0.002
Catch/Angler Hr.	0.007	0.011	0.025	0.007	0.020	0.013	0.015	0.017	0.010	0.010	0.005

Table A8. Total length (inches), weight (lbs), and age statistics for coho salmon sampled April 15 - September 30 during the 1985-2015 NYSDEC Lake Ontario fishing boat surveys.

	Year Sampled										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Mean length and weight data for coho salmon sampled April 15 - September 30:											
Mean Length (in)	24.0	24.6	24.6	25.5	23.9	25.1	24.0	26.1	25.0	23.8	23.7
Mean Weight (lbs)	-	6.47	6.64	8.09	6.30	7.15	6.27	8.29	6.70	6.37	6.55
Estimated weight (lbs) for standard length coho salmon sampled April 15 - September 30:											
Standard Length											
18.0 inches	-	1.90	1.80	1.97	1.90	1.84	1.87	2.01	1.97	1.84	1.99
20.0 inches	-	2.81	2.67	2.92	2.82	2.75	2.79	2.92	2.84	2.76	3.06
22.0 inches	-	3.99	3.83	4.16	4.04	3.96	4.01	4.11	3.95	4.00	4.52
24.0 inches	-	5.50	5.32	5.75	5.61	5.52	5.57	5.60	5.35	5.60	6.45
26.0 inches	-	7.40	7.19	7.75	7.59	7.50	7.54	7.45	7.07	7.64	8.94
28.0 inches	-	9.67	9.46	10.15	9.98	9.90	9.92	9.66	9.10	10.13	12.02
30.0 inches	-	12.54	12.33	13.18	13.00	12.96	12.95	12.41	11.61	13.30	16.01
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%	2.6%
15.0-15.9 in	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
16.0-16.9 in	0.6%	0.0%	0.0%	0.9%	0.7%	0.0%	0.0%	0.0%	0.0%	3.8%	0.0%
17.0-17.9 in	2.2%	0.0%	1.5%	1.8%	4.3%	0.0%	1.4%	0.0%	0.0%	7.7%	0.0%
18.0-18.9 in	3.6%	0.0%	2.5%	6.4%	6.1%	0.5%	7.7%	0.8%	2.4%	10.3%	2.6%
19.0-19.9 in	6.4%	0.9%	6.5%	10.1%	7.6%	3.3%	6.3%	3.1%	4.9%	5.1%	2.6%
20.0-20.9 in	10.2%	6.6%	8.5%	2.8%	7.2%	1.9%	10.6%	7.7%	4.9%	5.1%	2.6%
21.0-21.9 in	12.1%	11.9%	15.9%	0.9%	10.1%	12.2%	9.6%	7.7%	8.5%	3.8%	5.3%
22.0-22.9 in	10.0%	17.7%	9.0%	1.8%	10.4%	7.5%	5.3%	7.7%	13.4%	2.6%	21.1%
23.0-23.9 in	8.1%	15.0%	5.0%	3.7%	2.2%	9.9%	6.7%	4.6%	8.5%	3.8%	7.9%
24.0-24.9 in	6.4%	9.7%	3.0%	3.7%	4.0%	15.0%	9.6%	3.8%	9.8%	7.7%	23.7%
25.0-25.9 in	5.9%	6.6%	1.0%	5.5%	6.8%	11.7%	11.1%	5.4%	8.5%	5.1%	18.4%
26.0-26.9 in	6.1%	4.4%	8.0%	15.6%	11.2%	9.9%	5.8%	6.2%	6.1%	16.7%	5.3%
27.0-27.9 in	7.3%	8.4%	11.9%	15.6%	15.5%	8.5%	8.7%	14.6%	11.0%	15.4%	5.3%
28.0-28.9 in	7.3%	8.0%	13.4%	17.4%	9.4%	5.6%	9.1%	16.9%	4.9%	7.7%	0.0%
29.0-29.9 in	5.6%	7.5%	7.5%	8.3%	3.6%	7.5%	4.8%	9.2%	11.0%	2.6%	2.6%
30.0-30.9 in	3.9%	1.3%	6.0%	2.8%	0.7%	3.8%	2.4%	8.5%	1.2%	1.3%	0.0%
31.0-31.9 in	1.8%	1.8%	0.5%	0.0%	0.0%	1.4%	0.5%	3.1%	2.4%	0.0%	0.0%
32.0-32.9 in	0.9%	0.0%	0.0%	1.8%	0.0%	1.4%	0.0%	0.0%	2.4%	0.0%	0.0%
>32.9 in	0.3%	0.0%	0.0%	0.9%	0.4%	0.0%	0.5%	0.8%	0.0%	1.3%	0.0%
Percent age composition of coho salmon sampled April 15 - September 30:											
Age-1	4.6%	2.6%	1.6%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Age-2	94.5%	97.4%	93.8%	93.3%	99.6%	99.9%	99.3%	98.0%	100.0%	97.2%	100.0%
Age-3	0.8%	0.0%	4.6%	6.7%	0.0%	0.1%	0.7%	2.0%	0.0%	2.8%	0.0%
Length data (inches) for age-2 coho salmon sampled April 15 - September 30:											
April Mean	20.57	21.3	20.6	18.7	18.5	21.4	19.4	21.0	20.5	18.3	-
September Mean	28.08	28.6	28.2	27.4	27.2	29.3	28.2	28.2	28.1	26.3	24.1
Avg Monthly Gain	1.65	1.59	1.72	1.89	1.97	1.72	1.93	1.59	1.68	1.90	-

Table A9a. Chinook salmon harvest and catch data collected April 15 – September 30, 1985-2015.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	53,837	39,439	53,336	35,520	54,964	31,676	46,333	55,137	38,292	47,935	34,951
Catch	75,116	59,606	84,842	55,776	101,427	61,960	97,899	88,851	62,570	76,626	58,870
% Harvested	71.6	66.2	62.9	63.7	54.2	51.1	47.3	62.1	61.2	62.6	59.4
Monthly estimates of harvest for all fishing boats:											
April	1,861	381	15	117	200	156	86	2,180	115	0	145
May	7,585	4,513	4,422	4,385	12,978	3,932	1,594	5,358	4,102	8,067	9,138
June	2,297	586	3,584	1,334	887	3,804	2,166	4,858	2,277	3,133	955
July	6,957	8,241	13,883	5,293	16,984	5,282	17,509	11,004	8,560	11,074	6,857
August	21,649	18,228	20,112	16,195	13,086	13,909	16,885	21,746	20,670	16,908	12,030
September	13,489	7,489	11,320	8,195	10,829	4,592	8,093	9,991	2,568	8,754	5,826
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	22,677	14,083	17,947	14,790	23,605	10,927	14,042	17,459	17,417	13,314	14,349
West/Central	5,732	3,643	4,072	880	2,957	1,750	2,047	3,277	2,223	2,458	3,593
East/Central	11,955	15,177	16,863	11,126	18,057	12,160	17,550	16,097	13,258	20,796	10,808
East	13,473	6,535	14,454	8,724	10,345	6,839	12,694	18,305	5,394	11,367	6,200
Monthly estimates of catch for all fishing boats:											
April	2,648	591	45	117	448	156	267	3,781	164	232	261
May	11,986	10,597	11,611	9,057	40,831	5,866	4,511	11,827	6,948	13,020	18,854
June	5,282	1,425	7,531	2,999	3,537	10,250	8,483	10,058	5,200	7,829	3,594
July	10,942	12,689	20,033	9,946	23,944	16,280	42,582	19,848	15,682	14,608	10,525
August	28,197	25,089	31,108	21,965	19,623	23,084	31,239	31,097	30,649	29,562	17,823
September	16,062	9,216	14,514	11,692	13,043	6,307	10,817	12,239	3,926	11,375	7,813
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	35,546	26,022	35,059	26,841	53,358	23,577	43,599	34,937	32,474	25,615	28,640
West/Central	9,616	6,333	8,209	2,810	9,887	9,774	7,038	9,223	6,622	10,001	6,896
East/Central	14,971	19,532	22,138	14,994	26,077	20,061	30,606	22,321	16,963	27,082	15,710
East	14,984	7,719	19,436	11,132	12,105	8,548	16,657	22,370	6,511	13,928	7,624
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	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% Catch	99.8	99.9	99.9	100.0	100.0	100.0	99.9	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	40.7	53.9	46.1	52.8	41.6	42.8	40.2	42.7	47.1	51.5	50.9
% Catch	35.7	39.3	36.0	43.0	27.8	35.8	32.3	32.3	38.3	38.9	39.4

Table A9b. Chinook salmon harvest and catch rate data collected April 15 – September 30, 1985-2015. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.538	0.825	0.925	0.693	0.886	0.633	0.935	1.197	0.806	0.970	0.757
Catch/Boat Trip	0.777	1.246	1.472	1.089	1.635	1.238	1.975	1.928	1.316	1.550	1.276
Harv/Angler Trip	0.186	0.277	0.310	0.232	0.290	0.209	0.314	0.398	0.261	0.308	0.245
Catch/Angler Trip	0.268	0.419	0.493	0.365	0.534	0.408	0.662	0.640	0.426	0.492	0.412
Harv/Angler Hour	0.032	0.049	0.055	0.041	0.048	0.038	0.056	0.070	0.043	0.052	0.042
Catch/Angler Hr.	0.047	0.074	0.088	0.064	0.089	0.073	0.118	0.113	0.070	0.083	0.070
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.117	0.095	0.005	0.041	0.055	0.060	0.034	0.921	0.045	0.000	0.064
May	0.390	0.567	0.402	0.604	0.881	0.418	0.198	0.639	0.519	0.958	1.056
June	0.207	0.214	0.611	0.280	0.171	0.981	0.502	0.946	0.360	0.571	0.221
July	0.508	0.998	1.359	0.572	1.943	0.572	1.606	1.189	0.886	1.255	0.842
August	0.791	1.257	1.204	0.982	0.860	0.769	1.196	1.684	1.299	0.999	0.975
September	0.655	0.724	1.042	0.774	0.744	0.670	0.839	1.249	0.500	1.113	0.558
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.837	1.277	1.113	1.189	1.272	0.766	0.954	1.378	1.274	1.101	1.264
West/Central	0.361	0.534	0.580	0.205	0.383	0.314	0.406	0.587	0.335	0.393	0.557
East/Central	0.415	0.905	1.022	0.651	0.941	0.726	1.159	1.184	0.868	1.312	0.775
East	0.466	0.496	0.802	0.501	0.624	0.507	0.867	1.288	0.451	0.746	0.430
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.182	0.147	0.015	0.041	0.124	0.060	0.106	1.598	0.064	0.121	0.116
May	0.627	1.331	1.055	1.247	2.772	0.624	0.560	1.410	0.878	1.547	2.178
June	0.494	0.521	1.285	0.630	0.680	2.643	1.967	1.958	0.821	1.426	0.832
July	0.857	1.536	1.962	1.074	2.739	1.763	3.906	2.145	1.624	1.655	1.293
August	1.064	1.731	1.864	1.332	1.291	1.278	2.208	2.407	1.926	1.746	1.444
September	0.805	0.888	1.334	1.104	0.896	0.920	1.122	1.529	0.764	1.446	0.749
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	1.391	2.359	2.175	2.158	2.875	1.654	2.959	2.757	2.375	2.118	2.523
West/Central	0.683	0.928	1.172	0.655	1.280	1.753	1.394	1.652	0.998	1.596	1.070
East/Central	0.542	1.163	1.341	0.877	1.359	1.198	2.022	1.640	1.111	1.708	1.127
East	0.530	0.585	1.078	0.640	0.731	0.634	1.137	1.575	0.545	0.914	0.529
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	1.576	2.403	2.685	2.148	2.319	1.588	2.260	3.087	1.946	2.542	1.820
Catch/Boat Trip	1.957	2.645	3.335	2.749	2.859	2.596	3.838	3.765	2.588	3.069	2.370
Harv/Angler Trip	0.314	0.476	0.522	0.412	0.457	0.304	0.433	0.606	0.374	0.481	0.349
Catch/Angler Trip	0.391	0.524	0.649	0.527	0.563	0.498	0.736	0.739	0.497	0.581	0.454
Harv/Angler Hour	0.044	0.070	0.074	0.060	0.066	0.047	0.068	0.092	0.054	0.071	0.054
Catch/Angler Hr.	0.054	0.077	0.092	0.077	0.081	0.077	0.116	0.112	0.072	0.086	0.070
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.367	0.466	0.593	0.395	0.615	0.436	0.670	0.822	0.529	0.586	0.472
Catch/Boat Trip	0.581	0.928	1.120	0.748	1.403	0.958	1.603	1.564	1.009	1.178	0.982
Harv/Angler Trip	0.144	0.186	0.230	0.156	0.230	0.169	0.264	0.316	0.205	0.223	0.187
Catch/Angler Trip	0.229	0.371	0.434	0.296	0.524	0.371	0.632	0.602	0.391	0.448	0.389
Harv/Angler Hour	0.027	0.036	0.045	0.030	0.040	0.033	0.050	0.060	0.036	0.041	0.034
Catch/Angler Hr.	0.043	0.072	0.085	0.057	0.092	0.072	0.119	0.114	0.070	0.082	0.071

Table A10. Total length (inches), weight (lbs), and age statistics for Chinook salmon sampled April 15 - September 30 during the 1985-2015 NYSDEC Lake Ontario fishing boat surveys.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Mean length and weight data for chinook salmon sampled April 15 - September 30:											
Mean Length (in)	31.9	32.9	32.6	32.1	31.6	29.7	29.6	31.4	32.6	31.1	31.1
Mean Weight (lbs)	-	15.9	14.5	15.4	14.5	13.4	12.8	14.1	15.6	13.5	13.6
Estimated weight (lbs) for standard length chinook salmon sampled July & August:											
Standard Length:											
16.0 inches	-	1.42	1.37	1.47	1.31	1.47	1.36	1.34	1.47	1.38	1.33
20.0 inches	-	2.90	2.81	3.01	2.77	3.04	2.89	2.82	2.98	2.85	2.83
24.0 inches	-	5.24	5.07	5.47	5.15	5.55	5.39	5.23	5.34	5.18	5.26
28.0 inches	-	8.59	8.33	9.00	8.65	9.18	9.09	8.76	8.72	8.55	8.84
32.0 inches	-	13.25	12.84	13.92	13.62	14.27	14.35	13.77	13.38	13.25	13.93
36.0 inches	-	19.40	18.82	20.44	20.32	21.04	21.46	20.50	19.52	19.49	20.79
40.0 inches	-	27.21	26.40	28.74	28.97	29.69	30.64	29.17	27.27	27.44	29.64
Percent length composition of chinook salmon sampled April 15 - September 30:											
<16.0 in	1.3%	0.1%	0.6%	0.3%	0.3%	0.2%	0.9%	0.5%	0.5%	0.9%	1.2%
16.0-17.9 in	2.9%	0.7%	0.3%	1.2%	1.3%	2.4%	3.5%	0.8%	1.7%	1.9%	0.8%
18.0-19.9 in	3.4%	3.4%	0.8%	1.9%	3.1%	9.1%	7.8%	1.6%	2.8%	1.9%	1.6%
20.0-21.9 in	3.2%	3.7%	0.8%	1.9%	2.1%	8.9%	5.7%	3.5%	2.8%	3.0%	1.0%
22.0-23.9 in	3.5%	3.4%	1.7%	3.6%	3.0%	8.7%	3.9%	3.0%	2.8%	2.6%	2.5%
24.0-25.9 in	4.5%	3.2%	3.8%	6.3%	5.6%	5.5%	4.3%	5.3%	2.6%	4.4%	7.9%
26.0-27.9 in	6.3%	4.8%	6.0%	7.0%	6.4%	5.9%	5.8%	6.8%	4.9%	10.4%	8.3%
28.0-29.9 in	7.2%	7.2%	8.6%	6.4%	7.9%	5.7%	6.7%	12.8%	9.2%	10.3%	11.8%
30.0-31.9 in	8.2%	7.3%	15.2%	12.1%	12.6%	6.3%	13.7%	14.0%	9.9%	16.4%	15.9%
32.0-33.9 in	11.0%	9.9%	17.5%	12.6%	17.5%	10.2%	21.2%	17.7%	14.4%	15.0%	18.6%
34.0-35.9 in	14.1%	16.6%	22.1%	17.1%	19.9%	12.9%	16.2%	15.9%	15.5%	13.6%	16.9%
36.0-37.9 in	17.5%	23.1%	15.7%	17.1%	14.7%	12.6%	7.5%	9.6%	16.2%	11.6%	9.5%
38.0-39.9 in	11.9%	12.4%	6.1%	11.1%	4.7%	7.0%	1.9%	6.1%	12.3%	7.1%	3.3%
40.0-41.9 in	4.3%	4.1%	0.7%	1.3%	0.8%	4.3%	0.8%	2.2%	3.8%	1.1%	0.8%
42.0-43.9 in	0.6%	0.0%	0.0%	0.0%	0.1%	0.4%	0.0%	0.1%	0.5%	0.0%	0.0%
>43.9 in	0.0%	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	11.6%	9.0%	3.2%	3.1%	4.8%	33.7%	22.2%	5.0%	10.7%	8.3%	3.7%
Age-2	35.5%	28.9%	46.4%	47.9%	29.5%	24.9%	68.9%	70.8%	37.0%	52.7%	46.5%
Age-3	49.2%	57.8%	47.7%	46.6%	64.8%	38.6%	8.6%	24.1%	52.0%	36.5%	49.1%
Age-4	3.7%	4.3%	2.7%	2.3%	0.9%	2.8%	0.2%	0.2%	0.3%	2.5%	0.7%
Age-3&4 combined	52.9%	62.1%	50.4%	49.0%	65.7%	41.4%	8.8%	24.2%	52.3%	39.0%	49.8%

Table A11. Mean length at age data (total length in inches) for Chinook salmon sampled July-September during the 1991-2015 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)
	2014	17.85	(13)	19.55	(24)	20.48	(12)
	2015	18.33	(3)	17.34	(12)	17.97	(3)
	91-'15 avg	18.92		19.65		21.64	
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)
	2014	29.36	(83)	29.97	(104)	32.00	(63)
	2015	27.63	(81)	29.39	(80)	31.10	(50)
	91-'15 avg	29.26		30.51		32.13	

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

Age	Year Sampled	July Mean Length	July (n)	August Mean Length	August (n)	September Mean Length	September (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)
	2014	35.58	(48)	36.47	(58)	36.70	(80)
	2015	34.82	(60)	35.88	(67)	35.04	(47)
	91-'15 avg	35.95		36.83		37.08	
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	40.50	(1)	-	(0)	-	(0)
	2014	37.73	(3)	37.17	(3)	37.61	(7)
	2015	-	(0)	39.00	(1)	-	(0)
	91-'15 avg	37.91	(55	38.31		38.78	

Table A12. Chinook salmon relative harvest (age-specific harvest per 50,000 boat trips) by year class and year sampled, from the 1985-2015 NYSDEC Lake Ontario fishing boat surveys.

Year	Fing Equiv	Chinook Salmon Harvested Per 50,000 Boat Trips				
Class	Stocked	Age-1	Age-2	Age-3	Age-4	Total
1981	862,840				531	
1982	1,175,354			7,510	392	
1983	2,544,180		5,837	9,043	1,267	
1984	2,957,230	5,022	8,347	15,102	1,185	29,665
1985	3,252,830	3,990	10,715	13,297	2,478	30,481
1986	2,810,771	4,026	8,038	21,317	1,112	34,494
1987	3,368,296	3,148	11,346	13,699	1,904	30,110
1988	3,104,104	3,017	7,040	13,759	784	24,630
1989	3,018,754	1,161	7,423	9,109	1,238	18,931
1990	2,964,722	1,779	6,428	11,901	1,217	21,325
1991	3,129,453	3,471	8,902	18,263	1,155	31,790
1992	3,004,329	3,334	12,489	11,690	2,645	30,212
1993	1,846,892	822	4,168	8,955	1,057	15,002
1994	1,221,491	357	1,976	4,135	364	6,832
1995	1,364,090	5,357	17,531	13,108	795	36,790
1996	1,495,138	3,334	6,754	14,007	0	24,096
1997	1,911,040	1,821	6,189	9,800	151	17,961
1998	1,903,929	3,616	7,016	7,159	209	18,000
1999	1,767,524	2,907	9,847	7,405	64	20,224
2000	1,906,543	2,716	8,562	19,445	326	31,048
2001	1,893,686	1,774	11,839	15,862	440	29,953
2002	1,908,002	1,751	25,606	38,454	1,758	67,570
2003	1,700,374	3,020	18,954	23,849	1,262	47,085
2004	1,962,565	2,103	11,925	22,083	812	36,923
2005	2,075,169	3,710	21,455	16,162	399	41,727
2006	1,898,083	1,483	16,602	28,719	873	47,677
2007	2,055,075	1,090	13,076	12,225	81	26,472
2008	1,038,844	2,113	7,877	4,041	99	14,129
2009	1,981,055	10,663	32,236	14,404	116	57,418
2010	1,911,756	10,398	42,386	20,939	1,207	74,929
2011	2,060,874	2,966	14,922	17,690	284	35,862
2012	1,816,778	4,314	25,569	18,581		48,464
2013	2,010,290	4,019	17,609			21,627
2014	2,229,494	1,400				1,400

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

Year Sampled	Salmonid Boat Trips	Chinook Salmon Harvested Per 50,000 Boat Trips				
		Age-1	Age-2	Age-3	Age-4	Total
1985	126,155	5,022	5,837	7,510	531	18,900
1986	148,950	3,990	8,347	9,043	392	21,772
1987	165,678	4,026	10,715	15,102	1,267	31,122
1988	160,805	3,148	8,038	13,297	1,185	25,699
1989	177,223	3,017	11,346	21,317	2,478	38,159
1990	181,867	1,161	7,040	13,699	1,112	23,013
1991	152,357	1,779	7,423	13,759	1,904	24,865
1992	118,054	3,471	6,428	9,109	784	19,845
1993	103,125	3,334	8,902	11,901	1,238	25,375
1994	102,718	822	12,489	18,263	1,217	32,791
1995	92,346	357	4,168	11,690	1,155	17,371
1996	70,151	5,357	1,976	8,955	2,645	18,932
1997	64,351	3,334	17,531	4,135	1,057	26,058
1998	64,060	1,821	6,754	13,108	364	22,046
1999	60,573	3,616	6,189	14,007	795	24,608
2000	64,589	2,907	7,016	9,800	0	19,723
2001	63,026	2,716	9,847	7,159	151	19,910
2002	50,826	1,774	8,562	7,405	209	17,949
2003	47,622	1,751	11,839	19,445	64	33,099
2004	57,397	3,020	25,606	15,862	326	44,813
2005	57,510	2,103	18,954	38,454	440	59,952
2006	47,812	3,710	11,925	23,849	1,758	41,244
2007	57,620	1,483	21,455	22,083	1,262	46,283
2008	51,229	1,090	16,602	16,162	812	34,668
2009	62,028	2,113	13,076	28,719	399	44,306
2010	50,059	10,663	7,877	12,225	873	31,639
2011	49,548	10,398	32,236	4,041	81	46,756
2012	46,059	2,966	42,386	14,404	99	59,855
2013	47,520	4,314	14,922	20,939	116	40,290
2014	49,434	4,019	25,569	17,690	1,207	48,484
2015	46,142	1,400	17,609	18,581	284	37,873

Table A13. Number of fingerling equivalents and average size (grams) of Chinook salmon stocked into Lake Ontario from 1981-2014 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		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	6.0			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
2013	1,212,907	4.7			443,566	5.5	294,324	5.6	59,494	8.4	2,010,290	5.2
2014	1,394,560	4.9			505,990	6.0	246,124	5.6	82,820	8.1	2,229,494	5.5

Table A14a. Rainbow trout harvest and catch data collected April 15 – September 30, 1985-2015.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	24,541	10,750	12,861	19,685	24,060	23,856	16,131	12,617	17,203	16,729	9,212
Catch	34,684	17,959	25,892	33,943	54,501	46,249	36,533	32,975	34,611	37,462	17,509
% Harvested	70.1	59.9	49.7	58.0	44.1	51.6	44.2	38.3	49.7	44.7	52.6
Monthly estimates of harvest for all fishing boats:											
April	1,254	186	228	262	473	463	56	199	76	101	127
May	5,484	1,872	2,619	2,481	1,698	1,548	410	939	2,099	2,315	1,773
June	3,641	526	1,112	978	813	2,406	1,095	2,156	965	5,102	614
July	3,130	1,901	3,666	2,889	5,816	4,831	7,299	4,301	5,488	2,461	1,750
August	8,399	1,948	3,613	9,800	10,096	13,568	4,587	4,381	7,567	5,670	3,876
September	2,633	4,318	1,622	3,275	5,164	1,040	2,684	640	1,009	1,080	1,072
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	14,565	6,763	8,537	14,945	19,388	18,973	11,637	8,622	11,437	9,225	6,143
West/Central	2,805	1,516	1,578	760	1,728	1,447	2,023	1,245	2,333	1,871	1,057
East/Central	5,911	2,102	2,335	3,603	2,221	3,065	2,340	1,852	3,036	4,800	1,442
East	1,261	369	411	377	722	370	131	898	397	833	570
Monthly estimates of catch for all fishing boats:											
April	2,117	399	429	565	1,197	867	305	442	379	649	387
May	8,045	3,736	7,264	5,840	7,418	2,724	2,060	3,100	4,824	6,341	3,816
June	5,300	787	2,708	2,197	2,676	4,828	1,813	6,515	2,077	13,747	2,384
July	4,280	3,004	6,504	6,026	9,053	8,856	18,448	11,100	11,489	4,050	3,560
August	11,229	3,912	6,520	14,823	22,335	27,121	9,037	10,858	14,198	11,072	5,701
September	3,712	6,120	2,467	4,492	11,822	1,851	4,869	960	1,644	1,603	1,661
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	20,362	10,945	16,537	23,556	35,347	36,512	26,897	22,064	23,021	16,603	9,899
West/Central	4,879	3,383	3,130	1,727	12,065	3,891	3,377	5,355	5,055	7,394	2,949
East/Central	7,886	3,249	5,382	8,040	5,824	5,166	5,164	4,195	5,957	10,976	3,456
East	1,556	382	843	620	1,266	681	1,096	1,361	578	2,489	1,204
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.7	100.0	100.0	99.8	100.0	100.0	99.8	100.0	100.0	99.7	100.0
% Catch	99.6	100.0	99.9	99.7	99.8	99.9	99.9	100.0	99.9	99.9	100.0
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	50.2	66.3	50.0	59.4	50.7	49.8	50.2	45.9	54.3	56.5	50.3
% Catch	40.0	51.1	36.8	47.0	34.7	35.5	33.5	27.1	39.0	38.7	36.8

Table A14b. Rainbow trout harvest and catch rate data collected April 15 – September 30, 1985-2015. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.250	0.225	0.223	0.384	0.388	0.477	0.325	0.274	0.362	0.337	0.200
Catch/Boat Trip	0.353	0.376	0.449	0.661	0.877	0.923	0.737	0.716	0.728	0.757	0.379
Harv/Angler Trip	0.086	0.076	0.075	0.129	0.127	0.157	0.109	0.091	0.117	0.107	0.065
Catch/Angler Trip	0.121	0.126	0.150	0.221	0.287	0.305	0.247	0.238	0.235	0.240	0.123
Harv/Angler Hour	0.015	0.013	0.013	0.023	0.021	0.028	0.019	0.016	0.019	0.018	0.011
Catch/Angler Hr.	0.021	0.022	0.027	0.039	0.048	0.055	0.044	0.042	0.039	0.041	0.021
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.114	0.046	0.076	0.091	0.131	0.177	0.022	0.084	0.030	0.053	0.056
May	0.292	0.235	0.238	0.342	0.115	0.165	0.051	0.112	0.265	0.275	0.205
June	0.359	0.192	0.190	0.199	0.156	0.620	0.254	0.420	0.152	0.920	0.142
July	0.225	0.230	0.359	0.312	0.665	0.523	0.669	0.465	0.569	0.279	0.215
August	0.306	0.134	0.217	0.594	0.665	0.750	0.323	0.339	0.476	0.335	0.314
September	0.136	0.418	0.149	0.309	0.355	0.152	0.278	0.080	0.196	0.137	0.103
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.654	0.613	0.530	1.201	1.044	1.331	0.789	0.680	0.836	0.763	0.541
West/Central	0.163	0.222	0.227	0.177	0.224	0.260	0.401	0.223	0.352	0.299	0.164
East/Central	0.188	0.125	0.141	0.209	0.116	0.183	0.155	0.136	0.199	0.303	0.103
East	0.034	0.028	0.023	0.022	0.044	0.027	0.009	0.063	0.033	0.052	0.040
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.205	0.099	0.143	0.197	0.332	0.332	0.121	0.187	0.147	0.338	0.172
May	0.441	0.469	0.660	0.804	0.504	0.290	0.256	0.370	0.610	0.753	0.441
June	0.532	0.288	0.459	0.449	0.515	1.238	0.417	1.268	0.328	2.495	0.552
July	0.297	0.364	0.637	0.647	1.035	0.959	1.692	1.199	1.188	0.459	0.437
August	0.405	0.270	0.391	0.899	1.465	1.500	0.638	0.841	0.892	0.654	0.462
September	0.191	0.592	0.227	0.424	0.811	0.270	0.505	0.120	0.320	0.204	0.159
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.907	0.992	1.026	1.893	1.904	2.561	1.826	1.741	1.682	1.373	0.872
West/Central	0.308	0.495	0.447	0.399	1.559	0.698	0.669	0.959	0.762	1.183	0.457
East/Central	0.255	0.194	0.326	0.466	0.300	0.307	0.340	0.309	0.390	0.692	0.248
East	0.042	0.029	0.047	0.036	0.076	0.050	0.075	0.096	0.048	0.160	0.084
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.883	0.805	0.702	1.340	1.236	1.391	0.981	0.759	1.008	0.973	0.474
Catch/Boat Trip	1.004	1.035	1.040	1.828	1.919	1.925	1.484	1.169	1.455	1.494	0.659
Harv/Angler Trip	0.176	0.159	0.136	0.257	0.244	0.267	0.188	0.149	0.194	0.184	0.091
Catch/Angler Trip	0.200	0.205	0.202	0.351	0.378	0.369	0.284	0.230	0.280	0.283	0.126
Harv/Angler Hour	0.024	0.024	0.019	0.037	0.035	0.041	0.030	0.023	0.028	0.027	0.014
Catch/Angler Hr.	0.027	0.030	0.029	0.051	0.055	0.057	0.045	0.035	0.040	0.042	0.019
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.142	0.093	0.133	0.187	0.227	0.289	0.194	0.178	0.206	0.182	0.126
Catch/Boat Trip	0.242	0.226	0.337	0.421	0.680	0.717	0.587	0.626	0.552	0.577	0.304
Harv/Angler Trip	0.056	0.037	0.052	0.074	0.085	0.112	0.077	0.068	0.080	0.069	0.050
Catch/Angler Trip	0.095	0.090	0.131	0.167	0.254	0.278	0.232	0.241	0.214	0.220	0.120
Harv/Angler Hour	0.010	0.007	0.010	0.014	0.015	0.022	0.014	0.013	0.014	0.013	0.009
Catch/Angler Hr.	0.018	0.017	0.026	0.032	0.045	0.054	0.044	0.046	0.038	0.040	0.022

Table A15. Length (total length in inches) and weight (lbs) statistics for rainbow trout sampled April 15 – September 30 during the 1985-2015 NYSDEC Lake Ontario fishing boat surveys.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Mean length and weight data for rainbow trout sampled April 15 - September 30:											
Mean Length (in)	24.3	24.2	24.9	25.1	25.0	25.3	24.7	24.9	24.5	24.6	25.3
Mean Weight (lbs)	-	5.9	6.0	6.2	6.0	6.8	6.1	5.9	6.0	5.9	6.1
Estimated weight (lbs) for standard length rainbow trout sampled April 15 - September 30:											
Standard Length:											
18.0 inches	-	2.43	2.07	2.22	2.10	2.40	2.09	2.05	2.21	2.31	2.17
20.0 inches	-	3.26	2.86	3.02	2.89	3.26	2.92	2.83	3.04	3.10	2.94
22.0 inches	-	4.25	3.83	3.99	3.85	4.30	3.95	3.80	4.06	4.05	3.87
24.0 inches	-	5.42	5.00	5.13	5.00	5.53	5.21	4.97	5.28	5.17	4.97
26.0 inches	-	6.78	6.38	6.47	6.36	6.97	6.71	6.35	6.73	6.46	6.25
28.0 inches	-	8.30	7.97	7.99	7.92	8.60	8.46	7.94	8.39	7.91	7.70
30.0 inches	-	10.06	9.85	9.77	9.75	10.51	10.53	9.82	10.34	9.60	9.39
32.0 inches	-	12.04	12.00	11.78	11.84	12.67	12.92	11.98	12.58	11.50	11.30
Percent length composition of rainbow trout sampled April 15 - September 30:											
<15.0 in	0.3%	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%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%
16.0-16.9 in	1.0%	0.5%	0.0%	0.3%	0.2%	0.0%	0.0%	0.0%	0.0%	0.9%	0.0%
17.0-17.9 in	2.2%	1.0%	0.4%	0.3%	1.5%	0.3%	1.3%	0.5%	0.5%	2.3%	0.0%
18.0-18.9 in	4.6%	2.9%	3.5%	3.8%	1.2%	1.1%	1.3%	0.5%	0.5%	3.6%	2.0%
19.0-19.9 in	6.7%	5.4%	2.6%	1.4%	3.2%	1.6%	3.3%	1.6%	1.1%	4.5%	2.0%
20.0-20.9 in	8.2%	8.3%	7.5%	4.8%	5.4%	4.1%	4.6%	5.3%	8.1%	1.8%	2.9%
21.0-21.9 in	9.0%	9.3%	9.7%	8.7%	8.2%	8.5%	12.8%	7.4%	9.7%	7.7%	5.9%
22.0-22.9 in	9.2%	7.8%	8.4%	10.4%	9.2%	11.8%	12.1%	10.1%	14.1%	7.7%	9.8%
23.0-23.9 in	8.7%	15.6%	15.4%	6.2%	9.9%	11.5%	10.8%	16.0%	15.1%	7.7%	9.8%
24.0-24.9 in	7.7%	13.2%	5.3%	9.3%	7.7%	10.4%	7.5%	12.2%	9.2%	14.4%	13.7%
25.0-25.9 in	6.9%	8.3%	5.3%	8.7%	12.6%	8.5%	7.9%	11.2%	10.8%	13.5%	10.8%
26.0-26.9 in	6.2%	5.4%	7.5%	12.5%	10.1%	11.8%	11.1%	7.4%	8.1%	10.8%	11.8%
27.0-27.9 in	7.0%	6.8%	8.4%	12.5%	9.4%	9.0%	8.2%	12.8%	7.6%	7.7%	8.8%
28.0-28.9 in	5.8%	6.3%	10.1%	9.3%	9.9%	7.4%	9.5%	5.3%	5.4%	9.5%	6.9%
29.0-29.9 in	5.1%	4.4%	6.2%	6.6%	5.0%	4.9%	4.3%	3.7%	5.9%	4.5%	7.8%
30.0-30.9 in	4.3%	2.4%	4.4%	2.8%	4.0%	4.9%	3.6%	3.2%	1.1%	1.4%	3.9%
31.0-31.9 in	3.2%	1.5%	2.6%	1.4%	1.7%	1.4%	1.3%	1.1%	0.5%	2.3%	2.0%
32.0-32.9 in	1.9%	0.0%	1.8%	0.0%	0.7%	1.9%	0.0%	0.5%	0.5%	0.0%	1.0%
33.0-33.9 in	1.0%	0.5%	0.4%	0.3%	0.0%	0.5%	0.3%	1.1%	0.5%	0.0%	0.0%
>33.9 in	0.8%	0.5%	0.0%	0.7%	0.0%	0.3%	0.0%	0.0%	1.1%	0.0%	0.0%

Table A16. Atlantic salmon harvest and catch data collected April 15 – September 30, 1985-2015.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	338	0	14	79	532	624	398	310	200	66	275
Catch	1,254	158	214	233	1,273	1,826	1,519	592	599	639	638
% Harvested	26.5	0.0	6.5	33.9	41.8	34.2	26.2	52.4	33.4	10.3	43.1
Monthly estimates of harvest for all fishing boats:											
April	64	0	0	0	105	98	128	29	0	28	24
May	146	0	0	28	222	79	95	183	175	25	24
June	50	0	14	0	15	24	54	46	0	0	12
July	29	0	0	16	66	301	76	51	25	14	169
August	43	0	0	0	124	108	25	0	0	0	25
September	6	0	0	35	0	15	21	0	0	0	20
Seasonal estimates of harvest among four geographic areas for all fishing boats:											
West	84	0	14	51	226	205	236	126	51	39	0
West/Central	57	0	0	0	161	182	0	0	44	0	0
East/Central	97	0	0	0	74	204	106	93	105	0	136
East	101	0	0	28	71	33	56	91	0	27	139
Monthly estimates of catch for all fishing boats:											
April	231	31	0	0	201	273	296	56	48	180	132
May	405	17	72	88	430	223	439	387	251	215	194
June	165	0	114	64	66	231	171	46	77	0	37
July	210	0	28	16	211	648	212	90	165	162	209
August	172	110	0	30	365	372	340	13	58	82	25
September	71	0	0	35	0	79	62	0	0	0	41
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	293	72	116	52	363	560	526	242	186	121	26
West/Central	220	31	70	36	337	397	366	46	77	112	-
East/Central	384	0	0	47	509	650	339	211	255	209	368
East	357	55	28	98	63	219	287	93	81	197	244
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	98.8		100	100	100	100	100	100	100	100	100
% Catch	95.8	100	100	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	0.276	0.000	0.024	0.154	0.858	1.247	0.803	0.673	0.421	0.134	0.596
Catch/Boat Trip	1.010	0.330	0.371	0.455	2.052	3.648	3.066	1.285	1.261	1.293	1.383
Harv/Angler Trip	0.096	0.000	0.008	0.052	0.280	0.411	0.269	0.224	0.136	0.042	0.193
Catch/Angler Trip	0.352	0.111	0.124	0.152	0.671	1.203	1.028	0.427	0.408	0.411	0.447
Harv/Angler Hour	0.016	0.000	0.001	0.009	0.047	0.074	0.048	0.039	0.022	0.007	0.033
Catch/Angler Hr.	0.060	0.020	0.022	0.027	0.111	0.217	0.183	0.075	0.067	0.070	0.076

Table A17a. Brown trout harvest and catch data collected April 15 – September 30, 1985-2015.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	31,854	13,667	27,855	14,989	23,148	18,311	32,937	23,305	18,969	20,626	12,590
Catch	45,095	21,957	46,258	22,030	33,484	32,604	49,661	39,507	27,793	44,487	20,780
% Harvested	70.2	62.2	60.2	68.0	69.1	56.2	66.3	59.0	68.3	46.4	60.6
Monthly estimates of harvest for all fishing boats:											
April	8,422	3,304	5,795	1,420	4,023	3,855	3,558	5,802	2,730	5,094	3,247
May	11,333	4,117	9,083	3,828	11,256	2,266	12,255	5,436	7,810	5,404	3,138
June	4,366	1,068	4,052	4,164	2,393	611	4,941	1,456	3,315	612	3,591
July	3,870	3,630	4,570	3,280	576	7,782	6,695	5,631	2,656	5,202	1,188
August	3,278	1,398	4,100	1,945	4,538	3,543	4,968	4,307	2,197	3,593	1,045
September	585	150	256	352	362	255	519	672	259	721	380
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	2,601	453	2,633	1,052	209	1,153	2,563	2,006	1,649	4,267	560
West/Central	3,128	1,164	2,667	541	1,744	1,487	2,163	2,792	1,566	2,958	503
East/Central	17,515	9,322	15,145	3,969	17,399	11,156	16,327	8,932	9,850	8,199	7,903
East	8,609	2,727	7,410	9,427	3,796	4,515	11,883	9,575	5,903	5,202	3,624
Monthly estimates of catch for all fishing boats:											
April	11,489	4,342	10,656	1,996	5,997	5,501	8,160	10,558	4,450	13,369	6,962
May	15,470	5,181	15,302	5,983	15,838	3,913	17,584	9,446	9,329	15,497	4,657
June	5,808	1,262	5,337	6,110	3,463	1,342	6,658	3,345	3,918	913	4,516
July	6,033	5,225	9,167	4,692	888	14,421	10,026	7,751	5,169	8,331	1,876
August	5,406	5,567	5,347	2,654	6,720	6,993	6,193	7,236	4,284	5,048	1,498
September	890	381	449	595	579	434	1,041	1,171	643	1,330	1,271
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	4,093	828	3,828	1,408	344	2,043	4,760	4,122	2,451	12,153	1,249
West/Central	6,298	2,273	6,652	1,162	3,182	3,005	5,710	6,836	4,933	6,544	1,785
East/Central	23,632	14,537	25,705	6,117	25,272	20,730	22,945	13,860	12,722	15,761	12,243
East	11,072	4,319	10,073	13,344	4,686	6,826	16,246	14,689	7,687	10,028	5,504
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	98.8	99.3	98.6	98.9	99.4	98.9	99.8	99.8	99.8	99.6	99.9
% Catch	98.5	99.1	98.9	98.3	98.9	97.8	99.8	98.8	99.5	99.8	99.8
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	44.9	73.2	51.1	43.9	70.3	54.7	53.3	55.6	72.9	57.9	62.6
% Catch	37.7	59.1	42.2	34.1	59.6	49.8	43.4	42.3	58.7	36.4	47.4

Table A17b. Brown trout harvest and catch rate data collected April 15 – September 30, 1985-2015. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.325	0.284	0.477	0.289	0.371	0.362	0.664	0.505	0.398	0.416	0.273
Catch/Boat Trip	0.469	0.455	0.794	0.423	0.534	0.637	1.000	0.848	0.582	0.898	0.450
Harv/Angler Trip	0.112	0.095	0.160	0.097	0.121	0.119	0.223	0.168	0.129	0.132	0.088
Catch/Angler Trip	0.162	0.153	0.266	0.142	0.175	0.210	0.335	0.282	0.188	0.285	0.145
Harv/Angler Hour	0.019	0.017	0.028	0.017	0.020	0.021	0.040	0.030	0.021	0.022	0.015
Catch/Angler Hr.	0.028	0.027	0.047	0.025	0.029	0.038	0.060	0.050	0.031	0.048	0.025
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	1.016	0.821	1.933	0.494	1.114	1.477	1.413	2.452	1.060	2.653	1.442
May	0.635	0.517	0.825	0.527	0.764	0.241	1.522	0.648	0.987	0.642	0.363
June	0.464	0.357	0.655	0.851	0.438	0.140	1.134	0.283	0.523	0.106	0.831
July	0.294	0.440	0.438	0.352	0.066	0.834	0.614	0.603	0.272	0.583	0.144
August	0.124	0.096	0.240	0.116	0.298	0.196	0.352	0.334	0.138	0.212	0.085
September	0.030	0.015	0.024	0.033	0.025	0.029	0.054	0.084	0.050	0.092	0.036
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.111	0.041	0.163	0.082	0.011	0.081	0.174	0.158	0.119	0.353	0.049
West/Central	0.271	0.170	0.383	0.126	0.226	0.267	0.429	0.500	0.236	0.473	0.078
East/Central	0.597	0.556	0.899	0.226	0.908	0.658	1.079	0.653	0.645	0.514	0.567
East	0.269	0.200	0.406	0.541	0.220	0.330	0.808	0.674	0.494	0.339	0.251
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	1.428	1.079	3.555	0.695	1.661	2.108	3.241	4.462	1.719	6.963	3.093
May	0.889	0.644	1.390	0.816	1.074	0.416	2.184	1.126	1.179	1.841	0.538
June	0.616	0.428	0.867	1.228	0.617	0.329	1.518	0.579	0.615	0.161	1.039
July	0.453	0.633	0.888	0.505	0.102	1.498	0.920	0.827	0.529	0.938	0.229
August	0.212	0.383	0.312	0.158	0.441	0.387	0.439	0.560	0.269	0.298	0.121
September	0.048	0.034	0.041	0.056	0.035	0.056	0.108	0.146	0.120	0.167	0.122
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.176	0.075	0.237	0.111	0.019	0.143	0.323	0.325	0.176	1.004	0.110
West/Central	0.579	0.324	0.955	0.268	0.413	0.539	1.131	1.224	0.744	1.047	0.277
East/Central	0.817	0.865	1.533	0.345	1.306	1.201	1.513	1.000	0.830	0.991	0.877
East	0.348	0.320	0.554	0.760	0.274	0.501	1.105	1.020	0.641	0.656	0.381
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	1.050	1.129	1.556	0.754	1.650	1.174	2.128	1.698	1.492	1.231	0.805
Catch/Boat Trip	1.271	1.465	2.131	0.862	2.022	1.903	2.611	2.187	1.760	1.667	1.008
Harv/Angler Trip	0.210	0.224	0.302	0.145	0.325	0.225	0.408	0.333	0.287	0.233	0.154
Catch/Angler Trip	0.254	0.290	0.414	0.165	0.398	0.365	0.500	0.429	0.338	0.316	0.193
Harv/Angler Hour	0.029	0.033	0.043	0.021	0.047	0.035	0.064	0.050	0.041	0.035	0.024
Catch/Angler Hr.	0.035	0.043	0.059	0.024	0.057	0.057	0.079	0.065	0.049	0.047	0.030
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.201	0.092	0.273	0.194	0.129	0.195	0.371	0.268	0.134	0.216	0.129
Catch/Boat Trip	0.330	0.226	0.542	0.332	0.253	0.377	0.678	0.582	0.297	0.710	0.299
Harv/Angler Trip	0.079	0.037	0.106	0.077	0.048	0.075	0.146	0.103	0.052	0.082	0.051
Catch/Angler Trip	0.130	0.090	0.210	0.131	0.094	0.146	0.267	0.224	0.115	0.270	0.119
Harv/Angler Hour	0.015	0.007	0.021	0.015	0.008	0.015	0.027	0.020	0.009	0.015	0.009
Catch/Angler Hr.	0.024	0.017	0.041	0.025	0.017	0.028	0.050	0.042	0.020	0.049	0.022

Table A18. Length (inches), weight (lbs), age, and fin clip statistics for brown trout sampled April 15 – September 30 during the 1985-2015 NYSDEC Lake Ontario fishing boat surveys.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Mean length and weight data for brown trout sampled April 15 - September 30:											
Mean Length (in)	20.1	20.5	20.0	20.0	19.0	20.8	20.7	20.4	21.1	20.2	20.0
Mean Weight (lbs)	-	5.33	4.62	4.59	3.70	5.39	5.30	4.92	5.87	4.48	4.21
Estimated weight (lbs) for standard length brown trout sampled April 15 - September 30:											
16.0 inches	-	2.33	2.01	2.11	1.99	2.32	2.16	1.96	2.32	1.89	1.71
18.0 inches	-	3.32	2.98	3.06	2.88	3.30	3.15	2.89	3.30	2.76	2.55
20.0 inches	-	4.61	4.28	4.30	4.05	4.54	4.44	4.13	4.56	3.90	3.69
22.0 inches	-	6.18	5.94	5.83	5.50	6.06	6.06	5.70	6.10	5.33	5.14
24.0 inches	-	8.09	8.01	7.71	7.27	7.89	8.04	7.64	7.96	7.08	6.97
26.0 inches	-	10.36	10.55	9.96	9.41	10.06	10.44	10.00	10.16	9.21	9.21
28.0 inches	-	12.97	13.54	12.58	11.89	12.54	13.23	12.78	12.69	11.68	11.87
Percent length composition of brown trout sampled April 15 - September 30:											
<15.0 in	1.5%	0.6%	0.0%	0.0%	0.4%	0.2%	0.1%	0.0%	0.3%	1.2%	0.3%
15.0-15.9 in	2.0%	0.3%	1.7%	1.3%	3.3%	0.2%	0.1%	1.7%	1.7%	3.5%	6.3%
16.0-16.9 in	6.0%	4.8%	5.0%	7.0%	16.7%	3.1%	1.6%	4.8%	3.5%	8.9%	12.9%
17.0-17.9 in	12.4%	10.3%	11.6%	11.4%	21.1%	8.3%	7.0%	17.4%	8.7%	16.1%	17.4%
18.0-18.9 in	18.2%	17.0%	17.5%	17.8%	20.7%	14.0%	16.6%	15.7%	16.7%	13.2%	10.8%
19.0-19.9 in	16.1%	12.8%	18.0%	16.9%	10.3%	14.0%	19.3%	14.8%	14.2%	9.3%	6.3%
20.0-20.9 in	12.3%	13.1%	17.0%	14.1%	8.6%	18.8%	16.9%	10.2%	10.4%	9.3%	6.3%
21.0-21.9 in	9.0%	14.1%	11.0%	10.8%	4.4%	13.3%	11.4%	7.6%	7.6%	9.5%	9.1%
22.0-22.9 in	6.9%	8.7%	6.6%	7.7%	4.2%	10.2%	10.1%	5.7%	6.3%	8.8%	8.4%
23.0-23.9 in	4.9%	5.1%	4.6%	3.5%	3.9%	7.1%	6.9%	6.3%	9.0%	6.0%	8.0%
24.0-24.9 in	3.6%	5.4%	2.9%	4.2%	3.3%	2.4%	3.9%	5.9%	6.9%	5.6%	4.9%
25.0-25.9 in	2.8%	4.5%	2.0%	3.1%	1.7%	2.6%	2.0%	3.9%	5.6%	2.9%	5.2%
26.0-26.9 in	2.1%	2.2%	1.1%	2.0%	0.9%	3.8%	2.0%	1.7%	4.5%	2.3%	2.8%
27.0-27.9 in	1.0%	0.6%	0.5%	0.2%	0.4%	1.0%	1.0%	2.0%	2.8%	1.6%	1.0%
28.0-28.9 in	0.7%	0.0%	0.1%	0.0%	0.0%	0.7%	0.6%	1.5%	0.7%	1.0%	0.3%
>28.9 in	0.6%	0.3%	0.4%	0.0%	0.2%	0.2%	0.4%	0.7%	1.0%	0.6%	0.0%
Percent fin clip composition of brown trout sampled April 15 - September 30:											
No Clips	74.5%	80.4%	86.6%	88.4%	81.4%	87.6%	88.7%	92.4%	91.0%	88.1%	91.3%
LV	2.2%	2.9%	2.0%	0.2%	3.0%	2.9%	1.2%	0.4%	1.0%	0.4%	0.7%
LV-Ad	4.2%	3.5%	1.9%	3.1%	6.1%	2.6%	0.6%	1.7%	1.0%	1.9%	1.4%
LP	3.0%	1.0%	0.3%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
LP-Ad	4.2%	3.5%	2.6%	1.7%	1.1%	2.6%	4.3%	2.2%	2.1%	1.2%	2.8%
Ad	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%
RV	3.9%	3.5%	2.8%	4.8%	4.4%	2.1%	0.6%	0.7%	3.5%	6.2%	2.1%
RV-Ad	0.4%	1.3%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%
RP	4.3%	2.9%	2.0%	1.4%	2.6%	1.0%	2.6%	1.5%	1.0%	1.4%	0.3%
RP-Ad	0.1%	0.0%	0.0%	0.0%	0.2%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Misc.	1.3%	1.0%	1.7%	0.4%	0.9%	1.2%	1.9%	1.1%	0.3%	0.4%	1.4%
Percent age composition of brown trout sampled April 15 - September 30:											
Age-1	-	0.5%	0.0%	0.0%	0.2%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%
Age-2	-	72.5%	85.6%	78.9%	80.0%	80.6%	78.7%	74.6%	60.0%	62.6%	58.3%
Age-3	-	23.6%	11.6%	19.6%	17.2%	15.2%	17.2%	21.3%	34.6%	28.8%	30.9%
Age-4	-	3.4%	2.2%	1.0%	2.4%	3.4%	3.9%	3.3%	2.7%	7.8%	9.2%
Age-5+	-	0.0%	0.5%	0.5%	0.2%	0.4%	0.3%	0.7%	2.6%	0.8%	1.6%
Mean length (inches) of aged brown trout sampled in April 15-30:											
Age-2	-	17.8	18.4	17.7	17.4	18.2	18.6	17.9	18.0	17.4	17.0
Age-3	-	22.5	21.7	23.2	21.8	23.1	22.8	23.1	23.3	21.7	21.6

Table A19a. Lake trout harvest and catch data collected April 15 – September 30, 1985-2015.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	32,621	2,964	2,570	2,875	4,842	5,403	7,017	7,829	20,511	15,870	18,780
Catch	70,083	8,656	7,147	6,757	11,241	11,753	24,336	22,206	35,533	33,108	52,294
% Harvested	41.7	34.2	36.0	42.5	43.1	46.0	28.8	35.3	57.7	47.9	35.9
Monthly estimates of harvest for all fishing boats:											
April	2,882	215	555	15	388	188	255	1,442	1,393	757	596
May	6,270	1,173	345	594	190	2,461	840	2,311	6,311	2,207	6,148
June	6,106	560	1,142	387	501	262	1,478	1,456	4,455	2,561	1,151
July	9,654	86	122	1,229	254	1,845	2,266	1,216	4,346	3,967	3,062
August	6,736	930	390	465	3,026	648	1,871	899	2,066	6,230	5,718
September	972	0	15	184	483	0	308	505	1,941	148	2,105
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	6,729	309	963	602	190	739	1,751	1,417	1,605	1,717	3,038
West/Central	3,524	1,646	391	609	1,018	885	1,358	1,491	5,327	6,099	4,038
East/Central	8,044	73	115	209	317	1,552	1,950	2,134	6,602	2,500	4,183
East	14,324	936	1,101	1,454	3,318	2,227	1,959	2,786	6,977	5,553	7,521
Monthly estimates of catch for all fishing boats:											
April	6,506	1,728	765	15	1,235	464	885	3,823	1,955	3,728	2,214
May	12,492	2,855	2,993	1,539	2,558	5,660	8,956	8,397	12,288	7,417	28,246
June	13,010	1,193	1,457	927	1,395	552	3,789	3,533	7,818	5,812	2,611
July	21,296	1,688	371	2,276	705	3,247	7,626	2,871	7,971	6,150	7,553
August	14,732	1,151	1,285	1,712	4,699	1,678	2,484	2,903	3,178	9,563	8,836
September	2,048	40	275	288	649	151	596	679	2,323	438	2,834
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	18,380	2,968	3,962	2,924	2,387	2,095	11,226	6,487	5,219	7,740	28,107
West/Central	8,955	4,132	1,158	1,681	3,296	3,346	3,772	3,699	9,099	10,454	6,697
East/Central	16,531	461	265	289	1,120	3,079	6,419	6,121	11,400	4,652	6,145
East	26,217	1,094	1,763	1,864	4,438	3,233	2,920	5,899	9,815	10,262	11,345
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	99.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.7	100.0
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	60.5	93.7	56.7	81.3	88.7	69.6	64.9	67.2	77.9	72.5	82.0
% Catch	43.0	47.4	26.7	48.0	55.0	48.1	33.1	33.5	60.2	46.8	39.5

Table A19b. Lake trout harvest and catch rate data collected April 15 – September 30, 1985-2015. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.268	0.062	0.045	0.056	0.078	0.108	0.142	0.170	0.432	0.321	0.407
Catch/Boat Trip	0.609	0.181	0.124	0.132	0.181	0.235	0.491	0.482	0.748	0.668	1.133
Harv/Angler Trip	0.094	0.021	0.015	0.019	0.026	0.036	0.047	0.056	0.140	0.102	0.131
Catch/Angler Trip	0.211	0.061	0.042	0.044	0.059	0.077	0.165	0.160	0.242	0.212	0.366
Harv/Angler Hour	0.016	0.004	0.003	0.003	0.004	0.006	0.008	0.010	0.023	0.017	0.022
Catch/Angler Hr.	0.036	0.011	0.007	0.008	0.010	0.014	0.029	0.028	0.040	0.036	0.062
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.236	0.053	0.185	0.005	0.107	0.072	0.101	0.609	0.541	0.394	0.265
May	0.265	0.147	0.031	0.082	0.013	0.262	0.104	0.276	0.798	0.262	0.710
June	0.504	0.205	0.195	0.081	0.096	0.068	0.343	0.283	0.703	0.467	0.266
July	0.583	0.010	0.012	0.133	0.029	0.200	0.208	0.131	0.450	0.449	0.376
August	0.218	0.064	0.023	0.028	0.199	0.036	0.132	0.070	0.130	0.368	0.463
September	0.049	0.000	0.001	0.017	0.033	0.000	0.032	0.063	0.378	0.019	0.202
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.201	0.028	0.060	0.048	0.010	0.052	0.119	0.112	0.117	0.142	0.268
West/Central	0.299	0.241	0.056	0.142	0.132	0.159	0.269	0.267	0.803	0.976	0.626
East/Central	0.227	0.004	0.007	0.012	0.017	0.093	0.129	0.157	0.433	0.158	0.300
East	0.381	0.071	0.061	0.084	0.200	0.165	0.134	0.196	0.584	0.364	0.522
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.765	0.429	0.255	0.005	0.342	0.178	0.351	1.616	0.759	1.942	0.984
May	0.578	0.359	0.272	0.212	0.174	0.602	1.113	1.001	1.553	0.871	3.263
June	1.111	0.437	0.249	0.195	0.268	0.142	0.879	0.688	1.234	1.059	0.599
July	1.273	0.204	0.036	0.246	0.081	0.352	0.699	0.310	0.826	0.697	0.928
August	0.485	0.079	0.077	0.104	0.309	0.093	0.176	0.225	0.200	0.565	0.716
September	0.104	0.004	0.025	0.027	0.045	0.022	0.062	0.085	0.452	0.056	0.272
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.627	0.269	0.246	0.235	0.129	0.147	0.763	0.512	0.382	0.633	2.476
West/Central	0.804	0.605	0.166	0.392	0.427	0.600	0.747	0.662	1.372	1.673	1.039
East/Central	0.478	0.027	0.016	0.017	0.058	0.184	0.424	0.450	0.747	0.293	0.439
East	0.712	0.083	0.098	0.107	0.268	0.240	0.199	0.415	0.821	0.673	0.787
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	1.106	0.314	0.159	0.268	0.435	0.440	0.552	0.690	1.724	1.185	1.574
Catch/Boat Trip	1.843	0.463	0.208	0.372	0.626	0.662	0.976	0.975	2.309	1.596	2.111
Harv/Angler Trip	0.225	0.062	0.031	0.051	0.086	0.084	0.106	0.135	0.331	0.224	0.302
Catch/Angler Trip	0.370	0.092	0.041	0.071	0.123	0.127	0.187	0.191	0.444	0.302	0.405
Harv/Angler Hour	0.031	0.009	0.004	0.007	0.012	0.013	0.017	0.020	0.048	0.033	0.046
Catch/Angler Hr.	0.051	0.014	0.006	0.010	0.018	0.020	0.029	0.029	0.064	0.045	0.062
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.143	0.005	0.023	0.013	0.010	0.040	0.060	0.067	0.119	0.110	0.093
Catch/Boat Trip	0.413	0.117	0.108	0.083	0.097	0.147	0.394	0.384	0.370	0.441	0.870
Harv/Angler Trip	0.056	0.002	0.009	0.005	0.004	0.015	0.024	0.026	0.046	0.042	0.037
Catch/Angler Trip	0.161	0.047	0.042	0.033	0.036	0.057	0.155	0.148	0.143	0.168	0.344
Harv/Angler Hour	0.010	0.000	0.002	0.001	0.001	0.003	0.004	0.005	0.008	0.008	0.007
Catch/Angler Hr.	0.030	0.009	0.008	0.006	0.006	0.011	0.029	0.028	0.025	0.031	0.062

Table A20. Length and weight statistics for lake trout sampled April 15 - September 30 during the 1985-2015 NYSDEC Lake Ontario fishing boat surveys.

	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Mean length and weight of lake trout sampled April - September:											
Mean Length (in)	25.1	24.5	26.8	26.5	25.1	23.4	25.5	26.3	25.9	27.2	27.5
Mean weight (lbs)	-	6.28	8.61	8.03	6.81	5.71	7.37	8.00	7.41	8.46	8.82
Percent length composition of lake trout sampled April - September:											
<15.0 inches	0.1%	0.0%	0.0%	0.0%	0.0%	0.8%	0.0%	0.0%	0.0%	0.5%	0.0%
15-15.9 inches	0.1%	0.0%	0.0%	0.0%	0.0%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%
16-16.9 inches	0.3%	0.0%	1.9%	0.0%	1.3%	1.6%	0.0%	0.0%	0.4%	0.0%	1.7%
17-17.9 inches	1.2%	0.0%	1.9%	0.0%	0.0%	4.1%	0.8%	0.9%	2.5%	0.0%	2.6%
18-18.9 inches	1.6%	2.6%	1.9%	0.0%	3.8%	7.3%	2.5%	3.4%	2.9%	0.0%	2.6%
19-19.9 inches	3.6%	10.3%	3.8%	2.0%	10.1%	2.4%	4.2%	1.7%	2.5%	1.8%	0.9%
20-20.9 inches	4.9%	7.7%	5.7%	0.0%	7.6%	10.6%	4.2%	2.6%	3.6%	0.9%	0.0%
21-21.9 inches	8.4%	5.1%	5.7%	6.0%	3.8%	13.0%	6.7%	6.8%	4.7%	1.4%	0.0%
22-22.9 inches	10.9%	2.6%	3.8%	14.0%	3.8%	9.8%	7.5%	4.3%	4.3%	5.1%	3.0%
23-23.9 inches	13.2%	20.5%	3.8%	14.0%	3.8%	14.6%	10.8%	3.4%	6.1%	4.1%	3.0%
24-24.9 inches	14.0%	15.4%	5.7%	6.0%	10.1%	4.9%	8.3%	6.8%	8.7%	8.8%	5.7%
25-25.9 inches	9.5%	17.9%	3.8%	6.0%	11.4%	3.3%	15.0%	14.5%	10.5%	11.5%	8.7%
26-26.9 inches	5.9%	2.6%	3.8%	6.0%	5.1%	5.7%	7.5%	11.1%	8.7%	13.8%	9.6%
27-27.9 inches	2.9%	0.0%	9.4%	10.0%	17.7%	1.6%	11.7%	15.4%	15.5%	10.6%	13.5%
28-28.9 inches	2.2%	0.0%	13.2%	12.0%	8.9%	7.3%	1.7%	5.1%	10.8%	12.9%	9.6%
29-29.9 inches	3.8%	0.0%	11.3%	6.0%	1.3%	4.1%	2.5%	4.3%	7.9%	11.1%	14.3%
30-30.9 inches	6.0%	5.1%	9.4%	4.0%	3.8%	4.1%	4.2%	7.7%	4.7%	7.8%	9.1%
31-31.9 inches	5.0%	2.6%	7.5%	0.0%	2.5%	1.6%	3.3%	7.7%	1.8%	3.7%	6.5%
32-32.9 inches	2.6%	2.6%	0.0%	6.0%	3.8%	2.4%	5.0%	0.9%	2.2%	1.4%	2.2%
33-33.9 inches	2.1%	2.6%	0.0%	4.0%	1.3%	0.0%	1.7%	0.0%	1.1%	2.8%	3.9%
34-34.9 inches	1.4%	0.0%	1.9%	2.0%	0.0%	0.0%	1.7%	2.6%	1.1%	1.4%	0.9%
>34.9 inches	0.4%	2.6%	5.7%	2.0%	0.0%	0.0%	0.8%	0.9%	0.0%	0.5%	2.2%
30.0+ inches	17.4%	15.4%	24.5%	18.0%	11.4%	8.1%	16.7%	19.7%	10.8%	17.5%	24.8%
25.0-29.9 inches	24.3%	20.5%	41.5%	40.0%	44.3%	22.0%	38.3%	50.4%	53.4%	59.9%	55.7%

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, 1985-2015.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	50,024	17,759	19,058	11,104	6,833	4,892	6,442	5,683	7,536	12,538	2,942
Catch	256,044	73,781	78,661	50,727	30,494	18,048	25,795	24,032	21,446	31,807	16,821
% Harvested	20.7	24.1	24.2	21.9	22.4	27.1	25.0	23.6	35.1	39.4	17.5
Monthly estimates of harvest for all fishing boats:											
April	3	0	0	0	2	0	0	0	0	0	0
May	58	0	0	0	0	0	0	0	0	0	0
June	8,307	3,392	2,651	4,721	1,565	1,258	268	1,178	1,073	6,740	0
July	14,736	6,240	7,280	2,084	647	1,643	668	2,702	3,846	2,520	1,306
August	17,480	7,139	5,987	2,687	1,695	1,727	3,331	1,377	853	2,928	738
September	9,441	989	3,139	1,612	2,923	265	2,176	426	1,764	350	899
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	3,734	384	1,048	882	163	182	254	800	556	208	118
West/Central	3,461	320	626	376	108	43	261	36	48	176	-
East/Central	25,694	5,864	9,579	3,522	3,250	1,785	700	1,940	1,214	589	1,078
East	17,135	11,191	7,805	6,324	3,312	2,882	5,227	2,907	5,718	11,566	1,746
Monthly estimates of catch for all fishing boats:											
April	467	1,955	91	979	240	136	22	82	438	480	60
May	6,584	691	915	1,180	1,264	483	1,299	1,558	350	364	1,564
June	33,160	11,643	15,557	16,685	5,734	2,159	1,604	4,987	2,859	12,380	2,296
July	80,951	28,348	19,726	12,168	3,983	4,437	8,026	9,561	10,239	7,057	4,831
August	91,833	24,084	32,958	13,757	11,115	8,571	10,407	5,611	2,732	8,957	5,187
September	43,049	7,060	9,414	5,958	8,159	2,263	4,437	2,234	4,829	2,570	2,884
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	23,776	2,825	6,354	6,400	1,610	2,565	2,459	5,768	3,009	4,818	3,059
West/Central	37,745	3,664	10,043	2,140	2,143	384	799	1,048	634	672	1,013
East/Central	129,053	40,039	42,400	22,653	15,862	9,462	5,830	6,648	5,916	4,088	7,265
East	65,470	27,253	19,864	19,534	10,878	5,638	16,706	10,567	11,888	22,229	5,484
Percent of seasonal harvest and catch made by boats seeking smallmouth bass during the **traditional open season**:											
% Harvest	92.3	96.4	92.8	87.6	69.0	83.8	96.4	88.5	94.5	98.4	99.2
% Catch	87.6	89.7	79.7	77.7	58.2	62.6	78.1	85.9	86.4	91.8	82.4
Estimates of catch by boats seeking smallmouth bass during the **catch and release season**:											
April	-	-	0	0	0	0	0	0	0	0	0
May	-	-	0	196	422	28	0	196	0	0	1116
June	-	-	3482	88	24	55	502	24	146	195	48
Total	-	-	3482	284	446	83	502	220	146	195	1164
Percent of seasonal catch made by boats seeking smallmouth bass during the **catch and release season**:											
% Catch	-	-	4.4%	0.6%	1.5%	0.5%	1.9%	0.9%	0.7%	0.6%	6.9%

Table A21b. Smallmouth bass harvest and catch rate data collected April 15 – September 30, 1985-2015.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seasonal rates of harvest and catch for boats seeking smallmouth bass during the **traditional open season**:											
Harv/Boat Trip	2.013	1.260	1.219	0.760	0.544	0.700	0.992	0.811	1.667	1.794	0.599
Catch/Boat Trip	9.605	4.873	4.323	3.082	2.047	1.928	3.219	3.327	4.337	4.244	2.847
Harv/Angler Trip	0.874	0.553	0.534	0.341	0.250	0.339	0.451	0.372	0.784	0.868	0.295
Catch/Angler Trip	4.196	2.140	1.893	1.380	0.939	0.933	1.464	1.528	2.040	2.052	1.400
Harv/Angler Hour	0.258	0.178	0.171	0.117	0.097	0.126	0.145	0.120	0.226	0.242	0.104
Catch/Angler Hr.	1.247	0.689	0.606	0.472	0.363	0.346	0.471	0.492	0.587	0.572	0.493
Monthly harvest rates per boat trip for boats seeking smallmouth bass during the **traditional open season**:											
April & May	-	-	-	-	-	-	-	-	-	-	-
June	1.833	1.069	0.885	1.807	0.877	1.948	0.259	0.701	1.188	3.514	0.000
July	1.709	1.006	1.460	0.401	0.125	0.694	0.225	0.943	2.716	1.355	0.550
August	2.271	1.907	1.152	0.702	0.399	0.498	1.886	0.829	0.823	1.256	0.621
September	2.289	0.902	1.283	0.530	1.070	0.305	2.353	0.585	1.384	0.384	1.122
Seasonal harvest rates per boat trip among geographic areas for boats seeking smallmouth bass during the **traditional open season**:											
West	1.220	0.314	0.521	0.783	0.118	0.169	0.312	0.605	1.577	0.126	0.150
West/Central	0.875	0.144	0.238	0.107	0.074	0.065	0.333	0.000	0.085	0.289	0.000
East/Central	2.146	0.862	1.306	0.538	0.584	0.388	0.209	0.720	0.991	0.280	0.472
East	2.726	2.688	2.055	1.470	1.053	2.013	2.761	1.449	2.454	3.421	1.186
Monthly catch rates per boat trip for boats seeking smallmouth bass during the **traditional open season**:											
April & May	-	-	-	-	-	-	-	-	-	-	-
June	6.164	3.625	2.514	6.279	2.796	2.907	0.612	2.940	2.256	6.299	3.368
July	9.176	4.568	3.690	2.148	0.932	1.581	2.871	3.766	7.177	3.292	2.017
August	11.530	6.221	6.358	2.628	2.236	2.058	4.803	3.210	2.326	3.808	3.958
September	10.004	5.235	3.606	2.473	2.701	1.779	3.944	3.016	3.759	2.881	3.360
Seasonal catch rates per boat trip among geographic areas for boats seeking smallmouth bass during the **traditional open season**:											
West	6.867	1.463	2.758	5.000	0.796	1.605	1.450	5.397	6.534	3.585	3.227
West/Central	8.283	1.470	2.292	0.732	1.031	0.514	0.739	0.534	1.043	0.775	0.122
East/Central	10.281	5.278	5.434	2.881	2.499	1.545	1.103	2.086	4.285	1.661	2.807
East	9.936	6.545	4.428	4.329	2.748	3.585	8.264	5.204	4.862	6.468	3.384
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	0.661	7.098
Catch/Angler Trip	-	-	3.831	0.402	0.417	0.153	1.887	0.170	0.327	0.293	3.660
Catch/Angler Hr.	-	-	1.625	0.151	0.181	0.099	1.035	0.072	0.188	0.124	1.257
Monthly catch rates per boat trip for boats seeking smallmouth bass during the **catch and release season**:											
April	-	-	-	-	-	-	-	-	-	-	-
May	-	-	0.000	4.558	1.323	0	0.000	0.590	0.000	0	10.731
June	-	-	9.949	0.272	0.074	1.000	2.523	0.127	1.390	0.878	0.800

Table A22. Yellow perch harvest and catch data collected April 15 – September 30, 1985-2015.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	8,514	13,858	25,630	33,589	51,653	18,405	31,830	16,701	6,572	6,066	6,960
Catch	18,217	39,801	87,736	67,342	102,442	61,816	65,394	35,836	15,345	17,966	17,384
% Harvested	53.9	34.8	29.2	49.9	50.4	29.8	48.7	46.6	42.8	33.8	40.0
Monthly estimates of harvest for all fishing boats:											
April	9	0	0	29	0	1,198	0	2,653	972	0	0
May	1,018	0	1,220	1,357	0	7,656	112	4,203	2,016	0	0
June	1,428	7,360	7,566	10,349	34,963	3,665	2,194	6,116	973	0	24
July	1,993	1,476	5,039	3,612	2,810	1,906	5,637	1,913	304	2,453	6,042
August	1,594	2,233	5,149	6,114	7,816	3,648	16,979	1,755	2,040	3,535	12
September	2,470	2,789	6,656	12,128	6,064	332	6,908	61	267	78	882
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	2,093	521	15	61	-	468	0	14	0	-	0
West/Central	874	1,240	908	3,824	1,035	1,080	30	2,816	1,136	-	759
East/Central	4,087	8,499	24,252	26,845	19,372	9,762	22,363	7,814	4,227	3,050	6,104
East	1,460	3,598	454	2,858	31,246	7,094	9,438	6,057	1,209	3,016	97
Monthly estimates of catch for all fishing boats:											
April	47	186	-	69	143	1,962	-	5,293	2,172	-	-
May	1,784	462	5,980	3,443	95	37,864	112	10,211	4,420	-	-
June	3,784	16,614	17,363	25,153	52,025	5,287	5,055	13,440	1,921	1,800	264
July	4,007	10,323	16,158	8,637	10,792	4,371	14,419	2,508	923	7,691	13,740
August	3,841	3,631	18,513	10,494	23,739	11,735	29,676	4,298	5,642	8,241	781
September	4,753	8,585	29,722	19,545	15,648	596	16,132	86	267	234	2,599
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	2,828	1,737	1,405	77	2,444	906	-	49	0	-	0
West/Central	1,896	3,232	2,878	5,999	1,749	2,026	193	4,384	3,890	45	2,411
East/Central	10,480	26,915	78,438	51,333	58,517	40,091	50,878	20,510	9,527	10,439	14,131
East	3,013	7,917	5,016	9,933	39,732	18,793	14,323	10,893	1,928	7,482	842

Table A23. Walleye harvest and catch data collected April 15 – September 30, 1985-2015.

	Year Surveyed										
	1985-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	672	164	1,403	116	123	106	458	130	318	182	350
Catch	813	408	4,508	130	147	301	531	130	388	421	446
% Harvested	75.1	40.2	31.1	89.2	83.7	35.2	86.3	100.0	82.0	43.2	78.5
Monthly estimates of harvest for all fishing boats:											
April	0	0	0	0	0	0	0	0	0	0	0
May	105	73	0	28	14	0	16	50	0	50	26
June	58	0	1,112	32	0	0	26	0	23	12	0
July	48	15	114	28	0	0	88	80	0	0	0
August	363	15	77	28	109	44	160	0	27	120	252
September	99	62	101	0	0	62	168	0	267	0	72
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	56	72	187	29	44	106	86	84	0	92	246
West/Central	2	0	45	32	0	0	0	22	21	0	0
East/Central	54	77	34	56	14	0	0	0	0	40	0
East	560	15	1137	0	66	0	372	24	297	50	104
Monthly estimates of catch for all fishing boats:											
April	12	31	0	0	10	0	15	0	0	0	12
May	123	286	0	28	28	0	16	50	0	50	26
June	67	0	3,991	32	0	0	26	0	23	12	0
July	85	15	142	28	0	0	147	80	70	0	0
August	415	15	199	42	109	213	160	0	27	338	336
September	111	62	176	0	0	87	168	0	267	22	72
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	91	286	413	43	47	180	142	84	59	163	327
West/Central	3	0	62	32	0	0	0	22	22	165	0
East/Central	83	107	66	55	29	0	20	0	0	41	0
East	635	15	3967	0	71	121	369	24	306	51	119

Table A24. Estimates of sea and silver lampreys observed by boat anglers April 15 – September 30, 1986-2015.

	Year Surveyed										
	1986-05 avg	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
April 15 - September 30 estimated numbers of lamprey observed:											
April	220	138	564	87	218	429	558	575	68	100	118
May	635	731	2,117	688	1,769	551	1,618	1,266	835	595	775
June	340	178	1,059	296	150	372	769	294	353	384	212
July	351	1,288	2,147	390	1,358	486	1,155	460	789	567	460
August	575	1,173	2,009	954	1,142	697	842	707	829	951	767
September	175	381	528	399	526	64	184	138	53	401	63
Total	2,297	3,889	8,423	2,814	5,164	2,599	5,125	3,441	2,927	2,998	2,375
April 15 - September 30 estimated numbers of lamprey observed among four geographic areas:											
West	929	1381	2830	1194	2,026	946	1,163	1,147	969	894	1,251
West/Central	286	530	713	18	540	338	565	609	396	308	267
East/Central	596	1572	3051	845	2,126	799	1,812	1,007	1,242	976	510
East	486	406	1829	757	472	516	1,585	678	320	819	347
Percentage of lamprey observed that were attached to angler caught trout and salmon:											
Percent	99.1%	98.3%	98.5%	98.3%	97.0%	98.9%	96.8%	97.9%	98.4%	98.3%	99.1%
April 15 - September 30 estimated number of lamprey attached to angler caught trout & salmon, per 1000 trout & salmon caught:											
April	10.79	14.74	39.57	23.32	19.36	48.73	45.60	29.72	9.28	5.16	11.35
May	13.55	25.51	41.48	27.82	23.08	26.78	45.50	34.03	22.70	12.93	13.55
June	12.77	33.17	50.56	23.58	12.67	19.85	34.61	12.13	17.58	13.31	16.06
July	10.91	56.32	58.84	16.74	38.27	10.50	14.04	10.83	19.18	16.88	19.18
August	10.58	31.11	42.18	22.87	20.45	11.08	16.68	12.63	15.41	16.91	22.21
September	8.35	22.65	26.98	20.28	16.30	6.34	9.57	7.95	5.46	24.00	4.17
Total	11.55	32.20	44.35	22.39	23.12	15.53	23.09	17.50	17.34	14.93	15.38
April - Sept. estimated number of lamprey attached to angler caught trout & salmon by geographic area, per 1000 trout & salmon caught:											
West	12.70	29.93	36.66	20.78	19.49	13.13	12.43	15.56	14.25	13.41	17.85
West/Central	11.20	31.13	34.61	2.32	17.93	15.27	25.57	23.22	15.01	8.72	14.38
East/Central	10.89	37.18	53.11	27.19	34.19	15.44	26.87	20.53	25.33	16.10	13.04
East	11.31	26.49	52.75	25.75	17.46	24.03	40.76	14.24	12.58	21.47	13.03
April 15 - September 30 percent composition of host species to which the lampreys were attached:											
Coho Salmon	2.4%	2.7%	3.4%	4.3%	2.6%	3.2%	3.4%	2.9%	1.6%	2.6%	0.0%
Chinook Salmon	37.9%	78.8%	58.6%	64.3%	73.1%	51.6%	37.4%	60.0%	68.8%	58.1%	64.8%
Rainbow Trout	7.3%	3.5%	5.6%	10.4%	10.9%	14.0%	5.6%	8.6%	5.6%	18.8%	10.2%
Atlantic Salmon	0.7%	0.0%	0.0%	0.0%	0.0%	3.2%	0.0%	2.1%	0.0%	0.0%	0.0%
Brown Trout	17.0%	14.2%	31.7%	20.0%	13.5%	26.9%	47.5%	22.1%	13.6%	17.9%	12.0%
Lake Trout	34.7%	0.9%	0.7%	0.9%	0.0%	1.1%	6.1%	4.3%	10.4%	2.6%	13.0%
April 15 - September 30 percent of total host-specific angler catch with attached lampreys:											
Coho Salmon	0.6%	0.8%	1.1%	1.8%	0.6%	0.6%	1.4%	0.8%	0.6%	0.9%	0.0%
Chinook Salmon	1.3%	5.0%	5.7%	3.1%	3.5%	2.1%	1.9%	2.3%	3.1%	2.2%	2.6%
Rainbow Trout	0.8%	0.8%	1.8%	0.8%	1.0%	0.8%	0.8%	0.9%	0.5%	1.5%	1.4%
Atlantic Salmon	5.0%	0.0%	0.0%	0.0%	0.0%	4.5%	0.0%	12.2%	0.0%	0.0%	0.0%
Brown Trout	1.1%	2.5%	5.6%	2.4%	2.0%	2.1%	4.7%	1.9%	1.4%	1.2%	1.4%
Lake Trout	1.2%	0.4%	0.9%	0.3%	0.0%	0.2%	1.3%	0.7%	0.8%	0.2%	0.6%

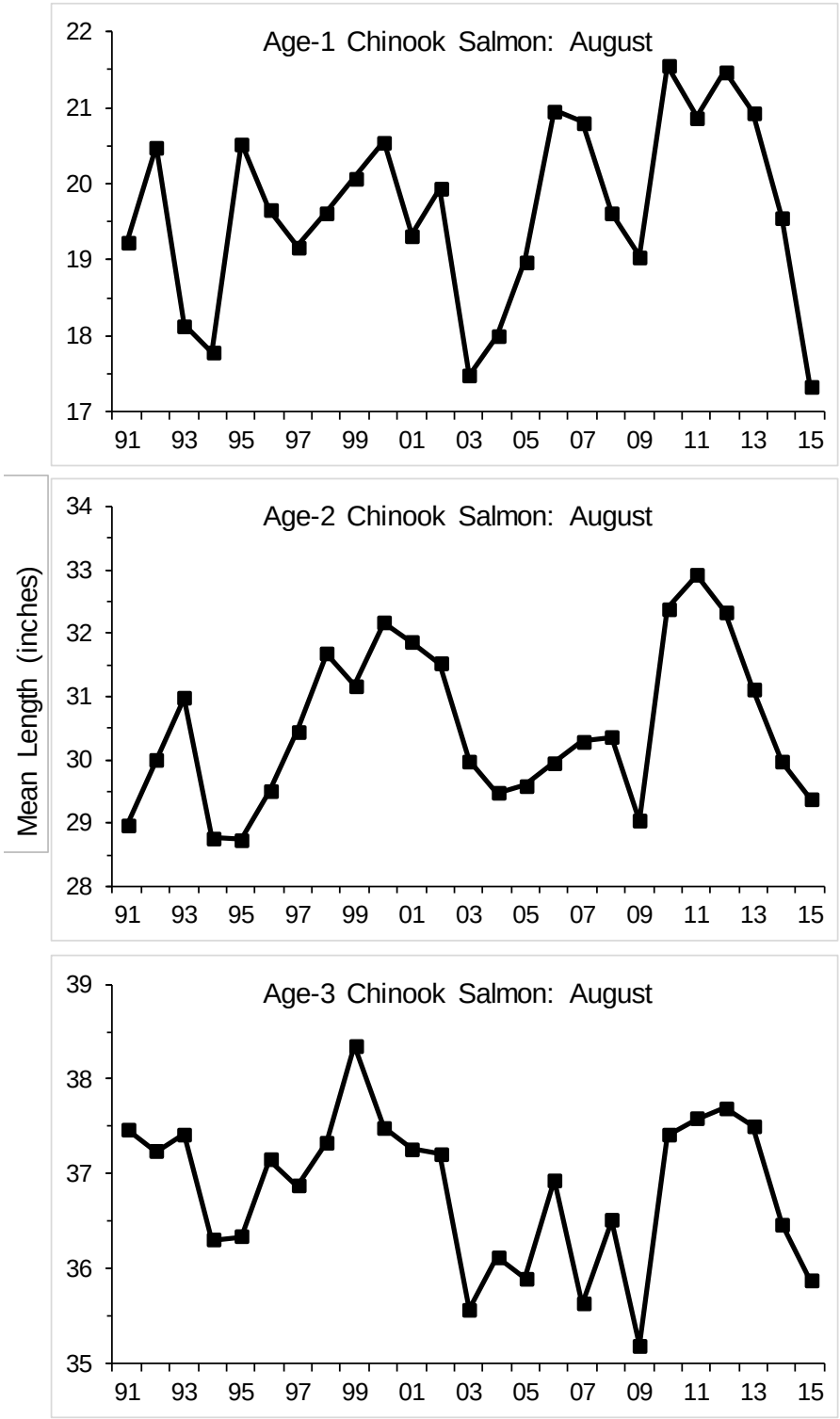

Figure A1. Mean length (total length in inches) of age-1, age-2, and age-3 Chinook salmon sampled in August during the 1991-2015 NYSDEC Lake Ontario fishing boat surveys.

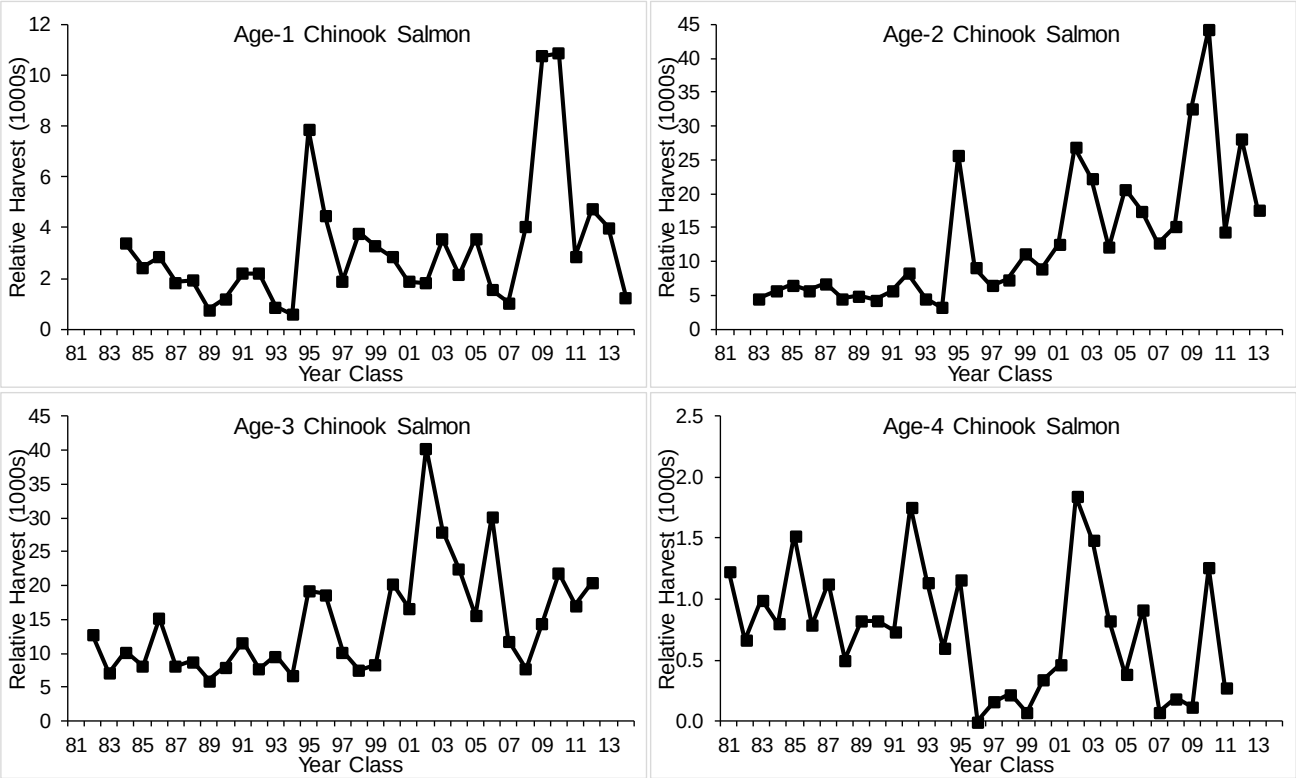

Figure A2. Relative harvest (age-specific harvest per 50,000 fishing boat trips, per 2,000,000 fingerling equivalents stocked) of age-1, age-2, age-3, and age-4 Chinook salmon from the 1985-2015 NYSDEC Lake Ontario fishing boat surveys.

Update on Mass Marking Studies of Chinook Salmon in Lake Ontario 2015

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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 and Forestry (OMNRF) 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, and 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 provide a fishery there and 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 was unknown. This information is, however, important for fisheries managers to evaluate current stocking strategies in meeting fisheries objectives.

One strategy used by NYSDEC 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 (Sanderson et al. 2016). Chinook salmon raised in net pens are typically released at larger sizes than salmon

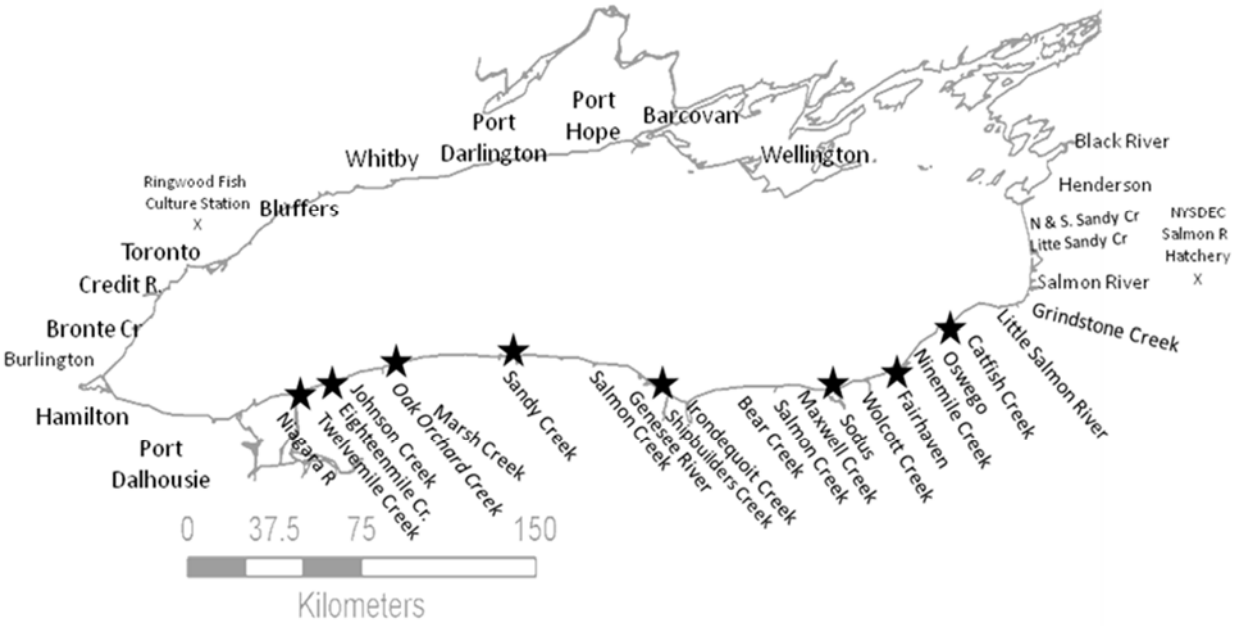

Figure 1. Map of Lake Ontario showing sampling regions and other locations in this report. Sites where Chinook salmon were raised in pens are noted with stars.

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 YCs 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.

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; 3) to compare the relative contributions and of pen vs. direct stocked Chinook salmon to the lake fishery; and 4) to compare the relative returns (i.e., as a measure of imprinting) of pen and direct stocked Chinook salmon to tributary fisheries.

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]. Fish from these year classes 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, and from Normandale hatchery post-2011); however, conditions at SRH led to unplanned NY stocking reductions in 2008 and 2010, with 799,000 and 1.583 million Chinook salmon stocked, respectively (Bishop and Prindle 2008, Connerton 2012). OMNRF 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 (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 study 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, 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	**# fish AD-CWT**	**# Fish AD only**	**Pen Total**	**#lots**	**# Pens**	**Pen Density**	**# fish AD-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 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 (although all were clipped), 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 2008-2011 for the wild study and they were not marked in 2012-2013. At Salmon River, fish were marked with AD-CWT in 2008-2010 for the SRH homing and wild studies, were AD clipped for the wild study in 2011 and were not marked in 2012-2013 (Table 1).

For the pen vs. direct stocked evaluations, 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. 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 manually clipped and tagged. 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, and 2013).

Although tagged fish rarely shed their CWT, it is most likely to occur within 30 days of 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 were 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 and 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 from the hatchery truck at the stocking site. 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 dates, and CWT codes on hatchery tank movement forms 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, 2009-2015 (Lantry and Eckert 2016). Two technicians were also deployed by the U.S. Fish and Wildlife Service (Service) from July-October 2010-2011 and 2014-2015 (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 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, 2010-2015), 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). Extra NYSDEC technicians (6-8) were assigned to tributary sites to visit each site at least 15 days during the spawning run. Since most fish were sampled from fish 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 (2012-2015), and electrofishing some streams (2013-2015).

Assigning Age to Chinook salmon

To determine the proportion of wild Chinook salmon in the Lake and tributary harvests by year class, ages were determined for the 2008-2011 year classes sampled from 2009-2015.

Ages of Chinook salmon collected in New York waters were mostly determined from impressions of fish scales on acetate film, and counting annuli using 2x-10x magnification. All scales samples collected during the Lake Ontario Fishing Boat Survey from 2009- 2015 were aged using this method and verified with CWT when available (Lantry and Eckert 2016). For samples collected during 'headhunting' , some were aged using scales (n = 3,593 in 2010; 4,587 in 2011; 4,485 in 2012; 3,102 in 2013; 2,120 in 2014; 824 in 2015) and others were aged using other methods. Fish containing CWTs were aged using their tag's unique code which identified age and stocking location (n=330 in 2011; 1,527 in 2012; 2,487 in 2013; 2,274 in 2014; 1,973 in 2015). In 2012-2014, some samples were aged using monthly stratified age-length keys (n=2,003 in 2012; n=2,000 in 2013; 3,775 in 2014). In 2015, since only age-4 from the wild study remained in the lake, fish >380mm were aged using scales. This length was chosen based on previous age-length keys from 2014 which showed that few age-4 fish were less than this length. 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; n=385 in 2014; n=160 in 2015), 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. Any salmon containing code 23 in 2014 (n=8) were age-4 since 2010 was the last year of tagging for that study. Sampled carcasses (n=683 in 2012; n=283 in 2013; n=517 in 2014; n=59 in 2015) were measured for TL, checked for AD clips and CWTs. Those without CWTs (n=530 in 2012; 128 in 2013; 361 in 2014) were aged using monthly stratified age-length keys created based on each year's scale ageing. Also in 2011-2015, 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) OMNRF's western Lake Ontario angler survey conducted from May-August, 2011-2013 at selected ports; and 3) tournaments and derbies throughout the summer 2011-2014 (for details of these programs, see OMNR 2014). In 2010-2014, Chinook salmon were measured for fork length (FL) and weight, and examined for fin clips and CWTs (n= 404, 499, 877, 731, and 127, respectively). FL was converted to TL by TL= 1.052(FL) + 18.939 (OMNRF unpublished data). A subsample of Chinook salmon otoliths was collected for ageing in 2010-2013 (n=204, 241, 171, 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. In 2014, OMNRF collections (ON) were made only at tournaments and all ON fish (n=127) were aged using monthly age-length keys derived by collections and ageing in New York. No Chinook were sampled from Ontario waters of the Lake in 2015.

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 2009-2014. 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 [2010, 2011, 2012, 2013, 2014] for TL, weight and age distribution results).

In 2009- 2011, jacks were sampled (n=124 in 2009, n= 93 in 2010 and n=174 in 2011) on two to four occasions 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, four to six 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 <29.0 inches TL in 2009, <30.1 in. TL in 2010 and <27.7 in. TL in 2011). Sample totals examined for estimating homing, straying and percent wild of the 2008-2010 YCs and from 2009-2014 are shown in Table 6.

Since tagging of pen and direct salmon began in 2010, the specific stocking origin of strays was identified by unique CWT codes from 2011-2015, (and will continue until 2017) as strays from the 2010, 2011, and 2013 YCs returned to the hatchery. 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. In 2014, jacks were scanned for CWTs as part of regular sampling (n=63) and annual reporting at the hatchery (see Prindle and Bishop 2015) and to identify strays from pen and direct stocked sites. Additional samples of AD clipped salmon of other ages in 2014 were sorted and checked for tags at SRH (n=524) and in Beaverdam Brook just downstream of the SRH (n=307) to identify strays from direct and pen stocking sites. In 2015, salmon were scanned for CWTs as part of regular sampling (n=909) and annual reporting at the hatchery (Prindle and Bishop 2016), and to identify strays from pen and direct stocked sites. Additional samples of AD clipped salmon in 2015 were sorted and checked for tags at SRH (n=117).

For all sampling from 2009-2015, snouts were collected from all fish containing CWTs, and CWTs were extracted and read at GLFTRL.

Data Analyses

We determined the proportions of angler caught Chinook salmon that were wild and stocked in each year of sampling from 2009-2015 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., 2008-2010 YCs) from 2009-2014. 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 (2008-2010 YCs) 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, for ages 3-4 in 2013, and for age 4 in 2014. 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 Salmon River.

Tagging of Salmon River stocked Chinook salmon from 2008-2010 for the homing study also afforded us an opportunity to evaluate the relative contribution of this stocking site to the lake harvest compared to pen and direct stocked salmon for the 2010 year class. Chinook stocked at the Salmon River are normally held at the hatchery until June each year to promote imprinting. These salmon averaged 8.2 grams in size when released in 2010 (compared to pen and direct sizes of 6.3 and 4.6 respectively), which may have provided a survival advantage. In 2014, fish from 2010 YC were fully recruited to the fishery, and in 2015 we revisited these data and calculated the relative contribution to the lake per number stocked of Salmon River stocked fish compared to pen and direct stocked fish. For this analysis we only included fish harvested April through July each year when we assumed fish are mixed in the lake and prior to staging outside of natal tributaries.

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 2011-2015 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 2011-2015 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 were marked and tagged for the pen study. Only the 2010 and 2011 year classes were fully recruited to the fishery in 2015; therefore, at this time we can report on recoveries of pen and direct stocked fish for these year classes. Future reports will provide analyses of the 2013 YC. For the 2010 and 2011 YCs 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). Lake returns were compared for the 2010 and 2011 YCs in this report. The returns for the 2013 YC will be compared in future reports when fully recruited to the fishery.

To evaluate imprinting of stocked Chinook salmon to the eight stocking sites (Figure 1, Table 2), the numbers of tagged salmon sampled at each tributary site in 2013 were tabulated according to their stocking origin, i.e., the YC (2010 or 2011), stocking location (1 of 8 sites) and stocking method (pen vs direct) which were identified by their unique tag code. The numbers of tagged fish returning to each tributary site were adjusted for numbers stocked according to their stocking origin, and then the proportions of fish stocked at the site vs. stocked at other sites were compared.

To compare returns of pen and direct stocked salmon (i.e., to evaluate imprinting) to the eight pen stocking sites (Figure 1, Table 2), we sampled Chinook salmon in the tributaries September-November 2011-2015 at each pen site. For each tagged Chinook sampled, we determined stocking origin (as above), age, and year class from the retrieved CWT. At each site and for each stocking origin, the total number of salmon recovered was divided by the numbers stocked according to their stocking origin to adjust for different numbers stocked at the sites and permit comparison of returns. Since we were interested in evaluating imprinting only and the numbers of pen and direct stocked salmon returning to tributaries were also affected by survival after stocking until return to the tributaries, we further adjusted the numbers returning to each of eight pen tributary sites by dividing by the lake recovery ratio of the stocking YC and Site (Table 7). For example, the recovery ratio of pen to direct stocked salmon in the lake for the 2010 YC at Oak Orchard was 2.2; therefore, the

number of pen fish returning to Oak Orchard was first divided by the numbers stocked (number of 2010 YC pen-reared at Oak Orchard), then divided by 2.2. This adjustment for potential survival differences was done for specific sites, year class, and age; and then the tributary recovery ratios of pen to direct stocked salmon returning to each tributary were calculated and compared to expected ratios using chi-square Goodness of Fit tests. Logically, recovery ratios should equal stocking ratios if no differences in returns (i.e., imprinting) exist between the stocking methods. Prior to pooling samples across years, tests of homogeneity were performed and samples were pooled if the null hypothesis of homogeneity was not rejected.

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%).

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, 2013
ND= No data
NM=Not Marked
* No fish were marked in 2012

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 all four year-classes. Only age-4 Chinook from the 2011 YC remained in the lake in 2015. Age 1, 2 and 3 Chinook sampled in 2015 were not part of the study to evaluate the percent wild in the Lake Ontario fishery. The percentages of wild age-4 Chinook salmon in the open-lake harvest were 50% and 40% in NY west and east regions respectively. Sample size for age-4 was low, however, which resulted in wide confidence intervals. No age-4 Chinook salmon were sampled in the Province of Ontario region in 2015.

The percentages of unclipped (wild) Chinook salmon are presented in Table 4 for each year class sampled from 2009-2015. These data and results complete this part of the study to determine the proportions of wild Chinook salmon in the Lake Ontario angler harvest. For detailed comparisons of wild percentages among regions and ages for each YC, see Connerton et al. (2011, 2012, 2013, 2014, and 2015). Overall, the percentages of wild Chinook in Lake Ontario varied among regions and ages from 2010-2015. Regional differences may relate to differences in wild production potential 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. The proportions of wild fish at age-2 were not significantly different among regions for the 2008 or 2009 YCs, but were significantly different for the 2010 and 2011 YCs, with the east region (2010 YC) and Ontario regions (2011 YC) containing significantly higher proportions of wild fish (Connerton et al. 2012, Connerton et al. 2014). Significant differences among regions were also observed at age-3 for the 2009 and 2010 year classes, with Ontario and NY east regions containing significantly higher proportions of wild fish (Connerton et al, 2012, 2013). These regions, especially the Salmon River and north shore tributaries in Ontario are the largest sources of wild Chinook for the lake. Although tag data from mass marking has shown that Chinook salmon adults are well mixed in April-July, tagging data also suggests that as fish home to their spawning streams in August/September, a higher proportion of angler harvest for a particular region is comprised of fish stocked in that region. The staging fishery can represent a large portion (as much as 60%) of a year's harvest (Lantry and Eckert 2016) so it stands to reason that regions with higher wild reproduction in tributaries also may contain higher proportions of wild fish as the staging fishery occurs. For example, the proportions of wild fish at ages 2 and 3 in the NY east region significantly increased in August/September, likely corresponding to mature fish returning to natal tributaries, compared to June/July and significantly decreased in the NY west region, where wild production is lower and where fewer staging fish are wild (Connerton et al. 2013). More research is needed to understand dispersal and distribution of wild and hatchery Chinook salmon.

Percentages of wild Chinook also varied by year class and age from 2009-2015 with age-1 ranging from 17.0% to 59.8%, age-2 from 29.0% to 64.1%, age-3 from 32.7% to 76.2% and age-4 from 40% to 100% (Table 4). Some year classes had higher proportions of wild at each age than other year classes. Wild reproduction of the 2010 year class was particularly strong (Bishop et al. 2014) in the Salmon River and this was reflected in the percentages of wild fish in the lake data (e.g., 76.2% wild at age 3; Table 4). Conversely, 2008 was a particularly weak year for wild reproduction at Salmon River (Bishop et al. 2014) and this year class was less represented in the lake (e.g., 33.3% - 37.4% wild at age 3; Table 4). Noteworthy is that only 50% of the stocking target was stocked by New York in 2008 which would have inflated the proportion of wild fish sampled from 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 survive better (based on results of the 2010 and 2011 YC presented in this report), so equal survival may not be assumed for pen and direct stocked fish. Each year 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 survival rates

of hatchery and wild fish, and to evaluate factors explaining Chinook year class strength.

Another interesting pattern apparent in the data may relate to size differences between hatchery and wild Chinook at ages 1 and 2 (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 reared Chinook, which would under-represent wild age-1 fish sampled (Connerton et al. 2011). The percentages of wild fish also increased from age-2 to age-3 for two of the year classes examined (2009 and 2010). 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 percentages 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 2009-2015 wild Chinook salmon represented an important component of the lake Ontario boat fishery representing an average of 47% of the harvest of age-2 and age-3 Chinook salmon across all years and regions sampled. These ages make up the majority of the Chinook harvested 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 - November 5 each year from 2010 to 2015. Some sampling was also done in fall 2009 in the Salmon River. For details about 2010-2014 sample collections, and sample distributions among ages and tributaries see Connerton et al. (2011, 2012 2013, 2014, 2015).

In 2015, only age-4 fish (2011 YC) remained as part of the study. The percentages of wild age-4 Chinook salmon in tributaries were 25%, 20%, and 100% for Chinook salmon in the west, east, and Salmon River regions respectively; sample size was low for age-4 fish, however, which resulted in wide confidence intervals. The percentages of unclipped (wild) Chinook salmon are presented in Table 5 for each year class sampled from 2009-2015. These results complete this part of the marking study to determine the proportion of wild Chinook salmon in Lake Ontario tributaries for the 2008-2011 YCs. Previous reports provided age-specific percentages of wild Chinook salmon among regions, and tested for significant differences between and among regions. For these details, see Connerton et al. (2011, 2012, 2013, 2014, 2015).

For the four year classes studied (2008-2011), the percentages of wild Chinook in New York tributaries varied among regions, year class and age. In west region tributaries, wild percentages ranged from 5.9% to 12.9% for age-1, 3.3 to 16.5% for age-2, 3.7% to 20.4% for age-3, and 0 to 25% for age-4. In the east, wild percentages ranged from 4.1% to 20% for age-1, 5.4 to 24.2% for age-2, 9.4% to 29.2% for age-3, and 20% to 80% for age-4. In the Salmon River, percentages of wild Chinook ranged from 32% to 75.9% for age-1, 44.7% to 74.8% for age-2, 28.5% to 79.0% for age-3, and 77.8% to 100% for age-4. Overall, the percentages of age-2 and age-3 wild Chinook salmon in New York tributaries averaged 7.5% in western region tributaries, 18% in eastern region tributaries, and 58% in the Salmon River. Age-2 and age-3 salmon make up the majority of the spawning run and tributary harvest each year. Lower proportions of wild Chinook in west and east regions compared to the Salmon River were consistent across the years studied, and may be due to several factors including warm temperatures and low water, limited quality spawning habitat, and impassible barriers present in these regions. 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).

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 2009-2015. 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[a]		-	-	-	-															
2010	NY west[b]	2	64	137	31.8	[25.8, 38.6]	1	83	301	21.6	[17.8, 26.0]										
	NY east[b]		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]		C	C	C	c										
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]		c	c	c	c					
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		ND	ND	ND			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]		C	C	C	c		c	c	c	c		c	c	c	c
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]		c	c	c	c		c	c	c	c
2014	NY west											4	10	9	52.6	[31.7,71.7]	3	184	319	36.6	[32.5, 40.9]
	NY east												22	11	66.7	[49.5, 80.4]		430	662	39.3	[36.5, 42.3]
	ON												0	1	d	d		29	31	48.5	[35.5, 59.8]
	Regions Combined												32	21	60.4	[46.9, 72.4]		643	1012	38.8	[36.5, 41.2]
2015	NY West																4	3	3	50.0	[18.8, 81.2]
	NY East																	2	3	40.0	[11.7, 76.3]
	ON																	ND	ND	ND	

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

[a] 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

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

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

d Low sample size. No further analysis was completed.

ND= No age-4 samples were collected from Ontario waters in 2012 and 2015

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 2009-2015. 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]
2014	NY west											4	5	23	17.0	[7.4, 36.1]	3	388	1511	20.4	[18.7,22.3]
	NY east												6	6	50.0	[25.3, 74.6]		308	754	29.2	[26.6 32.1]
	NY east & west												11	29	37.9	[22.6, 56.1]		a	a	a	a
	Salmon River												7	2	77.8	[44.3, 94.7]		149	127	54.0	[48.1, 59.8]
2015	NY West																4	5	15	25.0	[11.2, 46.9]
	NY East																	1	4	20.0	[3.6, 62.4]
	Salmon River																	4	0	100.0	[51.1, 100.0]

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)

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 2009-2014. 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	14	400	9
3	81.9	11.5	6.6	61	6.5	75.6	18.6	5.8	107	5.9	51.4	22	26.5	306	13.2
4*	80.0	20.0	0.0	5	20.0	20.0	20.0	60.0	5	25.7	0	62.5	37.5	8	28.1
Avg	**84.6**	**13.4**	**1.4**		**12.4**	**74.3**	**23.6**	**2.2**		**8.4**	**61.6**	**23.3**	**14.5**		**10.9**

Avg= weighted average for yearclass (weighted by sample size for each yearclass, age)
n= sample size. * Note that sample size is very small for age-4 salmon so results for this age on their own are not very meaningful.

Significantly higher percentages of wild fish in the Salmon River compared to other NY tributaries were evident in all of the year classes studied (Connerton et al. 2011, 2012, 2013, 2014, 2015). The Salmon River watershed 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 (Table 5). Everitt (2006) estimated that 5-10 million Chinook salmon parr were produced in the Salmon River watershed in 2005; however, it was unknown what proportion of these parr survived and contributed to the sport fishery. Each year, some portion does survive and represents an important component of both the lake and Salmon River sportfishery.

Straying and Homing to Salmon River Hatchery

Returns of Chinook salmon to the SRH from 2009-2014 suggested a high degree of homing to SRH by Salmon River stocked fish and a low degree of straying to the hatchery by fish stocked at other NY sites (Table 6). For each year from 2009-2014, 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 61.6% of the samples made up of homing fish, and 13.4%, 23.6%, and 23.3% 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).

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 (i.e., 0.8, 0.26, 0.28 for 2008-2010 YCs, respectively). Clearly this was not the case based on observed homing:straying ratios. We estimated that an average of 12.4%, 8.4%, and 10.9% 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. All of the YCs (2008-2010) for this study have now been fully evaluated after age-4 salmon (2010 YC) returned to the hatchery in 2014. Overall, straying to the hatchery by fish stocked at other NY sites was low with straying rates averaging 10.6% for the entire study. This suggests that stocking timing and methods used by NYSDEC are working and straying back to SRH is minor. Of course, salmon do stray, both to the hatchery and to other stocking sites, but not at a level that should concern fishery managers.

Wild Chinook Straying to the Salmon River Hatchery

The percentages of wild fish in the hatchery from 2009-2014 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 14.5% for the 2008-2010 year classes, respectively (Table 6). The 2010 year class showed the highest percentages of wild 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 percentages of wild fish entering the hatchery, and low percentages of wild fish in the Lake and River. More wild fish may "stray" into the hatchery in years with higher proportions of wild fish in the population. Another pattern that emerges requiring 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 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

Overall, samples from angler-harvested fish in the Salmon River and its tributaries from 2010-2014 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 et al. 2012, 2013), but these straying rates were low (7.0%, 14.3% and 16% for the 2008-2010 year classes, respectively). Straying to the Salmon River certainly occurs but straying rates in the SRH and in Salmon River angler harvest indicate that it is only minor and probably not a concern for fisheries managers. We will continue to track coded-wire-tagged pen and direct stocked fish returning to the Salmon River and SRH until 2017, which will provide a more complete picture of the sources of these strays (also see this report, Table 9, and Connerton et al. 2015)

Straying from the Salmon River to other tributaries

Fish stray not only *to* the Salmon River to spawn, but some also stray *from* the Salmon River to other tributaries. Chinook stocked at the Salmon River were tagged from 2008-2010, and sampling efforts in tributaries from the Black River to the Niagara River during fall 2010-2014 afforded us a glimpse at straying of fish stocked in Salmon River to other streams. No fish from these YCs remained in 2015. In 2014, only age-4 salmon from the SRH tagging study remained in the population. A total 40 age-4 salmon were sampled in other tributaries in 2014, and none of these were fish stocked at Salmon River. In previous years, however, Salmon River strays were found in other tributaries. In 2013, a total of 1,222 age-3 AD-clipped salmon from the 2010 year class were sampled in other tributaries and of these, eight (<1%) 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 (2009 YC) was found at Maxwell Creek in 2013. In 2012, a total of 2,102 AD clipped salmon were sampled by headhunters, and of these, 108 Salmon River strays (5.0%) 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 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 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 Salmon River 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 Salmon River strays at one site were recovered at the Little Salmon River (LSR) in 2012, where 35% of age-2 (n=79 AD clipped salmon sampled) at LSR and 48% of age-3 (n= 48) at LSR were strays from the Salmon River. This site also contained a high proportion of strays from other sites in 2012 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 Salmon River 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 through 2017 when the tagging study is completed. Overall, straying from the Salmon River to other tributaries occurs, but appears to be fairly low based on recoveries from 2010-2014 in which nearly 5,000 AD-CWT fish were sampled but only 3.7% were Salmon River strays.

Evaluation of Pen and Direct Stocking

Since fish were marked for the pen study in 2010-2011 and 2013, only the 2010 and 2011 YCs were sufficiently recruited to the fishery in 2011-2015 for analyses comparing recoveries of pen and direct stocked fish. Future reports will provide analyses of the 2013 YC and will examine returns to tributaries.

For the 2010 YC, a total of 981 tagged Chinook salmon from pen and direct stockings were recovered from the lake fishery from 2011-2014. In 2014, only age-4 fish from this YC remained in the population and just four tagged fish were sampled from the lake fishery, so no additional analyses were pursued. 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 1.9 greater contributions to the lake fishery per number stocked than direct stocking (Table 7). 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 7). For Niagara and Sandy Creek sites, pen to direct recovery ratios were 1.3 and 1.4, respectively; however, there was no statistically significant difference between the stocking methods at these sites.

For the 2011 YC, a total of 1,230 tagged Chinook salmon from pen and direct stockings were recovered from the lake fishery from 2012-2014 (Table 8). In 2015, only age-4 fish from this YC remained in the population and just five tagged fish were sampled, so no additional analyses were pursued. All recoveries were adjusted for numbers stocked by each method at each site. Similar to the 2010 YC, pen stocking provided on average 2.4 fold higher relative returns compared to direct stocking. Recovery ratios were

Table 7. 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 (2010 YC). 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 Tagged	Recoveries in the Lake per 50,000 stocked in Year 2011	2012	2013	2014	Total	X^2 Test for Homogeneity Across Years X^2	P	X^2 Test for Differences Pen vs Stocked X^2	P	Lake Recovery Ratio (Pen:Direct)
Niagara	Pen	75,650	8	29	17	1	55	0.08	0.9613	2.78	0.0956	1.3
	Direct	75,400	6	21	14	0	41					
Eighteenmile	Pen	66,310	10	53	13	0	76	1.81	0.4039	19.36	<0.0001*	2.2
	Direct	67,300	3	23	9	1	36					
Oak Orchard	Pen	75,600	8	32	14	0	54	1.88	0.391	9.02	0.0016*	1.9
	Direct	63,900	4	14	11	0	29					
Sandy Creek	Pen	37,900	11	38	21	0	70	0.20	0.905	2.78	0.0954	1.4
	Direct	37,700	7	29	13	0	49					
Genesee River	Pen	75,300	13	52	18	0	83	6.44	0.0400	5.27	0.0216*+	1.5
	Direct	75,066	5	29	20	0	54					
Sodus Bay	Pen	37,800	24	66	24	0	114	7.23	0.0297*	7.98	0.0048*+	2.0
	Direct	37,900	5	28	24	1	58					
Fairhaven	Pen	24,200	8	52	19	0	79	1.59	0.4514	13.89	0.0002*	3.3
	Direct	25,300	0	16	8	0	24					
Oswego	Pen	37,900	11	20	45	1	77	0.18	0.9127	4.68	0.0305*	1.6
	Direct	37,650	8	13	27	0	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.

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 2011 (2011 YC). For sites with P-values <0.05, returns of pen-stocked and direct stocked fish were significantly different at α=0.05.

			Recoveries in the Lake Per 50,000 Stocked in Year					X^2 Test for Homogeneity Across Years		X^2 Test for Differences Pen vs. Stocked		Lake Recovery Ratio
Site	**Stocking Method**	**Number Tagged**	**2012**	**2013**	**2014**	**2015**	**Total**	**X^2**	**P**	**X^2**	**P**	**(Pen:Direct)**
Niagara	Pen	75,960	3	17	30	0	49	0.82	0.6621	22.7	1.91E-06*	2.88
	Direct	75,790	1	7	9	0	17					
Eighteenmile	Pen	67,490	10	61	59	1	131	2.82	0.2437	46.61	8.65E-12*	2.61
	Direct	66,000	3	18	29	0	50					
Oak Orchard	Pen	75,330	13	56	59	1	129	7.89	0.0194*+	13.01	0.000309*	2.47
	Direct	64,244	9	13	30	2	54					
Sandy Creek	Pen	38,750	19	54	54	1	129	1.14	0.5634	36.92	1.23E-09*	3.45
	Direct	37,865	4	13	20	0	37					
Genesee River	Pen	75,350	8	48	17	1	73	1.06	0.5883	24.23	8.53E-07*	2.36
	Direct	73,530	5	18	8	0	31					
Sodus Bay	Pen	37,720	9	37	62	0	109	1.3	0.5229	22.62	1.97E-06*	2.67
	Direct	38,120	1	17	22	0	41					
Fairhaven	Pen	25,520	4	27	157	0	188	0.12	0.9428	9.82	0.001726*	1.71
	Direct	25,040	2	14	94	0	110					
Oswego	Pen	37,690	4	19	36	0	58	1.18	0.552	0.33	0.5672	1.16
	Direct	36,910	1	20	28	0	50					
											Average Recovery Ratio (Pen:Direct) =	**2.42**

* Significant at α=0.05

+Oak Orchard recoveries of pen and direct were not homogenous among years, with year 2013 and 2014 marginally significantly different

(X^2 =5.53, P=0.0542), so recoveries from 2012-2014 were pooled and tested for differences (shown above); recoveries from 2013 were tested separately (X^2 = 34.2, df = 1, *P*= 4.967e-09.

significantly greater for all sites except for the Oswego River where the recovery ratio was 1.16, but there was no significant difference between the stocking methods there. It should be noted that Wilkinson et al. (2012) raised concerns about water quality at the Oswego pen site in 2011. Results of this study corroborate these concerns and emphasize the need for proper care and maintenance of pens by cooperators to achieve annual benefits.

Results at Oak Orchard for both YCs showing higher relative recoveries of pen fish, and at Niagara for the 2010 YC showing no significant difference between stocking methods were consistent with the previous study by Bishop et al. (2006). That study was conducted by sampling salmon at tributaries only, and not from the lake fishery. Returns to the tributaries by pen or direct stocked salmon could result from differences in survival, imprinting, or a combination of the two. Results from the lake fishery in this study showing higher recoveries of 2010 and 2011 YC pen fish may have resulted from differences in survival or in vulnerability to capture. Both groups are fully recruited to the fishery and assumed to be equally vulnerable to harvest after age 1 (assuming maturity is the same), suggesting that pen fish do exhibit higher survival in their first year in Lake Ontario. Results to date indicated that pen stocking does not produce a negative outcome. These results are based on two year classes, however, with the 2013 YC remaining to be evaluated.

It is important to note that comparisons between individual pen sites were not an objective of this study and is invalid. Sampling relied on angler caught fish, and was therefore subject to fish distribution, fishing effort, and success, which varied by location and year. 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 among sites.

Straying to Salmon River by Pen and Direct Stocked

Tagging of pen and direct stocked Chinook salmon took place from 2010-2011, and in 2013. In each year from 2011-2015 some tagged strays have returned to the Salmon River and the SRH which afforded us a glimpse at the origin of straying fish. For each site, and each year class, we tested whether the observed

Table 9. The number of straying Chinook salmon from 2011 (2011 YC) pen and direct stocking sites recovered during sampling at the Salmon River Hatchery 2012-2015. For sites with P-values <0.05, returns of pen-stocked and direct stocked fish were significantly different at α=0.05.

Stocking Site	Pen	Direct	# Recovered 2012 Pen	# Recovered 2012 Direct	# Recovered 2013 Pen	# Recovered 2013 Direct	# Recovered 2014 Pen	# Recovered 2014 Direct	# Recovered 2015 Pen	# Recovered 2015 Direct	# Recovered per 50,000 stocked Pen	# Recovered per 50,000 stocked Direct	χ2	P
Niagara	75,960	75,790	0	0	2	0	3	4	0	0	3	3	0	1.0000
Eighteenmile	67,490	66,000	0	1	0	7	1	16	0	0	1	18	19.85	<0.00001
Oak Orchard	75,330	64,244	0	14	6	40	4	65	0	1	7	93	108.95	<0.00001
Sandy Creek	38,750	37,865	2	9	2	3	4	12	0	0	10	32	7.38	0.0066
Genesee	75,350	73,530	5	2	3	4	5	22	0	0	9	19	8.91[a]	0.0028
Sodus	37,720	38,120	9	2	12	4	32	30	0	0	70	47	3.04	0.08105
Fairhaven	25,520	25,040	3	1	5	1	3	3	0	0	22	10	1.47	0.2256
Oswego	37,690	36,910	1	0	2	4	3	6	0	0	8	14	0.63	0.4285

[a] Proportions among sample years in 2012-2014 for Genesee were not homogenous (χ2=7.7, degrees of freedom (D.F.)=2, P=0.02); with proportions in 2012 significantly different from proportions in 2014 (χ2=8.1, P=0.02); only samples from 2013-14 were pooled for this site. [b] marginal cell totals were <5, so Fisher Exact test was used instead of chi-square.

return ratios of pen to direct stocked Chinook salmon recovered at Salmon River were different than expected based on stocking ratios. If so, this would suggest that one stocking method either had higher lake survival or that one method led to higher straying to the River.

For a detailed summary of 2010 YC strays from pen and direct stocking sites to SRH, see Connerton et al. (2014). For the 2010 YC, the numbers of direct and pen stocked Chinook recovered in the hatchery were not significantly different than expected except for the Oak Orchard site, where a significantly higher ratio of pen to direct stocked Chinook salmon were found (Connerton et al. 2014). The relative recoveries of pen fish at Oak Orchard were also higher in the lake; however, so returns to the River are not necessarily a result of higher straying by pen stocked fish from this site, but probably just be a reflection of higher survival in the lake.

For the 2011 YC, the ratios of pen to direct stocked fish were significantly different from stocking ratios for four sites including Eighteenmile Creek, Oak Orchard, Sandy Creek, and the Genesee River (Table 8). In these cases, relative survival of direct stocked fish was lower in the lake, so higher returns by direct fish to the hatchery cannot be attributed to survival differences but more likely to higher straying rates. Straying of direct and pen stocked Chinook to the Salmon River were not significantly different for Sodus, Fairhaven and Oswego for this year class.

Again, results are preliminary and analyses of returns from the 2013 YC and at the tributaries may shed more light on this subject. Results thus far suggest that straying by fish stocked at other sites is variable; that direct stocked fish can stray more in some years from some sites albeit inconsistently, and that overall, straying by fish stocked at other sites to the River is low (Table 6).

Relative Contribution of Salmon River Stocking to the Lake Fishery (April – July)

We evaluated the relative contribution of the 2010 Salmon River stocking to the lake fishery compared to pen and direct stocked salmon from the same year class. For this analysis we only included fish harvested in April through July each year when we assumed fish are mixed in the lake and prior to staging outside of natal tributaries. Analysis of tag recoveries from 2011-2014 showed Salmon River stocked fish and pen stocked fish contributed significantly better than direct stocked fish (about 2:1, Table 10), but Salmon River and pen stocked fish were not significantly different from each other (X-squared = 0.26405, p-value = 0.6073, df = 1). Fish stocked at Salmon River are deliberately held at the hatchery until June each year to encourage imprinting; results of tag recoveries from the 2010 YC in the lake, hatchery (Table 6) and tributaries suggest that these methods are working. Salmon

River stocked fish also show a survival advantage compared with direct stocked fish which are stocked at almost half the size. There was no apparent survival advantage compared with pen stocked fish, however, despite being stocked about 40% larger.

Imprinting of Pen and Direct Stocked Salmon

We compared the relative return of pen and direct stocked Chinook salmon stocked in 2010 and 2011 to tributaries during fall spawning from 2011-2015 at the eight stocking sites, hereafter referred to as return-ratios (Table 11). To evaluate the imprinting of pen and direct salmon to these sites without the effect of post-stocking survival, the return ratios of pen vs direct stocked salmon were adjusted for lake performance and compared.

For the 2010 YC, return ratios to tributaries by pen and direct stocked salmon (Table 10) were slightly lower than lake recovery ratios (Table 7) with pen fish returning about 1.45 to 1 on average across sites compared with 1.9 ti 1 in the lake. Tributary return ratios were higher than lake return ratios at three sites (i.e., Oak Orchard, Sandy Creek, and Genesee). Tributary return ratios were lower than lake return ratios at Eighteenmile Creek, Fairhaven and Oswego and similar at Niagara River and Sodus. After adjusting for lake performance, the average return ratio of pen and direct stocked fish across all sites was 0.9 indicating little difference between imprinting of pen and direct stocked salmon. There was no significant difference between returns of pen and direct stocked salmon at five of eight sites. At Genesee River, pen fish returned significantly better than direct stocked fish. At Fairhaven and Oswego, pen fish returned to these sites significantly worse than direct stocked fish after adjusting for lake performance.

For the 2011 YC, return ratios to tributaries by pen and direct stocked salmon (Table 12) were similar to lake recovery ratios (Table 8) at individual sites; i.e., pen fish returned about 2.4 to 1 on average prior to adjusting the return ratios for lake performance. Only

Table 10. ***Recoveries from the Open Lake harvest[1] per 50,000 stocked of coded-wire tagged Chinook salmon stocked into Lake Ontario at Salmon River compared to pen and direct stockings in New York in 2010 (2010 YC).***

	Direct	Pen	Salmon River
Mean Stocking Size (g)	4.6	6.3	8.2
Tags Recovered 2011-2014	100	231	172
Total Stocked in 2010	420,216	430,660	339,410
Recoveries in the Lake per 50,000 stocked	11.90	26.82	25.34
Ratio (to direct stocked)	**1.00**	**2.25**	**2.13**
X^2		47.9	37.1
P		P<0.0001	P<0.0001

1 Based on tag recoveries from April-July only

Table 11. Relative return of pen and direct stocked Chinook Salmon to eight tributary stocking sites in New York from 2011-2014 (2010 YC). Numbers returning to tributaries were adjusted by numbers stocked and by the lake recovery ratio (pen:direct) for that site to evaluate imprinting to stocking sites. (See Methods for more explanation). For sites with P-values <0.05, returns of pen-stocked and direct stocked fish were significantly different at α=0.05

Site	Number Tagged Pen	Number Tagged Direct	Recovered Per 50,000 Stocked Pen	Recovered Per 50,000 Stocked Direct	Tributary Recovery Ratio Pen: Direct	Lake Recovery Ratio Pen:Direct	Adjusted Recovery Ratio Pen: Direct	X^2	P
Niagara	75650	75960	62	59	1.06	1.3	0.84	1.76	0.184
Eighteenmile	66310	67490	97	61	1.56	2.2	1.05	0.07	0.787
Oak Orchard	75600	75330	217	59	3.50	1.9	1.17	0.34	0.559
Sandy Creek	37900	37865	24	15	1.64	1.4	1.40	1.30	0.255
Genesee	75300	75350	49	32	1.80	1.5	0.60	3.91	0.048
Sodus	37800	37720	23	20	1.13	2.0	1.38	0.91	0.340
Fairhaven	24200	25520	15	80	0.18	3.3	0.33	48.66	<0.0001
Oswego	37900	37690	91	116	0.78	1.6	0.56	17.19	<0.0001
Average Return Ratio (Pen: Direct)					**1.45**	**1.9**	**0.91**		

Table 12. Relative return of pen and direct stocked Chinook Salmon to eight tributary stocking sites in New York from 2012-2015 (2011 YC). Numbers returning to tributaries were adjusted by numbers stocked and by the lake recovery ratio (pen:direct) for that site to evaluate imprinting to stocking sites. (See Methods for more explanation). For sites with P-values <0.05, returns of pen-stocked and direct stocked fish were significantly different at α=0.05

Site	Number Tagged		Recovered Per 50,000 Stocked		Tributary Recovery Ratio Pen: Direct	Lake Recovery Ratio Pen:Direct	Adjusted Recovery Ratio Pen: Direct	X^2	P
	Pen	Direct	Pen	Direct					
Niagara	74870	75400	112	39	2.89	2.88	0.96	0.24	0.6210
Eighteenmile	66000	67300	289	77	3.74	2.61	1.52	24.57	<0.0001
Oak Orchard	64244	63900	170	47	3.64	2.47	1.48	5.47	0.0194
Sandy Creek	37865	37700	143	59	2.40	3.45	0.73	6.37	0.0116
Genesee	73530	75066	56	23	2.41	2.36	1.08	0.13	0.7221
Sodus	38120	37900	45	20	2.29	2.67	0.96	0.01	0.9048
Fairhaven	25040	25300	51	82	0.62	1.71	0.35	23.77	<0.0001
Oswego	36910	37650	99	84	1.18	1.16	1.09	0.16	0.6886
Average Recovery Ratio (Pen: Direct)					**2.5**	**2.4**	**1.02**		

at Fairhaven did pen fish not return better than direct stocked fish. This site is unusual because pens are not associated with any tributary, while direct stocked fish are released into Sterling Creek each year. Recoveries were focused at this stream and at nearby Wolcott Creek where the majority of fish were from the Fairhaven stockings. Efforts were made to locate staging fish near the pen stocking site (Anchor Marina) but none were found. Pen fish from Fairhaven did perform significantly better in the lake (Pen:Direct = 1.71) but unadjusted return ratios indicated poorer returns to the streams (Pen:Direct = 0.62). After adjusting for lake performance, there were no differences between pen and direct stocking returns at four out of eight tributary sites (i.e., Niagara, Genesee, Sodus and Oswego). At Eighteenmile Creek and Oak Orchard, pen fish returned significantly better than direct stocked fish even after adjusting for lake performance. Adjusted return ratios indicated that pen fish returned significantly worse than direct stocked fish at Sandy Creek and Fairhaven. Overall, the average of 2011 YC adjusted return ratios of pen to direct stocked fish across all sites was 1.02, and there was no consistent difference in imprinting between pen and direct stocked fish.

Imprinting of Chinook Salmon to Stocking Sites

We evaluated imprinting of stocked salmon to eight stocking sites during the fall spawning run in 2013. At each tributary sampled, we determined stocking origin of each tagged salmon from the retrieved CWT. Samples included fish from the 2010 and 2011 YCs (n=1,689). The numbers of tagged fish returning to each tributary were adjusted for numbers stocked according to their stocking origin, and then the numbers of fish sampled that were stocked at the site were compared to the numbers of fish stocked at other sites.

Most fish returning to each stocking site were stocked at the site; at least 80% of the fish at each of the eight sites were from the site (Figure 2), and the majority of strays were from nearby stocking sites. For example, strays at Eighteenmile Creek consisted of salmon from Niagara River and Oak Orchard Creek stockings. At Sandy Creek, the majority of strays were from stockings at Oak Orchard Creek and the Genesee River; and at Genesee River the majority of strays were from Sandy Creek and Sodus stockings. This was not the case at the Oswego River where strays were from several sites including western (Oak Orchard, Eighteenmile Creek) and eastern sites (Sodus, Fairhaven) perhaps because of its proximity to the Salmon River. Regardless, the numbers of strays from other sites to Oswego was relatively low, similar to the other sites.

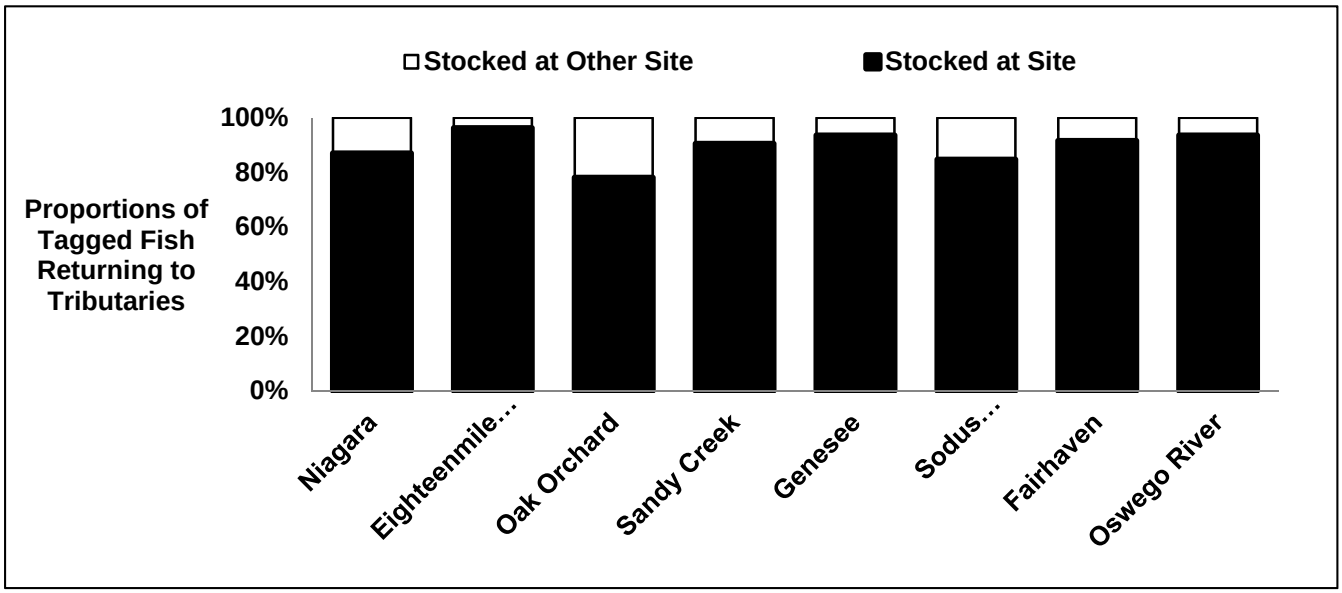

Figure 2. Relative proportions of tagged Chinook Salmon harvested at eight tributary sites during the fall spawning run in 2013. Tagged fish included both 2010 and 2011 YC adjusted for numbers stocked.

Despite results suggesting little difference in imprinting between pen and direct stocked fish, results of returns to stocking sites indicate that the vast majority of fish are imprinting to the tributary at which they are stocked and straying to other tributaries is minor. Chinook are apparently stocked into pens early enough and small enough (~4 g) to permit imprinting, and are held until they reach a larger size (~6g) which improves survival. Direct stocked salmon are released at about the same size as pen fish are when placed into pens (~4 g), permitting imprinting; however, survival is worse for direct stocked fish than for pen fish.

Summary

1. Only fish from the 2011 year classes remained in 2015 as part of the wild study. The percentage of wild age-4 Chinook salmon in the Lake Ontario fishery was 45.5% in 2015.

2. For the four year classes studied (2008-2011), percentages of wild Chinook salmon in Lake Ontario varied by year class, age, and among regions from 2009-2015, but overall wild Chinook were an important component of the Lake Ontario fishery averaging 47% of the age 2- and age-3 lake harvest.

3. For the four year classes studied (2008-11), the percentages of wild Chinook salmon in New York tributaries varied among regions from 2009-2015 with percentages of age 2-3 wild salmon averaging 7.5% in western region tributaries, 18% in eastern region tributaries, and 58% in the Salmon River.

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%, 8.4%, and 10.9%, respectively.

5. Preliminary results from the 2010 and 2011 YCs indicate that pen stocking at eight sites provided an average of 1.9 and 2.4 greater contribution, respectively, to the lake fishery per number stocked than direct stocking. The 2013 YC remains under study, so final conclusions cannot be drawn.

6. Chinook salmon stocked at the Salmon River in 2010 provided about 2.1 greater contributions to the lake fishery per number stocked than direct stocked salmon.

7. The majority of fish returning to stocking sites were stocked at those sites indicating good imprinting of both pen and direct stocked Chinook salmon

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Eastern Basin of Lake Ontario Warmwater Fisheries Assessment, 1976-2015

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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 2015 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 2012-2015.

Methods

A standardized, stratified random design gillnetting assessment was conducted annually from 1976 through 2015 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 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 to be 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 alewife, 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 nets 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 to be zero when scheduled at a location with stable water temperatures <50°F for at least 9 ft off bottom.

In 2015, 29 randomly chosen netting locations were determined prior to initiation of the assessment on August 3. From August 3-14 we completed 25 unbiased net sets, three additional net sets were canceled and catch of warmwater fish was assumed zero due to bottom water temperatures <50°F, and one net set was biased and not re-set. Mean stratified catch-per-unit-effort (CPUE = fish per overnight net set) was calculated for each fish species captured and for the total warmwater fish catch. 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 2003-2015 and in addition to scales, we collected otoliths from smallmouth bass >13.8 in, yellow perch >8.7 in, all walleye, and freshwater drum (*Aplodinotus grunniens*).

Species composition, depth stratum-specific species richness and CPUE, and trends in abundance indices were described. Additional data analyses completed for smallmouth bass include: 1) scales (1976-2015) and otoliths (2004-2015) were aged to determine age composition, age-specific CPUE and mean length-at-age; 2) relative weight (Wr) was determined for each fish (Wr = 100*actual weight ÷ standard weight [Ws]; where: $\log_{10}$ [Ws] = -5.329 + 3.20 [$\log_{10}$ TL]; Kolander et al. 1993, Anderson and Neumann 1996); 3) condition (Fulton's K) was calculated for each inch increment (7-19 in); and 4) the average percent maturity of male and female age 1-7 bass sampled was determined.

Results and Discussion

2015 Water Temperature

In 2015, bottom temperatures for all nets set in depth strata 1 (12-30 ft) and 2 (31-50 ft) ranged from 71.1°F to 75.6°F and 54.1°F to 75.2°F, respectively. In stratum 3 (51-100 ft), bottom temperatures at net set locations ranged from 47.5°F-70.9°F. Four unbiased net sets in depth stratum 3 may have experienced some periods of water temperatures <50°F, given that 25 coldwater fish (5 cisco, 20 lake trout) were captured in those nets.

Species Richness and Composition

Since 1976, 45 fish species (34 warm and cool water species) were captured during the eastern basin gillnetting assessment (Table 1). In 2015, 646 fish were captured in unbiased net sets, representing 17 warm and cool water species (620 fish) and three coldwater species (26 fish). The greatest species richness (16 species; CPUE=48.1) occurred in depth stratum 1, followed by depth strata 2 (12 species; CPUE=18.0) and 3 (7 species; CPUE=2.5). 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. From 1990-2013, 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. In 2014, catch was dominated by white perch (38.2% of total catch). Smallmouth bass was the second most commonly caught species (24.3%) followed by yellow perch (8.3%; Table 1). In 2015, smallmouth bass was the most commonly caught species (29.2% of total catch), however, white perch and gizzard shad represented the second and third largest components of catch (24.7% and 7.3%, respectively). Yellow perch was the fifth most commonly caught species in 2015 (only 5.5% of total catch), which was attributed to the substantial decline in CPUE (0.8 fish per net, the lowest in the 40-year time series).

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 2000-2015. 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 through 2013 when 84.0% of the non-empty bass stomachs contained goby. In 2014, 76.3% of the 135 non-empty bass stomachs contained goby. In 2015, 71.7% of the 120 non-empty bass stomachs contained goby. Gobies were present in walleye diets each year from 2006-2010 and 2012-2015. Round gobies were also observed in the diets of northern pike, brown trout (*Salmo trutta*), lake trout, and lake whitefish (*Coregonus clupeaformis*). 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. Round goby 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), and were documented in DCC diets each year since. Gobies dominated DCC diets by 2004 at the Snake and Pigeon Island colonies, and by 2005 at the Little Galloo Island colony (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 1995-2014, at least one sturgeon was collected in 15 of the 21 years, suggesting improved population status. Although lake sturgeon remain rare in the survey, three were captured in 2015.

Occurrence of Chain Pickerel

Chain pickerel (*Esox niger*) presence in Ontario waters was confirmed in 2008 (Hoyle and Lake 2011). This species was first captured in this assessment in 2013 when three were caught in two nets (each set in 15 ft water depth). They were likely not captured in this assessment sooner because nets are distributed at water depths 12-100 ft, beyond preferred chain pickerel habitat. It was also reported in angler catches during the Lake Ontario Fishing Boat Survey each year 2008-2010 and 2013 (Lantry and Eckert 2016). Occurrence of chain pickerel in recent years is

attributed to range expansion (Hoyle and Lake 2011). No chain pickerel were captured during this survey in 2014 or 2015.

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 14.91 and 94% lower than the 1976-1979 average (Table 1, Figure 2). From 1996 to 2014, mean stratified CPUE for total warmwater fish varied without trend averaging 26.6 and ranging between 15.7 (2001) and 44.4 (2008; Table 1, Figure 2). In 2015, the mean stratified CPUE of 14.92 was similar to the 1995 record low and a 52.7% decrease compared to the previous 10-year (2005-2014) average. The 2015 decrease is largely attributed to decreased catches of yellow perch, smallmouth bass and white perch. For a second consecutive year, water temperatures were colder than those measured in recent years, particularly in the deepest waters which may have contributed to reduced catches.

Other species that influenced fish community trends in the eastern basin were alewife (*Alosa pseudoharengus*), walleye, and smallmouth bass. 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 to 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. CPUE has remained variable at about the same level since then (2008-2015 average = 5.0). Each year 2008-2011 and 2013 white perch was the third most common species in the assessment, representing 9.6%-19.4% of the total warm water fish catch (Table 1, Figure 3). In 2014, white perch CPUE (7.9) was comparable to 2008, but with the decrease in yellow perch CPUE, was the most commonly caught species (38.2% of total catch). It was the second mostly commonly caught species in 2015, representing 24.7% of the total catch (CPUE = 3.7).

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, and remained near that level through 2013. Then catches declined and were at the lowest levels recorded (2014 CPUE = 1.7; 2015 CPUE = 0.8 fish per net night; Table 1). This decrease may be attributable to water temperature patterns and catch variability;

however, angler reports of reduced catches (anecdotal and as reported in Lantry and Eckert 2016) also suggest lower yellow perch abundance. Variability of yellow perch catch in gill nets is relatively high (long-term average RSE=37.4%) when compared to smallmouth bass (long-term average RSE=21.0%), and is likely attributable to the schooling nature of perch. For 2015, yellow perch RSE (37.4%) was comparable to (+1.6%) the long-term average.

Reduced population size and/or changes in distribution are likely contributing factors to reduced catch of yellow perch in 2014 and 2015. Yellow perch populations have been in decline in Ontario waters (e.g., Bay of Quinte and Ontario eastern outlet basin; OMNRF 2016) for several years, as determined from the annual index netting and commercial fishery catches, but only recently declined in New York waters. Angler catches, reported during the Lake Ontario Fishing Boat Survey (Lantry and Eckert 2016), were reduced in recent years (2013-2015) and anecdotal reports from eastern basin anglers indicate reduced fishing quality and possibly reduced population size. Additionally, two consecutive long, cold winters (2013/2014 and 2014/2015) followed by below average summer temperatures (2014 and 2015) may have impacted perch growth and distribution. More colder water within the area surveys as compared to previous years may have contributed to the substantially decreased catches in 2014 and 2015 (the lowest values recorded; 1.7 fish/net and 0.8 fish/net, respectively). Yellow perch catches can be highly variable compared to other species, likely due to their schooling nature and the influence of temperature.

We do not attribute the recent reduced catch of yellow perch during this assessment in 2014 and 2015 to Double-crested cormorant (DCC) predation, although DCC predation contributed to reduced population size during the 1990s (O'Gorman and Burnett 2001). Since then, DCC population management 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 the opportunistic DCC, further reducing predation pressure on yellow perch in recent years (Johnson et al. 2014).

In 2015, yellow perch total lengths ranged between 7.0 in (179 mm) and 12.0 in (305 mm), and averaged 8.3 in (212 mm). Approximately 13% of perch captured were ≥ 9 in (≥ 228.6 mm; Figure 17). Weights of yellow perch captured in 2015 ranged from 2.3 oz (66.0 g) to 14.7 oz (417.0 g).

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) increased to the highest level since 1981 (CPUE=2.8), likely due to the warm winters in 2011-2012 and 2012-2013. The 2014 CPUE was 0.3 gizzard shad per net, a decrease which may have been due in part to the relatively cold winter of 2013/2014. In 2015, CPUE increased slightly to 1.0 fish per net night despite a second consecutive long, cold winter during 2014/2015.

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. Abundance subsequently declined, and has been at a relatively stable level since 2011 (Figure 6). In 2015, the rock bass CPUE (1.1) was a slight decrease (-9.0%) 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 alewife were caught during the 2010 or 2013 assessments. The 2015 alewife CPUE was 0.5 fish

per net set. 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). Declining 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, but has remained relatively stable since the late 1990s (Figure 8). The 2015 CPUE of 1.0 was a 46.8% decrease compared to the previous 5-year average. Although walleye CPUE declined in 2015, the walleye population is expected to remain near levels observed during the last decade because strong year classes remained well-represented in the catch (see below). Variability of gill net catches was highest when CPUE was low (Figure 8) with RSE averaging 44.6% during 1980-1989. RSE fluctuated at a lower level without trend from 1990-2015 (average RSE=26.8%).

Otoliths collected from walleye were aged and indicated that strong year classes were produced in 2003, 2005, 2008, 2011, and 2014 (Figure 18). The 2003 year class were first captured as age 1s in 2004 when they represented 25.9% of the 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, OMNRF 2011a and 2011b). Good to strong 2005 and 2008 year classes were also produced in Ontario waters (OMNRF 2009, 2010, 2011a, 2012). Fall young-of-the-year (YOY) bottom trawling in the Bay of Quinte indicated that a strong 2011 year class was produced there (OMNRF 2012). The 2015 catches of the 2011 year class at age 4 (15.4% of total walleye catch) during this survey are the first indications of good production in New York waters (0% of catch in 2012 [age 1], 5.7% in 2013 [age 2] and 5.2% in 2014 [age 3]; Figure 18). OMNRF (2015) reported production of a strong 2014 year class and several (10.3% of catch) were caught at age 1 during this assessment in 2015. Strong year class production in the Bay of Quinte also occurred in 2015 (OMNRF 2016).

In 2015, walleye total lengths ranged between 11.7 in (297 mm) and 29.8 in (756 mm), and averaged 23.2 in (590 mm; Figure 17). Walleye weights ranged from 0.6 lb (253 g) to 10.6 lb (4,813g) and averaged 5.5 lb (2,497 g).

Smallmouth Bass Abundance Trends, Growth, Condition, Maturity, and Age Composition

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). By the early 2000s, the eastern basin fish community was being impacted by many perturbations including reduced lake productivity, Dreissenid mediated ecosystem changes (e.g., increased water clarity), increased abundance of DCC, and a variety of invasive species (e.g. *Bythotrephes*, *Cercopagis*, round goby). Studies demonstrated that the DCC population was contributing to reduced populations of smallmouth bass and yellow perch at that time (e.g., Adams et al. 1999, NYSDEC 1999, NYSDEC 2001, O'Gorman and Burnett 2001, Lantry et al. 2002), but direct impacts of other system stressors were not well understood. Angler surveys reported reduced smallmouth bass fishing quality in the eastern basin (Eckert 1999, McCullough and Einhouse 1999). By 2001, the smallmouth bass population declined to the lowest level in the data series (Figure 9). DCC management was initiated in 1999 and management plan objectives were met by 2006 (McCullough and Mazzocchi 2014). Meanwhile additional stressors were emerging including Type E Botulism (early to mid-2000s), viral hemorrhagic septicemia virus (VHSv; 2005 with a major NY outbreak effecting bass in 2006), and

Hemimysis anomola (bloody red shrimp; 2006).

The index of abundance for Lake Ontario's eastern basin smallmouth bass population was improved during 2005-2013 from 2000-2004 record lows; however, those levels were lower than expected following achievement of DCC population management objectives. In addition, smallmouth bass have not produced strong year classes relative to those produced in the 1970s and 1980s. In recent years, year classes that appear strong at ages 2-4 did not persist and 2014-2015 CPUEs declined. Factors confounding comparisons of recent to historic data include increased bass growth resulting in accelerated recruitment to assessment gear, and earlier maturation that may be affecting bass longevity. These issues are discussed in detail in the following sections.

Abundance Trends

Smallmouth bass 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 1973 and 1983 year classes during these respective time periods (Figures 9, 20a, and 20b). These strong year classes were evident in gillnet catches through at least age 8 when CPUEs were 9.4 and 4.4, respectively (Chrisman and Eckert 1999; Figures 19 and 20b).

Smallmouth bass CPUE declined through the early 1990s and reached record-low levels during 2000-2004 (2000-2004 mean CPUE=4.2; Figures 9, 19, and 20a). Relatively high CPUE of young fish indicated that moderately strong year classes had been produced in 1987 and 1988 (Chrisman and Eckert 1999, Eckert 2000, Casselman et al. 2002; Figures 19, 20a and 20b); however, increased CPUE of these year classes at older ages (i.e., ages $\geq$ 5) was not evident (Figures 19 and 20b). Unlike the strong 1973 and 1983 year classes, the moderately strong 1987 and 1988 year classes were nearly absent by age 8 (CPUEs 0.4 and 0.5, respectively). 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 remained relatively stable through 2013 and near 1994-1999 levels (i.e., years when there were angler concerns about the status of the bass population; Figure 9). The CPUE increase in 2005 is attributed to the 2002 year class (age 3 in 2005; Figure 20b), which represented 33.8% of the catch. CPUE of the 2002 year class peaked in 2005 (CPUE=3.8), then declined, and was nearly absent from the population by age 8 (2010 assessment, CPUE=0.8). The 2008 and 2009 catches were dominated by the 2005 year class (ages 3 and 4, respectively; Figure 20), which represented 37.1% and 48.3% of total smallmouth bass catch, respectively. By 2014, catch of the 2005 year class (age 9) was relatively small (CPUE=0.7), but represented 13.8% of total catch (Figure 20b). In 2015, CPUE (4.4; RSE = 14.6%) declined to the lowest level since 2004 and was comparable to (+3.6%) record low levels observed during 2000-2004. This recent decline is attributed to the production of only poor to weak year classes since 2006.

Growth

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 (mean lengths-at-age $\leq$ 11.1 in; Figure 21). Bass are not fully vulnerable to assessment nets until approximately 12 in TL (generally age 5 or 6 for years prior to the mid-1990s). 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 21). 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 (Figures 21

and 22). By 2010, a portion of bass sampled reached 12 in TL by age 2 (Figure 22), and average length of age-3 bass was over 12 in TL in 2010, 2012, and 2014. From the mid-2000s through 2014 mean length-at-age remained at or near record high for all ages 2-10, and unlike early years of this survey, gill nets now effectively sample many age-2 and age-3 bass, and likely all age-4 bass (Figure 21). In 2015, mean length-at-age remained at or near record highs for all ages except for age-2 bass, which was the lowest average (7.8 in) since 1992 (7.6 in) and approximately two inches shorter than the previous three years (Figure 21). These bass hatched in 2013 and likely only experienced approximately four months of good growth before experiencing the record cold winter of 2013/2014, followed by below average summer 2014 temperatures. These fish were then subjected to a second, record cold winter (2014/2015), followed by below average temperatures in summer 2015. Colder water temperatures can slow metabolism, resulting in reduced growth rates. Growth rates of these age-2 bass may have also been impacted by prey availability during the extended period of cold temperatures. Changes in growth rates throughout the data series confounds comparisons of "historic" (prior to mid-1990s) data with more recent data, including age-specific CPUE and survival.

In 2015, smallmouth bass total lengths ranged between 7.0 in (178 mm) and 21.3 in (541 mm), and averaged 16.1 in (408 mm; Figure 17). Bass weights ranged from 0.17 lb (76 g) to 6.1 lb (2,782 g) and averaged 3.0 lb (1,349 g).

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). Mean length-at-age continued to increase following establishment of round goby in the system.

Condition

Condition of smallmouth bass in the eastern basin began increasing in the mid-2000s (Figure 23). This coincided with a shift from a diet dominated by crayfish and no round goby, to one dominated by round goby and very low occurrence of crayfish. Smallmouth bass condition varied about the long-term mean from 1976-2005, then increased for each length group from 7-12 in (Figure 23). Condition of bass in 2015 remained good and within the range of values observed in recent years (Figure 23). Crane et al. (2015) found a significant increase in smallmouth bass condition following invasion of round goby into lakes Ontario and Erie. Increased condition of bass $\geq$ age 2 indicates that they are not limited by prey availability.

Mean relative weight varied without trend 1976-2005 and averaged 96.1 (range: 92.1 [1984] - 100.8 [2005]) suggesting that during that time period the bass population was likely in balance with the food supply (Flickinger and Bulow 1993; Figure 24). Each year beginning in 2006, mean relative weight exceeded 105 (2006-2015 average=107.7) indicating that the system could support more fish (Flickinger and Bulow 1993).

In addition to increased growth and condition, an increasing contribution of large smallmouth bass (i.e., $\geq$ 4 lb) in assessment nets was documented (Figure 25). Prior to 1991, no bass > 4 lbs were caught. The first bass $\geq$ 4 lbs was caught in 1992 (0.2% of total [n=483] catch). Beginning in 1998, bass $\geq$ 4 lbs were caught with increasing regularity. In 2015, 32.6% of all smallmouth bass caught (n=176) were $\geq$4 lbs, the highest contribution on record and nearly 75% higher than the 2014 record high (Figure 25). Bass weighing $\geq$ 5 lbs were caught each year since 2005 and remained near record high in 2015 (5.5% of all bass caught). Bass $\geq$ 6 lbs were first caught in the 2005 survey (0.2% of total smallmouth bass caught), and again in 2011. Each year 2011-2015, 0.3-0.7% of bass caught weighed more than 6 lbs. These increases are attributed to good growth and condition (Figures 21, 23-25) and are not due to increased abundance of older aged bass (Figure 19).

Maturity and Longevity

Fish populations with increased growth rates tend to mature at earlier ages (e.g., Carlander 1969, 1977, 1997; Heibo et al. 2005). Analysis of percent maturity of male and female bass ages 1-7 sampled prior to (1976-1995) and after (1996-2015) the observed increased growth rates indicated that a higher percentage of bass matured at younger ages in recent years (Figure 26). This began as early as age 2 for both males and females. For example, an average of 28.9% of age-4 females were identified as mature during 1976-1995 compared 61.3% mature during 1996-2015 (Figure 26). For both time periods and sexes, ≥99.3% of the smallmouth bass sampled were mature by age 7. Across the time series, a higher percentage of male bass were mature at age 2-5 than female bass (Figure 26).

Life span is generally shorter where growth is faster (e.g., Carlander 1969, 1977, 1997; Heibo et al. 2005), further confounding population structure evaluations. CPUE of older bass was evaluated to determine if abundance of older bass declined following increased growth rates. During 1976-1995, mean CPUE of age 10+ smallmouth bass was 1.8 (range: 0.4-3.6; Figure 27). Since then (1996-2015), mean CPUE was 67.4% lower (mean CPUE=0.6; range: 0.3-1.1). Increasing growth of older bass (ages 8+) was observed as early as about 1990 (Figure 21) and may have influenced bass life span; however, this also coincides with a period of reduced survival rates that were attributed to DCC predation (Chrisman and Eckert 1998; Lantry et al. 2002). The year classes that reached age 10+ in recent years were impacted by DCC predation, improved growth (Figure 21), and mostly poor year class production (Figure 20a), all of which can contribute to continued relatively low CPUE of bass ages 10+ (Figure 27).

Age Composition and Year Class Strength

Age composition of the smallmouth bass catch is influenced by several factors including, assessment net mesh size, size-selective predation by DCC, and year class strength. Through 1994, bass catches were dominated by age-5+ bass (1976-1994 mean CPUE=16.1, representing 73.2% of total bass catch; Figure 19). Catches of bass ≤ age 4 were substantially lower (1976-1994 mean CPUE=5.5 representing an average of 26.8% of total bass catch; Figure 19). Through the 1990s and early 2000s, ecosystem changes, increasing DCC predation and accelerated bass growth rate influenced age-specific CPUE and age composition of bass caught in nets. Since 1995, CPUE of age-5+ bass varied at a lower level than the previous time period, averaging 3.3 and representing 47.2% of the total bass catch (79.7% and 35.5% decreases, respectively). There is no evidence of a strong year class persisting strongly at ages ≥5 since the 1983 year class (Figure 19). CPUE of younger bass (ages ≤ 4) also decreased during 1995-2015 (mean CPUE=3.7) relative to 1976-1994 (mean CPUE=5.5; Figure 19), despite increased vulnerability to capture due to increased growth.

Most recently, size-selective predation by cormorants was likely not having a substantial impact on the bass population because of effective DCC population management and a shift in DCC diets to round goby. Despite reduced predation pressure, CPUE of bass ≤ age 4 was 32.6% below the earlier time period (1976-1994) when bass of the same age were less vulnerable to gill nets due to slower growth rates (Figures 19 and 21). In 2015, CPUE of bass ≤ age 4 was the lowest since the 2000-2004 time period, and is likely attributed to below average water temperatures negatively impacting bass production over the last two years.

I further evaluated age composition of smallmouth bass ≥ 12 in TL because they are both fully vulnerable to assessment nets across the entire 40-year time series and are harvestable in the sport fishery (i.e., minimum harvestable size is 12 in TL). Age structure of bass ≥ 12 in TL changed such that for years prior to the mid-1990s, 98.1% (1976-1996 mean) of bass ≥ 12 in were age 5 and older (Figure 22). The increased growth rate since the mid-1990s resulted in some bass reaching 12 in TL at a younger age (Figure 21). During 1997-2015, between 50.5% (2009) and 94.2% (2004) of the bass ≥ 12 in TL were age 5 and older (1997-2005 average=82.2%; 2006-2015 average=74.8%). The contribution of younger

bass (i.e., ages 2-4) that were 12 in TL increased from an average of 1.9% prior to 1997 to 21.7% since 1997 (1997-2005 average=17.9%; 2006-2015 average=25.2%; Figure 22).

Discussion – Smallmouth Bass

Fish communities in Lake Ontario have been impacted by many perturbations that have altered habitat, productivity, food web linkages, and population dynamics. These include water level regulation, phosphorus declines, DCC population increases, and invasive species (e.g., Dreissenid mussels, round goby, *Bythotrephes*, VHSv). Ongoing changes in the Lake Ontario ecosystem confound predictability. Although it is unlikely that the system will support bass abundance at pre-1990s levels, the production of only poor to weak year classes in recent years occurs at a time when conditions appear favorable for good year class production and recruitment.

Predation of bass by DCC in the eastern basin was substantially reduced nearly a decade ago when round goby became the dominant prey item for DCCs and DCC management reduced the number of cormorant feeding days to near the target level (Ross et al. 2003, Johnson et al. 2005, McCullough and Mazzocchi 2014, Johnson et al. 2014). Round goby is now an important and abundant prey item for smallmouth bass. Increased growth and condition indicate that the bass population (ages $\geq$ 2) is not limited by food availability. Finally, warm summer water temperatures during 2008, and 2010-2013 were expected to produce good to strong year classes given the positive correlation between mean summer (June-August) water temperatures and smallmouth bass recruitment (e.g., Casselman et al. 2002, Einhouse et al. 2002); however, the year class-specific catch curves for these year classes indicate that they are only poor to weak (Figure 20). Below average summer temperatures during 2014 and 2015 likely resulted in two additional years of poor production.

A number of other factors can impact bass recruitment including condition of spawning habitat, predation on bass eggs or fry by round goby or other predators, prey availability for young-of-year bass, and 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 for bass from fry to age 1 is unknown and may be impacted, through competition for prey with the invasive macroinvertebrate *Hemimysis* sp. 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, or if VHSv is hindering bass reproductive success.

To better understand eastern basin smallmouth bass population dynamics and manage the sportfishery we need to correct gill net catch data for the change in selectivity by age. Selectivity by size has not changed over the time series; therefore, analysis of size-specific CPUE may improve our ability to compare historic and recent population metrics (i.e., year class strength, abundance, recruitment dynamics, growth, survival, maturity, longevity).

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Table 1. Stratified mean catch per unit effort data from the 1976-2015 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	136.4	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	257.1	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 1976-2015 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	2002
Lake Sturgeon	0	0	0	0	0	0	0.02	0	0.02	0.06	0.04	0.10	0.02	0
Longnose Gar	0	0.08	0	0	0.48	0.35	0	0	0.02	0.02	0.08	0	0.02	0
Bowfin	0	0	0	0.02	0	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	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	0.02
Gizzard Shad	0.69	1.26	1.39	1.79	0.12	0.06	0	0	0	0.08	0.08	0.13	0	0.06
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	0.19
Chain Pickerel	0	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	0
Goldfish X Carp	0	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	0
Golden Shiner	0	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	0
Quillback	0.04	0.04	0.08	0	0.04	0	0	0.04	0	0.04	0	0	0	0
Longnose Sucker	0	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	0.78
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	0.17
Shorthead Redhorse	0	0	0	0	0	0.02	0	0	0.02	0	0	0	0.02	0
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	0.21
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	0.21
Stonecat	0.02	0	0.02	0	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	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	1.09
White Bass	0.08	0	0.10	0	0.02	0	0	0	0	0.04	0	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	1.10
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	0.46
Bluegill	0	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	3.76
Largemouth Bass	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0
Black Crappie	0.02	0.06	0	0	0.04	0	0	0	0	0.02	0	0	0	0.06
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	9.65
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	1.08
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	0.23
Round Goby	0	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	19.06

Table 1 (continued). Stratified mean catch per unit effort data from the 1976-2015 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												
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Lake Sturgeon	0.04	0.02	0.02	0.09	0.10	0	0	0.08	0.02	0	0.02	0	0.063
Longnose Gar	0	0.06	0.17	0.12	0.08	0.10	0.21	0.75	0.62	0.02	0.23	0.44	0.67
Bowfin	0	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	0
Alewife	0.08	0	0	0.07	0.14	0.19	1.19	0	0.16	0.46	0	0.31	0.47
Gizzard Shad	0	0	0	0	0	0	0.10	0	0.12	0.19	2.08	0.32	1.09
Northern Pike	0.15	0.17	0.19	0.08	0.06	0.23	0.09	0.10	0.02	0.02	0.12	0.12	0.02
Chain Pickerel	0	0	0	0	0	0	0	0	0	0	0.06	0	0
Muskellunge	0	0.02	0.02	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	0.02	0.15	0.14	0.11	0.02	0.05	0.10	0.02	0.02	0	0.15	0.11	0.05
Golden Shiner	0	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	0
Quillback	0	0	0	0	0	0	0	0	0	0	0.08	0.02	0.02
Longnose Sucker	0	0	0	0	0	0	0	0	0	0	0	0	0
White Sucker	1.66	0.41	1.03	0.72	0.573	0.65	1.31	0.48	0.25	2.35	0.19	0.16	0.57
Silver Redhorse	0.10	0.42	0.33	0.02	0.02	0.08	0.07	0.04	0	0.06	0.06	0	0
Shorthead Redhorse	0	0	0	0	0	0	0	0	0	0	0	0	0
Brown Bullhead	0.40	0.35	0.48	0.31	0.54	2.12	0.81	1.48	0.42	0.82	1.97	1.54	0.46
Channel Catfish	0.12	0.79	0.81	0.15	0.12	0.57	0.54	0.42	0.17	0.21	0.42	0.07	0.31
Stonecat	0	0	0.06	0.02	0	0	0	0.04	0.02	0.02	0	0	0
Trout-perch	0	0	0	0	0	0	0	0	0	0	0	0	0
White Perch	0.42	1.18	1.94	0.92	0.81	7.75	3.02	6.22	3.72	1.04	6.41	7.87	3.69
White Bass	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock Bass	1.84	2.09	2.70	2.43	0.70	3.27	2.52	1.54	1.31	0.75	1.21	1.00	1.06
Pumpkinseed	0.46	0.52	0.50	1.15	0.21	0.10	0.28	0.04	0.21	0.29	0.38	0.02	0.04
Bluegill	0	0	0	0	0	0	0	0	0	0	0	0	0
Smallmouth Bass	5.43	3.84	11.33	10.45	6.39	9.27	9.81	7.90	6.09	8.12	7.65	5.01	4.36
Largemouth Bass	0	0.02	0.02	0.02	0	0	0.03	0.02	0	0	0.02	0	0
Black Crappie	0	0.02	0.06	0	0.04	0.05	0.03	0.04	0.04	0.02	0.06	0.02	0.00
Yellow Perch	9.82	6.74	8.93	9.13	13.95	16.91	7.37	16.31	15.29	14.99	10.32	1.70	0.82
Walleye	2.12	1.69	2.38	1.94	1.33	2.33	2.65	1.91	1.97	2.38	1.34	1.55	0.97
Freshwater Drum	0.27	0.60	0.19	0.32	0.23	0.26	0.36	0.08	0.19	0.19	0.29	0.34	0.26
Round Goby	0	0	0.04	0.10	0.26	0.42	0.95	0.36	0.08	0.07	0.02	0	0
Total	22.92	19.1	31.36	28.16	25.6	44.36	31.44	37.84	30.73	32.02	33.09	20.62	14.92

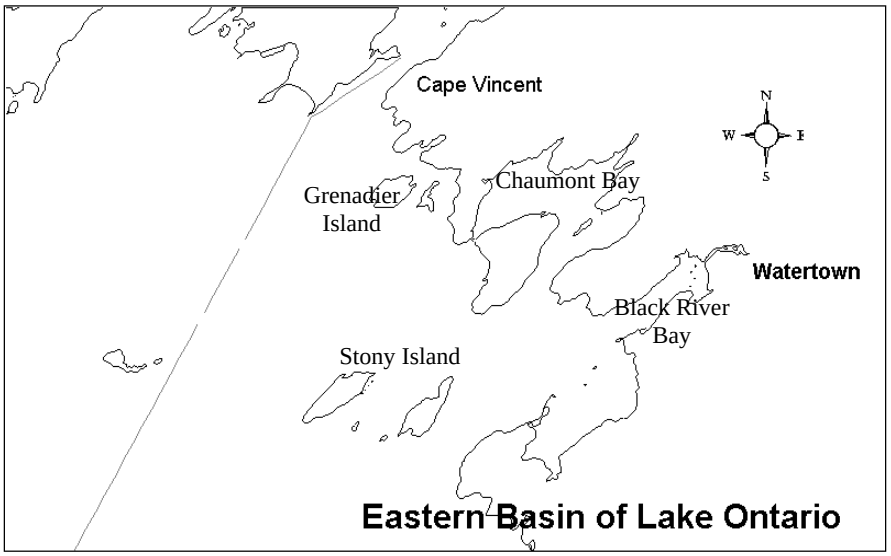

Figure 1. Map of New York waters of Lake Ontario's eastern basin showing five area strata used in the 1980-2015 warmwater assessment.

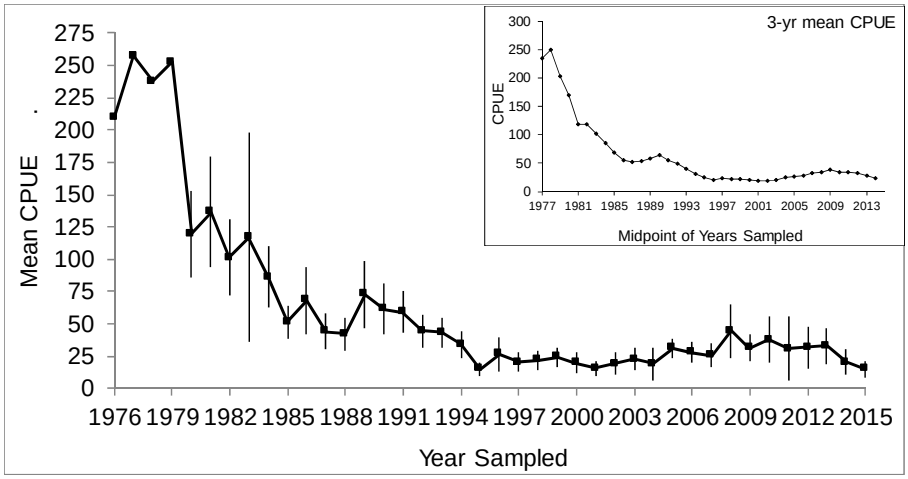

Figure 2. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for all warmwater fish from the 1976-2015 assessments.

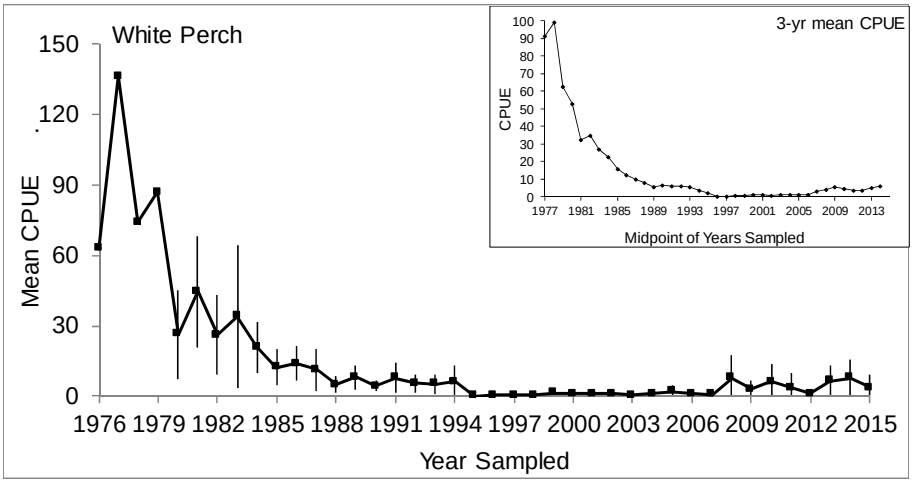

Figure 3. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for white perch, 1976-2015.

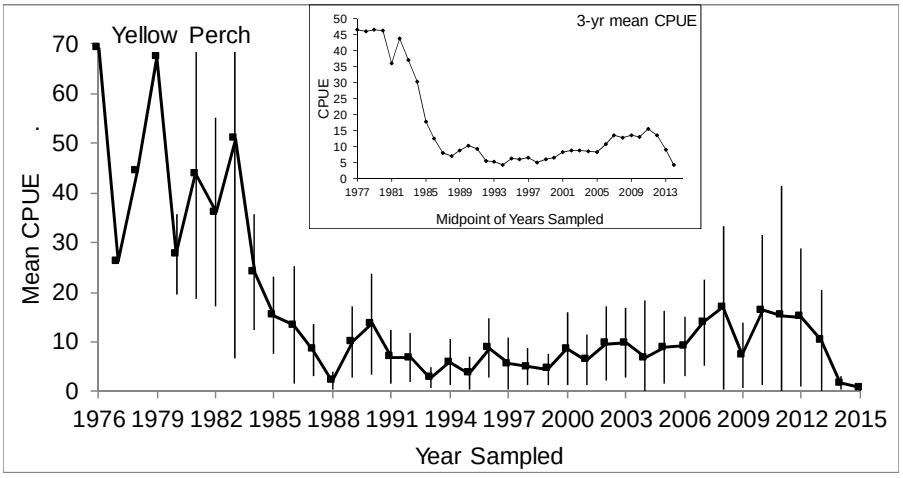

Figure 4. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for yellow perch, 1976-2015.

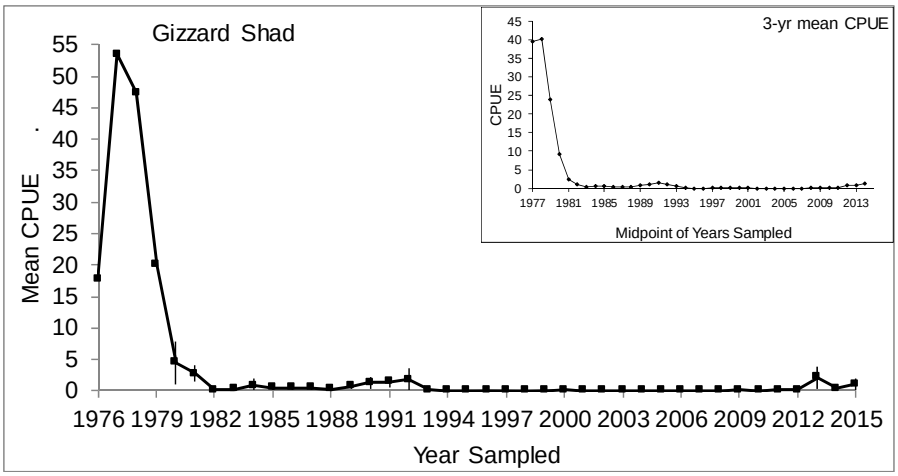

Figure 5. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for gizzard shad, 1976-2015.

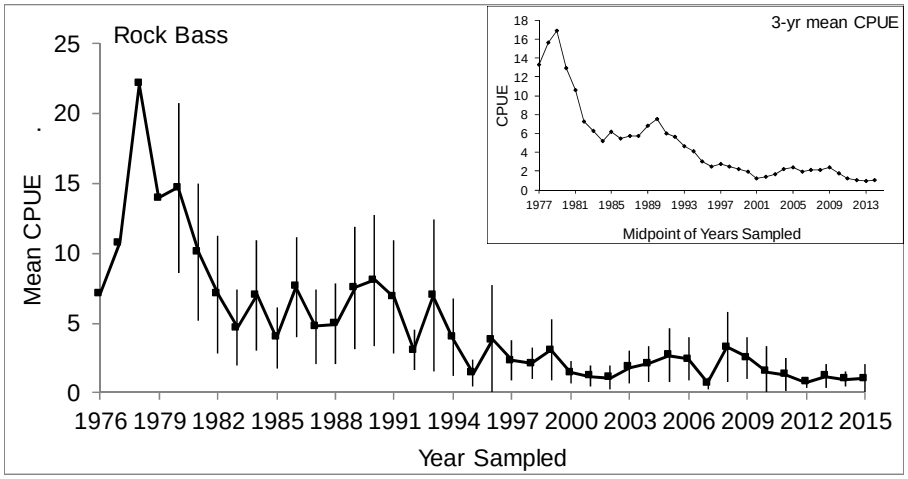

Figure 6. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for rock bass, 1976-2015.

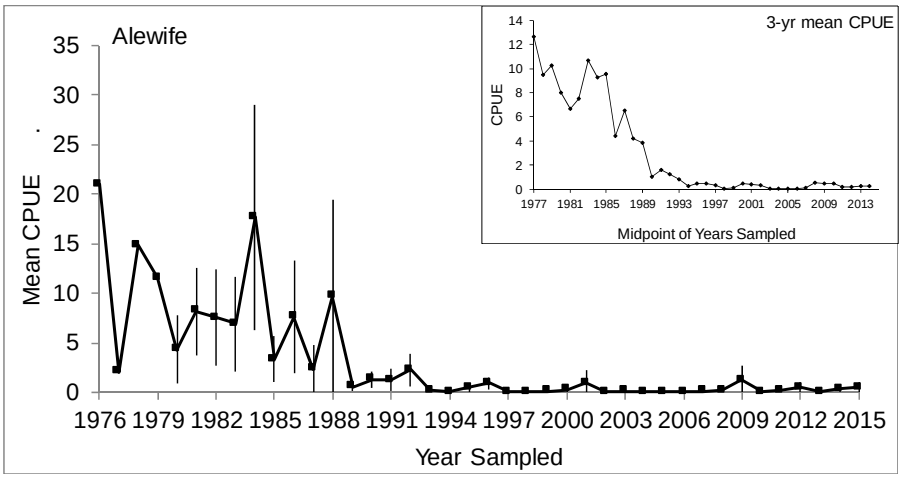

Figure 7. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for alewife, 1976-2015.

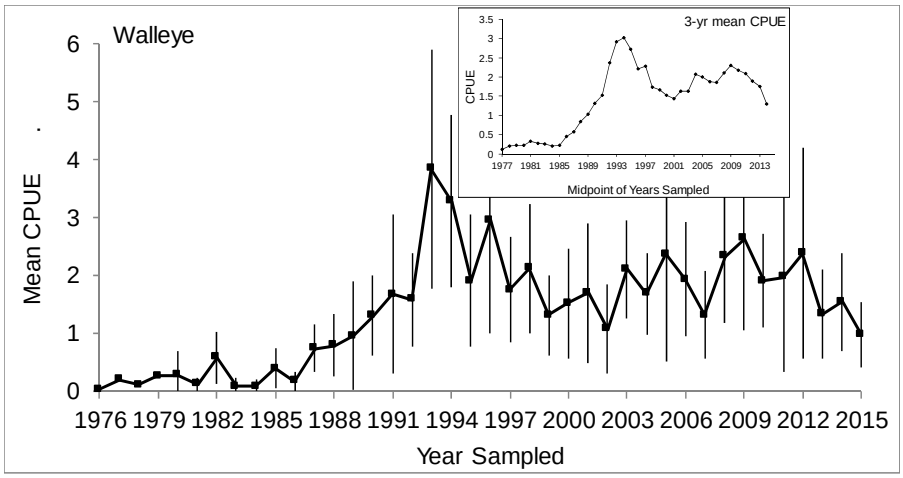

Figure 8. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for walleye, 1976-2015.

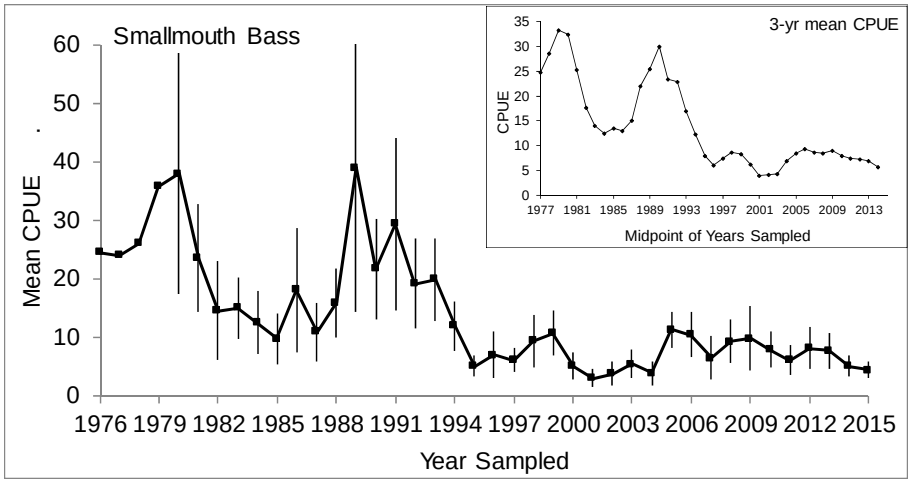

Figure 9. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for smallmouth bass, 1976-2015.

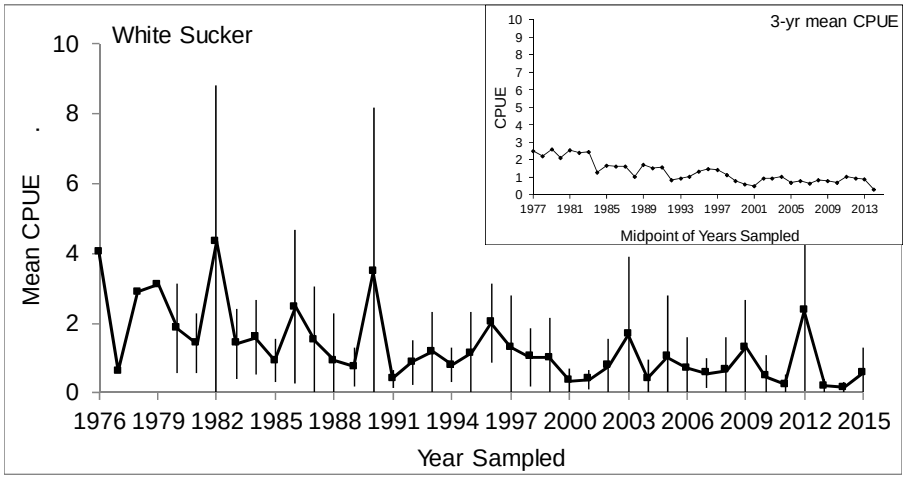

Figure 10. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for white sucker, 1976-2015.

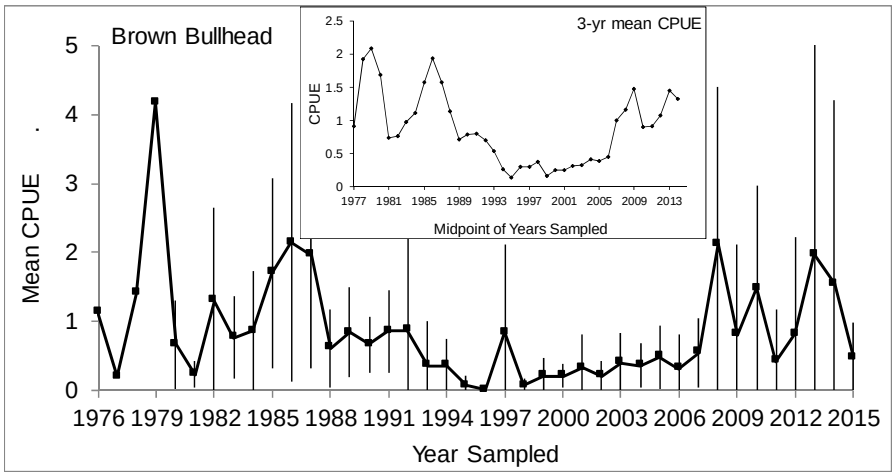

Figure 11. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for brown bullhead, 1976-2015.

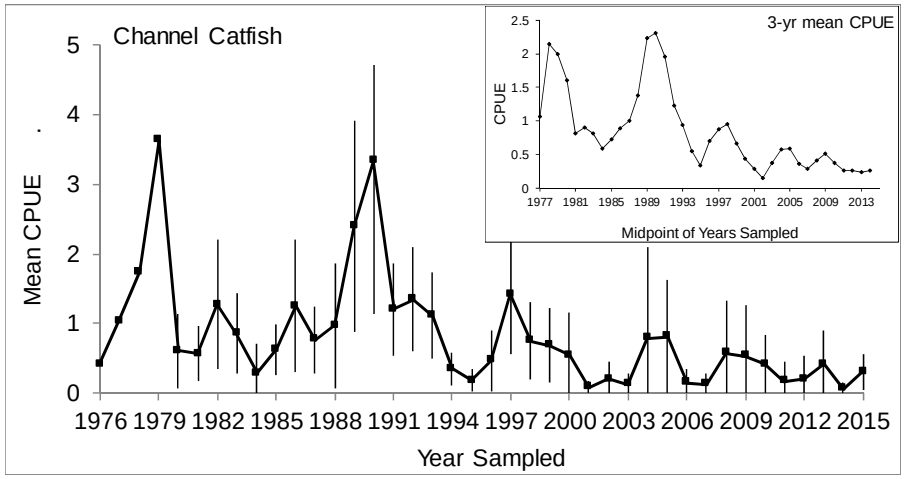

Figure 12. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for channel catfish, 1976-2015.

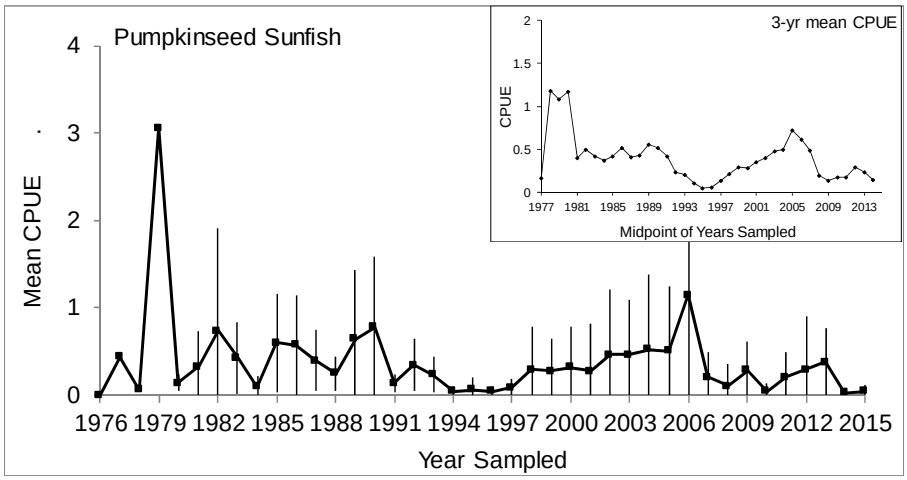

Figure 13. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for pumpkinseed sunfish, 1976-2015.

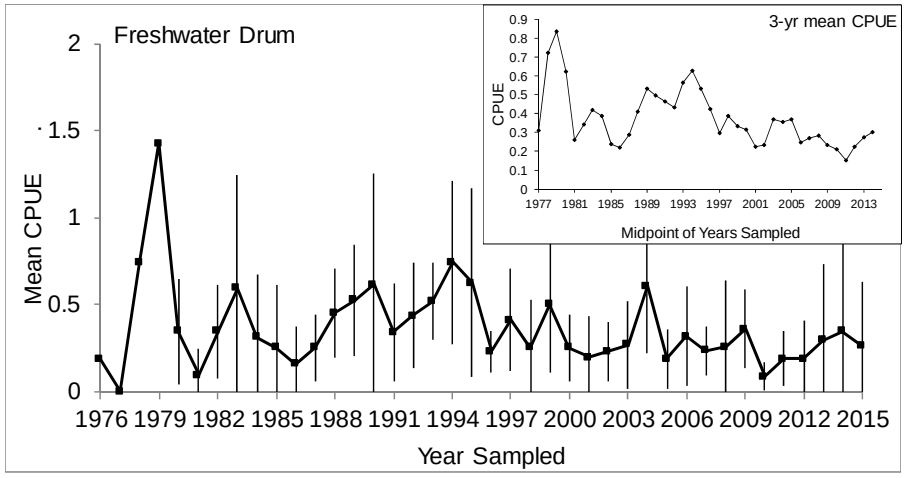

Figure 14. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for freshwater drum, 1976-2015.

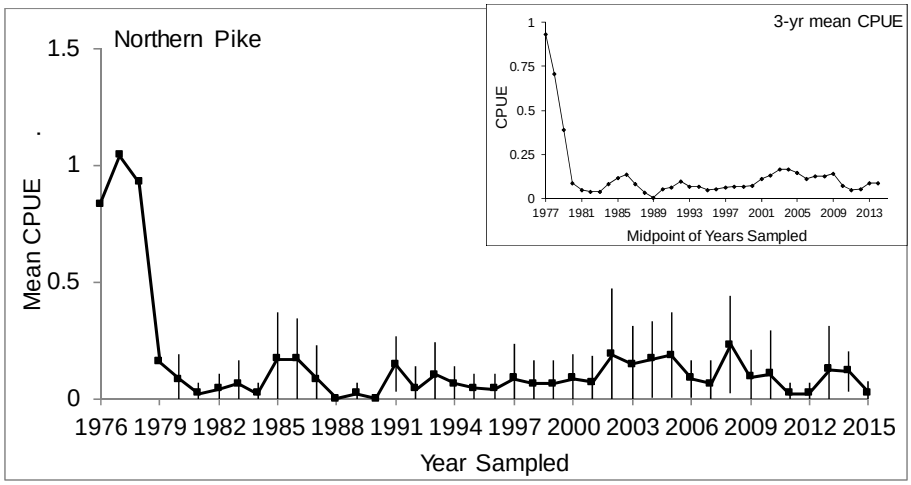

Figure 15. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for northern pike, 1976-2015.

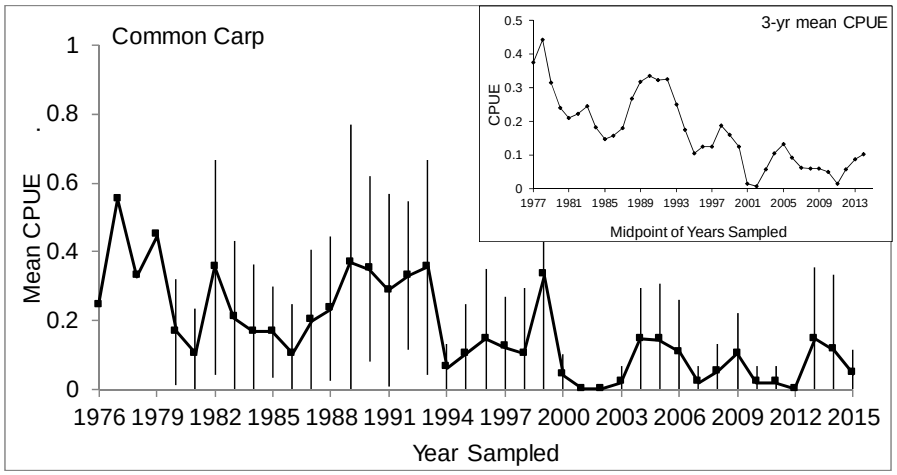

Figure 16. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for common carp, 1976-2015.

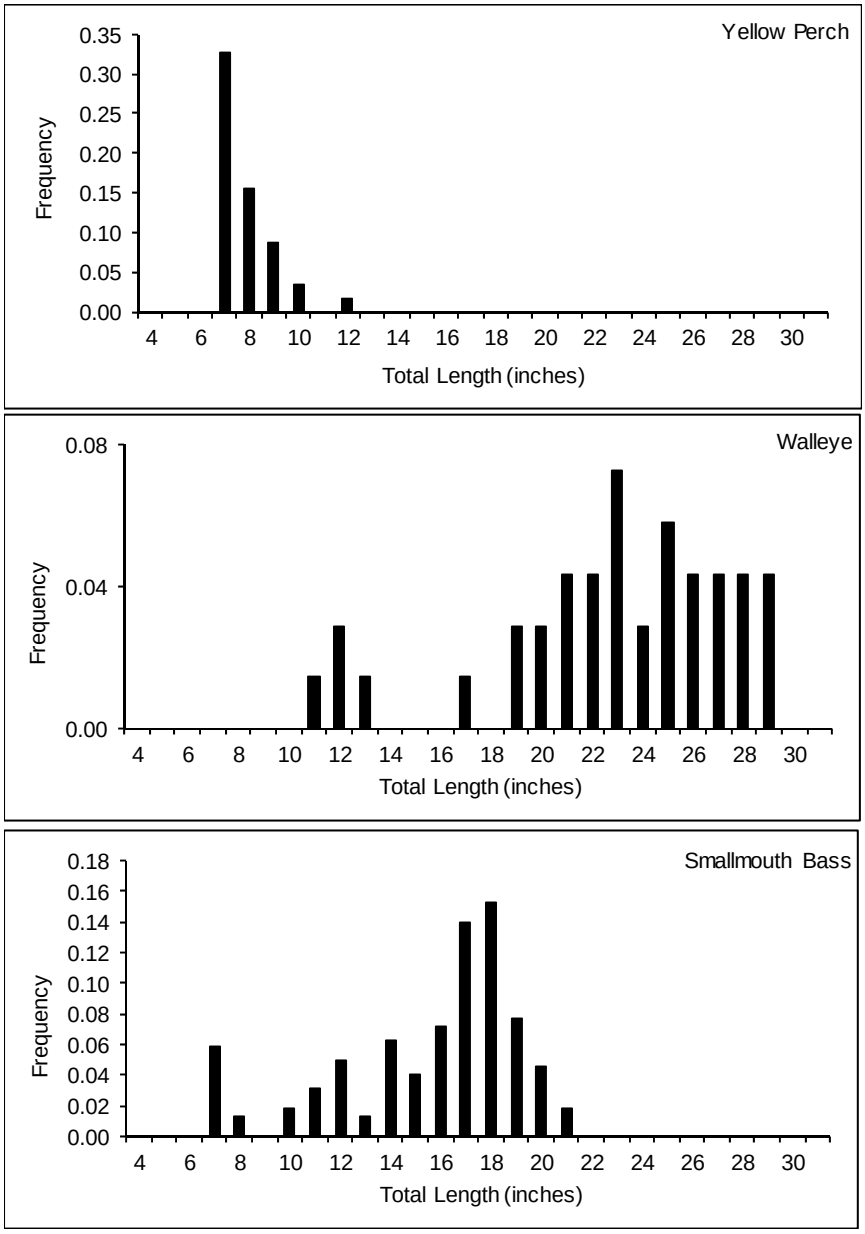

Figure 17. Length frequency distribution of yellow perch, walleye, and smallmouth bass collected during the warmwater assessment in 2015.

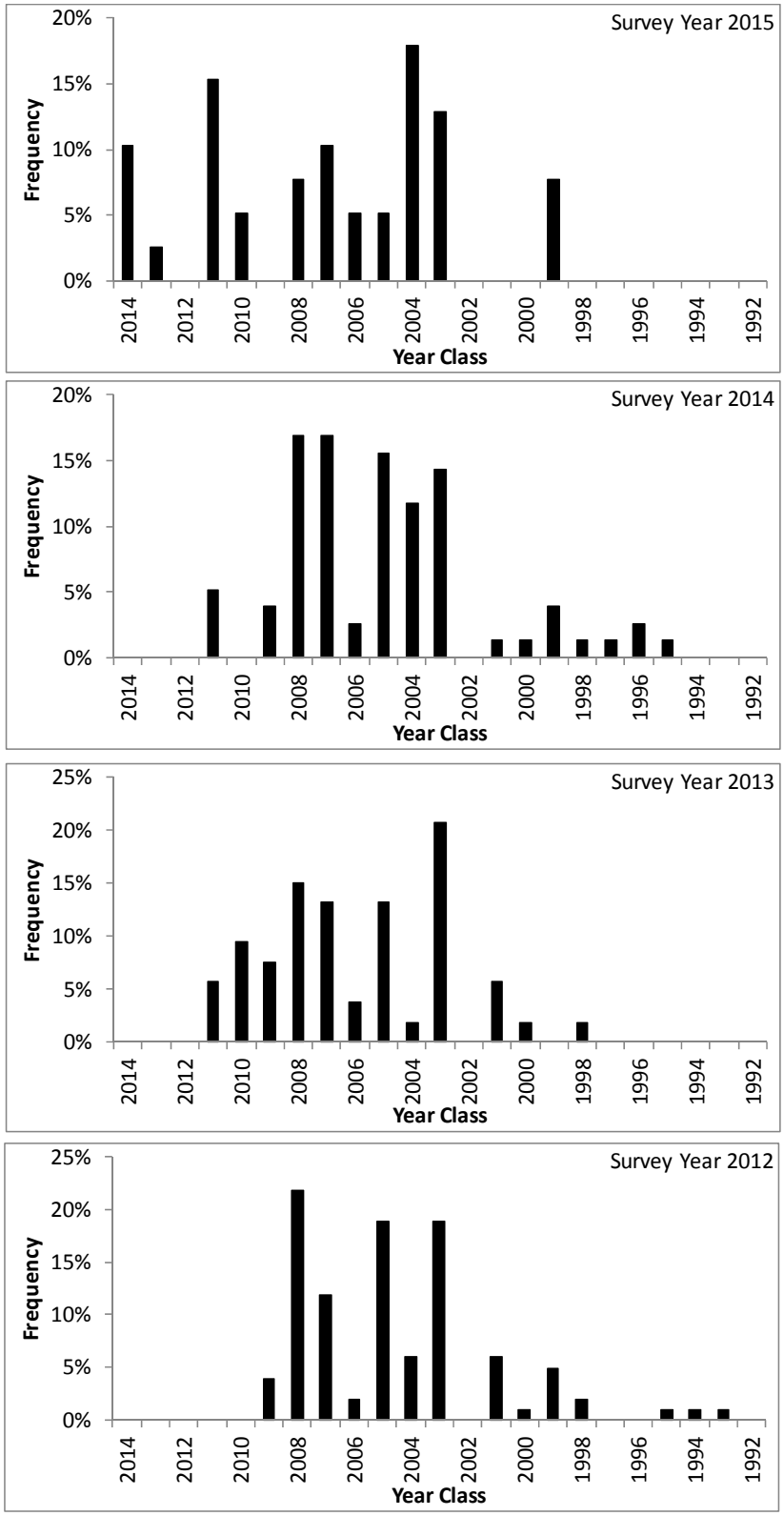

Figure 18. Year class frequency distribution of walleye collected during the warmwater assessment in 2012-2015.

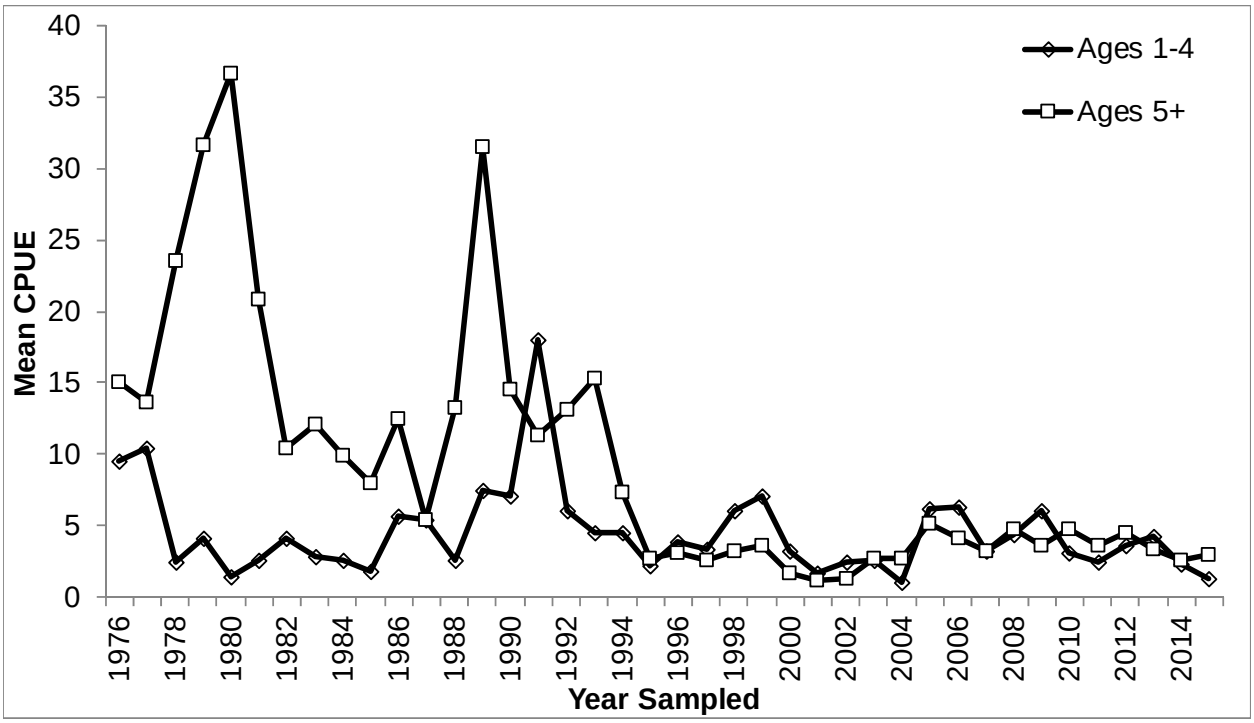

Figure 19. Stratified mean catch per 450 ft gill net gang for catch of bass ages ≤ 4 and ages ≥ 5, 1976-2015. Note: Increased growth and changes in net catchability confound inter-annual comparisons of age-specific CPUE.

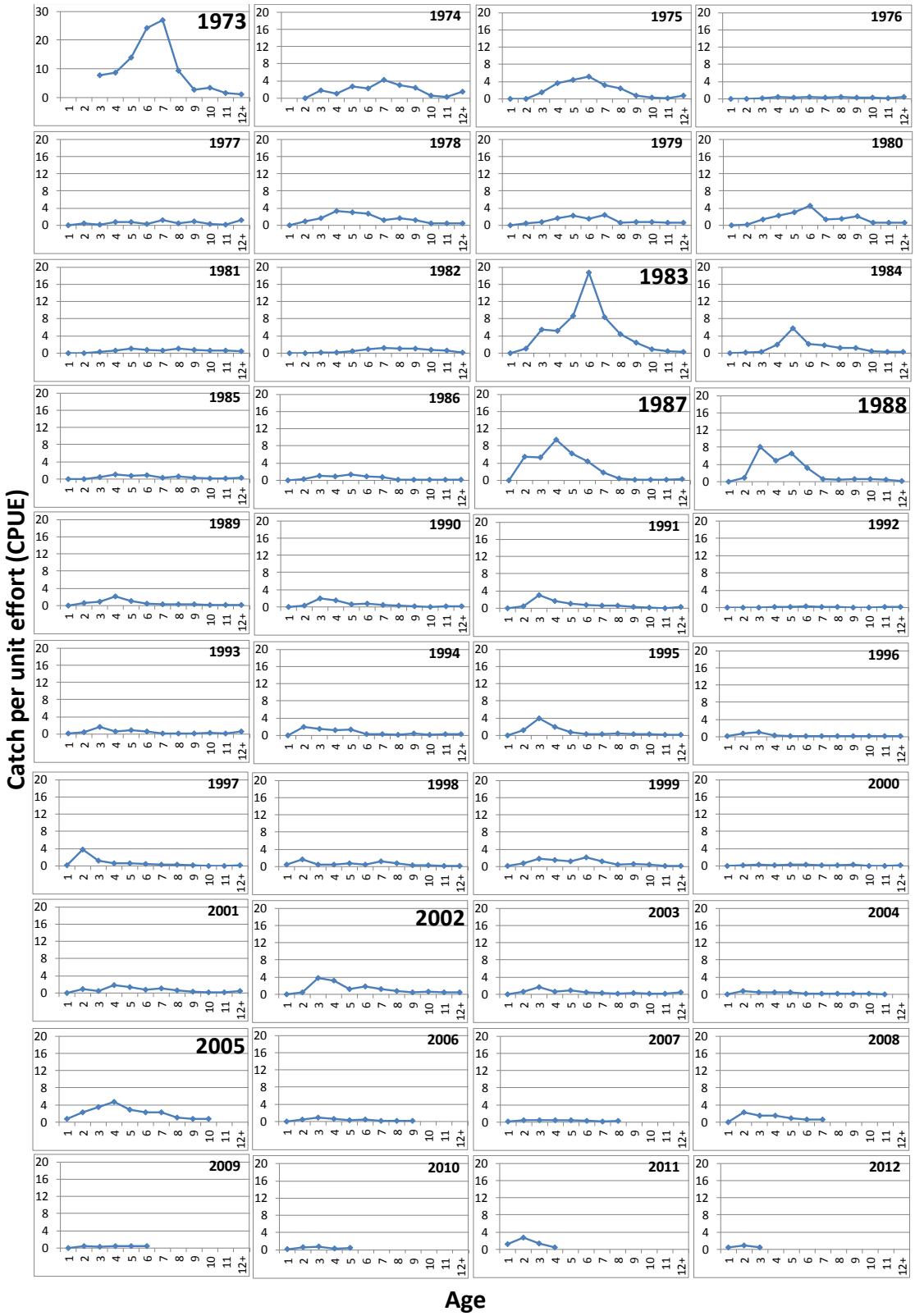

Figure 20a. Year class-specific catch curves (CPUE by age), 1973-2012 year classes. Note the difference in y-axis scale for the 1973 year class vs. the y-axis scale 1974-2012 year classes.

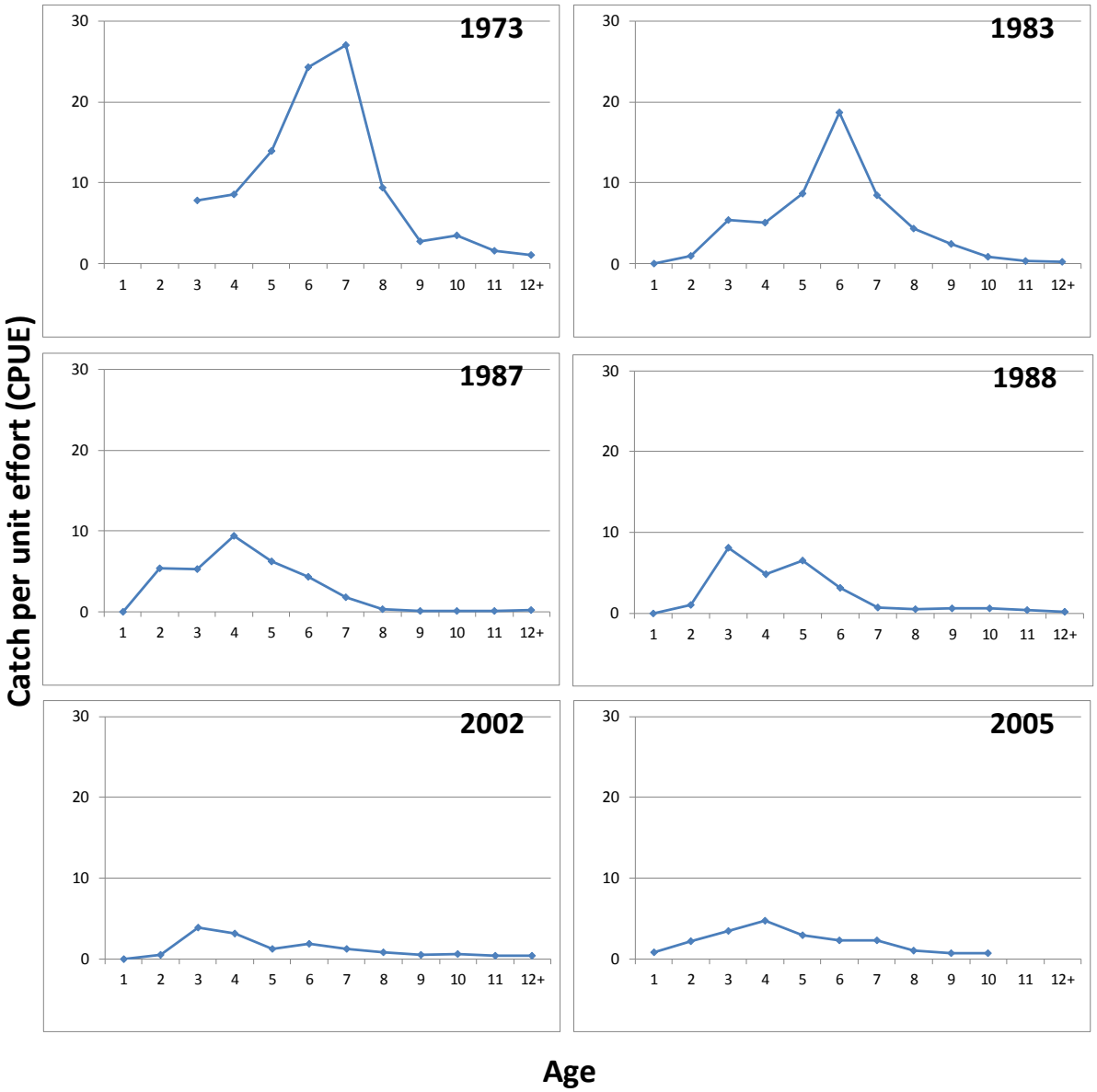

Figure 20b. Year class-specific catch curves (CPUE by age) for the 1973, 1983, 1987, 1988, 2002, and 2005 year classes.

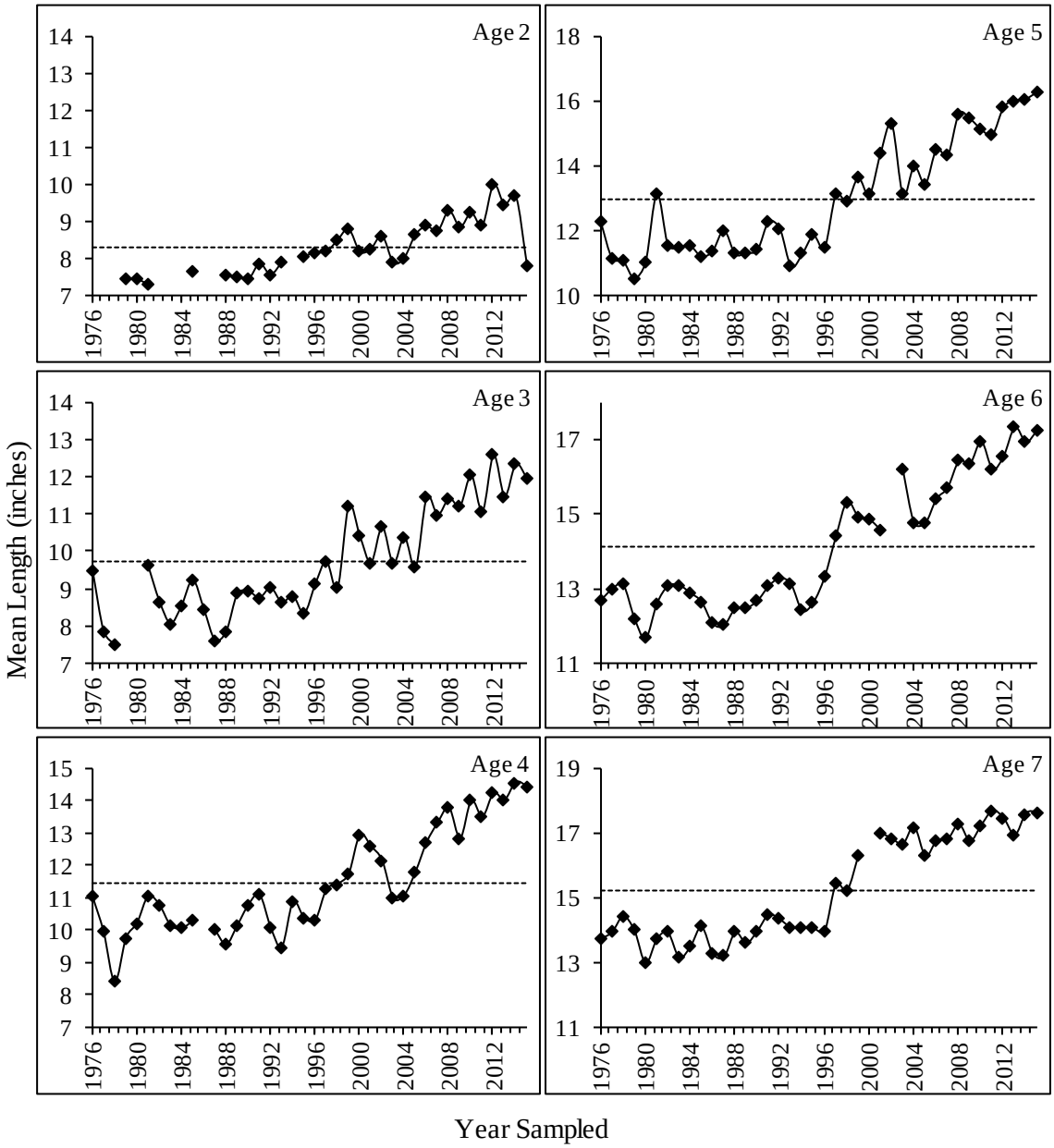

Figure 21. Mean length at age (age 2-13) by year sampled (1976-2015) for smallmouth bass collected during the warmwater assessment (continued on next page). Dotted lines represent longterm mean lengths.

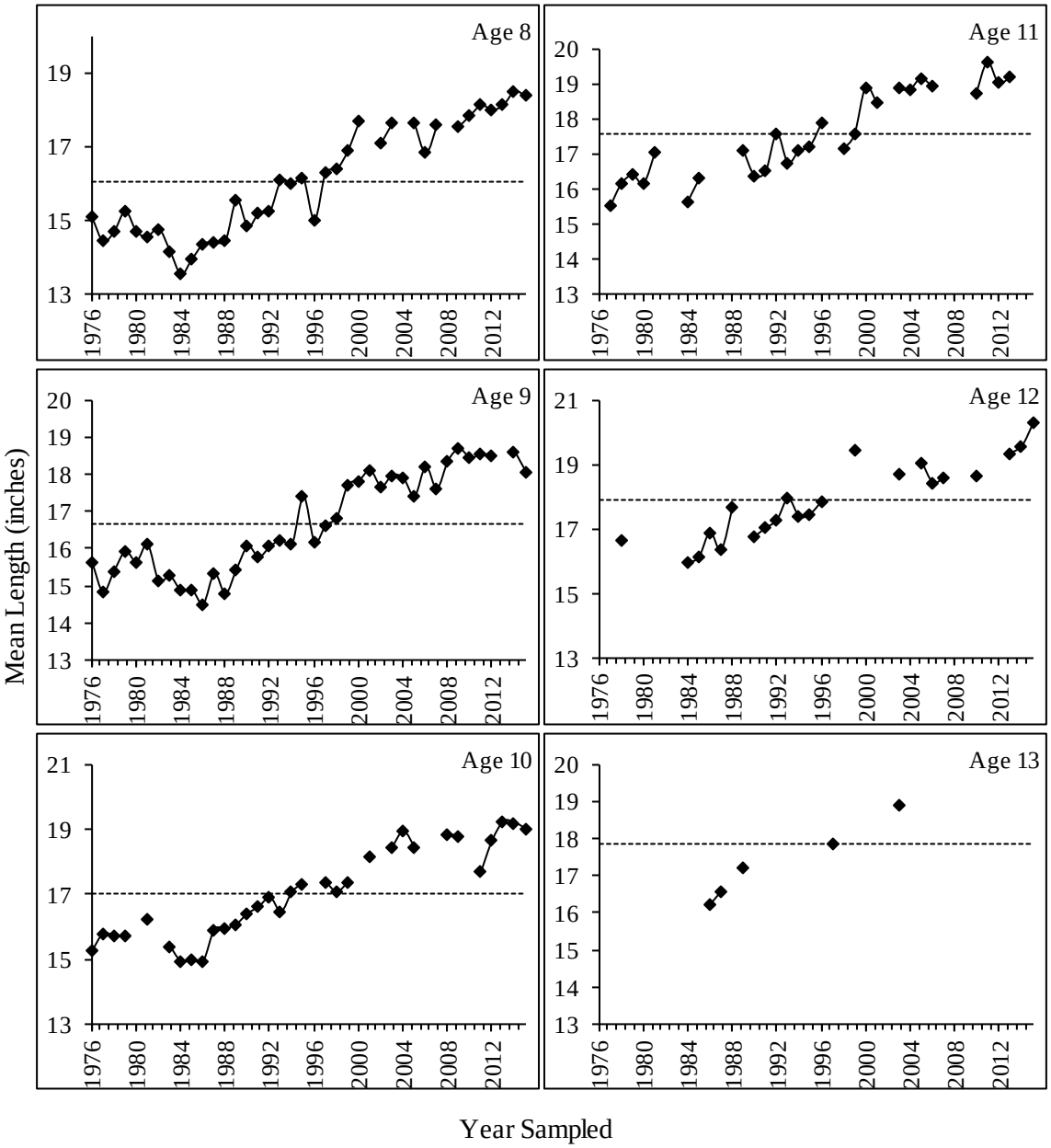

Figure 21 (continued). Mean length at age (age 2-13) by year sampled (1976-2015) for smallmouth bass collected during the warmwater assessment. Dotted lines represent the longterm mean lengths.

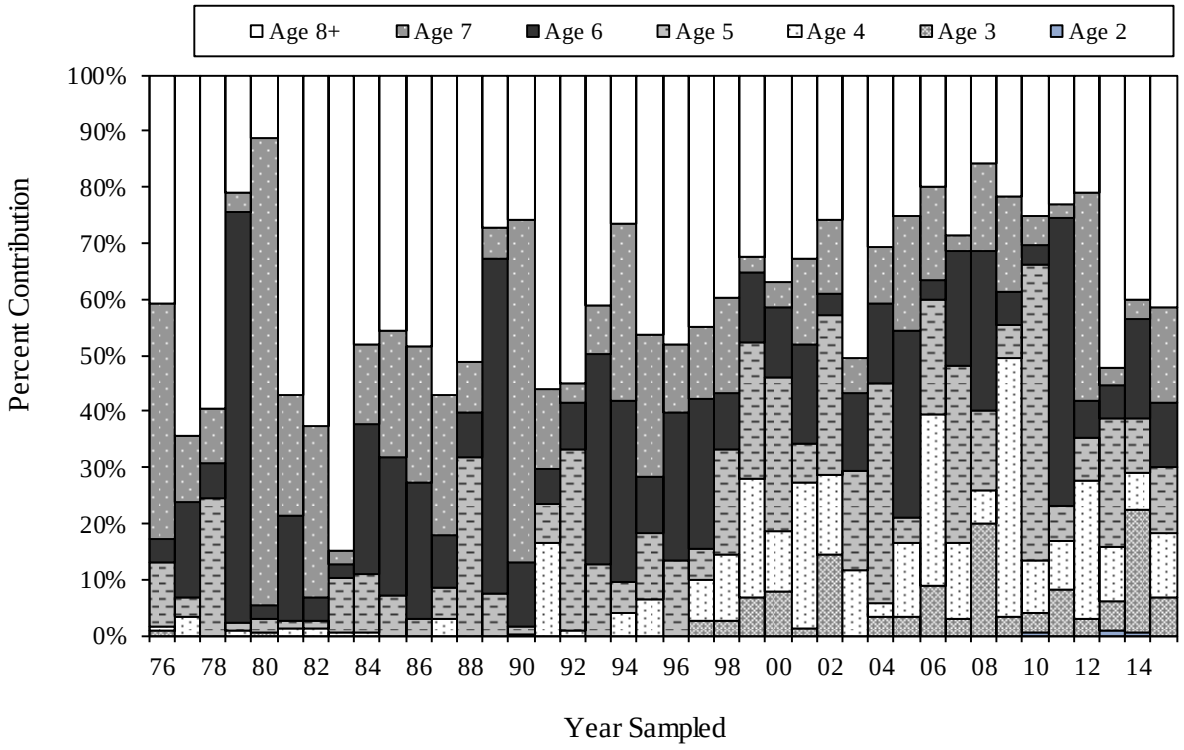

Figure 22. Age composition of smallmouth bass ≥ 12 inches in the warmwater assessment (1976-2015).

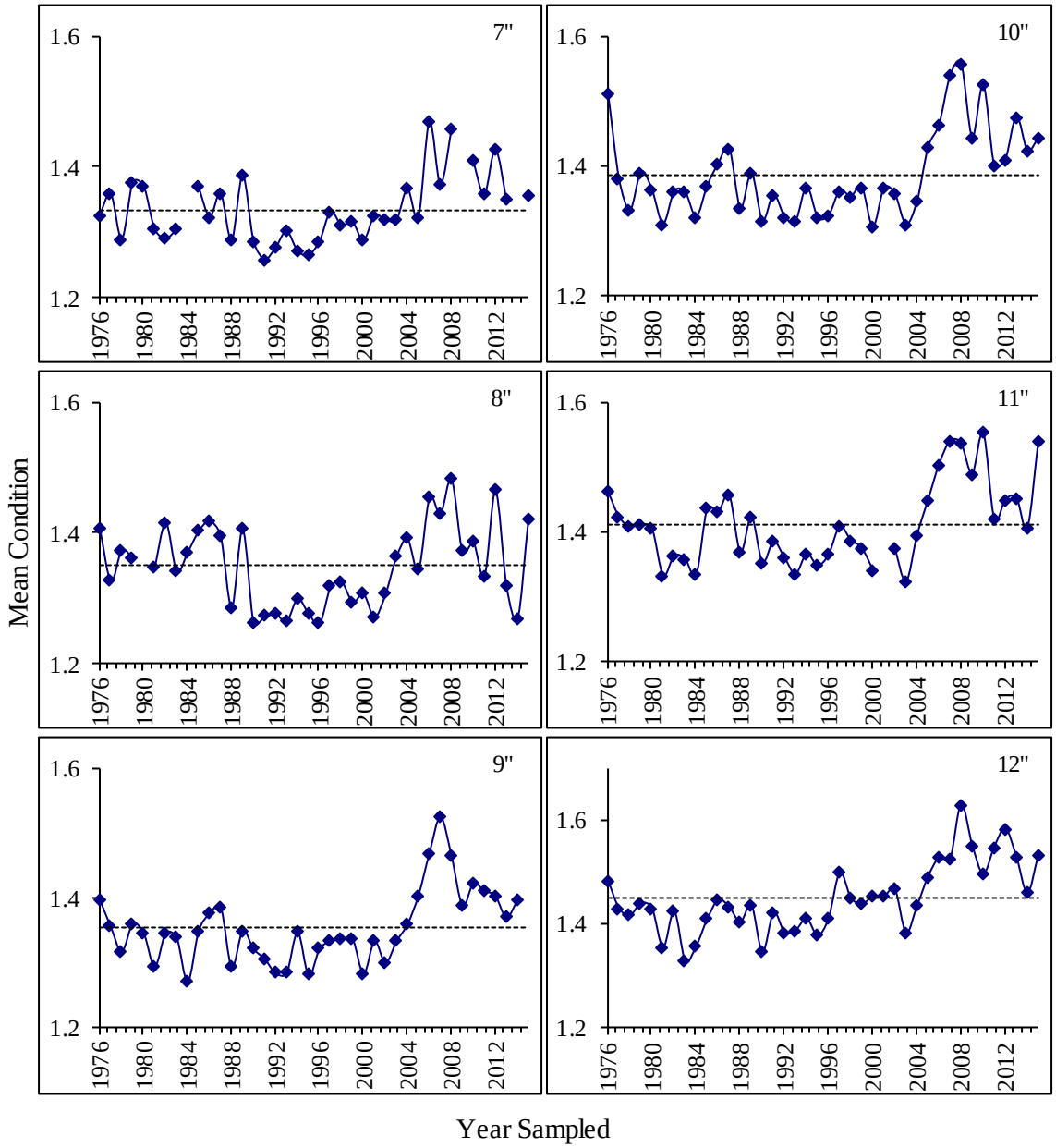

Figure 23. Mean condition (7-18 inch increments) by year sampled (1976-2015) for smallmouth bass collected during the warmwater assessment (continued on next page).

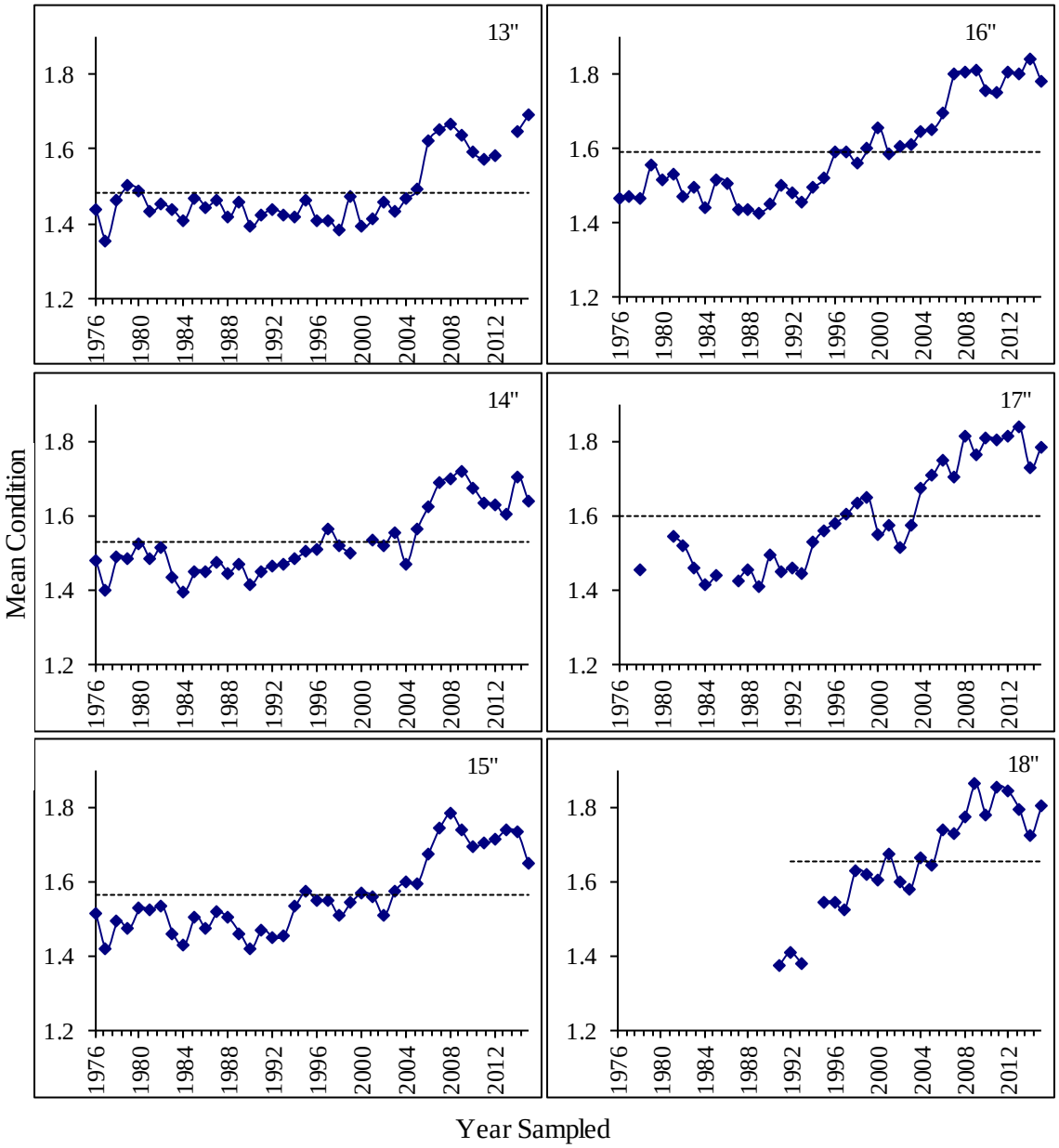

Figure 23 (continued). Mean condition (7-18 inch increments) by year sampled (1976-2015) for smallmouth bass collected during the warmwater assessment.

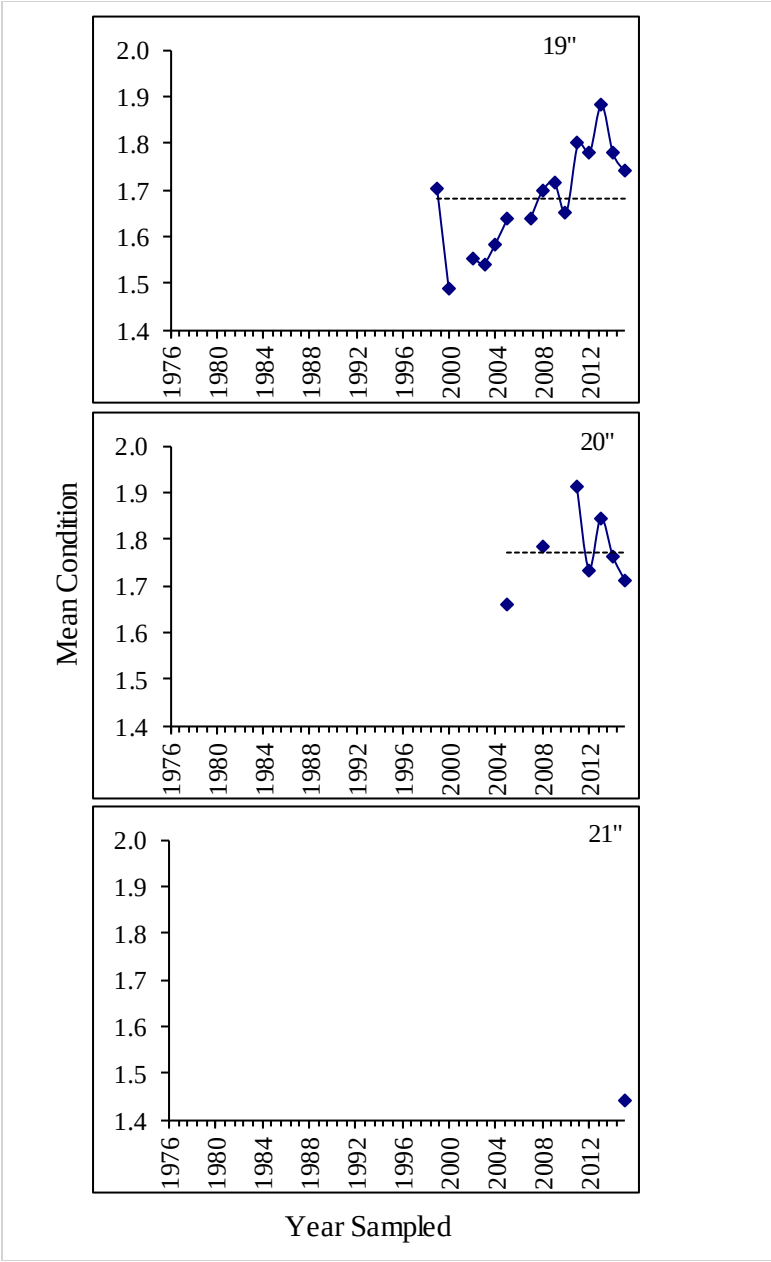

Figure 23 (continued). Mean condition (7-18 inch increments) by year sampled (1976-2015) for smallmouth bass collected during the warmwater assessment.

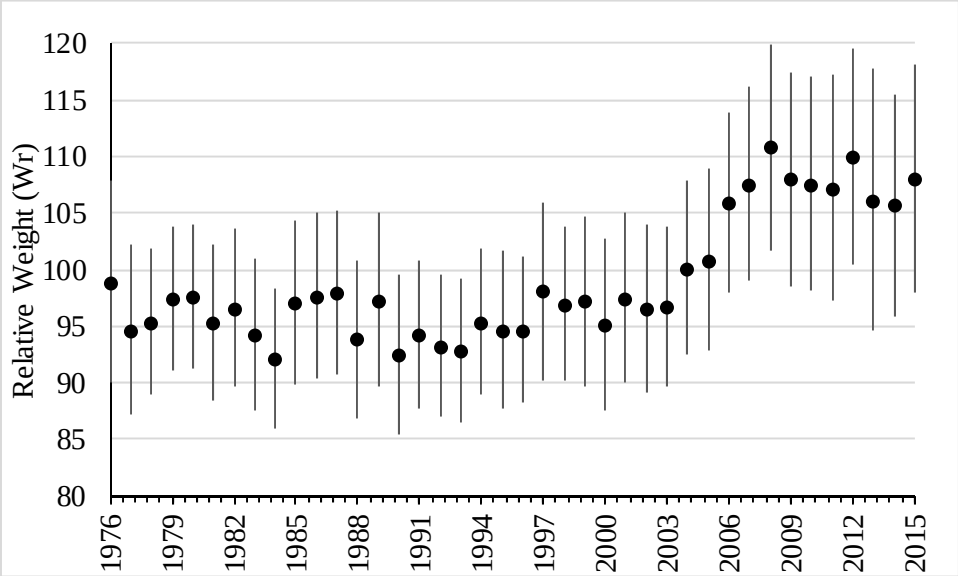

Figure 24. Mean relative weight of smallmouth bass caught in the warmwater assessment (1976-2015) (± 1 standard deviation).

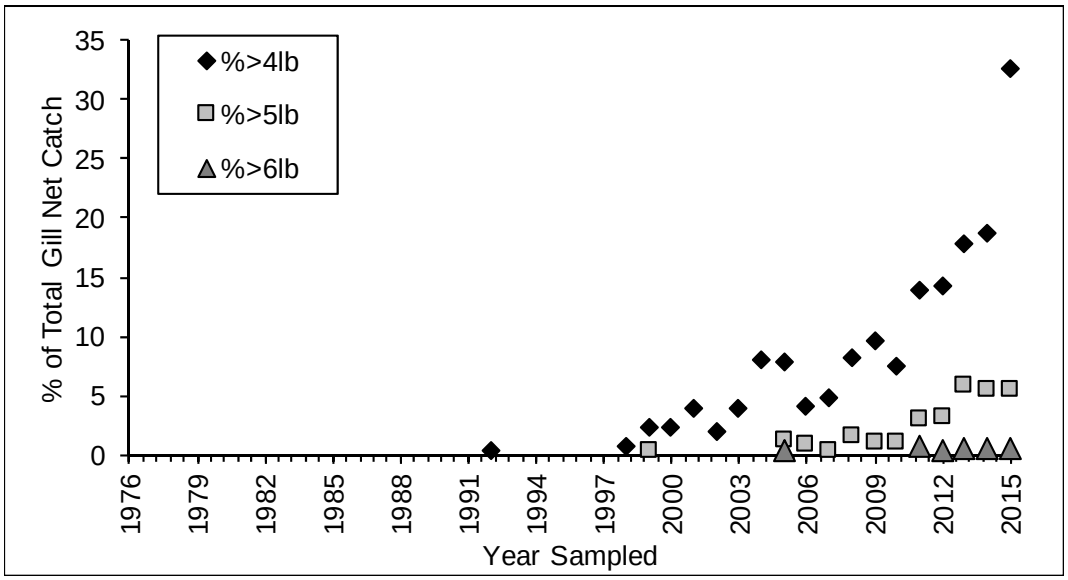

Figure 25. Percentage of total smallmouth bass catch during the warmwater assessment (1976-2015 catches) that were >4lb, >5lb, and >6lb.

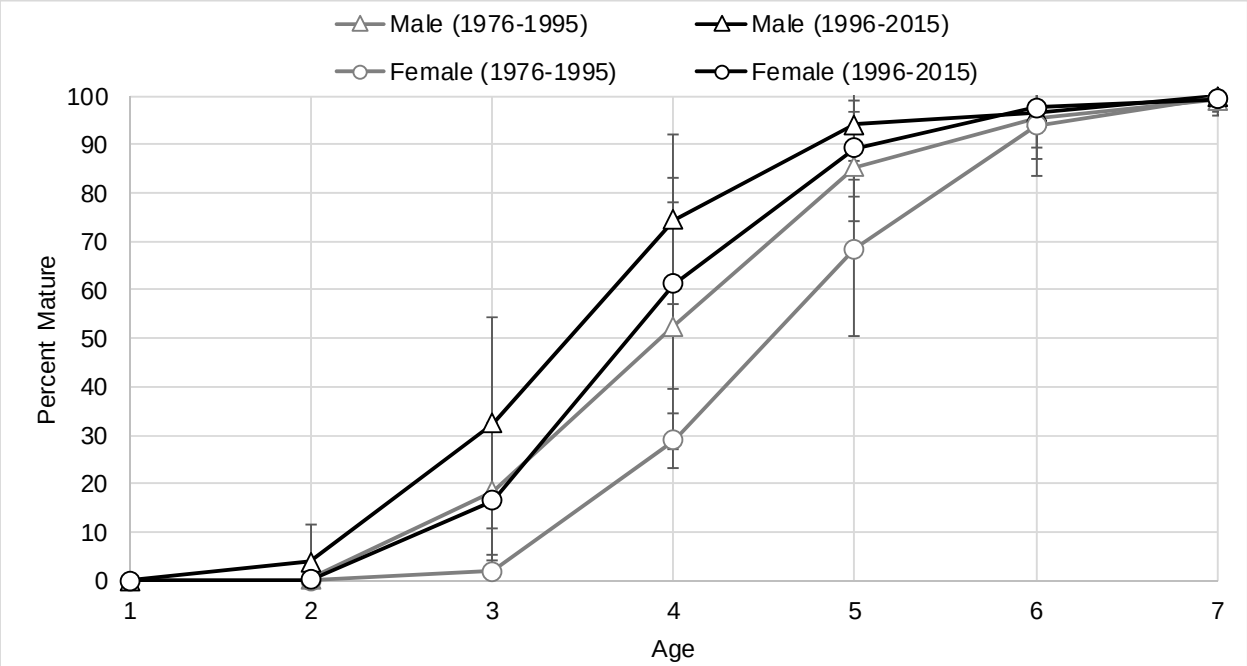

Figure 26. Average (± 1 standard deviation) percent maturity of age-1 to age-7 male and female smallmouth bass sampled during survey years 1976-1995 and 1996-2015.

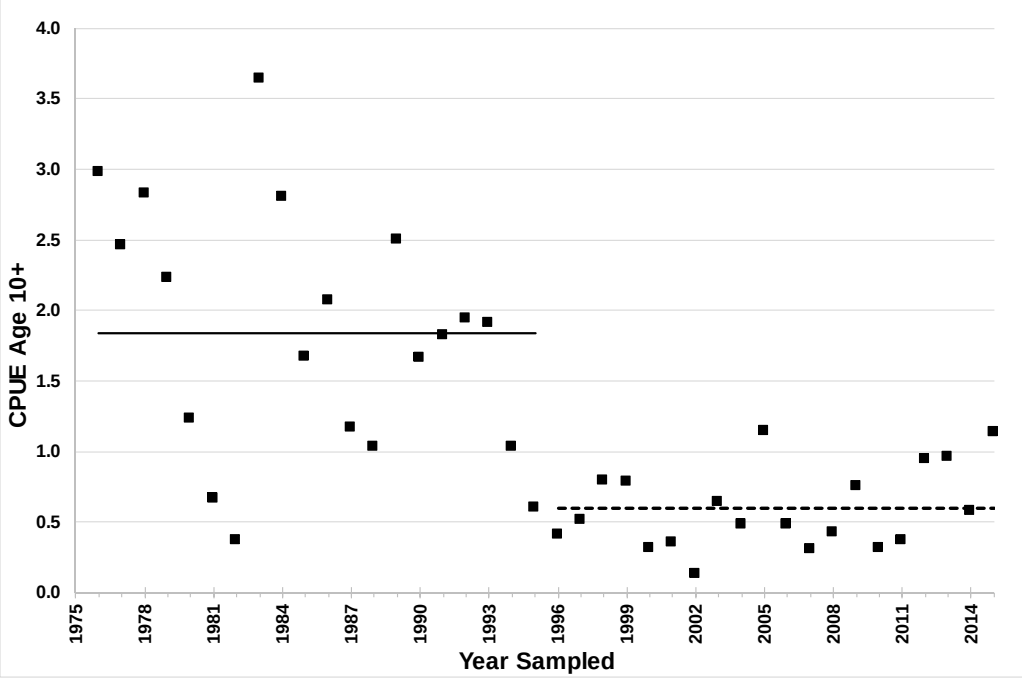

Figure 27. CPUE of smallmouth bass ages 10+, 1976-2015 sample years.

Lake Trout Rehabilitation in Lake Ontario, 2015

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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. The first-year survival index for the 2013 year class declined by 32% from the relatively high values observed for the 2010 and 2012 year classes. The catch per unit effort of adult lake trout in gill nets increased each year from 2008-2014, recovering from historic lows recorded during 2005-2007. Adult abundance in 2015 declined by 18% from the 2014 level, but was nearly equivalent to the 1999-2004 mean which at the time appeared to be the new stable abundance following from the 1993 stocking cuts. The 2015 rate of wounding by sea lamprey* (Petromyzon marinus) *on lake trout caught in gill nets (1.94 A1 wounds per 100 lake trout) was below target (2 wounds per 100 lake trout). Estimates from the NYSDEC fishing boat survey indicated 2015 angler catch and harvest rates were more than nine times higher than the lows observed in 2007. Condition of adult lake trout, indexed in September from the predicted weight for a 700mm lake trout from annual length-weight regressions and Fulton's K for age-6 males, has generally remained at a high level during 2007-2015, but both values have exhibited a downward trend since 2011. July-August condition of juvenile lake trout indexed from the predicted weight of a 400 mm individual and Fulton's K for age-2 fish were among the lowest values recorded for the 1979-2015 time series. 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 2009-2015. Twenty one cohorts of naturally produced lake trout have been collected since 1994 with the largest catches occurring in 2014 and 2015.*

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 and Forestry [OMNRF]) developed the Joint Plan for Rehabilitation of Lake Trout in Lake Ontario (Schneider et al. 1983, 1997) which guided restoration efforts and evaluation through 2014. A revised document, A Management Strategy for the Restoration of Lake Trout in Lake Ontario, 2014 Update (Lantry et al. 2014), will guide future efforts. The present report documents progress towards restoration through 2015.

Methods

Adult Gill Net Survey

During September 1983-2015, 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. monofilament netting) has changed through the years. For a description of survey history including gear changes and corrections see Elrod et al. (1995).

During September 2015, 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 (0.5 in) increments. At the 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. At two sites in the eastern basin, three nets were fished in waters from 23 to 48 m due to thermocline depth.

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, 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 (Elrod et al. 1995). 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 and Prindle 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), and 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 ≥433 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 1982-2015. 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 2016). The survey uses boat trips as the primary unit of effort. Boat counts are made at boat access locations and interviews are based on trips completed during April 15 - September 30, 1985-2015.

Juvenile Trawl Survey

From mid-July to early-August 1980-2015, 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 generally 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. In 2013 effort was reduced because no lake trout from the 2011 year class were stocked in U.S. waters during 2012 (Lantry and Lantry 2013) and thus no U.S. stocked age-2 lake trout were present in 2013. Effort returned to routine levels in 2014 and in 2015 trawling was conducted at 14 locations during July 5 - 17. 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.

Data collection from trawl-captured lake trout was the same as that described above for fish captured with gill nets. Survival indices were calculated from catches of age-2 lake trout that were stocked in U.S. waters. 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 CWL strain or the Niagara River stocking location which were the factors that necessitated catch adjustment. Catches of the 1995 through 2013 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 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 U.S. target of 1.25 million yearlings. The stockings of the 1979-1986 year classes approached that level, averaging about 1.07 million annually. The number of yearling

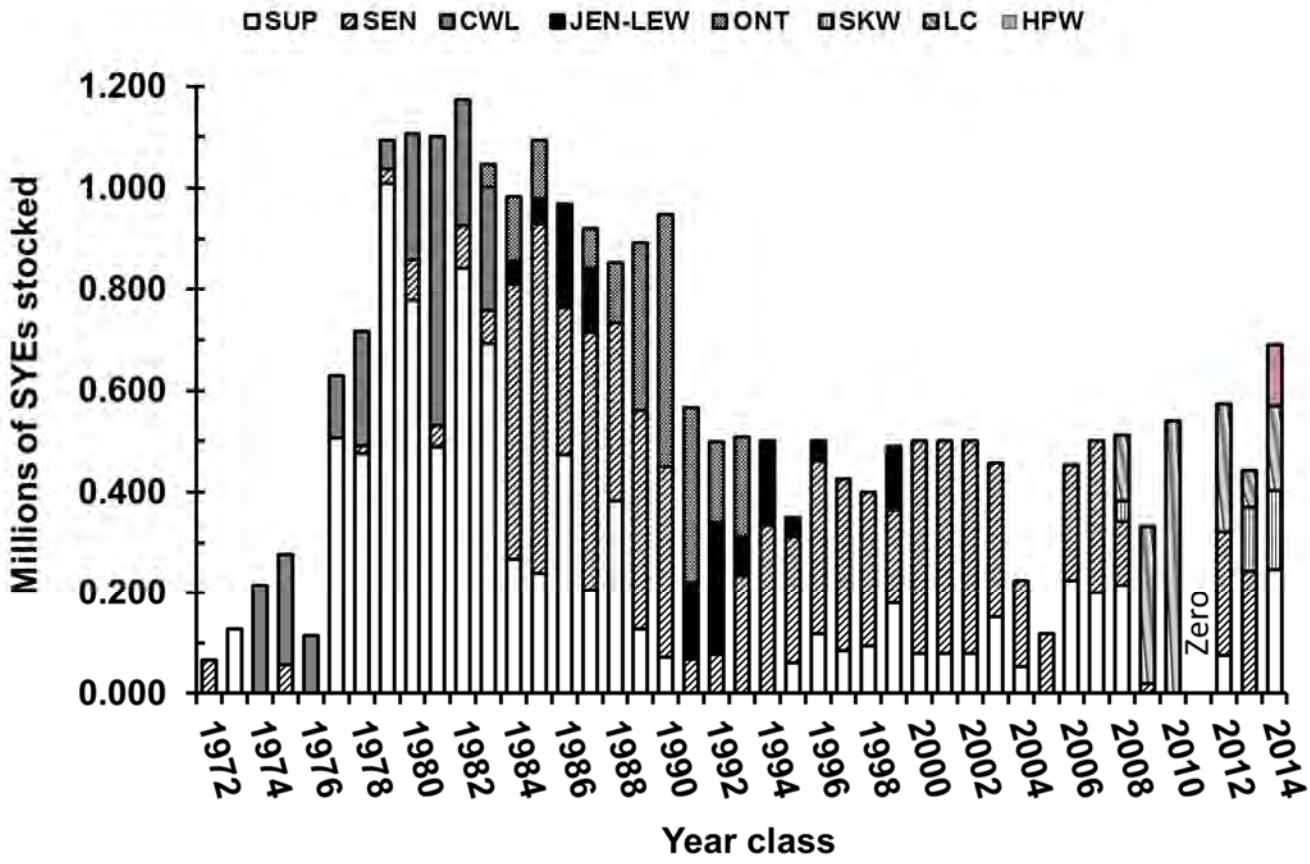

Figure 1. Total spring yearling equivalents (SYE) for lake trout strains (strain descriptions for ONT, JEN-LEW, CWL, SEN, LC, SUP, SKW, HPW appear in Appendix 1) stocked in U.S. waters of Lake Ontario for the 1972 – 2014 year classes. SYE = 1 spring yearling or 2.4 fall fingerlings (Elrod et al. 1988). No lake trout from the 2011 year class were stocked in 2012.

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 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. Annual stockings were near the revised target level in 15 of 22 years during 1993-2014 (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. During 2014, combined production of the 2013 year class at ANFH and ENFH resulted in stockings of approximately 442,000 spring yearlings. That same year, fish managers increased the lake trout stocking target to 800,000 spring yearling equivalents (Lantry et al. 2014). Combined production of the 2014 year class at ANFH and ENFH resulted in stocking of nearly 528,000 fall fingerlings and 521,000 spring yearlings (Connerton 2016). During fall 2015, nearly 454,000 fall fingerlings (2015 year class) were stocked (Connerton 2016).

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 for the 1993 – 2009 year classes, fluctuating by greater than 40-fold with no general trend apparent. The survival indices for the 2010 and 2012 year classes were similar and represented the greatest values observed since the 1990 year-class. 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. The survival indices for the 2013 year-class declined by 32% from the mean of the 2010 and 2012 year-classes, but remained high compared to the 1995-2010 year-classes.

Abundance of age-3 and older Lake Trout

A total of 718 lake trout were captured in the September 2015 gill net survey resulting in a total CPUE of mature adults of 11.5 (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 9.1% and 10.7%, 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

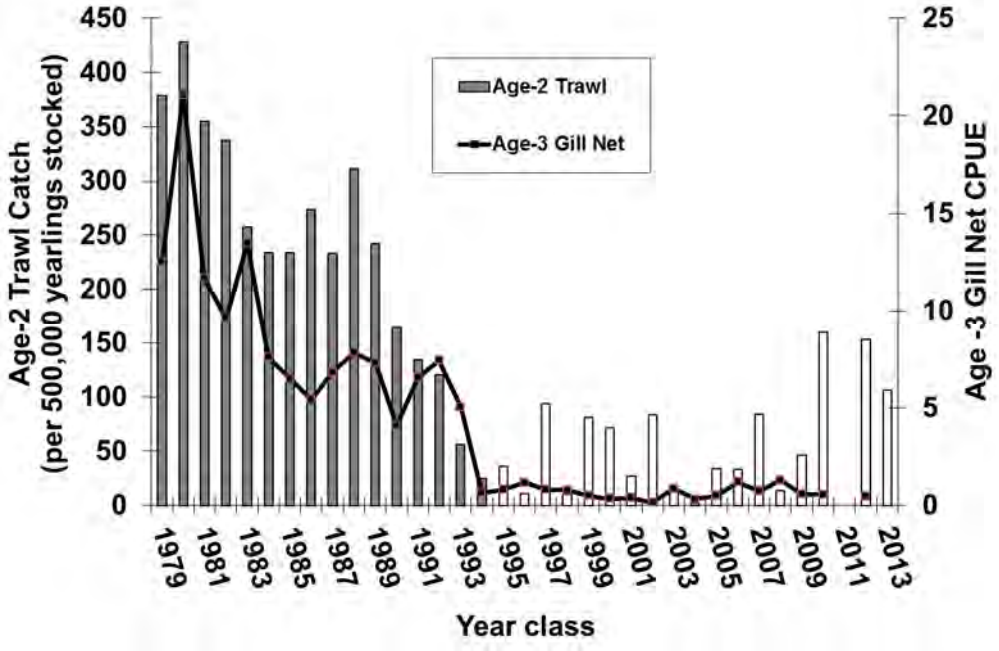

Figure 2. Survival indices lake trout stocked in U.S. waters of Lake Ontario (no 2011 year-class lake trout were stocked into U. S. waters in 2012). Survival was indexed at age 2 as the total catch from bottom trawls (BTR) fished in July-August per 500,000 fish stocked (Note: White bars represent data 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).

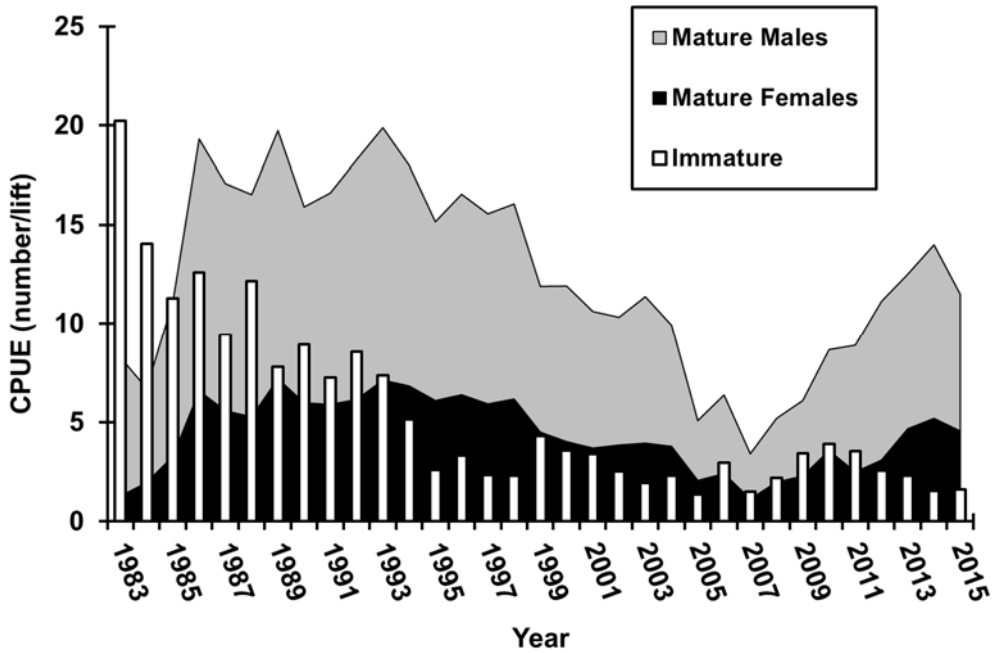

Figure 3. Abundance of mature (generally males ≥ age 5 and females ≥ age 6) and immature (sexes combined) lake trout calculated from catches made with gill nets set in U.S. waters of Lake Ontario, during September 1983-2015. CPUE (number/lift) was calculated based on four strata representing net position in relation to depth of the sets.

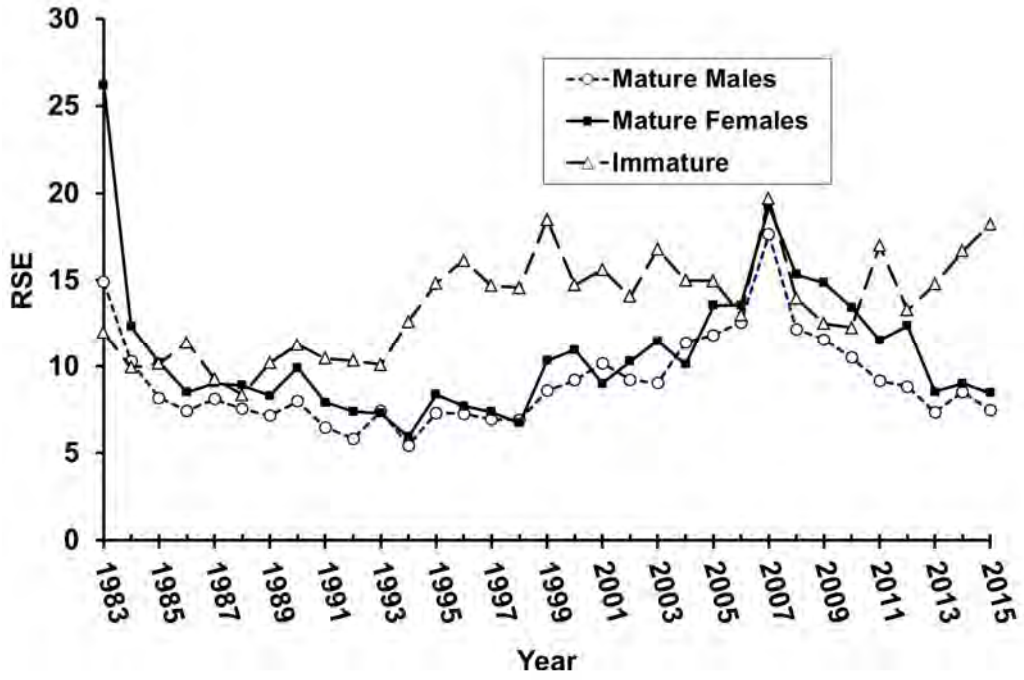

Figure 4. Relative standard error (RSE = {SE / Mean}*100) of the annual CPUE for mature and immature (sexes combined) lake trout caught with gill nets set in U.S. waters of Lake Ontario, during September 1983 – 2015.

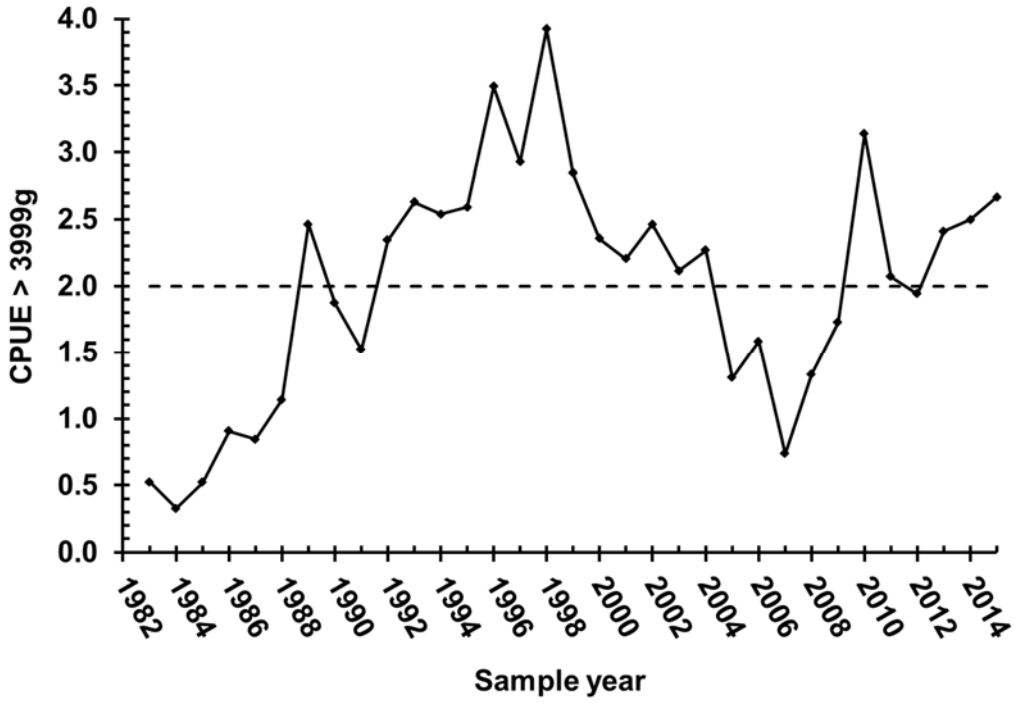

Figure 5 Abundance of mature female lake trout >4000g calculated from catches made with gill nets set in U.S. waters of Lake Ontario, during September 1983-2015. The dashed line represents the target CPUE from Schneider et al. (1997).

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 during 2008-2014. Adult abundance in 2015 (CPUE: 11.5) was similar to the 1999-2004 average (CPUE: 11.1). Similar to the catch of age-2 lake trout from bottom trawls, the CPUE 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 2015 (CPUE: 1.6).

Schneider et al. (1997) established a target 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 2008-2014, the CPUE of mature females ≥ 4,000 g also increased and during 2010-2015 CPUEs have remained near or above target.

Angler Catch and Harvest

Fishing regulations, lake trout population size, and availability of other trout and salmon species influenced angler harvest through time. Since 1988, lake trout harvest was limited by a slot size limit designed to increase the number and ages of spawning adults. In 1992, the regulation permitted a limit of three lake trout harvested outside of the protected length interval of 635 to 762 mm (25 to 30 in). 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 635 to 762 mm slot.

Annual catch and harvest of lake trout from U.S. waters of Lake Ontario (Figure 6) declined over 84% from 1991 to the early-2000s (Lantry and Eckert 2016). Catch and harvest declined further from the early to the 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 2016). 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

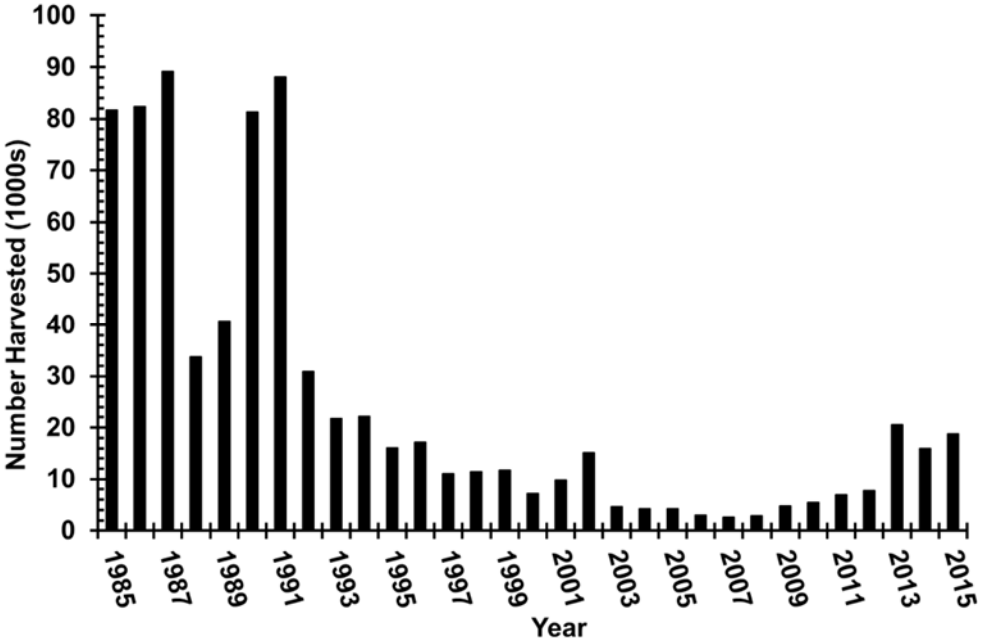

Figure 6. Estimated numbers of lake trout harvested by boat anglers from U.S. waters of Lake Ontario, during April 15 – September 30, 1985 – 2015 (Lantry and Eckert 2016). Beginning with the 2012 report, all harvest values have been reported reflecting a 5.5 month sampling interval. Prior reports were based on a 6 month sampling interval (April 1 – September 30).

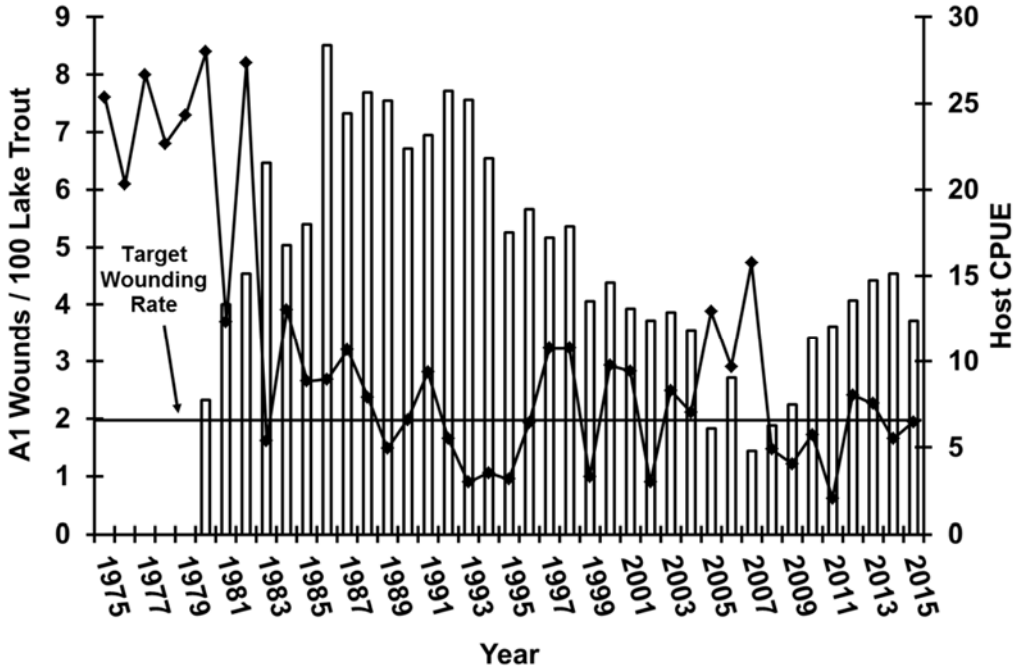

Figure 7. Wounding rates (A1 wounds per 100 lake trout, line) inflicted by sea lamprey on lake trout ≥ 433 mm (17.1 in) TL and the gill net CPUE of lake trout hosts (≥ 433 mm TL, bars) collected from Lake Ontario in fall, 1975 – 2015.

(Lantry and Eckert 2016). Harvest at that time was more than 97% below the 1991 estimate. After 2007, however, catch and harvest rates increased for six consecutive years. The 2015 catch and harvest rates were more than nine times higher than the lows observed in 2007 (Lantry and Eckert 2015). In 2015, angler catch (52,294 fish) and harvest (18,780 fish) were more than 2-fold higher than the respective previous 10-year averages. These increases follow the October 2006 regulation change, and coincide with an increase in lake trout abundance and anecdotal reports of anglers targeting lake trout more frequently during 2013-2015.

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 well 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). While the rate was slightly above target again in 2012 (2.41) and 2013 (2.26), it fell once again below target in 2014 (1.65) and 2015 (1.94).

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 thereafter. The population survival of the most recent completely tagged year class (2003) sampled at ages 7-11 was above target. The SEN strain survival and the population survival for the 2004 and 2005 yearclasses are identical because the stockings for both yeaclasses were predominantly SEN. Stockings for both of those yearclasses were also far below the 500K target with all 224K of the 2004 yearclass being stocked at one site in the eastern basin and all 118K of the 2005 yearclass released at one site in the western part of the lake. Despite a somewhat unbelievable 100% age 7 to 11 survival value for the 2005 yearclass, the CPUEs for each age were surprisingly consistent ranging only from 0.22 to 0.29 2005 YC SEN per gillnet set for that five year period.

Table 1. Annual survival of various strains (strain descriptions appear in Appendix 1) of lake trout, U.S. waters of Lake Ontario, 1985-2015. 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	0.84	-	-	-	-	
2000	7-11	0.90	-	-	-	-	
2001	7-11	0.73	-	-	-	-	
2003	7-11	0.72	-	0.53	-	-	0.68
2004	7-11	0.78					0.78
2005	7-10	1	-	-	-	-	1.00
2006	7-9	0.739	-	-	-	-	0.70

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 (3653.4 g, 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 the 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 have generally remained at a high level during 2007-2015, although both have shown a declining trend after 2011.

Predicted weights of 400-mm lake trout, based on bottom trawl catches of 250-500 mm fish, and Fulton's K for an age-2 lake trout changed between the late 1990s and early 2000s (Figure 9). The mean predicted weight during 1999-2015 declined by almost 15g below the 1979-1998 mean, paralleling declines in native benthic prey resources (Weidel et al. 2014). Predicted weight increased for a brief period 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.) and in all years during 2010-2015, except 2014, remained at values that were among the lowest for the time series.

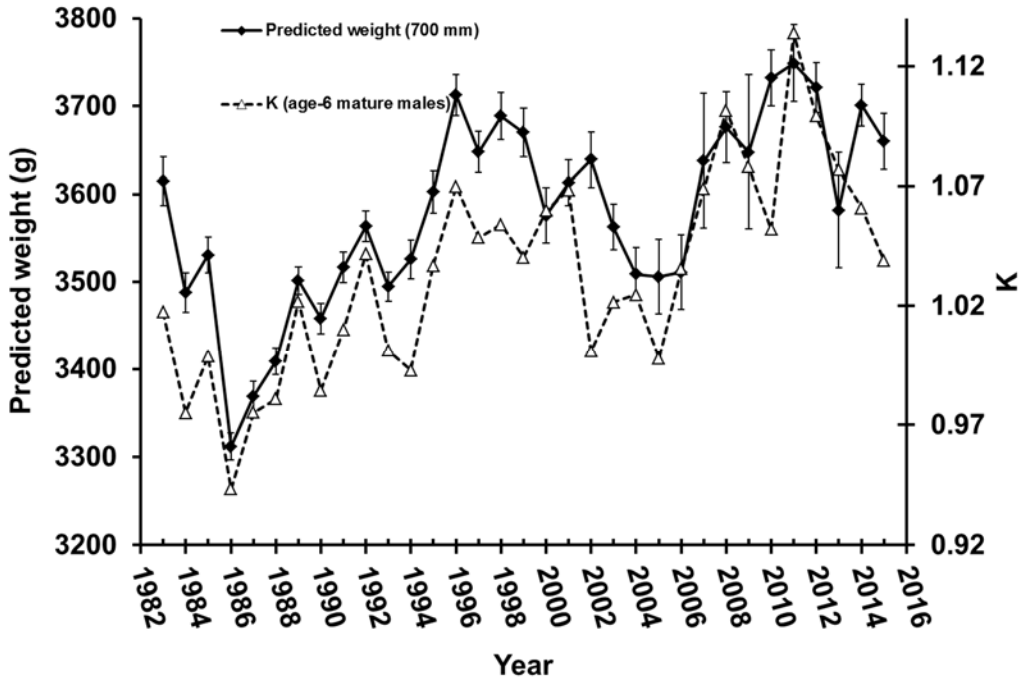

Figure 8. Lake Ontario lake trout condition (K) for age-6 mature males and predicted weight at 700-mm (27.6 in) TL from weight-length regressions calculated from all fish collected during each annual gill net survey, September 1983 – 2015. Error bars represent the regression confidence limits for each annual value.

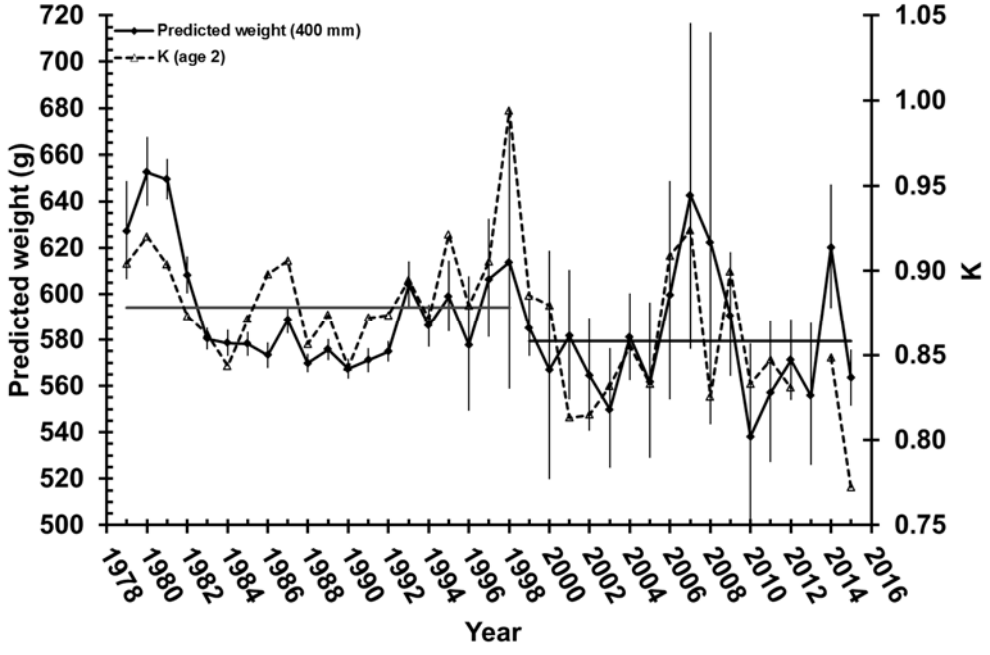

Figure 9. Lake Ontario lake trout condition (K) for age-2 coded wire tagged fish and predicted weight at 400-mm (15.8 in) TL from annual weight-length regressions calculated from fish 250 mm-500 mm (9.8 to 19.7 in). All lake trout were sampled from bottom trawls, July -August 1978 – 2015. The horizontal lines represent the mean predicted weights during 1979-1998 and during 1999-2015. 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 to 1999. In 2005, the index dropped by 40%

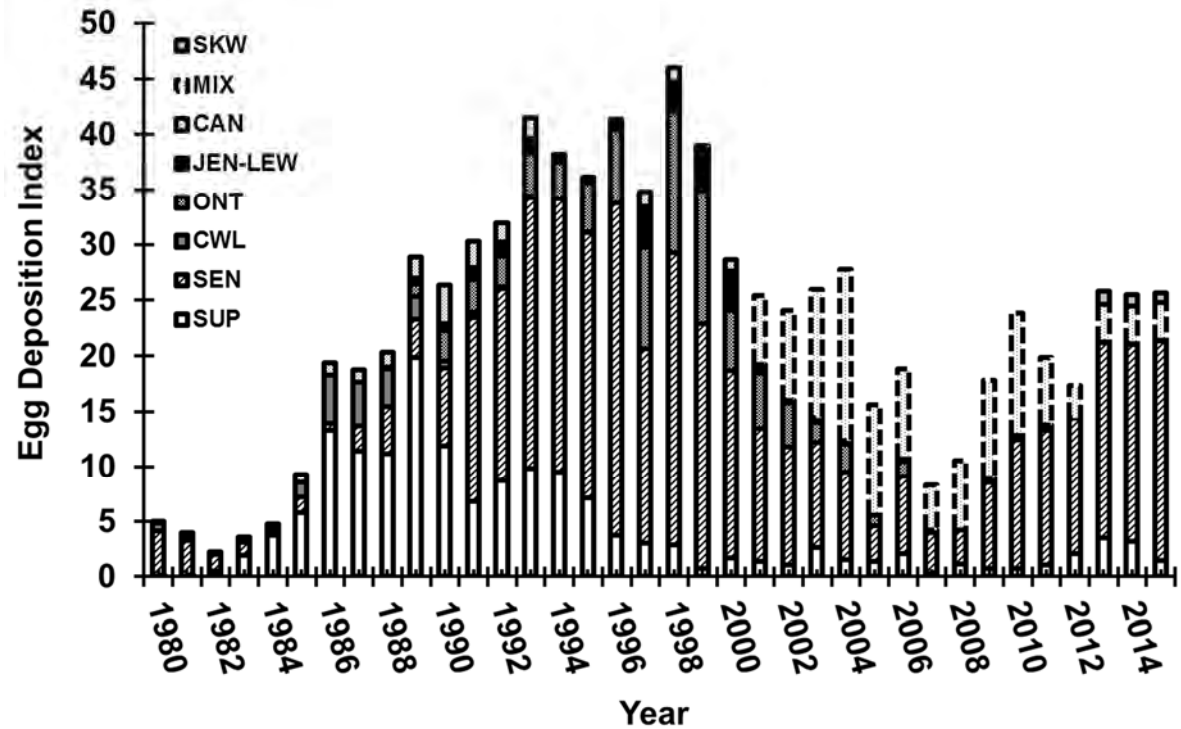

Figure 10. Egg deposition indices by strain (strain descriptions for ONT, JEN-LEW, CWL, SEN, SUP and SKW appear in Appendix 1) for lake trout in U.S. waters of Lake Ontario during 1980-2015. CAN represents a mix of the strains stocked by OMNRF and MIX represents values for untagged females stocked since 1997 for which strain could not be determined.

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 mean for 2001-2004. In 2013-2015 egg deposition indices were similar to 2001-2004 values and, for the first time, included contributions from Klondike strain (SKW) lake trout from the 2008 year class (see Appendix 1 from strain descriptions).

Natural Reproduction

Evidence of survival of naturally produced lake trout past the summer/fall fingerling stage occurred in each year during 1993-2014 (Figure 11) except 2008, representing production of 21 year classes. Numbers caught represent the entire annual bottom trawl catch from four surveys occurring during April-October 1979-2014 (Owens et al. 2003). Catch was not corrected for effort due to the low catch in most years and a relatively constant level of effort expended within the depth range (20m - 100m) where age-0 to age-2 naturally reproduced lake trout are most often encountered in Lake Ontario. Low numbers of small (<100 mm, 3.9 in), wild fish captured in recent years (1997-2012) may have been due in part to a change in our trawl gear that was necessary to avoid abundant dreissenid mussels. The wild yearlings captured in 2010-2015 were the first wild yearlings caught since 2005. In 2014, the largest catch in the 20-year time-series occurred with 47 age-1 (93-186 mm, 3.7-7.3 in) and 70 age-2 wild lake trout (176-291 mm, 6.9-11.5 in) caught. The second largest catch in the time series occurred in 2015 with 24 age-1 (94-147 mm, 3.7-5.8 in) and 48 age-2 (167-262 mm, 6.6-10.3 in) wild lake trout.

The distribution of catches of wild fish suggests that lake trout are reproducing throughout New York waters of Lake Ontario with the greatest concentration coming off the Niagara Bar area at the mouth of the Niagara River (Figure 12). Catches from at least 21 cohorts of wild lake trout since 1994 and survival of those year classes to older ages demonstrates the feasibility of lake trout rehabilitation in Lake Ontario (Schneider et al. 1997). Although recent large catches of wild lake trout are encouraging, achieving the goal of a self-sustaining population requires consistent production of relatively large wild year classes and survival of those fish to reproductive ages.

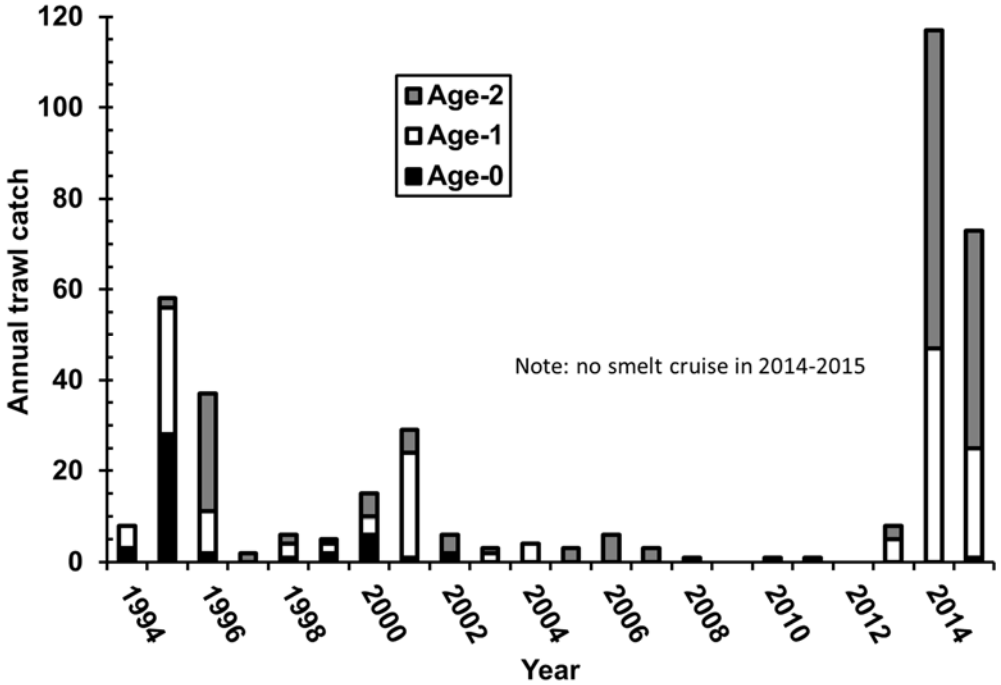

Figure 11. Numbers and ages of naturally produced (wild) lake trout captured with bottom trawls in Lake Ontario by NYSDEC and USGS, 1994-2015. During 1980-1993, only one naturally produced lake trout was captured with bottom trawls.

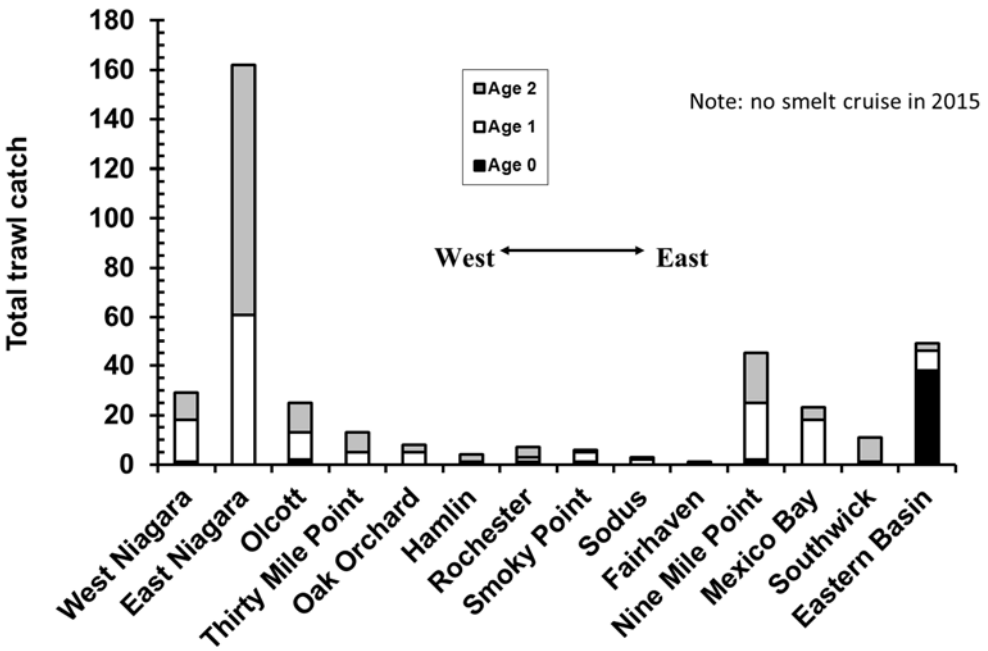

Figure 12. Numbers of wild lake trout (age 0 to 2) captured with bottom trawls at various locations in Lake Ontario by NYSDEC and USGS, 1994 – 2015. (Note: east and west Niagara are only sampled once per year whereas the other locations are usually sampled four times per year.

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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 brood stock 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 brood stocks derived from "lean" Lake Superior lake trout. Brood stock 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 and 2012 year classes). Traverse Island strain originated from a restored "lean" Lake Superior stock. The STW brood stock was phased out of production at USFWS Iron River National Fish Hatchery (IRNFH) and is no longer be available as a source of eggs for future Great Lakes stockings. The Apostle Island strain was derived from a remnant "lean" Superior stock restored through stocking efforts, was phased out of production at USFWS Iron River National Fish Hatchery (IRNFH) and is no longer be available as a source of eggs for future Great Lakes stockings.

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 have been held at the USFWS Sullivan Creek National Fish Hatchery and USFWS Iron River National Fish Hatchery. The USFWS Berkshire National Fish Hatchery developed a SKW brood stock to supply fertilized eggs to ANFH for rearing and stocking into Lake Ontario.

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).

HPW - "Lean" lake trout strain originated from a self-sustaining remnant population located in Parry Sound on the Canadian side of Georgian Bay in Lake Huron. A captive HPW broodstock is maintained at

the USFWS Sullivan Creek National Fish Hatchery and is the source of eggs for HPW reared at USFWS Alleghany National Fish Hatchery in Warren, Pennsylvania for stocking into Lake Ontario. The first HPW lake trout stocking into Lake Ontario occurred in fall 2014.

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 vitreus*] [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 (% = .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 in 2015 was slightly lower than in recent years at 69-71°F (20-22°C). Bottom temperature at 36 ft (11 m) was 70°F (21.1°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 2015, transparency was moderate with Secchi depth at 26.3 ft (8.0) m) (Table 1).

Stock composition

A total of 37 species have been represented in Thousand Islands gill net sampling between 1977 and 2015 (Table 2). These nets were not designed to catch

small-bodied species so that cyprinids, other than carp, are rarely captured. Total annual catch (for 32 net sets) has historically ranged from 847 fish in 2012 to 2,080 fish in 1988. Diversity has ranged from 13 species in 1995 to 19 species (six times). Total catch in 2015 was a record low at 752 individuals (adjusted to multifilament standard); diversity tied the record low for 32 net sites, with 13 species represented (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 in all but one year (2013) 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 and White Sucker (*Catostomous commersonii*) as the predominant group. In 2015, Alewife were unusually abundant, and in addition to Yellow Perch, Rock Bass, Smallmouth Bass and Walleye made up over 90% of the catch (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 abundance has steadily declined since, apparently reaching a near record low in 2015. 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), while the proportion of the sample composed of age-3 and age-4 fish has been increasing (Table 4). 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. Age 5 and 6 bass (2009, 2010 year classes) were much less abundant than expected in 2015 (Figure 4). This anomaly may be related to the small sample size (n=60) of smallmouth bass this year.

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. Since Round Goby establishment in 2005, mean total length at age 5 has steadily increased (linear regression slope +9.03, r^2=0.97). In 2014 age-5 bass averaged a record 15.7 inches (399 mm) and was essentially unchanged (15.8 in, 402 mm) in 2015 (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 tended to vary 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. Unlike most other St. Lawrence River piscivorus fishes, growth (mean total length at age-4) of pike has not increased since establishment of Round Goby in 2005 (linear regression slope = 0.39, r = 0.003).

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 in 2005. Catches increased in 2006 and remained moderately high in 2007 and 2008. Abundance then declined to a record low in 2012 and has remained relatively low since (Figure 9).

There have been several reasonably strong Yellow Perch year classes since 2000. A moderately strong 2007 year class was apparent in 2010, but produced average catches since then. The 2008 year class was unusually well represented in the 2011 sample and reasonably well represented in 2012, despite generally low catches that year. Representation of the 2010 year class has been well above the 1997-2006 average since 2013 (Figure 10).

Growth rate of age-4 Yellow Perch has generally increased since 1994 (Figure 11). Increased growth since 2005 may be attributable to the availability of Round Goby as forage (linear regression slope = 4.88, r=0.84). Total length of age-4 perch reached a record high of 8.6 inches (218 mm) in 2013 but has since declined.

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 catches have been substantially more abundant to date (excepting an apparently anomalous low catch in 2012;Figure 12). As in lake Ontario's eastern basin, Walleye is the only sportfish species that increased in abundance since the inception of this assessment (Lantry 2010).

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, and were detected at very low levels from 1989 through 2006. The catch rate in 2009 was the highest yet recorded, declined close to the background level by 2014, and increased substantially in 2015 (Figure 13) . Like salmonids, many of the alewives in the river probably strayed 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*) have been captured occasionally. 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). Only 10 muskellunge have been caught 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, are now found at much lower abundance, and were near record low abundance in 2015 (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 this assessment 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 and were at record low abundance in 2015. Channel Catfish have been sampled regularly throughout the survey period. Through 2009 they had generally been present at substantially lower abundance than Brown Bullhead, but with the decline in bullhead in recent years (Figure 14), the two species are now about equally abundant. 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 historically been the most common sunfishes in Thousand Island gillnet sampling and 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 2014 and 2015 Rock Bass were an order of magnitude more abundant than Pumpkinseed, which were at record low abundance.

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*) were found in low numbers through 2003;none have been caught since.

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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)				
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)		2014	20-22 (68-71)	12.0 (39.5)
1996	21-21 (70-70)	8.8 (29)	2015	20-22 (69-71)	8.0 (26.3)

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	2014	23.6	18	755a
				2015	23.5	13	752a

* 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	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
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
Common 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	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
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
Common 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	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Lake Sturgeon	.03	0	0	0	.03	0	0	0	0	0	0			
Longnose Gar	0	0	0	0	0	0	0	0	0	0	0			
Bowfin	.03	0	0	0	0	.03	0	.03	.03	.03	0			
Alewife	.09	.03	2.25	.59	8.78	2.13	2.56	.50	.41	.13	3.59			
Gizzard Shad	0	0	0	0	0	0	0	0	0	0	0			
Coho Salmon	0	0	0	0	0	0	0	0	0	0	0			
Brown Trout	0	0	0	0	0	0	0	0	0	0	0			
Lake Trout	0	0	0	0	0	0	0	0	0	.03	0			
Rainbow Smelt	0	0	.06	0	0	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	1.53	1.13			
Muskellunge	0	0	0	0	0	0	0	0	0	0	.03			
Common Carp	.12	.19	.16	.19	.09	.06	.16	.16	.22	.03	.06			
Rudd	0	0	0	0	0	0	0	.22	0	0	0			
Golden Shiner	0	0	.03	0	.03	.03	.03	0	0	0	0			
Fallfish	0	0	0	0	0	0	0	.03	.06	1	0			
Longnose Sucker	0	0	0	0	0	0	0	0	0	0	0			
White Sucker	1.10	1.16	.88	.81	.63	.34	.69	.53	.78	.31	.31			
Silver Redhorse	.03	.06	.03	.03	.03	.19	.03	.03	.03	.41	0			
Shorthead Redhorse	0	0	0	0	0	0	0	0	0	0	0			
Greater Redhorse	0	0	0	0	.16	0	0	0	.03	.03	0			
Brown Bullhead	1.53	2.47	1.22	.81	1.56	.72	.75	.97	.50	.19	.09			
Yellow Bullhead	0	0	0	0	0	0	0	.03	0	0	0			
Channel Catfish	.38	.44	.25	.31	.84	1.06	0.03	.31	.34	.31	.13			
Stonecat	0	0	0	0	0	0	0	0	0	0	0			
Burbot	0	0	0	0	0	0	0	0	0	0	0			
White Perch	0	.03	0	0	0	0	0	0	0.13	0	0			
White Bass	0	.03	0	0	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*	6.48*	7.00*			
Pumpkinseed	1.88	2.41	.97	.88	.81	.72	.69	.47	.94	.09	.09			
Bluegill	.06	.03	.13	.06	0	.06	.09	.25	.09	.03	0			
Smallmouth Bass	4.75	7.84	5.13	6.69	4.19	7.5	5.0	8.91	6.41	4.59	1.88			
Largemouth Bass	0	0	.19	0	0	.03	0	.31	.06	0	0			
Black Crappie	0	0	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*	7.75*	8.18*			
Walleye	.75	.81	1.34	.84	1.03	.84	1.06	.47	.81	1.22	1.22			
Freshwater Drum	.06	0	.13	0	0	0	.09	.06	0.03	0	0			
Round Goby	0	0	.09	.53	.19	.16	.75	.06	0	.37	.13			

Table 4. Trends in age composition of Smallmouth Bass sample (linear regression of proportion of sample).

Age	Slope	Coefficient of Variation
3	+0.46	0.37
4	+0.49	0.21
5	+0.11	0.01
6	- 0.38	0.18
7	- 0.31	0.21
8	- 0.20	0.19
9	- 0.06	0.06
10	- 0.007	0.001

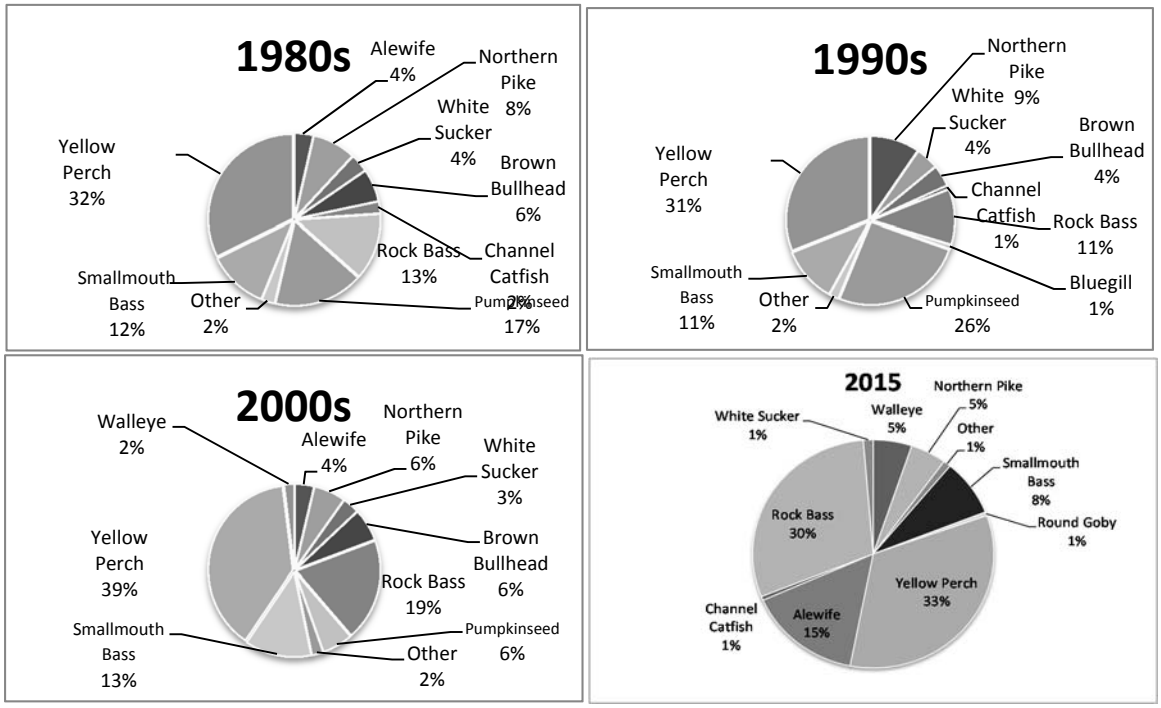

Figure 1. Composition of the warm/coolwater fish stock assessment sample from mid- depths of the St. Lawrence River Thousand Islands area.

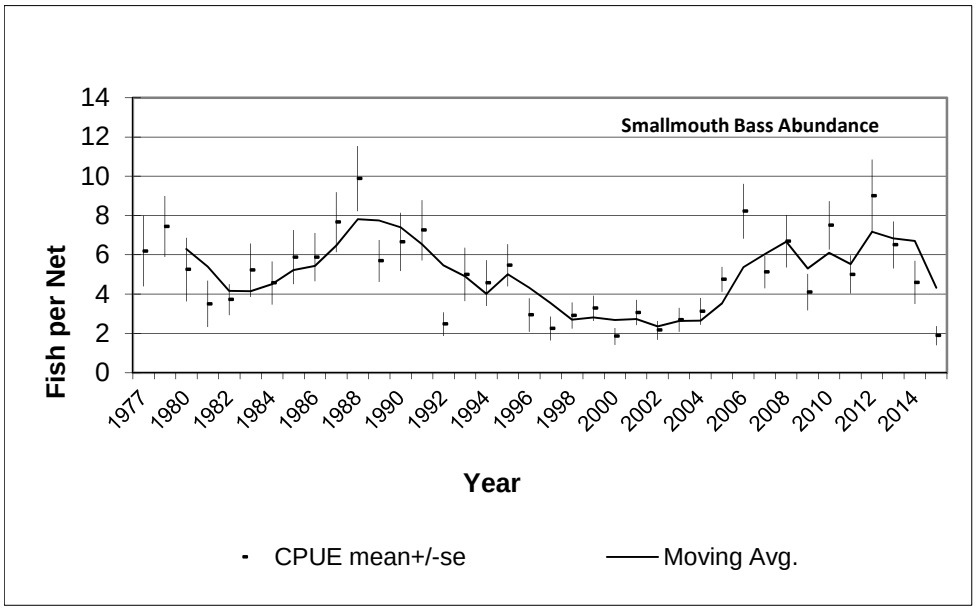

Figure 2. Smallmouth bass abundance index in the St. Lawrence River Thousand Islands area (Catch per Unit Effort +/- SE and 3-year moving average).

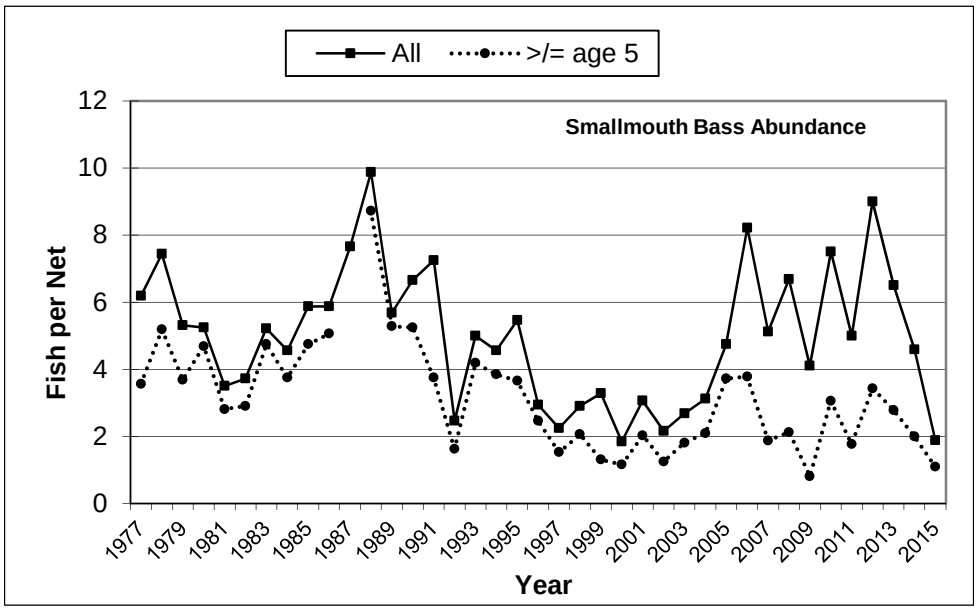

Figure 3. Smallmouth Bass abundance index in the St. Lawrence River Thousand Islands area (all bass sampled and bass greater than or equal to age 5).

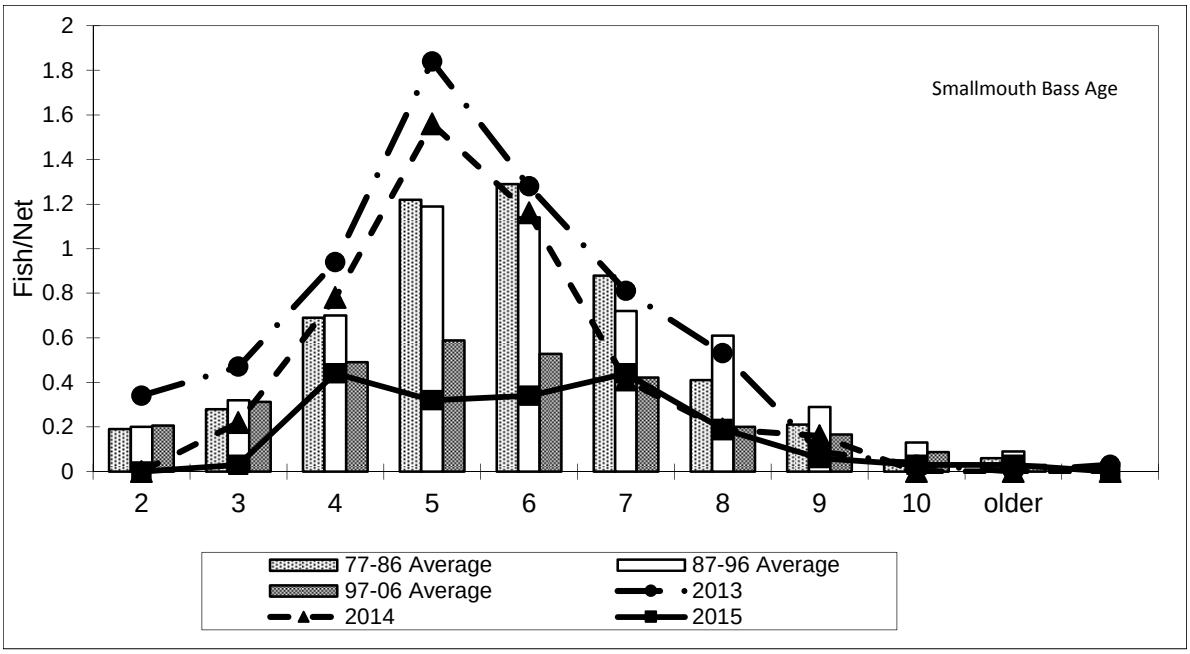

Figure 4. Smallmouth Bass age distribution in the St. Lawrence River Thousand Islands area.

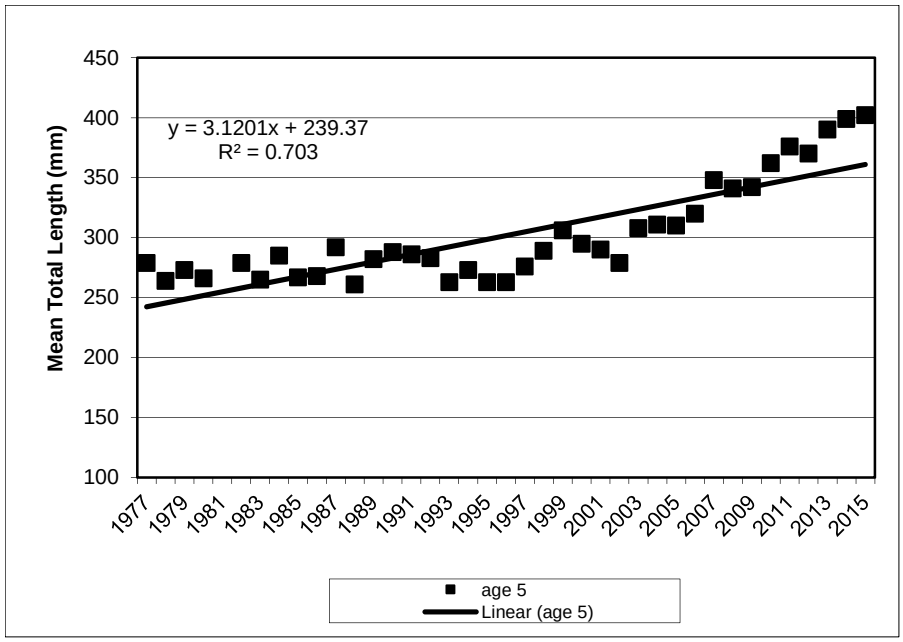

Figure 5. Mean total length of Smallmouth Bass at age 5 in the St. Lawrence River Thousand Islands area.

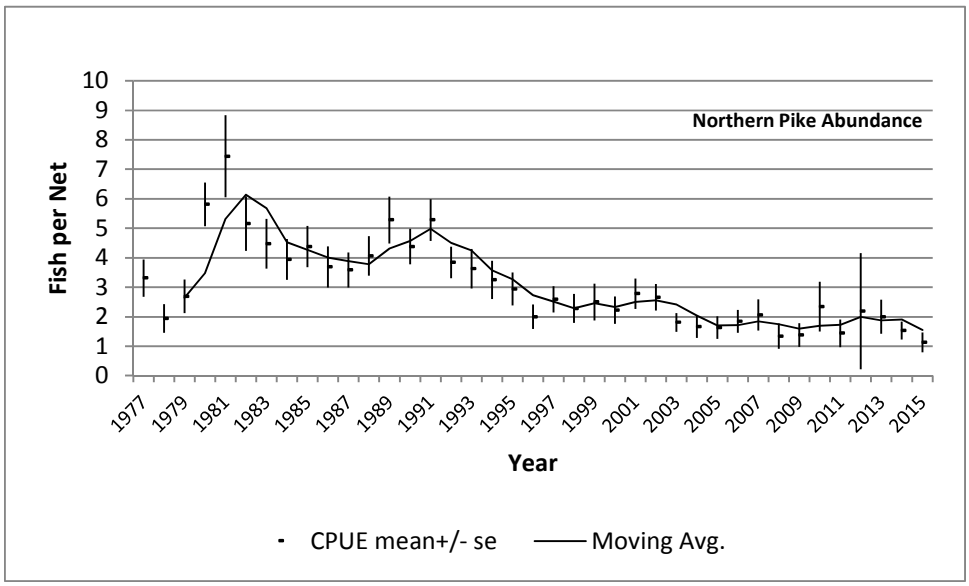

Figure 6. Northern Pike abundance index in the St. Lawrence River Thousand Islands area.

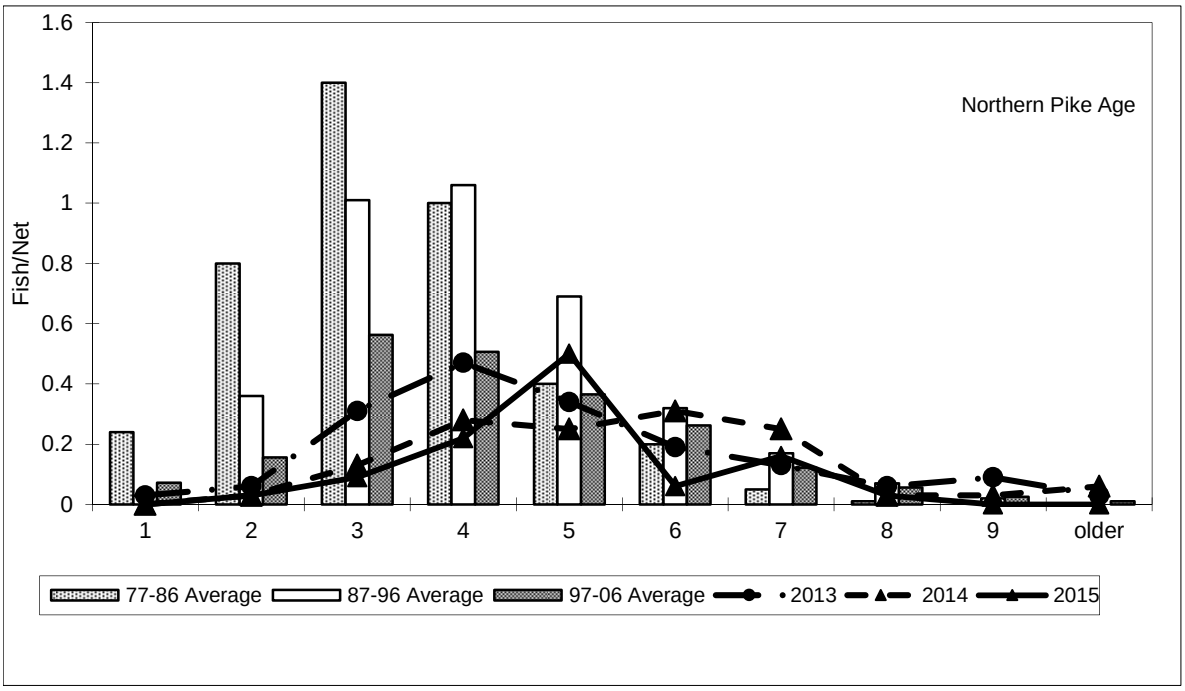

Figure 7. Northern Pike age distribution in the St. Lawrence River Thousand Islands area.

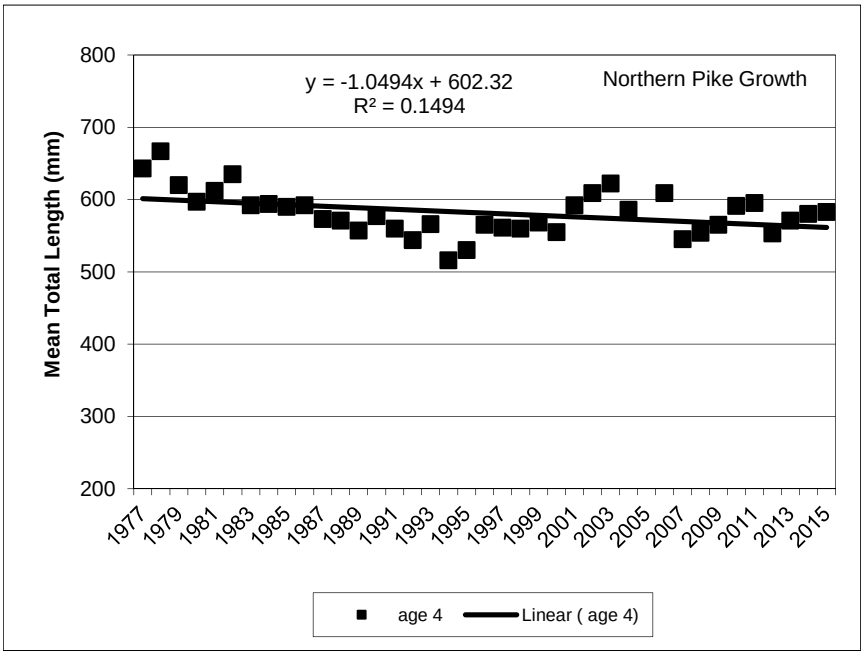

Figure 8. Mean total length of Northern Pike at age 4 in the St. Lawrence River Thousand Islands area.

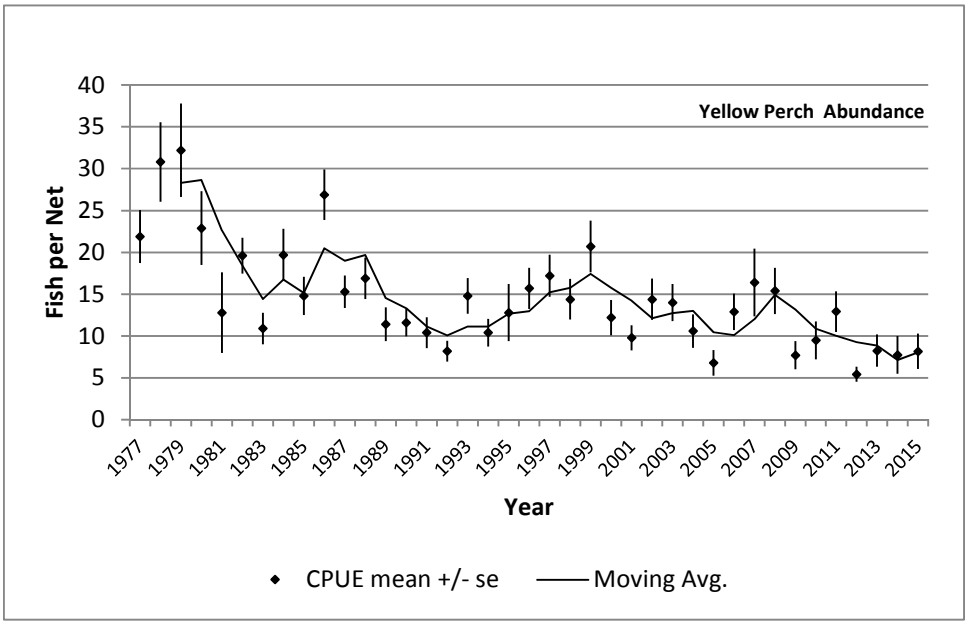

Figure 9. Yellow Perch abundance index in the St. Lawrence River Thousand Islands area.

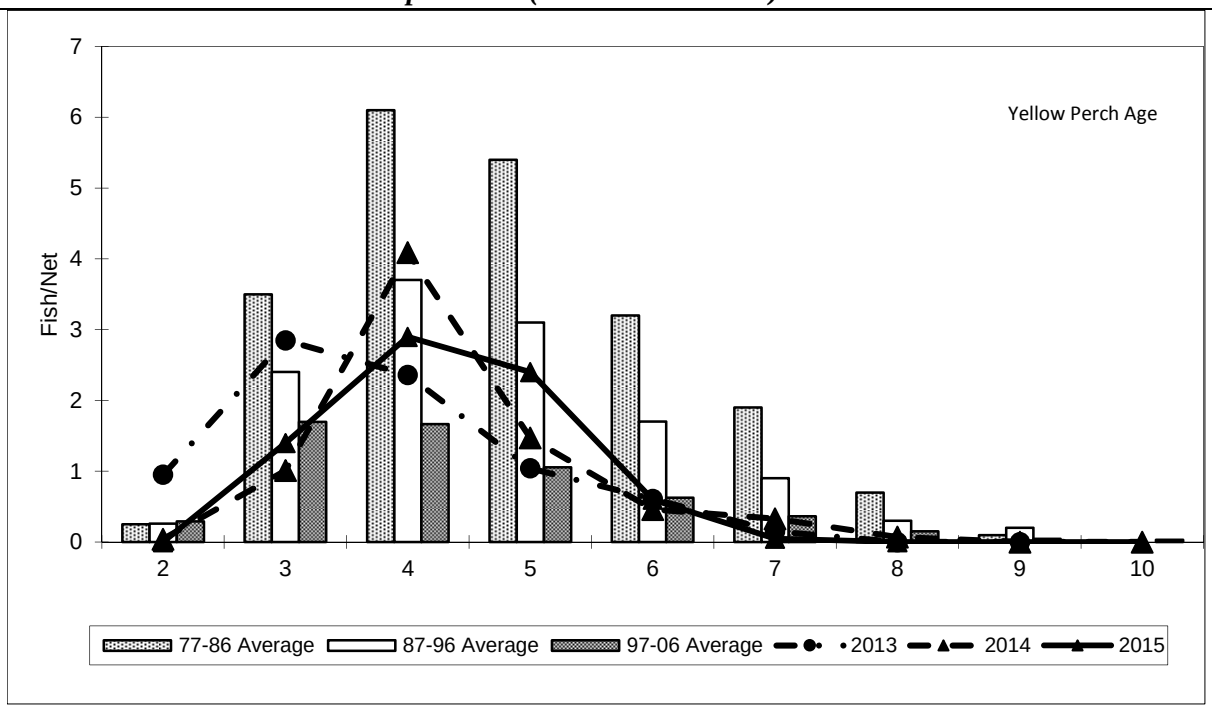

Figure 10. Yellow Perch age distribution in the St. Lawrence River Thousand Islands area.

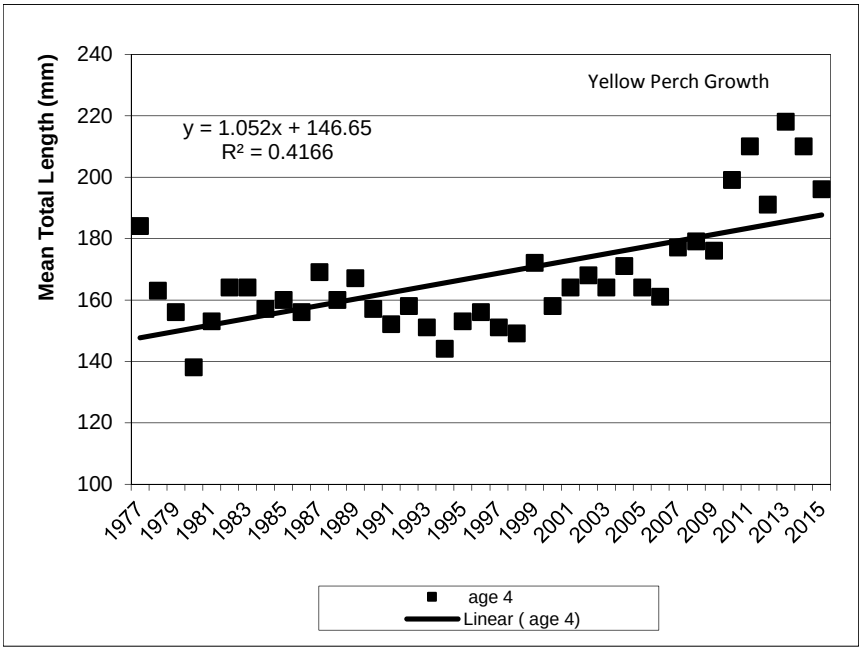

Figure 11. Mean total length at age 4 for Yellow Perch in the St. Lawrence River Thousand Islands area.

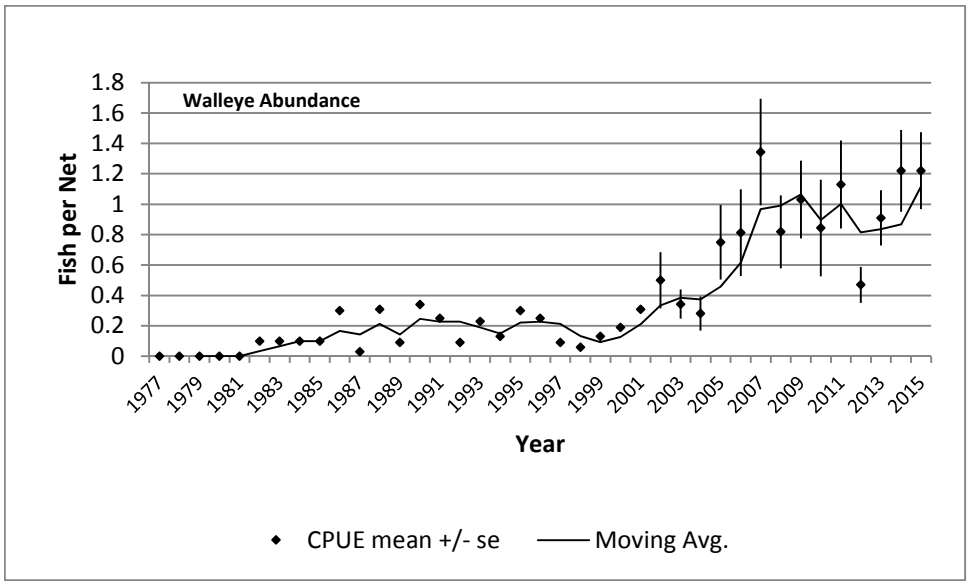

Figure 12. Walleye abundance index in the St. Lawrence River Thousand Islands area.

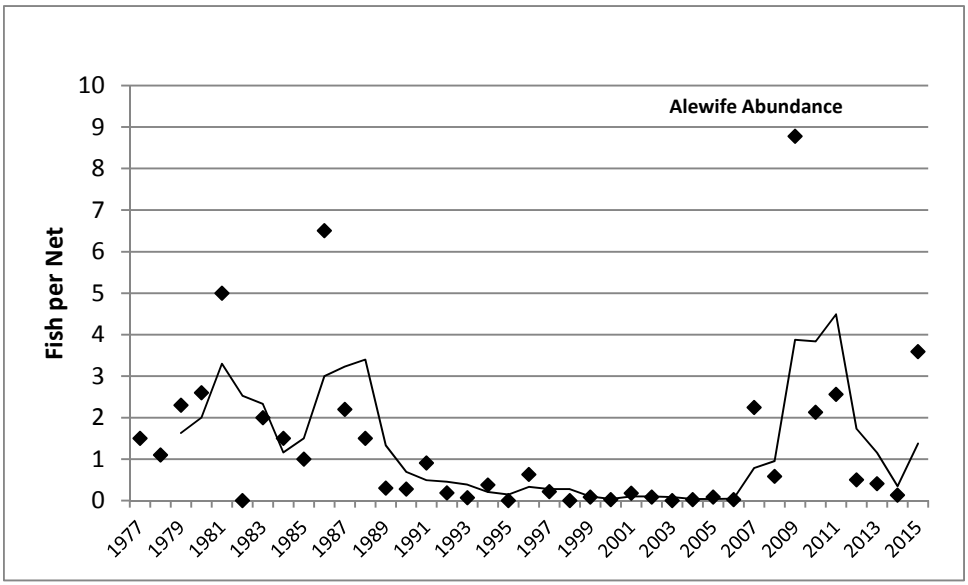

Figure 13. Abundance index for Alewife in the St. Lawrence River Thousand Islands area (with 3-year moving average).

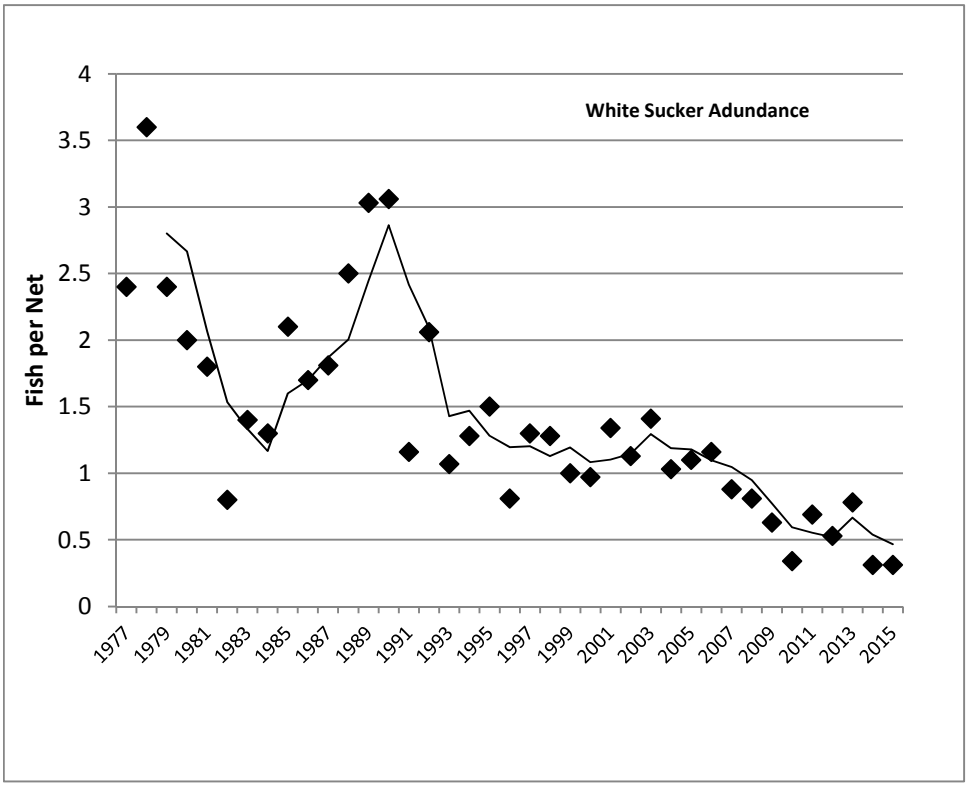

Figure 14. Abundance index for White Sucker in the St. Lawrence River Thousand Islands area (with 3-yr moving average).

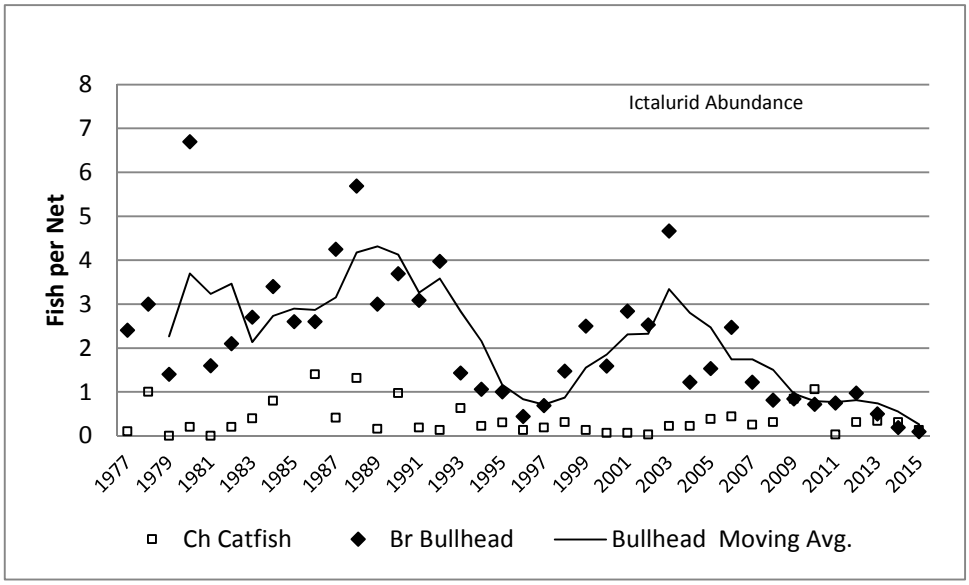

Figure 15. Abundance index for Brown Bullhead and Channel Catfish in the St. Lawrence River Thousand Islands area.

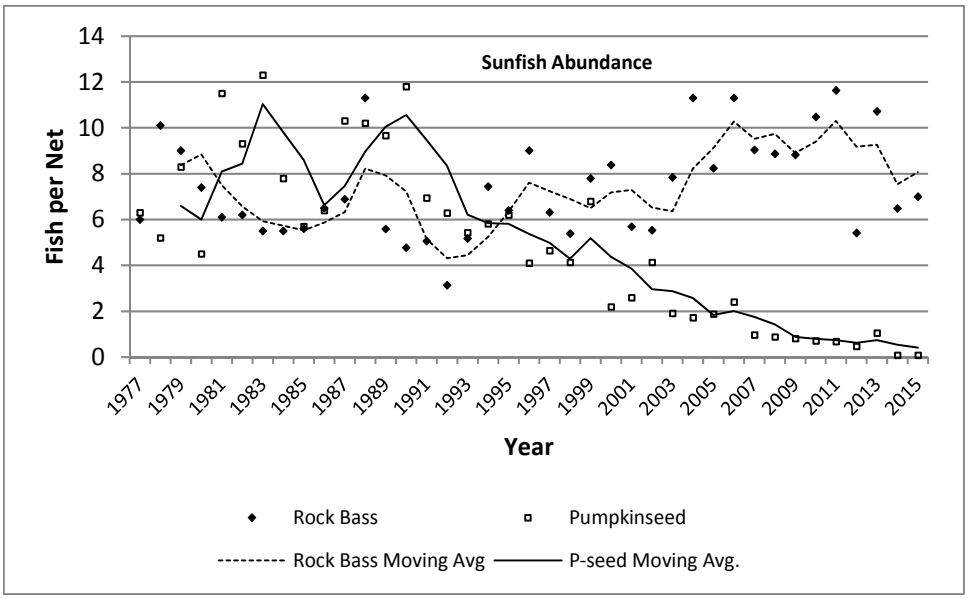

Figure 16. Abundance index for Rock Bass and Pumpkinseed sunfish in the St. Lawrence River Thousand Islands area (with 3-year moving averages).

2015 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 and Forestry (OMNRF) 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 (Klindt 2006). 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 18.2 hours (SD=0.59) 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 2015 Lake St. Lawrence assessment was conducted from 14 to 17 September. Surface water temperatures ranged from 69-70°F (17.2-18.9^{o}C). A sample of 639 fish comprising 20 species was collected (Table 1). The catch was dominated by yellow perch (44.4%), rock bass (17.5%) and smallmouth bass (11.3%).

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. depicts species that comprise 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. Largemouth bass, while not depicted in the figure, had their second highest recorded catch (N=14) in 2015, which may illustrate a changing system. Species poorly represented in earlier surveys now make up even smaller proportions of the overall assemblage.

Total CUE decreased by 8.3% from 21.72 fish in 2014 to 19.97 in 2015. While total catch declined for the fourth consecutive year, 2015 still ranks tenth highest since 1985 (Figure 2). Total CUE is generally driven by fluctuations in yellow perch catch. The 2014 CUE was elevated from a record white perch catch.

Yellow perch CUE increased by 18% from 7.5 in 2014 to 8.9 in 2015 (Figure 3). Since 2008 the perch catch has shown large annual fluctuations. Predation from Double-crested Cormorant (*Phalacrocorax auritus*; DCC) has been demonstrated to influence yellow perch numbers in Lake St. Lawrence in the past (Klindt and Gordon 2013). DCC diet data are no longer available for Lake St. Lawrence, however, cormorant nesting

colonies will continue to play a role in altering the fishery as they have in the Thousand Islands (McCullough and Gordon 2013) and Lake Ontario (Lantry et al. 1999).

The majority of perch collected ranged from 6-7" with few perch <6" and a high proportion of fish >9" (19.9%, Figure 4). From 2006 to 2015, perch >9" have comprised 19.8-33.9% of the catch. Age-3 yellow perch comprised the majority of fish collected in 2015 (Figure 5). The ten year average CUE at age indicates that 2015 had a higher than average catch for each age class. Perch tend to leave the fishery by age-7.

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 6. 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 =0.45), an increasing growth rate trend remains apparent for the entire data series. A more recent short term trend (2000-2011 year classes) implies that growth rate is stabilizing. 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 forage.

Smallmouth bass CUE had been relatively stable from 1998-2004, but has fluctuated substantially from 2005 to the present. Smallmouth bass CUE (2.25) was at the long term average of 2.26 in 2015 (Figure 7). For a second consecutive year the length-frequency distribution is relatively uniform, without the dominance of large fish (Figure 8). Age-3 bass were well represented (2012 year class) and the 2011 year class continues to perform well at age-4 (Figure 9). The average 10 year age frequency distribution demonstrates low density of fish of age-5. Predicting year class strength of smallmouth bass has been difficult in this assessment 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 10. The relationship is weak (r^2=0.11), however, it depicts an overall increase in growth rate. Data 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 10 to demonstrate a similar trend of increasing growth. When considering only the 2002-2009 year classes, it appears that growth rate may be stabilizing.

Walleye CUE (0.84) decreased 38% in 2015 and fell below to the long term average of 1.45 fish/net night (Figure 11). Overall catch has been in decline since 2009 in spite of the appearance of a very strong 2007 year class. The length-frequency distribution of the walleye catch (Figure 12) was dominated by 18-20 inch fish. Catch was dominated by age-3 fish, from the 2012 year class (Figure 13). Walleye in Lake St. Lawrence tend to fully recruit to our gear as age 2 fish (11-12") as shown by the 10 year average age frequency. High densities of young of year or age 1 fish don't necessarily persist in the catch through time. All walleye to date have been aged using scales which may have led to some inconsistencies in reporting age of older fish. Future surveys may incorporate otoliths as aging structures since many researchers report improved accuracy (Beamish and McFarlaine 1987).

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. Northern pike CUE (0.13) in 2015 remained low, consistent with a declining trend since 2001 (Figure 14). Total length of northern pike ranged from 9.7-31.6 in (Figure 15). Fish age-0, 4 and 6 were represented in the catch (Figure 16).

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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, 1983-2015.

	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, 1983-2015 (continued).
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, 1983-2015 (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, 1983-2015 (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, 1983-2015 (continued).

	Year	2010	2011	2012	2013	2014	2015	LT Avg.
SPECIES	**# Nets**	32	32	32	32	32	32	
Lake Sturgeon		0.06	0.03	x	x	x	x	0.01
Bowfin		0.03	x	x	0.03	x	0.03	0.01
Alewife		x	0.03	0.09	x	0.03	x	0.18
Gizzard Shad		0.06	0.03	0.63	0.44	x	0.03	0.11
Rainbow Trout		x	x	x	x	x	X	0.00
Brown Trout		x	x	x	x	x	X	0.01
Lake Trout		x	x	x	x	x	X	0.00
Rainbow Smelt		x	x	x	x	x	X	0.00
Northern Pike		0.28	0.31	0.19	0.28	0.09	0.13	0.44
Muskellunge		x	0.03	x	x	x	X	0.00
Lake Chub		x	x	x	x	x	X	0.00
Carp		0.19	0.16	0.41	0.25	0.09	0.25	0.60
Golden Shiner		x	x	0.03	x	x	X	0.00
Fallfish		0.19	0.19	0.16	0.47	0.16	0.25	0.15
White Sucker		0.44	0.53	1.22	0.72	0.59	0.41	0.80
Silver Redhorse		0.19	0.63	0.44	0.38	0.25	0.31	0.43
Shorthead Redhorse		x	x	x	0.03	x	0.03	0.02
Greater Redhorse		0.06	0.03	x	0.03	0.03	X	0.01
Yellow Bullhead		x	x	x	x	x	X	0.00
Brown Bullhead		0.16	0.22	0.66	0.31	0.78	0.25	0.96
Channel Catfish		0.03	0.09	0.09	0.09	0.06	0.06	0.07
White Perch		0.41	1.03	1.75	2.16	3.41	1.59	0.91
White Bass		x	x	x	x	x	X	0.02
Rock Bass		8.03	3.41	5.16	3.97	5.22	3.50	2.96
Pumpkinseed		0.19	0.09	0.16	0.38	0.16	0.56	0.37
Bluegill		x	x	x	x	x	0.09	0.01
Smallmouth Bass		2.22	1.34	2.66	3.09	1.97	2.25	2.26
Largemouth Bass		0.22	0.22	0.69	0.09	0.03	0.44	0.08
Black Crappie		x	x	x	0.03	x	0.03	0.04
Yellow Perch		18.78	9.03	16.69	7.94	7.50	8.88	6.74
Walleye		2.75	1.81	2.09	2.06	1.38	0.84	1.43
Freshwater Drum		0.03	x	0.03	0.03	x	0.03	0.03
TOTAL CATCH		34.25	19.34	33.16	22.93	21.78	19.97	18.66

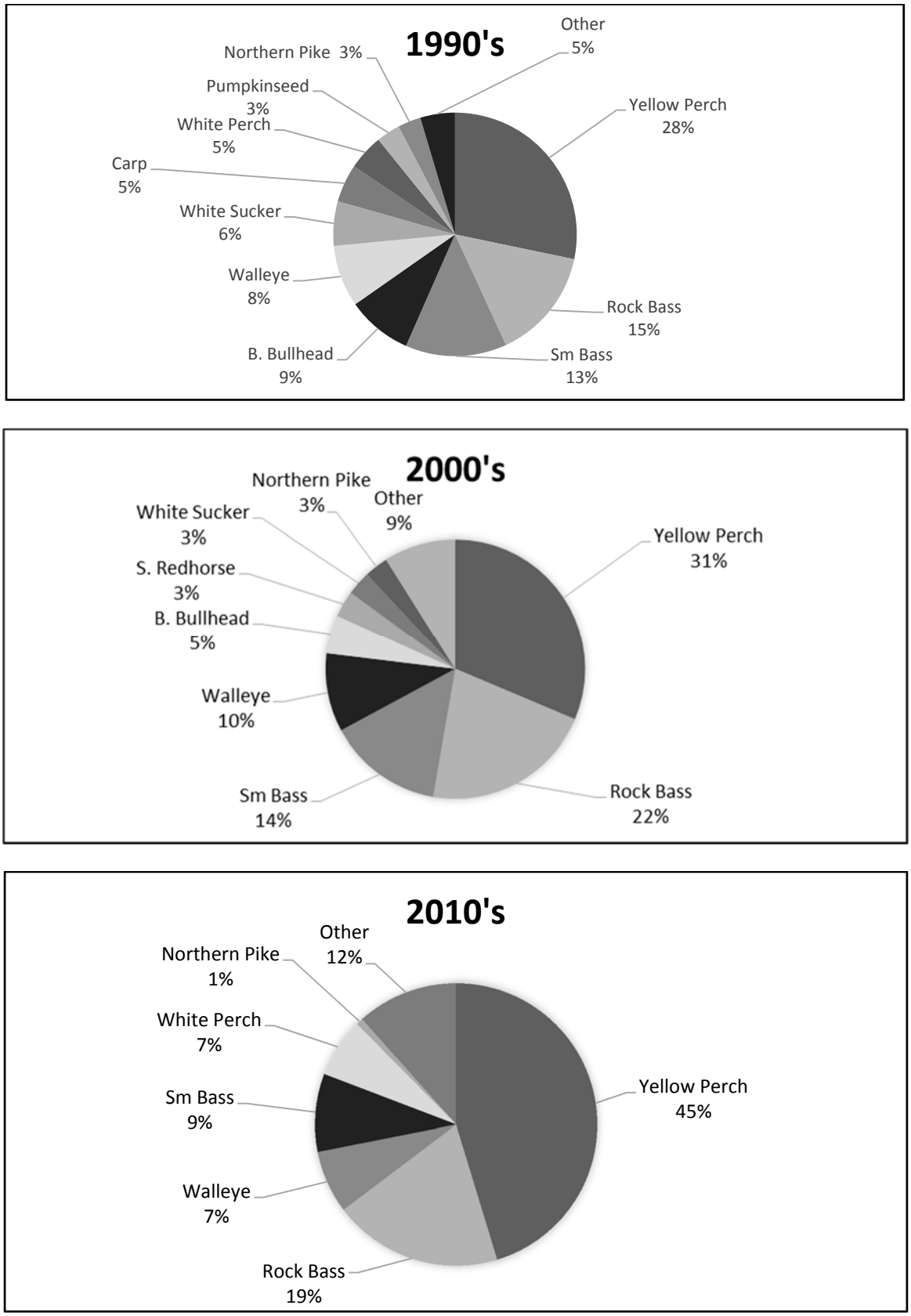

Figure 1. Composition of the Lake St. Lawrence fish community sampled by gill nets and presented by decade.

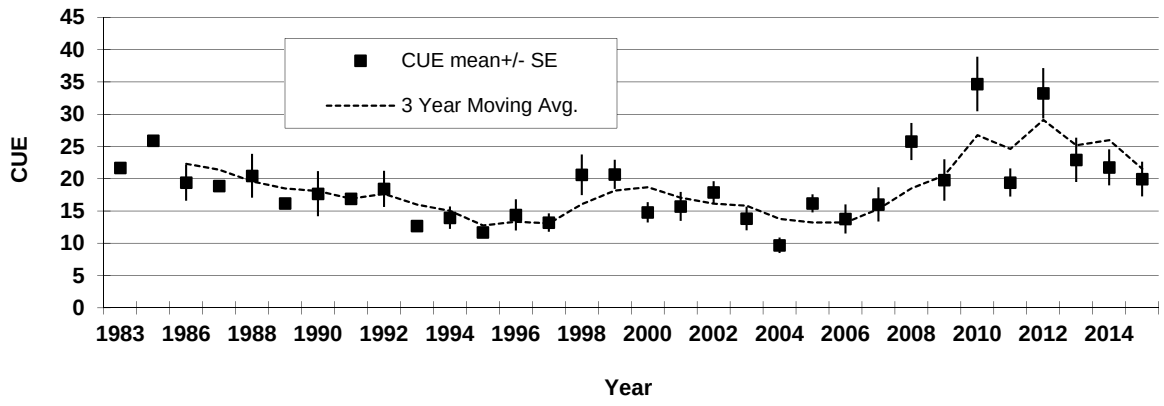

Figure 2. Total catch per gill net night (CUE) for Lake St. Lawrence, 1983-2015.

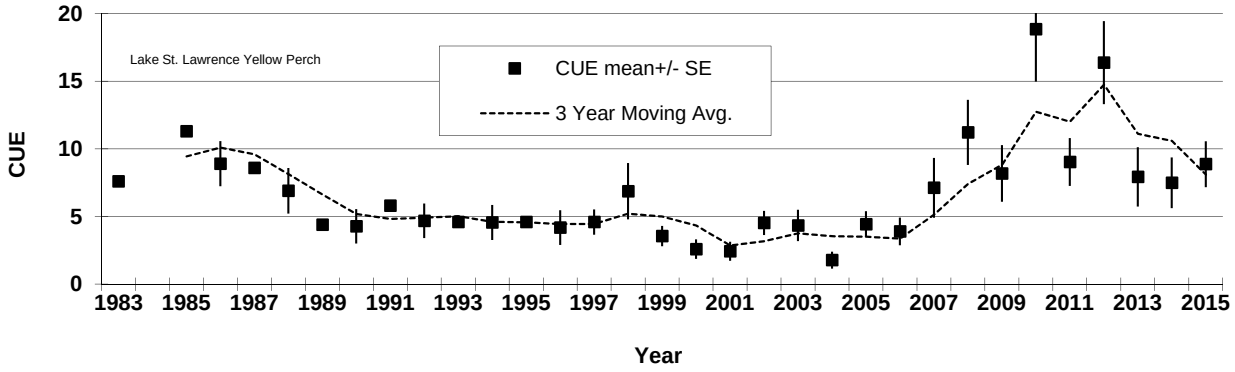

Figure 3. Yellow perch total catch per gill net night (CUE) for Lake St. Lawrence, 1983-2015.

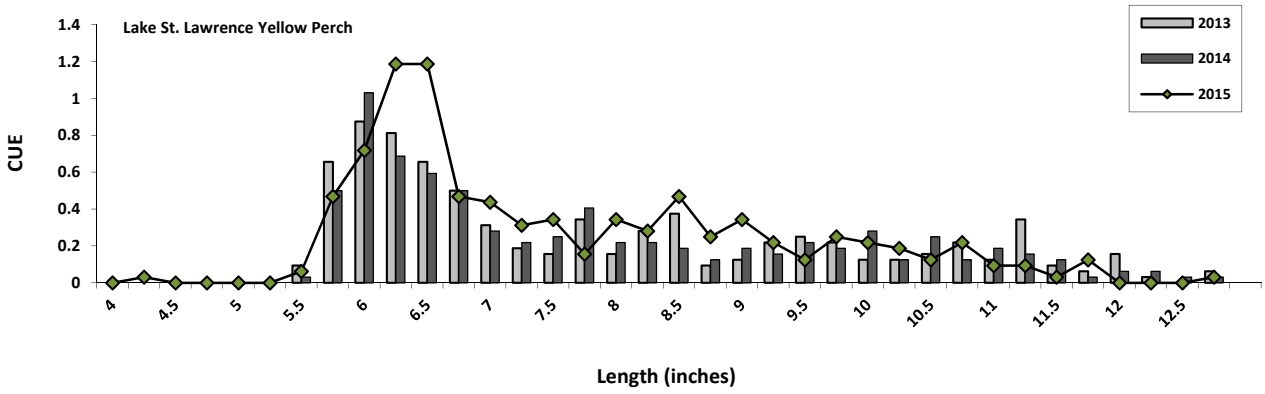

Figure 4. Yellow perch length-frequency distribution for Lake St. Lawrence.

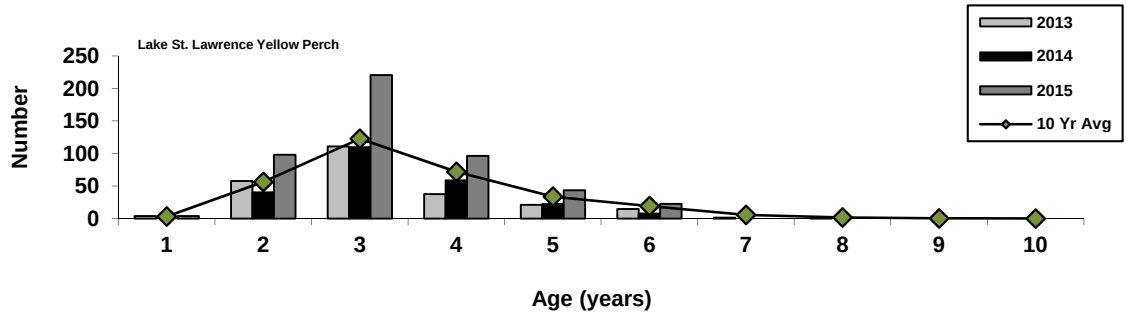

Figure 5. Yellow perch age-frequency distribution for Lake St. Lawrence.

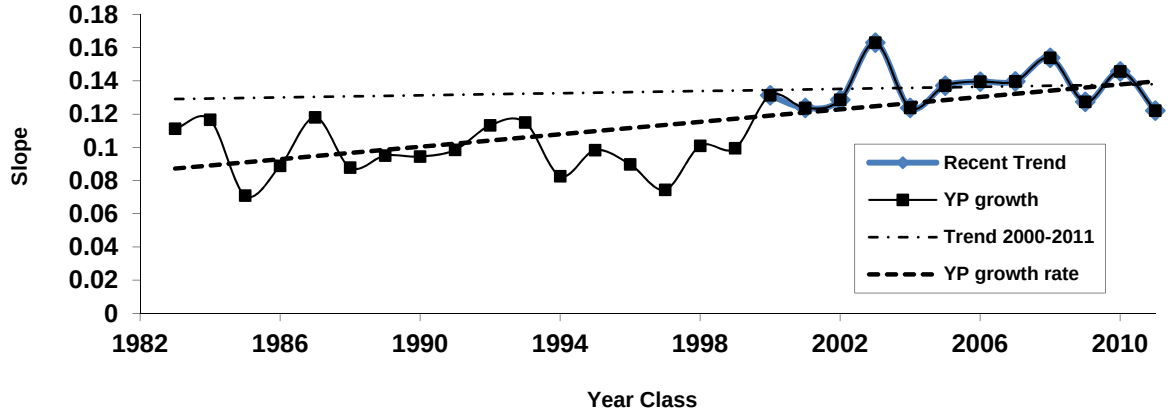

Figure 6. Yellow perch growth rates by year class using fish ages 2-7.

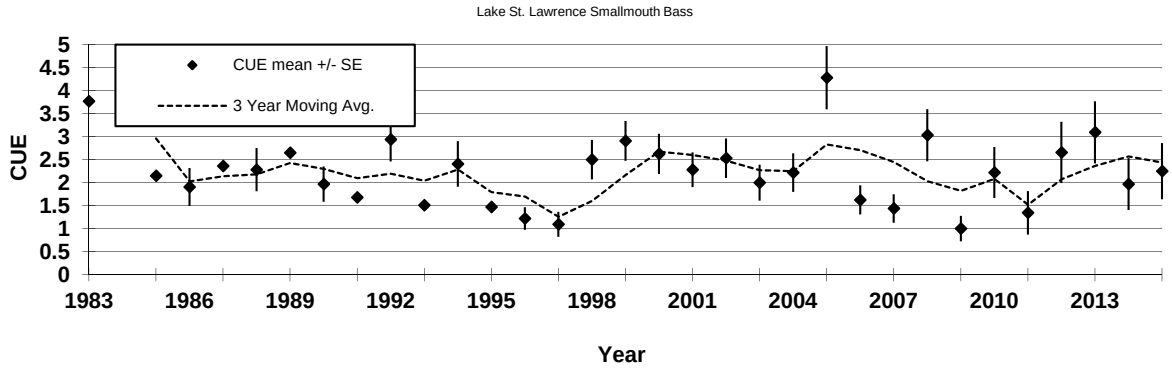

Figure 7. Total catch per gill net night (CUE) for smallmouth bass in Lake St. Lawrence, 1983-2015.

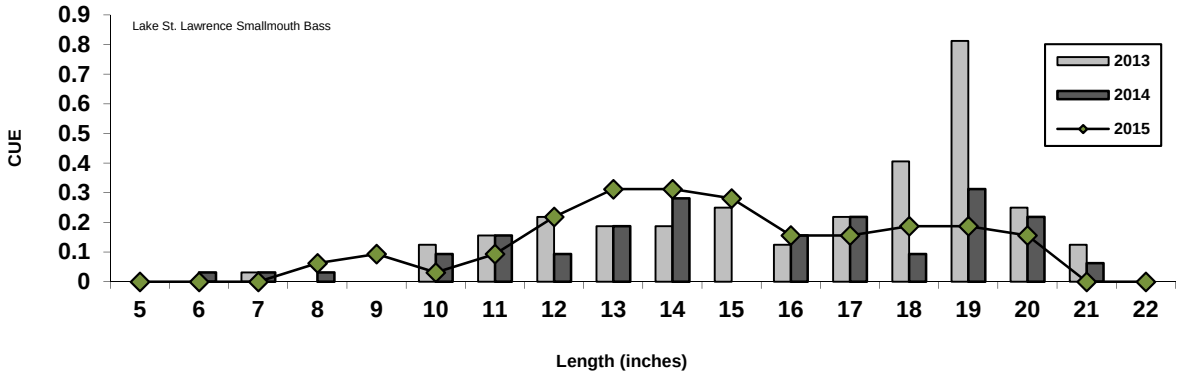

Figure 8. Smallmouth bass length-frequency distribution for Lake St. Lawrence.

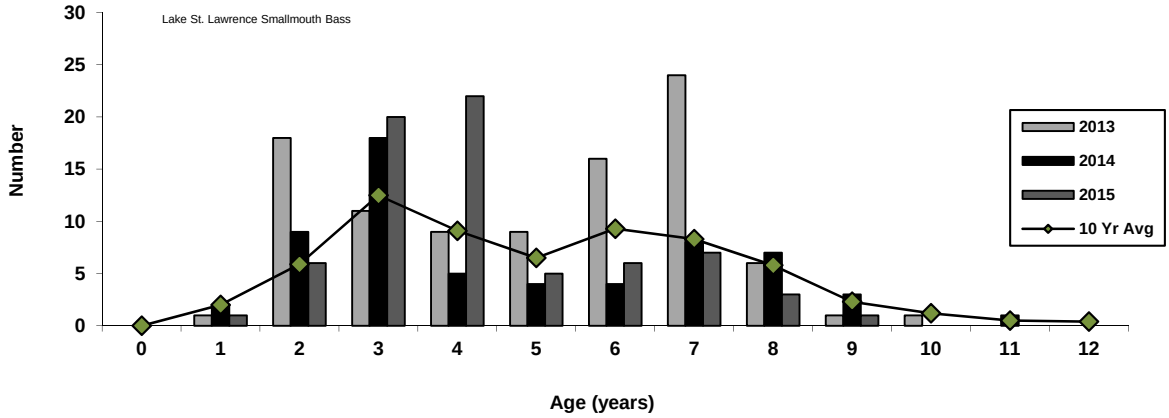

Figure 9. Smallmouth bass age-frequency distribution for Lake St. Lawrence.

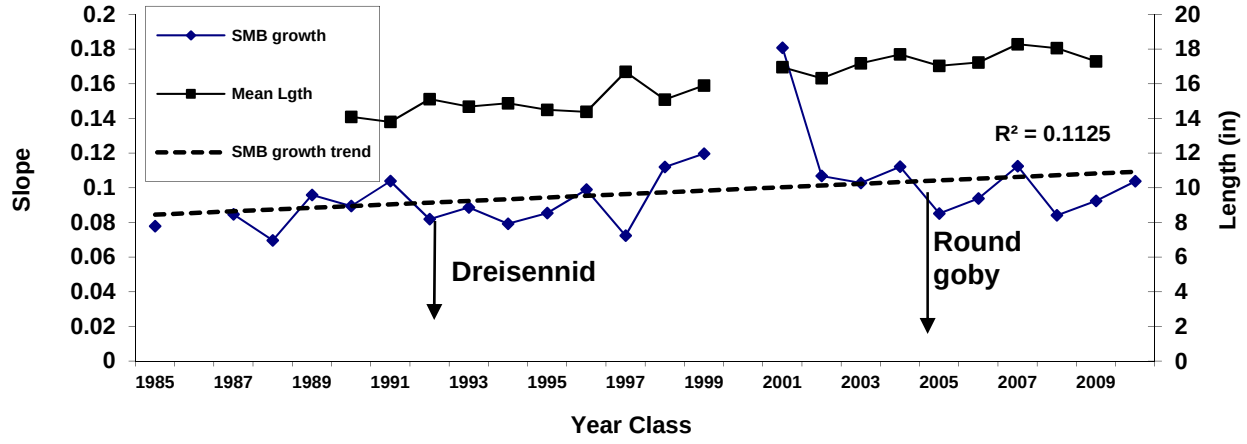

Figure 10. Smallmouth bass growth by year class described using two methods: growth rate (slope) using fish ages 3-7 and mean length (in) at age-6.

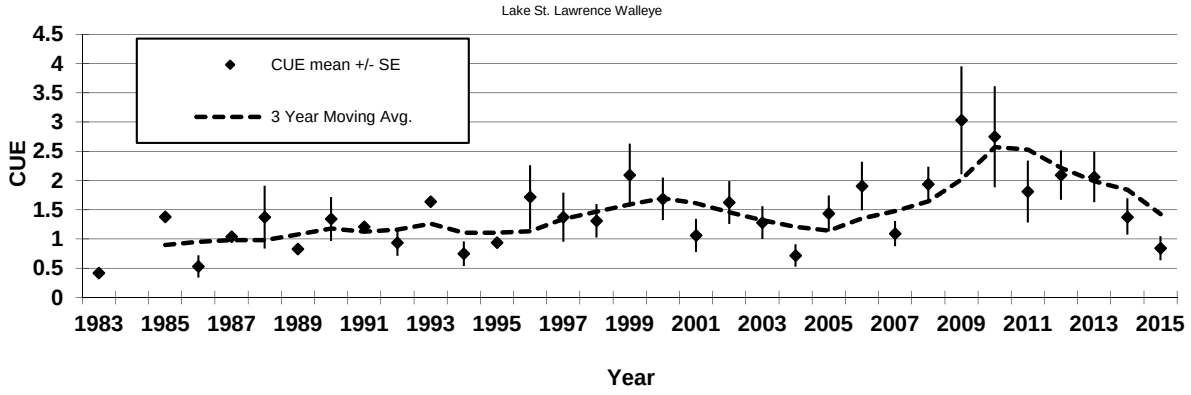

Figure 11. Total catch per gill net night (CUE) for walleye in Lake St. Lawrence, 1983-2014.

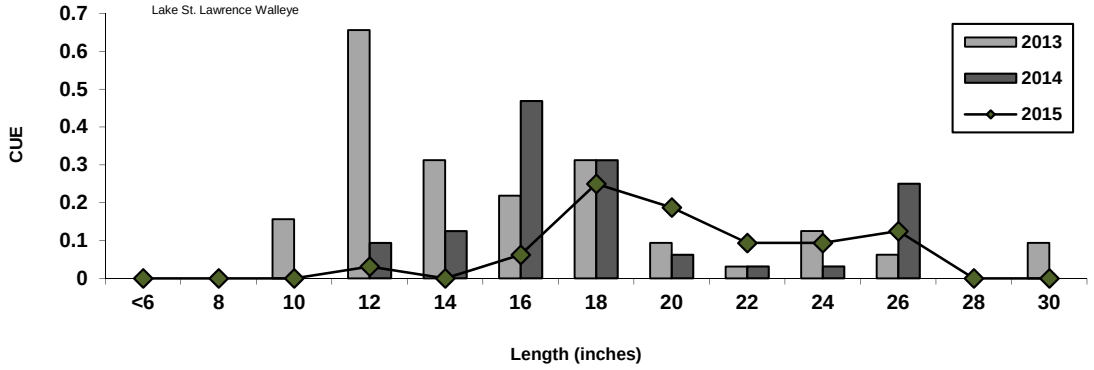

Figure 12. Walleye length-frequency distribution for Lake St. Lawrence.

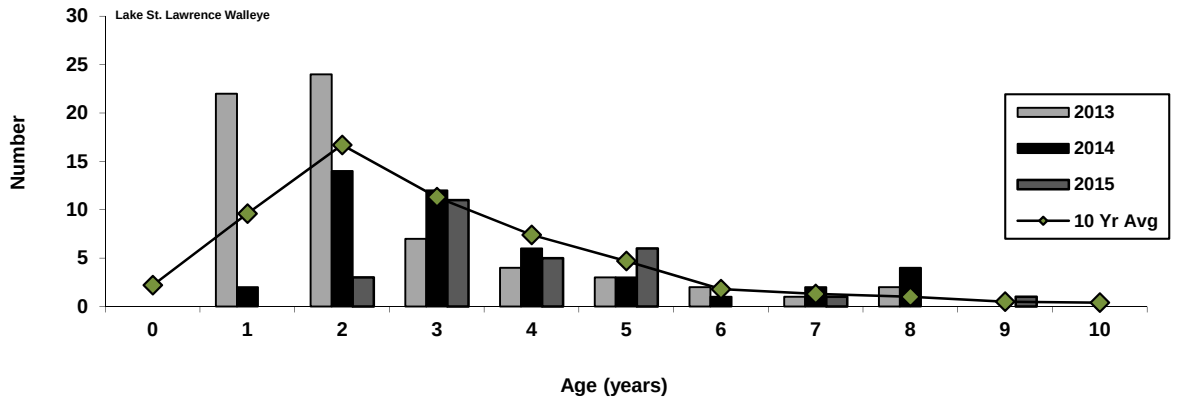

Figure 13. Walleye age-frequency distribution for Lake St. Lawrence.

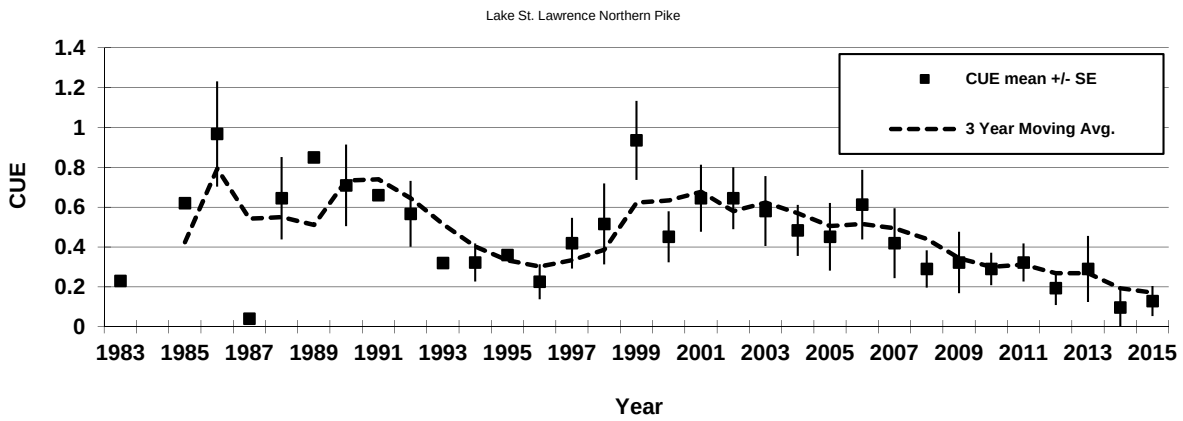

Figure 14. Total catch per gill net night (CUE) for northern pike in Lake St. Lawrence, 1983-2015.

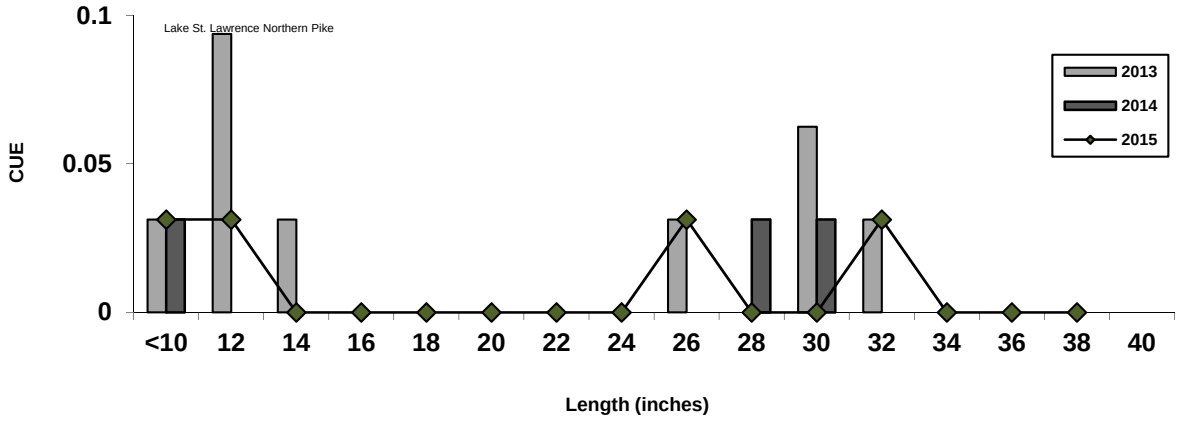

Figure 15. Northern pike length-frequency distribution for Lake St. Lawrence.

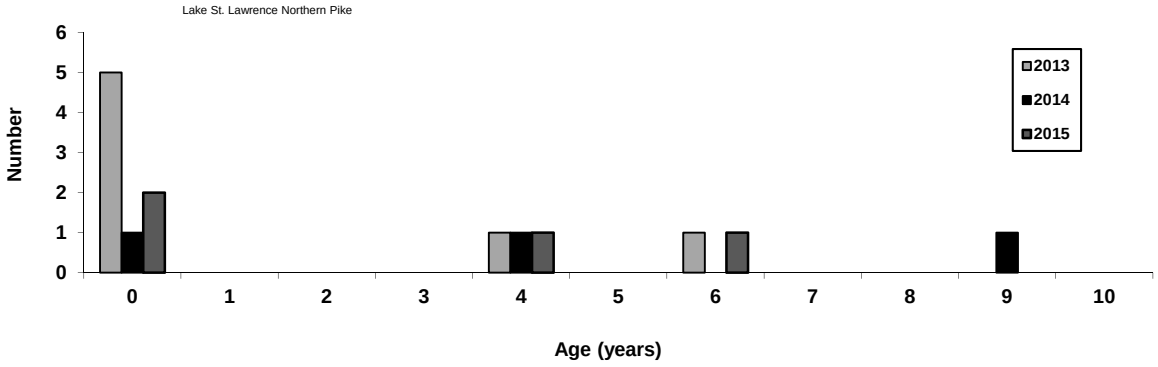

Figure 16. Northern pike age-frequency distribution for Lake St. Lawrence.

2015 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 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

The survey design calls for weekly seine hauls during May and June at 4 sites: Altmar, Pineville, County Rt. 2A, and Douglaston (Figure 1). In June, we were limited to a single sampling date (16 June) due to high flows the rest of the month. 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 an estimate of relative 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. 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). We used correlation and regression analyses to study the relationship between flow characteristics and resulting production (SAS rel. 9.3, Cary NC).

Results and Discussion

High rainfall resulted in high June flow events that prevented sampling in all except the 2nd week in 2015. We are confident, however, that we captured the peak abundance with our surveys during the last three weeks of May. The mean peak catch of 608 YOY Chinook/haul was over double the 2001-2014 average of 283, the second highest mean peak catch observed (Figure 2). Catch was well above average during the last 3 weeks of May (Figure 3). The single largest catch was 2,197 at Altmar on 12 May (second week, Figure 4).

We have previously reported on the importance of adequate flows during the spawning period (October 1 – 21) to allow fish access to the upper river in the face of intense fishing pressure and the negative effects of high flow events during the incubation period (October 22 through May 31) which potentially move bed load and disturb redds. The relationships between flows and subsequent production are not linear and we found the best correlations to be on natural log transformed flows and catches. Mean peak catches were positively correlated with mean spawning flows ($r = 0.53$, $p = 0.04$) and negatively correlated with maximum incubation flows ($r = -0.64$ $p = 0.01$) for the 15 year

study period. Correlation between the mean spawning and maximum incubation flows was weak and insignificant ($r = -0.25$ $p = 0.37$). Additionally, fitting a second order polynomial (i.e., adding an x^2 term) to the spawning flow regression model (Figure 5) increased the explained variability in catch (from $r^2 = 0.28$ to $r^2 = 0.44$ with $p = 0.04$ and 0.03, respectively). Combining the polynomial mean spawning flows and maximum incubation flows in a single model yielded the following regression ($r^2 = 0.64$, $p = 0.01$):

$$y = -0.477x^2 + 6.637x - 0.904z - 7.907$$

Where y = log mean peak catch, x = log mean spawning flow and z = log maximum incubation flow.

Note in Figure 5 that the 2002, 2005, 2012, 2014 and 2015 year classes all had near baseflow conditions (335 cubic feet/second or cfs or log= 5.8) during the spawning period. The largest year class was produced in 2012, and the 2002 year class was below average. This suggests that the prescribed baseflow of 335 cfs generally allows sufficient numbers of fish to reach the spawning grounds, which are predominately located in the upper stretches of the river.

The two years of lowest production were 2003 and 2008. These year classes were both subjected to the lowest mean spawning flows on record, well below the prescribed 335 cfs. Additionally, they were subjected to relatively high maximum incubation flow events. There were, however, some relatively strong year classes produced which withstood similar maximum incubation flows to those of the 2008 year class, suggesting that the spawning flow in fall 2007 likely limited production. Not coincidentally, numbers of Chinook salmon reaching the Salmon River Hatchery in the fall 2007 were insufficient to meet the egg take quota.

The three years of highest production were 2010, 2012 and 2015. Spawning flows were at or near the prescribed base flow of 335 cfs during the spawning period in 2011 and 2014. The 2010 year class resulted from above average spawning flows during the fall of 2009, followed by below average incubation flows. Slightly reduced spawning flows in 2012 (228 cfs) and above average incubation flows resulted in a moderately abundant 2013 year class.

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 Lake and the Salmon River systems (Connerton et al. 2016, Section 3 of this report). From 2010-14, an average of 51% of age-2 and age-3 in the Salmon River harvest were wild. The proportions of wild age-2 and age-3 Chinook salmon in other New York tributaries were lower (3.3% - 24.2%) 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.

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Federal Energy Regulatory Commission (FERC). 1996. Order issuing original license (Major Project). Washington, D.C.: Federal Energy Regulatory Commission. FERC Project No. 11408, New York.

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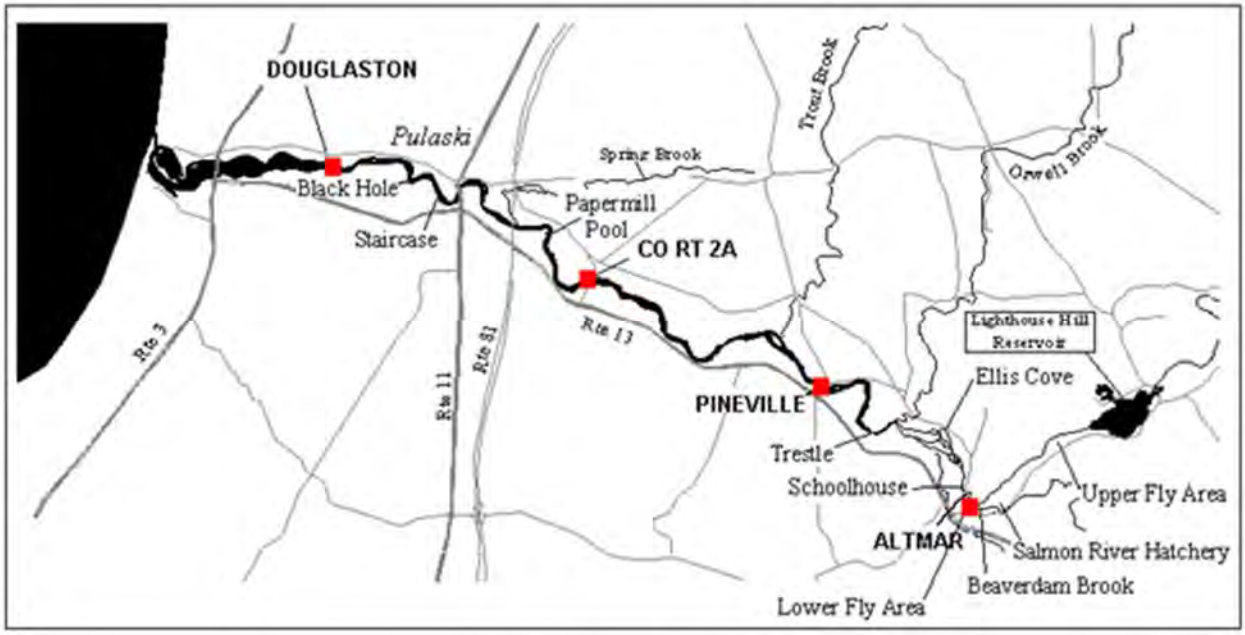


Figure 1. Sampling sites for the USGS/DEC Salmon River seining program.

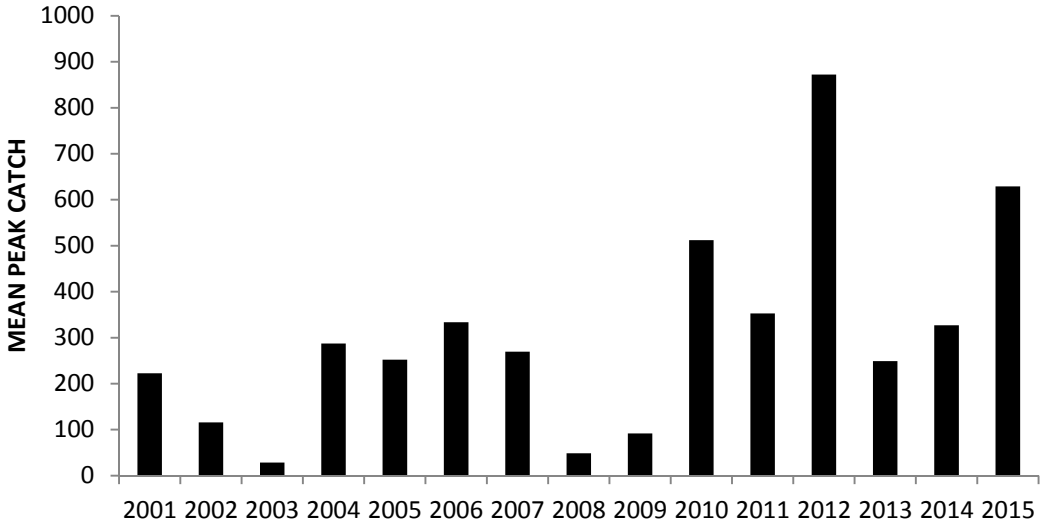


Figure 2. Mean peak catches of YOY Chinook salmon (mean number per seine haul) captured in the three consecutive weeks with the highest catches from the USGS/DEC Salmon River seining program 2001-2015.

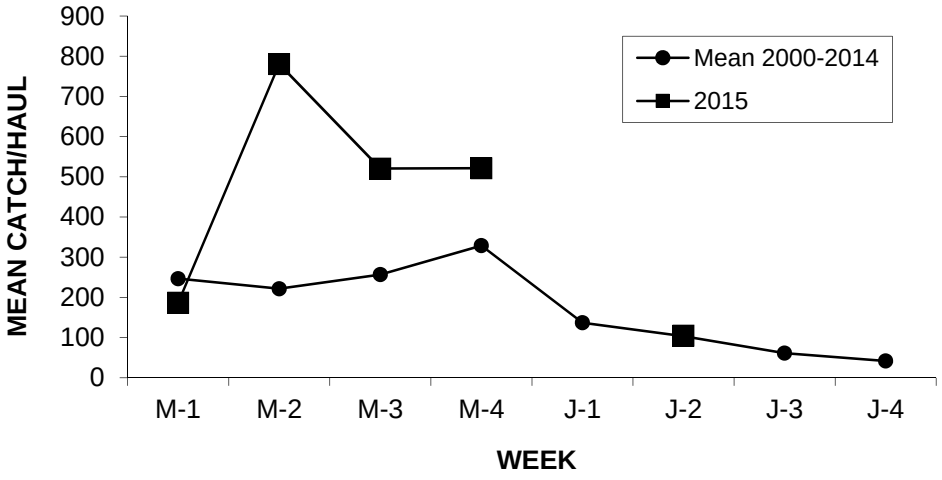


Figure 3. Mean numbers of YOY Chinook salmon captured per seine haul by week in the USGS/DEC Salmon River seining program for 2000-2014 and 2015 (M=May, J=June).

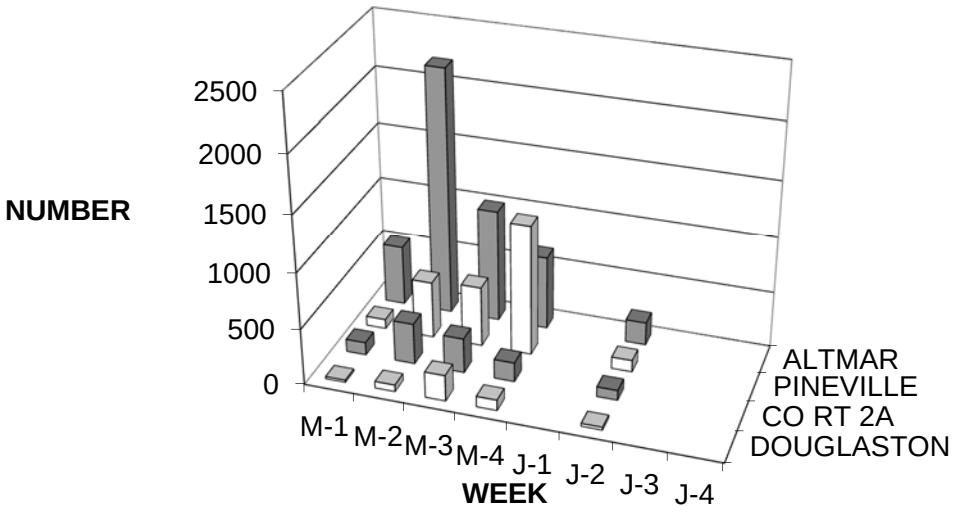
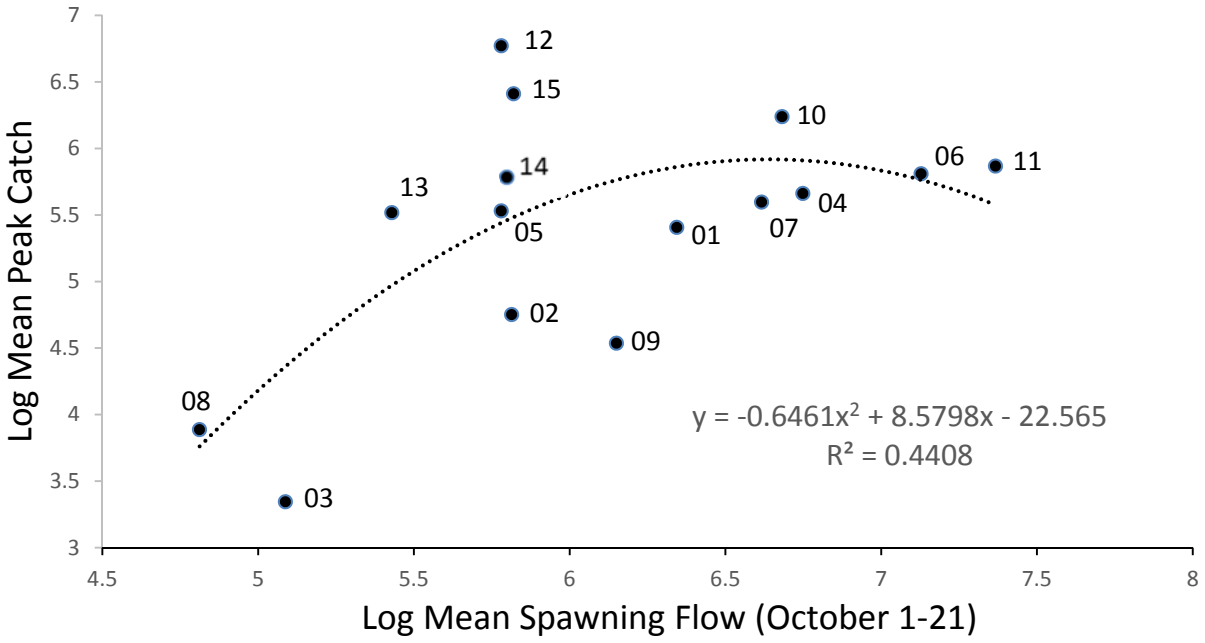


Figure 4. Numbers of YOY Chinook caught by week and site from the USGS/NYSDEC seining program 2015.



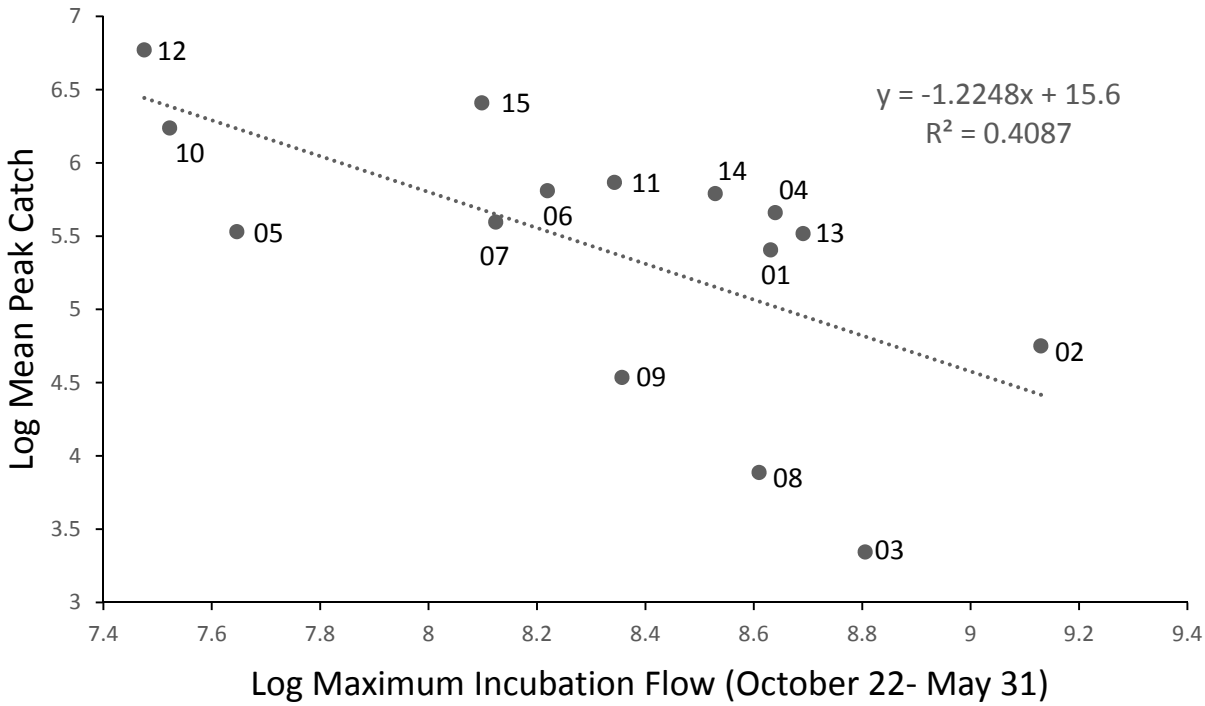


Figure 5. Mean spawning flows from fall of the previous year (top graph) and maximum incubation flows (bottom graph) predicting mean peak catches of YOY Chinook salmon from the USGS/NYSCEC seining program 2001-2015. Combining both flow factors in a single regression model yields (r^2 = 0.64 p = 0.01).

Population Characteristics of Pacific Salmonines Collected at the Salmon River Hatchery 2015

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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

Hatchery Sampling

Staff at the Salmon River Hatchery processed 2,340 steelhead during the spring 2015 spawning operations (Nelson 2015a). Adult Washington strain (Chamber's Creek) winter run fish comprised 93% (2,172) of the returns. Marked Skamania strain summer run fish (left pelvic) accounted for the remaining 7% (168)

A total of 2.5 million Washington strain steelhead eggs were taken from 778 females. The Skamania egg total was 210,000 from 72 females. Biological data were collected from 254 Washington strain steelhead.

Returns of Pacific salmon in the fall included 1,904 Chinook salmon (791 females) and 6,457 coho salmon. Biological data were collected at the hatchery from 907 Chinook salmon and 284 coho salmon. The egg totals were 3.7 million Chinook salmon from 746 females and 2.4 million coho salmon from 842 females (Nelson 2015b).

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 2015 was 3.8 pounds which was the second lowest value in the 1988-2015 time series (Figure 1). They weighed significantly less than in 22 of the 29 years compared. Age 2 males were 1.1 pounds below the long term average (13.4 lbs) with 15 years being significantly heavier. Age 2 females were 1.9 pounds below the long term average (14.7 lbs), with only one year (2007) being significantly lighter (Figure 2). Age 3 males were nearly 4 lbs below average (15.0 lbs), significantly lighter than weights observed in 23 of 29 years compared. Age 3 females were 2.4 lbs below the long term average (19.1 lbs), but nearly a pound heavier than in 2014. Mean lengths and weights at age for all species sampled in 2015 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 16.7 pounds in 2014, which was 0.1 pounds above the long term average and nearly identical to the previous three years. This is the eighth consecutive year of at or above average condition, following six consecutive years of below average condition (Figure 3).

The relatively low weights of Chinook salmon sampled in 2014 and 2015 may have been influenced by the preceding winters' unusually cold weather and relatively cooler water temperatures during the summers of 2014 and 2015 which likely contributed to reduced growth rates. Reduced salmon growth during this time period was also reported by Lantry and Eckert (2016).

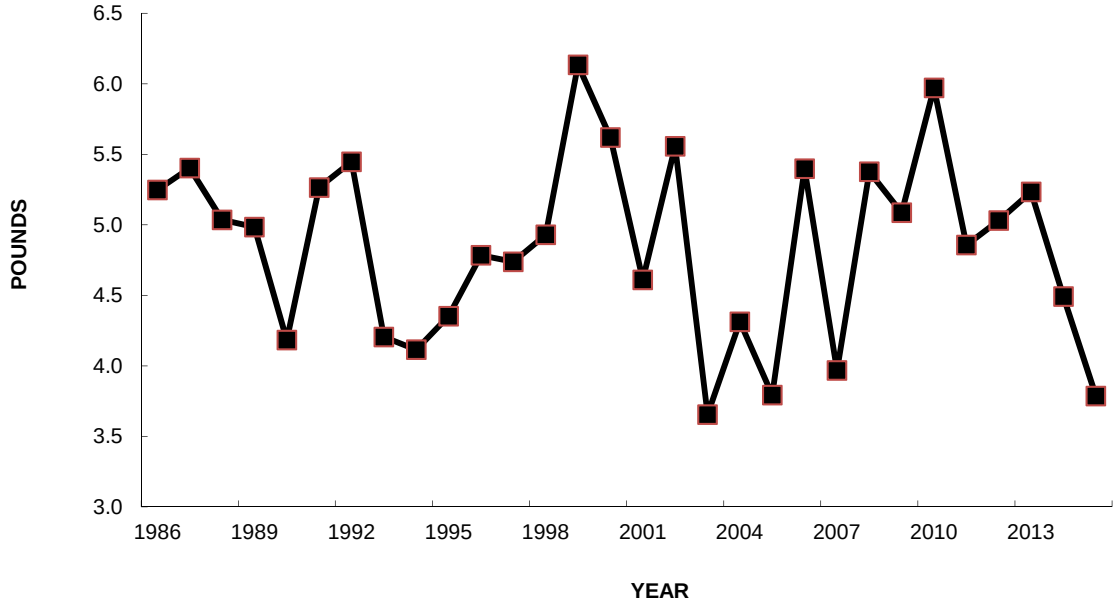

Figure 1. Mean weights of Chinook jacks at Salmon River Hatchery, 1986-2015.

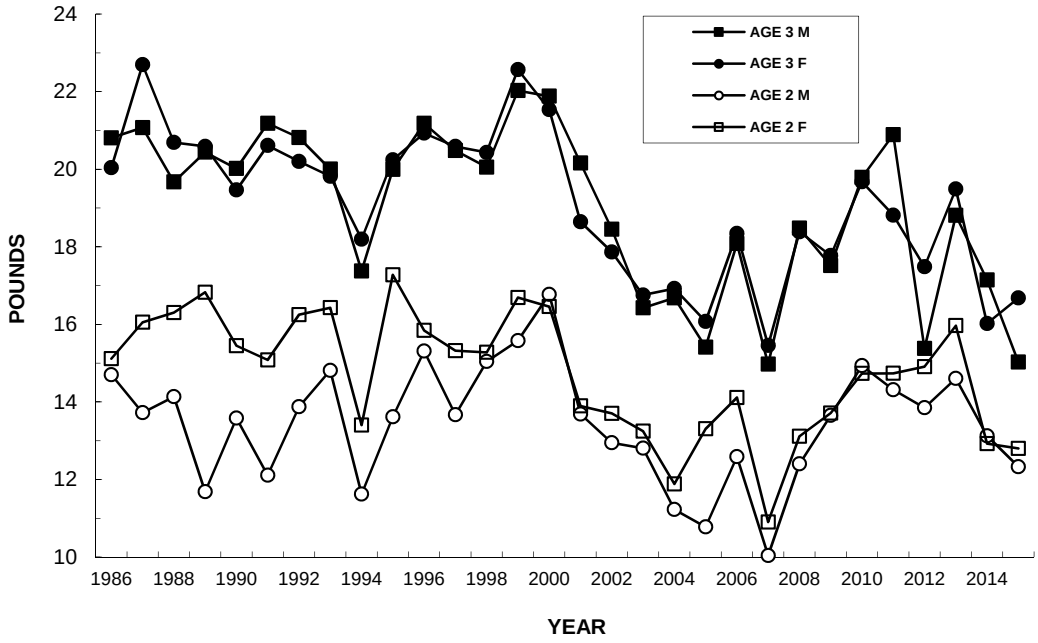

Figure 2. Mean weights of age 2 and 3 Chinook salmon at Salmon River Hatchery, 1986-2015.

Table 1. Mean lengths and weights of Chinook salmon, coho salmon and Washington steelhead sampled at Salmon River Hatchery 2015 (STD= standard deviation).

AGE	SEX	N	MEAN LENGTH (in)	STD	MEAN WEIGHT (lbs)	STD
			CHINOOK SALMON			
1	M	37	21.6	1.7	3.8	0.9
2	M	297	32.3	2.2	12.3	2.6
2	F	89	32.2	4.9	12.8	2.4
3	M	71	35.1	3.5	15.0	3.9
3	F	230	35.8	1.9	16.7	2.9
			COHO SALMON			
1	M	38	13.0	1.9	0.7	0.3
2	M	129	24.4	1.9	5.1	1.4
2	F	117	25.1	1.2	5.9	1.0
			WASHINGTON STEELHEAD			
3	M	95	25.0	2.8	5.3	2.1
3	F	61	26.7	2.8	6.8	2.1
4	M	19	28.2	2.6	7.0	1.9
4	F	64	29.4	1.7	8.8	1.7
5	M	2	32.2	2.0	10.3	3.1
5	F	14	30.3	1.3	9.5	1.5

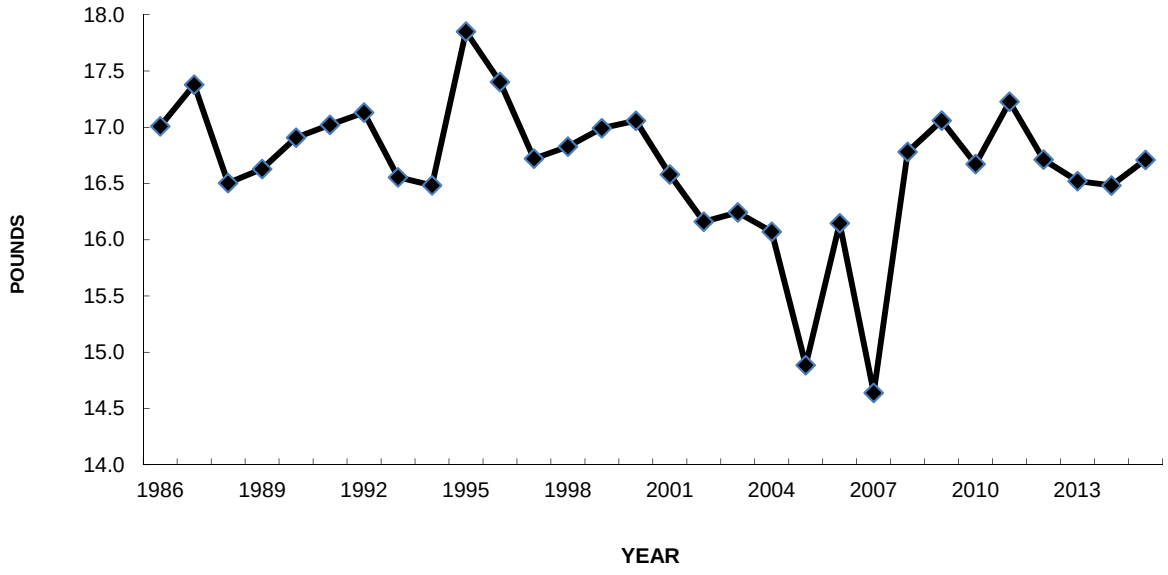

Figure 3. Estimated weights of a 36-inch Chinook salmon from the Salmon River Hatchery fall (October) collections 1986-2015.

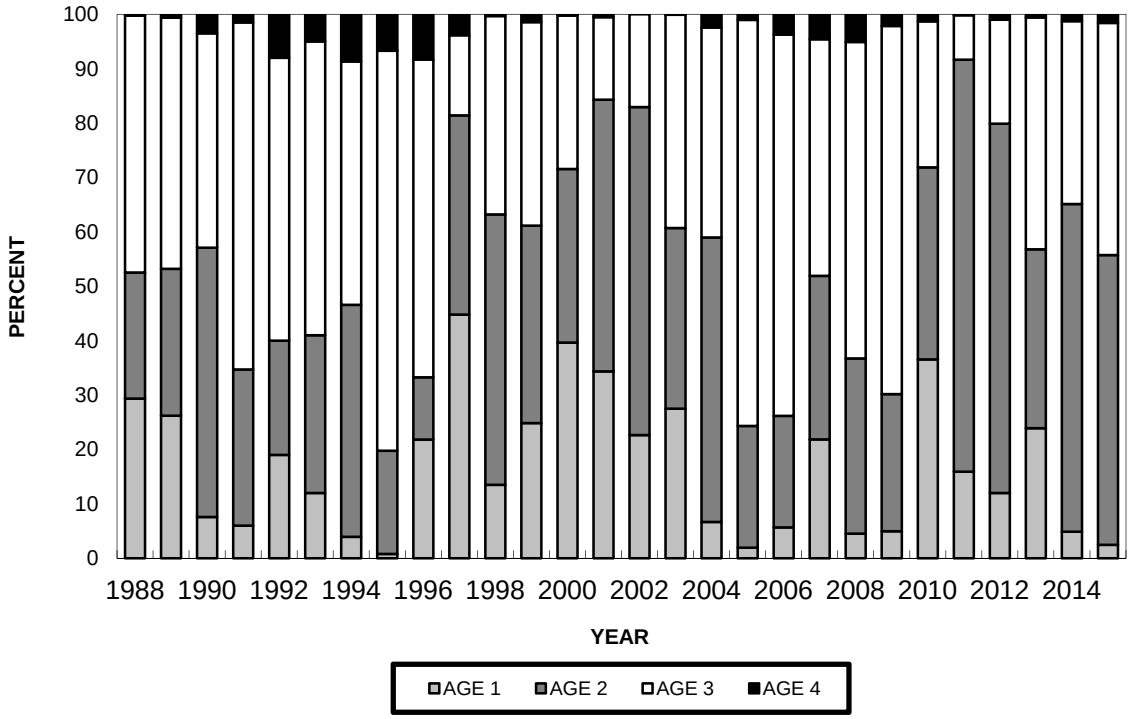

Figure 4. Estimated age structures of Chinook salmon runs at Salmon River Hatchery 1989-2015.

Prey abundance and/or distribution can also influence predator growth. While yearling alewife were at record-low abundance in 2015, adult abundance has been relatively stable since 2011 (Walsh et al. 2016). Given average Chinook condition, it appears that reduced growth was not likely due to nutritional stress.

Age Structure

The estimated age structure of the 2015 Chinook salmon run to the Salmon River Hatchery was 2.5% age-1 males, 53% age-2, 43% age-3, and 1.6% age-4 (Figure 4). This is a fairly normal result following the pattern of either age-2 or age-3 fish comprising the majority of the run. Changes in the dominant age represented in the run are likely influenced strongly by relative Chinook year class strength.

Coho Salmon

Growth

The average weight of age-2 female coho salmon in 2015 (5.9 pounds) was approximately 2.5 pounds less than the long term average (8.4 lbs, Figure 5). Age-2 males (5.1 pounds) weighed 3.1 pounds less than the long term average (8.2 lbs., Figure 5). The males were significantly smaller than every other year in the time series. The 2015 female coho were also the smallest observed, and were significantly different from fish sampled in 27 of 29 years.

Washington Steelhead

Growth

Steelhead are sampled in the spring and, unlike Chinook and coho salmon, do not reflect growth during the 2015 growing season. Weights reported here reflect conditions prior to and including 2014. The mean weights of age-3 males and females were 5.3 and 6.8 lbs, respectively, which were both approximately 0.25 pounds more than their respective long-term averages (Figure 6). The mean weights of age-4 males and females were 7.0 lbs and 8.8 lbs, respectively, with males 0.1 lbs and females 0.3 lbs lighter than their long-term averages. Only age-3 females in 1996 and 2001 (8.7 and 7.7 lbs.) were significantly heavier than those in 2015. Age 3 males fell in the middle of the time series weighing significantly less than those in 11 years.

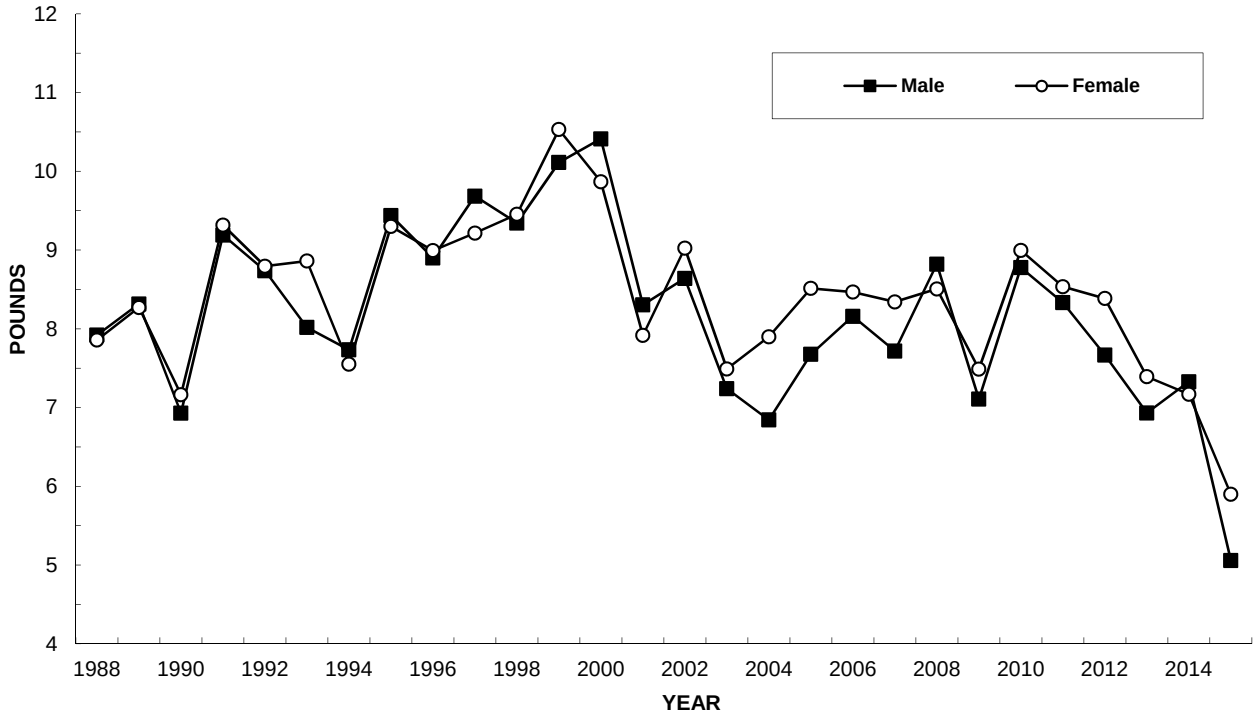

Figure 5. Mean weights of age-2 coho salmon at Salmon River Hatchery, 1988-2015.

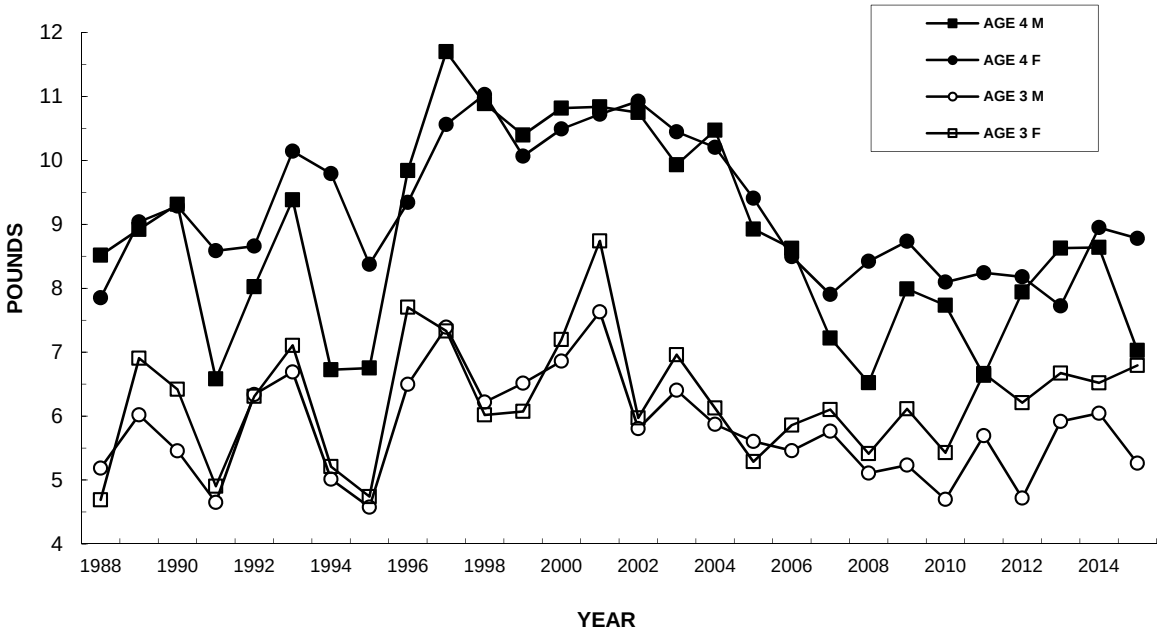

Figure 6. Mean weights of ages 3-4 Washington steelhead at Salmon River Hatchery, 1988-2015.

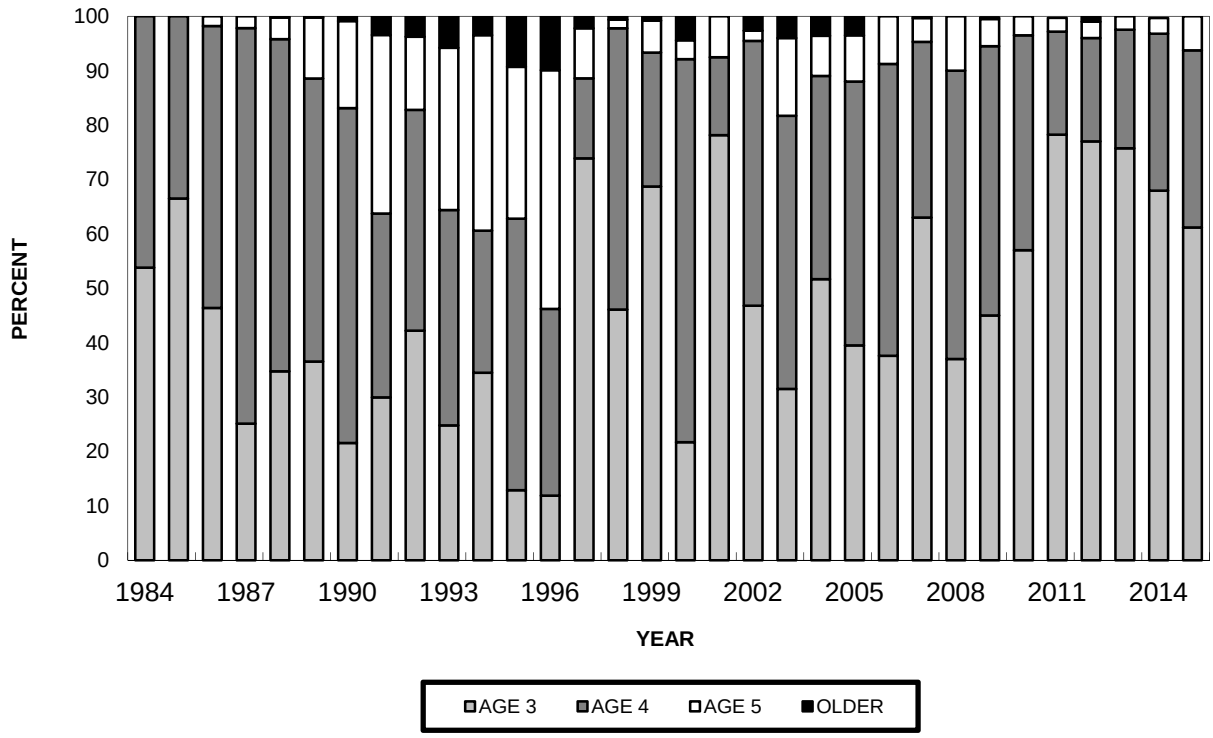

Figure 7. Age structures of Washington steelhead samples at Salmon River Hatchery, 1984-2015.

Age 4 males were not significantly heavier than those in any other year, and were significantly lighter in nine years (none in the last decade). As with age 3 males, Age 4 female average weight was mid-range for the time series, but was not significantly different than in 17 of the 27 years.

Age Structure

Similar to age structures observed in recent years, age-3 and age-4 steelhead dominated the run again in 2015 (Figure 7). As in the previous three years, 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 61% age-3, 33% age-4, 6.3% age-5.

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2015 New York Cooperative Trout and Salmon Pen-Rearing Projects

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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 from 2011-2013. Skamania strain steelhead were reared at Little Salmon River pen site in 2014, and Washington strain in 2015.

This report summarizes pen-rearing activities and results for 2015, the eighteenth 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 2015. 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 (DEC; 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 2015 is provided in Table 2.

Water temperature was monitored primarily using hand-held and digital thermometers, with manual recording of observations. Frequency of

temperature measurements is provided in Table 2.

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 (Connerton et al. 2016). 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 39,560 Washington strain steelhead were raised at seven pen sites, comprising 11.2% of DEC's Lake Ontario steelhead stocking allotment in 2015. (Table 3). Observed mortalities were relatively low at most steelhead pen sites, ranging from 0.02 to 0.36%. Results for all steelhead pen projects are summarized in Table 3.

Seven pen-rearing sites raised a total of 450,800 Chinook salmon fingerlings, representing 25.5% of NYSDEC's 2015 Chinook salmon stocking allotment. Observed mortalities were also low ranging from 0.0 to 0.09%. Results for all Chinook salmon pen projects are provided in Table 3.

At the Olcott, Wilson, Oak Orchard, Sandy Creek, Little Salmon River, and Oswego pen sites, water temperatures approached the release threshold (65°F) established for pen projects. These instances are discussed further in individual project results, which appear below with site location arranged from east to west.

Little Salmon River

Washington strain steelhead for the Little Salmon River project were placed in a pen on 29 April at 20 fish per lb. The steelhead were released 9 days later on 8 May at a weight of 15 fish per lb. Two 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 28 April, weighing 138 fish per lb. Salmon were released on 8 May after 10 days at a weight of 98 per lb. Eleven mortalities were observed.

Little Sodus Bay

At Little Sodus Bay**,** steelhead weighing 20 fish per lb. were delivered to a pen on 29 April. Steelhead were released on 20 May weighing 14.6 fish per lb. Pens were towed to the bay outlet for fish release. Only 1 mortality was reported by the coordinator.

Chinook salmon were also delivered to the pen site on 29 April. Salmon weighed 137 fish per lb when delivered and weighed 65 fish per lb when released on 20 May. Salmon pens were towed to the bay outlet for fish release. No mortalities were reported by the coordinator.

Sodus Bay

Low water levels at Arney's Marina in springs of 2013 and 2014 necessitated moving the pens to a deeper water location at Krenzer Marina in 2015. The same Krenzer Marina site was used from 2000-2003. Chinook salmon were placed into pens on 27 April and grew from 126.9 to 78.6 fish per lb after 19 days. Average length of released salmon was 3.4 in. Forty seven mortalities were recorded. The salmon were released on 16 May at a water temperature of 62°F.

Genesee River

Steelhead were placed into pens on 21 April and held for 22 days. They were released on 13 May weighing 14 fish per lb, compared to a delivery weight of 22 fish per lb. Mortalities were not reported.

Chinook salmon were delivered to Shumway Marina at a weight of 135.5 fish per lb on 21 April. They were held in pens for 22 days and released on 13 May weighing 84.9 fish per lb. Mortalities were not reported.

Sandy Creek

Low water levels at the Sandy Creek pen site caused water temperatures to approach the mandatory release threshold of 65 degrees immediately prior to the scheduled stocking date of 24 April. Hence, all steelhead and Chinook salmon were directly stocked into Sandy Creek near the mouth of Lake Ontario on 30 April and 21 May, respectively. The steelhead were stocked at 20 fish per lb and the Chinook salmon were stocked at 130 fish per lb.

Oak Orchard Creek

Steelhead were delivered at a weight of 22 fish per lb on 22 April. Because of low water levels and temperatures approaching the release threshold of 65 degrees, they were held for only 12 days and released on 4 May. The steelhead weighed 16.3 fish per lb with an average total length of 6 in at release. Mortalities were not reported.

Chinook salmon were delivered at a weight of 133.2 fish per lb on 22 April. They were also held for only 12 days and released on 4 May. At release, the Chinooks weighed 110.8 fish per lb with an average total length of 3.3 in. Salmon and steelhead were released at the pen site, rather than towed to the lake because a large flock of cormorants was observed on the pier at the mouth of Oak Orchard Creek. Water temperature was 65°F on the release date. Mortalities were not reported.

Olcott Harbor

Steelhead were delivered at a weight of 20 fish per lb. on 24 April. They were held for 13 days and released on 7 May weighing 16 fish per lb. Steelhead were released at the pen site several days early due to rising water temperature concerns. Nine mortalities were observed.

Chinook salmon were delivered at a weight of 140 fish per lb. on 24 April. They were held for 14 days and released on 8 May weighing 63 fish per lb. Chinook salmon were released at the pen site several days early due to rising water temperature concerns. Nine mortalities were observed.

Wilson Harbor

The Wilson pen location moved in 2015 from Wilson Boatyard Marina to Bootlegger's Cove Marina. The new site is in the harbor directly at the outflow of E. Branch Twelvemile Creek. Steelhead were delivered at a weight of 20 fish per lb on 27 April. They were held in the pen for 10 days and released on 7 May weighing 14 fish per lb. Steelhead were released at pen site several days early due to rising water temperature concerns. Water temperature at release was 63F. Four mortalities were observed.

Lower Niagara River

The lower Niagara River pen site is typically last to receive fish due to slowly warming water temperatures. Steelhead were delivered on 7 May, weighing about 25 fish per lb. They were held for 19 days and released on 26 May, weighing 12 fish per lb. Steelhead mortalities were not reported.

Chinook salmon were delivered at a weight of 130 fish per lb on 7 May. They were held for 20 days and released on 27 May, weighing 55 fish per lb. Both steelhead and Chinook salmon were released at pen site, and release water temperatures were 60F. Mortalities were not recorded.

Conclusions

Of the seven locations where steelhead were penned, target weights (12-15 fish per lb) were reached at five sites in 2015. Results at other sites were just below target, about 16 per lb.

Chinook target weights (90 fish per lb) were exceeded at five sites, and approached at Oswego (98 per lb). It is likely that a large percentage of the penned salmon imprinted to their respective pen sites, increasing the likelihood that salmon will return as spawning adults.

The eighteenth year of pen-rearing steelhead and Chinook salmon along the New York shoreline of Lake Ontario was successful due to low fish mortality, a substantial percentage of the 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 2015 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 Sodus Point	Krenzer'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 Town of Newfane (including Town Marina)
Wilson Harbor	Bootlegger's Cove Marina	Town of Wilson Wilson Boat House Restaurant Bootlegger's Cove Marina
Lower Niagara River	Constitution Park, Youngstown	Fox Fence Company Niagara River Anglers Association Village of Youngstown

Table 2. Methods used at 2015 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	5	not noted	Pen towed to river mouth for fish release
Oswego Harbor	Hydraulic transfer	5	Rarely	4 times	Fish released at pen site.
Little Sodus Bay	Hydraulic transfer	Automated	1-5	not noted	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	--	--	--	--	--
Oak Orchard Creek	Hydraulic transfer	5	2	every five days	Fish released at pen site; cable ties cut to release fish
Olcott Harbor	Hydraulic transfer	5	5	2/week	Fish released at pen site
Lower Niagara River	Hydraulic transfer	5	1	not noted	Fish released at pen site
Wilson	Hydraulic transfer	5	5	2/week	Fish released at pen site

Table 3. Results of 2015 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	21 Apr	135.5	13 May (22)	84.9	N/A	--
Little Sodus	Chinook	25,000	2	29 Apr	137	20 May (21)	65	0	0.00
Lower Niagara	Chinook	75,000	1	7 May	130	27 May (20)	55	N/A	--
Oak Orchard	Chinook	106,750	5	22 Apr	133.2	4 May (12)	110.8	N/A	--
Olcott	Chinook	67,100	3	24 Apr	140	8 May (14)	63	9	0.013
Oswego	Chinook	41,890	3	28 Apr	138	8 May (10)	98	11	0.03
Sandy Creek	Chinook	0	0	--	--	--	--	--	--
Sodus	Chinook	50,000	2	27 Apr	126.9	16 May (19)	78.6	47	0.09
Genesee	steelhead	7,090	2	21 Apr	22	13 May (22)	14.1	N/A	--
Little Salmon	steelhead	3,410	1	29 Apr	20	8 May (9)	15	2	0.06
Little Sodus	steelhead	4,250	1	29 Apr	20	20 May (21)	14.6	1	0.02
Lower Niagara	steelhead	7,090	1	7 May	25	26 May (19)	12	N/A	--
Oak Orchard	steelhead	9,920	2	22 Apr	22	4 May (12)	16.3	N/A	--
Olcott	steelhead	2,480	1	24 Apr	20	7 May (13)	16	9	0.36
Sandy Creek	steelhead	0	0	N/A	--	N/A	--	--	--
Wilson	steelhead	5,320	2	27 Apr	20	7 May (10)	14	4	0.08

N/A not available

Sea Lamprey Control in Lake Ontario 2015

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Introduction

This report outlines the actions undertaken during 2015 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. Approximately 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.

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 performance of the SLCP is evaluated by contrasting lake-specific adult Sea Lamprey index estimates and Lake Trout marking rates with prescribed targets. Adult Sea Lamprey abundance indices are estimated by the Service and Department by summing mark-recapture estimates from a set of index streams that were selected based on a strong trapping history and large Sea Lamprey spawning runs. The index approach was first used during 2015, replacing regression model estimates of lake-wide abundance that were derived from multiple variables.

Lake Trout marking rates are assessed and collected

by member agencies that comprise the lake committees and their technical committees. A target marking rate of less than 2 A1 marks per 100 Lake Trout was explicitly identified in the Lake Trout rehabilitation plan for Lake Ontario as producing tolerable mortality. The adult index target for Lake Ontario of 11,368 ± 2,917 Sea Lampreys 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).

During 2015, the index of adult abundance in Lake Ontario was estimated to be 10,298 (95% CI; 6,287 – 12,997), which is lower than the index target. The number of A1 marks on Lake Trout from standardized fall assessments in 2015 has not yet been analyzed.

Lampricide Control

Tributaries harboring Sea Lamprey larvae are treated periodically with lampricides to eliminate or reduce larval populations before they recruit to the lake as feeding juveniles. Service and Department control units administer lampricide formulations (TFM or TFM augmented with Bayluscide 70% wettable powder or 20% emulsifiable concentrate) and analyze active ingredients during stream treatments, and apply Bayluscide 3.2% granular (gB) to control populations inhabiting lentic and slow moving estuarine areas. Specialized equipment and techniques are employed to deliver and maintain lampricides at concentrations that eliminate approximately 93% 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, 34 tributaries (16 Canada, 18 U.S.) have been treated with lampricides at least once during 2006-2015. Twenty-seven tributaries (13 Canada, 14 U.S.) are treated on a regular 3-5 year cycle. Details on lampricide applications to Lake Ontario tributaries and lentic areas during 2015 are found in Table 1 and Figure 1.

- Lampricide applications were conducted in 19 streams (10 Canada, 9 U.S.), and in 1 lentic area.
- Altmar Creek (Salmon River tributary, New York) and The Owasco Outlet (Oswego River tributary) were treated in October 2015, based on larval assessments conducted earlier in the field season.
- Twenty-eight hectares of the Black River lentic area was treated for the first time, coinciding with the application of TFM.

Alternative Control

The Service and Department continue to coordinate with the Commission and other partners to research and develop alternatives to lampricide treatments to provide a broader spectrum of strategies to control Sea Lampreys. During 2015, barriers were the only operational alternative control method used. Alternative control methods that are currently being investigated include the use of attractants (e.g. pheromones), repellents (e.g. alarm cues), juvenile trapping, nest destruction 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.

Table 1. Details on the application of lampricides to tributaries of Lake Ontario during 2015 (letter in parentheses corresponds to location of stream in Figure 1).

Tributary	Date	Discharge (m^3/s)	Distance Treated (km)	Liquid TFM (kg)[1]	Soaild TFM (kg)[1]	Wettable Powder Bayluscide (kg)[1]	Emulsifiable Concentrate Bayluscide (kg)[1]	Granular Bayluscide (kg)[1]
Canada								
Rouge R. (A)								
Little Rouge R.	Jun- 2	1.1	17.3	323.0	---	---	---	0.1
Duffins Cr. (B)	Jun-22	3.9	18.1	1138.3	---	---	---	0.1
Lynde Cr. (C)	Jun-3	1.0	24.0	190.6	---	---	---	0.1
Oshawa Cr. (D)	Jun-17	1.0	23.4	270.3	---	---	---	0.1
Farewell Cr. (E)	Jun-25	1.5	12.3	395.3	2.5	---	---	0.1
Wilmot Cr. (F)	Jun-19	0.7	19.0	273.1	---	---	---	0.1
Salem Cr. (G)	Apr-12	0.3	2.2	77.8	---	---	---	---
Proctors Cr. (H)	Apr-13	0.7	5.9	200.8	---	---	---	---
Trent R. (I)								
Mayhew Cr.	Apr-14	0.9	2.5	218.3	---	---	---	---
Moira R. (J)	Jun-01	---	---	---	---	---	---	17.2
Total (Canada)		**11.1**	**124.7**	**3087.5**	**2.5**	**0**	**0**	**17.8**
United States								
Black R. (K)	Aug-08	35.0	9.3	2941.0	---	34.4	---	---
Lentic	Aug-07	---	---	---	---	---	---	131.3
Salmon R. (L)								
Altmar Cr.	Oct-08	0.1	1.2	8.0	0.6	---	---	---
Snake Cr. (M)	Apr-19	0.3	4.1	33.7	1.0	---	---	0.1
Catfish Cr. (N)	Apr-19	4.5	1.5	261.9	---	---	---	---
Oswego R. (O)								
Owasco Outlet	Oct-08	4.4	21.6	1112.0	---	---	---	---
Eightmile Cr. (P)	Apr-16	0.9	4.5	82.5	---	---	---	0.1
Sterling Cr. (Q)	May-25	0.7	27.5	284.1	2.9	---	---	0.3
Red Cr. (R)	Apr-18	1.2	11.1	233.4	1.7	---	---	0.1
Sodus Cr. (S)	Apr-17	0.6	2.2	165.8	0.8	---	---	---
Total (United States)		**47.7**	**83**	**5122.4**	**7**	**34.4**	**0**	**131.9**
Total for Lake		**58.8**	**207.7**	**8209.9**	**9.5**	**34.4**	**0**	**149.7**

[1] Lampricide quantities are reported in kg of active ingredient.

Barrier Inventory and Project Selection System (BIPSS)

- Field crews visited 23 structures on tributaries to Lake Ontario to assess Sea Lamprey blocking potential and to improve the information in the BIPSS database.

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 two Canadian and one U.S. barrier:
  - Duffins Creek – The water intake box and the Johnson Screen were relocated closer to the integrated Sea Lamprey trap to improve water inflow and to reduce clogging of the screen with sediment and floating debris.
  - Cobourg Creek –Streambed modifications completed in 2013 to increase flow through the fishway and minimize clogging of the intake screen have been successful for the 2015 operating season. The flow through the fishway will be monitored during the 2016 Sea Lamprey migration for any changes.

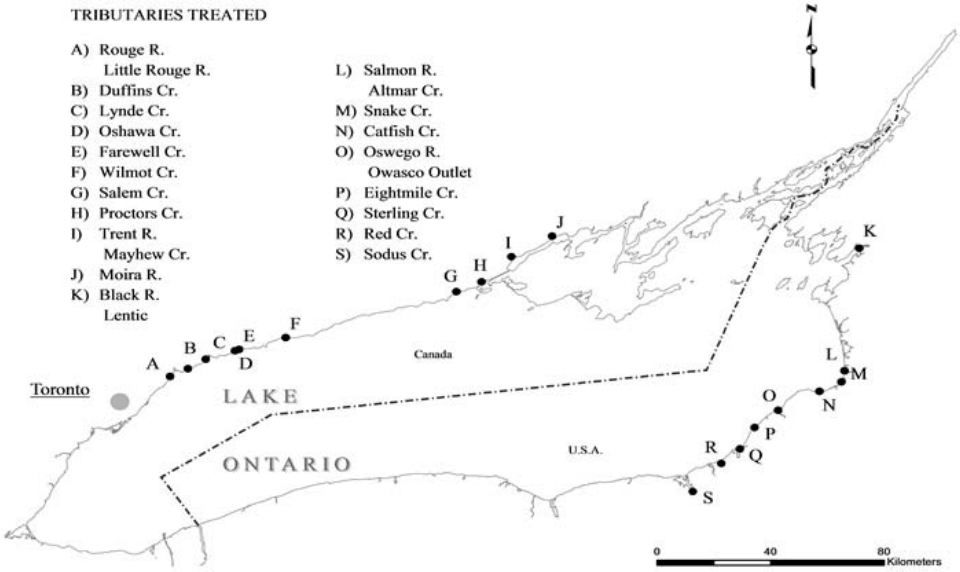

Figure 1. Location of Lake Ontario tributaries treated with lampricides (corresponding letters in Table 1) during 2015.

- Orwell Brook –Restoration of the landowner's footbridge was completed in 2015 at the barrier site on Orwell Brook (Salmon River tributary, New York). The bridge was washed out during the 2014 spring flood.

Ensure Blockage to Sea Lamprey Migration

- Duffins Creek – An investigation is underway to improve safety at the barrier while restoring its Sea Lamprey control function.
- Credit River – Escapement at the Steetsville Dam on Credit River has occurred since it was rehabilitated as a Sea Lamprey barrier in the mid-2000s. Improvements, including installation of an overhanging lip, were completed during 2013-2015. Data loggers were installed in fall of 2015 to gather data on the hydraulic conditions at the barrier.
- Consultations to ensure blockage were conducted with partner agencies for two sites in two streams during 2015 (Table 2).

New Construction

- No new construction projects were initiated or underway.

Assessment of Candidate Streams

- Rouge River: The Toronto Regional Conservation Authority (TRCA) has completed a draft Fisheries Management Plan (FMP), which includes recommendation of a Sea Lamprey barrier feasibility study. The FMP compliments the 2007 Rouge River Watershed Management Plan, which identifies the evaluation of the installation or maintenance of barriers to partition species or to exclude invasive species as a priority for the watershed. Portions of the watershed that were formerly under TRCA jurisdiction will be incorporated

into an Urban National Park under Parks Canada (PC). The latter agency has been apprised of the Department's barrier feasibility studies, including the identification of a barrier site approximately 100 m downstream from the Highway 401 bridge. Topographic data was collected at the site in July 2015.

Assessment

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

1. Larval Assessment determines the abundance and distribution of Sea Lamprey larvae in streams and lentic areas. These data are used to predict where larvae ≥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 an index of adult Sea Lamprey abundance 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 indices is the primary metric used to evaluate the effectiveness of the SLCP.

Larval Assessment

Tributaries being considered for lampricide treatment during 2016 were assessed during 2015 to define the distribution and estimate the abundance 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. Infested areas were ranked for treatment during 2016 based on the most cost-effective kill of larval Sea Lampreys ≥100 mm, based on estimates 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 96 tributaries (65 Canada, 31 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 7 tributaries (5 Canada, 2 U.S.).
- Surveys to detect the presence of new larval Sea Lamprey populations were conducted in 67 tributaries (50 Canada, 17 U.S.). No new populations were detected.
- Post-treatment assessments were conducted in 16 tributaries (10 Canada, 6 U.S.) to determine the effectiveness of lampricide treatments conducted during 2014 and 2015.
- Surveys to evaluate barrier effectiveness were conducted in 8 tributaries (6 Canada, 2 U.S.).
- In 2015, two tributaries to the Credit River system were found to be infested for the first

Table 2. Status of concurrence requests for barrier removals, replacements, or fish passage projects in Lake Ontario tributaries.

Mainstream	Tributary	Lead Agency	Project	SLCP Position	Comments
Gill Cr.		USACE[1]	Gill Cr. Dam	Concur	Lack of habitat
Oswego R.	Spring Br.	NFWF[2]	Stillwell Rd. culvert	Concur	Upstream of blocking barrier

[1]U.S. Army Corps of Engineers.
[2]National Fish and Wildlife Foundation.

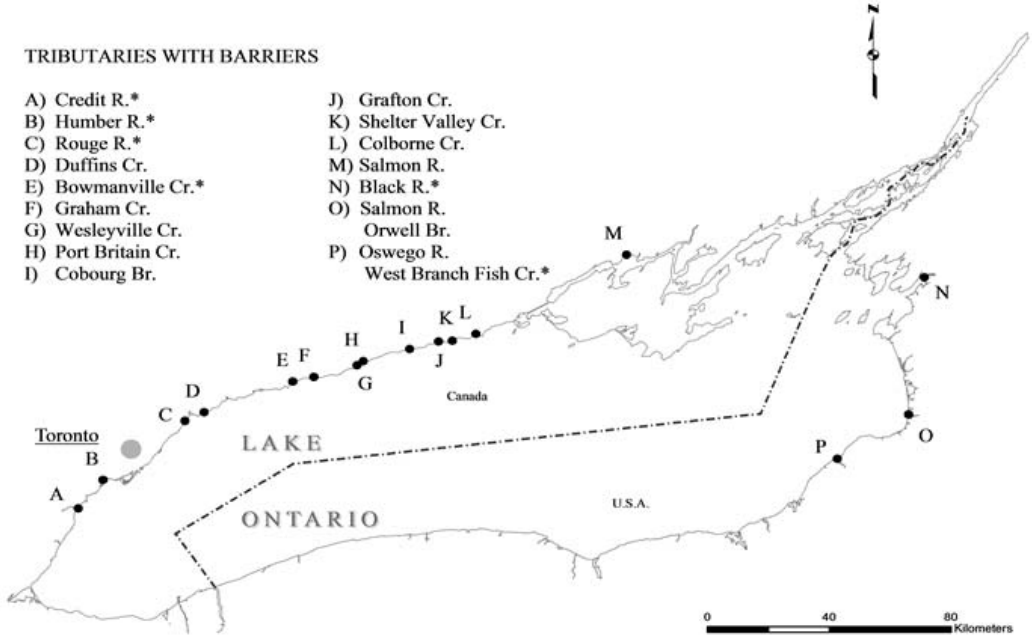

Figure 2. Location of Lake Ontario tributaries with Sea Lamprey barriers. Structures that were not constructed by the Commission, but have been modified to prevent the upstream migration of sea lampreys are indicated by an asterisk (*).

time. Multiple age classes including larval and juvenile life stages were found and are scheduled for treatment during 2016.

- Altmar Creek, a previously uninfested tributary to New York's Salmon River, was found to contain multiple age classes, including juvenile Sea Lampreys.
- A report of adult Sea Lampreys spawning in the Owasco Lake Outlet (Oswego River System) led to the discovery of multiple age classes, including juveniles, in the river.
- Surveys were completed on Bowmanville Creek to evaluate the production potential of Sea Lamprey upstream from the Goodyear Veyance Dam by quantitatively assessing larval habitat and native lamprey abundance and distribution as a surrogate for Sea Lampreys. The larval population estimate of American Brook Lamprey (*Lethenteron appendix)* for the watershed above the Goodyear Veyance Dam was 267,969.
- Larval assessment surveys were conducted in non-wadable lentic and lotic areas using 33.2 kg (active ingredient) of gB.

Juvenile Assessment

The juvenile life stage is assessed through the interpretation of marking rates by feeding juvenile Sea Lampreys on Lake Trout. Used in conjunction with adult Sea Lamprey abundance to annually evaluate the performance of the SLCP, marking rates on Lake Trout are contrasted against the targets set for each lake. Marking rates on Lake Trout are estimated from fisheries assessments conducted by state, provincial, tribal and federal fishery management agencies associated with each lake, and are updated when the data become available. These data provide a

Table 3. Status of larval Sea Lampreys in Lake Ontario tributaries with a history of Sea Lamprey production and estimates of abundance from tributaries surveyed during 2015.

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	Jun-14	---	Yes	---	---	Unknown
Ancaster Cr.	May-03	Jun-15	---	Yes	---	---	Unknown
Grindstone Cr.	Never	Jun-14	---	Yes	---	---	Unknown
Bronte Cr.	Jun-13	Aug-13	Yes	Yes	---	---	***2016***[1]
Sixteen Mile Cr.	Jun-82	Jul-14	No	No	---	---	Unknown
Credit R.	Jun-14	Oct-15	Yes	Yes	137,603	91,289	***2016***
Humber R.	Never	Jun-14	---	No	---	---	Unknown
Rouge R.	Jun-11	Jun-15	---	Yes	---	---	Unknown
Little Rouge. R.	Jun-15	Jun-15	No	No	---	---	Unknown
Petticoat Cr.	Sep-04	Jul-14	No	No	---	---	Unknown
Duffins Cr.	Jun-15	Jul-15	No	No	---	---	2018[1]
Carruthers Cr.	Sep-76	Jul-13	No	No	---	---	Unknown
Lynde Cr.	Jun-15	Jul-15	No	No	---	---	2018[1]
Oshawa Cr.	Jun-15	Jul-15	Yes	No	---	---	2018[1]
Farewell Cr.	Jun-15	Jul-15	Yes	No	---	---	2018[1]
Bowmanville Cr.	May-14	Jul-14	No	No	---	---	2017[1]
Wilmot Cr.	Jun-15	Jul-15	No	No	---	---	2018[1]
Graham Cr.	May-96	Jul-15	---	No	---	---	Unknown
Wesleyville Cr.	Oct-02	Jul-14	No	No	---	---	Unknown
Port Britain Cr.	Apr-12	Jul-15	---	Yes	5,930	1,399	**2016**
Gage Cr.	May-71	Jul-13	---	No	---	---	Unknown
Cobourg Br.	Oct-96	Jun-15	---	Yes	---	---	Unknown
Covert Cr.	Jun-13	Jun-15	Yes	No	14,050	2,632	***2016***
Grafton Cr.	May-14	Jul-14	No	No	---	---	Unknown
Shelter Valley Cr.	Sep-03	Jul-15	---	Yes	454	151	***2016***
Colborne Cr.	May-14	Jul-14	No	No	---	---	Unknown
Salem Cr.	Jun-15	Jul-15	Yes	No	---	---	2018[1]
Proctor Cr.	Jun-15	Jul-15	Yes	No	---	---	Unknown
Smithfield Cr.	Sep-86	Jul-15	No	No	---	---	Unknown
Trent R. (Canal System)	Sep-11	May-14	No	Yes	---	---	Unknown
Mayhew Cr.	Jun-15	Jul-15	No	No	---	---	2018[1]
Moira R.	Jun-15	Jul-15	Yes	No	---	---	Unknown
Salmon R.	Jun-00	Jun-15	---	Yes	2,935	677	***2016***
Napanee R.	Never	Jul-15	---	Yes	---	---	Unknown
United States							
Black R.	Aug-15	Aug-14	---	---	---	---	2018[1]
Stony Cr.	Sep-82	Aug-14	---	No	---	---	Unknown
Sandy Cr.	Never	Aug-14	---	No	---	---	Unknown
South Sandy Cr.	Apr-13	Aug-15	No	Yes	---	---	***2016***[1]

Table 3. continued

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
Skinner Cr.	Apr-05	Aug-15	---	No	---	---	Unknown
Lindsey Cr.	Jun-14	Aug-15	Yes	Yes	---	---	2017[1]
Blind Cr.	May-76	Aug-14	---	No	---	---	Unknown
Little Sandy Cr.	May-13	Aug-15	No	Yes	---	---	***2016***[1]
Deer Cr.	Apr-04	Aug-14	No	No	---	---	Unknown
Salmon R.	May-14	Aug-14	Yes	Yes	---	---	2017[1]
Orwell Brook	May-14	Aug-15	No	No	---	---	Unknown
Trout Brook	May-14	Aug-14	Yes	Yes	---	---	2017[1]
Altmar Cr.	Oct-15	Aug-15	---	---	---	---	2017[1]
Grindstone Cr.	Apr-13	Aug-15	Yes	Yes	---	---	***2016***[1]
Snake Cr.	Apr-15	Aug-15	No	No	---	---	2017[1]
Sage Cr.	May-78	Jul-13	---	No	---	---	Unknown
Little Salmon R.	Apr-12	Aug-14	No	Yes	---	---	2017[1]
Butterfly Cr.	May-72	Apr-12	No	No	---	---	Unknown
Catfish Cr.	Apr-15	Aug-14	No	Yes	---	---	2018[1]
Oswego R.							
Black Cr.	May-81	Aug-14	No	No	---	---	Unknown
Big Bay Cr.	Sep-93	Aug-15	No	No	---	---	Unknown
Scriba Cr.	Jun-10	Apr-14	No	No	---	---	Unknown
Fish Cr.	Jun-13	Aug-15	No	Yes	---	---	***2016***[1]
Carpenter Br.	May-94	Apr-12	No	No	---	---	Unknown
Putnam Br./							
Coldsprings Cr.	May-96	Aug-15	No	No	---	---	Unknown
Hall Br.	Never	Aug-15	---	No	---	---	Unknown
Crane Br.	Never	Apr-12	---	No	---	---	Unknown
Skaneateles Cr.	Never	Oct-10	---	No	---	---	Unknown
Owasco Outlet	Oct-15	Aug-15	---	---	---	---	Unknown
Rice Cr.	May-72	Aug-15	---	No	---	---	Unknown
Eight Mile Cr.	Apr-15	Aug-15	Yes	Yes	---	---	Unknown
Nine Mile Cr.	May-11	Aug-14	No	Yes	---	---	Unknown
Sterling Cr.	May-15	Aug-15	Yes	Yes	---	---	2018[1]
Blind Sodus Cr.	May-78	Jul-13	---	No	---	---	Unknown
Red Cr.	Apr-15	Aug-15	No	Yes	---	---	Unknown
Wolcott Cr.	May-79	Aug-14	No	No	---	---	Unknown
Sodus Cr.	Apr-15	Aug-15	No	No	---	---	Unknown
Forest Lawn Cr.	Never	Aug-15	---	Yes	59	59	Unknown
Irondequoit Cr.	Never	Aug-14	---	No	---	---	Unknown
Larkin Cr.	Never	Aug-15	---	No	---	---	Unknown
Northrup Cr.	Never	Aug-15	---	No	---	---	Unknown
Salmon Cr.	Apr-05	Aug-15	No	Yes	---	---	Unknown
Sandy Cr.	Apr-14	Aug-14	No	Yes	---	---	Unknown

Table 3. continued

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
Oak Orchard Cr.							
Marsh Cr.	Apr-14	Aug-14	No	Yes	---	---	Unknown
Johnson Cr.	Apr-10	Aug-15	No	No	---	---	Unknown
Third Cr.	May-72	Aug-14	No	No	---	---	Unknown
First Cr.	May-95	Aug-14	No	No	---	---	Unknown

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

Table 4. Status of larval sea lampreys in historically infested lentic areas of Lake Ontario during 2015.

Tributary	Lentic Area	Last Surveyed	Last Survey Showing Infestation	Last Treated
Canada				
Duffins Cr.	Duffins Cr. - lentic	Aug-15	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	Aug-14	Aug-14	Aug-15

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

metric of the mortality inflicted on Lake Trout on a lake-wide basis. The Commission contracts with the Service's Green Bay Fish and Wildlife Conservation Office (GBFWCO) to calculate marking statistics and lake trout abundance estimates to better understand the damage caused by Sea Lampreys.

- Lake Trout marking data for Lake Ontario are provided by the U.S. Geological Survey, Ontario Ministry of Natural Resources and Forestry, and the New York State Department of Environmental Conservation, and analyzed by the Service's GBFWCO.
- The number of A1 marks per 100 Lake Trout >431 mm from standardized fall assessments during 2015 has not yet been analyzed as they are submitted in February of the following year (2016).
- Based on standardized fall assessment data, the marking rate during 2014 was 1.6 A1 marks per 100 Lake Trout >431 mm. The current marking rate is below or very close to the target and has been since 2009 (Figure 3).

Adult Assessment

An annual index of adult Sea Lamprey abundance is derived by summing individual population estimates from traps operated in a specific suite of streams (index streams) during spring and early summer. Mark-recapture estimates are attempted in each index stream, however, in the absence of an estimate due to an insufficient number of marked or recaptured Sea Lampreys, abundance is estimated using the annual pattern of adult abundance observed in all streams and years, and adjusted to the stream-specific average abundance estimate in the time series.

- A total of 4,184 Sea Lampreys were trapped in 8 tributaries, 5 of which are index locations. Adult population estimates based on mark-recapture were obtained from 4 of the 5 index locations; the other (Bowmanville Cr.) was estimated using the relative annual pattern of abundance (Table 4, Figure 4).
- The index of adult Sea Lamprey abundance was 10,298 (jackknifed range; 6,287-12,997), which was less than the target of 11,368 (Figure 5).

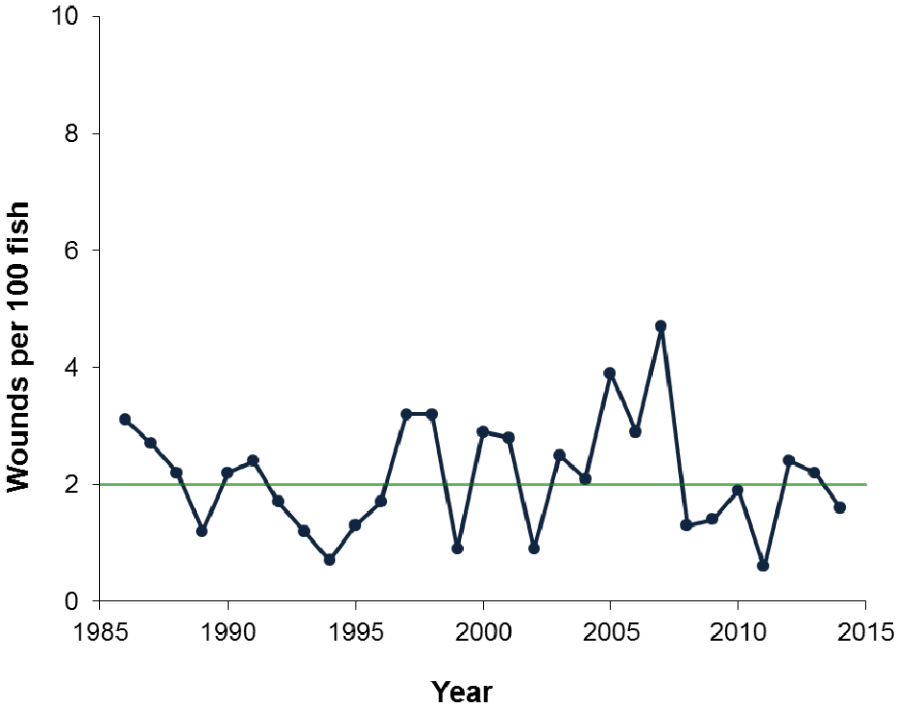

Figure 3. Number of A1 marks per 100 Lake Trout >431 mm from standardized fall assessments in Lake Ontario. The horizontal line represents the target of 2 A1 marks per 100 Lake Trout.

Table 5. Information collected regarding Sea Lamprey adults captured in assessment traps or nets in tributaries of Lake Ontario during 2015 (letter in parentheses corresponds to stream in Figure 4). Tributaries that are not index locations are denoted with a [3].

Tributary	Number Caught	Adult Estimate	Trap Efficiency	Number Sampled[1]	Percent Males[2]	Mean Length (mm) Males	Mean Length (mm) Females	Mean Weight (g) Males	Mean Weight (g) Females
Canada									
Humber R. (A)	1,249	1,733	72	124	50	479	475	246	246
Duffins Cr. (B)	233	441	53	23	52	524	480	311	251
Bowmanville Cr. (C)	25	---	---	5	80	509	511	268	298
Cobourg Cr.[3] (D)	168	265	66	54	59	475	457	249	207
Salmon R.[3] (E)	4	---	---	---	---	---	---	---	---
Total or Mean (Canada)	**1,679**	**---**	**---**	**206**	**53**	**484**	**472**	**255**	**239**
United States									
Black R. (F)	2,316	6,434	36	173	59	504	504	267	277
Salmon R.(G)									
Orwell Br.[3]	40	390	10	1	0	---	456	---	228
Sterling Cr. (H)	149	797	19	17	47	497	483	297	295
Total or Mean (U.S.)	**2,505**	**---**	**---**	**191**	**58**	**503**	**501**	**269**	**279**
Total or Mean (for lake)	**4,184**			**397**	**55**	**493**	**485**	**262**	**257**

[1] The number of Sea Lampreys used to determine percent males, mean length, and mean weight.
[2] Gender was determined using external characteristics.
[3] Not an index location.

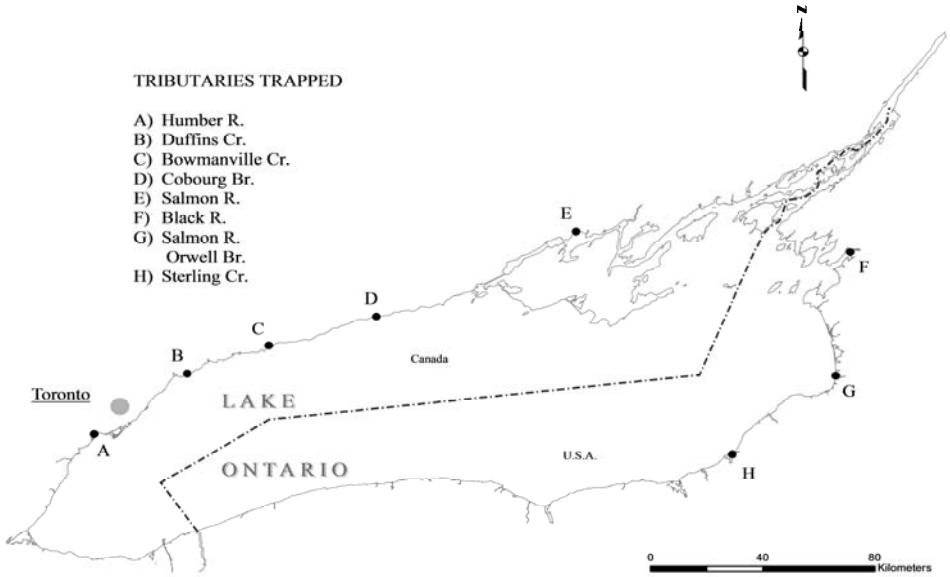

Figure 4. Location of Lake Ontario tributaries where assessment traps were operated (corresponding letters in Table 5) during 2015.

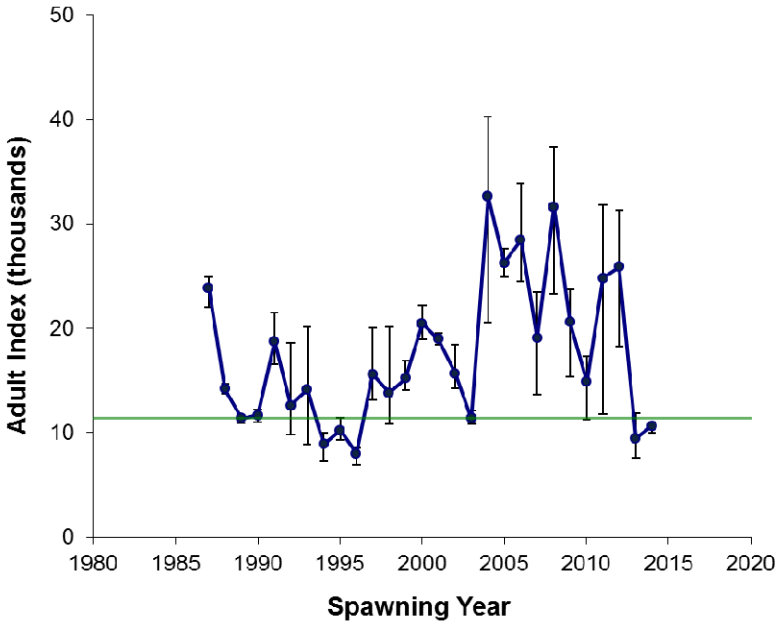

Figure 5. Index estimates with jackknifed ranges (vertical bars) of adult Sea Lampreys. The adult index in 2015 was 10,298 with jackknifed range (6,287-12,997). The point estimate met the target of 11,368 (green horizontal line). The index target was estimated as the mean of indices during a period with acceptable marking rates (1993-1997).

Status of Alewife and Rainbow Smelt in the U.S. Waters of Lake Ontario, 2015

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Abstract

In 2015 the joint USGS and NYSDEC surveys for Alewife and Rainbow Smelt were combined for the first time into a comprehensive spring pelagic prey fish survey. The adult Alewife abundance and weight indices in 2015 increased slightly from 2014 levels, and adult Alewife abundance has remained relatively stable for the past five years. Adult Alewife condition in both spring and fall increased from 2014 values and was above long-term means. Yearling Alewife abundance was the lowest observed in the 38-year time series. Alewife year class strength at age 1 is related to the number of spawning adults and summer temperatures and winter duration in the first year after hatching. Moderate year classes were produced during 2009-2011, and 2012 was the largest year class in the time series. However, severe winters in 2013-2014 and 2014-2015 contributed to two successive very small year classes for the first time in the time series. We expect adult Alewife abundance and biomass to decline in 2016 as older and larger fish decline in the population. The number of spawning adults increased in 2015, summer temperatures were slightly below average, and the anticipated winter duration is below average (i.e., milder winter) for 2015-2016, so these conditions will likely produce a low to moderate year class. A third successive weak year class could be problematic for the Lake Ontario Alewife population and may be of concern to binational lake managers. Rainbow Smelt were also assessed and the population continues to persist at a low and stable level.

Introduction

Non-native Alewife *Alosa pseudoharengus* is the most abundant pelagic planktivore in Lake Ontario and is an important prey for native and introduced salmon and trout and other piscivores (Lantry 2001, USGS 2013 unpublished data). Alewife became established in Lake Ontario in the late 1800s after the opening of the Erie Canal system (Smith 1970), and when populations are abundant, Alewife can alter zooplankton species composition and reduce recruitment of native species by predation on their larvae (Brandt et al. 1987; Johannsson et al. 1991; Madenjian et al. 2008). Alewife also contain the enzyme thiaminase which breaks down thiamine (vitamin B1). Predators that

consume Alewife, like salmon and trout, can suffer from thiamine deficiency which impacts reproductive success (Fitzsimons et al. 1995; Ketola et al. 2000).

Non-native Rainbow Smelt were first reported in Lake Ontario in 1929 and are thought to have gained access from the upstream Finger Lakes, where they were intentionally introduced in 1917 (Greely 1939, Nellbring 1989, Rooney and Patterson 2009). Since the 1960s, Rainbow Smelt have been the second most common pelagic prey fish behind Alewife (Wells 1969). When abundant, Rainbow Smelt were an important diet component of stocked and native Lake Ontario salmonids, as well as native Burbot (Elrod 1983, Brandt 1986). Christie (1972) suggested Lake Ontario Rainbow Smelt negatively influenced native prey fish species, noting that the Rainbow Smelt population increases in the 1940s coincided with declines of native Cisco (*Coregonus artedi*) populations in western lake regions.

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. These data are critical for understanding the ecology of Lake Ontario and for fisheries managers to balance stocked predators and prey populations. Objectives of the collaborative survey include indexing the abundance of Alewife and Rainbow Smelt adults and yearlings, tracking Alewife body condition, collecting aging structures from both species, evaluating diets of dominant prey fish species, and synthesizing data to project the future direction of the Alewife population by providing model estimates of the strength of the next year class. These data, combined with the joint NYSDEC and Ontario Ministry of Natural Resources and Forestry (OMNRF) summer hydroacoustic survey for pelagic fishes and other OMNRF assessment programs, provide a broader perspective on abundance and distribution of both Alewife and Rainbow Smelt and strengthen conclusions of all agencies (see Holden et al. 2016).

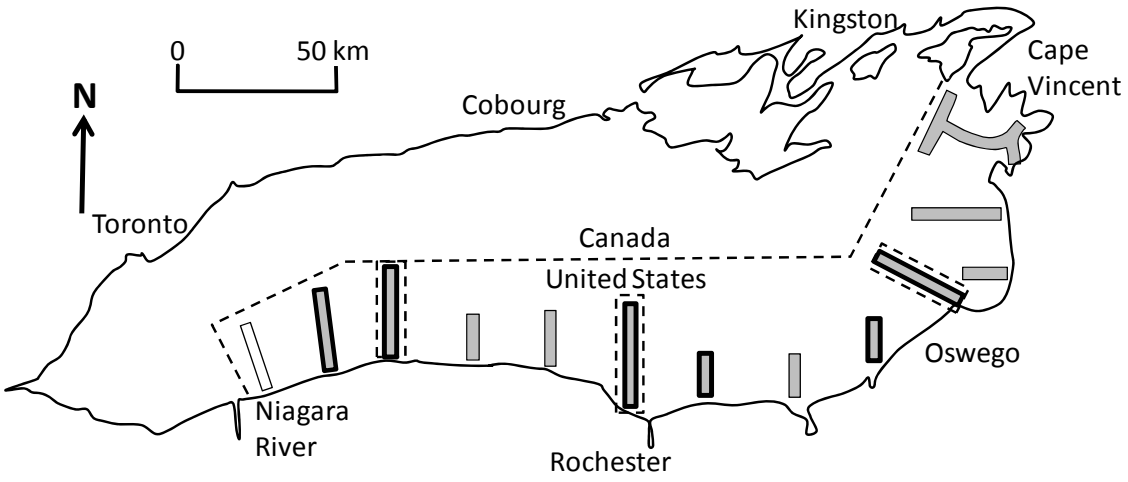

Figure 1. Lake Ontario showing 13 transects sampled in spring 2015 by USGS and NYSDEC with bottom trawls. Historic transect locations, noted as gray bars, from west to east are: Olcott, Thirty Mile Point, Oak Orchard, Hamlin, Rochester, Smoky Point, Sodus, Fair Haven, Oswego, Mexico Bay, Southwick, and Cape Vincent. The dashed outline denotes three "surveillance" transects. Farthest to the west, noted as a white bar, is a new transect located east of the Niagara River, which was sampled by USGS.

Methods

Historically, the USGS and NYSDEC cooperatively conducted two bottom trawling surveys each year in Lake Ontario, one in late April and one in late May for evaluating the status of Alewife and Rainbow Smelt populations, respectively. Analysis of both survey data series investigated the feasibility of conducting a combined spring prey fish survey to index both species while increasing the efficiency and use of vessel time and agency resources (Weidel et al. 2015). Results of these analyses showed that the two survey's data provided similar population trends for Rainbow Smelt, and concluded that one late April-early May survey could index both species by slightly expanding trawl sites and simultaneously collecting biological data for both species.

In our depth-stratified design, effort is allocated equally into western areas (Rochester and West) and eastern areas (Smoky Point and east; Figure 1). We sample three "surveillance transects" across the entire depth range on both spring and fall prey fish assessments, and the July juvenile Lake Trout bottom trawl assessment to allow for comparison of these sites seasonally and annually (Figure 1). Fixed-station sampling designs are commonly used for assessing fish populations in the Great Lakes and in northern Europe (ICES 2004). Although random sampling is preferable for estimating precision, the systematic, fixed-station sampling employed in Lake Ontario is optimal for generating a precise estimate of relative abundance even though the variance of the estimated relative abundance will be biased (ICES 2004). Historic sampling designs were based on targeting single species and used depth distributions of those species to allocate effort for efficient sampling by maximizing effort in areas of predicted higher abundances. To target Alewife, effort focused on deeper (>70 m) depths, while the Rainbow Smelt assessment allocated more effort to shallower depths.

The revised 2015 sampling design increased shallower sites on existing transects, expanded sampling in the Eastern Basin and added a transect east of the Niagara River to expand geographic coverage and habitat sampled (Figure 1). Previously, approximately 100 tows were conducted annually on each survey. In the new design, a total of 144 tows were made during the combined spring cruise. Indices for both species are expressed as depth stratified catch per unit effort for a 10-min bottom trawl tow. Despite additional tow sites added to the research cruise in 2015, the indices for both species were still calculated from specific fixed and randomly selected tows as in past years (see Walsh et al. 2015, Weidel et al. 2015 for more detail) to maintain consistency in indices. To track the variability in abundance indices for both Alewife and Rainbow Smelt, we use the relative standard error (RSE; RSE = 100 * {standard error of the index / the index}). Overall, the changes to sampling strategy allow assessment of both important pelagic prey fish species in a more efficient design. Better coverage of the depth range in U.S. waters also builds flexibility into the survey design to collect other native prey fishes that are relevant to Fish Community Objectives for Lake Ontario (e.g., Emerald Shiner, Threespine Stickleback; Stewart et al. 2013) and increase likelihood of detection of invasive fish species.

For each bottom trawl tow during the survey, Alewife and Rainbow Smelt were counted, weighed, and length-frequency (mm-TL) measured on an appropriate subsample of the catch (50-100 individuals). At each transect, a subsample of Alewife and Rainbow Smelt were measured for individual length and weight, and stomachs, muscle tissue, and aging structures

(whole otoliths for Alewife and fin rays for Rainbow Smelt) were removed for later analyses or archival storage. To index Alewife adult condition annually, we used length-weight regressions (collected in both spring and fall) to estimate the wet weight of a 165-mm (6.5-in) alewife.

The original gear used on this assessment was a nylon Yankee bottom trawl with an 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 changing to a polypropylene 3N1 bottom trawl (3N1 indicates the taper pattern of the trawl) with an 18-m (59 ft) headrope and slotted, metal, cambered V-doors. Paired tows (n=104 during 1995-1998; O'Gorman et al. 2000) were used to calibrate catches between the two sets of gear, and a correction factor derived from these comparison tows is used annually to adjust the 3N1 catch to Yankee trawl equivalents for the Alewife population indices only (correction was not needed for Rainbow Smelt).

In 2015, the USGS included two targeted, complementary hydroacoustics projects during our assessment on the R/V Kaho to 1) evaluate cross-lake daytime distribution of Alewife (one transect in the western region of Lake Ontario and one in eastern region), and 2) evaluate Alewife distribution near bottom during bottom trawl tows. Analyses from these two projects are not completed at this time and results will be reported in the future.

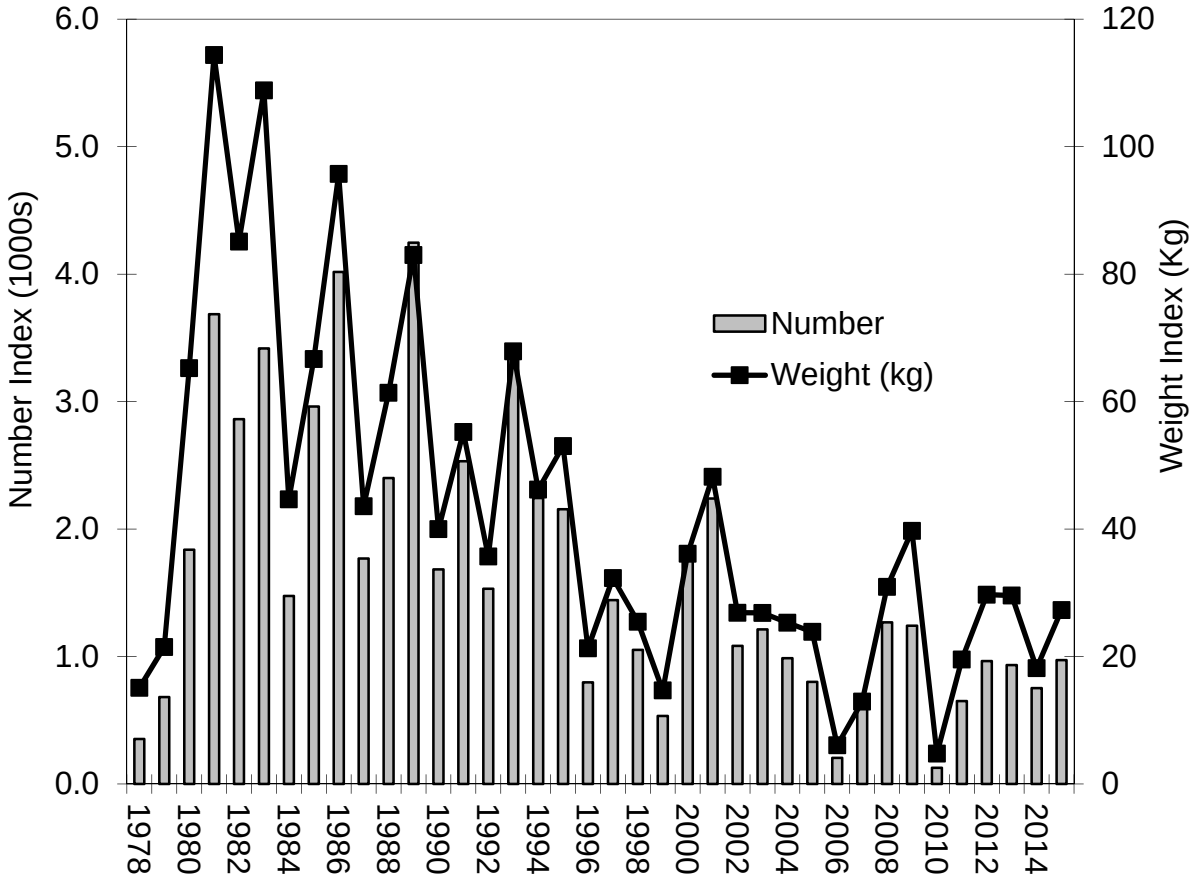

Figure 2. Abundance and weight indices (depth-stratified mean per 10-minute trawl tow) for adult (age-2 and older) Alewife in the U.S. waters of Lake Ontario during late April – early May, 1978-2014. 1 kg = 2.205 lbs.

Results and Discussion

Alewife

In 2015, both the abundance (number) and weight (kg) indices for adult Alewife (age-2 and older) in U.S. waters of Lake Ontario increased slightly compared to 2014 values (Figure 2). The 2015 adult abundance index (972) was 1.29 times the previous 10-year average (772) and about 7.6 times higher than the record low in 2010 (128). The weight index (27.3 kg or 52.1 lb) was 1.25 times the previous 10-year average and 5.7 times higher than the record low from 2010 (4.76 kg or 10.5 lb). Adult Alewife abundance has remained relatively stable for the past five years.

The summer hydroacoustic prey fish survey conducted annually by the NYSDEC and OMNRF, which reports yearling and older Alewife numbers combined, indicated a 45 percent decline in Alewife abundance from 2014 to 2015 (Connerton and Holden, this report). The hydroacoustic and bottom trawl results are consistent, however, because the record low number of yearlings observed in 2015 during the spring bottom trawling survey (see text below) is included in the adult summer hydroacoustic estimate. Targeted analyses of catchability and selectivity of both the bottom trawl and hydroacoustic program are ongoing to better understand population density estimates derived from each method.

Remote sensors have been used on trawling gear (i.e. trawl mensuration gear) over the past decade to measure changes in the shape of the bottom trawl as it is deployed and fished at a variety of depths. Sensors are attached at various points on the trawl and/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 3N1 bottom trawl have enabled us to estimate time on bottom and area-swept by the trawl and allowed us to evaluate these variables relative to fishing depth. These data, also confirmed by underwater cameras in 2013, suggest the 3N1 trawl is in contact with the bottom and being pulled at effective speeds to capture fish for longer periods of time than previously thought. This additional time and area swept increases with fishing depth such that the area covered by a trawl towed at 170 m (558 ft) is three times greater than the area covered by the trawl at 8 m (26.2 ft) when towed for the same amount of time (Weidel and Walsh 2013). The relationships between area swept and fishing depth will allow us to estimate fish density over different depths (e.g, see Weidel and Walsh 2015, Section 13 of this report for benthic fishes). The historical use of indices allows comparison among years, but a measure of lake-wide Alewife density or biomass would be more useful to make inferences and comparisons between Lake Ontario and other Great Lakes or other inland lakes. However, additional research is suggested to better understand aspects of Alewife catchability and distribution and behavior around the bottom trawl.

Understanding recruitment dynamics of Alewife helps managers evaluate population structure and make predictions about adult stock size. Age-0 Alewife are not effectively captured by bottom trawls, so we index year class strength during the next spring's bottom trawling survey when Alewife are age 1. The age-1 Alewife abundance index in spring 2015 was the lowest value in the 38-year times series and 23 percent of the long term mean (390) (Figure 3). Age-1 Alewife abundance has been shown to be influenced by summer temperatures [heating degree days >10° C (50° F) before August], winter duration [the number of days near shore water is < 4° C (39° F)], and the number of spawners (adults >150 mm or 5.9 in) (O'Gorman et al. 2004).

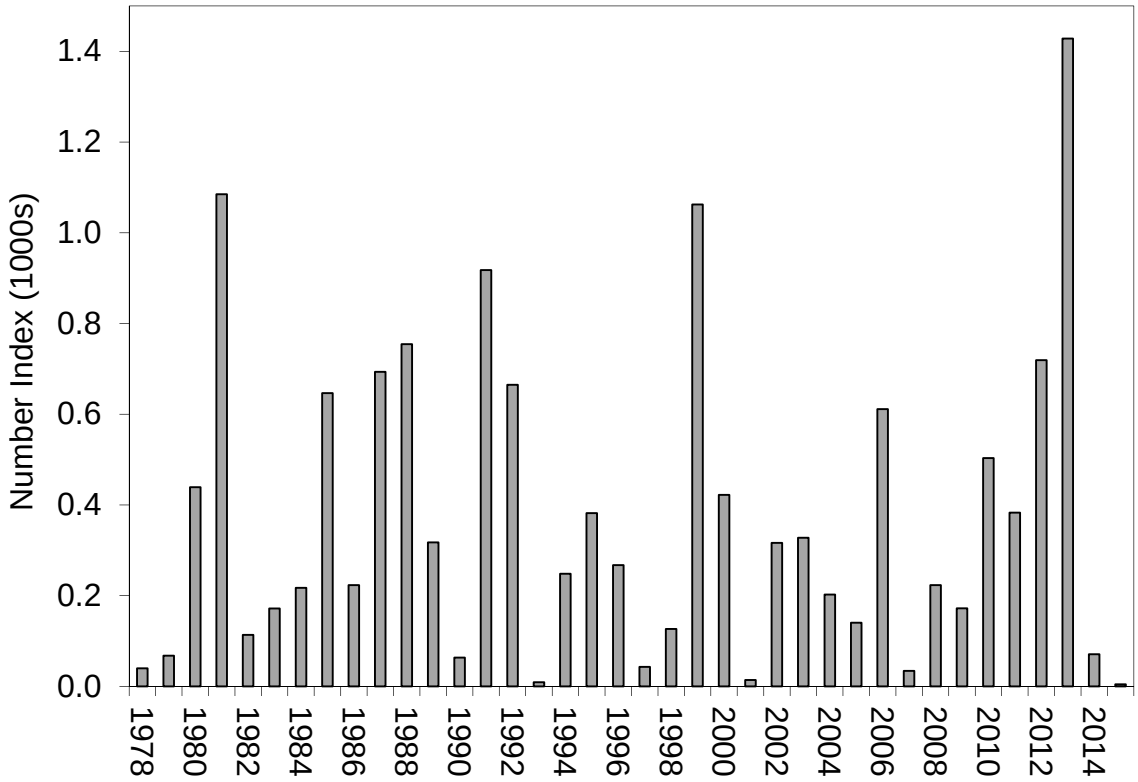

Figure 3. Abundance index (depth-stratified mean per 10-minute trawl tow) for yearling (age-1) Alewife in the U.S. waters of Lake Ontario during late April – early May, 1978-2015.

Weak year classes from 2013 and 2014 (indexed at age 1 in 2014 and 2015, respectively) were likely related to below average summer temperatures and long winter durations in both 2013-2014 and 2014-2015.

The RSE of the adult and yearling indices in 2014 were 17 percent and 26 percent, respectively (Figure 4). These values are below their respective survey averages of 24 and 28 percent.

Adult Alewife condition is measured as the estimated weight of a 165 mm (6.5 in) Alewife and represents the relative plumpness of the fish as a surrogate measure of overall health and resource availability. In 2014, adult Alewife condition had declined slightly from the consistently high range of values observed during 2003-2013, but the 2015 values were above the survey means in both spring (2015=31.5 g or 1.1 oz, mean=30.8 g or 1.09 oz) and fall (2015=34.7 g or 1.2 oz, mean=32.5 g or 1.15 oz) (Figure 5). Our spawner-recruit model for Alewife incorporates the indices of summer and winter temperatures described above (O'Gorman et al. 2004) and predicted the below average year classes observed at age 1 in both 2014 and 2015. The four relatively strong year classes produced from 2009-2012 (including a record high year class of 2012) are now all part of the adult spawning population in Lake Ontario. However, Alewife >150 mm (5.9 in) are currently 76 percent of the population and will be subject to increased mortality through time, with few smaller fish in the

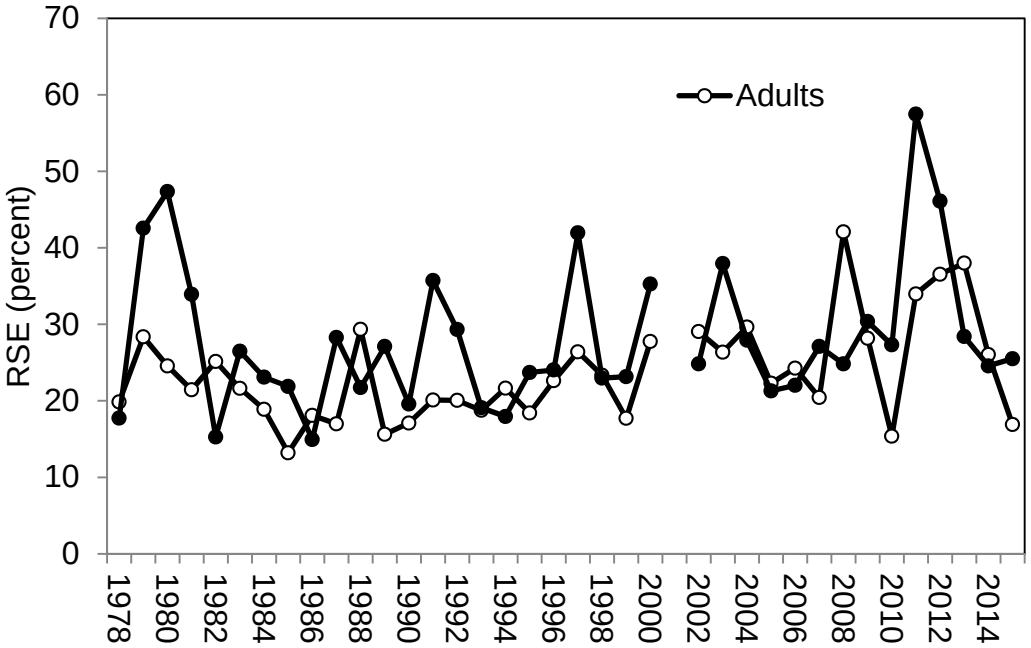

Figure 4. Relative standard error (RSE) for the yearling and adult Alewife abundance indices in U.S. waters of Lake Ontario, 1978-2015. The RSE (RSE = 100 * {standard error of the index / the index}) is a measure of variability in the indices of the index / the index}) is a measure of variability in the indices.

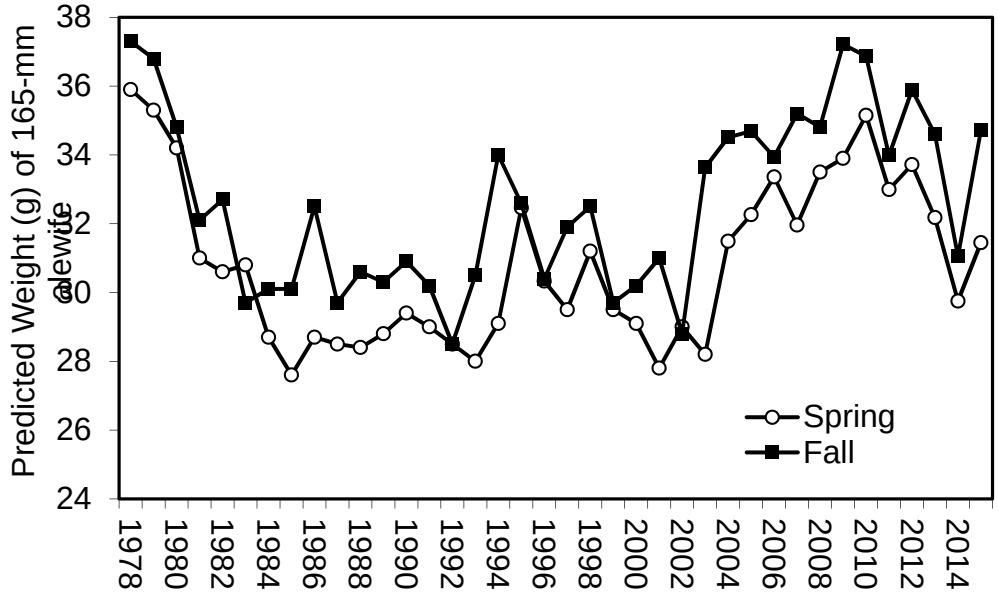

Figure 5. Wet weight of a 165-mm (6.5 in) Alewife predicted from annual length-weight regressions in spring (circle) and fall (square) in Lake Ontario, 1978-2015. 1 gram = 0.035 ounce. Note that the x-axis is truncated to highlight relatively small differences among years.

population due to the weak year classes in 2013-2014.

In Lake Michigan, where Alewife numbers were near historic lows in recent years, the age structure was truncated with less than 1 percent of Alewife older than age 3 and no alewife older than age 5 (Madenjian et al. 2013). Older Alewives in sufficient number are important for reproduction. The maximum age observed in Lake Ontario was nine.

The adult Alewife population in Lake Ontario has remained relatively stable for the last five years, however, its future direction will depend on temperature conditions in 2016 and persistence of the large 2012 year class in the spawning population. A strong year class is needed in the next two years to sustain the Alewife population. Summer conditions during 2015 were cool, and the temperature index was 76 percent of the mean value since 1978. However, the winter of 2015-2016 has been mild, and the spawning stock of Alewife is relatively strong. Given these conditions we predict a low to moderate year class. A third successive weak year class could be problematic for the Alewife population and would raise concern about imbalance in predator-prey dynamics in Lake Ontario.

Rainbow Smelt

The adult population has remained at low and stable levels since around 2000, and in 2015, the abundance index for adult (age-1 and older) Rainbow Smelt increased relative to 2014 (Figure 6). Variability in the adult abundance index was within the range of the historic time series (Figure 7). Despite low population levels, there is successful reproduction each year to maintain the population. The 2015 abundance index was approximately 60 percent of the 10-year average. The relative standard error of the Rainbow Smelt abundance index has increased over the past 30 years as abundance has declined (Figure 2). Hydroacoustic estimates of Rainbow Smelt density support the bottom trawling population trends for 2015 (Connerton and Holden, this report).

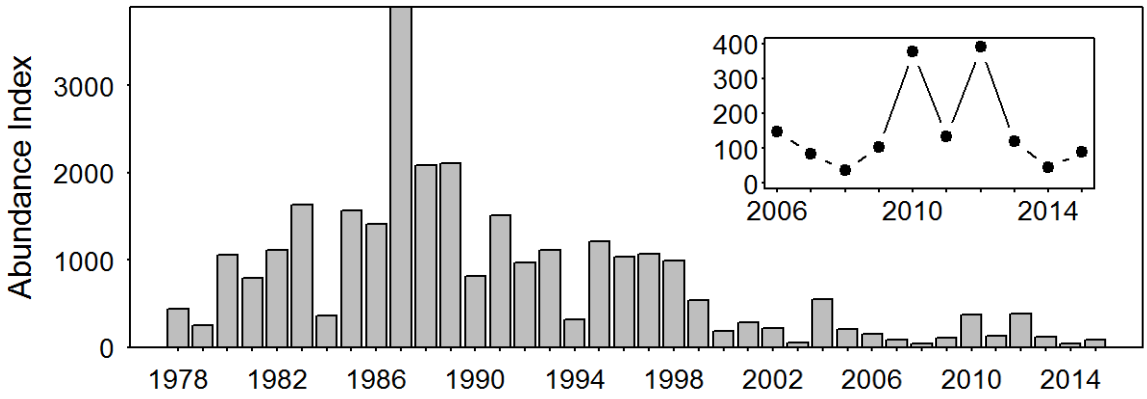

Figure 6. Stratified mean catch of Rainbow Smelt (age-1 and older) from bottom trawls in U.S. waters of Lake Ontario shoreward of the 175-m (574 ft) bottom contour in late May-early June, 1978 - 2015. The inset graph illustrates the last 10 years of data.

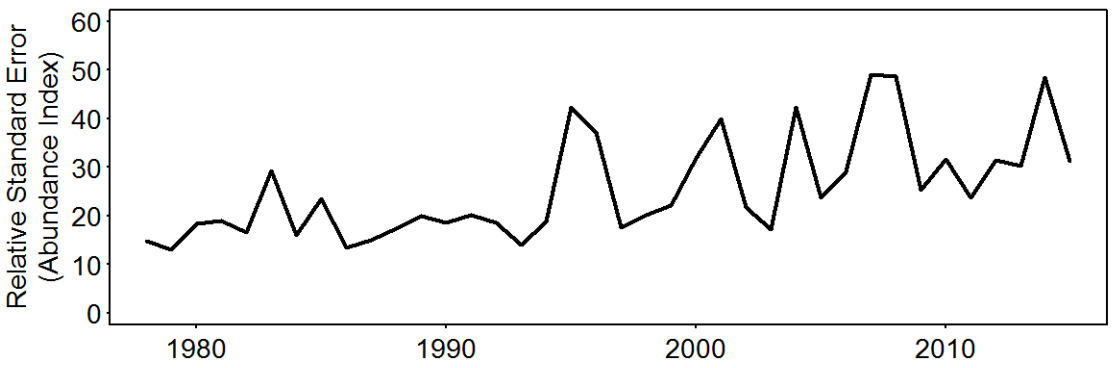

Figure 7. Relative standard error (RSE) of the age-1 and older Rainbow Smelt abundance index (Figure 1) 1978 - 2015.

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Lake Ontario Benthic Prey Fish Assessment, 2015

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Benthic prey fishes are a critical component of the Lake Ontario food web, serving as energy vectors from benthic invertebrates to native and introduced piscivores. Since the late 1970's, Lake Ontario benthic prey fish status was primarily assessed using bottom trawl observations confined to the lake's south shore, in waters from 8 – 150 m (26 – 492 ft). In 2015, the Benthic Prey Fish Survey was cooperatively adjusted and expanded to address resource management information needs including lake-wide benthic prey fish population dynamics. Effort increased from 55 bottom trawl sites to 135 trawl sites collected in depths from 8 - 225m (26 – 738 ft). The spatial coverage of sampling was also expanded and occurred in all major lake basins. The resulting distribution of tow depths more closely matched the available lake depth distribution. The additional effort illustrated how previous surveys were underestimating lake-wide Deepwater Sculpin, Myoxocephalus thompsonii*, abundance by not sampling in areas of highest density. We also found species richness was greater in the new sampling sites relative to the historic sites with 11 new fish species caught in the new sites including juvenile Round Whitefish,* Prosopium cylindraceum*, and Mottled sculpin,* Cottus bairdii. *Species-specific assessments found Slimy Sculpin,* Cottus cognatus *abundance increased slightly in 2015 relative to 2014, while Deepwater Sculpin and Round Goby,* Neogobius melanostomus*, dramatically increased in 2015, relative to 2014. The cooperative, lake-wide Benthic Prey Fish Survey expanded our understanding of benthic fish population dynamics and habitat use in Lake Ontario. This survey's data and interpretations influence international resource management decision making, such as informing the Deepwater Sculpin conservation status and assessing the balance between sport fish consumption and prey fish populations. Additionally a significant Lake Ontario event occurred in May 2015 when a single juvenile Bloater* Coregonus hoyi*, was captured during the spring bottom trawl survey at 95m (312 ft) near Oswego, NY. This native, deep-water prey fish, last captured in Lake Ontario survey trawls in 1983, is part of an international, collaborative coregonid restoration effort in the Great Lakes.*

Introduction

Benthic prey fish community dynamics and the role of benthic fishes in the Lake Ontario food web has changed dramatically over the past five decades. For instance, during the 1970's, native Slimy Sculpin dominated the Lake Ontario benthic prey fish community. At that time, Deepwater Sculpin and deepwater cisco species such as Bloater were considered extremely rare or extirpated in Lake Ontario, such that Slimy Sculpin were the only remaining native benthic prey fish population in offshore lake habitats. Slimy Sculpin underwent two periods of decline, first, when their preferred food, the amphipod *Diporeia* sp., disappeared in the 1990's and again as the nonnative Round Goby increased in the early 2000's (Weidel and Walsh, 2015). Round Goby, a suspected ballast water introduction, were first detected in the Great Lakes in 1990 (Jude et al., 1992) and were first reported in southwestern Lake Ontario in 1998 near the entrance to the Welland Canal (Owens et al., 2003). Since their introduction, Round Goby have become the most common species in the Lake Ontario benthic prey fish community (Weidel and Walsh, 2015). Historically, Slimy Sculpin were an important diet item for native juvenile Lake Trout *Savelinus namaycush* (Elrod and O'Gorman, 1991), but since Slimy Sculpin abundance has declined, Round Goby have become the most important benthic prey fish for Lake Ontario Lake Trout (Rush et al., 2012). Deepwater Sculpin, which is listed on various threatened and endangered species lists, has seen a dramatic population recovery since the mid-2000s (Lantry et al., 2007; Weidel and Walsh, 2015). From 1973-1996 no Deepwater Sculpin were recorded in Lake Ontario catches (Lantry et al., 2007), yet in the 2014 Benthic Prey Fish Survey (BPFS) Deepwater Sculpin were the second most common benthic fish after Round Goby (Weidel and Walsh, 2015) . The United States Geological Survey (USGS) BPFSfunded through the USGS's Ecosystems Mission Area Fisheries Program, has been the critical long-term data series reflecting how the Lake Ontario benthic prey fish community has changed over time.

The BPFS was originally designed to assess the Slimy Sculpin population across the southern shoreline of the lake, yet as the ecosystem changed so did the information needs of resource management and conservation. In 2015, the single-species, targeted survey was substantially modified in order to address lake-wide information needs, especially those related to Deepwater Sculpin and Round Goby. The new, cooperative, lake-wide survey was designed and initiated by the Lake Ontario Prey Fish Working Group and utilized three research vessels: the New York State Department of Conservation's (NYSDEC) RV Seth Green and the Ontario Ministry of Natural Resources and Forestry's (OMNRF) RV Ontario Explorer and the USGS's RV Kaho. The survey expanded bottom trawl sampling to include west, north, and east regions of the lake, while also spreading effort into both shallower and deeper waters to more completely sample the available lake depths (Figure 1). As with the previous survey, data and species assessments are reported to all partner agencies and serve as a primary data source to assess the bi-national Lake Ontario Committee's (LOC) Fish Community Objectives (FCOs; Stewart et al., 2013).

This annual publication reports on the population and community dynamics of Lake Ontario benthic prey fishes with an emphasis on information that supports the LOC's FCO 3.3 that seeks to:

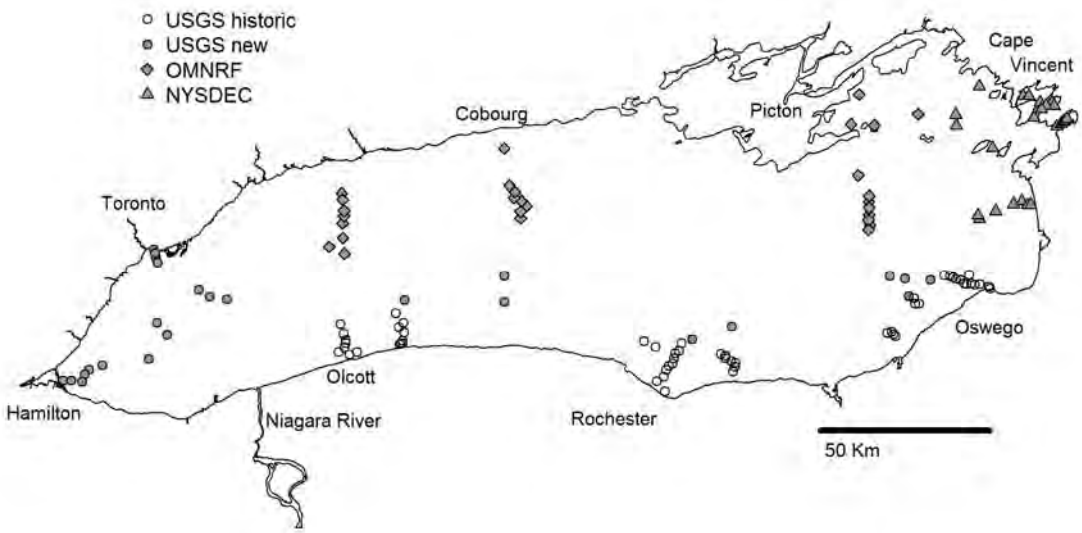

Figure 1. Bottom trawl sites sampled in the 2015 Lake Ontario Benthic Prey Fish Survey. The original sites are noted by open symbols and new sites are shaded gray, with the symbol shape referring to the sampling research vessel.

"*Increase prey fish diversity – maintain and restore a diverse prey fish community that includes deepwater ciscoes, Slimy Sculpin, and Deepwater Sculpin.*"

The specific survey objectives vary slightly by collaborating agency but generally follow those of the USGS Great Lakes Science Center study plan (BASIS+ ND00GAP7) for benthic prey fishes which are to:
1) improve our understanding of native and invasive Lake Ontario benthic prey fish population dynamics and ecology using enhanced partnerships and interdisciplinary approaches and, 2) maintain, develop, and utilize time series, predictive models and assessment tools, using both local and regional data, to quantify anthropogenic impacts on benthic prey fishes and support resource management decision making.

Methods

Sampling - The Lake Ontario BPFS design was initially focused on Slimy Sculpin population dynamics and sampled six transects along the southern shore of Lake Ontario from Olcott, NY to Oswego, NY. Trawl duration was typically 10 minutes and sampled depths from 8 – 150 m (26 – 492 ft), which at the time spanned the entire range of depths inhabited by Slimy Sculpin. The original trawl was a nylon Yankee bottom trawl with an 11.8 m (38.7 ft) headrope, and spread with rectangular wooden trawl doors (2.12 m x 0.95m or 7 X 3 ft). Abundant dreissenid mussel catches led to a variety of alternate polypropylene bottom trawls and metal trawl doors being used from 2004 - 2010. Comparison towing indicated alternate trawls had low and variable catchability for benthic fishes and the alternative trawl doors influenced net morphometry. Since 2011, the survey has

used the historical standard Yankee trawl and reduced tow times to reduce mussel catches. Experimental sampling at new transects and or deeper habitats (maximum tow depth = 220 m or 722 ft in 2014) began in 2012 and revealed the catch composition of new habitats differed, reinforcing the need for a more spatially-distributed survey. In addition to the fall survey, indices for some species are also reported using observations from the Spring Bottom Trawl Survey (e.g., Round Goby, Bloater). That survey focuses on sampling Alewife, *Alosa psuedoharengus*, and Rainbow Smelt, *Osmerus mordax*, and switched sampling gear in 1997 to a "3N1" bottom trawl that is much less effective for capturing benthic fishes as it was designed to avoid capturing dreissenids mussels. Additional details on that survey can be found in the Alewife section of this report.

Analysis - Species assessment methods have also changed to accommodate varied sample designs and take advantage of new trawl morphometry information. Originally, benthic prey fish species-specific abundance indices were based on area-weighted means from two strata: a shallow stratum from 8 - 55 m (461 km^2 or 178^2 mi) and a deep stratum from 60 - 160 m (670 km^2 or 259^2 mi). Population dynamics were reported using abundance or weight indices since estimates of the area swept by trawls were unavailable or unreliable. Advances in our understanding of trawl morphometry, especially with respect to fishing depth, have allowed us to report current and historical catch data in density (e.g. number per hectare) or biomass density (e.g. grams per hectare; Weidel and Walsh 2013). Reporting in these units provides data in a more readily useable form to address ecosystem scale questions and make species and community comparisons across lakes. Time series are still regarded as density indices since we lack estimates of trawl catchability. Catchability is the proportion of fish caught by the trawl that are actually present. Evidence from a similar Lake Erie trawling program suggest that this proportion can be significantly less than one (Kocovsky and Stapanian, 2011), therefore our density indices represent a lower bound

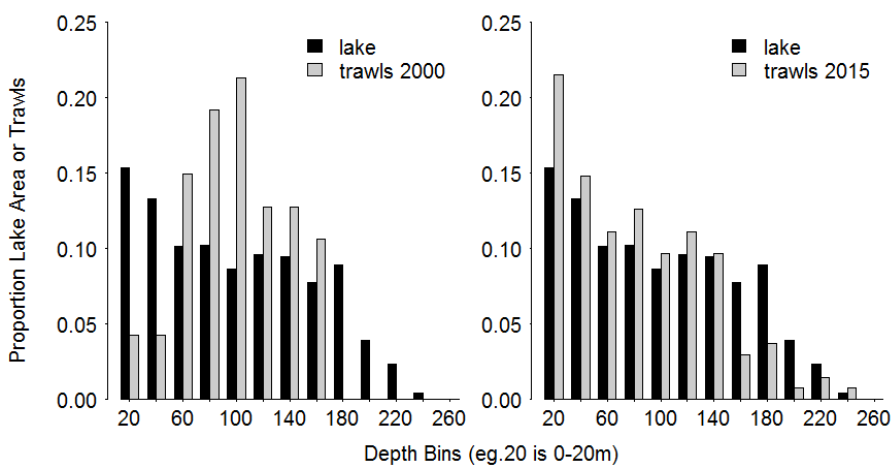

Figure 2. The Lake Ontario Benthic Prey Fish Survey trawl depth distribution (as a proportion of the total) relative to the available lake depths for the 2000 survey (left panel) that more closely followed the historic sampling design and the revised sampling design in 2015 (right panel). Total number of trawls in the historic design ranged from 55 - 60 trawls focused along the southern shore, whereas the new survey is based on 135 trawls from across the lake.

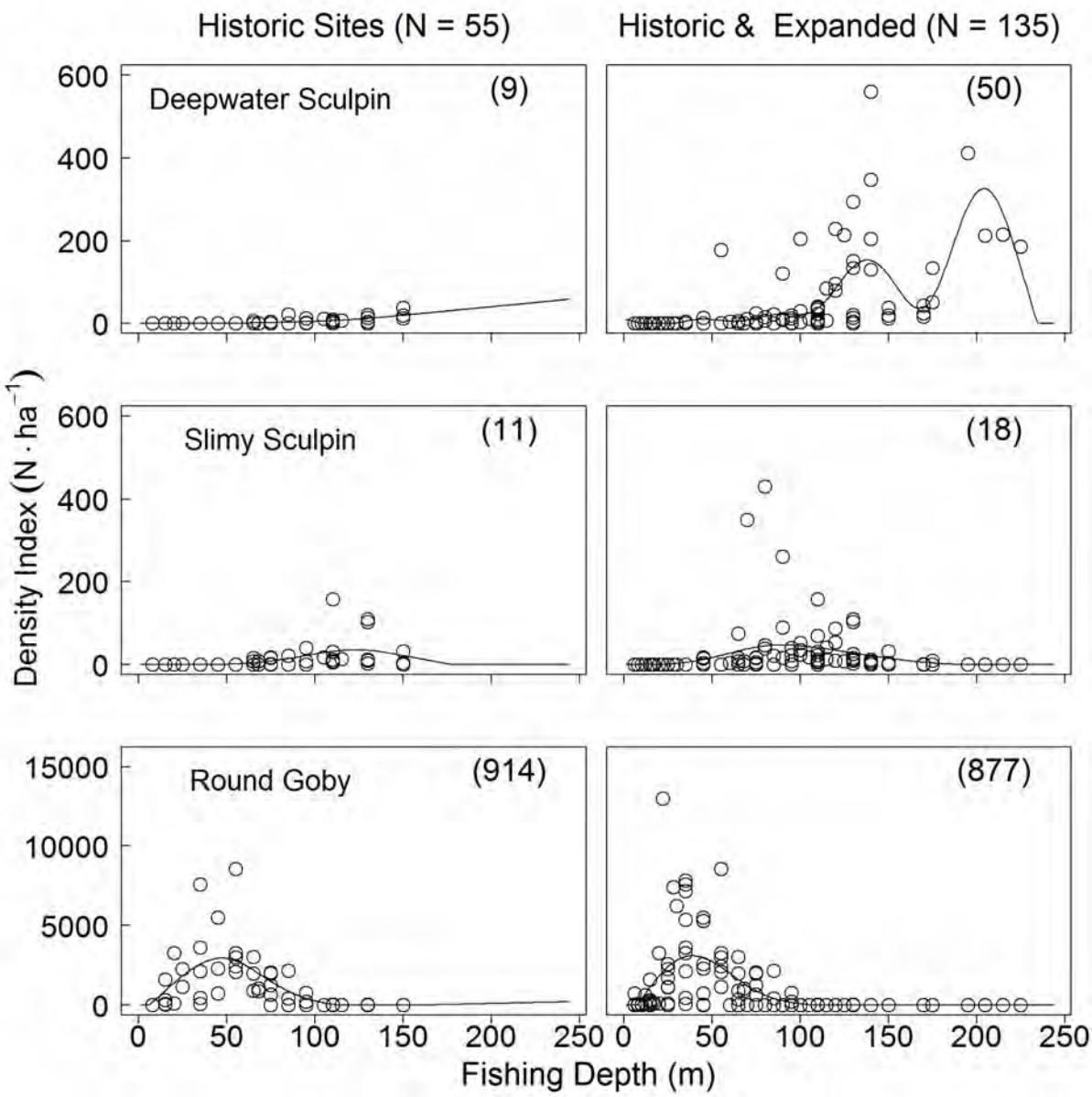

Figure 3. Benthic prey fish density as number per hectare (N·ha^{-1}) based on fishing depth (m) for the three most common Lake Ontario benthic fishes based on the 2015 Benthic Prey Fish Survey. The left panels illustrate observations and model results from the historically sampled sites (N = 55) and the right panels illustrate the same species but use the entire set of lake-wide observations (N = 135). The nonlinear models are generalized additive models with a smoothed depth variable, fit using the mgcv package in R (Wood, 2011). The number in parenthesis of each panel represents the overall lake-wide density estimate in fish per hectare based on the nonlinear model as weighted by lake area at a given depth. Fish density values (N· ha^{-1}) are presented as an index because they have not been corrected for trawl catchability and therefore are likely biased low.

on the true density. Lake wide estimates for density or biomass density are currently based on nonlinear generalized additive models that predict density and biomass density based on fishing depth. These models are fit using the 'mgcv' package in R (Wood, 2011) and scaled to whole-lake estimates by weighting the model-derived average density at a depth by the proportion of that depth relative to the whole lake area.

Results and Discussion

Expanded Sampling - Changes to the 2015 sampling design increased benthic prey fish observations beyond the historically sampled southern shore sites (Figure 1). The new sampling design specifically added additional shallow and deep tows across all lake basins so that the proportion of depths sampled more closely matched the available lake depths (Figure 2). The expanded survey dramatically changed our understanding of Deepwater Sculpin habitat use and density across the lake (Figure 3). For example, if we use 2015 trawl catch observations from only the 55 historic sampling sites to estimate lake-wide Deepwater Sculpin density we would conclude density is approximately 9 Deepwater Sculpin per hectare (or 3.6 fish per acre), whereas using the entire 135 sites yields an estimate of 50 fish per hectare (or 20.2 fish per acre; Figure 3). The expanded survey did not appreciably change our understanding of Round Goby or Slimy Sculpin habitat use with respect to depth or our density estimates for those species, although the lake-wide coverage increased our confidence in making interpretations about these populations at the lake-wide scale (Figure 3)

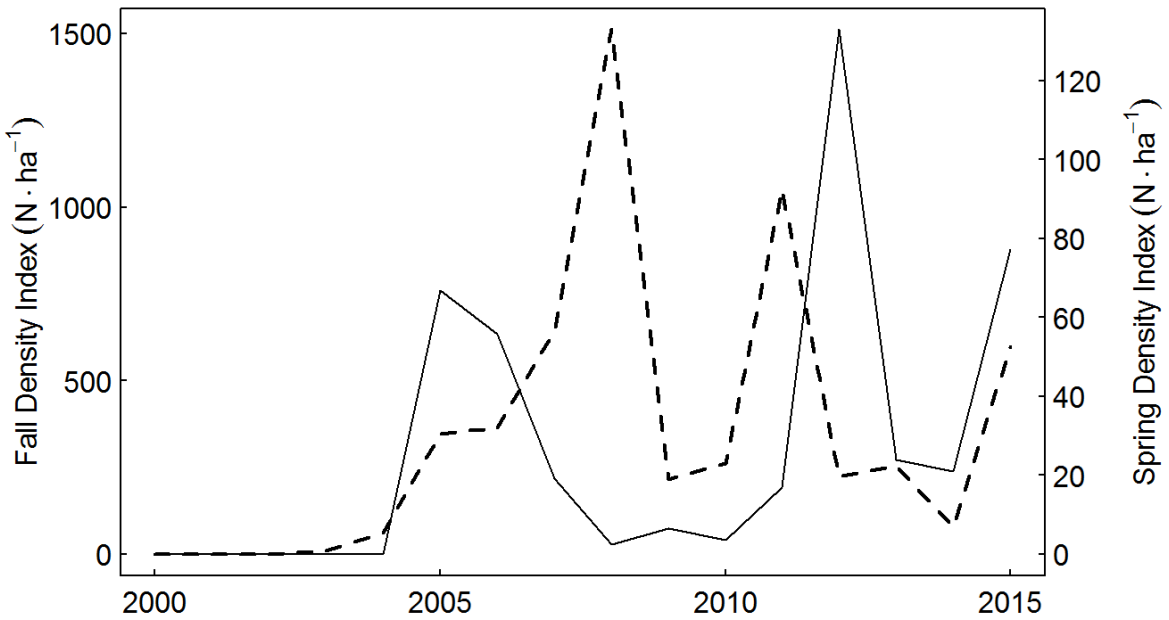

Figure 4. Round Goby density indices as number per hectare (N·ha^{-1}) from the fall Benthic Prey Fish Survey (left y-axis and solid line) and the spring bottom trawl survey (right y-axis and dashed line). Note the substantial difference between the fall and spring survey estimates is partly a result of different trawls employed on each survey, where the spring survey trawl is designed avoid catching driessenid mussels. Note: density values are presented as an index because they have not been corrected for trawl catchability and data prior to 2015 are based on Lake Ontario south shore transects only, while data from 2015 are based on a whole-lake survey.

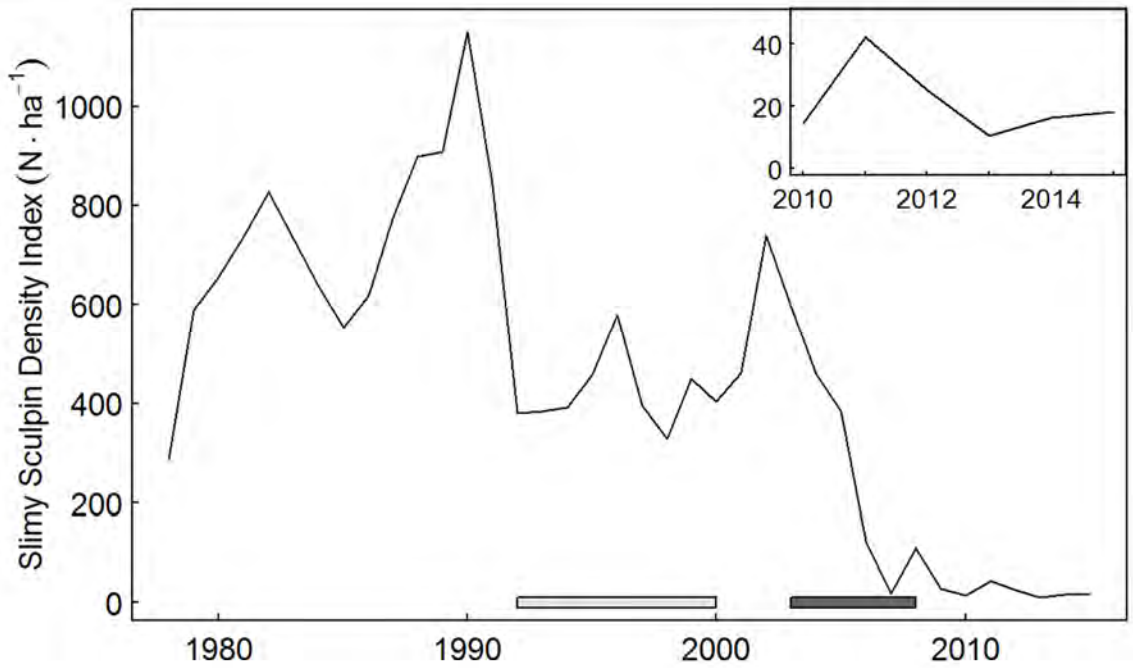

Figure 5. Slimy Sculpin density index in Lake Ontario based on fall bottom trawl surveys from 1978-2015 (no assessment in 1983). The light gray bar above the x-axis represents the range when Dreissena sp. mussels were introduced and proliferated, while the darker gray bar represents when introduced Round Goby abundance increased. Note: density values are presented as an index because they have not been corrected for trawl catchability and data prior to 2015 are based on Lake Ontario south shore transects only, while data from 2015 are based on a whole-lake survey.

<u>*Status of Species*</u>

Round goby abundance indices increased in 2015 in both the spring and fall bottom trawl surveys relative to 2014, however both 2015 estimates are within the range previously observed in the time series (Figure 4). As has been observed in previous years, some proportion of the 2015 Round Goby population underwent a habitat shift associated with depth, where they moved from deep (100 – 150 m or 328 – 492 ft) winter habitats into shallower (< 30 m or 98 ft) summer habitats and by the fall survey were moving deeper as the highest fall catches were recorded at over depths from 25 – 75 m (82 – 246 ft). Over the past five years Round Goby biomass density in Lake Ontario (1.0 – 7.0 kg·ha^{-1}) is greater than both Lake Michigan (0.5 - 3.0 kg·ha^{-1}; Bunnell et al., 2015) and Lake Huron (0.2 – 0.6 kg·ha^{-1}; Roseman et al., 2015). Lake-wide biomass densities in Lake Ontario may also be similar or higher than those reported for Lake Erie where biomass density in the early 2000's reportedly ranged from 0.07 - 1.8 kg·ha^{-1}(Johnson et al., 2005).

Slimy Sculpin abundance in 2015 was similar to 2014, however both values are among the lowest observed across the Lake's 38-year time series (Figure 5). Biomass density of Slimy Sculpin in Lake Ontario over the past five years (0.15 – 0.40 kg·ha^{-1}) was similar to the Lake Michigan range of 0.01-0.70 kg·ha^{-1} (Bunnell et al., 2015), but notably higher than the Lake Huron range of 0.00 – 0.03 kg·ha^{-1} (Roseman et al., 2015), or Lake Superior where three common sculpin species in nearshore habitats are combined for reporting and are 0.02 - 0.05 kg·ha^{-1} (Vinson et al., 2015). As in previous years,

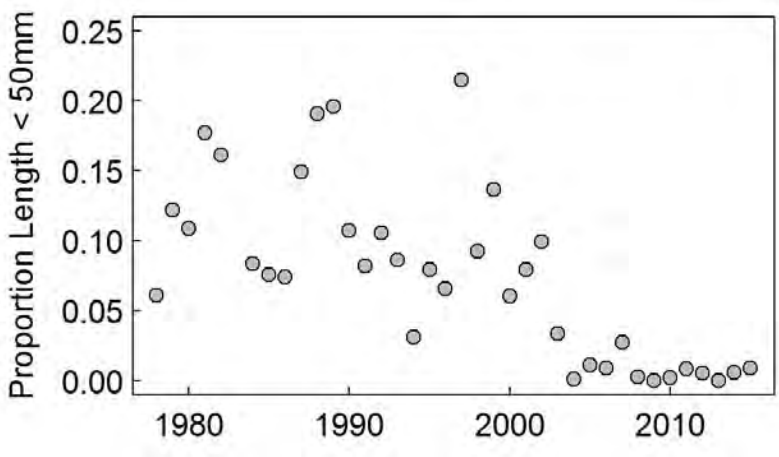

Figure 6. The proportion of all Slimy Sculpin caught that were 50mm and smaller has decreased substantially in trawls in the late 2000's, coincident with the increases in introduced Round Goby that occurred around 2005 (Figure 4). Note: data prior to 2015 are based on Lake Ontario south shore transects only, while data from 2015 are based on a whole-lake survey.

few juvenile Slimy Sculpin less than 50 mm or 2 in were caught in Lake Ontario in 2015 (Figure 6). While this metric varied across the period of observation in the 1970's through 1990's the sharp decline in juveniles in the mid2000s corresponds to the concurrent increases in Round Goby (Figure 4, Figure 6).

Deepwater Sculpin, previously considered extirpated and listed on threatened and endangered species lists, have undergone a dramatic population recovery since the mid-2000s (Lantry et al., 2007; Weidel and Walsh, 2015). Based on both density indices, the Deepwater Sculpin population increased in 2015 relative to 2014 and the population has substantially increased since the first individuals were captured in the 2005 BPFS (Figure 7). Comparing Lake Ontario Deepwater Sculpin density (or biomass density) estimates to other Great Lakes, where the species has been more common, provides context for how this population has recovered in Lake Ontario. The current lake-wide, Lake Ontario biomass density estimate for Deepwater Sculpin was 1.5 $kg \cdot ha^{-1}$ which is similar to Lake Michigan over the past five years (2010 – 2014; approximately 0.5 – 3.0 $kg \cdot ha^{-1}$) (Bunnell et al., 2015) reportedly ranged from. Over the same time period, Lake Huron Deepwater Sculpin biomass densities ranged from approximately 0.0 - 1.0 $kg \cdot ha^{-1}$ (Roseman et al., 2015). Data from this USGS-led survey are currently being used by conservation groups and agencies in both the United States and Canada to reevaluate the conservation status of Deepwater Sculpin in Lake Ontario.

A juvenile Bloater was caught during the spring prey fish bottom trawl survey at 95 meters or 312 ft off of Oswego NY in May 2015. This individual fish was most likely from a 2014 stocking, which is part of the collaborative restoration effort underway in Lake Ontario between the USGS, NYSDEC, OMNRF, and U.S. Fish and Wildlife Service (Connerton, 2015; Lake, 2015). This species, once common in Lake Ontario, was an important species for commercial

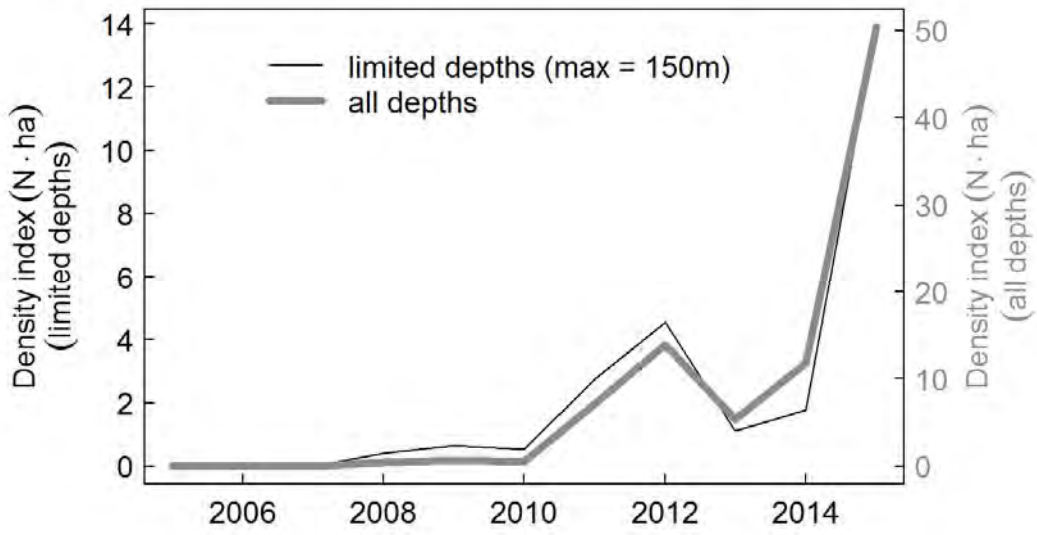

Figure 7. Lake Ontario Deepwater Sculpin density indices ($N \cdot ha^{-1}$) based on different depth ranges from the Fall Benthic Fish Survey, 2005-2015. The thin black line represents density estimates for lake areas less than or equal to 150m which have been consistently sampled through time. The thick gray line incorporates all trawls, including trawl tows deeper than 150m which were sampled collected sporadically in recent years. The similar pattern of the two lines suggests the historic, but depth-limited observations may accurately portray the Deepwater Sculpin population trend over time. Note: density values are presented as an index because they have not been corrected for trawl catchability and data prior to 2015 are based on Lake Ontario south shore transects only, while data from 2015 are based on a whole-lake survey.

fishing but had dramatically declined by the mid-1900's (Christie, 1973). From 1978-2014, the only record of Bloater caught in over 14,000 USGS or NYSDEC bottom trawls was a single fish caught in 1983, east of Rochester NY.

<u>*Benthic Prey Fish Community*</u>

The Lake Ontario benthic prey community continues to be dominated by Round Goby, however, the proportion of Deepwater Sculpin in the community has steadily climbed since 2009 (Figure 8). Over the past 37 years, this survey collected on average 16 different species, however, the expanded effort in 2015 collected 28 different species. Species richness was highest near shore and declined as depth increased, however, that change was most pronounced for the new sites relative to the historic sites (Figure 9). The higher species richness in the new sites was associated with shallow sampling in both the eastern and western portions of the lake and may have been the result of more diverse habitat types available in these lake regions. Catches of note in 2015 include multiple trawls containing juvenile Round Whitefish, Lake Whitefish *Coregonus clupeaformis*, and Threespine Stickleback *Gasterosteus aculeatus* in the western lake regions and wild or naturally-reproduced Lake Trout captured in the north shore and Eastern Basin. Eastern Basin trawls also recorded a variety of native benthic prey fishes that were once more common in the south shore sites, including Trout-perch, *Percopsis omiscomaycus*, Log Perch, *Percina caprodes*, Spottail Shiner, *Notropis hudsonius*, and Johnny Darter *Etheostoma nigrum.*

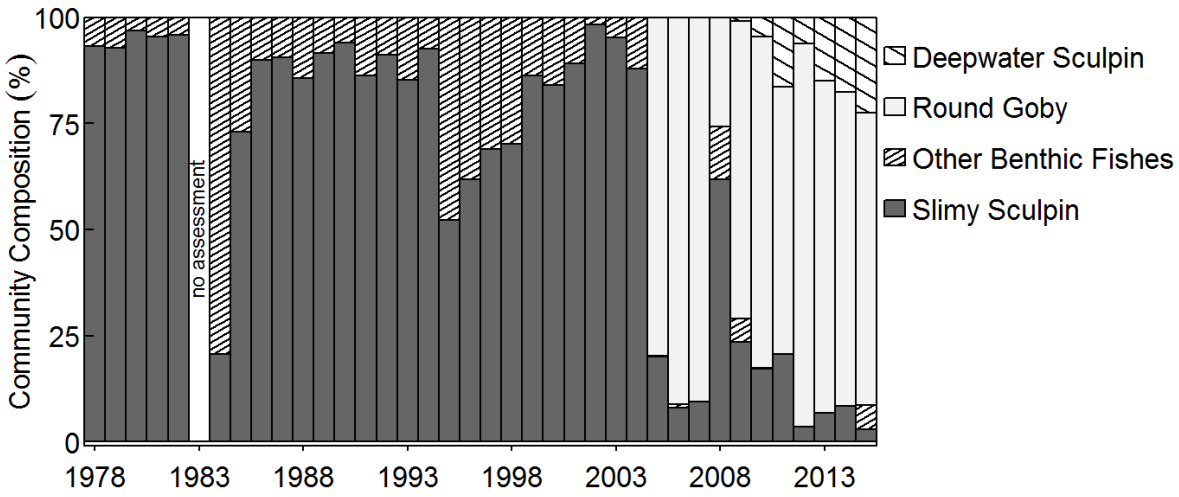

Figure 8. Lake Ontario benthic prey fish community composition, by biomass density from fall bottom trawl surveys 1978-2015. The 'Other Benthic Fishes' is primarily composed of Trout-perch, Johnny Darter, and Spottail Shiner. Note: data prior to 2015 are based on Lake Ontario south shore transects only, while data from 2015 are based on a whole-lake survey.

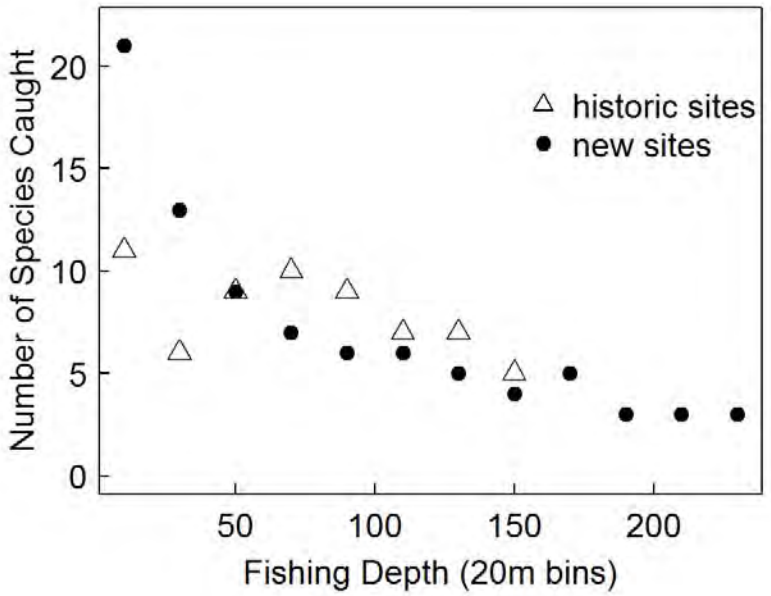

Figure 9. Lake Ontario species richness based on all species caught within a given 20 m depth bin from the 2015 Benthic Prey Fish Survey. Closed circles represent catches from the 80 new sites that were distributed along the west, north, and eastern parts of the lake, while the open triangles illustrate richness along the historic south shore sites of Lake Ontario, 2015.

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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 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 includes feeding by 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 New York State and managed by NYSDEC. Bass and Calf Islands are privately owned. The islands historically contained several colonial waterbird colonies (Table 1), of which most 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 efforts 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 nests were culled (Table 2).

Annual treatment of accessible cormorant nests on Little Galloo Island, with food grade vegetable oil, began in spring 1999 using 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 effectiveness 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 on site.

In addition to nest removal, oiling and culling activities, the NYSDEC conducted cormorant diet studies from 1992 through 2013, by collecting regurgitated pellet samples at Little Galloo Island from mid-April through mid-October. All samples were analyzed by the USGS Great Lakes Science Center (Johnson et al. 2014). Colony feeding days for Little Galloo Island cormorants were calculated according to the Casselman-Weseloh model (unpublished, 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 natural 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. Also, cormorants have not attempted to nest on Calf Island since 2009 (Table 2.)

In 2015 on Gull Island, a total of 769 nests were removed over six visits between 13 May and 10 August. No birds were culled. Peak one day nest removal was 276 (Table 2). The total count of nests removed increased by 12% and the peak count increased 17% relative to 2014.

Eggs were oiled on four occasions at Little Galloo Island between 7 May and 6 July 2015. The peak number of nests oiled on Little Galloo Island was 1,546 (Table 2), and no cormorants were culled in 2015. There were 293 unoiled tree and control nests. Peak nest count was 2,264, including control subcolonies, tree, and “empty” but apparently occupied, nests (Table 1). Peak nest count was 1,546 nests (5%) lower than in 2014. Note that peak nest counts do not necessarily correspond to nest numbers in Bureau of Wildlife trend reports (mid June counts), 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 527 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 814,622 feeding-days occurred at the Little Galloo Island colony in 2015, somewhat above the target of 780,000 (Figure 1). Cormorant feeding days at Little Galloo Island have remained within 10% of target most years since 2006. Since nest counts and feeding day estimates were near target and showed relatively little change from last year (Figure 1), substantial adjustment of management efforts may not be needed in 2016.

Nest counts for other colonial waterbirds (except Ring-billed Gulls) were conducted in 2015 on the four eastern basin islands. Caspian Terns continued to maintain a robust colony on Little Galloo Island. Bass Island hasn't supported any colonial waterbird nesting since 2007. Great Black-backed Gulls have not been detected on any of the four islands since 2008. Black-crowned Night Herons have not been found on Little Galloo Island since 2008, although they continue to be found on Gull Island. Common Terns nested on Little Galloo Island for the first time in 2013, 30 were present in 2015 (Table 1).

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 in 2010. The project has been operating at maintenance level since 2007 (Figure1).

Reduced population levels at Little Galloo Island, is believed to be related to egg oiling, which 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 et al. 2014).

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 eastern 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.

Radiotelemetry studies indicated that nest oiling also reduced the residence time of nesting adults on the colony, further reducing consumption (Mazzocchi 2003).

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. 2014). 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).

Cormorant management activities do not appear to negatively effect and may actually enhance nesting activities for other nesting colonial waterbirds such as Caspian Terns, Common Terns and Herring Gulls. Common Terns are a new nesting species on Little Galloo Island and Caspian Terns and Herring Gulls had record high nest counts on the island in 2014 (Table 1).

Many variables can influence cormorant management results 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 efforts, 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 have successfully met objectives for limiting production of cormorants on New York's Lake Ontario eastern basin islands and reducing predation on fishes of interest.

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 on Bass and Gull Islands are for active nests after management activity and may not match Bureau of Wildlife trend numbers which are taken in mid June (dash indicates not checked for given species).

Species	Island	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Double-crested Cormorant	Little Galloo Island	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	2,283	2,264
	Gull Island	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	Bass Island	0	0	0	35	12	5	5	5	0	0	0	0	0	0	0	0
	Calf Island	-	-	-	-	0	-	-	-	0	0	0	0	0	0	0	0
Ring-billed Gull	Little Galloo Island	-	-	-	60,000	-	-	-	-	37,500	-	-	-	43,324	-	-	-
	Gull Island	-	-	-	0	-	-	-	-	0	-	0	-	0	0	0	0
	Bass Island	-	-	-	2,500	-	-	-	-	0	-	0	-	0	0	0	0
Herring Gull	Little Galloo Island	-	-	-	313	-	-	367	0	375	356	364	459	512	645	979	784
	Gull Island	-	-	-	42	-	-	40	67	58	42	89	91	52	89	109	-
	Bass Island	-	-	-	10	-	-	10	16	0	0	0	0	0	0	0	0
Great Black-backed Gull	Little Galloo Island	-	19	15	12	-	-	4	1	1	0	0	0	0	0	0	0
	Gull Island	-	0	1	0	-	-	0	0	9	0	0	0	0	0	0	0
	Bass Island	-	0	0	0	-	-	0	0	9	0	0	0	0	0	0	0
Caspian Tern	Little Galloo Island	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	1,848	2,436	2,084
Black-crowned Night Heron	Little Galloo Island	1	1	1	3	3	4	0	0	1	0	0	0	0	0	0	0
	Gull Island	20	50	24	35	78	81	77	127	78	78	105	151	44	56	79	106
	Bass Island	36	13	36	47	17	46	32	0	0	0	0	0	0	0	0	0
	Calf Island	-	0	-	-	0	-	-	-	-	13	0	0	0	0	0	0
Common Tern	Little Galloo Island	0	0	0	0	0	0	0	0	0	0	0	0	0	20	34	30

Table 2. Number of cormorant nests removed or oiled and cormorant (DCCO) adults culled; nests with no intact eggs were not oiled. [2]Cumulative nests removed. Number in ( ) is peak one day count

Island	Activity	2000	2001	2002	2003	2004	2005	2006	2007	008	2009	2010	2011	2012	2013	2014	2015
Little Galloo Island	Peak nests oiled	4,301	3,865	3,707	3,389	3,359	2,896	2,275	2,502	1,804	2,166	1,104	2,000	1,600	1,456	1,625	1,546
	Nests removed	0	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	150	0
Bass Island [2]	Peak nests oiled	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nests removed	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)	0	0
	DCCO culled	-	-	-	-	167	281	200	124	0	0	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	0
	Nests removed	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)	603 (235)	769 (276)
	DCCO culled	-	-	-	-	3	0	0	20	2	0	0	0	29	0	0 0	0
Calf Island [2]	Peak nests oiled	0	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	0
	DCCO culled	-	-	-	-	37	0	0	0	6	2	0	0	0	0	0	0

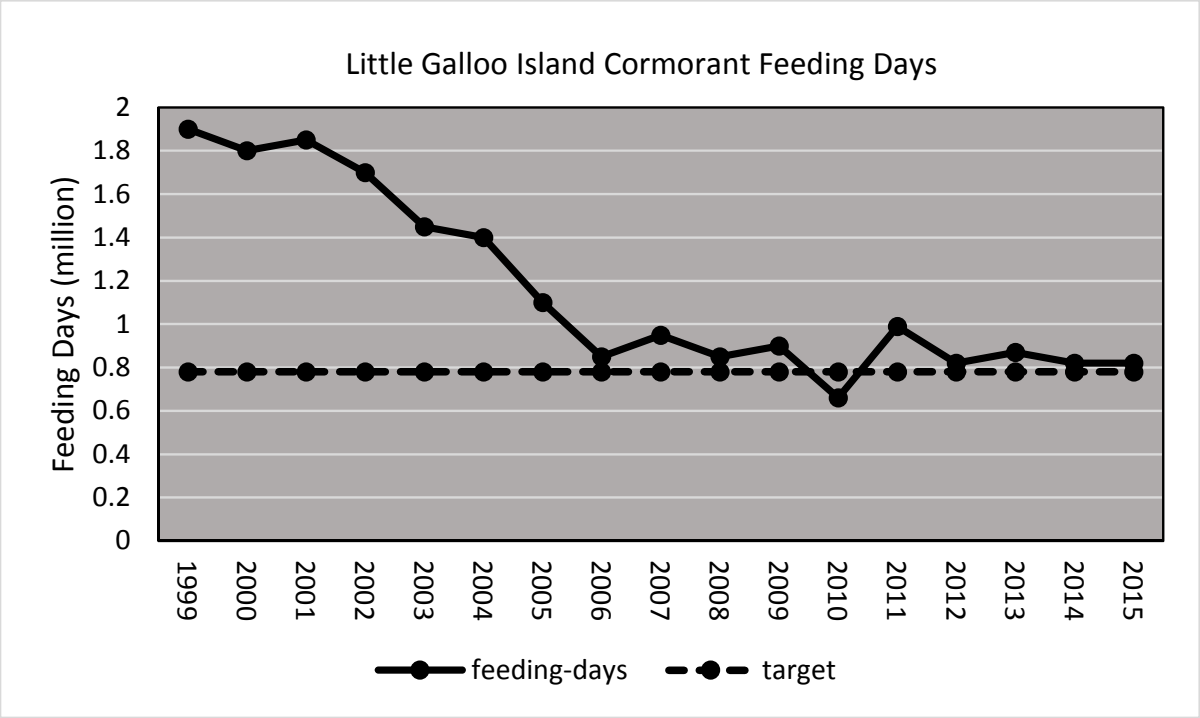

Figure 1. Trend in cormorant feeding days for the Little Galloo Island colony.

Fall 2015 Lake Ontario Tributary Angler Survey

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Angler surveys of all major tributaries to Lake Ontario in New York were conducted in 2005-2006, 2006-2007, and 2011-2012 (Prindle and Bishop 2013). The purpose of these periodic surveys is to monitor the quality of the Lake Ontario tributary fishery and the relative performance of stocked and wild salmonids. The most recent survey is being conducted in 2015-2016. Prior to the 2005-2006 study the last comprehensive tributary survey was the 1984 New York State Great Lakes Angler Survey (NYSDEC 1984). Creel surveys of varying duration and purpose were also conducted on the Salmon River in 1989 (Connelly et al. 1989), 1992 (Bishop 1993), and 1997 through 2004 (Bishop 1998-2004, Bishop and Penney-Sabia 2005). The 1989 survey covered the fall fishery, through the salmon and early steelhead runs. The 1992 survey captured the salmon run, but ended on November 1st, missing most of the fall steelhead fishery. The 1997-2003 surveys were conducted from mid-October through the last weekend in November to examine the fall steelhead angling seasons. The 2004 survey ran from the day after Labor Day through the last weekend in November, to cover the fall salmon and steelhead fisheries. Several creel surveys have also been conducted on eastern Lake Ontario tributaries since 1982 (McCullough 2003).

The 2015 survey commenced on September 1st on the Salmon River and September 15th on the other tributaries, and is scheduled to run through April 2016. Results presented herein cover the fall 2015 salmon and early steelhead fisheries through November.

Methods

Data Collection

Four agents surveyed 23 Lake Ontario tributaries (Figure 1) in 2015. This is a reduction from the five agents and 31 streams surveyed in the previous three studies to reduce survey costs and improve survey effectiveness, a number of low use tributaries were eliminated and the lower Niagara River, was added.

We used an instantaneous access site survey design on the Salmon River that duplicated those completed since 2004. We used an instantaneous roving design on the other tributaries. Counts (numbers of anglers, vehicles and/or boats) and interviews were conducted for each tributary (Lockwood et al. 1999).

We estimated effort (numbers of angler hours and angler trips), catch and harvest (total numbers), and catch and harvest rates (fish per angler hour) for each species in each tributary. For interviews, we recorded site, date, interview time, residency, angler party size, start time, time taken for breaks, trip status (complete versus incomplete), species targeted, fish kept and released, weather effects, and any relevant comments made by the angler or creel agent. The proportion of non-NYS resident participation in the tributary fisheries was calculated individually for “high use” tributaries and collectively for groups of tributaries assigned to “medium use” and “low use” categories based on levels of estimated effort.

This report summarizes the fall portion of the 2015-16 survey and provides comparisons with past surveys. A detailed description of the statistical analyses used in this report is provided in Appendix 1. All statistical analyses were conducted with SAS release 9.3 (SAS Institute 2012).

Salmon River

On the Salmon River, the creel agent sampled three randomly selected weekdays and one weekend day each week. A staggered shift was used to cover the morning counts and interviews, which continued until ½ hour after sunset. Twenty-five sites were sampled for vehicle, angler, and boat (or boat trailer) counts and angler interviews.

Counts were done twice each day during the early part of the survey when days were longer and once daily as day length shortened. Angler counts were necessary in the Village of Pulaski and in the estuary because anglers were not confined to designated parking areas. Angler counts were also done in the lower fly-fishing area in Altmar because anglers used various parking lots for both conventional shore fishing and the special regulations fly-fishing area. Boat counts were done in the estuary.

Interviews on the Salmon River were obtained at angler access parking areas. Angler interviews were done later in the day to question anglers that had fished for several hours. Consequently, there were a high proportion of completed trip interviews. Interviews consisted of a series of questions posed to angler parties (a party is all of the anglers associated with a vehicle, boat, or drift boat) returning to access sites after fishing. Time spent interviewing anglers at individual sites was at the agent's discretion and was roughly proportional to activity at the sites.

Effort and interview data were stratified by week and the interview data were also stratified by fishing type (conventional regulations shore access, drift boat, special regulations catch and release fly fishing, tributary, and estuary boat) to estimate angler effort, catch, and harvest of trout and salmon. We used the ratio of means catch/harvest estimator on all Salmon River interviews because of the high proportion of completed trips, and incomplete trips where anglers had fished for several hours (Lockwood et al.1999).

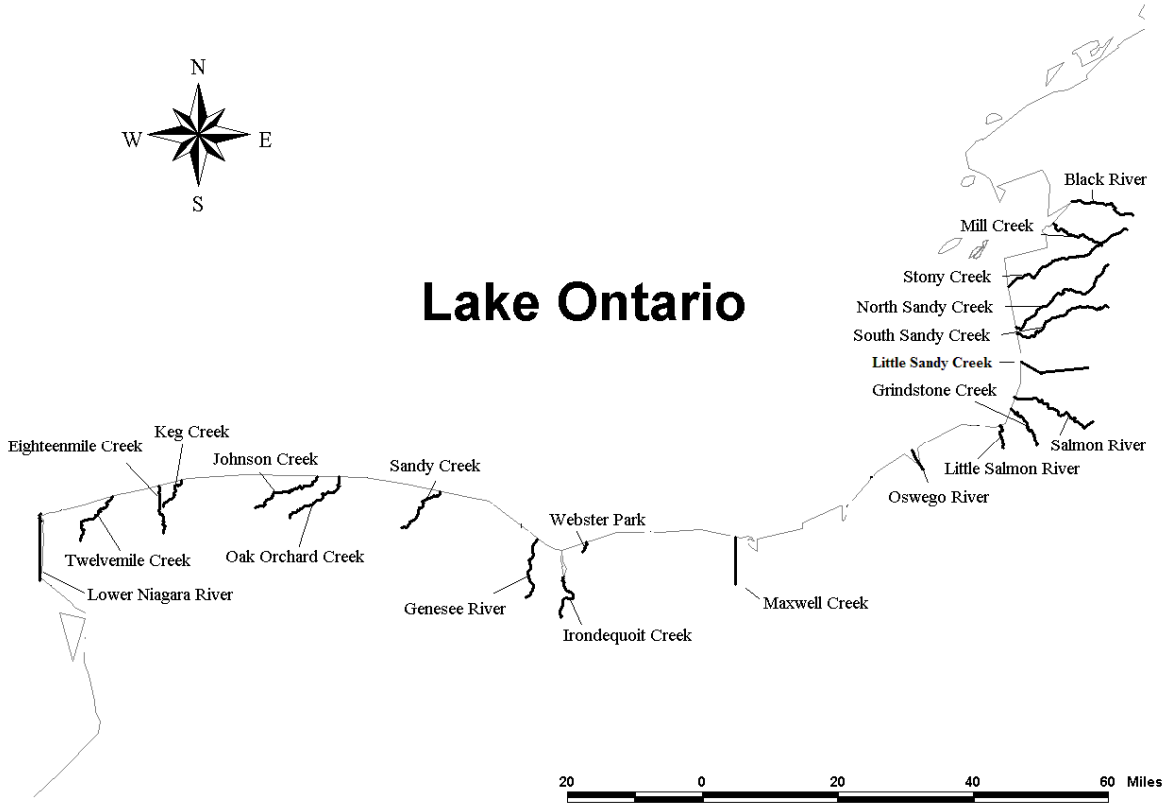

Figure 1. Lake Ontario tributary creel survey stream locations for 2015.

Non-Salmon River Tributaries

The non-Salmon River tributaries were sampled on three randomly selected weekdays each week, including all holidays, and each weekend day. Each agent was responsible for two routes that consisted of sites on three or more adjacent tributaries. Each route was surveyed every other sampling day. The sampling day was defined from ½ hour after sunrise to ½ hour after sunset and was divided into eight hour AM and PM shifts. One shift was randomly selected for each sampling day.

Instantaneous counts of anglers and/or vehicles were done at a randomly selected time within a shift for that route. Vehicle counts were used for sites where anglers were not readily visible. To estimate the number of anglers, vehicle counts were multiplied by the mean angler party size obtained from the interview data for that tributary. Boats were counted on the Black, Niagara, and Oswego rivers. The boat counts were multiplied by the mean boat party size specific to that river to estimate the number of boat anglers. The estimates of boat anglers were added to estimates (or actual counts) of shore anglers to estimate the total number of anglers present on that day.

Time not spent conducting the instantaneous count during a shift was used to interview anglers. Interviews from anglers who had been fishing for at least ½ hour were used in the analyses. Interviews were obtained from both parking areas and streamside, resulting in a mixture of completed trip and incomplete trip interviews.

Effort data were stratified by month (with October split into two strata) and day-type (weekend or weekday). Interview data used in calculating catch and harvest rates were stratified by month. We used the ratio of means estimator for completed trip interviews and a mean of ratios estimator on incomplete trip interviews to estimate catch and harvest rates. These values were then combined to obtain a single weighted estimate (Appendix 1).

Results and Discussion

Angler Effort

The total estimated effort for all tributaries was 763,357 angler hours (Table 1). The Salmon River accounted for 77% of the total with 588,498 angler hours. The 2015 overall effort for all non-Salmon River tributaries decreased by 51% from the 2011 study (174,859 versus 360,235 hours) and was the lowest total of the four comprehensive fall surveys. While 2015 Salmon River effort decreased 22% from 2011, declining from 751,127 to 588,498 angler hours, it was higher than in both 2005 and 2006 (483,792 and 500,456 hours, respectively). A fall 2010 Salmon River creel survey yielded an estimated 705,229 angler hours (Prindle and Bishop 2011).

Five other tributaries accounted for at least 10,000 estimated angler hours: Eighteenmile Creek and Niagara River in Niagara County, Genesee River in Monroe County, South Sandy Creek in Jefferson County, and Oak Orchard Creek in Orleans County. The most notable change in effort occurred on the Oswego River, which declined 82% from the 2011 survey (49,482 hours in 2011 to 8,800 hours in 2015). The likely cause of this decline was the closure of the Leto Island access on the east side of the river. The other major tributary that experienced a noticeable decline in angler hours was Eighteenmile Creek, where there was a 68% decline from 2011 (97,511 in 2011 to 30,777 hours in 2015). Conversely, angler hours on Oak Orchard Creek increased by approximately 11,000 hours from the 2011 survey.

Note that estimates for angler trips presented in Table 1 are not proportional to the estimates of angler hours. This is because angler trips were estimated by dividing the estimates of angler hours by the mean lengths of completed trips for each tributary (from the interview data), and trip length on the Salmon River was much longer.

The estimated total number of angler trips for all 21 tributaries is 191,331, a 33% decrease from the 2011 survey (283,912 trips). This was the lowest estimated number of trips recorded in the four comprehensive fall surveys (Table 1). The

Table 1. Estimated number of angler hours and angler trips on Lake Ontario tributaries September through November 2005, 2006, 2011, and 2015.

	Angler hours				Angler trips			
Tributary	***2005***	***2006***	***2011***	***2015***	***2005***	***2006***	***2011***	***2015***
12mile Creek	2,224	2,200	2,329	559	1,222	1,350	+++	821
18mile Creek	62,189	64,413	97,511	30,777	32,295	29,146	45,740	14,940
Bear Creek	1,032	712	***	***	564	1,187	***	***
Black River	17,448	12,173	24,760	3,805	4,754	12,549	8,901	1,109
Catfish Creek	3,462	1,619	***	***	2,903	1,799	***	***
Genesee River	14,004	10,262	9,954	10,375	5,670	3,563	5,115	6,963
Fourmile Creek	----	165	***	***	----	165	***	***
Grindstone Creek	1,782	1,421	816	3,984	1,443	928	245	2,238
Irondequoit Creek	2,219	2,798	4,578	3,584	1,694	1,676	2,845	2,506
Johnson Creek	4,179	7,142	6,236	4,489	2,533	3,322	3,981	3,426
Keg Creek	346	1,912	0	0	190	885	0	0
Lindsey Creek	41	0	***	***	23	0	***	***
Little Salmon River	4,354	3,364	3,974	1,236	2,884	3,331	2,175	641
Little Sandy Creek	1,787	1,968	***	2,338	2,152	2,071	***	2,998
Marsh Creek	73	1,238	***	***	40	----	***	***
Maxwell Creek	9,078	13,183	19,919	5,800	4,099	7,990	13,260	4,000
Mill Creek	3,428	636	4,152	129	3,061	636	+++	NA
Niagara River	***	***	25,056	16,116			4,554	3,722
Ninemile Creek	982	2,570	***	***	555	1,521	***	***
North Sandy Creek	15,911	5,686	8,489	1,992	10,628	5,922	6,674	647
Oak Orchard Creek	60,329	44,317	40,801	51,812	47,015	20,053	16,042	24,325
Oswego River	60,811	44,311	49,482	8,800	31,508	17,445	24,924	4,018
Sandy Creek	11,872	4,142	15,909	11,076	7,987	2,203	11,282	9,230
Skinner Creek	419	234	***	***	230	+++	***	***
Slater Creek	5,285	4,419	86	***	3,722	2,209	+++	***
South Sandy Creek	21,145	20,749	44,387	16,811	10,908	22,553	25,027	8,281
Sterling Creek	1,908	1,409	***	***	751	312	***	***
Stony Creek	775	918	548	1,061	610	918	+++	NA
Webster Creek	1,451	2,724	1,248	117	1,481	1,792	1,038	+++
Non-Salmon River Totals	308,534	256,685	360,235	174,859	180,922	145,529	171,803	89,865
Salmon River	483,792	500,456	751,127	588,498	75,985	83,409	112,109	101,465
Overall Totals	792,326	757,141	1,111,362	763,357	256,907	228,938	283,912	191,331

Key: ---- = No interviews obtained, *** = Tributary not surveyed, +++ =No complete trips interviews

Salmon River accounted for 53% (101,465) of all trips, and the five aforementioned tributaries (with over 10,000 angler hours of effort each) combined accounted for 30% of the total estimated angler trips. The estimated number of angler trips on the Salmon River in 2015 was 101,465, a 9% decline from the 2011 estimate of 112,109 trips. The 2015 estimate was, however, considerably higher than both the 2005 and 2006 values of 75,985 and 83,409 trips, respectively (Table 2). Salmon River flows during October 2015 were very favorable for fishing (at, or very near, the regulated baseline flow of 335 cubic feet per second for the entire month; Figure 2), in contrast to years, such as 2010, when severe flooding occurred during the typical peak of the season (Figure 2). In addition to the consistent, somewhat low water levels, river temperatures remained quite warm through the 2015 season. Higher fall flows and cooler temperatures are presumed to be the main triggers for the spawning run, neither of which was typical in 2015. Many of the smaller, western tributaries never experienced a salmon run because there was no high flow event to remove gravel bars that form annually at their mouths. Additionally, two severe winters (2013/2014 and 2014/2015) may have affected Chinook survival in the lake, therefore impacting the subsequent spawning run as well.

The overall trend in Salmon River fishing effort appears similar to that observed in the open lake boat fishery (Eckert 2007), with a peak in the late 1980's and early 1990's (Table 2). Effort on the Salmon River, however, has generally increased in recent surveys (Table 2).

Estimated angler effort from New York's Lake Ontario boat fishery in 2015 (5.5 months) was 879,681 angler hours or 157,151 angler trips from April through September (Lantry and Eckert 2016). Estimated effort for the tributary fishery (September through November) was 763,357 angler hours, or about 13% less than the open lake effort. The tributary estimate of 191,331 angler trips represented about 18% more angler trips than that for the open lake.

Catch and Harvest

Chinook Salmon

Sixteen of 21 tributaries surveyed had reported catches of Chinook salmon. The estimated catch and harvest of Chinook salmon on all tributaries surveyed in 2015 was 43,589 and 26,045, respectively (Tables 3 and 4). The 2015 total Chinook catch (43,589) declined dramatically from the three previous comprehensive fall survey estimates that ranged from 125,180 to 155,960 fish landed (Table 3). Chinook harvest also declined, but not as severely as catch, to about half of the three previous surveys (Table 4). The percentage of fish caught that were harvested (all tributaries combined) increased from 36% in 2011 to 60% in 2015. The Salmon River accounted for 55% (23,940) of the total catch and 47% (12,305) of the total harvest. Salmon River anglers harvested from 58% to 70% of their catches in the 1984, 1989, and 1992 surveys, but only 28% to 37% in the 2004 to 2011 surveys (Table 2). An estimated 51% of Chinook caught in the Salmon River in 2015 were harvested, signaling a return to more historic harvest levels. In comparison, the open lake fishery harvested 59.3% (catch = 58,870; harvest = 34,951) of all Chinooks caught in 2015 (Lantry and Eckert 2016).

The increased release rates observed in more recent tributary surveys may be related to the ban on snagging, which was phased out during the mid-1990s, and an increase in the popularity of catch and release fishing. It is likely that the fewer fish apparently available during the traditional spawning run period in 2015 likely contributed to the higher percent harvest in this study. The top Chinook salmon waters following the Salmon River were Oak Orchard, Eighteenmile, and North Sandy creeks (Table 3). Eight of the 16 tributaries had an estimated 1,000 or more Chinook salmon caught.

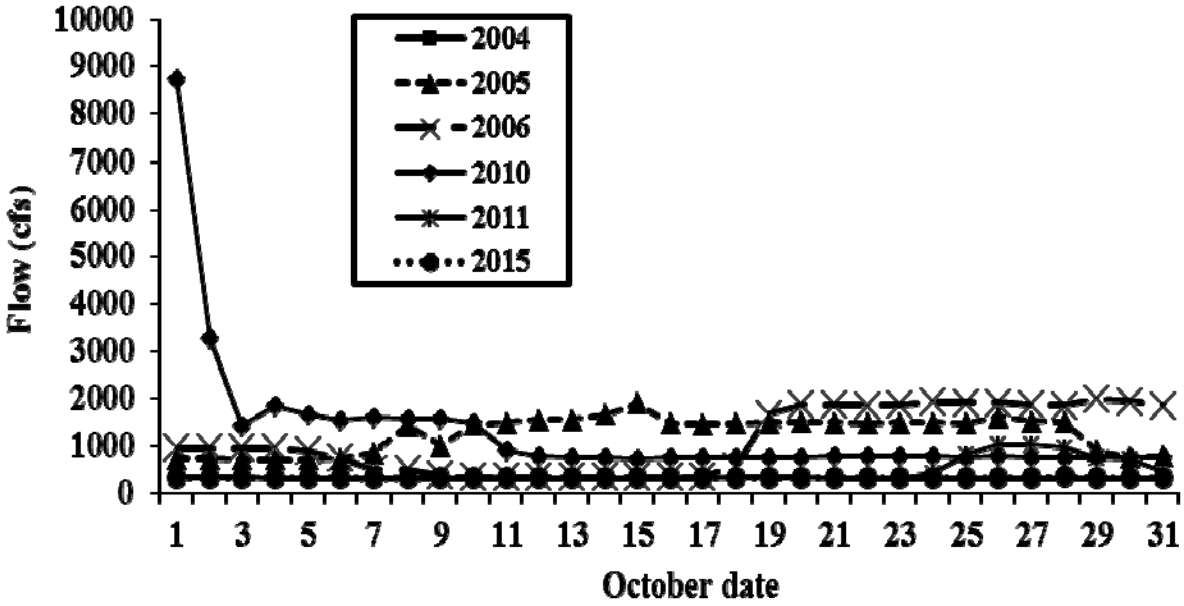

Figure 2. October Salmon River water flow by year and date.

Table 2. Summary statistics for creel surveys conducted on the Salmon River since 1984.

			Chinook salmon		Steelhead	
Year	Dates	Angler trips	Catch	Harvest	Catch	Harvest
1984	Sept-Nov	107,306	143,244	83,784	15,529	8,359
1984	Jan 1 to Dec 31	140,911	143,244	83,784	36,925	20,699
1989	Aug 17 to Dec 4	180,400	150,100	69,200	8,150	4,350
1992	Sept 3 to Nov 1	103,900	80,300	55,900		
1997	Oct 20 to Nov 30	7,061	----	----	1,543	554
1998	Oct 19 to Nov 29	7,009	----	----	2,830	523
1999	Oct 18 to Nov 28	11,372	----	----	4,751	1,010
2000	Oct 16 to Nov 26	11,231	----	----	2,870	806
2001	Oct 15 to Nov 25	12,563	----	----	3,660	746
2002	Oct 21 to Dec 1	9,381	----	----	2,743	555
2003	Oct 20 to Nov 30	6,183	----	----	1,960	357
2004	Sept 7 to Nov 28	90,825	85,251	24,360	6,924	1,314
2005	Sept 6 to Nov 30	75,985	89,448	25,998	7,738	1,441
2005-2006	Sept 6 to May 15	98,959	89,448	25,998	20,705	2,713
2006	Sept 9 to Nov 26	83,409	96,088	33,530	9,509	2,002
2006-2007	Sept 9 to May 16	87,539	96,088	33,530	21,489	3,869
2010	Sept 7 to Nov 28	113,747	66,134	28,914	32,146	3,954
2011	Sept 1 to Nov 27	112,109	85,106	31,516	39,697	3,657
2015	Sept 1 to Nov 29	101,465	23,940	12,305	11,334	1,401

1 – The 1984 survey ran September through May on the tributaries but September through November is presented here for comparison.

Table 3. Estimated catch and respective catch rates (fish/angler hour or CPUE) for Chinook salmon by tributary from September through November 2005, 2006, 2011 and 2015.

	2005		2006		2011		2015	
Tributary	CPUE	Est. Catch	CPUE	Est. Catch	CPUE	Est. Catch	CPUE	Est. Catch
12mile Creek	0	0	0.005	10	0	0	0.000	0
18mile Creek	0.195	12,109	0.192	12,385	0.1	9,703	0.091	2,799
Bear Creek	0.037	38	0.003	2	***	***	***	***
Black River	0.442	7,708	0.369	4,497	0.154	3,824	0.083	318
Catfish Creek	0.473	1,637	0.04	64	***	***	***	***
Fourmile Creek	****	***	0	0	***	***	***	***
Genesee River	0.183	2,568	0.32	3,289	0.132	1,318	0.100	1,036
Grindstone Creek	0.01	17	0.05	71	0.529	431	0.052	206
Irondequoit Creek	0.046	101	0.022	62	0.064	292	0.011	38
Johnson Creek	0.239	998	0.232	1,654	0.082	508	0.095	426
Keg Creek	0	0	0.041	79	0	0	0.000	0
Lindsey Creek	----	----	----	----	***	***	***	***
Little Salmon River	0.226	986	0.105	354	0.319	1,269	0.000	0
Little Sandy Creek	0.181	324	0.129	254	***	***	0.763	1,784
Marsh Creek	----	----	----	----	***	***	***	***
Maxwell Creek	0.014	128	0.037	492	0.124	2,466	0.038	222
Mill Creek	0.467	1,601	0.457	291	0.249	1,035	0.000	0
Niagara River	***	***	***	***	0.035	878	0.040	649
Ninemile Creek	0.047	46	0.183	469	***	***	***	***
North Sandy Creek	0.238	3,794	0.221	1,257	0.03	257	1.297	2,585
Oak Orchard Creek	0.142	8,597	0.376	16,659	0.237	9,674	0.119	6,190
Oswego River	0.121	7,360	0.084	3,706	0.083	4,088	0.118	1,035
Sandy Creek	0.116	1,374	0.033	135	0.095	1,506	0.084	929
Skinner Creek	----	----	----	----	***	***	***	***
Slater Creek	0.084	444	0.142	629	----	----	***	***
South Sandy Creek	0.754	15,952	0.291	6,042	0.061	2,706	0.074	1,242
Sterling Creek	0.265	505	0.181	256	***	***	***	***
Stony Creek	0.205	159	0	0	0	0	0.178	189
Webster Park	0.045	65	0.928	2,527	0.095	119	0.000	0
Non-Salmon River Totals		66,512		55,185		40,074		19,649
Salmon River	0.185	89,448	0.192	96,088	0.115	85,106	0.041	23,940
Totals		155,960		151,273		125,180		43,589

Key: ---- = No interviews obtained, *** = Tributary not surveyed

Table 4. Estimated harvest and respective harvest rates (fish/angler hour or HPUE) for Chinook salmon by tributary from September through November 2005, 2006, 2011 and 2015.

	2005		2006		2011		2015	
Tributary	HPUE	Est. Harvest	HPUE	Est. Harvest	HPUE	Est. Harvest	HPUE	Est. Harvest
12mile Creek	0	0	0	0	0	0	0.000	0
18mile Creek	0.005	331	0.05	3,249	0.022	2,106	0.037	1,150
Bear Creek	0.037	38	0	0	***	***	***	***
Black River	0.275	4,797	0.24	2,924	0.082	2,029	0.043	163
Catfish Creek	0.331		0.035	56	***	***	***	***
Fourmile Creek	****	***	0	0	***	***	***	***
Genesee River	0.075	1,050	0.14	1,442	0.048	478	0.090	932
Grindstone Creek	0.001	2	0.05	71	0	0	0.052	206
Irondequoit Creek	0	0	0.022	62	0.007	33	0.007	25
Johnson Creek	0.18	750	0.075	538	0.025	153	0.061	276
Keg Creek	0	0	0.021	40	0	0	0.000	0
Lindsey Creek	----	----	----	----	***	***	***	***
Little Salmon River	0.161	701	0.097	327	0.276	1,095	0.000	0
Little Sandy Creek	0.089	160	0.129	254	***	***	0.763	1,784
Marsh Creek	----	----	----	----	***	***	***	***
Maxwell Creek	0.009	81	0.019	250	0.015	305	0.036	209
Mill Creek	0.208	713	0.096	61	0.132	546	0.000	0
Niagara River	***	***	***	***	0.026	642	0.025	403
Ninemile Creek	0	0	0.102	263	***	***	***	***
North Sandy Creek	0.096	1,524	0.115	656	0.015	125	1.297	2,585
Oak Orchard Creek	0.014	864	0.138	6,133	0.056	2,299	0.066	3,413
Oswego River	0.065	3,943	0.038	1,700	0.024	1,212	0.073	640
Sandy Creek	0.046	549	0.001	3	0.056	884	0.062	691
Skinner Creek	----	----	----	----	***	***	***	***
Slater Creek	0.026	140	0.142	629	----	----	***	***
South Sandy Creek	0.259	5,477	0.167	3,470	0.039	1,747	0.064	1,073
Sterling Creek	0.132	251	0.013	19	***	***	***	***
Stony Creek	0.16	124	0	0	0	0	0.178	189
Webster Park	0.02	29	0.247	673	0.035	44	0.000	0
Non-Salmon River Totals		22,673		22,821		13,698		13,740
Salmon River	0.054	25,998	0.067	33,530	0.042	31,516	0.021	12,305
Totals		48,671		56,351		45,214		26,045

Key: ---- = No interviews obtained, *** = Tributary not surveyed

Table 5. Estimated catch and respective catch rates (fish/angler hour or CPUE) for Coho salmon by tributary from September through November 2005, 2006, 2011 and 2015.

	2005		2006		2011		2015	
Tributary	CPUE	Est. Catch	CPUE	Est. Catch	CPUE	Est. Catch	CPUE	Est. Catch
12mile Creek	0	0	0	0	0	0	0.000	0
18mile Creek	0	0	0.032	2,072	0.011	1,041	0.000	7
Bear Creek	0	0	0	0	***	***	***	***
Black River	0	0	0.003	34	0.004	98	0.007	26
Catfish Creek	0	0	0	0	***	***	***	***
Fourmile Creek	***	***	0	0	***	***	***	***
Genesee River	0	0	0	0	0	0	0.000	0
Grindstone Creek	0	0	0	0	0	0	0.000	0
Irondequoit Creek	0	0	0	0	0	0	0.000	0
Johnson Creek	0.007	30	0.011	77	0	0	0.031	140
Keg Creek	0	0	0.001	1	0	0	0.000	0
Lindsey Creek	----	----	----	----	***	***	***	***
Little Salmon River	0	0	0	0	0.003	10	0.000	0
Little Sandy Creek	0	0	0	0	***	***	0.000	0
Marsh Creek	----	----	----	----	***	***	***	***
Maxwell Creek	0.001	11	0.002	25	0.01	189	0.005	28
Mill Creek	0	0	0	0	0.007	29	0.000	0
Niagara River		***	***	***	0.001	34	0.003	51
Ninemile Creek	0	0	0	0	***	***	***	***
North Sandy Creek	0	0	0	0	0.003	29	0.000	0
Oak Orchard Creek	0	0	0.025	1,087	0.002	85	0.000	13
Oswego River	0.001	44	0.002	93	0.001	33	0.001	8
Sandy Creek	0.003	32	0.018	75	0	0	0.005	50
Skinner Creek	----	----	----	----	***	***	***	***
Slater Creek	0.005	25	0.001	5	----	----	***	***
South Sandy Creek	0	0	0	0	0	0	0.000	0
Sterling Creek	0	0	0	0	***	***	***	***
Stony Creek	0	0	0.19	175	0	0	0.000	0
Webster Park	0.002	3	0.002	6	0	15	0.000	0
Non-Salmon River Totals		3,650		145		1,563		323
Salmon River	0.012	14,513	0.029	5,659	0.039	29,113	0.010	5,738
Totals		18,163		5,804		30,676		6,061

Key: ---- = No interviews obtained, *** = Tributary not surveyed

Table 6. Estimated harvest and respective harvest rates (fish/angler hour or HPUE) for Coho salmon by tributary from September through November 2005, 2006, 2011 and 2015.

	2005		2006		2011		2015	
Tributary	HPUE	Est. Harvest	HPUE	Est. Harvest	HPUE	Est. Harvest	HPUE	Est. Harvest
12mile Creek	0	0	0	0	0	0	0.000	0
18mile Creek	0	0	0.013	858	0.002	176	0.000	7
Bear Creek	0	0	0	0	***	***	***	***
Black River	0	0	0.003	34	0.001	15	0.007	26
Catfish Creek	0	0	0	0	***	***	***	***
Fourmile Creek	***	***	0	0	***	***	***	***
Genesee River	0	0	0	0	0	0	0.000	0
Grindstone Creek	0	0	0	0	0	0	0.000	0
Irondequoit Creek	0	0	0	0	0	0	0.000	0
Johnson Creek	0.007	30	0	30	0	0	0.031	140
Keg Creek	0	0	0	0	0	0	0.000	0
Lindsey Creek	----	----	----	----	***	***	***	***
Little Salmon River	0	0	0	0	0.003	10	0.000	0
Little Sandy Creek	0	0	0	0	***	***	0.000	0
Marsh Creek	----	----	----	----	***	***	***	***
Maxwell Creek	0	0	0.001	1	0.002	49	0.003	16
Mill Creek	0	0	0	0	0	0	0.000	0
Niagara River	***	***	***	***	0.001	20	0.003	51
Ninemile Creek	0	0	0	0	***	***	***	***
North Sandy Creek	0	0	0	0	0	0	0.000	0
Oak Orchard Creek	0	0	0.015	651	0	0	0.000	0
Oswego River	0	13	0.001	8	0	6	0.001	8
Sandy Creek	0	14	0.018	14	0	0	0.002	27
Skinner Creek	----	----	----	----	***	***	***	***
Slater Creek	0.005	25	0	25	----	----	***	***
South Sandy Creek	0	0	0	0	0	0	0.000	0
Sterling Creek	0	0	0	0	***	***	***	***
Stony Creek	0	175	0.19	175	0	0	0.000	0
Webster Park	0.002	23	0.002	32	0	15	0.000	0
Non-Salmon River Totals		1,743		72		291		275
Salmon River	0.005	3,002	0.006	2,177	0.014	10,154	0.004	2,307
Totals		4,745		2,249		10,445		2,582

Key: ---- = No interviews obtained, *** = Tributary not surveyed

Coho Salmon

Coho salmon were a small component of the tributary fishery in 2015, with only 6,061 fish being caught in nine of the 21 tributaries surveyed (Table 5). Coho catches vary considerably from year to year, ranging from 5,804 in 2006 to 30,676 in 2011. The Salmon River accounted for 95% of the catch (5,738; Table 5) and 89% of the harvest (2,307; Table 6). This compares to the 1984 study when an estimated 13,831 Coho were caught and 10,608 harvested (NYSDEC 1984). Johnson Creek (140 fish) was the only other tributary to have an estimated Coho catch over 100 fish in 2015 (Table 4). In comparison, the 2015 open lake boat fishery had an estimated catch and harvest of 4,260 and 2,078 Coho salmon, respectively (Lantry and Eckert 2015).

The percent harvest for Coho salmon decreased on the tributaries from 77% in 1984 to 26% in 2006, but increased to 43% in 2011.

Steelhead

Steelhead is the primary species sought by post-salmon run tributary anglers. This fishery gains momentum in mid-October as fish enter the tributaries and the salmon runs begin to decline, and extends into April or May in some cases. As a result, steelhead are the most important species in the tributary fishery for a large portion of the tributary angling season since the salmon run is essentially limited to September and October.

Twelve of the 21 tributaries surveyed had reported catches of steelhead (Table 7). This is down from 17 of 21 tributaries producing steelhead catches in 2011. For all the tributaries surveyed, the total estimated catch and harvest was 17,223 (Table 7) and 2,623 (Table 8), respectively.

The Salmon River had the highest estimated catch (11,334 or 66% of total; Table 7) and harvest (1,401 or 53% of total; Table 8). The percent harvest for steelhead caught was 12% on the Salmon River and 15% for all tributaries combined.

Other tributaries producing substantial steelhead catches were Oak Orchard and Eighteenmile creeks (Table 7), each with estimated catches exceeding 1,000 fish. Additionally, three tributaries (Niagara River as well as Sandy and Maxwell creeks) produced estimated catches over 500 fish.

The 1984 study had an estimated 15,529 steelhead caught on the Salmon River over a comparable time period, with 8,359 harvested (Table 2). Note that tributary anglers harvested a much larger proportion of steelhead caught in 1984 (46%) compared with 2015 (12%). Boat anglers on the open lake harvested 9,212 or 53% of the 17,509 steelhead that they caught in 2015 (Lantry and Eckert 2016).

The long-term decline in Salmon River steelhead since the 1984 census appeared to be reversing itself until the 2015 results (Table 2). Increasing release rates for steelhead on the tributaries in recent years are a result of anglers' desire to conserve steelhead to maintain the quality of the fishery. Additionally, tributary anglers requested, and received, a reduction in the daily harvest limit on the tributaries from 3 to 1 in 2004.

What is largely unknown regarding the relatively poor steelhead catches of steelhead during fall 2015 is what effect the thiamine deficiency related mortality event during the winter of 2014/2015, most visible in the Salmon River, may have had on the overall population. There were certainly many steelhead that succumbed to the condition in the Salmon River, but it is unknown how many may have perished before ever reaching the river mouth. There were scattered reports of steelhead swimming erratically toward the end of this survey, but not on the scale of the winter of 2014-2015. One contributing factor to reduced catches may be the much warmer temperatures during the fall of 2015.

Brown Trout

Ten of the 21 waters surveyed had reported catches of Brown Trout (Table 9). For all tributaries surveyed, estimated Brown Trout catch and harvest were 13,650 and 3,441 respectively (Tables 9 and 10). The estimated catches from the previous three comprehensive

fall surveys ranged from 27,419 in 2006 to 40,192 in 2005 (Table 9).Eighteenmile Creek (1,866 fish) produced the highest Brown Trout catches in previous surveys, but was surpassed in 2015by Sandy Creek(4,178 fish) and Oak Orchard Creek (2,896 fish). Irondequoit Creek was the only other tributary to produce an estimated Brown Trout catch over 1,000 fish (Table 9). The percent harvest for all Brown Trout caught was 25%. Percent harvest from the three previous comprehensive fall surveys ranged from 14% in 2005 to 37% in 2006. Percent harvest in the Salmon River was 7%, the lowest in the four most recent fall surveys.

The 1984 survey estimated 29,856 Brown Trout caught and 27,481 harvested in Lake Ontario tributaries (NYSDEC 1984). The percent harvest was 92%, an order of magnitude higher than that in 2015. Estimates from the 2015 open lake boat fishery were 20,780 Brown Trout caught and 12,590 kept (Lantry and Eckert 2016). This represents percent harvest of 61% on the open lake compared to 25% on the tributaries.

Atlantic Salmon

There were an estimated 247 Atlantic salmon caught in the Salmon River during fall 2015, with only 29 harvested. The only other tributary with significant reported catches was Oak Orchard Creek, with an estimated 134 fish caught and no fish harvested.

Angler residency

Sixty-five percent of the anglers surveyed on the Salmon River were non-New York State residents, while 58% of the anglers on all "high-use" tributaries (including Salmon River) were non-NYS residents (Table 11). By contrast, non-residents comprised only 30% and 15% of the anglers surveyed on "medium use" and "low use" tributaries, respectively. This is probably because the higher use and more well-known tributaries attract angling attention from greater geographic distances than the smaller waters.

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Table 7. Estimated catch and respective catch rates (fish/angler hour or CPUE) for Steelhead by tributary from September through November 2005, 2006, 2011 and 2015.

	2005		2006		2011		2015	
Tributary	CPUE	Est. Catch	CPUE	Est. Catch	CPUE	Est. Catch	CPUE	Est. Catch
12mile Creek	0	0	0.046	102	0	0	0.019	10
18mile Creek	0.103	6,410	0.174	11,223	0.027	515	0.033	1,026
Bear Creek	0.008	8	0.731	521	***	***	***	***
Black River	0	0	0.009	112	0.017	411	0.000	0
Catfish Creek	0	0	0	0	***	***	***	***
Fourmile Creek	***	***	0	0	***	***	***	***
Genesee River	0.141	1,973	0.032	326	0.005	52	0.017	174
Grindstone Creek	0	0	0	0	0.048	39	0.000	0
Irondequoit Creek	0.176	390	0.093	261	0.13	597	0.098	353
Johnson Creek	0.291	1,216	0.198	1,414	0.004	25	0.034	151
Keg Creek	0	0	0.28	536	0	0	0.000	0
Lindsey Creek	----	----	----	----	***	***	***	***
Little Salmon River	0	0	0	0	0.003	10	0.000	0
Little Sandy Creek	0.003	5	0.023	45	***	***	0.000	0
Marsh Creek	----	----	----	----	***	***	***	***
Maxwell Creek	0.028	251	0.086	1,135	0.19	3,782	0.092	532
Mill Creek	0	0	0	0	0.014	57	0.000	0
Niagara River	***	***	***	***	0.037	926	0.043	696
Ninemile Creek	0.002	1	0.083	213	***	***	***	***
North Sandy Creek	0.081	1,285	0.086	490	0.16	1,355	0.000	0
Oak Orchard Creek	0.1	6,033	0.122	5,413	0.056	2,275	0.036	1,843
Oswego River	0.021	1,292	0.024	1,068	0.025	1,227	0.014	119
Sandy Creek	0.02	235	0.045	186	0.063	1,001	0.072	799
Skinner Creek	----	----	----	----	***	***	***	***
Slater Creek	0.019	102	0.013	58	----	----	***	***
South Sandy Creek	0.001	22	0.007	152	0.151	6,685	0.011	184
Sterling Creek	0	0	0	0	***	***	***	***
Stony Creek	0	0	0.952	874	0	0	0.000	0
Webster Park	0.133	193	0.305	830	0.154	192	0.000	0
Non-Salmon River Totals		19,417		24,959		19,149		5,889
Salmon River	0.016	7,738	0.019	9,509	0.054	39,697	0.019	11,334
Totals		27,155		34,468		58,846		17,223

Key: ---- = No interviews obtained, *** = Tributary not surveyed

Table 8. Estimated harvest and respective harvest rates (fish/angler hour or HPUE) for Steelhead by tributary from September through November 2005, 2006, 2011 and 2015.

	2005		2006		2011		2011	
Tributary	HPUE	Est. Harvest	HPUE	Est. Harvest	HPUE	Est. Harvest	HPUE	Est. Harvest
12mile Creek	0	0	0.038	83	0	0	0.000	0
18mile Creek	0.012	752	0.047	3,046	0.007	126	0.006	181.84589
Bear Creek	0	0	0.106	45	***	***	***	***
Black River	0	0	0.004	48	0.002	45	0.000	0
Catfish Creek	0	0	0	0	***	***	***	***
Fourmile Creek	***	***	0	0	***	***	***	***
Genesee River	0.007	92	0.013	40	0	0	0.000	0
Grindstone Creek	0	0	0	0	0	0	0.000	0
Irondequoit Creek	0	0	0.042	32	0	0	0.000	0
Johnson Creek	0	0	0.068	489	0	0	0.000	0
Keg Creek	0	0	0.038	72	0	0	0.000	0
Lindsey Creek	----	----	----	----	***	***	***	***
Little Salmon River	0	0	0	0	0.003	10	0.000	0
Little Sandy Creek	0.002	3	0.023	45	***	***	0.000	0
Marsh Creek	----	----	----	----	***	***	***	***
Maxwell Creek	0.011	103	0.022	47	0.023	452	0.020	116.83641
Mill Creek	0	0	0	0	0	0	0.000	0
Niagara River	***	***	***	***	0.025	617	0.021	337.13494
Ninemile Creek	0	0	0.016	18	***	***	***	***
North Sandy Creek	0.023	363	0.037	211	0.015	123	0.000	0
Oak Orchard Creek	0.006	348	0.051	2,271	0	0	0.006	300.31051
Oswego River	0.003	193	0.008	64	0.002	83	0.004	33.238334
Sandy Creek	0	0	0.001	1	0	0	0.006	68.92151
Skinner Creek	----	----	----	----	***	***	***	***
Slater Creek	0	0	0.013	18	----	----	***	***
South Sandy Creek	0.001	22	0.001	25	0.004	171	0.011	183.9682
Sterling Creek	0	0	0	0	***	***	***	***
Stony Creek	0	0	0.381	350	0	0	0.000	0
Webster Park	0.063	92	0.096	68	0.065	82	0.000	0
Non-Salmon River Totals		1,968		6,972		1,709		1,222
Salmon River	0.003	1,441	0.004	2,002	0.005	3,657	0.002	1,401
Totals		3,409		8,974		5,366		2,623

Key: ---- = No interviews obtained, *** = Tributary not surveyed

Table 9. Estimated catch and respective catch rates (fish/angler hour or CPUE) for Brown trout by tributary from September through November 2005, 2006, 2011, and 2015.

	2005		2006		2011		2015	
Tributary	CPUE	Est. Catch	CPUE	Est. Catch	CPUE	Est. Catch	CPUE	Est. Catch
12mile Creek	0	0	0.018	39	0	0	0.000	0
18mile Creek	0.328	20,413	0.231	14,895	0.112	10,941	0.061	1,866
Bear Creek	0.119	123	0.184	131	***	***	***	***
Black River	0.138	2,416	0.012	147	0.007	164	0.000	0
Catfish Creek	0.046	161	0	0	***	***	***	***
Fourmile Creek	***	***	0	0	***	***	***	***
Genesee River	0	0	0.036	370	0.004	38	0.000	0
Grindstone Creek	0	0	0	0	0	0	0.000	0
Irondequoit Creek	0.278	618	0.298	833	0.334	1,528	0.347	1,243
Johnson Creek	0.053	221	0.141	1,007	0.004	25	0.024	106
Keg Creek	0	0	0.238	455	0	0	0.000	0
Lindsey Creek	----	----	----	----	***	***	***	***
Little Salmon River	0	0	0	0	0	0	0.000	0
Little Sandy Creek	0	0	0	0	***	***	0.000	0
Marsh Creek	----	----	----	----	***	***	***	***
Maxwell Creek	0.126	1,142	0.111	1,460	0.317	6,314	0.120	697
Mill Creek	0	0	0	0	0	0	0.000	0
Niagara River	***	***	***	***	0.005	123	0.005	88
Ninemile Creek	0.034	34	0.013	33	***	***	***	***
North Sandy Creek	0.008	122	0.016	93	0	0	0.000	0
Oak Orchard Creek	0.052	3,118	0.065	2,877	0.072	2,933	0.056	2,896
Oswego River	0.023	1,376	0.009	408	0.059	2,930	0.013	111
Sandy Creek	0.368	4,364	0.351	1,455	0.574	9,138	0.377	4,178
Skinner Creek	----	----	----	----	***	***	***	***
Slater Creek	0.072	383	0.027	120	----	----	***	***
South Sandy Creek	0	0	0	0	0.005	240	0.050	835
Sterling Creek	0	0	0	0	***	***	***	***
Stony Creek	0	0	0	0	0	0	0.000	0
Webster Park	0.128	185	0.218	595	0.123	153	0.000	0
Non-Salmon River Totals		34,675		24,917		34,527		12,020
Salmon River	0.011	5,517	0.005	2,502	0.005	3,523	0.003	1,630
Totals		40,192		27,419		38,050		13,650

Key: ---- = No interviews obtained, *** = Tributary not surveyed

Table 10. Estimated harvest and respective harvest rates (fish/angler hour or HPUE) for Brown Trout by tributary from September through November 2005, 2006, 2011 and 2015.

	2005		2006		2011		2011	
Tributary	HPUE	Est. Harvest	HPUE	Est. Harvest	HPUE	Est. Harvest	HPUE	Est. Harvest
12mile Creek	0	0	0.017	38	0	0	0.000	0
18mile Creek	0.025	1,560	0.097	6,265	0.026	2,503	0.019	580
Bear Creek	0.103	106	0.116	83	***	***	***	***
Black River	0.092	1,611	0.009	115	0.002	38	0.000	0
Catfish Creek	0.024	83	0	0	***	***	***	***
Fourmile Creek	***	***	0	0	***	***	***	***
Genesee River	0	0	0	0	0	0	0.000	0
Grindstone Creek	0	0	0	0	0	0	0.000	0
Irondequoit Creek	0.046	102	0.022	62	0.029	131	0.112	402
Johnson Creek	0.024	99	0.113	808	0	0	0.000	0
Keg Creek	0	0	0.052	99	0	0	0.000	0
Lindsey Creek	----	----	----	----	***	***	***	***
Little Salmon River	0	0	0	0	0	0	0.000	0
Little Sandy Creek	0	0	0	0	***	***	***	***
Marsh Creek	----	----	----	----	***	***	***	***
Maxwell Creek	0.024	221	0.033	431	0.054	1,072	0.075	437
Mill Creek	0	0	0	0	0	0	0.000	0
Niagara River	***	***	***	***	0.003	86	0.004	68
Ninemile Creek	0.015	15	0.004	10	***	***	***	***
North Sandy Creek	0.003	47	0.016	93	0	0	0.000	0
Oak Orchard Creek	0.007	439	0.03	1,318	0.012	475	0.011	581
Oswego River	0.003	173	0.003	141	0.017	843	0.005	43
Sandy Creek	0.024	285	0.025	105	0.056	894	0.047	522
Skinner Creek	----	----	----	----	***	***	***	***
Slater Creek	0.047	248	0	0	----	----	***	***
South Sandy Creek	0	0	0	0	0	0	0.041	696
Sterling Creek	0	0	0	0	***	***	***	***
Stony Creek	0	0	0	0	0	0	0.000	0
Webster Park	0.04	58	0.041	112	0.101	126	0.000	0
Non-Salmon River Totals		5,046		9,679		6,168		3,330
Salmon River	0.001	542	0.001	500	0.001	445	0.000	112
Totals		5,588		10,179		6,613		3,441

Key: ---- = No interviews obtained, *** = Tributary not surveyed

Table 11. Angler residency from the 2005, 2006, 2011, and 2015 Lake Ontario tributary angler surveys.

	Number of interviews				**% non NYS resident**			
High use tributaries	*2005*	*2006*	*2011*	*2015*	*2005*	*2006*	*2011*	*2015*
Salmon River	1,786	1,488	2,468	1,939	64	70	63	65
Oswego River	627	977	877	117	50	55	38	46
Oak Orchard Creek	100	174	76	1,008	59	42	25	66
Eighteenmile Creek	160	199	470	891	43	36	47	57
All high use	2,673	2,838	3,891	3,955	54	51	55	58
Medium use tributaries[1]	569	722	1,497	1,414	37	35	33	30
Low use tributaries[2]	498	588	115	221	38	28	26	15

1 = Black, Niagara, and Genesee Rivers, North Sandy, South Sandy, Sandy, and Maxwell Creeks

2 = Mill, Stony, Skinner, Lindsey, Grindstone, Catfish, Ninemile, Sterling, Bear, Webster Park, Irondequoit, Johnson, Marsh, Keg, Fourmile, Twelvemile and Little Sandy Creeks, and Little Salmon River

Appendix 1. Calculations and Formulas

Effort estimates for the Salmon River

Estimates of effort were done using "instantaneous" counts of anglers, vehicles, drift-boat trailers, and boats in the estuary. Means of the counts were used for days when multiple count occur. Effort data were stratified by week. Daily estimates of angler effort (angler hours) were calculated as follows:

$$\hat{H}_{j,h} = [A_t + A_e + (V_{sr} + V_{uf} + V_t - Db) * P_{sh} + Db * P_{db} + B_e * P_{be}]_{j,h} * daylength_{j,h}$$

where:

$\hat{H}_{j,h}$ = the number of angler hours on day *j* in stratum *h*

A_t = the number of anglers counted in Pulaski

A_e = the number of shore access anglers counted in the estuary

V_{sr} = the number of vehicles counted along the main stem of the Salmon River including those counted at the lower fly area in Altmar and excluding those counted in Pulaski, the upper fly fishing area and those attached to drift-boat trailers

V_{uf} = the number of vehicles counted at the upper fly fishing area

V_t = the number of vehicles counted at the tributary access points

D_b = the number of drift-boat trailers counted. Note: the (Vsr + Vuf + Vt + -Db) term accounts for one pickup vehicle per drift-boat being left in a downstream parking area

P_{sh} = the mean size of shore access parties (anglers/vehicle)

P_{db} = the mean size of drift-boat parties

B_e = the number of boats counted in the estuary

P_{be} = the mean party size (anglers/boat) for boat access fishermen in the estuary

$daylength_j$ = the number of hours from ½ hour before sunrise to ½ hour after sunset on day *j*.

The estimator for mean angler hours for all days sampled in stratum h is:

$$\hat{H}_h = \frac{\sum_{j=1}^{n_h} \hat{H}_{j,h}}{n_h}$$

n_h = the number of days sampled in stratum *h*

and the stratum variance is:

$$s_h^2 = \frac{\sum_{j=1}^{n_h} (\hat{H}_{j,h} - \hat{H}_h)^2}{n_h - 1}$$

and the variance of $\hat{H}_h$ is:

$$v(\hat{H}_h) = \frac{s_h^2}{n_h}\left(\frac{N_h - n_h}{N_h}\right)$$

where N_h is the total number of days in the stratum h and $\left(\frac{N_h - n_h}{N_h}\right)$ is the finite population correction factor, and the standard error of $\hat{H}_h$ is:

$$SE(\hat{H}_h) = \sqrt{\mathrm{var}(\hat{H}_h)}$$

The estimated total for all angler hours is:

$T_H = \sum_{h=1}^{L} N_h(\hat{H}_h)$ where L is the total number of stratum and the variance of the total is:

$$\mathrm{var}(T_H) = \sum_{h=1}^{L} N_h^2 \,\mathrm{var}(\hat{H}_h)$$

and the standard error of the total is:

$$SE(T_H) = \sqrt{\mathrm{var}(T_h)}$$

The effort estimates were partitioned by fishing type into boat fishing in the estuary, shore access and drift-boat fishing in the normal regulations portion of the main stem, fishing in the tributaries, and fishing in the special regulations catch and release fly fishing only areas. This was done to provide appropriate weighting factors for stratification of the catch data.

Drift-boat effort was calculated by taking the number of drift-boat trailers counted and multiplying by the mean size of drift-boat party (from the interview forms). Special regulations fly fishing effort was estimated by multiplying the number of vehicles in the upper fly fishing parking area by the mean size of shore fishing parties (again, from the interview forms) and adding the number of anglers counted in the lower fly fishing area in Altmar. Note that the overall estimate of angler effort accounts for special regulations area fly fishermen with vehicle counts only. We had to count the anglers in the lower fly fishing for the estimate of effort for the special regulations fly fishing areas, however, because there was no way to know whether vehicles parked in Altmar belonged to anglers fishing the fly fishing area or the normal regulations area of the river. We also had to count anglers in Pulaski and in the estuary because they did not all park in designated lots. Similar partitions of the data allowed us to estimate boat effort in the estuary and effort in the tributaries. Angler trips were estimated by dividing the estimates for angler hours by the mean lengths of completed trips for each fishing type and for the overall estimate.

Effort estimates for Non-Salmon River Tributaries

$$\hat{H}_{j,h} = [A_t + (V_{vc} * P_{vc}) + (B_e * P_{be})]_{j,h} * daylength_{j,h}$$

where:

$\hat{H}_{j,h}$ = the number of angler hours on day *j* in stratum *h*

A_t = the number of anglers counted on the stream

V_{vc} = the number of vehicles at sites on stream *i* where a direct angler count is not possible

P_{vc} = the mean size of angler party on stream *i*

B_e = number of drift-boats counted on stream *i*

P_{be} = the mean size of drift-boat angler party on stream *i*

The remaining effort calculations are the same as for the Salmon River.

The total angling effort on a given day for the non-Salmon River tributaries is the sum of the direct count anglers plus the adjusted vehicle counts for those areas where a direct count is not readily obtainable. This adjusted value is simply the vehicle count multiplied by the stream specific mean angling party size, which comes from the interview data. Additionally for the Black and Oswego rivers the drift-boat angling effort is added to the total angler count. For these waters the number of drift-boats is counted and multiplied by the stream specific drift-boat party size, again coming from the interview data.

Catch and Harvest

These parameters were stratified for the Salmon River the same as the effort data (by week) and additionally by 5 fishing types: shore access (normal regulations section of the river), special regulations fly fishing, drift-boat fishing, boat fishing in the estuary, and tributary fishing.

Catch and harvest data for the non-Salmon River waters were stratified by month only.

Mean catch rates were calculated as follows with the ratio of means estimator being used for the Salmon River survey. The ratio of means estimator is appropriate for access site creel surveys and the calculations followed Lockwood *et al.* 1999.

Both the ratio of means and mean of ratios estimators are used for the non-Salmon River waters complete versus incomplete interviews, respectively. Since neither interview type was consistently predominant, a weighted mean catch rate formula was used to combine the two estimates into a single value (Lockwood 2005).

Ratio of Means Stratified Catch Rate Estimator for Complete Trip Interviews

y = fish caught or harvested, *x* = hours fished by angler *i* in stratum *h* and *L* is the total number of strata.

$\hat{R}_h = \frac{\bar{y}_h}{\bar{x}_h}$ is the rate in stratum *h* and $\hat{R} = \frac{\bar{y}_{st}}{\bar{x}_{st}}$ is the overall estimator

where:

$$\bar{y}_{st} = \frac{\sum_{h=1}^{L} N_h \bar{y}_h}{N} \quad \text{And} \quad \bar{x}_{st} = \frac{\sum_{h=1}^{L} N_h \bar{x}_h}{N}$$

and the variance of $\hat{R}_h$ is:

$$V(\hat{R}_h) = \left(\frac{N_h - n_h}{N_h} \right) \frac{\sum_{i=1}^{n_h} \left(y_{i,h} - \hat{R}_h x_{i,h} \right)^2}{n_h (n_h - 1) \bar{x}_h^2}$$

and the variance of $\hat{R}$ is:

$$V(\hat{R}) = \sum_{h=1}^{L} \left(\frac{N_h}{N} \right)^2 V(\hat{R}_h)$$

Mean of Ratios Stratified Catch Rate Estimator for Incomplete Trip Interviews

The catch rate estimator for stratum *h* is:

$$\overline{R}_h = \frac{\sum_{i,h=1}^{n_h} R_{i,h}}{n_h}$$

where:
i,*h* = interviewed angler *i* (sampling unit) in stratum *h*
n_h = the number of anglers interviewed in stratum *h*

$$R_{i,h} = \frac{y_{i,h}}{x_{i,h}}$$

$y_{i,h}$ = the number of fish caught or harvested by angler *i* in stratum *h*
$x_{i,h}$ = the number of hours fished by angler *i* in stratum *h*

And the combined catch rate estimator for all strata is:

$$\overline{R} = \frac{\sum_{h=1}^{L} N_h \left(\overline{R}_h\right)}{N}$$

where:
L = total number of stratum
N_h = total estimated anglers in stratum *h* (from interview data)
N = total estimated anglers in all strata (from interview data)

And the variance of $\overline{R}$ is:

$$V\left(\overline{R}\right) = \sum_{h=1}^{L} \left(\frac{N_h}{N}\right)^2 \frac{s_{R,h}^2}{n_h}$$

where:

$$s_{R,h}^2 = \left(\frac{1}{n_h - 1}\right) \sum_{i=1}^{n_h} \left(R_{i,h} - \overline{R}_h\right)^2$$

is the sample variance of catch or harvest rates in stratum *h*

Weighted Mean Stratified Catch Weight Estimator for analyses using both interview types

$$\tilde{R} = \frac{\hat{R}\, n_{\hat{R}} + \overline{R}\, n_{\overline{R}}}{n_{\hat{R}} + n_{\overline{R}}}$$

And the variance of $\tilde{R}$ is:

$$V\left(\tilde{R}\right) = \frac{Var\ (\hat{R})\, n^{2}{}_{\hat{R}} + Var\ (\overline{R})\, n^{2}{}_{\overline{R}}}{(n_{\hat{R}} + n_{\overline{R}})^{2}}$$

Catch and harvest were estimated by multiplying the rates by the estimates of angler hours. Variances were calculated using the formula for variance of a product from Mood et al. (1963).

$$\mathrm{V(xy)} = \mathrm{x2V(y)} + \mathrm{y2V(x)} + \mathrm{V(x)V(y)}$$

Where: x = catch or harvest rate (fish/angler hour) and y = effort (angler hours) and the standard error of the estimated rate is: $SE\ (xy) = \sqrt{V\ (xy)}$

The 95% confidence interval is: $1.96 \times SE\ (xy)$

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Acoustic Assessment of Pelagic Planktivores, 2015

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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 are also important prey for warm water predators, notably Walleye (*Sander vitreum*). Abundance of Alewife and smelt has declined since the early 1990s, likely due to reduced nutrient loading, proliferation of invasive 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.

Hydroacoustic assessments of Lake Ontario prey fish have been conducted since 1991 with a standardized mid-summer survey initiated in 1997. The survey is conducted jointly by the Ontario Ministry of Natural Resources and Forestry (OMNRF) and the New York State Department of Environmental Conservation (NYSDEC). Results from the hydroacoustic survey complement information obtained in spring bottom trawling surveys conducted in the U.S. waters of the Lake (Walsh et al. 2016) and provide whole-lake indices of abundance for Alewife, Rainbow Smelt and *Mysis* (Watkins et al. 2015). In addition, the results provide insights into the midsummer distribution of these species.

The hydroacoustic survey indexes pelagic preyfish abundance, and like other assessments, this survey employs a fairly consistent approach. Increasingly, however, there is strong interest by Great Lakes scientists in knowing the total abundance and biomass of prey fish (and predators) for understanding and modeling predator-prey balance. Rainbow Smelt bottom trawling and hydroacoustic survey indices are correlated (r^2=0.68) and they produce abundance estimates within the same order of magnitude. While hydroacoustic and bottom trawling indices for Alewife in Lake Ontario are correlated (e.g., Alewife r^2=0.57), bottom trawl estimates of total Alewife abundance are higher by at least a factor of ten. As with other assessment gears (e.g. gill nets, bottom trawls), making the transition from relative to absolute abundance requires rigorous testing of assumptions of gear catchability. Bottom trawling has its own assumptions and unknowns regarding gear catchability and we are currently addressing these with our U.S. Geological Survey partners (e.g., Weidel and Walsh 2013). Experimental sampling with vertical gillnets and upward looking hydroacoustics conducted during 2008-2014 has identified some limitations to using the traditional down-looking hydroacoustic approach for achieving accurate, whole-lake estimates of Alewife abundance. Increasing evidence indicates that Alewife can be oriented near the surface at night and potentially undetectable with traditional down-looking acoustics because vessel draft, transducer depth, and acoustic "cone" area create a near-field acoustic "blind-spot" in the first four meters (13.1 ft) of surface water. In addition, the sound and/or vibration of the research vessel may cause surface-oriented Alewife to scatter or dive which affects fish target strength, detectability and ultimately abundance estimates. NYSDEC and OMNRF have been experimentally towing acoustic equipment away from the boat hull in deep water with the transducer aimed upward to detect fish near the surface. Results of upward looking acoustics conducted from 2010-2014 suggest that an average of 50% of the Alewife are near the surface during the survey and undetected by downlooking acoustic methods (Connerton and Holden 2015). In addition to reporting typical survey abundance indices, we are also exploring alternative, refined analyses for generating more objective and accurate estimates of Alewife and Rainbow Smelt abundances. In this report, we present analyses of survey data from 1997-2015 with these new methods and compare the results with the traditional survey index and the spring bottom trawling index.

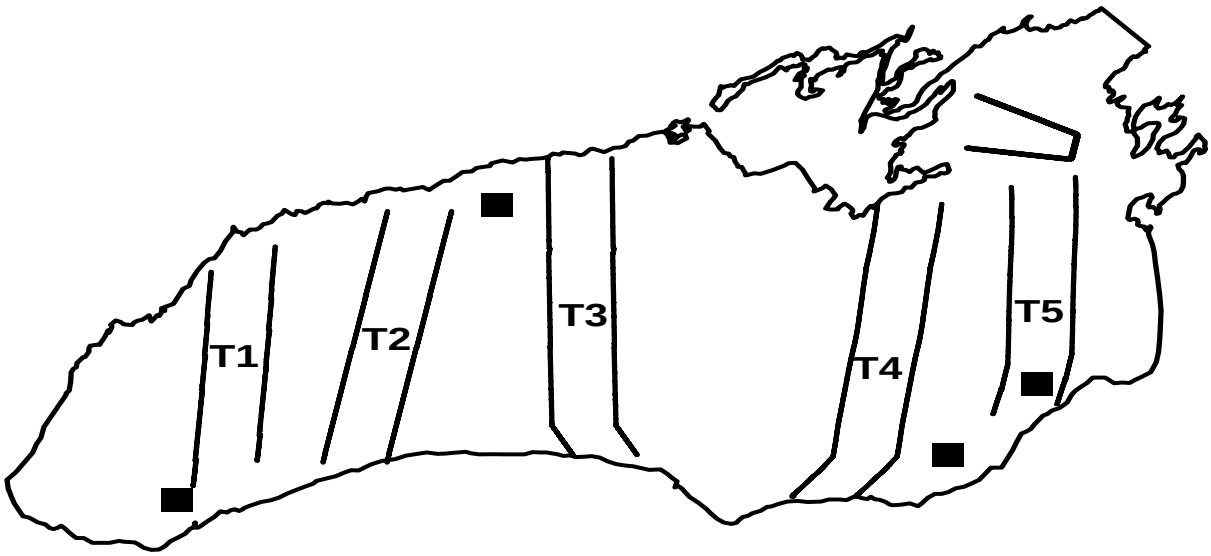

Figure 1. The Lake Ontario Lake-wide prey fish survey uses cross-lake hydroacoustic transects. Transect corridors are logistically constrained but utilize a random starting point within the corridor for each annual survey. The filled squares represent additional transects that were used in 2014 for comparison of up-looking and down-looking acoustic methods.

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 systematic with a random start. The randomly chosen offset in 2015 was 1, meaning that transects were offset 0.1 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.

The 2015 hydroacoustic survey was conducted from July 22-31 using two research vessels (R/V), OMNRF's R/V Ontario Explorer and NYSDEC's R/V Seth Green. Acoustic data 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 (32.8 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.

In addition to the six standard survey transects in 2015, comparisons between mobile down-looking and up-looking acoustics (Figure 1) were done along six additional transects at four locations (8-24 km [5 – 15 miles] long spanning 40 m to 120 m (131-394 ft) bottom depth. To assess abundance of Alewife-sized targets at or near the surface, up-looking acoustic data were collected with a BioSonics DT-X SUB echosounder with a 121 kHz split-beam transducer. The echosounder and transducer were mounted in a tow-body and attached to a trawl door towed at about 30 m (98.4 ft) depth with the transducer facing towards the surface. The trawl door acted as a depressor for the towfish and pulled it off to the port side of the vessel approximately 75 m (246 ft) to avoid surface-noise and bubbles generated by the vessel wake.

Limnological sampling was also conducted at seven stations in 2015 for the Lake Ontario Biomonitoring project, which indexes phosphorus and plankton levels in the lake annually (see Holeck et al. 2016). A temperature profile was measured hourly at points along each transect.

Analytical methods for estimating Alewife and Rainbow Smelt abundance have varied somewhat throughout the hydroacoustic program (1997-2015), but in general, hydroacoustic data were stratified by thermal layer[1] (2 layers, upper: ≥10°C (50°F) to surface, and lower: <10°C to 100 m (328 ft) bottom depth) and geographic zone (6 zones: NW, SW, N-Central, S-Central, SE, NE), and whole-lake abundance estimates were calculated as the area-weighted average of these zones. The data were processed with Echoview software (Myriax Inc. version 6.1) using -64 decibels (dB) volume backscattering strength and target strength thresholds. Target strength assignments were previously verified with mid-water trawling (Schaner and Lantry 1999) and vertical gillnetting (Connerton and Holden 2015).

Rainbow Smelt have traditionally been defined with acoustic target strengths between -55 and -28 dB in the lower layer (Schaner and LaPan 2003). For Alewife, the scaled, integrated voltage estimates of total target abundance in the upper layer were split into 1 dB target strength (TS) bins according to results of single target analysis, which typically produces a histogram with three modes representing: 1. Zooplankton, *Mysis* and larval fish; 2. A mix of larval alewife, smelt and other fish, and possibly larger, diving fish exhibiting lower target strengths); and 3. Yearling and older alewife (YAO) (Schaner and LaPan 2003). The abundances of YAO were apportioned from the resulting target strength histograms by fitting normal curves to the three modes using a solver routine (SR) which minimizes the partial sums of squares, and then by calculating the proportions of each curve relative to the total target strength frequency distribution (Schaner and LaPan 2003). Histograms were processed to identify the proportions of targets in the mode at or around -40 dB, and typically include a proportion of the targets from -45dB to -28dB which were assumed to be YAO Alewife (Warner et al. 2002, Love 1977). The solver routine, however, is sensitive to the approximation of initial starting conditions and the distribution of non-fish targets, and the results can be affected by user judgment which makes it difficult to apply a standard method annually.

[1] From 1997-2009, the thermal layer dividing line was generally set at 15°C for the HIS method. Analysis of midwater trawling data collected from 1993-2005 suggested that 10°C was more appropriate and this was used from 2011 onward. For the AW and BO methods, 10°C was used in all years.

In 2014 and 2015, we explored alternative methods for analyzing hydroacoustic survey data to improve estimates of whole-lake abundance (Connerton and Holden 2015). Three analytical approaches were compared for each species. For Rainbow Smelt, the three methods included:

1) HIS- using the previous area weighted approach and the traditionally defined average density of targets between -55 and -28 dB in the lower layer;
2) AW- using the previous area weighted approach, but limiting the target strength range from -52 to -39 dB (rather than -55 to -28 dB) which represents the Rainbow Smelt size distribution (60-250 mm or 2.4-9.8 in total length [TL]) typically observed in Lake Ontario (Weidel et al. 2015); and
3) BO- bootstrapping the average target strength and mean densities of targets between -52 and -39 dB measured in 500 m (1,640 ft) intervals on all transects across the Lake rather than HIS. Bootstrapping is a statistical procedure (Singh and Xie 2010) that uses simulation to resample the data 1000s of times to explore how the sample estimate (in this case, fish abundance) varies. It provides an alternative abundance estimate and the sampling distribution (e.g., confidence intervals). An abundance estimate is derived for each 500m acoustic interval and then bootstrapping derives a sample of intervals from which the average abundance estimate is calculated. This procedure is done 1000s of times, rather than the HIS method which simply uses the area-weighted average of six zones.

For Alewife, analytical methods explored included:

1) SR-using the previous area-weighted approach with the SR and the target strength range of -45dB to -28dB (i.e., assumed to be YAO Alewife);
2) AW-using the previous area-weighted approach but eliminating the SR step to apply a more objective method not affected by user judgment. For Alewife we included all targets with target strengths as low as -50 dB (rather than a proportion under the fitted curve as in SR) since research has shown that in-situ alewife target strength (Brookings and Rudstam 2009) can vary depending on fish orientation (e.g. if Alewife dive to avoid the vessel). We also decreased the upper limit of target strength from -28dB to -35dB, to more closely represent the maximum size for Lake Ontario Alewife (240 mm or 9.4 in TL);
3) BO-using the bootstrap method, with targets between -50 and -35 dB.

In 2014, eight years of data (2006-'09, 2011-'14) were reanalyzed using each of the above methods, and trends were compared across the time series (Connerton and Holden 2015). In general, results produced by the three methods for both species were well correlated, and most of the differences between the methods' results were attributed to varying TS thresholds employed by each method (Connerton and Holden 2015). In this 2015 report, we reanalyzed additional years of survey data from 1997-2005 using the three methods and compared the results across the entire time series from 1997-2015, except for years 1999, 2002, and 2010. Because only a partial survey was conducted in 1999, estimates for AW and BO were not completed and may be biased. Estimates for smelt were not completed for 2002 because of excessive signal noise in the lower layer data, but we are investigating additional noise filtering techniques and may present these results in future reports. No hydroacoustic survey was completed in 2010 due to bad weather during the scheduled survey time.

Biomass values for both Alewife and Rainbow Smelt were estimated by multiplying acoustic abundance estimates by the average weight of an Alewife or Smelt collected during spring bottom trawling in each year from 1997-2015 (Walsh et al. 2015, Weidel et al. 2015). This method is likely conservative because fish growth from May-July is not accounted for; however, it is a more consistent approach overall through time, was adopted in 2014, and will be used in the future. In the past, average weights of Alewife and smelt were estimated from midwater trawls or vertical gillnetting conducted during the survey, from previous 5-year averages if no fish sampling was conducted that year, or from spring bottom trawling surveys. For a description of biomass methods used in specific years, please see previous NYSDEC and OMNRF Lake Ontario reports 1993-2013.

Results and Discussion

Rainbow Smelt

YAO Rainbow Smelt abundance indices using the three different analyses are presented in Figure 2. All three estimates show an increase in Rainbow Smelt abundance in 2015. For 2015, the BO method produced the highest estimate (29.9 million fish) followed by HIS (29.3 million) and AW (23.5 million). Mean Rainbow Smelt weight was determined from bottom trawl catches during spring trawling (from the smelt survey from 1978-2014, and from the combined spring preyfish survey in 2015 [Walsh et al 2016]). Mean smelt weight increased from 3.7 g in 2014 to 4.5 g in 2015 (0.13 to 0.16 oz respectively), resulting in mean biomass estimates of 0.07 kg/ha (HIS, 0.06 lb/ac), 0.05 kg/ha (AW, 0.04 lb/ac), and 0.07 kg/ha (BO, 0.06 lb/ac, Figure 4a) which were 20%, 66% and 45% of the previous ten-year averages respectively. Rainbow Smelt densities were higher in the eastern basin and along the northern portions of three out of five main-lake transects in 2015 (Figure 5a); however, smelt distribution does not show a prevailing geographic pattern from year to year, except in the eastern basin where densities tend to higher (Holden et al. 2014). The highest concentrations of smelt were found over bottom depths of 60 to 100 m or 197 to 328 ft (Figure 6a).

All three analysis methods were correlated with each other for the 1997-2015 time series studied (HIS/AW

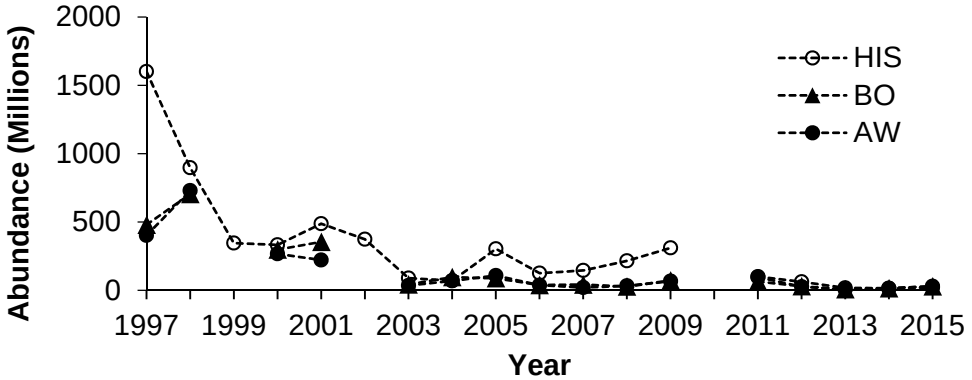

Figure 2. Abundance (in millions of fish) of yearling-and-older Rainbow Smelt from 1997-2015. Abundance estimates for 2006-2014 are presented for three different methodologies: the traditional area-weighted abundance of targets between -55 and -28 dB (HIS, open circles); area-weighted abundance of targets between -52 and -39 dB (AW, filled circles) and a bootstrap approach using 200 m horizontal bins and targets between -52 and -39 dB (BO, filled triangles). No acoustic survey was conducted in 2010.

R^2=0.61; HIS/BO R^2=0.68; AW/BO R^2=0.96). Target strength was likely the main driver behind the differences between the HIS and the AW/BO methods since AW and BO use the same TS range. Throughout the time series, the HIS method generally produced higher estimates than BO/AW as would be expected considering its broader target strength range. The differences between HIS and the other two methods was greater from 2006-2009 than from 2011-2014 which may be attributed to disproportionately more targets between -55 and -52 dB in the earlier years (Connerton and Holden 2015). The differences may also be attributed to the delineation between upper and lower layers. From 1997-2009, 15^{0}C (59°F) was typically used as the dividing line between Alewife and smelt layers (upper and lower layers) when applying the HIS method and calculating the traditional index. In 2009, analyses of midwater trawling data collected from 1993-2005 showed that 10°C (50°F) was a more appropriate dividing line for partitioning Alewife and smelt (T. Schaner, OMNRF, 2009 unpublished data), and this delineation was used from 2011 onward for HIS. Midwater tows in depths where water temperatures were 9°C or warmer were dominated by catches of Alewife (95% total catch weight of prey fish species) whereas tows in depths at temperatures below 9°C (48.2^{o}F) included mostly Rainbow Smelt (84%). For the new AW and BO methods in this report, we used 10°C throughout analysis of the time series, which effectively decreased smelt and increased Alewife density estimates compared to the HIS traditional survey index. This is especially evident in 1997, when the change was greatest between HIS and BO/AW; and large densities of fish were present in the 10-15°C (50 ^{o}F to 59 ^{o}F) layer.

When comparing the AW and BO results, BO estimates were typically higher than AW (by 25% on average), but not always. In 1998, 2005, 2008, and 2011, BO was less than AW (by 18% on average). These differences may be attributed to the variability across regions in any one year using AW. For example, if one or two regions contained higher densities of smelt, the lakewide AW estimate could be biased high that year compared to BO which averages across 500 m (1640 ft) intervals and is less likely to be influenced by high regional densities.

When comparing methods with the spring bottom trawling survey index, BO had the highest correlation (R^2=0.68) with the bottom trawl survey time series (1997-2015) but the other two methods were only slightly lower (R^2=0.67 for both AW and HIS. The advantage of the BO method over the HIS method is that it can be applied with objective repeatability whereas the HIS results can be affected by user judgement. BO also produces robust estimates of confidence intervals compared with the both the HIS and AW methods which calculate an area-weighted average of six regional estimates. Although we will continue evaluating all three methods, we are favoring BO as the future index for smelt.

Alewife

Three analytical approaches to estimate YAO Alewife were applied from 1997-2015 for comparison. Alewife abundance in 2015 declined using all three analyses, however, estimates varied between methods (Figure 3). The SR method estimated a 45% decline in abundance from 2014 to 2015 (199 million to 105 million). The declines estimated by AW and BO (to 369 million and 448 million, respectively) are more similar (41% and 45%, respectively). Despite an increase in mean Alewife size from 21.7 g to 28.0 g (0.77 oz to 0.99 oz) measured in the bottom trawl survey in 2014 to 2015, respectively, overall biomass estimates indicate a decline from 2013 (SR = 32%, AR = 24%, BO = 29%) due to lower abundance (Figure 4b).

As with Rainbow Smelt, estimates from BO were marginally different than AW but are highly correlated (R^2 = 0.93, $p < 0.001$) throughout the time series (1997-2015). Both tended to produce estimates that were higher than SR. Neither method was well correlated with SR (SR-AW: R^2=0.08 and SR-BO: R^2 =0.05 for BO), although all three methods showed a general trend of decline in the late 1990s and fluctuating abundances since then. The correlation appears to be especially lacking prior to 2011, when the SR method was using the 15°C (59 ^{o}F) as the dividing line between Alewife and smelt. Differences between SR and AW/BO method's time series can also be attributed to the different target strength ranges applied by the methods.

When we compared the three Alewife acoustic time series with the Alewife spring bottom trawling results (BTR=annual total of yearling and adults), the SR method was correlated with BTR (R^2=0.57), but the AW and BO methods were not (R^2=0.05 and 0.04 respectively). More work is needed to understand which factors are driving the differences between the results of the acoustic analytical methods and apparent lack of correlation of AW/BO with the bottom trawl survey index. Correlation with the BTR is an important criterion for choosing a future

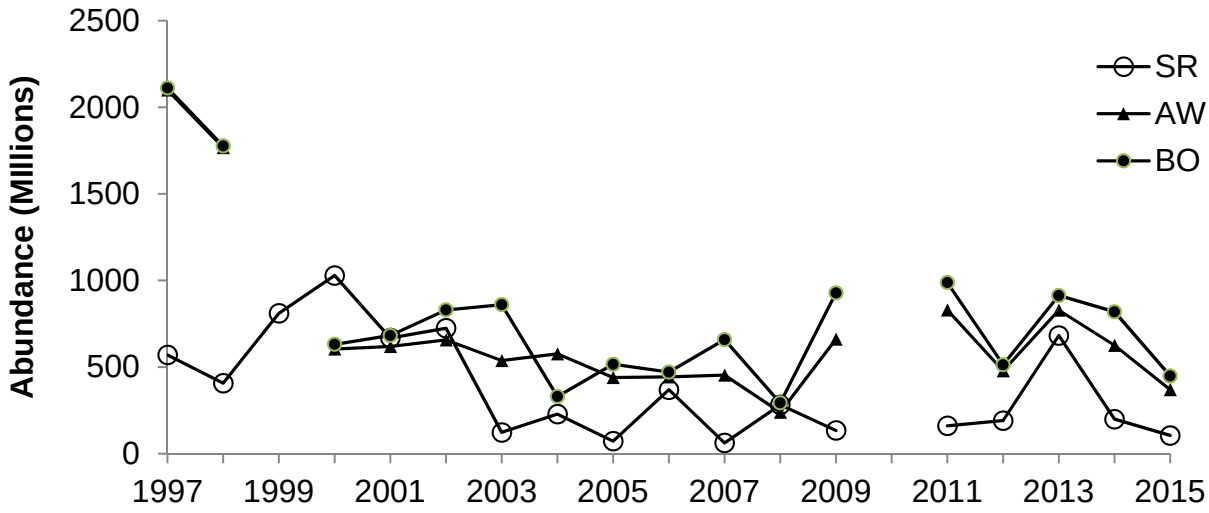

Figure 3. Abundance (in millions of fish) of yearling-and-older Alewife from 1997-2015. Abundance estimates are presented for three different methodologies: area-weighted estimates using a solver routine to identify Alewife sized targets (SR, open circles); area-weighted abundance of targets between -50 and -35 dB (AW, filled circles) and a bootstrap approach using 200 m horizontal bins and targets between -50 and -35 dB (BO, filled triangles). No acoustic survey was conducted in 2010.

acoustic index, however both surveys went through several methodological changes since 1997, concurrent with ongoing ecological shifts in the lower food web, and we are currently working towards a better understanding of how those changes affect both the acoustic and trawling survey indices. In the coming year we also plan to look more closely at the results of all three acoustic analysis methods and will report on those analyses next year.

In 2015, there appeared to fewer Alewife in the southern portions of the lake (Figure 5b) and the highest concentrations were found over bottom depths between 30 and 70m (Figure 6b). Previous analyses found no discernable consistent geographic patterns in Alewife distribution in 2013-2014 (Connerton et al. 2014), nor any consistent regional trends from 2006-2014 (Holden et al. 2014). Distribution of Alewife may be more related to recent physical (e.g., weekly prevailing winds) and biological factors (e.g. zooplankton blooms) but more research is needed in this area and we are currently exploring other factors to explain their distribution.

Analyses of uplooking data collected in 2015 were not completed yet; however results of up-looking acoustics and vertical gillnetting conducted from 2010-2014 supported the hypothesis that a substantial portion of the Alewife occupied the down-looking acoustic blind spot (Connerton and Holden 2015). Vertical gillnet data from 2010-2014 indicated that 50% of the Alewife were caught in this blind spot and comparisons of uplooking and downlooking acoustics conducted from 2012-2014 (10 transects total), the mean correction factor was 2.2, so about as many alewife occupied the top 4 meters as in the rest of the water column from 4 m down to the 10^0C isotherm. We are currently exploring how factors such as thermocline depth and wave height contribute to the variability observed in the proportion of alewife near surface.

Hydroacoustics remains an important survey for indexing midsummer preyfish abundance. Although up-looking acoustics and vertical gillnetting data suggest that a substantial portion of the Alewife occupy the downlooking acoustic blindspot, total backscatter in each depth measured by up-looking and down-looking transducers were well correlated (R=0.49 in comparable portions of the water column (4m-10^oC depth) indicating that traditional down-looking methods still provide a valuable index of abundance. Future whole-lake abundance and biomass estimates will require application of an appropriate correction factor to account for Alewife in the 0-4m portion of the water column. Like other fisheries assessment gear, hydroacoustics has a set of assumptions of ‘catchability’ when extrapolating to whole lake abundance. While hydroacoustics has its challenges, research has also identified new opportunities including estimating the abundance of other important animals in the Lake Ontario foodweb like *Mysis* and zooplankton. Comparisons between *Mysis* densities using nets and acoustics were very similar in 2005, 2006, and 2008 (Watkins et al. 2015). Acoustics also provide information about

preyfish spatial distribution, including Ontario waters, which is not currently accomplished with bottom trawling. We will continue to work towards improving the application of this technology.

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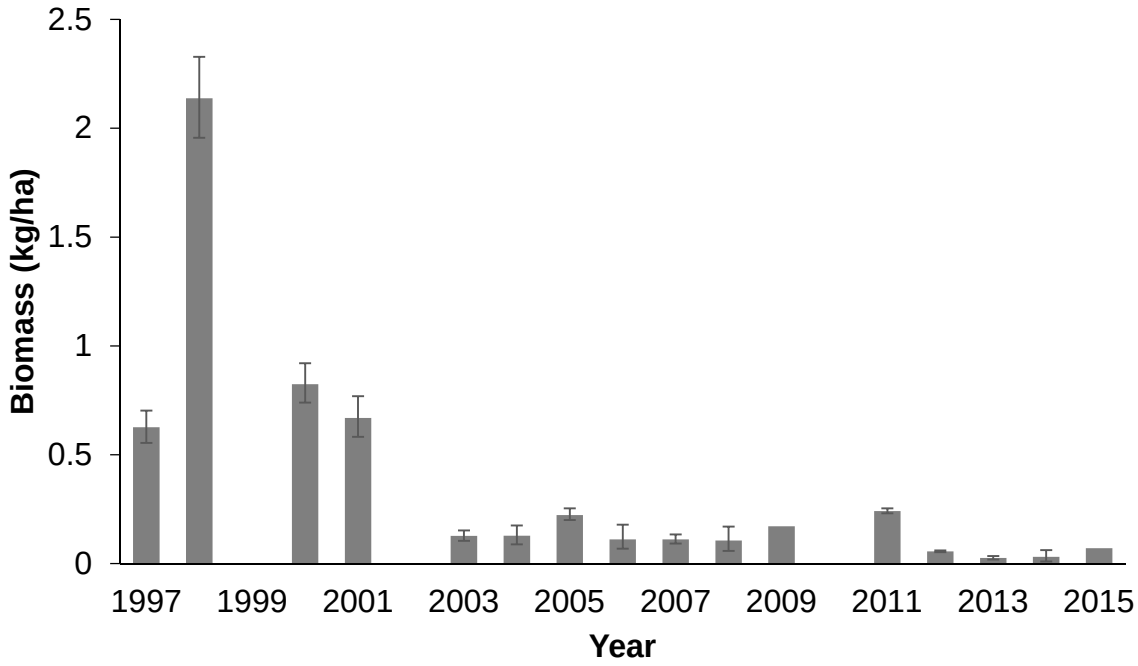
(a)



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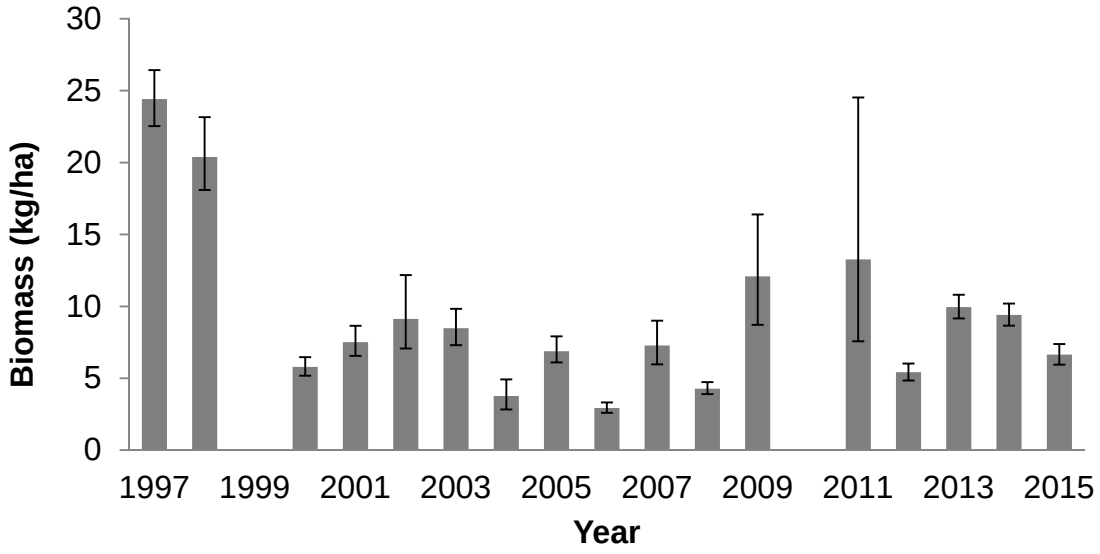
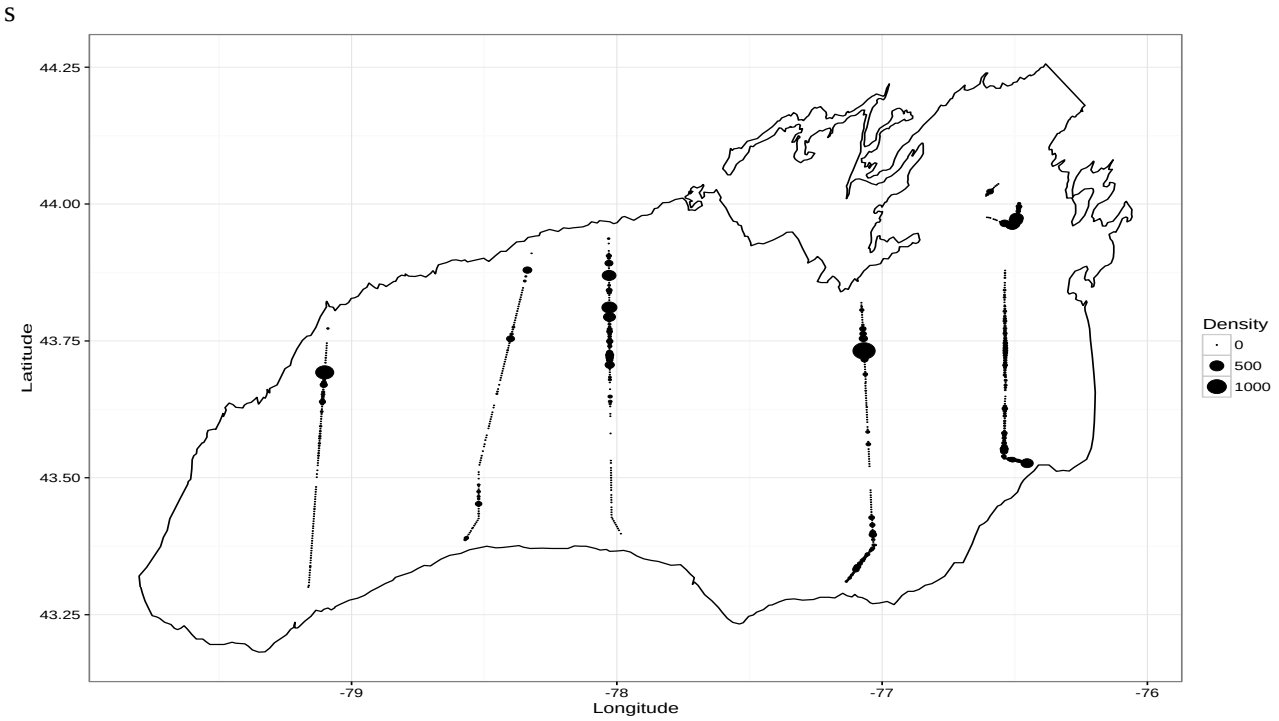


Figure 4. Biomass (kg/ha) of Rainbow Smelt (a) and Alewife (b) from 1997-2015. Biomass estimates were obtained by multiplying the bootstrapped whole-lake hydroacoustic abundance estimates by the average weights of Alewife or Rainbow Smelt measured during bottom trawling surveys. The acoustic survey was not conducted in 2010.

(a)



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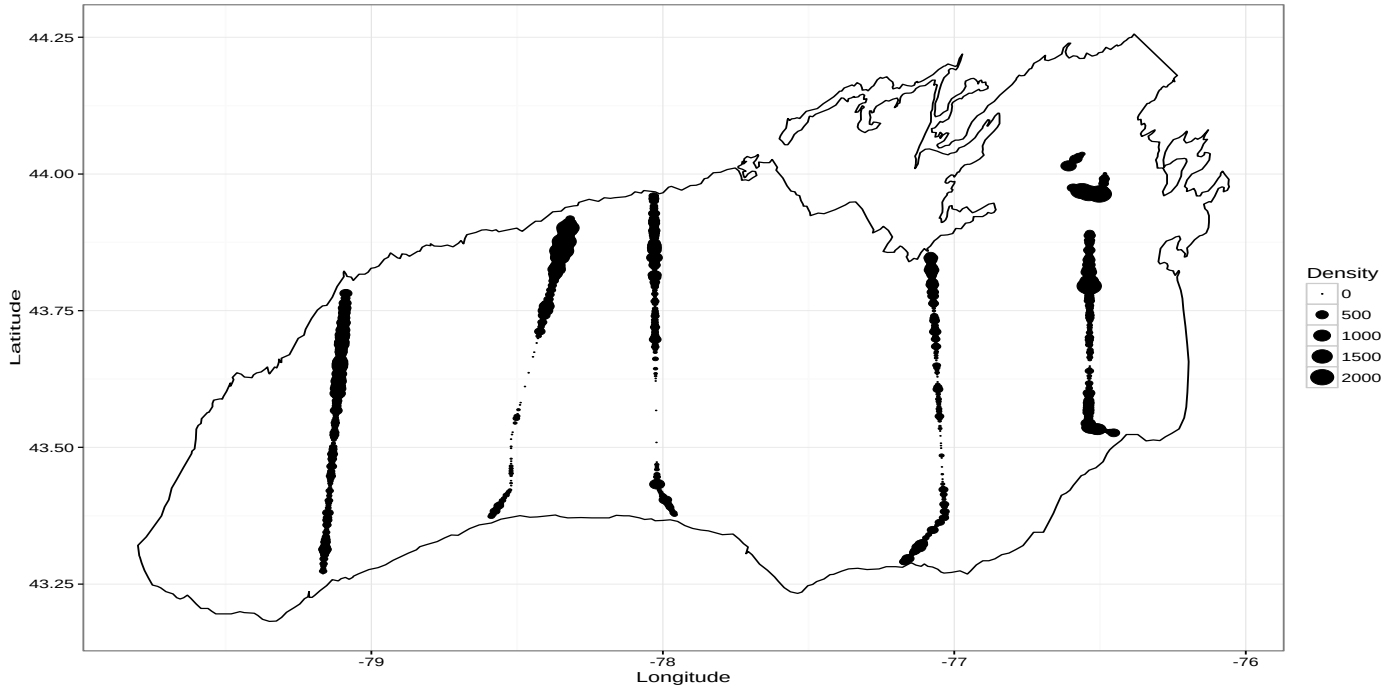
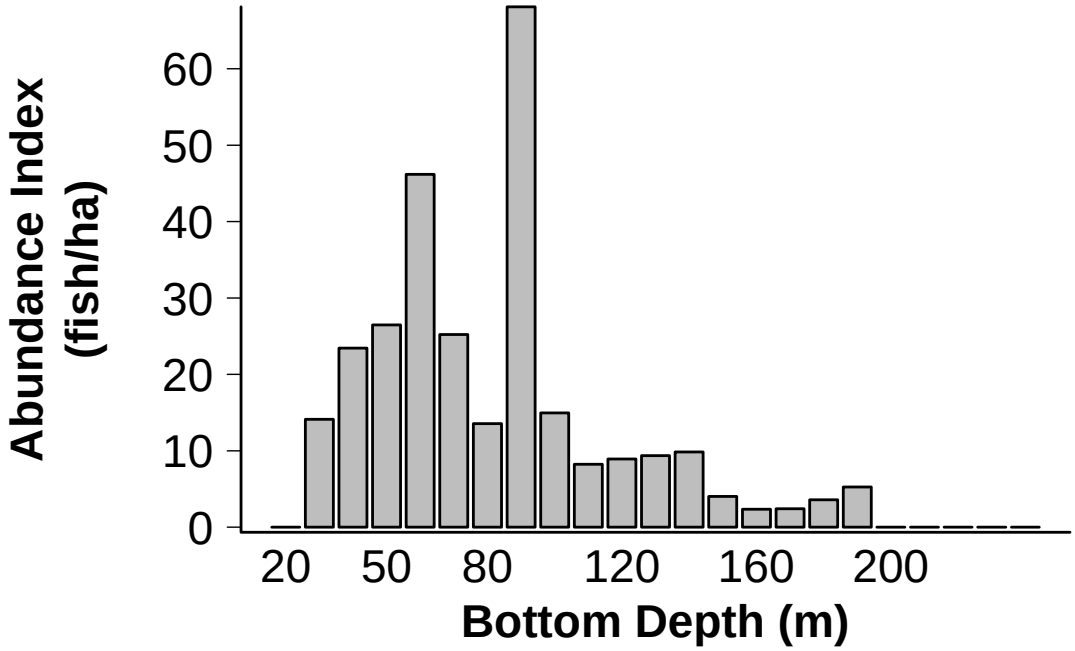


Figure 5. Relative distribution (fish/ha) of Rainbow Smelt (a) and Alewife (b) observed during the hydroacoustic survey in July 2015.

a)



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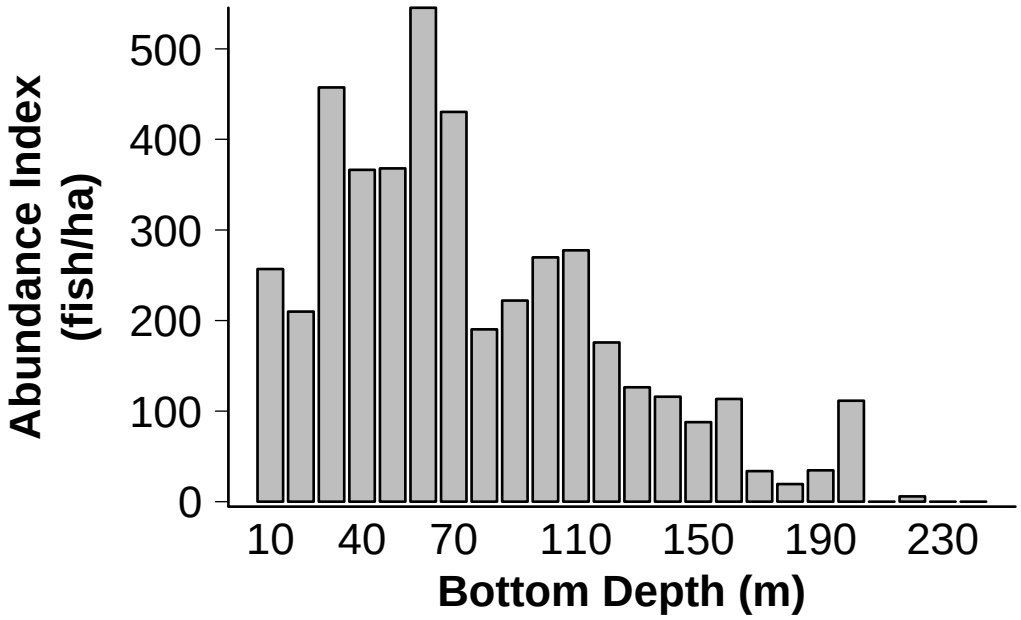

Figure 6. Abundance index (fish/ha) of Rainbow Smelt (a) and Alewife (b) relative to bottom depth during the hydroacoustic survey in 2015.

2015 Status of the Lake Ontario Lower Trophic Levels

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Significant Findings for Year 2015:

1) Offshore spring total phosphorus (TP) in 2015 was 4.2 µg/L, the same as in 2014; this is lower than 2001 – 2013, but there is no significant time trend 2001 - 2015. Offshore soluble reactive phosphorus (SRP) was very low in 2015; Apr/May – Oct mean values were ≤1 µg/L at most sites. SRP has been stable in nearshore and offshore habitats since 1998 (range, 0.4 – 3.3 µg/L). TP concentrations were low at both nearshore and offshore locations (range 4.2 – 8.1 µg/L), and TP and SRP concentrations were significantly higher in the nearshore as compared to the offshore (6.8 µg/L vs 4.8 µg/L, TP; 1.1 µg/L vs 0.7 µg/L, SRP).
2) Chlorophyll-*a* and Secchi depth values are indicative of oligotrophic conditions in nearshore and offshore habitats. Offshore summer chlorophyll-*a* declined significantly 2000-2015. Nearshore chlorophyll-*a* increased 1995 - 2004 but then declined 2005 - 2015. Epilimnetic chlorophyll-*a* averaged between 0.9 and 1.9 µg/L across sites, and offshore concentrations (1.4 µg/L) were significantly higher than nearshore (1.1 µg/L). Summer Secchi depth increased significantly in the offshore 2000 -2015 and showed no trend in the nearshore, 1995 – 2015. Apr/May – Oct Secchi depth ranged from 5.0 m to 13.0 m at individual sites and was higher in the offshore (9.5 m) than nearshore (6.2 m).
3) In 2015, Apr/May – Oct epilimnetic zooplankton density, size, and biomass were not different between the offshore and the nearshore, but cyclopoid biomass was higher in the offshore (8.3 mg/m^3 vs 2.0 mg/m^3) and *Bythotrephes* biomass was higher in the nearshore (0.17 mg/m^3 vs 0.04 mg/m^3).
4) Zooplankton density and biomass peaked in September, an atypical pattern. This coincided with peaks in calanoid copepod, daphnid, and *Holopedium* biomass. *Holopedium* biomass in the nearshore has increased significantly since 1995.
5) The predatory cladoceran *Cercopagis* continued to be abundant in summer in the nearshore (3.4 µg/L) but not in the offshore (0.8 µg/L). *Bythotrephes* biomass was very low (<0.3 µg/L) in both nearshore and offshore habitats. Combined biomass of these predatory cladocerans in the offshore was the lowest recorded since 2001.
6) Summer nearshore zooplankton density and biomass declined significantly 1995 – 2004 and then increased significantly 2005 – 2015. The decline was due to reductions in bosminids and cyclopoids and the increase was due mostly to a rebound in bosminids.
7) Summer offshore zooplankton density and biomass increased significantly 2005 – 2015. The increase was due to an increase in bosminids and cyclopoids. In 2015, offshore summer epilimnetic zooplankton biomass was 52 mg/m^3 (2005 – 2014 mean=18 mg/m^3).
8) Most zooplankton biomass was found in the metalimnion in July and in the hypolimnion in September. Cyclopoids and *Limnocalanus* dominated the metalimnion and *Limnocalanus* dominated the hypolimnion. Whole water column samples taken show a stable zooplankton biomass but changing community composition since 2010. Cyclopoids increased 2013 – 2015 and daphnids declined 2014 – 2015.

Introduction

This report presents data on the status of lower trophic levels of the Lake Ontario ecosystem (zooplankton, phytoplankton, nutrients) in 2015 collected by the US Biological Monitoring Program (BMP). Trophic level indicators for 2015 are compared with data collected by this program since 1995 and with similar long-term data from other sources. Production at lower trophic levels determines the lake's ability to support the prey fish upon which both wild and stocked salmonids depend. High nutrient concentrations can also lead to unwanted algae blooms. There are therefore competing concerns regarding lake productivity. First, there are concerns about the ability of the lake to support current alewife production in the offshore due to declining nutrient levels and zooplankton biomass (Bunnell et al. 2014). A decline in offshore lower trophic level productivity is considered a main cause for the collapse of the alewife population and decline in Chinook salmon fishery in Lake Huron after 2003 by some authors (e.g. Barbiero et al. 2011, Bunnell et al. 2012), although others point at the importance of predation and winter severity as the causative mechanisms (Dunlop and Riley 2013, He et al. 2015, Riley and Dunlop 2016, Bence et al. 2016). Alewives have not returned to Lake Huron as of 2015. Concerns of a similar crash in Lake Michigan led to a decision to decrease Chinook stocking rates in that lake. On the other hand, high nutrient levels close to shore are contributing to excessive growth of attached algae (e.g., *Cladophora*) in some shoreline and beach areas (Makarewicz et al. 2012). This simultaneous desertification of the offshore and eutrophication of the nearshore (Dove 2009, Koops et al. 2015) was considered one of the major research and management issues in Lake Ontario by a 2012 bi-national workshop discussing the lake's research needs (Stewart et al. 2016).

From 1995 - 2015 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), soluble reactive phosphorus (SRP), chlorophyll-*a* (chl-*a*), Secchi depth (SD), and crustacean zooplankton (density, biomass, species composition, and size structure). Samples were collected from late April through early October. These indicators were 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, and these nutrients fuel biological activity during the entire year. Therefore, spring TP is an important indicator. 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 2015, included the New York State Department of Environmental Conservation (NYSDEC) Lake Ontario Unit and Regions 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.

We have recently summarized time trends in the BMP data and compared them with data from the Lake Ontario Lower food web Assessments (LOLA) from 2003 and 2008 (Munawar et al. 2015) as well as the Cooperative Science and Monitoring Initiative from 2013 and other data series (Rudstam et al. 2016). Nutrients, chlorophyll, and zooplankton declined in the long term data series (since 1981), but showed little further decline since the mid-1990s (Holeck et al. 2015, Rudstam et al. 2015). In addition, phytoplankton below the thermocline can be abundant and productive (Twiss et al. 2012, Watkins et al. 2015), and has not been considered in past studies. However, Dove and Chapra (2015) reported continued decline in spring TP in the lake based on the Environment Canada surveillance data. Therefore, we are especially interested in any evidence of further decreases in lower trophic level indicators in the 2015 (and 2014) BMP data compared to the

1995 - 2013 data collected by the same program and whether any such further decrease occurred in both the nearshore and offshore areas of the lake. This is particularly important as failed alewife year classes in Lake Ontario for two years in a row (2013 and 2014, see Walsh et al. 2016) may indicate the beginning of similar declines as were observed in Lakes Huron and Michigan.

In contrast to the stable nutrient concentrations observed 1995 - 2015, epilimnetic zooplankton declined abruptly around 2005. This decline was primarily due to declines in cyclopoid copepods and the small cladoceran *Bosmina longirostris*. Rudstam et al. (2015) attributed this decline to increased presence of the predatory cladoceran *Bythotrephes longimanus*. This invasive predatory zooplankton species increased in the lake around 2005, likely a result of decreased alewife abundance (see also Barbiero et al. 2014). Whole water column zooplankton biomass was less affected (Barbiero et al. 2014, Rudstam et al. 2015, 2016) due to increases in large calanoid copepods associated with deep chlorophyll layers. Concentration of zooplankton in deeper waters may be the new normal for Lake Ontario and lead to changes in fish distributions. As *Bythotrephes* declined again in 2013 and stayed at low abundance in 2014 (and 2015, see below), we are particularly interested in whether the zooplankton community composition and biomass is now returning to the pre-2005 levels. We are also interested in any changes in vertical distributions as the presence of *Bythotrephes* induces vertical migrations in several zooplankton species (Pangle and Peacor 2006).

Report Objectives

Using data from 1995 to 2015, we address the following questions:

(1) What is the status of Lake Ontario's lower trophic levels in 2015, and what differences exist between nearshore and offshore sites this year?
(2) How does the year 2015 compare to the same indicators in 1995-2014 (using BMP data and other long-term data)?
(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 or invertebrate predation, or lake productivity?
(5) Is the vertical distribution of different zooplankton groups changing, possibly a result of more phytoplankton production in deeper water?

Methods

Sampling

We measured total phosphorus (TP), soluble reactive phosphorus (SRP), chlorophyll-*a* (chl-*a*), Secchi depth (SD), 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 2015 (12 potential sampling weeks). Inclement weather precluded sampling during one week at Galloo Island (GIL), Chaumont Bay (CBL), Niagara East (NEL), and Niagara West (NWL) and during five weeks at Sandy Pond (SPL). Offshore samples were collected during late April-early May, July, and September by the R/V Seth Green, and approximately monthly (April–October) by the R/V Kaho. In addition, seven stations were sampled at night in July during the hydroacoustic survey conducted by the R/V Seth Green. Nearshore sites had depths ranging from 9.0 m to 15.5 m (30 to 51 ft), and offshore site depths ranged from 21 m to 209 m (69 to 686 ft). Nearshore sampling totaled 77 samples taken from seven sites. Offshore sampling totaled 55 daytime samples taken from seven sites and seven nighttime samples from seven 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 (APHA 1998; SM 4500-P). 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 (APHA 1998 SM 4500-P). TP and SRP samples were analyzed at the Upstate Freshwater Institute. Chl-*a* was analyzed at CBFS using a calibrated Turner 10-AU benchtop fluorometer and the EPA standard operating procedure SOP LG 405 (Revision 9, March 2013).

Quality Control and Variability

To measure analytical precision at nearshore sites we processed replicate samples for TP and SRP. In July, six aliquots of water were taken from the same sample at each nearshore site. We also collected replicate samples at nearshore sites to determine within-site variability of TP, SRP, and chl-*a*. Triplicate samples were collected once in August. From each of the three samples, one aliquot was taken for TP, one for SRP, and one for chl-*a* analysis. At offshore locations, duplicate samples for TP, SRP, and chl-*a* were collected 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 8.5 to 11 m. At offshore sites, epilimnetic tow depths ranged from 5 to 53 m (to the thermocline when stratification was present). At offshore sites less than 100 m bottom depth (four daytime sites) a total water column sample (bottom minus 2 m) was collected in addition to the epilimnetic sample when stratification was present. At sites greater than 100 m bottom depth (three daytime sites), one 50 m and one 100 m tow were obtained in addition to the standard epilimnetic sample. At nighttime sites, a single tow was taken from the lesser of 100 m or bottom minus 5 m. 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.

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 (or all animals from samples where fewer than 100 were present) 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 small 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*, SD, zooplankton density, size, and biomass, and zooplankton group biomass between the two habitats by first obtaining monthly means for each site and then fitting a general linear model with month and habitat as categorical predictor variables. With the exception of chl-*a* and SRP, all data were log-transformed prior to analysis. Offshore data collected in late April was analyzed with May nearshore data because of the proximity of nearshore to offshore sampling dates for those months. Data from June and August were omitted from this analysis because the offshore was not sampled during those months. We divided zooplankton into the following six groups: daphnids (*Daphnia mendotae, D. pulicaria, D. retrocurva, D. longiremis, D. schodleri*); 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 (*Alona sp., Ceriodaphnia quadrangula, Chydorus sphaericus, Diaphanosoma sp., Alona sp., Polyphemus pediculus, Leptodora kindtii, Camptocercus sp., Scapholeberis sp., Ilyocryptus sp.*); and nauplii. Four individual species were analyzed separately from the groups. Those species are: *Bythotrephes longimanus*; *Cercopagis pengoi, Holopedium gibberum,* and *Limnocalanus macrurus.* Differences were considered significant at $p<0.05$.

Change point analyses (Taylor Enterprises, Inc. 2003) were performed separately on nearshore and offshore data using the entire data series (1995–2015 for nearshore and 2000–2015 for offshore) to test for breaks in the data. SRP data were available for 1998 – 2015 in both habitats. Analyses were performed on spring TP, Apr/May – Oct SRP, 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 1000 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 v12.0.1, SAS Institute Inc. 2015) were performed on two time stanzas (1995–2015 and 2005–2015) for the offshore and three time stanzas (1995 – 2015, 1995 – 2004, and 2005 - 2015) for the nearshore using spring TP, summer chl-*a*, summer epilimnetic zooplankton density and biomass, and zooplankton group biomass. Night time zooplankton data are not included in time trend analyses. Zooplankton migrate up in the water column at night causing an increase in density and biomass in the epilimnion; therefore results from daytime and nighttime are not comparable.

Results

Quality Control and Variability

To estimate analytical precision (i.e. within sample variability), we analyzed 42 TP samples and 42 SRP samples (7 sites x 6 samples per site). Coefficients of variation (CV=SD/mean) ranged from 4 to 34% (mean of 15%) for TP and from 12 to 48% (mean of 21%) for SRP. Values from replicated sampling occasions were averaged for all analyses.

The analysis of August nearshore TP, SRP, and chl-*a* triplicate samples showed that the CV for TP ranged from 0 to 27% (mean of 11%), the CV for SRP ranged from 17 to 46% (mean of 29%), and the CV for chl-*a* ranged from 6 to 42% (mean of 19%). Within site variability for TP was similar to analytical precision, and ranges represent typical variation observed in previous years. Values were averaged for later analyses. Within site variability for SRP was higher than that observed for analytical precision which could be expected based on the observed SRP concentrations (0.5 – 2.0 µg/L) where a small difference in absolute concentration could result in a large CV. Values were averaged for later analyses.

2015 Water Quality

May through October mean chl-*a*, TP, SRP, and SD were similar across nearshore sites in 2015

(Table 1). TP was highest at Chaumont Lake (CBL; 8.5 µg/L TP) and lowest at Sodus Lake (SOL; 5.3 µg/L TP). SOL also had the lowest SRP (0.6 µg/L). SD was lowest at the site east of the Niagara River (NEL; 5.0 m) and highest at SOL (7.8 m). Chl-*a* was lowest at NEL (0.7 µg/L) and highest at Oak Orchard Lake (OOL; 1.3 µg/L) (Table 1). With the exception of SD, measurements of the same parameters at offshore locations also showed low variability. Chl-*a* ranged from 0.9 µg/L (Main Duck) - 1.9 µg/L (Oak Orchard-N), TP ranged from 3.6 µg/L (Oak Orchard-O) - 5.8 µg/L (Mid Lake), SRP ranged from 0.4 µg/L (Oak Orchard-O) – 1.0 µg/L (Main Duck and Mid Lake), and SD ranged from 7.5 m (Oak Orchard-N and Smoky Point-N) – 13.0 m (Oak Orchard-O) (Table 1). Apr/May – October SRP concentrations were very low (<1.6 µg/L) in both habitats (Figure 5a). TP concentrations at nearshore (7.0 µg/L) and offshore (4.8 µg/L) sites were below the 10 µg/L target established by the Great Lakes Water Quality Agreement (International Joint Commission 1988) for offshore waters (Figure 4a). Apr/May – Oct mean TP and SRP concentrations were significantly higher at nearshore sites while chl-*a* and SD were significantly higher offshore (Table 2).

Seasonal trends were also observed for most variables. Nearshore SD was 8.4 m in Apr/May and declined to 5.1 m in October, while offshore SD remained high (10 – 11 m) in all months except September when it dipped to 5.8 m. (Figure 2a). Monthly chl-*a* concentrations increased from Apr/May to September at both nearshore and offshore locations and then decreased in October. Offshore chl-*a* was higher (1.2 – 2.0 µg/L) than nearshore chl-*a* (0.6 – 1.4 µg/L) in all months except October (Figure 3a). The TP pattern mirrored that of chl-*a*; concentrations increased in both habitats Apr/May to September and then decreased in October. However, nearshore TP (5.4 – 8.1 µg/L) was higher than offshore (4.2 – 5.6 µg/L) in all months (Figure 4a). SRP concentrations peaked in June in the nearshore (1.5 µg/L) and in September in the offshore (1.0 µg/L; Figure 5a).

Water Quality Trends Since 1995

Comparisons with data collected since 1995 show that 2015 had average SD in the nearshore and above average SD in the offshore (Figure 2b). Summer chl-*a* concentrations were at an all-time low in the nearshore (Figure 3b). Offshore chl-*a* was higher than nearshore and higher than in 2014, but still below the 1995 – 2014 mean. Spring TP and Apr/May – Oct SRP were below average in both nearshore and offshore habitats (Figure 4b, 5b). Summer chl-*a* decreased significantly 2000 – 2015 in the offshore, and there was a negative change point in 2009. In the nearshore, summer chl-*a* increased 1995 – 2004 and decreased 2005 – 2015; there was a positive change point in 2003 and a negative change point in 2009 (Table 3). TP and SRP were stable in nearshore (1995 – 2015) and offshore (2000 – 2015) habitats.

2015 Zooplankton

In 2015, mean Apr/May-Oct zooplankton density, size, and biomass did not differ significantly between nearshore and offshore sites (Table 2, Figure 6). Density and biomass were highest during July in the offshore and in August in the nearshore (Figure 6). This coincided with peaks in cyclopoid copepod biomass in the offshore and daphnid and other cladoceran biomass in the nearshore (Figure 7). High mean zooplankton size observed in Apr/May was due to large calanoid copepods in both habitats as the low temperatures preferred by these copepods occurred throughout the water column at that time (Figure 7).

As with total epilimnetic zooplankton biomass, most individual group biomasses were not significantly different between nearshore and offshore habitats (Table 2; Figure 7). However, cyclopoid copepods (primarily *Diacyclops thomasi*) were higher in the offshore (8.3 µg/L) than in the nearshore (2.0 µg/L), and *Bythotrephes* was higher in the nearshore (0.17 µg/L) than in the offshore (0.04 µg/L) (Table 2). Cyclopoid copepods represented the greatest proportion of biomass in the offshore (28%) while daphnids accounted for the greatest proportion of biomass in the nearshore (28%).

In 2015, *Cercopagis* and *Bythotrephes* were detected in samples from both habitats (Figures

7, Table 2). *Cercopagis* was first detected in late May in the nearshore and in mid-July in the offshore. *Cercopagis* peaked during late July to early August in the nearshore and offshore (Figure 7). *Bythotrephes* was present in late May in the nearshore, was absent until July, and peaked in late September. It did not appear until late September at offshore locations when its biomass was similar to that in the nearshore (Figure 7). Combined biomass of *Cercopagis* and *Bythotrephes* represented 8% of the zooplankton community at nearshore sites and 2% at offshore sites, with most of that biomass contributed by *Cercopagis*.

Comparison of epi-, meta-, and hypolimnetic daytime zooplankton tows showed that most zooplankton were present in the metalimnion at 2 of the 3 deep sites during the July stratified period (Figure 8). At Oak Orchard-O 7/6 zooplankton biomass was more evenly distributed between the metalimnion and hypolimnion. Toward the end of the stratified period (September), more zooplankton were found in the hypolimnion except at the Mid Lake site (9/11) which had most biomass in the metalimnion. Epilimnetic biomass represented only 2 – 26% of total water column biomass during the July stratified period and 24 – 27% during September (Figure 8). At sites less than 100 m bottom depth, epilimnetic biomass ranged from 8 – 68% during the stratified period. In July and September, an average of 82% of the zooplankton biomass at deep offshore sites resided in the meta- and hypolimnion.

Results of the epi-, meta-, and hypolimnetic tows from July, September, and October deep sites (>100 m) showed that the vertical distribution and species composition of zooplankton changed seasonally (Figure 9). Most zooplankton biomass occurred in the metalimnion in July but shifted to the hypolimnion in September and October. In the epilimnion, cyclopoids and bosminids represented the greatest biomass in July. By September daphnids and *Holopedium* dominated the epilimnion. In October, cyclopoids and calanoids (other than *Limnocalanus*) dominated the epilimnion. Cyclopoids and *Limnocalanus* dominated zooplankton biomass in the metalimnion during July and September while *Limnocalanus* and other calanoids were dominant in October. *Limnocalanus* and other calanoids dominated the hypolimnion in all months (Figure 9).

Zooplankton Trends Since 1995

Nearshore summer total zooplankton density and biomass declined significantly 1995 – 2015 (Figures 10 and 11, Table 3). These declines were driven by significant declines from 1995 – 2004 after which density and biomass increased significantly (Table 3, regression results). Change point analysis showed that a negative break occurred in nearshore total zooplankton density and biomass in 1998 and in zooplankton density in 2005 (Figures 10 and 11, Table 3). In the offshore, there was no decline in summer epilimnetic zooplankton density or biomass from 2000 – 2015, but both density and biomass increased significantly from 2005 – 2015 (Figures 10 and 11; Table 3). Change point analysis showed a negative break in density and biomass in 2005 followed by a positive break in density in 2014 (Table 3).

Several trends were noted in nearshore summer zooplankton group biomass (Figure 12, Table 3). From 1995 – 2015, significant declines occurred in bosminid, cyclopoid, and daphnid biomass. At the same time, *Bythotrephes* and *Holopedium* biomass increased significantly (Table 3). Bosminids decreased from 1995 – 2004 and then increased, 2005 – 2015. Cyclopoid copepods declined 1995 – 2004 but then remained stable thereafter. *Holopedium* biomass increased 1995 – 2004 and 2005 – 2015. In the offshore, calanoid and *Holopedium* biomass increased, 2000 – 2015, and bosminids, cyclopoids and daphnids increased, 2005 – 2015 (Figure 13, Table 3). *Cercopagis* and *Bythotrephes* biomasses were low compared to overall zooplankton biomass. Therefore, we plotted them separately to better depict patterns in their biomass (Figure 14). The nearshore showed negative change points in *Bythotrephes* biomass (2002 and 2012) and a positive change point in 2006 (Table 3). *Cercopagis* showed a negative change point in 2007. In the offshore, *Bythotrephes* showed a positive change point in 2005 and a negative change point in 2015. Change points in the nearshore were also evident with cyclopoid copepods (negative, 1998, 1999;

positive, 2013), bosminids (negative, 2005; positive, 2011), calanoids (negative, 1996) and *Holopedium* (positive, 2003 and 2015) (Table 3). In the offshore, change points occurred in bosminids (negative, 2004; positive, 2014) cyclopoids (negative, 2005; positive, 2015) and other cladocerans (positive, 2004) (Table 3).

Summer whole water column zooplankton biomass has been stable, 2010 – 2015 (Figure 15) and no sharp increase was observed in 2015 as was seen in the epilimnetic biomass (Figure 13). However, zooplankton community group composition changed during this time. Cyclopoids increased 2013 – 2015 and daphnids and calanoids (other than *Limnocalanus*) declined 2014 – 2015 (Figure 15).

Discussion

Secchi depth, chl-*a*, and TP are indicators of lake trophic status (Carlson 1977). In 2015, average Apr-Oct values for all sites ranged from 5.0 to 13.0 m SD, 0.7 to 1.9 µg/L chl-*a*, 3.6 to 8.5 µg/L TP, and 0.4 to 1.8 µg/L SRP. These values are within the range for oligotrophic (low productivity) systems (0.3-3.0 µg/L chl-*a*, 1-10 µg/L TP; Wetzel 2001).

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 low spring TP concentrations. Spring TP declined from values between 20 and 25 µg/L in the 1970s to values 3-7 µg/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 (Dove and Chapra 2015) and EPA's lower trophic level assessments in the intensive field years of 2003, 2008, and 2013 (Holeck et al. 2008; Holeck et al. 2015; Rudstam et al. 2016). Spring TP has been mostly below or only slightly above the goal of 10 µg/L at both offshore and nearshore sites since the BMP program started in 1995 (Figure 4b).

Although it is clear that spring TP has declined since the 1970s in both habitats, the BMP data does not show any further decline since 1995 suggesting that nutrient loading into Lake Ontario in both the offshore and nearshore has remained relatively stable over the last two decades. However, in a recent analysis of the Canadian Surveillance data, Dove and Chapra (2015) found continued decline in spring TP in Lake Ontario through 2013. Rudstam et al. (2016) compared trends in spring TP data using averages for all data available to them (EPA-GLNPO, OMNRF, CSMI, DFO-Canada, Environment Canada, BMP) and did not find a decline up to 2013. However, they note that the EC Surveillance data did show a marginally significant decline from 1995 to 2013 when considered alone ($p<0.08$). Since the values for 2014 and 2015 are even lower in EC data (Dove, unpubl data), it is likely that the declining trend is significant for the time period 1995 – 2015 in that data series. We note that both the 2014 and 2015 TP levels are also low in the BMP data.

Summer chl-*a* did not change from 1995 to the mid-2000s (nearshore) but decreased significantly in the nearshore and offshore after 2005 with negative change points in 2009 in both habitats. Declines in offshore summer chl-*a* were also observed by Environment Canada and EPA-GLNPO programs since 2005 (Dove and Chapra 2015, Rudstam et al. 2016). Summer Secchi depth has not changed significantly since 1995 in the nearshore but has increased significantly in the offshore. Thus, two of the three common trophic level indicators (SD and chl-*a*) show a significant trend towards increased oligotrophication in offshore Lake Ontario. Although the trend in TP levels is not significant in the BMP data, the measured TP levels are lower in 2014 and 2015 than in most previous years.

In contrast to the trend towards continued oligotrophication in the offshore, summer epilimnetic offshore zooplankton biomass increased in 2015, with cyclopoid copepods and bosminids accounting for most of that increase. This continues a trend that started in 2013. Prior to 2013, epilimnetic density and biomass had declined in the offshore in 2005 (Figure 13) and in the nearshore in 1998 (Figure 12), declines we attributed to increased *Bythotrephes* abundance in the offshore and also *Cercopagis* in the nearshore (Warner et al. 2006, Barbiero et al. 2014, Rudstam et al. 2015). These trends are

consistent with observed effects of these predatory zooplankton elsewhere (Lehman and Caceres 1993, Yan et al. 2001, Pangle et al. 2007). Low *Bythotrephes* abundance continued in 2015. Additionally, the combined biomass of *Cercopagis* and *Bythotrephes* in the offshore was the lowest since 2001. As was anticipated, we observed the return to a zooplankton community with a larger proportion of bosminids and cyclopoids, similar to the community present pre-2005 in the offshore. This is strong support for the importance of *Bythotrephes* predation on zooplankton in Lake Ontario.

Generally, *Bythotrephes* abundance is negatively correlated with alewife abundance due to predation (Johannsson and O'Gorman 1991, Barbiero et al. 2014). In Lake Ontario, *Bythotrephes* biomass was low 2012 – 2015 compared with 2005 – 2011 (Figure 14). However, alewife abundance was relatively stable 2005 – 2015 with the exception of 2006 and 2010 when abundance was very low (Walsh et al. 2016). *Bythotrephes* biomass was at a record high level in 2010 but was only slightly above average in 2006. In addition, a year of relatively high alewife abundance (2008; Walsh et al. 2016) had the second highest biomass of *Bythotrephes* (Figure 14). These inconsistencies suggest additional factors are impacting trends in *Bythotrephes* and alewife (e.g., lower trophic level changes, salmonid predation). For example, although a strong 2012 year class was expected to increase the adult alewife population, that did not happen and biomass remained lower during 2014-2015 than during the 1990s. In addition, alewife abundance is measured in spring while *Bythotrephes* peak biomass estimates are from fall (September-October). Therefore, changes that occur over the course of the summer may also contribute to the lack of consistency between alewife abundance and *Bythotrephes* biomass.

The deep chlorophyll layer and associated zooplankton are not part of the long term data set collected by the BMP program. However, we have given this more attention since 2010 and are now collecting whole water column (100 m or bottom minus 2 m to the surface) zooplankton tows, as does the EPA-GLNPO program. EPA data show little decline in the offshore zooplankton biomass from 1998 to 2013 (Barbiero et al. 2014, Rudstam et al. 2016), and whole water column data from the BMP (2010 – 2015) support this observation (Figure 15). However, calanoids and daphnids declined in whole water column tows, 2010 – 2015 and this decline was evident in the epilimnion as well. The observed decline in calanoid biomass could be due in part to redistribution. Results from summer (July) stratified zooplankton hauls indicated that epilimnetic biomass of calanoids represented only 7% of the total biomass of calanoids. Most (76%) calanoids were found in the metalimnion at this time. The lower daphnid biomass observed in 2014 – 2015 in July is due in part to an altered seasonal pattern. In both these years, daphnid biomass peaked in September during which most daphnid biomass occurred in the metalimnion (2014) and in the epilimnion (2015).

Another interesting observation is the rapid increase in *Holopedium* since 1995. Jeziorski et al. (2014) reported that *Bythotrephes* facilitated the replacement of daphnids by *Holopedium* in some lakes because *Holopedium* has a jelly-like coating that makes it less vulnerable to predation by *Bythotrephes*. We may therefore expect higher densities of *Holopedium* from 2005 to 2012 when *Bythotrephes* were abundant. However, *Holopedium* began increasing in the nearshore after 1995 (Table 3). Fall biomass of *Bythotrephes* in 2014 and 2015 was at its lowest level since 2004 when the biomass of *Holopedium* was high. Therefore the reason for the increase in *Holopedium* remains unclear. It is possible that *Bythotrephes* facilitated the replacement of daphnids by *Holopedium* but that a lag time exists in this sequence of events. In addition, *Holopedium* may also replace *Daphnia* in calcium poor lakes (Jeziorski et al. 2014). However, low Ca is unlikely to be responsible for the observed increase in *Holopedium* because Ca concentrations have been stable in Lake Ontario since 2000 (Chapra et a. 2012) and Lake Ontario levels (i.e., 34-42 mg/L, Chapra et al. 2012) were well above the low levels reported by Jeziorski et al. (1-3 mg/L; 2014).

The BMP data from 2015 showed interesting and partly contradictory patterns in the lower

trophic levels. Nutrient and chl-*a* concentrations suggest lower offshore productivity in 2015, although the change in TP is not significant. On the other hand, zooplankton density and biomass have increased in the epilimnion suggesting increased food availability for alewife. This is likely due to low *Bythotrephes* and *Cercopagis* abundance since 2013. Although caution about decreased offshore productivity is warranted, our data suggest changes primarily in zooplankton community composition and overall abundance towards levels and structure observed pre-2005 in Lake Ontario. This is not what we would expect from a decrease in phytoplankton production. In addition, we have not seen a decline in whole water column biomass of zooplankton which includes a large proportion of deep water forms, such as large calanoids, consistent with patterns through the 2000s (Barbiero et al. 2014, Rudstam et al. 2015, 2016).

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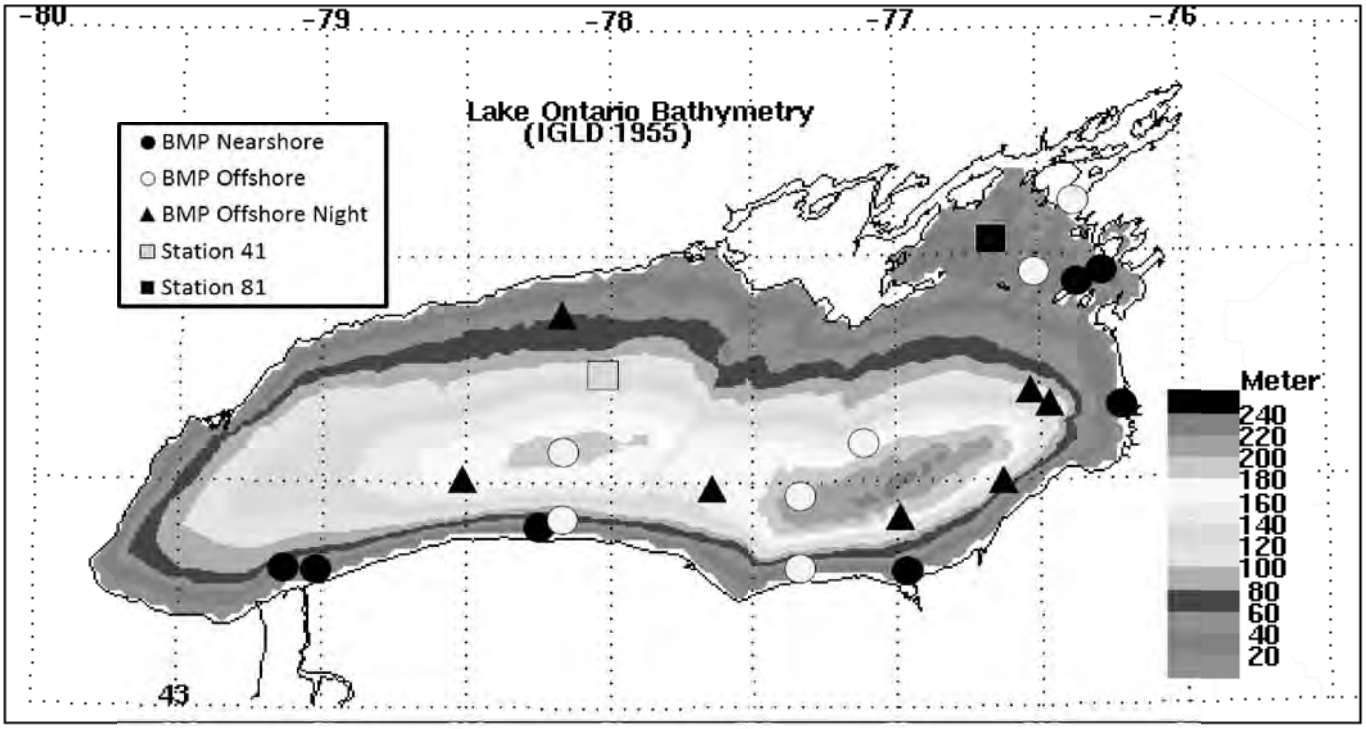

Figure 1. Map of Biomonitoring Program sites, 2015. Station 41 and station 81 are locations sampled by the Department of Fisheries and Oceans Canada's Bioindex Program (1981 – 1995) and are included here as reference for long-term data included in subsequent figures.

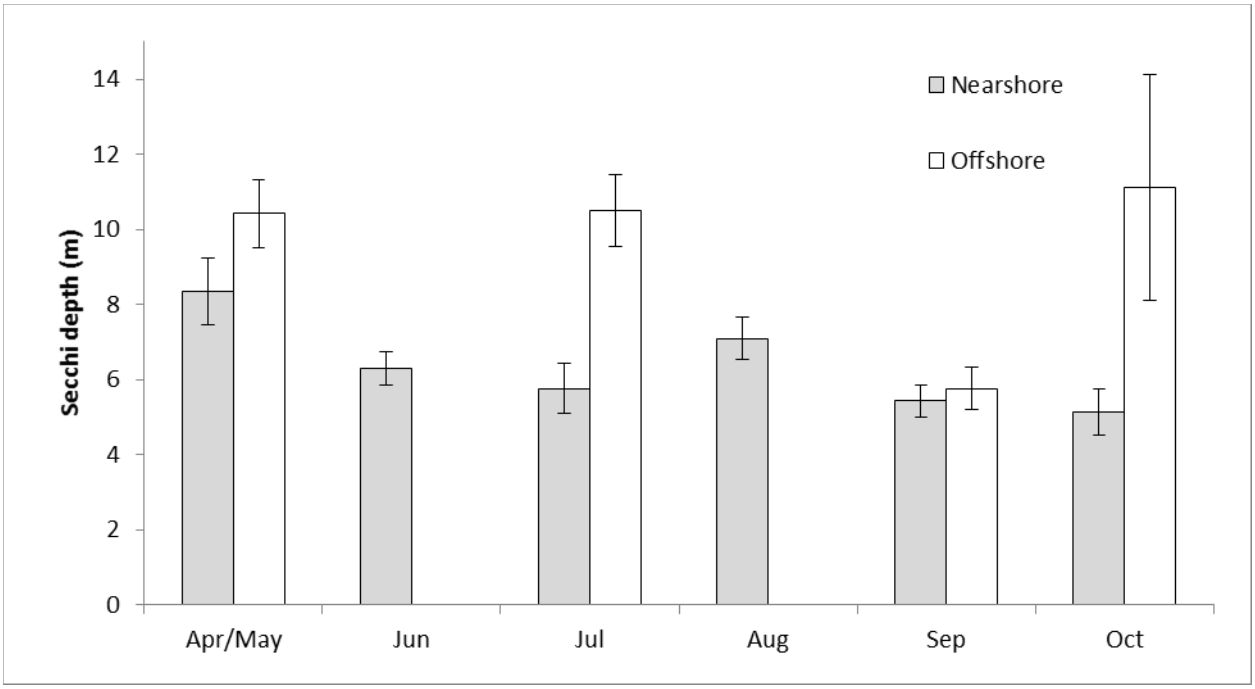

Figure 2a. Mean monthly Secchi depth (meters) for nearshore and offshore habitats in Lake Ontario, Apr/May - October, 2015. Error bars are ± 1SE.

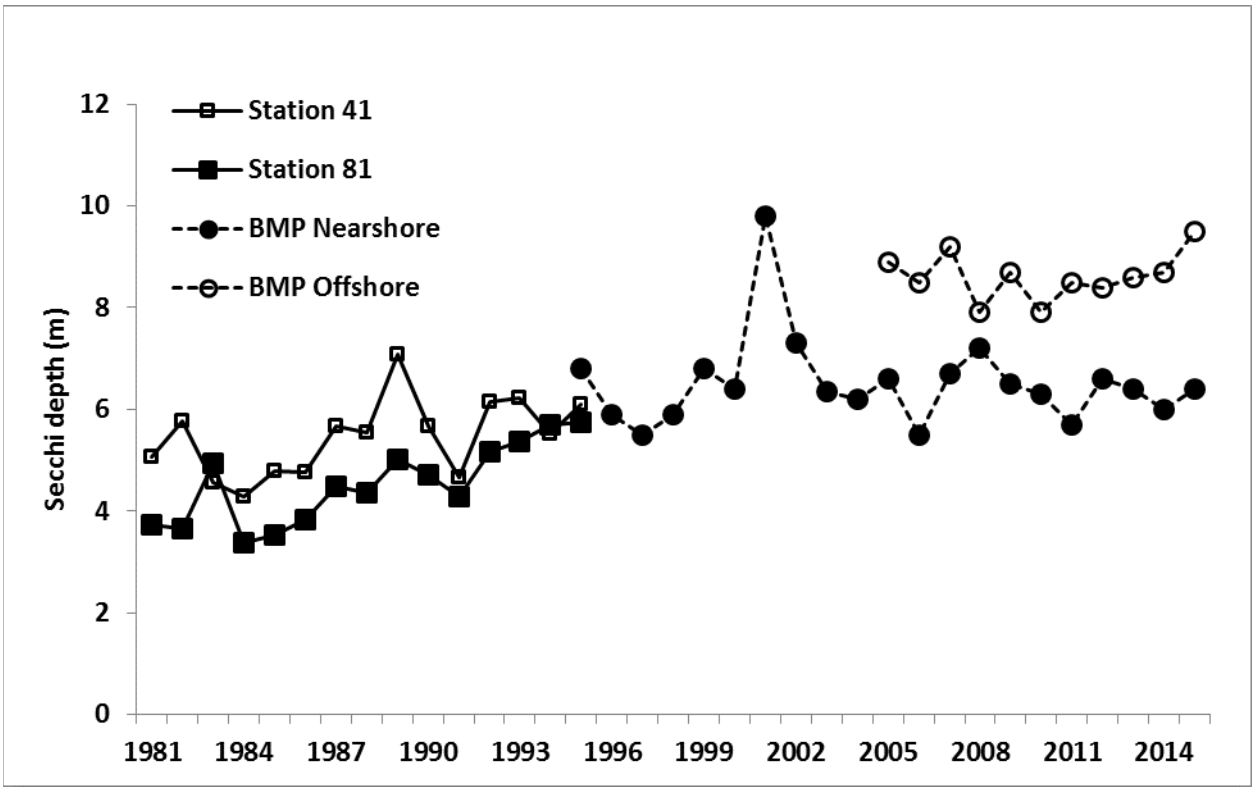

Figure 2b. Long-term mean Apr/May – Oct Secchi depth (meters) in Lake Ontario, 1981 – 2015. Station 41 and Station 81 are from the Department of Fisheries and Oceans Canada's Bioindex Program. Data from 1995 – 2015 are from the US Biomonitoring Program (BMP).

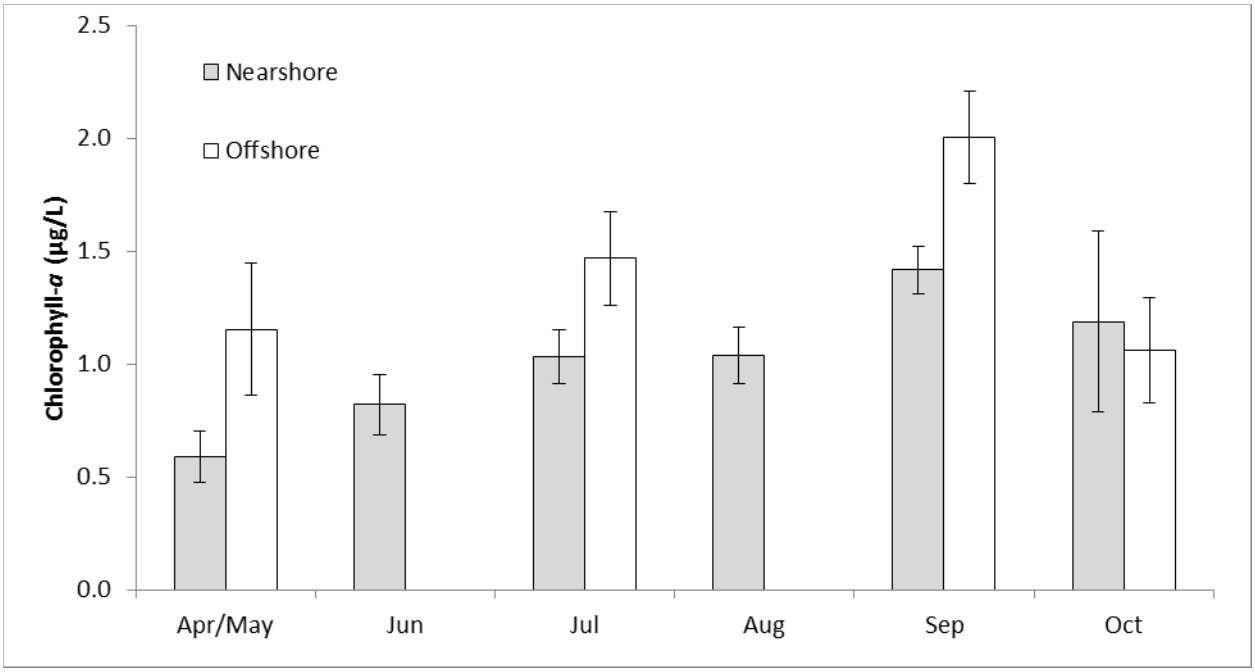

Figure 3a. Mean monthly epilimnetic chlorophyll-a concentrations for nearshore and offshore habitats in Lake Ontario, Apr/ May - October, 2015. Error bars are ± 1SE.

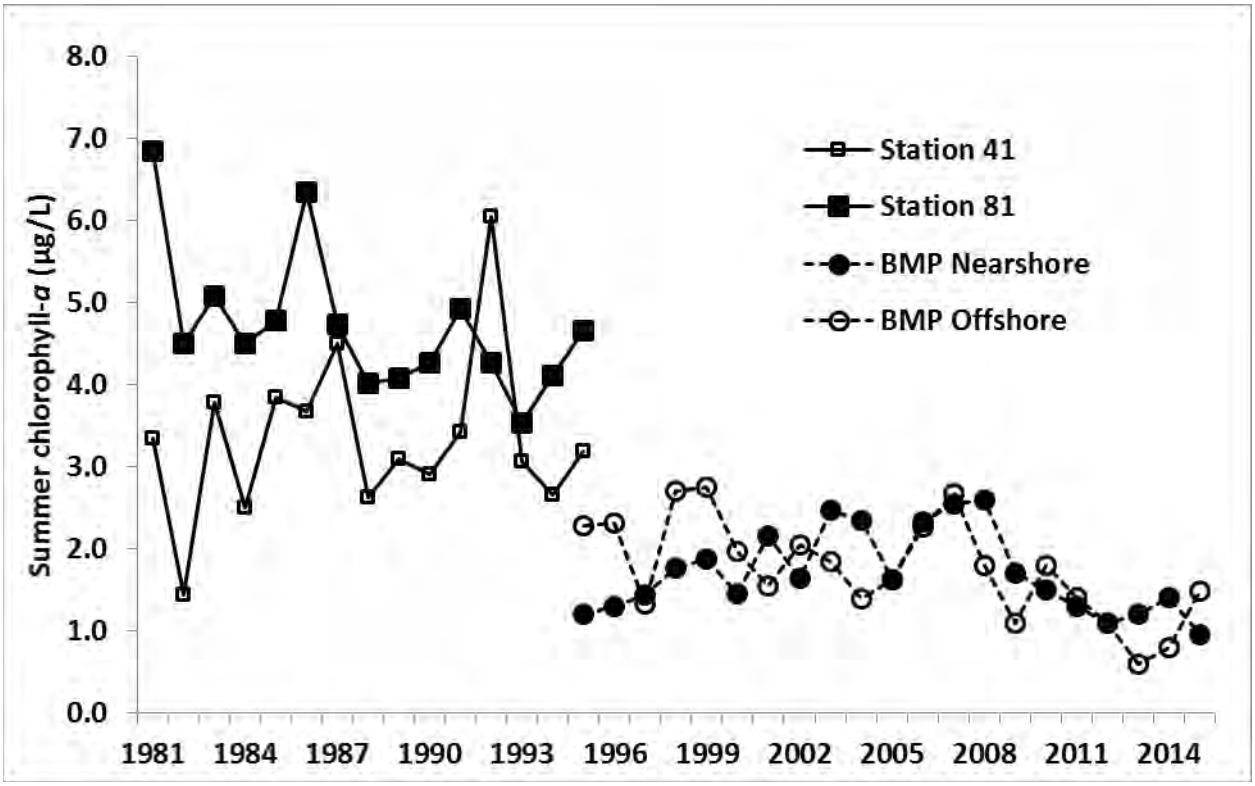

Figure 3b. Long-term summer (Jul – Aug) epilimnetic chlorophyll-a concentrations in Lake Ontario, 1981 - 2015. Station 41 and Station 81 are from the Department of Fisheries and Oceans Canada's Bioindex Program. Data from 1995 – 2015 are from the US Biomonitoring Program.

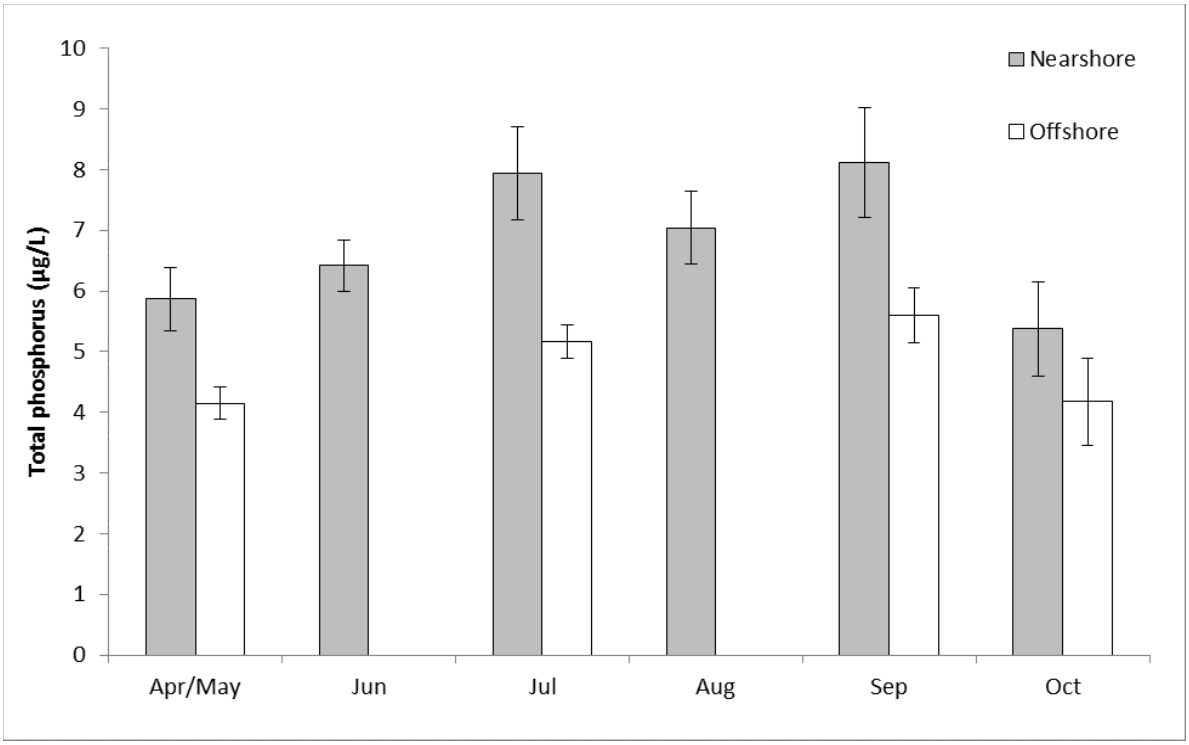

Figure 4a. Mean monthly total phosphorus concentrations for nearshore and offshore habitats in Lake Ontario, Apr/May - October, 2015. Error bars are ± 1SE.

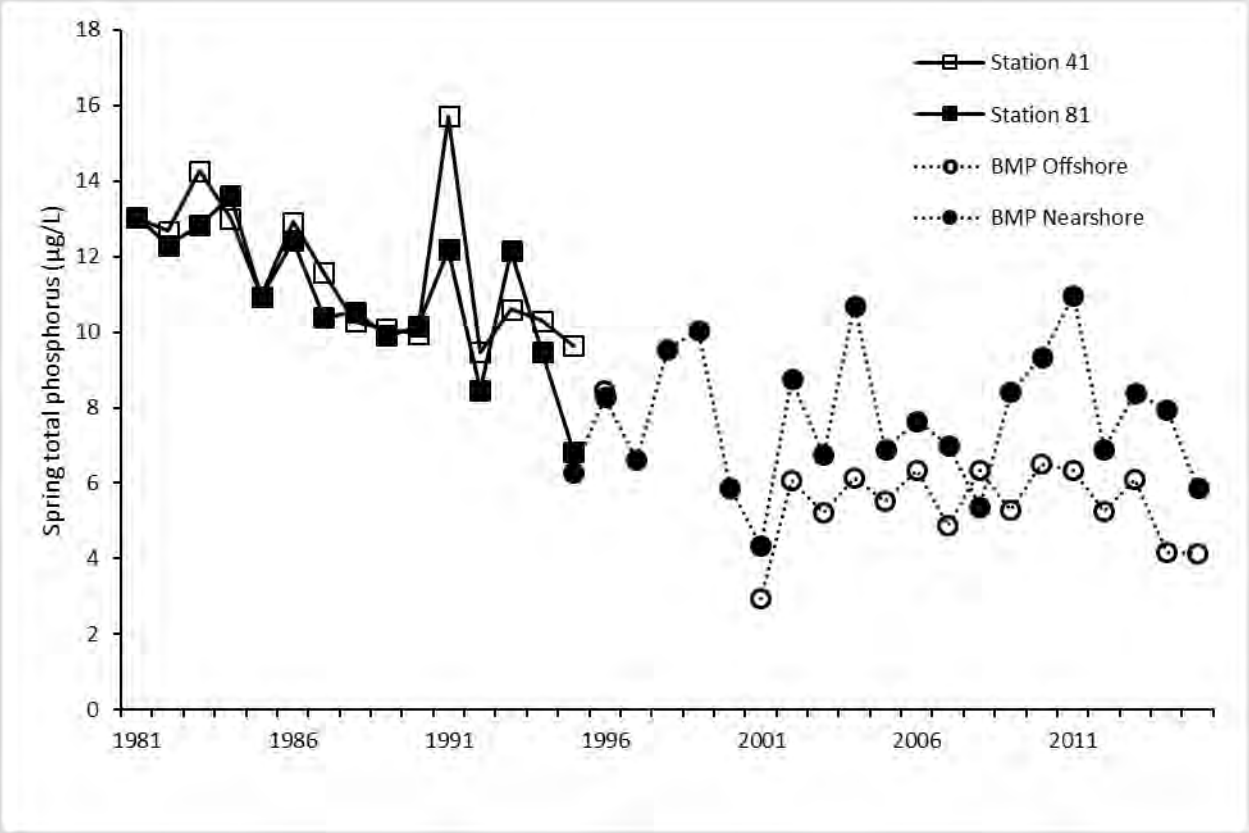

Figure 4b. Long-term spring (Apr – May) epilimnetic total phosphorus concentrations in Lake Ontario, 1981 - 2015. Data from 1981 – 1995 are from the Department of Fisheries and Oceans Canada's Bioindex Program. Data from 1995 – 2015 are from the US Biomonitoring Program.

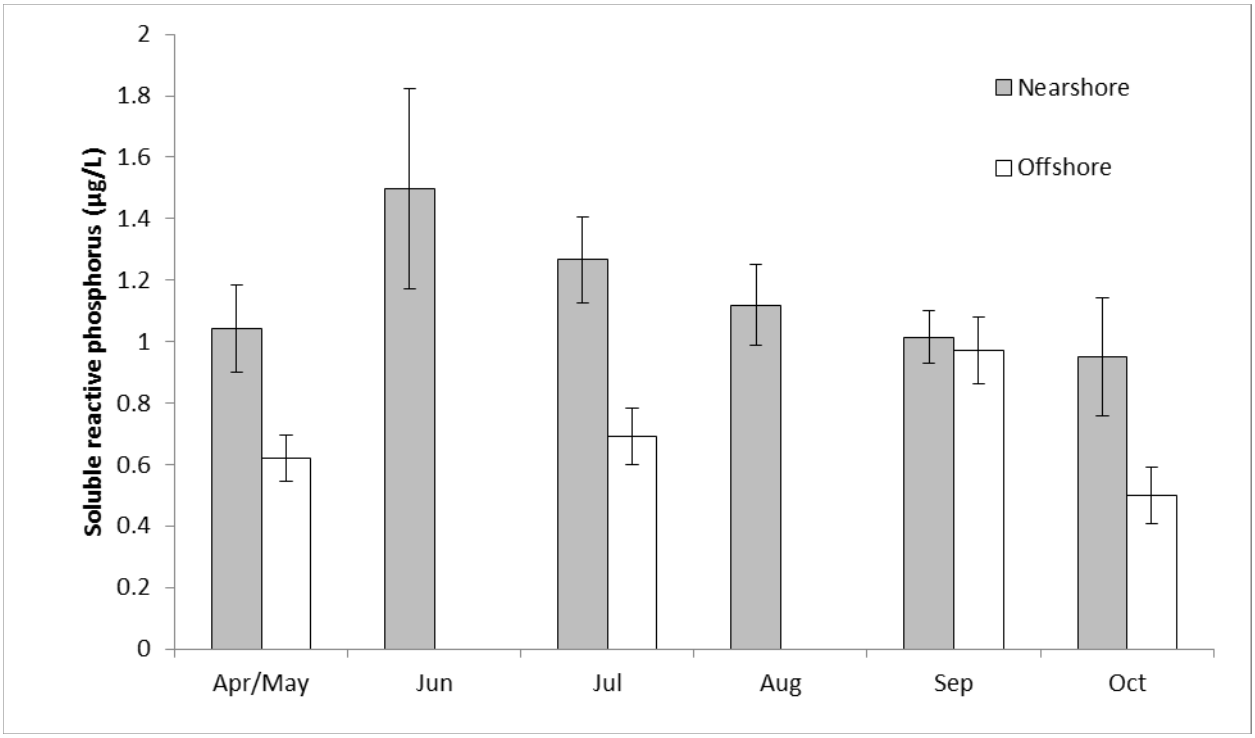

Figure 5a. Mean monthly soluble reactive phosphorus concentrations for nearshore and offshore habitats in Lake Ontario, Apr/May - October, 2015. Error bars are ± 1SE.

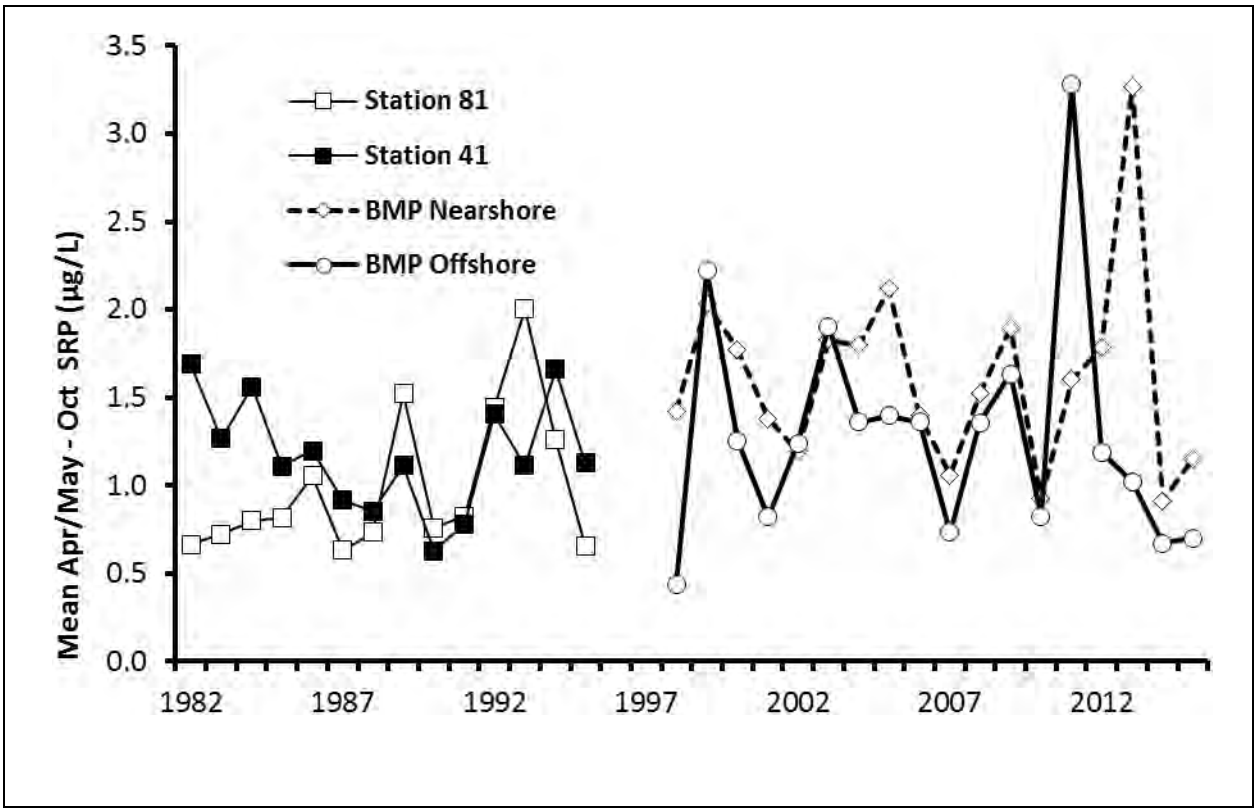

Figure 5b. Long-term mean Apr/May – Oct soluble reactive phosphorus concentrations in Lake Ontario, 1982 – 2015. Station 41 and Station 81 are from the Department of Fisheries and Oceans Canada's Bioindex Program. Data from 1998 – 2015 are from the US Biomonitoring Program.

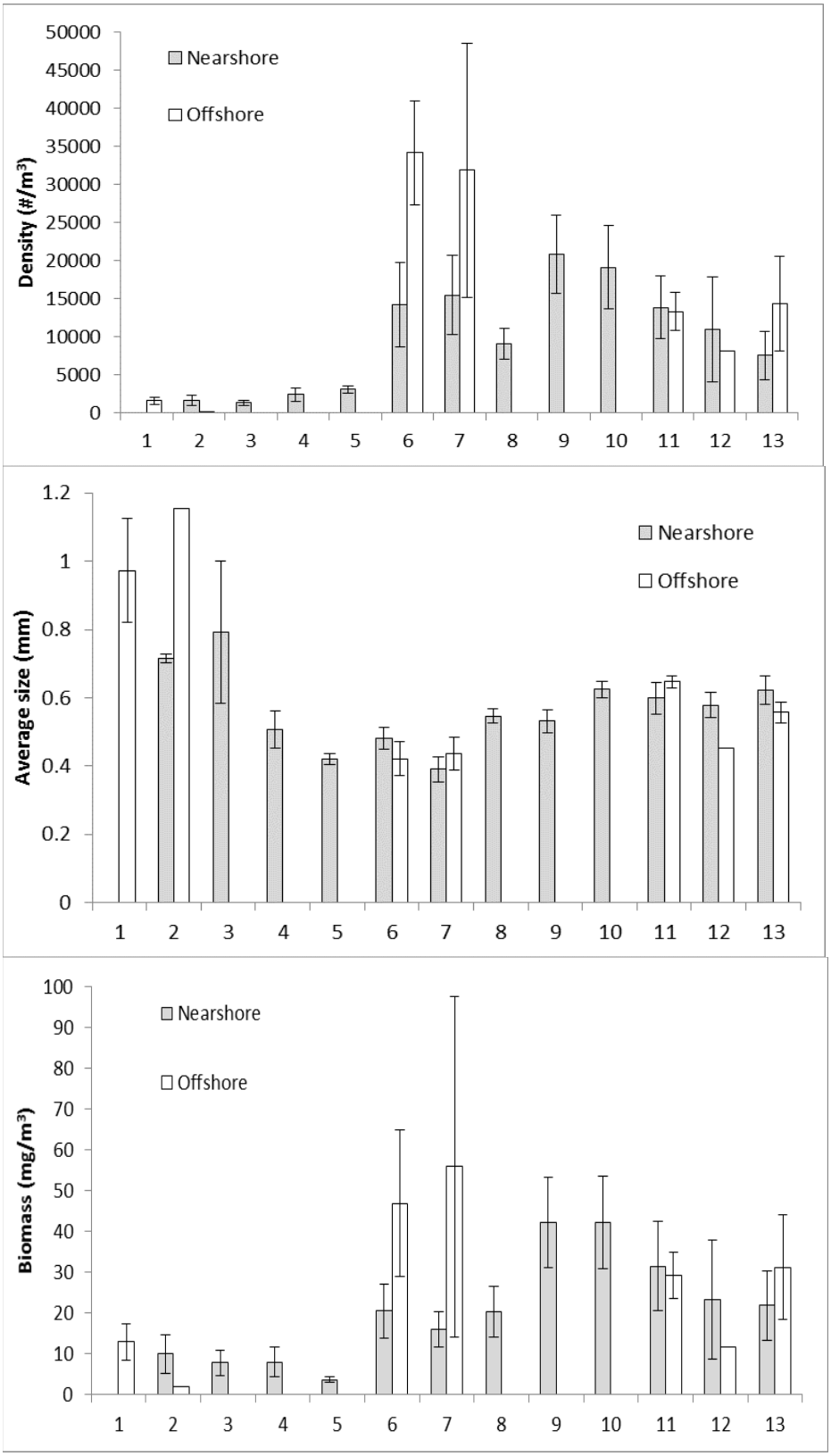

Figure 6. Biweekly means (± 1 SE) of epilimnetic zooplankton density, size, and dry biomass for April through October 2015, nearshore and offshore sites on Lake Ontario. On the x-axis, biweeks are designated by the numbers 1-13. When no error bar is present, only one sample was taken that biweek.

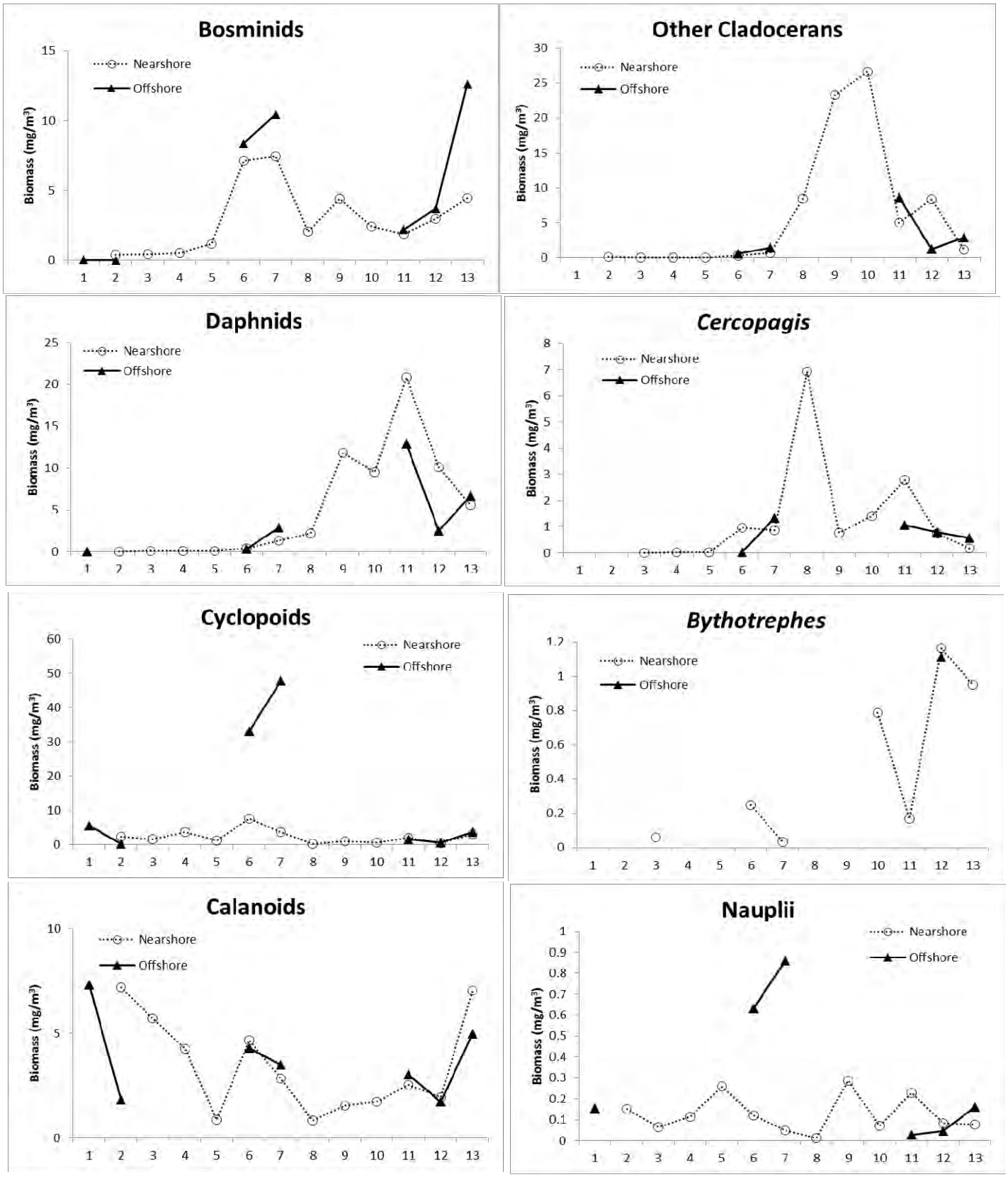

Figure 7. Epilimnetic dry biomass of zooplankton community groups for nearshore and offshore areas of Lake Ontario, April - October 2015 (biweeks 1-13 on x-axis). Note different y-axis scales.

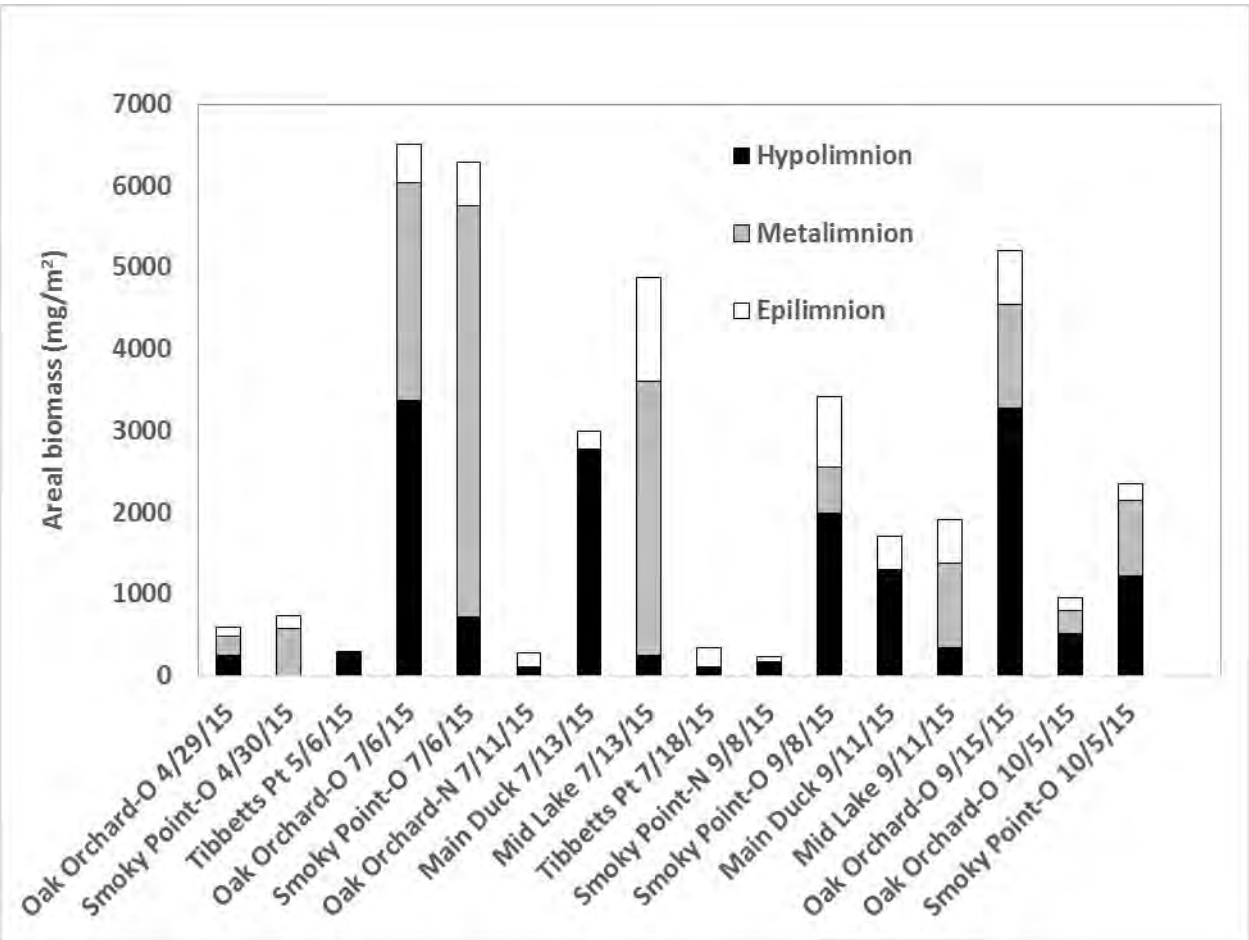

Figure 8. Daytime epilimnetic, metalimnetic, and hypolimnetic zooplankton dry biomass (areal) in Lake Ontario's offshore, 2015. Epilimnetic values determined directly from the epilimnetic tow. Metalimnetic values determined by subtracting epilimnetic tow values from the metalimnetic tow. Hypolimnetic values determined by subtracting metalimnetic tow values from the hypolimnetic tow. Stations without metalimnetic values are from shallower stations where only two tows were performed (Tibbetts Pt 5/6 and 7/18, Oak Orchard-N 7/11, Main Duck 7/13 and 9/11, and Smoky Point-N 9/8). Stations without hypolimnetic values are from a site where hypolimnetic values were negative (Smoky Point-O 4/30) due to variation in catch of zooplankton between metalimnetic and hypolimnetic tows.

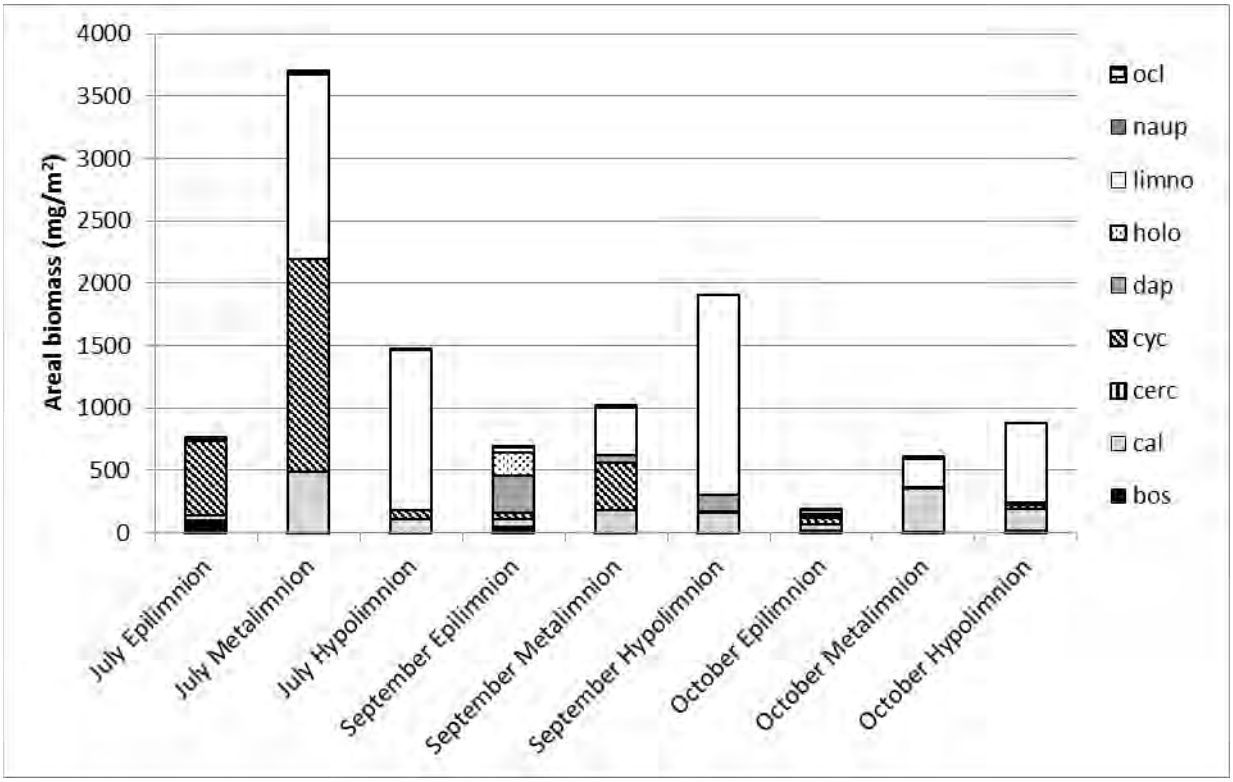

Figure 9. Comparison of mean zooplankton biomass (dry) in epilimnetic, metalimnetic, and hypolimnetic samples taken from deep (>100m) sites in Lake Ontario's offshore, July, September, and October 2015. The epilimnetic strata includes zooplankton from the thermocline (7 – 23 m) up to the surface, the metalimnetic strata includes zooplankton from 50 m up to the thermocline, and the hypolimnetic strata contains zooplankton from 100 m up to the metalimnion. Abbreviations are BOS=bosminids, BYTH=Bythotrephes, CAL=calanoid copepods excluding Limnocalanus, CERC=Cercopagis, CYC=cyclopoid copepods, DAP=Daphnids, HOLO=Holopedium gibberum, LIMNO=Limnocalanus macrurus, NAUP=nauplii, OCL=other cladocerans. A value of zero was assigned when values were negative due to variation in catch of zooplankton between epilimnetic and metalimnetic tows or between metalimnetic and hypolimnetic tows.

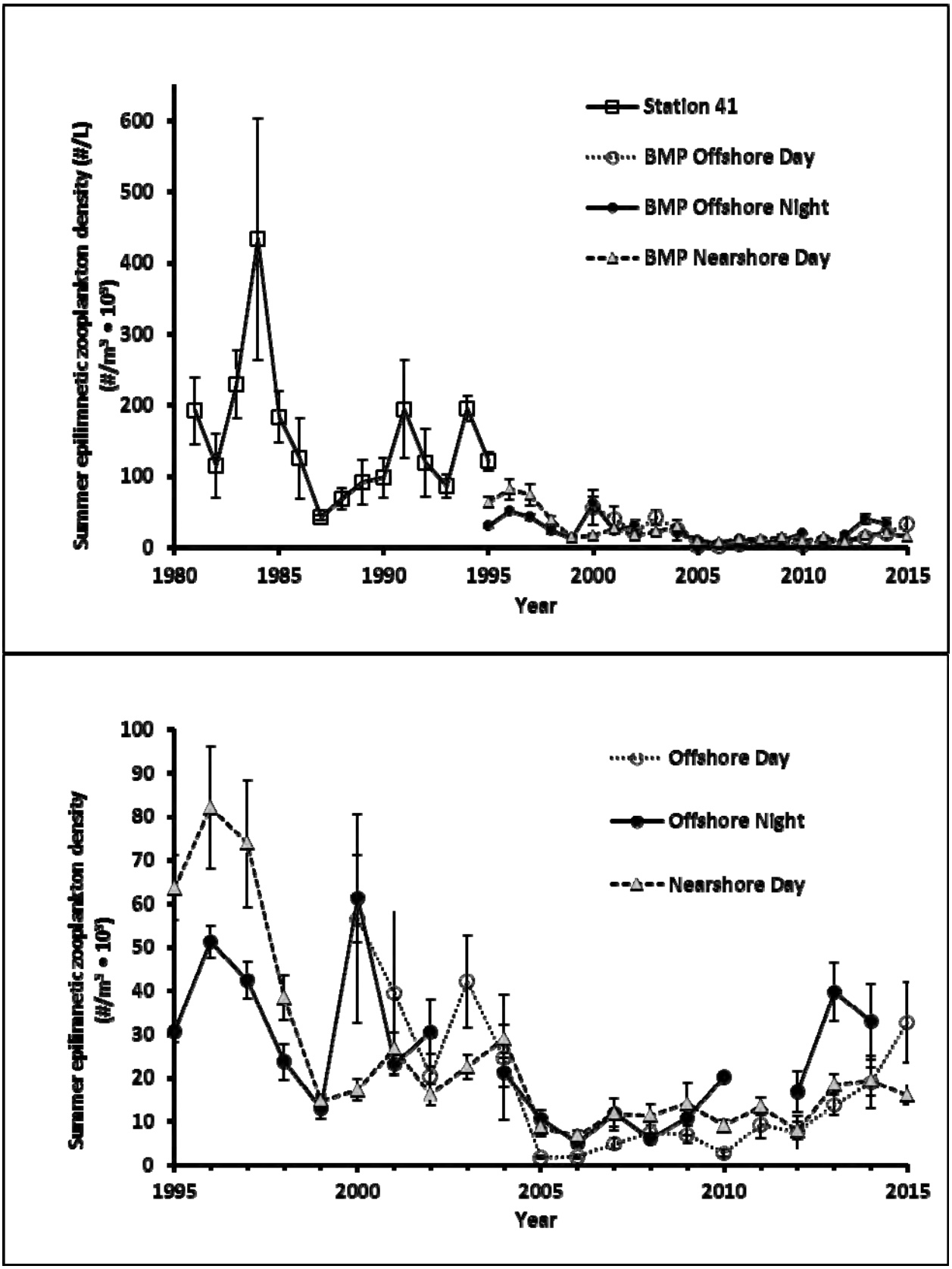

Figure 10. Mean summer (Jul-Aug) epilimnetic zooplankton density in nearshore and offshore habitats in Lake Ontario, 1981 – 2015 (top panel) and from 1995 – 2015 (bottom panel). Station 41 data are from the Department of Fisheries and Oceans Canada's Bioindex Program. Error bars are ± 1 SE.

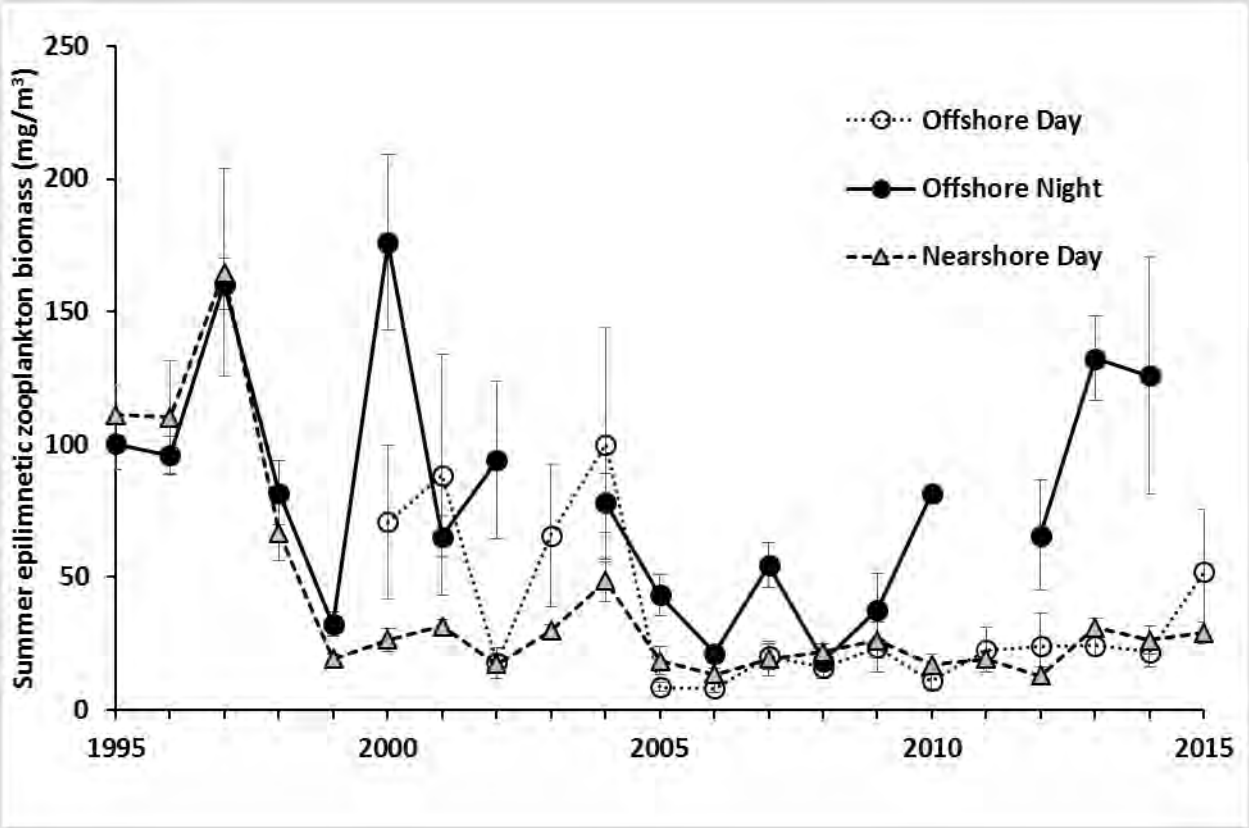

Figure 11. Mean summer (Jul – Aug) epilimnetic zooplankton biomass in nearshore and offshore habitats in Lake Ontario, 1995 - 2015. Error bars are ± 1 SE.

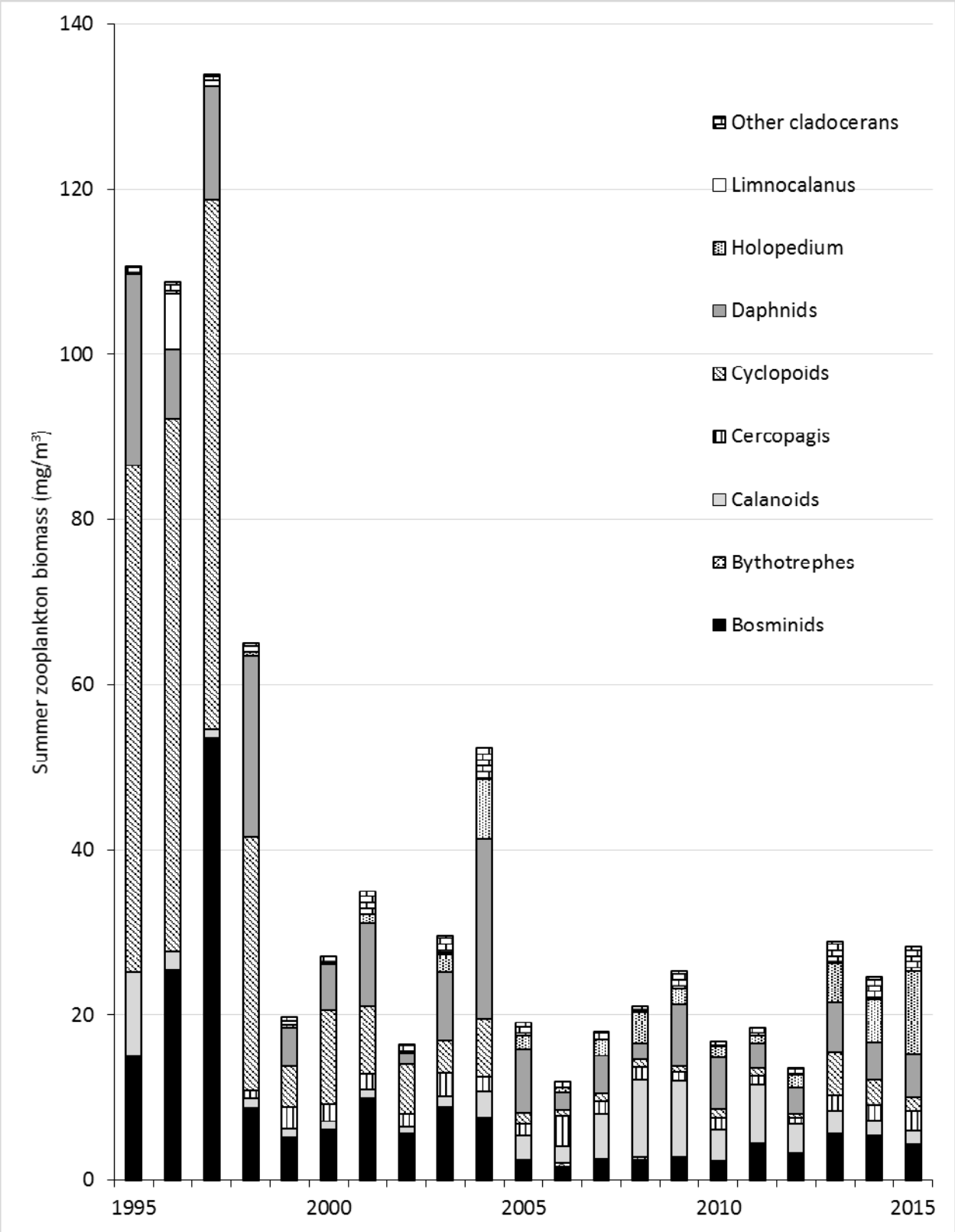

Figure 12. Mean summer (Jul – Aug) epilimnetic nearshore zooplankton group biomass in Lake Ontario, 1995 – 2015.

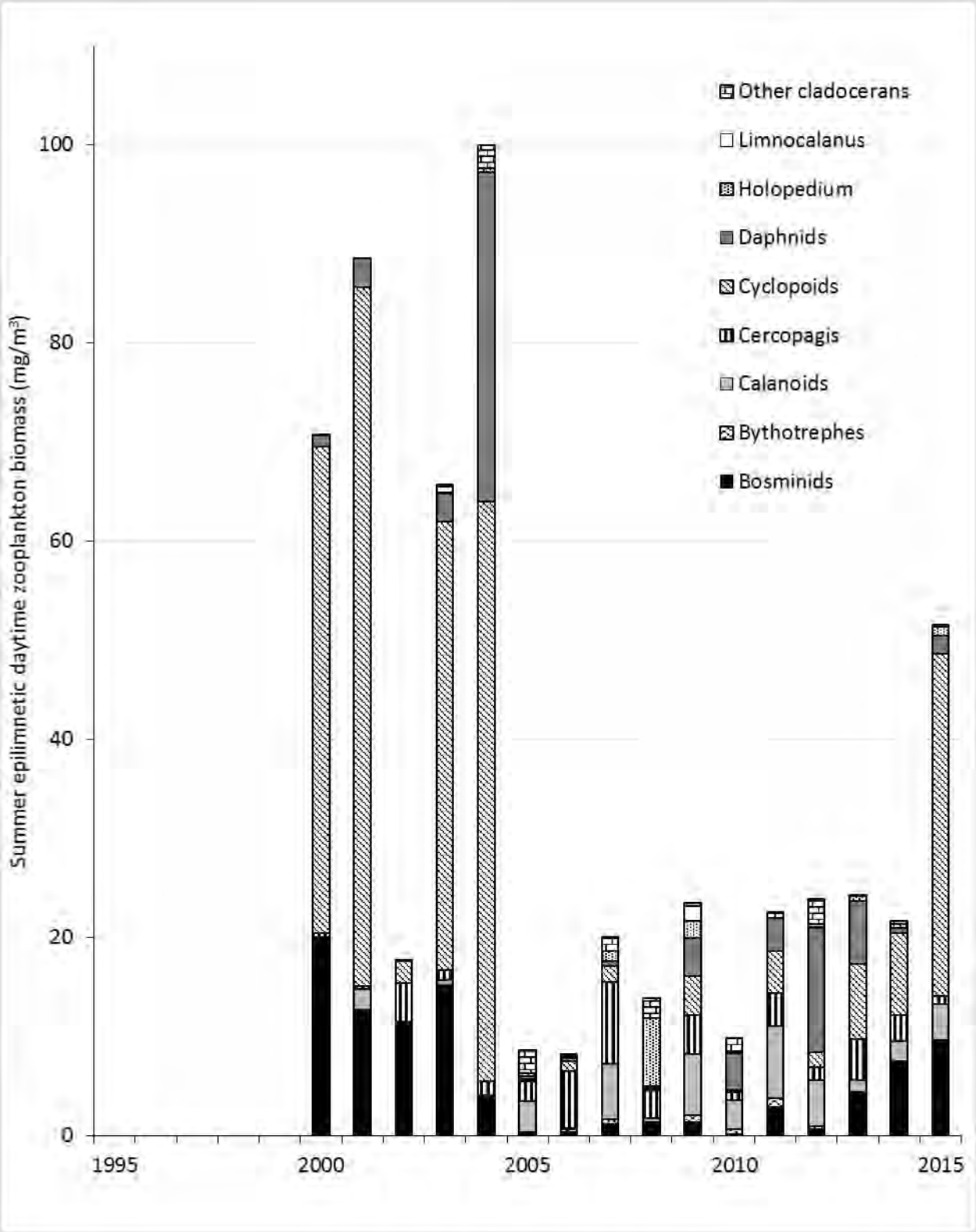

Figure 13. Mean summer (Jul – Aug) epilimnetic offshore zooplankton group biomass in Lake Ontario, 2000 – 2015.

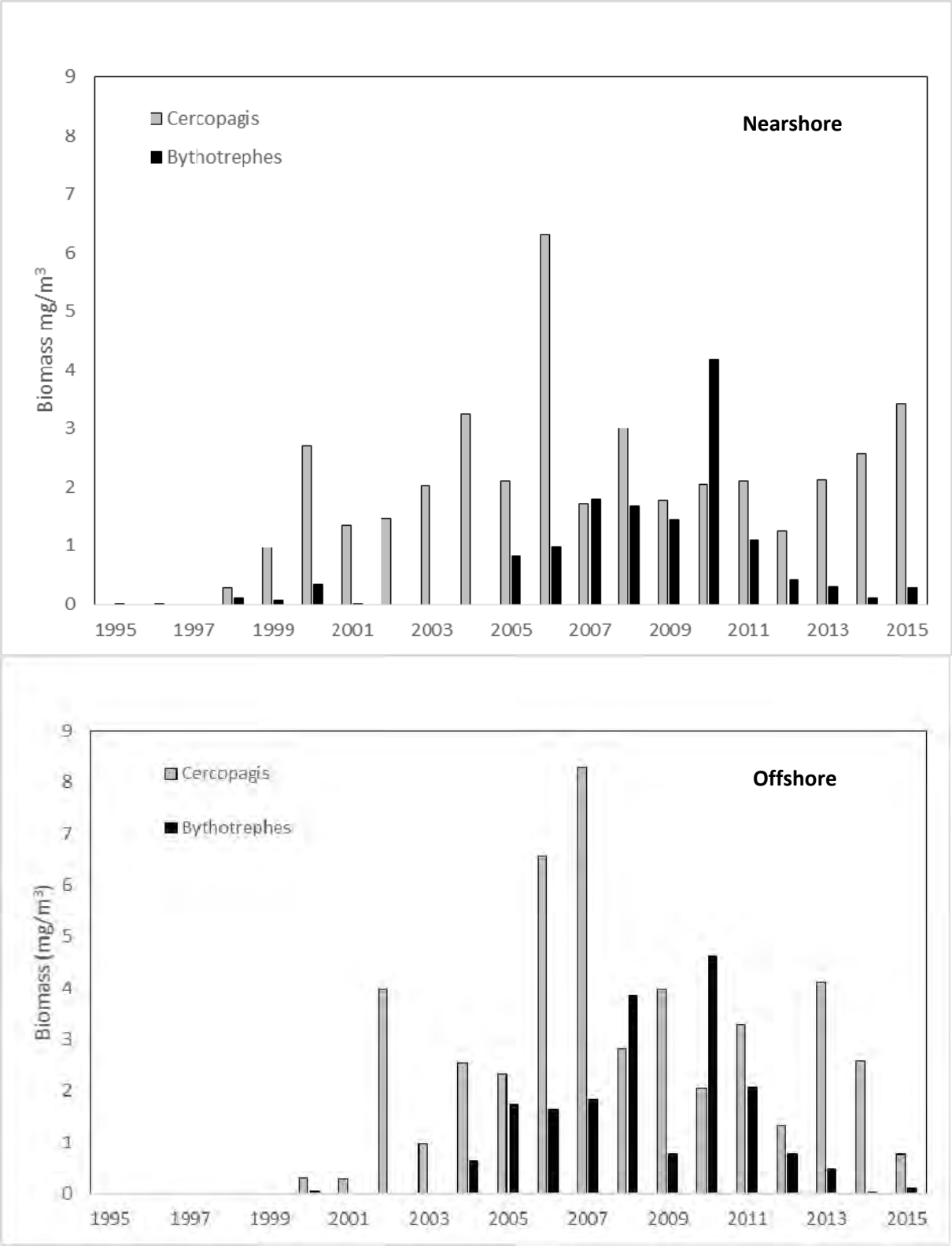

Figure 14. Daytime nearshore and offshore fall (September and October) **Bythotrephes** ***and summer (July)*** **Cercopagis** ***biomass in Lake Ontario, 1995 – 2015.***

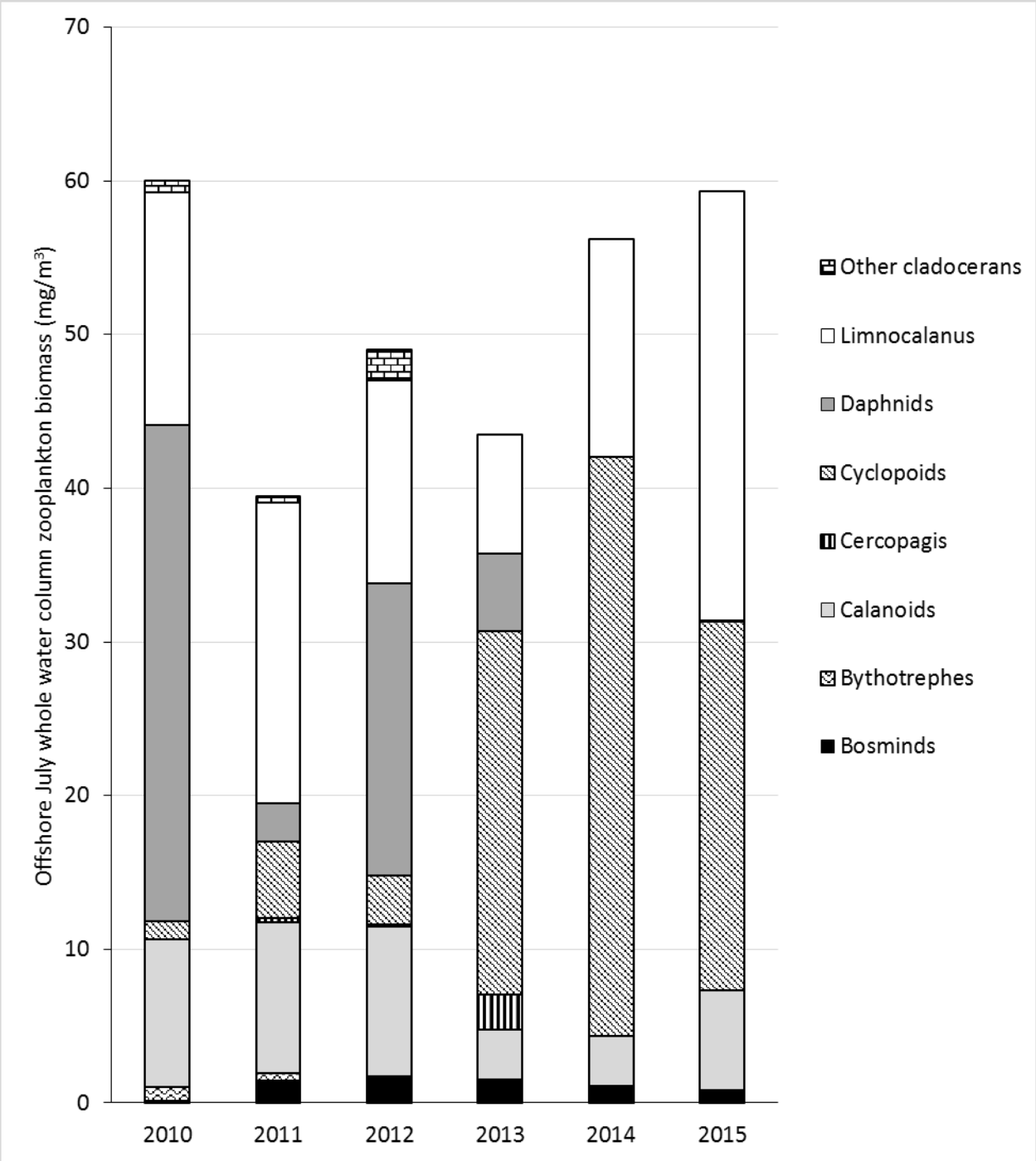

Figure 15. Mean July whole water column offshore zooplankton group biomass in Lake Ontario, 2010 – 2015.

Table 1. Mean chl a, TP, SRP and Secchi depth (± 1 SE) for nearshore and offshore sites, April – October 2015.

	Mean ± 1 SE			
Sites	Chlorophyll-*a* (µg/L)	Total phosphorus (µg/L)	Soluble reactive phosphorus (µg/L)	Secchi depth (m)
Nearshore				
Chaumont Lake (CBL)	1.0± 0.1 (n=11)	8.5± 1.0 (n=11)	1.3± 0.2 (n=11)	5.8± 0.4 (n=11)
Galloo Island (GIL)	1.1± 0.2 (n=11)	6.1± 0.4 (n=9)	1.0± 0.1 (n=10)	7.3± 0.6 (n=11)
Oak Orchard (OOL)	1.3± 0.2 (n=12)	6.8± 0.6 (n=12)	1.2± 0.1 (n=12)	6.0± 0.9 (n=11)
Sodus Lake (SOL)	0.9± 0.2 (n=12)	5.3± 0.4 (n=12)	0.6± 0.04 (n=12)	7.8± 0.7 (n=12)
Sandy Pond Lake (SPL)	1.0± 0.2 (n=7)	8.1± 0.5 (n=7)	1.0± 0.1 (n=7)	7.1± 0.9 (n=6)
Niagara East Lake (NEL)	0.7± 0.1 (n=11)	7.4± 0.4 (n=11)	1.5± 0.2 (n=11)	5.0± 0.3 (n=12)
Niagara West Lake (NWL)	0.9± 0.1 (n=11)	7.0± 0.5 (n=11)	1.8± 0.5 (n=11)	5.9± 0.7 (n=12)
Offshore				
Kaho				
Oak Orchard-N	1.9± 0.3 (n=3)	5.2± 0.4 (n=3)	0.5± 0.04 (n=3)	7.5± 1.5 (n=4)
Oak Orchard-O	1.0± 0.3 (n=3)	3.6± 0.7 (n=3)	0.4± 0.1 (n=3)	13.0± 2.3 (n=4)
Smoky Point-N	1.6± 0.3 (n=4)	5.2± 0.4 (n=4)	0.7± 0.1 (n=4)	7.5± 1.3 (n=4)
Smoky Point-O	1.7± 0.2 (n=4)	4.3± 0.3 (n=4)	0.5± 0.2 (n=4)	9.9± 2.0 (n=4)
Seth Green				
Main Duck	0.9± 0.4 (n=3)	4.6± 0.9 (n=3)	1.0± 0.1 (n=3)	9.2± 2.0 (n=3)
Mid Lake	1.4± 0.1 (n=3)	5.8± 0.8 (n=3)	1.0± 0.1 (n=3)	8.2± 1.4 (n=3)
Tibbetts Point	1.4± 0.7 (n=3)	4.9± 1.1 (n=3)	0.8± 0.1 (n=3)	9.3± 2.4 (n=3)

Table 2. Comparison of nearshore and offshore sites Apr/May-October, 2015 by fitting a general linear model with month and habitat as the effects on log-transformed (TP, Secchi depth, and zooplankton density, size, and biomass) or untransformed (Chl-a and SRP) Apr/May – Oct mean values. Reported p-values are for the significance of habitat, not month. For zooplankton group biomass (daphnids, other cladocerans,* Cercopagis, Bythotrephes, Holopedium, and Limnocalanus*) data could not be normalized by transformation and the nonparametric Wilcoxon test was used. Values shown are arithmetic means summarized by site and then across months 4/5, 7, 9, and 10. Months 6 and 8 were removed from the analysis because the offshore was not sampled during those months. 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)	6.8	4.8	**<0.0001**
	Soluble reactive phosphorus (µg/L)	1.1	0.7	**<0.0001**
	Chlorophyll *a* (µg/L)	1.1	1.4	**0.0073**
	Secchi depth (m)	6.2	9.5	**0.0001**
Total zooplankton:				
	Density (#/m^3)	8263	15281	0.45
	Size (mm)	0.62	0.65	0.70
	Biomass (mg dw/m^3)	18.9	30.3	0.26
Group biomass (mg dw/m^3):				
	Bosminids	3.0	5.2	0.19
	Daphnids	5.2	4.9	0.21
	Calanoid copepods (excluding *Limnocalanus*)	2.9	3.6	0.17
	Cyclopoid copepods	2.0	8.3	**0.04**
	Other cladocerans (excluding *Holopedium*)	0.4	0.2	0.11
	Cercopagis pengoi	1.3	0.6	0.49
	Bythotrephes longimanus	0.17	0.04	**0.05**
	Holopedium gibberum.	2.2	2.6	0.50
	Limnocalanus macrurus	1.3	3.9	0.06

Table 3. Results of regression analyses performed on data from two time stanzas in Lake Ontario's offshore (2000 – 2015 and 2005 – 2015) and for three time stanzas in Lake Ontario's nearshore (1995 - 2015, 1995 – 2004, and 2005 – 2015). Paucity of data precluded analysis of the offshore 1995 – 2004 time period. SRP data were available from 1998 – 2015 in both habitats. All regression data were log-transformed prior to analysis. Trends are indicated by (+) or (-). Significant p-values are indicated in bold. Marginally significant p-values (0.05<p<0.1) are reported but not bolded. ns=not significant. Change is the slope of the log-linear regression and represents instantaneous rates per year. Change point analyses were performed on 2000 -2015 in the offshore and 1995 – 2015 in the nearshore. No breaks – no significant break points at p<0.10 level. **change point performed on ranks due to outliers. SRP data not available for 1995 – 1997. Secchi depth data not available 1995 – 1996. Offshore Secchi depth data 1997 – 2015 from USGS.

	Regression						Change Point Analysis
Offshore	2000 – 2015	Change			2005 – 2015		2000 - 2015
Apri/May – Oct SRP (µg/L)	ns				ns		no breaks
Spring TP (µg/L)	ns (2001-2015)				ns		no breaks
Summer Secchi Depth (m)	**(+) p=0.03**	**0.02**			**(+) p=0.01**	**0.06**	no breaks
Summer chlorophyll *a* (µg/L)	**(-) p=0.009**	**0.05**			**(-) p=0.026**	**0.09**	(-) 2009
Summer epilimnetic zooplankton density (#/L)	ns				**(+) p=0.001**	**0.24**	(-) 2005, (+) 2014
Summer epilimnetic zooplankton biomass (µg/L)	ns				**(+) p=0.004**	**0.13**	(-) 2005
Summer epilimnetic zooplankton group biomass							
Bosminids	ns				**(+) p=0.010**	**0.30**	(-) 2004, (+) 2014
Bythotrephes longimanus	ns				ns		(+) 2005, (-) 2015
Calanoid copepods	**(+) p=0.023**	**0.17**			ns		no breaks
Cercopagis pengoi	ns				ns		no breaks
Cyclopoid copepods	ns				**(+) p=0.008**	**0.39**	(-) 2005, (+) 2015
Daphnids	ns				(+) p=0.068		no breaks
Other Cladocerans	ns				ns		(+) 2004
Limnocalanus	ns				ns		no breaks
Holopedium	**(+) p= 0.034**	**0.31**			ns		no breaks
	Regression						Change Point Analysis
Nearshore	1995 - 2015	change	1995 - 2004	change	2005 – 2015	change	1995 -2015
Apri/May – Oct SRP (µg/L)	ns		ns		ns		no breaks
Spring TP (ug/L)	ns		ns		ns		no breaks
Summer Secchi Depth (m)	ns		ns		ns		no breaks
Summer chlorophyll *a* (µg/L)	ns		**(+) p=0.003**	**0.07**	**(-) p=0.005**	**0.08**	(+) 2003, (-) 2009
Summer epilimnetic zooplankton density (#/L)	**(-) p=0.001**	**0.08**	**(-) p=0.023**	**0.15**	**(+) p=0.023**	**0.07**	(-) 1998, (-)2005
Summer epilimnetic zooplankton biomass (µg/L)	**(-) p=0.002**	**0.07**	**(-) p=0.028**	**0.18**	(+) p=0.105		(-) 1998
Summer epilimnetic zooplankton group biomass							
Bosminids	**(-) p= 0.001**	**0.09**	(-) p=0.067		**(+) p=0.002**	**0.11**	**(-) 2005, (+) 2011
Bythotrephes longimanus	**(+) p=0.049**	**0.04**	ns		ns		**(-) 2002, (+) 2006, (-) 2012
Calanoid copepods	ns		ns		ns		(-) 1996
Cercopagis pengoi	ns		ns		ns		(-) 2007
Cyclopoid copepods	**(-) p<0.001**	**0.20**	**(-) p=0.001**	**0.34**	ns		(-) 1998, (-) 1999, (-) 2013
Daphnids	**(-) p=0.031**	**0.06**	ns		ns		no breaks
Other Cladocerans	ns		(+) p=0.093		ns		no breaks
Limnocalanus	ns		ns		ns		no breaks
Holopedium	**(+) p<0.001**	**0.28**	**(+) p=0.002**	**0.68**	**(+) p=0.030**	**0.16**	(+) 2003, (+) 2015

Nearshore Fish Community Sampling in the St. Lawrence River: Summary 2002-2015

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Watertown, New York 13601

Muskellunge (*Esox masquinongy*) and Northern Pike (*Esox lucius*; pike) are two of the most sought after gamefish inhabiting the St. Lawrence River (Klindt 2011). Like many species, these fish utilize productive shallow littoral zone areas for much of their life history (Smith 1985).

Fisheries management often focuses on large scale collection efforts with gear that samples large "harvestable" size fish. This can leave many questions regarding early life stage productivity for many species, and the structure of the nearshore forage base. Seining offers an opportunity to not only index productivity of certain gamefish at earlier life stages, but to observe and document changes in the nearshore fish community.

In 2002 a local sportsman group, under supervision of the New York State Department of Environmental Conservation (DEC), began propagating and stocking Northern Pike fry at selected sites in Chippewa Bay. As part of this experimental stocking, DEC began a systematic process of assessing the stocking program and monitoring nearshore nursery habitats for the entire fish community assemblage. From 2002-2006 the focus area was the Thousand Islands region (Chippewa Bay), specifically to assess the success of the stocking initiative. After the initial experiment concluded, the seining program continued with the addition of Lake St. Lawrence in 2007. Currently, sampling attempts to index annual esocid (Muskellunge, pike, pickerel) productivity, assess available forage (cyprinids, centrarchids), and document changes with invasive species (e.g. round goby).

Study Area

The upper St. Lawrence River from Cape Vincent to Massena, NY, has been categorized into three distinct regions; Thousand Islands (TI), Middle Corridor (MC), and Lake St. Lawrence (LSL). The Thousand Islands hosts a complex archipelago of islands and wetlands while the Middle Corridor has a comparatively featureless shoreline with limited wetland complexes. Lake St. Lawrence was severely altered (i.e. impounded) by construction of the St. Lawrence Seaway and Power project. There are several large islands, and wetlands are limited to flooded upland areas with poor soils.

Study sites were limited to the U.S. side of the of the river. Chippewa Bay is the primary focus in the Thousand Islands with six standard sites. Lake St. Lawrence also has six standard sites that span from just upstream of the Iroquois Control Dam to the upstream end of the Wilson Hill Wildlife Management Area. Other sites have been added to the project annually as time and weather conditions permit.

Methods

Sampling typically takes place during the first two weeks of August but may vary up to one week depending on regional program needs. A 60' bag seine (5' deep, 0.25" delta mesh) was pulled through embayments at depths from 0-4 feet. A one foot length of 0.25" chain is hung on the lead line at each corner of the bag to inhibit rolling when pulling through heavy vegetation. Each haul was approximately 100' in length which allowed standardization for comparative purposes. Catch per Unit Effort (CUE) is calculated as fish/standard 100' seine haul.

A minimum of three people are necessary per seine haul, two to pull and one to monitor the bag and keep rolling to a minimum. If available, extra crew are on hand to aid the bag tender and to observe the bag for signs of esocids within the seine prior to "bagging". If possible, esocids observed prior to bagging are scap netted to reduce escapement. Each haul is bagged in the water as shorelines typically do not allow for beaching the seine effectively. All fish species are identified and enumerated. Esocids and Longnose Gar (*Lepisosteus osseus*) young of year (YOY) are measured to the nearest millimeter total length and released. The process similar to that described in Farrell and Werner (1999).

Habitat variables including substrate particle size, substrate distribution, and vegetation density are estimated for each site. Substrate, and vegetation in particular, play a large role in defining the habitats utilized by the resident fish populations.

Bottom type (particle size) and relative percent composition were estimated visually at each seining site visited. Each type present was ranked on a scale of 0-4 (scale: **0** 1-5%, **1** 6-25%, **2** 26-50%, **3** 51-90%, **4** >90%) for the overall site. This ranking system is used for recording data in the NYS Statewide Fisheries Database site characteristics record.

Vegetation is characterized at each site by visual estimation. Density is recorded as the average of the entire site where the seine is hauled and is ranked on the same scale used for substrate. While percent coverage by individual species is not recorded, the order of plant species abundance is.

In general seine hauls were done in habitats containing a minimum of 20% vegetation coverage since the target species (esocids) occupy habitats with cover for foraging. Areas with extremely heavy vegetation (>90%) are typically avoided as seining efficiency decreases in these situations.

Results and Discussion

The average ranking for particle sizes encountered separated by region appears in Table 1. In general the Chippewa Bay sites have a soft bottom composed predominantly of muck, clay and silt. In contrast, Lake St. Lawrence sites were generally hard bottomed composed predominantly of sand, gravel, and rubble. Lake St. Lawrence was heavily disturbed by flooding and dredging during seaway construction in the 1950's, and, much of the current wetland area was upland prior to flooding. Wetland complexes within Lake St. Lawrence tend to be close to the main channel which increases exposure to wave action and the rate of flushing, and therefore deposition and accumulation of small particles is lower than many areas of the Thousand Islands.

The percentage of sites where a particular species of vegetation dominates the community, and the average density of vegetation between regions, is shown in Table 2. Eel grass (*Vallisneria americana*) has been identified in previous research (Farrell et al. 2007) as being a common component of the vegetative community in known Muskellunge nursery areas. While eel grass is common to most submerged aquatic communities in the St. Lawrence River, it tends to be more dominant in the Lake St. Lawrence seining sites used in this assessment by nearly 3.5:1 when compared to the Chippewa Bay sites. Cvetkovic et al. (2010) found that the aquatic plant communities in Great Lakes wetlands were excellent predictors of the associated fish community.

Average vegetation density ranks were 2.61 and 2.13 for the Thousand Islands and Lake St. Lawrence, respectively (Table 2). These ranks, while appearing similar, were significantly different ($P<0.007$, T-test) indicating that, in general, vegetation densities were higher for sample sites in the Thousand Islands than Lake St. Lawrence.

Three species of esocids are routinely collected in the seining assessment. Along with pike and Muskellunge, Grass Pickerel (*Esox americanus vermiculatus*) are found in the St. Lawrence River. To date our collections have only found Grass Pickerel in the Thousand Islands. While not collected in our sampling, Chain Pickerel (*Esox niger*) were documented in the Thousand Islands region in 2011 (Dr. John Farrell, SUNY ESF, personal communication). Data specific to gar are taken as nursery habitat is similar to that of Muskellunge making gar a surrogate when assessing the appropriateness of sites for Muskellunge.

Muskellunge YOY catches in Chippewa Bay are intermittent and have not shown any discernable trend throughout the time frame of this assessment. Farrell and Barry (2013) demonstrated a significant drop in production at their standard sites after the introduction of Viral Hemorrhagic Septicemia (VHSv) in 2005. Muskellunge catches in Chippewa Bay were low prior to VHSv and have remained low to date with the exception of 2008 (Figure 1).

Lake St. Lawrence sites (added in 2007) have produced relatively high Muskellunge catches compared to Chippewa Bay (Figure 1). The 2005 data for Lake St. Lawrence is biased as standard sites were not in place at that time and only two sites were sampled. We believe that suitable spawning habitats are limited in Lake St. Lawrence, forcing mature adults to congregate at higher densities and concentrating production into fewer sites.

Muskellunge YOY can differ dramatically in total length, even within the same seine haul. The highest differential occurred in 2011 where fish collected within the same week ranged from 2.7-6.3 inches (70-161 mm). Variables such as spawning date, water temperature, and forage availability all play a role in the rate of development, and can vary substantially even within a particular embayment. Figure 2 illustrates the total length of all Muskellunge collected in this assessment. There are too few data from Chippewa Bay to test for differences in growth rates between locations.

Northern Pike YOY production in Chippewa Bay has been in decline since a period of relative stability from 2002-2005 (Figure 3). A sharp increase in 2008 CUE, which initially appeared as an anomaly in the data, was detectable in the warmwater gill net index in 2010 at age-2 (McCullough and Gordon 2011). The 2008 year class remained relatively strong in the gill net assessment through 2014 with fish age-6 (McCullough and Gordon 2015). Northern Pike YOY catches in Lake St. Lawrence have tended to be higher although sporadic from 2005-2015. A similar gill net assessment in Lake St. Lawrence, which collects fewer pike relative to the Thousand Islands survey(Klindt and Gordon 2015), did not detect a similar spike in 2008 pike production.

Grass Pickerel have shown a steady decline in our catches since 2007 (Figure 4). Little information exists on the early life history of this species. The majority of pickerel collected over time likely fall into the age-0 or 1 category (Kleinart and Mraz 1966, Figure 5). Lumping catch in blocks of 4-5 inches suggests that the overall catch for all presumed age groups has declined proportionally and implies that fish may not be recruiting to spawning age.

Species occurrence between the two regions is similar with a total of 47 species or taxa recorded (Table 3). Eight species occurred in only one of the two regions. Most of the differences between regions may be attributed to differences in habitat characteristics. Blueback Herring have been documented in both Chippewa Bay (2002) and Lake St. Lawrence (2012) when voucher specimens were sent to the NYS Museum. These are the only known records of this species in the St. Lawrence River.

While species composition is similar between the two regions, the proportions of the assemblage

are different. In 2015, a typical year, the Thousand Islands combined catch was dominated by Yellow Perch and cyprinids whereas Lake St. Lawrence is dominated by centrarchids (*Lepomis sp*.) and Round Goby (Figure 6). Esocids are generally caught in higher numbers in Lake St. Lawrence but are a small proportion of the catch.

Round Goby, an invasive species, is a major component of the fish assemblage in both regions, although proportionally they tend to dominate in Lake St. Lawrence. Gobies first appeared in our collections in 2005 in Lake St. Lawrence and were absent from the Thousand Islands until 2007 (Figure 7). From 2010-15 gobies averaged 9.5 and 28.5 % of the catch in the Thousand Islands and Lake St. Lawrence, respectively.

Cormorant diet analysis at nesting colonies in the Thousand Islands (near Chippewa Bay), Middle Corridor and Lake St. Lawrence (Johnson et al. 2004, 2005, 2008) demonstrated that Round Goby colonized the Middle Corridor first in 2003, with the other regions following in 2004. Initial detection in cormorant diet was < 2.0% for colonies monitored in each region. Gobies in cormorant diets increased rapidly in the Middle Corridor and Lake St. Lawrence in 2007 (13.1%), when they were first detected in the seining assessment at Chippewa Bay.

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***Table 1. Estimated average substrate occurrence in seining sites separated by region. Substrate is listed in descending order of abundance for each region. Substrate for each site is categorized by visual estimate using the following scale**: **0** 1-5%, **1** 6-25%, **2** 26-50%, **3** 51-90%, **4** >90%.*

Bottom Type	Thousand Islands		Bottom Type	Lake St. Lawrence
Muck	2.08		Sand	2.09
Clay	1.83		Gravel	1.80
Silt	1.83		Rubble	1.67
Sand	1.81		Silt	1.48
Mud	1.80		Cobble	1.28
Bedrock	1.11		Mud	1.13
Boulder	1.00		Muck	1.00
Plant Debris	0.80		Clay	0.94
Cobble	0.78		Boulder	0.67
Woody Debris	0.67		Bedrock	0.00
Rubble	0.60		Plant Debris	0.00
Gravel	0.00		Woody Debris	0.00

Table 2. Occurrence of vegetation for all data (2002-2015) presented as a percentage of sites per region where a species dominates the vegetative community. Average density is calculated from the rank score for coverage (range 0-4).

Vegetation		Lake St. Lawrence	Thousand Islands
Eel Grass	*Vallisneria sp.*	57.58	17.33
Water Plantain	*Alisma sp.*	18.18	0.00
Pondweed	*Potamogeton sp.*	12.12	2.67
Milfoil	*Myriophyllum sp.*	3.03	5.33
Muskgrass	*Chara/Nitella*	3.03	37.33
Waterweed	*Elodea sp.*	6.06	0.00
Bushy Pondweed	*Najas sp.*	0.00	18.67
Fil. Algae		0.00	10.67
Pond Lily	*Nuphar/Nymphae sp.*	0.00	2.67
Bulrush	*Schoenoplectus sp.*	0.00	5.33
Avg. Vegetation Density		2.13	2.61

Table 3. Fish species list for areas sampled in the Thousand Islands (Chippewa Bay) and Lake St. Lawrence from 2002-2015. Species present are similar between the two areas with several exceptions. Blueback Herring (blue highlight) were confirmed and vouchered at the NYS Museum.

Common Name	**Chippewa Bay**	**Lake St. Lawrence**
Longnose Gar	X	X
Bowfin	X	X
Blueback Herring	X	X
Alewife	X	X
Gizzard Shad	X	
Central Mudminnow	X	X
Grass Pickerel	X	
Northern Pike	X	X
Muskellunge	X	X
Common Carp	X	X
Eastern Silvery Minnow	X	X
Golden Shiner	X	X
Pugnose Shiner	X	X
Emerald Shiner	X	X
Bridle Shiner	X	X
Common Shiner	X	X
Blackchin Shiner	X	X
Spottail Shiner	X	X
Spotfin Shiner	X	X
Phoxinus sp.	X	X
Bluntnose Minnow	X	X
Fathead Minnow	X	X
Creek Chub		X
Fallfish	X	X
White Sucker	X	X
Yellow Bullhead	X	
Brown Bullhead	X	X
Tadpole Madtom	X	
Trout-Perch		X
Banded Killifish	X	X
Brook Silverside	X	X
Brook Stickleback	X	X
White Perch	X	

Table 3 Continued. Species list for areas sampled in the Thousand Islands (Chippewa Bay) and Lake St. Lawrence from 2002-2015. Species present are similar between the two areas with several exceptions. Blueback Herring (blue highlight) were confirmed and vouchered at the NYS Museum.

Common Name	**Chippewa Bay**	**Lake St. Lawrence**
Lepomis sp.	X	X
Rock Bass	X	X
Pumpkinseed	X	X
Bluegill	X	X
Smallmouth Bass	X	X
Largemouth Bass	X	X
Black Crappie	X	X
Tessellated Darter	X	X
Yellow Perch	X	X
Logperch	X	X
Walleye		X
Round Goby	X	X
Moxostoma sp		X
Cottus sp	X	

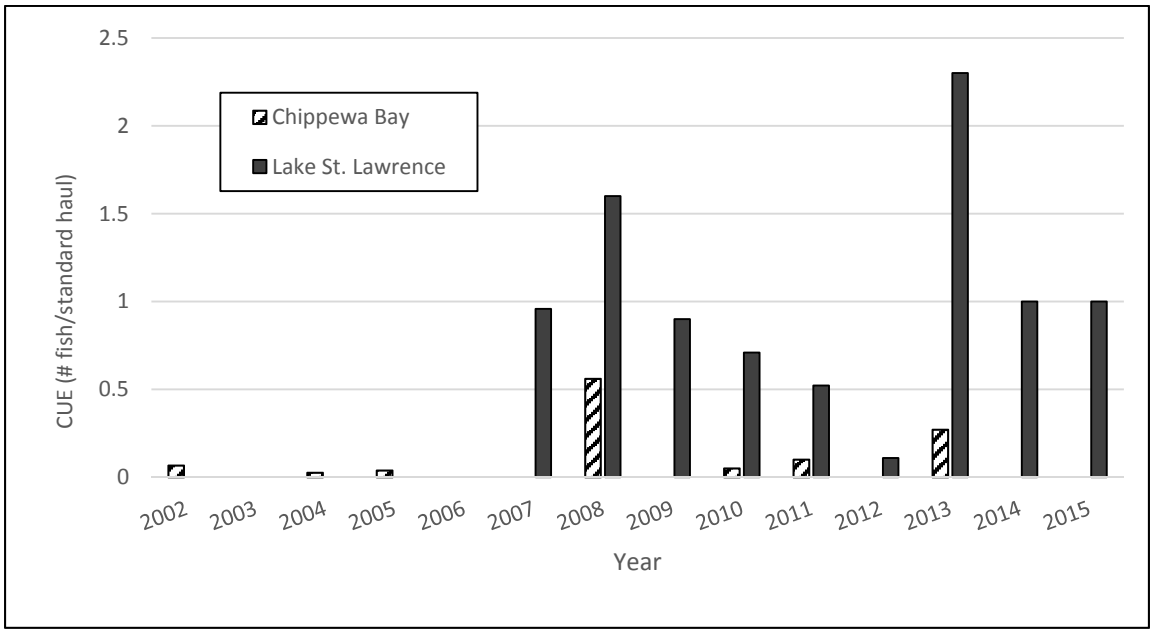

Figure 1. Muskellunge YOY CUE for seining sites in Chippewa Bay (TI) and Lake St. Lawrence from 2002-2015.

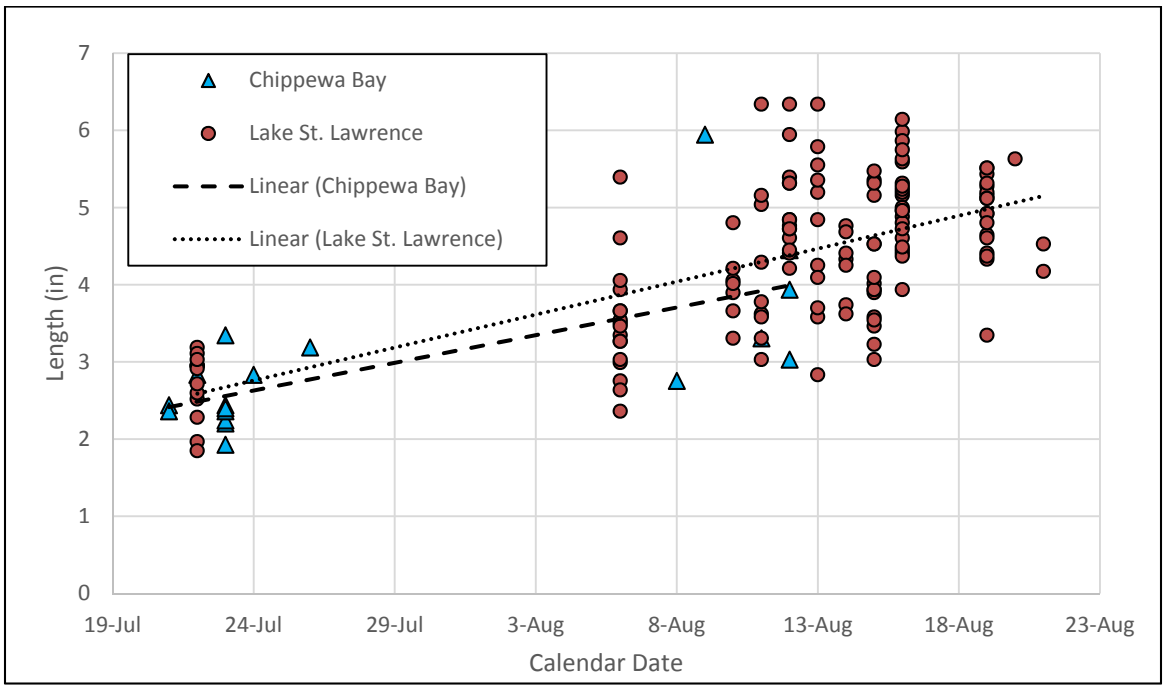

Figure 2. Size of Muskellunge (inches) collected by seining in Chippewa Bay (TI) and Lake St. Lawrence from 2002-2015 by calendar date.

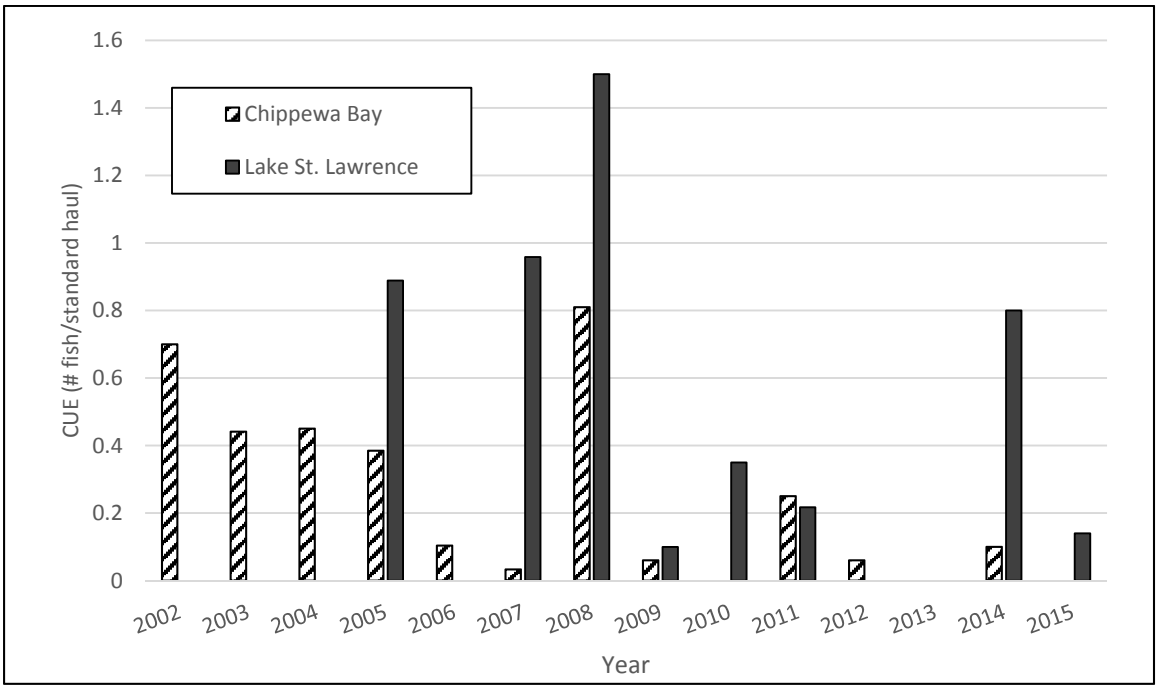

Figure 3. Northern Pike YOY CUE for seining sites in Chippewa Bay (TI) and Lake St. Lawrence from 2002-2015.

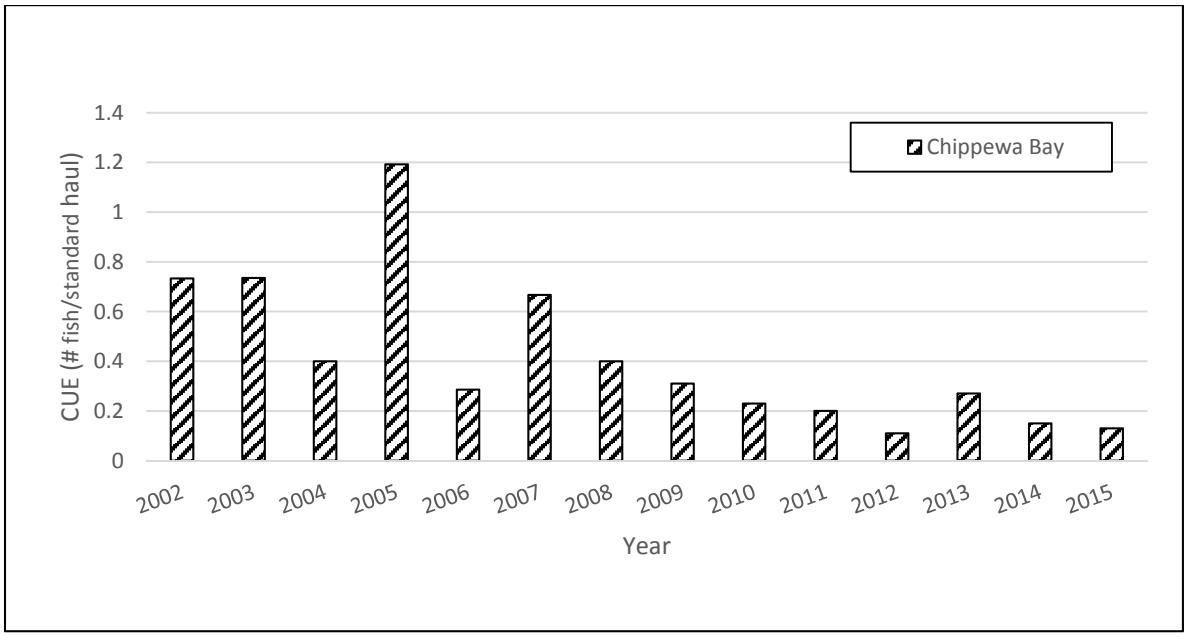

Figure 4. Grass Pickerel CUE for seining sites in Chippewa Bay (TI) from 2002-2015. The distribution considers fish of all sizes and age classes.

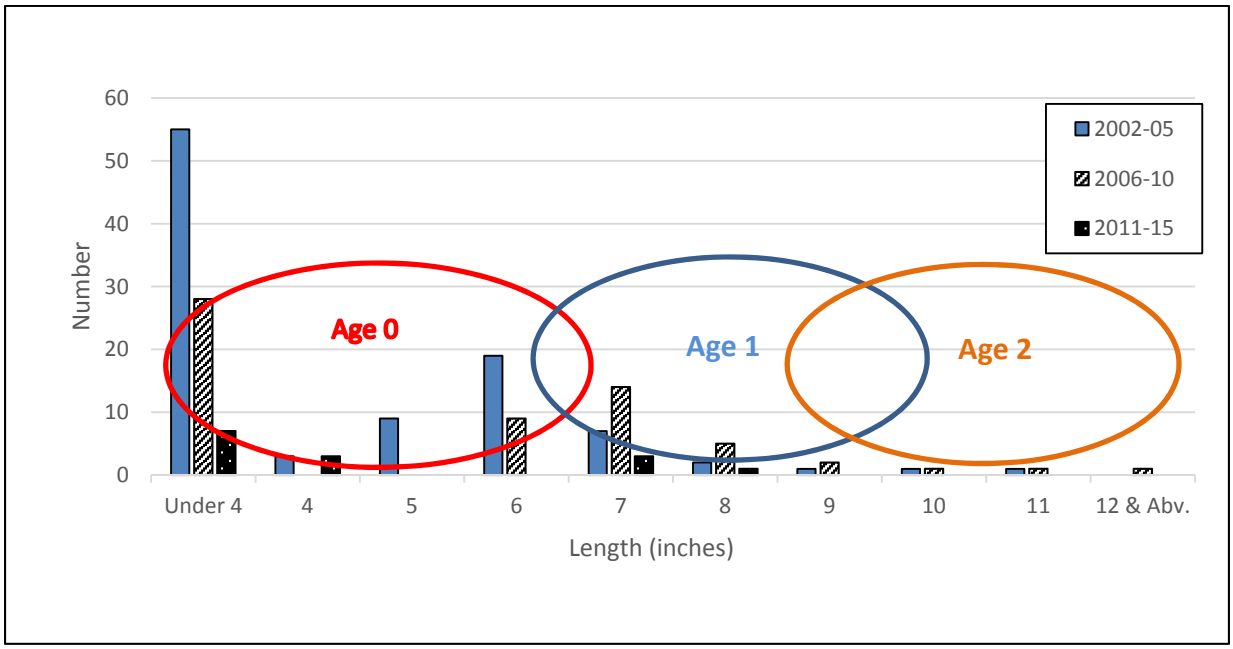

Figure 5. Grass Pickerel length frequency distribution for fish collected in late July through early August over three time periods. Ellipses indicate the age estimates for fish at a particular size range collected in late September (Kleinart and Mraz 1966).

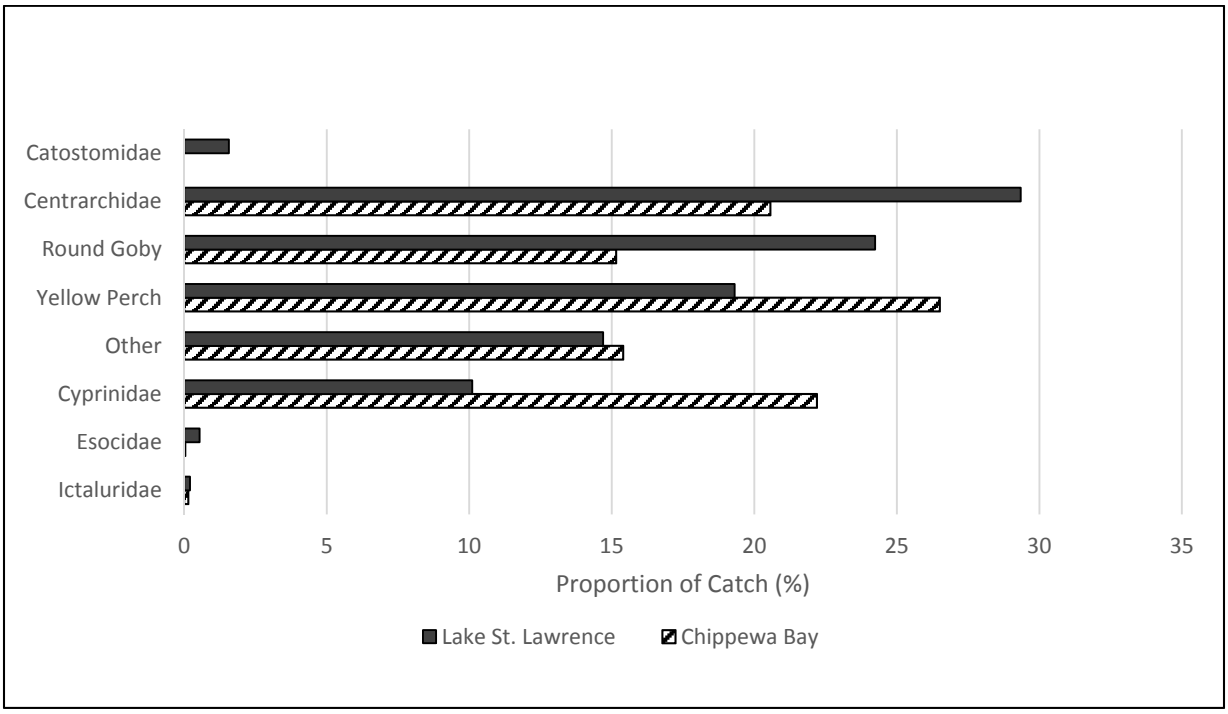

Figure 6. Proportion of seine catch by family or species for 2015 separated by region. Round Goby are separated because the make up a high percentage of the catch. Other refers to species that are commonly collected but make up a relatively small portion of the catch individually.

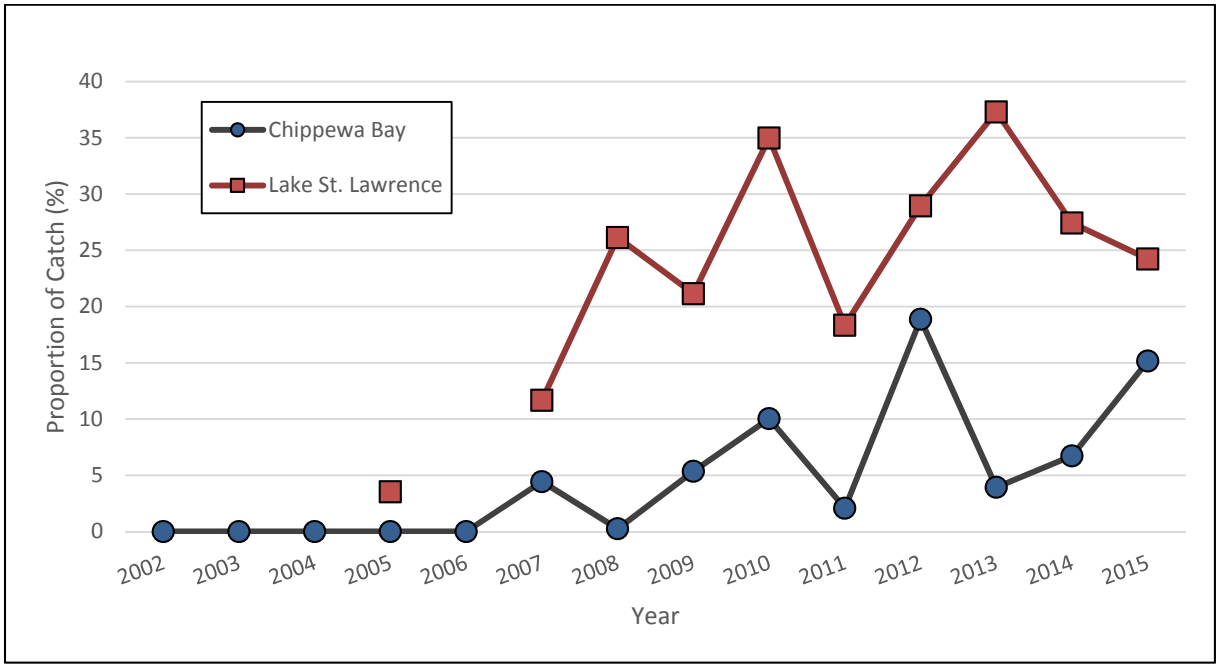

Figure 7. Round Goby seine catches expressed as a percentage of the total catch for Chippewa Bay (TI) and Lake St. Lawrence from 2002-2015. Standard collections did not begin in Lake St. Lawrence until 2007.

Lake Sturgeon Tagging Study and Egg Take 2015

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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 by the NYS Department of Environmental Conservation (DEC) in 1976. Lake Sturgeon were listed as a threatened species by NYSDEC in 1986, 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 tagging method that allows for long term fish identification has become important when considering brood stock genetics, understanding spawning site fidelity and gaining general biological knowledge.

This project is a continuation of a project funded 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 have been collected annually at various sites in the St. Lawrence River and Eastern Basin of Lake Ontario since 2010. Fish were evaluated for basic biological information and then scanned for Passive Integrated Transponder (PIT) tags to determine if they had been previously tagged. A PIT tag was 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.

Restoration of Lake Sturgeon has been ongoing in NYS since 1993 through propagation and stocking. Wild broodstock are collected downstream of the Moses Power Project (Massena, NY) adjacent to the South Channel annually. Gametes are collected, fertilized, and cultured at the Oneida Fish Culture Station (New York) and the Genoa National Fish Hatchery (Wisconsin). Progeny are stocked into the St. Lawrence River, various tributaries, and the Eastern Basin of Lake Ontario.

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 mouth of the St. Lawrence River at Cape Vincent, approximately 800 mi^2. Water less than 100 feet in depth was considered suitable for Lake Sturgeon sampling.

Collection

Lake Sturgeon were collected from April-August in 2015. Collections included netting targeting sturgeon, and existing annual gill net surveys to assess warmwater fish populations which capture sturgeon periodically.

Spawning sturgeon were sampled in Lake Ontario (Black River Bay), and in the St. Lawrence River immediately downstream of the Moses Power Dam (Dam). 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. St. Lawrence and Black River Bay netting sites are shown in Figure 1.

All fish were collected with monofilament gill nets fished from 22.8 – 24.8 hours in waters from 13-55 feet in depth. Gill net configurations used are described in Table 1.

Lake Sturgeon (sturgeon) collected were measured to the nearest millimeter total length (TL), weighed, and examined/scanned for existing Floy® or PIT tags. Sex could only be reliably verified in fish captured during the spawning period through extrusion of gametes. 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 or fish that were previously Floy® tagged. Tags were placed under the fourth dorsal scute, the standard location for the DEC, Ontario Ministry of Natural Resources and Forestry (OMNRF), and U.S. Geological Survey (USGS). All fish, with the exception of those held for egg and milt collections, 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 DEC has sampled St. Lawrence River sturgeon since the early 1990's below the 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 and has been the primary method of uniquely marking sturgeon to the present. In 2010 a FEMRF grant provided tags and related equipment for large scale tagging of sturgeon in the St. Lawrence River and Eastern Basin of Lake Ontario.

Overall 2015 Results

DEC personnel captured a total of 169 Lake Sturgeon throughout the sampling area in 2015. PIT tags were applied to 145 sturgeon (81% St. Lawrence River; 19% Lake Ontario), ranging in length from 18.5-66.9 inches TL and weighing from 3.1-71.5 pounds. Length-weight relationships were constructed using data from all sturgeon collected from 2010-2015 (Figure 2) and separated by sex (Figure 3). Sturgeon body form can be quite variable as demonstrated by the relationships. A total of 23 recaptures were recorded in 2015, two from historic collections (SUNY College of Environmental Science and Forestry (ESF), 1995-1998) and 21 from 2005-2014 collections. The majority of recaptured fish came from the general area of initial tagging with the exception of one fish described below

Ripe males (N=65) accounted for 39.2% of the catch while ripe females (N=9) constituted 5.4%. The remaining fish were either immature or of undetermined sex (N=95, 55.4%). Few juvenile sturgeon are represented in the catch, due to the large mesh size of gill nets used in targeted surveys, and the possibility that index gill net surveys, which utilize nets with smaller mesh sizes, do not cover areas of preferred juvenile habitat.

Lake Ontario (Black River Bay & Eastern Basin)

Lake Sturgeon spawning in the Black River was first documented in 2005 (Klindt and Adams 2006). Sampling since 2005 has targeted spawning fish to acquire biological information and apply Floy® or PIT tags either in the Black River or Black River Bay depending on environmental conditions.

Due to high discharge in the Black River (range 6,900-18,200 cfs, USGS gage 04260500, Watertown) from April 3-28, no attempt was made to collect fish there. The effective flow limit of 6000 cfs for effective netting was exceeded throughout the majority of the sampling period. Effort was shifted to Black River Bay to collect staging sturgeon prior to entering the river.

A total of 33 lake sturgeon were captured in Black River Bay from April 23- May 6, 2015. Water temperature warmed through the period and ranged from 44-59 ^{o}F. A total effort of 399.75 net-hrs was expended resulting in a catch per unit effort (CUE) = 0.09 fish/hr (Table 2). Sturgeon ranged in length from 46.1-62.4 in. and weight from 17.6-61.7 lbs. Sex could not be determined for most of the fish collected, however one ripe male was identified. It is unclear whether all sturgeon in the bay are staging for migration to spawn or simply aggregate in common near shore areas in the spring. Black River Bay likely serves as a staging area for some fish that will later migrate to spawning sites upstream.

Seven fish tagged from 2006-2014 were recaptured in Black River Bay, all of which were initially tagged in that area. This suggests a relatively small spawning population using the Black River. One sturgeon was captured for the fourth time in the bay since originally tagged in 2006. Since its original capture this male fish has increased in total length by 9 inches (225 mm) and weight by 15.4 pounds (7 kg).

The annual index gill net survey conducted by the DEC's Lake Ontario Unit in the Eastern Basin collected three sturgeon in 2015. Nets were fished at 25 sites with a total effort of 467.4 net-hrs (Table 2). One fish was a recapture from Black River Bay originally tagged in 2013.

St. Lawrence River Below Moses Power Dam

The confluence of the bypassed reach of the 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 DEC since 1996 (LaPan et al. 1999). This area is considered a staging area for sturgeon spawning at the base of the Dam. Net sites used for this collection typically produce large numbers of fish, accounting for 80-90% of the annual Lake Sturgeon catch, including both potential spawners and resident fish.

A total of 133 sturgeon were collected from May 21-28, 2015 at four net sites with an effort of 332.52 net-hrs (Table 2). Water temperature in the South Channel ranged from 55-59°F during the sampling period. Catch rate in 2015 (0.40 fish/hr) fell within the range of previous years (CUE range 2009-2014; 0.24-0.59 fish/hr). Ripe males (N=66) represented 49.6% of the catch whereas females (N=9) represented 6.8%. Sex could not be determined for the remainder of the catch (N=58, 43.6%). Sturgeon collected in 2015 ranged in length from 33.3-66.9 in and in weight from 6.6-71.6 lb. Fish used for the 2015 egg take (females N=4, males N=9) were taken from this group.

There were 14 recaptures at this location in 2015 which were classified as either historic (N=2) or recent (N=12). Historic recaptures were fish originally Floy® tagged from 1995-1998 by researchers at SUNY ESF. Recent recaptures included fish tagged (Floy® or PIT) by DEC from 2006-2014.

One recaptured fish was originally tagged by USGS in 2010 at the mouth of the Oswegatchie River. Total minimum distance between the capture and recapture site is approximately 43 miles. This was the fourth PIT tagged fish known to have either been entrained through the Dam, or migrated through the Wiley-Dondero Canal (Eisenhauer and Snell locks).

The purpose of stocking is to enhance the genetic diversity of new and rehabilitated populations for future spawning success. The annual egg take took place on June 2, 2015. Prior to the egg take fish were collected and evaluated for gamete maturation. Fish selected (F=5, M=13) were treated with hormones to induce ovulation and spermiation (Klindt 2014). Approximately 100,000 fertilized eggs were distributed between

two culture facilities in New York and Wisconsin. In August and October of 2015 approximately 20,500 coded wire tagged fingerlings were stocked into various waters of NYS (Table 5). Current rates of stocking are intended to continue through 2023.

The use of PIT tags below the 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 Dam netting site, targeted sturgeon sampling upstream of the Dam has been limited. Occasional catches have been observed in the Thousand Islands (N=6) and Lake St. Lawrence (N=13) index gill net surveys (DEC regional Warm Water Assessment database). A combined survey effort of 1213.95 net-hrs (62 net-nights) in 2015 did not collect any sturgeon (Table 2). There were no targeted collections in this portion of the river in 2015.

Summary

The intent of this program was to collect biological data from and PIT tag sturgeon across a broad geographic area and create a long term database of individual fish that will be used to support ongoing species rehabilitation. Due to the unique life history of this species, collecting these data are a long term commitment which will continue.

From 2010-2015 a total of 1,077 unique sturgeon have been PIT tagged. Male fish and those classified as unknown are similar in percent occurrence (Table 3). Total female fish handled is approximately 5% of the sample, which is characteristic of spawning populations (Dr. Molly Webb, personal communication).

Recapture information to date indicates that most fish remain within a distinct population unit. Seven sturgeon collected through this project are known to have made long movements from initial capture sites. Six fish traveled substantial distances downstream to a different spawning population, which included movement over, around, or through (entrained) a hydroelectric facility (Table 4).

With the preceding exceptions, spawning site fidelity appears to be high, with little documented movement between known spawning sites. Recapture rate was calculated for the broodstock collection at the South Channel. Regardless of netting effort the recapture rate ranged from 3-4% of catch for most years. The recapture rate for 2015 was 10.5%.

Several spawning congregations both in the St. Lawrence River and Lake Ontario have been identified, and, continually attract fish for reproduction. Past studies of age and growth (Jolliff and Eckert 1971, Johnson et al. 1998) would indicate that most sturgeon collected in this project range in age from 10-30 years.

Recommendations

1. Continue focused sampling 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 sampling effort on areas of the St. Lawrence River with demonstrated concentrations of Lake Sturgeon such as Oak Point, Morristown, and Coles Creek.

4. Continue exploratory netting in areas of Lake Ontario around Point Peninsula, Grenadier Island, and Henderson Bay.

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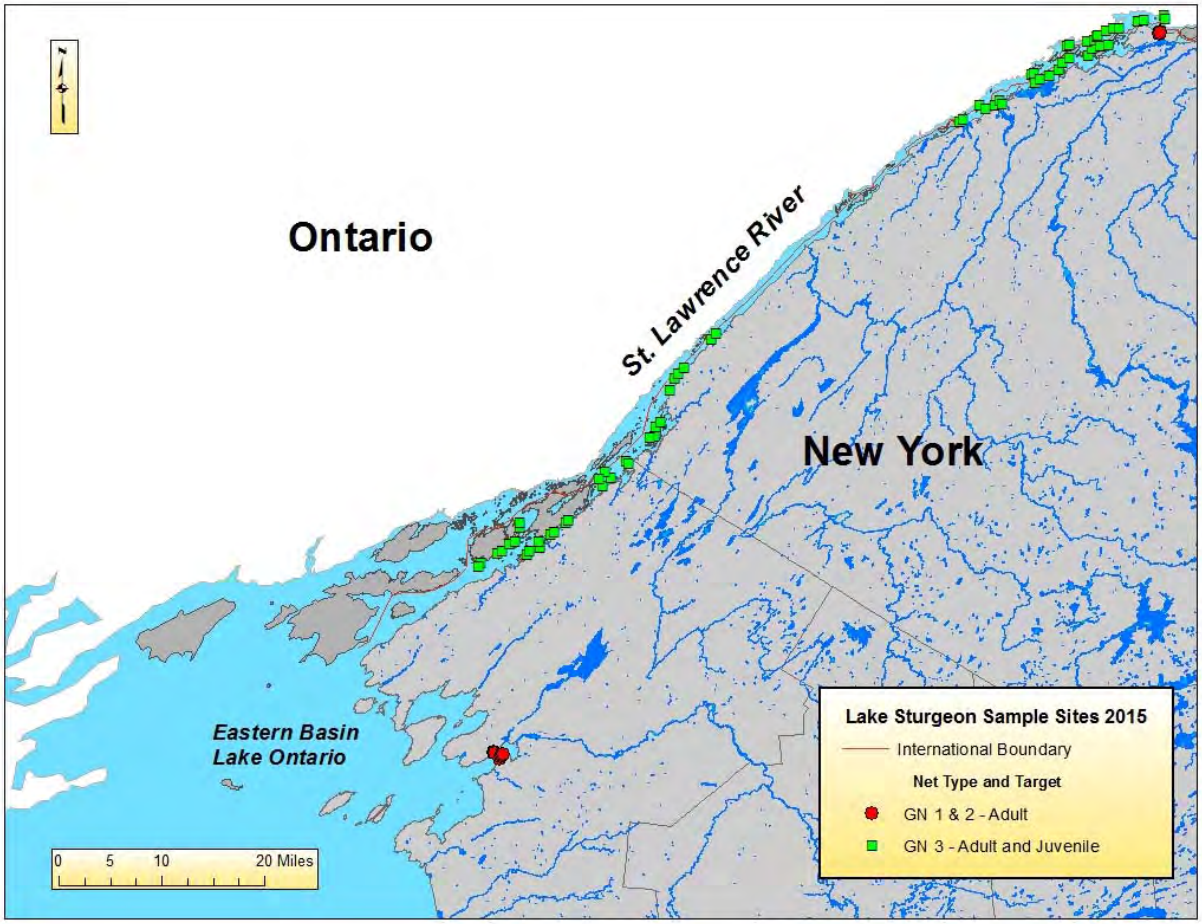

Figure 1. Lake Sturgeon sampling locations and targets for 2015. Adults were targeted with large mesh gill nets only (GN1 & 2). Existing index projects in the Thousand Islands and Lake St. Lawrence potentially targeted both juveniles and adults, utilizing primarily experimental gill nets (GN3). Net site location data for the Eastern Basin Lake Ontario gill net assessment (GN4) were not available for this figure.

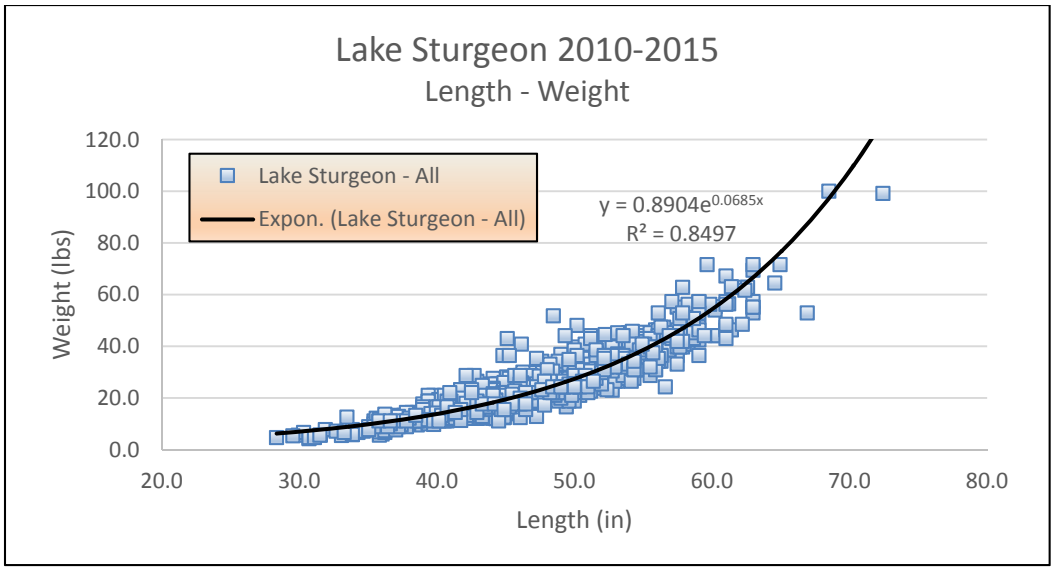

Figure 2. Length-weight relationship for Lake Sturgeon collected by DEC from 2010-2015. Fish from the St. Lawrence River, Lake Ontario, and the Black River were combined with no differentiation to sex.

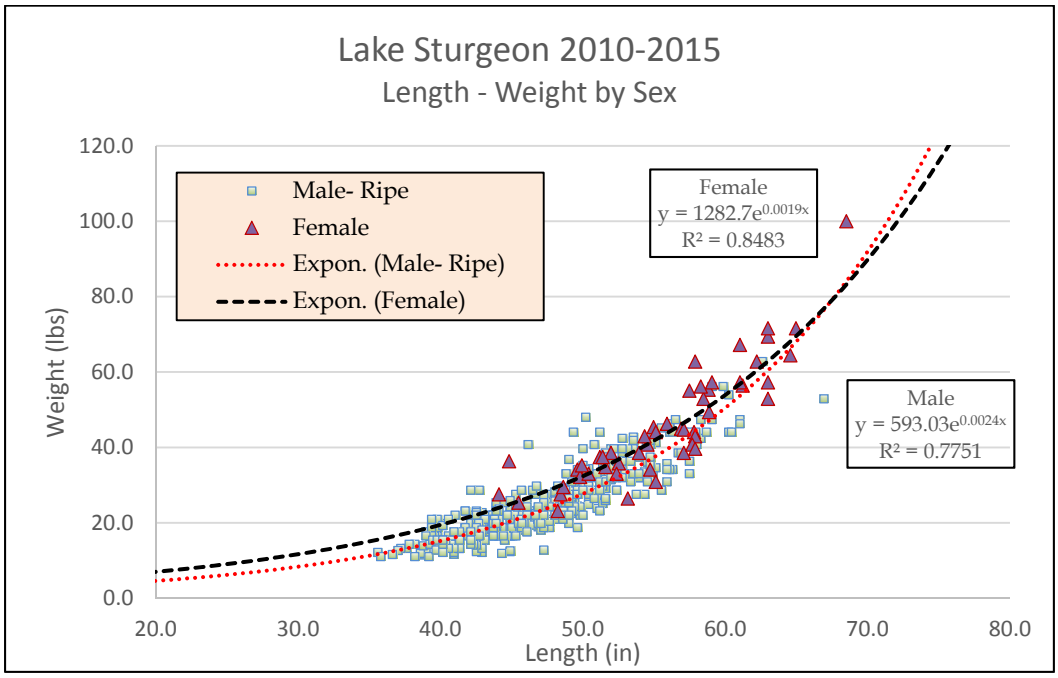

Figure 3. Length-weight relationship for Lake Sturgeon collected by DEC from 2010-2015 separated by sex. Fish from the St. Lawrence River, Lake Ontario, and the Black River were combined. Only female and ripe male sturgeon are presented.

Table 1. Specifications of nets used for collecting Lake Sturgeon in 2015. 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 2015. Targeted surveys specifically attempted to collect sturgeon. Existing project surveys targeted the major fish assemblage with sturgeon as a possible component. (A=adult or B=both adult and juvenile)

Location	Dates	# Sites	Target	Net Code	Effort (hrs)	Catch	CUE (fish/hr)
Targeted							
Black River Bay	4/23-5/6/2015	8	A	GN1 & GN2	399.75	33	0.09
SLR@ South Channel	5/21-28/2015	4	A	GN1 & GN2	332.52	133	0.40
Existing projects							
SLR- TI	7/27-30/2015	32	B	GN3	630.95	0	0.00
LO Gill Net	8/4-14/2015	25	B	GN4	467.35	3	0.01
SLR- LSL	9/14-17/2015	32	B	GN3	583.0	0	0.00

Table 3. Total unique Lake Sturgeon catch from 2010-2015. Fish listed as Male or Female were confirmed via direct evidence of gametes. Fish that did not produce gametes through palpation or direct examination were listed as Unknown.

Sex	Number	Percentage
Male	463	43.0
Female	54	5.0
Unknown	560	52.0

Table 4. Tagging and recapture locations for seven study fish that relocated substantial distances from initial capture. The "Dam" column indicates whether the fish had an interaction with a hydroelectric dam to reach its Recapture Point. Distance is the approximate straight line water distance (miles) from initial tagging to the recapture point. Tag type indicates the tag used to identify the fish.

Initial Tagging Location (year)	Recapture Point (year)	Dam	Distance (mi) from Tag Location	Tag Type
Black River (2006)	SLR, Mth Oswegatchie River (2010)	N	85	Floy
SLR, Coles Creek (2008)	SLR, South Channel (2011)	Y	18.5	PIT
SLR, Mth Oswegatchie River (2009)	SLR, South Channel (2011)	Y	43	PIT
St. Regis River stocking at Brasher Falls (2003)	SLR, South Channel (2013)	Y	30	Floy
Oneida Lake (2005)	Black River Bay (2014)	Y	92	PIT
Oswegatchie River blw Eel Weir (2009)	SLR, South Channel (2014)	Y	45	PIT
SLR, Mth Oswegatchie River (2010)	SLR, South Channel (2015)	Y	43	Floy

Table 5. Lake Sturgeon stocking for New York in 2015. All fish stocked received a coded wire tag (CWT) in the rostrum for the purpose of identifying their origin (hatchery vs. wild). Fish stocked on 8/10/2015* were considered "cull" fish from the hatcheries with a lower anticipated survival. Remaining fish were stocked on 10/8/2015.

Water	Number	Avg. Length at Stocking (in)	Mark
Black Lake	2000	7.5	CWT
Cayuga Lake	2500	7.5	CWT
Genessee River	1000	7.5	CWT
Lake Ontario (Chaumont Bay) *	7500	4	CWT
Oneida Lake	500	7.5	CWT
Oswegatchie River (Oxbow, Elmdale)	1700	7.5	CWT
Raquette River	500	7.5	CWT
Salmon River (Franklin Co.)	1000	7.5	CWT
St Regis River	1000	7.5	CWT
St.Lawrence River (Ogdensburg) *	2500	4	CWT
St.Lawrence River (Massena, blw dam)	300	7.5	CWT

Research, 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 (EWG) 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 muskellunge per hour fished). The EWG is composed of resource managers from the US and Canada and 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 risks subsequent to an invasive viral hemorrhagic septicemia (VHS) 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. From 2005 through 2008, however, widespread mortality of adult muskellunge was observed and attributed to VHS 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 understand the population's response to perturbations such as disease-induced mortality and changes to habitat or fish community structure. For example, the nonnative species, round goby, (*Neogobius melanostomus*) has invaded littoral nursery habitats of muskellunge (Farrell et al. 2010). Miano (2015) demonstrated in experimental treatments of habitats and northern pike and muskellunge that round goby significant egg predators of esocids, a broadcast spawning species. Round goby are also known as reservoirs and vectors for VHSV (Groocock et al. 2007). Further, the St. Lawrence River esocid seining index has detected changes in the nearshore fish assemblage associated with the dominance of round goby that potentially affects esocid prey availability.

Because of these stressors, maintenance of productive spawning and 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 et al. 1996, Cooper 2000, Farrell 2001), 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 YOY response to invasions by non-native prey fish (Kapuscinski and Farrell 2014). The information obtained in

these studies is being 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

Trapnet surveys have been used to monitor spring spawning adult muskellunge populations at a set of index bays for 15 years, 1997-2000, 2003, and annually since 2006). In 2015, sixteen nets, including 3' and 4' hoop nets and 6' Oneida trap nets were fished near shore in eleven muskellunge spawning bays from May 8th to June 17th. An additional two sites (Buck Bay and French Bay) were surveyed using roving net placement in an attempt to increase catch of spawning muskellunge.

Data collected include total length (TL), sex, spawning condition, and weight when possible. All adult muskellunge were tagged with Passive Integrated Transponder (PIT) tags. Catch data are reported as an index to monitor trends in relative 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 fish movements, particularly as it pertains to spawning site fidelity. In addition to collecting muskellunge-specific data, all other fishes are identified and enumerated to characterize fish assemblages present at muskellunge spawning sites and this information will be summarize elsewhere.

To estimate relative survival of YOY muskellunge in nursery sites, we repeated a larvae 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. Fry were immersed in 700 ppm oxytetracycline (OTC) for 8 hours to produce an identifiable mark in the otolith. Subsamples of OTC immersed fry were retained to evaluate mark quality. Fry were released into four bays previously stocked in the 1990s (Affluence, Boscobel, Deer and Rose Bays) and their presence assessed through seining. In addition to the OTC analysis to indicate stocked fry origin, site-specific seining catch per unit effort (CPUE) data from 1990 to 2015 were used to compare the relative catch of YOY muskellunge with and without fry stocking. Additional fry stocked sites (n=21) were sampled a minimum of once during summer seining to assess YOY presence.

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 occurred, 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). Habitat data collected include geographic coordinates, depth, temperature, vegetation type, and coverage. Juvenile esocid data collected comprises abundance, distribution, and total length (mm). Seining survey data are used to monitor trends in abundance and growth between periods, and to monitor fish assemblage/habitat relationships at muskellunge nursery locations. Diet information for YOY muskellunge was obtained from selected juveniles >80 mm or 3.2 in TL by gastric lavage (Farrell 1998, Kapuscinski et al. 2012).

A fin tissue sample was retained in 95% non-denatured ETOH for genetic analysis of all muskellunge sampled (both YOY and adults). Samples from multiple years (including those from angler cooperators) were sent to the lab of Dr. Louis Bernatchez at Laval University for genomic analyses using whole genome sequencing focusing on single nucleotide repeats (SNP) as markers. These samples will build on our current understanding of population and genetic structure of muskellunge in the upper St. Lawrence River, its tributaries (Kapuscinski et al. 2013) and downriver Quebec populations.

Angler diary program

We continue to maintain an angler diary program with participants ranging in angling

frequency from casual to dedicated muskellunge anglers to several professional guides. Cooperators are selected based on the quality of information volunteered in previous diary projects and responses to requests for program assistance. Anglers are asked to record data on daily effort (rod hours), catch and harvest rates, total lengths, and approximate location of angled muskellunge.

Muskellunge catch and release program

A partnership with a local environmental advocacy group, Save the River, continued through 2015 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 (54 inch) 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.

Results and Discussion

Spring trapnetting survey

A total of eleven spawning adult muskellunge were captured (catch rate = 0.019 fish/net night) in 2015 (Table 1, Figure 1). The mean number of muskellunge caught in the spring trapnetting survey before the VHS outbreak was 0.063 muskellunge per net-night (SD = 0.032), but a mean of 0.020 (SD = 0.012) muskellunge per net-night have been captured in subsequent years. The 2015 catch rate of 0.019 muskellunge per trap net night was slightly greater than that of 2014 (0.016) (Figure 1). One recaptured muskellunge was not recorded in the 2015 CPUE, having been tagged earlier that year. A single tiger muskellunge was captured in Garlock Bay on June 16th, a likely natural northern pike (*Esox lucius*) x muskellunge hybrid. Increased prevalence of natural hybrids is expected given greater overlap of esocid spawning times due to changes in northern pike habitat and later pike spawning during spring (Farrell 2001, Cooper et al. 2008).

Summer seining surveys

The annual standardized YOY muskellunge seining index was completed in 2015 and showed elevated CPUEs due to the influence of fry stocking at five index locations during 2013-2015 (see fry survival section below). A total of 11 bays were sampled during July with a fine-mesh seine (90 hauls). A total of 21 YOY muskellunge were captured and 11 of these fish originated from stocked sites. CPUE equaled 0.23 fish/haul (Figure 3). During the August large-mesh seine series, 13 YOY muskellunge were captured (10 at stocked sites) in 90 seine hauls (CPUE = 0.13) (Figure 3).

Stocked muskellunge fry survival study

Eggs were stripped and fertilized on May 15 from five (3 males; 2 females) spawning muskellunge captured in Flynn Bay, and on May 20 from a second pair captured at Frink's Bay. Advanced fry (Mean = 21 mm or 0.83 in; SD = 0.76 mm) were cultured at the Thousand Islands Biological Station in 2015. A total of 10,453 fry were released on July 7th in four index bays (Affluence, Boscobel, Deer, and Rose Bay) for comparison to fry survival estimates from the 1990s that occurred at those sites. Millen's Bay, an index site where long-term monitoring indicated the muskellunge population had collapsed, was stocked (4,000 fry) for the first time. An additional 36,574 fry were released on July 7-8 at 21 locations in the Thousand Islands Region (Table 4.).

During seining, five YOY muskellunge were retained from Rose Bay, one from Boscobel and four from Buck Bay. Otolith analysis on these fish revealed that seven of ten (70%) YOY muskellunge had a discernable OTC mark under ultraviolet fluorescent light indicating fry stocking origin. Long-term seining CPUE for the August large-mesh seining survey with and without stocking at four muskellunge nursery locations suggests a strong influence of stocking on YOY abundance following the steep decline in natural reproduction (Figure 2). In 2015, YOY muskellunge (all of stocked origin) were only detected at Rose Bay and Boscobel Bay during the August survey. Successful muskellunge reproduction may have ceased in these locations (and others) since the VHSV outbreak.

At the 21 additional fry stocking sites (Table 4) seining was used to evaluate YOY presence, and a total of 90 hauls were completed in the Thousand Islands during July, resulting in a catch of 19 YOY muskellunge (CPUE = 0.20) (Table 3). At Carrier Bay, a formerly productive muskellunge spawning and nursery site (LaPan 1985) that subsequently lost its reproductive capacity, a single YOY muskellunge was captured (likely from fry stocked origin), suggesting this site still has potential to support muskellunge. At Fergusons Cove, Oak Point NY, a site where habitat restoration activities were completed by Ducks Unlimited to remove invasive hybrid cattail (Farrell et al. 2014) and where advanced fry were released, two YOY muskellunge were captured indicating potential for survival. At Flynn and Buck Bay, a total of 12 hauls were completed during August, resulting in a catch of 7 YOY muskellunge (CPUE = 0.58; Table 5). Intensive seining at Rose Bay and Buck Bay revealed an abundance of YOY muskellunge in an offshore area dominated by water celery (*Vallisneria americana*). On September 16-17, 22 YOY muskellunge were captured in 36 seine hauls (CPUE = 0.61/haul) in Rose Bay. A 150 mm (5.9 in.) total length individual was sacrificed and otolith analysis revealed presence of fluorescence indicating stocking origin. From September 11 to 17, 34 seine hauls were completed at Buck Bay in a similar water celery dominated habitat and nine YOY muskellunge were captured (CPUE=0.26; Table 5). September seining at Flynn Bay and Millen's Bay was dominated by northern pike catches and only one YOY muskellunge was captured (Table 3).

Due to the low natural reproduction of YOY muskellunge, we recommended that monitoring efforts continue in addition to the advanced fry stocking research. Research investigating potential muskellunge spawning and nursery habitat enhancement techniques should also be continued.

Angler diary program

In 2015, anglers from the angler diary program fished 770 hours of effort for 28 muskellunge captured (0.036 fish / hour; Figure 4). The catch rate was an increase over 2014 where 17 muskellunge were captured in 587 hours of effort (0.029), and similar to 2013 where 23 muskellunge were captured in 632 hours of effort (0.036 fish/hour). Despite an increase in catch rate in 2015, rates remain well below the management goal of 0.1 fish per hour.

Muskellunge catch and release program

In 2015, five anglers participated in the Muskellunge Catch and Release program with TIBS and Save the River. Anglers submitted only five muskellunge release award affidavits, for fish ranging from 54 to 56 inches (average 55 inches). Anglers participating in this program estimated their angling effort ranging from 12 to 200 hours, with an average of 65.8 angler hours to catch a 54" or greater muskellunge. The increase in the muskellunge size limit and reductions in muskellunge has reduced participation in the release award program.

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Table 1. Locations, number of trapnets, trapnet effort (net nights), muskellunge catch, and CPUE for index and roving bays in the St. Lawrence River, 2015. A single tiger muskellunge captured at Garlock Bay was not included in the catch.

Bay	# Nets	Effort	Musky	CPUE
Index				
Blind	2	73	0	0.000
Cobb Shoal	1	32	1	0.031
Densmore	1	36	0	0.000
Flynn	4	122	6*	0.049
Frink's	1	32	2	0.063
Garlock	1	39	0	0.000
Lindley	1	36	0	0.000
Millen's	1	33	1**	0.030
Peos	1	29	0	0.000
Rose	2	66	1	0.015
Swan	1	38	0	0.000
Sub-Total	16	536	11	0.021
Roving				
Buck	1	31	0	0.000
French	1	2	0	0.000
Sub-Total	2	33	0	0.000
Total	18	569	11	0.019

* indicates a single same season muskellunge recapture not included in catch; not used to calculate CPUE; **fish lost during handling

Table 2. Summary of location of catch, total length (TL-mm), sex, reproductive stage, and tag number, and recapture history of spawning adult muskellunge caught and released from trapnets in St. Lawrence River bays, 2015. The tag entry number is for PIT type tags.

Date	Bay	Sex	Stage	TL (mm)	Recap Tag no.	Tag No.
5/10/2015	Rose	M	R	1210	-	900118001353023
5/13/2015	Flynn	M	R	1081	-	900118001355960
5/14/2015	Flynn	M	R	1091	-	900118001104558
5/15/2015	Flynn	M	R	1095	-	900118001355461
5/15/2015	Flynn	M	R	993	-	900118001352515
5/15/2015	Flynn	F	R	1295	-	900118001102022
5/15/2015	Flynn	F	R	1052	-	900118001103661
5/15/2015	Millen's	-	-	-	-	-
5/18/2015	Flynn	M	R	1081	-	900118001355960
5/19/2015	Frink's	F	-	1410	-	900118001104662
5/19/2015	Frink's	M	R	1283	-	900118001356155
6/01/2015	Cobb	M	R	1203	-	900118001103643
6/16/2015*	Garlock	N/A	N/A	595	-	900118001105754

*indicates a tagged tiger muskellunge

Table 3. Seining catch summary for 2015 sampling using a 1/8" fine-mesh 30' bag seine (top panel) and a 1/4" large-mesh 60' bag seine (bottom). Millen's Bay was stocked for the first time in 2015; remaining index sites were stocked in the 1990s and during 2013 and 2014.

Index Seining (30')					
Bay	Hauls	Muskie	NP	CPUE M	CPUE NP
FRY STOCKED SITES					
Affluence	6	2	0	0.33	0.00
Boscobel	6	1	0	0.17	0.00
Deer Island	6	3	1	0.50	0.17
Millen's	12	2	11	0.17	0.92
Rose	10	3	0	0.30	0.00
Total	40	11	12	0.275	0.300
NATURAL REPRODUCTION ONLY					
Cobb Shoal	12	0	0	0.00	0.00
Frinks	10	0	1	0.00	0.10
Garlock	10	0	0	0.00	0.00
Lindley	6	3	0	0.50	0.00
Peos	6	3	0	0.50	0.00
Salisbury	6	4	0	0.67	0.00
Total	50	10	1	0.200	0.020
Overall	**90**	**21**	**13**	**0.233**	**0.144**

Index Seining (60')					
Bay	Hauls	Muskie	NP	CPUE M	CPUE NP
FRY STOCKED SITES					
Affluence	6	0	0	0.00	0.00
Boscobel	6	3	0	0.50	0.00
Deer Island	6	0	0	0.00	0.00
Rose	10	7	0	0.70	0.00
Millen's	12	0	1	0.00	0.08
Total	40	10	1	0.250	0.025
NATURAL REPRODUCTION ONLY					
Cobb Shoal	12	1	0	0.08	0.00
Frinks	10	0	1	0.00	0.10
Garlock	10	0	0	0.00	0.00

Lindley	6	1	1	0.17	0.17
Peos	6	0	0	0.00	0.00
Salisbury	6	1	2	0.17	0.33
Sub-total	50	3	4	0.060	0.080
Overall	**90**	**13**	**5**	**0.144**	**0.055**

Table 4. Seining (30'- 1/8" mesh) assessment summary indicating effort, catch and catch per effort (CPUE) of stocked advanced fry muskellunge released at 21 locations in the Thousand Islands region of the St. Lawrence River. Data for northern pike captures are also shown. Sites receiving habitat enhancement are indicated with an asterisk.

Additional Seining (30') – Fry Stocked Sites					
Bay	Hauls	Muskie	NP	CPUE M	CPUE NP
Swan	3	0	0	0.00	0.00
Aunt Jane's	7	2	5	0.29	0.71
Bartlett Cove	3	0	0	0.00	0.00
Blind	6	1	2	0.17	0.33
Buck	6	5	0	0.83	0.00
Carrier	7	1	1	0.14	0.14
Delaney	5	1	0	0.20	0.00
Escanaba	4	0	0	0.00	0.00
Ferguson's Cove*	6	2	0	0.33	0.00
Flynn	8	1	4	0.13	0.50
French	3	0	1	0.00	0.33
French Creek	4	0	0	0.00	0.00
Jolly Island	3	5	1	1.66	0.33
Long Point	3	0	1	0.00	0.33
Mead Island	3	1	0	0.33	0.00
Point Vivian	11	0	2	0.00	0.18
Red Barn	3	0	0	0.00	0.00
Reed Point	1	0	0	0.00	0.00
Roods Cove	3	0	0	0.00	0.00
Rusho	3	0	0	0.00	0.00
Whitehouse	5	0	0	0.00	0.00
Total	**97**	**19**	**17**	**0.20**	**0.18**

Table 5. Seining (60'- ¼"mesh) assessment summary indicating effort, catch and catch per effort (CPUE) of stocked advanced fry muskellunge released at locations in the Thousand Islands region of the St. Lawrence River. Data for northern pike captures are also shown.

Additional Seining (60') – Fry Stocked Sites					
Bay	Hauls	Muskie	NP	CPUE M	CPUE NP
August					
Buck	4	4	0	1.00	0.00
Flynn	8	3	2	0.38	0.25
Total	**12**	**7**	**2**	**0.58**	**0.17**
September					
Rose	36	22	0	0.61	0.00
Buck	34	9	0	0.26	0.00
Flynn	28	1	21	0.04	0.75
Millen's	9	0	3	0.00	0.25
Total	**107**	**32**	**24**	**0.30**	**0.22**

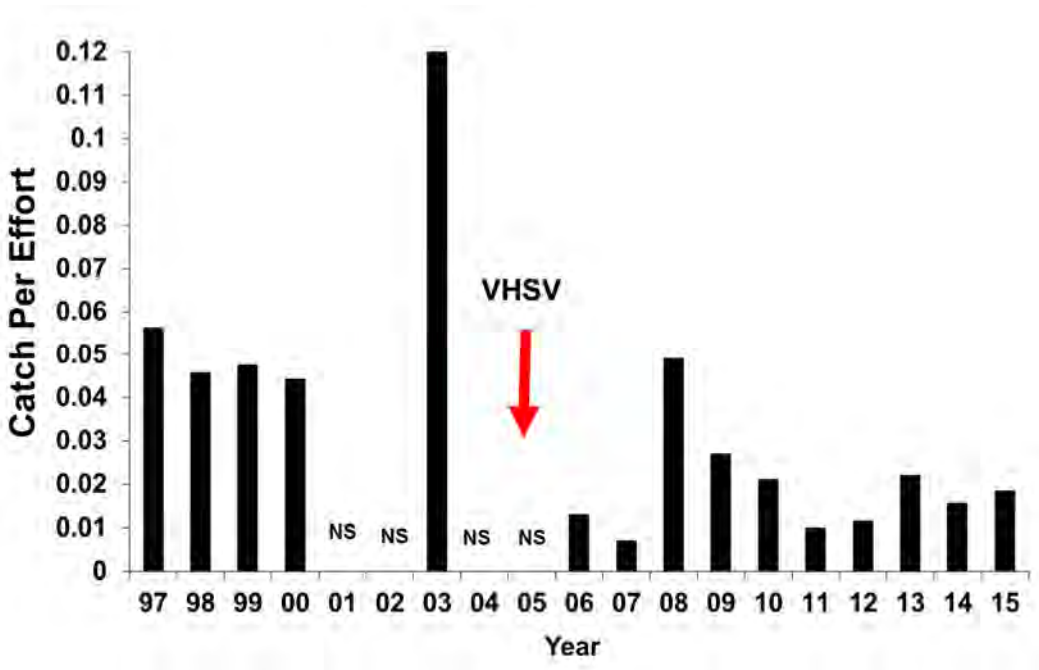

Figure 1. Total catch per net-night of muskellunge during spring trapnet sampling during 1997- 2015. Samples were not collected in 2001-02 and 2004-05 (NS) because of a decision of the Esocid Working Group to monitor muskellunge every third year. Following VHSV outbreak it was decided to resume annual monitoring.

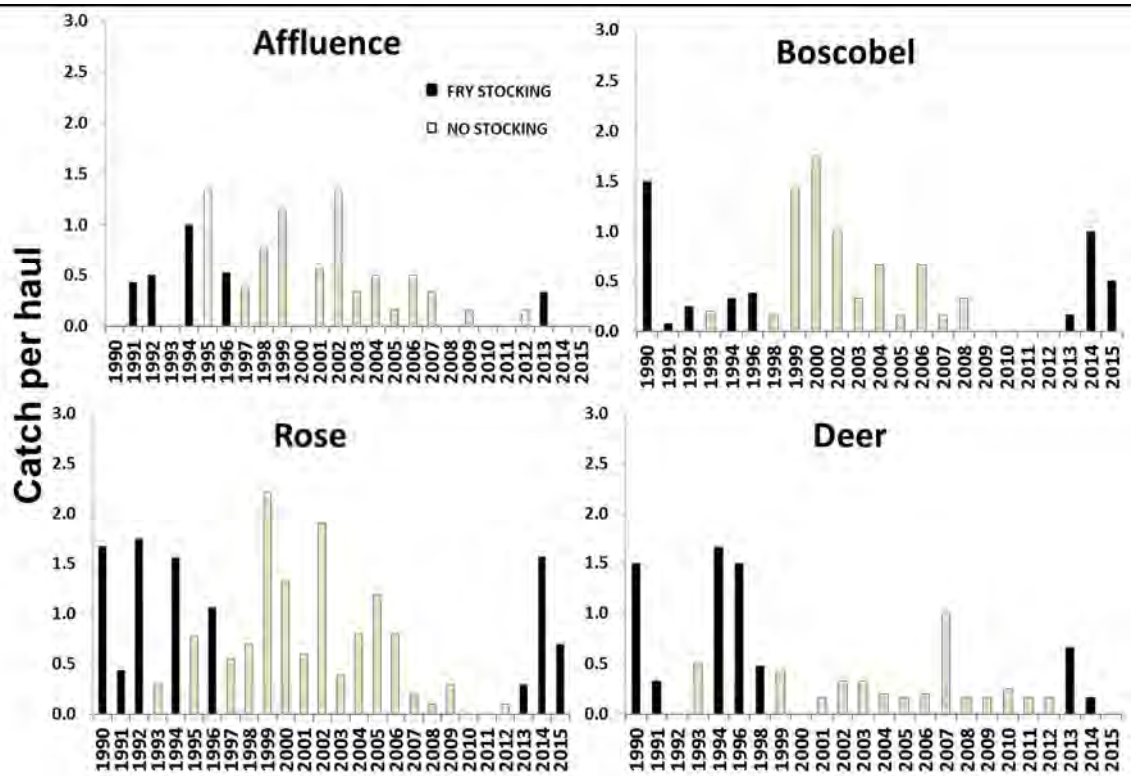

Figure 2. Catch per unit effort of YOY muskellunge captured in standardized seine hauls in four upper St. Lawrence River nursery sites from 1990 to 2015 during years of advanced muskellunge fry stocking (1990-92, 1994, 1996 and 2013-2015, black bars) and no stocking (all other years, white bars). All sites were stocked at a rate of 750 fry per hectare in areas <1.5m (5') water depth.

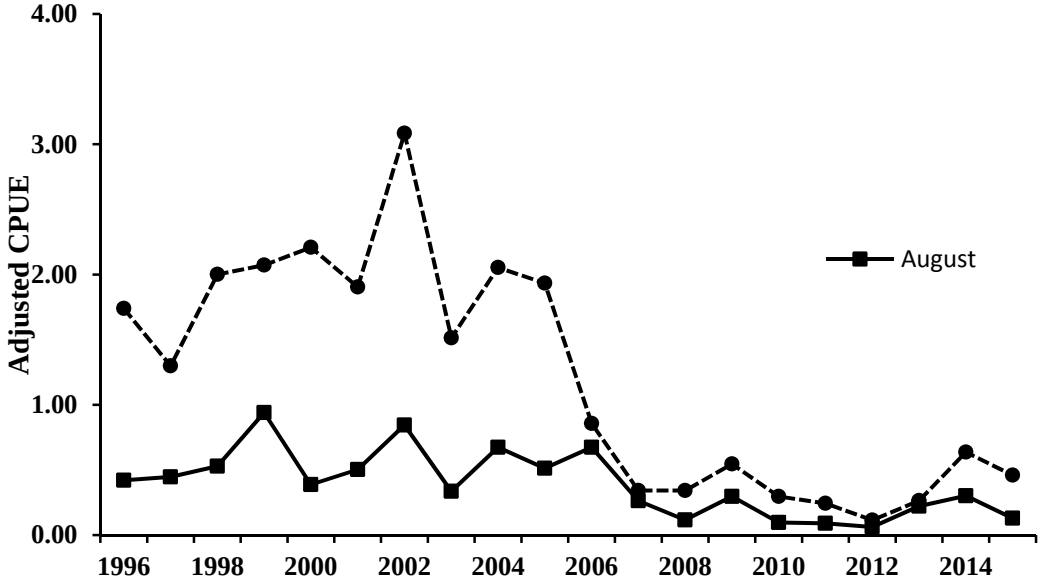

Figure 3. Catch per unit effort of YOY muskellunge captured in standardized seine hauls in eleven upper St. Lawrence River nursery sites from 1996 to 2015. A 9.14 m (30') fine-mesh seine was used during the month of July and an 18.3 m (60') large-mesh seine was used during the month of August. The fine-mesh seine CPUE was doubled to standardize the area swept among the two gears. Detection of VHSV occurred in 2005 and widespread mortality of muskellunge continued through 2008 in the upper River.

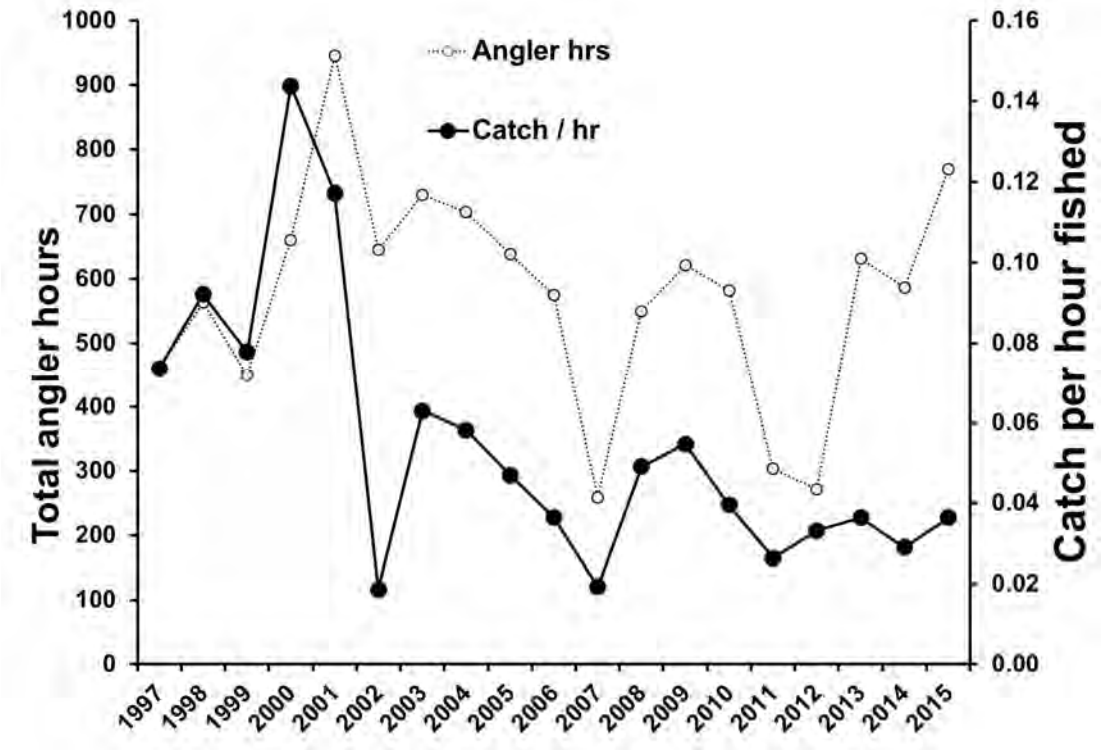

Figure 4. Thousand Islands Region Muskellunge Angler Diary Program data showing angler hours compared to average catch per angler hour. The management target goal is 0.1 fish per angler hour or 1 muskellunge per 10 hours fished. Note relationship between catch and effort over time, however relatively high effort since 2012 has not produced large increases in catch of muskellunge.

Lake Ontario Commercial Fishery Summary, 2000-2015

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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 2015. Commercial harvest generally targets yellow perch (*Perca flavescens*), however, harvest of lake herring (*Coregonus artedii*), whitefish (*Coregonus* clupeaformis), and white perch (*Morone americana)* was also reported in 2015. Herring harvest went unreported for a number of years, and fishers were reminded of reporting requirements (all fish caught, whether sold or not) in 2009. Of five licensed commercial fishermen, only two actively fished in 2015 (Table 2). Data from previous years are reported by LaPan (2005).

References

LaPan, S.R. 2005. Lake Ontario commercial fishing summary 1997-2004. Section 22 *in* NYSDEC 2004 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commissions Lake Ontario Committee.

Table 1. Approximate reported value ($US) of the 2015 commercial catch from the New York waters of Eastern Lake Ontario (*estimated, weighted mean value, as price fluctuates throughout the year).

SPECIES	TOTAL POUNDS	PRICE/POUND*	TOTAL VALUE
Yellow Perch	46,473	$2.39	$110,799
White Perch	859	$ .62	$ 316

Table 2. Reported* commercial fish catch in pounds from the New York waters of Eastern Lake Ontario, 2000-2015.

	# 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	-	1,820	-	-	-	-	-	-	12
2014	2	44,143	63	815	22	-	-	-	-	-	20
2015	2	46,473	-	859	-	-	-	11	-	-	52

*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

Lower Niagara River Warmwater Fisheries Assessment

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The lower Niagara River flows approximately 14 miles from the base of Niagara Falls to Lake Ontario. Below Niagara Falls the river flows through a steep gorge that is characterized by rapids and deep holes that can reach depths of up to 190 feet. From Lewiston, NY to Lake Ontario the river widens and the current slows. Average depths from Lewiston to Lake Ontario are around 40 feet. The littoral zone in the lower Niagara River is very narrow, as its bottom profile quickly transitions to deeper water.

The lower Niagara River is best known for its migratory salmonid fishery, but the river also has an excellent warm water fishery with Smallmouth Bass (*Micropterus dolomieu*) as the primary target (NYPA 2005). Little is known, however, about the population structure and status of the warm and cool water fish communities in the lower Niagara River. In an effort to gather baseline data on warm and cool water (hereafter combined as warm water) fishes, the NYSDEC conducted an electrofishing survey of the lower Niagara River during the summer of 2015. The goals of the survey were to: 1) assess the warm water fish community and 2) evaluate the effectiveness of electrofishing as a method for warm water fisheries surveys in the lower Niagara River.

Methods

The warm water fish community of the lower Niagara River was assessed by boat electrofishing from June 29th – July 1st 2015, following methods in the NYSDEC Centrarchid Sampling Manual (Green 1989). The survey covered the entire New York shoreline from Lewiston to the mouth of the River. Electrofishing was done using two scap netters on a Smith Root SR-18EH electrofishing boat that generated a pulsed DC electric field (7.5 A, 360 v, and a pulse frequency of 60) with 33 inch (838 mm) diameter, six dropper anodes .

Sampling effort was divided into nine separate electrofishing runs, three runs targeted all fish and six runs targeted game fish only. “All fish” runs were 15 minutes in duration and game fish runs were 30 minutes in duration. All fish were identified to species and measured to the nearest millimeter. Smallmouth Bass were weighed to the nearest gram. Scale samples were taken from all Walleye (*Sander vitreus*) and a sub sample of Smallmouth Bass for age determination. Relative weight (Wr) was determined for Smallmouth Bass using the formulas reported by Kolander et al. (1993).

Results and Discussion

We caught a total of 1034 fish, representing 20 species, during 3.75 hours of electrofishing (Table 1). Alewife were the most abundant species collected and Smallmouth Bass were the most abundant game fish collected.

Smallmouth Bass

We caught a total of 291 Smallmouth Bass with an average catch rate of 76.4 fish per hour (*SD* = 43.3), one of the highest catch rates ever recorded in New York. The statewide average electrofishing catch rate for Smallmouth Bass is four fish per hour, and the highest reported catch rate from an inland lake in New York is 45 fish per hour (Perry et al. 2014). Comparable electrofishing catch rates for Smallmouth Bass are not available for the St. Lawrence River or Lake Ontario because Smallmouth Bass populations in these areas are assessed using gill nets. One electrofishing survey was conducted in Lake Erie, within Dunkirk Harbor, with an

average catch rate of 99.8 fish per hour (*SD* = 24; NYSDEC unpublished data).

Total length of Smallmouth Bass ranged from 4.5 inches (115 mm) to 19.2 inches (488 mm) with an average of 14.1 inches (359 mm; *SD* = 2.5; Figure 1). Relative weight (Wr) of Smallmouth Bass in the lower Niagara River ranged from 79.9 to 132.5 with an average of 96.5 (*SD* = 8.7). An average Wr of 96.5 is within the desired range for a balanced population (Green 1989) and is greater than the statewide average of 90. It is, however, slightly lower than that reported for the eastern basin of Lake Ontario, Lake Erie (Perry et al. 2014) and the St. Lawrence River (Loukmas and Perry 2015).

Smallmouth Bass reached legal size of 12 inches during their third growing season in the lower Niagara River (Figure 2). The growth rate of Smallmouth Bass in the lower Niagara River was greater than the statewide average (Perry et al. 2014), similar to the St. Lawrence River (McCullough and Gordon 2015), but was slower than the eastern basin of Lake Ontario (Lantry 2015) and Lake Erie (Robinson 2015). The Smallmouth Bass catch was dominated by age 3 to age 6 fish with smaller numbers of older fish (Figure 3). Virtually no age 1 and age 2 fish were caught during the survey, likely due to electrofishing not being as effective at sampling smaller fish, and should not be interpreted as a lack of young fish in the population.

Overall the Smallmouth Bass population in the lower Niagara River is in excellent condition and the river should be considered one of the top Smallmouth Bass fishing destinations in New York.

American Eel

American Eel are a catadromous fish that spends most of its life in freshwater and migrates to the Sargasso Sea to spawn. They are native to Lake Ontario and the lower Niagara River and can spend up to 30 years in freshwater before migrating out to sea (Dittman et al. 2010). American Eels are in decline throughout their range and currently listed as a species of Greatest Conservation Need in New York.

One of the most interesting findings of this survey was the abundance of American Eel in the lower Niagara River. We caught 12 eels and observed 13 others for an average catch rate of 3.1 (*SD* = 2.8) fish per hour and an average observation rate of 6.2 (*SD* = 4.2) fish per hour. American Eel ranged in size from 20 inches (510 mm) to 34.2 inches (868 mm) with an average length of 25.2 inches (641 mm; *SD* = 4.5). The only other survey targeting American Eel in the lower Niagara River was done in September 2002 and reported a catch rate of 1.1 (*SD* = 1) fish per hour (Dittman 2003). Our catch rate was higher than 2002, and likely reflects increased eel abundance due to experimental stocking of > 4 million glass eels in Ontario waters of Lake Ontario and the St. Lawrence River between 2006 and 2010 (OMNRF 2015).

Walleye

Walleye were the second most abundant game fish collected during the survey. While only nine Walleye were caught all fish were well above the minimum size of 18 inches. The average length of Walleye was 22.5 inches (572 mm) and the largest was 27.1 inches (690 mm). Several other large Walleye were observed during the survey that escaped capture. Walleye are currently the only warm water fish that is stocked in lower Niagara River. New York currently stocks 23,200 Walleye fingerlings each year and there is an excellent Walleye fishery throughout the entire season. However, electrofishing does not appear to be an effective method for assessing the Walleye population in the lower Niagara River. Future surveys should incorporate gill nets to determine if higher numbers of Walleye can be captured using this gear.

Suckers (Catostomidae spp.)

Another noteworthy finding of this survey was the diversity of suckers in the lower Niagara River. We caught four different species including Greater Redhorse (*Moxostoma valenciennesi*), Shorthead Redhorse (*Moxostoma macrolepidotum*), Golden Redhorse (*Moxostoma erythrurum*) and White Sucker (*Catostomus commersonii*). Suckers are not normally targeted by anglers but they can be an important forage fish for Walleye and Smallmouth Bass.

Methods evaluation

Electrofishing was very effective at sampling a portion of the warm water fish community in the lower Niagara River. Most notably adult Smallmouth Bass and Suckers. However, the method was less effective at sampling young Smallmouth Bass, Walleye and the prey fish community. Electrofishing is also restricted to a narrow ribbon of shallow water habitat along the bank of the river and does not effectively sample the deep water portion of the river. Electrofishing should continue to be used as the primary method for assessing the warm water fish community in the lower Niagara River. However, future surveys should also include seining and gill netting to evaluate the effectiveness of these gear types in assessing nearshore prey fishes, young-of-year Smallmouth Bass, Walleye and deep water habitats.

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Table 1. Species and number of fish sampled during electrofishing on the lower Niagara River in 2015.

Common Name	Scientific Name	Number Caught
Alewife	*Alosa pseudoharengus*	616
American Eel	*Anguilla rostrata*	12
Brown Bullhead	*Ameiurus nebulosus*	6
Brown Trout	*Salmo trutta*	8
Emerald Shiner	*Notropis atherinoides*	17
Freshwater Drum	*Aplodinotus grunniens*	8
Gizzard Shad	*Dorosoma cepedianum*	16
Golden Redhorse	*Moxostoma erythrurum*	1
Greater Redhorse	*Moxostoma valenciennesi*	13
Largemouth Bass	*Micropterus salmoides*	1
Longnose Gar	*Lepisosteus osseus*	3
Northern Pike	*Esox lucius*	1
Quilback	*Carpiodes cyprinus*	4
Rock Bass	*Ambloplites rupestris*	3
Round Goby	*Neogobius melanostomus*	1
Shorthead Redhorse	*Moxostoma macrolepidotum*	5
Smallmouth Bass	*Micropterus dolomieu*	291
Walleye	*Sander vitreus*	9
White Bass	*Morone chrysops*	3
White Sucker	*Catostomus commersonii*	16

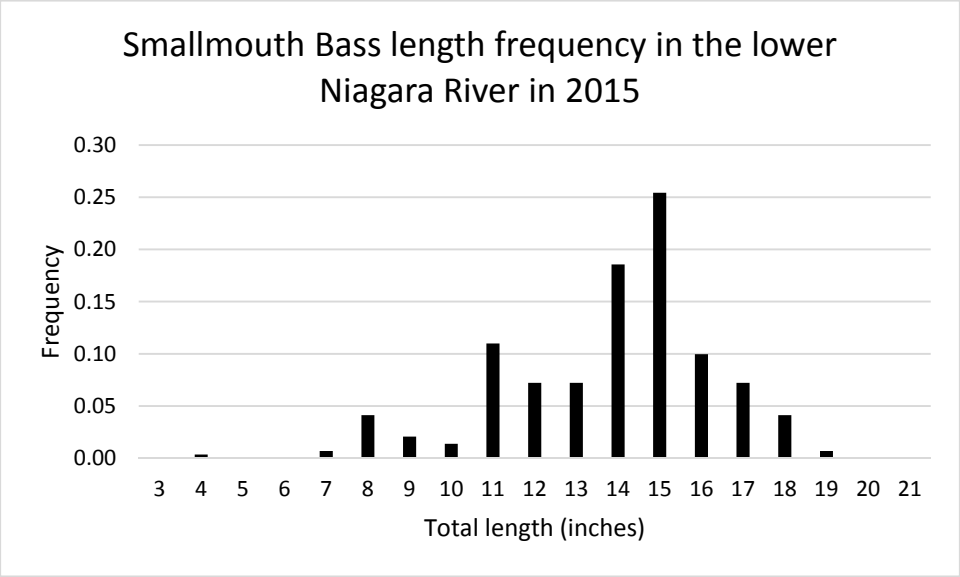

Figure 1. Length frequency of Smallmouth Bass in the lower Niagara River 2015.

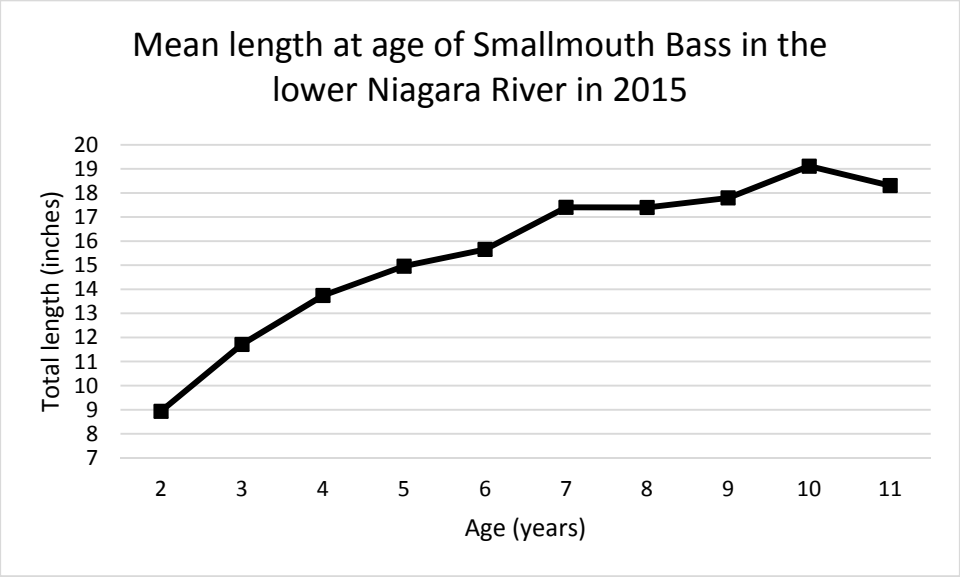

Figure 2. Mean length at age of Smallmouth Bass in the lower Niagara River 2015.

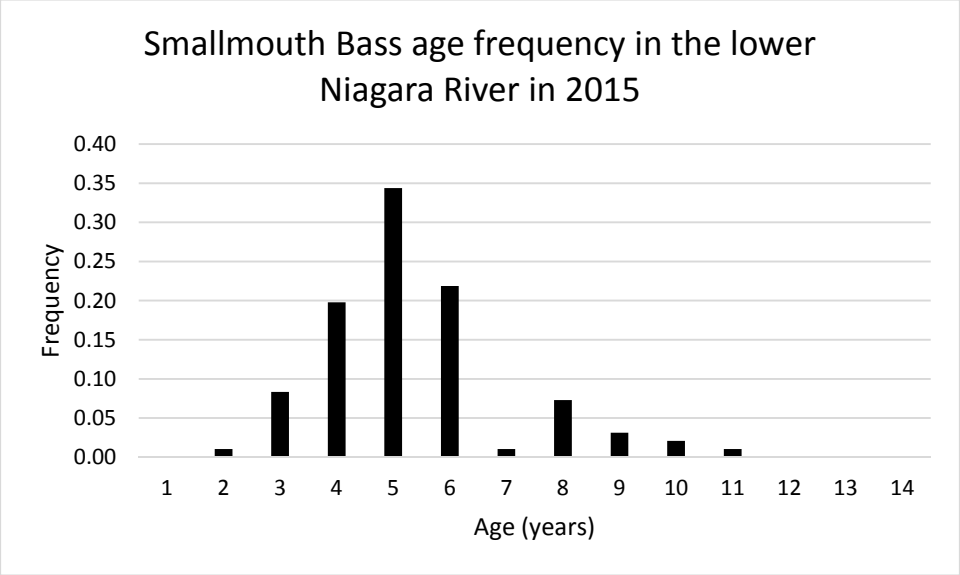

Figure 3. Age distribution of Smallmouth Bass in the lower Niagara River 2015.

Northern Pike Research, 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 2016) continues to indicate low population levels. Smith et al. (2007) demonstrated an overall dampening in the strength of Thousand Islands northern pike year classes beginning in the 1990s and seining indices show low young of the year (YOY) abundance corresponding to the adult population trend. Models of YOY northern pike 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 or 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). Water levels at three 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 early indications of success with managed marshes demonstrating significant production of emigrating fingerlings (Farrell et al. 2003), it is hypothesized that low abundance 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 (Farrell and Runner 2014a) and in larger bays and in tributaries. Overall YOY production has declined significantly from historic levels. 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 one managed spawning marsh. Tributaries included French Creek, Cranberry Creek,

Cranberry Creek extension (tributary), Little Cranberry Creek, and Chippewa (Creek) Tributary. The managed marsh was Carpenters Branch of French Creek (Figure 1). A trapnet was also set at French Bay, Clayton NY to monitor northern pike.

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 (19.7inches). 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 ~0.6 m or about 2 feet above main river level at Carpenters Branch and Delaney Marsh. Delaney marsh was not included in the spring spawning survey because of its remote island location, but was surveyed for emigrating YOY pike. The 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 fall to spring 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.

In early summer, YOY pike are surveyed during emigration from marshes by capture in spillway traps set and emptied daily. All fish captured were identified and enumerated. Northern pike were measured for total length (mm), and a pelvic fin for all fish greater than 80 mm (2.3 in.) was removed to evaluate the presence of marsh-origin fish during subsequent summer seining surveys and future spring adult trapnetting surveys.

YOY pike traps were also set at the outlets of excavated marsh spawning pools. Spawning pool and connecting channel excavations within dense hybrid cattail stands were created in an attempt to experimentally increase YOY pike production.

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') long seine (90 hauls) and during August with a large-mesh, 18.3 m (60') long seine (100 hauls) (for methods details see Murry and Farrell 2007). In addition, 21 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. Seining also occurs at Delaney Bay in an attempt to detect marsh-origin northern pike.

Results and Discussion

Spawning run trapnet survey

A total of 38 northern pike were captured at five index tributary sites from April 9th to April 24th, 2015, comprising an effort of 99 net nights, and resulting in a catch per unit of effort (CPUE) of 0.38 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 considerably higher at Cranberry Creek (26 pike in 14 net-nights, 1.86 fish per night) compared to all of the tributary sites.

No northern pike were captured at Carpenter's Branch, a managed marsh. Current and past trapnet catches continue to indicate a remarkable dominance of female pike in the spawning run at the managed marsh sites. For 577 pike of known sex captured at Carpenter's Branch in eleven seasons since 2003, 402 were female or 2.30 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.

Emigration of northern pike at managed marshes and excavated spawning pools

In 2015, traps were deployed at Delaney marsh from 6/19 to 7/2 and Carpenter's Branch from 6/19 to 7/3. Catches at the Delaney Marsh site remained low compared to historic levels at 153

northern pike YOY captured over 21 days of monitoring (Table 2). Carpenter's Branch had its lowest catch ever recorded with 0 northern pike YOY captured over 14 days of monitoring. The Delaney Marsh catch rate decreased to 0.62 fish emigrating per day, higher than other sites monitored, yet still low in comparison to similar sites early in the program. Low production of northern pike from the Carpenter's and Delaney spawning marshes has continued for seven consecutive years (Figure 3).

A total of 371 net nights of trapping effort was expended at excavated spawning pools, resulting in a total catch of 27 YOY pike (CPUE=0.07 fish/day; Table 2).

Summer seining surveys

The YOY seining survey at eleven index sites targeting muskellunge produced 13 northern pike YOY from the 30' seine series in 90 hauls (standardized CPUE = 0.14 fish; Table 3) and 5 in the 60' seine series in 100 hauls (standard CPUE = 0.05 fish/haul). Twenty-one additional upper St. Lawrence River bays were sampled by seining and 17 YOY pike were captured (N=97 hauls; CPUE=0.18). Seine hauls at Delaney Bay (N=5) resulted in no catch of YOY pike (Table 3).

Conclusions and Recommendations

Continued low density of adult and YOY northern pike on spawning/nursery grounds suggests low adult stock size and skewed sex ratios continue to confound development of strong pike year classes. Managed water level marshes are a tool to enhance YOY production, but pike runs have declined.

Transfers of spawning adult northern pike from connecting bays to managed marshes should be explored further. 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. We recommend additional evaluation of the adult transfer approach to evaluate pike productivity within managed spawning marshes.

We also suggest stocking oxytetracycline (OTC) marked northern pike larvae within marshes to test if these habitats can support early life stages. The use of local genetic strains of pike are recommended as an egg source (Bosworth and Farrell 2006). It is anticipated that Oneida-type trapnets set in French Bay and Delaney Bay will capture enough spawning adults in springtime to be used for egg take. Evaluations of the relative contribution of stocked pike to unmarked pike during marsh out-migration will provide insights into the productive capacity of managed marshes.

We are also engaged in a study designed to identify northern pike sex determining genes (SDGs) to use in development of a molecular diagnostic tool (using PCR). 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. Development of a test to determine gender for early life stages of northern pike will allow determination of the proximal cause in the sex ratio skewness in the St. Lawrence River population. In collaboration with Dr. Ben Koops' lab at the University of Victoria, we are now mapping chromosomes of known parental and progeny genomics to identify the SDG. In 2015, we cultured progeny of three single male x female pairings to a range of sizes and examined histology preparations of body cavity sections stained and slidemounted by MassHisto™. A secondary question was to determine what sizes (TL-mm) of YOY were required for histological evaluation that enable gender determination. Histology preparations were evaluated for male and female YOY pike by two independent readers at ESF from a range of fish sizes. It was determined that nearly 100% confidence in gender determination could be achieved at fish sizes >70mm or 2.8 in.

Additionally, the chromosome mapping work from the parents and the few resulting progeny from the above histological work has made significant progress. Eric Rondeau (U. Victoria Ph.D. candidate) who is completing the molecular work, reported that all six parents were screened, along with sexed offspring, on 381 microsatellites to find markers that were

polymorphic. The 100 most informative microsatellites were chosen to screen the offspring. We were unable to score two fish, but the remaining 98 were successful and informative in at least one of the six families. Unfortunately, the number of offspring surviving to the size at which gender could be determined was too low. Appropriate sized offspring were split between three families, presenting difficulty in finding markers that were informative across all offspring. We therefore had to rely on a combination of markers to represent each region on the chromosome. The single male per family also allowed no room for recombination when trying to identify alleles that were male-specific versus female specific. It is advised to provide additional parental groups in 2016 and culture n=80 fish per family to a size >70mm for histological gender determination to improve maps and build on progress made to date.

On a positive note, recent habitat enhancements with created spawning pools with connectivity enhancements engineered by Ducks Unlimited and evaluated by SUNY-ESF for YOY northern pike densities (Farrell et al. 2014) have demonstrated greater YOY northern pike production relative to the managed marshes. Spawning pool enhancements, however, indicated modest production and it is recommended that these habitats be monitored in the future along with spawning marshes for YOY northern pike outmigration. Continued monitoring of YOY pike from natural sites (seining), and from spawning marshes and other habitat enhancements, along with the proposed releases of larvae and transfer of spawning adults, will provide balanced comparative information relative to these management methods.

It is also recommended that efforts continue to be taken by DEC, the US Fish and Wildlife Service (FWS) and Ducks Unlimited (DU) to enhance critical spawning and nursery habitat in the region.

A recent effort by IJC and its partners will address adaptive management of water levels in the Lake Ontario-St. Lawrence River system. Efforts continue among a binational group to continue to develop baseline data collection for water levels indicators including wetland plant indicators. The long-term monitoring developed in this study will additionally 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.

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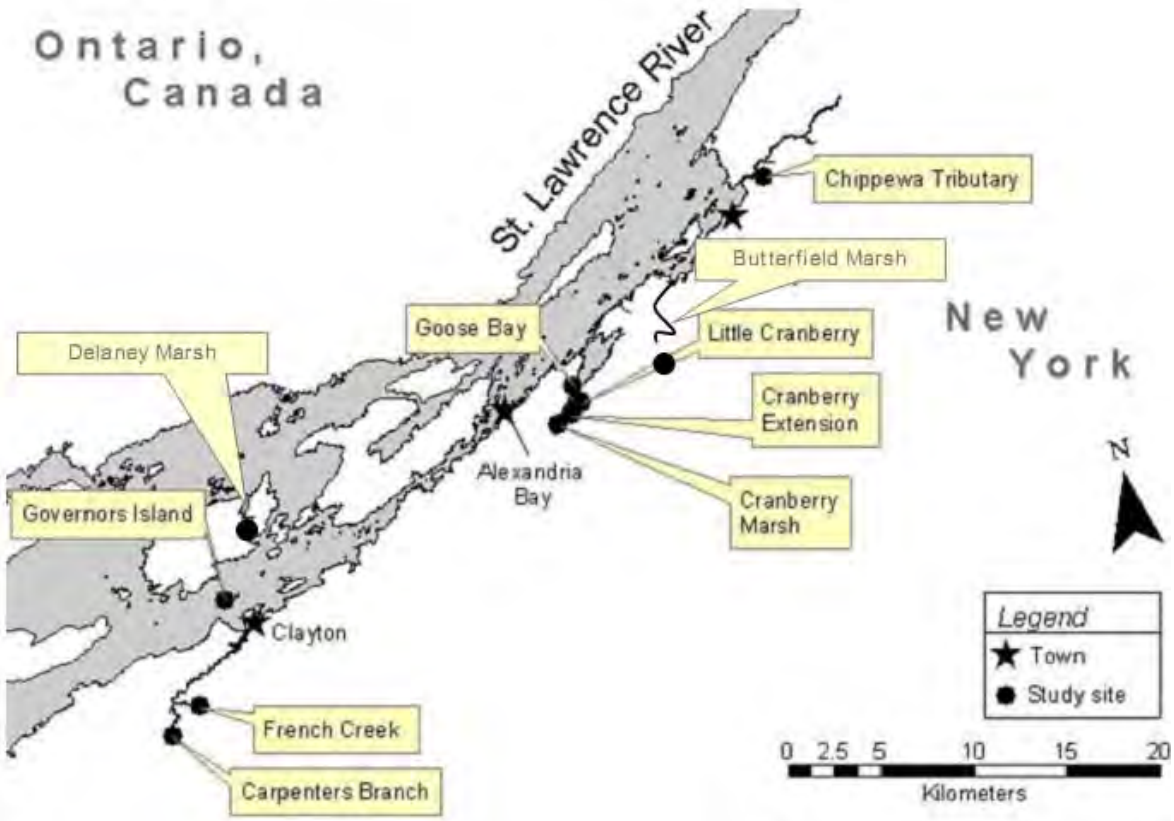

Figure 1. Study sites in the Thousand Islands Region of the upper St. Lawrence River in Clayton and Alexandria Bay, New York, including spawning marshes at Carpenters Branch (French Creek Wildlife Management Area) and Delaney Marsh (Grindstone Island) and sampling index locations at French Creek, Little 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 is under repair by the US Fish and Wildlife Service. Additional seining locations (not shown) are index YOY muskellunge monitoring sites and other regional embayments.

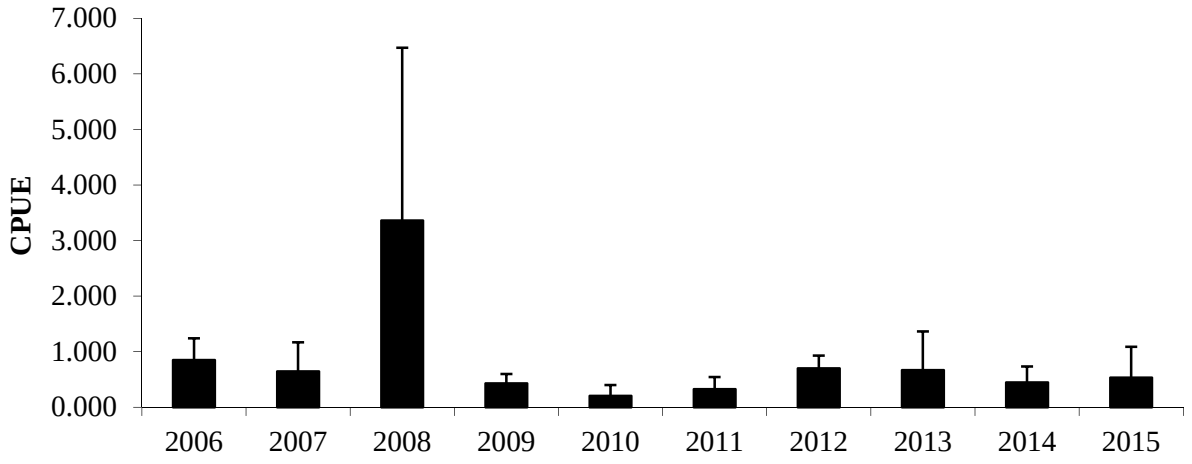

Figure 2. Average catch per net-night of northern pike in five spring spawning index trapnetting locations from 2006 to 2015 with 90% confidence limits.

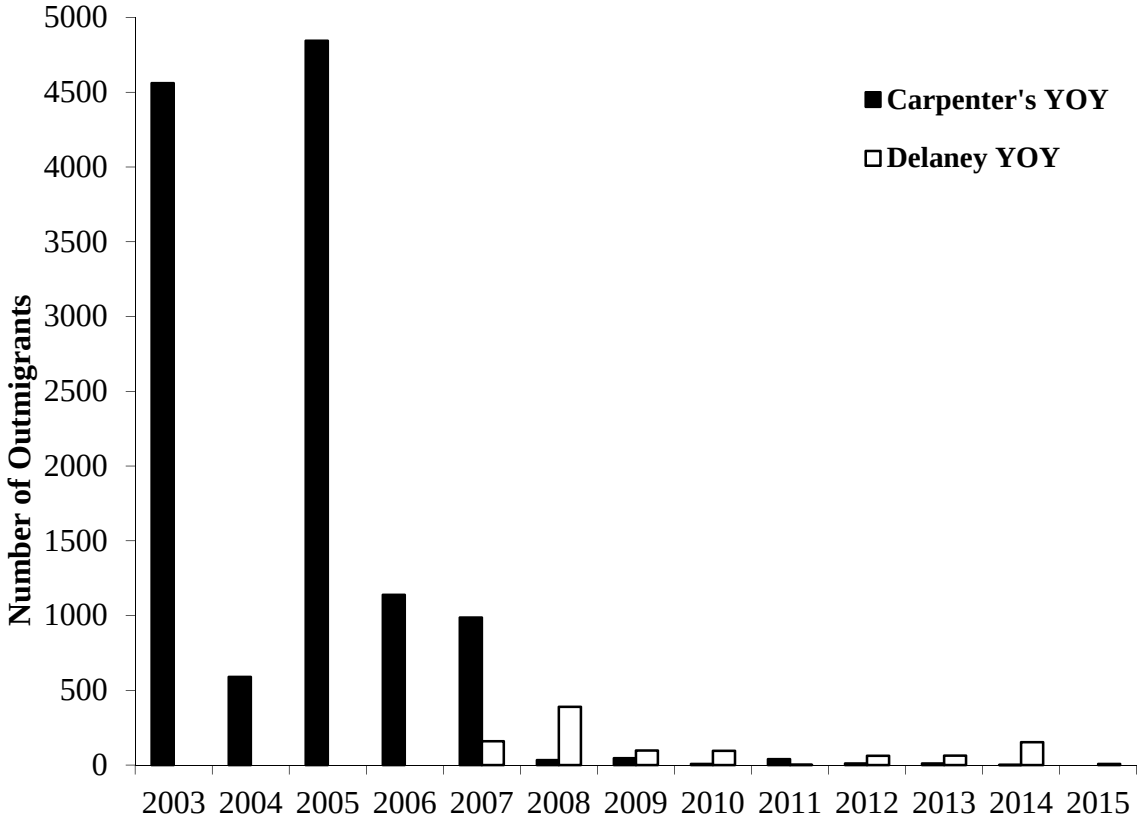

Figure 3. Number of out-migrant northern pike YOY from managed spawning marshes at Carpenter's Branch (2003 to 2015) and Delaney Marsh (2007 to 2015).

Table 1. 2015 upper St. Lawrence River northern pike spawning survey effort and results by site. One managed marsh was sampled in 2015; Carpenters Branch and one supplemental site; Rose Pond.

2015 NP Spawning							
Site	Gear	Start Date	End Date	Net Nights	NP Catch	CPUE	M/F Ratio
Chippewa Tributary	Hoop	4/9/2015	4/24/2015	15	6	0.40	2/1
Cranberry Creek	Oneida	4/10/2015	4/24/2015	14	26	1.86	10/16
Cranberry Ext.	Hoop	4/9/2015	4/24/2015	15	0	0.00	0/0
French Creek	Hoop	4/9/2015	4/24/2015	15	3	0.20	3/0
Little Cranberry	Hoop	4/9/2015	4/24/2015	15	3	0.20	2/1
Managed Marsh							
Carpenters Branch	Hoop	4/11/2015	4/24/2015	13	0	0.00	0/0
Total				**99**	**38**	**0.38**	**0.94**

Table 2. Catch of YOY northern pike in emigration traps set at spillways associated with managed spawning marshes at Carpenters Branch of French Creek and Delaney Marsh on Grindstone Island, and traps set at outlet of spawning pools at French Creek, Point Vivian Marsh, Ferguson's Cove, and Rose Pond (denoted with an *). Spawning pool excavations funded by the Fish Enhancement, Mitigation, and Restoration Fund are denoted with an *.

2015 NP Emigration					
Location	**Set Date**	**End Date**	**Net Nights**	**NP Catch**	**CPUE**
French Creek 10*	6/17/2015	7/6/2015	19	1	0.05
French Creek 9*	6/17/2015	7/6/2015	19	2	0.11
French Creek 8*	6/17/2015	7/6/2015	19	2	0.11
French Creek 7*	6/17/2015	7/6/2015	19	3	0.16
French Creek 6*	6/17/2015	7/6/2015	19	2	0.11
French Creek 5*	6/17/2015	7/6/2015	19	7	0.37
French Creek REF E*	6/17/2015	7/6/2015	19	1	0.05
French Creek REF W*	6/17/2015	7/6/2015	19	1	0.05
French Creek REF N*	6/17/2015	7/6/2015	19	0	0.00
Point Vivian 3*	6/17/2015	7/3/2015	16	5	0.31
Point Vivian 1*	6/17/2015	7/3/2015	16	0	0.00
Point Vivian 10*	6/17/2015	7/3/2015	16	0	0.00
Point Vivian 9*	6/17/2015	7/3/2015	16	0	0.00
Point Vivian 8*	6/17/2015	7/3/2015	16	0	0.00
Point Vivian 7*	6/17/2015	7/3/2015	16	0	0.00
Point Vivian 6B*	6/17/2015	7/3/2015	16	1	0.06
Point Vivian REF2*	6/17/2015	7/3/2015	16	0	0.00
Point Vivian REF1*	6/17/2015	7/3/2015	16	1	0.06
Ferguson South*	6/17/2015	7/3/2015	16	0	0.00
Ferguson North DSL*	6/17/2015	7/3/2015	16	1	0.06
Ferguson North DSR*	6/17/2015	7/3/2015	16	0	0.00
Rose Pond*	6/25/2015	7/3/2015	8	0	0.00
Carpenter's Branch	6/19/2015	7/3/2015	14	0	0.00
Delaney Marsh	6/19/2015	7/2/2015	13	8	0.62
Total			**398**	**35**	**0.09**

Table 3. Seining catch summary for 2015 sampling using a 1/8" fine-mesh 30' bag seine in index sites (top), exploratory sites (middle), and the 1/4" large-mesh bag seine targeting esocids. Grey lines represent sites that were stocked with larval muskellunge in 2015.

2015 30' Index Seining					
Bay	Hauls	Muskie	NP	CPUE M	CPUE NP
Affluence Bay	6	2	0	0.33	0.00
Boscobel	6	1	0	0.17	0.00
Cobb Shoal	12	0	0	0.00	0.00
Deer Island	6	3	1	0.50	0.17
Frinks	10	0	1	0.00	0.10
Garlock	10	0	0	0.00	0.00
Lindley	6	3	0	0.50	0.00
Millens	12	2	11	0.17	0.92
Peos	6	3	0	0.50	0.00
Rose	10	3	0	0.30	0.00
Salisbury	6	4	0	0.67	0.00
Total	**90**	**21**	**13**	**0.23**	**0.14**

Table 3. Continued

2015 60' Index Seining					
Bay	Hauls	Muskie	NP	CPUE M	CPUE NP
Affluence Bay	6	0	0	0.00	0.00
Boscobel	6	3	0	0.50	0.00
Cobb Shoal	12	1	0	0.08	0.00
Deer Island	6	0	0	0.00	0.00
Frinks	10	0	1	0.00	0.10
Garlock	10	0	0	0.00	0.00
Lindley	6	1	1	0.17	0.17
Millens	12	0	1	0.00	0.08
Peos	6	0	0	0.00	0.00
Rose	10	7	0	0.70	0.00
Salisbury	6	1	2	0.17	0.33
Total	**90**	**13**	**5**	**0.15**	**0.06**

Table 3. Continued

2015 30' Exploratory Seining					
Bay	Hauls	Muskie	NP	CPUE M	CPUE NP
Aunt Jane's Bay	7	2	5	0.29	0.71
Bartlett Cove	3	0	0	0.00	0.00
Blind Bay	6	1	2	0.17	0.33
Buck Bay	6	5	0	0.83	0.00
Carrier Bay	7	1	1	0.14	0.14
Delaney	5	1	0	0.20	0.00
Escanaba Bay	4	0	0	0.00	0.00
Fergusons Cove	6	2	0	0.33	0.00
Flynn Bay	8	1	4	0.13	0.50
French Bay	3	0	1	0.00	0.33
French Creek	4	0	0	0.00	0.00
Jolly Island	3	5	1	1.67	0.33
Long Point	3	0	1	0.00	0.33
Mead Island	3	1	0	0.33	0.00
Point Vivian	11	0	2	0.00	0.18
Red Barn	3	0	0	0.00	0.00
Reed Point	1	0	0	0.00	0.00
Roods Cove	3	0	0	0.00	0.00
Rusho Bay	3	0	0	0.00	0.00
Swan Bay	3	0	0	0.00	0.00
Whitehouse Bay	5	0	0	0.00	0.00
Total	**97**	**19**	**17**	**0.20**	**0.18**